Guidelines for Next Generation of Flood Maps

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Introduction

Historically, FEMA has developed flood maps for both coastal and inland waters of the US in support of assessing flood risks and setting insurance rates. The maps, Flood Insurance Rate Maps (FIRMS), are widely available both directly from the FEMA mapping center (https://msc.fema.gov/portal/home) and from state offices of emergency management. The maps typically are expressed in the form of Base Flood Elevations for 100 yr flooding. BFEs include both surge levels and the associated wave conditions. FEMA FIRMs maps also include 500 yr flood zones but only the surge levels. Figure 1 shows an example for Fields Point, Providence, RI from the RI Emergency Management Agency (RI EMA) Flood Plain Viewer (https://riema.ri.gov/planning-mitigation/floodplain-management/mapping).

The maps are historically embedded in the design standards for structures in the flood zone under the ***Minimum Design Loads and Associated Criteria for Buildings and Other Structures*** (ASCE/SEI 7-22) (https://www.asce.org/publications-and-news/civil-engineering-source/article/2021/12/02/updated-asce-7-22-standard-now-available). They are also included in ***ASCE Hazard Tool*** (https://ascehazardtool.org/) (Figure 2). The ASCE design standards are also typically included in state building codes. In the presence of climate change, the use of FEMA FIRMS is increasingly being challenged since they do not include the impacts of sea level rise, changes in storm patterns and strength, and enhanced precipitation.



Figure 1 FEMA FIRM for Fields Point, Port of Providence. RI Emergency Management Agency, Flood Plain Viewer.

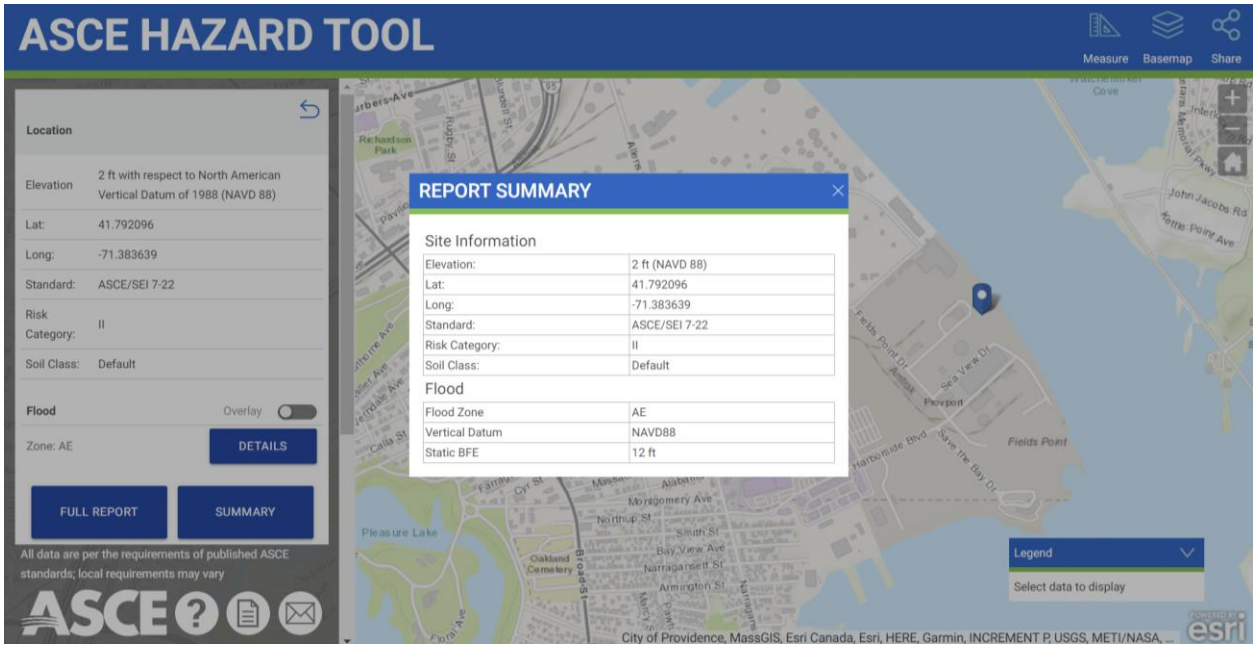


Figure 2 ASCE Hazard tool applied to a location in Port of Providence. The site selected is in AE zone with a BFE of 12 ft.

