

Houston-Based Recommendations on Natural Infrastructure for Flood Mitigation

The Greater Houston Area is prone to inland riverine and coastal flooding. Following catastrophic flooding caused by Hurricane Harvey and with three consecutive years with 500-year storms, public officials and a diverse array of stakeholders are reexamining the region's approach to flood mitigation. In addition to improving existing gray infrastructure, communities are showing interest in the use of natural and nature-based solutions for reducing flood risks and impacts.

Natural infrastructure refers to natural and nature-based systems – for example, wetlands, prairies, bioswales, and natural floodplains – that provide essential services and benefits to society, including flood protection, erosion control, and water purification. Natural infrastructure has become a focus of local studies and planning efforts throughout the Houston area, reflecting the growing recognition of the vital role that nature plays in supporting, sustaining, and protecting people and their livelihoods.

Natural infrastructure approaches can be more cost-effective than traditional gray infrastructure (such as concrete culverts, dams, and retention ponds) for flood mitigation. Additionally, these techniques often provide additional environmental, economic, and societal benefits (or “multi-benefits”). For example, land conservation and restoration projects can reduce flood risks by increasing the capacity of land to absorb and slow storm water, while also providing multi-benefits such as recreation, improved air and water quality, carbon sequestration and storage, and wildlife habitat. These multi-benefits further help to reduce community vulnerability to a range of societal, health, and economic risks.

Texas has adopted [new statewide funding measures to invest in flood mitigation](#), called the Flood Infrastructure Fund and the Texas Infrastructure Resiliency Fund. In addition, Texas is embarking on a novel [regional and statewide flood planning process](#) that will determine which flood mitigation strategies can be funded with state dollars. Natural infrastructure is an eligible project category under these new flood mitigation programs, and this approach needs to be prioritized and prominently featured as projects and strategies in the regional and state flood plans.

The Texas Living Waters Project has been actively engaged in these emerging flood mitigation funding opportunities to promote investments in effective and equitable nature-based approaches where appropriate. As part of this effort, we compiled and synthesized existing flood mitigation recommendations that have been made by Houston-based entities in recent years. This includes 8 groups representing local governmental entities, universities, and nonprofits that have released 12 documents, including reports, studies, and planning documents, related to flood mitigation. While Houston has a full range of options to reduce future risks, **we urge decision makers to invest in natural infrastructure and nonstructural flood mitigation measures that support or enable the use of natural systems and their multi-benefits.** To that aim, we have identified 5 overarching strategies related to natural infrastructure and flood mitigation as high priorities for Houston:

- Expand green infrastructure and promote resilient building design
- Invest in habitat restoration to defend against flooding
- Develop a strategic and coordinated buyout program
- Prioritize conservation and sound land management
- Deploy public education, awareness, and engagement campaigns

This document introduces each of these strategies with a brief description, a list of related recommendations put forth by local entities, relevant funding opportunities, and incentives to promote and expand its use.

The [Texas Living Waters Project](#) is a collaborative effort of the National Wildlife Federation and the Sierra Club, Lone Star Chapter, Galveston Bay Foundation, and Hill Country Alliance. Together, Texas Living Waters Project partners bring together water policy, science, and education to build a future with freshwater for every living thing. For more information, contact Amanda Fuller, Director, Texas Coast and Water Program, National Wildlife Federation: FullerA@nwf.org or 512-610-7773.

Expand Green Infrastructure & Promote Resilient Building Design



Description: Green infrastructure (GI) is an integrated approach to urban stormwater management that uses natural and nature-based features designed to mimic or preserve natural drainage processes and capture stormwater runoff at the source to improve water quality and reduce flooding. Low-impact development (LID) is a closely related term that is often used interchangeably with GI for stormwater management. GI techniques use plant or soil systems and permeable surfaces, such as rain gardens, bioswales (i.e., vegetated trenches), and green roofs to reduce stormwater flows to sewer systems and surface waters. These techniques often go hand-in-hand with updates to building codes that promote resilient building design – creating a built environment that can absorb greater amounts of rainwater on site. Building codes are an effective way to require resilient building design.

