CHAPTER

5

BETTER SITE DESIGN METHODS (WQv Credits)

5.1 Introduction

Stormwater management begins with the site planning and design process. Development projects can be designed to reduce their impact on watersheds when careful efforts are made to preserve natural areas, reduce impervious cover and better integrate stormwater treatment throughout the proposed development. By implementing a combination of these nonstructural approaches, collectively known as stormwater “better site design” practices, it is possible to reduce the amount of runoff and pollutants that are generated from a site and provide for some nonstructural on-site treatment and control of runoff.

The goals of better site design practices include:

- Managing stormwater (quantity and quality) runoff as close to the point of origin as possible, minimizing the need for large-scale collection and conveyance;
- Preventing stormwater impacts rather than mitigating them;
- Utilizing simple, nonstructural methods for stormwater management that are lower cost and lower maintenance than structural controls;
- Creating a multifunctional landscape; and
- Using hydrology as a framework for site design.

Better site design for stormwater management includes a number of site design techniques that lay-out the natural and proposed man-made site elements in a way that reduces the stormwater impact. This is achieved primarily by reducing the amount of impervious surfaces and utilizing natural features on the site for stormwater management. The aim is to reduce the environmental impact “footprint” of the site while retaining and enhancing the owner/developer’s purpose and vision for the site. Many of the better site design concepts can reduce the cost of infrastructure while maintaining, and in some cases increasing, the value of the property.

Reduction of adverse stormwater runoff impacts through the use of better site design should be the **first** consideration of the design engineer. Operationally, economically, and aesthetically, the use of better site design practices offers significant benefits over treating and controlling runoff downstream. Therefore, it is often advantageous to explore and exhaust all options for better site design before considering structural stormwater controls.

The reduction in runoff and pollutants using better site design techniques can reduce peak discharges and runoff volume that need to be conveyed and controlled on a site and, therefore, the size and cost of necessary drainage infrastructure and structural stormwater controls. In some cases, the use of better site design practices may eliminate the need for structural controls entirely. Hence, better site design concepts can be viewed as both a water quantity and water quality management tool. The use of stormwater better site design can also have a number of other ancillary benefits including:

- Reduced construction costs;
- Increased property values;
- More open space for recreation;
- More pedestrian friendly neighborhoods;
- Protection of sensitive forests, wetlands and habitats;
- More aesthetically pleasing and naturally attractive landscape; and,
- Easier compliance with wetland and other resource protection regulations.

Several of the site design practices described in this section provide a calculable reduction in the volume of water required for treatment. Such a volume reduction is henceforth called a "credit". Section 5.2 discusses each credit in detail, provides the credit criteria and calculation rules, and presents examples of their application. A more general discussion of better site design practices is presented in Section 5.3.

5.2 Water Quality Volume (WQv) Credits

5.2.1 Introduction

Nonstructural stormwater control practices are increasingly recognized as a critical feature in every site design. As such, a set of stormwater "credits" has been developed to provide developers and site designers an incentive to implement better site design practices that can reduce the volume of stormwater runoff and minimize the pollutant loads from a site. The credit system directly translates into cost savings to the developer by reducing the size of structural stormwater control and conveyance facilities.

The basic premise of the credit system is to recognize the water quality benefits of certain site design practices by allowing for a reduction in the water quality treatment volume (WQv). If a developer incorporates one or more of the credited practices in the design of the site, the requirement for capture and treatment of the WQv will be reduced. Site designers are encouraged to utilize as many credits as they can on a site. Greater reductions in stormwater storage volumes can be achieved when many credits are combined (e.g., disconnecting rooftops and protecting natural conservation areas).

5.2.2 Site Planning Using WQv Credits

During the site planning process described in Chapter 4 of this manual, there are several steps involved in site layout and design, each more clearly defining the location and function of the various components of the stormwater management system. The integration of WQv credits can be integrated with this process, as generally shown in Table 5-1.

Table 5-1. Integration of Site Design Credits with Site Development Process

Site Development Phase	Site Design Credit Activity
Initial Site Reconnaissance	• Identify and delineate natural features and potential preservation areas (natural areas, stream buffers, steep slopes, wetlands, springs and sinkholes, etc.). • Identify potential areas for better site design and WQv credits.

Site Development Phase	Site Design Credit Activity
Concept Plan	• Reduce impervious surface area through various better site design techniques. ✓ Preserve natural areas, stream buffers, steep slopes, wetlands, springs, sinkholes and other sensitive areas during site layout. ✓ Identify locations for use of vegetated channels. ✓ Look for areas to disconnect impervious surfaces. • Document the use of any WQv credits.
Design Plan	• Perform layout and design of credit areas – integrating them into treatment trains. • Ensure that WQv and channel protection volume (CPv) are satisfied. • Ensure appropriate documentation of WQv credits in accordance with credit criteria specified in this manual. • Develop maintenance requirements and documents for stormwater facilities and credited areas.
Construction	• Ensure proper protection of preservation areas and buffers. • Ensure correct final construction of areas required to achieve credits.
Final Inspection	• Prepare and submit As-Built certification, including credited areas as appropriate. • Make any necessary corrections to easements on final plats. • Ensure credit areas are identified on final plan and plat if applicable.

5.2.3 General Policies for WQv Credits

The WQv credits that are available in the local municipalities are listed in Table 5-2, and discussed in detail in the following sections.

Table 5-2. Summary of WQv Credits

Credit	Description
Credit 1: Natural area preservation	Undisturbed natural areas are conserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics.
Credit 2: Managed area preservation	Managed areas of open space are preserved on a site, reducing total site runoff and retaining near pre-development hydrologic and water quality characteristics.
Credit 3: Stream and vegetated buffers	Stormwater runoff is treated by directing sheet flow runoff through a naturally vegetated or forested buffer as overland flow.
Credit 4: Vegetated channels	Vegetated channels are used to provide stormwater treatment.

Credit	Description
Credit 5: Impervious area disconnection	Overland flow filtration/infiltration zones are incorporated into the site design to receive runoff from rooftops and other small impervious areas.
Credit 6: Environmentally sensitive large lot neighborhood	A group of site design techniques are applied to low and very low density residential development.

General requirements and policies applicable to all the WQv credits are as follows.

1. WQv credit can only be claimed if the area or practice for which credit is requested conforms to all of the required minimum criteria and conditions stated in Section 5.2 of this manual. Credit will not be given to areas or practices that do not conform to such criteria and conditions. The intent of this policy is to avoid situations that could lead to a credit being granted without the corresponding reduction in pollution attributable to an effective better site design practice.
2. WQv credits cannot be claimed twice for an identical area of the site (e.g. claiming credit for stream buffers and disconnecting rooftops over the same site area).
3. General better site design practices and techniques performed without regard to the criteria and conditions stated herein, many of which are discussed in Section 5.3, will not be awarded WQv credits. However, it is important to remember that these practices, which reduce the overall impervious area on a site, already implicitly reduce the total amount of stormwater runoff generated by a site, and thus reduce the required WQv.

5.2.4 Credit #1: Natural Area Preservation

Description

A credit may be granted when undisturbed, natural areas are preserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics. Under this credit, a site designer can subtract preserved areas from total site area when computing water quality volume requirements. The area can be used as an undisturbed buffer for sheet flow discharge for site design Credit #3, or for sheet flow of disconnected impervious areas under Credit #5. An added benefit of the use of the natural area preservation credit will be that the post-development peak discharges will be smaller for all design events, and hence other required control volumes and peak discharges (i.e., CPv and the locally regulated storm events) will be reduced due to lower post-development curve numbers or rational formula “C” values.

Rule

Subtract preserved natural areas from the total site area (A) when computing the water quality volume (WQv). The percent impervious (I) is held constant when calculating WQv. Areas qualifying for this credit receive a one-hundred percent (100%) TSS reduction value in pollutant reduction computations.

Design/Implementation Criteria

1. The vegetative target for the preserved natural area is undisturbed, mature forest (i.e., trees) with woody shrubs and understory vegetation. Areas that can be characterized as an early successional (i.e., immature) forest, consisting of a combination of grasses, vines, shrubs, tree saplings and possibly even a few mature trees will qualify for the credit.
2. It is preferable that vegetation in the preserved natural area be native and non-invasive.
3. The City may require (or allow if requested by the property owner) restoration or enhancement of preserved natural areas that do not conform to the vegetative requirements stated in item 1 above at the time of development, in order to receive credit.

4. Areas that do not conform to the vegetative target defined in item 1 can be planted with vegetation as appropriate to achieve the vegetative requirements. For these areas, a restoration plan must be submitted that is developed in accordance with the provisions and guidance presented in this manual. Guidance on the natural area restoration plan is provided below. Credit will be granted only after approval of the plan.
5. The preserved natural area cannot be disturbed during project construction without prior approval by the City. If it is already disturbed prior to development or redevelopment, it can be restored as a natural area to receive credit.
6. The limits of disturbance on the site surrounding the preserved natural area shall be clearly shown on all construction drawings. The area must be staked in the field prior to issuance of a grading permit.
7. The preserved natural area shall be protected in perpetuity by deed restrictions, and/or a permanent preservation easement or conservation easement that is recorded with the deed.
8. If the area is not publicly owned, the easement must be held by a viable third party such as a land trust, land management company or utility. The purpose of the third party is to provide monitoring and oversight to ensure the perpetual protection of the area in accordance with the requirements of a conservation or preservation area. The organization shall:
   a. have the legal authority to accept and maintain such easements;
   b. be bona fide and in perpetual existence;
   c. have conveyance instruments that contain an appropriate provision for re-transfer in the event the organization becomes unable to carry-out it functions.
9. The easement and/or deed restriction must give the City the authority to enforce the easement or deed restriction terms.
10. The easement must clearly specify how the natural area vegetation shall be managed and how the boundaries of the area will be marked. (Note: managed turf areas, such as playgrounds and regularly maintained open areas, are not an acceptable form of vegetation management.)
11. The preserved natural area shall have a minimum contiguous area requirement of 10,000 square feet.

Natural Area Restoration Plan Requirements

When vegetative restoration or enhancement of a preserved natural area is desired or required to receive the WQv credit, the City may approve, or require, a natural area restoration plan. The plan must be submitted and approved by the City in order to receive the credit. Natural area restoration plans must include the following information:

1. A drawing or plan that shows the location of the preserved natural area in relation to the existing or planned development. The plan should display the area proposed for restoration and the limits of disturbance, grubbing and grading (if permitted);
2. Best management practices for erosion prevention and sediment control during the vegetation restoration or enhancement (if not already submitted with a stormwater management plan for site development or redevelopment);
3. Verbiage and/or drawings indicating the species and density of proposed vegetation. Mortality must be accounted for in the initial planted density of all vegetation;
4. Verbiage, guidance, and/or drawings indicating the planting practices that will be utilized;
5. A maintenance and monitoring plan for one full growing season; and,
6. An implementation schedule.

Example 5-1 presents an example calculation of the preserved natural area credit. The example utilizes the WQv equation presented in Volume II Chapter 3 of this manual.

Example 5-1. Nature Area Preservation Credit Calculation
Proposed site: residential subdivision
Site area = 38 acres
Preserved natural area = 7 acres
Site impervious area = 13.8 acres
Rainfall depth for 85% storm event = 1.0 inches

Credit Rule: Subtract the preserved natural area from the total site area when computing WQv. The percent impervious (I) is held constant.

I = site percent imperviousness = (13.8 acres)/(38 acres) * 100% = 36.3%

Runoff coefficient = Rv = 0.015 + 0.0092*(I) = 0.015 + 0.0092*(36.3%) = 0.35
Drainage area = total site area – preserved natural area = 38 acres – 7acres = 31 acres

WQv (acre-ft) = P*Rv*A/12
Before credit:
WQv = (1.0 in)*(0.35)*(38 acres)/12 = 1.11 ac-ft
With credit:
WQv = (1.0 in)*(0.35)*(31 acres)/12 = 0.90ac-ft

The preserved natural area credit resulted in a 19% reduction in the WQv required for the site. The area will also receive a 100% TSS reduction value in the TSS calculation.

5.2.5 Credit #2: Stream and Vegetated Buffers

Description

This credit may be granted when stormwater runoff is effectively treated by a stream buffer or other vegetated buffer. Effective treatment constitutes treating runoff as overland sheet flow through an appropriately vegetated and forested buffer. Under this credit, a site designer can subtract areas draining via overland flow to the buffer from total site area when computing water quality volume requirements. The area draining to the buffer and the buffer itself qualify for credit. In addition, the volume of runoff draining to the buffer can be subtracted from the channel protection volume (CPv).

Rule

Subtract areas draining via overland flow to the buffer from total site area when computing the water quality volume (WQv). The Rv value derived from impervious percentage is held constant when calculating WQv. For stream buffers with a grassed outer zone that have been established and managed in accordance with the provisions of Chapter 6 of this manual, the buffer and areas draining to the buffer qualify for the credit and receive an eighty percent (80%) TSS reduction credit. For buffers that are at least fifty (50) feet in width and are comprised entirely of undisturbed forest vegetation, the buffer itself can qualify for credit #1 as a natural conservation area or if preserved as managed open space can qualify for credit #2, while the areas draining to the buffer qualify for the buffer credit and receive an eighty percent (80%) TSS reduction value.

Design/Implementation Criteria

1. This credit is not applicable if the impervious area disconnection credit (Credit 5) is already being applied to the same area.

2. The portion of the buffer that is utilized for stormwater treatment must have a minimum buffer width of fifty (50) feet. If buffer averaging is utilized, portions of the buffer that have a width less than fifty (50) feet are not eligible to receive this credit. Increases in buffer width and/or widths of forest vegetation are strongly encouraged.
3. At a minimum, buffers must be designed and managed (in perpetuity) in accordance with the requirements and policies for water quality buffers presented in Chapter 6 of this manual.
4. Undisturbed, forested buffers that are at least fifty (50) feet wide can qualify for credit #1 as a natural conservation area. Areas preserved as managed open space can qualify for credit #2.
5. Stormwater runoff must enter the buffer as overland sheet flow. A level spreader can be utilized if sheet flow does not occur naturally, or if average contributing slope criteria cannot be met.
6. The minimum contributing length of sheet flow shall be ten (10) feet.
7. The maximum contributing length of sheet flow shall be two-hundred twenty-five (225) feet, with a maximum of one hundred fifty (150) feet for pervious surfaces, and seventy-five (75) feet for impervious surfaces.
8. The average contributing slope shall be three percent (3%) maximum unless a level spreader is used.
9. The design of the buffer treatment system must use appropriate methods for conveying flows above the annual recurrence (1-yr storm) event.

Example 5-2. Stream and Vegetated Buffer Credit Calculation

Residential Subdivision
Site Area = 38 acres
Impervious Area = 13.8 acres
Area of undisturbed forested buffer having a 50' width = 2 acres
Area Draining to Buffer = 5 acres
Rainfall depth for 85% storm event = 1.0 inches

Credit Rule: Subtract the area draining to the buffer when computing WQv. Since this is an undisturbed buffer area at least 50' in width, the area of the buffer can be considered a natural area under credit #1, and therefore can also be subtracted from the total site area when computing WQv. The percent impervious (I) is held constant.
I = site percent imperviousness = (13.8 acres)/(38 acres) * 100% = 36.3%
Runoff coefficient = Rv = 0.015 + 0.0092*(I) = 0.015 + 0.0092*(36.3%) = 0.35
Drainage area = Total site area – buffer area – area draining to buffer
Drainage area = 38 acres – 2 acre – 5 acres = 31 acres

Before credit:
WQv = P*Rv*A/12
WQv = (1.0)(0.35)(38 acres)/12 = 1.11 ac-ft
With credit:
WQv = (1.0)(0.35)(31 acres)/12 = 0.90 ac-ft

The buffer credit resulted in a 19% reduction in the WQv required for the site. The buffer area will also receive a 100% TSS reduction value in the TSS calculation. The area draining to the buffer will receive an 80% TSS reduction value.

5.2.6 Credit #3: Use of Vegetated Channels

This credit may be granted when vegetated (grass) channels are used for water quality treatment. Site designers will be able to subtract the areas draining to a grass channel and the channel area itself from the total site area when computing water quality volume requirements. A vegetated channel may be able to fully meet the water quality volume requirements for certain kinds of low density residential development (see Credit #6). An added benefit will be that the post-development peak discharges will likely be lower due to a longer time of concentration for the site.

