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# **Pennsylvania Stormwater Best Management Practices Manual**

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## **Section 1 Introduction and Purpose of Stormwater BMP Manual**



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## **Section 1 Introduction and Purpose of Stormwater BMP Manual**

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## Section 1 Introduction and Purpose of Stormwater BMP Manual

### 1.1 Introduction and Purpose of This Manual

The purpose of this Pennsylvania Stormwater Management Manual (referred to as the BMP or Best Management Practices Manual) is to improve stormwater management throughout Pennsylvania. PA includes over 2,550 municipalities and 350 designated watersheds, with significant natural, social, and cultural differences. Many Pennsylvanians, in both the public and private sectors, in municipal government as well as in county, regional, state, interstate, and federal agencies, now recognize that existing stormwater management is not providing the water quantity and water quality performance that is essential for the protection of Pennsylvania’s water resources. Serious stormwater-related problems have been identified in PA Department of Environmental Protection (PADEP) Storm Water Management Act 167 Plans (P.L. 864, No. 167, October 4, 1978), in PA Department of Conservation and Natural Resources (PADCNR) River Conservation Plans, and in numerous other official and unofficial reports. In some watersheds across the state, stormwater impacts appear to be on the increase, with a variety of stormwater-linked indicators showing water resource deterioration, rather than water resource improvement. In short, changing and improving the way stormwater is managed has become a priority for the state and its watersheds.

This BMP Manual is part of a broader effort by PADEP to develop a new Stormwater Management Policy and Program that will improve the way stormwater is managed across the state. Issued in 2002, PADEP’s new stormwater program consists of a multi-pronged approach (Figure 1-1), which integrates the state’s existing Act 167 stormwater management planning program for watersheds, as well as the new National Pollution Discharge Elimination System (NPDES) Phase II Permit Program for Municipal Separate Stormwater Sewer System (MS4) municipalities and the NPDES Construction Permits Program. One of the key elements of this new PADEP multi-pronged approach is this BMP Manual, which is intended to provide important technical guidance on methods and materials that can prevent, reduce, and mitigate the impacts of stormwater. Particular focus is placed on technical management solutions that can be applied in conjunction with **new land development** and, perhaps even more importantly, in conjunction with **in-fill development and re-development** in already urbanized areas. These technical management solutions are both non-structural (the preventive Best Management Practices set forth in Section 5) and structural (structural BMP’s in Section 6) in nature.

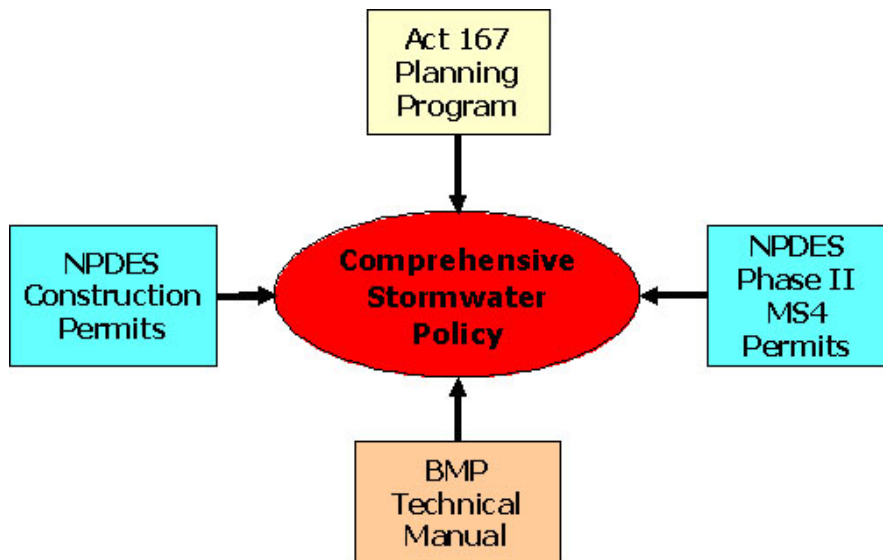


Figure 1-1 Pennsylvania DEP’s multi-pronged approach to Stormwater Management

This Manual advocates a stormwater management program, which is both **comprehensive** and **integrated**. As discussed in more detail in Section 3, the most important elements of comprehensiveness relate to the multiple ways in which land development impacts water resources through the generation of stormwater, including:

- Increased stormwater **runoff volumes**
- Increased **peak rates** of stormwater runoff
- Decreased **volumes of infiltration and groundwater recharge**
- Increased **stream impacts**, including streambank erosion and scouring, loss of stream pools and riffles, reduced substrate richness, decreased species abundance and diversity
- Increased **temperature** impacts

**Comprehensive** stormwater management means that management practices are put in place, which either prevent and/or substantially mitigate the full range of these stormwater impacts. These stormwater impacts can be avoided if comprehensive stormwater standards as set forth in Section 3 are achieved in an integrated manner. An **integrated** stormwater management program means:

- Integrating as many of the stormwater management standards as simply as possible. By selecting BMP's which **achieve multiple standards** (e.g., using volume control to achieve peak rate, water quality, and stream standards), the design will require as few BMP's as possible
- Integrating both **Non-Structural** BMP's, as defined in Section 5, with the more **Structural** BMP's defined in Section 6
- Integrating **natural system-based BMP's** that use existing vegetation, soil, and other natural systems, together with more conventionally-structured BMP's
- Integrating stormwater management into the **total site design** as part of the initial site planning process.

Throughout the various sections of this BMP Manual, a key and recurring theme is the concept of an **integrated** program that is based on an understanding of the natural systems of land and water that control stormwater management. Such an integrated understanding of the natural systems demands, in turn, an **integrated** approach to stormwater management, so critical to "doing it better, doing it smarter." In most cases, such BMP's provide multiple functions and achieve multiple standards. This Manual first offers an array of preventive non-structural approaches (Section 5), which by definition avoid the full range of stormwater impacts described here. More mitigative structural practices also are set forth in Section 6 which are based on an understanding of the interrelationships between land and water systems and how these natural systems are impacted through the land development process. Carefully selected structural BMP's typically provide multiple benefits. Finally, the Manual advocates a stormwater management approach whereby **successful stormwater management is integrated into the total site design and site planning process from the earliest stages of planning**. Stormwater management relegated to the final step in planning for the site, typically occurring on residual and "leftover" portions of the site, as so often has been the case in the past, is likely to fail.

## 1.2 A Brief Review of Stormwater Problems in Pennsylvania

The perception of what constitutes a stormwater problem has changed in recent years, as the full range of impacts of land development on the hydrologic cycle has become better documented and recognized. Pennsylvania has experienced serious and sometimes devastating impacts from stormwater during the past century, resulting in news headlines that tend to be associated with major storm events. These impacts have included worsened flooding of communities, large and small,



*Flooding impacts are devastating communities, even with conventional stormwater management programs. (F. Thorton)*

which are located along streams and rivers, large and small. To a large extent, the flooding that results from extreme storms and hurricanes such as Floyd, Agnes, and Gloria, occurs naturally and will continue to occur. Stormwater management will not eliminate flood impacts. On the other hand, in many developing watersheds in different parts of the state, flooding problems seem to have gotten much worse. A rain storm of 3 inches in 24 hours (approximately a two-year frequency rainfall) results in more serious flooding after development, than the same storm produced before development. Over the years it has become increasingly obvious that much of this worsened flooding is a result of an ever-increasing volume of

stormwater runoff being discharged throughout the watershed. These increased volumes of runoff are the direct result of increased impervious surfaces, as well as substantial areas of natural landscape being converted to lawns on highly compacted soil. This stormwater runoff takes with it significant quantities of eroded topsoil and sediment, which degrade water quality. Along with the sediment has come an increasingly worrisome mix of other water quality pollutants, washed from the impervious and altered land surfaces. The mix of nonpoint source (NPS) pollutants ranges from sediment and organic detritus to varying quantities of nutrients, organic chemicals, petroleum hydrocarbons, and other constituents.

Land development is now recognized as one of the major causes of stormwater quality and quantity problems. In developing watersheds, the greater volumes of stormwater runoff that are discharged with every rainfall turn small meandering streams into highly impacted and deeply incised stream channels (Figure 1-2). Of course, stream meandering is a natural process, and all channels are in a constant process of alteration. However, as the volume of runoff with each storm event has increased, natural stream channels have experienced bankfull and partial-bankfull conditions more frequently. In response, streams change their natural shape and form, and pools and riffles that support aquatic life are disrupted as channels become eroded and streambanks are undercut. These stream channel impacts are intensified because they occur during the small-to-moderate precipitation events, which occur so much more frequently, as opposed to the major flooding events.

