20/20

TMAC

TECHNICAL MAPPING ADVISORY COUNCIL

Annual Report

dedication

This report is dedicated to the memory of Mark Crowell, the first Designated Federal Officer assigned to the Technical Mapping Advisory Council (TMAC) when it was reestablished in 2013, who passed away in September 2020. Mark worked tirelessly to stand up the charter and responsibilities for the TMAC. He supported and provided guidance that allowed the TMAC to perform its duties and make recommendations to FEMA to improve the National Flood Mapping Program.

Through enthusiasm and passion, Mark inspired FEMA colleagues to join the Designated Federal Officer (DFO) team, and was always willing to share his expertise gained from years pioneering the DFO position. This dedication set a standard of excellence that serves as an example and guides future DFOs towards successful service, ultimately enabling TMAC's success. Mark's service will continue to benefit the success of the DFO team, which will continue to follow his standard of excellence for many years to come.

TMAC

Technical Mapping Advisory Council

March 2021

Bob Fenton
Acting Administrator
Federal Emergency Management Agency
500 C Street SW
Washington, DC 20472

Acting Administrator Fenton,

As Chair of the Technical Mapping Advisory Council (TMAC), I am pleased to forward to you the TMAC *2020 Annual Report* for your consideration. This Annual Report includes three new recommendations for FEMA to consider.

Typically, the TMAC would conduct a mix of in-person and virtual meetings; however, due to the Coronavirus pandemic, the TMAC was forced to hold all of its meetings virtually. Even without any in-person meetings, the TMAC was able to effectively conduct its business to deliver the *2020 Annual Report*. The TMAC conducted five virtual public meetings and two virtual administrative meetings between January 2020 and March 2021. Subcommittees were established and met regularly with invited subject matter experts, who presented information relevant in the construction of the proposed recommendations contained in the 2020 Annual Report. Through much effort, discussion, and deliberation, which culminated in voting in March 2021, the TMAC concurred to submit the *2020 Annual Report*.

The *2020 Annual Report* focuses on two areas: 1) identifying the best practices to be incorporated into a future flood hazard and flood risk identification program; and 2) providing a framework for FEMA to transition to the future flood hazard and flood risk identification program. As part of its work in 2020, the TMAC conducted a robust stakeholder engagement process and engaged over 780 stakeholders through a survey, webinars, and several focus groups. The feedback from the stakeholders was informative and supports the three recommendations in the *2020 Annual Report*.

The TMAC is beginning the work of responding to Mike Grimm's letter dated February 23, 2021 in order to prepare the *2021 Annual Report*.

Respectfully,

Jeffrey L. Sparrow, P.E., CFM
Chair
Technical Mapping Advisory Council

Executive Summary

The year 2020 was a devastating year for natural disasters in the United States with a record 22 disaster events that each caused $1 billion or more in damage. Floods have always been and remain the most prevalent natural disaster in the nation, and the impacts of flooding continue to disrupt lives and communities. As a nation, we must continue to improve our understanding of flood risk and then use that understanding to takes steps to mitigate those risks.

Through the National Flood Insurance Program (NFIP) and the National Flood Mapping Program (Program), the Federal Emergency Management Agency (FEMA) aims to provide comprehensive flood risk data to inform people's flood insurance and risk mitigation investment decisions and foster a culture of preparedness across the nation. The Technical Mapping Advisory Council (TMAC), a Federal Advisory Committee, supports FEMA in its efforts by making recommendations to FEMA as authorized and directed by the Biggert-Waters Flood Insurance Reform Act of 2012 and the Homeowner Flood Insurance Affordability Act of 2014.

Since its establishment in 2014, TMAC has delivered seven reports that include 37 recommendations and 13 implementation actions. Many of these recommendations and actions are being considered and implemented as FEMA continues to improve program delivery.

In 2020, FEMA tasked TMAC to address two priority topics of key importance as it considered ways to improve how flood data is generated and delivered, and evolved its products and services to best meet customer needs:

- Identify the best practices to be incorporated into a future flood hazard and flood risk identification program; and
- Provide a framework for FEMA to transition to the future flood hazard and flood risk identification program.

In response to the task from FEMA, TMAC conducted an extensive public engagement process consisting of a survey, webinars, and focus groups. The feedback from these engagements was informative and assisted TMAC in developing the Annual Recommendations (AR) in Table ES-1.

Table ES-1 / TMAC Recommendations 2020

TOPIC	RECOMMENDATION	
Risk Management	AR 35	TMAC recommends that FEMA explore how to implement enterprise risk management frameworks that help communities whose objectives are to become more flood resilient and to transition toward proactive flood risk management while meeting or exceeding existing minimum federal floodplain management requirements.
Products	AR 36	TMAC recommends that FEMA develop a set of integrated floodplain management- and mitigation-focused prototype products and services that help stakeholders better understand, communicate, and manage their current and future flood risks.
Partnerships	AR 37	TMAC recommends that FEMA utilize the Cooperating Technical Partners and other partnerships for the implementation of this transition and investigate ways to incorporate data and technology from other stakeholders such as regional and local governments; state and federal agencies; and academic, nonprofit, and private stakeholders.

**AR = Annual Recommendation*

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Acronyms and Abbreviations

3D	three-dimensional
3DEP	3D Elevation Program
3DNTM	3D National Terrain Model
ADFO	Alternate Designated Federal Officer
AEP	Annual Exceedance Probability
AMEC	Alaska Mapping Executive Committee
ANFI	Associate in National Flood Insurance
AR	Annual Recommendation
ASFPM	Association of State Floodplain Managers
BFE	Base Flood Elevation
BLE	Base Level Engineering
BW-12	Biggert-Waters Flood Insurance Reform Act of 2012 (42 U.S.C §§ 4001-4130)
CAP	Community Assistance Programs
CFM	Certified Floodplain Manager
CFS	Certified Floodplain Surveyor
CRS	Community Rating System
CTP	Cooperating Technical Partners
CWMS	(US Army) Corps (of Engineers) Water Management System
DFO	Designated Federal Officer
DSS-WISE™	Decision Support System for Water Infrastructure Security
EC	Elevation Certificate
FEMA	Federal Emergency Management Agency
FFRD	Future of Flood Risk Data
FIMA	Federal Insurance and Mitigation Administration
FIRM	Flood Insurance Rate Maps
FIS	Flood Insurance Study
FORM	First order reliability method
FRIS	Flood Risk Information System

FUB	Flood Uncertainty Band
H&H	hydrologic and hydraulic
HUC	hydrologic unit code
IT	Information Technology
Lidar	Light Detection and Ranging
LOMC	Letters of Map Changes
NFIP	National Flood Insurance Program
NGO	non-governmental organization
NHD	National Hydrography Dataset
NID	National Inventory of Dams
NLD	National Levee Database
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
NSI	National Structure Inventory
NWM	National Water Model
NWS	National Weather Service
PFRA	Probabilistic Flood Risk Assessment
PTS	Production and Technical Services
RiskMAP	Risk Mapping, Assessment, and Planning Program
RR2.0	Risk Rating 2.0
SFHA	Special Flood Hazard Area
SLR	Sea Level Rise
SLS	Sea Level Scenario
SLTT	state, local, tribal, and territorial
TMAC	Technical Mapping Advisory Council
USACE	US Army Corps of Engineers
U.S.C.	United States Code
USGS	United States Geological Survey
WSEL	Water Surface Elevation

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Background and Introduction

The year 2020 has been historic in many ways. While faced with a global pandemic, the United States (U.S.) also dealt with a record number of natural disasters that included significant flooding in such states as Louisiana, Texas, North Carolina, Florida, Alabama, Michigan, and Alaska. Flooding accounts for the majority of federally declared disasters that have caused over $155 billion in property damage in the past decade.

Helping Americans before, during, and after disasters is the Federal Emergency Management Agency's (FEMA's or Agency's) mission. Through the National Flood Insurance Program (NFIP) and the National Flood Mapping Program (Program), FEMA aims to provide comprehensive flood hazard and risk data to inform flood insurance and flood risk mitigation.

The Technical Mapping Advisory Council (TMAC or Council), a federal advisory committee, supports FEMA in its efforts by supplying review and recommendations on matters related to flood hazard and risk mapping as authorized and directed by the Biggert-Waters Flood Insurance Reform Act of 2012 (42 United States Code [U.S.C.] Sections 4001–4130) (BW-12), the Homeowner Flood Insurance Affordability Act of 2014, and Agency tasking.

1.1 / Background

BW-12 mandated that FEMA establish a federal advisory committee to review flood mapping and related products and to assess future conditions as they relate to flooding. Pursuant to BW-12, the charter filed with Congress on July 29, 2013, formally establishing the Council.

FEMA administers the NFIP through the Federal Insurance and Mitigation Administration (FIMA). Created with the passage of the National Flood Insurance Act of 1968, the NFIP is an insurance, mapping, and floodplain management program that makes federally backed flood insurance available to home and business owners and renters in communities that participate in the program. By participating in the NFIP, communities agree to adopt ordinances and enforce minimum building requirements that reduce the risk of flooding. TMAC sees elements of today's NFIP as a significant part of a new, much stronger foundation for an improved national flood risk management framework that recognizes the complex nature of flood risk and the diverse ways in which it is managed.

1.2 / TMAC Responsibilities

TMAC's Charter outlines the principles and functions of TMAC, including the objectives and scope of TMAC activities, description of duties, member composition, frequency of meetings, and other pertinent items related to TMAC's establishment and operation.

TMAC's bylaws establish and describe rules of conduct, regulations, and procedures regarding its membership and operation.

Since its establishment in 2014, TMAC has delivered seven reports to FEMA that provide recommendations on a broad range of topics that are interrelated. These past reports can be found on FEMA's TMAC website.

The 2020 TMAC members, subcommittee members, and designated federal officers (DFOs) are listed below in Table 1 through Table 3.

1.3 / TMAC Members and Designated Federal Officers

The 2020 TMAC members, subcommittee members, and designated federal officers (DFOs) are listed below in Table 1 through Table 3.

Table 1 / TMAC Member List

MEMBER NAME	JOB TITLE, COMPANY/AGENCY	BW-12 MEMBERSHIP TITLE
Douglas Bellomo (TMAC Vice Chair)	Vice President, AECOM	Engineering Member
Nancy Blyler	Physical Scientist, USACE	US Army Corps of Engineers Representative
Scott Giberson	Compliance Principal, CoreLogic Flood Services	Flood Hazard Determination Firm Member
Jeffrey Giering	State Hazard Mitigation Officer –Louisiana Governor's Office of Homeland Security and Emergency Preparedness	State Hazard Mitigation Officer
David Guignet	State NFIP Coordinator, Maryland Department of the Environment	State Cooperating Technical Partner Representative
Suzanne Jiwani	Floodplain Mapping Engineer, Minnesota Department of Natural Resources	Floodplain Management Member
Carey Johnson	Environmental Scientist Consultant Senior, Commissioner's Office, Kentucky Department for Environmental Protection	State Cooperating Technical Partner Representative
Carolyn Kousky	Executive Director, Wharton Risk Center	Risk Management Member
Tony LaVoi	Geospatial Information Officer, National Oceanic and Atmospheric Administration (NOAA), Office for Coastal Management	National Oceanic and Atmospheric Administration/Commerce for Oceans and Atmosphere Designee
David Love	Project Manager, Engineering and Mitigation Program, Mecklenburg County Storm Water Services	Local Cooperating Technical Partner Representative
Robert Mason	Extreme Hydrologic Events Coordinator, U.S. Geological Survey	U.S. Department of the Interior Designee
Salomon Miranda	Water Supply Evaluations Section Chief, California Department of Water Resources	State National Flood Insurance Coordination Office Representative
James Nadeau	Owner, Nadeau Land Surveys	Surveying Member
Ngoc Nguyen	Civil Engineer, Santa Clara Valley Water District	Local Cooperating Technical Partner Representative
Jon Paoli	Communications & Technology Bureau Chief, Iowa Homeland Security & Emergency Management Department	State Geographic Information System Representative
Luis Rodriguez	Director, Engineering and Modeling Division, FEMA	Federal Emergency Management Agency Designee
Jonathan Smith	Director, Resource Inventory Division, Natural Resources Conservation Service	U.S. Department of Agriculture Designee
Jeffrey Sparrow (TMAC Chair)	Senior Vice President, Moffatt & Nichol	Mapping Member

MEMBER NAME	JOB TITLE, COMPANY/AGENCY	BW-12 MEMBERSHIP TITLE
Joshua Stuckey	Chief Administrative Officer, Harris County Engineering Department	Regional Flood and Storm Water Management Member
Michael Tischler	Director, National Geospatial Program, USGS	U.S. Geological Survey Representative

Table 2 / Subcommittee Lists

TMAC 2020 SUBCOMMITTEE: **STAKEHOLDER ENGAGEMENT**	
Doug Bellomo	Subcommittee Co-Chair/ Subcommittee Member
Nancy Blyler	Subcommittee Member
Jeffrey Giering	Subcommittee Member
Dave Guignet	Subcommittee Co-Chair/ Subcommittee Member
Tony LaVoi	Subcommittee Member
David Love	Subcommittee Member
Jim Nadeau	Subcommittee Member
Jonathan Paoli	Subcommittee Member
Luis Rodriguez	Subcommittee Member
Joshua Stuckey	Subcommittee Member

TMAC 2020 SUBCOMMITTEE: **FRAMEWORK DEVELOPMENT**	
Scott Giberson	Subcommittee Member
Suzanne Jiwani	Subcommittee Member
Carey Johnson	Subcommittee Co-Chair/ Subcommittee Member
Carolyn Kousky	Subcommittee Member
Robert Mason	Subcommittee Member
Salomon Miranda	Subcommittee Co-Chair/ Subcommittee Member
Ngoc Nguyen	Subcommittee Member
Jonathan Smith	Subcommittee Member
Jeff Sparrow	Subcommittee Member
Michael Tischler	Subcommittee Member

Table 3 / Designated Federal Officers

NAME	FEMA TITLE	DESIGNATED FEDERAL OFFICER (DFO) / ALTERNATE DFO (ADFO)
Michael Nakagaki	Senior Policy Advisor, Federal Insurance and Mitigation Administration (FIMA)	DFO
John Ebersole	Attorney, FIMA Legal Division	TMAC Legal Counsel/ADFO
Brian Koper	Emergency Management Specialist, FIMA	ADFO
Sarah Abdelrahim	Emergency Management Specialist, FIMA	ADFO

1.4 / Acknowledgements

TMAC would like to acknowledge the efforts of several Subject Matter Experts and support staff, without whom this report would not have been possible. Will Lehman is a flooding and risk expert with the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center, and was instrumental in the development of many sections of this report, providing expertise and context, and helping to develop much of the content throughout Chapters 3 and 4. The Production and Technical Services (PTS) support staff also provided exceptional support throughout the process of writing this report. Jen Marcy developed and executed the stakeholder engagement process that built the foundation of this report. Phetmano Phannavong coordinated and supported Subcommittee 1, responsible for Chapter 3. Molly Tuttle, Ryan O'Connor, and Heidi Carlin were responsible for coordinating and supporting Subcommittee 2, responsible for Chapter 4, and also led the effort of editing and revising this report and developing the graphics and layout for the entire document. Thank you as well to Henry Cauley and Alexis Richmond and the rest of the TMAC Project Management Team for their efforts in coordinating the many logistical requirements of the Council.

1.5 / 2020 TMAC Focus

Each year, FEMA asks TMAC to focus its efforts in specific areas as a complement to efforts FEMA is undertaking to adapt and improve delivery of the NFIP. In 2020, FEMA tasked TMAC with the following tasks:

1. Work with stakeholders to identify best practices that can be incorporated into a future flood hazard and flood risk identification program that will equip them to:
    - Understand flood hazards in a graduated way;
    - Identify flood risk to improved property in a graduated way; and
    - Promote increased investments in flood mitigation through new incentives.
2. Provide a framework for FEMA to transition to future flood hazard and flood risk identification initiatives through the following activities:
    - Identifying obstacles;
    - Highlighting opportunities;
    - Identifying useful portions of the current program that are important to continue; and
    - Proposing specific roles that could be played by state, local, tribal, territorial (SLTT), private, nonprofit, academic, and other entities in assessing, communicating, and managing flood hazards and risks.

In addition to working with key stakeholders, FEMA asked that the following elements be considered by the TMAC in its efforts:

- Gather input on the Program's transition from a binary understanding of flood hazards to a graduated flood risk approach
- Ensure a significant and appropriate role for the private sector and for SLTT entities
- Increase access to flood hazard data to improve resulting mitigation and insurance actions at the local and private levels
- Modernize the management and delivery of the flood hazard mapping program

TMAC responded specifically to this tasking in developing this report. While this is not necessarily representative of the absolute priorities of the Council, it is a reflection of the shared priorities of TMAC and FEMAas communicated through the tasking letter.

1.6 / Overview of 2020 TMAC Report

The 2020 TMAC report covers the work by TMAC subcommittees and members to address FEMA's priorities and provide three recommendations. The report details TMAC's extensive outreach and findings with key stakeholder groups, approaches and recommendations for the future flood hazard and flood risk identification program, and a framework for FEMA to transition to the envisioned flood hazard and flood risk identification program.

1.6.1 / Key Concepts & Assumptions for TMAC 2020

There are several key terms and concepts used by TMAC throughout this report whose intended meanings are worthy of clarifying. This includes areas related to the National Flood Mapping Program and the authority FEMA has to create maps under NFIP, the meaning of "binary versus graduated," and how that is different from what is meant when TMAC addresses "probabilistic versus deterministic."

National Flood Mapping Program

The term "National Flood Mapping Program," as used in BW 12, has been defined as the existing national program involved in flood mapping. FEMA executes the responsibility of flood mapping through the Risk Mapping, Assessment, and Planning (Risk MAP) program. In this TMAC report, "Future of Flood Risk Data" (FFRD) refers to the future vision of the program, and how leveraging new technologies to provide flood information is more efficient, accurate, and consistent with the goal of a more flood resilient nation.

Binary Risk Versus Graduated Risk

In 1968, with the passage of the National Flood Insurance Act of 1968, Congress tied minimum federal standards for local community enforcement of floodplain management to local community participation in the NFIP. In 1973, the National Flood Insurance Act was amended to establish *areas of special flood hazards* as the areas in which these minimum floodplain management standards and the newly established mandatory purchase of flood insurance requirement would be enforced. By doing so, this effectively establishes in statute a binary approach to considering flood risk, which is used today to understand and enforce compliance with the standards and requirements of the NFIP. However, flood risk is more graduated than the "in/out" dichotomy of the statute; therefore, a graduated depiction of that risk is important to communicate flood hazards more effectively. The shift from a binary to graduated depiction and communication of risk includes using data and tools that can enhance understanding of the probability of flood scenarios beyond the current practice of binary risk assessment.

Probabilistic Approach Versus Deterministic Approach

In this report, the term "probabilistic approach" refers to the practice of taking a variety of input parameters to yield a variety of potential outcomes. These many outcomes are compiled and represented through probabilities. On the other hand, a deterministic approach uses one set of input parameters to yield a single given outcome, an example of which is the 100-year floodplain, or the Special Flood Hazard Area (SFHA). Section 3.2 covers this issue in greater detail.

As part of the 2020 tasks from FEMA, TMAC was asked to "*work with stakeholders to identify best practices that can be incorporated into a future flood hazard and flood risk identification program.*" Through our stakeholder outreach, TMAC concludes it to be more appropriate to use such terms as "current practices" or "applied approaches" in floodplain mapping rather than "best practices."

1.6.2 / TMAC 2020 Annual Report Outcomes

In this report, TMAC offers three recommendations as to how FEMA can work with stakeholders to identify approaches that could be incorporated into a future flood hazard and flood risk identification program, and also provides a framework for FEMA to transition to the envisioned flood hazard and flood risk identification program. Key and specific obstacles, opportunities, and current practices are offered, including how to engage key players in assessing, communicating, and managing flood hazards and risks in the future. The TMAC 2020 recommendations are shown in Table 4.

Table 4 / TMAC Recommendations 2020

TOPIC	RECOMMENDATION	
Risk Management	AR 35	TMAC recommends that FEMA explore how to implement enterprise risk management frameworks that help communities whose objectives are to become more flood resilient and to transition toward proactive flood risk management while meeting or exceeding existing minimum federal floodplain management requirements.
Products	AR 36	TMAC recommends that FEMA develop a set of integrated floodplain management- and mitigation-focused prototype products and services that help stakeholders better understand, communicate, and manage their current and future flood risks.
Partnerships	AR 37	TMAC recommends that FEMA utilize the Cooperating Technical Partners and other partnerships for the implementation of this transition and investigate ways to incorporate data and technology from other stakeholders such as regional and local governments; state and federal agencies; and academic, nonprofit, and private stakeholders.

AR = Annual Recommendation

2

Stakeholder Engagement

In the 2020 tasking from FEMA, TMAC was asked to work with stakeholders to provide programmatic insights on mitigation incentives, recommended practices for incorporation into future efforts that will include graduated risk understanding and a risk-informed NFIP, and feedback on obstacles, opportunities, and roles for stakeholders across all elements of the program. There are numerous benefits to conducting a broad stakeholder engagement program, including the following:

- Gathering perspectives and insights from the primary users of FEMA's data and products;
- Allowing TMAC to make informed decisions on recommendations to incorporate into the 2020 report;
- Building trust and goodwill with stakeholders whom TMAC hopes to continue to engage in future years; and
- Providing transparency and accountability.

2.1 / Overview of Framework

The goal of TMAC's 2020 stakeholder engagement plan was to identify best practices to equip stakeholders for understanding flood hazards and flood risks in a graduated way; promote increased investments in flood mitigation; and identify obstacles, opportunities, and roles for stakeholders across all elements of the program.

The engagement plan was based on a three-pronged, virtual approach that began with a large group of survey participants from across the spectrum of identified stakeholders. Those survey participants willing to continue in the engagement process were invited to take part in one of a series of webinars intended to further explain the proposed shift from binary to graduated risk and solicit more detailed feedback than was obtainable from the survey. Finally, several focus groups, based on the members' professional roles, met to discuss in detail the proposed shift and related concerns. A schematic diagram of the engagement plan is provided in Figure 1.

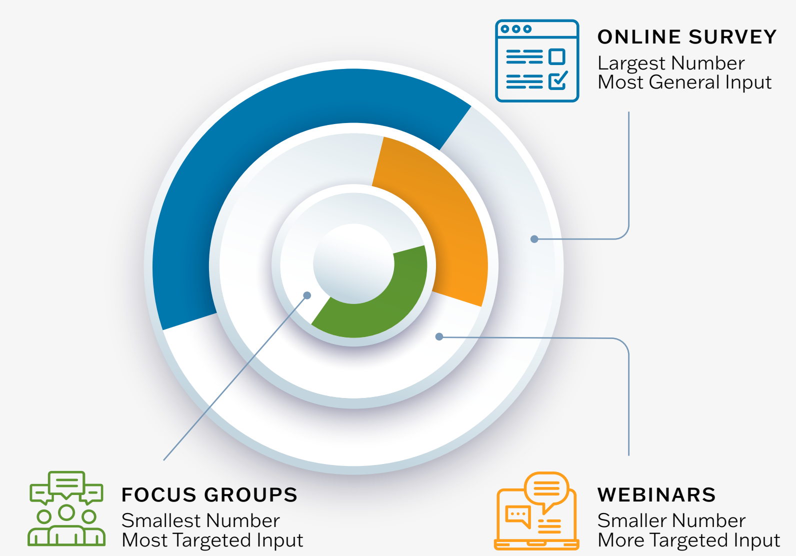


Figure 1 / TMAC stakeholder three-element engagement plan

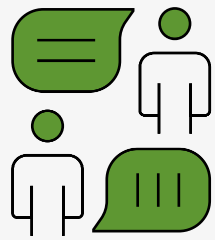
2.1.1 / Online Survey

The online survey focusing on the shift from binary to graduated was made public in July 2020 and remained open until August 31, 2020. It was announced to identified stakeholder groups by TMAC members with ties to the specific associations or other affiliations (e.g., surveyors, mapping contractors, local floodplain managers). The nature of the survey questions is summarized in Figure 2 and a summary of the survey participants is shown in Figure 3.

Figure 2 / Online survey areas of focus

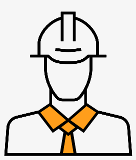
Online Survey Data

781 total responses recorded



75% of respondents reported having the Certified Floodplain Manager (CFM) accreditation

The most common job functions:



Engineer

28% of participants

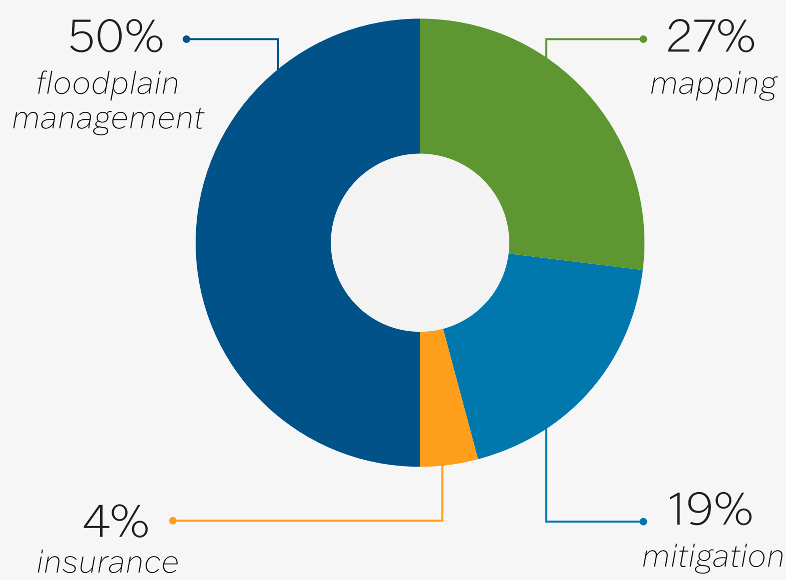
Floodplain Administrators

19% of participants

Land-Use Planning/ Zoning Official

8% of participants

Respondent indentification regarding NFIP program elements:



Refer to Appendix D; raw survey data is also available at this webpage.

Figure 3 / Online survey data

A total of 781 responses was recorded. The most common job functions reported by survey participants were engineer (28 percent of participants), floodplain administrators (19 percent), and land-use planning/zoning officials (8 percent). Seventy-five percent of respondents reported having the Certified Floodplain Manager (CFM) accreditation. With regard to NFIP program elements, 50 percent of respondents identified with floodplain management, 27 percent with mapping, 19 percent with mitigation, and 4 percent with insurance. A summary and analysis of all responses, including primary job functions, roles of respondents, and the findings supporting all six areas of focus in Figure 2, are provided in Appendix D. The raw survey data are also available at this webpage.

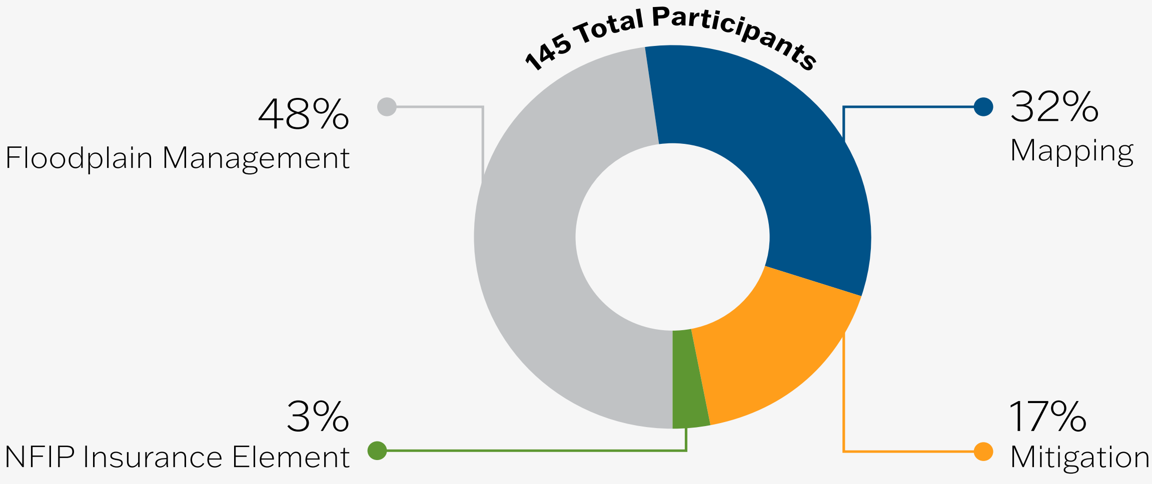
2.1.2 / Webinars

On August 14, 2020, and again on September 24, 2020, webinars were presented to the survey participants that had indicated an interest in learning more about the proposed shift from binary to graduated risk. Webinar content began with an introduction to the purpose of TMAC and to the 2020 tasking memo. This was followed by a discussion of deterministic versus probabilistic methods and how FEMA is proposing to move toward a graduated understanding of flood risk. Multiple-choice answer polls were interspersed among the presentation material, and the sessions concluded with a series of free-response (open-ended) questions, all intended to extract greater detail on issues identified in the initial survey. Those questions were as follows

- "In a flood hazard mapping sense, what should FEMA allow state, local, tribal, and territorial governments, private, academia, etc. stakeholders to do more of—or to do more independently?”
- “How can FEMA create a more consistent flood risk message in the context of flood insurance, floodplain management, flood hazard mapping, and flood mitigation?”
- “How should FEMA utilize flood hazard mapping to enhance floodplain management and flood hazard mitigation?”
- “Is there some topic that you think TMAC should address next year?”

Between the two sessions, there was a total of 145 webinar participants, of which 48 percent identified with floodplain management, 32 percent with mapping, 17 percent with mitigation, and 3 percent with the insurance element of the NFIP.

Graphical representations of the full range of responses to the multiple-choice polls and both categorized and raw responses to the free-response (open-ended) questions are provided in Appendix D, as well as a link to the raw data and a recording of one of the webinars.



Webinar Participation

2.1.3 / Focus Groups

A series of focus group meetings were held in November and December 2020 to provide a deeper understanding of the survey and webinar participant responses regarding binary versus graduated flood risk and to supplement information obtained from the survey and webinars. An important focus group objective was to gain further insights into stakeholder needs, specifically as they relate to products that support a graduated view of flood risk. In addition, the focus groups were conducted to facilitate better understanding of the following:

- Important floodplain and flood risk management objectives key stakeholders wish to achieve (e.g., supplying accurate flood risk information, reducing flood risk and associated impacts, implementing higher standards compliance procedures, enhancing emergency response procedures);
- The roles of different stakeholder groups and interdependencies among them to achieve better understanding of flood risk and actions leading to reducing flood risk;
- The resources that are needed to accomplish these objectives (e.g., flood risk products, tools, best practices, guidance, technical assistance);
- The obstacles standing in the way of accomplishing priority objectives; and
- What is needed to overcome these obstacles.

Details about the focus groups, including participation information, questions posed, and a summary of findings, are included in Appendix D.

2.2 / Key Findings and Stakeholder Insights

The 2020 stakeholder engagement effort resulted in tens of thousands of data points, including tabular data from 22 multiple-choice questions (14 from survey, eight from webinar), hundreds of free text responses to five open-ended questions that were read, sorted, and categorized to identify trends and key insights, and multiple iterations of white boards illustrating conversational feedback from 27 different probing questions covering the five focus groups that were assembled in late 2020.

Throughout this report, specific survey insights, relevant quotes, and key findings from all elements of the stakeholder engagement exercise, are highlighted using easily identifiable graphic elements, shown below:

Survey Insight

Key Finding

Quote

The key findings are crucial higher-level concepts which served to inform TMAC as it considered its formal recommendations to FEMA. These findings represent comments and ideas that were repeated by multiple stakeholders throughout the engagement and via multiple means (e.g., survey, free text, webinars, and focus groups) and therefore emerged as common and critical themes. Below are the key findings which are interspersed in the report.

KEY FINDING

Big Picture vs. Narrow Details

Across the program, most stakeholders are hopeful about the shift to graduated risk and see positive **programmatic benefits** to doing so (*survey, free text, webinars, focus groups*), but are apprehensive about how the shift will impact **their daily activities** (*free text, focus groups*). Stakeholder apprehensiveness could be lessened with the rollout of further details as they become known, including specific timing and a clear plan for the phasing out of current program elements and the phasing in of new ones. (*focus groups*).

KEY FINDING

Flexibility

Stakeholders **prefer flexibility across all areas** of the program: in mapping processes (streamlining cumbersome processes, community-driven products, and updates), in products/data (tools versus static products and matching products to community needs), and in services the program provides (including tailored technical assistance). Insurance and floodplain management program flexibility is also encouraged (*free text, webinars, focus groups*).

KEY FINDING

Programmatic Alignment

Stakeholders acknowledged that graduated risk information could be beneficial for all program elements (Mapping, Insurance, Floodplain Management, and Mitigation), but cited lack of clarity on how **all elements of the program are working together** (for example, how new products will impact floodplain management, regulations, lender requirements, and grants) and stressed the importance of programmatic alignment, especially with mitigation (*free text, webinar, focus groups*).

KEY FINDING

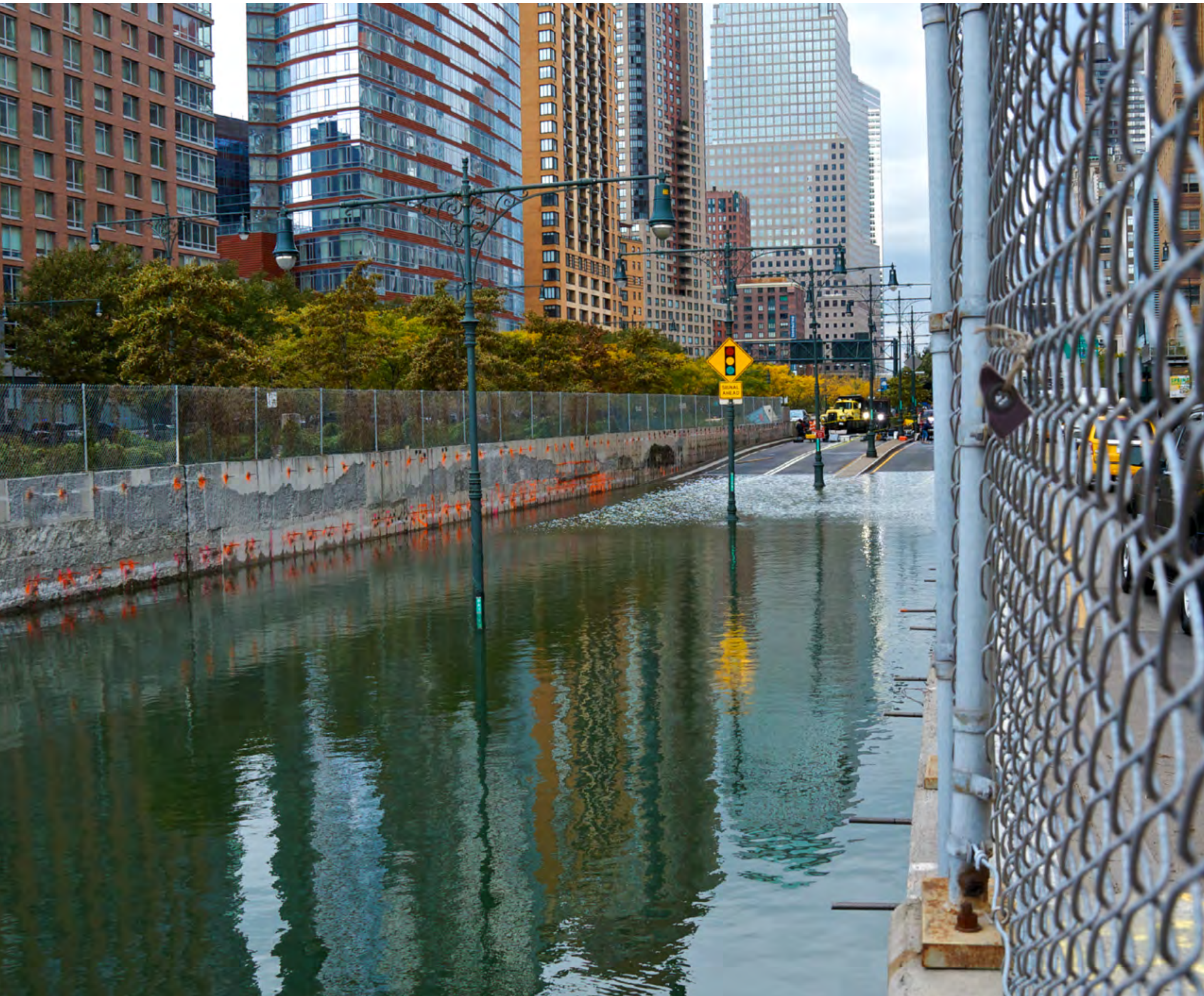
Risk Communication

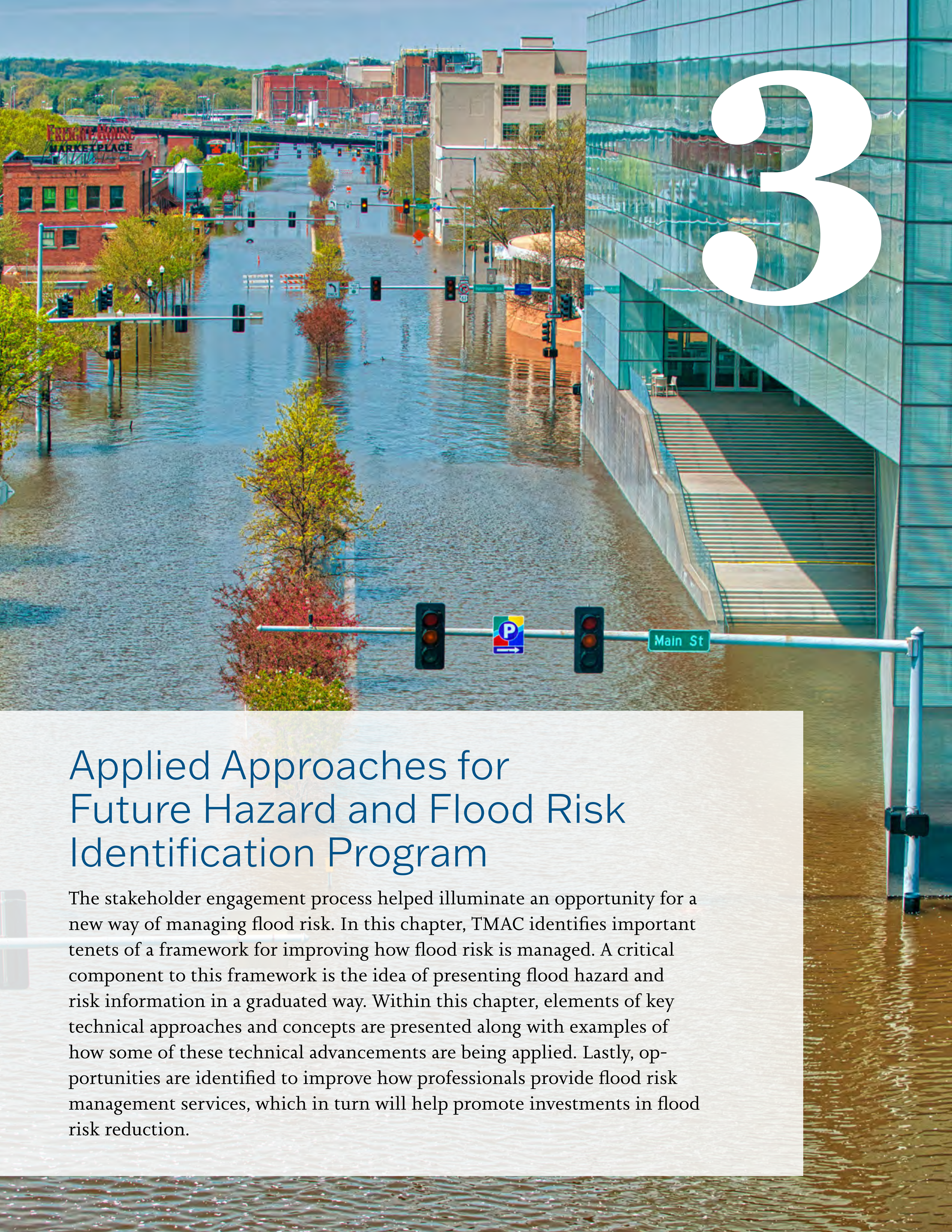
Stakeholders expressed a need for future products to communicate risk clearly and for risk **communication to be an important element of the shift.** This includes providing proper messaging for primary stakeholders to use when communicating with non-technical audiences and incorporating risk communication principles into new products/data displays (*survey, free text, webinar, focus groups*).