Rule

Subtract the areas draining to a vegetated (grass) channel from total site area when computing the water quality volume (WQv). The percent impervious (I) shall be held constant when calculating WQv. Areas qualifying for this credit receive an eighty percent (80%) TSS reduction value.

Design/Implementation Criteria

1. The vegetated channels must be located within a drainage, water quality or preservation easement.
2. The credit shall only be applied to residential land uses that have a maximum density of three (3) dwelling units per acre.
3. The maximum flow velocity in the channel for the WQv design storm shall be less than or equal to one (1.0) feet per second.
4. The minimum residence time for the water quality storm shall be five (5) minutes.
5. The bottom width shall be a maximum of six (6) feet. If a larger channel is needed, use of a compound cross-section (i.e., a benched channel) is required.
6. The side slopes shall be 3:1 (horizontal:vertical) or flatter.
7. This credit will not be granted if engineered grass channels are being used as a limited application structural stormwater control in order to meet the 80% TSS removal goal for WQv treatment.

Example 5-3. Vegetated Channels Credit Calculation

Residential Subdivision
Site Area = 38 acres
Impervious Area = 13.8 acres
Area draining to vegetated channels = 12.5 acres
Rainfall depth for 85% storm event = 1.0 inches
Credit Rule: Subtract the area draining to the vegetated channels when computing WQv. The percent impervious (I) is held constant.

I = site percent imperviousness = (13.8 acres)/(38 acres) * 100% = 36.3%
Runoff coefficient = Rv = 0.015 + 0.0092*(I) = 0.015 + 0.0092*(36.3%) = 0.35
Drainage area = Total site area – area draining to vegetated channels
Drainage area = 38 acres – 12.5 acres = 25.5acres
Before credit:
WQv = P*Rv*A/12
WQv = (1.0)(0.35)(38 acres)/12 = 1.11 ac-ft
With credit:
WQv = (1.0)(0.35)(25.5 acres)/12 = 0.74 ac-ft

The credit resulted in a 33% reduction in the WQv required for the site. The area draining to the channel will also receive an 80% TSS reduction value in the TSS calculation.

5.2.7 Credit #4: Impervious Area Disconnection

This credit may be granted when impervious areas are disconnected from the stormwater control system via overland flow filtration/infiltration (i.e., pervious) zones. These pervious areas are incorporated into the site design to receive runoff from rooftops or other small impervious areas (e.g., driveways, small parking lots, etc). This can be achieved by grading the site to promote overland vegetative filtering or by providing infiltration or "rain garden" areas. If impervious areas are adequately disconnected in accordance with the criteria listed below, they can be deducted from the total site area when computing the water quality volume requirements. An added benefit will be that the post-development peak discharges will likely be lower due to a longer time of concentration for the site.

Rule

If impervious areas are adequately disconnected, they can be deducted from the total site area when computing the water quality volume (WQv). The percent impervious area (I) shall be held constant when calculating WQv. Areas qualifying for this credit receive an 80% TSS reduction value in pollutant reduction computations.

Design/Implementation Criteria

1. For those areas draining directly to a buffer, either the impervious area disconnection credit or the stream buffer credit can be used, but not both.
2. Relatively permeable soils, soil amendments, or placed topsoil (hydrologic soil groups A and B) should be present in the pervious areas that receive discharges from disconnected impervious areas.
3. Impervious area disconnection credits will not be given for areas that have, or will have after development, the land uses listed below:
    a. Developments or facilities that include on-site sewage disposal and treatment systems (i.e., septic systems), raised septic systems, subsurface discharges from a wastewater treatment plant, or land application of biosolids or animal waste;
    b. Landfills (demolition landfills, permitted landfills, closed-in-place landfills);
    c. Junkyards;
    d. Commercial or industrial facilities that store and/or service motor vehicles;
    e. Commercial greenhouses or landscape supply facilities;
    f. Agricultural facilities, farms, feedlots, and confined animal feed operations;
    g. Animal care facilities, kennels, and commercial/business developments or facilities that provide short-term or long-term care of animals; or,
    h. Other land uses deemed by the local municipality to have the potential to generate higher than normal pollutant loadings.
4. The maximum contributing impervious flow path length shall be 75 feet.
5. Downspouts shall be at least 10 feet away from the nearest accessible impervious surface (including off site impervious areas) to discourage "re-connections" or flow concentration along a paved edge.
6. The disconnection shall drain continuously through a vegetated channel, swale, or filter strip to the property line or to a structural stormwater control.
7. The length of the "disconnection" shall be equal to or greater than the contributing length.

8. The entire vegetative disconnection shall be on a slope less than or equal to 3 percent.
9. The impervious surface area to any one point discharge location shall not exceed 5,000 square feet.
10. There must be a note in the final plat that indicates the locations of the disconnected downspouts, and states that such downspouts "shall remain disconnected from the impervious surfaces and shall forever be discharged onto pervious surfaces".

Example 5-4. Impervious Area Disconnection Credit Calculation
Office Building
Site Area = 3.0 acres
Impervious Area = 1.9 acres
Disconnected impervious area = 0.5 acres
Rainfall depth for 85% storm event = 1.0 inches

Credit Rule: Subtract the area disconnected impervious areas when computing WQv. The percent impervious (I) is held constant.

I = site percent imperviousness = (1.9 acres)/(3 acres) * 100% = 63.3%
Runoff coefficient = Rv = 0.015 + 0.0092*(I) = 0.015 + 0.0092*(63.3%) = 0.60

Drainage area = Total site area – disconnected impervious area
Drainage area = 3 acres – 0.5 acres = 2.5 acres

Before credit:
WQv = P*Rv*A/12
WQv = (1.0)(0.60)(3 acres)/12 = 0.15 ac-ft

With credit:
WQv = (1.0)(0.60)(2.5 acres)/12 = 0.13 ac-ft
The credit resulted in an 13% reduction in the WQv required for the site. The disconnected impervious areas will also receive an 80% TSS reduction value in the TSS calculation.

5.2.8 Credit #5: Environmentally Sensitive Large Lot Neighborhoods

This credit is targeted toward large lot residential developments that implement a number of Better Site Design practices to reduce stormwater discharges from the development as a whole. This credit may be granted when a group of environmental site design techniques are applied to low and very low density residential development (e.g., 1 dwelling unit per acre [du/ac] or lower). The credit can eliminate the need for structural stormwater controls to treat water quality volume requirements. This credit will likely have limited application.

Rule

The requirement for structural controls to necessary to achieve the water quality volume treatment design criteria shall be waived.

Design/Implementation Criteria

1. There are two development density options:
   a. The maximum density of the residential development shall be one (1) dwelling unit per acre, and shall have a total impervious cover footprint (including streets, sidewalks, and other impervious infrastructure) no greater than twelve percent (12%); or,
   b. The maximum density of the residential development shall be one (1) dwelling unit per two

(2) acres, and shall have a total impervious cover footprint (including streets, sidewalks and other impervious infrastructure) no greater than fifteen percent (15%).

2. To verify the amount of development in an impervious area, the developer must provide one of the following with the stormwater management plan:
   a. The impervious footprints for roadways and lots, and the calculated percent imperviousness for the site. This option requires the developer to know the housing footprints and the general locations of each house on each lot so that driveway areas can be measured.
   b. The impervious footprint for roadways, the maximum expected impervious footprint per lot, and the calculated percent imperviousness for the development. The developer simply needs to know the size range of housing .to be constructed in the development and to justify the per lot imperviousness based upon the housing size range anticipated.
3. Restrictive covenants, easements or other legal instrument must be used to limit imperviousness for each lot or development, or to set open space aside as perpetually undeveloped. The legal instrument must be conveyed to each property within the development, and must transfer accordingly with any subsequent property transfers.
4. Grass channels shall be used to convey runoff versus curb and gutter.
5. Impervious areas shall be disconnected, in accordance with the criteria set forth in Credit #5, to the maximum extent practicable.

5.3 Better Site Design Practices

5.3.1 Overview

The remainder of this chapter has been developed to provide the developer and/or site designer detailed guidance on the use of a number of better site design practices. While the better site design practices presented herein are not required by the City, they are strongly encouraged. A number of these practices can be utilized to gain WQv credits, as discussed previously in this chapter. However, beyond the credits, there is strong incentive to utilize better site design practices that is provided by the use of the WQv approach. That is, the goal of many better site design practices is the reduction of imperviousness which, in the WQv approach, will reduce the volume of stormwater runoff required for treatment.

5.3.2 Incorporating Better Site Design Practices into Site Design Process

Better site design should be done in unison with the design and layout of stormwater infrastructure in attaining the stormwater management goals and criteria discussed in Chapters 1 and 3 of Volume II of this manual. Figure 5-1 illustrates the four major steps of the site design process.

Figure 5-1. Stormwater Better Site Design Process

The first step in stormwater better site design involves identifying significant natural features and resources on a site such as undisturbed forest areas, stream buffers and steep slopes that should be preserved to retain some of the original hydrologic function of the site. Next, the site layout is designed such that these conservation areas are preserved and the impact of the development is minimized. A number of techniques can then be used to reduce the overall imperviousness of the development site. Finally, natural features and conservation areas can be utilized to serve stormwater quantity and quality management purposes.

5.3.3 Discussion of Better Site Design Practices

The stormwater better site design practices and techniques covered in this chapter are grouped into four categories and are listed below:

❑ **Conservation of Natural Features and Resources**

- Preserve undisturbed natural areas
- Preserve riparian (i.e., stream) buffers
- Avoid development and grading in floodplains
- Avoid steep slopes
- Minimize development on porous or erodible soils

❑ **Lower Impact Site Design Techniques**

- Fit design to the terrain
- Locate development in less sensitive areas
- Reduce limits of clearing and grading
- Utilize open space development
- Consider creative development design

- **Reduction of Impervious Cover**
  - Reduce roadway lengths and widths
  - Reduce building footprints
  - Reduce the parking footprint
  - Reduce setbacks and frontages
  - Use fewer or alternative cul-de-sacs
  - Create parking lot stormwater "islands"

- **Utilization of Natural Features for Stormwater Management**
  - Use buffers and undisturbed areas
  - Use natural drainageways instead of storm sewers
  - Use vegetated swales instead of curb and gutter
  - Drain rooftop runoff to pervious areas

More detail on each site design practice is provided in the Stormwater Better Site Design Practice Summary Sheets in subsections that follow. These summaries provide the key benefits of each practice, examples and details on how to apply them in site design.

5.3.4 Conservation of Natural Features and Resources

Conservation of natural features is integral to better site design. The first step in the better site design process is to identify and preserve the natural features and resources that can be used in the protection of water resources by reducing stormwater runoff, providing runoff storage, reducing flooding, preventing soil erosion, promoting infiltration, and removing stormwater pollutants. Some of the natural features that should be taken into account include:

- Areas of undisturbed vegetation;
- Floodplains and riparian areas;
- Ridgetops and steep slopes;
- Natural drainage pathways;
- Intermittent and perennial streams;
- Wetlands;
- Groundwater recharge/well head areas;
- Soils;
- Shallow bedrock or high water table;
- Other natural features or critical areas.

Some of the ways used to conserve natural features and resources described over the next several pages include the following methods, which correspond to the fact sheets that follow:

1. Preserve undisturbed natural areas
2. Preserve riparian buffers
3. Avoid floodplains
4. Avoid steep slopes
5. Minimize development on porous or erodible soils

Delineation of natural features is typically done very early in the development process, through an analysis of the features and resources on the site. From this site analysis, the preservation and protection of natural features can be integrated into the vision for the prior to development of the concept plan.

Better Site Design Practice #1:
Preserve Undisturbed Natural Areas

Conservation of Natural Features and Resources

Description: Important natural features and areas such as undisturbed forested and vegetated areas, natural drainageways, steep slopes, stream corridors, wetlands, erodible soils and other important site features should be delineated and placed into conservation areas.

KEY BENEFITS

- Preserves a portion of the site's natural hydrology prior to development.
- Can be used as filtering and infiltration zones for stormwater runoff from developed areas.
- Preserves some of the site's natural character and aesthetic features.
- May increase the value of the developed property.
- A stormwater site design credit can be taken if the area complies with the criteria listed in section 5.2.

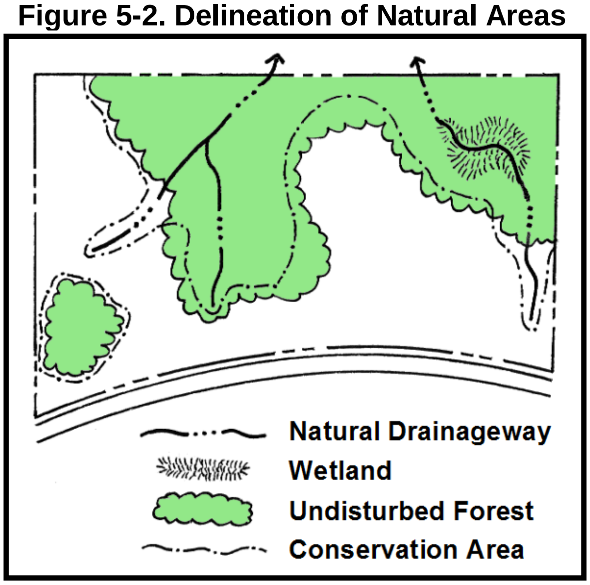
USING THIS PRACTICE

- ☑ Delineate natural areas before performing site layout and design.
- ☑ Ensure that conservation areas and native vegetation are protected in an *undisturbed state* throughout construction and occupancy.

Preserving natural conservation areas such as undisturbed forested and vegetated areas, natural drainageways, stream corridors and wetlands on a development site helps to preserve the original hydrology of the site and aids in reducing the generation of stormwater runoff and pollutants. Undisturbed vegetated areas also promote soil stabilization and provide for filtering, infiltration and evapotranspiration of runoff.

Natural conservation areas are typically identified through a site analysis using maps and aerial/satellite photography, or by conducting a site visit. These areas should be delineated before any site design, clearing or construction begins. When done before the concept plan phase, the planned conservation areas can be used to guide the layout of the site. Figure 5-2 shows a site map with undisturbed natural areas delineated.

Figure 5-2. Delineation of Natural Areas



Preserved natural areas should be incorporated into site plans and clearly marked on all construction and grading plans to ensure that equipment is kept out of these areas and that native vegetation is kept in an undisturbed state. The boundaries of each natural area should be mapped by carefully determining the limit which should not be crossed by construction activity.

Once established, natural areas should be managed by a responsible party that is able to maintain the areas in a natural state in perpetuity. Typically, conservation areas are protected by legally enforceable deed restrictions, conservation easements, and maintenance agreements. If the natural area is utilized for WQv credits, the City requires the use of a responsible third party to achieve the perpetual preservation of the area. Refer to Credit #1 for more information on the Natural Area Preservation Credit.

Better Site Design Practice #2:
Preserve Riparian Buffers

Conservation of Natural Features and Resources

Description: Preserve naturally vegetated buffers along perennial streams, rivers, lakes, and wetlands.

KEY BENEFITS	USING THIS PRACTICE
• Can be used as nonstructural stormwater filtering and infiltration zones. • Keeps structures out of the floodplain and provides a right-of-way for large flood events. • Helps to preserve riparian ecosystems and habitats. • A stormwater site design credit can be taken if it fulfills the criteria listed in section 5.2.	☑ Delineate and preserve naturally vegetated riparian buffers. ☑ Ensure that buffers are established, maintained and protected in accordance with guidance set forth in Volume II Chapter 6.

As discussed subsequently in Chapter 6, buffers are a special type of natural conservation area located along a stream, wetland or pond/lake where development is restricted or prohibited. In the City, water quality buffers are required on all waterbodies that can be designated as "community waters" as defined in this manual. Such buffers must be established, maintained and protected in accordance with the provisions of Chapter 6 of this manual. This section simply provides some general information about buffers.

Figure 5-3. Riparian Stream Buffer

The primary function of buffers is to protect and physically separate a waterbody from future disturbance or encroachment. If properly designed, a buffer can provide stormwater management functions, can act as a right-of-way during floods, and can sustain the integrity of stream ecosystems and habitats. An example of a riparian stream buffer is shown in Figure 5-3. The City's buffer requirements include provisions for a minimum fifty (50) foot dual-zone, forested and grassed buffer along streams, and a minimum twenty-five (25) foot one-zone forested or grass buffer around wetlands and ponds/lakes, respectively.