The loss of rainfall as an important resource to replenish the groundwater is also significant. When the increased volume of runoff is allowed to drain away during a storm event, rather than being

infiltrated, evapotranspired, and recharged, this rainfall is “lost” to the hydrologic balance of the watershed. If this volume of precipitation is prevented from natural infiltration, the recharge of groundwater aquifers is also reduced. As a consequence, during drier periods of the year and especially during extreme periods of drought, the groundwater resource is reduced by the lost rainfall. Stream base flows rapidly diminish and may even cease, deprived of the constant groundwater discharge of base flow. This balanced water cycle of precipitation, infiltration, groundwater recharge, and stream base flow has sustained Pennsylvania’s essential aquatic biota community for thousands of years. As this hydrologic balance is disrupted by development, these essential links are altered. The measures described in this Manual are intended to reestablish this balance, and sustain the biotic community and overall water quality.



*Undercut streambanks are a common impact of increased stormwater runoff.*

While the BMPs discussed in this Manual are limited to land development, most of the impacts described can also result from other activities on the land surface. Farming changes the natural woodland cover to cultivated and harvested vegetation, and in so doing alters how water moves on, through, and into the soil mantle and sub-surface aquifers, producing significant stormwater quantity and quality impacts. Mining of various types can eliminate the natural land cover and alter sub-surface water movements, with significant stormwater quantity and quality impacts. In fact, any activity that alters the natural land surface may translate into significant stormwater problems.

As urban communities developed in Pennsylvania, little attention was paid to stormwater management. Before the public streets were paved over a century ago, stormwater was a nuisance that disrupted



*Parking lots are common impervious surfaces that impact stormwater runoff*

transportation and resulted in elevated sidewalks. The introduction of wooden planks, cobblestones and finally pavements was regarded as a great convenience. Over time, stormwater collection systems were designed and constructed to collect, convey and dispose of stormwater as rapidly as possible developed areas. In many older cities and towns a single sewer system was built to convey both sanitary wastes and stormwater to a nearby waterbody. As treatment facilities were constructed at the end of the sewer system to partially treat the wastewaters, they may be quickly overloaded by stormwater flows. As a

result, overflow outlets from the sewer system were built to allow the discharge of combined wastewater and stormwater surcharges in the system, labeled combined sewer overflows (CSO's). In highly urban communities with combined sewers, these discharges during rainfall have become major water quality problems, seemingly without simple solutions. Current engineering studies in some of these urban areas focus on peak rate and volume reduction, to reduce the frequency of CSO overflows. In Europe, the design solutions for stormwater management in combined sewer communities has focused on new building construction and the requirement of vegetated roof systems, reinforced by municipal ordinances encouraging such BMP's.



*Pollutant-laden runoff degrades water quality.*

### **1.3 The Existing Stormwater Management System in Pennsylvania: Overview**

As important as new technical stormwater solutions might be, understanding the institutional realities of stormwater management is just as critical. To make change happen, an accurate understanding of the management system is essential. Although this Manual is non-regulatory in nature, the institutional reality is the springboard for implementing the technical changes that are so important for stormwater management.

Legal and regulatory responsibility for water quality, and overall water resource management, resides primarily with the state government through the PADEP. All matters pertaining to the "...waters of the Commonwealth," ranging from water diversions to water discharges and wastewater treatment to public water supply, are regulated by the PADEP, consistent with the Pennsylvania Constitution. The legal basis of water resources management in Pennsylvania begins with the Pennsylvania Clean Stream Law of 1937. This state law has been affected by passage of a series of federal laws, such as the Clean Water Act (CWA) of 1972, which have been modified and expanded over time. Enactment of federal regulatory programs is implemented on the state level by the PADEP, such as the new NPDES Phase II Program (see description below). With a few exceptions, these regulatory programs have not been delegated to local government.

Most of this body of water quality law does not directly target stormwater management per se, although these laws and regulations do focus on important aspects of water resources that are linked to stormwater. For example, the state regulatory program relating specifically to control of construction phase erosion and sedimentation (E&S) resulting from new land development activities, as mandated under Chapter 102 of the Pennsylvania Code, relates to stormwater in several ways. Some aspects of this E&S management have been delegated to county conservation districts across the state, depending upon their willingness and capability. There are a variety of other water-related management elements, which exist on the state level, such as the Pennsylvania State Water Plan, but these management elements, at least in the past, have not addressed stormwater management in any direct manner.



