Pennsylvania Stormwater Best Management Practices Manual

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Section 3
Stormwater Management Principles, Goals, and a Management Model

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3.1 Introduction

Stormwater management in Pennsylvania is largely a "bottom-up" system, as discussed in Section 1. Municipalities shoulder the brunt of the stormwater management burden, including regulation. In contrast to many other states, Pennsylvania laws and regulations in most cases do not directly manage stormwater at the state level, although some additional state level management is occurring as NPDES Phase II and other "top down" programs are put into place. In cases where municipalities have no zoning ordinance and subdivision and land development regulations, there may be little or no formal stormwater regulation on the municipal level. With expanding state programs, such as NPDES Phase II and PADEP's Post Construction Management Plans/Permits for sites disturbing more than 1 acre, as well as Act 167 Stormwater Management Plans for designated watersheds, some stormwater management by county conservation districts and by PADEP itself does occur, and will increase. Although these new and expanding NPDES Phase II and Act 167 programs, as well as the new PADEP Stormwater Policy, provide some level of consistency and uniformity for stormwater management in Pennsylvania, there nevertheless remains a basic lack of guidance around which the many different municipalities in the state can structure their respective stormwater management programs. Although this Manual is not regulatory in nature, this section of the Manual and the Manual in its entirety is intended to provide uniform and consistent guidance for municipalities desiring to improve their stormwater management programs.

Sections 4, 5, 6, 7 and 8 of the Manual provide a substantial amount of technical information describing what to do (or not do) and how to do it – the Best Management Practices and land development approaches appropriate for the many different development contexts and physical site conditions across Pennsylvania. This technical guidance is extensive, but first this Section 3 addresses an important stormwater management issue, which embraces all aspects of BMP selection and design:

> **What level of site performance for volume control, peak rate control, and water quality should be achieved in the context of a given watershed or planning region?**

As desirable as management uniformity might be, Pennsylvania communities vary tremendously. Therefore, any recommended site control guidelines set forth in this Manual also need to be sensitive to this variability, reflecting natural systems and their similarities and differences, as well as the vast socioeconomic and socio-cultural similarities and differences between nearly pristine watersheds and highly urbanized drainage areas. In all cases, municipalities are encouraged to strive to enact the most rigorous management programs possible. Even in the absence of Act 167 watershed plans or river conservation plans, individual municipalities should look to their watershed neighbors and strive to integrate their individual municipal actions with the watershed system as a whole.

3.2 Recommended Site Control Guidelines

Site control guidelines and related stormwater management standards, designed to achieve the water quantity and water quality functions discussed in Section 2, should be comprehensive, effective, equitable, and flexible. Guidelines must be applicable at each individual site, as well as for the watershed as a whole.

To be **comprehensive,** site control guidelines must reflect the Pennsylvania Comprehensive Stormwater Policy. As such, they must:

- Achieve total volume control objectives, which work to maintain pre-development hydrology, including holding surface runoff volume, infiltration, and aquifer recharge volumes reasonably constant. This guideline will balance stream base flow and prevent increased frequency of damaging bank full flows.

- Protect, maintain, and improve stream uses and the surface water and groundwater quality (including temperature regimes) that sustains these uses.

- Prevent any increase in peak runoff rate for larger rainfalls (2- through 100-year frequency) on a site-by-site basis. Where appropriate, additional release rate controls to reduce cumulative flooding impacts in larger storms, as recommended in Act 167 watershed level planning where it exists, must be integrated as well.

In order to be **effective,** the site control guidelines set forth below must be achieved. In addition, the prevention of morphologic impacts on streams, which result from the discharge of increased volumes of runoff during smaller storms, is also important. Stormwater management guidelines must be effective not only on a site-by-site basis, but must work on a broader watershed-wide level as well. These recommended site control guidelines must be effective in meeting comprehensive stormwater management goals as set forth in this Manual.

To be **equitable,** site control guidelines should be expected to perform in approximately the same ways for everyone – for all types of development - from urbanized areas to undeveloped regions. In general, stormwater management standards for new land development should not be expected to mitigate for the lack of stormwater management at older sites, lacking management. Clearly, a significant portion of existing older land development in the state has done little or nothing to effectively managed stormwater impacts. Alternative solutions will have to be put in place for retrofitting of BMP's and mitigating the problems of the past.

The guidelines must also be **flexible.** Pennsylvania's approximately 2,550 municipalities enjoy great diversity, which presents major challenges in providing for uniform management of any sort. Physical conditions also vary. The type of land development being undertaken will vary by socioeconomic and cultural context. The engineering community that will implement these new stormwater management guidelines may also have pre-set notions as to effectiveness of any given BMP, and so they must be flexible in their application.

Many municipalities have no zoning ordinances or adopted land development regulations, including stormwater management regulations, while other municipalities actually have full-time engineering, planning and supporting staff. Even different engineering methodologies are currently being used across the state, a situation that will not change overnight. Thus the comprehensive stormwater management site control guidelines that are recommended in this Manual must be flexible enough to coexist with this substantial variability across the state.