Since the design lives from most structures are typically 30 to 50 yr, the use of FEMA FIRMs to assess flood risks is increasingly challenged in the presence of climate change. Some

municipalities and states have addressed this problem by having offsets, typically 2-5 ft to be added to the FEMA FIRM. Other states have revisited the issue and produced flooding maps that explicitly include the impact of sea level rise. In the RI **STORMTOOLs** initiative, Design Elevation(SDE) maps have been generated for all coastal areas of the state and are publicly available via **STORMTOOLS ArcGIS Hub** (https://stormtools-mainpage-crc-uri.hub.arcgis.com/). The SDE maps are currently being extended to inland areas of the state to assess the impact of enhanced precipitation resulting from climate change on flooding, with support from the FEMA BRIC 2022 program.

In 2022 ASCE revised the flood design standards (ASCE/SEI 7-22) to increase the mean return interval (MRI) of flooding for residential (Risk Category II) and higher risk structures (Risk Category III (high occupancy) and IV (emergency facilities)) and to explicitly consider sea level rise over the design life of the structure. For residential structures the design standard is 500 yr. For Risk Categories III and IV the MRIs have increased to 750 and 1000 yr, respectively. FEMA FIRMs provide 500 yr surge levels but do not consider either sea level rise or the corresponding wave conditions. They do not provide any information for 750 and 1000 yr MRI conditions.

Suggested Guidelines

As a result of working on the development of coastal flooding maps, that explicitly include the impacts of climate change (sea level rise), over the past decade some guidelines have emerged that might be useful to consider as others move down this path. These are provided below.

1. **BFE Metric.** Maps should use BFE metric to present the results since they include both surge and the corresponding wave conditions. They are embedded in the ASCE/SEI design standards and widely used. They are the de-facto standard.

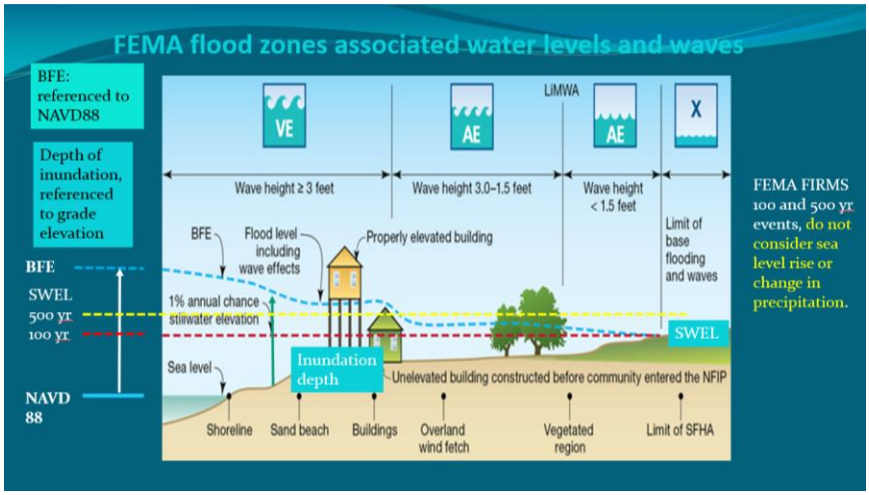


Figure 3 Schematic of the components (surge and waves) of the FEMA BFE.

2. **State of art methods.** Following FEMA's example, state of the art methods should be used to generate the BFE maps. Some widely used models for assessing flood risk include hydrodynamics: ADCIR, ROMS, FVCOM, et al., wave models: SWAN, STWAVE, et al; and morpho dynamic models: XBeach, FUNWAVE, et al. The models need to be able to predict surge height, waves, and erosion and accretion of coastal areas from extreme events.

3. **Model grid resolution.** The model grid system needs to be able to represent key features of the topography/bathymetry and its spatial variation, the presence of engineered structures that impact flooding paths and levels, and the density of structures and infrastructure. This will likely require a modeling framework that has high resolution or a variable grid size to keep computational costs reasonable.

Figure 4 shows an example of the flooding and associated damage to residential structures for 100 yr, no sea level rise (SLR) event. The color of the dots represents the percent damage. The background shows the BFE for this case. The model resolution is approximately 30 ft and hence provides adequate representation of the spatial variation of the location of the structures and variations in the BFEs.

