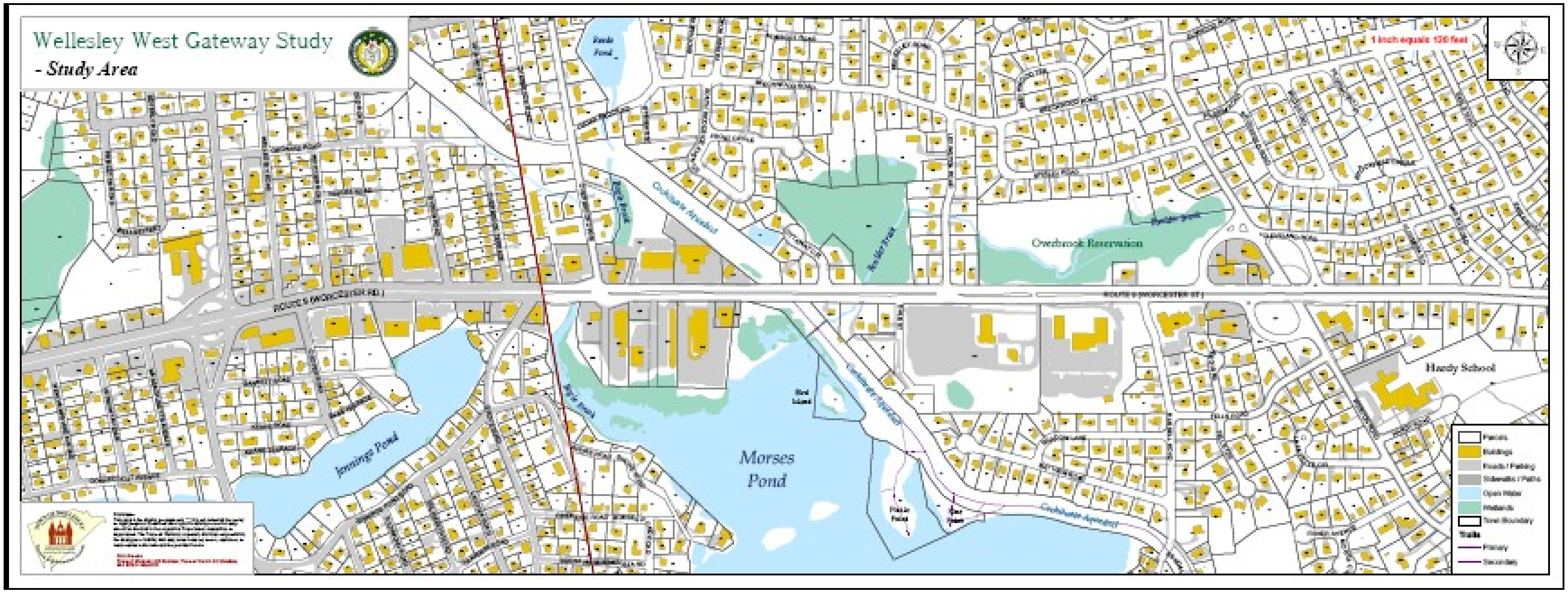
APPENDICES

A. Study Area


Wellesley West Gateway Study
- Study Area
Morses Pond
Jennings Pond
Overbrook Reservation
Hardy School
1 inch equals 120 feet

B. Scope of Work

PLANNING STUDY
DRAFT SCOPE OF WORK
ROUTE 9 @ NATICK LINE
ST. JAMES CHURCH SITE

Study Area – The land consists of the lots having frontage on the north and south sides of Route 9 (Worcester Street) from the Natick Town Line to and including the intersection of Route 9 and Weston Road. The specific lots involved are numbered #859-1005 (odd), 854-990 (even) and #315 Weston Road (public housing).

The Project shall include:

Preparation of an Outline for an Interactive Public Process.

Meeting with Town Staff to review plan documents and obtain additional details from Town in advance of first public forum. Town will assemble all relevant planning materials and provide synopsis of the materials and a history of planning efforts.

Present proposed process to Planning Board for review/discussion on October 24, 2006.

Identification of stake-holders. Recommendations for a Steering Committee.

Conducting a Public Forum
Notification/s to be the responsibility of Town of Wellesley

Overview of the Planning process:
Break out into small groups, dot votes
Re-assemble for reports of break-out groups, summation of issues and priorities.

Town of Wellesley GIS:
Need Maps – land use, development constraints, environmental resources, zoning & transportation networks

Determine:
Assets & likes
Challenges & dislikes
Things that are missing
Opportunities for change

MAPC: 1 day
MWGMC: 2.5 days

Preparation of a Vision Statement for the study area created out of discussion at the Forum.

THE STUDY SHALL IDENTIFY:

Past planning efforts;

Land Use:

Physical conditions and constraints, land characteristics, including environmental considerations;

Legal status, zoning and regulatory considerations;

Conceptual land use goals for the area and for each major parcel including St. James and the Wellesley Motor Inn;

Desirable future uses considering improving the tax base as well as degree of compatibility with surrounding areas;

Uses or classes of uses which should be encouraged and discouraged;

MAPC: .5 days
MWGMC: 3 days

Transportation:

Opportunities for pedestrian and bicycle circulation, trails, sidewalks and amenities with attention to safety and links to and between existing uses in the area and to other destinations;

Opportunities to improve traffic circulation;

Opportunities to promote transportation demand management and public transportation and/or links to public transportation;

Application of New Highway Design Manual/Guidebook/Regional Bike Plan to above areas of planning

Town will provide assistance from traffic consultant as needed.

MAPC Transportation Planner: 3 days

Economic Vitality:

Recommendations to promote the economic vitality of the area considering current and future land uses.

Housing:

Opportunities for additional 40B housing as well as opportunities for assisted living with medical support.

Environmental Considerations:

Measures to improve the watershed ecology and the health of Morse's Pond. Recommendations to include land uses and engineering measures (stormwater systems) that would not degrade Morse's Pond but may improve water quality and the environment.

Route 9 Corridor

Considerations for compliance with the recommendations contained in the Mass Highway Route 9 Corridor Plan.

MAPC: 2 days
MWGMC: 6 days

Chapter 40 Considerations:

Opportunities to advance community housing needs;

Opportunities for building preservation and reuse;

Next steps and recommendations for further or more detailed study.

MAPC: 1 day
MWGMC: 4 days

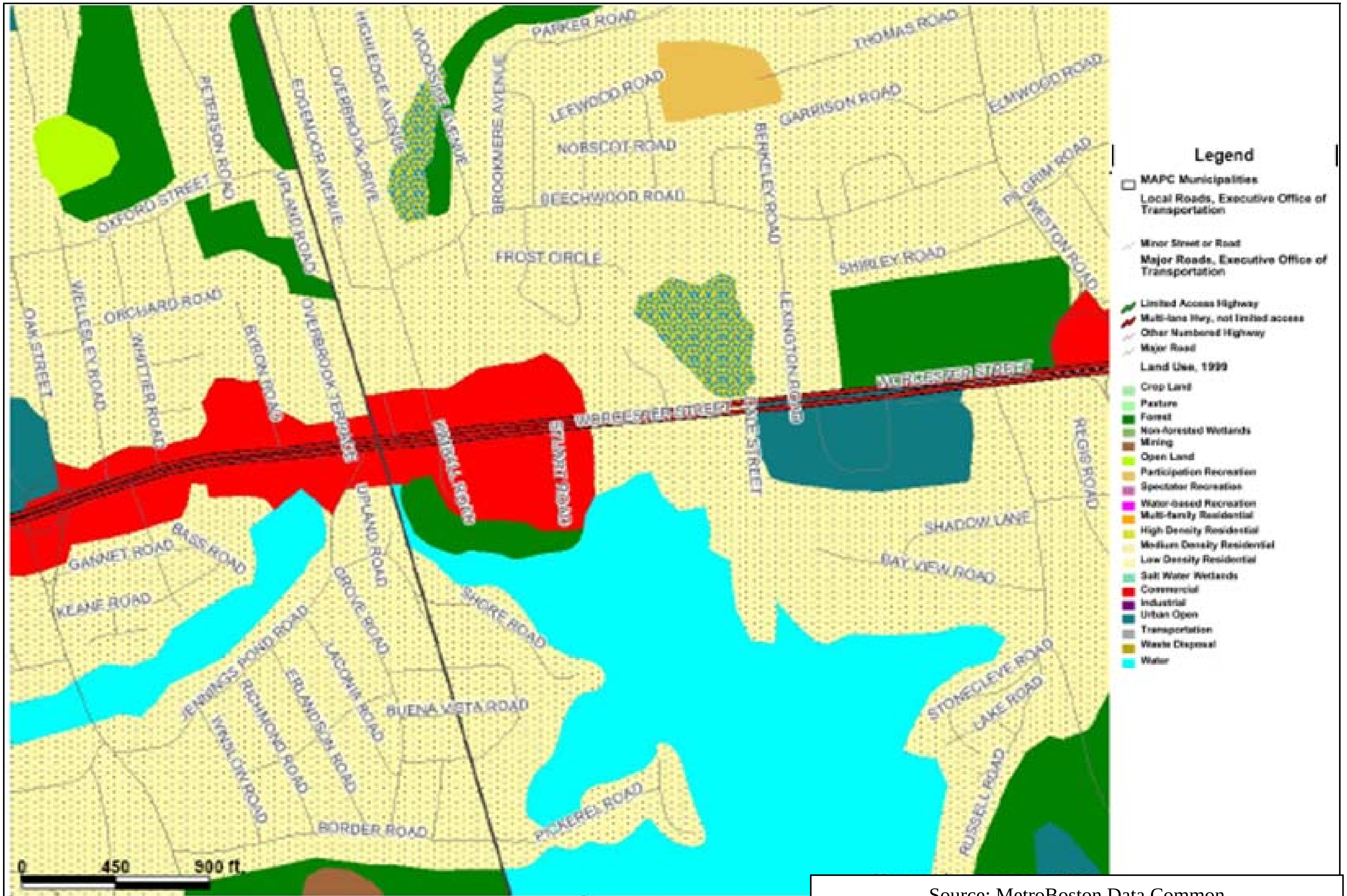
Meetings with town staff and Planning Board subcommittee
3 meetings with Planning Board
2 public forums

Total Cost to Town of Wellesley = $10,000

C.

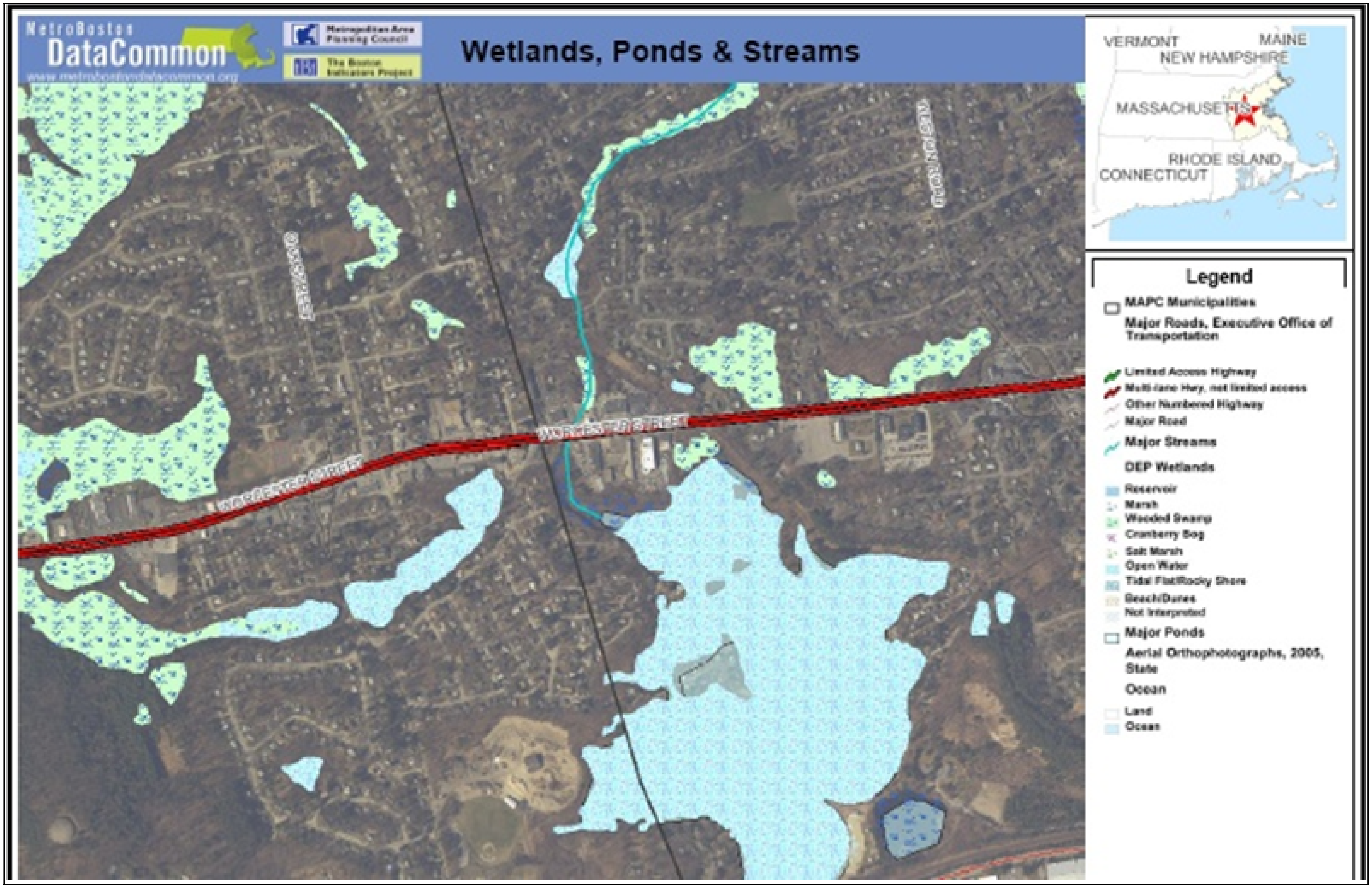
0

Land Uses as of 1999

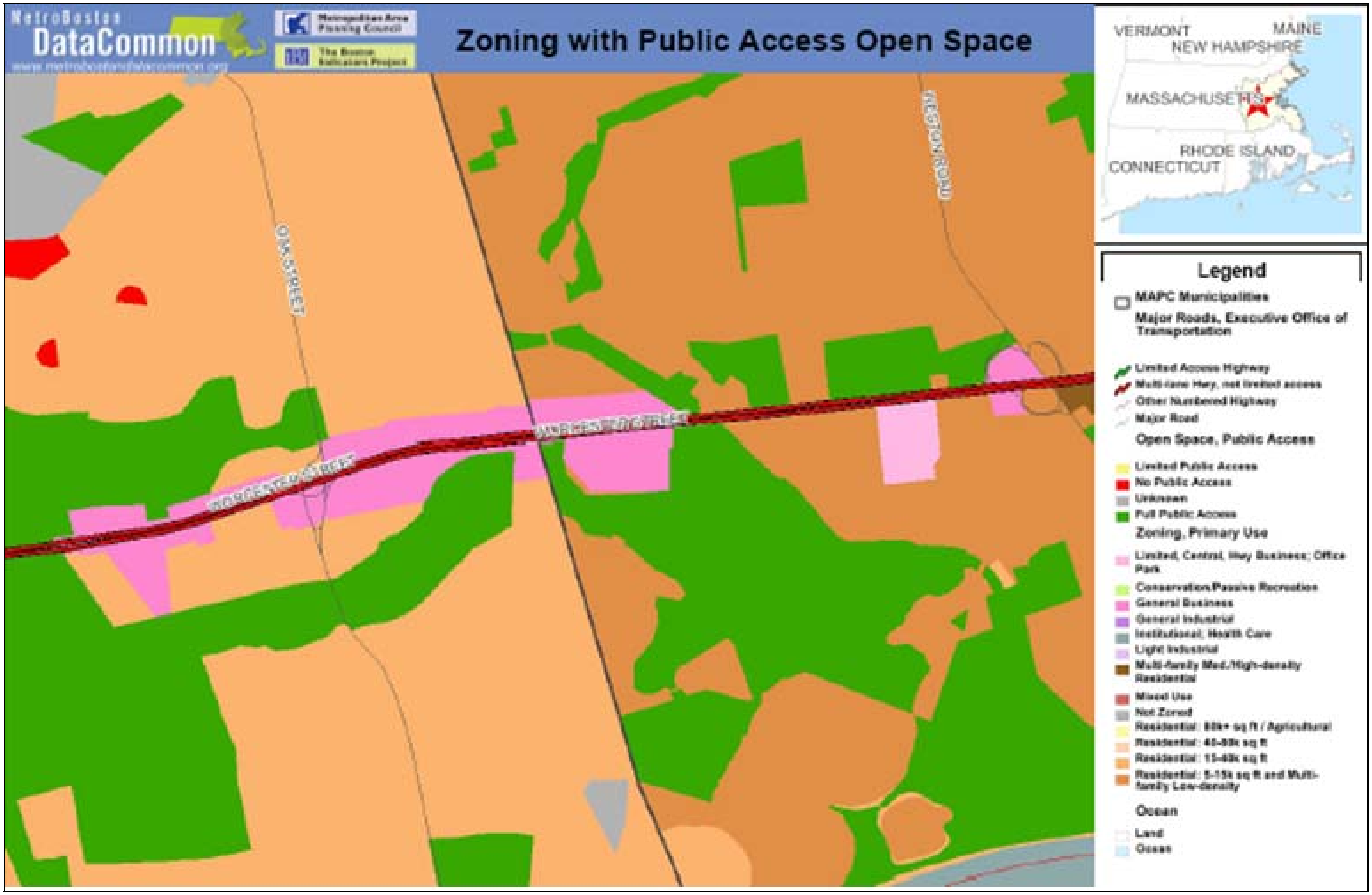


Source: MetroBoston Data Common

D. Wetlands, Ponds and Streams



E. Zoning with Public Access Open Space



F. Public Participation

December 14, 2006

Wellesley West Gateway Forum

7:30	**Welcome – Rosemary Donahue, Planning Board Vice-Chair** ***The Town of Wellesley, in collaboration with MetroWest Growth Management Committee(MWGMC) and the Metropolitan Area Planning Council (MAPC), is seeking your thoughts and advice about the Route 9 Corridor from the Natick town line to Weston Road.***
7:35	**Introductions – Marc Draisen, MAPC Executive Director**
7:45	**Overview** –Brief history of planning efforts **Rick Brown, Town of Wellesley Planning Director**
7:55	**Existing Zoning** - **Meghan Conlon, Town Planner**
8:00	**Process Explanation and Ground Rules** **Donna Jacobs, MWGMC Director** **Mark Racicot, MAPC Manager, Government Services**
8:05	**Group Discussion** Determine: - Assets & likes - Challenges & dislikes - Opportunities for change
8:50	**Prioritizing Opportunities To Move Ahead** ***Participants will rank priority issues using the Dot Voting Method***
9:10	**Wrap Up – What We've Learned, Next Steps, Thank You** **Rick Brown, Town of Wellesley Planning Director**

June 7, 2007

Wellesley West Gateway Forum

7:30	**Welcome – Don McCauley** ***The Town of Wellesley, in collaboration with MetroWest Growth Management Committee (MWGMC) and the Metropolitan Area Planning Council (MAPC), is seeking your thoughts and advice about the Route 9 Corridor from the Natick town line to Weston Road.***
7:35	**Overview** –Brief history of planning efforts, Existing Zoning **Meghan Conlon, Town Planner**
7:50	**Recap of December Forum** **Donna Jacobs, MWGMC Director**
8:00	**What's Happened Since December?** - **Rick Brown** - **Morse's Pond** **Neal Seaborn, Chairman of the Wellesley Natural Resources Commission**
8:30	**Tools for Your Consideration** - **Low Impact Development** - **Mixed Use Development** - **Traditional Neighborhood Development** - **Expedited Permitting**
9:00	**Wrap Up – Next Steps** - **What we heard tonight** - **What happens over the summer?** > **Jim Gallagher's work on transportation/traffic issues** > **Martin Pillsbury's work on environmental issues** - **Next Event – September 20th**

Wellesley West Gateway Forum

Open Space/Natural Resources

1. *There are natural resources within the study area. Which natural resources should be protected?*
2. *The study area is adjacent to town-owned land where either playing fields or trails could be placed. Is this an important factor to consider when planning future development and/or redevelopment?*
3. *The aqueduct is a regional historic asset. Should it also serve as a trail system?*

Housing

1. *Is this study area a location where Wellesley can make some progress in ensuring that Wellesley is affordable for your children?*
2. *What creative opportunities can we take to provide a range of housing types and densities?*
3. *Would the study area be a good location for "empty-nester" housing?*

Economic Development

1. *Are their improvements that can be made within the study area to keep the commercial life of Wellesley viable?*
2. *Is additional commercial and/or industrial development needed or wanted in this study area to support the tax base? If so, how could that be accommodated?*
3. *Should mixed use development be a major component?*
4. *Should the study area become a business district that would serve nearby neighborhoods?*

Transportation

1. *Are additional sidewalks necessary? Where and why?*
2. *Other than sidewalks, what improvements should be made to make pedestrians safe?*
3. *Where are the most dangerous sections of roadways or intersections?*
4. *What steps can Wellesley take to encourage alternative modes of transportation and energy efficient transportation in the study area?*
5. *Is parking in the study area insufficient at present? How can it be improved?*
6. *Is it important to create off-road connections between lots/businesses in the study area?*

Aesthetics

1. *The study area is the gateway to Wellesley. What should be done to visually improve the study area?*
2. *Overhead utility wires are often viewed as a blight on an area. Is burying the overhead utilities important to the future success of the study area?*
3. *Is signage an issue within the study area?*
4. *Landscaping can be an important factor in creating an attractive setting. How important is landscaping in redevelopment within the study area?*

G. Sample Design Standards

High density mixed use neighborhood district

(D) ***Land Use Standards*.**

(1) *Density*. Residential developments in the High Density Mixed-Use Neighborhood District shall have an overall minimum average density of twenty (20) dwelling units per net acre of residential land.

