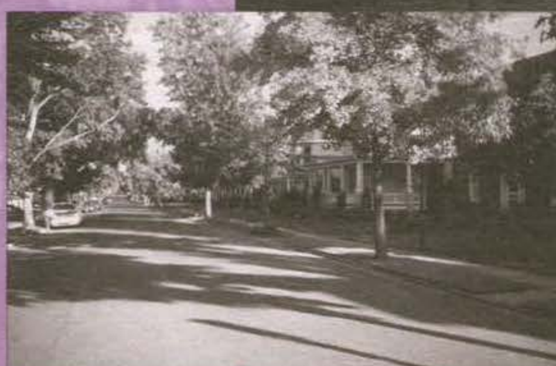
Prepared by the
Center for Watershed Protection
8390 Main Street Ellicott City, Maryland 21043

Prepared for the
Site Planning Roundtable



BETTER SITE DESIGN:
A Handbook for Changing Development Rules in Your Community

with assistance from
The Morris and Gwendolyn Cafritz Foundation
US EPA Office of Wetlands, Oceans, and Watersheds
Chesapeake Bay Trust
Turner Foundation
Chesapeake Bay Program

CENTER FOR WATERSHED PROTECTION

Better Site Design: A Handbook for Changing Development Rules in Your Community

PREPARED BY THE
Center for Watershed Protection
8391 Main Street
Ellicott City, Maryland 21043
(410) 461-8323 phone
(410) 461-8324 fax
www.pipeline.com/~mrrunoff/

PREPARED FOR THE

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The Morris and Gwendolyn Cafritz Foundation
US EPA Office of Wetlands, Oceans, and Watersheds
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AUGUST 1998

Printed on Recycled Paper

CENTER FOR WATERSHED PROTECTION

PREFACE

This document is the culmination of the Site Planning Roundtable, a consensus process initiated to create more environmentally sensitive, economically viable, and locally appropriate development. The primary audience for this manual is the local planner, engineer, developer, and official involved in the designing and building of new communities. This manual continues the Center's efforts to protect streams, rivers, and estuaries by advancing innovative and effective resource management techniques. It is hoped that through application of the Model Development Principles presented in this document, conservation of natural areas and prevention of stormwater pollution will become an integral part of new development.

Primary funding support for the preparation of this manual has been provided by The Morris and Gwendolyn Cafritz Foundation; the US EPA Office of Wetlands, Oceans, and Watersheds; the Chesapeake Bay Trust; the Turner Foundation; and the Chesapeake Bay Program.

PROJECT TEAM

Whitney Brown
Deb Caraco
Richard Claytor
Peg Hinkle
Hye Yeong Kwon
Tom Schueler
Chris Swann
Jennifer Zielinski

ACKNOWLEDGMENTS

Preparation of this manual would not have been possible without the contributions of many experts from the planning, design, development, and environmental professions. The Center especially would like to acknowledge the invaluable assistance provided by the members of the Site Planning Roundtable. Their dedication and insight throughout the Roundtable process was instrumental in crafting this document.

Ken F. Kobetsky, PE
American Association of State Highway Transportation Officials

Cheryl Kollin, ASLA, ISA
American Forest Association

Christopher J. Gribbs, Assoc. AIA
American Institute of Architects

Jeffrey Soule, AICP
American Planning Association

Sarah L. Layton
American Public Works Association

Tina Yin
American Rivers

Kyle Schilling, PE, DEE
American Society of Civil Engineers

J. William Thompson, ASLA
American Society of Landscape Architects

Menchu Martinez
Chesapeake Bay Program

Nancy Jacobsen
Community Associations Institute

Edward T. McMahon, JD
The Conservation Fund

Bruce G. Douglas, AICP
Office of Comprehensive Planning
County of Fairfax, VA

Joseph H. Necker, Jr., PE
Howard Research & Development Corporation, an affiliate of the Rouse Company

Lisa M. Fontana
Institute of Transportation Engineers

Kendra J. Briechle and Barbara Yuhas
International City/County Management Association

Andrew Zepp
Land Trust Alliance

Steven Z. Kaufman, JJD
Linowes & Blocher

Douglas E. Lohmeyer, PE
Loiederman Associates, Inc.

Dean D. Dubbe, PE
Michael T. Rose Company

Derrick P. Berlage, Councilmember
Montgomery County Council

Donald L. Woodsmall, Esq.
Natelli Communities

Robert McNamara, AICP
National Association of Home Builders

Roger Platt
National Realty Committee

Diane Cameron and Peter Lehner
Natural Resource Defense Council

Larry S. Coffman
Prince Georges County, Department of Environmental Resources

J. Glenn Eugster and Jamal Kadri
U.S. EPA Office of Sustainable Ecosystems & Communities

John L. Cochran
U.S. Fire Administration

Michael Pawlukiewicz
Urban Land Institute

Lowell W. Adams, PhD
Urban Wildlife Resources

We would like to extend special appreciation to the chairs of the Research Subgroups: Lisa Fontana (Habitat for Cars), Roger Platt (Habitat for Nature), and Richard Claytor (Habitat for People). Special thanks are also extended to Randall Arendt (Natural Lands Trust), Diane Cameron (formerly of Natural Resource Defense Council), Rod Frederick (EPA, Nonpoint Source Control), Abigail Freidman (National Association of Counties), Robert Goo (EPA, Office of Wetlands, Oceans, and Watersheds), and Peter Hawley (American Planning Association) for their constructive insight. Our deep appreciation is extended to Bob Hoyt (Maryland Department of the Environment) and the staff and students of Widener University Law School for their research into public liability issues.

Table of Contents

CHAPTER 1

CHANGING THE RULES TO PROTECT THE ENVIRONMENT

More than 1.5 million acres of land are developed each year in the United States. Development alters the surface of the land by replacing natural cover with roof tops, roads, parking lots, and sidewalks. These hard surfaces are impermeable to rainfall and are collectively known as impervious cover.

Recent watershed research has shown that impervious cover has a profound and often irreversible impact on the quality of our nation's aquatic resources. More than thirty different scientific studies have documented that stream, lake and wetland quality declines sharply when impervious cover in upstream watersheds exceeds 10 percent (see Table 1) . The strong influence of impervious cover on aquatic systems presents a major challenge to communities interested in sustainable development.

Table 1: Impacts to Aquatic Resources Due to Impervious Cover, A Summary of Research

1. Higher peak discharge rates and greater flooding
2. More frequent bankfull flooding
3. Lower stream flow during dry weather
4. Enlargement of the stream channel
5. Greater streambank erosion
6. Increased alteration of natural stream channels
7. Less large woody debris (LWD) in streams
8. Loss of pool and riffle structure
9. Increased number of stream crossings, with greater potential to affect fish passage
10. Degradation of stream habitat structure
11. Decline in stream bed quality (imbedding, sediment deposition, turnover)
12. Fragmentation of the riparian forest corridor
13. Warmer stream temperatures
14. Greater loads of stormwater pollutants
15. Bacterial levels that exceed recreational contact standards
16. Lower diversity of aquatic insects and freshwater mussels
17. Lower diversity of native fish species
18. Loss of sensitive fish species (e.g., trout, salmon)
19. Lower spawning success of anadromous fish
20. Decline in wetland plant and animal diversity

At the same time, many communities are discovering that their own development rules create needless impervious cover. The term "development rules" refers to the often bewildering mix of subdivision codes, zoning regulations, parking and street standards, and other local ordinances that collectively shape how development happens. These rules create the wide streets, expansive parking lots, and large-lot subdivisions that crowd out natural areas and open space.

Another characteristic of local development rules is that their complexity and inflexibility often make it difficult and even impossible to design sites to protect the quality of streams, lakes and wetlands. Innovative developments simply cannot be approved in many communities, and require a greater investment of time, money, and perseverance in others. The message is clear. We cannot protect the quality of the local environment unless we manage impervious cover and we cannot reduce impervious cover until we systematically reform the local development rules that are responsible for creating it.

This document outlines a process for changing the rules. It starts by presenting a series of model development principles that outline a fundamentally different way of developing land and designing our communities (Chapter 2). These principles were developed over the course of two years by a group of over thirty influential individuals from various organizations from around the nation. Taken together, the principles reduce impervious cover, conserve natural areas and prevent stormwater pollution from new development, while at the same time maintaining quality of life within our communities.

A four-step process is recommended to adapt local development rules to more closely conform to the model development principles. The four steps are:

Step 1: *Find Out What the Development Rules are in Your Community*

Step 2: *See How Your Rules Stack Up to the Model Development Principles*

Step 3: *Consider Which Development Rules Might Be Changed*

Step 4: *Start a Local Roundtable Process*

This document is designed to guide the reader through this lengthy but important process.

STEP 1: FIND OUT WHAT THE DEVELOPMENT RULES ARE IN YOUR COMMUNITY

The purpose of the first step is to find out what the actual development rules are in your community. In most cases, this will require an extensive search to find the key local documents that influence how land is developed in your community (Table 2). Few communities include all of their rules in a single document, so the search can take some time. It may be helpful to enlist the talents of a local land planner, land use attorney, or civil engineer in your search, since they work under the rules every day and are often familiar with local practices. It is also helpful to find out which local agencies and authorities actually administer and enforce each of the development rules at this stage. Be forewarned. It is not uncommon to find more

Table 2: Key Local Documents

Zoning Ordinances
Subdivision Codes
Street Standards
Covenants
Fire Codes and Standards
Parking Requirements
Building Regulations/Standards
Stormwater Management Ordinances
Buffer or Floodplain Regulations
Environmental Regulations

than a dozen different local and state agencies that exert some authority over development rules in your community.

STEP 2: SEE HOW YOUR RULES STACK UP TO THE MODEL DEVELOPMENT PRINCIPLES

Once you locate all of your development rules, you can begin to compare them with the model development principles. We have developed a simple worksheet to make this comparison easy. The worksheet is presented in **Chapter 3**, and it allows you to compare local development rules against 77 site planning benchmarks. Each benchmark asks a single question about local site design practice, such as the minimum diameter of cul-de-sacs, the minimum width of streets, etc. If the local development rule compares favorably with the site planning benchmark, points are then awarded. The total number of points possible for all of the site planning benchmarks is 100. The overall score provides a general indication of your community's ability to support environmentally sensitive development. As a general rule, if the score is lower than 80, then it may be advisable to systematically reform your local development rules. The worksheet also helps to identify specific site development rules that may be candidates for change.

STEP 3: CONSIDER CHANGING SOME LOCAL DEVELOPMENT RULES

Does it really make sense to change a particular development rule? Given how much effort is needed to change development rules, it is important to evaluate which ones are really worth it. Also, the fact that a local development rule does not conform to a model development principle doesn't always mean that the rule should be or can be changed. More research is still needed to examine the rationale behind both local development rules and the model principles.

In addition, advocates of change need to satisfy a broad range of community concerns, such as how the changes will impact the cost of development, local liability, property values, public safety, and a host of other factors. To guide the process of change, we have prepared a series of summary sheets on the 22 model development principles in **Chapter 4.** Each summary sheet begins with background on both the conventional and recommended site planning practice. The summary sheets also profile the most common objections and concerns associated with the recommended site planning practice. Economic data, environmental research, marketing studies and public surveys that pertain to the site planning practices are reviewed, and local case studies are presented. Each summary sheet also contains a "Where to Get Started" section that recommends more detailed references and resources to consult during your research. Some of this information can be complex and highly technical, so a **glossary** is provided to explain some of the planning and engineering terminology.

STEP 4: START A LOCAL ROUNDTABLE

The process to reform local development rules is called a local site planning roundtable. It is a consensus process to make better choices in the design of local communities. The primary tasks of a local roundtable are to systematically review existing development rules in the context of the model development principles, and then determine if changes can or should be made to the rules.

Perhaps the most critical factor in the success of a roundtable is getting the right people to the table. Participants should include key players from the local government, development and environmental communities. It is vitally important to get every local agency with authority for development review to the table. Diverse representation outside of government is also needed in order to obtain the broad consensus needed to achieve sweeping change. Some possible participants that could be invited to a local roundtable are listed in Table 3.

Table 3: Potential Members of a Local Roundtable

Planning Agency or Commission	Land Use Lawyers
Department of Public Works	Engineering Consultants
Road or Highway Department	Homeowner Associations
Developers	Chamber of Commerce
Land Trusts	Elected Officials
Realtors	Urban Forester
Real Estate Lenders	Site Plan Reviewer
Civic Associations	Stormwater Management Authority
Fire Official	Municipal Insurance
Health Department	Watershed Advocates
	Residents/ Land Owners

Elected leaders can play an important role in the success of a local roundtable. In particular, they are needed to give a strong charge to the roundtable that reform is welcomed and will be acted upon. After all, elected officials will ultimately be asked to vote on the proposed changes. They can also ensure that the many local agencies involved in development review get to the table and stay there.

An outside facilitator is often needed to guide and structure the roundtable process. This third party helps to ensure that all views and perspectives are considered, and guides the participants toward consensus and action.

The first phase of a roundtable involves identifying the development rules which could potentially be changed. The site planning worksheet and summary sheets can be helpful in screening the development rules.

The second phase of a roundtable involves finding out which agencies of local government have the actual authority to make a change to the development rules. In some cases, no authority currently exists, so the roundtable must consider whether a new one should be created. In other cases, a local government may find that they have no real authority to make changes to a development rule (e.g., a state agency such as the Department of Transportation has reserved the authority).

The longest phase of a local roundtable involves the negotiation of the changes to the development rules. It should be expected that a roundtable will need to meet many times over the course of a year to come to agreement on the changes that need to be made to the maze of codes, engineering standards, guidelines, regulations and ordinances that collectively shape local development. The devil is always in the details, so it is often useful to set up workgroups to iron out the technical language, and discuss legal and economic implications. The last phase of a roundtable is implementation. It is a good idea to combine all of the proposed changes into a unified package, so that both elected leaders and the public can understand them as a whole.

CHAPTER 2

MODEL DEVELOPMENT PRINCIPLES

Sustainable development combines economic growth with protection of the natural environment. Communities have long struggled to achieve this goal. However, many have found that their own development codes and standards can actually work against their efforts to achieve sustainable development. For example, local codes and ordinances often promulgate inflexible standards that result in highway-wide residential streets, expansive parking lots, and mass clearing and grading of forested areas. At the same time, local codes often give developers little or no incentive to conserve natural areas. Consequently, communities may need to re-evaluate their local codes to ensure better development.

The Site Planning Roundtable was convened in 1996 to examine impediments to better development at the local level and to craft model principles to promote environmentally sensitive and economically viable development. The Site Planning Roundtable represented a diverse and wide cross-section of interests involved in planning, designing and building new communities.

Nearly two years later, the Site Planning Roundtable agreed on a set of twenty-two model development principles. Applied together, the model development principles measurably reduce impervious cover, conserve natural areas and reduce stormwater pollution from new development. Application of these principles can enhance both the natural environment and improve the quality of life in local neighborhoods. Some of the documented benefits include:

- protection of local streams, lakes, and estuaries
- reduction of stormwater pollutant loads
- reduced soil erosion during construction
- reduced development construction costs
- increases in local property values and tax revenues
- more pedestrian friendly neighborhoods
- more open space for recreation
- protection of sensitive forests, wetlands, and habitats
- a more aesthetically pleasing and naturally attractive landscape
- safer residential streets
- more sensible locations for stormwater facilities
- easier compliance with wetland and other resource protection regulations
- neighborhood designs that provide a sense of community
- urban wildlife habitat through natural area preservation

The twenty-two model development principles provide design guidance for economically viable, yet environmentally sensitive development. They are designed to be used by planners, developers, and local officials as benchmarks to investigate where existing ordinances could be modified to reduce impervious cover, conserve natural areas, and prevent stormwater pollution. The model development principles, however, are not intended to be national design standards.

Model Development Principles

In many ways, the suburban landscape is a mix of three habitats. The first habitat is devoted to the automobile, and includes roads, driveways, and parking lots. The second is the habitat where we live and work, including our yards and homes. The third habitat includes the open spaces and natural areas that are relatively undeveloped. The size, appearance, location, and design of all three areas are determined in large part by local subdivision codes and zoning ordinances.

The model development principles generally fall into one of three areas which have been designated as follows:

- Residential Streets and Parking Lots
- Lot Development
- Conservation of Natural Areas

Each principle represents a simplified design objective in site planning. More detail on each principle can be found in the Site Planning Summary Sheets in Chapter 4.

Residential Streets and Parking Lots

These principles focus on those codes, ordinances, and standards that determine the size, shape, and construction of parking lots, roadways, and driveways in the suburban landscape.

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

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

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

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

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

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

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

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

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

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

Lot Development

Principles 11 through 16 focus on the regulations which determine lot size, lot shape, housing density, and the overall design and appearance of our neighborhoods.

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

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

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

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

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

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

Conservation of Natural Areas

The remaining principles address codes and ordinances that promote (or impede) protection of existing natural areas and incorporation of open spaces into new development.

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

18. The riparian stream buffer should be preserved or restored with native vegetation that can be maintained throughout the delineation, plan review, construction, and occupancy stages of development.

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

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

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

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

Adapting the Principles for Your Community

The following guidance is offered to township, city, and county officials as they adapt the model development principles to achieve better development.

- It should be clearly recognized that the principles must be adapted to reflect the unique characteristics of each community. Further, not all principles will apply to every development or community. In some cases, the principles may not always fully complement each other.
- The principles are offered as a benchmark to guide better land development. Communities should consider the principles as they assess current zoning, parking, street and subdivision codes.
- The principles will not only protect natural and aquatic resources, but can also enhance the quality of life in the community.
- The principles should be used as part of a flexible, locally-adapted strategy for better site planning.

- The principles should be considered togther with the larger economic and environmental goals put forth in comprehensive growth management, resource protection, or watershed management plans.
- Where possible, infill and redevelopment should be encouraged to reduce new impervious cover in the landscape.
- These principles primarily apply to residential and commercial forms of development, but can be adapted, with some modifications, to other types of development.

CHAPTER 3

CODE AND ORDINANCE WORKSHEET

The Code and Ordinance Worksheet allows an in-depth review of the standards, ordinances, and codes (i.e., the development rules) that shape how development occurs in your community. You are guided through a systematic comparison of your local development rules against the model development principles. Institutional frameworks, regulatory structures and incentive programs are included in this review. The worksheet consists of a series of questions that correspond to each of the model development principles. Points are assigned based on how well the current development rules agree with the site planning benchmarks derived from the model development principles.

The worksheet is intended to guide you through the first two steps of a local site planning roundtable.

Step 1: Find out what the Development Rules are in your community.

Step 2: See how your rules stack up to the Model Development Principles.

The homework done in these first two steps helps to identify which development rules are potential candidates for change.

PREPARING TO COMPLETE THE CODE AND ORDINANCE WORKSHEET

Two tasks need to be performed before you begin in the worksheet. First, you must identify all the development rules that apply in your community. Second, you must identify the local, state, and federal authorities that actually administer or enforce the development rules within your community. Both tasks require a large investment of time. The development process is usually shaped by a complex labyrinth of regulations, criteria, and authorities. A team approach may be helpful. You may wish to enlist the help of a local plan reviewer, land planner, land use attorney, or civil engineer. Their real-world experience with the development process is often very useful in completing the worksheet.

Identify the Development Rules

Gather the key documents that contain the development rules in your community. A list of potential documents to look for is provided in Table 4. Keep in mind that the information you may want on a particular development rule is not always found in code or regulation, and may be hidden in supporting design manuals, review checklists, guidance document or construction specifications. In most cases, this will require an extensive search. Few communities include all of their rules in a single document. Be prepared to contact state and federal, as well as local agencies to obtain copies of the needed documents.

Table 4: Key Local Documents that will be Needed to Complete the COW

Zoning Ordinance
Subdivision Codes
Street Standards or Road Design Manual
Parking Requirements
Building and Fire Regulations/Standards
Stormwater Management or Drainage Criteria
Buffer or Floodplain Regulations
Environmental Regulations
Tree Protection or Landscaping Ordinance
Erosion and Sediment Control Ordinances
Public Fire Defense Masterplans
Grading Ordinance

Identify Development Authorities

Once the development rules are located, it is relatively easy to determine which local agencies or authorities are actually responsible for administering and enforcing the rules. Completing this step will provide you with a better understanding of the intricacies of the development review process and helps identify key members of a future local roundtable.

Table 5 provides a simple framework for identifying the agencies that influence development in your community. As you will see, space is provided not only for local agencies, but for state and federal agencies as well. In some cases, state and federal agencies may also exercise some authority over the local development process (e.g., wetlands, some road design, and stormwater).

Using the Worksheet: How Do Your Rules Stack Up to the Model Development Principles?

Completing the Worksheet

Once you have located the documents that outline your development rules and identified the authorities responsible for development in your community, you are ready for the next step. You can now use the worksheet to compare your development rules to the model development principles.

The worksheet is presented at the end of this chapter. The worksheet presents seventy-seven site planning benchmarks. The benchmarks are posed as questions. Each benchmark focuses on a specific site design practice, such as the minimum diameter of cul-de-sacs, the minimum width of streets, or the minimum parking ratio for a certain land use. You should refer to the codes, ordinances, and plans identified in the first step to determine the appropriate development rule.

The questions require either a yes or no response or a specific numeric criteria. If your development rule agrees with the site planning benchmark, you are awarded points.

Calculating Your Score

A place is provided on each page of the worksheet to keep track of your running score. In addition, the worksheet is subdivided into three categories:

- Residential Streets and Parking Lots (Principles No. 1 - 10)
- Lot Development (Principles No. 11 - 16)
- Conservation of Natural Areas (Principles No. 17 - 22).

For each category, you are asked to subtotal your score. This **"Time to Assess"** allows you to consider which development rules are most in line with the site planning benchmarks and what rules are potential candidates for change.

The total number of points possible for all of the site planning benchmarks is 100. Your overall score provides a general indication of your community's ability to support environmentally sensitive development. As a general rule, if your overall score is lower than 80, then it may be advisable to systematically reform your local development rules. A score sheet is provided at end of the Code and Ordinance Worksheet to assist you in determining where your community's score places in respect to the Model Development Principles.

Once you have completed the worksheet, go back and review your responses. Determine if there are specific areas that need improvement (e.g., development rules that govern road design) or if your development rules are generally pretty good. This review is key to implementation of better development: assessment of your current development rules and identification of impediments to innovative site design. This review also directly leads into the next step: a site planning roundtable process conducted at the local government level. The primary tasks of a local roundtable are to systematically review existing development rules and then determine if changes can or should be made. By providing a much-needed framework for overcoming barriers to better development, the site planning roundtable can serve as an important tool for local change.

Table 5: Local, State, and Federal Authorities Responsible for Development in Your Community

Development Responsibility		State/Federal	County	Town
Sets road standards	Agency:			
	Contact Name:			
	Phone No.:			
Review/approves subdivision plans	Agency:			
	Contact Name:			
	Phone No.:			
Establishes zoning ordinances	Agency:			
	Contact Name:			
	Phone No.:			
Establishes subdivision ordinances	Agency:			
	Contact Name:			
	Phone No.:			

Table 5: Local, State, and Federal Authorities Responsible for Development in Your Community (Continued)

Development Responsibility		State/Federal	County	Town
Reviews/establishes stormwater management or drainage criteria	Agency:			
	Contact Name:			
	Phone No.:			
Provides fire protection and fire protection code enforcement	Agency:			
	Contact Name:			
	Phone No.:			
Oversees buffer ordinance	Agency:			
	Contact Name:			
	Phone No.:			
Oversees wetland protection	Agency:			
	Contact Name:			
	Phone No.:			
Establishes grading requirements or oversees erosion and sediment control program	Agency:			
	Contact Name:			
	Phone No.:			
Reviews/approves septic systems	Agency:			
	Contact Name:			
	Phone No.:			
Reviews/approves utility plans (e.g., water and sewer)	Agency:			
	Contact Name:			
	Phone No.:			
Reviews/approves forest conservation/ tree protection plans?	Agency:			
	Contact Name:			
	Phone No.:			

1. Street Width

What is the minimum pavement width allowed for streets in low density residential developments that have less than 500 average daily trips (ADT)? ________ feet

*If your answer is between **18-22 feet**, give yourself **4** points* ☞ [ ]

At higher densities are parking lanes allowed to also serve as traffic lanes (i.e., queuing streets)? YES/NO

*If your answer is **YES**, give yourself **3** points* ☞ [ ]

2. Street Length

Do street standards promote the most efficient street layouts that reduce overall street length? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

3. Right-of-Way Width

What is the minimum right of way (ROW) width for a residential street? ________ feet

*If your answer is **less than 45 feet**, give yourself **3** points* ☞ [ ]

Does the code allow utilities to be placed under the paved section of the ROW? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

4. Cul-de-Sacs

What is the minimum radius allowed for cul-de-sacs? ________ feet

*If your answer is **less than 35 feet**, give yourself **3** points* ☞ [ ]

*If your answer is **36 feet to 45 feet**, give yourself **1** point* ☞

Can a landscaped island be created within the cul-de-sac? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Are alternative turn arounds such as "hammerheads" allowed on short streets in low density residential developments? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Subtotal Page 15 [ ]

5. Vegetated Open Channels

Are curb and gutters required for most residential street sections? YES / NO

*If your answer is **NO**, give yourself **2** points* ☞

Are there established design criteria for swales that can provide stormwater quality treatment (i.e., dry swales, biofilters, or grass swales)? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞

6. Parking Ratios

What is the minimum parking ratio for a professional office building (per 1000 ft^2 of gross floor area)? ________ spaces

*If your answer is **less than 3.0 spaces**, give yourself **1** point* ☞

What is the minimum required parking ratio for shopping centers (per 1,000 ft^2 gross floor area)?

*If your answer is **4.5 spaces or less**, give yourself **1** point* ☞

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

*If your answer is **less than or equal to 2.0 spaces**, give yourself **1** point* ☞

Are your parking requirements set as maximum or median (rather than minimum) requirements? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞

7. Parking Codes

Is the use of shared parking arrangements promoted? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

Are model shared parking agreements provided? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

Are parking ratios reduced if shared parking arrangements are in place? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

If mass transit is provided nearby, is the parking ratio reduced? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

Subtotal Page 16

8. Parking Lots

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

*If your answer is **9 feet or less**, give yourself **1** point* ☞ [ ]

What is the minimum stall length for a standard parking space? ________ feet

*If your answer is **18 feet or less**, give yourself **1** point* ☞ [ ]

Are at least 30% of the spaces at larger commercial parking lots required to have smaller dimensions for compact cars? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Can pervious materials be used for spillover parking areas? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

9. Structured Parking

Are there any incentives to developers to provide parking within garages rather than surface parking lots? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

10. Parking Lot Runoff

Is a minimum percentage of a parking lot required to be landscaped? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Is the use of bioretention islands and other stormwater practices within landscaped areas or setbacks allowed? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Time to Assess: Principles 1 - 10 focused on the codes, ordinances, and standards that determine the size, shape, and construction of parking lots, roadways, and driveways in the suburban landscape. There were a total of **40** points available for Principles 1 - 10. What was your total score?

Subtotal Page 15 _____ +Subtotal Page 16 _____ +Subtotal Page 17 _____ = [ ]

Where were your codes and ordinances most in line with the principles? What codes and ordinances are potential impediments to better development?

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____

11. Open Space Design

Are open space or cluster development designs allowed in the community? YES / NO

*If your answer is **YES**, give yourself **3** points* ☞ [ ]

*If your answer is **NO**, skip to question No. 12*

Is land conservation or impervious cover reduction a major goal or objective of the open space design ordinance? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Are the submittal or review requirements for open space design greater than those for conventional development? YES / NO

*If your answer is **NO**, give yourself **1** point* ☞ [ ]

Is open space or cluster design a by-right form of development? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Are flexible site design criteria available for developers that utilize open space or cluster design options (e.g, setbacks, road widths, lot sizes) YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

12. Setbacks and Frontages

Are irregular lot shapes (e.g., pie-shaped, flag lots) allowed in the community? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

What is the minimum requirement for front setbacks for a **one half (½) acre** residential lot? ______ feet

*If your answer is **20 feet or less**, give yourself **1** point* ☞

What is the minimum requirement for rear setbacks for a **one half (½) acre** residential lot? ______ feet

*If your answer is **25 feet or less**, give yourself **1** point* ☞

What is the minimum requirement for side setbacks for a **one half (½) acre** residential lot? ______ feet

*If your answer is **8 feet or less**, give yourself **1** points* ☞

What is the minimum frontage distance for a **one half (½) acre** residential lot? ______ feet

*If your answer is **less than 80 feet**, give yourself **2** points* ☞

13. Sidewalks

What is the minimum sidewalk width allowed in the community? ______ feet

*If your answer is **4 feet or less**, give yourself **2** points* ☞

Are sidewalks always required on both sides of residential streets? YES / NO

*If your answer is **NO**, give yourself **2** points* ☞

Are sidewalks generally sloped so they drain to the front yard rather than the street? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

Can alternate pedestrian networks be substituted for sidewalks (e.g., trails through common areas)? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

14. Driveways

What is the minimum driveway width specified in the community?

*If your answer is **9 feet or less (one lane) or 18 feet (two lanes)**, give yourself **2** points* ☞

Can pervious materials be used for single family home driveways (e.g., grass, gravel, porous pavers, etc)? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞

Can a "two track" design be used at single family driveways? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

Are shared driveways permitted in residential developments? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

15. Open Space Management

Skip to question 16 if open space, cluster, or conservation developments are not allowed in your community.

Does the community have enforceable requirements to establish associations that can effectively manage open space? YES/NO

*If your answer is **YES**, give yourself **2** points* ☞

Are open space areas required to be consolidated into larger units? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

Does a minimum percentage of open space have to be managed in a natural condition? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

Are allowable and unallowable uses for open space in residential developments defined? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

Can open space be managed by a third party using land trusts or conservation easements? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

16. Rooftop Runoff

Can rooftop runoff be discharged to yard areas? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞

Do current grading or drainage requirements allow for temporary ponding of stormwater on front yards or rooftops? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞

Subtotal Page 20

Time to Assess: Principles 11 through 16 focused on the regulations which determine lot size, lot shape, housing density, and the overall design and appearance of our neighborhoods. There were a total of **36** points available for Principles 11 - 16. What was your total score?

Subtotal Page 18 _____ +Subtotal Page 19 _____ +Subtotal Page 20 ______ = [ ]

Where were your codes and ordinances most in line with the principles? What codes and ordinances are potential impediments to better development?

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17. Buffer Systems

Is there a stream buffer ordinance in the community? YES / NO

*If your answer is **YES**, give yourself **2** point* ☞ [ ]

If so, what is the minimum buffer width? ________ feet

*If your answer is **75 feet or more**, give yourself **1** point* ☞ [ ]

Is expansion of the buffer to include freshwater wetlands, steep slopes or the 100-year floodplain required? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

18. Buffer Maintenance

If you do not have stream buffer requirements in your community, skip to question No. 19

Does the stream buffer ordinance specify that at least part of the stream buffer be maintained with native vegetation? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Subtotal Page 21 [ ]

Does the stream buffer ordinance outline allowable uses? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Does the ordinance specify enforcement and education mechanisms? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

19. Clearing and Grading

Is there any ordinance that requires or encourages the preservation of natural vegetation at residential development sites? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Do reserve septic field areas need to be cleared of trees at the time of development? YES / NO

*If your answer is **NO**, give yourself **1** point* ☞ [ ]

20. Tree Conservation

If forests or specimen trees are present at residential development sites, does some of the stand have to be preserved? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Are the limits of disturbance shown on construction plans adequate for preventing clearing of natural vegetative cover during construction? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

21. Land Conservation Incentives

Are there any incentives to developers or landowners to conserve non-regulated land (open space design, density bonuses, stormwater credits or lower property tax rates)? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Is flexibility to meet regulatory or conservation restrictions (density compensation, buffer averaging, transferable development rights, off-site mitigation) offered to developers? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

22. Stormwater Outfalls

Is stormwater required to be treated for quality before it is discharged? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Subtotal Page 22 [ ]

Are there effective design criteria for stormwater best management practices (BMPs)? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ ______

Can stormwater be directly discharged into a jurisdictional wetland without pretreatment? YES / NO

*If your answer is **NO**, give yourself **1** point* ☞ ______

Does a floodplain management ordinance that restricts or prohibits development within the 100 year floodplain exist? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ ______

Time to Assess: Principles 17 through 22 addressed the codes and ordinances that promote (or impede) protection of existing natural areas and incorporation of open spaces into new development. There were a total of **24** points available for Principles 17 - 22. What was your total score?

Subtotal Page 21 ______ +Subtotal Page 22 _____ +Subtotal Page 23______ = ______

Where were your codes and ordinances most in line with the principles? What codes and ordinances are potential impediments to better development?

____

____

____

____

To determine final score, add up subtotal from each **Time to Assess**

Principles 1 - 10 (Page 18) ______

Principles 11 - 16 (Page 21) ______

Principles 17 - 22 (Page 23) ______

TOTAL ______

SCORING (A total of **100** points are available):

See Page 10 to determine where your community's score places in respect to the site planning roundtable Model Development Principles:

Your Community's Score		
90- 100	☞	Congratulations! Your community is a real leader in protecting streams, lakes, and estuaries. Keep up the good work.
80 - 89	☞	Your local development rules are pretty good, but could use some tweaking in some areas.
79 - 70	☞	Significant opportunities exist to improve your development rules. Consider creating a site planning roundtable.
60 - 69	☞	Development rules are inadequate to protect your local aquatic resources. A site planning roundtable would be very useful.
less than 60	☞	Your development rules definitely are not environmentally friendly. Serious reform of the development rules is needed.

CHAPTER 4

TECHNICAL SUPPORT FOR THE MODEL DEVELOPMENT PRINCIPLES

Changing local development codes and regulations is not easy. Advocates of change are going to be asked hard questions. The hard questions will come from many diverse members of the community and government, including fire chiefs, traffic engineers, developers, homeowners, and elected officials, and tend to focus on economic, public safety, and convenience issues. For example, will the proposed changes:

- make it more difficult to park?
- increase the cost of development?
- increase our exposure to lawsuits?
- increase the cost of maintenance for local governments or individual homeowners?
- make it more difficult to sell new housing developments?
- reduce property values?
- lower the response time for fire trucks and emergency vehicles?
- increase the risk that our children will be struck by cars?
- decrease quality of life for homeowners?

Therefore, it is essential to have good answers to these and other questions during the roundtable process. Real change to the rules can only happen when these questions are thoroughly addressed and community concerns are satisfied.

The answers to some of the hard questions is generally either a resounding no, or at least a somewhat qualified no. In other cases, the answers are more ambiguous, suggesting that implementation of the model development principles will require a careful balancing of several competing community objectives–a trade-off perhaps between a smaller parking lot and the possibility of parking congestion a few days a year, or between a narrower road and the inconvenience of having to pull over to let a driver in the opposite direction pass by. Another important trade-off involves balancing a small but real safety risk against the environmental and economic benefit of a particular model development principle.

This balancing is best resolved through a local site planning roundtable, where a community can come together through a consensus process to make better choices about the design of new development.

To get this process started, we have compiled summary sheets for the 22 Model Development Principles. Each summary sheet consists of five key sections:

- **Current Practice.** This section describes the typical development practice in many communities across the country and explains why it leads to increased impervious cover and greater stormwater runoff.

- **Recommended Practice.** This section shows how the existing development rules could be changed to reduce impervious cover, conserve natural areas or better manage stormwater. While the recommended practices are often very specific, we have not endorsed any single, numerical design criteria. Many of the current problems in subdivision codes stem from the "cookbook" mentality, where communities adopted national subdivision "recipes" without modifying them to fit their individual needs. It is not intended that the recommended practice replace current cookbooks with a national one.

- **Perceptions and Realities.** In this section, the most common negative perceptions about the site planning topic are raised, followed by an objective assessment of the data. The data is drawn from a host of economic studies, public surveys, market studies, and environmental research. In some cases, the data is thin or contradictory, and this is so noted.

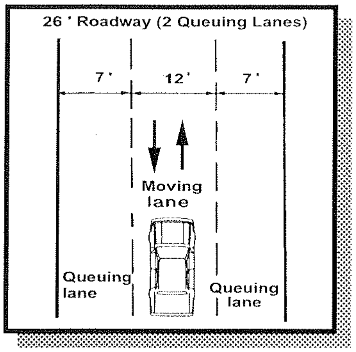
- **Case Studies.** This section presents case studies from across the country where communities have successfully applied the ideas presented in the model development principles.

- **Where to Get Started.** This last section of each summary sheet provides more detailed references and resources to consult as you begin the process of changing your local development rules.

On the following page is an index that will guide you directly to the summary sheet for the site planning topic that you are interested in.

INDEX TO SUMMARY SHEETS

Principle No.



PRINCIPLE NO. 1

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

CURRENT PRACTICE

Many communities require that residential streets be 36 feet wide or more, even when they serve developments that produce small volumes of traffic. These wide streets result from blanket application of high volume and high speed highway design criteria, as well as a perceived need to supply both on-street parking and unobstructed access for fire trucks. However, residential streets are often unnecessarily wide and the excessive widths contribute to making them the largest single component of impervious cover in a subdivision. Narrowing residential street widths can help reduce the amount of impervious cover created by excessive street widths requirements.

RECOMMENDED PRACTICE

Several national engineering organizations have recommended that residential streets can be as narrow as 22 feet in width (AASHTO, 1994; ASCE, 1990) if they serve neighborhoods that produce low traffic volumes (less than 500 daily trips, or 50 homes) In addition, several communities such as Buck's County, Pennsylvania and Boulder, Colorado have implemented narrower streets with success (see Table 1.1).

Table 1.1: Examples of Narrow Residential Street Widths

Organization, Source	Residential Street Pavement Width	Maximum Average Daily Traffic (trips/day)
State of New Jersey	20' (no parking)	0-3,500
	28' (parking on one side)	0-3,500
Boulder, Colorado	20'	150
	20' (no parking)	350-1,000
	22' (one side)	350
	26' (both sides)	350
	26'(one side)	500-1,000
Bucks County, PA	12' (alley)	--
	16-18' (no parking)	200
	20'-22'(none)	200-1,000
	26' (one side)	200
	28' (one side)	200-1,000

Note: Street options are influenced by housing density and the need for on-street parking

Streets do need to be wider when they serve higher density developments. It is still possible, however, to design a relatively narrow street even when housing densities begin to require more on-street parking. A common solution is the use of queuing streets. In the queuing street design, only one traffic lane is used and parking lanes serve as queuing lanes where oncoming vehicles pull over to allow another vehicle to pass by (Bray and Rhodes, 1997; ASCE, 1990; and Figure 1.2 for an illustration).

Communities have a significant opportunity to reduce impervious cover by revising their street standards, so that streets are the minimum width to carry traffic and meet residential parking demand.

Perceptions and Realities about Street Width

Any effort to narrow residential streets will need to satisfy community concerns about parking, safety, fire truck access, congestion and other factors. Much of the available research profiled in Table 1.2, however, suggests that careful design of narrow streets can address these concerns.

On-Street Parking Demand

The need for on-street parking is often used to justify wider residential streets. Most communities require that 2 or 2.5 parking spaces be provided for each home. Depending on its dimensions, 2 spaces can usually be provided by the driveway which leaves at most one space that must be provided on the street. These on-street parking spaces need to be about 20 feet long and seven feet wide. Providing a continuous parking lane on both sides of the street, however, is a very inefficient and expensive way to satisfy this relatively minor parking need. Each on-street parking lane increases a street's impervious cover by 25% (Sykes, 1989) while creating unutilized parking capacity. If one or both of the on-street parking lanes also serve as a traffic lane (i.e, a queuing street), both traffic movement and parking needs can be met by a narrower street.

Street Width and Safety

The potential for increased vehicle-pedestrian accidents is often cited for not allowing narrower streets. Many studies, however, indicate that narrow residential streets may be safer than wider streets. The Federal Highway Administration (1997) noted that narrow street widths tend to reduce the speed at which drivers travel. This finding has also been noted by the ITE (1997) and ULI (1992). Slower vehicle speeds provide drivers with more time to react and prevent potential accidents. Slower speeds also reduce the severity of injuries sustained in accidents.

Fire Safety

Another common impediment is the perception that narrow streets do not provide adequate access for emergency vehicles, particularly fire vehicles. The conventional wisdom is that very wide streets are needed to ensure access. However, a number of local fire codes permit roadway widths as narrow as eighteen feet (Table 1.3).

Table 1.2: Perceived Impediments to Narrow Streets

Perception	Facts, Case Studies, and Challenges	
1. Narrow streets interfere with the ability to clear and stockpile snow.	FACT:	"Narrow" snowplows are available. Snowplows with 8' width, mounted on a pick-up truck are common. Some companies manufacture alternative plows on small "Bobcat" type machines (Frink America, 1997).
	FACT:	Snow stockpiles on narrow streets can be accommodated if parking is restricted to one side of the street (ITE, 1997).
2. Narrow streets will cause traffic congestion.	FACT:	Narrow streets are generally appropriate only in residential areas that experience less than 500 trips per day. Street width is largely a function of traffic volume. Design criteria based on volume generally provide safe and efficient access in residential areas (ITE, 1993).
3. Narrow streets do not provide enough room for on-street parking.	FACT:	Parking can be accommodated through the use of "queuing streets" with only one travel lane (Bray and Rhodes, 1997; ASCE, 1990).
	FACT:	Most communities require some off-street parking accommodation in residential subdivisions. Olympia, Washington requires two parking spaces per dwelling unit. On-street parking is used for visitor parking or parkable vehicles, such as boats (Wells, 1995).
4. Narrow streets can cause pedestrian/ vehicle accidents.	FACT:	In a study of over five thousand pedestrian and bicycle crashes, a narrow roadway was a factor in only two cases (FHA, 1996). Unsafe driving speed, on the other hand, contributed to 225 accidents.
	FACT:	Narrower street widths reduce the speed at which vehicles can drive (FHA, 1996).
5. Narrow streets do not provide access for maintenance and service vehicles.	FACT:	Trash trucks require only a 10.5' travel lane (Waste Management, 1997), with a standard truck width of approximately 9' (BFI, 1997). In residential neighborhoods, trash collection often occurs simultaneously on both sides of the street; cars must wait for trash trucks to pass regardless of street width.
	FACT:	Half ton mail trucks, smaller than many privately owned vehicles, are generally used in residential neighborhoods. Hand delivery of mail is also an option (US Post Office, 1997).
	CASE STUDY:	School buses are typically eight feet wide (nine feet from mirror to mirror). Both Prince Georges County and Montgomery County, Maryland require only a 12' driving lane for bus access. Furthermore, school buses usually do not drive down every street, but instead meet children at bus stops on larger roads.

Table 1.3: Street Width Requirements for Fire Vehicles

Width	Source
18'-20'[1]	US Fire Administration (Cochran, 1997)
24' (on-street parking) 16' (no on-street parking)	Baltimore County Fire Department
18' minimum	Virginia State Fire Marshal
24' (no parking) 30' (parking on one side) 36' (parking on both sides) 20' (for fire truck access)	Prince Georges County Department of Environmental Resources
18' (parking on one side)[2] 26' (parking on both sides)	Portland Office of Transportation

[1]Represents typical "fire lane" width, which is the width necessary to accommodate a fire vehicle.

[2]Applicable to grid pattern streets or short cul-de-sacs.

Economic Benefits

Significant construction cost savings can be achieved by building narrower streets. Construction costs for paving are approximately $15 per square yard. For example, a local jurisdiction currently requires all residential streets with one parking lane to be a minimum of 28 feet wide. The jurisdiction adopts a new standard: 18 feet wide queuing streets. This new standard would reduce the overall imperviousness associated with a 300 foot road by 35% and construction costs by $5,000. Additional economic benefits include reduced clearing and grading, infrastructure, and stormwater management costs. Long-term pavement maintenance costs would also be reduced.