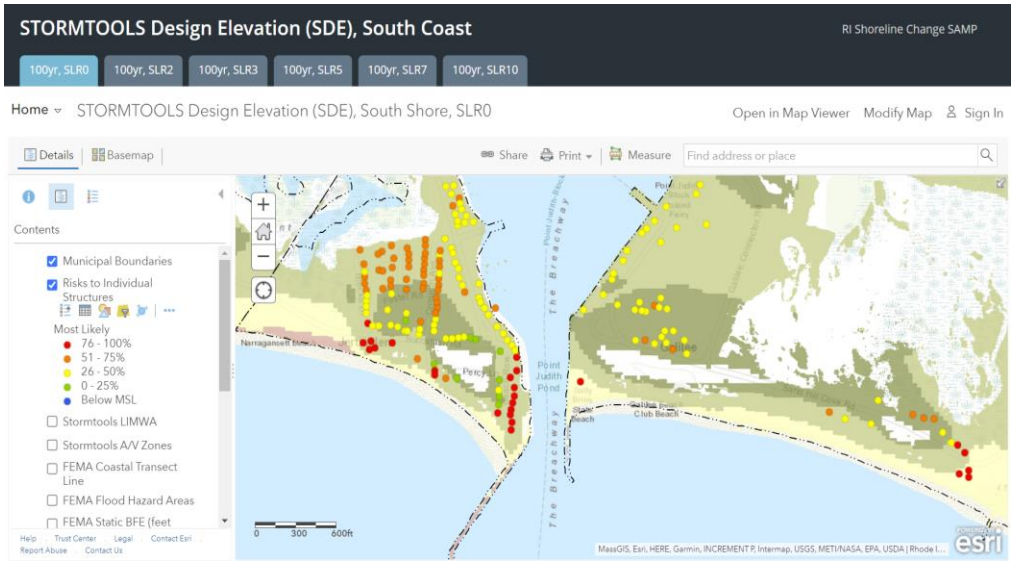


Figure 4 SDE and Coastal Environmental Risk Index (CERI) map for 100 yr, no SLR event for the entrance to Port of Gallie. Dots represent residential structures, and the color provides estimates of the damage from flooding.

4. **Sea level rise values.** In performing simulations, one must specify the sea level values over the time of interest. At a minimum, the period is typically the design life of the structure. NOAA provides SLR predictions for a range of uncertainty: low to

high. As an example, Figure 5 shows the projections from 2022 by NOAA NOS # 8452660, Newport, RI from 2020 to 2160. (https://oceanservice.noaa.gov/hazards/sealevelrise/sealevelrise-tech-report-sections.html).