2.3 / TMAC's Commitment to Continuing Stakeholder Engagement

The 2020 stakeholder engagement effort resulted in the compilation of numerous insights and findings, and uncovered issues and obstacles that might not have been apparent without the stakeholder feedback TMAC received. TMAC is committed to continuing to engage stakeholders because their experiences and insights are important considerations as TMAC develops recommendations for FEMA now and in the future.

From the 2020 engagement effort, TMAC realizes that certain cohorts of stakeholders are more likely than others to engage in efforts to discuss the future of FEMA's mapping program. These more active groups include engineers, floodplain managers, and land-use officials. The input from these professionals is critical and TMAC looks forward to continued engagement with the group. In addition, TMAC hopes to increase its engagement and elicit more active participation in the future from professionals in stakeholder groups associated with the insurance part of the program, including insurance professionals, real estate agents, lenders, appraisers, and others.





3

Applied Approaches for Future Hazard and Flood Risk Identification Program

The stakeholder engagement process helped illuminate an opportunity for a new way of managing flood risk. In this chapter, TMAC identifies important tenets of a framework for improving how flood risk is managed. A critical component to this framework is the idea of presenting flood hazard and risk information in a graduated way. Within this chapter, elements of key technical approaches and concepts are presented along with examples of how some of these technical advancements are being applied. Lastly, opportunities are identified to improve how professionals provide flood risk management services, which in turn will help promote investments in flood risk reduction.

3.1 / An Opportunity for A New National Flood Risk Management Framework

In his February 12, 2020, memo to TMAC, Mike Grimm, the Assistant Administrator for Risk Management for FIMA, specifically requested TMAC to *"work with stakeholders to identify best practices that can be incorporated into a future flood hazard and flood risk identification program that will equip them to"* understand flood risks and hazards in a graduated way and promote increased investments in flood mitigation. A natural starting point for TMAC in meeting this objective was to develop a description of what a National Flood Mapping Program might look like in the future. To aid in this, TMAC took a clean slate approach unencumbered by the practical realities and challenges associated with the financial and legal constraints of the current program.

Nonetheless, TMAC has considered the fact that FEMA has launched multiple initiatives to transform the NFIP into a risk-informed program that will reduce disaster suffering. One of the initiatives leading the NFIP transformation, called Risk Rating 2.0 (RR2.0), includes establishing a new, modernized approach for pricing flood insurance. The RR2.0 initiative, the above charge from Mike Grimm, and the availability of a suite of new technologies creates a unique opportunity to focus flood data and map uses more on the needs of floodplain managers, emergency managers, and others who have come to rely on the information to save lives, reduce human suffering, and lessen the damage caused each year by flooding. Specifically, there is an opportunity to leverage new ideas and technologies so that the Program becomes less about pricing insurance and more about helping state government, tribal nations, local communities, business owners, landowners, and others to more effectively manage their flood risk going forward.

KEY FINDING

Programmatic Alignment

While the *Risk Rating 2.0* supporting data is key to providing future graduated flood hazard and risk data and products, the connection is not clear from the stakeholder point of view.

With this opportunity in mind, TMAC adopted, by vote, the following vision for a future state of FEMA's current mapping programs. TMAC adopted this vision to guide its efforts this year and to provoke thought on what execution of FEMA's current authorities might look like in the future: **a more flood-resilient nation.**

The above vision statement is clear and straightforward. The focus on increasing resilience is deliberate, and intended to lead to improvements in our nation's ability to prepare for, withstand, recover from, and adapt to current and future flood threats. The vision acknowledges that there are parts of our nation that are resilient, but that many areas remain vulnerable. Importantly, it suggests a continuous striving for improvement, while recognizing that becoming completely flood proof is not possible. Moreover, TMAC believes FEMA's mapping authority under NFIP and through the Program authorized in Section 216 of BW-12, is sufficient to make progress on this vision going forward.

Vision for a Future Mapping Program:

A more flood resilient nation

A central theme to this vision and many of the prior TMAC recommendations has involved the development and display of flood hazards and risk data that are graduated and more complete, rather than the binary and limited view presented in

SURVEY INSIGHT

Stakeholders rated the expected usefulness of graduated data to meet their floodplain or flood risk management needs to be 19 percent higher than the usefulness of the current binary data.

current depictions of today's "Special Flood Hazard Areas." Although current laws, regulations, and NFIP practices use this binary view to implement the mandatory flood-insurance purchase requirement and floodplain management regulations, new technologies are facilitating improved assessment of flood hazards and methods for managing flood risks. These technologies, coupled with FEMA's efforts to implement the RR2.0 initiative, make it possible to create an improved national flood risk management framework that is more modern and effective than the de facto and somewhat unintentional framework that emerged from the creation of the NFIP in the late 1960s.

TMAC sees the Program and elements of today's NFIP as a significant part of a new, much stronger foundation for an improved national flood risk management framework that recognizes the complex nature of flood risk and the diverse ways in which it is managed. This new framework should not be built on an unrealistic and incomplete binary view of flood hazards and risks. Rather, it should be built on the reality that flood hazards and their associated risks are inherently uncertain, lie on a continuum ranging from low to high probability, and change with time.

3.1.1 / Important Tenets

TMAC envisions this new national framework for managing flood risk as being built upon existing programs; however, adoption of other important tenets are key to increasing awareness of the value of healthy functioning floodplains while also reducing human suffering, economic loss, and environmental damage resulting from flooding. These tenets are illustrated in Figure 4 and include facilitating expanded partnerships and collaborations, acknowledging the existence of flood hazards across the full range of natural variability that communities face, enabling people to make risk-informed (rather than just hazard-aware) decisions, building adaptive infrastructure, and others as outlined below. These tenets are not listed in order of priority or importance; rather, they must all be advanced in order to make progress toward the vision: A more flood-resilient nation. Indeed, flood resilience is best achieved through strong partnerships and collaboration, leading with data and science, focusing on user needs, adapting strategic approaches over time, and valuing the natural and beneficial functions of floodplains.

Figure 4 / Key elements of a new flood risk management framework

1. Partnerships and Collaboration

   Flood risk management is a shared responsibility. While all levels of government play a critical role, the responsibility does not end there. Corporate leaders, philanthropic organizations, academics, and individuals each play a part in managing flood risks. Collectively well-rounded teams of government and non-government groups are most effective when it comes to increasing preparedness, mitigating risks, responding to unfolding events, and recovering after disaster strikes. Given this fact, partnerships and a focus on collaboration are key to ensuring flood risks and hazards are credibly assessed, effectively communicated, and acted upon in a way that suits those sharing in the flood risk management challenge. Ideally, any partnerships formed would lead to outcomes where those receiving the greatest benefits shoulder an appropriate share of the effort, and those at greatest risk have a voice in expressing the challenges and shaping the solutions brought to bear—regardless of their social or economic status.

2. Acknowledge the Natural Variability of Flood Hazard More Completely

Flooding is possible throughout communities, although the annual probability of flooding is not the same for every location. Historically, the NFIP has focused on a narrow sliver of the flood-hazard probability space—primarily, the 1-percent-annual-chance flood. Larger floods are inevitable. Indeed, approximately 40 percent of NFIP claims filed between 2015 and 2019 were outside the mapped 1-percent-annual-chance floodplain. Achieving a more effective NFIP requires the identification of the expected extent of these larger, but rarer, flood hazards so that individuals and communities can assess the risks they face and take action to mitigate those risks. Providing such information will require modeling and mapping far more of the community, including the portions that lie above and below the 1-percent-annual-chance floodplain.

3. Make Risk-Informed Decisions

Nothing is done without risk, and regardless of where a community's tolerance for flood risk might lie, it is critical for those making choices about their homes, money, impacts on the natural environment, and life safety to have some understanding of the hazards and subsequent risks they face in making those choices. Enabling people to make risk-informed decisions means providing them with data and information that is current, credible, relevant, and understandable in the context of the choices being made. Importantly, these choices need to be informed with estimates of both current and future risk to the environment, people, and the economy, given our understanding of possible changes in both the climate and the built environment. This means that individuals and communities must be given more than flood hazard maps. They will need maps, simulations, and loss estimates that illustrate the resources that are threatened by flooding, and the potential consequences. This information is not only needed for the current condition (an absolute minimum requirement) but also be projected into the future to avoid unchecked growth in risk over time.

KEY FINDING

Risk Communication

In addition to maps, simulations, and loss estimates, primary stakeholders say they need messaging, tools, and support for communicating risk to secondary (often non-technical) stakeholders such as homeowners, elected officials, and developers.

4. Adaptive Strategies

Regardless of how credible, relevant, and understandable our estimates of current and future flood risks are, information changes over time. Technological advances, physical changes to the landscape and built environment, and new experiences shape and continue to re-shape our understanding of flooding and its consequences. Any effective strategy for managing flood risk must include a process for both routine updates and event-driven updates (e.g., updates following potentially significant changes in flood risk due to wildfires, major floods that change our understanding of flood probability, major flood infrastructure investments, and more). In fact, the best strategies will anticipate such events and promote adjustments to capitalize on them.

5. Natural and Beneficial Floodplain Functions

In addition to reducing the frequency and severity of floods, natural floodplains play an important role in maintaining water quality and recharging groundwater. They also provide areas for nature to thrive and people to recreate. It is important that flooding and floodplains also be viewed as providing valuable services, thereby acting as assets in meeting a multitude of objectives from improving water quality and supply to providing space for people and nature to thrive. Making room for floodplains so that storm surges, river flooding, and excessive rainfall can be absorbed naturally reduces human suffering and economic loss while improving the quality of life for people, plants, and animals.

SURVEY INSIGHT

New products should be developed with end users in mind: how they think and behave, and what will lead to mitigation actions.

6. User-Centric Design

In the past, TMAC has written extensively for a large and growing set of flood hazard and risk data consumers. Modern data development and delivery mechanisms offer opportunities for FEMA and its partners to serve information that is fit for use without having to develop a one-size-fits-all product. This is particularly true with the advancement of probabilistic flood risk assessments, for which significant amounts of flood hazard and risk data are developed and can be served in smart ways to inform emergency managers responding to an unfolding event, floodplain managers looking to assess current and future flood risks, property owners seeking to better understand their risks, homebuyers wanting to make an informed choice, lenders looking to understand risk to their portfolios, and infrastructure design professionals. By using modern technology and looking through the lens of users beyond the historical insurance pricing focus, FEMA can improve the way it serves the nation in its mission to reduce flood risk.

The above tenets are critical and work together to form a cohesive launching pad for a new and improved national framework for managing flood risk. New technology, consistently rising flood damage, and an appetite for change have made it possible to create an improved national flood risk management framework that is more modern and effective. That framework must be built on the reality that flood hazards and risks change with time, form a continuum from high to low, and are by their nature uncertain. Both the National Flood Mapping Program and elements of today's NFIP can be used to form a strong foundation for an improved national flood risk management framework that is less focused on the price of insurance and more focused on the needs of floodplain managers, emergency managers, and others who require better information to save lives, reduce human suffering, and lessen the damage caused each year by flooding.

3.2 / Understanding Flood Hazards and Risks in a Graduated Manner

In an effort to describe flood hazards and risks in a graduated manner, the following section outlines the current practice, points out differences between the binary view and a graduated view, discusses the usage of deterministic modeling versus probabilistic modeling, and provides remarks for how to connect the output from probabilistic risk-based methods to support decision makers and regulatory programs.

3.2.1 / Current Practice of Presenting Flood Hazards and Risks in a Binary Manner

NFIP maps that are used to define regulatory floodplains were created under a common set of standards and federal guidelines. These standards and guidelines model floodplain extent based on past events and standards, which represent a subset of available data. These maps generally limit consideration of flooding to a single frequency-based event and occasionally fail to stay up to date with changes in conditions, including land surface changes that can increase runoff (e.g., wildfires or new development) as well as quantifiable changes in climate patterns. While they can inform users of current flood hazards and risks, the current NFIP data and associated Flood Insurance Rate Maps (FIRMs) are largely developed to facilitate insurance pricing, and compliance with the statutory flood insurance purchase requirement and minimum floodplain management requirements tied to program participation. These requirements and the maps/data used to facilitate their implementation have led to a binary view of flooding (e.g., users focus on determining if a property is inside or outside of the mapped floodplain) based on a metric described by a singular deterministic flood frequency (the 1-percent-annual-chance flood), which fails to communicate the most important thing known about potential flooding: floods do not respect the SFHA boundary; bigger floods are inevitable even without increased basin development or climate change.

Floods outside of the SFHA can cause significant loss to any given community in any given year. This in no way denigrates the methods employed or the technical competence of those identifying SFHAs; rather, it speaks to the limited utility of the SFHA, which is largely a tool for administering legal mandates rather than facilitating risk-informed decisions and improved flood risk management. As mentioned above, FEMA has created an opportunity to present flood hazards and risks in new ways and is providing room for improving communication and risk management strategies by considering flood hazard and risk information beyond the SFHA.

Moreover, the current binary nature of the SFHA and focus on flood insurance can undercut effective and efficient flood damage mitigation by suggesting minimum federal floodplain management standards are "good enough" when cases arise where a more proactive and forward-looking flood risk management practice is warranted. Furthermore, communities who adopt the federal minimum standards for participation in the NFIP are regulating based on a single flood metric (e.g., the best estimate of the 1-percent-annual-chance flood). By doing so, they may be ignoring the reality that flooding beyond the SFHA should be expected. The net result is that the public gets a false sense of security and are surprised and unprepared when flooding above and beyond the SFHA happens, and federal minimum floodplain management requirements are found to be insufficient at avoiding or reducing flood losses. This leads to a lack of confidence in the data, and in the federal government more generally, for not setting standards sufficient to have avoided flood damage, rather than a correct recognition that the standard was not designed to provide complete protection. The problem is not the mere regulation of risk, but its perception. This is a particularly disturbing reality for local officials who may have thought the federal minimums provided adequate risk mitigation as they made decisions on how and where to build—a serious responsibility that is fundamentally about making tradeoffs between short-term gains and longer-term prosperity. Without a complete picture of flood hazards and risks that describes the full range of possibilities and acknowledges that uncertainties exist, the land-use and building code choices made by state, local, and tribal officials are a dangerous guessing game. With a fuller picture of the hazards and risks and better understanding, these same officials can make more informed choices and properly balance risks and rewards, particularly in situations where their tolerance for risk may be lower than that prescribed by any given set of federal minimum requirements.

In summary, FIRMs and specifically their SFHAs answer the question: What properties are most likely to be flooded by the 1-percent-annual-chance flood? The answer to that question helps identify individual prop-erties subject to the mandatory flood insurance requirement or floodplain management regulations, but it does not inform the overall community about the full range of dangers from flooding. Address-ing that need requires answers to other questions, such as: What is the chance that any property in the community will be flooded? And: What are the potential damages associated with those floods? Systematically answering those questions is best handled by a shift from a binary depiction of flood hazards and risks to a graduated depiction as described below.

3.2.2 / Graduated Flood Hazards and Risks

Flood hazards impact the entire United States at varying levels of frequency and intensity. They vary from infrequent and severe to frequent and less severe based on many geophysical interactions. This variation of severity and frequency is continuous and graduated, and should be represented as such, contrary to present NFIP practices.

"I strongly support this shift. The binary approach has actually been counterproductive to managing flood risk in America. A graduated flood hazard and insurance rate approach will incentivize the public and local governments to make better decisions related to managing their flood risk."

Furthermore, flood severity can be intersected with geospatial locations attributed with value and vulnerability information, allowing analysis of potential property losses due to flooding. Scaling the consequence estimates by the frequency of flooding can produce an estimate of risk. Risk of flooding at a building may be different from that of a neighboring structure due to differences in structure valuation, vulnerability of the structure itself to flood damage, and flood hazard severity. Risk varies from low to high in a graduated way, but because risk is largely structure specific, the spatial depiction of differences in risk may not be as smooth as depictions of flood hazard (e.g., two neighboring structures may have the same hazard severity and frequency, but they may differ in construction and valuation, therefore vulnerability and significance, thus expressing different risks).

It is critical to recognize the factors that influence the graduated nature of flood hazards and flood risks. To produce a graduated view of flood hazards, the evaluation must span the entire variability in the range of potential flooding—from the typical annual flood normally contained within the river channel to floods of much greater magnitude that may inundate large portions of a watershed and the communities within it. This expanded range in flood sampling and simulation within flood modeling software is fundamental to developing graduated hazard and risk products and may require more frequent extrapolation of flood estimates beyond levels previously employed to produce SFHA maps. This extrapolation may result in greater uncertainty in the map products. In the interest of transparency, the impact of uncertainty in the process of computing flood hazard frequencies or flood damage frequencies must be included in the evaluation and presentation of information.

The following sections of this chapter are intended to describe the difference between FEMA's current deterministic approach to flood modeling and mapping and alternative probabilistic approaches, including differences in how uncertainty is quantified for each. Also included is a section on a variety of state mapping programs that have deployed some of the techniques described as well as other applications of probabilistic approaches in use today.

3.2.3 / Deterministic and Probabilistic Modeling: Defining the Flood-Risk Spectrum

Deterministic modeling produces a single output for a given set of fixed inputs. Probabilistic modeling provides a range of outputs given a range of possible inputs.

Currently, flood hazard mapping under the NFIP employs a deterministic approach where the mean 1 percent-annual-chance flood elevation is determined, and then used to regulate floodplain development, provide a basis for rating federal flood insurance, and enforce statutorily mandated flood insurance purchase requirements. Although the depiction of this single flood event is beneficial for administrative purposes, it creates a binary view of the hazard, causing users to think structures are safe if they are outside the SFHA or built to the minimum federal floodplain management standards, despite the fact that larger floods can and often do occur. While determining if a structure is built in compliance with NFIP requirements is helpful, knowing how frequently each structure in a community is likely to be flooded and the likely associated damages provides a fuller picture of risk—at both the individual property scale and across any given community as a whole. That fuller picture yields a better understanding of the spectrum of flood hazards and risks faced by a community, which helps redirect the conversation from a debate about legal mandates and administrative requirements to a broader conversation about how best to balance risks and rewards. Moving to that fuller conversation about how much flood risk exists and how much is acceptable to individuals or communities as they move to achieve their goals is possible with the richer data sets that come from probabilistic rather than deterministic approaches.

Risk assessment requires combining probability and consequences together. The most effective way to do this is through a probabilistic approach. Probabilistic modeling (in the context of flood risk) leverages a well-integrated system of geospatial, hydrological, statistical, and hydraulic software applications and models run with probabilistic sampling that properly covers the potential range of events from annual flooding (small-magnitude, high-frequency floods) to large-magnitude more infrequent events. This allows modelers to describe more fully what is known about floods—that the largest among them are not confined to the indicated extent of the NFIP regulatory products such as the SFHA. Where deterministic systems seek to provide the best estimate for a given decision metric (such as 1-percent-annual-chance flood), a probabilistic approach seeks to provide a range of possible outcomes, each weighted by their likelihood. Concretely, by sampling and modeling the full range of flood magnitudes as well as variations in other parameters affecting the extent and severity of flooding, the probability of flooding can be modeled and determined for every land surface pixel in a community, not just along the SFHA boundary. The resulting pixelated "heatmap" of annual flood probabilities presents a detailed and locally specific measure of the likelihood of complete or partial inundation of every property in the community—a graduated view of the flood hazard.

SURVEY INSIGHT

Stakeholders believe that the shift to graduated risk will help support the need for floodplain management standards beyond the current SFHA.

Taking the process further and including estimates of the consequences provides a mechanism for describing the potential estimated damages and losses wherever there is an exposed asset, which may be either inside or outside the regulated floodplain. By estimating potential damages across the full range of flood events, analysts can look beyond the floodplain boundary to include areas impacted more frequently inside the boundary and less frequently outside of the boundary. This expected or average annualized loss can be expressed in terms of dollars, which provides more meaningful and more relevant personal risk communication and facilitates more actionable information than is now communicated on current FEMA FIRMs.

3.2.4 / Using Probabilistic Model Output for Regulatory Purposes

Regulatory programs and decision-making processes can be informed with risk-based metrics such as expected annualized losses or annual exceedance probabilities. There are many strategies for using probabilistic modeling results to inform regulatory programs or risk-based decision-making processes. Two basic options are described below.

1. Maintaining Status Quo

   Probabilistic methods can be summarized into products that support a binary In/Out (of the floodplain) regulatory program. An Annual Exceedance Probability (AEP) map that incorporates both the natural variability of flooding events and the knowledge uncertainty inherent in estimating and predicting natural phenomena can be summarized into a single, best-estimate, iso-line representing the 1-percent-annual-chance floodplain boundary. This depiction would be an improvement over the current deterministic approach because it would synthesize a broader sample of all the possible events modeled using the more robust probabilistic approach. However, it may not help with the safe/unsafe perception associated with presenting flood hazard and risk information in a binary way. Nonetheless, FEMA could deploy probabilistic approaches, highlight the annual exceedances associated with the SFHA boundary, and then create non-regulatory products, which could then be used to more effectively communicate a broader view of flood risks that would incentivize investments in mitigation strategies aimed at exceeding federal minimum standards

2. Enhancing the Regulatory Program

   Instead of engaging in a binary in-or-out-of-the-floodplain framework for administrative and regulatory purposes, probabilistic methods also allow the risk to be managed more directly. Because each individual and each political entity can have different risk tolerances, some may be willing to take more risk in hopes of greater reward, whereas others may take a more conservative approach. Risk is inevitable, and it must be managed coherently. Making decisions that result in risk transfers or risk acceptance without having enough information is reckless. Today, many home buyers and land-use decision makers are making choices while misinterpreting the meaning of the implied federal minimum standard of the SFHA. *This leads to an incredibly dangerous type of moral hazard—one that leads to surprises and often blame.*

KEY FINDING

Flexibility

Moving toward a more flexible program as described here would likely be supported by stakeholders, who reported the need for flexibility across the program.

A full representation of probabilistic flooding is superior over deterministic approaches if lawmakers decide to administratively move the NFIP from a program focused on insurance and managing floodplains to a program focused more directly on managing flood risk. Moving to a risk management framework has the promise of greater flexibility and resilience. Providing stakeholders with a probabilistically derived fuller range of flood hazard and risk data would enable people with less risk tolerance to set more stringent requirements, while allowing those willing to adopt federal minimums to do so while also understanding that larger, more devastating floods should be expected. States, for example, may evaluate the information provided by probabilistic measures and identify more restrictive regulatorily criteria based on their own risk tolerance and capacity. For instance, the State of California requires cities and counties within the Sacramento and San Joaquin Valleys to mitigate flood risk behind urban levees for flooding that has a 0.5 percent chance of occurring before approving land-use decisions. The state adopted this more stringent criterion due to a lower tolerance for risk. Providing data to make these decisions easier lowers the cost of reducing disaster suffering in new ways. With probabilistic products, it will be easier for states and others to identify mitigation actions that align with their objectives. The information gives power to decision makers so they can develop alternatives that align with their risk tolerance and other objectives.

Moving beyond simple flood hazard mapping criteria is possible using risk-based metrics. Instead of regulatory products focusing on regulating development within a specified geographic domain, it could be based on flood risk estimates (e.g., expected annualized losses) across a broad area and people's tolerances for accepting those risks. This can give rise to more detailed analysis of land-use management strategies, watershed-scale planning, and wise use of our natural resources. For example, an individual or a community might be willing to accept average annualized losses due to flooding of X dollars at the 95 percent confidence level. In doing so, they would need to continuously monitor how individual choices or external factors might impact that threshold. National coverage of graduated hazard and risk information from probabilistic outputs can support these decisions. When actions or other factors cause losses to increase beyond their tolerance level, they would need to take action to reduce their risks. This also provides the states with flexibility in applying regulatory frameworks in ways that are more efficient. Instead of strict rules mandated for all development, a group could manage construction in a broader geographic domain to collectively meet the requirements by making trade-offs across the domain. In order to balance economic justification with social equity, the definition of minimum regulations need careful thought to properly align incentives.

Establishing a maximum flood risk capacity for the United States would be achievable with probabilistic expected loss information across the nation. This could allow a flood risk transfer program to be developed. If a specific community is unable to keep risk within its tolerance level, they could purchase unused flood risk capacity from places that exceed the criteria. This concept is similar to other cap-and-trade markets, only applied to flood risk. The only way for such a market to exist is through estimates of expected losses developed through consistently applied probabilistic modeling approaches.

Defining Uncertainty

Another important shortcoming of deterministic modeling approaches is that they do not permit us to confidently quantify what we do not know. Distilling the complex system of natural processes that influence the frequency of hazard at various locations in the floodplain to a single estimate is an inadequate representation of what we know in light of what we do not know. Probabilistic analyses seek to describe the variability of nature (natural variability) while accounting for our lack of knowledge due to limited historic evidence or models that do not completely capture the physics of such systems (knowledge uncertainty). Done correctly, the probabilistic methods report both our best estimate of the annual probability of inundation for every location within the mapped area and the uncertainty associated with each estimate. Both are powerful pieces of information for decision makers regarding the risk of loss they are willing to take, given any potential rewards of taking on that risk.

Estimating flood risks requires a series of linked and sequenced models. Each model—indeed, each input to each model—contributes some level of uncertainty around the final estimate of the probability of flooding at each pixel location in the geospatial domain. For example, estimating the flood flow requires one or more hydrologic or statistical models, each contributing uncertainty. Subsequently distributing the selected flows across the floodplain requires one or more hydraulic models, each also contributing additional uncertainty.

The simplest output from the hydraulic model is an estimate of flood depth (often referred to as "stage"). The image in Figure 5 shows how the uncertainty in flow estimates, given a conditional probability of occurrence, influences the uncertainty of estimates of the stage associated with that event. The range of possible outcomes of stage for a given flow can be vast and is influenced by many sources of uncertainty.

Figure 5 was created to illustrate this problem and is generally an overstatement of the impact, but useful for illustration purposes. In the figure, a range of flows (gray distribution in the plot on the left) and a best estimate is associated with an exceedance probability setting the initial or expected flow. If the best estimate flow only is transferred to the flow-stage relationship, this results in a deterministic estimate. If the uncertainty in stage is sampled for a deterministic estimate of flow, the result is the light-gray bell curve on the lower right (stage axis of the flow stage relationship). If instead a range of flows (gray distribution in the plot on the left) is sampled, and that range of inputs is transferred to the flow-stage relationship on the right, this creates a best estimate and a distribution of flood stages that is wider in range. Combining complex systems compounds errors together in ways that are difficult to assess, and using statistical relationships for the errors and probabilistic methods can provide a way to prop-

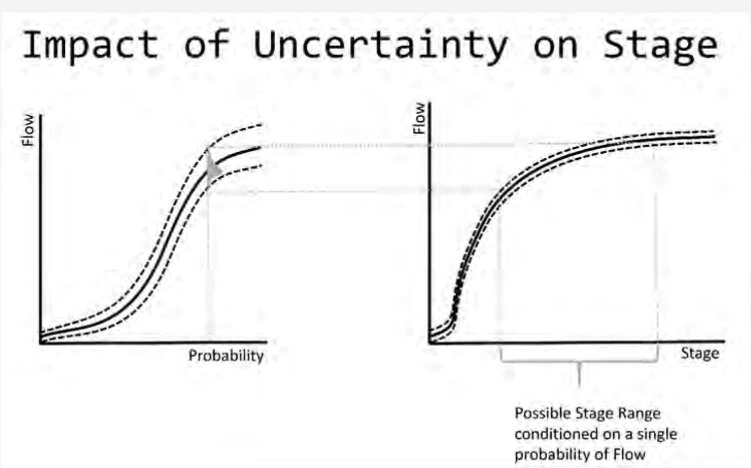


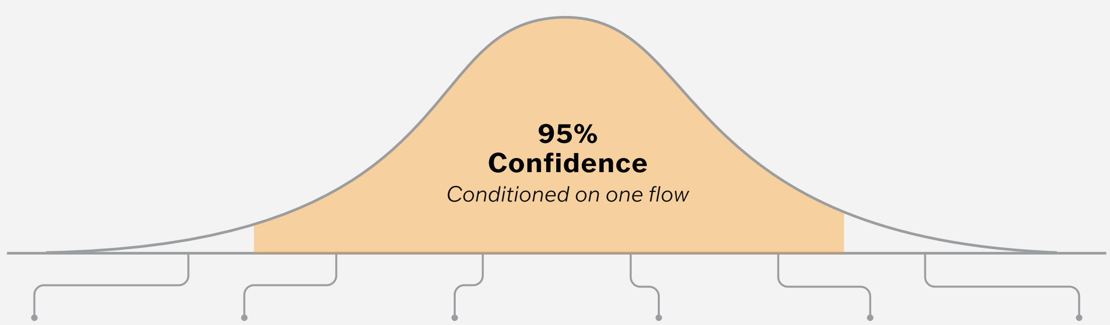
Figure 5 / The relation between uncertainty in flood flow estimation and uncertainty in flood stage estimation erly make the combinations of errors across multiple systems represent the range of variability and uncertainty in the estimates.

The concept also applies to other geophysical and meteorological processes. Among those sources of uncertainty are the estimation of flows and hydraulic inputs and their uncertainty. For example, assuming we know how much rainfall might land in a watershed, the resulting flow in a river can be influenced by various antecedent conditions in the watershed, which change the flood flow and have a cascading influence on the resulting flood stages in a floodplain.

Uncertainty is generally measured as the variability around an estimate. It can be pictured as a bell curve of repeated measurements or simulated results. The row in Figure 6 titled "Probabilistic Hydraulics" illustrates the uncertainty about a best estimate of flood flow given the uncertainty of the hydrologic conditions at the time of the precipitation event.

Likewise, given a conditional flow, a range of possible stages can occur depending on the characteristics of the event and the watershed. The row in Figure 6 titled "Probabilistic Rainfall Runoff" illustrates the distribution of stages conditional on aninput flow given the uncertainty and variability in other parameters that influence the relationship of flow to stage or depth.

Although managing with uncertainty may be challenging, it is not impossible. In fact, quantifying the uncertainties allows analysts to place confidence limits around their point estimates. These confidence intervals can help decision makers align their objectives so that they can be more certain in



		No Flooding *(Insignificant Flow)*	Basement Floods Minimally *(Minor Flow)*	Basement Floods *(Lower Flow)*	Ground Elevation Floods *(Average Flow)*	One foot of Flooding *(Moderate Flow)*	Two feet of Flooding *(Highest Flow)*
Probabilistic Hydraulics *For the deterministic flow*	**Neighborhood Model**	Clear channel, culverts, and storm sewers	A culvert a few blocks away got got clogged, my neighbors are flooded	Erosion has increased conveyance	Average Conditions	Vegetation in the floodplain is greater than average	Recent fires have created large amounts of sediment and debris
Probabilistic Rainfall Runoff *For the best estimate "100 year" Peak Rainfall Depth*	**Watershed Model**	Ground receptive to infiltration and steady setup	Ground receptive to infiltration and high intensity	Dry ground but very high intensity precipitation	Average Conditions	Saturated ground and moderate overall volume	Long duration and high volume

Figure 6 / The relationship between uncertainty in probabilistic hydraulics and uncertainty in rainfall runoff meeting them. For example, a decision maker may want to have high confidence that the land he or she buys is beyond the reach of a 1-percent-annual-chance flood. If an analyst simply used a FEMA flood map and identified sites outside the SFHA, the decision maker may inadvertently purchase property with a 50/50 chance of flooding during a 1-percent-annual-chance event. The specific outcome of a coin toss is not something that can be determined with high confidence. By using a probabilistic approach, which includes estimates of uncertainty, that same analyst can identify sites where he or she is 95 percent confident that it will not flood during the 1-percent-annual-chance event. In fact, decision makers can adjust the confidence limit to 99 percent, 65 percent, or any other value, to meet their objective (e.g., being beyond the reach of a 1-percent-annual-chance flood). Mathematically, the probabilistic approach will not allow users to denote anything as being 100 percent certain, thereby making it clear to decision makers they cannot eliminate the possibility of flooding, which opens the dialogue for discussions about how to manage residual risk.

Probabilistic approaches provide tools to quantify and reveal the effects of uncertainty; they do not inherently reduce uncertainty. Only reductions in knowledge uncertainty (improved flood-hydrology models) and better understanding of natural variability (longer, more accurate observational records) can reduce the uncertainty surrounding flood hazard estimates or mapped depictions of them.

Representing 100-year flood elevations as single numbers might be a convenient way to achieve administrative or regulatory goals, but the tradeoff is a gross misrepresentation of the complex and uncertain nature of flooding. The solution to balancing regulatory needs and ease of administration with the natural variability of flooding is not to pretend there is an absolute measurement of flood hazard frequency, nor an absolute standard for safety, but to use confidence boundaries to make more informed decisions that match specific objectives by knowing the magnitude of and the drivers behind that uncertainty and variability. Figure 7 shows some possible views of how we can describe our best estimate of the variability across the range in flood hazard conditions in relation to the notion of a deterministic regulatory FIRM.

