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AN EXAMINATION OF FEDERAL FLOOD MAPS IN A CHANGING CLIMATE

JOINT HEARING

BEFORE THE

SUBCOMMITTEE ON ENVIRONMENT
SUBCOMMITTEE ON INVESTIGATIONS
AND OVERSIGHT

OF THE

COMMITTEE ON SCIENCE, SPACE,
AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

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February 27, 2020

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AN EXAMINATION OF FEDERAL FLOOD MAPS IN A CHANGING CLIMATE

THURSDAY, FEBRUARY 27, 2020

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENVIRONMENT,
JOINT WITH THE SUBCOMMITTEE ON
INVESTIGATIONS AND OVERSIGHT,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittees met, pursuant to notice, at 2:58 p.m., in room 2318 of the Rayburn House Office Building, Hon. Mikie Sherrill [Chairwoman of the Subcommittee on Environment] presiding.

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENVIRONMENT
SUBCOMMITTEE ON INVESTIGATONS & OVERSIGHT
U.S. HOUSE OF REPRESENTATIVES

HEARING CHARTER

An Examination of Federal Flood Maps in a Changing Climate

Thursday, February 27, 2020
2:00 p.m.
2318 Rayburn House Office Building

PURPOSE

The purpose of this hearing is to discuss how flooding and sea level rise affect American property owners, how the Federal Emergency Management Agency (FEMA) uses science to inform its flood products, how the National Oceanic and Atmospheric Administration (NOAA) researches and communicates flooding and sea level rise, and whether additional federal resources are needed to research and communicate present and future flood risk to the public. In addition, we will discuss what tools exist to help property owners, coastal managers, community planners and other stakeholders understand and evaluate their flood risk, including FEMA and NOAA flood map products.

WITNESSES

- **Mr. Michael Grimm,** Assistant Administrator for Risk Management, Federal Insurance and Mitigation Administration, Federal Emergency Management Agency, U.S. Department of Homeland Security
- **Mr. Mark Osler (OSS-ler),** Senior Advisor for Coastal Inundation and Resilience, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
- **Mr. Ryan R. Branfort, PLS, GISP,** Senior Vice President, Wilson & Company, Inc., Engineers & Architects
- **Mr. Chad Berginnis (Ber-GHIN-is), CFM,** Executive Director, Association of State Floodplain Managers

OVERARCHING QUESTIONS

- What is the intended purpose of FEMA flood maps, and how are they being used today?
- What science and modeling techniques does FEMA use to develop flood maps, and are there any data gaps?
- Are there any new modeling or analysis tools that could help FEMA update flood maps with greater frequency/at less cost without sacrificing quality?

- What products exist to help homebuyers, coastal managers, and community planners evaluate future flooding risks?
- How does NOAA science inform FEMA flood products, including FEMA flood maps?
- When will FEMA show future conditions on flood maps?
- What flood information, tools, and services does the National Oceanic and Atmospheric Administration (NOAA) provide to help property owners, managers, community planners and other stakeholders understand and evaluate coastal and inland flood risk?
- What is NOAA's role in researching and communicating the role of climate change in accelerating sea level rise, changing precipitation patterns, and other resulting impacts that affect flooding and flood risk?
- What would the ideal collaboration be between FEMA and science agencies like NOAA to develop the highest-quality and most useful flood hazard and risk products?

BACKGROUND

Flood Risk and Climate Change

Flooding is the most prevalent and most expensive type of natural disaster in the United States.[1] Flood events have occurred in all 50 states and U.S territories since May 2018.[2] Flooding has cost the U.S. over $1 trillion in inflation-adjusted dollars since 1980.[3] It also costs lives, causing approximately 80 deaths on average per year for the last 30 years.[4]

There are four main types of flooding: fluvial floods (river, lake, or stream floods), pluvial floods (flash floods and surface water), coastal floods (storm surge), and urban flooding. Fluvial flooding can be due to excessive rain or snowmelt, while pluvial flooding occurs during extreme rainfall and is independent of overflowing water bodies. Coastal flooding can be from intense windstorms during high tides, and tsunamis.[5] Urban flooding, or flooding in densely populated areas, occurs when a source of inundation – rainfall, hurricane, groundwater seepage, river overflow, infrastructure failure – overwhelms stormwater systems and causes water accumulation.[6]

Flood risk is an expression of the likelihood that a flood hazard will incur damages to humans, buildings, and infrastructure.[7] While flooding is a natural and recurring event, flood risk is increasing due to sea level rise, climate change, land use change, and increased development in

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[1] U.S. FEMA, "TMAC: Future Conditions Report Interim," October 2015, Accessed here: https://www.fema.gov/media-library-data/1448469075684-d54e851ba84ab6b998ae9cbeb6d42eac/TMAC_2015_Future_Conditions_Report-INTERIM_508_11252015.pdf

[2] Congressional Research Service, "A Brief Introduction to the National Flood Insurance Program," December 30, 2019, Accessed here: https://fas.org/sgp/crs/homesec/IF10988.pdf

[3] Ibid.

[4] National Oceanic and Atmospheric Administration, National Weather Service, "Weather Related Facility and Injury Statistics," 2018, Accessed Here: https://www.weather.gov/hazstat/

[5] Zurich Insurance Company, "Three Common Types of Flood Explained," 2020 Accessed Here: https://www.zurich.com/en/knowledge/topics/flood-and-water-damage/three-common-types-of-flood

[6] U.S. Global Change Research Program, "National Climate Assessment: Floods," 2020, Accessed Here: https://nca2014.globalchange.gov/highlights/report-findings/extreme-weather/content/floods

[7] U.S. FEMA, "Hazard Identification and Risk Assessment," February 5, 2020, Accessed Here: https://www.fema.gov/hazard-identification-and-risk-assessment

floodplains.[8] Climate change is expected to increase the frequency and intensity of flooding events in the U.S. by changing the factors that contribute to floods.[9] These factors include: heavy precipitation events that are projected to increase;[10] warmer temperatures that are leading to earlier and faster snowmelt in the western U.S.;[11] strong hurricanes that are becoming more frequent causing more storm surge;[12] and rising sea levels.[13]

By the end of the century, our nation's floodplains – land areas adjacent to rivers and streams that are subject to recurring inundation – are expected to grow by approximately 45 percent.[14]

National Flood Insurance Program

The primary federal policy used to manage flood risk in the United States is the National Flood Insurance Program (NFIP) administered by the Federal Emergency Management Agency (FEMA), through the Federal Insurance and Mitigation Administration (FIMA).[15] The NFIP was created under the National Flood Insurance Act of 1968,[16] and was most recently reauthorized by Congress on December 20, 2019.[17]

Communities that choose to participate in NFIP must adopt in their state or local governments' minimum land management standards with enforcement mechanisms and must regulate development in the floodplain. Communities may choose to adopt more stringent standards than required by NFIP if they wish.[18] Currently, over 22,000 communities in 56 states and jurisdictions participate in the NFIP.[19]

In addition to the NFIP providing access to federally-backed flood insurance, it also has a mandate to mitigate the nation's flood risk through floodplain management.[20] The NFIP maps flood hazards, releases flood maps to the public, requires local land-use and building code standards, offers funding mechanisms to rebuild after floods, and provides grants and incentives for property owners and localities to invest in risk reduction measures.[21]

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[8] Ibid. at 1
[9] Intergovernmental Panel on Climate Change, "Special Report: Global Warming of 1.5 °C, Summary For Policymakers," 2018 Accessed Here: https://www.ipcc.ch/sr15/chapter/spm/
[10] U.S. Global Change Research Program, "Climate Science Special Report, Chapter 8: Droughts, Floods, and Wildfire," 2017 Accessed Here: "https://science2017.globalchange.gov/chapter/8/
[11] U.S. Global Change Research Program, "Fourth National Climate Assessment, Chapter 24: Northwest," 2017, Accessed Here: https://nca2018.globalchange.gov/chapter/24/
[12] Intergovernmental Panel on Climate Change, "Chapter 3: Changes in Climate Extremes and their Impacts on the Natural Physical Environment," 2017, Accessed Here: https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap3_FINAL-1.pdf
[13] U.S. Global Change Research Program, "Climate Science Special Report, Chapter 12: Sea Level Rise," 2017, Accessed Here: https://science2017.globalchange.gov/chapter/12/
[14] AECOM, "The Impact of Climate Change and Population Growth on the National Flood Insurance Program Through 2100," June 2013, Accessed here: https://www.aecom.com/fema-climate-change-report/
[15] Congressional Research Services, "*A Brief Introduction to the National Flood Insurance Program,*" Accessed: 2019
[16] 42 U.S.C. 4001 et se
[17] U.S. FEMA, "National Flood Insurance Program: Reauthorization," December 23, 2019, Accessed Here: https://www.fema.gov/national-flood-insurance-program/national-flood-insurance-program-reauthorization-guidance
[18] FEMA operates a program called the Community Rating System, which provides discounts for some flood insurance policies in communities that adopt stricter standards and risk reduction measures.
[19] U.S. FEMA, "Policies in Force By Month," December 19, 2019, Accessed Here: https://www.fema.gov/policies-force-month
[20] Ibid. at 1
[21] FEMA administers three hazard mitigation programs, the Hazard Mitigation Grant Program (HMGP), the Pre-Disaster Mitigation (PDM) Grant Program, and the Flood Mitigation Assistance Grant Program (FMA). See CRS Report IN11187, "Federal Emergency Management Agency (FEMA) Hazard Mitigation Assistance" for information on each.

NFIP is funded primarily through the premiums, fees, and surcharges paid by policyholders, but it also receives direct annual appropriations for the mapping and risk analysis program only – primarily, the development of Flood Insurance Rate Maps (FIRMs). To date, NFIP has invested $6.6 billion ($10.6 billion in 2019 dollars) in flood hazard mapping.[22]

FEMA Flood Insurance Rate Maps (FIRMs)

Communities that have opted into the NFIP must work with FEMA to create Flood Insurance Rate Maps (FIRMs). The FIRMs serve as a regulatory tool, showing a picture of risk that is used to determine which properties are required to purchase flood insurance, as well as the areas required to adopt flood management standards. This creates incentives for communities to minimize the depiction of risk on the FIRMs, in order to lessen their constituents' flood insurance rates and mitigation costs.

The NFIP is required to identify on the FIRMs the Special Flood Hazard Area (SFHA), the area with 1% or greater risk of flooding each year, also known as the 100-year flood zone. In a community that has opted into the NFIP, property owners within the SFHA are required to purchase flood insurance as a condition of receiving a federally backed mortgage. These property owners within the SFHA may purchase the Standard Flood Insurance Policy of the NFIP or private flood insurance, if the coverage of the private flood policy is at least as broad as the NFIP.[23] Communities within the SFHA that have opted into the NFIP must enact minimum standards for development on the floodplain.[24]

Since its inception, the mapping practice for NFIP has been to apply historical climate information to existing topography and development conditions; therefore, current FIRMs do not reflect future flood hazards based on future climate and sea level. The Technical Mapping Advisory Council (TMAC) is a federal advisory committee created in the *Biggert-Waters Flood Insurance Reform Act of 2012* to provide recommendations to FEMA on NFIP. In 2015, the TMAC submitted a report to FEMA on "Future Conditions Risk Assessment and Modeling," which recommends that all future conditions flood risk (i.e. long term erosion and sea level rise) information and maps be advisory (non-regulatory) at the NFIP administration level but that communities should be allowed to adopt future conditions for local regulatory and decision-making purposes.[25] In spite of TMAC's recommendations, FEMA FIRMs only look at current risk.

In addition to FIRMs, other regulatory flood products FEMA provides include Flood Insurance Studies (FIS), Flood Boundary and Floodway Maps, Letters of Map Change, and GIS databases.

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[22] Association of State Floodplain Managers, Inc. (ASFPM), "Flood Mapping for the Nation: A Cost Analysis for Completing and Maintaining the Nation's NFIP Flood Map Inventory,: January 2020, Accessed Here: https://asfpm-library.s3-us-west-2.amazonaws.com/FSC/MapNation/ASFPM_MaptheNation_Report_2020.pdf

[23] Requirements for private insurers are defined further at 42 U.S.C. §4012a(b)(7). See Congressional Research Service, "Private Flood Insurance and the National Flood Insurance Program (NFIP)," December 30, 2019, Accessed Here: https://crsreports.congress.gov/product/pdf/IN/IN10450.

[24] U.S. FEMA, "FEMA Flood Map Service Center: Welcome!," Accessed Here: https://msc.fema.gov/portal/home

[25] Ibid. at 1

FEMA also provides non-regulatory flood products, including Flood Risk Products (FRP), and Hazus.[26]

FEMA Flood Mapping Process

FIRMs are developed under FEMA's Risk Mapping, Assessment and Planning (Risk MAP) process. The regulatory, as well as scientific, nature of the Risk MAP process means that the FIRMs do not always represent the best-available science of risk for an area. There is no standard, reliable schedule for when a community can update its map through the Risk MAP process.

The official FIRMs in place across the United States, and even in close-by communities, are not uniform in when they were last mapped and in scientific accuracy. In general, FEMA issues and revises flood maps in clusters of municipalities within a single county. FEMA prioritizes "remapping" according to population growth, development factors, better science, and changing environmental conditions.[27] Users can see the status of a property under NFIP, as well as all FIRMs, at a FEMA website called the Flood Map Service Center, where it is possible to search the address of any commercial or residential property.

The Risk MAP process is determined by requirements in statute. FEMA does not itself conduct the mapping exercise. Rather, it relies on private sector engineering companies ("mapping partners") to conduct the data collection and technical flood studies that inform the maps.[28,29] FEMA is required to communicate closely with the community, incorporate waiting periods between steps, and collect data from communities. The map process can become a negotiation process between FEMA and local entities over the data; communities with the resources to hire their own firms collect their own data. There is an appeals process for the maps for community members who present conflicting scientific information, and an option to appeal to an independent panel of experts known as a Scientific Resolution Panel.[30] The current FIRM process follows practices that were in place when the NFIP was established and have not changed substantially since the 1970s.[31] As of October 2019, it takes FEMA 3-5 years on average to update a community's flood map.[32]

In general, the current FIRM process, and subsequent rating system, combines two sources of flood risk: fluvial (river) flooding and coastal flooding – to establish a base flood elevation, or

[26] U.S. FEMA, "FEMA Flood Map Service Center: Products and Tools Overview," February 2020, Accessed Here: https://msc.fema.gov/portal/resources/productsandtools
[27] FEMA uses a process called the Coordinated Needs Management Strategy to prioritize and track the need to update FIRMs through RiskMAP. (FEMA, https://www.fema.gov/coordinated-needs-management-strategy)
[28] Office of Inspector General, "FEMA Needs to Improve Management of Its Flood Mapping Programs," September 27, 2017, Accessed Here: https://www.oig.dhs.gov/sites/default/files/assets/2017/OIG-17-110-Sep17.pdf
[29] U.S. FEMA, "Cooperating Technical Partners Programs," September 24, 2019, Accessed Here: https://www.fema.gov/cooperating-technical-partners-program
[30] The SRP was authorized in the Biggert-Waters Reauthorization Act of 2012. https://www.floodsrp.org/
[31] Congressional Research Service, "National Flood Insurance Program: The Current Rating Structure and Risk Rating 2.0," November 7, 2019, Accessed Here: https://fas.org/sgp/crs//homesec/R45999.pdf
[32] U.S. FEMA, "Technical Mapping Advisory Council Annual Report," December 2015, Accessed Here: https://www.fema.gov/media-library-data/1454954097105-a94df962a0cce0eef5f84c0e2c814a1f/TMAC_2015_Annual_Report.pdf

BFE.[33] The BFE is the elevation (in feet) to which flood waters are anticipated to rise during the 1% annual chance flood event. FEMA's contractors project fluvial and coastal flooding by evaluating hydraulic and hydrology (H&H) factors.

FEMA then combines the flood zones established in the FIRMs with other information about the properties themselves and other flood protection measures in the area (such as levees) to develop a picture of risk and in turn, establish premiums.

While the National Flood Insurance Reform Act of 1994 requires that FEMA assess the need to revise and update the flood maps every 5 years,[34] 75% of FEMA flood maps are older than 5 years and 11% have not been updated since the 1970s or 1980s.[35] In 2017, the Department of Homeland Security's Inspector General's Office reported that only 42% of FEMA's flood maps currently reflected accurate flood risk projections, in spite of the program's goal of 80%.[36] Furthermore, to date, FEMA has mapped 1.2 million miles of rivers and coastline, out of 3.5 million miles total, meaning only 33% of the rivers and streams in the U.S. have flood hazard information available.[37]

FEMA's Plan to Improve Flood Risk Assessment: Risk Rating 2.0

FEMA announced it would be replacing the current risk rating system with a new rating plan, called Risk Rating 2.0 that pairs state-of-the-art industry catastrophe (CAT) models with the NFIP's mapping data in order to provide a more comprehensive understanding of flood risk. Risk Rating 2.0 will be the first time the current rating methodology will undergo a significant change since it was first developed in the 1970s. FEMA's website also says it will use data from other federal agencies (USGS publicly available data; NOAA Sea, Lake, and Overhead Surges from Hurricanes (SLOSH) data; and USACE data sets) and third-party sources (commercially available structural and replacement cost data).[38]

While little information has been reported on Risk Rating 2.0, FEMA's website says that "Risk Rating 2.0 will incorporate a broader range of flood frequencies," instead of relying on the 1-percent-annual-chance-event. It remains to be seen how much Risk Rating 2.0 will take into consideration future conditions.

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[33] Ibid. at 31
[34] U.S. FEMA, "National Flood Insurance Reform Act of 1994," September 16, 2009, Accessed Here: https://www.fema.gov/media-library/assets/documents/7281
[35] U.S. FEMA, "National Flood Insurance Program Community Status Book," September 24, 2019, Accessed Here: https://www.fema.gov/national-flood-insurance-program-community-status-book
[36] Office of Inspector General, "FEMA Needs to Improve Management of Its Flood Mapping Programs," September 27, 2017, Accessed Here: https://assets.documentcloud.org/documents/4066233/OIG-17-110-Sep17.pdf
[37] Association of State Floodplain Managers, Inc. (ASFPM), "Flood Mapping for the Nation: A Cost Analysis for Completing and Maintaining the Nation's NFIP Flood Map Inventory" January 2020, Accessed Here: https://asfpm-library.s3-us-west-2.amazonaws.com/FSC/MapNation/ASFPM_MaptheNation_Report_2020.pdf
[38] U.S. FEMA, "NFIP Transformation and Risk Rating 2.0," November 15, 2019, Accessed Here: https://www.fema.gov/nfiptransformation

FEMA deferred implementation by one year to October 1, 2021 in order to "conduct a comprehensive analysis of the proposed rating structure so as to protect policyholders and minimize any unintentional negative effects of the transition."

NOAA's Role in Characterizing Flood Risk

As a science agency, the National Oceanic and Atmospheric Administration (NOAA) has no regulatory flood mapping products, unlike FEMA. Instead, it has informational products and forecasts that provide data on flooding across weather and climate timescales. In 2016, NOAA developed the NOAA Water Initiative,[39] which outlines a vision and five-year plan to provide integrated, high-resolution, water information products to help inform community water management decisions, including the efforts below.[40]

Office of Water Prediction and the National Water Center

The Office of Water Prediction (OWP) within the National Weather Service (NWS) works to support, develop, and disseminate information about water resources through monitoring, prediction, and analysis.[41] This information includes hydrologic analyses, forecasts, data, guidance, and decision support for emergency management, NWS's 122 Weather Forecasting Offices, and water resource managers across all relevant timescales.[42] OWP operates water forecast modeling and data assimilation systems in collaboration with the NWS, other federal agencies, academia, and stakeholders.[43] OWP also transitions key water resources research, whether inside or outside NOAA, to operations.[44]

Built in 2015, the National Water Center, located in Tuscaloosa, Alabama, serves as a base for the Integrated Water Resources Science and Services (IWRSS) partnership between NOAA, the U.S. Geological Survey (USGS), FEMA, and the U.S. Army Corps of Engineers (USACE). This partnership works to leverage the mission and resources of each agency, as well as academia, to improve and modernize water information and forecasts.[45]

Since 2016, the National Water Center provides water information data and products from the National Water Model (NWM).[46] The NWM provides high-resolution, street-level, forecasts of soil moisture, surface runoff, snow water equivalent and other parameters. The NWM provides

[39] National Oceanic and Atmospheric Administration, "NOAA Water Initiative: Vision and Five-Year Plan," December 2016, Accessed Here: https://www.noaa.gov/sites/default/files/atoms/files/NOAA_Water_Initiative%20Plan-final-12202016.pdf
[40] National Oceanic and Atmospheric Administration, U.S. Climate Resilience Toolkit, "National Water Model," August 2, 2019, Accessed Here: https://toolkit.climate.gov/tool/national-water-model#:~:targetText=NOAA%20is%20seeking%20to%20establish,respond%20to%20extreme%20water%20events.
[41] National Oceanic and Atmospheric Administration, "Office of Water Prediction Organization ," 2020, Accessed Here: https://www.weather.gov/organization/owp
[42] National Oceanic and Atmospheric Administration, "Office of Water Prediction," 2020, Accessed Here: https://water.noaa.gov/
[43] Ibid at 1
[44] Ibid.
[45] University Corporation for Atmospheric Research (UCAR), Cooperative Programs for the Advancement of Earth System Sciences (CPAESS), "NOAA Office of Water Prediction Overview," 2020, Accessed Here: https://cpaess.ucar.edu/nwc
[46] National Oceanic and Atmospheric Administration, "The National Water Model," 2020, Accessed Here: https://water.noaa.gov/about/nwm

water flow forecasts for 2.7 million river locations, utilizing both USGS stream gauges and atmospheric modeling.[47]

National Hurricane Center National Storm Surge Hazard Maps

Predictions of rainfall and storm surge are crucial to hurricane forecasts; flooding causes the majority of deaths from hurricanes. To supplement traditional hurricane forecasts, NWS created a Storm Surge Unit within the National Hurricane Center (NHC), which provides storm surge forecasts using the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model.[48] NOAA's storm surge modeling is a key input to FEMA flood mapping efforts.[49] The NHC also issues National Storm Surge Hazard Maps, which depict areas of the U.S. that are vulnerable to storm surge during hurricane.[50]

NOAA Digital Coast Platform and USGS Flood Inundation Maps Library

The Office for Coastal Management (OCM), part of NOAA's National Ocean Service, oversees the state and local implementation of coastal management programs mandated under federal statutes, providing technical assistance and other guidance.[51] Digital Coast is a web platform that provides coastal intelligence through visualization tools, predictive tools, trainings,[52] and data sets from satellite to lidar to economic data.[53] Digital Coast aims to help the coastal management community stay informed and make better decisions.[54] Its nearly 70 tools include the Sea Level Rise Viewer, FUSION lidar data sets, Surging Seas sea level rise and storm surge visualization, and Coastal Flood Exposure Mapper.[55]

Digital Coast also links to the USGS Flooding Inundation Maps Library, created through a partnership between USGS, NOAA OCM, NOAA NWS, USACE, and FEMA. This program provides technical assistance to communities to help them develop and validate maps. It also provides public access to the maps and real-time data, forecasts, and predicted costs.[56]

The U.S. Interagency Elevation Inventory and 3DEP

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[47] National Oceanic and Atmospheric Administration, "Weather-Ready Nation (WRN), The National Water Model," August 2016, Accessed Here: https://water.noaa.gov/documents/wrn-national-water-model.pdf
[48] National Hurricane Center, "Storm Surge Unit," 2020, Accessed Here: https://www.nhc.noaa.gov/surge/ssu.php
[49] U.S. FEMA, "Guidance for Flood Risk Analysis and Mapping: Coastal Water Levels," May 2016, Accessed Here: https://www.fema.gov/media-library-data/1472001436394-84b6440ba15f6af5723869b3443f89c4/Coastal_Water_Levels_Guidance_May_2016.pdf
[50] National Hurricane Center, "National Storm Surge Hazard Maps-Version 2," November 2018, Accessed Here: https://www.nhc.noaa.gov/nationalsurge/
[51] National Oceanic and Atmospheric Administration, Office for Coastal Management, "Protecting Coastal Communities," 2020 Accessed Here: https://coast.noaa.gov/
[52] National Oceanic and Atmospheric Administration, Office for Coastal Management, "Digital Coast Academy Training," 2020, Accessed Here: https://coast.noaa.gov/digitalcoast/training/home.html
[53] National Oceanic and Atmospheric Administration, Office for Coastal Management, "Digital Coast Data," 2020, Accessed Here: https://coast.noaa.gov/digitalcoast/data/home.html
[54] National Oceanic and Atmospheric Administration, Office for Coastal Management, "Strategic Plan for the Digital Coast 2016 to 2021," 2016, Accessed Here: https://coast.noaa.gov/data/digitalcoast/pdf/digitalcoast-strategic-plan.pdf
[55] National Oceanic and Atmospheric Administration, Office for Coastal Management, "Digital Coast Tools," 2020, Accessed Here: https://coast.noaa.gov/digitalcoast/tools/
[56] National Oceanic and Atmospheric Administration, U.S. Climate Resilience Toolkit "Flood Inundation Mapper," August 2, 2019, Accessed Here: https://toolkit.climate.gov/tool/flood-inundation-mapper

Elevation data from LIDAR (Light Detection and Ranging), a remote sensing method, is crucial to flood mapping efforts; the way the surface of the earth changes greatly impacts inundation and storm surge patterns. The U.S. Interagency Elevation Inventory is a federal, nationwide listing of topographic and bathymetric data. It is a collaboration between USGS, NOAA, FEMA, U.S. Department of Agriculture (USDA), and USACE, and supports the 3D Elevation Program (3DEP) and NOAA's Integrated Ocean and Coastal Mapping effort.[57]

3DEP is managed by USGS to provide three-dimensional representations of elevation data; a key input to FEMA flood maps. It is a partnership between USGS and many federal agencies including NOAA, FEMA, EPA, and the Bureau of Land Management (BLM). Its goal is to acquire nationwide LIDAR by 2023, a challenge both in cost and data management.[58]

[57] United States Geological Survey, "3D Elevation Program (3DEP)," September 9, 2019, Accessed Here: https://www.usgs.gov/core-science-systems/ngp/3dep/collaboration-and-partnerships
[58] United States Geological Survey, "What is 3D Elevation Program (3DEP)," Accessed Here: https://www.usgs.gov/core-science-systems/ngp/3dep/what-is-3dep

Chairwoman SHERRILL. This hearing will come to order. Without objection, the Chair is authorized to declare recess at any time. Good afternoon, and welcome to the Environment Subcommittee's first hearing of 2020. This is my first hearing since taking over the Subcommittee Chairmanship from my colleague and friend Mrs. Fletcher. I'm looking forward to continuing the bipartisan work of this Subcommittee with Ranking Member Marshall on issues related to the environment, climate change, and weather research, issues that are critical to New Jersey, and to the country. This is also a joint Subcommittee hearing with the Investigations and Oversight Subcommittee, and I'd like to welcome my fellow Chair, Dr. Foster, and Ranking Member, Mr. Norman. I assume they will be here shortly.

The focus of today's hearing is painfully salient in New Jersey, a historically flood-prone State. New Jersey is a place where both coastal and inland communities have unfortunately had to deal with extensive flooding events, and, as a result, actively invest in understanding and mitigating these flood risks. In my district, towns such as Pequannock, Little Falls, Woodland Park, Pompton Lakes, and Wayne, that experience some of the most extreme flooding, work hard to protect their residents with measures like home buyouts, elevations, dredging waterways, and even flying drones to proactively identify flood hazards in rivers. They appreciate that the National Flood Insurance Program (NFIP) is a critical part of providing this protection to communities, and are committed to partner with you to get the science underlying the FEMA (Federal Emergency Management Agency) flood mapping process right.

Assessments of flood risks today must consider that climate change is accelerating rates of sea level rise, intense heavy rains, and other extreme weather events, creating flooding patterns distinct and more damaging than norms of the past. And it's not just New Jersey and coastal communities, as Ranking Member Marshall knows too well. Inland States faced billions of dollars of damage from extreme wet conditions consistent with climate change last year, with a similar forecast just released by the National Oceanic and Atmospheric Administration (NOAA) for the coming year for the Mississippi River and Great Plains Basin.

The FEMA flood maps are intended to determine insurance rates for 1 year ahead, and set building standards for the floodplain. Despite this intention, the reality is that homeowners and local governments continue to use the maps to make both short and long term decisions like buying a home, choosing a mortgage, and planning adaption measures to deal with future flooding events. Given the public need, we must ensure that the most up-to-date science of predicting flood risk is accessible in a centralized, accurate, and easy to understand way. While we are primarily focused today on supporting inter-agency efforts in Federal flood mapping, I also want to emphasize the importance of incorporating on the ground community feedback into the FEMA flood mapping process.

My understanding from local officials and constituents in my district is that providing such input can be onerous, expensive, and frustrating. We have, for example, a case in Pequannock where scientific models adopted by an approved FEMA cooperating technical partner in New Jersey had not been admitted into a remapping ap-

peals process, and instances of delays and resolutions that put homeowners and our communities in a flood map limbo, affecting their ability to sell homes, make improvements to their property, and move forward on important municipal planning decisions.

I believe this local expertise is critical to getting the science of our flood maps right, and want to understand how we can best support FEMA's efforts to partner with communities not only in New Jersey, but across the country to incorporate local scientific expertise efficiently, and in a common sense way. In this hearing I hope we can have a constructive conversation about how agencies can leverage their unique capabilities and local information to improve the science and communication around flood risk. While FEMA is the expert in administering disaster aid, and mitigating risk on the floodplain, science agencies like NOAA are hard at work collecting data on flood prone environments, developing state-of-the-art models, and generating forecasts, maps, and other communications. I hope that we can find inter-agency synergies that improve the science and get it out there into communities, where it is sorely needed.

And science is only one part of the solution, as the other communities of jurisdiction working hard on flood mitigation know well. In fact, this morning I submitted a statement for the record to the Transportation and Infrastructure Committee for their Member Day Hearing outlining my district's priorities related to the development of the *Water Resources Development Act*, or WRDA, which included the need to address flood risk. I am pleased to welcome our distinguished panel to today's hearing. They will provide the perspective of both the Federal Government and on-the-ground experts.

[The prepared statement of Chairwoman Sherrill follows:]

Good afternoon, and welcome to the Environment Subcommittee's first hearing of 2020. This is my first hearing since taking over the Subcommittee Chairmanship from my colleague and friend, Ms. Fletcher. I am looking forward to continuing the bipartisan work of this Subcommittee with Ranking Member Marshall on issues related to the environment, climate change, and weather research; issues that are critical to New Jersey, and to the country. This is also a joint Subcommittee hearing with the Investigations & Oversight Subcommittee, and I would like to welcome my fellow Chair Dr. Foster and Ranking Member Mr. Norman.

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I am pleased to welcome our distinguished panel to today's hearing. They will provide the perspective of both the federal government and on-the-ground experts.

Chairwoman SHERRILL. The Chair now recognizes Dr. Marshall for an opening statement.

Mr. MARSHALL. All right. Thank you so much for holding this joint Subcommittee hearing, Chairwoman Sherrill and Chairman Foster. As you said earlier, this is the first time the Environment Subcommittee has convened since you were appointed, Chairwoman, so let me welcome you as well to the Subcommittee, and I look forward to working with you as well.

I want to express my appreciation for this Committee's focus on improving our preparedness in a changing climate. We have held hearings of all kinds of extreme weather. From windstorms, to hurricanes, to weather prediction models, policy that helps protect lives and property is a responsibility that should be at the top of every Member of Congress's priority list. Today's hearing is another chance to discuss a type of extreme weather event, and how we are preparing to lessen the damage and effects it causes. Flood events occur in every State and territory, and cause an average of 80 deaths per year. It's easy to see how coastal areas, like Florida or New Jersey, are susceptible, but these events also have a great impact on agriculture, food, supply, and crop insurance for inland States like Kansas.

In 2019 Kansas saw one of the worst years of extensive flooding, with at least $15 million of infrastructure damage, and $3.8 million in Federal flood insurance claims. It's impossible to gauge just how much damage this has caused on topsoil loss, land realignment, and other factors that affect the day to day life of the agriculture community. What we do know is that 13 dams were damaged, and

well systems were overwhelmed so much that trucks are still delivering up to 40,000 gallons of clean water every day to Northeast Kansas. But as the saying goes, from challenges come opportunity.

The Kansas Department of Agriculture, already underway with a project to map the State's floodplains with 2D technology, has used the 2019 floods as a way of validating their models, and getting trust among communities. They have also spread more awareness of the State's Base Flood Elevation (BFE) Portal, a collaborative project that allows users to draw a polygon for their property, and see BFE value, as well as the approximate lowest adjacent grade value-based on LIDAR (Light Detection and Ranging). This type of tool is extremely helpful because it gives property owners an idea of their chances to obtain a Letter of Map Revision before they spend money on a surveyor.

I look forward to hearing Mr. Ryan Branfort's testimony on how similar technologies and services, along with geospatial data, can help improve the flood mapping of FEMA and other Federal agencies. I also look forward to hearing from all our witnesses on the progress of the USGS (United States Geological Survey) 3D Elevation Program, or 3DEP, as it moves forward with the goal of completing a nationwide LIDAR mapping by 2023. 67 percent of the Nation has been completed, and more than 600 different applications will benefit from this enhanced elevation data, including flood risk management and precision agriculture. And now I'd like to enter this document into the record showing organizations that support 3DEP.

Chairwoman SHERRILL. Without objection.

Mr. MARSHALL. The idea that a Federal program can satisfy multiple needs and be used in so many different ways is what every program should strive to achieve. If we are going to spend millions of taxpayer dollars in a multi-year coordinated effort, I hope the final result is not a simple one trick pony. I want to again thank our witnesses for being here, and I look forward to hearing your testimony. Thank you, Madam Chair, and I yield back the balance of my time.

[The prepared statement of Mr. Marshall follows:]

Thank you for holding this joint Subcommittee hearing, Chairwoman Sherrill and Chairman Foster. I believe this is the first time the Environment Subcommittee has convened since you were appointed Chairwoman, so welcome to the subcommittee and I look forward to working with you.

I want to express my appreciation for this Committee's focus on improving our preparedness in a changing climate. We have held hearings on all kinds of extreme weather—from windstorms to hurricanes to weather prediction models. Policy that helps protect lives and property is a responsibility that should be at the top of every Member of Congress' priority list.

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They have also spread more awareness of the state's Base Flood Elevation Portal, a collaborative project that allows users to draw a polygon for their property and see BFE value, as well as the approximate lowest adjacent grade value based on LiDAR.

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The idea that a federal program can satisfy multiple needs and be used in so many different ways is what every program should strive to achieve. If we are going to spend millions of taxpayer dollars in a multi-year coordinated effort, I hope the final result is not a simple one trick pony.

I want to again thank our witnesses for being here and I look forward to hearing your testimony. Thank you Madam Chair and I yield back the balance of my time.

Chairwoman SHERRILL. Thank you. The Chair now recognizes the Chair of the Subcommittee on Investigations and Oversight, Dr. Foster, for an opening statement.

Mr. FOSTER. Thank you, Chairwoman Sherrill. The nuts and bolts of the National Flood Insurance Program are something that we've spent countless hours on in the Financial Services Committee, the other hat I wear around here. You know, there are a lot of factors that go into the insurance side of the program that we won't get into today, but I'm very glad that the Science Committee is taking a look at the whole Federal enterprise of flood prediction and decision support tools. This is one of those policy topics where the scientific inputs and outputs have a direct impact on the daily lives of millions of Americans. If we don't prioritize accuracy, precision, and granularity in the mapping and forecasting of flood hazards, and make the investments necessary to get the data to make those predictions accurate, then insurance requirements that we apply on American businesses and homeowners will never be fair.

And the changing climate adds an uncontrollable variable into the quest for quality maps. The *National Flood Insurance Act* became law in 1968. Back then, anthropogenic climate change was not really a part of the public discourse, and Federal policymakers saw the global climate as static. It made sense to create a program that would evaluate risk and designate premiums on a, you know, simple 1-year annual outlook because it was believed that the climate in 2020 would look more or less like that of 1968. But now we know better. Global concentrations of carbon dioxide in the air have risen from 320 to 400—to over 400 parts per million. And setting aside the influence of methane and the other greenhouse gases, which are roughly 30 percent of the other heat-trapping gases in the atmosphere—yields a situation where global tempera-

tures have already gone up about 1.4 degrees Fahrenheit since 1968. And the incidence of—and severity of flooding has increased as a result, and by no means are flood risks limited to coastal zones.

Extreme rainfall events are driving record river overflows and urban flooding throughout the Midwest. Last May Illinois Governor Pritzker had to activate the Illinois National Guard to address the historic flood conditions. Illinois farmers saw so much hardship that, as a result, the USDA (United States Department of Agriculture) issued an agricultural disaster declaration. And it's not just homes, businesses, and farms that are being affected. Last week I visited Strategic Air Command and Offutt Air Force Base, which flooded badly last spring, and the cleanup there is estimated to cost almost $1 billion dollars.

We can't ignore the fact that climate change is here today. It's affecting our homes and our livelihoods, and the Federal Government needs to deploy new tools to address it. So I look forward to the hearing today about the opportunities to use the most advanced technologies and models to evaluate present day flood risk so we get an answer that's more accurate and more detailed than the status quo. You know, there are advancements in LIDAR, lower cost flood sensors, drones, artificial intelligence, algorithms can all help FEMA—make the FEMA map more accurate, and perhaps lower the cost of producing it. Perhaps there are also ways to leverage new applications for flood evaluation and prediction using the existing network of earth monitoring satellites and supercomputers, such as Aurora, which is being built in my district at Argonne National Lab.

The hydrology and climate data products put out by Mr. Osler's team at NOAA are first-rate, but maybe there are more effective ways to leverage those and improve those resources. Yes, there'll be tough questions anytime FEMA makes changes to their methods that affect the rates that people pay under the National Flood Insurance Program, and we're not going to resolve all those issues today, but I think we can all agree that a sophisticated scientific foundation is the best place to start.

And I also want to thank—to think about the art of the possible for providing forward-looking decision support tools that will help property buyers understand their flood risk over the life of a 30-year mortgage. FEMA's flood maps are an insurance product that aren't really designed to show future conditions. We need to acknowledge that people may be counting on FEMA's maps for things that they weren't meant for. And we need to acknowledge that homebuyers want to make informed decisions about future flood risks when they take on a mortgage, and also that most homebuyers can't afford to pay for a fancy private mapping firm in order to do that.

Thank you to all of our witnesses for making time today, and I look forward to a productive conversation. I yield back.

[The prepared statement of Mr. Foster follows:]

Thank you, Chairwoman Sherrill.

The nuts and bolts of the National Flood Insurance Program are something I've spent a lot of time on in the Financial Services Committee. There are a lot of factors that go into the insurance side of the program that we won't get into today. But I'm glad the Science Committee is taking a look at the whole federal enterprise of

flood prediction and decision support tools. This is one of those policy topics where the scientific inputs have a direct impact on the daily lives of millions of Americans. If we don't prioritize accuracy, precision and granularity in mapping and forecasting flood hazards, the insurance requirements we apply to American businesses and homeowners will never be fair.

And the changing climate throws a curveball into the quest for quality maps. The National Flood Insurance Act became law in 1968. Back then, anthropogenic climate change was not yet a part of the public discourse and federal policymakers saw the global climate as static. It made sense to create a program that would evaluate risk and designate premiums on a simple one-year annual outlook, because it was believed that the climate in 2020 would look more or less like 1968.

But now we know better. Global concentrations of carbon dioxide in the air in 1968 were 320 parts per million. Today we are at 413. Setting aside the influence of methane and other greenhouse gases—that's 30% more heat-trapping gases in the atmosphere. Global average temperatures have gone up by 1.4 degrees Fahrenheit since 1968. The incidence and severity of flooding has increased as a result, and by no means are flood risks limited to coastal zones.

Extreme rainfall events are driving record river overflows and urban flooding in the Midwest. Last May, Governor Pritzker had to activate the Illinois National Guard to address the historic flood conditions. Illinois farmers saw so much hardship as a result that USDA issued an agricultural disaster declaration. My hometown of Naperville saw the DuPage River overflow and swallow parts of the riverwalk. And it's not just homes and businesses that are being affected—just last week I visited Offutt Airforce Base which flooded last spring and the cleanup is estimated cost almost one billion dollars.

We can't ignore the fact that climate change is here today, it is affecting our homes and our livelihoods, and the federal government needs to deploy new tools to address it.

I look forward to hearing today about the opportunities to use more advanced technologies and models to evaluate present-day flood risk that is more accurate and more detailed than the status quo. Advancements in LIDAR, lower cost flood sensors, drones, and artificial intelligence can all help FEMA map more acreage more effectively, and perhaps at a lower cost. Perhaps there are ways to leverage new applications for flood evaluation and prediction using the existing network of earth monitoring satellites and supercomputers like Aurora, which is being built at Argonne National Lab as we speak. The hydrology and climate data products put out by Mr. Osler's team and NOAA are first-rate, and maybe there are more effective ways to leverage those resources. Yes, there will tough questions anytime FEMA makes changes in their methods that affect the rates that people pay under the National Flood Insurance Program. We can't resolve all those issues today, but I think we can all agree that a sophisticated scientific foundation is the best place to start.

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Thank you to our witnesses for making the time today and I look forward to a productive conversation. I yield back.

Chairwoman SHERRILL. Thank you. The Chair now recognizes the Ranking Member for the Subcommittee on Investigations and Oversight, Mr. Norman, for an opening statement.

Mr. NORMAN. I want to thank all the witnesses, thank you, Chairwoman Sherrill and Chairman Foster for having this meeting. This is near and dear to my heart. I'm a real estate developer who has developed property dealing with flood maps residentially, commercially. Also dealt with it on the wetland credits, with regulations that are out of the roof that seven years, generally, to deal with the Corps, which hopefully we can make some suggestions and improvements.

But we're here today to discuss how flooding impacts property owners, and the ways that flood hazards and risks are commu-

nicated to the public, which is a big part of it. We will examine the science and data that FEMA and NOAA leverage to generate and distribute Federal flood products, the steps being taken to incorporate future flood hazards into these products, and the tools and technologies that exist to help property owners, coastal managers, and community stakeholders better understand and evaluate their flood risk.

Flooding is both the most common and most costly natural disaster in the United States. Floods have caused more than $155 billion in property damage over the last 10 years, and nearly 4,000 deaths since 1950. Roughly 75 percent of all Presidential disaster declarations are related in some manner to flooding. In my home State of South Carolina, flooding is an even greater concern. A significant percentage of all South Carolina lands fall within floodplains designated as special flood hazard areas by FEMA. And although it ranks 23rd in total population, South Carolina is ranked seventh among all States in coastal flooding vulnerability, with roughly 400,000 people at risk of inland and coastal flooding throughout our State.

Addressing our Nation's flood risks requires buy-in from Federal, State, local, and community stakeholders, not red tape and useless bureaucracy. Recognizing this, in 2018 Governor McMaster established the South Carolina Floodwater Commission to develop recommendations to alleviate and mitigate flood impacts to the State. Under the leadership of its Chairman, Retired Major General Tom Mullikin, this commission, unique for our State, took a realistic and a hands-on approach to mitigate flooding in our State. The recommendations offered by this extraordinary committee are the cornerstone of my home State's fight against extreme weather events. In recognition of their achievement, I offer to submit their report for the Congressional Record as an example to be admired and followed nationally.

Yet in spite of these valiant efforts I recognize that South Carolina alone cannot solve our Nation's flooding challenges. That's why I'm pleased to see that FEMA, NOAA, and the USGS are making positive strides in confronting this issue. They're working collaboratively to improve our understanding of flood hazards and risks, and how best to communicate these risks to State and local communities, and also the general public, which needs to be informed. I encourage them to continue to improve and expand their interagency coordination to ensure that Federal flood products are accurate, reliable, and comprehensible to the communities, like those in South Carolina, who rely on them for planning, zoning, and land use management.

Preparedness is critical to combatting the challenges that flooding presents, but proper preparation means taking steps now to improve our resilience to flood hazards and mitigate present and future flood risks. I look forward to learning more today about what FEMA and NOAA are doing to improve Federal flood mapping, and how they are leveraging modern technology to gain a more accurate and granular understanding of flood risks and hazards in South Carolina and throughout our Nation.

Flooding events presents a great challenge, but through collaboration and coordination between all levels of government, commu-

nity stakeholders, and private sector experts, it's a challenge that we can overcome, and we can be successful. I again want to thank the witnesses for taking the time to be here today. Thank you, Chairwoman Sherrill, and I yield back

[The prepared statement of Mr. Norman follows:]

Thank you, Chairwoman Sherrill and Chairman Foster, for convening this hearing, and thank you to the witnesses for your testimony this afternoon.

We are here today to discuss how flooding impacts property owners and the ways that flood risks and hazards are communicated to the public. We will examine the science and data that FEMA and NOAA leverage to generate and distribute Federal flood products, the steps being taken to incorporate future flood hazards into these products, and the tools and technologies that exist to help property owners, coastal managers, and community stakeholders better understand and evaluate their flood risk.

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I again want to thank the witnesses for being here today. I look forward to your testimony.

Thank you, Chairwoman Sherrill. I yield back the balance of my time.

Chairwoman SHERRILL. Thank you. We are honored to have the full Committee Chairwoman, Ms. Johnson, here with us today. The Chair now recognizes the Chairwoman for an opening statement.

Chairwoman JOHNSON. Thank you very much, and good afternoon. The FEMA flood mapping process is not a topic this Committee has explored very deeply in the past. Our friends in the Financial Services Committee work hard to look after the authoriza-

tions and policy changes that the program needs, and they stay very busy doing it. But, as with so many Federal programs, there is an opportunity here for the Science, Space, and Technology Committee to make sure innovative technologies and cutting-edge strategies for analysts are being put to work for the good of the taxpayer. When we leverage the best available science, we can help make government programs perform better, deliver services quicker, and save money.

In the case of dealing with flooding, this country may need all the help it can get. By all objective measures, the severity and frequency of flooding is on a significant upward trend. The National Flood Insurance Program reached its maximum authority to borrow money in order to cover ratepayers' claims in September of 2017, and, for the first time, the Treasury canceled a $16 billion debt. This happened in just time—just in time for the Hurricanes Harvey, Irma, and Maria, which delivered unprecedented damages in Texas, Florida and Puerto Rico, as well as several neighboring States. FEMA had to borrow another $6.1 billion in order to address the heavy losses from these disasters. I will note that these communities are still healing from the 2017 hurricane season today. Even the best insurance can't fix the physical and emotional devastation caused by a flood that takes your home or your business.

It is time to think creatively about how to help get better technologies for flood mapping, evaluation, and prediction into the marketplace. FEMA is working on a process called Risk Rating 2.0 that will incorporate new data points, modeling strategies, and enhanced granularity in order to provide a more accurate picture of flood risk. It would be beneficial if the process would also allow FEMA and its contracting partners to update its maps in a more timely fashion. FEMA will need to talk to Congress if it needs support or resources to make Risk Rating 2.0 a success. It's always worth asking the question of what research and development capabilities are available to an agency when it embarks upon an ambitious project like Risk Rating 2.0. I hope that the Science and Technology Directorate at the Department of Homeland Security is playing a role in this process.

The resources we have at other agencies like the National Oceanic and Atmospheric Administration, or NOAA, also need to be deployed to their greatest potential. NOAA's capabilities for Earth observation and predictive modeling along coastlines are unparalleled. NASA (National Aeronautics and Space Administration) Earth Sciences and the U.S. Geological Survey have observational capabilities that we want to make sure are in that mix as well. As climate change continues to move the goalposts for flood risk, we need to make sure that all Federal science agencies are coordinating closely in order to deliver information to taxpayers that can help them make sound decisions and keep themselves and their families safe.

Texas has—had a bad year for flooding in 2017. I know Oklahoma had a tough year with flooding in 2019. Ranking Member Lucas and I both understand that no region in the country is immune to flood risk, and that an ounce of prevention is worth a pound of cure. I look forward to working with the Members of both

sides of the aisle, and with the administration, on strategies to leverage all our scientific capabilities to address the challenges associated with increased flooding.

I want to say as an aside, early last year I had a meeting of my entire COG area, the Council Of Governments area, in North Texas, which is generally thought of as an inland area, which included FEMA and all the other agencies at every level of government, and we all decided we would work together to prevent, because prevention is so much better than having to pay for it afterwards. So I hope we will continue that, and thank you, and I yield back.

[The prepared statement of Chairwoman Johnson follows:]

Good afternoon and thanks to all our witnesses for being here. The FEMA flood mapping process is not a topic this Committee has explored very deeply in the past. Our friends in the Financial Services Committee work hard to look after the authorizations and policy changes that program needs, and they stay very busy doing that.

But as with so many federal programs, there is an opportunity here for the Science, Space, and Technology Committee to make sure innovative technologies and cutting-edge strategies for analysis are being put to work for the good of the taxpayer. When we leverage the best available science, we can help make government programs perform better, deliver services quickly, and save money.

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I yield back

Chairwoman SHERRILL. Thank you, Madam Chair. At this time Dr.—if there are any Members who wish to submit additional opening statements, your statements will be added to the record at this point. And at this time I'd like to introduce our witnesses. First I'll

turn it over to Dr. Marshall, who will introduce his witness, Mr. Branfort.

Mr. MARSHALL. All right. Thank you again, Chairwoman Sherrill. It's an honor and a privilege to welcome a constituent of mine as a witness today. Mr. Ryan Branfort is a Senior Vice President at Wilson and Company, Incorporated, Engineers and Architects, where he manages the Surveying, Mapping, and GIS (Geographic Information System) Division. More importantly, though, he is a Kansas State University graduate.

With a staff of nearly 100 individuals, his division performs work for a variety of Federal, State, municipal, and private entities. He's held nearly every type of position in the Surveying and Mapping Division, including field surveyor, party chief, CAD (Computer Aided Design) technician, GIS specialist, photogrammetrist, that's a new one, and various supervisory positions, giving him a well-rounded background in the field. He's spent the last 15 years as part of the company's executive leadership team, and served six years on Wilson and Company's Board of Directors.

Wilson and Company itself has nearly 500 employees in 15 offices across nine States, but I'd also like to point out that Mr. Branfort is based in the Salina office, which is less than a five minute drive from my district office, so it's nice to have a constituent and a workplace neighbor here in D.C. Thank you, Mr. Branfort, for making the trip up here, and taking the time to testify. With that, I yield back, Madam Chair.

Chairwoman SHERRILL. Thank you, and thank you, Mr. Branfort.

Next we have Mr. Michael Grimm, who serves as the Assistant Administrator for Risk Management at the Federal Insurance and Mitigation Administration within FEMA. Under Mr. Grimm's direction, the Risk Management Directorate produces data, modeling, and programs that inform the public of national disaster risk. The Risk Management Directorate manages the risk mapping, analysis, and planning, a risk map program, within the National Flood Insurance Program, as well as other programs that prioritize Federal investments and resilience projects, and help to implement standards. Mr. Grimm has previously directed both FEMA's disaster mitigation programs and its Individual Assistance Division.

Prior to joining FEMA, Mr. Grimm worked in several other governmental positions, including with the city of Fort Collins, Colorado, the State of Wyoming, and the United States Geological Survey National Research Program. He holds a Master of Science in Earth Resources from Colorado State University. That's a little far afield from my home State of New Jersey, but welcome.

Next we have Mr. Mark Osler, who serves as Senior Advisor for Coastal Inundation and Resilience at the National Oceanic and Atmospheric Administration, NOAA. Mr. Osler works to coordinate and advance coastal flood science at NOAA, and improve decision-makers' ability to prepare for and respond to ongoing changes affecting coastal communities. He also advises NOAA leadership on coastal research, applied science, and policy strategy. He's focused on improving inter-agency coordination and strengthening partnerships with non-Federal organizations. Prior to joining NOAA, Mr. Osler worked in the private sector for 17 years. He received a Mas-

ter's Degree in Coastal Engineering from the University of Delaware, and we're happy to have you here today.

Our final witness is Mr. Chad Berginnis. Mr. Berginnis has served the Executive Director for the Association of State Floodplain Managers (ASFPM) since 2012. Prior to this, he served in several other roles at ASFPM in—and in floodplain management at the State and local level in Ohio. He has also worked in private sector hazard mitigation. In all, he has been working in floodplain management for nearly 30 years. As executive director for AFS—ASFPM, Mr. Berginnis works with Federal agencies and Congress to advocate for policies dealing with flood risk, water management, and natural disaster resilience. He also develops tools for local decisionmakers, and works with professional associations, ASFPM chapters, and private sector partners. Mr. Berginnis holds a Bachelor of Science in Natural Resources from Ohio State University, and is a certified floodplain manager. Thank you all for being here today.

As our witnesses should know, you will each have 5 minutes for your oral testimony. Your written testimony will be included in the record for the hearing. When you all have completed your spoken testimony, we'll begin with questions. Each Member will have 5 minutes to question the panel, and I ask your help in—as you see you're getting closer to your 5 minutes, starting to wrap up your answer so everyone has opportunities. And so we will start today with Mr. Grimm.

TESTIMONY OF MR. MICHAEL GRIMM, ASSISTANT ADMINISTRATOR FOR RISK MANAGEMENT, FEDERAL INSURANCE AND MITIGATION ADMINISTRATION, FEDERAL EMERGENCY MANAGEMENT AGENCY, U.S. DEPARTMENT OF HOMELAND SECURITY

Mr. GRIMM. Good afternoon, Chairman Foster, and Chairwoman Sherrill, Chairwoman Johnson, Ranking Members Norman and Marshall, and Members of the Committee. My name is Michael Grimm, and I'm the Assistant Administrator for Risk Management for the Federal Insurance and Mitigation Administration. Thank you for the opportunity to testify today about the flood insurance rate maps (FIRMs), and the steps FEMA is taking to help communities better understand the hazards posed by catastrophic flooding. As millions of American families have unfortunately experienced firsthand, flooding is the most common and costly natural disaster in the United States. Over the past 10 years, floods alone have caused over $155 billion in property damage. 98 percent of counties have experienced a flooding event.

The most prevalent cartographic tool used to help communities understand their flooding risks are the flood insurance rate maps, or flood maps, and they provide the backbone of effective floodplain management. Flood maps are used for a variety of purposes. While most often associated with determining flood insurance premiums in the National Flood Insurance Program, flood maps also play a fundamental role in establishing land use, zoning, and building standards. Flood maps help communities ensure that development and infrastructure are constructed to protect lives and property.

The local adoption of minimum NFIP standards has resulted in $100 billion in losses avoided over the past 40 years.

Since the inception of the NFIP in 1969, our Nation has invested approximately $10.6 billion in inflation-adjusted dollars for flood mapping. Although the type of data needed to create dependable flood maps has remained relatively consistent over the past 50 years, the tools and technology used to gather and share this information has changed substantially. For instance, paper-based flood maps have become digitally accessible to millions of Americans, and the traditional surveying methodologies have been replaced with more accurate and cost-saving techniques. One example is LIDAR technology, which has allowed FEMA and its partners, such as NOAA, to map flood hazard zones with increased efficiency and accuracy by measuring landscapes with laser-based surveying methodologies from aircraft.

The modernization of techniques has made digital flood maps more adaptable and easier to update. As conditions change, flood maps require maintenance. With current resources, FEMA is able to validate 20 percent of our inventory annually to ensure that maps meet current standards. Working with States and communities, we must prioritize which maps should be updated in accordance with the highest risk or need, and then work with our partners to begin the cyclical process anew.

While maintaining current flood maps is critical, we're still far from completing the initial job of mapping the entire nation. FEMA and State and local partners have historically prioritized limited mapping resources for areas with the greatest population levels and flood insurance policies on the assumption that these places represent the highest risk. While this approach has produced accurate and detailed maps in counties and communities with higher population levels, the unfortunate consequence is that many areas with potential for future development remain unmapped.

Despite the progress we've made in modernizing the flood mapping process, there's still ample opportunity for continuous improvement. One of the most notable opportunities concerns the timeline for production of new flood maps. Although due process and careful deliberation is vital to ensure both the map's accuracy and buy-in of local partners, the extent of procedures necessary to comply with current law can result in a situation in which new maps have technically expired by the time they're approved and publicly available. The development of a new flood map takes 7 years on average to complete. That juxtaposes present statutes, which require FEMA to re-assess flood maps every 5 years in order to qualify as current.

Another data concern often raised regarding current flood maps is lack of consideration about future conditions and sea level rise. These are important factors for a variety of reasons, as exemplified by the acceleration of daily tidal flooding in more than 25 Atlantic and Gulf Coast cities. While maps do not currently reflect the ways in which flood risks may change in the future, FEMA strongly encourages communities to incorporate anticipated future conditions into their projects and planning. For example, FEMA is actively coordinating with New York City through FEMA's Cooperating Technical Partners Program to pilot non-regulatory flood products that

address future flooding scenarios. The intent is to ensure that today's designs address tomorrow's risks by integrating future sea level rise data into building code requirements and floodplain management.

Improving the production of flood maps within the context of changing conditions and expanding nationwide flood insurance coverage is a strategic priority of FEMA. Through an initiative known as the Future of Flood Risk Data, FEMA aims to provide a comprehensive picture of the country's flood hazards through a graduated risk analysis. The more—this more holistic understanding of present and future risk can serve as a basis for a range of both regulatory and non-regulatory products. Presently flood insurance rate maps are a binary representation of a single flood hazard, the 1 percent chance annual flood. As a result, FIRMs can give a false impression to communities outside the of the special flood hazard area that they have little or no flood risk. Graduated risk analysis could more effectively inform decisionmaking and drive action.

FEMA looks forward to closely coordinating with our congressional and Federal partners to improve this process, and thank you for the opportunity to testify and discuss this important aspect of our mission.

[The prepared statement of Mr. Grimm follows:]

TESTIMONY

OF

MICHAEL GRIMM
ASSISTANT ADMINISTRATOR FOR RISK MANAGEMENT
FEDERAL INSURANCE AND MITIGATION ADMINISTRATION
FEDERAL EMERGENCY MANAGEMENT AGENCY
U.S. DEPARTMENT OF HOMELAND SECURITY

BEFORE
THE
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT
SUBCOMMITTEE ON ENVIRONMENT

UNITED STATES HOUSE OF REPRESENTATIVES
WASHINGTON, D.C.

Submitted
By
Federal Emergency Management Agency
500 C Street SW
Washington, D.C. 20472

February 27, 2020

Good morning, Chairman Foster and Chairwoman Sherrill, Ranking Members Norman and Marshall, and Members of the Committee. My name is Michael Grimm, and I am the Assistant Administrator for Risk Management for the Federal Insurance and Mitigation Administration (FIMA). I would like to thank you for the opportunity to discuss how the Federal Emergency Management Agency (FEMA) and the National Flood Insurance Program (NFIP) oversee the National Flood Mapping Program (NFMP) and the production of flood hazard and flood risk information.

Introduction to the National Flood Mapping Program

As millions of American families have unfortunately experienced first-hand, flooding is the most common and costly natural disaster in the United States. Ninety-eight percent of counties across our country have experienced a flooding event, and flood waters continue to pose a greater potential for damage than any other natural disaster. Moreover, in the last decade, floods alone have caused over $155 billion in property damages and they continue to account for the majority of federally declared disasters.

FEMA's mission is helping the American people before, during, and after disasters. One of the most effective and fiscally responsible ways to begin is by building a culture of preparedness before these disasters take place. Developing resilient communities ahead of an incident reduces both the loss of life and economic disruption, and every dollar invested in mitigation is estimated to save the American taxpayer six dollars in future spending.

Considering the frequency and high costs of flooding, a key component of widespread preparedness is to help communities better understand the risks posed by floodwaters and to provide them with the information they need to make informed decisions about prudent land development practices and the adoption of building codes. Working in concert with the tools provided by Congress in the National Flood Mapping Program (NFMP) as part of the Biggert-Waters 2012 Reform Act, FIMA seeks to both educate and incentivize our partners to increase their investments in pre-disaster mitigation. The most utilized regulatory tool to help communities manage their flooding risks is the Flood Insurance Rate Map (FIRM), which I will refer to interchangeably throughout the testimony as FIRMs, flood maps, or just maps.

FIRMs are only as good as the data they are based upon, and FEMA works to ensure the methods employed in developing flood maps are scientifically and technically appropriate. FEMA confirms that flood hazard analysis and mapping standards are updated, published, vetted, and peer-reviewed annually to stay aligned with current best practices. The FIRM is built collaboratively with state, local, tribal and territorial communities, and their partners to ensure local knowledge, areas of concern, and data sources are incorporated. Ultimately NFIP-participating communities create, adopt and own the FIRM and are responsible for working with FEMA to keep them up to date.

What are FIRMs used for?

As the most prevalent type of flood map in the United States, FIRMs are used to determine flood insurance premiums as well as a basis for local floodplain management and development decisions. The maps are useful for flood mitigation planning activities – including the establishment of zoning, land-use, and building standards. Local adoption of minimum standards has resulted in $100 Billion in avoided losses over the last 40 years. Without complete or accurate flood maps, local officials face significant difficulties in guiding development away from the most flood prone areas and ensuring that development is properly built to protect lives and property. Similarly, the information within flood maps also provides significant benefit to the private sector, including mortgage lenders, mortgage insurers, mortgage securities, and real estate investors, mortgage securities, and real estate investors.

With FEMA's assistance, more than 22,000 communities have developed, adopted, and taken ownership of their FIRMs as participants in the NFIP, representing more than 5 million flood insurance policies that provide over $1.3 trillion in coverage. History has demonstrated repeatedly that individuals, communities, and businesses that transfer their flood risk through insurance recover faster and more fully after a disaster. If an individual does not have the full value of their home or belongings within their savings account, insurance will help them to fill that financial void when a disaster occurs. Furthermore, while insurance benefits those directly affected by a disaster, it also reduces the need for federal disaster assistance and lowers the overall costs for American taxpayers. But when direct federal disaster assistance is needed, FIRMs play an essential role beyond preparedness to support FEMA response and recovery, such as when staging disaster operations.

Leveraging Technology and Partnerships to Achieve Efficiencies

Since the inception of the NFIP in 1969, our Nation has invested approximately $10.6 billion in inflation adjusted dollars for flood hazard mapping. These cartographic tools have consistently improved both community planning and the construction of vital infrastructure lifelines such as highways, bridges, and water treatment facilities.

Although the type of data needed to create dependable maps has remained relatively consistent over the last five decades, the tools and technology used to gather or share this information has changed substantially. Within the past 20-years, paper-based flood maps have become digitally accessible to millions of Americans. Traditional surveying methodologies of the 20th century have been replaced with more accurate and cost-saving techniques. For example, the 3-Dimensional Elevation Program (3DEP) managed by the U.S. Geological Survey's (USGS) National Geospatial Program collects Light Detection and Ranging (LiDAR) data, allowing FEMA and its state, local, tribal and territorial partners to map flood hazard zones with increasing accuracy by measuring landscapes with laser-based surveying methodologies from aircraft. Many federal agencies contribute funding for LiDAR data acquisition, including NOAA and FEMA. FEMA has invested over $190 million in LiDAR since FY2014 through the 3DEP program.

