

# The Role of Green Infrastructure in Coastal Systems: Resilience, Water Quality and Sustainability

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**A Technical Conference on Coastal Resilience: The Environment,  
Infrastructure, and Human Systems**  
21-23 May 2014  
New Orleans, Louisiana, USA

# Outline

- Definition of Green Infrastructure
- Green Infrastructure's Role in Resilience
- Data Needs
- Coastal Green Infrastructure
- Nexus between nitrogen enrichment and viability of coastal marshes
- Site-scale Urban Green Infrastructure/Benefits
- Current Activities

# Definition of GI

- Green infrastructure defined:

The integration of natural systems and processes, or engineered systems that mimic natural systems and processes, into investments in resilient infrastructure.

- Sandy Rebuilding Task Force *Hurricane Sandy Rebuilding Strategy*

# Accepted Concept for Resiliency

*Gaining the benefits of the  
flood risk reduction capacity of natural processes  
and simultaneously reducing vulnerability would  
dramatically reduce our flood risk exposure and contribute  
to a redirection of resources that are now applied to  
compensate for losses and recover from disasters.*

**American Society of Civil Engineers Task Force on Flood Safety and Policies  
Civil Engineering Magazine  
April 2014**

[http://www.civilengineering-digital.com/civilengineering/april\\_2014?pg=49#pg50](http://www.civilengineering-digital.com/civilengineering/april_2014?pg=49#pg50)

# Data Needs

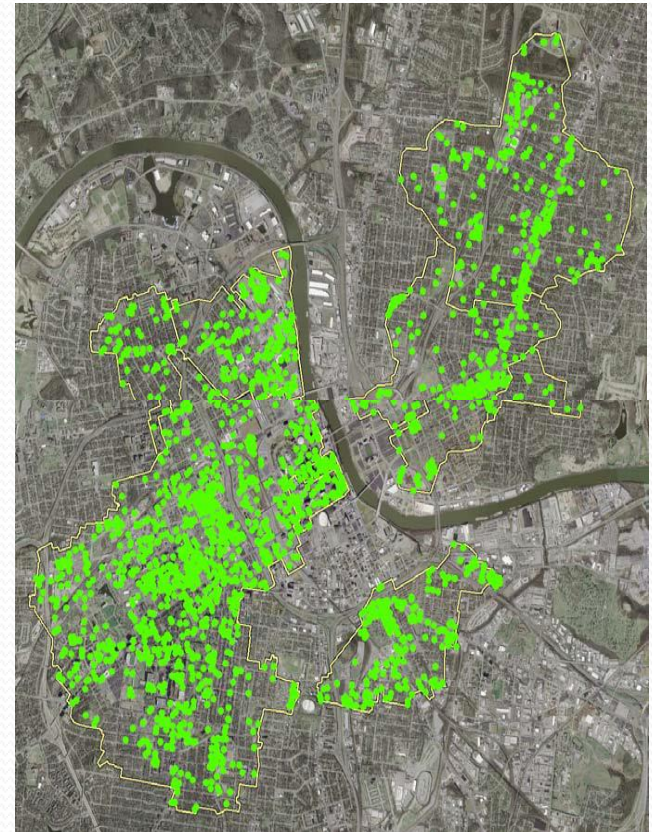
- More information is needed to assess performance
- USACE evaluating of coastal GI for storms
- Role of water quality for maintaining natural systems
- US EPA evaluating GI for water quality protection
- Water Environment Federation Best Management Practices Database for Site Scale Practices
- The more we understand the value, the more we will be willing to invest.

# Green Infrastructures Reduces Excess Runoff

- Modeling small storm retention and GI:
  - USEPA modeled the effect small storm retention policies on just new and redevelopment – by 2040 avoided losses are over \$100 M/year – a smarter way to build
  - USACE and USDA-FSA modeled flood reduction benefits of Conservation Reserve Program (such as riparian buffer) to downstream urban areas: Hundreds of thousands to millions of \$\$ in avoided losses.

