

# **Introducing Green Infrastructure for Coastal Resilience**

**National Oceanic and Atmospheric Administration (NOAA)  
Office for Coastal Management**



# What we'll talk about today

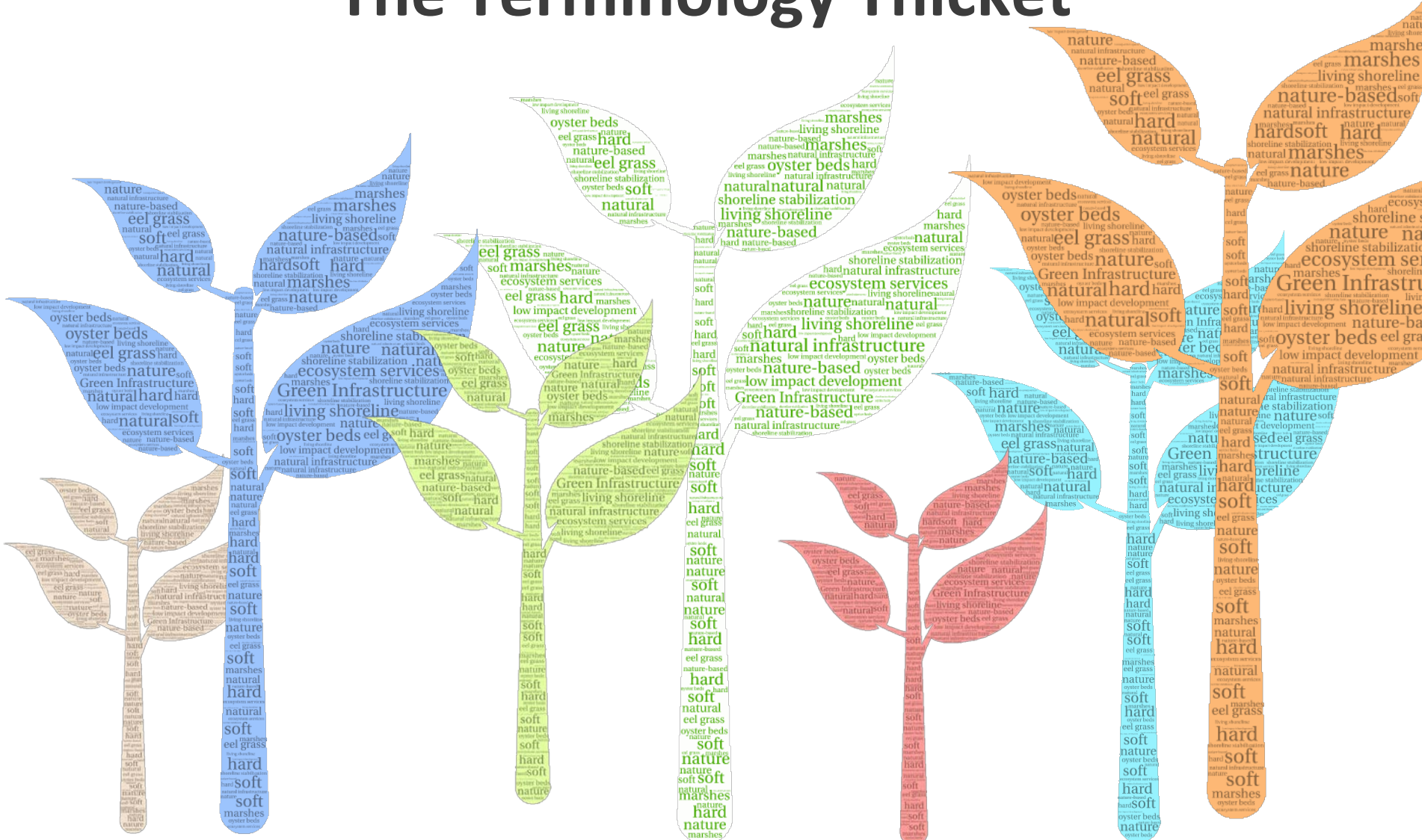
- 1. Green infrastructure concepts**
- 2. Practices**
- 3. Getting to Implementation**







# The Terminology Thicket





# Green infrastructure

Natural *and* nature-based approaches work together to mimic natural processes such as absorbing rainfall, lessening wave energy, and reducing erosion



# What Is “Resilience”?

*Introducing Green Infrastructure for Coastal Resilience*



Credit: Justin Selden, Michigan Sea Grant

“Resilience is our ability to prevent a short-term hazard event from turning into a long-term community-wide disaster.”



# Section 1: Green Infrastructure Concepts and Principles





# Foundations of Green Infrastructure

*Green Infrastructure Concepts and Principles*



Landscape  
Architecture  
1860s



Landscape  
Ecology  
1930s



Design with  
Nature  
1960s



Conservation  
Biology  
1970s



Clean Water  
Act  
1970s







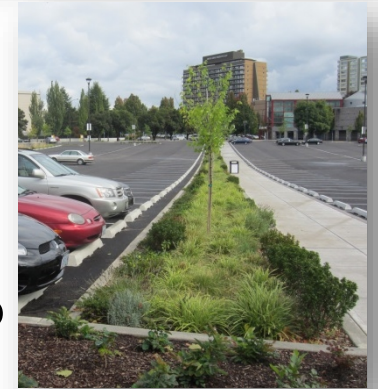
# Foundations of Green Infrastructure

*Green Infrastructure Concepts and Principles*

Landscape approach?



Site-level approach?

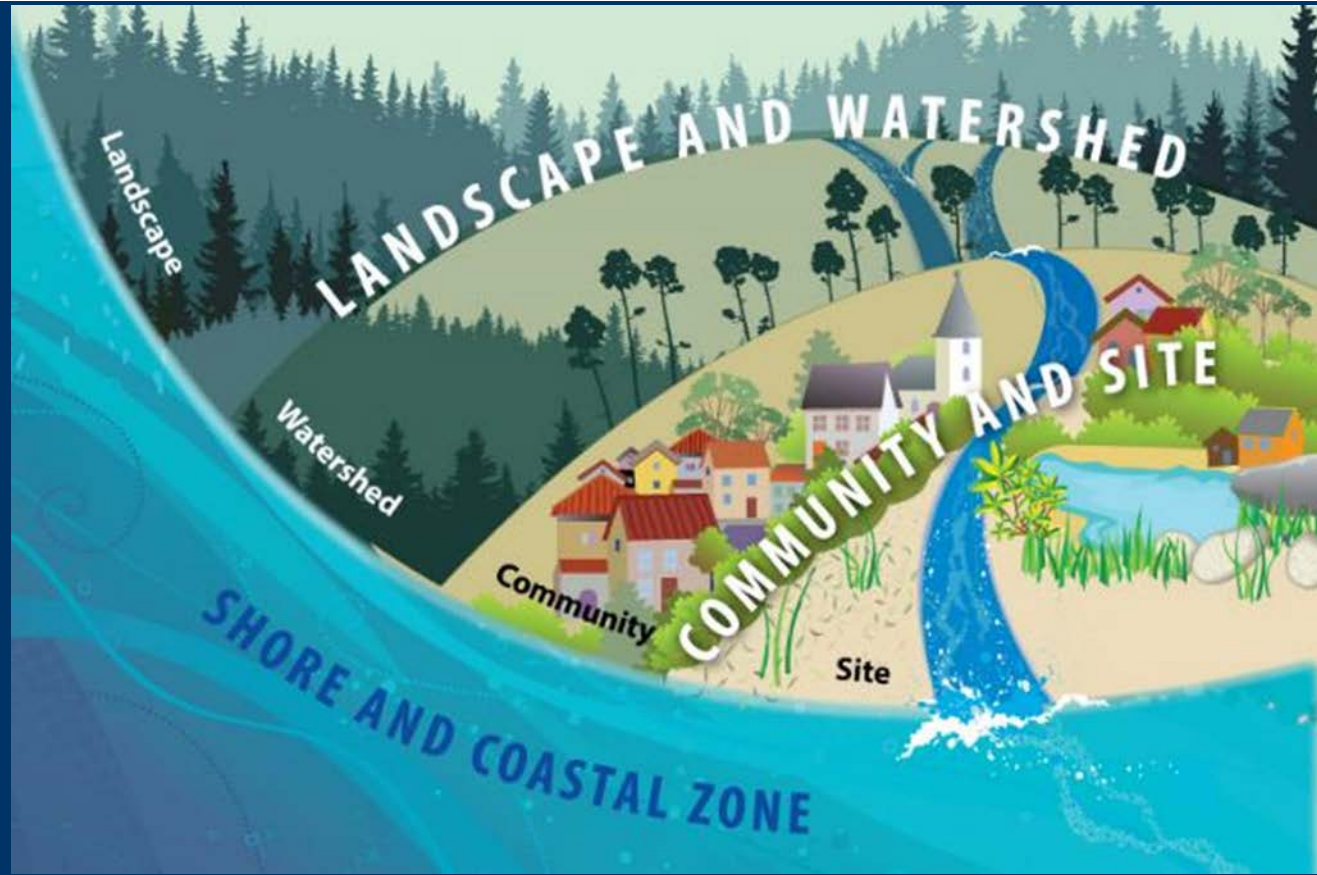


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# Works at all scales

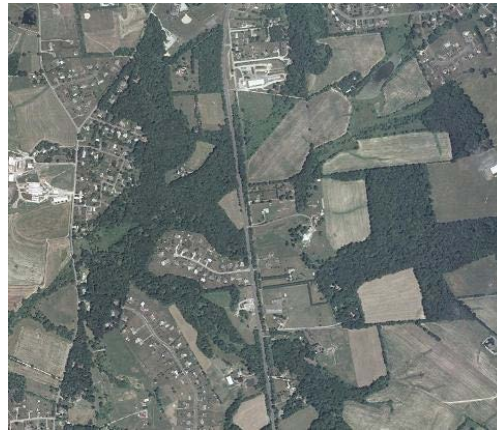
- Landscape
- Watershed
- Community
- Site
- Shoreline





# The Importance of Context

Green infrastructure practices are context sensitive.



