



INDIANA OFFICE OF
Community & Rural Affairs

Welcome!

Green Infrastructure Curriculum & Training

SIP the Green Juice!

Session 3: Implementation of Green Infrastructure



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Today's Speakers



**CHRISTOPHER B. BURKE
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CURRY & ASSOCIATES, INC.
CONSULTING ENGINEERS & ARCHITECTS

Sarah Hudson



JRM Environmental

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Three Sessions

1. Overview of Green Infrastructure
2. Policies, Incentives, and Funding for Green Infrastructure
- 3. Implementation of Green Infrastructure**



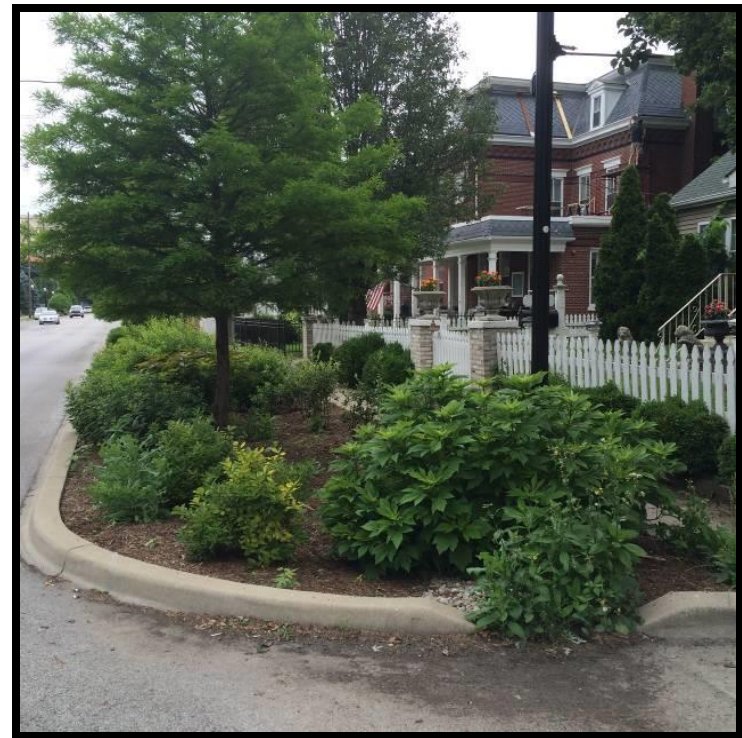
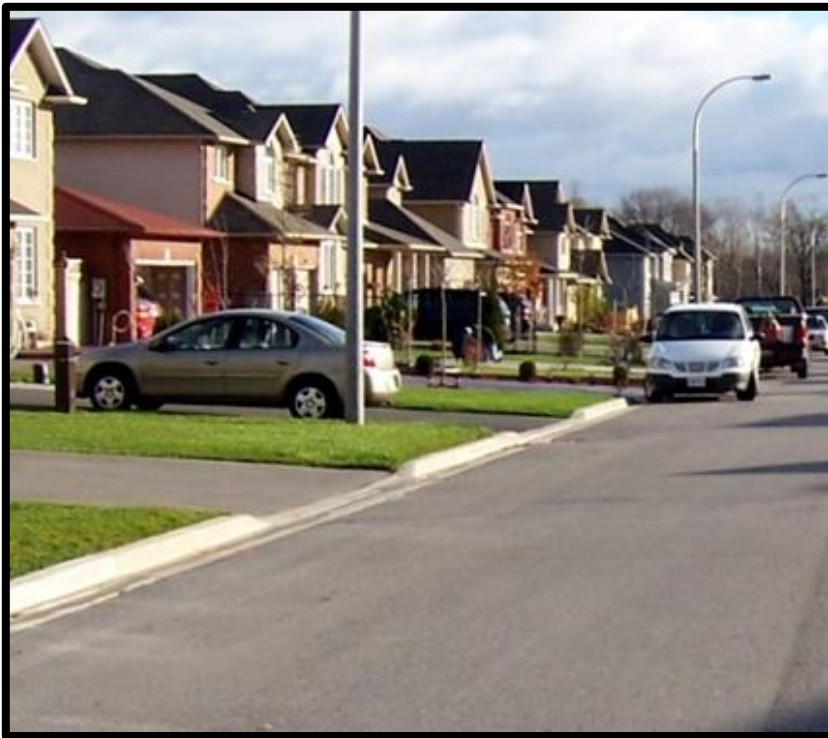
Grey to Green Benefits

- Improves environmental health
- Promotes community identity
- Attractive to employers and residents



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Grey to Green





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Grey to Green





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Grey to Green





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Grey to Green





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Grey to Green





Grey to Green

- Be creative and innovative
- Create a space with multiple benefits
- Store and treat stormwater





BMP Selection

1. Site Assessment & Site Design
2. Source-control & Water Quality Treatment
3. Site Restoration



1. Site Assessment & Site Design

- Planning and site design techniques to address stormwater runoff from entire site or larger scale
- Preserve function of natural areas and minimize impact development



MINIMIZE DISTURBED AREAS



**PROTECT SENSITIVE AREAS and
PRESERVE NATURAL FLOW PATHS**



CAUTION CONSTRUCTION AREA

**MINIMIZE SOIL
COMPACTION**



**MINIMIZE IMPERVIOUS SURFACES
STORMWATER DISCONNECTION**



2. Source-control/Water Quality

- Location specific practices to capture and treat stormwater runoff at source
- Engineered systems to address runoff volume and runoff quality

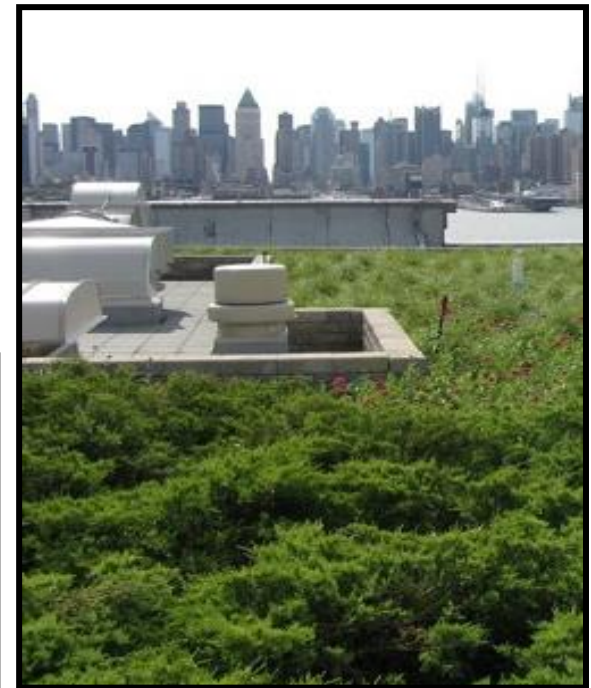


**PERMEABLE PAVEMENT
BIORETENTION/RAIN GARDENS
PLANTER BOXES/TREE BOXES**



**VEGETATED
SWALE/BIOSWALE
INFILTRATION PRACTICES**

**STORMWATER PONDS
CONSTRUCTED WETLANDS**



**GREEN ROOFS
RAINWATER HARVESTING**



3. Site Restoration

- Restore site's natural ability to intercept, store, filter, and infiltrate stormwater
- Revegetation and soil restoration practices