Scale: These techniques can be applied to an individual building or site; however, they are most effective at reducing flood impacts if distributed and integrated across an entire neighborhood or community.

Multi-benefits: These techniques can reduce runoff and flash flooding while generating additional benefits such as improved air and water quality, wildlife habitat, and beautification.

44 Existing Houston-Based Recommendations Related to GI/LID 12 reports | 8 entities*

Example Recommendations:

- Develop **LID maintenance programs**. - *Houston-Galveston Area Council*
- Design a **green infrastructure network** as a strategically planned and managed network of natural lands, working landscapes, and other open spaces that conserve ecosystem functions and provide additional benefits to human populations. - *The Conservation Fund*
- Train and grow a **green stormwater infrastructure workforce**. - *City of Houston*
- Promote more **efficient site design in new developments** and ensure they are not requiring more paving of an area than is required. - *Houston-Galveston Area Council*
- Create a **regional LID guidelines template** and **LID performance criteria** for local and county governments. - *Greater Houston Flood Mitigation Consortium*
- **Codify requirements for new construction and redevelopment** through a Green Building Code. - *City of Houston*
- **Align transportation system to waterway functions** to manage runoff; retrofit parking lots and other paved areas with plantings and pervious paving to lower impact of runoff on drainage systems. - *City of Houston*
- Create **“Interceptor Streets”** as blue-green streets that align with historic corridors, commercial streets, and public transit routes to harness the interrelationships between vegetation and the water cycle and provide multiple benefits. - *City of Houston*



Top: Rain garden in Houston (Environment Texas); *Middle:* Green roof in Houston (Texas A&M AgriLife Research photo by Kathleen Phillips); *Bottom:* Bioswales with underground storage tanks in Spring, Texas (Harris County Engineering Department).

Example Funding:

- TWDB Flood Infrastructure Fund (FIF)
- TWDB Texas Infrastructure Resiliency Fund (TIRF)
- FEMA Building Resilient Infrastructure and Communities Program (BRIC)
- TWDB Clean and Drinking Water State Revolving Fund Programs
- TWDB DFund’s Water Quality Enhancement Account

Example Incentives:

- Increase public demonstration projects
- Use transferable development rights (city purchases property from landowners and they work cooperatively to manage it appropriately)
- Streamline all flood-related permitting and reduce permitting fees for GI projects
- Decrease water detention volume requirements
- Offer stormwater fee discounts
- Create a GI project award & recognition program

Invest in Habitat Restoration to Defend Against Flooding

Description: Healthy riparian habitat, wetlands, prairies, and urban ecosystems can serve as natural defenses against inland and coastal flooding. Restoration of natural habitats and open spaces can enhance the flood mitigation capacity of these systems, such as by improving soil conditions and enhancing infiltration rates, reducing runoff and peak flows. Restoration techniques vary and include approaches like native plantings, sediment augmentation, and invasive species removal.

Scale: Riparian and habitat restoration is most effective at a large scale, which maximizes the ability of these systems to reduce flood risk and enhance habitat value for people and wildlife. Small-scale restoration efforts can also enhance a habitat's ability to serve as a natural defense against flooding.

Multi-benefits: Habitat restoration provides many additional benefits beyond reducing flood risks, including: improved air and water quality; creating and preserving important fish and wildlife habitat; sequestering and storing atmospheric carbon dioxide; and supporting the outdoor economy.

22 Existing Houston-Based Recommendations Related to Habitat Restoration 6 reports | 4 entities*

Example Recommendations:

- **Restore and enhance bayou corridors:** 1) Create an ecosystem toolkit for bayou and floodplain restoration, 2) Enhance ecological patches and corridors using restoration in city parks as a model, and 3) Support the Headwaters to Baywaters Initiative. – *City of Houston*
- **Restore portions of the Katy Prairie** that have been converted to agricultural land to increase the flood control benefit of that land. – *Greater Houston Flood Mitigation Consortium*
- Preserve and **reclaim the floodplain and floodways** for integrated flood control, recreation, natural habitat, and open space. – *Houston Parks Board*
- **Maintain and enhance** the current 9%, or 477,879 acres, of protected nature-based land in the Houston-Galveston area. – *The Conservation Fund*
- **Support local bond referendums and other funding** sources for additional nature-based infrastructure, stabilization techniques, soil enhancements and other tools that **better integrate development with natural ecosystems.** – *The Conservation Fund*
- Encourage funding for **large-scale marsh & dune restoration.** – *The Conservation Fund*
- Create and implement **regional invasive species and riparian forestry management plans.** – *The Conservation Fund*
- Facilitate **multi-partner initiatives to increase native plants and trees** in riparian, developed, preserved, agricultural and coastal lands. – *The Conservation Fund*
- Acquire all undeveloped land upstream of Armand Bayou Park and **restore it to prairie.** – *Greater Houston Flood Mitigation Consortium*



Top: Brays Bayou urban wetland creation project at John T. Mason Park, Harris County (Texas A&M AgriLife Extension). Bottom: Wetland planting at Exploration Green in Clear Lake (Sierra Club Lone Star Chapter)

Example Funding:

- TWDB Flood Infrastructure Fund (FIF)
- HUD Community Development Block Grants – Mitigation (CDBG-MIT)
- FEMA Building Resilient Infrastructure and Communities Program (BRIC)
- FEMA Hazard Mitigation Assistance Program
- RESTORE Act Funding

Example Incentives:

- Incentivize denser urban infill to reduce development pressure on natural and greenfield areas. – *Greater Houston Flood Mitigation Consortium*
- Encourage land-use projects that secure riparian floodways and wetlands as buffers. – *The Conservation Fund*
- Invest in habitat restoration demonstration projects. – *City of Houston*

Develop a Strategic and Coordinated Buyout Program

Description: Unfortunately, homes are not always built with flooding in mind. Houston is notorious as a developer friendly city and has continued to build in the 100-year floodplain after Hurricane Harvey. Even the most informed homebuyers may be unaware of the true flood risk associated with a home. For repetitive-loss properties, often the best solution is for state or local governments to purchase the property, remove structures, successfully relocate residents, and ensure no future development occurs in that area. Buyouts are often done voluntarily, with the homeowner applying for a buyout through the local, state, or federal government.

Scale: Buyouts can be applied to an individual home, residence, or building; however, they are most effective at flood abatement when multiple connected units are bought out in a flood prone area. Buyout candidates should be prioritized based on residents' vulnerability to flooding and their ability to move out of the floodplain.

Multi-benefits: In addition to removing people from the floodplain, bought out properties can be retrofitted to enhance local stormwater storage, thereby reducing runoff to neighboring areas.

21 Existing Houston-Based Recommendations Related to Buyouts 7 reports | 5 entities*

Example Recommendations:

- Create an **efficient buyout process** by having a single entity in charge, local funding available to spend promptly, probabilistic risk maps, a comprehensive plan, and community meetings to create buy-in. – *Greater Houston Flood Mitigation Consortium*
- Target **buyouts in repetitive loss areas**. – *The Baker Institute*
- Create an **affordable housing** program. Without a coordinated housing plan that creates new housing concurrently with buyouts, extensive buyout programs could significantly reduce the supply of affordable housing, and more people will agree to buyouts if viable relocation options exist. – *Greater Houston Flood Mitigation Consortium*
- Strategically **prioritize buyout investments to achieve multiple benefits**. Integrate environmental value data into buyout decisions. – *The Nature Conservancy*
- Make buyout programs more effective by conducting **extensive public outreach**, active case management, and relocation assistance. – *Greater Houston Flood Mitigation Consortium*
- Existing single and multifamily residences must be **equitably moved out of the floodway**. – *City of Houston*
- Engage in **pre-disaster buyout planning** where applicants can be pre-approved to reduce the time it takes to process a buyout. – *Greater Houston Flood Mitigation Consortium*
- **Utilize local and philanthropic funding** to provide a more flexible buyout process that addresses properties within a buyout area that don't meet federal requirements and avoid the "checkerboard effect." – *Greater Houston Flood Mitigation Consortium*