Rural



Urban

Coastal



Upland



# Why Green Infrastructure?

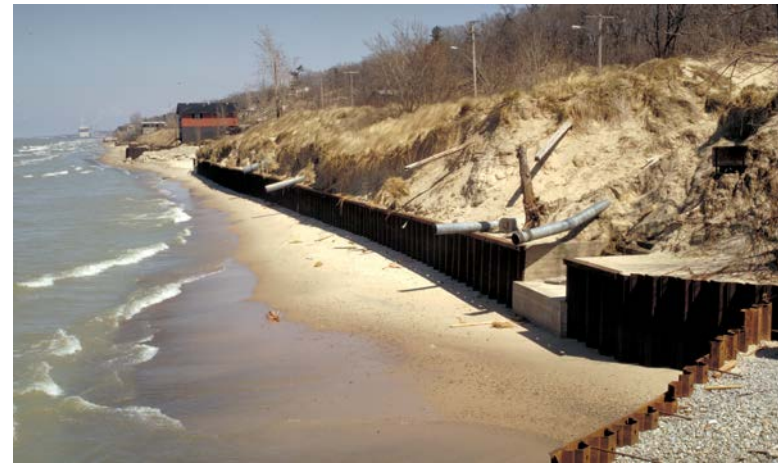


Photo credit: Michigan Sea Grant



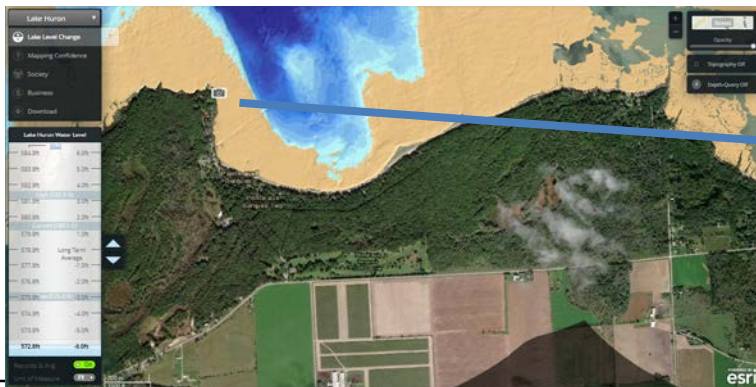


# Lake Level Viewer

*Green Infrastructure Concepts and Principles*



**6 Feet Increase – 584.8 ft**

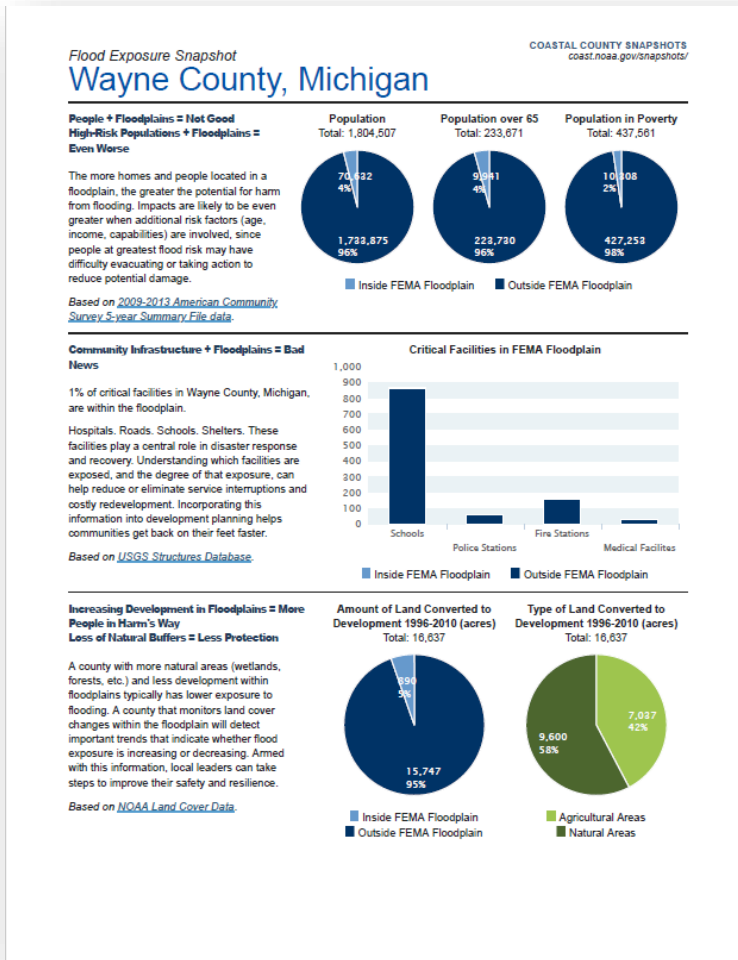


**6 Feet Decrease – 572.8 ft**

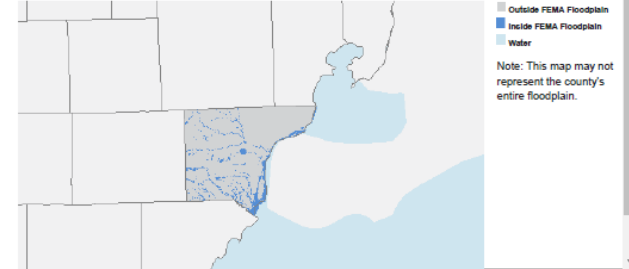
[coast.noaa.gov/digitalcoast/tools/llv](https://coast.noaa.gov/digitalcoast/tools/llv)

# Flood Exposure Snapshot

## Green Infrastructure Concepts and Principles



### Wayne County Floodplain



### Next Steps

Through adaptation planning, all communities can be better prepared to face coastal hazards. While each community is different, there are some basic steps that all communities can follow to become more resilient.

- Know your risks** – If your county has a hazard mitigation plan, get a copy of it from your county emergency management office or the [Federal Emergency Management Agency \(FEMA\)](#) (<https://www.fema.gov/hazard-mitigation-plan-status>). Having county information about potential hazards, vulnerabilities, and priority hazard mitigation projects is important. Use the [Coastal Flood Exposure Mapper](#) (<https://coast.noaa.gov/digitalcoast/tools/flood-exposure.html>) to create maps showing exposure to coastal flood hazards in your community. The [Using Flood Exposure Maps](#) (<https://coast.noaa.gov/digitalcoast/training/flood-exposure.html>) webinar can help you get started.
- Develop a team** – To see the issues and opportunities from as many perspectives as possible, engaging a diverse group of stakeholders is always a good idea. The [County Snapshots](#) (<https://coast.noaa.gov/snapshots>) are used to help people visualize the issues.
- Know what resources are available** – Federal and state agencies have funds available for risk reduction activities. See the funding opportunities listed below to learn more. There are also data and tools available to help people visualize the issues and solutions. For information on creating inundation maps for your community, visit the Visualization section of the [Coastal Inundation Toolkit](#) (<https://coast.noaa.gov/apply/inundation/visualize.html>).  
**Funding Sources**
  - [FEMA](https://www.fema.gov/hazard-mitigation-grant-program) (<https://www.fema.gov/hazard-mitigation-grant-program>)
  - [NOAA Coastal Management Program](https://coast.noaa.gov/funding/) (<https://coast.noaa.gov/funding/>)
- Discover what others are doing** – See how other communities are addressing these issues. Visit the discover section of the [Coastal Inundation Toolkit](#) (<https://coast.noaa.gov/apply/inundation/discover.html>). You may also contribute a story about your community efforts.

Additional information and resources can be found within the Digital Coast's [Coastal Inundation Toolkit](#) (<https://coast.noaa.gov/apply/inundation/understand.html>).

[Frequently Asked Questions](https://coast.noaa.gov/snapshots/fair/flood-exposure.pdf) (<https://coast.noaa.gov/snapshots/fair/flood-exposure.pdf>)

### Data Sources for This Snapshot

- [Flood Zones](https://msc.fema.gov/portal/) (<https://msc.fema.gov/portal/>) – Based on FEMA 1% annual chance flood zones
- [Critical Facilities](https://nationalmap.gov/structures.html) (<https://nationalmap.gov/structures.html>) – USGS Structures Database
- [Demographic Data](https://coast.noaa.gov/digitalcoast/data/acs/) (<https://coast.noaa.gov/digitalcoast/data/acs/>) – NOAA
- [Land Cover Data](https://coast.noaa.gov/dataregistry/search/collection/info/locaregional/) (<https://coast.noaa.gov/dataregistry/search/collection/info/locaregional/>) – NOAA







# Ecosystem Services

*Green Infrastructure Concepts and Principles*

Natural ecosystems provide multiple benefits to people, including food and water production, improved air and water quality, and recreation and spiritual inspiration.



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# Multiple Benefits

- Environmental
- Societal
- Economic







# Whose Benefit

*Green Infrastructure Concepts and Principles*

A wide variety of stakeholders stand to benefit. Engaging stakeholders is an essential part of understanding the benefits and how they are valued by people.





# Table Activity

**List coastal hazards impacting your community**

**Identify what ecosystem services will reduce coastal hazard impacts**

10 minutes



# Section 2: The Practice of Green Infrastructure



# Design Concepts

*The Practice of Green Infrastructure*

Successful green infrastructure practices incorporate

- Multi-functionality
- Resilience
- Sense of place
- Return on investment





# Landscape and Watershed Practices

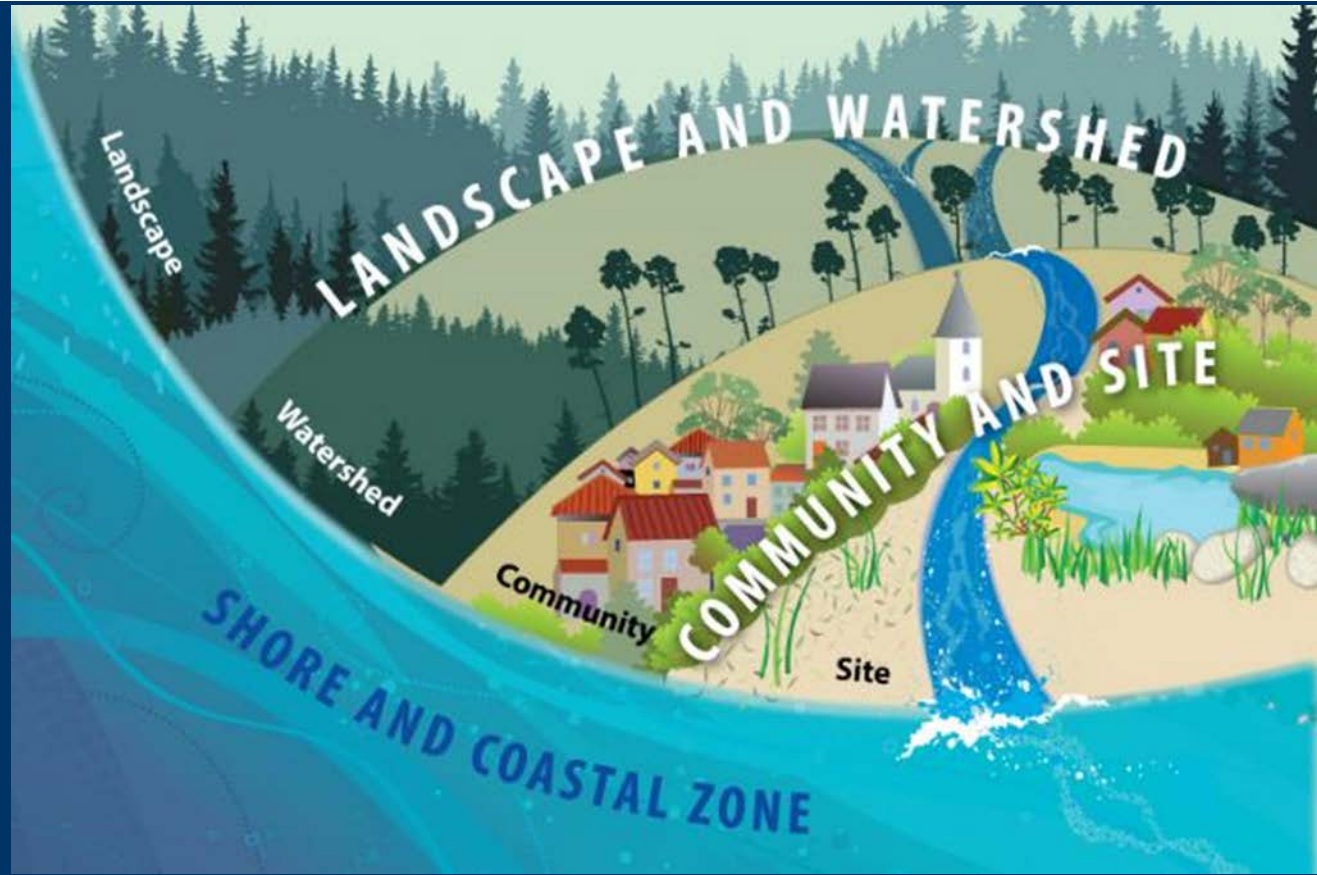
Landscape

Watershed

Community

Site







Shoreline





# Landscape Design Concepts

*The Practice of Green Infrastructure*

	<b>BETTER</b>	<b>WORSE</b>
<b>Area</b>		
<b>Proximity</b>		
<b>Connectivity</b>		





# Landscape Approaches and Resilience

*The Practice of Green Infrastructure*

- Recent study\* on flood reduction during Hurricane Sandy showed:
  - Coastal wetlands saved more than \$625 million in flood damages
  - Where they exist, coastal wetlands reduced damages by more the 10% on average
  - In Ocean County, NJ wetland conservation reduces average annual losses by more than 20%