FEMA has also collaborated with NOAA to incorporate bathymetry studies of submarine topography which play a critical role in forming a more comprehensive understanding of coastal flooding risks. Both LiDAR and bathymetry data are needed to model complex coastal flooding

scenarios. Furthermore, FEMA also utilizes NOAA/National Weather Service Atlas 14 data for the hydrologic modeling used for riverine flood studies.

Another way in which FEMA has improved the production of flood maps through a Base Level Engineering (BLE) initiative, which uses automated flood modeling of more rural riverine floodplain areas where high quality topographic information exists. Because riverine flood studies represent the single largest cost variable, the use of BLE could become a significant cost savings initiative for the program.

Throughout the process of creating FIRMs, FEMA works closely with state, local, tribal and territorial communities and their partners to ensure local knowledge, areas of concern, and data sources are integrated into mapping studies and flood maps. FEMA encourages community officials to submit scientific or technical data in order to support a local revision to these flood maps to leverage partner contributions to enhance flood mapping projects. As an example, the Cooperating Technical Partners (CTP) Program is one way in which FEMA builds partnerships with participating NFIP communities, regional agencies, state agencies, tribes, and universities that have the interest and capability to become more active participants in the flood hazard mapping program.

Maintaining and Expanding the Nation's Flood Hazard Information

The modernization of flood mapping techniques has made digital mapping more adaptable and easier to update and reflect natural changes to landscapes or improved floodplain management techniques. As conditions change, flood maps require maintenance. It is necessary to consistently work with local community partners and reassess the maps approximately every five years to ensure that individual flood insurance rates are accurate and that NFIP communities are provided with the critical information they need to pursue responsible economic development. With current resources we must prioritize which maps need to be updated in accordance with the highest risks or need, and work with our state, local, tribal and territorial partners to begin the cyclical process anew.

While maintaining current flood maps is critical, we are still far from completing the initial job of mapping the entire Nation. There are many counties and communities throughout the Nation identified as not having flood maps at all. FEMA, in coordination with state, local, tribal and territorial governments, has historically prioritized limited mapping resources for areas with the greatest population levels and flood insurance policies on the assumption that these areas represent the highest risk. While this approach has produced accurate and detailed maps in counties and communities with higher population levels, the unfortunate consequence is that areas of potential future development remain unmapped. Furthermore, there are roughly 3,300 communities with maps that are over 15 years old. This is not to say that each of these older maps have limited utility. While FEMA reassesses FIRMs every five years, the age of a flood map is not the only indicator of the map's usefulness. For areas where natural and man-made features have not changed, the actual risk of a one percent annual chance of flooding may remain consistent over a long timeframe.

Additionally, our understanding of flood risk can change with advances in modeling and technology and as we learn from recent flooding events. FEMA and our partners are looking at ways to better leverage knowledge and technological advancements to drive a more accurate and comprehensive understanding of flood risk across the Nation.

Changing Conditions and Current Data Concerns

Despite the progress we have made in modernizing the flood mapping process, there are still ample opportunities for continuous improvement. One of the most notable opportunities for improvement concerns the timeline of production for new flood maps. Although due process and careful deliberation is vital for ensuring both a map's accuracy and the buy-in of local partners, the extended processes necessary to comply with current regulations can result in a situation in which maps have technically expired by the time they are approved and publicly available. A new flood map requires seven years on average to complete, and that juxtaposes present statutes that mandate FEMA reassessment of flood maps every five years for them to qualify as current.

Another data concern often raised regarding current flood maps is the lack of consideration about future weather patterns and changing coastal conditions. These are important factors for a variety of reasons, as exemplified by the acceleration of daily tidal flooding in more than 25 Atlantic and Gulf Coast cities in addition to communities along the Great Lakes. These trends are expected to continue. Disasters are becoming more costly. Direct average annual flood losses have quadrupled from approximately $4 billion per year in the 1980's to roughly $17 billion per year between 2010 and 2018. With 39 percent of Americans now living in coastal areas, our exposure to costly flood related damages has increased; however, simply increasing distance from large bodies of water is no guarantee of protection from flood damage or changing weather patterns. These trends may also be found far from coastlines and well within the American heartland. For example, historic flooding in 2019 due to pluvial (rain) and fluvial (riverine) changes impacted millions of families across mid-western and southern states.

In 2015, the congressionally established Technical Mapping and Advisory Council (TMAC) provided recommendations through the Future Conditions Risk Assessment and Modeling Report. The TMAC recommended FEMA produce non-regulatory products and information that incorporates future flood hazard conditions. We fully support the TMAC's recommendations, and we are looking for ways to implement them with our federal partners such as the National Oceanic and Atmospheric Administration (NOAA) and USGS.

While FIRMs do not currently reflect the ways in which flood risks may change in the future, FEMA strongly encourages communities to incorporate future conditions and information into its projects and plans. Addressing future risks, such as those posed by extreme weather events, is key to FEMA's mission. Wherever possible, FEMA brings data to bear and work in support of state, local, tribal, and territorial needs and priorities. By addressing future risks, FEMA's partners are best prepared for future extreme weather events and can bounce back faster at the individual and community level.

FEMA has conducted several pilot studies on sea level rise and is working to identify any specific research gaps to inform the design of additional future conditions pilot projects. Presently, FEMA is coordinating with New York City through the CTP Program to pilot non-regulatory flood products that address future flooding scenarios for the boroughs. The intent is to ensure that today's designs address future risks by integrating sea level rise data into building code requirements and for floodplain management. FEMA is also working to identify best practices for developing products and tools useful in communicating risk around future conditions to communities.

Additionally, in 2015, FEMA released the State Mitigation Plan Review Guide that serves as FEMA's official policy on the natural hazard mitigation planning requirements. The guide asks states to consider the probability of future hazard events, including changing future conditions, development patterns, and population demographics. The Guide clarifies that the probability of future hazard events must include considerations of changing future conditions, including the effects of long-term changes in weather patterns and climate on the identified hazards.

Moreover, in 2019, FEMA and its partners introduced a new initiative titled "the National Mitigation Investment Strategy", in close coordination with experts across governmental agencies, academia, and non-governmental organizations. The National Mitigation Investment Strategy represents a robust interagency and cross-government planning effort to develop a single national strategy for advancing hazard mitigation investments to reduce future risks such as those posed by changing coastal patterns and extreme weather events. FEMA will continue to work with its partners across all levels of government to strengthen partnerships and access new sources of scalable capabilities.

The Future of Flood Maps and Flood Risk Data

As stewards of taxpayer dollars, we routinely assess our programs, policies, and actions to ensure we operate effectively and efficiently to meet the needs and interests of our stakeholders while fulfilling our statutory requirements. Improving the production and scope of FIRMs within the context of changing conditions is an important aspect of this strategic priority in order to increase the Nation's understanding of flood risk and the actions that can be taken to reduce it. Through an initiative known as the Future of Flood Risk Data (FFRD), FEMA aims to provide a more comprehensive and dynamic picture of the country's flood hazards that can serve as a basis for a range of outcome-oriented regulatory and non-regulatory products.

To begin, FEMA is exploring ways to provide graduated flood risk analyses a more nuanced set of information that would enhance our understanding of probabilities across a broader range of flood scenarios that is beyond the current practice of binary risk assessment. Presently, FIRMs are primarily representative of a single flood hazard and the one-percent-annual-chance of flooding. As a result, FIRMs may give a false impression to communities outside of the one percent annual chance flood plain that they have little to no flood risk. In just the past 3 years, over 40% of claims have been for properties that are either not mapped or mapped outside of the SFHA. Furthermore, FIRMs do not always account for residual risks posed by areas behind dams or levees, and an improved understanding is needed of the nation's levees. In recent years,

FEMA has been working with the U.S. Army Corps of Engineers (USACE) to improve data in the National Levee Database (NLD), which will ultimately support a graduated approach to levee risk. Graduated risk information could more effectively inform decision-making and drive actions to mitigate flood risk. For example, a better understanding of this graduated risk can support our partners' planning efforts for very high-risk areas such as those affected by regular tidal flooding that cannot be adequately depicted by the current binary representation of the flood hazard.

The transition from binary to graduated risk analysis is key component of FFRD. We also believe the future depends on three other elements: continuing to ensure a significant and appropriate role for the private sector and state, local, tribal, and territorial entities; increasing access to flood hazard data for a range of stakeholders; and modernizing the management and delivery of flood risk data through our IT infrastructure and new technologies.

Conclusion

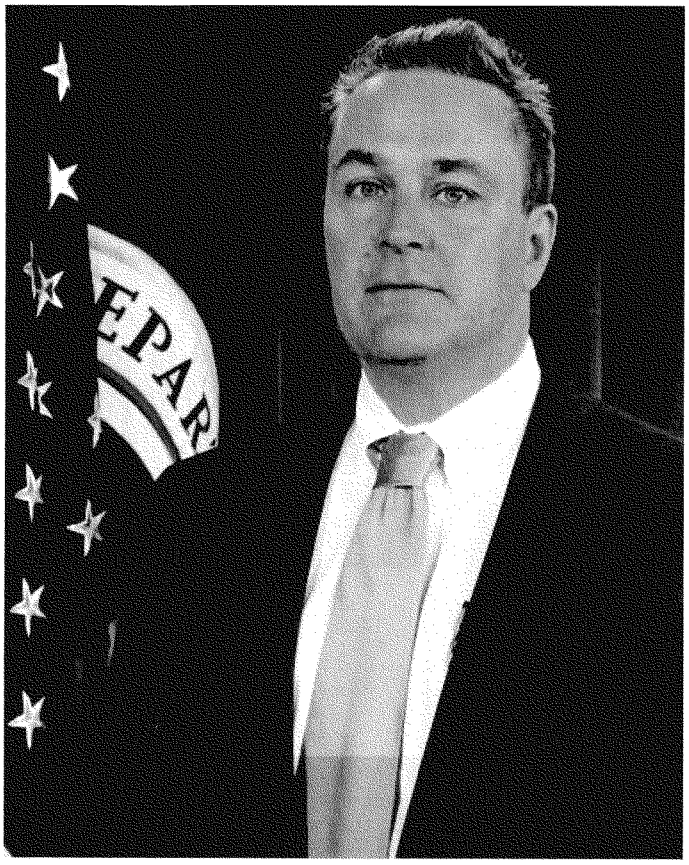
In conclusion, flooding continues to be the most common and costly natural disaster in the United States, with the greatest damage potential of natural hazards worldwide. FIRMs and flood risk information have helped communities, households, and businesses reduce flood risk, support flood risk analysis, expand sound floodplain management practices across the country, and support insurance policies that reduce the financial burden to survivors when floods occur.

Although we remain far from completing the initial job of mapping the Nation, FEMA is continuously exploring how to streamline our mapping efforts and shift from the paradigm of binary risk assessment to delivering a more comprehensive and graduated approach of managing flood risk across a range of probabilities, including future conditions.

The framework for flood mapping as prescribed by the National Flood Mapping Program (NFMP) in the Biggert-Waters 2012 Reform Act recognizes many of these existing needs. While many of the mapping requirements from 2012 are still being addressed, FEMA is exploring ways to leverage new technologies to provide flood information more efficiently, accurately, and consistently across the Nation through the FFRD initiative. In moving towards this future, FEMA must continue to bolster partnerships with other federal agencies whose expertise is essential in building a broader national understanding of flood risk. FEMA must also continue to partner with private sector, and state, local, tribal, and territorial stakeholders. Collectively, these partnerships will ensure that FEMA is leveraging the latest data and technologies and being a good steward of the taxpayer dollar, while better serving the diverse needs of our citizens. Flood risk reduction is most effective when locally implemented, state prioritized, and federally supported. This is exemplified by the $100 Billion in avoided losses associated with local adoption of the minimum flood standards over the past 40 years.

Thank you again for affording me the opportunity to speak with you today about these programs and Flood Insurance Rate Maps. I look forward to answering any questions you may have.

Michael M. Grimm



Mr. Grimm serves as the Federal Emergency Management Agency's Assistant Administrator for Risk Management within the Federal Insurance and Mitigation Administration (FIMA). Throughout his more than 20-year career at FEMA, Mr. Grimm has worked to improve coordination, collaboration, and transparency across the various levels of government, to align the larger national mitigation policy agenda on reducing risk nationally and creating more disaster-resilient communities. Mr. Grimm was appointed to the Senior Executive Service in 2011.

Under Mr. Grimm's direction, the Risk Management Directorate delivers quality risk data, modeling, and programs that increase the public's awareness of risk across the range of natural hazards. Mr. Grimm directs FEMA's Risk Management programs ensuring the Federal Government is a leader in prioritizing federal investments for mitigation and resilience, implementing higher codes and standards for federal action, and assisting communities in reducing disaster costs. These programs include the Risk Mapping, Analysis, and Planning (RiskMAP) Program which includes the Flood Hazard Mapping Program under the National Flood Insurance Program (NFIP), the Building Sciences Program, the National Earthquake Hazard Reduction Program (NEHRP), and the National Dam Safety Program. He also directs the national hazard mitigation planning requirements under the Stafford Act and FEMA's actuarial and catastrophic modeling responsibilities. Additionally, the Risk Management Directorate is responsible for the inter-agency Mitigation Framework Leadership Group (MitFLG) that coordinates mitigation and resilience efforts across the Federal Government in consultation with state, local, tribal, and territorial (SLTT) governments as well as the private sector including the development of the National Mitigation Investment Strategy (NMIS).

From 2014-2018, Mr. Grimm directed FEMA's pre- and post-disaster mitigation programs that support sustainable, disaster-resilient communities, to avoid or reduce the loss of life, property, and financial impacts of natural hazards. These programs included the Hazard Mitigation Grant Program, the Pre-Disaster Mitigation Grant Program, the Flood Mitigation Assistance grants, the Floodplain Management component of the National Flood Insurance Program (NFIP), and the Community Rating System under the NFIP. In addition, Mr. Grimm led the hazard mitigation disaster workforce cadre and overall disaster operations for the Federal Insurance and Mitigation Administration.

From 2011-2014, Mr. Grimm directed FEMA's Individual Assistance Division and was responsible for FEMA disaster response and recovery programs including the Individuals and Households Program, the Temporary Housing Program, Disaster Case Management Program, Crisis Counseling Program, Disaster Unemployment Assistance Program, Disaster Legal Services, Emergency Food and Shelter Program, as well as Mass Care and Emergency Assistance under Emergency Support Function #6 of the National Response Framework. He served as co-Chair (with American Red Cross and National Voluntary Agencies Active in Disasters (NVOAD)) of the Mass Care Council and as FEMA representative on Board of Directors for NVOAD.

Prior to joining FEMA, Mr. Grimm worked in other governmental positions including with the City of Fort Collins, Colorado, emergency and floodplain management program; with the State of Wyoming, Department of Environmental Quality; and for the United States Geological Survey, National Research Program, in Denver,

Colorado. Mr. Grimm holds a Bachelor's degree in Environmental Studies from the University of Vermont and a Master of Science in Earth Resources from Colorado State University. Mr. Grimm also received a certificate in Public Leadership from the Brookings Institution and Washington University in St. Louis, Olin Business School.

Chairwoman SHERRILL. Thank you so much. And I have to apologize, I will be leaving shortly, the vote schedule upended my day a little bit. Fortunately, this is, as I mentioned, a very critical issue for my district, so I have two of my district directors here. I have Kellie Doucette and Jill Hirsch, and I look forward to hearing about your testimony and reviewing it afterwards. Thank you again.

Next we have Mr. Osler.

TESTIMONY OF MR. MARK OSLER, SENIOR ADVISOR FOR COASTAL INUNDATION AND RESILIENCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE

Mr. OSLER. Good afternoon, Chairwoman Sherrill, Chairman Foster, Ranking Member Marshall, Ranking Member Norman, and Members of the Subcommittees. Thank you for inviting me to testify. Part of NOAA's core mission is to protect lives and property, and enhance the national economy. We do this by providing environmental information and predictions to the public. From real time observations, to daily weather and water forecasts and warnings, to climate monitoring, and sea level rise analysis, NOAA's products and services provide vital information to the public. These insights are underpinned by cutting edge research, collaborative external partnerships, and thousands of dedicated scientists across the Nation. To carry out our important mission in a changing world, NOAA has recently launched strategies to optimize our use of unmanned systems, artificial intelligence, and cloud computing to ensure that our work remains at the forefront of innovation.

Our Nation has a special challenge along our coasts. Our coasts are economic drivers. Coastal counties produce more than $8 trillion of goods and services annually, and employ 56 million Americans. If our coastal counties were combined to be an individual nation, it would rank third in the world in GDP (Gross Domestic Product). This economic engine along our coasts is increasingly at risk. Water levels are rising. We observe more frequent flooding during high tides, even in the absence of storms, Great Lakes water levels are at record heights, and increased development along our coasts mean the impact of coastal hazards are more costly than ever.

NOAA is at the forefront in the national response to these challenges. We deliver an array of water level and mapping services, which include NOAA's comprehensive inland flood watches and warnings, together with real time hurricane surge forecasts and warnings, which provide a comprehensive picture of flooding and real time impacts, which enable life saving evacuation decisions. NOAA also supports coastal decisionmakers through platforms like Digital Coast, which include our sea level rise viewer, empowering communities to incorporate future risk within their long-range planning and capital improvement investments.

And all of these products and services themselves are built on underlying data which NOAA produces to determine where the land and water are in relation to one another, and how they are changing over time. NOAA builds and maintains the National Spatial Reference System, which defines latitude and longitude and

elevation for the Nation. We're currently hard at work modernizing this system to improve measurement accuracy. NOAA also maintains our Nation's long-term network of tide stations. These stations provide tidal datums, historic water levels, and track rising sea levels.

In order to deliver our mission, NOAA works with and supports many agencies, including FEMA. For example, NOAA actively participates in the Federal Inter-Agency Floodplain Management Task Force, FEMA's community rating system task force, and provides experts to participate in FEMA's Technical Mapping Advisory Council (TMAC). NOAA's working together with the U.S. Geological Survey, the Army Corp of Engineers, and FEMA to provide integrated real time and forecast flood inundation maps along our Nation's streams and rivers, and during natural disasters NOAA has pre-scripted mission assignments in place which enable FEMA to request NOAA's support with emergency weather forecasting, aerial and underwater surveys that are used to identify hazards, and accelerate response and recovery.

There's a lot of talk these days about resilience, the ability to anticipate, adapt, withstand, and evolve from any disruption. The science involved in predicting and mapping environmental information is complex. We must continue to support the research and observations which enable these tasks. However, we must also respect the fact that even the best science and mapping will not increase safety and reduce economic loss without a clear understanding of how the public understands risk. Local decisionmakers must be supported in discovering for themselves how the relevant science relates to their local priorities and values to their culture, to their history, and to the future they wish to forge for themselves.

NOAA is proud to join together with FEMA and myriad partners in and outside of government to enhance our scientific understanding and participate in this shared engagement with the public about the risks that we face today and in the future. Thank you for the opportunity to be in dialog together today. I look forward to answering your questions.

[The prepared statement of Mr. Osler follows:]

WRITTEN TESTIMONY OF
MARK OSLER
SENIOR ADVISOR FOR COASTAL INUNDATION AND RESILIENCE
NATIONAL OCEAN SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

HEARING ON
AN EXAMINATION OF FEDERAL FLOOD MAPS IN A CHANGING CLIMATE

BEFORE THE
HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
SUBCOMMITTEES ON ENVIRONMENT AND INVESTIGATIONS AND OVERSIGHT

FEBRUARY 27, 2020

INTRODUCTION

Good afternoon Chairwoman Sherrill and Chairman Foster, Ranking Members Marshall and Norman, and members of the Subcommittees. My name is Mark Osler and I am the Senior Advisor for Coastal Inundation and Resilience in the National Oceanic and Atmospheric Administration's (NOAA) National Ocean Service. I collaborate across federal agencies and with our respective partners to guide NOAA's work in providing data, tools and expertise that reduce risks and inform efforts to respond to changing environmental conditions such as sea level rise and coastal storms.

Thank you for inviting me to testify today. It is my honor to be here along with my colleagues from the Federal Emergency Management Agency (FEMA), the Association of State Floodplain Managers, and industry.

I appreciate the Subcommittee's interest in exploring how flooding and sea level rise affect American property owners, communities, and economies. My testimony today will highlight how NOAA provides world class science and decision support services to U.S. taxpayers, empowers national and local decision makers to enact science-informed policies, and serves as a convener and supporter of an "all of government" approach to how federal agencies can support one another to reduce impacts from flooding on our Nation's citizens and economy.

THE COASTAL CHALLENGE

If the U.S. coastal counties were an individual nation, it would rank third in the world in gross domestic product, surpassed only by the United States and China. Annually, our coastal counties produce more than $8.3 trillion in goods and services, employ 56 million people, and pay $3.4 trillion in wages. Forty percent of the U.S. population lives along the coast. The coastal and ocean economy -- also called the blue economy -- is the fastest growing segment of our economy. This engine of American prosperity is being placed under unprecedented stress from the impacts of extreme weather and sea level rise. If not properly addressed, these threats will undermine our national security as well as our economic security.[1]

Our coasts face threats from all sides. The impacts from rising seas and coastal storms are increasing. These forces, combined with upland development and increased riverine flooding are speeding the erosion of natural features like shorelines, beaches and wetlands that protect our coastal infrastructure and support fish and wildlife habitat. When our natural defenses are overwhelmed, our communities and businesses become vulnerable to disruption. Frequent or widespread disruptions impact our Nation's economic vitality and national security.

The threats to our coasts are real and increasing. Global sea level has risen seven to eight inches since 1900, with almost half of this rise occurring since 1993. We are likely to see an additional rise of several inches in the next 15 years, and increases of one to four feet by 2100.[2] Communities from Texas to New England and along parts of the Pacific are already experiencing more frequent high-tide flooding events and associated impacts such as flooded streets and business fronts, damage to critical infrastructure, and increasing impediments to commerce and daily life. These higher water levels also result in greater impacts from powerful hurricanes and coastal storms. Coastal inundation also threatens other coastal dependent uses, such as port operations, military readiness, commercial fishing, tourism, and recreation.

Coastal states, counties and communities are being asked by their citizens to take action to protect their economies and way of life from severe weather and high tide flooding in the short-term and from sea level rise in the long-term. Yet, local governments have limited resources and expertise to address these complex issues. Increasingly, they are turning to NOAA as a trusted source of science, information and expertise as they consider major investments in infrastructure upgrades and other activities to make their communities more resilient to impacts from flooding and inundation. NOAA is utilizing its vast amounts of environmental monitoring data to provide communities with meaningful information to inform decision making. NOAA is helping to build local knowledge and capacity that communities can use to solve local issues, enabled by and built upon consistent and authoritative science.

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[1] https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html

[2] https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf & https://science2017.globalchange.gov/chapter/executive-summary/

NOAA's science, data and services are critical to predicting environmental change, the impacts of these changes on our communities, and to help to continue to sustainably grow our economy. Just as we have built a more Weather Ready Nation, we too must work to strengthen partnerships and provide the services necessary to build more resilient coastal communities, economies and ecosystems. Coordinated federal science, partnered with local government insight, and private sector and academic innovation, is the only way we can effectively address this complex and increasingly urgent issue of coastal inundation in ways that are both locally and nationally relevant. Our coastal communities sorely need more data to sustain and grow their economies and livelihoods, as well as more and detailed surveys, maps and observations. We also need a more integrated and detailed system of disseminating standardized information across our entire national coastline so that communities and businesses can use it to make informed decisions.

Such an undertaking will require an inclusive effort across federal, state, local, tribal and territorial governments, and directed partnerships within academia, private sector, non-governmental and philanthropic organizations. While building seawalls and erecting levees are viable options in some circumstances, they can be costly and, in some cases, can inadvertently impact wildlife and habitats. In some instances, nature-based solutions may provide more efficient, effective and longer-term solutions. NOAA is already working with partners to coordinate efforts and resources to develop multidisciplinary approaches and an integrated suite of economic, social, engineering, and science alternatives to meet these emerging challenges. Scientific and technological advances are already providing a means to develop and deliver these services and will continue to do so into the future.

Today, I would like to highlight some of NOAA's most relevant programs and services along with some exciting new initiatives. I will also highlight several of our engagements with FEMA.

RECENT COMMITMENTS AND INITIATIVES

Before providing updates on several long-standing NOAA programs and missions, there are several recent efforts that will further NOAA and the Nation's capabilities across many mission areas, including observing, mapping, modeling and forecasting flooding and coastal change.

In November, the White House convened the Summit on Partnerships in Ocean Science and Technology (Ocean S&T Summit). The Summit brought together over 100 leaders and experts to identify opportunities for partnerships to develop and employ science and technology (S&T) for the conservation, management, and balanced use of America's oceans.

Following the Ocean S&T Summit, President Trump issued a Presidential Memorandum titled, "Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska." It directs federal agencies to develop a national strategy to map the United

States Exclusive Economic Zone and a strategy to map the Alaskan coastline to advance our understanding of our oceans and coastlines and to promote efficient permitting related to ocean exploration activities. Last fall, NOAA also announced new draft strategies to dramatically expand the agency's application of four emerging science and technology focus areas:

- Unmanned Systems Strategy: The NOAA Unmanned Systems Strategy provides a framework to provide requirements-driven, safe, cost-effective, and compliant Unmanned Systems services across the agency and prioritize strategic partnerships and investments.
- Artificial Intelligence Strategy: The NOAA Artificial Intelligence (AI) Strategy promotes use of AI to advance NOAA's requirements-driven mission priorities. Through this strategy, NOAA seeks to reduce the cost of data processing, and provide higher quality and more timely scientific products and services.
- 'Omics Strategy: "'Omics" is a new term referring to a suite of leading-edge methods used to analyze materials such as DNA, RNA, or proteins; it is used in such study fields as genomics and proteomics. The NOAA 'Omics Strategy recognizes the opportunities and challenges presented by emerging tools to analyze these materials and provides a framework to advance the application of 'omics to address mission priorities.
- Cloud Strategy: NOAA's Cloud Strategy will build on NOAA's robust experience with cloud applications in areas such as satellite data products and services, numerical weather prediction, ocean models, and big data analysis, storage and dissemination. Cloud services will be further leveraged to expand benefits in these and other areas.

The Weather Research and Forecasting Innovation Act of 2017 (Weather Act) instructs NOAA to prioritize improving weather data, modeling, computing, forecasting and warnings for the protection of life and property and for the enhancement of the national economy. The National Integrated Drought Information System Reauthorization Act of 2018 builds upon the Weather Act and instructs NOAA to establish the Earth Prediction Innovation Center (EPIC) to accelerate community-developed scientific and technological enhancements into the operational applications for numerical weather prediction. EPIC will accelerate community-developed scientific and technological advancements into the operational applications for numerical weather prediction by supporting a Unified Forecast System community model. NOAA is working closely with entities in the weather enterprise (public, private, and academic) to inform the planning, development, and strategy for EPIC. The draft EPIC strategic plan was released on January 10, 2020, and NOAA anticipates the Request For Proposal for EPIC will be released in the next few months.

RELEVANT NOAA PROGRAMS AND ACTIVITIES

From Coast to Coast: NOAA's National Spatial Reference System

The Earth is constantly changing. Tectonic motion of the earth's plates, including earthquakes, can cause significant and immediate terrestrial shifts. But there are also ongoing, more gradual changes. In some places the earth's surface is rising (uplift), in others it is sinking (subsidence). NOAA's National Geodetic Survey's mission is to define and provide access to a consistent, underlying coordinate framework across the Nation – known as the National Spatial Reference System (NSRS). Elements of the NSRS include - but are not limited to - defining latitude, longitude, elevation, gravity, and shoreline position. The NSRS defines the foundation for all geospatial datasets that support surveying, mapping, and charting and many activities including construction, transportation, and agriculture. NSRS enables scientists, engineers, and surveyors to combine different datasets and provide geospatially aligned floodplain mapping products. Floodplain mapping would be impossible without an accurate NSRS.

As surveying and positioning technologies continue to improve, so does the accuracy of the NSRS's foundational elevation and positioning information. NOAA is in the process of modernizing the NSRS, which will improve the accuracy of known points to one or two centimeters. Planned for completion by 2022, this represents an excellent opportunity for all surveyors, mapping and geospatial data providers to adopt a singular and much more accurate and uniform version of the NSRS across the Nation.

NOAA Coastal Products and Services

Shoreline and Coastal Mapping

NOAA's Coastal Mapping Program defines the Nation's 95,000-mile shoreline. This shoreline dataset is used to define the territorial limits of the United States and has many other purposes. For example, an up-to-date shoreline is an integral component of NOAA's nautical charts and informs a wide range of coastal management applications, such as flooding modeling, habitat characterization, coastal management, and damage assessment following coastal storms. Collecting shoreline data that is georeferenced both to NSRS and to tidal and sea level change is also essential to monitoring coastal change over time.

NOAA and its contract partners use remote sensing technologies (imagery, Lidar, radar, etc.) from various sources (aircraft, satellites) and continually assess new technologies. Data collection is coordinated across agencies, like FEMA, through the Interagency Working Group on Ocean and Coastal Mapping with an understanding that the carefully georeferenced data will have to be transformed to the modernized NSRS in a few years. This data is publicly available and can be used in floodplain mapping products. NOAA and FEMA also work closely with and contribute funding to the U.S. Geological Survey (USGS) 3-D Elevation Program. This program

collects high accuracy Lidar data nationwide. Lidar is a primary base dataset used to support FEMA floodplain mapping activities.

FEMA also turns to NOAA to collect and rapidly disseminate aerial imagery and Lidar data in response to manmade and natural disasters, such as hurricanes, floods, and tornados. FEMA uses the imagery to assess impacts, direct emergency response efforts, and inform decisions on federal assistance. For example, during the 2017 hurricane season, NOAA received eight mission assignments from FEMA to collect imagery in response to hurricanes Harvey, Irma, and Maria. NOAA collected 64,848 images, covering an area of 24,279 square kilometers. In a powerful example of how important this imagery can be, NOAA quickly processed imagery after Hurricane Michael and noticed someone had spelled "HELP" on the ground. The location was readily identified, and rescue aid was provided.

Tides and Water Levels

In addition to providing the framework for land-based positioning through the NSRS, NOAA maintains the Nation's foundational coastal water level data and datums. This ensures the accuracy of hydrographic surveys, nautical charts, shoreline mapping, and marine boundary determinations and supports many coastal activities, including navigation, dredging, construction, marine civil works, and coastal restoration projects. These core services, and products such as NOAA's Seasonal High Tide Bulletins and Annual High Tide Flooding Outlooks, are increasingly valued by coastal communities to inform actions to address increased occurrences of tidal flooding and inform plans to help them mitigate and adapt to sea level rise and coastal change.

At the core is the National Water Level Observation Network (NWLON), the Nation's permanent observing system consisting of more than 200 long-term continuously operating water level gauges throughout the coastal United States, its territories, and the Great Lakes. NWLON is the source for accurate real-time and historical water levels for governments, the commercial navigation sector, and recreational users. NWLON data provide irreplaceable design insights to civil engineers, environmental engineers, city planners, and the insurance industry, enabling each to quantify risk along the coast today and in the future.

Hydrography, Bathymetry and Nautical Charting

NOAA's Office of Coast Survey is the Nation's leader in seafloor mapping, i.e., hydrographic surveying, which is studying the physical features of water bodies, and bathymetric surveying, which is studying the depths and shapes of underwater terrain. Accurate surveys of available depths and the location of obstructions is essential to NOAA's mission to produce and maintain the Nation's nautical charts for safe and efficient marine navigation. NOAA also deploys navigation response teams to address specific needs and conduct emergency hydrographic surveys to reopen ports following hurricanes and other coastal disasters. Today, NOAA has transformed its nautical charting mission to digital formats and is meeting the need for precision navigation information to support marine commerce where vessels can exceed 1,300 feet in

length and plunge as many as 80 feet below the surface. Coastal/nearshore bathymetry is an important component to inform models and predictions of storm surge and coastal flooding.

NOAA Storm Surge and Coastal Flooding Forecasts and Warnings

NOAA's National Hurricane Center (NHC) specializes in forecasting hurricane hazards and their associated impacts on the public and infrastructure. As it pertains to coastal flooding from storm surge, the NHC's Storm Surge Unit specializes in three areas/missions: (1) real-time forecasts and warnings, including the provision of high-resolution inundation mapping and specialized Geographic Information System (GIS) support to emergency managers; (2) pre-computed storm surge flooding risk maps utilized for planning and mitigation; and (3) post-storm hindcasts and inundation mapping utilized to enable fast, efficient damage threshold assessments, emergency response and recovery, and disaster declarations. NHC's coastal flood modeling and mapping is used exclusively for life-safety and life-saving decision-making (i.e. evacuations, evacuation planning, mitigation, etc.) and focuses exclusively on flooding potential from the combined effects of coastal storm surge, waves, and tide.

The National Hurricane Program (NHP) is a Federal Partnership Program among FEMA, the U.S. Army Corps of Engineers (USACE), and NOAA. The NHP is mandated by federal law (Robert T. Stafford Disaster Relief and Emergency Assistance Act, PL 100-707) to conduct Hurricane Evacuation Studies (HES) for the U.S. Gulf of Mexico and Atlantic coastlines as well as U.S. territories and tribal lands. A HES consists of several related analyses (Hazards, Vulnerability, Shelter, Behavioral, and Transportation) that develop technical data concerning hurricane hazards, vulnerability of the population, public response to evacuation advisories, timing of evacuations, and sheltering needs for various hurricane threat situations. Their purpose is to provide emergency management officials with critical information and tools that assists them in hurricane evacuation planning and decision making.

One of the primary inputs required to conduct a HES is identification of the storm surge risk, namely identification of areas most vulnerable to storm surge, within the HES area. NOAA, specifically the National Weather Service's NHC, provides high-resolution inundation risk maps under varying scenarios. These maps include thousands of hurricane simulations spanning intensities from Category 1 storms through Category 5 major hurricanes. The resulting catalogue of flood risk maps allow decision-makers and emergency managers to quickly and easily access their flood risk potential from all possible scenarios including derivation of worst-case flooding from extreme and rare events. This information is then provided to the NHP for application in the HES. In addition to aiding hurricane evacuation decision-making, these maps are also provided to Federal, State, Local, and Tribal Emergency Managers to assess coastal inundation flood

risk and take mitigation actions long before a hurricane threatens. This data also provides critical information days in advance of a threatening storm allowing the pre-positioning of recovery assets in strategic and safe locations. Emergency managers also find these studies very effective in public awareness, training, and hurricane preparation presentations in advance of hurricane season.

This risk mapping also provides critical infrastructure and economic planning capabilities to vulnerable coastal communities. Examples include prioritizing hospital backup power requirements, power plant salt water ingress mitigation projects, power grid resiliency improvements, road work project planning and residential community project planning, to name a few. These data represent a compliment to FEMA's Flood Insurance Rate Maps (FIRMs), which primarily depict the one-percent-annual chance flooding scenario. NOAA's risk mapping data provides a broader spectrum of risk (i.e. worst-case scenarios), thus allowing a more graduated analysis of flood risk. By enabling a comprehensive analysis of flood risk, critical decisions can be made well before a hurricane threatens to ensure minimal loss of life. For example, the American Red Cross uses this data to perform shelter analyses and develop policies to prevent the use of flood-prone shelters during land-falling hurricanes.

Digital Coast

In addition to providing core data and services such as NSRS, NWLON, and shoreline mapping, NOAA continues to create and improve our services in response to the needs of coastal communities, particularly with regard to decision support and providing highly complex information in formats and tools that are more readily understood and actionable. NOAA is committed to working with state partners and other federal agencies to help provide information and services, such as the Digital Coast and many others, in cost-effective ways that meet the diverse needs of these communities.

Before 2007, and before the development of Digital Coast, coastal planners, managers, and other decision-makers did not have ready access to data relevant to coastal issues. The Digital Coast, created by NOAA's Office of Coastal Management, leverages technology to meet user needs and operates under three guiding principles: (1) Inform coastal decision-making; (2) Provide value for the target audience and for the nation; and (3) Evolve continuously and sustainably. Several of Digital Coast's tools, such as the Coastal Flood Exposure Mapper and the Sea Level Rise Viewer, help communities assess their coastal hazard risks and vulnerabilities by creating customized maps that show the people, places, and natural resources exposed to coastal flooding.

ADDITIONAL COLLABORATIONS WITH FEMA AND OTHER NOAA PARTNERSHIPS

In carrying out its mapping, navigation, observing, positioning and flood-related missions, NOAA works with many agencies, including the USGS, the Bureau of Ocean Energy Management, the United States Coast Guard, the USACE, and of course FEMA. In addition to the instances already described, there are many examples of coordination between NOAA and FEMA, including efforts to sustain long-term partnerships with coastal states and communities in "boots on the ground" efforts to promote resilient communities.

NOAA's Emergency and Disaster Coordination with FEMA
NOAA works closely with FEMA on a daily basis and during emergencies. NOAA has staff assigned to FEMA headquarters and provides meteorological and other support before, during, and after emergency declarations. NOAA and FEMA have pre-scripted agreements in place for NOAA to provide meteorological, mapping, hydrographic, geodetic, oil and chemical spill, and marine debris support to FEMA response efforts.

Coastal management, natural resource, weather, and water experts, and other staff are often dispatched to support FEMA-led longer-term recovery efforts. For example, NOAA, FEMA, and the Department of the Interior worked on coral reef restoration following Hurricanes Irma and Maria.

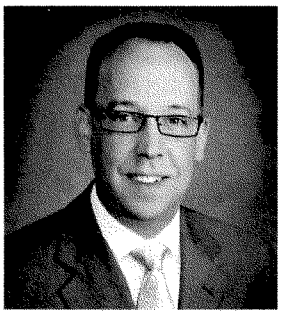
NOAA's Partnerships and Interagency Work with FEMA
Various NOAA offices represent the agency on different FEMA groups such as the Community Rating System Task Force, the Federal Interagency Floodplain Management Task Force, and the Mitigation Framework Leadership Group. NOAA has a representative on FEMA's Technical Mapping Advisory Council where NOAA provides subject matter expertise and recommendations for FEMA's flood hazard mapping program. That Council's 2020 priority activities include working with stakeholders in order to recommend elements of a future Flood Hazard Mapping Program. NOAA looks forward to working with FEMA on this effort and tying it to our new 2022 vertical datum.

One of NOAA's hallmark and unique roles in the Federal Government is our extensive network of partners and constituents, especially along the coast. These partnership efforts have extensive networks of state and academic experts in place to collaborate on hazards and resilience planning issues and projects, often involving coordination and engagement with FEMA.

Conclusion

NOAA will continue to do what we have done successfully for more than 50 years: providing world class science and decision support services to U.S. taxpayers, empowering decision-

makers to understand how they can relate these science and services to local values and priorities, and by serving as a convener and supporter of an "all of government" approach to reducing impacts from flooding, and major storm events. Much has been accomplished to enable more informed decisions. However, there are additional gaps to fill, needs to address, and partnerships to enhance as we work to sustain and support our coastal communities and economies now and for the future. NOAA stands ever ready to rise to these challenges. Thank you again for the opportunity to testify today. I appreciate the Subcommittee's time and attention and look forward to answering any questions you may have.



Mark S. Osler
Senior Advisor for Coastal Inundation and Resilience
National Oceanographic and Atmospheric Administration

Mark Osler is the Senior Advisor for Coastal Inundation and Resilience for the U.S. National Oceanic and Atmospheric Administration (NOAA). His leadership advances coastal inundation science and the ability of decision makers to prepare for and respond to changes affecting the nation's coastlines. He serves as senior advisor to NOAA leadership on defining research, applied science, and policy priorities related to understanding and reducing impacts of coastal risk to the public, our national security, and our nation's economy.

Mark's inter-agency leadership includes:
US Government representative to the G7's Ocean Risk and Resilience Action Alliance
NOAA representative within various White House interagency fora including the National Security Council, Office of Science and Technology Policy, and the Council on Environmental Quality.

Prior to joining NOAA Mark worked for 17 years in the private sector. He holds a bachelor's degree in civil engineering from Lehigh University and a master's degree in coastal engineering from the University of Delaware's Center for Applied Coastal Research.

Ms. BONAMICI [presiding]. Thank you for your testimony. I now recognize Mr. Branfort for 5 minutes for your testimony.

TESTIMONY OF MR. RYAN BRANFORT, PLS, GISP, SENIOR VICE PRESIDENT, WILSON AND COMPANY, INC., ENGINEERS AND ARCHITECTS

Mr. BRANFORT. Thank you, Chairwoman Sherrill, Chairmen Foster and Norman, and especially to Dr. Marshall, for this opportunity. I am a licensed surveyor, practicing photogrammetrist, and GIS professional, and I'm honored to present my piece on how GIS spatial data technology and services can improve FEMA flood mapping and better serve the American people.

Our changing, evolving climate, sea level rise, subsidence, and other natural phenomena affects flooding and impacts American property owners, taxpayers, and FEMA, as the custodian of the National Flood Insurance Program. As a Kansan, I can tell you these phenomena also affect American agriculture, crop insurance, and our food supply. America is blessed with a vibrant, capable, and qualified private sector geospatial community that provides an extraordinary array of data technology and services that contribute to our quality of life. I'd like to share with you today some thoughts on how these technologies can be used to predict future flood rather—future flood mapping, rather than mapping past flood results. This would significantly save lives, protect property, improve building practices, and save tax dollars.

I've got a few slides here that show some of the technologies and examples of state-of-the-art geospatial technologies that are available to assist FEMA. Now, this first slide is several examples of—you've heard talk about LIDAR, which is Light Detection and Ranging. There's elevation data collected with a new laser system. Next slide, please. Oops, I can turn it here. The USGS 3DEP Elevation Program, or 3DEP, is satisfying the growing demand for consistent, high quality topographic data and other three-dimensional representations of natural and constructed features, primarily using LIDAR. Among the leading applications that benefit from 3DEP is flood risk management.

While FEMA has been the leading contributor to 3DEP, apart from USGS itself, the program is not coming close to the $146 million per year that is needed to complete the mapping of the project and implement an 8-year update cycle. As my second slide slows—shows here, about 67 percent of the Nation has been mapped under 3DEP, but many areas still need elevation data. Before the 3DEP implementation, the average elevation data for the Nation was 30 years old. In the areas that are white, this area—this data's still being used.

Coastal mapping—if you'd read Chief Justice Roberts's dissenting views in the Supreme Court's decision in Massachusetts vs. EPA, he noted the Plaintiffs did not submit mapping to document the shoreline that it was losing. In fact, as the National Academy pointed out, there are at least 22 different Federal, State, and local definitions of shorelines. It's noted a single nationally accepted and consistent U.S. shoreline does not exist, and the use of inconsistent shoreline definitions between maps, charts, GIS outputs, and other

products leads user to—to—leads to user confusion and ill-informed decisionmaking.

This map shows subsidence across the country. This is—there's natural and anthropogenic subsidence in many areas of coastal and inland America. In many studies, this is ignored or discounted. This map shows there are portions of our nation that are extremely vulnerable to subsidence, and other regions where there's no data at all. Coastal areas, such as Houston, that experience extreme subsidence, are vulnerable to flooding. Rural inland areas, such as the San Joaquin Valley in California, experience subsidence due to groundwater extraction. This next slide shows the San Joaquin Valley, where the extreme subsidence occurs. There's also—this slide here shows the Atlantic coast, Jersey Shore, subsidence occurring. NASA's beginning a program, the very small-scale National Land Level Change Map, to monitor subsidence change.

For inland bathymetry, the Army Corps of Engineers has reservoirs that are 50 years old. Sediment buildup has greatly reduced the capacity of these reservoirs. As this slide shows, there's other areas—the same could be said for other lakes and inland waterways. We need bathymetric mapping and surveying of sediment monitoring to measure the capacity, and to be able to more accurately forecast flooding. For structures inventories, it is essential that all FEMA maps show structures. FEMA should investigate means for presenting flood risks to individual homeowners based on their elevations to their lowest adjacent grades, or lowest floor elevations. LIDAR technology in particular is ideal for determining these elevations.

In conclusion, I want to commend FEMA for the—for doing the best job possible. It is a difficult job. I hope the constructive recommendations I've put forward today will be accepted, and the program provide an even greater service to our Nation. I thank you for the invitation to present, and I'll be looking forward to questions.

[The prepared statement of Mr. Branfort follows:]

Testimony of Ryan R. Branfort, PLS, GISP
Senior Vice President
Wilson & Company, Inc., Engineers & Architects
Salina, KS
Before the Subcommittee on Environment and Subcommittee on Investigations and Oversight
Committee on Science, Space, and Technology
U.S. House of Representatives
Hearing on
An Examination of Federal Flood Maps in a Changing Climate
February 27, 2020

Madam Chair, Mr. Chairman, Dr. Marshall, members of the Subcommittees, I'm Ryan Branfort, a professional land surveyor and certified geographic information systems professional and Senior Vice President with Wilson & Company, Inc., Engineers & Architects, based in Salina, Kansas. Thank you for the invitation to testify. I am honored to present my views on how geospatial data, technology, and services can improve flood mapping of the Federal Emergency Management Agency (FEMA) and better serve the American people.

Our changing and evolving climate, sea level rise, subsidence, and other natural and anthropogenic phenomena affects flooding impacting American property owners, taxpayers, and FEMA as the custodian of the National Flood Insurance Program. As a Kansan, I can also tell you these phenomena also affect American agriculture, crop insurance, and our food supply.

Congress passed, and President Trump signed into law the Geospatial Data Act on October 5, 2018 as subtitle F of the FAA Reauthorization Act, Public Law 115-254. That law defines geospatial data as "(A) ... information that is tied to a location on the Earth, including by identifying the geographic location and characteristics of natural or constructed features and boundaries on the Earth, and that is generally represented in vector datasets by points, lines, polygons, or other complex geographic features or phenomena: (B) may be derived from, among other things, remote sensing, mapping, and surveying technologies; (and) (C) includes images and raster datasets, aerial photographs, and other forms of geospatial data or datasets in digitized or non-digitized form..."

America is blessed with a vibrant, capable, and qualified private sector geospatial community that provides Federal, state, and local government, as well as commercial clients, with an extraordinary array of data, technology and services that contributes to our quality of life. From total station data collectors for land surveying to satellite imagery and positioning, and a plethora of instruments, software, analytics, and applications in between, the geospatial profession provides data and solutions from the sky above the Earth to below the Earth's surface.

I'd like to share with you today some thoughts on how those technologies can be better used by FEMA and other Federal agencies for flood mapping and other applications, as well as observations on public policy issues that can contribute to a more successful program.

Specifically, the utilization of new mapping data and technologies can be used to predict future flooding rather than mapping flood results. This would significantly save lives, protect property, improve building practices, and save tax dollars.

Here are a few slides that show how state-of-the-art geospatial technology, data, and services can assist FEMA:

- LiDAR. The USGS 3-D Elevation program or 3DEP is satisfying the growing demand for consistent, high-quality topographic data and a wide range of other three-dimensional representations of the Nation's natural and constructed features, primarily through elevation data collected with Light Detection and Ranging (LiDAR). Among the applications that benefit from 3DEP data are flood risk management; infrastructure; landslides & other hazards; water resources; aviation safety; telecom; homeland security; emergency response; precision agriculture; energy; pipeline safety; and other areas. USGS has identified more than 600 applications that benefit from such enhanced elevation data and the list is growing every day. 3DEP promotes economic growth, facilitates responsible environmental protection, resource development and management, assists with infrastructure improvement, and generally enhances the quality of life of all Americans. The USGS, with involvement from the private sector and other stakeholders, conducted a National Enhanced Elevation Assessment (NEEA) to determine and document the need for national elevation data within government and private markets. The results indicated that enhanced elevation data have the potential to generate $13 billion in annual benefits, at a benefit:cost ratio of 4.7 to 1. While FEMA has been the leading contributor to 3DEP apart from USGS itself, the program is not coming close to the $146 million per year that is needed to complete the nation and implement an update cycle of eight years. This slide shows about 67 percent of the Nation has been mapped under 3DEP. But many flood-prone or flood-vulnerable areas still need new elevation data. Prior to the initiation of 3DEP, the average elevation data for the nation was 30 years old. Therefore, this program must be funded so the nation can be accurately mapped and the re-mapping process can begin. It must be noted that each time we put a shovel in the ground or natural disaster occur the surface changes. That is why remapping on a consistent cycle is so important. I would like to thank Committee members Representatives Foster of Illinois, Casten of Illinois, and Biggs of Arizona for cosigning the bipartisan letter to the House Appropriations Committee last year requesting robust funding for 3DEP in FY 2020.
- Coastal Mapping. If one reads Chief Justice Robert's dissenting views in the Supreme Court's decision in Massachusetts v. Environmental Protection Agency, 549 U.S. 497 (2007), it is noted that the plaintiffs did not submit any mapping to document the amount of shoreline it was losing. Justice Roberts wrote, "One declaration states that 'a rise in sea level due to climate change is occurring on the coast of Massachusetts, in the metropolitan Boston area,' but there is no elaboration. And the declarant goes on to identify a 'significan[t]' non-global-warming cause of Boston's rising sea level: land subsidence [i.e., the sea is not rising; the land is sinking]. Thus, aside from a single conclusory statement, there is nothing in petitioners' standing declarations and

accompanying exhibits to support an inference of actual loss of Massachusetts coastal land from 20th century global sea level increases. It is pure conjecture." He went on to write, "The Court's attempts to identify 'imminent' or 'certainly impending' loss of Massachusetts coastal land fares no better. One of petitioners' declarants predicts global warming will cause sea level to rise by 20 to 70 centimeters by the year 2100. Another uses a computer modeling program to map the Commonwealth's coastal land and its current elevation, and calculates that the high-end estimate of sea level rise would result in the loss of significant state-owned coastal land. But the computer modeling program has a conceded average error of about 30 centimeters and a maximum observed error of 70 centimeters. As an initial matter, if it is possible that the model underrepresents the elevation of coastal land to an extent equal to or in excess of the projected sea level rise, it is difficult to put much stock in the predicted loss of land. But even placing that problem to the side, accepting a century-long time horizon and a series of compounded estimates renders requirements of imminence and immediacy utterly toothless." This landmark case ordered the EPA to regulate CO2 emissions under the Clean Air Act, as the lack of regulation allegedly causes polar ice caps to melt, resulting in rising sea levels that eroded the shoreline of Massachusetts and other coastal states. However, there is not a robust program to consistently map the shoreline over time to or quantify seal level rise and shoreline loss. In fact, as the National Academy pointed out, there are at least 22 different Federal, state and local definitions of shorelines and submerged lands. (A Geospatial Framework for the Coastal Zone, National Academies Press, 2004)

- Subsidence. There is natural and anthropogenic subsidence in many areas of coastal and inland America. In many studies, this is ignored or discounted, particularly when compared to sea level rise. USGS did a special local study in the Hampton Roads/Tidewater region of Virginia and concluded 50 percent of the change in land level was due to subsidence. "Data indicate that land subsidence has been responsible for more than half the relative sea-level rise measured in the region." (Land Subsidence and Relative Sea-Level Rise in the Southern Chesapeake Bay Region (2013)) and nationally, "an area of more than 15,000 square miles in 45 States experience land subsidence." (Land Subsidence in the United States, (1999)). As the images I provided show, there are portions of our Nation which are extremely vulnerable to subsidence, and other regions where we have no data at all. NASA is beginning a program, with USGS and NOAA, to provide a very small-scale National Land Level Change Map using existing Sentinel 1 satellite data with existing ARIA/GRFN data processing workflow. This is only a start. For larger scale, regional, local and site specific data collection, land surveys and other more accurate technologies will be required.
- Inland Bathymetry. Wilson & Company does a considerable amount of work for the U.S. Army Corps of Engineers. It is our experience that Corps reservoirs are now more than 50 years old and sediment buildup has substantially reduced capacity for storage of water. The same can be said for lakes and reservoirs of other owners, as well as inland waterways. Inland bathymetric and sediment monitoring is needed to measure the capacity of such bodies of water for more accurate flood forecasting, and the determine the need and extent of any required dredging.

- Structures Inventory. It is essential that all FEMA maps show structures. FEMA should investigate means for presenting flood risks to individual homeowners based on the elevations of their lowest adjacent grade (LAG) and/or lowest floor elevations compared with water surface elevations computed for standard flood frequencies. By showing the probability of flooding to various depths for individual structures, we believe many more homeowners would recognize that their risk of flooding is serious and may even be more probable than their risk from other hazards (e.g., fire). LiDAR technology, in particular, is ideal for determining the elevations of LAG elevations for automated comparison with water surface elevations for 100-year and 500-year floods that **have an annual chance of occurring each year**. This is needed for risk management, flood rating, mitigation, and for response when flooding does occur. Through LiDAR and ground surveying, a structure inventory is technically feasible. This can enable more frequent application of "Freeboarding", a factor of safety usually expressed in feet above a flood level for purposes of floodplain management, and can help improve construction practices in vulnerable areas.

The reason Congress passed the Geospatial Data Act was because of past hearings, Government Accountability Office reports, and other studies that identified inadequate coordination among the dozens of Federal agencies involved in surveying, mapping and geospatial activities, as well as with state and local government, the private sector, and the university community.

In 2012, Congress passed the Biggert-Waters Flood Insurance Reform Act, in the MAP-21 Act (Public Law 112-141). It included section 100220, which can be utilized to pool funding from Federal, state and local government entities for elevation data. Specifically, it calls for FMEA, with the Director of the Office of Management and Budget and others, to submit to Congress "an interagency budget crosscut report that displays relevant sections of the budget proposed for each of the Federal agencies working on flood risk determination data and digital elevation models".

Section 100121 required a National Academy of Public Administration (NAPA) study on how FEMA can improve interagency and intergovernmental coordination on flood mapping, including a funding strategy to leverage and coordinate budgets and expenditures and establish joint funding mechanisms with other Federal agencies and units of State and local government to share the collection and utilization of data among all governmental users.

In 2013, NAPA published "FEMA Flood Mapping: Enhancing Coordination to Maximize Performance" in which it proposed (page 11): "Recommendation 15: The Office of Management and Budget should use the 3DEP implementation plan for nationwide elevation data collection to guide the development of the President's annual budget request." In light of the controversy over FEMA flood insurance rates, particularly as that influenced the recent enactment of the Homeowner Flood Insurance Affordability Act of 2014 Public Law, 113-89, on March 21, 2014, there is an even more urgent and compelling need for the high-quality elevation data that the USGS 3DEP program provides.

There is currently before Congress several legislative proposals that are worthy of support and should be enacted into law.

H.R. 3111 by Rep. Velazquez of New York, the "National Flood Insurance Program Administration Reform Act of 2019" makes improvements to the National Flood Insurance Program's appeals and litigation process following the numerous flaws identified in the oversight, accountability, and transparency of the claims process in the aftermath of Superstorm Sandy. It was unanimously approved last year by the House Financial Services Committee.

Section 2 authorizes a report to be presented to Congress by March 31, 2025, by the FEMA Administrator regarding the pilot program on pre-existing conditions of structures. This pilot program can be utilized by FEMA as the agency focuses on populating datasets leading to a National Structure Inventory.

Section 15 authorizes a study by GAO of the treatment, under flood insurance coverage made available under the National Flood Insurance Act, of earth movement and subsidence, including earth movement and subsidence caused by flooding, which shall include an assessment of the effects on the National Flood Insurance Program of covering earth movement and subsidence caused by flooding.

The Digital Coast Act, H.R. 2189, By Representatives Ruppersberger of Maryland and Young of Alaska was added to a larger bundled package of about a dozen bills that passed the House in December. It is now part of H.R. 729, the "Coastal and Great Lakes Communities Enhancement Act". It authorizes NOAA to establish a constituent-driven program to provide digital geospatial information capable of efficiently integrating coastal data with decision-support tools, training, and best practices and to support collection of priority coastal geospatial data to inform and improve local, State, regional, and Federal capacities to manage the coastal and Great Lakes regions. The Senate version of the bill, S. 1069, has been reported by the Senate Commerce Committee.

H.R.3167, the "National Flood Insurance Program Reauthorization Act of 2019", introduced by Rep. Waters of California, won approval by the House Financial Services Committee by a bipartisan vote of 59-0 in 2019 and is awaiting full House action.

Section 201 authorizes $500 million for each year over five years for flood mapping. This is an increase of $100 Million above current $400 Million/Year level.

Section 202 expands flood mapping to all areas of the United States. This section also requires FEMA to utilize updated mapping technology, such as LiDAR, and provides for digital displays, and property specific mapping. It requires FEMA to submit an annual report to Congress on the progress achieved in the mapping program under this section including recommendations to reduce the cost and improve implementation. Lastly, this section requires that in updating and maintaining maps, the FEMA Administrator shall ensure that maps are adequate for identifying future flood risk. Qualifications-Based-Selection (QBS) is applicable to all levels of contracting for the professional services of any surveying, mapping, and geospatial data collection associated with the NFIP. Specific emphasis is placed on the importance of LiDAR data collection and geospatial data-sharing as part of the U.S. Geological Survey's stream gage and streamflow networks and FEMA's NFIP. And finally, there is specific language on "cadastral data" and the need for such data for NFIP flood risk assessment.

Parts of this section are similar to H.R. 4905 from the 115th Congress, sponsored by Representatives Gonzalez of Texas and Mooney of West Virginia.

H.R. 2318, the "Flood Insurance Rate Map (FIRM) Interagency Technology (IT) Act", introduced by Representative Posey of Florida would direct FEMA to consult with the Department of Defense, USGS, and NOAA to obtain the most up-to-date information relevant to National Flood Insurance Program (NFIP) rate maps. This will allow Americans who utilize NFIP to have the most accurate data for flood hazard identification. This legislation focuses on data sharing, and specifically improving efforts on topographic and cadastral data where it is available while adding essential features to FEMA flood insurance rate maps (FIRMs), making greater use of state-of-the-art geospatial technology, and makes the maps more accurate and useful.

There are a few other issues of which Congress should be aware that are important to FEMA, other Federal agencies, and the nation in general.

First, governmental agencies are not taking full advantage of the extensive resources and highly technical capacities of the private sector. While great progress has been made, there is still too much government competition with, and duplication of, the private sector. While FEMA does not have in-house mapping capabilities, and agencies such as USGS have made significant transformations (the 3DEP program is entirely performed by private sector contractors to USGS), there are still many commercial activities in the surveying, mapping, and geospatial field that are performed by government employees.

The challenge for FEMA and other Federal agencies is to continually move ahead with more accurate and efficient technologies while restraining use of antiquated or even early, unproven methods and technologies. That is why it is critical to have oversight of all surveying and mapping activities by a licensed professional. This will ensure a thorough understanding of the basics of map accuracy. Professional knowledge of datums and coordinate systems to ensure mapping data is accurate and relative to other data and designs is also essential. One of the lessons of Hurricane Katrina was the need for strong understanding of datums.

With technology ranging from satellites, to collection from manned airborne platforms, to drones, to field surveying, to ground penetrating radar, subsurface utility engineering, and underwater hydrography and bathymetry, an understanding of the capabilities and limitations of the most efficient hardware, software, and computer systems is essential to any mapping project or program. This can be a great asset to reduce costs and increase map accuracies. No single, perfect technology or approach can be universally applied to all mapping projects. Similarly, there are lower cost "one button" mapping systems with unproven claims that can also cause problems. Having experienced, licensed professionals involved in such programs provides guidance needed to match the proper tool to the project.

I would urge Congress to focus our Federal workforce on inherently governmental activities and utilize the private sector for those activities that are commercially available.

Second, there is no coordination among Federal agencies, or with the National Science Foundation, on surveying, mapping and geospatial research and development. R&D dollars are

expended on an ad hoc basis, with no strategic objectives. Geospatial R&D is not a topic on the agenda of the Federal Geographic Data Committee (the Federal entity responsible for coordination) or the National Geospatial Advisory Committee (the Federal entity established to provide outside advice to the government). Private geospatial firms have seen too many instances where universities are funded by NSF, only to find those university programs competing with the private sector. Moreover, NSF has no mechanism for vetting its R&D agenda, funding opportunities, or proposals before professionals in the private sector. As a result, tax dollars have too frequently gone to universities to perform research and development on tools, methodologies, instruments, hardware, software, and applications that are already readily available in the commercial market.

Finally, I would call to the attention of the subcommittees a 1984 report by this Committee, (Structural Failures in Public Facilities (H. Rept. 98-61)). Based on hearings of the Subcommittee on Investigations and Oversight, chaired by then Representative Al Gore, Jr. of Tennessee, Congress recognized the importance of professional licensing in design disciplines in its report which recommended "all necessary architectural and engineering design and on-site services in public construction projects are furnished by licensed professionals who are qualified and experienced to assure the construction of safe structures". I would argue the same principle is true of surveying and mapping. All 50 states license surveyors and I am concerned that some states are failing to recognize the impact surveying-related services have on public health, welfare and safety. The movement to relax occupational licensing that is sweeping the Nation fails to distinguish between architecture, engineering and surveying on one hand and floral arranging and hair braiding on the other hand. I would urge legislation expressing the sense of the Congress on this distinction and recognizing the importance of licensure in the design professions.

That same report also pointed to the importance of competence and qualifications, as opposed to low bid, in the procurement of professional design services. It found, "procurement practices that lead to or promote the selection of architects and engineers on a low bid basis should be changed to require prequalification of bidders with greater consideration given to prior related experience and past performance." Again, this principle applies to flood mapping as well. For the record, this is not a partisan issue. As President Ronald Reagan said at a ceremony recognizing design excellence in Federal buildings, "Good design doesn't cost money. Good design saves money, and you know how that warms my heart." I would urge Congress to strengthen the "Brooks Act" (40 U.S. C. 1101 et. seq.) to assure that all agencies use the qualifications based selection process for the broad range of surveying and mapping services we are discussing today.

In conclusion, I want to commend FEMA for doing the best job possible. It is a difficult job. I hope the constructive recommendations I put forward today will be accepted and the program can build on its past success and provide an even greater service to our Nation.

Madam Chair, Mr. Chairman, Dr. Marshall, thank you for the invitation to present my views and I will be happy to answer any questions.