3.2.1 Recommended Volume Control Guideline

Land development typically results in significant increases in runoff volumes, when conventional management practices are used. Figure 3-1 illustrates the relative increases in runoff volumes for rainfalls of different magnitude and frequency. The net increase in runoff volume during a given storm depends on the pre-development permeability of the natural soil and the vegetative cover, with poorly drained soils resulting in less of an increase in runoff volume (Figure 3-2). Even developed land considered to be open space and vegetated with grass following development can significantly increase runoff, as the result of severe compaction of the disturbed and graded soil mantle (Figure 3-3). For the larger, less frequent rainfalls, this increase in runoff volume is of such a magnitude that the cumulative impact in developed watersheds simply overwhelms the natural and human-made conveyance systems, producing the flooding downstream that has become all too frequent around the state. It is interesting to note that in both Figures 3-1 and 3-2, the runoff volume increase spikes upward from the 1.5-inch storm to the 3.27-inch storm, with the runoff volume increases being somewhat more subtle thereafter. This is even more true for the "tighter" Hydrologic Soils Group C soils, than for the more permeable Hydrologic Soils Group B soils. Such observations, as discussed below, provide an additional argument for use of the 2-year storm as a volume control guideline – if the 2-year storm is used as the basis for the volume control guideline, the bulk of the increased runoff volumes – even from larger storms – would be captured or managed. Furthermore, the relative fraction of net runoff volume increases, which would be mitigated by use of the 2-year rainfall volume, is even greater on the poorly drained soils.

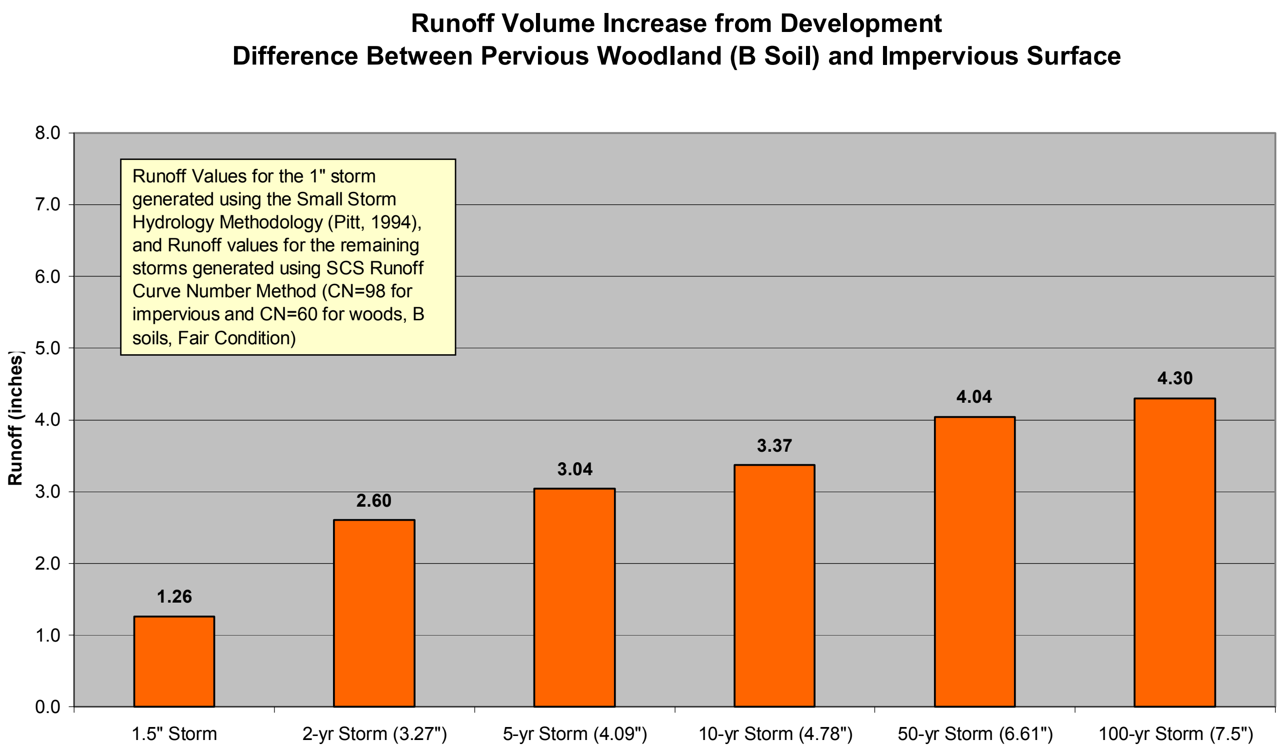

Figure 3-1. Runoff volume Increase from Impervious Surfaces - B Soils.