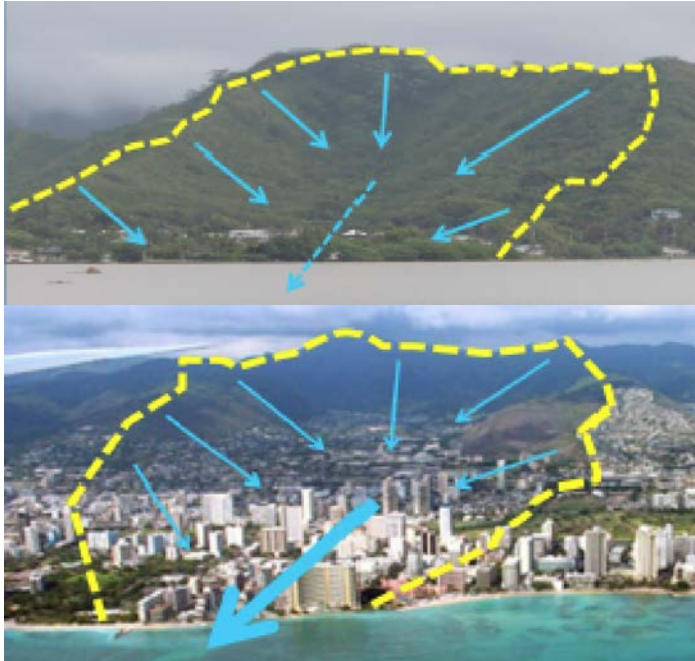
\*Coastal Wetlands and Flood Damage Reduction: Using Risk Industry-Based Models to Assess Natural Defenses in the NE USA, 2016.



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# Watershed Design Concepts

*The Practice of Green Infrastructure*



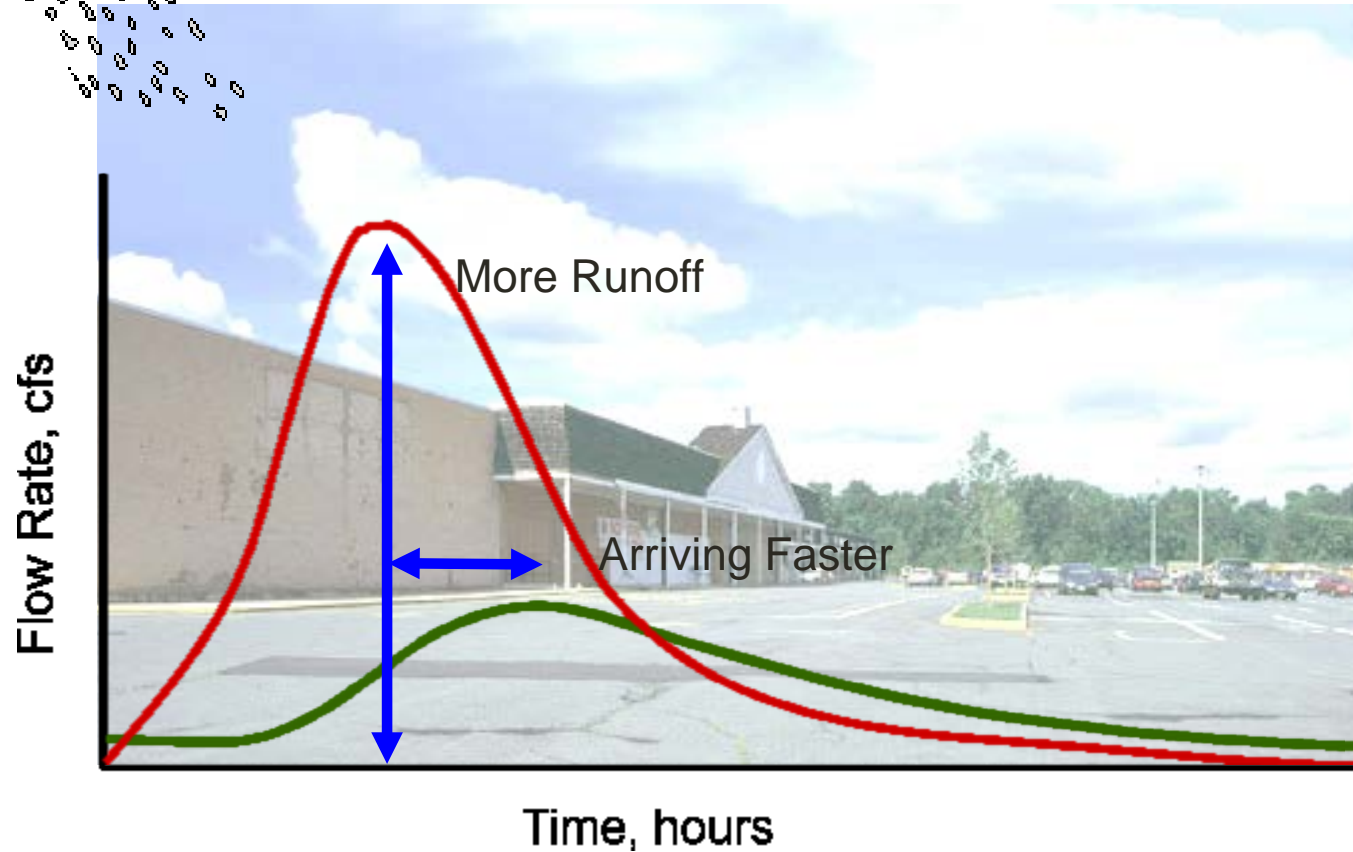
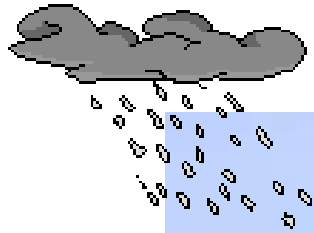
Source: Horsley Witten Group; Center for Watershed Protection

- Preserve native vegetation
- Protect steep slopes
- Buffer stream channels
- Reduce connected impervious cover
- Seek multiple benefits

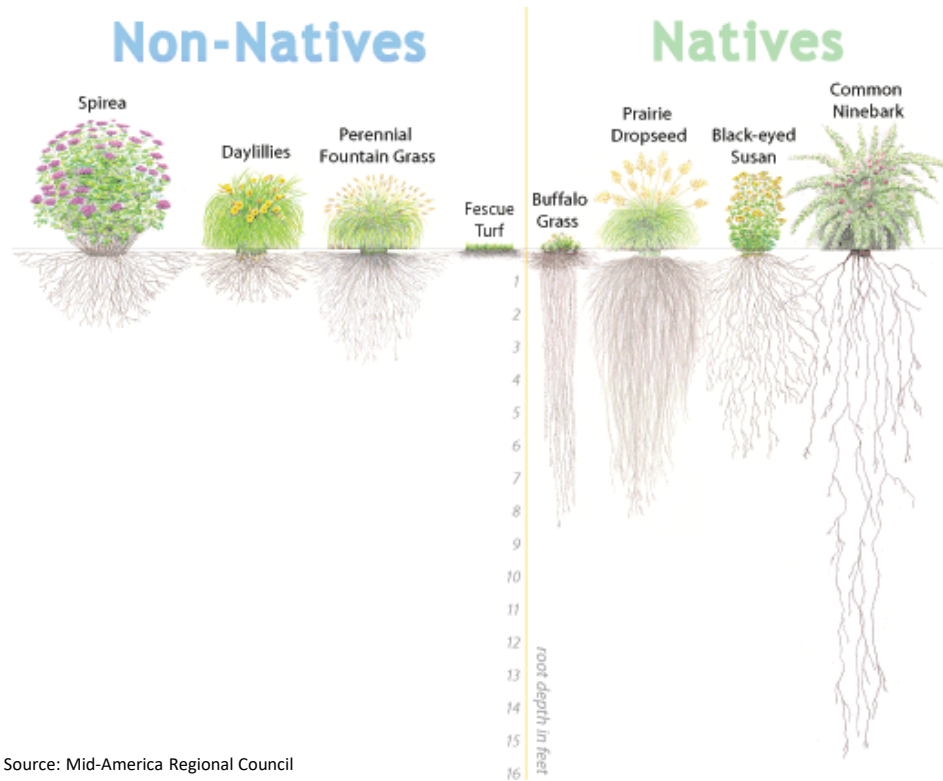


# Hydrologic Impacts of Development

*The Practice of Green Infrastructure*



# Preserve native plants and trees



Source: Mid-America Regional Council

Native Plant Society of Texas List – <https://npsot.org/wp/southtexas/resources/>



# Reduce impervious surfaces

## Approaches:

- Narrow streets
- Replace curb and gutter with bioswales
- Bioretention in parking lots
- Multi-story parking garages
- Smaller driveways
- Green roofs
- Keep or plant trees



# Create and conserve open spaces





# Example: golf course converted to wetland park

## Exploration Green

- 178 acres being converted to wetlands and open space
- 3000 homes will be protected
- Half billion gallons of stormwater drained



[www.explorationgreen.org/](http://www.explorationgreen.org/)

