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Erie County

Act 167 County-Wide Stormwater Management Plan

August 2010

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Section I – Introduction

This stormwater management plan is the product of a collaborative effort between the varied stakeholders within the Act 167 Designated Watersheds in Erie 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. However, the volume and rate of runoff are substantially increased as land development occurs. Stormwater management is a general term for practices used to reduce the impacts of this accelerated stormwater runoff. Stormwater management practices such as detention ponds and infiltration areas are designed to mitigate the negative impacts of increased runoff. Volume of runoff and rate of runoff are often referred to by the term "water quantity". Water quantity controls have been a mainstream part of stormwater management for years. Another aspect of runoff is water quality. This refers to the physical characteristics of the runoff water. Common water quality traits include temperature, total suspended solids, salts, and dissolved nutrients. Water quality is an emerging topic in stormwater management and the general water resources field. Both water quantity and water quality can contribute to degradation of surface waters.

As development has increased, so has the problem of managing the increased quantity of stormwater runoff. Individual land development projects are frequently viewed as separate incidents, and not necessarily as an interconnected hydrologic and hydraulic system. This school

of thought is exacerbated when the individual land development projects are scattered throughout a watershed (and in many different municipalities). However, it is has been observed, and verified, that the cumulative nature of individual land surface changes dramatically influences flooding conditions. This cumulative effect of development in some areas has resulted in flooding of both small and large streams, with substantial financial property damage and endangerment of the public health and welfare. Therefore, given the distributed and cumulative nature of the land alteration process, a comprehensive (i.e., watershed-level) approach must be taken if a reasonable and practical management and implementation approach or strategy is to be successful.

Watersheds are an interconnected network in which changes to any portion within the watershed carry throughout 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 which contribute to a watershed's degradation. While land use regulation remains at the municipal level, the framework established within a watershed plan enables municipalities to see the impact of their regulations on the overall system, and coordinate their efforts with other stakeholders 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 base flows, and relatively high water quality. When all of these conditions are present the 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 an equilibrium over time to convey the runoff from its contributing area within the channels banks. Typically, the channel will be large enough to accommodate the runoff from a storm, 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

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

4. Base Flows – Loss of groundwater recharge, as described above, leads to insufficient groundwater available to replenish stream flow during dry weather. As a result, streams that may have an adequate base flow during dry weather under natural conditions may experience reduced flow, or become completely dry, during periods of low precipitation in developed watersheds. Thermal degradation of the waterbody often accompanies the reduction of base flow originating from groundwater. This source of base flow is generally much cooler than surface water sources. The increase in water temperature can be detrimental to many ecological communities.
5. Water Quality – Stormwater from developed surfaces carries a wide variety of contaminants. Pesticides, herbicides, fertilizers, automotive fluids, hydrocarbons, sediment, detergents, bacteria, increased water temperatures, and other contaminants that are found on land surfaces are carried into streams by runoff. These contaminants affect the receiving streams in different way, 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 the 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, such as severe channel erosion and significant in-stream sediment deposits resulted. These impacts lead to unstable, deepened and widened channels, nuisance flooding, infrastructure damage, increased culvert and bridge maintenance requirements, and have a detrimental affect on the stream quality in terms of habitat for aquatic organisms. In addition, large amounts of rainfall are lost to the watershed and become unavailable for infiltration and groundwater recharge, and contaminants on the land surface enter the stream untreated. This approach cannot be considered stormwater management in any meaningful terms.

This approach was later replaced with the stormwater management standards that 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 significant failings with this approach.

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

1. Stormwater regulatory responsibility, absent arrangements to the contrary, rests with the municipal governments in Pennsylvania. Therefore, stormwater management regulations, if applied at all, are implemented by a municipality only within the boundaries of its own jurisdiction. There is no guarantee that all municipalities 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 which originate in areas they have no control over.
2. Each area within a watershed is unique in terms of it's contribution to the overall watershed hydrology. When the same standards are implemented throughout a municipality, and the overall watershed hydrology is not considered, these standards can result in over-management in some areas and under-management in other areas. In some cases, this type of management could actually exacerbate stormwater problems. Further, this "one-size-fits-all" approach does not take into account conditions such as soil infiltration rates, slopes, or channel conditions, which vary throughout a watershed and municipality.

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

LOW-IMPACT DEVELOPMENT AND STORMWATER MANAGEMENT

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

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

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

The overall design concepts and specific design measures for BMPs are derived from the following conceptual framework (Prince 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 approaches. These concepts, as they apply to stormwater, are the basis for the stormwater management approach presented in this Plan.

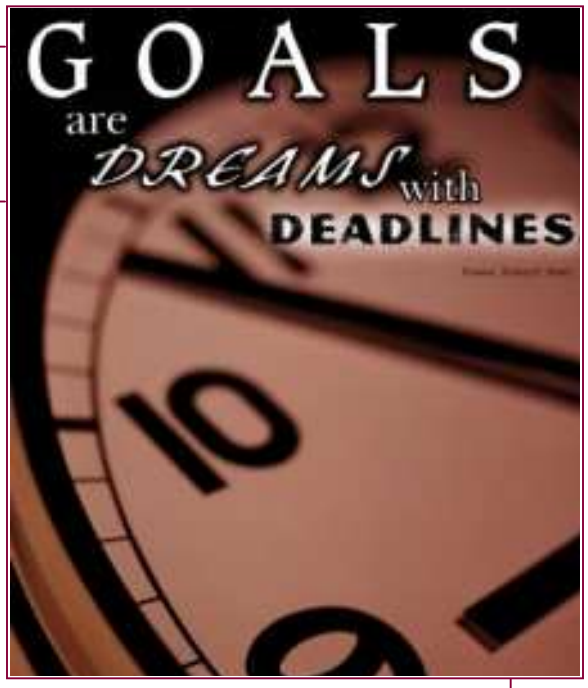
LID Approach		Traditional Approach	
Approach	Examples	Approach	Examples
1. Integration of Pre-Development Hydrology	A development built around a drainage way outside of functional floodplain	Elimination of all water features from project site	Redirection and conveyance of drainage; alteration of floodplain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

Table 10.1. Comparison of LID Versus Traditional Stormwater Management Approach

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

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, and to fullfill the policy and purpose of Act 167 as shown in table 2.1 and the requirements of Act 167 as shown in table 2.2. 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 Erie 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 Erie County.

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

5. Preserve the existing natural drainage ways and water courses.

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

These goals provided the focus for the entire planning process. A scope of work was developed in Phase 1 that focused efforts on gathering the necessary data and developing strategies that address the goals. With the general focus of the Plan determined, Phase II further researched county specific information, provided in-depth technical analysis, and developed a model ordinance to achieve these goals. On the following page, ***Table 2.0*** shows the preferred stategies to address the goals, and where these strategies are addressed in the Plan:

1. Manage stormwater runoff created by new development activities by taking into account the cumulative basin-wide stormwater impacts from peak runoff rates and runoff volume	
Develop models of selected watersheds to determine their response to rainfall	***Section 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 BMPs	***Section VII***
3. Provide uniform standards throughout Erie 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 Erie 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 drainage ways and water courses	
Provide education on the function and importance of natural drainage ways	***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***
Analyze problem areas and provide conceptual solutions to the problems	***Section V***

Table 2.0. 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).

Section 2 of Act 167 presents a statement of legislative findings of the General Assembly of the Commonwealth of Pennsylvania. Section 3 of the Act sets forth its purpose and policy. Refer to table 2.1.

Act 167, Section 2 Statement of Legislative Findings of PA General Assembly	
(1)	Inadequate management of accelerated runoff of storm water resulting from development throughout a watershed increases flood flows and velocities, contributes to erosion and sedimentation, overtaxes the carrying capacity of streams and storm sewers, greatly increases the cost of public facilities to carry and control storm water, undermines flood plain management and flood control efforts in downstream communities, reduces ground-water recharge, and threatens public health and safety.
(2)	A comprehensive program of storm water management, including reasonable regulation of development and activities causing accelerated runoff, is fundamental to the public health, safety and welfare and the protection of the people of the Commonwealth, their resources and the environment.
Act 167, Section 3 Purpose and Policy	
(1)	Encourage planning and management of storm water runoff in each watershed which is consistent with sound water and land use practices.
(2)	Authorize a comprehensive program of storm water management designated to preserve and restore the flood carrying capacity of Commonwealth streams; to preserve to the maximum extent practicable natural storm water runoff regimes and natural course, current and cross>section of water of the Commonwealth; and to protect and conserve ground waters and ground>water recharge areas.
(3)	Encourage local administration and management of stormwater consistent with the Commonwealth's duty as trustee of natural resources and the people's constitutional right to the preservation of natural, economic, scenic, aesthetic, recreational and historic values of the environment.

Table 2.1. Elements of Act 167

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

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

SECTION 5b Each watershed stormwater plan shall include, but shall not be limited to:

(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. Required information may also be found by referring to NRCS Soil Maps (http://websoilsurvey.nrcs.usda.gov/app/).

(2) A survey of existing significant obstructions and their capacities;

The municipalities, through the PAC, responded to a survey which compiled an inventory of obstructions. Section 5 provides the inventory as well as a discussion. Capacities of the obstructions were not fully developed as Budgetary impacts reduced the scope of the Plan. Plate 7 shows the identified obstructions.

(3) An assessment of projected and alternative land development patterns in the watershed, and the potential impact of runoff;

A hydrologic model was developed and used to assess the impacts future land development alternatives in order to address the potential impacts of increased runoff, as discussed in the following portions of the Plan: Section 3 (Land Use and Surface Water Quality), Section 5 (Significant Problem Areas and Obstructions) Sections 6 (Technical Analysis) and Section 7 (Technical Standards and criteria for control of stormwater runoff), Section 9 (Water Quality Impairments and Recommendations), and Section 10 (Additional Recommendations Low-Impact Development Site Design) as well as Appendix A.

(4) An analysis of present and projected development in the flood hazard areas, and its sensitivity to damages from future flooding or increased runoff;

Federal flood insurance studies have been used as reference for the location of flood plain areas as identified in Plate 8. Section 3 provides a discussion and an analysis showing damages to existing development due to flood hazard areas caused by increased runoff in the watershed. Recommendations where made with measures to mitigate future damages in Section 7.

(5) Survey of existing drainage problems and proposed solutions;

The municipalities, through the PAC, responded to a survey which compiled an inventory of existing problem areas. Section 5 provides the inventory as well as a discussion. Plate 7 shows the identified problem areas as well as Appendix C.

(6) A review of existing and proposed stormwater collection systems;

The more urbanized areas of the County contain storm sewer systems, as do the many roadways that traverse the County. Storm sewer collection systems have a significant effect on the hydrologic response of a watershed as pipe networks rapidly increase runoff rate. If stormwater control facilities do not intercept runoff from storm sewer systems, flooding often increases, as well as other stormwater problems such as streambank erosion and sedimentation. Plate 7 shows the collection systems as identified by the municipalities through the PAC.

(7) An assessment of alternative runoff control techniques and their efficiency in the particular watershed;

Section 7 of the Plan identifies a variety of runoff control techniques are available for use in all watersheds in the County. It references and expands upon the Pennsylvania Stormwater Best Practices Manual to identify innovative methods of controlling runoff. In addition, traditional engineering solutions such as drainage structure replacement, streambank restoration, etc. were also identified in situations where alternative runoff controls are not applicable.

(8) An identification of existing and proposed state, federal and local flood control projects located in the watershed and their design capacities;

Section 3 lists the local, state, and federal flood control projects in the County which was shown on Plate 8. Where the effectiveness in mitigating flooding or design capacity data was readily available, this information was also documented.

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

Table 2.2. Elements of Act 167

PLAN ADVISORY COMMITTEES

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 Plan Adisory Committee meetings were facilitated throughout the development of this Plan.

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

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

PAC Meeting	Purpose of Meeting	Meeting Dates
1	Phase 1 Start-up Meeting - Introduce the Act 167 Planning process focusing on importance of full municipal involvement. Present data collection questionnaire.	12/13/2007
2	Present summary of the data collection questionnaire from Phase 1, overview of proposed work for Phase 2	4/10/2008
3	Phase 2 Start-up Meeting – Re-introduction of the Phase 2 Planning process. Present summary of the data collection questionnaire from Phase 1; Introduction of Integrated Water Resources Planning; review problem areas	4/9/2009
IWRP-1	Workshop with municipalities about developing a stormwater program and identifying stormwater needs exercise.	4/15/2009
IWRP-2	Workshop with municipalities to review of stormwater Issues and begin discussions of root causes and strategies to address them.	6/23/2009
4-E	With PAC & municipal engineers, review the project status, technical issues for detailed models: Review model selection and setup, initial modeling runs, calibration procedures, solicit input on technical standards, water quality issues as well as ordinance content.	10/21/2009
5	Meetings 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	3/25/2010

	Ordinance sent to municipalities prior to meeting).	
6	Meeting with PAC and municipal engineers 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).	TBD
7	Meeting with PAC and municipal engineers reviewing comments and responses prior to finalization of the Plan.	6/22/2010
Public Hearing	Conduct the hearing as required by Act 167 to present the Plan to the public.	TBD
8	Municipal Implementation Workshop: Provide assistance to municipalities on implementation of the Plan including adaptation, enactment, and implementation of the ordinances and other action items.	TBD
Public Workshop	Public Implementation Workshop: Provide introduction and overview of the Plan to public.	TBD

Table 2.3. Summary of PAC Meetings

Section III – Erie County Description

Erie County was established by an act of the legislature on March 12, 1800 from part of Allegheny County. The county joined Crawford, Mercer, Venango, and Warren counties, also formed by the same act, in a five-county governing body that was located in Meadville, Crawford County. All five counties were governed from this seat until Erie elected its own county officials in 1803. Prior to becoming part of Pennsylvania, this land was part of "The Triangle" which five states (Pennsylvania, New York, Connecticut, Massachusetts, and Virginia) and the Iroquois all laid claim upon. This region became part of Pennsylvania in 1792 when it was purchased from the United States government. The county was named after Lake Erie, which was named for the Erie Indians who are presumed to have inhabited the region.

Erie County is located in the extreme northwest corner of Pennsylvania. It is about a two-hour drive from Pittsburgh, Cleveland, or Buffalo. The county is bounded to the north by Lake Erie. It is bordered to the northeast by Chautauqua County, New York; to the southeast by Warren County, Pennsylvania; to the south by Crawford County, Pennsylvania; and to the west by Ashtabula County, Ohio. According to the U.S. Census Bureau, the county has a total area of 1558 square miles, of which, 802 square miles is land and the remaining 756 square miles is water. The land consists of low hills that rise toward the southeast. The elevation range of the county is from a low of 573 feet on Lake Erie to a high of 1,900 feet at a point south of Corry, in Concord Township (Socolow, 1973).

The lakeside city of Erie, the county seat, is Pennsylvania's only port on the St. Lawrence Seaway. The city developed with the opening of the Erie and Pittsburgh Canal and railway construction. Another town, Waterford, is the site of Fort-Le-Boeuf, a French fort used during the French and Indian War. Erie carries great historical significance in the French and Indian War and the War of 1812 where Admiral Perry's American Navy defeated the British Navy. Area attractions include Presque Isle State Park, which is named for Fort-Presque-Isle, built by the French in 1753.

POLITICAL JURISDICTIONS

Erie County is classified as a third class county and is comprised of 38 municipalities. The political jurisdictions include 2 cities, 14 boroughs, 1 first class township, and 21 second class townships. The county has a total population of 280,843 according to the 2000 census. Erie City has the largest population with 103,717. Mill Creek Township and Harborcreek Township are the only other municipalities to exceed 15,000 people (with 52,129 and 15,178, respectively). Elgin Borough has the smallest population with 236 people. Waterford Township is the largest municipality geographically with a total land area of 50.1 square miles which is closely followed by Washington Township with 45.1 square miles, while Wattsburg Borough is the smallest covering just 0.3 square miles. The City of Erie is the county seat and serves as the administrative headquarters of the county. The 38 Erie County municipalities in are listed with their associated land area in ***Table 3.1*** on the following page:

Municipality	Area (mi^2)	Municipality	Area (mi^2)	Municipality	Area (mi^2)
Cities		Union City Borough	1.9	Greene Township	37.5
Corry City	6.1	Waterford Borough	1.2	Greenfield Township	33.8
Erie City	22.0	Wattsburg Borough	0.3	Harborcreek Township	34.2
Boroughs		Wesleyville Borough	0.5	Le Boeuf Township	33.7
Albion Borough	1.1	**1st Class Townships**		Mckean Township	36.6
Cranesville Borough	0.9	Lawrence Park Township	1.9	Millcreek Township	29.5
Edinboro Borough	2.3	**2nd Class Townships**		North East Township	42.4
Elgin Borough	1.6	Amity Township	28.3	Springfield Township	37.7
Girard Borough	2.4	Concord Township	33.0	Summit Township	23.9
Lake City Borough	1.8	Conneaut Township	43.4	Union Township	36.5
Mckean Borough	0.6	Elk Creek Township	34.6	Venango Township	43.6
Mill Village Borough	0.9	Fairview Township	29.2	Washington Township	45.1
North East Borough	1.3	Franklin Township	28.8	Waterford Township	50.1
Platea Borough	3.3	Girard Township	31.7	Wayne Township	38.3

Table 3.1. Erie County Municipalities

LAND USE

Land use is a crucial component of stormwater management planning. An analysis of existing land use provides background information for estimating existing stormwater runoff. Existing land use and general development patterns are used to forecast future land use. General growth patterns and future land use is essential information used to develop stormwater management controls that are appropriate for a particular region.

EXISTING LAND USE

In 1980, the county's population was 279,780; by 2000, the population had increased to 280,843. This represents a population change of less than one percent (1%), yet the changes in land use during this same time period are substantial. The ***Erie County Land Use Plan*** (2003) classified all the land uses within the county in 2002.

Description	Area (mi^2)	Area (%)
Residential	68.85	8.6
Commercial	7.99	1.0
Industrial	6.85	0.9
Public/Institutional	13.79	1.7
Agricultural	213.6	26.5
Open, Wooded, Vacant or Water	434.6	54.2
Roads & Highways	25.3	3.1
Airport & Rail	3.45	0.4
State Lands	28.69	3.6

Table 3.2. 2002 Erie County Land Use

As shown in ***Table 3.2***, just over half of the county's land is undeveloped and over one quarter of the land is in agricultural use. Overall, the developed area of the county has been increasing over the past 25 years. The vast majority of that growth occurred from new residential development. Other important trends include a nearly 40% decrease in agricultural land use, a 41% increase in open land, and an increase in industrial land use area by over 45%.

Transportation

Transportation in the county has influenced the hydrology of the watersheds. The county is served by two important major transportation routes. Interstate 79, the north-south link from Interstate 80 and Pittsburgh terminates in the City of Erie. Interstate 90 runs east-west through the County and provides access to adjacent states of Ohio (Cleveland) and New York (Buffalo). Other minor transportation routes include United States Highway No. 6 which crosses the county from northwest to southeast, State Route 8 which crosses the county from southwest to northeast, State Route 5 crossing the county from west to east (also a seaways corridor), and State Route 19 which is a commercial corridor that runs south to north. These major thoroughfares and crossroads provide a critical transportation and commuting link for county residents. A review of land use patterns shows development is heavily clustered along these and other transportation networks.

To a lesser extent, rail lines have also influenced the hydrology of the county. Several major railroad lines cross the county, mostly serving the industrial needs. One major airport, Erie International Airport, Tom Ridge Field, serves the county. Lake Erie provides a major transportation and shipping route through the Port of Erie. Over the past 25 years, the county has seen a decrease in the amount of land used for "other transportation" (i.e. not roads and highways). This is likely a result of rail lines and rail yard abandonment (Erie County, 2003).

Residential Development

According to the 2003 ***Land Use Plan***, much of the increase in residential land use is a direct result of low-density suburbanization patterns. Residents are leaving older urban places, such as Erie City, and relocating to more suburban and rural areas, but often to areas still not too far from jobs and shopping. This accounts for the development of extensive suburbs in Fairview, Harborcreek, McKean, Millcreek, and Summit Townships, as well as expansion of suburban developments into townships adjacent to other urbanized areas such as Edinboro, Girard/Lake City and North East.

This suburban/rural growth is generally at a much lower density than the urban locations. A single suburban dwelling might be placed on a lot from 10,000 square feet to over one acre in size versus the 7,200 square foot size parcel which is typical in the Cities of Erie and Corry. As a result, residential density has changed from 9.3 persons per developed residential acre in 1980 to 6.4 persons in 2002.

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 tasked the Soil Conservation Service to inventory the prime and unique farmlands, and farmlands of state and local importance, to assist planners and other officials in their decision making to avoid unnecessary, irrevocable conversion of good farmland to other uses. Of Erie County's total land area 19.9% (102,813 acres) are classified as prime farmland (NRCS, 2009). According to the USDA, prime farmland soils are usually classified as capability Class I or II.

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. Of Erie County's total land area 59.0% (305,480 acres) is classified as farmland of statewide importance (NRCS, 2009). These soils are usually classified as capability Class II or III.

Agricultural land use represents 26.5% of the county's land. 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 as part of a comprehensive stormwater policy.

Between 1978 and 2002, the county lost over 26% of the existing agricultural lands. To address this problem, Erie County and its municipalities have active Agricultural Security Area and Farmland Preservation programs as shown below:

Agricultural Security Areas: 18 participating municipalities, 68,264 acres protected as of 2/2008.

Clean & Green Program: Over 5,819 parcels totaling about 202,850 acres participate in the program, as of 2/2008.

Agricultural Easements: Through Erie County Land Preservation Board, 44 easements have been purchased totaling 5,151 acres as of 3/2008.

GENERAL DEVELOPMENT PATTERNS

The general development patterns in Erie County are well described in the ***Erie County Land Use Plan*** (2003):

> "…certain overall observations can be made. First, it is readily apparent that Erie City remains the development center of the County. Development radiates outward from the City. A second observation focuses on the attraction of the Lake Plain. Most developed land in Erie County is found north of I-90, in a strip from North East to the Girard-Lake City axis. A second development corridor is found along I-79 in the McKean, Washington, and Edinboro areas. Next are the rural development centers (i.e., Corry, Union City, Waterford, and Albion-Cranesville), which are all focused on one or two major highways. Finally are the patterns of suburban residential development. In the immediate Erie suburban area, land use patterns show nearly continuous ribbons of residential use along nearly all roads. In the more rural areas, and in the prime farmlands such as North East, more traditional land use patterns still prevail. To a large extent, these patterns represent a more limited number of residences along rural, secondary roads."

CLIMATE

Erie County is situated in the Northwest Plateau Climatic Divisions and the climate is classified as humid continental. In general, the winters in Erie County are moderately cold and the summers are warm and somewhat humid. Mean temperature in the summer is about 67°F while the winter mean temperature is about 27°F. Cloudiness is prevalent in winter as a result of the "lake effect" of cold air passing over the relatively warm Lake Erie, picking up moisture and resulting in cloud formation. Annual precipitation is about 39.4" with maximum precipitation occurring in the month of September (3.9") and the minimum precipitation in February (2.1"). The average annual snowfall amounts to about 84 inches a year. Snow is produced as Canadian air masses travel south over unfrozen lake waters. The air masses absorb considerable amounts of moisture and warmth as they move over the Great Lakes. As the warm, moistened lower level air reach land and rise through the cold air above, heavy snow squalls are produced that are capable of depositing one to two feet of snow on the County. Lake Erie is subject to this "lake effect"

snowfall during November and December. As the lake surface freezes over, snowfalls of this type become less frequent.

RAINFALL

Figures 3.1 and 3.2 show the rainfall statistics for Erie County. The average rainfall, shown in ***Figure 3.1*** portrays the amount of precipitation throughout each year since 1926. Although there can be significant variation in the annual rainfall total (between 24 and 62 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, 48-hour) that receives the focus of most stormwater regulations.

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

Historical focus on the annual maximum rainfall and the larger magnitude, low frequency storm events as done in previous stormwater planning efforts throughout Pennsylvania has 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 Erie County comes from storms of low magnitudes. Only 10% of the daily rainfall values between 1926 and 2009 exceeded 0.63 inches, which is below any design standards currently being used in the County. Thus, any stormwater policy should incorporate provisions such as water quality, infiltration, or retention BMPs that account for these small events. It is important to acknowledge that many of these smaller rainfall events lead to larger runoff events as they may be saturating the soils prior to a larger storm or occurring within a short time period that still overwhelm existing conveyance facilities.

For the gage shown in ***Figure 3.1*** and ***3.2***, the NOAA Atlas 24-hour, 2-year storm event total of 2.15 inches was exceeded 38 times in more than 80 years of data. When analyzing only the annual maximum series, the NOAA Atlas 24-hour, 2-year storm was exceeded only 32 times. Analysis of these datasets results in 16% fewer events exceeding the 2-year storm when using only the annual maximum data. Viewing only the annual maximum series neglects a substantial number of significant historical rainfall events. The implication for stormwater policy in Erie County is that best management practices should incorporate the NOAA Atlas 14, partial duration data series to ensure the best available data is being used for design purposes.

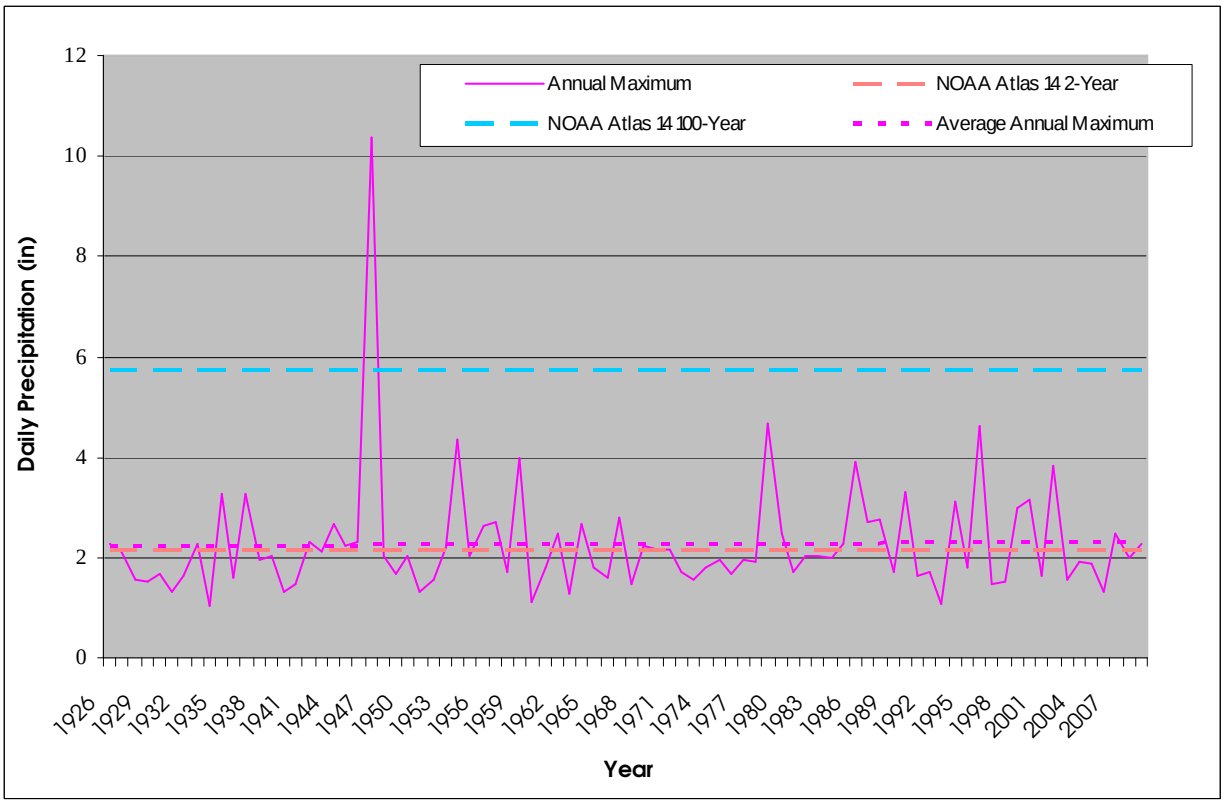


Figure 3.1. Annual Precipitation at Erie INT AP, Pennsylvania (Coop ID #362682)

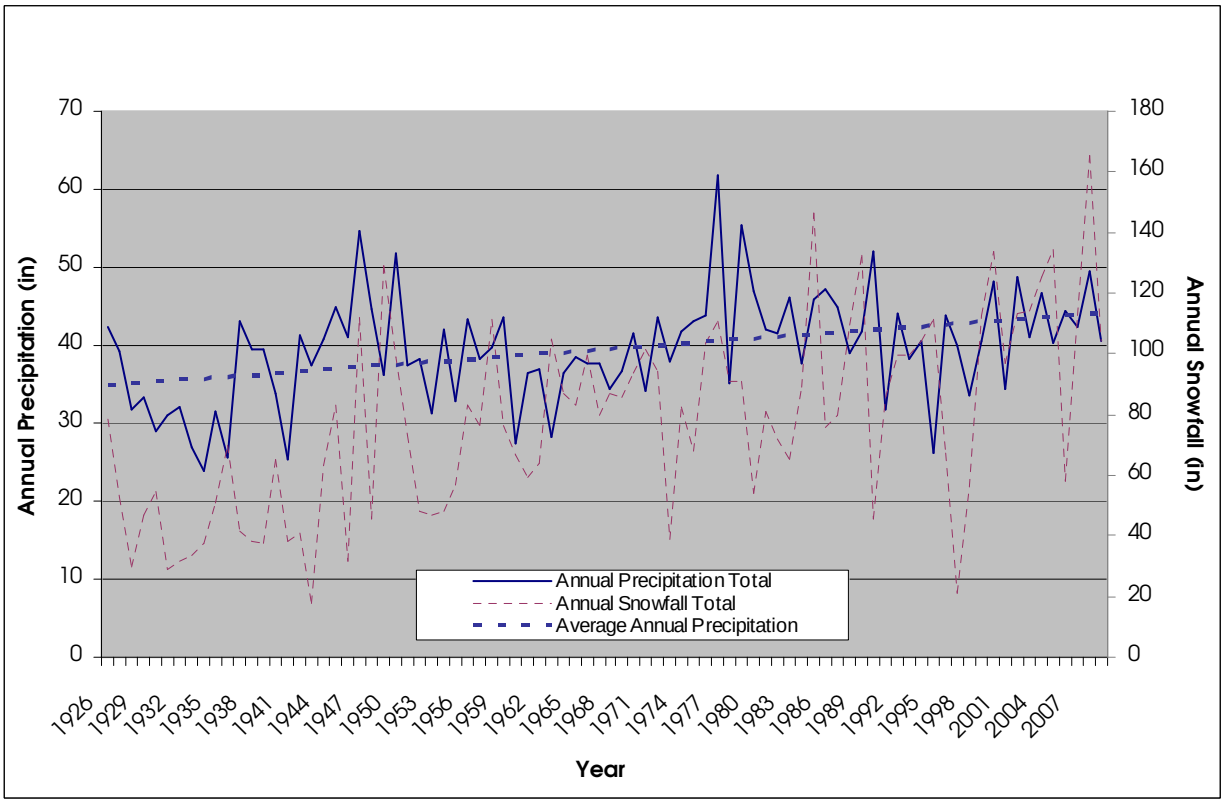


Figure 3.2. Daily Precipitation at Erie INT AP, Pennsylvania (Coop ID #362682)

GEOLOGY

Erie County is located mostly in the Northwestern Glaciated Plateau Section of the Appalachian Plateaus Physiographic Province, with the northwestern part of the county near Lake Erie in the Eastern Lake Section of the Central Lowlands Province. The Appalachian Plateaus Physiographic Province is by far the largest province in the state. It contains mostly rock that is not faulted and folded but site relatively flat. Many of the folds that do exist in this province are high amplitude and stretch for miles. The dominant topographic form of the Glaciate Plateau Section is broad, rounded upland and deep, steep-sided, linear valleys partly filled with glacial deposits. It has very low (0 to 100 feet) to moderate (301 to 600 feet) local relief and a dendritic drainage pattern. The Central Lowlands Province is part of the Great Lakes area and is the smallest Province in Pennsylvania. It exists along a glacial escapement adjacent to Lake Erie. The Eastern Lake Section is characterized by northwest-sloping, low-relief ridges that are parallel to the lake. The local relief is very low (0 to 100 feet) to low (101 to 300 feet) with a parallel drainage pattern (Sevon, 2000). Refer to ***Plate 6 – Geology*** for more information. The areas within the two Physiographic Provinces are further described as follows:

Central and Lowland Province - The area adjacent to Lake Erie lies within the Eastern Lake Section of the Province. This section consists of a series of northwest-sloping, lake-parallel, low-relief ridges. These ridges are made up of unconsolidated sands and gravels that were deposited during the most recent deglaciation of the area about 18,000 years ago. Steep-sided, narrow valleys cut through these ridges into the underlying shales and siltstones and flow into Lake Erie. Originally, the ridge bordering Lake Erie sloped gently into the lake. However, erosion of the shoreline has caused the lake-land interface to move southeastward so that today there is a steep bluff adjacent to the lake. Continued erosion of this bluff is a key environmental problem in the area.

Appalachian Plateaus Province – The majority of the County lies within the Northwestern Glaciated Plateau Section of the Appalachian Plateaus Province and consists of much broad, rounded upland cut by long, linear valleys. The uplands have a southeast-oriented linearity that is pronounced in eastern Erie County. The uplands are cut by many flat-floored valleys that are separated from adjacent uplands by steep slopes on one or both sides of the valley. The valleys are very linear and are oriented northwest-southeast for the most part although some valleys are perpendicular to this orientation. The valley floors are often wetlands. There is frequently a considerable depth of unconsolidated material beneath the valley floor.

BEDROCK FORMATIONS

Erie County has been completely covered by at least three glaciers. The last glacier occurred during the Wisconsin stage. The Wisconsin glacier advanced into the county and receded five times. The last glacial advance receded about 10,000 years ago. Glacial scour, deposition, and meltwater from this glacier created the topography and geology from which most of the county's soils formed.

The time between the early and late stages of the Wisconsin glaciation caused distinct differences in drainage, which have ultimately impacted county land use. Well-developed drainage patterns are associated with the early Wisconsin stage, while poorly drained areas are associated with the late Wisconsin stage. Considerable glacial outwash can be found along the stream valleys.

Bedrock in Erie County includes ten different geologic formations that were formed primarily in the Devonian geologic period but also the older Mississippian and much older Quaternary periods. The formations consist of Argillaceous shale, sand, sandstone, shale, and siltstone primary lithology, and includes conglomerate as well as the previously named lithologies in

smaller proportions. At the Lake Erie shore, the bedrock formation is the Sands of Presque Isle formation of the Quaternary Age. Along the southern portion of the county, bedrock formations are that of the Cuyahoga Group of the Mississippian Age. The formation names are as follows (Berg et al., 1980):

Formation	Dominant Lithology	% of County
Berea Sandstone through Riceville Formation, undivided	Sandstone	3.2%
Berea Sandstone through Venango Formation, undivided	Sandstone	6.10%
Chadakoin Formation	Siltstone	33.2%
Corry Sandstone through Riceville Formation, undivided	Sandstone	6.8%
Cuyahoga Group	Siltstone	1.4%
Girard Shale	Argillaceous shale	14.4%
Northeast Shale	Shale	7.6%
Sands of Presque Isle	Sand	0.3%
Shenango Formation	Sandstone	< 0.1%
Venango Formation	Siltstone	26.9%

Table 3.3. Geologic Formations

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). Erie County contains four of these resources as identified below.

Devils Backbone – This unique topographic feature, created by stream erosion, is located in Girard Township, along Little Elk Creek about 3.2 miles southeast of Girard. The shape of the land within a series of meanders in Little Elk Creek resembles a "backbone".

Drumlins – This feature is located 2 miles northeast of Wattsburg along Macedonia Road, near State Game Lands No. 191 in Venango Township. Drumlins are low, smoothly rounded, elongated hills, mounds, or ridges of compact glacial till, built under the margin of ice and shaped by its flow, or carved out of the older moraine by re-advancing ice. The drumlin's longer axis is parallel to the direction of ice movement, a blunt nose pointing in the direction from which the ice approached, and gentler slope tapering in the opposite direction. These features are very common to the glaciated northwestern area of Pennsylvania, however, drumlins located at this site are almost perfect textbook examples.

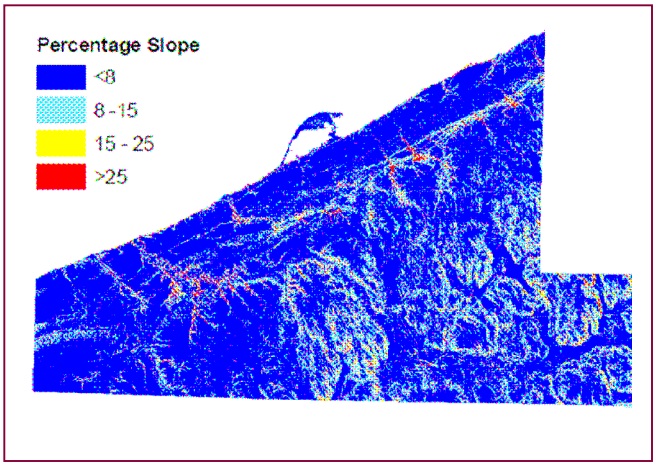
Presque Isle – Located in Millcreek Township, along the southern shore of Lake Erie in Presque Isle State Park. Presque Isle is a relatively recent geologic feature of glacial origin, have developed less that 13,000 years ago, after the final retreat of glacial ice from northwestern Pennsylvania, The peninsula, approximately 6 miles long, is composed of sand deposits brought into the area from the west by lake currents. Within record, Presque Isle has grown so that presently the neck is about three time longer, the exposed land area three to four time greater, and the overall reach of the feature nearly three times greater than in 1790. The site is also of historical importance because it is associated with Admiral Perry's great victory of the Battle of Lake Erie in the War of 1812. It is a registered National Natural Landmark.

Titus Bog – Located in Amity Township approximately 20 miles southeast of Erie. This is a marl bog that contains an acid sphagnum mat surface. It is an excellent example of a sphagnum bog surrounded by a well-developed swamp forest. It is a registered National Natural Landmark.

SLOPES

The slope of the land not only delineates drainage patterns, but it is an indication of suitable land uses and the ability to develop land. Erie County's land area is comprised of varying degrees of slope, ranging from nearly level plateaus to severe slopes. The general characteristics and development potentials and limitations of each category of slope are described as follows:

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 77% is classified as having flat to moderate slopes of 8% or less. This slope range has vey few associated land use restrictions. Slope values are broken into four categories and shown in ***Table 3.4*** below. Also shown is the total area in Erie County within each category, the total area as a percentage of all land in the county, and the general slope restrictions associated with each category.



Slope Classification	Slope Range	Land Area (mi^2)	Portion of Total Area	Slope Restrictions
Flat to Moderate	0-8%	622.2	77.4	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%	122.6	15.2	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%	42.8	5.3	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%	16.5	2.0	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 3.4. Summary of Slopes in Erie County

Section III – Erie County Description

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 Erie County have variable drainage characteristics and have various restrictions on their ability to drain, promote vegetative growth, and allow infiltration. The following table describes the predominant soil series in Erie County (NRCS, 2009). For more on Hydrologic Soils see Appendix E which is excerpted from Appendix A of the NRCS TR-55 manual.

Series Name	Map Symbols	Hydrologic Soil Group	% of County	Restrictions
Allis	AaA, AaA3, AaB, AaB3, AaC3, AaD, AaD3, AaE	D	0.86%	Paralithic bedrock (12-30 in)
Beach and Riverwash	Ba	A	0.16%	
Beach Sand	Bb	A	0.17%	
Berrien	BcA, BcB, BcB3, BcC, BcC3, BcD	A/D	0.94%	
Birdsall	BdA, BdB	D	2.04%	
Canadice	CaA, CaB, CaB3	D	0.74%	
Caneadea	CdA, CdB, CdB3, CdC, CbC3, CbD, CbD3	D	0.19%	
Chagrin	CcA, CcA3, CdA, CeA, CeB, Cf	B	0.57%	
Conotton	CgB, CgB3, CgC, CgC3, CgD, CgD3, ChA, ChB, ChB3, ChC, ChC3, CkB, CkB3, CkC, CkC3, CkD, CkD3, CmA, CmB, CmB3	A	5.39%	
Colonie	CoB, CoD	A	0.00%	
Conneaut	CtA	C/D	0.04%	
Dalton	DaA, DaB, DaB2	D	2.13%	Fragipan (12-22 in)
Darien and Platea	DeC	C/D	0.00%	Fragipan (14-26 in)
Dune Sane	Ds	A	0.10%	
Ellery and Alden	EaB	D	5.34%	Fragipan (8-20 in)
Erie	EbA, EbB, EbB2, EbB3, EbC, EbC2, EbC3, EbD. EbD2. EbD3	C/D	32.07%	Fragipan (10-28 in)
Elnora	EnB	A/D	0.00%	
Fredon	FaA, FaB	C/D	3.77%	
Fresh Water Marsh	Fm	B/D	0.07%	
Gageville	GaF	C/D	0.01%	
Glenford	GfC, GfD	C/D	0.00%	
Halsey	HaA	C/D	1.50%	
Howard	HbA, HbB, HbB3, HbC, HbC3, HbD, HbD3, HbE, HbE3	A	4.55%	
Harbor	HoA	B/D	0.00%	
Hornell	HrA, HrB	D	0.00%	Paralithic bedrock (20-40 in), Lithic Bedrock (40-69 in)
Kingsville	KfA	A/D	0.02%	
Langford	LaB, LaB2, LaB3, LaC, LaC2, LaC3, LaD, LaD2, LaD3, LbE, LbE3	C/D	7.04%	Fragipan (21-36 in)
Lobdell	LcA, LcA3, LdA, LdB	C	1.48%	
Made Land	Ma	C	0.10%	Lithic Bedrock (48-99 in)
Mahoning	MbB, MbB2, MbC, MbC2, MbC3	D	0.08%	

Series Name	Map Symbols	Hydrologic Soil Group	% of County	Restrictions
Manlius and Lordstown	McC, McE	D	0.96%	Lithic Bedrock (14-39 in)
Mardin	MdB, MdB3, MdC, MdC3, MdD, MdD3, MeE, MeE3	C/D	1.10%	Fragipan (10-36 in)
Miner	MfA	D	0.24%	
Mill	MhA	D	0.02%	
Muck and Peat	Mp	A/D	0.07%	
Ottawa	OaA, OaB, OaB3, OaC, OaC3, OaD, OaD3, ObA, ObB, ObB3, ObC, ObC3, ObD, ObD3	A	1.32%	
Otego	OtA	B/D	0.00%	
Phelps	PaA, PaB, PaB3, PaC, PaC3	B/D	4.55%	
Platea	PbA, PbB, PbB3, PbC, PbC3, PbD, PbD3, PcA, PcB, PcB3, PcC, PcC3, PcD, PcD3	C/D	5.58%	Fragipan (14-30 in)
Painesville	PvA	B/D	0.01%	
Rimer	RaA, RaB, RaB3	A/D	0.97%	
Scio	SaA, SaB, SaC, SaC3	B/D	0.40%	
Sloan	SbA, ScA	B/D	1.30%	
Sebring	SrA	C/D	0.00%	
Stanhope	StA	C/D	0.04%	
Trumbull	TaA, TaB, TaB2, TaB3, TaC, TaC2, TaC3	D	1.50%	
Tyner-Otisville	TyB	A	0.01%	
Unadilla	UaA, UaB, UaB3, UaC, UaC3	B	0.25%	
Udorthents	Ud	N/A	0.01%	
Volusia	VaA, VaB, VaB3, VaC, VaC3, VaD, VaD3, VbA, VbB, VbB3, VbC, VbC3, VbD, VbD3	D	3.58%	Fragipan (10-22 in)
Wallington	WaA, WaB, WaB3, WaC, WaC3, WaD, WaD3, WbA, WbB, WbB3, WbC	D	1.68%	Fragipan (12-24 in)
Wausen	WcA	A/D	0.51%	
Wayland	WdA	C/D	3.97%	
Williamson and Collamer	WeA, WeB, WeB3, WeC, WeC3, WeD, WeD3, WfA, WfB, WfC	C/D	0.27%	Fragipan (22-30 in)
Wooster	WgB, WgC, WgD, WgE, WgE3	B	0.08%	
Wick	WkA	D	0.02%	
Other	Dams, Escarpments, Gravel Pits, Misc. Water, Quarries, Water	N/A	2.19%	

Table 3.5. Soil Characteristics of Erie County (NRCS, 2009)

One of the impediments to drainage throughout Erie 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 8-36 inches below the surface in Erie County (Ciolkosz and Waltman, 2000; NRCS, 2009). 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 weathered bedrock, respectively) although if the depth to bedrock is large enough, it may not impede drainage. ***Table 3.6*** displays the proportion of fragipan and bedrock in Erie County.

Restrictions	% of County
Paralithic bedrock	0.9%
Lithic bedrock	1.1%
Fragipan	58.8%
None identified	39.3%

Table 3.6. Soil Restrictions in Erie County

An additional indicator of the response to rainfall of the soils in Erie 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*** shows a summary of the hydrologic soil groups for Erie County. Some soils have variable runoff potential depending on whether they are drained or undrained. For example, an agricultural field with tile drainage may decrease the runoff potential from hydrologic soil group D to hydrologic soil group A (Refer to ***Plate 4 – Hydrologic Soils***).

Hydrologic Soil Group	Runoff Potential	% of County
A	Low	11.6%
A/D		2.5%
B	Low to moderate	1.0%
B/D		6.3%
C	Moderate to high	1.6%
C/D		55.4%
D	High	19.4%
Unidentified		2.2%

Table 3.7. Hydrologic Soil Groups in Erie County

Groundwater recharge rates are variable over time and space. In Pennsylvania, 80% of groundwater recharge occurs from November to May, with March typically having the greatest amount of recharge. Areas that receive the most recharge are typically those that get the most rainfall, have favorable surface conditions, and are less susceptible to the influences of high temperatures and thus evapotranspiration. Across Pennsylvania, mean-annual recharge values range from about 7-22 inches. Reese and Risser (2010) identified ranges for mean-annual recharge value based on Hydrologic Unit Code watershed boundaries. In Erie County, these values fall into one of four ranges: 10.01-12 in, 12.01-14 in, 14.01-16 in, or 16.01-18 inches.

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. According to NRCS, the following table lists the hydric soils found in Erie County:

Alden	Chippewa	Kingsville	Terric haplosaprists
Allis	Ellery	Mill	Trumbull
Atkins	Fredon	Miner	Udorthents, wet spots
Birdsall	Frenchtown	Rimer	Wauseon
Brinkerton	Halsey	Sebring	Wayland
Canadice	Henrietta	Sloan	Wick
Carlisle	Holly	Stanhope	

Table 3.8. Hydric Soils in Erie County

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 protected by state law and should be examined before deciding on any type of development activity.

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 times a watershed is called a "basin" but is also a "subbasin" to an even larger watershed. This indistinct nature often leads to confusion when trying to categorize watersheds. As show in ***Figure 3.3***, DEP has divided Pennsylvania into seven different major river basins, based upon the major waterbody to which they are tributary. These include: Lake Erie Basin, Ohio River Basin, Genesee River Basin, Susquehanna River Basin, Potomac River Basin, Elk & Northeast / Gunpowder Rivers Basin, and Delaware River Basin.

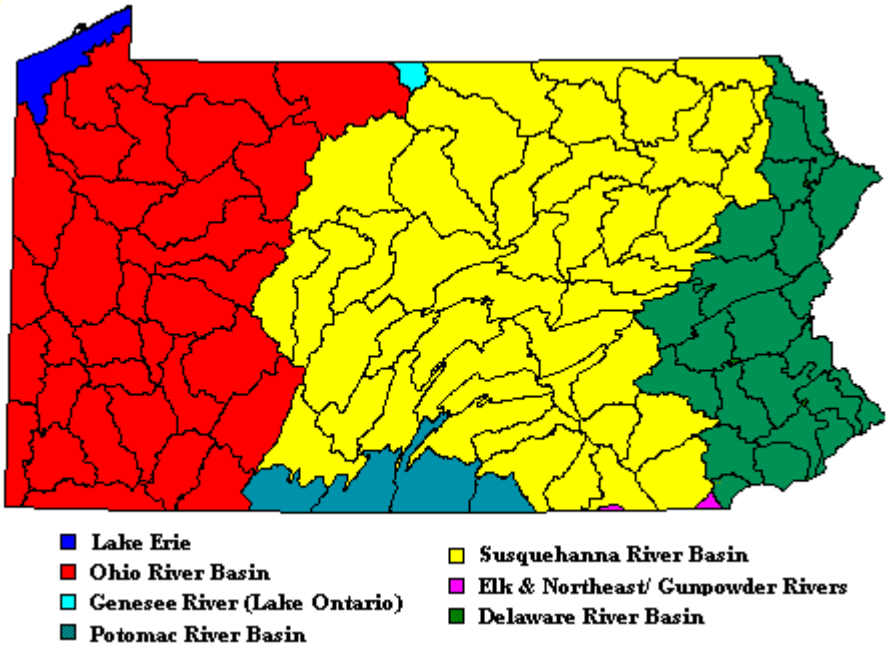


Figure 3.3. Pennsylvania's Major River Basins as Delineated by DEP (DEP, 2009)

For the purpose of this Plan, these are the largest basins within the Commonwealth. The major river basins are further divided into "subbasins" and "Act167 Designated Watersheds" for stormwater management purposes. Act 167 divided the Commonwealth into 29 subbasins and 357 designated watersheds. Erie County lies within two major river basins: The Lake Erie Basin and the Ohio River Basin. The Act 167 Designated Watersheds within the Lake Erie basin are all direct discharges to Lake Erie, therefore this basin is not divided into subbasins. The Ohio River Basin is divided into eleven subbasins (including direct discharges as a unique subbasin). However, all Act 167 Designated Watersheds within Erie County are within the Allegheny River (from New York state line to confluence with Clarion River) subbasin. The county contains at least a portion of

eight different Act 167 Designated Watersheds. This classification of the county's watersheds is summarized in ***Table 3.9*** below:

MAJOR RIVER BASIN	SUBBASIN	ACT 167 DESIGNATED WATERSHED
Lake Erie Basin	Direct Discharges	Ashtabula River
		Conneaut Creek
		Lake Erie / Elk Creek
Ohio River Basin	Allegheny River	Brokenstraw Creek
		Cussewago Creek
		French Creek
		Muddy Creek[1]
		Oil Creek

[1]Detailed GIS analysis of the topography clearly indicates that Kelly Run is a tributary to French Creek and no area of Muddy Run is within Erie County boundaries.

Table 3.9. Classification of Erie County Watersheds

ACT 167 DESIGNATED WATERSHEDS

All runoff in Erie County is tributary to one of eight Act 167 Designated Watersheds. Each of these basins drains surface water into the major streams and rivers running through the county. The Act 167 Designated Watersheds within Erie County are shown in ***Figure 3.4***.

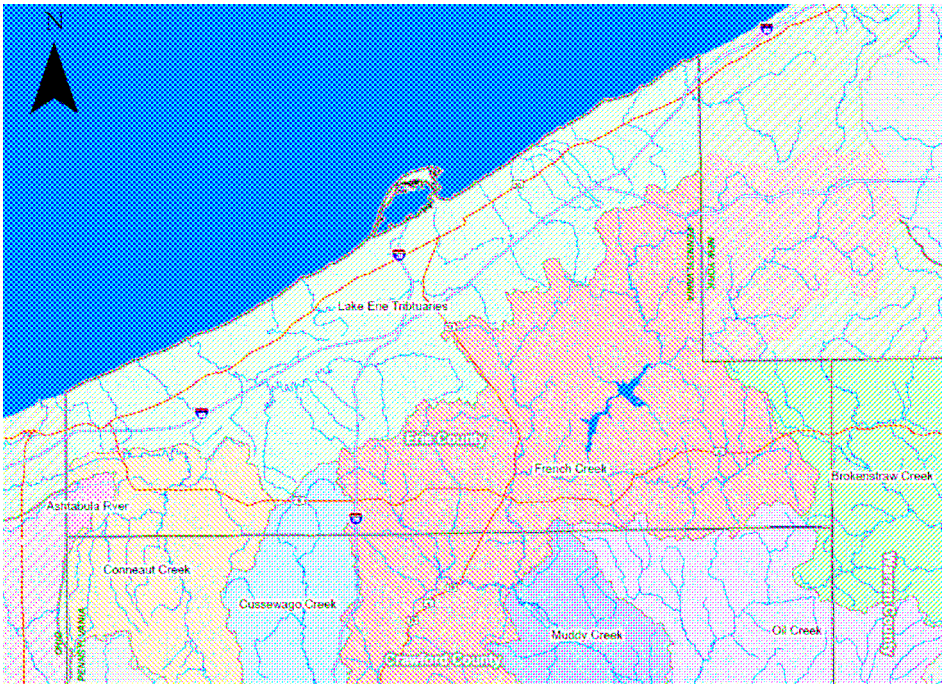


Figure 3.4. Act 167 Designated Watersheds in Erie County

The majority of the county (85.7%) lies within two of these watersheds: Lake Erie/Elk Creek and French Creek. This Plan included detailed analysis of both of these watersheds. All of the Act 167 Designated Watersheds in the county are listed in ***Table 3.10*** along with the total area of each watershed (as delineated within Pennsylvania) and the area of the watershed that is within Erie County.

Watershed	Total Area (mi^2)	Area within County (mi^2)
Ashtabula River	8.2	7.8
Brokenstraw Creek	266.2	28.7
Conneaut Creek	151.8	54.8
Cussewago Creek	97.7	16.0
French Creek	743.0	340.0
Lake Erie\Elk Creek	347.5	347.5
Muddy Creek	253.1	0.9
Oil Creek	320.2	6.6

Table 3.10. Act 167 Watershed Areas in Erie County

French Creek

This watershed begins in the headwaters of the main stem and the West Branch of French Creek, located in Chautauqua County, New York. These two streams flow southwest towards their confluence in Erie County. From this point, French Creek continues to flow southwest towards the confluence with South Branch of French Creek. The South Branch originates near the city of Corry and flows west where it joins French Creek west of the Union City Borough. French Creek then flows south as it leaves the county and into Crawford County, then through Mercer County, and finally into Venango County where it flows into the Allegheny River at Franklin, Pennsylvania. ***Table 3.11*** on the following page lists the municipalities within the watershed, and their contributing area.

Watershed	Municipality	Area (mi^2)
French Creek	Amity Township	28.3
	City Of Corry	0.8
	Concord Township	23.7
	Edinboro Borough	2.4
	Elgin Borough	1.5
	Franklin Township	3.9
	Greene Township	23.7
	Greenfield Township	24.6
	Le Boeuf Township	32.2
	Mckean Township	1.7
	Mill Village Borough	0.9
	North East Township	0.8
	Summit Township	7.0
	Union City Borough	1.8
	Union Township	35.0
	Venango Township	42.8
	Washington Township	39.6
	Waterford Borough	1.2
	Waterford Township	47.8
	Wattsburg Borough	0.3
	Wayne Township	19.8

Table 3.11. Municipalities within the French Creek Watershed

The topography of the French Creek watershed is characteristic of glaciated regions found in northwestern Pennsylvania. Advancing glaciers gouged out broad uplands separated by linear valleys and long, linear, rounded ridges. Landscape features run northwest to southeast, which was the flow direction of the glaciers as well as pre-glacial drainage (Sevon et al., 1999). As the glaciers receded, they left huge deposits of clay, silt, sand, and gravel, known as glacial drift, in the valleys and across the landscape. Glacial activity is also attributed for the many wetland areas and glacial lakes in the watershed. French Creek is arguably the most ecologically significant waterway in Pennsylvania. It contains more species of fish and freshwater mussels than any other comparably sized stream in the Commonwealth and possibly the northeastern United States (Western Pennsylvania Conservancy, 2002).

Areas likely to experience stormwater related problems include areas identified by the ***Erie County Land Use Plan*** (2003) as "Designated Growth Areas". This list includes the City of Corry, Union City, Waterford, Edinboro, and Wattsburg Boroughs as well as adjacent areas.

Lake Erie / Elk Creek

The Lake Erie / Elk Creek watershed borders Lake Erie and extends south for a minimum of 6.1 miles to a maximum of 25 miles. The watershed is comprised of a series of streams that discharge directly to Lake Erie in a parallel drainage pattern. These streams generally flow northwest from their headwaters towards Lake Erie. The watershed contains 19 major subwatersheds within 24 different Erie County municipalities.

Watershed	Municipality	Area (mi^2)
Lake Erie\Elk Creek	City Of Erie	19.1
	Conneaut Township	2.1
	Elk Creek Township	8.1
	Fairview Township	29.2
	Franklin Township	21.7
	Girard Borough	2.3
	Girard Township	31.8
	Greene Township	13.8
	Greenfield Township	9.4
	Harborcreek Township	34.1
	Lake City Borough	1.8
	Lawrence Park Township	1.8
	McKean Borough	0.6
	McKean Township	35.4
	Millcreek Township	31.6
	North East Borough	1.3
	North East Township	41.7
	Platea Borough	3.3
	Springfield Township	34.9
	Summit Township	16.8
	Venango Township	0.9
	Washington Township	2.6
	Waterford Township	2.6
	Wesleyville Borough	0.5

Table 3.12. Municipalities within the Lake Erie / Elk Creek Watershed

Typical of the region, glacial activity modified the topographic and geologic features that establish the stream drainage patterns within the watershed. Repeated glacial advances and retreats deposited fine-grained, poorly drained "drift" material on the surface of southern portions of the watershed, resulting in irregular stream patterns. The watershed is roughly bisected by portions of two physiographic provinces. Bordering the southern shore of Lake Erie, is a relatively narrow southwest-northeast-trending zone that has very low to flat relief. To the south of this is a similarly southwest-northeast-trending zone composed of rolling land that is notably higher in elevation than the costal lowland. These zones are separated by a narrow transitional strip of sometimes steeply sloping land called the Escarpment Slope (Lake Erie Region Conservancy, 2008).

The City of Erie and its surrounding municipalities of Millcreek Township, Lawrence Park Township, and Wesleyville Borough, and portions of Fairview Township, McKean Township, Summit Township, Greene Township and Harborcreek Township have been identified by the ***Erie County Land Use Plan*** (2003) as "Designated Growth Areas". Other projected growth areas include Girard, Lake City, and North East Boroughs. These areas are more likely to experience problems relate to stormwater runoff. A previous Act 167 Stormwater Management Plan for this watershed identified a number of problem areas were identified, primarily reported as flooding problems (Chester Engineers, 1996).