Top: Multi-family residences flooded during Hurricane Harvey (Brett Coomer, Houston Chronicle); Middle: Hurricane Harvey flooded home demolished after getting bought out by Harris County (Godofredo A. Vasquez, Houston Chronicle); Bottom: Homes in floodplains that aren't bought out floodproof their homes, such as by elevating (Allison Lee, Houston Public Media)

Example Funding:

- TWDB Flood Infrastructure Fund (FIF)
- HUD Community Development Block Grants – Mitigation (MIT) and Disaster Recovery (DR)
- FEMA Building Resilient Infrastructure and Communities Program (BRIC) and Hazard Mitigation Grant Program (HMGP)

Example Incentives:

- Allow homeowners to choose between receiving a pre-disaster value check for their home or to swap their home for a new one – *Greater Houston Flood Mitigation Consortium*

Prioritize Conservation and Sound Land Management

Description: Conservation and sound land management are essential nature-based tools to mitigate flooding. Land that is not developed, but conserved, can provide natural flood mitigation benefits by capturing water and allowing it to infiltrate into the ground. This reduces runoff and alleviates strain on traditional drainage systems and other flood infrastructure during flooding events. Conservation efforts can be achieved through various mechanisms such as fee simple land acquisition or conservation easements. Further, sound land management techniques enhance the land's potential to provide flood mitigation benefits. Examples of sound land management techniques include connecting greenspaces to increase the ability of open areas to capture and store water and prioritizing land acquisitions around key areas such as bayous to reduce downstream flooding.

Scale: Conservation and sound land management practices can be applied to an individual plot of land; however, they are most effective if distributed and integrated across an entire neighborhood, community, or region.

Multi-benefits: Land acquisition and sound land management create additional benefits, such as increased recreational opportunities, improved air and water quality, and improved wildlife habitat.

41 Existing Houston-Based Recommendations Related to Conservation and Sound Land Management 8 reports | 6 entities*

Example Recommendations:

- **Make space for bayous** by working with the Bayou Greenways 2020 initiative. – *City of Houston*
- **Bring back the prairie** by supporting prairie habitat conservation efforts in the greater Houston region, which can reduce runoff, preserve recreational and ecological amenities, and lower the urban heat island effect. – *City of Houston*
- Create a **multifunctional perimeter greenbelt** around Kashmere Gardens. – *City of Houston*
- **Acquire land along bayous and creeks** where watersheds remain undeveloped. – *Greater Houston Flood Mitigation Consortium*
- **Protect land with acquisition and easements** on high value land within the green infrastructure network, including linkages to Big Thicket National Park and National Wildlife Refuges. – *The Conservation Fund*
- Pursue additional **open space connectivity opportunities offered by utility corridors** while encouraging their ecologic value to the region. – *Houston Parks Board*
- Purchase **flood mitigation easements**. – *Greater Houston Flood Mitigation Consortium*

Example Funding:

- TWDB Flood Infrastructure Fund (FIF) & Texas Infrastructure Resiliency Fund (TIRF)
- TWDB Drinking and Clean Water State Revolving Funds (SRFs)
- HUD Community Development Block Grants – Mitigation (MIT) & Disaster Recovery (DR)
- FEMA Building Resilient Infrastructure and Communities Program (BRIC) & Hazard Mitigation Grant Program (HMGP)
- NOAA Coastal and Estuarine Land Conservation Program (CELCP)

Example Incentives:

- Provide financial incentives that recognize farmers and ranchers managing their lands in ways that improve water quality and preserve natural open space. – *Greater Houston Flood Mitigation Consortium*
- Establish programs to preserve habitats using market-based approaches that pay landowners to raise a “crop” of stored water. – *The Baker Institute*
- Support carbon capture demonstration projects in areas identified as having high carbon sequestration value. – *The Conservation Fund*
- Expand landowner interest in the Forest Legacy and Community Forest conservation easement programs. – *The Conservation Fund*