# Community and Site Practices

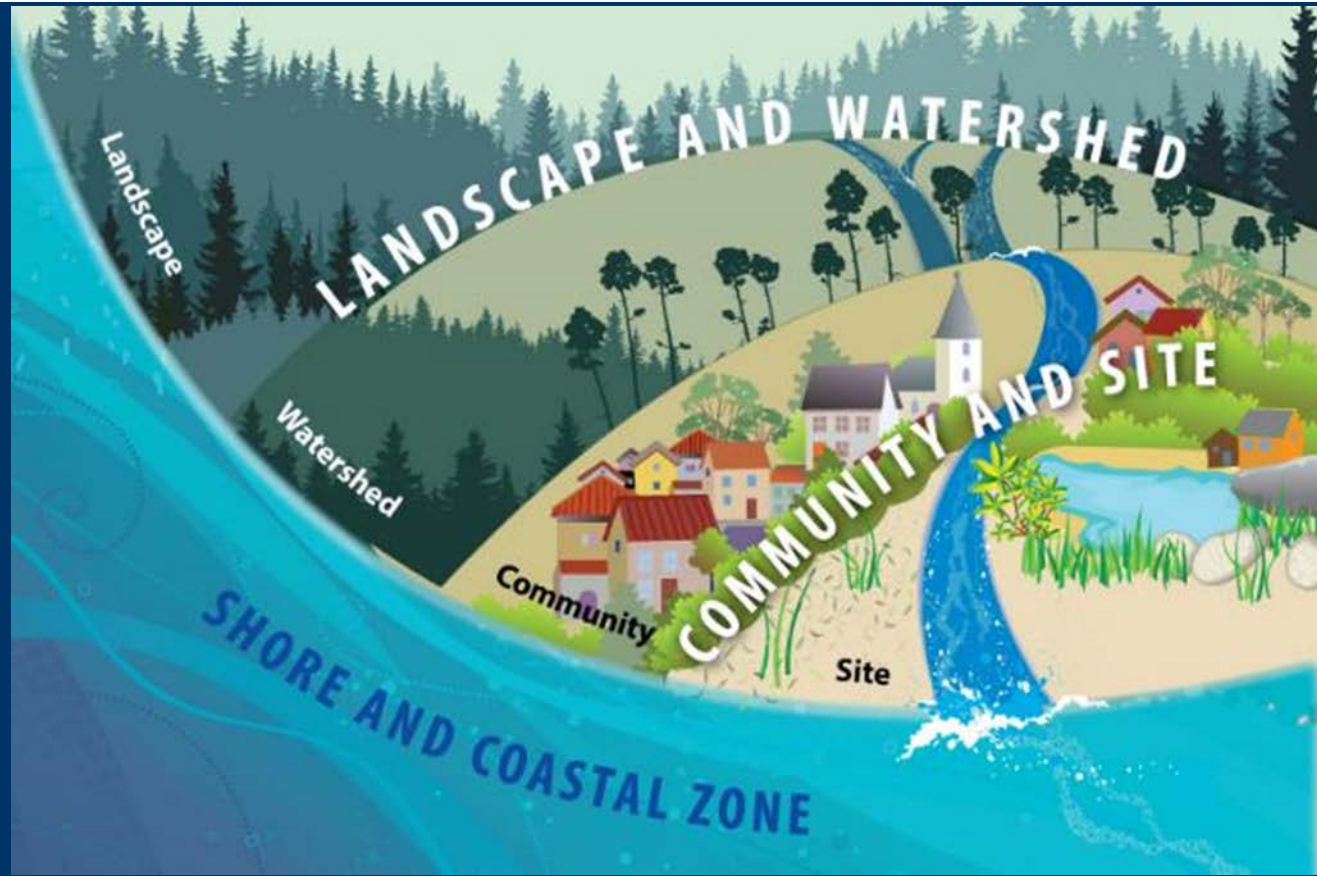
Landscape

Watershed

Community

Site

Shoreline





# Community and Site Design Concepts

*The Practice of Green Infrastructure*

- Natural areas and open spaces should serve multiple functions
- Connect people to open areas through greenways and trails
- Preserve or mimic the natural hydrological functions of a site or drainage area
- Use urban streetscapes to provide ecosystem benefits in urban areas



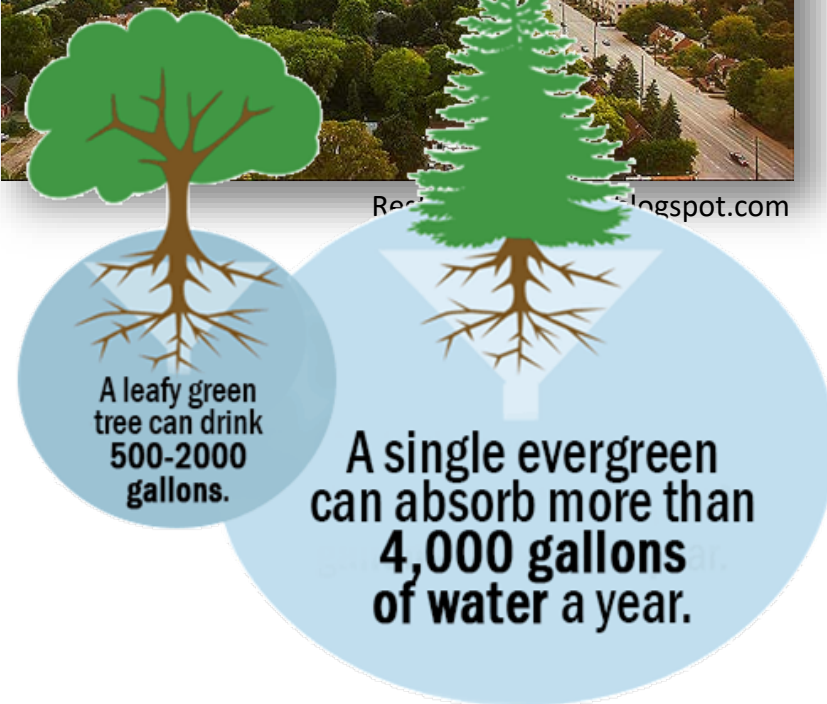


# Community and Site Approaches

*The Practice of Green Infrastructure*

## Urban Forestry

- Trees provide enormous environmental, economic, and societal benefits
- Develop a tree planting program designed to maximize benefits
- To the extent possible, protect existing forested areas, particularly large specimen trees



# Street trees/urban forestry



“Shoppers claim they are willing to pay 9%-12% more for goods in business districts having a quality urban canopy and landscape” - Texas A&M University







# Community and Site Approaches

*The Practice of Green Infrastructure*

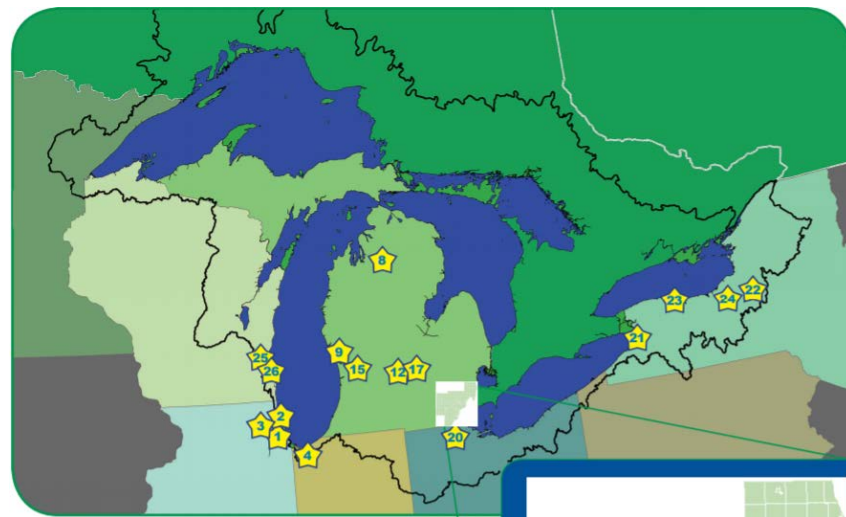
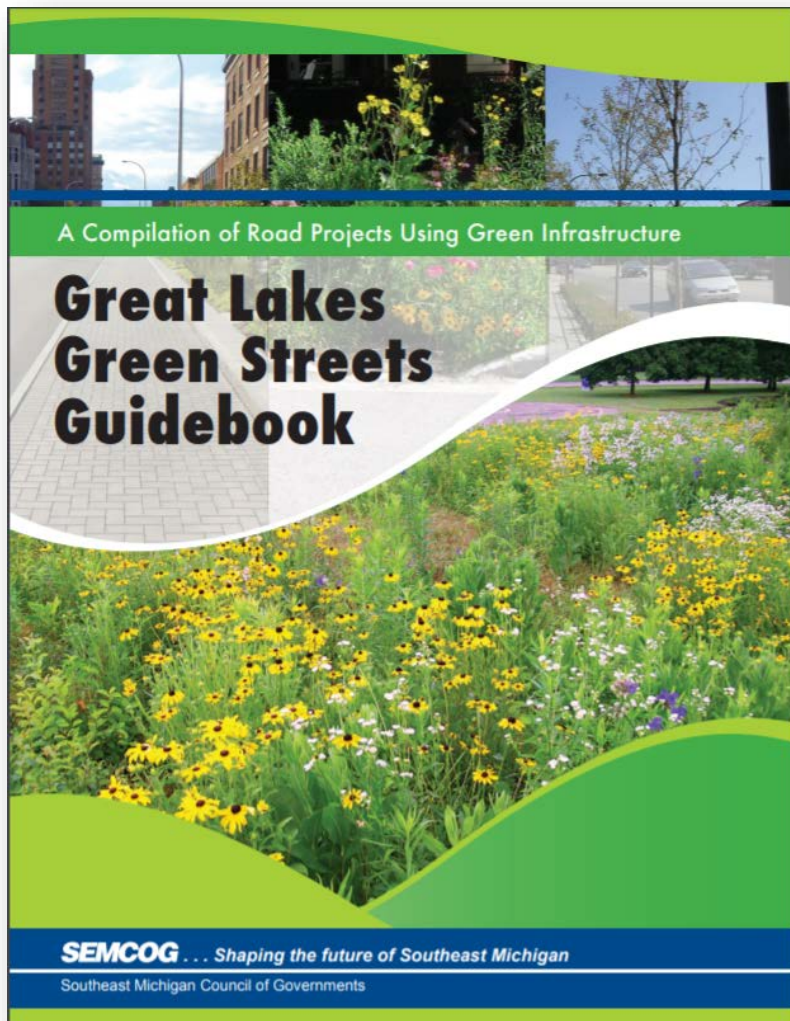
## Green Streets

- Key linking component in green infrastructure network
- Design dependent on local conditions but generally include
  - Alternative street widths
  - Swales
  - Bioretention
  - Permeable pavements
- Provides multiple benefits





# Great Lakes Green Streets Guidebook



## ● Case Studies

- Project summary
- Benefits, Challenges, Maintenance
- Sponsor, designer, contractor
- Design and construction cost
- Partners
- Contact Information

[https://semcog.org/Reports/GLGI\\_Guidebook/files/assets/basic-html/page-1.html#](https://semcog.org/Reports/GLGI_Guidebook/files/assets/basic-html/page-1.html#)



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# Community and Site Approaches

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## Environmental Site Design

- Place the site in context to greater community
- Preserve and enhance natural features
- Mimic or enhance existing hydrology
- Minimize impervious cover
- Key component of low impact development (LID)



TrockWorks Architectural Services



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# Community and Site Approaches