RYAN BRANFORT, RLS, GISP
Senior Vice President
Surveying, Mapping & GIS Division Manager
Wilson & Company, Inc., Engineers & Architects

YEARS OF EXPERIENCE	TOTAL 32 WITH FIRM 31
EDUCATION	Coursework, Engineering, Kansas State University, 1981 A.S., Civil Engineering Technology & Surveying Technology, Kansas College of Technology, 1989
LICENSES AND REGISTRATIONS	Registered Land Surveyor: Kansas #1140 (1991), Arizona #44944 (2006), Alaska #12309 (2008) Geographic Information Systems Professional #00061641 (2009)
ORGANIZATIONS, TRAINING, PUBLICATIONS, AWARDS	Member National Society of Professional Surveyors (NSPS), American Society of Photogrammetrists & Remote Sensing (ASPRS), Kansas Society of Land Surveyors (KSLS), and The Society of American Military Engineers (SAME), U.S. Geospatial Executives Organization (U.S. GEO)

Ryan manages Wilson & Company's Surveying and Mapping Division with a staff of nearly 100 individuals performing work for a variety of federal, state, municipal, and private entities. He has held nearly every type of position in the surveying and mapping division, including field surveyor, party chief, CAD technician, GIS specialist, photogrammetrist, and various supervisory postions, giving him a well-rounded background in the field. Ryan specializes in assisting clients by listening to their needs and determing the best combination of technologies to meet their budget, schedule, accuracy, and delivery requirements.

He has spent the last 15 years as part of the company's Executive Leadership Team and served 6 years on Wilson & Company's Board of Directors.

Wilson & Company, Inc., Engineers & Architects is a Kansas S-Corporation founded in 1932 with nearly 500 employees in 15 offices in nine states. They provide engineering, architecture, planning, environmental, survey and mapping, and construction management services.

Ms. BONAMICI. Thank you for your testimony. I now recognize Mr. Berginnis for 5 minutes for your testimony.

TESTIMONY OF MR. CHAD BERGINNIS, CFM, EXECUTIVE DIRECTOR, ASSOCIATION OF STATE FLOODPLAIN MANAGERS

Mr. BERGINNIS. All right. Thank you, Chairwoman, Chairman Foster, Ranking Member Marshall, Ranking Member Norman, and the Members of the Subcommittees for holding this important hearing, and inviting the Association of State Floodplain Managers to testify. I am Chad Berginnis, Executive Director of ASFPM, whose 20,000 members include many of the boots on the ground State and local officials that use flood maps thousands of times each day to help guide development within their communities.

If we measured success in how we managed flood risk by total losses in the Nation, we're not doing so well. In the past decade our conservative estimate is the Nation's experienced an average of $17 billion in flood losses annually. This is up from $10 billion annually in the 2000s. Why is this happening? There's a number of reasons, but the fact remains that far too many headlines repeat a familiar theme, people didn't know that they were at risk. For many years our members at the State and local level have been concerned they simply don't have enough data to inform property owners about flood risks, to guide development, to plan for emergencies, or prioritize flood mitigation actions.

In areas we have basic information, like the 100- and 500-year flood data, we don't have information on other flood hazards or future conditions. These data are not available when development's occurring, and then we actually are building tomorrow's flood problems today. Think about this example. A subdivision is proposed in a community in an area that was previously agricultural. Because the small stream running through the property was never identified as a floodplain, homes are built, and then, because there's now a risk, it becomes a priority for FEMA mapping. A floodplain is identified after the fact, and now everybody's upset. Community officials and property owners then fight like heck to dispute the map, almost always to make sure that the mandatory purchase of flood insurance doesn't kick in.

Another variation of this problem in a coastal area would be where revised flood maps come out, and let's say the flood elevations are actually lower than existing maps due to new modeling techniques. Because the maps don't include future flood conditions, however, local officials are stuck applying land use and building standards too low, given that the home will likely be there for 100 years or more. Future flood maps will eventually come out, and even if they just reflect the effect of sea level rise, property owners will face the same dilemma, why didn't they know about—when they built the home, and why didn't the community protect its tax base by building more resiliently?

The fact is we have a lot of work to do to fully implement the National Flood Mapping Program as envisioned by Congress when it was authorized in 2012. The program requires the identification and mapping of the 100 and 500 year in flood areas, areas of present and future population, future flood conditions, residual risk

zones, and requires the inclusion of other relevant data from Federal agencies. In short, the expectation set by Congress reflects how we the people already view the FEMA flood mapping products as the authoritative source of flood hazard information.

FEMA should continue to lead this effort. At the time Congress passed the National Flood Mapping Program, I recall testifying to Congress about the status of flood mapping in the country. Then we were talking a lot more about quality issues in FEMA's existing map inventory. Fortunately, FEMA's made good progress on that. The overall quality of the existing inventory has improved significantly, and the quality of the maps coming out today, by using advanced techniques and technologies is quite good.

However, we do what we measure, and while FEMA has made progress on the quality of mapping inventory, there's been little or no progress on expanding that inventory to map the Nation as the law requires. The fact is only 1/3 of our streams, rivers, and coastlines in the country are mapped. No appreciable mapping has occurred of future conditions, and while there's been some mapping of residual risk areas in the country, the data's not being reflected on FEMA's flood maps, and it's generally not publicly available. We can sympathize with FEMA's dilemma, because to fully implement the vision of the National Flood Mapping Program—because Congress must appropriate those resources to get the job done.

Earlier this month ASFPM released our updated cost analysis for fully implementing the National Flood Mapping Program. A copy of that has been included with our testimony. While the costs are large, the cost of inaction and flood losses are much larger. The cost to get the job done is less than the cost of 6 months of flood disasters occurring in the United States. By investing in flood mapping now, we can avoid the increasingly large bill for unwise development decision and disaster losses later.

In closing, I want to mention that our written testimony identifies some key points—or key inputs into flood models and flood mapping. Please understand that having accurate flood maps to make the country more resilient requires not only a resourced and functioning National Flood Mapping Program, but we must also have accurate information establishing rainfall frequencies, probable maximum precipitation estimates, create and maintain a robust network of stream gauges, and have tools to help our coastal and inland floodplain managers to be more effective, such as the digital coast website. Our testimony identifies several recommendations for you to take action. Thank you.

[The prepared statement of Mr. Berginnis follows:]

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TESTIMONY

An Examination of Federal Flood Maps in a Changing Climate

Before the

House Committee on Science, Space and Technology
Subcommittee on the Environment & Subcommittee on Investigations and Oversight

By

Chad Berginnis, CFM
Executive Director
Association of State Floodplain Managers

February 27, 2020

Introduction

The Association of State Floodplain Managers is pleased to participate in this hearing to explore how flooding and sea level rise affect American property owners, how the Federal Emergency Management Agency (FEMA) uses science to inform its flood products, and whether additional federal resources are needed to research and communicate future flood risk to the public. We are especially pleased that Congress is exercising its oversight function as it examines the National Flood Mapping Program at FEMA and we appreciate the opportunity to discuss our views and recommendations for the future of the program. We thank you, Chairwoman Sherrill, Chairman Foster, Ranking Member Marshall, Ranking Member Norman and Members of your Subcommittees for your interest in this important subject.

ASFPM is a national nonprofit scientific and educational organization whose mission is to reduce flooding and to recognize the inherently important functions of our natural floodplains. ASFPM and its 37 chapters represent more than 20,000 local and state officials, private sector, academia, and other professionals engaged in all aspects of flood risk management and flood hazard mitigation, including management of local floodplain ordinances, flood risk mapping, engineering, planning, community development, hydrology, forecasting, emergency response, water resources development, protection of valuable floodplain functions, and flood insurance. All ASFPM members are concerned with reducing our nation's flood-related losses. For more information on the association, visit our website at *www.floods.org*.

Our Nation's Flood Risk is Increasing Dramatically

Floods are the nation's most frequent and costly hazard. The cost to taxpayers continues to increase at an alarming rate. ASFPM estimates average annual flood losses were about $5.6 billion in the 1990s. This increased to an average annual flood loss of $10 billion in the 2000s, and in this past decade came close to doubling again with a conservative estimate of $17 billion per year.

Climate change is manifesting itself in several ways as it relates to flood risk. But the two primary ways are sea level rise and more intense storms. For instance, a 2016 study updated the estimates on the amount of ice melting in Antarctica and concluded that the increase in sea level may be twice the level that was previously estimated. And, an additional source of uncertainty is the willingness and ability of the world's nations to change the trajectory of climate change. The success of agreements like the Paris Climate Conference and future agreements hold the potential to mitigate some of the projected impacts of climate change. It

appears there is increasing consistency in new scientific investigations that we have likely underestimated the amount of future sea level rise and that it is likely accelerating faster than originally projected.

In inland areas all across the country, local officials are observing more intense rainfall events. And this is showing up in the data, too. Warming conditions mean more water vapor in the air. When rain-triggering conditions are favorable, more saturated air leads to heavier precipitation. One public works official from Arkansas recently noted "It was easier when we could plan for and put in stormwater infrastructure that can handle one to two inches of rain each hour, but now we are seeing events where you might get four inches of rain in a half hour, and I am not sure how we are going to handle that." Recent research by Climate Central reinforces this observation, showing an upward trend with more days with significant rainfall events. These more intense rainfall events have resulted in an increasing threat of urban flooding, essentially when there is too much water for the local stormwater system to handle. The ASFPM Foundation recently released a report on urban flooding which concludes that much of the work to address the issue needs to happen at the state and local level; however, federal resources and assistance, including a national assessment can be an appropriate role for the federal government.

How Does Flooding and Sea Level Rise Affect Property Owners?

Flooding and sea level rise affect many property owners nationwide. Unfortunately, for those less fortunate who have little financial ability to move out of high risk areas, many federal policies create a moral hazard as well. Recent studies estimate that as many as 60 million people live in flood hazard areas—whether it be the 1% annual chance (100-year) floodplain or the .2% annual chance (500-year) floodplain. This does not account for the other flood hazard areas such as storm surge zones, tsunami zones, residual risk areas as a result of impoundment or the release of waters from dams, residual risk areas from levee failures and an increasingly impactful urban flooding threat. Indeed, flood risk is far more widespread than is perceived or known. Through flood hazard identification, the flood risk can be better known, but as a society, we are not doing enough to reduce flood risk until it is often too late and a flood is bearing down on an area. Individual property owners are affected differently from flooding risks and sea level rise depending on the actions that they have or have not taken to reduce that risk.

Consider the plight of the low income renter who finds HUD subsidized housing in a flood hazard area. While rent may be cheaper, federal policy has created a moral hazard whereby those in society who can least withstand the impact of a major flood are placed squarely in harm's way. Or consider the first time homeowner who just a day before closing finds out that the property is in a special flood hazard area, and flood insurance is required on their mortgage. Typically, the news is not well received; however, some of those property owners who later face a damaging flood become true believers in the importance of flood insurance. Others spend large amounts of time and effort fighting the flood zone determination because they do not believe they are at risk. Indeed, social scientists tell us that as individuals we tend to think of low frequency, high impact events in an irrational way, often thinking it will not happen to us...until it does. Small business owners are particularly vulnerable as most of their liquid assets are tied up in their business and flood insurance is often not a consideration. Yet data shows that 40-60% of small businesses never reopen after a disaster. There is the ongoing struggle between community leaders who potentially face the loss of tax base when thinking about solutions that would reduce the occupancy of the floodplain through buyouts or long term land use planning, even though such options are in the best interest of the property owner. And there is the plight of existing at-risk property owners who, due to lenient floodplain management standards in their own community, are put at increased risk from new development because the standards and community do not account for off-site impacts. Our members often work with those who have previously flooded, and we often see impacts largely hidden from the disaster cost tallies such as heightened anxiety, suicide, stress, and other emotional and health impacts.

Living in and around floodplains is complicated and there are constantly competing priorities. When it comes to floodplains, there are no great solutions. Instead you are choosing the least worst solution. A reality that is too often overlooked is the simple fact that flood hazard areas exist regardless of maps and ultimately it is a very hazardous area.

The future flooding condition (including sea level rise) is bleak for many of the nation's communities and at-risk property owners, especially those on the coast. In a 2016 Insight report, Sean Becketti the Vice President and Chief Economist of Freddie Mac wrote the following:

> While technical solutions may stave off some of the worst effects of climate change, rising sea levels and spreading flood plains nonetheless appear likely to destroy billions of dollars in property and to displace millions of people. The economic losses and social disruption may

> happen gradually, but they are likely to be greater in total than those experienced in the housing crisis and Great Recession. That recent experience illustrated the difficulty of allocating losses between homeowners, lenders, servicers, insurers, investors, and taxpayers in general. The delays in resolving these differences at times exacerbated the losses. Similar challenges will face the nation in dealing with the impact of climate change.

Among the several issues the report ponders, one relates to the equity in a person's home. If those homes become uninsurable and/or unmarketable, the value of the homes will plummet, perhaps to zero. Unlike after the Great Recession, homeowners will have no expectation that the values of their homes will ever recover. Especially when it comes to sea level rise, how will the housing finance system work for properties that today are dry but in 30 years—the duration of a mortgage—will largely be wet due to tides or outright continuous inundation? At what point will lenders stop providing loans in these areas?

In the 2018 report *Underwater: Rising Seas, Chronic Floods, and the Implications for US Coastal Real Estate* by the Union of Concerned Scientists, several conclusions should raise alarm:

- Accelerating sea level rise in the lower 48 states, primarily driven by climate change, is projected to worsen tidal flooding, putting as many as 311,000 coastal homes with a collective market value of about $117.5 billion today at risk of chronic flooding within the next 30 years—the lifespan of a typical mortgage
- The consequences of chronic flooding of properties in specific communities could translate not just into eroding property values, but also into unlivable houses and falling tax revenues that fund schools, roads and emergency services in those places. The properties at risk by 2045 currently house roughly 550,000 people and contribute nearly $1.5 billion toward today's property tax base. These numbers jump to about 4.7 million people and $12 billion by 2100. Municipalities are looking at even deeper revenue declines when commercial property, sales, and other business tax losses are factored in.
- With chronic inundation, homeowners and owners of commercial properties are directly at risk of significant financial losses as the value of their properties declines. Such losses have ramifications for the local community, which could see its property tax base eroded and its ability to fund local services compromised. There will also be implications for the wider economy, including for banks with outstanding mortgage loans on properties at risk of inundation, coastal property developers, investors and insurers, business owners whose places of business may face flooding, and US taxpayers, broadly, who may face increased taxes to pay for measures to cope with flooding and to reduce flood risk.

So the ultimate question from a public policy standpoint is how do we get property owners and communities ready for a future where flood risk is more significant and in some areas predictably far worse? What adjustments do we need to make in our approach to flood risk management to increase awareness of hazards and align our policies and programs to ensure a high degree of resiliency as communities face tough choices about where to grow and where to invest? Experience tells us that at the community scale, flood resilience is a multi-decadal process. The most progressive communities in the country, such as Charlotte, North Carolina or Tulsa, Oklahoma have been "mitigating" flood risk for three decades or more and still much remains to be done.

Data, Analysis, and Information – An Appropriate Federal Role

If we do not have robust systems in place to provide updated and anticipated hydrologic data, flood maps, and reliable topography (and to provide sufficient resources going to research and development), we will simply never get ahead of new development in flood risk areas and create more properties at risk from flooding. ASFPM believes that that one of the most important roles the federal government can undertake in flood risk management is to provide data, analysis and information for the nation. For better or worse, the enterprise of providing current, actionable flood data is a cooperative effort among several federal agencies. Before delving further into the NFIP itself—and FEMA's role—it is important that the subcommittees understand the overall framework under which flood risk information is generated.

One trend that we are seeing across the country is that rain events are getting more intense. To compound matters, our nation tends to use outdated hydrology which only further underestimates the risk. Hydrologic information is the key input into flood models which produce flood risk data and flood maps. Traditionally, the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) has the responsibility for updating precipitation frequency estimates for various parts of the United States and affiliated territories. Updated precipitation frequency estimates, accompanied by additional relevant information, are published as "NOAA Atlas 14" and are available for download from the Precipitation Frequency Data Server (PFDS). This data is used in everything from hydrologic modeling for producing flood maps, to thousands of design decisions every day for development and redevelopment in our communities, highways and other infrastructure throughout the nation. However, NOAA has neither the budget nor clear mandate to provide this in a timely way. In fact, a note in NOAA's most recent progress report extending through March 2019 indicated

that "No funding is available to extend NOAA Atlas 14 coverage to the remaining five northwestern states: ID, MT, OR, WA, WY in Volume 12.[1]"

Consider the new Atlas 14 data for Texas which was issued in the fall of 2018. That data basically determined that the previous 100-year rainfall amounts for Houston is now about a 25-year event. In Austin, the previous 100-year rainfall amount is now about a 50-year event. As one of ASFPM's Texas members put it, "pretty much all of the flood maps in the state of Texas are now outdated." And this particular Atlas 14 update was not even looking at the future. Rather it is updating 40-50 year old data that was developed in the 1960s and 1970s. ASFPM is supportive of current NOAA efforts to test the feasibility of incorporating future climate projections into precipitation frequency analysis examining the inclusion of such data into future Atlas 14 updates.

- **NOAA should be given the mandate and full budget to update our nation's rainfall frequency information at least every 10 years and this update must include future climate projections into precipitation frequency analysis.**

Stream and tidal gages are the stethoscopes of our hydrologic network and are another important input into flood models and maps. Ask any local official about a critical data need and most will say that there needs to be more streamgages. Yet funding for even those deemed critical by the federal government is in short supply. For example, the Federal Priority Streamgages (FPS) Network (previously known as the National Streamflow Information Program) was conceived in 1999 to be a core, federally funded network. The original network design included 4,300 then active, previously discontinued, or proposed new gages that were strategically positioned across the country to address long-term Federal information needs (such as supporting NWS flood forecasts, or interstate and international compacts and decrees). At present (2018), more than 4,700 locations meet the criteria for inclusion in the FPS network, but only about 3,600 FPS streamgages are active because of funding limitations. These active FPS are supported through a combination of Federal and partner funding—less than one-quarter are fully funded by Congress through the United States Geologic Survey.

- **Congress should fully fund our critical national stream gauge and tidal gauge networks.**

Today's flood maps are based on models that incorporate hydrologic information and topographic information. Good progress has been made in the last decade on high quality

[1] Hydrometeorological Design Studies Center Progress Report for Period OCTOBER 2018 to MARCH 2019, page 4.

topographic information for the nation through the United States Geological Survey (USGS) 3 Digital Elevation Program (3DEP). These high quality topographic data inform critical decisions that are made across the nation every day ranging from immediate safety of life, property and long-term planning for infrastructure projects. Currently at 60% complete, the goal of 3DEP is to complete the acquisition of nationwide high resolution elevation data by 2023.

- **Congress should ensure that the USGS 3DEP program is fully funded to provide high quality topographic information for the entire nation.**

Even if good flood data is developed, there are some policy hurdles preventing it from being publicly available. For example, ASFPM was pleased with the release of the US Army Corps of Engineers (Corps) new policy on Emergency Action Plans (EAPs) which requires several types of flood inundation mapping (EC 1110-2-6074). This policy standardizes inundation mapping (maps showing the areas that will be flooded when the dam or levee fails or is overtopped), and establishes inundation mapping requirements for dams and levees. In theory, having inundation mapping available to the public can help avoid debacles like those witnessed around Barker and Addicks Reservoirs post-Harvey in Texas, when thousands of homes in inundation areas of those structures were impacted. Had local land use planners, property owners and others been aware of these risks, additional steps could have been taken to reduce that risk. The new EAP policy, however, includes the following statement: *EAP maps are considered sensitive data and must be marked "For Official Use Only" according to AR 380-5 and DoDM 5200.01.* In other words, inundation maps associated with EAPs are still not publicly available. Why would we be withholding this vital information on flood risk from property buyers and owners?

The 2016 TMAC report National Flood Mapping Program Review, identified a legacy DHS policy through its Security Classification Guide for the Protection of Critical Infrastructure and Key Resources, which listed dam failure inundation maps as "For Official Use Only." However, this policy conflicts with the National Flood Mapping Program requirements that such areas be provided on Flood Insurance Rate Maps and on publicly-available databases such as National Levee Database (NLD) and National Inventory of Dams (NID). As noted in the report, a Virginia law passed in 2008 essentially requires that all inundation mapping developed for state-regulated dams be made available to communities and the public. This has now been implemented for a decade without issues and state officials there believe in supporting wider public availability of this data. More recently, when speaking to agency officials, there has been

a mistaken belief that this issue had been dealt with. It is clear to ASFPM that it has not and the unwillingness of agencies to act on it demands congressional intervention.

- **Congress should mandate that any flood risk data, including all dam/levee inundation mapping, developed by the federal government and/or associated with any federal program be made publicly available.**

More recently, flood risk data, and in particular flood insurance claims data, has been more difficult to obtain from FEMA as a result of FEMA's evolving compliance with the Federal Privacy Act. These data help inform local mitigation plans, can provide heat maps on claims hotspots, are needed to apply for and administer flood mitigation grants, property disclosure, and are useful in communicating flood risk. Given that some flood mapping programs are beginning to incorporate structure specific information, the lack of available claims data and the inherent conflict between the benefits of communicating these data and the Privacy Act need to be resolved.

For the past decade, a novel approach to data management, tool development and data dissemination has been piloted at NOAA through the Digital Coast Partnership. Developed and maintained by NOAA, hundreds of organizations and federal, state, and local agencies have contributed to this curated collection of high-quality authoritative data and tools focused on coastal and ocean issues. "More than Just Data" is the slogan of the Digital Coast because data alone is not enough, especially when users of that data do not know how it can be used, or what steps to take to get information they need. Digital Coast tools and training help users turn data into powerful information that continues to increase the coastal knowledge of our nation.

For example, one of the most popular tools being used by practitioners today on the Digital Coast website is the Sea Level Rise viewer. ASFPM was a founding member of the Digital Coast Partnership and strongly believes that to better understand the future flooding risk in coastal areas and manage that risk, programs like Digital Coast will be vital.

- **Congress should pass the Digital Coast Act.**

Federal Agency / Programs and Policies

There are numerous programs and federal agencies that address the threat of flooding and floodplain management. As part of a research project in 2012, ASFPM analyzed more than 130 federal programs that had some impact on the use and development of floodplains. ASFPM works with many of the federal agencies in addressing flood risk whether it be through commenting on statutory authorities or policies, serving on task forces or advisory groups, or using our own power to convene agencies so they can work together to address cross-cutting issues.

We would like to highlight a key federal coordinating entity. In 1975, Congress established the Federal Interagency Floodplain Management Task Force (FIFM-TF). Its purpose was to carry out the responsibility of the president to prepare for the Congress proposals necessary for a Unified National Program for Floodplain Management. For more than 40 years, some form of an interagency group has worked to better understand the appropriate roles of local, state and federal governments in reducing flood losses, the interactions between human actions and natural systems in the floodplain environment and to make recommendations to reduce the loss of life and property caused by floods. Also, the task force is useful to identify and address policy or programmatic conflicts among federal agencies that may be resulting in poor floodplain management decisions. The main report of the FIFM-TF, a Unified National Program for Floodplain Management was first written in 1979, then updated in 1986 and last updated in 1995. Unfortunately, the report hasn't been updated in almost 25 years while the threats resulting from flooding have exploded. Not only is research showing significant social impacts of flooding, new flooding types like urban flooding are emerging.

Today, the FIFM-TF is still operational; however, it is under resourced and not as effectively utilized as it could be. One concern expressed by the subcommittees was the state of federal coordination on flood science, mitigation and risk communication. The FIFM-TF, if properly resourced, and enabled, could serve capably to enhance these functions.

The NFIP is a National Comprehensive Flood Risk Reduction Program

Central to the nation's efforts in managing flood risk is the National Flood Insurance Program (NFIP). It was created by statute in 1968 to accomplish several objectives. Among other things, the NFIP was created to:

- Provide for the expeditious identification of and dissemination of information concerning flood-prone areas through flood mapping

- Provide communities the opportunity to voluntarily participate in the National Flood Insurance Program in order for their citizens to buy flood insurance and, as a condition of future federal financial assistance, to adopt adequate floodplain ordinances consistent with federal flood loss reduction standards
- Require the purchase of flood insurance in special flood hazard areas by property owners who are being assisted by federal programs or by federally supervised, regulated or insured lenders or agencies (mortgages from federally backed lenders).
- Encourage state and local governments to make appropriate land use adjustments to constrict the development of land exposed to flood damage so homes and businesses are safer and to minimize damage caused by flood losses and reduce future taxpayer costs for disasters
- Guide the development of proposed future construction, where practicable, away from locations threatened by flood hazards (avoidance of high risk flood areas)
- Authorize a nationwide flood insurance program through the cooperative efforts of the federal government and private insurance industry
- Provide flexibility in the program so flood insurance may be based on workable methods of distributing burdens equitably among those protected by flood insurance and the general public who benefit from lower disaster costs

Beyond merely providing flood insurance, the NFIP is unique as it integrates multiple approaches for identification of flood risk, communication of risk, and techniques to reduce flood losses and to mitigate existing flood risk. It is a unique collaborative partnership enlisting participation at the state and local level. It is a multi-faceted, multiple objective program—a four-legged stool, as it is often called. The four legs of the stool are (1) floodplain mapping, (2) flood standards, (3) flood hazard mitigation and (4) flood insurance. Altering one leg without careful consideration of impacts on the other three legs can have serious repercussions on reducing flood losses. NFIP on the whole provides substantial public benefits as it is, in effect, a national flood risk management program.

Floodplain Mapping under the NFIP

In addition to being an important part of the NFIP, floodplain mapping is the foundation of all flood risk reduction efforts, including design and location of transportation and other infrastructure essential to support businesses and the nation's economy. The flood maps are also used for emergency warning and evacuation, community planning, and locating critical facilities like hospitals and emergency shelters. Floodplain mapping is cost-effective with at least a 2-to-1 taxpayer benefit, and floodplain maps support communities' resilience actions. Inasmuch as flood maps identify areas where new development must be built to NFIP construction standards, flood maps reduce disaster costs as such structures suffer 80% less damage than those that are not built to NFIP standards.

For most of the history of the NFIP, flood mapping was done to primarily support two functions of the NFIP: flood insurance rating and floodplain management standards. As a result, two pieces of data were typically produced: the 100-year and the 500-year flood. However, as the NFIP grew and as flood risk management became more important, the nation's citizens looked to the FEMA flood maps as the primary source of any kind of flood risk information for a given area. In 2012, Congress, for the first time, authorized a National Flood Mapping Program (NFMP) as part of the NFIP reform legislation which took this more expansive view of flood mapping. It required, among other things, several new, mandatory types of flood risks to be shown on the nation's Flood Insurance Rate Maps (FIRMs) beyond the 100-year and 500-year flood including:

1. All populated areas and areas of possible population growth located within the 100-year and 500-year floodplains;
2. Areas of residual risk, including areas that are protected by levees, dams, and other flood control structures and the level of protection provided by those structures;
3. Ensuring that current, accurate ground elevation data is used;
4. Inclusion of future conditions risk assessment and modeling incorporating the best available climate science; and
5. Including any other relevant data from NOAA, USACE, USGS and other agencies on coastal inundation, storm surge, land subsidence, coastal erosion hazards, changing lake levels and other related flood hazards.

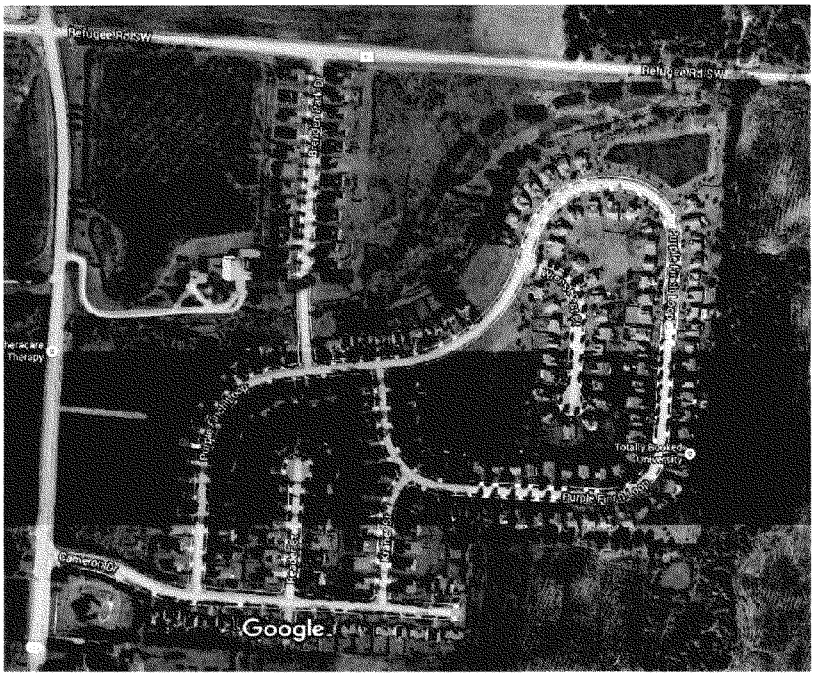
Unfortunately, ASFPM is not aware of any single flood map in the entire country that exists today where all of these data sets exist on either a FIRM panel or in the accompanying data FEMA provides. Therein lies the problem. We have had a National Flood Mapping Program authorized since 2012, but many key elements have not been implemented. In fairness to FEMA since 2012, progress has been made on improving the quality of the existing flood maps, in use of high resolution topography, and in the area of communicating information to communities and the public (either through the mapping process itself or through technologies and tools). Nevertheless, we believe these additional elements are essential for an effective national flood mapping program.

What is the gap then? ASFPM believes that the gap lies in getting the job done initially mapping the nation. Consider:

- Based on the National Hydrography Dataset (NHD) and NOAA shoreline data, there are approximately 3.5 million miles of streams and rivers, and 95,471 miles of coastlines in the nation. **Currently, only 1.14 million stream miles and 45,128 shoreline miles have flood maps. By this metric, only about 1/3 of the nation has been mapped**.
- **Over 3,300, or roughly 15%, of NFIP communities have maps over 15 years old, with many of these over 30 years old and still having "un-modernized" paper maps.**
- **Many of the added mapping requirements from 2012 haven't even been started beyond studies and research.** This includes residual risk mapping around flood control structures and future conditions mapping. A 2016 TMAC report reviewing the National Flood Mapping Program stated *"To create technically credible flood hazard data, FEMA needs to address residual risk areas in the near term. Residual risk areas associated with levees and dams are of great concern."*

ASFPM believes this gap in data is contributing significantly to the increasing flood losses in the nation. A 2018 study shows that the total US population exposed to serious flooding is 2.6–3.1 times higher than previous estimates, and that nearly 41 million Americans live within the 100-year floodplain (compared to only 13 million when calculated using FEMA flood maps). This translates into 15.4 million housing units. The same study indicates that over 60 million people live in the 500-year floodplain.

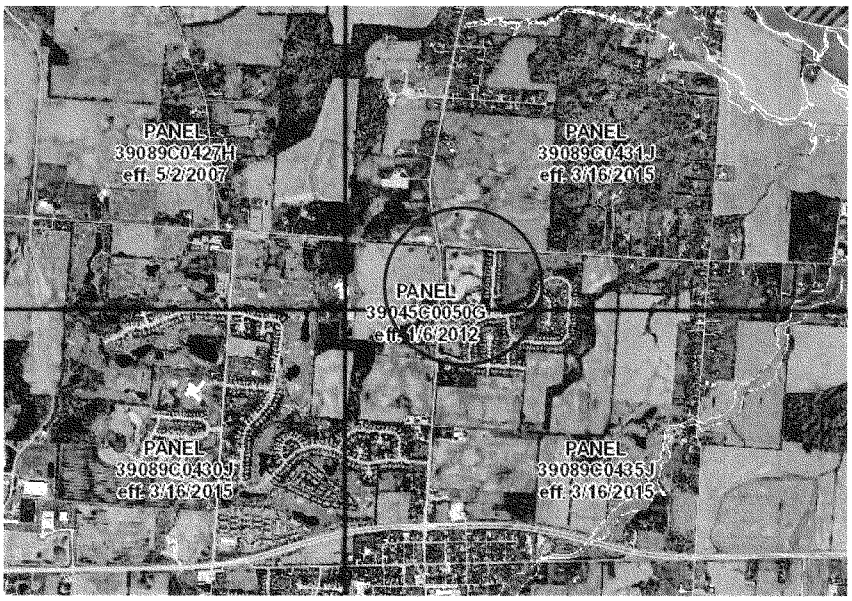
To better understand the gap between what is mapped and what needs to be done to finish the job, here is a specific example. Cameron Chase is an 87-acre residential subdivision developed in the early 2000s in Licking County, Ohio. It is 17 miles from downtown Columbus, Ohio (metro area population 2+ million). An unnamed stream flows through the subdivision:



(Above: Aerial view of Cameron Chase division, Etna Township, Licking County Ohio. The unnamed stream is highlighted as the dashed blue line)

The unnamed stream is not mapped on the FEMA maps that were effective at the time, and even on today's maps. Why? The old guideline for mapping these small streams was that you needed about 10 square miles of land draining into the stream for it to reach a threshold for FEMA mapping in rural areas. In the case of this tributary, it only had about 760 acres, or just

over one square mile of drainage. Also, the land previously had been a cornfield, and as a result it never had enough property at risk for FEMA to map prior to development.



(Above: Portion of FEMA FIRM Index Panel for Licking County, Ohio. The Cameron Chase subdivision is circled; note that the unnamed stream <u>does not have a FEMA mapped floodplain</u> – it does not show up until several miles downstream)

Luckily, Licking County is one of the rare communities in the nation that has strong local floodplain management regulations exceeding federal minimum standards and the regulations required the developer to map the floodplain on any stream where one wasn't identified. So prior to development, a flood study (similar to one that FEMA would prepare) was completed. The result? A 100-year floodplain that ranged from 150 feet wide to 300 feet wide and, more importantly, a map to guide the proposed development and ensure that local flood protection standards applied. But most communities do not have such standards, and what happens then? The development occurs with no flood standards. What you see happening with

Cameron Chase is happening in thousands of subdivisions across the country: areas that were once cornfields and cow pastures are developing into tens of thousands of housing units. Later, after there is significant development at risk and often after a flood or two, FEMA comes in and maps it. Then the dynamic changes and everything becomes adversarial. People think FEMA put a floodplain "on them," when it was there all along. The property owner is angry because they have to buy flood insurance at high premiums because flood elevations were previously unknown. Realtors are upset because it is a surprise and may have an impact on the future salability of homes. And local elected officials fight to minimize the size of the mapped floodplain, spending thousands of dollars on competing flood studies.

Why, then, is there such a gap in the extent of flood hazard identification? ASFPM believes there are several reasons for this.

Funding. Direct appropriations for flood mapping has varied significantly since the inception of the NFMP from a low as $89 million in FY 2013 to a high of $262.5 million in FY 2019. In ASFPM's recently released *Flood Mapping for the Nation* report, we estimate it will cost between $3.2 billion and $11.8 billion to "complete" the flood mapping in the nation, and then the steady-state annual cost to maintain this flood map inventory will be between $107 million and $480 million. Currently the NFMP is authorized at $400 million in annual appropriations. The bottom line is that to complete the initial job of mapping the nation consistent with Congress' mandate, more funding needs to be appropriated by Congress both in the form of a higher authorized amount for the NFMP and higher annual appropriations.

Existing program momentum and metrics. Prior to the NFMP being authorized by Congress, FEMA had just initiated a new flood mapping program called RiskMAP. However, in the years since, it did not appear that RiskMAP program nor its program metrics were ever re-evaluated or incorporated these important new mandates from Congress. Further, flood mapping priorities have been complicated by over 100 recommendations from the Technical Mapping Advisory Council which included the identification of additional mapping priorities such as structure specific information and graduated risk zones for insurance rating purposes. With no Congressional oversight, more requirements than funding and a new RiskMAP program, there was little impetus to focus on the required mapping elements under the NFMP.

Unfortunately, the adaptation of RiskMAP metrics ended up resulting in considerable confusion as to the status of flood mapping in the nation. Here are the two most egregious examples. The administration's proposed budget for FEMA in 2021 indicates that 98% of the population

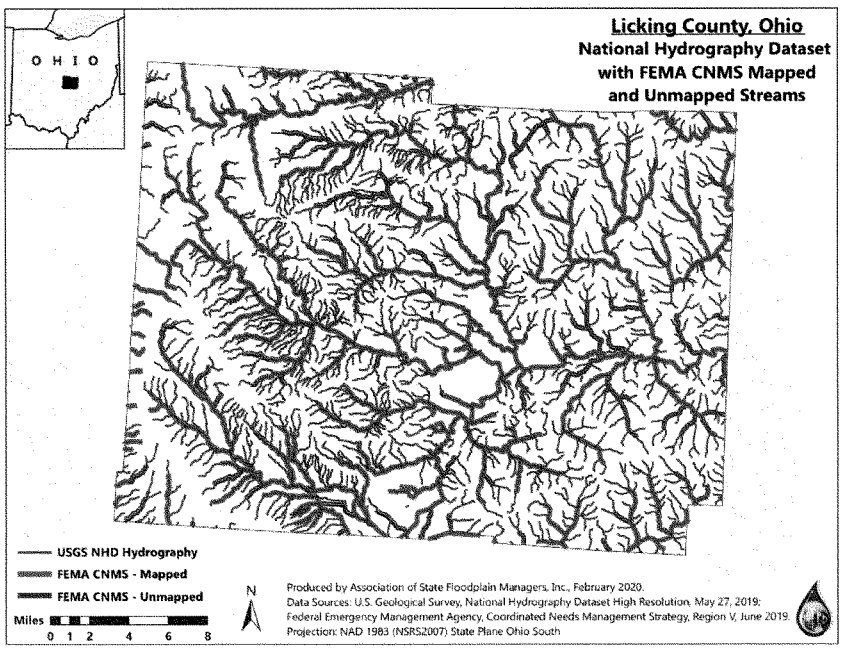
has been mapped (this is a metric FEMA's leadership has used as talking points on the topic). This metric, however, grossly overstates the population covered. This problem is discussed in the 2015 TMAC Future Conditions Assessment and Modeling report:

> *However, this population metric has two challenges for moving forward. First, the metric over-predicts the population covered by a modernized map. FEMA generally studies streams that drain a drainage area of greater than one square mile. If a census block group has 10 miles of stream and only 1 mile is studied, the current metric will count 100 percent of the population within the census block group as being covered by a modernized map, as opposed to the 10 percent that may actually be covered. Therefore, the current metric can lead to a significant over-prediction of the population covered by a modernized map. This could lead policy makers to believe that flood hazards have been more widely identified than the reality. If the metric is changed to be more reflective of the streams studied within a census block group, then it may more realistically illustrate that the country has flood hazard areas defined for only somewhere* ***between 16 percent and 22 percent of all streams.*** [EMPHASIS ADDED]

The bottom line is that the deployment metric has been grossly misapplied and should be replaced or supplemented with a metric based on the number of stream miles studied in the nation. A program does what it measures and if we aren't measuring the number of stream miles mapped, it is hard to envision mapping for the entire nation ever getting done.

In recent years, FEMA has also discussed its work towards meeting the New, Valid, or Updated Engineering (NVUE) metric over the past several years with the goal being 80% NVUE compliant. For this metric, it is important to understand what NVUE is and what it is not. It is a metric to assess the quality of the existing FEMA flood map inventory. And FEMA's flood map inventory overall has improved significantly. It is not, however, a metric to understand how much of the nation has flood mapping. The NVUE percent attained is a ratio of all NVUE study miles divided by the total miles in FEMA's mapped inventory. That means when FEMA attains 80% NVUE, it means that only about 910,000 miles of flood mapping have updated or valid studies, the remaining 230,000 miles have not been updated, and 2.36 million miles have not been mapped at all. Also, even on NVUE-attained stream miles, it is important to remember that these have not been evaluated to be "valid" when it comes to residual risk zones or future conditions. Too often, though, NVUE gets confused with completing the job of mapping the nation.

Again using Licking County as an example, the following map shows that there are 1,032 stream miles and approximately 463 of those miles are mapped (less than 50%). Because FEMA considers Licking County to have a modified digital FIRM, all of the population of the county contributes to the 98% digital data (deployment) metric. All of the blue and red streams are those that need mapping in Licking County, Ohio and nearly all of that land, especially in the western part of Licking County, is suitable for and will likely result in future residential and commercial development.



Recognition of other federal, state and local data. In doing research for the updated Flood Mapping for the Nation report, ASFPM was concerned when we discovered that it appeared

that FEMA had not really progressed when it came to the number of stream miles mapped in the country since the time the original report was published in 2013. Yet the FEMA Administrator's 2016 Report to Congress on TMAC Recommendations identified the completion of "large scale automated engineering for 45,000 stream miles." ASFPM believes this is a reference to the base level engineering (BLE), an innovative automated flood mapping process that provides high quality, low cost flood risk information for non-urbanized areas. More recently ASFPM inquired as to whether these BLE miles were included in FEMA's flood mapping inventory and were told they were not. Further, some states have active flood mapping programs. Indiana, for example, recently completed a milestone in their state – all streams up to a square mile of drainage have been mapped. Unfortunately, these additional miles are not included in FEMA's inventory. According to the state flood mapping coordinator, it is difficult and inefficient to tell property owners that not only do they need to look at FEMA's flood maps/inventory, but they need to look at the state's inventory as well. ASFPM suspects that progress has indeed been made on increasing the number of stream miles mapped nationwide and urges FEMA to determine how their systems can serve up and account for these additional mapping activities.

Inclusions under the NFMP are tied to the Flood Insurance Rate Map (FIRM) which is problematic. Since the early days of the NFIP, the primary "map" that people are familiar with is the FIRM. Yet, today, digital databases serve up "layers" of flood hazard data. For example, FEMA's National Flood Hazard Layer (NFHL) serves up not only flood map data such as the 100-year or 500-year floodplain, but also information such as Coastal Barrier Resource System (CBRA) zones. Unfortunately, under the NFMP, all of these data are to be provided on the FIRM which provides for logistical challenges and could further delay the actual release of these data. The point is that at a minimum, FEMA should be able to collect, include, track and count for the purposes of metrics, data that it generates like BLE and data from other agencies such as residual risk inundation mapping from the Corps of Engineers (mentioned earlier) which would meet the intent of providing residual risk mapping information for the purposes of the NFMP. These additional flood risk datasets could be provided through mechanisms like the NFHL.

- **As part of the reauthorization of the NFIP, Congress should increase the authorization of the National Flood Mapping Program to at least $600 million annually.**
- **A metric must be developed for National Flood Mapping Program that measures the completeness of the required mapping elements for the entire nation.**

- **FEMA should prioritize the elimination of the paper map inventory and the modernization of all un-modernized maps.**
- **FEMA should establish national program performance standards and include various flood hazard related data layers for all flood hazard-related data layers (residual risk, base level engineering, future conditions, erosion, subsidence, closed lake basins, frazil ice, ice jams, tsunamis, debris flow and mud slides, relevant wetland and groundwater) so that data created by state, local, and other mapping partners can be readily utilized by FEMA and incorporated into the National Flood Hazard Layer and FIRMs as necessary.**
- **FEMA should develop a program and timeline to ensure future conditions flood data and residual risk data are incorporated into every new flood study.**

Cooperating Technical Partners Program

While part of FEMA's flood mapping effort, it's very popular Cooperating Technical Partners (CTP) program is a mechanism whereby states, tribes, regional agencies, communities, and universities can assume delegated flood mapping responsibilities in accordance with their capabilities. This partnership capitalizes on the interest, capability and most importantly local knowledge of flood mapping issues. From a risk communication standpoint, CTPs are often viewed as a trusted source of local knowledge. For example, when a CTP is introducing a preliminary flood map in a community, there is more ownership in the products by the community which can, in turn, fundamentally change the "us versus FEMA" mentality. Previously, legislation has been introduced in Congress to somehow create a mechanism for states and communities to produce flood maps. ASFPM believes that such legislation is not needed and efforts should be made to strengthen the existing CTP program instead.

DHS Flood Apex R&D Program

One deficiency ASFPM has noted is that unlike other science and regulatory agencies, FEMA does not have a robust research and development (R&D) capacity. While FEMA does well in some regards incorporating some of the best available science and technology when applied to the flood mapping program in particular, ASFPM believes that this ability is hampered by not having an internal R&D capacity. This, in turn, leads to not having an intentional R&D agenda. Intentionality is the key.

The Department of Homeland Security Science and Technology Directorate's Flood Apex Program was created in 2016 at the request of the Administrator of the Federal Emergency Management Agency (FEMA) to bring together new and emerging technologies designed to increase communities' resilience to flood disasters and provide flood predictive analytic tools

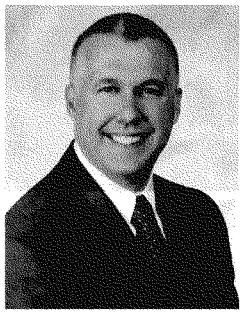
to FEMA, state and local governments, and other stakeholders. The program has a particular focus on new and emerging technologies including activities that focus on developing them. For example, one project is focused on using time-series satellite imagery to compliment flood risk mapping and visualizations. Another is using high performing and artificial intelligence to detect physical buildings from satellite images to develop a national inventory of structures in the floodplain. In short, Flood Apex has been a capable approach to addressing FEMA's R&D needs and could be of significant support to the flood mapping program in the future. Unfortunately, this program is slated to expire in FY 2021.

- **Congress should ensure that there is a specific function within DHS Science and Technology dedicated to Research and Development activities for flood loss reduction and ensure that FEMA's R&D needs are met.**

In Conclusion

Floods are this nation's most frequent and costly natural disasters and the trends are worsening. Comprehensively identifying the flood hazards in the United States is the foundational step that must be taken in order to have effective flood risk reduction policies and programs. As our testimony identifies, though, the pathway to providing that information involves multiple agencies and programs. While FEMA flood maps and their mapping platform may be the ultimate point of dissemination, we have already wasted too much time in developing a true national picture of flood risk.

ASFPM appreciates this opportunity to share our observations and recommendations with the Subcommittees. For any questions, please contact Chad Berginnis, ASFPM Executive Director, at *cberginnis@floods.org* (608 828-3000); or Merrie Inderfurth, ASFPM Washington Liaison, at *merrie@floods.org* (703 732-6070).



Chad Berginnis, CFM, is the Executive Director for the Association of State Floodplain Managers (ASFPM), a national non-profit organization of over 19,000 members and 37 state chapters whose mission is to promote policies, approaches, and activities that mitigate current and future losses, costs, and human suffering caused by flooding; and to protect the natural and beneficial functions of floodplains - all without causing adverse impacts.

Mr. Berginnis has 26 years of experience in various aspects of natural hazard management, flood loss reduction, and land use planning / programs at the state, local and private sector level. As a state official, Mr. Berginnis worked in the Ohio Floodplain Management Program and was Ohio's State Hazard Mitigation Officer. He was involved in creating/administering the Appalachian Flood Risk Reduction Initiative, administered the Community Assistance Program, authored a comprehensive revision of the model state floodplain management regulations, oversaw state hazard mitigation operations in three Federally declared flood disasters and authored the 2008 update of Ohio's mitigation plan. As a local official, Mr. Berginnis administered land use, economic development and floodplain management programs in Perry County, Ohio as well as assisted Perry County communities with their post-disaster floodplain management responsibilities following a major flood. In the private Sector, Mr. Berginnis was the national Practice Leader in hazard mitigation for Michael Baker Jr. Inc.

Mr. Berginnis is a recognized national expert in floodplain management and hazard mitigation, having participated on national research / focus groups, providing agency (FEMA, USACE, OMB, CRS, IG, CBO, various states) and Congressional testimony, and was selected to participate on an advisory panel to the Chinese Government on the development of a national floodplain management strategy. He recently served on a National Academies of Science committee on urban flooding. Chad is also currently an advisory board member for the Coastal Resilience Center at the University of North Carolina-Chapel Hill and for the Natural Hazards Center at the University of Colorado-Boulder. He is also past Insurance Committee Chair, Mitigation Policy Committees' Coordinator, Vice Chair, and Chair of ASFPM Mr. Berginnis holds a Bachelor of Science in natural resources from Ohio State University and is a Certified Floodplain Manager.

Ms. BONAMICI. Thank you all for your testimony. I know we all appreciate your expertise. Before we proceed to questions from the Members, I'd like to bring the Subcommittee's attention to five documents we have received in preparation for this hearing. The documents all speak to the importance of improving science inputs into Federal flood mapping and resilience efforts.

The first is a statement from Dave Rosenblatt, the Chief Resilience Officer and Assistant Commissioner for Climate and Flood Resilience at the New Jersey Department of Environmental Protection. The second is a letter from Dr. Rachel Cleetus and the Union of Concerned Scientists' Climate and Clean Energy Program. Third we have a statement from the Association of State Dam Safety Officials. And fourth is a report from Princeton University's Woodrow Wilson School of Public and International Affairs titled "Improving Coastal Resilience Toward a New National Flood Hazards Reduction Program". And, finally, we have a letter from CoreLogic, Inc., a corporation that provides risk analysis and other intelligence information to clients. Without objection, I'll place these documents in the record.

And at this point we will begin our first round of questions. The Chair recognizes herself for 5 minutes.

Well, thank you again to all the witnesses for being here today. According to the fourth National Climate Assessment, projected increases in inland flooding over the coming century is estimated to result in an average annual damages of $1.2 to $1.4 billion each year by 2050, and, as a result of sea level rise, coastal storms and high tides have already amplified coastal flooding and erosion. The Pacific Northwest, and my home State of Oregon, which I noticed on your map, Mr. Branfort, didn't have a lot of green in your LIDAR mapping, we have a challenging history of flooding. Some as a result of early snowpack melt, increased precipitation in warm temperatures in the spring. The mighty Columbia River, in fact, completely engulfed the community of Vanport in 1948. It crested 15 feet higher than the floodplain, jeopardized the livelihoods of thousands of residents. Then, in 1996, I remember this one, the Willamette River flooding saturated the region, resulting in evacuations, mudslides, and significant property damage.

In rural Columbia County in 1996 and 2007 there was serious flooding from the Nehalem River in Vernonia. It destroyed homes and schools in 2007, and then they had another major flood in 2015. And just earlier this month Oregon declared a state of emergency in several counties as a result of flooding that had already occurred this year. We can only expect that these events will become more extreme and more frequent with the climate crisis.

So, first, according to the National Academies report from last year titled "Framing the Challenge of Urban Flooding in the United States", FEMA mapping methods for river and coastal flood hazards do not currently consider distinctive urban flood hazards. So, Mr. Berginnis, how could FEMA better address the growing urban flood risk?

Mr. BERGINNIS. Urban flood risk is a topic that's evolving very significantly. Actually, when I go out and talk to our chapters, one of the things that has struck me over the last couple years is almost everybody says, you know, it's one thing we design our infra-

structure for one to two inches of rain an hour, but we're seeing rainfall events that give you three to four inches in a half hour. How do we deal with that? And the National Academies study is one of three studies, actually, that came out in the last 12 months or so. There's also one by the University of Maryland, and the ASFPM Foundation just released a report a couple weeks ago on that.

And I mention those because they're exploring different dimensions on it right now, in the practitioner community, there actually isn't a lot of agreement on how we address urban flooding. There's a couple takeaways that we have, I think, on the practitioner's side. One, the Federal Government can probably provide tools and resources, but there is a clear preference of not having something that emerges from the Federal Government that's regulatory. So—because a lot of the storm water management and the land use management associated with urban flooding is really done at that local and——

Ms. BONAMICI. Sure. It varies a lot, I'm sure, from——

Mr. BERGINNIS. Yeah, exactly.

Ms. BONAMICI [continuing]. Area to area.

Mr. BERGINNIS. So that would be—I would say that would be about the area of consensus right now, is kind of tools and resources, but not regulatory.

Ms. BONAMICI. Thank you. And, Mr. Osler, how could Federal science agencies, including NOAA, help FEMA better incorporate climate trends into urban flood risk assessments?

Mr. OSLER. I think one of the key areas where we can collaborate, I think, more closely is that we seek connections in the day to day at the practitioner level, but organizationally we have a greater need to be directed, I think, to have direct linkages. A lot of our programs between FEMA and NOAA are complementary, and they have grown up in recognition of each other, and yet that is a—that's people just paying attention to good government, as opposed to a strict mandate of how that linkage should happen and might happen.

Ms. BONAMICI. Thank you. I'm going to get another question in. The climate crisis is changing the frequency and intensity of flooding. Floodplains are no longer as static as perhaps they were when the National Flood Insurance Program was created in 1968. So, Mr. Berginnis, is focusing on whether a property is or is not in the 100- or 500-year floodplain an accurate use of the best available science, or is the 1 percent annual chance flood the most appropriate indicator of high flood risk areas today?

Mr. BERGINNIS. Well, again, there's a lot of debate, and, interestingly, there is a trend that we're starting to see some communities, especially those that are feeling the effects of climate change, moving to a higher standard, such as the 500-year flood elevation. Most recently Houston and Harris County have done that. The city of Austin is doing that temporarily, until they get new flood maps that reflect the current conditions.

Ms. BONAMICI. Thank you. And I'm going to try to set a good example and yield back the balance of my time. I have an additional question I'll submit for the record. Next I recognize Mr. Gonzalez for 5 minutes for your questions.

Mr. GONZALEZ. Thank you, Madam Chair, and for your consideration on the timeliness. So thanks for this hearing. I'm also on the Financial Services Committee, so we've sort of wrestled with this issue in that Committee. Good to see it here. It's obvious to me that this needs to be done in collaboration. It's clear to me that we have to better adapt to a changing climate, and take proactive steps that ensure Americans are protected from harm. One way to do that is to make sure that we're not building new homes or businesses in areas that have the potential to be wiped out.

I'd like to start with Mr. Grimm. In your testimony you highlighted the significant increase in annual flood losses since the 1980s. In your estimation, what percentage of today's NFIP costs are associated with repetitive loss properties?

Mr. GRIMM. Repetitive loss properties create a significant drain on the National Flood Insurance Program. You know, those are the properties that flood repeatedly. Many of them are outside of the floodplain, which causes the issue around the mapping program, in terms of getting to mapping beyond the binary line. I'll have to get back to you on the exact percentage that is the drain on—the number of claims on the program. It is significant. What I'd like to draw the attention to, though, is on the mapping program, moving away from the binary in and out nature of our flood maps.

Mr. GONZALEZ. Yeah.

Mr. GRIMM. As one of the Members pointed out, in 1968, when the maps were originally designed to be an insurance tool, many communities, and States, and local governments have moved well beyond that. We have to move away from that to a graduated risk analysis so that we can address those areas that flood outside of the current flood mapped area.

Mr. GONZALEZ. Can an individual today build a property in a flood prone region and expect to be eligible for insurance coverage from NFIP?

Mr. GRIMM. In a participating community in the National Flood Insurance Program, flood insurance is available for anybody inside a special flood hazard area or outside of the special flood hazard area.

Mr. GONZALEZ. I mean, it seems to me that this sort of behavior should be discouraged. I mean, the way I look at this, from a climate standpoint or an energy standpoint, is we're very early stages with respect to what'll probably be a multi-decade energy transition, unless somebody can tell me that they can make steel, cement, plastic, or ammonia without fossil fuels. I have no idea how to do that at scale without them, and so I think we're very, very early stages, and so adaptation has to be central to the discussion and mitigation. And I don't know that we spend enough time on that, frankly, with respect to the flood program, but—talking about energy issues period is just the realities of where we are currently at in the energy transition, and what it's going to take, and how long it's going to take to get there. I think multi-decades, at minimum.

I'll stick with you, Mr. Grimm, for my last question. As you noticed in your testimony, in 2015 TMAC recommended FEMA incorporate future flood hazard conditions. To this date, however, FEMA continues to only look at current risk. What specific steps is FEMA

taking to incorporate this change, and what have been the biggest barriers to seeing it through?

Mr. GRIMM. Sure. Yeah, FEMA continues to consider all the recommendations of the Mapping Advisory Council around future conditions. They recommend, for non-regulatory products, looking at future conditions. To date we've done a number of pilot efforts. I mentioned one in my oral testimony, that we're currently working with New York City on sea level rise. We've also done a few others around the Nation, on the West Coast, as well as some inland areas, and some erosion—future erosion potential.

As I mentioned—I think as Chad mentioned, there's 3.5 million miles of streams in the United States. We've only mapped 1.1 million miles. Our resources and the decisions that we've had to make around—with State and local governments is to focus those resources in those higher risk areas that we are—have made the assumption on insurance policies and population, therefore, there are certain things that we have not been able to directly attack, in the sense of future conditions on every flood map. What we do is we look to our partners, such as NOAA, and the Sea Level Rise Viewer, and other technologies. Chad also mentioned, and Mark mentioned, the Atlas–14, and keeping that up-to-date so that we can incorporate the appropriate data and technologies, in particularly around the Sea Level Viewer.

Mr. GONZALEZ. Thank you, and I yield back.

Ms. BONAMICI. Thank you. I now recognize Mr. Lamb from Pennsylvania for 5 minutes for your questions.

Mr. LAMB. Thank you, gentlemen, for being with us. We found out last year that the Army Corps of Engineers, their flood risk management efforts, just in the Upper Ohio River in my district—this was in 2018—prevented an estimated $1.11 billion in flood damages, and historically, kind of in the modern era, they estimate that to be $36 billion just for the Ohio. Anyone who's been to Pittsburgh knows we have three rivers that converge at the city of Pittsburgh, and, if you look at it, all told, it's potentially more than $100 billion. A lot of it from the reservoirs that they built, you know, 100 years ago, in the 1920s.

Does FEMA—I'll start with you, Mr. Grimm, if that's OK. Does FEMA look at these steps that are being taken by the Army Corps historically, and on an annual basis, to prevent flooding damage as part of your assessment of—and creation of the flood maps? Do you—I guess do you work with the Corps and take into account their research and work, and their actual efforts on the ground?

Mr. GRIMM. Yeah, thank you, sir. We absolutely do. The Corps is, in fact, one—a very, very close partner. I currently have somebody from the Corps actually sitting outside my office who's on detail for 6 months, and we're coordinating on residual risk in the National Levee Data base, and other projects. When a project is constructed, FEMA absolutely works with the Corps of Engineers and State and local partners, and, when appropriate, we incorporate those structures into our flood mapping program, and the resulting flood maps.

Mr. LAMB. OK. So if they could do—like, let's say that next year in Western Pennsylvania the Corps could only do 80 percent of the work that they did this year, you know, because of less personnel

and less budget. You know, they couldn't work on the reservoirs as much, or locks and dams, or whatever—all the stuff that they do. Would that make it maybe harder to plan for future floods, or you would have to think that there might be more financially? You know, that $1 billion money saved figure might get a little higher if the Corps is doing less work, would you agree on that?

Mr. GRIMM. Yeah. So, in order to have a Corps of Engineers structure reflected on the flood insurance rate map, it has to meet certain engineering standards that it reduces risk. So, as those structures progress and get completed, they get incorporated into the maps. If there's something that's, for example, under construction, but not providing protection yet, we would not recognize that on the flood map, so any slowdown in work would, as a result, may not be reflected.

Mr. LAMB. OK. That's helpful. And I was referring to the, you know, President's budget again this year offers to cut 22 percent from Army Corps' overall budget, which, regardless of, you know, where they say that would come from, I think we can all assume it would lead to a slowdown in a lot of projects and ongoing construction, so I'm happy to hear you say that's important to your work, and we'll do what we can to restore, or even grow that funding.

The last thing—I just wanted to ask Mr. Branfort, you mentioned working with the Corps as well, which is obviously, you know, they're very important to our region for a lot of reasons, but, you know, we have these huge and historic reservoirs on the upper parts of our rivers, especially up on the Allegheny. I was not familiar with the terms that you used, and if you could just repeat the—I keep wanting to say Ba'athification, which is a word from the Iraq War, but was——

Mr. BRANFORT. Bathymetric.

Mr. LAMB. Bathymetric, OK. So is that something that the Corps is already doing at reservoirs like we have on our rivers, or you're saying it's something they should be doing in the future——

Mr. BRANFORT. It is happening on some of the reservoirs——

Mr. LAMB. OK.

Mr. BRANFORT [continuing]. And river, yes.

Mr. LAMB. But it could be——

Mr. BRANFORT. Primarily——

Mr. LAMB [continuing]. To a greater——

Mr. BRANFORT. Historically it's been on navigable rivers, is where we've done that, and then the—dredge it to keep the river channels open, but it has been occurring over the last several years on a number of reservoirs to monitor sediment buildup.

Mr. LAMB. OK. Is—would it be fair to say that the older a reservoir is, the more likely it should undergo that kind of analysis?

Mr. BRANFORT. That would make the most sense.

Mr. LAMB. Like these 100-year-old ones?

Mr. BRANFORT. Yeah.

Mr. LAMB. OK. And is it—essentially what you're saying that the sediment builds up over time on the sides and bottom so it's—you're sort of squeezing water——

Mr. BRANFORT. You have less capacity—yes. We've seen—the one example I had up with the map was Cochiti Reservoir in New Mex-

ico, where the upper reaches are filled in 70 feet of sediment vertically.

Mr. LAMB. And do they—does the Corps contract with firms like yours to do that work, or do they just do it themselves? Do they contract——

Mr. BRANFORT. Both.

Mr. LAMB. OK, both. OK. Excellent. Thank you, gentlemen. Madam Chair, I yield back.

Ms. BONAMICI. Thank you. I now recognize Dr. Babin from Texas for 5 minutes for your questions.

Mr. BABIN. Thank you, Madam Chair, and thank you all for being here, your expert witness testimony. I appreciate the opportunity to have this discussion on flood mapping, which happens to be of great importance to my district in Southeast Texas. I represent the 36th District from Houston over to Louisiana. Southeast corner of Texas has been hit many times over the last few years.

The accuracy and consistency of flood mapping is critical in my district, carrying tremendous impacts on communities and homeowners. It is important to realize that these maps cannot be done on a one-size-fits-all approach, and that the data that they're based on is critical to having accurate maps. I represent a community down in Hardin County, for example, Hardin County, Texas, which just went through an arduous process of redoing their flood maps with FEMA. Long story short, the new flood maps were almost drawn with the data from 1975, instead of using the more recent data from 2010. This mistake was fixed by the community, but had it not been caught by local water control improvement district, it could've had a very significant detrimental impact on the community.

So, Mr. Grimm, I have other counties that are using flood maps that are based on data from 20 to 30 years ago, and while different counties have maps like Hardin County, using up to date data based on aerial surveys and extensive studies, what is the determination for who is getting updated maps? Please, sir.

Mr. GRIMM. Sure, thank you, sir.

Mr. BABIN. Yes, sir.

Mr. GRIMM. So FEMA works with—this is a shared responsibility, No. 1. This is a responsibility that—working with the local government, working with the State government, and the Federal Government, and all the partners, to work through the process of the mapping. We start the mapping process with what's called a discovery meeting, where we get together at the local level and bring everybody to the table to talk about what needs to be studied, what areas are at risk, and what areas we need to extend the mapping to. It's a conversation that takes some time. We then go into the data collection phase of that process, and eventually we get through the data collection and producing the flood map. It then goes through a process of public review, and——

Mr. BABIN. That.

Mr. GRIMM [continuing]. It's——

Mr. BABIN. When you say public review, are you talking about that individual county, or city, or——

Mr. GRIMM. Yeah.