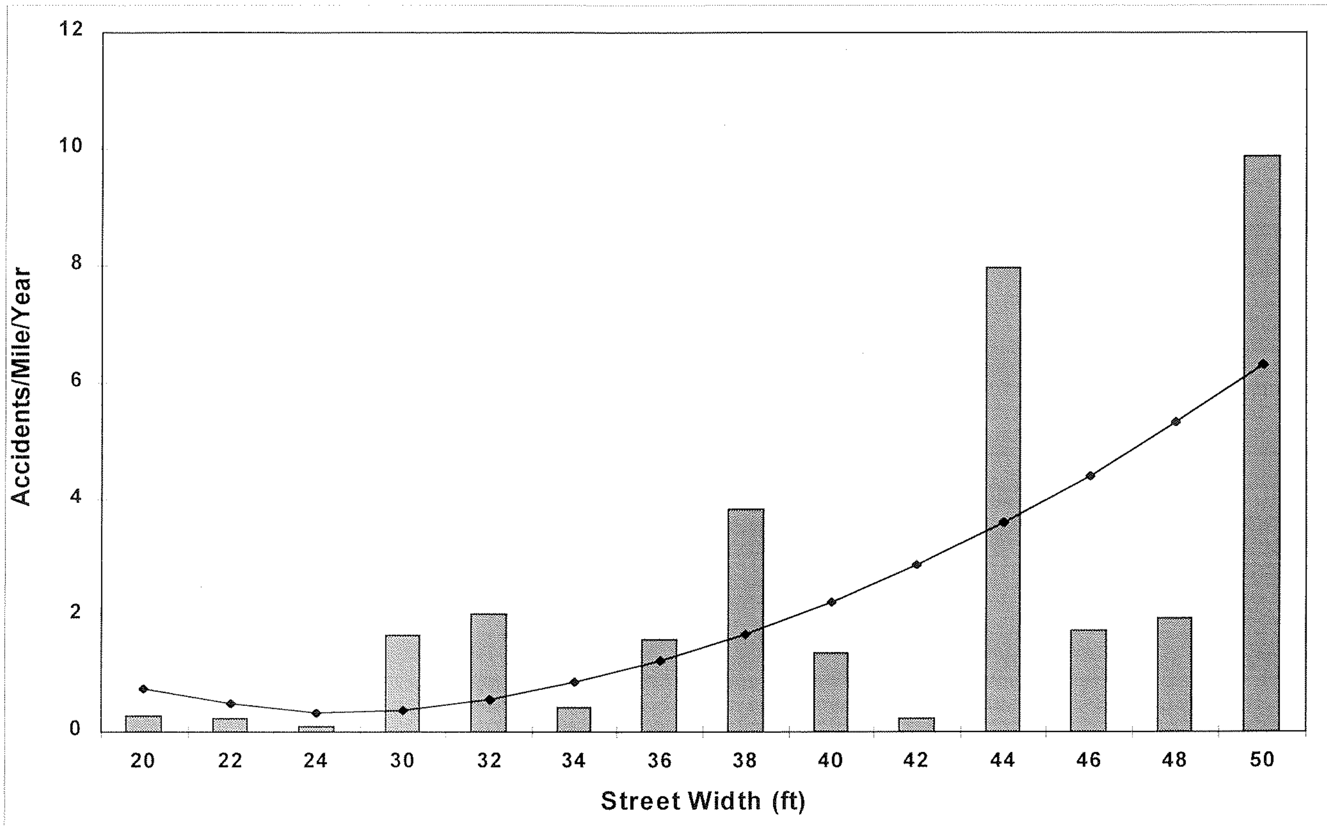
Case Study: Longmont, Colorado

(Source: Swift, et al, 1998)

The City of Longmont, Colorado is experiencing rapid growth. The quality and type of new development has become an important issue as more development and non-conventional site designs are proposed. Part of this discussion is acceptable residential street design.

Over 20,000 police reports were examined to determine the relationship between street design and safety. The study focused specifically on residential streets with maximum ADTs of 2,500. Accidents attributable to poor road conditions or substance abuse were excluded from the study. As shown in Figure 1.1, the study results suggested that narrow residential streets are safer than wide streets. Specifically, streets between 22 to 30 feet in width were found to be the safest. The study further indicated that curvilinear streets were safer than straight streets. In general, the Longmont study suggests that narrow, curved streets can safely be used in residential developments.

Figure 1.1: Relationship Between Street Width and Accidents in Longmont, Colorado based on Swift, et al., (1998)



The curve illustrates the increase in the number of accidents as street width increases.

CASE STUDY: PORTLAND, OREGON

(Source: Portland Office of Transportation, 1994)

The City of Portland investigated the use of queuing streets as described by ASCE (1990) to reduce street widths. The ASCE design assumes that cars will wait between parked cars, or "queue", while the approaching traffic passes (see Figure 1.2). The new design reduces existing street widths by up to eight feet. Prior to implementing the revised standard, the Portland Department of Transportation studied existing narrow streets to determine if reduced street widths would endanger pedestrians and residents. The findings of this study were:

- A bicycle and a car can fit down a 24 foot wide street with parking on both sides.
- A dump truck can fit down a 24 foot wide street with parking on both sides.
- Fire trucks can easily drive down 26 foot wide streets with parking on both sides.
- A fire truck can make the turn from an 18 foot wide to a 20 foot wide road at slow speeds.
- Traffic engineers could point to no accident history relating to narrow street widths.

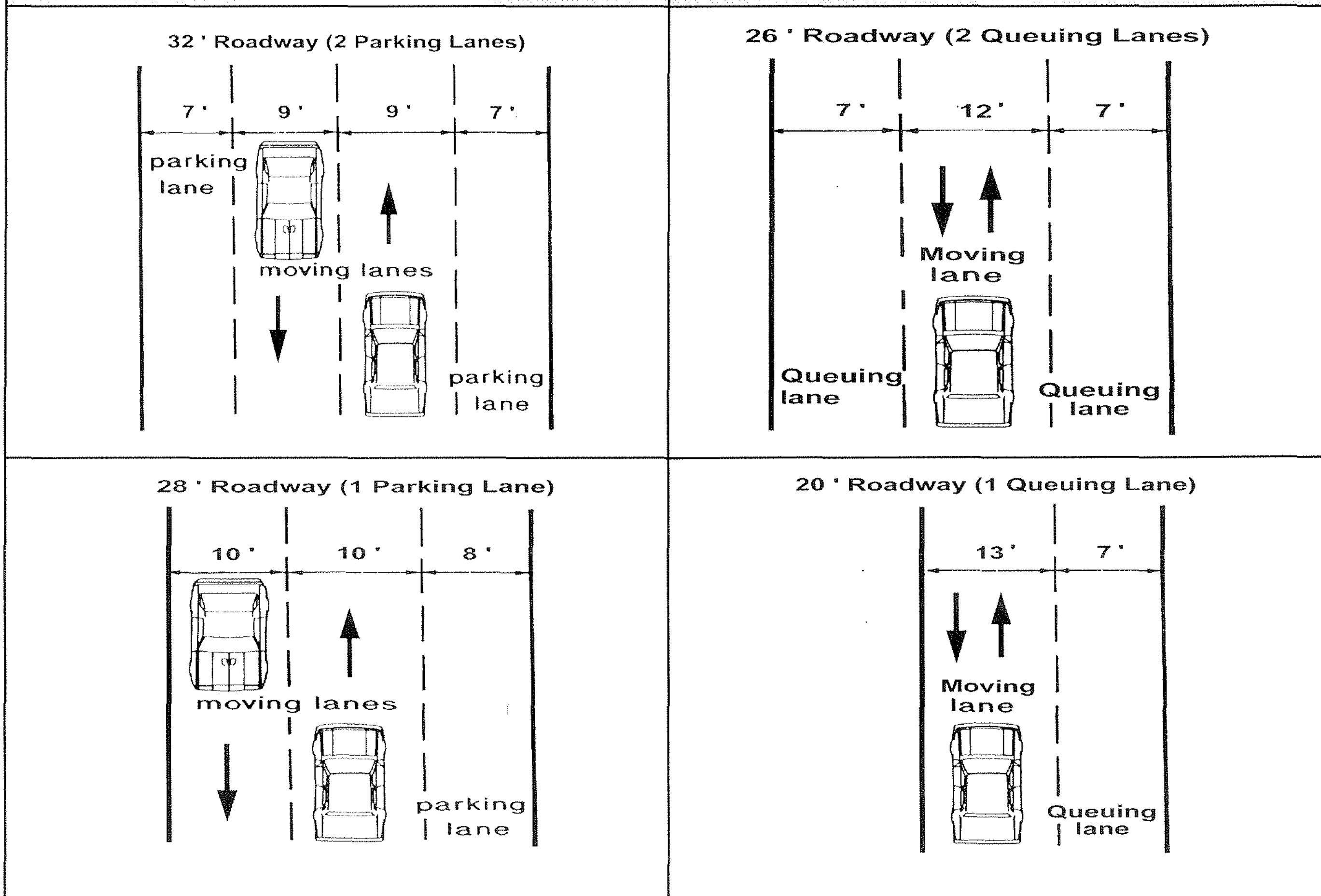
- The Portland fire chief was amenable to streets as narrow as 18 feet with parking on one side in grid pattern streets or on short cul-de-sacs.
- No citizen has charged that fire rescue time was impeded by skinny streets since the inception of this program in 1991 (Bray, 1997)

One exception was noted with respect to long roads leading to cul-de-sacs (e.g., 1500 feet); these streets require two travel lanes for adequate fire vehicle access. The fire bureau therefore retained the right to veto narrow streets on long cul-de-sacs.

In the City of Portland, the cost savings realized from narrow streets allowed the city to improve less-developed portions of the roadway which, in turn, encouraged infill development. Infill development refers to development or enhancement within existing urban areas as an alternative to developing surrounding rural areas.

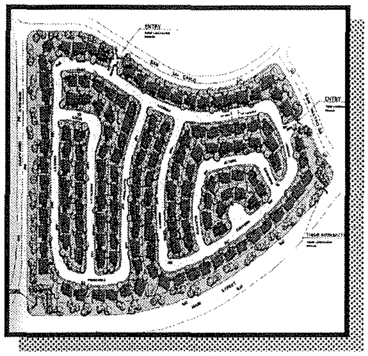
Figure 1.2: A Comparison of Queuing Streets vs. Traditional Streets [Source: Portland (OR) Office of Transportation, 1994]

Original Standards (Separate travel lanes and parking lanes)	Revised Standards (Parking lanes serve as Queuing lanes)



WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
A Policy on Geometric Design of Highways and Streets (1994) by American Association of State Highway and Transportation Officials (AASHTO) Provides guidance on highway design including shared use of transportation corridors and cost-effective highway design that reflects the needs of non-users and the environment.	AASHTO Publications 444 North Capitol Street, NW Washington, DC 20001 888-227-4860
Report on New Standards for Residential Streets in Portland, Oregon (1994) by Portland Office of Transportation Summarizes new residential street standards that encourage less costly street improvement with minimal impact on water quality and urban forests.	City of Portland Office of Transportation 1120 S.W. Fifth Avenue Room 802 Portland, OR 97204-1971 503-823-7004
Performance Streets: A Concept and Model Standards for Residential Streets (1980) by Bucks County Planning Commission. Presents model standards focusing on pedestrian as well as vehicular traffic and reducing overdesigned street networks.	Bucks County Planning Commission Route 611 and Almshouse Road Neshaminy Manor Center Doylestown, PA 18901 215-345-3400
Residential Streets (2nd Edition) Includes discussion of design considerations for pedestrian walks and paths.	Urban Land Institute 1025 Thomas Jefferson Street, NW Washington, DC 20007 800-321-5011 Also available from the American Society of Civil Engineers and the National Association of Home Builders



Source: ULI 1992

PRINCIPLE NO. 2

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

CURRENT PRACTICE

Most communities do not explicitly require site designers or traffic engineers to use the shortest street network needed to serve individual lots on residential streets. It is generally assumed that the cost of constructing roads is sufficient incentive to assure short street networks. However, in many cases, the overriding consideration for traffic engineers is that streets operate at a certain service level (Ewing 1996). Streets are designed to accommodate rapid, smooth traffic flow and, consequently, total street length is rarely the most important design consideration. Traffic movement tends to be given even more weight as the size of the development increases.

The most common types of street networks used are grid and curvilinear (see Figure 2.1). The grid pattern is a traditional urban street network. The curvilinear pattern is a more contemporary subdivision network. Grid patterns typically require 20 to 25 percent more total street length than curvilinear patterns. When narrower pavement widths are used, however, the reduced street widths can offset the greater street length associated with the grid pattern (Bookout, 1992).

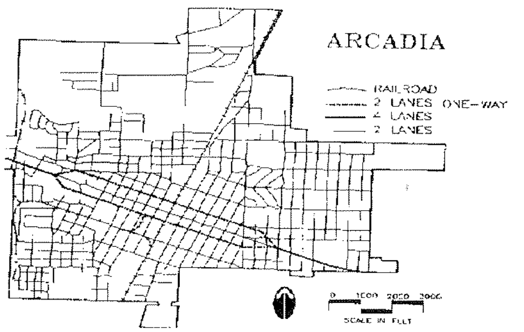
Another street network used is the hybrid street network. This design combines both grid and curvilinear patterns to create a bending grid of roads in a wheel and spoke design. Cul-de-sacs, loops, and short straight streets feed off the basic grid to provide residential access (Ewing, 1996). This road layout design accommodates the contours and natural features of a site while still providing interconnectivity (Figure 2.2).

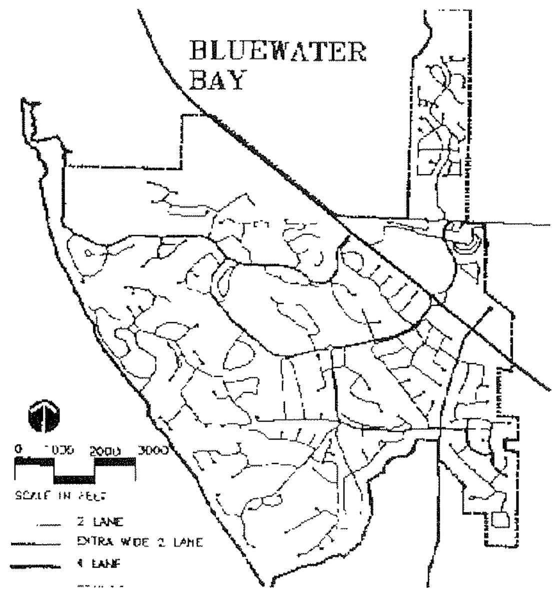
RECOMMENDED PRACTICE

Total street length is a function of the distance between house lots and site layout. There is no one street layout that is guaranteed to minimize total street length in residential developments. Instead, site designers are encouraged to actively look for opportunities to reduce street length. Generally, a more compact street network can be achieved by reducing frontage distances and side yard setbacks and allowing narrower lots (Principle No. 12). Smaller lots clustered together (Principle No. 11) can also reduce the total street length. Site designers should also reduce the number of non-frontage roads. In other words, as many homes as possible should be directly accessible from the main streets. Long streets serving only one or two homes should be discouraged.

Site designs that lend themselves to reduced street length include the "traditional neighborhood development" and "open space development."

Figure 2.1: Grid and Curvilinear Road Patterns (Based on Ewing, 1996)





Grid (Traditional Urban Pattern)	Curvilinear (Contemporary Suburban Pattern)
Characteristics	**Characteristics**
Short block lengths	Cul-de sacs
Straight streets	Long block lengths
Systematic layout	Branching street networks
Advantages	**Advantages**
Greater dispersal of traffic	Uses natural topography to reduce excavation
Greater direct access	Eases avoidance of natural areas
More pedestrian friendly	Reduces cut-thru traffic
Transit oriented	Reduces vehicle speeds due to curving nature
Maximizes number of homes fronting a street	
Typically provides water main system with greater pressure	

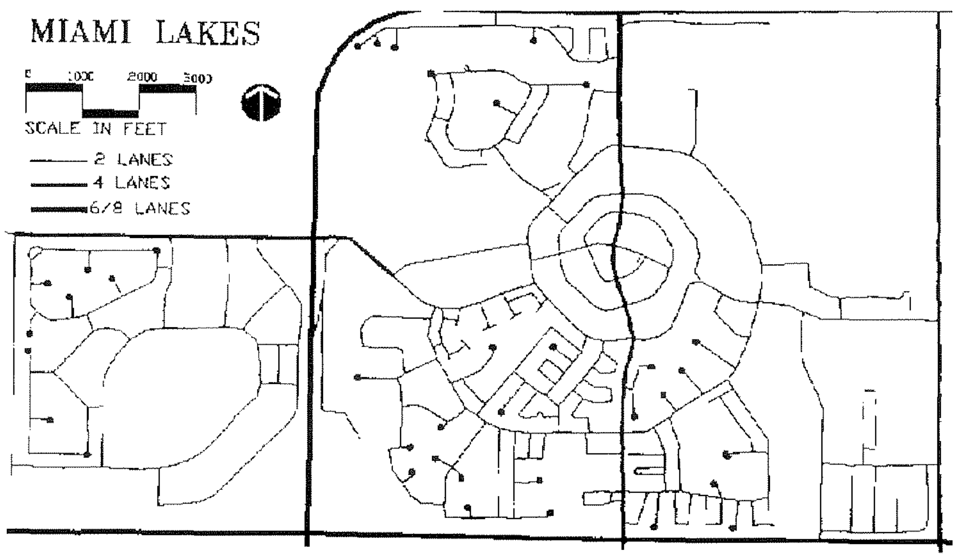
Traditional Neighborhood Development (TND)

Also called neo-traditional development, this development pattern is designed to emulate the characteristic of small, older communities of the 18th through the early 20th centuries. A central feature of traditional neighborhood development (TND) is to shift the focus of the infrastructure from serving the automobile to serving pedestrians. To do so, designers must carefully consider the connectedness of the street and alley network while lowering auto speeds and providing reasonable safety for pedestrians. ITE (1997) has produced detailed guidelines on how to design more efficient street systems within TNDs.

In the TND design, streets tend to be laid out in a grid pattern, more community open space is provided, and a variety of housing types are employed with smaller front yards. TNDs often employ a variety of land use activities in a single project. One goal of TNDs is to provide communities where residents can walk from home to jobs and commercial establishments.

TND can minimize the environmental impacts associated with extensive roadways. The idea is to provide a critical mass of residents, in close proximity to jobs, shopping, and mass transit to help reduce reliance on the automobile for transportation.

Figure 2.2: Hybrid Street Networks (Ewing, 1996)



Open Space Development

Open space development is a compact form of development that concentrates density on one portion of the site in exchange for reduced density elsewhere. Minimum lot sizes, setbacks and frontage distances are relaxed to provide common open space. The distance between homes is shortened, allowing shorter streets.

Most open space developments use either a curvilinear or hybrid street pattern. The curvilinear pattern is a flexible option that allows the site designer to follow the topography of the site and avoid sensitive environmental areas. Clearing and grading requirements are minimized and more protection is provided for forests, wetlands, and trees.

Arendt (1996) recommends that open space site designers make street layout their ***third*** priority. Identification of conservation areas and location of house lots are the first two priorities. This ensures minimal disturbance to natural areas. Because narrow, small lots are an integral part of open space design, the resulting street network will most likely be smaller than that achieved using a conventional design. Additional street length reduction can be achieved by reducing the length of the access roads (i.e., placing homes closer to the subdivision entrance).

Table 2.2: Perceived Impediments to Shorter Street Networks

Perception	Fact, Case Studies, and Challenges	
1. Shorter street lengths reduce on-street parking.	FACT:	The average number of vehicles in a household is 1.66 which can usually be accommodated between the driveway, garage, and on-street parking (Pisarski, 1996).
	FACT:	Many open space and TND designs include garages and/or driveways. Further, many of today's subdivision ordinances shift on-street parking to off-street locations such as driveways, garages, and parking lots (Ewing, 1996). This trend is echoed in the joint ASCE, NAHB and ULI document Residential Streets (ULI, 1990). Specifically, "All residential occupant parking should be off-street parking, accommodated by driveways, carports, and garages, or, in higher-density developments, parking lots. Only visitor parking should overflow onto the street."
	CHALLENGE:	Designers must consider the trends in vehicle ownership. The percentage of households with 3 or more vehicles decreased by 1% from 1980 - 1990. However, this decrease is significant in light of the extraordinary increase in such households (10-fold) between 1960 and 1980 (Pisarski, 1996).
2. As housing density increases, traffic will become more congested.	FACT:	Shorter block lengths typically encourage greater street connectivity. This greater connectivity usually increases the amount of traffic local streets can accommodate. Additionally, more route options are available for traffic dispersal, leading to a reduction in congestion (ITE, 1994b).
3. Shorter roads increase the likelihood of accidents and the liability of planners.	FACT:	Shorter street lengths reduce traffic speeds (ITE, 1997). At reduced speeds (20 mph or less) there is a 95% chance a pedestrian will survive an accident (Ewing, 1996).
	FACT:	Knoblauch, et al (1988) found that local streets where parking was permitted on both sides of the road were more hazardous relative to those with parking restrictions.
	FACT:	Shorter streets allow for more travel options for emergency vehicles to reach an accident scene (Fontana, 1998).

PERCEPTIONS AND REALITIES ABOUT STREET LENGTH

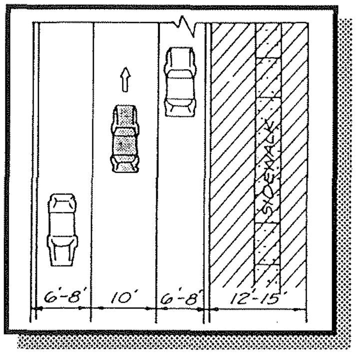
The purpose of considering alternative road layout patterns is to minimize the overall street length. There are some concerns that shorter street lengths will significantly reduce the amount of available on-street parking. Other potential impediments to shorter street networks include concerns regarding traffic congestion and safety (Table 2.1). There is also a perception that public officials, transportation planners, and plan reviewers will be held liable for these potential safety impacts. Courts, however, tend to support the design decisions of planning agencies as long as significant professional errors were not made and decisions are consistent with a level of ordinary care. Ordinary care means that design decisions are based on the level of care and knowledge that can be expected of a reasonably experienced and prudent professional (NHI, 1996).

ECONOMIC BENEFITS

A savings of approximately $150 per linear foot can be achieved by shortening roads (CBP, 1993). This includes savings achieved through reduced pavement, curb and gutter, and the storm sewer construction. Using this figure, a 100 foot reduction in road length will result in a savings of about $15,000. In addition, the costs for providing other utilities such as gas, water, and electricity will be reduced because less cable and pipe will be required. Additional long-term savings will be realized due to reduced roadway maintenance.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Traditional Neighborhood Development Street Design Guidelines (1997) by Institute of Traffic Engineers. Presents design guidelines that include street use by non-automobile traffic and the street's relationships to adjacent and future land use.	Institute of Transportation Engineers 525 School Street, SW Suite 410 Washington, DC 20024-2797 202-554-8050
Best Development Practices: Doing the Right Thing and Making Money at the Same Time (1996) by Reid Ewing Presents practices for developers and local governments regarding land use, transportation, the environment, and housing.	American Planning Association Planners Book Service 122 S. Michigan Avenue Suite 1600 Chicago, IL 60603 312-786-6344



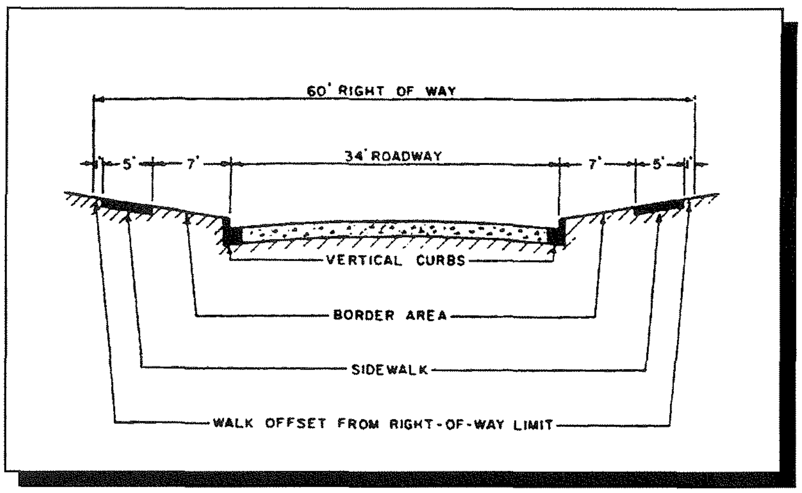
PRINCIPLE NO. 3

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

CURRENT PRACTICE

A street right-of-way (ROW) is a public easement that creates a corridor to move traffic, pedestrians, utilities, and stormwater through a development. In many communities, a single right-of-way width of 50 or 60 feet is applied to all residential street categories. Some examples of ROW for residential streets are presented in Table 3.1, and a typical cross-section of a wide right-of-way is shown in Figure 3.1. A wide ROW is only needed when utilities and sidewalks are located some distance from the paved section of the roadway.

Figure 3.1: Cross Section of Currently Used ROW (Source: ITE, 1993)



While a wide right-of-way does not necessarily create more impervious cover, it can work against better site design for several reasons. First, it subjects a greater area to clearing during road construction, which may result in needless loss of existing trees. Second, and more importantly, a wide right-of-way consumes land that may be better used for housing lots, making it more difficult to achieve a more compact site design.

Table 3.1: Examples of Conventional Right-of-Way (ROW) Requirements (Includes Pavement)

Right-of-Way Width	Source	Comment
50 - 60 feet	ITE (1993)	ITE is currently considering reduced ROW recommendations
50 - 60 feet	Frederick County, Maryland	Minimum for all residential streets 20' to 32' feet wide
60 feet	El Paso (1981)	
50-60 feet	Bucks County Planning Commission (1980)	Minimum for all residential streets

RECOMMENDED PRACTICE

A narrower right-of-way can generally be accommodated on many residential streets without unduly compromising safety or utility access. Some communities have recently narrowed ROWs for residential streets to 35 to 45 feet (see Table 3.2). This is done by redesigning each of the main components of the right-of-way. First, the pavement width is reduced on some streets (see Principle No. 1). Second, sidewalks are either narrowed or restricted to one side of the street (see Principle No. 13). Third, the border width, which separates the street from the sidewalk, can be slightly relaxed. Lastly, utilities are installed underneath street pavement at the time of construction. When these design techniques are combined together, the width of most residential ROWs can be reduced by 10 to 25 feet.

Table 3.2: Examples of Narrower ROW Widths

Source	ROW Width	Pavement Width and Purpose
Portland, Oregon	35' 40	20' residential street 26' residential street
Montgomery County, Maryland	20' 44' 46'-60'	16'; residential alley 20'; residential street 26'; residential streets
ASCE, 1990 (Recommendation)	24-26' 42'-46'	22'-24 residential alley 26' residential street

It should be noted that a narrow right of way may not always be desirable if stormwater is conveyed by swales along the road (see Principle No. 5). Swale designs that provide the best stormwater treatment and prevent standing water may require 10 to 12 feet along one or both sides of the road. Several options for narrower rights-of-way are provided in Figure 3.2.

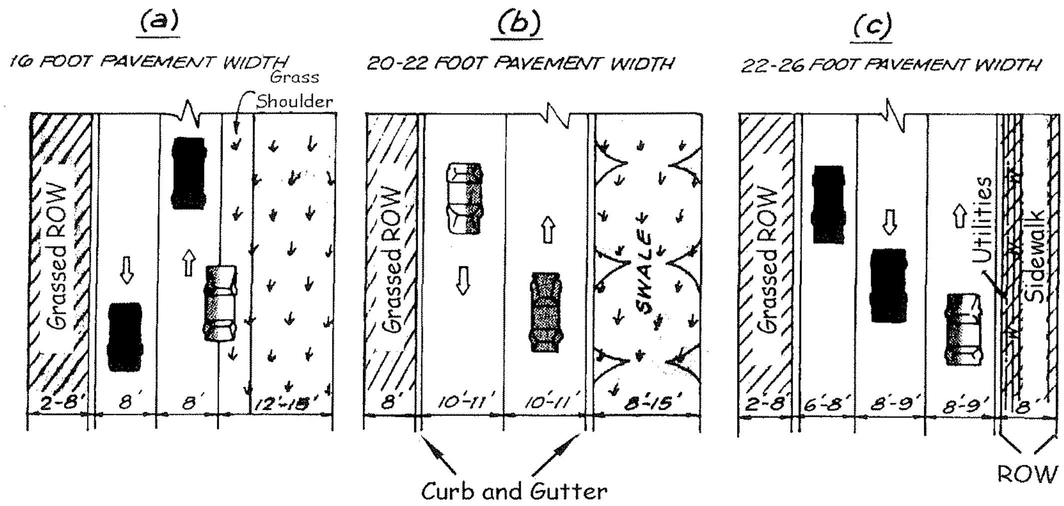
PERCEPTIONS AND REALITIES ABOUT NARROWER RIGHT-OF-WAYS

Two common concerns about narrowing rights-of-way include pedestrian safety and utility maintenance, which are reviewed below. Other potential barriers to narrower street ROWs are reviewed in Table 3.4.

Pedestrian Safety

A wide separation between street and sidewalk is one approach to protect pedestrians from traffic. An equally effective approach involves designing narrower roads that reduce traffic speed (Principle No. 1), designing narrower sidewalks for pedestrian movement (Principle No. 13) and ensuring adequate sight distance. Sight distance refers to the distance that allows a driver to see a pedestrian in time to stop or avoid an accident. In most cases, a narrow ROW does not greatly impair sight distance. In general, narrower ROW widths correspond to low traffic volume streets. As discussed in Principle No. 1, cars tend to travel slower through narrower streets, reducing the likelihood and severity of accidents.

Figure 3.2: Potential Design Options for Narrower ROW on Residential Streets (Schueler, 1995)



Utility Maintenance

It is common practice for communities require water and sewer lines be installed underneath the pavement section at the time of construction (see example design standards in Table 3.3). Any utility that is installed below the paved section, however, will eventually need to be accessed for repair or replacement. Traffic flow may be temporarily impeded during these operations, and utility companies will incur the additional cost of repaving the road where they need to work. The amount of pavement turned up during these operations can be reduced through better diagnostic tests and trenchless technologies for utility construction and repair (see Table 3.4). A narrower right-of-way can still be created, even if local agencies cannot require placement of utilities under the street by narrowing pavement sections, modifying sidewalk requirements, and reducing grass border areas.

Table 3.3: Example Water and Sewer Design Guidelines

Jurisdiction	Guidelines
Frederick County, Maryland	• Water mains and sewer lines shall be placed seven feet from the street center line in developments with curb and gutter, or five feet from the street center line in streets without curb and gutter, on opposite sides of the street.
Washington Suburban Sanitary Commission	• Water lines should be designed seven feet from the street center line. • Water lines should be separated from sewer lines by at least ten feet.

Table 3.4: Perceived Cost Impediments to Narrower ROW Widths

Perception		Fact, Case Studies, and Challenges
1. Placing utilities under the roadway increases construction and maintenance costs for water and sewer lines.	FACT:	Many communities currently place water and sewer pipes under the pavement (see Table 3.3 for example Water and Sewer Guidelines).
2. Costs of installing and maintaining cable or electric utilities will be higher.	FACT:	During construction, utilities can be put in place prior to pavement construction.
	FACT:	Many "trenchless" technologies are available to minimize impacts to pavement (ISTT, 1997). In these techniques, pipes are tunneled into the surface. Although consistent cost data are not available on the application of these methods, they may provide a viable alternative in some situations.
	CHALLENGE:	Cost impacts for excavating new lines and repairing them are unknown, but many public works officials are concerned that private utility companies will damage public roads.
3. Narrow ROW widths do not allow future road widening.	FACT:	The traffic volume of most residential streets is constant over time; thus, few streets ever need to be widened.
4. A larger ROW may be needed for open channel development.	CHALLENGE:	If a community encourages open channel development, it may need to keep a larger ROW.

Where to Get Started

Suggested Resources

Report on New Standards for Residential Streets In Portland, Oregon (1994) by Portland Office of Transportation

Summarizes new residential street standards that encourage less costly street improvement with minimal impact on water quality and urban forests.

Design Standards (1996) by Montgomery County Maryland Department of Public Works and Transportation

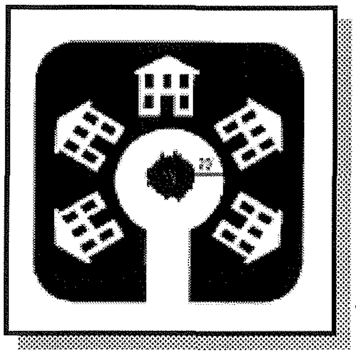
Standards for design of highways, streets, shoulders, driveways, drainage, and landscaping.

How to Get a Copy

City of Portland
Office of Transportation
1120 S.W. Fifth Avenue
Room 802
Portland, OR 97204-1971
503-823-7004

Montgomery County Department of Public Works and Transportation
Design Section
101 Monroe Street
Rockville, MD 20850
301-217-2121

Suggested Resources	How to Get a Copy
Residential Streets (2^{nd} Edition) Includes discussion of design considerations for pedestrian walks and paths.	Urban Land Institute 1025 Thomas Jefferson Street, NW Washington, DC 20007 800-321-5011 Also available from the American Society of Civil Engineers and the National Association of Home Builders
Site Planning for Urban Stream Protection (1995) by Thomas R. Schueler Chapter 6 discusses right-of-way criteria and cites various ROW design standards currently in use.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323



Principle No. 4

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

Current Practice

A cul-de-sac is a local street open at only one end. A large "bulb" is located at the closed-end to enable emergency and service vehicles to turnaround without having to back up. Cul-de-sacs are a prominent feature in many contemporary residential developments. Many communities require that the bulb be 50 to 60 feet or more in radius, which creates a large circle of impervious cover that is never fully utilized for turning movements.

Recommended Practice

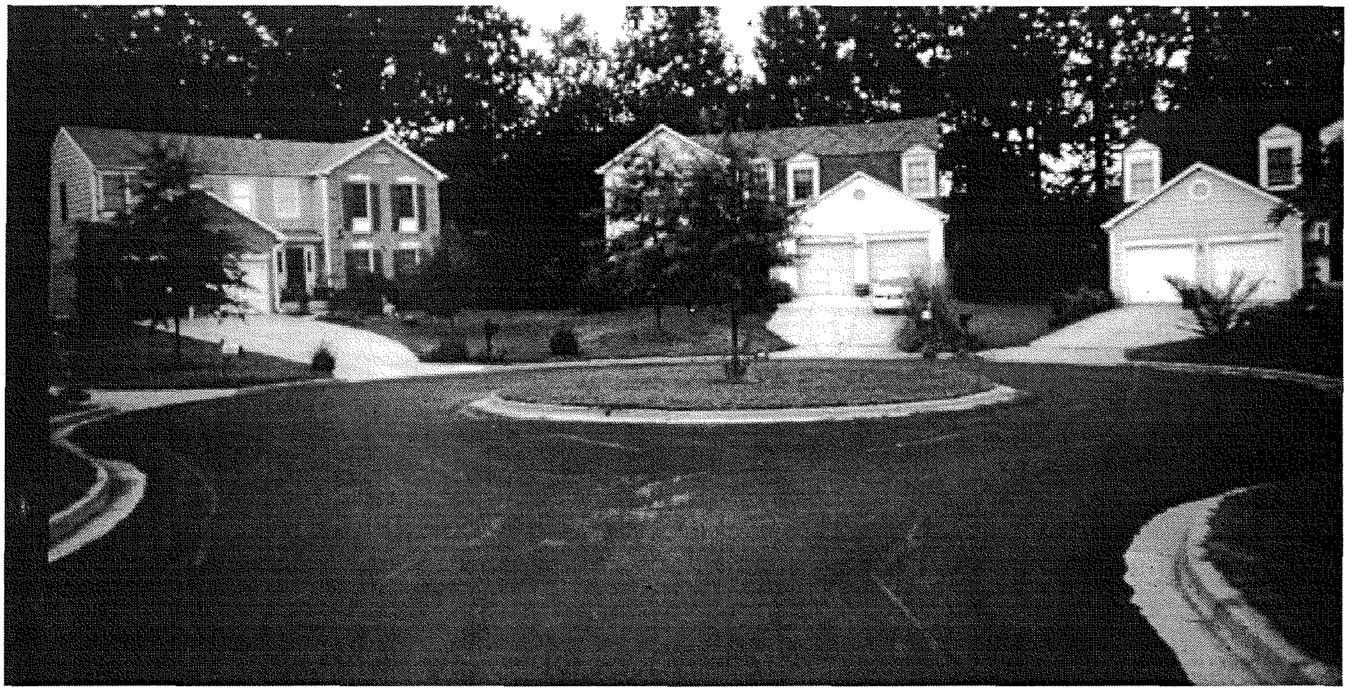
One option to reduce the impervious cover associated with cul-de-sacs is to reduce the radius of the turnaround bulb. A number of communities are now allowing smaller radii, ranging from 33 to 45 feet (see Table 4.1). Reducing the radius by even a few feet can sharply reduce the impervious cover created by a cul-de-sac (Schueler, 1995). See Figure 4.2 for an illustration of the varying amounts of impervious cover generated by various turnaround types.

A second option for designing cul-de-sacs involves the placement of a pervious island in the center of the turn. Vehicles only travel along the outside of a cul-de-sac when turning, leaving an unused "island" of pavement in the center (see Figure 4.1). These cul-de-sac islands can be attractively landscaped and also designed to store and treat stormwater runoff (see Principle No. 20) Concerns regarding sight impairment can be addressed by using slow-growing shrubs or ground cover.

Table 4.1: Recommended Cul-de-Sac Turnaround Radii

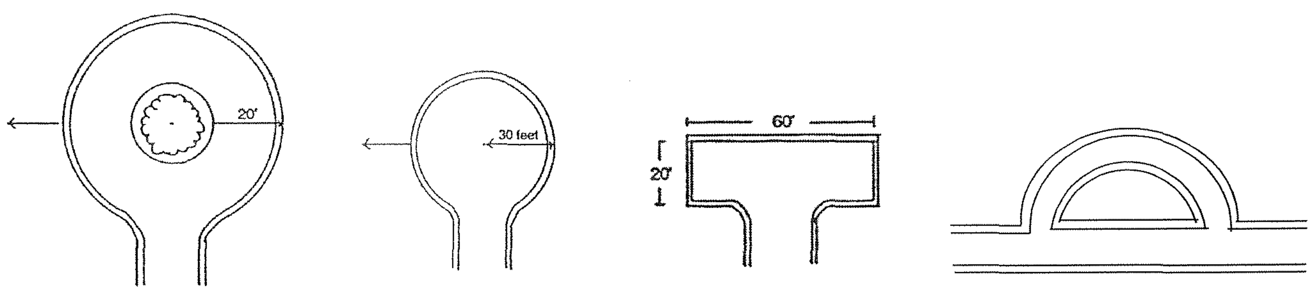
Turning radius	Source
35 feet (with approval of fire dept.)	Portland (OR) Office of Transportation
38 feet outside turning radius	Bucks County (PA) Planning Commission
45 feet	Fairfax Co (VA) Fire and Rescue Department
35 feet	Baltimore County (MD) Fire Department
45 feet	Montgomery County (MD) Fire Department
43 feet	Prince Georges County (MD) Fire Department

Figure 4.1: Cul-de-sac With Small Landscaped Island



Cul-de-sacs are not the only turnaround option. Other designs can be used to create less impervious cover. A T-shaped turnaround (also known as a "hammerhead") generates approximately 75% less impervious cover than a 40 foot radius circular turnaround. T-shaped turnarounds are only generally applied to cul-de-sacs when streets are short (less than 200 feet) or when lot sizes are very large. The minimum dimensions for a T-shaped turnaround are 60 feet by 20 feet (ULI, 1990; NAHB, 1990). Figure 4.1 illustrates various turn around options.

Figure 4.1: Four Turnaround Options for Residential Streets



(a) 40 ft cul-de-sac with landscaped island

(b) 30 ft radius cul-de-sac

(c) 60 by 20 ft T-shaped turnaround

(d) Loop road

Another alternative to circular cul-de-sacs is the loop road. A loop road is a curved road that joins with another road at each end, providing two points of entry and exit. Loop roads provide multiple access points for emergency vehicles and reduce the need for backing-up of vehicles. Further, trips for residents may be shortened since each house has access to an exit on either end of the loop. Finally, loop roads are generally allowed to carry double the traffic volume of cul-de-sacs since there are two ways out. In Performance Streets it was noted that "residential access loop streets may serve twice as many units as a cul-de-sac, since it is assumed that the traffic volume will be equally divided between both halves of the loop"(Bucks County, 1980).

PERCEPTIONS AND REALITIES ABOUT CUL-DE-SACS

It is widely perceived that large cul-de-sac radii (upwards of 60 feet) allow fire trucks, emergency vehicles and service trucks to turnaround. An analysis of the actual turning radii for most vehicles suggests that most cul-de-sacs are wider than they really need to be (see Table 4.2).

Table 4.2: Perceived Impediments to Smaller Cul-de-sacs

Perception	Facts and Case Studies	
1. The need for adequate turning radii for school buses and maintenance and emergency vehicles requires large cul-de-sacs.	FACT:	Fire trucks with 30 - 40 foot turning radii are available (ULI, 1990).
	FACT:	Many newer large service vehicles are being made with tri-axles which allow for sharper turns. (Waste Management Inc, 1997)
	FACT:	Smaller minimum turnaround radius of 30 feet has been suggested by several organizations (ULI, 1990; NAHB, 1990).
	FACT:	School buses do not typically enter cul-de-sacs.
2. Homeowners like the "end of the road" appeal of cul-de-sacs.	FACT:	Loop roads can also provide end of road appeal while reducing impervious cover.
	FACT:	"End of the road" appeal can be accommodated in an open space development, particularly for lots that back onto open space areas.

Developers often add cul-de-sacs to their site designs because they feel that they provide premium lots. Some home buyers clearly do prefer lots on cul-de-sacs, attracted by the lower traffic and the end-of-the road appeal. However, home buyers exhibit an even greater preference for natural and open space and parks (see Table 4.3). Many of these premium development features can be easily incorporated into open space or cluster design.

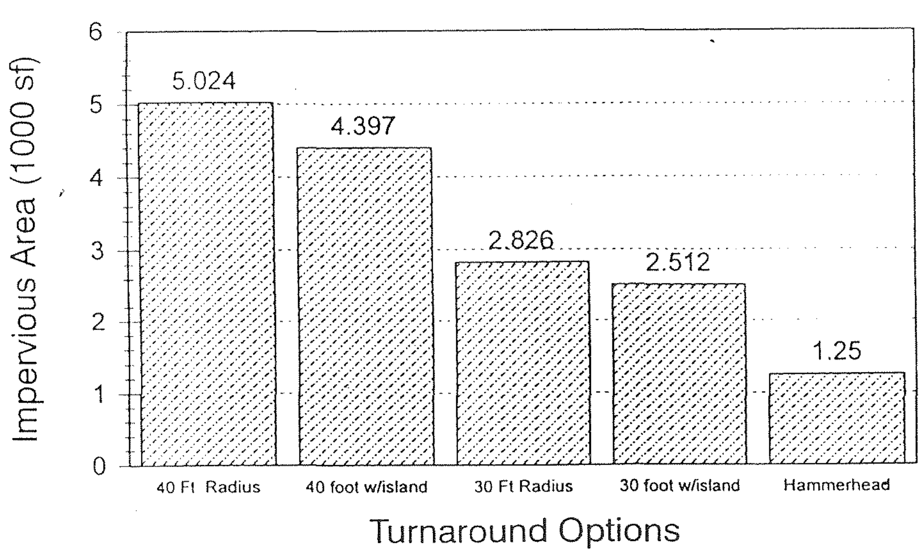
Table 4.3: Home Owner Preference for Proximity to Open Space Features (Source: Emmerling-DiNovo, 1995)

Open Space Feature	Mean Score
Adjacent to wet pond	4.44
Adjacent to natural area	4.27
On a cul-de-sac	3.83
Adjacent to golf course	3.67
Adjacent to public park	3.10
Adjacent to dry pond	2.05

CASE STUDIES

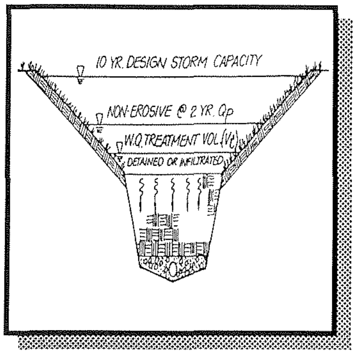
Several areas of the country have experimented with reducing the size and/or number of cul-de-sacs. As previously mentioned, the City of Portland (Oregon) has implemented smaller radii cul-de-sac turnarounds. Bucks County, Pennsylvania, has also reduced the size of residential cul-de-sacs. In North Carolina, the town of Carrboro recently passed an ordinance proposing that all roads should be interconnected when possible, and that cul-de-sacs should not be used unless the topography of the land makes a connecting road impractical (Raleigh News and Observer, 1997). In Middletown, Delaware, a "mobility-friendly" design initiative created by the Wilmington Area Planning Council (WILMAPCO) is being incorporated into a study of new standards that may lead to the region's first pedestrian-oriented planning model. One of the recommendations is to use short interconnected streets with direct routes and loops as opposed to cul-de-sacs (Taft, 1997).