In general, forested zones of buffers should be maintained and reforestation should be encouraged where no wooded buffer exists. Chapter 6 of this manual contains provisions and guidance for buffer reforestation (herein called "enhancement"). Proper enhancement of forested areas should include all layers of the forest plant community, including understory shrubs and groundcover, not just trees. Native vegetation is required in forested zones. Impervious areas are prohibited in all areas of the buffer.

Better Site Design Practice #3:
Avoid Floodplains

Conservation of Natural Features and Resources

Description: Development in floodplain areas should be avoided to minimize potential property damages and safety risks, and to allow the natural stream corridor to accommodate flood flows.

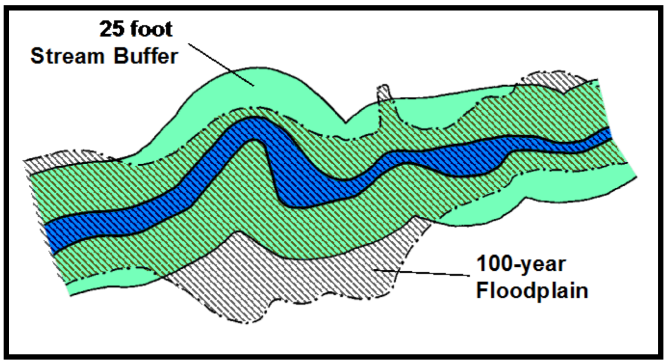
KEY BENEFITS	USING THIS PRACTICE
• Provides a natural right-of-way and temporary storage for large flood events. • Keeps people and structures out of potentially flooded areas. • Helps to preserve riparian ecosystems and habitats. • Can be combined with riparian buffer protection to create linear greenways.	☑ Be aware of the City's floodplain development requirements. ☑ Do not encroach into designated floodplain areas. Maps are available from the City.

Floodplains are the low-lying flat lands that border streams and rivers. When a stream reaches its capacity and overflows its channel after storm events, the floodplain provides the natural storage and conveyance areas for these excess flows. When left in a naturally vegetated state with forest, shrubs and other woody vegetation, floodplains can provide a reduction in discharge velocities and peak discharges rates during flood events. Floodplains also play an important role in reducing sedimentation and filtering runoff, and provide habitat for both aquatic and terrestrial life. Development in floodplain areas can reduce the ability of the floodplain to convey stormwater, potentially causing safety problems or significant damage to the site in question, as well as to both upstream and downstream properties. As participant communities of the National Flood Insurance Program (NFIP), the City regulates the use of floodplain areas to minimize the risk to human life as well as to avoid flood damage to structures and property.

As such, all floodplain areas should be avoided on a development site. Ideally, the entire 100-year floodplain should be avoided for clearing or building activities, and should be preserved in a natural undisturbed state where possible. At a minimum, developers should also ensure that their site design complies with the City's floodplain requirements. Floodplain maps and flood elevation profiles can be obtained from the City.

Floodplain protection is complementary to riparian buffer preservation. Both practices preserve stream corridors in a natural state and allow for the protection of vegetation and habitat. Depending on the site topography, 100-year floodplain boundaries may lie inside or outside of a preserved riparian buffer corridor, as shown in Figure 5-4.

Figure 5-4. Floodplain and Buffer



Better Site Design Practice #4:
Avoid Steep Slopes

Conservation of Natural Features and Resources

Description: Development on steep slopes should be avoided due to the potential for soil erosion and increased sediment loading to nearby streams. Excessive grading and flattening of hills and ridges should be minimized.

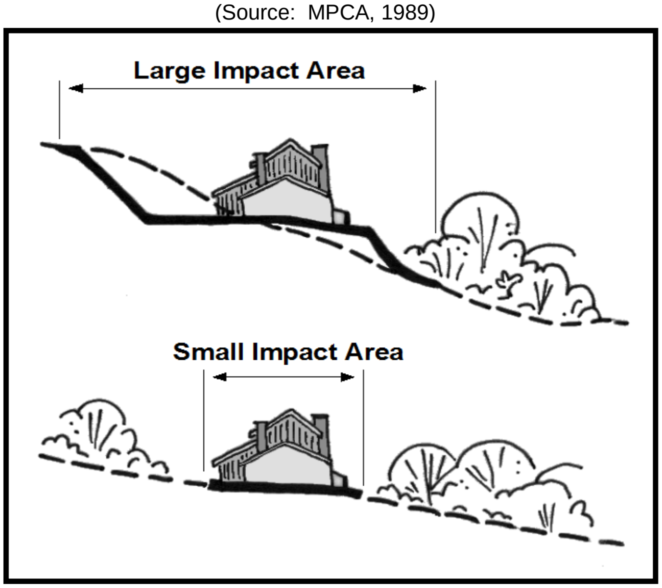
KEY BENEFITS	USING THIS PRACTICE
• Preserving steep slopes helps to prevent soil erosion and degradation of stormwater runoff. • Steep slopes can be kept in an undisturbed natural condition to help stabilize hillsides and soils. • Building on flatter areas will reduce the need for cut-and-fill and grading.	☑ Avoid development on steep slope areas, especially those with a grade of 15% or greater. ☑ Fit the development into the natural terrain, as opposed to modifying the terrain to fit the development. ☑ Minimize grading and flattening of hills and ridges.

Development in steep slope areas has the potential to cause excessive soil erosion and stormwater runoff during and after construction. Past studies by the Soil Conservation Service (now Natural Resource Conservation Service) and others have shown that soil erosion is significantly increased on slopes of 15 percent or greater. In addition, greater areas of soil and land area are disturbed when development is located on steep slopes as compared to flatter slopes. This is demonstrated in Figure 5-5.

Therefore, development on slopes with a grade of 15 percent or greater should be avoided to limit soil loss, erosion, excessive stormwater runoff, and the degradation of surface water. Excessive grading should be avoided on all slopes, as should the flattening of hills and ridges. Steep slopes should be kept in an undisturbed natural condition to help stabilize hillsides and soils.

On slopes greater than 25 percent, no development, regrading, or stripping of vegetation should be considered unless the disturbance is for roadway crossings or utility construction and it can be demonstrated that the roadway or utility improvements are absolutely necessary in the sloped area.

Figure 5-5. Impacts of Development on Slopes
(Source: MPCA, 1989)



Better Site Design Practice #5:

Minimize Development on Porous and Erodible Soils

Conservation of Natural Features and Resources

Description: Porous soils such as sand and gravels provide an opportunity for groundwater recharge of stormwater runoff and should be preserved as a potential stormwater management option. Unstable or easily erodible soils should be avoided because they are more likely to erode.

KEY BENEFITS	USING THIS PRACTICE
• Areas with highly permeable soils can be used for infiltration of stormwater runoff. WQv credits can be taken if the area complies with the criteria listed in section 5.2, potentially for a Natural Area Preservation credit or Impervious Area Disconnection credit. • Avoiding high erodible or unstable soils can prevent erosion and sedimentation problems and water quality degradation.	☑ Use soil surveys to determine site soil types. ☑ Leave areas of porous or highly erodible soils as undisturbed preservation areas.

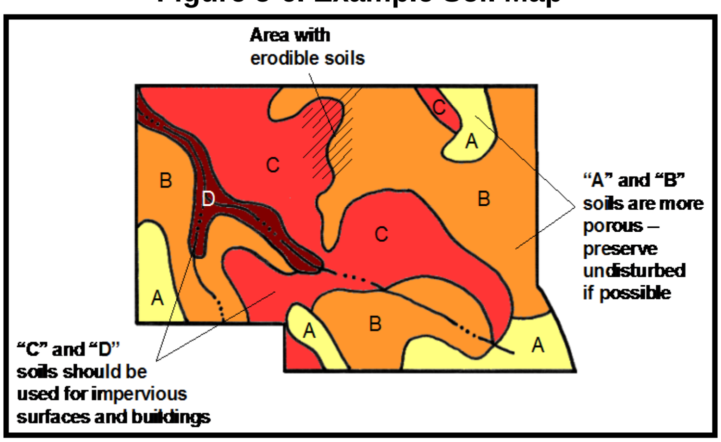
Infiltration of stormwater into the soil reduces both the volume and peak discharge of runoff from a given rainfall event, and also provides for water quality treatment and groundwater recharge. Soils with maximum permeability (hydrologic soil group A and B soils, such as sands and sandy loams) allow for the most infiltration of runoff into the subsoil. Thus, areas of a site with these soils should be conserved as much as possible and these areas should ideally be incorporated into undisturbed natural or open space areas. Conversely, buildings and other impervious surfaces should be located on those portions of the site with the *least* permeable soils.

Similarly, areas on a site with highly erodible or unstable soils should be avoided for land disturbing activities and buildings to prevent erosion and sedimentation problems as well as potential future structural problems. These areas should be left in an undisturbed and vegetated condition.

Soils on a development site should be mapped in order to preserve areas with porous soils, and to identify those areas with unstable or erodible soils as shown in Figure 5-6. The City soil surveys can provide a considerable amount of information relating to all relevant aspects of soils. Soil surveys are available from the local National Resource Conservation Service office.

General soil types should be delineated on concept site plans to guide site layout and the placement of buildings and impervious surfaces.

Figure 5-6. Example Soil Map



5.3.5 Low Impact Site Design Techniques

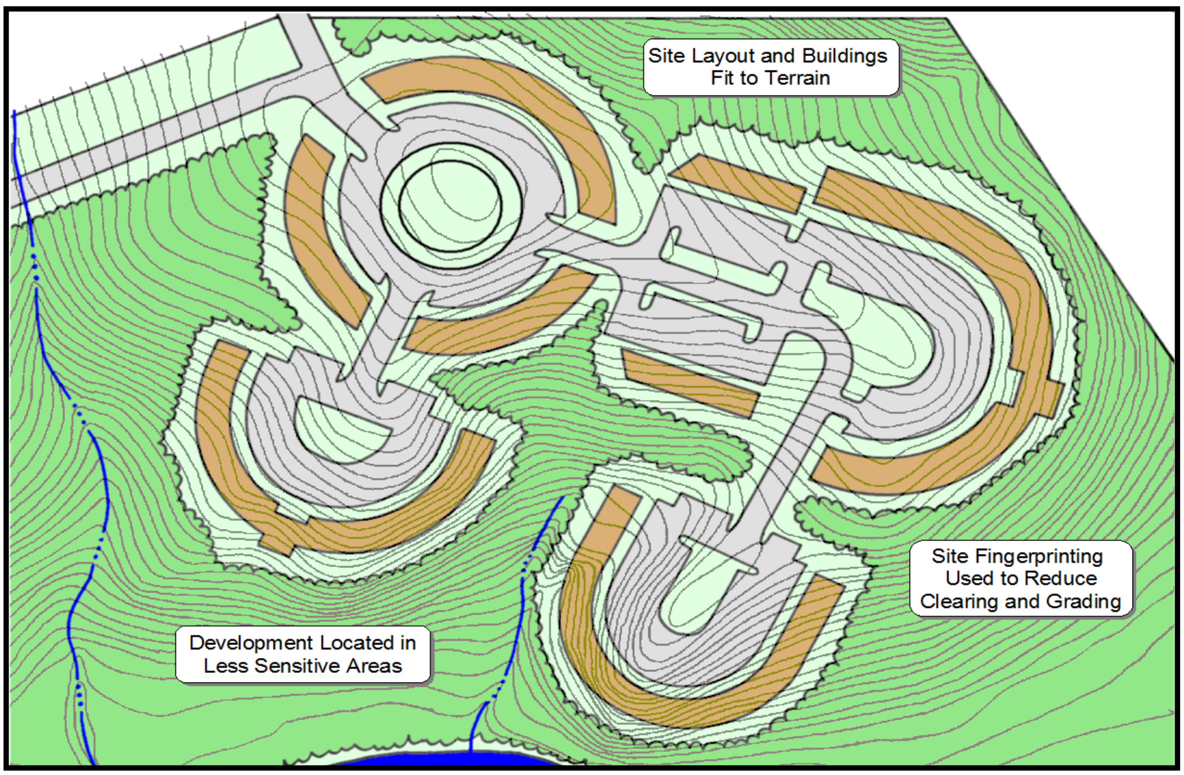
After a site analysis has been performed and conservation areas have been delineated, there are numerous opportunities in the site design and layout phase to reduce both water quantity and quality impacts of stormwater runoff. These primarily deal with the location and configuration of impervious surfaces or structures on the site and include the following practices and techniques covered over the next several pages:

5. Fit the Design to the Terrain
6. Locate Development in Less Sensitive Areas
7. Reduce Limits of Clearing and Grading
8. Utilize Open Space Development
9. Consider Creative Development Design

The goal of low impact site design techniques is to lay out the elements of the development project in such a way that the site design (i.e. placement of buildings, parking, streets and driveways, lawns, undisturbed vegetation, buffers, etc.) is optimized for effective stormwater management. That is, the site design takes advantage of the site's natural features, including those placed in conservation areas, as well as any site constraints and opportunities (topography, soils, natural vegetation, floodplains, shallow bedrock, high water table, etc.) to prevent both on-site and downstream stormwater impacts.

Figure 5-7. shows a development that has utilized several low impact site design techniques in its overall layout and design.

Figure 5-7. Example of Lower Impact Site Design Techniques



Better Site Design Practice #6:
Fit Design to the Terrain

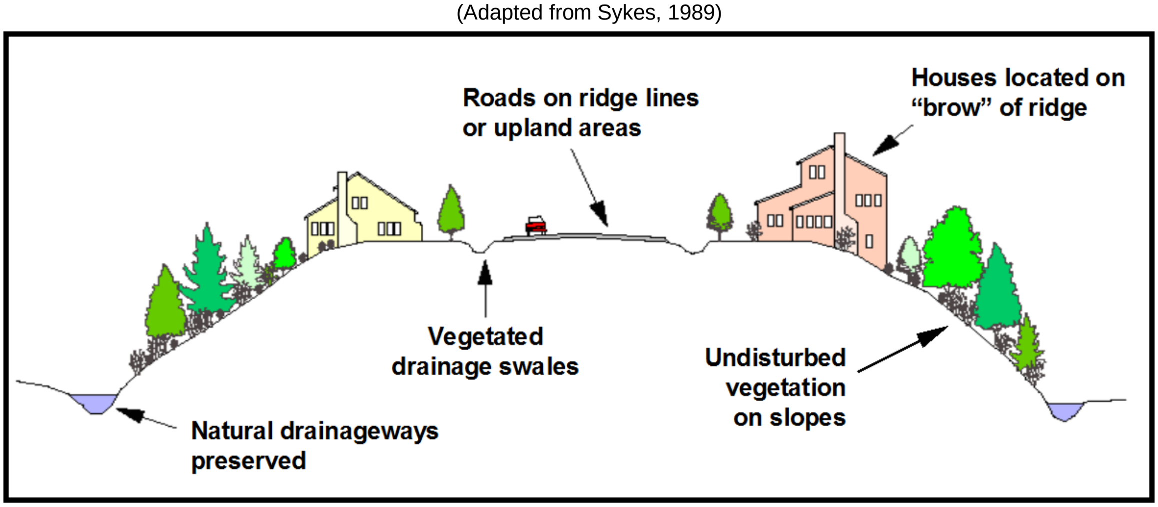
**Low Impact
Site Design Techniques**

Description: The layout of roadways and buildings on a site should generally conform to the landforms on a site. Natural drainageways and stream buffer areas should be preserved by designing road layouts around them. Buildings should be sited to utilize the natural grading and drainage system and avoid the unnecessary disturbance of vegetation and soils.

KEY BENEFITS	USING THIS PRACTICE
• Helps to preserve the natural hydrology and drainageways of a site. • Reduces the need for grading and land disturbance. • Provides a framework for site design and layout.	☑ Develop roadway patterns to fit the site terrain. ☑ Locate buildings and impervious surfaces away from steep slopes, drainageways, and floodplains.

All site layouts should be designed to conform with or "fit" the natural landforms and topography of a site. This helps to preserve the natural hydrology and drainageways on the site, as well as reduces the need for grading and disturbance of vegetation and soils. Figure 5-8 illustrates the placement of roads and homes in a residential development.

