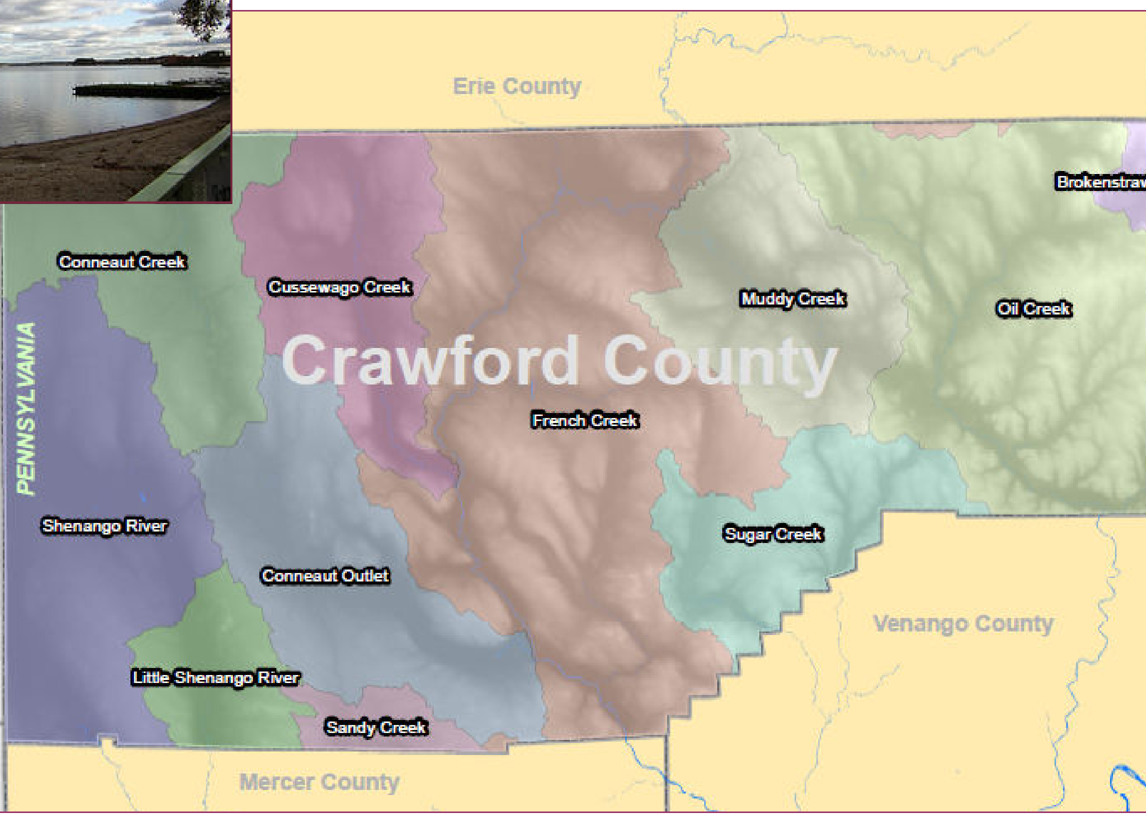
Crawford County Planning Commission

Act 167 County-Wide Watershed
Stormwater Management Plan for Crawford County
Part 1 of 2
Phase II

June 2010



[BUILDING RELATIONSHIPS.
DESIGNING SOLUTIONS.]

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ACKNOWLEDGEMENTS

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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 Crawford 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 results 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 peak runoff substantially increase 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. Both water quantity and water quality can contribute to degradation of surface waters.

Section I – Introduction

As development has increased, so has the problem of managing the increased quantity of stormwater runoff. Individual land development projects are frequently viewed as separate entitities, and not necessarily as an interconnected hydrologic and hydraulic system. This school of thought is often further promoted when the individual land development projects are scattered throughout a watershed (and in many different municipalities). However, it is has been observed that the cumulative nature of individual land surface changes measurably 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 should 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 stresses 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 convey 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 were lost to the watershed and become unavailable for infiltration and groundwater recharge, and contaminants on the land surface entered the stream untreated.

The conveyance approach was later replaced with the stormwater management standards that largely exist today in municipalities. This latter approach required 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.

The second key failing is that this approach does not consider the aspects of water quality, channel protection, or the importance of volume 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.

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 its contribution to the overall watershed hydrology. When the same standards are implemented throughout a municipality, and the overall watershed hydrology is not considered, these standards can result in over-management in some areas and under-management in other areas. In some cases, this type of management could actually exacerbate stormwater problems. Further, this "one-size-fits-all" approach does not take into account conditions such as soil infiltration rates, slopes, or channel conditions, which vary throughout a watershed and municipality.

LOW-IMPACT DEVELOPMENT AND STORMWATER MANAGEMENT

Low-Impact Development (LID), partly the theoretical basis for this Plan, 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 1.1. Comparison of LID Versus Traditional Stormwater Management Approach

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

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

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

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

The overall objective of this Plan is to provide a plan for comprehensive watershed stormwater management throughout Crawford 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 Crawford 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, along the principles of Low Impact Development, provided the focus for the entire planning process. A scope of work was developed in Phase 1 that focused efforts on gathering the necessary data and developing strategies that address the goals. With the general focus of the Plan determined, Phase II further researched county specific information, provided in-depth technical analysis, and developed a model ordinance to achieve these goals. On the following page, *Table 2.1* shows the preferred stategies to address the goals, and where these strategies are addressed in the Plan:

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

Table 2.1. Preferred Strategies to Address Plan Goals

STORMWATER PLANNING AND THE ACT 167 PROCESS

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

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

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

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

SECTION 5b
(1) A survey of existing runoff characteristics in small as well as large storms, including the impact of soils, slopes, vegetation and existing development;
Section 3 identifies and analyzes factors that impact the hydrologic response of the identified watershed for including existing and future land use conditions. Section 6 discusses the technical analysis performed on the on focused watersheds. The other watersheds within the County should be considered in future Plans. Appendix A details the modeling completed to perform the technical analysis. In addition, relevant details of the factors and elements impacting the hydrologic response of the watersheds are shown graphically in the Plates.
(2) A survey of existing significant obstructions and their capacities;
The municipalities, through the PAC, responded to a survey which compiled an inventory of obstructions. Section 5 provides the inventory as well as a discussion. Capacities of the obstructions were not fully developed as Budgetary impacts reduced the scope of the Plan. Plate 7 shows the identified obstructions.
(3) An assessment of projected and alternative land development patterns in the watershed, and the potential impact of runoff;
A hydrologic model was developed and used to assess the impacts future land development alternatives in order to address the potential impacts of increased runoff, as discussed in Sections 6 and 7 as well as Appendix A.
(4) An analysis of present and projected development in the flood hazard areas, and its sensitivity to damages from future flooding or increased runoff;
Federal flood insurance studies have been used as reference for the location of flood plain areas as identified in Plate 8. Section 3 provides a discussion and an analysis showing damages to existing development due to flood hazard areas caused by increased runoff in the watershed. Recommendations where made with measures to mitigate future damages in Section 7.
(5) Survey of existing drainage problems and proposed solutions;
The municipalities, through the PAC, responded to a survey which compiled an inventory of existing problem areas. Section 5 provides the inventory as well as a discussion. Plate 7 shows the identified problem areas as well as Appendix C.
(6) A review of existing and proposed stormwater collection systems;
The more urbanized areas of the County contain storm sewer systems, as do the many roadways that traverse the County. Storm sewer collection systems have a significant effect on the hydrologic response of a watershed as pipe networks rapidly increase runoff rate. If stormwater control facilities do not intercept runoff from storm sewer systems, flooding often increases, as well as other stormwater problems such as streambank erosion and sedimentation. Plate 7 shows the collection systems as identified by the municipalities through the PAC.
(7) An assessment of alternative runoff control techniques and their efficiency in the particular watershed;
Section 7 of the Plan identifies a variety of runoff control techniques are available for use in all watersheds in the County. It references and expands upon the Pennsylvania Stormwater Best Practices Manual to identify innovative methods of controlling runoff. In addition, traditional engineering solutions such as drainage structure replacement, streambank restoration, etc. were also identified in situations where alternative runoff controls are not applicable.
(8) An identification of existing and proposed state, federal and local flood control projects located in the watershed and their design capacities;

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

Table 2.2. Elements of Act 167

PLAN ADVISORY COMMITTEES

Public participation by local stakeholders is an integral part of comprehensive stormwater management planning. Coordination amongst these various groups facilitates a more inclusive Plan, 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.

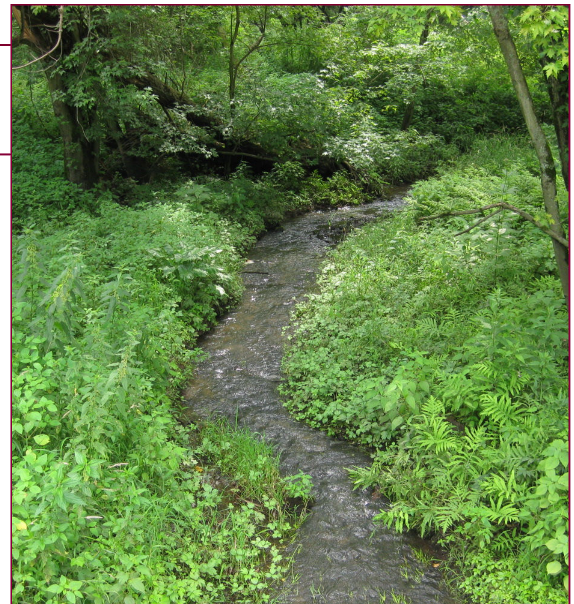
As per Act 167, the Committee is responsible for advising the county throughout the planning process, evaluating policy and project alternatives, coordinating the watershed stormwater plans with other municipal plans and programs, and reviewing the Plan prior to adoption. *Table 2.3* is a summary of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

Implementation workshops are recommended to be held following the adoption of the Plan. It is recommended that separate workshops be held. The first would be for municipalities which would provide assistance to municipalities on implementation of the Plan including adaptation, enactment, and implementation of the Model Ordinance and other action items. Onother would target the general public where the overall Plan would be presented as well as its effects on future development.

PAC Meeting	Purpose of Meeting	Meeting Dates
1	Phase 1 Start-up Meeting - Introduce the Act 167 Planning process. Emphasize the importance of full municipal involvement. Present data collection questionnaire.	East: 1/29/2008 West: 1/22/2008
2	Present summary of the data collection questionnaire from Phase 1, overview of proposed work for Phase 2	East: 5/8/2008 West: 5/5/2008
3	Phase 2 Start-up Meeting - Introduce the Phase 2 Planning process. Emphasize the importance of full municipal involvement. Present summary of the data collection questionnaire from Phase 1.	East: 2/18/2009 West: 2/17/2009
4	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.	East: 6/3/2009 West: 6/1/2009
E	With 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.	6/17/2009
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 Ordinance sent to municipalities prior to meeting).	1/27/2010
6	Meetings with PAC, municipal engineers and solicitors reviewing draft Plan, review technical comments, and revised Model Ordinance. Gather general comments and feedback prior to finalization of the Plan. (Draft Plan sent to municipalities prior to meeting).	4/26/2010
Public Hearing	Conduct the hearing as required by Act 167 to present the Plan to the public.	TBD

Table 2.3. Summary of PAC Meetings

Section III – Crawford County Description



Crawford County is located in northwest Pennsylvania between Pittsburgh and Erie. It is bordered by the Pennsylvania counties of Erie, Warren, Mercer, and Venango, and the Ohio counties of Ashtabula and Trumball. Crawford County was created on March 12, 1800 from part of Allegheny County and named for Colonel William Crawford. Predominantly rural, the County has significant industrial history. In 1859, Colonel E. L. Drake had successfully drilled a well which produced oil in eastern Crawford County (Warren County, 2010). Other industries developed in Meadville and Titusville including the famous Talon zipper manufacturing. Agriculture remains a prominent industry, especially in the rural areas. Recreation is a thriving segment of the County's economy with many lakes, streams and areas for outdoor enthusiasts.

POLITICAL JURISDICTIONS

The County is comprised of 51 municipalities. The political jurisdictions include 35 townships, 14 boroughs, and two (2) cities. Crawford County is the 10th largest county in the Commonwealth; in terms of population, the county is ranked 34th of 67 counties with a population of 88,411 (according to the 2008 population estimates from the US Census Bureau). This is a reduction in population of 2% of 90,366 in the 2000 US Census.

The 51 municipalities in Crawford County and their associated statistics are shown in *Table 3.1*.

Municipality	2008 Population	Land Area (mi²)	Municipality	2008 Population	Land Area (mi²)
Athens Twp	750	28.3	Rockdale Twp	1,474	36.0
Beaver Twp	843	36.7	Rome Twp	1,716	41.2
Bloomfield Twp	2,083	38	Sadsbury Twp	2,844	23.7
Blooming Valley Boro	467	1.9	Saegertown Boro	1,036	1.4
Cambridge Springs Boro	2,632	0.9	South Shenango Twp	1,971	26.6
Cambridge Twp	1,456	21.5	Sparta Twp	1,625	42.0
Centerville Boro	236	1.8	Spartansburg Boro	314	0.7
Cochranton Boro	1,065	1.2	Spring Twp	1,553	45.6
Conneaut Lake Boro	660	0.4	Springboro Boro	459	0.9
Conneaut Twp	1,485	40.9	Steuben Twp	847	24.5
Conneautville Boro	788	1.1	Summerhill Twp	1,319	25.4
Cussewago Twp	1,651	41.0	Summit Twp	2,104	25.8
East Fairfield Twp	830	12.8	Titusville City	5,774	2.9
East Fallowfield Twp	1,494	28	Townville Boro	286	0.6
East Mead Twp	1,467	22.9	Troy Twp	1,279	31.6
Fairfield Twp	1,054	19.4	Union Twp	1,004	15.8
Greenwood Twp	1,407	36.2	Venango Boro	267	0.3
Hayfield Twp	3,083	38.9	Venango Twp	1,104	16.9
Hydetown Boro	567	2.2	Vernon Twp	5,421	29.6
Linesville Boro	1,091	0.8	Wayne Twp	1,610	35
Meadville City	13,233	4.4	West Fallowfield Twp	624	11.5
North Shenango Twp	1,337	18.8	West Mead Twp	5,064	18.2
Oil Creek Twp	1,787	32.3	West Shenango Twp	512	6.8
Pine Twp	497	6.6	Woodcock Boro	136	0.6
Randolph Twp	1,791	43.3	Woodcock Twp	2,932	32.6
Richmond Twp	1,382	36.4			

Table 3.1. Crawford County Municipalities

LAND USE

GENERAL DEVELOPMENT PATTERNS

During approximately the same time period as discussed earlier (2000-2006), the county showed a 2% increase in housing (Crawford County, 2008). Part of the population decline is associated with population leaving the county, but there is also internal transition as more significant population decreases have been observed in the Cities of Meadville (-3%) and Titusville (-6%), and some of the Boroughs. This generally corresponds with the perception in the 2008 *Comprehensive Plan Update* that people are moving away from the urban center into the more rural townships.

