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Stormwater Management Practices

Methods for Conserving an Under-Utilized Resource

BOARD OF COUNTY COMMISSIONERS

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Introduction

Water that runs off the surface of the land from rain or melting snow or ice is known as stormwater runoff (Stormwater Journal, 2000; Gannett Fleming, 2001). As development occurs, the volume or amount of stormwater runoff and its rate of runoff substantially increase (Borton-Lawson Engineering, undated; PA DEP, 2001a). Construction of impervious surfaces and the installation of storm sewer pipes, which efficiently collect, convey, and discharge stormwater runoff, prevents the infiltration of rainfall into the soil, thereby reducing ground water recharge (Gannett Fleming Engineering, 2001).

Increased water runoff during storm events, combined with reduced flood storage capacity in our streams and floodplains, can result in severe flooding if existing drainage systems are inadequately sized to handle the increased flow (PA DEP, 2001a). Heavy precipitation or snowmelt can also cause sewer overflows which, in turn, may lead to contamination of water sources with untreated human and industrial waste, toxic materials, and other debris (EPA, 2001a). Left unmanaged, stormwater runoff not only flushes pollutants into surface waters from the land surface, but is a major cause of flash flooding which can result in the loss of life and property damage. Stormwater runoff not only impacts human life. Unmanaged stormwater runoff can also result in stream bank scouring, habitat destruction, water quality impairment, and streambed sedimentation (PA DEP, 2001b). This can lead to raised stream temperatures, impairment of the aquatic food chain, and a reduction in the base flow of streams, all of which is imperative to aquatic life during the drier summer months (Borton-Lawson Engineering, undated).

Increased stormwater runoff, associated with increasing development within Chester County, has heightened the awareness of residents to the problems associated with stormwater runoff, such as human health and safety, water quality, and the impact of stormwater runoff on adjacent lands. Within Chester County, flooding is generally localized and often limited to incidental street flooding (CCWRA, 2002). In some locations, however, more severe flooding that creates regional impacts, such as closure of regional transportation routes, is experienced (CCWRA, 2002). To address this issue, Chester County has taken a comprehensive approach to stormwater management for the protection of our streams, lakes, and rivers from water quality and quantity impacts (CCWRA, 2002). Stormwater management involves the planning, design, construction, maintenance, financing, and regulation of the facilities (both constructed and natural) that collect, store, control, and/or convey stormwater runoff (Stormwater Journal, 2000; Gannett Fleming Engineering, 2001). Comprehensive stormwater management strives to maintain or re-establish the natural hydrological characteristics of a watershed while accommodating for planned growth and the protection of public safety (CCWRA, 2001).

The Chester County Water Resources Authority (CCWRA) as part of the planning efforts completed for *Watersheds*, Chester County's Integrated Water Resources Management Plan, developed "Ten Principles of Comprehensive Stormwater Management" (Table 1). These "Ten Principles" present a holistic approach to watershed management. They are intended to be implemented collectively through an integrated design process that will accomplish the ten principles with the minimum total system volume and site disturbance.

Table 1—Ten Principles of Comprehensive Stormwater Management

1. Minimize the volume of stormwater runoff generated.
   - Review/revise ordinances to eliminate unnecessary requirements for impervious cover
   - Use conservation development designs
   - Disperse flow to pervious areas
2. Define "Pre-Development Condition" as "Meadow Condition".
   - Exceptions – existing woodland areas; urban sites
3. Protect infiltration and ground water recharge.
   - Where suitable conditions exist, infiltrate net increase in runoff from 2-year storm
   - Infiltrate net increase in runoff from 1" rainfall event (everywhere)
4. Protect water quality by removing pollutants prior to discharge to streams.
   - Capture and remove pollutants from runoff from 1" storm prior to release to streams
5. Protect instream channels and geomorphology conditions.
   - Attenuate/retain/detain runoff from 1-year 24-hour storm for 12 to 24 hours and release at rate to maintain receiving streamflow below top of channel
6. Reduce impacts of development to flood flows.
   - Reduce peak runoff rate for storms up to and including 10-year event to that of 2-year event
   - Reduce peak runoff rate of storms larger than 10-year event up to and including 100-year event to "pre-development" ("meadow condition") peak runoff rate for corresponding frequency
   - Where frequent downstream flooding occurs, reduce peak runoff rate of storms larger than 10-year event up to and including 100-year event to 90% of "pre-development" ("meadow condition") peak runoff rate for corresponding frequency
7. Protect adjacent lands from direct stormwater discharge.
   - Obtain easements and design appropriate conveyance structures/channels to protect receiving property from flooding and erosion
8. Ensure long-term operation and maintenance of stormwater facilities.
   - Require O&M plan, designation of entity responsible for maintenance, funding
   - Establish municipal right, but not responsibility, to enter and repair and to be reimbursed
9. Establish forested riparian buffer networks.
   - Implement conservation development design to move development area away from natural resources and buffer areas
   - Reduce street setbacks to accommodate buffer setbacks
   - Establish forested riparian buffers along natural intermittent and perennial streams, lakes, wetlands
   - 100' width (each side of waterway) including: 35' undisturbed forest, 40' managed forest, 25' meadow grass/filter/flow dispersion zones
   - Where conservation development design and comprehensive stormwater management techniques are implemented, reduce to average width of 75'(each side), but not less than 50' wide (each side) at any location
   - Agricultural and urban lands – establish the maximum width practicable for the site conditions and use, preferably >35'
   - 5' to 15' no mow zone for existing small (<1 acre) residential lots
   - Native species, management plan, designated responsible entity, demarcation/signage of upland edge
   - Extend buffers to maximum extent practical and inter-connect with other buffers/greenways/corridors
10. Protect wetlands and floodplains to reduce runoff and flooding.
    - Avoid fill, construction in floodplains and wetlands
    - Enforce floodplain management regulations

Stormwater and the Hydrologic Cycle

Comprehensive stormwater management strives to accommodate for planned growth in a manner that protects public safety and maintains, or re-establishes, the natural hydrologic characteristics of watersheds—specifically ground water recharge, stream baseflows, stable stream channel (geomorphology) conditions, and ground water and surface water quality—to the maximum extent possible (CCWRA, 2002).

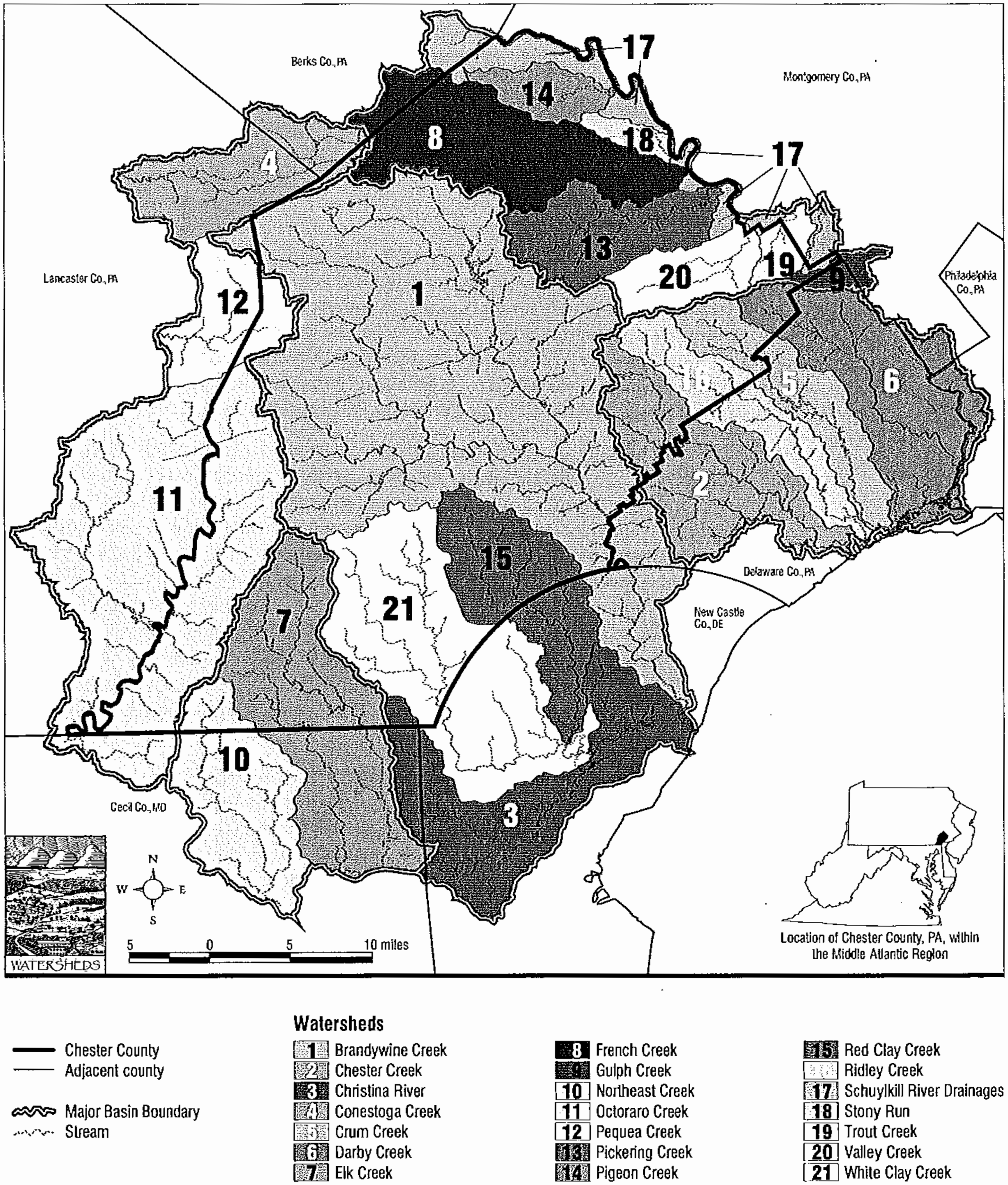
Within Chester County there are 25 watersheds, 21 of which originate within the county (CCWRA, 2002); these are shown in Map 1, "Watersheds of Chester County." All of these watersheds are located in the Piedmont Region, an area of gently rolling to hilly land lying between the Appalachian Mountains and the Atlantic Coastal Plain. These watersheds are the areas of land that catch rain and snow and drain or seep the water into a common marsh, stream, river, or lake. Found in a variety of shapes and sizes, watersheds are not limited by local, county, or state lines (CCWRA, 2002). Instead, the topography of the area determines the boundary of the watershed. Bounded by ridgelines connecting the highest elevation points surrounding a stream, the watershed collects any precipitation falling within those ridgelines, transporting it down into the stream and onward to the next watershed.