Figure 5-8. Preserving the Natural Topography of the Site
(Adapted from Sykes, 1989)



Roadway patterns on a site should match the terrain. In rolling or hilly terrain, streets should be designed to follow natural contours to reduce clearing and grading. Street hierarchies with local streets branching from collectors in short loops, and cul-de-sacs located along ridgelines help to prevent the crossing of streams and drainageways as shown in Figure 5-9. In flatter areas, a traditional grid pattern of streets or "fluid" grids which bend and may be interrupted by natural drainageways may be more appropriate (see Figure 5-10). In either case, buildings and impervious surfaces should be kept off of steep slopes, away from natural drainageways, and out of floodplains and other lower lying areas. In addition, the major axis of buildings should be oriented parallel to existing contours.

Figure 5-9. Example Subdivision Design for Hilly or Steep Terrain

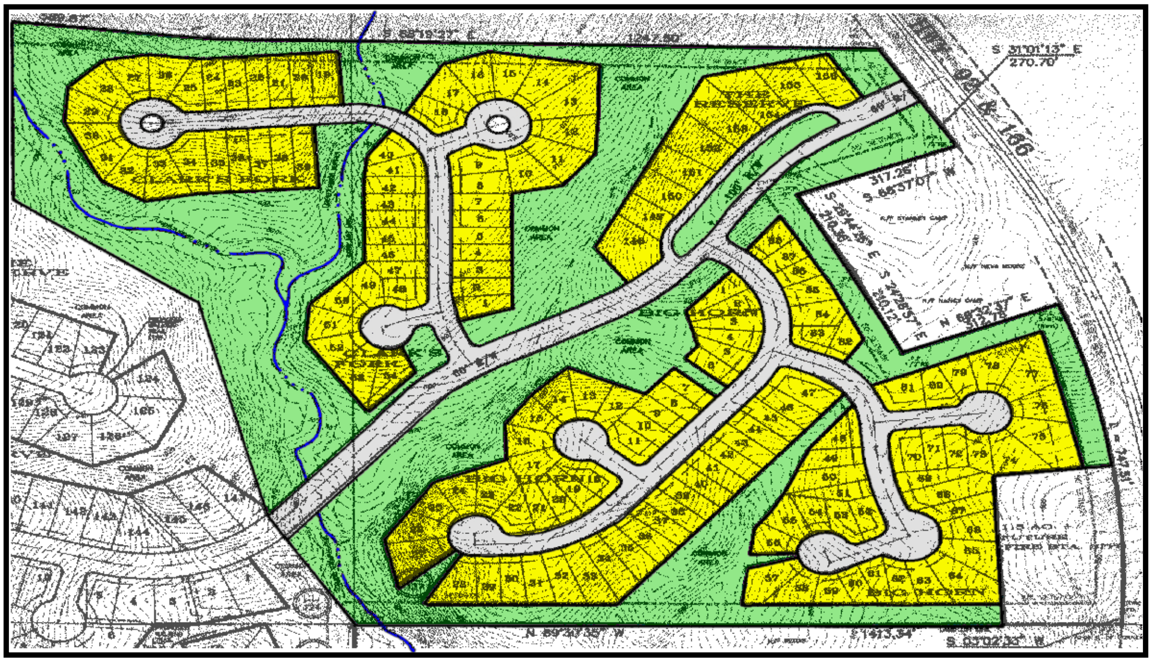
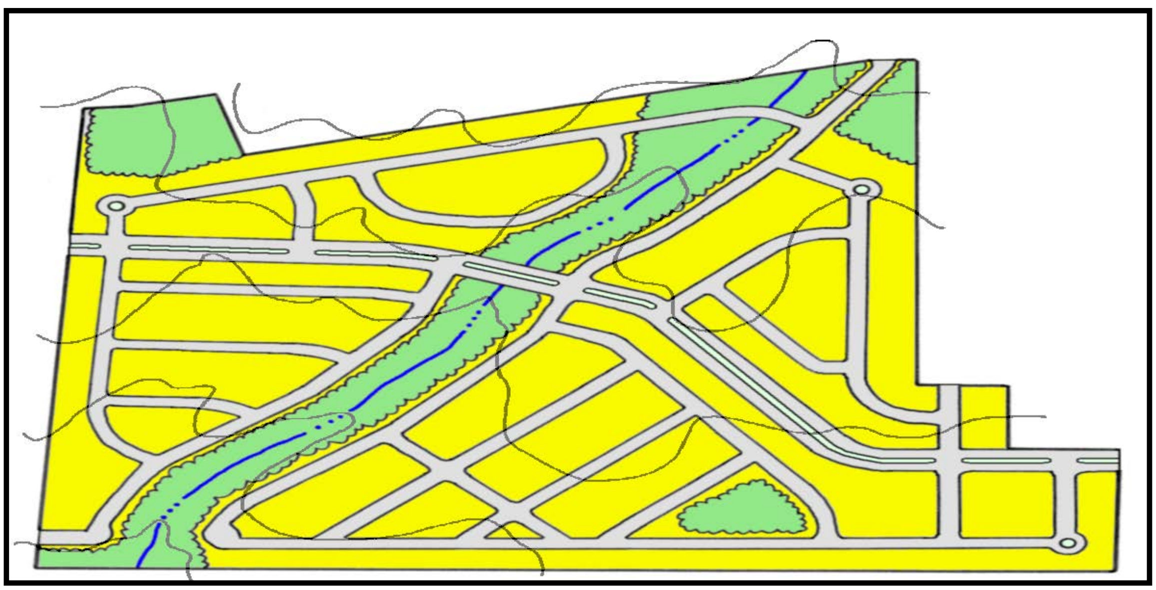


Figure 5-10. Example Subdivision Design for Flat Terrain



Better Site Design Practice #7:
Locate Development in Less Sensitive Areas

Low Impact
Site Design Techniques

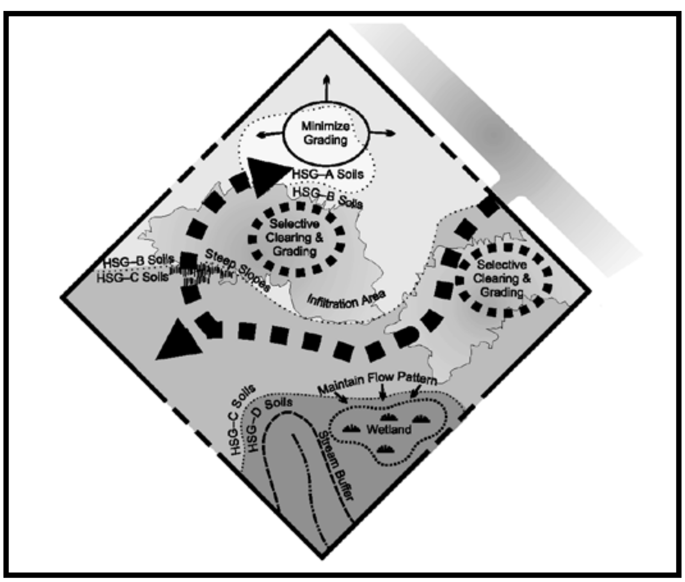
Description: To minimize the hydrologic impacts on the existing site land cover, the area of development should be located in areas of the site that are less sensitive to disturbance or have a lower value in terms of hydrologic function.

KEY BENEFITS	USING THIS PRACTICE
• Helps to preserve the natural hydrology and drainageways of a site. • Makes the most efficient use of natural site features for preventing and mitigating stormwater impacts. • Provides a framework for site design and layout.	☑ Lay out the site design to minimize the hydrologic impact of structures and impervious surfaces.

In much the same way that a development should be designed to conform to terrain of the site, a site layout should also be designed so that the areas of development are placed in the locations of the site that minimize the hydrologic impact of the project. This is accomplished by steering development to areas of the site that are less sensitive to land disturbance or have a lower value in terms of hydrologic function using the following methods:

- Locate buildings and impervious surfaces away from stream corridors, wetlands and natural drainageways. Use buffers to preserve and protect riparian areas and corridors.
- Areas of the site with porous soils should left in an undisturbed condition and/or used as stormwater runoff infiltration zones. Buildings and impervious surfaces should be located in areas with less permeable soils.

Figure 5-11. Guiding Development to Less Sensitive Areas of a Site
(Source: Prince George's County, MD, 1999)



- Avoid construction on areas with steep slopes or unstable soils.
- Minimize the clearing of areas with dense tree canopy or thick vegetation. Ideally, preserve these areas natural conservation areas
- Ensure that natural drainageways and flow paths are preserved, where possible. Avoid the filling or grading of natural depressions and ponding areas.

Figure 5-11 shows a development site where the natural features have been mapped in order to delineate the sensitive areas. Through careful site planning, sensitive areas can be set aside as natural open space areas In many cases, such areas can be used as buffer spaces between land uses on the site or between adjacent sites.

Better Site Design Practice #8:
Reduce Limits of Clearing and Grading

Low Impact
Site Design Techniques

Description: Clearing and grading of the site should be limited to the minimum amount needed for the development and road access. Site footprinting should be used to disturb the smallest possible land area on a site.

KEY BENEFITS	**USING THIS PRACTICE**
• Preserves more undisturbed natural areas on a development site. • Techniques can be used to help protect natural conservation areas and other site features.	☑ Establish the limits of disturbance for all development activities. ☑ Use site footprinting to minimize clearing and land disturbance.

Minimal disturbance methods should be used to limit the amount of clearing and grading that takes place on a development site, preserving more of the undisturbed vegetation and natural hydrology of a site. These methods include:

- Establishing a limit of disturbance (LOD) based on maximum disturbance zone radii/lengths. These maximum distances should reflect reasonable construction techniques and equipment needs together with the physical situation of the development site such as slopes or soils. LOD distances may vary by type of development, size of lot or site, and by the specific development feature involved.
- Using site "footprinting" which maps all of the limits of disturbance to identify the smallest possible land area on a site which requires clearing or land disturbance. Examples of site footprinting are illustrated in Figures 5-12 and 5-13.
- Fitting the site design to the terrain.
- Using special procedures and equipment which reduce land disturbance.

Figure 5-12. Example of Limits of Clearing
(Source: DDNREC, 1997)

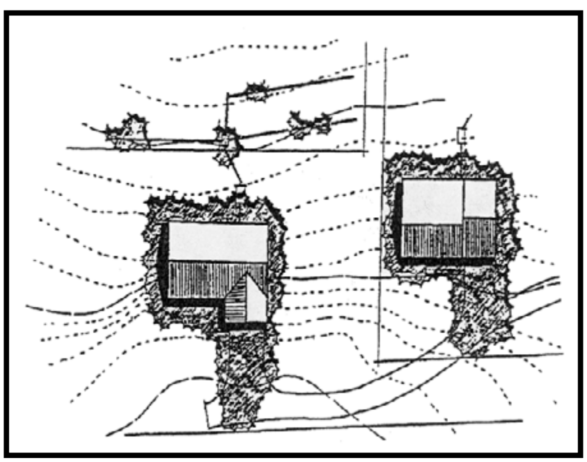


Figure 5-13. Example of Site Footprinting

Better Site Design Practice #9:
Utilize Open Space Development

Low Impact
Site Design Techniques

Description: Open space site designs incorporate smaller lot sizes to reduce overall impervious cover while providing more undisturbed open space and protection of water resources.

KEY BENEFITS	USING THIS PRACTICE
• Preserves conservation areas. • Can be used to preserve natural hydrology and drainagways. • Can be used to help protect natural conservation areas and other site features. • Reduces the need for grading and land disturbance. • Reduces infrastructure needs and overall development costs.	☑ Use a site design which concentrates development and preserves open space and natural areas of the site.

Open space development, also known as *conservation development* or *clustering*, is a better site design technique that concentrates structures and impervious surfaces in a compact area in one portion of the development site in exchange for providing open space and natural areas elsewhere on the site. Typically smaller lots and/or nontraditional lot designs are used to cluster development and create more conservation areas on the site.

Open space developments have many benefits compared with conventional commercial developments or residential subdivisions: they can reduce impervious cover, stormwater pollution, construction costs, and the need for grading and landscaping, while providing for the conservation of natural areas. Figures 5-14 presents an example of the concept of open space site design for a residential area. Figure 5-15 provides an example of an existing open space development.

Along with reduced imperviousness, open space designs provide a host of other environmental benefits that most conventional designs lack. These developments reduce potential pressure to encroach on conservation and buffer areas because enough open space is usually reserved to accommodate these protection areas. Since less land is cleared during the construction process, alteration of the natural hydrology and the potential for soil erosion are also greatly diminished. Perhaps most importantly, open space design reserves 25 to 50 percent of the development site in conservation areas that would not otherwise be protected.

Open space developments can also be significantly less expensive to build than conventional projects. Most of the cost savings are due to reduced infrastructure cost for roads and stormwater management controls and conveyances. While open space developments are frequently less expensive to build, developers find that these properties often command higher prices than those in more conventional developments. Several studies estimate that residential properties in open space developments garner premiums that are higher than conventional subdivisions and moreover, sell or lease at an increased rate.

Once established, common open space and natural conservation areas must be managed by a responsible party able to maintain the areas in a natural state in perpetuity. Typically, the conservation areas are protected by legally enforceable deed restrictions, conservation easements, and maintenance agreements.

Figure 5-14. Open Space Subdivision Site Design Example

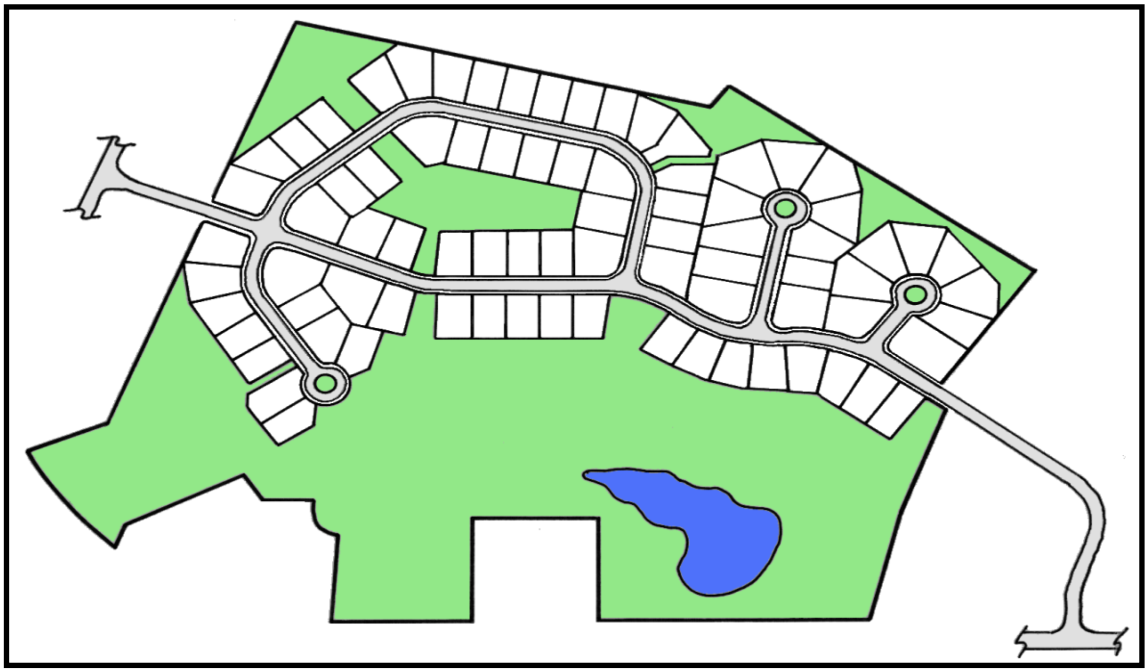


Figure 5-15. Aerial View of an Open Space Subdivision

Better Site Design Practice #10:
Consider Creative Development Design

Low Impact
Site Design Techniques

Description: Planned Unit Developments (PUDs) allow a developer or site designer the flexibility to design a residential, commercial, industrial, or mixed-use development in a fashion that best promotes effective stormwater management and the protection of environmentally sensitive areas.

KEY BENEFITS	USING THIS PRACTICE
• Allows flexibility to developers to implement creative site designs which include stormwater better site design practices. • May be useful for implementing an open space development.	☑ Check with the Metropolitan Planning Commission to determine the type and nature of deviations allowed and other criteria for receiving PUD approval.

A Planned Unit Development (PUD) is a type of planning approval available in some communities which provides greater design flexibility by allowing deviations from the typical development standards required by the local zoning code with additional variances or zoning hearings.

