

Nonstructural Best Management Practices

A core concept of LID is preventing stormwater runoff by integrating site design and planning techniques that preserve natural systems and hydrologic functions, protect open spaces, as well as conserve wetlands and stream corridors on a site. This chapter provides detailed technical information on integrating nonstructural Best Management Practices (BMPs) early into the site design process.

The nonstructural BMPs are:

- Cluster development,
- Minimize soil compaction,
- Minimize total disturbed area,
- Protect natural flow pathways,
- Protect riparian buffers,
- Protect sensitive areas,
- Reduce impervious surfaces, and
- Stormwater disconnection.

Specifically, this chapter discusses:

- The benefits of using nonstructural BMPs,
- The process for selecting nonstructural BMPs,
- Fact sheet overviews of each BMP, and
- Detailed information for each BMP including design considerations, construction guidelines, stormwater calculations, and maintenance and cost information.

What does nonstructural mean?

The primary LID characteristic of nonstructural BMPs is preventing stormwater runoff from the site. This differs from the goal of structural BMPs which is to help mitigate stormwater-related impacts after they have occurred.

More specifically, nonstructural BMPs take broader planning and design approaches, which are less “structural” in their form. Many nonstructural BMPs apply to an entire site and often to an entire community, such as wetland protection through a community wetland ordinance. They are not fixed or specific to one location. Structural BMPs, on the other hand, are decidedly more location specific and explicit in their physical form.

Benefits of using nonstructural BMPs

There are numerous benefits of incorporating nonstructural BMPs into a site. While individual benefits are discussed in detail under each BMP, there are many benefits that apply to most, if not all, of the nonstructural BMPs. These include:

- Reduced land clearing costs,
- Reduced costs for total infrastructure,
- Reduced total stormwater management costs,
- Enhanced community and individual lot aesthetics, and
- Improved overall marketability and property values.

Figure 6.1
LID Site Design Process

Step 1

Property acquisition and use analysis

Step 2

Inventory and evaluate the site

Step 3

Integrate municipal, county, state, and federal requirements

Step 4

Develop initial concept design using nonstructural BMPs

Step 5

Organize pre-submission meeting and site visit with local decision makers

Step 6

Incorporate revisions to development concept

Step 7

Apply structural BMP selection process

Step 8

Apply the LID calculation methodology

Step 9

Develop the preliminary site plan

BMP Selection Process

This chapter focuses on Step 4 in the site design process for LID (Figure 6.1) to develop the initial concept design using nonstructural BMPs. Selection of nonstructural BMPs should focus on information gathered in Steps 1-3 of the site design process. Following are specific questions and issues to provide guidance in the selection process.

- How is the property being used? A residential development may have more applicability for certain nonstructural BMPs than other land uses. For example, cluster development is an applicable BMP for residential development, but may be less used in more urban situations.
- What natural features are on site? A thorough site inventory will provide the necessary information to assess the ability to implement many of the BMPs, including preserving sensitive and riparian areas.
- What local, county, state, and other regulations need to be met? A review of local, county, state, and other regulations can also provide guidance on selecting the right mix of nonstructural BMPs.

BMP Fact Sheet and Detailed Nonstructural BMP Information

Each BMP begins with a fact sheet that provides a quick overview of the BMP, along with a local case study. The fact sheets can be removed separately from the manual and serve as a stand-alone document for quick reference. Fact sheet ratings have been condensed to general categories (High, Medium, and Low) with these summary ratings often discussed in more detail in the BMP text. Stormwater Quality Functions are based on a compilation of recent national/international studies rating pollutant removal performance.

Following each fact sheet is detailed information on the BMP which includes:

Variations

Discusses the variations to the BMP, if there are applicable. Examples include alternatives in design that can increase storage capacity or infiltration rates.

Applications

Indicates land use types for which the BMP is applicable or feasible.

Design Considerations

This section includes a list of technical procedures to be considered when designing for the individual BMP. This specific design criteria is presented, which can assist planners in incorporating LID techniques into a site design, as well as provide a basis for reviewers to evaluate submitted LID techniques.

Stormwater Calculations and Functions

Provides specific guidance on achieving sizing criteria, volume reduction, and peak rate mitigation, as applicable. This section also references Chapter 9 which discusses in detail how to achieve a specific standard or implement measures that contribute to managing water onsite in a more qualitative manner.

Construction Guidelines

Provides a typical construction sequence for implementing the BMP. However, it does not specifically address soil erosion and sedimentation control procedures. Erosion and sediment control methods need to adhere to the latest requirements of MDEQ's Soil Erosion and Sedimentation Control Program and local standards.

Maintenance

Provides guidance on recommended maintenance procedures for the BMP.

Winter Considerations

Discusses how well the BMP performs in Michigan's cold climate.

Cost

Provides general cost information for comparison purposes. If specific dates of costs are not referenced in this section, the costs reflect 2007 conditions.

Designer/Reviewer's Checklist

Developed to assist a designer and or reviewer in evaluating the critical components of a BMP that is being designed. It references not only individual design considerations, but also suggests review of additional pertinent sections of the LID manual that may need to be considered for implementation of that BMP.

References

Provides a list of sources of information utilized in the creation of this section of the manual. This list also provides additional sources that can be used for additional information.

Each fact sheet includes:

BMP Fact Sheet

Title

Short definition of BMP

Applications – Indicates in what type of land use BMP is applicable or feasible (**Yes, No, or Limited**).

Stormwater Quantity Functions – Indicates how well the BMP functions in mitigating stormwater management criteria (**High, Medium, or Low**).

Stormwater Quality Functions – Indicates how well the BMP performs in terms of pollutant removal (**High, Medium, or Low**).

Applications		Stormwater Quantity Functions	
Residential		Volume	
Commercial		Groundwater Recharge	
Ultra Urban		Peak Rate	
Industrial		Stormwater Quality Functions	
Retrofit		TSS – Total Suspended Solids	
Highway/Road		TP – Total Phosphorus	
Recreational		TN or NO3 – Total Nitrogen/Nitrate	
		Temperature	

Additional Considerations

Cost – Indicate whether cost is high, medium or low by the following categories

- **High** – => adds more than 5% to total project cost
- **Medium** – adds 1–5% to total project cost
- **Low** – =< adds less than 1% to total project cost

Maintenance – Indicates level of maintenance required to maintain BMP (**High, Medium, or Low**).

- **High** – Maintenance intensive (i.e., year-round maintenance)
- **Medium** – Several times per year
- **Low** – One time per year

Winter Performance – Indicates if BMP provides equivalent performance throughout the winter (**High, Medium, or Low**)

- **High** – BMP performs very well in winter conditions
- **Medium** – BMP has reduced performance in winter conditions
- **Low** – BMP still performs in winter conditions, but performance is significantly reduced.

Variations (optional)

List of variations to the BMP if applicable

Key Design Features

Bulleted list of information that is key to the design of BMP

Site Factors (optional)

List of specific factors that relate to BMP performance:

- Water table/bedrock separation distance
- Soil type
- Feasibility on steeper slopes
- Applicability on potential hotspots (e.g., brownfields)

Benefits

List of benefits directly related to implementing the BMP

Limitations

List of site constraints associated with implementation

Case Study: Title

The second page of the fact sheet includes a Michigan case study highlighting several features of the use of an individual BMP. Each case study includes a description of the project, as well as several site considerations including:

Case Study Site Considerations	
Project Type	
Soil Conditions	
Estimated Total Project Cost	
Maintenance Responsibility	
Project Contact	

BMP Fact Sheet

Cluster Development

Cluster development (also known as open space development) concentrates development on smaller lots on a portion of a larger site. Clustering allows the site planner to avoid resource sensitive and constrained areas at a site, such as steep slopes and water-sensitive areas including riparian buffers, wetlands, and floodplains without sacrificing the level of development.

Clustering reduces the amount of required infrastructure and various development-related costs. Clustering lends itself to residential development, with greatest potential in municipalities where large-lot residential development is typical. Clustering can reduce total impervious area and total disturbed areas at development sites, thereby reducing stormwater peak rates of runoff, reducing total volume of runoff, and reducing nonpoint source pollutant loads.



Aerial view of cluster development in Ann Arbor, MI

Source: Atwell Hicks

Potential Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	High
Commercial	Yes*	Groundwater Recharge	High
Ultra Urban	Limited	Peak Rate	High
Industrial	Limited	Stormwater Quality Functions	
Retrofit	No	TSS	High
Highway/Road	No	TP	High
Recreational	Limited	NO ₃	High
		Temperature	High

Additional Considerations	
Cost	Low
Maintenance	Low/Med
Winter Performance	High

Variations

- Clustering as an option
- Clustering mandated by the municipality
- Clustering with incentives such as density bonuses

Key Design Features

- Develop inventory
- Map sensitive areas
- Reduce total site disturbance and develop cluster plan
- Increase undisturbed open space

Benefits

- Reduces required infrastructure
- Increases open space
- Protects environmentally sensitive natural resources

Limitations

- Site specific based on land topography and individual conditions

*Depending upon site size, constraints, and other factors.

Case Study: Pokagon Band of Potawatomi Indians Pokagonek Edawat Housing Development

Dowagiac, MI

The Dowagiac River Watershed Management Plan was used as the basis for the design principles in this project which led to integrating LID techniques into the development.

This Native American housing development used nine LID BMPs to arrive at an overall strategy to protect and use natural flow pathways and preserve natural features in overall stormwater planning and design. This development also maximized stormwater infiltration to groundwater through use of pervious pavement, rain gardens, and bioswales. In addition, homes were clustered to conserve open space and reduce infrastructure costs.

The housing units were clustered in loops following the site topography, with 17 units in the first phase and 16 units scheduled for the second phase. Clustering reduced costs by shortening roads and utility runs. Smaller lots have reduced lawn and yard maintenance. Clustering also allowed for shared bioswales to be established among the buildings, helping to manage runoff. The footprints of the homes were minimized, through minimizing hallway space and eliminating foyers, while still providing for maximum usable space.



Clustering of houses

Source: Pokagon Band of Potawatomi Indians

Case Study Site Considerations	
Project Type	Cluster development
Estimated Total Project Cost	Mostly associated with prescribed burns and turf maintenance
Maintenance Responsibility	Pokagon Banb Housing Department
Project Contact	Mark Parrish, mark.parrish@pokagon.com 269-782-9602

Description and Function

Cluster development is driven by reducing minimum lot size, though not necessarily changing the total number of lots or amount of development occurring. As lot sizes decrease, the portion of the site which remains as undisturbed open space increases. If clustering is done carefully, this remaining open space can and should include those areas which are most sensitive environmentally and/or which offer special value functions not otherwise protected from development (e.g., high-quality woodlands areas).

Several amendments were made to the Township Zoning Act (TZEA), the County Zoning Act (COZEA), and the City and Village Zoning Act (CVZEA) in 2001, requiring that municipalities (unless classified as “exempt”) include clustering as an option in their respective zoning ordinances. According to the Michigan Association of Planning web site, regulatory provisions for clustering include:

“...land zoned for residential development may be developed using cluster development designs at the option of the land owner, the development of the specified land to be not more than 50% of the land that could have been developed (CVZEA 80%), density equivalency to be 2 or fewer dwelling units per acre, or if land is served by public sewer and water, 3 or fewer dwelling units per acre (all three statutes), land to remain perpetually in an undeveloped state to be not less than 50% for both TZEA and COZEA while CVZEA would be allowed 20%, all undeveloped land would be maintained as conservation easements, plat dedications, restrictive covenants, or other legal means; however land development would not depend upon the extension of public sewer or water unless the exercise of the option for development would depend upon an extension.”

Variations

One variation to a typical cluster development allows for a density bonus to incentivize use of this technique. A density bonus allows for additional lots to be added to the site beyond what the yield plan would show with a conventional subdivision. Proponents of this method state that allowing an additional lot or two may

be the incentive needed to increase implementation of this technique. Opponents of this variation state that a density bonus is not needed since the development already costs less due to less stormwater and transportation infrastructure.

A second clustering variation for municipalities to consider, subject to legal review, is establishing clustering as the baseline requirement, at least in some zoning categories. Conventional non-clustered development would still be an option (variance, conditional use, etc.), but only if a variety of performance standards are satisfied.

A third variation for consideration relates to the nature and extent of development types subject to clustering provisions. As discussed above, clearly single-family residential development at lower densities/on larger lots is ready-made for clustering. However, clustering concepts can provide LID benefits in larger corporate office parks, in retail centers, and other uses. Often this clustering concept takes on its own nomenclature e.g., New Urbanist, Smart Growth, Planned Integrated Development, and others. In these cases, not only are individual lots reduced in size, but the physical form of the development typically undergoes change (i.e., 50,000 square feet of retail can move from a one-story box to stacked development with a much different New Urbanist configuration). Depending upon the nature and extent of the uses involved, “clustering” of nonresidential uses (e.g., daytime offices with evening/weekend retail), if carefully planned can offer potential for reduced parking requirements.

Applications

Residential clustering

The most common clustering option is residential clustering on new development. Figure 6.2 illustrates a more traditional development scenario where lots are placed across the entire site. In this example, the lot and house placement does avoid major natural features such as floodplain and wetlands, but still substantially encroaches into woodlands and riparian buffer features. Such a development layout (“yield plan”) provides an estimate of a site’s capacity to accommodate lots and houses at the base density hypothetically allowed under a municipal zoning ordinance.

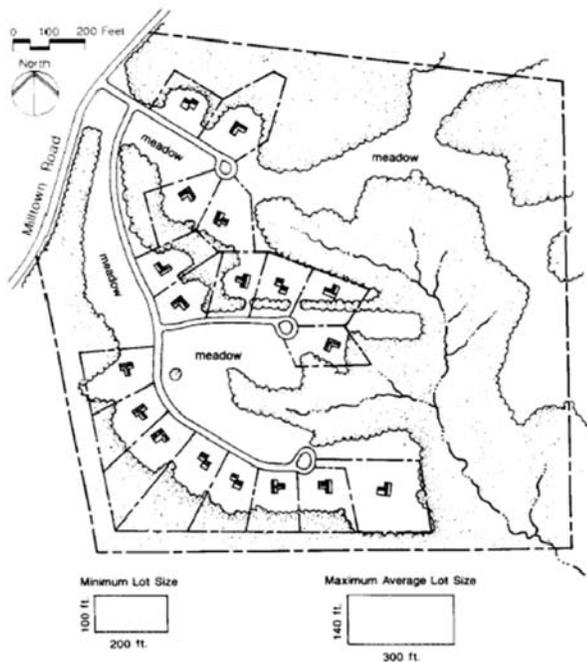
Figure 6.2
Conventional development



Source: Growing Greener: Putting Conservation into Local Codes. Natural Lands Trust, Inc., 1997

Figure 6.3 illustrates a “density-neutral” approach to clustering, where the number of lots and houses is held constant at 18 lots; however, the lot size has been reduced significantly allowing for 50 percent of open space area.

Figure 6.3
Clustered development



Source: Growing Greener: Putting Conservation into Local Codes. Natural Lands Trust, Inc., 1997

Nonresidential clustering

Conventional nonresidential development (e.g., retail commercial development) can also be configured in the form of low-rise (one story), relatively low-density strip or “big box” centers.