NATIVE REVEGETATION



RIPARIAN BUFFER RESTORATION

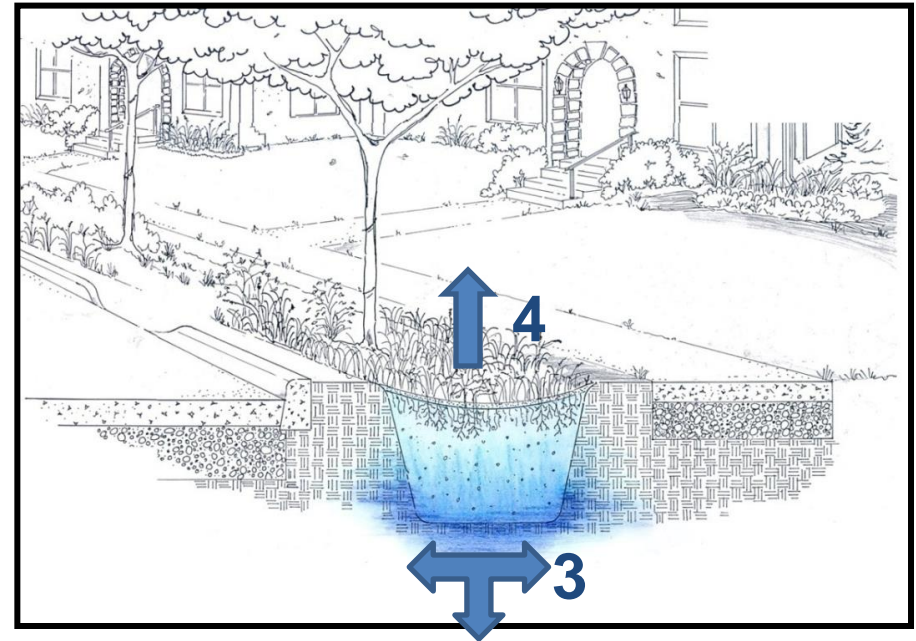
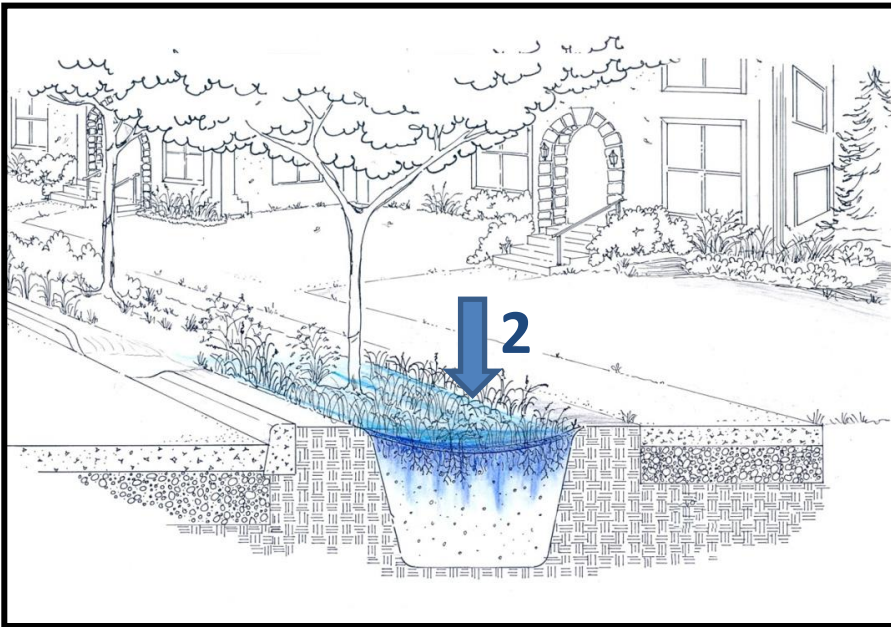
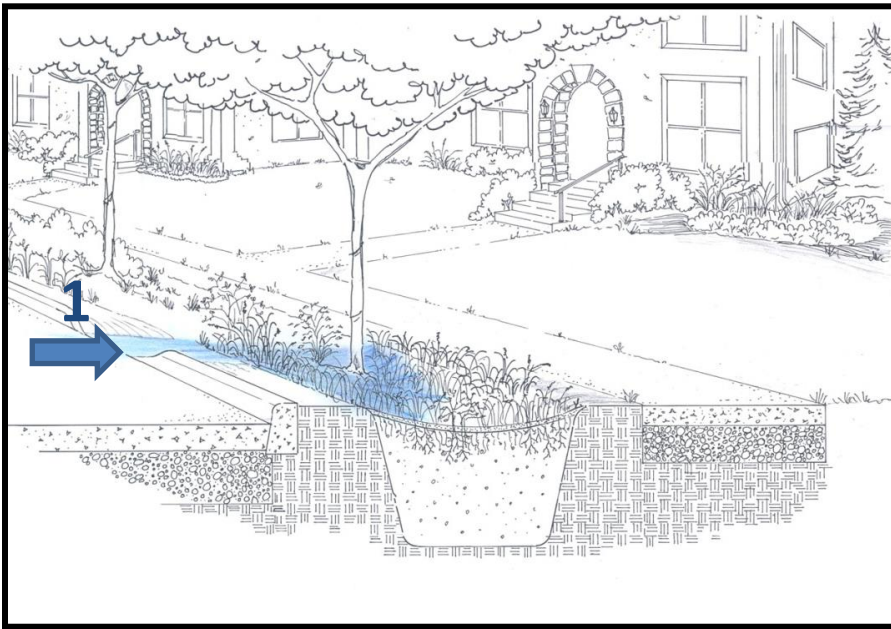


SOIL RESTORATION



BMP Function

1. Storage
2. Filtration
3. Infiltration
4. Evapotranspiration





BMP Performance

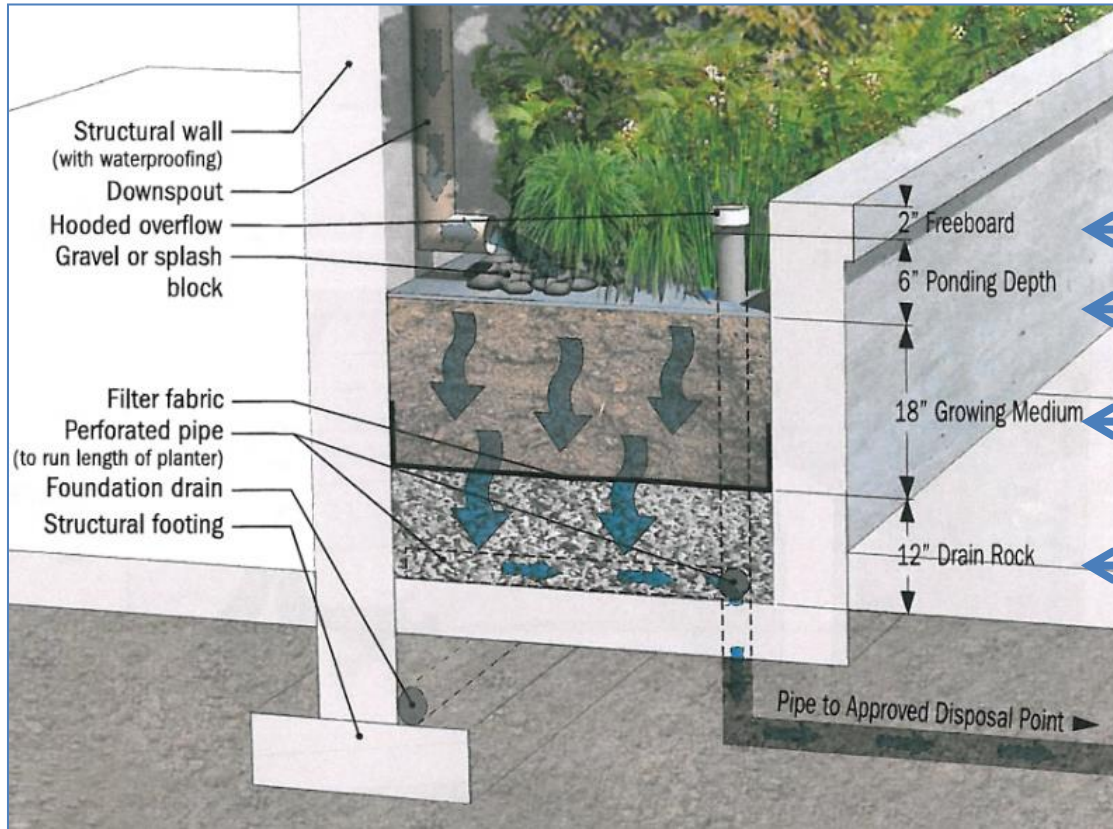
1. Stormwater Storage Potential
2. Stormwater Pollutant Removal