The state itself did pass two important laws specifically relating to stormwater in 1977 and 1978, following disastrous flooding events in Pennsylvania. These laws, including Act 167 (the Pennsylvania Storm Water Management Act of 1978), have provided the legislative basis for much of the stormwater management planning carried out by the state through PADEP since their passage, watershed by designated watershed. The Act 167 stormwater management planning program is somewhat unique in that although mandated, administered, and mostly funded by the state (75 percent share), Act 167 planning must be performed by the respective counties in a given watershed, and then adopted and implemented by the municipalities, a rather uniquely structured “sharing” of government authority and powers. PADEP, through its program of Growing Greener and other watershed grants, has reinforced this stormwater management planning across the state.

Stormwater management ultimately involves both water and land. Given the highly decentralized nature of municipal government in Pennsylvania and the historical primacy of land management exclusively on the local or municipal level, land use and land development activities have rarely been the subject of Pennsylvania law and direct or indirect management action on the state level, with the exception of the Pennsylvania Municipalities Planning Code (MPC). This law enables but does not require comprehensive planning, zoning, and subdivision/land development regulation on the municipal, county, and regional levels. These land use regulations are at the heart of the stormwater management issues in development situations. A few municipalities and even fewer counties, or regions have used the MPC to regulate and comprehensively manage watersheds through stormwater programs, although the potential for such programs appears to exist under current state level law. In fact, recent changes in the MPC specifically encourage more area-wide planning to be undertaken on a multi-municipal basis, further reinforced by funding subsidies being provided by the Pennsylvania Department of Community and Economic Development (PADECD). Such planning, though not specifically watershed and stormwater based, can be creatively structured to reinforce Act 167 stormwater management plans. River Conservation Plans, as developed for designated watersheds by the PADCNR, also can be used to promote improved stormwater management and land use policies.

#### **1.4 Recent Changes to Pennsylvania’s Stormwater Management System**

Until the recent past, major changes in the state’s stormwater management program have been relatively slow in coming, likely related to the complex mix of laws, regulations, and overall land management institutions which characterizes the state. With over 2,550 different municipal governments and 67 county governments, overlain by 353 state-designated watersheds in the Act 167 program alone, the land-water management system is confusing at the very least. But changes are occurring and are reflected in an array of new management initiatives, which have emerged on the state level.

**A New Comprehensive Stormwater Policy for PADEP:** As the result of an intensive public participation process in a series of state-wide water forums during 2001, PADEP developed a new comprehensive policy for stormwater management which is designed:

- To address critical water quality issues;
- To sustain stream base flow and groundwater in general through stormwater management systems which infiltrate and provide for groundwater recharge;
- To minimize site-specific and watershed-wide flooding problems; and
- To prevent serious stream bank erosion and overall stream impact with related aquatic biota damage.

All of these comprehensive stormwater management objectives are to be achieved, as EPA's NPDES Phase II stormwater permitting program, pursuant to the CWA, is fully implemented across the State. Implementation of the Phase II program includes both construction permits for new land developments (issued by PADEP as Post Construction Stormwater Management Plans), as well as "NPDES Phase II permits", issued to NPDES Phase II Municipal Separate Storm Sewer System (MS4) jurisdictions, including 929 municipalities, 30 counties, 14 potential municipalities, and state and federal institutions (both discussed below). Furthermore, the Policy expands and reinforces the role of the existing Act 167 Stormwater Management Program. A more detailed discussion of this new Comprehensive Stormwater Policy is located at: <http://www.dep.state.pa.us/dep/deputate/watermgmt/wc/Subjects/StormwaterManagement/GeneralInformation/default.htm>

**NPDES Construction Permits (Post Construction Stormwater Management Plans):** As required by recently expanded requirements of the federal CWA, construction permits (Post Construction Stormwater Management Plans) from PADEP are now required for all of those land development projects which involve disturbance of 1 acre or more (previously 5 acres or more). These permits must act to protect designated stream uses as per Chapter 93 of the Pennsylvania Code and must maintain existing water quality. All permits require erosion and sediment control plans to minimize pollutant generation from earth disturbance activities. BMP's must be identified, designed, and constructed with careful consideration given to long-term maintenance and operation. Stormwater management standards must be compatible with any existing Act 167 stormwater management plan requirements and with any existing MS4 (defined below) ordinance requirements; lacking these specific requirements, BMP's are to be designed in such a manner so that discharge of total volume of runoff for up to the 2-year storm is not increased, pre- to post-development. In Special Protection Waters, Individual Permits are required; in non-Special Protection Waters, General Permits are required. A more detailed discussion of Individual NPDES Construction Permits (Post Construction Stormwater Management Plans) is located at: <http://www.dep.state.pa.us/dep/deputate/watermgmt/wc/Subjects/StormwaterManagement/GeneralInformation/default.htm>.