(a) The minimum residential density of any phase in a multiple-phase development plan shall be at least sixteen (16) dwelling units per acre of residential land.

(2) *Dimensional Standards*.

(a) Minimum building height for new structures, or for additions to existing structures when such additions exceed twenty-five (25) percent of the gross floor area of such existing structures, shall be one and one-half (1½) stories.

(b) Maximum building height shall be five (5) stories.

(c) Minimum front yard setback from an arterial street shall be forty-five (45) feet and from all other streets shall be thirty (30) feet. For all setback standards, building walls over thirty-five (35) feet in height shall be set back an additional one (1) foot beyond the minimum required, for each two (2) feet or fraction thereof of wall or building that exceeds thirty-five (35) feet in height. Terracing or stepping back the mass of large buildings is encouraged.

(E) ***Development Standards*.**

(1) *Buildings.*

(a) Doorways Facing Streets. New buildings shall provide doorways facing the street, at grade level or slightly elevated.

(b) Relationship of Doorways to Streets. If the street is a nonarterial street, then such doorways required under subsection (a) above shall be principal entrances with sidewalk access to the street. If the street is an arterial street, then such doorways may be secondary (e.g. for patio or deck access only).

(c) Front Yards. Building design, in conjunction with site design, shall include structured elements to mark the transition from the public street to doorways. Examples of such elements are porches, pediments, pergolas, low walls or fencing, railings, pedestrian light fixtures and hedges.

(d) Roof Form. Buildings shall have either: 1) sloped roofs, or 2) combined flat and sloped roofs, provided that the sloped portion(s) forms a substantial part of the building and is related to the street facade, the integral structure and building entries.

(e) Facade Variations. Buildings shall be articulated with projections, recesses, covered doorways, balconies, covered box or bay windows and/or other similar features, dividing large facades into human-scaled proportions that reflect single-family dwellings nearby and avoiding repetitive monotonous, undifferentiated wall planes.

(f) Outdoor Activity. Buildings and extensions of buildings shall be designed to form outdoor spaces such as balconies, terraces, patios, decks or courtyards.

(2) *Site Design.*

(a) Street Sidewalks. Developments with new construction or with additions which exceed twenty-five (25) percent of the gross floor area of the existing structure shall include replacement of all existing substandard sidewalks with sidewalks which comply with the current regulations of the city.

(b) Parking Lots. Development plans shall be arranged so that any new parking lots or other vehicle use areas are located in side or rear yards, not in front yards

Corridor District:

(a) Maximum building height for all nonresidential uses shall be six (6) stories. Maximum building height for residential uses shall be three (3) stories.

(b) All new structures greater than eighty thousand (80,000) square feet in gross leasable area shall be subject to Planning and Zoning Board review.

(c) Any building addition that exceeds eighty thousand (80,000) square feet in gross leasable area and exceeds twenty-five (25) percent of the gross leasable area of the existing building shall be subject to Planning and Zoning Board review.

(4) *Density/Intensity*. All residential development in the Corridor District shall have an overall minimum average density of seven (7) dwelling units per net acre of residential land.

(5) *Mix of Housing Types*. A mix of permitted housing types shall be included in any development plan proposing residential uses as secondary uses. The following standards are intended to promote a variety of housing within such a development plan:

(a) A minimum of two (2) housing types shall be required on any residential portion of a development plan greater than ten (10) acres but less than thirty (30) acres in size, including parcels which are part of a phased development. A minimum of three (3) housing types shall be required on any residential portion of a development plan greater than thirty (30) acres in size, including parcels which are part of a phased development.

(b) If single-family detached housing is proposed, at least an equivalent number of single-family attached housing, two-family dwellings or multi-family dwelling units (or combination thereof) must also be provided.

(c) Lot sizes and dimensions shall be varied for different housing types to avoid monotonous streetscapes.

(d) Lot pattern. The lot size and layout pattern shall be designed to allow buildings to face toward a street.

(6) *Access to a park, central feature or gathering place*. Within any development proposal that contains a residential component larger than ten (10) acres in size, at least ninety (90) percent of the dwellings shall be located within one thousand three hundred twenty (1,320) feet (one-quarter [¼] mile) of either a neighborhood park, a privately owned park or a central feature or gathering place that is located either within the project or within adjacent development, which distance shall be measured along street frontage without crossing an arterial street. Such parks, central features or gathering places shall contain one (1) or more of the following uses:

(a) Public parks, recreation areas or other open lands.

(b) Privately owned parks meeting the following criteria:

1. Size. Such private parks must be a minimum of ten thousand (10,000) square feet.

2. Location. Such parks must be highly visible, secure settings formed by the street layout and pattern of lots and easily observed from streets. Rear facades and rear yards of dwellings shall not abut more than two (2) sides or more than fifty (50) percent of the perimeter frontage of the park.

3. Accessibility. All parts of such parks shall be safely and easily accessible by pedestrians, and open to the public.

4. Facilities. Such parks shall consist of multiple-use turf areas, walking paths, plazas, pavilions, picnic tables, benches or other features for various age groups to utilize.

5. Ownership and Maintenance. Such parks may, in the discretion of the city, be acquired by the city (through dedication or purchase), or be privately owned and maintained by the developer or property owners' association.

6. Storm Drainage. When integrating storm drainage and detention functions to satisfy this requirement, the design of such facilities shall not result in slopes or gradients that conflict with other recreational and civic purposes of the park.

(c) Community facilities or neighborhood support/recreation facilities (which are permitted as an accessory use to housing). If one (1) of these buildings or structures is used to meet the requirements of this subsection, then it must also include a year-round, publicly accessible, outdoor space of at least ten thousand (10,000) square feet in a usable configuration. Such a space may be a park-like lawn, garden, plaza, pavilion or courtyard to

accommodate such activities or outdoor gatherings, neighborhood events, picnicking, sitting or active and/or passive recreation.

(7) *Access to Neighborhood Center*. At least ninety (90) percent of the dwellings of a residential development proposal shall be located within three thousand nine hundred sixty (3,960) feet (three-quarter [¾] mile) of either a neighborhood center pursuant to the requirements of Division 4.4(D)(3)(c) that is located within the project or within adjacent development, or an existing or planned Neighborhood Commercial District commercial project, which distance shall be measured along street frontage without crossing an arterial street.

(E) ***Development Standards.***

(1) *Corridor Development Standards.* All development in the Corridor District shall also comply with the Corridor design standards as adopted by the city and the following specific standards to the extent that such standards apply to the property proposed for development.

(2) *Site Design*.

(a) In the case of multiple parcel ownership, to the extent reasonably feasible, an applicant shall enter into cooperative agreements with adjacent property owners to create a comprehensive development plan that establishes an integrated pattern of streets, outdoor spaces, building styles and land uses.

(b) Where an employment or industrial use abuts a residential area, there shall be no drastic and abrupt change in the scale and height of buildings.

(c) All commercial/retail and industrial uses, except for off-street parking and loading, shall be conducted or carried out entirely within completely enclosed buildings or structures.

(3) *Building Design.* To the extent reasonably feasible, industrial buildings shall provide a primary entrance that faces and opens directly onto the adjacent street sidewalk or a walkway, plaza or courtyard that has direct linkage to the street sidewalk without requiring pedestrians to cross any intervening driveways or parking lots. The following exceptions shall be permitted to this standard and to the requirements contained in Section 3.5.3(B):

(a) Buildings may orient away from the street if the development provides a campus or park-like development block with a unifying, formative internal framework of outdoor spaces and connecting walkways that functions as an alternative to street sidewalks by organizing and connecting buildings within the site and directly connecting to common destinations in the district (such as transit stops, restaurants, child care facilities and convenience shopping centers). Such an internal network shall provide direct pedestrian access to the street sidewalk(s).

(b) The streetfront orientation requirement may be met by facing only a portion of the front facade to the adjacent street with no intervening front yard parking, provided that the streetfront facade adjoins a landscaped yard with a connecting walkway. Such building face shall not consist of a blank wall. In no case shall the streetfront facade be less than thirty (30) percent of the building frontage.

H. Sample Fiscal Impact Assessment

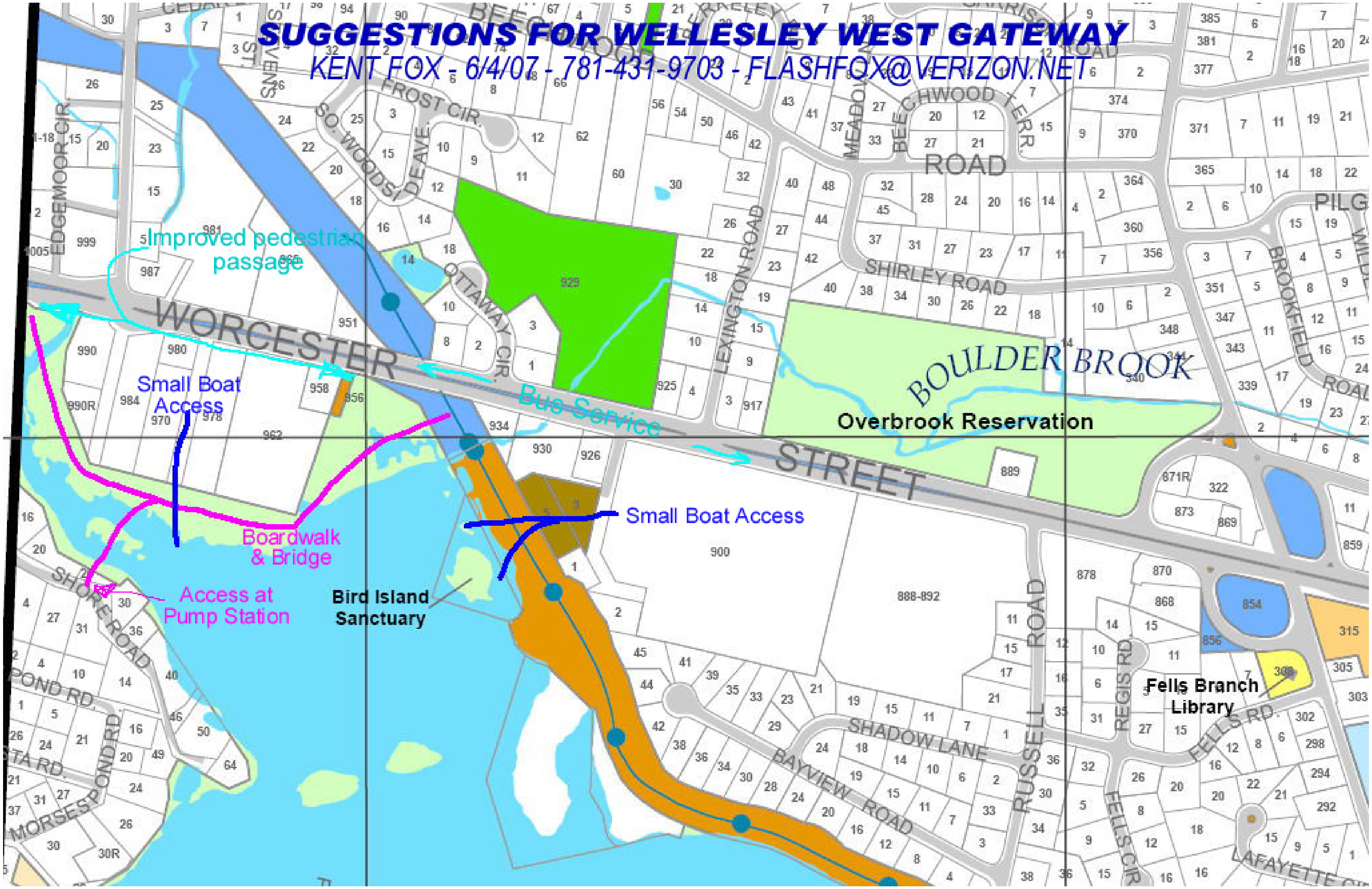
DRAFT FISCAL IMPACT ASSESSMENT *				
	* figures should be updated annually			
	For Impacts due to Commercial Development fill in the following information			
1	Market Value of Proposed Commercial Development			
2	Commercial Assessment Ratio for Tax Purposes (source: MASSDOR)	100.00%		
3	Commercial Tax Rate per $1,000 (source: Assessors)	$30.00		
4	Total Tax Levy (source: Town Treasurer)			
5	Appropriated Expenditures excluding schools (Source: Treasurer)			
6	Equalized Value of Commercial/Industrial Property			
7	Commercial Proportion of real property (Source: Treasurer)			
8	Average Value of Dwelling Unit (Source: Assessors)			
9	Residential Tax Rate per $1,000 (Source: Assessors)	$15.00		
10	Capital Improvements Costs			
	(As a result of this project, will expanded or new capital improvements be required?			
	If Yes, Amount. in Dollars for: School Buildings			
	Roads			
	Sewer System			
	Water System			
	Fire Company			
	Police Department			
	Electric System			
	Other			
11a	The # of years over which costs will be spread	30		
11b	Finance Rate per Year (as a percent)			
11c	What is the percentage of capital costs attributed to new development			

	COMPUTER GENERATED CALCULATIONS			
	FISCAL IMPACT OF COMMERCIAL DEVELOPMENT			
I	**REVENUE FROM NEW COMMERCIAL DEVELOPMENT**			
A.	**Revenue from Property Tax on Development**			
A-1.	Market Value of Development	$0.00		
	multiplied by			
A-2.	Assessment Ratio	100.00%		
A-3.	Actual Assessed Value	$0.00		
	multiplied by			
A-4.	Commercial Tax Rate /$1000	$30.00		
A-5.	**Estimated Property Tax Revenue**	**$0.00**		
II	**COSTS DUE TO NEW COMMERCIAL DEVELOPMENT**			
A.	**Service Costs Due to Development**			
	(Costs associated with Library, Health, Recreation, Police, Fire & Road Maintenance)			
A-1.	Town expenditures excluding Schools	$0.00		
	multiplied by			
A-2.	Commercial portion of Equalized Value	0.00%		
A-3.	Service Costs due to Commercial use	$0.00		
	divided by			
A-4.	Equalized Value of all Commercial Property	$0.00		
A-5.	Service Cost per $1 in value	#DIV/0!		
	multiplied by			
A-6.	Value of new development	#REF!		
A-7.	**Town Service Costs for Commercial Development**	**#REF!**		
B	**Capital Improvements Cost due to Development**			
B-1.	Total Costs due to Capital Improvements	0		
B-2.	The # of years that costs will be spread over	30		
B-3.	Finance Rate per Year (as a percent)	0		

B-4.	Debt Service (principal+interest) per year	0		
B-5.	What is the %age attributed to new development	0		
B-6.	**Capital Improvement Costs due to Development**	**0**		
C	**Total Costs due to Development**	#REF!		
III	**Net Fiscal Impact Resulting from Development**			
A	Total Revenue from Commercial Development	#REF!		
B	Total Costs due to Commercial Development	#REF!		
C	**Net Fiscal Impact per Year**	**#REF!**		
IV	**Change in Tax Rates due to New Development**			
	(negative #s indicate a decrease in tax payments, thus a gain to homeowners			
A	**Change in Town Tax Rate**			
A-1.	Total Tax Levy	$0.00		
	divided by			
A-2.	Tax Rate/thousand	$15.00		
A-3.	Amount affecting Tax Rate			
	by one dollar	$0.00		
A-4.	Net Fiscal Gain	#REF!		
	divided by			
A-5.	Amount affecting Tax Rate			
	by one dollar	$0.00		
A-6.	**Decrease (Increase) in Tax Rate**	**#REF!**		
B.	**Impact on Average Home Owner**			
B-1.	Value of Home	$0.00		
B-2.	Tax Rate per 1000 *at Present*	$15.00		

B-3.	Annual Tax Payment without Further Growth	$0.00		
B-4.	Value of Home	$0.00		
B-5.	Tax Rate per 1000 after New Development	#REF!		
B-6.	Annual Tax Payment after New Development	#REF!		
B-7.	**Total Yearly Savings (Loss) after New Development**	**#REF!**		
	IN SUMMARY			
A.	**NET BENEFIT (LOSS) TO THE TOWN**	**#REF!**		
B.	**DECREASE (INCREASE) IN TAX RATE**	**#REF!**		
C.	**TOTAL YEARLY SAVINGS (LOSS) TO AVE. HOMEOWNER**	**#REF!**		

I. Potential Vision



J. Glossary

A

Accessory Dwelling Unit (ADU): A self-contained housing unit incorporated within a single-family dwelling (not within accessory structures, except with a Special Permit) that is clearly a subordinate part of the single-family dwelling.

Adequate Public Facilities: Adequate public facilities ordinances prevent new construction until municipal services, including water, sewer, roads, and schools, are available to serve that development.

