# Pennsylvania Stormwater Best Management Practices Manual

## Chapter 4

## Integrating Site Design and Stormwater Management

363-0300-002 / December 30, 2006

# Chapter 4 Integrating Site Design and Stormwater Management

## 4.1 A Recommended Site Design Procedure for Comprehensive Stormwater Management

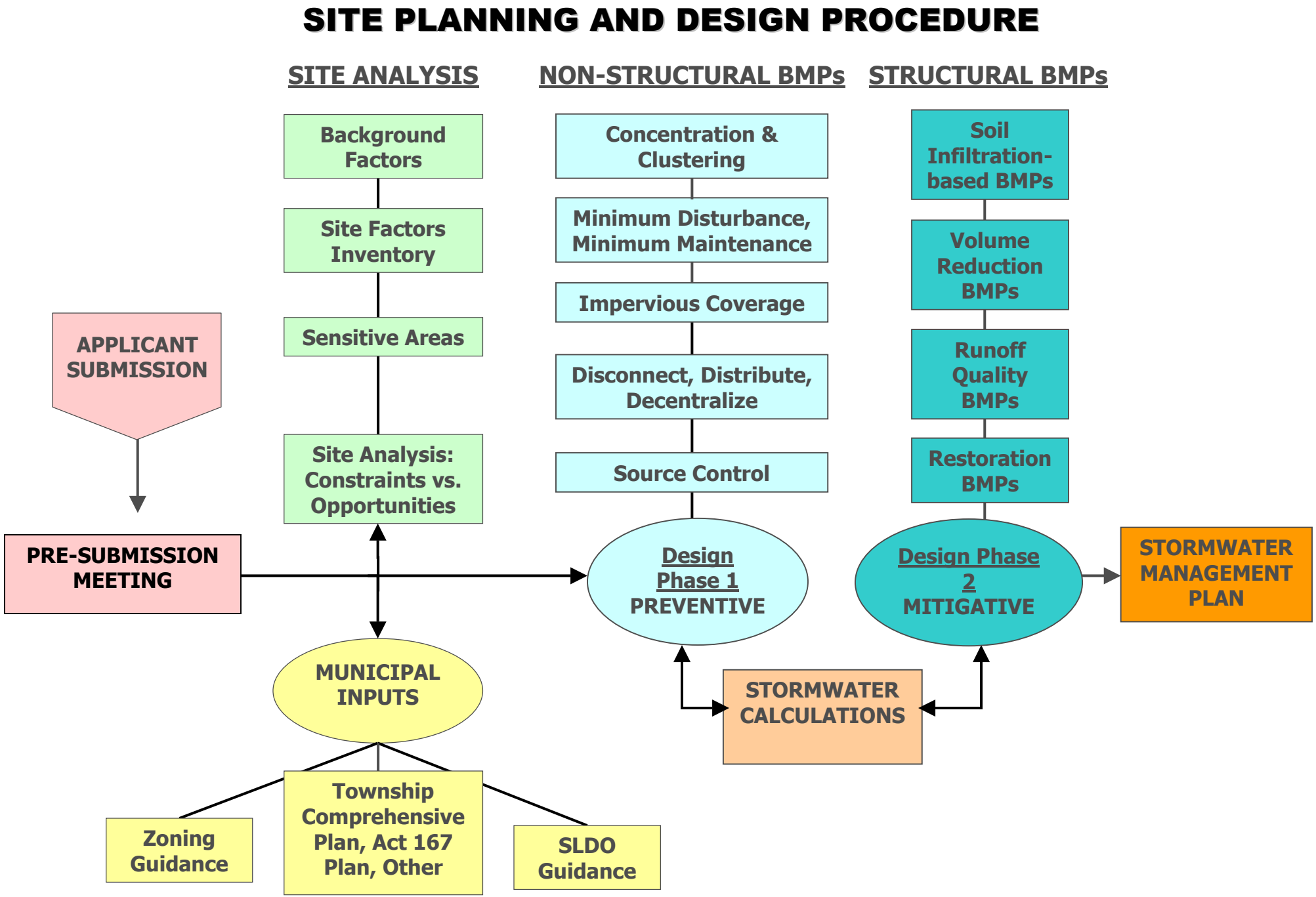
Chapters 5 and 6 describe multiple Non-Structural and Structural BMPs that can be used to achieve the Recommended Site Control Guidelines for comprehensive stormwater management described in Chapter 3. Obviously, not all of these BMPs are appropriate for all land development activities or every site. How can BMPs be selected to maximize their performance? What is the optimal blend between Non-Structural and Structural BMPs? How can stormwater management be best integrated into the site planning process?