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. Route 6 and 19 also provide a north-south line through the middle portion of the County. US 322 crosses the lower portion of the County. Route 77 provides a southwest to northwest corridor and Route 8 provides a north-south corridor on the eastern side of the County.

These major thoroughfares and crossroads provide a critical transportation and commuting link for County residents. However, these routes create an increase of impervious surfaces throughout the watershed. These impervious surfaces create more surface runoff and are non-point source pollution during precipitation events. This increases the stress on the drainage systems in the watershed, reduces water quality, and exacerbates streambank erosion, especially at already-known problem areas.

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. Crawford County presently has two airports - Port Meadville Airport (owned by a County Authority) and the Titusville Airport, (owned by the municipality).

FARMLANDS

Prime farmland, as defined by the U.S. Department of Agriculture (USDA) in the National Soil Survey Handbook, is the land that is best suited to producing food, feed, forage, and fiber and oilseed crops. It has the soil quality, growing season, and water supply needed to economically produce a sustained high yield of crops when it is treated and managed using acceptable farming methods (NRCS, 2007). In 1972, the USDA assigned the Soil Conservation Service the task of inventorying the prime and unique farmlands and farmlands of state and local importance. This inventory was designed to assist planners and other officials in their decision making to avoid unnecessary, irrevocable conversion of good farmland to other uses. On the USDA's important farmland inventory map, the farmlands are categorized into four classifications: prime farmland, unique farmland, additional farmland of statewide importance, and additional farmland of local importance. Of Crawford County's total land area, 57,290 acres (9%) are classified as Prime Famland (NRCS, 2008). These are mostly located in the southeastern quadrangle of the county.

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. Approximately 476,950 acres (72% of the county) have this classification (NRCS, 2008).

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

CLIMATE

Crawford County is situated in the Northwest Plateau Climatic Division and the climate is classified as humid continental. In general, the winters in Crawford County are moderately cold and the summers are warm and somewhat humid. Average high temperature in the summer is 81°F (July) while the average low temperature is 16°F (January) (Weather Channel, 2010). Over the past 30 years, annual precipitation is about 41.9" with maximum average precipitation occurring in the month of June (4.5") and the minimum average precipitation in February (2.6"). At the City of Meadville, the average annual snowfall amounts to about 64.5" with a minimum of 22" (1965) and a maximum of 122" (1977).

RAINFALL

Figures 3.1 and 3.2 show the rainfall statistics for Crawford County. The Jamestown Gage (actually located within Crawford County) was utilized as it was the source of the best data available. The average rainfall, shown in Figure 3.1 portrays the amount of precipitation throughout each year since 1932. Although there can be significant variation in the annual rainfall total (between 25 and 55 inches). While this variation can have a significant impact on water supply and vegetative growth, it is the quantity of rain in a relatively short time period (1-hour, 6-hour, 24-hour, 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 Crawford County comes from storms of low magnitudes. Only 10% of the daily rainfall values between 1932 and 2009 exceeded 0.65 inches, which is below any design standards currently being used in the County. Thus, any stormwater policy should incorporate provisions such as water quality, infiltration, or retention BMPs that account for these small events. It is important to acknowledge that many of these smaller **rainfall** events lead to larger **runoff** events as they may be saturating the soils prior to a larger storm or occurring within a short time period that still overwhelm existing conveyance facilities.

For the gage shown in Figure 3.1 and 3.2, the NOAA Atlas 24-hour, 2-year storm event total of 2.54 inches was exceeded 17 times in more than 60 years of data. It is possible, however, that there is several extreme events in the same year. Thus, viewing only the annual maximum series could neglect some significant historical rainfall events. The implication for stormwater policy in Crawford 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.

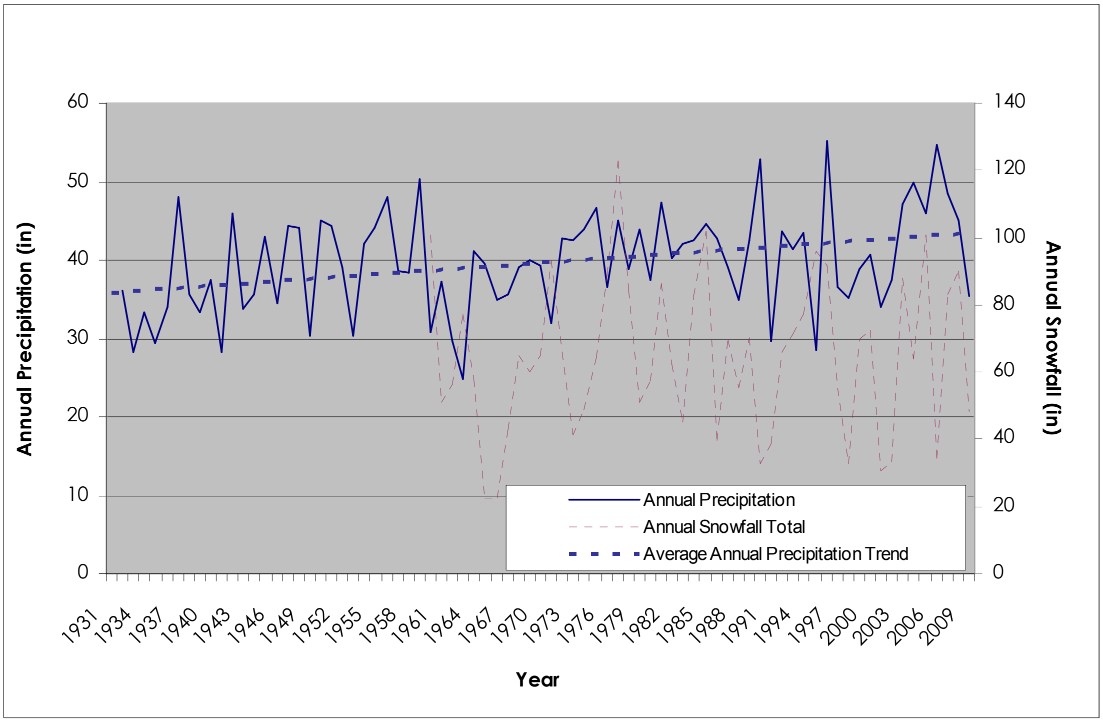


Figure 3.1. Annual Precipitation at Jamestown, Pennsylvania (Coop ID #364325)

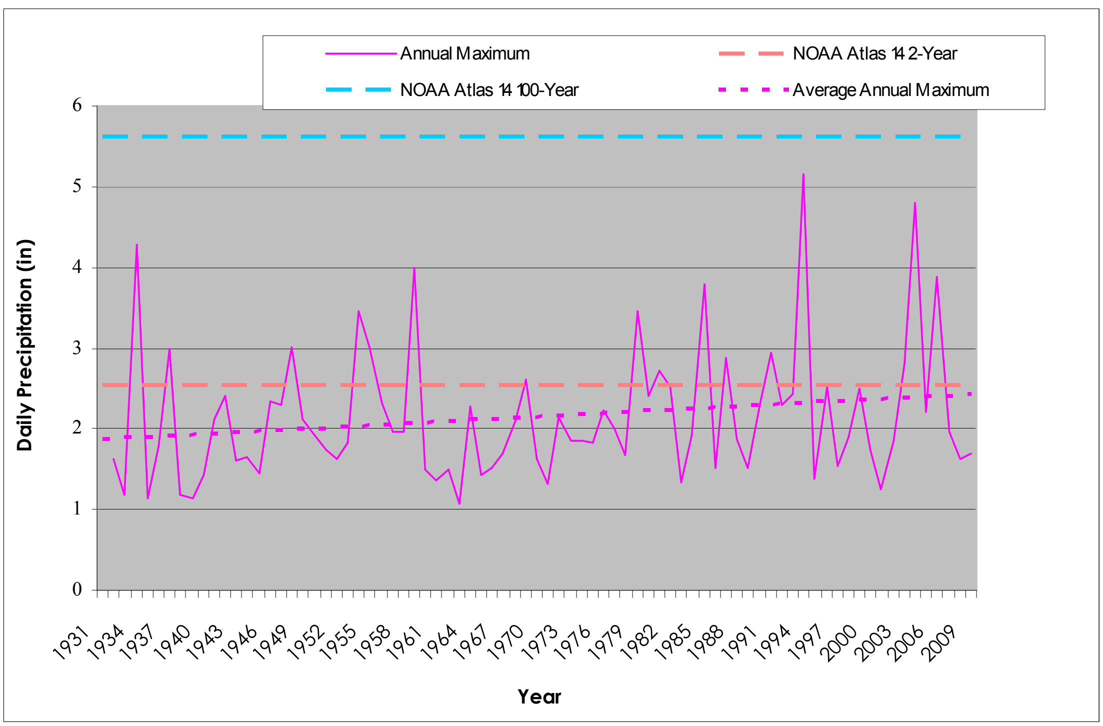


Figure 3.2. Annual Maximum Precipitation at at Jamestown, Pennsylvania (Coop ID #364325)

GEOLOGY

Crawford County is located within two sections of the Appalachian Plateaus Physiographic Provinces – the Northwester Glaciated Plateau Section and the High Plateau Section (Sevon, 2000).

Northwestern Glaciated Plateau Section – The majority of the County lies within this Section and consists of much broad, rounded upland cut by long, linear valleys (PA Geologic Survey, 2010). The uplands have a southeast-oriented linearity that is pronounced in eastern Crawford 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.

High Plateau Section – The very small portion of the County lies within this Section at the extreme southeastern corner (PA Geologic Survey, 2010). This section consists of high, broad, and flat uplands cut by sharp and shallow river valleys. Much of this area was not covered by the Late Wisconsinan glacier but there is evidence of pre-Wisconsinan glaciers in the area.

BEDROCK FORMATIONS

Crawford 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.

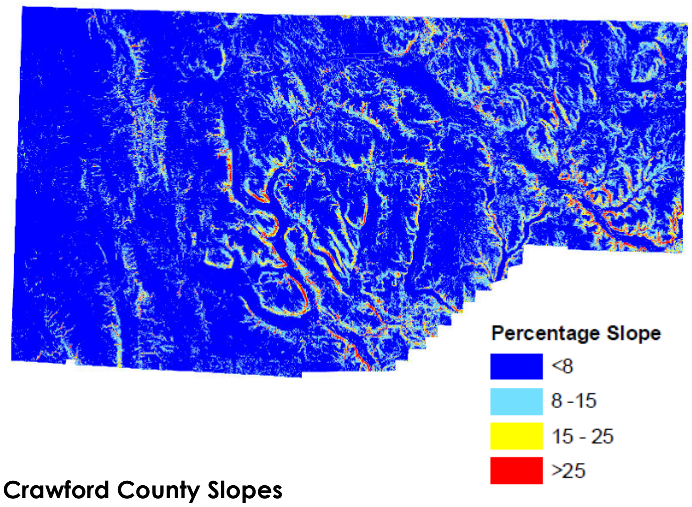
The time-elapse between the early and late stages of the Wisconsin glaciation caused distinct differences in drainage, which have ultimately impacted County land use. Well-developed drainage patterns are associated with the early Wisconsin stage, while poorly drained areas are associated with the late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

Formation	Dominant Lithology	% of County
Berea Sandstone through Riceville Formation, undivided	Sandstone	7.23%
Berea Sandstone through Venango Formation, undivided	Sandstone	28.03%
Chadakoin Formation	Siltstone	1.66%
Corry Sandstone through Riceville Formation, undivided	Sandstone	9.15%
Cuyahoga Group	Siltstone	29.50%
Pottsville Formation	Sandstone	8.40%
Shenango Formation	Sandstone	11.05%
Venango Formation	Siltstone	4.98%

Table 3.2 Geologic Formations

SLOPES

A result from Crawford County's geologic history, as previously discussed, is a County with relatively mild slopes. 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 seven percent is classified as having slopes of 15% or greater. Slope values are broken into four categories and shown in *Table 3.3* below. Also shown is the total area in Crawford 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.



Crawford County Slopes

Slope Classification	Slope Range	Land Area (mi²)	Percent of Total Area	Slope Restrictions
Flat to Moderate	0-8%	814.6	78.5	Capable of all normal development for residential, commercial, and industrial uses; involves minimum amount of earth moving; suited to row crop agriculture, provided that terracing, contour planting, and other conservation practices are followed
Rolling Terrain and Moderate Slopes	8 - 15%	153.5	14.8	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%	51.9	5.0	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%	17.2	1.7	No development of an intensive nature should be attempted; land not to be cultivated; permanent tree cover should be established & maintained; adaptable to open space uses (recreation, game farms, & watershed protection)

Table 3.3. Summary of Slopes in Crawford County

SOILS

The behavior of a soil's response to rainfall and infiltration is a critical input to the hydrologic cycle and in the formation of a coherent stormwater policy. The soils within Crawford County are generally moderately to poor drained and have a high runoff potential.

Series Name	Map Symbols	Hydrologic Soil Group	% of County	Restrictions
Alden	Ad	D	3.3	
Alvira	AvA, AvB	C/D	1.2	Fragipan (16-28in.)
Braceville	BrA, BrB	C/D	1.3	Fragipan (18-26in.)
Cambridge	CaA, CaB, CaC, CaD	C/D	15.3	Fragipan (18-30in.)
Carlisle	CM	A/D	1.4	
Frenchtown	CbB	D	0.2	Fragipan (16-28in.)
Udorthents	CF		<0.1	
Cambridge	CbD, CcB	C/D	0.8	Fragipan (18-30in.)
Canadice	Cd	D	0.3	
Caneadea	CeA, CeB	D	0.5	
Chenango	CoA, CoB, CoC	A	1.9	
Chippewa	CpB	D	<0.1	Fragipan (8-20in.)
Frenchtown	FhA, FhB, FvB	D	11.8	Fragipan (15-32in.)
Halsey	Ha	C/D	1.3	Strongly contrasting textural stratification (0-0in.)
Hanover	HnA, HnB, HnC, HoB, HoD	C/D	1.7	Fragipan (17-26in.)
Haven	HvA, HvB	B	1.7	
Holly	Hy, Hz	B/D	7.6	
Mardin	MaC	C/D	<0.1	Fragipan (14-26in.)
Philo	Ph	B	0.4	
Platea	PkB	C/D	1.1	Fragipan (18-26in.)
Pope	Po	B	0.6	
Red Hook	Rh	B/D	3.6	
Bethesda	SM	C	<0.1	
Scio	ScA, ScB	B/D	0.9	
Sheffield	Sh	D	4.3	Fragipan (18-28in.)
Shelmadine	SmA, SmB	D	0.2	Fragipan (20-30in.)
Valois	VLF, VaB, VaC, VaD, VmB, VmC	B	6.3	
Venango	VnA, VnB, VnC, VoB, VoC	C/D	27.3	Fragipan (16-28in.)
Wyoming	WyA, WyB, WyC, WyD	A	2	
Other	W, QU, GP, DAM,	--	3	Water, quarry, pits, dams

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

One of the impediments to drainage throughout Crawford County is the presence of fragipan soils, typically a loamy, brittle soil layer that has minimal porosity and organic content and low or moderate in clay but high in silt or very fine sand. With fragipans, upwards of 60% of input water moves laterally above the fragipan layer which is typically 14-36 inches below the surface in Crawford County (Ciolkosz and Waltman, 2000; NRCS, 2008). Thus, higher runoff rates and reduced infiltration capacity typically exist in these soils. Additional impediment to subsurface drainage include lithic and paralithic bedrock (i.e., solid and weather or broken layers of bedrock) although the depths (varying between 2'-10') and type of bedrock (i.e., carbonate bedrock) may offer excellent drainage. *Table 3.5* displays the proportion of fragipan and bedrock in Crawford County.