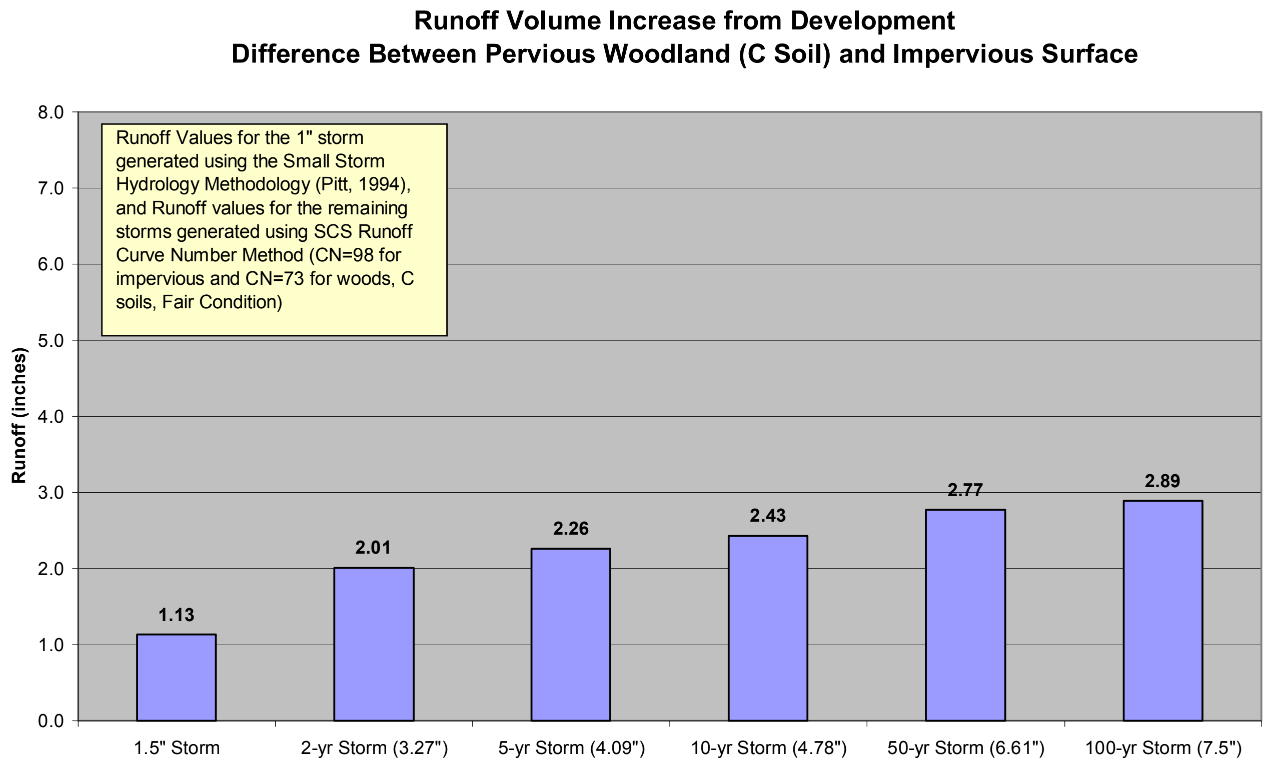

Figure 3-2. Runoff Volume Increase from Impervious Surfaces - C Soils.

The probability of larger rainfalls decreases with magnitude of the storm. In discussions in Section 2, analysis of precipitation data indicates that the vast majority of storms come in the form of the small and more frequent storm events. A rainfall of 1 inch represents over 65% of the average annual rainfall volume, while the rainfall of a two-year frequency accounts for over 95 percent of the total volume of average annual rainfall (see Figure 2-5). Larger storms, such as the 50-year and 100-year storms, obviously are much larger in terms of their rainfall volumes, but because they occur so rarely, they actually constitute a very small and relatively insignificant portion of total rainfall volumes, when averaged year after year. Therefore, the focus of stormwater management in terms of volume is logically on the smaller storms, typically the 2-year storm and under. Furthermore, storms of greater magnitude than the 2-year storm will produce an increase in runoff volume that would be impractical to use as a design standard for volume reduction. In practice, a BMP sized for a much greater volume would be empty most of the time and function at capacity only once in many years, and therefore would not seem to be cost effective from a volume control perspective. Of course, these larger storms need to be managed in terms of flooding and peak rate control, to the extent possible. On the other hand, the relative increase in runoff volume from impervious surfaces with the less frequent storms (see Figure 3-1) will add to the downstream flooding impact, if only detention BMP measures are provided.