Design Considerations

The design process for implementing clustering at a proposed development site can occur in a variety of ways. Randall Arendt’s *Growing Greener: Putting Conservation into Local Codes* (1997) provides clustering guidance in several straight-forward steps. The process typically begins with the applicant applying existing conventional code to the site with any necessary net outs to develop a “yield plan.” The purpose is to determine how many units can be developed conventionally:

- Step 1: Identify land to be protected: Primary conservation areas,
 - Identify land to be protected: Secondary conservation areas, and
 - Delineate potential development area.
- Step 2: Locate house sites on potential development area
- Step 3: Connect with streets and trails
- Step 4: Draw in lot lines

A major issue to address is the extent to which a clustering process is consistent with municipal ordinance requirements. How many house sites with what lot size are going to be located in the potential development area?

If the existing municipal code is fully flexible, applicants can comprehensively “zone out” primary and secondary conservation areas and be confident that the baseline “yield plan” unit count can be loaded into the potential development area at whatever lot size is necessary (some applicants/developers believe that smaller lots translate into less valuable and marketable units and are reluctant to make considerable reductions in lot sizes). Often, however, such reduced lot sizes are less than the municipal ordinance allows. In such cases, the applicant is motivated to reduce primary and secondary conservation areas, so that the potential development area can be enlarged.



Cluster development at Pokagonek Edawat Housing Development

Source: Pokagon Band of Potawatomi Indians

Stormwater Functions and Calculations

Volume and peak rate

Cluster development is a technique that results in increased open space, which reduces stormwater peak rate and volume. These open spaces are often associated with other BMPs from this manual, including preserving sensitive areas and protecting riparian corridors. These BMPs are not to be included in the disturbed stormwater management area when calculating runoff volume (Chapter 9 and Worksheet 3).

Any portion of the open space that is mitigated or revegetated/reforested should be included in the disturbed stormwater management area, but may be granted credit in accordance with the applicable BMP for native revegetation, soil restoration, minimize soil compaction, riparian buffer restoration, or minimize total disturbed area.

Water quality improvement

Clustering minimizes impervious areas and their associated pollutant loads, resulting in improved water quality. In addition, clustering preserves open space and other natural features, such as riparian corridors, which allow for increased infiltration of stormwater and removal of pollutant loads. (See Chapter 9 for calculation methodology).

Maintenance

Preserving open space creates concerns regarding responsibility for maintenance activities. Legally, the designated open space may be conveyed to the municipality. More likely, ownership of these natural areas will be assumed by homeowners' associations or the specific individual property owners where these resources are located. Specific maintenance activities will depend on the type of vegetation present in the preserved natural area. For example, woodlands require little to no maintenance and open lawns require higher maintenance. An objective of cluster development is to conserve the existing natural systems with minimal, if any, intervention and disturbance.



Cherry Hill Village, Canton Township, MI

Cost

Clustering is beneficial from a cost perspective. Costs to build 100 clustered single-family residential homes is less due to less land clearing and grading, less road and sidewalk construction (including curbing), less lighting and street landscaping, potentially less sewer and water line construction, potentially less stormwater collection system construction, and other economies of scale.

Post-construction, clustering also reduces costs. A variety of studies from Rutgers University's landmark *Costs of Sprawl* studies and later updates show that delivery of a variety of municipal services such as street maintenance, sewer and water services, and trash collection are more economical on a per person or per house basis when development is clustered. Furthermore, services such as police protection are made more efficient when residential development is clustered.

Additionally, clustering has been shown to positively affect land values. Analyses of market prices of conventional development over time in contrast with comparable clustered residential developments (where size, type, and quality of the house itself is held constant) indicate that clustered development increases in value at a more rapid rate than conventionally designed developments. This is partly due to the proximity to permanently protected open space.

Designer/Reviewer Checklist for Cluster Development

ITEM	YES	NO	N/A	NOTES
Has nonstructural BMP Protect Sensitive Resources been applied? If not, complete this BMP.				
Has a baseline “yield plan” been developed by applicant?				
What municipal ordinance provisions - obstacles and opportunities - exist for clustering?				
Has a Potential Development Area, or comparable, which avoids Sensitive Resources, been delineated?				
Has “yield plan” house/unit count been loaded into Potential Development Area?				
What clustered lot size assumptions are being used? Compatible with municipal ordinance?				
Compare disturbed area/developed area of “yield plan” with clustered plan?				

References

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U.S. Environmental Protection Agency. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, 840-B-92-002, 1993.

BMP Fact Sheet

Minimize Soil Compaction

Minimizing soil compaction is the practice of protecting and minimizing damage to existing soil quality caused by the land development process. Enhancing soil composition with soil amendments and mechanical restoration after it has been damaged is addressed in Chapter 7 as a separate structural BMP.



Minimizing disturbance of soil to protect wooded area

Source: City of Andover, Minnesota

Key Design Features

- Reduce disturbance through design and construction practices
- Limit areas of heavy equipment
- Avoid extensive and unnecessary clearing and stockpiling of topsoil
- Use top quality topsoil; maintain topsoil quality during construction

Benefits

- Increases infiltration capacity
- Provides healthy environment for vegetation
- Preserves low areas, which offer added benefit when runoff is directed there from impervious areas

Limitations

- Difficult to implement on small development sites

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	Med/High
Commercial	Yes	Groundwater Recharge	Med/High
Ultra Urban	Limited	Peak Rate	Low/Med
Industrial	Yes	Stormwater Quality Functions	
Retrofit	Limited	TSS	Med/High
Highway/Road	Limited	TP	Med/High
Recreational	Yes	NO ₃	Low
		Temperature	Med/High

Additional Considerations	
Cost	Low/Med
Maintenance	Low
Winter Performance	Low/Med

Case Study: Minimizing soil compaction near an oak tree

City of Troy, MI

Minimizing soil compaction is not only important for drainage of a site, but also for minimizing impacts to established vegetation. In order to protect a culturally significant pin oak tree, the City of Troy utilized orange construction fencing at the drip line of the tree to protect the roots from any damage that could potentially be caused by machinery. The construction in the area included the assembly of a permanent picnic shelter that included a concrete foundation and steel I-beam construction. Prior to any construction commencing, the City placed the stakes and temporary fencing around the 30-inch oak tree, and notified the contractor that the area was to be protected.

Heavy equipment used within the drip line of a tree can cause soil compaction, resulting in the death of tree roots. Damage done to a tree's root system may take 3-4 years after construction to be present in a tree's canopy. Currently, the shelter has been completed, and the damage was successfully minimized to the pin oak tree.



Fencing around oak tree to minimize soil compaction

Source: City of Troy

Case Study Site Considerations	
Project Type	Minimize soil compaction
Estimated Total Project Cost	Minimal – Utilized DPW stakes
Maintenance Responsibility	City of Troy
Project Contact	Jennifer Lawson, 248-524-3881

Description and Function

Minimizing soil compaction relates directly to reducing total site disturbance, site clearing, site earthwork, the need for soil restoration, and the size and extent of costly, engineered stormwater management systems. Ensuring soil quality can significantly reduce the cost of landscaping vegetation (higher survival rate, less replanting) and landscaping maintenance. Fencing off an area can help minimize unnecessary soil compaction.



Preventing soil compaction adjacent to a stand of trees
Source: City of Andover, Minnesota

Soil is a physical matrix of weathered rock particles and organic matter that supports a complex biological community. This matrix has developed over a long time period and varies greatly within the state. Healthy soils, which have not been compacted, perform numerous valuable stormwater functions, including:

- Effectively cycling nutrients,
- Minimizing runoff and erosion,
- Maximizing water-holding capacity,
- Reducing storm runoff surges,
- Absorbing and filtering excess nutrients, sediments, and pollutants to protect surface and groundwater,
- Providing a healthy root environment,
- Creating habitat for microbes, plants, and animals, and
- Reducing the resources needed to care for turf and landscape plantings.

Undisturbed soil consists of pores that have water-carrying and holding capacity. When soils are overly compacted, the soil pores are destroyed and permeability is drastically reduced. In fact, the runoff response of vegetated areas with highly compacted soils closely resembles that of impervious areas, especially during

large storm events (Schueler, 2000). Recent research studies indicate that compacted soils from development practices end up as dense as concrete.

Applications

Minimizing soil compaction can be performed at any land development site during the design phase. It is especially suited for developments where significant “pervious” areas (i.e., post-development lawns and other maintained landscapes) are being proposed. If existing soils have already been excessively compacted, soil restoration is applicable (see soil restoration BMP in Chapter 7).

Design Considerations

Early in a project’s design phase, the designer should develop a soil management plan based on soil types and existing level of disturbance (if any), how runoff will flow off existing and proposed impervious areas, trees and natural vegetation that can be preserved, and tests indicating soil depth and quality. The plan should clearly show the following:

1. **No disturbance areas.** Soil and vegetation disturbance is not allowed in designated no disturbance areas. Protecting healthy, natural soils is the most effective strategy for preserving soil functions. Not only can the functions be maintained, but protected soil organisms are also available to colonize neighboring disturbed areas after construction.
2. **Minimal disturbance areas.** Limited construction disturbance occurs, but soil restoration may be necessary for such areas to be considered fully pervious after development. In addition, areas to be vegetated after development should be designated minimal disturbance areas. These areas may allow some clearing, but no grading due to unavoidable cutting and/or filing. They should be immediately stabilized, revegetated, and avoided in terms of construction traffic and related activity. Minimal disturbance areas do not include construction traffic areas.
3. **Construction traffic areas.** Construction traffic is allowed in these areas. If these areas are to be considered fully pervious following development, a soil restoration program will be required.

4. **Topsoil stockpiling and storage areas.** If these areas are needed, they should be protected and maintained. They are subject to soil restoration (including compost and other amendments) following development.
5. **Topsoil quality and placement.** Soil tests are necessary to determine if it meets minimum parameters. Critical parameters include: adequate depth (four inches minimum for turf, more for other vegetation), organic content (five percent minimum), and reduced compaction (1,400 kPa maximum) (Hanks and Lewandowski, 2003). To allow water to pass from one layer to the other, topsoil must be “bonded” (See Construction Guidelines #4) to the subsoil when it is reapplied to disturbed areas.



Construction site disturbance showing grading and soil compaction

Construction Guidelines

1. At the start of construction, no disturbance and minimal disturbance areas must be identified with signage and fenced as shown on the construction drawings.
2. No disturbance and minimal disturbance areas should be strictly enforced.
3. No disturbance and minimal disturbance areas should be protected from excessive sediment and stormwater loads while adjacent areas remain in a disturbed state.
4. Topsoil stockpiling and storage areas should be maintained and protected at all times. When topsoil is reapplied to disturbed areas it should be “bonded” with the subsoil. This can be done by spreading a thin layer of topsoil (2-3 inches), tilling it into the subsoil, and then applying the remaining

topsoil. Topsoil should meet locally available specifications/requirements.

Stormwater Functions and Calculations

Volume and peak rate reduction

Minimizing soil compaction can reduce the volume of runoff by maintaining soil functions related to stormwater infiltration and evapotranspiration. Designers that use this BMP can select a lower runoff coefficient (i.e., curve number) for calculating runoff volume and peak rate from the area of minimized soil compaction. Chapter 9 and worksheets three and four show how to calculate the runoff credit for this BMP.

Where no-disturbance areas are specified, which are also sensitive areas maintained in their presettlement state, there will be no net increase in stormwater runoff from that area. Calculation methodology to account for the protection of sensitive areas is provided in Chapter 9.

Water quality improvement

Minimizing soil compaction improves water quality through infiltration, filtration, chemical and biological processes in the soil, and a reduced need for fertilizers and pesticides after development. See Chapter 9 for information on how to calculate the volume of runoff that needs water quality treatment.

Maintenance

Sites that have minimized soil compaction properly during the development process should require considerably less maintenance than sites that have not. Landscape vegetation, either retained or re-planted, will likely be healthier, have a higher survival rate, require less irrigation and fertilizer, and have better aesthetics.

Some maintenance activities such as frequent lawn mowing can cause considerable soil compaction after construction and should be avoided whenever possible. Planting low-maintenance native vegetation is the best way to avoid damage due to maintenance (Appendix C). No disturbance areas on private property should have an easement, deed restriction, or other legal measure imposed to prevent future disturbance or neglect.

Cost

Minimizing soil compaction generally results in significant construction cost savings. Design costs may increase slightly due to a more time intensive design.

Criteria to Receive Credits for Minimize Soil Compaction BMP

To receive credit under a local regulation, areas of no disturbance and minimal disturbance must meet the following criteria:

- The no disturbance and minimal disturbance areas are protected by having the limits of disturbance and access clearly shown on the Stormwater Plan, all construction drawings, and delineated/flagged/fenced in the field.
- No disturbance and minimal disturbance areas are not be stripped of existing topsoil.
- No disturbance and minimal disturbance areas are not be stripped of existing vegetation.
- No disturbance and minimal disturbance areas are not be subject to excessive equipment movement. Vehicle movement, storage, or equipment/material lay-down is not be permitted in these areas.
- Use of soil amendments and additional topsoil is permitted in other areas being disturbed, as described above. Light grading may be done with tracked vehicles that prevent compaction.
- Lawn and turf grass are acceptable uses. Planted meadow is an encouraged use.
- Areas receiving credit is located on the development project.

Designer/Reviewer Checklist for Minimize Soil Compaction

ITEM	YES	NO	N/A	NOTES
Have no disturbance areas been defined on plans (see minimize total disturbed area BMP)?				
Have no disturbance areas been fenced/flagged in field?				
Have minimal disturbance areas been defined on plans?				
Have construction traffic areas been defined on plans?				
Is soil restoration BMP committed to construction traffic areas, post-construction phase?				
Are soil stockpiling and storage areas defined on plan?				
Have proper topsoil quality and placement specifications been committed in the plans?				

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BMP Fact Sheet

Minimize Total Disturbed Area

A key component of LID is to reduce the impacts during development activities such as site grading, removal of existing vegetation, and soil mantle disturbance. This can be achieved through developing a plan to contain disturbed areas.



Minimizing disturbance to existing trees during residential construction

Source: Insite Design Studio, Inc.

Key Design Features

- Identify and avoid special value and environmentally sensitive areas (See Protect Sensitive Areas BMP)
- Maximize undisturbed open space
- Minimize disturbance lot-by-lot
- Maximize soil restoration and restore soil permeability
- Minimize and control construction traffic areas
- Minimize and control construction stockpiling and storage areas

Benefits

- Reduced runoff volume
- Reduced peak rates
- High water quality benefits
- Increased infiltration capacity
- Provides healthy environment for vegetation

Limitations

- Difficult to achieve on small development sites

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	High
Commercial	Yes	Groundwater Recharge	High
Ultra Urban	Limited	Peak Rate	High
Industrial	Yes	Stormwater Quality Functions	
Retrofit	Limited	TSS	High
Highway/Road	Limited	TP	High
Recreational	Yes	NO ₃	High
		Temperature	High

Additional Considerations	
Cost	Low
Maintenance	Low
Winter Performance	High

Case Study: Longmeadow Development

Niles, MI

Longmeadow is 400 acres of rolling land divided by ponds, meadows, clusters of trees, wetlands, and horse paddocks in Niles, MI. The development was picked by The Conservation Fund as a demonstration project in the State of Michigan for watershed protection.

The design was dictated by the land, resulting in separate areas for a variety of housing types and lot sizes. It also resulted in the preservation of 50 acres of open space, providing opportunities for fishing, community gardens, walking trails, private roads for biking and hiking. The design accounted for the need to preserve habitat for wildlife. This includes eliminating street lighting and maintaining animal corridors.

The wetland areas on site were not disturbed, and are maintained by a vegetated buffer greater than 75 feet wide. The site design also incorporated long vistas of seeded upland prairie meadows and homes tied in with miles of white horse fence.