Example Language

- removal of floatables in stormwater runoff and treatment, to the maximum extent practicable, of all major pollutants of concern... for the first inch of rainfall
- “maximum extent practicable” criterion is subject to a minimum of 80% removal of Total Suspended Solids (TSS)

BMP Storage Potential



2" Freeboard

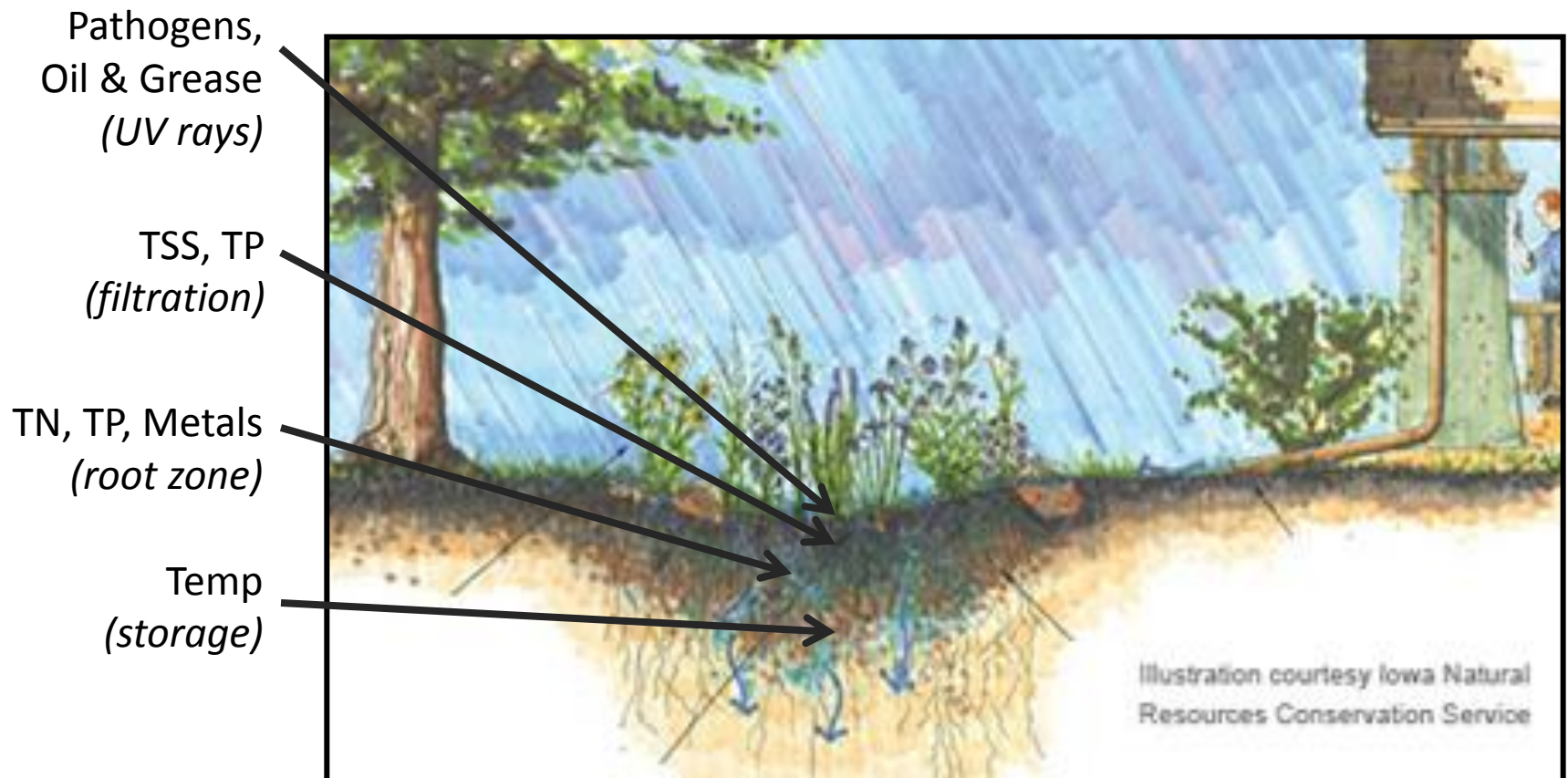
6" Ponding Depth

18" Growing Medium
(30% voids=5.4")

12" Drain Rock
(40% voids=4.8")

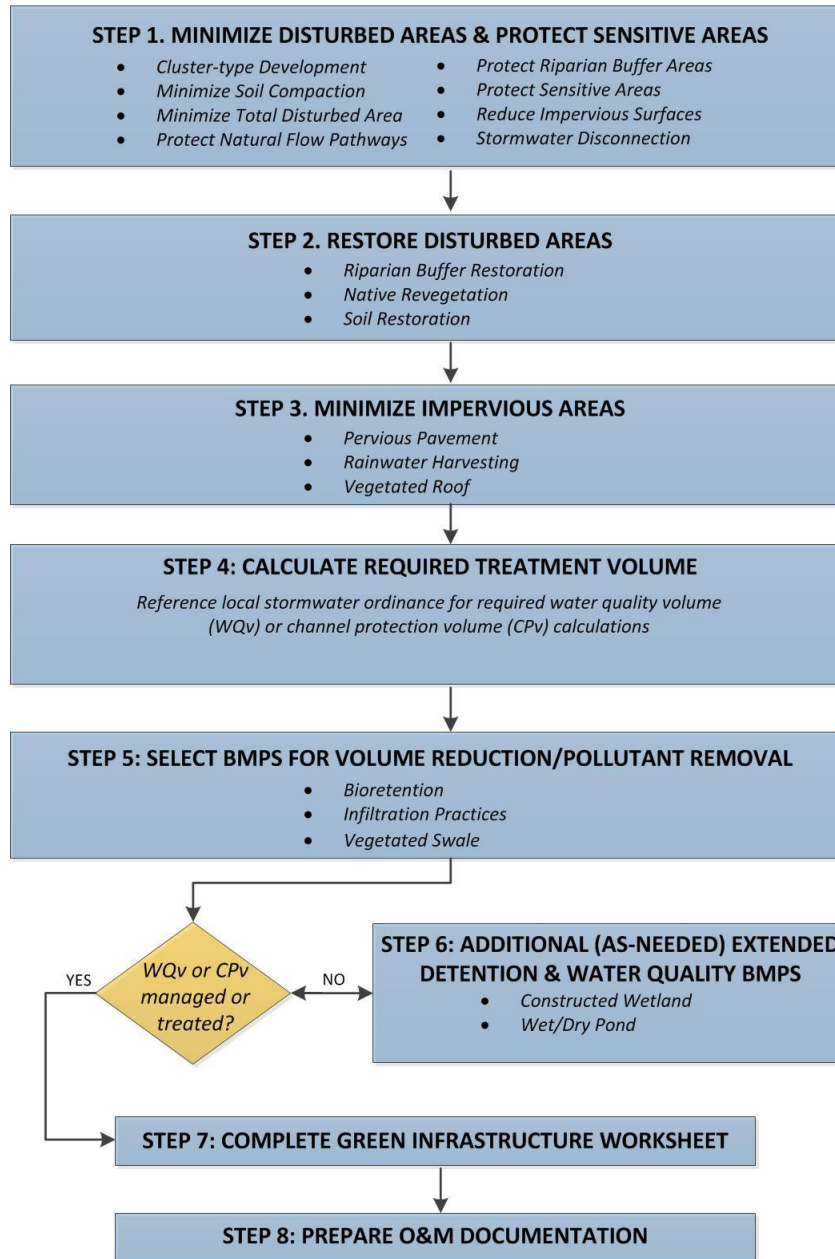
Pipe to Approved Disposal Point

Pollutant Removal



BMP	STORAGE & POLLUTANT REMOVAL SUMMARY	
	Storage/ft2	Pollutant Removal
Bioretention/ Rain Garden	10.8"	TP = 55% TN = 64% TSS = 70%
Rainwater Harvesting	1"	TP = 75% TN = 75% TSS = 75%
Green Roof/ Blue Roof	1.5"	TP = 45% TN = 40% TSS = 70%
Permeable Pavement	9.6"	TP = 59% TN = 59% TSS = 80%
Tree Boxes	10.8"	TP = 55% TN = 64% TSS = 70%