A flow chart depicting a Site Design Procedure For Comprehensive Stormwater Management (Procedure) is set forth in Figure 4-1 (also referenced to the Checklist Summary in Figure 4-2 which is discussed in Section 4.2 below). This procedure begins with an assessment of the site and its natural systems and then proceeds to integrate both Non-Structural and Structural BMPs in the formulation of a comprehensive stormwater management plan. The intent of the planning process is to promote development of stormwater management "solutions" which achieve the rigorous quantity and quality standards set forth in Chapter 3. Some aspects of the procedure will not be fully applicable in all land development cases. For example, Non-Structural BMPs may be challenging to apply in those cases where higher densities/intensities are proposed on the smallest of sites in already developed areas.

An essential objective of the Procedure is to maximize stormwater "prevention" through use of Non-Structural BMPs (Chapter 5). Once prevention has been maximized, some amount of stormwater peaking and volume control will likely remain to be managed. These stormwater management needs should be met with an array of natural-system based Best Management Practices (Vegetated Swales, Vegetated Filter Strips, etc.), with the remaining stormwater management needs met with structural Best Management Practices such as infiltration basins, trenches, porous pavement, wet basins, retention ponds, constructed wetlands, and others presented in Chapter 6.

This Procedure, or a process similar to it, is an integral part of comprehensive stormwater management and transcends the bounds of conventional stormwater management that has existed in most Pennsylvania municipalities. Perhaps most importantly, the Procedure involves the total site design process. Conventional stormwater management has usually been relegated to the final stages of the site design and overall land development process, after most other building program issues have been determined and accommodated. To the contrary, the Procedure places stormwater management in the initial stages of site planning process, when the building program is being fitted and tested on the site. In this way, comprehensive stormwater management can be integrated effectively into the site design process.

*Figure 4-1 Recommended procedures for comprehensive stormwater management.*



Much of the information relied on for the Procedure is information already required to satisfy other aspects of existing municipal land development ordinances. The Procedure is intended to more effectively utilize this already-collected site data to generate better stormwater management in the context of a markedly improved site plan. To the extent that this information is not already being collected and assessed, the information needs to be collected as part of the site design process.

## 4.2 The Site Design Checklist for Comprehensive Stormwater Management

Coordinated with the Recommended Site Design Procedure for Comprehensive Stormwater Management is a series of questions structured to facilitate and guide an assessment of the site's natural features and stormwater management needs. The Site Design Checklist for Comprehensive Stormwater Management (Figure 4-2) is intended to help facilitate the Procedure. The initial questions in the Checklist focus on Site Analysis, including Background Site Features, a Site Factors Inventory, Site Factors Analysis and Constraints and Opportunities. The checklist relates directly to the first Non-Structural BMP category: Protect Sensitive and Special Value Features, which include:

**BMP 5.4.1 Protect Sensitive/Special Value features**
**BMP 5.4.2 Protect/conserve/enhance utilize riparian areas**
**BMP 5.4.3 Protect/utilize natural flow pathways in overall stormwater planning and design**

Because these first steps in the Procedure are so important, they are further discussed below in Section 4.3 – "Importance of Site Assessment".

The Procedure continues with potentially multiple cycles of "testing" and "fitting" preventive Non-Structural BMPs at the site. The Checklist provides questions designed to identify the potential application of additional Non-Structural BMPs. Once Non-Structural BMPs have been "maximized," the Recommend Procedure then continues with the testing/fitting of Structural BMPs, again facilitated by the Checklist questions. This testing/fitting of Non-Structural and Structural BMPs can continue through several cycles. At the completion of the Procedure, a comprehensive stormwater management plan emerges, satisfying the Chapter 3 Recommended Site Control Guidelines. If the Checklist questions are addressed thoroughly and the Procedure is fully and effectively applied, the critical objective of managing stormwater comprehensively will be achieved in a cost effective manner. The Procedure, though largely common sense, constitutes a change from conventional engineering practice in many Pennsylvania municipalities.