IMPOUNDMENTS

There are numerous small lakes, ponds and impoundments located throughout Erie County. Most of these are small run-of-the-river dams that have some localized impacts but do not have a significant impact on the overall watershed hydrology. These waterbodies include Cranberry Pond, Howard Eaton Reservoir, Leisure Lake, Long Pond, Niagara Pond, Ridge Pond, Siegel Marsh Reservoir, and Smith Reservoir. The county also contains three of the nine glacial lakes in western Pennsylvania - Lake Pleasant, Lake LeBoeuf, and Edinboro Lake. Lake Pleasant is located in Venango Township and is approximately 60 acres in size. LeBoeuf Lake is a natural lake approximately 70 acres in size and is located in Waterford Township. Edinboro Lake is located in the Borough of Edinboro and Washington Township. It is approximately 252 acres and flows into Conneauttee Creek, part of the French Creek watershed.

The Lake Erie watershed contains one impoundment that was considered large enough to have significant impact on the hydrology of the watershed. Grahamville Reservoir is located in North East Borough within the East Branch Sixteen Mile Creek subwatershed. The tributary drainage area to this is 1.52 mi^2 and the storage provided by the facility is approximately 184 acre-feet.

Four impoundments were considered to significantly impact the hydrology of the French Creek watershed. These include Bull Reservoir (2,363 acre-ft) on Black Brook, the Union City Water Supply Dam (306 acre-ft) on Bentley Run, Edinboro Lake (2,462 acre-ft), and Union City Dam (47,662 acre-ft) on French Creek.

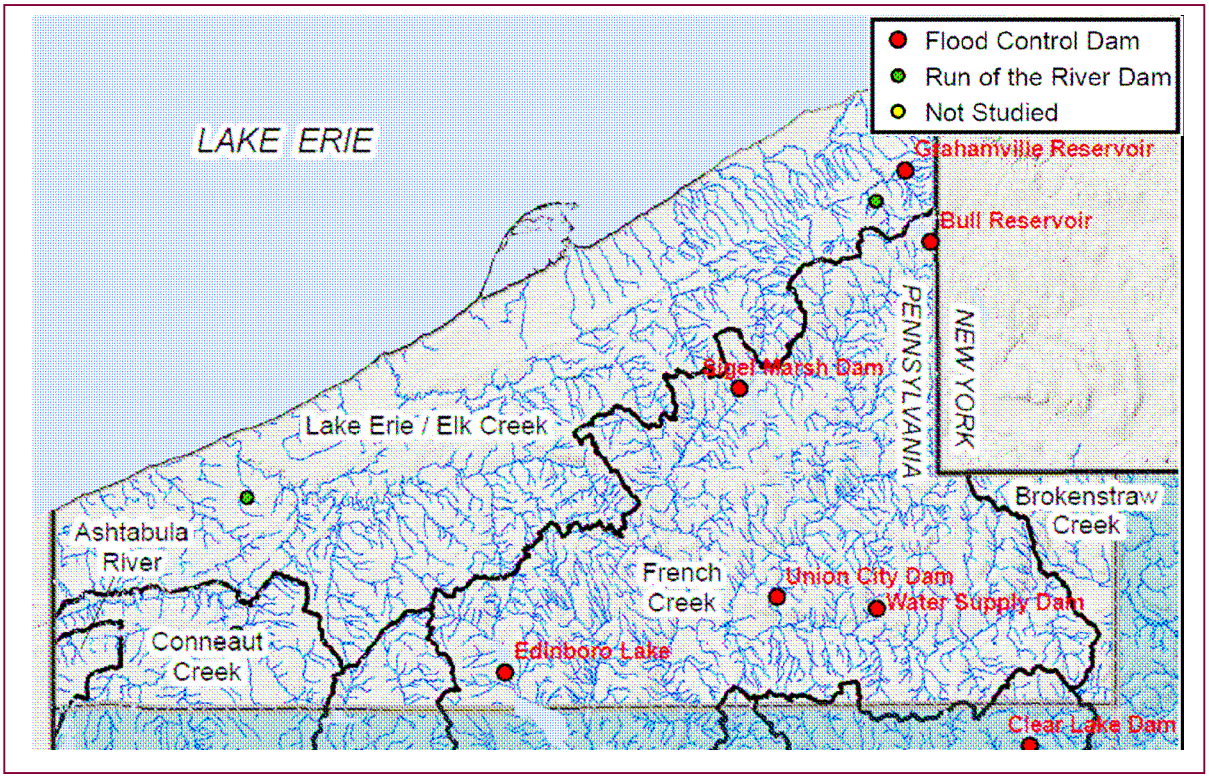


Figure 3.5. Erie County Impoundments

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 or Exceptional Value 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***.

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

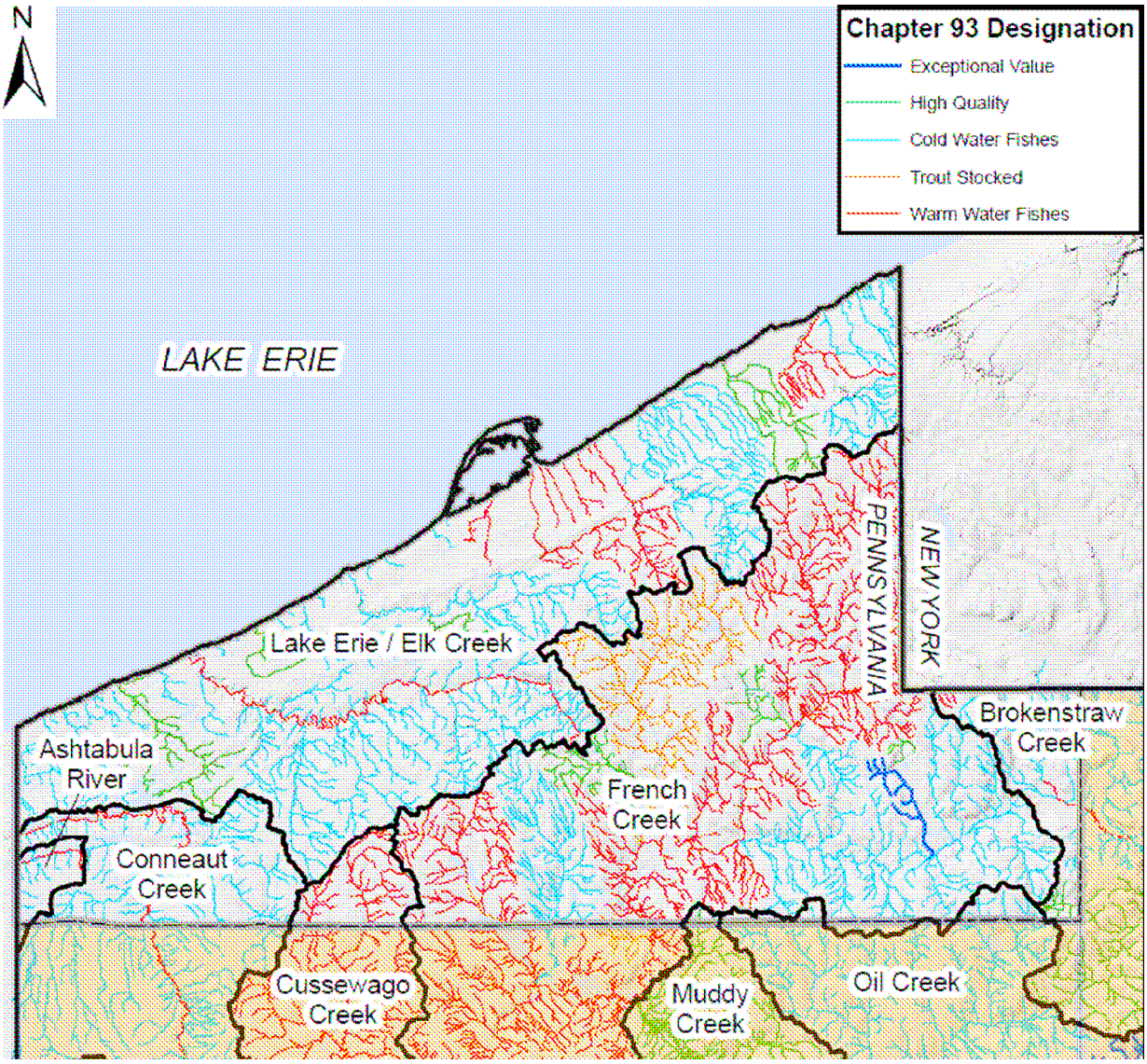


Figure 3.6. Chapter 93 Classification of Erie County Streams

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 list of the impaired waters within Erie 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 characterized in terms of return periods, e.g., the 50-year flood event. In regulating floodplains, the standard is the 100-year floodplain, the flood that is defined as having a 1 percent chance of being equaled or exceeded during any given year. These floodplain maps, or Flood Insurance Rate Maps (FIRMs), are provided to the public (http://msc.fema.gov/) for floodplain management and insurance purposes.

In 2007, the Pennsylvania Emergency Management Agency (PEMA) completed a statewide study to determine damage estimates for all major flood events. The study computed damages in dollars for total economic loss, building and content damage, and also estimated the number of damaged structures (PEMA, 2009). ***Table 3.13*** summarizes the findings from this study.

Storm Event	Number of Buildings at Least Moderately Damage	Total Economic Loss
10	110	$57.5 million
100	169	$72.3 million
500	248	$109.2 million

Table 3.13. Potential Impact Due to Flooding (PEMA, 2009)

With the exception of Platea Borough, all of Erie County's municipalities have FIRMs in effect. Most of the county's municipalities have Flood Insurance Studies (FIS) completed through FEMA. Thirty seven waterbodies within the County have delineated floodplains associated with an FIS. According to FEMA Q3 data about 35% of the areas within the Special Flood Hazard Area are detailed and 65% are non-detailed (shallow flooding, approximate, or area "D").

Detailed Studies

There are various levels of detail in floodplain mapping. Detailed studies (Zones AE and A1-A30 on the floodmaps) are conducted at locations where FEMA and communities have invested in engineering studies that define the base flood elevation and often distinguish sections of the floodplain between the floodway and flood fringe. See ***Figure 3.6*** below for a graphical representation of these terms. For a proposed development, most ordinances state that there shall be no increase in flood elevation anywhere within the floodway; the flood fringe is defined so that any development will not cumulatively raise that water surface elevation by more than a designated height (set at a maximum of 1'). Development within the flood fringe is usually allowed but most new construction is required to be designed for flooding (floodproofing, adequate ventilation, etc).

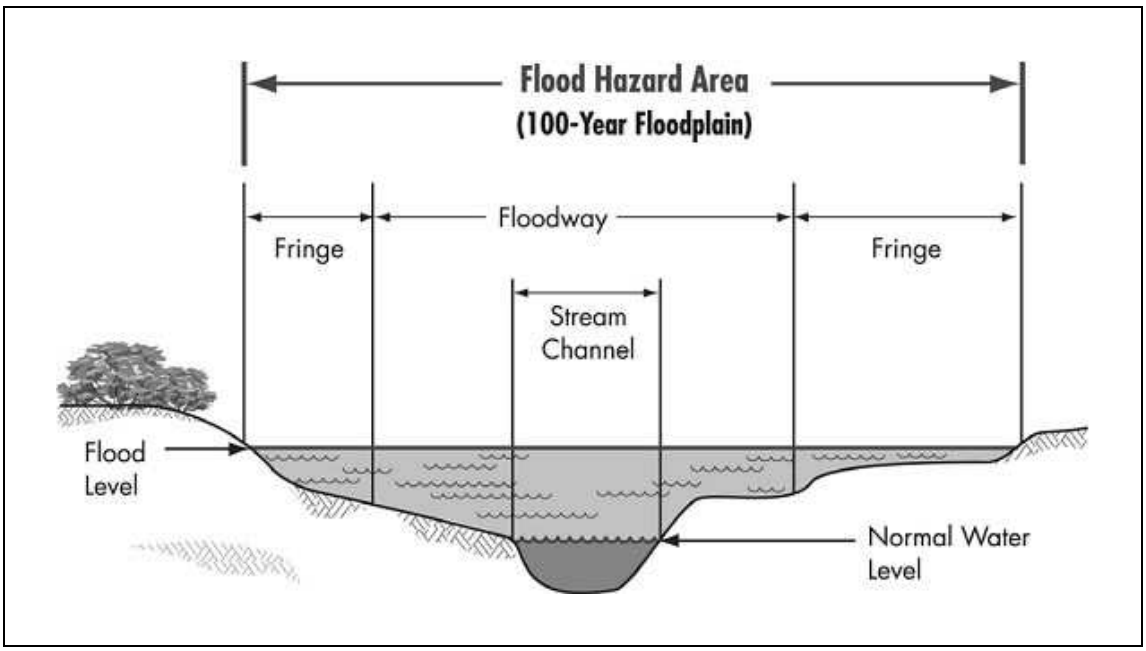


Figure 3.7. Floodplain Cross Section and Flood Fringe (NH Floodplain, 2007)

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.

One limitation of FIRMs and older Flood Insurance Rate Maps is the false sense of security provided to home owners or developers who are technically not in the floodplain, but are still within an area that has a potential for flooding. Headwater streams, or smaller tributaries located in undeveloped areas, do not normally have FEMA delineated floodplains. This leaves these areas unregulated at the municipal level, and somewhat susceptible to uncontrolled development. 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.

Levees and Other Flood Control Structures

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

Project	Owner	Waterbody
Corry Project	City of Corry	Hare Creek
Lawrence Park Project	Lawrence Park Township	Four Mile Run

Table 3.14. Levee Systems in Erie County

There are two levee projects in Erie County: the Corry Project, and the Lawrence Park Project. The PAL status of each of the levee systems was not available at the time of publication of this Plan.

Community Rating System (CRS)

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

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

FIRM Updates

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

Section IV – Existing Stormwater Regulations and Related Plans

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

NPDES MUNICIPAL SEPARATE STORM SEWER SYSTEMS (MS4)

Polluted storm water runoff is often transported to municipal separate storm sewer systems (MS4s) and ultimately discharged into local rivers and streams without treatment. EPA's Stormwater Phase II Rule establishes an MS4 stormwater management program that is intended to improve the Nation's waterways by reducing the quantity of pollutants that stormwater picks up and carries into storm sewer systems during storm events.

In 1990, EPA promulgated rules establishing Phase I of the National Pollutant Discharge Elimination System (NPDES) stormwater program for those that generally serve populations greater than 100,000. The Stormwater Phase II Rule extends coverage of the NPDES stormwater program to "small" MS4s which are municipalities located in "urbanized areas" (UAs) as defined by the Bureau of the Census (unless waived by the NPDES permitting authority).

Operators of regulated small MS4s are required to design their programs to:

(1) Reduce the discharge of pollutants to the "maximum extent practicable" (MEP);
(2) Protect water quality; and
(3) Satisfy the appropriate water quality requirements of the Clean Water Act.

Implementation of the MEP standard requires the development and implementation of BMPs and the achievement of measurable goals to satisfy each of the six Minimum Control Measures (MCM). A small MS4 stormwater management program implements the six MCMs in concert to significantly reduce pollutants discharged into receiving waterbodies.

Table 4.2 lists all the MS4 communities in the County:

MS4 Municipalities	
City of Erie	Harborcreek Township
Girard Borough	Lawrence Park
Lake City Borough	McKean Township*
Wesleyville Borough	Millcreek Township
Fairview Township	Summit Township
Girard Township	Penn State Berhend
Greene Township*	*Permit Waiver Approved

Table 4.2. MS4 Municipalities

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 4.3***.

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

Table 4.3. Existing State Regulations

STATE WATER QUALITY STANDARDS

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

General Provisions (§93.1 - §93.4)

The general provisions of Chapter 93 provide definitions, citation of legislative authority (scope), and the definition of protected and statewide water uses. DEP's implementation of Chapter 93 is authorized by the Clean Streams Law, originally passed in 1937 to "preserve and

improve the purity of the waters of the Commonwealth for the protection of public health, animal and aquatic life, and for industrial consumption, and recreation," and subsequently amended. ***Table 4.4*** is a summary of the protected water uses under Chapter 93 that are applicable to Erie 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 Stocking (TSF)		Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
Cold Water Fishes (CWF)		Maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat.
Special Protection		
High Quality Waters (HQ)		A surface water that meets at least one of chemical or biological criteria defined in §93.4b
Exceptional Value Waters (EV)	Highest	A surface water that meets at least one of chemical or biological criteria defined in §93.4b <u>and</u> additional criteria defined in §93.4b.(b)

Table 4.4. Chapter 93 Designations in Erie County

<u>Antidegradation Requirements (§93.4a - §93.4d)</u>

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

For a new, or additional, point discharge with a peak flow increase to an HQ or EV water, the developer is required to use a non-discharge alternative that is cost-effective and environmentally sound compared with the costs of the proposed discharge. If a non-discharge alternative is not cost-effective and environmentally sound, the developer must use the best available combination of treatment, pollution prevention, and wastewater reuse technologies and assure that any discharge is non-degrading. In the case where allowing

lower water quality discharge is necessary to accommodate important economic or social development in an area, DEP may approve a degrading discharge after satisfying a multitude of intergovernmental coordination and public participation requirements (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 watersheds within Erie County have a cold water fisheries designated use. This is also the leading designated use within the county, in terms of total miles, with almost 214 miles of stream designated as cold water fisheries and another 30 miles designated as High Quality – Cold Water Fisheries. ***Table 4.5*** below summarizes the designate uses of all stream uses in Erie County.

Designated Use	Total Length (mi)	Percentage
Warm Water Fishes (WWF)	133.8	32.4%
High Quality Waters (HQ-WWF)	2.2	0.5%
Cold Water Fishes (CWF)	213.6	51.7%
High Quality Waters (HQ-CWF)	30.1	7.3%
Trout Stocking (TSF)	29.0	7.0%
Exceptional Value (EV)	4.3	1.0%

Table 4.5. Summary of Designated Uses for Erie County Waters

Table 4.6 shows the Chapter 93 designated uses for Erie 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>

Stream (Zone)	Designated Use
Alder Brook	WWF
Alder Run	CWF
Ashtabula Creek (main stem, source to PA-OH state border)	WWF
Bailey Brook	WWF
Bear Run	CWF
Beaver Run	EV
Brandy Run	CWF
Cascade Creek	WWF
Conneaut Creek (main stem, source to PA-OH state border)	WWF

Conneauttee Creek (main stem, outlet of Edinboro Lake to Erie-Crawford County border)	TSF
Conneauttee Creek (source to outlet of Edinboro Lake)	WWF
Crooked Creek	HQ-CWF
Cutting Brook (all sections in PA)	WWF
Darrow Brook (all sections in PA)	WWF
East Branch Ashtabula River (all sections in PA)	CWF
East Branch Conneaut Creek	CWF
Eightmile Creek	CWF
Elk Creek (main stem)	WWF
Falk Run	CWF
Fourmile Creek	WWF
French Creek (all sections in PA; PA-NY state border to mouth)	WWF
Godfrey Run	HQ-CWF
Goodban Run	CWF
Halls Run	CWF
Herrick Creek (all sections in PA)	WWF
Hubble Run	HQ-WWF
Hubble Run	WWF
Lake Erie	CWF
Lake Erie (Outer Erie Harbor and Presque Isle Bay)	WWF
Lake Erie (Outer Erie Harbor and Presque Isle Bay)	WWF
Lake Pleasant Outlet	HQ-CWF
Lamson Run	CWF
Le Boeuf Creek (source to Trout Run)	TSF
Le Boeuf Creek (Trout Run to mouth)	TSF
Little Elk Creek	CWF
Marsh Run	CWF
Mill Creek	WWF
Raccoon Creek	CWF
Sevenmile Creek	CWF
Sixmile Creek	CWF
Sixteen Mile (all sections in PA; source to I-90)	CWF
Sixteen Mile (I-90 to mouth)	WWF
South Branch French Creek (Beaver Run to mouth)	CWF
South Branch French Creek (source to Beaver Run)	CWF
Stone Run	CWF
Thomas Run	HQ-CWF
Townley Run	WWF
Trout Run	HQ-CWF
Trout Run	CWF
Turkey Creek (main stem, source to PA-OH state border)	CWF
Twelvemile Creek	HQ-CWF
Twentymile Creek (main stem, PA-NY state border to mouth)	CWF

Unnamed Tributaries (all sections in PA; source to PA-OH state border)	CWF
UNT to Ashtabula Creek (all sections in PA; PA-OH state border to mouth)	CWF
UNT to Ashtabula Creek (all sections in PA; source PA-OH state border)	CWF
UNT to Brokenstraw Creek (all sections in PA; PA-NY state border to mouth)	CWF
UNT to Brokenstraw Creek (all sections in PA; source to PA-NY state border)	CWF
UNT to Conneaut Creek (all sections in PA; PA-OH state border to mouth)	CWF
UNT to Conneauttee Creek (outlet of Edinboro Lake to Erie-Crawford County border)	WWF
UNT to Elk Creek	CWF
UNT to French Creek (all sections in PA; PA-NY state border to mouth)	WWF
UNT to French Creek (all sections in PA; source to PA-NY state border)	WWF
UNT to Hare Creek (Scotia Street bridge to mouth)	CWF
UNT to Lake Erie (all sections in PA; PA-OH state border to Presque Isle)	CWF
UNT to Lake Erie (Longitude 80°01'50"to PA-NY state border)	CWF
UNT to Lake Erie (Presque Isle to UNT at RM 23.22)	WWF
UNT to Lake Erie (UNT at RM 23.22 to Longitude 80°01'50")	WWF
UNT to Lake Erie at RM 23.22	CWF
UNT to Turkey Creek (all sections in PA; PA-OH state border to mouth)	CWF
UNT to Turkey Creek (all sections in PA; source PA-OH state border)	CWF
UNT to Twentymile Creek (all sections in PA; source to PA-NY state border)	CWF
UNT to Twentymile Creek (main stem, PA-NY state border to mouth)	CWF
UNT to Walnut Creek	CWF
UNT to West Branch French Creek (all sections in PA; source to PA-NY state border)	WWF
Walnut Creek (main stem)	CWF
West Branch Conneaut Creek (all sections in PA)	CWF
West Branch French Creek (main stem, PA-NY state border to mouth)	WWF
Wheeler Creek	WWF

Table 4.6. Erie County Designated Water Uses

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 4.7*** provides a summary of existing regulations for the 38 municipalities within Erie County.

Municipality	Zoning	Subdivision & Land Development (SALDO)	Stormwater	Flood Hazard
Albion Borough	12/18/1997	1/20/1994	n/a	3/23/1989
Amity Township	9/4/2001	n/a	n/a	5/19/1990
Concord Township	8/8/2000	n/a	n/a	3/6/1984
Conneaut Township	n/a	n/a	n/a	n/a
Corry City	4/18/1991	1981	1993	2/20/1978
Cranesville Borough	5/5/1981	n/a	n/a	see zoning
Edinboro Borough	1/31/1994	4/14/1997	n/a	5/18/1981
Elgin Borough	11/1/1999	n/a	n/a	6/1/1983
Elk Creek Township	n/a	n/a	4/6/1998	n/a
Erie City	12/28/2005	5/22/1989	5/27/1998	n/a
Fairview Township	2/7/2005	4/7/1998	1/5/1998	see zoning
Franklin Township	5/29/1997	5/12/2009	5/4/1997	see zoning
Girard Borough	10/19/1992	10/19/1992	6/16/1997	8/15/1984
Girard Township	10/11/2005	10/11/2005	7/14/1998	11/13/1990
Greene Township	1996	12/10/1996	5/13/1997	5/27/1986
Greenfield Township	7/14/2008	7/14/2008	4/14/1997	2/5/1979
Harborcreek Township	8/22/1984	11/28/2001	3/17/2004	7/9/1980
Lake City Borough	1/20/1997	5/16/1994	7/12/2004	9/16/1985
Lawrence Park Township	10/7/1991	10/7/1991	5/28/1996	10/7/1991
LeBoeuf Township	8/12/1994	n/a	n/a	n/a
McKean Borough	12/4/1995	11/10/1997	11/10/1997	1977
McKean Township	6/11/1983	12/5/1996	2/26/1997	see zoning
Mill Village Borough	12/15/1994	n/a	n/a	3/26/1981
Millcreek Township	12/30/1974	7/11/2006	2/25/1997	n/a
North East Borough	2000	2000	6/2/1997	n/a
North East Township	6/6/2005	9/28/1983	10/6/1997	1983
Platea Borough	n/a	n/a	3/16/1998	n/a
Springfield Township	10/1/2007	5/7/1990	n/a	5/7/1990
Summit Township	5/18/1992	2/3/2003	2/18/1997	8/3/1981
Union City Borough	1/1/1987	1/1/1987	n/a	12/4/1984
Union Township	2/14/1983	n/a	n/a	n/a
Venango Township	8/5/1978	10/2/2000	5/5/1997	n/a
Washington Township	2/2/1999	2/2/1999	9/2/1997	n/a
Waterford Borough	2/11/1991	2/11/1991	n/a	12/7/1981
Waterford Township	1991	7/11/1972	5/7/1997	see zoning
Wattsburg Borough	5/4/1987	n/a	n/a	n/a
Wayne Township	6/1/1999	n/a	12/4/2006	9/24/1984
Wesleyville Borough	11/8/1989	2/9/2000	11/13/1996	n/a
Erie County	n/a	2/3/1998	n/a	n/a

Table 4.7. Erie County Municipal Ordinance Matrix

The majority of the municipalities have a Stormwater Management Ordinance (24 of 37) with a few more having stormwater regulations within their SALDO. Many of the Stormwater Management Ordinances are based on the Lake Erie/Elk Creek Act 167 Model Ordinance. This Model Ordinance identifies the release rate method as the primary performance standard along with calculation methodology. The model ordinance provides design standards for infiltration facilities but contains no water quality or groundwater recharge requirements. The municipalities lacking Stormwater Management Ordinances are located along the southern portion of the County.

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
Lake Erie – Elk Creek Act 167 Stormwater Management Plan	August 1996	Chester Engineers / Erie County Department of Planning
Erie County Transportation Plan	October 2008	Erie County Department of Planning
Erie County Land Use Plan	December 2003	Erie County Department of Planning
Erie County Natural and Historic Resources Plan	December 2003	Erie County Department of Planning
Erie County Community Facilities and Utilities Plan	December 2003	Erie County Department of Planning
Northwest Pennsylvania Greenways, Erie County, PA	February 2010	Pashek Associates / Erie County Planning Department
French Creek Watershed Conservation Plan	January 2002	Western Pennsylvania Conservancy / French Creek Project
Pennsylvania Lake Erie Watershed Conservation Plan	August 2008	The Lake Erie Region Conservancy

Table 4.8. Related Plans Review

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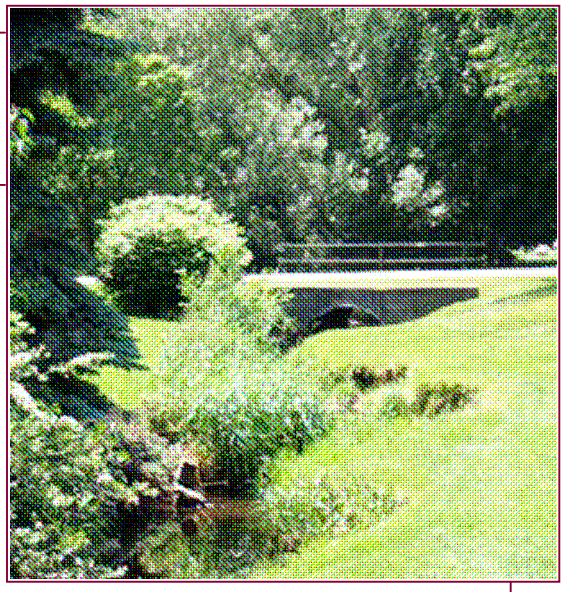
Section V – Significant Problem Areas and Obstructions



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 than evaluation of the identified problem areas and obstructions.

The first task was to identify the location and nature of existing drainage problems within the study area, and where appropriate, gather field data to be used for further analysis of the problem. The geographical location data of each problem area are provided in Plates 7-8a, 7-8b, and 7-8c. 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 idication 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 task was to analyze individual problem areas and obstructions, determine potential solutions for the problems, and provide recommendations that can be implemented through the Erie County Stormwater Management Plan. The following provides the results from these efforts.

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 Erie County. The questionaire enabled the municipalities to report all of the known problem areas and obstructions within their municipality. Of the 38 municipalities in Erie County, 37 participated in the assessment process by returning completed questionaires. The responses are summarzied in table 5.2. 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. 165 problem area were identified by the municipalities; 134 of these were visited and given a concepetual level of analysis. The remaining problem areas either could not be field located (9), were repeats of other problem areas (7), or were problem areas for which a solution had been provided during the completion of this Plan (15).

All of the reported problem areas, obstructions, and structures are listed in ***Table 5.1*** on the following pages. A more detailed explanation of each site can be found in ***Appendix C – Significant Problem Area Modeling and Recommendations***, which contains a summary of all of the data collected for each of the problem areas and obstructions reported throughout the county.

ID	Municipality	Location	Notes
EO024	Amity Twn	Lowe Rd	Beaver dams. This is a previous gravel roads project where culvert was installed. Beavers have blocked the channel.
EP116	Conneaut Twn	Twp wide	No site visit required.
EO017	Corry City	Airport Rd Extended	During the field visit, it appeared that the problem was fixed. The culvert appears adequate.
EO018	Corry City	W. Church St	The conveyance system is fully clogged in the Spring St-Euclid St area. Upstream gravel road probably contributes to sediment in pipe network.
EO019	Corry City	Highway bridge at ST RT 6	The bridge appears to be in poor condition.
EO020	Corry City	Railroad bridge	Northern drainage area of Hare Creek confluences here. The railroad bridge appears to have adequate capacity but there is noticeable stream bank erosion upstream and downstream of the bridge.
EO021	Corry City	Railroad culvert	A culvert with no hydraulic capacity. Ponding occurs at the culvert inlet. There has been no maintenance for 30 years. Approval for mitigation has been difficult to obtain from the railroad owners.
EO022	Corry City	Corry Middle School	Stream is eroding and depositing in different locations. Culvert appears to have adequate capacity although this depends on maintenance. The upstream source of sediment needs to be determined.
EO023	Corry City	E. Washington St	Problem area unable to be located during field visit.
EP045	Corry City	E. Columbus & Scotia St	Conveyance system appear to have inadequate hydraulic capacity.
EP046	Corry City	W. Main St	Railroad culvert appears to have inadequate hydraulic capacity.
EP047	Corry City	E. Columbus	Channel is eroding and depositing debris onto ST RT 0006. The downstream channel has been cleaned out and widened but the site continues to need regular maintenance.
EP048	Corry City	E. Washnton St	The conveyance network along this relatively long, mildly sloped roadway appears to be inadequate.
EP049	Corry City	White St	The conveyance network along this relatively long, mildly sloped roadway appears to be inadequate.
EP050	Corry City	Liberty St	The conveyance network appears to be inadequate.
EP051	Corry City	W. Pleasant St	The conveyance network appears to be inadequate.
EP007	Cranesville Boro	Temple Creek @ John Wms Ave	Culvert appears to have inadequate hydraulic capacity.
EP008	Cranesville Boro	Crosby Circle & John Wms Ave	Inadequate roadside channels overtop and flood along Crosby Cr.
EO028	Edinboro Boro	Water St & Green Oaks	Conveyance system appears to have inadequate hydraulic capacity. The entire surrounding area floods and is likely located in a regulatory floodplain.
EP058	Edinboro Boro	W. Plum & Willow St	Problem is currently being mitigated.
EP059	Edinboro Boro	ST RT 99	Flooding occurs near the floodplain, particularly when the level on Edinboro Lake are high.

Table 5.2. Reported Problem Areas for Erie County

ID	Municipality	Location	Notes
EP060	Edinboro Boro	Heather Rd	Culvert appears to have inadequate hydraulic capacity. Outlet is obstructed by utility line.
EP061	Edinboro Boro	N of Industrial Dr	Beaver dam.
EP062	Edinboro Boro	Peach St (e of lake)	Pollution has been documented coming from upstream waste water treatment plant. The effluent is currently being re-routed and given additional treatment.
EP063	Edinboro Boro	N of Lake	Pollution has been documented coming from upstream waste water treatment plant. The effluent is currently being re-routed and given additional treatment.
EP064	Edinboro Boro	Penn Union Site	Penn-Union had a chemical spill. They have installed a treatment system to prevent future contamination.
EP065	Edinboro Boro	Wipple Creek enterance to Lake	Heavy sediment deposition. Source of sediments needs to be determined.
EP066	Edinboro Boro	Elm St storm sewer into Lake	See P058.
EP067	Edinboro Boro	Conneaut/Shenago Watersheds	Heavy sediment deposition. Source of sediments needs to be determined.
EP068	Edinboro Boro	Minor trib into Lake	Heavy sediment deposition. Source of sediments needs to be determined. The Boro describes this problem as relatively minor.
EO025	Elgin Boro	S. Main St	This problem area is being mitigated as a bridge replacement project is currently in process.
EP108	Elk Creek Twn	Morley Rd	Seasonal flooding in low lying wetland/ floodplain area.
EP109	Elk Creek Twn	Griffis Rd	Culvert appears to have inadequate hydraulic capacity.
EP110	Elk Creek Twn	Temple Creek	Bridge occasionally floods but appears to have adequate hydraulic capacity.
EP111	Elk Creek Twn	Hickernell Rd	Bridge appears in poor condition and may be in need of replacement. Some sediment appears to be depositing downstream.
EP112	Elk Creek Twn	Ivoray Rd	Bridge appears in poor condition and may be in need of replacement. Some sediment appears to be depositing downstream.
EP113	Elk Creek Twn	Fillinger Rd	Bridge appears in poor condition and may be in need of replacement. Some sediment appears to be depositing downstream.
EP114	Elk Creek Twn	N of Carberry Rd	Beaver dams.
EP115	Elk Creek Twn	Temple Creek @ Resevior Rd	Beaver dams.
EO011	Fairview Twn	Trout Run	Low lying area that is heavily vegetated. Properties in this area are in the floodplain. This problem area has been mitigated since the area downstream has been cleared and maintained.
EO012	Fairview Twn	Bear Run	Beaver dam. Frequent flooding results.
EP029	Fairview Twn	Trout Run	See EO011.
EP030	Fairview Twn	Bear Run	See EO012.
EP031	Fairview Twn	PennDOT infrastructure	Conveyance system appears to be in need of maintenance. The stream meander appears to be threatening a structure.

Table 5.2 (continued). Reported Problem Areas for Erie County

ID	Municipality	Location	Notes
EP032	Fairview Twn	Subdivision has combined sewers	Problem is currently being mitigated.
EP033	Fairview Twn	Entire Twn	High coliform at some outfalls. Problem is currently being mitigated.
EP034	Fairview Twn	Walnut Creek	Streambank stabilization and stormwater mitigation is needed in several locations along Walnut Creek.
EO015	Franklin Twn	Throughout Twp	There are 67 deficient culverts and bridges reported.
EP121	Franklin Twn	New Rd	Culvert appears to have inadequate hydraulic capacity.
EP122	Franklin Twn	New Rd, Mohawk Rd	Culvert appears to have inadequate hydraulic capacity.
EP123	Franklin Twn	Carbury Rd	Culvert appears to have inadequate hydraulic capacity.
EP124	Franklin Twn	Clair Wright Rd	Culvert appears to have inadequate hydraulic capacity.
EP125	Franklin Twn	Clair Wright Rd	Culvert appears to have inadequate hydraulic capacity.
EP126	Franklin Twn	West Stancliff Rd	Culvert appears to have inadequate hydraulic capacity.
EP127	Franklin Twn	Shadduck Rd	Culvert appears to have inadequate hydraulic capacity.
EP128	Franklin Twn	Shadduck Rd	Culvert appears to have inadequate hydraulic capacity.
EP129	Franklin Twn	Shadduck Rd	Culvert appears to have inadequate hydraulic capacity.
EP130	Franklin Twn	West 17th St Area	Conveyance system appears to be full of debris and is need of maintenance. Debris may be coming from Bizzarro's Salvage Yard.
EP131	Franklin Twn	Sassafras St	Conveyance system on the upper part of Sassafras Rd appears to be insufficient. This system appears to discharge to the lower "new" system on Sassafras Rd at the Convention Center.
EP132	Franklin Twn	West 8th	Conveyance system in the area appears to be insufficient.
EP043	Franklin Twn	Entire Twn	See EP121 to EP129.
EP018	Girard Borough	Sunset Drive North	This heavily vegetated channel leading to Lake Erie is in need of maintenance. The railroad culvert may have insufficient hydraulic capacity.
EO029	Girard Twn	S. Creek Rd	Culvert appears to have inadequate hydraulic capacity.
EO030	Girard Twn	Cindy Lane & Daggett	Runoff from upstream culverts discharges to the low point along Cindy Ln and Daggett. There is no outlet on the south side of Cindy Ln.
EO031	Girard Twn	Route 20	The conveyance system along ST RT 20 becomes smaller as it approaches its outfall and appears to have inadequate hydraulic capacity. New development also appears to have impacted the area.
EP073	Girard Twn	Gloskey Rd Bridge	Bridge appears to have inadequate hydraulic capacity and is in poor overall condition. The relatively small widening leads to very high velocity (>8 ft/s in the 2-year storm event) and subsequent erosion.

Table 5.2 (continued). Reported Problem Areas for Erie County

ID	Municipality	Location	Notes
EP074	Girard Twn	Route 20	Runoff ponds along ST RT 20 in low lying areas. There is no outlet for the runoff.
EP075	Girard Twn	Route 20	See EP074.
EO010	Greene Twn	May Rd @ gamelands	Area is in wetlands and prone to flooding. May Rd is only feet away from the waterbody. It appears the water from the wetlands may back up and flood the properties on the west side of May Rd.
EP019	Greene Twn	Sampson Rd	Property flooding near wetlands.
EP020	Greenfield Twn	German Rd	Beaver dams. Dams are blocking the dual 48" HDPE culverts. Culverts may provide adequate capacity if dams were removed. The Twn has removed the dams several times.
EP021	Greenfield Twn	Ashton Rd	Beaver dams. Dams are blocking the dual 48" HDPE culverts. Culverts may provide adequate capacity if dams were removed.
EP022	Greenfield Twn	Wilson Rd	Culverts appear to have been recently replaced.
EP023	Greenfield Twn	Wilson Rd	Beaver dams. The bridge appears to provide adequate capacity if the dam would be removed.
EP024	Greenfield Twn	New Rd	Beaver dams. The culvert appears to provide adequate capacity if the dam would be removed.
EP025	Greenfield Twn	Dougan Rd	Culverts appear to have been recently replaced.
EP026	Greenfield Twn	Raymond Mills	Beaver dams. Dams are blocking the dual 48" HDPE culverts. Culverts may provide adequate capacity if dams were removed. The Twn has recently removed the dams.
EP027	Greenfield Twn	N of I 86	Wetlands created for mitigation during I-86 highway construction.
EP119	Greenfield Twn	German Rd	Beaver dams. This is a continuous problem.
EP120	Greenfield Twn	Raymond Rd	Beaver dams. Twn has recently cleared and maintained area.
EO009	Harborcreek Twn	Backus Rd culvert	Culvert does not appear to have adequate hydraulic capacity. It is in poor condition and may be structurally deficient.
EP012	Harborcreek Twn	Fairfield area	The existing culvert does not appear to provide sufficient conveyance capacity.
EP013	Harborcreek Twn	Villa Sites Rd	Vague description of problem area provided by the Twn. Culvert appears adequate. Discharge from culvert leads to low lying areas located on neighboring properties which experience frequent flooding. The general area is a floodprone area.
EP014	Harborcreek Twn	Lewis-Mooreheadville Rds Area	Inadequate roadside drainage.
EP015	Harborcreek Twn	Beaver Rd - Nagle to Clark	Problem area unable to be located during field visit.
EP016	Harborcreek Twn	Brookside Area	This area is relatively low and receives substantial upslope runoff from residential properties. The conveyance channel through area appears to be insufficient. A new conveyance system with new culverts is likely needed.
EP017	Harborcreek Twn	Clark Rd to Firman Rd	The culverts and channels along Clark Rd appear to overtop and flood the neighboring properties.

Table 5.2 (continued). Reported Problem Areas for Erie County

ID	Municipality	Location	Notes
EP052	Lake City Boro	Eagle St	An old foundation is deteriorating in the channel of Kelly Run.
EO013	Lawrence Park Twn	Iroquois Ave - E.B. Ln	The E.B. Ln slopes to a low point where runoff ponds. There are no drainage structures present.
EO014	Lawrence Park Twn	Snoopy & Cricket	It appears the conveyance under the railroad tracks is insufficient. The whole network appears in need of maintenance.
EP035	Lawrence Park Twn	Iroquois Ave - EB Ln	See EO013.
EP036	Lawrence Park Twn	Snoopy & Cricket	See EO014.
EP037	Lawrence Park Twn	695 Smithson Ave	The yard area of the church is flooding during storm events.
EP039	Lawrence Park Twn	Crotty, Smithson, Morse, Emmet	It appears neighboring property owners have been placing concrete pieces in the stream to prevent stream bank erosion.
EP040	Lawrence Park Twn	Napier playground	It appears that Curtis Park playground is in or very close to the regulatory floodplain.
EP041	Lawrence Park Twn	Four Mile Creek	Stream bank erosion. Debris is also present in creek.
EP042	Lawrence Park Twn	Four Mile Creek	Pedestrian bridges constrict the floodplain causing stream bank erosion near their footings.
EP053	Mckean Twn	Old 99	Property near Lamson Run frequently floods.
EP054	Mckean Twn	Baron, West, Old 99, Reichert	Frequent flooding with areas near or in the floodplain of Elk Creek.
EP055	Mckean Twn	Reichert Rd	Bridge is to be replaced in near future.
EO006	Mill Village Boro	Depot St Culvert	Culvert was replaced in 2008.
EO007	Mill Village Boro	Railroad Culvert #1	Culvert does not appear to have adequate hydraulic capacity.
EO008	Mill Village Boro	Railroad Culvert #2	Large sediment deposit is blocking culvert inlet. There is also a large deposit positioned at the outlet. It appears that the culvert would have adequate hydraulic capacity if channel was cleared.
EP009	Mill Village Boro	French Creek Trib	Upstream sediment is depositing in within stream, creating an obstruction. Downstream of area appears to have adequate capacity.
EO032	Millcreek Twn	Asbury Rd SR4009 underpass	There appears to be inadequate drainage under the PennDOT bridge. The emergency spillway for the Lowe's discharges onto Asbury Road.
EO033	Millcreek Twn	Heidler Rd Channel	A heavily vegetated channel that appears to have inadequate hydraulic capacity frequently floods. Runoff from multiple upslope developments discharges to the channel.
EO034	Millcreek Twn	Cider Mill to Lake Pleasant	Stream obstructions from large woody debris within Mill Creek.
EP076	Millcreek Twn	Riviera Estates	Frequent flooding. Depth of water in general area varies between 2' -4' depth during storm events.
EP077	Millcreek Twn	15th & Harper	Frequent flooding of homes, businesses, and roadways. SWM conveyance system may be inadequate.
EP078	Millcreek Twn	Taki Mobile Home Park	Frequent flooding. Runoff is directed to a low lying area water backs up to Trailer #1545 and beyond.

Table 5.2 (continued). Reported Problem Areas for Erie County

ID	Municipality	Location	Notes
EP079	Millcreek Twn	17th & Harper	Frequent flooding of homes, businesses, and roadways. SWM conveyance system may be inadequate.
EP080	Millcreek Twn	22nd & James	Frequent flooding of homes, businesses, and roadways. Upslope runoff appears to be conveyed towards Paragon Stair & Rail, Inc. The conveyance system appears to be in need of maintenance and may be hydraulically insufficient.
EP081	Millcreek Twn	22nd & Homer to Midland	Frequent flooding of parking lots, businesses, and roadways. There is a low lying area along the property of Erie Advanced Manufacturing that appears to flood. The conveyance system may be insufficient and in need of maintenance.
EP082	Millcreek Twn	EBCO Park	Frequent flooding of parking lots, businesses, and roadways. The SWM facility in area has no outlet. Infiltration appears to be the only means of discharge.
EP083	Millcreek Twn	20th & 23rd, Lowell to Evanston	Street & yard flooding. No conveyance facility could be located.
EP084	Millcreek Twn	InsulBoard & RR tracks	Frequent flooding of business, parking lot and truck dock. The channel along railroad appears to flood and backup into the parking lot and loading dock.
EP085	Millcreek Twn	Sterling RR - Powell Ave	Frequent flooding of parking lots, businesses, and roadways. Channel along the railroad may back up and cause parking area to flood.
EP086	Millcreek Twn	13th & 14th, Idaho Ave	Frequent yard flooding. Channels along Idaho Ave may be insufficient causing runoff to flood the neighboring properties.
EP087	Millcreek Twn	12th St Area to Peninsula Dr	Frequent flooding of 4 lane highway, business, home, and yards. Conveyance system may be insufficient.
EP088	Millcreek Twn	Enfield Lane	Frequent home & yard flooding. The storm system may be insufficient.
EP089	Millcreek Twn	Walnut Ck to Timber Ridge	Frequent home & yard flooding. The storm system may be insufficient.
EP090	Millcreek Twn	Shadybrock to Brockhollow	Frequent home & yard flooding. The storm system may be insufficient.
EP091	Millcreek Twn	Michigan & Oregon, N of 10th	Frequent yard flooding. The channel behind the homes along road overtops regularly and backs water up close to homes. Channel is beginning to erode and appears to be insufficient.
EP092	Millcreek Twn	28th & Contessa area	Frequent yard flooding. The storm system may be insufficient.
EP093	Millcreek Twn	Arcadia Ave, S of 26th	Frequent home and yard flooding. The conveyance system near 2626 Arcadia Ave discharges to Marshall Run. The conveyance system may be insufficient.
EP094	Millcreek Twn	16th to 18th	Frequent road, home and business flooding. A conveyance system is not present in this area.
EP095	Millcreek Twn	Budd Dr, Southern Dr, Hidden Ln	Frequent yard flooding. Existing conveyance system may be insufficient.
EP096	Millcreek Twn	Scarbor, Windsor, Feilder Area	Frequent yard flooding. This is a general problem in the entire development.

Table 5.2 (continued). Reported Problem Areas for Erie County

ID	Municipality	Location	Notes
EP097	Millcreek Twn	15th W of Pittsburgh	Frequent road, parking lot & business flooding. The conveyance system along 15th St appears to backup and cause flooding. The culvert appears to be obstructed by large debris and is in need of maintenance.
EP098	Millcreek Twn	S of RR, Colonial to Lowes	Frequent business & yard flooding. A large upslope watershed discharges to this point.
EP099	Millcreek Twn	32nd & Zuck	Frequent roads, parking lot and yard flooding. The conveyance network appears to be insufficient.
EP100	Millcreek Twn	32nd, Pittsburgh to Zuck	Frequent home & yard flooding. The conveyance system appears to be insufficient.
EP101	Millcreek Twn	Atlantic, 36th to 38th	Frequent home & yard flooding. The conveyance system appears to be insufficient.
EP102	Millcreek Twn	Rt 99 & Interchange	Road frequently floods. The conveyance system appears to contain a lot of debris.
EP103	Millcreek Twn	Mill Creek, Conrad Rd to Rt 8	Frequent parking lot & yard flooding. This is a low lying area along mill creek. Area is in the floodplain.
EP104	Millcreek Twn	Home & Glenwood Park Ave	Frequent yard flooding. Conveyance system may be inadequate.
EP105	Millcreek Twn	Marshall Run Trib, Timberwood	Frequent garage and yard flooding. Upslope runoff discharges to 3833 DBF Rd and does not drain. Conveyance system may be insufficient.
EP106	Millcreek Twn	W 23rd Walmart drainage	Portions of store and parking lot flood. The channel behind Wal-Mart appears to flood. A culvert under the railroad appears to be full of debris.
EP107	Millcreek Twn	UNT Mill Creek S Arbuckle Rd	Frequent yard flooding. Properties in this area are flood prone.
EP117	Northeast Boro	Various	Problem area unable to be located during field visit.
EO026	Northeast Twn	Mouth of 16 Mile & 20 Mile Cks	Ice jams. When Lake Erie freezes close to shore, ice from Sixteen and Twenty Mile Creeks can not discharge to lake.
EO027	Northeast Twn	Baker Run Creek	Debris from an upstream concrete plant and various large woody debris blocks the stream and overflows into Northeast Boro Waste Water Treatment Plant #1 property.
EP056	Northeast Twn	Orchard Beach Creek Road	Culvert appears to provide adequate capacity. Neighboring properties located near the culvert outlet will most likely flood during even minor storm events.
EP057	Northeast Twn	Brickyard Rd north of Law Rd	Bridge abutments appear to be deteriorating. The bridge severely constricts the floodplain, creating scouring velocities of up to 11 ft/s during the 2-year storm event.
EO016	Platea Boro	Platz Rd Bridge	During the field visit, it appeared that the problem was fixed. The culvert appears adequate and the conveyance appears to be sufficient.
EP044	Platea Boro	Rt 18 & West Peach St.	Runoff flows to lower railroad bed and floods during storm events.
EP010	Springfield Twn	Tubbs Rd	Outflow from culvert discharge to a channel that makes an abrupt turn. An additional culvert at beginning of Tubbs Rd appears to provide adequate capacity but channel and culvert are not aligned correctly.

Table 5.2 (continued). Reported Problem Areas for Erie County

ID	Municipality	Location	Notes
EP011	Springfield Twn	Various streams	Beaver dams.
EO003	Summit Twn	LeBoeuf Creek	Beaver dams.
EP118	Summit Twn	LeBoeuf Creek	Beaver dams.
EO002	Union Twn	Union LeBoeuf Rd	Stream debris has been reported in the past. During the field visit, the stream appeared to be free of debris.
EP028	Venango Twn	French Creek & Knoyle Rd	Frequent flooding. Area is within the floodplain.
EO004	Waterford Twn	Sedgwick Rd	Beaver dams reported, but they appeared to be removed during the field visit.
EO005	Waterford Twn	Juva Valley Rd	Culverts do not appear to have adequate hydraulic capacity.
EP003	Waterford Twn	1000' of Himrod Rd	Flooding occurs because of inadequate drainage. The Erie County Conservation District is currently applying for funds to mitigate.
EP004	Waterford Twn	750' of Flatts Rd	The wooden bridge is closed due to its poor condition. Flooding occurs upstream and downstream of the bridge.
EP005	Waterford Twn	Sedgwick Rd	Same as EO004.
EP006	Waterford Twn	Haugh Rd	Dirt and Gravel Roads project completed in 2008.
EO001	Wattsburg Boro	Main St	Collapsed storm drains under Main St. Inlet box at house # 14400 is full of debris. Runoff that drains to this area has no outlet. Failure to replace the failing infrastructure may endanger public health and welfare. Area is very close to floodplain.
EP001	Wattsburg Boro	North St near Wattsburg Lumber	Road appears to have inadequate drainage. Inlets are full of debris. Gravel from neighboring lots enters the inlets and reduces the hydraulic capacity.
EP002	Wattsburg Boro	French Creek	Overbank flow and flooding. Problem area is located in the floodplain.
EP069	Wayne Twn	Hill Crest	Land was developed prior to SWM plan requirements. There is no outlet for water that collects at low points. Water appears to infiltrate rapidly in this area. This corresponds with soil maps (Howard and Phelps, "A" and "B" type soils).
EP070	Wayne Twn	Country Club Rd Sudbivision	New upslope development is causing flooding impacts on downstream properties.
EP071	Wayne Twn	Route 6 west of hatchery	Runoff that was diverted through a now defunct fish hatchery is now is diverted through neighboring properties. Runoff then ponds along ST RT 0006 and neighboring properties. The culvert outfall under ST RT 0006 is blocked.
EP072	Wayne Twn	Dugway Stream	Severe erosion along state line road.

Table 5.2 (continued). Reported Problem Areas for Erie County

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 have also to be considered in whether or not to evaluate the 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	Overtopping Flow (cfs)	Overtopping or Failure Frequency (year)
EO005	Waterford Twn	Juva Valley Road	Culvert	105	5
EO007	Mill Village Bor	Railroad Culvert # 1	Culvert	183	>100
EO009	Harborcreek Twn	Backus Road Culvert	Culvert	210	24
EO029	Girard Twn	South Creek Road	Culvert	118	19
EP046	Corry City	West Main Street	Culvert	45	2
EP057[1]	Northeast Township	Brickyard Road (North of Law Road)	Bridge	1,030	2
EP060	Edinboro Bor	Heather Road	Culvert	517	8
EP071	Wayne Twn	Rt. 6 W. Of Hatchery	Storm Drain	9	3
EP073[1]	Girard Twn	Gloskey Rd	Bridge	650	2
EP109	Elk Creek Twn	Griffis Rd	Culvert	230	5
EP121	Franklin Twn	New Road	Culvert	63	2
EP122	Franklin Twn	New Road, Mohawk Road	Culvert	8	2
EP123	Franklin Twn	Carbury Road	Culvert	207	4
EP124	Franklin Twn	Clair Wright Road	Culvert	108	19
EP125	Franklin Twn	Clair Wright Road	Culvert	17	9
EP126	Franklin Twn	West Stancliff Road	Culvert	50	6
EP127	Franklin Twn	Shadduck Road	Culvert	57	>100
EP128	Franklin Twn	Shadduck Road	Culvert	297	>100
EP129	Franklin Twn	Shadduck Road	Culvert	12	7

Notes:

[1] For problem areas EP057 and EP073, excessive velocities were found to occur in the 2-year storm event. The results were estimated using HEC-RAS.

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

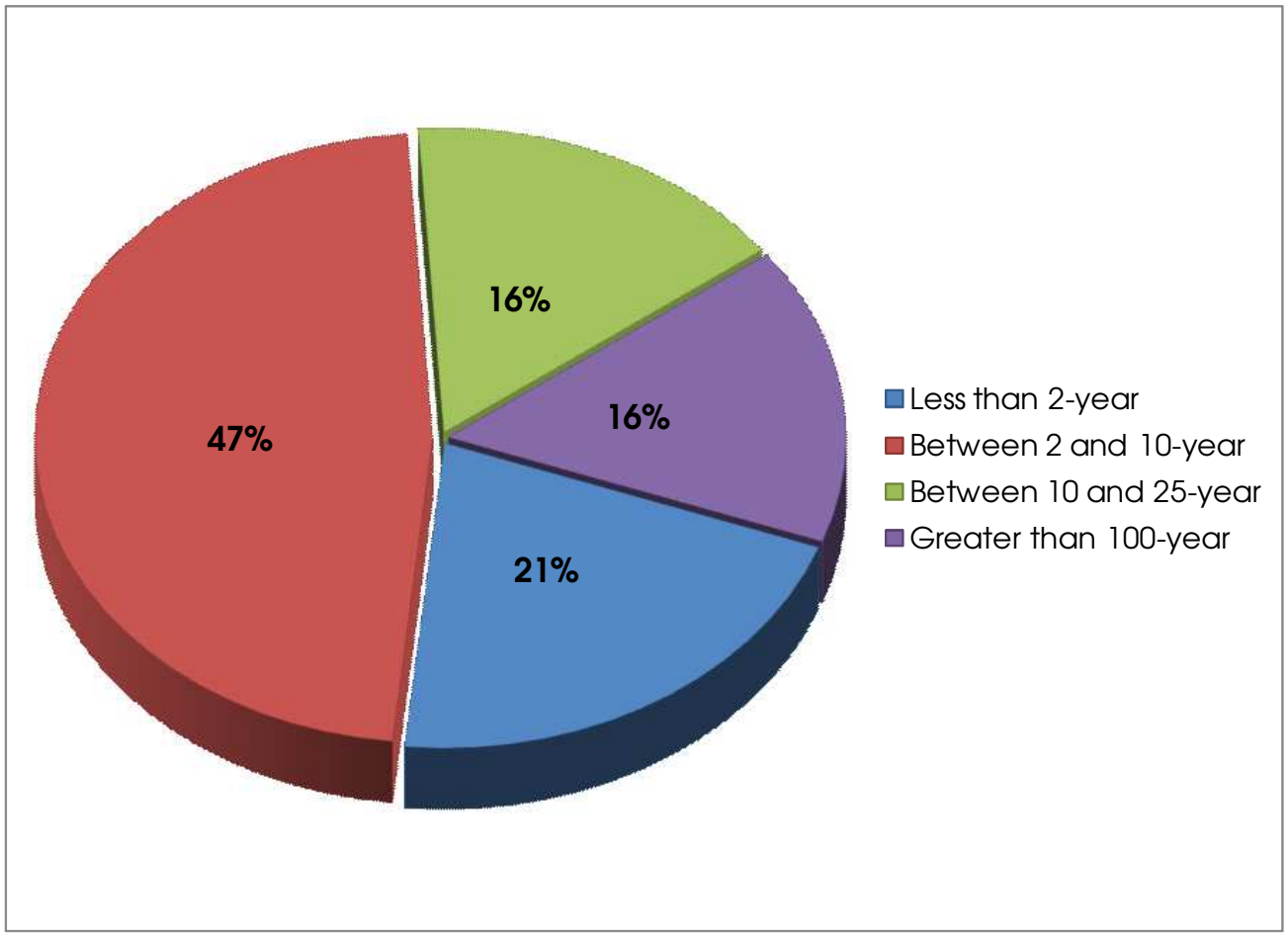


Figure 5.1. Overview of Problem Area Conveyance Capacity

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, is it recommended that the be further evaluated to determine other possible causes of flooding.

The results from the hydraulic analysis only present a snap shot of each area's hydraulic performance. The problem area site visits did not occur at the same time of a significant rainfall event and areas that receive regular maintenance may appear to have more capacity that they typically do.

The detailed data sheets in ***Appendix C*** list the proposed problem areas and 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. However, 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 1 and 10 for each of the six criteria. The six criteria were equally weighted in order to calculate a single relative rating between 1 and 10 for each problem.

Criteria	Description	Rating
Health & Safety	To what extent will the problem endanger human life?	1 to 10
Non-health & Safety Human Impact	How will the problem affect financial aspects of the surrounding areas?	1 to 10
Environmental Impact	To what extent will the problem contribute to erosion and sediment pollution?	1 to 10
Expected Life of Existing System	When will the system associated with the problem fail?	1 to 10
Frequency of Problem	How likely will the problem occur based on a 2-yr storm event?	1 to 10
Cost of Solution	Will the solution cost thousands, hundreds 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 of three categories based on their composite score: 1) High Priority Problem, 2) Significant Problem, or 3) General Problem. A composite rating between of 7 and 10 would classify a problem area or obstruction as a Highest Priority Problem. A composite rating between 4 and 6.9 would classify a problem area or obstruction as a Significant Problem and a rating between 1 and 3.9 would be classified as a General Problem. Because each problem was evaluated independently, each municipality can use this assessment as the basis to develop their own problem area prioritization list. ***Figure 5.2*** shows the resulting calculations for the problem area prioritization.