*The Practice of Green Infrastructure*

## Low Impact Development Practices



### Bioretention (Infiltration and Filtering)

- Rain gardens
- Bioswales
- Stormwater planters



### Green Roofs (Storage and Evapotranspiration)

- Blue roofs
- Cisterns



### Permeable Pavements (Infiltration)

- Porous asphalt/concrete
- Grass or gravel pavers
- Pavers

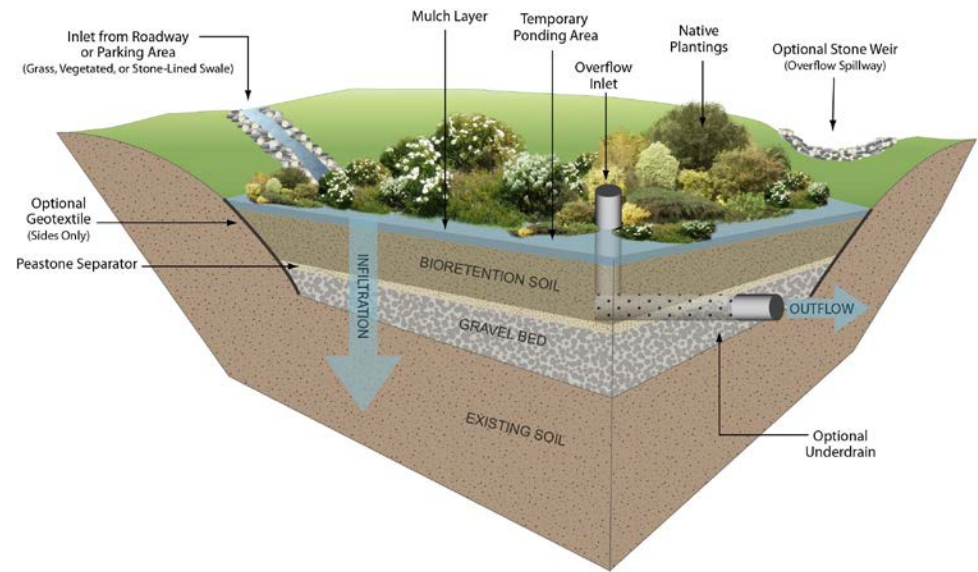




# Bioretention

## Design Components:

- Ponding area
- Plants
- Soil
- Stones
- Underdrain
- Inlet
- Overflow device or outlet





# Bioretention inspection and maintenance

- Look for standing water
- Water plants during dry times
- Maintain health of plants
- Overflow bypass is functional
- Look for erosion along banks
- Aerate compacted areas to restore infiltration

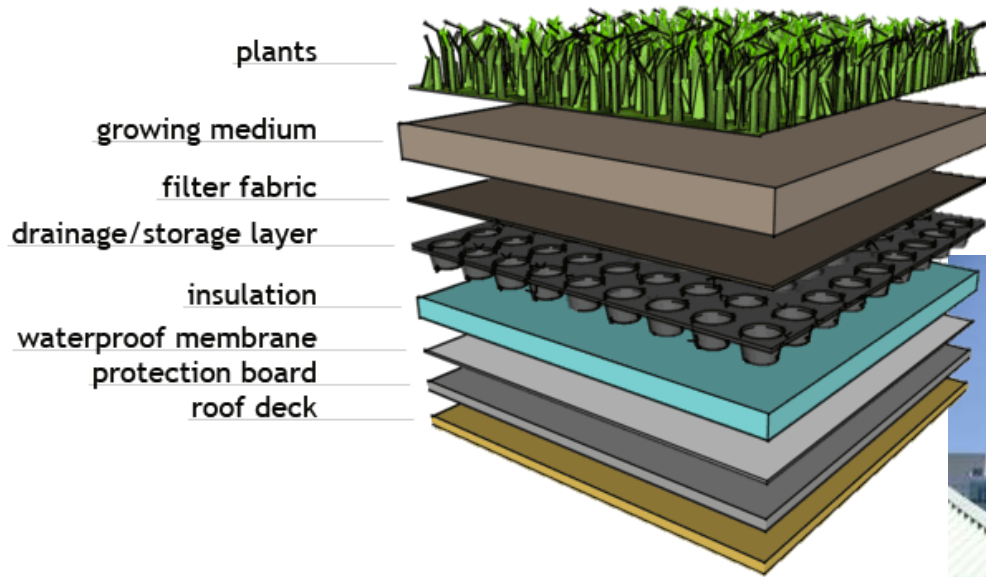
UNH Stormwater Center Maintenance Checklist

[goo.gl/Xbj2Wu](https://goo.gl/Xbj2Wu)





# Green Roof Detail





# Green roof maintenance

- Weed
- Fertilize
- Check for standing water
- Check structural components
- Check soil depth
- Inspection checklist -  
*(The link provided was broken and has been removed)*



# Green roofs example: River Rouge Truck Plant

- 10.4 Acres
- Installed 2003
- Monitoring performance
- Extensive roof-type
- Plantings created biodiversity



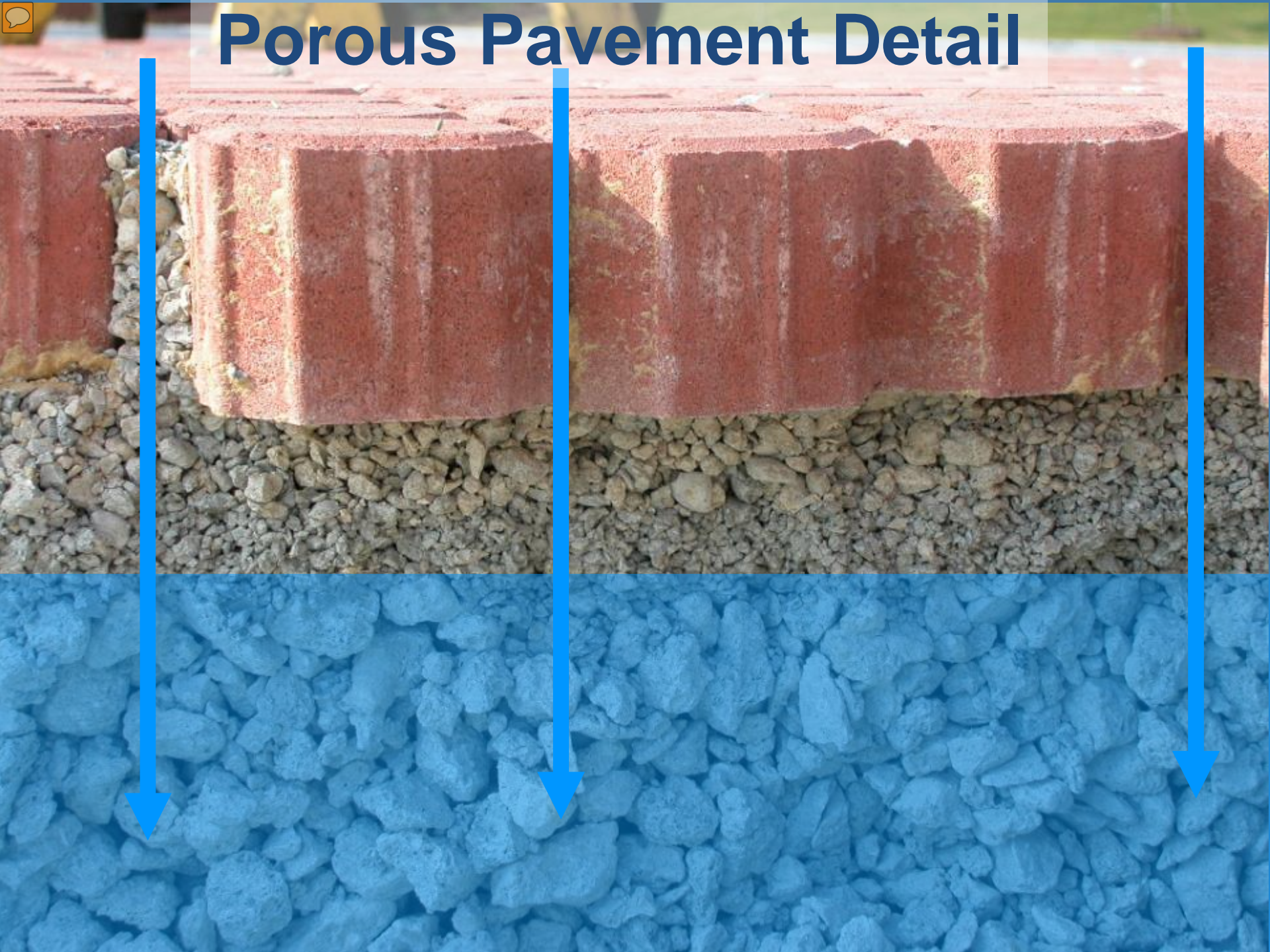
# Pervious pavements

Concrete or asphalt that has larger void spaces to allow water to seep through





# Porous Pavement Detail





# Pervious pavement inspection and maintenance

- Remove sediment and organic debris via vacuum street sweeper (2-4x/year)
- Inspect for deterioration (unraveling) (2-4x/year)
- Maintenance of nearby landscaping to prevent debris
- UNH Stormwater Center Checklist  
[goo.gl/jsV7pD](http://goo.gl/jsV7pD)



# Community and Site Approaches and Resilience

*The Practice of Green Infrastructure*

- Many studies on the effectiveness of these practices for
  - Reducing the heat island effect
  - Improving water quality
  - Recharging groundwater
  - Providing societal benefits
- For LID, flood reduction is a ‘co-benefit’
  - City of Portland, OR reduced peak flow of stormwater runoff by 93%, cooling costs by 27%, and heating costs by 15%.







**BREAK**



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# Speaker: Landscape-Scale Green Infrastructure

Detroit River Area of Concern:  
GLRI Restoration Projects

**Mary Bohling**  
**Michigan Sea Grant**





# **Speaker: Community/Site Scale Green Infrastructure**

**Terry Croad and Brandy Siedlaczek  
City of Southfield**







# Share Your Green Infrastructure Projects

Discuss green infrastructure projects (or ideas) that can provide ecosystem services to reduce hazard impacts

*Write on flipchart:*

- Table #
- Brief description
- “P” for Project OR “I” for Idea
- Location
- Contact info (name and email)



# Share Your Green Infrastructure Projects

*Write on flipchart:*

- Table #
- Brief description
- “P” for Project OR  
“I” for Idea
- Location
- Contact info:  
(name and email)