Most of the trees on site were preserved and extra care was taken to preserve a very old, large oak tree at the entrance to the development. Visual separation of housing types was designed using existing fence rows of trees. In addition, bioswales were installed to provide infiltration along the roads and between homes.



View of existing wetland

Source: Longmeadow Development, Owner: Jane Tenney

Case Study Site Considerations	
Project Type	Bioswale, preservation of sensitive areas
Soil Conditions	Well drained soils on ridgetops, knolls, and plains. Permeability is moderate to moderately rapid. Suited well for most building and septic tank absorption. Main issue to address is maintaining slope and erosion control
Estimated Total Project Cost	N/A
Maintenance Responsibility	Longmeadow Homeowners Association
Project Contact	Jane Tenney: janetenney@comcast.net

Description and Function

Disturbance at a development site can occur through normal construction practices, such as grading, cutting, or filling. Minimizing the total disturbed area of the site requires the consideration of multiple BMPs, such as cluster development and identifying and protecting sensitive areas. These BMPs serve to protect area resources by reducing site grading and maintenance required for long-term operation of the site.

Minimizing the total disturbed area of a site specifically focuses on how to minimize the grading and overall site disturbance, maximizing conservation of existing native plant communities and the existing soil mantle of a site. If invasive plant species are present in the existing vegetation, proper management of these areas may be required in order for the vegetation to achieve its greatest hydrological potential.

Minimize grading

Reduction in grading can be accomplished in several ways, including conforming the site design with existing topography and land surface, where road alignments strive to follow existing contours as much as possible, varying the grade and alignment criteria as necessary to comply with safety limits.

Minimize overall site disturbance

Site design criteria have evolved in municipalities to ensure that developments meet safety standards (i.e. sight distance and winter icing) as well as certain quality or appearance standards. Roadway design criteria should be flexible in order to optimize the fit for a given parcel and achieve optimal roadway alignment. The avoidance of environmentally sensitive resources, such as important woodlands, may be facilitated through flexible roadway layout.

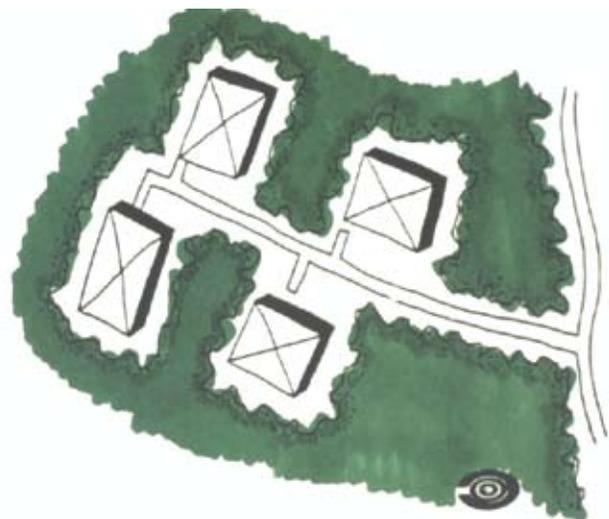


Disturbance of native trees minimized during residential construction

From the single-lot perspective, the conventional lot layout can impose added earthwork and grading. Although the intent of these municipal requirements is to provide privacy and spacing between units, the end result is often a cleared and graded lot, which reduces stormwater benefits. And although configuring lots in a rectilinear shape may optimize the number of units, municipalities should consider requiring that the total site be made to fit the natural landscape as much as possible.

Municipal criteria that impose road geometry are usually contained within the subdivision and land development ordinance. Densities, lot and yard setbacks, and minimum frontages are usually contained in the zoning ordinance. Flexibility in the following land development standards will help to minimize site disturbance on an individual lot basis, thereby achieving area-wide stormwater quality and quantity results:

- Road vertical alignment criteria (maximum grade or slope)
- Road horizontal alignment criteria (maximum curvature)
- Road frontage criteria (lot dimensions)
- Building setback criteria (yards dimensions)



Minimally disturbed development

Source: Metropolitan Washington Council of Governments

Applications

Minimizing the total disturbed area of a site is best applied in lower density single-family developments, but can also be applied in residential developments of all types including commercial, office park, retail center, and institutional developments. Larger industrial park developments can also benefit from this BMP. However, as site size decreases and density and intensity of development increases, this BMP is uniformly more difficult to apply successfully. At some larger sites where Ultra Urban, Retrofit, or Highway/Road development is occurring, limited application may be feasible.

Design Considerations

During the initial conceptual design phase of a land development project, the applicant's design engineer should provide the following information, ideally through development of a Minimum Disturbance/Minimum Maintenance Plan:

1. Identify and Avoid Special Value/Sensitive Areas

Delineate and avoid environmentally sensitive resources using existing data from appropriate agencies (see Protect Sensitive Areas, Riparian Corridors, and Natural Flow Pathways BMPs).



Woodlands Protected through Minimum Disturbance Practices

2. Minimize Disturbance at Site

Modify road alignments (grades, curvatures, etc.), lots, and building locations to minimize grading, and earthwork as necessary to maintain safety standards and municipal code requirements. Minimal disturbance design should allow the layout to best fit the land form without significant earthwork, such as locating development in areas

of the site that has been previously cleared, if possible. If cut/fill is required, the use of retaining walls is preferable to earthwork. Limits of grading and disturbance should be designated on plan documentation submitted to the municipality for review/approval and should be physically designated at the site during construction via flagging, fencing, etc.

In addition, utilizing natural drainage features generally results in less disturbance and requires less revegetation.

3. Minimize Disturbance at Lot

To decrease disturbance, grading should be limited to roadways and building footprints. Municipalities should establish maximum setbacks from structures, drives, and walks. These setbacks should be designed to be rigorous but reasonable in terms of current feasible site construction practices. These standards may need to vary with the type of development being proposed and the context of that development (the required disturbance zone around a low density single-family home can be expected to be less than the disturbance necessary for a large commercial structure), given necessity for use of different types of construction equipment and the realities of different site conditions. For example, the U.S. Green Building Council's Leadership in Energy & Environmental Design Reference Guide (Version 2.0 June 2001) specifies:

“...limit site disturbance including earthwork and clearing of vegetation to 40 feet beyond the building perimeter, 5 feet beyond the primary roadway curbs, walkways, and main utility branch trenches, and 25 feet beyond pervious paving areas that require additional staging areas in order to limit compaction in the paved area...”

Stormwater Functions and Calculations

Volume

Any portion of a site that can be maintained in its presettlement state by using this BMP will not contribute increased stormwater runoff and will reduce the amount of treatment necessary. In addition, trees protected under this requirement can get a “credit” by receiving a curve number reflecting a woodlot in “good” condition. Calculation methodology to account for this BMP is provided in Chapter 9.

Peak rate

Runoff from the minimized disturbed area may be excluded from peak rate calculations for rate control, provided that the runoff from the area is not conveyed to and/or through stormwater management control structures. If necessary, runoff from the minimized disturbed area should be directed around BMPs and stormwater pipes and inlets by means of vegetated swales or low berms that direct flow to natural drainageways.

Water quality improvement

Water quality is benefited substantially by minimizing the disturbed area.

Maintenance

Minimizing site disturbance will result in a reduction of required maintenance of a site in both the short- and long-term. Areas of the site left as intact native plant communities do not typically require replacement with hard surfaces or additional vegetation to retain function. On the other hand, artificial surfaces such as pavement or turf grass require varying levels of maintenance throughout the life of a development. Higher levels of disturbance will also typically require significant maintenance of erosion control measures during the active development of a parcel, thus adding to short-term development costs.

While intact natural areas may require small amounts of occasional maintenance (typically through invasive species control) to maintain function, levels of maintenance required for hard surfaces or turf grass will remain static or, in most cases, increase over time. Avoiding disturbance to natural areas benefits the short term developer and the long-term owner by minimizing time and money needed to maintain artificial surfaces.

Cost

The reduced costs of minimized grading and earthwork should benefit the developer. Cost issues include both reduced grading and related earthwork as well as costs involved with site preparation, fine grading, and seeding.

Calculation of reduced costs is difficult due to the extreme variation in site factors, (amount of grading, cutting/filling, and haul distances for required trucking,). Some relevant costs factors are as follows (as based on R.S. Means, Site Work & Landscape Cost Data, 2007):

Site clearing

- Cut & chip light trees to six-inch diameter \$3,475/acre
- Grub stumps and remove \$1,600/acre
- Cut & chip light trees to 24-inch diameter \$11,600/acre
- Grub stumps and remove \$6,425/acre

Strip topsoil and stockpile

- Ranges from \$0.52 to \$1.78 / yard³ because of Dozer horse power, and ranges from ideal to adverse conditions
- Assuming six inches of topsoil, 500 ft haul \$2.75 - 9.86 per yard³
- Assuming six inches of topsoil, 500 ft haul \$9,922 -16,746 per acre

Site preparation, fine grading, seeding

- Fine grading w/ seeding \$2.91 /sq. yd.
- Fine grading w/ seeding \$14,084 /acre

In sum, total costs usually range from \$29,000 - \$49,000 per acre and could certainly exceed that figure substantially at more challenging sites.

Criteria to Receive Credits for Minimizing Total Disturbed Area

To receive credit for protection of existing trees under a local regulation, the following criteria must be met:

- Area has not be subject to grading or movement of existing soils.
- Existing native vegetation are in a healthy condition as determined through a plant inventory and may not be removed.
- Invasive vegetation may be removed.
- Pruning or other required maintenance of vegetation is permitted. Additional planting with native plants is permitted.
- Area is protected by having the limits of disturbance clearly shown on all construction drawings and delineated in the field.
- Area is located on the development project.

Designer/Reviewer Checklist for Minimize Total Disturbed Area

ITEM	YES	NO	N/A	NOTES
Do municipal requirements for open space and related resource protection exist? Applied here?				
Have related BMPs (Protect Sensitive Areas, Natural Flow Pathways, Riparian Buffers, Clustering) been applied?				
Has Potential Development Area been defined?				
Have infrastructure connections/constraints been analyzed?				
On site, have roads been aligned to fit topography, to parallel contours and minimize cut/fill? On areas previously cleared? With terracing? Compatible with natural flow pathways?				
On lots, have buildings been located to reduce disturbance?				
On lots, have maximum disturbance radii been established and applied?				
No disturbance areas shall be clearly delineated on construction plans and flagged/fenced in field				
Have no disturbance zones been assessed qualitatively for invasive management needs?				

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BMP Fact Sheet

Protect Natural Flow Pathways

A main component of LID is to identify, protect, and use natural drainage features, such as swales, depressions, and watercourses to help protect water quality. Designers can use natural drainage features to reduce or eliminate the need for structural drainage systems.



Natural flow pathway in residential development

Source: Brandywine Conservancy, Environmental Management Center, 1998

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	Low/Med
Commercial	Yes	Groundwater Recharge	Low
Ultra Urban	No	Peak Rate	Med/High
Industrial	Yes	Stormwater Quality Functions	
Retrofit	Yes	TSS	Low/Med
Highway/Road	Yes	TP	Low/Med
Recreational	Yes	NO ₃	Low
		Temperature	Low

Additional Considerations	
Cost	Low
Maintenance	Low/Med
Winter Performance	Low/Med

Variations

- Check dams to slow velocity
- Earthen berms for additional storage
- Additional native vegetation for increased infiltration

Key Design Features

- Identifies and maps natural drainage features (e.g., swales, channels, ephemeral streams, depressions, etc.)
- Uses natural drainage features to guide site design
- Distributes non-erosive surface flow to natural drainage features
- Keeps non-erosive channel flow within drainage pathways
- Uses native vegetative buffers

Benefits

- Maximizes natural hydrological functions
- Reduces structural management practices
- Reduces management costs

Limitations

- Minimal water quality benefits

Case Study: Marywood Health Center

Grand Rapids, MI

When the new Marywood Health Center was designed and constructed, care was taken to make a building and setting that met the needs of the nuns, preserved the natural beauty of the area, and protected the creek.

The design and construction of the health center building preserved the natural topography. The stormwater from the roof of the new health center has been diverted to create a pond landscaped with native perennial wildflowers. The stormwater from the health center parking lot is conveyed along a series of wildflower-planted swales and small ponds to a stormwater prairie that matured in 2007. An additional feature is a rain garden and detention pond next to the parking lot at Aquinata Hall.

The stormwater features on the campus created wildlife habitat and natural beauty, enhancing the grounds for the residents and local community to enjoy. The large prairie only needs to be mowed every other year to maintain the planting, reducing the cost of grounds keeping. The stormwater systems have become a regional attraction, as this is the first stormwater prairie planted in Grand Rapids, MI.

It takes three years for a prairie to mature, and until that time, it is not as attractive as it will be once flowers and grasses reach full size. During the first years of growth, the area can be beautifully enhanced with annual, non-invasive wildflowers such as cosmos, and the soil stabilized with annual ryegrass.

Native prairie vegetation in natural flow pathway



Case Study Site Considerations	
Project Type	Protect natural flow pathways, native vegetation, preserve sensitive areas.
Estimated Total Project Cost	\$2,000 (Rain garden and soil replacement)
Maintenance Responsibility	Volunteers and Marywood staff
Project Contact	Maureen Geary, Grand Rapids Dominicans Leadership Vicereess (616) 647-0133

Description and Function

Many natural undeveloped sites have identifiable drainage features such as swales, depressions, and watercourses which effectively manage the stormwater that is generated on the site. By identifying, protecting, and using these features, a development can minimize its stormwater impacts. Instead of ignoring or replacing natural drainage features with engineered systems that rapidly convey runoff downstream, designers can use these features to reduce or eliminate the need for structural drainage systems.

Naturally vegetated drainage features tend to slow runoff and thereby reduce peak discharges, improve water quality through filtration, and allow some infiltration and evapotranspiration to occur. Protecting natural drainage features can provide for significant open space and wildlife habitat, improve site aesthetics and property values, and reduce the generation of stormwater runoff itself. If protected and used properly, natural drainage features generally require very little maintenance and can function effectively for many years.

Site designs should use and/or improve natural drainage pathways whenever possible to reduce or eliminate the need for stormwater pipe networks. This can reduce costs, maintenance burdens, and site disturbance related to pipe installation. Natural drainage pathways should be protected from significantly increased runoff volumes and rates due to development. The design should prevent the erosion and degradation of natural drainage pathways through the use of upstream volume and rate control BMPs, if necessary. Level spreaders, erosion control matting, revegetation, outlet stabilization, and check dams can also be used to protect natural drainage features.



Preservation of natural features in residential development

Variations

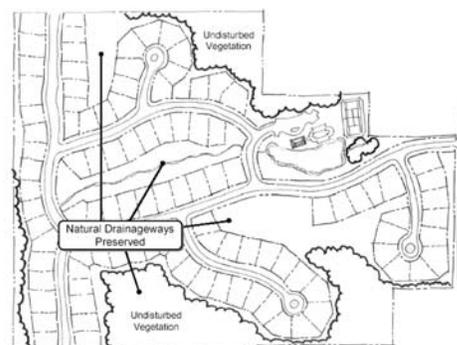
Natural drainage features can also be made more effective through the design process. Examples include constructing slight earthen berms around natural depressions or other features to create additional storage, installing check dams within drainage pathways to slow runoff and promote infiltration, and planting additional native vegetation within swales and depressions.