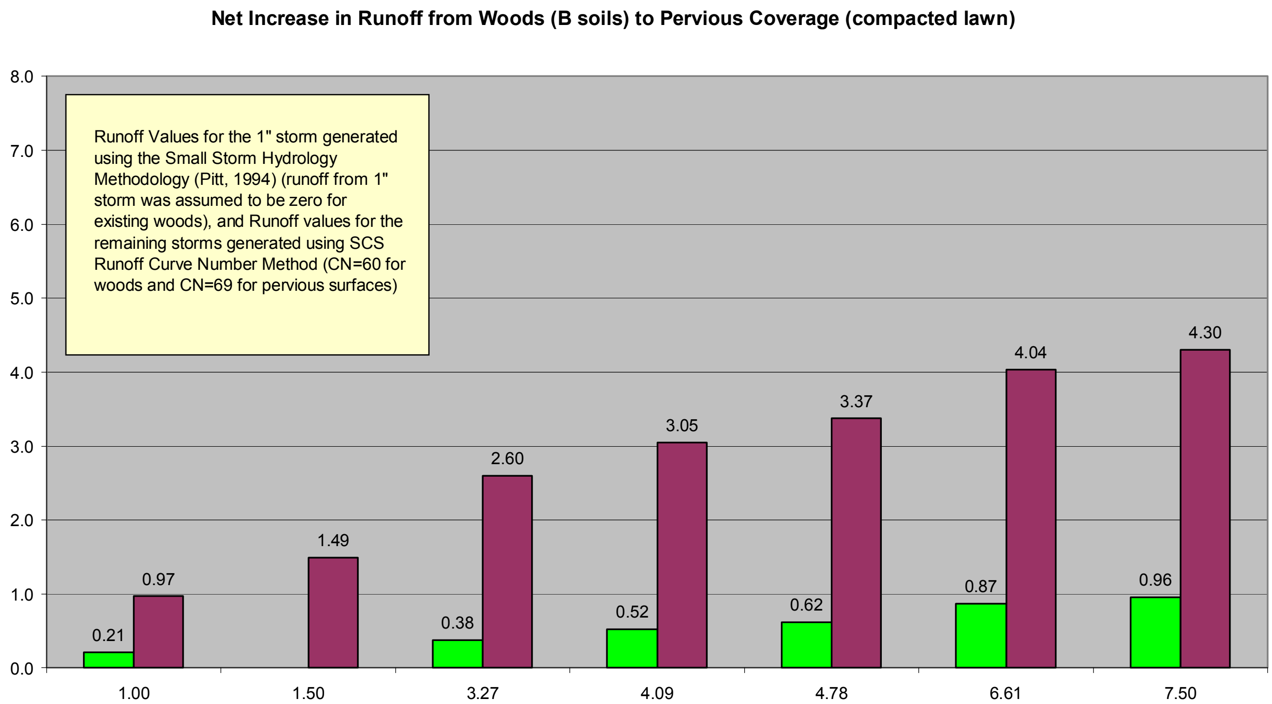

Figure 3-3 Net Increase in Runoff from Woods to Compacted Lawn

Volume reduction techniques for smaller storms, if designed and constructed properly, can often achieve peak rate control for larger storms. For instance, a volume control strategy consisting of one or more infiltration techniques designed to mitigate the increased volume of the 2-year, 24-hour storm event can often achieve peak rate attenuation for all storms up to and including the 100-year event, if the BMPs are properly infiltrating and draining during the initial period of rainfall. In this way, storage capacity is still available in the BMPs when the peak rainfall intensity occurs. Computer modeling has demonstrated this to be true for many real world and hypothetical designs. If the soil is very poorly drained or if the infiltrating surface is limited, then additional storage may be required to assure peak rate mitigation during severe rainfalls.

More specifically, during a large storm event, an infiltration BMP is a dynamic system that is simultaneously filling up, seeping into the ground, and ultimately discharging via an overflow outlet control set higher in elevation than the volume storage design. In this way, an infiltration technique is sometimes compared to a typical bathtub, albeit one with multiple drains in the bottom. The hydraulic principles are virtually the same, with the exception being that infiltration BMPs require an overflow defined by the contributing surface area. The overflow elevation of an infiltration measure is typically set to retain the net increase in volume from the 2-year, 24-hour storm. A case study of a successful volume control / peak rate control application is presented below.

Case Study:

Application for Runoff Volume Control and Peak Rate Control

To demonstrate peak rate control of larger storms through volume control of smaller storms, a hypothetical 3-acre commercial site was considered (Figure 3-4). Under existing conditions, the site was assumed to be meadow consisting of Hydrologic Soil Group B soils (SCS Curve Number of 58, SCS Lag Time of 12 min). The development plan calls for a 0.39-acre building, 1.11 acres of non-building development (parking, driveway, sidewalk), 1.0 acre of planted green area, and 0.5 acre of undisturbed meadow (SCS Curve Number of 79, SCS Lag Time of 6 min). Stormwater management for the development was considered in two ways: traditional detention (peak rate only) versus infiltration (volume control). The traditional detention approach assumed a 2-ft deep, 0.46-acre-ft basin located in the area of undisturbed meadow. The infiltration approach, which allows for the undisturbed meadow area, consisted of 0.40 acre of porous asphalt with two feet of uniformly-graded crushed aggregate (0.32 acre-ft of storage, approximately the 2-year storm volume increase). The overflow elevation of the infiltration bed was set at 0.80 ft.

Both approaches to stormwater management at this hypothetical site were modeled using HEC-HMS (Hydrologic Engineering Center - Hydrologic Modeling System). (The infiltration bed and the detention basin were considered to be “reservoirs” in the program, and infiltration was mimicked as a “diversion”. An infiltration rate of 2 in/hr was assumed for well-draining B soils.) The results of the model, illustrated in Figures 3-5 and 3-6 and summarized in Tables 3-1, 3-2, and 3-3, clearly indicate that an infiltration strategy, sized in this case for the 2-year storm volume increase, can be just as effective as a traditional detention strategy at controlling peak rates up to the 100-yr storm. It should also be noted that the modeled infiltration design resulted in less than existing-level discharge volume for all storms, while the detention design more than quadrupled the existing 2-year volume.