As rain falls onto the land's surface, a percentage of the precipitation that falls within a watershed percolates down through the surface, becoming ground water, while a portion becomes stormwater runoff that eventually flows directly into streams. The amount of stormwater runoff depends on a number of factors. The most important of these factors is whether the land surface is impervious or pervious. Impervious surfaces usually include land covers such as pavement, buildings, or compacted earth. If impervious, usually close to 100 percent of the rainfall becomes stormwater runoff, except in those areas where impervious surfaces drain to pervious areas. Pervious surfaces usually include those that are open and vegetated. If pervious, stormwater runoff rates are primarily affected by the intensity and duration of the storm, the soil type, the slope, and the type of cover vegetation. Each land use has a different percentage of impervious surface associated with it, and thus, each land use affects stormwater runoff differently (CCWRA, 2001).

Stormwater runoff alters the natural state of streams. Streams are dynamic and ever changing as they evolve in their size, shape, geometry, and meander patterns over time. This evolution in nature generally occurs over thousands of years. However, streams receiving runoff from developed lands experience much more rapid changes than they are prepared for. Collectively, these impacts result in the stream channel being straightened, its flood carrying capacity reduced, and property damage occurring on properties located along the stream corridor. These impacts can extend over many miles downstream of the source of stormwater runoff (CCWRA, 2002).

Stormwater runoff influences ground water recharge. Ground water is the water that is located underground that saturates the spaces between particles of sand, silt, and clay, or fills the crevices or fractures in rock (CCWRA, 2002). The function of ground water is intertwined with that of surface water. Feeding water to streams, wetlands, and lakes, ground water is also recharged through streambed infiltration. In this sense, ground water is responsible for maintaining the hydrologic balance of surface streams, lakes, wetlands, and marshes (CCWRA, 2002). Conveying stormwater from the point of generation during rain events can mean that the ground water table does not get recharged and there is inadequate ground water to provide stream base flow during times of drought. Properly managing stormwater not only minimizes the quantity of the runoff, but also infiltrates the runoff through the soil to recharge ground water resources and provide base flow for surface waters during times of drought (PA DEP, 2001b).

Map 1—Watersheds of Chester County, PA



Source: Chester County, Pennsylvania Water Resources Compendium (CCWRA 2001)

Regulatory Framework

The key laws governing stormwater management are summarized below:

Clean Water Act

The Environmental Protection Agency (U.S. EPA) is responsible for regulation of water quality at the Federal level as required by the 1972 Federal Water Pollution Control Act, which set the basic structure for regulating discharges of pollutants to waters of the United States. The Clean Water Act (CWA) is a 1977 amendment to the Federal Water Pollution Control Act of 1972, allowing for focus on reducing toxic pollutants in the environment (U.S. EPA, 1997). In 1987, the CWA was reauthorized and again focused on toxic substances, and established regulations and funding for sewage treatment plants (U.S. EPA, 1999).

The CWA focuses on improving the quality of the nation's waters by restoration and preservation. By providing a thorough structure of standards, technical tools and financial assistance it addresses the many causes of pollution and poor water quality, including municipal and industrial wastewater discharges, polluted stormwater runoff from urban and rural areas, and habitat destruction (U.S. EPA, 1997). U.S. EPA regulations require states to develop water quality standards for streams within their borders and to develop programs for preventing further degradation of present day water quality. More information on the CWA can be obtained by accessing the U.S. EPA Web site (*www.epa.gov*).

National Pollution Discharge Elimination System (NPDES) Phase I & II

Introduced in 1972, the NPDES permit program is authorized under the Clean Water Act (U.S. EPA, 2001b). The NPDES program controls water pollution by setting limits on the amount of pollutants that can be discharged from point sources. Point sources are discrete conveyances such as pipes or man-made ditches (U.S. EPA, 2001b).

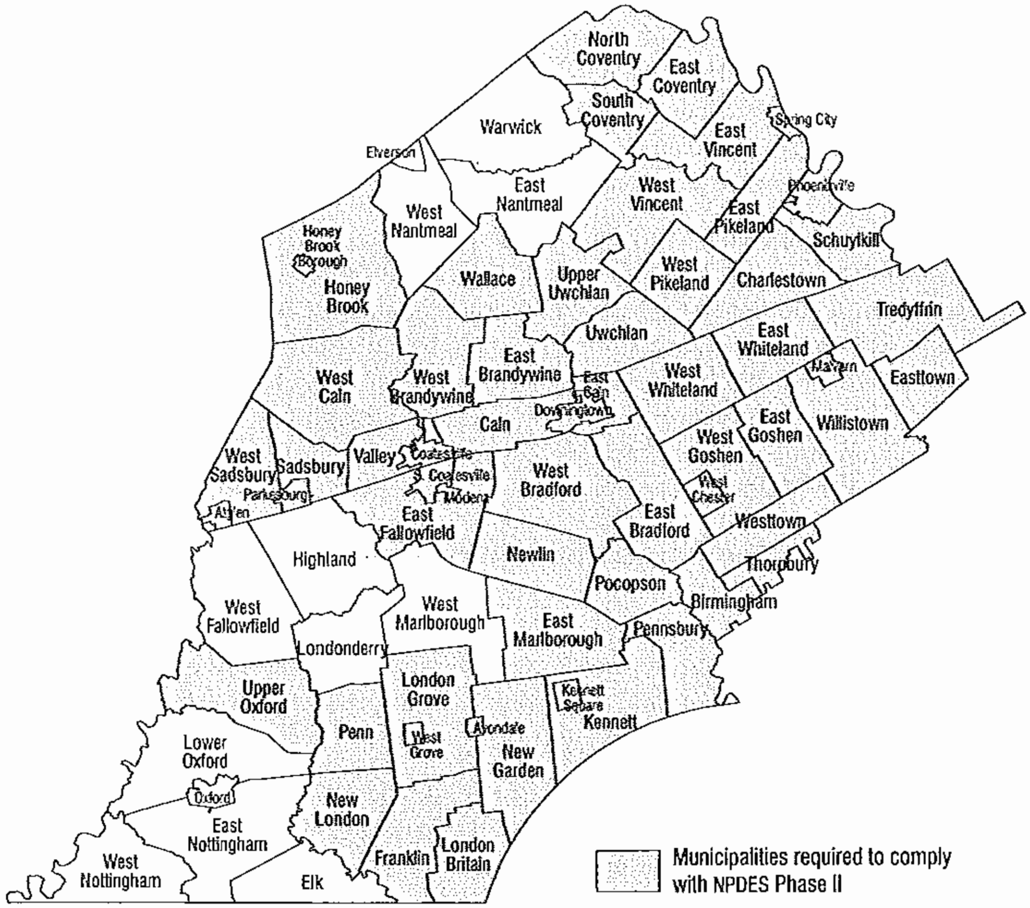
Phase I of the NPDES program was developed in 1990 to address sources of stormwater runoff that were likely to have the greatest impact on water quality. Under Phase I construction sites larger than 5 acres, certain industrial sites, and "medium" and "large" Municipal Separate Storm Sewer Systems (MS4S) located in incorporated places or counties with populations of 100,000 or more were required to obtain an NPDES permit (U.S. EPA, 2001b).

In 1999, Phase II of the NPDES permit program was published in the Federal Register. The implementation of the Phase II regulations requires construction sites that are between 1–5 acres and smaller urbanized area MS4S to be permitted. In addition to expanding the NPDES program, Phase II also requires that designated municipalities with MS4S must develop six (6) minimum control measures:

- Public education.
- Public participation.
- Illicit discharge detection and elimination.
- Construction site runoff control.
- Post-construction run-off management.
- Pollution prevention from municipal operations.

NPDES Phase II requires operators of small MS4S to have fully developed and implemented their stormwater management programs by 2008 (U.S. EPA, 2001b). Within Chester County there are 58 municipalities affected by the Phase II permitting requirements (Map 2). Further information on NPDES can be obtained from the U.S. EPA Web site (*www.epa.gov*) and the Pennsylvania Department of Environmental Protection (PA DEP) Web site (*www.dep.state.pa.us*).

Map 2—NPDES Phase II Municipalities



Municipalities Planning Code

In Pennsylvania, the authority and responsibility for implementing stormwater management regulations lies with the municipalities through the Pennsylvania Municipalities Planning Code (MPC), Act 247 as amended (CCWRA 2002). The MPC authorizes Pennsylvania cities, boroughs, townships, and counties to prepare comprehensive plans for community development, zoning ordinances, and subdivision and land development ordinances and regulations. Through this authorization, municipalities may include provisions for drainage and stormwater management. Article III, Section 301 of the MPC specifically permits the preparation of comprehensive plans while Article V, Section 503(3) allows municipalities to include standards in the subdivision and land development ordinance governing how improvements will be installed as a condition of final plan approval (CCPC, 1997). In addition, Section 503(5) allows municipalities to enact provisions for the regulation of subdivisions and land development including provisions for "practices which are in accordance with modern and evolving principles of site planning and development" (CCPC, 1997). Furthermore, Article IV, Section 401 allows municipalities to designate stormwater management areas on their Official Map (CCWRA, 2002).

Stormwater Management Act, Act 167

The Stormwater Management Act, Act 167, was enacted by the Pennsylvania legislature in 1978 to authorize a program of comprehensive watershed stormwater management that retains local implementation and enforcement of stormwater ordinances similar to local responsibility for the administration of subdivision and land development regulations (PA DEP, 2001a). This approach enables municipalities in each watershed to manage runoff and still develop in a consistent and coordinated manner (Gannet Fleming Engineering, 2001). Under the Act, counties develop stormwater management plans for each of the watersheds within their boundaries. The PA DEP develops grant agreements with counties to pay for 75% of the cost to prepare the plans. The regulations specify that stormwater management plans be undertaken in two phases; Phase I, the preparation of a scope of study (level of effort, personnel details undertaking the effort, time frame, and cost estimates for Phase II) and Phase II, the actual plan preparation (PA DEP, 2000). Upon county completion and adoption of a plan along with a model ordinance for the watershed, and after PA DEP approval, municipalities located within the watershed have six months to amend local ordinances or adopt a separate stormwater management ordinance consistent with the plan (Gannet Fleming Engineering, 2001). Following plan implementation, developers and other applicants are required to follow the local drainage regulations that incorporate the standards of the stormwater management plan when preparing land development and subdivision plans.