Figure 4.2: Impervious Cover Created by Various Turnaround Options (Source: Schueler, 1995)



WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Performance Streets: A Concept and Model Standards for Residential Streets (1980) by Bucks County Planning Commission. Presents model standards focusing on pedestrian as well as vehicular traffic and reducing overdesigned street networks.	Bucks County Planning Commission Route 611 and Almshouse Road Neshaminy Manor Center Doylestown, PA 18901 215-345-3400
Residential Streets (2nd Edition) Chapter 2 discusses design considerations and vehicle turning requirements for cul-de-sacs.	Urban Land Institute 1025 Thomas Jefferson Street, NW Washington, DC 20007 800-321-5011 Also available from the American society of Civil Engineers and the National Association of Home Builders
Rural by Design (1994) by Randall Arendt Chapter 11 discusses design alternative cul-de-sac design.	American Planning Association Planners Book Service 122 S. Michigan Avenue Suite 1600 Chicago, IL 60603 312-786-6344



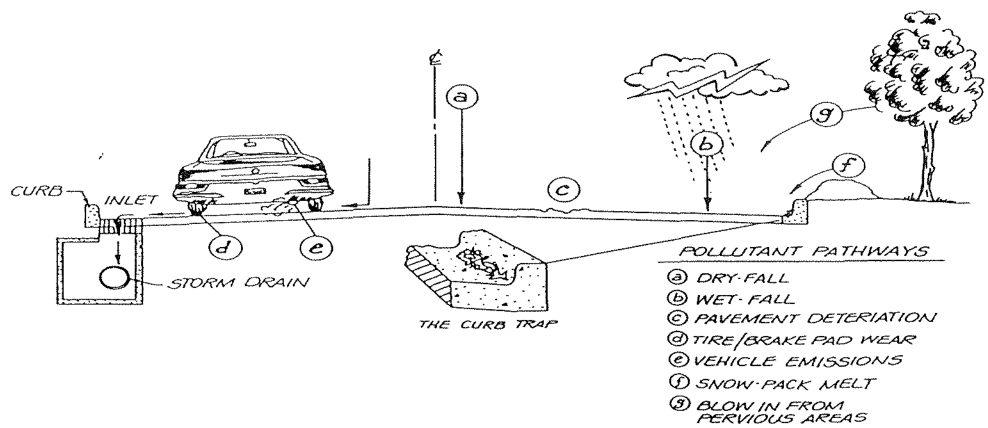
PRINCIPLE NO. 5

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

CURRENT PRACTICE

Streets contribute higher loads of pollutants to urban stormwater than any other source area in residential developments (Bannerman, et al., 1993 and Steuer, et al., 1997). The sources of pollutants to streets are numerous. Some examples are atmospheric deposition, vehicle emission, pavement deterioration, tire and brake pad wear, pet waste, lawn runoff, and blow in from adjacent pervious areas (Figure 5.1). Research in Michigan and Wisconsin has indicated that residential streets contribute a majority of the sediment, phosphorous, copper, zinc, and fecal coliform bacteria found in urban stormwater runoff (see Figure 5.2).

Figure 5.1: Stormwater Pollutant Pathways (Schueler, 1995)

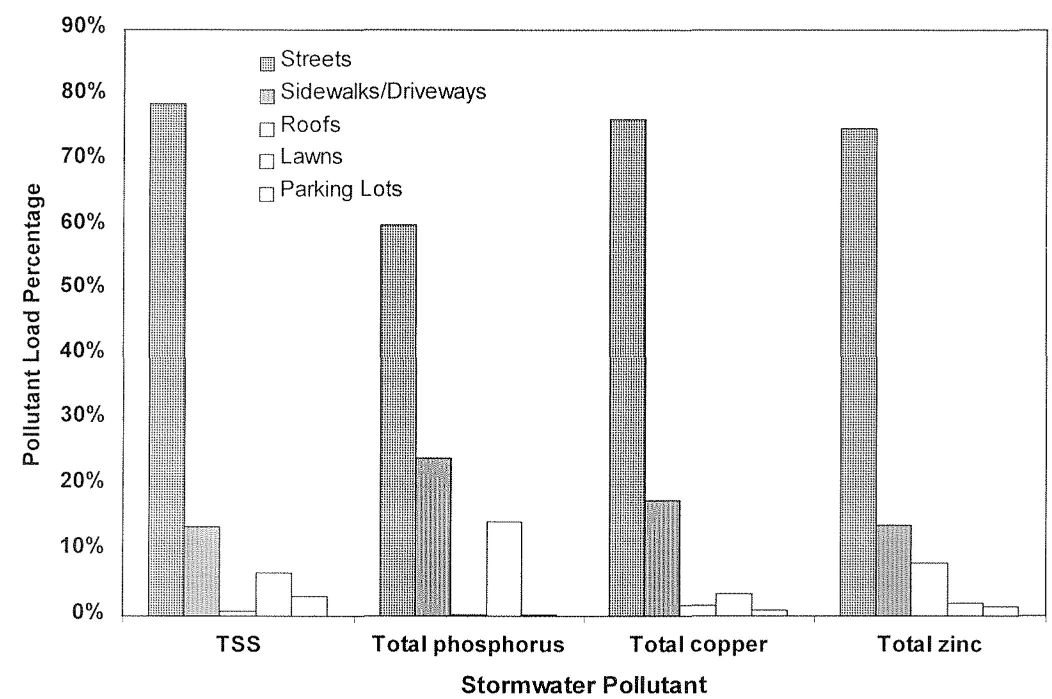


Streets provide several pathways for stormwater pollutants. Atmospheric pollutants settle or are washed onto the street during rain events (a, b). Pavement fragments also contribute to stormwater pollution (c). Vehicles contribute emissions and tire and brake pad particles (d, e). Snow collected at the street edge melts and contributes salts (f). Leaves and pollen from trees are blown into the street (g). Curb and gutter systems channel polluted stormwater directly into streams.

Most jurisdictions require that curb-and-gutter systems be installed along residential streets to convey stormwater runoff. Curb-and-gutter systems, however, provide no stormwater treatment and quickly discharge stormwater directly into streams. By contrast, open vegetated channels that could provide better treatment are usually discouraged or prohibited in many subdivision codes.

Public works agencies often favor curb and gutter over swales because they are easy to maintain, and eliminate many of the perceived problems associated with roadside ditches such as erosion, standing water, mosquitos, and break up of the road edge.

Figure 5.2: Key Pollutant Sources in Residential Areas (based on Bannerman and Dodd, 1992)



Recommended Practice

The use of engineered swales should be encouraged in residential streets where soils, slope and housing density permit. These engineered swales are a far cry from the roadside ditches that have plagued public works officials in the past.

Unlike curb-and-gutter systems, which move stormwater with virtually no treatment, open vegetated channels remove pollutants by allowing infiltration and filtering to occur. Open channels also encourage groundwater recharge, and can reduce the volume of stormwater runoff generated from a site.

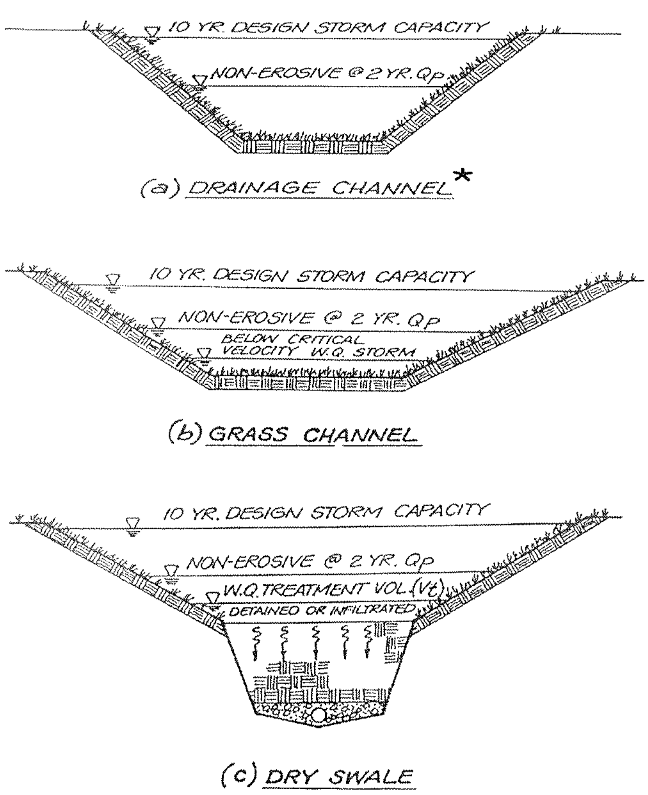
Types of Engineered Channels

There are two types of engineered channels that can be used for residential developments: grass channels and dry swales (see Figure 5.3). These channel designs differ primarily in bottom width, longitudinal and side slopes, and the underlying soil bed beneath the channel. The pollutant removal effectiveness of these channeling options is summarized in Table 5.1.

Grass Channels or Biofilters

Compared to roadside ditches, grass channels have a wider bottom, gentler slopes, and denser vegetation. They are designed to detain stormwater flows for ten to twenty minutes to allow sediments and heavy particles to filter out. Grass channels are relatively easy to construct and maintain. If applied under the right site conditions, and installed properly, grass channels experience few of the nuisance problems associated with roadside ditches.

Figure 5.3: Open Channel Options (Schueler, 1995)



*refers to roadside ditches

Dry Swales

Dry swales are essentially "engineered" grass channels that provide full treatment of stormwater pollutants. The dry swale design includes a layer of prepared sandy loam soil topped by dense turf. Runoff flows into the swale, depositing some of its sediment load as it flows through the dense vegetation. Water quality treatment is provided as the runoff infiltrates through the sandy loam layer. The treated runoff is collected in an underdrain pipe system and discharged into the downstream receiving waters or into a stormwater BMP for further treatment or attenuation. Because the swale is designed to dewater within a few hours after a storm, standing water and its other associated nuisance problems are generally not a concern.

Dry swales are a relatively new design and have only been applied in a few communities. Recent experience with dry swales in Carroll County, Maryland is very promising. Grass channels, on the other hand, have been in use for many years.

It should be noted that the feasibility of using engineered swales at a development site is determined by a number of factors, including drainage area, slope, length, housing density, and street type. In general, open channel systems are most appropriate for smaller drainage areas, mildly sloping topography, and housing density less than 4 dwelling units per acre.

Table 5.1: Pollutant Removal Capability of Open Channels (based on Brown and Schueler, 1997)

BMP	Pollutant Removal			
	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Metals
Roadside ditch	30%	10%	- 0 -	
Grass channel	65%	25%	15%	hydrocarbons: 65% metals: 20 - 50% bacteria: negative
Dry swale	90%	65%	50%	metals: 80 - 90%

PERCEPTIONS AND REALITIES ABOUT OPEN CHANNELS

Most of the concerns regarding open channels (Table 5.2) focus on potential maintenance problems, impacts to pavement stability, and potential nuisance problems. These concerns, for the most part, can be addressed through the careful design and integration of open channels along residential streets.

Table 5.2: Perceived Impediments to Open Channels

Perception	Facts, Case Studies, and Challenges	
1. Increased maintenance of the shoulder and the open channel may be required.	FACT:	Maintenance requirements for grass channels are generally not excessive in comparison to maintenance requirements for curb-and-gutter systems. The major requirements are mowing of turf, removal of sediment build-up and debris, and periodic inspections.
	FACT:	Maintenance requirements for dry swales are similar to those for grass channels. The most significant additional requirements are replacement of filter beds and periodic replacement of the top layer. These maintenance requirements may be offset by savings associated with reduced curb-and-gutter construction, replacement, and maintenance costs.
2. Lack of curbing may increase the potential for failure of the road surface at the pavement/grass interface.	FACT:	Based on an informal survey of local public works officials, the potential for failure at the pavement/grass interface can be alleviated by "hardening" the pavement grass interface. For example, grass pavers or geo-synthetics can be placed beneath the grass immediately adjacent to the pavement to provide additional protection from structural failure. Other options include placement of a low rising concrete strip along the pavement edge.
3. Snow removal may be more difficult.	CHALLENGE:	Plow blades may scrape the edge of the pavement, making removal more challenging. On the plus slide, roadside swales increase snow storage at the road edge. Smaller snowplows are available.
4. Cars may be more likely to hit pedestrians due to the lack of curbing.	FACT:	In a study of over 3,826 pedestrian and car crashes, only 0.2% of the crashes were associated with low soft shoulders. Even when loose material shoulders are factored in, these crashes still represent less than 1% of all crashes (FHA, 1996).
	FACT:	Alternative road designs place the sidewalk on the far side of the swale, furthest from the road, thereby providing a barrier between pedestrians and cars.
5. Open channel BMPs may harbor pests and standing water may interfere with homeowners' ability to mow their front yards.	FACT:	The potential for snakes and other vermin can be minimized by more frequent mowing.
	FACT:	Grass channels are not designed to detain water for any appreciable length of time. Properly designed dry swales will drain within 24 hours, minimizing the potential for mosquitoes and interference with mowing.

Economic Benefits

Engineered swales are very attractive to developers because they are a much less expensive option for conveying stormwater than the curb and gutter/storm drain inlet and storm drain pipe system that they replace. The cost of a curb and gutter/storm drain pipe system typically ranges from $40 to $50 per running foot (SMBIA, 1990) which is about 2 to 3 times more expensive than an engineered swale.

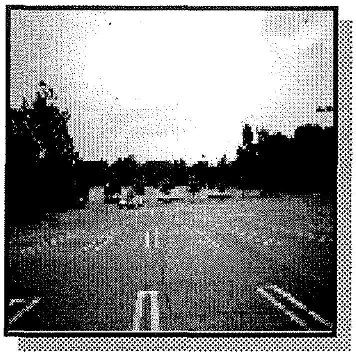
Case Study: Sarasota, Florida

(Source: Ewing, 1996)

Environmentally sensitive site design techniques were used extensively in Palmer Ranch, a large (more than 10,000 acre) development southeast of Sarasota, Florida. Forty percent of the acreage in this development is preserved in a natural state. A key component of the site design was creation of an integrated stormwater conveyance and treatment system. This system incorporates open channel drainage and existing drainageways. This integrated approach included a vegetated swale as well as a restored creek that had been confined in a manmade channel. The swales were provided throughout the community wherever soils, water table elevation, and density permitted. This integrated approach has been cited as the chief reason that post-development nutrient and sediment loads are significantly less than pre-development loads.

Where to Get Started

Suggested Resources	How to Get a Copy
Design of Stormwater Filtering Systems (1996) by Richard A. Claytor and Thomas R. Schueler Presents detailed engineering guidance on ten different stormwater filtering systems.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323
Biofiltration Swale Performance: Recommendations and Design Considerations (1992) by Washington Department of Ecology	Washington State Department of Ecology Olympia, WA 98507
Start at the Source (1997) by Bay Area Stormwater Management Agencies Association Detailed discussion of permeable pavements and alternative driveway designs presented.	Bay Area Stormwater Management Agencies Association 2101 Webster Street Suite 500 Oakland, CA 510-286-1255
Best Development Practices: Doing the Right Thing and Making Money at the Same Time (1996) by Reid Ewing Chapter 5 discusses open vegetated channels and other stormwater management options. Developments that use these options are highlighted.	American Planning Association Planners Book Service 122 S. Michigan Avenue Suite 1600 Chicago, IL 60603 312-786-6344



PRINCIPLE NO. 6

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

CURRENT PRACTICE

A parking ratio is set by local communities and expresses the number of parking spaces that must be provided for a particular land use. It is typically stated as the number of spaces per square foot of building space, number of dwelling units (d.u.'s), persons, or seats. Parking ratios usually represent the minimum number of spaces needed to accommodate the highest hourly parking at the site (Wells, 1995). Parking demand refers to the number of spaces actually used for a particular land use (ITE 1987). Table 6.1 gives examples of conventional parking requirements and compares them to average parking demand.

Table 6.1: Conventional Minimum Parking Ratios (Source: ITE, 1987; Smith, 1984; Wells, 1994)

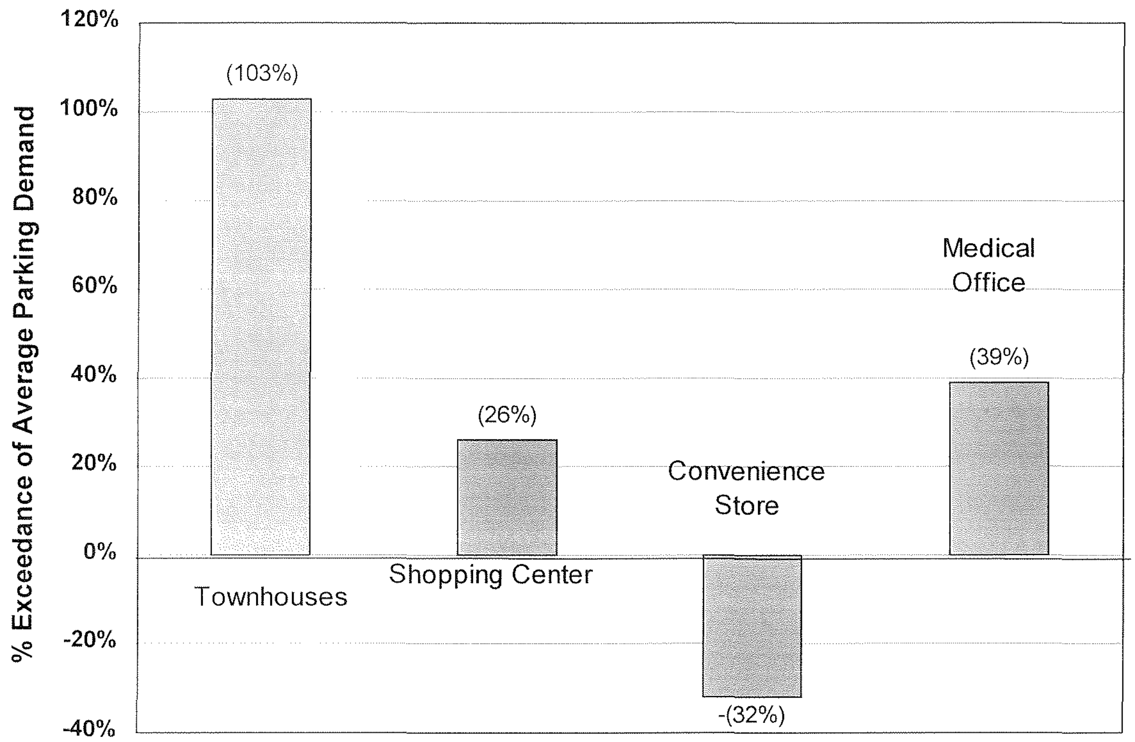
Land Use	Parking Requirement		Actual Average Parking Demand
	Parking Ratio	Typical Range	
Single family homes	2 spaces per dwelling unit (d.u.)	1.5 - 2.5	1.11 spaces per d.u.
Shopping center	5 spaces per 1000 ft^2 GFA[1]	4.0 - 6.5	3.97 per 1000 ft^2 GFA
Convenience store	3.3 spaces per 1000 ft^2 GFA	2.0 - 10.0	--
Industrial	1 space per 1000 ft^2 GFA	0.5 - 2.0	1.48 per 1000 ft^2 GFA
Medical/dental office	5.7 spaces per 1000 ft^2 GFA	4.5 - 10.0	4.11 per 1000 ft^2 GFA

[1]Abbreviated GFA and refers to the gross floor area of a building, without storage and utility spaces

Communities often determine minimum parking ratios by either adopting and modifying the requirements of neighboring communities or by using the Institute of Transportation Engineers informational publication. In many cases, these parking ratios result in far more spaces than are actually required. This occurs because ratios are typically set as minimums and not maximums. Therefore, builders and developers are free to provide excess parking. The excess parking is provided to prevent complaints from residents, employees, and customers regarding inadequate parking. Commercial landowners are particularly sensitive to this issue, reluctant to risk losing customers due to lack of parking. Further, loans for commercial development often require more parking spaces than are established by the local minimum parking ratio.

As a result, parking lots are often fully utilized only for a few hours each year. During off-peak periods, a significant portion of most parking spaces will be empty. Figure 6.1 illustrates the percentages of excess parking for different land uses.

Figure 6.1: Excess Parking Under Conventional Parking Requirements (Source: ITE, 1987; Morris, 1989; Smith, 1984)



RECOMMENDED PRACTICE

Communities should re-evaluate the parking demand ratios that they currently have in the books to make sure they are in line with national or regional averages. In addition, local surveys of actual parking lot utilization rates for a mix of common land uses or activities may be desirable as well. When combined with local experience, the data can often be used to modify, and hopefully lower, the parking demand ratios on the books.

Communities should also check their parking codes to make sure they clearly state that the parking ratios should be interpreted as the maximum possible number of spaces that can be built at a project, unless compelling data justify more parking spaces are actually needed (i.e., actual parking demand studies). In reevaluating their parking demand ratios, communities can benefit from conducting a local study or referring to national averages.

PERCEPTIONS AND REALITIES ABOUT PARKING

The major impediment to reduced parking ratios is the perception that more stringent parking ratios will lead to inadequate parking (Table 6.2). This in turn may lead to increased complaints from residents, employees, and customers. Research has indicated, however, that many parking ratios can be revised downward without significant impacts to parking availability.

Table 6.2 : Perceived Impediments to Reduced Parking Ratios

Perception	Facts, Case Studies, and Challenges	
1. Large retailers desire excess parking.	CHALLENGE:	Retailers do desire excess parking and many lending institutions also require excess parking.
2. Retailers fear loss of customers to competitors with more parking.	CHALLENGE:	The potential loss of customers due to reduced parking ratios is unknown.
3. There is a lack of research on parking demands for various land uses and activities.	FACT:	Parking demand for various land uses has been well documented. Many cities have conducted parking demand studies to determine the appropriate minimum, median, or maximum parking ratio requirements. The publication Parking Generation (ITE, 1987) documents actual parking demand for various land uses.
4. A lack of adequate parking may occur at peak parking demand times.	FACT:	Several studies have documented excess parking during peak periods. The City of Olympia recently surveyed 31 sites representing 15 land uses. Of these, 18 had less than 75% occupancy rates during their peak period (Wells, 1995).
5. Parking may spillover into residential or commercial areas when parking lots are full.	CHALLENGE:	Spillover parking into residential areas is a problem faced by many communities. Many have taken actions to reduce or prevent this problem, including preferential parking for residents, and enforcement of meter feeding and time limit codes.

ECONOMIC BENEFITS

To avoid the effects and costs of excess parking, ratios should be reexamined to reflect actual parking demand. Excess parking increases impervious cover and leads to greater construction and maintenance costs. Stormwater runoff also increases which leads to higher stormwater management costs. The costs associated with parking lot construction can be quite high. Costs per space range from $1,200 to $1,500 (Markowitz, 1995). For example, if a 50,000 ft^2 shopping mall is being considered and the maximum parking ratio is 5 spaces per 1000 ft^2 GFA, the total cost of constructing the parking lot could be as high as $337,500 (at $1,350 per space). When a more reasonable ratio of 3.97 spaces per 1000 ft^2 GFA is used, construction costs would be $268,650. This represents a savings of $68,850.

Case Study: Scarborough, Ontario

(Source: Smith, 1984)

A parking study was conducted at 14 office sites in Scarborough, Ontario to determine an appropriate parking ratio. A parking ratio of 3.5 spaces per 1000 square feet GFA was recommended. This ratio allowed adequate employee and visitor parking in sites that were not affected by parking demand factors (e.g., mass transit availability, large indoor storage areas, recreational facilities, and executive offices). The borough did not accept the recommendation and adopted their own lower standard of 3.0 spaces for 1000 square feet GFA. Experience with this standard has not resulted in any parking problems. In fact, to foster an even greater use of mass transit, Scarborough has since implemented an even lower requirement.

Where to Get Started

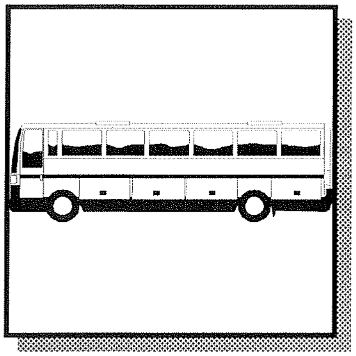
Suggested Resources	How to Get a Copy
Impervious Surface Reduction Study: Final Report (1995) by Cedar Wells Presents recommendations for pervious materials and shared parking. Based on results of study to identify strategies for reducing impervious surface in Olympia, Washington.	City of Olympia Public Works Department P.O. Box 1967 Olympia, WA 98507 360-753-8454
Parking Generation (1987) by Institute of Transportation Engineers Provides parking data for 64 land uses and discusses three methods for determining average parking occupancy of a land use or building.	Institute of Transportation Engineers 525 School Street, SW Suite 410 Washington, DC 20024-2797 202-554-8050
Flexible Parking Requirements (1984) by Thomas P. Smith Discusses local parking policies, flexible parking requirements, and case studies of parking demand for four land uses.	American Planning Association Planning Advisory Service 122 S. Michigan Avenue Suite 1600 Chicago, IL 60603 312-786-6344 Report No. 377

Suggested Resources

Site Planning for Urban Stream Protection (1995)
by Thomas R. Schueler
Chapter 7 discusses downsizing parking areas, impervious cover associated with various parking ratios, and local experience with parking codes.

How to Get a Copy

Center for Watershed Protection
8391 Main Street
Ellicott City, MD 21043
410-461-8323



PRINCIPLE NO. 7

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

CURRENT PRACTICE

Parking demand represents the actual number of parking spaces required to accommodate the parking needs of a particular land use. It is typically based on average parking requirements. Depending on site conditions (i.e., proximity to mass transit or mix of land uses), it may be possible to reduce the number of parking spaces needed. When site conditions are appropriate, communities could actively encourage developers to reduce the number of parking spaces constructed.

Mass transit can lower parking demand directly by reducing the number of vehicles driven, and, therefore, vehicles parked. Further, mass transit is a key strategy for reducing traffic congestion and air pollution. Encouraging car users to switch to mass transit has not been easy, as seen in the decline of the market share (i.e., share as a percent of all ridership) in transit ridership from 3% of all trips to only 2% from 1980 to 1992 (Schulz, 1994). Still, there are some communities where mass transit ridership is strong, and the amount of parking provided could be reduced. Only a handful of communities, however, require or even encourage developers to reduce the number of parking spaces built when mass transit is readily available.

Shared parking is a strategy that reduces the number of parking spaces needed by allowing adjacent land uses to share parking lots. This arrangement is possible when peak parking demands occur at different times during the day or week. Only a few communities, however, have actively encouraged shared parking arrangements, and individual businesses are often hesitant to employ it as an option.

RECOMMENDED PRACTICE

Mass Transit Credits

Mass transit can lower parking demand by reducing the number of cars entering (and parking in) commercial and business districts. To alleviate the increasing demand for parking spaces, local governments should reduce parking ratios to account for mass transit present at a site.

Some communities have successfully encouraged mass transit use. In Bellevue, Washington, there has been an increase in transit ridership from 4% in 1980 to 11% in 1992. This increase corresponded with the implementation of a maximum parking ratio for office use; an increase in transit service, the development of a transit center, the addition of urban HOV lanes, and an increase in parking prices (Federal Transit Administration, 1997). In Seattle, Washington the transit share downtown is 45%. Transit share is defined as the percentage of trips using a particular mode of travel. Seattle has instituted a maximum requirement of 1 parking space per 1,000 square feet, imposed requirements on developers to encourage transit, and improved transit service in the downtown area (Federal Transit Administration, 1997).

Shared Parking Credits

Shared parking arrangements can significantly reduce the area needed for parking, but this option is not widely used in most communities. Although shared parking arrangements can be difficult to implement, they have been successfully used in many cities across the country. For shared parking to operate successfully, the participating facilities should be in close proximity to each other and should have different peak operating times on a daily, weekly, monthly, or seasonal basis. Examples of facilities with different daily peak hours are presented in Table 7.1. Required parking in shared facilities is typically based on the land use with the highest parking demand.

When shared parking is implemented with an accompanying reduction in required parking, developers can recognize a substantial cost savings by building fewer parking spaces. Other potential benefits and drawbacks associated with shared parking are presented in Table 7.2.

Table 7.1: Land Uses with Different Peak Daily Operating Hours

Land Uses with Daytime Peak Hours	Land Uses with Evening Peak Hours
Banks	Bowling Alleys
Business Offices	Hotels (without conference facilities)
Professional Offices	Theaters
Medical Clinics	Restaurants
Service Stores	Bars
Retail Stores	Night clubs
Manufacturer/Wholesale	Auditoriums
Grade Schools/High Schools	Meeting Halls

Communities need to actively promote shared parking, make it easy to implement, and offer real reductions in parking ratios. Surprisingly, some communities that use shared parking do not require a corresponding reduction in parking spaces. Instead, the number of required parking spaces in the shared lot is calculated as the sum of the parking needed during the peak demand time for each individual land use, which translates to no net reduction in parking lot area and no reduction in total impervious cover.

Table 7.2: Pros and Cons of Shared Parking

Pros of Shared Parking	Cons of Shared Parking
Reduced impervious cover Reduced construction and maintenance costs for parking lots Increased land available for tax revenue-generating purposes Increased attractiveness of city-scape Increased ability for developers to complete projects that otherwise would have been denied due to insufficient parking	Possible shortage of parking if land ownership and/or land uses change Parking cannot be reserved for 24 hours for a particular use Potential difficulty in dealing with multiple developers Developers' perceptions that large parking lots are a necessity

Perceptions and Realities about Transit Use and Shared Parking

There are significant challenges to increasing mass transit usage and implementing shared parking arrangements (Table 7.3). However, as congestion becomes more of a problem, many communities, including Charlotte, North Carolina; Washington, DC; and Los Angeles, California; are beginning to re-examine mass transit options. Shared parking arrangements are currently being examined by the Institute of Traffic Engineers and have been used with some success in several communities including Niles, Illinois; Rockville, Maryland; and Pasadena, California (ITE, 1995). A model shared parking agreement can be found Appendix B.

Table 7.3: Perceived Impediments to Mass Transit and Shared Parking

Perception	Facts, Case Studies, Challenges	
1. There is a lack of widespread acceptance and use of mass transit in many areas.	CHALLENGES:	In many areas of the country the transit system is geared towards the car, and mass transit is not commonly used or available.
	CASE STUDIES:	Incentive programs can be used to encourage use of mass transit. Montgomery County, Maryland subsidizes monthly transit passes on the MARC rail and Metro public transit systems for its employees.
2. Shared parking arrangements are difficult to implement.	CHALLENGES:	Shared parking arrangements can be difficult to implement, but may yield potentially significant environmental benefits, construction cost savings, and aesthetic improvements (see Table 7.2).

Case Studies

Many communities allow a reduction in required parking in conjunction with mass transit. Examples are presented in Table 7.4. Model shared parking ordinance provisions can be found in Appendix A.

Table 7.4: Sample of Communities that Reduce Required Parking in Conjunction with Mass Transit

Community	Description of Program
Olympia, WA	Allows reduction in required parking in concert with public transportation
Loudoun County, VA	Allows a reduction of up to 20% of the required parking for any use, building or complex within 1,000 feet of any regularly scheduled bus stop
Chicago, IL	Offers reduction in required parking for buildings connected to underground transit stations[1]
Hartford, CT	Reduces minimum required parking in return for developer carpool and transit encouragements)[1]
Montgomery County, MD	Reduces minimum parking requirements in proximity to rail stations [1]
Phoenix, AZ	Allows relaxations in proximity to bus transit [1]
Orlando, FL	Allows payments which support a transportation management program in-lieu of on-site parking [1]

[1]Source: Federal Transit Administration, 1997

The City of Olympia, Washington requires applicants to provide proof that shared parking is infeasible when adjacent land uses have different hours of operation. Mixed use and shopping center developments with similar operating hours may also be required to submit a parking demand study to determine if parking can be combined. Additional shared parking case studies are presented in the document "Shared Parking Planning Guidelines," an informational report of the Institute of Transportation Engineers. The studies presented include the following:

Location	Land Use
414 Hungerford Drive, Rockville, MD	Office/retail/restaurant in suburban commercial center
Brown's Wharf Parking Study, Baltimore, MD	Retail/restaurant/office/marina in a highly urbanized, tourist-oriented environment
Pasadena Towers, Pasadena, CA	Retail/office/bank
Concourse Project, Skokie, IL	Hotel/restaurant/office
Downtown Mountain View, CA	Primarily restaurant/retail in a low-to-moderate density suburban commercial business district (CBD)
Yorkdale Shopping Center Expansion/Rail Station Parking, Toronto Metropolitan Area (North York), Ontario	Regional retail center expansion and rapid transit station
Simpsons Galleria (Bay-Adelaide Centre), Toronto CBD, Ontario	Retail/office

CASE STUDY: DOWNTOWN OAKLAND, CALIFORNIA

(Source: ITE, 1995)

The shared parking concept is essential for a city like Oakland because it furnishes much of the parking for its commercial areas. Providing adequate, convenient parking in these areas is very important in reducing parking problems in residential areas. Zoning regulations specifically incorporate heavier mass transit use and walk-in clientele.

A thorough study of short- and long-term parking demand was performed that included an inventory of existing land uses, a parking inventory, and an occupancy study. Parking rates were redesigned to reflect such variables as, vacancy factors, mass transit access, low auto ownership per household, and operations of special use facilities like the convention center. The study concluded that the parking rate for office space could be reduced from 3 spaces to 1.44 spaces per 1000 GSF.

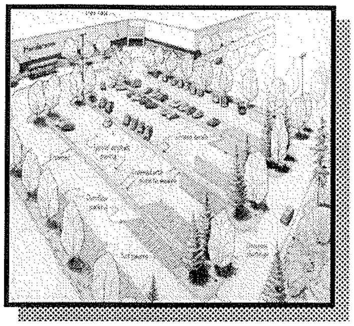
Oakland's experience provided several worthwhile lessons. Shared parking can work very well in urban areas because parking needs often vary over the course of a day. The costs of constructing additional parking facilities can make shared parking a very attractive alternative. Also, the financial burdens of shared facilities can be distributed through assessments among more businesses over a longer time frame. Shared parking should be applied on a block-by-block basis and should include on-street spaces. This is because overflow from a shared parking facility can effect parking availability on adjacent streets. While the overflow could be problematic, it is useful in determining an appropriate size and location for a shared use facility.

The study also concluded that a shared parking facility located within 1000 feet of a subway station in the heavily urbanized downtown Oakland area could reduce parking generation by up to 40% for offices, 75% for retail, 58% for residential, and 72% for hotel.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Shared Parking Planning Guidelines (1995) by Institute of Transportation Engineers Discusses shared parking issues and guidelines, including detailed case studies and results of local government survey.	Institute of Transportation Engineers 525 School Street, S.W., Suite 410 Washington, DC 20024-2797 202-554-8050
Parking Supply Management (1997) by Federal Transit Administration Discusses mass transit use and its relationship to reduction in required parking through case studies of several communities.	Web address: http://www.fta.dot.gov/fta/library/planning/tdmstatus/FTARPKSP.HTM.

Suggested Resources	How to Get a Copy
Impervious Surface Reduction Study: Final Report (1995) by Cedar Wells Presents recommendations for pervious materials and shared parking. Based on results of study to identify strategies for reducing impervious surface in Olympia, Washington.	City of Olympia Public Works Department P.O. Box 1967 Olympia, WA 98507 360-753-8454



Source: *Wells 1995*

PRINCIPLE NO. 8

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

CURRENT PRACTICE

The size of a parking lot is driven by stall geometry, lot layout, and, as discussed in Principle No. 6, parking ratios. A parking space is composed of five impervious components, of which the stall is only one part. The five components include:

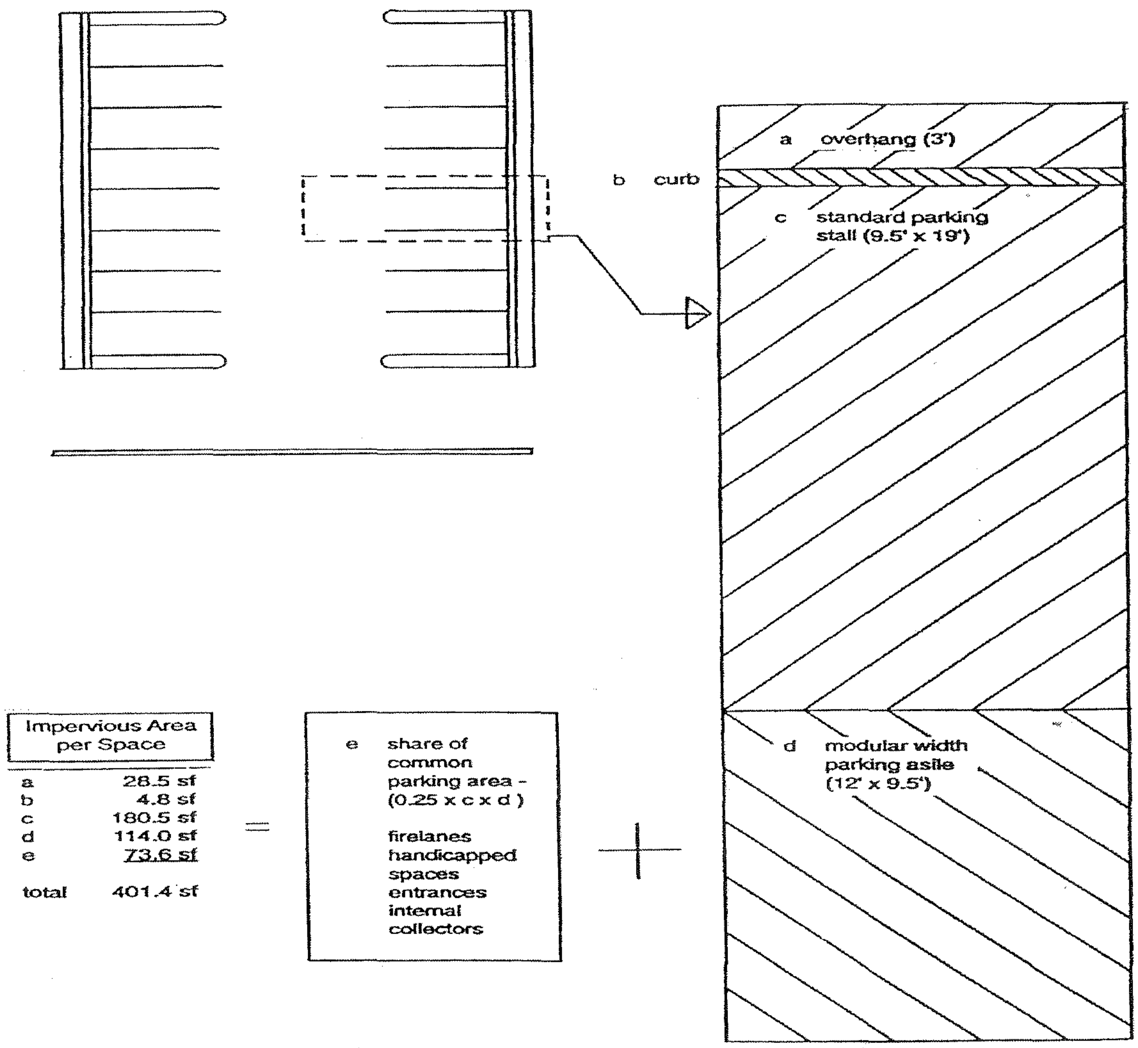
- the overhang at the edge of the stall (beyond the car)
- a narrow curb (or curb stop);
- the parking stall;
- the parking aisle that allows access to the stall; and
- a share of the common impervious area (e.g., fire lanes, entrances, and traffic lanes).

The impervious area associated with each parking space is more than double the area of an individual stall (see Figure 8.1). In most local parking codes, stall size can range from 162 to 185 square feet–often 10 feet wide and 19 feet long.

Another component of lot layout is the internal geometry or traffic pattern. Two-way traffic aisles require greater widths than one-way aisles. One-way aisles used in conjunction with angled parking stalls can significantly reduce the overall size of the parking lot.

Parking lots are the largest component of impervious cover in most commercial and industrial zones, but conventional design practices do little to reduce the paved area in parking lots. For example, many parking codes require a standard parking stall dimension that is geared to larger vehicles. Communities seldom allow smaller parking spaces that can handle compact cars, despite the fact that these smaller cars comprise 40 to 50% of all cars on the road (ITE, 1994a). In addition, local construction specifications for parking lots specify an impermeable asphalt or concrete surface. Use of more permeable surfaces, such as grass pavers and porous concrete, is usually frowned upon by reviewing authorities. Most parking codes also do not distinguish between regular parking areas that are used most of the time and spillover parking, which is used for a few days per year. Spillover parking areas are often the best locations to use more permeable paving options.

Figure 8.1: The total impervious area needed to support a single parking stall.



A parking stall is supported by a larger parking space that includes the (a) overhang, (b) curb, (c) stall, (d) parking aisle needed to get into the stall, and (e) the stall's share of common parking area, such as entrances, internal collectors, fire lanes and handicapped parking spaces. When these extra features are added in, the approximately 180 ft^2 needed for each parking stall increases to over 400 square feet.

Recommended Practice

The amount of impervious cover created by parking lots can be reduced in three basic ways. Communities should first evaluate whether their standard parking stall dimensions are too spacious, and if so, consider shaving six inches or a foot off of their length and width. Second, communities may wish to amend their parking codes to require that a fixed percentage of all parking stalls (e.g., 15 to 35%) be dedicated for compact cars; with correspondingly smaller stall dimensions. Compact parking stalls create up to 30% less impervious cover than stalls for larger cars. Increasing the percentage of compact car parking stalls can lead to smaller parking lots, less impervious cover, and reduced construction and maintenance costs.

Third, communities may want to require designation of spillover parking areas for larger parking lots and promote the use of alternative paving materials in these areas. Pervious materials such as permeable pavement, grass pavers, grass and gravel, are usually less durable than traditional paving materials, and are appropriate for less traveled spillover parking areas. Pervious paving materials can infiltrate stormwater runoff while simultaneously providing a stable travel pathway.

Perceptions and Realities about Parking Lots

There are impediments to changing the way parking lots are constructed. First, there is a perception that today's cars and trucks won't fit into smaller parking stalls. Second, there is a reluctance to use pervious materials due to expense, potential conflicts with the Americans With Disabilities Act, uncertainties about long-term performance and durability. These impediments are summarized in Table 8.1 and are further addressed in the following discussion.

Are Larger Stalls Needed for Sport Utility Vehicles?

One argument against making parking stalls smaller is that today's consumers are buying larger vehicles – in particular, sport utility vehicles (SUVs), mini-vans, and 4 x 4 trucks. Since 1970, SUV sales have climbed by 47% in the U.S., and presently account for about 25% of the sales of the big-three auto makers (AAMA, 1997). It is important to keep in mind that most SUV's are less than 7 feet wide and can comfortably fit into a standard space. With a few exceptions, most of the size of SUV is vertical – they stand taller than sedans, but are often not much wider or longer than a full-size car. In fact, many SUV models are actually smaller than a typical car (e.g., Jeep Wranglers).

Alternative Paving Issues

Alternative paving materials can make sense in many parking lot designs, but accessibility, site conditions, and long-term performance need to be carefully considered.

Accessibility

In general, conventional paving material should be used in handicapped parking areas and on public pathways such as sidewalks to ensure a smooth surface for travel. Note that the City of

Olympia has found that UNI Eco-Stone, an alternative pavement option, does comply with the ADA (Wells, 1997), providing a uniform travel surface.