Applications

As density and overall land disturbance decreases, this BMP can be used with a greater variety of land uses and development types. It is best used in residential development, particularly lower density single-family residential development. Where municipal ordinances already require a certain percentage of the undeveloped site to remain as undeveloped open space, this open space requirement can be overlain onto natural flow pathways/drainage features, as well as floodplains, wetlands, and related riparian areas. After minimizing runoff as much as possible, reduced runoff quantities can then be distributed into this natural flow pathway system, on a broadly distributed basis, lot by lot.

Other land uses such as commercial and industrial developments tend to be associated with higher density development. This results in higher impervious coverage and maximum site disturbance allowances, making protecting and conserving natural flow pathways/drainage areas more difficult.

Applications for both retrofit and highway/road are limited. In terms of retrofitting, some developed sites may have elements of natural flow pathways/drainage features intact, although many presettlement site features may have been altered and/or eliminated. Developed sites of lower densities may offer limited retrofit potential. Similarly, highway/road projects are likely to be characterized by both limited site area, given the difficulties of right-of-way acquisition, as well as substantial disturbance of this limited site area.



Schematic of a site design protecting natural drainage features
Source: Georgia Stormwater Management Manual, Volume 2: Technical Handbook, First Edition. August, 2001

Design Considerations

1. **Identify natural drainage features.** Identifying and mapping natural drainage features is generally done as part of a comprehensive site analysis. This process is an integral first step of site design. Subtle site features such as swales, drainage pathways, and natural depressions should be delineated in addition to commonly mapped hydrologic elements such as wetlands, perennial and intermittent streams, and waterbodies.



Natural drainage features can guide the design

Source: Delaware Department of Natural Resources and Environmental Control - Conservation Design for Stormwater Management

2. **Use natural drainage features to guide site design.** Instead of imposing a two-dimensional paper design on a particular site, designers can use natural drainage features to steer the site layout. Drainage features define contiguous open space and other undisturbed areas as well as road alignment and building placement. The design should minimize disturbance to natural drainage features. Drainage features that are to be protected should be clearly shown on all construction plans. Methods for protection, such as signage and fencing, should also be noted on applicable plans.
3. **Use native vegetation.** Natural drainage pathways should be planted with native vegetative buffers and the features themselves should include native vegetation where applicable. If drainage features have been previously disturbed, they can be restored with native vegetation and buffers.

Stormwater Function and Calculations

Volume reduction

Protecting natural flow pathways can reduce the volume of runoff in several ways. Reducing disturbance and maintaining a natural cover reduces the volume of runoff through infiltration and evapotranspiration. Using natural flow pathways further reduces runoff volumes through allowing increased infiltration to occur, especially during smaller storm events. Encouraging infiltration in natural depressions also reduces stormwater volumes. Employing strategies that direct non-erosive sheet flow onto naturally vegetated areas also promotes infiltration – even in areas with relatively impermeable soils. (See Chapter 9 for volume reduction calculations.)

Artesian spring in Northville Ridge Subdivision, Northville Township, MI

When the subdivision was being developed, the Johnson Creek Protection Group requested that the developer relocate one of the proposed residential homes and create a small park above the spring so as not to interrupt the groundwater flow. They agreed and the spring still flows year around creating a focal point for the park.



Source: Wayne County Department of Environment

Peak rate mitigation

Protecting natural flow pathways can reduce the peak rate of runoff in several ways. Reducing disturbance and maintaining a natural cover reduces the runoff rate. Using natural flow pathways can lower discharge rates by slowing runoff and increasing onsite storage.

Water quality improvement

Protecting natural flow pathways improves water quality through filtration, infiltration, sedimentation, and thermal mitigation. (See Chapter 9 for Water Quality calculations.)

Maintenance

Natural drainage features that are properly protected and used as part of site development should require very little maintenance. However, periodic inspections are important. Inspections should assess erosion, bank

stability, sediment/debris accumulation, and vegetative conditions, including the presence of invasive species. Problems should be corrected in a timely manner

Protected drainage features on private property should have an easement, deed restriction, or other legal measure to prevent future disturbance or neglect.

Cost

Protecting natural flow pathways generally results in significant construction cost savings. Protecting these features results in less disturbance, clearing, and earthwork and requires less revegetation. Using natural flow pathways reduces the need and size of costly, engineered stormwater conveyance systems. Together, protecting and using natural flow pathways reduces and even eliminates the need for stormwater management facilities (structural BMPs), lowering costs even more.

Designer/Reviewer Checklist for Protect Natural Flow Pathways

ITEM	YES	NO	N/A	NOTES
Identify in plan all natural flow pathways before proposed development?				
Identify in plan natural flow pathways protected post-development?				
Highlight in plan natural flow pathways which are integrated into stormwater management?				
Have measures been taken to guarantee that natural pathways won't be negatively impacted by stormwater flows?				
Have credits been calculated for natural flow pathways being protected?				

References

Center for Watershed Protection. *Better Site Design: A Handbook for Changing Development Rules in your Community*. Ellicott City, MD, 1998.

Coffman, Larry. *Low Impact Development Design Strategies: An Integrated Design Approach*. EPA 841 B 00 0023. Department of Environmental Resources, Programs, and Planning, Prince George's County, MD, 2000.

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BMP Fact Sheet

Protect Riparian Buffer Areas

Riparian buffer areas are important elements of local communities' green infrastructure and/or LID tool box. These areas are critical to the biological, chemical, and physical integrity of our waterways. Riparian buffer areas protect water quality by cooling water, stabilizing banks, mitigating flow rates, and providing for pollution and sediment removal by filtering overland sheet runoff before it enters the water. The Environmental Protection Agency defines buffer areas as, "areas of planted or preserved vegetation between developed land and surface water, [which] are effective at reducing sediment and nutrient loads."

Physical restoration of riparian buffer areas is located in Chapter 7 as a structural BMP. A detailed description of the characteristics of riparian buffer areas is combined with a discussion of their stormwater functions in the restoration BMP.



Maintaining a riparian buffer

Source: JFNew

Key Design Features

- Physical protection
- Protection through planning tools

Benefits

- Improves water quality
- Reduces runoff velocities
- Reduces flow
- Enhances site aesthetics, habitat
- Reduces shoreline and bank erosion
- Improves flood control
- Reduces water temperature

Limitations

- Limited in reducing total runoff volumes
- Size of lot and/or development site may reduce ability to protect riparian buffers

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	Low/Med
Commercial	Yes	Groundwater Recharge	Low/Med
Ultra Urban	Limited	Peak Rate	Low/Med
Industrial	Yes	Stormwater Quality Functions	
Retrofit	Yes	TSS	High
Highway/Road	Limited	TP	High
Recreational	Yes	NO ₃	Medium
		Temperature	High

Additional Considerations	
Cost	Low/Med
Maintenance	Low
Winter Performance	High

Case Study: Macomb County Public Works Riparian Corridor Preservation

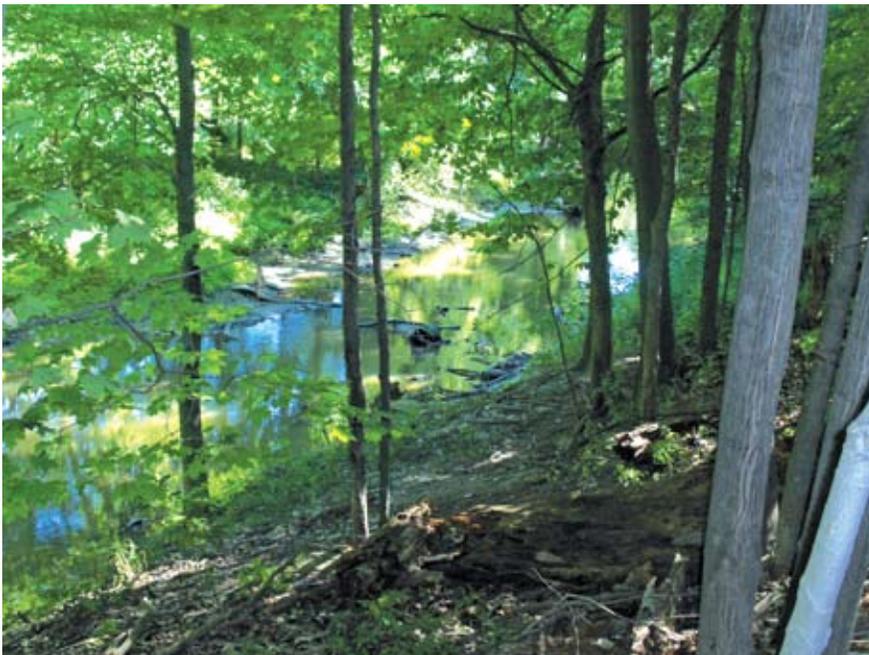
Clinton Township, MI

Macomb County Public Works incorporated LID techniques into the development of their new public works building. One element of the property is a 35 acre riparian area located along the North Branch of the Clinton River.

The county is committed to preserving this riparian corridor and is researching the option of a permanent easement that would be under the ownership and maintenance of a local land conservancy.

Other LID techniques used on this project include:

- Rain garden to catch roof runoff,
- Bioswale that captures parking lot runoff,
- Porous pavers along the sidewalks entering the building, and
- Native plantings located around the site, including the rain garden and bioswale.



Source: Macomb County Public Works Office

Case Study Site Considerations	
Project Type	Protect riparian areas, porous pavers, rain garden, bioswale
Project Contact	Lynne Seymour, 586-307-8229

Applications

As with the “protect sensitive areas” nonstructural BMP, protecting riparian buffer areas has great value and utility for virtually all types of development proposals and land uses. This BMP works best on larger sites. Therefore, although riparian buffer programs should be advocated in the densest of settings, their application is likely to be limited in high density contexts. Creative design can maximize the potential of riparian buffers. Clustering and density bonuses are design methods available to increase the amount and connectedness of open space areas such as riparian buffers.

Design Considerations

Physical design

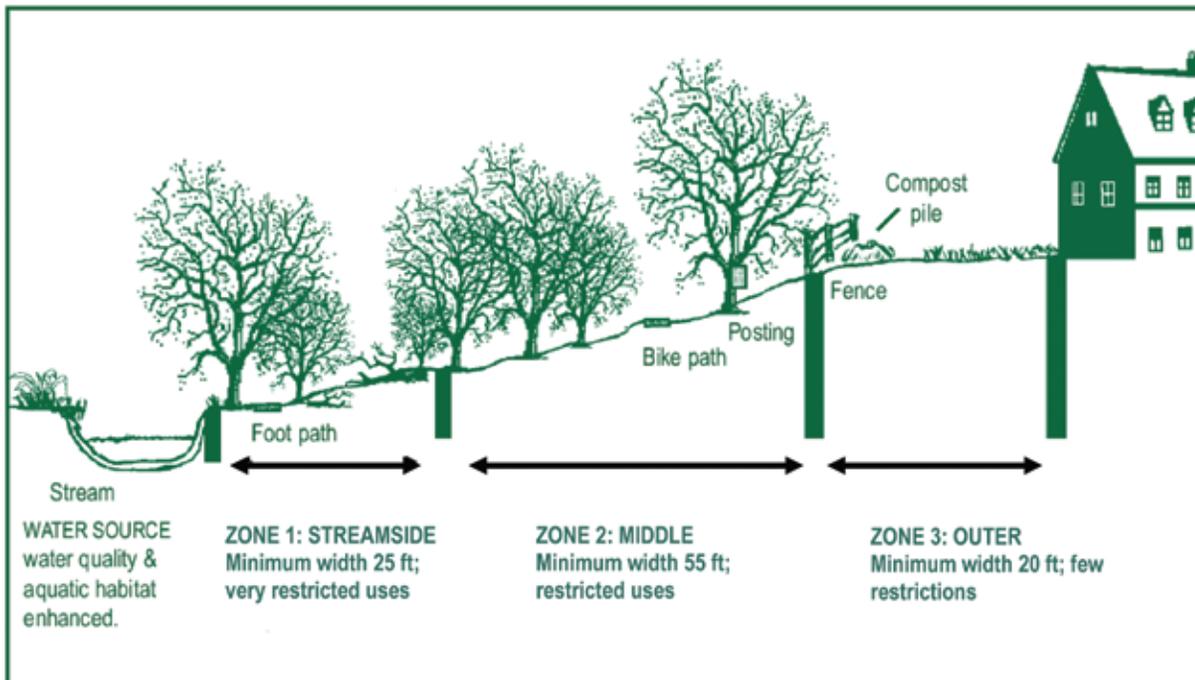
Consider the following when protecting the proper riparian buffer area width and related specifications:

- Existing or potential value of the resource to be protected,
- Site, watershed, and buffer characteristics,
- Intensity of adjacent land use, and
- Specific water quality and/or habitat functions desired. (*Chesapeake Bay Riparian Handbook*)

Riparian buffers can be divided into different zones that include various vegetation to enhance the quality of the body of water.

Zone 1: Also termed the “streamside zone,” begins at the edge of the stream bank of the active channel and extends a minimum distance of 25 feet, measured horizontally on a line perpendicular to the water body. Undisturbed vegetated area aims to protect the physical and ecological integrity of the stream ecosystem. The vegetative target for the streamside zone is undisturbed native woody species with native plants forming canopy, understory, and duff layer. Where such forest does not grow naturally, then native vegetative cover appropriate for the area (such as grasses, forbs, or shrubs) is the vegetative target. (*HRWC Model Ordinance*)

Zone 2: Also termed the “middle zone,” extends immediately from the outer edge of Zone 1 for a minimum distance of 55 feet. This managed area of native vegetation protects key components of the stream ecosystem and provides distance between upland development and the streamside zone. The vegetative target for the middle zone is either undisturbed or managed native woody species or, in its absence, native vegetative cover of shrubs, grasses, or forbs. Undisturbed forest, as in Zone 1, is encouraged strongly to protect future water quality and the stream ecosystem. (*HRWC Model Ordinance*)



Buffer width recommendations

Source: Schueler, *Watershed Protection Techniques*, 1994 (Graphic courtesy of the Center for Watershed Protection)

Zone 3: Also termed the “outer zone,” it extends a minimum of 20 feet immediately from the outer edge of Zone 2. This zone prevents encroachment into the riparian buffer area, filters runoff from adjacent land, and encourages sheet flow of runoff into the buffer. The vegetative target for the outer zone is native woody and herbaceous vegetation to increase the total width of the buffer; native grasses and forbs are acceptable. (*HRWC Model Ordinance*)

Community planning and riparian buffers

Numerous tools exist at the community level to protect riparian buffers, including ordinances, integrating buffers into plans, and public education.

Community buffer regulations

To effectively manage riparian buffer areas, a community must properly plan for these resources. Some Michigan communities have riparian buffer ordinances that explicitly regulate these areas. Typical components of a riparian ordinance include:

- Exemptions,
- Width requirements,
- Permitted and prohibited uses within the riparian buffer,
- Maintenance requirements,
- Waivers and variances, and
- Maintenance and construction of utilities and public roads along the stream corridor.

Natural features setback standards establish a minimum setback (buffer width) from natural features to prevent physical harm or destruction of the feature. These standards recognize the relationship between terrestrial and aquatic ecosystems and should be applied to both lakes and rivers. Each community establishes buffer width standards at their discretion.

In general, the wider the buffer, the greater the number of ecological functions the riparian zone will provide. Communities may choose to establish fixed or variable width buffers or a combination of the two. (*Oakland County Planning & Economic Development Services*)

Integrating buffer protection into plans

In addition to implementing a riparian buffer ordinance, communities can include riparian buffer area protection in the following planning tools:

- Community master plans,
- Park and recreation plans, and
- Subdivision and land development ordinances.