An additional indicator of the response to rainfall of the soils in Crawford County is the hydrologic soil group assigned to each soil. This classification varies between "A" which has very low runoff potential and high permeability and "D" which typically has very high runoff potential and low impermeability. *Table 3.6* show a summary of the hydrologic soil groups for Crawford County.

Some soils have variable runoff potential depending on whether or not they are drained or undrained. For example, agricultural field with tile drainage may decrease the runoff potential from hydrologic soil group D to hydrologic soil group A. Over 80% of the soils in Crawford County are hydrologic soil groups B/D C/D or D indicating a high runoff potential for all of the soils without some kind of soil treatment (e.g., soil drains; Refer to *Plate 4 – Hydrologic Soils*).

Restrictions	% of County
Fragipan	65.4
Strongly contrasting textural stratification	1.3
Lithic bedrock	0
None identified	33.3

Table 3.5. Soil Restrictions in Crawford County

Hydrologic Soil Group	Runoff Potential	% of County
A	Low	3.9
A/D		1.4
B	Low to moderate	8.9
B/D		12.1
C	Moderate to high	0
C/D		50.1
D	High	20.6
Unidentified		3

Table 3.6. Hydrologic Soil Groups in Crawford County

HYDRIC SOILS

The analysis of hydric soils has recently become an important consideration when performing almost any kind of development review. These soils are important to identify and locate because they provide an approximate location where wet areas may be found. Wetland areas are lands where water resources are the primary controlling environmental factor as reflected in hydrology, vegetation, and soils. Thus, the location of hydric soils is one indication of the potential existence of a wetland area. Wetland areas are now protected by DEP and should be examined before deciding on any type of development activity. The Crawford County Soils Survey identifies hydric soils that total about 30% of the County's surface, which are listed in *Table 3.7*.

Alden	Halsey
Candice	Holly
Carlisle	Rexford
Chippewa	Sheffield
Frenchtown	Shelmadine

Table 3.7. Hydric Soils

WATERSHEDS

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

Watersheds are delineated and subdivided for the sake of management and analysis. The physical boundaries of a watershed depend on the purpose of the delineation. Often 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 3.4*, DEP has divided Pennsylvania into seven different major river basins, based upon the major waterbody to which they are tributary. These include: Lake Erie Basin, Ohio River Basin, Genesee River Basin, Susquehanna River Basin, Potomac River Basin, Elk & Northeast / Gunpowder Rivers Basin, and Delaware River Basin.

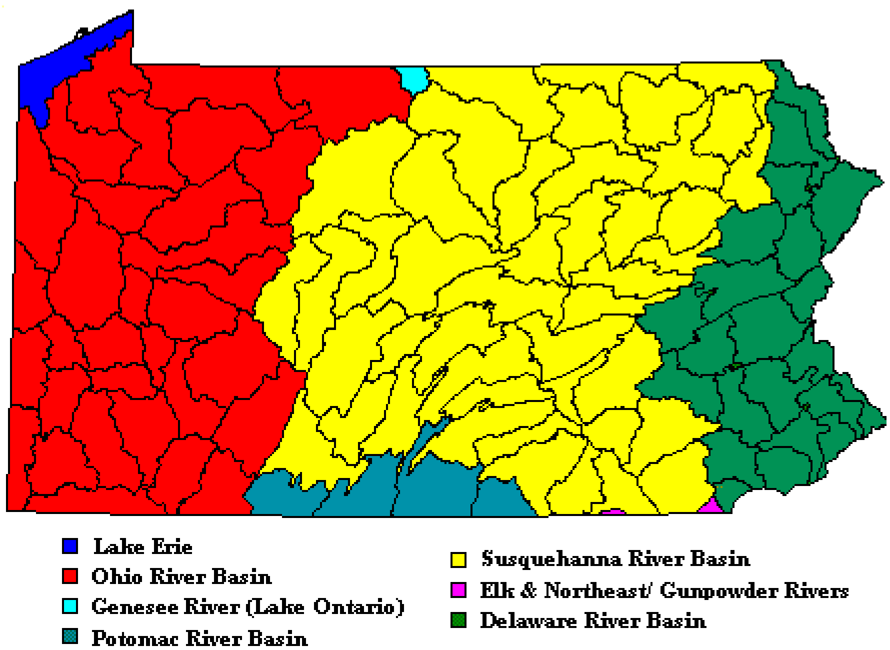


Figure 3.3. Pennsylvania's Major River Basins as Delineated by DEP (DEP, 2009)

For the purpose of this Plan, these are the largest basins within the Commonwealth. The major river basins are generally further divided into "subbasins" and "Act167 Designated Watersheds" for stormwater management purposes. Act 167 divided the Commonwealth into 29 subbasins and 357 designated watersheds. Crawford County lies completely within the Ohio River and Lake Erie Basins. Crawford County contains at least a portion of twelve different Act 167 Designated Watersheds. Figure 3.4 show the Act 167 watershed for Crawford County.

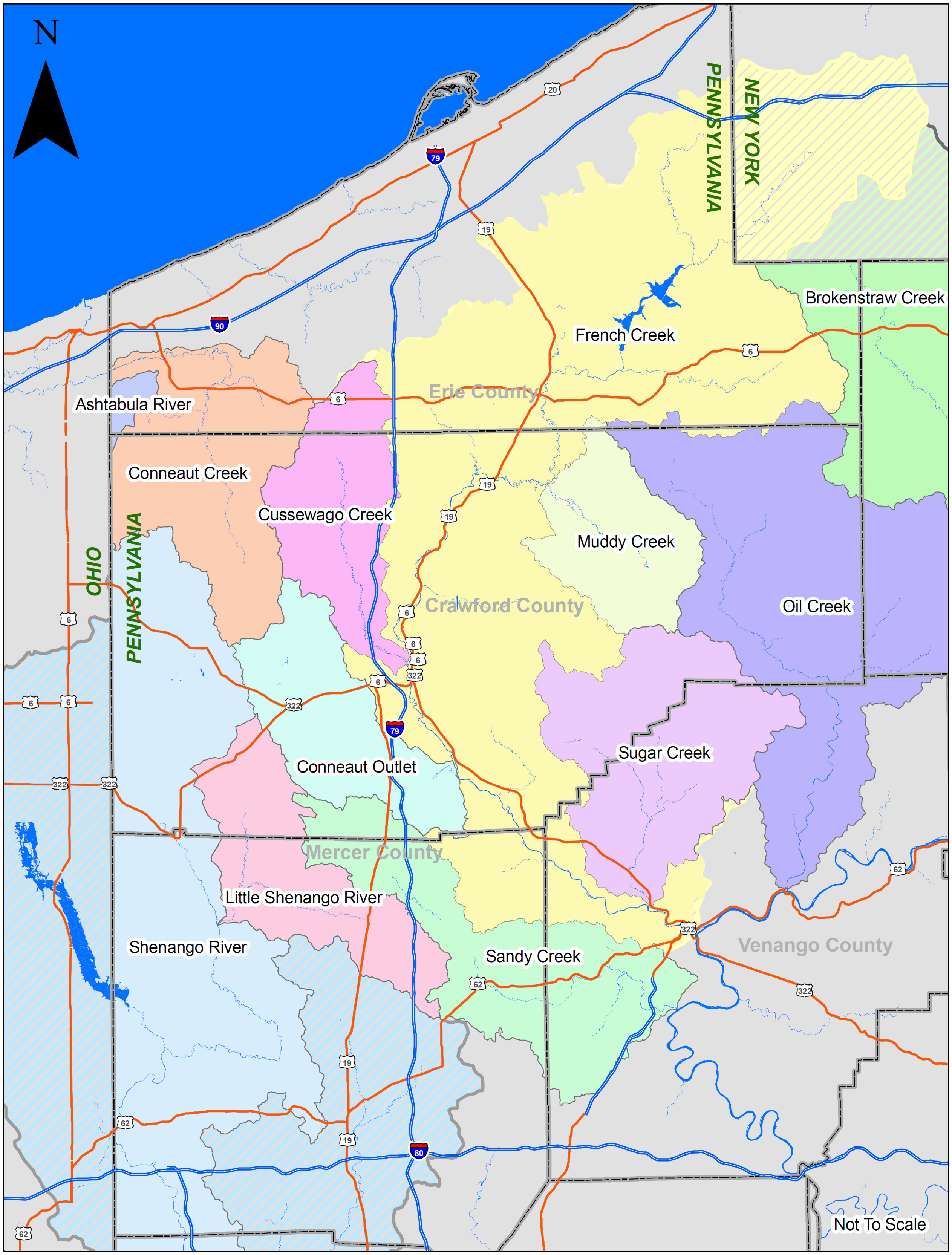


Figure 3.4. Act 167 Watersheds in Crawford County

This classification of the county's watersheds is summarized in the following table:

<table>
<tr><th>Major River Basin</th><th>Subbasin</th><th>Act 167 Designated Watershed</th></tr>
<tr><td rowspan="10">Ohio River Basin</td><td rowspan="5">French Creek
(50.6% of County)</td><td>French Creek</td></tr>
<tr><td>Muddy Creek</td></tr>
<tr><td>Cussewago Creek</td></tr>
<tr><td>Conneaut Outlet</td></tr>
<tr><td>Sugar Creek</td></tr>
<tr><td rowspan="3">Allegheny River
(24.7% of County)</td><td>Brokenstraw Creek</td></tr>
<tr><td>Oil Creek</td></tr>
<tr><td>Sandy Creek</td></tr>
<tr><td rowspan="2">Shenango River
(15.3% of County)</td><td>Shenango River</td></tr>
<tr><td>Little Shenango River</td></tr>
<tr><td colspan="2" rowspan="2">Lake Erie (9.3% of County)</td><td>Conneaut Creek</td></tr>
<tr><td>Ashtabula River</td></tr>
</table>

Table 3.8. Classification of Crawford County Watersheds

Detailed analyses were conducted on the French Creek and Oil Creek Act 167 watershed as part of the Plan. The remaining watersheds were included in a general study of the entire county.

An existing Act 167 was prepared for the Conneaut Outlet was prepared in 1993 (Chester Environmental, 1993). Elements of this plan have been incorporated into this plan.

ACT 167 DESIGNATED WATERSHEDS

French Creek Watershed

The physical limits of the French Creek watershed begin in New York, traverse south through Erie County and enter Crawford County on the northern border, forming a boundary between Venango Township and Cambridge Spring Township. At the point it enters Crawford County drains an area of approximately 403 square miles, before draining 998 square miles as it leaves the county through the south. It finally drains 1,235 square miles at its confluence with the Allegheny River at Franklin, Pennsylvania in Venango County. The DEP designated Act 167 occupies 259 square miles in Crawford County. *Table 3.9* details the municipalities within the watershed, and their contributing area.

The major tributaries of the French Creek watershed as it affects Crawford County include the South Branch of French Creek, the West Branch of French Creek, Muddy Creek, Conneauttee Creek, Woodcock Creek, Cussewago Creek, Conneaut Outlet. Many of the unique topographical, ecological, and hydrologic characteristics of French Creek come from its glacial history including a terminal moraine that runs through southeast Crawford County; drumlins, the smooth, low-lying hills of glacial material; and, numerous wetlands (WPC and French Creek Project., 2002).

Substantial effort has been invested in assessing and developing protection for the ecological diversity of French Creek. *The French Creek Watershed Conservation Plan* documents in detail the overall watershed, its land, water, biological and cultural resources in addition to identifying potential threats and recommendations (WPC and French Creek Project, 2002). As discussed in Section 4 of this Act 167 Plan, many of the goals and recommendations from the French Creek Watershed Conservation Plan are in close alignment with this Plan.

Watershed	Municipality	Area (mi²)
French Creek	Bloomfield Township	1.8
	Blooming Valley Borough	2.0
	Cambridge Springs Borough	0.8
	Cambridge Township	21.7
	City Of Meadville	4.1
	Cochranton Borough	1.2
	Cussewago Township	10.8
	East Fairfield Township	12.8
	East Mead Township	23.3
	Fairfield Township	7.7
	Hayfield Township	13.2
	Randolph Township	19.4
	Richmond Township	14.4
	Rockdale Township	15.5
	Saegertown Borough	1.5
	Sparta Township	0.4
	Troy Township	0.0
	Union Township	7.9
	Venango Borough	0.3
	Venango Township	16.9
	Vernon Township	9.8
	Wayne Township	21.2
	West Mead Township	18.8
	Woodcock Borough	0.7
	Woodcock Township	32.9

Table 3.9. French Creek Watershed

Oil Creek Watershed

Oil Creek is located in the eastern of Crawford County. Its headwaters begin slightly north of the Crawford County border near Bloomfield and Sparta Townships and continues southward through the entire length of the county before it confluence with the Allegheny in Oil City in Venango County. Oil Creek drains 176 square miles near the southern county border, 172 of which lie within the county boundary. *Table 3.6* shows the area of each Township within the Oil Creek watershed.

Watershed	Municipality	Area (mi²)
Oil Creek	Athens Township	7.0
	Bloomfield Township	28.5
	Centerville Borough	1.8
	City Of Titusville	2.9
	Hydetown Borough	2.2
	Oil Creek Township	32.2
	Rockdale Township	0.2
	Rome Township	41.3
	Sparta Township	35.2
	Spartansburg Borough	0.7
	Steuben Township	14.3
	Troy Township	5.6

Table 3.10. Oil Creek Watershed

IMPOUNDMENTS

Several significant flood control facilities are located throughout the County. *Figure 3.5* shows the location of these facilities. Dams have a significant impact on watershed hydrology and stream hydraulics as flows from runoff from storms are impounded and released at a controlled rate. The magnitude of these impacts varies depending on the size of the facility, the location in the watershed, and the general watershed hydrology. Only the facilities within French Creek and Oil Creek were considered in this Plan. *Table 3.11* provides a summary of the significant flood control facilities in Crawford County.