Agricultural Districts/Preservation Areas: Areas designed to keep land in agriculture that are legally recognized. Landowners may voluntarily enroll in programs and may receive special benefits and protection from regulation.

Agricultural Preservation Restriction Program (APR): A voluntary program which is intended to offer a non-development alternative to farmers and other owners or "prime" and "state important" agricultural land who are faced with a decision regarding future use and disposition of their farms. Towards this end, the program offers to pay farmers the difference between the "fair market value" and the "agricultural value" of their farmland in exchange for a permanent deed restriction which precludes any use of the property that will have a negative impact on its agricultural viability.

Agricultural Zoning: Agricultural zoning, including forestry zoning, restricts land uses to farming and livestock, other kinds of open-space activities and limited home building. It is sometimes used in tandem with urban growth restrictions.

Annexation: A change in existing community boundaries resulting from the incorporation of additional land.

Aquifer: A water-bearing geologic formation, sometimes confined between clay layers and sometimes on the surface. The source of ground water for drinking and irrigation.

B

Biodiversity: The variety and essential interdependence of all living things; it includes the variety of living organisms, the genetic differences among them, the communities and ecosystems in which they occur, and the ecological and evolutionary processes that keep them functioning.

Bioretention System: The bioretention system (also referred to as a "rain garden" or a "biofilter") is a stormwater management practice to manage and treat stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression. The method combines physical filtering and adsorption with bio-geochemical processes to remove pollutants. The system consists of an inflow component, a pretreatment element, an overflow structure, a shallow ponding area (less than 9" deep), a surface organic layer of mulch, a planting soil bed, plant materials, and an underdrain system to convey treated runoff to a downstream facility.

Blight: Physical and economic conditions within an area that cause a reduction of or lack of proper utilization of that area. A blighted area is one that has deteriorated or has been arrested in its development by physical, economic, or social forces.

BMP: Best Management Practice; refers to the practice considered most effective to achieve a specific desired result for protection of water, air and land and to control the release of toxins.

Brownfields: Sites that are underutilized or not in active use, on land that is either contaminated or perceived as contaminated.

Buffer Zone: A strip of land created to separate and protect one type of land use from another; for example, as a screen of planting or fencing to insulate the surroundings from the noise, smoke, or visual aspects of an industrial zone or junkyard.

Built Environment: The urban environment consisting of buildings, roads, fixtures, parks, and all other improvements that form the physical character of a city.

C

Carrying Capacity: The level of land use or human activity that can be permanently accommodated without an irreversible change in the quality of air, water, land, or plant and animal habitats. In human settlements, this term also refers to the upper limits beyond which the quality of life, community character, or human health, welfare, and safety, will be impaired, such as the estimated maximum number of persons that can be served by existing and planned infrastructure systems, or the maximum number of vehicles that can be accommodated on a roadway.

Catch Basin: A conventional structure for the capture of stormwater utilized in streets and parking areas. It includes an inlet, sump, and outlet and provides minimal removal of suspended solids. In most cases a hood also is included to separate oil and grease from stormwater. Catch basins are differentiated from drainage "inlets", which do not contain sumps or hoods.

Charrette: A Charrette is a planning session in which participants brainstorm and visualize solutions to a design issue. Charrettes provide a forum for ideas and offer the unique advantage of giving immediate feedback to designers while giving mutual authorship to the plan by all those who participate. The term "charrette" comes from the French term for "little cart" and refers to the final intense work effort expended by architects to meet a project deadline. At the Ecole de Beaux Arts in Paris during the 19th century, proctors circulated with little carts to collect final drawings, and students would jump on the charrette to put finishing touches on their presentations minutes before their deadlines.

Cluster Development: A pattern of development in which industrial and commercial facilities, and homes are grouped together on parcels of land in order to leave parts of the land undeveloped. Cluster development is often used in areas that require large lot sizes, and typically involves density transfer. Zoning ordinances permit cluster development by allowing smaller lot sizes when part of the land is left as open space.

Compact Building Design: Refers to the act of constructing buildings vertically rather than horizontally, and configuring them on a block or neighborhood scale that makes efficient use of land and resources, and is consistent with neighborhood character and scale. Compact building design reduces the footprint of new construction, thus preserving greenspace to absorb and filter rain water, reduce flooding and stormwater drainage needs, and lower the amount of pollution washing into our streams, rivers and lakes. Compact building design is necessary to sustain transit ridership at levels necessary to make public transit a viable transportation option.

Comprehensive Plan: Regional, state, or local documents that describe community visions for future growth. Comprehensive plans describe general plans and policies for how communities will grow and the tools that are used to guide land use decisions, and give general, long-range recommendations for community growth. Typical elements include, land use, housing, transportation, environment, economic development, and community facilities.

Conservation Areas: Environmentally sensitive and valuable lands protected from any activity that would significantly alter their ecological integrity, balance, or character, except in cases of overriding public interest.

Conservation Easements: Conservation easements are voluntary, legally binding agreements for landowners that limit parcels of land or pieces of property to certain uses. Land under conservation easements remains privately owned, and most easements are permanent.

Context Sensitive Design (CSD): A collaborative, interdisciplinary approach that involves all stakeholders to develop a facility that fits its physical setting and preserves scenic, aesthetic, historic, and environmental resources. CSD is an approach that considers the total context within which a project will exist.

D

Deed Restriction: A legally binding restriction on the use, activity, and/or limitation of property rights, recorded at the registry of deeds.

Density: The average number of people, families, or housing units on one unit of land. Density is also expressed as dwelling units per acre.

Density bonus: Allows developers to build in specified areas densities that are higher than normally allowed.

Design Standards: Design standards or guidelines can serve as a community's desire to control its appearance, from within and without, through a series of standards that govern site planning policies, densities, building heights, traffic and lighting.

Detention Ponds: (Extended Detention Basins) An area surrounded by an embarkment, or an excavated pit, designed to temporarily hold stormwater long enough to allow settling of solids and reduce local and downstream flooding.

Development Rights: Development rights give property owners the right to develop land in ways that comply with local land use regulation.

District Improvement Financing (DIF): Economic tool that promotes redevelopment by channeling dollars into targeted redevelopment districts.

Downzoning: A change in zoning classification to less intensive use and/or development.

E

Ecological Footprint: The impact of humans on ecosystems created by their use of land, water, and other natural resources. Ecological footprint used as a complex sustainability indicator that answers the question: How much of the Earth's resources does your lifestyle require?

Economic Opportunity Area (EOA): An area or several areas within a designated Massachusetts Environmental Target Area of particular need and priority for economic development.

Ecosystem: The species and natural communities of a specific location interacting with one another and with the physical environment.

Energy Efficiency: Using less energy to achieve the same outcome. For example, better insulation would enable a home to stay warm utilizing less energy.

Energy Service Company (ESCO): A company that offers to reduce a client's energy costs by capitalizing the upfront expenditures and sharing the resulting future cost savings with the client. This is typically accomplished through the use of an energy-performance contract (EPC) or a shared-savings agreement.

EPA (Environmental Protection Agency): The federal body charged with responsibility for natural resource protection and oversight of the release of toxins and other threats to the environment.

Eminent Domain: The legal right of government to take private property for public use, provided the owner is offered just compensation for the taking of property.

Environmental Impact Statement (EIS): A comprehensive study of likely environmental impacts resulting from major federally-assisted projects; statements are required by the National Environmental Policy Act (NEPA).

Endangered: Species that are in danger of extinction. It also is a category that denotes protection under federal law (Endangered Species Act).

Estuary: A water body where salt and fresh water meet resulting in brackish water. These areas usually have associated marshlands and are critical nursery and feeding habitat for a variety of marine species.

Eutrophication: The natural aging process of water bodies, by siltation and organic decomposition, which reduces both water volume and oxygen levels. Surface run-off or airborne deposition of nitrogen and phosphorus accelerate this.

F

Fair Market Value: The price an owner willing, but not under compulsion, to sell, ought to receive from a buyer willing but not under compulsion to buy.

Federal Tax Incentives: The federal government offers financial and tax incentives to individuals and business that install renewable energy systems at their homes or offices. This section provides a summary of these incentives and who to contact for more information.

Fiscal Impact Analysis: The analysis of the estimated taxes that a development project would generate in comparison to the cost of providing municipal services demanded by that project.

Flood Hazard Area: Total stream and adjacent area periodically covered by overflow from the stream channel containing 1) the floodway which is the channel itself and portions of the immediately adjacent overbank that carry the major portion of flood flow, and 2) the flood fringe beyond it which is inundated to a lesser degree.

Flood Plain: The land adjacent to a water body ? stream, river, lake or ocean - that experiences occasional flooding.

Floor Area Ratio (FAR): A measure of development intensity. FAR is the ratio of the amount of floor area of a building to the amount of area of its site. For instance, a one-story building that covers an entire lot has an FAR of 1. Similarly, a one-story building that covers 1/2 of a lot has an FAR of 0.5.

Frontage: The continuous linear distance along any approved way, measured on the street line, between the side lot lines.

G

GIS (Graphic Information Systems): GIS technology is used to develop maps that depict resources or features such as soil types, population densities, land uses, transportation corridors, waterways, etc. GIS computer programs link features commonly seen on maps (such as roads, town boundaries, water bodies) with related information not usually presented on maps, such as type of road surface, population, type of agriculture, type of vegetation, or water quality information. A GIS is a unique information system in which individual observations can be spatially referenced to each other.

Green Building or Green Design: Building design that yields environmental benefits, such as savings in energy, building materials, and water consumption, or reduced waste generation.

Greenfields: Newly developed commercial real estate on what was previously undeveloped open space.

Greenway: A linear open space; a corridor composed of natural vegetation. Greenways can be used to create connected networks of open space that include traditional parks and natural areas.

Groundwater: All water below the surface of the land. It is water found in the pore spaces of bedrock or soil, and it reaches the land surface through springs or it can be pumped using wells.

Growth Management: A term that encompasses a whole range of policies designed to control, guide, or mitigate the effects of growth.

H

Habitat: Living environment of a species, that provides whatever that species needs for its survival, such as nutrients, water and living space.

Housing Element: A comprehensive assessment of current and projected housing needs for all economic segments of the community. It sets forth local housing policies and programs to implement those policies.

Historic Area: An area or building in which historic events occurred, or one which has special value due to architectural or cultural features relating to the heritage of the community. Elements in historic areas have significance that necessitates preservation or conservation.

HVAC: Heating, ventilation, and air conditioning.

I

Impact Fees: Costs imposed on new development to fund public facility improvements required by new development and ease fiscal burdens on localities.

Imperviousness Overlay Zoning: One form of the overlay zoning process. Environmental aspects of future imperviousness are estimated based on the future zoning build-out conditions. Estimated impacts are compared with environmental protection goals to determine the limit for total impervious surfaces in the watershed. Imperviousness overlay zoning areas are then used to define subdivision layout options that conform to the total imperviousness limit.

Impervious Surface: Any surface through which rainfall cannot pass or be effectively absorbed. (Roads, buildings, paved parking lots, sidewalks etc.)

Incentive Zoning: Provides for give and take compromise on zoning restrictions, allowing for more flexibility to provide environmental protection. Incentive zoning allows a developer to exceed a zoning ordinance's limitations if the developer agrees to fulfill conditions specified in the ordinance. The developer may be allowed to exceed height limits by a specified amount in exchange for providing open spaces or plazas adjacent to the building.

Inclusionary zoning: A system that requires a minimum percentage of lower and moderate income housing to be provided in new developments. Inclusionary programs are based on mandatory requirements or development incentives, such as density bonuses.

Infill Development: Infill projects use vacant or underutilized land in previously developed areas for buildings, parking, and other uses.

Infrastructure: Water and sewer lines, roads, urban transit lines, schools and other public facilities needed to support developed areas.

Intermodal: Those issues or activities which involve or affect more than one mode of transportation, including transportation connections, choices, cooperation and coordination of various modes. Also known as "multimodal."

K

L

Land Trusts: Nonprofit organizations interested in the protection of natural resources and historic areas. Activities include public education, purchase and coordination of conservation easements, and planning services.

Land Use: The manner in which a parcel of land is used or occupied.

LEED: Leadership in Energy and Environmental Design Green Building Rating System is a nationally accepted benchmark for the design, construction, and operation of high performance green buildings. Administered by the U.S. Green Building Council LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.

LEED "Plus": Created by the Massachusetts Sustainable Design Roundtable to address shortcomings with standard LEED certification these standards apply to construction of state facilities. This standard specifically mandates certain LEED points for energy performance, building commissioning, achievement of smart growth objectives, and water conservation.

Level of Service (LOS): A qualitative measure describing operational conditions within a traffic stream in terms of speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety. Level A denotes the best traffic conditions while Level F indicates gridlock. An Environmental Impact Report (EIR) for a development proposal evaluates the impact the development will have on the LOS standards for police, fire, utilities, parks, schools and traffic in the effected area.

Lot Area: area is the total square footage of horizontal area included within the property lines. Zoning ordinances typically set a minimum required lot area for building in a particular zoning district.

Low Impact Development (LID): An approach to environmentally friendly land use planning. It includes a suite of landscaping and design techniques that attempt to maintain the natural, pre-developed ability of a site to manage rainfall. LID techniques capture water on site, filter it through vegetation, and let it soak into the ground where it can recharge the local water table rather than being lost as surface runoff. An important LID principle includes the idea that stormwater is not merely a waste product to be disposed of, but rather that rainwater is a resource.

M

MassGIS: The Commonwealth's Office of Geographic and Environmental Information, within the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA). Through MassGIS, the Commonwealth has created a comprehensive, statewide database of spatial information for environmental planning and management.

Master Plan: A statement, through text, maps, illustrations or other forms of communication, that is designed to provide a basis for decision making regarding the long term physical development of the municipality.

Mitigation: Process or projects replacing lost or degraded resources, such as wetlands or habitat, at another location.

Mixed Use Development: Development that is created in response to patterns of separate uses that are typical in suburban areas necessitating reliance on cars. Mixed use developments include residential, commercial, and business accommodations in one area.

Modal Split: A term that describes how many people use alternative forms of transportation. Frequently used to describe the percentage of people using private automobiles as opposed to the percentage using public transportation.

N

National Environmental Policy Act (NEPA): A comprehensive federal law requiring analysis of the environmental impacts of federal actions such as the approval of grants; also requiring preparation of an Environmental Impact Statement (EIS) for every major federal action significantly affecting the quality of the human environment.

Neo-Traditional Development: A traditional neighborhood, where a mix of different types of residential and commercial developments form a tightly knit unit. Residents can walk or bike to more of the places they need to go and municipal services costs are lower due to the close proximity of residences. A more compact development also reduces the amount of rural land that must be converted to serve urban needs.

New Urbanism: Neighborhood design trend used to promote community and livability. Characteristics include narrow streets, wide sidewalks, porches, and homes located closer together than typical suburban designs.

NIMBY ("Not In My Backyard"): NIMBY is an acronym for the "Not in my backyard" sentiment that exists among some people who do not want any type of change in their neighborhood.

Non-Point Source Pollution (NPS): Pollution that cannot be identified as coming from a specific source and thus cannot be controlled through the issuing of permits. Storm water runoff and some deposits from the air fall into this category.

O

Open Space: Used to describe undeveloped land or land that is used for recreation. Farmland as well as all natural habitats (forests, fields, wetlands etc.) is lumped in this category.

Open Space Residential Design (OSRD): A form of residential subdivision that maximizes resource protection and conservation of natural areas through the use of design strategies that result in permanent open space preservation.

Overlay Districts: Zoning districts in which additional regulatory standards are superimposed on existing zoning. Overlay districts provide a method of placing special restrictions in addition to those required by basic zoning ordinances.

P

Performance Zoning: Establishes minimum criteria to be used when assessing whether a particular project is appropriate for a certain area; ensures that the end result adheres to an acceptable level of performance or compatibility. This type of zoning provides flexibility with the well-defined goals and rules found in conventional zoning.

Plan: A statement of policies, including text and diagrams, setting forth objectives, principles, standards, and plan proposals for the future physical development of the city or county.

Planning: The process of setting development goals and policy, gathering and evaluating information, and developing alternatives for future actions based on the evaluation of the information.

Planned Unit Development (PUD): PUDs are areas that are planned and developed as one entity, by a single group. Planned unit developments usually include a variety of uses, including different housing types of varying densities, open space, and commercial uses. Project planning and density is calculated for the entire development rather than individual lots.

Purchase of Development Rights: Programs through which local governments may purchase development rights and dedicate the land for conservation easements, protecting it as open space or agricultural areas.

Q

Quality of Life: Those aspects of the economic, social and physical environment that make a community a desirable place in which to live or do business. Quality of life factors include those such as climate and natural features, access to schools, housing, employment opportunities, medical facilities, cultural and recreational amenities, and public services.

R

Receiving District: An overlay zoning district established by the Town Meeting/ Town Council upon recommendation from the Planning Board as an area suitable to receive transferred development rights.

Recharge: Water that infiltrates into the ground, usually from above, that replenishes groundwater reserves, provides soil moisture, and affords evapotranspiration.

Rehabilitation: In communities with a large stock of older housing or other structures that could lend themselves more easily to conversion into residential units, rehabilitation can be a very affordable and environmentally-friendly way to provide more housing, commercial areas, and offices.

Residential Site Improvement Standards (RSIS): Development rules (disseminated by DCA) that delineate infrastructure requirements for new residential areas. (Road widths, sidewalks, type of materials used, etc.)

Riparian Area: Vegetated ecosystems along a waterbody through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding.

Runoff: The water that flows off the surface of the land, ultimately into our streams and water bodies, without being absorbed into the soil.

S

Sending District: An overlay zoning district established by the Town Meeting/Town Council upon recommendation from the Planning Board as an area in which use or development rights should be restricted and from which development rights may be transferred to a Receiving District.

Siltation: Process by which loose soil is transferred and builds up in streams, rivers, and lakes, causing changes in stream channels and in depth. It may result in filling in an area and/or causing flooding.

Site Plan: A scaled plan showing proposed uses and structures for a parcel of land. A site plan could also show the location of lot lines, the layout of buildings, open space, parking areas, landscape features, and utility lines.

Smart Energy: Is the use of renewable resources to create electricity and to heat and cool buildings, as well as more efficient use of energy through conservation and high efficiency technologies.

Smart Growth: Well-planned development that protects open space and farmland, revitalizes communities, keeps housing affordable and provides more transportation choices.

Special Districts: Geographic areas in which fees or taxes are collected to fund investments or services benefiting properties within the district.

Special Permit: A use that would not be appropriate generally, or without restriction through the zoning district but which, if controlled as to number, area, location, or relation to the neighborhood, would promote the public health, safety, welfare, order, comfort, convenience, appearance, prosperity or general welfare. Such uses may be permitted in such zoning districts as special permits, where specific provision for such special permits is made in a Town zoning bylaw or City zoning ordinance.

Sprawl: Development patterns where rural land is converted to urban/suburban uses more quickly than needed to house new residents and support new businesses, and people become more dependent on automobiles. Sprawl defines patterns of urban growth that includes large acreage of low-density residential development, rigid separation between residential and commercial uses, residential and commercial development in rural areas away from urban centers, minimal support for non-motorized transportation methods, and a lack of integrated transportation and land use planning.

State Tax Incentives: Massachusetts offers tax incentives to individuals and business that install renewable energy systems at their homes or offices. This section provides a summary of these incentives and who to contact for more information.