Mr. BABIN [continuing]. Metropolitan area?

Mr. GRIMM. Yeah.

Mr. BABIN. The reason I'm asking this is because Hardin County, for example, they're scared to death. These new flood maps, they want to have input from the county, and they want to have transparency. So go ahead, resume. Thank you.

Mr. GRIMM. Yeah. Yes, sir, I couldn't agree with you more.

Mr. BABIN. Yeah.

Mr. GRIMM. I mean, the—FEMA wants community and county input and review to be partners in this process. It is—we believe it is a shared responsibility, and we cannot do it without that conversation to happen. And, you know, I will commit to you that I am glad to reach out to our regional office and ensure that is happening. I am——

Mr. BABIN. Really appreciate——

Mr. GRIMM. —Region Six Office, I am confident that they do that, and I'd be glad to loop back with our regional folks to extend that.

Mr. BABIN. That would be wonderful. And so I'm going to go on to you, Mr. Osler. Let's talk about the Atlas–14 approach. What is the methodology of this approach, and are there any arbitrary standards to this approach?

Mr. OSLER. Thank you, sir. So Atlas–14, for the room, is a product by NOAA that helps to understand the statistical frequency of rainfall in different parts of the Nation. One thing that's important to know, there is no steady authorized stream of funding for Atlas–14. It is not a funded, supported product by NOAA, despite its critical contribution to this discussion across the Nation. And so, what you asked about methods, that changes. That—there is a pool funding mechanism to fund Atlas–14, where local municipalities or States essentially pass the hat to create the funding to trigger NOAA's uptake of an update to Atlas–14, typically at the State level.

And so the approach, then, is state of the science, state of the measurements, that—whenever that update has been made. But if you look across the Nation, it's a patchwork coverage now in the degree to which those data are up to date or not.

Mr. BABIN. OK. Thank you. I have a few seconds left. Mr. Branfort, one of the slides you showed earlier zoomed on a specific area outside of Houston that I recognize as Burnet Bay, which is in my district. Firstly, I'd like to know if this site was chosen for a reason other than its proximity to Johnson Space Center, and secondly, other than knowing where we might lose land mass where businesses or houses have been developed, what is the value of knowing where land subsidence is occurring? Obviously comparing images taken years ago to present images shows a change, but does this data help predict where subsidence might take place elsewhere in the country?

Mr. BRANFORT. You know, first of all, that image is selected because that is a significant area of subsidence. It's just the amount of subsidence that's occurring there. We have very little data nationwide as—we—monitoring subsidence nationwide, it's just the areas we've known where it's occurred and, you know, watched it. I don't think that that gives us a forecasting tool for where—when it happened in other places. One of the major problems with sub-

sidence is it's gradual over a larger area, which takes down the survey control that you use to typically monitor elevation data, and it takes down the whole area, so you can get a broader, more accurate map over the area.

Mr. BABIN. All right, thank you. I have other questions, but I'm out of time, so thank you, Mr. Chairman.

Mr. LAMB [presiding]. Recognize Mr. Tonko for 5 minutes.

Mr. TONKO. Thank you, Mr. Chair, and thank you to all of the—my colleagues that—who have helped work on putting this hearing together, and we thank all of our witnesses for their time and expertise that's shared today.

As we have heard over and over again, floods are the primary culprit of natural disasters in the U.S., causing over $190 billion in damages last decade. This damage total has been increasing due to climate change driven extreme weather events, raising concern amongst homeowners and investors about the safety and security of their property. The tool they must rely on to assuage those concerns, however, seems broken. FEMA's flood insurance rate maps, or FIRMs, are meant to identify statistically likely flood risk. However, they have done a poor job of doing that lately.

External estimates show that about three times as many people live in serious flood risk as are shown on FEMA maps, and these findings were sadly affirmed a few years back during Hurricane Harvey. Eighty percent of the high-water rescues during Harvey, 80 percent, were outside the 500-year flood plan—floodplain. So, to repeat, the Federal tool designed to predict even the slightest possibility of flood risk failed to predict 80 percent of the flood risk when they needed it most. No one should accept this failure rate, and we must improve our flood maps for the sake of American homeowners, business owners, and investors.

So, Mr. Berginnis, you highlight one major strategy to improve our FEMA maps, simply finish mapping elevations. And I agree with you that we must finish this critical task, however, do you believe that accurate elevation data are enough to predict flood damage from these extreme storms, such as Hurricane Harvey?

Mr. BERGINNIS. In finishing the job, one of the things that I think's a credit to Congress, in 2012, is recognizing the fact that we use flood maps in a lot of different ways, and have different types of flood hazard areas, so not just a statistical floodplain, but residual risks, future conditions. And so, when we talk about finishing the maps, we're also talking about adding those things that currently are not on the flood map, so it's actually doing both, and we think at least that's a good start, because one of the other aspects, and we mentioned this in our written testimony, is that other Federal agencies and States are producing unique products, but one of the problems right now is that while FEMA has developed a good online tool that can layer data, there is not good connectivity to those State or other Federal resources. FEMA had recently been able to work to get COBRA (*Coastal Barrier Resources Act*) maps that now interface with that, and so we think that FEMA's going in the right direction, but it's not there yet.

Mr. TONKO. OK. And I—thank you for that. And it's important that we recognize the widespread need for these climate data products. Climate data do more than predict temperatures. They save

billions of dollars and thousands of lives. This administration is actively putting citizens at risk by decimating critical budget items needed to collect data critical for flood prediction. It looks to cut the USGS and NOAA, agencies that collect the data needed to predict future rainfall, stream flow, and floods, by 40 percent and 24 percent respectively. It zeroes out NASA's Earth science missions that monitor global climate. So I appreciate all of the work that is being done to improve our flood maps despite these backward views, however, we should demand that American scientists are given every tool available to do this job right for the American people.

I'm just curious too, with our agencies represented, is there a discussion about climate change, and the impact on flood mappings?

Mr. GRIMM. Absolutely. Climate is changing. FEMA is addressing climate in our program areas. We have incorporated sea level rise curves into our Mitigation Grant Program, in our benefit-cost analysis for use in grant awards, into our planning guidance for—to States and local governments for addressing mitigation planning at the national level. Most recently we released the National Mitigation Investment Strategy, which is to bring the whole community together to align our investments, including around future conditions.

Mr. TONKO. And NOAA would do the same thing? Do you discuss climate change?

Mr. OSLER. Not only discuss it, sir, but NOAA's—one of NOAA's core missions is to research and monitor our——

Mr. TONKO. Well, then——

Mr. OSLER [continuing]. Changing climate.

Mr. TONKO [continuing]. My question—obvious question is how does that not percolate to the top of the executive branch? If we have climate impacting a lot of this mapping and data assimilation, why do we not accept the concept of climate change? OK. I yield back.

Mr. LAMB. Last round. I think, for me, I just have one broad question that I'd like to throw out to each of you. As the science for identifying flood hazards evolves, FEMA's flood mapping program updates its engineering and mapping standards, including the models that are used. The standards are published, vetted, peer reviewed, and updated regularly to ensure that they're aligned with current best practices. Every 5 years FEMA re-assesses the studies behind each flood map to see if the data and models that were used to create it meet current standards. Despite this, current best practices do not always grant accurate results in a nation with a rapidly changing climate and rising sea levels, with change in some areas occurring faster than 5-year intervals. So I think that's uncontroversial, and more or less what we heard today.

For each of you that would care to comment, I think the closing question we have is what sources of data require improved data collection and/or additional funding? So national rainfall frequency data, stream gauge data, tidal gauge data. In other words, if you were sort of designing your wish list data set, or dream data set, what would it include, and any suggestions for how we could get it to you? Maybe starting with Mr. Grimm?

Mr. GRIMM. Sure. I think you read off the list, honestly. You know, when we're pulling data together to make a flood map, you

know, you're putting together four buckets, four elements, to a flood map, the topographic data, so that LIDAR, that 3DEP Program, right, it's a critical element to what we do. We cannot produce accurate flood maps without accurate elevation data. Then you move into the hydrology and hydraulic areas, in terms of how much water falls. That's my buddy here, NOAA Atlas–14, and the hydraulics, and advancements in technology on automated mapping techniques, for example, that the private sector often develops.

Then you move into the base mapping, and, you know, the streets, the infrastructure, and collecting all of that data. You know, looking down the row here, there's a lot of folks who are collecting this data, and a lot of agencies that collect this type of data that, without it, FEMA won't be able to advance and move technology forward, and have accurate data to produce an accurate flood map. One—and one thing I want to say, we want to move away from risk identification of that binary line. We want to move into graduated risk analysis and true flood management of multi-frequency hazards, including future conditions.

Mr. LAMB. Thank you. Mr. Osler?

Mr. OSLER. Thank you. Mr. Grimm nailed it, in terms of the typical ingredients of Earth science data that are needed to map floods, and so I would double down on that statement about foundational information. Where's the ground, where's the water? How are those changing, both water from the ocean and from precipitation? I would note on the sea level rise front we maintain just over 200 authoritative water level gauges which were—have been installed, in some cases, for over 100 years, and these have been the harbingers of sea level rise, and help us actually track and understand rates of change on the ground.

The purpose of those gauges, when they were initiated, was not to track changing climate, but to help marine commerce, and that mission remains strong today. However, there are significant gaps now that sea level rise is affecting every part of our coastline, and changing water levels on the Great Lakes. So we have gaps in our ability to accurately, and in real time, predict seal level change impacts in the areas in between those gauges, so we're talking seriously about revolutionizing the ability to model and fill in those gaps so that we can help provide even more detailed information.

Mr. LAMB. Thank you. Mr. Branfort?

Mr. BRANFORT. Definitely—both of them referred to the 3DEP elevation-based model. There is a significant portion of this country, about a third of the country—Mr. Grimm referred to digital copies of paper maps, where the old paper maps have been converted to a digital format, but they're still—they were low accuracy to begin with, and been converted, and then we've had massive changes since then, so the base 3DEP elevation data for the Nation is a starting point for all——

Mr. LAMB. That's the key. And, last, Mr. Berginnis?

Mr. BERGINNIS. And maybe, being last, I could say all of the above. But the one thing I do want to point out, and it was from Mr. Osler's testimony, while 3DEP, while stream gauging, the Flood Mapping Program, all have ongoing programs, authorities, requirements, and funding, Mr. Osler pointed out something I think that's key, and that is our precipitation frequency informa-

tion that Atlas–14—currently there's no mandate, and there's no sustained funding at all. That is a huge problem, because that's a key input into flood maps.

Mr. LAMB. Thank you all. Before we bring this to a close, I want to thank the witnesses for testifying. The record will remain open for 2 weeks for additional statements from the Members, or any additional questions the Committee may ask of the witnesses. The witnesses are now excused, and the hearing is adjourned.

[Whereupon, at 4:20 p.m., the Subcommittees were adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. Michael Grimm

Question#:	1
Topic:	Collaborating with NOAA
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Mikie Sherrill
Committee:	SCIENCE (HOUSE)

Question: To what extent do FEMA and NOAA collaborate on flood risk mapping and communication to the public, and how can your respective agencies combine their unique and vital capabilities to improve how flood science is used across the board, including to better inform the flood insurance rate maps?

Response: The Federal Emergency Management Agency (FEMA) relies on National Oceanic and Atmospheric Administration (NOAA) data for the production of Flood Insurance Rate Maps (FIRMs). For example, FEMA uses NOAA Atlas 14 Precipitation Frequency Estimates, developed by NOAA's Office of Water Prediction, for hydro meteorological input to riverine flood studies. NOAA bathymetry data (measurement of the depth of water) is another critical component needed to model complex coastal flooding scenarios. FEMA also maintains a direct ongoing relationship with NOAA's National Geodetic Survey (NGS) and participates in the Federal Geodetic Control Subcommittee. The NGS, in cooperation with state, local, tribal and territorial governments, manages the control systems necessary to make the horizontal and vertical measurements needed for flood hazard mapping.

FEMA also relies on the expertise of NOAA and other agencies to improve broader flood mapping and communication processes. For example, NOAA is a member of the congressionally mandated Technical Mapping Advisory Council (TMAC), which makes recommendations to FEMA regarding the national flood mapping program and how agencies can collaborate to improve flood information across the nation. NOAA is also a member of the Community Rating System (CRS) Task Force, which provides recommendations to FEMA's CRS program. The CRS program is a voluntary, incentive-based community program that recognizes, encourages, and rewards local floodplain management activities that exceed the minimum standards of the National Flood Insurance Program (NFIP). NOAA provides important perspectives to the Task Force, especially through the agency's own work with local stakeholders on coastal issues.

In addition to the regulatory and non-regulatory products that FEMA produces with NOAA data, FEMA routinely points its stakeholders to NOAA-produced communication and decision-support tools, such as the Sea Level Rise Viewer. Through the "Future of Flood Risk Data" (FFRD) initiative, FEMA is exploring ways to provide more comprehensive flood information across the nation, using new technologies and more efficient processes. To do so, FEMA recognizes the importance of continued collaboration with NOAA and other agencies to maximize our resources and expertise, while avoiding duplication of effort.

Question#:	2
Topic:	Improving Collaboration
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Mikie Sherrill
Committee:	SCIENCE (HOUSE)

Question: Is there a need for improved mechanisms for interagency collaboration or coordination in flood mapping between FEMA and the science agencies involved in flood research like NOAA? If so, how can this collaboration be improved to better serve floodplain communities around the nation?

Response: Through FEMA's FFRD initiative, FEMA is looking at ways to provide communities with a broader range of flood scenarios, beyond the 1-percent-annual-chance event that is depicted on a FIRM. FEMA recognizes the value that the U.S. Geological Survey (USGS), NOAA and other agencies with water resource management responsibilities can bring to the table to improve the flood information that FEMA produces. FEMA has identified a few specific needs that could be met through collaboration with other agencies. These include a consistent, comprehensive ground elevation dataset for the nation (building on existing interagency collaboration for Light Detection and Ranging [LiDAR] acquisition through the interagency 3D Elevation Program [3DEP]), managed by the USGS, a statistical storms database for the nation's interior, a centralized modeling repository that includes consistent flood model coverage for the nation, and a national loss modeling framework that better informs preparedness, response, recovery, and mitigation activities.

FEMA looks forward to deepening broader, long-term collaboration with NOAA and other agencies to explore how FEMA can provide a more holistic view of flood hazard and flood risk information to its stakeholders. The Integrated Water Resources Science and Services (IWRSS) initiative includes NOAA, USGS, FEMA and U.S. Army Corps of Engineers (USACE). IWRSS agencies are working together toward an integrated Flood Inundation Map that identifies and employs the best available information for real-time flood mapping. The IWRSS umbrella is one potential mechanism for formalizing expanded collaboration to develop a more comprehensive range of flood information and scenarios.

FEMA is also working with other parts of the U.S. Department of Homeland Security (DHS), including with the DHS Science & Technology Directorate (S&T) to improve the quality of our flood information and enhance our understanding of probabilities across a broad range of flood scenarios. Our partnership with S&T includes contributions from the DHS S&T Flood Apex Program, Technology Centers Division/Enduring Sciences Branch, and the Office of University Programs/Coastal Resilience Center.

Question#:	3
Topic:	Community Engagement
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Mikie Sherrill
Committee:	SCIENCE (HOUSE)

Question: As I mentioned in my opening remarks, we need to improve the way that local community expertise informs the flood mapping process. A flood resilience officer in my district recently told me: "FEMA Flood maps are an immensely powerful tool. Executed properly, they communicate accurate flood risk levels to homeowners so they can take the necessary precautions. Handled ineptly, they can financially devastate a homeowner and their community." Our communities understand that flood risk mapping is a complicated subject, and they want to be partners in this process. I am entering into the record examples of the types of scientific information that my communities have to offer to the flood mapping process but have had difficulty getting considered. These consist of letters from the Township of Pequannock, the Borough of Lincoln Park, and a consultant who has worked with multiple towns in NJ11.Community engagement is a stated part of the FEMA process, and mechanisms exist like the Community Consultation Process and Cooperating Technical Partners to accomplish this. But my understanding is that these tools are not being implemented effectively or consistently in my district.

How do we improve FEMA's community engagement component of the mapping process?

Response: FEMA does not apply a one-size-fits-all approach to a community's mapping project. Instead, each flood risk project to update a FIRM is tailored to the community's needs and capabilities for using flood hazard information. Because of this, FEMA places a strong emphasis on community engagement and technical credibility. Every project involves partnerships with state, local, tribal and territorial officials who have the opportunity to see that the right data goes into the map and to point out the places where it is most needed. Local partners have knowledge and data FEMA does not, so the process must be collaborative.

Before and during a flood study, FEMA uses a transparent process to obtain state, local, tribal and territorial officials' input and discuss the results as they are produced. Regional staff and local partners host a series of official meetings with community leaders and residents at specific points during the years-long process of updating a FIRM. At these meetings, they explain how the project is progressing, and they officially request local input on draft products before finalizing them.

Specifically, at the beginning of a flood map update process, our teams sit down to meet with state, local, tribal and territorial officials and review their existing maps. We learn about the data they can contribute to the process and discuss where they have identified high-risk areas. We also make sure we have their information about previous flood events. Armed with this information, FEMA gathers the additional data needed for flood hazard analysis, which may include topographic, hydrologic, and hydraulic data.

Question#:	3
Topic:	Community Engagement
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Mikie Sherrill
Committee:	SCIENCE (HOUSE)

It is important to note information from any source, including the communities, must meet the specific guidance and standards created for consistent and technically credible flood hazard mapping across the nation. These guidance and standards are outlined in detail on FEMA's website.

FEMA also leverages partnerships in collecting and producing flood risk data. Among these are the Cooperating Technical Partners (CTP) program, which allows interested and capable communities, regional and state agencies, universities, and tribal nations to become active partners in the flood hazard mapping program. FEMA works hand-in-hand with these partners, providing technical assistance and funding. Since 2006, the New Jersey Department of Environmental Protection (NJDEP) has produced flood studies and products such as FIRMs for New Jersey. For this work, NJDEP has a dedicated production team with capabilities in water resource engineering, hydrology, hydraulics, flood risk hazard mapping, geographic information systems (GIS) and land surveying. Other partners in New Jersey include the Richard Stockton College of New Jersey Coastal Research Center, Stevens Institute of Technology, Sea Grant, Monmouth University, and Jacques Cousteau National Estuarine Research Reserve of Rutgers University.

Recognizing the need to support community engagement and risk communication in New Jersey, FEMA and the NJDEP also provide communities with non-regulatory flood risk products that can be used in planning efforts to mitigate flood risk, to communicate with the public, and to create a dialogue with neighboring communities about ways to reduce future flood risk. These tools include innovative GIS datasets and maps, as well as supporting reports. These are important resources to support community planning efforts.

Near the end of the Flood Insurance Study process, statutory appeal periods give communities and individuals affected by revisions the opportunity to submit appeals for any proposed flood hazard determinations. If necessary, an independent Scientific Resolution Panel can be convened to review and resolve conflicts related to scientific and technical data submitted by a community to challenge FEMA's proposed flood hazard data. A Flood Insurance Study (FIS) is a compilation and presentation of flood hazard data for specific watercourses, lakes, and coastal flood hazard areas within a community. When a flood study is completed for the NFIP, the information and maps are assembled into an FIS. The FIS report contains detailed flood elevation data in flood profiles and data tables.

After a FIRM is adopted by the NFIP participating community and becomes effective, FEMA strongly encourages communities to submit information and technical data to keep the flood hazards shown on the maps up to date. Changes can be driven by construction projects, surface erosion, or natural events that affect the community's floodplains. FEMA does not and could not monitor development in every floodplain, but community officials can submit scientific or

Question#:	3
Topic:	Community Engagement
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Mikie Sherrill
Committee:	SCIENCE (HOUSE)

technical data at any time to support a local FIRM revision. This data must also meet the specific guidance and standards created for consistent flood hazard mapping. These guidance and standards are outlined in detail on FEMA's website.

FEMA continually looks for ways to improve its engagement with communities during the flood map update process. One important tool informing how we do this is the Community Engagement and Risk Communication Playbook, which details engagement and collaboration recommendations for each phase of the Risk Mapping, Assessment, and Planning (Risk MAP) process. FEMA recently updated its guidance for staff and mapping partners on how to approach community engagement throughout a mapping project. This guidance includes best practices for partnering with communities to understand and act on flood risk. FEMA places a great emphasis on the value of developing relationships through both official meetings and informal communication.

FEMA is exploring how the Risk MAP program should evolve in the future through the FFRD initiative. A key component of this initiative is examining how we can ensure a significant and appropriate role for the private sector and our state, local, tribal and territorial partners in developing flood risk data. As we test and pilot new approaches, FEMA will see which advanced engagement and collaboration techniques work best and implement them more broadly across the program.

Question#:	4
Topic:	Flood Map Service Center
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Mikie Sherrill
Committee:	SCIENCE (HOUSE)

Question: We know that homeowners and communities use the FEMA flood maps to make long-term decisions, including mortgages and investments in adaptation. However, the mapping process was created to show only the current year's flood risk for insurance rates, not to predict climate change impacts on flood risk or urbanization. In many cases, even the present risk shown is outdated.

Is FEMA working on methods to improve the usability of the existing Flood Map Service Center website for the public? If not, what would FEMA need to accomplish this?

Response: Information provided on FIRMs has resulted in the preservation of life and property. Over the last 40 years, local adoption of minimum floodplain management standards resulted in $100 billion in avoided losses. However, FEMA recognizes a FIRM's limitations. FEMA is looking at ways to provide communities with a broader range of data and flood scenarios, beyond the 1-percent-annual-chance event that is depicted on a FIRM.

Through the Flood Map Service Center's National Flood Hazard Layer (NFHL) viewer, FEMA has explored how to make additional data layers available to the public. For example, the NFHL includes the most up-to-date information on the Coastal Barrier Resources System (CBRS) unit boundaries. Although the CBRS maps are maintained by the U.S. Fish and Wildlife Service (FWS), FEMA has historically shown CBRS boundaries on FIRMs. The incorporation of CBRS data into the NFHL enables FEMA to provide the CBRS data in a more user-friendly, digital environment where NFIP stakeholders can access revised CBRS boundaries as FWS updates them, as opposed to waiting until FEMA makes the next regulatory update of a community's FIRM. This process challenged FEMA to explore other ways it can leverage relevant data sources maintained by other Federal agencies. Incorporating other data sources could provide more information about changing and future conditions.

The success of bringing CBRS boundary information from the FWS into the NFHL shows the advantages of providing information to communities outside the FIS process from.

A FIS is a variety compilation and presentation of sources. flood hazard data for specific watercourses, lakes, and coastal flood hazard areas within a community. When a flood study is completed for the NFIP, the information and maps are assembled into an FIS. The FIS report contains detailed flood elevation data in flood profiles and data tables.

As FEMA explores leveraging additional data beyond the 1-percent-annual-chance flood to empower communities to mitigate their flood risk, we are exploring innovative ways to share this information publicly. This exploration presents an opportunity to better partner with many of

Question#:	4
Topic:	Flood Map Service Center
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Mikie Sherrill
Committee:	SCIENCE (HOUSE)

our Federal partners to make a broad range of flood information that they produce more readily available to NFIP customers through the Flood Map Service Center.

Question#:	5
Topic:	S&T R&D
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Bill Foster
Committee:	SCIENCE (HOUSE)

Question: The Department of Homeland Security Science & Technology directorate conducts research and product development to support the very broad range of mission needs under the umbrella of the Department. Is DHS S&T working on any R&D to support advanced modeling tools or other capabilities that could make it possible for FEMA to map more locations, to update maps more quickly, or to improve the quality of maps?

Response: FEMA is working with S&T to improve the quality of our flood information and enhance our understanding of probabilities across a broad range of flood scenarios. Our partnership with S&T includes contributions from the S&T Flood Apex Program, Technology Centers Division/Enduring Sciences Branch, and the Office of University Programs/Coastal Resilience Center.

The collaboration with S&T includes several activities:

- Research and development of a historically observed flood extents product for the continental United States that uses LandSAT imagery to extend our flood risk information catalog
- Expansion of low-cost, Internet of Things Flood Sensors to advance the state-of-the-art flood monitoring capabilities in local communities
- Enhancements to dam breach modeling and simulation (Decision Support System for Water Infrastructure Security tools) for the national dam safety and flood management community

FEMA has additional scientific advisory support and research with S&T through the Enduring Sciences Branch. This support and research relates to flood risk communication, floodproofing standards and best practices, flood insurance innovation studies, and civic innovation partnerships for cultivating new approaches to improving community resilience from flood disasters.

FEMA also routinely engages the S&T Coastal Resilience Center (CRC) to improve the modeling of coastal storm hazards. Presently, CRC is helping us develop the necessary methods to transition to probabilistic coastal flood modeling.

Question#:	6
Topic:	Climate Change
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Bill Foster
Committee:	SCIENCE (HOUSE)

Question: In March of 2018, FEMA removed all mentions of "climate change" from its five-year strategic plan. Then in October 2019, FEMA put out a new National Disaster Preparedness report which completely omitted any discussion of climate change, sea-level rise, or drought.

Do you agree that climate change from greenhouse gases will affect flooding in the United States and that any thoughtful flood mapping exercise should accommodate the influence of climate change?

Response: FEMA's mission is to help people before, during, and after disasters. To continue to accomplish our mission in the years to come, FEMA is working collaboratively with stakeholders across the whole community to ensure the United States is preparing and planning for both current and future risks. These future risks include a wide array of changes, including shifting demographics, aging infrastructure, and the possibility for increases in number and severity of extreme weather events.

Addressing future risks, such as those posed by extreme weather events regardless of their cause, is key to FEMA's mission. Wherever possible, FEMA brings data to bear and works in support of state, local and tribal needs and priorities. By addressing future risks, state, local, tribal and territorial governments are better prepared for extreme weather events and can bounce back faster at the individual and community level.

It is important to note that extreme weather events are just one of many future risks FEMA plans for, but one that could significantly alter the types and magnitudes of hazards impacting communities and the emergency management professionals serving them. Accordingly, consistent with FEMA's focus on enabling disaster risk reduction nationally, FEMA is supporting state, local, and tribal governments with efforts to prepare for these impacts through adaptation, which means planning for the changes that are occurring and expected to occur.

The Stafford Act sets the statutory framework from which FEMA manages its role in mitigation of future risk. The Stafford Act stipulates that post-disaster mitigation activities must "substantially reduce the risk of future damage." This law mandates that FEMA address future risk and helps ensure federal taxpayer dollars are used responsibly given the possibility of changing conditions.

Additionally, the Stafford Act requires actions by communities to address future risk by requiring state, local and tribal governments to develop mitigation plans for hazards, risks and vulnerabilities in their respective jurisdictions. State, local and tribal mitigation plans are required to include the "probability of future hazard events" occurring in a given jurisdiction.

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Also, the plans must contain a mitigation strategy that speaks to reducing or avoiding the long-term vulnerabilities the hazards pose. Without this future look, a community cannot adequately prepare to mitigate against future loss of life and property.

FEMA is exploring ways to support communities in planning for future conditions. FEMA is required to map current flood risk on the FIRMs, under 44 CFR 65.6(a)(3), interpreting 42 U.S.C. 4101(a). FIRMs are created using the best available data about local flood hazards, and they are a snapshot of the risk at the time the map becomes effective. Revisions cannot be made based on the effects of proposed projects or future conditions. While FIRMs do not currently reflect the ways in which flood risks may change in the future, the TMAC recommended FEMA develop *non-regulatory* products that reflect information about future conditions. FEMA is working to address TMAC's recommendations through the development of pilot projects and exploration of our Federal partners' work in this area. Our intent is to provide information to complement regulatory products such as the FIRM. FEMA also feels it is important to leverage other Federal agency resources without duplicating effort. FEMA acknowledges many Federal agencies produce sea level rise and future conditions information, and FEMA regularly points communities to this information. For example, FEMA encourages communities to use NOAA's Sea Level Rise Viewer. FEMA is also exploring ways to provide more comprehensive flood information, including future conditions information, through its FFRD initiative.

Question: Does FEMA agree with the consensus position established in the National Climate Assessment that climate change is causing flooding to intensify in the United States?

Response: FEMA released the State Mitigation Plan Review Guide ("Guide"). The Guide is FEMA's official policy on the natural hazard mitigation planning requirements from Title 44 Code of Federal Regulations Part 201, and federal regulations for state hazard mitigation plans, inclusive of the District of Columbia and five U.S. territories. The guide supports state, tribal, and local government mitigation planning to identify risks and vulnerabilities associated with natural hazards and establish a long-term strategy for protecting people and property in future hazard events. State mitigation plans are one of the eligibility prerequisites to receive certain FEMA assistance, such as Public Assistance and Hazard Mitigation Assistance grants (Pre-Disaster Mitigation Grant Program, Flood Mitigation Assistance Grant Program, and the Hazard Mitigation Grant Program). States are required to update their mitigation plans every five years.

This guide asks states to consider the probability of future hazard events, including changing future conditions, development patterns, and population demographics. The Guide clarifies that the probability of future hazard events must include considerations of changing future conditions, including the effects of long-term changes in weather patterns and climate on the identified hazards. States must continue to provide an overview of all natural hazards that can affect their jurisdiction, using maps and data where appropriate.

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Primary:	The Honorable Bill Foster
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To better reduce risk and enhance resilience, the Guide encourages states to take a holistic approach and include not only emergency management, but also the sectors of economic development, land use and development, housing, health and social services, infrastructure, and natural and cultural resources in their planning process and mitigation program, where practicable.

Question#:	7
Topic:	Accurate Predictions
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Bill Foster
Committee:	SCIENCE (HOUSE)

Question: If resources were no constraint, what kind of data sets would you make available to FEMA in order to enable the most accurate, timely and granular flood predictions? Are there any particular tools such as supercomputers for modeling, ground penetrating radars for visualizing underground waterflow, or LIDAR that you believe would be most constructive in improving flood mapping?

Response: The state of science and technology for flood hazard identification and flood risk assessment have advanced throughout the 50-year history of the NFIP. Because our statutory and regulatory authorities led us to invest in a precise representation of a single flood hazard, the 1-percent-annual-chance (100-year) flood, which is costly to produce and maintain, there are still large gaps and inconsistencies across the nation with respect to the coverage and quality of flood hazard information. Without a consistent, comprehensive baseline of flood hazard information across the nation, we are not able to fully leverage many of the advances in computational efficiencies and flood modeling techniques that could support timely, graduated, actionable flood risk assessments.

Fundamental to changing the nation's understanding of flood risk is an environment where there is close and consistent intergovernmental collaboration, and where sharing of flood hazard information and data is required and not limited by internal policies of federal, state tribal and territorial agencies. Datasets enabling FEMA to improve the nation's understanding of flood risk could include:

- **A consistent, comprehensive ground elevation dataset for the nation.** Elevation data has been and will continue to be a critical component for consistent identification of flood hazards. The 3DEP managed by the USGS' National Geospatial Program collects LiDAR data, allowing FEMA and its state, local, tribal and territorial partners to map flood hazard zones with increasing accuracy by measuring landscapes with laser-based surveying methodologies from aircraft. Many federal agencies contribute funding for LiDAR data acquisition, and FEMA invested over $190 million in LiDAR since Fiscal Year 2014. Continuing this interagency partnership is critical.
- **A statistical storms database.** One major missing component is a statistical storms database for the interior of the nation complementing and integrating with the database we use for our coastal flood hazard analyses. Such a database would drive a consistent understanding of precipitation frequency and its spatial and temporal variation. It must provide more information than point intensity frequency. The dataset must differentiate between storm types and not be limited by mixed storm type statistics. Ideally, the inland storms dataset would integrate

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with existing coastal storm databases and allow for seamless storm generation to enable efficient flood simulations across both the coastal and inland portions of the United States. This effort would require close coordination between Federal agencies, with especially agencies such as NOAA, USGS, and USACE who have expertise and defined needs and could frame the effort.

- **A national flood modeling framework:** A centralized modeling repository that includes consistent flood model coverage for the entire nation. A repository would enable the Federal family to bring existing flood models together, conduct a gap analysis, and consider an investment strategy to close the identified gaps in flood hazard data. Such a framework should be able to incorporate relevant flood operation and flood infrastructure datasets (such as dams and levees), existing models, and the statistical storm dataset described above. This modeling framework would need to be computable on super computers or distributed in a cloud computing capability and must be accessible to all Federal agencies and private sector, state, local, tribal, and territorial partners for analysis. Including a publicly accessible national structure inventory dataset would also aid flood risk assessments as granular as the individual structure level. Some of these tools or datasets currently exist but are not sufficiently resourced to meet the needs of a national view of risk at a level as granular as an individual structure.
- **A national loss modeling framework:** A centralized loss modeling framework would ingest authoritative hazard and vulnerability information to generate risk assessments to be used to inform preparedness, response, recovery, and mitigation activities. Such a framework should be able to seamlessly ingest, analyze, and calculate risk based on the hazard outputs from the national flood modeling framework outlined above and vulnerability outputs (building, economic, and social impacts). Such a modeling framework ought to able to support mitigation "what if" scenarios to assist stakeholders in understanding the potential return on investment for mitigation grant opportunities. Like the national flood modeling framework described above, the loss modeling framework would also need to be computable on super computers or distributed in a cloud computing capability and must be accessible to all Federal agencies and private sector, state, local, tribal, and territorial partners for analysis. The results of this loss modeling framework need to be communicated to the public in an easily understandable format through common risk communication mediums and technologies to encourage individual household actions to reduce risk.

Question#:	8
Topic:	Future Conditions
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Eddie Bernice Johnson
Committee:	SCIENCE (HOUSE)

Question: In the U.S., we're already seeing the effects of climate change. Sea level rise, more intense rainfall events, and an increase in storm frequency and intensity all contribute to a rapidly changing landscape, but FEMA flood maps do not reflect future flood risk from climate change and other human activities. Americans cannot afford to make decisions about their property based on information that does not show how flood risk may impact them in the future.

Why don't the FEMA flood maps currently reflect expected future conditions from climate change, and when does FEMA plan to show future predicted conditions on flood maps?

Response: FEMA is required to map current flood risk on the FIRMs, under 44 CFR 65.6(a)(3), interpreting 42 U.S.C. 4101(a). FIRMs are created using the best available data about local flood hazards, and they are a snapshot of the risk at the time the map becomes effective. Revisions cannot be made based on the effects of proposed projects or future conditions. While flood maps do not currently reflect how flood risks may change in the future, FEMA strongly encourages communities to incorporate future conditions information into projects and plans that govern future growth. Wherever possible, FEMA brings data to bear and works in support of state, local, tribal, and territorial needs and priorities.

Communities can also ask FEMA to show future conditions floodplains, based on projected land use, on their flood map as an addition to the current floodplain. If communities choose this option, they must give FEMA information about any land-use changes they have planned and other required data. FEMA will show the future-conditions 1-percent-annual-chance floodplain on the flood map as "Zone X (Future Base Flood)" or "Shaded Zone X." This option is typically used in riverine (rather than coastal) areas, and only a few communities have asked for this information to be included on their flood maps. If interested, communities should discuss this option with FEMA at the beginning of the FIS process. An FIS is a compilation and presentation of flood hazard data for specific watercourses, lakes, and coastal flood hazard areas within a community. When a flood study is completed for the NFIP, the information and maps are assembled into an FIS. The FIS report contains detailed flood elevation data in flood profiles and data tables.

Communities may ask FEMA for assistance in understanding how future conditions, such as sea level rise, will impact their flood risk. TMAC recommended FEMA develop *non-regulatory* products reflecting information about future conditions. FEMA is working to address TMAC's recommendations, in part through the development of pilot projects at the regional and local level. FEMA has conducted several pilot studies on incorporating sea level rise into current flood mapping methodologies. In 2013, for example, FEMA worked with USACE, NOAA, and the U.S. Global Change Research Program to develop a sea level rise viewer tool to support post-

Question#:	8
Topic:	Future Conditions
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
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Committee:	SCIENCE (HOUSE)

Sandy recovery. The viewer included coastal areas of New York and New Jersey and depicted future 1-percent-annual-chance floodplains across a range of future sea level rise projections. Tools like the sea level rise viewer provide information that can complement regulatory products such as the FIRM and are part of what FEMA is exploring through its FFRD initiative.

FEMA acknowledges many other agencies produce sea level rise and future conditions information, such as NOAA's Sea Level Rise Viewer, and FEMA regularly points communities to this information. As FEMA considers how to incorporate future conditions information into its mapping efforts, the Agency believes it is also important to leverage existing resources without duplicating effort.

Question: What challenges does FEMA currently face in communicating future flood risk to the public?

Response: Flood risk is dynamic, and the impacts are broad. Future conditions, such as sea level rise, more intense winter storms and more frequent heavy rains, heat waves, tornados, drought, and extreme flooding, may all result in changes to risk. Risks also change when communities decide to implement changes to the landscape, such as new housing developments, improved business districts, or new roads. These changes can increase the amount of water draining into the watershed. Communicating the wide-ranging potential impacts of future conditions remains a challenge.

Further, evaluating the impacts of future conditions is based on the understanding risk will be different in the future without certainty of all the ways risks may change or the effect those changes may have. The challenges in this space are represented by several behavioral science biases affecting communication and comprehension of future conditions. For example:

- **Availability:** Decisions are swayed by how easily we can think of examples of a specific object or event. Predicting is inherently difficult for humans.
- **Optimism:** People generally believe they are less likely to experience a hazardous event than someone else.
- **Projection:** The belief our needs, beliefs, and attitudes will remain unchanged in the future.
- **Status Quo:** When forced to choose between uncertain options and a default of doing nothing, people tend to prefer the latter.
- **Hyperbolic Discounting:** The tendency for people to increasingly choose a smaller-sooner reward over a larger-later reward. This leads to low impetus to act on future conditions information.

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Question: Will flood maps be more likely to include future conditions on flood maps after the introduction of Risk Rating 2.0, when they will not be used for setting insurance premiums?

Response: Even after the introduction of Risk Rating 2.0, the regulatory requirements associated with mandatory purchase and floodplain management will still be tied to the FIRM's Special Flood Hazard Area. As a regulatory product, the FIRM is required to depict present-day flood risk, under 44 CFR 65.6(a)(3) (interpreting 42 U.S.C. 4101(a)). As mentioned in part a, some communities elect to incorporate future floodplain conditions into the FIRMs they adopt. In some instances, the shaded Zone X depicted on a FIRM is used to show areas that a community believes will become part of the 1-percent-annual-chance floodplain in the future, due to projected urban development and land use. Risk Rating 2.0 will not change the regulatory requirements associated with the Flood Insurance Rate Maps, but it will provide complementary flood risk information improving the nation's understanding of flood risk.

Question: Are you aware of communities other than New York City which are using a map with expected future conditions for planning purposes?

Response: Communities across the United States are using future conditions information for planning and decision making, and many communities develop their own maps and decision support resources. The Federal family offers communities many important national-level tools and resources for future conditions planning, such as NOAA's Sea Level Rise Viewer, the USGS Coastal Hazards Change Portal, and the U.S. Climate Resilience Toolkit, a multi-agency effort that aggregates many tools into one place. FEMA also offers technical assistance to communities upon request.

Federal agencies have supported several regionally and locally specific initiatives to examine future conditions. FEMA piloted ways to identify potential future risk related to sea level rise in communities such as New York, NY, and Miami, FL. FEMA Region I, in collaboration with USGS, studied a highly erosive area in Nantucket, MA. FEMA then extended this study to the entire state of Massachusetts. In FEMA Region IX, USGS led the development of the Coastal Storm Modeling System (CoSMoS), a numerical modeling system to predict coastal flooding due to combined sea level rise and storms, driven by climate change. Although the modeling system was initially developed for use in the high wave-energy environment of the U.S. west coast, CoSMoS is not site-specific and can be used on sandy and/or cliff-backed coasts throughout the world. The CoSMoS modeling system provides additional information to FEMA about areas that need to consider additional dynamic modeling.

As mentioned, FEMA also partnered with some communities to show areas of future hazards (shaded Zone X) on the regulatory FIRM. For example, in Manhattan, KS, a future conditions flood zone was developed based on the City's long-term master planning document (i.e., future

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development and runoff information). This zone is used by the community to enact higher regulatory standards at the local level.

Question#:	9
Topic:	Unmapped Regions
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Eddie Bernice Johnson
Committee:	SCIENCE (HOUSE)

Question: FEMA's RiskMap process prioritizes its limited resources to areas with the greatest population and flood insurance policies. This provides accurate and detailed maps in counties and communities with high population levels, but there are many regions that have paper maps over 30 years old and many locations without flood maps at all. This approach ignores lesser populated, rural areas, and areas without the resources to enlist contractors or researchers to create their own maps.

How is FEMA working to ensure that regions of the United States that have been previously unmapped or are under-resourced are able to acquire flood maps?

Response: Across the nation, there are approximately 3.5 million stream miles. 1.1 million miles is mostly remote land or state and federal lands, and mapping is likely not needed. FEMA has mapped approximately 1.1 million miles of rivers and streams in the United States. Approximately 1.3 million miles remain that require additional investigation for regulatory flood hazard data and mapping.

FEMA, in coordination with state, local, tribal, and territorial governments, prioritizes mapping resources for areas with the greatest population levels and flood insurance policies, on the assumption these areas represent the highest risk.

While maintaining current flood maps is critical, we are still far from completing the initial job of mapping the the 2.4 million miles across the nation that are not on state and federal lands.. Some geographical areas within FEMA's map inventory still have paper maps. The cost and effort required to convert the paper-based inventory to a digital format, while maintaining accuracy, quality and minimizing alterations to the floodplain, ranges widely among unmodernized communities. While FEMA strives to modernize these maps, the age of the maps is not always an indicator of their utility. For areas where natural and man-made features have not changed, the actual risk of a 1-percent-annual-chance flooding event may remain consistent over several decades.
FEMA is exploring new cost-effective technologies and approaches that can deliver information to lesser populated areas, in the absence of a FIRM or in areas with older FIRMs. For example, FEMA is using the Base Level Engineering (BLE) approach, which uses engineering models software and high-resolution topographic data to produce credible engineering analysis for many watercourses depicted as Zone A floodplains on a FIRM. BLE data, which is produced on a watershed scale, provides updated flood hazard information communities can use as best available information. BLE data can arm a community with more data to use for making informed regulatory and development decisions.

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Approaches like BLE help FEMA provide communities with crucial information at a higher efficiency. FEMA is interested in exploring other strategies and approaches like BLE that provide accurate data through more streamlined processes. Such approaches help FEMA to serve a greater number of communities across the country.

Question#:	10
Topic:	Additional Comments
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Eddie Bernice Johnson
Committee:	SCIENCE (HOUSE)

Question: Was there anything else that you would like to address that you did not get a chance to at the hearing?

Response: FEMA recognizes the importance of providing more comprehensive flood information, especially in the face of changing weather conditions. This includes information taking into account future conditions (e.g., climate change, urbanization, etc.) and other residual perils that are not as well understood, such as risks posed to areas behind dams and levees. FEMA looks forward to adapting its processes to better meet the diverse needs of stakeholders across the nation.

The current mapping process outlined in law blends regulatory and non-regulatory products in ways that can create confusion. The regulatory action of identifying special flood hazard areas (SFHAs) – or areas with a 1-percent-annual-chance of flooding - carries with it a substantial and time-consuming regulatory process, in part because it drives the mandatory purchase of flood insurance. The identification of SFHAs has resulted in the adoption of minimum flood standards, leading to $100B in savings over the past 40 years. However, it can also give the false impression that if you are outside of the SFHA, you do not have any flood risk. As a result, the regulatory product does not always achieve Congress's intent of encouraging more people to understand and reduce their flood risk through the NFIP.

On the other hand, FEMA has been able to demonstrate that accurate and informative non-regulatory products that provide additional flood risk information and encourage mitigation action can quickly be delivered to the public. As Congress moves forward with its reauthorization efforts, making it clear to FEMA and the public which requirements are regulatory in nature and which are not will further mutual understanding of Congressional intent. Further, history has taught us that the mapping process will continue to evolve as technologies change and as we collectively learn more from recent flooding events.

Question#:	11
Topic:	Risk Rating 2.0
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Charlie Crist
Committee:	SCIENCE (HOUSE)

Question: Last year, FEMA announced they would be working on a new rating methodology called Risk Rating 2.0. Thus far, FEMA has provided very little information about Risk Rating 2.0 and what it will mean for the 5-million NFIP policyholders nationwide. For example, it's unclear what methodology FEMA will use to determine flood risk, what types of data will be considered, how mitigation projects will be incorporated into the methodology, and - most importantly - how Risk Rating 2.0 will impact the pocketbooks of American homeowners. Currently, NFIP rate increases average between 7 and 9 percent each year, with some variation for different classes of properties. There is concern that under Risk Rating 2.0 homeowners in higher-risk areas will be faced with unsustainable rate increases year-over-year - threatening their ability to afford flood insurance or, even worse, to stay in their home. Under Risk Rating 2.0, will policyholders see their premiums increase even faster? Specifically, will rate increases reach, or come close to, the 18 and 25 percent caps under current law?

Response: Thank you for your inquiry about the NFIP's Risk Rating 2.0 initiative. Many of your questions regarding the new rating methodology, data, technology, and economic impacts will require additional time for FEMA to provide a complete and accurate response. We appreciate your patience while my team works to provide those answers.

Last year FEMA announced the Risk Rating 2.0 initiative to deliver flood insurance rates that people can trust, can value, are easier to understand and better reflect a property's unique flood risk. Knowing the true risk of one's property is critical to ensure adequate insurance coverage and claim payments after a flood. Additionally, it informs property owners on mitigation measures they can take to reduce their flood risk.

FEMA recognizes and shares your concerns about flood insurance affordability. In April 2018, at the direction of Congress, FEMA released the framework titled, "*An Affordability Framework for the National Flood Insurance Program*". The Affordability Framework, for the first time, provides data-driven analysis of the cost-burden borne by current flood insurance policyholders and potential future policyholders. The Affordability Framework identifies populations most burdened by the cost of flood insurance and provides tangible options for policymakers. In 2019, FEMA submitted a legislative proposal to establish a means-tested program that would cap premium increases for certain policyholders. FEMA looks forward to working with Congress to pass and implement the proposal

Initially, the agency announced the new rates for single-family homes would go into effect nationwide on October 1, 2020. Additional time is required to communicate with policyholders allowing them enough time to understand what the changes mean, and to give NFIP insurers ample opportunity to test and work with the new rating engine. To reduce complexity, FEMA is

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Committee:	SCIENCE (HOUSE)

revising the implementation of Risk Rating 2.0 by one year, to October 1, 2021. This extension allows for all NFIP policies – including, single-family homes, multi-unit and commercial properties – to change over to the new rating system at one time instead of a phased approach, as originally proposed.

Risk Rating 2.0 is the continuation of FEMA's multi-year effort to transform the NFIP. As the current rating methodology has not changed since it was implemented in the 1970s, technology has evolved and so has our understanding of flood risk. The new methodology will distribute premiums more equitably across all policyholders. This is the right thing to do for policyholders who have been overpaying for flood insurance based on the value of their home and their property's individual flood risk.

While FEMA needs additional time to respond to your inquiry, the questions and concerns you share will help us as we plan to actively engage with Congress and other key stakeholders about Risk Rating 2.0 and the overall transformation of the NFIP to ensure a clear view and understanding of the implementation process.

If you need additional information or assistance, please have a member of your staff contact the Office of External Affairs, Congressional and Intergovernmental Affairs Division, by telephone at (202) 646-4500.

Question#:	12
Topic:	Rate Increases
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Charlie Crist
Committee:	SCIENCE (HOUSE)

Question: Has FEMA given any consideration to policyholders who may see unsustainable rate increases? How will FEMA help those policyholders who can no longer afford their coverage or homes due to Risk Rating 2.0?

Response: Thank you for your inquiry about the NFIP's Risk Rating 2.0 initiative. Many of your questions regarding the new rating methodology, data, technology, and economic impacts will require additional time for FEMA to provide a complete and accurate response. We appreciate your patience while my team works to provide those answers.

Last year FEMA announced the Risk Rating 2.0 initiative to deliver flood insurance rates that people can trust, can value, are easier to understand and better reflect a property's unique flood risk. Knowing the true risk of one's property is critical to ensure adequate insurance coverage and claim payments after a flood. Additionally, it informs property owners on mitigation measures they can take to reduce their flood risk. FEMA administers Mitigation Grant Programs to include Flood Mitigation Assistance (FMA), Pre-Disaster Mitigation (PDM) and Hazard Mitigation Grant Program (HMGP) that may provide funding opportunities for eligible mitigation activities.

FEMA recognizes and shares your concerns about flood insurance affordability. In April 2018, at the direction of Congress, FEMA released an Affordability Framework for the National Flood Insurance Program. The Affordability Framework, for the first time, provides data-driven analysis of the cost-burden borne by current flood insurance policyholders and potential future policyholders. The Affordability Framework identifies populations most burdened by the cost of flood insurance and provides tangible options for policymakers. In 2019 and 2020 FEMA submitted a legislative proposal to establish a means-tested program that would cap premium increases for certain policyholders. FEMA looks forward to working with Congress to pass and implement the proposal.

Initially, the agency announced the new rates for single-family homes would go into effect nationwide on October 1, 2020. Additional time is required to communicate with policyholders allowing them enough time to understand what the changes mean, and to give NFIP insurers ample opportunity to test and work with the new rating engine. To reduce complexity, FEMA is revising the implementation of Risk Rating 2.0 by one year, to October 1, 2021. This extension allows for all NFIP policies – including, single-family homes, multi-unit and commercial properties – to change over to the new rating system at one time instead of a phased approach, as originally proposed.

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Question#:	13
Topic:	Economic Impact
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Charlie Crist
Committee:	SCIENCE (HOUSE)

Question: Will FEMA be performing an economic impact analysis of Risk Rating 2.0? If so, when will that analysis be complete, what factors will it consider, and will that analysis be made public?

Response: Thank you for your inquiry about the NFIP's Risk Rating 2.0 initiative. Many of your questions regarding the new rating methodology, data, technology, and economic impacts will require additional time for FEMA to provide a complete and accurate response. We appreciate your patience while my team works to provide those answers.

Last year FEMA announced the Risk Rating 2.0 initiative to deliver flood insurance rates that people can trust, can value, are easier to understand and better reflect a property's unique flood risk. Knowing the true risk of one's property is critical to ensure adequate insurance coverage and claim payments after a flood. Additionally, it informs property owners on mitigation measures they can take to reduce their flood risk.

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Question#:	14
Topic:	Engagement with Congress
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Charlie Crist
Committee:	SCIENCE (HOUSE)

Question: As previously mentioned, FEMA has not provided much information on Risk Rating 2.0 thus far, despite multiple congressional and stakeholder inquiries. In a press release from November 2019 - in which FEMA announced a one-year delay of Risk Rating 2.0 - FEMA promised to continue working with Congress and other stakeholders to "ensure transparency and visibility." How will FEMA improve its transparency and engagement with Congress and others as FEMA moves through the process of developing and implementing Risk Rating 2.0?

Response: Thank you for your inquiry about the NFIP Risk Rating 2.0 initiative. Many of your questions regarding the new rating methodology, data, technology, and economic impacts will require additional time for FEMA to provide a complete and accurate response. We appreciate your patience while my team works to provide those answers.

Last year FEMA announced the Risk Rating 2.0 initiative to deliver flood insurance rates that people can trust, can value, are easier to understand and better reflect a property's unique flood risk. Knowing the true risk of one's property is critical to ensure adequate insurance coverage and claim payments after a flood. Additionally, it informs property owners on mitigation measures they can take to reduce their flood risk.

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While FEMA needs additional time to respond to your inquiry, the questions and concerns you share will help us as we plan to actively engage with Congress and other key stakeholders about Risk Rating 2.0 and the overall transformation of the NFIP to ensure a clear view and understanding of the implementation process.

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Question#:	15
Topic:	Information Prior to Implementation
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Charlie Crist
Committee:	SCIENCE (HOUSE)

Question: Will Congress be provided information on methodology, rate changes, and other details of Risk Rating 2.0 - with ample time to review - prior to implementation?

Response: Thank you for your inquiry about the NFIP Risk Rating 2.0 initiative. Many of your questions regarding the new rating methodology, data, technology, and economic impacts will require additional time for FEMA to provide a complete and accurate response. We appreciate your patience while my team works to provide those answers.

Last year FEMA announced the Risk Rating 2.0 initiative to deliver flood insurance rates that people can trust, can value, are easier to understand and better reflect a property's unique flood risk. Knowing the true risk of one's property is critical to ensure adequate insurance coverage and claim payments after a flood. Additionally, it informs property owners on mitigation measures they can take to reduce their flood risk.

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Question#:	16
Topic:	Remote Sensing Imagery
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Paul Tonko
Committee:	SCIENCE (HOUSE)

Question: Can you describe the plans for FEMA and NOAA to incorporate the use of remote sensing imagery from commercial sources to inform the flood mapping program based on the ability for these sources to provide high-cadence, high-resolution satellite imagery, to support resilience, recovery, and mitigation activities?

Response: To perform the flood risk analysis needed for NFIP mapping and to produce the mapping products, FEMA needs basic framework mapping data. The most important type of data needed for these purposes is ground elevation data. FEMA also uses ortho-imagery extensively as a base map to provide the horizontal positioning and context to its flood mapping products. Ortho-imagery provides and overhead view of features on the ground with the geometric accuracy of a map from aerial photographs.

FEMA works with USACE, USGS, NOAA, the U.S. Department of Agriculture's Natural Resources Conservation Service, and other Federal agencies through the 3DEP and other interagency mechanisms to maximize interagency collaboration on the development of digital elevation data and to reduce duplications of effort. FEMA also works with a number of agencies that produce ortho-imagery through the National Digital Orthophoto Program.

The goal of 3DEP is to acquire updated elevation data for the Nation, meeting a minimum national standard, by maximizing Federal, State, and local partnerships. The USGS will manage the data and make it available to the public. The 3DEP activity responds to growing needs for high-quality and high-resolution elevation data to capture changes in the Nation's natural and constructed features.

FEMA also has a significant interest in geodetic control. The precise elevation measurements needed to map flood risk, assess risk at a particular structure, and design new construction to minimize flood risk is technically challenging and reliant on good geodetic control and systems for measuring elevations. NOAA's National Geodetic Survey (NGS) is responsible for national geodetic control infrastructure, the precise earth measurement frameworks needed to measure position and elevation on the earth. NGS, in cooperation with state, local, tribal and territorial governments, manages the control systems necessary to make the horizontal and vertical measurements needed for flood hazard mapping. FEMA maintains a direct ongoing relationship with NGS and participates in the Federal Geodetic Control Subcommittee, an interagency coordination group.

Question#:	17
Topic:	Up to Date Flood Maps
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Paul Tonko
Committee:	SCIENCE (HOUSE)

Question: In order for FEMA and NOAA to provide local communities with the best tools to enable local flood resilience programs, how are FEMA and NOAA incorporating the use of remote sensing imagery from commercial sources to ensure they have the most up to date flood maps?

Response: Updating flood maps to reflect the best science and data available is important for avoiding future losses, guiding safer building, pricing insurance appropriately, and helping to ensure the NFIP is implemented consistently and fairly. To choose the correct methodologies and data sources for each NFIP mapping project, FEMA uses the expertise of our private sector contractors, close coordination with other federal agencies across a range of scientific and technical disciplines, and input from the TMAC, the National Academy of Sciences, and others.

The National Flood Hazard Layer and other digital flood data products can be combined with commercial imagery so communities can see how recent changes on the landscape relate to the NFIP floodplains and related information. FEMA worked with the S&T Flood Apex program to acquire national historical flood extent data based on LandSat imagery from private industry. The data is not intended to update maps, but it can serve as a critical data point to help FEMA evaluate where there could be mapping update needs. The dataset will reflect historical flood areas in the nation and reinforce FEMA's message that flooding is not limited to the areas identified on a Flood Insurance Rate Map. FEMA hopes this data will become available to the Agency by the end of this fiscal year and plans to evaluate the data once it is received.

To systematically collect enhanced elevation data in the form of high-quality LiDAR data, FEMA works with other federal agencies through the 3DEP and other interagency mechanisms. Some purchases are made as assisted acquisitions through the USGS, in projects that include other funding partners, when possible. FEMA also funds LiDAR elevation projects through its CTP Program, through agreements with other Federal agencies, and through FEMA's own contracts.

Question#:	18
Topic:	Repetitive Losses
Hearing:	An Examination of Federal Flood Maps in a Changing Climate
Primary:	The Honorable Anthony Gonzalez
Committee:	SCIENCE (HOUSE)

Question: How much are repetitive losses costing the NFIF?

Response: Since 1978, there have been approximately 2.5 million NFIP claims filed with building and contents payments totaling $70.1 billion. Of these claims, properties meeting the NFIP definition for Repetitive Loss (2 or more losses $1,000+ within 10 years) have accounted for 30 percent of all claims payments, which total over $20 billion.

For losses in more recent history, occurring since January 1, 2015, the NFIP has received more than 345,000 claims with payments totaling over $19.1 billion. Of those claims, NFIP designated Repetitive Loss properties make up approximately 17 percent of claims payments for the time period, with nearly 50,000 claims totaling over $3.3 billion.

Responses by Mr. Mark Osler

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"*An Examination of Federal Flood Maps in a Changing Climate*"

Questions for the Record to:

Mark S. Osler

Senior Advisor for Coastal Inundation and Resilience

National Oceanic and Atmospheric Administration

U.S. Department of Commerce

Submitted by Subcommittee on Environment Chairwoman Mikie Sherrill

1. *To what extent do FEMA and NOAA collaborate on flood risk mapping and communication to the public, and how can your respective agencies combine their unique and vital capabilities to improve how flood science is used across the board, including to better inform the flood insurance rate maps?*

   The National Oceanic and Atmospheric Administration (NOAA) and the Federal Emergency Management Administration (FEMA) collaborate in a variety of ways, including data sharing and expert advising. NOAA supplies essential data to FEMA, like topographic and bathymetric data for flood modeling and mapping, foundational datasets (e.g. gravity and geodetic control, vertical transformation tools like NOAA Vdatum) needed to ensure accurate height information used for Base Flood Elevations, and hydrology inputs (such as NOAA's Atlas 14 Precipitation Estimates) for riverine flood studies. Likewise, NOAA uses FEMA data, such as the FEMA Flood Insurance Study river model data or FEMA riverine flood insurance study models (HEC-RAS), to produce collections of potential inundation scenario maps.

   NOAA works extensively with communities to help them understand their flood risks, including providing data and analysis of the extent of flood heights that FEMA uses to administer the National Flood Insurance Program. The National Weather Service National Hurricane Center's storm surge modeling is also used for both storm specific forecasting and hurricane evacuation planning in partnership with states, FEMA, and the US Army Corps of Engineers. FEMA, NOAA, and other agencies continue to take steps to improve the sharing of information, expertise, and services in providing flood risk information.

   Additionally, NOAA's National Water Center (NWC) is improving flood-related decision support services. The recent demonstrations of new, real-time, and event-based flood inundation mapping (FIM) capabilities in portions of Texas depicted the spatial extent and depth of flood waters. This capability leverages forecast guidance generated by NOAA's new National Water Model as well as the river forecasts produced by the thirteen National Weather Service River Forecast Centers. This new FIM capability, soon to be expanded to the Northeastern United States, may enable emergency managers to better mitigate the

impacts of flooding and build more resilient communities. NOAA, FEMA, the United States Geological Survey (USGS), and the United States Army Corps of Engineers (USACE) – through the Integrated Water Resources Science and Services Flood Inundation Mapping Standard Operating Procedure Workshop – are working together toward an integrated FIM that identifies and employs the best available maps for use during flood events. The NWC has begun testing these tools.

Is there a need for improved mechanisms for interagency collaboration or coordination in flood mapping between FEMA and the science agencies involved in flood research like NOAA? If so, how can this collaboration be improved to better serve floodplain communities around the nation?

NOAA currently collaborates with FEMA in key ways, such as the interagency implementation of the Geospatial Data Act of 2018, to improve management of geospatial data, technologies, and infrastructure in accordance with the nation's evolving flood mapping needs and priorities.

Atlas 14 is the official peer-reviewed record of precipitation frequency estimates for the United States and affiliated territories, and updates to the estimates help improve the national characterization of future flood risk and support future efforts to mitigate floods. Atlas 14 information quantifies the precipitation amount, at a particular location and for a given duration, that qualifies as a "NN-year" precipitation event (i.e., has a 1-in-NN chance of being exceeded in any given year). Precipitation frequency estimates are needed for infrastructure design, development and planning regulations, environmental management, and hydrometeorological modeling and analysis. NOAA's Atlas 14 is funded by affected states and other users on a cost-reimbursable basis. As such, the volume update cycle is driven by stakeholder requirements and partner engagement. Individual volumes are supported by a pooled fund approach managed by the Department of Transportation, with contributions from partners at the local, county, state, and federal level.

Collaboration on certain services to floodplain communities is currently occurring and existing mechanisms provide a basis for increasing cooperation. NOAA's representative on FEMA's Technical Mapping Advisory Council provides subject matter expertise and recommendations for FEMA's flood hazard mapping program. NOAA staff also work onsite with FEMA as they establish the new Building Resilient Infrastructure and Communities grant program. Resilient natural infrastructure, such as coral reefs, oyster beds, and wetlands, can protect shore-based communities while also having economic, recreational, and other benefits.

Other potential collaboration efforts could better connect FEMA with NOAA's network of robust coastal partnerships and extensive research, restoration and resilience projects. Such a network of partners includes state Sea Grant programs, state Coastal Zone Management programs, Regional Integrated Sciences and Assessments, Integrated Ocean Observing

System regional partners, Sectoral Applications of Research Program, and Coastal and Ocean Climate Applications.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"*An Examination of Federal Flood Maps in a Changing Climate*"

Questions for the Record to:

Mark S. Osler

Senior Advisor for Coastal Inundation and Resilience

National Oceanic and Atmospheric Administration

U.S. Department of Commerce

Submitted by Subcommittee on Investigations and Oversight Chair Bill Foster

1. *If resources were no constraint, what kind of data sets do you believe would be the most useful in order to enable the most accurate, timely and granular flood predictions at FEMA or elsewhere? Are there any particular tools such as supercomputers for modeling, ground penetrating radars for visualizing underground water flow, or LIDAR that you believe would be most constructive in improving flood mapping and prediction services?*

   There are a variety of key datasets that are used to create accurate and granular flood predictions. We have grouped these data sets below as Spatial Reference System, Elevation Data, and Water Observations and Modeling.

   Spatial Reference System

   The National Spatial Reference System (NSRS) provides the underlying framework for elevation data on floodplain maps and is a foundational element of FEMA's flood maps. NOAA is in the process of modernizing the NSRS, including conducting extensive airborne gravity surveys over all states and territories, and increasing the density of Continuously Operating Reference Stations that provide Global Navigation Satellite System (GNSS) data in support of three dimensional positioning, surveying and mapping, and other applications throughout the United States and its territories. Together these systems enable surveyors to access accurate positioning and height information with GNSS (also known as GPS) technology throughout the country in a timely manner and improve our understanding of the direction(s) water will flow.