The intent is to encourage better designed projects through the relaxation of some development requirements, in exchange for providing greater benefits to the community. PUDs can be used to implement many of the other stormwater better site design practices covered in this Manual and to create site designs that maximize natural nonstructural approaches to stormwater management.

Examples of the types of zoning deviations which are often allowed through a PUD process include:

- Allowing uses not listed as permitted, conditional or accessory by the zoning district in which the property is located
- Modifying lot size and width requirements
- Reducing building setbacks and frontages from property lines
- Altering parking requirements
- Increasing building height limits

Many of these changes are useful in reducing the amount of impervious cover on a development site (see Better Site Design Practices #11 through #16).

5.3.6 Reduction of Impervious Cover

The amount of impervious cover, i.e. rooftops, parking lots, roadways, sidewalks and other hardened surfaces that do not allow rainfall to infiltrate into the soil, is an essential factor to consider in better site design for stormwater management. Increased impervious cover means increased stormwater generation and increased pollutant loadings.

By reducing the area of total impervious surface on a site, a site designer can directly reduce the volume of stormwater runoff and associated pollutants that are generated by a site. It can also reduce the size and cost of infrastructure for stormwater drainage, conveyance, and control and treatment. Some of the ways that impervious cover can be reduced in a development include:

- # 11. Reduce Roadway Lengths and Widths
- # 12. Reduce Building Footprints
- # 13. Reduce the Parking Footprint
- # 14. Reduce Setbacks and Frontages
- # 15. Use Fewer or Alternative Cul-de-Sacs
- # 16. Create Parking Lot Stormwater Islands

Figure 5-16. shows an example of a residential subdivision that employed several of these principles to reduce the overall imperviousness of the development. The next several pages cover these methods in more detail.

Figure 5-16. Examples (clockwise from upper left): (a) Cul-de-sac with Landscaped Island; (b) Narrower Residential Street; (c) Landscape Median in Roadway; and (d) "Green" Parking Lot with Landscaped Islands

Better Site Design Practice #11:
Reduce Roadway Lengths and Widths

Reduction of Impervious Cover

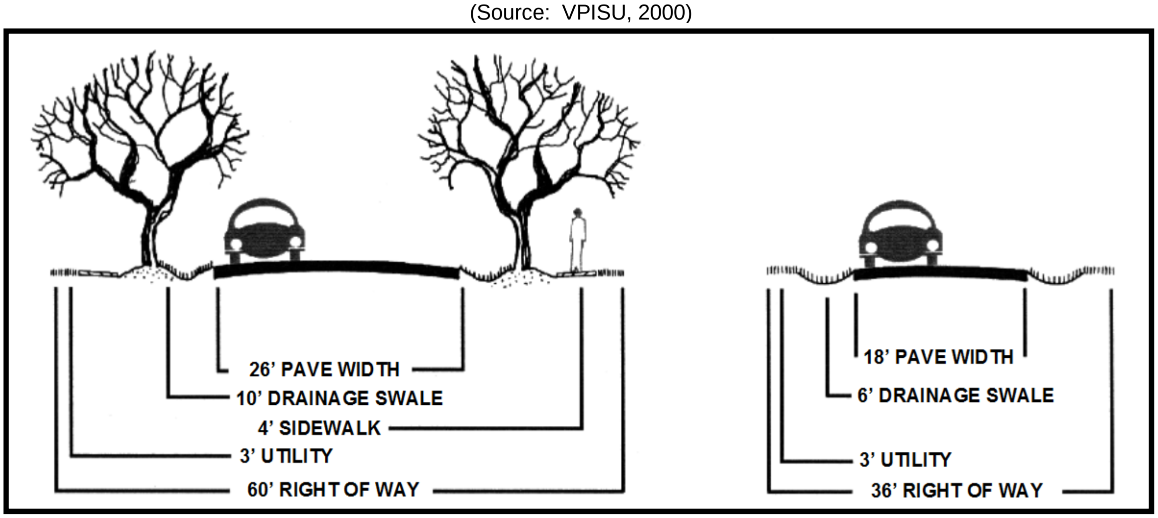
Description: Roadway lengths and widths should be minimized on a development site where possible to reduce overall imperviousness.

KEY BENEFITS	USING THIS PRACTICE
• Reduces the amount of impervious cover and associated runoff and pollutants. • Reduces the costs associated with road construction and maintenance.	☑ Consider different site and road layouts that reduce overall street length. ☑ Minimize street widths by using narrower street designs.

The use of alternative road layouts that reduce the total linear length of roadways can significantly reduce overall imperviousness of a development site. Site designers are encouraged to analyze different site and roadway layouts to see if they can reduce overall street length. The length of local cul-de-sacs and cross streets should be shortened to a maximum of 200 ADT (average trips per day) to minimize traffic and road noise so that shorter setbacks may be employed.

In addition, residential streets and private streets within commercial and other development should be designed for the minimum required pavement width needed to support travel lanes, on-street parking, and emergency access. Figure 5-17 shows a number of different options for narrower street designs. Many times on-street parking can be reduced to one lane or eliminated on local access roads with less than 200 ADT on cul-de-sac streets and 400 ADT on two-way loops. One-way single-lane loop roads are another way to reduce the width of lower traffic streets.

Figure 5-17. Potential Design Options for Narrower Roadway Widths
(Source: VPISU, 2000)



Better Site Design Practice #12:
Reduce Building Footprints

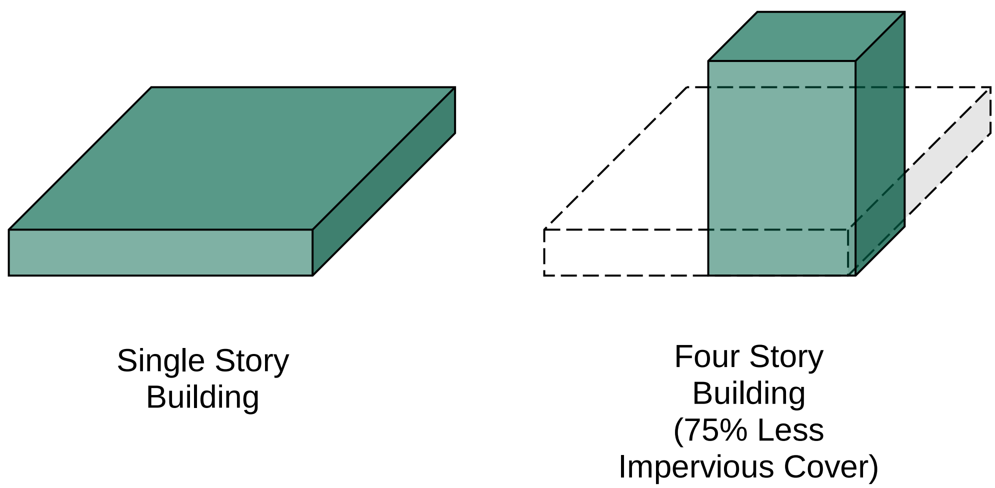
Reduction of Impervious Cover

Description: The impervious footprint of commercial buildings and residences can be reduced by using alternate or taller buildings while maintaining the same floor to area ratio.

KEY BENEFITS	**USING THIS PRACTICE**
• Reduces the amount of impervious cover and associated runoff and pollutants.	☑ Use alternate or taller building designs to reduce the impervious footprint of buildings.

In order to reduce the imperviousness associated with the footprint and rooftops of buildings and other structures, alternative and/or vertical (taller) building designs should be considered. Consolidate functions and buildings, as required, or segment facilities to reduce the footprint of individual structures. Figure 5-18 shows the reduction in impervious footprint from a taller building as opposed to a single story building.

Figure 5-18. Impervious Cover Comparison



Better Site Design Practice #13:
Reduce the Parking Footprint

Reduction of Impervious Cover

Description: Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, parking decks, and using porous paver surfaces or porous concrete in overflow parking areas where feasible and possible.

KEY BENEFITS	USING THIS PRACTICE
• Reduces the amount of impervious cover and associated runoff and pollutants generated	☑ Reduce the number of parking spaces ☑ Minimize stall dimensions ☑ Consider parking structures and shared parking ☑ Use alternative porous surface for overflow areas

Setting maximums for parking spaces, minimizing stall dimensions, using structured parking, encouraging shared parking and using alternative porous surfaces can all reduce the overall parking footprint and site imperviousness.

Many parking lot designs result in far more spaces than actually required. This problem is exacerbated by a common practice of setting parking ratios to accommodate the highest hourly parking during the peak season. By determining average parking demand instead, a lower maximum number of parking spaces can be set to accommodate most of the demand. Table 5-3 provides examples of conventional parking requirements and compares them to average parking demand.

Table 5-3. Conventional Minimum Parking Ratios
(Source: www.stormwatercenter.net)

Land Use	Parking Requirement		Actual Average Parking Demand
	Parking Ratio	Typical Range	
Single family homes	2 spaces per dwelling unit	1.5–2.5	1.11 spaces per dwelling unit
Shopping center	5 spaces per 1000 ft^2 GFA	4.0–6.5	3.97 per 1000 ft^2 GFA
Convenience store	3.3 spaces per 1000 ft^2 GFA	2.0–10.0	--
Industrial	1 space per 1000 ft^2 GFA	0.5–2.0	1.48 per 1000 ft^2 GFA
Medical/ dental office	5.7 spaces per 1000 ft^2 GFA	4.5–10.0	4.11 per 1000 ft^2 GFA
GFA = Gross floor area of a building without storage or utility spaces.			

Another technique to reduce the parking footprint is to minimize the dimensions of the parking spaces. This can be accomplished by reducing both the length and width of the parking stall. Parking stall dimensions can be further reduced if compact spaces are provided. While the trend toward larger sport utility vehicles (SUVs) is often cited as a barrier to implementing stall minimization techniques, stall width requirements in most local parking codes are much larger than the widest SUVs.

Structured parking decks are one method to significantly reduce the overall parking footprint by minimizing surface parking. Figure 5-19 shows a parking deck used for a commercial development.

Shared parking in mixed-use areas and structured parking are techniques that can further reduce the conversion of land to impervious cover. A shared parking arrangement could include usage of the same parking lot by an office space that experiences peak parking demand during the weekday with a church that experiences parking demands during the weekends and evenings.

Figure 5-19. Structured Parking at an Office Park

Utilizing alternative surfaces such as porous pavers or porous concert is an effective way to reduce the amount of runoff generated by parking lots. They can replace conventional asphalt or concrete in both new developments and redevelopment projects. Figure 5-20 is an example of porous pavers used at an overflow lot. Such pavers can also capture and treat runoff from other site areas. However, porous pavement surfaces generally require proper installation and more maintenance than conventional asphalt or concrete. For more specific information using these alternative surfaces, see Section 4.3 of this manual.

Figure 5-20. Grass Paver Surface Used for Parking

Better Site Design Practice #14:
Reduce Setbacks and Frontages

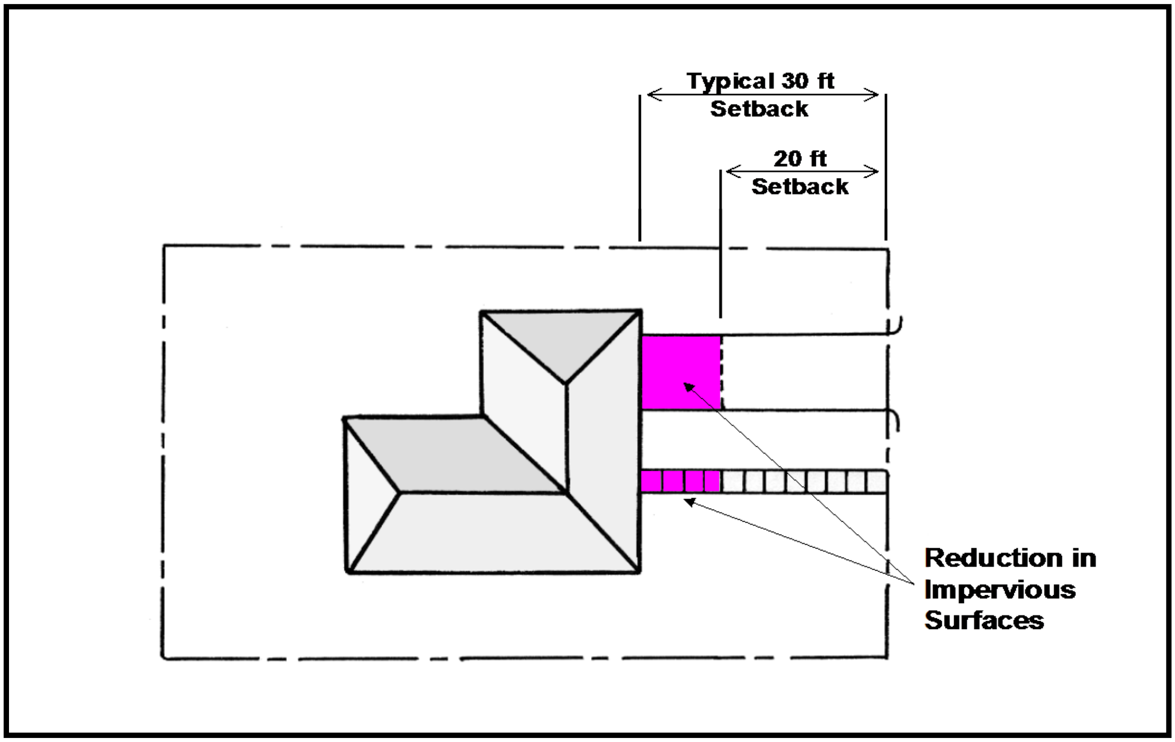
Reduction of Impervious Cover

Description: Use smaller front and side setbacks and narrower frontages to reduce total road length and driveway lengths.

KEY BENEFITS	USING THIS PRACTICE
• Reduces the amount of impervious cover and associated runoff and pollutants generated.	☑ Reduce building and home front and side setbacks. ☑ Consider narrower frontages.

Building and home setbacks should be shortened to reduce the amount of impervious cover from driveways and entry walks. A setback of 20 feet is more than sufficient to allow a car to park in a driveway without encroaching into the public right of way, and reduces driveway and walk pavement by more than 30 percent compared with a setback of 30 feet (see Figure 5-21).

Figure 5-21. Reduced Impervious Cover by Using Smaller Setbacks
(Adapted from: MPCA, 1989)

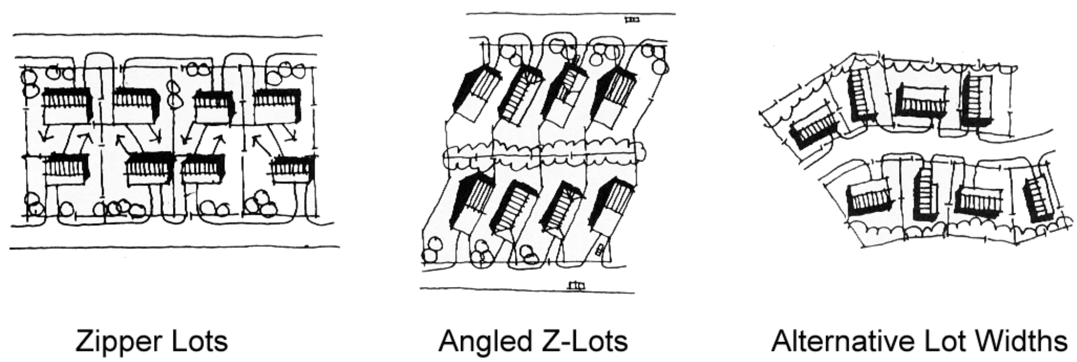


Further, reducing side yard setbacks and using narrower frontages can reduce total street length, which is especially important in cluster and open space designs. Figure 5-22 shows residential examples of reduced front and side yard setbacks and narrow frontages.

Flexible lot shapes and setback and frontage distances allow site designers to create attractive and unique lots that provide homeowners with enough space while allowing for the preservation of natural areas in a residential subdivision. Figure 5-23 illustrates various nontraditional lot designs.

Figure 5-22. Examples of Reduced Frontages and Side Yard Setbacks

Figure 5-23. Nontraditional Lot Designs
(Source: ULI, 1992)



Better Site Design Practice #15:
Use Fewer or Alternative Cul-de-Sacs

Reduction of Impervious Cover

Description: 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 also be considered.