# Green Infrastructure Plans Support Resilience

- Nashville TN experienced 1000-yr flood in 2011
- In addition to structural controls, Nashville's open space plan calls for the protection of 22,000 acres over the next 25 years.
- Evaluating urban site-scale opportunities

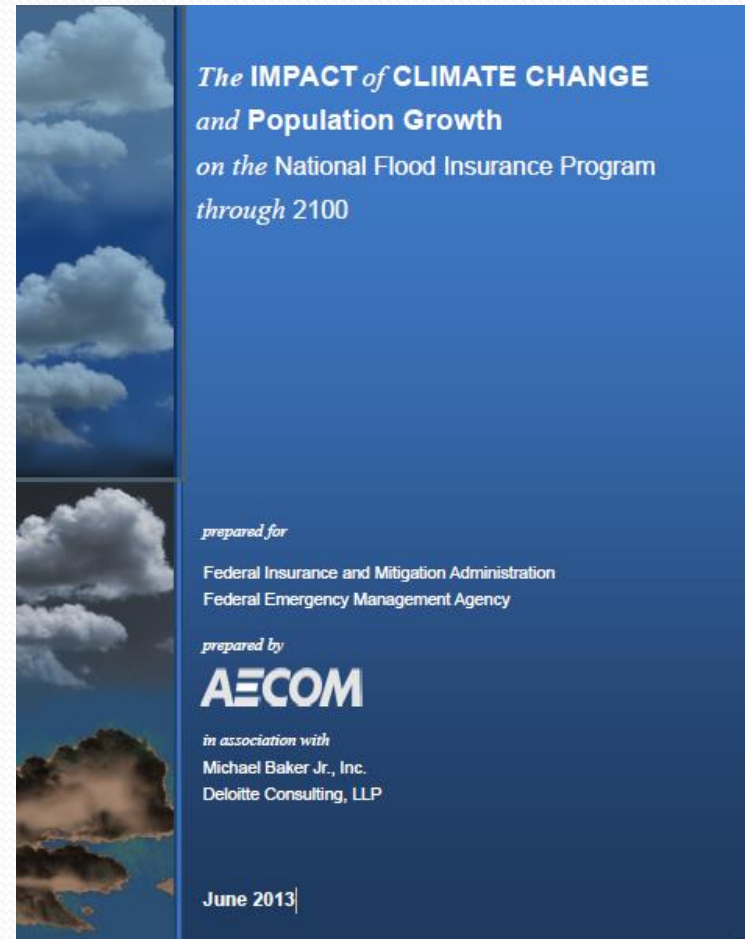


Green infrastructure opportunities in downtown Nashville. Photo credit: Nashville Green Infrastructure Master Plan



# Green Infrastructure Helps Adapt to Change

- Approximately one third of the estimated growth in the 100-year floodplain over the coming decades is attributable to upstream development. The other two thirds of this growth can be accounted for by climate change.
  - (FEMA, 2013)





# Green Infrastructure Encouraged in Hurricane Sandy “Rebuilding Strategy”

- Coastal marshes benefits cited<sup>1</sup>
- Example: During Sandy, oyster reefs installed years ago in NC absorbed energy and decreased erosion.
- *Infrastructure Resilience Guidelines* encourage sustainable and resilient infrastructure: Protect, retain, and enhance natural defenses

<sup>1</sup>ESA PWA, Analysis of the Costs and Benefits of Using Tidal Marsh Restoration As A Sea Level Rise Adaptation Strategy in San Francisco Bay (<http://bay.org/bay-restoration/the-horizontal-levee>;  
The Protective Role of Coastal Marshes: A Systematic Review and Meta-analysis (<http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0027374>

# Coastal Wetlands as Green Infrastructure

- Documented protection value (Costanza et.al. Royal Swedish Academy of Sciences, 2008)
- Lost storm protection value in the tens of billions
- Not including ecosystem services: one outcome of Sandy strategy is an interagency effort to quantify valuation of these services