Table 8.1: Perceived Impediments To Reduced Parking Lot Imperviousness

Perception	Facts, Case Studies, and Challenges	
1. Existing stall sizes are already too small for the largest cars.	CHALLENGE:	There is an increasing trend towards larger sport utility vehicles (SUVs).
	FACT:	Many SUVs are actually small cars (e.g., Jeep Wranglers, Suzuki Sidekick, Toyota Rav4).
	FACT:	Stall width requirements in most local parking codes are much larger than the widest SUVs.[1]
2. Alternative paving is expensive.	FACT:	Yes, but long term costs savings may be achieved. Less imperviousness may reduce the need for stormwater management or eliminate the need for curb and gutter.
3. Alternative paving may not comply with ADA.	FACT:	Alternative paving materials that do not conflict with the ADA are available.
	FACT:	Alternative paving is recommended for spillover parking only. ADA compliant parking spaces typically will be placed near the building in the permanent parking area paved with traditional materials.
4. Alternative paving performance is uncertain.	CHALLENGE:	The performance of alternative pavements (other than porous pavement) is not well documented.

[1]One of the largest SUVs, the Ford Expedition, is 6'7" wide; most local codes set parking stall width as high as 9.5'

Site Conditions

The most successful installations of alternative pavements are found in coastal areas where slopes are flat, sandy soils are present, and winter sanding and salting are minimal (BASMAA, 1997). However, in coastal areas with very coarse sands, infiltration through the pavement may be too rapid to allow adequate water quality treatment. In these cases, the pavement may need to be augmented with a peat liner to enhance water quality treatment (Cahill, 1994). On the other hand, pervious pavement will not work if existing soil conditions do not allow for minimum necessary rates of infiltration (0.5 inches per hour or more).

Pervious pavement has been successfully applied in cold climates but is only recommended for spillover parking. In addition, sand causes clogging and should be completely eliminated as a method for handling snow or ice.

Performance

The performance of alternative paving materials is dependent upon proper installation and maintenance. For example, tests by the Florida Concrete and Products Association show the permeability of new pervious concrete surfaces as high as 56"/hr with proper installation. With improper installation, permeability is reduced to 12"/hr (BASMAA, 1997).

Some common causes of pavement failure include:

- Lack of erosion and sediment control during construction;
- Compaction of the subsoils during construction;
- Clogging due to sand used to deice in the winter;

- Fine silt particles pass through the pavement and settle in the underlying bed, reducing infiltration capability over time;
- Damage by snow plows (plow blades may catch the edge of individual blocks);
- Placement of alternative pavement on impermeable layer; and
- Poor geotechnical testing or engineering design (improper soils/ infiltration rate).

Issues related to cost and the relative effectiveness in meeting water quality goals are summarized in the Table 8.2.

Table 8.2: Summary of Issues Related to Various Types of Alternative Pavements, based on BASMAA (1997)

Material	Initial Cost	Maintenance Cost	Water Quality Effectiveness*
Conventional Asphalt / Concrete	Medium	Low	Low
Pervious Concrete	High	High	High
Porous Asphalt	High	High	High
Turf Block	Medium	High	High
Brick	High	Medium	Medium
Natural Stone	High	Medium	Medium
Concrete Unit Pavers	Medium	Medium	Medium
Gravel	Low	Medium	High
Wood Mulch	Low	Medium	High
Cobbles	Low	Medium	Medium

* Relative effectiveness in meeting stormwater quality goals

ECONOMIC BENEFITS

Construction costs for pervious pavements are generally greater than those for conventional pavements (see Table 8.3). Construction cost savings due to reduced curb and gutter and reduced stormwater management requirements may offset this initial cost difference. Similarly, reduced storm sewer and stormwater management facility maintenance requirements may offset the generally greater maintenance requirements associated with pervious pavement. For example, the City of Olympia "paved" an overflow parking lot at Olympia High School with Geoweb (a geotextile usually planted with grass). The Geoweb cost $\$60.50/yd^2$; conventional paving would have cost approximately $\$48/yd^2$. The Geoweb cost, however, included the cost of constructing an infiltration trench, in lieu of a retention pond (Runoff Report, 1997).

Table 8.3: Costs of Various Types of Permeable Pavements

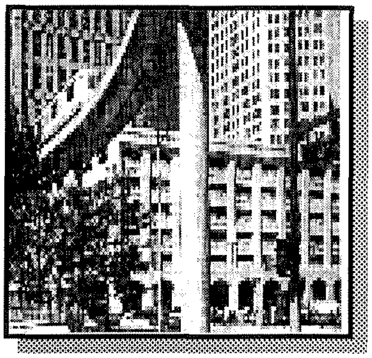
Product	Manufacturer	Cost per square foot*
Asphalt	Various	$0.50 - $1
Geoweb	Presto Products, Inc.	$1 - $2
Grasspave2™, Gravelpave2™	Invisible Structures, Inc.	$1 - $2
GRASSY™ PAVERS	RK Manufacturing	$1 - $2
Geoblock	Presto Products	$2 - $3
Checkerblock	Hastings Pavement Co.	$3 - $4
Grasscrete	Bomanite Corp.	$3 - $4
Turfstone	Westcon Pavers	$2 - $3
UNI Eco-Stone	Concrete Paving Stones	$2 - $3

This table was adopted from the table "Summary Characteristics of Widely Available Permeable Pavement Systems" in Booth et. al., 1997.

* Includes material cost, typical shipping and installation on a fully prepared base course. Does not include cost of gravel or soil and grass fill, or labor. These costs add approximately $0.10 to $0.25 per square foot.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Start at the Source (1997) by Bay Area Stormwater Management Agencies Association Detailed discussion of permeable pavements and alternative driveway designs presented.	Bay Area Stormwater Management Agencies Association 2101 Webster Street Suite 500 Oakland, CA 510-286-1255
The University of Washington Permeable Pavement Demonstration Project (1997) by Derek B. Booth, Jennifer Leavitt, Kim Peterson Reviews and provides information on types and characteristics of permeable pavements.	**Parking Supply Management** (1997) by Federal Transit Administration Discusses mass transit use and its relationship to reduction in required parking through case studies of several communities.



Source: ULI 1997

PRINCIPLE NO. 9

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

CURRENT PRACTICE

Most communities do not specify the type of parking structure to be built (e.g., surface lot or parking garage). The type of parking facility constructed in a given area is a reflection of the cost of land and construction expenses. In suburban and rural areas where land is relatively inexpensive, surface parking costs much less than a parking garage. However, in highly urban areas, garages may be more economical to build than purchasing additional land.

ITE (1994a) discussed the influence of land cost on parking facility development. Where land is abundant and inexpensive, surface lots are usually built. In areas with higher land costs, multi-deck garages may be more economical per car space than open lots. For sites limited by size or extremely high land prices such as downtown business districts, combination facilities with vertically mixed land uses may be the most feasible.

RECOMMENDED PRACTICE

Vertical parking structures can significantly reduce impervious cover by reducing acreage converted for parking. Given the economics of parking lots, however, it is not likely that developers will be willing to build a parking garage when a surface parking lot would be cheaper. Local governments should consider using incentives to encourage the building of multi-level, underground, and under-the-building parking garages. Incentives for defraying some of the costs of parking structures could come in the form of tax credits; stormwater waivers; or density, floor area, or height bonuses.

One way that developers can eliminate land expenses is by incorporating parking into a multipurpose building. The parking is located above or below a ground floor level of retail establishments, with additional floors containing offices, hotels, or apartments. This reduces the land cost chargeable to parking (ITE ,1994a). Lastly, communities should practice what they preach and use garages where feasible in the many parking areas they administer.

PERCEPTIONS AND REALITIES ABOUT STRUCTURED PARKING

The strongest impediment to structured parking is the high cost associated with construction of parking garages. The construction costs of vertical parking structures are significantly higher than of surface lots. ITE (1994a) pointed out that for a typical site, construction of an above-ground garage may be four times the cost per space in a surface lot. Construction costs for a parking garage can range from $7,500 to

$20,000 per parking space, whereas a surface lot averages $1,200 to $1,500 per space (Markowitz, 1995; IPI, 1997). Underground facilities are even more expensive, with an average cost of $35,000 per space (Markowitz, 1995). ITE (1994a) calculated that an underground parking facility is an additional 1.5 to 2 times per space cost compared to an above-ground structure. Table 9.1 discusses the impediments to structured parking.

Table 9.1 Perceived Impediments to Parking Structures

Perception	Reality	
1. Garages cost more to construct than surface lots.	FACT:	Traditional parking garages do cost more to construct (see above). Alternatives for establishing parking facilities could include eliminating land costs by building in air rights above or below another use or by incorporating parking into multipurpose buildings (ITE, 1994a)[1].
	FACT:	Recent investigation into innovative parking structures built with pre-fabricated steel components has shown that the construction and maintenance costs could be competitive with the cost of surface lots (Hardigg, 1998).
2. Garages are more crime ridden than surface lots.	FACT:	There is no unbiased data at this time to deny or support this perception.

[1] Air rights refer to the area above a structure where development may take place.

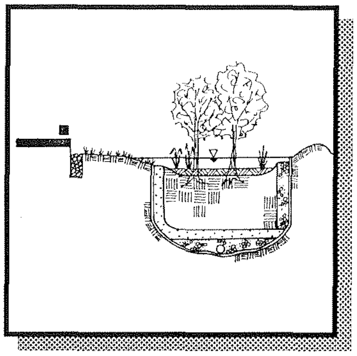
CASE STUDY: OLYMPIA, WASHINGTON

(Source: Wells, 1995)

The City of Olympia has proposed a comprehensive plan that supports the redevelopment of surface parking lots in commercial districts. According to the draft requirements, surface parking lots will be slated for more intensive use and allowable building heights will be increased if parking is incorporated into the structure. In one commercial zone, for example, one story may be added if at least 50% of the parking is under the building. This is a unique way to simultaneously reduce imperviousness while providing convenient parking areas.

Where to Get Started

Suggested Resources	How to Get a Copy
Guidelines for Parking Facility Location and Design (1994) by Institute of Transportation Engineers. Detailed discussion of surface, structured, and handicapped parking design, including discussion of driveways.	Institute of Transportation Engineers 525 School Street, SW Suite 410 Washington, DC 20024-2797 202-554-8050
Impervious Surface Reduction Study: Final Report (1995) by Cedar Wells Presents recommendations for pervious materials and shared parking. Based on results of study to identify strategies for reducing impervious surface in Olympia, Washington.	City of Olympia Public Works Department P.O. Box 1967 Olympia, WA 98507 360-753-8454
Shared Parking Planning Guidelines (1995) by Institute of Transportation Engineers Discusses shared parking issues and guidelines, including detailed case studies and results of local government survey.	Institute of Transportation Engineers 525 School Street, S.W., Suite 410 Washington, DC 20024-2797 202-554-8050



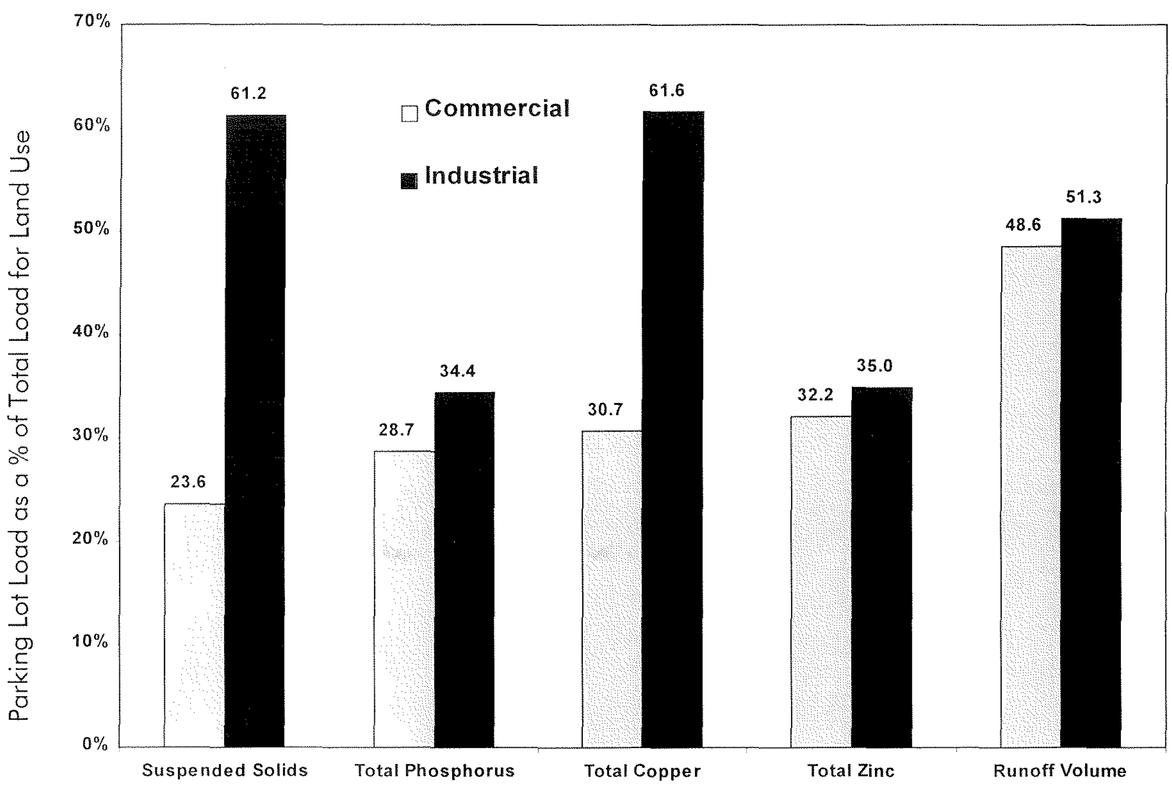
PRINCIPLE NO. 10

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

CURRENT PRACTICE

Parking lots are a significant source of stormwater pollutants in the suburban landscape, particularly lots in commercial areas. These large impervious areas also generate a significant volume of runoff. Vehicle wear and tear, emissions and leakage, and atmospheric deposition are the key pollutant sources. Parking lots are almost completely impervious, so much of the pollutants deposited on the lot surface will be washed off by stormwater runoff.

Figure 10.1: Percent of Stormwater Pollutant Load and Stormwater Runoff Volume Attributable to Parking Lots by Land Use for Various Stormwater Pollutants (Based on Bannerman et al. 1992)



Bannerman (1992) documented the significance of parking lot runoff. His study showed that for commercial and particularly industrial land uses, parking lots are a critical source of stormwater pollution (Figure 10.1). In fact, parking lot runoff accounted for approximately one-fourth to two-thirds of the suspended solids, total phosphorus, total copper, and total zinc loads in the commercial and industrial areas studied.

Although parking lots are a significant source of stormwater pollution, many communities do not require developers to provide stormwater quality control. In addition, opportunities to minimize the amount of stormwater runoff generated or to manage runoff are often overlooked.

RECOMMENDED PRACTICE

There are several techniques that communities can use to reduce the volume of stormwater generated at parking lots. These include:

- reducing minimum parking requirements to allow smaller lots to be built (see Principle No. 6);
- allowing developers to use pervious materials for spillover parking (see Principle No. 8); and
- promoting the use of parking garages which expose less impervious cover to rainfall (see Principle No. 9).

Another option is to require onsite stormwater management. Existing landscape areas in parking lots can be used to provide some stormwater management. Many communities already require developers to landscape parking lot islands. Typically, the landscaping is used to enhance the appearance of a parking lot or to visually separate land uses or development. These areas often account for 10 - 15% of the total parking lot surface area (see Table 10.1).

Table 10.1: Parking Lot Landscape Requirements for Various Communities

Jurisdiction	Requirements
Portland, Oregon	• Landscaping required in building and street setbacks (typically 5 - 10 feet in width) • Landscaping primarily consists of ground cover plants and a mixture of trees, high shrubs, and low shrubs
St. Tammany Parish, Louisiana	• Two trees must be provided for every eight (8) parking spaces (excluding commercial parking garages and multi-level parking)
James City County, Virginia	• Landscaping required for off-street parking areas containing ten or more parking spaces. • Existing trees must be preserved (as feasible) • Landscaped areas must account for at least 10% of the parking lot surface area • At least one tree and two shrubs must be provided for every five parking spaces
Colleton County, South Carolina	• Landscaping required for lots containing 20 or more parking spaces • Ten percent of the lot must be landscaped • Natural vegetation must be preserved

These landscaped areas can be used for stormwater management. There are several options, including:

- bioretention facilities
- dry swales
- perimeter sand filters
- filter strips

Bioretention Facilities

This technique uses planting strips to provide stormwater management (Figure 10.2). Runoff is directed into a shallow, landscaped area and temporarily detained. The runoff then filters down through the bed of the facility and is either infiltrated into the subsurface or collected in an underdrain pipe for discharge into another stormwater management facility or into a stream. Bioretention facilities can be attractively integrated into landscaped areas and can be maintained by commercial landscaping firms. The vegetation recommended for use in bioretention facilities is generally hardier than the species typically used in parking lot landscapes. This is a particular advantage in urban areas where plants often fare poorly due to poor soils and air pollution.

Figure 10.2: Bioretention Area (Prince Georges County, Maryland)

Bioretention encourages treatment of stormwater runoff at the source, before the runoff enters the stream system. Other advantages include:

- Can be used for snow storage during the winter season.
- Requires relatively little engineering design in comparison to other stormwater management facilities (e.g., sand filters);

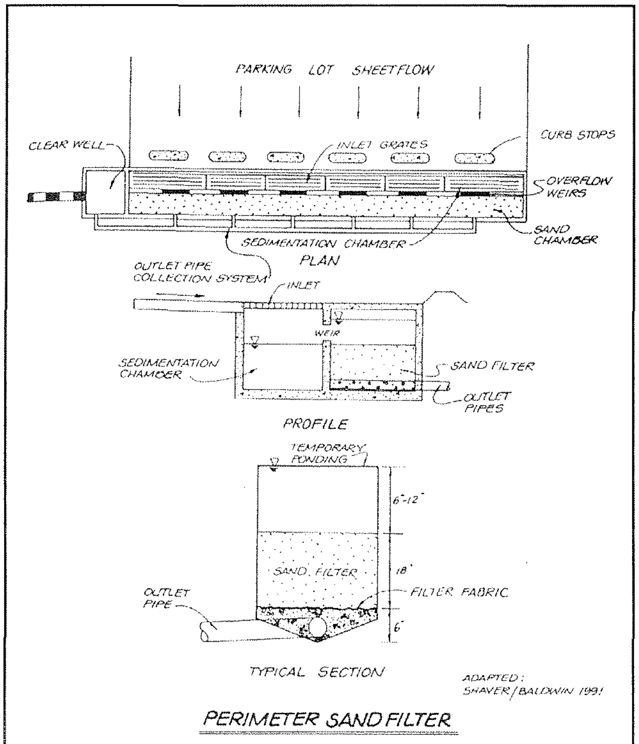
- Provides groundwater recharge when the runoff is allowed to infiltrate into the subsurface; and
- Enhances the appearance of parking lots.

Dry Swales

Dry swales are essentially "engineered" grass channels that provide full treatment of stormwater pollutants (see Principle No. 5 for additional information). The dry swale design includes a layer of prepared sandy loam soil topped by dense turf. Runoff flows into the swale, depositing some of its sediment load as it flows through the dense vegetation. Water quality treatment is provided as the runoff infiltrates through the sandy loam layer. The treated runoff is collected in an underdrain pipe system and discharged into the downstream receiving waters or into a stormwater BMP for further treatment or attenuation. Because the swale is designed to dewater within a few hours after a storm, standing water and its attendant nuisance problems are generally not a concern.

The feasibility of dry swales at parking lots is determined by a number of factors, including drainage area, slope, and length. The amount of stormwater runoff generated at parking lots could overwhelm a dry swale system. In general, dry swales are most appropriate for smaller parking lots (or drainage areas) or larger parking lots subdivided into smaller subdrainage areas and mildly sloping topography.

Figure 10.3: Perimeter Sand Filter (Claytor and Schueler, 1996)



Wet swales can also be used in parking lots, under some conditions. Wet swales are similar to dry swales, but do not have an underlying filter bed. The wet swale occurs when the water table is located very close to the surface. As a result, the swale is often fully saturated or filled with standing water during the greater part of the year. Concerns regarding the standing water may limit the usefulness of wet swales.

Perimeter Sand Filters

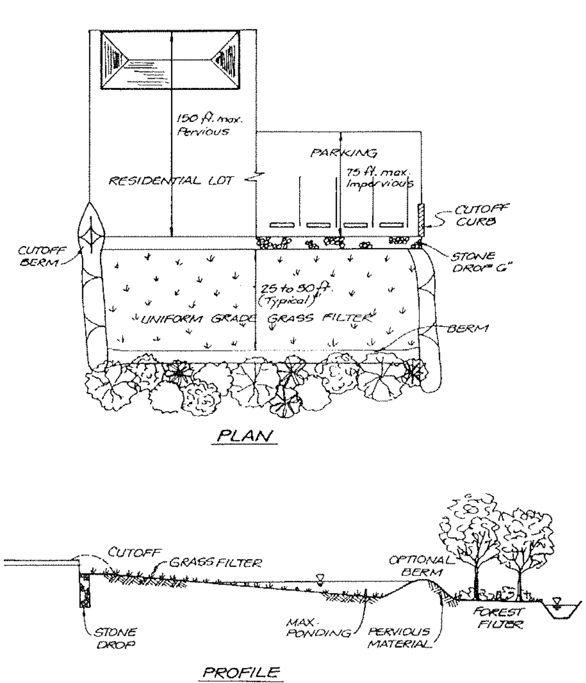
Perimeter sand filters (Figure 10.3) are a more engineered approach to treating parking lot runoff at the source. These devices are usually placed along the downstream edge of parking lots. Perimeter sand filters are particularly suited for parking lots because they are placed underground and consume little usable land.

Runoff flows over the surface of the lot into a grated sedimentation chamber where coarse sediments are trapped. The runoff is then spread over a filter bed and pollutants are captured as the runoff flows downward through the filter. The treated runoff is collected at the bottom and returned to the storm sewer or discharged to a receiving stream. Other types of sand filters include surface, underground, and organic sand filters.

Filter Strips

Filter strips rely on vegetation to slow runoff velocities and filter out sediments and other pollutants from stormwater runoff (Figure 10.4). To be effective, the runoff must flow as sheetflow across the filter strip. Once flow concentrates to form a channel, it effectively "short-circuits" the filter strip. Further, a significant amount of land is required (equivalent to 100% of the impervious drainage area). For these reasons, filter strips are only recommended for very small parking lots or parts of larger parking lots. The parking lot should be adjacent to stream buffers or open space.

Figure 10.4: Filter Strips (Claytor and Schueler, 1996)



Additional stormwater management options include porous pavements (see Principle No. 8) and infiltration trenches. Porous pavement is a pervious asphalt or concrete that allows rainfall to infiltrate into the subsurface. Infiltration trenches are stone-filled reservoirs. Pollutants are removed from the stormwater as the runoff flows downward through the soils beneath the reservoir. Infiltration trenches are typically located along the outer edges of parking lots. In comparison to bioretention facilities, infiltration trenches may require greater care in design, maintenance, and operation (Horner et al., 1994) unless the bioretention is used as a recharge BMP.

Perceptions and Realities about Parking Lot Stormwater Management On Site

Communities may be reluctant to require stormwater management at parking lots (Table 10.2). Although there is data on some BMPs, others are relatively new and their effectiveness has not been extensively documented. Unless BMPs are explicitly required, developers may be reluctant to provide stormwater management due to the cost. Maintenance requirements are a consideration for landowners.

It should be noted that bioretention facilities, open channels, sand filters, and filter strips provide little quantity control. (Quantity controls such as detention ponds are used to minimize the chance of onsite flooding.) These techniques, however, can often reduce the volume and velocity of runoff from parking lots. The amount of quantity control needed is therefore reduced. Thus, overall stormwater management requirements are minimized and smaller quantity controls can be used.

Table 10.2: Perceived Impediments to Parking Lot Stormwater Management

Perception	Facts, Case Studies, and Challenges	
1. Many of the stormwater management techniques are relatively new and their long term performance uncertain.	CHALLENGE:	A recent study by Brown and Schueler (1997) found only 3 performance studies for perimeter sand filters and 4 for dry swales. However, preliminary monitoring and results from the limited number of monitoring studies suggest that these BMPs can significantly reduce stormwater pollutants (See Table 10.3). If not properly maintained, infiltration trenches can have failure rates as high as 50% (Galli, 1993). Bioretention facilities are relatively untested. Brown and Schueler (1997) identified only one performance study for bioretention facilities, but also found some studies on biofilters and surface sand filters, which have pollutant removal capabilities similar to on-site BMPs.
2. The cost to provide onsite stormwater management may be more expensive than providing offsite management at one regional facility.	FACT:	The use of bioretention facilities and other on-site stormwater management facilities can significantly reduce the need for storm sewers, thus reducing stormwater infrastructure costs.
	FACT:	Filter strips, bioretention facilities, and dry swales may be placed in dead space areas such as setbacks and traffic islands, minimizing impacts to usable (i.e., buildable) land.
	CHALLENGE:	Sand filters are expensive, generally on the order of $10,000 - $50,000 per impervious acre. This cost may be offset by the costs for land acquisition, construction of the storm drain conveyance, and construction for a large offsite facility.
3. Maintenance requirements may be burdensome for lot owners.	FACT:	Bioretention areas can easily be maintained by commercial landscapers, but will require regular maintenance.
	CHALLENGE:	Maintenance and physical plant workers may require special training to ensure that open channels, sand filters, and filter strips are properly maintained.
4. The modifications to curbing around bioretention facilities, open channels, sand filters, and filter strips may cause the pavement to fail.	FACT:	Potential failure at the interface may be avoided through the use of a low-rising concrete lip.
	FACT:	Curbing can be used as long as curb cuts or some similar device are provided to allow parking lot runoff to enter bioretention areas or sand filters.
	CHALLENGE:	Care should be taken to ensure that runoff is conveyed away from the pavement. Standing water and water beneath the pavement may cause the pavement to fail. Steps that can be taken to avoid pavement failure include providing a gravel subgrade and requiring geotechnical testing.

Table 10.2: Perceived Impediments to Parking Lot Stormwater Management (Continued)

Perception	Facts, Case Studies, and Challenges	
5. Snow removal may be more difficult.	FACT:	Bioretention areas, filter strips and surface sand filters can be used for snow storage in the winter months (Caraco and Claytor, 1997).
6. Quantity control is difficult to achieve with bioretention areas, sand filters, filter strips, and open channels.	FACT:	Some jurisdictions do allow temporary ponding of stormwater in parking (lot) bays when detention and space limitations are a primary consideration (Bell, 1998).
	FACT:	By providing stormwater management at the source, these facilities can reduce downstream stormwater management requirements.
	CHALLENGE:	Bioretention areas, sand filters, filter strip, and open channels. are not specifically designed to provide quantity control.

Effectiveness

Because most of the stormwater management technology for parking lots is relatively new, only a limited amount of effectiveness data is available to evaluate the long-term performance. However, preliminary monitoring results suggest that these practices can significantly reduce sediment, nutrient, hydrocarbon, and metal loads (PGDER, 1997; Brown and Schueler, 1997).

Table 10.3: Pollutant Removal Effectiveness of Stormwater Management Practices for Parking Lots

Stormwater Management Practices	Pollutant Removal Effectiveness			
	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Metals
Bioretention facilities [1]	Assumed comparable to the dry swale.			
Dry swales[2]	91 %	67 %	92 %	metals: 80 - 90%
Sand filters[1,2]	85%	55 %	35 %	lead 60 % zinc 68 %
Filter strips[1]	70 %	10 %	30 %	metals 40 - 50 %

[1] Claytor and Schueler, 1996; [2] Brown and Schueler, 1997

Expense

The major expenses for parking lot stormwater management are land acquisition, construction, and maintenance. Land acquisition is particularly a concern because many parking lots are associated with commercial development. Commercial land is typically more costly than other land uses. Limiting stormwater management facilities to already required landscaped areas and setbacks could significantly reduce land acquisition costs.

The real challenge is that onsite stormwater management is often more costly than offsite management. However, construction costs for onsite stormwater management may be partially offset by reduced storm drain construction and avoidance of large offsite facilities. Also, even simple grading of the landscaped areas to accept runoff can provide some stormwater management.

Maintenance

Maintenance requirements, as well as relative expense, are summarized in Table 10.4.

Table 10.4: Comparison of Maintenance and Cost Requirements for Several Stormwater Management Facilities (Claytor and Schueler, 1996)

Stormwater Management Facilities	Maintenance Requirements	Relative Cost
Surface sand filter	• trash removal every 6 months and after major storms • mow to maintain grass at 18" • check and clean perforated standpipe and/or low flow orifice • remove deposited silt when > ½ inch in depth over filter bed	moderate
Underground sand filter	• monitor water level in filter chamber (4 times a year for first year, 2 times a year thereafter • pump out sediment chamber when sediment depth > 12 inches • remove deposited silt when > ½ inch in depth over filter bed	high
Perimeter sand filter	• inspect 2 times a year and after major storms • remove trash and debris • remove deposited silt when > ½ inch in depth over filter bed	high
Organic filter	• replace compost every 3 - 4 years • annual removal or roto-till of top layer • remove deposited silt when > ½ inch in depth over filter bed	high
Bioretention facility	• maintain landscape vegetation • annual inspection of plants • mulching 2 times a year • annual testing of soil bed for pH	low
Porous pavement*	• sweeping or vacuuming • replaced when clogged	moderate
Filter strip	• mowing • edge scrapping	low

* *Porous pavement alone is approximately the same cost as conventional asphalt or concrete. However, when the cost for the underground storage reservoir is factored in, porous pavement is more expensive than conventional pavement.*

CASE STUDY: PRINCE GEORGE'S COUNTY, MARYLAND

(Source: PGDER, 1997)

Prince George's County MD promotes the use of bioretention facilities at commercial, industrial and residential sites. This is an integral part of the County's strategy for development. The County is encouraging low impact (i.e., low imperviousness) development even in commercial and residential areas. The integration of bioretention facilities in landscape areas is a key part of this approach.

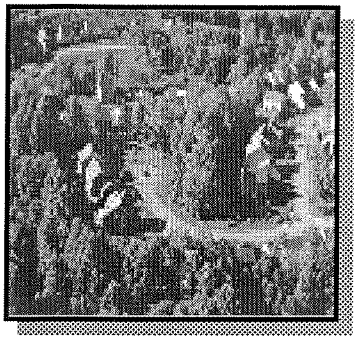
A mall developer in Prince George's County was required to construct a bioretention facility to treat runoff from a new parking lot. The developer graded the lot to drain to the bioretention facility and planted it with a variety of attractive and hardy plants (see Figure 10.2). The bioretention facility has worked successfully for several years. Customer response to the attractiveness of the bioretention facility was so great, that the developer constructed a "dummy" facility (i.e., it receives no stormwater runoff) in an upland portion of the parking lot.

Prince George's County hopes to encourage other developers to use bioretention facilities by offering a variety of incentives, including reduced stormwater management requirements and mitigation credit for environmental impacts. In addition, the County is collecting data to document reduced costs for site grading and infrastructure construction.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Start at the Source (1997) by Bay Area Stormwater Management Agencies Association Detailed discussion of permeable pavements and alternative driveway designs presented.	Bay Area Stormwater Management Agencies Association 2101 Webster Street Suite 500 Oakland, CA 510-286-1255
Design of Stormwater Filtering Systems (1996) by Richard A. Claytor and Thomas R. Schueler Presents detailed engineering guidance on ten different stormwater filtering systems.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323
Design Manual for Use of Bioretention in Stormwater Management (1993) Presents guidance for designing bioretention facilities.	Prince George's County Watershed Protection Branch 9400 Peppercorn Place, Suite 600 Landover, MD 20785

Suggested Resources	How to Get a Copy
Operation, Maintenance and Management of Stormwater Management (1997) Provides a thorough look at stormwater practices including, planning and design considerations, programmatic and regulatory aspects, maintenance considerations, and costs.	Watershed management Institute, Inc. 410 White Oak Drive Crawfordville, FL 32327 850-926-5310



Source: Arendt 1996

PRINCIPLE NO. 11

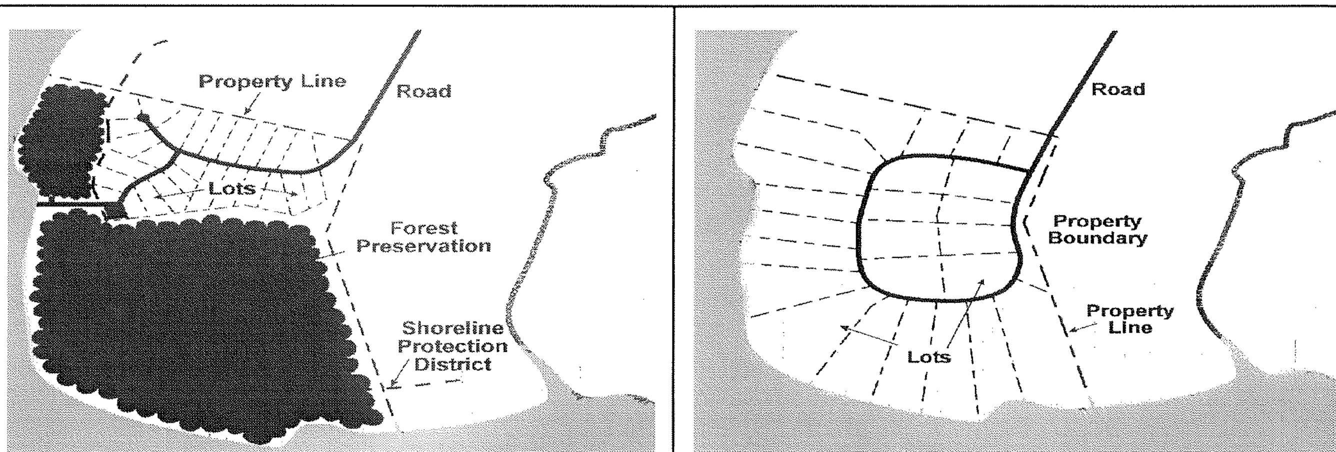
Advocate open space development that incorporates smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection.

CURRENT PRACTICE

Open space development, also known as cluster design, is a compact form of development that concentrates density on one portion of the site in exchange for reduced density elsewhere. Minimum lot sizes, setbacks and frontage distances are relaxed to provide common open space (see Figure 11.1).

Although open space development has been advocated by planners for many years, they are not included in the zoning regulations in all communities. Those communities that do allow open space development have done so for reasons largely unrelated to stream protection such as community design, preservation of rural character, or creation of affordable housing (Heraty, 1992). Fifteen percent of communities that allow open space development also provide density bonuses as an incentive which could actually increase the amount of impervious cover created at a site.

Figure 11.1 Open Space (Cluster) Development versus Conventional Development



Cluster | Conventional

When communities allow open space development it is usually the exception rather than the rule. In 95% of communities surveyed by Heraty (1992), clustering is a voluntary, rather than a mandatory, development option.

As it turns out, open space development is not always a widely exercised option by developers. Open space designs often require a special permit exception or zoning variance (i.e., they are not a by-right form of development). On the average, only 37% of all new subdivisions in these communities were clustered. Further, 18% of the communities reported that they had yet to receive a cluster proposal since first implementing the cluster program. Developers using open space designs often must submit more studies and undergo closer review than developers of conventional developments.

Some early cluster developments were badly designed, made poor use of open space, and were not marketable. In addition, adjacent residents frequently opposed cluster developments due to fears about density, traffic congestion, and property values.

Recommended Practice

Communities that currently allow open space development or cluster designs may wish to re-evaluate their current criteria to determine if they really meet impervious cover reduction and land conservation goals. In addition, they may want to implement program changes that will provide additional incentives to developers to make greater use of this option. In particular, communities should consider making open space development a "by-right" development option. Many communities impose an extended special review process on developers of open space developments. The certainty and speed of project approval are a prime consideration for developers, and until both become comparable to conventional subdivisions, it is not likely that many developers will choose to use cluster designs.

Arendt (1994) has suggested that the side-by-side, visual comparison of open space and conventional subdivisions will go a long way toward gaining acceptance for these new concepts by plan reviewers and developers.

The ability to implement open space designs depends to a great extent on the base zoning density of the open space design. Flexibility sharply declines as the density of the base zone increases. Generally, high density residential zones (more than six dwelling units per acre) are not feasible for open space developments simply due to the lack of space.

Benefits Provided by Open Space Design

Some measure of the value of open space design in reducing impervious cover can be gleaned from a series of "redesign" analyses (see Table 11.1). In each case, an existing conventional residential sub-division was "redesigned" using open space design, and the resulting change in impervious cover was measured from the two plans. These studies suggest that open space designs can reduce impervious cover by 40 to 60%, when compared to conventional subdivision designs, particularly if narrow streets can also be utilized at the site. The value of open space designs in reducing impervious cover is evident over most residential zones, although only minor reductions in impervious cover occur in areas which used very small lot size (1/8 acre lots and smaller) in the original zoning.

Less impervious cover translates directly into less stormwater runoff. According to the redesign analysis presented in Table 11.1, open space designs can produce about a 20 to 60% reduction in the annual runoff volume from a site. A corresponding increase in the amount of infiltration and groundwater recharge is also predicted by hydrologic models for the site.

Table 11.1: Redesign Analyses Comparing Impervious Cover and Stormwater Runoff from Conventional and Open Space Subdivisions

Residential Subdivision	Conventional Zoning for Subdivision	Impervious Cover at the Site			% Reduction in Stormwater Runoff
		Conventional Design	Open Space Design	Net Change	
Remlik Hall [1]	5 acre lots	5.4 %	3.7%	- 31%	20%
Duck Crossing [2]	3-5 acre lots	8.3 %	5.4 %	- 35%	23%
Tharpe Knoll [3]	1 acre lots	13%	7%	- 46%	44%
Chapel Run [3]	½ acre lots	29%	17%	- 41%	31%
Pleasant Hill [3]	½ acre lots	26%	11%	- 58%	54%
Prairie Crossing [4]	½ to ⅓	20%	18%	- 20%	66%
Rapahannock [2]	⅓ acre lots	27%	20%	- 24%	25%
Buckingham Greene [3]	⅛ acre lots	23%	21%	- 7%	8%
Belle-Hall [5]	High Density	35%	20% *	- 43%	31%

Sources: [1] Maurer, 1996; [2] CWP, 1998a; [3] DE DNREC, 1997; [4] Dreher, 1994; and [5] SCCCL, 1995.

Decreased stormwater runoff translates to less stormwater pollution. Again, several redesign analyses have compared the stormwater pollution loads of conventional and open space developments using simple models (see Table 11.2). As can be seen, significant reductions in stormwater pollutant loadings generally occur when open space designs are used— roughly on the order of what can be achieved if stormwater best management practices were installed at the conventional site.

Table 11.2: Redesign Analyses Comparing Stormwater Pollution Loads from Conventional and Open Space Subdivisions

Residential Subdivision	Change in Phosphorous Load	Change in Nitrogen Load	Other
Remlik Hall [1]	-42%	-42%	
Prairie Crossing [2]	-81%	N/A	92% TSS reduction
Rapahannock [3]	-60%	-45%	
Belle-Hall [4]	-67%	-69%	

Sources: [1] Maurer, 1996; [2] Dreher, 1994; [3] CWP, 1998; and [4] SCCCL, 1995.

Perceptions and Realities about Open Space Development

Despite the apparent benefits of open space design, there are many barriers and impediments toward its widespread use. Developers, for example, are often reluctant to use open space design. Smaller lot sizes and compact development are sometimes perceived as less marketable, and the lack of speed and certainty in the review process can be a concern. Prospective homebuyers may be reluctant to purchase homes in open space developments due to concerns regarding management of the community open space. Open space developments are also often perceived as applying only to upscale and affluent consumers. Finally, local governments may be reluctant to promote open space development because they believe the public is opposed to open space design. Open space developments are sometimes opposed due to concerns about incompatibility with older developments and traffic noise and congestion. As several case studies have shown, many of these impediments can be successfully addressed through thoughtful site design and a clear local ordinance (see Table 11.4).

Table 11.4: Perceived Impediments to Open Space Development

Perception		Facts, Case Studies, and Challenges	
1.	Smaller lot sizes and compact development are perceived as less marketable.	FACT:	Many studies show that open space designs are highly desirable and have economic advantages including cost savings and higher market appreciation.
		FACT:	A survey of recent home buyers conducted by American Lives, Inc. noted that 77% of the respondents rated natural open space as extremely important (Fletcher, 1997).
2.	Open space developments often require a special exception approval process.	CHALLENGE:	Generally, additional time, public hearings, and special reviews are required to implement open space designs, even when the community has an open space ordinance (see Principle No. 21). While developers are interested in reduced construction costs and market absorption rate, the total amount of time required for the project is a major driving force.
3.	Community association management of open space areas can be unreliable.	FACT:	There are several options for maintaining open space which can be reliable when properly implemented (see Principle No. 17).
		FACT:	Natural open space reduces maintenance costs and can help keep community association fees down (Arendt et al., 1994).
4.	Open space developments are perceived as applicable only for upper income housing.	FACT:	There are many examples of moderate and lower income open space developments (see Table 11.6).

Table 11.4: Perceived Impediments to Open Space Development (Continued)

Perception	Facts, Case Studies, and Challenges	
5. Open space developments are perceived as incompatible with adjacent land uses and are often equated with increased noise and traffic.	FACT:	Open space design allows preservation of natural areas, using less space for streets, sidewalks, parking lots, and driveways (BASMAA, 1997).
	FACT:	A good design utilizing buffers can help alleviate incompatibility with adjacent land uses and still maintain the character of the area (NEIPC, 1997).
	FACT:	Sound level is measured as a function of vehicle speed (AASHTO, 1994). Open space designs include skinnier streets and other traffic calming features which decrease the speed of cars (FHA, 1996), and consequently, the level of sound.
	FACT:	If the number of residential units built is kept the same as the non open space designs, traffic impacts on the surrounding area should be similar.

Marketability of Open Space Development

Many studies have shown that a well designed and marketed open space developments can be very desirable to home buyers. A few examples of successful open space developments are presented in Table 11.5.

Table 11.5: Some Examples of Successful Open Space Developments

Subdivision	Location	% Open Space	Notes
Farmview	Bucks County, PA	*	The fastest selling subdivision in its price range with lots from ½ to ⅓ the size of competing projects (Arendt, et al., 1994)
Haile Plantation	Gainesville, FL	29%	Captured 14% of the Gainesville market in 1994 (Ewing, 1996)
Palmer Ranch	Sarasota, FL	36%	93% of existing wetlands at the site preserved Accounted for 30% of new home market in Sarasota in 1994 Developer has experienced positive cash flow every year (Ewing, 1996)
Fields of St. Croix	Lake Elmo, MN	60%	80% of home sites in first phase sold within 6 months (NAHB, 1997)
Chatman Village	Pittsburgh, PA	64%	Built during the Depression Earned a 4.32% return on investment (NAHB, 1997)
Westgreen	Leesburg, VA	39%	Targeted to young professionals and empty-nesters Every lot in Phase I sold during first weekend (ULI, 1992)

* More than 23% was preserved as open space and 31% was preserved as productive farm land.

Table 11.5: Some Examples of Successful Open Space Developments (Continued)

Subdivision	Location	% Open Space	Notes
Spinnaker Ridge	Gig Harbor, WA	45%	Targeted to young professionals and older families Successful marketing campaign included radio and newspaper ads (ULI, 1992)
Apple Hill Lane	Duxbury, MA	55%	Built in 1981, one of the first cluster developments in Duxbury Approved within 2 months (Porter et al.,1988)
Chinook Way at Fairview Village	Fairview, OR	40%	Targeted to high wage earners and empty nesters Mix of apartments and townhomes

Open Space Management

Community associations are just one of several options for open space management. Other options include dedication to land trusts, establishing conservation easements. and local, state, or federal ownership. These various options are discussed in detail in Principle No. 15.

Affordable Housing

Since housing prices tend to decrease as housing density increases, open space development could be used as one method for promoting affordable housing within local communities. The Haile Plantation development near Gainesville, Florida, represents one such community where the use of open space design techniques has yielded a variety of lot sizes and preserved significant expanses of agricultural, natural, and recreational open space areas (Ewing, 1996). As shown in Figure 11.2, several of the neighborhoods in Haile Plantation fall within the moderate income price range. These homes correspond to net densities of approximately two to five units per acre. Other examples of successful moderate- and lower-income open space developments are presented in Table 11.6.