Stream Corridor: The area (containing wetlands, flood plains, woodlands, unique habitats, and steep slopes) which lies between relatively level uplands and stream banks and through which water, draining from the uplands, flows and is naturally cleansed and stored. Base flow for streams comes from ground water as springs and seeps.

Streetscape: The space between the buildings on either side of a street that defines its character. The elements of a streetscape include: building frontage/façade; landscaping (trees, yards, bushes, plantings, etc.); sidewalks; street paving; street furniture (benches, kiosks, trash receptacles, fountains, etc.); signs; awnings; and street lighting.

Sustainable Development: Development with the goal of preserving environmental quality, natural resources and livability for present and future generations. Sustainable initiatives work to ensure efficient use of resources.

Subdivision: A subdivision occurs as the result of dividing land into lots for sale or development.

Subdivision Rules and Regulations: Procedures, requirements, and provisions governing the subdivision of land that is specified in formal Rules and Regulations promulgated by a city or town under the authority vested in the Planning Board by section 81-Q of Chapter 41 of the General Laws of Massachusetts.

T

Taking: A taking occurs when a government action violates the 5th Amendment property rights of a landowner by taking a piece of property without offering fair compensation. "Takings" include physical acquisitions of land, and may include regulations that unduly deprive landowners of certain uses of their property or have the effect of diminishing the value of property.

Tax Increment Financing: A program designed to leverage private investment for economic development projects in a manner that enhances the benefits accrued to the public interest.

TEA-21 (Transportation Efficiency Act for the 21st Century): Federal legislation that encompasses all transportation regulation and funding (Inter-modal Surface Transportation Efficiency Act was the original title).

Traditional Neighborhoods: Traditional neighborhood development emphasizes two broad goals: to reduce the destruction of habitat and natural resources, and to reduce dependency on automobiles and their associated impacts; and to reduce polluting emissions, excessive use of energy and fragmentation of the landscape. Traditional neighborhood design is a development approach that reflects historic settlement patterns and town planning concepts such as gridded, narrow streets, reduced front and side setbacks, and an orientation of streets and neighborhoods around a pedestrian oriented "town center." Such an approach usually requires modifications to zoning and subdivision regulations.

Transfer of Development Rights (TDR): A system that assigns development rights to parcels of land and gives landowners the option of using those rights to develop or to sell their land. TDRs are used to promote conservation and protection of land by giving landowners the right to transfer the development rights of one parcel to another parcel. By selling development rights, a landowner gives up the right to develop his/her property, but the buyer could use the rights to develop another piece of land at a greater intensity than would otherwise be permitted.

Transit-Oriented Development (TOD): The development of housing, commercial space, services, and job opportunities in close proximity to public transportation. Reduces dependency on cars and time spent in traffic, which protects the environment and can ease traffic congestion, as well as increasing opportunity by linking residents to jobs and services.

Transit Nodes: Stops along a public transportation route where people board and disembark, often where one or more routes intersect with each other. These sites can provide ideal locations for mixed-use development as well as transit-oriented development.

Transportation demand management strategies (TDM): TDM is a general term for strategies that result in more efficient use of transportation resources, including incentives to reduce driving, use alternative options, and improve transit.

U

Upzone: To change the zoning of a tract or parcel of land from a lesser to greater intensity of usage. An example would be a change in zoning from single family to multi-family or mixed use.

USGS (United States Geological Survey): A federal agency which provides mapping of topography, aquifer levels, and areas where aquifers are recharged.

Use Value Taxation: Land assessments according to the value of the present use rather than the speculative value.

V

Variance: The relaxation of requirements of a zoning district for a specific parcel or tract of land. Variances are often issued to avoid unnecessary hardships to a landowner.

W

Watershed: The geographic area which drains into a specific body of water. A watershed may contain several sub-watersheds.

Wetlands: Area having specific hydric soil and water table characteristics supporting or capable of supporting wetlands vegetation.

X

Y

Z

Zero-lot-line Development: A development option where side yard restrictions are reduced and the building abuts a side lot line. Overall unit-lot densities are therefore increased. Zero-lot-line development can result in increased protection of natural resources.

Zoning: Classification of land in a community into different areas and districts. Zoning is a legislative process that regulates building dimensions, density, design, placement and use within each district.

K. Cape Cod Commission Model Access Management Regulation

Background

Roads are classified by the Metropolitan Planning Organization (a regional committee defined in Section 02.4, below) in coordination with the Commonwealth of Massachusetts and the Federal Highway Commission according to their role in the regional roadway system. The higher the classification of the road, the more the road is intended for through travel instead of access. At the highest level are limited access highways. At the lowest level, are roads considered as "local," providing access to limited commercial and residential districts. In order to allow the roadway system to function as intended, driveways and new access points should be minimized on higher class roads. If these access points are deemed necessary, they must nevertheless be spaced sufficiently apart.

This regulation is intended to strengthen Cape town's general bylaws and subdivision rules and regulations with respect to access from new land divisions onto public, and in some cases, private ways. As a general bylaw or ordinance, this model must be adopted by Town Meeting or Town Council in accordance with G.L. c. 43B §13. As a subdivision regulation, this model must be adopted by a planning board in accordance with G.L. c. 41 §81-Q.

01.0 Purpose: The purpose of this access management regulation is to provide reasonable access to development which is consistent with the intended function of the adjacent roadway system. This reasonable access is achieved through location and spacing criteria for driveways and subdivision road access points along town roadways, minimizing the number of driveways, consolidating existing driveways, encouraging driveways on collectors versus arterials for corner lots, encouraging shared driveways, controlling the geometric design of driveways, and locating driveways as far away from roadway intersections as possible.

02.0 Definitions: As used in this bylaw, the following words and terms shall have the meanings specified herein:

02.1 Driveway/Curb Cut: Any access point onto a roadway. This may include, but is not limited to, an entrance to a parcel, or an intersection with another roadway.

02.2 Driveway Interconnection: A private driveway connection between two lots that does not require traveling on the roadway system.

02.3 Functional Classification: The category of a road according to its intended purpose. At the highest end are roads designed to provide mobility, and at the lowest end are roads designed to provide access to land development. The Metropolitan Planning Organization (MPO) classifies roads as one of nine different classifications or as "unaccepted." For the purposes of this bylaw, these classifications have been consolidated into four types:

02.3.1 Arterial: Provides the greatest mobility at the greatest vehicle speed for the longest uninterrupted distance. Includes functional road classifications of "rural principal arterial," "urban extension of rural principal arterial," "rural minor arterial," "urban extension of rural minor arterial," and "urban minor arterial," with the exception of limited access roads.

02.3.2 Collector: Provides balance of mobility and land access, collects and distributes traffic between local and arterial roadways. Includes functional road classifications of "rural major collector," "urban collector" and "rural minor collector."

02.3.3 Local: Provides greatest land access and little or no through movement. Includes functional road classification of "local."

02.3.4 Unclassified: Private or unmaintained public roads that function like local roads. Includes functional road classifications of "unaccepted" and "unclassified."

When references are made in this bylaw to "higher" or "lower" functional class, the ranking of these classifications from high to low is arterial, highest, followed by collector and then local, lowest.

Commentary: The MPO/state method of classifying roads is useful for some purposes but too detailed for the needs of this bylaw. That is why they are grouped into three basic types (which are the types commonly used by transportation engineers). Limited access roads such as Route 6 before the Orleans/Eastham Rotary and Route 28 south of the Otis Rotary cannot have additional driveways or access points without extensive state review and approval and are thus not considered under this bylaw.

02.4 Metropolitan Planning Organization (MPO): A regional planning committee that consists of representatives of the Massachusetts Highway Department (MHD), Executive Office of Transportation and Construction (EOTC), the Cape Cod Regional Transit Authority (CCRTA) and the Cape Cod Commission (CCC). In consultation with its advisory group, the Cape Cod Joint Transportation Committee, the MPO is responsible for making decisions regarding transportation planning and development in Barnstable County, including classifying roads by their functional types.

02.5 Regional Roadways in Regional Policy Plan: All roads on Cape Cod that are not classified "local" or "unclassified."

03.0 Authorization: Pursuant to G.L. c. 43B §13 and G.L. c. 41 §81-Q, the Town of adopts a roadway classification program to protect the public health, safety and welfare. The roadway classification system is based on the roadway classification system adopted by the Metropolitan Planning Organization (MPO). The functional classification of town roads is shown in Figure 1.

Commentary: Each town should include in its bylaw a Figure listing the functional classification of town roads. The Cape Cod Commission can provide this information.

04.0 Classification of Future Roads: It shall be the responsibility of the planning board, at the time of the subdivision of land, to issue a determination as to the recommended classification of all roads to be created by said subdivision. Failure to designate a road classification shall mean that the roads are to be designated as local roads. These decisions will be passed on by the Town Planner to the MPO for approval in their functional classification.

05.0 Changes to Roadway Classification: The planning board, with the approval of the Town governing body, may recommend changes to town road classifications with the intent to enhance the protection of the general health, safety and welfare. These decisions will be passed on by the Town Planner to the MPO for approval in their functional classification.

Commentary: The above section is designed to provide the town with a method for choosing the functional classification they want for any new roads, or to decide to change them for existing roads. These changes are subject to MPO approval before becoming part of the state's functional classification but may be used by the town regardless. Towns may wish to include a provision for a public hearing as part of this process.

06.0 Curb Cuts: All driveways and changes to driveways shall:

06.1 be approved by the Town Department of Public Works and be issued an Access Permit by the Superintendent/Director of Public Works.

06.2 be located according to Figures 2a-2f. These distances are measured from the nearest side of the driveway to the nearest side of any other driveways. In cases where a specific distance cannot be determined from these Figures, the Superintendent/Director of Public Works shall make a determination as to the applicable distance based on extrapolation from the values in these Figures.

Commentary: While Figures 2a-2f are likely to apply all Cape towns, each municipality should review the guidelines established by these Figures to ensure reflection of local ingress/egress and road spacing criteria.

06.3 be consolidated into a single driveway where possible. All development and redevelopment shall provide the minimum number of driveways for the size and type of land use proposed and provide a maximum of one driveway for up to 50 feet of frontage, two driveways for 51 to 150 feet of frontage and three driveways for 151 to 500 feet of frontage.

06.4 be located and designed to provide safe sight distances at the driveway in accordance with American Association of State Highway Transportation Officials (AASHTO) guidelines for stopping sight distances under wet pavement conditions.

06.5 be in compliance with standard Massachusetts Highway Department design criteria.

06.6 operate at Level of Service C or better (Level of Service D or better in certified growth/activity centers) during the PM peak hour for a minimum of five years into the future from issuance of an Access Permit, as assessed by the project applicant and reviewed and approved by the town DPW Superintendent/Director.

06.7 provide appropriate traffic control devices in accordance with the Manual on Uniform Traffic Control Devices. Where traffic signals are proposed and warranted, traffic signals must be placed at uniform intervals as allowed by the road system, and must not be located less than 1/4 mile (1,320 feet) away from an existing or planned traffic signal. Proposed signals must also be consistent with all other town policies and regulations governing traffic signals.

06.8 prohibit turn movements that cause safety concerns through driveway geometry and signage, or for consistency with future roadway plans described in the Local Comprehensive Plan.

06.9 not intersect the storage, deceleration and transition taper areas of a proposed right-turn lane. Existing driveways shall be relocated outside this area consistent with the appropriate spacing requirements above as approved by the Superintendent/Director of Public Works. The relocation of existing driveways needing to be moved shall be provided by the proponent of the turning lane.

06.10 not intersect the storage, deceleration, and transition taper areas of a proposed left-turn lane. Existing driveways on either side of the road shall prohibit left-turn movements through geometric changes in the driveway design or be relocated outside this area consistent with the appropriate space requirements above as approved by the Superintendent/Director of Public Works. The relocation of existing driveways needing to be moved shall be provided by the proponent of the turning lane.

06.11 for corner lots where collector and arterial roads meet, be located on the collector road if possible.

Commentary: This requirement is designed to keep driveways off arterial roads if possible. Additional driveways on local roads within residential neighborhoods are not always encouraged, so this requirement only gives preference to collector over arterial roads. Note also that this portion of the bylaw grants review authority over new curb cuts to the Director of Public Works or his/her designee. Towns may wish to have another town agency responsible for issuing these permits such as the Planning Board.

07.0 Additional Requirements: All applicants for the division of land subject to the Subdivision Control Law and/or the Town of ____'s subdivision rules and regulations shall:

07.1 be responsible for the cost to provide access. Project applicant(s) may be required by the Town to install and pay for standard traffic control devices, pavement markings, channelization, or other access related improvements to facilitate safe and efficient traffic flow, or such improvements may be installed by the Town and up to one hundred per cent of the cost of such improvements may be assessed upon the applicant.

07.2 not consolidate traffic from existing development to justify signalizing a driveway, unless the location is at least 1/4 mile (1,320 feet) from any other existing or planned traffic signal.

Commentary: Although combining driveways is often to be encouraged, if such combination requires that a traffic signal be installed at the resulting access point, that signal can cause more problems than the original driveway arrangement unless sufficient space is provided between signals.

07.3 consult the town Director/Superintendent of Public Works regarding access on State Highway roadways prior to seeking a curb-cut permit from the Massachusetts Highway Department, and work with the Town and other authorizing agencies such as the MHD to agree on an overall access plan for the site prior to site approval.

07.4 provide shared access with adjacent development where feasible. Providing shared access can be used to satisfy a portion of trip reduction requirements in cases where a project is a Development of Regional Impact or requires trip reduction under the Local Comprehensive Plan.

07.5 provide a driveway interconnection between adjacent parcels to avoid short trips and conflicts on the main road. Providing a driveway interconnection can be used to satisfy a portion of trip reduction requirements in the case where a project is a Development of Regional Impact or requires trip reduction under the Local Comprehensive Plan.

07.6 consolidate existing driveways located adjacent to the desired driveway location where driveways cannot meet the spacing and location criteria.

07.7 be in conformance with the driveway spacing and location criteria as soon as practicable after a road is reclassified to a higher functional classification.

In any case where the requirements of this section cannot all be met due to space limitations, the Superintendent/Director of Public Works shall consult with the Planning Board and determine the most appropriate location(s) and number of driveways permitted for the site.

08.0 Subdivision Street Continuity

08.1 Proposed roads shall be in accordance with existing and proposed arterial, collector and local roads, based on the town's functional class map shown in Figure 1 and shall be designed to afford safe access to abutting lots.

08.2 Road alignment shall give due consideration to land contours and natural features.

08.3 Where required by the Planning Board provision shall be made for the extension of the road to abutting property. The plan of any proposed subdivision shall show all work required to connect and complete the improvements between the proposed road pattern and any connecting road in an existing subdivision.

08.4 Location of any proposed subdivision road shall require an Access Permit as required in the town bylaws; and shall conform to all other town bylaws regarding access management.

08.5 In order to provide safe access and egress for all subdivisions, no temporary or permanent gate, fence or other obstruction may be erected on any portion of the traveling surface of the road unless permitted by the Director/Superintendent of Public Works in consultation with the Planning Board.

Commentary: The above-noted provisions should help strengthen the town's subdivision regulations with respect to road layouts and new road access. Towns should note that some of these provisions may be included within existing subdivision rules and regulations. In addition, note that if the text of this model regulation is adopted as a general town bylaw, the provisions of Section 08.0 above may nevertheless need to be adopted by the Planning Board as revisions to the Town subdivision rules and regulations.

09.0 Severability:

09.1 If any provision of this bylaw/regulation is held invalid by a court of competent jurisdiction, the remainder of the bylaw shall not be affected thereby. The invalidity of any section or sections or parts of any section or sections of this bylaw/regulation shall not affect the validity of the remainder of the [town]'s general bylaws/regulations.

Commentary: This Section is a generic severability clause. Severability clauses are intended to allow a court to strike or delete portions of a regulation that it determines to violate state or federal law. In addition, the severability clause provides limited insurance that a court will not strike down the entire bylaw should it find one or two offending sections.

Go to the Cape Cod Commission's
Model Bylaws and Regulations Page

L. LID Fact Sheets

What is Low Impact Development?

- Comprehensive, landscape-based approach to sustainable development
- Set of strategies to maintain existing natural systems, hydrology, ecology
- Cost-effective, flexible approach based on a toolkit of simple techniques
- Collection of practices that have been implemented nationwide
- NOT rocket science
- NOT formulaic
- NOT the answer to every challenge

The Traditional Landscape

- Mostly impervious lawn, building and driveway
- High water use non-native ornamentals
- High inputs of chemicals and fertilizers
- High maintenance, little ecological value, high impact to water resources, little site specification

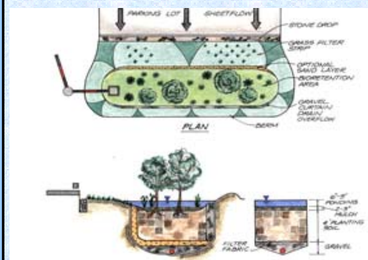
The Environmental Design Approach

- Minimizes runoff & maximizes infiltration
- Minimizes chemical & fertilizer applications to prevent water quality impacts
- Minimizes water use & captures impervious surface runoff for on site water supplies for watering purposes

LID STRATEGIES: Bioretention

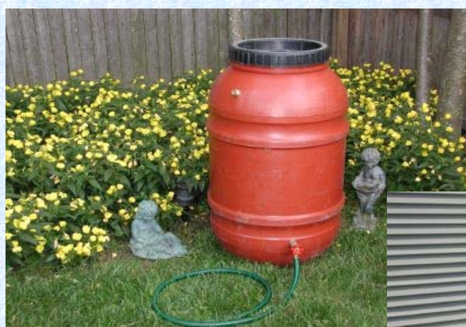
Treatment, retention, infiltration, landscaping

- **Excavation filled with engineered soil mix**
- **Herbaceous perennials, shrubs, trees**
- **Ponded water infiltrates within 72 hours**
- **Overflow outlet and optional underdrain**



Bioretention: Practical Applications

LID STRATEGIES: Rain Barrels & Cisterns

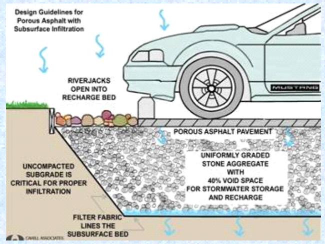


LID STRATEGIES: Permeable Paving

- **Grass pavers**
- **Paving stones**
- **Porous asphalt**
- **Pervious concrete**

Applications:

- Parking stalls
- Overflow parking
- Driveways
- Walkways, patios and plazas

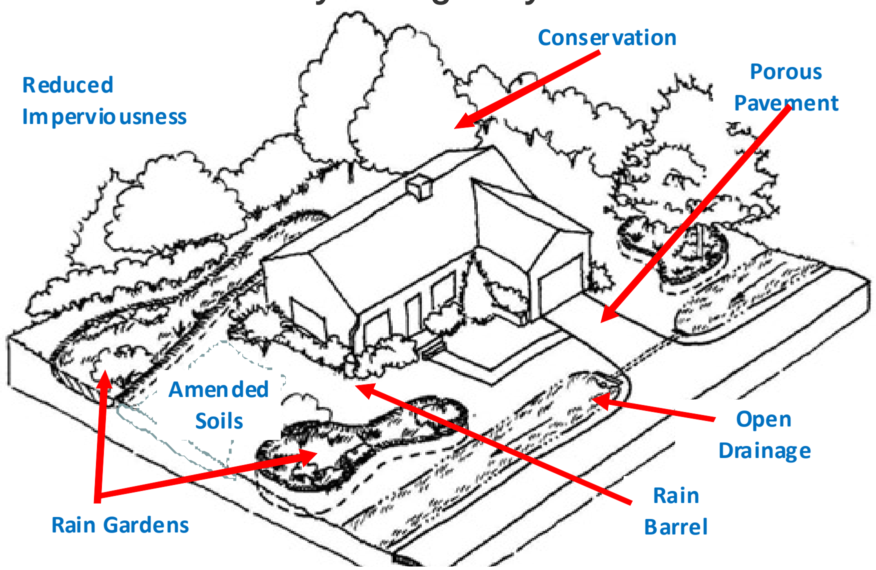


LID STRATEGIES: Green Roofs

Using light-weight media and geo-synthetic fibers and membranes, contemporary green roofs can be readily engineered to conform to the load requirements of most roofs.