Key planning elements of a local riparian area protection program*

- Provide ample setbacks for sanitary facilities on buffer areas.
- The wider the riparian buffer, the greater the water quality protection and habitat value of the area.
- Establish setbacks from rivers and streams.
- Regulate road placement adjacent to the riparian buffer area.
- Restrict clearing, construction, and development within the 100-year floodplain.
- Zone areas adjacent to riparian buffer areas for low intensity development.
- Establish minimum lot size, frontage, and width requirements.
- Include reference to floodplain, soil, and sedimentation controls administered by other agencies in riparian regulations.
- Screen new structures with native vegetation.
- Limit industrial use along riparian corridors and regulate through special use permits subject to pre-designated standards.
- Limit the amount of impervious surfaces allowed adjacent to buffer area.
- Clearly outline appropriate and inappropriate use of riparian buffer areas.
- Promote intergovernmental coordination of regulations among communities along the river corridor.

*Adapted from *Michigan Wetlands – Yours to Protect*

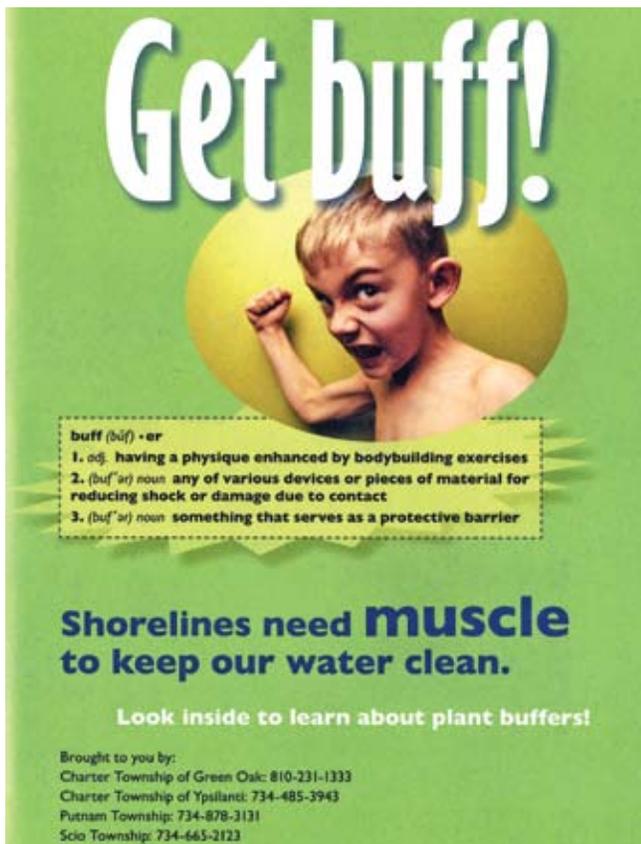


Combination of established and new riparian vegetation
Source: Huron River Watershed Council

Park and recreation plans can adopt the goals, policies, and objectives for riparian protection that are listed in the community master plan, or include its own park and recreation-specific recommendations for riparian buffer management. Content may focus on defining appropriate and inappropriate recreational uses for riparian areas located within parks. Park and recreation plans may also provide guidelines for proper construction and maintenance of river access points, and rules and regulations for public access as these topics relate to potential impacts on riparian buffers. (*Oakland County Planning & Economic Development Services*)

Riparian buffer education

Educational opportunities for the general public are an important component in community planning. Informing riparian owners of the importance of buffer areas will help to ensure these areas are understood and maintained over time. Public education activities include hosting public meetings, direct mailings to riparian homeowners, and educational workshops. These activities can be developed to meet the specific needs of your community through partnerships with local watershed groups.



Educational riparian booklet

Source: Huron River Watershed Council

Design measures

The following elements represent a menu of design measures for riparian and natural resource protection that communities may choose to encourage or require developers to incorporate during the site plan review process.

Conservation subdivision or open space regulations:

- Prepare natural features inventory on proposed project sites.
- Require certain percentage of total parcel acreage to be retained as open space.
- Reference minimum buffer widths for riparian buffer areas and identify upland areas adjacent to riparian buffer areas as preferred green space designated for low-impact residential recreation activities.
- Advocate cluster development that concentrates construction on land with less conservation value, and allows owners of house lots in the development to share undivided ownership of the portion of property remaining in a scenic and natural condition.
- Advocate lot averaging standards for retaining riparian resources and natural features on smaller sites.

Lot size and density regulations:

- Provide flexible lot size and density standards to guide development away from a stream buffer or other sensitive land.
- Provide developers with density bonuses for land-conserving design and density disincentives to actively discourage land-consuming layouts.

Minimum frontage and road setback regulations:

- Provide flexibility in frontage and road setback standards to minimize development intrusion on riparian buffer areas.

Stormwater management guidelines:

- Regulate erosion control before, during, and after construction.
- Encourage developers to retain natural vegetation already protecting waterways.
- Create a variable-width, naturally vegetated buffer system along lakes and streams that also encompasses critical environmental features such as the 100-year floodplain, steep slopes, and wetlands.

- Limit clearing and grading of forests and native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection.
- Promote riparian buffer areas as part of stormwater management planning.

Source: *Planning for Green River Corridors*, Oakland County Planning & Economic Development Services.



Wide buffer maintained during residential construction

Source: Huron River Watershed Council

Stormwater Functions and Calculations

Any portion of a site that can be maintained in its presettlement state by using this BMP will not contribute increased stormwater runoff and will reduce the amount of treatment necessary. Calculation methodology to account for this BMP is provided in Chapter 9.

Volume

Protected riparian buffers are not to be included in the disturbed stormwater management area when calculating runoff volume (Chapter 9 and Worksheet 3).

Any portion of a riparian buffer area that is mitigated or revegetated/reforested should be included in the disturbed stormwater management area, but may be granted credit in accordance with the applicable BMP for native revegetation, soil restoration, minimize soil compaction, riparian buffer restoration, or minimize total disturbed area.

Peak rate

Runoff from the riparian buffers may be excluded from peak rate calculations for rate control, provided that runoff from the riparian buffers is not conveyed to and/or through stormwater management control structures. If necessary, runoff from riparian buffers should be directed around BMPs and stormwater pipes and inlets by means of vegetated swales or low berms that direct flow to natural drainageways.

Water quality improvement

Water quality is benefited substantially by avoiding negative impacts which otherwise would have resulted from impacts to riparian buffers (e.g., loss of water quality functions from riparian buffers, from wetland reduction, etc.).

Cost

The costs of protecting riparian areas relate to a reduction in land available for development. However, most riparian areas are located in wetlands or floodplains, restricting the amount of buildable area.

Designer/Reviewer Checklist for Protect Riparian Buffer Areas

ITEM	YES	NO	N/A	NOTES
Define municipal programs requirements or resources for riparian buffer protection, if any				
Based on above and relevant sources, establish riparian buffer protection standards for development site				
Map riparian resources at the site which need buffer protection				
Apply Zone1/Zone2/Zone3 determinations; adjust for steep slopes and/or other natural/made factors.				
Overlay development program onto site, avoiding/minimizing Riparian Buffer Zone impacts.				
Provide for Riparian Buffer Zone maintenance?				
Provide for Riparian Buffer Zone protection in perpetuity (deed restrictions? covenants? easements)?				

References

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BMP Fact Sheet

Protect Sensitive Areas

Protecting sensitive and special value features is the process of identifying and avoiding certain natural features during development. This allows these features to be used for various benefits, including reducing stormwater runoff.

Protecting sensitive areas can be implemented both at the site level and throughout the community. For prioritization purposes, natural resources and their functions may be weighted according to their functional value. Sensitive areas should be preserved in their natural state to the greatest extent possible and are not the appropriate place to locate stormwater infrastructure.



Protection of existing native woodlands and wetlands, Kalamazoo, MI
Source: Fishbeck, Thompson, Carr & Huber, Inc.

Key Design Features

- Identify and map the following: floodplains, riparian areas, wetlands, woodlands, prairies, natural flow pathways, steep slopes, and other sensitive areas.
- Identify and map potential development areas

Benefits

- Improved water quality
- Mitigation of runoff volume and peak rates

Limitations

- Difficult to implement on smaller sites

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	High
Commercial	Yes	Groundwater Recharge	High
Ultra Urban	Limited	Peak Rate	High
Industrial	Yes	Stormwater Quality Functions	
Retrofit	No	TSS	High
Highway/Road	Limited	TP	High
Recreational	Yes	NO ₃	Low
		Temperature	High

Additional Considerations	
Cost	Low/Med
Maintenance	Low/Med
Winter Performance	High

Case Study: Western Michigan University

WMU, Business, Technology, and Research Park

Over 20 acres of this 200-acre development in Kalamazoo, MI was designated for a unique stormwater treatment system, which contained the preservation of natural features including woodlands and riparian corridors. In addition, other LID practices were also implemented on this site consisting of prairie restoration to provide habitat, minimize stormwater runoff, and improve water quality. Multi-cell ponds, bioretention, and wetlands were also designed to reduce outflow from the site to below the pre-developed rate and volume. The overall low impact design was imperative because it addressed the concerns of downstream residential neighbors who were very concerned that a large institutional development would negatively impact the quality of their lake.

Prior to development, over 10 acres of woodland and riparian areas were preserved as natural buffer areas and marked off during construction. These areas were supplemented with additional native herbaceous and woody plantings, which have matured into a beautiful landscape and nature area. All are low maintenance in terms of pest control and watering.

The benefits of sensitive area preservation are many for the park. One concern expressed by the neighborhood residents was the loss of greenspace because the former fields and woodland edge were used by many for nature hikes. In the end, the nature area preserved in the park is far more accessible to a wider range of people who enjoy the greenspace and diverse wildlife it attracts. The quality of life for these local residents was also preserved.



Trail through prairie restoration at the park

Source: Fishbeck, Thompson, Carr & Huber, Inc.

Case Study Site Considerations	
Project Type	Preservation of natural features, constructed wetlands, native vegetation.
Estimated Total Project Cost	\$5 million
Maintenance Responsibility	WMU
Project Contact	David Dakin, 269-387-8543

Description and Function

Protecting sensitive areas challenges the site planner to inventory and then, to the greatest extent possible, avoid resource sensitive areas at a site, including riparian buffers, wetlands, hydric soils, floodplains, steep slopes, woodlands, valuable habitat zones, and other sensitive resource areas. Development, directed away from sensitive areas, can be held constant, if BMPs such as cluster development are also applied.

A major objective of LID is to accommodate development with fewer impacts to the site. If development avoids encroachment upon, disturbance of, and impact to those natural resources which are especially sensitive to land development impacts and/or have special functional value, then low impact development can be achieved.

The first step in protecting sensitive areas is for the site planner to define, inventory, and map which resources are especially sensitive and/or have special value at a site proposed for development. Although many sensitive areas are common to all municipalities across Michigan, they can vary by region. The most detailed inventories are often compiled at the municipal or county level. For those areas without municipal or county-level data, state-level data can be used. (Table 6.1 is a partial list of potential sensitive area resources.)

Table 6.1
Data Sources for Environmentally Sensitive Areas

Resource	Agency Responsible for Data Development/Upkeep
Lakes and Streams	Michigan Center for Geographic Information, municipal and county agencies
Designated Trout Lakes/Streams and Natural Rivers	Michigan Center for Geographic Information Michigan Geographic Data Library
Wetlands Indicators	SEMCOG, Michigan Center for Geographic Information
Flood Prone Areas	SEMCOG, FEMA, municipal and county agencies
Wellhead Protection Areas	Michigan State University and Michigan Department of Environmental Quality
Woodlands	SEMCOG, Michigan Center for Geographic Information
Parks and Recreation Areas	SEMCOG, Ducks Unlimited, municipal and county agencies
Historic Sites	Michigan Center for Geographic Information, municipal and county agencies
Heritage Routes and Natural Beauty Roads	Michigan Department of Transportation and County Road Commissions, municipal and county agencies
Historic Bridges	Michigan Department of Transportation
Nonmotorized Facilities	Michigan Trails and Greenways Alliance, Community Foundation for Southeast Michigan
Sand Dunes	Michigan Center for Geographic Information

Source: SEMCOG



Protection of sensitive areas in residential development in Washington Township, MI

Preserving open space in multiple development areas throughout a community can ultimately evolve to form a unified open space system, integrating important conservation areas throughout the municipality and beyond. Many communities within Michigan are undertaking “green infrastructure” planning initiatives to proactively map these systems in order to restore or protect them as development occurs. The objective of these plans is to avoid impacting sensitive areas by: 1) carefully identifying and mapping these resources (resource areas, primary and secondary) from the start of the site planning process, and 2) striving to protect resource areas by defining other portions of the site free of these resources (potential development areas).

At the community level, local governments can implement community-wide regulations that protect sensitive areas such as wetlands, woodlands, riparian areas, and floodplains. Appendix H contains model ordinances for various sensitive resources developed for communities in Michigan.

Potential Applications

Regardless of land use type, protecting sensitive areas is applicable across all types of land development projects, whether residential of varying densities or office park, retail center or industrial and institutional uses. As density and intensity of uses increases, ease of application of this BMP decreases. In such limited cases, it is especially important that sensitive areas be prioritized.

Environmentally Sensitive Resources

SEMCOG has analyzed possible impacts on environmentally sensitive resources from planned transportation projects in Southeast Michigan, which may be helpful in minimizing site disturbance in certain development areas.

SEMCOG has defined these environmentally sensitive resources and potential impacts of planned transportation projects in the document, *Integrating Environmental Issues in the Transportation Planning Process: Guidelines for Road and Transit Agencies*.

The transportation projects were identified from the *2030 Regional Transportation Plan for Southeast Michigan (RTP)* and were mapped using Geographic Information Systems (GIS).

Please visit www.semco.org to download maps of the sensitive resources in PDF or to download data in GIS format.

Design Considerations

1. Identify, map, and inventory sensitive areas.

Mapping a site’s sensitive areas is an important step in preserving them (Figure 6.4). These features often include wetlands, steep slopes, woodlands, floodplains, and riparian areas. These data may give the community a general idea of the sensitive resources that could be on the site. In addition, the mapping will help the site designer define a potential development area which avoids encroachment upon and disturbance of defined and mapped sensitive areas.

The inventory of sensitive areas should also include an assessment of the *quality* of the existing natural communities. Because plant communities will exist in a variety of states based on historic disturbance and degradation, the quality of the given community needs to be considered in comparison to other similar communities. For instance, two upland forests in adjacent parcels may have significantly differing floristic quality, thus influencing the selection of land for site development. A floristic quality inventory (FQI) may be used to quantify the quality of a given natural community. As a general

rule of thumb, FQIs of 20 or lower have little ecological value, while those greater than 35 are have ecological importance across the state. FQIs greater than 50 represent only our highest quality plant communities and should never be considered for development.

The quality of a given plant community must also be considered in comparison to other plant communities in the state. For example, oak openings are considerably rarer in Michigan than dry southern forests. So, when given a choice of development for unregulated land, the more rare plant community should typically be avoided. A ranking system for Michigan’s natural communities, characterizing all communities statewide and globally on a 1-5 scale, is available at <http://web4.msue.msu.edu/mnfi/communities/index.cfm>.