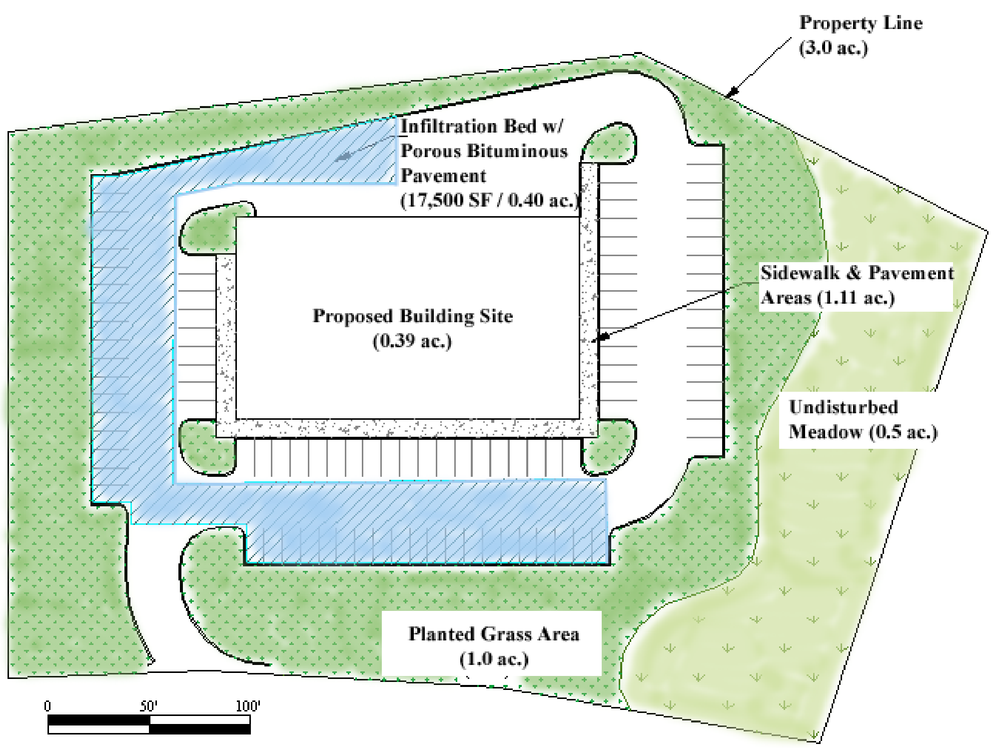

Figure 3-4 Commercial Case Study, (CA, 2004)

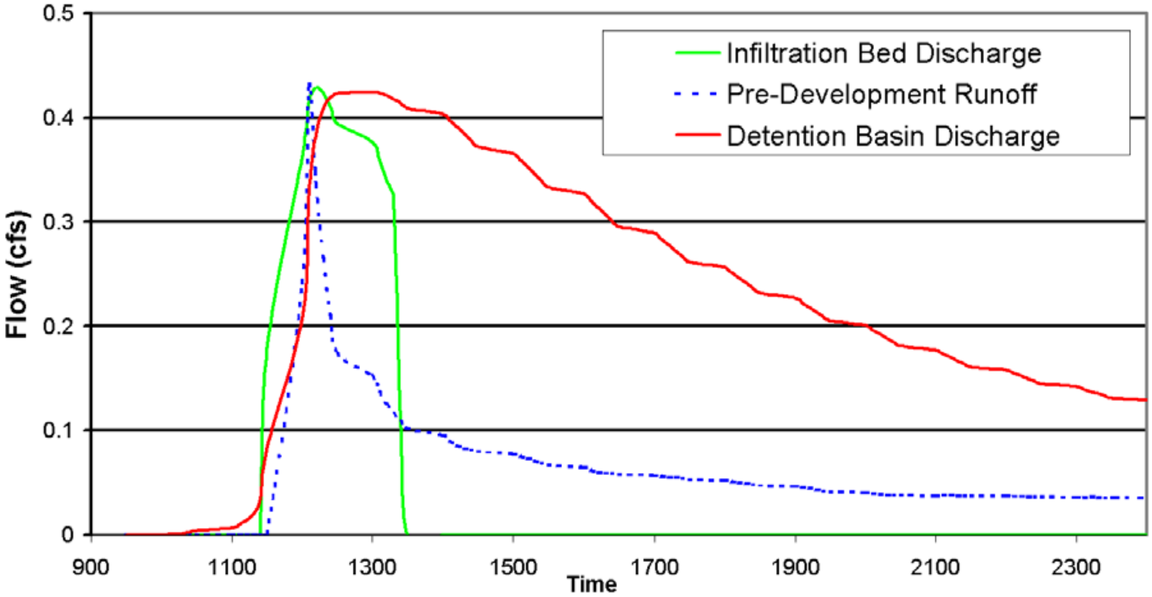

Figure 3-5. 2-year Storm Peak Rates

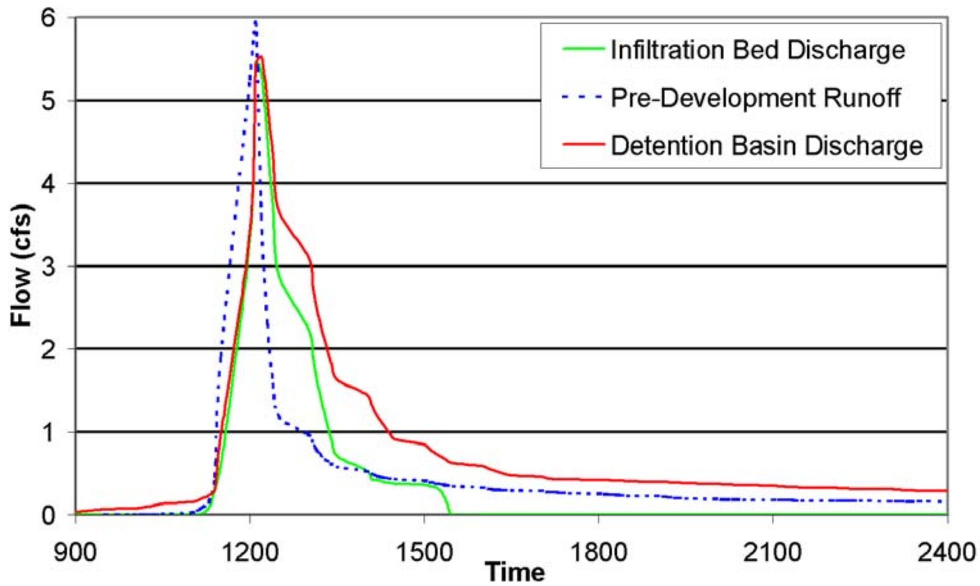

Figure 3-6. 100-year Storm Peak Rates

Table 3-1 Peak Rate Summary Results

Storm Frequency (year)	Existing Runoff Rate (cfs)	Unmitigated Post-Dev. Runoff Rate (cfs)	Infiltration Bed Discharge (cfs)	Detention Basin Discharge (cfs)
2	0.43	4.58	0.43	0.42
10	2.59	9.89	2.59	2.59
25	3.52	11.75	3.40	3.48
100	5.93	16.14	5.45	5.53