Table 1

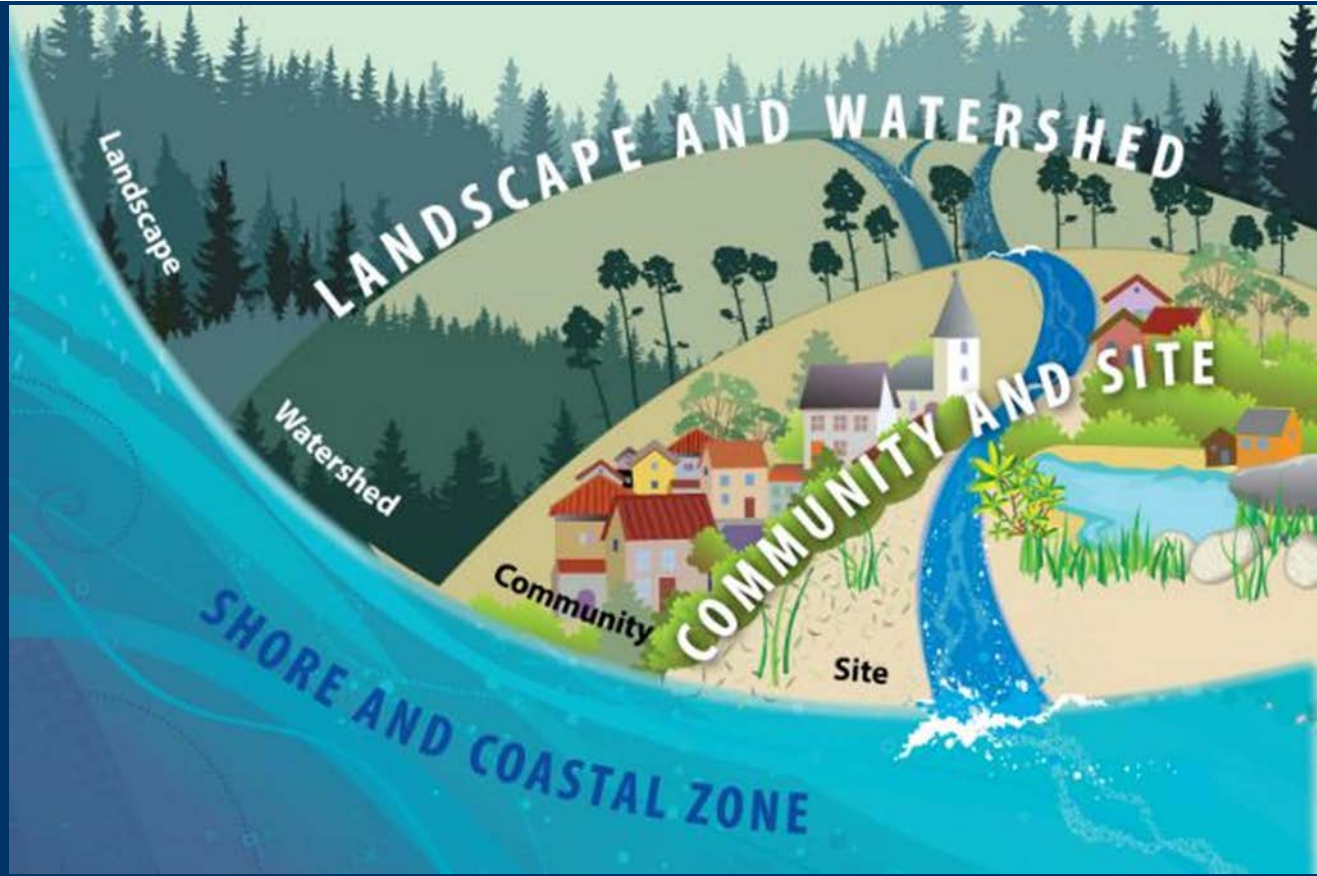
- Rain garden at Jefferson **I**  
Elementary with signage
  - Jefferson Elementary School,  
Montpellier
  - POC: T. Jefferson
- 
- Educational Outreach **P**
  - Anytown, USA
  - Anytown Extension System





# Shoreline Practices

- Landscape
- Watershed
- Community
- Site
- Shoreline**





# Shoreline Design Concepts

*The Practice of Green Infrastructure*

- **Natural or Nature-Based**
  - Dunes and beaches
  - Vegetated features (salt marsh, wetlands, submerged aquatic vegetation)
  - Oyster and coral reefs
  - Barrier islands
  - Maritime forest/shrub communities
- **Hybrid**
  - Natural and structural features
- **Nonstructural**
  - Floodplain policy and management
  - Flood proofing



Marysville, Michigan Shoreline Restoration, (Before and After). Courtesy Brian Majka

# Natural or Nature-Based Shorelines



## Dune and Beach Creation

- Break waves
- Attenuate wave energy
- Slow inland water transfer



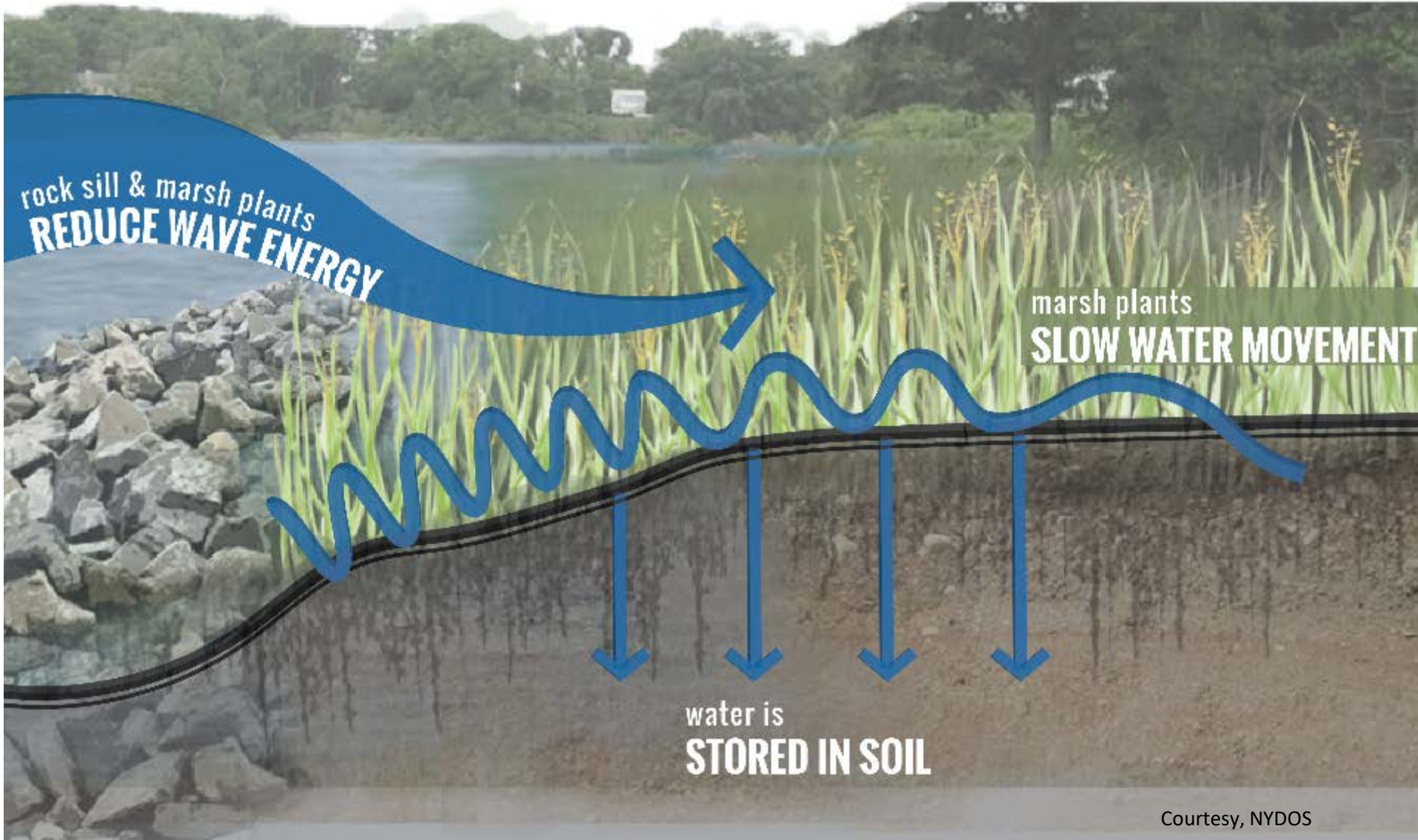
## Wetlands, Vegetation, SAV

- Break waves
- Attenuate wave energy
- Slow inland water transfer
- Increase infiltration





# Hybrid Living Shorelines



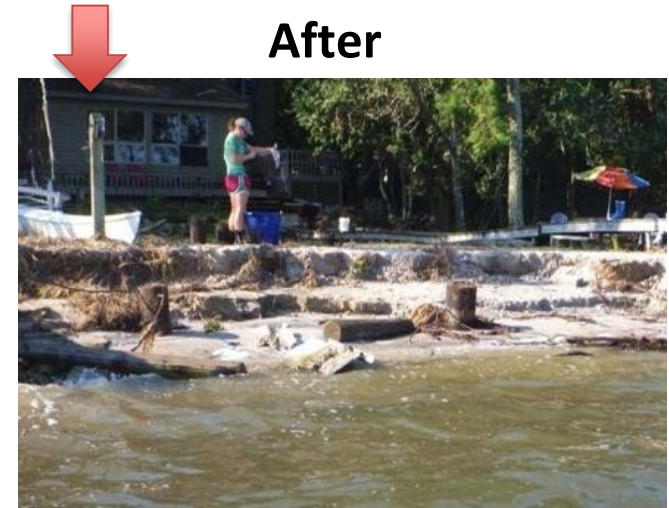


# Shoreline Approaches and Resilience

*The Practice of Green Infrastructure*

Hurricane Irene, North Carolina

76% of bulkheads were damaged in the storm



No damage occurred to shorelines with or without sills



\*Marshes with and without sills protect estuarine shorelines from erosion better than bulkheads during a Category 1 hurricane, 2014



# Speaker: Shore and Coastal Green Infrastructure

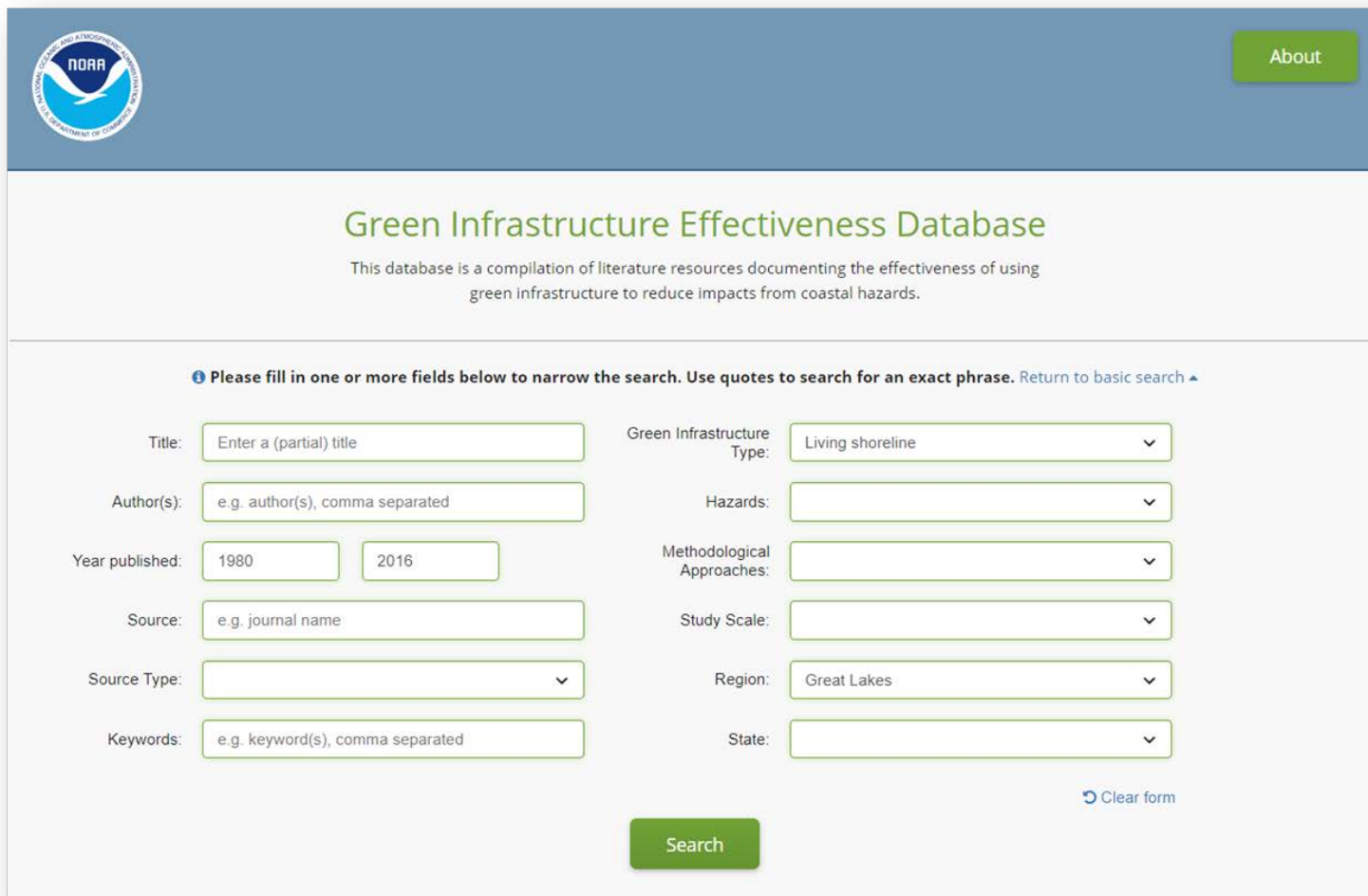
Natural Shoreline Protection  
in the Great Lakes