GREEN INFRASTRUCTURE BMP IMPLEMENTATION PROCESS



NOTES

- Map and calculate sensitive areas to be protected
- Layout design to minimize disturbance and avoid sensitive areas
- Refer to BMP fact sheets in Appendix C

- Identify and calculate areas where restoration practices could be used to reduce stormwater runoff
- Refer to BMP fact sheets in Appendix C

- Identify and calculate areas where impacts of impervious area can be reduced
- Refer to BMP fact sheets in Appendix C

- Calculate the disturbed areas (exclude protected area Step 1)
- Assign a credited CN for areas restored or impact minimized from Step 2 & 3
- Calculate the WQv or CPv needed

- Select and size appropriate BMPs for volume reduction and pollutant removal
- Refer to BMP fact sheets in Appendix C

- Select, as needed, additional BMPs for volume reduction and pollutant removal
- Refer to BMP fact sheets in Appendix C

- Summarize BMP practices and calculations
- See worksheet in Appendix B

- Assemble O&M materials
- See O&M materials in Appendix I

GREEN INFRASTRUCTURE WORKSHEET

This checklist is a tool to allow both the regulatory agency and the Developer to reference various GI measures implemented within the development in order to meet the development's Post-Construction Stormwater Management requirements.

Project Name:	Engineer:	Developer:
Total Site Area:	_____	sf
Proposed Disturbance Area:	_____	sf
Existing Impervious Area:	_____	sf

GI Approach Step	Potential BMPs	v	Total Surface Area (sf) of GI Measure/BMP	Plan page # of GI Measure	Page # of Calculations for GI Measure
1. Minimize Disturbed Areas	Protect Sensitive Areas				
	Protect Riparian Buffers				
	Protect Natural Flow Pathways				
	Minimize Total Disturbed Area				
	Cluster-type Development				
2. Restore Disturbed Areas	Minimize Soil Compaction				
	Soil Amendment and/or Restoration				
	Native Revegetation				
	Riparian Buffer Restoration				
3. Minimize Imperviousness	Pervious Pavement				
	Vegetated Roof				
	Stormwater Disconnection				
4. Provide Distributed Volume Reduction/ Infiltration	Bioretention				
	Infiltration Practices				
	Vegetated Swale				
	Pervious Pavement				
	Planter Box				
5. Additional (as-needed) Extended	Bioretention				
	Detention Basins				
	Infiltration Practices				



BMP Design

- Good design essential to function and performance
- Site conditions, underlying soils, siting and sizing BMPs, plants selection, and materials (geotextiles, stone, sand, amended soil, etc.)

BMP Fact Sheet

PLANTER BOXES

Planter boxes receive runoff from multiple impervious surfaces, which is used for irrigation of the vegetation in the planter box preventing stormwater from directly draining into nearby sewers. They also play an important role in urban areas by minimizing stormwater runoff, reducing water pollution, and creating a greener and healthier appearance of the built environment by providing space for plants and trees near buildings and along streets. There are three main types of planter boxes which can be used on sidewalks, plazas, rooftops, and other impervious areas: contained, infiltration, and flow-through.



Figure 1 Streetside planter, Portland, OR (city of Portland, Bureau of Environmental Services)

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

Additional Considerations	
Cost	High
Maintenance	Medium
Winter Performance	Medium

Variations

- Contained
- Infiltration
- Flow-through

Key Design Features

- May be designed as pretreatment
- May be designed to infiltrate
- Captures runoff to drain out in three to four hours after a storm event
- Receives less than 15,000 ft² of impervious area runoff
- Planters should be made of stone, concrete, brick, or pressure-treated wood

Benefits

- Enhances the area where they are placed
- Potential air quality and climate benefits
- Can be used in a wide range of areas, including ultra-urban

Limitations

- Limited stormwater quantity/quality benefits
- Relatively high cost due to structural components

Appendix C includes information on:

- APPLICATION
- STORMWATER FUNCTION
- VARIATIONS
- KEY DESIGN FEATURES
- SITE FACTORS
- BENEFITS
- LIMITATION
- DESCRIPTION & FUNCTION
- CALCULATIONS
- CONSTRUCTION
- MAINTENANCE
- COST
- AESTHETICS/HABITAT
- COLD CLIMATE
- DESIGN/REVIEWER CHECKLIST

Appendix C



BMP Construction Inspection

- Improper construction and installation affects function and performance
- Vague details/specifications and/or inexperienced contractors
- Construction Quality Assurance Plans
- Construction Inspection Checklist



Bioretention swale, installed too early during active construction, has become clogged with sediment.



Bioretention area does not drain because of improper soil media, soils compacted during installation, and/or filter fabric under media.



Curb inlets to bioretention swale have eroded because of improper sizing of stone.



High plant mortality has occurred because improper species were substituted during construction.



Site runoff by-passes bioretention swale because of small elevation changes during construction.



Some site runoff by-passes bioretention because of inadequate slope of filter strip.

CONSTRUCTION INSPECTION CHECKLIST

Inspection occurs at all stages of project construction. Field verification of LID/GI design assumptions should occur at the beginning of construction, materials should be verified/certified (e.g., engineered soil media, plants), and LID features should be inspected throughout project construction, and, ultimately, the form and function of LID practices should meet standards of construction prior to return of the contractor's performance bond. The following list of items should be inspected and certified during construction.

Prior to Construction

- Divert runoff from adjacent areas.
- Clear the area where the LID practice will be constructed.
- Establish and protect a nearby project benchmark.
- Stake out and confirm grades of the practice location.
- In infiltration areas, test the soil for permeability to confirm design assumptions.
- Verify groundwater and bedrock design assumptions.
- Ensure temporary erosion and sediment controls have been properly installed.

Excavation

- Ensure the contractor has the right equipment.
- Discuss the goals of the project and purpose of the LID practices with the operators and crew.
- Ensure side slopes are stable and within design range.
- Stabilize stockpile locations with vegetation and/or silt fence. Stockpiles must not be adjacent to excavation area.
- Scarify soils compacted during excavation.
- If necessary, adjust the facility's depth to meet soil type and permeability design assumptions.
- Put sufficient perimeter controls in place to protect the practice.

Structural Components

- Ensure materials (aggregate, perforated pipe, etc.) are per specifications.
- Ensure forms are adequately sized.
- Place and install geotextile drainage fabrics or impervious liners per plan.
- Install underdrain system to grade.
- Install anti-seep collars per plan.
- Install inlets/outlets and emergency overflows at correct elevations per plans.