Table 5.4, shown below, is a list of the High Priority Problems. ***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. The data sheets in ***Appendix C*** for these problem areas include a more descriptive overview and a more detailed recommended solution.

For Millcreek and Franklin Townships it was difficult to differentiate between problem area since most of them cited undersized or poorly maintained storm drain systems as problem areas. These systems would require more detailed hydrologic and hydraulic analysis than was provided for this Plan. For both of these townships, and possibly others within Erie County, a towship-specific analysis is recommended.

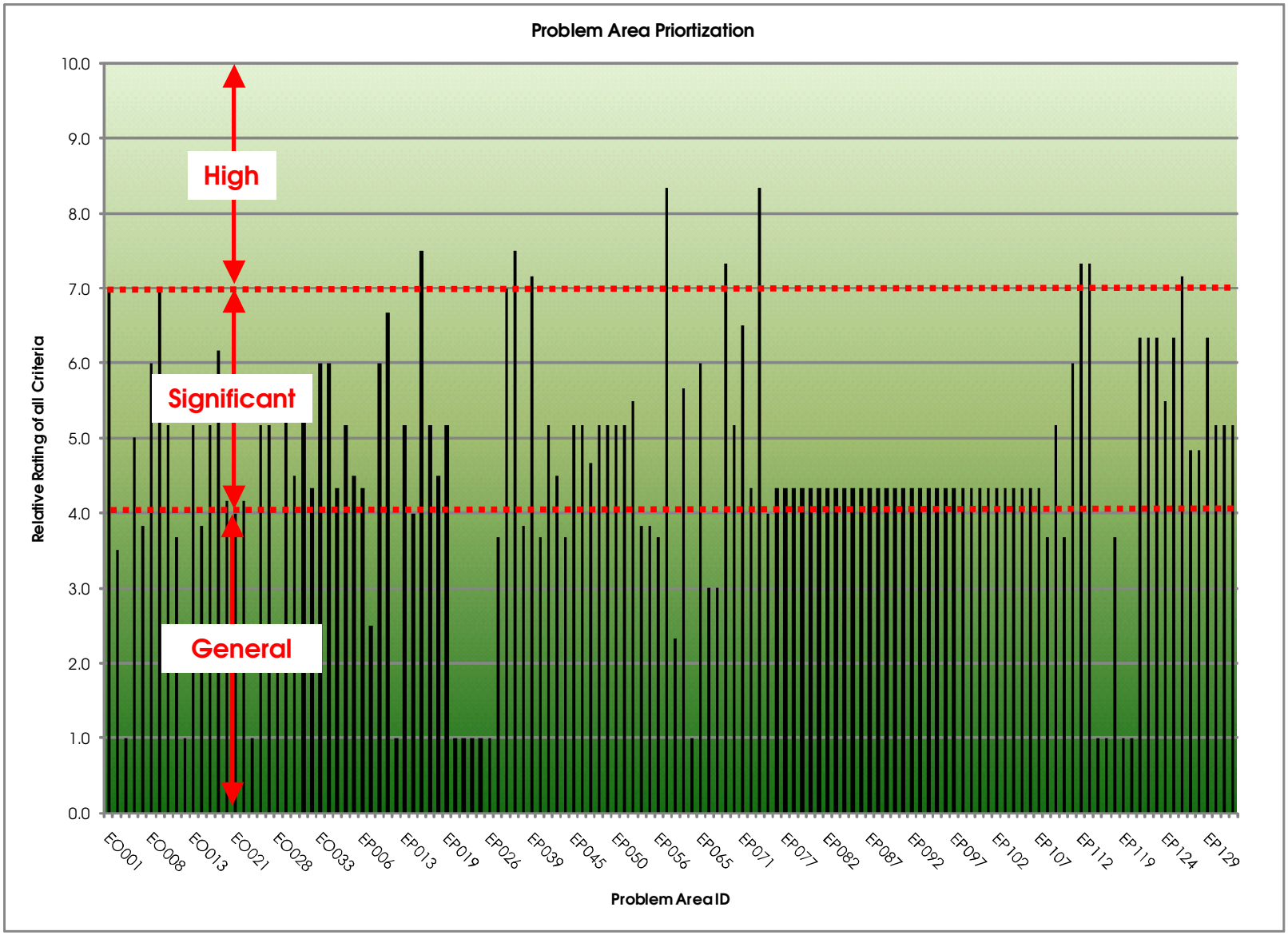


Figure 5.2. Problem Area Prioritization

Rank	P&ONumber	Municipality	Stucture	Priority
1	EP057	Northeast Twn	Bridge	High
	EP073	Girard Twn	Bridge	
2	EP016	Harborcreek Twn	Stream	
	EP034	Fairview Twn	Stream	
3	EP112	Elk Creek Twn	Bridge	
	EP113	Elk Creek Twn	Bridge	
	EP069	Wayne Twn	Storm Drain	
4	EP039	Lawrence Park Twn	Stream	
	EP126	Franklin Twn	Culvert	
5	EO001	Wattsburg Bor	Storm Drain	
	EO009	Harborcreek Twn	Culvert	
	EP031	Fairview Twn	Stream	

Table 5.4. Highest Priority Problem Areas for Erie County

Rank	P&ONumber	Municipality	Stucture	Priority
6	EP010	Springfield Twn	Stream	Significant
7	EP071	Wayne Twn	Storm Drain	
8	EP121	Franklin Twn	Culvert	
	EP122	Franklin Twn	Culvert	
	EP123	Franklin Twn	Culvert	
	EP125	Franklin Twn	Culvert	
	EP129	Franklin Twn	Culvert	
9	EO019	Corry City	Bridge	
10	EO008	Mill Village Bor	Stream	
	EO033	Millcreek Twn	Stream	
	EO034	Millcreek Twn	Stream	
	EP009	Mill Village Bor	Stream	
	EP065	Edinboro Bor	Stream	
	EP111	Elk Creek Twn	Bridge	
11	EP060	Edinboro Bor	Culvert	
12	EP052	Lake City Bor	Stream	
	EP124	Franklin Twn	Culvert	
13	EO031	Girard Twn	Storm Drain	
	EO029	Girard Twn	Culvert	
14	EO010	Greene Twn	Floodplain	
	EO013	Lawrence Park Twn	Storm Drain	
	EO018	Corry City	Storm Drain	
	EO026	Northeast Twn	Stream	

Table 5.5. Significant Priority Problem Areas for Erie County

Rank	P&ONumber	Municipality	Stucture	Priority
14	EO027	Northeast Twn	Stream	Significant
	EP002	Wattsburg Bor	Floodplain	
	EP013	Harborcreek Twn	Floodplain	
	EP017	Harborcreek Twn	Culvert	
	EP019	Greene Twn	Floodplain	
	EP041	Lawrence Park Twn	Stream	
	EP045	Corry City	Storm Drain	
	EP046	Corry City	Culvert	
	EP048	Corry City	Storm Drain	
	EP049	Corry City	Storm Drain	
	EP050	Corry City	Storm Drain	
	EP051	Corry City	Storm Drain	
	EP070	Wayne Twn	Storm Drain	
	EP109	Elk Creek Twn	Culvert	
	EP130	Franklin Twn	Storm Drain	
	EP131	Franklin Twn	Storm Drain	
	EP132	Franklin Twn	Storm Drain	
15	EO005	Waterford Twn	Culvert	
16	EP127	Franklin Twn	Culvert	
	EP128	Franklin Twn	Culvert	
17	EP047	Corry City	Storm Drain	
18	EO030	Girard Twn	Storm Drain	
	EP004	Waterford Twn	Bridge	
	EP018	Girard Borugh	Culvert	
	EP042	Lawrence Park Twn	Bridge	
19	EO032	Millcreek Twn	Storm Drain	
	EP001	Wattsburg Bor	Storm Drain	
	EP006	Waterford Twn		
	EP072	Wayne Twn	Storm Drain	
	EP076	Millcreek Twn	Floodplain	
	EP077	Millcreek Twn	Storm Drain	
	EP078	Millcreek Twn	Floodplain	
	EP079	Millcreek Twn	Storm Drain	
	EP080	Millcreek Twn	Storm Drain	
	EP081	Millcreek Twn	Storm Drain	
	EP082	Millcreek Twn	Storm Drain	
	EP083	Millcreek Twn	Storm Drain	

Table 5.5 (continued). Significant Priority Problem Areas for Erie County

Rank	P&ONumber	Municipality	Stucture	Priority
19	EP084	Millcreek Twn	Floodplain	Significant
	EP085	Millcreek Twn	Floodplain	
	EP086	Millcreek Twn	Storm Drain	
	EP087	Millcreek Twn	Storm Drain	
	EP088	Millcreek Twn	Storm Drain	
	EP089	Millcreek Twn	Storm Drain	
	EP090	Millcreek Twn	Storm Drain	
	EP091	Millcreek Twn	Floodplain	
	EP092	Millcreek Twn	Storm Drain	
	EP093	Millcreek Twn	Storm Drain	
	EP094	Millcreek Twn	Storm Drain	
	EP095	Millcreek Twn	Storm Drain	
	EP096	Millcreek Twn	Floodplain	
	EP097	Millcreek Twn	Culvert	
	EP098	Millcreek Twn	Storm Drain	
	EP099	Millcreek Twn	Storm Drain	
	EP100	Millcreek Twn	Storm Drain	
	EP101	Millcreek Twn	Storm Drain	
	EP102	Millcreek Twn	Storm Drain	
	EP103	Millcreek Twn	Storm Drain	
	EP104	Millcreek Twn	Storm Drain	
	EP105	Millcreek Twn	Storm Drain	
	EP106	Millcreek Twn	Culvert	
	EP107	Millcreek Twn	Floodplain	
20	EO020	Corry City	Bridge	
	EO022	Corry City	Stream	
21	EO021	Corry City	Culvert	
	EP014	Harborcreek Twn	Storm Drain	
	EP074	Girard Twn	Storm Drain	

Table 5.5 (continued). Significant Priority Problem Areas for Erie County

Rank	P&ONumber	Municipality	Stucture	Priority
22	EO007	Mill Village Bor	Culvert	Moderate
	EO014	Lawrence Park Twn	Storm Drain	
	EP037	Lawrence Park Twn	Floodplain	
	EP053	Mckean Twn	Floodplain	
	EP054	Mckean Twn	Floodplain	
23	EP040	Lawrence Park Twn	Floodplain	
	EO011	Fairview Twn	Floodplain	
	EP044	Platea Bor	Railroad	
	EP108	Elk Creek Twn	Floodplain	
	EP110	Elk Creek Twn	Bridge	
	EP028	Venango Twn	Floodplain	
	EP056	Northeast Twn	Floodplain	
	EP117	Northeast Bor		
24	EO002	Union Twn	Stream	
25	EP067	Edinboro Bor	Stream	
	EP068	Edinboro Bor	Stream	
26	EP008	Cranesville Bor	Stream	
27	EO028	Edinboro Bor	Storm Drain	
	EP059	Edinboro Bor	Floodplain	
28	EO004	Waterford Twn	Beaver	
	EO012	Fairview Twn	Beaver	
	EO024	Amity Twn	Beaver	
	EP011	Springfield Twn	Beaver	
	EP020	Greenfield Twn	Beaver	
	EP021	Greenfield Twn	Beaver	
	EP023	Greenfield Twn	Beaver	
	EP024	Greenfield Twn	Beaver	
	EP026	Greenfield Twn	Beaver	
	EP061	Edinboro Bor	Beaver	
	EP114	Elk Creek Twn	Beaver	
	EP115	Elk Creek Twn	Beaver	
	EP119	Greenfield Twn	Beaver	
	EP120	Greenfield Twn	Beaver	

Table 5.6. General Priority Problem Areas for Erie County

RECOMMENDATIONS

The 165 problem areas identified in this Plan have occurred for a variety of reasons. ***Table 5.7*** provides a count of the type of each problem area in addition to providing an outline of overall areas for improvement.

Structure	Number	Percentage	Overall areas for Improvement
Storm Drain	49	29.7	• Improve storm sewer maintenance practices • Reduce effects from new development • Improved design practices (appropriate sizing and consideration of maintenance)
Culvert	24	14.5	• Improve design practices (appropriate sizing and consideration of geomorphologic processes) • Improve maintenance practices
Floodplain	23	13.9	• Improve enforcement of floodplain ordinances
Stream Instability	20	12.1	• Prepare detailed stream assessments • Improve design practices (consideration of geomorphologic processes) • Improve maintenance practices
Beaver	16	9.7	• Improve maintenance practices
Bridge	13	7.9	• Improve design practices (use appropriate dimensions for height and width of the opening and consideration of geomorphologic processes) • Improve maintenance practices
Quality	5	3.0	• Reduce effects from new development development
Railroad	1	0.6	• Improved maintenance practices
Unidentified	14	8.5	--
Total	165	100.0	--

Table 5.7. Type of Problem Areas for Erie County

Almost all of these problems are related to three general issues relative to this Plan: 1) historical development practices; 2) poor design practices; and 3) lack of maintenance activities. The overall focus of the plan is to improve historical development practices using Low Impact Development and improved overall stormwater management. This approach, if successfully adopted, may prevent the creation of future problems, but it does not necessarily solve the existing problems. The second issue, design practices, will be improved through the successful adoption and implementation of the Model Ordinance, but mostly this improvement will prevent future problems – not address existing problems. The third issue, the lack of maintenance activities, has the potential, however, to resolve many of the identified problems throughout the county.

Future development should consider the adequacy of downstream systems and identified problem area in their designs. Language has been used in past Act 167 efforts and exists in several of the existing ordinances that allows the municipality to prevent the worsening of an

"existing adverse hydrologic or hydraulic conditions". The problem areas identified in this plan and other similar studies provide the municipalities with documentation to ensure that all future developments account for both existing and potential future problems in their designs.

Installation of culverts and bridges need to consider the local geomoropholgy in their designs. In addition to the 20 problem areas identified as stream instabilities, many of the storm drains, culverts, and bridges in the county were designed without any consideration of the geomorphic condition of the relevant waterbody. Erosion and deposition are present at almost every stream crossing and it is unlikely that many of the designs ever accounted for this sediment flux. In several locations, detail stream assessments should be provided that consider the upstream and dowstream channel stability, and the impacts any potential solution might have.

Use the prioritzation of these problem areas to focus investment activity. Of the 12 highest priority problem areas, all but one of these are a result of deteriorating infrastructure and poor maintenance conditions. This prioritization provides a first iteration of for the County and municipalities to use in conjuction with other studies and further analysis. For many municipalities (i.e., Millcreek Township and Franklin Township) much more detail is needed to differentiate each problem area. A more detailed prioritization will provide cost estimates and ultimately provide economic and political justification for fixing specific problems.

Maintenance of existing stormwater management facilities should be strongly emphasized in the the implementation of this Plan. Maintenance activities may included inspection, cleaning, and periodic replacement of facilities. For future facilities, recommended provisions in the Model Ordinance include explicit maintenance agreements with the owners and developers and deed restrictions. At a minimum, these legal restrictions provide municipalities a means to assign responsibility. For existing facilities, where the maintenance responsibilities are not well defined or understood, municipalities may want to develope a more detailed prioritization of their problem areas to focus investment efforts and to develop an outline to address the municipality's critical infrastructure issues.

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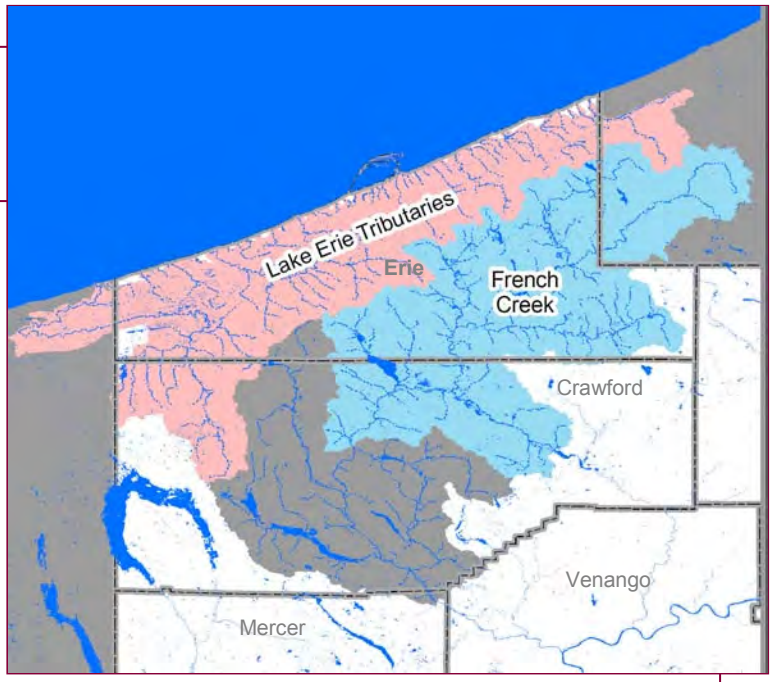
Section VI – Technical Analysis - Modeling



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 Pennsylvania Department of Environmental Protection. The results from these models increase the overall understanding of watershed response to rainfall and help guide management 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 Erie 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 in the PA Stormwater BMP Manual were developed. 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 in year 2010,

2. Establish a reasonable estimate or rainfall-runoff response under an assumed future condition land development in year 2020,

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.

This approach was used on the Lake Erie Tributaries and French Creek watersheds in Erie County. This section discusses the portion of the modeling effort that affects the Model Ordinance and the overall county stormwater policy. Generally, it was observed that the watersheds of Erie County have a relatively intense response to runoff (i.e., a little rain can result in large amounts of flow in the rivers). This response is a function of poorly drained soils throughout the county. It was also observed that there is only slight to moderate projected growth throughout the county. The modeling effort provided evidence that implementing the *PA Stormwater BMP Manual* guidelines will help reduce the impacts of future development. With the minimal projected change in land use and implementation of the proposed volume control standards, stormwater management districts are not necessary for many parts of Erie County.

A detailed explanation of this modeling effort is provided in *Appendix A*. 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.

LAND USE

The variable that most affects the outcome of the modeling effort is the projected change in land use between 2010 and 2020. *Tables 6.1* and *6.2* summarize the existing and proposed land use for the two modeled watersheds: Erie Tributaries and French Creek. In both watersheds, there are slight projected increases in commercial and residential land uses with a slight decrease in agriculture and forested land uses.

Land Use	Existing Land Use (Year 2010)		Proposed Land Use (Year 2020)		Change Future - Existing
	Acres	%	Acres	%	%
Brush	16,265.1	6.29	15,264.8	5.91	-0.39
Commercial and Business	11,044.4	4.27	11,805.3	4.57	0.29
Contoured Row Crops	8.2	0.00	8.2	0.00	0.00
Dirt	20.0	0.01	20.0	0.01	0.00
Industrial	6,402.9	2.48	6,458.2	2.50	0.02
Meadow	1.0	0.00	1.0	0.00	0.00
Open space	6,461.3	2.50	6,350.2	2.46	-0.04
Pasture	66,652.4	25.79	63,122.0	24.42	-1.37
Pavement	14,131.5	5.47	14,012.4	5.42	-0.05
Residential - 1 acre	0.8	0.00	0.8	0.00	0.00
Residential - 1/2 acre	30,769.5	11.90	37,858.0	14.65	2.74
Residential - 1/4 acre	1,585.0	0.61	1,574.4	0.61	0.00
Residential - 1/8 acre	1,105.2	0.43	1,099.9	0.43	0.00
Water	2,264.6	0.88	2,235.1	0.86	-0.01
Woods	101,775.0	39.37	98,676.4	38.17	-1.20
Total	258,486.9	100.00	258,486.9	100.00	n/a

Table 6.1. Existing and Future Land Use in the Erie Tributaries Watershed (within Erie County only)

Land Use	Existing Land Use		Proposed Land Use		Change Future - Existing
	Acres	%	Acres	%	%
Brush	24,775.9	10.81	24,532.9	10.71	-0.11
Commercial and Business	2,310.9	1.01	2,390.5	1.04	0.03
Contoured Row Crops	4.5	0.00	4.5	0.00	0.00
Industrial	2,106.6	0.92	2,104.7	0.92	0.00
Meadow	1.7	0.00	1.7	0.00	0.00
Open space	3,360.0	1.47	3,207.5	1.40	-0.07
Pasture	70,544.7	30.79	69,002.2	30.12	-0.67
Pavement	5,637.6	2.46	5,574.4	2.43	-0.03
Residential - 1 acre	0.9	0.00	0.9	0.00	0.00
Residential - 1/2 acre	9,550.7	4.17	12,056.9	5.26	1.09
Residential - 1/4 acre	226.6	0.10	226.6	0.10	0.00
Residential - 1/8 acre	695.5	0.30	695.3	0.30	0.00
Water	3,755.1	1.64	3,750.4	1.64	0.00
Woods	106,123.2	46.32	105,545.4	46.07	-0.31
Total	229,093.9	100.00	229,093.9	100	n/a

Table 6.2. Existing and Future Land Use in the French Creek Watershed (within Erie County only)

EFFECTS OF FUTURE LAND USE

Using the HEC-HMS models for the Lake Erie Tributaries and French Creek watersheds, the effects of the land use change between the years 2010 and 2020 were examined. *Figures 6.1* and 6.2 shows the increase in peak flows for the 2-year storm event throughout the Lake Erie Tributaries and French Creek watersheds, respectively. This increase in peak flows uses the assumption that no stormwater controls would be implemented in the next 10 years. Although this scenario is highly unlikely given the existing regulations in each municipality, or the regulations that would adopted with the recommendation of this Plan, it does provide a worst case scenario. More importantly, this scenario highlights the critical areas within the county where more stringent regulation might be beneficial.

For the Lake Erie Tributaries, the projected future increases are located mostly in the geographical center of the county on the outskirts of the developed area of the City of Erie. This development pattern is consistent with the projection of the 1996 Act 167 Plan (Chester Engineers,1996) and indicates the potential need for peak rate controls more stringent than the traditional 100% release rates.

For the French Creek watershed, the only significant increases occur around the Edinboro Lake area. The area east of Edinboro Lake was the only area within the French Creek watershed focused on for implementation of more stringent peak rate controls.

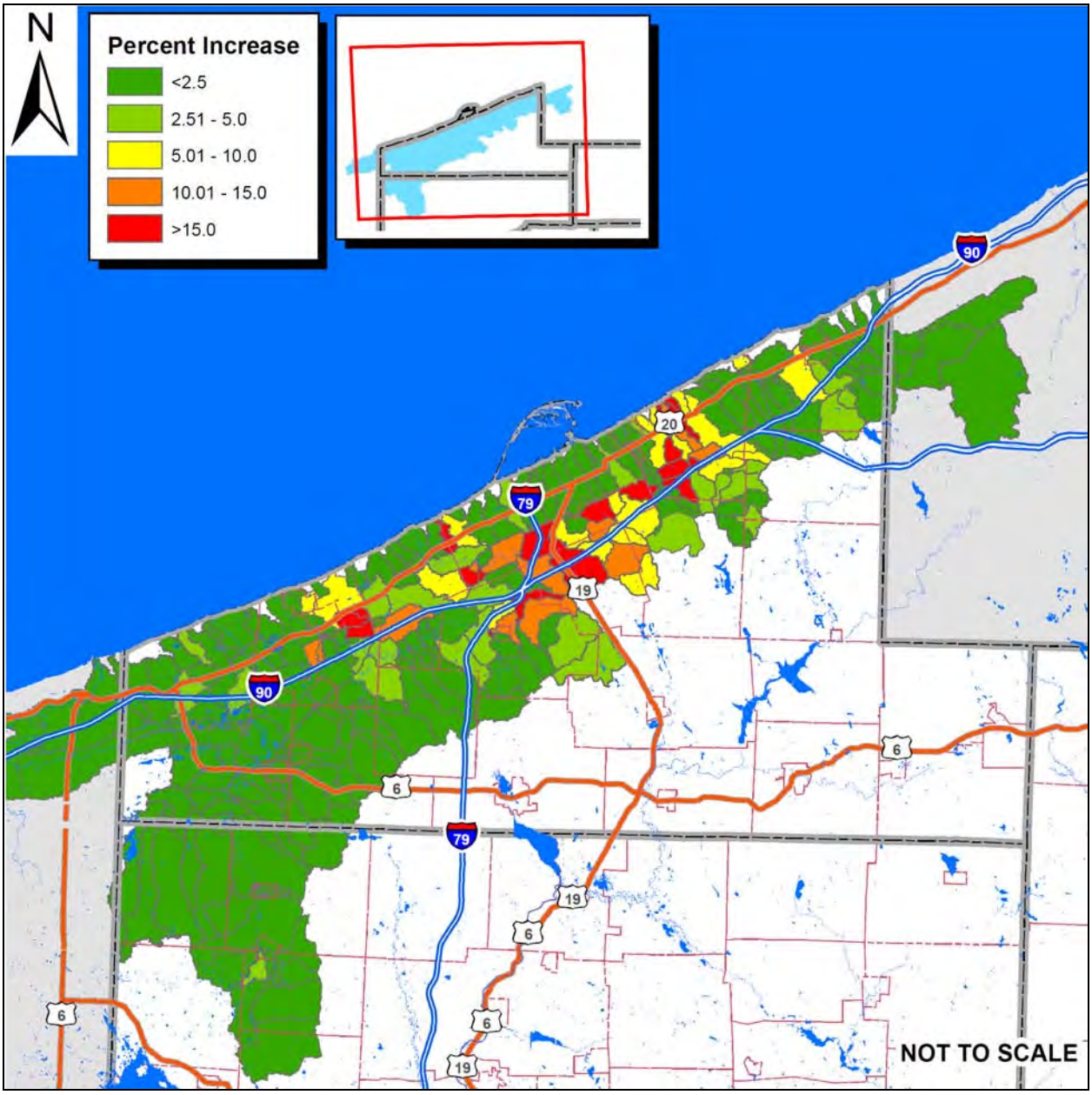


Figure 6.1. Percentage Increase in Peak Flows for the 2-Year Storm Event in the Lake Erie Tributaries Watershed

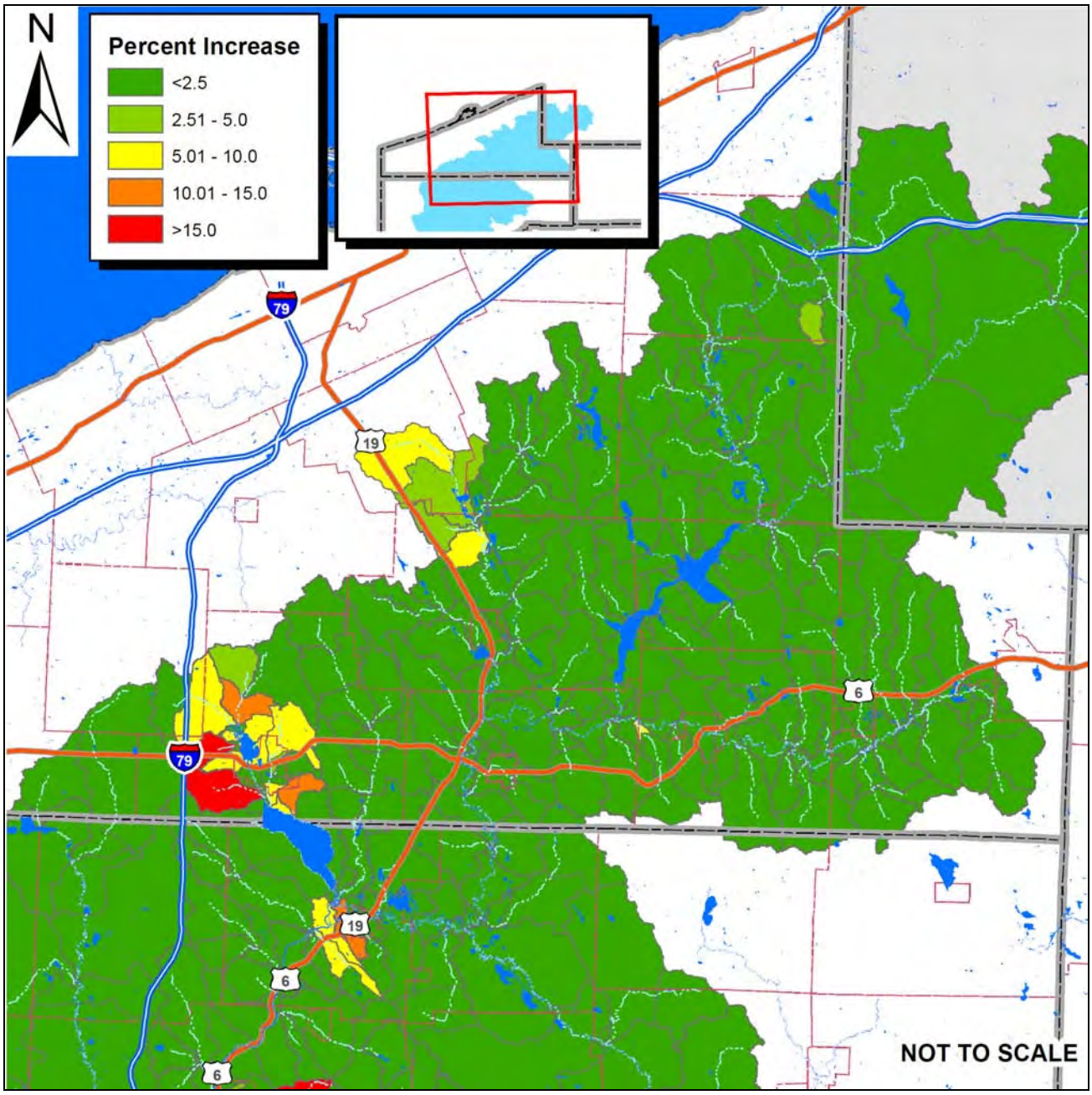


Figure 6.2. Percentage Increase in Peak Flows for the 2-Year Storm Event in the French Creek Watershed

STORMWATER MANAGEMENT DISTRICTS

When substantial increases are found in the HEC-HMS model due to the 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 Planning efforts. For example, 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 indicated a need for additional stormwater management controls, release rates were considered. The results from the hydrologic models were used as guidance to establish appropriate release rates. Ultimately, reasonable hydrologic judgment was used in the final designation of release rates.

Both the Lake Erie Tributaries and French Creek were evaluated on the above criteria for implementation of stormwater management districts. For the Lake Erie Tributaries, much of the future development is projected to occur in the middle to upper part of the watersheds, particularly in watersheds with numerous problem areas like Elk Creek, Walnut Creek, and Mill Creek. To prevent the creation of future problems areas, and further complicating the existing problems in these watersheds, release rates ranging between 70% and 100% were designated in various locations. The magnitude of release rates found in this study was consistent the release rate prescribed in the *Lake Erie Area Watershed Act 167 Plan* (Chester Engineers, 1996).

For the majority of French Creek, there is only moderate projected growth. The combination of implementing the proposed volume control standards and using traditional peak rate control (i.e. 100%) should be sufficient to limit the impact of the future projected growth. The exception to this is the area east of Edinboro Lake where it was determined that minimal release rates of 90% would be necessary to ensure that the numerous existing problem areas would not be exacerbated, and so that future development would not create additional problems in this area. In considering the additional criteria it was determined that stormwater management districts would not be implemented in the remainder of the watershed.

The location of the stormwater management districts is shown on *Plate 10 - Stormwater Management Districts*. It is noted that any release rate area may be mitigated or eliminated through the use of a single or the combination of regional stormwater facilities.

RECOMMENDATIONS

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

Curve number and time of concentration methodologies should be restricted to reflect the observed runoff response in the hydrologic models. For storm events greater than the 10-year storm events, the runoff response to NOAA Atlas 14 rainfall in Erie County was slightly lower than standard NRCS methods predict. This has the potential to allow designers to undersize their stormwater facilities and to increase peak discharges for the higher magnitude events. It is recommended for curve number calculations to assume 'good conditions' when using any curve number table, which is consistent with proposed control guidance. It is recommended for time of concentration computations to use the longest time of concentration provided by 1) the TR-55 segmental method and 2) the NRCS Lag Equation.

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

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

Provide a clear alternative volume-control and peak-rate control strategy for areas with poorly drained soils or areas with geologic restrictions. Erie County has a substantial number of potential limitations to infiltration facilities, particularly in the French Creek watershed: fragipans, 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 which provide the best known balance are chosen for implementation. The goal of this Plan is to manage stormwater as a valuable resource, and to manage all aspects of thies resource as effectively as possible. This Plan contains technical standards that seek to achieve this goal through four different methods. These standards are summarized as follows:

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

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

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

4. Water Quality Standards – The water quality standards contained in this Plan are meant to provide a level of pollutant removal from runoff prior to discharge to receiving streams. Stormwater runoff can deliver a wide range of contaminants to the receiving stream, which leads to a variety of 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 Erie County. Mathematical modeling techniques, as discussed in the previous chapter, were used to simulate the existing conditions throughout the county and to determine the effects anticipated future development will have on stormwater runoff within these watersheds. The models were used to determine the outcome of a variety of different stormwater control scenarios. These results were then used to determine a group of control criteria that provides the best results on a watershed wide basis. The outcome of each analysis is stormwater control criteria that are appropriate and applicable to that watershed.

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

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

PEAK DISCHARGE RATE CONTROLS

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

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

1. Areas not covered by a Release Rate Map:

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

2. Areas covered by a Release Rate Map:

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

VOLUME CONTROLS

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

The proposed volume controls for this Plan include two pieces:

1. Reduction of runoff generated through utilization of low impact development practices to the maximum extent practicable.

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

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

1. ***The Design Storm Method*** (CG-1 in the 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 duration precipitation.

   B. For modeling purposes:

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

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

2. ***The Simplified Method*** (CG-2 in the 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 best management practices to partially fulfill the volume control requirements the following procedure shall be used:

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

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

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

WATER QUALITY CONTROLS

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

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

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

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

CONTROLS FOR ROADWAY PROJECTS

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

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

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

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

RECOMMENDED BEST MANAGEMENT PRACTICES

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

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

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

Table 7.1. Stormwater Functions of Non-Structural Best Management Practices

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

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

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

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

Table 7.2. Stormwater Functions of Structural Best Management Practices

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

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

RAIN GARDENS & BIORETENTION

A rain garden, also referred to bioretention, is an excavated shallow surface depression planted with native, water-resistant, drought and salt tolerant plants with high pollutant removal potential that is used to capture and treat stormwater runoff. Rain gardens treat stormwater by collecting and pooling water on the surface and allowing filtering and settling of suspended solids and

sediment prior to infiltrating the water. Rain gardens are generally constructed to provide 12 inches or less of pending depth with shallow side slopes (3:1 max). They are designed to reduce runoff volume, filter pollutants and sediments through the plant material and soil particles, promote groundwater recharge through infiltration, reduce stormwater temperature impacts, and enhance evapotranspiration. Their versatility has proved extremely successful in most applications including urban and suburban areas (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 site with a high degree of flexibility and can be used in coordination with a variety of other structural best management practices. They can also enhance the aesthetic value of a site through the selection of appropriate native vegetation.

DRY WELL / ROOF SUMP

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

Roof drains are connected directly into the dry well, which can be an excavated pit filled with uniformly graded aggregate wrapped in geotextile or a prefabricated storage chamber. Runoff is collected during rain events and slowly infiltrated into the surrounding soils. An overflow mechanism such as an overflow outlet pipe, or connection to an additional infiltration area, is provided as a safety measure in the event that the facility is overwhelmed by extreme storm events or other surcharges (DEP, 2006). Dry wells are not recommended within a specified distance to structures or subsurface sewage disposal systems nor for non-residential applications.

VEGETATED SWALES

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

A vegetated swale typically consists of a band of dense vegetation, underlain by at least 24 inches of permeable soil. Swales constructed with an underlying 12 to 24 inch aggregate layer

provide significant volume reduction and reduce the stormwater conveyance rate. The permeable soil media should have a minimum infiltration rate of 0.5 inches per hour and contain a high level of organic material to enhance pollutant removal. A nonwoven geotextile should completely wrap the aggregate trench (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.

SURFACE INFILTRATION FACILITIES

Surface infiltration beds are created by placing storage facilities above the proposed surface grade which collects stormwater and provides temporary storage and allows water to slowly infiltrate. Infiltration facilities are designed to provide significant volume reduction through temporary storage and infiltration, which also benefits peak rate control and water quality. Surface beds are ideally suited for expansive, generally flat open spaces, such as lawns, playfields, and other recreational areas (DEP, 2006).

An infiltration bed usually consists of a layer of highly pervious planting soil and vegetation within a storage facility. The storage facility is very similar to a detention basin created by an earthen embankment. An overflow structure should be included to provide protection in case of extreme storm events or system failure. The bottom of the infiltration bed must be level and distribution systems must be added to larger facilities to ensure that water is infiltrated evenly over the entire surface area. For this reason, infiltration beds are typically shallower than detention basins. The soil layer and vegetation provide water quality through filtration and increase evapotranspiration. These facilities provide groundwater recharge while also preserving or creating valuable open space and recreation areas.

CONSTRUCTED WETLANDS

Constructed Wetlands are shallow marsh systems planted with emergent vegetation that are designed to treat stormwater runoff. Constructed Wetlands provide both exellent pollutant removal and mitigate peak rates. They also can provide considerable aesthetic and ecological benefits. An adequate source of inflow is needed to maintain the permanent water surface.

The underlying soils are important to the constructed wetland function where hydrologic soil groups "C" and "D" are suitable without modification. Soil permeability should be verified. The organic planting soil is critical to pollutant removal, have high water holding capacities, and facilitate proper plant growth. Constructed wetlands should have several different zones of vegetation with 50 to 80 percent of the normal water surface area being emergent vegetation (areas less than 18" deep).

EXTENDED DETENTION BASINS

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

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

IMPLEMENTATION OF STORMWATER MANAGEMENT CONTROLS

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

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

Section VIII – Economic Impact of Stormwater Management Planning

IMPLEMENTATION OF STORMWATER STANDARDS

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

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

DESIGN EXAMPLE 1

The following design example illustrates the methods used to design stormwater management facilities and structural BMPs in accordance with the volume and peak rate control strategies developed within this Plan. The design process encouraged by the *Pennsylvania Stormwater BMP Manual* is used to determine non-structural BMP credits and perform the calculations necessary to determine if the requirements of the *Model Ordinance* have been met. The 2-year design storm is utilized to illustrate the methods used to meet the volume requirements of the Ordinance. The SCS Runoff Curve Number Method is used for runoff volume calculations as suggested by the *Pennsylvania Stormwater BMP Manual* (2006). Refer to this document for additional guidance, rules and limitations applicable to these methods, and the design of structural and non-structural BMPs.

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

PRE-DEVELOPMENT CONDITIONS

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

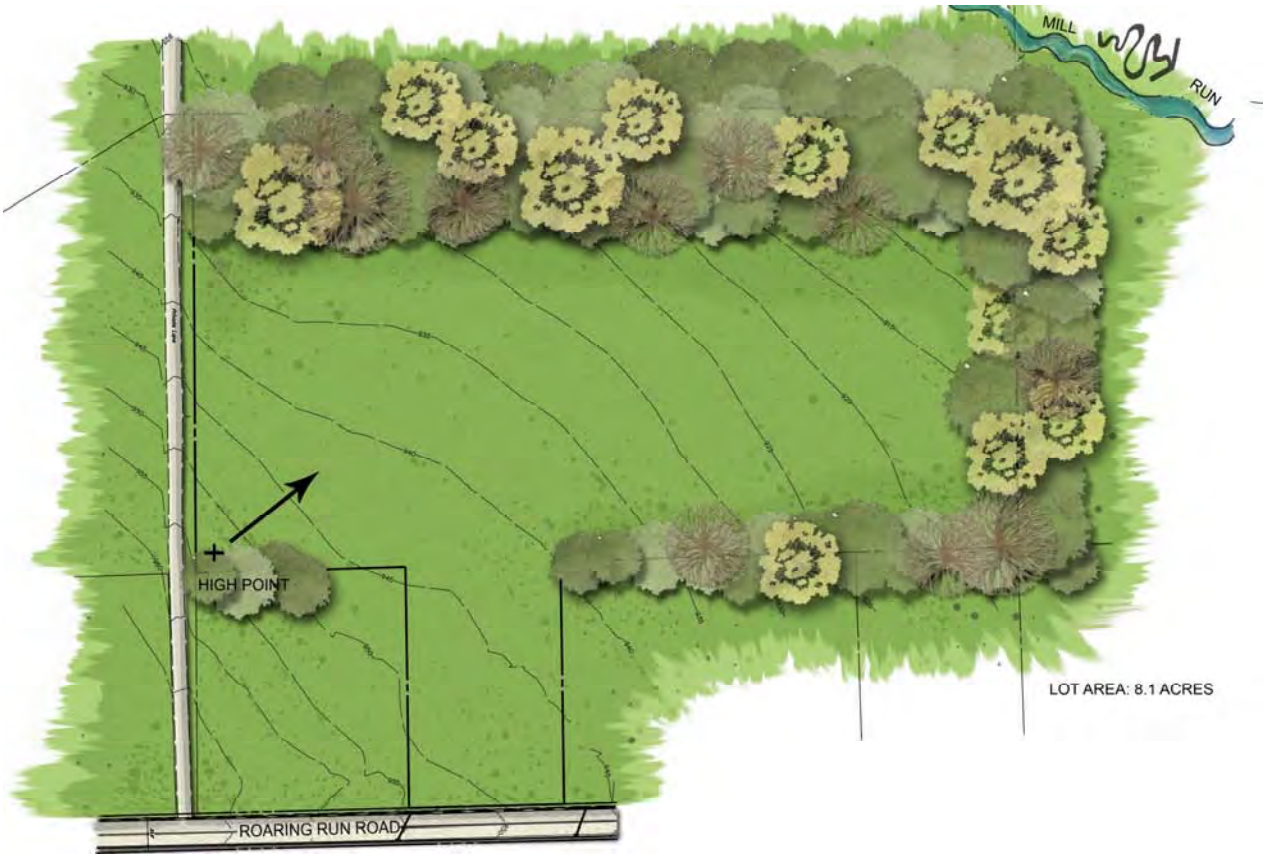

Figure 8.1. Design Example 1 – Pre-Development Conditions

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

Table 8.1. Pre-Development Data

POST-DEVELOPMENT CONDITIONS

All of the lots will be accessed by a single cul-de-sac road to be constructed for the subdivision. Each house has an assumed 2,150-sf impervious footprint. Various low impact design techniques

were used in the site design. A large portion of the existing woodlands (1.31 acres) was preserved during construction and will remain wooded through a permanent easement on lots 6-9, the back portion of lots 9-10 were protected from compaction during construction and will remain protected through an easement, roof drains are disconnected from the storm sewer system and directed to dry wells, and rain gardens will be installed on each lot. Runoff from the roadway is collected by swales and conveyed to a bioretention area.

Figure 8.2. Design Example 1 – Post-Development Conditions

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

Table 8.2. Post-Development Data

DESIGN PROCESS FOR VOLUME CONTROLS

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

Step 1

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

Step 2

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

Step 3

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

Step 4

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

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

Step 5

Worksheet 4 is completed to calculate the difference in the 2-year design storm runoff volume from pre-development conditions to post-development conditions. The 2-year

volume increase, minus the volume credits for non-structural BMPs, represents the volume that must be managed through structural BMPs.

Step 6

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

Summary of Results

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

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

Table 8.3. Summary of BMP Credits

DESIGN OF PEAK RATE CONTROLS

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

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

The SCS Unit Hydrograph Method was developed to be used in conjunction with the Curve Number Runoff Method of generating runoff depths to estimate peak runoff rates and runoff hydrographs. While these methods have numerous limitations, the principal application of this

method is in estimating runoff volume in flood hydrographs, or in relation to flood peak rates (NRCS, 2008). Therefore, the NRCS Rainfall-Runoff Method (i.e. using the Curve Number Runoff Method and SCS Unit Hydrograph Method together to produce rainfall-runoff response estimates) is the preferred method to calculate runoff peak rates and for rate control facility design calculations.

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

DESIGN PROCESS FOR PEAK RATE CONTROLS

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

Step 1

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

Step 2

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

Step 3

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

Step 4

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

Step 5

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

Step 6

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

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

Summary of Results

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

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

Table 8.4. Summary of Peak Rate Flows

ECONOMIC IMPACT OF STORMWATER MANAGEMENT STANDARDS

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

There are three principal methods available to assess the economics of implementing the proposed stormwater management regulations:

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

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

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

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

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

TRADITIONAL SUBDIVISION LAYOUT WITH PEAK RATE CONTROL DESIGN

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

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

LID SUBDIVISION LAYOUT WITH VOLUME CONTROL DESIGN

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

COST COMPARISON

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

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

Table 8.5. Results of Cost Comparison for Initial Construction Costs

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

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

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

Table 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

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

IMPAIRED STREAMS

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

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

The established goals are numerical, or narrative, water quality criteria that express the in-stream levels of substances that must be achieved to support the uses. This assessment effort is used to support water quality reporting required by the Clean Water Act. DEP uses an integrated format for the Clean Water Act Section 305(b) reporting and Section 303(d) listing in a biennial report called the "Pennsylvania Integrated Water Quality Monitoring and Assessment Report". The narrative report contains summaries of various water quality management programs including

water quality standards, point source control and nonpoint source control. In addition to the narrative, the water quality status of Pennsylvania's waters is presented using a five-part characterization of use attainment status (DEP, 2008). The listing categories are:

Category 1: Waters attaining all designated uses.

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

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

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

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

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

ERIE COUNTY IMPAIRMENTS

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

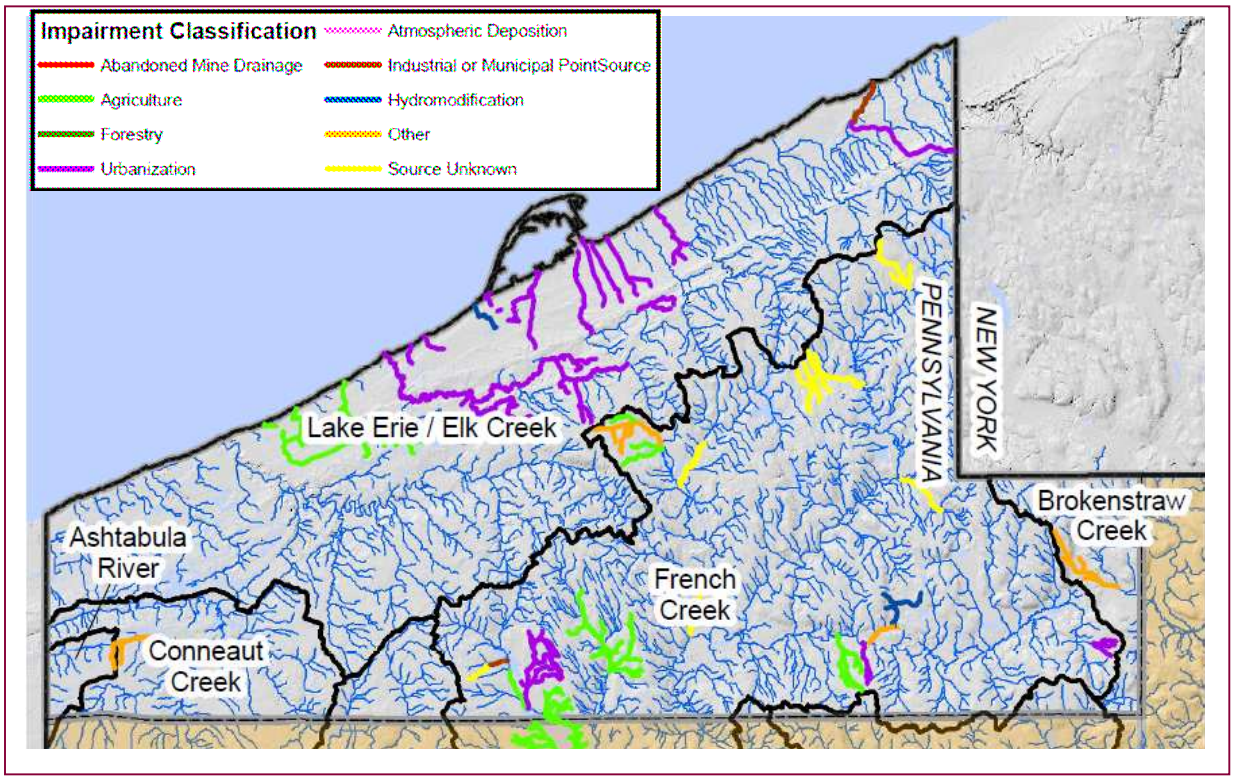

Figure 9.1. Impaired Stream Segments in Erie County

In Erie County, the non-attaining streams were primarily listed for Aquatic Life use attainment, which is reflective of any component of the biological community (i.e. fish or fish food organisms). A few segments are non-attaining because of fish consumption hazard due to mercury from unknown sources. 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 (stream miles where not indicated) →									
Classification	**Category**	**Ashtabula River**	**Brokenstraw Creek**	**Conneaut Creek**	**Cussewago Creek**	**French Creek**	**Lake Erie\Elk Creek**	**Muddy Creek**	**Oil Creek**	**Entire County**	**Percent of County**
Impaired (miles)	Abandoned Mine Drainage	--	--	--	--	--	--	--	--	0.0	0.0
	Agriculture	--	--	--	--	37.5	24.5	--	--	62.0	2.8
	Atmospheric Deposition	--	--	--	--	--	--	--	--	0.0	0.0

Forestry	--	--	--	--	--	--	--	--	0.0	0.0
Hydromodification	--	--	--	--	--	--	--	--	0.0	0.0
Industrial or Municipal Point Source	--	--	--	--	0.8	2.5	--	--	3.4	0.1
Urbanization	--	--	--	--	20.0	87.3	--	--	107.3	4.8
Source Unknown	--	--	--	--	28.7	--	--	--	28.7	1.3
Other	1.5	6.7	4.9	--	13.0	2.6	--	--	28.7	1.3
Total Impaired	1.5	6.7	4.9	0.0	100.1	117.0	0.0	0.0	230.1	10.2
Percent of Total	7.8	8.4	2.7	0.0	9.5	13.9	0.0	0.0	10.2	10.2

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. However, a precise implementation plan is not part of the approved TMDL. A TMDL is developed by determining how much of the pollutant causing the impairment can enter the waterbody without exceeding the water quality standard for that particular pollutant. The calculated pollutant load is then distributed among all the pollutant sources as follows:

$$TMDL = WLA + LA + MOS$$

Where: TMDL = Total Maximum Daily Load

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

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

MOS = Margin of Safety

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. National Pollution Discharge Elimination System, NPDES). Implementation of the Load Allocations for nonpoint sources can happen through a voluntary approach, or by means of existing state or local regulations.

There are currently no waterbodies with approved TMDLs in Erie County.

CRITICAL SOURCES OF IMPAIRMENT

The primary causes of water quality impairment are sediment/siltation, nutrients, metals, and pathogens. Nonpoint source (NPS) pollution is a general term for water pollution generated by

diffuse land use activities rather than from an identifiable or discrete facility. In Pennsylvania the leading nonpoint sources of impairment are:

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

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

URBANIZATION

Accounting for almost 47% of the listed impaired waters, urbanization is the leading cause of surface water impairment in the county. This is a broad category that includes the following three critical sources of impairment listed earlier in this section: 1) Urban Runoff/Storm Sewers, 2) Road Runoff, and 3) Small Residential Runoff. These sources have been grouped together because they are all types of urbanization, or human development activities. When development activities replace forests, fields, and meadows with impervious surfaces the landscape's capacity for initial abstraction is greatly reduced and surface runoff increases. This topic has been the focus of this Plan. The quantity of runoff from urbanized areas, and the water quality characteristics of the runoff, are the two base causes of surface water impairments. These two primary pollutants translate into surface water impairments in several different forms.

SEDIMENT/SILTATION

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

HABITAT ALTERATIONS

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

NUTRIENTS AND METALS

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

AGRICULTURAL ACTIVITIES

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

SEDIMENT/SILTATION

The most common agricultural cause for surface water impairment is sediment and siltation. Of the 230 miles of impaired streams in Erie County, agriculture related siltation is attributed for 38.9 miles of impairment. This pollutant results from typical agricultural practices such as plowing and tilling, livestock grazing, and livestock access to waterbodies. When appropriate conservation practices are implemented, these activities can be continued while reducing erosion and enhancing and protecting water quality.

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

NUTRIENTS

The second most common agricultural cause for surface water impairment is nutrients. Agricultural activity related nutrients account for 23.2 miles of the 230 miles of impaired streams in Erie County. Nutrients such as nitrogen, phosphorus, potassium and other micronutrients are

essential to proper plant growth and development. However, when the available nutrients exceed those required for plant development, or when nutrients are improperly applied, they pose potential environmental hazards. Nutrient pollution results from agricultural activities such as fertilizer and manure application, livestock access to waterbodies, and animal concentration areas.

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

RECOMMENDATIONS

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

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

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

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

RECOMMENDED URBAN PRACTICES

A variety of practices are available to help reduce urban impacts and to improve and protect water quality. These practices are intended to address specific concerns. The recommendations are split into two groups – preventive and restorative. Preventive practices begin with learning from previous impacts and committing to not repeating those. Restorative practices include BMP's to improve the existing conditions.

The following BMPs have been identified as particularly well suited to address the impairments identified in Erie County:

Preventive

Riparian Buffers - Riparian areas, land situated along the bank of a water source, typically occur as natural buffers between uplands and adjacent water bodies. They act as natural filters of nonpoint source pollutants before they reach surface waters. In urban areas most riparian buffers have been removed to utilize the ground for development many years ago but the practice continues. Protecting remaining riparian buffers provides significant water quality benefits as well as flood flow and storage.

Specific benefits include filtering of non-point pollutants prior to entering the waterbody, provide flood storage and protection, and forested buffers provide shade to the stream helping to reduce negative thermal impacts.

Low Impact Development - As stated in previous sections, encouraging a Low Impact Development approach through educational efforts and regulations that conserve and protect the environment. Specifically, development must integrate the site's hydrology into the planning and design process. Focus needs to transition toward Volume Control which looks toward the smaller magnitude storm events with de-centralized BMP's throughout the site to mitigate runoff impacts where they are created. By good planning efforts, the emphasis will lean toward non-structural BMP's that integrate the landscape and sustainable infrastructure.

Restorative

Streambank Restoration & Riparian Buffers – Both streambank restoration and riparian areas benefit the quality of the waterbody. Where opportunities present themselves, restoring the streambanks and riparian functions can only improve the waterbodies function. Streambank restorations have direct results as the erosion taking place will be reduced. Re-storing the riparian buffer by planting forest buffer or grass buffers adjacent to water bodies provides significant water quality benefits as well as flood storage and flow benefits.

Reducing imperviousness – It is clear that imperviousness of watersheds have a direct correlation to the health of a waterbody. Where impervious areas can be reduced through private re-development or through public initiatives, significant benefits can be achieved. By reducing the imperviousness, the required capacity of stormwater management facilities can be reduced toward levels that meet their intentions, thus, reducing the need to upgrade and replace some of the existing over-taxed system. Opportunities that target either existing parking lots or paved roads should be pursued by the community.

Retrofitting existing infrastructure – There are many existing stormwater management facilities implemented throughout the County to help mitigate runoff impacts of recent development. As the land is already dedicated toward mitigating this impact, retrofitting some of the facilities can be readily completed at minimal efforts. Retrofitting should look

at detention basins that have capacity and topography suited to implement a measure of volume control.

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 Erie County:

Streambank Protection

Streambank protection provides direct water quality results by reducing the amount of sediment, animal waste and nutrients entering the stream. Protection is implemented by excluding livestock from the stream and establishing buffer zones of vegetation around the stream (see ***Riparian Buffers***). The practice can be implemented with or without fencing; however it is much more effective when fencing is installed. This BMP usually requires installation of an alternate watering source for livestock and an animal crossing to allow animals access to pasture on both sides of the stream. According to the ***Chesapeake Bay Program Best Management Practices, Agricultural BMPS – Approved for CBP Watershed Model*** (DEP, 2007) the pollutant removal efficiency of this practice, with fencing and off-stream watering applied, is 60% (Nitrogen), 60% (Phosphorus), and 75% (Sediment). Without fencing, the efficiency is reduced to 30%, 30%, and 38% for nitrogen, phosphorus, and sediment respectively. This practice is eligible for several funding programs.

Riparian Buffers

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

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

Riparian buffers are part of a larger group of practices referred to as Conservation Buffers. This general practice is any area or strip of land maintained in permanent vegetation to

help reduce erosion and filter nonpoint source pollutants. This group also includes contour buffer strips, field borders, filter strips, vegetative barriers, and windbreaks (NRCS, 1999).

Barnyard Runoff Control

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

Nutrient Management

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

Animal Waste Management Systems

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

Cover Crops

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

protection when the fields need it most. The County Conservation District has several cost incentive programs to encourage use of cover crops. The efficiency of cover crops varies based on when the crop is planted and whether or not the crop is harvested. The pollutant removal efficiencies and cost incentive programs are identified in the Appendix.

Conservation Tillage

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

POTENTIAL FUNDING SOURCES

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

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

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

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

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

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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. However, there are many activities that fall outside the scope of stormwater management regulations that have a significant impact on stormwater runoff and the goals of sound stormwater management planning. Generally, standards for many of these activities are contained within Zoning Regulations and Subdivision and Land Development Ordinances. Some of these activities and their impact on stormwater management are discussed below.

These measures are included here because they are beyond the regulatory scope of this Plan but may provide valuable tools in obtaining the goals discussed in *Section II*. It is suggested that all municipalities consider these additional recommendations, and determine whether adoption of some of these policies could be beneficial to their respective communities. Municipalities with substantial stormwater problem areas could especially benefit from regulation of some, or all, of these activities. A holistic approach that considers all land use policies, and how they impact stormwater runoff, is necessary to maximize the effectiveness of a stormwater management program.