**(Figure 4-2) Checklist summary for use with Site Planning and Design Procedure**

## SITE ANALYSIS

**Background Site Factors**

***Describe hydrologic context and other natural elements***

- Chapter 93 stream use designation?
  - Special Protection Waters (EV, HQ)?
  - Fishery / Aquatic Life Use (WWF, CWF, TSF)?
- Any Chapter 303d/impaired stream listing classifications?
- Aquatic biota sampling?
- Existing water quality sensitivities downstream (water supply source?)?
- Location of any known downstream flooding?
- Includes any Special Areas?
  - Such as Previously Mined AMD/AML areas?
  - Brownfields?
  - Source Water Protection areas
  - Urban Areas?
  - Carbonate/Limestone?
  - Slide Prone Areas
  - Other

**Site Factors Inventory**

***Describe the size and shape of the site***

- Special constraints/opportunities?
- Special site border conditions and adjacent uses?

***Describe the existing developed features of the site, if any***

- Existing structures/improvements, structures to be preserved?
- Existing cover/uses?
- Existing impervious areas?
- Existing pervious maintained areas?
- Existing public sewer and water?
- Existing storm drainage systems at/adjacent to site?
- Existing wastewater, water systems onsite?

***Describe important natural features of site***

- Existing hydrology (drainage swales, intermittent, perennial)?
- Existing topography, contours, subbasins?
- Soil series found on site and their Hydrologic Soil Group ratings?
- Areas of vegetation (trees, scrub, shrub)?
- Special Value Areas?
  - Wetlands, hydric soils?
  - Floodplains/alluvial soils?
  - High quality woodlands, other woodlands and vegetation?
  - Riparian buffers?
  - Naturally vegetated swales/drainageways?
- Sensitive Areas?
  - Steep slopes?
  - Special geologic conditions (limestone?)?
  - Shallow bedrock (less than 2ft)?
  - High water table (less than 2ft)?
- PNDI areas or species?

**Site Factors Analysis**

***Characterize the constraint-zones at site***

- Avoid development on or near special and sensitive natural features

***Characterize the opportunity-zones at site***

- Location of well-draining soils
- Location and quality of existing vegetation
- Has a Potential Development Area been defined?
- Does building program fit the constraints and opportunities of natural features?

**BACKGROUND SITE CONDITIONS**

| MUNICIPAL INPUTS | |
|---|---|
| ***Township Comprehensive Plan and Zoning guidance*** | BACKGROUND SITE CONDITIONS |
| Guidance in Comprehensive Plan? | |
| Existing Zoning District? | |
| Total number of units allowed? | |
| Type of units? | |
| Density of units? | |
| Any allowable options? | |
| ***Township SLDO guidance and options*** | |
| Performance standards for neo-traditional, village, hamlet planning? | |
| Reduce building setbacks? | |
| Curbs required? | |
| Street width, parking requirements, other impervious requirements? | |
| Cut requirements? | |
| Grading requirements? | |
| Landscaping requirements? | |
| ***Township SLDO/stormwater requirements*** | |
| Peak rate and design storms? | |
| Total runoff volume? | |
| Water quality provisions? | |
| Methodological requirements? | |
| Maintenance requirements? | |
| ***Is applicant submission complete? Fully responsive to municipal zoning/ SLDO requirements?*** | |
| ***Are municipal zoning/SLDO requirements inadequate?*** | |
| ***Is useful interaction at sketch plan or even pre-sketch plan phases occurring?*** | |
| **SITE DESIGN: NON-STRUCTURAL BMPs** | DESIGN PHASE 1: PREVENTIVE |
| **Lot Concentration and Clustering** | |
| ***Reduce individual lot size?*** | |
| ***Concentrate/cluster uses and lots?*** | |
| ***Configure lots to avoid critical natural areas ?*** | |
| ***Configure lots to take advantage of effective mitigative stormwater practices?*** | |
| ***Orient built structures to fit natural topography?*** | |
| ***Minimize site disturbance (excavation / grading) at site?*** | |
| ***Minimize site disturbance (excavation / grading) for each lot?*** | |
| **Minimum Disturbance/Maintenance** | |
| ***Define disturbance zones for site?*** | |
| Protect maximum total site area from development disturbance? | |
| Protect naturally sensitive and special areas from disturbance? | |
| ***Minimize total site compaction?*** | |
| ***Maximize zones of open space and greenways?*** | |
| ***Consider re-forestation and re-vegetation opportunities?*** | |
| **Impervious Coverage Reduction** | |
| ***Reduce road widths? Lengths?*** | |
| ***Utilize turnarounds? Cul-de-sacs with vegetated islands?*** | |
| ***Reduce driveway length and width?*** | |
| ***Reduce parking ratios?*** | |
| ***Reduce parking sizes?*** | |
| ***Examine potential for shared parking?*** | |
| ***Utilize porous surfaces for applicable parking features (overflow)?*** | |
| ***Design sidewalks for single-side street movement?*** | |
| **Disconnect/Distribute/Decentralize** | |
| ***Rooftop disconnection?*** | |
| Existing downgradient yard area opportunities? | |
| Existing downgradient vegetated areas/woods? | |
| ***Disconnection from storm sewers/street gutters?*** | |
| Front/side yard opportunities? | |
| Space for vegetated swales, rain gardens, etc.? | |
| **Source Control** | |
| ***Provisions for street sweeping? Other?*** | |