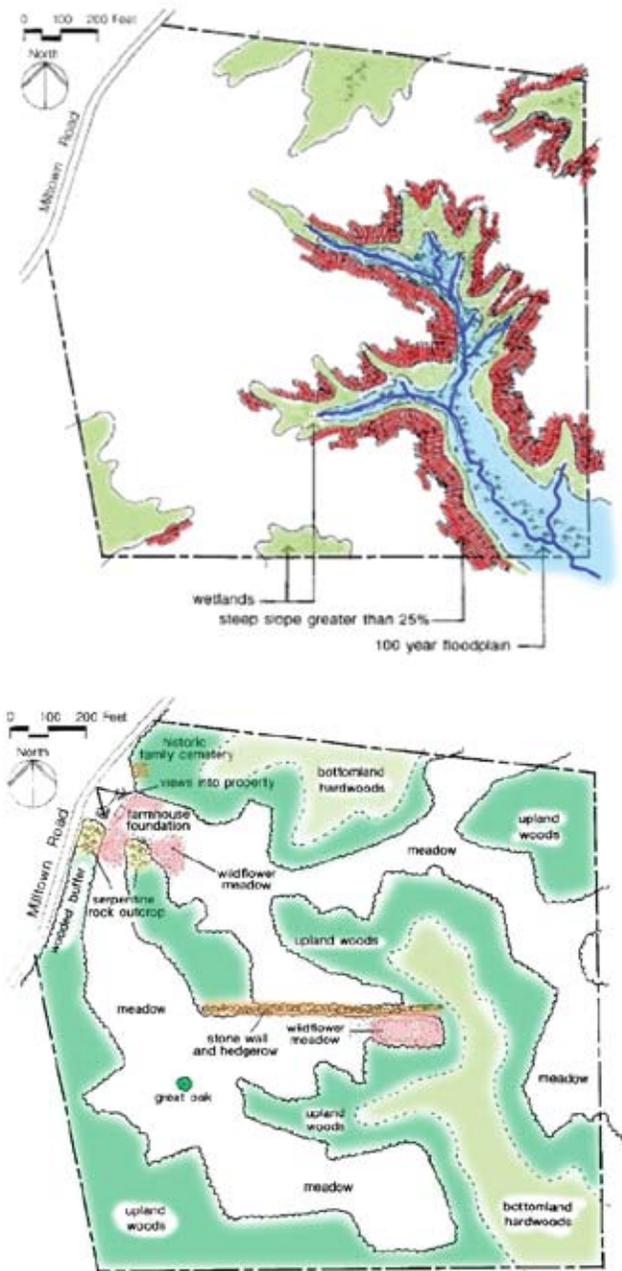
2. Combine mapped natural features into a sensitive resource areas map, prioritizing areas to avoid development.

All sensitive resource mapping should be overlain to produce a sensitive areas map. Randall Arndt in *Growing Greener* acknowledges prioritizing or weighting of sensitive areas by defining them as either Primary Conservation Areas (the most critical – avoid at all costs) or Secondary Conservation Areas (important resources which should be avoided when possible). Mapping the secondary resources of the site is an important step; the community can provide input to determine which features are important for preservation. Additionally, Primary and Secondary Conservation Areas can be defined in different ways, possibly varying with watershed context, (e.g., woodlands in some contexts may be classified as Primary Conservation Areas, rather than secondary). Given the substantial variability in Michigan’s natural resources from one ecoregion to another, this flexibility in weighting resource types is especially important.

3. Map potential development areas; prioritize/weight as necessary.

The potential development area should be delineated on the basis of protecting the primary and secondary resources on a site. Like the sensitive areas map, priorities and weightings may be reflected in the potential development area map. If sensitive areas have been prioritized,

Figure 6.4
Map of sensitive areas (top) and secondary resources (bottom)



Source: Arndt, Randall G. 1997

then weightings of potential development also may be established, varying with lack of degree of sensitivity measured by the resources themselves or overlapping of resources.

4. Municipal regulation

The level of regulation imposed on resource areas (primary and secondary) will likely vary by municipality. A municipal ordinance may prohibit and/or otherwise restrict development in primary and secondary resource areas, provided certain legal tests (such as a takings determination) are passed. Additional activities include:

1. Conservation easement – Given to land conservancy or maintained by homeowners association.
2. Requirements in the master deed and bylaws for protection and preservation.
3. Boundary markers at edges of lots to minimize encroachment.
4. Cooperative agreements for stewardship of sensitive areas between homeowners' associations and local conservation organizations.

Stormwater Functions and Calculations

Any portion of a site that can be maintained in its presettlement state by using this BMP will not contribute increased stormwater runoff and will reduce the amount of treatment necessary. Calculation methodology to account for this BMP is provided in Chapter 9.

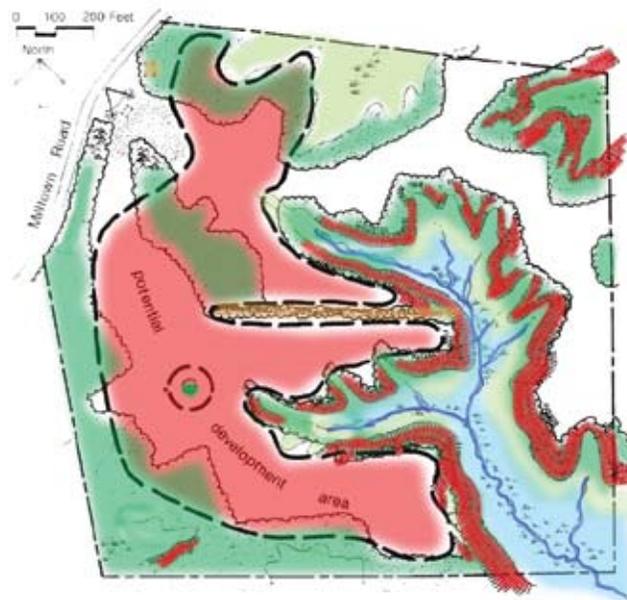
Volume

Protected sensitive areas are not to be included in the disturbed stormwater management area when calculating runoff volume (Chapter 9 and Worksheet 3).

Any portion of a sensitive area that is mitigated or revegetated/reforested should be included in the disturbed stormwater management area, but may be granted credit in accordance with the applicable BMP for native revegetation, soil restoration, minimize soil compaction, riparian buffer restoration, or minimize total disturbed area.

Peak rate

Runoff from the protected sensitive area may be excluded from peak rate calculations for rate control, provided that the runoff is not conveyed to and/or



Potential development area map

Source: Arndt, Randall G. 1997.

through stormwater management control structures. If necessary, runoff from protected sensitive areas should be directed around BMPs and stormwater pipes and inlets by means of vegetated swales or low berms that direct flow to natural drainageways.

Water quality improvement

Water quality is benefited substantially by avoiding negative impacts which otherwise would have resulted from impacts to sensitive areas (e.g., loss of water quality functions from riparian buffers, from wetland reduction, etc.).

Construction Guidelines

Although protecting sensitive areas happens early in the site plan process, it is equally important that the developer and builder protect these areas during construction.

The following guidelines describe good planning practices that will help ensure protection of a few common environmentally sensitive resources during construction.

Water resources

- If vegetation needs to be reestablished, plant native species, or use hydroseed and mulch blankets immediately after site disturbance.
- Use bioengineering techniques, where possible, to stabilize stream banks.



Native woodland area

Source: JFNew

- Block or protect storm drains in areas where construction debris, sediment, or runoff could pollute waterways.
- During and after construction activities, sweep the streets to reduce sediment from entering the storm drain system.
- Avoid hosing down construction equipment at the site unless the water is contained and does not get into the stormwater conveyance system.
- Implement spill control and clean-up practices for leaks and spills from fueling, oil, or use of hazardous materials. Use dry clean-up methods (e.g., absorbents) if possible. Never allow a spill to enter the stormwater conveyance system.
- Avoid mobile fueling of equipment. If mobile fueling is necessary, keep a spill kit on the fueling truck.
- Properly dispose of solid waste and trash to prevent it from ending up in our lakes and streams.
- When protecting riparian buffer areas, consider the three buffer zones in protection criteria:

Zone 1: Also termed the “streamside zone,” begins at the edge of the stream bank of the active channel and extends a minimum distance of 25 feet, measured horizontally on a line perpendicular to the water body. Undisturbed vegetated area aims to protect the physical and ecological integrity of the stream ecosystem. The vegetative target for the streamside zone is undisturbed native woody species with native plants forming canopy, understory, and duff layer; where such forest does

not grow naturally, then native vegetative cover appropriate for the area (such as grasses, forbs, or shrubs) is the vegetative target. (*HRWC Model Ordinance*, p. 8)

Zone 2: Also termed the “middle zone,” extends immediately from the outer edge of Zone 1 for a minimum distance of 55 feet. This managed area of native vegetation protects key components of the stream ecosystem and provides distance between upland development and the streamside zone. The vegetative target for the middle zone is either undisturbed or managed native woody species or, in its absence, native vegetative cover of shrubs, grasses, or forbs. Undisturbed forest, as in Zone 1, is strongly encouraged to protect further water quality and the stream ecosystem. (*HRWC Model Ordinance*, p. 8)

Zone 3: Also termed the “outer zone,” it extends a minimum of 20 feet immediately from the outer edge of Zone 2. This zone prevents encroachment into the riparian buffer area, filters runoff from adjacent land, and encourages sheet flow of runoff into the buffer. The vegetative target for the outer zone is native woody and herbaceous vegetation to increase the total width of the buffer; native grasses and forbs are acceptable. (*HRWC Model Ordinance*, p. 8)

Wetlands

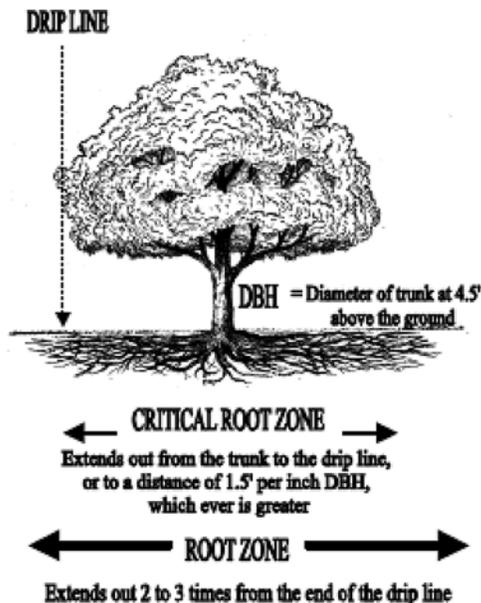
- Avoid impacts to wetlands whenever possible. If impractical, determine if a wetland permit is needed from the state or local government. (If any permit requirements or wetland regulations conflict with these guidelines, comply with the permit or regulation).
- Excavate only what is absolutely necessary to meet engineering requirements. Do not put excavated material in the wetland. (Excavated material could be used in other areas of the site to improve seeding success).
- If construction activities need to occur within a wetland, activities should be timed, whenever possible, when the ground is firm and dry. Avoid early spring and fish-spawning periods.
- Install flagging or fencing around wetlands to prevent encroachment.
- Travel in wetlands should be avoided. Access roads should avoid wetlands whenever possible. Crossing a wetland should be at a single location and at the edge of the wetland, if possible.
- Never allow a spill to enter area wetlands.

Floodplains

- Design the project to maintain natural drainage patterns and runoff rates if possible.
- Maintain as much riparian vegetation as possible. If riparian vegetation is damaged or removed during construction, replace with native species.
- Use bioengineering techniques to stabilize stream banks.
- Keep construction activity away from wildlife crossings and corridors.
- Stockpile materials outside of the floodplain and use erosion control techniques.

Woodlands

- Protect trees on sites with severe design limitations, such as steep slopes and highly erodible soils.
- Preserve trees along watercourses to prevent bank erosion, decreased stream temperatures, and to protect aquatic life.
- Protect the critical root zone of trees during construction. This is the area directly beneath a tree's entire canopy. For every inch of diameter of the trunk, protect 1.5 feet of area away from the trunk.



Critical root zone

Source: City of Falls Church, VA. Tree Preservation during Construction.

- Avoid trenching utilities through the tree's critical root zone.
- Avoid piling excavated soil around any tree.
- Replace trees removed during construction with native trees.
- Conduct post-construction monitoring to ensure trees impacted by construction receive appropriate care.

General construction considerations

- Conduct a pre-construction meeting with local community officials, contractors, and subcontractors to discuss natural resource protection. Communicate agreed-upon goals to everyone working on the project.
- Insert special requirements addressing sensitive natural areas into plans, specifications, and estimates provided to construction contractors. Note the kinds of activities that are not allowed in sensitive areas.
- Confine construction and staging areas to the smallest necessary and clearly mark area boundaries. Confine all construction activity and storage of materials to designated areas.
- Install construction flagging or fencing around sensitive areas to prevent encroachment.
- Excavate only what is absolutely necessary to meet engineering requirements. Do not put excavated material in sensitive areas. (Excavated material could be used in other areas of the site to improve seeding success.)
- Conduct onsite monitoring during construction to ensure sensitive areas are protected as planned. Conduct post-construction monitoring to ensure sensitive areas that were impacted by construction receive appropriate care.

Maintenance

The preservation of open space creates maintenance concerns related to who is required to perform the maintenance activities. Legally, the designated open space may be conveyed to the municipality. More likely, ownership of these natural areas will be assumed by homeowners' associations or simply the specific individual property homeowners where these resources are located. Specific maintenance activities will depend upon the type of vegetation present in the preserved natural area where woodlands require little to no maintenance and open lawn require higher maintenance.

Cost

When development encroaches into sensitive areas, dealing with their special challenges invariably adds to development and construction costs. Sometimes these added costs are substantial, as in the case of working with wetlands or steep slopes.

Sometimes costs emerge only in longer-term operation, like encroachment in floodplains. This can translate into added risk of building damage for future owners, as well as health and safety impacts, insurance costs, and downstream flooding. If all short- and long-term costs of impacting sensitive areas were quantified and tallied,

total real costs of sensitive area encroachment would increase substantially. Conversely, protecting sensitive areas results not only in cost savings, but also in water quality benefits.

At the same time, reduction in potential development areas resulting from protecting and conserving sensitive areas can have the effect of altering — even reducing — a proposed development program, thereby reducing development yield and profit. To address this, this BMP can be applied in tandem with the cluster development BMP.

Designer/Reviewer Checklist for Protect Sensitive Areas

ITEM	YES	NO	N/A	NOTES
Define sensitive resources at proposed development site (see Key Design Features for list of sensitive resources)				
Map sensitive resources at proposed development site				
Prioritize/weight sensitive areas, as necessary and appropriate				
Develop potential development area map, or comparable, defined as converse/negative of sensitive areas, with priorities/weightings as necessary and appropriate.				
Determine baseline development plan, compatible with municipal ordinance.				
Iteratively fit baseline development plan to potential development area, minimizing sensitive area encroachment?				
Is this BMP process required by municipality? Yes or no, has applicant followed these steps, or comparable?				

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BMP Fact Sheet

Reduce Impervious Surfaces

Reducing impervious surfaces includes minimizing areas such as streets, parking lots, and driveways. By reducing the amount of paved surfaces, stormwater runoff is decreased while infiltration and evapotranspiration opportunities are increased.