**Scott Dierks**  
**GEI Consultants**




# Green Infrastructure and Resilience

*The Practice of Green Infrastructure*



The screenshot shows the NOAA Green Infrastructure Effectiveness Database search page. At the top left is the NOAA logo, and at the top right is an 'About' button. The main heading is 'Green Infrastructure Effectiveness Database', followed by a description: 'This database is a compilation of literature resources documenting the effectiveness of using green infrastructure to reduce impacts from coastal hazards.' Below this is a search instruction: 'Please fill in one or more fields below to narrow the search. Use quotes to search for an exact phrase. Return to basic search'. The search form consists of two columns of fields. The left column includes: Title (text input), Author(s) (text input), Year published (two date pickers for 1980 and 2016), Source (text input), Source Type (dropdown), and Keywords (text input). The right column includes: Green Infrastructure Type (dropdown with 'Living shoreline' selected), Hazards (dropdown), Methodological Approaches (dropdown), Study Scale (dropdown), Region (dropdown with 'Great Lakes' selected), and State (dropdown). A 'Clear form' link is located at the bottom right of the form area, and a green 'Search' button is centered at the bottom.

 [About](#)

## Green Infrastructure Effectiveness Database

This database is a compilation of literature resources documenting the effectiveness of using green infrastructure to reduce impacts from coastal hazards.

**Please fill in one or more fields below to narrow the search. Use quotes to search for an exact phrase. [Return to basic search](#)**

Title:	<input type="text" value="Enter a (partial) title"/>	Green Infrastructure Type:	<input type="text" value="Living shoreline"/>
Author(s):	<input type="text" value="e.g. author(s), comma separated"/>	Hazards:	<input type="text"/>
Year published:	<input type="text" value="1980"/> <input type="text" value="2016"/>	Methodological Approaches:	<input type="text"/>
Source:	<input type="text" value="e.g. journal name"/>	Study Scale:	<input type="text"/>
Source Type:	<input type="text"/>	Region:	<input type="text" value="Great Lakes"/>
Keywords:	<input type="text" value="e.g. keyword(s), comma separated"/>	State:	<input type="text"/>

[Clear form](#)

[coast.noaa.gov/digitalcoast/training/GI-database](https://coast.noaa.gov/digitalcoast/training/GI-database)





# Section 3: Getting to Implementation

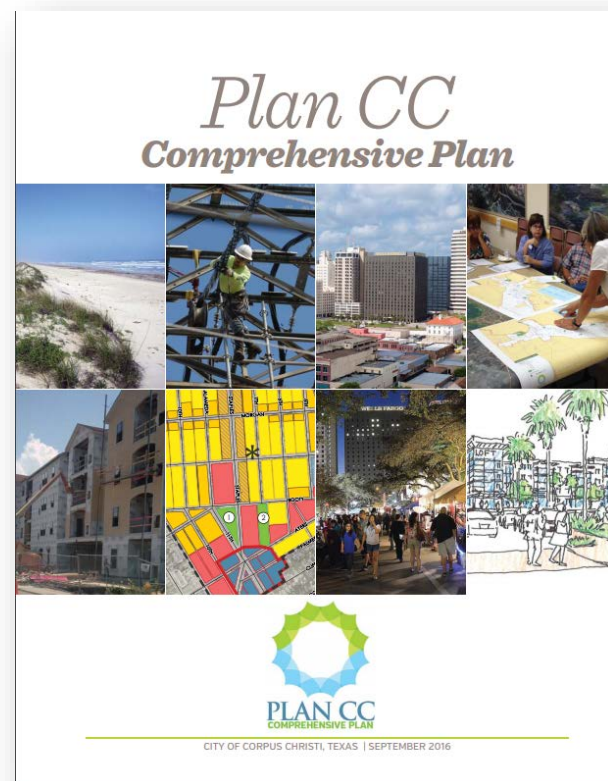


# Green Infrastructure Can Inform Planning

*Implementing Green Infrastructure*

Incorporate green infrastructure into planning efforts:

- Comprehensive
- Transportation
- Smart growth
- Watershed
- Conservation
- Hazard mitigation
- Stormwater
- Climate change adaptation
- Resilience
- Land use



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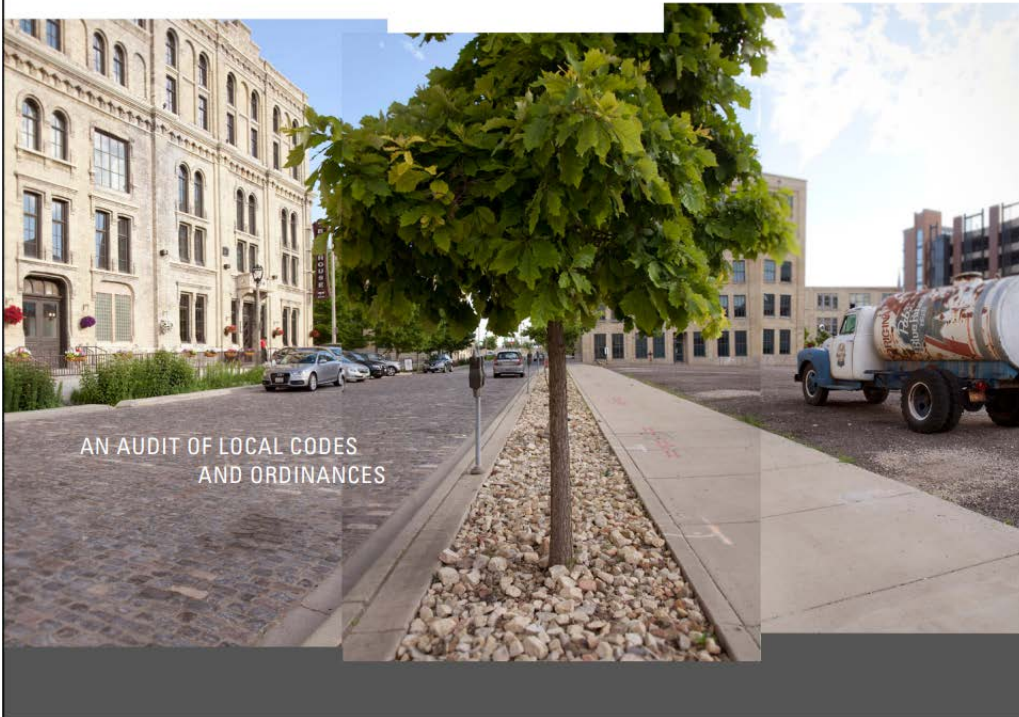
# Integrate into planned improvement projects

- What planned road or drainage projects do you have?
- What parks and recreation projects do you have?
- What economic development projects do you have?



# Local Codes and Ordinances

## TACKLING BARRIERS TO Green Infrastructure



[seagrant.wisc.edu/home/Portals/0/Files/Coastal%20Communities/Green\\_Infrastructure/DRAFT\\_GIworkbook\\_complete.pdf](https://seagrant.wisc.edu/home/Portals/0/Files/Coastal%20Communities/Green_Infrastructure/DRAFT_GIworkbook_complete.pdf)

## Implementing Green Infrastructure

### WHAT'S THE IMPACT: LANDSCAPING WITH NATIVE GRASSES, TREE PLANTINGS AND BIORETENTION

**Code Revision:** Encourage use of bioretention as landscaping and landscape-based stormwater control

- i. All yards sodded or seeded on at least 4 inches of topsoil. Rain gardens defined in the Chapter may be incorporated into lawn areas where planned and designed to receive drainage or runoff.
- ii. Trees and shrubbery appropriate for the development, and according to the plan approved under subsection (a) above. The incorporation of arroyo and soil areas, stormwater trees, and other vegetative stormwater control measures into landscaping plans is encouraged.

**(e) Parking Lot Landscaping**

1. Landscaping shall be provided on the perimeter and within the interior of all parking areas to provide screening, canopy cover, and stormwater treatment and control. The integration of vegetated stormwater control measures with parking lot landscaping is strongly encouraged. All landscaped areas shall be mulched or seeded in keeping with the overall landscaping plan. The Village may maintain a list of accepted species of trees and landscaping materials, including plants and trees suitable for use in vegetated stormwater control measures.
2. In parking lots, at least 5% of the interior parking area shall be landscaped with planting, and one tree of a minimum 2-inch caliper, for each 10 spaces, all as shall be submitted and approved as part of the plan provided for herein above. Planting required within the parking lot shall be in addition to, and not in lieu of, other planting requirements, such as for street trees. The planting plan may be varied to accommodate the design of vegetated stormwater control measures, so long as the total number of required trees is met within the overall parking area. The use of deciduous trees (which may function as stormwater trees, as defined in the Chapter) is encouraged to provide canopy shading within parking areas. Each interior landscaped area shall be a minimum of 25 square feet in size.

**Site:** Non-residential development (total area 4.12 acres)

- All parking areas drain to bioretention treatment or tree boxes (10,000 square feet)
- Roof-top drains to rain gardens in landscaped areas surrounding building
- Access drive drains through native vegetation filter strip
- All turfgrass replaced with native vegetation

Runoff volume reduction: **56%**  
Total suspended solids reduction: **64%**

TACKLING BARRIERS TO GREEN INFRASTRUCTURE

WHAT'S THE IMPACT 43

#### Do design standards allow siting of stormwater-control measures along facades?

Type of Barrier	Typs	Code References and Language	Notes, Mess and Strategies	Grade
Design guidelines	Zoning often will limit the structures that can be attached to a building facade or located within a setback. Codes should specify that rain barrels or cisterns and planter boxes may be sited along facades or extend into setbacks.			
Architectural standards				
Zoning setbacks				

#### Do standards allow for the waiver of design or architectural provisions to accommodate stormwater-control measures (planters, cisterns, green roofs, etc.)?