Impoundment	Owner	Drainage Area mi²	Maximum Storage (acre-feet)
Lake Canadohta	Bloomfield Township Municipal Lake Authority	7.8	3,136
Edinboro Lake	Borough of Edinboro	16.2	2,461
Bull Reservoir	Borough of North East	1.2	2,363
Water Supply Dam	Borough of Union County	2.6	307
PA 460 Dam	City of Meadville	3.4	470
McCabe Dam	Dr. A. L. McCabe	2.9	37
Pymatuning	PA Fish Commission	160.0	197,252
PA 461 Dam A	PA Fish Commission	5.4	2,348

Table 3.11. Significant Flood Control Facilities (adapted from DEP, 1970; USACE, 2009)

Impoundment	Owner	Drainage Area mi²	Maximum Storage (acre-feet)
PA 461 Dam B	PA Fish Commission	5.4	2,348
Custards Dam	PA Game Commission	78.0	1,228
Unnamed Dam	PA Game Commission	1.0	614
Upper Dam	PA Game Commission	13.6	1,037
Unnamed Dam	PA Fish Commission	68.0	2,762
Sigel Marsh Dam	PA Game Commission	11.4	153
Clear Lake Dam	Platt and Steadman	14.1	497
Dam No. 1	Rexford and Catherine Danner	0.7	9
Troyer Dam	Roy S. Troyer	0.7	187
Union City Dam	USACE	222.0	47,663
Woodcock Creek Dam	USACE	46	31,540

Table 3.11 (continued). Significant Flood Control Facilities (adapted from DEP, 1970; USACE, 2009)

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*.

Crawford County streams are shown with their Chapter 93 protected use classification in *Figure 3.6* below. Around 18% of all of streams (over 400 stream miles) in Crawford County are designated as Special Protection Waters. (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*.

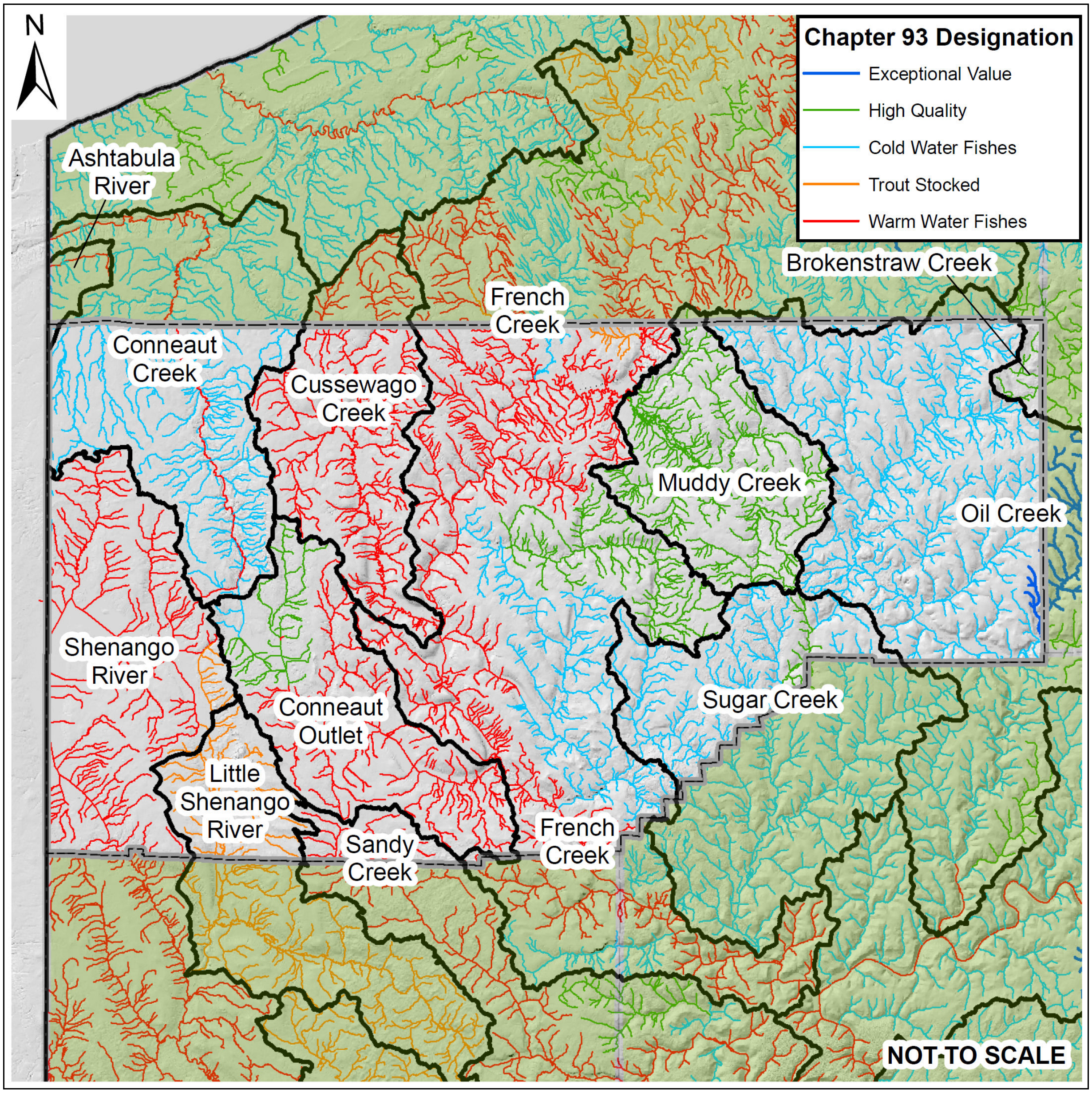


Figure 3.6. Chapter 93 Classification of Crawford County Streams

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 Crawford 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. Refer to *Plate* 9 for a review of all of the floodplains in Crawford County.

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

Storm Event	Number of Buildings at Least Moderately Damage	Total Economic Loss
10	374	$238 million
50	474	$290 million
100	495	$306 million

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

Detailed Studies

There are various levels of detail in floodplain mapping. Detailed studies (Zones AE and A1-A30 on the floodmaps) are conducted at locations where FEMA and communities have invested in engineering studies that define the base flood elevation and often distinguish sections of the floodplain between the floodway and flood fringe. See *Figure 3.5* below for a graphical representation of these terms. For a proposed development, most ordinances state that there shall be no increase in flood elevation anywhere within the floodway; the flood fringe is defined so that any development will not cumulatively raise that water surface elevation by more than a designated height (set at a maximum of 1'). Development within the flood fringe is usually allowed but most new construction is required to be designed for flooding (floodproofing, adequate ventilation, etc).

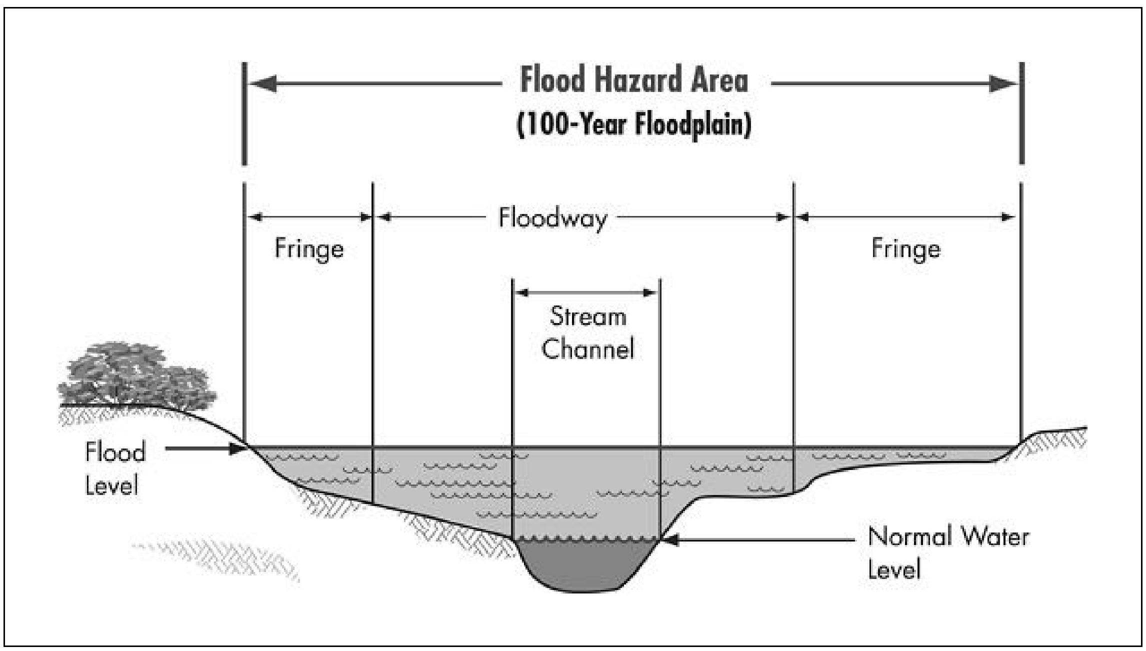


Figure 3.5. Floodplain Cross Section and Flood Fringe (NH Floodplain, 2007)

A review of the FIRMs revealed that several 100-year floodplains exist within Crawford County for the main streams draining the County. Detailed studies that clearly define the 100-year flood elevation and the floodway are provided for about 16.5% of the floodplains in Crawford County. These include sections along French Creek, Cussewago Creek, Oil Creek, and the Conneaut Outlet.

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 find it necessary to have the developer pay for a detailed study at the location in question. The majority of floodplains in Crawford County (83.5%) are delineated by approximate methods.

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

There is one documented levee project in Crawford County, located near the confluence of Mill Run and French Creek in the City of Meadville. It is currently not certified and therefore not shown as a protected area on the effective FIRM (FEMA, 2010).

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 Crawford 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. Crawford County is scheduled to have a new effective FIRM update available in October 2010. This will correspond to an effort by DCED to have all municipalities adopt and implement a new floodplain model ordinance that conforms to federal and state requirements.

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Section IV – Existing Stormwater Regulations and Related Plans

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

EXISTING STATE REGULATIONS

Pennsylvania has developed stormwater regulations that meet the federal standards and provide a statewide system for stormwater regulation. State regulations are much more specific than federal regulations. Statewide standards include design criteria and state issued permits. State regulations, found in *The Pennsylvania Code, Title 25*, cover a variety of stormwater related topics. A brief review of the existing state regulations is provided below in *Table 4.2*.

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

Table 4.2. Existing State Regulations

STATE WATER QUALITY STANDARDS

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

General Provisions (§93.1 - §93.4)

The general provisions of Chapter 93 provide definitions, citation of legislative authority (scope), and the definition of protected and statewide water uses. DEP's implementation of Chapter 93 is authorized by the Clean Streams Law, originally passed in 1937 to "preserve and improve the purity of the waters of the Commonwealth for the protection of public health, animal and aquatic life, and for industrial consumption, and recreation," and subsequently amended. *Table 4.3* is a summary of the protected water uses under Chapter 93 that are applicable to Crawford 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-WWF, HQ-TSF, or HQ-CWF)	↓	A surface water that meets at least one of chemical or biological criteria defined in §93.4b
Exceptional Value Waters (EV)	↓ Highest	A surface water that meets at least one of chemical or biological criteria defined in §93.4b and additional criteria defined in §93.4b.(b)

Table 4.3. Chapter 93 Designations in Crawford County

Antidegradation Requirements (§93.4a - §93.4d)

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

For a new, or additional, point discharge with a peak flow increase to an HQ or EV water, the developer is required to use a non-discharge alternative that is cost-effective and environmentally sound compared with the costs of the proposed discharge. If a non-discharge alternative is not cost-effective and environmentally sound, the developer must use the best available combination of treatment, pollution prevention, and wastewater reuse technologies and assure that any discharge is non-degrading. In the case where allowing lower water quality discharge is necessary to accommodate important economic or social development in an area, DEP may approve a degrading discharge after satisfying a multitude of intergovernmental coordination and public participation requirements (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. On the following page, *Table 4.4* shows the Chapter 93 designated uses for Crawford County as defined by §93.9. The majority of watersheds within Crawford County have watershed designated as either warm water fisheries or cold water fisheries, although there is a substantial variety of high quality waters throughout the county.

Category	Stream Miles												Percent of County
	Ashtabula River	Brokenstraw Creek	Conneaut Creek	Conneaut Outlet	Cussewago Creek	French Creek	Little Shenango River	Muddy Creek	Oil Creek	Sandy Creek	Shenango River	Sugar Creek	
EV	--	--	--	--	--	--	--	--	16	--	--	--	0.5
HQ-CWF	--	17	--	--	--	121	--	223	4	--	--	19	13.1
HQ-TSF	--	--	--	--	--	--	--	69	--	--	--	--	2.4
HQ-WWF	--	--	--	64	--	--	--	--	--	--	--	--	2.2
CWF	0	--	255	7	--	198	--	--	518	--	3	146	38.5
TSF	--	--	--	--	--	12	100	--	--	--	13	--	4.3
WWF	--	--	29	171	221	440	--	1	--	28	255	--	39.0
Total	0	17	284	242	221	771	100	293	538	28	271	165	100.0

Table 4.4. Crawford County Designated Water Uses by Act 167 Watershed

Water Quality Impairments and Recommendations

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

EXISTING MUNICIPAL REGULATIONS

In Pennsylvania, stormwater management regulations usually exist at the municipal level. A review of the existing municipal regulations helps us unravel the complex system of local regulation and develop watershed wide policy that both fits local needs and provides regional benefits. *Table 4.6* provides a summary of existing regulations for the 51 municipalities within Crawford County.