MUNICIPAL ZONING

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

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

Recommendations for Improved Municipal Zoning

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

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

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

RIVER CORRIDOR PROTECTION

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

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

FLOODPLAIN MANAGEMENT

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

As discussed in *Section III*, Erie County incurs a substantial economic loss in major hydrologic events (as much as $57.5 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 Erie County are updated, it is strongly recommended 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 the municipalities in the county.
- **Participate in the Community Rating System.** The CRS gives communities credit for reducing the risk of flood hazards. By implementing many of the same principles that are discussed in this Plan, municipalities can reduce flood insurance rates for residents inside of floodplains by up to 45%.
- **Provide open space preservation in floodplain areas.** Open space preservation may also provide credits to future developments by reducing impervious area and thereby reducing stormwater requirements.
- **Acquire and relocate flood-prone buildings so they are no longer within the floodplain.** Repetitive loss properties (properties for which two or more claims of at least $1000 have been paid by the NFIP within any 10-year period since 1978) constitute a large portion of the NFIP flood insurance claims. Nationally, less than 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, than to install structural alternatives such as levies, diversion projects, or dams.
- **Implement a drainage system maintenance program.** As noted in *Section V*, there are numerous locations where clogged or poorly maintained facilities result in flooding of areas not normally prone to flooding. Most engineering design calculations for stormwater detention and conveyance facilities, assume full function of a bridge or culvert. Implement a systematic inspection and maintenance program where periodic inspections are conducted on all channels, conveyance and storage facilities and remove debris and perform maintenance as necessary.

RIVER CORRIDOR PLANNING

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

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

Recommendations for River Corridor Planning

- **Identify areas that could benefit river corridor planning and initiate the planning process.** Identifying areas that could benefit from improved river corridor management can protect river resources and greatly reduce the economic impact caused by major hydrologic events. River corridor planning can be especially beneficial in areas with special value, areas that are likely to receive considerable future development near the river, or areas that currently experience persistent flood damage.
- **Identify and protect fluvial erosion hazard zones.** Flood damage may also occur as a stream channel changes course and meanders. The channel changes may result from either naturally occurring geologic processes or human-induced changes to watershed hydrology or hydraulics. A geomorphic assessment can identify the areas that are most likely to experience channel changes through erosion. These areas can then form the basis for an overlay zoning district or area with specified stream buffers for additional protection. Another option that has been implemented in the state of Vermont, is to integrate Fluvial Erosion Zones into the floodplain mapping process, so that all of the tools of floodplain management are available for the specified areas (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, flood plain, and any adjacent wetlands. The riparian zone is often overlapping with the river corridor, but has a slightly different connotation. The term riparian zone does not refer to an explicit width, rather a width that varies along the length of a given stream depending on the geography of the area. Natural riparian zones are typically covered with trees, shrubs, and other types of local vegetation, all of which provide a natural buffer between waterways and human land use as well as providing vital and unique natural habitat.

Riparian zones provide two principal benefits in regards to stormwater management. They offer flood protection by providing temporary storage area, slowing the velocity of flood waters, and provide a small amount of volume reduction through infiltration and permanent retention of water by disconnected low lying areas. The second primary benefit of riparian zones is the water quality functions they offer. The vegetation in the riparian zone provides shade that reduces

water temperature, traps and removes pollutants from stormwater, and provides protection from streambank erosion.

Recommendations for Riparian Zone Protection

- **Adopt and enforce the riparian buffer provisions of the Model Stormwater Management Ordinance.** The Model Ordinance includes provisions to require establishment of riparian buffers on all new development that occurs near watercourses. These requirements are in accord with the recently proposed changes to the statewide erosion and sediment pollution control regulations (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 affect on existing land uses in critical riparian areas. There are numerous existing incentive programs that offer technical and/or financial assistance to encourage land owners to alter existing land uses and establish riparian buffers. These include agricultural land retirement programs such as USDA's Conservation Reserve Enhancement Program (CREP) program, cost-share programs such as USDA's Environmental Quality Incentives Program (EQIP), as well as grant and loan programs.

WETLAND PROTECTION

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

Wetlands can also maintain good quality water and improve degraded water. Wetland vegetation also decreases water velocities causing suspended solids to drop out of suspension, thus decreasing the erosive power of the water. Wetlands also trap, precipitate, transform,

recycle, and export sediment, as well as nutrients, trace metals, and organic material. Water leaving a wetland can differ noticeably from that entering (Mitsch and Gosselink, 1993).

Recommendations for Wetland Protection

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

LOW-IMPACT DEVELOPMENT SITE DESIGN

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

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

LIMIT IMPERVIOUS COVER

Increased impervious area within a watershed is a direct contributor to increased storm flows and decreased water quality. Research in recent years has consistently shown a strong relationship between the percentage of impervious cover in a watershed and the health of the receiving stream (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, collector). Most ordinances assume a standard 12-foot wide travel lane and then add width for shoulders, parking lanes, bicycle lanes, and other considerations. Reducing the travel lane width to 11 feet for minor roads (e.g., roads within a subdivision development) could reduce the impervious cover of those roadways by up to 8 percent.
- **On-Street Parking** – Parking lanes are often specified to be 8 or 10 feet wide. Standardizing the maximum width of these lanes to 8 feet would reduce runoff. Also,

limiting parking to one side of a street, particularly in subdivisions, could result in a significant reduction in total runoff. Another option would be to require that the parking lanes be constructed of pervious pavement, grid blocks or another pervious surface.

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

LIMIT DISTURBANCE OR COMPACTION OF TOPSOIL

Topsoil is an absorbant top layer that provides significant stormwater management functions through initial abstraction. During rainfall events, no runoff occurs until the topsoil becomes saturated and the initial holding capacity of the soil is exceeded. The void spaces in undisturbed

topsoil can provide significant water storage. The ability for initial abstraction can alter drastically from one soil type to another or because of varied site conditions. However, soil compaction plays a significant role in the ability of a given soil type to hold water. As topsoil is disturbed, or compacted, the holding capacity of the soil is drastically reduced, thus limiting its effectiveness in reducing runoff. Previous studies (Gregory 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 a project should be limited to the minimum area necessary to complete the project. This provides the dual benefit of limiting erosion during construction and improving post construction stormwater management.
- **Adopt ordinance provisions that limit soil compaction where possible.** Areas that are not disturbed should be protected from compaction by construction activities to the maximum extent practicable. These areas should be designated on site plans and demarcated and protected by in-field measures. This is especially important for areas intended for infiltration based stormwater management facilities.

IMPEDIMENTS TO LID IMPLEMENTATION

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

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

Recommendations to Remove LID Impediments

- **Provide education activities and training workshops to various stakeholder groups.** As decision makers, and the group responsible for setting policy, municipal and county officials should be encouraged to obtain additional education on LID practices. Other stakeholders such as developers, builders, and homeowners should also have educational resources available to increase awareness and encourage implementation of LID practices. Education is the key to successful implementation of LID practices.
- **Promote guidance documents such as this Plan and included references.** There are a variety of publications and internet sites that discuss LID and offer design solutions: Low Impact Development Center (2009), DEP (2006), and Prince George's County (1999). These resources should be made available through municipal offices, websites, or trainings.

- **Alter existing Subdivision and Land Development Ordinances and Zoning Ordinances to allow for successful LID implementation.** Adoption of the Model Stormwater Management Ordinance in this Plan is an important tool in accomplishing the goals of LID. However, it is recommended that municipalities modify and enhance ordinances in order to provide enough flexibility to allow these innovative design methods to be employed by developers in order to advance the goals of this Plan. Potential alterations that may help create flexibility include: 1) creation of overlay zoning, 2) providing amendments to Ordinances to support LID efforts (i.e. reducing impervious cover and limiting topsoil compaction), or 3) creating an expedited waiver process for LID-specific requests.
- **Provide incentives for LID implementation.** Lassiter (2007) identifies tax credits, allowing for higher density developments, mitigation credits, and reduced land development fees for sites with LID developments as potential incentives to encourage developers to use LID.
- **Keep an inventory of LID efforts to help provide County-specific recommendations and successful BMP installation.** While considerable documentation exists on specific BMPs (e.g. National Research Council, 2008; DEP, 2006), very little scientific data exists within this region, and particularly this County. A valuable part of LID, one that is too often neglected, is the component of encouraging debate and expanding the LID knowledge base. Having an agency with a central role in land development permitting, such as the County Conservation District, would be invaluable to developers and design professional in determining what works in Erie County – and what may not.

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, and the benefits are vast for those who undertake the challenge. There is a substantial number of technical resources available to guide development of regulations for proactive thinking municipalities.

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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 Plan Advisory Committee review (with focused assistance from others including Legal Advisors and Municipal Engineer's review, Municipal review), and County review. Local review of the draft Plan is initiated with the completion of the Plan by the County and distribution to the aforementioned parties. Presented below is a chronological listing and brief narrative of the required local review steps through County adoptions.

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

    a. Municipal Engineers Review - This body has been formed to focus on the technical aspects of the Plan and to educate the Municipal Engineers on the ordinance adoption and implementation requirements of the Plan. The group met twice to solicit input as well as to receive comments and direction in the development of the model ordinance. The result of this is a revised draft model ordinance for Municipal and County consideration.

    b. Legal Advisory Review - This body has been formed to focus on the legal aspects of the Plan and to educate the Municipal solicitors on the ordinance adoption and implementation requirements of the Plan. The group was invited to Plan Advisory Committee meetings to provide input as well as to receive comments and direction in the development of the model ordinance.

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 Erie County - Act 167 - Stormwater Management Ordinance that will implement the Plan through municipal adoption is the primary concern during the municipal review. The output of the municipal review will be a letter directed to the County outlining the municipal suggestions, if any, for revising the draft Plan (or Ordinance) prior to adoption by the County.

3. County Review and Adoption - Upon completion of the review by the Plan Advisory Committee, with assistance from the Municipal Engineer and Legal Advisory focus groups, and each municipality, the draft Plan will be submitted to the Erie County Council for their consideration.

The Erie County review of the draft Plan will include a detailed review by the County Council and an opportunity for public input through the holding of public hearings. Public hearing 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 Erie County would be by resolution and require an affirmative vote of the majority of the members of the County Council.

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

IMPLEMENTATION OF THE PLAN

Upon final approval by DEP, each municipality within the county will become responsible for implementation of the Plan. Plan implementation, as used here, is a general term that encompasses the following activities:

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

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

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

Table 11.1. Models for Municipal Plan Implementation

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

It is important that the standards and criteria contained in the Plan are implemented correctly, especially if the municipality chooses to integrate the standards and criteria into existing regulations. In either case, it is recommended that the resulting regulatory framework be

reviewed by the local planning commission, the municipal solicitor, the Erie County Department of Planning and/or the Erie County Conservation District for compliance with the provisions of the Plan and consistency among the various related regulations. Additionally, the adopted regulations may be reviewed by PADEP for compliance with this Plan.

PROCEDURE FOR UPDATING THE PLAN

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

1. Monitoring of the Plan Implementation - The Erie County Planning Department 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 Planning Department will monitor the following data records (as provided by the municipalities):

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

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

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

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

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Section XI – Plan Adoption, Implementation and Update Procedures

PLAN REVIEW AND ADOPTION

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

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

    a. Municipal Engineers Review - This body has been formed to focus on the technical aspects of the Plan and to educate the Municipal Engineers on the ordinance adoption and implementation requirements of the Plan. The group met twice to solicit input as well as to receive comments and direction in the development of the model ordinance. The result of this is a revised draft model ordinance for Municipal and County consideration.

    b. Legal Advisory Review - This body has been formed to focus on the legal aspects of the Plan and to educate the Municipal solicitors on the ordinance adoption and implementation requirements of the Plan. The group was invited to Plan Advisory Committee meetings to provide input as well as to receive comments and direction in the development of the model ordinance.

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 Erie County - Act 167 - Stormwater Management Ordinance that will implement the Plan through municipal adoption is the primary concern during the municipal review. The output of the municipal review will be a letter directed to the County outlining the municipal suggestions, if any, for revising the draft Plan (or Ordinance) prior to adoption by the County.

3. County Review and Adoption - Upon completion of the review by the Plan Advisory Committee, with assistance from the Municipal Engineer and Legal Advisory focus groups, and each municipality, the draft Plan will be submitted to the Erie County Council for their consideration.

The Erie County review of the draft Plan will include a detailed review by the County Council and an opportunity for public input through the holding of public hearings. Public hearing 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 Erie County would be by resolution and require an affirmative vote of the majority of the members of the County Council.

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

IMPLEMENTATION OF THE PLAN

Upon final approval by DEP, each municipality within the county will become responsible for implementation of the Plan. Plan implementation, as used here, is a general term that encompasses the following activities:

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

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

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

Table 11.1. Models for Municipal Plan Implementation

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

It is important that the standards and criteria contained in the Plan are implemented correctly, especially if the municipality chooses to integrate the standards and criteria into existing regulations. In either case, it is recommended that the resulting regulatory framework be

reviewed by the local planning commission, the municipal solicitor, the Erie County Department of Planning and/or the Erie County Conservation District for compliance with the provisions of the Plan and consistency among the various related regulations. Additionally, the adopted regulations may be reviewed by PADEP for compliance with this Plan.

PROCEDURE FOR UPDATING THE PLAN

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

1. Monitoring of the Plan Implementation - The Erie County Planning Department 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 Planning Department will monitor the following data records (as provided by the municipalities):

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

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

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

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

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Engineering & Related Service

Draft Model Stormwater Management Ordinance

Erie County
Act 167 County-Wide
Stormwater Management Plan

August 2010

474 Windmere Drive • State College, Pennsylvania 16801 • 814.238.7117 (phone)

Using The Model Stormwater Management Ordinance

Municipal Requirements: This Model Stormwater Management Ordinance was developed during the ***Erie 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 ***Erie 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 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.

STORMWATER MANAGEMENT MODEL ORDINANCE

Implementing the Requirements of the

Erie County Stormwater Management Plan

ORDINANCE NO. _____ OF_____

_____, ERIE COUNTY, PENNSYLVANIA

Adopted at a Public Meeting Held on
_____, 2011

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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.

Section 103. Purpose

The purpose of this Ordinance is to promote health, safety, and welfare within ***(Municipality)***, Erie 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 stormwater management facilities and Best Management Practices (BMPs) that are constructed and implemented.

J. Provide standards to meet the NPDES permit requirements.

(FOR MS4 PERMITTEES)

K. Implement an "illicit discharge detection and elimination program" in MS4 permanent urbanized areas to address non-stormwater discharges into ***(Municipality's)*** separate storm sewer system.

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)***.

"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 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.

Section 110. Municipal Liability Disclaimer

A. Neither the granting of any approval under this Ordinance, nor the compliance with the provisions of this Ordinance, or with any condition imposed by a municipal official hereunder, shall relieve any person from any responsibility for damage to persons or property resulting there from, or as otherwise imposed by law nor impose any liability upon the Municipality for damages to persons or property.

B. The granting of a permit which includes any storm water management facilities shall not constitute a representation, guarantee or warranty of any kind by the Municipality, or by an official or employee thereof, of the practicability or safety of any structure, use or other plan proposed, and shall create no liability upon or cause of action against such public body, official or employee for any damage that may result pursuant thereto.

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.

Conservation District - The Erie County Conservation District. The Erie 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 landward from the top of the bank of the stream.

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 tank, 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 Erie 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.

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

Low Impact Development (LID) - 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. LID still allows land to be developed, but in a cost-effective manner that helps mitigate potential environmental impacts.

Main Stem (Main Channel) - Any stream segment or other runoff conveyance facility used as a reach in the Erie 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)***, Erie 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.

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, firm, trust, estate, municipality, governmental unit, public utility or any other legal entity whatsoever which is recognized by law as the subject of rights and duties. Whenever used in any section prescribing or imposing a penalty, the term "person" shall include the members of a partnership, the officers, members, servants and agents of an association, officers, agents and servants of a corporation, and the officers of a municipality or country, but shall exclude any department, board, bureau or agency of the Commonwealth.

Pervious Area - Any area not defined as impervious.

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

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 - 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:

   a) Preparation and implementation of an approved SWM Site Plan is required.
   b) 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.
   c) 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.
   d) 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.

D. The municipality may, after consultation with PADEP and the Conservation District, 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:

   a) Protect health, safety, and property.
   b) 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:
   a) 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.
   b) For developments taking place in stages, the entire development plan must be used in determining conformance with this Ordinance.
   c) (OPTION) For projects that add impervious area to a parcel, the total impervious area on the parcel is subject to the requirements of this Ordinance; except that the volume controls in Section 304 and the peak rate controls of Section 305 do not need to be retrofitted to existing impervious areas that are not being altered by the proposed regulated activity.

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.
   a) Applicant must provide an easement for proposed concentrated flow across adjacent properties to a drainage way or public right-of-way.
   b) 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 and include the 100-year water surface) 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, except 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.

K. Design storm volumes and precipitation intensities to be used in the analysis of discharge or runoff shall be obtained from either of the following sources:

   a) The Precipitation-Frequency Atlas of the United States, Atlas 14, Volume 2, Version 3.0, U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Weather Service, Hydrometeorological Design Studies Center, Silver Spring, Maryland. NOAA's Atlas 145 can be accessed at: http://hdsc.nws.noaa.gov/hdsc/pfds/.
   b) The Pennsylvania Department of Transportation Drainage Manual, Publication 584, Chapter 7, Appendix A.

L. 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.

M. 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.

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

O. Roof drains should not be connected to streets, sanitary or storm sewers, or roadside ditches.

P. Applicants are encouraged to use Low Impact Development Practices to reduce the costs of complying with the requirements of this Ordinance and the State Water Quality Requirements.

Q. When stormwater management facilities are proposed within 1,000 feet of a downstream Municipality, the Developer shall notify the downstream Municipality and provide a copy of the SWM Plan, if requested, for review and comment.

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 utilize the following BMPs 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's proposed development/additional impervious area may 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 footage)	**Applicant Must Provide**
0 – 1,000	---
1,000 – 2,500	Documentation of impervious area[3]
2,500 – 5,000	Volume Controls &**(OPTIONAL)** Small Project SWM Application[3]
> 5,000	Rate Controls, Volume Controls & SWM Site Plan

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] **(OPTIONAL)** The Small Project Stormwater Management Application included in Appendix E may be used for projects under 5,000 sf of new impervious surface and single family home construction. 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. **(OPTIONAL)** Single Family Residential activities are exempt from these requirements provided the construction:
   1. Comply with Sections 301.G, 302.A, 302.B, 302.C, and
   2. Have building setback 75 feet from downstream property lines, and
   3. 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.
   4. The municipality can require more information or require mitigation of certain impacts through installation of stormwater management BMP's if there is a threat to property, health, or safety.

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, man-made wetlands, or other BMP) has been designed or modified to address the potential stormwater flooding and volume impacts of the proposed development.

G. The purpose of 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.
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 activity is exempt from the rate control and SWM Site Plan preparation 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.

J. The Municipality may deny or revoke any exemption pursuant to this Section at any time for any project that the municipality believes may pose a threat to public health, safety, property or the environment.

Section 303. Waivers (OPTIONAL)

A. All waiver requests must meet the provisions of Section 303.G. and H. Waivers shall not be issued 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.

Municipalities will then consider waivers in accordance with Section 301.D; except that waiver requests for relief from the design requirements of Sections 701.B and 701.C will be processed by the Municipality at its sole discretion.

B. When Applicant demonstrates to the satisfaction of the governing body of the Municipality that a requirement of this Ordinance causes undue hardship as it applies to a proposed Project, and that an alternate design produces equal or better results in meeting the purpose and requirements of this Ordinance, the governing body of the Municipality, after completing a thorough technical review consistent with Paragraph A above, may grant a waiver request.

C. Applicants shall submit requests for waivers in writing and these requests shall be included as part of a permit application submission. In the request for waiver, the Applicant shall state in full the facts of undue hardship on which the request is based, identify the provision or provisions of the Ordinance that are causing such undue hardship, and state the minimum waiver or relief that is necessary. The Applicant shall state how the proposal in the Applicant's waiver request provides equal or better results in meeting the purpose and requirements of this Ordinance.

D. The Municipality shall keep a written record of all actions on waiver requests in the project file.

E. The Municipality may charge Applicants fees for waiver requests sufficient to cover all costs incurred by the Municipality to process the requests.

F. In processing waiver requests, the Municipality may impose reasonable conditions that will, in its sole judgment, resolve the undue hardship while meeting the purpose and requirements of this Ordinance.

G. The Municipality may grant requests for waivers when the following findings are made by the Municipality, when each is determined solely by the Municipality to be applicable and relevant:

1. That the waiver shall result in an equal or better means of complying with the purpose and requirements of this Ordinance.
2. That the waiver is the minimum necessary to provide relief from undue hardship.
3. That the applicant is not requesting a waiver based solely on cost considerations.
4. That existing down gradient stormwater problems will not be exacerbated by the proposed waiver request.
5. That runoff is not being diverted to a different drainage area in a manner that may cause hardship to others.
6. That increased flooding or ponding on off-site properties or roadways will not be caused by the waiver request.
7. That potential icing conditions will not be caused by the waiver request.
8. That increased or unusual municipal maintenance expenses will not result from the waiver request.
9. That operation and maintenance requirements are not reduced by the waiver request.

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 for all storms equal to or less than the 2-year 24-hour storm.

    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. A minimum 48-hour 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 provided to allow witnessing of the testing:

a. At a minimum, the following documentation shall be provided to justify the decision to reduce the use of 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. 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.
   v. A professional opinion stating that the proposed ground water recharge is consistent with natural recharge, is reasonable, and is consistent with this Ordinance.

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

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. Lands contained within Erie County that have not had release rates established under an approved Act 167 Stormwater Management Plan:

1. 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.

B. Lands contained within Erie County that have had release rates established under an approved Act 167 Stormwater Management Plan:

1. The post-development peak discharge rates shall be in accordance with the approved release rate map for the following watersheds (see Appendices for Release Rate Map):
   a. Lake Erie Watersheds

Section 306. Sensitive Areas and Stormwater Hotspots (OPTIONAL)

A. Sensitive areas and water quality sensitive developments 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 use that generates higher concentrations of hydrocarbons, trace metals, or toxicants than are found in typical stormwater runoff. As such, they have a high potential to endanger local water quality, and could potentially threaten ground water reservoirs. The Municipality 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 NAICS codes.

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. Applicants for projects involving 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. Drainage from 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.
4. Projects involving Stormwater Hotspots and development in sensitive areas must include Riparian Buffers as defined in Article VI.

ARTICLE IV - E&S STANDARDS (OPTIONAL)

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 Erie 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 Erie 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 Erie 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 (OPTIONAL)

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 for all Regulated Activities other than construction of a single family residence (and ancillary structures) 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 un-sewered 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:
   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
   (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.
   i. Manage close to source with collection with conveyance minimized
   ii. Consistent with site factors (e.g., soils, slope, available space, amount of sensitive areas, pollutant removal needs)
   iii. Minimize footprint and integrate into already disturbed areas/other building program components (e.g., recharge beneath parking areas, vegetated roofs)
   iv. Consider other benefits such as aesthetic, habitat, recreational and educational benefits
   v. BMP's select based on maintenance needs that fit owner/users
   vi. BMP's sustainable using a long-term maintenance plan

ARTICLE VI – RIPARIAN BUFFER STANDARDS (OPTIONAL)

Section 601. Riparian Buffer Requirements

Riparian Buffers are required for all Regulated Activities other than the construction of a single family residence (and ancillary structures) and shall be established as follows:

A. The buffer shall be measured perpendicularly from the top of the stream bank landward.
   1. High Quality or Exceptional Value Watersheds - a minimum of 150 feet;
   2. Impaired Watersheds – a minimum of 150 feet;
   3. All other watersheds - a minimum of 50 feet; or
   4. 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.
   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, NPDES Permit or other PADEP permit, where required, shall be submitted prior to issuance of local permits.

K. 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. Remove invasive plant species that may threaten the integrity of the buffer.
    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.

ARTICLE VII - DESIGN CRITERIA

Section 701. Design Criteria for Stormwater Management & Drainage Facilities (OPTIONAL)

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. Innovative 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 MunicipalityMunicipality (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 without approval from the Municipality or PennDOT.

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

3. The minimum horizontal distance between any stormwater holding facility and a building/structure 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 floodway 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. Flows from underdrains need not be accounted for in Volume or Rate Control calculations.

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 2% 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. Principal Outlet Structures: The primary outlet structure shall be designed to pass all 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 MunicipalityMunicipality. 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.
    c. Provide outlet aprons and shall extend to the toe of the basin slope at a minimum.

17. Emergency Spillways: Any stormwater management facility designed to store runoff shall provide an emergency spillway designed to convey the 100-year post-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. MunicipalityThe Municipality 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.

18. 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:
        i. For embankments up to 4', width shall be at least 6 feet;
        ii. For embankments between 4 and 6 feet, width shall be at least 8 feet;
        iii. For embankments over 6 feet, 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. Soils used shall be tested to determine its density analysis per ASTM 698. The embankments will be constructed in a maximum of 6 inch lifts. The lifts will each be compacted to a density at least 98% of it's the maximum dry density. Each layer of compacted fill shall be tested to determine its density per ASTM 2922 or ASTM 3017. One test per 50 cubic yards of material placed (at least one per layer) shall be performed by an Independent Testing Agency.
    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.

19. 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 MunicipalityMunicipality 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.

20. 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 MunicipalityMunicipality).

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 Municipality. 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 eighteen (18) 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 2-1/2 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.

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 400 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 MunicipalityMunicipality 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 or specifically approved by the Municipality). 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 of compatible material as the pipe 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 MunicipalityMunicipality.

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.

Section 702. Calculation Methodology

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

B. **(OPTIONAL)** Stormwater runoff from all development sites shall be calculated using either the Rational Method or the NRCS Rainfall-Runoff Methodology. Other methods shall be selected

by the design professional based on the individual limitations and suitability of each method for a particular site and approved by the MunicipalityMunicipality.

C. Rainfall Values: **(OPTIONAL)**

1. 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	2.13
2	2.56
10	3.71
25	4.46
50	5.09
100	5.76

D. Runoff Volume: **(OPTIONAL)**

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.

E. Peak Flow Rates: **(OPTIONAL)**

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-20 or HEC-HMS – no size limitations
   b. Other models as pre-approved by the Municipality

   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: **(OPTIONAL)**

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: **(OPTIONAL)**

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 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.

H. Time of Concentration: **(OPTIONAL)**

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 MunicipalityMunicipality:

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

d. 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. **(OPTIONAL)** 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.

J. **(OPTIONAL)** 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. 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. **(OPTIONAL)** The Municipality may 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.

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 Erie 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 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 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 separately 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. Construction sequence.

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

22. 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 MunicipalityMunicipality 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, where applicable:
   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
- 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 Municipality 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 Erie 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 MunicipalityMunicipality
3. One (1) copy to the Erie County Planning Department**(OPTIONAL)**
4. One (1) copy to the Erie County Conservation District **(OPTIONAL)**

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

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.
    2. Submission shall include a comparison of the constructed stage-storage (volume vs. elevation) of all above ground and below ground stormwater storage facilities to the approved design.

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

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 MunicipalityMunicipality 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 Municipality, 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.

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 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 may suspend or 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 submission of 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.

    3. Prior to conducting a scheduled inspection, the Municipality may inform the owner of its intent to conduct an inspection.

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. 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 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 Erie 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 line and fire hydrant flushings
-Irrigation drainage
-Air conditioning condensate
-Springs
-Water from crawl space pumps
-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
-Flows from riparian habitats and wetlands
-Uncontaminated water from foundations or from footing drains
-Lawn watering
-Dechlorinated swimming pool discharges
-Uncontaminated groundwater
-Water from individual residential car washing
-Routine external building washdown (which does not use detergents or other compounds)
-Diverted stream flows

E. In the event that the Municipality or DEP determines that any of the discharges identified in Subsection D significantly contribute to pollution of waters of this Commonwealth, the Municipality or DEP will notify the responsible person(s) to cease the discharge.

F. Upon notice provided by the Municipality or PADEP under subsection 1301.E, the discharger will have a reasonable time, as determined by the Municipality or PADEP, to cease the discharge.

G. 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.

ARTICLE XIV - FEES AND EXPENSES

Section 1401. General

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. 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.

B. 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 stormwater 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 Erie County, within (__) days of approval of the SWM Site Plan by the Municipality:

1. Operations and Maintenance Agreement (Appendix A), Operations and Maintenance Plan, and associated drawings.
2. Easements under Section 901.
3. 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.

(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

APPENDIX A - OPERATION AND MAINTENANCE AGREEMENT

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 _____, Erie County, Pennsylvania, (hereinafter "Municipality");

WITNESSETH

WHEREAS, the Landowner is the owner of certain real property as recorded by deed in the land records of Erie 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.

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 Erie 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 Erie, 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)**

APPENDIX B – LOW IMPACT DEVELOPMENT PRACTICES (OPTIONAL)

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

TABLE C-1 - RATIONAL METHOD RUNOFF COEFFICIENTS

Hydraulic Soil Group	Storm	A			B			C			D		
Slope Range		0-2%	2-6%	+6%	0-2%	2-6%	+6%	0-2%	2-6%	+6%	0-2%	2-6%	+6%
Cultivated	<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
Land	≥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	<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
Impervious	≥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

APPENDIX D – REVIEW FEE REIMBERSEMENT AGREEMENT

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 _____, Erie County, Pennsylvania, (hereinafter "Municipality");

WITNESSETH

WHEREAS, the Landowner is the owner of certain real property as recorded by deed in the land records of Erie 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 engineer or 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 Municipality or 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 Municipality or 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; (d) administrative cost and incurred expenses relating to the administration of this agreement and (e) Professional Consultant's fees associated with construction activities. 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 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 Engineer or 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 Erie, 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)**

APPENDIX E – SMALL PROJECTS SWM APPLICATION (OPTIONAL)

(MUNICIPALITY)
Small Project Stormwater Management Application

Per (municipality)'s Act 167 Stormwater Management Ordinance, a stormwater management plan is required whenever more than 2,500 square feet of impervious surface 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)**	**=**	**Proposed Impervious Area**
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		=	
Total Impervious Surface Area to be managed (sum of all areas)					

If the Total Impervious Surface Area is LESS THAN 2,500 Square Feet, please read, acknowledge and sign below.

If the Total Impervious Surface Area EXCEEDS 2,500 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 is ≤1,000 sf
- flow path of paved impervious area is not more than 75'
- soil at discharge 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	**Proposed Impervious Area** (from previous sheet)	**X**	**DIA Credit Factor**	**=**	**Impervious Area to be managed**	**÷**		**=**	**Required Capture Volume (ft^3)**
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	=	
					Total Req'd Capture Volume				

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 1" caliper tree and 3 feet tall shrub (min).
- Trees shall be adequately protected during construction.
- Trees shall be maintained until redevelopment occurs.
- No more than 25% of the required capture volume can be mitigated through the use of trees.
- Dead trees shall be replaced within 12 months.
- Non-native species are not applicable.

		Req'd Capture Volume (ft^3)
-		**Tree Planting Credit (ft^3)**
		Capture Volume to be managed (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 Sump or Trench?
		Capture Volume to be managed (ft^3)

Enter the volumes into the **Small Project SWM Plan Worksheet** on the next sheet.

Native Species Trees (Common Name)

- Blackgum
- Cucumber magnolia
- Hophornbeam
- Maple, (sugar, red or silver)
- Pine, (pitch or eastern white)
- Ironwood
- Hickory, sweet pignut or shag-bark
- Sycamore, American
- Cotton-wood, eastern
- Aspen, big-tooth or quaking
- Cherry, black
- Oak, (white, swamp white, scarlet, pin, red, black)
- Dogwood (silky or red osier)
- Tuliptree
- Willow, black
- Chokeberry (red or black)
- Basswood, American
- Serviceberry, (downy or shadbush)
- Elderberry
- Witch hazel
- Mountain laurel

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 ***Erie 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 Erie County Planning Department website (http://www.eriecountyplanning.org) which contains the Model Ordinance.

Regulated activities shall be conducted only after (municipality) approves a stormwater management plan. The ***Erie 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.** Alternative system proposed require 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 BELOW TO INDICATE THE STORMWATER MANAGEMENT PLAN FOR THIS SITE

☐ Minimum Control #1 Erosion & Sediment Pollution Control
Minimum Control #2: Source Control of Pollution
Minimum Control #3: Preservation of Natural Drainage Systems and Outfalls

☐ The relevant details from ***Erie County Act 167 Stormwater Management Plan*** 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	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	

☐ In lieu of meeting the above, an alternative and/or professional design is attached for approval AND the system will be located 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 F – RELEASE RATE MAP

Appendix A – Watershed Modeling Technical Data

An overview of the process that was used to complete the hydrologic modeling in preparation of this Plan is presented in *Section 6 – Technical Analysis* of this report. The following technical data is included here to supplement the general information provided in that section.

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 in and processed using GIS software. A description of GIS data collected, the source and its use is 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 outside of county boundary
Existing land use for year 2010	Erie County GIS	Curve number generation for watershed subareas for year 2010 within county boundary
Future land use for year 2020	Erie County GIS	Curve number generation for watershed subareas for year 2020 within county boundary
SURRGO Soils Data	NRCS (2008)	Curve number generation; analysis of infiltration limitations
Storage (percent of lakes, ponds, and wetlands)	USGS (2008d)	Calculation of parameters for USGS Regression Equations
Roadway Data	Erie County GIS	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 curve numbers using the scheme shown in *Table A.2*.

GIS Value	NLCD (2001) Description	NRCS (1986) Description	A	B	C	D
Existing Conditions – NLCD (2001)						
11	Open Water	Water	98	98	98	98
21	Developed, Open Space	Open space - Good Condition	39	61	74	80
22	Developed, Low Intensity	Residential - 1 acre	51	68	79	84
23	Developed, Medium Intensity	Residential - 1/2 acre	54	70	80	85
24	Developed, High Intensity	Commercial and Business	89	92	94	95
31	Barren Land (Rock/Sand/Clay)	Newly graded areas	77	86	91	94
41	Deciduous Forest	Woods - Good Condition	30	55	70	77
42	Evergreen Forest	Woods - Good Condition	30	55	70	77
43	Mixed Forest	Woods - Good Condition	30	55	70	77
52	Shrub/Scrub	Brush - Good Condition	30	48	65	73
71	Grassland/Herbaceous	Meadow - Good Condition	30	58	71	78
81	Pasture/Hay	Pasture - Good Condition	39	61	74	80
82	Cultivated Crops	Contoured Row Crops - Good Condition	65	75	82	86
90	Woody Wetlands	Woods - Good Condition	30	55	70	77
95	Emergent Herbaceous Wetlands	Water	98	98	98	98

Table A.2. Existing Curve Number Determination for areas outside of Erie County for each Hydrologic Soil Group

GIS Value	Existing Conditions – Erie County GIS	NRCS (1986) Description	A	B	C	D
110	Residential	Residential - 1/2 acre	54	70	80	85
111	Single Family Dwellings	Residential - 1/2 acre	54	70	80	85
112	Multi Family Dwellings	Residential - 1/4 acre	61	75	83	87
114	Mobile Home Parks / Courts	Residential - 1/8 acre	77	85	90	92
119	Other Residential	Residential - 1/2 acre	54	70	80	85
120	Commercial	Commercial and Business	89	92	94	95
121	Retail Sales/ Wholesale/ Professional Services	Commercial and Business	89	92	94	95
122	Vehicle Related Activities	Commercial and Business	89	92	94	95
123	Junk / Savage Yards	Commercial and Business	89	92	94	95
125	Warehouses and Temporary Storage	Commercial and Business	89	92	94	95
129	Other Commercial	Commercial and Business	89	92	94	95
131	Primary Prossing at Extraction Site and Extraction Equipment	Commercial and Business	89	92	94	95
132	Light Industry	Industrial	81	88	91	93
133	Heavy Industry	Industrial	81	88	91	93
137	Inactive/Dismantled Industrial Site	Industrial	81	88	91	93
140	Transportation/Communication	Industrial	81	88	91	93
141	Highways/Roads/Access Roads/Freeways/Interstates	Pavement	98	98	98	98
142	Parking Lots	Pavement	98	98	98	98
143	Railroads	Industrial	81	88	91	93
144	Airports	Industrial	81	88	91	93
145	Communications - Antennas	Industrial	81	88	91	93
146	Marinas/Port Facilities/Docks	Industrial	81	88	91	93
150	Utilities	Industrial	81	88	91	93
151	Water Treatment	Industrial	81	88	91	93
152	Sewage Treatment Plants	Industrial	81	88	91	93
153	Power Substations	Industrial	81	88	91	93
180	Public Spaces	Open space - Good Condition	39	61	74	80
186	Religious	Commercial and Business	89	92	94	95
187	Municipal Services	Commercial and Business	89	92	94	95
188	Road Repair and Maintenance Yard	Commercial and Business	89	92	94	95
189	Other Institutional/Governmental	Commercial and Business	89	92	94	95
193	Open Urban (Parks, Playgrounds, Golf Courses, Athletic Fields, Drive-In Theaters, Swimming Pools, etc.)	Open space - Good Condition	39	61	74	80
194	Open Rural (Ski Areas, Camp Grounds, etc.)	Open space - Good Condition	39	61	74	80

Table A.3. Existing Curve Number Determination for Erie County for each Hydrologic Soil Group

GIS Value	Existing Conditions – Erie County GIS	NRCS (1986) Description	A	B	C	D
199	Other Recreational	Open space - Good Condition	39	61	74	80
201	Residential Grass	Open space - Good Condition	39	61	74	80
211	Cropland	Pasture - Good Condition	39	61	74	80
212	Pasture	Pasture - Good Condition	39	61	74	80
213	Idle Fields	Pasture - Good Condition	39	61	74	80
214	Plowed, Unvegetated Fields	Pasture - Good Condition	39	61	74	80
220	Orchards/Nurseries/Horticulture	Pasture - Good Condition	39	61	74	80
240	Farmsteads and Farm Related Buildings	Pasture - Good Condition	39	61	74	80
290	Other Agricultural	Pasture - Good Condition	39	61	74	80
310	Herbaceous Rangeland	Brush - Good Condition	30	48	65	73
320	Shrub-Brush Rangeland	Brush - Good Condition	30	48	65	73
330	Mixed Rangeland	Brush - Good Condition	30	48	65	73
410	Deciduous Forest	Woods - Good Condition	30	55	70	77
420	Evergreen Forest	Woods - Good Condition	30	55	70	77
430	Mixed Forest	Woods - Good Condition	30	55	70	77
500	Water	Water	98	98	98	98
600	Wetlands	Woods - Good Condition	30	55	70	77
700	Barren Lands	Dirt (Including Right of Ways)	72	82	87	89
720	Beaches and River Banks	Open space - Good Condition	39	61	74	80
750	Extraction	Industrial	81	88	91	93
760	Transitional	Industrial	81	88	91	93

Table A.3 (continued). Existing Curve Number Determination for Erie County for each Hydrologic Soil Group

GIS Value	Future Conditions – Erie County GIS	NRCS (1986) Description	A	B	C	D
800	Residential	Residential - 1/2 acre	54	70	80	85
801	Industrial	Industrial	81	88	91	93
802	Commercial	Commercial and Business	89	92	94	95

Table A.4. Future Curve Number Determination for Erie County for each Hydrologic Soil Group

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.

HYDROLOGIC MODEL PREPARATION

Two Act 167 designated watersheds within the county were selected for hydrologic modeling: Lake Erie Tributaries and French 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.

LAKE ERIE TRIBUTARIES MODEL

The Lake Erie Tributaries watershed has a drainage area of 553.9 square miles and was divided into three subwatersheds which total 261 subbasins for the HEC-HMS model. The three subwatersheds are Lake Erie Tributaries West, Lake Erie Tributaries Central, and Lake Erie Tributaries East. Figures A.1 through A.4 illustrate the Lake Erie Tributary subwatersheds and cumulative discharge points.

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

This reservoir is located in North East, Erie County. The tributary drainage area to this dam is relatively small (1.52 mi^2, respectively) compared to the total drainage area of located within Erie County. Outflow data for Grahamville Reservoir was provided by DEP in the form of archived design files. This information was used to model the flows from the dam within the HEC-HMS model. The following table summarizes the impoundments within the watershed.

Impoundment	Stream	Location	Owner	Storage (acre-ft)
Grahamville Reservoir	East Branch Sixteenmile Creek	North East Borough	North East Borough	184.1

Table A.5. Impoundments within the Lake Erie Tributaries Watershed

FRENCH CREEK MODEL

The French Creek watershed within Erie County has a total drainage area of approximately 490 square miles. The watershed was divided into four subwatersheds which total 214 subbasins for the HEC-HMS model. The four subwatersheds are listed in *Table A.6*. Figures A.5 through Figure A.9 illustrates the French Creek subwatersheds and cumulative discharge points.

Subwatershed	Drainage Area (mi^2)
French Creek "D"	223
South Branch French Creek	81
French Creek "C"	115
French Creek "B"	134

Table A.6. French Creek Subwatersheds

This watershed contains four dams that were considered to have a significant enough impact on the hydrology of the watershed. The "run-of-the-river dam" criteria as discussed above for deciding whether or not a dam would be included was also used for French Creek.

The following table summarizes the impoundments within the watershed.

Impoundment	Stream	Location	Owner	Storage (acre-ft)
Water Supply Dam	Bentley Run	Union Twp.	Boro. of Union County	306
Edinboro Lake	Conneauttee Creek	Washington Twp.	Boro. of Edinboro	2,461
Bull Reservoir	Black Brook	Greenfield Twp.	Boro. of North East	2,363
Union City Dam	French Creek	Waterford Twp.	U.S. Army Eng. Pittsburgh Dist.	47,662

Table A.7. Impoundments within the French Creek Watershed in Erie County

FIGURE A.1

FIGURE A.2

FIGURE A.3

FIGURE A.4

FIGURE A.5

FIGURE A.6

FIGURE A.7

FIGURE A.8

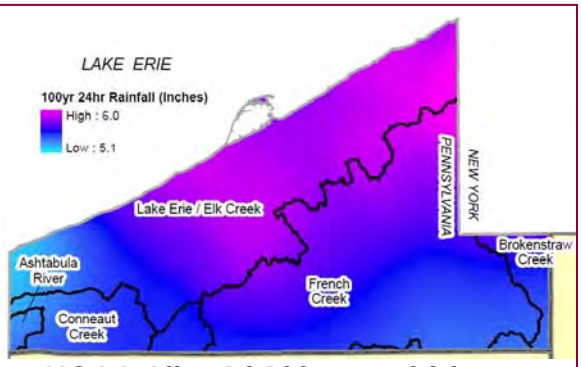
FIGURE A.9

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. 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. The following table provides the rainfall estimates used for various design storm frequencies for Erie County (NOAA, 2008):



NOAA Atlas 14 100-year, 24-hour Rainfall

Design Storm (years)	County Average/ Lake Erie Tributaries Design Depth (in)	French Creek "D" 24-hr Rainfall Depth (in)	South Branch French Creek 24-hr Rainfall Depth (in)	French Creek "C" 24-hr Rainfall Depth (in)	French Creek "B" 24-hr Rainfall Depth (in)
2	2.58	2.54	2.52	2.54	2.53
10	3.71	3.63	3.56	3.62	3.59
25	4.45	4.35	4.24	4.33	4.27
50	5.07	4.96	4.80	4.92	4.83
100	5.74	5.62	5.40	5.55	5.42

Table A.8. Rainfall Values for Erie County

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

SUBWATERSHED AREA

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

Basins with drainage area outside of the scope of this Plan (i.e., the Act 167 designated watersheds of Lake Erie Tributaries and French Creek) were beyond the scope of study so they were not studied at the same level of detail as portions of the watershed within the scope of this Plan. Generally, they were delineated into areas between 10 and 25 mi^2 and were assumed to have only negligible changes in hydrology due to future land use. This generalized approach

includes the Act 167 designated watersheds of Conneaut Creek and a portion of the French Creek watershed located outside of Pennsylvania.

SOILS

Soil properties, specifically infiltration rate and subsurface permeability, are an important factor in runoff estimates. Runoff potential of different soils can vary considerably. Soils are classified into four Hydrologic Soil Groups (A, B, C, and D) according to their minimum infiltration rate (SCS 1986). HSG A refers to soils with relatively high permeability and favorable drainage characteristics; HSG D soils have relatively low permeability and poor drainage characteristics. The runoff potential increases dramatically in order of group A (lowest), B, C, and D (highest). Soil cover data was used in conjunction with land use cover data within GIS to develop composite curve numbers for each subwatershed in the models.

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

LAND USE

Existing land use was derived from the Erie County Planning Department and are listed within Tables in Section 6. 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 A.2*.

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 depicted in the tables at the end of this section:

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

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 Erie County, the best estimate for time of concentration calculation was provided by the NRCS lag equation.

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 A.10* shows the dimensions as they are approximated.

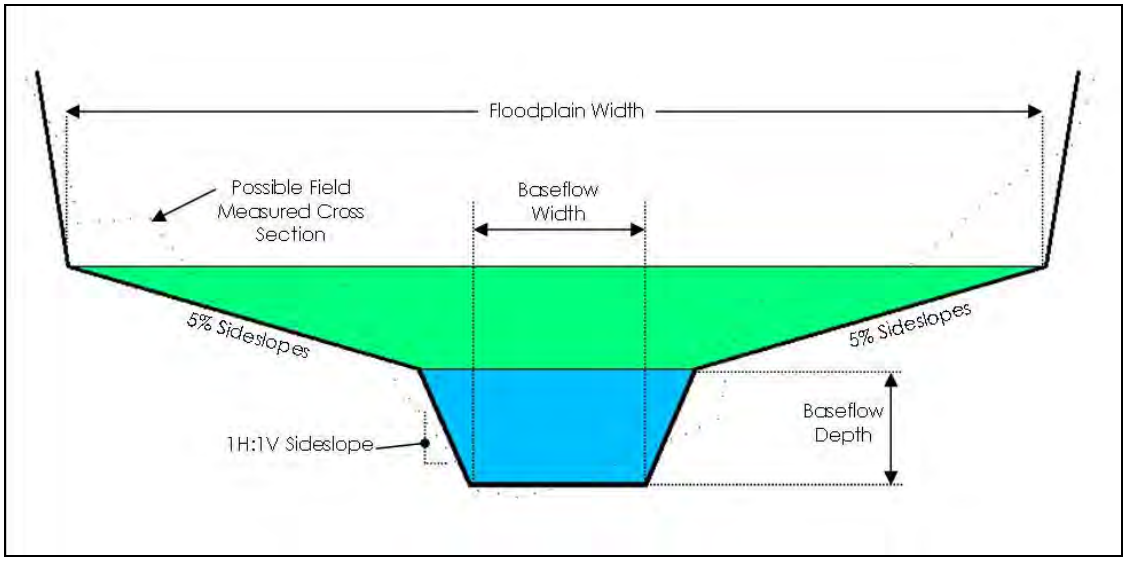


Figure A.10. Cross Sections Used for Reaches in HEC-HMS Model

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 Models.

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., $I_a = 0.2S$). CG1 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 storm. Using the HEC-HMS modeling output for $Q_{Existing}$, the initial abstraction for CG-1 may be calculated using the following equation:

$$I_a = P_{2-year} - \frac{1}{2}(Q_{Existing} \pm \sqrt{Q_{Existing}^2 + 4Q_{Existing}S_{Proposed}}) \text{ for the 2-year event}$$

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 storm 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 A.10 shows the effects of implementing a CG-1 policy on an example watershed. In the first figure representing a 2-year storm event, the hydrograph volumes are exactly the same and the peaks are similar. In the second figure representing a 100-year storm event, the hydrograph volumes are not the same since only the 2-year volume is abstracted; consequently there is still a substantial increase in peak flows, although the CG-1 implementation does reduce the peak flow.

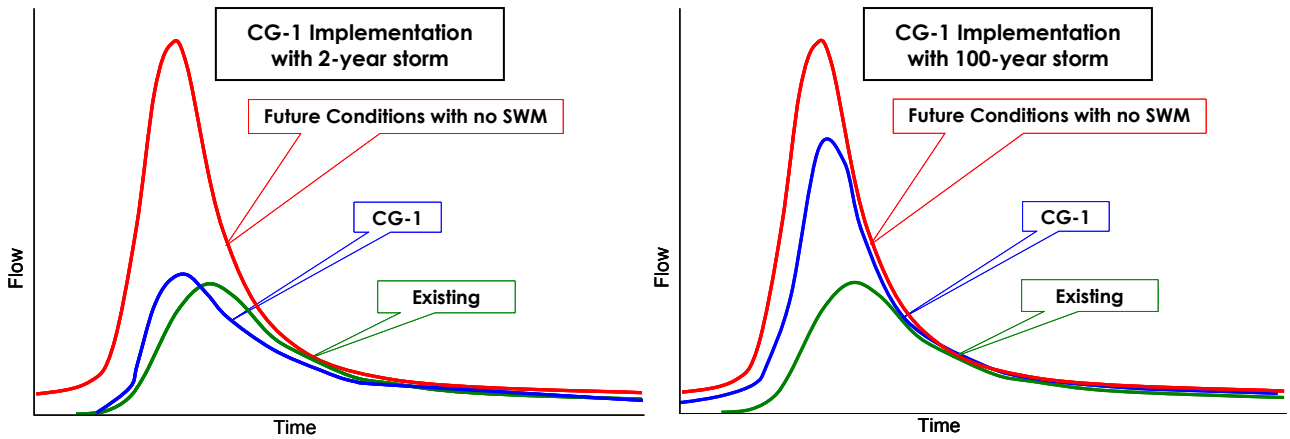


Figure A.11. Typical On-Site Runoff Control Strategy

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 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 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 event.

MODEL CALIBRATION

Three 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):

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 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 0 and 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 use curve numbers and 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.

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 nine USGS stream gages with adequate record associated with Lake Erie Tributaries and French Creek. The following table lists these gages and their respective statistics.

USGS Gage 04213075 Brandy Run near Girard, PA

USGS Stream Gage No.	Site Name	Drainage Area mi²	Number of Gage Years at Gage	Used in HEC-HMS Model
03015390	Hare Creek near Corry, PA	12.3	21	Not Used
03021350	French Creek near Wattsburg, PA	92.0	34	Used
03021410	West Branch French Creek near Lowville, PA	52.3	20	Used
03021500	French Creek at Carters Corners, PA	208.0	61	Used
03021520	French Creek near Union City, PA	221.0	20	Used
03021700	Little Conneauttee Creek near Mckean, PA	3.6	18	Used
04213040	Raccoon Creek near West Springfield, PA	2.5	35	Used
04213075	Brandy Run near Girard, PA	4.5	22	Used
04213200	Mill Creek at Erie, PA	9.2	32	Used

Table A.9. USGS Stream Gages Associated with Lake Erie Tributaries and French Creek

Flow estimates were derived at this gage using the Bulletin 17B methodology outlined in USGS (1982). This method produces estimates for storms of all of the frequencies desired in this study (between the 1 and 100 year storm events) for any gage that has more than 10 years of data.

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

The third available source of information that may be used for calibration is regression equation estimates. The regression equations were developed on the basis of peak flow data collected at numerous stream gages throughout Pennsylvania. This procedure is the most up-to-date method and takes into account watershed average elevation, carbonate (limestone) area, and minor surface water storage features such as small ponds and wetlands. The methodology for developing regression equation estimates within Pennsylvania is outlined in USGS Scientific Investigations Report 2008-5102 (USGS, 2008). Mean Elevation, Percent Carbonate Rock, and Percent Storage, the applicable parameters within Erie 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 the form of tables at the end of this section.

The following figures (*Figures A.12-A.19*) show the overall watershed calibration results for Lake Erie Tributaries and French Creek. As can be shown, the calibration results are in general agreement with the range of values for other hydrologic studies with the exception of USGS Gage 03021520 French Creek near Union City, PA which is affected by upstream regulation.

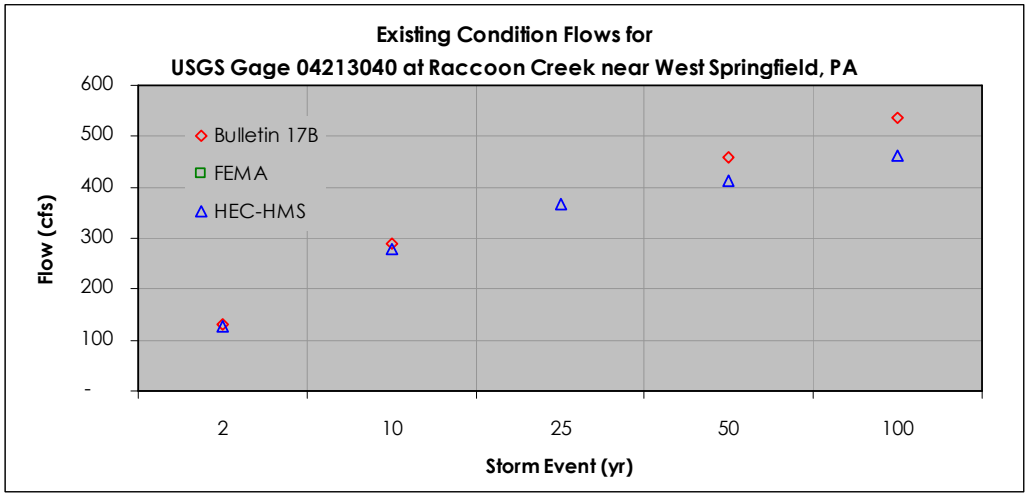
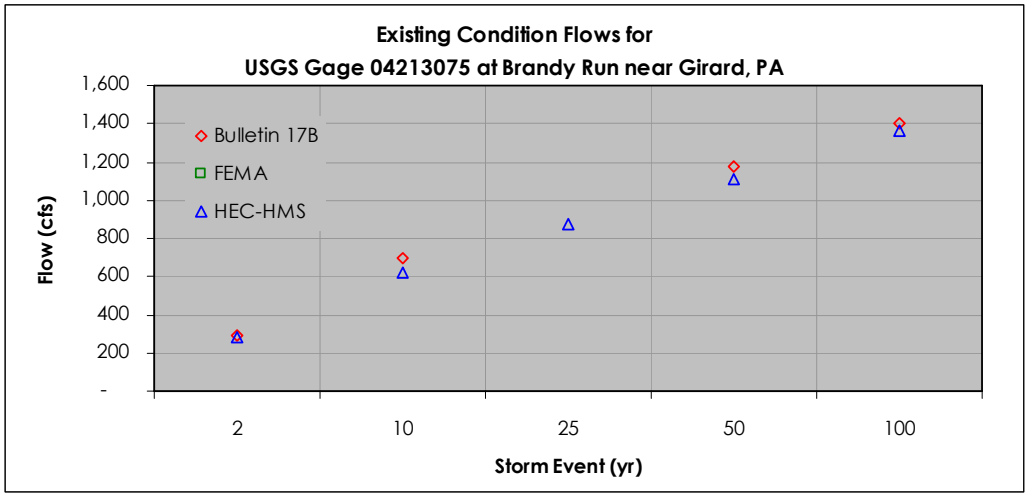


Figure A.12.



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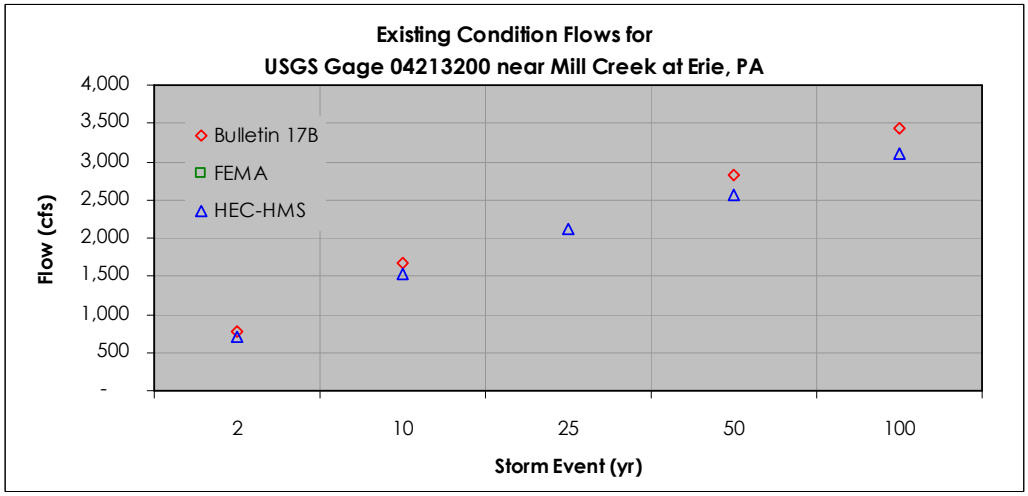

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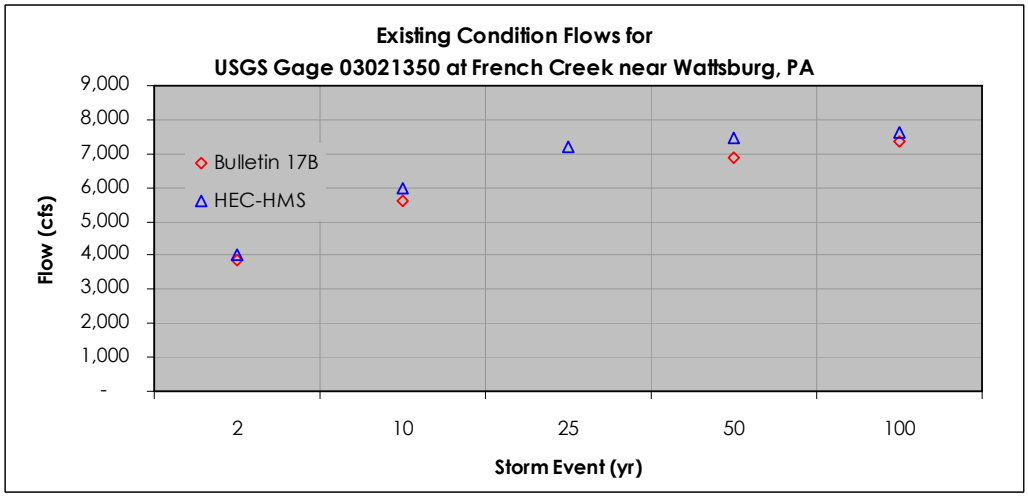

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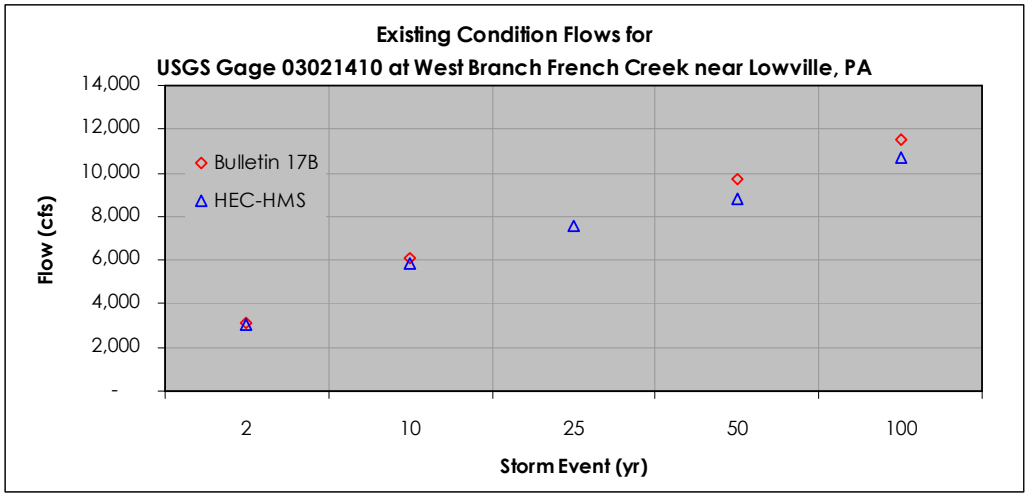

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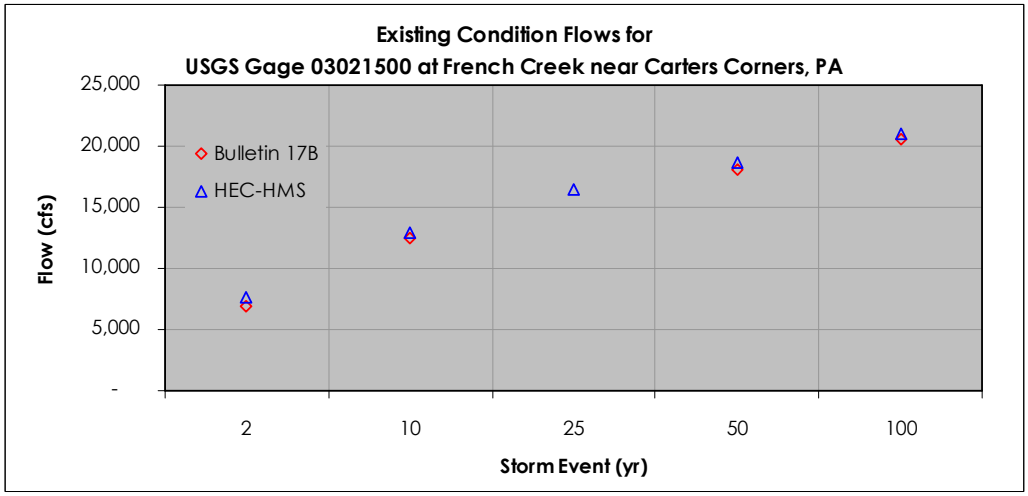

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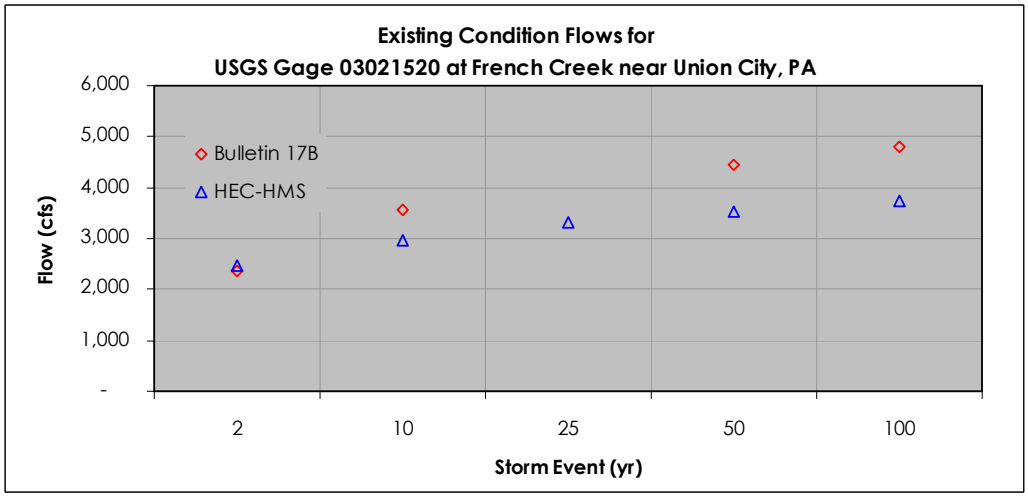


Figure A.18.