According to Section 3 of Act 167, the policy and purpose of the Act is to:

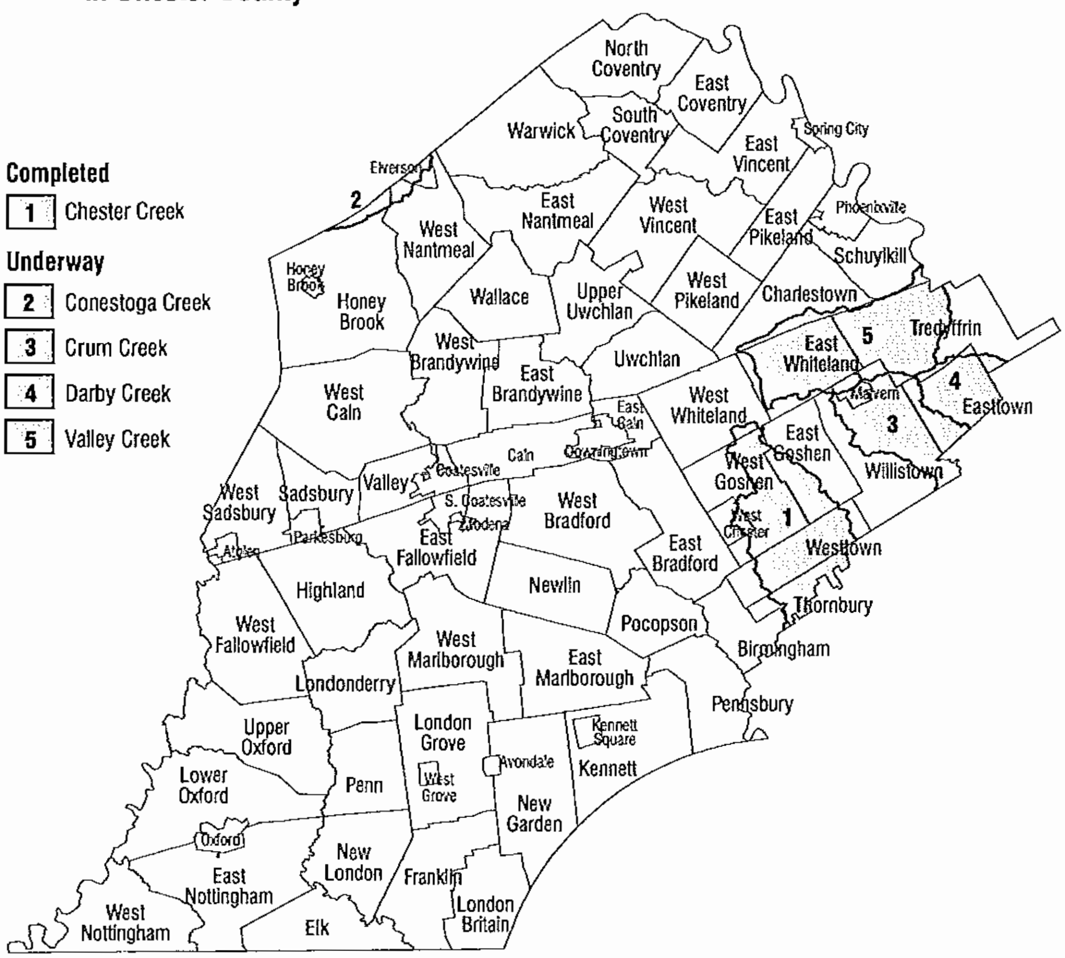
- Encourage planning and management of stormwater runoff in each watershed that is consistent with sound water and land use practices.
- Authorize a comprehensive program of stormwater management designated to preserve and restore the flood carrying capacity of Commonwealth streams; to preserve to the maximum extent practicable natural stormwater runoff regimes and natural source, current and cross-section of water of the Commonwealth; and to protect and conserve ground waters and ground-water recharge areas.
- Encourage local administration and management of stormwater consistent with the Commonwealth's duty as trustee of natural resources and the people's constitutional right to the preservation of natural economic, scenic, aesthetic, recreational, and historical values of the environment.

The PA DEP designated twenty watersheds within Chester County that the County is responsible for the preparation of Stormwater Management Plans. Of these twenty watersheds, a Plan has been completed for the Chester Creek watershed and Plans are underway for the Crum Creek, Darby Creek, and (East) Valley Creek watersheds. A Plan is also underway for the Conestoga Creek watershed. The Conestoga Creek watershed was designated by PA DEP to be completed by Lancaster County and is not one of the twenty watersheds designated to be completed by Chester County. The watersheds for which Stormwater Management Plans have been completed or are underway is shown in **Map 3**.

The Chester Creek Stormwater Management Plan was the first to be prepared within Chester County, and was prepared under the lead of Delaware County. Six Chester County municipalities are located in the Chester Creek watershed: East Goshen Township, Thornbury Township, West Chester Borough, West Goshen Township, Westtown Township, and West Whiteland Township. This plan, which began in 1996, received the final approval of the Chester County Commissioners in June 2002. PA DEP approved the Plan in March 2003. Municipalities are required to adopt the provisions of the model ordinance contained within the Plan by November 28, 2003. The Darby-Cobbs Creek Stormwater Management Plan is being prepared under the lead of Delaware County, along with Montgomery County and the City of Philadelphia. Two Chester County municipalities are located in the Darby Creek watershed: Easttown Township and Tredyffrin Township. This Plan is in Phase II and is anticipated to be completed in early 2004. The Conestoga Creek Stormwater Management Plan is being prepared by Lancaster County. Chester County is participating in the preparation of this Plan since there are three Chester County municipalities located in the Conestoga Creek watershed: Elverson Borough, Honey Brook Township, and West Nantmeal Township. This Plan is in Phase II.

The Crum Creek and (East) Valley Creek Stormwater Management Plans were begun in 2003. The Crum Creek Stormwater Management Plan is being prepared under the lead of Delaware County. Four Chester County municipalities are located in the Crum Creek watershed: Easttown Township, Malvern Borough, Tredyffrin Township, and Willistown Township. The (East) Valley Creek Stormwater Management Plan is being prepared under the lead of the Chester County Water Resources Authority. Seven Chester County municipalities are located in the (East) Valley Creek watershed: Charlestown Township, Easttown Township, East Whiteland Township, Malvern Borough, Schuylkill Township, Tredyffrin Township, and Willistown Township.

Map 3—Watersheds with Act 167 Stormwater Management Plans Completed or Underway in Chester County



Post-Construction Stormwater Control in the (East) Valley Creek Watershed

(East) Valley Creek watershed is a resource with unique environmental and historical significance. Containing Valley Forge National Historic Park within its boundaries, (East) Valley Creek is an Exceptional Value (EV) stream located in a highly urbanized area. PA DEP's Water Quality Standards, 25 Pa. Code § 93, require that the water quality of EV waters shall be maintained and protected. The preservation and safeguarding of the chemical, physical, and biological integrity of EV streams necessitates effective stormwater management. PA DEP, as of September 10, 2001, will be requiring that all new development and redevelopment projects, subject to the NPDES permit requirements, incorporate post-construction stormwater management controls and best management practices (PA DEP, 2001b). Pre-development hydrologic conditions that are consistent with the natural hydrologic characteristics of the watershed must be mimicked or replicated in these controls and practices. To ensure the proper management of stormwater runoff, PA DEP will require a Post-Construction Stormwater Management Plan (PCSWMP) be submitted with the individual NPDES permit application for discharge of stormwater from construction activities in the (East) Valley Creek watershed. PA DEP, in the requirements for Post-Construction Stormwater Control in the (East) Valley Creek Exceptional Value Watershed, states that the NPDES permit may not be approved unless the following requirements are addressed in the PCSWMP:

1. The post construction stormwater infiltration on the project site shall be no less than the stormwater that infiltrated under pre-development conditions. Where a project applicant demonstrates that site-specific conditions preclude achievement of this requirement, the project will be required to provide appropriate off-site infiltration within the watershed, preferably upstream from the project.

2. Applicants must demonstrate that the volume and rate of stormwater runoff will not cause or cumulatively contribute to scour or erosion. Applicants must make this demonstration either through the implementation of on-site controls or through a combination of on-site controls and off-site controls.

3. Applicants will be required to demonstrate that post-construction discharges from the project site will not cause a measurable change in the quality of the receiving stream through the addition of pollutants or a change in temperature.

PCSWMPS are not only required in (East) Valley Creek. PADEP, under the latest NPDES permitting regulations, requires PCSWMPS for all land disturbances of one (1) or more acres. Additional information on NPDES construction permit requirements can be obtained from southeast regional office of PA DEP and the Chester County Conservation District (CCCD).

Water Resources Plan, *Watersheds*

In 1996 the Chester County Commissioner's adopted ***Landscapes***, the Comprehensive Plan Policy Element of the Chester County Comprehensive Plan. To further the goals of ***Landscapes***, the Chester County Planning Commission (CCPC) also committed to three functional plans: the open space plan *Linking Landscapes*, the water resources plan *Watersheds*, and the transportation plan *Connecting Landscapes*.

The water resources plan, *Watersheds*, prepared by the CCWRA and adopted by the Board of County Commissioners on September 17, 2002, addresses the integrity of the natural waters of Chester County. CCWRA identified several efforts that were needed to provide the analyses, data collection, and technical information necessary to develop the *Watersheds* Plan. The *Chester County, PA Water Resources Compendium* presents the methodologies, results, and conclusions of the analyses, data collection, and public and stakeholder involvement efforts. All analyses and efforts undertaken for this Compendium were developed using the "watershed" as the basic planning unit. Since watersheds extend across political boundaries, it was necessary to expand the study area beyond the bounds of Chester County. Thus, the study area was expanded to include 1,408 square miles of land area that drain to the streams of Chester County. The study area includes all of Chester County and portions of Lancaster, Berks, Delaware, Montgomery, and Philadelphia Counties in Pennsylvania. It also includes parts of New Castle County, DE, and Cecil County, MD. In total the study area includes all or portions of 144 municipalities that are located within 8 counties and 3 states, 21 watersheds, and 78 subbasins (CCWRA, 2001).