Quality of Life

A well designed open space development can enhance the quality of life in neighborhoods and communities. A 1996 homeowner survey revealed that 75% of all buyers would pay more to live in a community where one could walk and bike everywhere (Harney, 1996). Studies also show that traditional big lawns are not necessarily desirable by all prospective homeowners. In fact, a 1996 homeowner survey found that many homeowners are willing to tradeoff the bigger yard to upgrade housing amenities and housing design (Probuilder Magazine, 1997). Another study found that in households where both members of the couple are working, there is a strong preference for smaller lawns to keep lawn maintenance minimal (Newsweek, 1995).

Table 11.6: Moderate and Lower Income Open Space Developments*

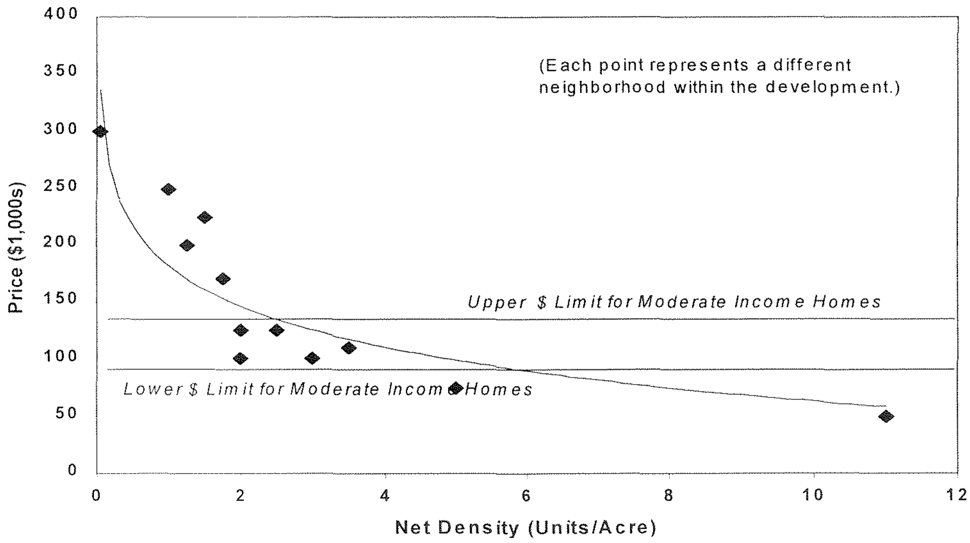
Development Name	Location	Base Price Range	Source
Haile Plantation	Gainesville, FL	$89,000 - $134,000	Ewing, 1996
Oakbridge	Lakeland, FL	$50,000 - $70,000	Ewing, 1996
Spinnaker Ridge	Gig Harbor, WA	$122,000 - $153,000	ULI, 1988
Westgreen	Leesburg, VA	$108,500 - $119,500	ULI, 1988
Casa Del Cielo	Scottsdale, AR	$118,900 - $135,900	ULI, 1988
California Meadows	Freemont, CA	$130,000 - $171,000	ULI, 1988
Coach Houses of Town Place	Boca Raton, FL	$ 97,500 - $143,000	ULI, 1988
Riverplace	New Haven, CN	$79,900 - $179,900	ULI, 1988
Sea Colony	San Diego, CA	$34,500 - $49,000	ULI, 1988

* *The 1996 national average price for a new home was $165,800 and $144,600 for an existing home (NAHB, 1997)*

ECONOMIC BENEFITS

Open space development can be significantly less expensive to build than conventional subdivision developments. Most of the cost savings are due to savings in road building and stormwater management conveyance costs. The use of open space design techniques at a residential development in Davis, California provided an estimated infrastructure construction costs savings of $800 per home (Liptan and Brown, 1996). Other examples demonstrate infrastructure costs savings ranging from 11 to 66%. Table 11.7 lists some of the projected construction cost savings generated by the use of open space redesign at several residential sites.

Figure 11.2: New Home Prices Versus Net Density at Haile Plantation (Florida), based on Ewing (1996)



As the number of housing units per acre increases, the price of a new home drops.

Table 11.7 : Projected Construction Cost Savings for Open Space Designs from Redesign Analyses

Residential Development	% Construction Savings	Notes
Remlik Hall [1]	52%	Includes costs for engineering, road construction, and obtaining water and sewer permits
Duck Crossing [2]	12%	Includes roads stormwater management, and reforestation
Tharpe Knoll [3]	56%	Includes roads and stormwater management
Chapel Run [3]	64%	Includes roads, stormwater management, and reforestation
Pleasant Hill [3]	43%	Includes roads, stormwater management, and reforestation
Rapahannock [2]	20%	Includes roads, stormwater management, and reforestation
Buckingham Greene [3]	63%	Includes roads and stormwater management
Canton, Ohio[4]	66%	Includes roads and stormwater management
Sources: [1] Maurer, 1996; [2] CWP, 1998; [3] DE DNREC, 1997; [4] NAHB, 1986		

CASE STUDY: FIELDS OF SAINT CROIX

The Fields of Saint Croix is an open space development in Lake Elmo, Minnesota. More than 60% of the 226-acre site is open space. Included in the open space is farmland, horticultural gardens, wooded slopes, and restored prairie (NAHB, 1998). Specific open space design techniques that are incorporated into the Field's of Saint Croix include:

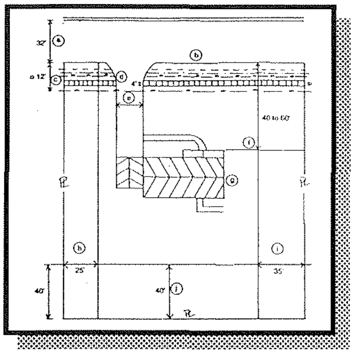
- irregular-shaped and narrow lots
- a density transfer
- onsite treatment of stormwater runoff (Principle No. 22);
- thirty acres of prairie restored with native vegetation (Principle No. 20);
- a public transit stop located at the entrance to the development (Principle No. 7);
- miles of pathways through the common open areas (Principle No. 13); and
- a conservation easement guaranteeing the open space owned by the community association and the developer (Principle No. 15).

Eighty percent of the homes offered during the first phase of the development sold within six months. The second phase is expected to do equally as well.

While reviewing the Field's of St. Croix proposal, and based on the success of similar developments, the City of Lake Elmo decided to develop a comprehensive open space development ordinance. The ordinance provides a base density of six dwelling units per 20 acres with a density bonus for common areas, pathways, and historic preservation. This ordinance covers residential development in 4,400 acres of the city.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Guidelines for Open Space Management in the Land Preservation District by the Montgomery County (Pennsylvania) Planning Commission	Montgomery County (Pennsylvania) Planning Commission Courthouse Norristown, PA 19404 215-278-3722
Conservation Design for Subdivisions: A Practical Guide to Creating Open Space Networks (1996) by Randall Arendt Discusses how to rearrange housing density so that no more than half of the buildable land becomes developed. Includes model zoning and subdivision ordinance provisions.	American Planning Association Planners Book Service 122 S. Michigan Avenue Suite 1600 Chicago, IL 60603 312-786-6344
Rural by Design (1994) by Randall Arendt Provides information on alternative neighborhood designs, including open space design, street design, greenways, zoning, and growth management.	American Planning Association Planners Book Service 122 S. Michigan Avenue Suite 1600 Chicago, IL 60603 312-786-6344
Site Planning for Urban Stream Protection. (1995) by Thomas R. Schueler Chapter 3 examines how conventional zoning techniques relate to stream quality and how local governments can institute watershed-based zoning.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323
Conservation Design for Stormwater Management (1997) by the Delaware Department of Natural Resources and Environmental Control and The Environmental Management Center of the Brandywine Conservancy Provides guidance for site design that incorporates conservation into land development. Emphasis is on retaining natural features in the development process to reduce the need for structural stormwater management controls.	Delaware Department of Natural Resources and Environmental Control Division of Soil and Water Conservation Sediment and Stormwater Program 89 Kings Highway Dover, DE 19901



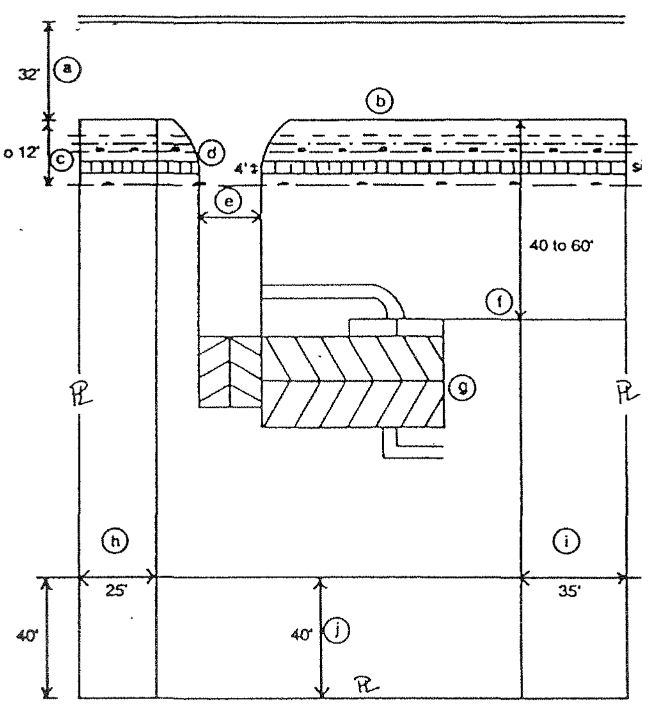
PRINCIPLE NO. 12

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

CURRENT PRACTICE

Many current subdivision codes have very strict requirements that govern the geometry of the lot. These include side yard setbacks, minimum lot frontages, and lot shape (Figure 12.1). These criteria constrain, and in some cases, prevent site planners from designing open space or cluster developments that can reduce impervious cover (see Principle No. 11). Minimum setbacks and frontage distances can increase impervious cover in the following ways. Front yard setbacks, which dictate how far houses must be from the street, can extend driveway length. Large side setbacks and frontage distances directly influence the road length needed to serve individual lots. In most local codes, the size of setbacks and frontage distances usually increase as housing density decreases. Smaller setbacks and frontage distances, which are often essential for open space designs, are typically not permitted, or require a zoning variance (which may be difficult to obtain).

Figure 12.1: Geometry of a Typical One Acre Lot (Schueler, 1995)



LEGEND

- a minimum street width
- b minimum lot frontage
- c minimum right-of-way, one side of the street, not including pavement
- d minimum sidewalk width
- e minimum driveway width
- f minimum front yard setback
- g maximum lot footprint
- h side yard setback
- i side yard setback
- j rear yard setback

Setbacks and frontage widths evolved over time and have been used in local jurisdictions to satisfy a variety of community goals. Often, setback and frontage distances are used to ensure uniform, equally-sized lots. Setbacks are often used for fire safety purposes (i.e., to prevent fire from spreading from forests to a house or from one house to another) and traffic concerns. Frontage distances are often set to provide residential parking. The availability of on-street parking is largely determined by the street length serving each lot, which is set by minimum frontage distance. Examples of typical setback and frontage requirements are presented in Tables 12.1 and 12.2.

Table 12.1: Minimum Setbacks for a Typical Conventional, Single Family Detached Home

Location	Front	Side	Back	Minimum Lot Area
Lenexa, Kansas	30'	7'	20'	8,000 sq. ft.
Newton, Massachusetts	30'	10'	15'	10,000 sq. ft.
Jonesboro, Arkansas	30'	10'	10'	8,000 sq. ft.
Carroll County, Maryland	25'	10'	40'	7,500 sq. ft.
Lake County, Illinois	30'	10'	40'	10,000 sq. ft.
Calvert County, Maryland*	25'	5'	20'	10,000 sq. ft.
Fort Worth, Texas*	20'	5'	5'	5,000 sq. ft.
Albemarle County, Virginia*	25'	10'	20'	~10,000 sq. ft.
Dekalb County, Georgia*	25'	15'	30'	6,000 sq. ft.

**These counties also have codes for open space development (clustered zoning).*

Table 12.2: Minimum Frontage Distances for Typical, Conventional Single Family Detached Homes

Community	Lot Size	Minimum Frontage Distance
James City County VA	≤ 20,000 ft^2	75 feet
	20,000 ft^2 - 1.0 acre	100 feet
	> 1 acre	150 feet
Loudon County VA	≤ 20,000 ft^2	100 feet
	20,000 ft^2 - 1.0 acre	175 feet
	> 1 acre	200 feet

Recommended Practice

Communities can improve impervious cover by relaxing or reducing front and side yard setbacks and allowing for narrower frontage distances. Allowing for narrower side yard setbacks leads to narrower lot widths. With narrower lots, shorter roads are required which reduces site imperviousness. Relaxing front yard setbacks leads to shorter front yards. This eliminates the need for long driveways which are found in many conventional subdivisions. Flexible setback and frontage requirements allow developers creativity in producing attractive, more compact lots with sufficient room for living, recreation, and open space. An example of a flexible criteria is presented in Table 12.3.

Table 12.3: Comparison of Conventional vs. Flexible Lot Dimensions for Development Density of 1 Dwelling Unit/ Acre (Schueler, 1995)

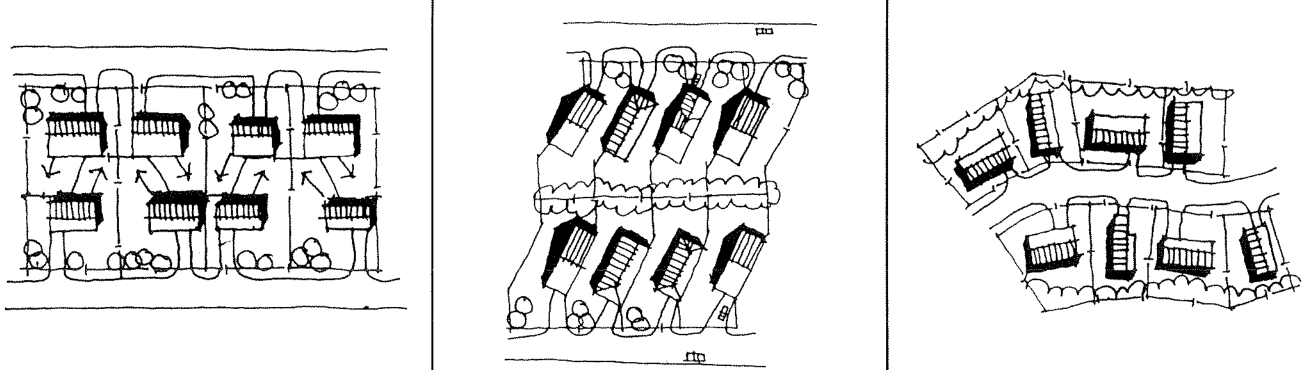
Site Factor	Detached Single Family - Conventional	Detached Single Family - Open Space*
Lot Size	40,000 sq. ft. minimum	10,000 sq. ft. minimum
Front Yard	40 ft. minimum	20 - 25 ft. minimum
Side Yards	25 ft. minimum/ 60 ft. total	10 ft. minimum
Rear Yard	40 ft. minimum	25 ft. minimum
Frontage Distance	150 ft. minimum	75 ft. minimum

* Note that these may be reduced further for a neo-traditional site design or village cluster.

Flexible setback, lot shape, and frontage distances allow site designers to create attractive and unique lots that provide homeowners with enough space for personal recreation while still creating common open space areas. Nontraditional lot designs which are commonly used include zipper lots, angled z-lots, and alternative lot widths (see Figure 12.2).

Figure 12.2: Nontraditional Lot Designs (ULI, 1992)

Zipper Lots	Angled Z-Lots	Alternative Lot Widths



PERCEPTIONS AND REALITIES ABOUT SMALLER LOTS

Impediments to flexible lots include concerns about potential lack of parking, safety issues, livability, and marketability. These are discussed below and summarized in Table 12.4.

Table 12.4: Perceived Impediments to Smaller Lots

Perception	Facts, Case Studies, and Challenges	
1. Narrow lots are less marketable.	FACT:	Home sales in many developments that incorporate narrow lots have been successful (ULI, 1998). See the ***Case Studies*** discussion for specific examples.
2. Narrow frontages and shorter driveways due to reduced setbacks will reduce the amount of available parking.	FACT:	The average number of vehicles in a household is 1.66 which can usually be accommodated between the driveway, garage, and on-street parking (Pisarski, 1996).
	FACT:	Many open space designs include garages and/or driveways.
	FACT:	Designers must consider the trends in vehicle ownership. The percentage of households with 3 or more vehicles decreased by 1% from 1980 - 1990. However, this decrease is significant in light of the extraordinary increase in such households (10-fold) between 1960 and 1980. (Pisarski, 1996).
3. Reduced setbacks will reduce homeowner privacy.	CHALLENGE:	They do reduce privacy, but site designers can include accommodations for privacy by eliminating windows on one side of a building, facing garages next to one of the neighbor's walls, etc.
4. Houses that are closer together may require fire walls and increased costs.	FACT:	A typical requirement allows detached housing to be as close as 5 feet without specific fire protection measures. For houses closer than 5', fire protection measures will most likely be required. These requirements may increase construction cost.
5. Homes placed close to the street will reduce drivers' sight distance (i.e., the length of roadway that can be easily viewed).	FACT:	Potential sight distance impairments can be minimized or avoided by placing visual obstructions (e.g., garages, front porches, etc.) 1.5 - 2.0' back from the curb. This setback is far less than the 30' front setback required by many jurisdictions (AASHTO, 1994).
6. Decreasing the front setback will increase the amount of noise.	FACT:	Site designers can incorporate narrower streets and traffic calming devices which decrease the speed of cars (FHA, 1996). Slow speeds reduce traffic noise as sound level is a function of speed (AASHTO, 1994).

Parking

Reduced frontages reduce overall street length and result in less on-street parking. However, a frontage distance of fifty feet allows for on-street parking of two cars for each resident. Parking concerns can usually be addressed through site design in most residential zones.

A common parking concern are extra automobiles or large recreational vehicles. In the unlikely event that the additional parking demand cannot be met, communities may consider providing a parking area adjacent to the housing site. When many homeowners are expected to own recreational vehicles or boats, "expanding" an existing driveway using a pervious material could provide adequate parking (see Principle No. 8 for discussion of pervious materials).

Safety

Safety considerations include fire protection and adequate sight distances for drivers. Fire protection concerns specifically focus on the proximity of structures to each other. When front and side setbacks are reduced, homes are closer together. This has led to the concern that fire could spread easily from one home to another. With the development of fire retardant materials and the use of fire walls, however, the need for large setbacks has been reduced.

Adequate sight distance is an important aspect of safe road design. Site designers tend to rely on local government street criteria (e.g. minimum horizontal and vertical curve criteria) and rarely consider site- (and lot) specific conditions when developing road layouts. According to AASHTO (1994), potential sight distance impairments can be avoided if visual obstructions (e.g., garages, front porches, etc.) are placed 1.5 feet or more from the curb, which is significantly less than the 30' front setback required by many communities.

Livability/Marketability

Market research and homeowner surveys have shown that, for the most part, flexible setbacks and frontage requirements can provide communities that are attractive to both homeowners and potential buyers (ULI, 1992).

CASE STUDIES

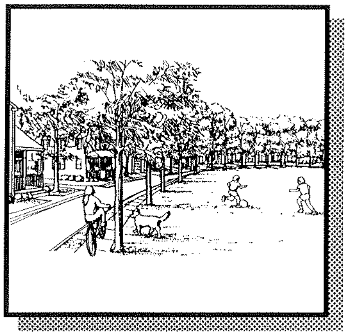
There are numerous examples of residential developments with these lot types that have performed well in the real estate market, including:

- Villa D'Este at Sweetwater in Longwood, Florida
- Casa Del Cielo in Scottsdale, Arizona
- Deerfield Knoll in Chester County, Pennsylvania
- Oakbridge in Lakeland, Florida
- Palmer Ranch in Sarasota, Florida

Sources: ULI, 1992; Arendt, 1994; Ewing, 1996

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Density by Design (1992) by James W. Wentling and Lloyd Bookout Over 20 case studies of higher density communities, many achieved through the use of flexible lot designs and reduced setbacks and frontages. Focus on design of lot and marketing.	Urban Land Institute 1025 Thomas Jefferson Street, NW Suite 500 West Washington, DC 20007 800-321-5011
Designing Open Space Subdivisions (1997) by Randall Arendt Presents case studies of developments using flexible lot standards. Also includes more expansive discussion regarding large, Euclidean lots versus flexible, smaller lots.	Natural Lands Trust Hildacy Farm 1031 Palmers Mill Road Media PA 19063 610-353-5587



Source: Arendt 1994

PRINCIPLE NO. 13

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

CURRENT PRACTICE

Sidewalk requirements are a common element of many subdivision codes. Most codes require that sidewalks be placed on both sides of residential streets (e.g., double sidewalks) and be constructed of impervious concrete or asphalt. Sidewalks can serve important functions in residential communities. Sidewalks protect children as they play and walk to and from schools, neighbors, and parks. They also provide a travel path for adults walking to and from parks, neighborhood shopping, and transit stops (ITE, 1993).

To ensure that these functions are met, many subdivision codes require sidewalks to be 4 to 6 feet wide and 2 to 10 feet from the street. Since sidewalks are provided along streets, little consideration is given to improving pedestrian movement to adjacent communities, parks, and shopping areas away from the streets.

RECOMMENDED PRACTICE

While sidewalk requirements protect pedestrians, needless sidewalks can also increase the amount of site imperviousness, thereby preventing infiltration of stormwater runoff into the soil. In general, the placement and width of sidewalks can be modified without impairing travel access or minimizing pedestrian safety.

Communities should consider more flexible sidewalk requirements that are based on improving pedestrian movement and diverting it away from the street. Communities may wish to allow sidewalks on only one side of the street, or eliminate them altogether where they don't make sense. In addition, communities can reduce the width of their sidewalks to 3 or 4 feet, and place them further away from the street. Lastly, sidewalks should be graded so that they drain to the front yard rather than to the street. These alternatives reduce imperviousness and provide practical, safe, and attractive travel paths.

PERCEPTIONS AND REALITIES ABOUT SIDEWALK PLACEMENT

Double sidewalk requirements have evolved in response to perceived safety and liability concerns as well as to provide convenience for residents. Accident research, however, has shown that single sidewalks are nearly as safe as double sidewalks. Another perception is that residents want sidewalks on both sides of the street. The reality is that many would prefer to have single sidewalks, thereby giving home buyers a choice of whether they want a sidewalk in front of their home or not (Woodsmall, 1998). Table 13.1 discusses perceived impediments to limiting sidewalks in residential areas.

Table 13.1 Perceived Impediments to Limiting Sidewalks

Perception	Facts, Case Studies, and Challenges	
1. Sidewalks on only one side of the street are unsafe.	FACT:	A recent survey showed that 7.7% of pedestrian accidents occurred on roads with single sidewalks and 7.3% of such accidents occurred on roads with double sidewalks (NHI 1996). Roads without sidewalks at all are by far the most hazardous to pedestrians, with 83.5% of pedestrian accidents (Knoblauch et.al., 1988; NHI, 1996).
2. Roads without sidewalks on both sides are a legal liability	FACT:	Careful design and policy implementation protects governments and professionals from undue liability (NHI,1996).
3. The ADA requires sidewalks on both sides of the street	FACT:	The ADA requires at least one accessible route from public streets, parking areas, and passenger loading zones along a route that generally coincides with that of the general public. There are no specific restrictions on roadway sidewalks.
4. Local government officials do not want to hear complaints from residents regarding sidewalk placement.	FACT:	Most complaints occur when sidewalks are installed after the development has been built and occupied, and not during initial construction.
	CHALLENGE:	Many local government officials feel that having sidewalks on both sides of the street will minimize complaints. One way to alleviate these concerns is by educating officials regarding homeowner preferences and by not trying to establish a blanket solution to resolving sidewalk complaints. The sidewalk application policy would not be required in existing neighborhoods, but only for new development projects.
5. Residents want sidewalks on both sides of the street	FACT:	There is no appreciable market difference between houses that are directly served by sidewalks (i.e., the sidewalk is on the same side of the street) and houses not directly served (i.e., sidewalk is on the opposite side of the street) (Woodsmall, 1998). Some residents do prefer to have access to a sidewalk in front of their property, while others prefer no sidewalks. These types of preferences are logically resolved at the time buyers purchase the property.

Safety Concerns

Safety considerations justifiably govern many local subdivision ordinances. One such ordinance is to require sidewalks on both sides of residential streets. While this is safer than having no sidewalks, safety statistics show that having a sidewalk on only one side of the street provides approximately the same level of safety as providing sidewalks on both sides of the street (NHI, 1996). See Table 13.2 for more information.

In residential areas, walking in the roadway is more hazardous than walking on sidewalks, but not as dangerous as one might think. Pedestrians walking in roadways account for slightly over 9% of the total pedestrian volume, yet only 5.8% of pedestrian accidents (Knoblauch et. al., 1988). This conclusion can be attributed in part to the relative safety of residential streets in comparison to other pedestrian areas. Less than 30% of all pedestrian accidents occur in suburban or rural areas. Most (over 70%) pedestrian accidents occur in highly urban areas.

In addition, the placement of sidewalks along the street right-of-way may discourage pedestrian movement, since the travel way is defined solely by the street, and may not connect to adjacent communities, parks or open spaces.

Table 13.2 Survey of Pedestrian Accidents Related to Sidewalk Presence (NHI, 1996)

Sidewalk Location	% of accidents
No sidewalk present	83.5%
Pedestrian sidewalk only	0.9%
Multi-Use sidewalk	0.6%
Sidewalk present on both sides of street	7.3%
Sidewalk present on at least one side of street	7.7%
Total:	**100%**

Liability Concerns

While safety is probably the most important issue governing pedestrians and the use of sidewalks, more and more governments, well insured organizations and professionals are being sued as a result of accidents involving pedestrians. It is true that taking simple and straightforward steps can reduce the occurrence of legal challenges and reduce the liability involved. The most important factor involving a government official or design professional in protecting themselves from legal challenges is the use of "ordinary care." Ordinary care means that design decisions are based on a basic level of care that can be expected of a reasonably experienced and prudent professional. Ordinary care is usually determined by using the "85 percentile rule," which simply means that designs are based on accommodating the behavior that can be expected of 85% of the travelers who use the facility in a reasonable manner (NHI, 1996). Other perceived impediments are presented in Table 13.1.

There are fewer suits claiming design flaws, as opposed to other potentially negligible behaviors (e.g., poor maintenance or improper signage), since design elements involve a longer term and more complex set of planning, policy, and budget decisions. Courts tend to support design decisions so long as significant professional errors were not made (NHI, 1996). Table 13.3 identifies some of the primary components which should be incorporated into sidewalk design to ensure a safe environment with a minimum of liability.

Disability Access

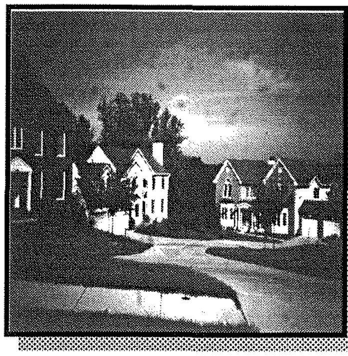
The Americans with Disabilities Act (ADA) does not specifically address sidewalks, but it does require accessible routes. There must be at least one accessible route within the site boundary from public transportation stops, parking, and passenger loading zones. There must be at least one accessible route from public streets or sidewalks to the buildings or facilities they serve. Accessible routes must coincide with the routes for the general public "to the maximum extent feasible." Sidewalks must be at least three feet wide (ADA Hotline, 1997; Dey, 1997).

Table 13.3 Design Elements for User Friendly, Safe and Legally Defensible Sidewalks (Partially adapted from NHI, 1996)

Sidewalk Design Element	Use, Safety, and Liability Considerations
4 feet minimum width	Allows users to walk side by side, helping to keep one user from walking in street
Provide a buffer from traffic	Limits potential accidents and resulting lawsuits
Provide access to streets and destinations	Provides linkage between automobiles, transit and other destinations, avoids "dumping" pedestrians out at unsafe locations
Provide shade where possible	Makes walking more pleasant in the heat of summer
Design to avoid areas of standing or flowing water across sidewalk	Standing or flowing water can freeze in the winter creating a hazard and potential liability situation
Design at the street level	Encourages sidewalk use and awareness of traffic situations
Limit the amount and strictly regulate vending machines (e.g., news stands, FedEx boxes, etc.)	These items take up valuable sidewalk space, potentially hinder sight distances, and can infringe on sidewalk area at critical locations, such as road crossings.
Provide places to sit	Provides rest spots and places for people to stop, out of the way of traffic and congestion
Provide adequate and well designed crossings	Helps minimize one of the major reasons for pedestrian accidents, that is, darting out in front of oncoming traffic

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Residential Streets (2nd Edition) Includes discussion of design considerations for pedestrian walks and paths.	Urban Land Institute 1025 Thomas Jefferson Street, NW Suite 500 West Washington, DC 20007 800-321-5011 Also available from the American Society of Civil Engineers and the National Association of Homebuilders
Pedestrian and Bicyclist Safety and Accommodation (1996) Course book that provides practical design information and an overview of laws and ordinances applicable to sidewalks.	National Highway Institute Federal Highway Administration US Department of Transportation To obtain a copy, call 301-577-0818 and ask for Publication No. FHWA-HI-96-028



PRINCIPLE NO. 14

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

CURRENT PRACTICE

Most local subdivision codes are not very explicit as to how driveways are designed. Most simply require a standard apron to connect the street to the driveway, and are silent about the width and surface material for the driveway. Typically, the single lane driveway for a residential home is 10 - 12 feet wide (Montgomery County, MD; El Paso, CO; Bucks County, PA) and 18 - 20 feet wide for homes with two car garages. Most builders use concrete or asphalt for the driveway surface. Local subdivision codes indirectly influence the length of the driveway when excessive front yard setbacks are required (see Principle No. 13). Taken together, most suburban driveways create from 400 to 800 square feet of impervious cover, or enough room to park two to four cars.

Most communities discourage or even prohibit the use of shared driveways that connect two or more homes together. The primary reason for this is a concern that multiple homeowners may not be able to agree on the long-term maintenance of the driveway.

RECOMMENDED PRACTICE

As much as 20% of the impervious cover in a residential subdivision consists of driveways (Schueler, 1995). The total site impervious area can be reduced when more than one home is served by a shared driveway. Impervious surfaces can be further reduced by using alternative paving surfaces (e.g., gravel, paver blocks, porous pavement) for some or all driveway surfaces.

Communities can reduce the impervious cover of driveways in a number of ways. First, they can specify narrower driveway widths. Second, they can reduce the length of driveways by relaxing front yard setbacks (see Principle No. 13). Third, communities can provide incentives for using permeable paving materials, two track driveways, and allow gravel or grass for the driveway surface. Lastly, communities can encourage the use of shared driveways where enforceable maintenance agreements and easements can be obtained.

Alternative Driveway Surfaces

Several alternative driveway surfaces are available that allow for more infiltration and reduce site imperviousness than conventional asphalt. A detailed comparison of alternative paving materials is provided in Table 8.2 (see Principle No. 8) that reviews their durability, performance, and cost.

Shared Driveways

Shared driveways can provide access from the street to the front door for up to six homes, depending on local regulations (see Figure 14.1). Typically paved, these driveways are privately owned and maintained. Most shared driveways are approximately 16 feet in width (wide enough for two cars to pass).

Successful use of shared driveways requires the developer, homeowners association, or some other legal entity to ensure that maintenance obligations are clearly explained to all affected homeowners. A mechanism should be provided to ensure that potential disagreements and misunderstandings are avoided. Some communities require shared driveway easements and covenants or legal agreements.

Proper design can ensure that all homeowners have sufficient access with shared driveways. Design criteria include adequate space to park vehicles without blocking a neighbor. Some inconveniences, however, are likely to occur when visitors are present.

Figure 14.1: Shared Driveway in Howard Co., Maryland

PERCEPTIONS AND REALITIES ABOUT DRIVEWAYS

Table 14.1 presents some perceived impediments to alternative driveway design. The major impediments regarding shared driveways are adequate access and maintenance responsibilities. These concerns can be alleviated, for the most part, through careful site design, material selection, and homeowner education. The major impediments include concerns regarding the impact of pervious paving materials on snow removal, handicap accessibility, and housing marketability. These concerns are also addressed in Principle No. 8.

Table 14.1 Perceived Impediments to Shared Driveways and Alternative Driveway Surfaces

Perception	Facts, Case Studies, and Challenges	
1. Alternative driveway surfaces make snow removal more difficult.	CHALLENGE:	Paver blocks can be damaged by snowplows and stone, gravel, or cobble driveways are difficult to plow. Brick, porous asphalt and pervious concrete will perform similar to conventional pavement although sand cannot be used on porous pavement (Caraco and Claytor, 1997).
2. Alternative driveway surfaces may limit disability access.	FACT:	The Americans with Disabilities Act (ADA) requires accessible routes on firm and stable surfaces to and between public facilities. Single family houses do not necessarily have to meet this requirement. Developers can choose to provide some houses with conventional paving or select alternative surfaces which will not become an obstacle to those with disabilities.
3. Developers have expressed concerns that some alternative surfaces are less marketable than conventional paving materials.	FACT:	Green development projects that incorporate environmentally sensitive techniques such as the use of pervious paving materials are increasingly being sought out by a range of consumers (Ewing, 1996).
	FACT:	More aesthetically pleasing alternative driveways, (e.g., brick pavers) while more expensive, can be quite marketable.
4. Homeowners and public works officials are wary of the uncertain maintenance obligations of shared driveways.	CHALLENGE:	Whenever there is more than one entity involved in maintenance of common areas there is a potential for inequitable sharing of responsibility. Some communities require shared driveway easements and covenants or other legal agreements to ensure that future disagreements will be minimized.
5. Homeowners have expressed concerns over insufficient access with shared driveways.	FACT:	Proper design can resolve many of these potential conflicts, by ensuring that adequate space is available to park vehicles, without blocking a neighbor.
	CHALLENGE:	Some inconveniences are likely to exist when visitors are present.

CASE STUDY: LEESBURG, VIRGINIA

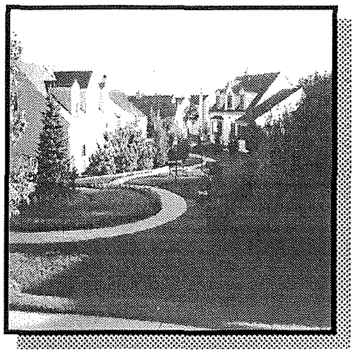
Westgreen is a 4.07 acre development in Leesburg, Virginia (ULI, 1992). Designed and built by Alternative Building and Design, Inc., Westgreen demonstrated that developments that use environmentally sensitive site design techniques such as shared driveways can be successfully marketed.

The site designers emphasized preservation of mature (greater than two inches in diameter) trees on each of the seventeen small-lot, single family home sites. One strategy used to minimize impacts to existing vegetation was to eliminate all seventeen separate driveway cuts. One common entrance and drive to the community was provided. Access from the common drive to the homes is provided by driveways. Many of the homes, however, share common driveways, further minimizing the need to cut down trees.

The development was marketed in two phases. The first phase completely sold out during the first weekend. The second phase sold during the second year with minimal advertising in spite of price increases ranging from $15,000 to $25,000 per home. Maintenance of the common drive and all driveways is included in the homeowner association fee.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Start at the Source (1992) by Bay Area Stormwater Management Agencies Association Detailed discussion of permeable pavements and alternative driveway designs presented.	Bay Area Stormwater Management Agencies Association 2101 Webster Street, Suite 500 Oakland CA 510 286-1255
Impervious Surface Reduction Study (1995) by Cedar Wells Presents recommendations for pervious materials and shared parking. Based on results of study to identify strategies for reducing impervious surface in Olympia, Washington.	City of Olympia Public Works Department PO Box 1967 Olympia, WA 98507 360-753-8454
Shared Parking Planning Guidelines (1995) by Institute of Transportation Engineers Presents guidelines, research findings, and case studies of cities that actively promote shared parking	Institute of Transportation Engineers 525 School Street, SW Suite 410 Washington, DC 20024-2797 202-554-8050
Density by Design (1992) by James W. Wentling and Lloyd Bookout Over 20 case studies of higher density communities, many achieved through the use of flexible lot designs and reduced setbacks and frontages. Focus on design of lot and marketing.	Urban Land Institute 1025 Thomas Jefferson Street, NW Suite 500 West Washington, DC 20007 800-321-5011



PRINCIPLE NO. 15

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

CURRENT PRACTICE

Many communities do not allow for open space developments in their zoning or subdivision codes (see Principle No. 11). Even communities that encourage open space development often restrict its use to larger development projects. A survey of local open space design regulations conducted by Heraty (1992) revealed that the open space requirements were poorly defined in most communities. For example, less than a third of local cluster ordinances required that open space be consolidated. Only 10% required that a specified portion of the open space be maintained and managed in a natural state. Similarly, few communities clearly specify allowable uses for open space areas. Instead, most communities rely on community associations to manage open space and determine allowable uses. Few community associations, however, have the legal or financial resources to adequately manage open space, particularly if it is intended for active recreation. Individual homeowners may be unwilling or unable to pay association fees. Community associations and residents may lack informational resources to understand the maintenance requirements of different types of common areas. A frequently cited reason for prohibiting or restricting open space designs is a concern that homeowners lack either the money or organization to adequately maintain common areas.

RECOMMENDED PRACTICE

Open space managed in natural condition has a minimal annual maintenance cost. This is one reason why communities should encourage designers to retain as much open space as possible in a natural condition. Communities should also explore more reliable methods to assure that the responsibility for open space management can be met within a development. The two primary options are to create a community association or to shift the responsibility to a third party, such as a land trust or park, by means of a conservation easement. The latter technique is especially useful in developments that have high quality conservation areas retained in open space. Lastly, communities that have cluster or open space ordinances should revisit them to ensure that open space is well planned. Clear performance criteria for open space consolidation, maintenance in natural condition, allowable uses, and future management should be carefully considered.

Community Associations

A successful community association begins with mandatory membership and a legal mandate to collect association fees. Availability of information on maintenance of common areas is also essential to keeping the open space properly managed through the long term. The development of a sound financial plan, assessing both yearly operating costs and possible long term requirements, is a key element to the success of the association. Table 15.1 outlines the primary elements found in association documents.

During site design, it is important to ensure that planned uses for open space areas (e.g., natural areas, stormwater management facilities, or pools) are in line with the expected future cost of maintenance. An overburdened community association cannot always manage open space, particularly in light of the traditional costs for street maintenance, snow removal and other common tasks of the homeowners associations.

Table 15.1: Elements of a Successful Community Association

Element	Description
Property Rights	Establishes owner's right to use common area and the right of the Association to delegate use and a fee for maintenance of the common area.
Membership and Voting Rights	Defines the voting rights of homeowners as members of the association.
Covenant for Maintenance Assessments	Outlines homeowner fees, uses of the fees, and obligates homeowner to make payments to the association (otherwise a of lien may be placed on the property).
Architectural Controls	Outlines any particular restrictions on color, architecture, or other design changes to promote harmony.
Use Restrictions and Easements	Establishes any rules on your personal property and/or easement.
Maintenance	Itemizes the specific responsibilities of the association for maintenance of common property and members personal obligation for maintenance of unit or building.
Insurance	Establishes associations obligation for obtaining insurance including liability and fiduciary coverage.
Party Walls (if applicable)	Outlines the rules for shared walls.
Management	Authorizes the associations' Board of Directors to obtain a management agent to carry out day-to-day operations on behalf of the association.
General Provisions	Includes issues of enforcement, rights of the local government and other disclosures about the document itself. Also includes a signature page making the document official.
Bylaws	Outlines the corporate responsibilities for meetings, elections, authority, and duties of directors, and other member issues. Bylaws may contain many of the provisions listed above when not included in the declaration or covenants, especially with condominiums.

Other Options for Open Space Management

Other options for managing open space include transfer to land trust ownership and public ownership. There are limitations to the different types of options and some options may not be applicable for all tracts of land. A comparison of the most commonly used management options is presented in Table 15.3.

Table 15.3: Options for Open Space Management

Option	Positive Factors	Limiting Factors
Conservation Easement	• guarantees protection from further development • may be tax deductible • can be tailored to different levels of giving • ownership maintained	• often not an option for smaller or non-contiguous tracts of land • monitoring responsibilities for easement holder • owner often expected to make contributions for monitoring
Transfer to Land Trust Ownership	• guarantees protection from further development • may be tax deductible • donator doesn't have to worry about monitoring	• loss of ownership • often not an option for smaller or non-contiguous tracts of land • public use may infringe on residents privacy
Community Association	• guarantees protection from further development • representation by homeowners	• community association fees • maintenance and enforcement decisions are reliant on association members
Publicly Owned Land	• no additional fees for homeowner • not being taxed • ensures some certainty over future land use • public funds for maintenance	• land use decisions may depend on political climate • community association interests compete with other groups • public use (park) may infringe on residents privacy

Conservation Easements

Since the goal of open space design is to form large areas of contiguous and natural common space, an alternative management scheme for the larger tracts of land is a conservation easement. A conservation easement legally and permanently limits the use of the land while leaving the property under private ownership (Land Trust Alliance, 1993).

By electing to protect open space with a conservation easement, the land trust or local, state, or federal government agency assumes the responsibility of monitoring the terms of the easement and, if necessary, enforcing them. Open space management by a third party provides greater certainty that the land will be maintained in a natural state. In addition, conservation easements can be written to provide the modest funding needed to pay for inspection, management plans, and maintenance for the natural areas. The specific elements of conservation easements are enumerated in Table 15.2.

Table 15.2: Elements of Conservation Easements (Barrett and Diehl, 1988)

- Legally binding
- Ownership retained by landowner, but permanently limits the uses of land it order to protect its conservation values.
- Managed by a 501(c)3 conservation or historic preservation organization.
- Tax deductible for perpetual conservation easements only (if donation is not required as part of the subdivision process).
- Can be written for as long as owner and grantee desires (although most land trusts deal only with perpetual easements).
- Owners usually asked to contribute to maintain the easement.
- Land must fit certain criteria for acceptance by the 501(c)3.
- Easement monitoring is responsibility of owner.

PERCEPTIONS AND REALITIES ABOUT OPEN SPACE MANAGEMENT

Proper open space design, enforceable maintenance responsibility, and sound budgetary considerations should allay most fears about the financial stability and sustainability of community associations. For larger open space designs, effective management requires that homeowners be continually educated about the purpose and boundaries of open space, and the financial responsibility of the community association to manage open space. Homeowners should also be included in the responsibilities of the associations. By keeping open space in its natural state, maintenance costs can be kept low. Table 15.4 examines some of the perceived impediments to community open space management.

Table 15.4: Perceived Impediments to Community Open Space Management

Perception	Facts, Case Studies, and Challenges	
1. Maintaining common areas, stormwater BMPs, and other facilities can be costly.	FACT:	Open space design reduces the amount of impervious area and should alleviate some of the stormwater BMP and paving costs required in a highly developed area (Table 15.5).
	FACT:	Common areas can be maintained naturally to minimize the costs associated with them (Table 15.5).
	FACT:	The cost to maintain natural open space areas as forests in a conservation easement is fairly low. Roser et al. (1997) estimated it to be less than $250/year.
2. Community fees may be a burden for low and moderate income housing.	FACT:	Open spaces can be protected either through outright donation or donation of conservation easements to land trust (Zepp,1998).

Table 15.4: Perceived Impediments to Community Open Space Management (Continued)

Perception	Facts, Case Studies, and Challenges	
3. Smaller community associations are perceived as potentially financially unstable and unable to effectively manage some properties.	FACT:	There are methods of assuring small maintenance fees and assuring that certain costs are always paid for by homeowners (Table 15.2).
	CHALLENGE:	Many uses (e.g., natural areas, stormwater management facilities, or pools) and types of common areas (e.g., open space areas, infrastructure maintenance) can strain community association resources. Care can be taken at the design stage to avoid overburdening the community association.
4. Enforcement of allowable and unallowable uses may be difficult.	FACT:	Allowable uses can be a voting issue for homeowner associations and in extreme cases legal action can bind homeowners.
5. Information regarding maintenance for residents and community associations is not readily available.	CHALLENGE:	There is a responsibility for the on-going collection and dissemination of maintenance information. There is often no procedure for accomplishing this task since education of residents is not implicit to actual maintenance of common space.