Beautiful vegetated roof covers weighing only 15 pounds per square foot have been installed. This weight is comparable to the weight of gravel ballast placed on many conventional roofs.

The Result: A Hydrologically Functional Lot

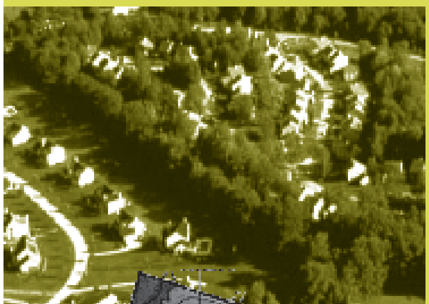


Low Impact Development strategies use careful site design and decentralized stormwater management to reduce the environmental footprint of new growth. This approach improves water quality, minimizes the need for expensive pipe-and-pond stormwater systems, and creates more attractive developments.

MASSACHUSETTS **LOW IMPACT DEVELOPMENT** TOOLKIT

FACT SHEET #1

LOW IMPACT SITE DESIGN



Overview

Conventional development strategies treat stormwater as a secondary component of site design, usually managed with "pipe-and-pond" systems that collect rainwater and discharge it off site. In contrast, Low Impact Development embraces hydrology as an integrating framework for site design, not a secondary consideration. Existing conditions influence the location of roadways, buildings, and parking areas, as well as the nature of the stormwater management system.

LID site design is a multi-step process that involves identifying important natural features, placing buildings and roadways in areas less sensitive to disturbance, and designing a stormwater management system that creates a relationship between development and natural hydrology. The attention to natural hydrology, stormwater "micromanagement," nonstructural approaches, and landscaping results in a more attractive, multifunctional landscape with development and maintenance costs comparable to or less than conventional strategies that rely on a pipe-and-pond approach.

Sensitive site landscaping is an important component of Low Impact Development. Ecological landscaping strategies seek to minimize the amount of lawn area and enhance the property with native, drought-resistant species; as a result, property owners use less water, pesticides, and fertilizers. The maintenance of vegetated buffers along waterways can also enhance the site and help protect water quality.

Applications and Design Principles

LID site planning is similar to Conservation Subdivision Design (CSD) process, though LID site planning can be applied to both residential and nonresidential development as well as redevelopment projects. The four step process of CSD (identify conservation areas; locate home sites; align streets and trails; draw in lot lines) provides a serviceable framework for the LID site design process, which involves designing a stormwater management system in conjunction with the second and third steps of the CSD process.

Management Objectives

- Develop a site plan that reflects natural hydrology.
- Minimize impervious surfaces.
- Treat stormwater in numerous small, decentralized structures.
- Use natural topopgraphy for drainageways and storage areas.
- Preserve portions of the site in undisturbed, natural conditions.
- Lengthen travel paths to increase time of concentration and attenuate peak rates.
- Use "end of pipe" treatment structures only for quantity/rate controls of large storms.

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Site Analysis

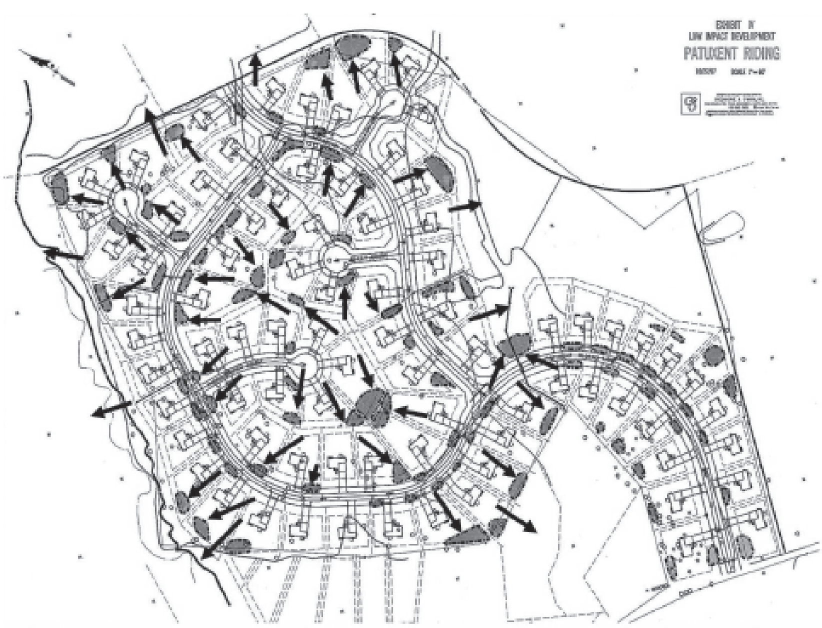
An LID site planning strategy will begin with an assessment of environmental and hydrologic conditions on a site and identification of important natural features such as streams and drainageways, floodplains, wetlands, recharge groundwater protection areas, high-permeability soils, steep slopes and erosion-prone soils, woodland conservation areas, farmland, and meadows. This investigation will help to determine what "conservation areas" should be protected from development and construction impacts, and what site features (such as natural swales) might be incorporated into the LID stormwater system.

The site analysis will also identify a "development envelope" where development can occur with minimal impact to hydrology and other ecologic, scenic, or historic features. In general, this will include upland areas, ridge lines and gently sloping hillsides, and slowly permeable soils outside of wetlands. The remainder of the site should be left in a natural undisturbed condition. It is important to protect mature trees and to limit clearing and grading to the minimum amount needed for buildings, access, and fire protection; lawn areas increase runoff that must be managed, whereas preservation of wooded areas reduces the volume of stormwater that must be treated. Construction activity, including stockpiles and storage areas, should be confined to those areas that will be permanently altered, and the construction fingerprint should be clearly delineated.

Locate Development and Roadways

Based on the development envelope from the site analysis, developers and their consultants should prepare potential site development layouts. These layouts should minimize total impervious area; reflect the existing topography; and utilize existing drainageways, swales, depressions, and storage areas in their natural state. The goal is to minimize the amount of runoff that must be treated in a stormwater management system.

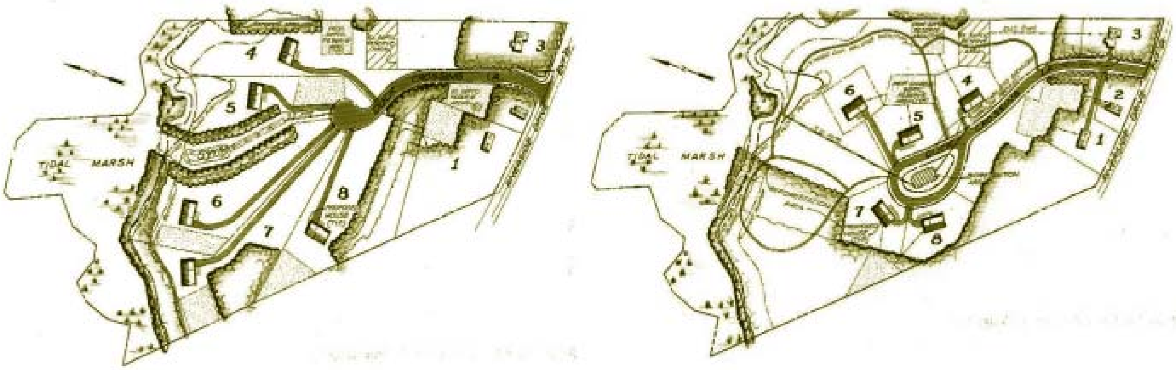
In order to reduce site coverage but not square footage, site development layouts may include buildings clustered together, parking structures (instead of lots), or taller buildings with a smaller footprint relative to floor area. However, these strategies may conflict with local land use regulations that address density, height, frontages, and lot coverage, so consultation with local officials is critical to help them



Conventional development strategies (above) concentrate stormwater runoff in storm sewers and deliver it to a few large ponds for treatment at the end of the pipe. Low Impact Development (right) seeks to create multiple small "sub-watersheds" on a site and treats runoff close to the source in smaller structures.

Cover, top: A clustered subdivision with smaller setbacks and preserved natural areas (left) contrasts with a conventional subdivision where all the trees have been removed.

Cover, bottom: A schematic diagram of a conservation subdivision design plan.



Above: Two alternative designs for an eight-lot subdivision. The low-impact on the right uses shared driveways and a one-way loop road to minimize impervious surfaces. The preservation of natural areas and the creation of trails adds value to the properties. *Images: Center for Watershed Protection*

Above: A commercial site design that uses clustering and multiple parking areas to protect water resources and provide opportunities for low impact stormwater management techniques. This design provides the same square footage and parking spaces as a conventional design that encroaches on a nearby marsh (at top). *Image: Center for Watershed Protection*

understand the rationale for the proposed development plan. Other strategies for minimizing impervious surfaces include reduced road widths, smaller parking areas, permeable paving, and green roofs, all of which are described in greater detail in other LID fact sheets.

Once approximate building locations are known, general roads alignments can be identified. Roads should not cross steep slopes, where cutting and filling will unnecessarily disturb drainage patterns; instead, roadways should follow existing grades and run along existing ridge lines or high points. As a rule of thumb, roadways should run parallel to contours on gentle slopes, and perpendicular to the contours on steeper slopes. Large expanses of parking should be broken up into multiple smaller parking lots; this will help to reduce grading on hilly sites, since separate parking areas can be placed at different elevations.

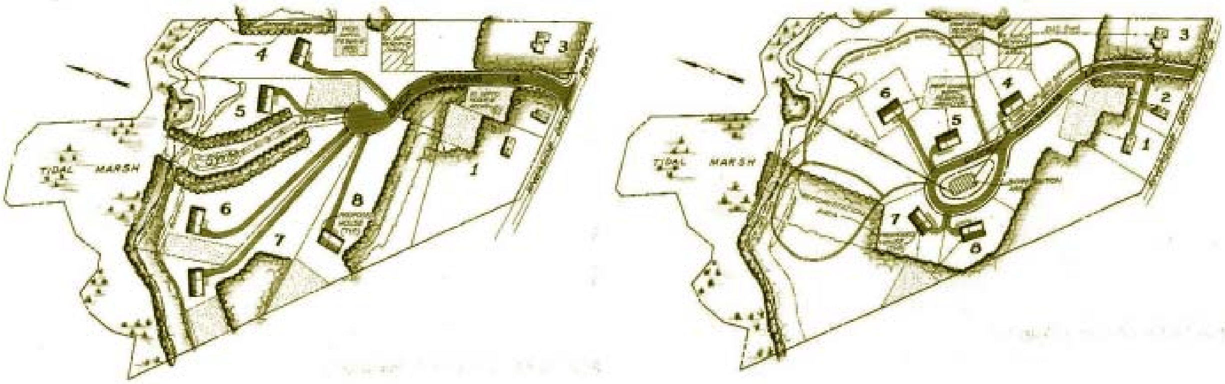
Create a Decentralized Stormwater System

The actual location of buildings and the alignment of roadways should be determined in conjunction with the design of the stormwater management system. The goal of this process is to minimize "directly connected impervious area"—those impervious areas that drain directly into a pipe-and-pond stormwater system. Designers should seek to maintain or create small sub-watersheds on the site and "micromanage" the runoff from these sub-watersheds in small decentralized structures, such as swales, bioretention areas, infiltration structures, and filter strips. Paved surfaces should be graded and crowned so that they form multiple "mini-watersheds;" the runoff from each small drainage area should to a different bioretention area, swale, or filter strip. Roof runoff should be sent to rain barrels, cisterns, dry wells, and vegetated areas via level spreaders.

LID site design should also seek to maximize the travel time for stormwater runoff. Conventional pipe systems increase the speed of stormwater runoff, resulting in bigger peak discharge rates (and therefore bigger ponds) at the end of the pipe. In contrast, LID seeks to increase the time of concentration (the average travel time for rainfall) through a variety of techniques: retain stormwater in small structures close to the source (described above), provide as much overland or sheet flow as possible, use open drainage systems, provide long travel paths, and use vegetation to increase surface roughness.

Wherever possible, site design should use multifunctional open drainage systems such as vegetated swales or filter strips which also help to fulfill landscaping or green space requirements. Swales and conveyances can be designed to increase travel length (and time of concentration) with long flow paths that loop around parking lots or other features, rather than more direct routes. The result is increased infiltration and more attenuated peak discharge at the downstream end of the site—the peak comes later and is smaller.

LID stormwater structures (such as bioretention areas and infiltration trenches) should be sized to treat the stormwater from frequent, low intensity storms for



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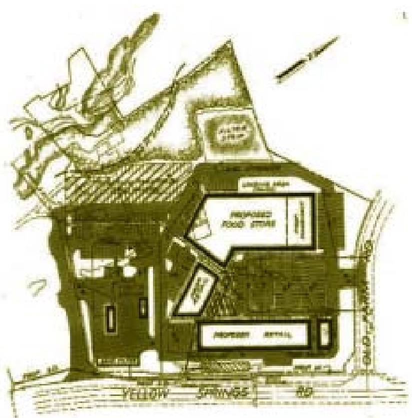

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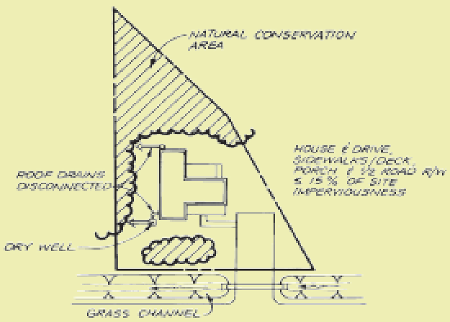

Above: A lot layout that uses infiltration, disconnection of rooftop runoff, conservation and vegetated swales to treat runoff.

water quality and infiltrate it into the ground or slowly release it; they should not be expected to completely manage the peak discharge rate or volume from large storms. Volume and rate controls at the downstream end of the site may still be necessary, but much smaller as a result of LID site design, decentralized stormwater management, and long travel paths.

Benefits and Effectiveness

- A comprehensive approach to site design is the most effective, cost-efficient means of minimizing stormwater runoff. A small investment in design at the outset of the project can reduce the expense associated with conventional stormwater systems.
- An LID site design approach based on natural hydrology will integrate the built space into the natural environment, giving the development integrity and an aesthetically pleasing relationship with the natural features of the site. Many LID stormwater management structures also serve as site landscaping.
- Developers who take a careful, comprehensive approach to site design—one that accommodates local development goals and protects important resources—run into less resistance from neighbors and local boards concerned about the aesthetic and environmental impacts of development.
- Site designs that involve a minimal amount of clearing, grading, and road/parking lot construction have lower overall site development costs.
- Small, distributed stormwater "micromanagement" techniques offer an advantage over centralized systems because one or more of the individual structures can fail without compromising the overall integrity of the stormwater management strategy for the site.
- Smaller decentralized facilities feature shallow basing depths and gentle side slopes, which reduce safety concerns as compared to deep ponds that must be fenced off.

Limitations

- The comprehensive LID site analysis and design process can rarely be conducted "in house" by developers; it requires the assistance of knowledgeable and qualified engineers and landscape architects.
- Some LID site designs that seek to cluster development and reduce lot coverage may conflict with local land use regulations or public perceptions about what type of development is desirable (a compact multistory building may be more visible than a single story building with a larger footprint.) Consequently, public education is necessary as well as cooperation among developers, advocates, and regulators who recognize the values of the LID site design approach.

Maintenance

There are no particular maintenance requirements associated with an LID site design, but by reducing the amount of stormwater runoff and associated stormwater management structures, LID can reduce the amount of maintenance required on a site.

Cost

The cost of an LID site design will vary depending on the site. The expertise necessary to create a comprehensive site plan may cost more than a simple engineering plan that ignores natural conditions and treats stormwater using a "pipe and pond" system; however, the resulting plans are commonly less expensive to construct and maintain, and the additional landscaping and aesthetic value of an LID development will add a premium to the sales price.

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Low Impact Development Design Strategies: An Integrated Design Approach; Prince George's County, Maryland, Department of Environmental Resources; June 1999. (available at http://www.epa.gov/owow/nps/lid/)

Better Site Design: A Handbook for Changing Development Rules in Your Community; Center for Watershed Protection; 1998

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Conservation Design for Subdivisions: A Practical Guide for Creating Open Space Networks; Randall Arendt; Island Press; 1996.

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This publication is one component of the Massachusetts Low Impact Development Toolkit, a production of the Metropolitan Area Planning Council, in coordination with the I-495 MetroWest Corridor Partnership, with financial support from US EPA. The Massachusetts Low Impact Development Interagency Working Group also provided valuable input and feedback on the LID Toolkit.

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MASSACHUSETTS **LOW IMPACT DEVELOPMENT** TOOLKIT

FACT SHEET #2

ROADWAY AND PARKING LOT DESIGN

Overview

One of the simplest ways to cut down on stormwater runoff is to reduce the amount of impervious cover associated with roadways and parking lots. Careful design is the key to reducing pavement while still providing good site access and adequate parking. Good road and parking lot design can also create opportunities for decentralized stormwater management in bioretention areas, roadside swales, and infiltration structures. Basic strategies for roadway design include low-impact roadway layouts, narrow road widths, shared driveways, and open-section roadways. Parking lots designers should look at strategies to break up large parking lots, maximize shared parking, rethink parking requirements, and use permeable paving where appropriate.

Alternative road and parking designs may offer cost savings for developers, because there is less pavement to construct and less stormwater runoff to treat. In some cases, more compact parking may allow higher site densities. The primary impediment to these strategies may be resistance at the permitting stage. Many communities stringently enforce elaborate and often excessive roadway and parking standards in an effort to prevent development. Developers, advocates, and regulators who understand the benefits of Low Impact Development need to work together to point out that alternative designs can provide safe access and sufficient parking, as well as environmental and aesthetic benefits.

Applications and Design Principles

Roadway Width

Excessively wide streets are the greatest source of impervious cover (and stormwater runoff) in most residential developments. Some local codes require streets up to 40 feet wide in subdivisions with only a dozen houses. These inappropriate standards result from blanket application of high volume/ high speed road design criteria, overestimates of on-street parking demand, and the perception that wide streets result in faster emergency response times.

Narrower road sections and alternative road profiles can reduce stormwater runoff and mitigate its impacts, while still allowing safe travel, emergency

Design Objectives

- Reduce total impervious surface.
- Reduce road/parking construction costs.
- Provide safe access and adequate parking.
- Minimize disturbance to natural site hydrology.
- Create opportunities for stormwater treatment and infiltration.
- Improve site appearance.