   Elevation Data

   Both topographic and bathymetric data are essential for modeling the physics of flooding and accurately displaying flood extents and depths in mapping products.

   NOAA is a partner in the USGS-led 3D Elevation Program (3DEP), which focuses on terrestrial elevations across the United States. NOAA co-chairs the Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM) with USGS; the IWG-OCM works in parallel with 3DEP to strive for seamless elevation data along the coast.

NOAA is both a contributor and a consumer of 3DEP data, particularly for the interior of the nation for weather and water prediction. NOAA is actively engaged with 3DEP in the coastal zone, where NOAA contributes to terrestrial collections. NOAA has often been the catalyst for multi-agency 3DEP projects, such as collecting LIDAR in the Pacific islands. NOAA also conducts combined topographic and bathymetric (i.e., topobathic) collections of coastal and nearshore waters; these data complement and improve 3DEP data in coastal states. NOAA shoreline data features heavily in topobathy DEMs that USGS produces.

NOAA hosts the U.S. Interagency Elevation Inventory, a public resource providing information on the elevation data that exists. This resource is used by 3DEP to track progress toward the goal of national elevation coverage with high-quality recent elevation data and identify gaps to be filled, often through collaborative multi-agency resources. It is critical to 3DEP operations. NOAA and USGS are the primary partners in maintaining the inventory with active participation from FEMA, USACE, the United States Department of Agriculture's (USDA) Natural Resources Conservation Service, and the National Park Service (NPS).

NOAA additionally supplies the underlying infrastructure, the National Spatial Reference System, that enables broad area elevation mapping to be done. This is a significant contribution to completing a baseline terrestrial elevation, a goal of 3DEP. Maintaining the NOAA Continuously Operating Reference Station (CORS) Network and completing the nationwide airborne gravity collection project, which is part of the Gravity for the Redefinition of the Vertical Datum program, are vital to attaining the elevation accuracies required by 3DEP.

NOAA and USGS are also co-funding a study on elevation — the 3D Nation Elevation Requirements and Benefits study – to look at both terrestrial and bathymetric (water depth) elevation needs. We anticipate finishing the study by the end of FY20.

Bathymetry is a dataset required to produce high quality hydrodynamic models of storm surge and wave impacts for coastal flood prediction. Analyses of wave runup and overtopping are highly sensitive to beach and dune topography and water depths through the surf zone. High quality coastal elevation data and shallow water bathymetry are important.

Water Observations and Modeling

Coastal water level information provided by NOAA's National Water Level Observation Network (NWLON) is critical to our understanding of how the land elevation relates to water levels. This information includes tidal datums, frequency of inundation, exceedance probabilities, and other products. Increased NWLON density or improved modeling based on existing stations would more effectively support flood predictions and coastal hazard mitigation. VDatum, a datum transformation tool produced primarily for coastal areas, converts geodetic and tidal datums from different references to one common system.

USGS and other federal partner data are critically important to NWS water and flood prediction. USGS stream and river gauges provide essential streamflow information for

NOAA's operational river and flood forecasting and warning services. USGS is currently in the process of enhancing the water-related observations they provide, through the implementation of their Next Generation Water Observing System (NGWOS) in select watersheds. Implementation of NGWOS will provide high temporal and spatial resolution data on streamflow, evapotranspiration, snowpack, soil moisture, water quality, groundwater/surface water connections, stream velocity distribution, sediment transport, and water use. These enhancements will be leveraged by NOAA's new National Water Model (NWM) to enhance predictions of flooding and associated inundation mapping at the neighborhood scale.

NOAA is exploring improvements to future conditions modeling, prediction, and mapping through better integration of different types of observations, enhanced data assimilation, and earth system modeling. As an important first step, NOAA is developing the capability to couple inland freshwater predictions with coastal inputs (e.g., coupled riverine and estuarine coastal models that include wave runup at the open coast) to provide better predictions of the total amount of water in the coastal zone. Specifically, as an initial operational total water forecast capability, NOAA is coupling the NWM with the Extratropical Surge and Tide Operational Forecasting System.

The same logic applies to incorporating projected precipitation information based on downscaled general circulation models. NOAA is also looking at improving predictions with process models that account for geomorphology changes to rivers and coasts (including long-term erosion), probabilistic information on both short-term changes (such as erosion and inundation) and long-term changes (such as changing ocean and riverine conditions and future land cover change estimates that take into account population growth and the impacts of runoff).

Atlas 14 is the official peer-reviewed record of precipitation frequency estimates for the United States and affiliated territories, and updates to the estimates help improve the national characterization of future flood risk and support future efforts to mitigate floods. Atlas 14 information quantifies the precipitation amount, at a particular location and for a given duration, that qualifies as a "NN-year" precipitation event (i.e., has a 1-in-NN chance of being exceeded in any given year). Precipitation frequency estimates are needed for infrastructure design, development and planning regulations, environmental management, and hydrometeorological modeling and analysis. NOAA's Atlas 14 is funded by affected states and other users on a cost-reimbursable basis. As such, the volume update cycle is driven by stakeholder requirements and partner engagement. Individual volumes are supported by a pooled fund approach managed by the Department of Transportation, with contributions from partners at the local, county, state, and federal level.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"An Examination of Federal Flood Maps in a Changing Climate"

Questions for the Record to:

Mark S. Osler

Senior Advisor for Coastal Inundation and Resilience

National Oceanic and Atmospheric Administration

U.S. Department of Commerce

Submitted by Chairwoman Eddie Bernice Johnson

1. *NOAA is one of a handful of federal agencies that collect water data in coastal areas. Sometimes, such as with tidal gauges, these data are very similar, leading to overlapping and uncoordinated efforts by multiple agencies. It seems there is a need for better coordinated data collection, to ensure the most efficient use of taxpayer dollars and the most accurate science possible. How can Congress help address the duplication of data collection on the coasts, and improve coordination on producing distinct, high quality datasets?*

   Federal agencies and non-federal entities collect water level data in coastal areas for specific purposes that are most often complementary rather than duplicative. High quality measurements of coastal water levels and uniform national coverage enable a properly-informed public and safe maritime commerce. NOAA understands that coordination and accurate measurements along our coasts are essential to achieve these goals.

   NOAA's NWLON is the underlying, authoritative, and permanent operational system (see 33 U.S.C. §883a. et. seq and 33 U.S.C. 892 et. seq.) for measuring the nation's coastal water levels. NWLON data is used for calculating and publishing NOAA's official tidal datums for vertical control, predicting and publishing NOAA's official U.S. Tide Prediction Tables, delineating marine boundaries, and calculating long-term relative sea level trends.

   NOAA has strict standards for water level data within centimeters of error. Other agencies' short-term stations, lower cost sensors, and high-density rapid deployment networks depend on these NOAA data. Comparing data from these short-term stations and other records to the long-term, highly accurate datasets provided by the NWLON enables the uncertainty of other measurements to be significantly reduced. NOAA continues to work with federal and state agencies and others to better coordinate efforts to accurately measure water levels.

NOAA's coordination with other agencies has improved greatly over the past decade, and coastal areas have benefited. For example, NOAA and USGS have been working more closely in coastal areas to collect water level meeting NOAA's strict standards for accuracy, which multiple agencies can then use. Additional examples include the 3D-Elevation Program (3DEP) and the U.S. Interagency Elevation Inventory with USGS, USDA, USACE, FEMA, NPS – projects that provide data essential for modeling the physics of flooding and accurately displaying flood extents and depths in mapping products. NOAA has been working with USACE since 2005, following Hurricane Katrina, to provide data collection guidance and tidal datum processing support for USACE coastal projects.

2. *Is there a need for improved resources at NOAA or for interagency coordination on collection of land elevation and water level data, and improved standards for data collection?*

   NOAA's NWLON is the underlying, authoritative, and permanent operational system for measuring the nation's coastal water levels.

   In 2008, and then updated in 2014, NOAA conducted a gaps analysis of the NWLON to determine how many NWLON stations are needed to provide vertical control (accurate tidal datums and long-term sea level trends) for the nation. NOAA currently has 210 NWLON stations around the nation, including the Great Lakes. The analysis revealed that additional NWLON stations are necessary to fill existing gaps around the country. These gaps may leave coastal communities and other types of infrastructure located within them vulnerable to inundation and sea level rise.

   NOAA has been working with USGS, its Integrated Ocean Observing System regional partners, and others to fill NWLON gaps in several of these coastal communities. In 2020 there will be upgrades to eight USGS stations. NOAA has also helped several state and local entities establish or modify their own storm surge and sea level trends monitoring networks to collect data to NOAA standards, as well as helped others establish water level sensors for safe navigation; these stations number over 100 and are growing.

   On land, FEMA relies on NOAA's National Spatial Reference System (NSRS) for the consistent definition of elevation on their floodplain maps and on National Flood Insurance Program Elevation Certificates. NOAA is currently in the process of modernizing the NSRS for alignment with positions obtained with GNSS technology, presenting an opportunity to adopt an updated NSRS and improve the accuracy of FEMA flood maps. As the manager of the NSRS, NOAA looks forward to working with FEMA to incorporate this improved positioning framework into floodplain maps.

3. *In the U.S., we're already seeing the effects of climate change. Sea level rise, more intense rainfall events, and an increase in storm frequency and intensity all contribute to*

a rapidly changing landscape, but FEMA flood maps do not reflect future flood risk from climate change and other human activities. Americans cannot afford to make decisions about their property based on information that does not show how flood risk may impact them in the future.

What are NOAA's current efforts to understand, characterize, and communicate future flood risk to Americans, and what NOAA products and services are available that communicate future flood risk?

NOAA's NWLON maintains the long-term sea level records for the coast based on the long-record times series of data. Using these data, NOAA, working with the Federal Interagency Sea Level Rise and Coastal Flood Hazard Scenarios and Tools Task Force, a joint task force of the U.S. Ocean Policy Committee and the U.S. Global Change Research Program, has produced a report looking at sea level rise scenarios across the nation to support coastal preparedness planning and risk management processes. In the report, the researchers relied on the latest published and peer-reviewed science to refine six global sea level rise scenarios (Low, Intermediate Low, Intermediate, Intermediate High, High, and Extreme) decade by decade for this century.

The report helps communities track a range of scenarios that are potentially applicable for each of the time frames and assess their risk of experiencing impacts under the scenario. The researchers scaled these scenarios down to a one-degree gridded resolution, or roughly 70 miles. This allows coastal managers from Miami, Florida, to Mobile, Alabama, to use the same scenario to prepare for different outcomes.

A similar method is already being used in state planning in the mid-Atlantic and Gulf of Mexico and has been previously used to assess risk to U.S. military installations worldwide in an interagency report prepared for the Department of Defense in 2016. USGS has taken this data and turned it into a sea-level scenario tool and interactive guide.

NOAA has a number of flood mapping products and technical assistance services that help communities understand their flood risks and prepare for flood scenarios. From maps that help illustrate the extent of riverine flood forecasts to information on potential storm surge flooding, coastal flood exposure, and potential sea level rise impact areas, these resources include:

- NOAA's National Hurricane Center's Potential Storm Surge Flooding Maps provide valuable information on storm surge flooding along the Gulf and East Coasts.
- NOAA's Center for Operational Oceanographic Products and Services provides both Annual and Seasonal High Tide Flooding Outlooks to provide information about possible flooding during high tides.
- NOAA's Office for Coastal Management's (OCM) Digital Coast Sea Level Rise Viewer visualizes community-level impacts from coastal flooding or sea level rise (and includes scenarios up to 10 feet above average high tide).
- OCM's Adapting Stormwater Management for Coastal Floods tool helps communities understand how sea level rise and lower-severity coastal floods will affect their stormwater systems.

- OCM provides technical assistance to communities to help them use these various products and services through online tutorials as well as in person tutorials and courses.

What challenges does NOAA currently face in communicating future flood risk to the public?

Properly measuring and modeling changing flood risk is a key component in communicating risk to the public. One challenge is improving the delivery and public awareness of the tools and information NOAA and others provide regarding flood risk. NOAA is building on its track record in raising local capacity by applying social science and less technical language in its outreach, services and products. NOAA is also building on its long-standing mission supporting coastal planning and management through capacity building and applying it to communicating flood risk.

What other resources does NOAA need to continue studying and addressing future flood risk?

NOAA is exploring integrating input from other science producing agencies (i.e., USGS, NASA, etc.) to account for the decision support needs of the public and other federal agencies (i.e., FEMA, USACE, DoD, etc.). This approach would ensure that taxpayer investment in observations, modeling, and communicating future flood risk is both efficient and responsive to the needs of stakeholders inside and outside of the Federal Government. At present, NOAA will continue to maximize its Federal resources while leveraging partnerships with other Federal agencies and public entities to their fullest extent.

Was there anything else that you would like to address that you did not get a chance to at the hearing?

Maintaining accurate flood risk assessments will require measuring and tracking subsidence and uplift along the coast. NOAA recognizes value in having continuously operating Global Navigation Satellite System (GNSS) to measure and track vertical and horizontal land motion over time. Risk assessment efforts benefit from integrating both land elevation and water level measurement capabilities, such as combining water level data with interferometric synthetic-aperture radar measurements of the relative rates of land subsidence.

NOAA echoes FEMA's Technical Mapping Advisory Council Future Conditions Risk Assessment and Modeling report's recommendations to:

- Obtain future population and land cover change data to determine watershed hydrology changes.
- Expand research and innovation for water data collection, such as using Doppler radar.
- Quantify the accuracies, degree of precision, and uncertainties associated with respect to flood studies and mapping products for existing and future conditions.

This should include the costs and benefits associated with any recommendation leading to additional requirements for creating flood-related products.

- Implement riverine erosion hazard mapping (channel migration zones), leveraging existing data, models, and approaches that reflect site-specific processes and conditions.

Additionally, NOAA is working to establish a subnetwork of 36 stations inside the NOAA Continuously Operating Reference Station (CORS) Network, the "NOAA Foundation CORS Network" (locations: https://www.ngs.noaa.gov/CORS/foundation-cors.shtml). These stations will act as the backbone of the larger NOAA Foundation CORS Network, ensure consistent national access to the NSRS, and enhance the connection of the NSRS to the International Terrestrial Reference Frame (ITRF).

The ITRF and NSRS alignment creates a more consistent worldwide spatial reference frame to improve planning for U.S. and international efforts to mitigate flood risks. The benefits include better forecasts of global sea level rise, improved inundation models, more accurate mapping and charting data, and well-positioned transportation and infrastructure plans.

"An Examination of Federal Flood Maps in a Changing Climate"

Questions for the Record to:

Mark S. Osler

Senior Advisor for Coastal Inundation and Resilience

National Oceanic and Atmospheric Administration

U.S. Department of Commerce

Submitted by Representative Paul Tonko

1. *Can you describe the plans for FEMA and NOAA to incorporate the use of remote sensing imagery from commercial sources to inform the flood mapping program based on the ability for these sources to provide high-cadence, high-resolution satellite imagery, to support resilience, recovery, and mitigation activities?*

   Within the Federal Government, the National Geospatial-Intelligence Agency (NGA) and the National Reconnaissance Office (NRO) are the lead agencies for acquiring commercial remote sensing data on behalf of other Federal users. NOAA accesses these data through the Civil Applications Committee and USGS. NOAA routinely accesses commercial data through this arrangement for various applications, including the following water hazard resilience, recovery, and mitigation activities: Mapping, Charting and Geodesy, Damage Assessment, Analysis of Climate Station Environment Change, Assessment and Validation of Severe Storm Events, Cyanobacteria Assessment Network Project, Marine Debris Detection and Tracking, NOAA Coastal Change Analysis Program Regional Land Cover and Change, and Oil Spill Detection and Monitoring.

   In addition, NOAA contracts with the private sector to collect airborne imagery and LIDAR data, particularly when re-mapping large areas of the country affected by hurricane damage. NOAA also contracts with the private sector to process data and create final products from surveys conducted on NOAA platforms. This relationship has resulted in continuous improvement and increased delivery of final products for every year since contract funds were made available in 2000.

   The National Centers for Environmental Information develop digital elevation models for coastal areas that inform the development of flood inundation mapping efforts. Looking forward to FY 2021, NOAA requested $5.0 million to implement the necessary infrastructure to utilize essential data and observations from an increasingly capable and diverse array of partner and commercial systems through the Data-source Agnostic

Common Services (DACS) initiative. DACS will provide a scalable framework that will exploit emerging IT innovations including cloud computing, artificial intelligence, and machine learning. The DACS will seamlessly integrate new commercial and partner data with NOAA data to meet mission needs, possibly including flood mapping.

In previous response events such as hurricanes, FEMA has provided mission assignments to NOAA's National Geodetic Survey to collect airborne imagery in coordination with the NWS River Forecast Centers (RFC). NOAA has access to the same data FEMA does through NGA; however, the NGA does not typically buy data for this purpose. The National Water Center and the River Forecast Centers use both commercial and government satellites (Maxar, Sentinel, GOES, POES) to look at the extent of flooding. FEMA also tasks the NGA with the collection of commercial satellite imagery and, in some extreme cases, provides mission assignments to NASA to collect airborne synthetic aperture radar data.

2. *In order for FEMA and NOAA to provide local communities with the best tools to enable local flood resilience programs, how are FEMA and NOAA incorporating the use of remote sensing imagery from commercial sources to ensure they have the most up to date flood maps?*

NOAA is routinely using commercial data from NGA and NRO for numerous purposes, as mentioned above, as well as uses contracts to acquire and process additional remote sensing data.

Responses by Mr. Ryan R. Branfort

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"An Examination of Federal Flood Maps in a Changing Climate"

Questions for the Record to:
Ryan R. Branfort, PLS, GISP
Senior Vice President
Wilson & Company, Inc., Engineers & Architects

Submitted by Subcommittee on Environment Chairwoman Mikie Sherrill

1. **Is there a need for improved mechanisms for interagency collaboration or coordination in flood mapping between FEMA and the science agencies involved in flood research like NOAA? If so, how can this collaboration be improved to better serve floodplain communities around the nation?**

   Collaboration or coordination on research is not a concern, but collaboration and coordination on funding is where improvement is needed. As I mentioned in my testimony, while FEMA is a major contributor to the USGS 3DEP program for LiDAR/elevation data, the total funding from all agencies is not coming close to the $146 million per year that is needed to cover the nation on an 8-year cycle. Better collaboration and coordination is needed to pool funds to reach the $146 million goal. There are several federal agencies that have significant mission needs for 3DEP data, but are contributing little or nothing. Moreover, Congress previously sought such collaboration and coordination when in 2012, it passed the Biggert-Waters Flood Insurance Reform Act, in the MAP-21 Act (Public Law 112-141). It included section 100220, which can be utilized to pool funding from Federal, state and local government entities for elevation data. Specifically, it called for FEMA, with the Director of the Office of Management and Budget and others, to submit to Congress "an interagency budget crosscut report that displays relevant sections of the budget proposed for each of the Federal agencies working on flood risk determination data and digital elevation models". This process, under both the Obama and Trump Administrations, has not produced the collaboration and coordination results the sponsors in Congress or the interested stakeholders had hoped for.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"An Examination of Federal Flood Maps in a Changing Climate"

Questions for the Record to:
Ryan R. Branfort, PLS, GISP
Senior Vice President
Wilson & Company, Inc., Engineers & Architects

Submitted by Subcommittee on Investigations and Oversight Chair Bill Foster

1. **If resources were no constraint, what kind of data sets would you make available to the land surveyors of the United States in order to enable the most accurate, timely and granular flood predictions? Are there any particular tools such as supercomputers for modeling, ground penetrating radars for visualizing underground waterflow, or LIDAR that you believe would be most constructive in improving flood mapping and prediction services?**

   For clarification, land surveyors gather and process data to produce accurate base maps for the engineering community to utilize for flood modeling and predictions. For flood modeling, the base map should consist of an accurate 3D model along with streets, roads and major structures. The USGS 3-D Elevation program or 3DEP is satisfying the growing demand for consistent, high-quality topographic data and a wide range of other three-dimensional representations of the Nation's natural and constructed features, primarily through elevation data collected with Light Detection and Ranging (LiDAR). Completing the initial 3DEP mapping and implementing a refresh cycle would provide a consistent base map for flood mapping and prediction services.

   Additionally, surveyors are users of data for application to their projects, as well as producers and collectors of data.

   As I mentioned in my testimony, the following data would be desirable: structures data, bathymetric data, subsidence data, shoreline data, stream flow/stream gage data, and other data as prescribed in H.R. 4905 from the 115th Congress, sponsored by Representatives Gonzalez of Texas and Mooney of West Virginia.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"An Examination of Federal Flood Maps in a Changing Climate"

Questions for the Record to:
Ryan R. Branfort, PLS, GISP
Senior Vice President
Wilson & Company, Inc., Engineers & Architects

Submitted by Chairwoman Eddie Bernice Johnson

1. **What are the best available technologies for doing land surveys and how can we ensure the rest of the nation is mapped using these technologies? How often do you think land elevation data needs to be collected to update flood risk maps?**

   There are a variety of different technologies available for surveying and mapping, each with different benefits as far as speed, accuracy, cost and final product. These include land based or terrestrial technologies, as well as data acquisition from unmanned aircraft systems (UAS) or "drones", manned aerial photography and LiDAR, and satellites. Survey professionals are best equipped to make the decision on which technology is best for the given situation. For flood mapping the use of Light Detection and Ranging (LiDAR) is typically the most efficient method for gathering data. The USGS 3-D Elevation program or 3DEP has suggested an eight year refresh cycle is appropriate.

2. **Was there anything else that you would like to address that you did not get a chance to at the hearing?**

   As stated in my submitted testimony, I believe two things are critically important when it comes to gathering and processing data to produce maps, whether it's for flood risk maps and predictions or infrastructure design or other uses. 1) All projects need to have proper professional oversight by Professional Land Surveyors and Certified Photogrammetrists. The processes and technology available today, though increasing efficiencies, can introduce significant accuracy issues if not utilized properly. 2) Land surveying, aerial mapping and LiDAR processing are all professional services covered by the Brooks Act and as such firms should be selected using Qualification Based Selection, not by low bid.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"An Examination of Federal Flood Maps in a Changing Climate"

Questions for the Record to:
Ryan R. Branfort, PLS, GISP
Senior Vice President
Wilson & Company, Inc., Engineers & Architects

Submitted by Representative Michael Waltz

1. **Given the numerous federal agencies involved in developing flood maps or providing data for mapping- FEMA, USGS, NOAA, USDA, USACE- how should Congress ensure agencies are working together in developing the most accurate flood maps and data?**

   Congress needs to work with the Office of Management and Budget (OMB) on a "funding pool" concept and a cross cut budget among all agencies involved in flood maps and flood control, as was envisioned in 2012, when the Biggert-Waters Flood Insurance Reform Act, in the MAP-21 Act (Public Law 112-141) was enacted. Section 100220, can be utilized to pool funding from Federal, state and local government entities for elevation data. Specifically, it called for FEMA, with OMB and others, to submit to Congress "an interagency budget crosscut report that displays relevant sections of the budget proposed for each of the Federal agencies working on flood risk determination data and digital elevation models".

2. **In your opinion, is it reasonable and potentially beneficial for those agencies to produce one federal risk map?**

   Yes. Computer technology, through the use of geographic information systems (GIS) enables the merging, aggregation, and layering of various geographic data sets. Technology also enables the concept of "map it once, use it many times".

3. **If so, what is your initial reaction to NIST, as the federal standards agency, taking the lead role in consolidating map data from agencies and producing one federal risk map?**

   Respectfully, I don't believe NIST has the expertise to take on such a role. Moreover, the issue is not standards or consolidation. It is funding.

Responses by Mr. Chad Berginnis

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June 3, 2020

Aria Kovalovich, Research Assistant
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Committee on Science, Space and Technology
US House of Representatives
2321 Rayburn House Office Building
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Re: Questions For the Record

Dear Aria:

Thanks again for your patience and the opportunity to testify before the subcommittee. Below, please find my responses to the questions for the record.

Respectfully,

Chad Berginnis, CFM
Executive Director

Dedicated to reducing flood risk and losses in the nation.

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Answers to questions from Chairwoman Mikie Sherrill:

1. Several mechanisms exist to foster interagency collaboration in flood mapping. The Technical Mapping Advisory Council (TMAC) is a federal advisory council mandated by Congress in the 2012 reform of the NFIP (Sec 100215) and includes designees from the Secretary of Interior, and Commerce (ostensibly reps from USGS an NOAA respectively). However, our observation on how TMAC operates as FACA committee, and that is also informed by observations from others who have previously been on FACA committees is that it operates rather differently. Perhaps the most significant difference is that it appears there is not much autonomy for the committee to explore issues beyond that given to them by FEMA in a tasking order. Another federal interagency coordinating body that appears to have more flexibility is the Federal Interagency Floodplain Management Task Force (FIFM-TF). The FIFM-TF has all of the federal agencies at the table that has some involvement in flooding issues. It is our observation that FIFM-TF is most constrained by not having dedicated staff or budget to carry out its functions. Historically, FIFM-TF has had a very important role and one way to enable better collaboration is to properly resource the FIFM-TF.

   Over the years, ASFPM has observed that even though these high level interagency coordination mechanisms exist, there is a need – usually driven by a specific topic – for interagency coordination. Historically, where ASFPM has identified such a need, we have tried to facilitate this coordination between federal agencies that should have already been coordinating. A final thought is that when federal agencies do this coordination, then need to involve states also, many states have excellent mapping expertise and many participate in FEMA's Cooperating Technical Partners program.

2. a. I believe that FEMA, states, and local/regional entities benefit greatly from FEMA's Cooperating Technical Partners (CTP) program. The program allows flood mapping activities to be delegated to qualified state and local authorities and a benefit to everyone is learning from the innovation that results. Also, wisely, Congress established the requirement that CTPs be part of the TMAC. If I were to advise a community today on how to leverage this local expertise, it would be to participate in the CTP program.

   b. Perhaps the best case is what occurred in Charlotte/Mecklenberg County, North Carolina. In that case, local innovation resulted in some of the first future conditions flood mapping (and this was due to future development conditions – not even climate change) in the nation. They had to work with FEMA to develop a FIRM product that both the feds and community could live with. We have had similar examples in Denver and

Phoenix/Maricopa County. Although I would say that the process itself wasn't optimal initially, it is my understanding that New York City is now working to update its flood maps to incorporate future conditions information it has developed.

3. I think that if would ask the public generally where they would go to get flood risk information they would point to the FEMA Flood Insurance Rate Map. Its usage and application nationwide is second to no other data set (I heard a statistic that for mortgage determinations alone, FIRMs are used 30+ million times each year). Rightfully or wrongly, the FEMA FIRM is the nation's default data set. FEMA has made significant improvements in the currency of data. I recall that in the Congressional deliberations preceding the 2004 NFIP reform act, there was an intense focus on accuracy and whether the maps were up to date. That is much less of an issue now; although there is still a need (we still have areas of the country that are using non-modernized paper maps). I also believe that FEMA gets unfairly critiqued because it isn't using the most up-to-date methods. FEMA is constantly working with the US Army Corps of Engineers and other entities who develop flood models. A current example of using cutting edge techniques is FEMA's piloting of Base Level Engineering. In Texas, the Texas Water Development Board is embracing the BLE approach for mitigation/resilience planning and project development purposes.

   What is lacking; however, are the inclusions such as future conditions, such as residual risk mapping, and the extent of mapping in the nation. FEMA doesn't have the resources to get it done and until recently it seems FEMA has been reluctant to adapt its mapping platform and products to create a suite what I would call essential products. I do note that FEMA has been experimenting and allowing some products like residual risk mapping below dams as options.

   On the issue of future conditions, there is no reason that FEMA couldn't do a range calculations of future conditions like the next 25, 50, 100 years, run those flows through models and put those maps as different layers in the digital model the community is provided. The community could then use different models for different needs and the added cost should be minimal.

Answers to questions from Chairman Bill Foster:

1. On one hand, FEMA is using new technologies. In my previous question from Chairwoman Sherrill, I mentioned the Base Level Engineering approach to leverage high quality topography and use the latest in automated modeling to create detailed and

low-cost flood maps for rural and yet to be developed areas. They are working with the US Army Corps of Engineers to try to figure out how to incorporate the "floodway" concept into 2 dimensional (2-D) modeling. At the same time, there hasn't been much progress in terms of future flood risk. Specifically, FEMA should be developing/implementing a national approach for mapping future flood conditions (as required under law) nor for residual risk mapping (as required under law).

2. Most definitely. The DHS Flood Apex Program was a five-year initiative begun in 2014 (7 years total, it sunsets in 2021) that specifically applies new and emerging technologies to improve community resilience. When Craig Fugate was director of FEMA, the director of the DHS Science and Technology Directorate asked what he needed help with. The immediate response was flooding. In reality, FEMA has neither the history nor the capacity currently to house an in-house R&D program. So Flood Apex became a pilot of sorts in terms of what was possible.

   It is evident to me that a program like Flood Apex could be brought to bear to improve the mapping process significantly. Some of the projects related to mapping under the current portfolio include using newly available technologies in new ways such as satellite imagery in time sequence to determine the flood history of a parcel that might be developed. Or, using supercompting technology paired with deep/machine learning to answer a question that has been around for decades – how many structures are in the floodplain and what kind are they?

3. I think it makes a lot of sense to have the R&D in DHS Science and Technology Directorate provided it is adequately funded and collaborates with FEMA. First, DHS is the parent agency of FEMA. Second, there is a research philosophy that draws on other areas of the Science and Technology directorate – research is rigorous and undoubtedly influenced by the fact that S&T has a university research program. Thus S&T has the relationships and processes to ensure a high degree of rigor and competence. At the same time, there has also been an entrepreneurial mindset – the APEX program has been as much of a technology incubator as it was a research program. And in this way, the program, under S&T leadership, excels in sharing the innovation challenge with private industry. I have seen no better model in the whole of the Federal government when it comes to pushing research results into the hands of practitioners and the private industry as the approach that DHS S&T has taken with Flood Apex.

   All of that being said, there is one major concern. There must be an intentional, protected effort to continue flood research if it is to continue as part of DHS S&T. DHS

has a huge mission including protecting the homeland from terrorists to bioterrorism, etc. Natural resource practitioners time and again have seen that while flooding is the hazard that impacts more Americans year in and year out, it plays second fiddle to other threats. It is safe to assume that from a DHS perspective, flood resarch is probably not as high on the agenda as are other research areas. Thus, Congress needs to be proactive in assuring resources continue and conducting rigorous oversight to ensure resources are not diverted to other DHS S&T research priorities.

4. The more cost-effective pathway to resilience are smart land use decisions before development occurs. This is predicated on a couple of things: That we know where all of the flood hazards exist today and tomorrow (we are continuing to underfund flood mapping where we have only mapped 1/3 of the nation's streams rivers and coastlines), and that we implement and use all of the land use management tools we have in the toolbox (comprehensive plans, zoning, subdivision standards, building codes and floodplain regulations). Though this pathway, communities can ensure long-term resilience at the lowest overall cost. Typically, the next lowest cost is through non-structural (as in non-large flood control structures) flood mitigation to address stuff that exists already and is at risk. This would be things like individual property protection, buyouts, relocations, etc. Please be aware that there is a lot of infrastructure protection that can be done as part of non-structural mitigation. For example, there might be a floodproofing project for a community's wastewater treatment plant. The mostcostly approach typically is using large flood control structures. Why? Because, as engineered systems, they typically require extensive maintenance and operational costs. Also, they tend to induce more development where people believe they are safe but actually have a residual risk of flooding. I recall an experience back in the 2000s where I worked in Columbus Ohio not long after the new Franklinton flood wall/levee was completed. A fairly significant storm happened, and a flood occurred behind the flood wall because the drainage system was not adequate. This not only resulted in costs to upgrade the "new" system but the losses that individuals and businesses suffered as a result. On top of all three of these, flood insurance is needed, even if you have flood protection systems. The reality is that they are engineered to withstand a certain level flood; however, our world is changing which means that the 100-year flood when a system was designed maybe 30 years ago is now 50 year flood.

   In reality, communities may need to implement all of these approaches. There are locations where only a floodwall or levee is appropriate. However, as a nation we haven't even remotely tapped the potential of the flood loss reduction capability that we have through effective land use management.

5. Not necessarily in order of importance:
   - Nationwide LIDAR (detailed topography) – it doesn't matter how good flood models are, if we don't understand how water will flow on the earth, we can't do effective flood management.
   - Complete flood mapping in the nation. For streams and rivers, go up in watersheds to 1 square mile of drainage (for urban areas, look at areas that are draining 60 acres or more), map residual risk areas, map coastal storm surge zones, identify the 500-year floodplain everywhere you have a 100-year floodplain as an alternative land use management tool.
   - Complete future conditions flood mapping for everywhere in the nation. While this could be seen as part of the bullet above, it deserves its own call-out. Future conditions scenarios should be inclusive of scenarios 100-years from now since we know that the average useful life of a residential structure is over 100 years.
   - Have a resourced nationwide Atlas 14 program that updates our rainfall-frequency information at a minimum every five years.
   - Fully resource the Federal Priority Streamgages (FPS) network. Currently less than ¼ are fully funded by USGS. These gages are our eyes on the ground that feed real-time data to those trying to predict flooding.

Answers to questions submitted by Chairwoman Eddie Bernice Johnson:

1. a. The observation preceding the question is spot on! Rural areas not mapped because no homes or policies, but development occurs, then it is mapped after the homes are built in high risk areas. Developers build the homes at risk and homeowner then stuck with high flood insurance rates after mapping done. This is a totally backwards process; we must map ahead of development! And, this isn't just limited to rural areas. We see this in urbanizing counties of major metropolitan areas as well. Small watercourses that flow through farmland are not mapped and therefore not considered as flood hazard areas. ASFPM has expressed to FEMA that a priority should be to at least complete the modernization of all of the maps in its inventory. There are still areas, mostly rural, that have unmodernized paper maps. I would imagine that maintaining this inventory in addition to the modernized maps is not only costly, but not helpful to communities who are trying to manage flood risk.

   b. The best available technologies for getting topography currently is LIDAR. And this is one area where FEMA has prioritized using some of its resources, pooling it with other agency resources and contributing to the 3DEP program. But in terms of flood

modeling, one promising approach is one FEMA is piloting called Base Level Engineering. It is able to map large, mostly rural areas, provide enough detail to establish flood elevations for land use management and regulatory programs, and is low cost. In terms of frequency of collecting land elevation data, it really depends on how fast the land itself is changing due to development. In areas where a large amount of development has occurred or where growth rates are high, updated LIDAR every 5-10 years may be appropriate. In other areas where there isn't much development occurring, even 20+ years between updates may be adequate.

2. I just wanted to express my appreciation to the subcommittees for holding this hearing. As mentioned in my testimony I believe this is the first oversight hearing on the National Flood Mapping Program. It is critical that Congress and these subcommittees exercise its oversight function considering it was Congress who very thoughtfully authorized the National Flood Mapping Program in 2012. Yet here we are in 2020 and many of the new inclusions that Congress wanted to see done have not even begun to show up on flood maps in any meaningful way. Also, ASFPM, along with the Technical Mapping Advisory Council, has, for several years, had concerns about the metrics FEMA is using measure the National Flood Mapping Program yet, we have not seen those metrics changed since before 2012. You don't do what you don't measure.

Appendix II

Additional Material for the Record

STATEMENTS SUBMITTED BY REPRESENTATIVE SUZANNE BONAMICI

February 27, 2020

U.S. House Committee on Science, Space and Technology, Subcommittee on Environment and Subcommittee on Investigations and Oversight

An Examination of Federal Flood Maps in a Changing Climate

Written Statement From: Dave Rosenblatt, Chief Resilience Officer & Assistant Commissioner for Climate and Flood Resilience, New Jersey Department of Environmental Protection

Governor Murphy has directed, by Executive Order, the Chief Resilience Officer of the State of New Jersey to develop a Climate Science Report and a Statewide Climate Change Resilience Strategy.

New Jersey is extremely vulnerable to the impacts of global warming and sea-level rise; this Executive Order recognizes the need to prepare and respond to increased temperatures, sea level rise, increased frequency or severity of rainfall, storms, and flooding.

There are three areas that need further investment by the federal government:

1. As FEMA updates their Flood Insurance Rate Maps, they should provide and incorporate sea level rise projections to provide guidance and strategies for State agencies, municipalities, and regional planning agencies to implement resilience measures.

2. Changes in the characteristics of extreme events are particularly important for human safety, infrastructure, agriculture, water quality and quantity, and natural ecosystems. The frequency of intense rainfall is increasing across the United States and globally and is expected to continue to increase. The federal government (FEMA, NOAA, NRCS and USGS) needs to update the precipitation depth and distribution values to reflect this trend in the flood mapping.

3. The modeling supporting many existing flood maps are several decades old. FEMA should more proactively evaluate if any changes have occurred including coastal area subsidence that warrants the revision and update of the flood study and maps.

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Testimony of the
Association of State Dam Safety Officials
to the
U.S. House Committee on Science, Space and Technology, Subcommittee on Environment and Subcommittee on Investigations and Oversight

For the Hearing:
An Examination of Federal Flood Maps in a Changing Climate
February 27, 2020

Dear Chairwoman Sherrill and Chairman Foster and Members of the Subcommittees:

The Association of State Dam Safety Officials (ASDSO) is pleased to offer this testimony to support your examination of federal flood maps in a changing climate. ASDSO commends the two subcommittees for allowing experts in the field to provide observations and recommendations for the record. As you review and improve the federal flood mapping program, we ask you to review the history of the federal government's role in estimating and providing extreme rainfall data and endorse a renewal of this role to ensure a consistent national approach to public safety as we face a changing climate.

The Association of State Dam Safety Officials is a national non-profit organization of more than 3,000 state, federal and local dam safety professionals and private sector experts dedicated to improving dam safety through research, advocacy, education and awareness. Our goal simply is to save lives, prevent damage to property and to maintain the benefits of dams by preventing dam failures. Several dramatic dam failures in the United States have called attention to the catastrophic consequences of failures. The failure of the federally-owned Teton Dam in 1976, which caused 14 deaths and over $1 billion in damages, and more recent incidents including the Oroville Dam spillway failure in 2017 and the Spencer Dam failure in 2019 create a constant reminder of the potential consequences associated with dams and the obligations to assure that dams are properly constructed, operated and maintained.

There are over 90,000 dams in the United States, serving many purposes. The majority of dams were not built or are used for flood control. Approximately 15,000 dams in the U.S. are determined to be high-hazard potential (meaning there would be loss-of-life should they fail but not reflecting the condition of the dam).

Most dams in the U.S. are privately owned. States regulate about 70% of the dams in this country, with the balance owned and/or regulated by federal agencies. These are a few facts that can inform the discussion about how dams fit into challenges that accompany flood risk management.

National extreme rainfall (Probable Maximum Precipitation [PMP]) standards have long been used for regulation and design of high-hazard potential infrastructure including dams. Those standards are used to bring consistency between Federal Agencies, State Agencies, and the private sector professional design community.

Federal leadership is again needed to update these standards.

The US National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS) first developed methodologies for estimating probable maximum precipitation (PMP) in the 1940s and, using historic data available at that time, applied them across the U.S. through hydro and hydrometeorological studies and reports between 1961 and 1999. State dam safety programs developed statutes, rules and guidance documents for design of safe facilities that are typically based on these federally sanctioned NWS studies.

Decades of storm event data (the basis for calculating the standards) have been recorded since the existing standards were published, along with considerable scientific advancements in understanding, modeling, and estimating extreme precipitation and flood risk. These reports, however, have never been officially updated to include new methods, technologies, or the decades of more recent storm data libraries.

These outdated reports continue to be used by many. Some state dam safety programs have changed their statutes to allow use of available new methodologies provided by entities outside the federal government and others find making and incorporating such changes too difficult to attempt. Inconsistencies between minimum design criteria of adjacent states and the tension between federal and state design/performance expectations within states are increasing.

It has recently been reported that there are nearly 1,700 high-hazard potential dams currently in need of repair across the country. It is reasonable to assume a percentage of those dams need spillway system improvements. Consistent and standardized modern methodologies for repair of spillways at those high-hazard potential dams currently rated as poor and unsatisfactory are needed in order to ensure the highest level of public safety.

Therefore, there is a clear need for NOAA to resume a leadership role toward developing 21st century national standards for estimating extreme rainfall (probable maximum precipitation) in a changing climate, in order to ensure consistent public safety in the future, across all states.

The recently completed Colorado-New Mexico Regional Extreme Precipitation Study (REPS) included state-of-the-practice updates to existing methodologies and included use of state-of-the-art NOAA research, expertise, and operational modeling tools for prediction of extreme rainfall. The REPS study also included an assessment of and recommendations for climate change considerations. The study was reviewed by a board of subject matter experts from numerous federal agencies and demonstrated possible approaches to updating extreme precipitation estimates at a national scale.

We recommend a National Academies of Science, Engineering and Medicine (NASEM) study be commissioned to study current state of the practice options for extreme rainfall estimation, including the REPS study, in order to provide NOAA clear direction toward development of 21st century national standards for estimating extreme rainfall (including PMP).

LETTERS SUBMITTED BY REPRESENTATIVE SUZANNE BONAMICI

United States House of Representatives
Committee on Science, Space and Technology
Subcommittee on Environment and Subcommittee on Investigations and Oversight

Hearing on February 27, 2020
"An Examination of Federal Flood Maps in a Changing Climate"

Letter for the Record

Dr. Rachel Cleetus
Policy Director, Climate and Energy Program
Union of Concerned Scientists (UCS)

Thank you, Chairwoman Sherrill, Chairman Foster, Ranking Members Marshall and Norman, and members of the Committee for providing this opportunity for me to submit this letter for the record. Below I share some perspectives from the Union of Concerned Scientists (UCS) on why accurate, up-to-date flood maps and a well-funded federal flood mapping program, using the latest technology, is vital to help protect people and our economy. Climate change is increasing the risks of both coastal and inland flooding significantly and it is very important that our flood maps reflect future conditions including climate change.

UCS puts rigorous, independent science to work to solve our planet's most pressing problems. We work on behalf of our more than 500,000 supporters and network of over 25,000 scientists to advance public awareness of the science of climate change and the solutions available to forestall the worst of climate impacts.

Insights from the Fourth National Climate Assessment

The Fourth National Climate Assessment (NCA4)[1] highlights several factors that link climate change to increasing risks of flooding. These include, but are not limited to:

- Sea levels are rising at an accelerating rate. Global average sea level has risen about 7-8 inches since 1900 and projections show that sea level is very likely to rise 1 to 4 feet relative to 2000 levels by the end of the century. Higher scenarios of a rise exceeding 8 feet by 2100, associated with the behavior of the Antarctic ice sheet, cannot be ruled out.
- The US East and Gulf coasts are already experiencing an increase in high tide flooding driven by sea level rise and this is projected to worsen. According to the NCA, "*Since the 1960s, sea level rise has already increased the frequency of high tide flooding by a factor of 5 to 10 for several U.S. coastal communities. The frequency, depth, and extent of tidal flooding are expected to continue to increase in the future, as is the more severe flooding associated with coastal storms, such as hurricanes and nor'easters.*"

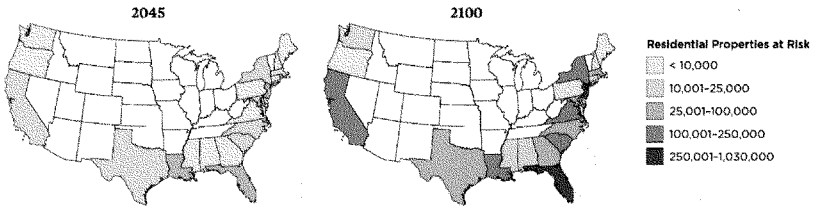
[1] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018

- Communities along our coasts face growing challenges from flooding, including threats to coastal property and infrastructure. These can have cascading impacts on other parts of the economy especially if we fail to take action to mitigate against these risks. The impacts of flooding can exacerbate preexisting long-standing social and economic inequities.
- Climate change has already contributed to an increase in extreme precipitation events in some regions of the country—especially the Northeast and Midwest—which in turn contributes to inland flooding alongside other risk factors such as development patterns. The frequency and intensity of extreme rainfall events are projected to increase over this century.

Impacts of sea level rise on coastal property

UCS research on the impacts of sea level rise to coastal communities shows that long before rising seas permanently submerge properties, millions of Americans living in coastal communities will face more frequent and disruptive high-tide flooding. In 2018 we released a report showing that, by the end of the century, under a high sea level rise scenario (which I will use throughout this letter unless otherwise indicated),[2] approximately 2.5 million US coastal homes and commercial properties currently worth more than $1 trillion would be at risk from chronic flooding—a threshold we defined as flooding that occurs 26 times per year or more.[3] By 2045, within the lifetime of a typical mortgage issued today, about 325,000 coastal properties worth $136 billion will be at risk of chronic flooding (see figures 1 and 2).

Figure 1: Homes at risk of chronic inundation

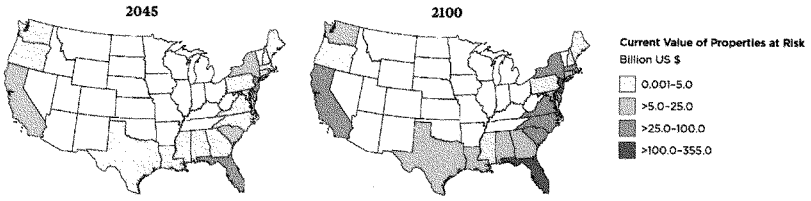


Credit: Union of Concerned Scientists. Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX).

[2] The high scenario, which is drawn from the 2014 National Climate Assessment, assumes rapid ice sheet loss and projects a global average sea level rise of 6.6 feet (2.0 m) above 1992 levels by the end of this century. This scenario is considered most applicable in situations with a low tolerance for risk. This makes it most suitable for estimating the scale of risk to residential properties, which typically represent a homeowner's greatest single asset. For more on our data and methodology, please see:
https://www.ucsusa.org/sites/default/files/attach/2018/06/underwater-analysis-full-report.pdf and
https://www.ucsusa.org/sites/default/files/attach/2018/06/underwater-analysis-technical-backgrounder.pdf

[3] https://www.ucsusa.org/resources/underwater

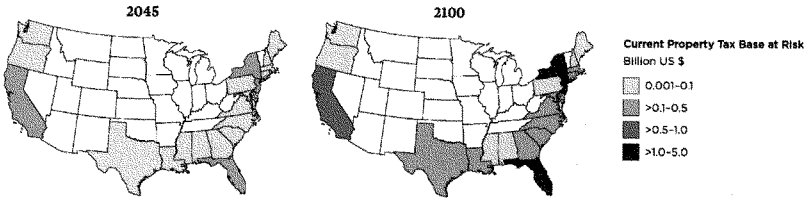
Figure 2: Value of homes at risk from chronic inundation



Credit: Union of Concerned Scientists. Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX).

The properties at risk by 2045 currently house 550,000 people and contribute nearly $1.5 billion toward today's property tax base. Those numbers jump to about 4.7 million people and $12 billion by 2100 (see figure 3).

Figure 3: Property tax base at risk from chronic inundation



Credit: Union of Concerned Scientists. Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX).

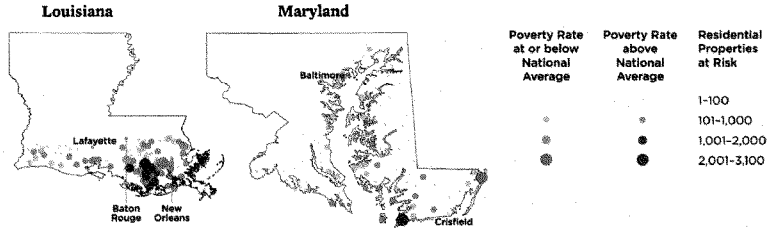
States with the most homes at risk by the end of the century are Florida, with about 1 million homes (more than 10% of the state's current residential properties); New Jersey, with 250,000 homes; and New York with 143,000 homes.

The declining value of coastal homes will be damaging, even devastating, to individual homeowners. It will also have more widespread consequences, including for affected communities, lenders, investors, and taxpayers. Falling property values mean reduced local tax revenue from those properties. Our calculations show that in about 120 communities along US coasts, the properties that would be at-risk in 2045 currently represent a full 20 percent or more of the local property tax base. Many coastal residents, whether they own homes or not, would be affected as property tax bases shrink, which typically leads to reduced services or tax hikes for remaining taxpayers. This could prevent cities and towns from fully funding schools, emergency services, and the maintenance and new construction of infrastructure—including critical adaptation measures that could help protect homes, businesses, and infrastructure itself from chronic flooding. Access to additional capital for such projects depends on a municipality's credit

rating; its credit rating depends on its financial health and degree of risk exposure, both of which are compromised as chronic flooding worsens. Mortgages on homes that could be chronically flooded during the term of the loan are inherently riskier, exposing lenders to losses.

Communities with fewer resources to start with, or that are otherwise disadvantaged, will likely be most heavily affected by chronic flooding and its accompanying financial losses. Nearly 175 communities nationwide can expect significant chronic flooding by 2045, with 10 percent or more of their housing stock at risk. Of those, nearly 40 percent—or 67 communities—currently have poverty levels above the national average. The largest share of these is in Louisiana, where there are 25 communities with above-average poverty rates and with 10 percent or more of the homes at risk by 2045. Louisiana is not the only state where poverty and exposure to chronic inundation intersect to create a hotspot of heightened risk. North Carolina, New Jersey, and Maryland also have significant numbers of highly exposed communities with above-average rates of poverty (see Figure 4). Within the next 30 years, about a dozen such communities along Maryland's eastern shore are projected to have one-third or more of their property tax base at risk.

Figure 4: Communities with high poverty rates at risk of chronic inundation in Louisiana and Maryland



These results do not include future development or new homes, nor do they include the impacts on critical infrastructure such as roads, bridges, power plants, airports, ports, public buildings, and military bases that will also be in harm's way. When all of these are taken together, the effects of chronic flooding could have staggering economic impacts.

UCS also developed an interactive map tool that lets you explore the risk sea level rise poses to homes in your congressional district and provides district-specific fact sheets about those risks.[4] What our maps show is that rising seas will begin to reshape many coastal communities in the coming decades, in some cases quite drastically. Communities need representatives in Congress who will advocate for the research, funding, and policies needed to help them cope with sea level rise and coastal flooding head-on. In some cases, that will include help with relocation to safer ground.

Our research also points to the choices we face: If the global community adheres to the primary goal of the Paris Agreement of capping warming below 2°C, and with limited loss of land-based ice, by the end of the century the United States could avoid losing residential properties that are currently valued at $780 billion, contribute $10 billion annually in property tax revenue, and house 4.1 million people.

[4] Interactive map, data and fact sheets for all coastal Congressional districts in the lower 48 states available here: https://ucsusa.maps.arcgis.com/apps/MapJournal/index.html?appid=b53e9dd7a85a44488466e1a38de87601

Growing Risks of Extreme Precipitation and Inland Flooding

Climate change is also shifting rainfall patterns, making heavy rain heavier and more frequent in many areas of the country. With human alteration of the land—like the engineering of rivers, the destruction of natural protective systems, increased construction on floodplains, and increased area of impermeable surface—many parts of the United States are at greater risk of experiencing destructive and costly floods.[5]

A growing body of evidence has linked specific extreme rainfall events to human-caused climate change. The record-breaking rainfall during Hurricane Harvey that brought devastating flooding to Houston, for example, was made about three (1.5-5) times more likely and around 15% (8-19%) more intense because of human-caused climate change[6]. Human-caused climate change also made the devastating rains in Louisiana in 2016—in which more than two feet of rain fell in a two-day period—more likely. A study of that particular event concluded that such downpours are expected to occur 40 percent more often and be 10 percent more intense now than they were before the Industrial Revolution.[7] Projections of future climate suggest that the frequency and intensity of extreme precipitation events will continue to increase across much of the United States in the coming decades[8].

A recent study found that 41 million people living in the conterminous US—some 13 percent of the population—are at risk from flooding due to extreme rainfall and river-flow exposure, which is more than three times the current estimate that is based on FEMA's current regulatory flood maps.[9]

Last spring brought extended flooding to many parts of the country, including Louisiana, Texas, the Midwest and the central part of the country along the Mississippi and Missouri rivers. NOAA data confirm that (at the end of April 2019) the US experienced the wettest 12 months on record.

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[5] https://www.ucsusa.org/sites/default/files/attach/2018/07/gw-fact-sheet-epif.pdf

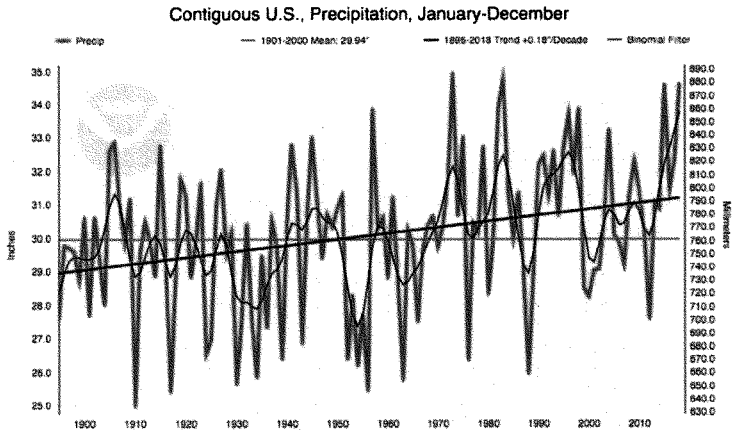
[6] van Oldenborgh, G.J., K. van der Wiel, A. Sebastian, R. Singh, J. Arrighi, F. Otto, K. Haustein, S. Li, G. Vecchi, and H. Cullen. 2017a. Attribution of extreme rainfall from Hurricane Harvey, August 2017. Environmental Research Letters 12(12):1–11. doi:10.1088/1748-9326/aa9ef2.

[7] van der Weil, K., S. B. Kapnick, G. J. van Oldenborgh, K. Whan , S. Philip, G. A. Vecchi, R. K. Singh, J. Arrighi , and H. Cullen. 2017. Rapid attribution of the August 2016 flood-inducing extreme precipitation in south Louisiana to climate change. Hydrol. Earth Syst. Sci., 21, 897–921, 2017 www.hydrol-earth-syst-sci.net/21/897/2017/ doi:10.5194/hess-21-897-2017. Online at https://www.hydrol-earth-syst-sci.net/21/897/2017/hess-21-897-2017.pdf

[8] Easterling, D.R., K.E. Kunkel, J.R. Arnold, T. Knutson, A.N. LeGrande, L.R. Leung, R.S. Vose, D.E. Waliser, and M.F. Wehner. 2017. Precipitation change in the United States. In Climate science special report: Fourth national climate assessment, volume 1, fourth edition, edited by D.J. Wuebbles, D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock. Washington, DC: US Global Change Research Program, 207–230. doi:10.7930/J0H993CC.
Intergovernmental Panel on Climate Change (IPCC). 2012. Summary for policymakers. In Managing the risks of extreme events and disasters to advance climate change adaptation: Summary for policymakers, edited by C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley. Cambridge, UK, 1–19. Online at http://www.ipcc.ch/pdf/special-reports/srex/SREX_FD_SPM_final.pdf

[9] Oliver E J Wing et al 2018 Environ. Res. Lett. 13 034023. Online at https://iopscience.iop.org/article/10.1088/1748-9326/aaac65/pdf

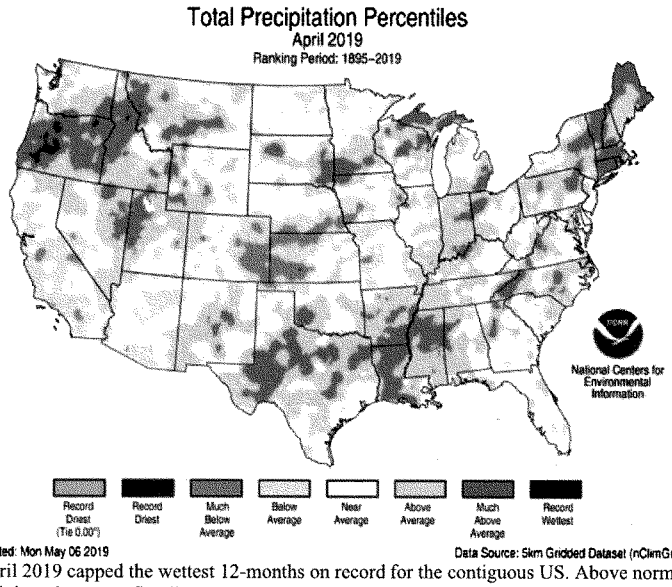
Figure 5: 2019 Precipitation in the Contiguous U.S.



While there is considerable variability from year to year and from decade to decade, total annual precipitation for the contiguous US as a whole has increased since 1900.

(NOAA data via https://www.wunderground.com/cat6/Wettest-12-Months-US-History?cm_ven=cat6-widget)

Figure 6: April 2019 Precipitation Relative to a Historical Baseline

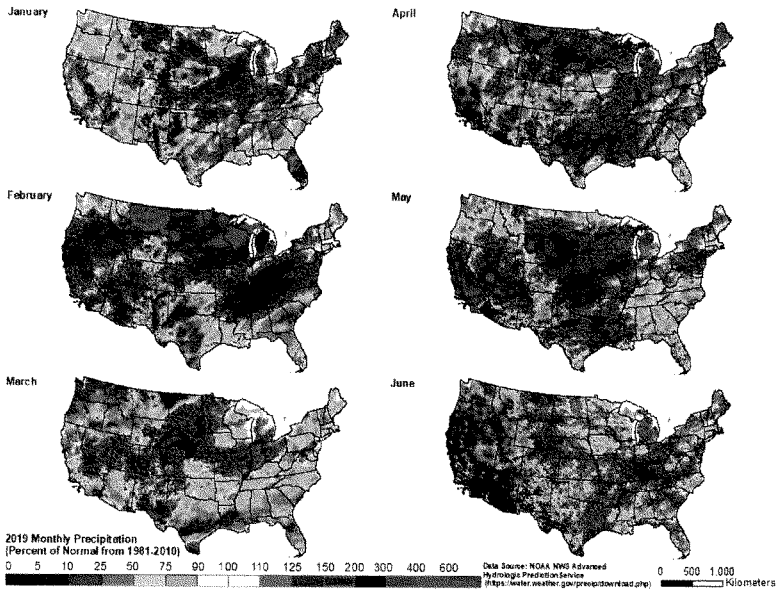


April 2019 capped the wettest 12-months on record for the contiguous US. Above normal precipitation and the subsequent flooding across the central US lead to widespread disruption of transportation by road and rail.

Source: NOAA[10]

According to NOAA data, between January and June, precipitation in many areas of the Northern Great Plains, the Southern Plains, and the Midwest was between 200-600 percent the historical normal amount (see Figure 7).

Figure 7: Precipitation between January and June 2019



Precipitation during January through June of 2019 in many areas Northern Great Plains, the Southern Plains, and the Midwest was between 200-600 percent the historical normal amount. Source: NOAA Advanced Hydrologic Prediction Center (https://water.weather.gov/precip/download.php).

This record-breaking flooding was devastating for farmers.[11] It also washed out roads and bridges in many places, sometimes for days on end, making it difficult for people to travel safely to work and school[12]. In Nebraska alone, the flooding caused an estimated $100 million in damage to the state's

[10] https://www.ncdc.noaa.gov/temp-and-precip/us-maps/1/201904#us-maps-select
[11] https://blog.ucsusa.org/juan-declet-barreto/record-2019-precipitation-in-midwest-financially-crushed-farmers
[12] https://www.washingtonpost.com/nation/2019/05/10/really-genuinely-scary-torrential-rain-houston-strands-cars-leaves-thousands-without-power/?utm_term=.9612e14621c9
https://kfor.com/2019/05/08/odot-several-highways-closed-due-to-flooding-across-the-state/

https://www.wxyz.com/getting-around-metro-detroit/flooding-across-metro-detroit-closes-several-roads-highways

highway system[13]. Rail lines in Nebraska and Missouri were shut down for weeks[14]. Businesses that rely on safe and reliable transportation were also affected[15].

Recommendations

Unfortunately, current federal flood risk maps do not include consideration of future conditions including projections of sea level rise, extreme precipitation and other climate-driven factors that are exacerbating flood risks. Therefore, many homeowners and communities are unaware of the risks coming their way. Lenders and investors, especially those at a distance from the specific location, are also either largely unaware of growing flood risks or not adequately accounting for it in their business decisions. Businesses may also rely on these maps for making investment decisions and find themselves exposed to risks.

The federal government can and should play a leading role in helping to communicate flood risks to the public so that people can take protective measures. More accurate advisory maps that include future conditions are critical. Note that these maps do not need to immediately be used for rate-setting purposes but by providing the risk information they can help guide more resilient investments and decision-making. As a recent ASFPM report points out, flood mapping is a cost-effective taxpayer investment and can help reduce the harms to people and the costs of disasters.[16]

UCS recommends that:

1. The federal government should ramp up investments in expanding and updating flood mapping around the nation and ensure that advisory maps reflect growing flood risks from climate change. According to the recent ASFPM report, "*Flood Mapping for the Nation,*" only one-third of the nation's streams have been mapped. ASFPM estimates the cost to complete flood mapping in the US at $3.2 billion to $11.8 billion, with a subsequent annual cost of $107 million to $480 million to maintain accurate up-to-date maps.[17]
2. Invest in data collection, resources and technical capabilities across agencies to improve our nation's ability to assess and respond to flood threats, both inland and coastal. This includes funding for expanding and upgrading the USGS streamgauge network and NOAA's tideguage network.
3. Implement the recommendations of the Technical Mapping Advisory Council (TMAC) to FEMA, including its recommendations in its 2016, 2017 and 2018 annual reports.
4. Improve coordination and sharing of technical information across federal agencies to help improve the coherence and effectiveness of our nation's response to the growing risks of flooding.
5. Federal agencies should work with state and local governments to help ensure that decisions on the ground are being guided by flood maps reflecting the best available science.
6. Congress should provide targeted funding and technical assistance to low-income communities and otherwise disadvantaged communities that are at risk from flooding so that they can invest in protective measures. Many of these communities suffer a disproportionate burden of flood risks

[13] https://dot.nebraska.gov/news-media/nebraska-flood-2019/
[14] https://www.grainnet.com/article/166508/transportation-impacts-of-midwest-flooding
https://www.freightwaves.com/news/railroad/rail-volumes-drop-for-march-30
[15] https://www.mprnews.org/story/2019/04/21/flooding-roundup-communities-weary

[16] ASFPM, 2020. Flood Mapping for the Nation. Online at https://asfpm-library.s3-us-west-2.amazonaws.com/FSC/MapNation/ASFPM_MaptheNation_Report_2020.pdf
[17] https://www.floodsciencecenter.org/products/flood-mapping-for-the-nation/

and often do not have the resources needed to mitigate these risks. They will also be disproportionately harmed if their properties lose value as a result of being identified as being at heightened risk of flooding.