KEY BENEFITS	**USING THIS PRACTICE**
• Reduces the amount of impervious cover and associated runoff and pollutants generated	☑ Consider alternative cul-de-sac designs

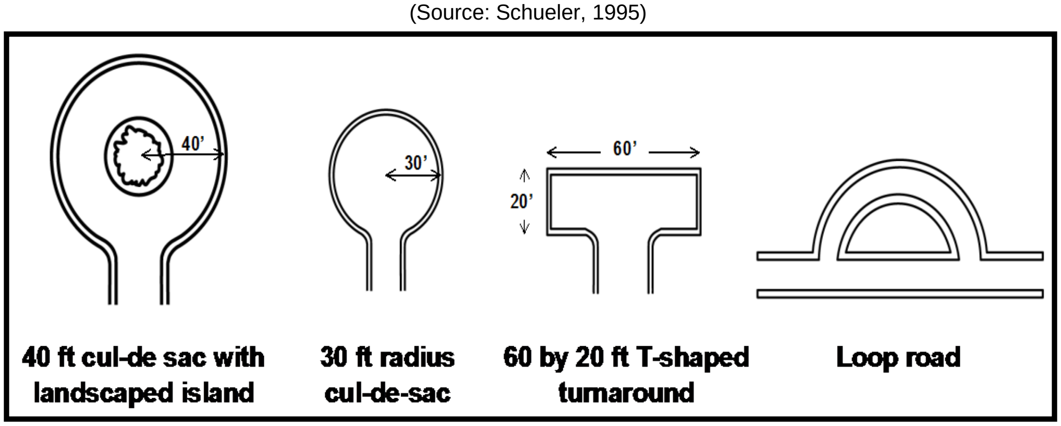
Alternative turnarounds are designs for end-of-street vehicle turnarounds that replace cul-de-sacs and reduce the amount of impervious cover created in developments. Cul-de-sacs are local access streets with a closed circular end that allows for vehicle turnarounds. Many of these cul-de-sacs can have a radius of more than 40 feet. From a stormwater perspective, cul-de-sacs create a huge bulb of impervious cover, increasing the amount of runoff. For this reason, reducing the size of cul-de-sacs through the use of alternative turnarounds or eliminating them altogether can reduce the amount of impervious cover created at a site.

Numerous alternatives create less impervious cover than the traditional 40-foot cul-de-sac. These alternatives include reducing cul-de-sacs to a 30-foot radius and creating hammerheads, loop roads, and pervious islands in the cul-de-sac center (see Figure 5-24).

Sufficient turnaround area is a significant factor to consider in the design of cul-de-sacs. In particular, the types of vehicles entering into the cul-de-sac should be considered. Fire trucks, service vehicles and school buses are often cited as needing large turning radii. However, some fire trucks are designed for smaller turning radii. In addition, many newer large service vehicles are designed with a tri-axle (requiring a smaller turning radius) and many school buses usually do not enter individual cul-de-sacs.

Implementing alternative turnarounds will require addressing local regulations and marketing issues. Communities may have specific design criteria for cul-de-sacs and other alternative turnarounds that need to be modified.

Figure 5-24. Four Turnaround Options for Residential Streets
(Source: Schueler, 1995)



Better Site Design Practice #16:
Create Parking Lot Stormwater "Islands"

Reduction of Impervious Cover

Description: 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.

KEY BENEFITS	USING THIS PRACTICE
• Reduces the amount of impervious cover and associated runoff and pollutants generated. • Provides an opportunity for the siting of structural control facilities. • Trees in parking lots provide shading for cars and are more visually appealing.	☑ Integrate porous areas such as landscaped islands, swales, filter strips and bioretention areas in a parking lot design.

Parking lots should be designed with landscaped stormwater management "islands" which reduce the overall impervious cover of the lot as well as provide for runoff treatment and control in stormwater facilities.

When possible, expanses of parking should be broken up with landscaped islands which include shade trees and shrubs. Fewer large islands will sustain healthy trees better than more numerous very small islands. The most effective solutions in designing for tree roots in parking lots use a long planting strip at least 8 feet wide, constructed with sub-surface drainage and compaction resistant soil.

Structural control facilities such as filter strips, dry swales and bioretention areas can be incorporated into parking lot islands. Stormwater is directed into these landscaped areas and temporarily detained. The runoff then flows through or filters down through the bed of the facility and is infiltrated into the subsurface or collected for discharge into a stream or another stormwater facility. These facilities can be attractively integrated into landscaped areas and can be maintained by commercial landscaping firms. For detailed design specifications of filter strips, enhanced swales and bioretention areas, refer to Chapter 4. An example of a parking lot stormwater "island" is presented in Figure 5-25.

Figure 5-25. Parking Lot Stormwater "Island"

5.3.7 Using Natural Site Features for Stormwater Management

Traditional stormwater drainage design usually ignores and replaces natural drainage patterns, which often results in overly efficient hydraulic conveyance systems. These conveyance systems are overly efficient in that they quickly collect and carry water away from sites rather than allowing water to infiltrate naturally. Conveyance systems are composed of structural stormwater controls that are costly and often require high levels of maintenance to operate properly. The use of natural site features and drainage systems through careful site design can reduce the need and size of structural conveyance systems and controls.

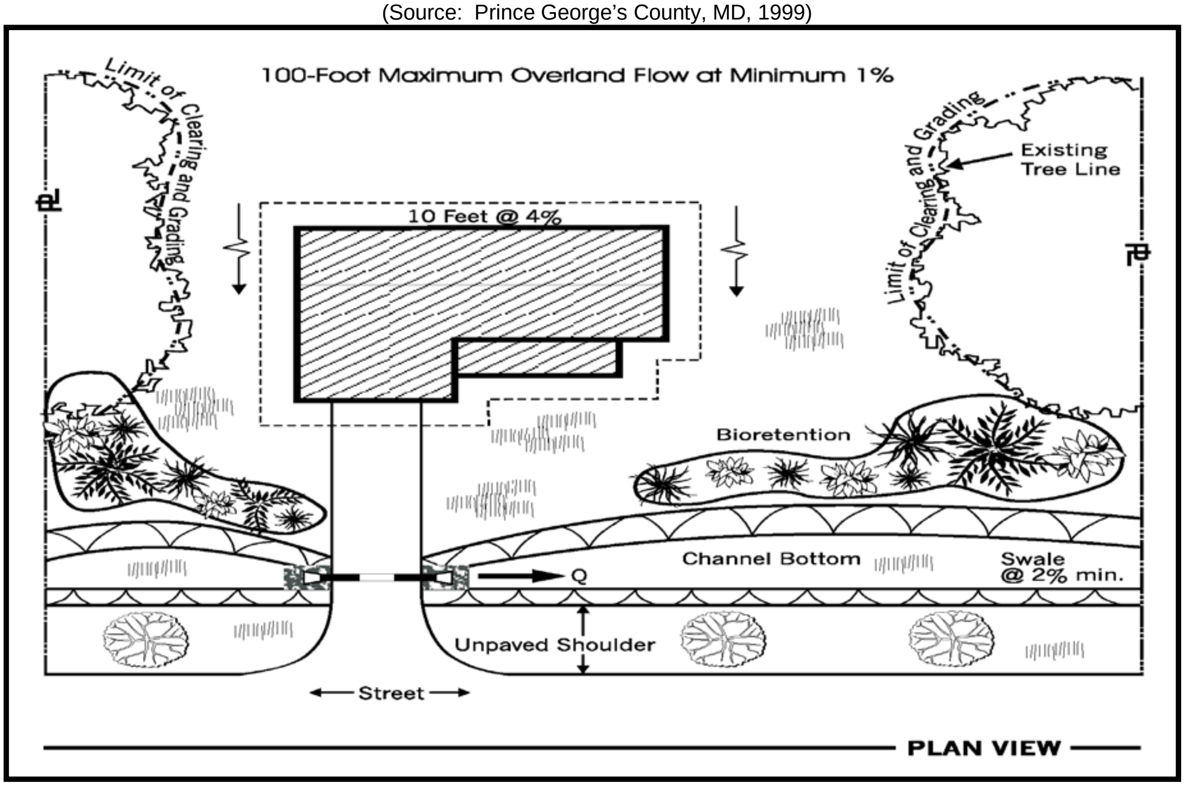
Almost all sites contain natural features which can be used to help manage and mitigate runoff from development. Features on a development site might include natural drainage patterns, depressions, permeable soils, wetlands, floodplains, and undisturbed vegetated areas that can be used to reduce runoff, provide infiltration and stormwater filtering of pollutants and sediment, recycle nutrients, and maximize on-site storage of stormwater. Site design should seek to utilize the natural and/or nonstructural drainage system and improve the effectiveness of natural systems rather than to ignore or replace them. These natural systems typically require low or no maintenance and will continue to function many years into the future.

Some of the methods of incorporating natural features into an overall stormwater management site plan include the following practices:

17. Use Buffers and Undisturbed Areas
18. Use Natural Drainageways Instead of Storm Sewers
19. Use Vegetated Swales Instead of Curb and Gutter
20. Drain Runoff to Pervious Areas

Figure 5-26 presents an example of these better site design practices on a residential lot. The following pages cover each practice in more detail.

Figure 5-26. Residential Site Design Using Natural Features for Stormwater Management
(Source: Prince George's County, MD, 1999)



Better Site Design Practice #17:
Use Buffers and Undisturbed Areas

Utilization of Natural Features for Stormwater Management

Description: Undisturbed natural areas such as forested preservation areas and stream buffers can be used to treat and control stormwater runoff from other areas of the site with proper design.

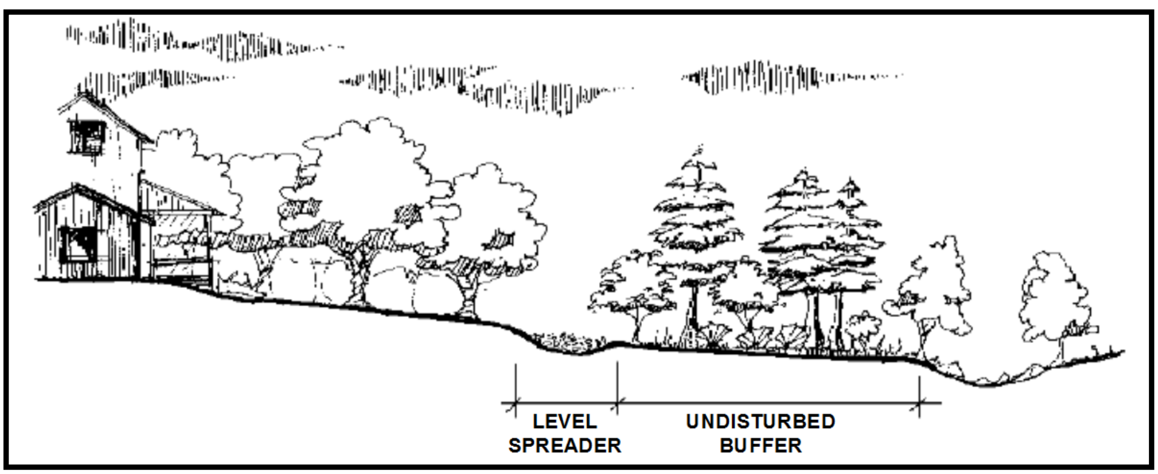
KEY BENEFITS	USING THIS PRACTICE
• Riparian buffers and undisturbed vegetated areas can be used to filter and infiltrate stormwater runoff • Natural depressions can provide inexpensive storage and detention of stormwater flows • A stormwater site design credit can be taken the areas comply with the criteria listed in Section 5.2	☑ Direct runoff towards buffers and undisturbed areas using a level spreader to ensure sheet flow ☑ Utilize natural depressions for runoff storage

Runoff can be directed towards riparian buffers and other undisturbed natural areas delineated in the initial stages of site planning to infiltrate runoff, reduce runoff velocity and remove pollutants. Natural depressions can be used to temporarily store (detain) and infiltrate water, particularly in areas with porous (hydrologic soil group A and B) soils.

The objective of using natural areas for stormwater infiltration is to intercept runoff before it has become substantially concentrated and then distribute this flow evenly (as sheet flow) to the buffer or natural area. This can typically be accomplished using a level spreader, as seen in Figure 5-27. A mechanism for the bypass of higher flow events should be provided to reduce erosion or damage to a buffer or undisturbed natural area.

Carefully constructed berms can be placed around natural depressions and below undisturbed vegetated areas with porous soils to provide for additional runoff storage and/or infiltration of flows.

Figure 5-27. Use of a Level Spreader with a Riparian Buffer
(Adapted from NCDENR, 1998)



Better Site Design Practice #18:

Use Natural Drainageways Instead of Storm Sewers

Utilization of Natural Features for Stormwater Management

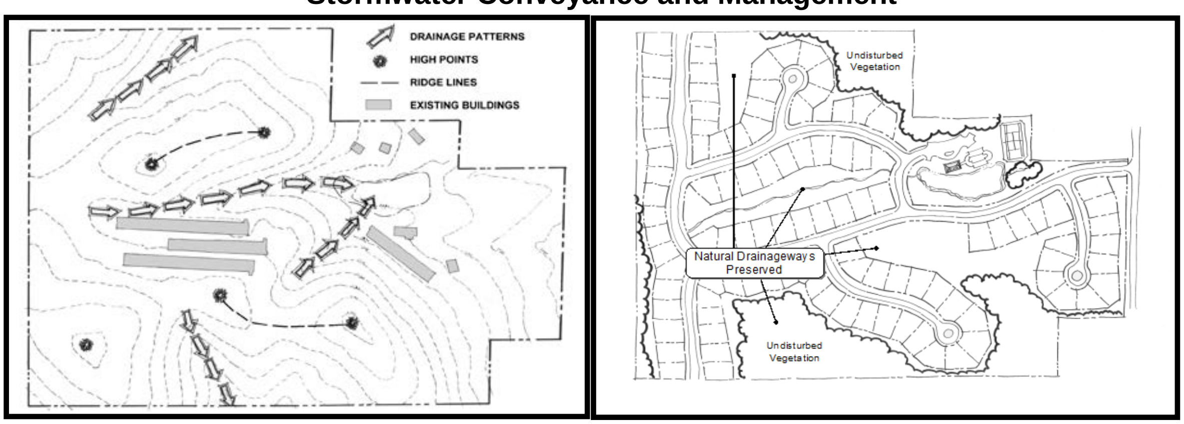
Description: The natural drainage paths of a site can be used instead of constructed underground storm sewers or concrete open channels.

KEY BENEFITS	USING THIS PRACTICE
• Use of natural drainageways reduces the cost of constructing storm sewers or other conveyances, and may reduce the need for land disturbance and grading. • Natural drainage paths are less hydraulically efficient than man-made conveyances, resulting in longer travel times and lower peak discharges. • Can be combined with buffer systems to allow for stormwater filtration and infiltration.	☑ Preserve natural flow paths in the site design ☑ Direct runoff to natural drainageways, ensuring that peak flows and velocities will not cause channel erosion

Structural drainage systems and storm sewers are designed to be hydraulically efficient in removing stormwater from a site. This type of system tends to increase peak runoff discharges, flow velocities, and pollutant loading to downstream waters. Alternatives are natural drainageways and vegetated swales (where slopes and soils permit), which carry stormwater flows to their natural outlets, particularly for low-density development and residential subdivisions.

The use of natural open channels allows for more storage of stormwater flows on-site, lower stormwater peak flows, a reduction in erosive runoff velocities, infiltration of a portion of the runoff volume, and the capture and treatment of stormwater pollutants. It is critical that natural drainageways be protected from higher post-development flows by applying downstream channel protection methods (including the CPv criteria) to prevent erosion and degradation. Figure 5-28 presents an example of the use of natural drainagways for stormwater conveyance.

Figure 5-28. Example of the Use of Natural Drainageways for Stormwater Conveyance and Management



Better Site Design Practice #19:
Use Vegetated Swales Instead of Curb and Gutter

Utilization of Natural Features for Stormwater Management

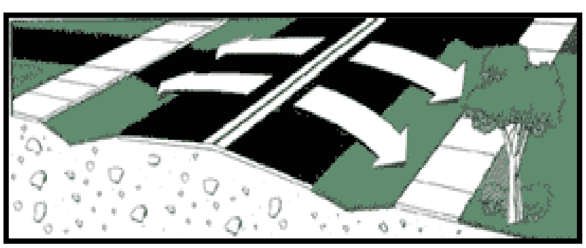
Description: Where density, topography, soils, slope, and safety concerns permit, vegetated open channels can be used in the street right-of-way to convey and treat stormwater runoff from roadways.