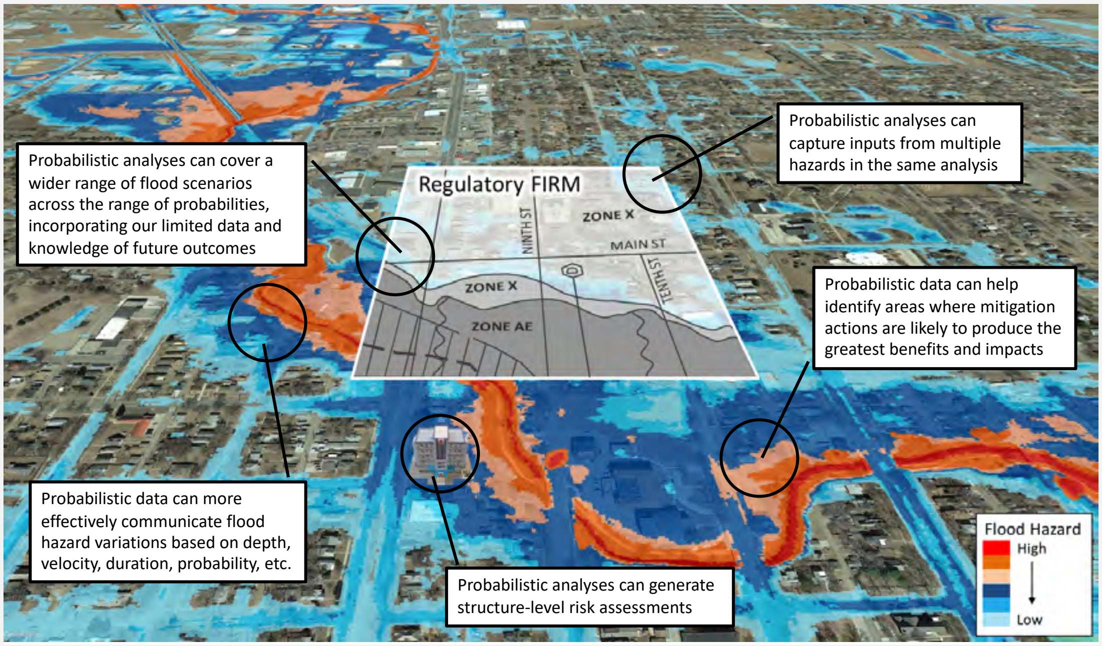


Figure 7 / Variability in flood hazard conditions compared to the regulatory FIRM
For ADA accommodation for this figure, please contact the TMAC DFO at FEMA-TMAC@fema.dhs.gov

Probabilistic methods founded on evidence-based approaches can be used to support a regulatory program. Through the use of these methods, the mapping program can evaluate multiple sources of hazards across the range of possibilities and evaluate risk through incorporation of structure-level consequence assessments. This basic information can better inform decision makers in all levels of government, along with individual homeowners. The use of graduated hazards and risks makes sense; it reveals information we know that is actionable and helpful to the public. It improves upon the existing information provided by the mapping program, clarifying the view of risk and hazard frequency to better inform the public. Using probabilistic methods allows users to model future conditions in the regulatory and non-regulatory products as the risk framework behind the mapping program continues to evolve and mature. This represents an opportunity of growth, extending the program beyond mapping into risk communication. The transition may be difficult and must come with clear communication for interpretation of the information presented on a map.

> The idea that the shift will be difficult but worth doing is born out by stakeholder sentiment as well: *"I think it is a great idea. With that great idea will come many challenges to fit this into the system we currently have in place (in a cost effective manner)."*

In many ways, the data are valuable beyond the mapping program to drive metrics that are not directly spatially correlated to help monitor risk management activities and communicate risk exposure to the public. For instance, the image shown in Figure 8 translates the AEP map from Figure 6 to an individual home and converts the spatial depiction of hazard on a map to a range of depths on a home. This more personalized view allows homeowners to see beyond the map, and better understand the uncertainty of estimates at their home and a broader range of the natural extent of flooding on their house. To move toward a risk-based framework, a similar graphic can be created to describe damage frequency while representing uncertainty. As you can see in Figures 8 and 9 below, there is uncertainty in the 1% Annual Chance Stage. Though the SFHA is defined by a deterministic estimate, there is still additional risk beyond that deterministic estimate due to uncertainty in the 1% stage, and uncertainty in less frequent events. The area shaded in gray represents residual risk beyond the BFE.

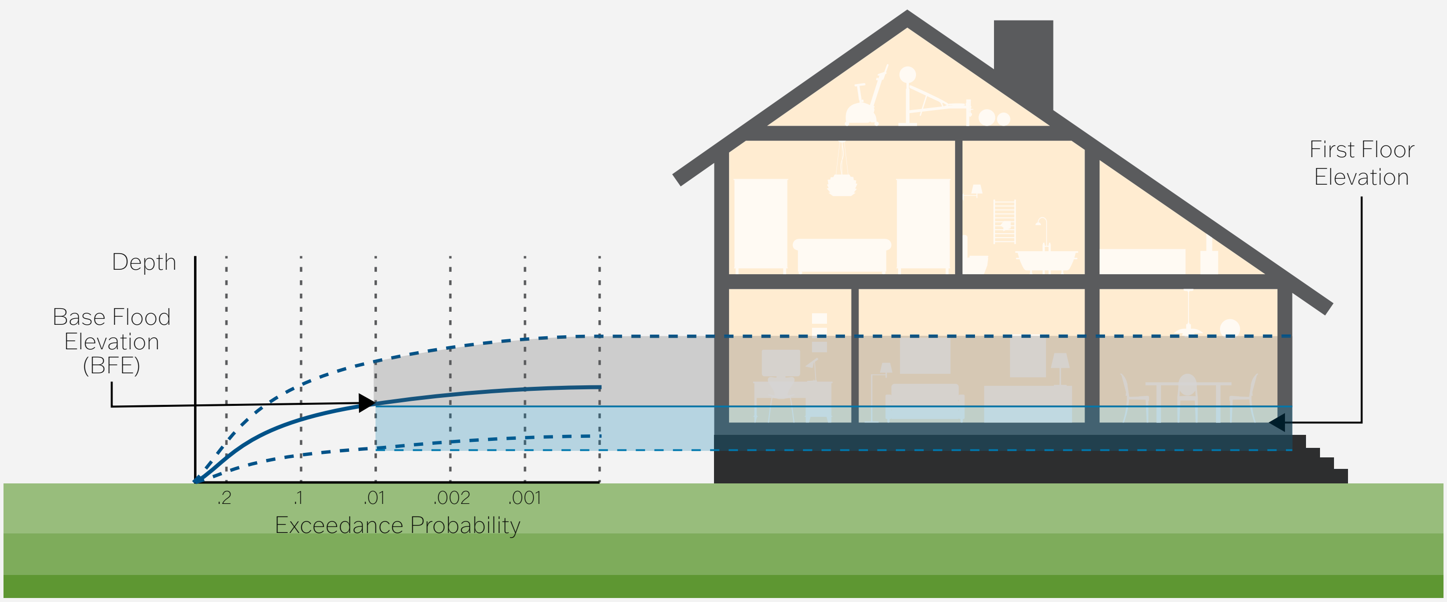


Figure 8 / The relationship between exceedance probability and flood depth

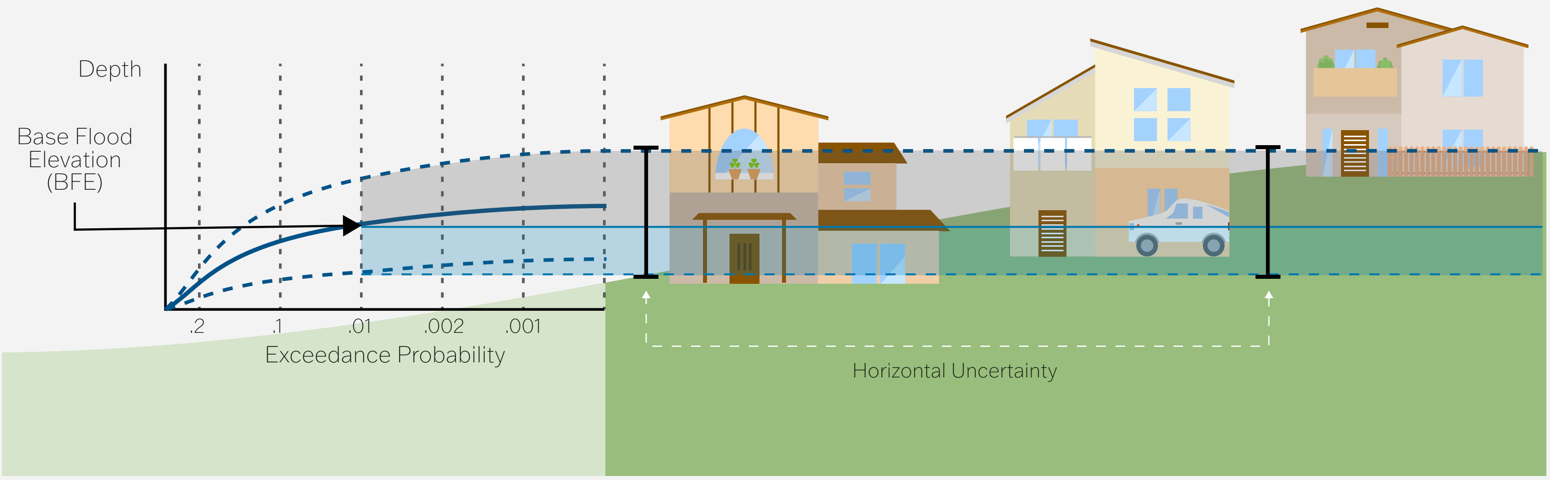


Figure 9 / Representation of the effect of uncertainty in exceedance probability on the horizontal extent of the floodplain

As you can see in Figure 9 (the multi structure image) the SFHA may contain two houses but their hazard frequency curves are different due to their differences in elevation. This means that the risk to the second structure from the left is less than the left most structure. Likewise, structures that may be mapped outside of the deterministic SFHA may still experience residual risk above the BFE like the right most structure. The SFHA does not tell the whole story of flood risk. FEMA should move to products that more clearly articulate the full range of events with their uncertainties.

FEMA's current legal and regulatory responsibilities for flood hazard identification and risk management are multifaceted. FEMA not only develops and delivers the data to service the nation's largest single-peril insurance program, but also develops and delivers the data to service the nation's largest voluntary and regulatory land-use program. While both programmatic objectives serve to manage and mitigate flood damage, the data needs are different and should not be directly compared to each other.

Shifting from binary in-or-out-of-the-floodplain products for regulatory purposes to products displaying graduated flood hazard and flood risk will be challenging due to the long-lived institutionalized approach and the widespread use of these products at all levels of government. However, the difficulty does not justify maintaining the status quo. To transform the NFIP and to build a more flood-resilient nation, change in the application of the mapping program is necessary. Use of well-designed incentives, along with more complete information about hazards and risks, can support the movement toward a risk-based program. Moving from risk analysis into a full-fledged risk management framework like Enterprise Risk Management[1] can provide opportunities for balancing

1 Enterprise risk management is for use by people who create and protect value in organizations by managing risks, making decisions, setting and achieving objectives, and improving performance. Find more information at https://www.iso.org/obp/ui/#iso:std:iso:31000:ed-2:v1:en.

the many requirements placed on the mapping program. Proper use and development of strategic objectives, risk metrics (especially metrics beyond the definition of the SFHA), profiles, appetites for change, risk tolerances, and capacities can improve the clarity and coordination of the many stakeholders following FEMA's lead into the future.

3.2.5 / Applied Practices for Graduated Flood Hazards and Risk

Modeling graduated hazard and risk using the probabilistic approach is not new. There are multiple applications of the probabilistic approach at a national scale in Europe, including multivariate extreme value modeling of sea conditions around the coast of England by the United Kingdom Environment Agency[2] and Hydra-Ring, a probabilistic model for computing failure probabilities of levee systems in the Netherlands.[3]

Furthermore, there are several state flood mapping programs, private firms, and federal partners that compute and display flood risks and/or hazards in a graduated way. No program has addressed the issue perfectly, but each shows steps in the process toward a common ideal of a fully probabilistic modeling system to support a risk framework. Some noteworthy examples can be found below.

Probabilistic Flood Risk Assessment (PFRA) by FEMA

Under the RR2.0 initiative, FEMA desires to redesign the NFIP risk rating system by leveraging industry best practices and current technology to deliver flood insurance rates that are "fairer, easier to understand, and better reflect a property's unique flood risk." Through these efforts, FEMA developed Probabilistic Flood Risk Assessment (PFRA) data. PFRA represents an exciting advance in developing comprehensive flood risk information for specific structures within a large watershed. PFRA performs the hydrologic and hydraulic (H&H) analyses that consider multiple sources of flood hazard and the performance of flood risk reduction structures (e.g., levees). The PFRA performs a structure-level assessment of flood risks for a wide range of events through advanced technologies of modeling simulation and data processing. As a result, Average Annualized Loss values are generated for identified structures within the project areas.

Probabilistic Flood Hazard Assessment by Nuclear Regulatory Commission

The Nuclear Regulatory Commission (NRC) is developing a Probabilistic Flood Hazard Assessment (PFHA) to support a broader risk analysis framework for siting nuclear facilities and evaluating the risks at existing nuclear facilities. The methodology takes great care in separating natural variability from knowledge uncertainty and seeks to extend the hazard frequency analysis to the extreme events ($10e^{-6}$ or further). This analysis incorporates dam failure and operation. The analysis is focused on describing the hazard at a nuclear site and makes no significant effort to map the entire floodplain or evaluate consequences directly. The product of the hazard frequency assessment is incorporated into a larger risk analysis process as a component of NRC's greater risk management framework for existing and future nuclear sites.

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2 Prof. Ben Gouldby, Chief Technical Director Flood Risk at HR Wallingford, said: "The output of our research is a dataset that represents 10,000 years' worth of extreme storm events that have been transformed via a sequence of computer models from offshore to every flood defense in England. This has been used to enhance our understanding of flood risk for England, and so improve the design of new coastal structures."(October 9, 2018) See https://www.hrwallingford.com/news/coastal-flooding-research-by-hr-wallingford-and-environment-agency-awarded-ice-medal-for-research-an.

3 Hydra-Ring is risk-based approach model using the first order reliability method (FORM). FORM is a probabilistic technique that linearizes the failure domain in the design point. FORM is an iterative process that searches for the design point using the partial derivative of the failure function with respect to each of the random variables. See https://hydraring.wordpress.com/ (dated January 26, 2012)

Flood Factor by First Street Foundation

The First Street Foundation developed the Flood Factor application to support communicating a personalized view of flood hazard exposure to every property[4] in the United States. The effort computes deterministic estimates of flood inundation at 10 frequencies across the range of possible events and describes the depths a property is exposed to for each of the events. Their outputs do not address uncertainty in estimation of flood inundation, but instead provide best estimates across the range of flood frequencies. The First Street team also computes estimates of future hazard due to multiple climate change projections and provides that information in an easily digestible report for each home in the United States. In the report, the First Street team indicates whether homeowners live behind a levee or not, but it does not indicate what mitigation is provided by the levee, nor the impact of levee performance on the hazard exposure to the home. The First Street Foundation has made strides in the arena of developing communication tools about flood hazards from a deterministic view across a range of flood frequencies.

Delta Adapts by Delta Stewardship Council

The Delta Stewardship Council, a California State agency, is undertaking climate change adaptation planning for the Sacramento-San Joaquin Delta and Suisun Marsh. There are two ongoing phases: a vulnerability assessment and an adaptation plan detailing strategies and tools that state, regional, and local governments can use to help communities, infrastructure, and ecosystems thrive in the face of climate change. Delta Adapts is a regional approach, planning level study that considers a wide range of plausible inputs including climate change. The study applies Delta Simulation Model II hydraulic model to explore local water level dependence on input conditions, develops regression equations as tool for rapid estimation of local water levels, and applies the Monte Carlo approach to develop stage-recurrence curves throughout the Delta, considering uncertainty in future climate.

SURVEY INSIGHT

Stakeholders noted a concern about duplication of efforts in areas where communities or states are already developing or using graduated data or other more comprehensive and complex datasets than the currently available NFIP data.

North Carolina Multi-frequency Approach

States have been exploring ways to move away from a binary view of flood hazard (in and out of SFHAs) by implementing their flood modeling and mapping programs that provide a wide range of flood hazard displays while maintaining the regulatory obligations under the NFIP, which importantly allows them to be stitched together to form a cohesive national picture of flood risk. Examples of state flood mapping programs include multiple frequency modeling/mapping and geomorphic floodplains that determine channel migration zones.

For example, North Carolina is undertaking a multi-frequency approach in statewide flood mapping to show a graduated view of flood risks. Raster datasets for the 10-, 25-, 50-, 100-, and 500-year floodplain have been generated for two thirds of the state (90 to 95 percent is expected to be complete by next year).

In 2012, North Carolina enhanced the statewide Digital FIRM database design for the future support and enhancement of FEMA's Risk MAP program. . The North Carolina Flood Risk Information

4 As of February 2021.

System (FRIS) contains digitally accessible flood hazard data, models, maps, risk assessments, and reports that are database driven. FRIS provides geospatial base map data, imagery, and light detection and ranging (lidar) data, along with H&H models that are available to download.

Insurance Market Approach for Graduated Risk

In 1966, Gilbert White, known as the "father of floodplain management," warned of the risks of providing federal subsidies for the flood insurance market.

> *"A flood insurance program is a tool that should be used expertly or not at all. Correctly applied, it could promote wise use of flood plains. Incorrectly applied, it could exacerbate the whole problem of flood losses. For the Federal Government to subsidize low premium disaster insurance or provide insurance in which premiums are not proportionate to risk would be to invite economic waste of great magnitude."*[5]

SURVEY INSIGHT

Stakeholders had several insurance-related insights, including:

- New mitigation credits are needed (actions that will impact insurance rates)
- Connect people to low-cost loans or grants to assist in mitigation to reduce insurance rates
- Begin marketing/ messaging flood insurance as part of a "resilience fund" for communities

To the extent that the NFIP is subsidizing flood insurance premiums, it may be biasing flood-risk assessments. However, the improvements in the insurance market through RR2.0 are making great strides to rectify the issue. Probabilistic modeling helps to articulate the presence of risk in or out of the SFHA with greater clarity, representing more completely what we know about floods. Some states are taking initiative to better represent the range of flooding; some nations have already provided national coverage. FEMA should take advantage of the momentum provided by RR2.0 for transformative change and provide products that can promote wise use of the floodplain. Providing a more complete view of the hazard and risk posed by flooding through probabilistic risk-based methodologies will help achieve a more flood-resilient nation.

3.3 / Increasing Value and Reducing Risk Over the Long Term

In order to shift from binary to graduated views of flood risk, FEMA should increase stakeholder education to improve program understanding, flood program purpose, and flood risk perceptions. In doing so, FEMA should consider:

1. Incentivizing certification and training for stakeholders providing flood insurance and risk management guidance. Improving flood maps by depicting risk in a graduated view is not sufficient to identify and promote actions to reduce risks. FEMA should continue working to change behaviors of program stakeholders through training and certification. FEMA could promote and incentivize local governments that have training programs in place by encouraging stakeholders to maintain certification and continuing education through the Community Rating System (CRS) program, mitigation grants, or other new avenues.

5 1966. White House Force. *A Unified National Program for Managing Flood Losses*. House Document 465. Washington, DC: U.S. Government Printing Office. Gilbert White.

2. Incentivizing to expand and enhance state real estate disclosure. Disclosure of flood risk early in a real estate transaction solidifies real estate values while improving the flood insurance and risk evaluation process, resulting in the protection of the wealth, safety, and welfare of the public. The Natural Resources Defense Council and the National Association of Realtors conducted and published state flood hazard disclosure assessments and surveys, respectively, that provide useful information on how all 50 states plus the District of Columbia, Guam, Puerto Rico, and the U.S. Virgin Islands establish and implement their disclosure law. FEMA could work closely with states, the District of Columbia, and territories to ensure the uniformity and adequacy of the implementation.

As noted in the prior section, it makes sense to move to a graduated view of flood hazards and risks using probabilistic approaches and by benchmarking examples of where and how this is being done. Although these actions are necessary, they are not sufficient for a program whose goal is to increase the nation's resilience to flooding. Along with the enhanced data and information must come improvements in how that information is communicated, enhancements in education for professionals advising decision makers about flood risks and hazards, and incentives for people to adopt standards that go beyond the minimum participation requirements of the NFIP when their objective is to increase resilience to flooding.

KEY FINDING

Risk Communication

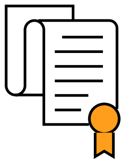
Stakeholders recommended several risk communication improvements:

- Consistent, accurate messaging regarding graduated risk products and associated mitigation options
- Better messaging regarding connections between community action/ inaction and insurance rates
- Focused messaging on the financial benefits of mitigation and higher standards
- Better communication regarding the emotional and socio-economic impacts of flooding

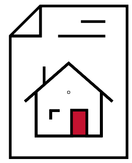
3.3.1 / Enhancing Communication and Expanding Education

Communicating flood risk to improved property in a graduated way requires program stakeholders to learn how actual flood risk can be very different from flood risk for purposes of securing collateral of a federally backed or insured loan. In the 2018 TMAC Annual Report (Recommendation #30), TMAC acknowledged this risk uncertainty due to the random nature of flooding. TMAC recommended an approach to estimate the amount of uncertainty by determining minimum and maximum extents of a 1-percent-annual-chance flood using proven statistical techniques. The Flood Uncertainty Band (FUB) concept demonstrates fairness in establishing an SFHA boundary, but at the same time, introduces an area of uncertainty around the SFHA boundary to encourage the public and key stakeholders to consider applying standards higher than those set by the federal government for the purposes of backing loans or making insurance available. This is particularly true for individuals and communities whose objective is to lower flood risks over the long term. The FUB is an example of this and coincides well with the NFIP's desire to transition from binary to graduated risk evaluation.

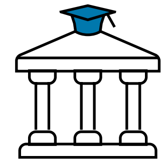
Practices to help program stakeholders identify flood risk to improved property in a graduated way are highlighted in three aspects:



Program Stakeholder Certification & Training



Real Estate Disclosure Laws



Higher Education Programs

3.3.2 / Certification, Training for Professionals Providing Flood Risk Management Advice

Graduated risk applications acknowledge many more parameters of flood risk, allowing an opportunity for program stakeholders to examine the various factors that contribute to risk, and to emphasize the importance of applying sound mitigation strategies. Program stakeholders need to acquire and maintain the required knowledge to communicate risk more effectively and support the NFIP mission of reducing the impact of flooding, and to provide affordable flood insurance that coincides well with the uncertainty of flood risk.

Professionals who provide floodplain management, mapping, and insurance services typically require state licensing for the specific profession in which they practice. Land surveyors, professional engineers, real estate agents, insurance agents, and lenders are all required to obtain state certification to provide professional service to the public with intention to protect the health, safety, and welfare of each individual.

Optional certifications that are offered to improve support at the state and community levels, as well as provide specialized consultation services to the public, include CFM, Certified Floodplain Surveyor (CFS), and Associate in National Flood Insurance (ANFI). The NFIP would benefit greatly from improved stakeholder education at the community level to effectively educate and guide the public through floodplain issues, options, and solutions.

SURVEY INSIGHT

Stakeholders support expanding professional development requirements and opportunities for developers and builders building in flood-prone areas as well as for real estate agents selling property in floodprone areas

Flood Insurance Agents

Section 207 of the Flood Insurance Reform Act of 2004 requires all producers selling flood insurance policies under the NFIP to be properly trained and educated about the NFIP to ensure they can best serve their clients. The Act directs FEMA, in cooperation with the insurance industry, state insurance regulators, and other interested parties, to establish minimum training and education requirements for all insurance agents who sell flood insurance policies. In 2005, FEMA published minimum training and education requirements, as required by Section 207, including a one-time 3-hour course related to flood insurance and the NFIP.[6]

6 70 Fed. Reg., 52117 (Sept. 1, 2005). See https://www.federalregister.gov/documents/2005/09/01/05-17444/flood-insurance-training-and-education-requirements-for-insurance-agents

State departments of insurance have taken various actions over the years to establish training requirements for insurance agents who sell flood insurance under the NFIP. For example, all New Mexico resident insurance agents licensed in property/casualty lines of authority that may sell a flood insurance policy must complete a one-time course related to the NFIP that provides at least 3 hours of continuing education credit.[7] For more information on state actions to implement Section 207 flood insurance training requirements for insurance agents, visit https://nfipservices.floodsmart.gov/training/agent-requirements.

The ANFI certification, developed by the Institutes[8] in collaboration with FEMA, provides the technical and practical knowledge and skills to flood insurance professionals, including agents, brokers, claim adjusters, and underwriters. FEMA could consider requiring insurance agents to obtain the ANFI certification to provide flood insurance guidance and policies, or to be educated in specific flood program information as it relates to the rating of a structure, subsidies, Letters of Map Change (LOMCs), and the flood determination process.

Land Surveyors, Engineers, and Other Stakeholders

The Association of State Floodplain Managers (ASFPM) established the national CFM program in 1998. The program requires passing an exam and then continuing education credits annually to maintain certification. Training, continuing education, and professional development are important keystones of the program, as floodplain management and the knowledge and performance of local, state, federal, and private-sector floodplain management professionals continually evolve. Currently, there are more than 10,000 CFMs nationally. Any government official or private stakeholder providing guidance or consultation would benefit greatly from obtaining the CFM.

Land Surveyors

North Carolina and Tennessee established the CFS program that educates surveyors on the NFIP, FIRMs, Elevation Certificates (ECs), LOMCs, the FEMA Map Center, and changing mapping technologies. There are currently over 200 CFSs in North Carolina and 56 CFSs in Tennessee. New Jersey is in the process of CFS establishment. To become CFS certified, licensed surveyors must successfully complete the 3-day certification seminar and pass the exam. A biennial re-certification is required to retain this certification.

Community Floodplain Administrators

West Virginia, New Mexico, Oklahoma, and Arkansas have state legislation that requires community floodplain managers to become certified or attend annual floodplain management training in order to issue permits at the community level. FEMA could encourage floodplain administrators to obtain the CFM certification to improve the delivery of program understanding to the public and stakeholders.

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7 New Mexico Public Regulation Committee (2007). "Flood Insurance Training Requirements." See https://www.osi.state.nm.us/wp-content/uploads/2019/04/Bulletin2007-005.pdf

8 The Institutes provides educational support, resources, and leading research to help those in risk management and insurance better serve the public. More information on the Institutes and ANFI: https://web.theinstitutes.org/designations/associate-national-flood-insurance

State Floodplain Coordinator

As a requirement to performing state duties in accordance to NFIP regulations, some state officials in charge of administering the program must obtain CFM certification. FEMA could encourage floodplain administrators to obtain CFM certification to ensure they possess a comprehensive level of current knowledge to guide constituents through floodplain issues they may encounter.

3.3.3 / Expanded Real Estate Disclosure

Although the real estate industry requires disclosure of anything that could affect a buyer's decision to purchase, or the purchase price or resale value of improved property, seller disclosure as it pertains to flood risk is not adequate. This often results in a "buyers beware" scenario where a seller is not required to disclose flood risk or damage. Individual state flood disclosure is often extremely deficient in valuable information that would allow an individual to make a fully informed decision.

Because the majority of improvements at risk are being used as loan collateral in a federally backed or insured loan, expanding real estate disclosure to include a more detailed section on flood risk would greatly improve the NFIP's long-term readiness for the increasing frequency and size of flooding events nationwide.

Real estate disclosure of flood risk and damage must improve with a goal of attaching risk to value. This relationship creates a more practical understanding of the overall condition of a property. Improved disclosure will also better protect large value adjustments for a homeowner while minimizing negative changes in a buyer's purchasing power. Disclosure of flood risk early in a real estate transaction solidifies real estate value, improving the protection of the wealth, safety, and welfare of each individual.

Although 21 states have no statutory or regulatory requirements for a seller to disclose a property's flood risks or past flood damages to a potential buyer, the other 29 states have varying degrees of disclosure requirements.

According to the Natural Resources Defense Council, Oklahoma, Louisiana, and Mississippi are three states that received Grade A for their disclosure law. For example, per Oklahoma's disclosure law, the Real Estate Commission developed a mandatory residential property condition disclosure statement. The form requires sellers to disclose the following:

1. Whether they are aware of the property being damaged or affected by flood problems
2. Whether they are aware of any flood insurance requirements concerning the property
3. Whether he/she is aware of flood insurance on the property
4. The flood zone status of the property
5. The floodway status of the property

In February 2019, the National Association of Realtors published the "State Flood Hazard Disclosures Survey." This publication is an important step toward acknowledging the importance of improved flood disclosure in a real estate transaction.

3.3.4 / Higher Education Programs

The economic, social, and environmental values affected by development in flood hazard areas require individuals trained to meet this increasing demand. In recent years, institutions of higher learning have developed flood risk management courses, minors, certificates, and degree programs, including 2-year associate degrees, 4-year bachelor's degrees, graduate, and doctoral programs. These programs promote floodplain management research and a more focused career path for the next generation of flood risk reduction professionals and floodplain managers. Floodplain managers' responsibilities are much more than water resources engineering or modeling and mapping. Floodplain managers address demands to develop, assess, and implement an array of flood risks, including flood risk reduction techniques and designs, programs to mitigate flood risks, and guidance to ensure protection of public and private property.

The following bachelor's and master's degree programs for floodplain management focus on ensuring highly qualified individuals are available to meet the nation's challenge on losses and damages to human, financial, and natural resources.

SURVEY INSIGHT

Stakeholders provided several ideas for expanding or improving existing incentives, including increasing Increased Cost of Compliance amounts and more flexibility on its use, providing grants that pay >100 percent market value for retreat or other national mitigation priorities, and maximum lifetime insurance payouts that require mitigation when met.

University of Pennsylvania's College of Liberal and Professional Studies

The University of Pennsylvania's has a course titled, "Floodplain Management in a Changing Climate" (Fall 2020) as part of their Master of Environmental Studies. The course explores the challenge of floodplain management in a changing climate through lectures, talks by guest speakers, readings and multimedia, and exploration in the field. The course looks at the NFIP, examines its goals, critiques its 50-year history, and debates reforms to the program at the same time the U.S. Congress is considering reauthorization of the program. It examines resiliency efforts that state and local governments are pursuing and the new city- and state-level position of Chief Resiliency Officer. The course also covers hazard mitigation planning, land use, hard and natural infrastructure, regulations, the CRS, and other issues pertaining to flooding and climate change, including social justice and public health issues. Throughout the course, material is introduced to prepare the student to take the CFM exam administered by ASFPM.

University of Washington's (UW) Department of Urban Design and Planning

The University of Washington has a Master of Infrastructure Planning and Management with a Floodplain Management Degree Option. Launched in 2011, the online Master of Infrastructure Planning and Management program is designed for early and mid-career professionals seeking advanced training in infrastructure planning and management. A flood risk track includes 17 courses, 12 of which are taught online, and five at the University of Washington's Seattle campus. The curriculum provides the professional knowledge, skills, and abilities required by prospective employers. Coursework presents a broad view of water management and associated risks. Water-related courses address stream and coastal mechanics, water management, law, and current issues within the larger profession of floodplain management. Core courses present key concepts about infrastructure, systems thinking, infrastructure finance, and the fundamental aspects of strategic and contingency planning, emergency management, and policy analysis. In addition, students explore the impacts and management required of changing climate.

Western Kentucky University

Western Kentucky University has a Bachelor of Interdisciplinary Studies Degree with Concentration in Floodplain Management.

A higher awareness of the available options to minimize actual flood risk while enhancing opportunities to protect life, personal assets, and our environment will provide important foundational work for improving community resilience. This process will be best supported with improved outreach and education about the flood program to the wide range of stakeholders and consultants who provide knowledge and guidance in our communities. Higher education through program certification and formal education along with improved site-specific information will provide the needed momentum.

3.3.5 / Promoting Increased Investments in Flood Risk Reduction Through New Incentives

Floodplain management is typically viewed as a verb and understood as resilient action to reduce the impacts of, and to better recover from, an identified flooding hazard through mitigation investments and regulation. However, less intuitively, Floodplain Management can also be a proper noun representing numerous connections and responsibilities of the federal, state, and local governments together making a single organization with a common goal—to effectively manage flood risk over time. The vision, values, and execution of this singular mission are diverse across the nation, depending on the actualized risk; potential benefits for risk taking; local and regional attitudes; and experiences of the state, local, and tribal communities. This is further codified via centralized minimum standards with decentralized execution by the state and local communities to meet that standard or adopt stricter standards as desired. When we view Floodplain Management through this organizational lens instead of the action lens, possibilities may emerge as it relates to creating incentives that can drive common values to support the vision, and a common vision to support the mission.

Behaviors in organizations are typically driven by decision rights, how they are measured, and incentives. The decision rights of federal government to increase the minimum standards are very limited because they take legislation to change. However, the decision rights of a local community are vast because they can adopt higher standards. But what drives them to do so? Unfortunately, communities are measured primarily as an after-the-fact perspective of how they fared in the recent storm. This leaves the creation of incentives to drive the desired decision communities have the right to make to support the mission of the organization as a primary driver toward adopting graduated risk as a community principle.

Looking at the entire community as an organization, and the incentives associated with success, we find the first and most important incentive to be based on a similar binary concept to the current mapping system: either you are in the program or out of the program. Since 1968, adherence to the minimum Code of Federal Regulations has been both the stick and carrot. If the community adheres to the minimum, it is a member of the NFIP, and if the community does not adhere, it will be taken out of the NFIP. With the advent of the Section 1316 process, this "in or out of the program" incentive can even be adjudicated at the parcel level.

What incentives exist beyond this adoption of the minimum standards to drive and justify the expense of adopting best practices, placing additional burdens on developers, or being the leading edge of innovation? To better understand the incentives, categorizing the community and its stakeholders may shed light on the incentives for increased mitigation or standards. Those stakeholders and the current incentives are as follows:

1. Community and Floodplain Manager Incentives

Safety

Protecting the people and infrastructure from harm. This is the most obvious incentive and charge of any community in the program. Projects of this nature come in three primary forms: eliminating risk through buyouts, reducing hazard through water surface elevation (WSEL) reduction projects, or reducing risk through elevation projects and increased regulations for future infrastructure.

Property Values

In communities with ad valorem tax, mitigation projects and higher standards can increase value and potentially reclaim previously unusable land. However, this is usually reviewed and balanced by the investment or long-term cost compared to the incentive.

Affordable Housing Stock

Affordable housing has become rare and is becoming scarcer across the nation. Mitigation projects provide numerous opportunities to increase the stock and preserve the stock into the future. Similarly, many U.S. Department of Housing and Urban Development programs have prohibitions on purchasing and developing within SFHAs without mitigating for them.

Community Rating System (CRS)

Although CRS is certainly a form of incentive, the CRS as an incentive has some limitations, such as the benefits of the incentives being borne by the purchasers of flood insurance at a discounted rate, and not by the community that adopts the best practices in order to support the organizational mission. By applying the incentive to the purchaser, it could be argued that discounting an already subsidized product could further exacerbate the pricing to risk signal disconnect of the community, potentially disincentivizing mitigation investment. Similarly, these incentives are applied to the whole community regardless of what the community CRS rating was when a structure was built. In an extreme example, a community that is fully built out and has never been a member of the NFIP could theoretically adopt standards that make it a highly rated community in the CRS program, but not build a single structure to these newly adopted standards, and enjoy the benefits of a steep discount on insurance. This then drives the opposing question and scenario of: Did a community adopt higher standards because it recognized the community risk and not because of the benefits of the CRS?

SURVEY INSIGHT

Stakeholders support strengthening the CRS Program and provided several recommendations, including allowing more points for floodplain management outside SFHA, freeboard, wetland/natural benefits, and increasing insurance uptake; creating a "losses avoided" annual report for CRS communities based on their actions to reduce risk; increasing opportunities for community-to-community mentoring; and allowing flexibility in CRS participation (groups of communities versus by Community ID (CID).

2. Developer Incentives

Increased Usable Land

This incentive bears out by the hundreds of LOMCs executed annually. Developers, special districts, and at times communities alongside developers in public-private partnerships, are changing topography with cut-and-fill projects and/or levee systems to reclaim land from hazard areas under the LOMC process. The primary incentive in many of these projects is to reclaim land from the hazard for future use.

Product Price and Differentiation

Mitigation projects not only reclaim land but also establish value compared to other products that have greater risk. Mitigating those risks reduces sales with mandatory purchase requirements and can potentially increase the client base because many local, state, and federal grants have adopted programmatic prohibitions to participation in flood hazard areas.

3. Home and Business Owner Incentives

Reduced Suffering

Homeowners are incentivized to support mitigation initiatives that reduce their suffering. The support level is typically based on their perceived risk developed from the recent event impacting their personal situation.

Reduced Insurance Premiums

Since BW-12 was enacted, though repealed and replaced, NFIP pricing and legislation has been clear: prices are headed away from subsidies and toward actuarial rates. With mandatory purchase requirements, the total cost of ownership could vary greatly between those required to buy insurance and those who are not. Homeowners are currently incentivized to be out of the floodplain; or if in, to have their finished floor as high as possible compared to the WSEL in a 100-year event.

FEMA should study what currently incentivizes a community to use local dollars (in whole or match) to execute mitigation projects, and similarly study what drives a community to adopt higher standards, and whether FEMA is currently a driving factor or not. This will be key in understanding and incentivizing the decentralized execution of the centralized mission of FEMA and graduated risk mapping. FEMA should also consider incentivizing graduated risk mapping by adding considerations for granting federal mitigation dollars to communities that articulate graduated risk in their mapping or regulations. Similarly, communities that need updated maps could qualify for federal funding to assist with the mapping if they adopt graduated standards and agreed that their new maps would have gradient risk profiles.

Graduated risk also takes graduated understanding. Although not as accurate compared to our current understanding of flood risk, a binary in-or-out-of-the-floodplain management technique is likely easier than multiple variations of risk to manage. Because of this, the cost to manage, update, and explain a graduated system will be higher initially. Grants to assist with the upfront training costs at the state and local level may assist with more frequent adoption.

Incentives should go beyond flood insurance and code/ordinance adoptions; they should focus efforts on the removal of the structure from the risk of the immediate hazard, or mitigation of the structure above the historic hazard. Educating communities on the risk potential of the hazards and how they could impact the built environment is a way to get them involved with developing incentives.

3.4 / Conclusion

TMAC sees opportunities for FEMA to create a more flood-resilient nation by executing under its current authorities using a flood risk management framework built on probabilistic rather than deterministic approaches. Fuller conversations about how much flood risk exists and how much is acceptable to individuals or communities is possible using modern technology, but it demands shifting away from the current binary view of flood hazards to a more graduated view of flood risks. Presenting flood hazards and risks in a graduated way helps stakeholders better understand the possible implications of their choices, thereby motivating flood risk reduction actions.