7. Reform and strengthen the National Flood Insurance Program (NFIP) including by updating flood risk maps, expanding access to flood insurance, phasing in risk-based rates while implementing affordability provisions for low- and fixed-income households, and providing more proactive resources for flood mitigation measures.[18]

Thank you once more for providing this opportunity for input. We look forward to working with the committee to move forward actionable recommendations to enhance our nation's flood mapping program to better protect communities around the nation.

Sincerely,

Rachel Cleetus

Rachel Cleetus
Policy Director, Climate and Energy Program
Union of Concerned Scientists

Union of Concerned Scientists
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1825 K Street NW, Suite 800, Washington, DC 20006-1232 t 202.223.6133 f 202.223.6162
500 12th Street, Suite 340, Oakland, CA 94607-4087 t 510.843.1872 f 510.843.3785
One North LaSalle Street, Suite 1904, Chicago, IL 60602-4064 t 312.578.1750 f 312.578.1751

[18] See https://blog.ucsusa.org/rachel-cleetus/congress-must-extend-and-reform-the-national-flood-insurance-program and https://blog.ucsusa.org/shana-udvardy/sos-congress-nations-flood-policy-is-not-keeping-up-with-climate-change-reality

CoreLogic

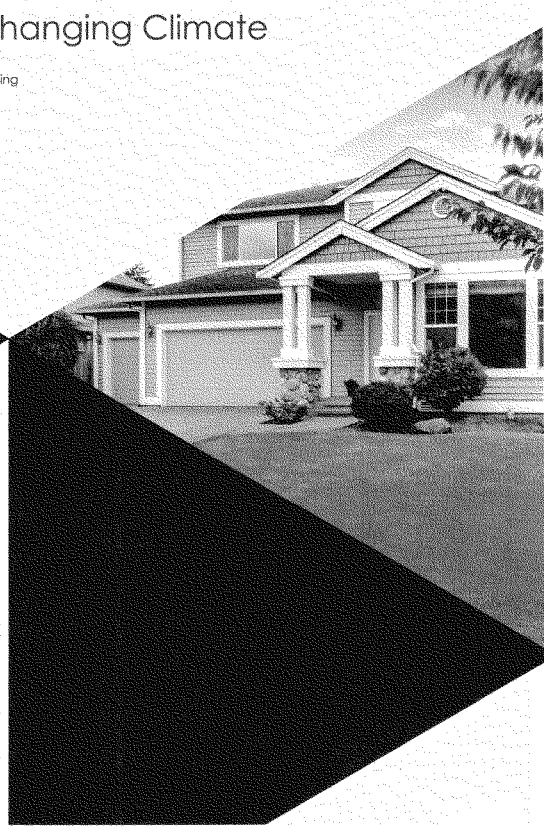
COMMENTS FOR THE RECORD » February 2020

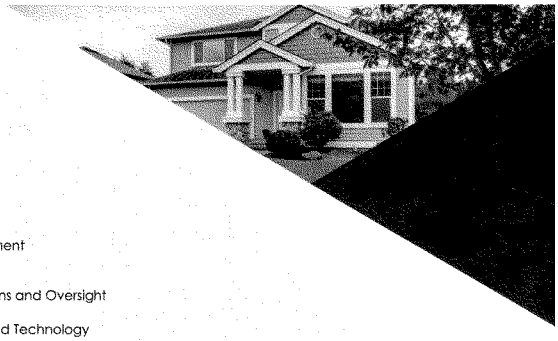
U.S. House Committee on Science, Space, and Technology

An Examination of Federal Flood Maps in a Changing Climate

February 27, 2020

2318 Rayburn House Office Building





CoreLogic

February 27, 2020

U.S. Representative Mikie Sherrill
Chairwoman, Subcommittee on Environment

U.S. Representative Bill Foster
Chairman, Subcommittee on Investigations and Oversight

House Committee on Science, Space, and Technology
2321 Rayburn House Office Building
Washington, DC 20515

RE: *An Examination of Federal Flood Maps in a Changing Climate*

Chairwoman Sherrill and Chairman Foster:

Floods are the most pervasive, destructive, and costly natural disasters in the United States, and they have only increased in frequency and severity over the past several years. Certain areas of Texas, Maryland, North Carolina have experienced extreme flooding events – determined to be 1 in 1,000-year events – more than once in a single calendar year, leaving many communities, families, and businesses unprepared and uninsured.

For over 40 years FEMA has been charged with mapping the 1 in 100-year flooding event, a national standard of measurement also known as the 'base flood', and creating Special Flood Hazard Areas (SFHAs) to identify locations that would be affected by such an event. The mapping of the base flood has played an important role in floodplain management and planning, in emergency response actions, and in providing support to banks and other lending institutions to ensure compliance with the federal mandatory purchase requirement. However, sole reliance on these flood maps to determine flood risk is obviously poor policy, especially if more severe flooding events – such as the 1 in 1,000-year – occur more frequently.

Our company is pushing the industry to create more advanced risk assessment tools, scores, and models that are driven by hydrological science, critical risk data, and our vast property data to provide a more graduated and expansive risk assessment that distinguishes incremental levels of flood risk for the entire nation. While we continue to support banks and other stakeholders that utilize the flood maps to make critical decisions leading to flood insurance protection for many families and small businesses, we know that our tools, data, and insight can drive changes in policy, insurance take-up, and resilience for the nation.

On behalf of CoreLogic, please accept the following statement for the record. Included with this letter are three CoreLogic data sheets that demonstrate our advanced capabilities in flood risk determination: our *Flood Risk Score*, our *Flash Flood Risk Score*, and our *U.S. Inland Flood Model*. We hope you find the included information useful and would welcome the opportunity to follow up with committee staff to further discuss these critical issues.

Sincerely,

Stuart Pratt
Global Head, Public Policy and Industry Relations
CoreLogic

CoreLogic

Flood Risk Score

Understand flood risk beyond the flood zone

The Need for Comprehensive Flood Data

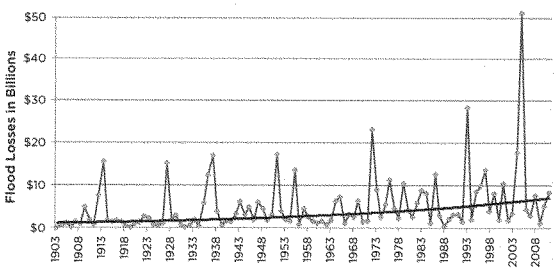
The most pervasive and expansive of all natural perils, flooding is also one of the most mismanaged and underinsured. The need for accurate and measurable flood risk management has always existed. By having comprehensive data beyond just the traditional "in/out" of flood zone, many industries have vastly improved their flood risk management using CoreLogic® flood risk data.

Flood Risk Score

Underwriting guidelines have historically relied on a flood zone determination—whether a property is "in" or "out" of a federally designated floodplain. Yet flood zone determinations have proven to have limited reliability. Approximately 25-30 percent of annual flood insurance claims originate from properties located "outside" of the floodplain.

Sophisticated flood underwriters have moved beyond flood zone determinations to CoreLogic Flood Risk Score (FRS), a much more advanced risk assessment tool that combines federal flood zones with hydrological science and critical risk data. Elevation and comprehensive hydrology data, combined with an internal database of over 90,000 dams, levees and customized flood analysis (e.g. Howard Hanson Dam in Washington) provide an extensive flood risk management solution. FRS provides a precise and graduated risk assessment that distinguishes incremental levels of risk for properties located both "in" and "out" of designated floodplains.

The entire process is fully automated, instantaneous and yields a simple and intuitive risk score/rating to enable customers the ability to accurately assess property-specific flood risk anywhere in the U.S.



Historical U.S. flood loss and trend (1903-2011). Average insured losses have more than doubled over the last 20 years.
Source: NOAA

KEY BENEFITS

- Enhanced risk selection, policy structure and pricing
- Improved management of risk accumulation based on visibility to incremental risk and comprehensive hydrologic science to ascertain risk
- Fully automated, instantaneous, simple and intuitive

KEY FEATURES

- Identifies high-risk areas "outside" the floodplain and differentiates levels of risk "inside" the special flood hazard area
- Flood Risk is calculated on a continuum via a numeric score (10-100), and categorizes those scores into risk ratings from "Very Low" to "Extreme"
- Provides additional flood risk factors including levee and dam proximity, FEMA-designated levee protected zones and hydrologic data to evaluate a property's overall flood risk

Risk Assessment Methodology

Properties are often exposed to an extended floodplain boundary or multiple flood zones, making it difficult to identify the most pertinent flood source. FRS resolves this issue by using 10m hydraulic profiles along national river systems and coastal zones and utilizing a multi-tiered methodology of drainage basins (e.g. catchment areas, subwatersheds, subbasins) to identify the correlation between properties and the special flood hazard area that poses the most immediate flood risk. FRS then calculates the proximity of the flood source in terms of elevation variance between the property and the most relevant hydraulic profile. Finally, the score is adjusted to reflect the presence of additional risk factors which includes storm surge, FEMA-designated levee protected zones and customized flood analysis done for specific geographic areas.

Comprehensive Hydrology Data

FRS takes advantage of the National Hydrography Dataset (NHD) which offers comprehensive coverage of hydrographic data for the United States that reflects regional flooding and drainage patterns. Incorporating this data provided by the United States Geological Survey (USGS) into FRS enables insurers to accurately mange risk accumulations based on hydrologic science, as opposed to county boundaries or ZIP codes.

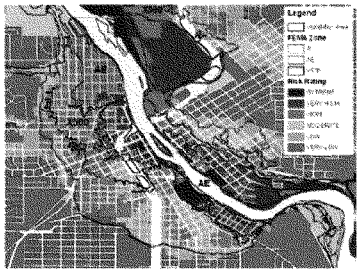
Flood Risk Factors

In addition to a comprehensive score, FRS also provides flood risk factors that can be utilized for determining risk. Based on hydraulic science, FRS provides proximity distances to the most significant 100-year and 500-year floodplains, levees and dams. Elevation data used to calculate the score is also provided along with Additional Impact Areas (AIA) that may impact a property's flood risk. Lastly, hydrologic names and unit codes are provided to allow customers the ability to identify properties within their portfolio that are subject to more catastrophic flood events.

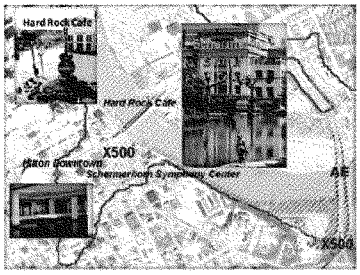
CoreLogic Advanced Flood Risk Solutions

Flood Risk Score is just one important part of CoreLogic advanced flood risk solutions. These solutions include scoring, data visualization, and other tools that collectively address the management of flood risk throughout the entire insurance process, from underwriting and portfolio management to risk transfer and reinsurance.

As a leading provider of risk assessment solutions to the insurance, financial and real estate industries, CoreLogic has managed flood risk for over 20 years, providing a comprehensive set of GIS, natural peril and property data solutions that can work for you.



Flood risk ratings by FRS and the FEMA inundation boundaries for the 2008 Cedar Rapids Flood.



Inundated landmark properties within the CoreLogic Inundation Boundaries from the Hydraulic Analysis for the 2010 Nashville Flood.

FOR MORE INFORMATION, PLEASE CALL 800-447-9959.

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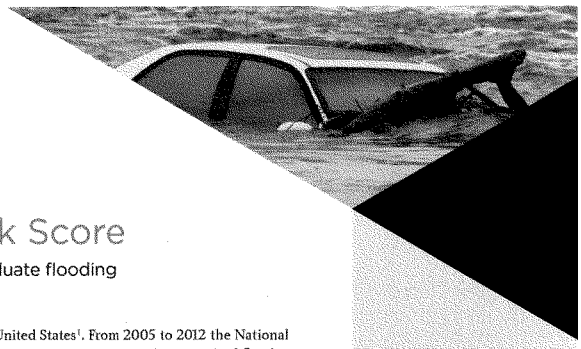


CoreLogic

Flash Flood Risk Score

An innovative approach to evaluate flooding

Flooding by the Numbers

Floods are the #1 natural disaster in the United States[1]. From 2005 to 2012 the National Weather Service (NWS) and National Climatic Data Center (NCDC) summarized flood damages incurred from riverine and flash flooding to be $23.7 billion dollars[2]. During this time, flash flooding damage contributed to $7.9 billion of the total damage, which is 33 percent of flood-related claims[2].

Flash floods are short-term events occurring within six hours of the causative event (heavy rain, dam break, levee failure, rapid, snowmelt and ice jams) and often within two hours of the start of high intensity rainfall[3]. Due to the short amount of time needed for a flash flood to occur, there is little opportunity to prepare or mitigate against it, which results in a high risk for loss and extensive property damage. According to historical storm event data from the NCDC, 70 percent of flood events causing flood losses in the United States have a flash flooding component[4]. For this reason, flash flood risk assessment cannot be ignored.

To accurately assess flood risk, it is imperative to also incorporate a flash flood risk component into the equation. FEMA flood maps, which are referenced for CoreLogic® Flood Risk Score (FRS), are based on flood insurance studies that focus on visible surface water bodies such as rivers, ponds, lakes and oceans—not on dry land. This exclusion of dry land contributes to the reality that FEMA flood studies have not been conducted comprehensively for the entire U.S. In fact, roughly 40 percent of the U.S. does not have a FEMA flood map associated with its geography at all[5]. Additionally, many communities do not participate in the National Flood Insurance Program (NFIP), therefore, no flood studies have been conducted in these areas leaving the flood risk unknown. Essentially, FEMA 100-year flood zones do not comprehend flash flooding.

New Insight with Flash Flood Risk Score

CoreLogic developed sophisticated methodology to provide insurers with CoreLogic Flash Flood Risk Score, an innovative flood scoring product that doesn't rely on FEMA flood maps, and takes an alternate approach to identify flood risk. FFRS provides flooding detail in areas where flooding resources are traditionally unavailable. More specifically, FFRS helps assess whether a flash flood component is identified, particularly in areas where CoreLogic Flood Risk Score is not available due to the flood zone not being mapped—in zones D and N. Essentially, FFRS fills in the flood risk assessment gaps where the previous focus was only on riverine and coastal flooding, and no initial flood insurance studies were ever conducted.

Utilizing a combination of hydrology, meteorological and environmental datasets, FFRS is calculated for the entire U.S. using a 10 meter grid. It generates a simple and easy to use 1-100 numeric risk score along with risk ratings from Very Low to Extreme. This risk score and risk rating can then be incorporated into the insurer's underwriting process to help set detailed guidelines for identifying flash flood risk exposure.

Key Features:

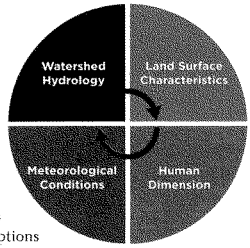
- Offers a 10 meter granularity
- Utilizes hydrology, meteorological and environmental datasets
- Returned data layers include intense rainfall, soil types, ground elevation and flow accumulation

Key Benefits:

- Provides a scoring component to assess a single property or entire portfolio for flash flood risk
- Allows insurers to mitigate the number of claims for flash flood risk
- Provides new insight and innovative models for flash flood risk

Flash Flood Risk Score Methodology

The FFRS model uses watershed hydrology and then extracts hydrologic properties from land information datasets, incorporating probabilistic characteristics of meteorological factors to simulate precipitation impact. All aspects of flash flooding factors are finally integrated to form an overall projection of flash flood risk. The model can pinpoint granular locations with high risk potential for flash flooding anywhere in the United States.



Watershed Hydrology: Identifies land slope, flow direction and flow accumulation in watersheds.

Land Surface Characteristics: Catchment slope, hydro properties/infiltration of soils, imperviousness of land use and interceptions of forest coverage which determine surface runoff potential from rainfall.

Meteorological Conditions: Rain fall intensity, hail probability and geographic distribution patterns and its probability in geographic areas to represent flash flooding in space and time.

Human Dimension: Building design, waste and debris, automobiles and poorly designed infrastructure.

Let Us Score Your Flood Risk

Flash flooding property damage makes up 33 percent of property damage resulting from inland flooding—flash flooding and riverine flooding combined[2]. That's why it's crucial to evaluate the complete flood risk for a property. Identifying and understanding flood risk can be daunting, so let us score the flash flood risk for you—for P&C, Inland Marine, E&S, Commercial Lines and Auto.

Flash Flood Risk Score—One Size Fits All Insurers:

- **P&C:** Evaluate a single property or an entire book of business for flash flood risk exposure to improve your loss ratio.
- **E&S:** Account for a higher level of flash flood risk beyond riverine flooding.
- **Commercial Lines:** Be better prepared for flash flood loss, especially for policies with high hazards and low flood ratings.
- **Auto:** Understand commuter risk for the auto policy holder, including home to office, nearby flash flood areas and areas near home. Write sound auto policies and avoid auto claims due to flash flooding.

Seamless Ordering & Delivery

We offer several options for insurers to access our industry-leading natural hazard risk scores and solutions which include:

Shapefiles: Available for loading into your existing infrastructure.

RiskMeter Online™: A web-based solution used to determine natural hazard risk exposure by simply typing in an address.

RiskMeter Integrated: An interface that delivers a set of services and tools that allow you to easily integrate natural hazard risk, tax jurisdiction, property characteristics (pre-fill), parcel and geocoding data directly into your applications.

The Right Solution for Better Coverage

Insurers want to provide the best coverage for their clients, while only writing properties that are good risks for their books of business. Many also don't realize that they are covering losses that could be more clearly understood with the right flood risk model. Whether using an aggregated or by-peril rating approach, CoreLogic can help you understand flash flood risk at the most granular level possible.

[1] FloodSmart.gov, 2014.
[2] National Weather Service, Summary of Natural Hazard Statistics in the United States from 2005-2012.
[3] National Weather Service, 2014.
[4] National Climatic Data Center, 2014.
[5] National Weather Service Annual Reports 2005-2012

FOR MORE INFORMATION, PLEASE CALL 855-267-7027
OR EMAIL US AT hazardrisk@corelogic.com

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CATASTROPHE RISK MANAGEMENT

U.S. Inland Flood Model

Enabling confidence in underwriting and managing flood risk

Highly Granular Risk Modeling

As the #1 natural disaster in the United States1 with annual economic loss increasingly exceeding billions of U.S. dollars, flooding represents a significant under-insured risk in the United States. As the market explores diversifying and growing business with flood products, our highly granular loss models address the management of a peril where the amount of damage is influenced by water flood depths measured in inches. The U.S. Inland Flood Model from CoreLogic® uniquely empowers the industry to appropriately and rationally estimate risk to obtain better business outcomes with:

- PxPoint™ parcel-based and structure level geocoding
- CoreLogic building-level property characteristics used in model validation and smart default assignment
- Detailed 10-meter cross section hydrologic modeling that includes 6 million miles of charted river and stream channels
- Availability to incorporate digital elevation resolution down to 3 or 1 meter(s) where available
- 60 geographic high-resolution layers down to 0.3 meters defining flood hydrology
- Accurate capture of tail risk with 300,000 simulation years of seasonal flooding

Key Features:

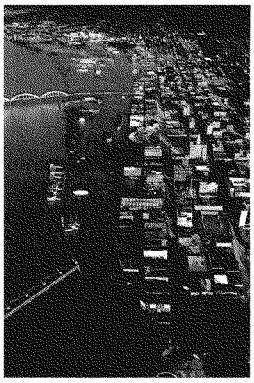
- An innovative approach to modeling
- Structure level geocoding
- Use of CoreLogic property characteristics
- Treatment of both water depth and water velocity damage
- Annual updates of key data layers
- Probabilistic treatment of flood defense damage or failure
- 6 million miles of charted river and stream channels
- Model elevation resolution down to 3 or 1 meter(s)
- 60 geographic high-resolution layers down to 0.3 meters
- Accurate capture of tail risk

Key Benefits:

- Unique fusion of 20+ years of experience in flood data with industry-leading risk solutions for a comprehensive and detailed view of flood risk
- Market-leading model resolution and data provides accuracy and confidence in enabling risk differentiation and pricing for underwriting and portfolio management
- Accurate capture and modeling of site characteristics and flood policy terms down to the coverage level
- An easy-to-access view of combined and separate hurricane precipitation and surge flood risk relevant to your unique insurance product terms

Comprehensive Flood Modeling Methodology

Damaging floods come in many different forms. The U.S. Inland Flood Model models all sources of precipitation driven flooding including riverine, stream, off-plain, and flash flooding. As flood risk evolves due to urbanization and change in baseline stream and sea levels, the flood risk methodology from CoreLogic is designed to stay abreast of the latest flood risk data and research, ensuring continuity of risk insights into the future. It delivers a comprehensive analytic view of the risk, utilizing widespread coverage of hydrologic and hydraulic data that reflects regional flooding and drainage patterns with:



- An innovative approach to modeling that accurately assesses actual flood experience on the ground
- Vulnerability modeling that incorporates both water depth and water velocity damage
- Building component based vulnerability addressing structure, contents, and time element coverage.
- Innovative development of key default unknown secondary structural characteristics utilizing market-leading CoreLogic property characteristic data.
- Detailed modeling of flood defenses that include probability of complete failure.
- Annual updates of 10-meter digital elevation and FEMA data.
- Over 23 historic flooding events available for modeling
- Stochastic flood footprints provided at various return periods as a consulting request for your portfolio
- Comprehensive reporting of exposure and modeled results in both spreadsheet and charting formats

Advanced Integrated and Transparent View of Flood Risk

Flood policy underwriting and management requires the incorporation of high resolution location, building, hazard and event response information in analytic output. CoreLogic is unique with its 20-plus year history in addressing the insurance, financial, real estate and government sectors in flood risk assessment. The U.S Inland Flood Model is just one important part of the advanced flood risk solutions from CoreLogic.

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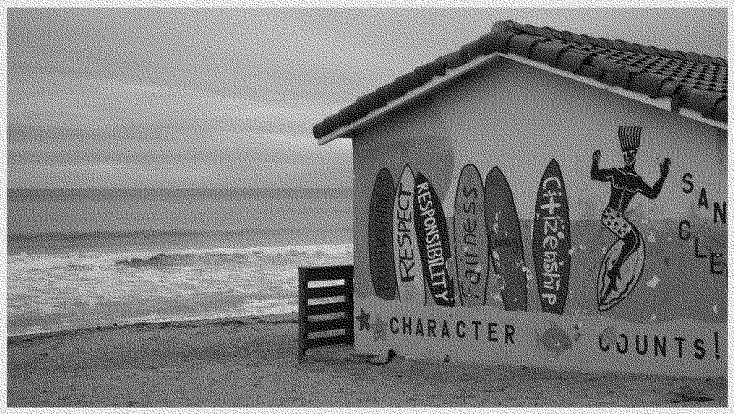
REPORT SUBMITTED BY REPRESENTATIVE SUZANNE BONAMICI

Improving Coastal Resilience

Toward a New National Flood Hazards Reduction Program



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Executive Summary

Floods are the most common and most expensive natural hazard in the United States. Federal action is required to address coastal flood hazards, yet the National Flood Insurance Program (NFIP) remains an inadequate tool to protect Americans against future floods. Because the federal government struggles to accurately determine risk and protect vulnerable homeowners, this report proposes the following three recommendations.

1. Congress should authorize a federal interagency program to coordinate the federal government's approach to coastal flood hazards reduction by improving understanding and communication of flood risk, consolidating the best available information, and anticipating the needs of coastal communities.
   - The proposed National Flood Hazards Reduction Program (NFHRP) would be modeled loosely on successful interagency groups such as the National Earthquake Hazards Reduction Program (NEHRP) and the National Windstorm Impact Reduction Program (NWIRP).
   - National Oceanic and Atmospheric Administration (NOAA) would lead NFHRP, which would consist of nine federal agencies and input from academia and the private sector.
2. The Federal Emergency Management Agency (FEMA) should improve and expand property buyouts to relocate the most vulnerable homeowners.
   - FEMA should take steps to speed up the post-disaster buyout process, as homeowners left waiting for uncertain buyouts are likely to rebuild their homes within the floodplain, leaving them vulnerable to future flooding events.
   - FEMA should streamline its multiple buyout grants into a single program with increased funding and resources, targeting vulnerable property owners and Repetitive Loss Properties (RLPs).
3. NFHRP data and information should be used to facilitate improved buyout programming and land use planning at the state and local level.
4. Vulnerable coastal regions continue to require large-scale, technical mitigation projects carried out by the U.S. Army Corps of Engineers (USACE). To improve and expand these projects, this report recommends the following.
   - USACE should address the equity concerns raised by the current Benefit-Cost Analysis (BCA).
   - USACE should ensure that projects are informed by the latest climate change science.

Introduction

Floods are the most common and most expensive natural hazard in the United States. The United States experienced ten separate billion-dollar natural disaster events in 2019 as of October, including five severe storms, two tropical cyclones, and three flooding events[1] and faced $260 billion cumulatively in flood damages from 1980-2013.[2] Not only do these damages harm the affected communities' livelihoods, but the cost of recovering from these damages is shared among federal, state, and local governments in the form of disaster assistance, insurance payouts, and other recovery measures at the expense of American taxpayers. Moreover, vulnerable populations—such as lower income, racial minority, non-English speaking communities—often experience the most hurt and the slowest recovery.[3]

Furthermore, the frequency and intensity of flooding events is expected to increase due to the effects of climate change.[4] Particularly vulnerable to these impacts are Americans living in coastal states. The Fourth National Climate Assessment predicts that "lasting damage to coastal property and infrastructure driven by sea level rise and storm surge is expected to lead to financial losses for individuals, businesses, and communities."[5] Coastal communities have an urgent need to accurately understand their flooding risk in order to prepare for and respond to the next flooding disaster.

The primary federal policy used to manage flood risk in the United States is the National Flood Insurance Program (NFIP) administered by the Federal Emergency Management Agency (FEMA). However, this program has suffered from longstanding financial troubles and has been ineffective in achieving its stated goals of discouraging development in risky areas and improving the long-term resilience of flood-exposed communities. Congress has made a number of attempts to reform the NFIP, including the 2012 Biggert Waters Act. These reforms have not lasted due in large part to a complicated mix of local government, development, and homeowner interests. Indeed, NFIP authorization is a perennial authorization battle that often includes piecemeal reform that does not solve the underlying financial troubles of the program. Furthermore, these efforts have not contributed to meaningful long-term sustainability of the nation's approach to managing coastal flood hazards.

We instead ask what other models besides insurance and NFIP might be used to address coastal flood hazards. These recommendations are built to complement rather than replace NFIP. Our intention is to provide policymakers with basic blueprints and best practices from other risk management regimes that might improve a federal coastal flood management approach currently dominated by NFIP.

The report proceeds as follows. Chapter 1 gives background on the shortcomings of the NFIP and this report's decision to focus on other policy tools. Chapter 2 proposes a new interagency approach, which we term the National Flood Hazards Reduction Program, drawing on lessons learned from existing programs on earthquake and windstorm hazards. Chapter 3 covers land management practices and provides recommendations for conducting voluntary buyouts. Chapter 4 covers improvements to technical mitigation and infrastructure. This report envisions that Chapter 3 and 4's recommendations could benefit from the proposed NFHRP but may also be pulled in an "off the shelf" manner to improve the status quo without embarking on large-scale regulatory reform.

Chapter I

Moving Beyond Flood Insurance

This chapter will establish the background for the NFIP, the goals it was meant to achieve, and a diagnosis of its shortcomings. NFIP has largely failed as an incentive mechanism to promote more resilient construction and is in financially dire shape. As NFIP does not seem likely to protect Americans against future flood risks, we emphasize an approach that centers on other mechanisms.

Problem Definition

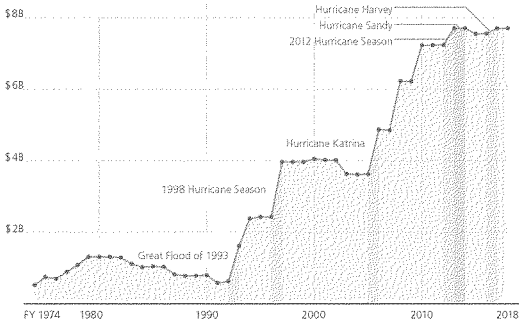
NFIP was established in 1968 with the passage of the National Flood Insurance Act. Prior to NFIP, the national response to flood disasters largely relied on infrastructure improvements to hold back or prevent flooding, a strategy that promoted development in flood prone areas. Government representatives in such regions faced tremendous pressure to help constituents harmed by natural disasters. As such, federal government was often called on to issue disaster aid packages to help communities rebuild in the wake of large and increasingly destructive events.

NFIP was intended to reduce the burden on taxpayers by shifting costs onto homeowners in order to better dissuade future development in flood zones and promote risk mitigating improvements to reduce losses. However, the program has not succeeded. Federal government disaster relief spending has continued to rise as the frequency of incidents increases and political pressures shift the burden from states to the federal government.[6] Between 1970 and 1980 the United States averaged $1 billion a year on disaster relief adjusted for inflation, compared to almost $8 billion per year since 2010.[7]

As of the first quarter of the 2019 fiscal year, the NFIP had $20.5 billion in outstanding debt with the U.S. Treasury.[8] This illustrates a major contradiction in the program's initial financial design: flood insurance would be funded by premium collection, not taxpayer money. In 2018, total revenue and total expenses yielded a deficit of $6.6 billion for the program, which continues to exert upward pressure on debt levels and raising sustainability concerns.[9]

In a broad financial sense, premium collection does not generate enough revenue stream to cover the costs of providing insurance. Large catastrophes exacerbated this situation and put the program in financial distress, to a point where the Government Accountability Office labeled it as a high-risk program. Since Hurricane Katrina, the U.S Treasury has provided NFIP with significantly more financial relief to cover expenses that the program is unable to pay.[10]

Disaster Relief Appropriations, 10-Year Rolling Median



Federal Disaster Relief Fund appropriations; adjusted for inflation; medians are for the decade ending in each fiscal year.

Credit: Modified from CRS and Labor Department data via the Washinton Post

This failure is for many reasons. First, actuarially fair premiums, and thus the sustainability of the program, are at odds with affordability for many homeowners. Attempts to increase premiums to accurately represent risk would significantly increase the cost of home ownership and rents, while also devaluing many families' homes. In some areas, risk-based insurance premiums could be over $10,000 per year, but even small increases can have significant impacts on vulnerable populations.[11] Second, the program places the financial burden for mitigation and risk on a group of individuals that lack the expertise and resources to make effective decisions, leading to very low voluntary uptake levels of flood insurance.[12] This is in part why in many high-risk areas of the United States, such as Puerto Rico, NFIP uptake is exceptionally low. And lastly, NFIP places the financial burden for flood insurance and mitigation on the same broad group of constituents that successfully lobbied politicians to cover their financial losses in the first place. The political mechanisms that were driving the demand for federal funding after disasters would become the same mechanisms that would fight against actuarially fair premiums.

Lawmakers are pressured to address affordability concerns through premium subsidies and work to keep FEMA flood maps out-of-date to prevent rate increases on a broad range of constituents. This political pressure in turn creates unintended consequences that incentivize living in high-risk areas by providing individuals with affordable subsidized insurance. NFIP also creates roadblocks to additional mitigation efforts. By tying insurance

to FEMA flood maps, NFIP has made it difficult to update maps to accurately reflect risk. Accurate maps would trigger increased costs for existing NFIP policy holders while broadening the group of constituents that may be required to purchase insurance in the future. As such, local municipalities lack the information necessary to help flood mitigation in communities and inform zoning decisions.

Lawmakers have made several changes to improve the effectiveness of NFIP. The Flood Insurance Reform Act of 2004 included provisions to limit payouts on repetitive loss properties. More recently, policymakers tried to increase the financial stability of NFIP and restore mitigation incentives. The 2012 Biggert-Waters Flood Insurance Reform Act increased premiums by reducing subsidies and grandfathered rates for buildings built prior to 1974, before the effective date of the initial Flood Insurance Rate Map (FIRM). Post-FIRM buildings would have been subject to new criteria that would also have increased rates. But these reforms were rolled back before implementation by the Homeowner Flood Insurance Affordability Act (2014). The 2014 legislation was in direct response to the affordability concerns raised by accurate risk-based premiums which received increased attention following Superstorm Sandy in Fall 2012. The quick overturn of risk-based premiums highlights the affordability versus sustainability problem NFIP has been unable to overcome.

Now FEMA is considering and developing Risk Rating 2.0; little is known about the full details of the program. FEMA has billed Risk Rating 2.0 as a new attempt to deliver rates that are, "fairer, easier to understand, and better reflect a property's unique flood risk."[13] While phrased differently, rates that "better reflect a property's unique flood risk" is the definition of risk-based/actuarially fair premiums, precisely what past reforms to NFIP have tried to do. Thus far, Risk Rating 2.0 appears to be another attempt to fix previously failed policy that will likely fall short.

Conclusion

NFIP is one of the primary federal tools that aims to protect Americans from flood risk. However, it is unlikely to adequately do so in the future, due to the reasons outlined in this chapter. In order to create more resilient communities, the U.S. Congress must move away from relying on NFIP as the key driver for mitigation and begin looking toward alternative solutions. The U.S. federal government must prioritize solutions that inform communities of best practices and provide accurate data and risk assessments that are not tied to insurance premiums. We need new methods for relocating households from high-risk areas that don't rely on placing punitive financial burdens on vulnerable populations to do so.

Chapter II

A National Flood Hazards Reduction Program

This section proposes a new National Flood Hazards Reduction Program (NFHRP). This proposed interagency process would be modeled on existing programs, most notably the National Earthquake Hazards Reduction Program. We outline the objectives, structure, and primary participants of the program, and end with a discussion of how this program would provide a needed elevation of social vulnerability dimensions of coastal flood hazards.

Problem Definition

Despite flooding being the most frequent natural hazard in the United States, there is not an integrated federal approach to managing the threat in coastal areas.[14] Many federal agencies support research on coastal flood risk and are statutorily expected to communicate that risk. However, the fragmentation and lack of consensus on risk management can confuse and frustrate state and local governments, stakeholders, and the American people. The problem becomes more concerning when considering the unknown costs and risk associated with a changing climate. For the federal government to adequately plan for and respond to the risks of coastal flood hazards, it must prioritize interagency coordination, cross-cutting research, and long-term planning.

Finding 1

Federal, state, and local agencies often have their own coastal flood risk research, data, risk analyses, and risk maps, which siloes best practices for floodplain management programs. As a result, there is no central place for best available information on coastal flood hazards.

The current approach to managing coastal flood risk is highly fragmented, which reduces the cost efficiency and effectiveness of policy responses. Responsibilities for hazard mitigation, response, and rebuilding are split across different entities. Programs, regulations, and funding sources often overlap across the federal, state, and local levels. Illustrating this vast array of government actions and resources, Appendix I provides a summary

Waterfront developments in San Juan, Puerto Rico often reference flood maps with inaccurate information.

Credit: Nathan Eckstein

of current federal agency flood risk and management programs; the problem is compounded by similarly fragmented state and local programming that varies across the United States. This inefficient use of resources is evident in contradictory coastal flood maps. Furthermore, the complex web of agencies makes it difficult for communities to understand and mitigate against their flood risk.

Finding 2

Various agencies, state governments, and private entities develop their own coastal flood risk maps for planning or regulatory purposes. FEMA regulatory maps are widely used as guidelines for flood policy and allocation of government funding but do not accurately reflect flood risk. Furthermore, FEMA maps do not include impacts of climate change such as sea level rise. As a result, there is ineffective dissemination of accurate information from public agencies on coastal flood risk.

The most significant consequence of federal disaggregation of flood risk management is conflicting and often outdated information on flood risk conveyed through maps.

Flood Insurance Rate Maps (FIRMs) created by the FEMA to inform NFIP premiums not only differ from maps created by other federal agencies such as NOAA but are also infrequently updated and do not accurately convey probabilistic flood risk, particularly beyond the 100-year floodplain. FEMA FIRMs underestimate both the extent of floodplains and the probabilistic depth of inundation across floodplains. Furthermore, FEMA FIRMs do not include projections of future climate impacts including sea level rise, coastal erosion and increasing frequency and intensity of storms, which have the potential to change floodplain boundaries and overall flood risk. As a result, many coastal communities are unaware of their flood risk and are unable to make informed decisions about flood preparation, mitigation, and homeownership.

Superstorm Sandy's damage in 2012 illustrates the inadequacy of the current mapping approach in appropriately communicating risk. A report released by the New York City government stated that "the area that flooded during the storm was more than one and a half times larger than the 100-year floodplain defined on FEMA's 1983 FIRMs,"[15] which had informed floodplain management in the city. The FEMA maps were outdated at the time of the storm, and updates were subject to political concerns regarding insurance rates and property values. As a result of outdated maps, "not only were residents unaware of the risks that they faced, but the buildings in which they lived and worked had not been subject to the flood-protective construction standards that generally apply within the floodplain."[16]

The inadequate information led to insufficient flood damage mitigation and larger and more expensive damages from the storm than would have occurred if the city had prepared for a more accurate estimation of flood risk. The Sandy example also illustrates the inadequacy of the standard 100-year floodplain in conveying risk as the impacts of climate change worsen. Americans would greatly benefit from understanding the presence and level of heightened risks both within and beyond the existing 100-year flood plain.

Finding 3

Within the federal government, there is an increasing need to consider and communicate short- and long-term flood risk, considering coastal resilience, climate change and social vulnerability.

The lack of an integrated coastal flood hazard approach diminishes the ability of the federal government to plan for and respond to coastal flood hazards today and in the future.

In order to effectively address flood hazards at the federal level, the federal government should draw on all agencies to build an improved understanding of coastal flood risk, including forward-looking projections of risk that incorporate the impacts of climate and coastal change. Furthermore, the federal government needs to better integrate its modelling and understanding of different types of coastal flood hazards, and the physical processes and consequences if they occur simultaneously. Finally, an integrated approach and best practices for incorporating social science and community vulnerability into flood risk management is needed to increase the resilience of coastal communities to flood risk.

Successful models for how to build an integrated federal approach to catastrophic natural hazards exist for earthquakes and wind hazards: the National Earthquake Hazard Reduction Program (NEHRP) and the National Windstorm Impact Reduction Program (NWIRP). This spread provides overviews of these programs and suggests how a national flood hazard reduction program can be modelled after these programs.

In 1977, Congress established NEHRP, through the Earthquake Hazards Reduction Act of 1977, to "reduce the risks of life and property from future earthquakes in the United States."[17] Since NEHRP's creation, Congress has periodically reviewed and reauthorized NEHRP, most recently in 2004. However, its current mission remains importantly close to its 1977 mandate: "To develop, disseminate, and promote knowledge, tools, and practices for earthquake risk reduction—through coordinated, multidisciplinary, interagency partnerships among the NEHRP agencies and their stakeholders—that improve the Nation's earthquake resilience in public safety, economic strength, and national security."[18]

NEHRP consists of four primary program agencies: FEMA, NIST, NSF, and USGS. The 2004 NEHRP Reauthorization Act placed NIST as the lead agency of the four and established the NEHRP Interagency Coordinating Committee. The Committee consists of the directors of the four primary program agencies, chaired by the Director of NIST, in addition to the White House Office of Science and Technology Policy (OSTP) and OMB. The Committee is charged with (1) overseeing NEHRP planning, management, and coordination, (2) developing the program's strategic plan, and a management plan for its implementation, and (3) creating and submitting NEHRPs budget and an annual report to Congress.[19]

In addition to the Interagency Coordinating Committee, the 2004 Reauthorization established the Advisory Committee on Earthquake Hazards Reduction, an external non-government source of expert advice that is meant to advise and recommend on NEHRP programming.[20] Specifically, the Advisory Committee is expected to assess scientific and engineering trends, advise on program effectiveness, and provide expert guidance on program management, coordination, and implementation. NIST worked in coordination with the other agencies to establish the 16 members of this committee.[21]

NEHRP's Strategic Plan, most recently updated and released in 2008, includes three goals: (A) Improve understanding of earthquake processes and impacts; (B) Develop cost-effective measures to reduce earthquake impacts on individuals, the built environment, and society-at-large; and, (C) Improve the earthquake resilience of communities nationwide.

In 2004, when re-authorizing NEHRP, Congress established NWIRP to achieve "major measurable reductions in the losses of life and property from windstorms through a coordinated federal effort, in cooperation with other levels of government, academia, and the private sector."[22] NWIRP's aim is to improve "the understandings of windstorms and their impacts" and to develop and encourage "implementation of cost-effective mitigation measures to reduce those impacts."[23]

NWIRP consists of the same four primary agencies as NEHRP: FEMA, NIST, NSF, and USGS. Most recently, formal coordination activities for NWIRP were transferred to the Interagency Coordinating Committee, which consists of the heads or designees of FEMA, NOAA, NSF, OSTP, and OMB, and is chaired by the Director of NIST. The Interagency Coordinating Committee is charged with (1) developing a strategic plan for NWIRP, (2) reporting to Congress on NWIRP progress, and (3) submitting annual coordinated budgets for the Program to Congress.[24]

Beyond the current Interagency Coordinating Committee, additional routes for coordination and knowledge creation also exist. First, NIST reestablished its version of a Windstorm Working Group in 2016 to provide additional working level coordination, in which in addition to the four core NWIRP agencies, other federal stakeholders can participate as well, to include: Department of Energy, the Federal Highway Administration, HUD, NASA, USACE, and a liaison member from OSTP. Second, per the 2015 Reauthorization bill, the National Advisory Committee on Windstorm Impact Reduction (NACWIR) works to incorporate non-government stakeholders in order to offer assessments and recommendations on an array of key NWIRP areas and goals.[25]

NWIRP's Strategic Plan, developed in March 2016, includes three goals, of which each have four or five objectives (with fourteen total, not shown): (A) Improve the Understanding of Windstorm Processes and Hazards; (B) Improve the Understanding of Windstorm Impacts on Communities; and (C), Improve the Windstorm Resilience of Communities.

The strategic plan also mapped each agency's statutory responsibilities to the strategic plan's goals. Notably, NIST holds both the responsibility as lead agency and one of the four designated program agencies. As lead agency, its responsibilities include planning and coordinating the program, ensuring that the program includes the necessary components to promote implementation, and, by extension, requesting assistance of other federal agencies to carry out programming.[26] As a program agency, its additional statutory responsibilities include support for performance-based engineering, coordination of federal post-windstorm investigations, and appropriate recommendations for model codes.[27]

Considering Other Models: NEHRP and NWIRP

NEHRP and NWIRP are proven models for a new flood hazards reduction program for several reasons. Both models facilitate critical knowledge-sharing across different expert groups and introduce cost-effective solutions through building code updates and other regulatory improvements. However, there are several limitations of NEHRP as a model for a similar program for coastal flooding. First, new NFHRP maps will be advisory and will not inform programs such as NFIP or buyouts unless agencies, states, or localities choose to adopt them for regulatory purposes. As a result, these new, more accurate, mapping products will not necessarily dictate flood policy and funding allocation. Second, the number of agencies involved in flood hazard management (detailed below) is much greater than the number of earthquake hazard management agencies. Interagency coordination thus might thus prove more challenging for NFHRP, since the number of federal agencies involved in coastal flood hazard management and the size of funding is much greater than the correlates of NEHRP and NWIRP (which each only has four participating agencies).

Still, the NEHRP and NWIRP models demonstrate that Congressionally mandated federal interagency programs can improve coordination and understanding of a hazard when properly structured with an effective lead agency. The goals of NEHRP and NWIRP as stated in their strategic plans are strikingly similar to what is needed for coastal flood hazards: an improved understanding of the hazard in order to improve community resilience. In particular, NEHRP contributed to improved characterizations and understandings of earthquakes, including effective earthquake warning systems, improvements in building codes and construction standards to mitigate against earthquake damages, advances in earthquake engineering research, and improved federal coordination on model building codes. Other accomplishments of the program include "improved understanding of earthquake source processes, fault system modeling, probabilistic earthquake forecasting, and the causes of induced seismicity."[28]

NEHRP facilitates knowledge-sharing and capacity-building for agencies working on risk characterization, prediction, and management, giving access to best practices to national and subnational agencies and stakeholders, and standardizing risk management processes across different regional seismic sensing networks. Similar to today's coastal flood risk management landscape, the status quo prior to NEHRP was a disjointed regional network model with critical knowledge gaps between seismic science and practitioners.

An interagency program to address coastal flood hazards modeled after NEHRP and NWIRP would capitalize on the successes of these models and make more efficient use of government resources currently invested in coastal flood risk management. Furthermore, the size of the challenge of preparing for and responding to coastal flood-related disasters, especially in the face of increasing risk associated with climate change, merits a federal government response elevated above the efforts of individual agencies. A coordinated approach would allow participants to exchange, combine and improve methods and data sources for coastal flood risk models currently developed by different states and agencies.

The following section proposes a National Flood Hazards Reduction Program model building on the lessons learned from NEHRP and NWIRP.

Recommendation 1: National Flood Hazards Reduction Program

This section conceptualizes what a federal coordinating mechanism for coastal flood hazards could look like. Like NEHRP or NWIRP, it would ultimately be up to the body itself—through an initial multi-year interagency process—to develop a mandated strategic plan and implementation strategy.

The National Flood Hazards Reduction Program (NFHRP) would elevate the evaluation of coastal flooding hazards to the national level while increasing efficiency and transparency across the existing suite of agency flood programs. NFHRP would include a statutorily mandated lead agency that would chair an interagency council and facilitate better cooperation at the federal level regarding coastal flood risk prediction, research, and knowledge transfer to all users of coastal flood risk evaluations. Additionally, NFHRP would be tasked with coordinating the annual federal budget proposal as it relates to coastal flooding, with the hope of reducing overlap and redundancies within the system.

While the initial envisioning of this interagency group focuses on costal, rather than inland, flooding hazards, there exists significant overlap in both existing federal programs and scientific processes between inland (including riverine and alluvial) and coastal flooding. The immediate priority for NFHRP will be to incorporate coastal changes due to climate change, such as sea level rise and increased storm intensity, into communication of flood hazards and risk. However, NFHRP should be designed to ultimately incorporate all types of flood hazards, including riverine flooding.

A potential envisioning of the NFHRP mission is:

NFHRP Mission Statement and Overall Objectives

> *To communicate future coastal flood risk to support the safety and management of coastal communities, infrastructure, and resources; and to improve our understanding of the magnitude and variability of different forms of coastal flooding in different contexts.*

In addressing the mission statement, the NFHRP should have overarching objectives that improve upon the problems identified with existing federal coastal flood risk management. We envision the following objectives:

- Draw on all agencies, academia and the private sector to improve the ability to predict and communicate current and future coastal flooding risk under varying coastal conditions.
- Anticipate and address the needs for understanding coastal flood risk in a manner that sustainably considers social science.
- Consolidate and disseminate the best available and real-time data and mapping methods on one publicly accessible and reliable data platform.
- Improve the efficiency and sustainability of the resources invested in predicting coastal flood risk for advisory purposes only.

The primary products of NFHRP would be country-wide advisory coastal flood risk maps that incorporate the best available data and methods on coastal flood hazards and risk. These maps should be publicly available and regularly updated according to improving mapping techniques and data; best practices and timelines will be defined by the NFHRP

Agency	Summary of Current Flood Related Activities	Anticipated Role in NFIP
NOAA	Conducts research and climate modeling and engages in national ocean & coastal program management to support coastal economies.	Lead agency. Coordinates interagency rules and timelines. Draws on existing research and programs on climate and coastal management to inform NFHRP products and services.
USGS	Collects and maps primary flood-related data used by federal agencies including FEMA and NWS, and studies physical processes of natural disasters and coastal change.	Leads data collection, research, and mapping efforts.
NIST	Conducts research on structural resilience to natural hazards and provides recommendations for community resilience procedures and standards.	Provide expertise on building codes and structural resilience as they relate to flood hazard reduction and risk
NWS	Part of NOAA, conducts precipitation and flood forecasting. The Federal Government's weather forecasting agency.	Hydrologic services and short-term flood forecasting
NSF	Funds research at the national and subnational level related to storm processes, impacts, risk assessment, modeling and mapping.	Academic and private sector research, modeling, and risk analysis

Lead Agency

Risk and Prediction Coordinating Agency

agencies. The goal of national coastal flood risk maps is to clearly communicate the best available information on the type, probability, and severity of expected coastal flood hazards across the coastal United States. As such, these maps should also include best-available sea level rise and climate change-related projections of future coastal flood risk.

NOAA's Digital Coast and Sea Level Rise Viewer are existing examples of comparable map products on a national single-agency scale.[25] NFHRP's new publicly available advisory maps will elevate national coastal flood risk information to the interagency level. Furthermore, by producing advisory rather than regulatory maps, NFHRP can overcome the challenges faced by FEMA in reflecting true coastal flood risk in its mapping products by producing advisory maps that do not affect insurance or funding decisions, thus decoupling accuracy of mapping products from political concerns.

Agency	Summary of Current Flood Related Activities	Anticipated Role in NFIP
NAS OSB	The National Academies are non-profit, independent groups composed of peer-elected experts. Organized by research area, they publish reports and host workshops on issues within a field, often at the request of agencies.	Conduct studies and reports at request of NFHRP agencies. Provide linkage to academic and non-governmental scientific expertise.
FEMA	Part of the Department of Homeland Security, FEMA is the lead federal agency responsible for emergency response. Administers the nation's primary flood hazard program, the National Flood Insurance Program.	Key contributor of information and end user of advisory products. FEMA retains statutory authority and responsibility for determining regulatory maps for FEMA programs (eg FIRMs).
USGCRP	Interagency group which assesses and communicates key impacts of climate change in the US, including through the quadrennial National Climate Assessment.	Provide a key linkage to ongoing federal agency work on climate change assessment and adaptation. Provide best practices in risk communication to end users within government and to the public.
HUD	HUD is a cabinet agency that promotes community development and housing access. HUD investigates housing discrimination under the Fair Housing Act, promotes homeownership, provides affordable housing, and administers the Community Development Block Grant program.	User group of interagency products and activities. Resource for other agencies on economic development, equity in disaster recovery , and housing policy.

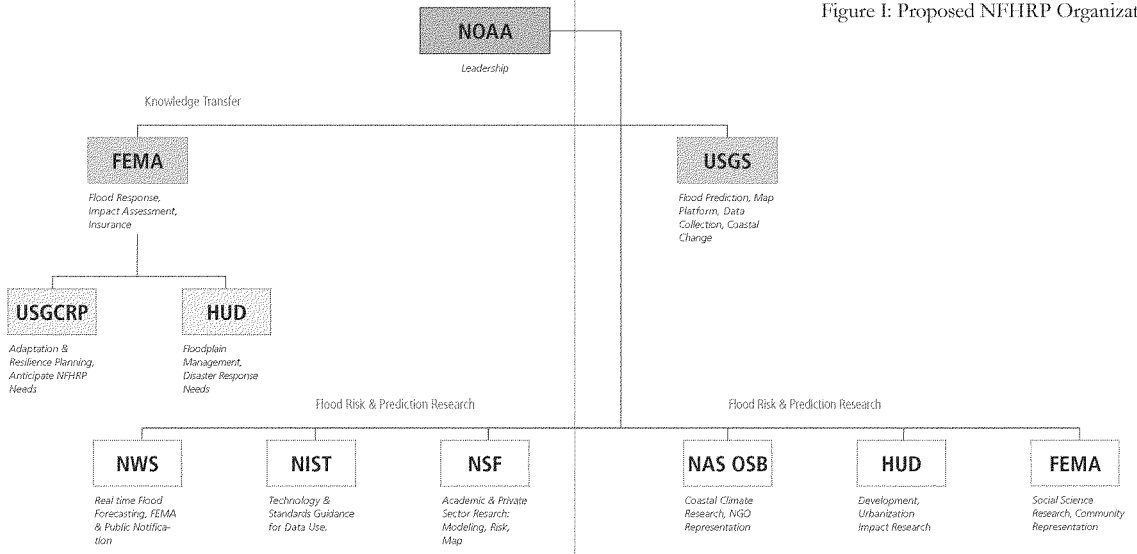
Knowledge Transfer Coordinating Agency

Figure 1 and *Table 1* provide a snapshot of anticipated NFHRP agencies and their roles, bearing in mind Appendix I's overview of existing coastal flood risk responsibilities by agency.

NFHRP Organization

The concept of NFHRP stands alone from this proposed structure. Close conversation and consultations between federal agencies and executive and legislative stakeholders would clarify which organization is best suited to the lead role, as several capable government agencies could be suited to assume responsibility as lead for its management.

Figure I: Proposed NFHRP Organization



However, we recommend that the National Oceanic and Atmospheric Administration (NOAA) serve as lead agency of NFHRP because of the breadth of its existing coastal flood and climate research and coastal flooding communication. Furthermore, NOAA already houses several programs, such as "Digital Coast," which seek to consolidate federal and state governments' best available data on national coastal flood risk.[30] The expertise required to aggregate existing data and research across federal agencies makes NOAA the best candidate to head NFHRP. In its lead role, NOAA will coordinate NFHRP agencies to set interagency rules and timelines, while continuing to draw on its existing programs and research to inform NFHRP products and services.

Like NEHRP and NWIRP, NFHRP should be mandated to have an Interagency Coordinating Committee in which the heads or designees of each agency are asked to meet annually or biannually. The Committee would be charged with developing the strategic plan, reporting to Congress, and submitting annual coordinated budgets. Additionally, a best practice for NFHRP would be to establish more frequent communication among working level civil servants.

Figure 1 and *Table 1* propose a structure for NFHRP participating agencies and suggested roles for each agency. These agency roles are broken into two primary functions to address NFHRP's mission and objectives: those engaged in improved risk characteri-

zation through flood risk and prediction research (indicated in blue) and those engaged in improved risk communication and knowledge transfer to local and state entities and other stakeholders (indicated in green). As shown below, we anticipate some agencies will be involved in both of these functions due to their existing programs and area expertise, and thus are listed twice.

First Year Stategic Plan

In its first year, the NFHRP should be tasked with specifying its short-, medium-, and long-term strategies in order to achieve the objectives listed above. NFHRP's First Year Strategic Plan should include two primary goals.

First, the NFHRP should define agency roles and responsibilities; confirm representatives and annual funding sources for these roles and responsibilities; agree on procedures for interagency communication and coordination; and establish methods for integrating research across member agencies, academia and the public, non-profit and private sectors. Additionally, NFHRP should identify gaps in the availability and accuracy of current coastal flood risk mapping products and data and will propose a timeline for regular updates and revisions to both maps and best practices for mapping methods. Revisions should include incorporating forward-looking and climate change-related projections of coastal flood risk.

Second, the NFHRP should establish a plan to provide a publicly available integrated platform of data related to coastal flood risk including but not limited to elevation, weather, climate patterns, development, and coastal change. This data platform should consolidate downloadable coastal flood hazard data and geographic models to proactively communicate coastal flood risk on a mapped display. A critical initial effort to the creation of this data platform is to establish data compatibility requirements, quality standards and processes to transfer and display data, and a public communication framework that clarifies the significance and assumptions of the data. Data update procedures and expectations should be standardized to ensure that data and coastal flood risk are reliable and current.

After the first year, the NFHRP should be prepared to move forward with developing and disseminating the most reliable coastal flood risk information and updating it with advances in data collection and availability, modeling, and the understanding of coastal flood risk. The data platform would become a needed centralized and reliable federal tool to communicate advisory coastal flood risk to stakeholders and the public. To ensure that the platform meets the needs of its users and that the data is accessible to users, it should include a user feedback and feedback response mechanism as of the first year.

Social Vulnerability

Like NEHRP, NFHRP should coordinate interagency efforts and support to social science research related to issues of flooding and coastal resilience. Particularly, the NFHRP should have a statutory responsibility to address considerations of—and improve the community's understanding and assessments of—social vulnerability as it relates to coastal flooding.

Social vulnerability can be thought of as "the probability of identifiable persons or groups lacking the capacity to anticipate, cope with, resist, and recover from the impacts"[31] of a hazard. In hazard vulnerability assessments, analyzing social vulnerability assesses the unique needs of socially vulnerable groups, including people with minimal wealth, people of racial and ethnic minorities, the elderly, disabled individuals; or, considering the variated choices of population segments based on these demographics or others like gender. Depending on the natural disaster, social vulnerability assessments

can also include considerations of the type of housing individuals own, how many dependents those individuals have, and other indicators that serve as proxies for identifying characteristics associated with social vulnerability.

In short, socially vulnerable populations are more likely to live in (1) high-risk communities and (2) high-risk structures, and are less likely to receive assistance (3) before the hazard, in the form of pre-impact interventions, and (4) after the hazard, in the form of emergency and disaster responses. The results of coastal flood, and all natural, hazards for socially vulnerable groups are distinct and more dangerous than for the rest of the population for several reasons:

- First, vulnerable populations might occupy hazard zones more frequently than others. Examples include flooding caused by Hurricane Harvey in Houston, Texas in 2017.[32]

- Second, vulnerable populations might live and work in less hazard-resistant structures than average. Uptake on building codes and enforcement is neither immediate nor uniform, and vulnerable populations are most consistently left out. Renters are most likely to be affected by landlords choosing not to update their buildings, and usually landlords have the political power to allow for delays in requirements for uptake. Vulnerable populations may also not have money on hand to complete capital-intensive projects such as mitigation, and as such, may be forced to take the risk of living in a less hazard-resistant structure.

- Third, vulnerable populations see lower rates of pre-impact interventions, such as community hazard mitigation, emergency preparedness, and recovery preparedness. For example, although FEMA translates and offers various post-disaster services in many languages,[33] it is unclear how many pre-impact resources exist in languages other than English or Spanish.

- Fourth, vulnerable populations face lower rates of post-impact emergency and recovery responses. In Puerto Rico, for example, community land trusts—which incorporate low-income, informal communities into a societal collective—had trouble accessing FEMA post-disaster resources.[34]

The effects of these higher risks are clear: these vulnerable groups are more likely to experience casualties and injury.[35] Additionally, socially vulnerable populations are likelier to experience "property damage, psychological impacts, demographic impacts, economic impacts, or political impacts—direct, indirect, or informational effects."[36]

Much of the initial research on this topic has been funded by programs like NEHRP, which has increasingly considered social vulnerability beyond earthquake hazards. A contemporary NFRHP would prioritize these considerations in strategic planning and coastal flood risk management by supporting this research, expanding it, and promoting its findings. Particularly, the NFRHP should address social vulnerability as it considers issues of affordability, codes and standards; best practices for guidance, training, and support, especially at the local level; and, assessments of the viability and implementation of community or individual relocation. Specifically, as federal agencies like FEMA consider programming such as increased buyouts, per our Recommendation 2, NFHRP should prioritize considering societal impacts and vulnerabilities and means by which to support vulnerable groups in program implementation.

Conclusion

Takeaway 1

The lack of a coordinated federal interagency approach to researching, modeling, and managing coastal flood hazards reduces national and subnational flood risk management effectiveness. The multiple current federal approaches do not adequately nor comprehensively consider the impacts of climate change and equity associated with coastal flooding. This undermines the ability of the nation to prepare for long-term coastal sustainability and community resilience. An integrated approach is needed to ensure that agencies incorporate the best available science into their coastal flood programs.

Takeaway 2

Successful federal interagency models exist in NEHRP and NWIRP. Addressing coastal flood hazards through a similarly modeled NFHRP will elevate and streamline coastal flood risk management above individual agencies, optimize funding and management processes, and produce more reliable advisory flood risk maps. While there are some differences between NEHRP and the proposed NFHRP ---particularly in the number of involved agencies ---they share a base problem of risk characterization that could be improved through increased interagency coordination.

Takeaway 3

Building on this model, a NFHRP mechanism would include a range of federal stakeholders with a statutory mandate in coastal flood hazards. These would span agencies focused on coastal flood risk and prediction research (e.g. USGS, NWS, NIST, NSF, NAS OSB, FEMA) and knowledge transfer to user agencies such as FEMA, HUD, and USGCRP. Critically, all NFRHP products would be advisory and not mandated to be used for regulatory purposes. Involved agencies would retain their Congressionally authorized responsibility and mandates for programs.

Takeaway 4

Like with NEHRP and NWIRP, Congressional leadership is required for improving interagency coordination, requiring the streamlining of advisory coastal flood risk maps, and mandating better thinking about long-term coastal threats. Accordingly, a potential timeline follows.

- **Start:** Congress mandates NFHRP, designates lead agency, organization, and expectations.
- **Year 1-2:** NFHRP provides Strategic Plan and implementation plan; NFHRP begins biannual status reports and coordinated budget proposals in year 2.
- **Year 2-4:** NFHRP provides integrated coastal flood risk map system.
- **Year 6-8:** NFHRP updates Strategic Plan as needed.
- **Year 10:** Congress re-evaluates NFHRP system.

The following chapters will provide overviews of two areas ---buyouts and technical mitigation ---which would benefit from the proposed NFHRP. These chapters also contain recommendations which may be implemented in the absence of the NFHRP as proposed here.

Chapter II

Improvements to Buyout Process and Land Use Planning

This chapter focuses on voluntary buyouts and acquisitions as strategies to protect lives, minimize financial exposure, and build long term community resilience to changing coastal flood hazards. Buyout and acquisition policies outlined here would benefit from an improved interagency approach to coastal flood hazards, using the latest science to determine communities' risks.

Problem Definition

Communities with the greatest floodplain risk exposure will eventually need to relocate with federal assistance. As climate change effects manifest in more frequent and more extreme ways, the federal government must become more proactive. Federal agencies will have to provide leadership and resources for better land use planning while preparing for managed retreat and targeted relocation and remaining attentive to social vulnerability concerns.

Relocation is done primarily through two tools: voluntary buyouts and acquisitions. Buyouts are purchases of land and property at pre-disaster values. Acquisitions are purchases at post-disaster values. A variety of federal, state, and local programs focus on relocation, but the majority of flood-related buyouts are conducted by FEMA's Hazard Mitigation Grant Program (HMPG).[37] State and local governments do not have the necessary financial resources for large-scale relocation, which is why the federal government has been and will continue to be the leading actor.

FEMA has conducted 45,000 buyouts since 1989, with a slight decline in purchases over time.[38] These numbers do not necessarily indicate a decreased appetite for buyouts. They are largely a result of the significant procedural and temporal obstacles faced by local governments and individuals that disincentivize buyouts.

Finding 1

The post-disaster buyout process is too slow.