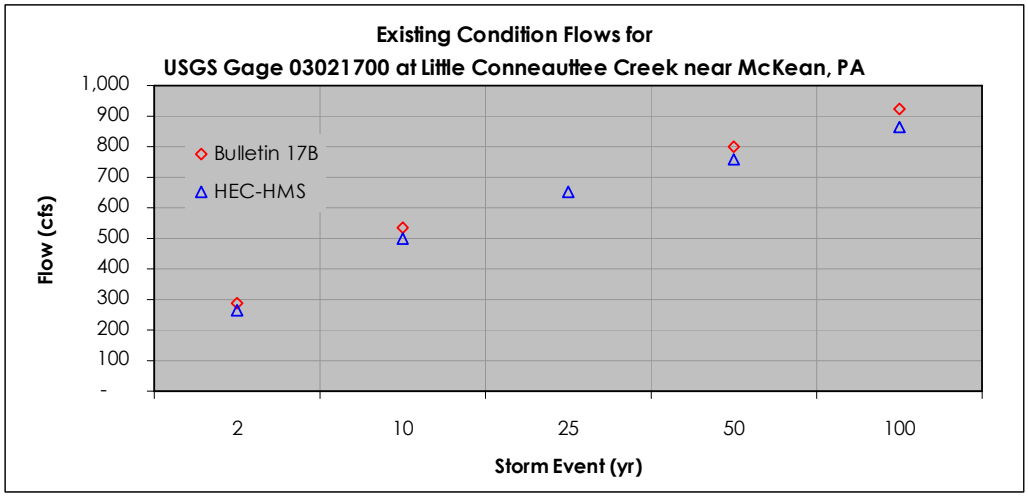


Figure A.19.

MODELING RESULTS

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

The following simulations were performed with HEC-HMS (2, 10, 25, 50 and 100-year) for Lake Erie Tributaries and French Creeks:

Existing Conditions (Ex)

An existing conditions model was developed and analyzed using the using the calibration procedures described above. Results from the existing conditions model reflect the estimated land uses from 2010. The existing condition flows are provided in the form of tables at the end of this section.

Future Conditions with No Stormwater Controls (F-1)

A future conditions model was developed and analyzed using the projected future land use coverage for the year 2020 provided by the Erie County. The revised land use resulted in an increased curve number and a decreased time of concentration for several subbasins. It was assumed that there was no required detention or any other stormwater controls in this simulation.

Future Conditions with Design Storm Method and Release Rates (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 illustrated in the form of tables at the end of this section.

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

LAKE ERIE TRIBUTARIES

For the Lake Erie Tributaries, the projected future increases are located mostly in the geographical center of the county on the outskirts of the developed area of the City of Erie. This development pattern is consistent with the projection of the 1996 Act 167 and indicates the potential need for peak rate controls more stringent that the traditional 100% release rates. The increases within the Lake Erie Tributaries are depicted in *Figure 6.1*.

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	93.1	3.0	47.5
10	64.8	2.3	45.6
25	57.1	2.1	44.8
50	53.4	2.0	45.2
100	51.1	2.0	44.4

Notes: [1] Area weighted averages

Table A.10. Future Condition Flows with No Stormwater Management Controls for Lake Erie Tributaries

Table A.11 shows the reduction in peak flows that would occur if only the Design Storm Method were implemented without any peak rate controls. The flows for the lower magnitude events are substantially reduced compared to future conditions with no stormwater management controls with the implementation of the Design Storm Method. The flows for the higher magnitude events are moderately reduced with implementation of the Design Storm Method, but significant increases still occur.

Storm Event (year)	Effects of CG-1 on Discharges		
	Maximum % Increase with CG1	Average % Increase with CG1[1]	Portion of subbasins with Increase (%)
2	5.0	0.3	24.9
10	18.6	0.8	35.2
25	23.0	1.0	35.6
50	25.8	1.1	36.4
100	28.0	1.1	37.9

Notes: [1]Area weighted averages

Table A.11 Future Subbasin Flows with Design Storm Method Only – No peak control for Lake Erie Tributaries Creek

FRENCH CREEK

For the French Creek watershed, the only significant increases occur around the Edinboro Lake area. The area upstream of Edinboro Lake was the only area of focus with the French Creek watershed for the potential need for peak rate controls. The increases within the French Creek watershed are depicted in *Figure 6.2*.

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	47.4	0.7	14.5
10	43.5	0.6	13.4
25	35.5	0.5	13.2
50	31.1	0.5	12.6
100	31.1	0.5	12.6

Notes: [1]Area weighted averages

Table A.12. Future Condition Flows with No Stormwater Management Controls for French Creek

Table A.13 shows the reduction in peak flows that would occur if only the Design Storm Method were implemented without any peak rate controls. The lower magnitude events are substantially reduced with the implementation of the Design Storm Method; the higher magnitude events are helped with implementation of the Design Storm Method, but significant increases still occur.

Storm Event (year)	Effects of CG1 on Discharges		
	Maximum % Increase with CG1	Average % Increase with CG1[1]	Portion of subbasins with Increase (%)
2	2.8	0.1	12.6
10	11.0	0.3	10.9
25	12.8	0.3	9.9
50	13.6	0.3	9.7
100	15.5	0.3	10.3

Notes: [1] Area weighted averages

Table A.13. Future Subbasin Flows with Design Storm Method Only – no peak control for French Creek

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 storm event.

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

Presented in *Figure A.20* is a typical on-site runoff control strategy for dealing with the increase in the peak rate of runoff with development. The Existing Condition curve represents the pre-development runoff hydrograph. The Developed Condition hydrograph illustrates three important changes in the site runoff response with development:

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 "squashing" the post-development runoff to the pre-development peak without reducing the volume is that the peak rate occurs over a much longer period of time. The instantaneous pre-development peak has become an extended peak (approximately two (2) hours long in this example) under the "Controlled" Developed Condition.

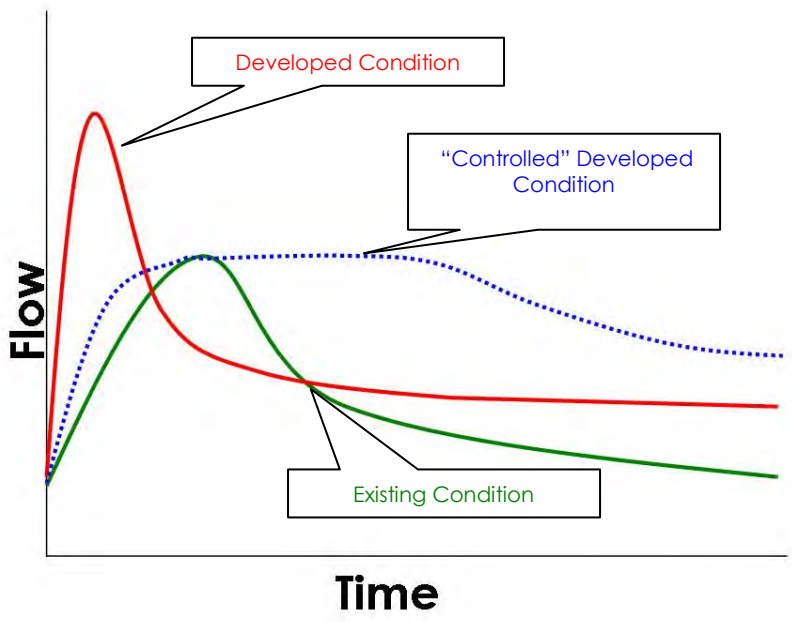


Figure A.20. Typical On-Site Runoff Control Strategy

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.21* and *A.22* illustrate the potential detrimental impact of this approach. *Figure A.21* represents the existing hydrograph at the point of confluence of Watershed A and Watershed B. The timing relationship of the

watersheds is that Watershed A peaks more quickly (at time T_{pA}) than the Total Hydrograph, while Watershed B peaks later (at time T_{pB}), than the Total Hydrograph, resulting in a combined time to peak approximately in the middle (at time T_p). Watershed A is an area of significant development pressure, and all new development proposals are met with the on-site runoff control philosophy as depicted in *Figure A.20*. The eventual end product of the Watershed A development under the "Controlled" Development Condition is an extended peak rate of runoff as shown in *Figure A.22*. The extended Watershed A peak occurs long enough so that it coincides with the peak of Watershed B. Since the Total Hydrograph at the confluence is the summation of Watershed A and Watershed B, the Total Hydrograph peak is increased under these conditions to the "Controlled" Total Hydrograph. The conclusion from the example is that simply controlling peak rates of runoff on-site does not guarantee an effective watershed level of control because of the increase in total runoff volume. The net result is that downstream peaks can increase and extend for longer durations.

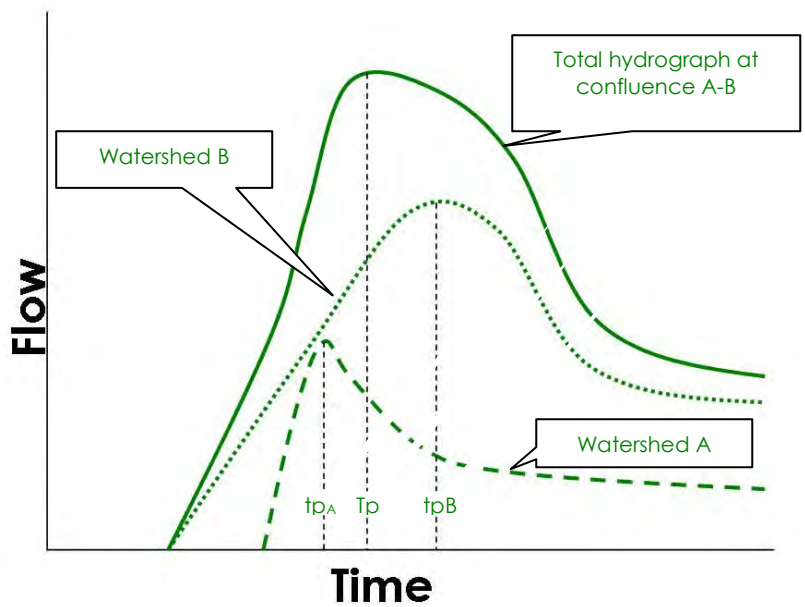


Figure A.21. Existing Hydrograph (Pre-Development)

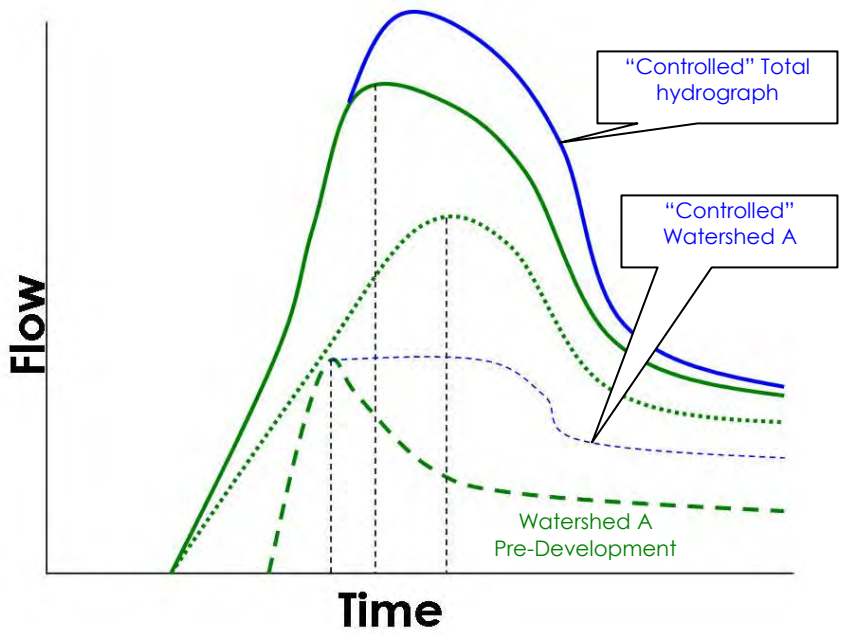


Figure A.22. Controlled Runoff Condition (Post-Development)

RELEASE RATE CONCEPT

The previous example indicated that, in certain circumstances, it is not enough to control post-development runoff peaks to pre-development levels if the overall goal is no increase in peak runoff at any point in the watershed. The reasons for this potential increase are how the various parts of the watershed interact, in time, with one another and the increased rate and volume of runoff associated with development and increases in impervious surfaces. The critical runoff criteria for a given site or watershed area is not necessarily its own pre-development peak rate of runoff but rather the pre-development contribution of the site or watershed area to the peak flow at a given point of interest.

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

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

Combining volume controls with peak rate controls, 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 Lake Erie Tributaries HEC-HMS Model

Hydrologic Results for Lake Erie Tributaries HEC-HMS Model

Hydrologic Parameters for French Creek HEC-HMS Model

Hydrologic Results for French Creek HEC-HMS Model

Calibration Results for Detailed HEC-HMS Models with 2010 Land Use

Hydrologic Parameters for Lake Erie Tributaries West HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Conneaut Creek	W792	1.82	70.2	75.6	70.2	75.6
	W794	0.26	67.6	35.2	67.6	35.2
	W802	0.19	76.4	40.3	76.4	40.3
	W804	0.00	73.6	5.0	73.6	3.1
	W806	0.36	77.2	61.6	77.2	61.6
	W808	0.01	78.1	20.1	78.1	13.4
	W810	0.01	68.2	14.9	68.2	14.9
	W814	0.10	74.5	28.7	74.5	26.1
	W816	0.30	75.1	67.1	75.1	67.1
	W820	1.98	76.5	150.0	76.5	149.9
	W832	3.28	75.3	212.2	75.3	212.0
	W852	1.34	71.5	69.4	71.6	69.2
	W854	5.44	70.5	140.0	70.5	140.0
	W856	9.68	72.8	161.5	72.8	161.5
	W858	6.04	70.0	124.5	70.0	124.5
	W860	0.31	57.7	65.7	57.7	65.7
	W862	3.49	74.5	141.0	74.5	117.4
	W864	0.08	71.0	26.0	71.0	25.9
	W866	9.77	76.5	190.3	76.7	189.1
	W868	0.03	75.9	15.6	75.9	15.6
	W872	0.13	75.7	37.9	75.7	37.9
	W874	0.01	62.8	23.3	62.8	23.3
	W876	9.37	76.1	248.6	76.2	247.7
	W878	0.93	75.0	87.5	75.0	87.5
	W880	1.57	74.3	117.0	74.4	116.9
	W882	0.05	67.7	42.2	67.7	42.2
	W884	1.78	69.7	186.7	69.7	186.6
	W886	2.58	72.7	175.0	72.7	175.0
	W888	4.25	71.3	201.7	71.3	201.7
	W890	4.21	71.8	155.6	71.8	155.5
	W892	3.32	72.0	109.1	72.1	108.7
	W894	10.41	75.1	211.2	75.1	176.0
	W896	12.53	69.3	303.1	69.3	303.1
	W898	5.01	68.4	200.6	68.4	200.6
	W900	3.08	73.9	233.9	73.9	146.1
Crazy Run	W812	3.67	79.0	149.1	79.0	149.1
East Branch Conneaut Creek	W782	3.83	74.0	176.5	74.0	176.4
	W784	2.37	74.5	167.8	74.6	167.5
	W786	3.37	75.6	204.0	75.6	203.8
	W822	9.14	79.9	377.1	79.9	377.1
	W824	0.75	77.3	161.8	77.3	147.1
	W826	0.30	76.3	80.6	76.3	80.6
	W848	0.66	79.6	58.6	79.6	58.6
	W850	0.78	75.2	99.6	75.3	99.1

Hydrologic Parameters for Lake Erie Tributaries West HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Fish Creek	W788	3.85	78.0	145.8	78.0	145.8
	W790	0.21	69.4	40.7	69.4	40.7
Foster Run	W796	4.15	78.3	154.3	78.5	153.8
	W798	0.02	69.5	16.9	69.5	13.0
Marsh Run	W834	4.31	77.0	317.7	77.0	226.6
	W836	3.02	77.1	171.9	77.1	143.1
	W837	0.01	51.7	88.9	51.7	88.9
Meyler Run	W768	1.15	78.0	93.1	78.4	92.2
	W800	0.00	65.6	5.5	65.6	5.5
Middle Branch Conneaut Cre	W770	6.89	78.9	340.5	78.9	425.6
Mud Run	W774	3.57	78.5	230.3	78.5	287.9
Raccoon Creek	W756	1.51	68.5	202.0	68.6	134.2
	W758	2.60	73.6	162.4	73.7	108.1
	W760	2.20	67.7	140.2	68.0	139.0
	W762	1.83	70.9	179.6	70.9	149.4
Stone Run	W818	8.09	78.7	300.7	78.7	300.7
Temple Creek	W776	1.71	72.3	86.7	72.3	86.7
	W778	1.85	73.6	90.3	73.6	90.3
	W779	0.04	76.0	21.6	76.0	16.6
	W780	2.59	72.3	147.4	72.3	133.9
	W838	4.17	77.7	167.4	77.7	167.4
	W840	3.50	72.6	108.4	72.7	108.2
	W842	0.27	71.0	44.7	71.0	44.7
	W844	0.87	69.1	79.9	69.1	79.9
	W846	0.20	76.7	34.8	76.7	34.8
Turkey Creek	W764	5.08	69.2	334.4	69.3	208.7
	W766	3.41	70.8	343.8	70.9	245.2
West Branch Conneaut Creek	W772	7.18	77.6	420.1	77.6	525.1
	W828	2.43	76.6	160.2	76.6	145.6
	W830	1.68	74.6	118.4	74.7	118.2

Hydrologic Parameters for Lake Erie Tributaries West 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
Conneaut Creek	W792	70.2	70.5	67.3	64.8	62.0	59.2
	W794	67.6	67.6	66.2	64.2	61.9	59.9
	W802	76.4	76.4	75.2	73.5	71.6	69.8
	W804	73.6	73.6	72.3	70.6	68.5	66.7
	W806	77.2	77.2	76.0	74.4	72.5	70.8
	W808	78.1	78.1	76.9	75.3	73.5	71.8
	W810	68.2	68.2	66.7	64.8	62.6	60.5
	W814	74.5	74.5	73.2	71.5	69.5	67.6
	W816	75.1	75.1	73.8	72.1	70.1	68.3
	W820	76.5	77.6	78.2	76.1	74.8	73.4
	W832	75.3	79.8	81.2	79.7	77.9	76.9
	W852	71.5	70.0	66.1	63.2	59.8	57.6
	W854	70.5	69.5	63.8	60.2	55.9	53.0
	W856	72.8	74.0	71.6	69.0	65.9	63.8
	W858	70.0	71.3	67.5	64.6	61.0	58.4
	W860	57.7	57.7	56.1	53.9	51.5	49.4
	W862	74.5	74.4	72.8	70.5	67.6	64.5
	W864	71.0	71.0	69.6	67.7	65.6	63.6
	W866	76.5	76.1	74.7	72.5	69.8	68.0
	W868	75.9	75.9	74.7	73.0	71.0	69.3
	W872	75.7	75.7	74.4	72.7	70.8	69.0
	W874	62.8	62.8	61.3	59.2	56.9	54.7
	W876	76.1	79.2	79.4	76.8	75.0	73.3
	W878	75.0	75.0	73.7	72.0	70.1	68.2
	W880	74.3	76.6	77.0	74.9	73.5	72.0
	W882	67.7	67.7	66.2	64.3	62.0	60.0
	W884	69.7	77.0	76.0	73.7	71.0	68.7
	W886	72.7	74.3	71.3	68.5	65.0	62.6
	W888	71.3	71.2	65.8	62.1	57.4	54.9
	W890	71.8	74.4	72.3	69.5	66.5	64.2
	W892	72.0	72.3	69.3	66.5	63.2	61.1
	W894	75.1	72.6	68.1	64.7	60.4	57.5
	W896	69.3	74.6	70.1	66.3	62.1	59.1
	W898	68.4	72.8	68.3	64.8	60.4	57.6
	W900	73.9	71.5	65.4	61.6	56.9	54.3
Crazy Run	W812	79.0	76.2	75.7	74.0	72.1	70.1
East Branch Conneaut Creek	W782	74.0	77.9	78.0	76.5	74.7	72.6
	W784	74.5	78.3	79.1	77.8	76.3	74.0
	W786	75.6	79.2	80.2	78.9	77.3	75.2
	W822	79.9	84.4	87.2	86.2	84.9	83.8
	W824	77.3	77.3	76.1	74.5	72.6	70.9
	W826	76.3	76.3	75.1	73.4	71.5	69.8
	W848	79.6	79.6	78.5	77.0	75.2	73.6
	W850	75.2	75.2	73.9	72.2	70.2	68.4

Hydrologic Parameters for Lake Erie Tributaries West 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
Fish Creek	W788	78.0	75.1	73.7	71.8	69.6	67.4
	W790	69.4	69.4	68.0	66.0	63.9	61.9
Foster Run	W796	78.3	75.8	74.8	73.0	71.0	68.9
	W798	69.5	69.5	68.1	66.2	64.0	62.0
Marsh Run	W834	77.0	72.7	68.0	64.4	60.0	58.4
	W836	77.1	75.9	74.2	71.8	68.9	66.0
	W837	51.7	51.7	50.1	47.9	45.5	43.4
Meyler Run	W768	78.0	74.2	73.3	71.7	69.9	68.3
	W800	65.6	65.6	64.1	62.1	59.8	57.7
Middle Branch Conneaut Cree	W770	78.9	83.8	86.7	87.3	88.0	87.5
Mud Run	W774	78.5	81.2	83.1	83.3	83.4	82.3
Raccoon Creek	W756	68.5	69.0	64.5	62.5	60.3	57.5
	W758	73.6	70.3	68.2	65.5	62.4	59.1
	W760	67.7	66.4	61.1	58.1	54.5	52.4
	W762	70.9	63.7	56.6	53.8	50.6	50.6
Stone Run	W818	78.7	82.0	83.9	82.7	81.4	79.7
Temple Creek	W776	72.3	72.0	69.5	67.4	65.0	62.2
	W778	73.6	72.4	70.1	68.2	65.9	63.0
	W779	76.0	76.0	74.7	73.1	71.1	69.3
	W780	72.3	76.3	75.9	73.2	71.2	68.9
	W838	77.7	76.3	75.6	73.6	71.3	69.6
	W840	72.6	73.1	71.1	68.8	66.1	64.0
	W842	71.0	71.0	69.6	67.7	65.6	63.7
	W844	69.1	69.1	67.7	65.8	63.6	61.6
	W846	76.7	76.7	75.6	73.9	72.0	70.3
Turkey Creek	W764	69.2	67.3	60.5	56.9	52.4	49.3
	W766	70.8	67.9	61.3	57.6	53.1	50.5
West Branch Conneaut Creek	W772	77.6	83.9	85.5	85.3	85.1	83.4
	W828	76.6	78.3	79.3	76.8	75.4	73.7
	W830	74.6	76.5	76.7	74.5	73.4	71.8

Hydrologic Parameters for Lake Erie Tributaries West 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
Conneaut Creek	W792	70.2	70.5	67.3	64.8	62.0	59.2
	W794	67.6	67.6	66.2	64.2	61.9	59.9
	W802	76.4	76.4	75.2	73.5	71.6	69.8
	W804	73.6	73.6	72.3	70.6	68.5	66.7
	W806	77.2	77.2	76.0	74.4	72.5	70.8
	W808	78.1	78.1	76.9	75.3	73.5	71.8
	W810	68.2	68.2	66.7	64.8	62.6	60.5
	W814	74.5	74.5	73.2	71.5	69.5	67.6
	W816	75.1	75.1	73.8	72.1	70.1	68.3
	W820	76.5	77.6	78.2	76.1	74.8	73.4
	W832	75.3	79.8	81.2	79.7	77.9	76.9
	W852	71.6	70.1	66.2	63.3	59.9	57.7
	W854	70.5	69.5	63.8	60.2	55.9	53.0
	W856	72.8	74.0	71.6	69.0	65.9	63.8
	W858	70.0	71.3	67.5	64.6	61.0	58.4
	W860	57.7	57.7	56.1	53.9	51.5	49.4
	W862	74.5	74.4	72.9	70.5	67.7	64.5
	W864	71.0	71.0	69.7	67.8	65.7	63.7
	W866	76.7	76.3	74.9	72.7	70.1	68.2
	W868	75.9	75.9	74.7	73.0	71.0	69.3
	W872	75.7	75.7	74.4	72.7	70.8	69.0
	W874	62.8	62.8	61.3	59.2	56.9	54.7
	W876	76.2	79.3	79.5	76.9	75.1	73.4
	W878	75.0	75.0	73.7	72.0	70.1	68.2
	W880	74.4	76.6	77.0	75.0	73.6	72.1
	W882	67.7	67.7	66.2	64.3	62.0	60.0
	W884	69.7	77.0	76.0	73.7	71.0	68.7
	W886	72.7	74.3	71.3	68.5	65.0	62.6
	W888	71.3	71.2	65.8	62.1	57.4	54.9
	W890	71.8	74.5	72.4	69.6	66.5	64.2
	W892	72.1	72.4	69.4	66.7	63.4	61.3
	W894	75.1	72.6	68.1	64.7	60.4	57.5
	W896	69.3	74.6	70.1	66.3	62.1	59.1
	W898	68.4	72.8	68.3	64.8	60.4	57.6
	W900	73.9	71.6	65.4	61.6	56.9	54.3
Crazy Run	W812	79.0	76.2	75.7	74.0	72.1	70.1
East Branch Conneaut Creek	W782	74.0	77.9	78.1	76.5	74.8	72.6
	W784	74.6	78.3	79.2	77.9	76.4	74.1
	W786	75.6	79.3	80.3	78.9	77.4	75.3
	W822	79.9	84.4	87.2	86.2	84.9	83.8
	W824	77.3	77.3	76.1	74.5	72.6	70.9
	W826	76.3	76.3	75.1	73.4	71.5	69.8
	W848	79.6	79.6	78.5	77.0	75.2	73.6
	W850	75.3	75.3	74.1	72.4	70.4	68.6

Hydrologic Parameters for Lake Erie Tributaries West 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
Fish Creek	W788	78.0	75.1	73.7	71.8	69.6	67.4
	W790	69.4	69.4	68.0	66.0	63.9	61.9
Foster Run	W796	78.5	75.9	74.9	73.1	71.1	69.0
	W798	69.5	69.5	68.1	66.2	64.0	62.0
Marsh Run	W834	77.0	72.8	68.0	64.5	60.1	58.5
	W836	77.1	75.9	74.2	71.8	68.9	66.0
	W837	51.7	51.7	50.1	47.9	45.5	43.4
Meyler Run	W768	78.4	74.6	73.7	72.1	70.3	68.7
	W800	65.6	65.6	64.1	62.1	59.8	57.7
Middle Branch Conneaut Cre	W770	78.9	83.8	86.7	87.3	88.0	87.5
Mud Run	W774	78.5	81.2	83.1	83.3	83.4	82.3
Raccoon Creek	W756	68.6	69.2	64.7	62.7	60.4	57.6
	W758	73.7	70.4	68.3	65.6	62.5	59.2
	W760	68.0	66.7	61.5	58.4	54.8	52.7
	W762	70.9	63.8	56.7	53.9	50.6	50.6
Stone Run	W818	78.7	82.0	83.9	82.7	81.4	79.7
Temple Creek	W776	72.3	72.0	69.5	67.4	65.0	62.2
	W778	73.6	72.4	70.2	68.2	65.9	63.0
	W779	76.0	76.0	74.7	73.1	71.1	69.3
	W780	72.3	76.3	75.9	73.2	71.2	68.9
	W838	77.7	76.3	75.6	73.6	71.3	69.6
	W840	72.7	73.2	71.1	68.8	66.1	64.1
	W842	71.0	71.0	69.6	67.7	65.6	63.7
	W844	69.1	69.1	67.7	65.8	63.6	61.6
	W846	76.7	76.7	75.6	73.9	72.0	70.3
Turkey Creek	W764	69.3	67.3	60.6	56.9	52.5	49.3
	W766	70.9	68.0	61.3	57.6	53.2	50.5
West Branch Conneaut Creek	W772	77.6	83.9	85.5	85.3	85.1	83.4
	W828	76.6	78.3	79.3	76.8	75.4	73.7
	W830	74.7	76.5	76.7	74.6	73.4	71.9

Hydrologic Results for Lake Erie Tributaries West HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	CP033	1253737.2	580972.3	3.85	302	630	826	964	1,112	302	630	826	964	1,112
2	CP031	1258594.2	584415.5	1.82	153	326	437	504	578	153	326	437	504	578
3	CP215	1252505.5	589949.2	4.15	331	691	904	1,057	1,223	335	697	911	1,065	1,233
4	J1612	1253169.5	590269.0	5.32	407	858	1,128	1,325	1,543	413	867	1,140	1,337	1,557
5	USGS 04213040	1234844.3	659381.6	2.60	126	280	366	413	461	127	282	368	416	463
6	J1554	1232092.2	666142.6	6.31	253	526	700	797	915	257	533	708	807	926
7	J_Lake-Raccoon Ck	1225648.4	676127.9	8.15	293	593	793	904	1,071	298	600	803	914	1,084
8	J1538	1221516.6	668306.9	5.08	114	188	239	248	280	115	189	240	250	282
9	J_Lake-Turkey Ck	1212416.7	670495.8	8.49	192	317	401	417	477	193	319	403	419	480
10	EP111	1273738.3	636046.9	1.85	165	353	474	558	632	165	354	475	559	632
11	J1602	1272697.5	635522.6	1.89	167	357	479	563	638	167	357	479	564	638
12	J1534	1259564.1	644253.6	3.83	322	678	878	1,026	1,173	322	679	879	1,027	1,175
13	CP089	1253854.3	604942.6	0.19	44	92	120	141	165	44	92	120	141	165
14	CP090	1254722.9	605480.6	0.36	64	129	168	198	231	64	129	168	198	231
15	CP088	1253828.4	605156.5	0.37	64	130	170	199	233	64	130	170	199	233
16	CP087	1254299.6	606923.7	0.10	25	53	70	83	98	25	53	70	83	98
17	J1502	1226386.3	623963.3	9.14	649	1,317	1,639	1,889	2,169	649	1,317	1,639	1,889	2,169
18	J1510	1226533.8	626865.4	16.78	1,158	2,359	3,016	3,553	4,094	1,158	2,359	3,016	3,553	4,094
19	J1516	1226583.0	630185.6	24.26	1,615	3,245	4,161	4,916	5,636	1,615	3,245	4,161	4,916	5,636
20	J1514	1234477.8	629890.5	30.26	1,835	3,696	4,752	5,632	6,467	1,835	3,696	4,752	5,632	6,467
21	J1530	1242569.4	638793.7	4.31	159	278	344	363	444	160	280	346	365	446
22	J1526	1245766.6	637859.1	7.33	307	580	730	807	932	308	582	733	810	934
23	J1506	1270533.2	626127.6	5.88	410	858	1,116	1,294	1,505	410	858	1,116	1,294	1,506
24	J1524	1262908.9	638523.1	13.86	1,003	2,109	2,744	3,196	3,694	1,005	2,113	2,748	3,200	3,699
25	EP110	1262171.1	640589.1	14.14	1,012	2,126	2,765	3,221	3,724	1,014	2,129	2,769	3,225	3,729
26	EP007	1261016.9	642335.3	15.00	1,046	2,201	2,867	3,342	3,867	1,048	2,204	2,871	3,347	3,872
27	J1532	1258236.0	642778.0	21.40	1,575	3,331	4,328	5,054	5,816	1,579	3,337	4,336	5,062	5,826
28	J1528	1255161.7	640195.6	25.43	1,875	3,956	5,129	5,989	6,880	1,880	3,963	5,138	6,000	6,892
29	J1634	1214973.3	655960.6	1.34	114	235	308	343	409	115	237	312	347	413
30	CP032	1258260.6	571181.9	9.68	649	1,298	1,666	1,873	2,197	649	1,298	1,666	1,873	2,197
31	J1648	1257301.4	580529.6	19.79	1,179	2,351	3,076	3,506	4,120	1,179	2,351	3,076	3,506	4,120
32	J1616	1256489.8	585817.4	22.17	1,240	2,470	3,230	3,692	4,343	1,240	2,470	3,230	3,692	4,343
33	CP210	1254165.3	589297.8	25.66	1,370	2,711	3,518	4,034	4,742	1,370	2,711	3,518	4,034	4,742
34	J1646	1253366.3	590391.9	31.06	1,669	3,331	4,336	4,992	5,897	1,671	3,334	4,339	4,995	5,900

Hydrologic Results for Lake Erie Tributaries West HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J1640	1253764.5	604818.3	41.03	2,147	4,304	5,587	6,416	7,536	2,155	4,315	5,601	6,432	7,552
36	J1642	1253102.4	605271.5	41.44	2,157	4,320	5,608	6,440	7,564	2,165	4,331	5,622	6,456	7,580
37	J1610	1251669.3	607411.3	45.23	2,317	4,652	6,042	6,948	8,147	2,326	4,665	6,059	6,967	8,168
38	J1608	1251718.5	607731.0	45.63	2,317	4,652	6,042	6,948	8,148	2,327	4,665	6,059	6,968	8,168
39	J1504	1243528.5	624356.8	63.09	3,198	6,423	8,253	9,540	11,117	3,213	6,445	8,281	9,572	11,152
40	J1508	1244610.7	626914.6	66.01	3,126	6,244	7,999	9,241	10,755	3,140	6,265	8,026	9,272	10,790
41	J1518	1245496.1	630898.9	99.52	4,866	9,704	12,419	14,481	16,745	4,880	9,724	12,445	14,511	16,777
42	J1512	1246258.5	631341.6	102.85	4,961	9,896	12,665	14,771	17,089	4,975	9,916	12,691	14,801	17,122
43	J1522	1246209.3	637982.1	111.97	5,085	10,080	12,877	14,982	17,338	5,099	10,101	12,904	15,014	17,373
44	J1520	1251939.8	641130.1	140.76	5,410	10,642	13,591	15,829	18,324	5,425	10,664	13,619	15,862	18,360
45	J1540	1247808.0	649959.5	145.01	5,218	10,203	12,996	15,111	17,467	5,232	10,224	13,022	15,140	17,500
46	J1636	1228673.5	649689.0	149.22	5,159	10,141	12,927	15,035	17,383	5,174	10,161	12,953	15,064	17,415
47	J_PA-Conneaut Ck	1214656.8	646454.1	152.55	5,158	10,154	12,955	15,075	17,439	5,172	10,175	12,981	15,105	17,472
48	J1604	1186540.5	639307.3	162.95	5,177	10,248	13,097	15,249	17,654	5,191	10,269	13,124	15,279	17,688
49	USGS 04213000	1191924.1	654214.4	175.49	5,193	10,351	13,255	15,443	17,897	5,207	10,373	13,282	15,474	17,932
50	J1546	1203488.9	657460.8	187.27	5,185	10,348	13,260	15,456	17,923	5,199	10,370	13,287	15,487	17,958
51	J_Lake-Conneaut Ck	1207399.4	669979.3	190.35	5,156	10,300	13,202	15,390	17,850	5,171	10,322	13,229	15,421	17,885

Hydrologic Parameters for Lake Erie Tributaries Central HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Brandy Run	W638	0.31	59.4	67.6	59.4	67.7
	W682	3.21	73.0	161.4	74.3	155.4
	W684	0.93	61.1	63.5	63.4	59.8
	W686	0.17	63.8	26.3	63.8	26.3
Crooked Creek	W736	3.11	71.3	137.2	71.7	135.9
	W738	0.18	65.7	36.7	65.7	36.7
	W740	4.59	73.4	162.9	73.5	162.6
	W742	4.77	73.2	152.9	73.2	152.6
	W744	2.38	67.8	186.3	67.8	186.0
	W746	2.11	69.8	139.5	70.0	138.9
	W748	3.35	66.3	157.5	66.5	156.8
Elk Creek	W640	0.03	62.8	12.9	69.0	11.0
	W650	1.39	78.2	139.2	79.9	132.3
	W652	2.10	72.9	118.6	73.0	118.2
	W662	1.11	75.6	89.1	76.3	87.3
	W664	3.12	73.8	139.7	74.1	138.4
	W692	0.79	68.2	75.9	69.3	73.8
	W694	0.01	81.5	4.4	81.5	4.4
	W696	5.07	68.6	118.5	68.8	117.8
	W698	4.84	71.4	122.5	71.6	121.6
	W700	1.57	70.6	88.2	70.6	88.2
	W702	3.53	72.6	108.4	73.6	105.3
	W704	0.00	68.5	6.8	68.5	6.8
	W708	1.22	73.5	74.1	74.5	71.9
	W710	0.06	74.9	31.4	77.1	29.4
	W712	2.71	74.9	85.9	75.3	85.0
	W714	3.50	69.0	150.9	69.2	150.1
	W716	0.96	71.9	64.0	71.9	64.0
	W718	1.18	72.3	59.6	72.3	59.6
	W720	0.65	68.5	56.5	68.5	56.5
	W722	1.67	71.5	87.5	71.8	86.8
	W724	1.28	72.2	66.7	72.4	66.2
	W726	1.33	68.5	80.6	68.5	80.6
	W728	0.36	73.3	68.2	74.5	66.1
	W730	2.58	73.7	96.3	73.7	96.1
	W732	3.95	70.5	205.2	70.6	204.9
Falk Run	W670	4.15	74.2	190.6	74.3	190.2
	W672	1.76	72.5	82.2	72.5	82.1
Goodban Run	W668	3.80	73.5	178.3	73.7	177.1
Halls Run	W648	0.95	73.3	86.4	73.4	86.2
	W688	1.46	73.6	147.7	73.7	147.6
	W690	3.67	73.5	103.2	73.6	103.0
Lamson Run	W634	2.08	73.0	90.4	73.1	89.9
	W636	0.00	88.2	2.7	88.2	2.7

Hydrologic Parameters for Lake Erie Tributaries Central HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Lamson Run	W656	3.21	67.9	109.7	68.0	109.3
	W658	2.65	70.5	85.0	70.5	84.9
	W660	1.51	72.3	72.4	72.4	72.2
Little Elk Creek	W642	0.85	71.6	124.1	71.6	124.1
	W644	0.63	72.2	88.2	72.2	88.2
	W646	4.40	73.3	205.6	73.3	205.3
	W674	4.86	73.4	158.6	73.4	158.5
	W676	2.04	72.9	107.3	72.9	107.2
	W678	3.07	71.8	115.8	71.9	115.4
	W680	3.85	72.5	122.2	72.7	121.4
Porter Run	W666	3.60	73.4	141.0	73.5	140.7
Trout Run	W614	4.33	72.2	210.1	72.8	206.9
	W616	2.69	74.6	170.0	74.8	169.4
Unnamed Tributary to Lake Erie	W610	0.88	71.1	109.9	71.1	109.8
	W612	0.92	66.8	71.5	67.0	118.8
	W618	1.10	67.1	149.6	67.2	149.1
	W620	1.33	70.8	108.7	71.2	107.6
	W622	0.44	71.7	76.4	74.7	70.2
	W624	1.15	70.1	80.4	72.0	76.3
	W626	3.73	69.4	258.8	70.1	253.9
	W628	0.56	70.9	65.8	70.9	73.1
	W630	0.77	78.5	98.1	79.0	96.5
	W632	0.49	74.4	61.1	74.6	60.7
	W734	2.02	68.8	221.5	68.9	221.4
	W750	1.01	67.8	190.8	67.8	190.7
	W752	2.04	70.2	228.0	70.3	227.3
	W754	1.20	73.3	163.3	73.5	162.3

Hydrologic Parameters for Lake Erie Tributaries Central 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
Brandy Run	W638	59.4	60.1	60.1	59.0	58.1	58.1
	W682	73.0	76.2	76.2	76.2	76.2	76.2
	W684	61.1	66.5	66.5	66.5	66.5	66.5
	W686	63.8	62.8	60.4	58.2	55.8	53.2
Crooked Creek	W736	71.3	68.2	62.3	56.0	53.1	51.1
	W738	65.7	64.6	63.1	61.4	59.6	58.3
	W740	73.4	70.2	65.9	62.5	58.3	55.4
	W742	73.2	72.9	71.6	69.8	67.7	66.3
	W744	67.8	71.3	67.0	64.3	61.0	58.5
	W746	69.8	68.9	63.8	60.1	55.6	52.8
	W748	66.3	71.7	68.0	65.5	63.8	61.9
Elk Creek	W640	62.8	63.4	63.4	62.4	61.6	61.6
	W650	78.2	72.6	70.8	68.7	66.3	63.5
	W652	72.9	70.7	67.9	65.5	62.7	59.6
	W662	75.6	70.9	68.8	66.6	64.1	61.7
	W664	73.8	71.8	69.8	67.6	65.1	62.3
	W692	68.2	67.3	65.0	62.9	60.5	58.0
	W694	81.5	81.9	79.2	77.7	75.9	74.0
	W696	68.6	66.3	59.8	54.0	50.2	47.9
	W698	71.4	69.5	65.7	62.7	59.2	55.5
	W700	70.6	69.6	66.3	63.7	60.8	57.8
	W702	72.6	69.7	66.0	63.2	60.0	56.5
	W704	68.5	67.5	65.2	63.1	60.8	58.3
	W708	73.5	69.3	66.1	63.5	60.5	57.3
	W710	74.9	74.0	72.0	70.1	68.0	65.7
	W712	74.9	69.2	65.3	62.3	58.8	56.3
	W714	69.0	73.1	71.3	68.9	67.7	66.4
	W716	71.9	71.0	68.9	66.9	64.6	62.2
	W718	72.3	68.8	65.3	62.8	59.8	56.9
	W720	68.5	67.5	65.3	63.2	60.8	58.3
	W722	71.5	71.0	69.2	67.3	65.3	63.1
	W724	72.2	69.6	67.1	64.9	62.4	59.7
	W726	68.5	70.9	68.3	67.1	65.8	63.8
	W728	73.3	72.5	70.4	68.5	66.3	63.9
	W730	73.7	71.7	70.4	68.7	66.9	64.8
	W732	70.5	76.5	77.3	76.3	75.3	74.1
Falk Run	W670	74.2	72.7	70.5	68.2	65.4	62.6
	W672	72.5	69.4	66.0	63.5	60.5	57.4
Goodban Run	W668	73.5	73.3	72.1	70.2	68.0	65.8
Halls Run	W648	73.3	72.4	70.3	68.4	66.2	63.8
	W688	73.6	74.4	73.5	72.7	71.8	70.9
	W690	73.5	70.9	68.5	66.3	63.7	61.0
Lamson Run	W634	73.0	68.9	65.0	61.9	58.3	54.8
	W636	88.2	87.7	86.6	85.5	84.2	82.8

Hydrologic Parameters for Lake Erie Tributaries Central 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
Lamson Run	W656	67.9	69.5	66.0	63.3	60.0	56.9
	W658	70.5	68.4	64.3	61.3	57.7	54.2
	W660	72.3	68.7	64.9	62.1	58.8	55.5
Little Elk Creek	W642	71.6	70.7	68.5	66.5	64.3	61.9
	W644	72.2	71.3	69.2	67.2	64.9	62.5
	W646	73.3	74.2	72.8	71.5	70.1	67.9
	W674	73.4	71.8	69.5	67.1	64.2	61.4
	W676	72.9	70.8	68.3	66.0	63.3	60.6
	W678	71.8	71.1	68.7	66.5	64.0	61.3
	W680	72.5	71.2	68.9	66.7	64.2	61.4
Porter Run	W666	73.4	71.6	69.2	66.9	64.1	61.2
Trout Run	W614	72.2	75.9	77.4	77.0	76.6	76.1
	W616	74.6	76.5	78.9	79.2	79.4	79.4
Unnamed Tributary to Lake Erie	W610	71.1	74.0	72.4	71.7	71.1	70.3
	W612	66.8	70.0	66.4	65.4	64.2	63.1
	W618	67.1	75.6	78.0	78.0	77.9	77.6
	W620	70.8	73.1	73.1	73.0	72.8	72.4
	W622	71.7	70.7	70.0	68.9	67.7	66.6
	W624	70.1	71.1	71.1	69.9	69.2	68.3
	W626	69.4	79.8	78.5	78.2	77.8	77.2
	W628	70.9	70.0	69.2	68.8	68.5	65.8
	W630	78.5	77.7	77.1	76.7	76.4	75.6
	W632	74.4	73.5	72.8	72.5	72.1	71.2
	W734	68.8	73.6	72.5	70.8	68.8	67.1
	W750	67.8	70.4	67.3	64.8	62.0	59.5
	W752	70.2	66.5	60.3	56.9	52.9	49.7
	W754	73.3	67.4	62.2	59.1	55.5	53.5

Hydrologic Parameters for Lake Erie Tributaries Central 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
Brandy Run	W638	59.4	60.0	60.0	58.9	58.1	58.1
	W682	74.3	77.4	77.4	77.4	77.4	77.4
	W684	63.4	68.6	68.6	68.6	68.6	68.6
	W686	63.8	62.8	60.4	58.2	55.8	53.2
Crooked Creek	W736	71.7	68.5	62.7	56.5	53.5	51.5
	W738	65.7	64.6	63.1	61.4	59.6	58.3
	W740	73.5	70.3	65.9	62.5	58.4	55.4
	W742	73.2	73.0	71.7	69.8	67.7	66.4
	W744	67.8	71.4	67.1	64.3	61.1	58.5
	W746	70.0	69.1	64.0	60.3	55.8	53.0
	W748	66.5	71.9	68.2	65.7	64.0	62.1
Elk Creek	W640	69.0	69.5	69.5	68.5	67.8	67.8
	W650	79.9	74.6	72.8	70.8	68.5	65.8
	W652	73.0	70.8	68.0	65.6	62.8	59.7
	W662	76.3	71.7	69.6	67.5	65.0	62.6
	W664	74.1	72.2	70.1	68.0	65.5	62.7
	W692	69.3	68.3	66.1	64.0	61.7	59.2
	W694	81.5	81.9	79.2	77.7	75.9	74.0
	W696	68.8	66.6	60.1	54.2	50.4	48.1
	W698	71.6	69.7	66.0	63.0	59.5	55.9
	W700	70.6	69.6	66.3	63.7	60.8	57.8
	W702	73.6	70.8	67.2	64.5	61.2	57.8
	W704	68.5	67.5	65.2	63.1	60.8	58.3
	W708	74.5	70.4	67.3	64.8	61.8	58.6
	W710	77.1	76.3	74.4	72.6	70.6	68.4
	W712	75.3	69.6	65.7	62.8	59.3	56.8
	W714	69.2	73.2	71.5	69.1	67.9	66.6
	W716	71.9	71.0	68.9	66.9	64.6	62.2
	W718	72.3	68.8	65.3	62.8	59.8	56.9
	W720	68.5	67.5	65.3	63.2	60.8	58.3
	W722	71.8	71.3	69.5	67.6	65.6	63.4
	W724	72.4	69.9	67.3	65.1	62.7	59.9
	W726	68.5	70.9	68.3	67.1	65.8	63.8
	W728	74.5	73.6	71.6	69.7	67.6	65.3
	W730	73.7	71.8	70.5	68.8	67.0	64.9
	W732	70.6	76.6	77.4	76.4	75.3	74.1
Falk Run	W670	74.3	72.8	70.6	68.3	65.5	62.7
	W672	72.5	69.4	66.1	63.5	60.5	57.4
Goodban Run	W668	73.7	73.5	72.3	70.4	68.3	66.0
Halls Run	W648	73.4	72.5	70.5	68.5	66.3	64.0
	W688	73.7	74.4	73.6	72.7	71.9	70.9
	W690	73.6	71.0	68.6	66.4	63.8	61.1
Lamson Run	W634	73.1	69.1	65.2	62.1	58.5	55.0
	W636	88.2	87.7	86.6	85.5	84.2	82.8

Hydrologic Parameters for Lake Erie Tributaries Central 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
Lamson Run	W656	68.0	69.6	66.2	63.4	60.2	57.0
	W658	70.5	68.4	64.4	61.3	57.7	54.2
	W660	72.4	68.9	65.0	62.2	58.9	55.6
Little Elk Creek	W642	71.6	70.7	68.5	66.6	64.3	61.9
	W644	72.2	71.3	69.2	67.2	64.9	62.5
	W646	73.3	74.3	72.9	71.6	70.1	68.0
	W674	73.4	71.8	69.5	67.1	64.3	61.4
	W676	72.9	70.8	68.4	66.0	63.3	60.6
	W678	71.9	71.2	68.8	66.6	64.1	61.5
	W680	72.7	71.5	69.2	67.0	64.5	61.7
Porter Run	W666	73.5	71.7	69.3	66.9	64.2	61.3
Trout Run	W614	72.8	76.4	77.8	77.5	77.1	76.6
	W616	74.8	76.6	79.1	79.3	79.5	79.5
Unnamed Tributary to Lake Erie	W610	71.1	74.0	72.4	71.8	71.1	70.4
	W612	67.0	70.1	66.6	65.5	64.3	63.2
	W618	67.2	75.7	78.1	78.1	78.0	77.7
	W620	71.2	73.4	73.4	73.3	73.2	72.7
	W622	74.7	73.8	73.1	72.1	71.0	70.0
	W624	72.0	73.0	73.0	71.9	71.2	70.3
	W626	70.1	80.3	79.1	78.7	78.4	77.8
	W628	70.9	70.0	69.2	68.8	68.5	65.8
	W630	79.0	78.2	77.6	77.3	77.0	76.1
	W632	74.6	73.8	73.1	72.7	72.4	71.4
	W734	68.9	73.6	72.5	70.8	68.9	67.2
	W750	67.8	70.4	67.3	64.9	62.0	59.6
	W752	70.3	66.6	60.5	57.1	53.1	49.8
	W754	73.5	67.7	62.4	59.3	55.7	53.8

Hydrologic Results for Lake Erie Tributaries Central HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	Lake-Unnamed 10	1286667.1	701165.0	0.88	78	166	234	293	358	78	166	235	293	358
2	Lake-Unnamed 9	1285685.4	700457.6	0.92	77	163	240	304	379	78	165	242	308	383
3	J1846	1284060.1	692458.6	4.33	275	646	882	1,085	1,301	289	669	910	1,118	1,339
4	Lake-Trout Run	1283592.8	699566.4	7.02	459	1,091	1,498	1,854	2,233	476	1,121	1,536	1,898	2,284
5	Lake-Unnamed 8	1276706.4	695951.0	1.10	89	222	306	378	456	90	224	308	381	459
6	J1862	1280016.0	683875.2	1.33	110	265	380	483	591	115	272	390	494	604
7	J1852	1276898.8	682817.6	1.77	108	275	401	512	632	114	286	414	527	648
8	J1854	1272793.2	681418.4	2.92	152	397	589	782	989	176	433	630	835	1,053
9	Lake-Unnamed 7	1272525.3	693958.9	6.65	418	889	1,231	1,528	1,840	444	931	1,283	1,587	1,906
10	Lake-Unnamed 6	1265309.1	690586.2	0.56	50	129	191	246	280	50	129	191	246	280
11	J1856	1264269.8	686577.7	0.77	100	205	282	348	414	106	214	292	360	427
12	Lake-Unnamed 5	1260498.7	689285.9	1.26	134	282	393	491	589	141	293	407	506	607
13	J1858	1317686.4	669826.0	2.08	131	275	360	397	434	135	280	367	404	442
14	EP112	1283876.6	648311.7	0.85	51	115	156	185	215	52	115	156	185	215
15	J1850	1283744.4	678072.9	0.31	7	33	53	73	101	7	33	53	72	100
16	J1550	1318516.8	659231.6	3.21	189	398	527	594	666	192	404	533	602	674
17	J1544	1317582.2	669905.6	7.94	400	813	1,073	1,198	1,354	405	822	1,084	1,211	1,372
18	J1008	1295261.5	659193.4	4.15	220	459	601	690	783	222	462	604	694	787
19	J1536	1279042.8	649639.8	6.34	355	758	1,003	1,158	1,320	355	760	1,005	1,160	1,323
20	J1542	1279854.4	658124.9	12.78	687	1,454	1,943	2,283	2,621	690	1,458	1,949	2,290	2,628
21	J1556	1279362.6	663314.3	15.85	823	1,752	2,368	2,790	3,212	827	1,759	2,376	2,799	3,223
22	J_Little Elk	1282012.4	669858.1	19.71	970	2,095	2,848	3,366	3,885	976	2,106	2,862	3,381	3,903
23	J1600	1283169.6	677377.2	3.55	259	570	801	1,004	1,233	293	626	869	1,083	1,323
24	USGS 04213075	1277752.7	675182.2	4.48	281	622	879	1,107	1,365	318	684	955	1,194	1,464
25	J1548	1270582.4	659034.8	2.41	173	377	516	626	746	174	379	518	628	748
26	J1848	1269085.5	674950.8	0.79	47	120	168	200	234	54	133	185	221	257
27	J1566	1341291.2	673668.5	5.07	202	354	371	401	490	208	364	381	412	505
28	J1582	1333371.8	678587.4	9.91	446	846	1,013	1,112	1,263	459	868	1,038	1,141	1,297
29	J1596	1328944.8	679866.3	11.48	505	964	1,172	1,295	1,466	519	987	1,199	1,326	1,502
30	J1598	1322796.2	679349.8	16.41	724	1,423	1,800	2,017	2,258	761	1,485	1,878	2,109	2,361
31	J1574	1322574.9	679276.0	18.51	823	1,649	2,116	2,388	2,679	863	1,719	2,204	2,491	2,796
32	J1860	1315934.4	676373.9	29.19	1,242	2,557	3,334	3,772	4,217	1,294	2,649	3,456	3,914	4,376
33	J1590	1314704.7	676988.7	30.36	1,284	2,652	3,471	3,932	4,402	1,345	2,752	3,603	4,083	4,573
34	J1592	1309908.8	678021.7	33.07	1,365	2,810	3,687	4,171	4,682	1,430	2,919	3,828	4,333	4,873