A flood risk management framework built on probabilistic approaches could create **a more flood-resilient nation.**

4

Framework for FEMA to Transition to Future Flood Hazard and Flood Risk Identification Initiatives

FEMA's vision for the future of the National Flood Mapping Program is a multi-year strategy of new concepts and approaches. The FFRD initiative,[1] which FEMA has defined as “an agile series of exploratory projects designed to help define the future direction of the mapping program,” identifies four major elements:

- Shift from binary to graduated risk analysis;
- Ensure a significant and appropriate role for the private sector and SLTT entities;
- Increase access to flood hazard data to improve resulting mitigation and insurance actions; and
- Modernize the management and delivery of flood hazard mapping.

1 “The Future of Flood Risk Data (FFRD). “ Release date: September 252020, www.fema.gov/fact-sheet/future-flood-risk-data-ffrd.

FEMA has envisioned FFRD as a multi-faceted initiative that meets the needs of flood hazard and risk data users and stakeholders across the nation. As outlined in Chapter 3, TMAC sees FFRD as a means to achieving a future state of the current programs that will lead to a more flood-resilient nation. However, TMAC believes FFRD should not focus on a "one size fits all" solution. Rather, it should work toward developing a suite of datasets, products, processes, and communication activities that can be tailored to meet user needs. As highlighted in Chapter 2 of this report, stakeholder feedback has provided excellent insight on use-case scenarios of flood hazard and risk data.

A fundamental shift in flood hazard and risk data and their uses will likely be perpetuated by the implementation of RR2.0, which is scheduled to be launched on October 1, 2021. Flood insurance premium rates will no longer be determined solely by FIRMs and flood insurance rating tables. Instead, RR2.0 adopts a dynamic rating approach that allows multiple data inputs into the "ratings engine" to determine flood insurance premiums. Those premiums will be determined using multiple data sources, including FIRMs and Flood Insurance Study (FIS) data, catastrophic risk modeling, distance from a flooding source, and several other datasets. This shift in how flood hazard and risk data will be used for flood insurance premiums, coupled with the benefits of having a nationwide geospatial dataset to depict flood hazards, creates the need for a transition framework to future initiatives.

SURVEY INSIGHT

Stakeholders support streamlining the mapping process, including providing a system by which communities can create and/or update maps.

Current FIRM and FIS data are often viewed as a "definitive source" for flood hazard data. The guidelines and specifications that govern how current FEMA flood hazard and risk data are created provide consistency, transparency, and the means for calibrating other flood hazard and risk assessments. However, given the regulatory nature of FIRM and FIS data, it often takes 3 to 5 years for FEMA flood hazard and risk data to be finalized. This contrasts with efforts like First Street Foundation's Flood Factor, CoreLogic, and other catastrophe modeling, which, although having no regulatory bearing, may be completed in a fraction of the time. As FEMA transitions to FFRD initiatives, TMAC believes it is necessary for FEMA to reduce its mapping products' delivery timeline so that current and updated flood risk data will be available to all stakeholders in less time.

Significant advances in modeling the natural environment (e.g., floods) and computing have allowed for the development of intricate models to depict flood hazards and risks. These types of tools were not considered when the SFHA, Base Flood Elevation (BFE), and floodway were developed for the NFIP over 50 years ago. As discussed in Chapter 3 of this report, the use of probabilistic modeling and depicting flood risk in a graduated manner are very possible to accomplish today. In addition, with the use of probabilistic modeling, future climate scenarios and the impacts of levees and dams on flood hazards may be incorporated rather expediently.

However, interim steps should be taken to create a "mosaic" of approaches for quantifying and depicting flood hazards and risks across the nation that provide a credible and scientific basis for decision-making purposes while FFRD is deployed and vetted. FFRD should not be solely viewed as an input into the ratings engine for RR2.0.

There are a multitude of other uses and applications for flood hazard and risk data as they exist today that must also be accounted for as part of FFRD. FEMA flood hazard and risk data are used for a variety of purposes, from regulating floodprone areas, to emergency management, to land-use planning, to lender compliance, to mitigation efforts. The FFRD transition must therefore lead to a gap where flood hazard and risk data become outdated or unusable by community officials, planners, engineers, surveyors, lenders, determination companies, and a multitude of other stakeholders, especially for floodplain management, flood mitigation, and banking purposes.

Any transitional framework used to help FEMA improve the nation's flood resilience must recognize and leverage the components of the current flood hazard and mapping programs that serve as a basis for the FFRD initiative. In addition, the FFRD initiative should leverage existing flood hazard and risk datasets and tools to inform what a future collaboration of flood hazard and risk would look like.

A transition to future initiatives should recognize and leverage the framework upon which it was built, which is FEMA's historic and current flood hazard and risk mapping programs. The transition framework to a future state of current programs should highlight the following: (1) the significant investment FEMA and its partners and stakeholders have already made in flood hazard and risk identification; (2) ways for FEMA to enhance flood hazard and risk data use and delivery while avoiding a "decay" in current flood data investments; and (3) leveraging the Information Technology (IT) and modeling tools, partnerships, and delivery mechanisms needed to achieve FFRD.

KEY FINDING

Big Picture vs. Narrow Details

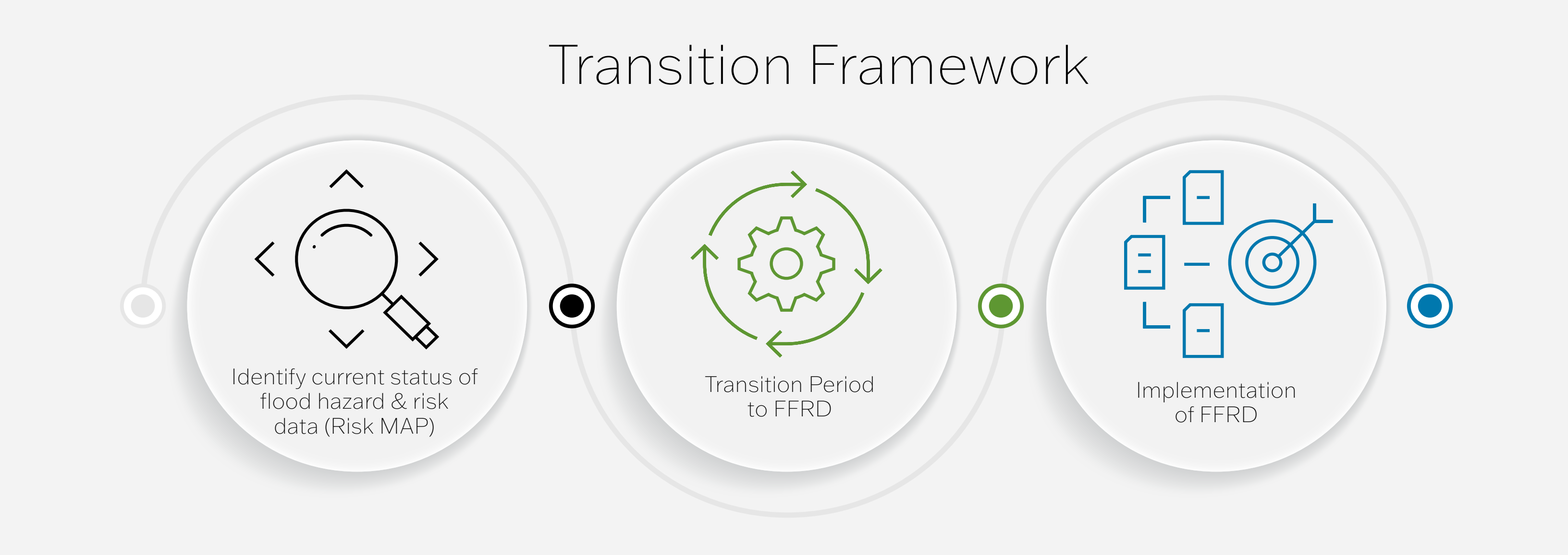
The "big picture" benefits to the shift from binary to graduated are clear, but a clear plan including a timeline and details about the phasing-out of current products/program elements and the phasing-in of new elements is needed.

As FEMA develops new ways of executing current programs, many opportunities exist. As is thoroughly vetted in the stakeholder engagement section of this report, there is general support from FEMA's stakeholders for the transition from binary to graduated flood risk. One of the primary concerns, however, lies in the details of how the transition occurs. Stakeholders are interested in how future products will be shared to collect input, what data they will consist of, and how the products may be employed, especially for floodplain management and flood mitigation purposes. There is a multitude of datasets and stakeholders with an interest in flood hazard and risk data; engaging these stakeholders and available data will be a key component in transitioning to a future state of current programs and a more flood-resilient nation.

This chapter attempts to articulate a framework for transitioning to a graduated flood hazard identification and risk communication program that will identify the broader range of flood risks affecting communities, identify community assets that floods threaten, and spur actions and investments at the individual and community levels to mitigate flood hazards and risks. This section of the report opens with an overview of a transition framework to a future state of the current programs that FEMA may consider, followed by the identification of real and potential obstacles to the implementation of FFRD. The section continues with a discussion of strategic developments that provide opportunities for creating a more flood-resilient nation; identifies elements of the current programs that should be carried forth; and identifies roles that other agencies, the private sector, and non-governmental organizations (NGOs) could play in the future, during the transition, and eventually when the future state of FEMA's current programs is achieved.

4.1 / A Framework for Transition to the Future of Flood Risk Data

As FEMA continues the strategic implementation of RR2.0 and transitioning to the future state of current programs, there remains a need to be responsive to stakeholders' desire for a more thorough, holistic view of community flood hazards and risk. However, it is important to realize that programmatic priorities for FEMA's current programs remain. For the foreseeable future, FIRM and FIS products and their resulting non-regulatory suite of products such as flood depth and analysis grids and flood risk assessments will likely continue.



With the goal of a "risk-informed" NFIP as part of a more flood-resilient nation, FEMA may consider focusing on a general set of guiding principles to help inform a transition framework, which includes the following:

- Life safety is paramount; infrastructure, economics, and social impacts must also be considered.
- Risk should inform floodplain management and decision-making processes.
- The urgency of completing flood mitigation actions should be commensurate with the level of flood risk being mitigated.
- Federal agencies should empower other SLTT, academic, nonprofit, and private entities to participate and lend their expertise to flood risk management programs.
- Flood risk communication must be well planned, timely, focused on areas of high social vulnerability, and involve all stakeholders potentially affected by flood hazards.

SURVEY INSIGHT

Stakeholders noted the value of local/state datasets, and encouraged:

- Flexibility in products with local data on top of national-level base data
- Flexibility to incorporate local standards, preferences, and anomalies into products (like new/local zones)
- Flexibility to be able to build scenarios (SLR scenarios, mitigation scenarios, etc.)

These guiding principles should also keep in mind the goals outlined in FEMA's Strategic Plan for 2018–2022, which include Building a Culture of Preparedness, Readying the Nation for Catastrophic Disasters, and Reducing the Complexity of FEMA.

FEMA and its stakeholders have made significant investments, especially over the past 15 years, through Map Modernization and Risk MAP, to modernize and update the nation's inventory of flood hazard data. During this period, significant investments in developing terrain data and H&H modeling for flood hazard identification have been made. These investments have served as the foundation of Risk MAP and allowed FEMA to accomplish metrics for the Risk MAP program, especially in light of New, Validated, and Updated Engineering data. More recently, FEMA has supported the development of Base Level Engineering (BLE), which is generally large-scale (often hydrologic unit code [HUC] 8 watershed in size), and employs automated H&H modeling practices. These efforts, particularly the flood models generated, can serve as a foundation for a transition to future initiatives. During this transition, FEMA should build on these efforts to enhance collaborative partnerships to depict varying flood hazards and risks, including—but certainly not limited to—Sea Level Rise (SLR) mapping, dam inundation zones from the National Inventory of Dams (NID), and levee risk areas depicted in the National Levee Database (NLD). In addition, the recently passed Digital Coast Act, which provides a mechanism for the National Oceanic and Atmospheric Administration (NOAA) to fill data needs and gaps for critical coastal management issues and support continued improvement in existing efforts to coordinate the acquisition and integration of key data sets needed for coastal management, will serve as key data input and partnership for FEMA's transition to future initiatives. In addition, tools such as Esri's ArcGIS suite of products and WebEOC Emergency Management software may also be employed to visualize dynamic flood hazards and risks, and to coordinate efforts to respond to and mitigate flood risk—all while using available flood data and any future flood hazard and risk data that are created through future iterations of FEMA's current programs.

As important as engaging stakeholders and communicating available datasets will be for any transition to the future state of FEMA's current programs, providing a means to better inform future flood hazard risk data needs should be implemented. This includes leveraging and investing in tools built by various stakeholders applying adaptive strategies and management practices. FEMA has long been the purveyor of regulatory flood hazard data, but several entities, ranging from public to private, have a stake in flood risk management and have built datasets and tools to support their goals. That said, all tools in the "toolbox" should be used as part of the transition framework to help build a "mosaic" of approaches for quantifying and depicting flood risk across the nation under the authority given to FEMA under the NFIP and BW-12. Managing flood hazards and mitigating flood risks is also largely impactful on economies—federal, state, and local. Therefore, economic-related data—business disruptions, infrastructure improvements and enhancements, and future growth—should be recognized and quantified accordingly to help inform a transition to future initiatives. FEMA should also consider enhancing the promotion of the viability of nature-based solutions as an overall strategy to achieve the natural and beneficial functions of floodprone areas. While the traditional development is often "gray," i.e., involving constructed and artificial structures, nature-based solutions encompass natural, green, and integrated "gray" measures that address and mitigate flood hazards and risks.

Recognizing the opportunity for a new national flood risk management framework, as discussed in Chapter 3, a transition should encompass and highlight the following:

SURVEY INSIGHT

Regarding communicating risk, the NFIP's products and tools are designed to serve users who in turn serve non-technical audiences. Tools and products that can be used to communicate to non-technical audiences may be a priority.

- The significant investment FEMA and its stakeholders have already made in flood hazard and risk identification
- Support for current and future uses of RR2.0
- Enhanced flood hazard and risk data use and delivery while avoiding a "decay" in flood data investments
- Support and enhancement of the IT, engineering and mapping tools, partnerships, and delivery mechanisms needed to achieve future states of FEMA's current programs

Using the transition framework outlined above will allow FEMA to identify stakeholders and opportunities to enhance available tools, data, and implementation strategies that will be vital to achieving a risk-informed NFIP. The remainder of this chapter outlines opportunities for FEMA to build upon historic investments, identifies challenges and opportunities to achieving future initiatives, and outlines relevant stakeholders and their potential roles that will support future efforts to achieve a more flood-resilient nation.

4.2 / Real and Potential Obstacles to Achieving the Future of Flood Risk Data

The opportunity for a new national flood risk management framework, as outlined in Chapter 3, highlights the important tenets that must be realized to support a transition to future initiatives. The potential for a new flood risk management framework that has its basis in fostering partnerships and collaboration, acknowledges the natural variability of flood hazards, supports risk-informed decisions, applies adaptive strategies, and employs a user-centric design that highlights natural and beneficial floodplain functions poses significant opportunities for advancing current and future flood resilience efforts. However, FEMA and its stakeholders should also realize the obstacles that must be strategically planned for during any transition to future efforts.

Resource limitations and the current statutory and regulatory frameworks that govern the NFIP and the Program should continually inform any future efforts. However, TMAC believes that a transition from current programs to future efforts and initiatives lies within FEMA's current authorities. Therefore, this section discusses those inherent limitations, but focuses on a discussion of the obstacles posed by the need to effectively communicate flood risk by overcoming the "In/Out" binary view, and the priority that must be given to gaining and maintaining public trust and support during a transition to future states of current programs.

The TMAC stakeholder engagement conducted in 2020 outlined some areas of caution and consideration for FEMA as it moves toward a graduated risk model. Among the primary obstacles identified by stakeholders for the transition to future efforts are: (1) integrating the changes into existing processes, and (2) the resulting confusion about use and implementation of future flood risk datasets and products. Additionally, a lack of long-term planning will likely prolong current flood hazard mapping and flood risk data challenges that will carry forth into any future flood hazard and risk mapping program. This highlights the need to develop a sound strategy to address currently unmapped areas, urban (pluvial) flooding, and areas of residual risk. Future conditions will also likely continue to be a lower priority until a transition framework to future initiatives is developed and implemented. There are many agencies at the federal, state, regional, and local levels that have some semblance of flood hazard management or flood risk reduction in their respective missions. This highlights the need to enhance flood risk management collaborative efforts to support a new framework that fosters partnerships, acknowledges the natural variability of flood hazards, supports risk-informed decisions, applies adaptive strategies, and highlights natural and beneficial floodplain functions.

4.2.1 / Resource Limitations

Funding for the current flood hazard mapping program is currently provided through a combination of Congressional appropriations and a federal policy fee that is charged to each NFIP flood insurance policy and renewal. However, much of the funding from the federal policy fee is used for "staffing, program management, IT infrastructure, maintaining a call center … [and to support] the cost for processing Letters of Map Change … all of which do not provide a significant contribution to the effort to develop new or updated maps" (*ASFPM, Flood Mapping for the Nation, January 2020, p. 10*). The federal policy fee has its critics who point to the broader benefit of flood mapping to the nation beyond

Almost $500 million in losses are avoided each year due to structures being constructed with freeboard.

flood insurance rating, thus creating an inequitable charge for policyholders. With the growth of the private flood insurance market and the advent of RR2.0, this opinion has the opportunity to spread. FEMA's resource limitations inherently limit multi-year planning efforts (as previously recommended by TMAC), especially for Cooperating Technical Partners (CTP). Previous efforts, such as FEMA's Multi-Year Hazard Identification Plan for Map Modernization in Federal FY 2005–2009, were used to develop a 5-year framework plan for the Program. This multi-year plan mainly focused on digital flood hazard metrics instead of producing a holistic view of community flood risk, future conditions, and co-benefit uses by stakeholders other than flood insurance rating. The implementation of the FFRD initiative is especially important to consider in relation to and as a result of RR2.0. Once the costs to maintain future flood hazard and risk data are better defined, sustained funding will be critical to ensure that the data remain current, credible, and usable.

Beyond federal funding, a key component of funding for mapping is through the CTP program. CTP leverage often equals or exceeds the federal contribution for flood mapping projects. Further, CTP partners understand and operate under FEMA's existing "Guidelines and Specifications for Flood Hazard Mapping Partners"; therefore, it will be critical for these existing and potential partners to understand and support any new requirements in order for the CTP program to continue to play an important role. As mentioned in the following sections, the CTP program is a component of the existing program that should remain. However, challenges remain for the smaller, more rural, or less affluent communities that may not have the resources or receive the attention of larger, more populated communities.

In the 2016 National Flood Mapping Program Review report, TMAC recommended that "FEMA should evaluate the benefits and costs and its value to the nation as a result of different levels of funding to the National Flood Mapping Program" (p. 36). There are various ways to measure the benefits and the value of the mapping program to the nation. The ASFPM Flood Mapping for the Nation Report referenced a 2018 FEMA assertion that "there are $1.6 billion in avoided damages every year for buildings constructed in compliance with NFIP standards … [which] would have not been possible without the flood maps" (*ASFPM, Flood Mapping for the Nation, January 2020, p. 11*). A recent report released by FEMA on the benefits of enforcing higher building standards states that each year, almost $500 million in losses are avoided due to structures being constructed with freeboard (*FEMA, Building Codes Save: A Nationwide Study, November 2020*). As the costs are identified for a transition to future programs designed toward producing graduated risk outputs, the measure of the relative benefits must be identified, weighted, and compared.

SURVEY INSIGHT

Focus Group members had several recommendations regarding communicating flood risk, including:

- The need for consistent, accurate messaging regarding risk and mitigation options
- Better messaging on the connections between community action/inaction and insurance rates
- Focused messaging on the financial benefits of mitigation and higher standards
- Better communication of the emotional and socio-economic impacts of flooding

4.2.2 / Statutory and Regulatory Requirements for FEMA and the NFIP

A transition to future initiatives should precipitate a comprehensive review and analysis of statutory and regulatory citations that may affect the proposed new flood risk management framework. Keeping in mind the four-legged stool that comprises the NFIP—floodplain mapping, floodplain management, mitigation, and flood insurance—there are numerous other federal programs reliant upon the current statutory and regulatory structure, including federal building standards, banking, environmental and historic protection, emergency management, and others. Often, federal guidance informs SLTT laws, regulations, and guidelines, all of which will in some way be affected by the transition from current programs to future initiatives.

Importantly, TMAC is not suggesting to FEMA that each particular statute or regulation needs to be altered, nor that each concept within the existing statutory or regulatory framework needs to be changed. In fact, under the existing statutory and regulatory framework, mandatory flood insurance purchase and minimum building requirements should remain, but perhaps other future program elements should be addressed in federal, state, or local guidelines to provide needed flexibility for non-regulatory purposes. As an example, consider the SFHA, which could remain in statute for the minimum mandatory purchase of flood insurance requirements or minimum floodplain management requirements, but could be removed from certain regulations and guidelines that do not rely on the use of this specific delineated floodplain. Further, concepts such as "flood zones" or "panels" may or may not be necessary, depending on the use case.

The last major overhaul to the NFIP occurred in 2012 and 2014 with the BW-12 and the resultant Homeowner Flood Insurance Affordability Act. Both acts had impacts on the national flood mapping program but did not provide the groundwork for a transition to future states of current programs. It is important, therefore, for FEMA to use the flexibility it possesses in programmatic implementation under current authorities to strategically identify opportunities to support a transition to the envisioned new framework for future flood risk data.

4.2.3 / Effectively Communicating Flood Risk in a Graduated Manner and Overcoming the "In/Out" View of Flood Risk

FEMA must design and implement a communication strategy to effectuate an appropriate understanding of flood risk that overcomes the binary view of a property as either being "in" or "out" of a flood hazard area. In the inaugural report of the second TMAC (given authority by BW-12), the Council discussed this objective: overcoming the "In/Out" View of Flood Risk. In fact, approximately 20 of TMAC's recommendations relate at least in part to this objective (*Technical Mapping Advisory Council, TMAC 2019 Annual Report*). Looking back even further, the first TMAC established by Congress with the 1994 National Flood Insurance Reform Act urged FEMA to tackle the misunderstandings of flood hazard information: "FEMA must take other steps to help convince people that they face real risks: loss of life and property from flood. The Council believes that, at a minimum, FEMA should establish a budget for a study leading to recommendations for effective nomenclature to refer to flood probability and severity and to distinguish between those two components of risk" (*TMAC 2000 Annual Report*). Importantly, the historic TMAC report also points out that use of the nomenclature "1-percent-annual-chance flood" instead of "100-year flood" "does little to encourage public action" (*TMAC 2000 Annual Report*). Effectively communicating risk is as important as the information itself. TMAC encourages FEMA's consideration in the 2018 TMAC Annual Report to conduct a behavioral risk audit. Through this audit, TMAC believes that FEMA can gather information necessary to develop a more effective strategy that overcomes or addresses the risk of systematic biases in how people deal with the uncertainty of floods and their consequences (*TMAC 2018, p. 19*).

Introducing a depiction of flood hazards and risks in a graduated manner will require a coordinated outreach and education effort to all SLTT, academic, nonprofit, private, and other stakeholders. A concerted outreach and education effort will be necessary to develop and carry the message. The flood hazard risk message should be developed locally to focus on geographic and social differences, and then communicated locally, regionally, and nationally to ensure a unified message. To accomplish this, a "mosaic" of approaches for quantifying and depicting flood hazards and risks across the nation that leverages partner input should be fostered for inclusion into future efforts. Even though FEMA has undertaken considerable strides to better communicate flood risk by developing non-regulatory flood assessment and risk products (flood depth and analysis grids, flood risk assessment, depth/velocity grids, etc.), many floodplain administrators struggle to use these non-regulatory flood mapping products in their communities. In addition, LOMCs remain viable floodplain management tools, while often miscommunicating holistic flood hazards and risks.

For many, mandatory purchase of flood insurance and regulatory floodplain management continue to be perceived as burdens and not as minimum requirements established to protect public and private assets. With the implementation of FFRD, and a transition to these future initiatives, FEMA should ensure that the nomenclature related to flood hazard and risk messages used broaden the understanding of risk by the public, by elected officials at all levels, and by other stakeholders that use "floodplain" maps.

Gaining and maintaining public trust and support **will only come with a transparent process** *that includes stakeholder engagement along the way.*

4.2.4 / Gaining and Maintaining Public Trust and Support Must Be the Priority

With the understanding that graduated flood risk information is a step in the right direction to achieve greater resiliency, it is imperative that developers, lenders, realtors, elected officials, floodplain managers, and other stakeholders maintain trust in this future flood risk construct. This trust cannot be possible without the direct engagement of FEMA leveraging resources and increasing efforts to support local and watershed actions that minimize flood risk. In addition, flood data should be made available to support prioritization of beneficial mitigation actions. By making the data—not only a map—and subject matter expertise available to stakeholders, FEMA will be supporting multiple purposes, such as development of community-based resilience plans that may address repetitive losses, identification of mitigation co-benefits for Benefit-Cost Analyses, and overall implementation of mitigation activities.

The largest and most complex cohort for FEMA to consider in terms of trust is the taxpayers. Given that taxpayers fund the majority of the development and production of flood hazard and risk data, and these same taxpayers elect the representatives that authorize and appropriate this outlay, the level of ongoing funding for flood mapping may be expected to be commensurate with the level of public trust and support for the program. Congress recognizes the importance of this trust by requiring per statute that FEMA's mapping program should only be implemented "after review by the Technical Mapping Advisory Council, that, when applied, results in technically credible flood hazard data" (emphasis added, *Section 17, Homeowner Flood Insurance Affordability Act of 2014, P.L. 113-89, 128 Stat. 1021-22*). By contrast, the public has too often perceived the flood elevations as being gerrymandered and not depicting the actual flood risk. Some of the specific recommendations that TMAC has provided to FEMA in an effort to deliver credible flood data are (1) enhance communication and transparency with stakeholders, (2) leverage current high-resolution topographic data, and (3) shorten the flood study and mapping process (*Technical Mapping Advisory Council, TMAC 2016 National Flood Mapping Review, p. 5*). The current Risk MAP program outlines a foundation for flood hazard mapping stakeholder engagement with Discovery, Flood Risk Review, Consultation Coordination Officer, and Resilience meetings. Therefore, future efforts must realize and leverage the best aspects of current programs and strategically utilize them to inform future programmatic development and implementation.

In summary, one of the most important aspects moving forward is for stakeholders to understand FEMA's expectations for the future flood hazard mapping program, and vice versa. FEMA has many proof-of-concept assessments and projects under way related to future flood risk data—such as probabilistic modeling assessments and development of non-regulatory products to communicate flood risk. For a transition to RR2.0 and graduated flood hazards and risk, FEMA must remain transparent and engaged with operational partners and users of flood hazard data. Any future flood mapping effort should identify current and future at-risk areas (including those outlined in BW-12—dams, levees, and coastal erosion residual risks), but should also inform current and future asset investments (e.g., structures, infrastructure) related to coastal, riverine, and pluvial flood hazards. Additionally, future flood data should easily prioritize and incentivize mitigation actions and enhance environmentally sensitive areas such as wetlands, dunes, and other open space areas that support natural and beneficial functions. Any future efforts should be built with partnerships in mind in order to enhance, consume, and utilize the data, while keeping in mind that regional flood-related hazards such as flood after fire, fluvial erosion, sinkhole flooding, and mudslides are a priority for some stakeholders.

4.3 / Opportunities to Support the FFRD Initiative

FEMA's FFRD initiative will provide a more comprehensive picture of flood hazards and risks by leveraging new technologies to include more efficient, accurate, and consistent flood risk information across the nation. Providing more comprehensive hazard and risk information complements the improvements in flood risk communication being advanced through RR2.0, and offers a basis for a range of outcome-oriented regulatory and non-regulatory products (*FEMA, 2020*). A structure-based, graduated flood-hazard and flood-risk approach greatly advances the ability to understand flood hazards and communicate flood risks, which is vital to protecting lives and property. The models upon which graduated flood risk depictions and other flood-risk products rely require detailed and accurate data representations of the real world. These models, and the underlying data, are undergoing empowering technical transformations that will benefit FEMA in the FFRD initiative. Additionally, tools have been or are currently under development that can support FEMA's mandate outlined in BW-12 regarding residual flood risks related to areas impacted by dams, levees, or other manmade structures and areas of coastal flood hazards and risks. These tools, in addition to the advancements in geospatial techniques, statistical flood characterization, and trends in detection, provide meaningful input on the transition to future efforts.

4.3.1 / Leveraging Geospatial Advancements

FEMA's transition to future initiatives arrives during a time of unprecedented innovation and technology development in the geospatial community, including industry. Legislation like the Geospatial Data Act and Open Government Data Act reinforces the value and desire for standards-based, interoperable geospatial data for evidence-based decision making across the country. The United States now has access to more information describing the earth's surface, built environment, hydrologic cycle, and climate and weather patterns than ever before, and at resolutions that continue to increase in precision and fidelity. Terrain data, hydrologic data, economic data, and critical infrastructure, among many other sorts of data, can be leveraged to support future efforts.

Some datasets do not exist, and agencies are actively working to coordinate the development and production of needed datasets. It is pertinent for the transition to future flood mapping efforts for agencies to adhere to the frameworks for agency coordination and data management outlined in the Geospatial Data Act and Office of Management and Budget Circular A-16 to ensure there is no existing or planned duplication of effort or resources in either managing datasets or conducting modeling activities. Future datasets that describe the statistical recurrence of damages in multiple categories (e.g., economic, life safety, and environmental) across the nation must start with proper statistical representation of storms across the domain of the nation (and their spatial colorations), model them through the water cycle all the way to the consequence receptors (e.g., structures, infrastructure, ecosystems), and properly scale the impacts of the hazards based on the value and vulnerability of the consequence receptors. Without these components, a full understanding of risk cannot be realized. The convergence of improved methods and increased availability of high-quality, foundational geospatial information presents several opportunities for the future of FEMA flood hazard identification and risk communications.

There are five key areas of opportunity to explore during the transition to future efforts and initiatives, and they include:

- Improving access to data related to residual risks associated with areas impacted by dams, levees, or other manmade structures and areas of coastal flood hazards and risks;
- Improving the national building footprint database;
- Improving hydrographic data to include engineered and groundwater systems;
- Improving integration of surface topography, natural and engineered hydrography, and near-surface geology, including improving flood modeling in Alaska; and
- Improving understanding of flood risk to, and impact of, community lifelines.

In addition, recent developments in the use of flood record extension techniques will serve as an informative and useful tool for probabilistic flood hazard analyses.

4.3.1.1 / Improving Flood Control Structure Datasets and Coastal Flood Hazards and Risks

NOAA's Digital Coast website provides coastal data to meet the needs of the coastal management community. Digital Coast content includes visualization tools, predictive tools, and tools that make coastal data easy to find and use. Content for Digital Coast comes from many sources and is vetted by NOAA. The most-used datasets in Digital Coast include lidar, economic, and land cover information, while the most-used tools include the Sea Level Rise Viewer and Land Cover Atlas. Stakeholders from a variety of partnerships, including the American Planning Association, ASFPM, Coastal States Organization, the National States Geographic Information Council, and several others, contribute to the viability of the coastal products and tools available. Additionally, the recently passed Digital Coast Act further supports and enhances the development of the Digital Coast website and allows greater stakeholder involvement. As a best practice, the Digital Coast website lays the groundwork for FEMA to not only partner with NOAA and other SLTTs for coastal management practices, but also provides

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Stakeholders believe that the program needs better modeling and access to data and that new products should:

- Include residual risks related to flood control structures (levees and dams)
- Include a factor of safety (e.g., horizontal freeboard or other ways to include higher standards into basic program components)
- Be flexible and scalable to match community needs and capabilities

an excellent blueprint on how datasets and tools from a variety of stakeholders may be used to comprehensively manage and mitigate flood risks.

Significant efforts have recently been made to inventory and characterize flood control structures, including dams and levees. FEMA has an established partnership with USACE and other stakeholders to support data development and flood risk communication related to dams and levees. The NID is a geospatial database that contains information on over 45,000 dams nationwide that meet the regulatory definition of a dam—generally, those impounding structures that equal or exceed 25 feet in height and exceed 15 acre-feet of storage, or structures that equal or exceed 50 acre-feet in storage and exceed 6 feet in height. State or territorial dam safety agencies are responsible for updating data in the NID annually, and these dam safety programs are at least partially supported by grant funds from FEMA's National Dam Safety Program. By the end of 2021, it is anticipated that USACE will make all dam inundation zone mapping present in the NID available for public consumption. Additionally, FEMA has supported the development of DSS-WISE™ lite, a web-based, automated, two-dimensional dam-break flood modeling and mapping capability developed by the National Center for Computational Hydroscience and Engineering at the University of Mississippi. DSS-WISE lite is used by dam safety agencies and stakeholders across the nation to characterize the risks related to dam failure incidents.

The NLD is maintained and published by USACE and provides a dashboard that assists in finding and understanding levee information. The NLD contains information about the condition and risk information for approximately 2,000 levee systems (approximately 15,000 miles) of levees, mostly with USACE programs. An additional 6,000 levee systems—approximately 15,000 miles—have location information, but little to no information about condition and risk. This poses a significant opportunity for enhancement as FEMA continues with FFRD. The database includes attributes of levees and floodwalls relevant to flood fighting, design, construction, operation, maintenance, repair, and inspection. Because the location and characteristics of levee systems can be viewed on a map with real-time data from other sources, it is a useful tool for a variety of public agencies and individuals, including floodplain managers, emergency management agencies, levee system sponsors, and other stakeholders. Embankments of earth—either as a result of natural river geomorphology or outdated and unmaintained local flood measures—direct flow during a flooding event. However, many of these embankments are not captured in the NLD, leaving flood modeling without the ability to easily include these landscape features in the computation. The proliferation of airborne and satellite earth observation systems, coupled with advanced algorithms and high-performance computing, present opportunities for capturing these geologic features in a highly automated and scalable manner. Targeted investments by FEMA, in partnership with interested federal agencies and academic partners, could capitalize on this opportunity to develop a hydrologically reinforced representation of the nation.

4.3.1.2 / Improving National Building Footprint Database

Structure-based flood-risk identification depends on an accurate depiction and attribution of the structure for which the risk is being calculated. Flooding is a hazard for which a very small offset in data accuracy may impact projected flood damages, so a highly precise and thoroughly vetted dataset related to the built environment is paramount. The past few years have seen additions of open-source building footprints from Microsoft and OpenStreetMap, among others. However, there is no explicit commitment to update these databases, nor plans to improve accuracy, and license restrictions may prove prohibitive in practice for private databases or for use and distribution of open datasets. However, an opportunity exists for FEMA to lead nationally by investing in development of a national building footprint database.

FEMA has invested heavily in the United States Geological Survey (USGS) 3D Elevation Program (3DEP) goal to acquire lidar coast-to-coast. Three-dimensional (3D) lidar point clouds include detailed information about aboveground features, including buildings and other infrastructure. Lidar is commonly used to extract building footprint polygons, and research is ongoing at organizations such as Oak Ridge National Laboratory on the use of machine learning techniques to refine building footprint polygons using lidar and aerial imagery. Lidar is used to determine building roof elevation and to extract data such as the number of stories in a building, or to build virtual models of buildings for insurance estimation, fire response, population estimates, and other applications. Lidar can also be used to measure first-floor elevation more accurately, which can be used to estimate the severity of building inundation during flood events (for example, to identify where people may be stranded on roofs in need of rescue). More accurate and comprehensive building information derived from lidar could be used by FEMA and its stakeholders to better understand and quantify the threat from floods to human lives and infrastructure at a highly detailed level.

In addition, USACE manages the National Structure Inventory (NSI). It was originally developed for use by USACE to drive dam safety modeling, levee safety modeling, and real-time consequences to support the Corps Water Management System (CWMS) National Implementation. The first iteration of the NSI was created by translating aggregated Census block-level data from FEMA's Hazus, a public domain source, into a format where points represented individual structures. The NSI is currently on the third iteration of the dataset, reflecting the most accurate federal point-based dataset built to date, representing a picture of the nation's inventory in 2018. This accuracy comes at the cost of licensed data restricting the access of the NSI to federal partners. Accurately attributed point-feature structures increase the precision, performance, and resolution of risk analysis when combined with detailed hazard data, and this information is critical to support communication and mitigation on an individual structure level. The NSI currently stores attributes describing the type of structures,

There is great interest and real need across the federal geospatial community **for a database for building footprints.**

valuation, population, ground elevation, and foundation height for each of the point locations in the database. USACE has worked informally with FEMA to improve the NSI and the Hazus data through these collaborative efforts. It is recommended that FEMA and the NSI team work jointly in a more formal arrangement to explore publicly available, non-restricted structure attribute sources and data to allow access to the NSI data for SLTT governments in the near-term, and full public access in the long-term.

There is great interest and real need across the federal geospatial community for a database for building footprints and other structure geometry and attribution. The Census Bureau, Department of Homeland Security, National Geospatial-Intelligence Agency, and USGS would all be immediate users of such a database. As with 3DEP, FEMA could drive investment in a national solution that would not only provide a consistent, updated, high-quality building database to meet their specifications, but also contribute to the needs and requirement of other federal and SLTT governments, among others.