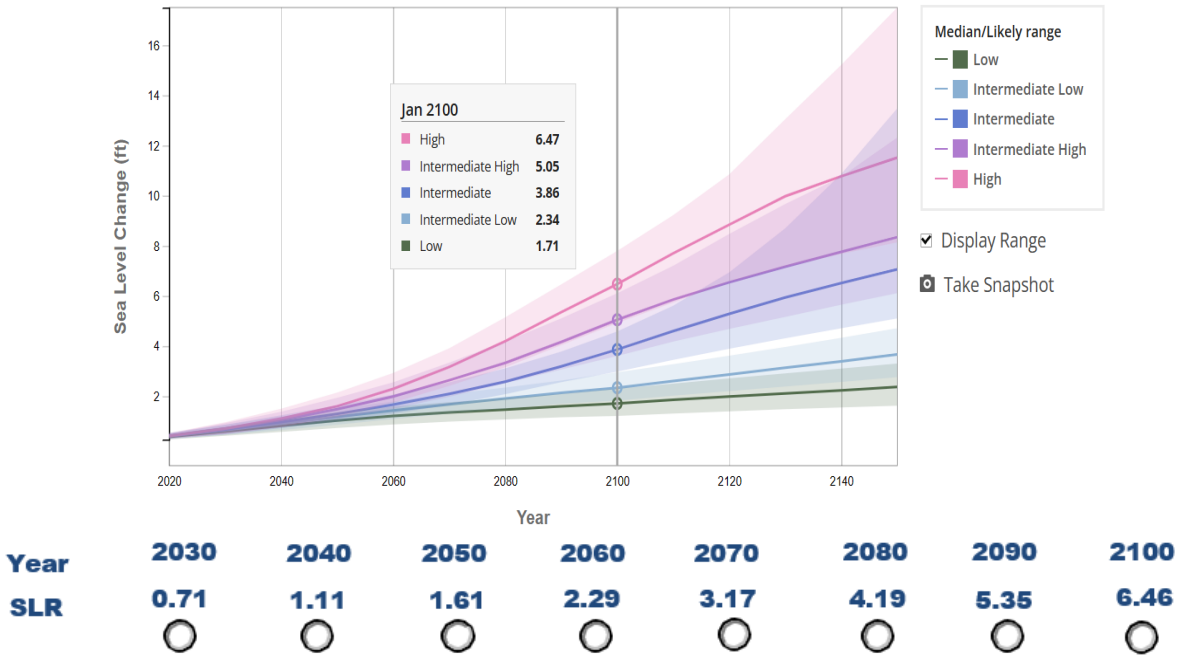


Figure 5 NOAA sea level rise projections at NOAA NOS #8452660, Newport, RI.

The lower section of the figure shows the projections for the NOAA High Curve by decade. The high value is mandated in RI by the RI Coastal Resources Management Council (RI CRMC).

It is important to note that NOAA updates the sea level projections every 5 yrs, with the most recent update in 2022. The value can change substantially over this period, as new data becomes available and additional analyses are performed. As an example, the NOAA High curve for Newport, RI in 2100 was 9.5 ft in 2017 and was reduced to 6.46 ft in 2022. The risk level selected should likely be linked to the risk category for the structure or infrastructure of interest. Given this changing landscape and risk level, it is likely best to label BFE with MRI and SLR values but NOT the date, or risk level since these keep changing.

5. **Uncertainty Assessment.** In generating BFE maps the uncertainty needs to be documented and explicitly included in the map products. This is particularly important given the large uncertainty in surge and wave levels from tropical and extratropical storm events.

As an example, Figure 6 shows the peak water levels (m- MHHW) at NOAA NOS station # 8452660 at Newport, RI vs return period (yr.). The curves show the mean and lower and upper (95% confidence limit) values. The highest observed water levels (black dots) are for 1954 Carol and 1938 hurricanes. One can clearly see that both events exceed the upper 95% projection.

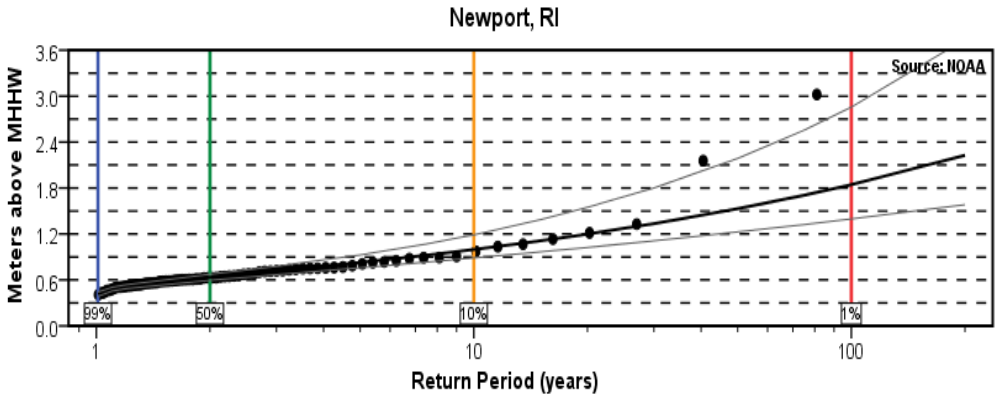


Figure 6 Peak water levels (MHHW) vs return period at Newport, RI, NOAA NOS #8452660. Solid black line is the mean value and light black lines the upper and lower 95% value.

In generating the SDE maps, the state elected to address this uncertainty by selecting the upper 95% value. The uncertainty in the FEMA maps is not highlighted but typically is well below the 95% confidence limit but above the mean value. Care must be taken when specifying this value.

6. **Erosion/Accretion Shoreline.** During storm events the shoreline is subject to erosion and thus may dramatically change the degree of flooding. This is likely to be more pronounced as the storm return period gets longer and sea level rise increases.

As an example, Figure 7 shows SDE predictions of the BFE for 100 yr, 5 ft SLR case for Charlestown Beach, RI. The figure shows multiple breaches of the dune system (dark purple). These result in surge channels and over wash fans and thus flood water entering Ninigret Pond. Figure 8 shows an aerial photo of the over wash fans and surge channels post hurricane Carol, 1954. One can see that the spatial scale of these individual features (dark purple) is quite limited. The methods used to estimate this erosion must have the resolution to represent the events and thus these features.