Hydrologic Results for Lake Erie Tributaries Central HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J1580	1300194.0	674750.7	39.70	1,648	3,414	4,533	5,210	5,923	1,722	3,542	4,702	5,406	6,155
36	J1578	1297021.3	672783.1	44.25	1,791	3,718	4,957	5,719	6,518	1,867	3,853	5,137	5,927	6,760
37	J1552	1292618.9	672438.8	49.23	1,973	4,126	5,528	6,417	7,345	2,052	4,269	5,724	6,641	7,604
38	J1572	1290159.5	670200.7	55.80	2,213	4,638	6,217	7,222	8,271	2,294	4,790	6,421	7,454	8,539
39	J_Elk ab Little Elk	1282354.5	670579.3	57.47	2,230	4,648	6,230	7,237	8,298	2,311	4,796	6,428	7,467	8,563
40	J1560	1282018.7	670323.7	77.18	2,923	6,073	8,239	9,660	11,154	3,014	6,242	8,472	9,932	11,466
41	J1576	1276632.6	673471.7	83.10	3,031	6,314	8,556	10,075	11,687	3,126	6,481	8,786	10,342	11,991
42	J1584	1269918.3	675144.2	90.51	3,178	6,608	8,965	10,596	12,334	3,274	6,778	9,199	10,870	12,646
43	J1588	1269082.1	675463.9	91.67	3,162	6,585	8,922	10,539	12,266	3,257	6,752	9,151	10,806	12,571
44	J1594	1261079.3	680908.8	94.25	3,190	6,631	8,965	10,583	12,319	3,285	6,795	9,189	10,845	12,618
45	Lake-Elk Ck	1256465.2	687859.5	98.20	3,275	6,801	9,178	10,846	12,646	3,370	6,963	9,398	11,101	12,938
46	Lake-Unnamed 4	1248718.0	684342.5	2.02	103	224	297	352	416	103	224	298	352	417
47	EP010	1250052.1	666173.3	3.11	137	244	250	291	362	143	254	261	304	377
48	EP073	1256299.5	658598.6	4.59	220	420	532	567	644	222	423	536	571	649
49	J1558	1250980.6	669143.1	12.64	589	1,165	1,464	1,673	1,995	596	1,177	1,478	1,690	2,015
50	J1632	1248152.3	670397.5	15.02	702	1,376	1,740	1,985	2,357	711	1,390	1,756	2,003	2,379
51	J1570	1248373.6	672217.4	17.13	782	1,522	1,921	2,177	2,581	792	1,537	1,939	2,198	2,606
52	Lake-Crooked Ck	1238167.0	681342.0	20.48	890	1,731	2,195	2,516	2,991	901	1,749	2,217	2,541	3,020
53	Lake-Unnamed 3	1237748.9	681096.0	1.01	44	91	121	139	162	44	91	121	139	162
54	Lake-Unnamed 2	1232534.9	678513.6	2.04	54	96	125	134	150	55	97	127	136	152
55	Lake-Unnamed 1	1231428.1	678095.5	1.20	44	82	109	120	148	45	84	112	123	151

Hydrologic Parameters for Lake Erie Tributaries East HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Bear Run	W590	3.04	72.3	149.3	72.9	146.8
Belson Creek	W284	6.64	71.7	192.3	71.7	192.3
Eightmile Creek	W344	3.92	74.2	179.6	74.3	179.2
	W346	0.20	73.2	35.9	73.2	35.9
Elliotts Run	W348	3.59	74.1	200.0	74.1	199.8
Fourmile Creek	W396	1.00	73.2	83.9	73.3	83.8
	W398	1.30	74.9	78.6	77.5	73.0
	W400	1.19	76.5	66.1	78.0	63.2
	W402	4.27	74.4	87.3	74.6	86.9
	W404	1.71	71.6	79.3	71.6	79.3
	W406	0.06	70.9	11.7	70.9	7.8
	W408	0.19	68.5	18.1	68.5	18.1
	W410	1.75	79.6	93.7	79.6	93.7
	W412	0.16	87.1	35.0	87.1	23.3
	W414	0.16	88.3	23.8	88.3	23.8
Mill Creek	W430	1.36	70.2	85.6	72.6	80.2
	W432	0.00	95.5	1.5	95.5	1.5
	W434	1.10	77.0	49.4	77.8	48.1
	W436	0.90	84.3	55.3	84.4	36.8
	W438	3.19	74.5	123.0	75.0	121.2
	W440	0.65	79.5	35.6	80.0	35.0
	W442	1.44	75.4	57.9	77.6	54.2
	W444	0.69	81.0	36.9	81.1	36.7
	W446	2.34	84.4	109.9	84.4	109.9
Scott Run	W342	2.77	73.1	193.7	73.2	193.4
Sevenmile Creek	W350	0.79	72.6	73.5	73.2	72.4
	W352	3.78	75.0	154.4	75.8	150.5
	W354	0.67	77.0	79.2	77.5	78.1
Sixmile Creek	W356	1.23	74.2	71.2	74.4	70.9
	W358	1.17	72.3	69.4	72.4	69.1
	W360	0.82	72.9	70.3	73.2	69.7
	W362	0.87	74.0	74.2	74.4	73.5
	W364	1.90	73.1	86.9	73.4	86.1
	W366	1.13	74.1	74.0	75.1	72.0
	W368	0.82	77.1	60.8	79.7	56.2
	W370	0.88	75.0	131.6	80.5	111.5
	W372	1.79	70.5	168.1	70.6	111.9
	W374	1.16	72.6	60.7	72.7	60.5
	W376	2.14	71.0	74.9	71.3	74.2
	W378	0.12	74.5	22.1	74.5	22.1
	W380	1.54	72.3	81.6	72.7	80.7
	W382	0.50	72.2	29.8	73.2	28.9
	W384	0.69	72.9	48.6	73.4	48.0
	W386	1.42	74.8	125.5	75.9	121.4

Hydrologic Parameters for Lake Erie Tributaries East HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Sixmile Creek	W388	0.62	68.7	109.1	72.3	98.9
Sixteenmile Creek	W304	1.52	74.7	83.9	74.8	83.7
	W306	0.25	74.4	29.5	74.4	29.5
	W308	3.67	73.1	121.6	73.4	120.6
	W310	2.51	78.8	129.0	78.8	129.0
	W312	2.88	72.4	114.3	72.5	114.1
	W314	0.75	74.5	44.2	74.7	44.0
	W316	2.00	77.1	68.9	77.3	68.5
	W318	3.68	76.6	128.5	77.1	126.5
	W320	1.57	72.2	104.2	72.3	103.8
Twelvemile Creek	W322	0.82	74.0	71.9	74.0	71.8
	W324	2.75	74.2	162.8	74.3	162.2
	W326	0.64	74.5	76.5	74.5	76.5
	W328	2.54	73.1	162.6	73.2	162.4
	W330	4.05	74.1	109.2	74.1	109.1
	W332	1.94	74.7	100.1	74.8	99.9
	W334	0.08	72.9	33.6	72.9	33.6
	W336	0.58	70.4	81.6	70.4	81.6
	W338	0.02	69.1	12.1	69.1	12.1
	W340	0.60	66.4	55.7	66.7	55.4
Twentymile Creek	W286	17.80	70.6	335.2	70.6	223.5
	W288	7.26	70.9	137.6	70.9	137.6
	W290	1.57	67.3	63.4	67.3	63.4
	W292	1.42	71.4	100.7	71.4	100.7
Unnamed Tributary to Lake Erie	W294	1.28	74.6	70.4	74.6	70.4
	W296	1.68	71.1	78.3	71.1	78.2
	W298	1.65	72.5	134.1	72.5	134.1
	W300	2.22	74.0	153.9	74.0	153.9
	W302	2.15	72.5	140.8	72.5	140.7
	W390	0.83	81.5	98.0	82.4	95.4
	W392	1.92	81.1	125.2	81.5	123.5
	W394	0.54	83.0	90.5	83.2	89.7
	W416	1.10	86.0	101.7	86.0	101.7
	W418	1.86	84.9	107.1	84.9	107.1
	W420	0.55	83.3	53.2	83.3	53.2
	W422	1.59	85.8	90.0	86.1	89.3
	W424	0.79	86.7	139.3	86.7	92.9
	W426	1.34	85.7	95.4	85.7	95.4
	W428	1.98	83.5	122.2	83.7	121.6
	W448	0.96	89.3	84.0	89.3	84.0
	W450	1.95	86.2	127.6	86.2	127.6
	W548	1.63	84.0	122.0	84.0	122.0
	W556	0.57	68.6	105.7	68.6	70.4
	W558	1.67	84.5	132.2	84.8	130.9

Hydrologic Parameters for Lake Erie Tributaries East HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Unnamed Tributary to Lake Erie	W560	2.50	85.5	112.4	85.5	112.4
	W562	2.06	84.5	128.4	84.5	128.4
	W564	0.59	77.7	48.1	77.7	48.1
	W566	0.14	82.9	34.7	82.9	34.7
	W568	0.09	89.6	34.5	89.6	34.5
	W570	1.55	78.7	90.7	79.1	89.5
	W572	1.03	78.8	111.1	82.0	100.4
	W574	1.11	81.3	97.6	81.3	97.6
Walnut Creek	W576	2.53	77.0	130.8	77.1	130.1
	W578	1.60	82.7	67.4	83.3	66.1
	W580	3.12	76.9	110.5	77.8	107.5
	W582	2.74	70.4	132.5	70.6	131.5
	W584	0.20	72.8	28.0	74.8	26.4
	W586	0.72	78.4	50.2	80.1	47.7
	W588	0.17	75.4	35.9	76.3	35.0
	W592	2.38	71.6	85.7	72.1	84.5
	W594	2.96	76.9	77.5	77.6	75.8
	W596	2.84	75.5	115.2	76.2	112.7
	W598	4.78	77.8	107.2	79.9	100.6
	W600	2.41	81.3	72.6	82.4	70.2
	W602	2.39	76.1	97.5	77.0	95.1
	W604	0.49	77.1	42.3	77.1	42.3
	W606	2.45	74.2	119.6	74.6	118.4
	W608	2.57	74.0	112.6	74.1	112.3
West Branch Cascade Creek	W546	1.50	86.5	166.8	86.5	111.2
	W550	1.72	85.6	134.1	85.6	89.4
	W552	0.11	79.7	41.6	79.7	27.7
	W554	0.02	70.5	14.2	70.5	9.5

Hydrologic Parameters for Lake Erie Tributaries East 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
Bear Run	W590	72.3	74.4	74.9	74.2	73.5	68.7
Belson Creek	W284	71.7	72.9	71.7	70.1	68.4	66.0
Eightmile Creek	W344	74.2	74.5	73.7	73.7	73.7	72.5
	W346	73.2	68.3	67.4	66.2	64.8	63.1
Elliotts Run	W348	74.1	76.2	76.4	73.8	72.3	71.7
Fourmile Creek	W396	73.2	69.3	66.9	63.5	59.4	57.5
	W398	74.9	68.7	66.1	63.4	60.2	57.3
	W400	76.5	68.5	65.9	63.9	61.7	59.4
	W402	74.4	67.0	63.4	60.7	57.6	56.6
	W404	71.6	68.1	65.0	62.7	59.9	56.1
	W406	70.9	65.8	64.9	63.6	62.2	60.4
	W408	68.5	63.2	62.2	60.9	59.5	57.7
	W410	79.6	71.4	70.8	69.3	67.6	65.1
	W412	87.1	84.2	83.6	82.8	82.0	80.8
	W414	88.3	85.7	85.2	84.4	83.7	82.6
Mill Creek	W430	70.2	74.8	74.2	72.4	70.2	68.3
	W432	95.5	94.4	94.1	93.8	93.5	93.0
	W434	77.0	71.2	70.4	68.6	66.5	65.4
	W436	84.3	81.0	80.3	79.4	78.5	77.1
	W438	74.5	71.0	69.8	68.4	66.9	65.6
	W440	79.5	75.3	74.6	73.5	72.3	70.8
	W442	75.4	70.9	70.1	68.9	67.6	66.6
	W444	81.0	77.1	76.3	75.3	74.2	72.7
	W446	84.4	73.3	73.3	73.2	73.1	73.3
Scott Run	W342	73.1	77.0	76.5	77.8	79.1	78.3
Sevenmile Creek	W350	72.6	67.7	66.6	65.6	64.0	63.4
	W352	75.0	73.5	73.2	72.6	71.9	70.5
	W354	77.0	72.5	71.7	70.6	69.4	67.7
Sixmile Creek	W356	74.2	68.3	63.7	61.4	58.7	55.7
	W358	72.3	68.2	63.6	60.5	56.9	53.9
	W360	72.9	68.0	67.1	65.9	64.5	62.8
	W362	74.0	69.3	68.4	67.2	65.9	64.1
	W364	73.1	69.0	66.9	65.3	63.5	62.0
	W366	74.1	69.7	66.7	63.9	60.5	57.8
	W368	77.1	72.7	71.8	70.7	69.5	67.8
	W370	75.0	70.3	69.4	68.2	66.9	65.2
	W372	70.5	73.7	71.3	68.5	65.6	63.3
	W374	72.6	67.5	62.9	59.7	55.9	53.7
	W376	71.0	67.8	63.0	59.6	55.3	53.9
	W378	74.5	69.7	68.9	67.7	66.4	64.6
	W380	72.3	69.5	66.3	63.3	59.6	56.9
	W382	72.2	67.2	66.3	65.0	63.7	61.9
	W384	72.9	68.0	67.1	65.9	64.6	62.8
	W386	74.8	74.7	74.5	73.2	71.7	69.5

Hydrologic Parameters for Lake Erie Tributaries East 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
Sixmile Creek	W388	68.7	63.4	62.5	61.2	59.8	57.9
Sixteenmile Creek	W304	74.7	67.4	62.1	60.4	58.6	57.0
	W306	74.4	69.7	68.8	67.6	66.3	64.6
	W308	73.1	69.1	65.5	62.6	59.3	57.3
	W310	78.8	72.5	71.3	69.6	67.7	64.8
	W312	72.4	69.5	65.5	62.8	59.8	57.1
	W314	74.5	69.7	68.8	67.6	66.3	64.6
	W316	77.1	68.3	65.0	63.4	61.6	61.1
	W318	76.6	72.4	71.2	69.7	68.1	63.7
	W320	72.2	71.5	71.4	70.2	69.0	67.4
Twelvemile Creek	W322	74.0	69.2	68.3	67.1	65.8	64.1
	W324	74.2	73.6	72.4	71.0	69.6	67.1
	W326	74.5	69.8	68.9	67.7	66.4	64.7
	W328	73.1	74.6	73.1	72.9	72.6	71.1
	W330	74.1	68.0	64.6	61.9	58.6	57.7
	W332	74.7	69.9	69.1	65.8	61.8	59.9
	W334	72.9	68.0	67.1	65.8	64.5	62.7
	W336	70.4	65.3	64.3	63.1	61.7	59.9
	W338	69.1	63.8	62.9	61.6	60.2	58.3
	W340	66.4	61.0	60.0	58.6	57.2	55.4
Twentymile Creek	W286	70.6	74.1	73.0	70.0	67.9	65.5
	W288	70.9	70.1	68.3	66.0	63.4	60.7
	W290	67.3	68.9	66.6	64.5	62.1	59.9
	W292	71.4	74.4	75.8	74.9	73.8	72.6
Unnamed Tributary to Lake Erie	W294	74.6	68.1	65.9	64.3	62.4	60.9
	W296	71.1	69.2	67.5	66.1	64.5	63.0
	W298	72.5	74.9	76.7	76.6	76.5	76.3
	W300	74.0	74.0	75.0	74.0	73.6	72.8
	W302	72.5	74.4	75.9	75.5	75.0	74.6
	W390	81.5	77.7	76.9	76.0	74.9	73.4
	W392	81.1	74.5	76.3	76.3	76.2	75.9
	W394	83.0	79.4	78.7	77.8	76.7	75.3
	W416	86.0	75.0	77.3	77.5	77.8	77.8
	W418	84.9	73.8	75.3	75.1	74.9	74.7
	W420	83.3	79.8	79.1	78.2	77.1	77.4
	W422	85.8	72.9	73.6	73.3	72.9	72.1
	W424	86.7	83.7	83.1	82.4	81.5	80.3
	W426	85.7	73.4	74.8	74.5	74.1	73.9
	W428	83.5	74.7	76.4	76.4	76.4	76.3
	W448	89.3	86.8	86.3	85.7	84.9	83.9
	W450	86.2	75.3	77.5	77.7	77.9	77.9
	W548	84.0	75.0	77.1	77.2	77.3	77.1
	W556	68.6	63.3	62.3	61.0	59.6	57.8
	W558	84.5	75.7	78.2	78.6	78.9	79.1

Hydrologic Parameters for Lake Erie Tributaries East 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
Unnamed Tributary to Lake Erie	W560	85.5	73.6	74.7	74.4	74.1	73.6
	W562	84.5	75.0	76.8	76.8	76.8	76.6
	W564	77.7	73.3	72.5	71.4	70.2	68.6
	W566	82.9	79.3	78.6	77.7	76.6	75.2
	W568	89.6	87.2	86.7	86.1	85.4	84.4
	W570	78.7	72.4	72.9	72.4	71.9	71.4
	W572	78.8	74.8	76.9	77.1	77.3	77.3
	W574	81.3	73.4	74.6	74.3	74.1	73.7
Walnut Creek	W576	77.0	72.7	72.2	71.2	70.2	65.4
	W578	82.7	70.8	68.8	67.8	66.8	66.8
	W580	76.9	71.1	69.2	67.7	66.2	61.9
	W582	70.4	72.8	71.4	69.8	68.7	63.7
	W584	72.8	67.9	67.0	65.8	64.5	62.7
	W586	78.4	74.2	73.4	72.3	71.1	69.5
	W588	75.4	70.8	69.9	68.7	67.5	65.8
	W592	71.6	68.8	66.0	64.2	62.2	56.1
	W594	76.9	68.4	65.5	63.7	61.7	59.9
	W596	75.5	71.0	69.4	68.0	66.5	62.2
	W598	77.8	68.6	64.8	62.6	60.2	59.9
	W600	81.3	70.0	68.3	67.0	65.5	64.9
	W602	76.1	71.3	70.3	69.2	68.1	64.3
	W604	77.1	72.7	71.8	70.7	69.5	67.8
	W606	74.2	73.1	73.3	72.6	71.8	68.1
	W608	74.0	73.3	73.8	73.3	72.7	69.4
West Branch Cascade Creek	W546	86.5	74.3	75.5	76.4	77.3	77.3
	W550	85.6	72.2	72.7	72.6	72.5	71.9
	W552	79.7	75.6	74.8	73.8	72.6	71.1
	W554	70.5	65.3	64.4	63.1	61.8	59.9

Hydrologic Parameters for Lake Erie Tributaries East 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
Bear Run	W590	72.9	75.0	75.4	74.8	74.1	69.4
Belson Creek	W284	71.7	72.9	71.7	70.1	68.4	66.0
Eightmile Creek	W344	74.3	74.6	73.7	73.7	73.7	72.5
	W346	73.2	68.3	67.4	66.2	64.8	63.1
Elliotts Run	W348	74.1	76.2	76.4	73.8	72.3	71.7
Fourmile Creek	W396	73.3	69.4	66.9	63.6	59.5	57.6
	W398	77.5	71.6	69.2	66.6	63.5	60.7
	W400	78.0	70.3	67.8	65.9	63.7	61.4
	W402	74.6	67.2	63.6	60.9	57.8	56.9
	W404	71.6	68.1	65.0	62.7	59.9	56.1
	W406	70.9	65.8	64.9	63.6	62.2	60.4
	W408	68.5	63.2	62.2	60.9	59.5	57.7
	W410	79.6	71.4	70.8	69.3	67.6	65.1
	W412	87.1	84.2	83.6	82.8	82.0	80.8
	W414	88.3	85.7	85.2	84.4	83.7	82.6
Mill Creek	W430	72.6	77.0	76.4	74.7	72.6	70.8
	W432	95.5	94.4	94.1	93.8	93.5	93.0
	W434	77.8	72.2	71.4	69.6	67.6	66.5
	W436	84.4	81.0	80.3	79.5	78.5	77.2
	W438	75.0	71.6	70.4	69.0	67.5	66.2
	W440	80.0	76.0	75.2	74.2	73.0	71.5
	W442	77.6	73.4	72.7	71.5	70.2	69.3
	W444	81.1	77.3	76.5	75.5	74.4	72.9
	W446	84.4	73.3	73.3	73.2	73.1	73.3
Scott Run	W342	73.2	77.1	76.5	77.9	79.1	78.3
Sevenmile Creek	W350	73.2	68.3	67.2	66.2	64.6	64.0
	W352	75.8	74.4	74.1	73.5	72.8	71.4
	W354	77.5	73.1	72.3	71.2	70.0	68.3
Sixmile Creek	W356	74.4	68.5	63.9	61.6	59.0	55.9
	W358	72.4	68.3	63.7	60.7	57.1	54.1
	W360	73.2	68.3	67.4	66.2	64.9	63.1
	W362	74.4	69.6	68.8	67.6	66.3	64.5
	W364	73.4	69.4	67.3	65.7	63.9	62.4
	W366	75.1	70.7	67.8	65.0	61.7	59.0
	W368	79.7	75.6	74.8	73.8	72.6	71.1
	W370	80.5	76.5	75.8	74.7	73.6	72.1
	W372	70.6	73.7	71.4	68.5	65.6	63.4
	W374	72.7	67.7	63.1	59.9	56.0	53.8
	W376	71.3	68.1	63.4	59.9	55.7	54.3
	W378	74.5	69.7	68.9	67.7	66.4	64.6
	W380	72.7	69.9	66.8	63.7	60.0	57.4
	W382	73.2	68.3	67.4	66.2	64.9	63.1
	W384	73.4	68.5	67.6	66.4	65.1	63.3
	W386	75.9	75.8	75.7	74.4	72.9	70.8

Hydrologic Parameters for Lake Erie Tributaries East 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
Sixmile Creek	W388	72.3	67.4	66.5	65.2	63.9	62.1
Sixteenmile Creek	W304	74.8	67.4	62.1	60.5	58.6	57.1
	W306	74.4	69.7	68.8	67.6	66.3	64.6
	W308	73.4	69.5	65.8	63.0	59.6	57.7
	W310	78.8	72.5	71.3	69.6	67.7	64.8
	W312	72.5	69.6	65.5	62.9	59.8	57.2
	W314	74.7	69.9	69.1	67.9	66.6	64.9
	W316	77.3	68.5	65.3	63.7	61.9	61.3
	W318	77.1	73.0	71.8	70.4	68.7	64.4
	W320	72.3	71.6	71.5	70.4	69.1	67.6
Twelvemile Creek	W322	74.0	69.2	68.4	67.2	65.8	64.1
	W324	74.3	73.7	72.5	71.2	69.7	67.2
	W326	74.5	69.8	68.9	67.7	66.4	64.7
	W328	73.2	74.6	73.2	72.9	72.6	71.1
	W330	74.1	68.0	64.7	61.9	58.6	57.8
	W332	74.8	69.9	69.1	65.9	61.9	60.0
	W334	72.9	68.0	67.1	65.8	64.5	62.7
	W336	70.4	65.3	64.3	63.1	61.7	59.9
	W338	69.1	63.8	62.9	61.6	60.2	58.3
	W340	66.7	61.2	60.2	58.9	57.5	55.6
Twentymile Creek	W286	70.6	74.1	73.0	70.0	67.9	65.5
	W288	70.9	70.1	68.3	66.0	63.4	60.7
	W290	67.3	68.9	66.6	64.5	62.1	59.9
	W292	71.4	74.4	75.8	74.9	73.8	72.6
Unnamed Tributary to Lake Erie	W294	74.6	68.1	65.9	64.3	62.4	60.9
	W296	71.1	69.2	67.5	66.1	64.6	63.1
	W298	72.5	74.9	76.7	76.6	76.5	76.3
	W300	74.0	74.0	75.0	74.0	73.6	72.8
	W302	72.5	74.4	75.9	75.5	75.1	74.6
	W390	82.4	78.7	78.0	77.0	75.9	74.5
	W392	81.5	75.1	76.8	76.8	76.7	76.4
	W394	83.2	79.7	79.0	78.1	77.0	75.7
	W416	86.0	75.0	77.3	77.5	77.8	77.8
	W418	84.9	73.8	75.3	75.1	74.9	74.7
	W420	83.3	79.8	79.1	78.2	77.1	77.4
	W422	86.1	73.2	74.0	73.6	73.2	72.4
	W424	86.7	83.7	83.1	82.4	81.5	80.3
	W426	85.7	73.4	74.8	74.5	74.1	73.9
	W428	83.7	74.9	76.6	76.6	76.6	76.5
	W448	89.3	86.8	86.3	85.7	84.9	83.9
	W450	86.2	75.3	77.5	77.7	77.9	77.9
	W548	84.0	75.0	77.1	77.2	77.3	77.1
	W556	68.6	63.3	62.3	61.0	59.6	57.8
	W558	84.8	76.1	78.6	78.9	79.3	79.4

Hydrologic Parameters for Lake Erie Tributaries East 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
Unnamed Tributary to Lake Erie	W560	85.5	73.6	74.7	74.4	74.1	73.6
	W562	84.5	75.0	76.8	76.8	76.8	76.6
	W564	77.7	73.3	72.5	71.4	70.2	68.6
	W566	82.9	79.3	78.6	77.7	76.6	75.2
	W568	89.6	87.2	86.7	86.1	85.4	84.4
	W570	79.1	72.9	73.3	72.9	72.4	71.9
	W572	82.0	78.5	80.4	80.5	80.7	80.7
	W574	81.3	73.4	74.6	74.3	74.1	73.7
Walnut Creek	W576	77.1	72.9	72.5	71.5	70.4	65.6
	W578	83.3	71.6	69.6	68.7	67.6	67.6
	W580	77.8	72.1	70.3	68.9	67.3	63.1
	W582	70.6	73.1	71.7	70.1	69.0	64.0
	W584	74.8	70.1	69.2	68.0	66.8	65.1
	W586	80.1	76.1	75.3	74.3	73.1	71.6
	W588	76.3	71.8	70.9	69.8	68.5	66.9
	W592	72.1	69.3	66.5	64.8	62.8	56.8
	W594	77.6	69.3	66.4	64.7	62.7	60.9
	W596	76.2	71.9	70.3	68.9	67.4	63.2
	W598	79.9	71.2	67.6	65.5	63.1	62.8
	W600	82.4	71.4	69.8	68.5	67.1	66.5
	W602	77.0	72.3	71.3	70.3	69.1	65.4
	W604	77.1	72.7	71.8	70.7	69.5	67.8
	W606	74.6	73.5	73.7	73.0	72.2	68.5
	W608	74.1	73.4	73.9	73.3	72.8	69.5
West Branch Cascade Creek	W546	86.5	74.3	75.5	76.4	77.3	77.3
	W550	85.6	72.2	72.7	72.6	72.5	71.9
	W552	79.7	75.6	74.8	73.8	72.6	71.1
	W554	70.5	65.3	64.4	63.1	61.8	59.9

Hydrologic Results for Lake Erie Tributaries East HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J1684	1438193.0	750181.6	17.80	704	1,477	1,829	2,163	2,480	704	1,477	1,829	2,163	2,480
2	J1688	1431970.7	757289.4	31.70	1,064	2,251	2,903	3,454	3,984	1,064	2,251	2,903	3,454	3,984
3	J1696	1423662.5	758391.5	33.27	1,087	2,297	2,966	3,528	4,071	1,087	2,297	2,966	3,528	4,071
4	Lake-Twentymile Ck	1418247.0	770742.5	34.69	1,115	2,357	3,048	3,627	4,188	1,115	2,357	3,048	3,627	4,188
5	J1692	1423525.3	753609.8	1.28	89	219	314	385	474	89	219	314	385	474
6	J1694	1418591.3	758273.2	2.96	208	508	726	896	1,097	209	509	727	897	1,099
7	Lake-Unnamed 33	1413328.1	767717.4	4.61	341	842	1,189	1,467	1,787	342	843	1,190	1,469	1,789
8	Lake-Unnamed 32	1409909.5	765331.8	2.22	154	373	507	631	763	154	374	507	631	763
9	Lake-Unnamed 31	1405974.4	763339.6	2.15	164	407	561	695	843	164	407	562	695	844
10	J1652	1412639.5	742655.7	4.65	172	349	503	613	749	174	351	507	617	754
11	J1682	1410647.3	742286.8	9.07	393	813	1,102	1,279	1,563	402	829	1,122	1,301	1,588
12	J1686	1401522.8	750452.2	11.07	461	946	1,275	1,489	1,829	472	964	1,297	1,514	1,859
13	J1690	1399702.8	754362.7	17.26	870	1,857	2,510	2,962	3,388	895	1,900	2,563	3,023	3,458
14	Lake-Sixteenmile Ck	1404793.9	763241.2	18.83	942	2,031	2,756	3,286	3,787	969	2,077	2,814	3,359	3,870
15	J1620	1393185.3	746443.3	0.64	50	128	182	226	270	50	128	182	226	270
16	J1678	1398596.1	737146.6	4.05	205	454	606	683	890	206	455	608	685	892
17	EP057	1390709.0	744418.8	5.99	312	709	926	1,028	1,310	313	712	929	1,031	1,314
18	J1622	1389373.2	744918.4	6.89	349	797	1,047	1,174	1,484	350	800	1,050	1,178	1,489
19	J1674	1383273.8	747181.1	10.22	541	1,221	1,628	1,879	2,293	545	1,228	1,637	1,890	2,305
20	J1618	1383275.2	748065.1	13.42	767	1,717	2,334	2,765	3,339	772	1,726	2,344	2,778	3,353
21	Lake-Twelvemile Ck	1382044.1	752542.7	14.02	776	1,741	2,368	2,808	3,391	781	1,750	2,379	2,821	3,406
22	J1680	1372649.0	745459.5	6.69	455	963	1,400	1,794	2,124	458	968	1,406	1,801	2,132
23	Lake-Eightmile Ck	1369132.0	745385.7	6.89	459	971	1,410	1,806	2,138	461	976	1,416	1,814	2,147
24	EO009	1381295.8	725407.5	0.79	51	138	203	252	322	55	146	214	264	336
25	J1676	1367976.1	741278.4	8.16	525	1,207	1,618	1,977	2,386	551	1,251	1,673	2,040	2,458
26	Lake-Sevenmile Ck	1364041.0	742434.4	8.83	552	1,264	1,697	2,075	2,504	579	1,311	1,755	2,142	2,580
27	J1638	1381822.7	708371.2	3.02	154	308	399	459	530	155	310	402	462	534
28	J1644	1382388.4	713413.0	5.35	272	548	733	828	959	277	556	742	839	972
29	J1658	1380543.8	719783.0	8.31	436	913	1,219	1,369	1,640	447	932	1,243	1,395	1,671
30	J1662	1378404.1	720176.5	9.30	496	1,066	1,434	1,633	1,959	509	1,088	1,463	1,665	1,997
31	J1664	1371862.0	720545.4	12.74	679	1,480	2,003	2,301	2,771	699	1,515	2,047	2,352	2,832
32	J1668	1369107.4	723890.2	14.37	741	1,611	2,178	2,504	3,010	766	1,652	2,231	2,564	3,082
33	J1670	1364606.7	730456.9	15.88	789	1,709	2,313	2,670	3,210	818	1,755	2,370	2,734	3,284
34	J1672	1362393.2	739089.5	18.18	919	1,999	2,713	3,170	3,814	971	2,072	2,799	3,269	3,930

Hydrologic Results for Lake Erie Tributaries East HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	Lake-Sixmile Ck	1362762.1	741573.6	18.80	933	2,038	2,771	3,244	3,907	990	2,120	2,866	3,355	4,036
36	Lake-Unnamed 30	1358507.3	738671.4	0.83	108	220	293	353	414	118	236	313	375	439
37	Lake-Unnamed 29	1355088.6	736556.3	1.92	162	408	569	710	862	171	423	587	731	886
38	Lake-Unnamed 28	1354462.7	736578.8	0.54	84	166	219	262	306	87	169	223	267	311
39	J1000	1362786.7	707914.6	4.27	225	507	692	791	1,037	231	518	705	807	1,056
40	J1650	1361089.7	715159.2	6.98	385	867	1,170	1,332	1,651	392	879	1,186	1,350	1,673
41	J1654	1361655.3	716757.9	8.34	466	1,053	1,418	1,613	1,970	495	1,098	1,474	1,678	2,044
42	J1656	1360401.0	719758.4	9.72	530	1,192	1,610	1,843	2,239	570	1,255	1,688	1,933	2,340
43	EP042	1352977.2	730650.0	11.47	628	1,414	1,914	2,213	2,673	671	1,487	2,005	2,318	2,799
44	J1864	1352233.4	731934.9	11.63	635	1,425	1,929	2,230	2,690	678	1,499	2,020	2,336	2,820
45	Lake-Fourmile Ck	1350415.7	734318.2	11.79	642	1,436	1,943	2,246	2,708	685	1,510	2,034	2,352	2,838
46	Lake-Unnamed 27	1349906.9	733727.3	1.10	113	288	404	507	616	113	288	404	507	616
47	Lake-Unnamed 26	1347193.8	732178.5	1.86	166	422	592	740	905	166	422	592	740	905
48	Lake-Unnamed 25	1345566.3	731141.6	0.55	132	258	340	406	499	132	258	340	406	499
49	Lake-Unnamed 24	1343627.7	730211.0	1.59	149	376	532	667	806	154	386	544	680	822
50	Lake-Unnamed 23	1341045.3	729153.4	0.79	118	212	273	323	374	118	212	273	323	374
51	Lake-Unnamed 22	1340364.4	729334.5	1.34	126	324	453	566	694	126	324	453	566	694
52	Lake-Unnamed 21	1338192.3	730014.2	1.98	172	431	602	753	917	175	436	609	761	926
53	J1878	1341571.8	705995.6	1.10	136	337	457	544	668	153	366	493	586	716
54	J1876	1350415.7	713610.0	1.36	156	346	453	529	617	195	409	530	617	718
55	J1624	1350391.1	713462.2	4.55	333	766	1,042	1,254	1,500	373	830	1,120	1,343	1,601
56	J1870	1347607.7	711687.1	5.20	364	826	1,121	1,348	1,610	407	896	1,207	1,446	1,721
57	J1628	1339495.8	708641.7	8.64	642	1,417	1,943	2,361	2,857	712	1,543	2,100	2,541	3,094
58	USGS 04213200	1337257.7	712313.9	9.33	701	1,538	2,107	2,562	3,099	774	1,669	2,271	2,752	3,336
59	Lake-Mill Ck	1336544.5	728932.1	11.67	875	1,990	2,760	3,393	4,145	947	2,123	2,926	3,584	4,382
60	Lake-Unnamed 20	1332437.2	725562.6	0.96	253	434	549	643	740	253	434	549	643	740
61	Lake-Unnamed 19	1330395.9	724062.4	1.95	173	434	605	756	919	173	434	605	756	919
62	J1660	1326436.2	719487.8	3.22	209	516	751	964	1,177	209	516	751	964	1,177
63	J1666	1328157.8	722635.9	4.96	344	855	1,231	1,566	1,910	344	855	1,231	1,566	1,910
64	Lake-WB Cascade Ck	1327395.4	722931.0	4.98	345	856	1,232	1,567	1,911	345	856	1,232	1,567	1,911
65	Lake-Unnamed 18	1323324.2	721092.0	0.57	17	54	82	106	129	17	54	82	106	129
66	Lake-Unnamed 17	1318738.2	718922.2	1.67	148	373	521	653	794	154	383	533	666	809
67	Lake-Unnamed 16	1313229.0	715970.8	2.50	211	530	743	927	1,128	211	530	743	927	1,128
68	Lake-Unnamed 15	1309823.9	713563.9	2.06	176	439	612	764	929	176	439	612	764	929

Hydrologic Results for Lake Erie Tributaries East HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
69	J1874	1308555.5	705285.1	0.14	45	88	116	139	162	45	88	116	139	162
70	J1866	1307683.4	704797.2	0.23	69	132	175	209	245	69	132	175	209	245
71	Lake-Unnamed 14	1302421.5	709786.4	0.59	91	210	290	355	420	91	210	290	355	420
72	Lake-Unnamed 13	1301669.7	709330.4	1.78	201	467	648	802	970	209	482	667	824	996
73	Lake-Unnamed 12	1299382.4	707707.1	1.03	97	247	347	435	530	139	316	429	528	635
74	Lake-Unnamed 11	1298767.5	707412.0	1.11	102	260	367	459	562	102	260	367	459	562
75	J1614	1313573.3	691474.8	5.27	368	837	1,147	1,415	1,448	378	853	1,167	1,438	1,474
76	J1868	1309847.8	693525.5	0.72	116	262	358	437	516	142	303	409	494	581
77	J1562	1351989.7	692311.0	2.38	154	353	499	608	566	165	373	525	638	597
78	J1630	1347980.9	701632.3	5.34	272	609	867	1,063	1,114	292	645	913	1,117	1,173
79	J1606	1339053.1	699000.7	8.18	385	860	1,226	1,513	1,679	412	909	1,293	1,593	1,783
80	J1872	1331281.3	703304.7	14.56	616	1,322	1,865	2,282	2,746	696	1,454	2,031	2,476	2,969
81	J1568	1322993.0	697598.8	20.09	802	1,748	2,488	3,054	3,693	915	2,009	2,844	3,470	4,186
82	J1626	1312786.3	694450.8	27.95	1,172	2,614	3,760	4,710	5,506	1,336	2,904	4,200	5,215	6,082
83	J1586	1311138.5	695951.0	29.33	1,186	2,654	3,795	4,749	5,543	1,349	2,939	4,216	5,234	6,100
84	J_Bear_Run	1297791.9	694917.8	3.04	223	521	717	884	913	236	544	746	916	950
85	J1564	1297390.2	695287.0	34.82	1,385	3,096	4,414	5,548	6,493	1,552	3,387	4,852	6,104	7,108
86	Lake-Walnut Ck	1292668.1	705764.2	37.39	1,443	3,226	4,597	5,786	6,770	1,609	3,517	5,036	6,338	7,398

Hydrologic Parameters for French Creek D HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Alder Bottom Creek	W128	10.78	70.3	142.3	70.3	142.3
Alder Brook	W152	3.34	68.9	116.9	69.0	116.8
	W153	1.22	71.6	78.9	71.7	87.4
	W154	2.02	70.1	132.9	70.2	120.5
Alder Run	W130	1.01	72.3	67.7	72.3	75.2
	W131	3.88	58.4	111.2	58.4	123.5
	W175	2.33	69.7	89.2	69.7	89.2
Bailey Brook	W151	4.46	70.9	131.5	71.0	146.1
Darrow Brook	W144	0.90	66.3	67.4	66.5	66.9
	W145	0.08	67.6	38.0	67.6	38.0
	W146	4.60	67.4	103.8	67.4	129.6
	W160	0.83	70.0	63.9	70.0	71.0
French Creek	W129	4.16	70.1	94.1	70.1	104.4
	W170	1.80	71.1	71.9	71.2	79.8
	W171	3.19	70.8	106.2	70.9	106.1
	W176	3.10	73.2	88.4	73.2	98.2
	W177	1.82	71.4	98.1	71.4	98.1
	W178	1.52	72.9	71.0	73.0	70.9
	W179	2.10	71.1	108.9	71.2	108.7
	W180	20.30	70.8	268.0	70.8	243.6
	W181	6.39	69.5	196.9	69.5	179.0
	W182	22.56	71.5	277.1	71.5	213.1
	W183	23.12	68.6	280.5	68.6	233.8
	W184	4.47	66.9	129.3	66.9	117.5
	W185	0.32	68.0	44.9	68.0	44.9
	W186	2.03	71.8	85.7	71.8	71.4
	W187	2.97	70.2	98.5	70.2	123.1
	W188	0.29	60.5	77.7	60.6	155.1
	W189	0.02	73.4	28.2	73.4	47.0
	W190	3.75	66.4	93.1	66.4	116.3
	W191	0.35	67.3	46.2	67.3	57.7
	W192	0.08	63.8	48.0	63.8	59.9
	W193	0.25	65.2	47.4	65.2	59.3
	W194	1.75	70.7	74.8	70.7	74.7
	W195	0.05	67.8	20.7	67.8	20.7
	W196	0.79	70.1	73.3	70.1	66.6
	W197	0.45	67.5	40.7	67.5	45.3
	W198	3.67	72.1	133.5	72.1	102.5
	W199	0.79	71.6	37.3	71.6	41.4
Hubbel Run	W132	1.36	71.7	86.7	71.8	96.3
	W133	3.43	62.6	94.4	62.6	104.8
	W134	1.43	70.3	65.8	70.4	73.0
	W135	2.14	69.0	159.6	69.0	106.4
	W136	0.02	70.1	68.0	70.1	45.4

Hydrologic Parameters for French Creek D HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Lake Pleasant Outlet	W172	2.64	70.3	63.5	70.3	70.4
	W173	2.22	66.5	107.1	66.5	89.1
	W174	2.09	68.1	119.7	68.2	108.7
Townley Run	W148	4.75	71.8	157.5	71.8	157.3
West Branch French Creek	W137	1.12	81.0	87.7	81.1	58.4
	W138	0.58	72.2	77.4	72.2	51.5
	W139	1.21	71.6	114.2	71.6	87.8
	W140	1.61	71.7	116.4	71.7	97.0
	W141	0.61	72.1	83.8	72.1	55.8
	W142	0.01	93.6	6.9	93.6	4.6
	W143	0.02	83.5	8.3	83.5	5.5
	W147	2.20	73.0	121.2	73.0	121.1
	W149	1.10	71.0	74.0	71.1	92.3
	W150	0.08	64.8	68.2	64.8	68.2
	W155	2.91	72.3	100.4	72.3	111.5
	W156	21.15	71.7	250.6	71.7	227.8
	W157	0.98	71.5	67.3	71.5	74.7
	W158	0.64	65.6	85.7	65.6	95.2
	W159	1.47	71.4	106.0	71.4	105.9
	W161	3.83	70.5	143.1	70.5	143.1
	W162	4.79	69.2	220.3	69.3	219.7
	W163	0.97	71.8	76.3	71.9	76.2
	W164	0.12	70.7	76.3	70.7	36.3
	W165	2.61	67.7	188.5	67.7	157.0
	W166	2.79	67.0	150.4	67.1	136.5
	W167	0.13	66.3	48.0	66.3	53.3
	W168	4.24	68.5	156.7	68.5	142.4
	W169	0.32	65.9	64.9	65.9	54.1

Hydrologic Parameters for French Creek D 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
Alder Bottom Creek	W128	70.3	68.4	61.7	59.0	55.9	51.5
Alder Brook	W152	68.9	73.7	68.3	67.3	66.2	63.0
	W153	71.6	71.6	71.0	70.0	69.0	65.9
	W154	70.1	70.1	69.5	68.5	67.4	64.3
Alder Run	W130	72.3	60.8	60.3	60.0	59.6	57.0
	W131	58.4	45.5	45.0	44.6	44.2	41.6
	W175	69.7	67.8	53.3	51.3	49.2	49.2
Bailey Brook	W151	70.9	70.9	70.3	69.4	68.3	65.2
Darrow Brook	W144	66.3	65.8	62.7	61.2	59.7	57.6
	W145	67.6	67.1	64.1	62.7	61.2	59.1
	W146	67.4	77.3	75.8	73.7	71.1	70.7
	W160	70.0	69.5	66.6	65.2	63.8	61.7
French Creek	W129	70.1	71.9	66.3	60.5	55.7	54.3
	W170	71.1	59.4	58.9	58.6	58.2	56.9
	W171	70.8	59.1	58.6	58.2	57.8	56.6
	W176	73.2	78.5	63.4	62.7	61.9	59.4
	W177	71.4	80.6	66.5	65.7	64.8	60.4
	W178	72.9	79.5	65.7	64.7	63.7	59.9
	W179	71.1	78.5	62.0	60.8	59.4	56.9
	W180	70.8	76.1	70.2	66.3	61.3	56.6
	W181	69.5	75.7	68.9	64.9	59.8	55.0
	W182	71.5	77.2	70.9	67.0	62.0	57.3
	W183	68.6	75.2	67.9	63.9	58.7	53.9
	W184	66.9	74.4	66.2	59.9	56.8	52.0
	W185	68.0	67.5	64.5	63.0	61.6	59.5
	W186	71.8	72.1	69.9	66.6	62.4	57.7
	W187	70.2	58.3	57.8	57.5	57.1	54.4
	W188	60.5	60.0	56.7	55.2	53.6	51.4
	W189	73.4	73.0	70.2	68.9	67.6	65.6
	W190	66.4	54.0	53.5	53.1	52.7	51.4
	W191	67.3	66.8	63.8	62.3	60.9	58.7
	W192	63.8	63.2	60.1	58.5	57.0	54.9
	W193	65.2	64.6	61.5	60.0	58.5	56.4
	W194	70.7	58.9	58.4	58.0	57.7	56.4
	W195	67.8	67.3	64.3	62.8	61.3	59.2
	W196	70.1	69.6	66.7	65.3	63.9	61.8
	W197	67.5	67.0	64.0	62.5	61.1	59.0
	W198	72.1	76.9	59.1	58.3	57.5	55.3
	W199	71.6	71.2	68.3	67.0	65.6	63.6
Hubbel Run	W132	71.7	60.1	59.7	59.3	58.9	56.3
	W133	62.6	49.9	49.4	49.0	48.6	45.9
	W134	70.3	58.5	58.0	57.6	57.2	54.6
	W135	69.0	57.0	56.5	56.1	55.7	53.0
	W136	70.1	69.6	66.7	65.3	63.9	61.8

Hydrologic Parameters for French Creek D 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
Lake Pleasant Outlet	W172	70.3	58.4	57.9	57.6	57.2	55.9
	W173	66.5	54.1	53.6	53.2	52.8	51.5
	W174	68.1	55.9	55.5	55.1	54.7	53.4
Townley Run	W148	71.8	80.7	79.4	77.5	75.2	74.8
West Branch French Creek	W137	81.0	80.7	78.5	77.4	76.3	74.7
	W138	72.2	71.7	68.9	67.6	66.2	64.2
	W139	71.6	80.6	79.3	77.4	75.1	74.7
	W140	71.7	80.7	79.4	77.5	75.2	74.8
	W141	72.1	71.6	68.8	67.4	66.1	64.1
	W142	93.6	93.5	92.6	92.2	91.8	91.1
	W143	83.5	83.2	81.2	80.2	79.2	77.7
	W147	73.0	81.7	80.4	78.6	76.3	75.9
	W149	71.0	71.0	70.4	71.6	73.4	69.7
	W150	64.8	64.2	61.1	59.6	58.1	55.9
	W155	72.3	72.3	71.7	70.8	69.8	66.7
	W156	71.7	80.7	79.4	77.9	76.1	75.2
	W157	71.5	71.1	68.2	66.8	65.5	63.4
	W158	65.6	65.1	62.0	60.5	59.0	56.8
	W159	71.4	80.5	79.1	77.6	75.9	74.9
	W161	70.5	79.8	78.4	76.9	75.1	74.1
	W162	69.2	78.7	77.3	75.7	73.9	72.8
	W163	71.8	71.4	68.6	67.2	65.8	63.8
	W164	70.7	70.2	67.3	65.9	64.5	62.4
	W165	67.7	72.5	70.3	68.4	67.1	65.0
	W166	67.0	69.7	68.4	67.0	66.4	64.3
	W167	66.3	65.8	62.7	61.2	59.7	57.6
	W168	68.5	71.1	69.8	68.5	67.8	65.8
	W169	65.9	65.4	62.3	60.8	59.3	57.2

Hydrologic Parameters for French Creek D 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
Alder Bottom Creek	W128	70.3	68.4	61.7	59.0	55.9	51.5
Alder Brook	W152	69.0	73.7	68.3	67.3	66.3	63.1
	W153	71.7	71.7	71.1	70.1	69.1	66.0
	W154	70.2	70.2	69.6	68.6	67.5	64.4
Alder Run	W130	72.3	60.8	60.3	60.0	59.6	57.0
	W131	58.4	45.5	45.0	44.6	44.2	41.6
	W175	69.7	67.8	53.3	51.3	49.2	49.2
Bailey Brook	W151	71.0	71.0	70.3	69.4	68.4	65.2
Darrow Brook	W144	66.5	66.0	63.0	61.5	60.0	57.9
	W145	67.6	67.1	64.1	62.7	61.2	59.1
	W146	67.4	77.3	75.9	73.7	71.2	70.7
	W160	70.0	69.5	66.6	65.2	63.8	61.7
French Creek	W129	70.1	71.9	66.3	60.5	55.7	54.4
	W170	71.2	59.4	59.0	58.6	58.2	56.9
	W171	70.9	59.1	58.6	58.3	57.9	56.6
	W176	73.2	78.5	63.4	62.7	61.9	59.4
	W177	71.4	80.6	66.5	65.7	64.8	60.4
	W178	73.0	79.6	65.7	64.8	63.8	59.9
	W179	71.2	78.5	62.1	60.8	59.4	56.9
	W180	70.8	76.1	70.2	66.3	61.3	56.6
	W181	69.5	75.7	68.9	64.9	59.8	55.0
	W182	71.5	77.2	70.9	67.0	62.0	57.3
	W183	68.6	75.2	67.9	63.9	58.7	53.9
	W184	66.9	74.4	66.2	59.9	56.8	52.0
	W185	68.0	67.5	64.5	63.0	61.6	59.5
	W186	71.8	72.1	69.9	66.6	62.4	57.7
	W187	70.2	58.3	57.8	57.5	57.1	54.4
	W188	60.6	60.1	56.8	55.3	53.7	51.5
	W189	73.4	73.0	70.2	68.9	67.6	65.6
	W190	66.4	54.0	53.5	53.1	52.8	51.4
	W191	67.3	66.8	63.8	62.3	60.9	58.7
	W192	63.8	63.2	60.1	58.5	57.0	54.9
	W193	65.2	64.6	61.5	60.0	58.5	56.4
	W194	70.7	58.9	58.4	58.0	57.7	56.4
	W195	67.8	67.3	64.3	62.8	61.3	59.2
	W196	70.1	69.7	66.8	65.3	63.9	61.9
	W197	67.5	67.0	64.0	62.5	61.1	59.0
	W198	72.1	76.9	59.2	58.4	57.6	55.3
	W199	71.6	71.2	68.4	67.0	65.6	63.6
Hubbel Run	W132	71.8	60.1	59.7	59.3	58.9	56.3
	W133	62.6	49.9	49.4	49.0	48.6	45.9
	W134	70.4	58.5	58.0	57.7	57.3	54.6
	W135	69.0	57.0	56.5	56.1	55.7	53.1
	W136	70.1	69.6	66.7	65.3	63.9	61.8

Hydrologic Parameters for French Creek D 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
Lake Pleasant Outlet	W172	70.3	58.5	58.0	57.6	57.2	55.9
	W173	66.5	54.1	53.7	53.3	52.9	51.6
	W174	68.2	56.0	55.5	55.1	54.8	53.5
Townley Run	W148	71.8	80.8	79.5	77.6	75.3	74.9
West Branch French Creek	W137	81.1	80.7	78.5	77.4	76.3	74.7
	W138	72.2	71.7	69.0	67.6	66.2	64.2
	W139	71.6	80.6	79.3	77.4	75.1	74.7
	W140	71.7	80.7	79.4	77.5	75.2	74.8
	W141	72.1	71.6	68.8	67.4	66.1	64.1
	W142	93.6	93.5	92.6	92.2	91.8	91.1
	W143	83.5	83.2	81.2	80.2	79.2	77.7
	W147	73.0	81.7	80.4	78.6	76.3	75.9
	W149	71.1	71.1	70.5	71.7	73.5	69.8
	W150	64.8	64.2	61.1	59.6	58.1	55.9
	W155	72.3	72.3	71.7	70.8	69.8	66.7
	W156	71.7	80.7	79.4	77.9	76.1	75.2
	W157	71.5	71.1	68.2	66.8	65.5	63.4
	W158	65.6	65.1	62.0	60.5	59.0	56.8
	W159	71.4	80.5	79.2	77.6	75.9	74.9
	W161	70.5	79.8	78.4	76.9	75.1	74.1
	W162	69.3	78.8	77.4	75.8	74.0	72.9
	W163	71.9	71.4	68.6	67.2	65.8	63.8
	W164	70.7	70.2	67.3	65.9	64.5	62.4
	W165	67.7	72.6	70.3	68.4	67.1	65.0
	W166	67.1	69.7	68.5	67.1	66.4	64.3
	W167	66.3	65.8	62.7	61.2	59.7	57.6
	W168	68.5	71.1	69.8	68.5	67.9	65.8
	W169	65.9	65.4	62.3	60.8	59.3	57.2

Hydrologic Results for French Creek D HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J1242	1417509.2	666732.9	4.86	22	153	319	496	585	22	154	320	497	587
2	J1256	1410081.7	673422.6	8.36	56	308	590	879	1,031	56	309	591	881	1,034
3	EP020	1413377.3	723791.8	1.61	220	405	512	585	712	220	406	512	585	712
4	J1310	1417312.4	721135.7	3.43	390	728	932	1,078	1,313	390	729	933	1,079	1,314
5	J1808	1417288.6	720644.6	3.44	387	724	926	1,071	1,304	388	724	927	1,071	1,304
6	J1806	1418320.2	712305.7	0.90	46	114	173	223	268	47	118	177	228	274
7	J1296	1420435.9	713634.4	5.58	579	1,156	1,500	1,736	2,144	582	1,161	1,506	1,743	2,152
8	J1810	1399825.8	704611.3	1.10	94	235	377	526	569	95	237	379	529	571
9	J1288	1392718.0	697377.5	4.56	352	651	935	1,178	1,310	353	653	938	1,181	1,315
10	J1298	1423854.5	723939.4	22.85	1,617	2,959	3,797	4,434	5,268	1,617	2,959	3,799	4,434	5,268
11	J1308	1417533.8	720053.5	27.29	1,821	3,317	4,250	4,958	5,894	1,821	3,317	4,252	4,958	5,894
12	J1300	1418443.8	716757.9	34.34	2,059	3,780	4,853	5,660	6,758	2,059	3,781	4,856	5,661	6,759
13	J1306	1411434.4	716634.9	38.02	2,218	4,069	5,224	6,089	7,294	2,219	4,069	5,226	6,090	7,295
14	J1294	1406318.7	712011.1	41.84	2,422	4,485	5,800	6,781	8,201	2,423	4,487	5,805	6,787	8,207
15	J1292	1398669.9	705542.8	51.38	3,063	5,813	7,538	8,811	10,671	3,069	5,822	7,551	8,825	10,687
16	USGS 03021410	1398325.6	704682.0	52.35	3,081	5,835	7,566	8,847	10,711	3,087	5,844	7,579	8,861	10,727
17	J1334	1399088.0	702739.1	53.65	3,097	5,842	7,575	8,866	10,717	3,103	5,851	7,588	8,880	10,732
18	J1286	1400662.0	695532.9	62.85	3,270	6,135	8,062	9,519	11,478	3,275	6,144	8,075	9,533	11,493
19	J1282	1403982.3	686949.5	70.09	3,335	6,251	8,274	9,824	11,836	3,341	6,260	8,286	9,837	11,851
20	J1272	1402826.3	685301.6	73.13	3,374	6,324	8,366	9,939	11,962	3,380	6,333	8,378	9,952	11,978
21	J1802	1408040.3	676841.2	77.37	3,443	6,463	8,560	10,211	12,299	3,448	6,472	8,572	10,225	12,316
22	J_W.Branch French Creek	1408059.5	674725.3	77.69	3,443	6,462	8,556	10,205	12,290	3,449	6,471	8,568	10,219	12,307
23	J1264	1385192.2	675218.0	2.64	40	212	388	564	730	40	214	390	567	733
24	J1252	1389176.4	668651.3	4.86	47	276	516	756	985	48	278	519	761	990
25	J1234	1402973.9	660608.9	4.89	24	104	205	320	378	24	105	205	320	378
26	J1804	1377371.1	665404.8	1.52	280	240	362	468	502	281	241	363	469	504
27	J1304	1463599.0	724923.2	20.30	1,056	1,623	1,948	1,980	2,027	1,056	1,623	1,948	1,980	2,027
28	J1290	1459516.4	712576.8	37.47	1,632	2,495	3,053	3,171	3,251	1,632	2,495	3,053	3,171	3,251
29	J1302	1437676.6	699222.1	60.02	2,845	4,275	5,195	5,364	5,505	2,845	4,275	5,195	5,364	5,505
30	J1004	1424629.2	682584.0	83.14	3,816	5,647	6,851	7,041	7,205	3,816	5,647	6,851	7,041	7,205
31	J_FrenchCreekPA/NY	1421837.8	681637.1	87.62	3,921	5,792	7,009	7,222	7,392	3,921	5,792	7,009	7,222	7,393
32	J1278	1420140.8	680800.9	92.09	3,996	5,909	7,143	7,366	7,565	3,996	5,909	7,143	7,366	7,565
33	USGS 03021350	1416205.7	680112.2	94.12	4,029	5,967	7,214	7,444	7,648	4,029	5,968	7,214	7,444	7,649
34	EP002	1410057.1	674549.6	97.10	4,048	6,019	7,290	7,542	7,760	4,048	6,019	7,290	7,542	7,760

Hydrologic Results for French Creek D HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J1260	1408581.4	673914.4	105.77	4,091	6,157	7,501	7,819	8,077	4,092	6,157	7,502	7,819	8,077
36	J1262	1408040.3	674430.9	183.48	7,479	12,604	16,055	17,986	20,242	7,486	12,614	16,068	17,999	20,256
37	J1250	1399358.5	668872.6	189.03	7,499	12,665	16,150	18,117	20,407	7,506	12,675	16,163	18,130	20,421
38	J1248	1396259.6	667077.2	192.57	7,522	12,723	16,236	18,230	20,547	7,529	12,733	16,249	18,243	20,561
39	J1246	1395349.6	666191.8	199.60	7,548	12,808	16,367	18,409	20,772	7,556	12,818	16,380	18,422	20,787
40	J1240	1394439.6	664519.4	207.07	7,585	12,880	16,483	18,566	20,967	7,592	12,891	16,497	18,580	20,982
41	USGS 03021500	1390077.5	659240.6	208.82	7,593	12,901	16,515	18,608	21,019	7,600	12,912	16,528	18,622	21,034
42	J1222	1390012.7	658813.5	211.97	7,644	12,956	16,591	18,706	21,134	7,652	12,967	16,605	18,720	21,150
43	J1232	1385610.3	657436.2	214.58	7,645	12,936	16,558	18,673	21,094	7,652	12,947	16,572	18,687	21,109
44	J1226	1385856.2	654853.8	218.65	7,714	13,015	16,668	18,810	21,253	7,722	13,026	16,681	18,824	21,268
45	USGS 03021520	1384085.4	641652.4	223.11	2,476	2,950	3,316	3,524	3,727	2,476	2,951	3,318	3,525	3,728