Table 3-2. Volume Summary Results - Infiltration

Storm Frequency (year)	Existing Runoff Depth (in)	Unmitigated Post-Dev. Runoff Depth (in)	Total Infiltration (in)	Infiltration Bed Discharge (in)	Percentage of Existing Volume
2	0.30	1.26	1.01	0.25	83%
10	1.11	2.71	1.68	1.03	93%
25	1.44	3.23	1.87	1.36	94%
100	2.33	4.48	2.30	2.18	94%

Table 3-3. Volume Summary Results - Detention

Storm Frequency (year)	Existing Runoff Depth (in)	Post-Dev. Runoff Depth (in)	Percentage of Existing Volume
2	0.30	1.26	420%
10	1.11	2.71	244%
25	1.44	3.23	224%
100	2.33	4.48	192%

A volume control guideline is essential to mitigate <u>all</u> of the impacts of increased runoff, discussed in more detail in Section 2, including:

1. Protect stream channel morphology
2. Maintain groundwater recharge
3. Prevent downstream increases in runoff volume and flooding impacts
4. Replicate the site hydrology before development to the greatest extent possible.

Protect Stream Channel Morphology: When stormwater management is only comprised of peak rate attenuation by detention, the volume of runoff substantially increases. This increased volume of runoff, in turn, results in an increase in the frequency of critical bankfull or near bankfull flow conditions in stream systems, which has comparably critical effect on stream shaping (including stream channel impacts and overall stream morphology). There will be an increase in sediment eroded from the stream bank if stormwater management fails to address increased runoff volume. The increased kinetic energy and erosive forces resulting from increased volumes of stormwater and sediment significantly impact the stream system, as banks are eroded and undercut, as stream channels are gouged and straightened. Important meanders, pools, riffles, and other essential elements of habitat are lost or diminished. Although bankfull flow varies from stream system to stream system, research has demonstrated that bankfull flows typically vary between the 1-year and the 2-year storm (often around the 1.5-year storm).

Maintain Groundwater Recharge: Under relatively natural conditions, most of the annual rainfall infiltrates into the soil mantle (Figure 2-2 indicates about 32 of the average annual 45 inches of precipitation) in Pennsylvania watersheds. A vital portion (again, Figure 2-2 indicates about 12 inches out of the 32 inches of infiltration) of this infiltrated rainfall provides groundwater recharge to maintain and feed the groundwater reservoir or aquifer (and all critical functions such as wells and wetlands which depend on the groundwater), which in turn maintains the stream system through base flow. All of these are critical benefits of volume control. Also important to note is that maintaining total evapotranspiration volumes for their temperature and diverse microclimatic functions is valuable, although is frequently not as readily recognized.

Prevent Downstream Increases in Runoff Volume and Flooding Impacts: Although rate control measures may mitigate the peak rate of runoff from a site – especially from the larger storm events which customarily have been recognized as the major cause of flooding, the increased volume of runoff and the change in timing of stormwater discharges from multiple watershed sites can result in **increased** peak flow rates on a watershed basis, as well as increased duration of flood flows, including more frequent and extended minor flooding events. This cumulative downstream flooding resulting from discharge of increased runoff volumes is a major reason why Pennsylvania's Act 167 stormwater management planning program has been developed. Although replicating pre-development runoff volumes for smaller storms does not address flooding for the major historical flood event – the 100-year storm and even the larger events which have been hitting the state in recent years, the vast majority of cumulative downstream flooding problems which plague so many developing watersheds will be substantially reduced.

Replicate the Site Hydrology before Development: The objective for stormwater management should be to develop a stormwater management program that replicates the pre-development volume and rate of stormwater discharge – the pre-development hydrograph, to the extent possible, through the application of an appropriate volume control guideline. In so doing, this volume control guideline is likely to achieve management objectives for infiltration, evapotranspiration, and groundwater recharge, although volume control can be achieved through a variety of non-infiltration oriented BMPs.

More specifically, where site conditions and proposed development offer the opportunity to reduce otherwise increased runoff volumes, the following volume control guideline is recommended: **Do not increase the post-development total runoff discharge volume for all storms equal to or less than the 2-year storm event**. Recommended control guidelines for volume, peak rate, and water quality are presented in Table 3-4. The scientific basis for this Control Guideline 1 is as follows:

- The 2-year storm event encompasses 95% or more of the annual volume of precipitation across the state
- Volume reduction BMPs based on this standard that utilize infiltration will provide a storage capacity that works to mitigate peak rate increases for larger storms, often up to the 100-year storm
- In a natural stream system in many mid-Atlantic state contexts, the bankfull stream flow tends to occur with a statistical frequency of approximately 1.5 years. If runoff volumes occurring from storms less than the 1.5-year event are not increased, a great many of the fluvial geomorphologic impacts imposed on streams in developing watersheds will be minimized, if not eliminated
- Practically speaking, the 2-year storm event is a defined storm event throughout the state that designers use for peak rate control standards, and designers can use methodologies currently used for stormwater management calculations.