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Above: Excessively wide streets (top) with conventional curb-and-gutter profiles create large volumes of runoff and concentrate it in storm sewers. Low-impact roadways (bottom) use a narrower, more traditional design that enhances neighborhood character. Less runoff is created and it is directed to roadside swales for treatment and conveyance.

Cover, top: A narrow roadway design can allow for on-street parking as well as plenty of room for safe travel and emergency vehicle access.

Cover, bottom: This photo shows a perforated curb that directs runoff into a roadside bioretention area with a drop overflow inlet into the storm drain system. This approach treats the "first flush" of runoff using a low-impact technique and directs the remaining stormwater to conventional practices. *Photo: Lower Columbia River Estuary Partnership*

Right: A schematic diagram of an open-section roadway, with permeable paving parking lanes and roadside swales. Swales should be located between the roadway and a sidewalk, where present. *Image: Valley Branch (MN) Watershed District*

vehicle access, and adequate parking. For most low-traffic roads, a 24' road width is sufficient to accommodate two way traffic, and even narrower widths should be used in very low traffic conditions (e.g., a six-lot subdivision.) The National Fire Protection Administration Uniform Fire Code (2003) recommends a minimum unobstructed width of just 20 feet, with the recognition that local authorities can set lower standards if turnouts or alternate exits are available.

Recommended Minimum Street Widths

Source	Width (feet)
National Fire Protection Administration	20
Massachusetts State Fire Marshall	18 (minimum)
AASHTO	22
Institute of Transportation Engineers	22
Prince George's County, Maryland	20
Portland, Oregon	18 (on-street parking on one side) 26 (parking both sides)

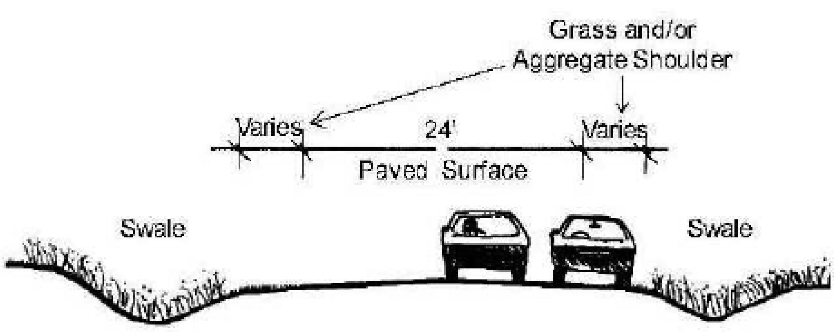
Source: Center for Watershed Protection

In order to achieve the environmental benefits of narrower street widths, regulators must make clear that they are willing to adjust site design standards to provide developers with the opportunity to try alternative designs. One preliminary step is to require parking on one side of the street only. This is appropriate where most houses have off–street parking. Design standards can also allow parking lanes or road shoulders made of permeable paving, such as grass pavers or paving blocks.

Some communities are moving to roadways that us a single travel lane and one or two "queuing lanes," which can be used for either parking or travel. This strategy can reduce street width by a third, and it does not affect travel except when two cars need to pass each other at the spot where a third car is parked, in which case one car pulls into the queuing lane until the oncoming car has passed. Research indicates that "tight streets" actually improve traffic safety by encouraging vehicles to slow down in residential neighborhoods. Throughout Massachusetts, many older neighborhoods built before current standards were enacted have narrow streets that function well, calm traffic, and lend character to the community.

Roadway Profile

Curbs and gutters concentrate stormwater runoff and increase its velocity, impeding decentralized treatment and infiltration. LID strategies recommend open-section roadways flanked by filter strips and swales instead of curbs and gutters. These LID techniques, built on the model of "country drainage," help to filter roadway runoff, promote infiltration, and reduce runoff velocity, resulting in lower peak discharge rates. If properly designed, open section roadways will be no more prone



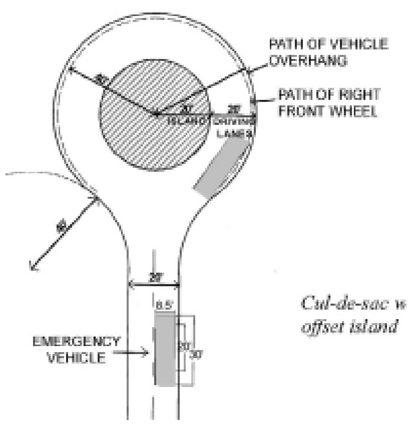
to flooding than conventional roadway profiles. If curbs are deemed necessary to stabilize the roadway edge, the design can use invisible curbs (same level as the road surface), periodic curb cuts, or perforated curbs to allow stormwater to run off the roadway edge.

Roadway layout

The location and layout of roadways can also be modified to improve post-development hydrology. Roadways should be placed to avoid crossing steep slopes where significant cut and fill will be required. They should run parallel to contours on gentle slopes and perpendicular to contours on steeper slopes. Design of a roadway network may involve some give and take between reducing total roadway length and road layouts compatible with existing topography. On low-speed streets, clearing and grading should be limited to a small strip of land (5') on either side of the roadway and sidewalk.

Above: Periodic curb cuts in an urban setting allow for streetside infiltration. *Photo: Lower Columbia River Estuary Partnership*

Below: A 20-foot diameter land-scaped island in a cul-de-sac can reduce impervious surface by 25%. Cul-de-sac islands can also be designed to treat and infiltrate runoff through bioretention. *Image: Valley Branch (MN) Watershed District*



In residential subdivisions, shared driveways can reduce site development costs as well as impervious surface coverage. Property owners will also realize some savings through shared snow plowing costs. Driveways can be limited to 9 feet in width. They should be sloped or crowned so that they drain evenly onto adjacent vegetated areas (not onto the street) where the runoff will infiltrate or travel via sheetflow.

Turnarounds and Cul-de-Sacs

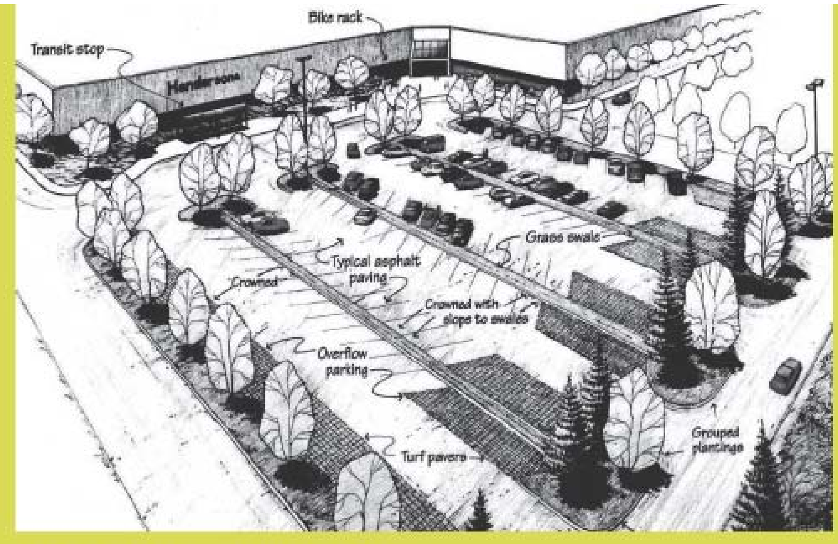
Many residential streets end in large cul-de-sacs up to 80 feet across, which generate large amounts of runoff during storms. Alternative designs can reduce runoff and improve neighborhood character, while still providing sufficient room for fire trucks and school buses to maneuver. One simple approach (applicable to both new construction and retrofits) is to create a landscaped island in the middle of a standard-size cul-de-sac. A 30-foot island in an 80-foot diameter cul-de-sac will reduce the impervious surface by 15%; if the island is designed and built as a bioretention area, and the roadway graded appropriately, this strategy can also treat roadway runoff.

Other design changes can produce even greater benefits. Reducing the radius of a cul-de-sac from 40 feet to 30 feet yields a 45% reduction in paved surface (5,000 sq. ft versus 2,800 sq. ft.) A T-shaped hammerhead occupies even less space but still provides sufficient room for turning vehicles and fire trucks (though it may require a 3-point turn.) Depending on the length of the street, designers should consider a one-way loop road with parking on one side. Cul-de-sac design is definitely one area where regulatory standards prevent creative designs; regulators should consider re-wording their regulations to replace geometric standards with performance standards.

Parking Lots

Expansive parking lots that drain to just a few catch basins create large volumes and high velocities that require the use of pipe-and-pond stormwater techniques. The LID approach encourages designers to create multiple smaller parking lots separated by natural vegetation and bioretention areas. On hilly sites, the creation of multiple parking areas at different elevations can reduce the amount of grading necessary and preserve natural hydrology.

Permeable paving is rarely appropriate for use in high traffic parking lots, but some success has been found with hybrid parking lots, which use conventional paving for driveways and aisles, and permeable paving for stalls. Permeable paving may also be appropriate for overflow parking areas, which are generally used only a few weeks out of the year.



Above: A schematic drawing of a parking lot that uses a variety of low impact techniques. Parking areas are separated by vegetated swales that convey runoff to bioretention areas, and permeable paving is used for overflow parking at the periphery of the lot. A bike rack and transit stop help to reduce the number of auto trips to the site. *Image: Robert W. Droll, ASLA*

Other strategies include reducing the total number of parking spaces and reducing the size of some parking spaces. Many communities have provisions for shared parking, so that mixed use developments, or single-use developments near other uses, can share parking according to a formula based on the peak demand periods; residents use the parking spaces at night and customers or employees use the same spaces during the day. Parking spaces designed for compact cars can also help to limit impervious coverage.

Considering the aesthetic and environmental impacts of large parking areas, community boards might consider parking maximums, as well as parking minimums, in order to prevent oversized parking lots and ensure that supply is in line with demand.

Benefits and Effectiveness

- Narrower roadways, smaller parking areas, and smaller stormwater management systems result in lower site development costs.
- A hierarchy of streets sized according to daily needs yields a wide variety of benefits: lower average speeds, more room for trees and landscaping, improved aesthetics, and reduced heat island effect.
- Designs that reduce the amount of parking and break it up into multiple smaller lots separated by vegetation create more attractive developments.

Limitations

- Alternative roadway and parking designs may conflict with local codes, which often have strict requirements for road widths and drainage systems. However, many boards may be willing to adjust their standards if developers, advocates, and neighbors support the alternative design.
- Emergency service access is a common concern with reduced street widths. Where possible, these concerns can be addressed through education or multiple points of access to a site.

Cost

Narrower streets and smaller parking lots cost less than conventional streets because less grading, base material, and pavement is required. Open section roadways cost considerably less than standard designs due to the elimination of curbs and gutters.

Additional References

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Shared Parking Guidelines; Institute of Transportation Engineers, Washington DC; 1995.

The American Planning Association (www.planning.org) has published a variety of reports on parking standards, as part of its Planners Advisory Service.

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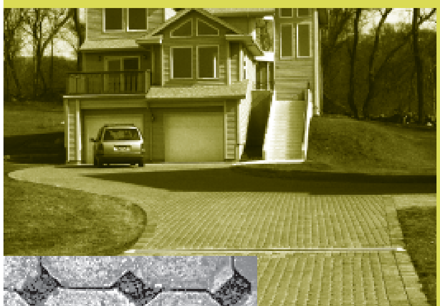
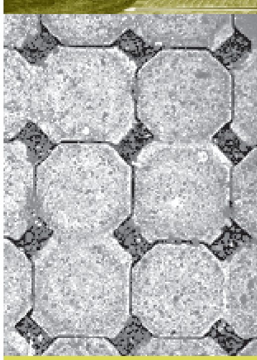
MASSACHUSETTS **LOW IMPACT DEVELOPMENT** TOOLKIT

FACT SHEET #3

PERMEABLE PAVING





Overview

Since impervious pavement is the primary source of stormwater runoff, Low Impact Development strategies recommend permeable paving for parking areas and other hard surfaces. Permeable paving allows rainwater to percolate through the paving and into the ground before it runs off. This approach reduces stormwater runoff volumes and minimizes the pollutants introduced into stormwater runoff from parking areas.

All permeable paving systems consist of a durable, load bearing, pervious surface overlying a crushed stone base that stores rainwater before it infiltrates into the underlying soil. Permeable paving techniques include porous asphalt, pervious concrete, paving stones, and manufactured "grass pavers" made of concrete or plastic. Permeable paving may be used for walkways, patios, plazas, driveways, parking stalls, and overflow parking areas.

Applications and Design Principles

Permeable paving is appropriate for pedestrian-only areas and for low- to medium-volume, low-speed areas such as overflow parking areas, residential driveways, alleys, and parking stalls. Underlying soils should have a permeability of at least 0.3" per hour; less permeable soils will require an underdrain. Permeable paving is an excellent technique for dense urban areas because it does not require any additional land. With proper design, cold climates are not a major limitation; porous pavement has been used successfully in Norway, incorporating design features to reduce frost heave.

Permeable paving is not ideal for high traffic/high speed areas because it generally has lower load-bearing capacity than conventional pavement. Nor should it be used on stormwater "hotspots" with high pollutant loads because stormwater cannot be pretreated prior to infiltration. Heavy winter sanding may clog joints and void spaces.

Management Objectives

- Reduce stormwater runoff volume from paved surfaces
- Reduce peak discharge rates.
- Increase recharge through infiltration.
- Reduce pollutant transport through direct infiltration.
- Improve site landscaping benefits (grass pavers only.)

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Cover: A driveway in Connecticut built with manufactured paving stones. Lower photo shows paving stone detail. Photo: *University of Connecticut, Jordan Cove Urban Monitoring Project*

Above: A parking lot with concrete grass paver parking stalls. Lower photo shows grass paver detail. *Photos: Lower Columbia River Estuary Partnership*

Right: A schematic cross section of permeable paving. In some applications, the crushed stone reservoir below the paving is designed to store and infiltrate rooftop runoff as well. *Image: Cahill Associates, Inc. 2004*

Three Major Types of Permeable Paving

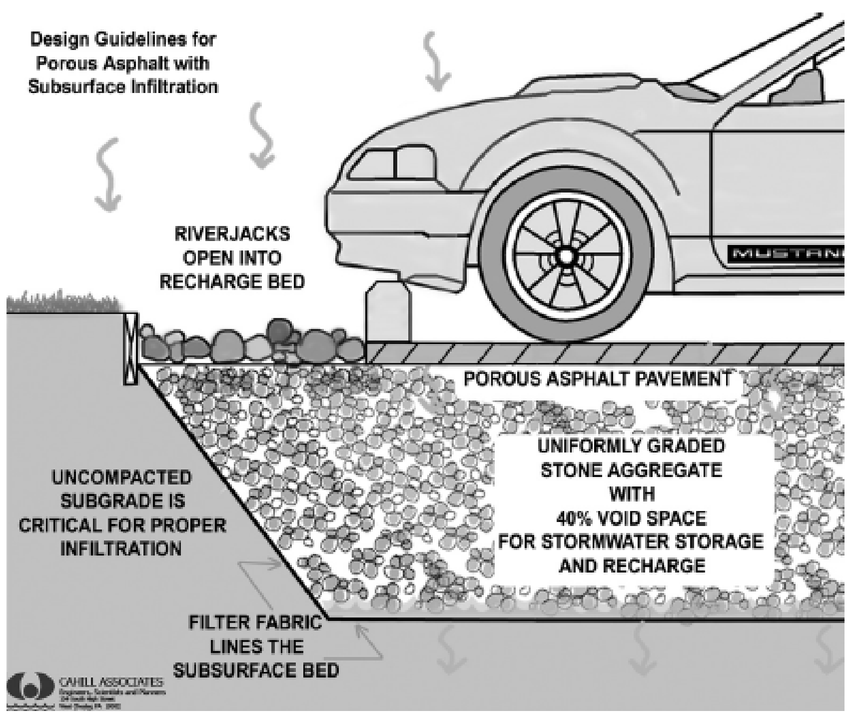
- Porous asphalt and pervious concrete appear to be the same as traditional asphalt or concrete pavement. However, they are mixed with a very low content of fine sand, so that they have 10%-25% void space and very low runoff coefficients.
- Paving stones (aka unit pavers) are impermeable blocks made of brick, stone, or concrete, set on a sand or crushed stone base. Joints are filled with stone or sand to allow water to percolate downward. Runoff coefficients range from 0.1 – 0.7, depending on rainfall intensity, joint width, materials, and base layer permeability. Open cell designs and coarse bed material can yield runoff coefficients less than 0.3.
- Grass pavers (aka turf blocks or grid pavers) are a type of open-cell unit paver in which the cells are filled with soil and planted with turf. The pavers, made of concrete or synthetic, distribute the weight of traffic and prevent compression of the underlying soil. Runoff coefficients are similar to grass, 0.15 to 0.6.

Each of these techniques is constructed over a base course that doubles as a reservoir for the stormwater before it infiltrates into the subsoil. The reservoir should consist of uniformly-sized crushed stone, with a depth sufficient to store all of the rainfall from the design storm. The bottom of the stone reservoir should be completely flat so that infiltrated runoff will be able to infiltrate through the entire surface. Some designs incorporate an "overflow edge," which is a trench surrounding the edge of the pavement. The trench connects to the stone reservoir below the surface of the pavement and acts as a backup in case the surface clogs.

Benefits and Effectiveness

Porous pavement provides groundwater recharge and reduces stormwater runoff volume. Depending on design, paving material, soil type, and rainfall, permeable paving can infiltrate as much as 70% to 80% of annual rainfall.

Porous pavement can reduce peak discharge rates significantly by diverting stormwater into the ground and away from the pipe-and-pond stormwater management system.



Above: A parking lot with conventional asphalt aisles and paving stone parking stalls. Paving stones are most appropriate for low-speed, low-traffic areas. *Photo: Lower Columbia River Estuary Partnership*

- Grass pavers can improve site appearance by providing vegetation where there would otherwise be only pavement.
- Porous paving increases effective developable area on a site because portions of the stormwater management system are located underneath the paved areas, and the infiltration provided by permeable paving can significantly reduce the need for large stormwater management structures on a site.

Limitations

- Permeable paving can be prone to clogging from sand and fine sediments that fill void spaces and the joints between pavers. As a result, it should be used carefully where frequent winter sanding is necessary because the sand may clog the surface of the material. Periodic maintenance is critical, and surfaces should be cleaned with a vacuum sweeper at least three times per year.
- In cold climates, the potential for frost is minimized with 24-hour design times for the reservoir. Some design manuals recommend excavating the base course to below the frost line, but this may not be necessary in rapidly permeable soils. In addition, the dead air and void spaces in the base course provide insulation so that the frost line is closer to the surface.
- Permeable paving should not receive stormwater from other drainage areas, especially any areas that are not fully stabilized.
- Permeable paving can only be used on gentle slopes (<5%). It should be used judiciously in high-traffic areas or where it will be subject to heavy axle loads.
- Snow plows can catch the edge of grass pavers and some paving stones. Rollers can be attached to the bottom edge of a snowplow to prevent this problem.

Above: A handicap-accessible park pathway made of permeable paving stones.
Photo: GeoSyntec Consultants, Inc.

Maintenance

- Post signs identifying porous pavement areas.
- Minimize use of salt or sand during winter months
- Keep landscaped areas well-maintained and prevent soil from being transported onto the pavement.
- Clean the surface using vacuum sweeping machines. Paving stones may require periodic addition of joint material to replace material that has been transported.
- Monitor regularly to ensure that the paving surface drains properly after storms.
- Do not reseal or repave with impermeable materials.
- Inspect the surface annually for deterioration.
- Grass pavers may require periodic reseeding to fill in bare spots.