A primary obstacle to post-disaster buyouts is process inefficiency. The median FEMA buyout takes more than five years to complete.[39] Funding streams move so slowly that some districts

apply for buyout funding every year, regardless of whether flooding occurs. This is partially due to the HMGP grant process. HMGP provides funding to a range of relief actions once a presidential disaster is declared, including voluntary buyouts.[40] Once FEMA announces funding availability for HMGP, state-level applicants must solicit and review applications from local government sub-applicants, who in turn must solicit and review applications from property owners before grants are even awarded and the buyout process can begin. Property owners in flooded areas cannot wait years to find out the result of their buyout application; they need somewhere to live in the short term. NFIP payments, often the other option, are made within weeks, offering the chance to rebuild quickly. When choosing between NFIP payments and uncertain buyouts that are potentially years away, property owners have strong incentives to rebuild in dangerous floodplains. However, these properties will likely flood again and require repairs at NFIP's expense.

Finding 2

Pre-disaster buyout spending is inadequate.

FEMA does not invest sufficiently in pre-disaster buyouts. 89% of FEMA buyouts are funded by HMGP, which only is awarded after a Presidential Disaster Declaration.[41] FEMA Pre-Disaster Mitigation (PDM) and Flood Mitigation Assistance (FMA) grants, the principal sources of pre-disaster buyouts, are funded anemically on a yearly basis by Congressional allocations. Pre-disaster buyouts can prevent loss of life, post-flood health risks, and financial strain on residents and governments by taking action prior to the flooding.

While PDM and FMA programs currently handle pre-disaster buyouts, they are funded by Congressional appropriators on an annual basis,[42] an inadequate timescale with which to regard climate change impacts.

The federal government has begun to expand pre-disaster buyouts in select communities. The Biloxi-Chitimachi Cocktaw Indian community located in Louisiana's Isle de Jean Charles and the Alaskan tribal fishing village of Newtok have received $48 million and $15 million respectively or, in individual relocation tallies, $600,000 and $42,000.[43]

Finding 3

Voluntary buyouts raise equity concerns.

To socially vulnerable populations —as outlined in Recommendation I— voluntary buyouts and acquisitions invoke historical urban renewal and housing policies associated with segregation and forced relocation. The federal government must take special care to avoid repeating the mistakes of urban planners in decades past and ensure that property owners accepting buyouts feel empowered to make a choice based on informed consent. While it is clear that communities will need to move and rebuild, relocation should only be a strategy of last resort. Federal and local governments should explore all other options before relocation, but act with speed once buyouts are determined to be the sole option.

Previous Urban Renewal policies inflicted harm, particularly on African American communities, many of which settled in some of the most flood prone areas as a result

of these and other disinvestment policies.[44] Their effects continue to play out, enmeshed within larger social vulnerability issues. Public health experts have linked Urban Renewal policies to post-traumatic stress, economic underperformance, the spread of the AIDS epidemic, and epigenetic ramifications.[45,46,47,48] Public health experts have described these effects as Root Shock, or, "the traumatic stress reaction to the destruction of all or part of one's emotional ecosystem."[49]

The recommendations below follow the findings in increasing order of size of structural change required within FEMA.

Recommendation 3.A: Improvements to FEMA's Post-Disaster Buyouts

The following recommendation applies to the current HMGP post-disaster buyout grant process and would function with or without the implementation of the larger structural changes proposed in Recommendation 2.B.

Allow Increased Cost of Compliance Coverage to be Used for Buyouts

NFIP insurance policies include an ICC coverage, which provides up to $30,000 to help cover the cost of mitigation measures for properties that are damaged in excess of 50% of their value.[50] While ICC coverage is largely used to elevate properties, it can also cover floodproofing (for non-residential properties), relocation, or demolition expenses.[51]

If transferable, the combined cost of NFIP and ICC claim payments could often cover the cost of a buyout. In 2018, the average NFIP claim payment was $42,580.[52] The median HMGP property buyout payment between 2000 and 2016 was approximately $50,300.[53] Claim payments, including ICC coverage, are usually distributed to recipients within weeks.

If Congress authorizes ICC coverage to be used for post-disaster buyouts, they will provide homeowners with an efficient alternative to bypass the lengthy HMGP process. Insured homeowners will be empowered to decide whether a rebuild or buyout makes more sense to them, with both options available on similar timelines.

Eliminate Matching Requirement

HMGP buyouts usually require non-federal sources to make up 25% of total costs of a state's HMGP projects. These costs can be covered by state government, local government, property owners, or non-profits. FEMA should eliminate this requirement for post-disaster buyouts. The matching requirement exacerbates delays for the buyout process, as local and state-level grant applicants take time to decide the amount of available funding.

According to the NFIP coordinator for the state of Oregon, one of the primary reasons communities choose to not to seek buyout (or mitigation) grant money is that they do not have an ability to meet the match requirements.[54] Part of what made the New York Rising buyout program after Hurricane Sandy a success was the decision by the state of New York to cover cost-matching, relieving municipalities of the burden.[55]

Though the matching requirement is intended to incentivize state and local spending on buyouts, without which federal financial burdens would increase, the cost savings and potential diminished local spending are not worth slowing down the process. FEMA should not miss the opportunity for buyouts due to the matching requirement, as buyouts are ultimately a cost-saving exercise (see Recommendation 8).

Furthermore, the federal government sometimes pays the full cost of HMGP buyout grants already: HUD Community Development Block Grants, which lose their federal identity once allocated, are sometimes used towards FEMA cost-matching.[56] Coordinating multiple grants and ensuring dual eligibility consumes time and resources.[57]

Finally, all of the potential actors to cover the 25% match (states, local government, property owners, non-profits) are under financial strain when responding to major flooding events. Floods that diminish property values shrink the tax base for property taxes, causing the match requirement to be a further burden.

Allow FEMA to Grant HMGP Funds for Completed Projects

Currently, FEMA cannot provide grants to projects that are completed or underway. The agency should reverse this policy with respect to buyouts. Without the need for a complicated grant process, non-profits such as land trusts can more quickly buy homes in floodplains. If FEMA and state governments develop relationships with such non-profits, these organizations will be empowered to increase the number of buyouts, operating under the understanding that they will be compensated for a substantial portion of completed buyouts.[58] This would functionally allow FEMA to award a portion of its buyouts more rapidly, bypassing the slow grant process. More generally, collaboration with land trusts will enable them to play a greater role in helping municipalities with land use planning as sea levels rise.[59]

Recommendation 3.B: Expand and Reframe the Buyout Program

Improving post-disaster buyouts is not a sufficient mitigation strategy. Expanding pre-disaster buyouts is crucial, particularly for the most vulnerable communities experiencing the brunt of climate change impacts. With an estimated 13 million households at risk from rising seas,[60] the magnitude of resources needed for relocation will be tremendous and the federal government should allocate sufficient funding to meet the challenge head-on. The recommendations below would ideally work in conjunction with the establishment of an NFHRP which would incorporate improved information about risk. However, these modifications could also strengthen and expand FEMA's buyout program in the absence of a NFHRP.

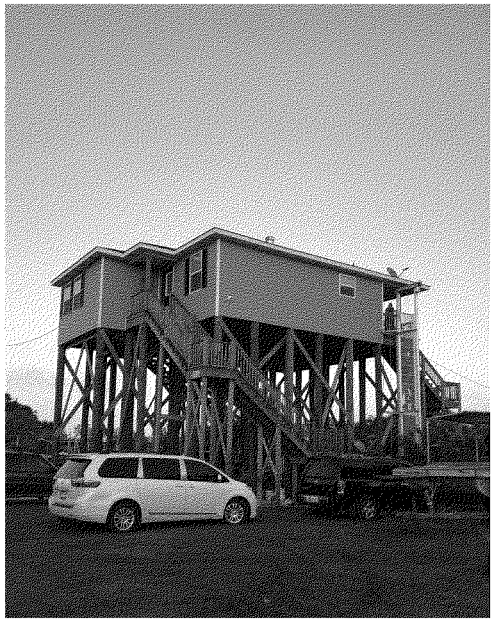
Create a Streamlined National Grant to Expand Buyouts Under FEMA

We recommend a unified FEMA buyout process, collapsing the three existing grants into a single stream that would deal with pre and post-disaster buyouts and mitigation. Under this model, the HMGP, PDM, and FMA programs would all fall under the HMGP structure that has already garnered the expertise through handling the majority of buyouts. The consolidated grant program would undertake projects at a community level, with input from HUD as a resource for other agencies on economic development, equity in disaster recovery, and housing policy.

The unified grant should receive increased funding, although the level of authorized appropriations is beyond the scope of this analysis. Congress should be mindful that buyouts are ultimately a cost-saving exercise. To be approved, state applicants must actuarily estimate greater future savings than costs through a formal cost-benefit analysis.[61] Nine out of fourteen FEMA studies of buyouts found that they did save money for communities.[62]

The unified grant would also change the way FEMA buyouts work. Buyout and mitigation funding for pre- and post-disaster homes would be available in perpetuity, rather than on timelines related to presidential disasters. It makes little sense to award buyout grants on a pre- and post-disaster basis, as many coastal communities will be affected by sea-level rise, often simultaneously and irrevocably. Synthesizing FEMA buyout programs places the federal government in the best position to avoid redundancies and act speedily.

In coordination with the unified FEMA grant, NFHRP should produce and commit to a clear procedural framework to avoid funding redundancies. Varying federal programs sometimes play out simultaneously in counterproductive ways. Residents of Smith Island in Chesapeake Bay have witnessed sea-level rise take 3,300 acres of their community and the rest could be gone as soon as 2025, but they chose to deny federal buyout aid partially because other federal sources provided funding for erosion slowdown projects.[63]



Raised house above the Base Flood Elevation (BFE) in Louisiana.

Credit: Avantika Gori

A unified buyout grant program in conjunction with a larger interagency process facilitated by NFHRP would aid decisionmakers weighing mitigation efforts versus buyouts.

This unified grant structure and eliminated redundancies would facilitate community-level buyouts.[64] The current communication, dissemination, and organizational problems with buyouts lead some homeowners to accept offers while others do not, creating a checker-board of empty plots which break up communities, stretch thin municipal resources, and limit project effectiveness.[65] Community-wide buyouts are the most effective way to avoid such problems, providing an opportunity to leverage continued investment resources towards the most disadvantaged communities.

Share Data and Technology Between NFHRP and Local Actors

FEMA should make use of the NFHRP products (e.g. advisory maps) put out by NOAA, USGS, and NWS. These products will draw on the work of other agencies, academia, and the private sector to consolidate and disseminate the best available and real-time data and mapping methods to identify communities, cities, or neighborhoods that are vulnerable to sea-level rise.

Pursuant with the NFHRP mission statement calling for a central information repository, FEMA should instruct local agencies and programs receiving administrative funds to provide risk assessments and collect a database of pertinent data for conducting buyouts to be shared with NFHRP.[66]

Future improvements to the buyout process could be better designed with greater transparency from FEMA under standards developed by NIST. Currently, there is not sufficient information available on applications that are denied or that do not go forward due to lack of funding.[67] In the buyout data that is published by FEMA, more than half of entries are empty for some fields.[68] A more complete database will allow analysts to precisely target what slows down the process, and how to expand buyouts in a cost-effective way. This data repository should be part of the data sharing agreement across agencies outlined in Recommendation I.

Increase Resources to Facilitate Buyouts at the Community Level

FEMA should also provide more funding and resources for states to help vulnerable communities relocate with bottom-up representation in the process. Local outreach and planning, as well as grassroots participation, are crucial to successful equitable buyout programs as the following cases demonstrate.

FEMA should provide funding for state and local programs to facilitate buyouts and should approach existing non-profit actors and community stakeholders about forming buyout committees. This could follow the example of Staten Island's Oakwood Beach. Oakwood Beach committee members were the most important advocates for the process of persuading unsure neighbors, reaching out to socially vulnerable individuals, and even convincing the governor's office to expand the buyout area. A particularly powerful tool was extending the mapping process to the community where they identify preferred relocation areas.[70]

We propose FEMA create a leadership position within the Resilience Office whose Director has a relevant background in social sciences (anthropology, sociology, or psychology). The office's work will inform the buyout framework: working with communities, conducting appropriate research, and providing a welfare perspective into the core mission of targeted relocation. FEMA and HUD should also reinstate an initiative started under President Obama[71] to create a behavioral sciences insight unit, examining how to open up dialogues with communities. The program would investigate how to gain community-wide acceptance for buyouts and relocation, avoiding the problem of checker-boarding.

Successful examples of community-level buyouts exist. The New York Rising program developed enhanced buyout zones that facilitated community-wide participation, incentivizing buyouts. New Jersey's Blue Acres Program identified Repetitive Loss Properties, conducted outreach to inform eligible property owners, provided case managers, and

hired experts to shorten the cost-benefit analysis process.[72] By contrast, the local emergency management hotline in Montgomery, Texas, received numerous inquiries about a buyout program post-Harvey, indicating a demand, but the county lacked resources to promote and solicit applications.[73]

FEMA should seek to relocate communities particularly at risk through targeted buyouts. When carrying out community relocation, FEMA should take care to ensure that the concerns and needs of the most vulnerable communities are considered when allocating departmental resources.

FEMA should also ensure that vulnerable communities do not feel undue pressure to relocate; it should be a choice they feel empowered to make. Though managed retreat and community relocation invoke historic Urban Renewal policy disasters, buyout programs ultimately benefit vulnerable homeowners, with flood victims reporting, "several mental health problems, including anxiety when it rains, increased stress levels, problems sleeping, and increased tension in relationships" as well as a litany of chronic gastrointestinal and respiratory health effects.[74] Appropriate steps must be taken to attenuate health and social vulnerability concerns. Furthermore, the community buyout process should incorporate social science and behavioral insights when planning for relocation, keeping in mind the injustices of historical government relocation programs.

Finally, relocation is a heavy burden for receiver communities. During Katrina's aftermath, the quarter million displaced people that settled in Houston —one of the Nation's strongest metropolitan economies— had a quantifiable impact on wage depression and unemployment,[75] effects whose magnitude would be stronger in less robust local economies.

Recommendation 3.C: Target Repetitive Loss Properties for Buyouts

Repetitive Loss Properties (RLPs) are buildings for which NFIP has paid at least two claims of more than $1,000. Severe Loss Properties (SLPs) are those which NFIP has made four payments over $5,000 or at least two payments that exceed the value of the property. SLPs represent just 0.6% percent of the 5.1 million properties insured by NFIP but made up nearly 10% of all claims payments between 1978 and 2015, totaling $5.5 billion.[76] Buyouts for these buildings are particularly cost-effective. One study found that by acquiring RLPs between 1993 and 2008, nine communities in Missouri avoided over $96 million in losses, with a Return on Investment of 212%.[77]

The Flood Management Assistance (FMA) grant attempts to prioritize RLP and SLP buyouts. However, in general SLPs have not been adequately targeted for buyouts. Only one in five SLPs have received federal financial assistance, less than half of which were purchased. Over 2,000 SLPs have been demolished with no federal assistance, indicating a lack of federal supply of grants to meet demand.[79]

Pre-approve RLPs and SLPs for Buyouts

To incentivize homeowners to accept buyouts and to speed up the process, an expanded FEMA buyout grant should pre-approve owners of RLPs and SLPs with insurance for both pre-disaster and post-disaster buyouts. By ensuring owners of RLPs and SLPs that they will be awarded a buyout, FEMA can reduce expensive rebuilding projects in dangerous floodplains.

Incentivize RLP and SLP Buyouts Through Reduced Premiums

The unified grant program should additionally offer a discount on NFIP premiums for owners of RLPs and SLPs that agree to a future buyout the next time their home is substantially flooded (the Environmental Law Institute has coined this proposal "discounts for buyouts.")[80] The discounted premium would be implemented after a signed agreement with FEMA that the home would be demolished after future flooding, and the property owner would be compensated with an agreed upon price.[81] This would mitigate the incentive for moral hazard in floodplains.

Recommendation 3.D: Work with Communities to Enhance Building Codes and Land Use Planning

Because most land use and development decisions fall under state and local jurisdiction, coastal flooding and its impacts cannot be solved solely through federal action. Federal initiatives should lead, incentivize, and prompt local authorities to improve building codes and land use planning.

We propose that the NFHRP prioritize studying how to improve model building codes and land use guidance documents for coastal flooding areas for use by local actors. Particular subjects to focus on could include performance-oriented design; low impact development and the effect of non-permeable surfaces on storm runoff and site drainage; and the incorporation of green infrastructure and ecosystem services valuation. This recommendation mirrors NEHRP's approach in improving the implementation of building codes and standards, which was facilitated through the publishing of model building codes and related products through increased interagency collaboration and the involvement of outside expert groups.

Improve Building Codes

FEMA, and by extension the interagency—through NFRHP or otherwise—can work harder to improve building codes and standards. Indeed, of the NEHRP's main successes was in municipal take-up of the building code revisions,[82] including Performance-Based Design, introduced in 1996 to surpass structural life-safety and address post-disaster critical infrastructure needs.

Similar guidance documents for flood hazards exist but suffer from low take-up and implementation. For instance, FEMA-15, "Design Guidelines for Damage Reduction began to identify strategies for floodplain construction and development;"[83] FEMA 424, "Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds,"[84] which applied the concept of Performance-Based Design to school construction; and, FEMA 445, "Next-Generation Performance-Based Seismic Design Guidelines." The latter publication asserted that "the technology used to implement performance-based seismic design is transferable. . . for use in performance-based design for other extreme hazards including fire, wind, flood, snow, blast, and terrorist attack."[85] Disparate sources of isolated knowledge exist, but Performance-Based Design needs to be central to the development of municipal building codes in areas affected by coastal flooding. Unlike FEMA-445, no central repository of knowledge exists for flood Performance-Based Design hampering local communities unable to conduct this research on their own.

Improve Land Use Planning

Local land use planning is one of the single most effective mitigation steps for coastal flooding, preventing building in hazardous floodplains areas that drain extensive municipal, state, and federal resources. Development in at-risk flood areas exacerbates harm by increasing the amount of non-permeable surface, concentrating storm runoff, and implementing a strategy of site drainage at the expense of downstream neighbors and the municipal storm-water system.[86] Moreover, localities should not bear the burden of gathering all of the necessary expertise with regards to green infrastructure, and there are tremendous benefits to standardizing strategies nationally. FEMA in addition to the interagency should prioritize strategies for standardization, through mechanisms such as the NFHRP if established and close consultation with industry and local government partners —just as NEHRP has done.

Conclusion

Takeaway 1

Voluntary buyouts and acquisitions are a critical tool to managing coastal flood hazards. This need will increase in face of climate change. The current system for conducting buyouts is ineffective.

Takeaway 2

The current process for conducting voluntary buyouts is slow, increasing the incentive for homeowners to accept redevelopment in floodplains over buyouts. Additionally:

- Current data on FEMA buyouts is unreliable. Data collection and aggregation should be expanded and data should made more easily accessible in order for the FEMA buyout process to be more transparent to analysts who seek information on the program's effectiveness.
- Improvements to streamline and speed up the buyout process include allowing ICC coverage to be used for buyouts, eliminating the local matching requirement, and allowing grants to fund completed projects.

Takeaway 3

The federal government needs to expand its role in conducting buyouts. In order to do this, FEMA should consolidate its existing buyout programs, receive more funding to effectively facilitate buyouts and incorporate a social sciences outlook into the process. This expanded program should be conscious of equity considerations and historical problems with community relocations.

Takeaway 4

Repetitive loss properties place a disproportionately large financial strain on the NFIP. The federal government's buyout program should target these properties first and pre-approve them for buyouts to reduce the financial strain on NFIP and streamline the process. FEMA could incentivize homeowners of repetitive loss properties to take buyouts by offering reduced insurance premiums with the promise of a future buyout.

Takeaway 5

FEMA should support responsible future growth for communities by providing expertise on flood risk at the building code, development, and zoning levels.

Chapter IV

Improvements to Technical Mitigation

This section covers improvements to technical mitigation projects. Technical mitigation is defined here as the suite of coastal flood mitigation options including structural elements such as walls, levees, and gates, etc., and nature-based elements such as beach nourishment, shoreline stabilization, etc. This definition is based on U.S. Army Corps of Engineers (USACE) activities outlined in their Planning Guidance Notebook.[87]

Problem Definition

Despite improvements to the NFIP and changes in zoning laws and building codes, there are many coastal areas across the US that will remain vulnerable to flooding or will become vulnerable in the future. A recent study estimates that cities like Miami, New York, New Orleans, and others across the US will see significant increases in flood risk by the year 2050, even assuming proper adaptation measures are taken to keep flood probability constant.[88] This study finds increasing risk is primarily driven by increasing exposure due to coastal development. Other studies have found that increases in coastal flood risk will occur due to sea level rise[89] and changes in extreme weather and storm climatology.[90] Addressing changes in future hazard and exposure will require strategic investment in coastal flood defenses that protects valuable commercial infrastructure and communities located near the coast.

The majority of large-scale technical mitigation projects are implemented in coordination with USACE and a non-federal partner, such as a state or local agency. Initially, the local/state entity submits a request for assistance. USACE then conducts a reconnaissance study to determine the scope and severity of the flood project. This is followed by a full feasibility study that evaluates potential plans and ends with a project recommendation. The evaluation and selection of the recommended project plan is based on maximizing "net economic benefits".[91] If a suitable plan is found, the project is sent for congressional approval, and ultimately Congress can appropriate funds for the project's implementation. However, even if a project is authorized by Congress, it may not necessarily receive funds for construction. There is a backlog of hundreds of approved projects that have not received funds yet, and these projects total $60 billion in federal funding requests.[92]

Finding 1

The backlog of funding for USACE projects has delayed many infrastructure projects that were designed to mitigate flood risk. In some cases, these projects are so delayed that their implementation today may not provide the benefits that were initially intended.

In addition to the current backlog of approved projects, there are several other areas for potential improvement with regard to the evaluation, coordination, and implementation of technical flood mitigation projects. We highlight three additional findings from our investigation below.

Finding 2

Current cost-benefit analysis methodology used by USACE can result in inequitable allocation of resources to vulnerable communities.

Finding 3

Although in recent years USACE has strived to incorporate the impacts of sea level rise in their project evaluation framework, there is need for greater consideration of changes in coastal extreme rainfall and more emphasis on anticipatory planning for projects in high-consequence regions.

Finding 4

Improvements to USACE's administrative framework, specifically regarding integration with other federal agencies and coordination with local/state agencies could improve the effectiveness of flood reduction activities.

Recommendation 4.A: Address Equity Concerns Regarding the USACE Benefit-Cost Analysis (BCA)

During the feasibility study phase of a potential project, USACE conducts a benefit-cost analysis in order to determine the net economic benefits of each proposed solution and evaluate whether the project is worthwhile to pursue. Benefits are calculated based on both direct damages avoided (physical damages to buildings and infrastructure) and indirect damages avoided (such as those resulting from emergency response to floods or loss of income/economic activity due to flooding).[93] In particular, this analysis focuses on national benefits, rather than local or regional benefits of the project. A study that conducted interviews with practicing engineers found that they indicated frustration with the emphasis on national benefits rather than local safety that resulted from the current USACE BCA.[94] The emphasis on national benefits is also perceived as unfair, since communities provide a large amount of funding for the project through the cost-share agreement, but ultimately the selected plan maximizes national benefits rather than benefits to the specific community.[95]

Additionally, focusing on average annual damages avoided as the primary benefit metric penalizes lower income communities where both property prices and economic

activity are depressed. Perversely, these are the areas where technical mitigation may be most needed,[96] since residents may not have flood insurance due to affordability issues and structures are unlikely to be equipped with flood-proofing measures. During a trip to Louisiana while researching this topic, several local and state agencies mentioned this equity issue as a major challenge inhibiting coordination with USACE, stating that many projects that would provide community benefits would not pass the benefit-cost ratio stipulated by the Corps.

At the state level, there have been efforts to address these equity concerns by moving away from the traditional method of BCA. In Louisiana the Coastal Master Plan is an aggregation of coastal flood reduction and restoration projects that prioritizes projects based on either square miles of restored land or reduction in average annual damages.[97] Although this initiative still relies on average annual damages like the USACE's methods, it does not require a benefit-cost ratio (BCR) greater than 1 for a project to be deemed viable.

In the literature other methods have been proposed to more effectively take into account income distribution when evaluating flood mitigation projects. One such example is the use of equity weights, which weigh benefits in lower income areas higher to produce equity-weighted expected annual damages (EWEAD).[98] Alternatively, a risk premium could be introduced that varies progressively with the fraction of household income lost in a flood event. Thus, areas where a higher percentage of household income is expected to be lost in a flood event would have a higher risk premium. This produces "certainty equivalent" expected annual damages[99] as the primary benefit metric.

Study on Alternate Benefits

USACE should commission a study to evaluate the use of alternate benefit metrics for projects that would protect underserved communities. This study should evaluate whether equity-weighted or other social vulnerability metrics could be incorporated in the analysis and assess what types of communities should be eligible for consideration under alternate metrics. This study could be done in conjunction with HUD through the NEHRP framework.

Alternate Application Process

USACE should develop an alternate application process for flood mitigation projects targeting socially vulnerable areas. USACE could allow a separate process for smaller projects that would provide flood reduction to under-served communities.

Recommendation 4.B: Continued and Expanded Considertation on Climate Change

In recent years the USACE has made significant efforts to incorporate the impacts of future sea level rise (SLR) in their project evaluation and decision-making process. Updated policies require all coastal flood reduction projects to consider future changes in sea level in the plan formulation phase, evaluation phase, to aid in decision-making, and to help craft long-term maintenance schedules for proposed projects.[100] In particular, sea level rise is considered by examining three future potential scenarios: a low scenario, medium scenario, and high scenario. The low scenario is based on a simple calculation of historical rates of sea level rise at the study area, while the medium and high scenarios are set by the National Research Council. Ultimately, a plan is chosen that maximizes net economic benefits while ideally being adaptable to future SLR. Plans can be selected that are reactive, adaptive, or precautionary. Reactive strategies are implemented after a major flood disaster, while adaptive strategies are implemented at various points during the project lifetime to adapt to observed changes in the environment, and precautionary strategies implement designs upfront that anticipate certain future conditions. USACE typically emphasizes the adaptive approach, and project plans can delineate future maintenance and update schedules.

While this planning process works well in cases where the baseline (low) scenario already results in a viable BCR for a potential project, it is more challenging to deal with situations where the present-day BCR is less than one, but under future medium/high scenarios the BCR is greater than one. This situation was outlined in a recent study[101] which evaluated a suite of structural and non-structural coastal flood projects for New York City. Structural solutions were only economically attractive under a future medium or high climate change scenario, and consequently the authors suggested delaying investment by 25 years. Ideally, this type of long-term scheduling of investment would produce the most favorable outcomes. In reality, the large backlog of projects and the difficulty in securing federal funds for a project many years in advance make adaptive strategies difficult to realize. Therefore, it may be worthwhile for USACE to consider a risk-averse precautionary strategy for some high-consequence areas like large coastal cities.

Precautionary Approaches

USACE should delineate clearly where precautionary approaches for project planning are appropriate and where adaptive approaches are viable. It may be worthwhile to begin constructing a project that has a BCR less than one now, if the project would provide high levels of protection under future scenarios. This ensures that flood defense projects can be authorized at times when there is increased political will instead of trusting that they will be implemented at the right time at some point in the future.

Fast-track Implementation

USACE should develop procedures for fast-tracking implementation of adaptations to current flood defenses. Proposals to upgrade existing infrastructure could be passed through a streamlined evaluation process so that adaptations can be implemented in an efficient and timely way.

Synthesize Studies on Climate Impacts

In addition to the advancements made in considering SLR, there should be expanded consideration of climate change to include changes in extreme rainfall at the coast. Numerous recent studies have suggested that TC rainfall is becoming more severe due to climate change.[102, 103, 104, 105] Traditionally, coastal flood hazard assessment has focused almost exclusively on storm surge. However, recent events suggest that extreme rainfall can also result in widespread flooding in coastal communities.

Currently, USACE offers guidance about incorporating climate impacts for inland hydrology projects,[106] but no such guidance exists for coastal areas subject to both storm surge and extreme rainfall. USACE should synthesize all relevant studies related to climate impacts on coastal extreme rainfall and summarize findings within a single technical document. This document should draw on work being conducted within NOAA and USGS in order to produce cross-departmental guidance as a first step in understanding current knowledge about future rainfall hazard and the extent to which coastal rainfall should be considered in hazard analysis. This preliminary guidance could be non-binding and could primarily serve as a foundation to begin considering the risks associated with coastal rainfall.

Recommendation 4.C: Improvements to USCACE Administrative Framework

A review of USACE's administrative framework in coastal flood risk control shows that powerful cross-agency coordination is lacking at both the federal and local levels. This coordination failure produces three consequences: (1) a disparate levee system safety evaluation principle that prompts perverse incentives for infrastructure sponsors in risk management, reducing preparedness for future flood risks; (2) a lack of strong leadership sub-nationally, which prevents consensus building from key stakeholders on crucial policy topics, fragments management, and slows down project implementation; and, (3) limited

support for USACE's local coordination platform (the Silver Jacket Program), which failed to motivate innovations in local management or utilize local talents and information.

First, the two de facto levee safety evaluation standards adopted by USACE and FEMA may invite regulation-shopping practice by non-federal project owners and reduce overall safety. Levee safety evaluation, a key component in the levee system accreditation process, determines whether an area in question behind the levee meets FEMA's hundred-year flood prerequisite; accreditation makes the area eligible for benefits within the NFIP.[107] In the aftermath of Hurricane Katrina, USACE has made its evaluation stricter, adopting risk-informed and probabilistic approaches.[108] By contrast, FEMA accreditation principles remain based on deterministic models informed by historical events.[109]

Given the geographical complexity and changing climatology across the country, the hundred-year flood threshold only amounts to a minimal standard. According to USACE, a comprehensive evaluation report not only improves predictions, but also communicates a better perception of risks to stakeholders, enhancing safety systematically.

However, more rigorous practice is wanting. On one hand, USACE only offers evaluation service to projects under its own purview; on the other hand, FEMA allows private levee certification for non-federal sponsors. The USACE's small project evaluation expenditure[110] suggests a low utilization of its "stricter" evaluation process and the prevalence of minimal safety standards within the system. Moreover, best practices could be used less frequently in the future. The Corps' 2014 levee inventory shows that projects directly managed by USACE account for the smallest portion of total projects.[111] It is likely that locally owned projects, those confirming to the looser certification standards, will become a larger potion of the total levee stock given public funding uncertainty.

Strategic planning at the state level often suffers from weak collective leadership, yet USACE's low visibility in planning process contributes to this problem. Though the Corps introduced early coordination in infrastructure projects in 2014,[112] its engagement efforts in nonstructural planning has varied. Literature produced by the USACE on indicate that participation is invite-based. This laid-back engagement approach prevents agreement on policy goals, which is particularly detrimental to flood mitigation planning since success is predicated on strong alignment among planners and buy-in from community stakeholders.

The New York Oakwood Beachwood buyout project post-Sandy offers a negative case in point—multiple agencies operated under respective mandates without agreeing on or even clarifying the end-goal of a proposal. The USACE was working to finalize a levee construction plan while New York state was promoting buyout in the residential areas behind the purported infrastructure. Conflicting, contradictory initiatives stirred confusion among community members andcity officials who wondered if the goal was managed retreat or infrastructure hardening. Such uncertainty further complicated, if not directly disrupted, the already fragile buyout process. Ultimately, the proposed vacancy turned out to be part of the Corps' planned drainage system, under informal co-development with the state.[113]

In addition to weak leadership, the Corp's flagship local coordination initiative, the Silver Jackets Program, failed to generate enthusiasm. This program aims to encourage non-structural flood risk mitigation by empowering local leads to utilize resources from multiple agencies. However, despite fast initial enrollment , the total number of projects only reached 280 from 2011 to 2017, with each participating state barely receiving one project.[114]

Resource constraints are potentially the culprit. First, the program is not a grant; instead, "expense" occurs primarily to purchase expertise within the organization, somewhat limiting the scope of project design. Second, the program has no designated shared resources across partners such as a joint funding pool or staff who can make executive

Waterfront park in Loiza, Puerto Rico eroding in spite of a sea-wall built by USACE.

Credit: Juan Pablo Ponce de León

decisions. As a result, each agency's support comes out of pocket separately. Fragmented information and administrative frameworks only increase management costs for project planners. Third, it is likely that the already small allotment will be further cut—shown in the Corps' 2020 budget, the Flood Control and Coastal Emergencies (FCCE), which houses the majority of non-structural programs, has dropped to $27k for FY2020 from $35k in FY 2018 and FY2019, an over 20% cut.[115]

Levee System Accreditation Standards

The federal government should direct USACE and FEMA to work towards reconciling levee system accreditation standards. The dual-standard system may create perverse incentives for project sponsors and reduce best practices in the flood risk control system. It is understandable for FEMA to keep minimal standards for practical concerns in the near term. The two agencies should move away from merely recognizing each other and begin to contemplate merging their functions.

Community Outreach

USACE should enhance its communicative outreach at local levels. This recommendation is two-pronged. First, the Corps' participation should be institutionalized at strategic planning meetings, and not optional, particularly in cases that involve USACE's existing project or projects in pipeline. Second, the Silver Jacket program needs a series of structural changes, including creating a cross-agency permanent

funding pool, assigning a designated manager to preside over joint resources, and allowing small discretionary spending on a per-project basis.

Ringfence Funding

USACE should increase ringfence funding for the two aforementioned purposes, whose success also predicates on firm material support. The funding volume may not need be large, partly because of macro-level fiscal constraints, and partly because it will be seeding programs purported to create momentum. However, these ideas, despite their strategic value, are highly prone to budgetary cuts, a process which favors programs with vested longstanding constituencies. Therefore, it is important to make these accounts cut-robust, for instance, by imposing a percentage rate on overall budget or programmatic expenditures.

Conclusion

Takeaway 1

There is an increasing need for continued technical mitigation projects as the effects of climate change worsen and projections change, but improvements to current USACE procedures are needed to more quickly, efficiently, and equitably implement flood hazard mitigation projects.

Takeaway 2

USACE should either incorporate equity weights or alternative risk premiums to improve measures of benefits provided by technical mitigation projects. USACE could also commission a study on alternative benefit metrics or consider an alternative application process that incorporates considerations of social vulnerability.

Takeaway 3

USACE should consider a risk-averse precautionary strategy for considering the impacts of climate change and sea level rise in high-consequence areas like large coastal cities. Higher weight and faster implementation timelines could be placed on projects that provide substantial future benefits. USACE also should synthesize all relevant studies related to climate impacts on coastal extreme rainfall and summarize findings within a single technical document.

Takeaway 4

There is room for USACE to enhance management integration horizontally across the agency as well as vertically amongst subnational stakeholders. To incentivize best practices within the system, Congress should direct the Army Corps and FEMA to work towards reconciling levee system accreditation standards, direct Army Corps to enhance communicative outreach to local governments, and ringfence funding for the two aforementioned purpose.

Appendix I

Current Agency Flood Risk Management Programs

National Oceanic and Atmospheric Agency (NOAA)

NOAA (under the Department of Commerce) has multiple roles in federal flood risk management, including through the National Weather Service (NWS) which is addressed separately below.[116] Coastal resilience and flood risk management are addressed through research and programs primarily housed within the National Ocean Service (NOS) and the Office of Oceanic and Atmospheric Research (OAR).

The National Ocean Service (NOS)'s mission is "to provide science-based solutions through collaborative partnerships to address evolving economic, environmental, and social pressures on our ocean and coasts." NOS carries out flood risk management through its coastal programs, including implementing the Coastal Zone Management Act and through the Digital Coast Partnership, which provides access to mapping products and data aggregated across government entities. These products include Coastal Flood Exposure maps and the Seal Level Rise viewer (which is incorporated into the Coastal Flood Exposure maps). While they do not cover the entirety of US coastline, the Coastal Flood Exposure maps are the best example of federal-level, user-oriented advisory maps that combine data from multiple agencies to communicate vulnerability of communities to multiple types flood hazards, including beyond the FEMA 1% annual chance floodplain. NFHRP could use these maps as a potential model for elevated nation-wide flood risk maps. Finally, NOS's Center for Operational Oceanographic Products and Services is responsible for producing national flood forecast maps that combine precipitation data with USGS streamflow data. The Coastal Inundation Dashboard displays this information for current and historic flooding events.

The Office of Coastal Management also administers the National Coastal Resilience Grants Program, which is a competitive grant program that funds projects to help "coastal communities and ecosystems prepare for and recover from extreme weather events, climate hazards, and changing ocean conditions." With a focus on natural infrastructure, post-disaster recovery, and assessing risk, funded projects require a non-federal match.

The Office of Oceanic and Atmospheric Research (OAR) is responsible for NOAA's research on climate, weather, coasts, marine science and other relevant topics. OAR's mission is to "conduct research to understand and predict the Earth system; develop technology to improve NOAA science, service, and stewardship; and transition the results so they are useful to society." It houses the Climate Program Office, which is responsible for climate modeling and led USGCRP's fourth national climate assessment.

The National Sea Grant College program, which seeks to help citizens "better understand, conserve, and utilize America's coastal resources" through research, is also housed within OAR. The Sea Grant program is a partnership among NOAA and 33 university programs in coastal and Great Lakes states.

United States Geological Service (USGS)

The USGS is a scientific agency within the U.S. Department of the Interior (DOI).[117] The USGS holds long-term, real-time and historical flood data for federal agencies and cooperative partners to mitigate hazards associated with floods; and it provides real-time scientific data to NWS for hazard warnings and flood alerts to assist communities in their flood preparation, response and recovery activities.

The USGS operates the primary national water data collection network and monitors streamflow, river levels, reservoir elevations, rainfall, floods, landslides, erosion, high sea-level stands, environmental conditions, storm tide and high-water mark data for major hurricanes and tropical storms, and many other weather-related earth processes. The USGS also has a nationwide streamgage network with real-time river and stream flow and level data, flood-frequency data, and timing of releases of flood-control reservoirs, which NOAA uses to delineate floodplains. Also, the USGS is collecting LIDAR data through the 3D Elevation Program and plans to have nationwide data by 2023. As the collector of the data that informs other federal agencies' flood risk programming, it is best equipped to host supplemental data from other agencies.

The USGS scientists, emergency managers, and administrators work with federal, state, and local agencies to understand coastal flood hazards, communicate their potential risks and impacts, and inform ways to mitigate large-scale loss of life and property. During flood events, the USGS provides real-time data to NWS, NOAA, the U.S. Army Corps of Engineers, and other state and local first responders. The USGS practices manual data discharge to ensure data accuracy and collects water quality and sediment samples to study flood impacts. In the immediate aftermath of flood events, the USGS repairs damaged equipment to ensure that flood information and response procedures are active, measures high-water marks with FEMA, and analyzes water quality and environmental health impacts. After flood events, USGS incorporates and communicates new flood and water quality data into data platforms, maps and models, and assesses damage.

Moreover, the USGS already produces flood risk communication tools and publications which are used by other federal agencies. These tools include the WaterWatch, WaterAlert, WaterNow, and other regional and local flood alerts; the Flood Inundation Mapper (FIM Program) which shows where flooding might occur over a range of water levels and is validated by localities; the Flood Event Viewer for large, short-term flood events like hurricanes and multi-state storms designed for communities to understand local flood risks and make cost-effective mitigation decisions; the Coastal Change Hazards Portal for extreme storms, shoreline change and prediction of coastal erosion and sea-level rise at local- and national-level scales; the Total Water Level and Coastal Change Forecast Viewer which aggregates tidal, surge and run-up flooding hazards and impacts to coastal erosion; the Aerial Coastal Photography Viewer which includes infrastructure damage prediction; and the West Coast ARkStorm storm model used by local authorities and first responders to prepare for expected storms.

Relevant USGS publications include: the 2019 Bulletin 17C Guidelines for Determining Flood Flow Frequency which provides estimates of flood frequency and magnitude and methods for estimating flood risk and which is used by public agencies at all levels for flood damage abatement and risk management planning; the 2017 "Field Manual for Identifying and Preserving High-water Mark Data;" the 2016 report "Identifying and

Preserving High-water Mark Data," which summarizes best available practices for understanding recent and historical flood events; the 2004 report "The World's Largest Floods, Past and Present: their Causes and Magnitudes;" the 2004 factsheet "Mapping a Flood Before it Happens," which summarizes USGS methods for how to make flood forecasting maps informing when, where and the depth of floodwater across a floodplain after a storm; the 2003 report "Large Floods in the U.S.: Where they Happen and Why," which presents a spatial analysis of large floods related to regional climate and topography; and, the 2000 report "Significant Floods in the U.S. during the 20th Century."

Additionally, through the National Assessment of Storm-Induced Coastal Change Hazards, the USGS conducts research on many aspects of coastal floods, including their causes, effects, and hazards. Research priorities include understanding the magnitude and variability of extreme storm impacts on sandy beaches; assessing the likelihood of beach erosion, deposition, overwash and inundation related to coastal flooding; and conducting scenario-based assessments, real-time storm response and storm-induced coastal processes modeling and video remote sensing. The USGS develops methodologies for creating flood forecasting maps and studies historical tsunamis to better understand their causes and impacts, and to propose evacuation plans.

The USGS currently obtains coastal flood-related funding from FEMA, the U.S. Army Corps of Engineers, the DOI, other federal agencies, and state and local partners. Its current annual funding for its various existing flood-related programs are approximately as follows: 40 million for the Coastal Hazards and Resources Program; 67 million for the National Geospatial Program; 24 million for the National Cooperative Mapping Program; 72 million for the Streamflow Information Program; 24 million for the Science Synthesis, Analysis and Research Program; 149 million for the National Land Imaging Program, Land Change Science Program, National and Regional Climate Adaptation Science Center; and 57 million for Cooperative Matching Funds to collaborate on water resource monitoring at the subnational level.

Federal Emergency Management Agency (FEMA)

The Federal Emergency Management Agency is a division of the Department of Homeland Security and is the main federal entity tasked with planning, response, and recovery for man-made and natural disasters. FEMA has a larger role in flood hazard management than in other hazards due to its responsibility for the National Flood Insurance Program, the primary federal policy for managing coastal flood hazards currently.

As part of NFIP's administration, FEMA is responsible for developing official flood maps to be used for insurance purposes. These maps, known as Flood Insurance Rate Maps (FIRMs), identify flood hazard areas and base flood elevations. Flood hazard areas are categorized by risk:[118]

- High flood hazard areas with a 1% annual chance of flooding, referred to as the Special Flood Hazard Area (Zones A, V);
- Moderate flood hazard areas with a 0.2% annual chance of flooding (Zones B, X shaded); and
- Minimal flood hazard area (Zones C, X unshaded).

All structures within a Special Flood Hazard Area (also referred to as the 100-year floodplain, or areas that have a 1% annual risk of flooding) must purchase flood insurance in order to receive a federally backed mortgage. All entities within a Special Flood Hazard Area must also develop floodplain management guidelines, which may include

building requirements and planning ordinances. Critically, all structures in a Special Flood Hazard Area must be built to a base flood elevation level. A FEMA-approved hazard mitigation plan is a requirement for receiving some types of non-emergency disaster funds. FIRMs are developed and updated in a process that includes petition opportunities for local governments to challenge flood map designations.[119]

FEMA has the greatest interface with the public in communicating flood risk. FIRMs are publicly available and searchable by address on the FEMA Flood Map Service Center.[120] The National Flood Hazard Layer (NFHL) is a major input to FIRMs and can be publicly viewed and incorporated into other spatial analysis and planning documents. These maps do not include sea level rise and other impacts of climate change.

In addition to mapping, FEMA operates a number of grant programs.[121] Most of these are available by application to government entities (namely states, U.S. territories, federally-recognized tribes, and localities, or SLTT) while others are available to individual NFIP plan-holders. Specifically, NFIP plan-holders may receive up to $30,000 through the Increased Cost of Compliance (ICC) coverage when rebuilding in order to meet flood management ordinances; ICC funds may also be used for demolition and relocation.

FEMA grant programs include:

- Pre-Disaster Mitigation (PDM):[122] available to government entities. Intended to engage in hazard mitigation and risk reduction activities prior to an event. In FY2019 $250 million was available.
- Hazard Mitigation Grant Program (HMGP):[123] available to government entities, individuals may be included in an application. Intended to help rebuild and reduce future risk following a Presidential major disaster declaration. Acquisition and demolition of properties is eligible for HMGP funds. FEMA cost-share is limited to 75% of total cost. HMGP is one of the FEMA's largest flood grant programs, distributing $13.8 billion between 1989 and February 2017.[124]
- Public Assistance:[125] available to government entities. Intended to help localities respond in aftermath of event through debris removal and rebuilding of critical public facilities. FEMA's largest flood grant program.
- Individual Assistance:[126] direct assistance available to individuals as well as assistance to government entities immediately following an event. There are multiple IA programs. One IA program, the Individuals and Households Program Assistance (IHP), offers financial and direct assistance for housing (including temporary relocation, rentals, and repair) and other needs assistance. IHP requires an onsite inspection by FEMA, and is not eligible for secondary residences or businesses. IHP assistance is limited to 18 months following a Presidential declaration. IHP is limited to 75% federal cost share.
- Flood Mitigation Assistance (FMA):[127] available to government entities, who may sponsor individual homeowners. Intended to reduce or eliminate claims from NFIP through mitigation and buyouts. $160 million available in FY 2019; $70 million set aside for community projects and $90 million available for traditional priorities.[128] Federal cost share limited to 75%, except for repetitive loss properties (eligible for 90% federal cost share) and severe repetitive loss properties (eligible for 100% federal cost share).

National Academies Ocean Studies Board

The National Academies are independent, nonprofit academies that function as expert convening groups. They produce (through the National Research Council) reports and hold workshops on issues of interest that often will synthesize current knowledge, gaps, and future research agendas. These reports are usually produced and funded at the request of Congress or federal agencies (the report "sponsor"). All reports are public.

The National Academies are grouped into different boards based on research areas, and usually have heavy emphasis on academics with some nonprofit and industry representatives. Experts, typically from academia, are elected to the national academies by their peers.

The relevant board for coastal flood hazards is the Ocean Studies Board. The mission statement of the Ocean Studies Board states: "The Ocean Studies Board explores the science, policies, and infrastructure needed to understand, manage, and conserve coastal and marine environments and resources. In addition to exercising leadership within the ocean community, the Board undertakes studies at the request of federal agencies, Congress, or other sponsors, or upon its own initiative.[129] Other NAS groups of interest include the Disasters Roundtable, the Board on Environmental Change and Society, and the Gulf Research Program.

National Weather Service (NWS)

NWS provides hydrologic services such as short-term flood forecasting hydrographs (flood-inundation maps) showing expected water height only.[130] NWS provides real time water levels and flood forecasts at individual locations across the country through its interactive Flood Information Map. Furthermore, NWS is responsible for annual flood loss reports to USACE for each state, including dollar amounts and fatalities.

National Institute of Standards and Technology (NIST)

Part of the Department of Commerce, NIST's mission is "to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life."[131] NIST conducts research on resilience of buildings and communities to the impact of multiple hazards, including flooding, with a focus on structural resilience. NIST is also home to NEHRP and NWIRP. NIST's research on resilience includes post-disaster studies that can provide the technical basis for improved standards, codes, and practices used in the design, construction, operation, and maintenance of buildings and infrastructure systems

NIST also provides a community resilience planning guide, which is "a practical and flexible approach to help all communities improve their resilience by setting priorities and allocating resources to manage risks for their prevailing hazards." The agency engages with public and private stakeholders to help communities implement its recommendations.

US Global Change Research Program (USGCRP)

The US Global Change Research Program is an interagency group that seeks to "coordinate Federal research and investments in understanding the forces shaping the global environment, both human and natural, and their impacts on society."[132] USGCRP consists of 13 Federal member agencies, which each contribute a budget amount for USGCRP research. These funds are self-identified by the USGCRP agencies as their contributions to USGCRP research - as such, the interagency group receives no independent funding. USGCRP is made up of a series of smaller interagency groups, including several with relevance in climate-related flood hazard research: the federal adaptation and resilience group, interagency group on integrated modeling, interagency crosscutting group on climate change and human health, and the social science coordinating committee.

USGCRP is responsible for regularly publishing the National Climate Assessment, the

most recent of which was released in 2018. The US Climate Resilience Toolkit aggregates information on climate change-related hazards and risk.

Housing and Urban Development (HUD)

HUD's mission is to "create strong, sustainable, inclusive communities and quality affordable homes for all."[133] Although FEMA and the Small Business Administration's Disaster Loan Program have primary responsibility for disaster recovery, HUD is involved with long term recovery and community rebuilding. Example work areas that could be involved responding to disasters include affordable housing (e.g. publicly owned housing and housing choice vouchers), community development (e.g. Opportunity Zones and Community Development Block Grant), and select protections for mortgage holders following a Presidential disaster declaration. For example, affected mortgage holders of a FHA-insured mortgage may be eligible for a foreclosure moratorium for 90 days after a Presidential disaster-declaration.[134]

HUD's primary involvement in flood hazards currently is through the Community Development Block Grant Disaster Recovery (CDBG-DR) program. These grants are intended to supplement other disaster recovery funds and to meet unmet need in the long-term recovery of an area following a disaster. CDBG-DR funds must respond to direct or indirect impacts of disasters and conform to CDBG requirements, including meeting a national CDBG objective such as poverty reduction.[135]

Unlike FEMA flood response funds which are classified as mandatory spending, CDBG-DR funds require a Congressional appropriation. HUD will then publish a notice listing eligibility criteria and priority areas which states and localities may apply for. CDBG-DR grants thus vary on the specific projects and priorities that they fund. HUD can be granted the ability to make waivers and exemptions in these appropriation acts. This flexibility is seen as a benefit of the CDBG-DR funds in the suite of federal disaster funding, and some stakeholders expressed that HUD can be easier to work with following a disaster than FEMA.

For example, in one of the CDBG-DR grants responding to Hurricane Harvey the largest line items were grants to Harris County for unmet need. The grant also included funding for a variety of issues that are also addressed through other agencies and programs, including buyouts, homeowner repair costs, and infrastructure enhancement.[137]

As of August 2019, HUD had $89.7 billion in active CDBG-DR grants in 137 grantees.[138] HUD issued the single largest CDBG-DR in its history in April 2018 following Congressional authorization. This $28 billion dollar package covered 2017 disasters (Hurricanes Harvey, Irma, Maria; and California wildfires) and residual unmet need in disasters going back to 2015 in nine states and two territories.[139]

These CDBG-DR grants set priority funding areas for long-term disaster recovery. As such, they provide a limited means to communicate federal priorities in rebuilding the built environment following a disaster. HUD is a potential customer for advisory maps and other products and would provide expertise on housing policy and community development approaches. Because HUD is not primarily focused on coastal flood and natural science hazards, they might lack sufficient funding and in-house resources to assess changing flood hazards. An integrated interagency approach would add value to the CDBG-DR and broader suite of HUD's housing and economic development programs. HUD in turn would provide a key linkage between the social science and flood hazard community, as many HUD programs are directed for low and moderate income and vulnerable households.

National Science Foundation (NSF)

The NSF is a U.S. government agency that supports fundamental academic and private sector research in non-medical fields of science and engineering.[140] To date, the NSF has supported research that better allows stakeholders to understand the physical processes of coastal flood risk, methodologies for predicting and evaluating flood risk, and studies of coastal and climatic changes that affect coastal flooding. For example, the NSF's Prediction of and Resilience Against Extreme Events (PREEVENTS) Program, established in 2017, awarded fifteen natural hazards research grants worth 19 million USD to improve the understanding of processes underlying natural hazards, and to increase capabilities to model and forecast natural hazards. These grants funded research regarding natural hazards relevant to coastal flooding including hurricanes, rain, coastal erosion, severe thunderstorms and monsoons. Additionally, the NSF funds most subnational flood modeling and other relevant research centers as well as the development of natural hazard response tools. Although the NSF does not have a specific natural hazard or flood risk management research agenda, it does prioritize support to advancing science which improves welfare and economic development and which protects national defense.

The NSF is responsible for twenty percent of federal funds to academic institutions, and grants Rapid Response grants for urgent research needs. Its current annual budget is approximately 7.5 billion USD and it offers approximately 12,000 grants (73 percent of funds), cooperative agreements (22 percent of funds) and contracts (5 percent of funds). NSF funds are awarded to academic institutions (77 percent of funds); private organizations (14 percent of funds); federally-funded research centers (4 percent of funds); and other international organizations, non-governmental organizations, and subnational organizations (6 percent of funds). Funding for the NSF's NFHRP responsibilities could potentially be derived from the Rapid Response grant pool or from the NSF Natural Hazard Engineering Research Infrastructure (NHERI), which had been proposed for 2015-19 but originally received no funding. The objective of the NHERI was to join the NSF Network Coordination Office, Computational Modeling Center and Post-disaster Rapid Response Research Facility to create a multiuser national research and innovation center to provide communities with access to and resources to conduct critical research.

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Our Team

Our team, made up of public affairs, architecture, and engineering graduate students at Princeton University, spent the semester studying major challenges to federal coastal flood risk management as a part of a course at the Woodrow Wilson School of Public and International Affairs. Our research was led by Professor Guy Nordenson, a structural engineer and professor of architecture and structural engineering at Princeton University.

As a part of our study, we traveled to three parts of the country that are facing unique coastal flooding challenges. One group traveled to Puerto Rico, where they learned about the progress and challenges in recovering from the devastating hurricanes Maria and Irma in 2017. Another group traveled to Louisiana, where they studied local, state, and federal government efforts to prepare its vulnerable coastal communities for future flooding and storm risks. The final group traveled to Oregon and Washington State, where they learned about the unique challenges of preparing for high-risk, low-probability flooding events such as tsunamis.

Lead Professor

Guy Nordenson is a practicing structural engineer and professor of architecture and structural engineering at Princeton University. He was the structural engineer for the Jubilee Church in Rome, the Santa Fe (NM) Opera House, the National Museum of African American History and Culture in Washington DC and over 200 other projects. Current projects include the expansion of the Frick Museum in NY, and the Museum of Fine Arts expansion, Glassell School of Art, Rice Moody Center, and Menil Drawing Institute all in Houston TX. In New York he is overseeing the design and installation of David Hammons' 325 foot Days End sculpture in the Hudson River.

Starting in the late 1970's Nordenson was active in earthquake engineering research and code development in California, and long-range national planning for FEMA and the USGS. He initiated and led the development of the New York City Seismic Code from 1984 to its enactment into Local Law 17/95 in 1995. Since 2007 he has been engaged in climate adaptation and coastal resilience research with research grants from the NSF and Rockefeller Foundation, and has been active on numerous related committees and task forces. He was Commissioner and Secretary of the New York City Public Design Commission from 2006 to 2015 and is a member of the NYC Panel on Climate Change. He is fellow of the American Academy of Arts and Sciences and the American Society of Civil Engineers. Recent books include Structured Lineages: Learning from Japanese Structural Design (MoMA, 2019); Structures of Coastal Resilience (Island Press, 2018), and Four Corridors: Design Initiative for RPA's Fourth Regional Plan (Hatje Cantz 2019).

Student Researcher

Born and raised in the Dominican Republic, **David Corcino** studied economics at the Pontificia Universidad Católica Madre y Maestra. As a student, he interned in the country's Central Bank in its monetary policy department. Upon graduating, he entered the Ministry of Presidency as a public policy analyst where he was first challenged by wage policy negotiations with health unions in the midst of a health sector reform. This past summer, he interned with The World Bank Group in Washington and worked on projects related to Domestic Resource Mobilization. Once he returns to his country, he aspires to lead several industrial policies at the Ministry of Industry and Commerce to enhance the economic complexity and competitive structure of the country and translate into sustainable and inclusive growth.

Marilú Corona is a civil and environmental engineer who has worked on water quality and distribution projects in California and internationally. She has contributed to public sector planning projects that directly affect disadvantaged communities, has assessed emergency conservation and construction projects in response to drought, and has modeled agriculture-related contaminants to inform California's groundwater policy. Marilú spent last summer with the UNESCO World Water Assessment Programme supporting the development of the 2020 World Water Development Report and supporting governments in integrating national and transboundary efforts to achieve the Sustainable Development Goals. This year, Marilú works with the Water and Environmental Team at UNICEF in New York.

A Southern California native, **Joe DeLaTorre's** interest in policy began during his time living abroad in the Air Force, an interest that turned into a passion during the 2008 housing market crash. Joe left his job in high-rise construction and returned to school to pursue a career in policy. After graduation, Joe moved to Washington, D.C., and interned with Representative Louise Slaughter and the Rules Committee before joining a communications firm. Joe has worked supporting causes, philanthropies and Fortune 100 companies on issues ranging from the opioid epidemic to expanding California's EITC. After graduating from the MPA program, he intends to work on issues concerning the regulation of markets and labor, seeking to bolster worker protections to battle rising inequality. He completed his summer internship at the State of New Jersey's Office of Innovation.

Hailing from Chicago, **Nathan Eckstein** graduated cum laude with an A.B. from the Woodrow Wilson School and a certificate in Latin American studies. From 2017 to 2019, through the Scholar in the Nation's Service Initiative, Nathan worked in the Office of the Under Secretary of Defense for Policy, both as a desk officer in Western Hemisphere Affairs and as country director for Australia, New Zealand, and the Pacific Islands. For his service, Nathan twice received the Office of the Secretary of Defense's Award for Outstanding Achievement. After graduation, he hopes to join the Foreign Service.

Avantika Gori is currently pursuing a PhD in civil and environmental engineering (CEE), and previously obtained her BS and MS in CEE from Rice University. Avi's research focuses on analyzing the impacts of urbanization and climate change on riverine and coastal flood hazard. In the past she has worked on projects quantifying the impact of Houston's urban sprawl on evolving floodplains, analyzing transportation disruption due to flooded roadways, and traveled to the Netherlands in 2017 to learn about international perspectives on flood hazard management. During her PhD, she has focused on understanding how storm surge and extreme rainfall can interact during tropical cyclone events, and how this type of flooding could worsen under future climate scenarios.

Katrina McLaughlin's background is in energy and public lands policy. Her past experience includes conducting energy policy analysis at a think tank and two seasons with AmeriCorps completing a variety of environmental restoration projects for the U.S. Forest Service, National Park Service, and Bureau of Land Management. She received bachelor degrees in Political Science and Environmental Economics & Policy from the University of California, Berkeley.

Owen Minott grew up in the Boston area before attending Bates College in Maine, where he graduated in 2014 with a major in politics. After school, he was awarded a Fulbright grant to teach English at a university in Rio de Janeiro. He then moved to D.C. to accept a position as a policy analyst at National Journal, where he covered congressional legislation, elections, and technology. With an MPA from Princeton, Owen plans to pursue a career in government and public policy to advance progressive causes. This summer, Owen completed an internship at the New York Metropolitan Transportation Authority (MTA) headquarters in the chairman's office, working on transit issues and budgetary policy.

Born in Mexico City but raised in Nevada, **Juan Pablo Ponce de León** is a Masters of Architecture Student. After graduating from Yale University, he moved back to Mexico City to work for Tatiana Bilbao Estudio on affordable and historic housing research projects. Before coming to the Princeton University School Architecture, he worked for San Diego-based ETCFF on MEXUS: their 2018 Venice Biennale project examining the US-Mexico border region as a shared watershed with a common environmental justice interest. This past summer he interned at Hector Design Studio, helping develop a youth-centered masterplan for two historic Detroit neighborhoods.

Yujing Yang grew up in Chongqing, an inland city in southwest China, where people feed on chili peppers. Influenced by her family members in public service, Yujing took special interest in politics and received a bachelor's degree of law from Shanghai International Studies University. After, Yujing returned to her home city and to work with the U.K. Foreign Office. Trying out different roles, from press officer to science and technology officer to climate change and energy officer, Yujing discovered the environmental and energy policy field was a place where she could not only insatiate her intellectual curiosity, but also continue her quest for inspiring-yet-practical solutions to one of the biggest global policy challenges: climate change. Last summer, she interned at the Energy Foundation in San Francisco.

Lindsay Wylie was born and raised in the town of Medford, New Jersey. She moved to Washington, D.C., to attend American University and study mathematics and international studies with a focus on environmental policy. After Hurricane Sandy devastated her home state, Lindsay became even more passionate about pursuing a career in fighting the threat of climate change. During her time in D.C., she participated in a scholarship program at the National Oceanic and Atmospheric Administration and an internship at the White House Council on Environmental Quality. She spent a semester studying the European Union in Brussels, Belgium. Lindsay worked on the Political Affairs team at the Environmental Defense Fund after graduating, putting her quantitative skills to work as a financial analyst. This summer, she returned to Washington to complete her internship at Resources for the Future.

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DOCUMENT SUBMITTED BY REPRESENTATIVE ROGER MARSHALL

Organizations Supporting 3DEP

Alliance of Crop, Soil, and Environmental Science Societies
American Bankers Association
American Council of Engineering Companies
American Geosciences Institute
American Institute of Professional Geologists
American Petroleum Institute
American Property Casualty Insurance Association
American Public Works Association
American Society for Horticultural Science
American Society of Agronomy
American Society of Civil Engineers
American Society of Farm Managers and Rural Appraisers
American Water Resources Association
American Water Works Association
Association of American State Geologists
Association of Environmental & Engineering Geologists
Association of State Floodplain Managers
Center for Data Innovation
Coalition of Geospatial Organizations
Crop Science Society of America
International Association of Emergency Managers
International Code Council
Interstate Council on Water Policy
Irrigation Association
Insurance Institute for Business & Home Safety
Land Improvement Contractors of America
National Agricultural Aviation Association
National Apartment Association
National Association of Development Organizations
National Association of Home Builders
National Association of REALTORS®
National Association of Tower Erectors
National Digital Elevation Program
National Emergency Management Association
National EMS Pilots Association
National Flood Association
National Geospatial Advisory Committee
National Ground Water Association
National Multifamily Housing Council
National Society of Professional Surveyors
National States Geographic Information Council
National Wildlife Federation
Property Casualty Insurers Association of America

Reinsurance Association of America
Rural & Agriculture Council of America
Society for Range Management
Soil and Water Conservation Society
Soil Science Society of America
U.S. Geospatial Executives Organization

SUMMARY SUBMITTED BY REPRESENTATIVE RALPH NORMAN

G. SUMMARY

A full report of each task force follows. The top takeaways of the task force report recommendations include:

Key Recommendations

1. Continue and enhance development of operational models for addressing deferred maintenance of the state's drainage system. Various stakeholder groups are being engaged for feedback on other flood and drainage projects. To date, the initial draft contains 244 projects from 31 counties and will be ongoing.

2. Incentivize the use of green infrastructure as a cost-effective approach for managing and reducing stormwater at its source, through such methods as tree canopies, stormwater tree trenching, stormwater basins and stormwater wetlands. Planting of native vegetation along the coast in conjunction with beach renourishment projects. Identify high-priority floodplains, wetlands and open spaces through existing maps and analyses on a county by county basis and maintain the flood storage capacity of floodplains, wetlands and critical open space.

3. Construct 1-2 demonstration artificial reefs seaward of coastal areas experiencing shoreline erosion in order to evaluate the impact of the engineered reef system and the protection potential for similar reefs covering significant segments of the coast. Additionally, continuation and investment in artificial oyster reefs to provide both erosion resilience and protection for wetlands and an economic boost.