Residential cul-de-sac with vegetation

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	High
Commercial	Yes	Groundwater Recharge	High
Ultra Urban	Limited	Peak Rate	High
Industrial	Yes	Stormwater Quality Functions	
Retrofit	Limited	TSS	Medium
Highway/Road	Yes	TP	Low
Recreational	Yes	NO ₃	Low
		Temperature	Medium

Additional Considerations	
Cost	Low
Maintenance	Low
Winter Performance	High

Key Design Features

Streets

- Evaluate traffic volumes and street parking requirements
- Consult with local fire department and road agencies
- If available, consider a private road ordinance as necessary to minimize width
- Minimize pavement widths and lengths by using alternative roadway layouts, restricting on-street parking, minimizing cul-de-sac radii, and using permeable pavers

Parking lots

- Evaluate parking requirements considering average demand as well as peak demand
- Consider smaller parking stalls and/or compact parking spaces
- Analyze parking lot layout to evaluate the applicability of narrowed traffic lanes and slanted parking stalls
- If appropriate, minimize impervious parking area by using overflow parking areas constructed of pervious paving materials

Lot level

- Use maximum lot coverage requirements to manage the amount of impervious surfaces
- Reduce front yard setbacks to allow for shorter driveways
- Use alternative materials for patios, sidewalks, driveways, as appropriate

Benefits

- Directly reduces runoff volumes and peak rates
- Reduces development and maintenance costs
- Enhances aesthetics and habitat

Limitations

- Must comply with local private road ordinances
- Must comply with vehicular safety standards

Case Study: Willard Beach Implementation Project

City of Battle Creek

The primary goal of the City of Battle Creek’s Willard Beach Park Project consists of showcasing LID practices to community residents by installing porous asphalt throughout the park roadway system and rain gardens. By implementing these two LID techniques, the amount of impervious material on site was reduced. The project complemented other LID projects undertaken by the city, such as several bioretention basins, rain gardens, and a vegetated roof. All of these sites were used as examples for area developers to model.



Pervious asphalt at Willard Beach Park

Source: City of Battle Creek

The project also reduced the impact of stormwater by volume and pollutant loading from the park’s four storm sewer discharge areas. Another goal of the project was to educate park users about the project and the importance of protecting water quality.

Porous asphalt requires vacuuming at least twice per year. Proper weeding of the rain gardens and bioretention basin causes the most concern. Keeping the native plants properly watered during establishment posed a challenge. Replanting was required in some areas. Estimated maintenance costs for the entire project are approximately \$2,500/year.

Estimated annual pollutant load reductions for the project:

- Sediment – 6.6 tons
- Nitrogen – 176 lbs
- Phosphorous – 18 lbs
- Volume – 78%

Case Study Site Considerations	
Project Type	Reduce imperviousness
Estimated Total Project Cost	\$450,425
Maintenance Responsibility	City of Battle Creek
Project Contact	Christine Kosmowski, 269-966-0712

Description and Function

Reducing street imperviousness performs valuable stormwater functions in contrast to conventional development in the following ways:

- Increases infiltration,
- Decreases runoff volumes,
- Increases stormwater time of concentration,
- Improves water quality by decreasing nonpoint source pollutant loading, and
- Decreases the concentration and energy of stormwater.

Imperviousness greatly influences stormwater runoff volume and quality by increasing the rapid transport of stormwater and collecting pollutants from atmospheric deposition, automobile leaks, and additional sources.

Stream degradation has been observed at impervious levels as low as 10-20 percent watershed-wide (Center for Watershed Protection, 1995), when these areas are managed conventionally. Recent findings indicate that degradation is observed even at much lower levels of imperviousness (Villanova University 2007 Stormwater Management Symposium, Thomas Schueler, Director, Chesapeake Stormwater Network). Reducing imperviousness improves an area's hydrology, habitat structure, and water quality.

Design Considerations

Street width

Streets usually are the largest single component of imperviousness in residential development. Universal application of high-volume, high-speed traffic design criteria results in excessively wide streets. Coupled with the perceived need to provide both on-street parking and emergency vehicle access, the end result is residential streets that may be 36 feet or greater in width (Center for Watershed Protection, 1998).

The American Society of Civil Engineers (ASCE) and the American Association of State Highway and Transportation Officials (AASHTO) recommend that low-traffic-volume roads (less than 50 homes or 500 daily trips) be as narrow as 22 feet. Some municipalities have reduced their lowest trafficable residential roads to 18 feet or less. Higher-volume roads are recommended to be wider. Table 6.2 provides sample road widths from different jurisdictions.

Need for adequate emergency vehicle access, notably fire trucks, also leads to wider streets. While it is perceived that very wide streets are required for fire trucks, some local fire codes permit roadway widths as narrow as 18 feet (Table 6.3). Concerns also exist relating to other vehicles and maintenance activities on narrow streets. School buses are typically nine feet wide, mirror to mirror. Prince George's and Montgomery Counties in Maryland require only a 12-foot driving lane for buses (Center for Watershed Protection, 1998). Similarly, trash trucks require only a 10.5-foot driving lane. Trash trucks have a standard width of nine feet (Waste Management, 1997; BFI, 1997). In some cases, road width for emergency vehicles may be added through use of permeable pavers for roadway shoulders.

Use of permeable pavers for roadway shoulders



Snow removal on narrower streets is readily accomplished with narrow, eight-foot snowplows. Restricting parking to one side of the street allows accumulated snow to be piled on the other side of the street. Safety concerns are also cited as a justification for wider streets, but increased vehicle-pedestrian accidents on narrower streets are not supported by research. In fact, wider streets have been shown to promote increased speeds and accidents. The Federal Highway Administration states that narrower streets reduce vehicle travel speeds, lessening the incidence and severity of accidents.

Higher density developments require wider streets, but alternative layouts can minimize street widths. For example, in instances where on-street parking is desired, impervious pavement is used for the travel lanes, with permeable pavers placed on the road apron for the parking lanes. The width of permeable pavers is often the width of a standard parking lane (six to eight feet). This design approach minimizes impervious area while

Table 6.2

Narrow residential street widths

Jurisdiction	Residential Street Pavement Width	Maximum Daily Traffic (trips/day)
State of New Jersey	20 ft. (no parking)	0-3,500
	28 ft. (parking on one side)	0-3,500
State of Delaware	12 ft. (alley)	---
	21 ft. (parking on one side)	---
Howard County, Maryland	24 ft. (parking not regulated)	1,000
Charles County, Maryland	24 ft. (parking not regulated)	---
Morgantown, West Virginia	22 ft. (parking on one side)	---
Boulder, Colorado	20 ft.	150
	20 ft. (no parking)	350-1,000
	22 ft. (parking on one side)	350
	26 ft. (parking on both sides)	350
	26 ft. (parking on one side)	500-1,000
Bucks County, Pennsylvania	12 ft (alley)	---
	16-18 ft. (no parking)	200
	20-22 ft. (no parking)	200-1,000
	26 ft. (parking on one side)	200
	28 ft. (parking on one side)	200-1,000

Source: Cohen, 1997; Bucks County Planning Commission, 1980; Center for Watershed Protection, 1998

Table 6.3

Fire Vehicle Street Requirements

Source	Residential Street Width
U.S. Fire Administration	18-20 ft.
Baltimore County, Maryland Fire Department	16 ft. (no on-street parking)
	24 ft. (on-street parking)
Virginia State Fire Marshall	18 ft. minimum
Prince George's County, Maryland Department of Environmental Resources	24 ft. (no parking)
	30 ft. (parking on one side)
	36 ft. (parking on both sides)
	20 ft. (fire truck access)
Portland, Oregon Office of Transportation	18 ft. (parking on one side)
	26 ft. (parking on both sides)

Source: Adapted from Center for Watershed Protection, 1998

also providing an infiltration and recharge area for the impervious roadway stormwater (**Maryland Stormwater Design Manual, 2000**).

Street length

Numerous factors influence street length, including clustering techniques. As with street width, street length greatly impacts the overall imperviousness of a developed site. While no one prescriptive technique exists for reducing street length, alternative street layouts should be investigated for options to minimize impervious cover. Successful clustering design consistently has shown to reduce required street lengths, holding development programs constant (i.e., 100 homes successfully clustered on a 100-acre property results in a significant reduction in street length and total imperviousness than 100 homes conventionally gridded in large-lot development format).

Cul-de-sacs

The use of cul-de-sacs introduces large areas of imperviousness into residential developments. Some communities require the cul-de-sac radius to be as large as 50 to 60 feet. Simply reducing the radius from 40 feet to 30 feet can reduce the imperviousness by 50 percent (Schueler, 1995).

When cul-de-sacs are necessary, three primary alternatives can reduce their imperviousness; reduce the required radius, incorporate a landscaped island into the center of the cul-de-sac, or create a T-shaped (or hammerhead) turnaround (Figure 6.5).

To reduce the radius, many jurisdictions have identified required turnaround radii (Table 6.4).

Table 6.4
Cul-de-sac turning radii

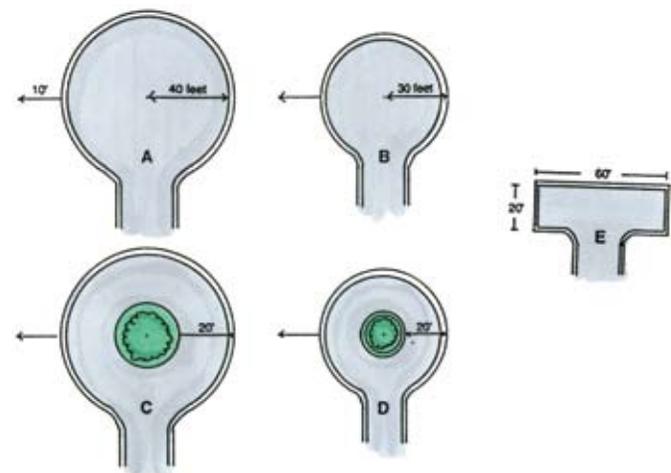
Source	Radius
Portland, Oregon Office of Transportation	35 ft (with fire dept. approval)
Buck County, Pennsylvania Planning Commission	38 ft (outside turning radius)
Fairfax County, Virginia Fire and Rescue	45 ft
Baltimore County, Maryland Fire Department	35 ft (with fire dept. approval)
Montgomery County, Maryland Fire Department	45 ft
Prince George’s County, Maryland Fire Department	43 ft

Source: Adapted from Center for Watershed Protection 1998

A landscaped island in the center of a cul-de-sac can provide the necessary turning radius, minimizing impervious cover. This island can be designed as a depression to accept stormwater runoff from the surrounding pavement, thus furthering infiltration. A flat apron curb will stabilize roadway pavement and allow for runoff to flow into the cul-de-sac’s open center.

A T-shaped turnaround reduces impervious surface even further – yielding a paved area less than half that of a 30-foot radius turnaround. Since vehicles need to make a three-point turn to drive out, T-shaped turnarounds are most appropriate on streets with 10 or fewer homes.

Figure 6.5
Five cul-de-sac options



Source: Center for Watershed Protection, 1998.

Parking

Parking lots often comprise the largest percentage of impervious area. Parking lot size is dictated by lot layout, stall geometry, and parking ratios. Modifying any or all of these three aspects can serve to minimize the total impervious areas associated with parking lots.

Parking ratio requirements and accommodating peak parking demand often provide parking capacity substantially in excess of average parking needs. This results in vast quantities of unused impervious surface. A design alternative to this scenario is to provide designated overflow parking areas.

The primary parking area, sized to meet average demand, might still be constructed on impervious pavement to meet local construction codes and American with Disabilities Act requirements. However, the overflow parking area, designed to accommodate increased parking requirements associated with peak demand, could be constructed on pervious materials (e.g., permeable pavers, grass pavers, gravel. See Porous Pavement BMP in Chapter 7). This design approach, focused on average parking demand, will still meet peak parking demand requirements while reducing impervious pavement.

Parking ratios

Parking ratios express the specified parking requirements provided for a given land use. These specified ratios are often set as minimum requirements. Many developers seeking to ensure adequate parking provide parking in excess of the minimum parking ratios. Additionally, commercial parking is often provided to meet the highest hourly demand of a given site, which may only occur a few times per year. However, average parking demand is generally less than the typical required parking ratios (Table 6.5).

Table 6.5

Example minimum parking ratios

Land Use	Parking Ratio	Average Parking Demand
Single Family Home	2 spaces per dwelling unit	1.1 spaces per dwelling unit
Shopping Center	5 spaces per 1,000 ft ² of GFA	3.97 spaces per 1,000 ft ² of GFA
Convenience Store	3.3 spaces per 1,000 ft ² of GFA	Not available
Industrial	1 space per 1,000 ft ² of GFA	1.48 spaces per 1,000 ft ² of GFA
Medical/Dental Office	5.7 spaces per 1,000 ft ² of GFA	4.11 spaces per 1,000 ft ² of GFA

GFA – gross floor area, excluding storage and utility space

Source: Institute of Transportation Engineers, 1987; Smith, 1984; Wells, 1994

Parking spaces and lot layout

Parking spaces are comprised of five impervious components (Center for Watershed Protection, 1998):

1. The parking stall,
2. The overhang at the stall's edge,
3. A narrow curb or wheel stop,
4. The parking aisle that provides stall access, and
5. A share of the common impervious areas (e.g., fire lanes, traffic lanes).

Of these, the parking space itself accounts for approximately 50 percent of the impervious area, with stall sizes ranging from 160 to 190 square feet.

Several measures can be taken to limit parking space size. First, jurisdictions can review standard parking stall sizes to determine their appropriateness. A typical stall dimension may be 10 feet by 18 feet, much larger than needed for many vehicles. The great majority of SUVs and vehicles are less than seven feet in width, providing opportunity for making stalls slightly narrower and shorter. In addition, a typical parking lot layout includes parking aisles that accommodate two-way traffic and perpendicularly oriented stalls. The use of one-way aisles and angled parking stalls can reduce impervious area.

Municipalities can also stipulate that parking lots designate a percentage of stalls as compact parking spaces. Smaller cars comprise a significant percentage of vehicles and compact parking stalls create 30 percent less impervious cover than average-sized stalls (Center for Watershed Protection, 1998).

Stormwater Functions and Calculations

Quantifying impervious areas at a proposed development site, pre- to post-development continues to dominate stormwater calculations. Stormwater calculations, as discussed in Chapter 9, are sensitive to pervious areas and their contribution to total volume of runoff, increased peak rate of runoff, and increased generation of nonpoint source pollutants. A reduction in imperviousness achieved through reduced street widths and lengths and reduced paved parking areas automatically reduces the volume and peak rate of runoff. To the extent that water quality is linked to runoff volume, reduction in imperviousness translates into a reduction in water quality management requirements as compared with standard design.

Maintenance

A reduction in impervious area results in decreased maintenance. For example, whether publicly or privately maintained, reducing roadway or parking lot imperviousness typically translates into reduction in all forms of maintenance required, from basic roadway repair to winter maintenance and snow removal.

Cost

Street width

Costs for paving are estimated to be approximately \$15 per square yard (Center for Watershed Protection, 1998), which would be considerably higher in current dollars. At this cost, for each one-foot reduction in street width, estimated savings are \$1.67 per linear foot of paved street. For example, reducing the width of a 500-foot road by five feet would result in a savings of over \$4,100, which would be considerably higher in current dollars. This cost is exclusive of other construction costs including grading and infrastructure.

Street length

Factoring in pavement costs at \$15 per square yard (as above), a 100-foot length reduction in a 25-foot-wide road would produce a savings in excess of \$4,000 (much higher in current dollars).

In addition to pavement costs, costs for street lengths, including traditional curb and gutter and stormwater management controls, are approximately \$150 per linear foot of road (Center for Watershed Protection, 1998), which would be considerably higher in current dollars.

Decreasing road length by 100 feet would save an additional \$15,000, for a combined total of \$19,100.

Parking

Estimates for parking construction range from \$1,200 to \$1,500 per space (Center for Watershed Protection, 1998), which would be significantly higher in current dollars. For example, assuming a cost of \$1,200 per parking space, reducing the required parking ratio for a modest 20,000 square foot shopping strip from five spaces per 1,000 square feet to four spaces per 1,000 square feet would represent a savings of \$24,000.