Economic Benefits

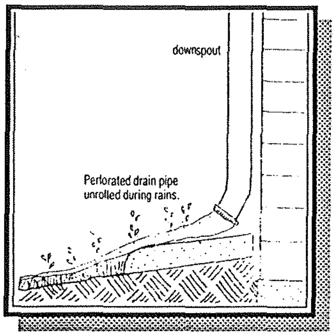
A survey of the annual cost to manage open space is provided in Table 15.5. At about $75/acre/year, managing open space in a natural condition is the least expensive maintenance strategy for community associations. By contrast, managing open space as turf increases maintenance costs by a factor of 5 to 10. If natural open space is designed to allow for passive recreation, such as trails and bike paths, annual maintenance costs may reach $200/acre.

Table 15.5: The Cost of Open Space Management

Maintenance Item	Approximate Annual Maintenance Costs	Source
Natural Open Space Only minimum maintenance, trash/debris cleanup	$75/acre/year	NPS, 1995
Lawns Regular mowing	$270 to $240/acre/year	Wildlife Habitat Council, 1992
Passive Recreation Trails, bike paths, etc.	$200/acre/year	NPS, 1995

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
The Conservation Easement Handbook (1988) by Janet Diehl and Thomas Barrett In-depth discussion of conservation easements. Includes review of tax benefits, acquisition guide, sample easement application, and model easement.	Land Trust Alliance 1319 F Street, NW Suite 501 Washington, DC 20004-1106 202-638-4725
Land Protection Options: A Handbook for Minnesota Landowners (1996) by Laurie Allman Describes options and incentives for protecting non-regulated natural areas. Discusses potential economic benefits for landowners.	The Trust for Public Land Midwest Region 420 North Fifth Street Suite 865 Minneapolis, MN 55401 612-338-8494
Guidelines for Open Space Management in the Land Preservation District by the Montgomery County (Pennsylvania) Planning Commission	Montgomery County (Pennsylvania) Planning Commission Courthouse Norrisstown, PA 19404 215-278-3722
Cluster Development Programs (1993) by Maureen A. Heraty A guidance report that uses the results of a national survey of cluster development regulations to examine the advantages and disadvantages to varying types of regulation and how improvements in regulations can provide more runoff control.	Metropolitan Washington Council of Governments Information Center 777 North Capitol Street, NE Suite 300 Washington, DC 20002-4201 202-962-3256
Community Associations	Website: www.caionline.org
American Farmland Trust	1200 18th Street, NW Suite 800 Washington, DC 20036 202-331-7300



PRINCIPLE NO. 16

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

CURRENT PRACTICE

Most subdivision codes require that yards have a minimum slope to ensure positive drainage away from the home (i.e. runoff moves away from the foundation of a home). A common code requirement is a minimum slope of 2.5% for all overland flow on yards or lawns and a minimum longitudinal gradient for swales, channels or ditches of 2.0%. In northern climates, codes may further specify that downspouts from rooftops to be directly connected to the stormwater conveyance system. These requirements stem, in part, from a desire to minimize nuisance ponding or puddling of water on private lots, and to prevent ice formation on driveways and sidewalks. Engineers are also accustomed to design criteria that mandates quick movement of stormwater through lots, ditches and roads. These code requirements discourage the storage and treatment of rooftop runoff on individual lots. Thus, a cost-effective opportunity for builders and homeowners to promote bioretention and infiltration is bypassed.

RECOMMENDED PRACTICE

Sending rooftop runoff over a pervious surface before it reaches an impervious surface can decrease the annual runoff volume from residential development sites by as much as 50% (Pitt, 1987). This grading technique can significantly can reduce the annual pollutant load and runoff volume being generated at a development site.

Perceptions about wet basements and/or soggy yards are legitimate concerns when it comes to rooftop runoff. Two recent publications, however, suggest that these concerns can be alleviated through careful design, construction inspection, and grading (see Table 16.1). The Low Impact Development Design Manual (PGDER, 1997) provides detailed guidance on methods to re-direct rooftop runoff to pervious surfaces. The Draft Maryland Stormwater Design Manual (MDE, 1997) also provides design criteria for rooftop runoff re-direction, and provides a stormwater management credit as a financial incentive.

Table 16.1 Design Elements for Re-Directing Rooftop Runoff to Pervious Areas

Low Impact Development Manual (Adapted from PGDER, 1997)	Draft Maryland Stormwater Design Manual (Adapted from MDE, 1997)
Encourage shallow sheet flow through vegetated areas. Use rock trenches to create level flow where necessary.	Rooftop runoff from certain land uses should not be re-directed over vegetated areas (e.g., industrial roofs).
Direct flow into BMPs specifically designed to receive rooftop runoff, such as, infiltration swales, infiltration trenches, and/or dry wells.	Limit the contributing path of stormwater flows off rooftops to a maximum length of 75 feet.
Direct flows from small drainage swales to stabilized vegetated areas.	Limit the contributing rooftop area to a maximum of 500 sq. ft. per downspout.
Divert runoff to on-lot swales and bioretention facilities.	The length of vegetated areas receiving runoff from the rooftop shall be equal or greater than the flow length of the contributing rooftop.
Provide wider drainage swales and/or swales with check dams.	Lot sizes must be greater than 6000 sq. ft. in area to receive a stormwater management reduction credit.
Direct rooftop runoff to depression storage areas.	The average slope of the vegetated area receiving rooftop runoff must be less than 5.0% for 75 ft.
	Downspouts must outlet flow at least 10 feet away from the nearest impervious surface.
	Flow from redirected downspouts must not contribute to basement seepage.

PERCEPTIONS AND REALITIES ABOUT RE-DIRECTING ROOFTOP RUNOFF

While the benefits of re-directing rooftop runoff have been documented, concerns regarding wet basements and/or soggy yards remain. It is true that diverting runoff through yard areas may result in creating small erosion gullies or shallow soggy areas. Careful design criteria and construction inspection can minimize these conditions. Likewise, if rooftop runoff is diverted to a depression storage area specifically designed to receive these flows, such as a bioretention area or an infiltration area, soggy lawn areas will be minimized or eliminated altogether. Figure 16.1 illustrates an on-lot bioretention area.

Similarly, specific criteria regarding the discharge from downspouts away from building foundations or basements can minimize or eliminate seepage or foundation damage. Additional concerns and perceived impediments to implementation are presented in Table 16.2.

Figure 16.1: Residential On-Lot Bioretention Area (Adapted from Claytor and Schueler, 1996)

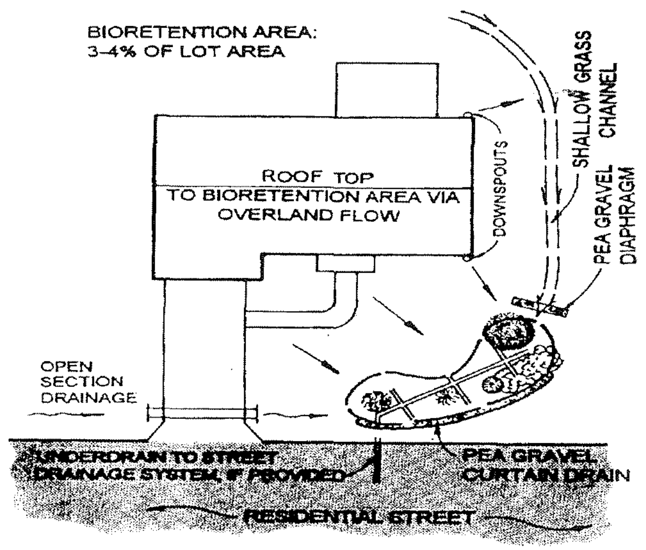


Table 16.2 Perceived Impediments to Re-Directing Rooftop Runoff

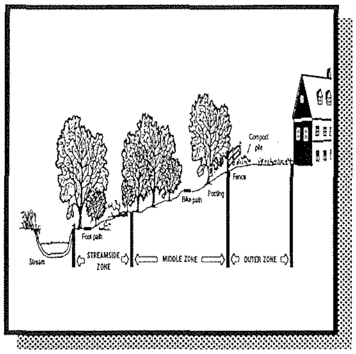
Perception	Facts, Case Studies, and Challenges	
1. Re-directed rooftop runoff may increase a property owner's maintenance burden.	FACT:	When designed properly, on-lot bioretention areas provide an attractive landscaping feature that does not require supplemental water.
2. Re-directed rooftop runoff can be directed onto impervious surfaces in the future.	CHALLENGE:	True, homeowners can always reconnect downspouts to the drainage system in the future. They are not likely to do so, however, unless they encounter problems due to poor grading or design.
3. Wet basements will result from re-directing rooftop runoff.	FACT:	These conditions can be minimized by setting specific criteria regarding the distance that downspouts must discharge from foundations, minimum adjacent slopes away for houses, and adequate construction inspection.
4. Local government codes and FHA lending criteria prohibit on-lot ponding and specify minimum slope requirements.	CHALLENGE:	Some local governments have grading ordinances which dictate minimum grades for lawns, yards, and drainage swales. These restrictions prohibit or discourage re-directing rooftop runoff. Developers must obtain waivers or exceptions to implement practices such as on-lot bioretention, water quality swales, or other flow attenuating BMPs.

CASE STUDY: SHAKER HEIGHTS, OHIO

An ordinance requiring re-direction of rooftop runoff was recently implemented in this neighborhood east of Cleveland. Principally motivated by a need to reduce stormwater volumes within a combined sewer overflow (CSO) system, the ordinance required homeowners to hydraulically disconnect rooftop runoff from the regular drainage network. The ordinance is backed up with enforcement measures, such as potential fines or civil citations. Nearly 100% of the residents have implemented their disconnections within a pilot study area. After the first year of monitoring, results suggest that annual runoff volumes are being reduced by approximately 25% (DeVaul, 1997).

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Maryland Stormwater Design Manual (draft 1997) by the Maryland Department of the Environment Describes disconnection of rooftop imperviousness as a potential nonstructural stormwater control.	Maryland Department of the Environment Water Management Administration 2500 Broening Highway Baltimore, MD 21224 410-631-3543
Low Impact Development Design Manual (1997) Discusses utility of and methods for disconnection of rooftop leaders.	Prince George's County Department of Environmental Resources 9400 Peppercorn Place Suite 600 Largo, MD 20785 301 883-5800
Start at the Source (1997) by Bay Area Stormwater Management Agencies Association. Section 5.5 describes techniques for collecting and treating rooftop runoff from individual buildings.	Bay Area Stormwater Management Agencies Association 2101 Webster Street, Suite 500 Oakland, CA 510-286-1255



PRINCIPLE NO. 17

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

CURRENT PRACTICE

Typically, communities have established stream buffer requirements for two reasons. The first is to regulate the type and location of development within the floodplain of a stream. The second is to protect the water quality of streams that have been designated as providing either valuable resources such as drinking water or unique aquatic habitat. A national survey of buffer programs indicated that for communities with buffer ordinances, the average width of the buffer is 100 feet. Expansion of the buffer to include all of the 100-year floodplain, steep slopes, and freshwater wetlands is not usually required.

RECOMMENDED PRACTICE

A small, but growing number of communities is now implementing buffer programs. Not merely a setback, a buffer is a vegetated system managed to protect the area adjacent to a shoreline, wetland, or stream. Characteristics such as width, target vegetation and allowable uses within the buffer are managed to ensure that the goals designated for the buffer are achieved.

The creation of a riparian buffer system is key in protecting the water quality of streams in urban areas. Buffers create a natural "right of way" for streams that protect aquatic ecosystems and provide a safe conduit for potentially dangerous flood waters. Buffers can also be used to treat stormwater and prevent drainage problems for adjacent homeowners. Stream buffers offer many economic advantages to the local community. The flood protection afforded to homeowners can represent a fairly significant economic benefit. Table 17.1 summarizes some of the environmental benefits that can be achieved with buffer systems.

Stream buffers can be valuable in other ways. They can serve as valuable park and recreational systems that enhance the general quality of life for residents. Buffers can also provide valuable wildlife habitat and act as wildlife corridors for smaller mammals and bird species which are present in urban areas. Wildlife biologists often recommend a much wider buffer to maintain wildlife corridor habitat. Table 17.2 presents a summary of buffer width recommendations based on wildlife corridor functions.

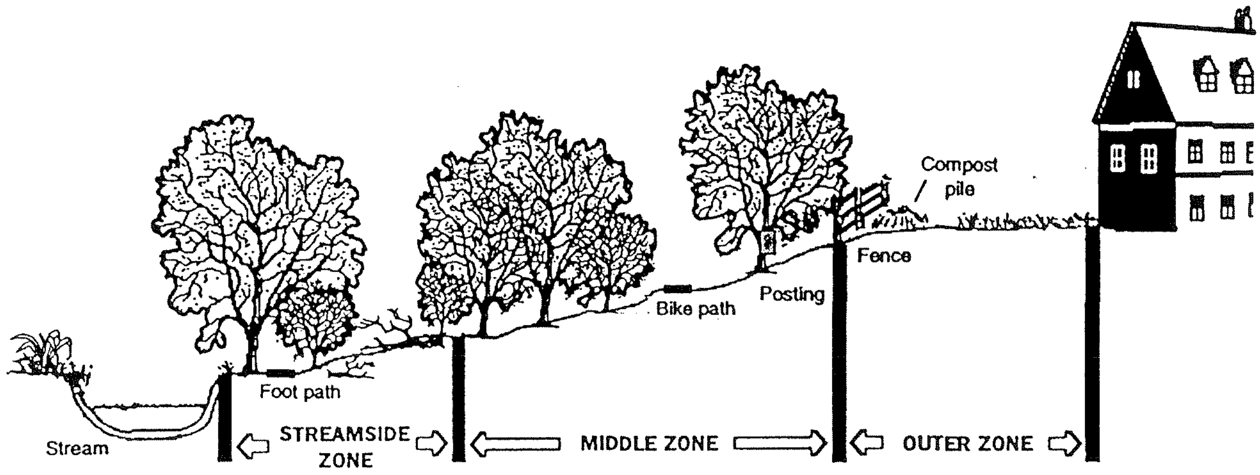
Table 17.1: Benefits of Urban Stream Buffers
1. Reduces small drainage problems and complaints
2. Allows for lateral movements of stream
3. Provides flood control
4. Protects from streambank erosion*
5. Increases property values*
6. Enhances pollutant removal
7. Provides a foundation for present or future greenways
8. Provides food and habitat for wildlife *
9. Protects associated wetlands
10. Prevents disturbances to steep slopes *
11. Mitigates stream warming*
12. Preserves important terrestrial habitat *
13. Supplies corridors for conservation*
14. Essential habitat for amphibians*
15. Fewer barriers to fish migration
16. Discourages excessive storm drain enclosures/channel hardening
17. Provides space for stormwater ponds
18. Allows for future restoration
** benefit amplified by or requires forest cover*

Table 17.2: Buffer Width Recommendations for Wildlife Corridors

Study	Recommendation
Cohen, 1997	300 feet is the generally accepted minimum width needed to provide adequate habitat and movement corridors for most wildlife species.
Keller et al, 1993	Corridors < 165 feet do provide habitat for many edge species, several of which are showing population declines (Droege and Sauer 1990, as cited in Keller et al, 1993).
Spackman and Hughes, 1994	To capture 90% of bird species (including forest interior species) requires a 450-525 foot corridor width on larger urban streams
Castelle et al, 1994	Buffer width to encourage species diversity: range: 10 - 350 ft

A three-zone urban buffer system may be the best option for protecting aquatic resources while providing flexibility for development (Welsch, 1991). Each of the three zones performs a different function, and each has a varying width requirement, vegetative type, and management scheme. Figure 17.1 shows the three zones and each of their characteristics.

Figure 17.1: The Three-Zone Urban Stream Buffer System (Adapted from Welsch, 1991)



Characteristic	Streamside Zone	Middle Zone	Outer Zone
Width	Minimum 25 feet plus wetlands and critical habitats.	50 - 100 feet depending on stream order, slope, and 100-year floodplain.	25 foot minimum setback from structures.
Vegetative Target	Undisturbed mature forest. Reforest if necessary.	Managed forest, some clearing allowed.	Forest encouraged, but usually turfgrass.
Allowable Uses	**Very Restricted** e.g., flood control, utility right-of-way, footpaths	**Restricted** e.g., some recreational uses, some stormwater BMPs, bike paths, tree removal by permit	**Unrestricted** e.g., residential uses including lawn, garden, compost, yard wastes, most stormwater BMPs

Three lateral zones comprise the foundation of an effective urban stream buffer zone. The width, function, management and vegetative target vary by zone.

Table 17.3 highlights several examples of buffer ordinances that have been implemented by communities in the United States.

Table 17.3: Example Buffer Ordinances and Programs

<table>
<tr><th>Program</th><th>Description</th></tr>
<tr><td>Loudoun County, VA Scenic Creek Valley Buffer Ordinance</td><td>Prohibits construction activities in areas adjacent to scenic rivers and major stream areas draining greater than 640 acres or one square mile. Measured from the stream bank, ordinance requires the following stream buffer sizes:
• 250 ft along Potomac river
• 200 ft along two state designated scenic rivers,
• 150 feet along other county streams
Buffer widths may be reduced by up to 100 feet provided stormwater BMP's are used or if streamside forests are preserved or planted. TDR allowed.</td></tr>
<tr><td>Baltimore County, MD Riparian Forest Buffer Regulation</td><td>A forest buffer for a stream system shall consist of a forested strip of land extending along both sides of a stream.
1st & 2nd order - measure from centerline
Class I stream buffer shall be the greater of the following
a) 75 feet
b) 25 ft from outer wetland boundary
c) 25 ft from the 100 yr floodplain reservation or easement boundary</td></tr>
<tr><td>MD MNCPPC Guidelines for Stream Valley Protection</td><td><table>
<tr><th>Slope Range (ft)</th><th>Water Contact Rec. Aquatic Life</th><th>Natural Trout Waters</th><th>Recreational Trout Waters</th></tr>
<tr><td></td><td colspan="3">Width of buffer on each side of the stream (ft)</td></tr>
<tr><td>0 to < 15</td><td>100</td><td>150</td><td>125</td></tr>
<tr><td>15 to < 25</td><td>125</td><td>175</td><td>150</td></tr>
<tr><td>≥ 25</td><td>150</td><td>200</td><td>175</td></tr>
</table></td></tr>
<tr><td>Portland, OR Willamette River Greenway System</td><td>Initiated by the state government and imposing a strict review process for public and private sector development within the greenway. The goal is to keep most of the greenway privately owned. Requires 150ft setback from both banks that incorporates existing urban areas. Requires developers to dedicate certain areas to open space which has resulted in a nature trail that links several riverfront parks and nature preserves (Flink and Searns, 1993).</td></tr>
<tr><td>Charles County, MD Resource Protection Overlay Zone</td><td>Established buffer widths based on stream order.
1st and 2nd order streams -- 50 foot minimum
3rd and 4th order streams -- 100 foot minimum
Minimum buffer extended outward to include all adjacent 100 year floodplains, adjacent non-tidal wetlands or wetlands within 25 feet, and steep slopes greater than 15 % adjacent to the buffer.</td></tr>
<tr><td>City of Austin, Texas Watershed Protection Ordinance</td><td>Establishes development restrictions and buffer zone requirements for suburban and rural water supply watersheds. Buffer zone sizes range from a minimum of 100 feet to a maximum of 300 feet depending on stream class (minor, intermediate, or major). The buffer extends from the outer edge of a Critical Water Quality Zone which is defined by the boundaries of the 100-year floodplain.</td></tr>
</table>

PERCEPTIONS AND REALITIES ABOUT BUFFER SYSTEMS

Potential impediments to buffer programs include concerns regarding private property owners rights, complaints about pests and nuisances, and additional costs to local governments due to implementation, regulation, and enforcement of a buffer program. Table 17.4 summarizes pertinent research regarding these concerns.

Table 17.4: Perceived Impediments to Buffers

Perception	Facts, Case Studies, and Challenges	
1. Buffers may result in a potential loss of developable land.	FACT:	A 100-ft wide stream buffer typically consumes only 5% of land in a typical watershed, depending on drainage density.
	FACT:	Regulatory tools and other incentives are available to protect the interests of property owners (See Principle No. 21).
2. Private landowners may be required to provide public access to privately held stream buffers.	FACT:	Effective buffers can be maintained in private ownership through deed restrictions and conservation easements. Heraty's (1993) survey of jurisdictions with buffer ordinances indicated that 95% of the jurisdictions considered buffers to be private open space for property owners use only.
3. Excessive nuisance species will be present due to the natural buffer area.	FACT:	The ultimate vegetative target for a streamside buffer is the pre-development riparian community - typically mature forests (Petit, 1995). Mature forests usually do not encourage the presence of nuisance vegetative species (i.e., poison ivy).
	CHALLENGE:	Buffers may encourage the presence of nuisance animal species. However, this can be controlled by managing the outer zone of the buffer to discourage animal habitation (e.g., fencing, selective thinning, good housekeeping practices) (Adams, 1994).
4. Buffer programs will place additional demand on scarce local government resources.	FACT:	In the Heraty (1993) buffer survey, a majority of local government respondents indicated that their staff spent only an additional 1-10 % of their time on site plan review and inspection due to implementation of a buffer program.

ECONOMIC BENEFITS

Stream buffers offer many economic benefits to the local community. These benefits can be either non-market which result in cost savings to community budgets or market related such as increases in property values for landowners. Examples of cost savings which may be realized due to buffer presence include:

- The Minnesota DNR estimated a cost savings of $300 per acre-foot associated with a minimized need for floodwater storage due to the preservation of riparian wetlands.
- Forested stream and shoreline buffers situated on the flat soils of the coastal plain have been found

to be effective in removing sediment, nutrients and bacteria from stormwater runoff and septic system effluent in a wide variety of rural and agricultural settings along the East Coast (Desbonnet et al., 1994).

- Buffers can sharply reduce the number of drainage complaints received by local public works departments and they are often an effective means to mitigate or even prevent stream or shoreline erosion.

The presence of buffers also tends to have a positive impact on the value of property adjacent to the buffer system. Examples of the positive market influence of buffers include:

- When managed as a "greenway", stream buffers can increase the value of adjacent parcels as illustrated by several studies. Pennypack Park in Philadelphia is credited with a 33% increase to the value of nearby property. A net increase of more than $3.3 million in real estate is attributed to the park (Chesapeake Bay Foundation, 1996). Another greenway in Boulder, Colorado was found to have increased aggregate property values by $5.4 million, resulting in $500,000 of additional tax revenue per year (Fausold and Lilieholm, 1996).
- Homes situated near seven California stream restoration projects had a 3 to 13% higher property value than similar homes located on unrestored streams (Streiner and Loomis, 1996). Most of the perceived value of the restored stream was due to the enhanced buffer, habitat, and recreation afforded by the restoration.
- Housing prices were found to be 32% higher if they were located next to a greenbelt buffer in Colorado (Correll et al., 1978). Nationally, buffers were thought to have a positive or neutral impact on adjacent property in 32 out of 39 communities surveyed (Schueler, 1995).
- Effective shoreline buffers can increase the value of urban lake property. A recent study in Maine found that water clarity was directly related to property values. Specifically, a measurable improvement in water clarity (visibility depth increased by 3 feet) resulted in $11 to $200 more per foot of shoreline property, potentially generating millions of dollars in increased value per lake (Michael et al., 1996).

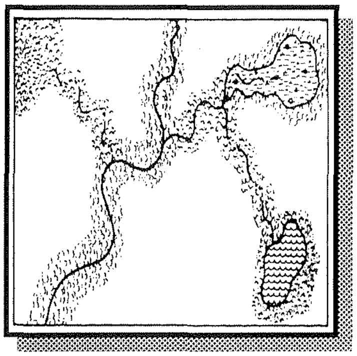
Case Study: Cane Creek Reservoir

(Source: Orange Water and Sewer Authority Board of Directors, 1997)

The Cane Creek reservoir is located in North Carolina and owned and operated by Orange Water and Sewer Authority. The reservoir supplies drinking water to the Towns of Chapel Hill and Carrboro as well as portions of Orange County. The long term watershed management plan for the reservoir recommended buffer requirements along the reservoir shoreline, and along all perennial and intermittent streams within the reservoir watershed. There are two types of recognized buffers; agricultural and development buffers. For development activities throughout the watershed, buffers are required to be a minimum width of 30 feet for low density development and a minimum of 100 feet for high density development. Property owners are encouraged to maintain at least the first 25 feet of the buffer next to the stream in a naturally vegetated or undisturbed state.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Subdivision Design in Flood Hazard Areas (1997) by Marya Morris Provides detailed support for keeping development out of the floodplain, discusses function of buffers in reducing flood damage, discusses how cluster development can be used to reduce flooding.	American Planning Association Planners Book Service 122 South Michigan Avenue Suite 1600 Chicago IL 60603 312-786-6344
Site Planning for Urban Stream Protection, Chapter 5: The Architecture of Stream Buffers (1995) by Thomas Schueler Describes benefits of stream buffers, community experience with buffer programs, pollutant removal capability of stream buffers, performance criteria, and resources needed for implementation.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410 461-8323
Riparian Forest Buffers (1991) by David J. Welsch Provides detailed information on the function and design of riparian forest buffers.	U.S. Department of Agriculture Forest Service Northeastern Area Radnor PA (610) 975-4024



PRINCIPLE NO. 18

The riparian stream buffer should be preserved or restored with native vegetation that can be maintained throughout the plan review, delineation, construction, and occupancy stages of development.

CURRENT PRACTICE

Few communities specify mature riparian forest as a target for their buffer program. Heraty (1993) found that over two-thirds of programs surveyed simply required that pre-development conditions be maintained, regardless of whether it was trees, weeds, turf, or concrete. Indeed, 20% of all buffer programs failed to specify any vegetative goal at all. Given the importance of riparian forests in the ecology of headwater streams, specific vegetative targets for stream buffers are desirable.

In many communities that have stream buffer ordinances, the buffer is merely a line drawn on a map, which is virtually invisible to contractors and landowners. Few communities require that buffer boundaries be marked or define allowable uses within the buffer. Moreover, few communities have notification or enforcement tools to prevent buffer encroachment either during construction or by future landowners (see Table 18.1). For example, in Heraty's (1993) survey of buffer programs, only 53% require buffers to be marked on the clearing and grading plan. Furthermore, only 3% require a preconstruction meeting to discuss buffer boundaries with contractors and construction crew. In addition, while most buffers are held in private ownership, only slightly more than half of all communities employed education and outreach programs to ensure that homeowners were aware of buffer uses and limits. For these and other reasons, encroachment of buffers is the norm rather than the exception.

Table 18.1: Typical Buffer Management Strategies (based on survey of 36 local buffer programs)

Requirements and Strategies	Respondents Enacting
Buffers must appear on site plan.	65%
Buffers must appear on the clearing and grading plan.	53%
Strong buffer awareness programs are implemented.	53%
A preconstruction meeting is held to ensure that the buffer is not damaged during construction.	3%
Allowable or unallowable uses are not defined in the buffer ordinance.	33%

Recommended Practice

The key to effective preservation and management of a local buffer program is development of a strong buffer ordinance. A buffer ordinance should outline the legal rights and responsibilities of the local government and the organization or landowner responsible for long-term management and maintenance of the buffer. Specific items which should be noted in the ordinance include:

- Criteria for a three-zone buffer system
- Defining allowable and unallowable uses for the buffer
- Conditions for buffer expansion or contraction
- Physical delineation requirements
- Conditions where the buffer can be crossed
- Integrating stormwater and BMPs within the buffer
- Buffer limit review
- Buffer education, inspection, and enforcement
- Buffer flexibility

Other Buffer Management Tips

In order to preserve and maintain the integrity of the buffer during all stages of development, communities should require that all buffers appear on clearing and grading plans and require that contractors attend a preconstruction meeting to ensure awareness of buffer boundaries. During the pre-construction phase, the local plan reviewer should meet with the developer and the construction representative to determine site constraints that may impact the buffer and to ensure that construction activities do not harm the buffer. Clearing and grading and erosion and sediment control plans should all be reviewed at this point

Throughout the construction phase the local plan reviewer should visit the site to determine if ongoing construction activities have violated the buffer integrity. The local government may require a construction maintenance bond to ensure that the developer repairs any damage to the buffer resulting from construction activity.

As discussed above, post-construction buffer maintenance requirements should be clearly outlined in the buffer ordinance. A buffer maintenance agreement can be useful in ensuring long-term buffer integrity. The agreement lists management activities (e.g., removal of dead trees) that can be performed by the landowner without a permit. Allowable uses may also be listed. This agreement gives the local government the authority to enter the buffer for the purpose of inspection. It also cites the conditions under which the landowner is responsible for repairs. Landowner liability for repairs is also listed.

Public information programs, such as signage along the buffers, should be considered to ensure long-term buffer maintenance. Other public outreach programs include:

- written disclosures regarding the buffer that convey with the deeds of buffer owner and all landowners adjacent to the buffer
- outline of buffer uses and maintenance requirements in the community association covenant
- occasional public service announcements or newspaper articles on the buffer program
- government sponsored "buffer walks"

PERCEPTIONS AND REALITIES ABOUT BUFFER MANAGEMENT

Some concerns have arisen over management of buffer systems. In particular, there are concerns that buffer regulations may be too restrictive, or interfere with individual property rights (Table 18.2). Most of these concerns can be alleviated with a carefully constructed and thoughtfully implemented buffer ordinance.

Table 18.2: Perceived Impediments to Stronger Stream Buffer Management

Perception	Facts, Case Studies, and Challenges	
1. The regulation of buffer programs will lack flexibility and create excessive restrictions for property owners.	FACT:	Techniques such as "buffer averaging" (Schueler, 1995) can limit the inflexibility of buffer requirements.
	FACT:	Buffers can be held in conservation easements, reducing the need for regulatory intervention (Heraty, 1993).
2. Buffer programs may lack the tools for delineation of buffer areas, which can create requirements that are too ambiguous or inflexible.	FACT:	"Ambiguity" of buffer delineation can be overcome through a program that incorporates specific delineation criteria and by clearly marking the buffer boundary on site plans and in the field. Heraty (1993) found that 65% of respondents required that buffers be delineated on a site plan.
3. Limitations on allowable uses in the buffer may be too restrictive, with no real mechanism to enforce them.	FACT:	Buffer restrictions can vary based on the distance from the stream, with only the innermost zone being severely restricted (Schueler, 1995).
	FACT:	While enforcement of buffer regulations has been weak, Cooke (1991) finds that simply making land owners aware of the buffer and its importance can increase the viability of the buffer system.
4. Forest succession may not be attractive to all residents.	FACT:	Mature trees add to property values (See Principle No. 21), but the succession of forest understory vegetation may detract from property values.
	FACT:	Only 3% of the respondents to the Heraty (1993) survey complained that the buffer was aesthetically unattractive.

Table 18.2: Perceived Impediments to Stronger Stream Buffer Management (Continued)

Perception	Facts, Case Studies, and Challenges	
5. Many suburban residents desire lawns and views instead of trees.	FACT:	60% of homeowners would accept a smaller yard in exchange for design amenities on their houses (Probuilder Magazine, 1997).
	FACT:	Lots with trees have an average value of approximately 5% to 7% higher than lots without trees, and these lots sell faster (MD DNR, 1996).

CASE STUDY: BALTIMORE COUNTY, MARYLAND

The buffer ordinance of Baltimore County, Maryland has several features that encourage effective maintenance and management of the buffer system. Among the key features are flexibility in delineating the buffer based on the field conditions, and a legally binding enforcement mechanism. Other features include:

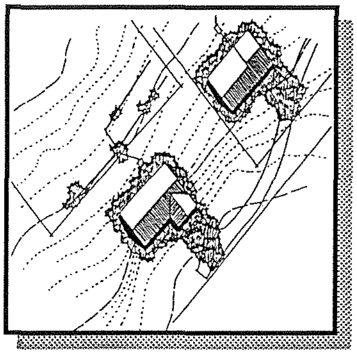
- Requirement that the forest buffer appear on any plans submitted to the county.
- Provisions for forest re-vegetation in some circumstances.
- Adjustment of the buffer width depending on stream quality and erosion potential.
- Restrictions on specific uses within the buffer system.
- List of specifically permitted uses.
- Enforcement mechanisms in the form of criminal and civil penalties.

ECONOMICS OF BUFFER MANAGEMENT

The economics of buffer management may, at first glance, seem unattractive to local governments. The additional management required for a more effective stream buffer program does mean that more resources will be needed for the plan review and delineation process. However, Heraty (1993) found that the additional time required on the part of the local planning staff should represent, on the average, less than 10% more staff time during the development review process.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Greenways: A Guide to Planning, Design, and Development (1993)by Charles Flink and Robert Searns Discusses creation, funding, and management of greenway systems including riparian buffers.	Island Press 1718 Connecticut Avenue, NW Suite 300 Washington, DC 20009 202-232-7933
Forest and Riparian Buffer Conservation: Local Case Studies from the Chesapeake Bay Watershed (1996) A collection of case studies that focus on innovation programs and implementation by local communities.	Rick Cooksey or Albert Todd USDA Forest Service Northeastern Area State and Private Forestry Chesapeake Bay Program 410 Severn Avenue, Suite 109 Annapolis, MD 21403 800-968-7229
Site Planning for Urban Stream Protection (1995) by Thomas R. Schueler Provides a summary of key performance criteria for designing urban stream buffers.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 (410) 461-8323



PRINCIPLE NO. 19

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

CURRENT PRACTICE

Most communities allow clearing and grading of an entire development site except for a few specially regulated areas such as jurisdictional wetlands, steep slopes, and floodplains. A handful of communities do encourage the preservation of some forests or specimen trees. However, very few communities clearly restrict clearing or grading of buffers, open space, and native vegetation during construction.

A survey conducted by Corish (1995) revealed that when jurisdictions do have clearing and grading restrictions, the specific regulations and measures available to enact them are relatively weak (Table 19.1). For example, less than 20% of the communities responding to the survey set specific limits or targets on how much vegetation could be cleared. Furthermore, barely half of the communities had enforcement mechanisms to ensure that grading occurs as planned.

Table 19.1: Characteristics of Local Clearing and Grading Programs (Based on Corish's Survey of 43 Communities with Erosion and Sediment Control Programs, 1995)

Item	% of Respondents
Community has developed laws that specifically address clearing and grading	77%
Community has established tree preservation requirements	65%
Community has provisions for enforcing compliance during the construction phase	63%
Community requires site inspection to confirm clearing/grading requirements prior to start of construction	40%
Community requires bond or other measure of assurance required before construction	40%
Community has regulations that specify percent of the site that can be cleared	17%

RECOMMENDED PRACTICE

It is desirable that as much of a site be conserved in a natural state as possible. Areas of a site that are conserved in their natural state retain their natural hydrology and do not erode during construction. As a general rule, clearing should be restricted to the minimum area required for building footprints, construction access, and safety setbacks. Communities have several existing tools that might be adapted to limit clearing, including:

- erosion and sediment control ordinances;

- grading ordinances;
- forest conservation or tree protection ordinances; and
- open space development.

Erosion and Sediment Control Ordinances

Many communities do have an erosion and sediment control (ESC) ordinance that can be modified to reduce clearing and grading of forested areas and native vegetation. Some areas that deserve scrutiny are:

- Clear delineation of tree or vegetation "save" areas on the ESC plan;
- Clear posting of the limits of disturbance by flag or fence at the site; and
- On-site pre-construction meetings to ensure that contractors are fully aware of the tree save areas.

Another key area is site fingerprinting. This technique minimizes the amount of clearing and grading conducted at a site by limiting disturbance to the minimum area necessary for the construction of buildings and roadways. Clearing of construction roads is permitted. However, the construction access should coincide with planned roadways whenever possible. A suggested limit of disturbance around structures is five to ten feet outward from the building pad (MD DNR, 1991). This distance may need to be increased in areas where potential wildfires are a concern.

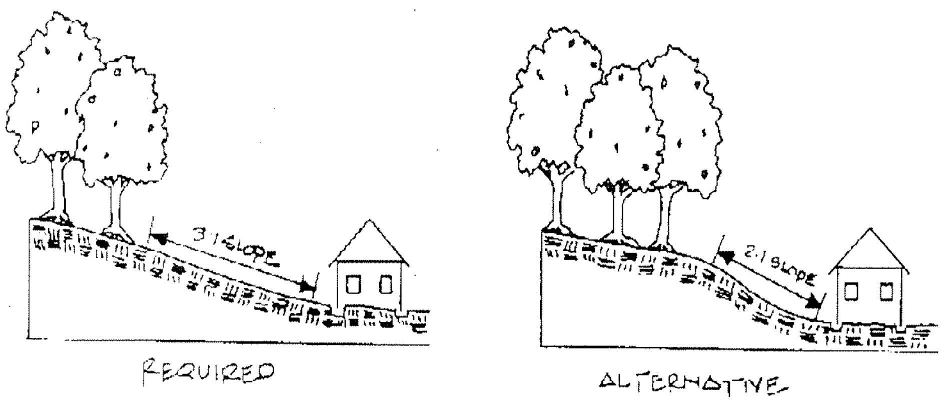
Grading Ordinances

Some communities also have grading ordinances that prescribe maximum and minimum slopes for house lots. To maximize preservation of trees and other vegetation, some variances to slope criteria should be considered. For example, allowing a steeper engineered slope than authorized (e.g., 2:1 versus 3:1) may preserve more trees (see Figure 19.1).

Forest Conservation Ordinance

Several communities and a few states have begun to require that developers conserve forests present at a site. Forest conservation ordinances typically outline targets for conservation of valuable forest habitat, and focus on preservation of high quality forests such as stands with high structural diversity; large contiguous forest tracts, particularly those that connect to other existing forest stands; and forests along streams, wetlands, and lakes (MD DNR, 1991).

Table 19.1: Example Showing Use of Grading Variance to Minimize Clearing and Grading and Preserve Trees (Based on MD DNR, 1991)



Maryland's Forest Conservation Act (Table 19.2) outlines specific thresholds for post-development forest cover depending on the zoning category. Reforestation is required for clearing in excess of the conservation threshold and tree planting may be required if no trees are currently present at the site.

Table 19.2: Forest Conservation Threshold (MD DNR, 1991)

Land Use	Conservation Threshold *
Residential Development (0.2 - 1.0 du/ac)	25 %
Residential Development (1.0 - 20 du/ac)	20 %
Commercial and Industrial	15 %

* Represents the minimum percentage of the site that must be preserved in a forested condition. Any clearing of forest areas below the threshold requires reforestation at a ratio of two acres for every one cleared, either at the site or at an off-site location.

Open Space Development

Open space development can conserve large forest stands in permanent open space. This approach to development facilitates the preservation of large, contiguous tracts of forest. Arendt (1994) suggests that to maximize the extent of open area preserved, site designers should begin the site layout process by first identifying areas that are to be preserved. These include primary conservation areas such as jurisdictional wetlands and steep slopes and secondary conservation areas such as forests and natural meadows. Open space should be designed to include both primary and secondary conservation areas and to connect them whenever possible.

Perceptions and Realities about Clearing Limits

Most of the concerns associated with clearing limits center on the added expense to developers, siting septic systems, liability, and wildfire concerns (see Table 19.3).

Table 19.3: Perceived Impediments to Clearing and Grading Restrictions

Perception	Facts, Case Studies, and Challenges	
1. The preservation of trees during construction is prohibitively expensive.	FACT:	Minimizing clearing during the construction phase can reduce earth movement and erosion and sediment control costs by up to $5,000/acre (DE DNREC, 1997).
	CHALLENGE:	More complex grading strategies may be required to preserve trees close to foundations and other structures.
2. Where septic systems are used to treat wastewater, the septic field area of a site will be affected by restricting clearing.	CASE STUDY:	In the State of Maryland, between 340 and 1,000 square feet septic area is required for a four bedroom house. This area can be accommodated while still restricting clearing of treed areas. Although 10,000 ft^2 of reserve disposal area is required in case the system fails, this area need not be cleared until the reserve field is needed (MD Department of the Environment, Title 26 Chap 02).
3. Local governments, or the developer may be liable for damage to property as a result of fallen trees.	FACT:	The government has liability for fallen trees only if the government owns the land the tree is on, and is negligent in maintaining the property (Widener, 1997).
	FACT:	Land owners are only responsible for tree damage if reasonable care and inspection would have prevented the damage, as in the case of an obviously damaged or diseased tree (Widener, 1997).
	FACT:	There is no precedent for the government being held liable for a tree preservation ordinance (Widener, 1997)
4. Vegetation near homes can be a fire risk; local governments may be responsible for this risk.	FACT:	In arid areas, such as chaparral regions in California, clearing is required within 100' of homes. This can be accommodated while still minimizing clearing over the entire site, particularly for open space development (Cochran, 1998).
	FACT:	The landowner is only held responsible for wildfire damage if the landowner negligently allows the fire to spread to other properties (Widener, 1997).
	CHALLENGE:	Wildfires are a potential risk to properties in the wildlands/urban interface. Greater clearing and grading distances may be required to reduce the risk of fires (see following discussion).
5. People prefer large lawns to treed areas.	FACT:	Lots with trees tend to sell more quickly than lots without trees. Treed lots also have an average value of 5 to 7 % more than lots without trees (MD DNR, 1996).
	FACT:	The American Lives survey of recent home buyers noted that 77% of the respondents rated natural open areas as extremely important. Further, 52% rated wilderness areas as extremely important (Fletcher, 1997).

Fire Hazard and the Wildlands/Urban Interface

In some communities, clearing and grading restrictions need to be carefully evaluated in light of the potential risk of wildfires. Increasingly, development in the western portion of the country is occurring in wildland environments where wildfire is a major element of the native plant community. Increasing development is expanding into the wildland/urban interface where structures are located next to large areas of natural vegetation. In these zones, structures are extremely vulnerable to large wildfires (e.g., California chaparral).

When development is being planned within the wildland/urban interface, clearing of vegetation or elimination of potential wildfire fuels (dead vegetation) may be a primary design consideration. Table 19.4 presents a rating system for estimating the hazard potential of developing in a wildland/urban interface area. If your community has a high potential risk for wildfire, then it makes sense to consider the vegetation management techniques that are described in Table 19.5. The most common technique is to clear or reduce vegetation that is within 70 feet of structures.

Table 19.4: Sample of Fire Hazard Rating System in the Wildland/Urban Interface (adapted from National Wildland/Urban Interface Fire Protection Program)[1]

Hazard Rating Category	Description of Hazard	Point Range	
I. Fuel Hazard Rating [2]	Low, medium or high hazard fuels (grasses, mixed hardwoods, evergreen timber)	Grasses	1 pt
		Woodland (open understory)	2-3 pts
		Woodland (heavy brush)	4 pts
		Large evergreen timber	5 pts
II. Slope Hazard Rating [2]	Mild, moderate, steep, to extreme slopes	Mild slopes (<5%)	1 pt
		Moderate slopes (6-15%)	2 pts
		Steep slopes (16-25%)	3 pts
		Extreme slopes (>25%)	4 pts
III. Structure Hazard Rating [2]	Roof and siding material combustibility	Non-combustible roof & siding	1 pt
		Non-comb. roof, comb. siding	3 pts
		Comb. roof, non-comb siding	7 pts
		Comb. roof & siding	10 pts
IV. Safety Zone Rating [2]	Number of homes that do not have a safety zone of at least 30 ft	30% of homes	3 pts
		31-60% of homes	6 pts
		61-100% of homes	10 pts

Table 19.4: Sample of Fire Hazard Rating System in the Wildland/Urban Interface (adapted from National Wildland/Urban Interface Fire Protection Program)[1]

Hazard Rating Category	Description of Hazard	Point Range	
V. Means of Access for Emergency Vehicles [3]	Number of access points or width of access	Only one access point	3 pts
		Width for one-way traffic only	3 pts
		Road grades > 15%	2 pts
		Turn-around inadequate	3 pts
		Bridge width limits emerg. equip.	3 pts
VI. Additional Factor Rating [3]	Other items that contribute to hazard potential	Most roads names not marked	2 pts
		Subdivision entrance not marked	2 pts
		Individual home #s not marked	2 pts
		Power lines not buried	2 pts
		Lack of municipal water sources	2 pts
		Area lacks static water sources	2 pts
		Long distance from fire dept.	2 pts
		Ease of plowing for fireline	1-5 pts

Total Hazard Rating: (0-19 Low Risk, 20-39 Medium Risk, 40-60 High Risk)

[1] Total hazard rating is the sum of all points awarded.
[2] For Hazard Rating Categories I - IV, assign points based on the one criterion that best describes the existing site conditions.
[3] For Hazard Rating Categories V and VI, points are awarded for all criteria that apply.