4.3.1.3 / Improving Hydrographic Data to Include Engineered and Groundwater Systems

The National Hydrography Dataset (NHD), maintained by the USGS, represents the most current and comprehensive mapping of the surface water and drainage basins of the United States. These authoritative data make up the hydrographic framework upon which advanced hydrologic modeling and flood forecasting are conducted by the National Weather Service (NWS), the USACE, academia, state and local governments, and water resource managers. NHDPlus HR (Beta version) for the Continental U.S., Hawaii, and Puerto Rico has recently been completed. Compared to NHDPlus Version 2.1, which is currently being used by the NFIP, NHDPlus HR has many more features, greater detail, improved positional accuracy, and in many areas is more up to date.

NHDPlus HR is designed to be incrementally updated, and updates will continue to improve the data quality over time. Future updates will incorporate improved elevation-derived hydrography from lidar or Interferometric Synthetic Aperture Radar, interactions with groundwater, and connections with engineered hydrography such as urban storm drain systems as part of the modernized 3D National Terrain Model (3DNTM). In most urban areas, information on storm drain systems is not currently available in the NHD, and is therefore not integrated into NHDPlus HR. Many states, regional entities, and other stakeholders collaborate with federal agencies to maintain and update the NHD data. This relationship should be enhanced by FEMA to further support precise hydrographic frameworks.

FEMA and TMAC have frequently stated that a knowledge and data gap exists in understanding and modeling flood response in urban environments, especially for locally intense pluvial events. Storm and wastewater systems are not consistently mapped, nor are they frequently integrated with the physical hydrographic networks that surround them. Recent developments and direction for the improvement of the NHD, and the modernization of FEMA's flood hazard modeling framework could be accelerated and advanced by targeted investments into improving the NHD and NHDPlus HR to integrate these systems, likely greatly improving the suitability and performance of hydrologic models for future flood hazard mapping initiatives. A national culvert database, for example, could be generated as part of the 3DNTM, greatly improving flood modeling capabilities. Without this dataset, accurate depictions of the risk associated with the pluvial hazard are unattainable—FEMA's PFRA modeling effort elevated the importance of understanding local storm and wastewater systems and their contribution to mitigation of flooding from locally intense rainfall.

4.3.1.4 / Improvement in Integration of Surface Topography, Natural and Engineered Hydrography, and Near-Surface Geology

As previously mentioned, flood hazard and risk depictions rely on many data sources, each of which is developed and produced independently, with little or no collaboration by the authoritative providers. Future directions in the generation of key topographic datasets offer an opportunity to more closely integrate those datasets for an improved and comprehensive understanding of the nation's response to extreme events and flooding.

The 3DNTM is the next generation of the 3D Elevation Program and NHDs, including inland bathymetry, hydrography derived from lidar, and connections to groundwater and engineered hydrographic systems such as storm sewers and irrigation systems. The model will be useful to federal, SLTT, academic, nonprofit, and private agencies to improve H&H networks and inform decision making on flood prediction and response. The USGS National Geospatial Program is working with partners, including the University of Texas; Lamar University; the Texas Departments of Transportation, Emergency Management, and Public Safety; USACE; local drainage districts; and local floodplain managers on developing a seamless terrain model above and below water surface in Southeast Texas as a pilot of the 3DNTM.

The goal of this flood coordination study is to improve flood prediction modeling at the local level for regional flood mitigation and response. This allows proper accounting of flow volumes contained within channels to better associate the frequency of flow that relates to flooding in the overbank. Without the seamless terrain model, hydrodynamic modeling frameworks assume flows associated with in-channel capacity, and this increases uncertainty with the probability of flooding in the overbank. Assumptions like this can greatly impact the probability of frequent flooding events, which can cause enormous error in the frequency of consequence estimates and skew the entire risk equation. The pilot study is a first step toward expanding the 3DNTM statewide or to other regions. FEMA could use the 3DNTM data to predict where and when flooding might occur at the local level for different weather events. USGS and FEMA could explore partnering on the development of 3DNTM to ensure that requirements for graduated flood risk products are explicitly addressed in support of a risk-informed NFIP.

An example of this kind of opportunity is the improvement of flood modeling in Alaska. Although flood modeling in Alaska is not often discussed owing to the low and dispersed population of the state, the recent improvement in foundational geospatial data represents an opportunity to increase flood mapping and risk modeling efforts for vulnerable coastal communities, cities, and native villages in an extremely dynamic and changing environment.

The Alaska Mapping Executive Committee (AMEC), a federal and state interagency governance body, was created in 2012 to address the need for improved mapping products across the State of Alaska. The AMEC, led by the Department of the Interior and Department of Commerce, have exerted tremendous political, technical, and commercial effort to modernize the geospatial foundation in Alaska. As a result, a 5-meter resolution Digital Elevation Model and imagery mosaic for the entire state are available for federal and state use, and a complete revision of the topographic mapping for the state—more than 11,000 new maps—will also soon be complete.

As FEMA transitions to future states of current programs, multiple opportunities exist that could take advantage of the proliferation of high-quality, interoperable, authoritative datasets currently available, in development, or which could be created with investment. These all have the potential to greatly improve the accuracy and performance of flood modeling products for FEMA, while also serving as a collaborative model framework for contributing needs and requirements of government and private partners throughout the nation.

4.3.1.5 / Improving Understanding of Flood Risk to, and Impact of, Community Lifelines

Community lifelines enable the continuous operation of critical government and business functions and are essential to human health and safety and economic security (FEMA Community Lifelines). These include a variety of federal, and SLTT services that provide safety and security, shelter (including water and food), medical support, energy, water, communications, transportation, and hazardous materials.

While considerable focus has been placed on understanding flood risk to residential and commercial structures, less attention has been given to how community lifelines would be affected by a flooding event. This is important to understand not only from a long-term loss perspective but is also critical to fostering an informed and effective community response.

Future flood hazard and risk mapping efforts have the opportunity to take advantage of recent work performed by FEMA and other agencies to categorize, describe, and digitize information related to community lifelines. FEMA's Modeling and Data Working Group has been working through the 200+ data needs identified initially for each lifeline. Those are now available on the GeoPlatform as part of FEMA's Geospatial Resource Center. The data are organized into seven Lifeline Dashboards [GeoPlatform] for real-time status of the assets, while the underlying data can be found in the lifeline data catalog. The data are open, discoverable, free, and easily integrated into common mapping platforms and applications. Incorporating these datasets, which are vital to local response into flood risk products and public communications, can heighten awareness of any vulnerability, while promoting flood protection mitigation measures to ensure continuity of critical government and business functions during an event.

4.3.2 / Leveraging Recent Developments in Flood Record Extension Techniques

As graduated depictions of flood hazards become more prevalent, probabilistic approaches will need to sample, model, and map flood flows of magnitudes and rarities well beyond those of the 1-percent-chance flood, exceeding those contained within most observed flood records. Although the process will extract more useful information and present it in a more useful way, the extrapolations will likely result in flood estimates and flood maps that are subject to very large uncertainties. These uncertainties may diminish public confidence in these products. As described previously, knowledge uncertainty is reducible. One of the largest contributors to knowledge uncertainty is hydrologic record length. Improving our understanding of the hydrologic systems that produce the floods (better models) and improved knowledge of historic floods through adding observations are ways to reduce that uncertainty.

The standard method for obtaining longer flood records is to extend the operations of stream garges, year upon year. While this approach has considerable benefit, flood records may be effectively extended more rapidly backward in time through examination of local public records and unofficial sources such as newspaper articles and written accounts of past flooding contained in private diaries, letters, and other memorabilia, as well as through paleoflood studies. Descriptions of flooding that reference flood heights or proximity to then-existing and still-standing structures is especially helpful. The development and adoption of methods described in "Bulletin 17C" (England and others, 2016) permits the use of such information to extend flood records available from the USGS and improve flood-frequency estimates. Where these sources of information have come to light, they may have been investigated and incorporated into specific flood mapping studies, but those data have generally not been systematically preserved in readily accessible databases such as the USGS peak streamflow file; however, they should be. The information may have direct application in future flood mapping studies and have transfer value to flood studies for other locations.

Though far more expensive and difficult, paleoflood techniques are used by the USGS, the Bureau of Reclamation, and the NRC to identify and study past major floods at sites now containing crucial infrastructure such as dams and nuclear power plants. These techniques document the timing, and often the magnitude, of floods that occurred before record-keeping, and in some cases, during prehistoric periods. They can also be used to extend existing streamflow records and improve flood-frequency estimates. Although these floods are usually rarer than the 1-percent-annual-chance flood, probabilistic mapping techniques could greatly leverage the information to estimate flood AEPs throughout a community. As depicted in Figure 10, the addition of paleoflood evidence has reduced the estimate of the natural variability (the solid green line is below the solid red line), with a narrowing of the uncertainty bounds across the full range of natural variability. These narrower uncertainty bounds improve our description of flooding substantially.

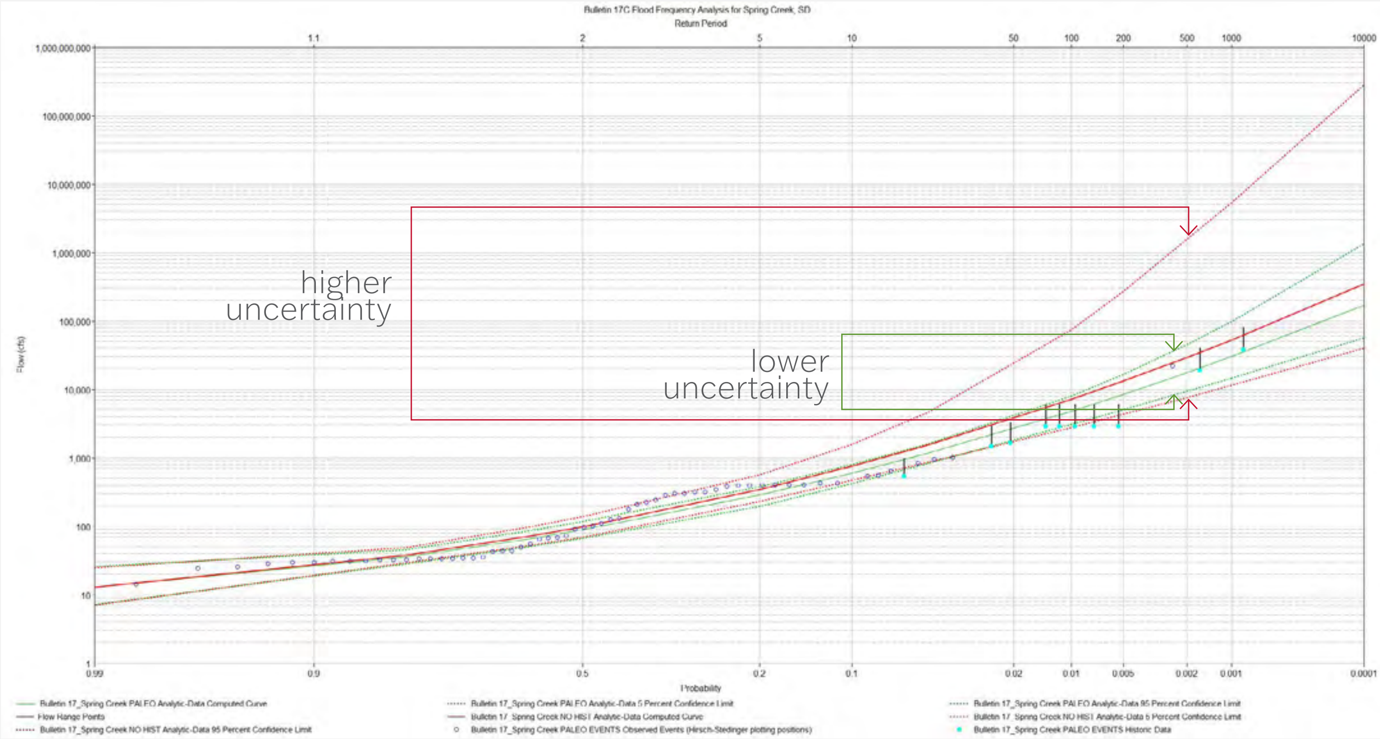

Figure 10 / Flood-frequency analysis output with range estimates of paleoflood: graph showing flood-frequency analysis output with (green) and without (red) range estimates of paleoflood (black)

Source: Andrea Veilleux, USGS based on data from Ryberg, K.R., Kolars, K.A., Kiang, J.E., and Carr, M.L., 2020, Flood-frequency estimation for very low annual exceedance probabilities using historical, paleoflood, and regional information with consideration of nonstationarity: U.S. Geological Survey Scientific Investigations Report 2020–5065, 89 p., https://doi.org/10.3133/sir20205065.

Conversely, the knowledge that floods exceeding some specific magnitude have not occurred within a community over some significant period of time is also a very powerful indirect indicator of the probability that a future flood will or will not exceed that magnitude. For example, documentation that a bridge or church has not been flooded over the last hundred years can be used to substantially augment even short flood records for a nearby stream. The USGS records "year last exceeded" estimates at a small fraction of its stream gages, but FEMA and the community discovery process could yield more such information that would be particularly useful to mapping flood hazards in a graduated way.

4.4 / What Should Be Continued from Current Flood Hazard and Risk Mapping Programs

While FEMA transitions to future initiatives and develops new flood hazard mapping tools and products, TMAC believes that successful and useful aspects of current programs should continue to assist communities in managing flood hazards and mitigating flood risks. The programmatic components described below are those that will likely support a transition or continue to play a role in future programs and initiatives.

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Stakeholders reported positive feedback on the CTP program, and CTPs seem happy with their level of autonomy.

4.4.1 / Partnerships, Specifically the CTP Program

The current program has facilitated the creation and maintenance of partnerships that have leveraged data creation, as well as the sharing of best management practices. The CTP program provides the opportunity to interject a tailored, local focus into the NFIP and incorporate localized approaches to flood hazard identification, communication, and risk reduction. Local and regional governments often develop flood hazard data as part of other programs such as stormwater management, streamflow gaging, water quality issues, or infrastructure development, which have been proven to be required for accurate flood hazard and risk depictions. The success relies on multiple players at all levels of government, academic, nonprofit, and private stakeholders remaining involved and invested, with each having an area of responsibility or expertise. More detail on the CTP program is discussed in Section 4.5.2.

SURVEY INSIGHT

This idea that having an authoritative source and record of flood hazard information by date was an important piece of feedback from insurance stakeholders. However, the issue of needing a record of effective dates and associated historical flood hazard information is also important to other areas of the program, such as floodplain management.

4.4.2 / A Process of Continuous Improvement and Updating of Data, Models, and Tools

The current program facilitates frequent improvement and updating of flood hazard data, models, and tools. Our understanding of the hydrologic cycle and the impacts of land-use decisions is always improving and necessitates a management system that acknowledges and incorporates these improvements. Increased resolution of geospatial products, more refined and powerful H&H models, and knowledge-guided artificial intelligence systems are just the most recent advancements that can lead to improved flood-hazard and risk products.

TMAC believes that continuing with “proof of concept” and “pilot project” activities that assess new datasets, tools, and policies are an important and useful component of the current Risk MAP efforts, and enhancement to these activities will only benefit the FFRD.

Given the existing regulatory or statutory requirements tied to FEMA’s flood hazard mapping, stakeholders rely upon FEMA’s products to ensure that they are protected against unanticipated exposure to liability because of the use of FEMA’s FIRMs and FIS data. Specifically, in the current program, FEMA assigns a FIRM panel number and suffix to a given iteration of a flood hazard, and maps have an effective date that communicates the status of the data and provides a historical record for implementation.

TMAC believes the FFRD needs to include an “effective date” or other indicator to formally establish a record of when the data and tools are applicable and provide a link to the plans that result from their application.

4.4.3 / Support for Floodplain Management and Flood Risk Mitigation

The current program has developed tools and products that stakeholders have found useful and that have become familiar to floodplain managers, government officials, and the public for reducing flood risk. These tools and products generally support floodplain management or inform risk mitigation efforts; therefore, the information they convey should continue to be made available. These include:

> **SURVEY INSIGHT**
>
> TMAC asked stakeholders which elements of the current program were important to maintain as the program evolves. The top five responses were flood elevations or depts, downloadable data in GIS format, flood hazard or flood risk zones, minimum floodplain management standards, and map change processes.

Minimum floodplain development and flood data standards to continue supporting flood hazard mapping, flood insurance, flood management, and mitigation.

Mandatory flood insurance purchase requirements for structures located in floodprone areas to ease the financial burden on property owners after flood losses.

Spatial datasets that have proven useful and have become familiar to floodplain managers, government officials, and the public. Examples include:

- National Flood Hazard Layer viewer to view flood hazard and risk data on a national scale; this includes flood study-supporting text and assumptions (e.g., purpose of study, community description, principal flood problems).
- Areas of concern where special development requirements may or may not apply (primary frontal dunes, coastal barrier resources system, levees, dams, etc.).
- Non-regulatory products—specifically, depth grids—to better understand, investigate, and communicate the variability of flood depths in areas identified as floodprone.

ECs to record pertinent elevations for new buildings and substantial improvements to existing structures in order to show compliance with the applicable floodplain management ordinance and/or regulations. A possible enhancement to the EC could be a digital, geospatial tool that informs and ties in with future flood hazard and risk mapping efforts.

LOMC processes: Letters of Map Revision, Letter of Map Amendment, and Letters of Map Revisions Based on Fill. While FEMA transitions to future initiatives and new depictions of flood hazards and risks, LOMCs or a similar process for minor map updates and adjustments are essential to (1) maintain regulatory requirements of the NFIP, and (2) change flood hazard zone designation as necessary.

BLE: This approach combines high-resolution ground elevation data and modeling technology advancements to create engineering models and flood hazard data at a large (watershed) scale.

Flood risk mitigation incentives:

- CRS, which encourages community floodplain management practices above the minimum requirements of the NFIP in exchange for discounted flood insurance premiums. The CRS 400 Series: Mapping & Regulations, has a direct tie-in to FFRD because it promotes Natural and Beneficial Uses, Higher Regulatory Standards, and Stormwater Management for local CRS communities.

- Hazard Mitigation Assistance grants, which will continue providing funding for eligible mitigation measures that reduce disaster losses.

4.5 / Potential Roles of Non-Federal Stakeholders in Assessing, Communicating, and Managing Flood Hazards and Risks

As noted throughout this report, FEMA has developed many partnerships in developing hazard and risk data. It should be recognized that maintaining and developing additional partnerships might not directly drive down the production costs for floodplain mapping data but will facilitate meeting the overall goal of a more flood-resilient nation. As mentioned earlier, groups like First Street Foundation are providing new methods for representing flood hazard data, and the transition to future initiatives will be dependent on leveraging these expertise, data, and communication strategies, and executing flood risk reduction activities from partners across the risk spectrum. As FEMA continues building toward a "risk-informed NFIP," and as mentioned throughout this report, maintaining appropriate flood hazard and risk information for the various stakeholders of the NFIP is as important as maintaining and building new partnerships. This section highlights many ongoing efforts that FEMA may consider during the transition to future efforts and initiatives. Table 5 provides a depiction of existing or potential partnerships for FEMA to consider.

Table 5 / Possible Collaborative Roles for FEMA Stakeholders

PARTNER	PROVIDE DATA	PROVIDE/ DEVELOP TOOLS	FLOOD RISK MANAGEMENT SERVICE	NOTES AND EXAMPLES
USGS	Y	Y	Y	Lidar – 3DEP, stream gauge data
NOAA	Y		Y	Sea-level data
NOAA-NWS	Y	Y	Y	Atlas 14 rainfall data, National Water Model, forecast models, flood inundation models
USACE	Y	Y	Y	Dam and levee information and risk assessments, flow data – riverine, reservoirs, etc., hydrologic and hydraulic models, model tools and support
States	Y		Y	Mapping data, flow data, hydraulics data, partners, outreach, education, leveraging funds, higher standard enforcement
Tribal	Y		Y	Mapping data, flow data, hydraulics data, partners/coordination, outreach, education, leveraging funds, higher standard enforcement
Local Municipalities	Y		Y	Mapping data, flow data, hydraulics data, partners/coordination, outreach, education, leveraging funds, higher standard enforcement
Regional/ watershed groups	Y		Y	Mapping data, flow data, hydraulics data, partners/coordination, outreach, education, leveraging funds, higher standard enforcement
Academia	Y			Research, mapping data, stakeholder engagement, data and tools
Non-profit Organizations	Y	Y		Project implementation, research, modeling, mapping data, outreach, education
Private Organizations	Y	Y		Data, coordination, modeling, leveraging funds

4.5.1 / Federal Partnerships and Roles

As shown in Table 5, FEMA supports the efforts and collaborates with USGS, NOAA, and the USACE in areas to advance new technologies related to topography, hydrology, and hydraulics that, ultimately, are used in flood hazard mapping. However, TMAC has identified other federal partners and endeavors that should be leveraged in future efforts to depict a more holistic view of flood hazards and risk, like the partnership already formed between FEMA and the U.S. Fish and Wildlife Service to develop the Coastal Barrier Resources System data and maps. TMAC believes that FEMA should explore similar efforts like the USACE's NLD, the NID, and the USGS's Flood Inundation Maps as it transitions to future states of current programs to depict residual flood risks that serve as floodplain management planning tools.

There is great interest in federal agencies developing operational hydrologic modeling. Three examples of large-scale operational hydrologic modeling include the development and release of the NWS National Water Model (NWM), the USGS National Hydrologic Model, and the national deployment of the USACE CWMS. These systems are based on advanced computing technologies that transform how meteorological forcing are applied, hydrologic processes are modeled, and how hydrologic forecasts to manage water, and near-term flooding in particular, are developed. All three modeling systems are based on the USGS NHD and use less detailed bathymetry and hydrologic data than those typically applied to a FEMA floodplain map in order to permit rapid (hourly) computations and streamflow forecasting across vast portions of the nation. The results that these systems are achieving demonstrate the very real possibility of crafting better water forecasts based on integrated modeling at a national scale.

The USGS, National Weather Service (NWS), Department of Energy, and other agencies are collaborating on developing integrated metrological and hydrological models, community testbeds, and other multiagency initiatives. There is an opportunity to add additional, local detail to these models and create a national flood model that could support modular, "hyper-resolution" simulations of localized hydrology, hydraulics, and future flooding, both for real-time operational (flood management) purposes and long-term flood characterization purposes to identify flood hazards and risks. These models could also provide ensemble outputs that could constitute important inputs to a probabilistic modeling framework. FEMA's efforts to develop an "open" Hazus model could complete the real-time water and flood management models of other agencies and provide key inputs on property valuation, fragility curves, and damages that could be integrated into a probabilistic modeling approach. The operational hydrologic model allows emergency management agencies to use hydrologic models for planning before, during, and after flood events.

SURVEY INSIGHT

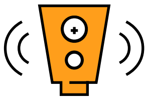
In answering the question, "In a flood hazard mapping sense, what should FEMA allow SLTT governments, private, academia, etc. stakeholders to do more of? Or to do more of independently?"
Stakeholders cited:

- Better use of community data in flood hazard identification
- Flexibility in local products, perhaps on top of national-level base data
- Allowing communities to map or update maps independently

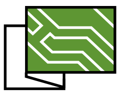
4.5.2 / FEMA's Cooperating Technical Partner Program and Potential Roles for State Flood Mapping Programs

FEMA works with states mainly through the CTP and Community Assistance Programs (CAPs). Currently, the CTP and CAPs allow partners to contribute in most aspects of the Risk MAP processes, which include planning, flood hazard data development, map production, communication, Letter of Map Revision review, etc. As FEMA transitions to future initiatives, TMAC believes that these partnerships play an important role in the development of flood hazard and flood risk mapping, and that FEMA should continue fostering these relationships by leveraging resources and funding.

As a result of these partnerships, the CTP and CAPs have been able to assist states in their efforts to minimize flood risks through tangible projects. Some of these include:

 Lidar acquisition

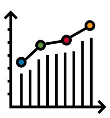
 Development of BFEs

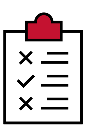
 Production of floodplain mapping for multi-flood frequencies

 Production of flood hazard data, models, maps, risk assessments, and reports

 Tsunami and geomorphic hazard maps

 Flood risk communication

 Flood hazard mapping beyond the 1-percent-annual-chance flood

 Development of higher flood hazard regulations (freeboard, setbacks)

The majority of the programs implement projects aligned with FEMA's priorities and use FEMA's standards and guidelines. Therefore, it is important that FEMA continue developing and sharing guidelines for future probabilistic, graduated risk methodologies.

There are state programs that develop priorities independent from FEMA. Several of the projects listed above started as independent state projects, but have successfully communicated flood risk with communities, increased access to modeling and other data, and developed products beyond FEMA's authorities. FEMA has incorporated some aspects of these projects into the main suite of products and launched the CTP Recognition Program in 2017 to recognize participating partners who demonstrate flood mapping program proficiency and best practices in management, technology, innovation, mapping, and/or communications.

Local Partners and their Potential Roles

Local governments and regional groups also play an important role in the development of local flood hazard data as part of stormwater management planning, dealing with water quality issues, or infrastructure development. In fact, the CTP program relies on many of its participants being local partners, whose expertise and data align with FEMA's flood mapping methods. Examples of local partners' collaboration with FEMA's CTP include:

1. San Antonio River Authority, which incorporates FEMA floodplain mapping with holistic watershed management for both flooding and water quality,

2. Harris County Flood Control District's real-time inundation mapping and the flood education and interactive mapping tools, and

3. Charlotte-Mecklenburg's technical and financial assistance for flood mitigation through the retrofit grant program.

By having local partners as CTPs, communities continue to benefit from better communication of hazard mitigation projects, floodplain management, and FEMA's flood mapping products.

TMAC believes that one of the potential roles FEMA could collaborate more effectively with local partners on is data sharing. Most local and regional information, like pluvial flood risk, is independent from FEMA's data and mapping, and if shared, could potentially enhance FEMA's mapping products. To breach this gap of data sharing, TMAC believes that FEMA should develop a proof of concept on the feasibility of collecting, sharing, and maintaining local data.

4.5.3 / Non-Governmental US Flood Modeling Efforts

Multiple private-sector firms, NGOs, and academic researchers also produce flood hazard and flood risk information. This section first summarizes some of these efforts and then discusses the challenges and opportunities facing FEMA's flood mapping program as it seeks to transition to future initiatives in an increasingly crowded space, with a focus on partnership challenges and opportunities.

Private-Sector Flood Mapping Activities

Flood modeling in the private sector is dominated by the catastrophe modeling sector. There are multiple catastrophe modeling firms that have inland and coastal U.S. flood models, including RMS, AIR, Aon, CoreLogic, and KatRisk. The models are large-scale, probabilistic simulation models that couple climate models with physically based H&H models. Most of the models include fluvial, pluvial, and coastal flooding. They typically go beyond modeling the flood hazard to also estimating damages based on building type at a property scale; because the models are probabilistic, losses are often reported as average annual losses or other metrics. Catastrophe modeling accelerated after Hurricane Andrew in 1992, and the models are extensively used by insurers and reinsurers in the property and casualty insurance industry today. While wind and earthquake losses have been modeled for decades, the inland flood models of these firms for the United States are newer. Increasingly, other private firms and public-sector entities are also turning to these firms for help in assessing property-level flood risk (including FEMA for their reinsurance and insurance-linked securities placements and for RR2.0). The models are continually updated as methods and data improve.

Beyond the large catastrophe modeling firms, there are a few other private-sector modelers of flood risk. One such firm, founded in 2017, is Jupiter, a data analytics and technology company that focuses on predicting climate risk. Their Flood Score model probabilistically predicts and maps future flood risk, taking into account multiple factors, including weather events, erosion and subsidence, elevation, groundwater, surge-river interactions, infrastructure, and climate change, among other variables. The planning tool produces flood probabilities from 6 months to 50 years; therefore, the operations tool predicts property-level flooding from 1 hour to 5 days in advance. Another new firm is 427, an affiliate of Moody's. While 427 is not an explicit flood modeler, they unite climate science with economic impact analysis. They evaluate a range of climate risks for securities and real assets, and help companies with scenario analysis for strategic decisions.

Esri is the firm behind the geographical information platform ArcGIS. While not a flood modeler, they have many tools that can be used in ArcGIS to model floods, and they provide information to users on these tools. They have also partnered with academic institutions and the public sector on flood modeling projects. They provide tutorials on how to access stream gauge data and the hourly NWM to make flood maps through their software.

NGO Flood Mapping Activities

A comprehensive flood model has been developed by the First Street Foundation, a group established to provide past, present, and future flood risk information for every home in the country. They built a probabilistic flood model for the contiguous U.S. that combines pluvial, fluvial, and coastal storm surge flooding at a 3-meter resolution. They built the model in partnership with academic modelers, and the methods are documented in peer-reviewed studies. First Street Foundation also applies results from climate model projections to forecast how flood risk will evolve over the next three decades. They have used their model to produce a 1 to 10 flood risk score for every home in the country. These scores—called Flood Factor—are now available through platforms such as Realtor.com or through their own website. Summary information is also available through their First National Flood Risk Assessment. They have also shared the data with researchers through their Flood Lab.

While the First Street Foundation focuses on a holistic examination of flood risk, another NGO looks specifically at the impact of SLR in coastal areas. Climate Central is an organization of scientists and journalists focused on communicating climate change. To that end, they have developed Surging Seas, a project founded in 2012 featuring a variety of maps and tools for tracking rising sea levels. These tools include a coastal risk screening tool that can filter by year, elevation, and water level; a global risk zone map; and a map of projected flooding in 2100. These maps are created using laser-based (lidar) elevation data and build on numerous peer-reviewed studies. Climate Central also releases national- and state-level reports and fact sheets for its maps and models.

Academic Flood Mapping Activities

There are many academic researchers around the country that model specific types of flood perils. Although many of these publish their results as academic publications, some researchers have also created tools or centers to share their flood modeling with external stakeholders. For example, the GeoPlan Center at the University of Florida has a Sea Level Scenario (SLS) Sketch Planning Tool. The SLS Sketch Planning Tool aims to identify transportation infrastructure vulnerable to current and future flood risks. Using data from the USACE and the Florida Department of Transportation, the SLS Sketch Planning Tool offers an interactive map of flood risk possibilities in the State of Florida (see Figure 11).

Another example is EarthTime, a partnership between the Community Robotics, Education and Technology Empowerment Lab at Carnegie Mellon University and the World Economic Forum. EarthTime offers multiple interactive data "stories," including predictive SLR maps covering major cities around the world, including some U.S. cities.This project uses data from government agencies, NGOs, and university research programs.

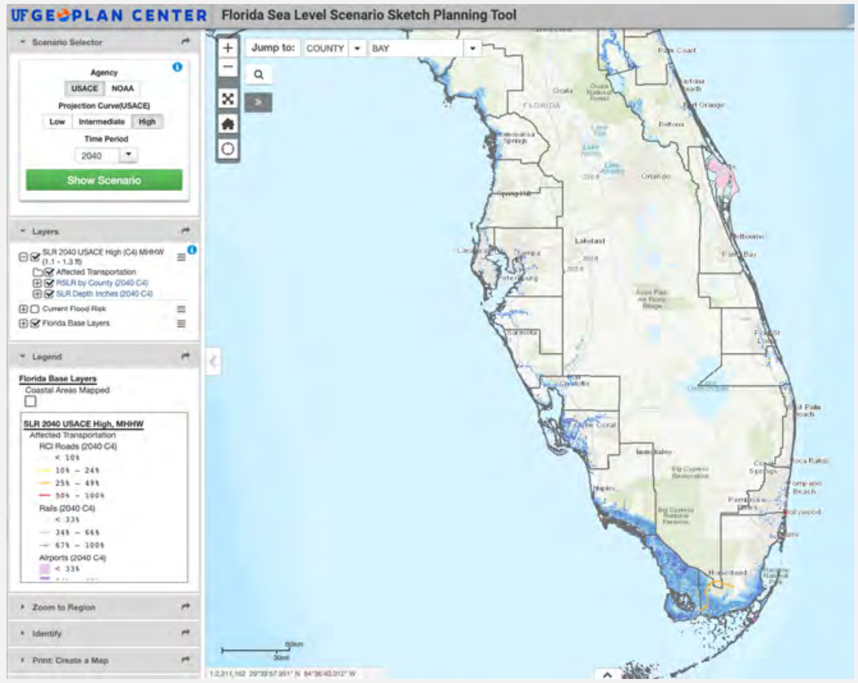


Figure 11 / An example of a flood risk possibility in Florida from the SLS Sketch Planning Tool

4.5.4 / Challenges and Opportunities

The number of organizations producing flood risk information in the United States has grown dramatically over the last decade. There are now a significant number of players producing various types of flood hazard and flood impact information for various users. FEMA is no longer the only—nor the primary—source of flood risk information for many stakeholders. The challenge of this proliferation is that there may be a lack of consistent messaging about flood risk, and there could be user confusion about which model is "best." When models conflict, without further education about model uncertainty and model design, users may not know which model to use, which to trust, or how to use the information to guide their decisions. The potential benefit of the variety in flood models, however, is that it is now possible for users to find flood information that is more appropriately tailored to their needs. A local floodplain manager, a potential homeowner, an engineer, and a governor may all need flood information, but at very different levels of specificity, precision, and scope. With more modelers, there is the ability to segment users and tailor products to needs. TMAC believes that FEMA should consider producing guidance that explains the different models and tools available and which is best for which user groups.

Another benefit of the proliferation in flood modeling is that it has created a stronger demand for high-quality input data, such as building footprints, elevation, and precipitation data. This has led to, and could continue to lead to, the generation of finer resolution and higher quality input data, something that all modelers, including FEMA, will benefit from going forward.

FEMA should consider leveraging some of the ongoing modeling efforts for its mapping program. RR2.0 has already made use of several flood catastrophe models for updating NFIP's flood insurance pricing. The disconnect between pricing, which has used modern catastrophe models, and the outdated flood zones of the FIRMs, will become problematic for the program when RR2.0 is implemented. This is bound to create consumer confusion and frustration. TMAC recommends that the mapping program partner with the NFIP actuaries and their use of catastrophe models to develop a plan for improving the convergence between the two sources of flood information. FEMA could also expand the CTP program to allow local governments to work with academic partners to produce flood maps faster and with better local data.

4.6 / Conclusion

In conclusion, this chapter has highlighted some of the ongoing efforts FEMA has undertaken to modernize its flood hazard and risk data products by leveraging technology advances in cartography and by working collaboratively with other federal and SLTT, NGOs, and private sectors. As FEMA transitions to future efforts and initiatives, TMAC believes that there are opportunities for maintaining and expanding flood hazard and risk data to better inform stakeholders of their flood risk. This could be accomplished by providing a graduated flood risk analysis and probabilities, including residual risks and future conditions, that not only help the floodplain management community, but also support the RR2.0 flood insurance engine. TMAC believes that FFRD should not be a "one size fits all" approach, but rather that the data should be curated to conform to user needs, especially considering the variability in flood hazards that face the nation. Consequently, TMAC recognizes that continued engagement with all stakeholders across the natural hazards risk spectrum is an asset for FEMA as it develops future mapping products.

As mentioned in this chapter, the FFRD initiative faces several challenges that cannot be ignored (resources, regulatory constraints, time to produce maps, public confidence, flood risk communication deficiencies, etc.). In the interim, FEMA should continue its efforts to work with stakeholders on producing valuable regulatory and non-regulatory flood hazard and risk information to minimize the impacts of flooding. As we strive for a more flood-resilient nation, it is important for future flood hazard and risk data products to capture the nation's true flood risk—one that goes beyond the 1-percent-annual-chance, and one that effectively influences future land-use planning and mitigation actions.

TMAC recognizes that ***continued engagement with all stakeholders across the natural hazards risk spectrum is an asset*** *for FEMA as it develops future mapping products.*

Chapter 5 / TMAC Recommendations and Conclusion

In a February 12, 2020, letter from Michael Grimm, FEMA requested TMAC to provide guidance in the following two major areas:

- Identify the best practices to be incorporated into a future flood hazard and flood risk identification program; and
- Provide a framework for FEMA to transition to the future program.

To address these requests, TMAC undertook a robust engagement process to gather input from various stakeholder groups. At first, TMAC envisioned meeting with stakeholder groups at various industry conferences. However, the reality of the COVID-19 pandemic required TMAC to take a different approach to stakeholder engagement. TMAC adopted a multi-tiered approach involving surveys, webinars, and focus groups. The information collected from stakeholders provided invaluable insight as TMAC responded to FEMA's request.

In addition to the stakeholder engagement process, TMAC met via virtual meetings (public, administrative, and as subcommittees) to receive presentations from subject matter experts and discuss guidance and recommendations.

TMAC provides guidance to FEMA throughout this report. However, the three recommendations below should be highlighted. The recommendation numbering continues from recommendations in previous TMAC reports to FEMA.

Recommendation 35

Probabilistic assessments of flood risk as recommended in many TMAC reports (i.e., AR 10, AR 17, AR 23, AR 33) provide valuable information to decision makers at all levels of government, while also providing helpful information at the property scale (e.g., for prospective land/home buyers and owners). This information provides opportunities to support communities in their journey toward increasing flood resiliency. Predicated on the development of probabilistic risk and hazard products as part of FEMA's FFRD initiative, TMAC sees the opportunity for leveraging the data to create a risk management framework to reduce disaster suffering more quickly.

RECOMMENDATION 35

TMAC recommends that FEMA explore how to implement enterprise risk management frameworks that help communities whose objectives are to become more flood resilient, and to transition toward proactive flood risk management while meeting or exceeding existing minimum federal floodplain management requirements.