Design Details

- For all permeable paving, base course is a reservoir layer of 1"-2" crushed stone; depth to be determined by storage required and frost penetration.
- Permeable paving require a single-size grading of base material in order to provide voids for rainwater storage; choice of materials is a compromise between stiffness, permeability, and storage capacity. Use angular crushed rock material with a high surface friction to prevent traffic compaction and rutting.
- The design may also include a 2" thick filter course of 0.5" crushed stone, applied over the base course. A geotextile fabric may be laid at the top of the filter layer to trap sediment and pollutants.
- For grass pavers, use deep-rooted grass species whose roots can penetrate the reservoir base course. Irrigation may be required but should be infrequent soakings so that the turf develops deep root systems. Grass pavers are not suitable for every day, all day parking because the grass will get insufficient sunlight. Better for use as occasional overflow parking.
- The introduction of dirt or sand onto the paving surface, whether transported by runoff from elsewhere or carried by vehicles, will contribute to premature clogging and failure of the paving. Consequently, permeable paving should be one of the last items to be built on a development site, after most heavy construction vehicles are finished and after the majority of the landscaping work is completed.

Cost

On most sites, permeable paving costs more than conventional asphalt or concrete paving techniques. In the case of porous asphalt and pervious concrete, construction costs may be 50% more than conventional asphalt and concrete. Construction costs of paving stones and grass pavers varies considerably and will depend on the application. As with any site improvement or stormwater management structure, property owners should provide a budget for maintenance of permeable paving, at an annual rate of 1%-2% of construction costs.

Permeable paving reduces the need for stormwater conveyances and treatment structures, resulting in cost savings elsewhere. Permeable paving also reduces the amount of land needed for stormwater management and may satisfy requirements for greenspace, allowing more development on a site.

Local Case Study

West Farms Mall – West Hartford, CT

Grass pavers were installed at the West Farms Mall off of I-84 at exit 40, to handle peak-season overflow parking associated with a mall expansion. Over four acres of reinforced turf was designed to accommodate 700 spaces of overflow parking for the peak shopping seasons. There are a few drains installed in the reinforced turf but are only used during very heavy storms. Because the reinforced turf works so well the existing storm drainage system did not have to be enlarged for the additional parking. The overflow parking area needs to be mowed on a regular basis and treated like a regular lawn. The area also needs to be plowed as any parking would be. Rollers were fit to the bottom of the snow plow so the reinforced turf would not be damaged. The manager of the Westfarms facility is satisfied with the turf.

Websites

www.unh.edu/erg/cstev/index.htm (University of NH)
www.invisiblestructures.com/GP2/whole_lotof_turf.htm
www.uni-groupusa.org/case.htm
www.nemo.uconn.edu/ (University of CT)
www.lowimpactdevelopment.org/epa03/pavespec.htm
www.epa.gov/ednnrmrl/repository/abstrac2/abstra2.htm
www.forester.net/sw_0503_advances.html
www.icpi.org (Interlocking Concrete Pavement Institute)

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Low Impact Development strategies use careful site design and decentralized stormwater management to reduce the environmental footprint of new growth. This approach improves water quality, minimizes the need for expensive pipe-and-pond stormwater systems, and creates more attractive developments.

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FACT SHEET #4

BIORETENTION AREAS

Overview

Bioretention is an important technique that uses soil, plants and microbes to treat stormwater before it is infiltrated or discharged. Bioretention "cells" are shallow depressions filled with sandy soil, topped with a thick layer of mulch, and planted with dense vegetation. Stormwater runoff flows into the cell and slowly percolates through the soil (which acts as a filter) and into the groundwater; some of the water is also taken up by the plants. Bioretention areas are usually designed to allow ponded water 6-8 inches deep, with an overflow outlet to prevent flooding during heavy storms. Where soils are tight or fast drainage is desired, designers may use a perforated underdrain, connected to the storm drain system.

Bioretention areas can provide excellent pollutant removal and recharge for the "first flush" of stormwater runoff. Properly designed cells remove suspended solids, metals, and nutrients, and can infiltrate an inch or more of rainfall. Distributed around a property, vegetated bioretention areas can enhance site aesthetics. In residential developments they are often described as "rain gardens" and marketed as property amenities. Routine maintenance is simple and can be handled by homeowners or conventional landscaping companies, with proper direction.

Applications and Design Principles

Bioretention systems can be applied to a wide range of development in many climatic and geologic situations; they work well on small sites and on large sites divided into multiple small drainages. Common applications for bioretention areas include parking lot islands, median strips, and traffic islands. Bioretention is a feasible "retrofit" that can be accomplished by replacing existing parking lot islands or by re-configuring a parking lot during resurfacing. On residential sites they are commonly used for rooftop and driveway runoff.

Management Objectives

- Provide water quality treatment.
- Remove suspended solids, metals, nutrients.
- Increase groundwater recharge through infiltration.
- Reduce peak discharge rates.
- Reduce total runoff volume.
- Improve site landscaping.

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Above: This bioretention cell at a office park also helps to fulfill site landscaping requirements. *Photo: Low Impact Development Center*

Right: This schematic diagram shows parking lot runoff directed to a bioretention cell, with pretreatment by a grassed filter strip. *Image: Prince George's County (MD) Bioretention Manual*

Cover, top: A rain garden in a Connecticut Subdivision infiltrates rooftop and driveway runoff, and can be marketed as an extra amenity. *Photo: University of Connecticut, Jordan Cove Urban Monitoring Project*

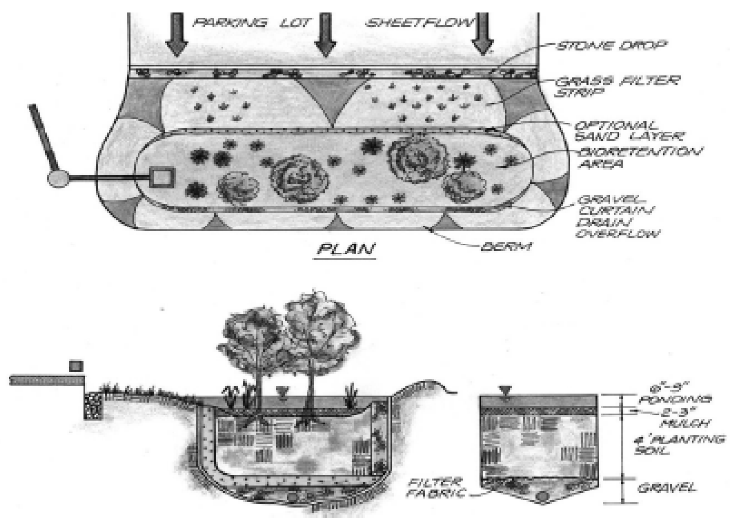
Cover, bottom: A narrow bioretention cell in a parking lot, planted with small trees to reduce the urban heat island effect. *Photo: Low Impact Development Center*

Bioretention cells are usually excavated to a depth of 4 feet, depending on local conditions. Generally, cells should be sized (based on void space and ponding area) to capture and treat the water quality volume (the first 0.5" or 1" of runoff, depending on local requirements.) Some manuals suggest a minimum width of 15', though much narrower bioretention cells have been installed in parking lot islands and are functioning well. Regardless of size, some type of filter should cover the bottom of the excavation. Filter fabric is commonly used but can be prone to clogging; consequently some engineers recommend a filter of coarse gravel, over pea gravel, over sand.

The cell should be filled with a soil mix of sandy loam or loamy sand. The area should be graded to allow a ponding depth of 6-8 inches; depending on site conditions, more or less ponding may be appropriate. The planting plan should include a mix of herbaceous perennials, shrubs, and (if conditions permit) understory trees that can tolerate intermittent ponding, occasionally saline conditions (due to road salt), and extended dry periods. The soil should be covered with 2-3" of fine-shredded hardwood mulch.

In very permeable soils, some bioretention areas can be designed as "off-line" treatment structures (no overflow necessary), but in most situations they will be an "on-line" component of the stormwater management system, connected to downstream treatment structures through an overflow outlet or an overflow drop inlet installed at the ponding depth and routed to the site's stormwater management system. Ideally, overflow outlets should be located as far as possible from runoff inlets to maximize residence time and treatment. In general, bioretention area should be designed to drain within 72 hours. In slowly permeable soils (less than 0.3 inches/hour) a perforated underdrain can be installed at the bottom of the excavation to prevent ponding.

Bioretention areas work best if designed with some pretreatment, either in the form of swales or a narrow filter strip. A stone or pea gravel diaphragm (or, better yet, a concrete level spreader) upstream of a filter strip will enhance sheet flow and better pre-treatment.



Benefits and Effectiveness

- Bioretention areas remove pollutants through filtration, microbes, and uptake by plants; contact with soil and roots provides water quality treatment better than conventional infiltration structures. Studies indicate that bioretention areas can remove 75% of phosphorus and nitrogen; 95% of metals; and 90% of organics,

Above, top: Bioretention cells are designed to allow ponded water six inches deep, which should infiltrate into the ground within 72 hours after a storm.

Above, middle: A large bioretention cell adjacent to a parking lot can reduce or eliminate expenses on storm sewers and detention basins. *Photo: Low Impact Development Center*

Above, bottom: Maintenance of rain gardens can generally be handled by homeowners. *Photo: Low Impact Development Center*

bacteria, and total suspended solids. Bioretention areas qualify as an organic filter according to the Massachusetts Stormwater Policy.

- In most applications, bioretention areas increase groundwater recharge as compared to a conventional "pipe and pond" approach. They can help to reduce stress in watersheds that experience severe low flows due to impervious coverage.
- Low-tech, decentralized bioretention areas are also less costly to design, install, and maintain than conventional stormwater technologies that treat runoff at the end of the pipe. The use of decentralized bioretention cells can also reduce the size of storm drain pipes, a major driver of stormwater treatment costs.
- Bioretention areas enhance the landscape in a variety of ways: they improve the appearance of developed sites, provide wind breaks, absorb noise, provide wildlife habitat, and reduce the urban heat island effect.

Limitations

- Because bioretention areas infiltrate runoff to groundwater, they may be inappropriate for use at stormwater "hotspots" (such as gas stations) with higher potential pollutant loads. On these sites, the design should include adequate pretreatment so that runoff can be infiltrated, or else the filter bed should be built with an impermeable liner, so that all water is carried away by the underdrain to another location for additional treatment prior to discharge.
- Premature failure of bioretention areas is a significant issue that results from lack of regular maintenance. Ensuring long-term maintenance involves sustained public education and deed restrictions or covenants for privately-owned cells.
- Bioretention areas must be used carefully on slopes; terraces may be required for slopes >20%.
- The design should ensure vertical separation of at least 2' from the seasonal high water table.

This parking lot bioretention cell is being constructed with an impermeable liner and a perforated underdrain, to provide retention and treatment of runoff (but not infiltration).

Maintenance

- Bioretention requires careful attention while plants are being established and seasonal landscaping maintenance thereafter.
- In many cases, maintenance tasks can be completed by a landscaping contractor working elsewhere on the site.
- Inspect pretreatment devices and bioretention cells regularly for sediment build-up, structural damage, and standing water.
- Inspect soil and repair eroded areas monthly. Re-mulch void areas as needed. Remove litter and debris monthly.
- Treat diseased vegetation as needed. Remove and replace dead vegetation twice per year (spring and fall.)
- Proper selection of plant species and support during establishment of vegetation should minimize—if not eliminate—the need for fertilizers and pesticides.
- Remove invasive species as needed to prevent these species from spreading into the bioretention area.
- Replace mulch every two years, in the early spring.
- Upon failure, excavate bioretention area, scarify bottom and sides, replace filter fabric and soil, replant, and mulch.

Cost

Bioretention areas require careful design and construction, the price of which will depend on site conditions and design objective. Generally, the cost of bioretention areas is less than or equal to that of a catch basin and underground chambers intended to treat the same area. Additionally, bioretention areas treat and recharge stormwater thereby reducing the amount/size of piping needed and the size of downstream basins and treatment structures.

Design Details

- Where bioretention areas are adjacent to parking areas, allow 3" of freeboard above ponding depth to prevent flooding.
- Determine the infiltrative capacity of the underlying native soil through an infiltration test using a double-ring infiltrometer. Do not use a standard septic system percolation test to determine soil permeability.
- Soil mix should be sandy loam or loamy sand with clay content less than 15%. Soil pH should generally be between 5.5-6.5, which is optimal for microbial activity and adsorption of nitrogen, phosphorus, and other pollutants. Planting soils should be 1.5-3% organic content and maximum 500ppm soluble salts.
- Planting soils should be placed in 1'-2' lifts, compacted with minimal pressure, until desired elevation is achieved. Some engineers suggest flooding the cell between each lift placement in lieu of compaction.
- Planting plan should generally include one tree or shrub per 50 s.f. of bioretention area, and at least 3 species each of herbaceous perennials, shrubs, and (if applicable) trees to avoid a monoculture.
- The bioretention landscaping plan should meet the requirements of any applicable local landscaping requirements.
- During construction, avoid excessive compaction of soils around the bioretention areas and accumulation of silt around the drainfield.
- In order to minimize sediment loading in the treatment area, only runoff from stabilized drainage areas should be directed to bioretention areas; construction runoff should be diverted elsewhere.

Additional References

Design Manual for Use of Bioretiention in Stormwater Management; Department of Environmental Resources, Prince George's County, MD; 1993.

Bioretention as a Water Quality Best Management Practice, Article 110 from Watershed Protection Techniques; Center for Watershed Protection; 2000 http://www.cwp.org/Downloads/ELC_PWP110.pdf

Storm Water Technology Fact Sheet, Bioretention, United States Environmental Protection Agency, Office of Water; 1999 http://www.lowimpactdevelopment.org/epa03/biospec. htm

Bioretention Fact Sheet, Federal Highway Administration www.fhwa.dot.gov/ environment/ultraurb/3fs3.html

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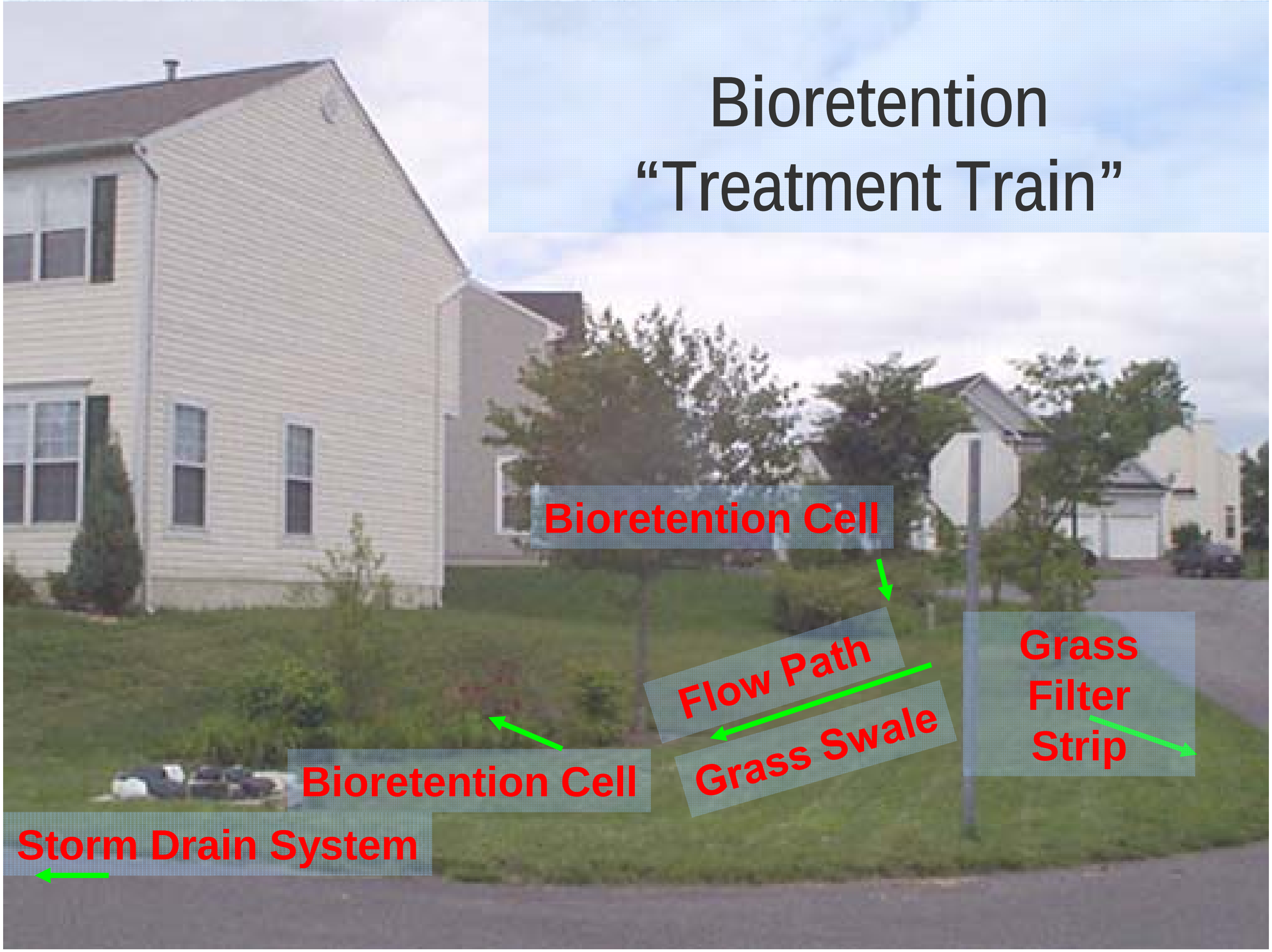
Bioretention
"Treatment Train"
Bioretention Cell
Flow Path
Grass Swale
Grass Filter Strip
Bioretention Cell
Storm Drain System

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FACT SHEET #5

VEGETATED SWALES

Overview

Vegetated swales are an important Low Impact Development technique used to convey stormwater runoff. These open, shallow channels slow runoff, filter it, and promote infiltration into the ground; as a result, runoff volumes are smaller, peak discharge rates are lower, and runoff is cleaner. This approach contrasts with conventional stormwater strategies that rely on gutters and pipes that increase the velocity of runoff and do nothing for water quality.

Swales are not just ditches under another name—they must be carefully designed and maintained to function properly. The vegetation in swales, usually thick grass, helps to trap pollutants (suspended solids and trace metals), and reduce the velocity of stormwater runoff; stormwater also percolates through the natural substrate.

Vegetated swales can replace curb and gutter systems as well as storm sewers that convey runoff. Swales require more room than curb and gutter systems but they require less expensive hardscaping; furthermore, the reduction in discharge rate and volume means that downstream treatment facilities can be smaller. Swales also double as landscaping features, increasing the value and attractiveness of the site, as well as its appeal to neighbors and regulatory boards.

Applications and Design Principles

Water quality swales are widely applicable on residential, commercial, industrial, and institutional sites. The amount of impervious cover in the contributing area to each swale should be no more than a few acres, and swales should not be used in areas where pollutant spills are likely. Grassed swales can be used in parking lots to break up areas of impervious cover. Roadside swales can be used in place of curb and gutter systems, except where there are numerous driveways requiring culverts. Where sidewalk and road are parallel, swale should be between the sidewalk and the road.