BMP Maintenance Inspection

- Routine inspection and maintenance needed to ensure proper performance
- Frequency: following major storm, monthly during growing season, annually
- Operations & Maintenance Manual
- Maintenance Checklist
- Maintenance Agreement

OPERATION & MAINTENANCE MANUAL

Subsequent to successful installation of post-construction BMPs, they need to be inspected and maintained regularly in accordance with the Operation and Maintenance (O&M) Manual required to be prepared for each BMP. An operations and maintenance manual for all private infrastructure, including but not limited to pipes, ponds, ditches, and BMPs (when required), shall be submitted for the final plan approval and permit process. The manual will become a maintenance guide for the drainage infrastructure once development is complete. The final O&M manual will be provided to the **Community** in both hard copy and digital formats. The O&M manual maintenance agreement along with a site map showing the BMP locations shall be recorded with the final plat. The O&M manual will include the following:

1. Owner name, address, business phone number, home phone number, email address, cellular phone number, pager number;
2. Site drawings (8½” by 11” or 11” by 17”), showing both plan and cross-section views, showing the infrastructure and applicable features, including dimensions, easements, outlet works, forebays, signage, etc., as well as an overall site map of the development showing all structures;
3. Guidance on owner-required periodic inspections;
4. Requirement of owner to perform maintenance specified by County inspection, if any;
5. Guidance on routine maintenance, including mowing, litter removal, woody growth removal, signage, etc.;
6. Guidance on remedial maintenance; such as inlet replacement, outlet works maintenance, etc.;
7. Guidance on sediment and trash removal, both narrative and graphical, describing when sediment removal should occur in order to insure that BMPs and other infrastructure remain effective as water quality and/or quantity control devices;
8. A statement that the County’s representatives have the right to enter the property to inspect the infrastructure;
9. A tabular schedule showing inspection and maintenance requirements; and
10. Identification of the property owner as the party responsible for all maintenance, including cost.

BIORETENTION (RAIN GARDEN) & VEGETATED SWALE (BIOSWALE) MAINTENANCE INSPECTION CHECKLIST

BMP Location:	Inspector's Remarks:
Overall Condition (circle one): <i>ACCEPTABLE</i> <i>UNACCEPTABLE</i>	
Inspection Date:	

FREQUENCY	MAINTENANCE ACTIVITY	COMMENTS
As Needed & Following > 1" Rainfall	<input type="checkbox"/> Irrigate if plants appear wilted or unhealthy; replace dead plants <input type="checkbox"/> Check for erosion, cracking, embankment failure, burrowing animals, and sediment clogging the drain and other pipes <input type="checkbox"/> Repair erosion with additional plant material similar to original and/or small stones for stability <input type="checkbox"/> Remove trash, debris, and sediment <input type="checkbox"/> Remove weeds and invasive plants <input type="checkbox"/> Replace bark mulch on bare, exposed soil	
Monthly (during growing season)	<input type="checkbox"/> Irrigate 1" water/week during the first growing season <input type="checkbox"/> Check/clean inlets, outlets/overflows and curb cuts from debris <input type="checkbox"/> Check plants for pest damage or disease <input type="checkbox"/> Remove trash, debris, and sediment <input type="checkbox"/> Remove weeds and invasive plants	
Semi-Annually (spring & fall)	<input type="checkbox"/> Redefine lawn edge	
Annually	<input type="checkbox"/> Cut perennial plantings and divide grasses and perennials to prevent overcrowding (fall) <input type="checkbox"/> Mow bioswale (> 6") (fall) <input type="checkbox"/> Check overflow and subsurface drain; check infiltration and flow-through rates (0.5"/hr) <input type="checkbox"/> Check pH of infiltration/planting soil (<5.2 add limestone; >7.0 add iron sulfate plus sulfur) <input type="checkbox"/> Check/correct for uniformity in cross-section and longitudinal slope (bioswale) <input type="checkbox"/> Replace mulch. Minimum every 3 years <input type="checkbox"/> Remove accumulated sediment and replace with approved soil mix, bark mulch, and vegetation (> 25% ponding depth for bioretention; >50% checkdam height for bioswale). Minimum every 5 years	
Upon Failure	<input type="checkbox"/> Redesign and reconstruct	

BMP	FACTORS AFFECTING PERFORMANCE			
	Sediment Buildup	Litter & Debris	Pipe Clogging	Invasive Vegetation
Surface Sand or Soil Filter	50%	30%	10%	0%
Infiltration Basin or Trench	36%	21%	10%	5%
Wet Pond	26%	19%	21%	10%
Underground Sediment Device	58%	21%	11%	0%
Rain Garden	33%	22%	7%	26%
Filter Strips or Swales	21%	26%	5%	26%

STORMWATER MANAGEMENT PRACTICES MAINTENANCE AGREEMENT

THIS AGREEMENT is made this _____ day of _____, 20____, by and between the [Community Name], a municipal corporation, with principal offices located at [Community address], hereinafter “[Community]” and _____ a _____ with principal offices located _____, hereinafter “Owner”.

[Owners Name], as “Owner(s)” of the property described below, in accordance with _____ [Community Regulations], agrees to install and maintain stormwater management practice(s) on the subject property in accordance with approved plans and conditions. The Owner further agrees to the terms stated in this document to ensure that the stormwater management practice(s) continues serving the intended function in perpetuity. This Agreement includes the following exhibits:

Exhibit A: Legal description of the real estate for which this Agreement applies (“Property”).

Exhibit B: Location map(s) showing a location of the Property and an accurate location of each stormwater management practice affected by this Agreement.

Exhibit C: Long-term Maintenance Plan that prescribes those activities that must be carried out to maintain compliance with this Agreement.

Note: After construction has been verified and accepted by the [Community Name] for the stormwater management practices, an addendum(s) to this agreement shall be recorded by the Owner showing design and construction details and provide copies of the recorded document to the [Community Name]. The addendum may contain several additional exhibits.



Function & Performance

- Design with maintenance in mind
- Be aware of material substitutions, compaction, siltation during construction
- Inspect and track progress
- Focus on preventative maintenance



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How do we integrate this into our municipal operations?



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Integration into Municipal Operations

STEP 1





Allow: Grey to Green

- Encourage green infrastructure
- Review and revise nuisance (high weed & grass) ordinances
- Consider using alternative language in codes to allow for green innovation



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Integration into Municipal Operations

STEP 2





Allow: Grey to Green

- Initial planning and installation
- Long term maintenance
- Funding needed for long term stewardship



Allow: Grey to Green

- Local Revenue: Stormwater Utility, Fees
- Borrowing: Bonds and loans
- Grants: OCRA, couple with DOT/HUD projects
- Private Sector Donations: Match with interests



Integration into Municipal Operations

STEP 3





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Allow: Green-Maintenance Plan





Allow: Green-Maintenance Plan

- Should understand basic function of BMP for early detection of problems and corrective action before failure
- Existing staff
- Handheld tools
- Plant identification





Integration into Municipal Operations

STEP 4



Train Staff



Allow: Staff Training

- Understand the purpose and function
- Install signage
- Remove invasive plants
- Communicate across departments and disciplines





Integration into Municipal Operations

STEP 5





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Promote: Visible Projects



Attention:
Wetlands Area





Promote: Public Education



Partner with
nearby MS4



Local Newspaper



Educate School Kids



Post Information
on Website



Public Demonstrations



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Promote: Public Involvement



Contact:

- Local groups
- Scouts
- School Groups
- Men's Clubs
- Women's Clubs
- Neighborhood Groups



Examples: Think about...

1. Would your codes allow this?
2. How would you fund this project?
3. Who would maintain these facilities?
4. Is your staff adequately trained?
5. Would this be a highly visible project in your community?



Examples: Also think about...