The Chester County Water Resources Compendium identified a number of problem priority areas within Chester County, for which goals and objectives were developed. One of the problem priorities identified in the Chester County Water Resources Compendium was stormwater runoff. Of the seven goals listed within *Watersheds*, the reduction of stormwater runoff and flooding became Goal Five. For Goal Five, there are 10 objectives listed in the plan for the reduction of stormwater runoff and the control of flooding and a number of key implementation strategies for accomplishing these objectives. The ultimate and collective purpose of these objectives is to accommodate planned growth in a manner that protects public safety and maintains or re-establishes the natural hydrologic characteristics of the watersheds and that sustains ground water recharge, stream baseflows, stable stream channel conditions, the flood carrying capacity of streams and their floodplains, and ground water and surface water quality to the maximum extent practicable (CCWRA, 2002). This can be accomplished through municipal implementation of "comprehensive stormwater management," which includes the "Ten Principles" listed in Table 1 on page 2.

The "Ten Principles of Comprehensive Stormwater Management" and the implementation strategies were distilled from discussions conducted by the CCWRA with many of the entities involved in stormwater management and regulations within the various states, counties and municipalities in the Chester County Water Resources Compendium study area. Not intended to be implemented in a piecemeal manner, these ten principles should be implemented collectively and through an integrated development design process to avoid further exacerbating stormwater management problems (CCWRA, 2001). Additional information on the rationale behind Goal Five, and the objectives and key implementation strategies behind this goal, can be found in Sections 4 and 8 of the *Watersheds* Plan. Municipalities should also refer to Section 13 of the Water Resources Compendium. This section goes into greater detail on the guidance and recommendations for municipal implementation of *Watersheds*.

Stormwater Management

Importance of Stormwater Infiltration and Water Quality

Infiltration is the entry of water from the ground's surface into the underlying earth material (Ferguson, 1994). As mentioned earlier, properly managing stormwater can not only minimize the quantity of the stormwater but can also infiltrate the remainder through the soil to recharge ground water resources and provide base flows for surface waters. Using the natural capacities of soil, vegetation, and landforms, stormwater infiltration controls the volume of stormwater runoff, keeping aggravated storm surges out of streams while restoring the direction, timing, and quality of hydrologic flows.

Infiltration directly affects the availability of stormwater, reducing the quantity of stormwater available for stormwater runoff. The only way known to suppress storm flow volume is stormwater infiltration, which also tends to reduce peak flow rate (Ferguson, 1994). By damping the surges of direct runoff, infiltration protects streams from frequent flushing and erosion (Ferguson, 1994). Impervious cover decreases infiltration rates and allows more stormwater to be converted to runoff (Holland and Schueler, 2000a). The loss of this infiltration affects the quantity of water available to recharge an aquifer, as well as the rate of recharge (Holland and Schueler, 2000a). This reduced recharge rate may result in wells using the aquifer going dry as ground water levels fall (Holland and Schueler, 2000).

Urbanization's deflection of flows away from subsurface paths makes base flows decline (Ferguson, 1994). Declining base flows are environmentally and economically critical: base flows must be sufficient to absorb pollution from sewage treatment plants and non-point sources, support aquatic life dependent on stream flow, and replenish water-supply reservoirs (Ferguson, 1994). Stormwater infiltration addresses the cause of the urban stormwater problem at the soil's surface where development takes place. It promises to restore the hydrologic balance of urban landscapes, returning hydrologic storage and flow regimes, and the ecosystems of which they are apart, to a self-sustaining equilibrium (Ferguson, 1994).

While infiltration of stormwater is important, the quality of the water that is recharging ground and surface water supplies is of the utmost importance and has a direct relationship with infiltration. To some degree, everything we do on the land's surface impacts the quality of streams and ground water. Chemicals intentionally applied to the land (fertilizers and pesticides for example), particularly if applied in quantities greater than what is taken up by the target plants, can run off into streams as pollutants (CCWRA, 2002). Where such chemicals build up in the soil, rainfall infiltrating into the ground can leach the chemicals from the soil and carry them as pollutants into the underlying aquifers (CCWRA, 2002).

Virtually all land surfaces (except forest and meadow) have some type and quantity of pollutants that are carried to streams and ground water by stormwater runoff or infiltration (CCWRA, 2002). The process of urbanization, and the percentage of impervious cover associated with urbanization, has a profound influence on the hydrology, morphology, water quality, and ecology of surface waters (Holland and Schueler, 2000a). Urban stormwater tends to have more pollutants and pathogens associated with it. This is due to the nature of impervious surfaces since they collect and accumulate pollutants deposited from the atmosphere, leaked from vehicles, or derived from other sources (Holland and Schueler, 2000b). During storms, these accumulated pollutants are quickly washed off and rapidly delivered to aquatic systems (Holland and Schueler, 2000).

As stated above, stormwater infiltration and water quality are of utmost importance for human health and well-being as well as for ecological stability. It is for these reasons that steps need to be taken to maintain the post-development hydrologic conditions that are consistent with natural conditions and the carrying capacity of the receiving streams, flood plains, and ground water (CCWRA, 2001). Further discussions on site development and best management practices (BMPs) that can be implemented to maintain or mimic pre-development hydrologic conditions are discussed in the following sections.

Site Development

Any development of a site involving the permanent alteration of the land surface will necessitate an analysis of the runoff occurring before (pre) development and the runoff to be generated after (post) development is completed. The approach used in analyzing the pre-developed condition is critical. *Watersheds* establishes this approach as described by the second of the "Ten Principles of Comprehensive Stormwater Management." This approach defines the meadow condition as the pre-development condition. Accepting the "meadow condition" as the "pre-development condition" for the design of the site development and its stormwater management system is the fundamental practice to maintaining the post-development hydrologic conditions that are more consistent with the natural conditions and carrying capacity of the receiving streams, flood plains, and ground water (CCWRA, 2001). It is recommended that all municipalities apply this definition in their stormwater management standards as the "pre-development condition" to be used in design calculations (CCWRA, 2001). By doing so, this will establish a basis of stormwater management that is more consistent with the carrying capacity of the receiving streams and floodplains, is consistent with other municipalities' standards elsewhere in the watershed, and will avoid confusion as to what design assumption to use regardless of the current land use of the proposed project site (CCWRA, 2001). This will ensure that both agricultural and site development BMPs are subjected to consistent standards and will result in stormwater management improvements being uniformly achieved as land uses change (CCWRA, 2001).

While accepting the "meadow condition" as the "pre-development condition" is strongly supported to successfully infiltrate as much stormwater as possible, there are circumstances where this condition will not apply. When the pre-existing condition of the development site is woodlands, the "woodlands condition" should be used as the "pre-development condition" (CCWRA, 2001). In urban areas, which have a high percentage of impervious cover, and areas undergoing "brown fields" redevelopment, adverse impacts to the ground water quality should be avoided (CCWRA, 2001). Urban areas are those that have historically been considered population centers and serve as the focal point for employment, commercial, and cultural resources. In these areas, recharge and runoff requirements should be made flexible to accommodate the special considerations associated with redevelopment. "Redevelopment" can be defined as any construction, alteration or improvement exceeding five thousand square feet of land disturbance on sites where existing land use is commercial, industrial, institutional, or multi-family residential (CCWRA, 2001). Requirements in these areas should allow for flexible stormwater sizing criteria dependent on the amount of increase or decrease in the impervious area created by the redevelopment project as opposed to assuming a meadow condition. Site development in urban areas should strive to implement water quality controls, such as infiltration, to the maximum extent possible. However, the main focus for urban areas should be the improvement of water quality for the protection of surface and ground water resources.

Stormwater Best Management Practices

Best Management Practices are design techniques that have shown to be most effective in providing for development, stormwater, and agricultural activities in a manner that is more consistent with the natural characteristics of the receiving watershed resources (CCWRA, 2002). The most effective stormwater BMPs and management measures are designed to be consistent with the characteristics of the watershed's surface and ground water. This results in the drainage from the developed site maintaining the volume of ground water recharge and the frequency, rate, and volume of surface runoff that would exist if the site were covered in open meadow. Important to remember in the selection of stormwater BMPs are the "Ten Principles of Comprehensive Stormwater Management" (**Table 1 on page 2**).

There are various stormwater BMPs that can be implemented for effective stormwater management. Municipalities should work with a qualified engineer to ensure that each BMP is appropriate to the specific management needs of the site. The "Ten Principles" rely on both infiltration and water quality BMPs as two key components to stormwater management. Types of infiltration and water quality BMPs are discussed below.

- **Infiltration BMPs**

Infiltration BMPs capture stormwater and store it prior to infiltration into the ground water system. With infiltration BMPs, the majority of the stormwater runoff for the design storm is infiltrated into the ground rather than discharged to the stream. Infiltration systems can include roof drains, infiltration basins, ponds, trenches, as well as porous pavement, swales and dry wells, among others.

Roof drains can be used to disconnect rooftop runoff from non-rooftop impervious surfaces (**Figure 1**), offering a way to limit stormwater runoff in commercial and suburban settings. Stormwater falling directly on flat roofs in commercial areas can be temporarily ponded and gradually released by incorporating controlled flow roof drains into building designs (CCWRA, 2001). Peak flows can be further reduced and greater stormwater infiltration accomplished by avoiding directly connected rooftops to stormwater systems. This allows municipalities to then consider deduction of rooftop impervious surface or non-rooftop impervious surface to developers when the runoff is directed to pervious areas where it can infiltrate into the soil or filter through it (CCWRA, 2001).