Recommendation 36

Through the stakeholder engagement process, TMAC learned that there is optimism about the future of the flood hazard and flood risk data initiative. However, there is uncertainty about the management and products that FEMA will provide to implement future efforts. To help alleviate this uncertainty, TMAC recommends that FEMA develop and test, in conjunction with stakeholders, prototype products and services that help stakeholders (floodplain managers, mitigation planners, emergency managers, real estate agents, insurance agents) understand, manage, and reduce flood hazards and risks.

RECOMMENDATION 36

TMAC recommends that FEMA develop a set of integrated floodplain management and mitigation-focused prototype products and services that help stakeholders better understand, communicate, and manage their current and future flood risks.

Recommendation 37

The current program has facilitated the creation and maintenance of partnerships with agencies, organizations, and private entities that have leveraged data creation, as well as the sharing of best management practices. Transitioning to the future framework requires creation of data in new format, prioritizing where to transition from deterministic to probabilistic data and graduated flood risk depictions, and communicating this new data and format to the public.

RECOMMENDATION 37

TMAC recommends that FEMA utilize the Cooperating Technical Partners and other partnerships for the implementation of this transition and investigate ways to incorporate data and technology from other stakeholders such as regional and local governments; state and federal agencies; and academic, nonprofit, and private stakeholders.

APPENDICES

Appendix A/ TMAC Charter

U.S. Department of Homeland Security
Federal Emergency Management Agency
Technical Mapping Advisory Council
Charter

1. Committee's Official Designation:

Technical Mapping Advisory Council

2. Authority:

Pursuant to section 100215 of the Biggert-Waters Flood Insurance Reform Act of 2012, Public Law 112-141, 126 Stat. 924, 42 U.S.C. § 4101a ("the Act"), this charter establishes the Technical Mapping Advisory Council (TMAC or Council). This statutory committee is established in accordance with and operates under the provisions of the *Federal Advisory Committee Act* (FACA) (Title 5, United States Code, Appendix).

3. Objectives and Scope of Activities:

The TMAC advises the Administrator of the Federal Emergency Management Agency (FEMA) on certain aspects of FEMA's flood risk mapping activities.

The TMAC recommends to the Administrator:

A. How to improve in a cost-effective manner the:
   1. Accuracy, general quality, ease of use, and distribution and dissemination of flood insurance rate maps and risk data; and
   2. Performance metrics and milestones required to effectively and efficiently map flood risk areas in the United States.

B. Mapping standards and guidelines for:
   1. Flood Insurance Rate Maps (FIRMs); and
   2. Data accuracy, data quality, data currency, and data eligibility;

C. How to maintain, on an ongoing basis, FIRMs and flood risk identification; and

D. Procedures for delegating mapping activities to State and local mapping partners.

The TMAC recommends to the Administrator and other Federal agencies participating in the Council:

A. Methods for improving interagency and intergovernmental coordination on flood mapping and flood risk determination; and

B. A funding strategy to leverage and coordinate budgets and expenditures across Federal agencies.

The TMAC submits an annual report to the Administrator that contains a description of the activities of the Council, an evaluation of the status and performance of FIRMs and mapping activities to revise and update FIRMs as required by the Act, and a summary of the activities of the Council.

4. Description of Duties:

The duties of the TMAC are solely advisory in nature.

5. Official to Whom the Committee Reports:

The TMAC provides advice and recommendations to the Administrator of FEMA.

6. Support:

FEMA shall be responsible for providing financial and administrative support to the Council. Within FEMA, the Risk Management Directorate of the Federal Insurance and Mitigation Administration provides this support.

7. Estimated Annual Operating Costs and Staff Years:

The estimated annual operating cost associated with supporting TMAC's functions is estimated to be $800,000 for FY2019 and $800,000 for FY2020. This includes surge support for all direct and indirect expenses. Three staff directly support the TMAC for a total of 1.5 FTE. One half-time, and two part-time FTEs.

8. Designated Federal Officer:

A full-time or permanent part-time employee of FEMA is appointed by the Administrator as the TMAC Designated Federal Officer (DFO). The FEMA Administrator may also appoint one or more Alternate DFOs. The DFO or an Alternate DFO approves or calls TMAC meetings, approves meeting agendas, attends all committee and subcommittee meetings, adjourns any meeting when the DFO determines adjournment to be in the public interest, and chairs meetings when requested in the absence of the Chair.

9. Estimated Number and Frequency of Meetings:

Meetings of the TMAC may be held with the approval of the DFO. The Council shall meet a minimum of two times each year at the request of the Chairperson or a majority of its members and may take action by a vote of the majority of the members.

Council meetings are open to the public unless a determination is made by the appropriate DHS official in accordance with DHS policy and directives that the meeting should be closed in accordance with Title 5, United States Code, subsection (c) of section 552b.

10. Duration:

Continuing

11. Termination:

This charter is in effect for two years from the date it is filed with Congress unless sooner terminated. The charter may be renewed at the end of this two-year period in accordance with section 14 of FACA.

12. Member and Designation:

Members of the Council are defined by Section 100215(b)(1) of the Biggert-Waters Flood Insurance Reform Act of 2012 and include four designated members and sixteen appointed members.

The four designated members of the Council serve as Regular Government Employees and consist of:

The FEMA Administrator or the designee thereof;
The Secretary of the Interior or the designee thereof;
The Secretary of Agriculture or the designee thereof;
The Under Secretary of Commerce for Oceans and Atmosphere or the designee thereof.

The sixteen additional members of the Council are appointed by the Administrator or designee. These members are appointed based on their demonstrated knowledge and competence regarding surveying, cartography, remote sensing, geographic information systems, or the technical aspects of preparing and using FIRMs.

To the maximum extent practicable, the membership of the Council will have a balance of Federal, State, local, tribal and private members, and include geographic diversity including representation from areas with coastline on the Gulf of Mexico and other States containing areas identified by the Administrator as at high risk for flooding or as areas having special flood hazard areas.

These members are selected from among the following professional associations or organizations:

a. One member of a recognized professional surveying association or organization;
b. One member of a recognized professional mapping association or organization;
c. One member of a recognized professional engineering association or organization;
d. One member of a recognized professional association or organization representing flood hazard determination firms;
e. One representative of the United States Geological Survey;
f. One representative of a recognized professional association or organization representing State geographic information;

g. One representative of State national flood insurance coordination offices;
h. One representative of the U.S. Army Corps of Engineers;
i. One member of a recognized regional flood and storm water management organization;
j. Two representatives of different State government agencies that have entered into cooperating technical partnerships with the Administrator and have demonstrated the capability to produce FIRMs;
k. Two representatives of different local government agencies that have entered into cooperating technical partnerships with the Administrator and have demonstrated the capability to produce flood insurance maps;
l. One member of a recognized floodplain management association or organization;
m. One member of a recognized risk management association or organization; and
n. One State mitigation officer.

The non-Federal members in a., b., c., d., i., l., m., and n. serve as Special Government Employees as defined in Title 18, United States Code, section 202(a), and must comply with all that requires (such as the annual filing of a new entrant Confidential Financial Disclosure Report (OGE 450)). The members in e., and h., serve as Regular Government Employees. The non-Federal members in f., g., j., and k. serve as representatives of their respective associations or organizations and are not Special Government Employees as defined in Title 18 of United States Code, section 202(a).

Members may serve terms of office of up to three consecutive years. The FEMA Administrator or his Designee may reappoint or extend members for additional terms up to a cumulative total of six consecutive years. When the TMAC terminates, all appointments to the Council shall terminate.

Officers:

The Council membership shall elect any one member to serve as Chairperson of the Council. The Chairperson shall preside over Council meetings in addition to specific responsibilities authorized under the Act.

13. Subcommittees:

The DFO may establish subcommittees for any purpose consistent with this charter. Such subcommittees may not work independently of the chartered committee and must present their work to the TMAC for full deliberation and discussion. Subcommittees have no authority to make decisions on behalf of the TMAC and may not report directly to the Federal government or any other entity.

14. Recordkeeping:

The records of the TMAC, established subcommittees, or other subgroups of the Council, shall be maintained and handled in accordance with General Records Schedule 6.2, or other approved agency records disposition schedule. These records are available for public inspection and copying, in accordance with the *Freedom of Information Act* (Title 5, United States Code, section 552).

15. Filing Date:

July 16, 2019
Department Approval Date

July 19, 2019
CMS Consultation Date

July 22, 2019
Date Filed with Congress

Appendix B/ TMAC Bylaws

06/10/2019

Federal Emergency Management Agency
Technical Mapping Advisory Council
Bylaws

ARTICLE I AUTHORITY

As required by the *Biggert-Waters Flood Insurance Reform Act of 2012* (BW-12), codified at 42 United States Code Section 4101a, the Federal Emergency Management Agency (FEMA) Technical Mapping Advisory Council (TMAC) is established. The Technical Mapping Advisory Council shall operate in accordance with the provisions of the *Federal Advisory Committee Act* (FACA), as amended (Title 5, U.S.C., Appendix).

ARTICLE II PURPOSE

The Technical Mapping Advisory Council provides advice and recommendations to the Administrator of FEMA to improve the preparation of Flood Insurance Rate Maps (FIRMs). The Technical Mapping Advisory Council will examine performance metrics, standards and guidelines, map maintenance, delegation of mapping activities to State and local mapping partners, interagency coordination including leveraging budgets and expenditures across agencies, and other requirements mandated by the authorizing BW-12 legislation. In addition, the Technical Mapping Advisory Council provides advice and recommendations to the FEMA Administrator on future risks from climate change, rising sea levels, and FIRM development, as mandated by BW-12.

ARTICLE III MEMBERSHIP AND MEMBER RESPONSIBILITIES

Section 1. Composition.

Members of the Council include designated members and additional members appointed by the FEMA Administrator or his designee. See 42 U.S.C. § 4101a.

The designated members of the Council are:

- The FEMA Administrator or the designee thereof;
- The Secretary of the Interior or the designee thereof;
- The Secretary of Agriculture or the designee thereof; and,
- The Under Secretary of Commerce for Oceans and Atmosphere or the designee thereof.

The appointed members may be selected from among the following professional associations or organizations:

- A member of a recognized professional surveying association or organization;
- A member of a recognized professional mapping association or organization;

- A member of a recognized professional engineering association or organization;
- A member of a recognized professional association or organization representing flood hazard determination firms;
- A representative of the United States Geological Survey;
- A representative of a recognized professional association or organization representing State geographic information;
- A representative of State national flood insurance coordination offices;
- A representative of the Corps of Engineers;
- A member of a recognized regional flood and storm water management organization;
- Two representatives of different State government agencies that have entered into cooperating technical partnerships with the Administrator and have demonstrated the capability to produce FIRMs;
- Two representatives of different local government agencies that have entered into cooperating technical partnerships with the Administrator and have demonstrated the capability to produce flood insurance maps;
- A member of a recognized floodplain management association or organization;
- A member of a recognized risk management association or organization;
- A State mitigation officer.

Subject Matter Experts/Technical Advisors: The Technical Mapping Advisory Council may hear from subject matter experts/technical advisors ("SMEs") who will be asked to provide specialized information or assistance as appropriate and approved by the Designated Federal Officer (DFO). Individual Technical Mapping Advisory Council members may request SMEs, by expertise or skillset, to appear before the Technical Mapping Advisory Council, as needed. Member requests will be made to the Chair for consideration and consultation with the Technical Mapping Advisory Council Designated Federal Officer (DFO). FEMA will not compensate SMEs for their services, but they may be reimbursed for travel and lodging expenses.

Section 2. Appointment.

With the exception of the Secretary of the Interior, Secretary of Agriculture, and Under Secretary of Commerce for Oceans and Atmosphere, members of the Technical Mapping Advisory Council are appointed by and serve at the pleasure of the FEMA Administrator in an advisory role. Membership is voluntary, and members are not compensated for their services. Appointments are personal to the member and cannot be transferred to another individual. Members may not designate someone to attend in their stead, participate in discussions, or vote. In compliance with FACA, members, while engaged in the performance of their duties away from their home or regular places of business, may be allowed travel expenses, including per diem in lieu of subsistence, as authorized by section 5703 of title 5, United States Code.

Section 3. Terms of Office.

Members may serve terms of office of up to three consecutive years. The FEMA Administrator or his Designee may reappoint or extend members for additional terms up to a cumulative total of six consecutive years. When the Technical Mapping Advisory Council terminates, all appointments to the Council shall terminate.

Section 4. Certification of Non-Lobbyist Status.

All members of the Technical Mapping Advisory Council who serve as Special Government Employees (SGEs) must annually self-certify that they are not registered lobbyists under the Lobbying Disclosure Act, Title 2 U.S.C., Section 1603, and must advise the Department of Homeland Security (DHS) through the Federal Emergency Management Agency if they register as a lobbyist while serving on the Technical Mapping Advisory Council. Members who are SGEs and who register as a lobbyist after their appointment or re-appointment will be replaced on the Council.

Representative Members Lobbyist Status: Members of the Technical Mapping Advisory Council who serve as representatives of an association or organization and who are not SGEs shall register as required in accordance with the requirements of the Lobbying Disclosure Act if they engage in lobbying activities or are a lobbying contact as defined in 2 U.S.C. 1602. Any individual who so registers shall advise the DFO of such registration within 30 days of the registration or prior to the next meeting of the Technical Mapping Advisory Council, whichever occurs earlier.

Section 5. Members' Responsibilities.

Because the membership of the Technical Mapping Advisory Council is constructed to balance as many perspectives on floodplain mapping and future risk assessment as possible, member attendance and participation at meetings is vital to the Technical Mapping Advisory Council's mission. Members are expected to personally attend and participate in Council, subcommittee meetings, and conference calls. Members will also be expected to provide written input to any final reports or deliverables.

The DFO or Chair may recommend to the FEMA Administrator that any appointed member unable to fulfill their responsibility be replaced on the Council or subcommittee. Members of the Technical Mapping Advisory Council may be recommended for removal for reasons such as, but not limited to:

a. Missing two consecutive meetings, including teleconference calls;

b. Registering as a lobbyist after appointment; or,
c. Engaging in activities that are illegal or violate the restrictions on members' activities as outlined below.

Section 6. Restriction on Members' Activities.

a. Members may not use their access to the Federal Government as a member of this Council for the purpose of soliciting business or otherwise seeking economic advantage for themselves or their companies. Members may not use any non-public information obtained in the course of their duties as a member for personal gain or for that of their company or employer. Members must hold any non-public information in confidence.
b. The Council as a whole may advise FEMA on legislation or recommend legislative action. In their capacities as members of the Technical Mapping Advisory Council, individual members may not petition or lobby Congress for or against particular legislation or encourage others to do so.
c. Members of the Technical Mapping Advisory Council are advisors to the agency and have no authority to speak for the Council, FEMA, or for the Department outside the Council structure.
d. Members may not testify before Congress in their capacity as a member of the Technical Mapping Advisory Council. If requested to testify before Congress, members of the Technical Mapping Advisory Council:

    1. Cannot represent or speak for the Council, DHS, any agency, or the Administration in their testimony;
    2. Cannot provide information or comment on Council recommendations that are not yet publicly available;
    3. May state they are a member of the Council; and,
    4. May speak to their personal observations as to their service on the Council.

e. If speaking outside the Council structure at other forums or meetings, the restrictions in Section (d) also apply.

ARTICLE IV OFFICIALS

Section 1. Technical Mapping Advisory Council Leadership.

Technical Mapping Advisory Council members will elect a Chair through a nomination and formal vote. (The FEMA Administrator, or his designee, shall serve in this capacity until a Chair is elected.) The Chair will be responsible for appointing one or more Vice Chairs. The Chair and Vice Chairs will serve for a two-year term. The Chair may be reelected for one additional two-year term. In the event the DFO determines that an extension of term of a Chair or Vice Chair is necessary in order to complete their oversight of an outstanding task or report, not to exceed six months. If a Chair of Vice-chair is not able to serve for their entire term, an additional election will be held. The Chair will select chairs for any subcommittee established. Only voting members can serve as subcommittee chairs.

Chair Responsibilities:

a. Appoints officers to assist in carrying out the duties of the Technical Mapping Advisory Council;
b. Works with the DFO to develop meeting agendas;
c. Sets and maintains a schedule for Technical Mapping Advisory Council activities (e.g., report development);
d. Works with the Technical Mapping Advisory Council membership to develop the draft annual report;
e. Signs the final reports addressed to the FEMA Administrator;
f. Coordinates with the DFO to form subcommittees with assigned areas of consideration;
g. Selects subcommittee chairs and vice chairs;
h. Resolves member conflicts.

Vice Chair Responsibilities:

a. Works with subcommittee chairs to ensure work is being completed;
b. Coordinates member engagement;
c. Assists Chair in conducting review of meeting minutes and recommendation reports;
d. Elevates any unresolved issues to the Chair;
e. Serves as Chair in absence of the Chair.

Subcommittee Chair Responsibilities:

a. Works with the DFO to develop subcommittee meeting agendas;
b. Facilitates subcommittee discussions;
c. Reports to the Chair and Vice Chair; and
d. Reports out subcommittee work at Technical Mapping Advisory Council meetings.

Section 2. Designated Federal Officer.

The DFO and Alternate DFO (ADFO), if one or more is appointed, serves as FEMA's agent for all matters related to the Technical Mapping Advisory Council and are appointed by the FEMA Administrator. In accordance with the provisions of the FACA, the DFO or ADFO must:

a. Approve or call meetings of the Council and its subcommittees;
b. Approve agendas for Council and subcommittee meetings;
c. Attend all meetings;

d. Adjourn meetings when such adjournment is in the public interest; and,
e. Chair meetings of the Council when directed to do so by the FEMA Administrator or when requested in the absence of the Chair.

In addition, the DFO is responsible for assuring administrative support functions are performed, including the following:

a. Notifying members of the time and place of each meeting;
b. Tracking all recommendations of the Council;
c. Maintaining the record of members' attendance;
d. Preparing the minutes of all meetings of the Council's deliberations, including subcommittee and working group activities;
e. Attending to official correspondence;
f. Maintaining official records and filing all papers and submissions prepared for or by the Council, including those items generated by subcommittees and working groups;
g. Reviewing and updating information on Council activities in the Shared Management System (i.e., FACA database) on a monthly basis;
h. Acting as the Council's agent to collect, validate and pay all vouchers for pre-approved expenditures; and
i. Preparing and handling all reports, including the annual report as required by FACA.

ARTICLE V MEETING PROCEDURES

Section 1. Meeting Schedule and Call of Meetings.

Technical Mapping Advisory Council will meet in plenary sessions approximately two to four times a year, with additional virtual meetings as needed, at the discretion of the DFO. The Council may hold hearings, receive evidence and assistance, provide information, and conduct research, as it considers appropriate, subject to resources being made available. With respect to the meetings, it is anticipated that some may be held via teleconference, with public call-in lines. Technical Mapping Advisory Council meetings will be open to the public unless a determination is made by the appropriate FEMA official that the meeting should be closed in accordance with subsection (c) of section 5 USC, Section 552b, Government in the Sunshine Act .

Section 2. Agenda.

Meeting agendas are developed by the DFO in coordination with the Technical Mapping Advisory Council Chair. In accordance with the responsibilities under FACA, the DFO approves the agenda for all Council and subcommittee meetings, distributes the agenda to members prior to the meeting, and publishes the agenda for Council meetings in the Federal Register. Subcommittee meeting agendas will be posted on FEMA's website, when they are available, and are not published in the Federal Register.

FEMA will publish the meeting notice and agenda in the Federal Register at least 15 calendar days prior to each Technical Mapping Advisory Council meeting or official public conference call. Once published in the Federal Register, the agenda items cannot be changed prior to or during a meeting.

Section 3. Quorum.

A quorum of the Technical Mapping Advisory Council is fifty percent plus one of the appointed Council members. In the event a quorum is not present, the Technical Mapping Advisory Council may conduct business that does not require a vote or decision among members. Votes will be deferred until such time as a quorum is present.

Section 4. Voting Procedures.

When a decision or recommendation of the Technical Mapping Advisory Council is required, the Chair will request a motion for a vote. A motion is considered to have been adopted if agreed to by a simple majority of a quorum of Technical Mapping Advisory Council members. Members vote on draft reports and recommendations in open meetings through a resolution recorded in the meeting minutes. Only members present at the meeting—either in person or by teleconference—may vote on an item under consideration. No proxy votes or votes by email will be allowed.

Section 5. Minutes.

The DFO will prepare the minutes of each meeting and distribute copies to each Council member. Minutes of open meetings will be available to the public on the Technical Mapping Advisory Council website at http://www.fema.gov/TMAC. The minutes will include a record of:

a. The time, date, and place of the meeting;
b. A list of all attendees including Council members, staff, agency employees and members of the public who presented oral or written statements;
c. An accurate description of each matter discussed and the resolution, if any, made by the Council;
d. Copies of reports or other documents received, issued, or approved by the Council; and
e. An accurate description of public participation, including oral and written statements provided.

The DFO ensures that the Chair certifies the minutes within 90 calendar days of the meeting to which they relate and prior to the next Technical Mapping Advisory Council meeting.

Minutes of closed meetings will also be available to the public upon request subject to the withholding of matters about which public disclosure would be harmful to the interests of the Government, industry, or others, and which are exempt from disclosure under the *Freedom of Information Act* (FOIA) (5 U.S.C., section 552).

Section 6. Open Meetings.

Technical Mapping Advisory Council meetings shall be open and announced to the public in a notice published in the Federal Register at least fifteen calendar days before the meeting. Members of the public may attend any meeting or portion of a meeting that is not closed to the public and, at the determination of the Chair and DFO, may offer oral comment at such meeting. Meetings will include a period for oral comments unless it is clearly inappropriate to do so. Members of the public may submit written statements to the Technical Mapping Advisory Council at any time. All materials provided to the Council shall be available to the public when they are provided to the members. Such materials, including any submissions by members of the public, are part of the meeting record.

Section 7. Closed Meetings.

All or parts of Technical Mapping Advisory Council meetings may be closed in limited circumstances and in accordance with applicable law. No meeting may be partially or fully closed unless the component head issues a written determination that there is justification for closure under the provisions of subsection (c) of 5 United States Code 552b, the *Government in the Sunshine Act*. Where the DFO has determined in advance that discussions during a Council meeting will involve matters about which public disclosure would be harmful to the interests of the government, industry, or others, an advance notice of a closed meeting, citing the applicable exemptions of the *Government in the Sunshine Act*, will be published in the Federal Register. The notice may announce the closing of all or just part of a meeting. If, during the course of an open meeting, matters inappropriate for public disclosure arise during discussions, the DFO or Chair will order such discussion to cease and will schedule it for a future meeting of the Council that will be approved for closure. No meeting or portion of a meeting may be closed without prior approval and notice published in the Federal Register at least 15 calendar days in advance. Closed meetings can only be attended by DFO, Council members, and necessary agency staff members. Presenters must leave immediately after giving their presentations and answering any questions.

Section 8. Other Meetings, No Public Notice Required.

Public notice is not required for meetings of administrative or preparatory work. Administrative work is a meeting of two or more Technical Mapping Advisory Council or subcommittee members convened solely to discuss administrative matters or to receive administrative information from a Federal officer or agency. Preparatory work is a meeting of two or more Technical Mapping Advisory Council or subcommittee members convened solely to gather information, conduct research, or analyze relevant issues and facts in preparation for a Technical Mapping Advisory Council meeting or to draft position papers for consideration by the Technical Mapping Advisory Council.

ARTICLE VI EXPENSES AND REIMBURSEMENTS

Expenses related to the operation of the Technical Mapping Advisory Council will be paid by the Federal Insurance and Mitigation Administration. Expenditures of any kind must be approved in advance by the DFO. All such expense reports will be sent to the DFO for action and reimbursement. The DFO will be responsible for handling the payment of expenses. Members are responsible for submitting expense reports by the deadlines set by the DFO or they may not be reimbursed. The DFO will be responsible for developing the procedures for expense reimbursement.

ARTICLE VII ADMINISTRATION

The Federal Insurance and Mitigation Administration shall be responsible for providing financial and administrative support to the Technical Mapping Advisory Council subject to the availability of appropriations.

ARTICLE VIII SUBCOMMITTEES

Section 1. Establishment of subcommittees.

The DFO may establish standing subcommittees with an overarching mission to work on specific focus areas and provide advice to the Technical Mapping Advisory Council on a continuing basis. The DFO may also establish ad-hoc subcommittees to work and report on specific focus areas. The number, designation, mission, scope, and membership of subcommittees are determined by the DFO in consultation with the Chair and Vice Chairs. The Chair may also request of the DFO to establish (or reorganize) a subcommittee. The creation and operation of the subcommittees must be approved by the DFO on behalf of FEMA.

Subcommittee Members: Technical Mapping Advisory Council subcommittees may consist of Technical Mapping Advisory Council members and non-Technical Mapping Advisory Council members as limited below. Technical

Mapping Advisory Council members may be named to serve on a specific subcommittee and may contribute to others as requested.

Subcommittees will not function independently of the Technical Mapping Advisory Council or provide advice or recommendations directly to FEMA. Subcommittees (standing and ad-hoc) must present all advice, recommendations, and reports to the full Technical Mapping Advisory Council during a public meeting or teleconference for discussion, deliberation, and final approval. In general, the requirements of FACA do not apply to subcommittees of advisory committees that report a parent advisory committee and not directly to a Federal officer or agency. However, minutes must be maintained for the public record and the DFO and/or ADFO must participate in all subcommittee proceedings.

Section 2. Membership.

Subcommittee membership should be balanced in relation to the subcommittee's mission and focus areas. The DFO and the Chair, with input from Council members, identify and determine the membership for the subcommittee, including a chair (and vice chair if deemed necessary).

Subcommittee chairs may request the DFO to invite non- Technical Mapping Advisory Council individuals to serve on the subcommittee, as necessary. Only Technical Mapping Advisory Council members may serve as the chair or vice chair of a subcommittee (standing or ad-hoc). The subcommittee chair can also advise the DFO that briefings from external subject matter experts are needed to provide pertinent and vital information not available among the current Technical Mapping Advisory Council membership or from Federal staff. All such requests shall be made to the DFO who will facilitate the process to obtain non-council members for their subject matter expertise.

Section 3 Subcommittee Quorum

A Subcommittee quorum consists of: (1) the presence (either in person or by teleconference) of fifty percent plus one of Technical Mapping Advisory Council members currently appointed to the Subcommittee; and (2) Technical Mapping Advisory Council members make up more than a third of the Subcommittee members present. In the event a Subcommittee quorum is not present, the Subcommittee may conduct business that does not require a vote or decision among members. Votes will be deferred until such time as a quorum is present.

Section 4 Subcommittee Voting Procedures

When a decision or recommendation of the Subcommittee is required, and a Subcommittee Quorum as defined above is present, the Subcommittee Chair may request a motion for a vote. A motion is considered to have been adopted if agreed to by a simple majority of the Technical Mapping Advisory Council

Subcommittee members present. Members may vote on draft reports and recommendations that will be presented to the full Technical Mapping Advisory Council. Only members present at the meeting—either in person or by teleconference—may vote on an item under consideration. No proxy votes or votes by email will be allowed.

Section 5. Focus Areas

Focus Areas are identified areas of consideration for the Council to review, either via subcommittee or by the Technical Mapping Advisory Council through discussion as an entire body. The DFO will determine focus areas in consultation with the Technical Mapping Advisory Council Chair. The DFO will then work with the Chair and Vice Chair to identify whether the focus area should be assigned to a standing subcommittee, an ad hoc subcommittee; or submitted to the Technical Mapping Advisory Council for discussion and review.

Section 6. Workload and meetings.

Subcommittees may have more than one focus area to address. Subcommittee chairs will recommend the appropriate number of conference calls necessary to address focus areas, working in coordination with the DFO.

The subcommittee chair determines what materials are needed to prepare a response and develop a report to the Technical Mapping Advisory Council. The DFO will supply the requested materials to the Technical Mapping Advisory Council subcommittee upon request and resource availability.

ARTICLE IX RECOMMENDATIONS AND REPORTING

P.L. 112-141 directs Technical Mapping Advisory Council to submit an annual report to the Administrator that contains a description of the activities of the Council; an evaluation of the status and performance of flood insurance rate maps and mapping activities to revise and update flood insurance rate maps; and a summary of recommendations made by the Council to the Administrator.

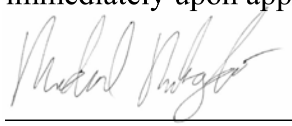
Once the Technical Mapping Advisory Council achieves consensus on a report and recommendations, the Technical Mapping Advisory Council Chair is responsible for providing a final version of the report to the FEMA Administrator. The final report and any accompanying memoranda will be posted on the Technical Mapping Advisory Council website.

ARTICLE X RECORDKEEPING

The DFO maintains all records of the advisory Council in accordance with the General Records Schedule 6.2, or other approved agency, or FEMA policies and procedures records disposition schedule. These records shall be available for public inspection and copying, in accordance with the *Freedom of Information Act* (Title 5, United States Code, section 552).. All documents, reports, or other materials presented to, or prepared by or for the Council, constitute official government records and are available to the public upon request.

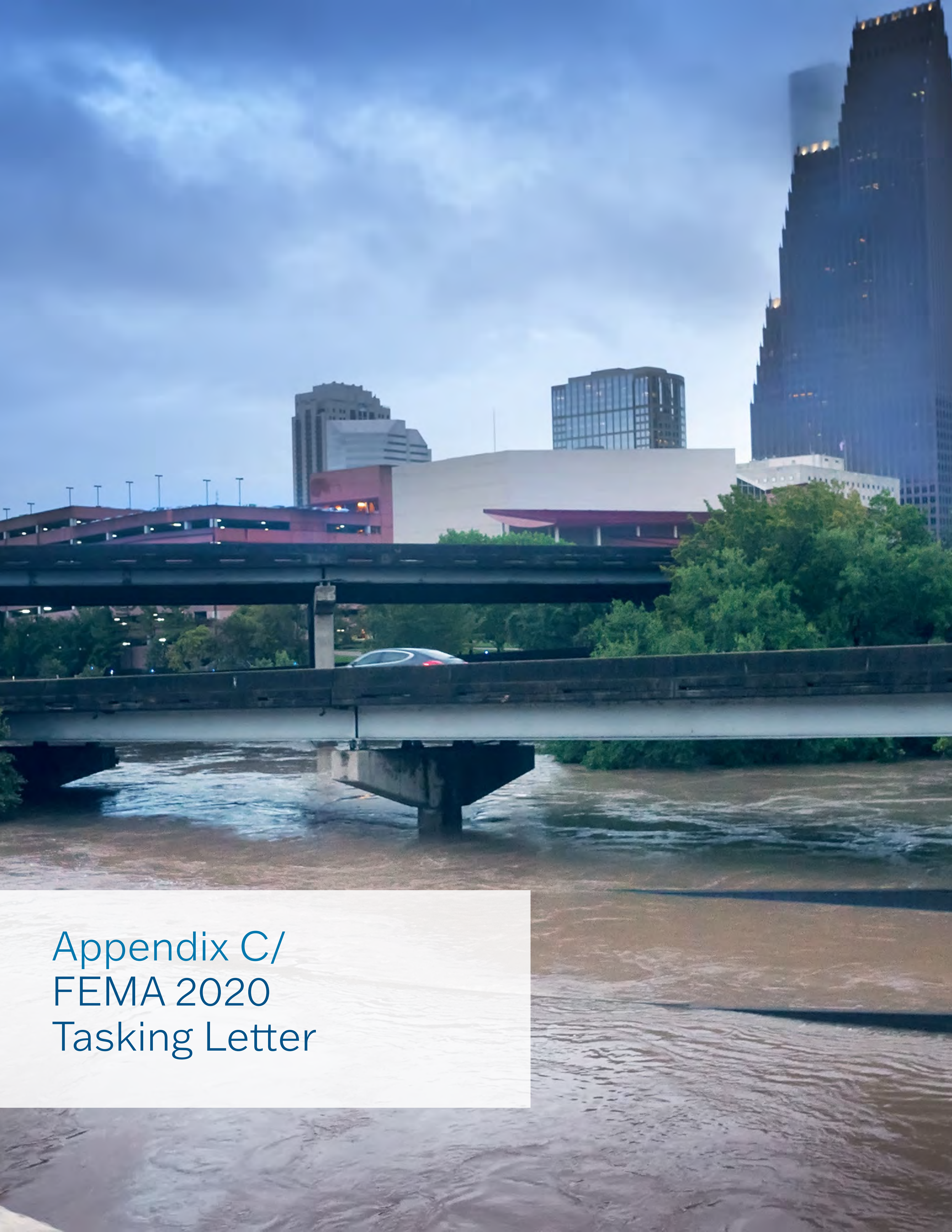
ARTICLE XI BYLAWS APPROVAL AND AMENDMENTS

The DFO may amend these bylaws at any time, and the amendments shall become effective immediately upon approval by the DFO/ADFO.



Michael Nakagaki
Designated Federal Officer

Date approved: June 10, 2019



Appendix C/ FEMA 2020 Tasking Letter

U.S. Department of Homeland Security
Washington, DC 20472

FEMA

February 12, 2020

Jeffrey Sparrow, P.E., CFM
Chair, Technical Mapping Advisory Council
21308 Small Branch Place
Ashburn, Virginia 20148

Dear Mr. Sparrow:

The Biggert-Waters Flood Insurance Reform Act of 2012 established the Technical Mapping Advisory Council (TMAC) to review and make recommendations to the Federal Emergency Management Agency (FEMA) on matters related to the National Flood Mapping Program for the National Flood Insurance Program (NFIP). FEMA appreciates the dedication the TMAC has shown to date and values the continued engagement as FEMA considers ways to improve how flood hazard and flood risk data is generated and delivered, redesigns flood risk rating for insurance, and evolves its products and services to best meet the NFIP customer needs.

In 2019 FEMA tasked the TMAC with reviewing previous TMAC recommendations and identifying any previous and/or new recommendations FEMA should consider tasking to the TMAC in the future. Based on these recommendations put forth by the TMAC in 2019, FEMA tasks the TMAC in 2020 to:

1. **Work with stakeholders to identify best practices that can be incorporated into a future flood hazard and flood risk identification program that will equip them to:**
    a. **Understand flood hazards in a graduated way,**
    b. **Identify flood risk to improved property in a graduated way, and**
    c. **Promote increased investments in flood mitigation through new incentives.**
2. **Provide a framework for FEMA to transition to the envisioned flood hazard and flood risk identification program by:**
    a. **Identifying obstacles,**
    b. **Highlighting opportunities,**
    c. **Identifying useful portions of the current program that are important to continue, and**
    d. **Proposing specific roles that could be played by State, local, Tribal, Territorial, private, nonprofit, academic, and other entities in assessing, communicating, and managing flood hazards and risks.**

www.fema.gov

FEMA's vision for the future of the National Flood Mapping Program is a multi-year strategy of new concepts and approaches that are built based on the progress of the Risk MAP program and focused on four elements, listed below. The TMAC should consider these four elements when exploring the two tasking elements for 2020:

1. **Shift from a binary to a graduated view of flood risks.**
2. **Ensure a significant and appropriate role for the private sector and for State, local, Tribal, and Territorial (SLTT) entities.**
3. **Increase access to flood hazard data to improve resulting mitigation and insurance actions at the local and private levels.**
4. **Modernize the management and delivery of the flood hazard mapping program**

FEMA recognizes the unique task given to the TMAC in 2020 and will support the TMAC's engagement with stakeholders to gather this feedback from the entire spectrum of stakeholders. The insight about the elements of a future program, as well as the features of a transition plan to an end state that is still being defined, will be invaluable as we move ahead. FEMA is confident that the TMAC members possess the expertise and ability to develop these findings in a way that will continue to advance how the nation approaches flooding. The TMAC should formulate its findings into an annual report as in previous years. In addition to the annual report, the TMAC may consider other ways of sharing stakeholder insight and input with FEMA.

I am excited about the continued engagement between FEMA and the TMAC. I appreciate the Council's continued dedication to sharing its knowledge and insight with the Agency to further strengthen our evolving flood mapping program, reduce risk, and help keep our nation safe.

Sincerely,

Michael M. Grimm
Assistant Administrator
Risk Management Directorate
Federal Insurance and Mitigation Administration

Appendix D/ Compilation of Stakeholder Engagement Results

This appendix is divided into three sections: a section detailing the survey questions and dissemination process, a description of the data-cleaning that was completed, and an overview of the July-August 2020 online survey results; a section including the polling questions and results from two webinars held in August and September 2020; and a section containing information about the process for, and final results from eleven Focus Group discussions held with five stakeholder groupings in November and December 2020.

Online Survey

An online survey was developed to obtain input from stakeholders regarding stakeholders served, flood risk management objectives, tools or resources needed from the program, the useful elements of the current program that should remain as the Federal Emergency Management Agency (FEMA) shifts from binary to graduated, obstacles expected as the shift is made from binary to graduated, sentiment on graduated versus binary, and stakeholder interest in further engagement with the Technical Mapping Advisory Council (TMAC).

PILOT SURVEY

A pilot survey was made available through a partnership with the Association of State Floodplain Managers (ASFPM) at the 2020 virtual conference in June 2020. In order to disseminate the survey, a social media distribution plan was developed and used to make ASFPM conference attendees aware of the survey, and several vendors posted information about the survey at their virtual booths. The 96 pilot survey responses received are included in the raw data available via download at the FEMA website https://www.fema.gov/flood-maps/guidance-reports/technical-mapping-advisory-council, and were mainly used to assess whether the feedback obtained using pilot questions was useful for the TMAC to support the 2020 tasking. The pilot survey in its entirety is included below:

Technical Mapping Advisory Council Survey on the Future of the Flood Hazard Identification Program

Flood hazard mapping and other products developed in support of the National Flood Insurance Program such as Flood Insurance Rate Maps are currently based on a binary (in or out) view of flood hazards: a property is either in the Special Flood Hazard Area or it is not. In reality, however, flood risk is not binary, as there is never "no risk." Some areas carry a great deal of risk due to a diverse range of factors, while in other areas, the risk is moderate or minimal. The program is in the process of envisioning a shift from this binary framework to a new future program in which the information produced will reflect the graduated nature of flood hazards and risk. The purpose of this shift is to more accurately understand and communicate flood risk so that communities can better manage risk and reduce flood losses.