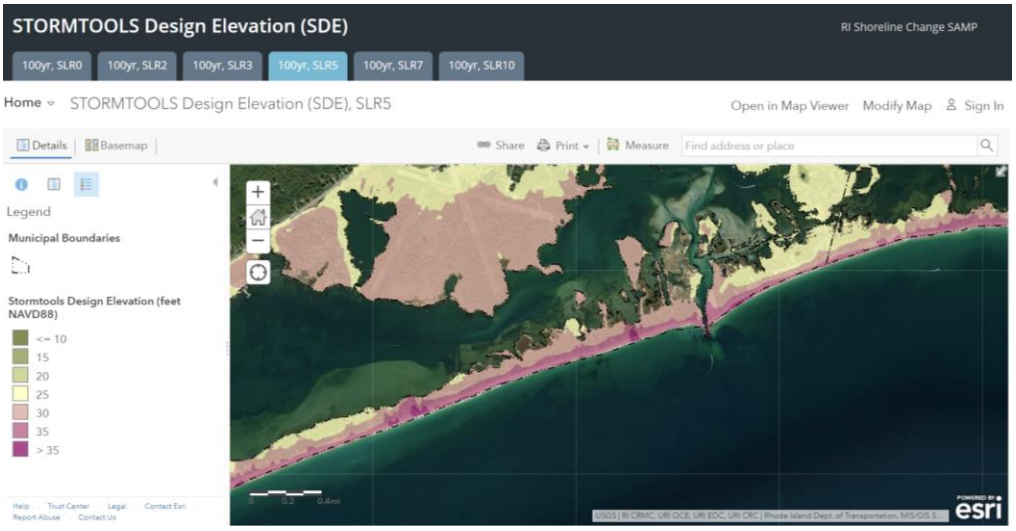


Figure 7 SDE maps for 100 yr 5 ft SLR for Charlestown Beach and Ninigret Pond.



Figure 8 Aerial photo post 1954 Carol hurricane of over wash pans entering Ninigret Pond. Charlestown Beach is to the left. Quonochontaug Pond is in the background.

7. **Validation of Model Predictions.** To have confidence in the prediction of models used to generate the maps, they should be validated against observations, ideally for multiple events for key storm events. These might be hurricanes but should also include extra-tropical events for the NE.

   In the case of the SDE maps, these are based on the USACOE North Atlantic Comprehensive Coast Study (NACCS) (https://www.nad.usace.army.mil/CompStudy/). The models used were validated with observations and documented in the study report.

8. **Mean Return Interval (MRI)**

   The MRI for Risk Class I structures has remained at 100 yr, but now includes SLR. For Risk Classes II – 500 yr, III- 750 yrs, and IV – 1000 yrs. All include sea level rise projections. Given the fact that Risk Class II (residential) dominates the focus for the next generation of flooding maps is now 500 yrs. Methods show be developed to allow scaling of these maps to address lower and higher MRI.

Summary and next steps

The overview presented above represents some thoughts on the key guidelines in generating the next generation of flooding maps for the coastal waters of the US in the presence of climate change. These are based on a decade of experience in RI leveraging the work done by the USACOE NACCS study. RI is one of the first states in the nation to have such maps integrated into its coastal permitting system. The maps are currently being extended into inland waters of the state. The next step in this process is to have a national, non-partisan, professional panel convened to review methods used to generate the next generation of flooding maps. Given their in-depth experience in this field and their professional standing, it is recommended that this be co-led by ASCE and the National Institute Building Sciences (NIBS). ASCE has a committee that has overseen the development of the ASCE/SEI 7- 22 design standards. NBIS has historically operated a Scientific Resolution Panel (SRP) (see summary below) that reviews challenges by counties to the FEMA FIRMS, so has access to large cadre of professionals from across the US and deep experience in the field. NIBS has also supported bipartisan legislation to update flood mapping standards (see article below).

Points of contact include:

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NIBS MATERIAL

SCIENTIFIC AND TECHNICAL EXPERTS WANTED - JOIN OUR SCIENTIFIC RESOLUTION PANEL CADRE

Posted By NIBS Staff

Tuesday, May 17, 2022

The National Institute of Building Sciences seeks qualified scientific and technical professionals from the public, private and academic sectors to serve on independent scientific panels. These Scientific Resolution Panels (SRPs) convene for the purpose of reviewing and resolving conflicting scientific and technical data, submitted by a community, challenging the Federal Emergency Management Agency's (FEMA) proposed flood hazard data.