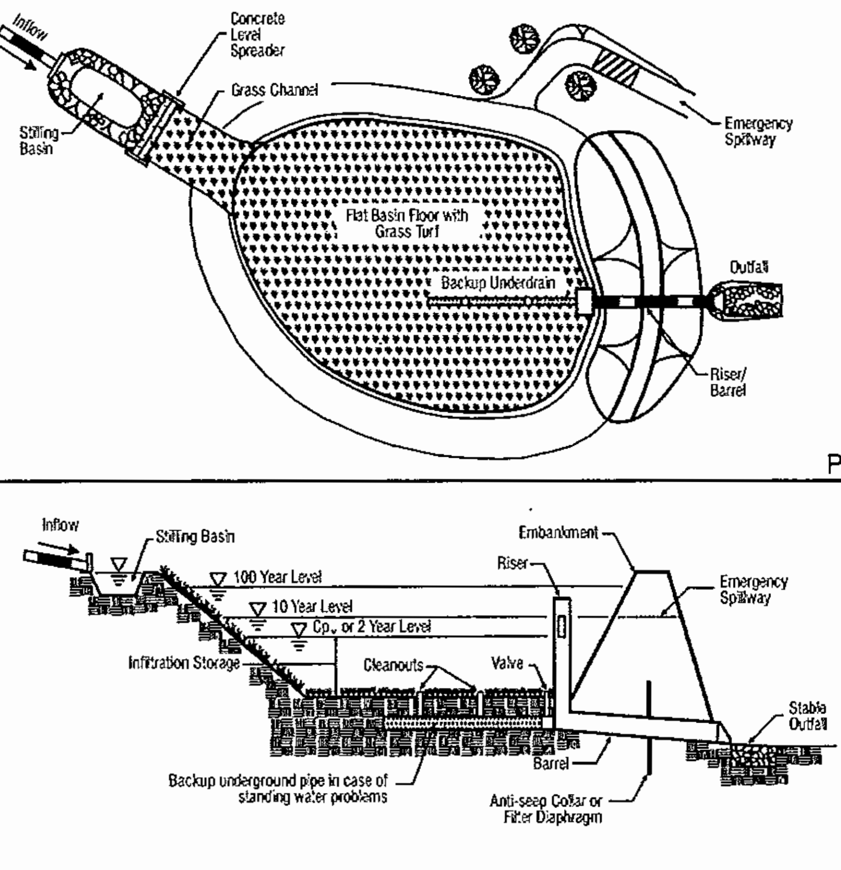
Figure 1

Photo taken of the Pocopson Township Public Works Depot rain garden, site 17 on the Chester County Self-Guided BMP tour. Roof runoff flows off a roof ledge and directly into a stone embankment into the rain garden. Vegetation planted in the structure must tolerate variable soil moisture conditions, including periodic inundation of stormwater following storm events and standing water. Soils in this structure must remain uncompacted and permeable to ensure stormwater infiltration into the subsurface. Disconnected Downspouts from the roof direct stormwater into stone banks that gradually slope toward the rain garden (Chester County Conservation District, April 2002).

Infiltration basins, ponds, and trenches are three BMPs that are commonly seen. Infiltration basins (**Figure 2**) are used in areas of high infiltration rates, where all the water is retained and eventually infiltrates into the ground (CCWRA, 2001). Depending on the weather conditions, basins can sometimes be dry and should typically drain within 48 hours after a storm event. Infiltration ponds, while having the tendency to permanently pool water, have sufficient infiltration rates along the bottom and sides of the pond to recharge most of the stormwater (CCWRA, 2001). Infiltration trenches are excavated trenches filled with crushed stone or gravel that increases infiltration rates and temporarily stores water for eventual infiltration into the ground water system (CCWRA, 2001). Designed to capture and infiltrate the first flush of stormwater, trenches can be constructed along existing parking lots and in tight urban spaces, significantly reducing total pollutant loads.

Figure 2—Schematic of an Infiltration Basin

Infiltration basins need to be applied very carefully, as their use is often sharply restricted by concerns over groundwater contamination, site feasibility, soils, and clogging at the site (Stormwater Manager's Resource Center, Undated-a).



Source: Maryland Department of the Environment. 2000. Maryland Stormwater Design Manual: Volumes I & II. [Online] Available: *www.mde.state.md.us* [2002, July]

Another approach to limiting the quantity of stormwater runoff is through the use of porous pavement. This BMP approach uses a special asphalt paving material that allows stormwater to infiltrate through at a high rate, storing the water below the pavement in a high-void aggregate base (CCWRA, 2001). While this technique provides stormwater detention and increases infiltration into the ground, it also can reduce development costs since it reduces the need for costly stormwater collection and conveyance systems (**Figure 3**). In areas of low traffic, such as parking areas, concrete grid (**Figure 4**) or modular paving materials can be used to accomplish infiltration and are a suggested alternative.

Figure 3

Porous pavement is a permeable surface paving material comprised of porous bituminous concrete mixtures that permits stormwater to infiltrate down through the pavement's tiny interstitial spaces. Below the porous pavement are subsurface seepage beds, commonly called recharge beds, which temporarily store stormwater before its infiltration into the ground and water table below (CCCD, 2002).

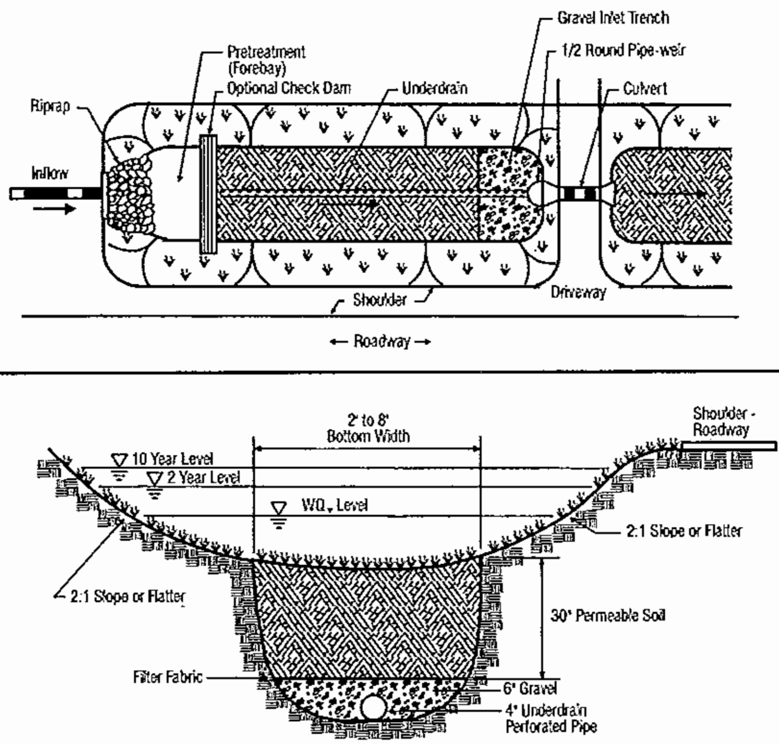
Figure 4

Photo taken of the Triple Fresh Market (East Fallowfield, Chester County) paver blocks, site 2 on the Chester County Self-Guided BMP tour. Paver blocks are used for a portion of the parking lot at this site, creating a semi-pervious surface in contrast to conventional concrete or asphalt surfacing. Their use was selected for the expanding parking area since they permit stormwater infiltration in and around individual blocks. This allowed the owner to provide additional parking spaces for his business while also saving an old beech tree by permitting water to reach the roots (Chester County Conservation District, April 2002).

The final infiltration BMP to be discussed in this planning bulletin is that of the swale or open grass channel. Swales intercept runoff, filter out some contaminants, and infiltrate water into the underlying soil. Grassed swales **(Figure 5)** are vegetated open channels that are designed to capture and treat stormwater and other pollutants within dry or wet cells formed by check-dams or other means (CCWRA, 2001). Vegetated swales are shallow, broad-bottomed ditches with established dense grass (CCWRA, 2001).

Figure 5—Schematic of a Grassed Swale

Designs incorporate a fabricated soil bed into the bottom of the channel. Existing soils are replaced with a sand/soil mix that meets minimum permeability requirements. An underdrain system is also installed under the soil bed. Typically, the underdrain system is created by a gravel layer that encases a perforated pipe. Stormwater treated by the soil bed flows into the underdrain, which conveys treated stormwater back to the storm drain system (Stormwater Manager's Resource Center, Undated-b).



PLAN VIEW

SECTION

Source: Maryland Department of the Environment. 2000. Maryland Stormwater Design Manual: Volumes I & II. [Online] Available: *www.mde.state.md.us* [2002, July]

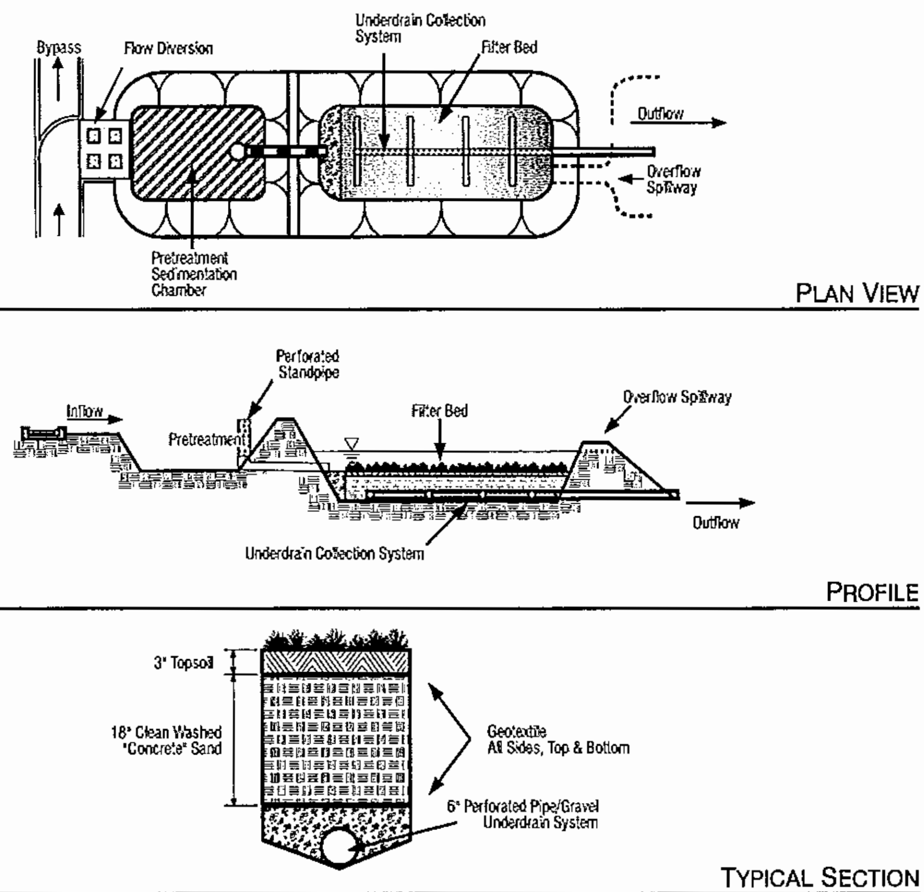
• Water Quality BMPs

Water quality BMPs are designed to capture, temporarily store, and pass stormwater through a filter bed of sand, organic matter, soil, or other media to remove small particle sediments (CCWRA, 2001). Due to the increased percentage of impervious cover, water quality BMPs are ideal for use in urban areas where pollutants accumulate on the ground's surface and can be flushed into the surface waters with stormwater runoff.