| SITE DESIGN: STRUCTURAL BMPs | |
|---|---|
| **Volume/Peak Rate Through Infiltration** | DESIGN PHASE 1: MITIGATIVE |
| ***Porous Pavement with Infiltration Beds?*** | |
| ***Infiltration Basins?*** | |
| ***Infiltration Trenches?*** | |
| ***Rain Garden/Bioretention?*** | |
| ***Dry Wells/Seepage Pits?*** | |
| ***Vegetated Swales?*** | |
| ***Vegetated Filter Strips?*** | |
| ***Infiltration Berm/Retentive Grading?*** | |
| **Volume/Peak Rate Reduction** | |
| ***Vegetated Rooftops?*** | |
| ***Capture & Reuse:*** | |
| Cisterns? | |
| Rain Barrels? | |
| Other? | |
| **Runoff Quality/Peak Rate Reduction** | |
| ***Constructed wetland?*** | |
| ***Wet pond/retention basin?*** | |
| ***Dry extended detention basin?*** | |
| ***Water quality filters: Constructed and Other*** | |
| Sand and sand/peat? | |
| Multi-chamber catch basins and inlets? | |
| Other types? | |
| **Other** | |
| ***Level Spreaders?*** | |
| ***Special Detention Storage: Parking Lots, Other*** | |
| **Site Restoration for Stormwater** | |
| ***Riparian Buffer Restoration?*** | |
| ***Landscape Restoration*** | |
| ***Soil Amendment/Restoration*** | |
| **Protocols** | |
| ***Soil Testing*** | |
| ***Site Infiltration*** | |
| **STORMWATER METHODOLOGY AND CALCULATIONS** | SOTRMWATER CALCULATIONS |
| **Iterative Process Occurring Throughout Planning and Design Practices to Max out Non-Structural and Structural Practices** | |
| Use acceptable methods, such as Soil Cover Complex Method (TR-55) for calculations | |
| Do not use Weighted Curve Numbers! | |
| **Strive to:** | |
| Minimize the pre to post development increase in Curve Numbers | |
| Maximize post-development Time of Concentration | |
| Assume "conservative" pre-development cover conditions (i.e., Curve Numbers) such as "Meadow Good" or "Woods" for all pre-development pervious areas? | |
| Respect natural sub-areas in the design and engineering calculations | |
| **Strive To Achieve Standards of Comprehensive Stormwater Management** | |
| No increase in volume of runoff, pre to post development, for up to the 2-yr storm | |
| No reduction in total volume of recharge, for up to the 2-yr storm | |
| No increase in peak rate of runoff, small to large storms | |
| No increase in pollutant loading | |
| **DEVELOP COMPREHENSIVE STORMWATER MANAGEMENT PLAN** | PLAN |
| **Has There Been Thorough Approach To Use of Both Non-Structural and Structural BMP's?** | |
| ***If not, what non-structurals and structurals might be used?*** | |
| ***Should the building program be modified?*** | |
| **What Related Benefits Are Being Achieved Through The Use of BMPs?** | |

## 4.3 Importance of Site Assessment

Comprehensive stormwater management begins with a thorough assessment of the site and its natural systems. Site assessment includes inventorying and evaluating the various natural resource systems which define each site and pose both problems and opportunities for stormwater management. Resources include the full range of natural systems such as water quantity, water quality, floodplains and riparian areas, wetlands, soils, geology, vegetation, and more. Natural systems range in scale from resources of areawide importance on a macro scale, down to micro- and site-specific detail.