**NPDES Phase II MS4 Program:** As per recently expanded requirements pursuant to the federal Clean Water Act, many more municipalities within Pennsylvania now must apply for and obtain a National Pollution Discharge Elimination System (NPDES) Phase II Municipal Separate Storm Sewer (MS4) permit from PADEP. As required by EPA, these permits must demonstrate that each jurisdiction has implemented a stormwater management program, which provides for "minimum control measures" as follows:

- Public education;
- Public participation and involvement;
- Proper management of illicit discharges;
- Proper management of construction phase stormwater;
- Proper management of post-construction phase stormwater; and
- Implementation of adequate pollution prevention and housekeeping measures.

Each of these minimum control measures can involve substantial management action. Permit program requirements in Pennsylvania vary as to whether the jurisdictional area happens to include Special Protection Waters, where Individual Permits must be issued, or non-Special Protection Waters, where General Permits may be issued. General Permits allow the municipality to: 1) follow a PADEP Stormwater Management Protocol, which sets forth a set of PADEP "pre-approved" tasks, with added financial support if Act 167 planning is involved and relaxed deadlines if multi-municipal planning

occurs on a watershed basis; or 2) develop its own stormwater management program, which requires PADEP approval and lacks funding support. A more detailed discussion of the NPDES Phase II MS4 Program is located at:

<http://www.dep.state.pa.us/dep/deputate/watermgt/wc/Subjects/StormwaterManagement/GeneralInformation/default.htm>.

**Act 167 Planning:** Although Act 167 planning (Figure 1-2) has been ongoing for more than 30 years, the program is being reinforced and expanded in scope, as part of this new Pennsylvania stormwater management program. Where Act 167 plans are being developed at present, jurisdictions may include all minimum control measures specified as part of the NPDES Phase II MS4 requirements, if desired. Given the State's 75 percent funding of Act 167 plans, this becomes a powerful incentive for all those 929 municipalities (and 30 counties and 14 potential municipalities), which are required to undertake NPDES Phase II to dovetail this NPDES Phase II planning with Act 167 planning. Perhaps even more importantly, PADEP is substantially expanding the substantive scope of Act 167 planning, to be consistent with the new Comprehensive Stormwater Policy. Act 167 planning is to include control standards for water quantity (both total runoff volume control and peak rate control) in order to achieve objectives for infiltration and recharge, aquifer and stream base flow protection, and water quality management. The overriding goal is to maintain the watershed's "natural" or pre-development water balance to the extent possible and to prevent degradation of water quality through addition of nonpoint source pollution resulting from stormwater runoff. The basic elements of Act 167 plans as set forth in Section 5(b) of the Act have not been changed, although the hydrologic modeling which typically has been a major part of Act 167 plans in the past, and which have resulted in release rate calculations, now will need to take into account the runoff volume control being provided at new land development sites.