Surface sand filters (**Figure 6**) are considered to have the largest capacity for handling large quantities of stormwater runoff. These systems consist of a sedimentation chamber followed by a large, surface filter bed with underdrains of perforated pipe to collect the filtered stormwater and move it to the outflow pipe (CCWRA, 2001). Where runoff is likely to carry a higher load of concentrated pollutants, underground sand filters can be used. Underground sand filters are two-chambered linear concrete structures that improve the water quality of runoff by providing sedimentation and filtration to the stormwater runoff (CCWRA, 2001). While in the past they have not been widely used, they could be applicable in fully developed areas in which land for more conventional and less expensive BMPs are unavailable. For small sites with flat terrain or a high water table, perimeter sand filters are another option. They can be used along the edge of a parking lot, and consist of a sedimentation chamber and sand filter set below grade (CCWRA, 2001).

Figure 6—Schematic of a Surface Sand Filter

The least expensive, and most widely used, filter option, the surface sand filter is designed so that only the water quality volume is directed to the filter (Stormwater Manager's Resource Center, Undated-c).

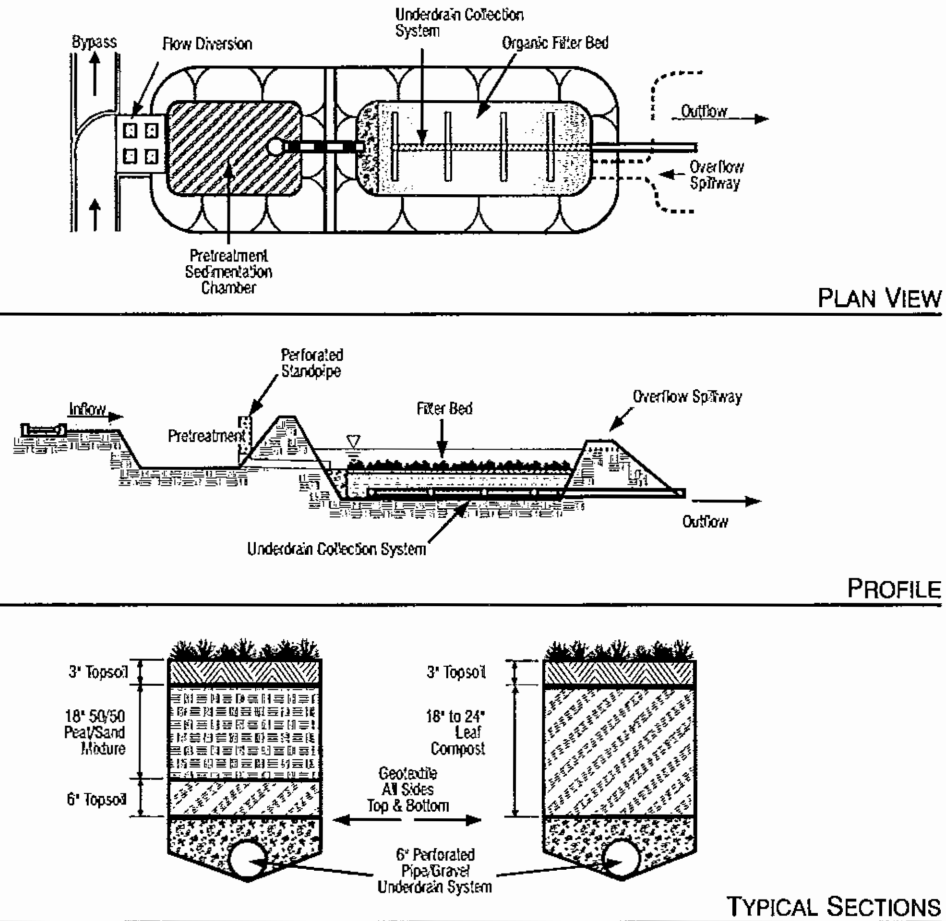


Source: Maryland Department of the Environment. 2000. Maryland Stormwater Design Manual: Volumes I & II. [Online] Available: *www.mde.state.md.us* [2002, July]

Organic media filters (**Figure 7**) are used in areas where stormwater is highly contaminated and the maximum quantity of nutrient and trace metal removal is desired (CCWRA, 2001). This bmp is a surface filter that uses topsoil, peat/sand, and sand in layers to filter the water. The pocket sand/media filter is another water quality bmp that can be applied to small sites with low sediment loading. Essentially a smaller surface sand filter, it incorporates a forebay, sand filter bed, and underdrains, with areas using pea gravel to allow infiltration if the sand filter should clog (CCWRA, 2001).

Figure 7—Schematic of an Organic Media Filter

Organic media filters are essentially the same as surface sand filters, with the sand media replaced with or supplemented with another medium. Two examples are the peat/sand filter, and the compost filter system. The assumption is that these systems will have enhanced pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter (Stormwater Manager's Resource Center, Undated-c).



Source: Maryland Department of the Environment. 2000. Maryland Stormwater Design Manual: Volumes I & II. [Online] Available: *www.mde.state.md.us* [2002, July]

Baffled inlet structures are a water quality BMP that can be used in urban areas where older stormwater systems are in place without detention basins. Baffled water quality inlet structures are available to catch the first flush of concentrated road residue, trash, salt, and domestic pet feces in one or more settling chambers (CCWRA, 2001). These structures can be designed to retrofit older stormwater systems unobtrusively, improving water quality.

Wet detention or stormwater ponds (**Figure 8**) have a combination of a permanent pool of water with extended detention or shallow wetlands (CCWRA, 2001). This BMP is essentially a pond with rooted wetland vegetation along the perimeter and within the extended shoreline or littoral zone. The objective of this BMP is to attenuate peak flows by controlling the outflow peak discharge and storing flood volumes within the basin (CCWRA, 2001). Wet detention ponds are also used to improve water quality by providing a quiescent volume of water for removing particulate and dissolved pollutants by sedimentation, physical and chemical interactions, and biological processes (CCWRA, 2001).

Figure 8

Photo taken of Applebrook Golf Course Community (East Goshen, Chester County) wet pond, site 3 on the Chester County Self-Guided BMP tour. A wet pond is a stormwater management structure that maintains a permanent pool of water and has additional capacity above the permanent pool for detaining stormwater runoff. There are two wet ponds at this site, the larger of which is pictured here and visible from Paoli Pike. This particular wet pond is designed of two cells, so that when the first cell fills up, water spills over into the second cell. The pond receives treated wastewater from a township-owned wastewater treatment facility; this water is then pumped from the pond and used in the site's fertigation system (Chester County Conservation District, April 2002).

Swales or open grass channels can be designed to provide infiltration, as stated earlier, but they can also be used to provide water quality benefits. This BMP can be incorporated into a design to reduce the amount of impervious cover and is essentially very easy to implement. Open grass channels can be a logical alternative to curbs and gutters in streets and parking lots.

Additional sources of information on stormwater management, including BMPs, can be found in Appendix 1.

- **Chester County Self-Guided Stormwater BMP Tour**

The Chester County Conservation District (CCCD) in 2002 developed a Self-Guided Stormwater BMP Tour and handbook. The self-guided tour highlights 21 sites throughout the County that demonstrate the use of stormwater BMPs. The BMPs on the tour and presented in the handbook include structural and non-structural measures that combine standard, innovative, and alternative practices and measures for managing stormwater runoff to minimize its adverse impacts to the waterways and watersheds. Commercial, residential, and recreational sites are featured on the tour, as well as both BMPs that are newly designed and constructed and those that have been in place and functioning for a number of years. BMPs on the tour include practices that: filter and trap stormwater runoff pollutants, recharge groundwater supplies, stabilize base flow in streams, and protect and preserve riparian lands and naturally occurring wetlands using institutional measures (CCCD, 2002).

The objective of the self-guided tour is to raise awareness among developers, designers, engineers, municipal officials, watershed associations, and conservation organizations about the available alternatives to standard stormwater management methods. Information on the Chester County Self-Guided BMP Tour can be obtained by contacting the CCCD at 610–696–5126 or visiting the CCCD Web site (*www.chesco.org/conservation*).

Municipal Efforts

In Pennsylvania, the Municipalities Planning Code enables municipalities to implement stormwater management regulations through their subdivision and land development ordinances. Discussed below are strategies that municipalities can utilize for comprehensive stormwater management.

Stormwater Ordinances

Counties are responsible for the preparation of an Act 167 Stormwater Management Plan for the watersheds within the County bounds as designated by the PA DEP. Due to the resource availability and time involved in the preparation of an Act 167 Stormwater Management Plan, Chester County will not complete a plan for all the PA DEP designated watershed(s) within the near future. However, this does not mean that municipalities should take a passive approach to stormwater management. Municipalities have the primary responsibility for managing stormwater within their boundaries through their ability to create a stormwater ordinance. Stormwater ordinances should be enacted in each municipality to address the "Ten Principles of Comprehensive Stormwater Management" presented within *Watersheds* and this planning bulletin update, and should strive to implement watershed-based standards that are consistent with other municipalities within their watershed(s). Municipalities are encouraged to coordinate with adjacent municipalities and other municipalities within their watershed(s) to establish consistent stormwater management criteria, while being careful to address localized conditions. The guidelines provided in the "Ten Principles of Comprehensive Stormwater Management" (Table 1) recommend a consistent set of principles and strategies to assist municipalities in establishing more effective, consistent and watershed-based controls (CCWRA, 2001). The Chester County Water Resources Authority is preparing a Model Stormwater Ordinance to address the design considerations outlined for stormwater management in *Watersheds* and the "Ten Principles of Comprehensive Stormwater Management." The management practices advocated within the model ordinance are intended to be used with conservation development design principles to conserve natural resources, maintain and/or restore natural drainage patterns, minimize grading, reduce impervious cover, and lessen the need for structural stormwater facilities. It is the intent of the model ordinance to provide municipalities with a holistic approach to watershed management.

As part of the Chester County Water Resources Compendium, twenty-nine stormwater management ordinances were reviewed for the twenty-one watersheds that were evaluated in the study area. Several of the ordinances, either specifically or cursorily reviewed for the Compendium inventory, only address peak rate runoff or volume control and peak rate runoff (CCWRA, 2001). The most thorough of the ordinances reviewed addressed four objectives: (1) peak rate runoff control, (2) volume control, (3) infiltration/recharge, and (4) quality control (CCWRA, 2001). The innovative techniques used by surveyed municipalities were also summarized (Table 2). For those municipalities experiencing increasing growth, the incorporation of the four objectives above and the addition of three additional objectives: reducing the amount of stormwater generated, protecting instream channels, and developing long-term operation and maintenance standards for stormwater facilities, will be important elements of an effective municipal stormwater management ordinance (CCWRA, 2001). Regardless of location however, all municipalities should more fully consider infiltration/recharge requirements for new development (CCWRA, 2001).