[http://seagrant.noaa.gov/Portals/0/Documents/what\\_we\\_do/social\\_science/ss\\_tools\\_reports/value\\_hurricane\\_protection.pdf](http://seagrant.noaa.gov/Portals/0/Documents/what_we_do/social_science/ss_tools_reports/value_hurricane_protection.pdf)

<http://water.epa.gov/type/wetlands/cwt.cfm>

# Coastal wetland loss continues rapidly

- Development and sea level rise are key issues
- *Status and Trends of Wetlands in the Coastal Watersheds, 2004-2009, USFWS*
- Losing 80,000 acres of coastal wetlands per year



# Living Shorelines as Green Infrastructure

- Evaluated Technical/Policy Issues: North Atlantic Comprehensive Coastal Study (NACCS)
- Sandy Rebuilding Strategy cites Chafee National Wildlife Refuge, RI
- Pilots: Delaware Estuary & Rutgers
- Long-term projects in NC; Installed by Corps at Roanoke Island
- VA Living Shorelines General Permit



Delaware Living Shoreline  
Initiative, [DelawareEstuary.org](http://DelawareEstuary.org)

# Water Quality is Key to Maintaining Protective Coastal Marshes

- NY DEC: *Nitrogen Pollution and Adverse Impacts on Resilient Tidal Marshlands*, April 22, 2014
- Potential for future physical destruction is limited, nitrogen loading is the source of loss of concern
- Research on Increased Levels of Nitrogen on Loss of Barrier Salt Marsh
- WWTPs and septic main N contributors
- WWTP upgrades and ocean outfalls recommended



# Protection Begins Upstream

- Green Infrastructure can help:
  - Agricultural conservation programs
  - Non-point source urban runoff



Image by Nathalie Shanstrom

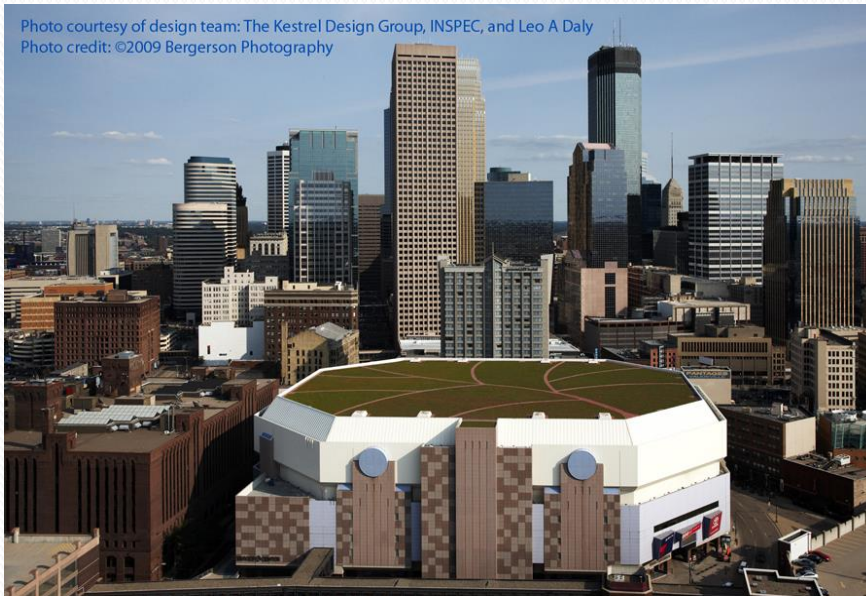


Photo courtesy of design team: The Kestrel Design Group, INSPEC, and Leo A Daly  
Photo credit: ©2009 Bergerson Photography