KEY BENEFITS	USING THIS PRACTICE
• Reduces the cost of road and storm sewer construction • Provides for some runoff storage and infiltration, as well as treatment of stormwater • A stormwater site design credit can be taken the swales comply with the criteria listed in section 5-2	☑ Use vegetated open channels (enhanced wet or dry swales or grass channels) in place of curb and gutter to convey and treat stormwater runoff

Curb and gutter storm drain systems allow for the quick transport of stormwater, which results in increased peak flow and flood volumes and reduced runoff infiltration. Curb and gutter systems also do not provide treatment for stormwater that has been polluted from vehicle emissions, pet waste, lawn runoff, and litter.

Open vegetated channels along a roadway (see Figure 5-31) remove pollutants by allowing infiltration and filtering to occur, unlike curb and gutter systems which move water with virtually no treatment. Engineering advances prevent past problems with roadside ditches, which suffered from erosion, standing water and break up at the road edge. Grass channels and enhanced dry swales are two such alternatives. If they are properly installed under the right site conditions, they are excellent methods for treating stormwater on-site. In addition, open vegetated channels can be less expensive to install than curb and gutter systems. Further design information and specifications for grass channels and enhanced swales can be found in Chapter 4 this manual.

Figure 5-29. Vegetated Swales Instead of Curb and Gutter



Better Site Design Practice #20:
Drain Runoff to Pervious Areas

Utilization of Natural Features for Stormwater Management

Description: Where possible, direct runoff from impervious areas such as rooftops, roadways and parking lots to pervious areas, open channels or vegetated areas to provide for water quality treatment and infiltration. Avoid routing runoff directly to the structural stormwater conveyance system.

KEY BENEFITS	USING THIS PRACTICE
• Sending runoff to pervious vegetated areas increases overland flow time and reduces peak flows • Vegetated areas can often filter and infiltrate stormwater runoff • A stormwater site design credit can be taken if the area complies with the criteria listed in Section 5-2.	☑ Minimize directly connected impervious areas and drain runoff as sheet flow to pervious vegetated areas

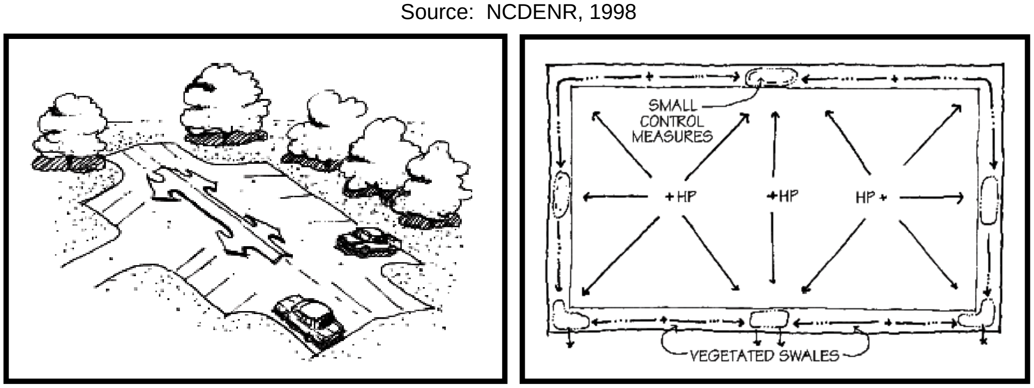
Stormwater quantity and quality benefits can be achieved by routing the runoff from impervious areas to pervious areas such as lawns, landscaping, filter strips and vegetated channels. Much like the use of undisturbed buffers and natural areas (Better Site Design Practice #17), revegetated areas such as lawns and engineered filter strips and vegetated channels can act as biofilters for stormwater runoff and provide for infiltration in porous (hydrologic group A and B) soils. In this way, the runoff is “disconnected” from a hydraulically efficient structural conveyance such as a curb and gutter or storm drain system.

Some of the methods for disconnecting impervious areas include:

- Designing roof drains to flow to vegetated areas
- Directing flow from paved areas such as driveways to stabilized vegetated areas
- Breaking up flow directions from large paved surfaces (see Figure 5-30).
- Carefully locating impervious areas and grading landscaped areas to achieve sheet flow runoff to the vegetated pervious areas

For maximum benefit, runoff from impervious areas to vegetated areas must occur as sheet flow and vegetation must be stabilized. See Chapters 3 and 7 for more design information and specifications on filter strips and vegetated channels.

Figure 5-30. Design Paved Surfaces to Disperse Flow to Vegetated Areas
Source: NCDENR, 1998



5.3.8 Better Site Design Examples (Source: ARC, 2001)

Residential Subdivision Example 1

A typical residential subdivision design on a parcel is shown in Figure 5-31(a). The entire parcel except for the subdivision amenity area (clubhouse and tennis courts) is used for lots. The entire site is cleared and mass graded, and no attempt is made to fit the road layout to the existing topography. Because of the clearing and grading, all of the existing tree cover and vegetation and topsoil are removed dramatically altering both the natural hydrology and drainage of the site. The wide residential streets create unnecessary impervious cover and a curb and gutter system that carries stormwater flows to the storm sewer system. No provision for nonstructural stormwater treatment is provided on the subdivision site.

A residential subdivision employing stormwater better site design practices is presented in Figure 5-31(b). This subdivision configuration preserves a quarter of the property as undisturbed open space and vegetation. The road layout is designed to fit the topography of the parcel, following the high points and ridgelines. The natural drainage patterns of the site are preserved and are utilized to provide natural stormwater treatment and conveyance. Narrower streets reduce impervious cover and grass channels provide for treatment and conveyance of roadway and driveway runoff. Landscaped islands at the ends of cul-de-sacs also reduce impervious cover and provide stormwater treatment functions. When constructing and building homes, only the building envelopes of the individual lots are cleared and graded.

Residential Subdivision Example 2

Another typical residential subdivision design is shown in Figure 5-32(a). Most of this site is cleared and mass graded, with the exception of a small riparian buffer along the large stream at the right boundary of the property. Almost no buffer was provided along the small stream that runs through the middle of the property. In fact, areas within the 100-year floodplain were cleared and filled for home sites. As is typical in many subdivision designs, this one has wide streets that can be used for on-street parking and large cul-de-sacs.

The better site design subdivision can be seen in Figure 5-32(b). This subdivision layout was designed to conform to the natural terrain. The street pattern consists of a wider main thoroughfare that winds through the subdivision along the ridgeline. Narrower loop roads branch off of the main road and utilize landscaped islands. Large riparian buffers are preserved along both the small and large streams. The total undisturbed conservation area is close to one-third of the site.

Commercial Development Example

Figure 4-33(a) shows a typical commercial development containing a supermarket, drugstore, smaller shops and a restaurant on an out-lot. The majority of the parcel is a concentrated parking lot area. The only pervious area is a small replanted vegetation area acting as a buffer between the shopping center and adjacent land uses. Stormwater quality and quantity control are provided by a wet extended detention basin in the corner of the parcel.

A better site design commercial development can be seen in Figure 5-33(b). Here the retail buildings are dispersed on the property, providing more of an “urban village” feel with pedestrian access between the buildings. The parking is broken up, and bioretention areas for stormwater treatment are built into parking lot islands. A large bioretention area, which serves as open green space, is located at the main entrance to the shopping center. A larger undisturbed buffer has been preserved on the site. Because of the bioretention areas and buffer provide water quality treatment, only a dry extended detention basin is needed for water quantity control.

Office Park Example

An office park with a conventional design is shown in Figure 5-34(a). Here the site has been graded to fit the building layout and parking area. All of the vegetated areas of this site are replanted areas. The better site design layout, presented in Figure 5-34(b), preserves undisturbed vegetated buffers and open space areas on the site. The layout has been designed to fit the natural terrain of the site. A modular porous paver system is used for the overflow parking areas.

Figure 5-31(a). Example 1 Traditional Residential Subdivision Design

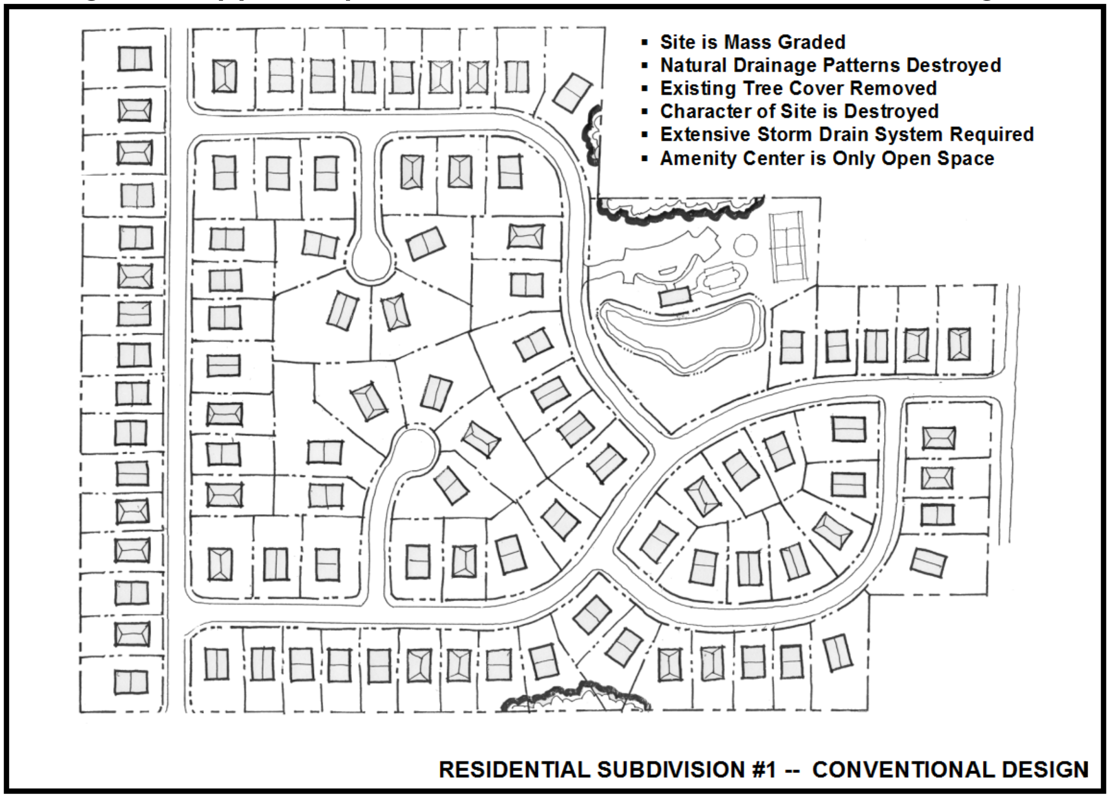


Figure 5-31(b). Example 1 Residential Subdivision Design after Application of Better Site Design Practices

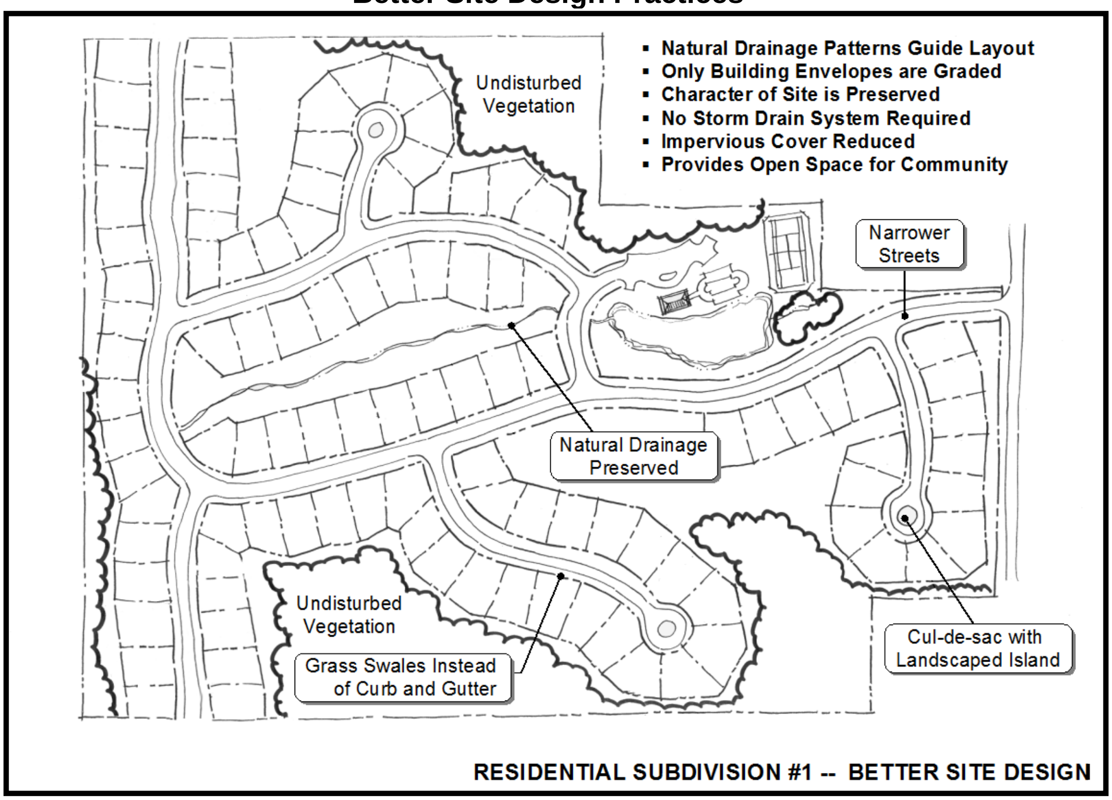


Figure 5-32(a). Example 2 Traditional Residential Subdivision Design

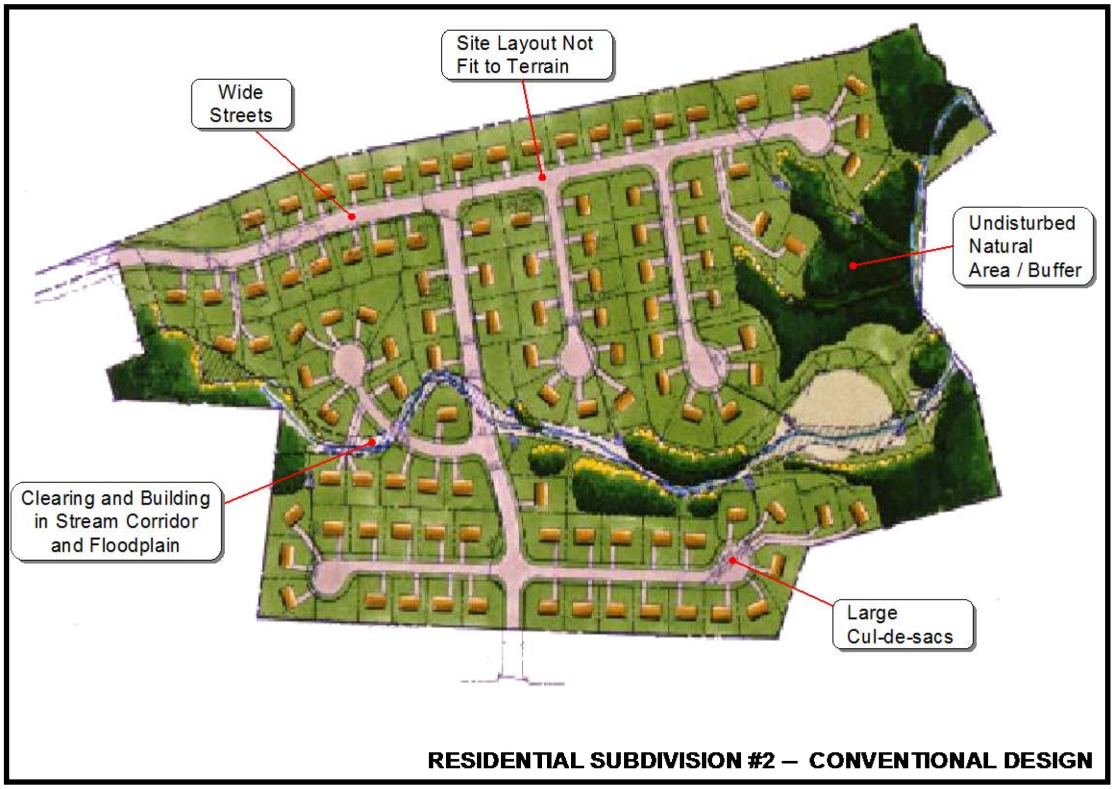


Figure 5-32(b). Example 2 Residential Subdivision Design after Application of Better Site Design Practices