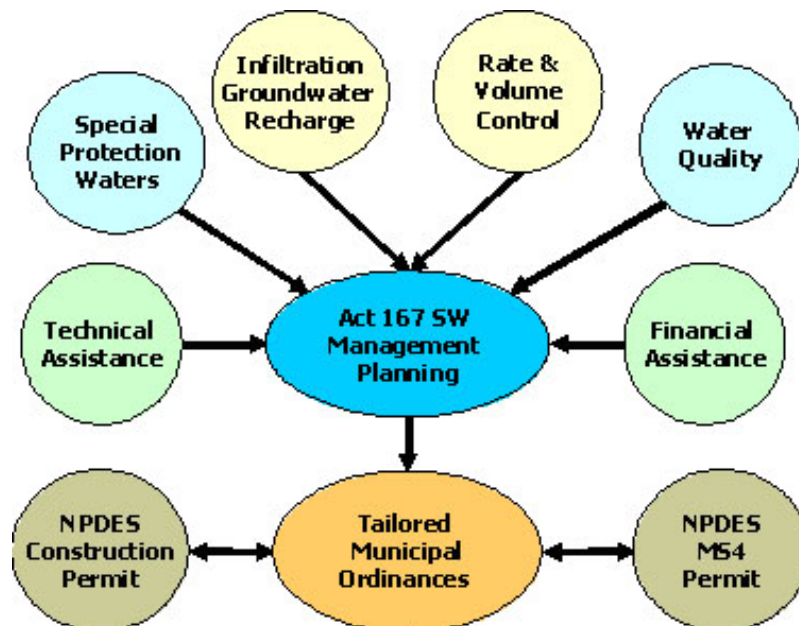


Figure 1-2 The Stormwater Management Planning Act 167 Structure

**County Level Actions:** In Pennsylvania, stormwater management has generally not been undertaken by county governments. The exception is the very significant Act 167 planning program. As described above, county level agencies (typically the county planning commission) proactively takes the lead in Act 167 watershed plans, in conjunction with the municipalities, which comprise the respective Act

167-designated watershed. In the past, some counties have taken much more initiative in the Act 167 planning program and developed more Act 167 plans than others. Many other counties have not developed any Act 167 plans (Figure 1-3).

Given the structure of county government in Pennsylvania, county governments have extremely limited authority in the actual implementation of any stormwater requirements, even if Act 167 planning has occurred and model ordinances have been prepared by the county and adopted by the respective watershed municipalities. Beyond the 167 program, a county planning commission can review a particular land development plan, pursuant to its Municipalities Planning Code authority, and may evaluate and comment upon stormwater management adequacy or inadequacy. County comments are advisory in nature, and approval authority remains on the municipal level. County level conservation districts, which historically have had a major role in Chapter 102 sediment and erosion control planning, have had their roles increased. The Conservation Districts are now participating in expanded stormwater management planning, and in some counties play a key role, with particular focus on Special Protection Waters. County Conservation District activity varies by county and with the Conservation District's delegated authority.

Counties may proactively involve themselves in stormwater management activities through related comprehensive planning and watershed level planning, possibly through preparation of PADCNR River Conservation Plans and other watershed planning programs. Perhaps the most vivid example of such planning is Chester County's recently developed *Watersheds Plan*, as prepared by the Chester County Water Resources Authority and Chester County Planning Commission. Stormwater management is a major element of the *Watersheds Plan*, which provides a potential model for other counties wanting to take more initiative in management of their water resources.