4. Stabilization of marsh edges by identifying locations coast-wide where living shorelines and other emerging methods may be used to allow marshes to regrow where they have been eroded, and replenish marshes not keeping up with sea-level rise. Identifying and conserving transition areas for future marsh movement inland.

5. Consolidation of state resources to create greater efficiencies and cost effectiveness. Coordination among multiple state agencies to develop a comprehensive, science-based regulatory process to address the design of living shorelines and streamline permitting processes where possible.

6. Grid protection through undergrounding of some distribution circuits and hardening the overall transmission systems to increase the stability of the grid in areas along with streamlining stricter vegetation management to protect the power lines. Additional Grid protection through continued development of Distributed Energy Resources (DERs), Microgrids and integrated planning.

7. Developing and coordinating of the sharing of available river modeling data, optimizing the modeling and then utilizing these results for development planning, emergency planning, and emergency operations. Shared modeling will allow South Carolina to develop in an ecologically friendly manner that reduces the potential for damage from

flooding. Build in control structures in the development and operate as part of the Smart River Operations with the goal of preparing real time smart river topography for the coordination of actions by states, counties, local authorities and private companies and individuals based on modeling before during and after emergencies.

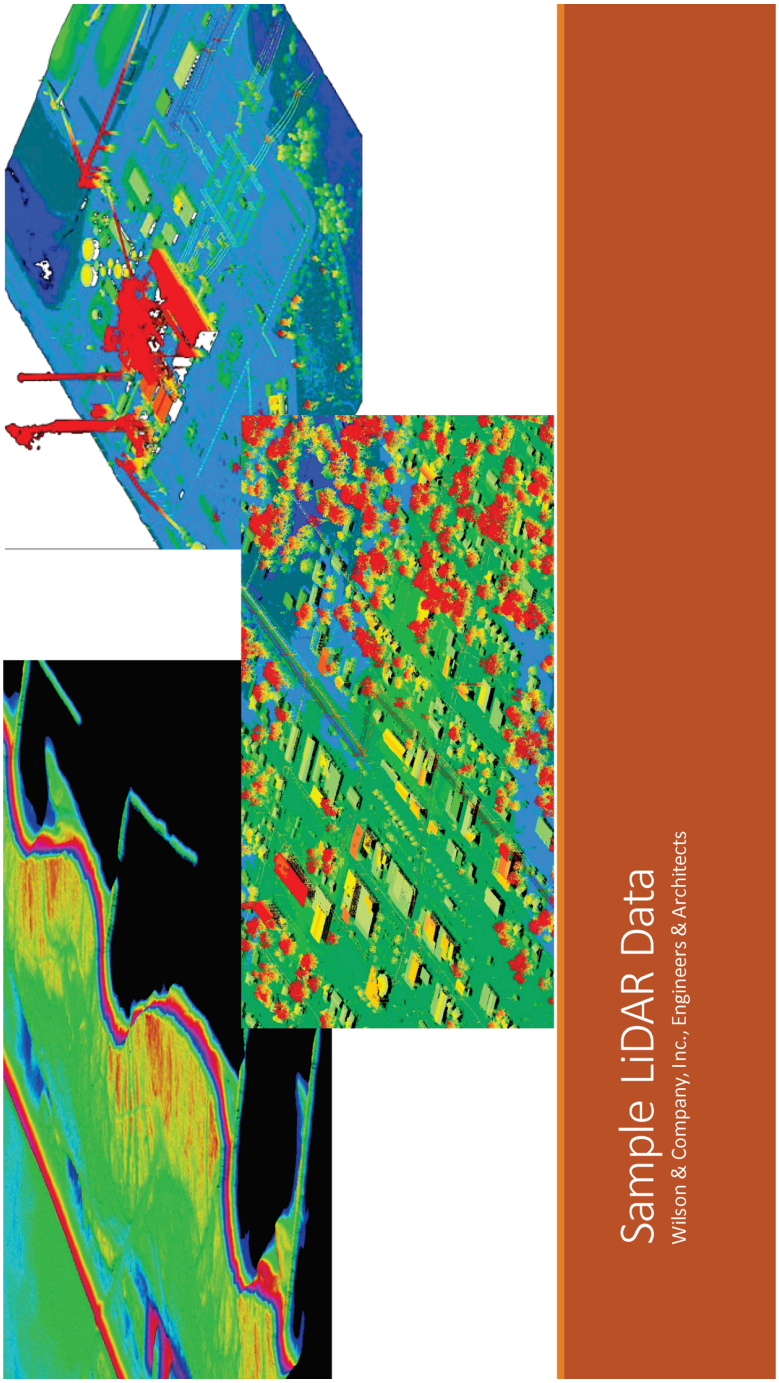
8. Ensuring that military facilities better withstand flooding and severe weather issues by coordination with the Department of Defense (DoD) to make appropriate changes to installation master planning, design, and construction standards including efforts to better understand rates of coastal erosion, natural and built flood protection infrastructure, and inland and littoral flood planning and mitigation.

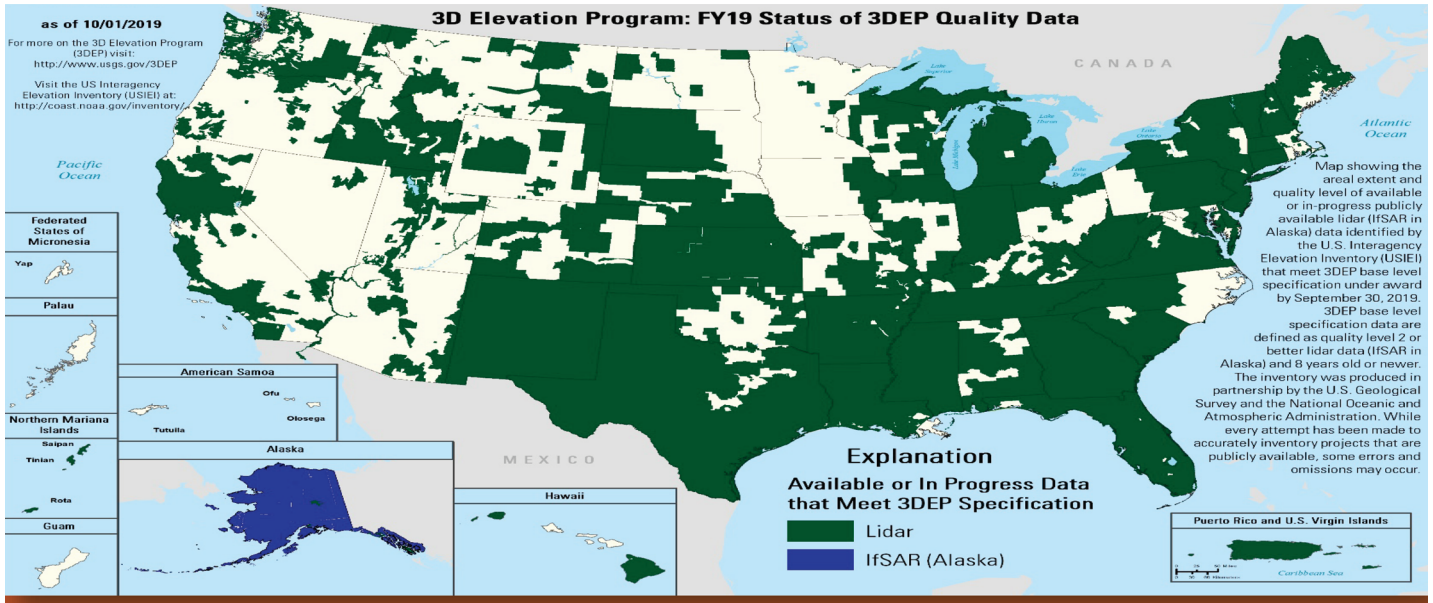
9. Development of flood water channelization and the construction of reservoirs to assist with flooding while providing regions with lakefront property, business and recreational opportunities and energy.

10. Development of a capacity building program to assist under-resourced local governments in identifying solutions and developing a plan and applying for federal funding. Timeliness of the release of federal disaster funds allocated to the state from the recent disaster relief bills is important to South Carolina's recovery from the devastation of storms. It is essential that efforts on initiatives to help recovery and preparation for the future be coordinated and data collection be shared at all levels.

(For full report, see https://governor.sc.gov/sites/default/files/Documents /Floodwater%20Commission/SCFWC%20Report.pdf)

PRESENTATION SUBMITTED BY MR. RYAN R. BRANFORT



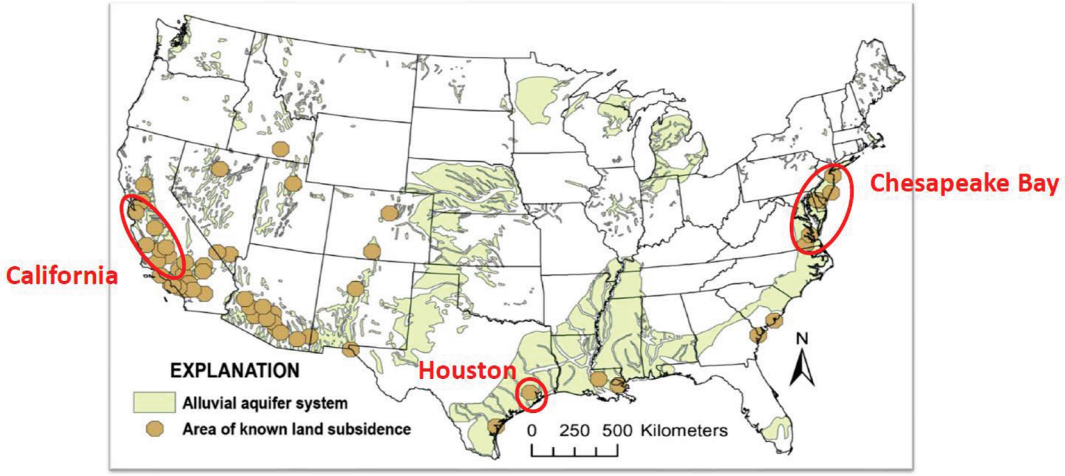


3DEP Status

As of October 1, 2019

67% of nation is complete

Subsidence outside the brown dots is unknown



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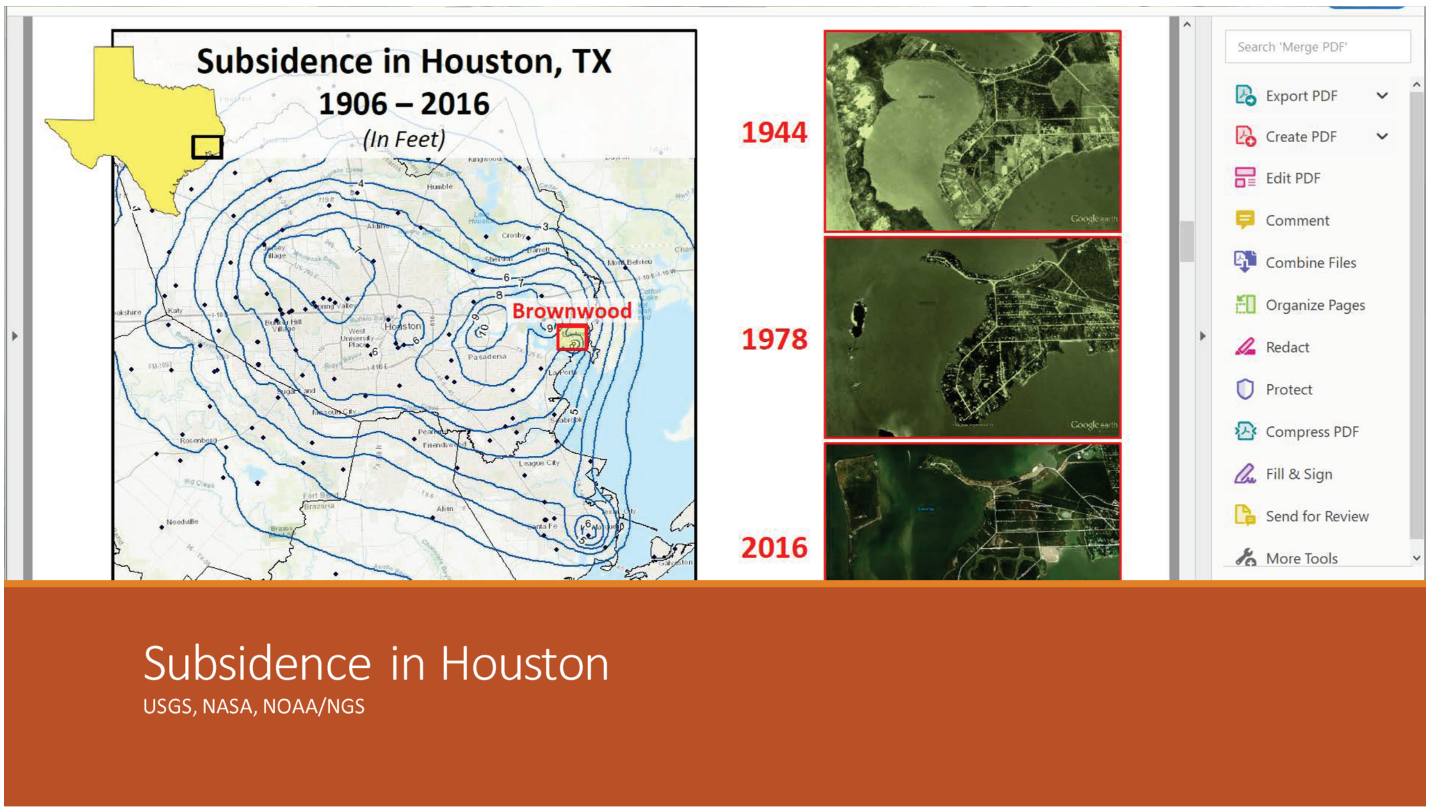
The Need for National Land Level Change Mapping

USGS, NASA, NOAA/NGS


Subsidence in Houston, TX
1906 – 2016
(In Feet)
Brownwood
1944
1978
2016
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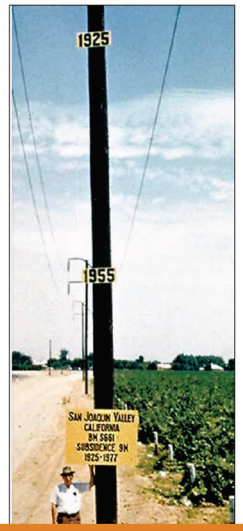
Edit PDF
Comment
Combine Files
Organize Pages
Redact
Protect
Compress PDF
Fill & Sign
Send for Review
More Tools
Subsidence in Houston
USGS, NASA, NOAA/NGS

Sometimes the bottom falls out…

Subsidence in San Joaquin Valley, CA

-33 feet

in less than a century



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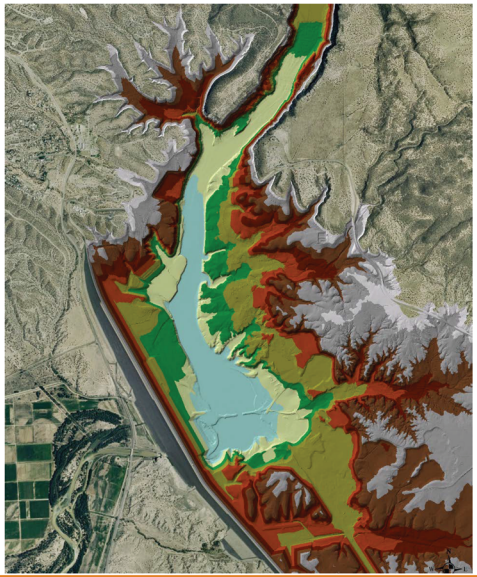
Subsidence is *NOT* solely a coastal phenomena

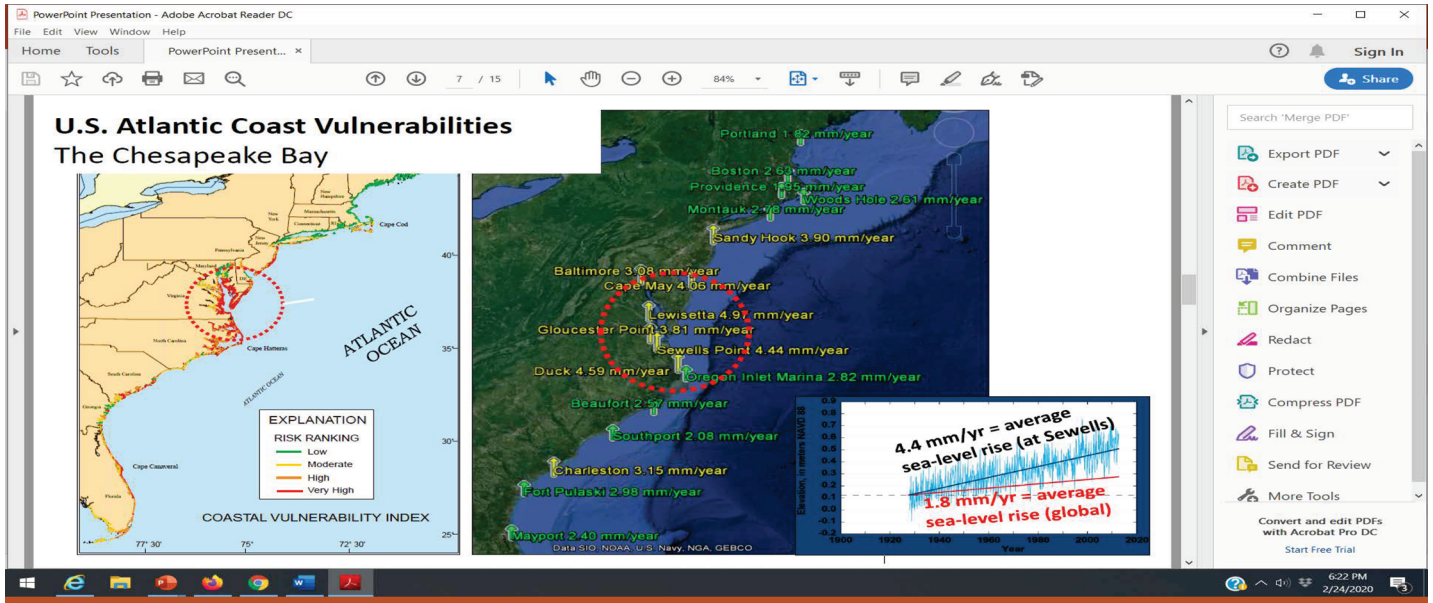
USGS, NASA, NOAA/NGS



LiDAR & Bathymetric Data

Cochiti Reservoir, New Mexico

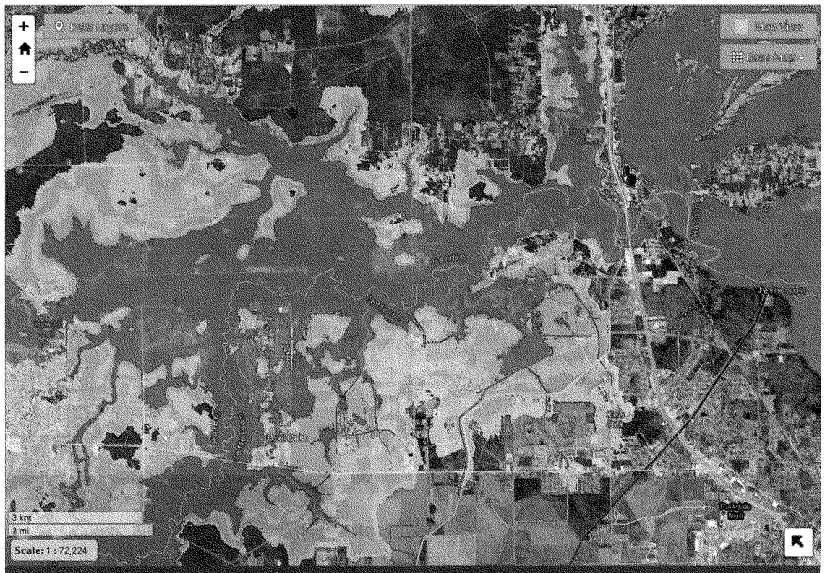
Wilson & Company, Inc., Engineers & Architects



East Coast & Chesapeake Bay

USGS, NASA, NOAA/NGS

STUDY SUBMITTED BY MR. CHAD BERGINNIS



Flood Mapping for the Nation

A Cost Analysis for Completing and Maintaining the Nation's NFIP Flood Map Inventory

January 2020

ASFPM FOUNDATION

Cover Image: Estimated Base Flood Elevation (estBFE) Viewer

Screenshot of FEMA Region VI BFE viewer. Base Level Engineering (BLE) assessments are produced using high resolution ground data to create technically creditable flood hazard information that may be used to expand and modernize FEMA's current flood hazard inventory. https://webapps.usgs.gov/infrm/estBFE/ (accessed December 2019)

Flood Mapping for the Nation

A Cost Analysis for Completing and Maintaining the Nation's NFIP Flood Map Inventory

January 2020

Association of State Floodplain Managers, Inc.
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608.828.3000
www.floods.org

The Association of State Floodplain Managers Inc. (ASFPM) published this report as part of its mission to promote education, policies and activities that mitigate current and future losses, costs and human suffering caused by flooding. Founded in 1977, the organization had over 19,000 members in 2019, including members in 37 state chapters. ASFPM supports professionals involved in floodplain management, flood hazard mitigation, flood preparedness and flood warning and recovery. Members represent local, state and federal government agencies, citizen groups, private consulting firms, academia, the insurance industry and lenders.

Suggested Citation:

Association of State Floodplain Managers. 2020. *Flood Mapping for the Nation: A Cost Analysis for Completing and Maintaining the Nation's NFIP Flood Map Inventory.* Madison, WI.

Flood Mapping for the Nation

Executive Summary

Since the inception of the National Flood Insurance Program (NFIP) in 1969, the nation has invested **$6.6 billion ($10.6 billion in 2019 dollars)** in flood hazard mapping to date, and realized multiple benefits from that investment. These benefits go beyond its uses for the NFIP to include community planning, design and construction of key infrastructure such as highways, bridges, water treatment facilities and much more. Commercial, private and public safety uses of flood hazard information reduce flood losses that would otherwise be paid for by taxpayers through federal and state disaster assistance. With a 2-to-1 benefit ratio, the $10.6 billion in investment equates to nearly $22 billion in savings from avoided flood damages.

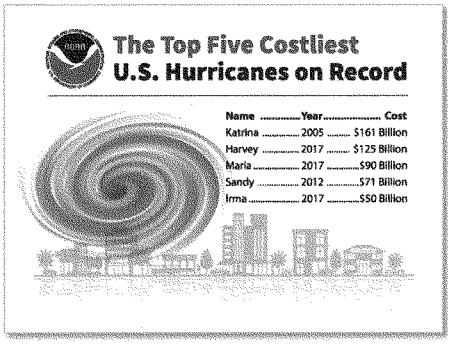
Direct average annual flood losses have increased from approximately $4 billion per year in the 1980's to roughly $17 billion per year between 2010 and 2018. These direct losses are likely under-reported and do not include indirect losses related to business closures, lost tax revenue, and public and mental health costs that often disproportionality impact socially vulnerable communities more. With increases in frequency and amount of heavy rainfall and hurricanes due to climate change and increased development pressure in coastal areas and watersheds, flood losses are expected to continue their upward trend.

We are far from completing the initial job of mapping the nation. Complete and adequate flood hazard mapping for the nation would reduce current and future flood losses. Roughly 1.14 million miles of streams have been mapped out of the approximately 3.5 million miles of streams in the country, meaning only 33% of the rivers and streams in the country have flood hazard information available. Existing maps must be continually reviewed and updated to keep them accurate and the remaining 2.3 million miles of streams need flood hazard maps.

The Association of State Floodplain Managers (ASFPM) has developed an estimate of the total cost to adequately complete and maintain flood hazard mapping for all U.S. communities based on the parameters specified in the Biggert-Waters Flood Insurance Reform Act of 2012. This estimate shows the cost to complete flood mapping for the nation ranges from **$3.2 billion to $11.8 billion** (basis for cost difference explained on p. 14). The steady-state cost to then maintain accurate and up-to-date flood maps ranges from **$107 million to $480 million** annually. Congress will need to decide how quickly we need to have flood mapping available to every community, and then set a level of funding that will achieve that goal.

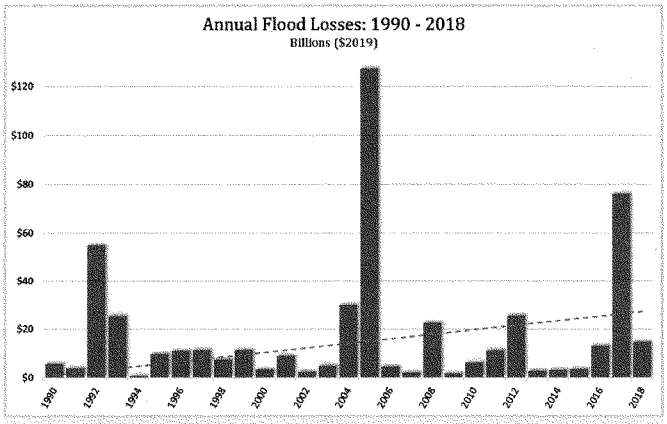
Costs and Impacts of Flooding

Since the beginning of 2017, the nation has experienced 11 U.S. billion-dollar weather disasters resulting from hurricanes and flood-related events. Sadly, three of the costliest hurricanes resulting in heavy flood losses occurred in 2017. Hurricane Harvey was the second costliest on record and 2017 set the record for the most disasters and costs in the US. The cost of the top five hurricanes since Katrina in 2005 reach almost $500 billion.



Floods are the leading cause of natural disaster losses in the United States, having cost approximately $155 billion in property damage since 2010 and accounting for a majority of federally declared natural disasters.

Direct average annual flood losses have jumped from approximately $4 billion per year in the 1980s, to nearly $17 billion per year between 2010 and 2018, with some years far beyond that.



Average annual flood losses have continually increased since 1990 based on analysis of the Spatial Hazard Events and Losses Database for the U.S. (SHELDUS) (CEMHS, 2019). www.sheldus.org

But the costs of flooding go far beyond these direct losses not included here. Unfortunately, the direct losses reported here are likely under-reported and do not include indirect losses related to business closures, lost tax revenue, and public and mental health costs that often more disproportionality impact socially vulnerable communities.

Individuals and businesses.

The effects of direct flood losses on individuals has been well documented. In addition to physical property losses, other indirect costs include lost wages, agricultural losses for crops and livestock, expenses for evacuating, risk for first responders and significant physical and mental health issues following the event, which for the most part have not been documented. For businesses, the effect of flooding is pronounced.

Across the nation, about 8.7 million properties are located within flood-prone areas.

Roughly 40 to 60 percent of small businesses never reopen their doors following a disaster.

Approximately 40 to 60 percent of small businesses do not reopen after a disaster (FEMA, 2015) and another 25 percent fail within one year according to FEMA. Similar statistics from the United States Small Business Administration indicate that over 90 percent of businesses fail within two years after being struck by a disaster. Businesses also experience indirect losses, such as lost revenues from being closed which, in turn, means lost taxes, jobs, and wages throughout the community. Businesses can additionally be impacted by employees being unable to get to work due to transportation system failures or their own homes being devastated. Supply lines can also be disrupted.

Communities. Communities suffer as well. Local funds earmarked for other uses must instead go to flood repair and recovery, physical and mental health, and the use of community resources (staff, equipment, and infrastructure) for response and rescue. Community infrastructure can be severely impacted, including the costliest elements such as water and wastewater treatment facilities. Debris collection and environmental cleanup can be significant. Local taxes (income, property, etc.) are reduced, both in the short and long term. While some of these costs will be reimbursed by the federal taxpayers in large disasters, smaller and more common disasters do not get federally declared and those costs are borne by states and communities as well as the property owners.

States. State infrastructure such as roads, bridges, and emergency facilities can be damaged or destroyed. State impacts of flooding include the diversion of state resources from necessary programs to response and recovery programs. State taxes (income, property, etc.) are reduced.

Federal Government. All taxpayers pay for the consequences of flooding. If property owners do not have flood insurance, taxpayers provide assistance through disaster relief. The casualty loss deduction allowance and lost wages due to business closure result in forgone tax revenue. Insurance subsidies, through either crop or flood insurance, result in costs to the U.S. Treasury.

What Does Flood Mapping for the Nation Mean?

FEMA is responsible for undertaking studies nationwide to identify areas having special flood, mudslide, and flood related erosion hazards; assess flood risk; and designate insurance zones. FEMA develops, in coordination with participating communities, Flood Insurance Rate Maps (FIRMs) that depict the community's flood hazards. With the passage of the Biggert-Waters Flood Insurance Reform Act of 2012, the **National Flood Mapping Program** (NFMP) was officially authorized and required FEMA to identify several new types of flood hazards including future conditions mapping described in the next section.

> "All flood hazard areas need to be mapped in order for the NFIP to fulfill its potential for reducing the rate of flood-related disaster costs." (Technical Mapping Advisory Council, 2000)

Section 100216 of the Biggert-Waters Flood Insurance Reform Act of 2012, Pub. L. No: 112-141, established the NFMP and describes the responsibility of FEMA to develop and maintain flood maps that are adequate to: 1) Make flood risk determinations and 2) Be used by state and local governments in managing development and reduce the risks associated with flooding. To accomplish this, the 2012 Act requires that FEMA shall review, update, and maintain NFIP maps with respect to:

1. All populated areas and areas of possible population growth located within the 100-year and 500-year floodplains[1];
2. Areas of residual risk, including areas that are protected by levees, dams, and other flood control structures and the level of protection provided by those structures;
3. Ensuring that current, accurate ground elevation data is used;
4. Inclusion of future conditions risk assessment and modeling incorporating the best available climate science; and
5. Including any other relevant data from NOAA, USACE, USGS and other agencies on coastal inundation, storm surge, land subsidence, coastal erosion hazards, changing lake levels and other related flood hazards.

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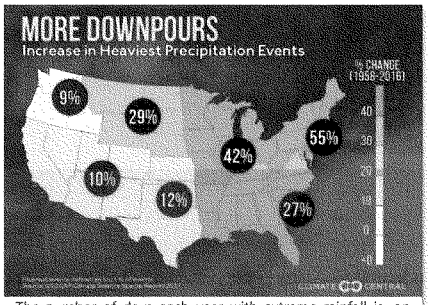
[1] ASFPM defines areas of possible population growth as any area that a property owner has the legal right to develop. Many rural floodplain managers will attest that rural subdivisions may be developed far away from existing population centers.

Future Conditions, Costs, and Impacts

The United States currently has a population of about 329 million, which is expected to be about 380 million by 2040 and 417 million by 2060. This population increase, combined with our desire to live near water, will lead to significantly increased pressure to develop in flood risk areas. Recent reports from the Government Accountability Office (GAO) and the National Climate Assessment and Development Advisory Committee indicate that there will be significant risk exposure to families, communities, infrastructure, and federal assets due to climate change and sea level rise.

What is the future condition?

Future costs and impacts of flooding will be driven primarily by two factors: **development** and **climate change**. Development occurs as a result of population changes, land use policies, and redevelopment of existing sites. Development anywhere in the watershed increases impervious surfaces, thus increasing runoff and flooding, Climate change is primarily realized through sea level rise, and more intense storms (including rainfall and hurricanes). One study on the impact of climate change and population growth on the NFIP indicated that by 2100, the 1% annual chance floodplain would increase in size by 45% in riverine areas (AECOM, 2013). Of that growth, 30% would be attributable to development and 70% to climate change. The same study predicted that coastal special flood hazard areas would increase by as much as 55% by 2100. Newer studies show that sea level rise is accelerating (R.S. Nerem, 2018), and that a majority of coastal communities will experience 30 days of high tide flooding annually by 2050 (NOAA Office for Coastal Management, 2020).



The number of days each year with extreme rainfall is, on average, increasing in every region of the U.S. (Climate Central, 2019)

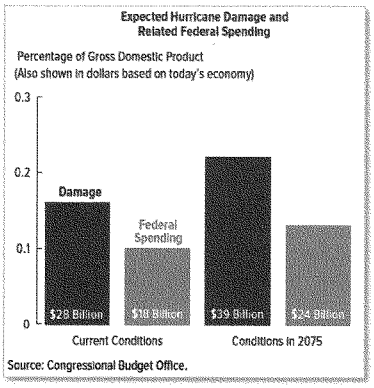
All areas of the country are experiencing more heavy rainfall events, which means more flooding. Trend data over the past 60 years – which is not even accounting for future conditions – shows this well. According to the Fourth National Climate Assessment (USGCRP, 2018) "Heavy precipitation is becoming more intense and more frequent across most of the United States, particularly in the Northeast and Midwest, and these trends are projected to continue in the future."

Today, stormwater systems that were designed to handle rainfalls of 1-2 inches per hour cannot handle 4 inches in a half hour without serious flooding.

In coastal areas, these conditions are exacerbated by sea level rise and more intense tropical storms. These, in turn, mean storm surges that push further inland and more frequent high tide flooding, sometimes referred to as "nuisance" flooding, estimated to be from 300% to 900% more frequent within US coastal communities than it was just 50 years ago (NOAA Office for Coastal Management, 2020).

What are the costs and impacts?

Financial impacts of flooding are high and will be higher in the future. Trends indicate that the federal taxpayer is paying a greater share of disaster costs than any time in history. A recent analysis shows that from 1989 to 2004, federal aid as a percentage of all economic costs from major hurricane events averaged 26% (J. David Cummings, 2010). Currently, the federal aid proportion has jumped dramatically to 64% and has been forecast to stay above 60% through the year 2075 (Congressional Budget Office, 2016).



Importance of Flood Mapping

It is nearly impossible to take action and reduce risk from flood hazards that haven't been identified. While it is estimated that 13 million Americans live in the FEMA identified 1% annual chance floodplain (or the 100-year floodplain or special flood hazard area), new models estimate that as many as 41 million Americans may live in the true 1% annual chance floodplain today (Wing, et al., 2018). That number increases to over 60 million for those that live in both the 1% and the 0.2% annual chance floodplain (or the 500-year floodplain).

Maps will not prevent floods from occurring, but they are an essential tool in avoiding or minimizing the damage to property and loss of life caused by floods, and for communicating flood risk. Without complete or accurate flood maps, local officials face serious difficulties in guiding development away from the most hazardous areas or to ensure that development is properly built to protect lives and property. The lack of maps showing which areas would flood in the mid-20th century was the reason the private insurance sector would not provide private flood insurance.

> Complete and updated flood hazard mapping for the nation is the foundation to any subsequent actions to reduce flood risk.

Consider the following two scenarios:

- A developer proposes a new residential subdivisions of hundreds of new homes. The piece of land has a small stream on it which has never had a floodplain identified by FEMA because the land was previously farmed and had low flood risk. Because the minimum NFIP land use/development standards and community subdivision regulations do not require the developer to generate flood data or maps, the subdivision is developed, and homes encroach on the natural – but unidentified – floodplain. Roads serving the homes are too low and bridges in the subdivision are undersized. Later, because the area is now at risk (since there is now development on the former farm field), FEMA maps the area and the identified floodplain shows the newly built structures at risk from flooding. Homeowners are angry, local officials are angry, and everybody is fighting the new flood maps because they don't want flood insurance mandated for their home. But the worst part is that we are creating tomorrow's flood problems today because we have not identified floodplains on all of the rivers and streams that could potentially be developed. Flood maps must be done ahead of development.
- A homeowners' association owns a dam. Unfortunately, the residual risk areas of that dam (areas protected by the dam, areas impacted by a downstream release of the dam or failure of the dam) have never been identified and several new residential subdivisions have since been built below the dam. Then, one year, a storm strikes, weakening the dam. The next year a bigger storm hits and the dam fails. Because nobody ever knew the residual risk in the first place, several homes were flooded and lives were lost.

In both scenarios, complete, up-to-date flood maps would have averted disaster losses to life and property. Yet both of these scenarios happen all over the country – hundreds of subdivisions are being built right now on streams and rivers with no identified floodplains and thousands of unknowing homeowners live in residual risk zones below dams.

The reality is that flood maps are used for many purposes. FEMA's Flood Insurance Rate Maps (FIRMs) – the primary type of flood maps in the United States – are used not only for flood insurance, but also development regulations, and flood preparation, evacuation, and response planning for those at risk.

Government officials use flood maps to:

- establish zoning, land-use and building standards;
- to support land use, infrastructure, transportation, flood warning, evacuation, and emergency management planning;
- and to prepare for and respond to floods.

Insurance companies, lenders, realtors, and property owners depend on these maps to determine flood insurance needs. For citizens, businesses, and communities, the FEMA flood maps are the nation's default source of flood hazard information, even though they are primarily designed for flood insurance.

Flood hazard maps showing the depth and velocity of flooding along with buildings impacted by the flood water helps both emergency managers and developers understand flood risk.

Maps depicting flood hazard areas are not only the foundation of the NFIP, but also the basis of sound floodplain management policies at the local, state, and federal levels. Adequate, accurate and current maps are essential for the NFIP to function. If a potential flood prone area is not mapped, the community has no tool to adequately guide development to be safer and to mitigate future flood losses. Local governments, with state assistance and authority, are the level of government with the tools to reduce future flood losses. Those tools are land use standards and building codes, which are used to guide development to lower flood risk areas, and to build resilience in flood risk areas so future damages and risk are reduced. Without flood mapping of the flood prone area there is no real tool to communicate flood risk to community officials, citizens or businesses. The sale of flood insurance is not mandated in areas outside special flood hazard areas mapped on FIRMs. Without adequate, accurate, and current maps, neither construction nor the insurance regulatory elements of the program can be effective (Technical Mapping Advisory Council, 2000).

Floodplain mapping is a cost-effective taxpayer investment. In 1997, FEMA conducted a benefit-cost analysis of its proposed flood mapping program (at that time it was called Map Modernization). Based on that analysis, floodplain mapping showed a benefit to the taxpayer of over $2 for every $1 invested in flood mapping.

In 2008, the State of North Carolina used the same methodology as FEMA, and calculated a benefit-cost ratio of 2.3 to 1. The North Carolina report further determined the following range of values of avoided losses per stream mile studied:

Flood Study Type	Range of losses avoided (per stream mile)
Detailed Study	$5,482 - $6,166
Limited Detailed Study	$1,713 - $2,539
Approximate Study	$721

The North Carolina report indicates that for the 29,733 stream miles studied throughout the state, the average benefit provided is $3,400 per year per mile and clearly shows significantly higher benefits of having more detailed flood studies (State of North Carolina, 2008).

Also, the flood mapping program tries to maximize diverse funding sources. The program operates through fees and appropriated funds. It incentivizes cost-sharing and leverages state and locally collected data. In fact, for every dollar appropriated since 2012, $1.30 has been added by alternative state, local and other funding sources.

Flood mapping reduces disaster costs. Development that complies with the floodplain management requirements is better protected against major flood-related damage. Since flood mapping is the basis for community floodplain management regulations, then it stands to reason that new construction in mapped floodplains would have to comply with such codes and be constructed to be more resilient in future disasters. In fact, buildings constructed in compliance with NFIP building standards suffer approximately 80 percent less damage annually than those not built in compliance (Federal Emergency Management Agency, 2012). Lower damage amounts can be a proxy for lower impacts and demands on disaster assistance. In its final report the TMAC indicated that a small investment in mapping can result in huge savings in flood-related disaster assistance in the future (Technical Mapping Advisory Council, 2000).

Importance of Elevation Data

High-quality topographic or elevation data is essential in the creation of high quality flood maps and flood hazard data. The 3D Elevation Program (3DEP) managed by the U.S. Geological Survey (USGS) National Geospatial Program has responded to the growing needs for high-quality topographic data. The goal of 3DEP is to complete acquisition of nationwide Lidar by 2023 to provide the first-ever national baseline of consistent high-resolution elevation data. 3DEP is based on the National Enhanced Elevation Assessment (NEEA) that documented "... more than 600 business uses across 34 federal agencies, all 50 states, selected local government and tribal offices, and private and nonprofit organizations." (USGS, 2019).

Lidar data can be used to extract building footprints (in red) and identify the finished floor elevation in order to quantify potential damage based on flooding depths and to determine if buildings are above the base flood elevation. Image courtesy of John Dorman, North Carolina Flood Mapping Program.

The 3DEP program began in 2016 and provides more than $690 million annually in new benefits to government entities, the private sector, and citizens and realizes a 5:1 return on investment. Through Federal fiscal year 2018, $382 million has been spent with an estimated $629 million needed to complete high-quality topographic data for the country (USGS, 2019). Acknowledging how essential quality topographic data is to credible flood hazard information, FEMA has invested over $190 million since fiscal year 2014 in LiDAR through the 3DEP program.

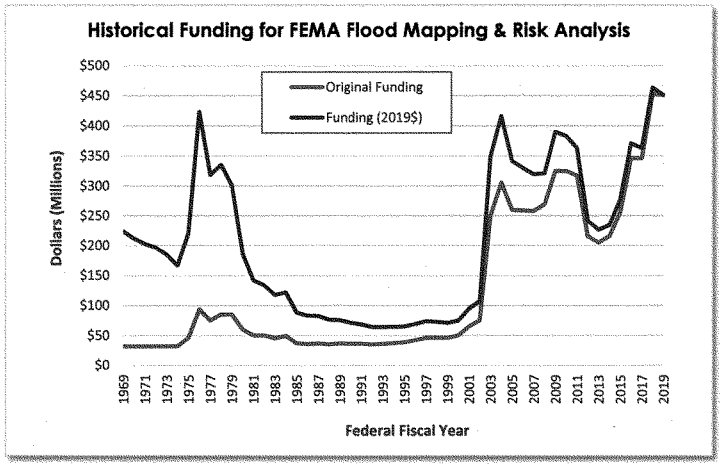
History and Current Status of Flood Hazard Mapping

Funding Sources – Appropriations and Fee Income

Flood hazard mapping and risk analysis is funded through the NFIP by two methods: direct annual appropriations from Congress, and since 1990, a Federal Policy Fee collected on receipts from premiums of flood insurance policies. Overall funding for the nation's flood hazard mapping and risk analysis program varies from year to year, with direct appropriations being as low as only $89 million as recent as FY2013, and reaching $262.5 million in direct appropriations in FY2019. Spending authority from fee collection for FY2019 includes $188.3 million for floodplain management and flood mapping. The combined total for FY2019 is $450.8 million (Congressional Research Service, 2019).

As identified in the original 2013 Flood Mapping for the Nation report, the majority of the floodplain mapping funding to produce new flood maps is derived from the direct annual appropriation for floodplain mapping. The majority of the Federal Policy Fee is used for operating the flood mapping program, including staffing, program management, IT infrastructure, maintaining a call center to support FEMA customers, acquisition services, and research and development. It also supports the cost for processing Letters of Map Change including Letters of Map Amendments (LOMA) and Letters of Map Revision (LOMR), all of which do not provide a significant contribution to the effort to develop new or updated maps.

Since the inception of the NFIP, an estimated **$6.6 billion ($10.6 billion in 2019 dollars)** has been invested in the nation's flood hazard mapping and risk analysis program. This amount includes both appropriated and fee generated funds.



Return on Existing Investment in the Nation's Flood Maps

What have been the results of investing in the nation's flood maps to date? The NFIP now claims there are $1.6 billion in avoided damages every year for buildings constructed in compliance with NFIP standards (FEMA, 2018). The Federal taxpayer would have largely paid for these losses through disaster relief and other programs. These losses avoided would have not been possible without the flood maps. So the investment in flood mapping since the inception of the program until now can be offset by losses avoided in just over six years.

- Over 22,000 communities participate in the NFIP. Those that have reasonably good flood data have been able to reduce flood damages to new development. Nearly, 5.1 million flood insurance policy holders have their financial investment in homes and businesses protected by flood insurance. These are all potential damages that are paid through an insurance mechanism rather than disaster assistance. Those who live at risk pay for at least part of the cost of those decisions. NONE of this would be possible without flood maps.
- Investment in floodplain mapping since 2003 has resulted in the creation of a digital platform for flood maps. This was a huge undertaking given that previous flood maps were developed using multiple, older cartographic methods. Now, the digital platform is

compatible with modern Geographic Information Systems, which means the maps can be integrated into federal, state, and local systems; positioning the nation to move quickly and more cost effectively to develop new and updated maps for every community in the nation. Furthermore, additional informational GIS datasets can be provided on the platform for use at the state and local level.

Cost of Flood Mapping for the Nation

Key Assumptions

To complete flood maps and flood risk data for the nation, it is necessary to make certain key assumptions about the mapping program. Below is the list of the key assumptions made in this report as it relates to what constitutes mapping the nation.

Assumption #1: The framework for mapping the nation going forward has been established in the 2012 Reform Act and dovetails well with FEMA's Risk MAP program and previous recommendations to improve floodplain mapping. In the past, and in the absence of clear Congressional direction, the mapping program was almost solely focused on supporting flood insurance rating as well as serving as a tool for the adoption and enforcement of local floodplain management regulations. However, the purpose of the National Flood Mapping Program is clearly meant to fulfill a broader mandate – to create the nation's flood risk data set so states, communities, and individuals can take action to reduce losses.

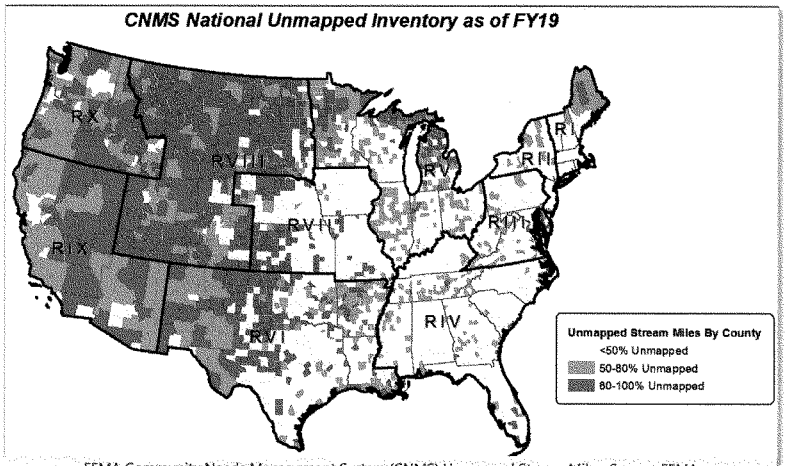
FEMA's Risk MAP program moved the discussion of flood hazard identification away from just the 1% annual chance flood and Flood Insurance Rate Maps to identifying multiple types of flood hazards and frequencies of flood risk. Further, the discussion has been shifted more to future and current risk, and what the property owner/community can do to reduce or mitigate risk, rather than whether a person is in or out of the Special Flood Hazard Area for purposes of determining mandatory flood insurance.

The Act makes a clear and unequivocal statement that flood maps produced by FEMA will be forward looking and inclusive of several types of flood risk data. Congress has, in effect, acknowledged what most state and local officials already know – that the FEMA flood map data should be the default and minimum national dataset for flood risk.

Assumption #2: Flood data and maps are developed for the entire nation. Based on the National Hydrography Dataset (NHD), there are approximately 3.5 million miles of streams in the nation. Currently, about 1.14 million stream miles have flood maps or just over 33% of the 3.5 million stream miles. For coastal or shoreline mapping, NOAA's official value for total length of U.S. shoreline is 95,471 miles (NOAA, 2018). Currently, about 44,158 miles of shoreline have flood maps or just over 46% of NOAA's total.

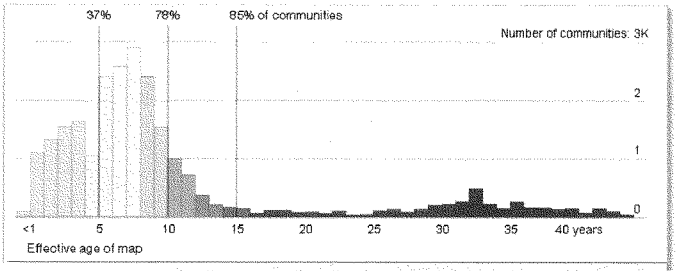
FEMA's floodplain mapping programs to this point have chosen to prioritize limited resources to those areas of greatest population and flood insurance policies on the assumption these are the highest risk areas. While this approach has produced accurate and detailed maps in counties

and communities with higher population levels (even in these communities there are flood prone areas that have not yet been mapped), there remains much more to be done. There are an estimated **2.3 million river and stream miles** and just over **50,000 coastal miles** that are *not mapped* as part of a Special Flood Hazard Area (SFHA).



FEMA Community Needs Management System (CNMS) Unmapped Stream Miles. Source: FEMA

There are over 6,500 counties and communities throughout the nation identified as *not having flood maps at all* and roughly 3,300 communities that have *maps over 15 years old*, with several of these *having paper maps over 30 years old* and based on using obsolete mapping methods.



Roughly 3,300 communities (or 15% of about 22,000 NFIP communities) around the nation have flood hazard maps that are over 15 years old, many of which are 30 years or older. Source: FEMA Data obtained by Bloomberg News (Bloomberg News, 2017)

The current approach ignores lesser populated areas that have considerable flood risk, especially in relation to the local economy, and may have rapidly developing areas with no flood data to guide development. These communities are found all over the nation and continue to find themselves less able to be resilient because the foundational flood data does not exist. Unmapped flood hazard areas present a serious threat to people who may choose to buy or build within them (Technical Mapping Advisory Council, 2000). Furthermore, much of that development may occur without regulation and pay less than full actuarial flood insurance rates, contributing to the NFIP deficit.

Nearly 1 million miles of streams exist on federal and state lands. While some development and infrastructure exists on these lands, the low future development potential coupled with other federal agencies primacy over such areas, this cost model only includes the cost to map federal and state lands in the high-cost range scenario. ASFPM believes that mapping these areas could have benefits; however, flood mapping could, and probably should be, developed by the owner agency as required by the federal Executive Order 11988.

Assumption #3: The minimal flood mapping level for the nation should be based on engineering models and include the ability to readily obtain flood elevation information. With advances over the past decade in automated technologies to map flood hazards and risk, and with high quality topographic data, the ability exists to map large geographic areas using methods such as Base Level Engineering (BLE) (FEMA, 2018). This mapping would be done at a cheaper cost and the quality would be much improved over maps produced 30+ years ago. Even if FEMA has correctly identified the general flood hazard area, communities and citizens need flood elevation data for important things like insurance rating, assessing actual flood risk and making development decisions, and to plan for resilient community growth in order to truly manage the flood risk at the local level.

Assumption #4: Up to date detailed elevation data (LIDAR or other topographic maps) are needed anywhere flood mapping and data are to be generated. The accuracy of elevation data has an enormous impact on the accuracy of flood maps. Having accurate topographic data for floodplain mapping is especially critical in regions with low relief, such as coastal areas --the very areas seeing the most significant population growth and development.

Assumption #5: Residual Risk is defined in this cost model as risk associated with levees and inundation/failure areas below dams; however, other residual risk areas should be identified. There is a new mandate in the law that all residual risk areas be identified, such as those areas repeatedly flooded by stormwater. The cost of mapping urban stormwater flooding is not included in the cost estimates for this report. It is important that TMAC work to help further define the term and criteria.

Assumption #6: The flood map inventory must be continuously updated. Flood map data is not static; it changes over time. Drivers of change include: 1) Change in hydrology, i.e.

updated rainfall records and changing storm patterns, 2) Changes in land use such as population growth or development causing changes in runoff, 3) Need for detailed flood studies as new areas develop, 4) Update of data based on new models, and 5) Technological advancements that allow for more dynamic analyses and presentation of flood risk. While the initial mapping effort for the nation must be completed, there too is an annual maintenance cost for the entire flood map and data inventory. The federal government's investment in the development of flood hazard data is considerable and must not be allowed to decay as happened in the mid-1980s and 1990s (see chart on Historical Funding for FEMA Flood Mapping).

The Cost

The national mapping program funding needs, shown in the table below, has been broken down into major program elements and provides a low and high cost associated with each. The basis for these costs are the assumptions explained in the preceding section and actual cost information obtained from FEMA, state flood mapping programs and other state and federal agencies involved in flood mapping efforts. Due to its complexity, the data behind these estimates is not included in this report, but is available from ASFPM upon request.

The most significant source of variability between the high and low range is due to assumptions made related to level of riverine flood studies for a given geographic area. While good cost data is currently available, it is important to note that changing technology as well as an assumption of nation-wide Lidar could result in reduced costs.

Program Element	Lower Range	Upper Range
Topographic Data Development – 3DEP Program	$ 630,000,000	$ 630,000,000
Discovery, Scoping, Risk Communication & Outreach	$ 39,000,000	$ 90,000,000
Riverine Flood Study	$ 1,819,000,000	$ 9,828,000,000
Coastal Flood Study	$ 13,300,000	$ 14,900,000
Levee	$ 373,000,000	$ 651,000,000
Dam Failure Inundation	$ 97,000,000	$ 199,000,000
DFIRM Production with QA/QC	$ 156,700,000	$ 206,000,000
Non-Regulatory Flood Risk Products	$ 50,000,000	$ 153,000,000
Total	**$ 3,178,000,000**	**$ 11,772,000,000**

The lower range does not include nearly 1 million miles of rivers and streams on federal and state lands, but does use the lower cost estimates associated with the latest mapping technology to generate minimal flood hazard data for rural areas. The upper range includes mapping flood hazard areas on all federal and state lands to ensure mapping of the 3.5 million

miles of rivers and streams in the nation. The upper range also considers the higher costs associated with urban areas and future development areas that as they become more developed (and thus more at-risk) there is an increased need for higher levels of detailed, engineered flood studies and thus higher costs. There is also significant variability for levee studies reflecting the relative uncertainty of the number of levee miles and the needed level of analysis.

Program Element	Lower Range	Upper Range
Steady-State Map Maintenance (Annual)	$ 106,900,000	$ 479,700,000
Total	**$ 106,900,000**	**$ 479,700,000**

In terms of map maintenance, the largest variable has to do with assumptions of map decay – or the accuracy of the map over time. Flood maps change over time due to several factors including changes in topography in the watershed, changes in development and growth, changes in precipitation, additional stream gage data, and changes in water levels in lakes and oceans. In areas where all of these are changing rapidly, maps need to be updated much more frequently than in some rural areas that have little growth and development. Also, accelerated sea level rise and climate change could result in higher decay rates than are presented in this cost estimate. All flood maps need to be periodically updated, but some more frequently than others. The more the flood maps reflect future conditions, the less the cost of updating those maps.

Cost Savings

The cost model developed by ASFPM for this report includes estimates based on available information from states and FEMA, and is also based on current technology and methods of providing flood map data, as well as the assumptions stated earlier. ASFPM believes there are ways to achieve cost savings by leveraging funding, advances in technology and other approaches. A few of these are presented below.

1. *Efficiencies in mapping using better technology.* Throughout the FEMA Map Modernization program and in Risk MAP, FEMA has been successful in driving program efficiencies. This is also a result of changing and improving technologies. One promising approach is called Base Level Engineering (BLE) which uses automated flood modeling of more rural riverine floodplain areas where high quality topographic information exists. Given that the single biggest cost variable is riverine flood studies, the use of BLE could be a significant cost savings to the program.
2. *Leveraging other federal, state and locally collected elevation data.* Some states routinely collect and maintain statewide, high-quality LIDAR data that can be used by FEMA for flood mapping. While contributing to the aforementioned 3DEP program, FEMA is still leveraging considerable benefits from 3DEP to the nation's flood mapping program.
3. *Maintaining/expanding the Cooperating Technical Partners Program.* The CTP Program is an innovative approach to creating partnerships between the FEMA and participating NFIP communities, regional agencies, state agencies, tribes and universities that have the interest

and capability to become more active participants in the FEMA flood hazard mapping program. The result can be the leveraging of partner contributions to flood mapping projects.

What remains to be done?

We are far from completing the initial job of mapping the nation. The framework for flood mapping as prescribed by the National Flood Mapping Program (NFMP) in the Biggert-Waters 2012 Reform Act, recognizes many of these existing needs and sets a robust course for moving forward. Unfortunately, as of January 2020, much remains to be done:

- Based on the National Hydrography Dataset (NHD) and NOAA shoreline data, there are approximately 3.5 million miles of streams and rivers, and 95,471 miles of coastlines in the nation. Currently, only 1.14 million stream miles and 45,128 shoreline miles have flood maps. By this metric, only about 1/3 of the nation has been mapped.
- Over 3,300, or roughly 15%, of NFIP communities have maps over 15 years old, with many of these over 30 years old and still having "unmodernized" paper maps. About 6,550 communities have never been mapped. Addressing both of these needs should be a priority for FEMA.
- Many of the added mapping requirements from 2012 are still not being addressed. This includes residual risk mapping around flood control structures and future conditions mapping. A 2016 TMAC report reviewing the National Flood Mapping Program stated "*To create technically credible flood hazard data, FEMA needs to address residual risk areas in the near term. Residual risk areas associated with levees and dams are of great concern.*" (Technical Mapping Advisory Council, 2016)

It should be noted that over the past several years, FEMA has stated that 90% plus of the population has been covered by a modernized map. However, this metric grossly overstates the population covered by a modernized map. This problem is discussed in the 2015 TMAC Future Conditions Assessment and Modeling Report:

> *However, this population metric has two challenges for moving forward. First, the metric over-predicts the population covered by a modernized map. FEMA generally studies streams that drain a drainage area of greater than one square mile. If a census block group has 10 miles of stream and only 1 mile is studied, the current metric will count 100 percent of the population within the census block group as being covered by a modernized map, as opposed to the 10 percent that may actually be covered. Therefore, the current metric can lead to a significant over-prediction of the population covered by a modernized map. This could lead policy makers to believe that flood hazards have been more widely identified than the reality. If the metric is changed to be more reflective of the streams studied within a census block group, then it may more realistically illustrate that the country has flood hazard areas defined for only somewhere between 16 percent and 22 percent of all streams."* (FEMA Technical Mapping Advisory Council, 2015).

Recognizing that much of the nation still needs to be mapped to adequate standards, FEMA is exploring ways to leverage new technologies to provide flood information more efficiently, accurately, and consistently across the nation through the Future of Flood Risk Data initiative. FEMA aims to provide a more comprehensive and dynamic picture of the nation's flood hazards, accounting for residual risks and multiple flood frequencies. This information could serve as a basis for a range of flood risk products. In moving towards this future, FEMA will need to develop strategic partnerships with other federal agencies, the private sector, and state, local, tribal, and territorial stakeholders. These partnerships will ensure that FEMA is leveraging the latest data and technologies, while serving the diverse needs of its customers.

Considerations for Congress and FEMA

The National Flood Mapping Program has yet to achieve its aim: to produce a reasonably complete set of flood data/maps for the country that identifies multiple types of flooding hazards and also future conditions. As Congress and FEMA consider the future and funding of the National Flood Mapping Program, the following factors should be included:

- We do what we measure. There must be an easily verifiable metric developed for the National Flood Mapping Program that more accurately reflects the extent of the flood mapping completed in the nation than what is currently being used. We suggest the NFIP measure the percent of miles mapped as a metric. Unmapped miles must be studied and added to FEMA's inventory so that flood risk information is available to communities ahead of development.

- Congress will need to decide how quickly we need to have flood mapping available to every community, and then set a level of funding that will achieve that goal. The current FY2019 authorization of about $450 million for the flood hazard mapping and risk analysis program is misleading because a much smaller amount of money is actually available (closer to $300 million) to create new flood maps. Using the median funding level of about $6-8 billion, one could divide by 10 if we agree the mapping should be available in 10 years. Congress should consider increasing the annual appropriation (ignoring the policy fee income since that is spent for operating costs like LOMA, LOMR, LOMC) for the national flood mapping program to accomplish that goal. Alternatively, some members of Congress have proposed a faster five-year effort in which a funding surge is appropriated to finish the job of initially mapping the nation.

- As directed by Congress in 2012, FEMA should begin providing residual risk and future conditions products as part of all flood mapping studies as soon as possible. The TMAC in its 2015 Future Conditions Report and in its 2016 National Flood Mapping Program Review support this view.

- The TMAC also identified the public policy hurdle related to the public availability of dam and related facility inundation maps. Congress may want to consider a specific provision as

part of a future NFIP reform bill or WRDA bill that would override the DHS Security Classification Guide for the Protection of Critical Infrastructure and Key Resources for dam failure inundation maps as "For Official Use Only."

- While not directly part of the National Flood Mapping Program, there is a critical need to ensure the intentional, funded update of the nation's rainfall frequency information which is a major data input into flood models. This past November, ASFPM testified that NOAA should be given the mandate and full budget to update our nation's rainfall frequency information at least every 10 years and this update must include future climate projections into precipitation frequency analysis.
- ASFPM also made a similar recommendation to fully fund the critical national stream gage and tidal gage networks. While more than 4,700 locations meet the criteria for inclusion in the Federal Priority Streamgage (FPS) Network, only 3,600 FPS are active due to funding limitations. These gages provide critical datasets over time so that trends can be identified.

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SUMMARY SUBMITTED BY MR. CHAD BERGINNIS

FLOODING
IS THE NATION'S #1 DISASTER

Legislation requires that FEMA develop and maintain flood maps. $6.6B, or $10.6B in present-day dollars, has been invested in flood hazard mapping, resulting in nearly $22B in losses avoided. **HOWEVER, MORE IS NEEDED!**
Currently, only 1/3 of the nation's streams and coasts have been mapped.

CAUSING AT LEAST $17B IN LOSSES on average per year.

INVESTING IN A FULLY MAPPED NATION REQUIRES

$3.2B to $11.8B + $107M to $480M FOR ANNUAL **MAP MAINTENANCE**

this **INVESTMENT WILL RESULT IN**

- **2.3M** new stream miles
- **6,500** newly mapped communities
- **3,300** communities with maps over 15 years old that would receive updated maps

FLOOD MAPS ARE ESSENTIAL TO:

Floodplain Mapping is a SOUND INVESTMENT with a **21 TAXPAYER BENEFIT**

- **Save lives and reduce disaster suffering.**
  58% OF AMERICAN VOTERS PERSONALLY IMPACTED BY FLOODING
- **Support communities' resilient actions, such as identifying where mitigation projects and land use & building standards are needed.**
  80% LESS DAMAGE ANNUALLY TO STRUCTURES BUILT TO NFIP STANDARDS
- **Reduce flood losses.**
  NEARLY $17B PER YEAR 2010-2018
- **Keep communities and businesses thriving.**
  40-60% OF SMALL BUSINESSES NEVER REOPEN AFTER A DISASTER, AND 90% OF BUSINESSES FAIL WITHIN 2 YEARS OF EXPERIENCING A DISASTER

IDENTIFYING RISKS TODAY
reduces tomorrow's flooding problems

ASFPM FOUNDATION

FOR MORE INFORMATION read the Map the Nation Report at **no.floods.org/MapTheNation**