When a community challenges the proposed FEMA flood elevations for a particular area, the community or FEMA may request that an SRP be convened. NIBS will convene an independent panel from its cadre of experts, co-selected by the challenging community and FEMA, to review FEMA's flood hazard data and the flood hazard data submitted by the community to determine which studies are technically and scientifically more accurate.

The panel then will render a written decision that denies or accepts the alternative flood elevations submitted by the community. The SRP's decision will serve as the recommendation to the FEMA Administrator for resolution of the conflicting data.

Who May Serve on a Panel

Interested professionals must have a minimum of 10 years of proven experience with expertise in one of the following surface water hydrology, hydraulics, coastal engineering, and other relevant engineering and scientific fields or a related field:

- Coastal storm and hydraulic engineering
- Coastal geotechnical engineering
- Water resource engineering (surface water hydrology, open-channel flow hydraulics, hydrologic engineering)
- Geotechnical engineering
- Alluvial fan engineering
- Levee analysis and mapping
- FEMA guidelines and standards for flood risk analysis and mapping

They also must have expertise with riverine, lacustrine, coastal flood hazard, surveying, topographic information, hydrologic analysis, hydraulic analysis, coastal analysis or other pertinent experience applicable to the development of flood elevations and Flood Insurance Rate Maps (FIRMs).

What Happens Next

If approved, SRP Cadre members may be called to serve on one to three SRPs per year, averaging the equivalent of two to five days' effort spread over three months.

Panels will be conducted virtually, with no travel involved. Panel members will be compensated for their services under contract with NIBS.

To become a member of the NIBS SRP Cadre, learn more about the scientific resolution panel initiative, or fill out an application, visit www.floodsrp.org/apply.

NIBS SUPPORTS BIPARTISAN HOUSE BILL TO PROTECT COMMUNITIES FROM FUTURE FLOOD DISASTERS

Monday, October 5, 2020

The Flood Resiliency and Taxpayer Savings Act would direct federal agencies to plan for future risks

(WASHINGTON, DC, October 2, 2020) – The National Institute of Building Sciences applauds the introduction of the Flood Resiliency and Taxpayer Savings Act of 2020 in the U.S. House of Representatives on Sept. 30. The bipartisan legislation was introduced by Representatives David Price (D-NC) and Lee Zeldin (R-NY) to better safeguard communities and infrastructure from future flooding events and storms.

NIBS joined more than 30 stakeholder groups to sign a letter that calls for a pragmatic approach to enhance the safety of federal investments and communities when building and rebuilding in flood-prone areas.

"Every American faces natural hazards risks, and the risk is growing," says Lakisha A. Woods, CAE, President and CEO of NIBS. "Most of the costs for the cycle of flooding, damage and repair fall on the taxpayer. This House bill ensures taxpayer dollars used to build or rebuild will not be wasted."

Communities and states across the nation are incorporating future flood risk, such as sea level rise and heavier downpours, when building and rebuilding.

It's overdue for the federal government to follow suit, and the Flood Resiliency and Taxpayer Savings Act offers a practical way to address this void by requiring federally funded projects account for future risk throughout a project's design life.

The Rising Cost of Floods

Flooding is the most common and expensive natural disaster in the United States. It has cost the nation more than $845 billion in estimated losses from flood- and hurricane-related disasters since 2000, according to the National Oceanic and Atmospheric Administration.

According to the NIBS **Natural Hazard Mitigation Saves 2019 Report**, more than one million older homes stand in the 100-year floodplain. Buyouts, elevation projects, and other retrofits could save society $1.3 trillion at a cost of $230 billion -- $6 saved for every dollar invested. The Mitigation Saves report represents the most comprehensive benefit-cost analysis of natural hazard mitigation, from adopting up-to-date building codes to the upgrade of utility and transportation infrastructure. It covers a number of natural disasters, including wind, hurricane surge, wildfires, and earthquakes.

About NIBS

National Institute of Building Sciences brings together labor and consumer interests, government representatives, regulatory agencies, and members of the building industry to identify and resolve problems and potential problems around the construction of housing and commercial buildings. NIBS is a nonprofit, non-governmental organization. It was established by Congress in 1974. For more information, visit nibs.org or follow @bldgsciences on Twitter and Facebook.

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