Management Objectives

- Provide water quality treatment; remove suspended solids, heavy metals, trash.
- Reduce peak discharge rate.
- Reduce total runoff volume.
- Infiltrate water into the ground.
- Provide a location for snow storage.
- Improve site landscaping.

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Vegetated swales may be parabolic or trapezoidal in cross section. Longitudinal slopes should be as low as possible, and never more than 4%; swales should follow natural topography and drainage patterns to the extent possible. Swales work best in sandy loams that facilitate infiltration; very sandy soils may be prone to erosion under high runoff velocities. Check dams placed along the length of the swale can help to slow the runoff even more and promote greater infiltration and pollutant removal. Careful hydrologic design is necessary to ensure adequate pretreatment of the water quality volume and nonerosive conveyance of large storms.

In some applications, swales are designed with a 2- to 3-foot deep soil bed of loamy sand to promote greater infiltration; on denser sites, this bed may include a perforated underdrain to ensure rapid drainage of the swale if groundwater infiltration is slow. In such applications, the runoff would end up (via the underdrain or swale termination) in the conventional stormwater system, but the swale would still provide considerable quality, quantity, and rate benefits.

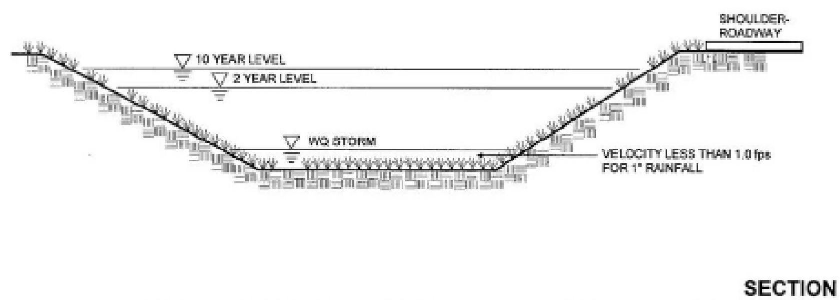
Benefits and Effectiveness

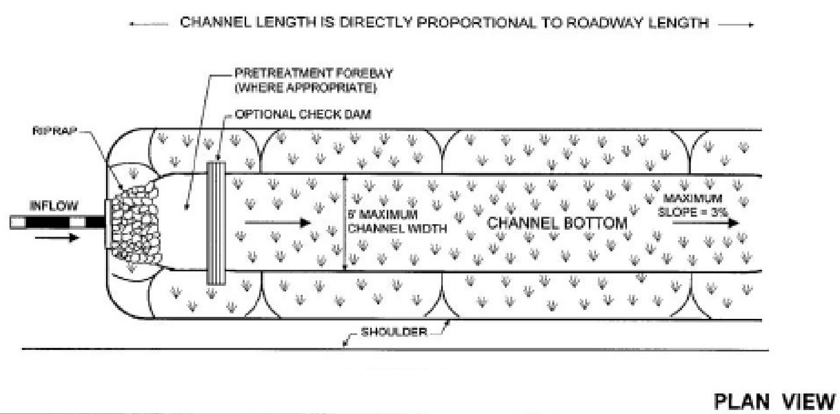
- Swales help to control peak discharges by reducing runoff velocity, lengthening flow paths, and increasing time of concentration.
- Infiltration through the natural substrate helps to reduce total stormwater runoff volume.
- Swales provide effective pretreatment for downstream BMPs by trapping, filtering and infiltrating particulates and associated pollutants. The design rate for TSS removal is 70%.
- Swales accent the landscape and may help to satisfy landscaping and greenspace requirements.
- Swales can provide a location for snow storage during winter months.
- Roadside swales effectively keep stormwater flows away from street surfaces.
- Construction may cost less than conventional curb and gutter systems.

Cover, top: Stone check dams in this roadside swale serve to slow run-off, promote settling, and increase infiltration. *Photo: Virginia Stormwater Management Handbook*

Cover, bottom: This swale in a residential neighborhood fits in with the landscaping. *Photo: University of Connecticut, Jordan Cove Urban Monitoring Project*

Below: A meandering grassed swale filters runoff and helps to improve site landscaping. *Photo: Low Impact Development Center.*





Above: This roadside swale can provide a convenient location for snow storage. As the snow melts, sand is filtered by the vegetation and some of the runoff will infiltrate. *Photo: University of Connecticut, Jordan Cove Urban Monitoring Project.*

Limitations

- Each grassed swale can treat a relatively small drainage area of a few acres, depending on land use and soil type. Large areas should be divided and treated using multiple swales.
- Swales are impractical in areas with steep topography.
- A thick vegetative cover is needed for these practices to function properly. Grass must not be mowed too short.
- Swales should be used carefully on industrial sites or areas of higher pollutant concentrations. If used, they should be part of a "treatment train" that includes other treatment BMPs.
- Swales can be subject to channelization, if erosive velocity is exceeded.
- Soil compaction can reduce infiltration capacity.
- Swales are not effective at reducing soluble nutrients such as phosphorous.
- In some places, the use of swales is restricted by law; many local municipalities may require curb and gutter systems in residential areas.

Maintenance

- Permits for water quality swales should specify schedules and responsibility for inspection and maintenance. Since swales may be located on private residential property, it is important for developers to clearly outline the maintenance requirements to property purchasers.
- Inspect on a semi-annual basis; additional inspections should be scheduled during the first few months to make sure that the vegetation in the swales becomes adequately established. Inspections should assess slope integrity, soil moisture, vegetative health, soil stability, compaction, erosion, ponding, and sedimentation.
- Mow at least once per year, but do not cut grass shorter than the design flow

Above: Swales can be used on commercial sites to convey runoff around the site and to help slow peak discharge rates. *Photo: Lower Columbia River Estuary Partnership*

depth because the effectiveness of the vegetation in reducing flow velocity and pollutant removal may be reduced. Grass cuttings should be removed from the swale and composted.

- Remove accumulated sediment when it is 3" deep or higher than the turf, to minimize potential concentrated flows and sediment resuspension.
- Irrigate only as necessary to prevent vegetation from dying.
- The application of fertilizers and pesticides should be minimal.
- Reseed periodically to maintain dense turf.
- Remove trash or obstructions that cause standing water.
- Prevent off-street parking or other activities that can cause rutting or soil compaction.

Cost

Vegetated swales typically cost less to construct than curbs and gutters or underground stormwater conveyance pipes. The cost of construction will depend on local conditions and management objectives. As with any stormwater management structure, property owners should provide a budget for ongoing maintenance, such as regular mowing and repairs as necessary.

Design Details

- The topography of the site should generally allow for a longitudinal slope of no more than 4% and no less than 0.5%. Flatter slopes can result in ponding, while steeper slopes may result in erosion (depending on soil type, vegetation, and velocity.) Use natural topographic low points and drainageways to minimize excavation.
- Underlying soils should be a sandy loam or a similar soil type with no more than 20% clay. Soil augmentation may be necessary.
- Side slopes should be 3:1 or flatter for maintenance and to prevent side slope erosion. Swale bottoms should generally be between 2 and 8 feet in width.
- Use pea gravel diaphragms for lateral inflows.
- Check dams can be utilized to establish multiple cells. Check dams at 50-foot intervals (<2' drop) help to maximize retention time, increase infiltration, promote particulate settling, and decrease flow velocities. Check dams are not necessary with very low longitudinal slopes. Provide for scour protection below check dam.
- Outlet protection must be used at any discharge point from swales to prevent scour.
- Select grass species that produce fine, uniform, and dense cover and that can withstand prevailing moisture conditions.
- Temporary erosion and sediment controls should be utilized during construction.
- Keep heavy equipment out of the channel during construction to minimize compaction. Even a bobcat grader can compact soils and reduce potential infiltration. Use excavator with a swing arm and work from the side of the swale.
- Mulch anchoring should be done immediately after seeding.

Additional References

- *Massachusetts Stormwater Management Policy: Volume Two: Stormwater Technical Handbook*; Massachusetts Department of Environmental Protection and Massachusetts Coastal Zone Management; 1997
- *Grassed Swales*; from The Wisconsin Stormwater Manual, University of Wisconsin-Extension Service; 2000

This publication is one component of the Massachusetts Low Impact Development Toolkit, a production of the Metropolitan Area Planning Council, in coordination with the I-495 MetroWest Corridor Partnership, with financial support from US EPA. The Massachusetts Low Impact Development Interagency Working Group also provided valuable input and feedback on the LID Toolkit.

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LID STRATEGIES: Rain Gardens

- Vegetative uptake of stormwater pollutants
- Pretreatment for suspended solids
- Groundwater recharge
- Aesthetically Pleasing
- Reduction of peak discharge rate

Low Impact Development strategies use careful site design and decentralized stormwater management to reduce the environmental footprint of new growth. This approach improves water quality, minimizes the need for expensive pipe-and-pond stormwater systems, and creates more attractive developments.

MASSACHUSETTS LOW IMPACT DEVELOPMENT TOOLKIT

FACT SHEET #6

GRASS FILTER STRIPS

Overview

Grass filter strips are low-angle vegetated slopes designed to treat sheet flow runoff from adjacent impervious areas. Filter strips (also known as vegetated filter strips and grassed filters) function by slowing runoff velocities, filtering out sediment and other pollutants, and providing some infiltration into underlying soils. Because they use sheet flow and not channelized flow, filter strips are often more effective than swales at removing suspended solids and trash from runoff. They provide good "pretreatment" of stormwater that will then be routed to another technique such as a bioretention area.

Filter strips were originally used as an agricultural treatment practice, but have recently been used in more urban and suburban locations. They differ slightly from buffer strips, which are natural vegetated areas alongside streams and lakes; buffer strips are left undisturbed for habitat protection and visual screening, while filter strips are altered areas designed primarily for stormwater management. Like many other LID techniques, vegetated filter strips can add aesthetic value to development. They cost significantly less than "hardscaped" stormwater infrastructure and also provide a convenient and effective area for snow storage and treatment.

Applications and Design Principles

Filter strips are appropriate for roadside applications and along the edge of small- to medium-sized parking lots, so long as the tributary area extends no more than 60 feet uphill from the buffer strip. They can also be used to treat roof runoff that is discharged over a level spreader. Filter strips are ideal components of the outer zone of a stream buffer, or as pretreatment to another stormwater treatment practice. They are generally require too much land area for applications in urban areas. The contributing drainage area should generally be less than five acres.

Management Objectives

- Remove suspended solids, heavy metals, trash, oil and grease.
- Reduce peak discharge rate and total runoff volume.
- Provide modest infiltration and recharge.
- Provide snow storage areas.
- Improve site landscaping.

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Filter strips work best when they are at least 20 feet long (downhill axis), though shorter strips will still provide some treatment. They should have slopes between 1% and 15%, preferably in the lower end of that range. It is critical for filter strips to be planar or convex, since any undulation in the surface or obstructions can cause concentrated flow that leads to erosion, channelization, and loss of water quality benefits.

The design should seek to keep runoff velocity in the low to moderate range (less than 2 feet per second) in order to maximize water quality benefits. This can be done by limiting the size of the contributing impervious surface. Both the top and toe of the slope should be as flat as possible to encourage sheet flow. A pea gravel or cement level spreader (with a lip) at the top of the filter strip will improve sheet flow and will capture some sediment.

Some filter strips are designed with a pervious berm at the downhill end of the filter strip, to detain water temporarily, increasing infiltration and reducing peak discharge rates. This berm can significantly enhance water quality benefits if it is designed to impound the water quality volume.

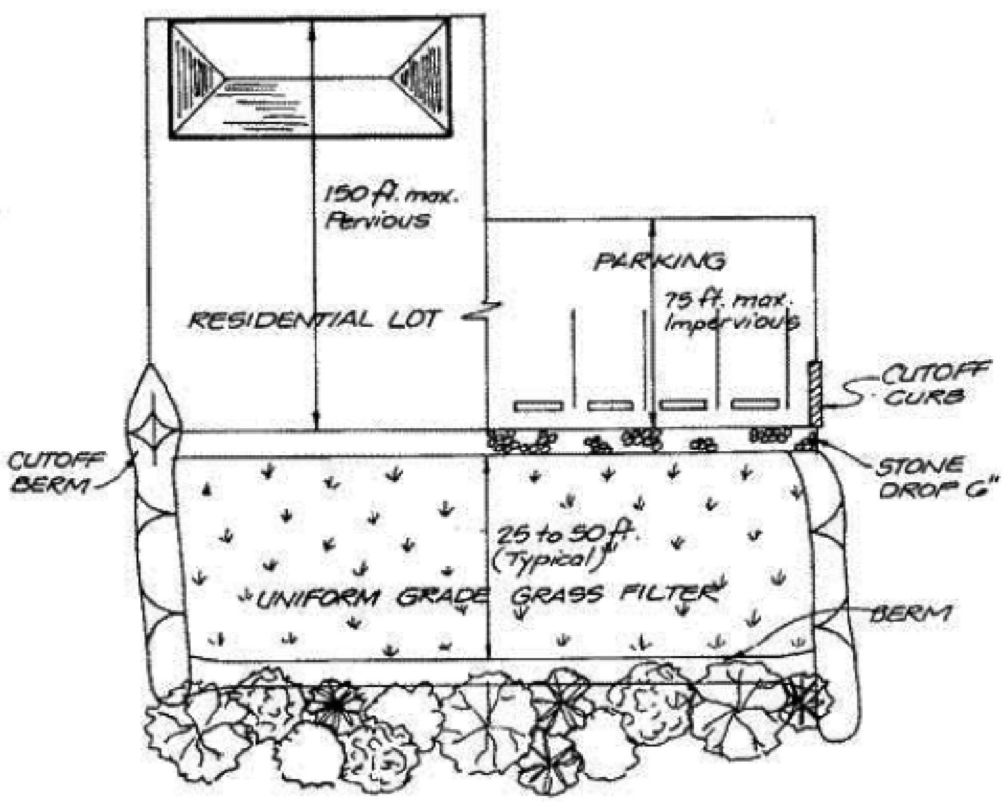
Cover, top: This 40-foot wide filter strip provides water quality pretreatment of runoff from the adjacent highway. *Photo: California Stormwater Quality Association.*

Cover, bottom: A filter strip adjacent to this filling station provides room for snow storage and can remove sediment and organics from runoff. *Photo: Steve Haubner, Atlanta Regional Commission*

Below right: A plan view of filter strips in residential and commercial settings. *Image: Center for Watershed Protection*

Benefits and Effectiveness

- Filter strips provide runoff pretreatment by trapping, filtering and infiltrating particulates and associated pollutants. TSS removal rates range from 40%-90%. Effectiveness depends largely on the quantity of water treated, the slope and length of the filter strip, the type of vegetation, and the soil infiltration rate.
- Vegetated filter strips also reduce runoff velocities and increase the time of concentration as compared to channelized flow, resulting in a reduction of peak discharge rates.
- Filter strips may provide groundwater recharge as runoff infiltrates into soil; recharge may be considerable if design incorporates a ponding area at the toe of the slope.



Above: Here a filter strip is being used as pretreatment for parking lot runoff directed to an infiltration basin. Note concrete level spreader (at right) to facilitate sheetflow across filter strip. *Photo: California Stormwater Quality Association*

- Filter strips can serve as a location for snow storage during winter months and will also help to trap and treat the salt and sand in snow when it melts.
- Filter strips are inexpensive to construct, especially when compared to conventional curb-and-gutter systems.
- Vegetated filter strips help to accent the natural landscape by providing green space adjacent to parking lots and roadways.

Limitations

- Because filter strips infiltrate runoff to groundwater, they could be inappropriate at stormwater "hotspots" (such as gas stations) with higher potential pollutant loads. They should be combined with other BMPs to ensure adequate treatment of polluted runoff prior to discharge.
- Channelization and premature failure may result from poor design, imprecise construction, or lack of maintenance. Proper design requires a great deal of finesse, and slight problems in the construction, such as improper grading, can render the practice less effective in terms of pollutant removal.
- Filter strips have low removal rates for nutrients, so they must be used in conjunction with other best management practices.
- Filter strips often require lots of space, making them often infeasible in urban environments where land prices are high.

Maintenance

- Inspect level spreader monthly and remove built-up sediment.
- Inspect vegetation monthly for rills and gullies and correct. Fill any depressions or channels. Seed or sod bare areas.
- In the year following construction, inspect the filter strip regularly to ensure that grass has established. If not, replace with an alternative species. Allow natural succession by native grasses and shrubs if it occurs.

This diagram shows a filter strip designed with a berm to impound water, resulting in improved water quality treatment and increased infiltration. *Image: Center for Watershed Protection*

- Mow grass, as rarely as 2-3 times per year, to maintain 4" to 6" of dense grass cover. Grass clippings should be collected and composted elsewhere. Provide a minimum of fertilizer only when necessary. Mow when the soil is dry and firm to prevent rutting.
- Semi-annually, remove sediment that has accumulated to prevent berms or channels.

Cost

Filter strips cost considerably less to construct than many hardscaped stormwater management structures such as curbs, storm sewers, and ponds. The primary direct expenses are clearing, grading, and seed or sod. Additional expenses may include construction of a level spreader at the top of the strip or a berm at the toe of the slope.

The most significant cost of filter strips may be an indirect expense, which is the cost of the land, which may be very valuable in dense urban settings. In many cases, however, open spaces and buffers are required by municipal landscaping or zoning regulations, and filter strips may be used to satisfy these requirements. Established vegetated buffers may also add value a property.

Design Details

- The limiting design factor for filter strips is not total drainage area but rather the length of flow contributing to it. Because sheetflow runoff becomes concentrated flow as distance increases, the contributing area to a vegetated buffer should be no more than 60 feet for impervious surfaces, and 100 feet for pervious surfaces.
- Slopes should be between 1% and 15%, though slopes less than 5% are preferred. The top and toe of the slope should be as flat as possible.
- The filter strip should be at least 20' long (downhill length) to provide water quality treatment. Minimum width is 8' or 0.2 X length of flow over the impervious surface upstream of the filter strip.
- Depth of sheetflow should be less than 0.5" for the design storm. Depending on the pollutant removal required, residence time should be at least 5 minutes, preferably 9 minutes or more.
- Use Manning's equation to calculate velocity, assuming hydraulic radius equals depth, with n values of 0.20 for mowed grass slope and 0.24 for infrequently mowed grass slope. Normal velocity should be <1.0 feet/second for design flow, with maximum permissible velocity of 3.0 feet/second for peak discharge during 10-year storm.
- Use a cement level spreader or pea gravel diaphragm at the top of the slope.
- Filter strips can be designed with a pervious berm of sand and gravel at the toe of the slope. This feature provides an area for shallow ponding at the bottom of the filter strip. Runoff ponds behind the berm and gradually flows through outlet pipes in the berm. The volume ponded behind the berm should be equal to the water quality volume.
- Designers should choose a grass that can withstand calculated flow velocities, and both wet and dry periods. Also consider depth to groundwater and choose facultative wetland species if appropriate.
- If filter strip will be used for snow storage, use salt tolerant vegetation (e.g., creeping bentgrass.)
- During construction, divert runoff from unstabilized areas away from filter strips.
- Protect the underlying soil from compaction to the extent possible: work from outside the boundaries of the filter strip or use oversized tires and lightweight equipment.

Additional Resources

Mass Highway Department Stormwater Handbook
(www.mhd.state.ma.us/mhd/environ/publications.htm)
www.stormwatercenter.net

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