Hydrologic Parameters for SB French Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Baskin Run	W254	4.81	71.5	235.4	71.5	156.9
Beaver Run	W258	4.52	64.2	231.0	64.2	153.9
	W259	1.99	67.0	218.0	67.0	145.2
	W260	0.22	63.9	134.6	63.9	89.8
Bentley Run	W271	2.01	60.4	139.5	60.4	93.0
	W272	0.46	65.1	79.6	65.1	53.0
	W273	1.70	59.3	138.9	59.3	92.5
Horton Run	W275	3.00	71.4	212.7	71.4	141.7
	W276	0.15	61.7	75.9	62.0	50.2
Hungry Run	W266	4.44	72.5	190.6	72.5	127.0
Lilley Run	W261	1.22	71.6	173.0	71.6	115.3
	W262	2.59	68.4	135.2	68.4	90.1
	W263	1.05	63.4	148.5	63.5	99.0
Pine Run	W268	2.69	68.2	202.9	68.3	135.2
Slaughter Run	W255	3.02	71.8	176.0	71.8	117.3
	W256	2.75	67.4	264.0	67.4	176.0
South Branch French Creek	W250	0.89	66.2	101.4	66.3	67.6
	W251	0.85	61.6	130.9	61.6	87.2
	W253	3.37	65.5	193.7	65.5	129.1
	W257	1.51	67.1	156.8	67.1	104.5
	W264	1.02	70.3	151.8	70.3	101.1
	W265	1.18	71.6	164.9	71.7	109.9
	W267	1.33	72.4	135.2	72.4	90.2
	W269	1.52	54.9	182.8	54.9	121.8
	W270	4.65	74.7	185.9	74.7	123.9
	W274	2.25	74.8	171.6	74.9	114.3
	W277	1.22	71.3	98.3	71.3	65.5
	W278	4.03	71.7	134.0	71.7	89.3
	W279	1.60	69.8	140.4	69.8	93.6
	W280	0.67	71.3	110.0	71.3	73.3
	W281	0.74	59.7	154.8	59.9	102.8
	W282	1.87	67.1	162.4	67.2	108.3
	W283	0.26	71.7	125.5	71.7	83.7
	W284	0.04	70.2	34.8	70.2	23.2
	W285	0.05	69.7	52.8	69.7	35.2
	W286	0.74	66.2	155.8	66.3	103.8
	W287	0.02	77.7	25.5	77.7	17.0
	W288	0.02	75.7	18.7	75.7	12.5
	W289	0.00	80.1	8.4	80.1	5.6
	W290	1.01	70.6	155.3	70.6	103.5
	W291	0.79	74.9	79.3	74.9	52.9
	W292	0.23	75.0	72.2	75.1	48.0
	W293	0.09	72.4	64.7	72.4	43.2
	W294	0.09	67.2	53.2	67.2	35.5

Hydrologic Parameters for SB French Creek HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
South Branch French Creek	W295	2.04	63.6	201.2	63.6	134.1
	W296	1.33	70.7	140.4	70.7	93.6
	W297	3.33	67.7	186.1	67.7	124.0
	W298	1.15	61.3	158.0	61.3	105.3
	W299	1.24	66.7	133.6	66.7	89.1
Spencer Creek	W252	3.18	69.5	163.2	69.5	108.8

Hydrologic Parameters for SB French 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
Baskin Run	W254	71.5	73.5	71.5	70.3	69.0	66.2
Beaver Run	W258	64.2	70.4	68.0	63.9	61.6	57.8
	W259	67.0	71.1	68.7	65.2	62.2	58.3
	W260	63.9	67.1	65.2	62.6	60.5	57.9
Bentley Run	W271	60.4	68.1	65.5	61.6	58.8	55.2
	W272	65.1	68.2	66.3	63.8	61.7	59.2
	W273	59.3	71.5	71.8	69.8	67.5	64.5
Horton Run	W275	71.4	75.1	76.2	74.4	72.4	70.4
	W276	61.7	65.0	63.0	60.4	58.3	55.6
Hungry Run	W266	72.5	72.8	72.3	70.3	67.9	65.0
Lilley Run	W261	71.6	74.4	75.7	73.9	71.8	70.3
	W262	68.4	71.2	70.3	67.6	65.7	62.8
	W263	63.4	70.5	69.1	65.7	62.6	60.5
Pine Run	W268	68.2	73.0	72.8	70.2	67.7	65.8
Slaughter Run	W255	71.8	72.5	71.8	70.0	68.0	65.2
	W256	67.4	74.2	74.4	71.9	68.8	66.3
South Branch French Creek	W250	66.2	69.3	67.5	65.0	62.9	60.4
	W251	61.6	64.9	62.9	60.3	58.2	55.5
	W253	65.5	68.2	63.4	60.1	56.2	51.5
	W257	67.1	73.3	74.1	72.1	69.7	66.8
	W264	70.3	73.0	73.0	70.6	69.2	67.2
	W265	71.6	69.3	66.2	62.6	58.3	53.5
	W267	72.4	72.0	71.6	69.6	67.4	64.6
	W269	54.9	68.0	66.1	62.5	58.2	54.0
	W270	74.7	71.1	69.3	66.3	62.8	58.5
	W274	74.8	74.0	74.7	73.4	71.9	69.8
	W277	71.3	67.7	63.8	60.6	56.9	52.1
	W278	71.7	70.2	67.6	65.3	62.7	59.1
	W279	69.8	72.3	71.1	69.5	68.5	66.2
	W280	71.3	74.1	72.4	70.2	68.3	65.9
	W281	59.7	63.0	61.0	58.3	56.2	53.5
	W282	67.1	64.7	57.8	52.3	48.2	47.9
	W283	71.7	74.4	72.8	70.5	68.6	66.3
	W284	70.2	73.0	71.3	69.0	67.1	64.6
	W285	69.7	72.6	70.9	68.5	66.6	64.1
	W286	66.2	69.3	67.5	65.0	62.9	60.4
	W287	77.7	80.0	78.7	76.7	75.1	73.0
	W288	75.7	78.1	76.7	74.6	72.9	70.7
	W289	80.1	82.2	81.0	79.2	77.7	75.8
	W290	70.6	65.3	59.4	56.2	52.5	51.2
	W291	74.9	77.4	75.9	73.8	72.1	69.8
	W292	75.0	77.5	76.0	73.9	72.2	69.9
	W293	72.4	75.1	73.5	71.2	69.4	67.1
	W294	67.2	70.2	68.4	65.9	63.9	61.4

Hydrologic Parameters for SB French 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
South Branch French Creek	W295	63.6	69.4	66.4	62.2	59.0	54.9
	W296	70.7	72.0	71.2	69.0	66.9	64.1
	W297	67.7	73.7	74.3	72.2	69.8	67.0
	W298	61.3	74.2	76.3	75.2	74.1	72.3
	W299	66.7	73.2	74.3	72.4	70.3	67.5
Spencer Creek	W252	69.5	70.5	67.5	65.1	62.4	58.7

Hydrologic Parameters for SB French 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
Baskin Run	W254	71.5	73.5	71.5	70.3	69.0	66.2
Beaver Run	W258	64.2	70.4	68.0	64.0	61.7	57.8
	W259	67.0	71.1	68.7	65.2	62.2	58.3
	W260	63.9	67.1	65.2	62.6	60.5	57.9
Bentley Run	W271	60.4	68.1	65.5	61.6	58.8	55.2
	W272	65.1	68.2	66.3	63.8	61.7	59.2
	W273	59.3	71.6	71.9	69.9	67.5	64.5
Horton Run	W275	71.4	75.1	76.2	74.5	72.4	70.4
	W276	62.0	65.2	63.3	60.7	58.5	55.9
Hungry Run	W266	72.5	72.8	72.3	70.3	67.9	65.0
Lilley Run	W261	71.6	74.4	75.7	73.9	71.8	70.4
	W262	68.4	71.2	70.3	67.6	65.7	62.8
	W263	63.5	70.5	69.1	65.7	62.6	60.5
Pine Run	W268	68.3	73.1	72.8	70.3	67.8	65.8
Slaughter Run	W255	71.8	72.5	71.8	70.0	68.0	65.3
	W256	67.4	74.2	74.4	71.9	68.8	66.3
South Branch French Creek	W250	66.3	69.3	67.5	65.0	63.0	60.4
	W251	61.6	64.9	62.9	60.3	58.2	55.5
	W253	65.5	68.2	63.4	60.1	56.2	51.5
	W257	67.1	73.4	74.1	72.1	69.7	66.8
	W264	70.3	73.0	73.0	70.6	69.2	67.2
	W265	71.7	69.4	66.2	62.6	58.3	53.5
	W267	72.4	72.0	71.6	69.6	67.4	64.6
	W269	54.9	68.0	66.1	62.6	58.2	54.1
	W270	74.7	71.1	69.3	66.3	62.8	58.6
	W274	74.9	74.1	74.7	73.4	71.9	69.9
	W277	71.3	67.7	63.8	60.6	56.9	52.1
	W278	71.7	70.2	67.7	65.4	62.7	59.1
	W279	69.8	72.3	71.1	69.5	68.5	66.3
	W280	71.3	74.1	72.4	70.2	68.3	65.9
	W281	59.9	63.2	61.2	58.5	56.3	53.7
	W282	67.2	64.7	57.8	52.3	48.2	47.9
	W283	71.7	74.4	72.8	70.5	68.6	66.3
	W284	70.2	73.0	71.3	69.0	67.1	64.6
	W285	69.7	72.6	70.9	68.5	66.6	64.1
	W286	66.3	69.3	67.5	65.0	62.9	60.4
	W287	77.7	80.0	78.7	76.7	75.1	73.0
	W288	75.7	78.1	76.7	74.6	72.9	70.7
	W289	80.1	82.2	81.0	79.2	77.7	75.8
	W290	70.6	65.3	59.4	56.2	52.5	51.2
	W291	74.9	77.4	75.9	73.8	72.1	69.8
	W292	75.1	77.6	76.1	74.0	72.3	70.1
	W293	72.4	75.1	73.5	71.2	69.4	67.1
	W294	67.2	70.2	68.4	65.9	63.9	61.4

Hydrologic Parameters for SB French 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
South Branch French Creek	W295	63.6	69.4	66.4	62.2	59.1	55.0
	W296	70.7	72.0	71.2	69.1	66.9	64.1
	W297	67.7	73.7	74.3	72.2	69.8	67.1
	W298	61.3	74.2	76.3	75.2	74.1	72.3
	W299	66.7	73.2	74.3	72.4	70.3	67.5
Spencer Creek	W252	69.5	70.6	67.5	65.1	62.4	58.7

Hydrologic Results for SB French Creek HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J1238	1428625.8	654587.2	3.02	157	349	462	542	605	157	349	463	543	606
2	J1220	1423879.1	647221.9	4.52	161	333	395	464	490	161	334	395	464	490
3	EO025	1425968.5	637637.7	6.51	235	483	578	669	706	236	484	578	670	707
4	J1130	1427863.4	627677.0	3.80	216	501	640	753	854	216	501	640	754	854
5	J1214	1406048.2	645655.5	2.01	81	180	216	247	265	81	180	216	248	265
6	J1798	1387848.4	637598.8	3.00	167	386	494	569	651	168	386	495	569	652
7	J1368	1449506.5	630677.5	1.22	59	123	158	168	162	59	123	158	168	162
8	J1366	1447145.4	636186.7	5.25	263	553	727	821	862	264	554	729	822	864
9	J1800	1448810.3	643302.0	6.85	349	746	991	1,147	1,236	350	748	993	1,149	1,238
10	J1210	1444759.7	644843.9	8.37	401	864	1,147	1,336	1,453	402	865	1,149	1,338	1,455
11	J1208	1442152.7	644425.8	12.28	551	1,174	1,562	1,815	1,972	552	1,176	1,565	1,819	1,976
12	J1204	1436742.0	641523.7	17.53	561	1,111	1,438	1,642	1,787	562	1,113	1,440	1,644	1,790
13	J_BaskinRun&SBFrench	1434503.9	639900.4	22.59	719	1,423	1,867	2,165	2,381	720	1,425	1,869	2,168	2,385
14	J1184	1433495.5	638818.3	23.52	734	1,454	1,907	2,214	2,437	736	1,456	1,910	2,217	2,440
15	J1186	1432438.0	638301.8	29.33	953	1,932	2,530	2,931	3,249	954	1,934	2,533	2,934	3,253
16	J1162	1428109.3	635473.4	31.58	983	1,987	2,594	3,001	3,329	984	1,989	2,597	3,004	3,333
17	J1164	1426879.6	634514.3	38.34	1,195	2,439	3,141	3,640	4,010	1,197	2,442	3,145	3,644	4,014
18	J1156	1426043.4	634489.7	43.21	1,323	2,729	3,514	4,077	4,509	1,325	2,733	3,517	4,081	4,514
19	J1158	1425895.9	634612.6	44.24	1,349	2,787	3,586	4,164	4,608	1,351	2,790	3,590	4,169	4,613
20	J1168	1419771.9	634219.1	46.43	1,346	2,741	3,506	4,052	4,484	1,348	2,744	3,509	4,056	4,488
21	J1142	1416304.0	632768.1	51.66	1,461	2,980	3,816	4,413	4,892	1,463	2,983	3,819	4,416	4,896
22	J1154	1413820.0	634071.6	53.22	1,487	3,031	3,881	4,488	4,978	1,488	3,034	3,884	4,492	4,982
23	J_PineRun&SBFrench	1414311.9	635375.1	56.01	1,540	3,139	4,013	4,639	5,157	1,542	3,142	4,017	4,643	5,162
24	J1170	1412713.3	635916.1	57.61	1,565	3,189	4,075	4,706	5,229	1,566	3,192	4,079	4,710	5,233
25	J1134	1404203.6	635522.6	64.30	1,677	3,420	4,364	5,031	5,581	1,679	3,424	4,368	5,035	5,586
26	J1172	1400366.9	637416.4	69.80	1,739	3,549	4,528	5,221	5,795	1,741	3,553	4,532	5,226	5,800
27	J1176	1392988.6	639211.8	75.39	1,841	3,776	4,825	5,569	6,196	1,843	3,780	4,828	5,573	6,201
28	J1192	1386815.4	639925.0	79.67	1,927	3,970	5,078	5,867	6,548	1,929	3,973	5,082	5,872	6,552
29	Outlet_SB_FrenchCreek	1382683.5	639925.0	80.91	1,944	4,007	5,127	5,924	6,612	1,946	4,011	5,130	5,928	6,617

Hydrologic Parameters for French Creek C HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Benson Run	W365	2.83	73.0	100.3	73.0	100.3
Campbell Run	W387	3.75	73.5	98.0	73.5	97.9
East Branch LeBoeuf Creek	W349	1.67	73.3	94.8	73.3	94.7
	W350	2.39	72.4	110.1	72.5	109.9
	W351	1.17	69.5	110.6	69.5	110.5
	W352	2.10	69.6	139.1	69.7	138.6
	W353	2.01	72.9	124.2	73.0	123.7
	W354	3.34	68.7	107.6	68.7	107.3
	W355	1.90	66.4	109.8	66.4	109.8
	W356	3.20	68.8	176.9	68.8	176.6
	W357	3.71	71.6	136.4	71.6	136.4
	W358	0.02	57.6	36.3	57.6	36.3
	W359	0.01	70.0	11.6	70.0	11.6
	W360	2.18	66.7	140.8	66.7	140.6
	W361	0.67	66.7	137.2	66.8	136.8
French Creek	W343	3.77	71.5	144.3	71.5	144.3
	W344	3.24	70.6	89.6	70.6	89.5
	W345	0.40	59.2	57.1	59.3	57.0
	W381	4.04	72.3	113.1	72.4	113.0
	W382	1.65	71.8	79.4	71.9	79.3
	W383	0.90	71.9	71.8	71.9	71.7
	W384	1.13	73.4	63.3	73.5	63.2
	W385	0.31	69.8	54.7	69.8	54.6
	W386	1.38	61.0	154.9	61.0	154.8
	W388	2.58	69.0	69.1	69.0	69.1
	W389	0.34	69.7	55.4	69.7	55.4
	W390	0.09	64.9	35.0	64.9	35.0
	W391	1.30	66.2	107.0	66.2	106.9
	W392	0.57	60.2	121.5	60.2	121.5
	W393	3.96	62.2	229.5	62.3	229.3
	W394	0.73	57.1	118.6	57.1	118.5
	W395	0.60	63.2	82.9	63.2	82.9
	W396	2.14	66.9	96.3	67.0	96.2
	W397	2.99	70.5	112.8	70.6	112.7
	W398	0.09	73.8	22.5	73.8	22.5
	W399	2.39	64.2	227.5	64.2	113.7
Kelly Run	W300	4.47	71.4	141.6	71.4	141.6
	W301	3.39	70.9	146.4	70.9	146.4
LeBoeuf Creek	W362	1.44	73.9	77.9	74.2	77.2
	W363	3.34	70.5	148.7	70.7	148.2
	W364	1.63	64.6	89.3	64.6	89.3
	W372	3.75	72.8	167.5	73.7	163.7
	W373	4.54	70.1	156.6	70.5	155.0
	W374	0.03	76.3	34.9	76.3	34.9

Hydrologic Parameters for French Creek C HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
LeBoeuf Creek	W375	1.39	69.0	86.6	69.4	85.6
	W376	0.27	66.2	75.9	66.2	75.9
	W377	3.13	64.3	128.0	64.5	127.4
	W378	2.35	69.6	122.0	69.6	122.0
	W379	0.72	64.9	116.3	65.0	116.0
	W380	2.77	65.3	158.5	65.3	158.4
Trout Run	W366	1.63	66.3	90.5	66.4	90.3
	W367	2.91	65.1	130.0	65.2	129.9
	W368	3.18	71.0	98.5	71.1	98.2
	W369	1.31	69.1	95.1	69.2	94.9
	W370	1.79	74.4	133.5	74.4	88.9
	W371	0.11	83.2	28.6	83.2	28.5
Wheeler Creek	W346	1.05	58.2	111.0	58.3	110.9
	W347	4.48	69.5	143.8	69.5	143.7
	W348	0.04	56.7	21.9	56.7	21.9

Hydrologic Parameters for French Creek C 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
Benson Run	W365	73.0	72.3	70.1	67.5	64.4	61.6
Campbell Run	W387	73.5	76.0	72.6	68.9	64.0	61.3
East Branch LeBoeuf Creek	W349	73.3	70.9	67.6	64.3	60.2	57.0
	W350	72.4	74.1	71.7	69.5	66.9	64.5
	W351	69.5	75.9	74.6	70.6	67.7	65.6
	W352	69.6	76.1	74.8	71.0	68.0	65.9
	W353	72.9	75.2	73.1	70.9	68.5	66.5
	W354	68.7	73.8	68.5	65.7	62.4	59.5
	W355	66.4	68.3	61.9	56.3	52.8	48.6
	W356	68.8	74.1	67.9	64.6	60.6	57.1
	W357	71.6	74.6	71.2	68.7	65.8	63.2
	W358	57.6	63.5	58.6	54.7	51.3	48.7
	W359	70.0	75.0	71.0	67.6	64.5	62.1
	W360	66.7	74.8	73.0	69.0	65.4	62.8
	W361	66.7	72.1	67.7	64.2	60.9	58.4
French Creek	W343	71.5	76.1	73.7	70.3	67.7	65.5
	W344	70.6	71.9	68.7	65.9	62.6	59.9
	W345	59.2	65.1	60.3	56.5	53.0	50.4
	W381	72.3	77.1	73.1	69.1	64.6	61.9
	W382	71.8	76.4	72.3	68.5	64.0	61.6
	W383	71.9	76.6	72.8	69.5	66.5	64.1
	W384	73.4	74.9	72.0	68.3	63.5	60.7
	W385	69.8	74.8	70.7	67.3	64.2	61.8
	W386	61.0	77.2	77.2	76.3	75.3	74.0
	W388	69.0	75.5	69.8	64.7	60.2	57.1
	W389	69.7	74.7	70.6	67.2	64.1	61.7
	W390	64.9	70.4	65.9	62.3	59.0	56.4
	W391	66.2	78.4	77.7	74.3	69.8	67.6
	W392	60.2	66.0	61.3	57.4	54.0	51.4
	W393	62.2	78.2	78.2	77.4	76.5	75.1
	W394	57.1	63.1	58.2	54.3	50.8	48.2
	W395	63.2	68.9	64.3	60.5	57.2	54.6
	W396	66.9	77.6	76.1	69.6	65.5	63.2
	W397	70.5	77.1	72.3	67.5	62.6	59.6
	W398	73.8	78.4	74.7	71.6	68.7	66.4
	W399	64.2	78.5	76.0	69.6	64.5	61.4
Kelly Run	W300	71.4	78.0	75.7	70.2	65.9	63.4
	W301	70.9	79.2	78.6	73.5	68.6	66.5
LeBoeuf Creek	W362	73.9	72.3	70.4	67.9	64.9	62.5
	W363	70.5	67.9	62.2	56.2	52.1	50.1
	W364	64.6	72.3	68.5	63.5	59.9	56.8
	W372	72.8	72.6	69.9	66.9	63.2	60.0
	W373	70.1	68.9	63.8	58.2	54.6	50.3
	W374	76.3	80.6	77.1	74.2	71.5	69.3

Hydrologic Parameters for French Creek C 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
LeBoeuf Creek	W375	69.0	66.6	60.6	54.9	50.6	49.0
	W376	66.2	71.6	67.2	63.6	60.4	57.8
	W377	64.3	69.0	60.8	55.5	51.4	47.2
	W378	69.6	70.2	65.7	62.2	57.9	54.3
	W379	64.9	70.4	66.0	62.3	59.9	56.4
	W380	65.3	73.6	70.7	65.0	61.5	58.3
Trout Run	W366	66.3	72.9	68.5	64.4	60.9	57.9
	W367	65.1	72.7	68.6	63.6	59.8	56.6
	W368	71.0	72.3	69.2	66.6	63.5	60.6
	W369	69.1	75.3	74.0	70.0	67.2	65.2
	W370	74.4	68.7	63.5	60.3	56.6	54.9
	W371	83.2	86.4	83.8	81.5	79.3	77.5
Wheeler Creek	W346	58.2	73.1	72.0	69.6	66.8	64.0
	W347	69.5	73.4	68.2	65.2	61.4	58.2
	W348	56.7	62.7	57.8	53.9	50.4	47.8

Hydrologic Parameters for French Creek C 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
Benson Run	W365	73.0	72.3	70.1	67.5	64.4	61.6
Campbell Run	W387	73.5	76.0	72.6	68.9	64.0	61.3
East Branch LeBoeuf Creek	W349	73.3	70.9	67.6	64.3	60.3	57.0
	W350	72.5	74.2	71.7	69.5	66.9	64.6
	W351	69.5	75.9	74.6	70.6	67.7	65.7
	W352	69.7	76.2	74.9	71.1	68.2	66.0
	W353	73.0	75.4	73.3	71.1	68.7	66.7
	W354	68.7	73.9	68.6	65.8	62.5	59.6
	W355	66.4	68.3	61.9	56.3	52.8	48.6
	W356	68.8	74.1	67.9	64.7	60.6	57.2
	W357	71.6	74.6	71.2	68.7	65.8	63.2
	W358	57.6	63.5	58.6	54.7	51.3	48.7
	W359	70.0	75.0	71.0	67.6	64.5	62.1
	W360	66.7	74.8	73.0	69.0	65.4	62.8
	W361	66.8	72.1	67.8	64.3	61.0	58.5
French Creek	W343	71.5	76.1	73.7	70.3	67.7	65.5
	W344	70.6	71.9	68.7	66.0	62.7	60.0
	W345	59.3	65.2	60.4	56.5	53.1	50.5
	W381	72.4	77.1	73.1	69.2	64.6	62.0
	W382	71.9	76.5	72.4	68.6	64.1	61.6
	W383	71.9	76.7	72.8	69.5	66.6	64.2
	W384	73.5	74.9	72.1	68.4	63.5	60.8
	W385	69.8	74.8	70.8	67.4	64.3	61.8
	W386	61.0	77.2	77.2	76.3	75.3	74.0
	W388	69.0	75.5	69.8	64.7	60.2	57.1
	W389	69.7	74.8	70.7	67.3	64.2	61.7
	W390	64.9	70.4	65.9	62.3	59.0	56.4
	W391	66.2	78.4	77.7	74.3	69.8	67.6
	W392	60.2	66.0	61.3	57.4	54.0	51.4
	W393	62.3	78.2	78.2	77.4	76.5	75.2
	W394	57.1	63.1	58.2	54.3	50.9	48.2
	W395	63.2	68.9	64.3	60.5	57.2	54.6
	W396	67.0	77.7	76.1	69.6	65.5	63.3
	W397	70.6	77.1	72.3	67.6	62.6	59.7
	W398	73.8	78.4	74.7	71.6	68.7	66.4
	W399	64.2	78.5	76.0	69.6	64.5	61.4
Kelly Run	W300	71.4	78.0	75.7	70.2	65.9	63.4
	W301	70.9	79.2	78.6	73.5	68.6	66.5
LeBoeuf Creek	W362	74.2	72.6	70.7	68.2	65.3	62.9
	W363	70.7	68.0	62.3	56.3	52.3	50.3
	W364	64.6	72.3	68.5	63.5	59.9	56.8
	W372	73.7	73.4	70.8	67.8	64.2	61.0
	W373	70.5	69.2	64.2	58.7	55.1	50.8
	W374	76.3	80.6	77.1	74.2	71.5	69.3

Hydrologic Parameters for French Creek C 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
LeBoeuf Creek	W375	69.4	67.0	61.1	55.4	51.1	49.5
	W376	66.2	71.6	67.2	63.6	60.4	57.8
	W377	64.5	69.1	61.0	55.7	51.6	47.3
	W378	69.6	70.2	65.7	62.2	57.9	54.3
	W379	65.0	70.5	66.1	62.4	60.0	56.5
	W380	65.3	73.6	70.8	65.1	61.5	58.4
Trout Run	W366	66.4	72.9	68.6	64.5	61.0	58.0
	W367	65.2	72.8	68.6	63.6	59.8	56.6
	W368	71.1	72.4	69.4	66.7	63.6	60.8
	W369	69.2	75.4	74.1	70.1	67.3	65.3
	W370	74.4	68.7	63.5	60.4	56.6	55.0
	W371	83.2	86.4	83.8	81.6	79.4	77.6
Wheeler Creek	W346	58.3	73.1	72.0	69.6	66.8	64.0
	W347	69.5	73.4	68.3	65.2	61.5	58.3
	W348	56.7	62.7	57.8	53.9	50.4	47.8

Hydrologic Results for French Creek C HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
1	J1698	1371753.9	612513.0	4.47	432	795	855	897	1,024	432	795	855	898	1,024
2	J1700	1363565.9	604237.9	7.86	775	1,466	1,588	1,645	1,888	776	1,466	1,588	1,645	1,889
3	J1160	1374247.7	634588.0	3.24	265	532	689	766	871	266	534	691	768	874
4	J1202	1372575.2	641523.7	5.53	372	663	844	924	1,027	373	664	846	926	1,029
5	J1792	1381840.8	685541.1	3.34	285	473	610	675	760	287	477	615	681	766
6	J1336	1379264.9	692434.0	5.25	351	587	735	815	901	353	591	740	820	907
7	J1284	1376018.5	694893.5	10.46	612	1,042	1,319	1,465	1,640	616	1,048	1,326	1,474	1,650
8	J1280	1366771.0	686851.1	15.83	831	1,468	1,889	2,121	2,403	835	1,476	1,899	2,133	2,417
9	J1274	1366549.6	686605.1	18.25	928	1,662	2,153	2,432	2,771	933	1,671	2,164	2,445	2,786
10	J1270	1366254.5	686260.8	19.43	982	1,770	2,285	2,585	2,954	987	1,779	2,297	2,598	2,970
11	J1268	1360130.5	677234.7	23.71	1,184	2,254	2,817	3,172	3,654	1,189	2,263	2,828	3,187	3,671
12	J1230	1348497.3	658051.1	3.18	252	504	655	734	828	255	510	661	742	836
13	J1236	1353194.9	658739.7	6.12	527	1,032	1,277	1,430	1,623	532	1,041	1,288	1,443	1,637
14	J1224	1360671.6	651287.6	10.81	794	1,511	1,837	2,032	2,316	801	1,521	1,849	2,047	2,332
15	J1276	1354719.7	682325.7	3.76	208	417	525	570	630	227	449	564	613	678
16	J1266	1358802.4	673643.9	32.67	1,440	2,663	3,327	3,725	4,215	1,462	2,699	3,373	3,777	4,274
17	J1258	1358900.8	672758.5	34.14	1,471	2,726	3,410	3,820	4,327	1,494	2,764	3,456	3,873	4,387
18	J1254	1360105.9	668946.4	38.87	1,566	2,898	3,595	4,019	4,573	1,590	2,937	3,644	4,075	4,636
19	J1794	1360565.4	666405.4	39.14	1,535	2,802	3,448	3,839	4,350	1,557	2,839	3,493	3,890	4,408
20	J1244	1365319.9	661051.6	45.10	1,530	2,709	3,285	3,634	4,086	1,551	2,741	3,324	3,678	4,136
21	J1218	1366057.7	653476.5	49.07	1,585	2,802	3,397	3,757	4,223	1,606	2,834	3,436	3,801	4,273
22	J1216	1362147.2	649320.1	60.71	1,779	3,133	3,799	4,212	4,750	1,801	3,167	3,840	4,259	4,802
23	J_LeBoeufCreek	1359927.5	640573.4	63.48	1,806	3,169	3,829	4,243	4,783	1,827	3,203	3,869	4,289	4,834
24	J1146	1364828.0	629792.1	2.03	288	527	638	677	772	289	529	641	680	775
25	J1796	1363189.9	631208.9	2.34	331	604	732	782	893	332	606	735	785	896
26	J1194	1382683.5	639925.0	303.83	4,214	6,479	7,768	8,697	9,496	4,217	6,483	7,773	8,702	9,503
27	J1152	1381281.7	639482.3	307.69	4,272	6,590	7,906	8,858	9,684	4,275	6,595	7,911	8,863	9,691
28	J1174	1373288.5	638129.6	312.62	4,329	6,693	8,035	9,004	9,854	4,331	6,697	8,040	9,010	9,861
29	J1178	1371517.7	640785.8	318.77	4,403	6,830	8,210	9,202	10,081	4,406	6,834	8,215	9,208	10,088
30	J1198	1359909.1	640195.6	386.21	6,196	10,141	12,262	13,719	15,200	6,219	10,178	12,306	13,770	15,256
31	J1196	1358753.2	637318.0	390.98	6,261	10,253	12,398	13,870	15,375	6,283	10,290	12,442	13,921	15,432
32	J1166	1356269.2	634022.4	393.22	6,276	10,284	12,434	13,907	15,419	6,299	10,322	12,478	13,958	15,476
33	J1150	1357203.8	626914.6	399.07	6,354	10,427	12,608	14,105	15,650	6,377	10,465	12,653	14,156	15,707
34	J1122	1360991.3	617790.1	405.81	6,414	10,539	12,737	14,240	15,805	6,437	10,576	12,782	14,291	15,863

Hydrologic Results for French Creek C HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	2010 Discharges with Existing SWM					2020 Discharges with No Future SWM				
		x	y		2-Year	10-Year	25-Year	50-Year	100-Year	2-Year	10-Year	25-Year	50-Year	100-Year
35	J1120	1361753.7	615945.5	408.47	6,445	10,587	12,794	14,302	15,876	6,468	10,625	12,838	14,353	15,933
36	Outlet_French_C	1359279.7	605363.3	419.31	6,588	10,873	13,120	14,654	16,287	6,611	10,911	13,165	14,705	16,345

Hydrologic Parameters for French Creek B HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
Boles Run	W519	0.85	76.2	124.9	76.2	78.0
	W564	1.33	76.7	119.4	76.7	74.6
	W565	2.81	75.4	190.3	75.5	118.8
	W566	3.59	74.2	209.1	74.2	130.7
Brookhouser Creek	W579	1.78	76.7	164.4	76.7	102.7
	W580	0.05	58.9	88.0	58.9	55.0
Conneauttee Creek	W524	0.97	68.0	131.4	69.0	79.9
	W537	3.95	66.6	126.6	66.8	126.2
	W540	1.18	76.3	74.4	79.0	62.3
	W541	0.15	80.6	35.1	80.6	31.9
	W542	2.65	71.7	178.2	73.7	105.5
	W550	1.75	62.4	143.0	62.8	141.8
	W551	1.42	60.1	134.1	61.5	129.5
	W553	0.87	66.7	88.3	67.2	87.3
	W554	1.35	77.9	77.1	78.3	76.2
	W555	0.46	78.7	67.8	79.0	42.1
	W556	0.10	73.0	70.4	73.0	44.0
	W557	0.31	69.8	91.2	69.8	57.0
	W558	0.36	61.9	167.9	62.7	103.0
	W559	3.57	66.5	335.7	66.6	209.8
	W560	0.41	69.9	152.4	69.9	95.3
	W561	0.04	74.3	32.8	74.3	20.5
Darrows Creek	W543	0.84	76.0	106.3	76.0	66.4
	W544	2.31	73.2	154.6	73.4	96.0
	W545	0.22	81.6	66.4	81.6	41.5
	W546	0.35	79.7	79.6	79.7	49.7
	W547	0.29	63.2	139.1	63.8	85.6
French Creek	W522	4.46	72.9	217.6	72.9	136.0
	W523	1.36	76.6	163.0	76.7	101.7
	W562	0.85	77.6	77.8	77.6	48.6
	W563	1.04	74.0	133.8	75.0	81.3
	W567	0.89	74.4	130.9	74.4	81.8
	W568	3.51	75.8	194.2	75.8	121.4
	W569	1.47	74.2	111.0	74.2	69.4
	W570	1.15	73.8	148.1	73.8	92.6
	W571	0.20	67.1	66.0	67.1	41.3
	W572	1.94	71.7	117.5	71.7	73.4
	W582	0.52	74.3	87.5	74.6	54.3
	W583	0.36	75.2	125.3	75.2	78.3
	W584	0.26	75.0	106.3	75.0	66.4
	W585	1.86	72.6	175.9	72.6	109.9
	W586	4.02	73.3	247.1	73.3	154.4
	W587	0.89	72.2	137.5	72.2	85.9
	W588	0.33	73.9	89.5	73.9	55.9

Hydrologic Parameters for French Creek B HEC-HMS Model

Subwatershed Name	Subbasin	Drainage Area (mi^2)	Existing Conditions (2010)		Future Conditions (2020)	
			CN	Lag (min)	CN	Lag (min)
French Creek	W589	0.96	75.4	130.0	76.5	78.7
	W590	1.22	72.0	128.4	72.7	78.8
	W591	0.02	71.2	20.5	71.2	12.8
	W592	0.04	66.3	31.8	66.3	19.9
	W593	2.34	73.4	107.1	73.4	66.9
	W594	0.44	66.0	90.1	66.0	56.3
	W595	0.48	73.9	86.5	73.9	54.1
	W596	4.65	72.9	139.9	72.9	87.5
	W597	2.43	72.0	128.4	72.0	80.3
	W598	0.44	64.6	122.1	64.6	76.3
	W599	0.40	71.3	54.7	71.3	34.2
Gravel Run	W573	1.29	73.9	154.1	73.9	96.3
	W574	2.24	69.4	125.3	69.4	78.3
	W575	3.46	73.8	143.4	73.8	89.6
	W576	0.01	71.1	15.8	71.1	9.9
	W577	4.65	72.0	197.1	72.0	123.2
Kerns Run	W578	2.36	75.9	137.7	75.9	86.1
Little Conneautee Creek	W525	2.56	73.3	139.9	73.4	87.3
	W526	0.77	72.4	88.3	72.5	55.0
	W527	2.50	70.0	151.6	70.0	94.7
	W528	1.12	67.8	102.5	67.8	64.0
	W529	3.52	71.5	187.9	71.5	117.3
	W530	3.60	69.5	169.5	69.6	105.5
	W531	1.71	65.5	137.8	65.6	86.1
	W532	0.04	57.8	36.0	57.8	22.5
	W533	1.26	69.0	94.0	69.0	58.7
	W534	3.86	71.2	188.9	71.2	118.0
	W535	2.55	71.1	224.3	71.2	139.9
	W536	1.91	66.5	422.9	66.5	264.3
Mohawk Run	W520	3.18	73.6	151.4	73.6	94.6
	W521	2.20	66.0	221.8	66.0	138.6
Shenango Creek	W538	2.43	74.8	108.2	74.9	108.0
	W539	3.56	72.7	139.0	73.4	123.9
	W552	0.17	73.3	48.8	73.3	44.3
Torry Run	W548	3.43	72.6	244.4	72.6	152.6
	W549	1.85	71.7	199.1	71.7	124.4
Wolf Run	W581	4.98	75.3	203.8	75.3	127.3

Hydrologic Parameters for French Creek B 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
Boles Run	W519	76.2	78.4	73.0	71.0	68.7	65.2
	W564	76.7	74.9	69.6	66.8	63.3	59.0
	W565	75.4	74.3	67.4	64.5	60.9	57.3
	W566	74.2	79.2	73.6	72.2	70.5	66.2
Brookhouser Creek	W579	76.7	75.3	69.7	66.9	63.6	60.6
	W580	58.9	61.8	54.7	52.2	49.6	45.5
Conneauttee Creek	W524	68.0	70.6	64.2	61.8	59.3	55.4
	W537	66.6	69.3	64.6	64.2	63.8	62.1
	W540	76.3	69.5	63.3	63.3	63.3	60.6
	W541	80.6	82.5	77.8	76.1	74.1	70.9
	W542	71.7	76.0	70.1	67.5	64.3	58.9
	W550	62.4	74.7	69.8	69.3	68.8	65.3
	W551	60.1	73.5	69.6	69.1	68.7	67.7
	W553	66.7	69.4	62.8	60.5	57.9	53.9
	W554	77.9	67.6	60.0	60.0	60.0	61.5
	W555	78.7	80.7	75.7	73.9	71.8	68.4
	W556	73.0	75.4	69.5	67.4	65.0	61.2
	W557	69.8	72.4	66.1	63.9	61.4	57.5
	W558	61.9	64.8	57.9	55.4	52.8	48.7
	W559	66.5	75.3	66.3	63.7	60.6	56.5
	W560	69.9	72.4	66.2	64.0	61.5	57.6
	W561	74.3	76.6	70.9	68.8	66.5	62.8
Darrows Creek	W543	76.0	78.1	72.7	70.7	68.5	64.9
	W544	73.2	77.3	71.5	70.2	68.8	64.0
	W545	81.6	83.4	78.9	77.2	75.3	78.7
	W546	79.7	81.6	76.8	75.0	72.9	76.6
	W547	63.2	66.0	59.1	56.7	54.1	58.9
French Creek	W522	72.9	69.8	57.1	55.1	53.0	53.0
	W523	76.6	76.5	73.2	72.2	71.1	64.9
	W562	77.6	79.7	74.5	72.6	70.4	67.0
	W563	74.0	77.5	72.3	70.5	68.4	63.9
	W567	74.4	76.7	71.1	69.0	66.7	63.0
	W568	75.8	76.9	72.6	70.3	67.5	63.9
	W569	74.2	73.9	68.7	65.6	61.9	57.9
	W570	73.8	78.4	72.9	71.4	69.7	64.8
	W571	67.1	69.8	63.2	60.9	58.3	54.4
	W572	71.7	75.9	69.1	66.4	63.1	57.6
	W582	74.3	76.6	70.9	68.9	66.5	62.8
	W583	75.2	77.5	71.9	69.9	67.6	64.0
	W584	75.0	77.3	71.7	69.7	67.4	63.7
	W585	72.6	71.8	62.3	59.5	56.2	53.7
	W586	73.3	72.3	62.7	60.2	57.4	54.6
	W587	72.2	74.6	68.6	66.5	64.1	60.3
	W588	73.9	76.2	70.5	68.4	66.1	62.3

Hydrologic Parameters for French Creek B 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
French Creek	W589	75.4	77.6	72.1	70.1	67.8	64.1
	W590	72.0	77.3	71.1	69.4	67.5	63.7
	W591	71.2	73.7	67.6	65.4	62.9	59.1
	W592	66.3	69.0	62.4	60.1	57.5	53.5
	W593	73.4	73.3	67.4	64.1	60.1	55.3
	W594	66.0	68.7	62.1	59.7	57.2	53.2
	W595	73.9	76.2	70.5	68.4	66.0	62.3
	W596	72.9	74.3	67.7	62.6	58.8	54.7
	W597	72.0	75.2	68.1	64.4	59.7	54.5
	W598	64.6	67.4	60.7	58.3	55.7	51.6
	W599	71.3	73.8	67.7	65.5	63.1	59.3
Gravel Run	W573	73.9	78.6	73.2	71.8	70.2	66.8
	W574	69.4	75.1	67.2	63.9	59.9	54.9
	W575	73.8	74.3	68.5	65.2	61.1	57.3
	W576	71.1	73.5	67.4	65.2	62.8	58.9
	W577	72.0	77.8	71.4	69.6	67.6	62.6
Kerns Run	W578	75.9	75.1	70.2	67.4	64.1	61.5
Little Conneautee Creek	W525	73.3	73.0	67.4	63.9	59.6	55.3
	W526	72.4	74.8	68.9	66.7	64.3	60.5
	W527	70.0	74.6	68.1	65.6	62.7	56.9
	W528	67.8	69.4	58.9	55.3	51.0	48.6
	W529	71.5	77.7	76.0	74.5	72.8	70.9
	W530	69.5	74.7	67.6	65.1	62.2	56.2
	W531	65.5	74.3	67.2	64.0	61.4	56.4
	W532	57.8	60.8	53.6	51.2	48.5	44.5
	W533	69.0	72.9	66.0	62.6	58.5	54.4
	W534	71.2	75.7	69.4	67.0	64.2	58.2
	W535	71.1	75.6	68.8	65.7	61.8	55.5
	W536	66.5	75.0	65.2	61.3	56.4	52.9
Mohawk Run	W520	73.6	75.2	69.4	67.7	65.8	61.1
	W521	66.0	72.0	59.9	54.8	51.3	47.6
Shenango Creek	W538	74.8	69.5	62.6	63.2	63.8	59.8
	W539	72.7	71.5	66.3	64.9	63.4	62.6
	W552	73.3	75.6	69.8	67.7	65.3	61.6
Torry Run	W548	72.6	78.3	73.8	71.6	69.8	64.3
	W549	71.7	78.1	74.1	71.5	70.0	65.2
Wolf Run	W581	75.3	77.1	72.3	69.8	66.8	63.3

Hydrologic Parameters for French Creek B 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
Boles Run	W519	76.2	78.4	73.0	71.0	68.7	65.2
	W564	76.7	74.9	69.6	66.8	63.3	59.0
	W565	75.5	74.3	67.5	64.5	60.9	57.4
	W566	74.2	79.2	73.6	72.2	70.5	66.2
Brookhouser Creek	W579	76.7	75.3	69.7	66.9	63.6	60.6
	W580	58.9	61.8	54.7	52.2	49.6	45.5
Conneauttee Creek	W524	69.0	71.6	65.3	63.0	60.5	56.5
	W537	66.8	69.4	64.7	64.3	64.0	62.2
	W540	79.0	72.8	66.9	66.9	66.9	64.3
	W541	80.6	82.5	77.8	76.1	74.1	70.9
	W542	73.7	77.7	72.1	69.6	66.5	61.3
	W550	62.8	75.0	70.1	69.6	69.1	65.6
	W551	61.5	74.6	70.8	70.3	69.9	68.9
	W553	67.2	69.8	63.3	61.0	58.4	54.4
	W554	78.3	68.1	60.5	60.5	60.5	62.1
	W555	79.0	81.0	76.0	74.2	72.1	68.7
	W556	73.0	75.4	69.5	67.4	65.0	61.2
	W557	69.8	72.4	66.1	63.9	61.4	57.5
	W558	62.7	65.5	58.6	56.2	53.6	49.5
	W559	66.6	75.3	66.3	63.7	60.6	56.5
	W560	69.9	72.4	66.2	64.0	61.5	57.6
	W561	74.3	76.6	70.9	68.8	66.5	62.8
Darrows Creek	W543	76.0	78.1	72.7	70.7	68.5	64.9
	W544	73.4	77.5	71.7	70.4	69.1	64.3
	W545	81.6	83.4	78.9	77.2	75.3	78.7
	W546	79.7	81.6	76.8	75.0	72.9	76.6
	W547	63.8	66.6	59.8	57.3	54.7	59.5
French Creek	W522	72.9	69.8	57.1	55.1	53.0	53.0
	W523	76.7	76.6	73.2	72.2	71.2	65.0
	W562	77.6	79.7	74.5	72.6	70.4	67.0
	W563	75.0	78.4	73.4	71.6	69.6	65.2
	W567	74.4	76.7	71.1	69.0	66.7	63.0
	W568	75.8	76.9	72.6	70.3	67.5	63.9
	W569	74.2	73.9	68.7	65.6	61.9	57.9
	W570	73.8	78.4	72.9	71.4	69.7	64.8
	W571	67.1	69.8	63.2	60.9	58.3	54.4
	W572	71.7	75.9	69.1	66.4	63.1	57.6
	W582	74.6	76.9	71.2	69.1	66.8	63.2
	W583	75.2	77.5	71.9	69.9	67.6	64.0
	W584	75.0	77.3	71.7	69.7	67.4	63.7
	W585	72.6	71.8	62.3	59.5	56.2	53.7
	W586	73.3	72.3	62.7	60.2	57.4	54.6
	W587	72.2	74.6	68.6	66.5	64.1	60.3
	W588	73.9	76.2	70.5	68.4	66.1	62.3

Hydrologic Parameters for French Creek B 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
French Creek	W589	76.5	78.6	73.3	71.3	69.1	65.5
	W590	72.7	77.9	71.8	70.1	68.3	64.5
	W591	71.2	73.7	67.6	65.4	62.9	59.1
	W592	66.3	69.0	62.4	60.1	57.5	53.5
	W593	73.4	73.3	67.4	64.1	60.1	55.3
	W594	66.0	68.7	62.1	59.7	57.2	53.2
	W595	73.9	76.2	70.5	68.4	66.0	62.3
	W596	72.9	74.3	67.7	62.6	58.8	54.7
	W597	72.0	75.2	68.1	64.4	59.7	54.5
	W598	64.6	67.4	60.7	58.3	55.7	51.6
	W599	71.3	73.8	67.7	65.5	63.1	59.3
Gravel Run	W573	73.9	78.6	73.2	71.8	70.2	66.8
	W574	69.4	75.1	67.2	63.9	59.9	54.9
	W575	73.8	74.3	68.5	65.2	61.1	57.3
	W576	71.1	73.5	67.4	65.2	62.8	58.9
	W577	72.0	77.8	71.4	69.6	67.6	62.6
Kerns Run	W578	75.9	75.1	70.2	67.4	64.1	61.5
Little Conneautee Creek	W525	73.4	73.1	67.5	64.0	59.7	55.4
	W526	72.5	74.9	69.0	66.8	64.5	60.7
	W527	70.0	74.6	68.1	65.6	62.8	56.9
	W528	67.8	69.4	58.9	55.3	51.0	48.6
	W529	71.5	77.8	76.0	74.5	72.8	70.9
	W530	69.6	74.9	67.8	65.3	62.3	56.4
	W531	65.6	74.3	67.3	64.1	61.5	56.5
	W532	57.8	60.8	53.6	51.2	48.5	44.5
	W533	69.0	72.9	66.0	62.6	58.5	54.4
	W534	71.2	75.7	69.4	67.0	64.3	58.3
	W535	71.2	75.7	68.9	65.8	61.9	55.6
	W536	66.5	75.0	65.2	61.3	56.4	52.9
Mohawk Run	W520	73.6	75.2	69.4	67.7	65.8	61.1
	W521	66.0	72.0	59.9	54.8	51.3	47.6
Shenango Creek	W538	74.9	69.6	62.7	63.3	63.9	59.9
	W539	73.4	72.2	67.1	65.7	64.2	63.4
	W552	73.3	75.6	69.8	67.7	65.3	61.6
Torry Run	W548	72.6	78.3	73.9	71.6	69.8	64.4
	W549	71.7	78.1	74.1	71.5	70.0	65.2
Wolf Run	W581	75.3	77.1	72.3	69.8	66.8	63.3

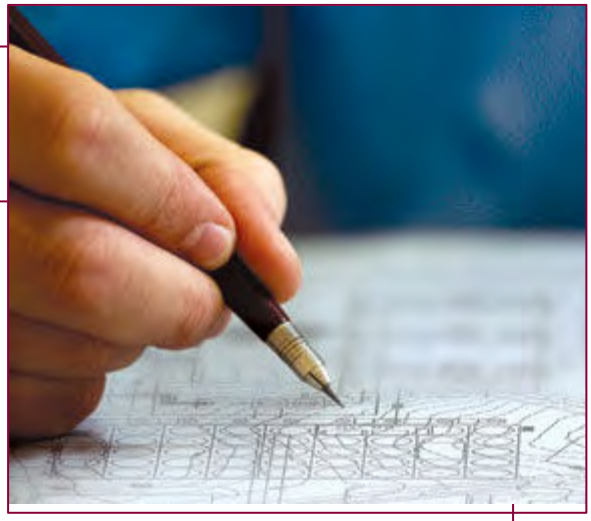
Hydrologic Results for French Creek B HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	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	J1106	1354965.7	593373.3	3.18	234	361	488	579	580	234	361	488	579	580
2	USGS 03021700	1333691.5	651582.8	3.52	267	501	650	758	868	268	502	651	760	870
3	J1228	1335978.8	645532.5	7.12	494	826	1,071	1,233	1,307	497	831	1,078	1,240	1,315
4	J1200	1339963.1	639113.4	11.39	729	1,181	1,513	1,710	1,779	734	1,189	1,522	1,721	1,790
5	J1182	1340233.6	638400.2	12.20	766	1,237	1,585	1,792	1,864	771	1,245	1,594	1,803	1,876
6	J1180	1341684.7	633924.0	13.46	817	1,310	1,675	1,888	1,963	823	1,318	1,685	1,899	1,975
7	J1140	1340159.9	627062.2	19.82	1,214	1,892	2,429	2,738	2,751	1,221	1,902	2,440	2,751	2,765
8	J1132	1337331.5	621257.9	23.49	1,384	2,125	2,717	3,043	3,035	1,391	2,136	2,731	3,058	3,051
9	J1206	1308113.4	644106.1	2.43	136	211	361	510	529	137	213	364	513	533
10	J1786	1316905.5	635498.0	1.18	86	141	233	319	358	126	203	315	418	469
11	J1790	1322714.4	632972.9	2.31	196	295	401	483	484	209	313	423	508	512
12	J1148	1322845.4	629742.9	3.37	296	445	594	705	732	311	468	623	739	769
13	EP060	1322599.5	629011.4	3.72	335	504	669	790	854	352	528	699	826	892
14	J1126	1328523.2	615370.5	3.43	222	354	448	526	514	222	355	449	527	515
15	J1212	1317951.1	643761.7	5.70	323	573	862	1,120	1,281	330	584	877	1,138	1,301
16	J1190	1317139.5	639039.6	13.11	748	1,290	1,946	2,527	2,918	784	1,344	2,017	2,611	3,014
17	J1788	1318108.5	637480.4	13.28	726	1,247	1,874	2,428	2,804	759	1,298	1,940	2,507	2,894
18	J1188	1318664.4	635793.2	15.48	774	1,320	1,978	2,556	2,944	814	1,381	2,055	2,646	3,046
19	J1784	1320656.5	628390.3	17.29	228	402	610	779	922	238	423	635	808	956
20	J1144	1321738.7	626496.5	20.04	294	494	740	929	1,070	319	522	773	966	1,116
21	J1138	1322771.6	624725.7	24.36	589	903	1,204	1,417	1,523	651	993	1,315	1,541	1,647
22	J1136	1326903.5	623004.1	25.69	647	993	1,323	1,553	1,656	714	1,091	1,444	1,689	1,804
23	J1128	1333740.7	610264.2	34.54	1,106	1,687	2,203	2,577	2,681	1,171	1,781	2,318	2,709	2,825
24	J_Conneauttee_Creek	1334404.8	608124.5	60.35	2,354	3,582	4,641	5,328	5,464	2,396	3,652	4,731	5,434	5,579
25	J1782	1336530.1	596825.4	0.85	146	221	284	326	350	146	221	284	326	350
26	CP080	1310000.9	616781.7	0.85	92	140	181	209	223	92	140	181	209	223
27	J1118	1317434.6	612330.1	4.99	342	519	659	726	764	343	520	660	727	767
28	J1094	1320435.2	600008.3	4.98	324	536	678	751	795	324	536	678	751	795
29	J1780	1323271.7	597737.5	6.13	431	697	892	1,003	1,047	431	697	892	1,003	1,047
30	J1078	1338585.8	582152.8	2.24	187	251	313	328	316	187	251	313	328	316
31	J1076	1336790.4	582989.0	5.70	430	635	786	823	837	430	635	786	823	837
32	J1084	1324739.2	588744.1	11.64	882	1,291	1,654	1,844	1,870	882	1,291	1,654	1,844	1,870
33	J1072	1310253.1	579718.0	4.14	304	490	618	677	759	304	490	618	678	759
34	J1074	1311015.5	579398.3	9.17	618	991	1,251	1,380	1,511	618	991	1,251	1,381	1,512

Hydrologic Results for French Creek B HEC-HMS Model

Discharge Point	HEC-HMS Node	Coordinates		Cumulative Area (mi^2)	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
35	J1116	1359294.3	605345.3	419.31	6,588	10,873	13,120	14,654	16,287	6,611	10,911	13,165	14,705	16,345
36	J1092	1356564.3	603181.0	494.57	8,244	13,770	16,806	18,824	21,015	8,265	13,803	16,845	18,869	21,065
37	J1108	1353613.0	603525.3	500.21	8,311	13,866	16,924	18,958	21,159	8,332	13,899	16,963	19,003	21,209
38	J1110	1347243.0	603377.8	502.07	8,256	13,769	16,800	18,815	20,996	8,277	13,802	16,839	18,859	21,046
39	J1112	1341463.4	606230.7	510.55	8,292	13,804	16,853	18,878	21,082	8,312	13,837	16,891	18,922	21,132
40	J1100	1337749.6	606525.9	512.80	8,285	13,800	16,851	18,877	21,079	8,305	13,833	16,889	18,921	21,129
41	J1778	1336132.7	607657.2	513.13	8,276	13,787	16,834	18,859	21,059	8,297	13,819	16,873	18,903	21,108
42	J1114	1333494.8	607632.6	574.48	9,163	15,242	18,775	21,152	23,603	9,196	15,297	18,842	21,227	23,692
43	J1102	1330469.7	603353.2	577.59	9,144	15,233	18,774	21,154	23,607	9,178	15,289	18,841	21,230	23,697
44	J1104	1329731.8	603008.9	586.19	9,234	15,391	18,977	21,387	23,862	9,268	15,447	19,045	21,463	23,952
45	J1098	1329240.0	602271.0	587.12	9,235	15,397	18,987	21,398	23,875	9,268	15,454	19,055	21,475	23,966
46	J1096	1325575.4	595433.8	595.79	9,275	15,460	19,081	21,508	23,997	9,319	15,518	19,150	21,586	24,088
47	J1088	1323878.4	592015.2	598.17	9,281	15,454	19,079	21,507	23,995	9,326	15,512	19,148	21,585	24,087
48	J1086	1324099.7	588252.2	610.30	9,563	15,637	19,320	21,784	24,297	9,608	15,697	19,390	21,863	24,390
49	J1080	1320041.7	582939.8	614.95	9,621	15,663	19,356	21,825	24,342	9,667	15,723	19,427	21,905	24,436
50	J1776	1313229.0	578814.3	617.38	9,623	15,652	19,347	21,814	24,327	9,670	15,712	19,418	21,894	24,421
51	J1070	1312884.7	575192.6	627.51	9,833	15,785	19,526	22,020	24,560	9,880	15,846	19,598	22,101	24,655
52	USGS 03022500	1314212.8	572997.7	627.91	9,818	15,775	19,514	22,005	24,542	9,865	15,836	19,586	22,086	24,637

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.

Summation of Non-Structural BMP Credits
= 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. Maximum loading ratios – 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. Expected runoff volume loading – 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 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	Area	Area	CN	S	I_a	Runoff Depth$_{2\text{-}yr}$	Runoff Volume$_{2\text{-}yr}$
	(HSG)	(sf)	(acres)			(0.2*S)	(in)	(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.

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**
= 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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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?
http://www.dep.state.pa.us/dep/deputate/watermgt/wqp/wqstandards/303d-Report.htm
Yes [ ] No [X]

List Causes of Impairment:

Is project subject to, or part of:

Municipal Separate Storm Sewer System (MS4) Requirements?
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/StormwaterManagement/GeneralPermits/default.htm
Yes [ ] No [X]

Existing or planned drinking water supply?
Yes [ ] No [X]

If yes, distance from proposed discharge (miles): _____

Approved Act 167 Plan?
http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/StormwaterManagement/Approved_1.html
Yes [X] No [ ]

Existing River Conservation Plan?
http://www.dcnr.state.pa.us/brc/rivers/riversconservation/planningprojects/
Yes [X] No [ ]

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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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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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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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Project ID: MILL RUN RESIDENTIAL
Owner:
Calculated: Date:
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WORKSHEET 5. STRUCTURAL BMP VOLUME CREDITS

SUB-BASIN: N/A

Check 25% Limit for Non-Structural BMP Credits: 615
÷ 11,311
5.4%

Required Control Volume (ft^3): 11,311
Allowable Non-structural Volume Credit (ft^3): - 615

Structural Volume Reqmt (ft^3): **10,696**
(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): 10,696

DIFFERENCE: 3,917 *(excess)*

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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 ft^2
Total Impervious Area: 55,660 ft^2

Proposed Infiltration BMP(s)		Infiltration Rate			Design Runoff Volume	Infiltration Period			Hydraulic Loading: Imperv. Drainage Area Loading				Hydraulic Loading: Total Drainage Area Loading				Target BMP Area[5]	Actual BMP Area[6]	Computed Infiltration Volume
		Measured Infilt Rate[1] *in/hr*	FOS	Design Infilt Rate *in/hr*	*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.*	*sq. ft.*	*sq. ft.*	*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.

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.

Pre-Development Soil-Cover Complex Data

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

Pre-Development Time of Concentration

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

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*.