Table 19.5: Recommendations for Target Vegetation Around Structures in Medium to High Hazard Wildfire Areas (adapted from National Wildland/Urban Interface Fire Protection Program)

Zone	Distance from Combustible Structure	Target Vegetation
A	Primary setback zone - 20 feet	All natural vegetation cleared, plant only low level, fire-resistant vegetation (lawn, low level ground covers, examples include: lily-of-the-valley, periwinkle, bearberry, lilac).
B	Wet zone - 70 feet	Most natural vegetation removed, area irrigated during dry conditions, planted with low level, fire-resistant vegetation.
C	Thinning zone - 120 feet	Remove all dead/dying vegetation and up to 50% of live natural vegetation (target most flammable, large foliage, shaggy bark, plants that develop dry or dead undergrowth for removal).
D	Thinning zone - 150 feet	Remove all dead/dying vegetation and up to 30% of live natural vegetation.

ECONOMIC BENEFITS

The economic benefits associated with minimizing clearing and grading are two-fold. First, DEDNREC (1997) estimated that minimizing clearing during the construction phase can reduce earth movement and erosion and sediment control costs by up to $5,000/acre. Second, through minimizing clearing, the volume of runoff generated at the site is reduced, thus the cost of stormwater management is reduced.

The cost to maintain forests in a conservation easement is fairly low. Roser et al. (1997) estimated it to be less than $250/year. Principle No. 20 discusses the economics of tree conservation in greater detail.

CASE STUDY: WEST BLOOMFIELD, MICHIGAN

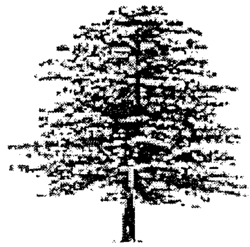
One method of retaining native vegetation is to incorporate clearing and grading requirements within tree preservation or natural resources preservation ordinances. While most tree preservation ordinances focus on protecting individual trees (e.g., trees with a specific diameter or historical value), natural resources preservation ordinances protect habitat areas. This type of legislation has the advantage of protecting a stand of trees, as opposed to individual large trees that may not survive alone. The woodland preservation ordinance of West Bloomfield, Michigan, protects forests of three acres or larger. Specific features of the woodland preservation ordinance include:

- Protects stands of trees greater than three acres in size.
- Requires a woodland permit for encroachment on woodlands.
- The developer must show woodland protection through selective clearing to create wooded lots or the creation of an open space area.
- The developer must pay a fee based on woodland loss.
- Application for a woodland permit must be accompanied by a site grading plan.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Clearing and Grading: Strategies for Urban Watersheds (1995) by Kathleen Corish Guidance report discussing problems associated with the clearing and grading activities which precede land development, and recommendations for minimizing impacts to receiving water bodies.	Metropolitan Washington Council of Governments Information Center 777 North Capitol Street, NE Suite 300 Washington, DC 20002-4201 202-962-3256

Suggested Resources	How to Get a Copy
Fire Protection in the Wildland/Urban Interface: Everyone's Responsibility by the National Wildland/Urban Interface Fire Protection Program Presents five step method for assessing fire hazards in wildland/urban interface. Presents case studies demonstrating how local governments can reduce the risk for fires in the wildland/urban interface.	National Interagency Fire Center Branch of Supply 3833 South Development Avenue Boise ID 83705-5354 208-387-5542
Forest Conservation Manual: Guidance for the Conservation of Maryland's Forests During Land Use Changes Under the 1991 Forest Conservation Act (1991) Provides guidance for preparing forest stand delineations and forest conservation plans. Includes methods for determining the size, location, and orientation of the forest areas to be retained; forests protection techniques; and reforestation and afforestation methods.	Maryland Department of Natural Resources Resource Conservation Service Forestry Division Tawes State Office Building 580 Taylor Avenue Annapolis, MD 21401



Principle No. 20

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

Current Practice

Currently, few communities require that trees and native vegetation be conserved during the development process. In communities that do have tree ordinances, the focus is often on "specimen trees" which represent trees that are old or rare to the area. Many communities promote the use of lawn instead of native vegetation. Today, over 24 million acres of lawn exist in the suburban environment (Daniels, 1995). In many jurisdictions, local ordinances set standards for the maintenance of lawns and open areas. These laws often include restrictions on the height of "weeds" and have been used to prevent landowners from managing their yards with native vegetation. Further, subdivision covenants and homeowner associations may determine exactly what plants may be used for landscaping and in what planting style. A few communities, however, require that a fixed percentage of the natural vegetation at the site be retained or replaced with native specimens.

Recommended Practice

Native trees, shrubs, and grasses are important contributors to the overall quality and viability of the environment. Therefore, existing codes should be revised to promote the preservation of trees and native vegetation. Care should be taken to identify and preserve the highest quality forest stands prior to development. Specific mature tree/native vegetation targets should be established at the pre-development stage. These targets should be based on reference sites and historical records. Explicit conservation regulations with enforcement measures should be adopted. Many tools that can be used to achieve these goals.

Several tools which can be used for tree conservation have been discussed in previous principles. Forest conservation ordinances can be used to cluster stands of forest and place structures around designated tree clusters. Open space development practices can be employed to protect vegetation and still allow for human activity. Planting of vegetation can be a requirement for street rights-of-way in order to reduce imperviousness. Clearing and grading requirements can include preservation of trees and native vegetation. Parking lots can be reduced in size and include vegetated islands.

Techniques for Vegetation Conservation

In some parts of the country where water supplies are limited, Xeriscaping is gaining in popularity. This technique uses drought tolerant native plants to landscape and thereby reduces the amount of water required to maintain a lawn. In some areas of the Southwest, programs have begun which provide a monetary rebate to homeowners who replace their lawn with native plantings.

Standards for the conservation of trees vary across the country. While some jurisdictions have adopted tree conservation ordinances, the specific regulations and measures to enforce these ordinances vary widely. Most ordinances seek to preserve some desirable trees during construction while providing for the replacement of other trees removed during the building process. As an example, the State of Maryland passed the Forest Conservation Act in 1991. This act seeks to prioritize the conservation or preservation of forest stands through forest stand delineation and development of a forest conservation plan. The primary intent of the conservation plan is to preserve existing forest cover and to restrict forest clearing to the minimum area essential to a development project. If retention of the existing tree stand is not possible, reforestation and off-site mitigation techniques are available.

Perceptions and Realities

Perceived economic hardship due to tree conservation and additional plantings, and concerns about human safety are often used as arguments against tree conservation and native landscaping. Table 20.1 reviews some of the research associated with urban tree conservation and native landscaping and their impacts on the urban environment.

Table 20.1: Perceived Impediments to Tree and Vegetation Conservation

Perception	Facts, Case Studies, and Challenges	
1. The additional costs of conserving of trees outweigh the benefits.	FACT:	Two regional economic surveys documented that conserving forests on residential and commercial sites enhanced property values by an average of 6 to 15% and increased the rate at which units were sold or leased (Morales, 1980 and Weyerhauser, 1989).
	FACT:	It has been conservatively estimated that over $1.5 billion per year is generated in tax revenue for communities in the U.S. due to the value of privately-owned trees on residential property. (USDA, as cited by the National Arbor Day Foundation, 1996).
	CASE STUDY:	Single family homes in Athens, GA with an average of five trees in the front yard sold for 3.5 to 4.5 percent more than houses without trees (National Arbor Day Foundation, 1996).
2. Native vegetation may harbor undesirable wildlife and insects.	FACT:	In a 1988 survey of wildlife acceptance, some 65% of the adult population reported that they enjoyed seeing or hearing wildlife while pursuing other activities around the home (US F&WS, 1993).
	FACT:	Natural vegetation does not provide a steady supply of the sort of food required to sustain a population of vermin. (Daniels, 1995).
	CHALLENGE:	Perceptions linger among many homeowners that natural vegetation harbors undesirable wildlife and insects. Public education programs must continue to alleviate these concerns.

Table 20.1: Perceived Impediments to Tree and Vegetation Conservation (Continued)

Perception	Facts, Case Studies, and Challenges	
3. Trees in street right-of-ways may be a safety hazard to motorist.	FACT:	Vegetation need not be cleared from the entire right-of-way but only as needed to accommodate utilities and sidewalks and permit a clear sight distance (ULI, 1990).
	FACT:	ITE guidelines for TND street design call for planting strips and street trees to provide a buffer between vehicles and nonmotorists. These planting strips also provide a snow storage area in northern climates (ITE, 1997).
	FACT:	Traffic calming designs for reducing traffic speed on residential streets often incorporate the presence of trees (see Figure 20.1).
4. Trees may represent a fire risk for homeowners.	FACT:	A Fire Hazard Rating System and National Wildland/Urban Interface Fire Protection Program has been established which provides recommendations for target vegetation around structures (See Principle No. 19 for greater detail).
	FACT:	In arid areas, such as chaparral regions in California, clearing is required within 100' of homes. This can be accommodated while still minimizing clearing over the entire site, particularly for open space development (Cochran, 1998).

Benefits of Conserving Trees and Native Vegetation

The evidence is very strong that trees have noticeable economic benefits for developers and homeowners. A 1993 survey of members of the National Association of Homebuilders indicated that 69.2% of the respondents described themselves as increasing the number of trees on their properties and were either thinking of or committed to continuing the practice (Andreasen and Tyson, 1993). Another study found that large old street trees were the most important indicator of community attractiveness (Coder, 1996). This community attractiveness is important due to its positive impact on property value.

Economic Benefits

The beneficial economic impacts of the presence of trees on property value has been well documented. Studies from numerous sources have found the following:

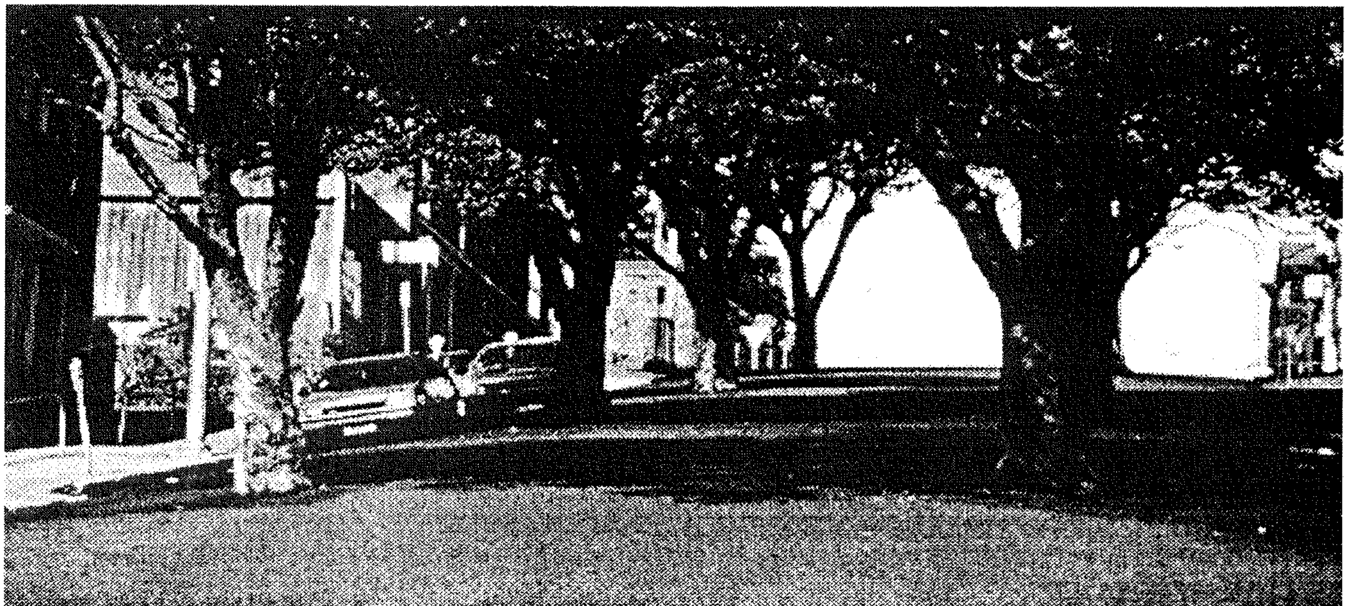
- The resale value of a home may be enhanced by as much as 15% with landscaping (American Nursery and Landscape Association, as cited in the Laurel Creek Nursery Newsletter, 1997).
- Landscaping has a 100-200% recovery value when selling a home (Laurel Creek Nursery Newsletter, 1997).
- A South Carolina developer found that bare house lots sold much faster after planting trees, with a $1,500 increase in the selling price (National Arbor Day Foundation, 1996).
- A study of 14 variables that might influence the price of suburban homes in Manchester, Connecticut and Greece, New York found that trees ranked sixth in influencing the selling price. Trees on the property increased sale prices by 5 to 15 percent (National Arbor Day Foundation, 1996).

- A 1990 survey of Seattle residents found that 62% of the respondents listed environmental factors such as greenery and greenbelts as one of the things they liked best about living in the city (SEATRAN, 1998).

Environmental Benefits

The environmental functions trees and other vegetation perform can also present a significant savings. Table 20.2 highlights some of the environmental benefits of trees in the urban landscape and their corresponding economic values.

Figure 20.1: Trees Incorporated into the Streetscape



Source: National Highway Institute, 1996

Table 20.2: Benefits of Trees in the Urban Landscape

Benefit	Case Study and Estimated Economic Benefits
Lowers air conditioning costs	In Atlanta, GA a six to nine degree temperature rise in the past 25 years which corresponds with a 65% loss in tree cover.[1] **Estimated Benefit: $73/tree/year[2]**
Trees can be used to retain carbon dioxide and control ozone.	In Milwaukee, WI urban forests sequester approximately 1,677 tons of carbon annually.[1] **Estimated Benefit: $50/tree/year[2]**
Trees reduce stormwater flows by encouraging infiltration and detaining rainfall.	In Austin, TX tree canopy reduced stormwater flows by up to 28%, saving the city $122 million.[1]
Trees reduce erosion and sediment control costs.	In a survey of erosion and sediment control programs, forest conservation that reduces exposed soil is ranked as a very effective erosion control measure with no maintenance costs (Brown and Caraco, 1996).[1] **Estimated Benefit: $75/tree/year[2]**
Trees provide wildlife habitat.	**Estimated Benefit: $75/tree/year[2]**

[1] *Case studies cited in MacDonald, 1996*
[2] *Economic benefit expressed as dollars saved per tree per year (MD DNR, 1996)*

Other studies have also found considerable benefits from the presence of trees in urbanized areas:

- The loss of trees in urbanized areas can have significant economic impacts in terms of cooling costs. A $242 savings per home per year in cooling costs is realized when trees are present (Coder, 1996).
- It has also been estimated that the urban-heat island effect created in large cities due to lack of vegetation and its cooling effects costs Washington, DC some $40,000 per hour in the summer (Petit et. al., 1995).
- In Atlanta, Georgia, it was found that a 20% loss in trees and other vegetation in the metropolitan region produced a 4.4 billion-cubic foot increase in stormwater runoff; officials estimated that at least $2 billion would be required to build containment facilities capable of storing the excess water (American Forests, as cited in US Water News, 1997).

Other environmental benefits derived from trees include air pollution control, oxygen production and carbon dioxide reduction, erosion and sediment control, and noise abatement.

Cost Savings

Conserving native vegetation results in significant cost savings for maintenance. Native vegetation is usually low-maintenance and is better adapted to the climatic changes and pests occur in various parts of the country. Native vegetation typically does not require the use of fertilizer or the constant watering is characteristic of the turf lawn. Americans spend over $7.5 billion each year on lawn care products to maintain turf lawns. This includes the purchase of over 67 million pounds of pesticides which often end up in stormwater runoff. It has also been estimated that the average lawn also requires about 10,000 gallons of water each summer to maintain its green state (Daniels, 1995).

Some indication of the savings associated with maintenance of native vegetation has been documented in a 1992 study by the Wildlife Habitat Enhancement Council. The Council found that corporate land owners can save between $270 - $640 per acre in annual mowing and maintenance costs when open lands are managed as a natural buffer area rather than turf.

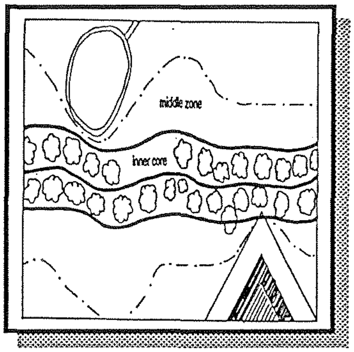
Case Studies

Two case studies illustrate the positive benefits of tree conservation. In the first case, an Indiana developer, Brad Chambers of The Buckingham Companies, redesigned a 130-unit apartment complex in order to reserve as much of the existing vegetation as possible. Roads and parking areas were reduced and relocated to conserve existing trees, and redesigned building units were fit into hillsides to reduce the need for grading. The changes resulted in an additional $300,000 in project costs, which translated into an additional $2.50 per square foot of construction. However, increased revenue and higher than normal resident retention rates offset the increased construction costs. The apartment complex reached full occupancy within its first year with minimal advertising, with a greater than normal retention rate for residents. The units commanded a higher rental rate and the property value also increased, which allowed the developer to secure an additional mortgage. These benefits help offset the added costs of the tree saving measures (Petit et.al., 1995).

The second case involves the conservation of trees during a road construction project. In 1993, Westminster, Maryland, began an effort to reconstruct East Main Street. The town identified a desire to avoid removal of 42 mature trees from the downtown area as one of its foremost concerns. By modifying the original plan to reduce street widths and extend curbing areas into the parking lane, 34 of the 42 trees were saved. In addition, 104 trees were added to the road section to create a more pedestrian-friendly streetscape. Realtors estimate that due to increased demand for downtown office and retail space, the added cost of the improved design will be recovered in 4 years (FHA, 1997).

Where to Get Started

Suggested Resources	How to Get a Copy
Building Greener Neighborhoods: Trees as Part of the Plan (1995) by Jack Petit, Debra Bassert, and Cheryl Kollin Demonstrates the environmental, economic, and aesthetic benefits of conserving and preserving trees in residential developments.	American Forests PO Box 2000 Washington DC 20013-2000 202-667-3300
The Wild Lawn Handbook: Alternatives to the Traditional Front Lawn (1995) by Steven Daniels Guidance for creating and maintaining a non-conventional lawn.	Check your local public library for this book.
Forest Conservation Manual (1991) by Jennifer Greenfeld, Lorraine. Herson, Natalie Karouna, Giselle Bernstein Provides guidance in preparing forest stand delineations and forest conservation plans the Maryland Forest Conservation Act. Also provides guidance on reforestation or afforestation methods.	Maryland Department of Natural Resources Tawes State Office Building 580 Taylor Avenue Annapolis, MD 21401
Forest and Riparian Buffer Conservation: Local Case Studies from the Chesapeake Bay (1996) Cites examples demonstrating how buffer programs have been implemented on the local level.	USDA Forest Service Washington DC



PRINCIPLE NO. 21

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

CURRENT PRACTICE

A limited number of communities require conservation and protection of non-regulated areas such as stream buffers, forests, and meadows. Even fewer provide incentives for developers to consider better site design techniques that promote preservation of natural areas. Indeed, existing conservation efforts are generally characterized by excessive administrative requirements, lengthy plan reviews, additional up-front costs for the developer, and unclear appeal procedures. These experiences have created friction between developers and communities, dissuading many developers from participating in conservation programs. Further, the small number of communities which do provide incentives or flexibility when administering conservation programs may be regarded with suspicion by some parties that worry that resource protection goals may be compromised.

RECOMMENDED PRACTICE

Conservation of natural areas at the site level can be made a more attractive option through flexibility and incentives. Examples of methods to encourage conservation include open space development, reduced stormwater management requirements for environmentally sensitive developments, buffer flexibility, property tax credits, density bonuses, and transferrable development rights.

By-Right Open Space Development

Open space development is a pattern of development that allows for increased density on one portion of a site in exchange for protected open space elsewhere on the site (Principle No. 11). One-third to four-fifths of the site may be preserved as open space (Heraty, 1992). Fifty percent or more of this open space may be dedicated to conservation areas, including regulated areas such as floodplains and jurisdictional wetlands and non-regulated areas such as forests and wild meadows.

In order to encourage open space development, communities should make sure that plan submittal requirements, plan review procedures, and the appeal process are no more arduous than that needed for approval of conventional subdivisions. Designation of open space development as a "by-right" option as opposed to a special exception or variance can further encourage this development option.

Density Compensation

Conservation requirements can result in the loss of buildable land or house lots. Density compensation is a flexible approach to conservation that compensates developers for lost house lots. Specifically, developers are not penalized for conserving natural areas. Instead, they can build approximately the same number of homes in a more compact design (see Table 21.1). The purpose of density compensation is to encourage preservation of stream buffers or other natural areas without penalty to the developer.

Table 21.1: Examples of Density Compensation for Base Density of 1 du/acre

% of Site Lost to Buffer or Other Natural Area	Density Compensation[1]
1 - 10%	1.0
11 - 20%	1.1
21 - 30%	1.2
31 - 40%	1.3
41 - 50%	1.4
51 - 60%	1.5
61 - 70%	1.6
71 - 80%	1.7
81 - 90%	1.8
91 - 91%	1.9

[1] Additional dwelling units allowed over base density of 1 du/acre

Stormwater Credits

Stormwater credits refer to different types of site level techniques that reduce stormwater management costs for developers. They are referred to as "credits" because they reduce runoff volumes and help to avoid construction of more costly stormwater management facilities. The different techniques include conserving natural areas, disconnecting impervious areas, crediting stream buffers, and utilizing environmentally sensitive development. These techniques are described in further detail in Table 21.2.

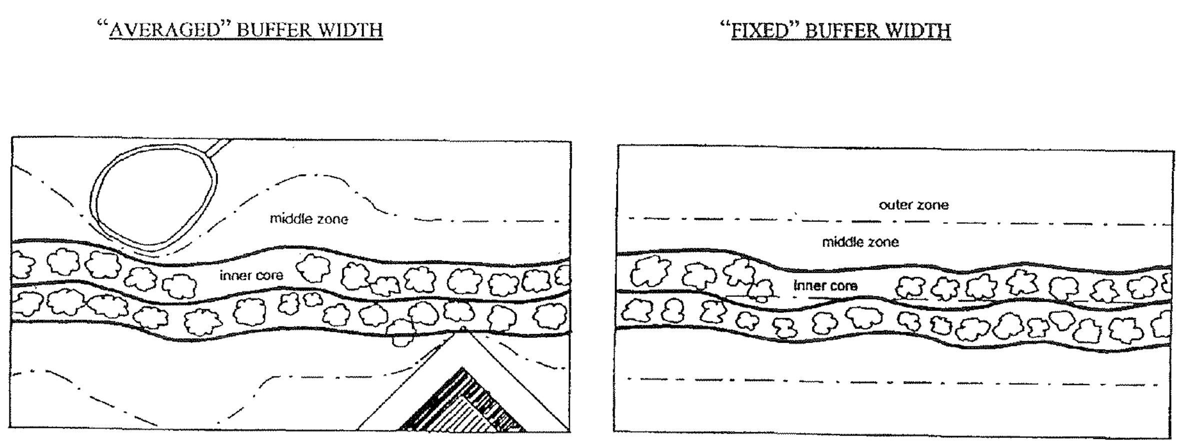
Buffer Averaging

A one hundred foot stream buffer can convert approximately five percent of the total land in a given watershed into unbuildable land. At some sites, this could potentially be a significant hardship for developers. Flexibility can be provided through buffer averaging. Buffer averaging allows developers to narrow the buffer width at some points if the average width of the buffer and the overall buffer area meet the minimum criteria. Buffer averaging is typically used to accommodate existing structures and recover lost lots (Figure 21.1). Variances can also be granted if the developer or landowner can demonstrate severe economic hardship or a unique circumstance that makes compliance with the buffer ordinance difficult. This variance provision should include access to an administrative appeal in case the request for a variance is denied.

Table 21.2: Examples of Stormwater Credits (MDE, 1997)

Types of Credits	Description
Natural area conservation	Given when natural areas are conserved at the site Natural areas retain pre-developed water quality and hydrologic characteristics Example: forest retention areas, non-tidal wetlands, floodplains, steep slopes
Disconnect impervious areas	Given when runoff from small impervious areas is directed to a pervious area where it can be infiltrated or filtered Site is graded to promote overland filtering or bioretention is provided Examples: disconnection of rooftop runoff, direction of parking lot runoff to filters strips
Stream buffers	Given when runoff from pervious and impervious areas is treated by an adjacent stream buffer Buffer is grassed or wooded Use of filter strip also recommended
Environmentally sensitive development	Given when suite of environmentally sensitive site design techniques is applied to low density development Examples: large lot rural residential development

Figure 21.1: Buffer Averaging (Schueler, 1995)



Under buffer averaging, the width of the buffer can vary from point to point, as long as the average width in the parcel meets the local criteria. The streamside zone, however, should not be encroached on.

Property Tax Credit

Property tax credits provide incentives for the owners of conserved land. Under this type of program, communities can reduce, defer, or exempt property taxes on conserved land. The community stipulates how the property must be managed. Conservation easements are usually exchanged for the property tax credit. Owners receive the property tax credit as long as they comply with the conservation easement. Property tax credit programs are particularly attractive to landowners in rapidly developing regions. Market pressure in these regions often lead to significant property tax increases as well as utility, transportation, and other infrastructure special tax assessments (Allmann, 1996). Property tax credit can alleviate financial hardships to landowners affected by market-driven tax increases and may offset some or all of the tax burden associated with rising tax assessments in rapidly growing regions. Minnesota has several programs including:

- Native Prairie Tax Exemption Program: prairies five acres or more in size can be exempted from property tax when this land is maintained in a natural state.
- Minnesota Agriculture Preserve Program: offers $1.50 per acre per year property tax credit for conserved farmland. Farmland receives some protection from eminent domain and annexation, public utility development, and special tax assessments for public works projects (Allmann, 1996).

Other states such as Massachusetts and New Hampshire also allow local property tax credits for land conservation. To date, most property tax credit programs have been employed to conserve prairies and farmland but could be extended to protect natural areas such as forests, stream buffers, and floodplains.

In order to be effective, property tax credit programs must provide a penalty if property is taken out of conservation use to be developed. This "correct use" penalty can be 10 - 25% of the assessed value of the property.

Density Bonus

Under the density bonus option, developers are rewarded for conservation of natural areas and are allowed to build more homes than would have been permitted under the base zoning density. The City of Maple Plains, New York, allows developers to increase the number of house lots by up to 5% based on the amount of open space conserved. Similar to density bonuses, density penalties also serve to encourage conservation of natural areas. Under this approach, the jurisdiction establishes a maximum and minimum density. Developers are allowed to build at the higher density if natural areas and open space techniques are used. If not, developers are restricted to the lower density (CBP, 1997).

Transferable Development Rights (TDRs)

Unlike the options discussed above, transferable development rights (TDR) provide **off-site** rather than on-site density compensation. Under the TDR scenario, landowners in areas targeted for conservation transfer their development rights to areas designated as growth zones. These development rights, usually expressed as residential dwelling units, are sold to developers in the same manner that land is sold. TDR owners can apply the development right to their site, effectively increasing density. For example, a developer in a designated growth zone owns a 20-acre parcel of land zoned at one dwelling unit per acre and wishes to increase the ultimate yield from 20 to 30 homes. The developer can achieve this goal by buying 10 TDRs. The sale of the TDRs means that 10 homes in the designated conservation area will not be built.

Off-site Mitigation

Wetlands are sometimes filled during development. Other disturbances, such as interruption of flow to the wetland, may occur. Developers who impact wetlands may be subject to mitigation requirements. Mitigation requires developers to either minimize damage to wetlands, restore damaged wetlands, or create new wetlands. When the restoration or creation takes place off the development site, it is called off-site mitigation. Off-site mitigation is usually allowed when on-site mitigation (i.e., mitigation at the development site) is not feasible. In 1991, the City of Eugene (Oregon) implemented a policy requiring developers who impact wetlands in designated growth areas to provide off-site mitigation (Lane Council of Governments, 1991).

Off-site mitigation consistent with locally adopted watershed plans should be encouraged. Off-site mitigation can be used to maintain or increase the amount and diversity of wetlands in the watershed. Communities can identify specific wetlands to be protected or restored. Developers who impact wetlands in other portions of the watershed are then required to restore or create wetlands in this designated area. Developers are usually required to restore or create at least one acre for every acre impacted. Additional mitigation can be required for impacts to high value wetlands. Off-site mitigation can also be required for impacts to forests.

Perceptions and Realities about Conservation Incentives

In general, no one is opposed to providing more economical and flexible approaches to conservation. However, some parties may feel that incentives and flexibility provide to many loopholes for developers, ultimately subverting conservation goals. Communities should carefully analyze these issues as they consider changes to their subdivision codes and zoning ordinances to better promote conservation.

Economic Benefits

Proximity to natural areas can significantly increase the marketability of homes, allowing developers to obtain higher prices for homes located near conserved open areas. A survey conducted by Baxter et. al (1985) indicated that proximity to a natural area was one of the preferences most frequently noted by people considering purchasing a home. Fausold and Lilieholm (1996) noted that land use restrictions designed to protect the Chesapeake Bay resulted in an increase in housing prices, ranging from 14 to 27% for homes in the affected areas. Additional potential benefits for landowners as well as developers are presented in Table 21.3. The preservation of natural areas can also provide significant economic benefits for local communities. These benefits are outlined in Principles No. 17 and 20.

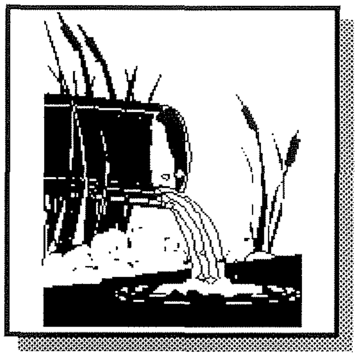
Table 21.3: Incentives for Private Landowners to Preserve Natural Areas

Type of Program	Description	Potential Benefits and Advantages
Conservation Easements	Voluntary agreement to legal transfer of development and land use rights to a piece of property to a conservation trust. Easements may be temporary or permanent.	Landowner retains title to the property. Public access is not required. Easement is tied to the title so that future landowners are bound by agreement. Potential tax deductions are available equal to the appraised value of the easement as a charitable gift. In Maryland, there is a 15-year state and local tax exemption on the land if it remains unimproved.
Land Retirement	Programs administered by governmental agencies which provide financial incentives for the removal of agricultural land from production or to leave natural lands undeveloped. Many of these programs are legislatively funded, and their status relies on the political process.	May provide a reliable and significant source of income. Landowners are capable of generating income from what could be marginal agricultural land. Some financial incentives available at the federal level include: • Partial debt cancellation of FHA loans for conservation easements. • Federal long term rental payments and cost-sharing of up to 50% through the Conservation Reserve Program. • Exclusion of the value of certain land from federal estate tax through the Taxpayer Relief Act.
Property Tax Relief	Reduces, defers, or exempts landowners from property tax assessments on land maintained in the condition stipulated by the program in which they are enrolled.	For some programs, property taxes for landowners are based on agricultural use value rather than market value. Landowners may avoid or defer assessments for public work projects built in the vicinity of enrolled land.
Restoration Cost-share Programs	Compensates a landowner for a share of the cost of projects designed to restore natural areas on private lands.	Owner receives a percentage of the cost of labor and materials for projects. Owners can receive free technical assistance. Owners may use multiple cost share funding sources to piggy-back project costs.
Donation of Land or Sale to Conservation Organization	Self-explanatory	The use of a below market sale to a nonprofit conservation organization may allow the seller to qualify for a charitable donation on their taxes as well as reducing the amount of capital gains tax which may be levied.

Source: Allman, 1996; MD Environmental Trust, 1997

Where to Get Started

Suggested Resources	How to Get a Copy
Land Protection Options: A Handbook for Minnesota Landowners (1996) by Laurie Allman Describes options and incentives for protecting non-regulated natural areas. Discusses potential economic benefits for landowners.	The Trust for Public Land Midwest Region 420 North Fifth Street Suite 865 Minneapolis, MN 55401 612-338-8494
Maryland Stormwater Design Manual (draft 1997) by the Maryland Department of the Environment Describes system of stormwater credits including preservation of natural areas.	Maryland Department of the Environment Water Management Administration 2500 Broening Highway Baltimore, MD 21224 410-631-3543
West Eugene Wetlands Special Area Study, Draft Technical Report (1991)by the Lane Council of Governments Describes methods used to identify protected wetlands and designated development zones. Also describes various options for on-site and off-site mitigation.	Lane Council of Governments 125 East Eighth Avenue Eugene OR 97401 (503) 687-4283 Contact: Steve Gordon, Senior Program Manager
A Guidebook for Creating a Municipal TDR Program (1995) Describes basic process for creating a TDR program. Discusses the amendments to zoning ordinances and provides a step-by-step process.	Maryland Department of the Environment Water Management Administration 2500 Broening Highway Baltimore, MD 21224 410-631-3543
Beyond Sprawl: Land Management Techniques to Protect the Chesapeake Bay (1997) Describes density bonuses and how they can be used to protect natural resources.	Chesapeake Bay Program 410 Severn Avenue Annapolis MD 21403 410-267-5700



PRINCIPLE NO. 22

New stormwater outfalls should not discharge unmanaged stormwater into jurisdictional wetlands, sole-source aquifers, or other water bodies.

CURRENT PRACTICE

Stormwater runoff generated from impervious cover can represent a significant threat to the quality of wetlands, surface water and groundwater. Research has shown that wetlands can be adversely impacted by both the quality and quantity of stormwater from upstream areas (Azous, 1997). Other researchers have found that stormwater runoff exerts an adverse impact on the quality of urban streams (for a review, see CWP, 1998). Sole-source aquifers, which are a key part of the drinking water supply in many communities, can be contaminated if stormwater pollutants are discharged underground (Witten and Horsley, 1995). Stormwater pollutants have also been directly linked to the closure of beaches and shellfish beds in several communities and have affected water quality in water supply reservoirs and urban lakes.

To avoid these impacts, some communities have adopted stormwater management requirements to control the *quantity* and/or the *quality* of stormwater runoff from new development sites. *Quantity* control is usually achieved by detention ponds, and helps minimize flooding and, in some cases, protect downstream channels from erosion. A complementary approach to quantity control is *floodplain management*, where new development is prohibited within the boundaries of the 100 year floodplain. *Quality* control typically involves the construction of *stormwater best management practices (BMPs)*, such as wet ponds, created wetlands, filters, infiltration trenches, and swales that remove pollutants from stormwater runoff and, in some cases, increase groundwater recharge. A *pollution prevention plan* may also be required for some land uses or activities (e.g, industrial sites). The plans consist of ways to prevent pollutants from coming into contact with rainwater and being washed off in stormwater runoff (e.g., spill response, material handling, employee training etc).

More communities will need to adopt stormwater management requirements to comply with EPA's municipal stormwater NPDES permitting program (i.e., Nationwide Pollutant Discharge Elimination System under the Clean Water Act). Currently, communities that have a population greater than 100,000 must have a municipal program to manage stormwater and smaller communities (50,000 to 100,000 will come under these requirements in 1999).

The scope and effectiveness of most local stormwater programs vary considerably in different communities around the country. Some require quantity control, but not quality control. Some programs are limited to floodplain management alone. Others require that pollution prevention plans be submitted, but don't require that BMPs be installed at new development sites. Engineering criteria for local stormwater programs vary widely from one community to another, and few communities link their criteria to solve specific stormwater problems in the watershed.

The cost of providing stormwater quantity and quality can be very high, ranging from $2,000 to $25,000 per impervious acre treated (Brown and Schueler, 1997). The initial cost of constructing stormwater BMPs is borne by the developer, but the long-term cost of maintaining BMPs must be borne by local government or property owners. Maintenance costs can be high. For example, the cost of maintaining a BMP typically exceeds the cost of its construction within twenty years (Wiegand, et al., 1986). Few communities are financially equipped to handle stormwater maintenance (WMI, 1997). The performance, longevity, and appearance of stormwater BMPs drops sharply without regular maintenance.

Recommended Practice

Most communities will need to either establish new stormwater management programs or reinvent their existing ones to better protect local aquatic resources. To become more effective, local stormwater programs must recognize the fundamental importance of site design in solving stormwater problems. By starting at the source--reducing impervious cover and utilizing green space for stormwater treatment--communities can sharply reduce the volume of stormwater runoff that must be treated. The volume of stormwater runoff and the mass of pollutant loads can be reduced as much as 20 to 60% at most development sites simply by implementing the land development principles advocated in this document (see Tables 11.1 and 11.2). A more detailed explanation of the stormwater management benefits of the land development principles can be found in Table 22.1.

While better site design is a critical first step in solving stormwater management problems, most developments will still need stormwater BMPs to control the runoff from the site. Communities should carefully consider how their programs can improve the effectiveness and longevity of stormwater BMPs. Key program elements to consider include:

- Adjustment of existing sizing criteria to ensure that recharge, pollutant removal, channel protection, and flood control objectives are being achieved within the community.
- Clear guidance on how to select, design, and locate stormwater BMPs within local watersheds.
- Creation of detailed engineering performance standards on constructing stormwater BMPs to prevent future safety, aesthetic, and maintenance problems
- A strong local commitment to stormwater maintenance, including inspection, enforcement, and financing
- Meaningful incentives that give developers credit if they apply the land development principles on their sites and reduce stormwater runoff.
- Floodplain management regulations that prevent development within the floodplain where it is prone to damage during extreme floods.

Table 22.1: Stormwater Management Benefits of Model Land Development Principles

Development Principle	Description
Minimize impervious area • Principles No. 1 - 4, 12 (Streets) • Principles No. 6 - 9 (Parking Lots) • Principle No. 13 (Sidewalks) • Principles No. 12, 14 (Driveways)	Minimize the amount of new impervious cover created by new residential development. Less impervious cover means that less stormwater runoff will be generated. Less stormwater runoff results in lower stormwater pollutant loads, and the need for smaller and less expensive stormwater BMPs.
Open space development • Principle No. 11, 12, 15	Open space development incorporates smaller lot sizes to minimize total impervious area and conserve natural areas, thus reducing the amount of stormwater runoff generated at the site.
Vegetated open channels • Principle No. 5	Vegetated open channels remove pollutants by allowing infiltration and filtering to occur. Open channels also encourage groundwater recharge, and can reduce the volume of stormwater runoff generated from a site.
Bioretention Areas • Principle No. 10	A stormwater management practice that uses landscaping and soils to treat stormwater runoff by collecting it in shallow depressions before filtering through soil.
Filter strips • Principle No. 10	A vegetated area that filters sheet flow, removing sediment and other pollutants. The strip may be grass-covered, forested, or of mixed vegetative cover.
Disconnect impervious areas • Principle No. 13 (Sidewalks) • Principle No. 16 (Rooftop Runoff)	Runoff from small impervious areas is directed to a pervious area where it can be infiltrated or filtered. The site is graded to promote overland filtering or bioretention is provided. Examples include directing parking lot runoff to filter strips.
Stream buffers • Principles No. 17, 18	Stream buffers include the 100 year floodplain, thereby preventing flood damages from extreme storms along the stream corridor. Runoff from pervious and impervious areas can also be directed to an adjacent stream buffer, providing some pollutant removal.
Natural area preservation • Principles No. 19 - 21	Natural areas at the site are conserved. These areas preserve pre-developed water quality and hydrologic characteristics. Examples include forest retention areas, non-tidal wetlands, floodplains, steep slopes.

PERCEPTIONS AND REALITIES ABOUT STORMWATER MANAGEMENT

Some communities are reluctant to require stormwater management. There is no one approach to stormwater management; so, to effectively protect waterbodies, communities must develop specific performance criteria based on local conditions. Further, additional staff and funding may be required. Some community associations may not be able to maintain onsite stormwater management facilities. Thus, the local government may ultimately become responsible for the maintenance of numerous residential stormwater facilities. Other impediments to stormwater management include concerns about costs to developers (Table 22.2).

Table 22.2: Perceived Impediments to Stormwater Management

Perception	Facts, Case Studies, and Challenges	
1. The term stormwater management is not universally understood and there is no one best approach to stormwater management.	FACT:	Stormwater management is usually defined by community and state regulators. Management techniques include quantity control for larger storms (e.g., the 2-, 10-, 25-, and/or 100-year storm event); quality control for the first flush of runoff and/or small storm events; and non-structural controls such as zoning restrictions.
	FACT:	There is no one choice for effective stormwater management. Stormwater management requirements should reflect local topographic, soil, and hydrological conditions. The requirements should be flexible and adaptable to local site conditions. A variety of options should be provided, including both structural and nonstructural controls.
2. Implementation of stormwater management may require communities to get additional staff and funds.	FACT:	Implementation of management programs may require restructuring, new staff, or additional funding. However, these additional costs may be offset by the savings achieved due to reduced flooding, improved drinking water quality, and protection of sensitive shellfish and recreational areas among other benefits (fishing, boating, etc.). For example, replacement of contaminated water supplies can be very costly. Witten and Horsley (1995) estimated that the cost for replacing a drinking well for a mid-size municipality ranged from $2.1 - $3.1 million (in1989 dollars). Stormwater management controls could be used to protect the groundwater supplies, reducing or eliminating replacement expenses. .
3. Community associations will be unable to maintain stormwater management facilities. Local governments will be required to maintain the facilities.	FACT:	Communities may wish to promote open space development. Open space design can reduce the amount of stormwater generated at a site. Thus, stormwater management cost and maintenance requirements can be reduced.
	FACT:	Annual maintenance costs for structural controls is approximately 2% of the construction cost (Brown, 1997). Community associations should ensure that sufficient funding is available for maintenance.
	CHALLENGE:	Communities may wish to consider legal options to ensure maintenance. One option is setting a minimum development size requirement for structural controls. For example, only allowing stormwater ponds in developments of fifty homes or more. Liens are another option.
4. The geotechnical and wetland studies required to confirm the location of wetlands and aquifers may be prohibitively expensive.	CHALLENGE:	True. However, NPDES regulations may require developers to provide stormwater management.
	FACT:	Open space design and other nonstructural controls can reduce stormwater management requirements. This reduced requirement may offset additional costs associated with geotechnical and wetland studies.
	FACT:	Communities can provide incentives to developers to protect and conserve natural resources such as wetlands (see Principle No. 21).

CASE STUDY: FALMOUTH, MASSACHUSETTS

The Falmouth, Massachusetts Planning Board has developed a stormwater management program to protect drinking water supplies and coastal waters. This program includes performance criteria for new development based on nutrient loading and carrying capacity. The nutrient load is the amount of nitrogen or phosphorous generated by the development and transported by stormwater runoff. The carrying capacity is the maximum nutrient concentration or load that can be sustained without degrading the water supply. In Falmouth, the carrying capacity for nitrate in drinking water supplies is 10 mg/l.

Developers building in public water supply watersheds or draining to coastal waters must compute the nutrient load for the proposed development. Stormwater management is required if the projected nutrient exceeds the carrying capacity. Developers must revise the site design to include management measures that will reduce the nutrient load to an acceptable level. Management measures that are effective in nitrogen removal are emphasized. These include nonstructural controls such as minimizing lot size.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Green Growth: Protecting Storm Water During Development, A Guide for Local Community Officials (draft 1997) by Brooks, Calhoun, and Tidwell Emphasizes water quality control techniques during all phases of construction. Targeted at local officials.	North Texas Council of Governments PO Box 5888 Arlington TX 76005-5888 817-695-9210
Maryland Stormwater Design Manual (draft 1997) by the Maryland Department of the Environment Describes structural and nonstructural stormwater management controls. Provides performance and design criteria for controls associated with new development.	Maryland Department of the Environment Water Management Administration 2500 Broening Highway Baltimore, MD 21224 410-631-3543
Operation, Maintenance, and Management of Stormwater Management Systems (1997) by E. Livingston, E. Shaver, and J. J. Skupien. Provides detailed information on the operation, maintenance, and management of stormwater management systems, including model inspection forms.	Watershed Management Institute P.O. Box 14 Ingleside, Maryland 21644 410 758-2731

Suggested Resources	How to Get a Copy
Conservation Design for Stormwater Management (1997) by the Delaware Department of Natural Resources and Environmental Control and The Environmental Management Center of the Brandywine Conservancy	Delaware Department of Natural Resources and Environmental Control Division of Soil and Water Conservation Sediment and Stormwater Program 89 Kings Highway Dover, DE 19901
A Guide to Wellhead Protection (1995) by Jon Witten and Scott Horsley Provides techniques for protecting aquifers.	American Planning Association Planners Book Service 122 South Michigan Avenue Suite 1600 Chicago, IL 60603 312-786-6344

APPENDIX A

MODEL SHARED PARKING ORDINANCE PROVISIONS

Weekday Parking Occupancy Rates
Percent of Basic Minimum Needed During Time Period
(Source: ITE, 1995)

Uses	Weekday Night Midnight-6 a.m.	Weekday Day 8 a.m. - 5 p.m.	Weekday Evening 6 p.m. - Midnight
Residential **	100%	60% (CBD=80%)	100%
Office	5	100	20
Commercial-Retail	5	90	80
Hotel (CBD)+	100	80	100
Hotel (non-CBD)+	100	70	100
Restaurant	10	70*	100
Movie Theater	10	40	80
Entertainment	10	40	100
Conference/Convention	5	100	100

*Fast-food, breakfast or lunch-oriented establishment = 100 percent.