Type of Barrier	Typs	Code References and Language	Notes, Mess and Strategies	Grade
Design guidelines	Where a community provides for waivers of architectural standards, "siting of green infrastructure measures" should be a specific reason for the grant of a waiver.			
Architectural standards				
Zoning setbacks				

#### Are pitched roofs required? If so, is a waiver or provision for green roofs or rainwater harvesting made?

Type of Barrier	Typs	Code References and Language	Notes, Mess and Strategies	Grade
Design guidelines	If design standards require pitched roofs of a certain slope (i.e., 3:1) or for buildings to match adjacent roof pitches, some allowance for changing pitch should be made for rainwater harvesting or green roof installation.			
Architectural standards				
Zoning setbacks				

ARCHITECTURAL DESIGN STANDARDS

GREEN INFRASTRUCTURE AUDIT TOOL 48

# Learning from Others

Office for Coastal Management  
DIGITALCOAST

ABOUT DATA TOOLS TRAINING TOPICS STORIES

## TRAINING

Digital Coast Academy offers a wide range of learning resources.

FIND mapping, sea level rise, etc.

View all 166 trainings

### Scheduled Training

- Classroom, Instructor-Led  
Bring these courses and our instructors to your location.
- Online, Instructor-Led  
Learn at your desk, or a coffee shop, with sessions taught in real time by our instructors.

### Upcoming Offerings

The NOAA Office for Coastal Management has a training

### On-Demand Products

- Self-Guided Resources  
Develop and practice new skills on your own time with interactive guides and structured courses.
- Case Studies**  
Learn from these peer-to-peer case studies how other coastal practitioners have tackled thorny issues.
- Publications  
Explore the digital library of topical publications and

## Implementing Green Infrastructure

Office for Coastal Management  
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### PEER-TO-PEER CASE STUDY

## Implementing Green Infrastructure At Multiple Scales To Enhance Resilience

#### Summary

As the Natural Resource Program question, "what is the issue or impacts, and how will they handle

In the last few years, Alachua County seen. In 2017, they recorded the average rainfall had been around received 16 inches in a two-day worry about sea level rise, they d

Stephen, along with other county a critical component in helping Al understood that that they needed scales—including the overall lanc objective of Alachua County's Gn

#### Lessons Learned

- Don't wait until the end of early as possible, and don't
- Timing matters. Be ready a Stephen. Hurricane Irma was hazard events are damaging
- Connect people's values it important and connect those how surface water runoff is t

<https://coast.noaa.gov/digitalcoast/training/atlachua-county.html>

#### Neighborhood

At the neighborhood standards for en to get developer beginning and to removing ordina them to try these

They had been l of Florida that in development as and consultants/

Now, when a ne space. If this isn areas they were gardens, to enh

At this scale, m the construction colleagues try to He is also trying he points out, "It save money."

Alachua County unnecessarily, a savings to maintain the county or lar

#### Individual and Household

At this scale, education and social marketing is key. Alachua County teaches and encourages residents to use natural landscape techniques to reduce the use of nutrients that go directly into the aquifer. "Since our community members understand that impacts to the aquifer directly affect their drinking water, we've been successful at making the link to stormwater runoff and flooding issues," Stephen says.

Alachua County has also been working with schools through an Environmental Protection Agency grant to put in rain gardens and rain barrels, along with signage. Almost every school in the county is engaged, and the students have not only been helping with the green infrastructure, but also have been submitting artwork for an annual Earth Day calendar that includes natural resources and environmental challenges. "We're hoping to build a strong environmental ethic as the kids grow up," Stephen says, "and hopefully they'll stay in our community."

<https://coast.noaa.gov/digitalcoast/training/atlachua-county.html>

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[coast.noaa.gov/digitalcoast/training/home.html](https://coast.noaa.gov/digitalcoast/training/home.html)

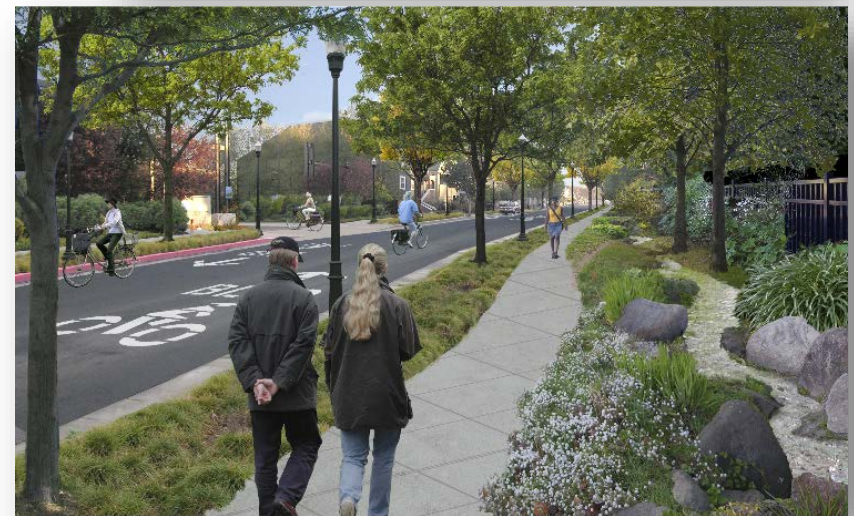




# Engaging Stakeholders

- Have a plan
- Speak to their interests, not yours
- Explain the hazard risk and offer solutions
- Use multiple ways to communicate

## *Implementing Green Infrastructure*





# Engaging Stakeholders

*Implementing Green Infrastructure*



# Engaging Stakeholders

## Implementing Green Infrastructure

Naturally **RESILIENT** Communities

Home Funding Resources **Explore Solutions & Case Studies**

### EXPLORE THE DIFFERENT TYPES OF NATURE-BASED SOLUTIONS

**COASTAL FLOODING & EROSION** **RIVER FLOODING & EROSION** **URBAN STORMWATER FLOODING**

Naturally **RESILIENT** Communities

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### EXPLORE THE DIFFERENT TYPES OF NATURE-BASED SOLUTIONS

**COASTAL FLOODING & EROSION** **RIVER FLOODING & EROSION** **URBAN STORMWATER FLOODING**

**BIOSWALE**

Bioswales are cost-effective drainage courses with vegetated or vegetated sloped sides that concentrate or remove silt and pollution from stormwater runoff. [LEARN MORE](#)

**FIND YOUR SOLUTION**

**HELP ME CHOOSE**

**Hazard Types**

- Coastal Erosion
- Flood Flooding
- Coastal Flooding
- Riverine Erosion
- Riverine Flooding
- Stormwater Flooding

**Region**

- Coastal West
- Great Lakes
- Gulf of Mexico
- Mid-Atlantic
- Midwest
- Northeast
- Pacific Northwest
- Rocky Mountain West
- Southeast
- Southwest

**Community Type**

- Rural
- Suburban
- Urban

**Scale**

- Community
- Neighborhood
- Site

**SOLUTIONS** 30 Results

**CASE STUDIES** 23 Results

**Rivers, Streams, and Floodplains**

Floodplains are the areas of low-lying ground adjacent to rivers, formed mainly...

**Coastal Marshes**

Coastal wetlands occur along marine, estuarine, and freshwater coastlines and may be...

**Beaches and Dunes**

Beaches and dunes occur in a variety of shapes, sizes, compositions, and...

**Mangroves**

Mangroves are a type of coastal or estuarine wetland, characterized by the...

**Seagrasses**

Seagrasses are a type of submerged aquatic vegetation that evolved over time...

**Oyster Reefs**

Oysters are a bivalve shellfish that are often referred to as "ecosystems"...

**Nrcsolutions.org**

# Engaging Stakeholders

## Implementing Green Infrastructure



### Put Green Infrastructure between Your Community and the Next Coastal Storm.

There are many benefits.

#### Tidal and Forested Wetlands

- Slow waves
- Filter and clean floodwaters
- Provide food and jobs

#### Green Streets

- Capture and clean stormwater
- Beautify streets and encourage economic development
- Provide pedestrian-friendly walkways

#### Oyster and Coral Reefs

- Slow storm surge
- Provide food
- Clean water

#### Sand Dunes

- Buffer waves as a first line of defense
- Build economy through tourism

#### Open Space and Parks

- Store floodwaters and recharge aquifers
- Increase property values

#### Urban Trees

- Reduce runoff and absorb floodwaters
- Shade and cool homes and businesses
- Provide clean air and water

#### Living Shorelines

- Slow waves and reduce erosion
- Protect property

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See the reverse of this page to learn more.

### Here's What You Can Do to Protect Your Community.

Green infrastructure can have multiple functions and cost less than using only gray infrastructure.



#### Conserve Existing Natural Areas

Natural areas such as wetlands, dunes, and vegetated shorelines absorb storm surge waves, reducing damage to nearby homes and roads.

**How do we know it works?** A study after Hurricane Sandy showed that areas containing wetlands had less damage than those without. Wetlands prevented an estimated \$600 million in property losses.



#### Increase Your Community's Ability to Absorb Stormwater

- Protect and plant trees.
- Implement other practices such as green streets to keep stormwater from running into sewers, lessening the strain on existing systems.
- Use capital improvement projects as an opportunity to fund stormwater projects.

**How do we know it works?** The City of Portland, Oregon, used a combination of green roofs, green streets, trees, and rain gardens to reduce the peak flow of stormwater runoff by 93 percent, cooling costs by 27 percent, and heating costs by 15 percent.



Photo: Tracy Skrabal, North Carolina Coastal Federation

#### Create Natural Shorelines

Create living shorelines using oysters, marsh grass, and other natural materials to absorb wave energy and reduce erosion.

**How do we know it works?** North Carolina properties that used natural shoreline protection measures withstood wind and storm surge during Hurricane Irene better than properties using seawalls or bulkheads.

To learn more, visit [coast.noaa.gov/digitalcoast/topics/green-infrastructure](http://coast.noaa.gov/digitalcoast/topics/green-infrastructure).

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# Funding for Green Infrastructure

*Implementing Green Infrastructure*

- US Environmental Protection Agency
- NOAA
- Federal Emergency Management Agency
- National Park Service
- National Endowment for the Arts
- US Department of Transportation
- Economic Development Administration
- National Recreation and Parks Association
- Funders Network for Smart Growth and Livable Communities
- Qualified Energy Conservation Bonds





# BREAK

Credit: Todd Marsee, Michigan Sea Grant



# **Speaker: Plans, Regulations, or Policies Supporting Green Infrastructure**

Green Infrastructure Planning for  
Southeast Michigan

**Katherine Grantham**  
**Southeast Michigan Council of Governments**



**OFFICE FOR COASTAL MANAGEMENT**  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION





# *Table Discussion 3*

*Implementing Green Infrastructure*

- **Part 1**: What barriers have you run into around implementing green infrastructure?
- **Part 2**: How can you overcome these barriers?





# One Last Thing . . .



Photo: MI Sea Grant

***Please fill out the Evaluation!***

**[https://www.surveymonkey.com/r/L1\\_IntroGI\\_17MAY2019](https://www.surveymonkey.com/r/L1_IntroGI_17MAY2019)**

# Thank You!

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