Nature-based Resilience for Coastal Highways

Transportation agencies must protect expensive public infrastructure from coastal flooding, especially as rising sea levels, higher storm surges, urbanization, and ecosystem stresses add complexity to already dynamic coastal systems and communities. An integrated approach to risk reduction includes natural and nature-based features in addition to structural and non-structural measures.

Photo from Federal Highway Administration (FHWA)

Nature-based features mimic characteristics of natural features and processes but are created by human design and engineering. Examples include dunes, wetlands, maritime forests, beaches, and reefs. These features can protect coastal highways from the brunt of storm surges and waves. Some can adapt to sea level rise by accreting sediment or migrating inland. They can also provide benefits such as recreation opportunities, habitat needed for commercial fisheries, and a healthier environment.

FHWA produced research and technical assistance that will enable transportation agencies to use natural and nature-based features, also called natural infrastructure or green infrastructure, to improve the resilience of transportation systems. FHWA sponsored five pilot projects, developed a white paper, regional peer exchanges, and an implementation guide.

FHWA Resources

- **Coastal Nature-Based Solutions: Lessons Learned** , August 2024. This fact-sheet summarizes emerging practices and lessons learned for planning, designing, and implementing Coastal Nature-Based Solutions.
- **Implementation Guide: Nature-based Solutions for Coastal Highway Resilience**, September 2019 (PDF 5.5 MB). The Implementation Guide is designed to help transportation practitioners understand how and where nature-based solutions can be used to improve the resilience of coastal roads and bridges. Upfront, it summarizes the potential flood-reduction benefits and co-benefits of these strategies. From there, the guide follows the steps in the project delivery process, providing guidance on how to consider nature-based solutions in the planning process, how to conduct a site assessment to determine whether nature-based solutions are appropriate, key engineering and ecological design considerations, permitting approaches, construction considerations, and monitoring and maintenance strategies.
- **Project Flyer: Using Natural Infrastructure to Protect Coastal Roads and Bridges** (PDF 1 MB)
- **White Paper: Nature-based Solutions for Coastal Highway Resilience**, March 2018. Briefly describes the current state of practice regarding the use of natural and nature-based features to protect coastal roads from flooding. Provides an overview of available tools for design, implementation challenges, and knowledge gaps. (PDF , 754 KB)
- **Peer Exchange Report: Nature-based Solutions for Coastal Highways**, August 2018 (PDF 3.6 MB)
  In Spring 2018, FHWA hosted four regional peer exchanges to inform the development of an implementation guide and to facilitate information exchange between transportation practitioners and coastal engineers and ecologists on nature-based solutions to protect roads from coastal flooding. This report provides a synthesis of the discussion, including project examples, successful approaches, and challenges in planning, permitting, design, and maintenance.

Pilot Final Reports

FHWA partnered with departments of transportation (DOTs) and others on five pilot projects to assess the potential for natural infrastructure to protect specific locations along coastal roads and bridges. See also the solicitation, which closed June 1, 2016. Pilot final reports are being posted below as they become available.

- **Maine and New Hampshire DOTs Pilot Final Report (2018)**
  These two DOTs partnered to assess the potential for green infrastructure to protect Route 209 in Phippsburg, ME and Route 1B in Portsmouth, NH. Results in Maine show it is possible to extend the time before a conventional gray infrastructure solution (sheet pile wall or riprap) becomes necessary to protect Route 209 through using sand fencing, root wads, and plantings. New Hampshire results show ecological benefits of elevating Route 1B and restoring habitat in the vicinity. (PDF , 13.1 MB)**US Army Corps of Engineers (Great Bay Boulevard, New Jersey) Pilot Final Report** (2018)
  US Army Corps of Engineers (USACE) explored green infrastructure solutions for reducing coastal flooding of Great Bay Boulevard in Ocean County, NJ. USACE analyzed thin layer placement of sediment to raise the marsh platform elevation in vulnerable locations along the road. USACE also analyzed a combination of oyster beds and native plants at the marsh edge to reduce wave energy. (PDF , 1.8 MB)
- **Delaware DOT Pilot Final Report** (2018)
  The Delaware Department of Transportation analyzed the flood vulnerability of State Route 1 between Rehoboth Beach and Fenwick Island and developed conceptual designs for nature-based protection, including marsh restoration and oyster reefs, at two sites. (PDF , 6 MB)
- **Mississippi DOT Pilot Final Report** (2018)
  Mississippi Department of Transportation (MDOT) assessed the potential for vegetated berms to protect the Henderson Point connector bridge on US Highway 90 from coastal storm surge. (PDF , 3.8 MB)
- **Oregon DOT Pilot Final Report** (2017)
  Oregon DOT developed conceptual designs for three locations along coastal highway US 101 vulnerable to storms and coastal bluff erosion. These designs include cobble beaches, artificial dunes, sand tubes, mechanically stabilized earth, rip rap, and planted terraces. Oregon DOT analyzed the coastal protection potential of these designs using wave runup analysis. Oregon DOT also engaged land use and permitting agencies on design options. (PDF , 5 MB)