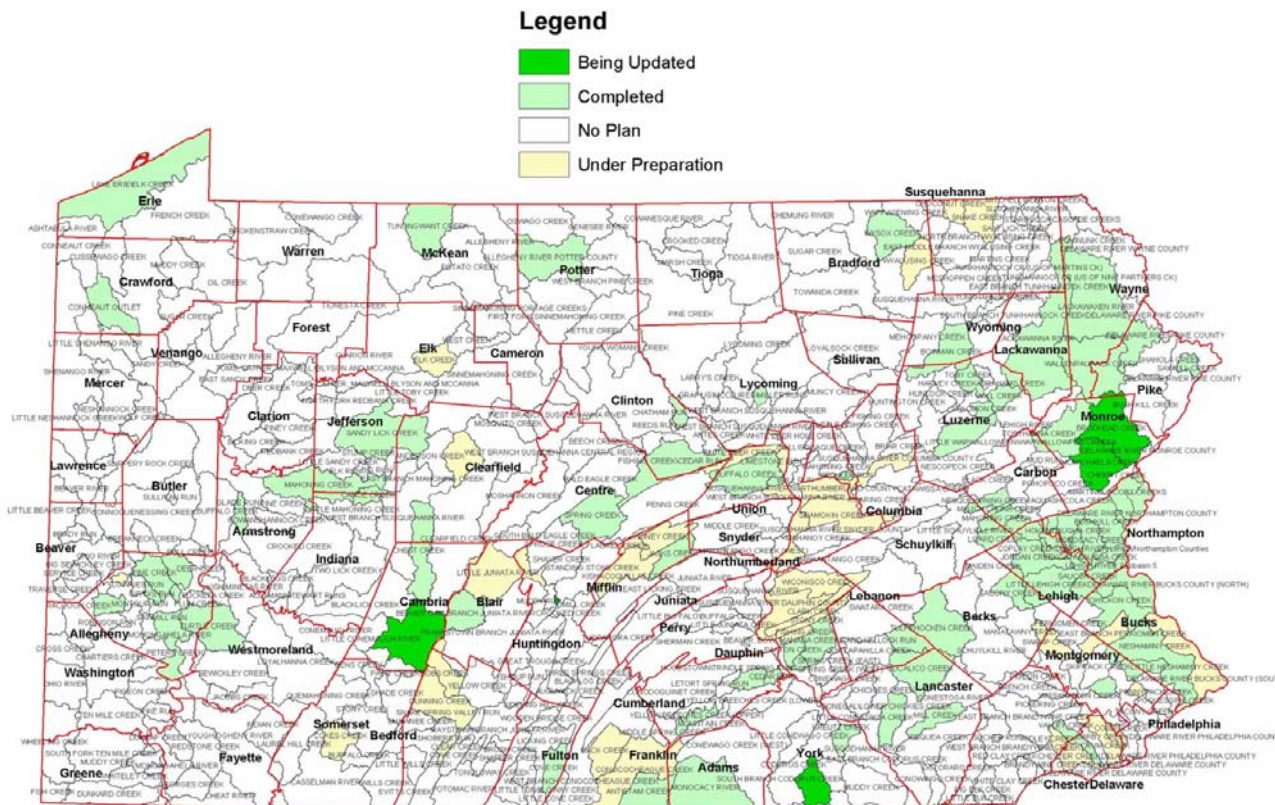


Figure 1-3 Stormwater Management Act 167 status map for Pennsylvania watersheds (DEP Website)

**Municipal Level Actions:** Municipalities are the most important single actor in the stormwater management system in Pennsylvania. In all of the new stormwater management initiatives, from NPDES Phase II, to PADEP Post Construction Stormwater Management Plans, to Act 167 plans, **stormwater management in Pennsylvania takes place most directly at the municipal level.**

Municipal regulation, if it exists, is typically located in the municipal subdivision and land development ordinance (SALDO) and is the single most important tool used to regulate and manage stormwater. If a Municipal Engineer has been designated, the Municipal Engineer reviews each land development plan and its stormwater elements and is usually the single most important professional in the stormwater management, planning, and regulation process, all reinforced by municipal planning commissions and governing boards. Even with the changes described above by the new and expanded programs, the importance of municipal action has not been reduced or limited. In most cases, the amount of work to be performed by the Municipal Engineer will have to be increased. Virtually all of the programs being implemented by PADEP and by “higher” authorities revolve around this highly decentralized municipal structure. The great challenge for improving stormwater management and implementing change is that **this change must therefore involve a tremendous number of municipal engineers, municipal planning commissions, municipal supervisors and commissioners.**

In fact, because much of this improved program for stormwater management involves a new comprehensive approach to stormwater management, as set forth in Sections 5 and 6, including non-structural actions that directly and indirectly relate to so many other aspects of a municipality’s total land use management program, the challenges for change on the municipal level becomes even greater.

**Private Actions:** The above discussion focuses on public action, public management, government regulation, and other types of management actions, stemming from governments of one type or another. The vast majority of land development activities are in fact privately undertaken, which means that the private sector, including **owners, developers, homebuilders and their private consulting engineers and other professional consultants, are pivotal in the stormwater management program.** Even as the campaign for stormwater management improvement is being mounted publicly, efforts must be made to educate all of the individuals who are instrumental in the land development process, from developers associations to professional engineering societies.

Accomplishing the changes in stormwater management set forth in this Manual will not be easy. New stormwater solutions must not only be technically understood, but these new solutions must also be considered necessary. Implementing the program set forth in this Manual will require mounting an intellectual and motivational campaign which targets municipal and private engineers, municipal elected officials, planning commissions, environmental advisory councils, and local stakeholders. Such change will require work in both the public and private sectors, reinforced by state and county and local organizations. It will require help from industry groups such as local chapters of Homebuilders Associations. It will require changes to land regulation, most of it on the municipal level, integrating the new State-managed NPDES Phase II and Act 167 watershed planning requirements. The technical guidance provided in this new BMP Manual defines what Pennsylvania municipalities need to do to bring about the stormwater management changes that are critical for water resources protection, but technical guidance by itself is only one of many steps in the process.