Minneapolis Target Center <http://tkdg.net/target-center-green-roof/>



Image by Nathalie Shanstrom

# Green Infrastructure for Water Quality

- Filtration
- Adsorption of trace metals
- Temperature reduction
- Nutrient reduction/cycling
- Biodegradation
- Reduction in runoff volume
- Reduction of scouring flows  
Urban, suburban, agricultural applications

Information Resources for  
Design and Case Studies  
<http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm>  
<http://water.epa.gov/polwaste/green/#guide>



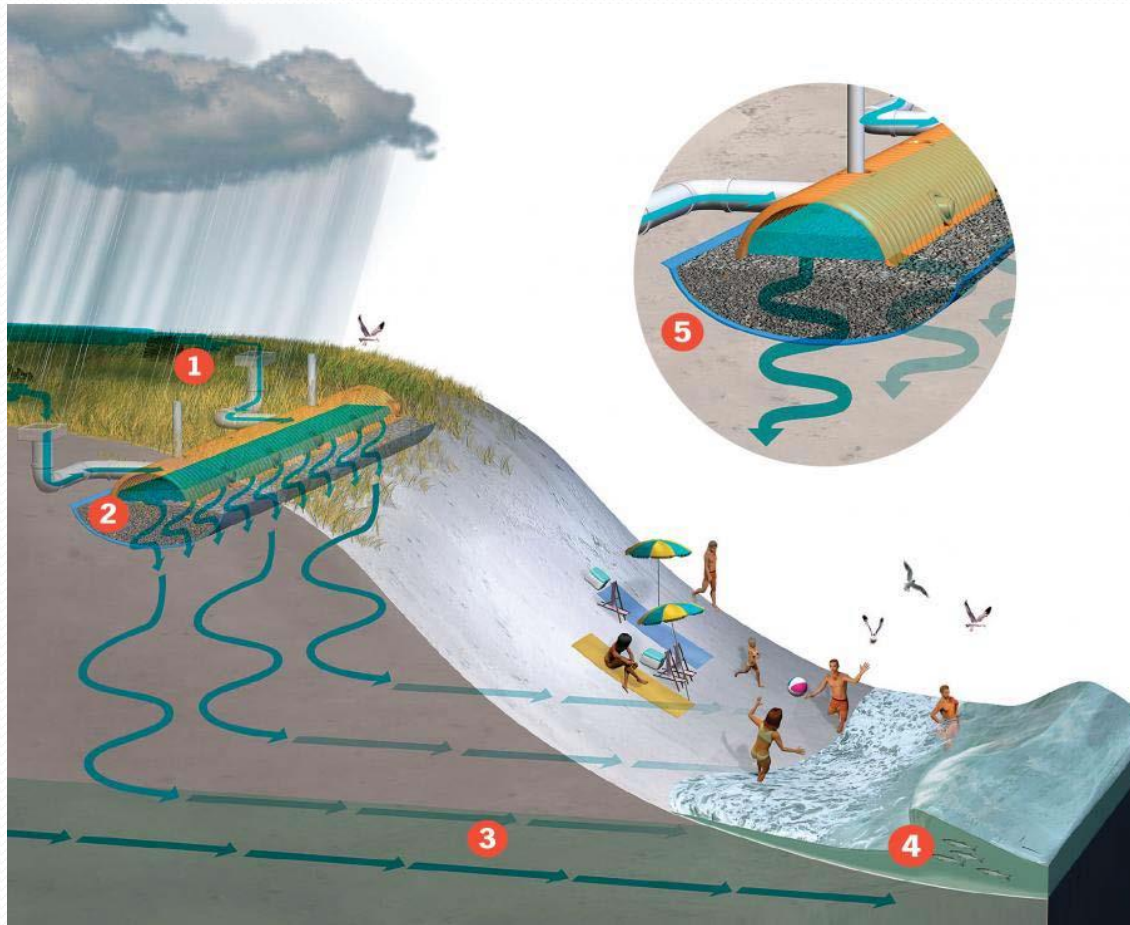
# Low Impact Development = Green Infrastructure for Stormwater Management

Distributed practices to replicate runoff volume of undeveloped site and use rainwater onsite.