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT (SALDO)	ZONING	FLOODPLAIN MANAGEMENT
Athens Township	--	--	--	--
Beaver Township	--	--	Yes	--
Bloomfield Township	SALDO; Peak (2, 10, 25, 100); 100% Release Rates; TR-55	Yes (2001)	Yes	--
Blooming Valley Borough	SALDO; Act 167 Reference only	Yes (2001)	Yes	--
Cambridge Springs Borough	SALDO; 50 year storm; TR-55	Yes (1999)	Yes	--
Cambridge Township	SALDO; 50 year storm; TR-55	Yes (1999)	Yes	--
Centerville Borough	--	--	--	--
Cochranton Borough	--	--	--	--
Conneaut Lake Borough	--	Yes (1969)	Yes	--
Conneaut Township	--	--	--	--
Conneautville Borough	--	--	Yes	--
Cussewago Township	--	Yes (1971)	Yes	--
East Fairfield Township	SALDO; Peak (2, 10, 25, 100); 100% Release Rates; TR-55	Yes (2000)	Yes	--
East Fallowfield Township	--	--	--	--
East Mead Township	--	Yes (1979)	--	--
Fairfield Township	--	--	--	--
Greenwood Township	SALDO; 50 year storm; TR-55	Yes (1986)	--	--
Hayfield Township	SALDO; 50 year storm; TR-55	Yes (2002)	Yes	--
Hydetown Borough	--	Yes	Yes	--
Linesville Borough	--	Yes (1973)	Yes	--

Notes: (--): Non-existent or not readily available at the time of this Plan

Table 4.6. Crawford County Municipal Ordinance Matrix

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT (SALDO)	ZONING	FLOODPLAIN MANAGEMENT
Meadville City	Title 7, Article 941, 943m 945, 947, 949, 951, 953, 955; 2005; Conformance clause with Act 167 adopted by County; Water Quality is specified	Yes (2010)	Yes	Yes; Article 1306.11 Flood Hazard Areas
North Shenango Township	--	Yes (1974)	Yes	--
Oil Creek Township	SALDO Section 402; 50 year storm; TR-55	Yes (1983)	Yes	--
Pine Township	SALDO Section 402; 50 year storm; TR-55	Yes (1994)	Yes	--
Randolph Township	--	--	--	--
Richmond Township	--	--	--	--
Rockdale Township	--	Yes	--	--
Rome Township	--	--	--	--
Sadsbury Township	SALDO; 50 year storm; TR-55	Yes (1986)	Yes (2001)	Yes; Overlay District Section 517
Saegertown Borough	SALDO; 50 year storm; TR-55	Yes (1987)	Yes (1996)	Yes; Overlay District Section 200
South Shenango Township	SALDO; Peak (10 yer (although more should be evaluated)); 100% Release Rates; TR-55	Yes (1981)	--	--
Sparta Township	--	--	--	--
Spartansburg Borough	--	Yes (2000)	--	--
Spring Township	--	County	County	--
Springboro Borough	--	Yes (1981)	Yes	Yes; Overlay District Article 10
Steuben Township	--	County	--	--

Notes: (--): Non-existent or not readily available at the time of this Plan

Table 4.6 (continued). Crawford County Municipal Ordinance Matrix

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT (SALDO)	ZONING	FLOODPLAIN MANAGEMENT
Summerhill Township	--	--	Yes (1983)	Yes; Floodplain District Section 506
Summit Township	--	Yes (1972)	Yes (2002)	Yes; Floodplain District Artcle 4
Titusville City	Article 933; Peak (2, 10, 25); 100% Release Rates; TR-55; Extended Detention for Water Quality based on 1-year, 24 hour storm	Yes (2008)	Yes (2008)	Yes; Separate Code (Title 5)
Townville Borough	--	--	--	--
Troy Township	--	County	--	--
Union Township	--	Yes (1995)	--	--
Venango Borough	--	--	Yes (1990)	Yes; Ordinance No. 1996-1
Venango Township	--	--	--	--
Vernon Township	--	Yes (1994)	Yes (1997)	Yes; Section 514
Wayne Township	--	--	--	--
West Fallowfield Township	--	Yes (1992)	--	--
West Mead Township	SALDO Article VIII; Peak (2-,10-, 25- and, 50-year)	Yes (2008)	Yes (1985)	Yes; Overlay District Section 511
West Shenango Township	--	Yes (1977)	--	--
Woodcock Borough	--	--	--	--
Woodcock Township	--	Yes (1995)	Yes (1986)	Yes; Floodplain District Section 880

Notes: (--): Non-existent or not readily available at the time of this Plan

Table 4.6 (continued). Crawford County Municipal Ordinance Matrix

At the time of the publication of this plan, at least 15 of the 51 municipalities within Crawford County have some stormwater management regulations in their local ordinances. An additional eight municipalities enacted SALDOs since 1990 and also likely at least some mention of stormwater management. Most of these regulations focus on peak rate control of larger storms (either the 10 or 50 year storm events). The encouragement of infiltration practices in rarely mentioned and water quality in mentioned in only two ordinances (the Cities of Meadville and Titusville).

The majority of municipalities that have zoning ordinance have articles or sections that provide for development within designated floodplains. For the municipalities that do not have zoning, language is often provided in the SALDO that could be used to regulate floodplain development, like the Pine Township SALDO:

"No land shall be subdivided or developed which is unsuitable for development by reason of flooding, poor drainage, adverse earth or rock formation, or any other condition likely to be harmful to the health, safety or welfare of future residents. Such lands shall remain unsubdivided or undeveloped until such time as the conditions causing unsuitability are corrected."

The specific enforcement mechanisms of this SALDO language is not documented, nor is it clear what defines the term "corrected."

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	Pertinent Plan Goals	Date	Author
Northwest Pennsylvania Greenways Plan	Promotion of environmentally sound development within critical areas for Crawford County	4-16-2009	Pashek Associates
2008 Crawford County Comprehensive Plan Update	Comprehensive Planning	6-25-2008	Crawford County Planning Commission
2000 Crawford County Comprehensive Plan	Comprehensive Planning	8-21-2000	Crawford County Planning Commission and RCS and A, Inc.
Municipal Comprehensive Plans	Comprehensive Planning	Various	Various
Shenango River Wateshed Conservation Plan	To document current conditions and identify additional initiatives aimed at improving the livability and attractiveness within Watershed	7-2005	Western Pennsylvania Conservancy
French Creek Water Conservation Plan	To preserve habitat, maintain biological diversity, and protect French Creek's endangered species	1-2002	Western Pennsylvania Conservancy and French Creek Project
Conneaut Outlet Act 167 Storm Management Plan	Same as this Plan	6-1993	Chester Environmental

Table 4.8. Related Plans Review

With regards to the Conneaut Outlet Act 167, some of the technical aspect are integrated into this Plan (i.e., release rate map). Provisions of the Conneaut Outlet Act 167 recommendations and Model Ordinance have been considered and integrated into this Plan, where appropriate.

Section V – Significant Problem Areas and Obstructions

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

The first task was to identify the location and nature of existing drainage problems within the study area, and where appropriate, gather field data to be used for further analysis of the problem. The geographical location data was used to plot all of the problem areas and obstructions on a single map (Reference *Plate 9 – Problem Areas & Obstructions*). Mapping the location of the sites in this manner enables identification of isolated problems and determination of 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 part of this task was to analyze individual problem areas and obstructions, determine potential solutions for the most significant problems, and provide recommendations that can be implemented through the Crawford County Stormwater Management Plan. This tasks was not completed as part of the Plan due to funding difficulties with Act 167 Program.

IDENTIFICATION OF PROBLEM AREAS AND OBSTRUCTIONS

Identification and review of existing information concerning the County's stormwater systems, streams, and tributary drainage basins within the project limits was conducted during Phase I and Phase II of this Plan. During Phase I, questionnaires were distributed to all of the municipalities in Crawford County. The questionaire enabled the municipalities to report all of the known problem areas and obstructions within their municipality. Of the 51 municipalities in Crawford County, 42 participated in the assessment process by returning completed questionaires. The responses were summarzied and reported in the Phase I report of this Plan. The responses were reviewed during Phase II of the Act 167 planning process. Field reconnaissance was subsequently conducted to confirm problem area locations, assess existing conditions, identify the general drainage patterns and gather data to complete a planning level analysis.

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

ID	Municipality	Location	Description
P1	Union Township	Trib Of French Creek	Undersized pipe
P2	Union Township	Main St	Flooding

ID	Municipality	Location	Description
P3	Union Township	Mt Pleasant Rd	Flooding / erosion
P4	Union Township	Wilson Chutes Rd	Flooding / road closer
P5	Union Township	Perry Highway At Conneaut Marsh	Flooding / road closer
P6	Union Township	Shafer And Towpath Rd	Flooding / erosion
P7	Union Township	Wightman Rd	Flooding
P8	Union Township	Campground At French Creek	Flooding
P9	Union Township	Zimmer Hill To Towpath Rd	Erosion
P10	East Fallowfield Township	Pine Rd	Undersized pipe
P11	East Fallowfield Township	Pine Rd	Debris
P12	East Fallowfield Township	Cole And Horne Rd	
P13	East Fallowfield Township	Laird Rd	
P14	East Fallowfield Township	Thomas Rd	Too much runoff
P15	East Fallowfield Township	Countyline Rd	Flooding
P16	Woodcock Township	Stoltz Rd	Erosion
P17	Woodcock Township	German Rd	Erosion
P18	Woodcock Township	Huson Rd	Undersized pipe
P19	Woodcock Township	Theuret Hill Rd.	Water ponding
P20	Townville Borough	W. Fremont St	Flooding, erosion, ice
P21	Townville Borough	Arnold Drive	Flooding, ice
P22	Townville Borough	Main St	Flooding
P23	Townville Borough	Cherry Ln	Rusted culvert
P24	Townville Borough	W Fremont St.	Older bridge
P25	Townville Borough	E Fremont St.	Older bridge
P26	Townville Borough	E Fremont St.	Swales
P27	Townville Borough	Main St	Flooding
P28	Summerhill Township	Dicksonburg Rd	Existing pipes too small
P29	Summerhill Township	Morris Rd	Flooding
P30	Summerhill Township	Trib Of Rundelltown Creek	Flooding
P31	Summerhill Township	Crozier Rd	Erosion
P32	Summerhill Township	Canal Rd	Flooding
P33	Summerhill Township	Fish Creek	Roadway damage from erosion
P34	Summerhill Township	Canal Rd	Flooding
P35	Athens Township	Muddy Creek	Flooding
P36	Athens Township	Dewey Rd	Roadway damage from erosion
P37	Athens Township	Dewey Rd	Roadway damage from erosion
P38	Athens Township	Cemetery Rd	Road closed due to old bridge

Table 5.1. Reported Problem Areas and Obstructions

ID	Municipality	Location	Description
P39	Steuben Township	Mystic Park Rd	Flooding and streambank eroding into roadway
P40	Steuben Township	Old Grade Rd	
P41	Steuben Township	Mercer Rd	See cp180
P42	Steuben Township	Wheelock Rd	
P43	Summit Township	Porter Rd	Erosion
P44	Summit Township	Faust Rd	Erosion
P45	Summit Township	Faust Rd	Erosion
P46	Summit Township	Hindman Rd	Beaver dam
P47	Summit Township	Agnew Rd	Sediment
P48	Summit Township	Gibson Rd	Stream bank erosion
P49	Summit Township	Port Ave	Flooding
P50	Summit Township	Walnut St	Flooding
P51	Greenwood Township	Mcmichael Rd	Erosion
P52	Greenwood Township	Mill Rd & Main St	Flooding
P53	Greenwood Township	Capt. Williams Rd	Erosion
P54	Greenwood Township	Rock Creek	Erosion
P55	Greenwood Township	Mercer Pike	Beaver dam
P56	Greenwood Township	Mattocks Rd	Bridge headwalls
P57	Greenwood Township	Brick Church Rd	Bridge headwalls
P58	Greenwood Township	Williams Road	Old stone culvert
P59	Greenwood Township	Miller Road	Beaver dam
P60	West Shenango Township	Quick Run	Erosion
P61	West Shenango Township	Trib Of Sugar Run	Area overgrown
P62	West Shenango Township	Bush Rd	Erosion
P63	West Shenango Township	Bush Rd	Erosion
P64	West Shenango Township	West Lake Rd	Stormwater moves too fast
P65	Rockdale Township	Mier Station Rd	Flooding
P66	Rockdale Township	Mier Station Rd	Flooding
P67	Oil Creek Township	Boghollow Rd.	Erosion
P68	Oil Creek Township	N Goodwill Rd	Erosion
P69	Oil Creek Township	Gilson Ridge Rd	Flooding
P70	Oil Creek Township	Finney Rd	Flooding
P71	Oil Creek Township	Kinsack Rd	Erosion
P72	Oil Creek Township	Foote Rd	Erosion
P73	Oil Creek Township	Cherrytree Rd.	Erosion
P74	Oil Creek Township	Dotyville Rd	Flooding
P75	Oil Creek Township	Duncan Rd	Flooding
P76	Oil Creek Township	Mckinney St.	Erosion
P77	Cussewago Township	Center Rd	Flooding

Table 5.1 (continued). Reported Problem Areas and Obstructions

ID	Municipality	Location	Description
P78	Cussewago Township	Creek Rd	Flooding
P79	Cussewago Township	Game Rd	Erosion
P80	Cussewago Township	Fry Rd	Roadway damage from erosion
P81	Cussewago Township	Hecker Rd	Roadway damage from erosion
P82	Cussewago Township	Center Rd	Erosion
P83	Cussewago Township	Hecker Rd	Erosion
P84	Cussewago Township	Hillview Rd	Erosion
P85	Saegertown Borough	Rt 0198	Poor water flow
P86	Hayfield Township	Rt 0198	Bridge debris
P87	Springboro Borough	Rt 0018	Stream channel
P88	Springboro Borough	Union St	Plugged culvert
P89	Springboro Borough	Depot Street	Plugged culvert
P90	Springboro Borough	Rt 0018	Culvert too small
P91	Springboro Borough	Beaver St	Plugged culvert
P92	Sadsbury Township	Konneyaut Tr	Flooding
P93	Sadsbury Township		Roadway / home flooding
P94	Sadsbury Township		Roadway / home flooding
P95	Sadsbury Township		Roadway / home flooding
P96	Sadsbury Township		Roadway / home flooding
P97	Sadsbury Township		
P98	South Shenango Township		Flooding
P99	South Shenango Township		Flooding
P100	Centerville Borough		Flooding
P101	Centerville Borough		Erosion (streambank?)
P102	Cambridge Springs Borough		Flooding
P103	Cochranton Borough		
P104	Cochranton Borough		
P105	Cochranton Borough		
P106	East Mead Township		Flooding
P107	East Mead Township		Roadway flooding
P108	East Mead Township		Roadway flooding
P109	East Mead Township		Roadway flooding
P110	East Mead Township		Beaver dam
P111	East Mead Township		Beaver dam
P112	Blooming Valley Borough		Flooding
P113	Blooming Valley Borough		Flooding
P114	Hydetown Borough		Streambank erosion
P115	Hydetown Borough		Flooding
P116	Hydetown Borough		Poor drainage