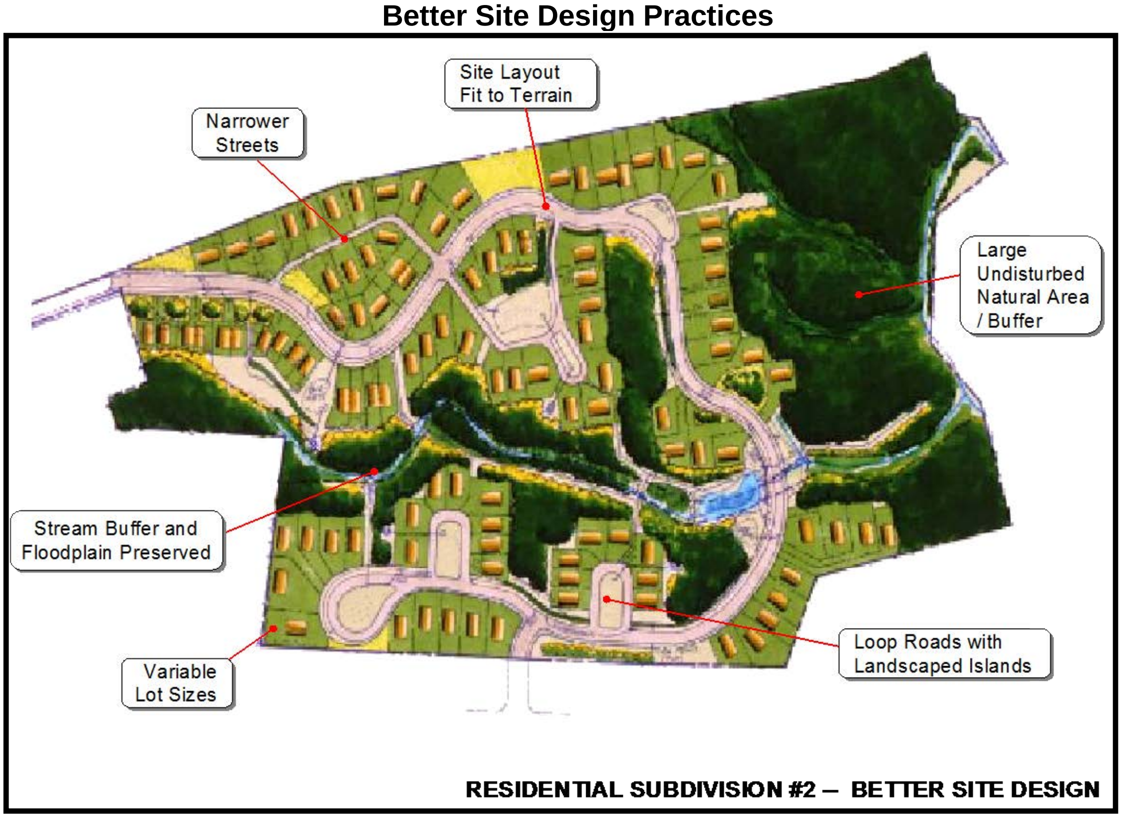


Figure 5-33(a). Example 3 Traditional Commercial Development Design

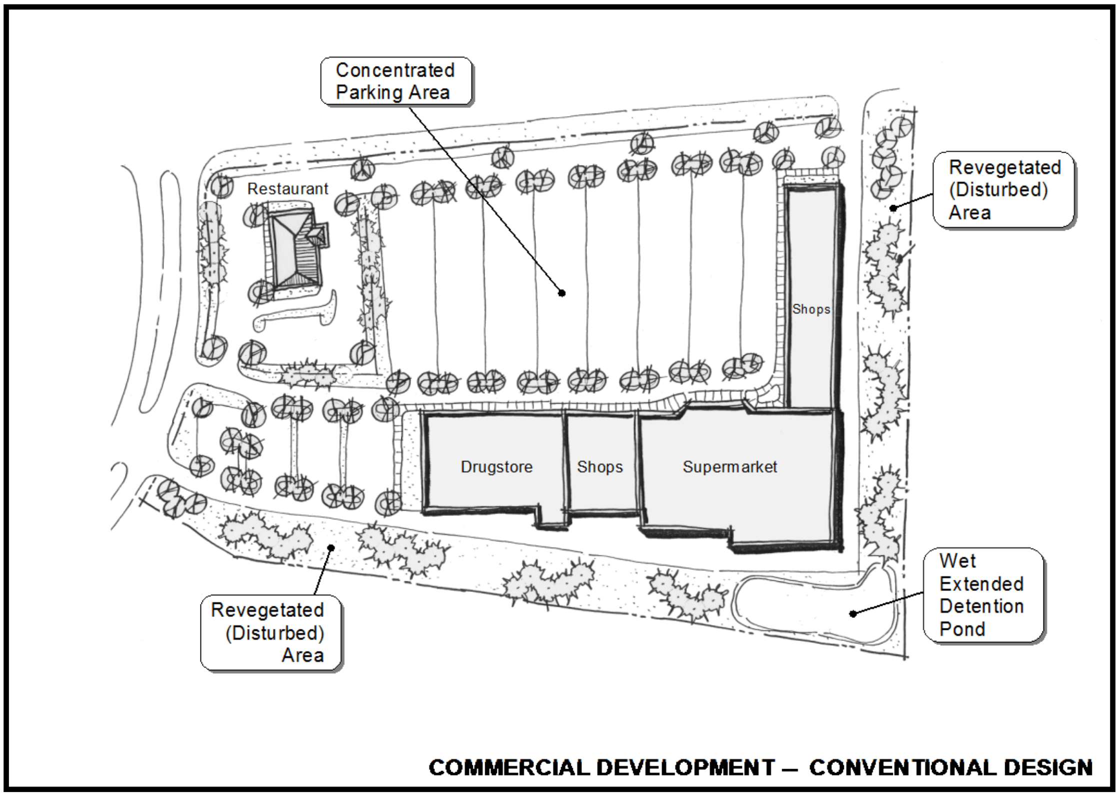


Figure 5-33(b). Example 3 Commercial Development Design after Application of Better Site Design Practices

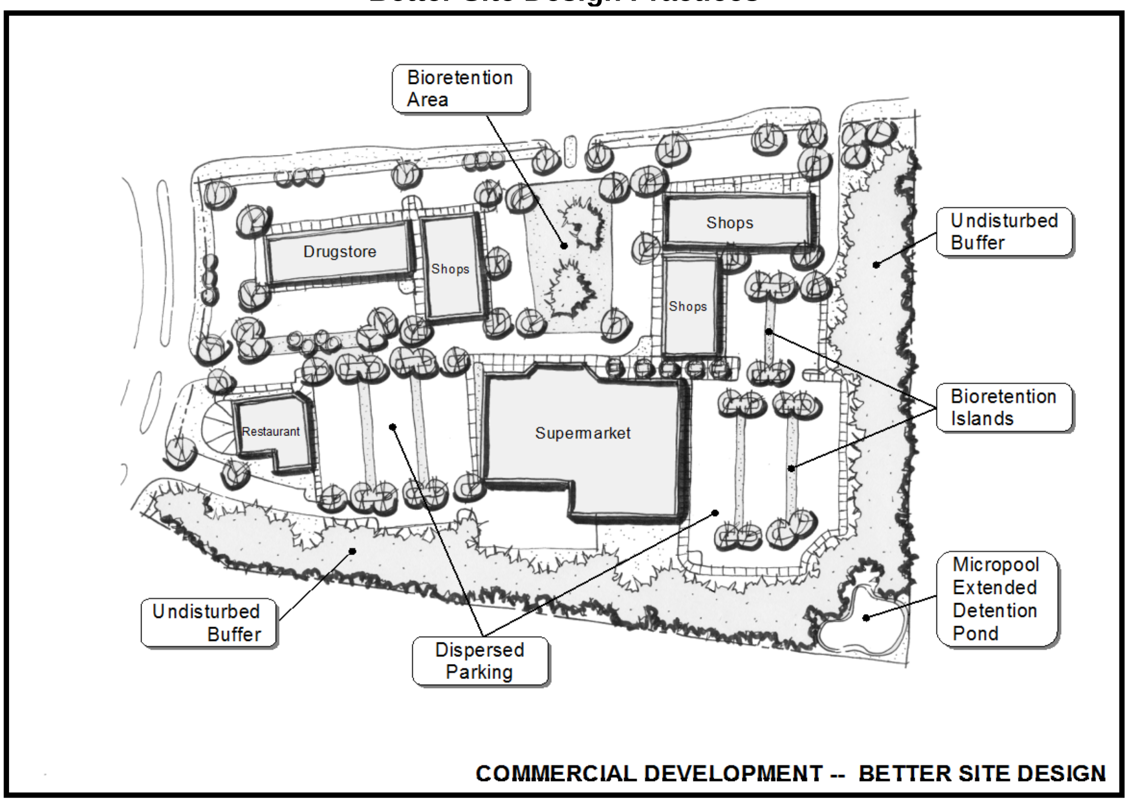


Figure 5-34(a). Example 4 Traditional Office Park Development

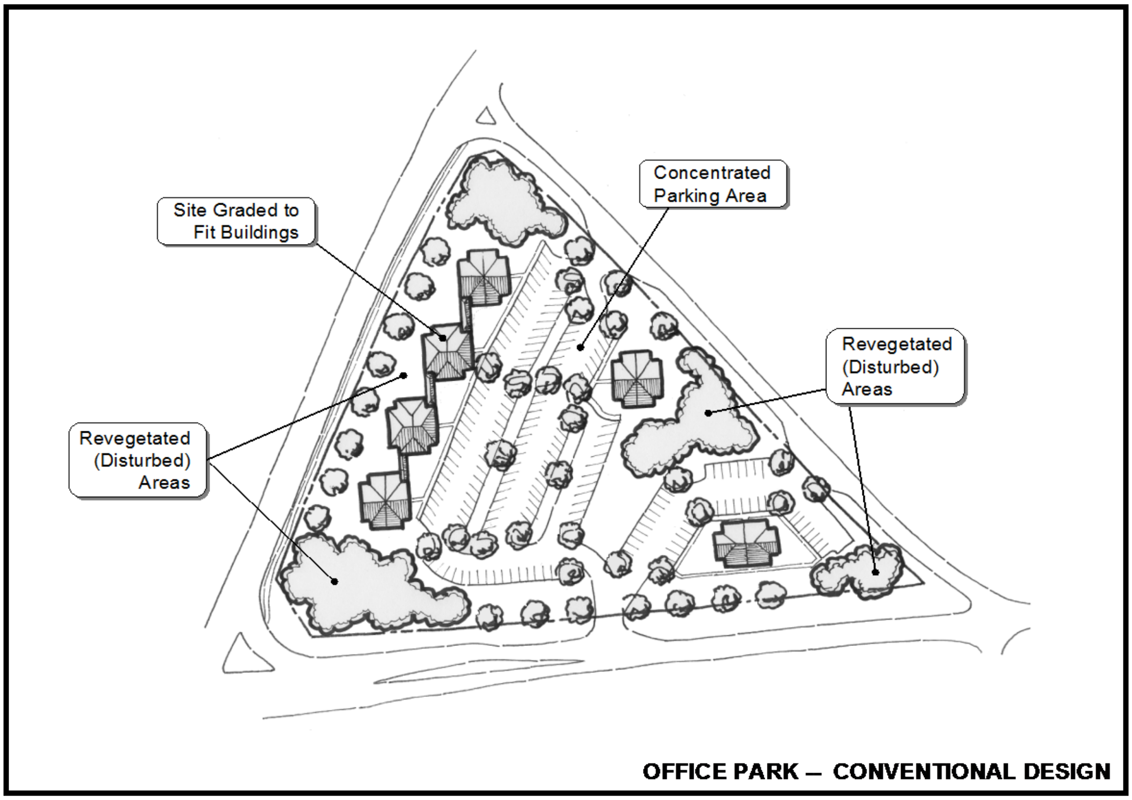
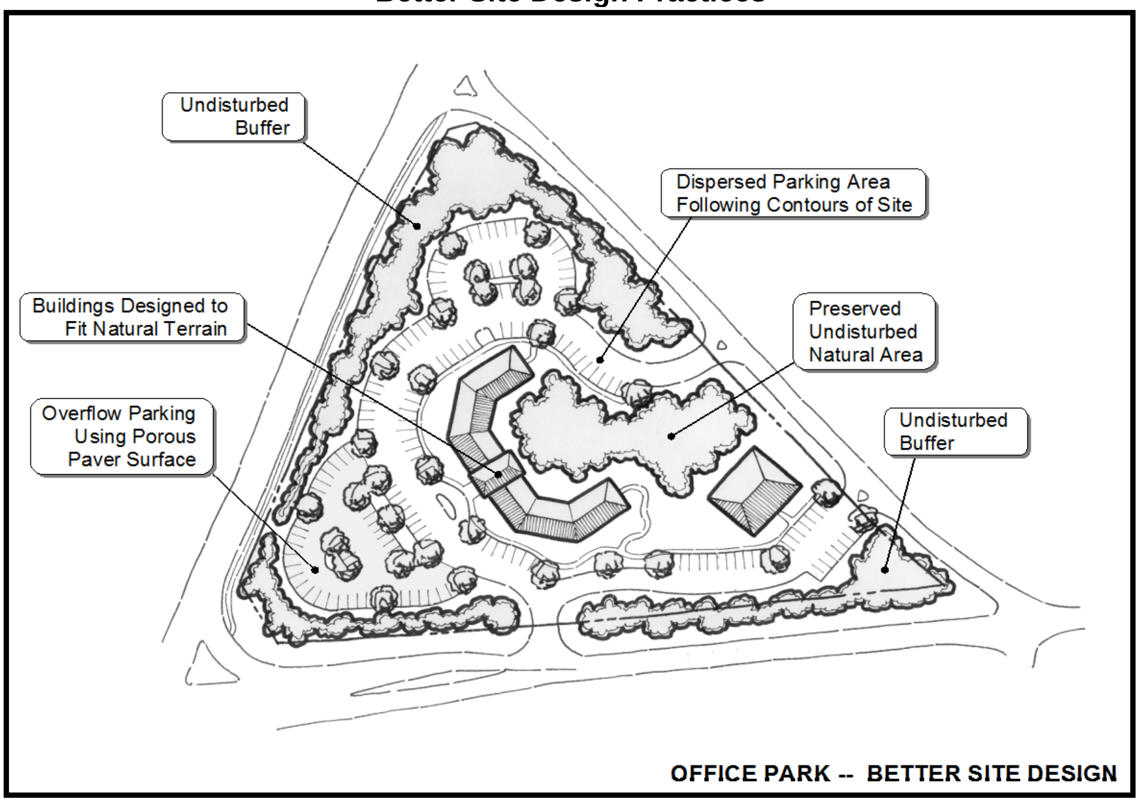


Figure 5-34(b). Example 4 Office Park Development after Application of Better Site Design Practices



5.4 References

AMEC. *Knox County Stormwater Management Manual Volume 2, Technical Guidance*.

Atlanta Regional Council (ARC). *Georgia Stormwater Management Manual Volume 1 Stormwater Policy Guidebook.* 2001.

Minnesota Pollution Control Agency (MPCA). *Protecting Water Quality in Urban Areas*. 1989.

North Carolina Department of Environment and Natural Resources (NCDENR). *Stormwater Management Site Planning*. 1998

Prince George's County, MD. *Low-Impact Development Design Strategies, An Integrated Design Approach*. 1999

Schueler, T. *Site Planning for Urban Stream Protection*. Prepared by Center for Watershed Protection (CWP). Metropolitan Washington Council of Governments, 1995.

Sykes, R.D. *Chapter 31 – Site Planning*. University of Minnesota. 1989

Urban Land Institute. *Density by Design*. 1992.

Virginia Polytechnic Institute and State University (VPISU), College of Architecture and Urban Studies. *Water Sensitive Site Planning*. 2000.

www.stormwatercenter.net Better Site Design: Green Parking. Accessed August 2006.