Washington D.C. Navy Yard –Navy Adopted LID Policies in 2007

# Coastal Application for Small Storms



Sand Trap illustration: Kevin Hand

North Carolina State  
University Project in  
*Popular Science*  
Magazine, September 2013

*Dune Infiltration Systems for  
Reducing Stormwater Discharge  
to Coastal Recreational Beaches  
– A Demonstration Project in  
Kure Beach, NC*

<http://www.bae.ncsu.edu/extension/ext-publications/water/protecting/ebae-400-12-dune-burch-hunt.pdf>

*Ecological Engineering* 52 (2013) 1-11;  
Price, Burchell, Hunt, Chescheir

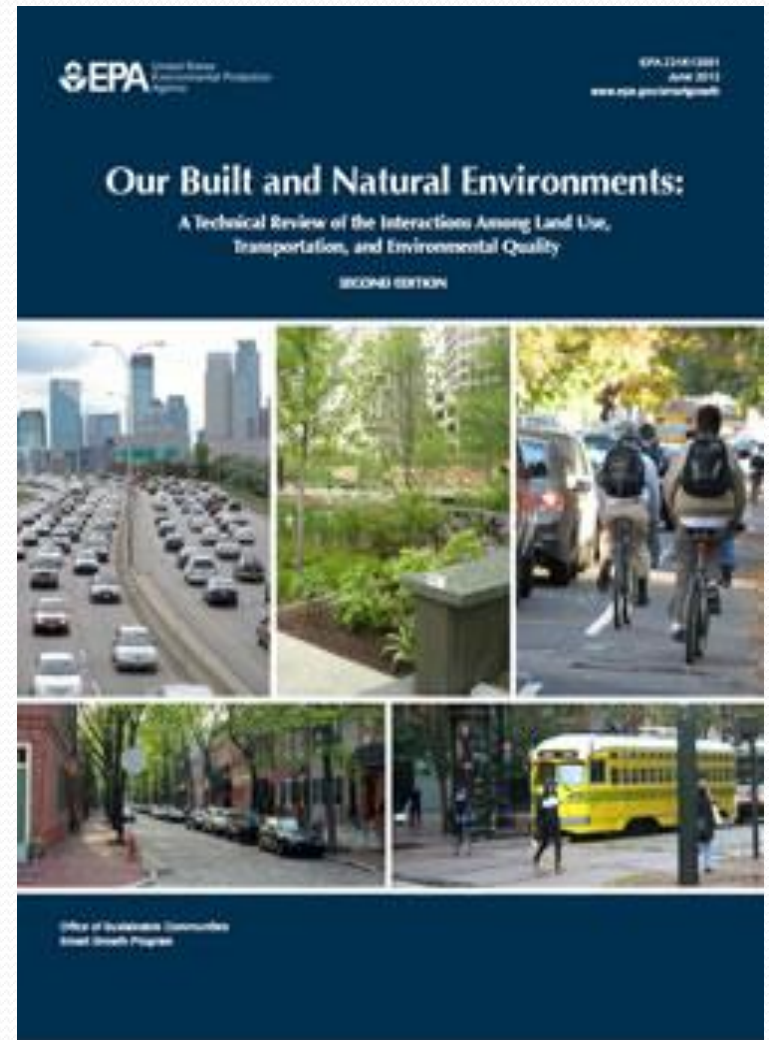


# Green Infrastructure Fits in Urban Design

- Smart Growth and Livability
- Parks interconnected for ecological function and stormwater/floodwater management
- Green Streets; Highway Design with median and roadside swale infiltration

<http://www.epa.gov/smartgrowth/built.htm>

<http://www.planning.org/cityparks/briefingpapers/greeninfrastructure.htm>



# Green Infrastructure Vision Solves Flooding with Multipurpose Solution

The mission of the Los Angeles Stakeholders was:

*“...to solve the local flooding problem while retaining all stormwater runoff from the watershed, increasing water conservation, recreational opportunities, wildlife habitat, and reducing stormwater pollution.”*

Sun Valley Watershed Management Plan, May 2004

It worked, and it changed the way LA manages its stormwater and floodplain programs.