Table 3-4 Recommended Site Control Guidelines

TYPE	GUIDELINE *	GOALS
Volume CG-1	*Do not increase runoff volume, pre-development to post-development, for up to the 2-year frequency, 24-hour duration rainfall. ***	Groundwater/ Water Table/ Stream Base Flow & Stream Conservation/ Stream Channel Protection
Volume CG-2	*Capture and remove runoff generated by 1.5 inches of rainfall with infiltration of the runoff from the initial 0.5 inches of rainfall.*	
Extended Detention (CG-2 only)	*Provide 24-hour extended detention of the 1-year frequency, 24-hour duration rainfall.*	Stream Conservation/ Stream Channel Protection
Peak Rate (CG-1 and CG-2)	*Do not increase peak rate of runoff for larger storms (1-, 2-, 10-, 25-, 100-year storms at minimum), pre-development to post-development; as necessary, provide additional peak rate control for largest storms through the Act 167 planning.*	Flood Protection: 1- through 100-Year Storms, Site by Site
		Cumulative Flood Protection as Needed through Act 167 Planning
Water Quality (CG-1 and CG-2)	*A reduction of 85% of particulate-associated pollutants (as represented by TSS), including 85% of Total Phosphorus. In addition, removal or prevention of 50% of solutes (as represented by NO3-N) is required. BMPs shall not result in a temperature increase of 3 degrees Fahrenheit.*	Groundwater Quality
		Surface Water Quality - reduction of 85% particulate-associated NPS; reduction of 50% solute loads
		Temperature

** These guidelines are recommended for use in watersheds throughout Pennsylvania. Guidelines may be further modified in Special Stormwater Management Areas and other zones where different stormwater guidelines for quantity and quality control are warranted.*

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

There are three methods to reduce the volume of runoff from land development:

1. Infiltration
2. Capture and Reuse
3. Vegetation systems that provide ET, returning rainfall to the atmosphere

Given the increasing number of methods available to achieve runoff volume reduction, satisfying Control Guideline 1 becomes feasible at many new land development sites across Pennsylvania. For some locations and site designs (e.g., where so-called Special Area constraints exist), it will not be possible to achieve Control Guideline 1. In these instances, a lesser volume reduction standard, Control Guideline 2, should be applied. Control Guideline 2 requires the capture and removal of the runoff produced by 1.5 inches of rainfall, with the runoff generated by the first 0.5 inches infiltrated into the soil mantle to assure that groundwater recharge, equal to base flow, is sustained in most physiographic regions. Inherent in this standard is the assumption that all soils allow some infiltration, and that the capability of the soil mantle may provide additional infiltration greater than the runoff from the initial 0.5 inches of rainfall. If this is not possible, a vegetated roof combined with capture/ reuse systems or other forms of runoff volume control will be necessary to achieve the required capture volume.

The potential benefits of Control Guidelines 1 and 2 applied in different areas of the state can be compared, as shown in Table 3-5. In terms of capture efficiency, the capture requirement for CG-2 represents approximately 68% of CG-1 in the southeast, but 83% in the southwest region. This comparison assumes a “C” soil, more prevalent in the southwest, and considers only the impact of new impervious surfaces. Table 3-6 considers the same design under different assumptions of site conditions and hydrologic model analysis applied, with significant differences in design criteria. In general, CG-2, although vastly better than conventional peak rate control, is not as effective as CG-1 for volume reduction.

Table 3-5. Control Guideline Volume Requirements for Impervious Areas on "C" soils

Location	2-yr Storm (in.)	Control Guideline 1 (in.) *	Control Guideline 2 (in.) **	Difference (%)
Philadelphia	3.3	2.2	1.49	32%
Pittsburgh	2.4	1.8	1.49	16%
Scranton	2.6	1.9	1.49	21%
State College	2.7	1.9	1.49	23%
Williamsport	2.8	2.0	1.49	24%
Erie	2.6	1.9	1.49	21%

** Based on a pre-developed land cover of Woods*
*** Small Storm Hydrology Method for "Large Impervious Areas"*

Finally, the volume control required with both control guidelines should result in removal of the major fraction of particulate-associated pollutants during most storms. Solutes will continue to be transported in runoff throughout the storm, regardless of magnitude. In terms of peak rate control, CG-1 will provide peak rate control for larger storms if the BMPs drain reasonably well and are adequately sized and distributed. CG-2 will not fully mitigate the peak rate for larger storms, and necessitates an increase in volume capacity or the addition of separate BMPs for peak rate control. In the event that this “secondary” BMP is added to assure rate mitigation during severe storms, it should be reduced in capacity to reflect the volume of runoff removed by other measures.

3.2.2 Extended Detention (CG-2 only)

As CG-2 may not fully control the increased runoff volume from storms responsible for fluvial geomorphologic impacts to stream channels (as discussed above), 24-hour extended detention of the 1-year frequency, 24-hour duration rainfall is recommended. The 24-hour period is defined as beginning at the time of peak discharge from the site. As illustrated in Section 9, a flow target that satisfies these requirements is proposed to assist in the design and review process. Both structural and nonstructural BMPs can be used to achieve extended detention.

3.2.3 Recommended Peak Rate Control Guideline (CG-1 and CG-2)

Peak rate control for larger storms, up to the 100-year frequency event, is essential in order to protect against immediate downstream erosion and flooding. This peak rate control standard has been in place in many municipalities for over twenty-five years. Historically, most designs have achieved peak rate control through the use of detention structures. Peak rate control can be integrated into many volume control BMPs in ways that eliminate the need for additional peak rate control detention systems, as demonstrated in Figures 3-5 and 3-6. Non-Structural BMPs can also contribute to rate control, as discussed in Sections 5 and 9.