### 4.3.1 Background Site Factors

Broader system characteristics should be described, including State Chapter 93 stream classifications, presence of Special Protection Waters, stream order (i.e., 1st order, 2nd order, etc.), source water supply designations, 303d/TMDL/Impaired Stream designations, flooding history, and other information that provides an understanding of how a particular site is functioning within its watershed context. More specific questions would include:

- Does the site drain to special waterbodies with special water quality needs?
- Determine if the site ultimately flows into a reservoir or other water body where special water quality sensitivities exist, such as use as a water supply source.
- Determine if a special fishery exists.
- Determine if the site is linked to a special habitat system, such as delineated in the Pennsylvania Natural Diversity Inventory. For both water quality and temperature reasons, approaches and practices that achieve a higher order of protection may become especially important.

**Are there known downstream flooding problems?**
Determine if a stream system to which the site discharge is currently experiencing flooding problems. This is especially important where urbanization already has occurred and where hydrology already has been altered. Unfortunately, the existing FEMA mapping and related studies do not adequately assess this issue. County agencies and municipal offices may be able to indicate anecdotally the extent to which downstream flooding is already a problem or has the potential to become a problem if substantial additional development is projected. Greater care should be taken in both floodplain management as well as stormwater management if problems exist or are anticipated.

**Does the site discharge to 1st, 2nd, 3rd order streams?**
Another important question relates to the site's location within its watershed. Sites located near the base of watersheds pose less of a threat to the hydrologic characteristics of the watershed system. Sites located farther up the watershed are potentially more problematic when additional stormwater is generated. Perhaps even more critical, sites located within headwaters must be managed most carefully in terms of stormwater to maintain pre-development infiltration and groundwater recharge rates.

### 4.3.2 Site Factors Inventory

Site-specific factors that influence comprehensive stormwater management include the following items:

**How does site size and shape affect stormwater management?**
As site size increases, the ability to use a variety of Non-Structural and Structural BMPs increases. Comprehensive stormwater management, especially through site planning and the use of Non-Structural BMPs, can reduce space requirements at a site and offer greater BMP flexibility. Oddly shaped sites can also be better adapted with BMPs set forth here, given their wide variety of shapes and sizes.

**What are the important natural features characterizing the site?**
At the heart of the comprehensive stormwater management procedure is an understanding of the natural systems characterizing each site. Existing vegetation and soil have tremendous importance and are the key to understanding land development impacts on natural systems. Careful accounting of existing vegetation is an important prerequisite for comprehensive stormwater management, followed closely by soils mapping for permeability ratings, and natural pre-development surface flow patterns. Critical site features, such as wetlands, floodplains, riparian areas, natural drainage ways, special habitat areas, special geological formations (e.g., carbonate), steep slopes, shallow depth to water table, shallow depth to bedrock, and other factors should be inventoried and understood. Critical areas include those with special positive functions that can be translated into real economic value or benefit. Elimination or reduction of these functions through the land development process leads to real economic losses. These special value areas, including wetlands and floodplains and riparian areas, should be conserved and protected during land development. Critical natural areas also include sensitive areas, such as steep slopes, shallow bedrock, high water table areas, and other constraining features, where encroachment by land development typically creates unnecessary or unanticipated problems. Care must be taken to avoid these potential pitfalls.

### 4.3.3 Site Factors Analysis

Identify site factors that constrain comprehensive stormwater management, and identify site factors that can be viewed as opportunities.

**How is the site constrained?**
Determine where buildings, roads, and other disturbance should be avoided and why.

**Where are the zones of site "opportunity," in terms of stormwater management?**
Determine where most infiltration occurs in terms of vegetation and in terms of soils. Both constraints and opportunities are grounded in the natural systems present at the site. Constraints and opportunities are not necessarily simple opposites of one another. For example, certain types of critical natural areas should be viewed as constraints in terms of direct land disturbance and building construction, yet also provide significant opportunity in terms of stormwater management, quantity and quality. Woodlands, which should be protected from direct land development, provide excellent opportunity for stormwater management, provided that the correct approaches and practices are

used. Vegetated riparian buffers should not be disturbed for building and road construction yet they can be used carefully with level spreading devices to receive diffuse stormwater runoff. Soils with maximum permeabilities at the site should not be made impervious with buildings and roads, but used for stormwater management where feasible. Conversely, buildings and other impervious areas should be located on those portions of a site with least permeable soils. Site opportunities for volume control can typically be defined in terms of vegetation types that minimize runoff, as well as soil types with maximum permeabilities.