The new program intends to identify and communicate flood risk in a more diverse manner, and specifically:

- *Examine risk over multiple flood frequencies*
- *Estimate and quantify uncertainty*
- *Consider a range of flood hazards (riverine, coastal, urban flooding, levee, etc.)*
- *Include data about the ramifications of flooding (e.g., damages to the built environment or infrastructure)*
- *Provide information that is not limited to the 1-percent-annual-chance flood or other specific flood recurrence interval*

The Technical Mapping Advisory Council (TMAC) is seeking input from a wide range of stakeholders regarding this future flood hazard and flood risk identification program. Your input will be summarized and considered by TMAC as they support the Federal Emergency Management Agency in considering the myriad ways to improve how flood hazard and risk information is generated and delivered. Your valuable feedback may inform the program's evolving products and services to best meet National Flood Insurance Program customer needs.

Directions: Please answer the following 13 questions. Most require you to select from multiple choice options and many have an option to write in more specific ideas or information.

1. What is your primary job function? (select all that apply)

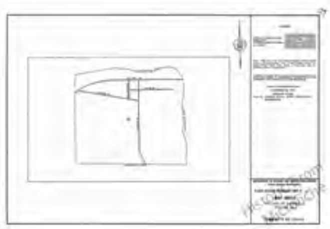
    a. Lender
    b. Flood Zone Determination Company
    c. Insurance Agent
    d. Floodplain Manager/Floodplain Administrator
    e. Land Use Planner
    f. Building Official
    g. Surveyor
    h. Professional Engineer
    i. Design Professional (Engineer, Architect)
    j. Real Estate Agent
    k. Developer
    l. Local, State, or Federal Elected Official
    m. Federal Agency
    n. State Agency

o. Emergency Management Professional
p. Resource Manager
q. GIS or Geospatial Specialist
r. Other (fill in the blank)

2. In your primary job function, which stakeholders do you most often provide products or services for/to? (Select all that apply)
   a. Local governments
   b. State governments
   c. Federal government
   d. Tribal Councils
   e. Territorial governments
   f. Regional Agencies
   g. Surveyors
   h. Engineers
   i. Insurance Agents
   j. Real Estate Agents
   k. Developers
   l. Homeowners
   m. Other (fill in blank)
3. Do you currently hold any of the following National Flood Insurance Program-supporting designations? (Select all that apply)
   a. Certified Floodplain Manager (CFM)
   b. Certified Floodplain Surveyor (CFS)
   c. Associate in National Flood Insurance (ANFI)
   d. None
4. Of the four main elements of the National Flood Insurance Program, with which element does your professional role most closely align? (Select one)
   a. Flood Insurance
   b. Floodplain Management and Regulation
   c. Flood Hazard Mapping
   d. Flood Hazard Mitigation
5. Of the following, which would you say are your three top floodplain management or flood risk management objectives? (Select 3)
   a. Protecting my investment or portfolio of investments or that of my clients
   b. Complying with mandates or laws (such as the mandatory purchase requirement)
   c. Supplying accurate information about flood hazard and risk
   d. Ensuring state and local floodplain management ordinances and building codes are followed
   e. Ensuring that floodplain management ordinances and building codes incorporate higher standards than those of the National Flood Insurance Program
   f. Ensuring that new development does not increase flood risk for others
   g. Lowering the flood risk that currently exists (though mitigation, planning, or other mechanism)
   h. Assuring proper emergency management planning
   i. Communicating flood risk to others

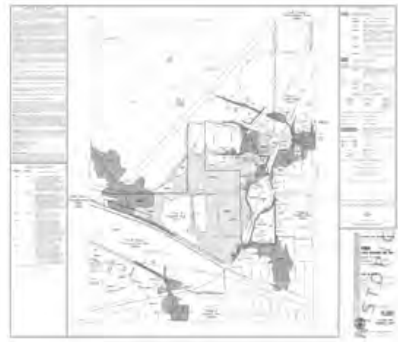
j. Expanding flood insurance coverage

6. In your professional role, do you use regulatory National Flood Insurance Program products to understand and convey flood risk information?

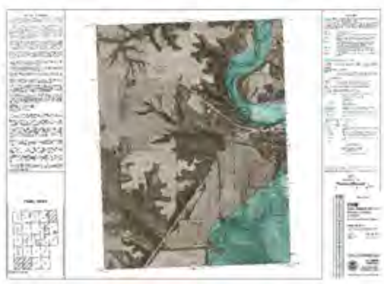


Flood Hazard Boundary Map

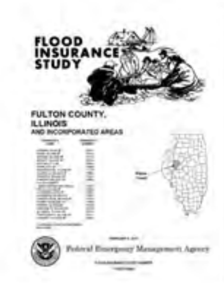
Flood Boundary and Floodway Map



Paper Format Flood Insurance Rate Map



Digital Format Flood Insurance Rate Map



Flood Insurance Study

a. Yes
b. No
c. I don't know

IF YES:

i. Which products are the most useful/effective to you? (select all that apply)

1) Flood Hazard Boundary Map
2) Flood Boundary and Floodway Map
3) Paper format Flood Insurance Rate Map
4) Digital format Flood Insurance Rate Map
5) Flood Insurance Study

ii. Which products are the least useful/effective to you? (select all that apply)

1) Flood Hazard Boundary Map
2) Flood Boundary and Floodway Map
3) Paper format Flood Insurance Rate Map
4) Digital format Flood Insurance Rate Map
5) Flood Insurance Study

iii. Why do you consider these products to be ineffective? (Select all that apply)

1) Product is difficult to use
2) Product is difficult to understand
3) Product is not necessary

7. In your professional role, do you use "non-regulatory" National Flood Insurance Program products, also called "Flood Risk Products" or other information provided by the program to understand and convey flood hazard and risk? (see https://www.fema.gov/risk-map-flood-risk-products for more information about the most common Flood Risk Products)[1].

   a. Yes
   b. No
   c. I don't know

   IF YES:

   i. Which products are the most useful/effective to you? (select all that apply):

      1) Data downloads from FEMA systems (e.g., policy counts and coverage information from PIVOT)
      2) Base Level Engineering information
      3) Changes Since Last FIRM
      4) Areas of Mitigation Interest
      5) Flood Risk Assessment (either for a single property or an area of a community)
      6) Depth and Analysis Grids (i.e., Water Surface Elevation Grids, Depth Grids, Velocity Grids, Percent-Annual-Chance Grids, 30-Year-Chance Grids, Arrival time Dam Scenario Grids, Flood Depth and Velocity Severity Grids, Flood Inundation Duration Grids, Peak Dam Grids, Water Surface Elevation Change Grids)
      7) Flood Risk Map
      8) Flood Risk Report
      9) Dams datasets (Dam Cross Sections, Dam Downstream Inundation Areas, Dam Easements, Dam locations, Dam Upstream Inundation Areas)
      10) Increased flood scenarios
      11) Levee datasets (Levee Breach Point, Levee Element Locations, Levee Inundation Areas, Levee Rating Curve, Levee Locations, Levee Freeboard, Levee Analysis Impact Area)
      12) Dune Size and Location
      13) Simple Coastal Zone
      14) Critical Facilities Points

   ii. Which products are the least useful/effective to you?

      1) Data downloads from FEMA systems (e.g.., policy counts and coverage information from PIVOT)
      2) Base Level Engineering information
      3) Changes Since Last FIRM
      4) Areas of Mitigation Interest
      5) Flood Risk Assessment (either for a single property or an area of a community)
      6) Depth and Analysis Grids (i.e., Water Surface Elevation Grids, Depth Grids, Velocity Grids, Percent-Annual-Chance Grids, 30-Year-Chance Grids, Arrival time Dam Scenario Grids, Flood Depth and Velocity Severity Grids, Flood Inundation Duration Grids, Peak Dam Grids, Water Surface Elevation Change Grids)
      7) Flood Risk Map

[1] Note that that the time of this survey, this link led to a list of non-regulatory products and their function. This link now leads to a different page. The new page that most closely resembles the original page is https://www.fema.gov/flood-maps/tools-resources/risk-map/products.

8) Flood Risk Report
9) Dams datasets (Dam Cross Sections, Dam Downstream Inundation Areas, Dam Easements, Dam locations, Dam Upstream Inundation Areas)
10) Increased flood scenarios
11) Levee datasets (Levee Breach Point, Levee Element Locations, Levee Inundation Areas, Levee Rating Curve, Levee Locations, Levee Freeboard, Levee Analysis Impact Area)
12) Dune Size and Location
13) Simple Coastal Zone
14) Critical Facilities Points

iii. Why do you consider these products to be ineffective?

1) Product is difficult to use
2) Product is difficult to understand
3) Product is not necessary
4) Other (fill in blank)

8. What type of tools or resources do you need to gain better understanding of flood hazards and risks for yourself or to promote understanding within your community? (Select all that apply)

a. N/A – I have all the information I need
b. Basic Flood Insurance Rate Maps
c. An upgrade of my current Flood Insurance Rate Maps
d. Life safety risk information (e.g., flood velocity information)
e. Impacts of key flood events (physical damage, economic losses, social impacts, etc.)
f. Information to support insurance communications (purchase requirements, rate changes, how to reduce rates, etc.)
g. Information about past flood events
h. Information to help me explain risks to elected officials, homeowners, developers, or others
i. Information to support mitigation projects (scenario planning, grant applications, executing and managing mitigation projects, etc.)
j. Data to help me comply with state-level requirements or enact higher standards
k. Unsteady-flow models that can help me understand floodplain storage requirements
l. Data to help me understand more complex risks, like mudflows, tsunamis, ice jams, and alluvial fans
m. Information to help me plan for rising sea levels
n. Information to help me plan for more intense localized rainfalls
o. Information to help me identify and manage stormwater, street flooding, or urban flood risk
p. Other (fill in blank)

9. On a scale of 1-10, how does the binary "in/out" aspect of the currently-available hazard mapping products through the National Flood Insurance Program help you meet your floodplain management or flood risk management objectives? Choose "0" for "N/A" if the currently-available flood hazard mapping products are not available to you.

1 2 3 4 5 6 7 8 9 10

It mostly works against meeting my objectives — It perfectly helps me meet my objectives

Binary versus Graduated Risk

The following table helps illustrate some of the important differences between binary and graduated approaches to flood hazard and risk understanding. Please keep these differences in mind while answering the next two questions:

CURRENT BINARY PRODUCTS	FUTURE GRADUATED PRODUCTS
Simplified approach to identify flood hazards on a map	More nuanced approach to identify flood hazards and assess flood risk at the individual structure level
Uses on representative value for model inputs (e.g., roughness, stream flow)	Accounts for many possible values for model inputs (acknowledging uncertainty within each input); and combines those values in many possible ways
Typically uses historical data as inputs	Potentially uses additional future-conditions data as an input to account for additional uncertainty
Models on major flooding source at a time (e.g., Riverine, Coastal)	Models multiple flooding sources (e.g., urban flooding, future-conditions related flood-ing), and combines them in many possible ways
Produces up to five water surface elevations, but utilizes one the 1-percent-annual-chance (Base Flood Elevation) as the basis of the program	Produces water surface elevations acros a wide range of flood frequencies including very high probability events and very low probability events (e.g., 2-year to 3,000-year) as output layers
Currently does not use "Depth of Water" to identify flood risk	Produces "Depth of Water" for a wide range of events (e.g., 2-year to 3,000-year) as output layers for better risk communication and assessment
The residual risk associated with levees is not considered	Accounts for many possible methods of levee failure (breaching, overtopping, etc.) to better estimate the residual risk associated with flood protection systems
Produces 100- and 500-year flood zones as output layers	Produces a wide range of events (e.g., 2-year to 3,000-year) as output layers
Risk assessment is a separate process from flood hazard mapping	Risk assessment is part of the process; quantified risk based on Average Annualized Loss can be shown at the individual structure level
No structure information is needed for mapping	Information on structures (e.g., types, uses, elevations) is obtained from reliable data soures and an algorithim determining their existence (e.g., basement) and possible range of their values (e.g., lowest floor elevations) would be used in the risk assessment

1. On a scale of 0-10, do you expect the proposed shift to graduated flood hazard and risk will be useful to you in your work or personal risk management activities? *Example: Select "0" if your community has basic needs that are already managed, select "5" if you don't know, or select "10" if it will be extremely useful*. (Scale rating with the following text at the far right and far left):

1 2 3 4 5 6 7 8 9 10

It will have zero impact — It will be a big improvement

2. What obstacles do you expect to encounter in the proposed shift to graduated risk-based products? (Select all that apply)

   a. Confusion about what new data or product options are available to better understand and communicate risks/hazards
   b. How to use graduated risk information to better manage flood risk
   c. Managing or understanding my existing job duties within the context of this new data
   d. Increased staff time/ resources will be needed to implement graduated risk information
   e. Explaining graduated risk to the public, elected officials, or others
   f. Integrating this change with stormwater management programs
   g. Integrating this change with the development permit process
   h. Using this data for disaster response and management
   i. Integrating this data with state-level requirements
   j. Understanding what new burdens or requirements this might place on my community

k. Other (fill in blank)

3. Is there any additional information you would like to comment on regarding the shift from binary to graduated flood hazard information? (free text responses)
4. Are you interested in being part of a webinar or a small, virtual focus group to further help TMAC explore this issue from your perspective? Yes/No/Maybe

   If Yes or Maybe, survey requested: name, email, and organization

TMAC received 96 responses to the pilot survey. Based on those responses, answer choices and/or answer types were edited with the goal of making the responses more useful in identifying obstacles and opportunities associated with the proposed shift. These changes are detailed below:

Question 1 *(primary job function):*
Eliminated duplicate answer options (e.g., "Design Professional [Engineer, Architect]" was eliminated and "Professional Engineer" and "Architect" were split up); new answer choices were added (i.e., "NFIP contractor or consultant," "NGO or non-profit staff," and "researcher or member of academic institution"); some answer choices were divided into more detailed descriptions (e.g., "State Agency" became "State NFIP Coordinator," "State Hazard Mitigation Officer," and "Other State Agency Official"); and answer type was changed from "Select all that apply" to "Select one.

Question 2 *(stakeholders served):*
Several stakeholder types were added, including "NGOs/non-profits," "Emergency Managers," "Lenders/Banks," "Researchers/Academia," Home Builders/Buyers," "Property Owners/Renters," and "General Public." "Homeowners" was eliminated in favor of the new options added.

Question 3 *(NFIP-supporting designations)*, Question 4 *(NFIP role alignment):*
No changes were made.

Question 5 *(floodplain or flood risk management objectives):*
Several answer choices were simplified (e.g., "Increasing the number of flood insurance policyholders" was revised to "Expanding flood insurance coverage") or combined (e.g. "Supplying accurate information about flood hazard and risk" and "communicating flood risk to others" were combined into one answer option "Supplying accurate information to others about flood hazard and risk"), and an "Other" answer choice was added for respondents to provide their own responses.

Question 6 *(regulatory product use)* and Question 7 *(non-regulatory product use)* and all of their sub-questions were eliminated entirely.

Question 8 *(tools and resources needed):*
Some details were added to answer choices (e.g., "erosion and channel migration zones" were added as examples of "Data to help me understand more complex risks"), and new answer choices were added (e.g., "Data to help me understand areas of conservation interest" and "Personalized, property-level risk information"). Note, after deleting Questions 6 and 7, this became Question 6 in the final survey.

Question 9 *(scale rating for how well binary data helps meet objectives):*
No changes other than question numbering due to the deletion of Questions 6 and 7 and their sub-questions. This became Question 7 in the final survey.

Question 10 *(scale rating on how well graduated data will be useful for meeting objectives):*
No changes other than question numbering due to the deletion of Questions 6 and 7 and their sub-questions. This became Question 9 in the final survey.

Question 11 *(obstacles expected in the shift from binary to graduated):*
The answer options for this question were heavily edited. Four new answer options were added (e.g., "Integrating this change with stormwater management requirements"), and three answer options were re-written or combined with others (e.g., "Integrating this change with the permit process" and "Integrating this data with state-level requirements" were combined into "Integrating this change with the permit process including building standards/Building Codes and state-level requirements"). A re-numbering occurred due to deleted questions 6 and 7, and a newly added question (see "Other changes" below). Due to these changes, this became Question 10 in the final survey.

Question 12 *(additional information in free text format)* and Question 13 *(interest in further engagements):*
No changes were made to these questions, other than re-numbering due to deleted Questions 6 and 7, and a newly added question (see "Other changes" below). These now became Questions 11 and 12 in the final survey.

Other changes:
The following question was added as Question 8 in the final survey: "What are useful elements of the current program that are important to continue as FEMA moves forward with shifting from binary to probabilistic risk?" This question was added to cover more of the 2020 tasking than the pilot questions covered.

Final Survey

The final survey was made public on July 2, 2020. It was announced to various stakeholder groups by TMAC members using their TMAC representation category, which is outlined in Table D-1. A survey distribution strategy including an email blast, and survey links including a QR code, were developed and shared with each TMAC member for their use in distributing the survey to industry associations, state and local/regional list servers or other membership groups, and federal agency staff. In this way, the survey was distributed to ASFPM, American Council of Engineering Companies, and other industry associations, as well as the Cooperating Technical Partners (CTP) community and many others. Table D-1 lists the categories representing the groups of stakeholders that received the online survey from TMAC members.

INDUSTRIES REPRESENTED	FEDERAL AGENCIES REPRESENTED	STATE AND LOCAL MEMBERSHIP CATEGORIES
Mapping Industry	USACE	State GIS Representatives
Engineering Industry	NOAA	State CTPs
Flood Hazard Determination Industry	DOI	SHMOs
Floodplain Management Industry	FEMA	Local CTPs
Risk Management Industry	USDA	State NFIP Coordinators
Surveying Industry	USGS	Regional Flood & Stormwater Mgmt Agencies

Table D-1 / TMAC Member Categories.
These categories represent the groups of stakeholders the TMAC members distributed the online survey to.

The final survey questions are provided below:

Flood hazard mapping and other products developed in support of the National Flood Insurance Program such as Flood Insurance Rate Maps are currently based on a binary (in or out) view of flood hazards: a property is either in the Special Flood Hazard Area or it is not. In reality, however, flood risk is not binary, as there is never "no risk." Some areas carry a great deal of risk due to a diverse range of factors, while in other areas, the risk is moderate or minimal. The program is in the process of envisioning a shift from this binary framework to a new future program in which the information produced will reflect the graduated nature of flood hazards and risk. The purpose of this shift is to more accurately understand and communicate flood risk so that communities can better manage risk and reduce flood losses.

The new program intends to identify and communicate flood risk in a more diverse manner, and specifically:

- Examine risk over multiple flood frequencies,
- Estimate and quantify uncertainty,
- Consider a range of flood hazards (riverine, coastal, urban flooding, levee, etc.),
- Include data about the ramifications of flooding (damages to built environment or infrastructure), and
- Provide information not limited to the 1-percent-annual-chance flood or other flood recurrence intervals.

The Technical Mapping Advisory Council (TMAC) is seeking input from a wide range of stakeholders regarding this future flood hazard and flood risk identification program. Your input will be summarized and considered by TMAC as they support the Federal Emergency Management Agency in considering the myriad ways to improve how flood hazard and risk information is generated and delivered. Your valuable feedback may inform the program's evolving products and services to best meet National Flood Insurance Program customer needs. Directions: Please answer the following questions, which should take around 10 minutes. Most require you to select from multiple choice options, and many have an option to write in more specific ideas or information.

1. What is your primary job function? (Select one)
    a. Lender
    b. Flood Zone Determination Company Professional
    c. Insurance Agent/Insurance Professional
    d. Floodplain Administrator
    e. Building Official
    f. Surveyor
    g. Professional Engineer
    h. Architect
    i. Real Estate Agent
    j. Developer
    k. Local, State or Tribal Elected Official
    l. Federal Agency Official
    m. State National Flood Insurance Coordinator
    n. State Hazard Mitigation Officer
    o. Other State Agency Official
    p. Local Emergency Management Professional
    q. GIS or Geospatial Specialist
    r. National Flood Insurance Program Contractor or Consultant
    s. Land Use Planning or Zoning Official
    t. NGO or Non-Profit Staff
    u. Researcher or member of Academic Institution
    v. Other (free text)
2. In your primary job function, which stakeholders do you most often provide product or service for/to? (Select all that apply)
    a. Federal government
    b. State governments
    c. Territorial governments
    d. Tribal councils
    e. Local governments
    f. Regional Agencies
    g. NGOs or Non-Profits
    h. Emergency Managers
    i. Surveyors
    j. Engineers
    k. Insurance Professionals
    l. Lenders, Banks
    m. Real Estate Agents

n. Construction Professionals or Developers
o. Researchers/Academia
p. Home Builders/Buyers
q. Property Owners/Renters
r. General Public
s. Other (free text)

3. Do you currently hold any of the following National Flood Insurance Program-supporting designations? (Select all that apply)

    a. Certified Floodplain Manager (CFM)
    b. Certified Floodplain Surveyor (CFS)
    c. Associate in National Flood Insurance (ANFI)
    d. None

4. Of the four main elements of the National Flood Insurance Program, with which element does your professional role most closely align? (Select one)

    a. Flood Insurance
    b. Floodplain Management and Regulation
    c. Flood Hazard Mapping
    d. Flood Hazard Mitigation

5. Of the following, what are your top three floodplain management or flood risk management objectives? (Select only three)

    a. Protecting my investment/portfolio of investments or that of my clients
    b. Complying with the mandatory purchase requirement
    c. Increasing the number of flood insurance policyholders
    d. Assuring proper emergency management planning
    e. Implementing and complying with the minimum National Flood Insurance Program standards for new development
    f. Implementing and complying with standards that are more stringent than the National Flood Insurance Program minimums for new development
    g. Lowering the flood risk that currently exists (through mitigation, planning, or other mechanism)
    h. Supplying accurate information to others about flood hazard and risk
    i. Protecting or restoring the natural and beneficial functions of floodplains
    j. Developing scientific data and tools to manage current flood risks
    k. Developing scientific data and tools to address impacts of future flood risk changes (e.g., climate change, sea level rise, channel migration, erosion, increased precipitation, etc.)
    l. Other (free text)

6. What types of tools or resources do you need to gain better understanding of flood hazards and risks for yourself or to promote understanding within your community? (Select all that apply)

    a. N/A - I have all the information I need
    b. Basic Flood Insurance Rate Maps
    c. An upgrade of my current flood insurance rate maps (e.g., from paper to digital, from approximate to detailed, etc.)
    d. Life safety risk information (e.g., flood velocity information)

e. Impacts (physical damage, economic losses, social impacts, etc.) of key flood events (predicted or past/actual)
f. Information to support insurance communications (purchase requirements, rate changes, how to reduce rates, etc.)
g. Information about extents of past flood events
h. Information to help me explain risks to elected officials, homeowners, developers, or others
i. Information to support mitigation projects (scenario planning, grant applications, executing and managing mitigation projects, etc.)
j. Data to help me comply with state-level requirements or enact higher standards
k. Unsteady-flow models that can help me understand floodplain storage requirements
l. Data to help me understand more complex risks, like mudflows, tsunamis, ice jams, alluvial fans, erosion, and channel migration zones
m. Information to help me plan for rising sea levels
n. Information to help me plan for more intense localized rainfalls
o. Information to help me identify and manage stormwater, street flooding or urban flood risk
p. Data to help me understand areas of conservation interest
q. Personalized, property-level risk information
r. Other (free text)

7. On a scale of 1-10, how does the binary "in/out" aspect of the currently available hazard mapping products through the National Flood Insurance Program help you meet your floodplain management or flood risk management objectives? (Select 0 for N/A if the currently available flood hazard mapping products are not available to you.)

0	1	2	3	4	5	6	7	8	9	10

It mostly works against meeting my objectives — It perfectly helps me meet my objectives

Binary versus Graduated Risk

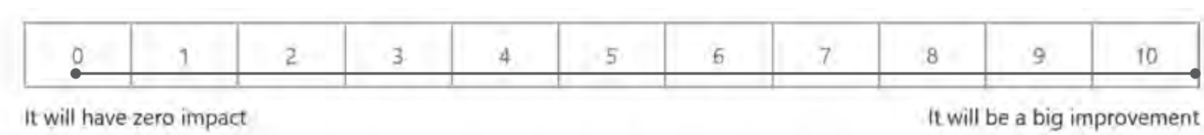
The following table helps illustrate some of the important differences between binary and graduated approaches to flood hazard and risk understanding. Please keep these differences in mind while answering the next four questions:

1. What are useful elements of the current program that are important to continue as FEMA moves forward with shifting from binary to probabilistic risk? (Select all the apply)

a. Minimum floodplain development standards tied to flood hazard information
b. Flood elevations and flood depths (e.g., Base Flood Elevations, stillwater elevations, flood depths in sheet flow areas, etc.)
c. Flood profiles showing different flood elevations graphically at multiple locations along a stream
d. Cross sections shown on a map or digital interface
e. Tables with specific hazard information at cross sections or other known location (e.g., Floodway Data Tables)
f. Tables with specific hydrologic information at cross sections or other known location (e.g., Summary of Discharges, Frequency-Discharge Drainage Area Curves)
g. Coastal transects shown on a map or digital interface
h. Flood Hazard or Risk Zones shown on a map or digital interface (e.g., current SFHA

    i. Floodways or other mechanism to identify special areas of concern or where special development requirements apply
    j. Flood Insurance Study supporting text (e.g., purpose of study, community description, principal flood problems, etc.)
    k. National Flood Hazard Layer viewer or other mechanism to view flood hazard and risk data on a national scale
    l. Downloadable data in GIS format
    m. Access to models
    n. Map change processes (LOMAs, LOMRs, etc.)
    o. Levee locations and associated hazard information
    p. Primary Frontal Dunes
    q. Other (free text)

2. On a scale of 0-10, do you expect the proposed shift to graduated flood hazard and risk be will be useful to you in your work or personal risk management activities? Example: Select 0 if your community has basic needs that are already managed, select 5 if you don't know, or select 10 if it will be extremely useful.



3. What obstacles do you expect to encounter in the proposed shift to graduated risk? (Select all that apply)
    a. Confusion about what new data or product options will be available and how to use them
    b. Costs to the program to develop, manage, and maintain the additional data
    c. Staff resources needed to implement graduated risk information
    d. Integrating this change with FEMA Mitigation Grants requirements (Special Flood Hazard Area determination, Benefit Cost Analysis, etc.)
    e. Integrating this change with the permit process, including building standards/Building Codes and state-level requirements
    f. Integrating this change with land use planning (including climate change or future planning)
    g. Integrating this change with flood insurance purchase requirements
    h. Integrating this change with stormwater management programs
    i. Explaining graduated risk to the public, elected officials, or others
    j. Managing my existing job duties within the context of this new data
    k. Understanding what new burdens or requirements this might place on my community
    l. Using this data for disaster response and management
    m. Other (free text)
4. Is there any additional information you would like to comment on regarding the shift from binary to graduated flood hazard information? (optional, free text response, no limit on characters)
5. Are you interested in being part of a webinar or a small, virtual focus group to further help TMAC explore this issue from your perspective? Yes/No/Maybe
    a. If **Yes or Maybe**, survey requested: name, email, and organization

A total of 781 responses were recorded. Given an early preponderance of Professional Engineer responses during the early results, additional effort was made to recruit participation from non-engineer stakeholders. However, no improvement in non-engineer participation was noted in the last month of the survey.

Data Cleaning and Analysis

Data-cleaning and organization activities were conducted by STARR II in order to obtain a better understating of the data and assess trends, and further categorize the information. The data cleaning and organization activities are detailed below.

1. Separating tabular data:

a. We created a table that split out instances where a respondent had selected multiple options for a given question so we could capture each unique response to each question.

b. We checked table outputs to ensure that we had captured all responses accurately. For example: If respondent 23 had checked 3 resources they needed, the original and modified tables are shown below.

Original

RESPONDENT NO.	RESOURCES NEEDED
23	Maps; Impacts; Better models

Modified

RESPONDENT NO.	RESOURCES NEEDED
23	Maps
23	Impacts
23	Better models

2. Categorizing “Other” answers:

a. Many of the survey questions included an ‘other’ field, where respondents were able to input free text. In addition, many questions allowed respondents to be very specific in their answers. In order to display the information in summary form, we took the following two steps:

   i. We reviewed responses to questions and categorized them into summary statements, or simplify the response statement to convey the key meaning.

   ii. Where possible, we grouped ‘other’ responses into these groups.

3. Grouping of responses

a. In order to tell the story of the data, we grouped the responses to several of the questions so that we could start to see the themes emerging from the survey responses.

b. The next few pages show how we grouped responses for questions where that was needed.

c. Upon initial review of the results and subsequent discussions, we saw that discussions tended to group respondents into a few categories based on the perspective they brought. We grouped 'primary job function' responses into "producers" or "users" of flood risk data.

d. Note: some of the responses may be cut off in the images below showing how they were grouped. The full text is included in the raw data, which is available for download here.

What is your primary job function?

USERS

Acquisition Agent

Appointed Local Official (Director of Public Works)

Assistant County Administrator - Former Community Development Director, Floodplain Administrator & CRS Coordinator.

Building Official

CFM

City Manager

Claims Manager

Code Enforcement Officer/ Floodplain Administrator

Code Enforcer

Community Rating System (CRS) Coordinator

CTP

Development Review

Educator

Engineering Geologist

Estuary Program Director

Farmer, retired engineer

FEMA CTP Partner - LOMR Review Partner

Flood Buyout Coordinator/ Planner

Flood Control District

Flood Control District Engineer (Staff)

Flood Resilience Officer

Flood Risk Manager

Flood Zone Determination Company Professional

Floodplain Administrator

Floodplain Manager

Floodplain, Airport, Inspections Permitting & Admin Assist for County Manager

Insurance Agent/Insurance Professional

Land Use Planning or Zoning Official

Lender

Local Emergency Management Professional

Local Flood Control Agency Counsel

Local Flood Control Program Manager

Local Floodplain Representative

Local Government Environmental Planner

Local Government Floodplain Management Official

Local Government Planner

Local Government Staff

Local Govt. Floodplain/ Stormwater Management Engineer

Local Municipal Employee/ Engineering Dept.

Local, State or Tribal Elected Official

Mitigation Planner

MS4 Assistant

MS4 Field Staff

NC State Project Coordinator for Floodplain Mapping

NGO or Non-Profit Staff

Other

Other State Agency Official

Permit Manager

Planner

Planning Branch Chief/ State NFIP Coordinator

Project Manager - Flood Control District of Maricopa County

Public Works Director

PW Local Official

Real Estate Appraiser - Educator

Regional Agency

Regional Governmental Agency

Regional Planning Commission Planner

Researcher or Member of Academic Institution

Resilience Planning Manager

Retired

Retired Local Floodplain Manager

Retired Real Estate Broker

Retired State Flood Hazard

Administrator

River Scientist

Small Minority Owned Environmental Services

State CTP (non-engineer)

State Floodplain Manager

State Floodplain Mapping Coordinator

State Hazard Mitigation Officer

State National Flood Insurance Coordinator

State NFIP Branch Planner, CFM

Stormwater Program Director

Surveyor

Sustainability Coordinator

Town Engineer & Floodplain administrator

Trade Association Staff

Transportation Manager

Tribal Watershed Manager

Village MS4 Outreach Coordinator

Water Resource Planner

Water Supply Manager

Watershed Coordinator, Region 6, LA

PRODUCERS

Agricultural Water Consultant

Coastal Scientist

Consultant

Contracto

Design Engineer

Energy Project/Siting Consultant

Engineer

Engineering Technician

Federal Agency Official

FEMA Contractor

Floodplain Buyout Consultant

Floodplain Mgnt & Building Code Consultant

GIS or Geospatial Specialist

Hazard Mitigation Project Manager

Hydraulic/Environmental Engineer

Inundation Modeling & Risk Analysis Subject Matter Expert

ISO/CRS Specialist

Land Use Planner & Floodplain Development Professional

National Flood Insurance Program Contractor or Consultant

Planning Consultant

Professional Engineer

Professional Hydrologist, consultant

Project Manager, Contracted to FEMA

Technology

In your primary job function, which stakeholders do you most often provide product or service for/to?

Construction Professionals or Developers

- Construction Professionals or Developers
- Developers

Emergency Managers

Engineers

Federal Government

General Public

Home Builders/Buyers

Insurance Professionals

- Insurance Companies Insurance Professionals

Lenders/Banks

Local Governments

- Local Agencies
- Local Elected Officials Local Governments

NGOs or Non-Profits

Property Owners/Renters

Real Estate Agents

Regional Agencies

Researches/Academia

State Governments

Surveyors

Territorial Governments

Tribal Councils

- Tribal Councils
- Tribal Government/Departments, Small Communities

Other

- Utility Reps
- Energy Project Developers
- Environmental Nonprofits
- Flood Policy Holders
- Food Processors
- N/A
- Natural Resource (protections)
- Sand & Gravel Mine Operations

Of the following, what are your top three floodplain management or flood risk management objectives?

Compliance with Requirements

- Assist Communities to enforce the minimum NFIPstandards and where appropriate implement higher standards.
- Complying with the mandatory purchase requirement
- Enforcing compliance with our local flood damage prevention ordinance
- Ensuring proper performance and maintenance of infrastructure used to manage floodplain risk
- Helping Local agencies navigate through mapping and local FPD regs for Envionmental review
- Implementing and complying with standards that are more stringent than the National Flood Insurance Program minimums for new development
- Supporting 50 Percent Rule determinations

Planning and Actions to Reduce Risk

- Assuring proper emergency management planning
- Protecting infrastructure in the natural environment
- Hazard Mitigation Planning
- Lowering the flood risk that currently exists (through mitigation, planning, or other mechanism)
- Preparing for future flood events

Supplying Information & Guidance

- Assuring tribes and local governments understand how their risk may change given impacts from climate change, and support them to assess and plan for this and build their resilience to it.
- Communicating flood risk for mitigation planning purposes
- Effectively communicating risks/hazards to stakeholders and increasing the understanding of the beneficial function of floodplains and natural resources.
- Offering free floodplain management advice
- Providing guidance for sound floodplain management
- Supplying accurate information to others about flood hazard and risk
- Trying to get local officials to pay attention to the risks of flooding.

Developing Data & Tools

- Developing accurate floodplains through modeling using the best available data allowed within the provided funding amount
- Developing scientific data and tools to address impacts of future flood risk changes (e.g., climate change, sea level rise, channel migration, erosion, increased precipitation, etc.)
- Developing scientific data and tools to manage current flood risks
- Mapping flood hazard risk

Implementing Higher Standards

- Implementing and complying with the minimum National Flood Insurance Program standards for new development
- Implementing solutions that achieve flood risk reduction, social, economic and environmental community benefits

- Improving CRS locally to develop a more robust comprehensive program

Protecting Investments (e.g., through insurance)

- Increasing the number of flood insurance policyholders
- Protecting infrastructure in the natural environment
- Protecting my investment/portfolio of investments or that of my clients

Other

- Preventing unethical engineers from utilizing 2D modeling as a smoke screeen of inaccurate results to allow development in high hazard areas including alluvial fans

Promoting Nature-Based Solutions

- Promotion of Nature-Based green stormwater infrastructure
- Protecting or restoring the natural and beneficial funtions of floodplains

What types of tools or resources do you need to gain better understanding of flood hazards and risks for yourself or to promote understanding within your community?

Enhanced Modeling Information

- Accurate reservoir/dam location, size, discharge dataComplying with the mandatory purchase requirement
- A 2-D alternative to the current 1-D floodway concept. 2) Definitive instruction to floodplain managers on how to assess BFEs on 2-D FIRMs. We have FPMs that only use the official layout of a cross section from the profile, completely ignoring the more accurate FIRM water surface elevations.
- Better information about the velocity of coastal flood water
- Dam inundation data
- Data and information Hydrology changes after fires
- Data to help me understand more complex risks, like mudflows, tsunamis, ice jams, alluvial fans, erosion, and channel migration zones
- Floodplain mapping for multiple return periods (in addition to the 1% annual chance event)
- Hydrologic data (especially streamflow data) to validate hydrologic models assumptions and application.
- Information about flood risk due to dam failure
- Information about levee-related risks
- Information to help me identify and manage stormwater, street flooding or urban flood risk
- Life safety risk information (e.g., flood velocity information)
- Maps that include all the factors that contribute to risk/hazards from flooding.
- Post-wildfire impacts on flooding
- Tools to better evaluate how infrastructure changes impact flood models
- Unsteady-flow models that can help me understand floodplain storage requirements
- Updated models that reflect current flows and also predicted future flow changes due to climate change. Our DFIRMS are based on 40-year old flow data.
- Updated watershed hydrology and unit hydrographs

Mitigation Project & Grant Planning Information

- Integration to advance mitigation
- Information to help my recover from events. Information on how to qualify for grants.
- Information to inform resiliency studies on infrastructure
- Information to support mitigation projects (scenario planning, grant applications, executing and managing mitigation projects, etc.)