The recommended control guideline for peak rate control is: Do **not increase the post-development peak rate of discharge between pre-development and post-development for the 1-year through 100-year storm events.** Where Act 167 planning has been undertaken, hydrologic modeling typically has been performed and has provided the basis for establishing additional "release rate" districts, where peak rates are required to be further reduced to less than the pre-development rate. As volume reduction BMPs are incorporated into stormwater management on a watershed basis, recommended release rates will warrant re-evaluation and adjustment. The control guidelines will reduce or perhaps even eliminate the increase in peak rate and volume, and a corresponding release rate adjustment is appropriate.

3.2.4 Recommended Water Quality Control Guideline (CG-1 and CG-2)

New land development produces significant non-point source pollutant loads, which are conveyed to surface waters in stormwater runoff. These pollutants include a variety of chemical types and are generally grouped by form, as particulate-associated or solutes. The concentration of any pollutant varies according to storm event and land use conditions. Particulate pollutants can vary significantly in concentration during a runoff period, as demonstrated by the "first flush" phenomenon. Increased volumes of runoff that result in bank erosion further contribute to the sediment pollutant load.

The recommended control guideline for water quality control is: Achieve **an 85 percent reduction in post-development particulate-associated pollutant load (as represented by Total Suspended Solids), including 85 percent reduction in post-development Total Phosphorus loads, and a 50 percent reduction in post-development solute loads (as represented by NO3-N), again all based on post-development land use.** These reductions may be estimated based on the estimated pollutant load for each land use type (see Table 2-2) and the pollutant removal effectiveness of the proposed BMPs, as shown in Sections 5 and 6 and discussed in Section 9. The inclusion of Total Phosphorus as a parameter is in recognition of the fact that most of the phosphorus in transit with stormwater is attached to the smallest (colloidal) particles, which are not subject to gravity settlement in conventional stormwater management detention structures, except over extended periods. With infiltration, however, the removal of both suspended solids and Total Phosphorus should be very high.

The site designer will not meet the recommended water quality control guideline with a dry detention basin, and a combination of Non-Structural measures and Structural BMPs will probably be required. Those new impervious surfaces that produce relatively little in the form of additional pollutants, such as rooftops, can be neglected from the site evaluation under most circumstances. Rainfall has some background concentration of nitrate (1 to 2 mg/l) as the result of fossil fuel combustion and fertilizer discharges to the atmosphere, and it would be unreasonable to require the removal of this pollutant load from stormwater runoff. The control of nitrate from new development should focus on reduction of fertilizer applications, rather than any type of BMP removal from runoff.

When the proposed development plan for a site is measured by type of surface (roof, parking lot, driveway, lawn, etc.), an estimate of potential pollutant load can be made based on the volume of runoff from those surfaces, with a flow-weighted pollutant concentration applied. The total potential non-point source load can then be estimated for the parcel, and the various BMPs, both Structural and Non-Structural, can be considered for their effectiveness. This method is described in detail in Section 9. In general, the Non-Structural BMPs are most beneficial for the reduction of solutes, with Structural BMPs most useful for particulate reduction. Because soluble pollutants, once they are contained in runoff, are extremely difficult to remove, prevention or reduction on the land surface, as achieved through Non-Structural BMPs described in Section 5, is the most effective approach.

3.3 Stormwater Standards for Special Areas

The recommended control guidelines acknowledge the need for possible modification and special consideration for sites situated in so-called “Special Areas.” This Special Areas designation includes a diverse mix of physical and land use conditions where the recommended control guidelines may need to be made more or less rigorous, depending on local conditions, the degree of prior land disturbance, and a host of other factors.

The Special Areas designation includes existing urban or developed sites, discussed more fully in Section 7, including the special case of contaminated or brownfield sites, the special case of Source Water Protection sites or the broader classification of sites situated in potentially more vulnerable karst/carbonate sites. In addition, development land that was previously used for deep or surface mining is considered as Mine Drainage Sites. The special land use category of roadway construction is also considered separately in Section 8 as Highway Project Sites. The nature and extent of stormwater management constraints for these types of sites are summarized in Table 3-7 and in subsequent Sections.

Table 3-6. Special Areas of Concern for BMP Application

SPECIAL AREA	CONSTRAINTS	BMP CONSIDERATIONS
Existing Urban Areas	High degree of impervious cover	Infiltration limited Building BMP’s suitable
Brownfield sites	Soil contamination (assumed)	Pollutant migration restricts infiltration Soil exposure limits pervious cover
Source Water Protection	Trace Organics as Solutes	Prevention in watershed
Special Protection Waters	Non-degradation requirements	CG-1 Standard only
Carbonate Aquifers	Sinkhole prevention	Distributed infiltration
Highways/roadways	Highly compacted and disturbed soils within ROW, spill potential	Limited opportunities
Mine Drainage Areas		
Surface mining	No soil mantle remaining, acid formation	Wetland systems as BMP’s
Deep mining	Bedrock honeycombed with acid forming potential	Infiltration BMP’s may add to acid formation rate

3.4 Boiling it Down: Top Ten Principles for Stormwater Management in Pennsylvania

Keeping track of all relevant control guidelines and integrating them into the site design process can get complicated, especially for the designer or local official who has not been involved in the process. Consequently, much of this Manual can be condensed into the following simplified principles:

1 Prevent stormwater impacts first, especially pollution.
2 Mitigate second; it is difficult to remove non-point source pollutants from runoff.
3 Manage stormwater as a resource – not a waste.
4 Maintain water cycle balance for quantity and quality.
5 Integrate stormwater in the initial site design process.
6 Preserve and utilize natural systems (soil, vegetation, etc.).
7 Manage stormwater as close to source as possible.
8 Disconnect/Decentralize/Distribute.
9 Slow it down – don't speed it up.
10 Do as much with as little as possible.