Designer/Reviewer Checklist for Reducing Impervious Surfaces

ITEM	YES	NO	N/A	NOTES
Check municipal ordinances for requirements/specifications for roads, drives, parking, walkways, other (problems vs. opportunities?), including safety requirements				
Have both macro (e.g., clustering) and micro site planning (e.g., reduced setbacks) activities been applied fully?				
Have LID impervious reduction standards for roads, drives, parking, and other impervious areas been consulted and applied?				
Have roads and drives been reduced or narrowed as much as possible?				
Have macro parking ratios, lot layout, sharing strategies, and micro strategies (sizes/dimensions) been applied fully?				
Have pervious surfaces been applied for roads, drives, walks, parking, patios, and other hard surfaces, with maintenance been provided?				

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BMP Fact Sheet

Stormwater Disconnection

Minimize stormwater volume by disconnecting roof leaders, impervious roads, and driveways and direct runoff to other BMPs including vegetated areas that infiltrate at the site.



Roofleader directed toward bioretention

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	High
Commercial	Yes	Groundwater Recharge	High
Ultra Urban	Limited	Peak Rate	High
Industrial	Limited	Stormwater Quality Functions	
Retrofit	Limited	TSS	High
Highway/Road	Limited	TP	High
Recreational	Yes	NO ₃	Low/Med
		Temperature	High

Additional Considerations	
Cost	Low
Maintenance	Low
Winter Performance	Low

Variations

- Rooftop disconnection
- Driveway/walkway/ small parking areas/patio disconnection
- Minor roads
- Distribute to existing vegetated services
- Distribute to existing depressions, re-graded areas
- Distribute via curb cuts/curb removal

Key Design Features

- Encourages shallow sheet flow through vegetated areas,
- Directs flows into stabilized vegetated areas, including on-lot swales and bioretention areas,
- Limits the contributing rooftop area to a maximum of 500 sq. ft. per downspout,
- Maximizes overland flows, and
- Minimizes use of curb and gutter systems and piped drainage systems.

Site Factors

- Water table to bedrock depth = two-foot minimum
- Soils = A, B
- Slope = max. 5 percent
- Potential hotspots = No
- Max. drainage area = rooftop area of 1,000 sq. ft.

Benefits

- Reduces runoff volume and peak rate
- Increases water quality benefits

Limitations

- Requires area for infiltration

Case Study: Saugatuck Center for the Arts

Saugatuck, MI

The Saugatuck Center for the Arts (SCA), in conjunction with the City of Saugatuck, Michigan Department of Environmental Quality, and private donors constructed a public garden that treats rain water that falls on the SCA roof. The original design was modified to accommodate rain water that would otherwise have entered Kalamazoo Lake untreated. The resulting design for the garden absorbs and infiltrates 100 percent of the rain water from the SCA roof, resulting in zero discharge to the nearby lake.

In addition to the garden at the Saugatuck Center for the Arts, the revised design incorporated a series of alternative stormwater Best Management Practices on City of Saugatuck property. These include porous pavers in the adjacent city parking lot and a rain garden/vegetated swale series at Coghlin Park to treat rain water from the city parking lot.

The design incorporated native plants to address management in an urban setting while visually integrating with the contemporary social fabric of Saugatuck. The design also incorporated an innovative oil-and-grit separator to remove over 80 percent of sediment and nutrients draining from approximately nine acres of urban land surrounding the SCA and city parking lot. Through this series, or “treatment techniques,” the SCA and City of Saugatuck are able to demonstrate a variety of innovative and unique alternatives for treating and reducing stormwater.



Center for the Arts stormwater disconnection

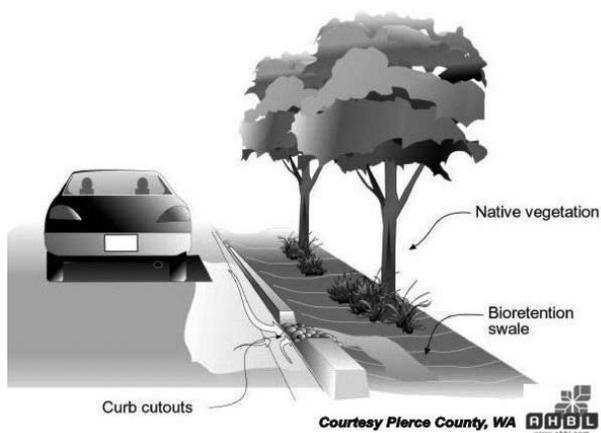
Case Study Site Considerations	
Project Type	Stormwater disconnection, porous pavement, rain garden.
Estimated Total Project Cost	\$200,000
Maintenance Responsibility	City of Saugatuck
Project Contact	Gordon Gallagher, 269-857-2603

Description and Function

Roofs, roads, and driveways account for a large percentage of post-development imperviousness. These surfaces influence stormwater quality and runoff volume by facilitating the rapid transport of stormwater and collecting pollutants from rainfall, automobile leaks, and additional sources.

Disconnecting roof leaders and routing road and driveway runoff from conventional stormwater conveyance systems allows runoff to be collected and managed onsite. Runoff can be directed to designed vegetated areas (discussed in Chapter 7) for onsite storage, treatment, and volume control. This is a distributed, low-cost method for reducing runoff volume and improving stormwater quality through:

- Increasing infiltration and evapotranspiration,
- Decreasing stormwater runoff volume, and
- Increasing stormwater time of concentration.



Curb cut-outs allow stormwater runoff from a parking lot to flow into a bioretention swale

Source – Pierce County, WA and RHBL

The suitability of vegetated swales to receive runoff depends on land use, soil type, imperviousness of the contributing watershed, and dimensions and slope of the vegetated swale system. Use of natural low-lying areas is encouraged; natural drainage courses should be used and preserved.

Some ponding of water in areas receiving runoff may occur. It is important to take into account site usage when applying this BMP so that ponding does not unnecessarily interfere with expected site use (including backyard play areas). These areas should be shown on plan documents and protected with easements and deed restrictions.

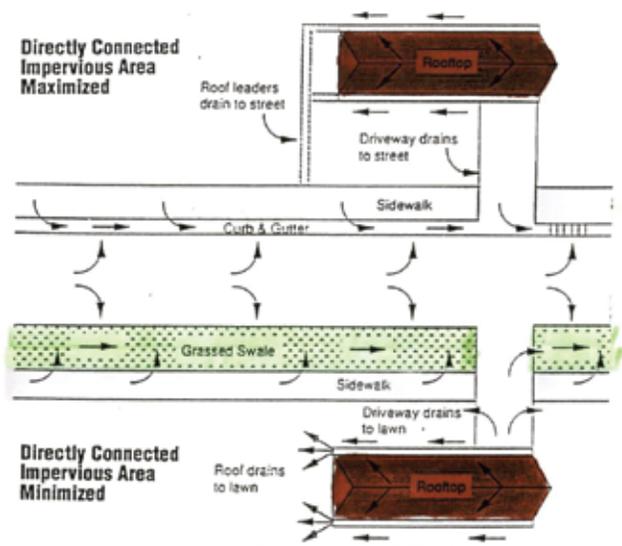
Although this BMP can be applied in a variety of development settings, it will likely be more successful as lot size increases and density decreases. In situations where clustering has not been fully exercised and lots remain relatively large, these lots and the large areas of perviousness make perfect candidates for stormwater disconnection.

Variations

Disconnecting stormwater can be achieved through identifying the source of runoff and how it will be managed once disconnection occurs.

Source

Stormwater can flow from rooftop areas or from impervious areas such as driveways, walkways, small parking areas, minor roadways, and ancillary outdoor areas such as patios. (Note: Roads and highways, because of their greater runoff generation require Structural BMPs.)



Difference between maximizing and minimizing runoff

Source – Center for Watershed Protection

Management practices

A common and successful management practice is to direct stormwater runoff to areas of existing vegetation. Vegetation can be of varying types, from established meadow to immature to mature woodland. A particular variation to consider is grading (crowning) of drives and minor roadways and eliminating curbing (or provision of curb cuts) so that runoff is allowed to flow in an even and unconcentrated manner onto adjacent vegetated areas.

In addition to directing runoff to vegetated areas, runoff may also be discharged to nonvegetated BMPs, such as dry wells, rain barrels, and cisterns for stormwater retention and volume reduction.

Another management practice includes routing runoff to existing grades and depressions that can be used to capture, store, and treat runoff. An important caveat is that applying this BMP should not prompt grading and disturbing areas which otherwise would not have been disturbed. However, assuming that grading and disturbance cannot be avoided, then subtle adjustments to grading may create additional management/storage opportunities for disconnected runoff.

An ideal coupling of BMPs is to minimize the total disturbed area of a site in coordination with stormwater disconnection. This not only reduces runoff volumes, peak rates, and pollutant loadings, but also provides multiple decentralized opportunities to receive disconnected flows.

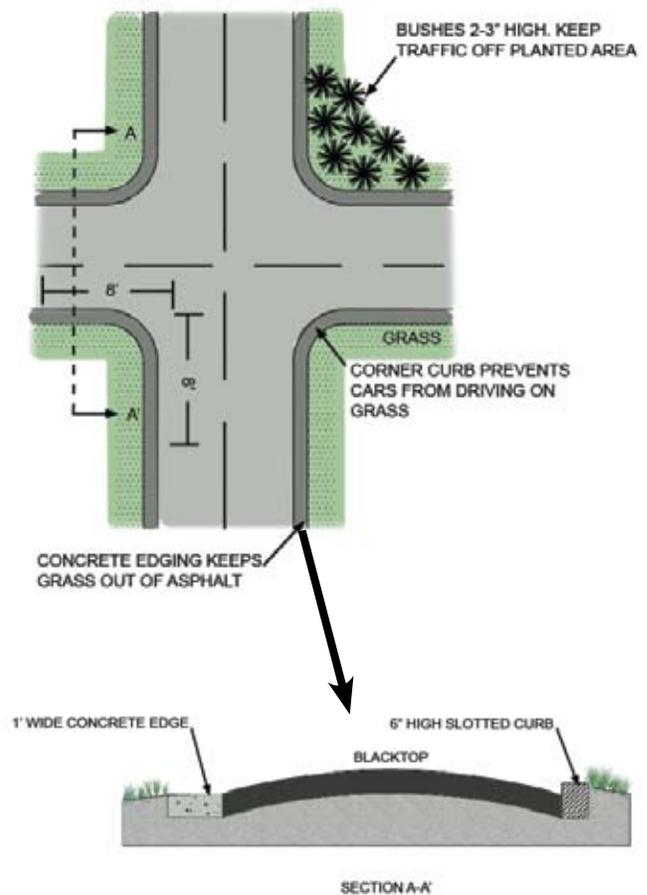
Applications

Disconnection is ideal for most single-family developments, but can also be applied to many development sites, including larger office parks and retail centers. Industrial developments, with their larger impervious covers and greater runoff volumes, make stormwater disconnection a challenge. Even so, there are isolated applications which are beneficial and promote LID objectives. Similarly, Ultra Urban and Highway/Road developments with large flows would be more limited in application.

If downspout disconnection is applied as a retrofit, downspouts should be extended away from the basement as many footing drains are attached to the sanitary sewer system.

Design Considerations

Careful consideration should be given to the design of vegetated collection areas. Concerns pertaining to basement seepage and water-soaked yards are warranted, with the potential arising for saturated depressed areas and eroded water channels. Proper design and use of bioretention areas, infiltration trenches, and/or dry wells reduces or eliminates the potential for surface ponding and facilitates functioning during cold weather months. Where basements exist, consider the direction of groundwater flow and proximity.



Curb cuts as a method of stormwater disconnection

Source: Center for Watershed Protection, modified by Cahill Associates, 2008



Stormwater disconnection in Washington Township, MI

Disconnection of small runoff flows can be accomplished in a variety of ways (Prince George's County Department of Environmental Protection, 1997; Maryland Department of the Environment, 1997; Cahill, 2008).

1. Encourage shallow sheet flow through vegetated areas.
2. Direct roof leader flow into BMPs designed specifically to receive and convey rooftop runoff.
3. Direct flows into stabilized vegetated areas, including on-lot swales and bioretention areas.
4. Rooftop runoff may also be directed to onsite depression storage areas.
5. The entire vegetated "disconnection" area should have a maximum slope of five percent.
6. Runoff should not be directed to vegetated areas if there is reason to believe that pollutant loadings will be elevated.
7. Roof downspouts or curb cuts should be at least 10 feet away from the nearest connected impervious surface to discourage "re-connections."
 - a. Limit the contributing impervious area to a maximum of 1,000 sq. ft. per discharge point.
 - b. Limit the contributing rooftop area to a maximum of 1,000 sq. ft. per downspout, where pervious area receiving runoff must be at least twice this size.
 - c. For contributing areas greater than 1,000 sq. ft., leveling devices are recommended.
8. The maximum contributing impervious flow path length should be 75 feet.
9. For impervious areas, the length of the disconnection area must be at least the length of the contributing area (a minimum 75 feet for discharges which are concentrated; 25 feet for discharges which are not concentrated).
10. In all cases, flows from roof leaders should not contribute to basement seepage.

Stormwater runoff from disconnection needs to be monitored to ensure that flows do not become channelized that can result in erosion. Attention must be given to safe overflowing of larger storms, though clearly the more frequent smaller storms are of greatest interest and concern for successful design (use two-year storm for erosion analysis). Make sure flow of water and temporary ponding of water in management areas will not become a problem.

See Criteria and Credits below for additional design detailing.

Stormwater Functions and Calculations

Peak rate and volume

This BMP reduces total volume and peak rates of runoff, as runoff is minimized from centralized stormwater management systems at the development site. Disconnection directly reduces volume and peak rates, which reduces the need for structural BMPs.

Water quality improvement

In terms of rooftop disconnection, this BMP has limited water quality benefit because rooftops typically have minimal pollution. In terms of other impervious area runoff sources being disconnected (driveways, walkways, ancillary areas, minor roads), water quality benefits can be significant given their greater pollutant loadings.

Maintenance

When disconnecting stormwater from rooftops or other impervious surfaces, maintaining the vegetated areas is required, but is limited.

If using structural BMPs, such as bioretention or vegetated swales, follow their specific maintenance activities. Typical maintenance of vegetation includes a biannual health evaluation of the vegetation and subsequent removal of any dead or diseased vegetation plus mulch replenishment, if included in the design. This can be incorporated into regular maintenance of the site landscaping. In some cases, if leaders are directing stormwater to lawn depressions, maintenance may be as simple as mowing.

Cost

Stormwater disconnection reduces both construction and maintenance costs due to less reliance on traditional stormwater management infrastructure. In addition, using existing or planned bioretention areas within a site creates a double usage of these BMPs.

Designer/Reviewer Checklist for Disconnection

ITEM	YES	NO	N/A	NOTES
Are site factors conducive to disconnection (infiltration-related factors? slope? other?)				
Is proposed development type (e.g., residential, commercial) conducive to disconnection? Free of hot spots?				
Are there any municipal ordinance provisions, obstacles, and opportunities for disconnection?				
Have potential disconnection runoff sources been adequately reviewed/utilized in terms of proposed plan?				
Have potential disconnection management measures been used/exploited for all potential sources?				
Have Criteria and Credits specifications for both rooftop and non-rooftop sources of disconnection been satisfied?				
Have disconnection calculation credits been properly entered, as specified in Criteria and Credits?				

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