Table 5.1 (continued). Reported Problem Areas and Obstructions

ID	Municipality	Location	Description
P117	Hydetown Borough		Flooding
P118	Hydetown Borough		Flooding
P119	Hydetown Borough		Roadway erosion
P120	Wayne Township		Erosion
P121	Troy Township		Stream bank erosion
P122	Pine Township		Flooding
P123	Pine Township		Flooding
P124	Pine Township		Flooding
P125	Pine Township		Erosion
P126	Pine Township		Erosion
P127	Pine Township		Flooding
P128	Pine Township		Erosion
P129	Pine Township		Erosion
P130	Pine Township		Flooding
P131	Linesville Borough		Flooding
P132	Linesville Borough		Flooding
P133	Linesville Borough		Flooding
P134	Linesville Borough		Flooding
P135	Linesville Borough		Flooding
P136	Linesville Borough		Flooding
P137	Linesville Borough		Flooding
P138	Linesville Borough		Flooding
P139	Linesville Borough		Flooding
P140	Linesville Borough		Flooding
P141	Venango Township		Flooding
P142	Bloomfield Township		Flooding
P143	Bloomfield Township		Flooding
P144	Cambridge Township		Failed culvert
P145	West Mead Township		Flooding
P146	West Mead Township		Erosion
P147	West Mead Township		Erosion
P148	West Mead Township		Erosion
P149	West Mead Township		Erosion
P150	West Mead Township		Flooding
P151	West Mead Township		Erosion
P152	West Mead Township		Flooding
P153	West Mead Township		Flooding
P154	West Mead Township		Flooding
P155	West Mead Township		Erosion
P156	West Mead Township		Flooding

Table 5.1 (continued). Reported Problem Areas and Obstructions

ID	Municipality	Location	Description
P157	North Shenango Township		Flooding
P158	North Shenango Township		Flooding
P159	North Shenango Township		Flooding
P160	North Shenango Township		Flooding
P161	North Shenango Township		Flooding
P162	North Shenango Township		Flooding
P163	North Shenango Township		Flooding
P164	North Shenango Township		Flooding
P165	Vernon Township		Flooding
P166	East Fairfield Township		Flooding
P167	East Fairfield Township		Flooding
P168	East Fairfield Township		Flooding
P169	Titusville City		Stream swells throughout oil creek twp
P170	Titusville City		See O27
P171	Titusville City		Ii&i into stormwater structures
P172	Titusville City		Retention area floods soccer fields & homes
P173	Titusville City		Outfall failure undermining gas & sanitary
P174	Titusville City		Abond. well spring water surfacing
P175	Titusville City		Scattered artesian well runoff
P176	Titusville City		Groundwater surfacing
P177	Titusville City		Clearcut for agriculture
P178	Richmond Township		Flooding
P179	Richmond Township		Road washout on edge
P180	Richmond Township		Road washout on edge
P181	Richmond Township		Ditchline erosion
P182	Richmond Township		
P183	Richmond Township		Beaver dam
P184	Richmond Township		Flooding
P185	Richmond Township		Side of road floods
P186	Sadsbury Township		Flooding
P187	Sadsbury Township		Flooding
P188	Sadsbury Township		Flooding
P189	Sadsbury Township		Flooding
P190	Sadsbury Township		Flooding
P191	Sadsbury Township		Flooding
P192	Sadsbury Township		Flooding
P193	Bloomfield Township		Flooding
P194	Bloomfield Township		Flooding

Table 5.1 (continued). Reported Problem Areas and Obstructions

ID	Municipality	Location	Description
P195	Bloomfield Township		Flooding
P196	Bloomfield Township		Flooding
P197	Bloomfield Township		Flooding
P198	Bloomfield Township		Flooding
P199	Bloomfield Township		Flooding
P200	Bloomfield Township		Flooding
P201	Bloomfield Township		Flooding
P202	Bloomfield Township		Flooding
P203	Bloomfield Township		Flooding
P204	Bloomfield Township		Flooding
P205	Bloomfield Township		Flooding
P206	Bloomfield Township		Flooding
P207	East Fairfield Township		Flooding
P208	Springboro Borough		Flooding
P209	Union Township		Heavy rains cause stream erosion
P210	Conneautville Borough		Flooding along stream. flooding of residential property
P211	Conneautville Borough		Ponding along route 18
P212	Conneautville Borough		Erosion along street
P213	Conneautville Borough		Erosion along street
P214	Conneautville Borough		Erosion along street
P215	Conneautville Borough		Severe bank erosion from stream threaten road integrity.
P216	Conneautville Borough		Erosion along street
P217	City Of Meadville		
P218	City Of Meadville		
P219	City Of Meadville		
P220	City Of Meadville		
P221	City Of Meadville		
P222	City Of Meadville		
O1	Union Township		Undersized pipe
O2	Rome Township		Beaver dam
O3	Woodcock Township		Waterway full of gravel
O4	Townville Borough		Inlet
O5	Summerhill Township		Remove beaver dam
O6	Athens Township		Flooding
O7	Summit Township		Bridge
O8	Greenwood Township		Installed riprap at inlet
O9	Greenwood Township		Need ditch to private property
O10	Greenwood Township		Replace drain pipes

Table 5.1 (continued). Reported Problem Areas and Obstructions

ID	Municipality	Location	Description
O11	West Shenango Township		Beaver dam
O12	West Shenango Township		Beaver dam
O13	West Shenango Township		State owned culvert too small
O14	Fairfield Township		Bridge too small
O15	Oil Creek Township		Erosion
O16	Cussewago Township		Beaver dam
O17	Cussewago Township		Beaver dam
O18	Saegertown Borough		Larger bridge
O19	Springboro Borough		Plugged culvert
O20	South Shenango Township		Collapsing culvert
O21	Troy Township		Beaver dam
O22	Troy Township		Beaver dam
O23	Linesville Borough		Clogging pipe
O24	Venango Township		Beaver dam
O25	Conneaut Lake Borough		Culvert
O26	Conneaut Lake Borough		Culvert
O27	Titusville City		Box culverts constrictions, sedimentation, flooding

Table 5.1 (continued). Reported Problem Areas and Obstructions

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

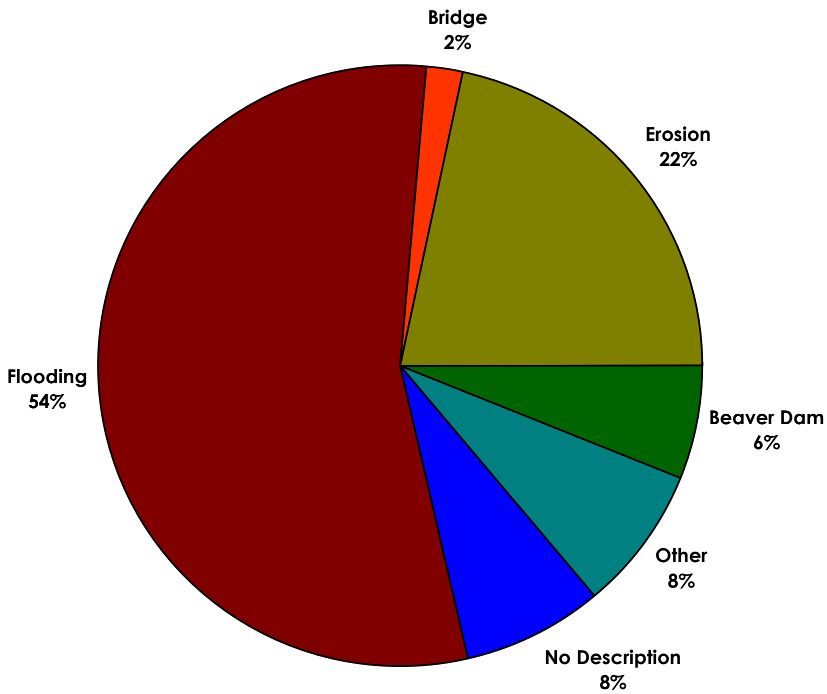


Figure 5.1. Overview of Problem Area Conveyance Capacity

Section V – Significant Problem Areas and Obstructions

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

PROBLEM AREA ASSESSMENT

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

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

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

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

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

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

RECOMMENDATIONS

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

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

1. A culvert or bridge has insufficient hydraulic capacity or is in poor condition. These account for 32% of the problem areas in the County.

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

2. There is a severe erosion and deposition problem in a stream or man-made channel. This accounts for 21% of the problem areas in the County.

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

3. There is an incomplete collection and conveyance system or a lack of a formal/comprehensive maintenance program for the existing storm drain system. These account for 17% of the problem areas in the County.

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

4. Problem areas are located in the floodplain area. About 19% of the problem areas were within or near floodplains.

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

5. About 7% of the problem areas within County were related to beaver dams and the continual maintenance difficulties found with these ubiquitous animals.

General Recommendation: The presence of beavers can lead to time-consuming and expensive maintenance requirements. Contact regional office of the Pennsylvania Game Commission for assistance with beaver removal at 814-432-3188. General strategies to prevent and mitigate beaver dams include dam removal and the installation of beaver fencing or water control devices.

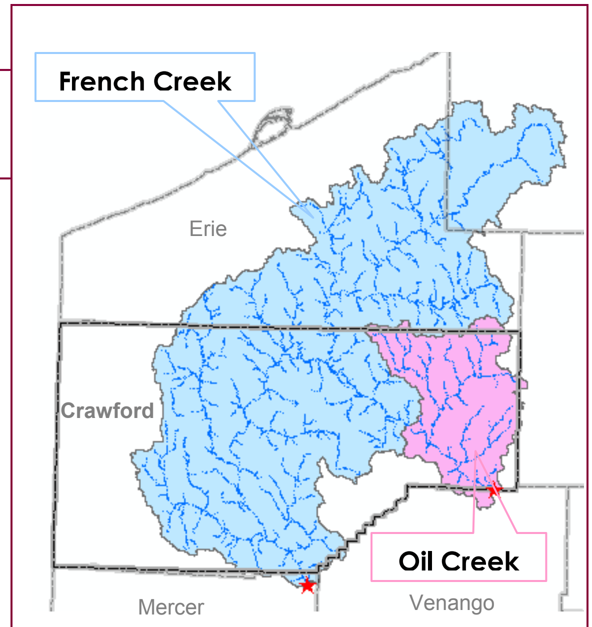
In addition, the problem areas mentioned in this section are more pronounced in the more populated/developed areas. This is most likely due to encroachments into floodplain areas and undersized culverts or bridges. Also, a large number of these stormwater related problems have been traced back to uncontrolled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

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

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

Stormwater master planning is one way to address all of the needs and potential threats to a watershed. However, implementation of these practices can be difficult and may not be economically feasible for many communities. Looking ahead, it is expected that the status of the current stormwater infrastructure will keep deteriorating with time. In addition to imposing stronger regulations to control new development, increased expenditures for maintenance and other improvements is necessary, or the systems will continue to deteriorate faster than the ability to fix and maintain them.

Section VI – Technical Analysis - Modeling



TECHNICAL APPROACH

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

The modeling approach in this study was to:

1. Establish a reasonable estimate of rainfall-runoff response under existing conditions 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 Oil Creek and French Creek in Crawford 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 Crawford 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 in will help reduce the impacts of future development. With the minor projected change in land use and the implementation of the BMP Manual Guidelines, no stormwater management districts are proposed for Crawford 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: Oil Creek 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	2,924.7	2.78	2,885.4	2.74	-0.04
Commercial and Business	59.9	0.06	81.3	0.08	0.02
Contoured Row Crops	7,866.2	7.47	7,708.2	7.32	-0.15
Meadow	252.9	0.24	248.8	0.24	0.00
Newly graded areas	90.7	0.09	90.7	0.09	0.00
Open space	3,863.7	3.67	3,812.9	3.62	-0.05
Pasture	23,477.8	22.31	23,231.5	22.07	-0.23
Residential - 1 acre	740.3	0.70	725.7	0.69	-0.01
Residential - 1/2 acre	255.4	0.24	1,188.2	1.13	0.89
Water	658.3	0.63	648.5	0.62	-0.01
Woods	65,067.1	61.82	64,635.8	61.41	-0.41
Total	105,257.0	100.00	105,257.0	100.00	n/a

Notes: All land uses assumed to be in Good Condition

Table 6.1. Estimated Existing and Future Land Use in the Oil Creek Watershed (within Crawford County only)

Land Use	Existing Land Use		Proposed Land Use		Change Future - Existing
	Acres	%	Acres	%	%
Brush	1,565.1	0.47	1,539.7	0.46	-0.01
Commercial and Business	341.1	0.10	2,221.2	0.67	0.56
Contoured Row Crops	54,035.7	16.21	53,526.1	16.06	-0.15
Meadow	4,698.6	1.41	4,619.1	1.39	-0.02
Newly graded areas	51.5	0.02	51.5	0.02	0.00
Open space	18,873.2	5.66	18,565.9	5.57	-0.09
Pasture	58,711.6	17.62	57,776.0	17.34	-0.28
Residential - 1 acre	7,339.9	2.20	7,724.8	2.32	0.12
Residential - 1/2 acre	1,462.2	0.44	3,144.8	0.94	0.50
Water	8,409.1	2.52	8,354.7	2.51	-0.02
Woods	177,771.4	53.34	175,735.8	52.73	-0.61
Total	333,262.3	100.00	333,262.3	100.00	n/a

Notes: All land uses assumed to be in Good Condition

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

EFFECTS OF FUTURE LAND USE

Using the HEC-HMS models for the Oil Creek 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 Oil Creek 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. This scenario provides a worst-case-scenario for projected future conditions. More importantly, this scenario highlights the critical areas within the county where more stringent regulation might be beneficial.

For the Oil Creek, the projected future increases are located mostly in the areas that currently have some development (City of Titusville, Borough of Spartansburg as shown in *Figure 6.1*). These projected increases are relatively close to large water bodies (e.g., Oil Creek or Lake Canadohta) where additional release rates would unlikely provide measurable benefits.

For the French Creek watershed, the only significant increases occur around the City of Meadville and Woodcock Township close to the main branch of French Creek and in areas below large flood control facilities. The location of these increases, combined with physical characteristics of the watershed (i.e., generally poor soils, mild slopes, and within the vicinity of large water bodies) indicate the additional release rates would unlikely provide significant benefits.