1. People (Social)
 - Human Health, Sense of Place
2. Planet (Environment)
 - Water Quality & Quantity, Air Quality, Wildlife Habitat
3. Profit (Economic)
 - Capital & Life Cycle Costs, Property Value





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Use: Residential Street Example



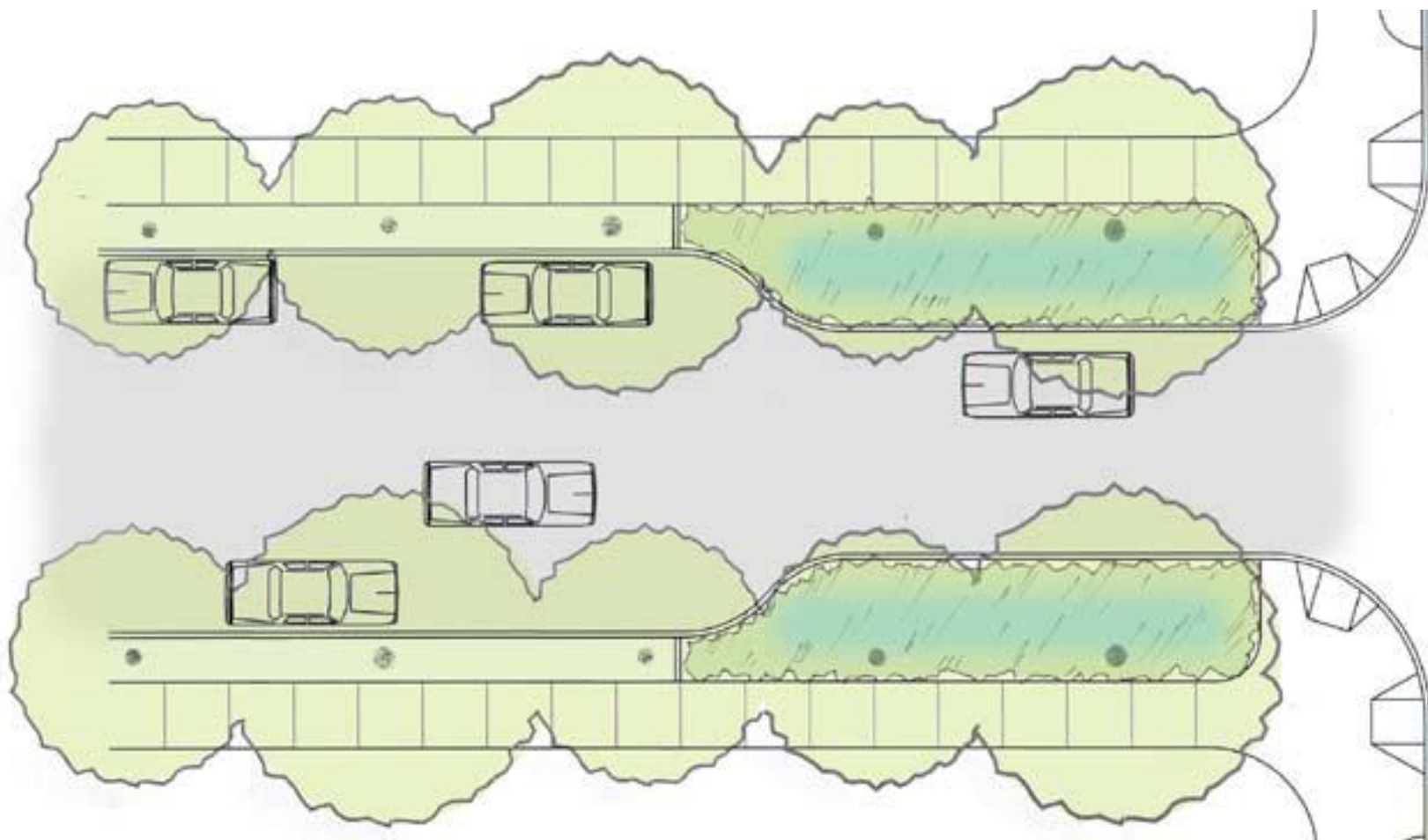
Existing



Opportunity



Implementation





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Use: Residential Street Example



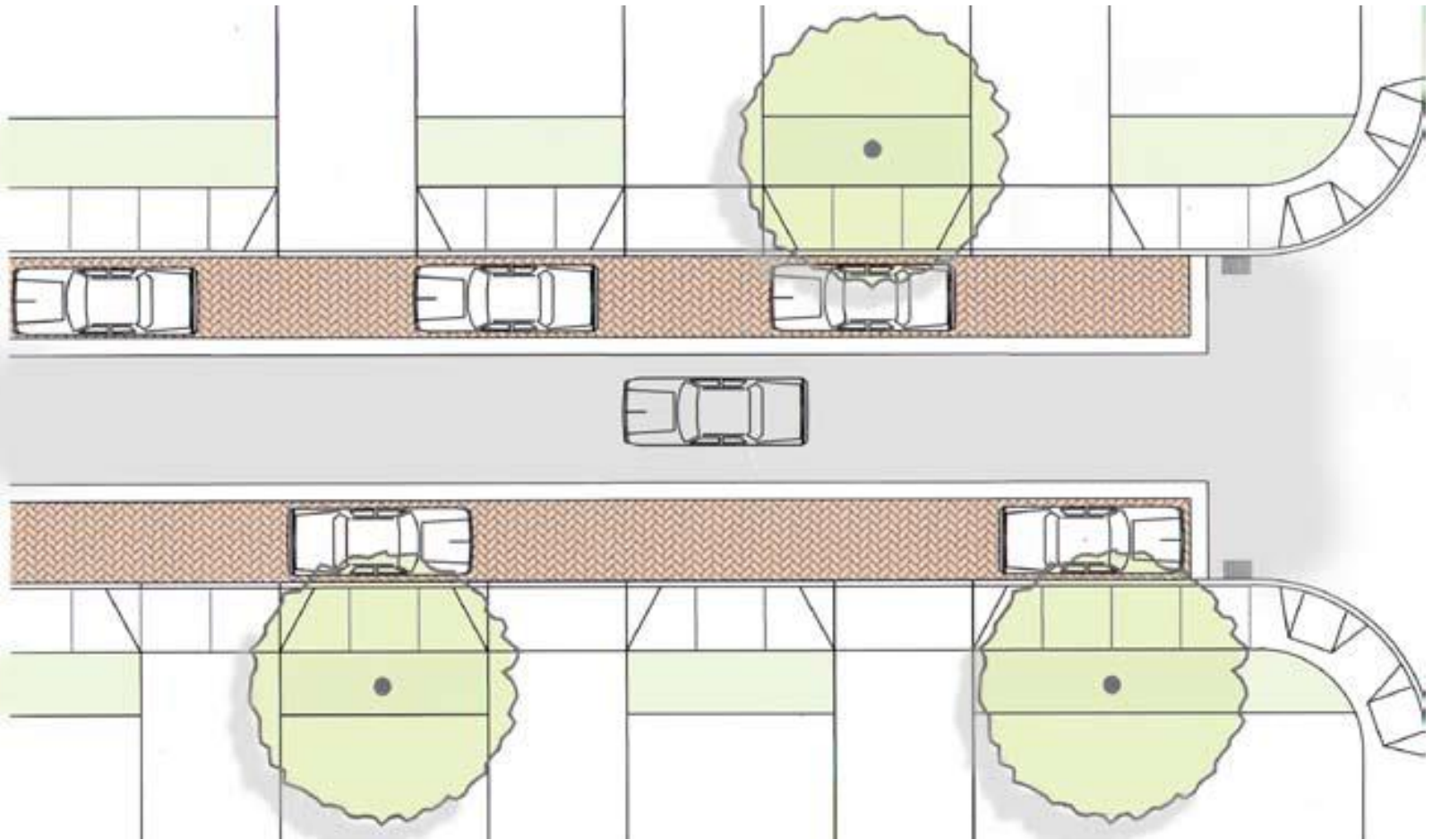
Existing



Opportunity



Implementation





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Use: Residential Street Example