# Green Infrastructure Reduces Damage

Replacing a roadside swale – green infrastructure - with pipe resulted in scouring damage in Aiken, South Carolina.



# Other Resilience Benefits of GI

- Water supply /availability
- Energy efficiency
- Community livability/recreational assets
- Habitat creation in urban areas

California Academy of Science: Green roof keeps the interior **10 degrees cooler** than a standard roof.





# Other Resilience Benefits

- Chicago City Hall (photo) green roof measures 80 degrees F cooler
- Analysis estimates savings 6 percent of total cooling and 10 percent of energy usage from green roof in Toronto – more further south



*National Center of Excellence/ASU*

<http://www.epa.gov/heatislands/resources/pdf/GreenRoofsCompendium.pdf>



# Status of LID Policies

- LID Required in New/Redevelopment in Many Areas
- State-wide: CA, NY, PA, NJ, MN, MD, DE<sup>1</sup>
- MS4 Permit Cities: MA, MT, NH, WV, TN, DC, OR, WA
- Some other cities adopted for flood management:  
Maricopa County (Phoenix), Kane/Lake Counties in IL
- Just for coastal protection: NC, SC counties
- For Federal facility buildings under EISA 2007<sup>2</sup>

<sup>1</sup>[www.epa.gov/npdes/pubs/sw\\_state\\_summary\\_standards.pdf](http://www.epa.gov/npdes/pubs/sw_state_summary_standards.pdf)

<sup>2</sup><http://water.epa.gov/polwaste/nps/section438.cfm>

# Status: Coastal North Carolina LID

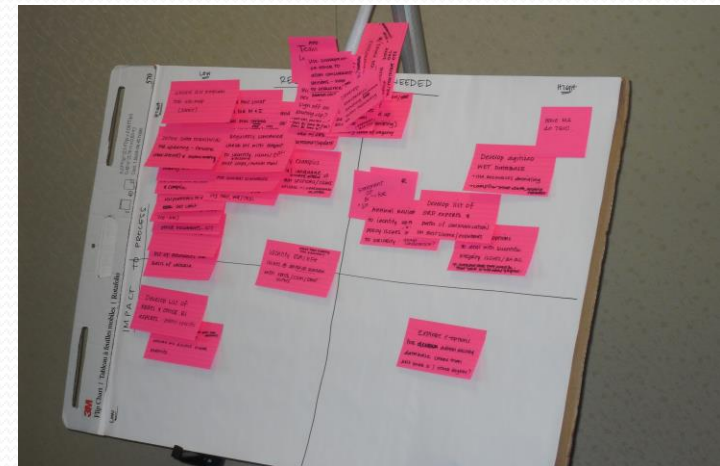
- Required For High-Density Coastal Areas
- ....uses...infiltration systems, wet detention ponds, bioretention systems, constructed stormwater wetlands, sand filters, rain barrels, cisterns, rain gardens or alternative stormwater management systems ...
- ...designed to store, control, and treat the stormwater runoff from all surfaces generated by ***one and one-half inch*** of rainfall.