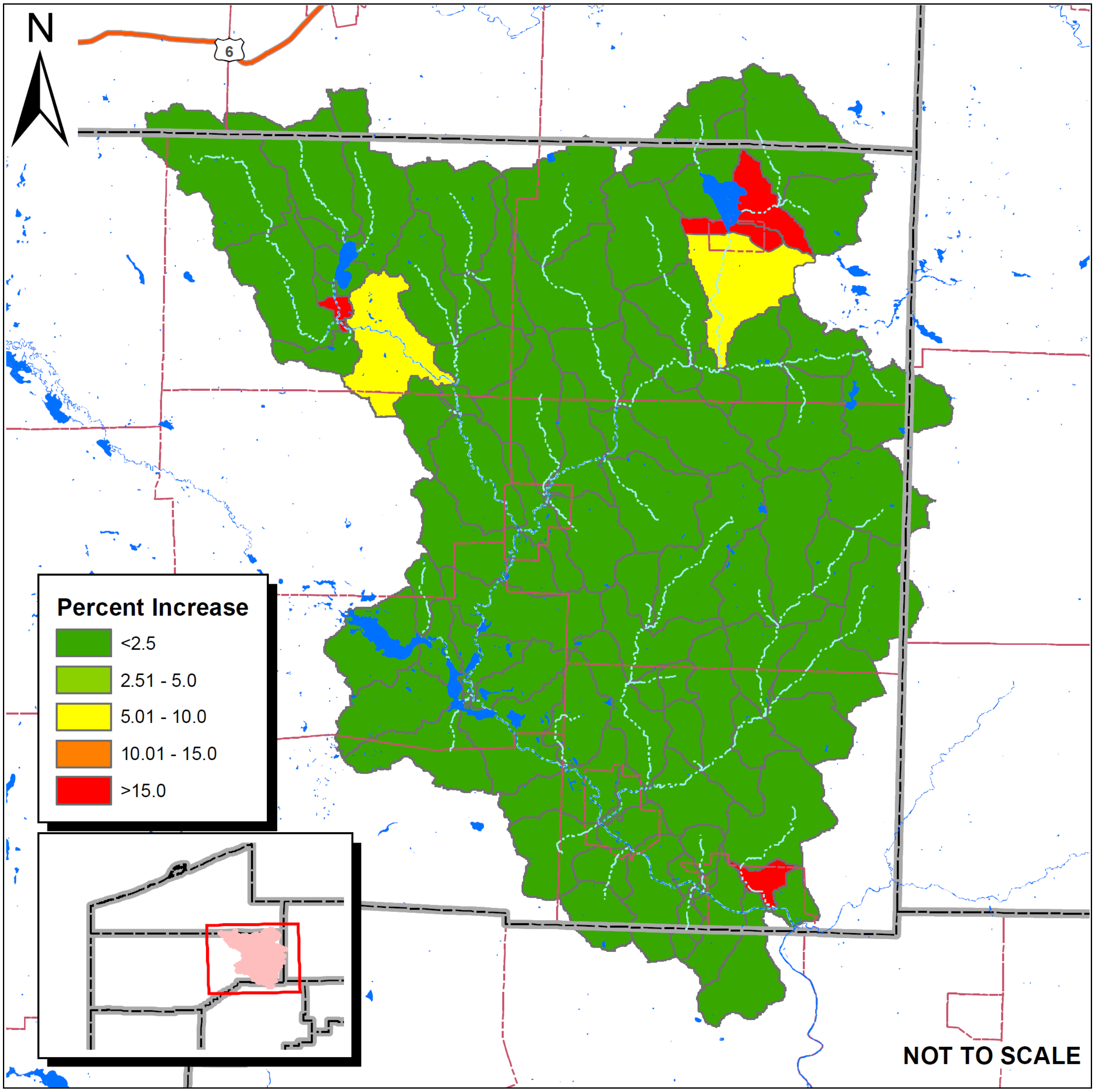


Figure 6.1. Percentage Discharge Increases for 2-year Storm Event with No Future Stormwater Management Land Use in the Oil Creek

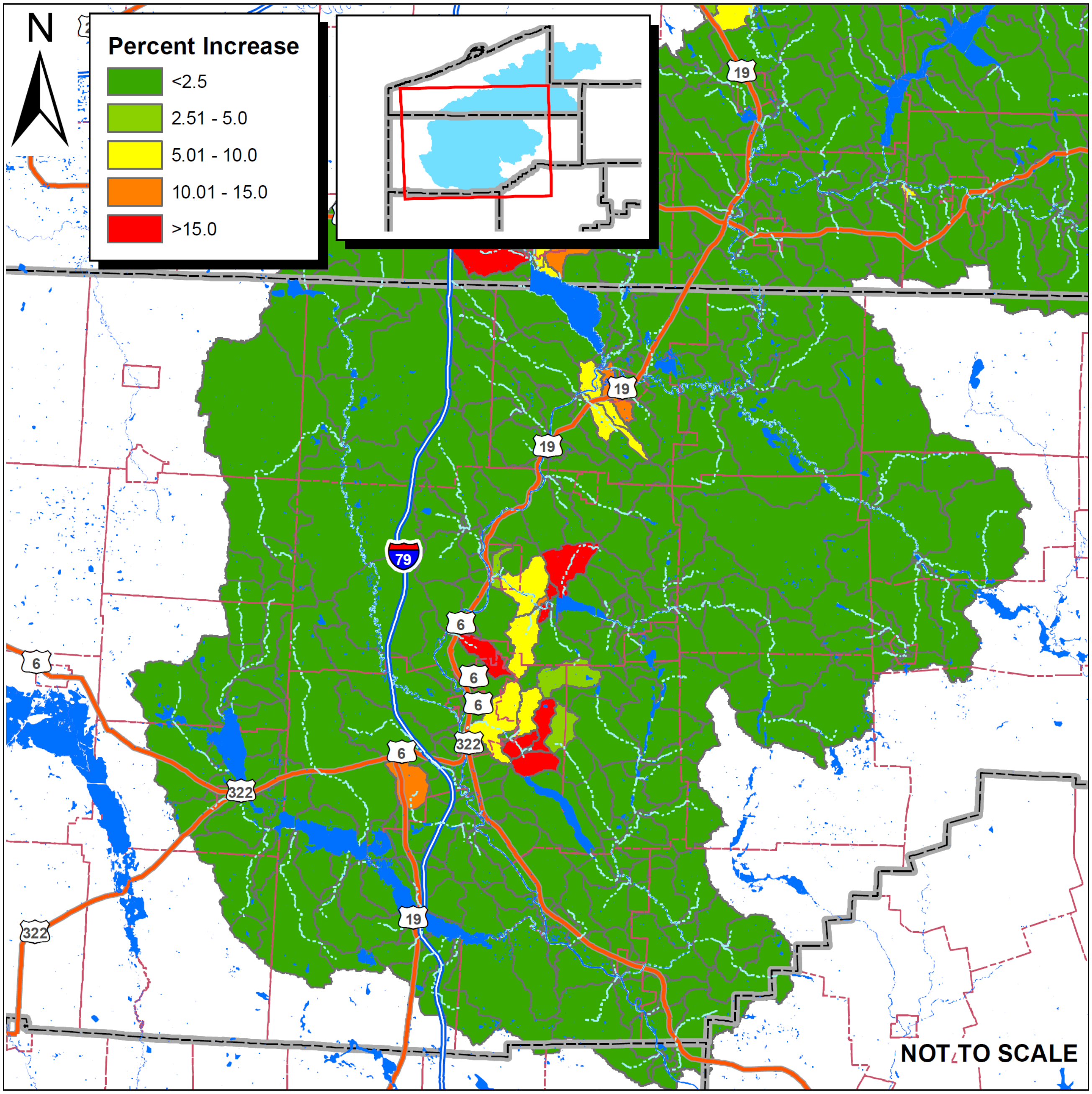


Figure 6.2. Percentage Discharge Increases for 2-year Storm Event with No Future Stormwater Management Land Use in the French Creek

STORMWATER MANAGEMENT DISTRICTS

When substantial increases are found in the HEC-HMS model due to additive effects of future development, it may be necessary to restrict post development discharges to a fraction of pre-development flow. The fraction has historically ranged between 50 and 100 percent of the pre-development flow in previous Act 167 efforts. 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 indicate a need for additional stormwater management controls, release rates are considered. The results from hydrologic models are used as guidance to establish appropriate release rates. Ultimately, reasonable hydrologic judgment is used in the final designation of release rates.

Both French and Oil Creek were evaluated on the above criteria for implementation of stormwater management districts. There is only moderate projected growth and the combination of implementing the *PA BMP Manual* volume control guidelines and using 100% peak rate control should be sufficient to limit the impact of the future projected growth. In considering the additional criteria it was determined that stormwater management districts would not be implemented for the French and Oil Creek watersheds.

For the Conneaut Outlet, stormwater management districts were developed for the Act 167 Stormwater Management Plan for that specific watershed. The approach in this Pan was to develop hydrology for the Conneaut Outlet and calculate existing condition flows where problem areas were identified. No future conditions analysis or release-rate analysis was attempted. There was no reevaluation of 1993 release rates or any technical component of the 1993 study. Thus, the stormwater management districts as designated for the Conneaut Outlet should be enforced until a more thorough evaluation of this study is prepared. These release rates are provided in *Plate 11*.

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 Crawford 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. To ensure conservative estimates of existing conditions flow, 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.

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

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

The field of stormwater management has evolved in recent years as additional research has increased our comprehension of how stormwater runoff is interrelated with the rest of our natural environment. Stormwater management practices will continue to evolve as additional knowledge becomes available. The goal of this Plan is to manage stormwater as a valuable resource, and to manage all aspects of this resource as effectively as possible. This Plan contains technical standards that seek to achieve this goal through four different methods. These standards are summarized as follows:

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

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

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

4. Water Quality Standards – The water quality standards contained in this Plan are meant to provide a level of pollutant removal from runoff prior to discharge to receiving streams. Stormwater runoff can deliver a wide range of contaminants to the receiving stream, which leads to a variety of 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 Crawford 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. The only applicable release rates in Crawford County are in the Conneaut Outlet (per the 1993 Act 167 Plan).

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 volume control is used as a stormwater management technique, multiple goals are achieved through implementation of a single practice. Volume control 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 use of low impact development practices to the maximum extent practicable.

2. Retaining of a portion of the runoff volume generated from the total runoff flow on the proposed project site.

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

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

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

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

B. The performance criteria for water quality best management practices should 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. 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* follows. 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:

BIORETENTION & RAIN GARDENS

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, especially with poorly draining soils. 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, typically within 10’.

Caution should be used in the application of dry wells, as with any infiltration system, in poorly drained soils. The drainage area contributing to a dry well must be limited to a 5:1 loading ratio.

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.

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 with 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 Crawford 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.

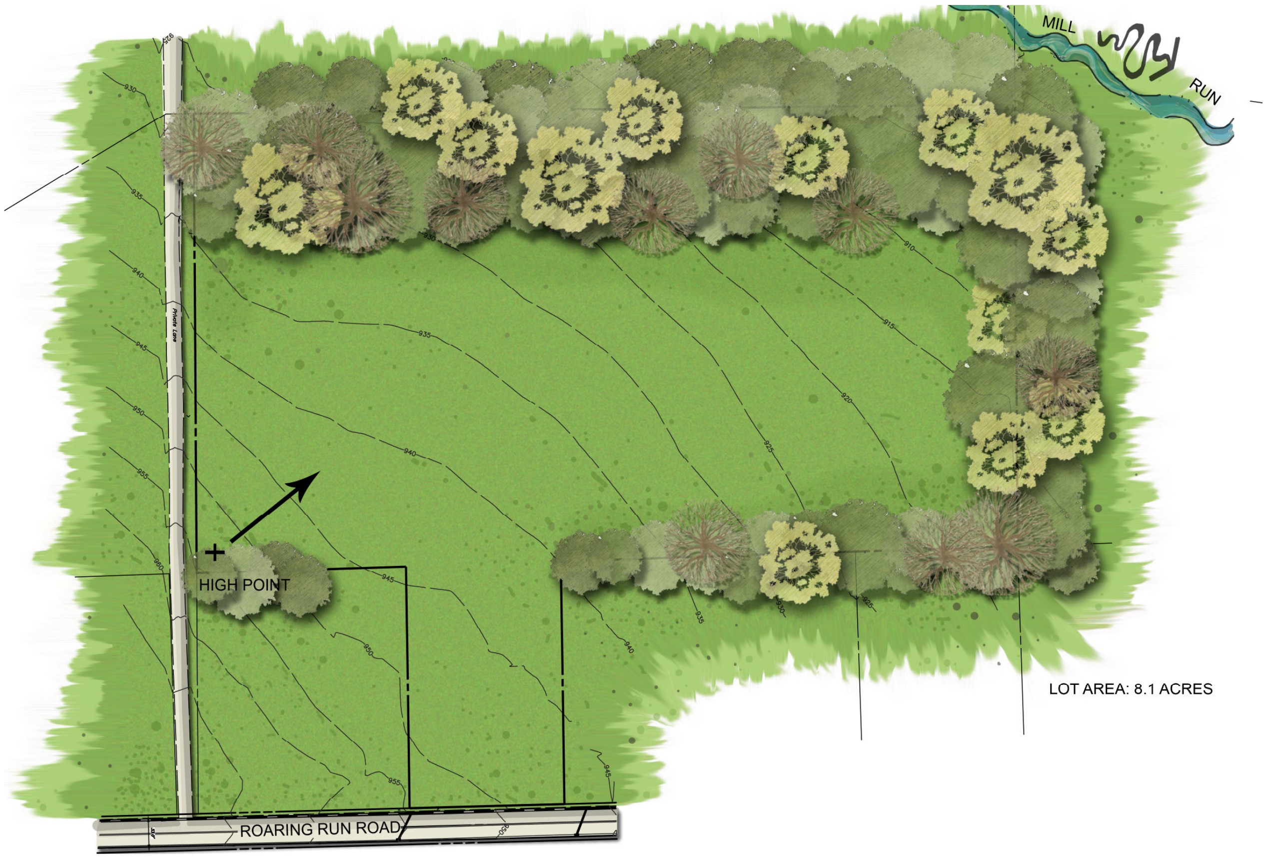


Figure 8.1. Design Example 1 – Pre-Development Conditions

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

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

Figure 8.2. Design Example 1 – Post-Development Conditions

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

Table 8.2. Post-Development Data

DESIGN PROCESS FOR VOLUME CONTROLS

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

Step 1

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

Step 2

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

Step 3

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

Step 4

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

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

Step 5

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

DRAFT

DESIGN OF PEAK RATE CONTROLS

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

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

The SCS Unit Hydrograph Method was developed to be used in conjunction with the Curve Number Runoff Method of generating runoff depths to estimate peak runoff rates and runoff hydrographs. While these methods have numerous limitations, the principal application of this 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. <u>Cost Comparison</u> – This is the most basic type of analysis. It is completed by comparing initial construction costs and other direct costs such as land value. This type of analysis is incomplete in scope in that it does to capture the benefits of improved stormwater management or variances in life-cycle costs such as operation and maintenance and life expectancy.

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

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

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

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

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.