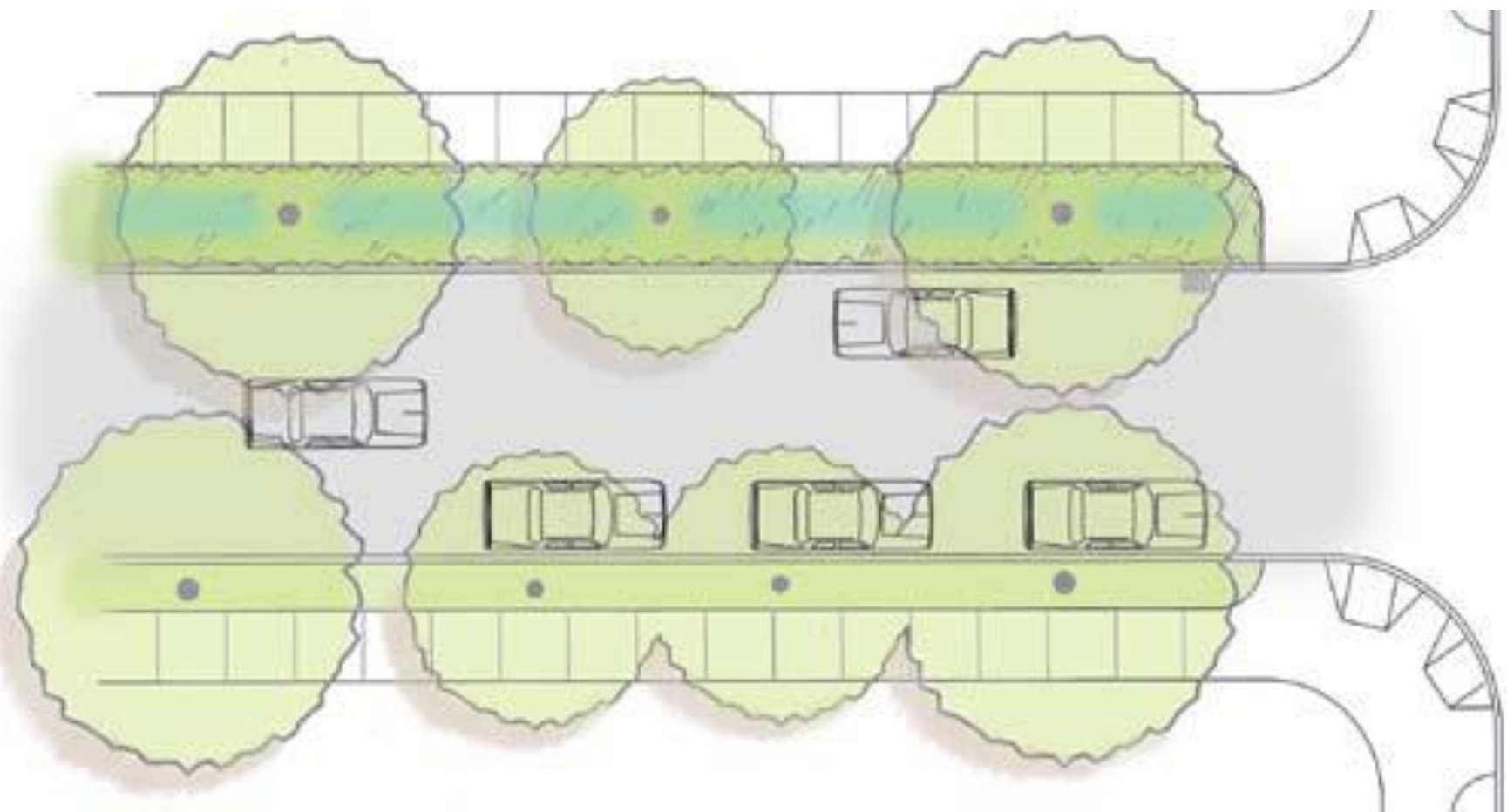
Existing



Opportunity



Implementation





Use: Commercial Street Example



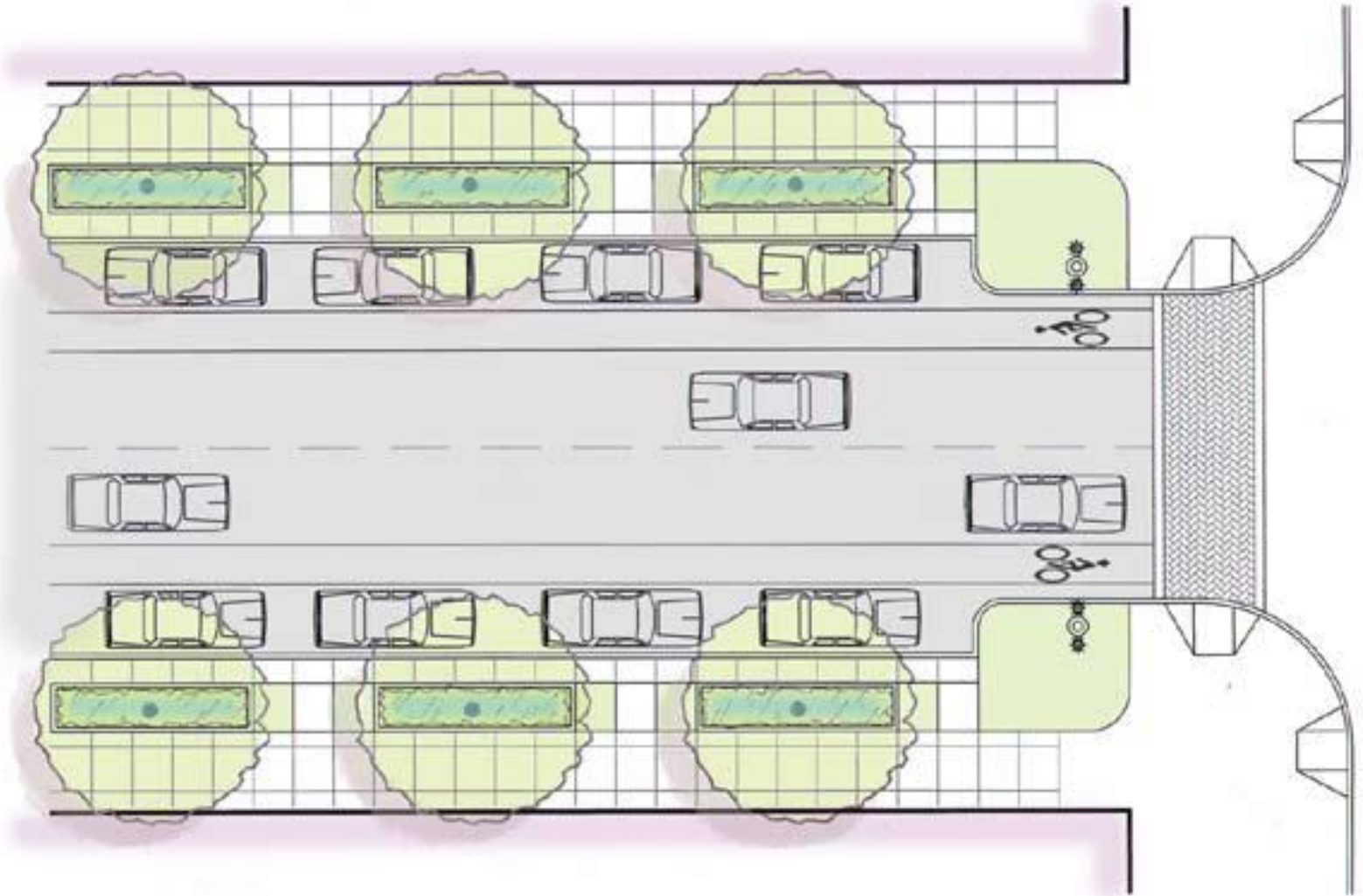
Existing



Opportunity



Implementation





Use: Commercial Street Example



Existing



Opportunity



Implementation





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Use: Commercial Street Example