Table 2—Summary Of Innovative Techniques Used By Surveyed Municipalities

Municipality(ies)	Innovative Technique
West Vincent, Easttown, London Britain	Require analysis of downstream impacts
London Grove	Require sizing of stormwater management facilities for 110% of proposed impervious cover
Pennsbury, Honey Brook, East Vincent, East Whiteland, Tredyffrin, Easttown, Willistown, East Marlborough, Londonderry	Require that post-development 10-year runoff be less than or equal to pre-development 2-year storm
Many municipalities	Require that runoff post-development not exceed pre-development (pre = post)
North Coventry, East Whiteland	Require infiltration of the 2-year storm, if possible
East Bradford	Require release rates from 2-year storm not exceed 50% of pre-development site conditions
Schuylkill, East Bradford	Require the 10-, 25-, and 100-year post rates not exceed 90% of pre-development site conditions
London Grove, East Bradford	Require that 75% of the percolation rate of a site be used to determine the storage volume of infiltration systems
London Grove	Require recharge of the 10-year storm at 75% of the tested percolation rates of soils on-site
North Coventry	Require release rates for storms up to 10-year be equal or less than 75% of the pre-development peak for same storm
Schuylkill, Willistown, Pennsbury, Cecil County, MD	Require quality protection - separators for parking areas (Schuylkill), water quality inlets (Willistown), meet volume and peak rate controls (Pennsbury), reduce pre-development pollutant loadings by 10% (Cecil County, MD)
Pennsbury, East Marlborough, North Coventry	Require no increase in runoff discharged from the 2-year storm, pre-development to post-development
West Caln	Require a water budget analysis
London Grove, West Vincent, East Marlborough	Contain ground water protection standards
East Coventry	Contain stream valley protection standards
West Fallowfield	Contains prohibition on transfers of stormwater from one watershed to another unless: the transfer is among subwatersheds of the same watershed and the subwatersheds join together within the perimeter of the property, the effect of the transfer does not alter the peak discharge of the adjacent lands, and easements from affected landowners are obtained
East Bradford, Pennsbury, Warwick	Require Environmental Impact Assessments (EIA) or Environmental Impact Statements (EIS)
Warwick	Contain standards for water collection and use off-site related to the Q7-10 stream flow

The greatest opportunity to reduce future impacts of land use is during the design and construction of new land development. Thus, it is recommended that municipalities develop performance standards within their stormwater ordinances to encourage effective stormwater management. Performance standards should address the "Ten Principles of Comprehensive Stormwater Management" (Table 1). Again, the fundamental strategy needed to maintain post-development hydrologic conditions that are consistent with natural conditions and carrying capacity of the receiving streams, flood plains, and ground water is to accept the "meadow condition" for the design of the site development and its stormwater management system. With the exception of the special circumstances mentioned earlier, it is recommended that all municipalities apply this definition in their stormwater management standards as the "pre-development" condition to be used in design calculations.

Subdivision Plan Reviews

The planning of new land development offers one of the most effective opportunities to improve and protect water resources. Municipalities routinely review site plans to determine whether the proposed development complies with the municipal land use regulations. Some long-standing ordinance requirements can unnecessarily generate additional stormwater and reduce ground water recharge, by directly or indirectly requiring more areas to be paved, and runoff to be collected and concentrated into piped flow, etc. While existing standards may be perceived as necessary for public health, safety and welfare purposes, often such purposes can be achieved through different design techniques while reducing other unintentional impacts such as increased pollutant runoff and flooding, and loss of ground water recharge (CCWRA, 2001).

To begin, municipalities should consider undertaking a comprehensive review of their existing governance regulations, policies and requirements to identify where they may be unnecessarily causing impacts to water resources. Examples may include requirements for minimum street widths that could be reduced, curbs that can be replaced with grassed swales, double side walks where single sidewalks could suffice, large radius cul-de-sacs where "hammerheads" or cul-de- sacs with vegetated islands could be used, and reducing impervious (paved) parking lot requirements (or encouraging porous parking alternatives), to name a few (CCWRA, 2001). The Center for Watershed Protection (CWP) endorses twenty-two model "Better Site Design" techniques to reduce total paved area, distribute and diffuse stormwater, and conserve natural habitats (Appendix 2). The twenty-two techniques are presented as simplified design objectives and actual techniques for achieving the principle goal and should be based on local conditions. The CWP also developed a Codes and Ordinances Worksheet (COW) to provide municipalities with a sense of how they stack up against the model development principles outlined in the twenty-two Better Site Design techniques (Appendix 3). The worksheet is intended to aid municipalities in recognizing areas where they can reduce the quantity of impervious surfaces required for new land development, therefore increasing the available land for infiltration.

The next step places more focus on the developer and the site plan that is submitted. Each site plan should contain a stormwater management plan addressing the impact the proposed land use will have on water quality and quantity (Gibbons, et al., 1995). Site-level stormwater management plans are generally composed of engineered drawings and a project narrative (Gibbons, et al., 1995). Used to show the existing site features and the proposed alterations, the drawings should also emphasize the location and type of the proposed stormwater management system. A description of the natural and proposed drainage system, a detailed description of projected runoff quantity and quality, and an explanation on the management practices chosen for pollution control is provided in the project narrative. One of the primary focuses within the project narrative should be a detailed description of the relationship of the proposed development to drainage and runoff within the entire watershed (Gibbons, et al., 1995). Municipalities should implement a set of guidelines, such as the "Ten Principles of Comprehensive Stormwater Management," that clearly state the key management principles they want each applicant to address in the site plan. As part of the site plan review, municipalities should require assurances that any stormwater management plan complies with these general guidelines.

Other Actions for Municipalities

In Chester County, 58 of the 73 municipalities are required by NPDES Phase II to have fully developed and implemented their stormwater management programs by 2008. The NPDES MS4 regulations create a framework that a municipality can use to construct a customized management plan for protecting and preserving their various water resources. However, the 6 minimum control measures required for NPDES Phase II regulated municipalities are useful policies for all municipalities to implement. Detecting and eliminating illegal discharges, controlling construction runoff, managing post-construction runoff, preventing pollution from municipal operations, and increasing public education and involvement in stormwater management provides a well rounded approach to comprehensively managing stormwater within the community.

Conclusion

Stormwater runoff impacts human health and safety, water quality, and the biological resources of adjacent lands. Increased stormwater runoff, associated with increasing development within Chester County, has heightened the awareness of Chester County residents to the problems associated with stormwater runoff. The "Ten Principles of Comprehensive Stormwater Management" offers an effective approach to managing the problems resulting from unmanaged, or improperly managed, stormwater runoff. Municipalities, by incorporating the "Ten Principles of Comprehensive Stormwater Management" into developing stormwater management plans, strengthening stormwater management ordinances, re-evaluating municipal land-use regulations, establishing stormwater management guidelines for site plan reviews, and implementing the six requirements of NPDES Phase II, can effectively and economically manage stormwater runoff within their borders.

Appendices

Appendix 1: Sources of Additional Information

Appendix 2: Twenty-two Model "Better Site Design" techniques

Appendix 3: Codes and Ordinances Worksheet

Appendix 4: List of Acronyms

Appendix 1

Sources of Additional Information

Alliance for the Chesapeake Bay
600 N. Second Street
Suite 300B
Harrisburg, PA 17101
Phone (717) 236-8825
www.acb-online.org/index.htm

Center for Watershed Protection
8391 Main Street
Ellicott City, MD 21043-4605
Phone (410) 461-8323
www.cwp.org/index.html

Chester County Conservation District
601 Westtown Road, Suite 240
P.O. Box 2747
West Chester, PA 19380-0990
Phone (610) 696-5126
www.chesco.org/conserve.html

Chester County Planning Commission
601 Westtown Road, Suite 270
P.O. Box 2747
West Chester, PA 19380-0990
Phone (610) 344-6285
www.chesco.org/planning

Chester County Water Resources Authority
601 Westtown Road, Suite 260
P.O. Box 2747
West Chester, PA 19380-0990
Phone (610) 344-5400
www.chesco.org/water

Delaware River Basin Commission
25 State Police Drive
P.O. Box 7360
West Trenton, NJ 08628-0360
Phone (609) 883-9500
www.state.nj.us/drbc

Environmental Management Center
Brandywine Conservancy
P.O. Box 141
Chadds Ford, PA 19317
Phone (610) 388-2700
www.brandywineconservancy.org/

Maryland Department of the Environment
2500 Broening Highway
Baltimore, MD 21224
Phone (800) 633-6101
www.mde.state.md.us/index.html

National Stormwater Best Management
Practices Database
www.bmpdatabase.org/index.html

Pennsylvania Association of Conservation
Districts, Inc.
4999 Jonestown Road
Suite 203
Harrisburg, PA 17109
Phone (717) 545-8878
www.pacd.org/default.htm

PA Department of Environmental Protection
South East Regional Office
Suite 6010 Lee Park
555 North Lane
Conshohocken, PA 19428-2233
Phone (610) 832-6028
www.dep.state.pa.us

Susquehanna River Basin Commission
1721 N. Front Street
Harrisburg, PA 17102
Phone (717) 238-0423
www.srbc.net

University of Delaware Water Resources
Agency
DCS Annex off Academy Street
University of Delaware
Newark, DE 19716
Phone (302) 831-4925
www.wr.udel.edu

U.S. Environmental Protection Agency
Office of Water
1200 Pennsylvania Avenue, NW
Washington, DC 20460
Phone (202) 564-5294
www.epa.gov/owm

Appendix 2

Twenty-two Model "Better Site Design" Techniques

Source: Center for Watershed Protection. Undated (a). Better Site Design. [Online] Available: www.cwp.org [2002, May]

The twenty-two "Better Site Design" techniques listed below have been divided into three categories based on their applicability. These categories are residential streets and parking lots, lot development, and conservation of natural areas.

Residential Streets and Parking Lots

1. Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume.

2. Reduce the total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length.

3. Wherever possible, residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible.

4. Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.

5. Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff.

6. The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to see if lower ratios are warranted and feasible.

7. Parking codes should be revised to lower parking requirements where mass transit is available or enforceable shared parking arrangements are made.

8. Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas where possible.