[http://portal.ncdenr.org/c/document\\_library/get\\_file?uuid=c431dd18-aa4b-4424-a9b5-6aa5d98c397b&groupId=38364](http://portal.ncdenr.org/c/document_library/get_file?uuid=c431dd18-aa4b-4424-a9b5-6aa5d98c397b&groupId=38364)

# Encouraging States and Municipalities

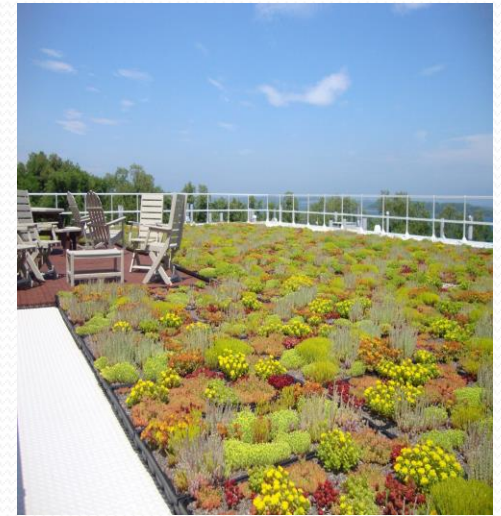
- Adopt and Implement LID policies
- Integrate GI as “business as usual” in public works - achieve wide scale and cost effective implementation.
- Departments working together can identify the most cost effective opportunities for green practices.

By adding green infrastructure along with grey infrastructure, communities can meet regulatory requirements for water quality while enhancing the urban environment for residents.



# Encouraging Local Decision-makers

- To Promote LID on private property
- Lead by municipal example, grants, stormwater fee reduction, tax incentives, facilitate building permits
- Hold design competitions to raise awareness
- Set goals: green roof target coverage with partial grant funding for private construction (Portland, Toronto, more)



# Encourage Implementation Widely

- \$2.2 M to 37 communities for GI program development.
- State Revolving Loan Fund: 20% Green Project Reserve
- 319 Non-Point Source Grants
- Urban Waters Program – Interagency Local Projects
- EPA Design competitions: Campus Rainworks, Local Efforts
- MOU with FEMA and with flood management association
- USFS grant coordination for Urban Forestry
- Green Highways Partnership ([greenhighwayspartnership.org](http://greenhighwayspartnership.org))
- Webcasts and Award Programs

<http://water.epa.gov/infrastructure/greeninfrastructure/gi.cfm>

# Sandy GI “Rebuilding Strategy”

- “Rebuild by Design”  
Design Competition -  
Sandy Rebuilding Task  
Force, HUD Lead, Many  
Private Contributors
- Water: teams examined  
water-based risk including  
places to store and retain  
water, combining green  
and blue space in resilient  
urban environments



<http://www.rebuildbydesign.org/>

Despite value, coastal wetland loss  
continues rapidly from development and sea  
level rise

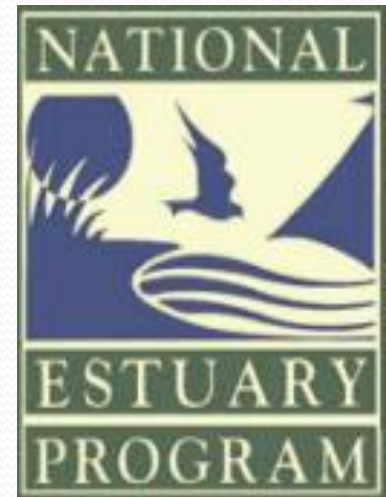


# Watershed Scale GI Programs

- EPA Healthy Watersheds Program protects the resiliency of watersheds still in good condition.
  - Builds state capacity to identify and protect healthy, functioning watersheds
- National Estuary Program (NEP) – 28 Estuaries
  - Green infrastructure grant programs and pilot implementation

<http://water.epa.gov/polwaste/nps/watershed/index.cfm>

[http://www.epa.gov/owow\\_keep/estuaries/](http://www.epa.gov/owow_keep/estuaries/)





# Path Forward: EPA Working with Federal Partners For Green Infrastructure

- EPA/FEMA – Sustainability, LID, smart growth
  - State Hazard Mitigation Plan Guidance (Blue Book),
  - Hazard Mitigation Grant Guidance
  - Community Rating System for NFIP
- Department of Transportation - Stormwater
  - TIGER Grants; Sustainable Highways Initiative
- USFS grant coordination for Urban Forestry

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