+Excludes conference/convention facilities.

**The minimum requirements for residents' own spaces must be met in exclusive (nonshared) parking, but guest parking and extra residents' parking may be shared.

Weekend Parking Occupancy Rates
Percent of Basic Minimum Needed During Time Period
(Source: ITE, 1995)

Uses	Weekend Night Midnight - 6 a.m.	Weekend Day 8 a.m. - 5 p.m.	Weekend Evening 6 p.m. - Midnight
Residential **	100%	80%	100%
Office	5	5	5
Commercial-Retail	5	100	70
Hotel (CBD)+	100	80	100
Hotel (non-CBD)+	100	70	100
Restaurant	20	70*	100
Movie Theater	10	80	100
Entertainment	50	80	100
Conference/Convention	5	100	100

*Fast-food, breakfast or lunch-oriented establishment = 100 percent.

+Excludes conference/convention facilities.

**The minimum requirements for residents' own spaces must be met in exclusive (nonshared) parking, but guest parking and extra residents' parking may be shared.

Appendix B

Model Legal Agreement for Shared Parking

MODEL LEGAL AGREEMENT FOR SHARED PARKING

(Source: Wells, 1995)

NOTE: *What follows is a shared parking easement which is offered as an example of an agreement which may be acceptable to the City of Olympia under the provisions of Section 18.38.180 - Shared Parking Facilities of the Olympia Municipal Code. This is not to say that other methods and approaches would not be acceptable to the City of Olympia, however, such agreements need to be reviewed by the City Attorney's office.*

EASEMENT FOR SHARED PARKING

WHEREAS, the parties to this easement wish to take advantage of the shared parking provisions of Chapter 18.38 of the Olympia Municipal Code.

1. For consideration of Ten Dollars ($10.00) paid in hand, present and future benefits to be derived by Grantor and other good and valuable consideration, receipt of which is hereby acknowledged, Grantor, ______________________________,
(Name)
doing business as ______________________________,
(Name)
hereby conveys and warrants to Grantee, ______________________________,
(Name)
doing business as ______________________________,
(Name)
its successors, heirs and assigns, a nonexclusive, perpetual easement for motor vehicle parking on the following described real property:

[Legal Description of Servient Estate]

situated in the City of Olympia, Thurston County, Washington for the benefit of Grantee's property described as:

[Legal Description of Dominant Estate]

situated in the City of Olympia, Thurston County, Washington.

Such parking easement shall be applicable only to the following parking lot(s) located on the above-described servient estate. *[Include a map or sketch of the lots or parking facilities applicable to this easement, should more than one exist upon the subject property.]*

SUBJECT TO THE FOLLOWING:

1. This easement shall not be altered or terminated without the express written permission of the Director of Community Planning and Development of the City of Olympia or his/her designee.

2. Grantor covenants that there are ___(#)___ of motor vehicle parking spaces on the above-described property and that Grantor shall not decrease that number of parking spaces without the express written permission of the Director of Community Planning and Development of the City of Olympia or his/her designee.

3. Grantee shall post and maintain signage on the dominant and servient estates directing its customers and employees to parking.

4. Grantor may temporarily close the subject parking lot(s) for maintenance and repair. Cost of repair and maintenance shall be paid by ____________________

5. Neither Grantee nor Grantor shall change, alter or expand the use of their respective properties described above so as to require additional parking under the provision of the Olympia Municipal Code in excess of existing parking spaces without the express written permission of the Director of Community Planning and Development of the City of Olympia or his/her designee.

DATED this ______ day of ____________________, 199___.

GRANTOR

____
(Signature)

____
(Print Name)

GRANTEE

____
(Signature)

____
(Print Name)

GLOSSARY

Access Street:

The lowest order street in the hierarchy of streets, it conducts traffic between individual dwelling units and higher order streets.

Alternative Lot Widths:

Site design which utilizes a combination of narrow and wide lots to offer a varied streetscape. (See graphic in principle 12)

Angled Z lot:

A lot design where units are tilted at a 30 to 45° angle relative to the street. (See graphic in principle 12)

Average daily traffic (ADT):

The average total number of vehicles that traverse a road on a typical day. For residential streets, the ADT is usually about 10 trips per residence times the number of residences.

Aquifer:

A permeable geologic formation capable of storing and yielding groundwater to wells and springs.

Best Management Practice (BMP):

A structural device designed to temporarily store or treat stormwater runoff in order to mitigate flooding, reduce pollution and provide other amenities. BMPs include wet ponds, created wetlands, filters, and infiltration trenches.

Bioretention:

A water quality practice that utilizes landscaping and soils to treat urban stormwater runoff by collecting it in shallow depressions before filtering it through a fabricated planting soil media.

Buffer:

An area adjacent to a shoreline, wetland or stream where development is restricted or prohibited.

Buffer averaging:

A technique for delineating the width of a buffer such that the buffer boundary can be narrower at some points along the stream and wider at others such that its average width meets the minimum criteria.

By-right open space development:

A form of development in which the developer does not need to seek special approval from planning boards in order to use open space design at a site.

CBD:

Acronym for commercial business district.

Community Association:

A planned residential condominium, cooperative and/or homeowner group with the primary function of addressing the concerns and needs of residents within a specific geographic area. Community associations usually include fees and their responsibilities may include maintenance, enforcement of allowable uses, and protection of open space areas from encroachment and future development.

Cul-de-sac:

A local access street with a closed circular end which allows for vehicle turnarounds.

Curvilinear street pattern:

A street design which follows the natural topography of the land and uses curving roads and cul-de-sacs to reduce vehicle speeds and cut-through traffic.

Density bonus:

A form of incentive to promote conservation natural and open space areas. Developers are allowed to build more homes than allowed by local zoning ordinances if such areas are conserved.

Density compensation:

Granting a credit for higher density elsewhere on a site to compensate for developable land lost due to environmental considerations.

Dryfall:

The deposition of atmospheric pollutants on the land surface.

Excess parking:

Parking spaces that are constructed over and above the number required or predicted based on the parking demand ratio for a particular land use or activity.

Floodplain:

Areas adjacent to a stream or river that are subject to flooding or inundation during severe storm events (Often called a 100 year floodplain, it would include the area or flooding that occurs, on average, once every 100 years).

Floodplain management:

To limit flood damage by prohibiting new development within the boundaries of the 100-year floodplain. In existing developments within the floodplain, management includes maintaining and increasing open space areas along waterways.

Frontage requirements:

A requirement in the subdivision code that mandates that each lot within a particular zoning category have a minimum length that fronts along the street.

Green space:

The proportion of open space that is retained in an undisturbed vegetative state.

Gross density:

The maximum number of dwelling units allowed within a particular zoning class, expressed in terms of dwelling units per acre.

HOV:

Acronym for High Occupancy Vehicle, which is used in reference to highway lanes that are reserved for vehicles with two or more occupants (carpooling).

Hybrid street network:

A street layout which incorporates both grid and curvilinear street patterns in a "wheel-and-spoke" design that conserves important natural features but still allows for interconnected roads.

Infiltration trench:

A stormwater quality treatment practice that consists of a stone-filled reservoir that allows runoff and accompanying pollutants to settle into the soil where further filtering can take place.

Impervious cover:

Any surface in the urban landscape that cannot effectively absorb or infiltrate rainfall.

Imperviousness:

The percentage of impervious cover within a development site or watershed.

Infill development:

Directing development away from rural areas by developing vacant lots or enhancing existing property in urban areas.

Jurisdictional wetland:

A wetland which is regulated by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act.

Lot:

A parcel of undivided land.

Minimum lot size:

The minimum area or dimension of an individual lot within a particular zoning category, as specified within the local subdivision code.

Net site density:

The maximum number of dwelling units which can be constructed on a site after all unbuildable land areas are subtracted out.

NPDES:

Acronym for the National Pollutant Discharge Elimination System, which regulates point source and stormwater discharge.

Open space:

A portion of a development site which is permanently set aside for public or private use and will not be developed with homes. The space may be used for passive or active recreation, or may be reserved to protect or buffer natural areas.

Open space development:

The use of designs which incorporate open areas into a development site. These areas can be used for either passive or active recreational activity or preserved as naturally vegetated land.

Open space management:

The legal and financial arrangements needed to manage open space according to its prescribed use (i.e., natural areas, recreation).

Ordinary care:

The basic level of care that can be expected of reasonably experienced and prudent professional in determining design decisions for roadways.

Parking lane:

A section of the roadway which has been designed to provide on-street parking for residential neighborhoods.

Parking demand:

The number of parking spaces actually used for a particular land use.

Parking ratios:

An expression of the required parking spaces that must be provided for a particular land use, often stated as a ratio of x spaces per y units.

Parking stall:

The total area needed to accommodate the parking of a single vehicle, extending outward from the curb, and between the stripes.

Perennial stream:

A stream channel that has running water throughout the year.

Pollution prevention plan:

A requirement for some land uses or activities (e.g., industrial sites) that outlines techniques to prevent pollutants from being washed off in stormwater runoff (e.g., spill response, material handling, employee training, etc.)

Queuing street:

A narrowed street which contains a single travel lane and which may occasionally require an opposing driver to pull over to allow an oncoming vehicle to pass.

Right-of-way:

The design area of a roadway which includes the pavement width, vegetated strip, sidewalk and space designated for utility location.

Riparian:

The land area which borders a stream or river and which directly affects and is affected by the water quality. This land area often coincides with the maximum water surface elevation of the 100 year storm.

Sand filter:

A stormwater quality treatment practice whereby runoff is diverted into a self-contained bed of sand. The runoff is then strained through the sand, collected in underground pipes and returned back to the stream or channel.

Sedimentation:

Soil particles suspended in stormwater that can settle in stream beds and disrupt the natural flow of the stream.

Setback:

The distance which a structure must be located from property lot lines or other structures as specified in the local zoning plan.

Shared parking:

A parking strategy which reduces the total number of parking spaces needed by allowing adjacent users to share a parking area during noncompeting hours of operation.

Sight distance:

The length of roadway ahead visible to the driver. The minimum sight distance should be long enough to allow a vehicle traveling at or near the speed limit to stop before reaching a motionless object in its path.

Sole–source aquifer:

An aquifer whose recharge area is the only source of drinking water to both public water supplies and private wells.

Steep slope:

An area of a development site that is too steep to (a) safely build on or (b) has a high potential for severe soil erosion during construction.

Stormwater credits:

A form of incentive for developers to promote conservation of natural and open space areas. Developers are allowed reductions in stormwater management requirements when they use techniques to reduce stormwater runoff at the site.

Stormwater management:

The programs to maintain quality and quantity of stormwater runoff to pre-development levels.

Stormwater outfall:

A discharge point for stormwater runoff which has been collected in a conveyance system.

Stormwater quality control:

The removal of pollutants from stormwater runoff through the use of stormwater best management practices (BMPs).

Stormwater quantity control:

To mitigate flooding through the use of detention ponds that restrict stormwater flow.

Stream buffer:

A variable width vegetated zone located along both sides of a stream.

Structured parking:

More commonly referred to as parking garages, these are parking facilities which expand vertically to provide parking on various levels. Structured parking allows more parking on sites where space for single level parking lots is no longer available.

Subdivision:

A new development that splits an existing tract, parcel or lot into two or more parts.

Subdivision code:

A set of local requirements that govern the geometric dimensions of a particular zoning category, and also specifies the nature and geometry of roads, drainage, waste disposal and other community services that must be constructed to serve the development.

SUV:

Acronym for sport utility vehicle.

Swale:

An open drainage channel or depression explicitly designed to detain and promote the filtration of stormwater runoff.

Transferable development rights:

A form of incentive for developers in which the developer purchases the rights to an undeveloped or underdeveloped piece of property in exchange for the right to increase the number of dwelling units on another site. Often used to concentrate development density in certain land areas.

Transit share:

The percentage of trips using a particular mode of travel.

Unbuildable lands:

The portions of a development site where structures cannot be located for physical or environmental reasons.

Variance:

A special allowance granted to a developer which permits the use of designs different from the requirements of the current code.

Vegetated open channels:

Also known as swales, grass channels, and biofilters. These systems are used for the conveyance, retention, infiltration and filtration of stormwater runoff.

Wetfall:

The deposition of atmospheric pollutants on the land surface that are washed out by precipitation.

Xeriscaping:

Landscaping which uses drought-tolerant vegetation instead of turf to reduce the amount of water required to maintain a lawn.

Zero Lot Line:

The location of a structure on a lot in such a manner that one or more sides of the structure rests directly on a lot line.

Zipper lot:

Lot design approach in which the rear lot line moves back and forth to vary the depth of the rear yard and concentrate open space on the side of the lot.

Zoning:

A set of regulations and requirements that govern the use, placement, spacing and size of buildings and lots within a specific area or in a common class (zone).

REFERENCES

ADA Hotline, 1997. Personal Communication. Americans with Disabilities Act Hotline, Washington, D.C.

Adams, L. 1994. Urban Wildlife Habitats-A Landscape Perspective. University of Minneapolis Press. Minneapolis, MN.

Allman, L. 1996. Land Protection Options: A Handbook for Minnesota Landowners. The Nature Conservancy, the Minnesota Department of Natural Resources, the Trust for Public Land, and the Minnesota Land Trust.

American Association of State Highway and Transportation Officials (AASHTO). 1994. A Policy on Geometric Design of Highways and Streets. AASHTO, Washington, DC. No. 33.

American Automobile Manufacturers Association (AAMA). 1997. Personal Communication. Detroit, Michigan.

American Planning Association. 1997. Creating Transit Supportive Land Use Regulations. PAS Report. APA. Chicago, Illinois.

American Society of Civil Engineers. 1990. Residential Streets. 2nd edition. Co-authors: National Association of Home Builders, and Urban Land Institute. Published by the Urban Land Institute, Washington, D.C. (see also National Association of Home Builders or Urban Land Institute)

Americans with Disabilities Act of 1990, 101st Cong., 2nd sess., S.933

Andreasen, Alan and C. Tyson. 1993. Improving Tree Management Practices of Home Builders: A Social Marketing Approach. Forest Policy Center, American Forests, Washington, DC.

Arendt, Randall. 1997. Designing Open Space Subdivisions. Natural Lands Trust, Media PA.

Arendt, Randall, et. al. 1994. Rural by Design. American Planning Association, Chicago, IL.

Arendt, Randall. 1994. Designing Open Space Subdivisions. Natural Lands Trust, Media, PA.

Arendt, Randall. 1996. *Creating Open Space Networks* in Environment and Development (May/June 1996 Issue). American Planning Association, Chicago, IL.

Azous, A. L. and R. R. Horner, Editors. 1997. Wetlands and Urbanization: Implications for the Future. Final report of the Puget Sound Wetlands and Stormwater Management Research Program. Washington State Department of Ecology, Olympia, WA, University of Washington, Seattle, WA.

Baltimore County Code, §14-331 to §14-350. Baltimore, MD.

Bannerman, et. al. 1993. Sources of Pollutants in Wisconsin Stormwater. Water Science Technology, 28(3-5): 241-259.

Bannerman, R. and R. Dodds. 1992. Sources of Pollutants in Wisconsin Stormwater. Wisconsin Department of Natural Resources, Madison WI.

Barrett, Thomas S. and Diehl, Janet. 1988. The Conservation Easement Handbook. Trust for Public Land and Land Trust Alliance, San Francisco, CA.

Baxter E., G. Mulamootil and D. Gregor. 1985. A Study of Residential Stormwater Impoundments; Perceptions and Implications. Water Resources Bulletin 21(1): 83-88.

Bay Area Stormwater Management Agencies Association (BASMAA). January 1997. Start at the Source: Residential Site Planning and Design Guidance Manual for Stormwater Quality Protection. BASMAA, San Francisco, CA.

Bell, Warren. 1998. Personal Communication. Alexandria (VA) Department of Public Works, Alexandria VA.

Best Friends Magazine. 1997. Edited by Michael Mountain. Best Friends Animal Sanctuary, Kanab, Utah. December, 1997.

BFI of Montgomery County. 1997. Personal Communication. Rockville, MD.

Bookout, L. 1992. Nontraditional Town Planning: Cars, Pedestrians, and Transit. Urban Land, February, pp.10-15.

Booth, D. B., Leavitt, J., and Peterson, K. 1997. The University of Washington Permeable Pavement Demonstration Project - Background and First-Year Results. Center for Urban Water Resources Management, Department of Civil Engineering, University of Washington. Seattle, Washington.

Bray, T.L. and V.F. Rhodes. In Search of Cheap and Skinny Streets. 1997. Places, 11(2):32-39.

Bray, T.L. 1997. Personal Communication. Portland Office of Transportation, Portland, Oregon.

Brown, Whitney E. 1997. The Economics of Stormwater BMPs in the Mid-Atlantic Region. Center for Watershed Protection, Ellicott City, MD. Prepared for Chesapeake Research Consortium, Edgewater, MD.

Brown, W. and T. Schueler. 1997. National Pollutant Removal Database for Stormwater BMPs. Center for Watershed Protection, Ellicott City, MD.

Brown, W. and D. Caraco. 1996. Task 2 Technical Memorandum: Innovative and Effective Erosion and Sediment Control Practices for Small Sites. Center for Watershed Protection, Ellicott City, MD.

Bucks County Planning Commission. 1980. Performance Streets: A Concept and Model Standards for Residential Streets. Bucks County Planning Department, PA.

Cahill, T. 1994. A Second Look at Porous Pavement/Underground Recharge. Watershed Protection Techniques 1(2). Center for Watershed Protection, Ellicott City, Maryland.

Caraco, Deborah and Richard Claytor. 1997. Stormwater BMP Design Supplement for Cold Climates. Center for Watershed Protection, Ellicott City MD.

Caraco, D. and Claytor, R. 1997. Stormwater BMP Design Supplement for Cold Climates. Center for Watershed Protection, Ellicott City, MD.

Castelle, A.J., A.W. Johnson, and C. Conolly. 1994. Wetland and Stream Buffer Size Requirements - A Review. Journal of Environmental Quality, Vol. 23, No. 4. pp 878-882.

Center for Watershed Protection. 1998. Nutrient Loading From Conventional and Innovative Site Development, for Chesapeake Research Consortium. Center for Watershed Protection, Ellicott City, MD.

Center for Watershed Protection. 1998. Rapid Watershed Planning Handbook, Review Draft. Center for Watershed Protection, Ellicott City MD.

Center for Watershed Protection. 1997. Stormwater BMP Survey for Cold and Snowy Climates. Center for Watershed Protection, Ellicott City, MD.

Charleston Harbor Projects. 1995. Getting a Rein on Runoff: How Sprawl and the Traditional Town Compare. South Carolina Coastal Conservation League. Land Development Bulletin, No 7., Charleston, SC.

Chesapeake Bay Foundation. 1996. A Dollars and Sense Partnership: Economic Development and Environmental Protection. Chesapeake Bay Foundation. Annapolis, MD. 21 pp.

Chesapeake Bay Program (CBP). 1997. Beyond Sprawl: Land Management Techniques to Protect the Chesapeake Bay. Chesapeake Bay Program, US EPA. CBP/TRS-190/97, EPA 903-B-97-005. Annapolis, MD.

Chesapeake Bay Program (CBP). 1993. Cost of Providing Government Services to Alternative Residential Patterns. Chesapeake Bay Program, Subcommittee on Population Growth and Development, US EPA. EPA Contract No. 68-WO-0043. Annapolis, MD

City of Eugene (Oregon) Planning and Development Department. 1991. West Eugene Wetland Special Area study. Draft Technical Report. Co-authors: Lane Council of Governments and City of Eugene Public Works Engineering, Eugene, OR.

City of Portland Planning Bureau. 1996. Zoning Code, Chapter 33.248, Landscaping and Screening. City of Portland Planning Bureau, Portland, Oregon.

City of Portland Planning Bureau. 1996. Zoning Code, Chapter 33.266, Parking and Loading. City of Portland Planning Bureau, Portland, Oregon.

Claytor, R. and T. Schueler. 1996. Design of Stormwater Filtering Systems. Center for Watershed Protection, Ellicott City, MD.

Cochran, J. 1997. Personal Communication. US Fire Administration, Emmitsburg, MD.

Coder, Dr. Kim D. 1996. Identified Benefits of Community Trees and Forests. University of Georgia Cooperative Extension Service, Forest Resources Unit. Publication FOR96-39

Coffman, Larry. 1997. Low-Impact Development Design Manual. Department of Environmental Resources, Prince Georges County, Maryland.

Cohen, R. 1997. Fact Sheet # 3: Functions of Riparian Areas for Wildlife Habitat. Massachusetts Dept. Of Fisheries, Wildlife and Environmental Law Enforcement, Riverways Program.

Colleton County Zoning Board. 1996. Colleton County Zoning Ordinance, Article VI, Off Street Parking and Loading. Colleton County, South Carolina.

Cooke, S. 1991. Wetland Buffers - A Field Evaluation of Buffer Effectiveness in Puget Sound. Washington Department of Ecology, Olympia, WA

Corish, K. 1995. Clearing and Grading: Strategies for Urban Watersheds. Environmental Land Planning Series. Metropolitan Washington Council of Governments, Washington, DC.

Correll, Mark R., JaneH. Lillydahl and Larry D. Singell, 1978. The Effects of Greenbelts on Residential Property Values: Some Findings on the Political Economy of Open Space. Land Economics 54(2).

Daniels, Stevie. 1995. The Wild Lawn Handbook: Alternatives to the Traditional Front Lawn. Macmillian Press, New York, NY. 223 pages

Delaware Department of Natural Resources and Environmental Conservation. 1997. Conservation Design for Stormwater Management. Delaware Department of Natural Resources and Environmental Conservation, Dover, DE.

Desbonnet, A., P. Pogue, V. Lee, and N. Wolff. 1994. Vegetated buffers in the coastal zone: a summary review and bibliography. Coastal Resources Center, University of Rhode Island.

DeVaul, R. 1997. Unpublished memorandum. Shaker Heights Department of Public Service. City of Shaker Heights, OH.

Dewberry and Davis. 1996. Land Development Handbook: Planning, Engineering and Surveying. McGraw-Hill Press, New York, NY.

Dey, T. 1997. The Real Influence of the Americans with Disabilities Act (ADA) on Local Design Standards. Widener University Environmental Law Clinic, Philadelphia, PA.

Dreher, D.W. and T.H. Price. 1992. Best Management Practice Guidebook for Urban Development. Northeastern Illinois Planning Commission, Chicago IL.

Dreher, D. and T. Price. 1994. Reducing the Impact of Urban Runoff: The Advantages of Alternative Site Design Approaches. Northeastern Illinois Planning Commission, Springfield IL.

Dreher, D.W. and T.H. Price. 1994. Reducing the Impacts of Urban Runoff: The Advantages of Alternative Site Design Approaches. Northeastern Illinois Planning Commission, Chicago IL.

El Paso County Department of Transportation. 1981. Subdivision Criteria Manual. El Paso County TX.

Emmerling-DiNovo, C. 1995. Stormwater Detention Basins and Residential Locational Decisions. *Water Resources Bulletin* 31(3): 515-521.

EPA, Office of Water. 1996. Green Development - Literature Summary and Benefits Associated with Alternative Development Approaches. Prepared by TetraTech, Inc.

Ewing, R. 1996. Best Development Practices: Doing the Right Thing and Making Money at the Same Time. American Planning Association, Chicago, IL.

Fairfax County (Virginia) Fire and Rescue Department. 1997. Personal Communication.

Fausold, C. And R. Lilieholm. 1996. The Economic Value of Open Space: A Review and Synthesis. Lincoln Institute of Land Policy, Cambridge, MA.

Federal Highway Administration. 1997. Flexibility in Highway Design. U.S. Department of Transportation, Federal Highway Administration, Washington, DC. Publication No. FHWA-PD-97-062.

Federal Transit Administration. 1997. Parking Supply Management. Web address: http://www.fta.dot.gov/fta/library/planning/tdmstatus/FTARPKSP.HTM.

Federal Highway Administration. 1996. Pedestrian and Bicycle Crash Types of the Early 1990's. U.S. Department of Transportation, Federal Highway Administration, Washington, DC. FHWA-RD-95-163.

Fletcher, June. 1997. Home Buyers are Shunning Developers' Pricey Extras. The Wall Street Journal, Friday, November 21, 1997.

Flink, C. A., and Searns, R. M. 1993. Greenways: A Guide to Planning, Design, and Development. L. Schwarz, editor. The Conservation Fund and Island Press, Washington, DC.

Fontana, Lisa. 1998. Personal Communication. Institute of Transportation Engineers, Washington, D.C.

Frederick County. Streets and Roads Design Manual. Frederick, MD.

Frederick County Department of Public Works. Design Guidelines for Water and Sewer Facilities. Frederick County Department of Public Works, Frederick, MD.

Frink America Incorporated. September 1997. Personal Communication. Frink America Incorporated, Clayton, New York.

Galli, John. 1993. Analysis of Urban BMP Performance and Longevity in Prince George's County, Maryland. Metropolitan Council of Governments, 202 pp.

Gerckens, Laurence. 1998. *Landmarks: Chatman Village* in Land Development (Spring-Summer 1998 Issue). National Association of Home Builders, Washington DC.

Hanaeus, J. and Stenmark, C. An Alternative Road Section for Northern Sweden. Division of Sanitary Engineering, Lulea University, S-951 87 Lulea, Sweden.

Hanson, S. And R. Rowntree. 1988. Influence of Urban Forest Cover on Radiation, Temperature, and Runoff in the Salt Lake Basin, Utah. pp. 412-415.

Hardigg, Bill. 1998. Personal communication. Bill Hardigg Consulting, Annandale, VA

Harney, K.R. 1996. The Nation's Housing - Home Buyers Want Modern Towns with Lots of Old Fashioned Charm. Washington Post, Final Edition. As Cited in EPA, 1996, Green Development: Literature Summary and Benefits Associated with Alternative Development Approaches.

Heraty, M. 1992. An Assessment of the Applicability of Cluster Development Regulations as a Nonpoint Source Pollution Best Management Practice. Metropolitan Washington Council of Governments. Produced for US EPA Office of Wetlands, Oceans and Watersheds. Washington, DC.

Heraty, M. 1993. Riparian Buffer Programs: A Guide To Developing and Implementing a Riparian Buffer Program as an Urban Stormwater Best Management Practice. Metropolitan Washington Council of Governments. Produced for US EPA Office of Wetlands, Oceans and Watersheds. Washington, DC

Horner, Richard, Joseph Skupien, Eric Livingston, and Earl Shaver. 1994. Fundamentals of Urban Runoff Management: Technical and Institutional Issues. Terrene Institute, Washington DC.

Institute of Transportation Engineers. 1987. Parking Generation. 2nd Ed. Institute of Transportation Engineers, Washington, D.C. 220 pp.

Institute of Transportation Engineers. 1993. Guidelines for Residential Subdivision Street Design. Institute of Transportation Engineers, Washington, D.C.

Institute of Transportation Engineers. 1994a. Guidelines for Parking Facility Location and Design. Institute of Transportation Engineers, Washington, D.C.

Institute of Transportation Engineers Transportation Planning Council Committee 5P-8. 1994b. Traffic Engineering for Neo-Traditional Neighborhood Design. Institute of Transportation Engineers. Washington, D.C.

Institute of Transportation Engineers. 1995. Shared Parking Planning Guidelines. Institute of Transportation Engineers, Washington, D.C.

Institute of Transportation Engineers Transportation Planning Council Committee 5P-8. 1997. Traditional Neighborhood Development Street Design Guidelines. Institute of Transportation Engineers. Washington, D.C.

International Parking Institute Representative. October 1997. Personal Communication.

International Society for Trenchless Technology. 1997. Introduction to Trenchless Technology. London, UK.

International Association of Fire Chiefs. 1997. Personal Communication and Sample Uniform Fire Code Policy.

James City County. 1997. James City County Zoning Ordinance. Section 20-86, Landscaping and tree preservation requirements. James City County, Virginia.

Keller, C.M.E., C. Robbins, and J. Hatfield. 1993. Avian Communities in Riparian Forests of Different Widths in Maryland and Delaware. Wetlands, Vol. 13, No. 2, June 1993. Produced by The Society of Wetland Scientists.

Knoblauch, R. L., B. H. Tustin, S. A. Smith, and M. T. Pietrucha. 1988. Investigation of Exposure Based Pedestrian Accident Areas: Crosswalks, Sidewalks, Local Streets and Major Arterials. US DOT, Federal Highway Administration, Office of Research and Development, Maclean, VA. Publication No. FHWA/RD-88.

Lacy, Jeff. 1990. An Examination of Market Appreciation for Clustered Housing with Permanent Open Space. Center for Rural Massachusetts, University of Massachusetts, Amherst, MA.

Land Trust Alliance. 1993. Conservation Options - A Landowners Guide. Land Trust Alliance, Washington, DC.

Lane Council of Governments. 1991. West Eugene Wetlands Special Area Study, Draft Technical Report. Lane Council of Governments, Eugene OR.

Laurel Creek Nursery Newsletter. 1997. Landscape to Raise the Resale Value of Your Home. Laurel Creek Nursery, Christiansburg, VA.

Lincoln Institute of Land Policy. 1996. Summary of Expense/ Revenue Ratios for Southern New England Towns. As taken from Cost of Community Services in Southern New England, Southern New England Forest Consortium. 1995.

Lincoln Institute of Land Policy. 1995. Alternatives to Sprawl. Lincoln Institute of Land Policy, Cambridge, MA.

Liptan, T. and C.K. Brown. 1996. A Cost Comparison of Conventional and Water Quality-Based Stormwater Designs. City of Portland, Portland OR.

MacDonald, L. 1996. Forests and the Quality of the Urban Environment. American Forests, Autumn, 1996.

Markowitz, F. August 1995. Shared Parking Planning Guidelines. Institute of Transportation Engineers, Washington, DC.

Maryland Code. Title 26, Chapter 02

Maryland Environmental Trust. 1997. Personal Communication. Crownsville, MD

Maryland Department of the Environment. 1997. Draft Maryland Stormwater Design Manual. Baltimore, MD.

Maryland DNR Forest Service. 1996. Maryland Forests: A Health Report. Maryland Department of Natural Resources, Annapolis, MD.

Maryland Department of Natural Resources. 1991. Forest Conservation Manual: Guidance for the Conservation of Maryland's Forests During Land Use Changes Under the 1991 Forest Conservation Act. Maryland Department of Natural Resources, Forestry Division, Annapolis MD.

Maryland National Capital Park & Planning Commission. 1991. Environmental Management of Development in Montgomery County, Maryland. MNCPPC, Planning Department, Environmental Planning Division, Ellicott City, MD.

Maurer, George. 1996. A Better Way to Grow: For More Livable Communities and a Healthier Chesapeake Bay. Chesapeake Bay Foundation, Annapolis MD.

McNamara, Robert. 1997. Personal Communication. National Association of Home Builders, Washington, DC.

Michael, H. J., K. J. Boyle and R. Bouchard. 1996. Water Quality Affects Property Prices: A Case Study of Selected Maine Lakes. University of Maine Agricultural and Forest Experimentation Station. Miscellaneous Report 398. 15 pp.

Montgomery County (Maryland) Department of Public Works and Transportation. 1996. Design Standards. Rockville, MD.

Montgomery County (Maryland) Fire Department. 1997. Personal Communication.

Montgomery County (Pennsylvania) Planning Commission. 1995. Guidebook for Creating a Municipal TDR Program. Montgomery County Planning Commission, PA.

Morales, D. J. 1980. The Contribution of Trees to Residential Property Values. Journal of Arboriculture 6(11): 301-302.

Morris, M. 1989. PAS Memo: Parking Standards - Problems, Solutions, Examples. American Planning Association. Chicago, Illinois. 6 pp.

Morris, Marya. 1997. Subdivision Design in Flood Hazard Areas. PAS Report 473. APA. Chicago, Illinois.

National Arbor Day Foundation. 1996. Placing a value on trees. Tree City USA Bulletin No. 28, Dr. James R. Fazio, Editor. Nebraska City, NE.

National Association of Homebuilders. 1986. Cost Effective Site Planning. Washington DC.

National Association of Home Builders. 1990. Residential Streets. 2nd edition. Co-authors: American Society of Civil Engineers, and Urban Land Institute. Urban Land Institute, Washington, D.C. (see also National Society of Civil Engineers or Urban Land Institute).

National Association of Home Builders. 1993. Proposed Model Land Development Standards and Accompanying Model State Enabling Legislation. NAHB Research Center, Upper Marlboro, MD.

National Association of Home Builders. 1997. Housing Facts and Figures. NAHB, Washington, DC.

National Association of Homebuilders. 1998. *Portfolio: The Fields of St. Croix* in Land Development (Spring-Summer 1998 Issue). National Association of Homebuilders, Washington DC.

National Highway Institute (NHI). 1996. Pedestrian and Bicyclist Safety and Accommodations. U.S. Department of Transportation, Federal Highway Administration, National Highway Traffic Safety Administration, Maclean, VA. Publication # FHWA-HI96-029. NHI Course No. 38061.

National Park Service, Rivers, Trails and Conservation Assistance Program. 1995. Economic Impacts of Protecting Rivers, Trails and Greenway Corridors. Fourth Edition. National Park Service, Western Office, San Francisco, CA.

Newsweek Magazine. 1995. Fifteen Ways to Fix the Suburbs. May 15, 1995.

New Jersey Administrative Code, Title 5, Chapter 21. 1997. Residential Site Improvement Standards

Northeastern Illinois Planning Commission (NEICP). 1997. Reducing the Impacts of Urban Runoff: The Advantages of Alternative Site Design Approaches. Northeastern Illinois Planning Commission, Chicago, IL.

Off-Street Parking Requirements for Albany, New York

Off-Street Parking Requirements for Dearborn, Michigan

Off-Street Parking Requirements for El Paso County, Colorado

Off-Street Parking Requirements for Irvine, California

Off-Street Parking Requirements for James City County, Virginia

Off-Street Parking Requirements for Loudoun County, Virginia

Off-Street Parking Requirements for Maple Plain, Minnesota

Off-Street Parking Requirements for Naperville, Illinois

Off-Street Parking Requirements for Nashville, Tennessee

Off-Street Parking Requirements for Olympia, Washington

Off-Street Parking Requirements for Portland, Oregon

Off-Street Parking Requirements for Sioux City, Iowa

Off-Street Parking Requirements for St. Tammany Parish, Louisiana

Off-Street Parking Requirements for Trenton, New Jersey

Orange Water and Sewer Authority. 1997. Final Recommendations for Protection the Cane Creek Water Supply. Carrboro, NC.

Pelley, Janet. 1997. The Economics of Urban Sprawl. Watershed Protection Techniques, Volume 2, Number 4. Center for Watershed Protection, Ellicott City, MD.

Petit, Jack, Debra Basset, and Cheryl Kollin. 1995. Building Greener Neighborhoods: Trees as Part of the Plan. Published jointly by American Forests and Home Builder Press, National Association of Home Builders. Washington, DC. 118 pages

Pisarski, A.E. 1996. Commuting in America II: The Second National Report on Commuting Patterns and Trends. ENO Transportation Foundation, Inc.

Pitt, R. E. 1987. Small Storm Urban Flow and Particulate Washoff Contributions to Outfall Discharges. Doctorate Thesis. University of Wisconsin-Madison.

Porter, Douglas R., P. L. Phillips, and T. J. Lassar. 1988. Flexible Zoning: How it Works. Urban Land Institute, Washington, DC. 200 pp.

Portland Office of Transportation. 1994. Report on New Standards for Residential Streets in Portland Oregon.

Prince George's County Department of Environmental Resources (PGDER). 1997. Low Impact Development Design Manual. Prince George's County, MD.

Prince George's County Department of Environmental Resource (PGDER). 1998. Interim Results of the Bioretention Performance Monitoring Study. University of Maryland, College Park, MD.

Prince George's County (Maryland) Fire Department. 1997. Personal Communication.

Probuilder Magazine. 1997. 23rd Annual Consumer Survey.

Raleigh News and Observer. 1997. Carrboro to Limit, but not Outlaw, Cul-de-Sacs. North Carolina Department of Transportation, Raleigh, NC.

Roser, K., E. Richardson and P. Bristow. 1997. Determining the Stewardship Costs of Conservation Easements. Colorado Coalition of Land Trusts.

Runoff Report. July/August 1997. Honeycombs Control Erosion, Runoff. p. 3.

Sample Homeowner Association Documents provided by Maryland National Park and Planning Commission and Montgomery County, Office of Public Records and Montgomery County Consumer Affairs, Rockville, MD 1997.

Schueler, Thomas, R. 1995. Site Planning for Urban Stream Protection. Center for Watershed Protection, Ellicott City, MD. Prepared for the Metropolitan Washington Council of Governments, Washington, DC.

Schueler, Thomas, R. 1997. The Economics of Watershed Protection. Watershed Protection Techniques, Vol.2, No. 4, June, 1997. Center for Watershed Protection, Ellicott City, MD.

Schulz, D. F. 1994. Reinventing Public Transportation. Remarks to the Regional V Biennial Conference, U.S. Department of Transportation, Federal Transit Administration. May 24, 1994. Chicago, Illinois.

Seattle Transportation (SEATRAN). 1998. Seattle's Street Trees. Seattle Department of Transportation. Seattle, WA.

Smith, Thomas. 1984. Flexible Parking Requirements. Planning Advisory Service Report No. 377. American Planning Association, Chicago, Illinois. 40 pp.

Soulé, Michael E. 1991. Land Use Planning and Wildlife Maintenance: Guidelines for Conserving Wildlife in an Urban Landscape. Journal of the American Planning Association, Vol.57, No. 3, Summer 1991. American Planning Association, Chicago, IL. pp. 313-323

South Carolina Coastal Conservation League (SCCCL). Fall 1995. Getting a Rein on Runoff: How Sprawl and Traditional Town Compare in SCCCL Land Development Bulletin (Number 7). South Carolina Coastal Conservation League, Charleston, SC.

Spackman, S. And J. Hughes. 1994. Assessment of Minimum Stream Corridor Width for Biological Conservation: Species Richness and Distribution Along Mid-Order Streams in Vermont, USA. Biological Conservation Vol. 71 (1995) pp 325-332. Elsevier Science Limited, Great Britain

St. Tammany Parish Zoning Board. 1996. St. Tammany Parish Land Use Ordinance. St. Tammany Parish, Louisiana.

Stabenfeldt, L. 1995. Residential Street Strategies for Urban Watersheds. Metropolitan Washington Council of Governments. US EPA. Washington, DC.

Steuer, et. al., 1997. Sources of Contamination in an Urban Basin in Marquette, Michigan and an Analysis of Concentrations, Loads, and Data Quality. U.S. Geological Survey Water Resources Investigation Report, No. 97-4242.

Streiner, C. and J. Loomis. 1996. Estimating the Benefits of Urban Stream Restoration Using the Hedonic Price Method. Dept. of Agriculture and Resource Economics, Colorado State University. 18 pp.

Suburban Maryland Building Industry Association (SMBIA). 1990. Unpublished data on the unit cost of residential subdivision development in suburban, Maryland.

Swift, Peter, Dan Painter, and Matthew Goldstein. 1998. Residential Street Typology and Injury Accident Frequency. Swift and Associates, Longmont CO.

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

Taft, G. Alexander. June 1997. Building a "Livable" Street System. New Castle Business Ledger, New Castle, DE.

Terrene Institute. 1997 Honeycombs Control Erosion, Runoff. in Runoff Report. July/August 1997. Terrene Institute, Alexandria, VA.

Transportation Research Board. 1987. Designing Safer Roads: Chapter 6. Tort Liability and Geometric Design. National Research Council, Transportation Research Board, Washington, D.C.

US Fish and Wildlife Service. 1988. 1985 National Survey of Hunting, Fishing and Wildlife Associated Recreation. U.S. Government Printing Office, Washington, DC.

U.S. Fish and Wildlife Service. 1993. 1991 National Survey of Fishing, Hunting, and Wildlife Associated Recreation. United States Dept. of Interior, Washington, D.C.

United States Post Office, Fleet Maintenance Center. 1997. Personal Communication. Maclean, VA.

U.S. Water News. 1997. Loss of trees in Atlanta area produces increased stormwater costs. U.S. Water News Online, August 1997.

US EPA. 1992. National Pollutant Discharge Elimination System Application Deadlines, General Permit Requirements for Storm Water Associated with Industrial Activity; Final Rule. 40 CFR Part 122. Federal Register, Vol. 57. No. 64.

US EPA. 1993. Guidance for Specifying Management Measures for Nonpoint Pollution in Coastal Waters. EPA 840-B-92-002, Washington, DC.

USDA Forest Service. 1996. Forest and Riparian Buffer Conservation: Local case studies from the Chesapeake Bay Program. USDA Forest Service, Washington, DC. 105 pp.

Urban Land Institute. 1983. Shared Parking. Urban Land Institute, Washington, DC. 145 pp.

Urban Land Institute. 1990. Residential Streets: 2nd edition. Co-authors: American Society of Civil Engineers, National Association of Home Builders. Urban Land Institute, Washington, D.C. (see also American Society of Civil Engineers and National Association of Home Builders).

Urban Land Institute. 1992. Density by Design (DBD). James W. Wetling and Lloyd W. Bookout, editors. Urban Land Institute, Washington, DC.

Urban Land Institute. 1997. America's Real Estate. Washington, DC.

Virginia State Fire Marshal's Office. 1997. Personal Communication. Richmond, VA

Washington Suburban Sanitary Commission, 1996. Pipeline Design Manual. Laurel, MD.

Waste Management of Montgomery County. 1997. Personal Communication. Rockville, MD.

Watershed Management Institute. 1997. Operation, Maintenance, and Management of Stormwater Management Systems . Watershed Management Institute, Ingleside, MD.

Wells, C. October 1997. Personal Communication. City of Olympia, Washington.

Wells, C. 1994. Impervious Surface Reduction Technical Study. Draft Report. City of Olympia Public Works Department. Washington Department of Ecology. 182 pp.

Wells, C. 1995. Impervious Surface Reduction Study: Final Report. City of Olympia Public Works Department. Water Resources Program. Olympia, WA. 206 pp.

Welsch, D. 1991. Riparian Forest Buffers. U.S. Dept. of Agriculture Forest Service. Forest Resources Management. FS Pub. No. NA-PR-07-91. Radnor, PA. 22 pp.

Weyerhauser Company. 1989. The Value of Landscaping. Weyerhauser Nursery Products Division. Tacoma, WA.

Widener University Environmental Law Clinic. 1997. Legal brief on municipal liability for fallen trees and wildfires. Widener University Environmental Law Clinic, Philadelphia, PA.

Wiegand, Cameron, Thomas Schueler, Wendy Chittendon, and Debra Jellick. 1986. The Cost of Urban Runoff Quality Controls. H.W. Henniker

Wildlife Habitat Enhancement Council. 1992. The Economic Benefits of Wildlife Habitat Enhancement on Corporate Lands. Silver Spring, MD.

Willson, R. W. 1992. Estimating the Travel and Parking Demand Effects of Employer-Paid Parking (Abstract). California University, Berkeley University of California Transportation Center. Berkeley, CA. 94720. 13 pp.

Witten, Jon and Scott Horsley. 1995. A Guide to Wellhead Protection. American Planning Association, Chicago IL.

Woodsmall, D. L. 1998. Personal Communication. Natelli Communities. Gaithersburg, MD.

Zepp, Andrew. 1998. Personal Communication. Land Trust Alliance, Washington, DC.