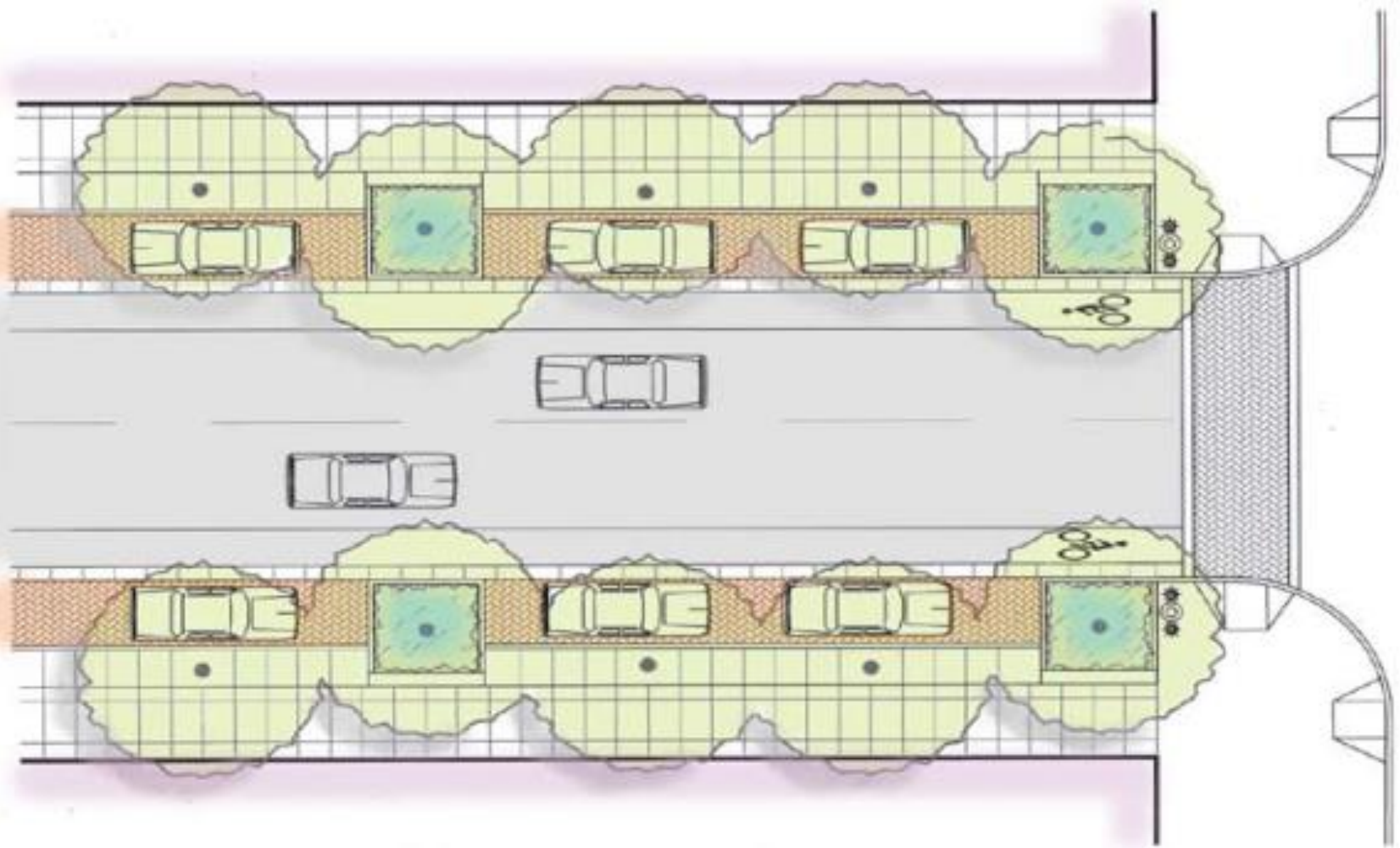
Existing



Opportunity



Implementation





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Use: Arterial Street Example



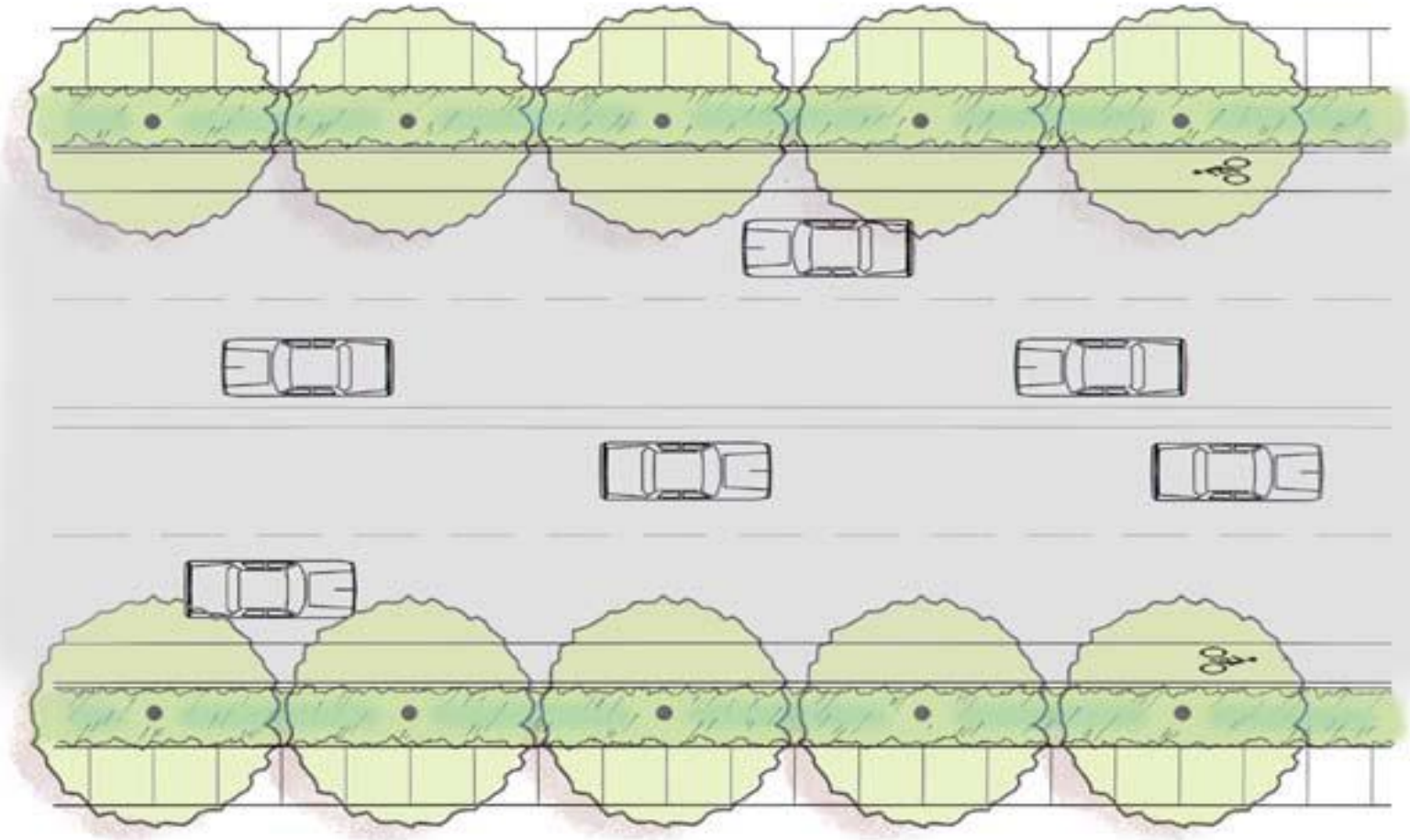
Existing



Opportunity



Implementation





Use: Permeable Paving Example



Existing



Opportunity



Implementation



Hands-on Exercise

1. Layout a new development site using green infrastructure principles
2. Incorporate green infrastructure into an existing site
3. Build a bioswale based on plant and soil properties



Call to Action

1. Allow Green Infrastructure
2. Promote Green Infrastructure
3. Implement Green Infrastructure