9. Provide meaningful incentives to encourage structured and shared parking to make it more economically viable.

10. Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.

Lot Development

11. Advocate open space design development incorporating smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection.

12. Relax side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.

13. Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.

14. Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.

15. Clearly specify how community open space will be managed and designate a sustainable legal entity responsible for managing both natural and recreational open space.

16. Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas and avoid routing rooftop runoff to the roadway and the stormwater conveyance system.

Conservation of Natural Areas

17. Create a variable width, naturally vegetated buffer system along all perennial streams that also encompasses critical environmental features such as the 100-year floodplain, steep slopes and freshwater wetlands.

18. The riparian stream buffer should be preserved or restored with native vegetation. The buffer system should be maintained through the plan review delineation, construction, and post-development stages.

19. Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner.

20. Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants. Wherever practical, manage community open space, street rights-of-way, parking lot islands, and other landscaped areas.

21. Incentives and flexibility in the form of density compensation, buffer averaging, property tax reduction, stormwater credits, and by-right open space development should be encouraged to promote conservation of stream buffers, forests, meadows, and other areas of environmental value. In addition, off-site mitigation consistent with locally adopted watershed plans should be encouraged.

22. New stormwater outfalls should not discharge unmanaged stormwater into jurisdictional wetlands, sole-source aquifers, or sensitive areas.

11. **Open Space Design**

a. Are open space or cluster development designs allowed in the community?

______If the answer is YES, award 3 points If the answer is NO, skip to question No. 12

b. Is land conservation or impervious cover reduction a major goal or objective of the open space design ordinance?

______If the answer is YES, award 1 point

c. Are the submittal or review requirements for open space design greater than those for conventional development?

______If the answer is NO, award 1 point

d. Is open space or cluster design a by-right form of development?

______If the answer is YES, award 1 point

e. Are flexible site design criteria available for developers that utilize open space or cluster design options (e.g, setbacks, road widths, lot sizes)

______If the answer is YES, award 2 points

12. **Setbacks and Frontages**

a. Are irregular lot shapes (e.g., pie-shaped, flag lots) allowed in the community?

______If the answer is YES, award 1 point

b. What is the minimum requirement for front setbacks for a one half (½) acre residential lot?

______If the answer is 20 feet or less, award 1 point

c. What is the minimum requirement for rear setbacks for a one half (½) acre residential lot?

______If the answer is 25 feet or less, award 1 point

d. What is the minimum requirement for side setbacks for a one half (½) acre residential lot?

______If the answer is 8 feet or less, award 1 points

e. What is the minimum frontage distance for a one half (½) acre residential lot?

______If the answer is less than 80 feet, award 2 points

13. **Sidewalks**

a. What is the minimum sidewalk width allowed in the community?

______If the answer is 4 feet or less, award 2 points

b. Are sidewalks always required on both sides of residential streets?

______If the answer is NO, award 2 points

c. Are sidewalks generally sloped so they drain to the front yard rather than the street?

______If the answer is YES, award 1 point

d. Can alternate pedestrian networks be substituted for sidewalks (e.g., trails through common areas)?

______If the answer is YES, award 1 point

14. Driveways

a. What is the minimum driveway width specified in the community?

______If the answer is 9 feet or less (one lane) or 18 feet (two lanes), award 2 points

b. Can pervious materials be used for single family home driveways (e.g., grass, gravel, porous pavers, etc)?

______If the answer is YES, award 2 points

c. Can a "two track" design be used at single family driveways?

______If the answer is YES, award 1 point

d. Are shared driveways permitted in residential developments?

______If the answer is YES, award 1 point

15. Open Space Management

a. Does the community have enforceable requirements to establish associations that can effectively manage open space?

______If the answer is YES, award 2 points

b. Are open space areas required to be consolidated into larger units?

______If the answer is YES, award 1 point

c. Does a minimum percentage of open space have to be managed in a natural condition?

______If the answer is YES, award 1 point

d. Are allowable and unallowable uses for open space in residential developments defined?

______If the answer is YES, award 1 point

e. Can open space be managed by a third party using land trusts or conservation easements?

______If the answer is YES, award 1 point

16. Rooftop Runoff

a. Can rooftop runoff be discharged to yard areas?

______If the answer is YES, award 2 points

b. Do current grading or drainage requirements allow for temporary ponding of stormwater on front yards or rooftops?

______If the answer is YES, award 2 points

17. Buffer Systems

a. Is there a stream buffer ordinance in the community?

______If the answer is YES, award 2 points

b. If so, what is the minimum buffer width?

______If the answer is 75 feet or more, award 1 point

c. Is expansion of the buffer to include freshwater wetlands, steep slopes or the 100-year floodplain required?

______If the answer is YES, award 1 point

Appendix 3

Codes and Ordinance Worksheet

Source: Center for Watershed Protection. Undated (b). Codes & Ordinances Worksheet. [Online] Available: www.cwp.org [2002, May]

The Codes & Ordinances Worksheet, or cow, is a simple worksheet that you can use to see how the local development rules in your community stack up against the model development principles outlined in Better Site Design. Answer the questions and see how environmentally-friendly your community is!

1. Street Width
   a. What is the minimum pavement width allowed for streets in low density residential developments that have less than 500 average daily trips (ADT)?
   ______If the answer is between 18-22 feet, award 4 points

   b. At higher densities are parking lanes allowed to also serve as traffic lanes (i.e., queu-ingstreets)?
   ______If the answer is YES, award 3 points

2. Street Length
   a. Do street standards promote the most efficient street layouts that reduce overall street length?
   ______If the answer is YES, award 1 point

3. Right-of-Way Width
   a. What is the minimum right-of-way (ROW) width for a residential street?
   ______If the answer is less than 45 feet, award 3 points

   b. Does the code allow utilities to be placed under the paved section of the ROW?
   ______If the answer is YES, award 1 point

4. Cul-de-Sacs
   a. What is the minimum radius allowed for cul-de-sacs?
   ______If the answer is less than 35 feet, award 3 points If the answer is 36 feet to 45 feet, award 1 point

   b. Can a landscaped island be created within the cul-de-sac?
   ______If the answer is YES, award I point

   c. Are alternative turn arounds such as "hammerheads" allowed on short streets in low density residential developments?
   ______If the answer is YES, award 1 point

5. Vegetated Open Channels
   a. Are curb and gutters required for most residential street sections?
   ______If the answer is NO, award 2 points

   b. Are there established design criteria for swales that can provide stormwater quality treatment (i.e., dry swales, biofilters, or grass swales)?
   ______If the answer is YES, award 2 points

6. Parking Ratios

a. What is the minimum parking ratio for a professional office building (per 1000 ft2 of gross floor area)?

______If the answer is less than 3.0 spaces, award 1 point

b. What is the minimum required parking ratio for shopping centers (per 1,000 ft2 gross floor area)?

______If the answer is 4.5 spaces or less, award 1 point

c. What is the minimum required parking ratio for single family homes (per home)?

______If the answer is less than or equal to 2.0 spaces, award 1 point

d. Are the parking requirements set as maximum or median (rather than minimum) requirements?

______If the answer is YES, award 2 points

7. Parking Codes

a. Is the use of shared parking arrangements promoted?

______If the answer is YES, award 1 point

b. Are model shared parking agreements provided?

______If the answer is YES, award 1 point

c. Are parking ratios reduced if shared parking arrangements are in place?

______If the answer is YES, award 1 point

d. If mass transit is provided nearby, is the parking ratio reduced?

______If the answer is YES, award 1 point

8. Parking Lots

a. What is the minimum stall width for a standard parking space?

______If the answer is 9 feet or less, award 1 point

b. What is the minimum stall length for a standard parking space?

______If the answer is 18 feet or less, award 1 point

c. Are at least 30% of the spaces at larger commercial parking lots required to have smaller dimensions for compact cars?

______If the answer is YES, award 1 point

d. Can pervious materials be used for spillover parking areas?

______If the answer is YES, award 2 points

9. Structured Parking

a. Are there any incentives to developers to provide parking within garages rather than surface parking lots?

______If the answer is YES, award 1 point

10. Parking Lot Runoff

a. Is a minimum percentage of a parking lot required to be landscaped?

______If the answer is YES, award 2 points

b. Is the use of bioretention islands and other stormwater practices within landscaped areas or setbacks allowed?

______If the answer is YES, award 2 points

18. Buffer Maintenance

a. Does the stream buffer ordinance specify that at least part of the stream buffer be maintained with native vegetation?

______If the answer is YES, award 2 points

b. Does the stream buffer ordinance outline allowable uses?

______If the answer is YES, award 1 point

c. Does the ordinance specify enforcement and education mechanisms?

______If the answer is YES, award 1 point

19. Clearing and Grading

a. Is there any ordinance that requires or encourages the preservation of natural vegetation at residential development sites?

______If the answer is YES, award 2 points

b. Do reserve septic field areas need to be cleared of trees at the time of development?

______If the answer is NO, award 1 point

20. Tree Conservation

a. If forests or specimen trees are present at residential development sites, does some of the stand have to be preserved?

______If the answer is YES, award 2 points

b. Are the limits of disturbance shown on construction plans adequate for preventing clearing of natural vegetative cover during construction?

______If the answer is YES, award 1 point

21. Land Conservation Incentives

a. Are there any incentives to developers or landowners to conserve non-regulated land (open space design, density bonuses, stormwater credits or lower property tax rates)?

______If the answer is YES, award 2 points

b. Is flexibility to meet regulatory or conservation restrictions (density compensation, buffer averaging, transferable development rights, off-site mitigation) offered to developers?

______If the answer is YES, award 2 points

22. Stormwater Outfalls

a. Is stormwater required to be treated for quality before it is discharged?

______If the answer is YES, award 2 points

b. Are there effective design criteria for stormwater best management practices (bmps)?

______If the answer is YES, award 1 point

c. Can stormwater be directly discharged into a jurisdictional wetland without pretreatment?

______If the answer is NO, award 1 point

d. Does a floodplain management ordinance that restricts or prohibits development within the 100 year floodplain exist?

______If the answer is YES, award 2 points

Total Scoring

90–100 Community has above-average provisions that promote the protection of streams, lakes and estuaries.

80–89 Local development rules are good, but could use minor adjustments or revisions in some areas.

70–79 Opportunities exist to improve development rules. Consider creating a site planning roundtable.

60–69 Development rules are likely inadequate to protect local aquatic resources. A site planning roundtable would be very useful.

< 60 Development rules are definitely not environmentally friendly. Serious reform is needed.

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