Top: Houston Parks Board Bayou Greenways Initiative 2020 (Anthony Rathbun); Bottom: Katy prairie habitat providing water capture benefits for Houston (Davis Land, Houston Public Media)

Deploy Public Education, Awareness, and Engagement Campaigns



Description: Public education, awareness, and engagement campaigns are an integral part of urban storm water management, flood mitigation, and Low Impact Development (LID). Public education and awareness refer to activities aimed at promoting public understanding of an issue. Public engagement refers to strategies that educate community members, achieve public involvement, and gain input from stakeholders to plan for complete communities. There are a variety of ways to educate and engage the public about flood risk and mitigation including: educational campaigns; community advisory groups; collaborative research; citizen science; and participatory arts. Comparable terms: Public Outreach, Community Engagement.

Scale: Public education, awareness and engagement strategies can be implemented at a neighborhood, municipal, regional, or state-wide scale. They are most effective when they reach a large proportion of residents.

Multi-benefits: In addition to increasing public knowledge of flood risk and nature-based flood protection strategies, public education, awareness, and engagement efforts increase community buy-in for flood mitigation projects and can lower flood insurance costs under the National Flood Insurance Program's Community Rating System.

16 Existing Houston-Based Recommendations Related to Public Education, Awareness and Engagement 6 reports | 3 entities*

Example Recommendations:

- **Implement robust and ongoing fact- and science-based education programs** that inform residents of flood risks, voluntary buyouts, and flood mitigation strategies. - *Greater Houston Flood Mitigation Consortium and Houston-Galveston Area Council*
- **Develop education and training programs** for local governments about LID construction requirements and maintenance programs. **Cultivate a water-aware culture** among the development community centered on increasing water storage and reducing flood risk. - *Houston-Galveston Area Council*
- **Increase resident awareness of flood risk** by participating in the National Flood Insurance Program, requiring real-estate transactions to disclose property flood risks, and conducting Community Rating System sanctioned public outreach activities. - *Greater Houston Flood Mitigation Consortium*
- **Deploy signage campaigns** identifying and explaining specific LID practices, and install plaques on home structures that inform residents on how to prepare for flood events. - *Greater Houston Flood Mitigation Consortium and Houston-Galveston Area Council*
- **Leverage arts and culture assets and add flood-focused artwork across the region** to memorialize flood events and engage residents in flood risk education, mitigation, and adaptation strategies. - *Greater Houston Flood Mitigation Consortium and City of Houston*

Example Funding:

- TWDB Flood Infrastructure Fund (FIF)
- HUD Community Development Block Grants – Mitigation (CDBG-MIT)
- FEMA Building Resilient Infrastructure and Communities Program (BRIC)
- TWDB Texas Infrastructure Resiliency Fund (TIRF)

Example Incentives:

- Encourage local drainage maintenance with Adopt-A-Drain programs. - *Greater Houston Flood Mitigation Consortium*
- Encourage GI/LID with award and recognition programs for project sponsors and elected officials. - *City of Houston*



Top: Resident participates in Adopt-A-Drain program (Mark Mulligan, Houston Chronicle); Middle: 2018 Community Design Charrette at University of Houston (Raj Mankad); Bottom: Mural by Houston Muralist Daniel Anguilu (Carrie Colbert)

*The following Houston-based entities and reports have developed these and other flood-related recommendations:



- [Designing for Impact: A Regional Guide to Low Impact Development](#)



- [Greater Houston Flood Mitigation Consortium Report](#)
- [The Flood Next Time: What We Can Do Now](#)



- [Living with Water](#)
- [Houston Incentives for Green Development](#)
- [Resilient Houston Plan](#)
- [Climate Action Plan](#)



- [Beyond the Bayou: A Vision for Expanding Houston's Public Realm](#)



- [Houston-Galveston Green Infrastructure and Ecosystem Services Assessment](#)



- [Gulf-Houston Regional Conservation Plan](#)



- [Strategic Property Buyouts to Enhance Flood Resilience](#)



- [Hurricane/Tropical Storm Harvey: Policy Perspectives](#)