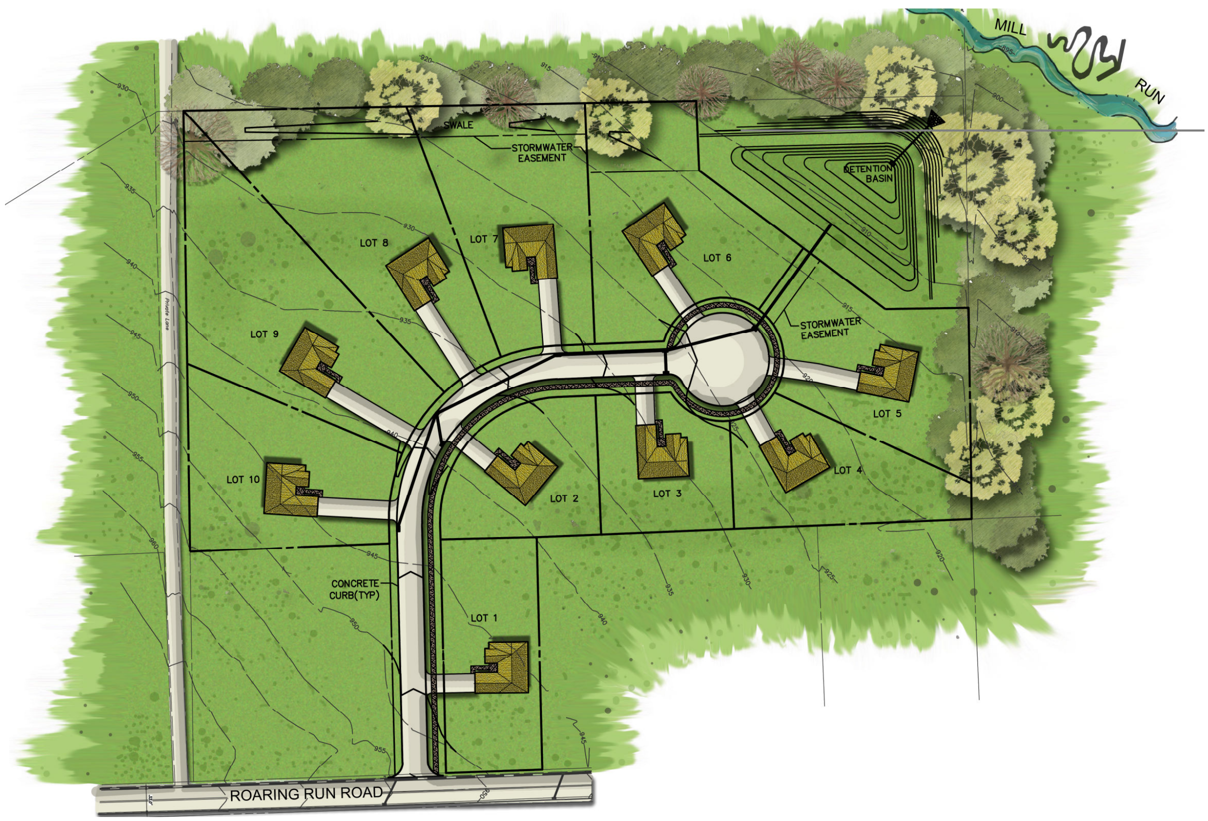


Figure 8.3. Traditional Subdivision Layout (Designed for Peak Rate Control)

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 which is consistent with building lots currently for sale within the County (Mullen Terrace, Grandview Heights for example). 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.

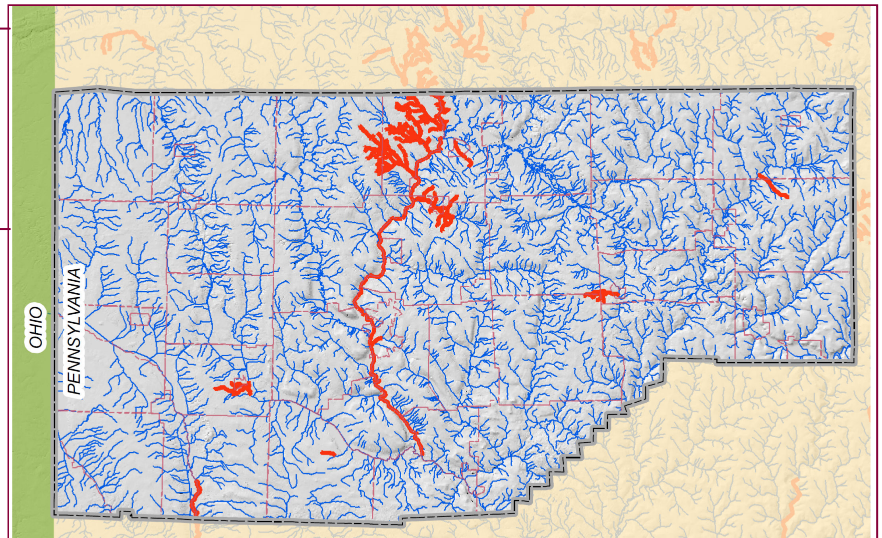
Description	Traditional Layout	LID Layout
Land Sale Value	$ 310,500	$ 240,701
Initial Construction Cost	$ 265,376	$ 182,887
Total Profit for Project:	$ 45,124	$ 57,814

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.

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

CRAWFORD 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 Crawford County and identifies the primary source of the impairment listing.

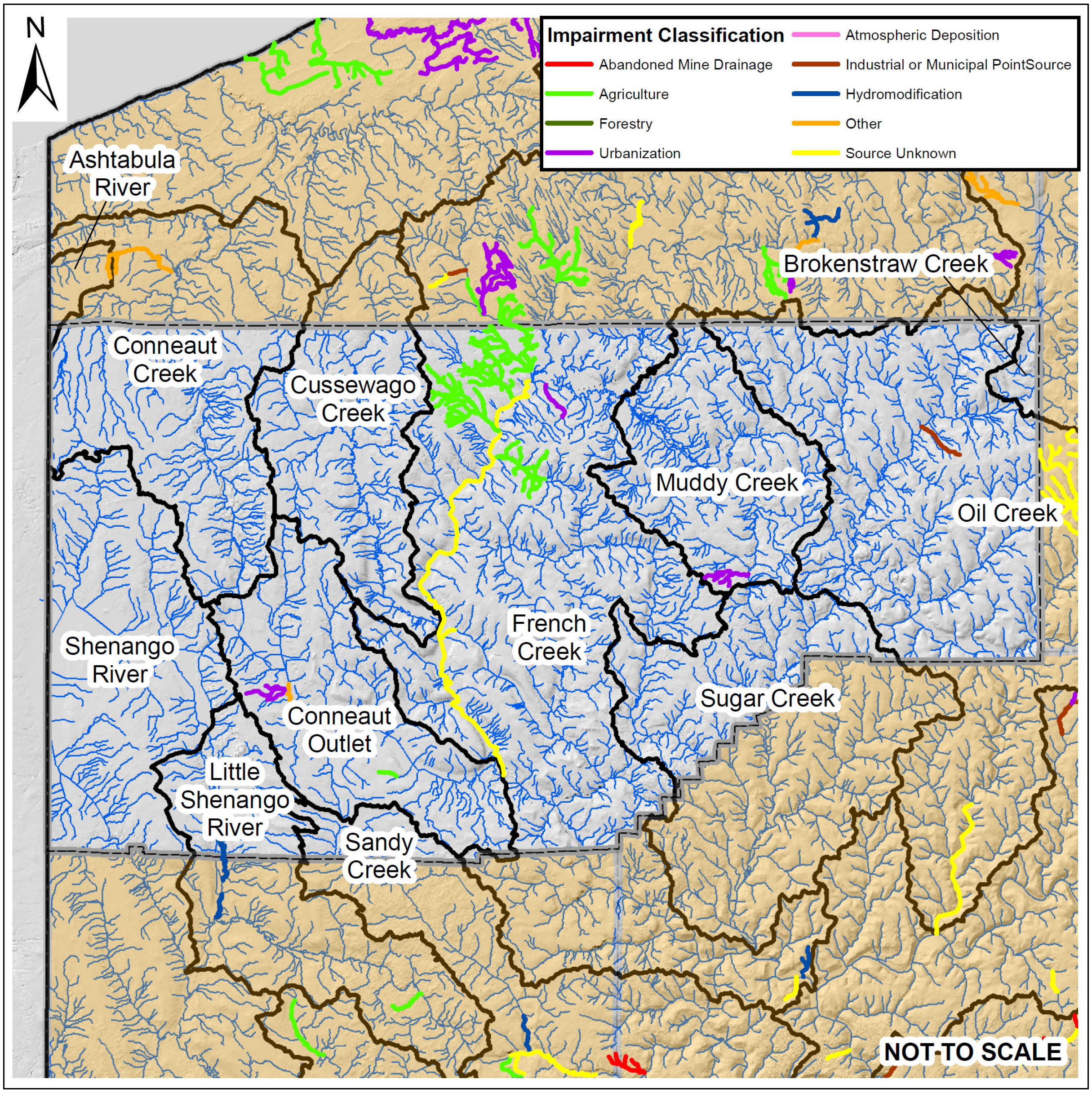


Figure 9.1. Impaired Stream Segments in CrawfordCounty

In Crawford County, all of the non-attaining streams were for Aquatic Life or Fish Consumption use attainment. Aquatic Life use attainment is reflective of any component of the biological community (i.e. fish or fish food organisms). The Fish Consumption use attainment is for elevated levels of mercury along French Creek that limit the recommended quantity of fish to be consumed by humans. 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.

Category	Act 167 Watersheds (Stream Miles)													Percent of County
	Ashtabula River	Brokenstraw Creek	Conneaut Creek	Conneaut Outlet	Cussewago Creek	French Creek	Little Shenango River	Muddy Creek	Oil Creek	Sandy Creek	Shenango River	Sugar Creek	Entire County	
Abandoned Mine Drainage	--	--	--	--	--	--	--	--	--	--	--	--	0.0	0.0
Agriculture	--	--	--	0.9	--	63.8	--	--	--	--	--	--	64.7	2.2
Atmospheric Deposition	--	--	--	--	--	--	--	--	--	--	--	--	0.0	0.0
Forestry	--	--	--	--	--	--	--	--	--	--	--	--	0.0	0.0
Hydromodification	--	--	--	--	--	--	--	--	--	--	--	--	0.0	0.0
Industrial or Municipal Point Source	--	--	--	--	--	--	--	--	3.1	--	--	--	3.1	0.1
Urbanization	--	--	--	4.4	--	2.1	--	4.3	--	--	--	--	10.8	0.4
Mercury (Source Unknown)	--	--	--	--	--	28.8	--	--	--	--	--	--	28.8	1.0
Other	--	--	--	1.2	--	--	5.7	--	--	--	--	--	6.9	0.2
Total Impaired	0.0	0.0	0.0	6.5	0.0	94.7	5.7	4.3	3.1	0.0	0.0	0.0	114.3	3.9
Percent of Total	0.0	0.0	0.0	2.7	0.0	12.3	5.7	1.5	0.6	0.0	0.0	0.0	3.9	3.9

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 two waterbodies with approved TMDLs in Crawford County as shown in *Table 9.2*.

Watershed	Category	Cause	Status
Conneaut Lake	Lake	Other Inorganics, Metals, pH	EPA Approved, 4/9/2001
Coon Run	Abandoned Mine Drainage	Metals	EPA Approved, 3/27/2009

Table 9.2. TMDLs in Crawford 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 Crawford County waters:

AGRICULTURAL ACTIVITIES

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

SEDIMENT/SILTATION

The most common agricultural cause for surface water impairment is sediment and siltation. 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. . 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.

URBANIZATION

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

SEDIMENT/SILTATION

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

HABITAT ALTERATIONS

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

NUTRIENTS AND METALS

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

RECOMMENDATIONS

Addressing water quality impairments is achieved most effectively through watershed wide planning and implementation. The water quality based approach is a common method of addressing impairments. The "Integrated Waters List" identifies impaired streams and identifies source-causes of impairment. The first step in the planning process must include provisions to address the expansion of the source cause. Implementing stormwater management standards that address water quality will help ensure the existing impairment does not worsen.

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.

In general, specific BMP's to be considered should include retrofitting existing stormwater management facilities to address water quality as well as implementation of riparian buffers.

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 Crawford 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

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

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

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

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

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

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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

Although not a goal or focus of this Plan, it must be recognized that 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*, Crawford County incurs a substantial economic loss in major hydrologic events (as much as $238 million in a 10-year storm event). Floodplain management policy serves to minimize the impact of such events by reducing the conflicts between human infrastructure and floodplains. While improved stormwater management will greatly reduce the occurrence of nuisance flooding, floodplains are necessary to attenuate flood waters from events that exceed the intended scope of stormwater policy. The most effective floodplain management policy provides preventive provisions that restrict future development within floodplains and corrective measures that reduce flood damage in existing problem areas.

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

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

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

RIVER CORRIDOR PLANNING

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

One particularly useful aspect of river corridor planning is to use the assessment information to designate corridors along the rivers where natural river changes are most likely to occur resulting in accelerated erosion or bank failures. These areas are sometimes referred to as "fluvial erosion hazard zones" and are responsible for a large portion of the damage to human infrastructure during flood events (Dolan 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 Conservation District would be invaluable to developers and design professional in determining what works in Crawford 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 are a substantial number of technical resources available to guide development of regulations for proactive thinking municipalities.

Section XI – Plan Adoption, Implementation and Update Procedures

PLAN REVIEW AND ADOPTION

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

1. Plan Advisory Committee Review - This body has been formed to assist in the development of the Crawford 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 four occasions to review the progress of the Plan. Municipal representatives on the Committee have the responsibility to report on the progress of the Plan to their respective municipalities. Review of the draft Plan by the Plan Advisory Committee will be expedited by the fact that the members are already familiar with the objectives of the Plan, the runoff control strategy employed, and the basic contents of the Plan. The output of the Plan Advisory Committee review will be a revised draft Plan for Municipal and County consideration.

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

    b. Legal Advisory Review - This body has been formed to focus on the legal aspects of the Plan and to educate the Municipal solicitors on the ordinance adoption and implementation requirements of the Plan. The group met to provide input as well as to receive comments and direction in the development of the model ordinance. The result of this effort is a revised draft model ordinance for Municipal and County consideration.

2. Municipal Review - Act 167 specifies that prior to adoption of the draft Plan by the County, the planning commission and governing body of each municipality in the study area must review the Plan for consistency with other plans and programs affecting the study area. The Draft Crawford 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 County Board of Commissioners for their consideration.

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

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

IMPLEMENTATION OF THE PLAN

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

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

Each municipality will need to determine how to best implement the provisions of this Plan within their jurisdiction. Two 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.)

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 Crawford County Planning and/or the Crawford 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 Crawford County Act 167 Stormwater Management Plan will be as outlined below.

1. Monitoring of the Plan Implementation - The Crawford County Planning Commission (Commission) will be responsible for monitoring the implementation of the Plan by maintaining a record of enacted municipal ordinances and possible review of land developments.

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

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

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