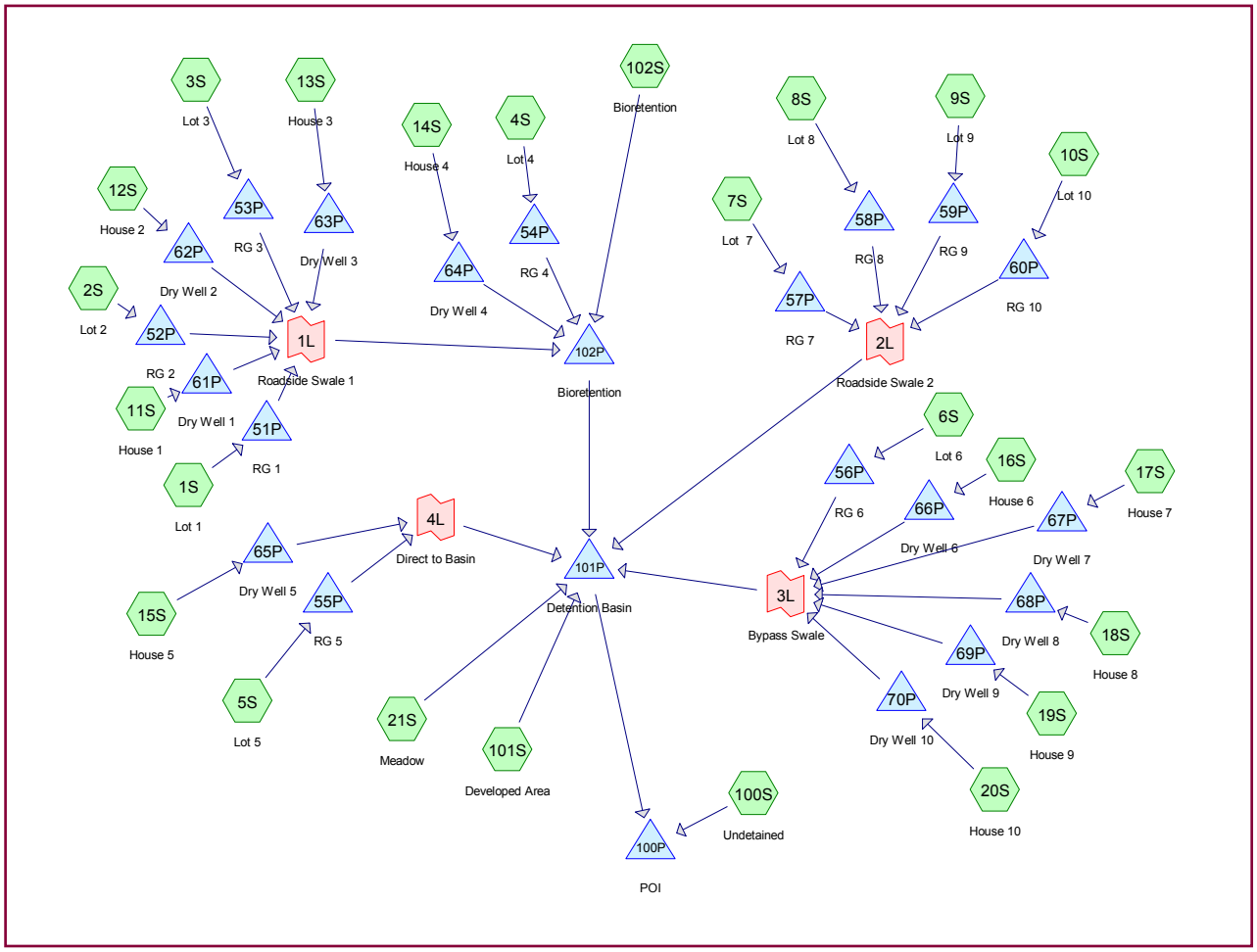


Figure B.1. Hydrologic Model of Post-Development Conditions

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)

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.

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.

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.

Due to funding constraints, no individual solutions were proposed.

Problem Area Hydrology

Although no hydrology was developed for the individual problem areas, the modeling effort as described in *Section 6* provided discharge estimates at some problem area locations, indicated in Table C.1.

Problem Area	Cumulative Area (mi²)	2010 Discharges with Existing SWM (cfs)					Data Source
		2-Year	10-Year	25-Year	50-Year	100-Year	
EO009	0.79	51	138	203	252	322	HEC-HMS
EO025	6.51	235	483	578	669	706	HEC-HMS
EP002	97.10	4,048	6,019	7,290	7,542	7,760	HEC-HMS
EP007	15.00	1,046	2,201	2,867	3,342	3,867	HEC-HMS
EP010	3.11	137	244	250	291	362	HEC-HMS
EP020	1.61	220	405	512	585	712	HEC-HMS
EP042	11.47	628	1,414	1,914	2,213	2,673	HEC-HMS
EP057	5.99	312	709	926	1,028	1,310	HEC-HMS
EP060	3.72	335	504	669	790	854	HEC-HMS
EP073	4.59	220	420	532	567	644	HEC-HMS
EP108	3.60	225	423	565	655	707	HEC-HMS
EP110	14.14	1,012	2,126	2,765	3,221	3,724	HEC-HMS
EP111	1.85	165	353	474	558	632	HEC-HMS
EP112	0.85	51	115	156	185	215	HEC-HMS

Table C.1. Problem Area Hydrology

Hydraulics

Due to funding constraints, no hydraulic calculations were provided at individual problem areas.

Erie County Act 167 Plan

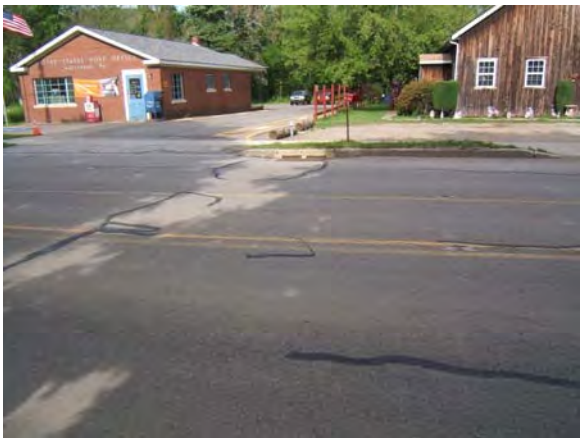
Problem Area Summary

Municipality: Wattsburg Borough **ID:** EO001

Location: Main St **Stream:**

Problem Description:

Collapsed storm drains under Main St. Inlet box at house #14400 is full of debris. Runoff that drains to this area has no outlet.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Union Township **ID:** EO002

Location: Union LeBoeuf Rd **Stream:**

Problem Description:

Stream debris has been reported in the past. During the field visit, the stream appeared to be free of debris.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Summit Township **ID:** EO003

Location: LeBoeuf Creek **Stream:**

Problem Description:

Beaver dams.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Waterford Township **ID:** EO004

Location: Sedgwick Rd **Stream:**

Problem Description:

Beaver dams reported, but they appeared to be removed during the field visit.

Erie County Act 167 Plan

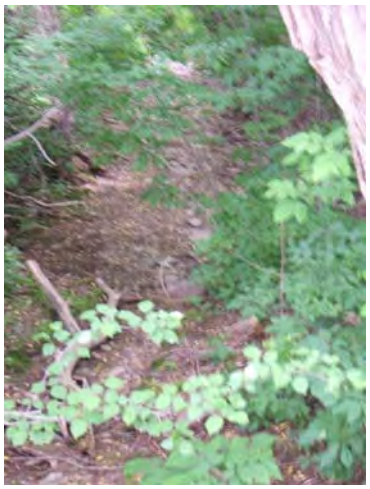
Problem Area Summary

Municipality: Waterford Township **ID:** EO005

Location: Juva Valley Rd **Stream:**

Problem Description:

Culverts do not appear to have adequate hydraulic capacity.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Mill Village Borough **ID:** EO006

Location: Depot St Culvert **Stream:**

Problem Description:

Culvert was replaced in 2008.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Mill Village Borough **ID:** EO007

Location: Railroad Culvert #1 **Stream:**

Problem Description:

Culvert does not appear to have adequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Mill Village Borough **ID:** EO008

Location: Railroad Culvert #2 **Stream:**

Problem Description:

Large sediment deposit is blocking culvert inlet. There is also a large deposit positioned at the outlet. It appears that the culvert would have adequate hydraulic capacity if channel was cleared. The source of upslope sediment needs to determined.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Harborcreek Township **ID:** EO009

Location: Backus Rd culvert **Stream:**

Problem Description:

Culvert does not appear to have adequate hydraulic capacity. It is in poor condition and may be structurally deficient.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greene Township **ID:** EO010

Location: May Rd @ gamelands **Stream:**

Problem Description:

Area is in wetlands and prone to flooding. May Rd is only feet away from the waterbody. It appears the water from the wetlands may back up and flood the properties on the west side of May Rd.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Fairview Township **ID:** EO011

Location: Trout Run **Stream:**

Problem Description:

Low lying area that is heavily vegetated. Properties in this area are in the floodplain. This problem area has been mitigated since the area downstream has been cleared and maintained.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Fairview Township **ID:** EO012

Location: Bear Run **Stream:**

Problem Description:

Beaver dam. Frequent flooding results.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Lawrence Park Township **ID:** EO013

Location: Iroquois Ave - E.B. Ln **Stream:**

Problem Description:

The E.B. Ln slopes to a low point where runoff ponds. There are no drainage structures present. An inlet and a culvert to the Creek would likely mitigate the problem.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Lawrence Park Township **ID:** EO014

Location: Snoopy & Cricket **Stream:**

Problem Description:

It appears the conveyance under the railroad tracks is insufficient. The whole network appears in need of maintenance.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Franklin Township **ID:** EO015

Location: Throughout Twp **Stream:**

Problem Description:

There are 67 deficient culverts and bridges reported.

Erie County Act 167 Plan

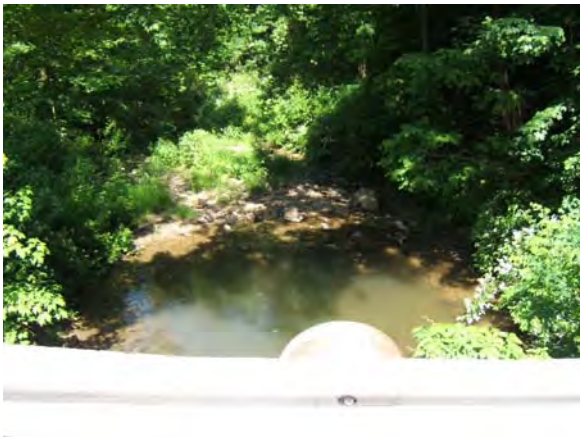
Problem Area Summary

Municipality: Platea Borough **ID:** EO016

Location: Platz Rd Bridge **Stream:**

Problem Description:

During the field visit, it appeared that the problem was fixed. The culvert appears adequate.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EO017

Location: Airport Rd Extended **Stream:**

Problem Description:

During the field visit, it appeared that the problem was fixed. The culvert appears adequate.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EO018

Location: W. Church St **Stream:**

Problem Description:

The conveyance system is fully clogged in the Spring St-Euclid St area. Upstream gravel road probably contributes to sediment in pipe network.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EO019

Location: Highway bridge at ST RT 6 **Stream:**

Problem Description:

The bridge appears to be in poor condition.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EO020

Location: Railroad bridge **Stream:**

Problem Description:

Northern drainage area of Hare Creek confluences here. The railroad bridge appears to have adequate capacity but there is noticeable stream bank erosion upstream and downstream of the bridge.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EO021

Location: Railroad culvert **Stream:**

Problem Description:

A culvert with no hydraulic capacity. Ponding occurs at the culvert inlet. There has been no maintenance for 30 years. Approval for mitigation has been difficult to obtain from the railroad owners.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EO022

Location: Corry Middle School **Stream:**

Problem Description:

Stream is eroding and depositing in different locations. Culvert appears to have adequate capacity although this depends on maintenance. The upstream source of sediment needs to be determined.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EO023

Location: E. Washington St **Stream:**

Problem Description:

Problem area unable to be located during field visit.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Amity Township **ID:** EO024

Location: Lowe Rd **Stream:**

Problem Description:

Beaver dams. This is a previous gravel roads project where culvert was installed. Beavers have blocked the channel.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Elgin Borough **ID:** EO025

Location: S. Main St **Stream:**

Problem Description:

This problem area is being mitigated as a bridge replacement project is currently in process.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Northeast Township **ID:** EO026

Location: Mouth of 16 Mile & 20 Mile Cks **Stream:**

Problem Description:

Ice jams. When Lake Erie freezes close to shore, ice from Sixteen and Twenty Mile Creeks can not discharge to lake.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Northeast Township **ID:** EO027

Location: Baker Run Creek **Stream:**

Problem Description:

Debris from an upstream concrete plant and various large woody debris blocks the stream and overflows into Northeast Borough Waste Water Treatment Plant #1 property.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Edinboro Borough **ID:** EO028

Location: Water St & Green Oaks **Stream:**

Problem Description:

Conveyance system appears to have inadequate hydraulic capacity. The entire surrounding area floods.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Girard Township **ID:** EO029

Location: S. Creek Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Girard Township **ID:** EO030

Location: Cindy Lane & Daggett **Stream:**

Problem Description:

Runoff from upstream culverts discharges to the low point along Cindy Ln and Daggett. There is no outlet on the south side of Cindy Ln.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Girard Township **ID:** EO031

Location: Route 20 **Stream:**

Problem Description:

The conveyance system along ST RT 20 becomes smaller as it approaches its outfall and appears to have inadequate hydraulic capacity. New development also appears to have impacted the area.

Erie County Act 167 Plan

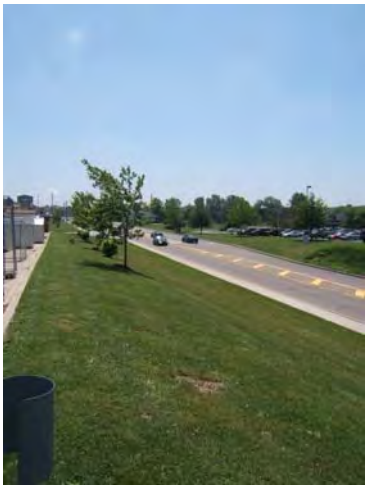
Problem Area Summary

Municipality: Millcreek Township **ID:** EO032

Location: Asbury Rd SR4009 underpass **Stream:**

Problem Description:

There appears to be inadequate drainage under the PennDOT bridge. The emergency spillway for the Lowe's discharges onto Asbury Road.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EO033

Location: Heidler Rd Channel **Stream:**

Problem Description:

A heavily vegetated channel that appears to have inadequate hydraulic capacity frequently floods. Runoff from multiple upslope developments discharges to the channel.

Erie County Act 167 Plan

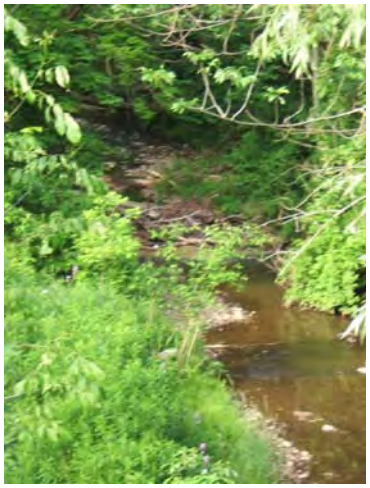
Problem Area Summary

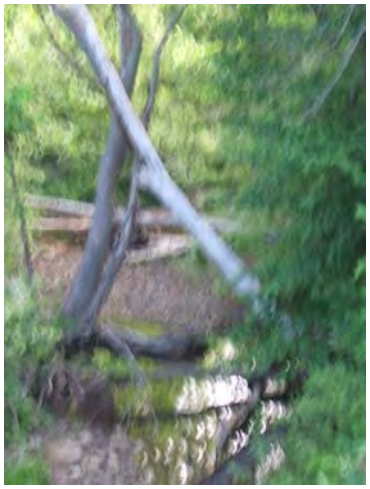
Municipality: Millcreek Township **ID:** EO034

Location: Cider Mill to Lake Pleasant **Stream:**

Problem Description:

Stream obstructions from large woody debris within Mill Creek.





Erie County Act 167 Plan

Problem Area Summary

Municipality: Wattsburg Borough **ID:** EP001

Location: North St near Wattsburg Lumber **Stream:**

Problem Description:

Road appears to have inadequate drainage. Inlets are full of debris. Gravel from neighboring lots enters the inlets and reduces the hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Wattsburg Borough **ID:** EP002

Location: French Creek **Stream:**

Problem Description:

Overbank flow and flooding. Problem area is located in the floodplain.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Waterford Township **ID:** EP003

Location: 1000' of Himrod Rd **Stream:**

Problem Description:

Flooding occurs because of inadequate drainage. The Erie County Conservation District is currently applying for funds to mitigate.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Waterford Township **ID:** EP004

Location: 750' of Flatts Rd **Stream:**

Problem Description:

The wooden bridge is closed due to its poor condition. Flooding occurs upstream and downstream of the bridge.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Waterford Township **ID:** EP005

Location: Sedgwick Rd **Stream:**

Problem Description:

Same as EO004.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Waterford Township **ID:** EP006

Location: Haugh Rd **Stream:**

Problem Description:

Dirt and Gravel Roads project completed in 2008.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Cranesville Borough **ID:** EP007

Location: Temple Creek @ John Wms Ave **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Cranesville Borough **ID:** EP008

Location: Crosby Circle & John Wms Ave **Stream:**

Problem Description:

Inadequate roadside channels overtop and flood along Crosby Cr. Overall, the conveyance system appears in need of maintenance.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Mill Village Borough **ID:** EP009

Location: French Creek Trib **Stream:**

Problem Description:

Upstream sediment is depositing in within stream, creating an obstruction. Downstream of area appears to have adequate capacity.

Erie County Act 167 Plan

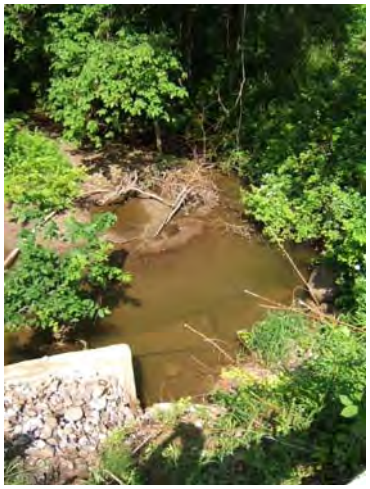
Problem Area Summary

Municipality: Springfield Township **ID:** EP010

Location: Tubbs Rd **Stream:**

Problem Description:

Outflow from culvert discharge to a channel that makes an abrupt turn. An additional culvert at beginning of Tubbs Rd appears to provide adequate capacity but channel and culvert are not aligned correctly.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Springfield Township **ID:** EP011

Location: Various streams **Stream:**

Problem Description:

Beaver dams.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Harborcreek Township **ID:** EP012

Location: Fairfield area **Stream:**

Problem Description:

Inadequate conveyance system.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Harborcreek Township **ID:** EP013

Location: Villa Sites Rd **Stream:**

Problem Description:

Culvert appears adequate. Discharge from culvert leads to low lying areas located on neighboring properties which experience frequent flooding.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Harborcreek Township **ID:** EP014

Location: Lewis-Mooreheadville Rds Area **Stream:**

Problem Description:

Inadequate roadside drainage.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Harborcreek Township **ID:** EP015

Location: Beaver Rd - Nagle to Clark **Stream:**

Problem Description:

Problem area unable to be located during field visit.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Harborcreek Township **ID:** EP016

Location: Brookside Area **Stream:**

Problem Description:

This area is relatively low and receives substantial upslope runoff from residential properties. The conveyance channel through area appears to be insufficient. A new conveyance system/network is likely needed.

Erie County Act 167 Plan

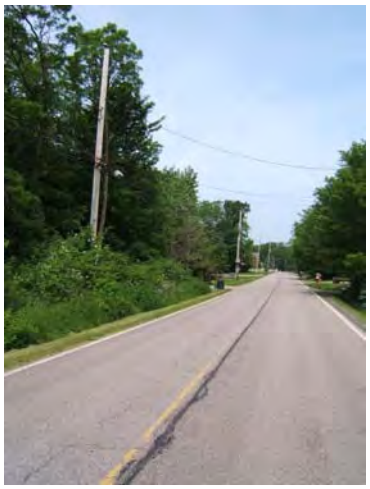
Problem Area Summary

Municipality: Harborcreek Township **ID:** EP017

Location: Clark Rd to Firman Rd **Stream:**

Problem Description:

The culverts and channels along Clark Rd appear to overtop and flood the neighboring properties.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Girard Boroughugh **ID:** EP018

Location: Sunset Drive North **Stream:**

Problem Description:

This heavily vegetated channel leading to Lake Erie is in need of maintenance. The railroad culvert may have insufficient hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greene Township **ID:** EP019

Location: Sampson Rd **Stream:**

Problem Description:

Property flooding near wetlands.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greenfield Township **ID:** EP020

Location: German Rd **Stream:**

Problem Description:

Beaver dams. Dams are blocking the dual 48" HDPE culverts. Culverts may provide adequate capacity if dams were removed. The Township has removed the dams several times.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greenfield Township **ID:** EP021

Location: Ashton Rd **Stream:**

Problem Description:

Beaver dams. Dams are blocking the dual 48" HDPE culverts. Culverts may provide adequate capacity if dams were removed.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greenfield Township **ID:** EP022

Location: Wilson Rd **Stream:**

Problem Description:

Culverts appear to have been recently replaced.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greenfield Township **ID:** EP023

Location: Wilson Rd **Stream:**

Problem Description:

Beaver dams. The bridge appears to provide adequate capacity if the dam would be removed.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greenfield Township **ID:** EP024

Location: New Rd **Stream:**

Problem Description:

Beaver dams. The culvert appears to provide adequate capacity if the dam would be removed.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greenfield Township **ID:** EP025

Location: Dougan Rd **Stream:**

Problem Description:

Culverts appear to have been recently replaced.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greenfield Township **ID:** EP026

Location: Raymond Mills **Stream:**

Problem Description:

Beaver dams. Dams are blocking the dual 48" HDPE culverts. Culverts may provide adequate capacity if dams were removed. The Township has recently removed the dams.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greenfield Township **ID:** EP027

Location: N of I 86 **Stream:**

Problem Description:

Wetlands created for mitigation during I-86 highway construction.

Erie County Act 167 Plan

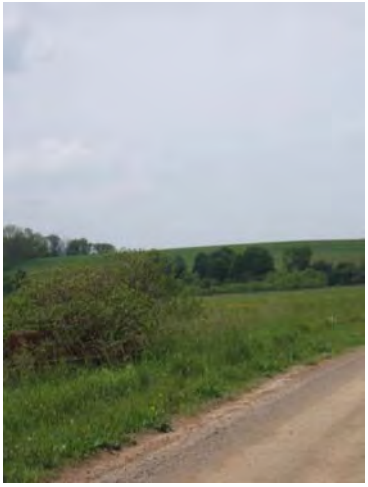
Problem Area Summary

Municipality: Venango Township **ID:** EP028

Location: French Creek & Knoyle Rd **Stream:**

Problem Description:

Frequent flooding. Area is within the floodplain.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Fairview Township **ID:** EP029

Location: Trout Run **Stream:**

Problem Description:

See EO011.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Fairview Township **ID:** EP030

Location: Bear Run **Stream:**

Problem Description:

See EO012.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Fairview Township **ID:** EP031

Location: PennDOT infrastructure **Stream:**

Problem Description:

Conveyance system appears to be in need of maintenance. The system apparently functions well when maintained.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Fairview Township **ID:** EP032

Location: Subdivision has combined sewers **Stream:**

Problem Description:

Problem is currently being mitigated.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Fairview Township **ID:** EP033

Location: Entire Township **Stream:**

Problem Description:

High coliform at some outfalls. Problem is currently being mitigated.

Erie County Act 167 Plan

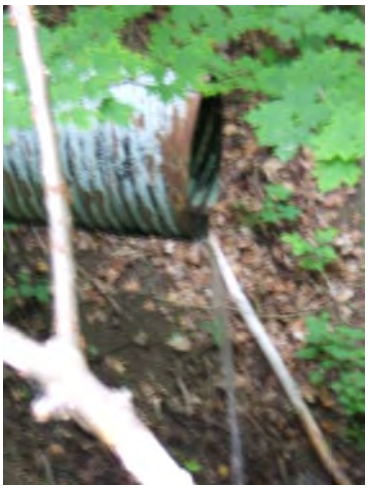
Problem Area Summary

Municipality: Fairview Township **ID:** EP034

Location: Walnut Creek **Stream:**

Problem Description:

Streambank stabilization and stormwater mitigation is needed in several locations along Walnut Creek.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Lawrence Park Township **ID:** EP035

Location: Iroquois Ave - EB Ln **Stream:**

Problem Description:

See EO013.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Lawrence Park Township **ID:** EP036

Location: Snoopy & Cricket **Stream:**

Problem Description:

See EO014.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Lawrence Park Township **ID:** EP037

Location: St. Marks Roman Catholic Church **Stream:**

Problem Description:

The yard area of the church is flooding during storm events.

Erie County Act 167 Plan

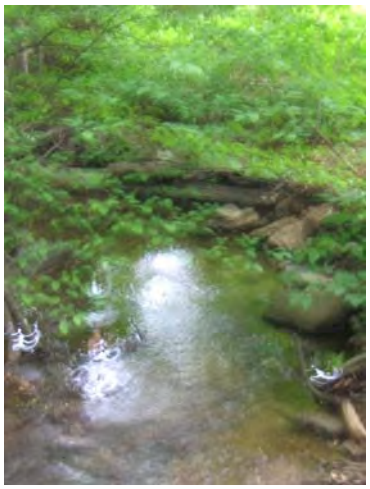
Problem Area Summary

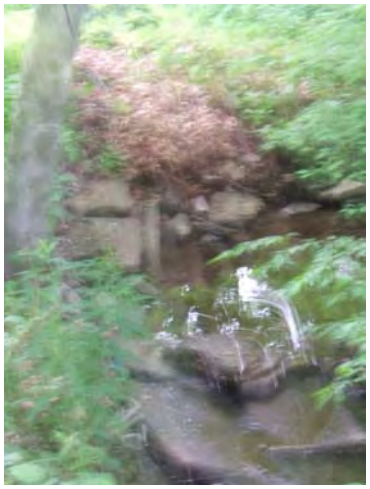
Municipality: Lawrence Park Township **ID:** EP039

Location: Crotty, Smithson, Morse, Emmet **Stream:**

Problem Description:

It appears neighboring property owners have been placing concrete pieces in the stream to prevent stream bank erosion.





Erie County Act 167 Plan

Problem Area Summary

Municipality: Lawrence Park Township **ID:** EP040

Location: Napier playground **Stream:**

Problem Description:

It appears that Curtis Park playground is in the floodplain.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Lawrence Park Township **ID:** EP041

Location: Four Mile Creek **Stream:**

Problem Description:

Stream bank erosion. Debris is also present in creek.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Lawrence Park Township **ID:** EP042

Location: Four Mile Creek **Stream:**

Problem Description:

Pedestrian bridges constrict the floodplain causing stream bank erosion near their footings.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Franklin Township **ID:** EP043

Location: Entire Township **Stream:**

Problem Description:

See EP121 to EP129.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Platea Borough **ID:** EP044

Location: Rt 18 & West Peach St. **Stream:**

Problem Description:

Runoff flows to lower railroad bed and floods during storm events.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EP045

Location: E. Columbus & Scotia St **Stream:**

Problem Description:

Conveyance system appear to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EP046

Location: W. Main St **Stream:**

Problem Description:

Railroad culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EP047

Location: E. Columbus **Stream:**

Problem Description:

Channel is eroding and depositing debris onto ST RT 0006. The downstream channel has been cleaned out and widened but the site continues to need regular maintenance.

Erie County Act 167 Plan

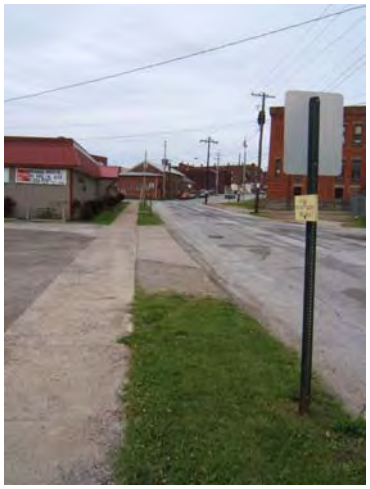
Problem Area Summary

Municipality: Corry City **ID:** EP048

Location: E. Washnton St **Stream:**

Problem Description:

The conveyance network along this relatively long, mildly sloped roadway appears to be inadequate.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EP049

Location: White St **Stream:**

Problem Description:

The conveyance network along this relatively long, mildly sloped roadway appears to be inadequate.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EP050

Location: Liberty St **Stream:**

Problem Description:

The conveyance network appears to be inadequate.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Corry City **ID:** EP051

Location: W. Pleasant St **Stream:**

Problem Description:

The conveyance network appears to be inadequate.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Lake City Borough **ID:** EP052

Location: Eagle St **Stream:**

Problem Description:

An old foundation is deteriorating in the channel of Kelly Run.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Mckean Township **ID:** EP053

Location: Old 99 **Stream:** LAMSON RUN

Problem Description:

Property near Lamson Run frequently floods.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Mckean Township **ID:** EP054

Location: Baron, West, Old 99, Reichert **Stream:**

Problem Description:

Frequent flooding with areas near or in the floodplain.

Erie County Act 167 Plan

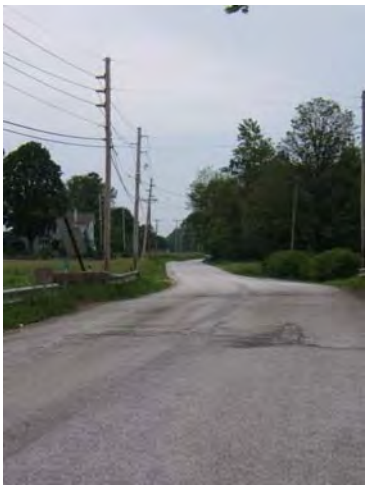
Problem Area Summary

Municipality: Mckean Township **ID:** EP055

Location: Reichert Rd **Stream:**

Problem Description:

Bridge is to be replaced in near future.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Northeast Township **ID:** EP056

Location: Orchard Beach Creek area **Stream:**

Problem Description:

Culvert appears to provide adequate capacity. Neighboring properties located near the culvert outlet will most likely flood during even minor storm events.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Northeast Township **ID:** EP057

Location: Brickyard Rd north of Law Rd **Stream:**

Problem Description:

Bridge abutments appear to be deteriorating.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Edinboro Borough **ID:** EP058

Location: W. Plum & Willow St **Stream:**

Problem Description:

Problem is currently being mitigated.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Edinboro Borough **ID:** EP059

Location: ST RT 99 **Stream:**

Problem Description:

Flooding occurs when Edinboro Lake levels are high.

Erie County Act 167 Plan

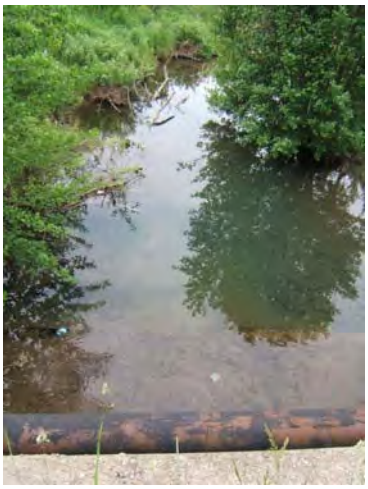
Problem Area Summary

Municipality: Edinboro Borough **ID:** EP060

Location: Heather Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Edinboro Borough **ID:** EP061

Location: N of Industrial Dr **Stream:**

Problem Description:

Beaver dam.

Erie County Act 167 Plan

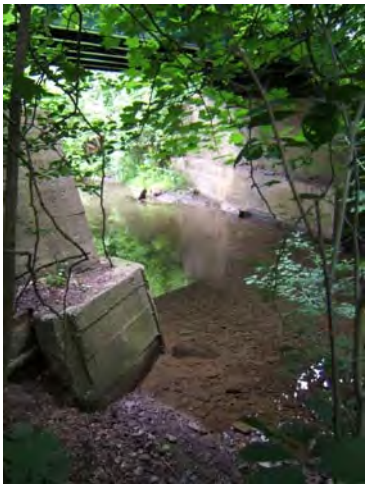
Problem Area Summary

Municipality: Edinboro Borough **ID:** EP062

Location: Peach St (e of lake) **Stream:**

Problem Description:

Pollution has been documented coming from upstream waste water treatment plant. The effluent is currently being re-routed and given additional treatment.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Edinboro Borough **ID:** EP063

Location: N of Lake **Stream:**

Problem Description:

Pollution has been documented coming from upstream waste water treatment plant. The effluent is currently being re-routed and given additional treatment.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Edinboro Borough **ID:** EP064

Location: Penn Union Site **Stream:**

Problem Description:

Penn-Union had a chemical spill. They have installed a treatment system to prevent future contamination.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Edinboro Borough **ID:** EP065

Location: Wipple Creek enterance to Lake **Stream:**

Problem Description:

Heavy sediment deposition. Source of sediments needs to be determined.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Edinboro Borough **ID:** EP066

Location: Elm St storm sewer into Lake **Stream:**

Problem Description:

Heavy sediment deposition. Source of sediments needs to be determined.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Edinboro Borough **ID:** EP067

Location: Conneaut/Shenago Watersheds **Stream:**

Problem Description:

Heavy sediment deposition. Source of sediments needs to be determined.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Edinboro Borough **ID:** EP068

Location: Minor trib into Lake **Stream:**

Problem Description:

Heavy sediment deposition. Source of sediments needs to be determined. The Borough describes this problem as relatively minor.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Wayne Township **ID:** EP069

Location: Hill Crest **Stream:**

Problem Description:

Land was developed prior to SWM plan requirements. There is no outlet for water that collects at low points. Water appears to infiltrate rapidly in this area.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Wayne Township **ID:** EP070

Location: Country Club Rd Sudbivision **Stream:**

Problem Description:

New upslope development is causing flooding impacts on downstream properties.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Wayne Township **ID:** EP071

Location: Route 6 west of hatchery **Stream:**

Problem Description:

Runoff that was diverted through a now defunct fish hatchery is now is diverted through neighboring properties. Runoff then ponds along ST RT 0006 and neighboring properties. The culvert outfall under ST RT 0006 is blocked.

Erie County Act 167 Plan

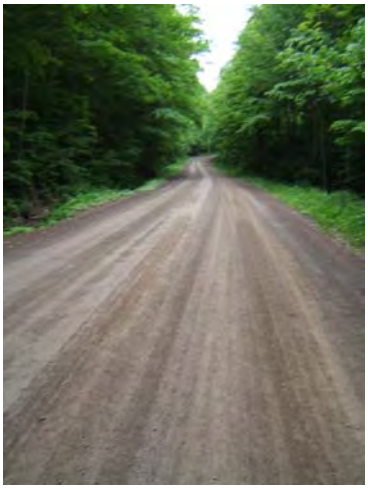
Problem Area Summary

Municipality: Wayne Township **ID:** EP072

Location: Dugway Stream **Stream:**

Problem Description:

Severe erosion along state line road.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Girard Township **ID:** EP073

Location: Gloskey Rd Bridge **Stream:** CRICKET CREEK

Problem Description:

Bridge appears to have inadequate hydraulic capacity and is in poor overall condition.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Girard Township **ID:** EP074

Location: Route 20 **Stream:**

Problem Description:

Runoff ponds along ST RT 20 in low lying areas. There is no outlet for the runoff.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Girard Township **ID:** EP075

Location: Route 20 **Stream:**

Problem Description:

Runoff ponds along ST RT 20 in low lying areas. There is no outlet for the runoff.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP076

Location: Riviera Estates **Stream:**

Problem Description:

Frequent flooding. Depth of water in general area varies between 2' -4' depth during storm events.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP077

Location: 15th & Harper **Stream:**

Problem Description:

Frequent flooding of homes, businesses, and roadways. SWM conveyance system may be inadequate.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP078

Location: Taki Mobile Home Park **Stream:**

Problem Description:

Frequent flooding. Runoff is directed to a low lying area water backs up to Trailer #1545 and beyond.

Erie County Act 167 Plan

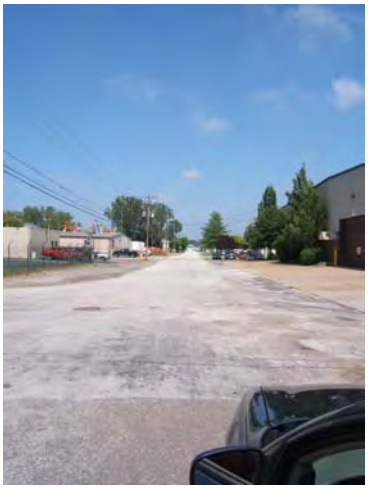
Problem Area Summary

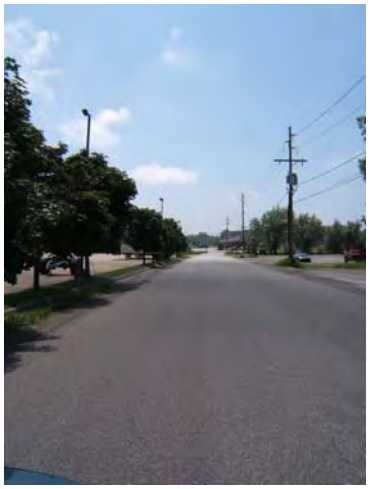
Municipality: Millcreek Township **ID:** EP079

Location: 17th & Harper **Stream:**

Problem Description:

Frequent flooding of homes, businesses, and roadways. SWM conveyance system may be inadequate.





Erie County Act 167 Plan

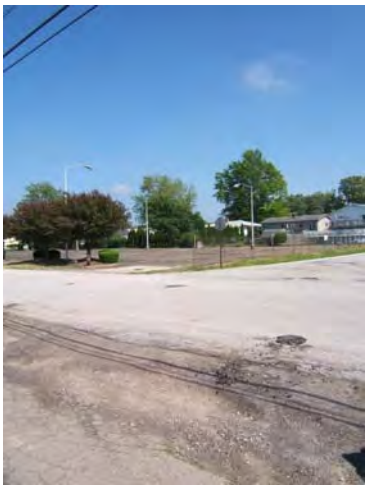
Problem Area Summary

Municipality: Millcreek Township **ID:** EP080

Location: 22nd & James **Stream:**

Problem Description:

Frequent flooding of homes, businesses, and roadways. Upslope runoff appears to be conveyed towards Paragon Stair & Rail, Inc. The conveyance system appears to be in need of maintenance and may be hydraulically insufficient.



Erie County Act 167 Plan

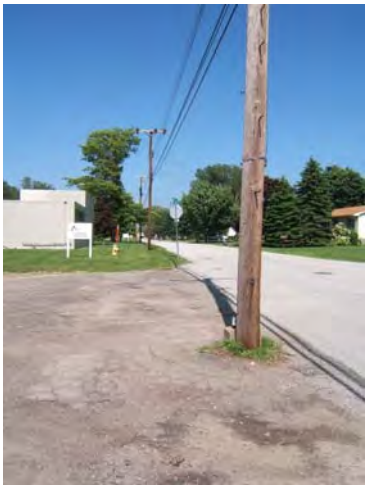
Problem Area Summary

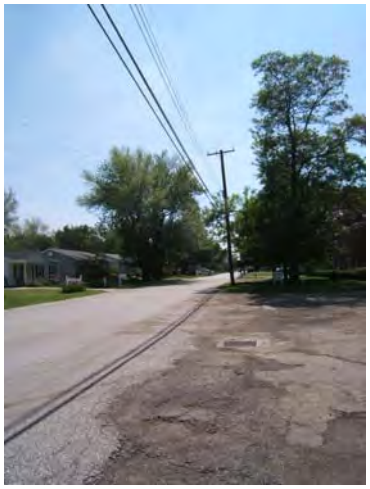
Municipality: Millcreek Township **ID:** EP081

Location: 22nd & Homer to Midland **Stream:**

Problem Description:

Frequent flooding of parking lots, businesses, and roadways. There is a low lying area along the property of Erie Advanced Manufacturing that appears to flood. The conveyance system may be insufficient and in need of maintenance.





Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP082

Location: EBCO Park **Stream:**

Problem Description:

Frequent flooding of parking lots, businesses, and roadways. The SWM facility in area has no outlet. Infiltration appears to be the only means of discharge.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP083

Location: 20th & 23rd, Lowell to Evanston **Stream:**

Problem Description:

Street & yard flooding. No conveyance facility could be located.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP084

Location: InsulBoard & RR tracks **Stream:**

Problem Description:

Frequent flooding of business, parking lot and truck dock. The channel along railroad appears to flood and backup into the parking lot and loading dock.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP085

Location: Sterling RR - Powell Ave **Stream:**

Problem Description:

Frequent flooding of parking lots, businesses, and roadways. Channel along the railroad may back up and cause parking area to flood.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP086

Location: 13th & 14th, Idaho Ave **Stream:**

Problem Description:

Frequent yard flooding. Channels along Idaho Ave may be insufficient causing runoff to flood the neighboring properties.

Erie County Act 167 Plan

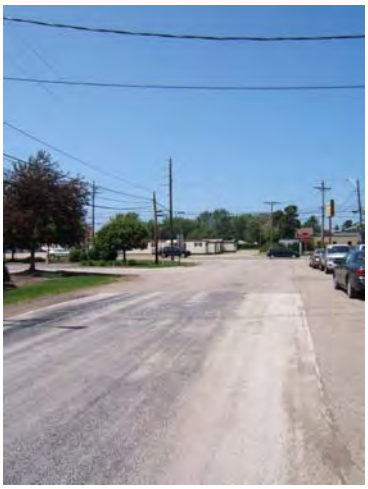
Problem Area Summary

Municipality: Millcreek Township **ID:** EP087

Location: 12th St Area to Peninsula Dr **Stream:**

Problem Description:

Frequent flooding of 4 lane highway, business, home, and yards. Conveyance system may be insufficient.



Erie County Act 167 Plan

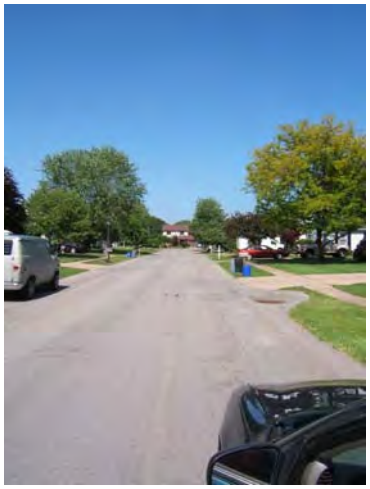
Problem Area Summary

Municipality: Millcreek Township **ID:** EP088

Location: Enfield Lane **Stream:**

Problem Description:

Frequent home & yard flooding. The storm system may be insufficient.



Erie County Act 167 Plan

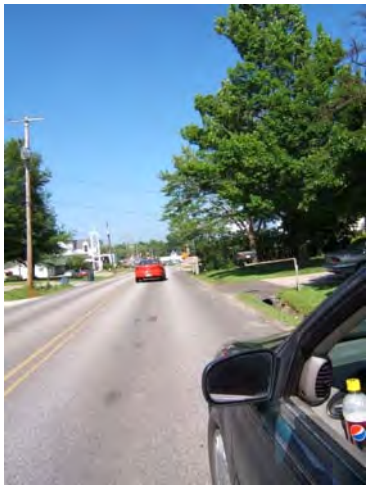
Problem Area Summary

Municipality: Millcreek Township **ID:** EP089

Location: Walnut Ck to Timber Ridge **Stream:**

Problem Description:

Frequent home & yard flooding. The storm system may be insufficient.



Erie County Act 167 Plan

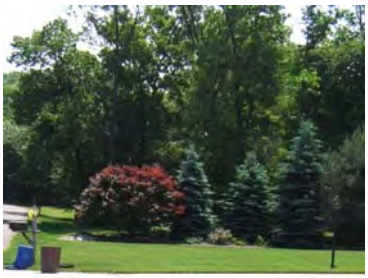
Problem Area Summary

Municipality: Millcreek Township **ID:** EP090

Location: Shadybrock to Brockhollow **Stream:**

Problem Description:

Frequent home & yard flooding. The storm system may be insufficient.



Erie County Act 167 Plan

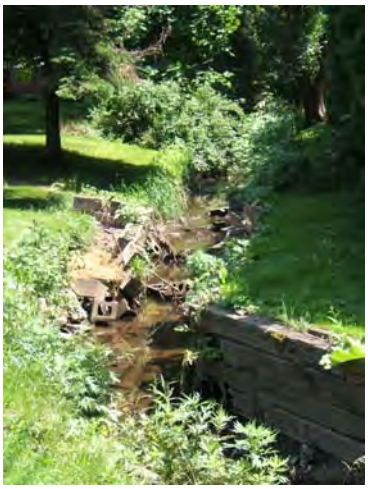
Problem Area Summary

Municipality: Millcreek Township **ID:** EP091

Location: Michigan & Oregon, N of 10th **Stream:**

Problem Description:

Frequent yard flooding. The channel behind the homes along road overtops regularly and backs water up close to homes. Channel is beginning to erode and appears to be insufficient.



Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP092

Location: 28th & Contessa area **Stream:**

Problem Description:

Frequent yard flooding. The storm system may be insufficient.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP093

Location: Arcadia Ave, S of 26th **Stream:**

Problem Description:

Frequent home and yard flooding. The conveyance system near 2626 Arcadia Ave discharges to Marshall Run. The conveyance system may be insufficient.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP094

Location: 16th to 18th **Stream:**

Problem Description:

Frequent road, home and business flooding. A conveyance system is not present in this area.

Erie County Act 167 Plan

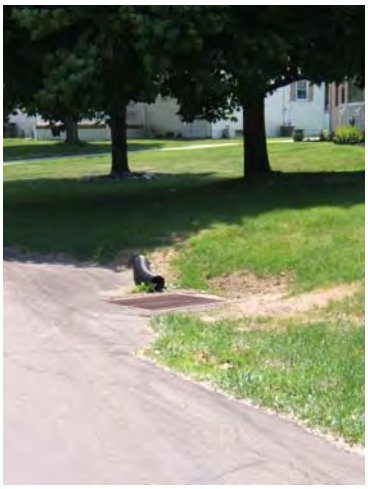
Problem Area Summary

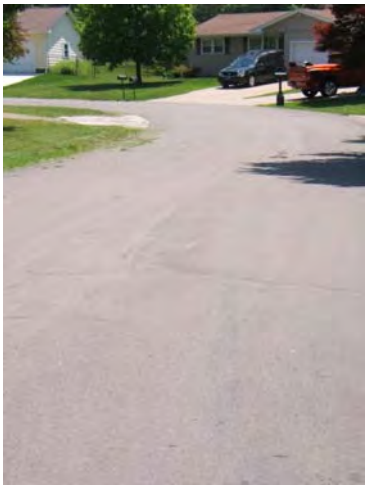
Municipality: Millcreek Township **ID:** EP095

Location: Budd Dr, Southern Dr, Hidden Ln **Stream:**

Problem Description:

Frequent yard flooding. Existing conveyance system may be insufficient.





Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP096

Location: Scarbor, Windsor, Feilder Area **Stream:**

Problem Description:

Frequent yard flooding. This is a general problem in the entire development.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP097

Location: 15th W of Pittsburgh **Stream:**

Problem Description:

Frequent road, parking lot & business flooding. The conveyance system along 15th St appears to backup and cause flooding. The culvert appears to be obstructed by large debris and is in need of maintenance.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP098

Location: S of RR, Colonial to Lowes **Stream:**

Problem Description:

Frequent business & yard flooding. A large upslope watershed discharges to this point.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP099

Location: 32nd & Zuck **Stream:**

Problem Description:

Frequent roads, parking lot and yard flooding. The conveyance network appears to be insufficient.

Erie County Act 167 Plan

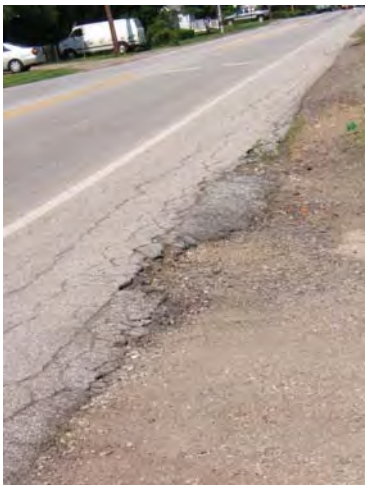
Problem Area Summary

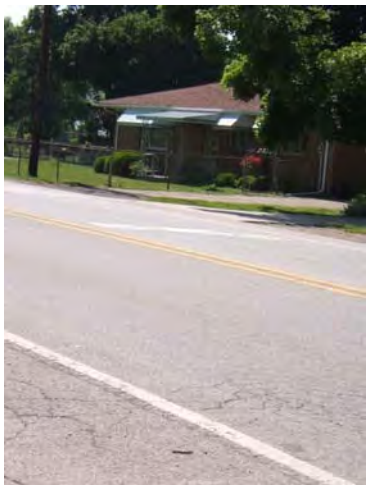
Municipality: Millcreek Township **ID:** EP100

Location: 32nd, Pittsburgh to Zuck **Stream:**

Problem Description:

Frequent home & yard flooding. The conveyance system appears to be insufficient.





Erie County Act 167 Plan

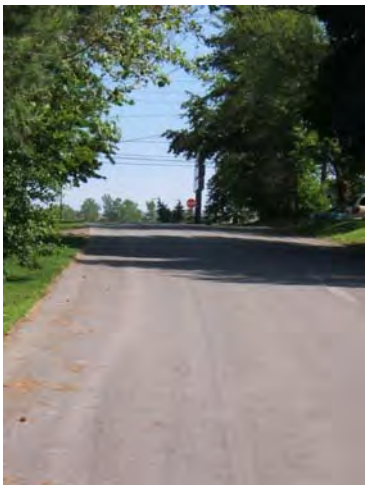
Problem Area Summary

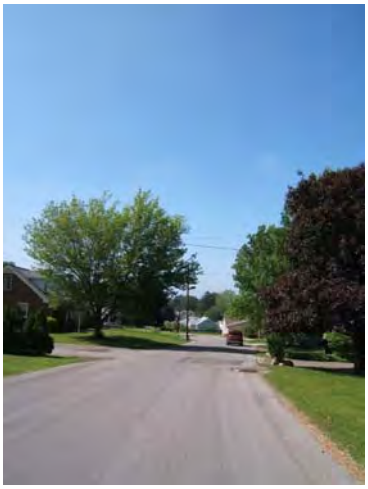
Municipality: Millcreek Township **ID:** EP101

Location: Atlantic, 36th to 38th **Stream:**

Problem Description:

Frequent home & yard flooding. The conveyance system appears to be insufficient.





Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP102

Location: Rt 99 & Interchange **Stream:**

Problem Description:

Road frequently floods. The conveyance system appears to contain a lot of debris.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP103

Location: Mill Creek, Conrad Rd to Rt 8 **Stream:**

Problem Description:

Frequent parking lot & yard flooding. This is a low lying area along mill creek. Area is in the floodplain.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP104

Location: Home & Glenwood Park Ave **Stream:**

Problem Description:

Frequent yard flooding. Conveyance system may be inadequate.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP105

Location: Marshall Run Trib, Timberwood **Stream:**

Problem Description:

Frequent garage and yard flooding. Upslope runoff discharges to 3833 DBF Rd and does not drain. Conveyance system may be insufficient.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP106

Location: W 23rd Walmart drainage **Stream:**

Problem Description:

Portions of store and parking lot flood. The channel behind Wal-Mart appears to flood. A culvert under the railroad appears to be full of debris.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Millcreek Township **ID:** EP107

Location: UNT Mill Creek S Arbuckle Rd **Stream:**

Problem Description:

Frequent yard flooding. Properties in this area are flood prone.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Elk Creek Township **ID:** EP108

Location: Morley Rd **Stream:**

Problem Description:

Seasonal flooding in low lying wetland/ floodplain area.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Elk Creek Township **ID:** EP109

Location: Griffis Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

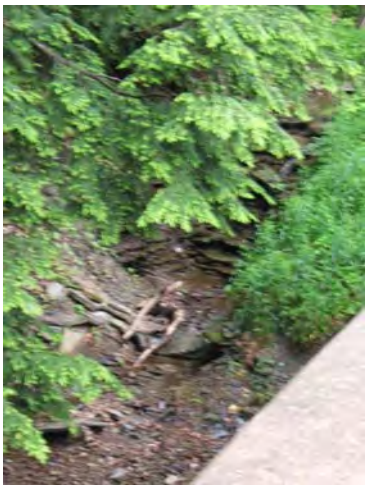
Problem Area Summary

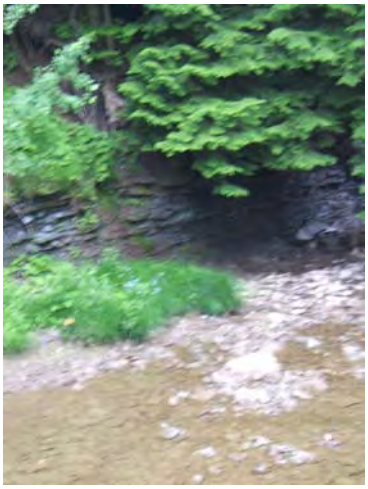
Municipality: Elk Creek Township **ID:** EP110

Location: Temple Creek **Stream:**

Problem Description:

Bridge occasionally floods but appears to have adequate hydraulic capacity.





Erie County Act 167 Plan

Problem Area Summary

Municipality: Elk Creek Township **ID:** EP111

Location: Hickernell Rd **Stream:**

Problem Description:

Bridge appears in poor condition and may be in need of replacement. Some sediment appears to be depositing downstream.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Elk Creek Township **ID:** EP112

Location: Ivoray Rd **Stream:**

Problem Description:

Bridge appears in poor condition and may be in need of replacement. Some sediment appears to be depositing downstream.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Elk Creek Township **ID:** EP113

Location: Fillinger Rd **Stream:**

Problem Description:

Bridge appears in poor condition and may be in need of replacement. Some sediment appears to be depositing downstream.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Elk Creek Township **ID:** EP114

Location: N of Carberry Rd **Stream:**

Problem Description:

Beaver dams.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Elk Creek Township **ID:** EP115

Location: Temple Creek @ Resevior Rd **Stream:**

Problem Description:

Beaver dams.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Conneaut Township **ID:** EP116

Location: Twp wide **Stream:**

Problem Description:

No site visit required.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Northeast Borough **ID:** EP117

Location: Various **Stream:**

Problem Description:

Problem area unable to be located during field visit.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Summit Township **ID:** EP118

Location: LeBoeuf Creek **Stream:**

Problem Description:

Beaver dams.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greenfield Township **ID:** EP119

Location: German Rd **Stream:**

Problem Description:

Beaver dams. This is a continuous problem.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Greenfield Township **ID:** EP120

Location: Raymond Rd **Stream:**

Problem Description:

Beaver dams. Township has recently cleared and maintained area.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Franklin Township **ID:** EP121

Location: New Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Franklin Township **ID:** EP122

Location: New Rd, Mohawk Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Franklin Township **ID:** EP123

Location: Carbury Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Franklin Township **ID:** EP124

Location: Clair Wright Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Franklin Township **ID:** EP125

Location: Clair Wright Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Franklin Township **ID:** EP126

Location: West Stancliff Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Franklin Township **ID:** EP127

Location: Shadduck Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Franklin Township **ID:** EP128

Location: Shadduck Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: Franklin Township **ID:** EP129

Location: Shadduck Rd **Stream:**

Problem Description:

Culvert appears to have inadequate hydraulic capacity.

Erie County Act 167 Plan

Problem Area Summary

Municipality: City of Erie **ID:** EP130

Location: West 17th St Area **Stream:**

Problem Description:

Conveyance system appears to be full of debris and is need of maintenance. Debris may be coming from Bizzarro's Salvage Yard.

Erie County Act 167 Plan

Problem Area Summary

Municipality: City of Erie **ID:** EP131

Location: Sassafras St **Stream:**

Problem Description:

Conveyance system on the upper part of Sassafras Rd appears to be insufficient. This system appears to discharge to the lower "new" system on Sassafras Rd at the Convention Center.

Erie County Act 167 Plan

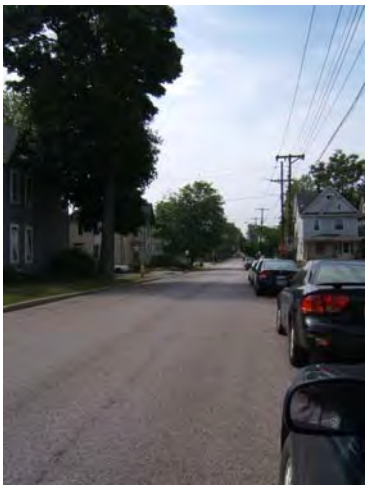
Problem Area Summary

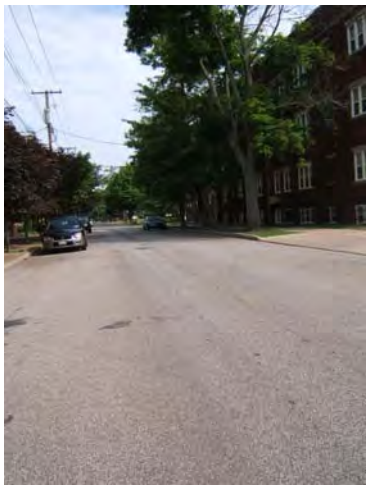
Municipality: City of Erie **ID:** EP132

Location: West 8th **Stream:**

Problem Description:

Conveyance system in the area appears to be insufficient.





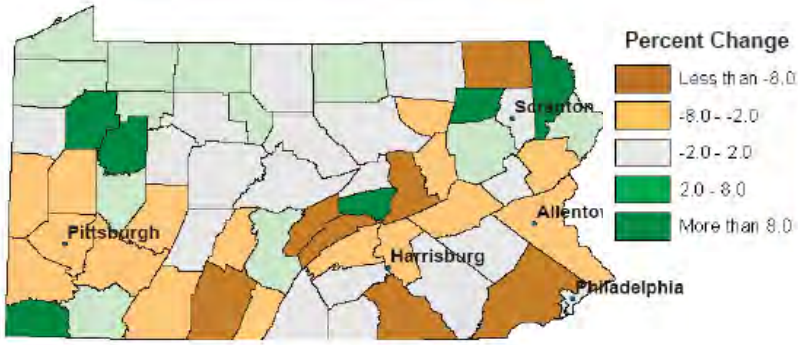
Appendix D – Natural Resource Activities Impacting Water Quality

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.

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 ERIE COUNTY

Although it is not a dominant sector, the wood products industry provides important economic opportunities in the county. In 2007, there were 40 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 Erie 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 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 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
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.

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.

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.

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

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 Erie 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.

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:

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

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

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

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.

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.

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:

- 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	

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.

Appendix E – Hydrologic Soil Groups

The following information has been excerpted from the NRCS TR-55 manual.

Appendix A Hydrologic Soil Groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983).

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.