Webinar Recordings

- **Nature-based Resilience for Coastal Highways: Finding Partners and Funding** (June 24, 2020) Staff from FHWA, NOAA, The National Fish and Wildlife Foundation, and DelDOT delve into two critical steps in getting nature-based solutions built: finding the right partners and finding funding. View the webinar recording.FHWA's Nature-based Solutions for Coastal
- **Highway Resilience: An Implementation Guide** (October 23, 2019) This webinar highlights FHWA's Nature-based Solutions for Coastal Highway Resilience: An Implementation Guide with presentations by staff from FHWA, the Army Corp of Engineers, NOAA, and the contractor team that helped develop the guide. View the webinar recording.
- **Green Infrastructure Pilots I** (November 2, 2017) Staff from the departments of transportation (DOTs) for Oregon, Maine, and New Hampshire present the results of their assessments. View the webinar recording.
- **Green Infrastructure Pilots II** (November 9, 2017) The pilot teams from Delaware, Mississippi and New Jersey present their results. View the webinar recording.

More Examples

- **Examples of Natural Infrastructure Protection of Coastal Highways** (2016)
  A compilation of examples from New York, California, Maryland, and Louisiana.

Resources from Other Agencies

Partnership

Systems Approach to Geomorphic Engineering (SAGE) is a community of practice of federal, state, and local agencies, non-governmental organizations, academic institutions, engineers, and private businesses working together to: 1) Use and promote green-gray approaches to ensure coastal community and shoreline resilience; 2) Broaden science, engineering, policy and marketing activity both domestically and internationally; and 3) Engage community partners in regional demonstrations.

Basics

- **Natural and Structural Measures for Shoreline Stabilization Brochure** (6 pages)
  Provides information on a continuum of green to gray shoreline stabilization techniques that can help reduce coastal risks and improve resilience.
- **PBS Video: As seas rise, Americans use nature to fight worsening erosion** (10 min)
  Illustrates how techniques such as marsh seedlings and bags of oyster shells can prevent shoreline erosion at cheaper cost than seawalls at some locations.
- **US Army Corps of Engineers Brochure on Natural & Nature-Based Features** (2 pages)
  Explains the USACE systems approach to coastal protection, combining natural and nature-based features, structural, and non-structural measures.
- **Green Infrastructure Protective Services Animation**
  Watch a short animation describing the protective benefits of green infrastructure.

Tools

- **Sea Level Rise Viewer – Marsh Migration**
  Look under the "marsh migration" tab of this tool to see how wetlands in your area may be impacted by sea level rise. Marshes on the Move – explores what's involved when modeling the impacts of sea level rise on coastal wetlands in the future.
- **Coastal Flood Exposure Mapper**
  Use this tool to see where your community assets, including natural resources, are most vulnerable to coastal flooding, and use this information to start conversations about local risk reduction strategies.
- **Green Infrastructure Mapping Guide**
  Use this guide to develop a GIS work plan to prioritize green infrastructure for coastal resilience.
- **Sea Level Change Curve Calculator**
  Outputs tables of sea level change projections by year for your selected location and parameters.

Reports

- **Use of Natural and Nature-Based Features (NNBF) for Coastal Resilience**, U.S. Army Corps of Engineers, 2015.
- **North Atlantic Coast Comprehensive Study Report**, U.S. Army Corps of Engineers, 2015.
- **Guidance for Considering the Use of Living Shorelines**, NOAA, 2015.
- **Ecosystem-Service Assessment: Research needs for coastal green infrastructure** ,
  Executive Office of the President, National Science and Technology Council, 2015.

Links

- **NOAA Natural Infrastructure**
- **USACE Engineering with Nature**
- **NOAA Restoration Living Shorelines**
- **US EPA Green Infrastructure**
- **Virginia Institute of Marine Science (VIMS), Center for Coastal Resources Management, Living Shorelines**
- **Coasts, Oceans, Ports & Rivers Institute (CORPI) Living Shorelines Database**