Information to Support Flood Risk or Insurance Communications

- 1). Fact sheets on how proposed and resultant nonbinary mapping will translate into flood insurance mandates and premiums. 2) Easier access to GIS data and hydraulic models. There are times we get bounced between FEMA offices.
- better explanation on maps of what the limits of the study mean. I know what it means but residents see a line with no floodplain delineated upstream of that line and they think something totally different
- Educational/training geared to elected officials to get them to understand this complex topic. It is very political and technical and the elected who make the decisions for communities are just not up to speed no matter what we professionals do.
- Information to help me explain risks to elected officials, homeowners, developers, or others
- Information to support insurance communications (purchase requirements, rate changes, how to reduce rates, etc.)
- Outreach materials
- Personalized, property-level risk information
- Risk Communication

Current or Enhanced NFIP Program Resources

- A repository of FEMA flood study models. Currently in Pennsylvania these must be obtained one at a time and at a minimum cost of $300 from the FEMA Engineering Library in Virginia.Information to help my recover from events. Information on how to qualify for grants.
- A working FEMA map Service Center
- Access to RL and SRL data from PIVOT
- An upgrade of my current flood insurance rate maps (e.g., from paper to digital, from approximate to detailed, etc.)
- Base Level Engineering data for my area
- Basic Flood Insurance Rate Maps
- BLE base Level Engineering
- Easily obtainable flood study information historic data
- GIS LOMA GIS information, current GIS structure layers
- More studies that determine base flood information
- N/A
- N/A - I have all the information I need
- Not the best worded question. I already have some of the info listed, so do not need it from others. Specifically what I need is access to individual claims data. My request has been rejected because, "Your research is not a FEMA project."

Flood Event Impacts

- A layer that shows specific past flood events that can be overlayed over current FIRMs.
- Impacts (physical damage, economic losses, social impacts, etc.) of key flood events (predicted or past/actual)
- Information about extents of past flood events

Future Conditions Information

- And all of the above at the upland/tidal zone, esp as that moves with SLRImpacts (physical damage, economic losses, social impacts, etc.) of key flood events (predicted or past/actual)
- Climate, flood data
- Examples from Tribes and work with Tribes to build resilience to future flood events that may be increased in frequency and volume due to climate change.
- Improved observation of flood flows and extreme precipitation
- Information to develop guidance, climate change information
- Information to help me plan for more intense localized rainfalls
- Information to help me plan for rising sea levels

Elevation & Topographic Data

- CORRECTED LIDAR or more accurate elevation locations (horizontal flood limits) than current mapping
- Detailed Transect Data to improve identification of limits of Velocity Zones
- Elevations of existing buidling stock
- High water marks, first flood elevations, etc.
- LIDAR data products

Information for Preserving/Restoring Natural Floodplain Function

- Data to better understand natural and beneficial function capacities to mitigate risk and cost-benefit data for those types of projects.
- Data to help me understand areas of conservation interest
- Grant opportunities to implement green infrastructure

Data to Support Floodplain Management Standards

- Data to help me comply with state-level requirements or enact higher standards
- Enforcement mechanisms to help keep people from skirting the Substantial Improvement/Substantial Damage Requirements.
- Support from the federal government on the enforcement of ethical engineering to ensure safety of development instead of support for and facilitation of unethical, unsafe development.
- What specific alterations and additions are allowed on buildings in the floodplain

Data to Support Disaster Operations

- Real-time and forecasted information to help support disaster operations - evacuations

Other

- Accurate Risk Mapping
- Dynamic flood maps that can be updated easily and represent a variety of scenarios

- FEMA reviewers that understand the rules
- How floodplain management, mitigation, and other local development codes work together
- How to work with FEMA regarding errors in draft maps associated with new VE
- I am a researcher so none apply
- Information to explain federal regulations for floodplain mapping due process
- Subsidence
- Variation of all options depending on the community I am consulting with

What are useful elements of the current program that are important to continue as FEMA moves forward with shifting from binary to probabilistic risk?

Downloadable Data in GIS Format

- Flood data geo-located and related to parcel/address data
- 1) We need easier access to GIS data and models. There are times we get bounced between FEMA offices.
- Downloadable data in GIS format
- We have developed some of these GIS layers based on local dynamic need already

Access to Models and Input Data

- Access to models
- LiDAR or topographic data used to develop models
- Machine-readable, discoverable, well-documented model input/output data and metadata

All Elements

- All of the above, and more. The table above and the questions that follow suggest a generally poor understanding of hazard, risk and the purpose of the NFIP, as is typical for our industry where the only frame of reference is the NFIP.
- Please do not discontinue any existing data

Flood Elevations and Flood Depths

- Benchmarks with elevation data
- Flood elevations and flood depths (e.g., Base Flood Elevations, stillwater elevations, flood depths in sheet flow areas, etc.)

Coastal transects shown on a map or digital interface

- Coastal transects shown on a map or digital interface

Cross sections shown on a map or digital interface

- Cross sections shown on a map or digital interface

Levee and Dam Locations & Assoicated Hazard Information

- Dam inundation areas
- Levee and Dam Locations & Assoicated Hazard Information

Flood Hazard or Risk Zones shown on a Map or Digital Interface

- Flood Hazard or Risk Zones shown on a map or digital interface (e.g., current SFHA designations or newly-identified zones based on risk)

Flood Insurance Study Supporting Text

- Flood Insurance Study supporting text (e.g., purpose of study, community description, principal flood problems, etc.)

Flood Profiles

- Flood profiles showing different flood elevations graphically at multiple locations along a stream

Floodways or Other Mechanism to Identify Special Areas of Concern

- Floodways or other mechanism to identify special areas of concern or where special development requirements apply

Map Changes Processes (LOMAs, LOMRs, etc.)

- Map Changes Processes (LOMAs, LOMRs, etc.)

Minimum Floodplain Development Standars Tied to Flood Hazard Information

- Minimum floodplain development standards tied to flood hazard information

Primary Frontal Dunes

- Primary Frotnal Dunes

Tables with Specific Hazard Information

- Tables with specific hazard information at cross sections or other known location (e.g., Floodway Data Tables)

Tables with Specific Hydrologic Information

- Tables with specific hydrologic information at cross sections or other known location (e.g., Summary of Discharges, Frequency-Discharge Drainage Area Curves)

Other

- But usually our clients and/or the general public don't use or care much about details besides what the flood risk looks like and what elevation developers need to build above
- Property specific LOMC information
- "Carolina Bays"
- (I don't work with coastal flood hazards so I am not familiar with whether or not the coastal transects and primary frontal dunes information should be kept.)
- 1% annual-chance stillwater "surge" elevation, not just the 1% annual-chance flood (BFE)
- 2D Hydraulic analysis tools and models
- assumptions underlying the generated probabilities
- Better information about coastal hazards - the newest maps oversimplify them
- building stock information. road network hazards and risk
- Change from statistic based modeling to geomorphic based mapping to determine the full area of flood risk, then

use statistical models to determine levels of risk within the actual flood prone area. IE MAP THE GEOLOGIC FLOODPLAIN

- Clear delineation of what falls into the mandatory purchase requirement for lenders
- Consideration of all factors contributing risk/hazard.
- CSLF is incredibly important for quickly communicating areas of change, how can we provide something similar for a change in risk? For instance, if there's more than a 20% increase in risk for instance because of rainfall events, or SLR, to highlight for local officials
- descriptions of the data used to develop the information
- Engineering Reports and Data for FIS available online (TSDN). FIS is becoming marginal in value.
- FEMA's Map Service Center
- Highest risk areas that should be open space (due to flood frequency, depth, velocity, erosion potential, etc.)
- Historic premium and loss data on a parcel by parcel basis
- Hydrodynamic modeling of flood events. Moving away from steady state hydraulic model.
- I didn't check FIS, but maintaining a list of all of the revised and new studies incorporated into the mapping would be important.
- Inland wave action (if a whole basin is coastally flooded)
- LIMWA, MHHW
- Mapping that better represents the whole watershep without it being chopped up and creating discrepancies.
- maps/data for other flood frequencies
- National Flood Hazard Layer viewer or other mechanism to view flood hazard and risk data on a national scale
- need BFE (1%) noted on returned & approved LOMA's, LOMR's
- NFIP maps are insurance maps not planning maps. Develop a planning map. They are no the same!
- none of these products help with the due process delays due to federal regulationsto feder
- Predictive flood models--30-50 years into the future would be ideal so building and management decisions can be informed decisions
- Risk-based analysis of non-levee structures that act like levees (roads, railroads, etc.).
- Simple, understandable, justifiable and repeatable modeling in all areas where there is no need for unnecessary complexity other than to use it to allow development in high hazard areas
- Table would not download
- The current FIS report version has become a collection of tables, where detailed information about history, methods and assumptions has been eliminated. I suggest that live links to TSDNs and any referenced publication are made available in the FIS report text.
- Updated Limwa
- visuals (maps, cross sections, transects) without jargon, or with jargon explained
- watershed studies from upper streams to downstreams
- WSEL and Depth grids

What obstacles do you expect to encounter in the proposed shift to graduated risk?

Explaining & Obtaining Buy in from the Public, Elected Officials or Other

- The number of complaints I will field over why they are now in the floodplain even with a LOMA
- "Shades of Gray" makes it more difficult to get compliance from some people. They will keep revising their question until they get the answer they want.
- Black box determinations made by third party 'FEMA partners', loss of local CFM authority
- communication to the public of what the new data means
- continuing challenge of explaining basis of maps to general public
- Convincing the public this is the greatest weakness in the current program that needed to be addressed
- Explaining graduated risk to the public, elected officials or others
- Many localities and public have a hard time understanding existing system, which I feel is very straightforward. I wonder if the new system may really confuse a lot of people at the local level, ,particularly in smaller communities with limited resources and staff not educated/trained to really understand the complexities of all the new information.
- obtaining buy-in due to the new/additonal costs to property owners
- Political pressure/pushback against forward looking data
- Political will to identify risk in the community.
- Public and Governmental resistance to change and anything that may cost money or raise insurance rates.
- Pushback from developers (building requirements) and property owners (property values, insurance rates, and building requirements) which often involves elected officials.

Integrating this Change into Existing Permit, Regulatory, Grant or Other Process

- any adjustment to current rules & statutes would be a step backwards, elimination of higher standards now in place
- Changing Law
- Clear cut regulation and enforcement boundaries
- Difficulty in ensuring alternate investigations, appeals, LOMCs, etc. meet standards and follow engineering guidelines and best practices and are within error/uncertainty tolerances
- How do you do this with FIRM maps from 1980?
- Integrating this change with FEMA Mitigation Grants requirements (Special Flood Hazard Area determination, Benefit Cost Analysis, etc.)
- Integrating this change with flood insurance purchase requirements
- Integrating this change with land use planning (including climate change or future planning)
- Integrating this change with stormwater management programs
- Integrating this change with the permit process including building standards/Building Codes and state-level requirements
- Integrating with current mandatory purchase requirements for lenders. How it will impact zone determination companies.
- Some form of minimum standard must be provided. The problem is justifying any change in standard.

Confusion about Data or Product Options and How to Use Them

- Confusion about what new data or product options will be available and how to use them

Cost & Staff Resources Needed to Implement

- Costs to the program to develop, manage, and maintain the additional data
- Ensuring local Floodplain Managers understand and know how to apply new data and craft new floodplain management ordinances in response.
- Getting local FP administrators to support new technology
- Staff resources needed to implement graduated risk information
- Understanding what new burdens or requirements this might place on my community

Managing my Existing Job Duties within the Context of this New Data

- Managing my existing job duties within the context of this new data

Using this Data for Disaster Response & Management

- Using this data for disaster response and management

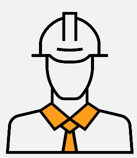
Other

- The impact that it will have to increase insurance cost
- A lack of consensus on SLR projections when selecting the preferred trend line leads to confusion between Planners and Floodplain Administrators.
- Accuracy or lack thereof.
- applicability to levee systems
- At some point, decision makers are going to need to harden the flood risk areas. Thus, is it "in" or "out" is still needed to make a decision.
- Complicating flood studies will only drive costs up with little benefit to property owners and local public agencies.
- engineering study submittal requirements for letters of map change (or equivalent)
- Everything will take time and require resources that are very limited, but a change is needed, binary applies black and white, when there are clearly many shades of grey
- Extended model review times
- federal auto adoption of floodplain maps is critical for the success of this program
- FEMA has difficulty managing the current system. Attempting to manage a more complicated system could have bad results.
- I expect this process to be manipulated ny unethical engineers and developers to justify and allow development in high hazard areas
- If this is real I don't think of it as a problem. The maps are bad, the underlying data is static from late 70s/early 80s. Floodplain management should be better.
- jargon and lack of clarity on what lines or polygons mean AND if they reflect future conditions based on climate change impacts.
- Keeping the graduated use models and maps up-to-date
- Lack of data. Our area is largely still using data and mapping from the 1980's. Without updated data or funding to help our local governments develop updated data, we will have difficulty integrating a new program
- Lack of regulation requiring using more than minimal mitigation.

- Litigation issues due to non binary solution.
- Many of these are opportunities--not obstacles, esp. land use planning and disaster response
- Potential to require all homeowners with a mortgage to obtain Flood Insurance
- Shifting current "in or out" ordinances to graduated applying to entire local jurisdiction
- the increased number of properties that will be put into the floodplain
- Understanding what new burdens or requirements this might place on my community
- Unsure
- We haven't been able to map the 1% annual chance floodplain for the nation with 15 years of good funding, how can the federal gov't map something significantly more complicated? Perhaps private enterprises should lead the development of different types of data, e.g., First Street Foundation.
- Without a thorough re-examination of both mandatory purchase requirements AND NFIP development standards, the new proposed maps will make it more difficult to get compliance with standards. It's great data but you cannot change one leg of the stool without changing them all.

Results

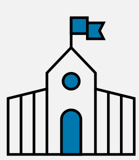
Most survey participants reported professional engineer as their primary job function, followed by floodplain administrator. The five most common reported job functions are listed below.



Engineer
28% of participants

Floodplain Administrators
19% of participants

Land-Use Planning Zoning Official
8% of participants



Other State Agency
7% of participants

NFIP Program Consultant
6% of participants

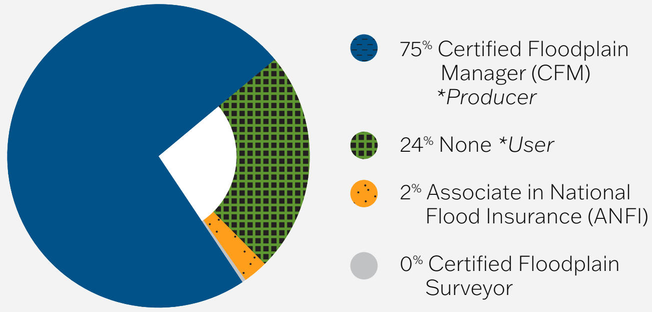


Figure D-1 / Respondent NFIP-related Certifications

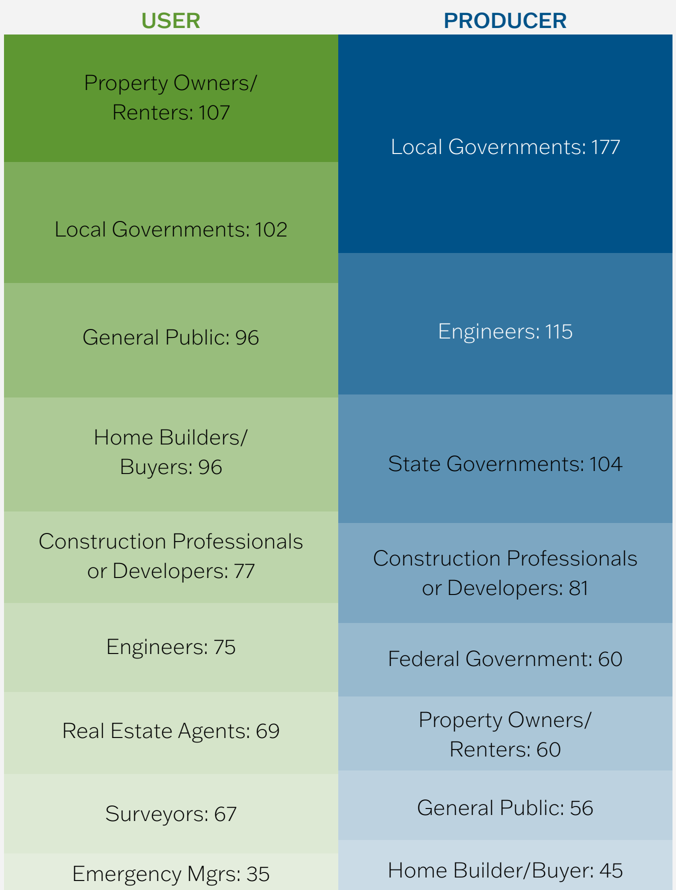


Figure D-2 / Primary Audiences Served by Floodplain Administrators and Professional Engineers

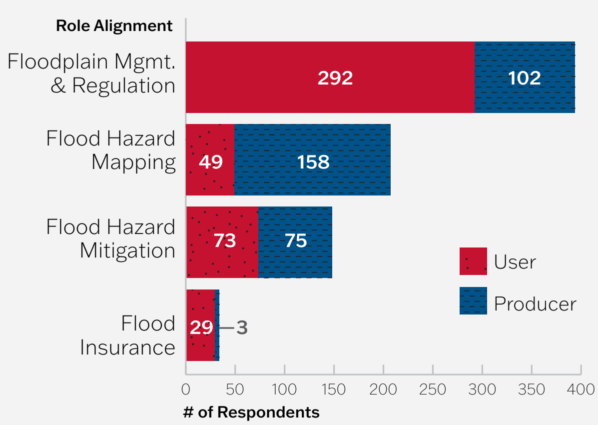


Figure D-3 / Respondent Identification with Components of the NFIP

Seventy-five percent of respondents reported having the CFM certification; see Figure D-1. Three respondents reported holding the Associate in National Flood Insurance certification. There were no responses from Certified Floodplain Surveyors—a credential currently available in North Carolina and Tennessee.

For further analytical purposes the responders were categorized as “Users” or “Producers” based on their primary job function. Producers consist of professional engineers as well as federal agency officials, GIS / geospatial specialists, and NFIP contractors. They represent 43 percent of respondents. Users are those in all the other job functions, but mostly floodplain administrators and SLTT officials. Users represented the majority (57 percent) of respondents. The remaining discussion of survey results will revolve around this “Users” and “Producers” distinction.

Both Users and Producers serve primarily local governments. Producers also serve state governments, engineers, and the federal government to a lesser extent. In addition to local government, Users serve property owners, the general public, and home builders/buyers. Figure D-2 shows additional detail on the primary audience served by floodplain administrators and professional engineers, the top job function represented in the Users and Producers categories.

As depicted in Figure D-3, Users are heavily identified with the floodplain management and regulatory component of the NFIP, while the Producers are matched with the mapping component. Those identified with mitigation are split evenly between Users and Producers, and the flood insurance representatives are almost entirely Users.

Figure D- 4 lists the top floodplain management / flood risk management objectives reported by survey respondents. For both Users and Producers, their top two objectives were in alignment: supplying information and guidance, and planning/actions to reduce risk. Beyond those two objectives, Users were more concerned with regulatory compliance and implementing higher standards; Producers with developing data and tools.

Producers requested enhanced modeling information as the top resource needed, with flood event impacts a close second. Users overwhelmingly requested information to support flood risk or insurance communications. See Figure D-5 for further breakdown of responses.

When asked to rank the usefulness of the binary "in/out" aspect of the current NFIP program, surveyors and building officials reported this as most useful for their work, while lenders and state officials (other than NFIP Coordinators and SHMOs) found it the least useful. When asked similarly about the expected usefulness of graduated risk information, insurance agents, lenders, state Hazard Mitigation Officers and federal agency official NFIP were most optimistic, and GIS/geospatial specialists, NGO/non-profit staff, and surveyors were least optimistic. Overall, the expected usefulness of graduated risk data ranked 26 percent higher than binary risk. See Figure D-6 for a detailed breakdown of responses around the usefulness of binary data and the promise of graduated data in the future.

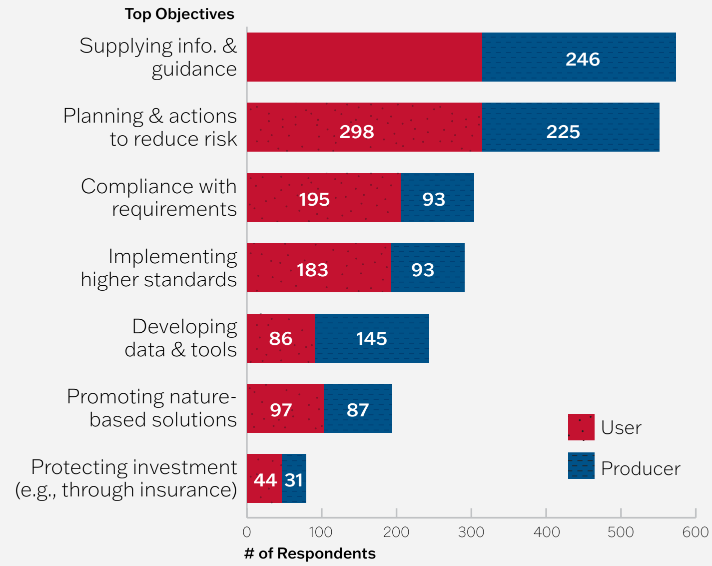


Figure D-4 / Top floodplain/flood risk management objectives by Users and Producers

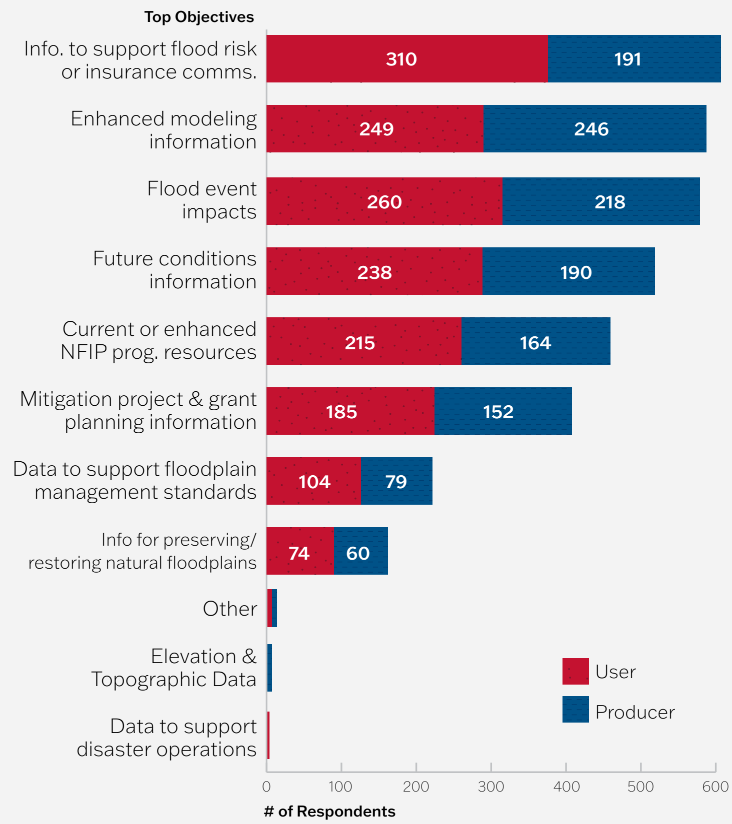


Figure D-5 / Most Requested Tools & Resources Needed to Promote Better Understanding of Flood Hazards and Risks

Promise of Graduate to Meet Needs

Primary Job Function	
Insurance Agent/Insurance Professional	**9.039**
Lender	**8.795**
State Hazard Mitigation Officer	**8.785**
Federal Agency Official	**8.630**
National Flood Insurance Program Consultant	**8.286**
Other State Agency Official	**8.182**
Real Estate Agent	**7.880**
Professional Engineer	**7.698**
Floodplain Administrator	**7.668**
State National Flood Insurance Coordinator	**7.561**
Other	**7.306**
Land Use Planning or Zoning Official	**7.245**
Local Emergency Management Professional	**7.183**
Local, State or Tribal Elected Official	**6.627**
Building Official	**6.430**
Researcher or Academic	**6.318**
GIS or Geospatial Specialist	**5.775**
NGO of Non-Profit Staff	**5.614**
Surveyor	**5.588**

Use of Binary (in/out) to Meet Needs

Primary Job Function	
Surveyor	**6.787**
Building Official	**6.422**
Insurance Agent/Insurance Professional	**6.261**
GIS or Geospatial Specialist	**6.230**
NGO or Non-Profit Staff	**6.122**
Real Estate Agent	**5.920**
Federal Agency Official	**5.786**
Land Use Planning or Zoning Official	**5.353**
Local Emergency Management Professional	**5.336**
State National Flood Insurane Coordinator	**5.237**
Professional Engineer	**4.999**
State Hazard Mitigation Officer	**4.993**
Local, State or Tribal Elected Official	**4.979**
Floodplain Administrator	**4.942**
Researcher or Academic	**4.552**
National Flood Insurance Program Consultant	**4.372**
Other	**4.301**
Other State Agency Official	**3.946**
Lender	**2.169**

Figure D-6 / Average Rankings (1-10 scale) by Primary Job Function on the promise of graduated data versus the use of binary data to meet needs

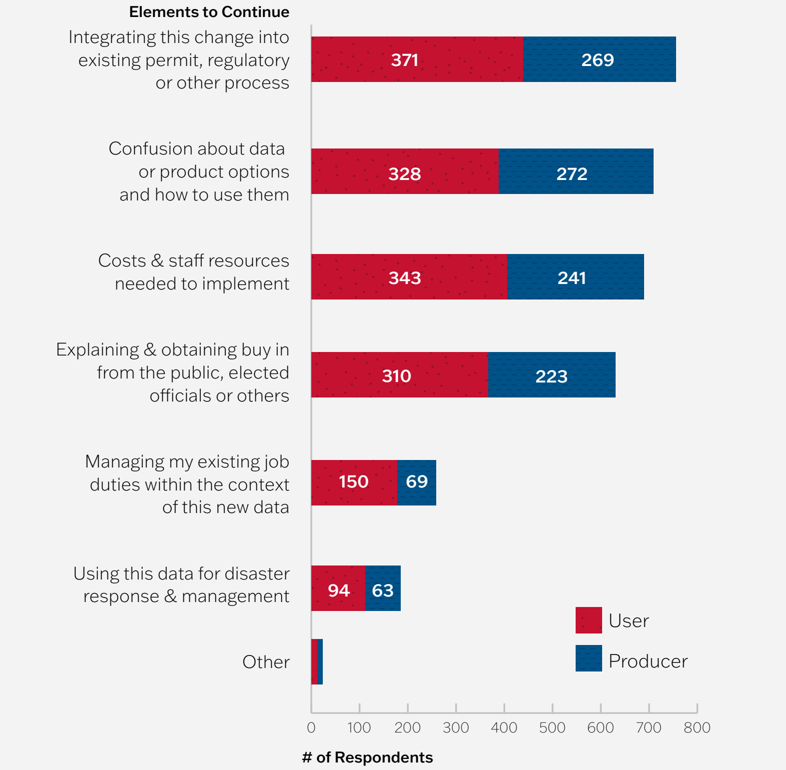


Figure D-7 / Expected obstacles in the shift from binary to graduated

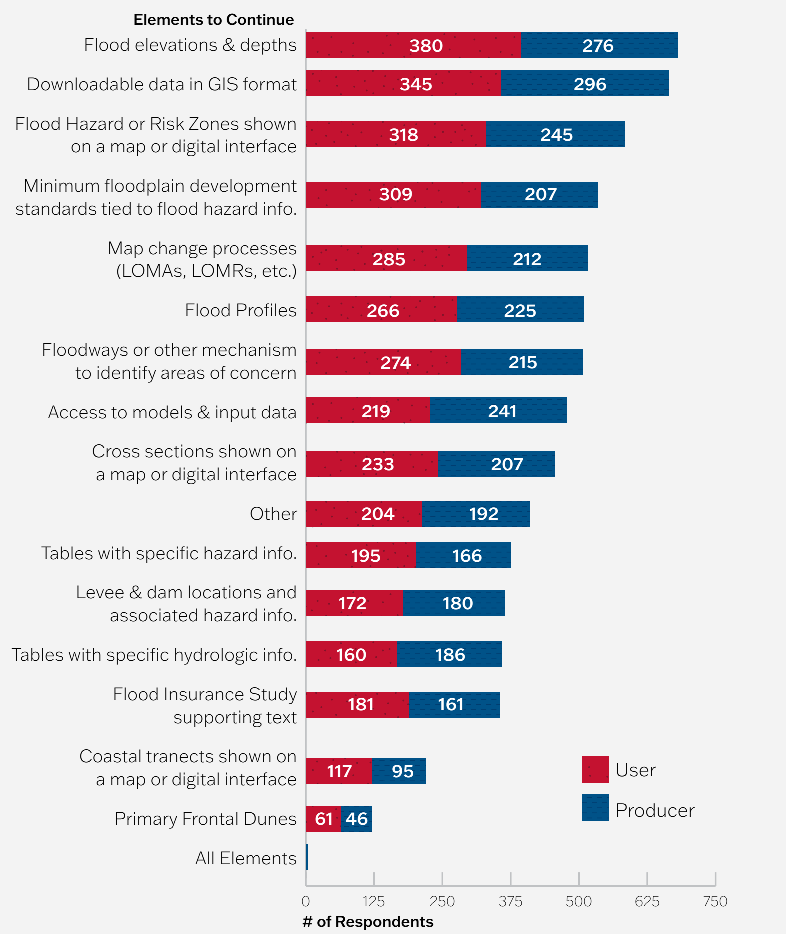


Figure D-8 /Useful Elements of the current Risk MAP Program

When asked what obstacles might be expected in the proposed shift to graduated risk, both Users and Producers agreed that the top obstacles they expected to see were integrating this into existing processes (including staff and financial resources needed to do so) and confusion about the new data and product options. Figure D-7 provides a breakdown of responses to this question.

From the current NFIP Risk MAP program, Users and Producers were in agreement on the top three elements to carry forward with the shift from binary to probabilistic risk: flood elevations and depths; downloadable data in GIS format; and flood hazard / risk zones shown on a map or digital interface. Coastal transects and primary frontal dunes were the least requested for carrying forward. Full breakdown of this survey question are provided in Figure D-8.

Free Text Responses

Survey Question 11 was, "Is there any additional information you would like to comment on regarding the shift from binary to graduated flood hazard information?" This was an optional question that allowed for free text answers of any length. The 244 free text submissions received in response to this question were analyzed for both sentiment (positive or negative sentiment related to the shift from binary to graduated) and content (see Figure D-9).

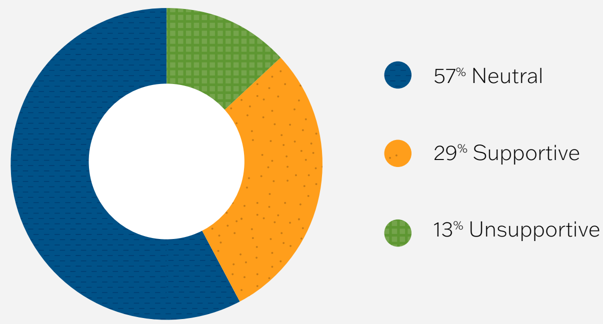


Figure D-9 / Sentiment of comments in response to Question 11: "Is there any additional information you would like to comment on regarding the shift from binary to graduated flood hazard information?"

Only 13 percent of the comments were clearly unsupportive of the shift from binary to graduated risk. An illustrative example of this kind of response was: "*I fear the movement towards PhD level data will make compliance more difficult … not less.*"

Overall, 87 percent of the comments were deemed to be either neutral or supportive of the planned shift. Of the supportive comments, 33 contained either general statements of support or listed specific benefits of probabilistic data. An example is: "*I strongly support this shift. The binary approach has actually been counterproductive to managing flood risk in America. A graduated flood hazard and insurance rate approach will incentivize the public and local governments to make better decisions related to managing their flood risk.*"

The content of the responses were also analyzed for trends, which can generally be divided into (1) recommendations, and (2) concerns. While the major recommendations and concerns are listed below, the raw data—including all of the free text received and the categorization of each comment—is available for download from the TMAC.

Specific recommendations included:

- 38 technical/modeling recommendations, generally around the topic of including certain data elements (e.g., Sea Level Rise) into future models
- 25 specific floodplain management or mitigation applications of the data, or recommendations on connecting the data to floodplain management or mitigation programs were provided (such as the need for new model ordinances that incorporate the concept of graduated risk or align to new products that will show graduated risk information).
- 21 communications/outreach recommendations were received, of which the majority supported the need for more outreach and communication from FEMA on program changes moving forward. This includes 4 responses indicating that this was their first time hearing about the proposed shift.
- 14 specific recommendations on future guidance needs were received, such as guidance on how LOMCs be impacted by the shift to graduated data, and other recommendations for future guidance needs prompted by the shift.

Specific concerns included:

- A concern about the understandability of future graduated products and data, including how they are developed, was noted in 22 of the responses. Some of these included "black box" statements such as, "*I think this is a great idea (even if it will take much time and thought to get it right). I also feel it's very important to be transparent about how the graduated risk is calculated, to both the public and the CTPs working to make these products. The calculations can not be kept in a 'black box'.*"
- 17 responses indicated the concern that local Floodplain Administrators and local officials will bear the brunt of implementation of any new program elements, including graduated risk data. These including 5 comments regarding underserved populations and small/rural communities n that may not have the resources to communicate and implement such a change. An illustrative comment supporting this concern is: "*Will FEMA be participating in an outreach campaign to educate the public on the changes and why individuals who were "out" are now "in"? Local Floodplain Managers will bear the brunt of any backlash and will need support. Education and outreach will be imperative for both the general public and local communities trying to navigate the changes.*"
- 16 of the responses indicated a concern about the program's resource constraints, including questions about how the program will finish Map Modernization, continue to execute Risk MAP, implement the new graduated risk program, and maintain all of them simultaneously. This concern may be best illustrated by the following quote from the responses: "*Currently, funding is insufficient to keep flood hazard data up to date. Adding more data layers without adequate funding will generate more out of date information.*"
- 10 responses indicated a concern about the program elements (grants/mitigation, flood insurance, mapping, floodplain management) becoming more disparate and unconnected to each other as

the shift occurs. Comments seemed to indicate the feeling that RR 2.0 is headed in one direction, the mapping program is moving towards graduated risk products and data (seemingly unrelated to RR 2.0), and the future of FPM and mitigation/grants related to this shift is not clear. No single comment illustrates this contention well since respondents tend to come from one element of the NFIP and view the change through one lens, so several examples are included here:

- *"I was hoping the insurance side would move more toward the regulatory side, but it appears the insurance side has gone into left field and is dragging regulatory with it."*
- *"This needs to be coordinated throughout the NFIP program - RR2.0 should not be changed without the proposed change in methodology mentioned in this survey - one without the other will make implementation of either very difficult."*
- *"The biggest challenge is going to be connecting this new information to FEMA Hazard Mitigation Assistance grants. There needs to be a connection back to a BCA waiver, e.g. different pre-calculated benefit caps in different zones."*
- *"The SFHA and floodway are currently written into the development code for communities in my state. If these boundaries are not available, local codes will need to be updated to maintain restrictions on floodplain development."*

- Other trends included a concern about complexity and quality of graduated data produced using probabilistic models (9 comments received), and a concern about duplication of efforts in areas where communities or states are already developing or using graduated data or other more comprehensive and complex datasets than the currently available NFIP data (7 comments received).

Stakeholder Webinars

On August 14, 2020, and again on September 24, 2020, webinars were hosted by TMAC Subcommittee 1 using the approximately 400 email addresses provided in the survey for those that answered "Yes" or "Maybe" to Question 12 on the final survey. These webinars were considered official Subcommittee 1 meetings that were open to the public. Webinar content began with an introduction to the purpose of TMAC and to the 2020 tasking memo. This was followed by a discussion of deterministic versus probabilistic methods and how FEMA is proposing to move toward a graduated understanding of flood risk. The sessions concluded with a series of participant polls to extract greater detail on issues identified in the survey, such as the expected obstacles that may result from the shift.

The polling questions used in both webinars are provided below:

1 Role Alignment (information obtained in registration process)

a. Flood Hazard Mapping
b. Flood Hazard Mitigation
c. Flood Insurance
d. Floodplain Management

2. What is your primary job function? (select one)
    a. Lender
    b. Flood Zone Determination Company Professional
    c. Insurance Agent/Insurance Professional
    d. Floodplain Administrator
    e. Building Official
    f. Surveyor
    g. Professional Engineer
    h. Architect
    i. Real Estate Agent
    j. Developer
    k. Local, State or Tribal Elected Official
    l. Federal Agency Official
    m. State National Flood Insurance Coordinator
    n. State Hazard Mitigation Officer
    o. Other State Agency Official
    p. Local Emergency Management Professional
    q. GIS or Geospatial Specialist
    r. National Flood Insurance Program Contractor or Consultant
    s. Land Use Planning or Zoning Official
    t. NGO or Non-Profit Staff
    u. Researcher or member of Academic Institution

3. Do you know of a successful project or program that promotes the understanding of risk in a graduated way that you are willing to share via follow up from a TMAC member? (Yes, No)

4. What do you believe the NFIP should provide in order to help you communicate flood risk to a wide range of audiences? (Select one)
    a. Base flood hazard and risk data
    b. Interactive tools to help me display the data in different ways depending on the audience
    c. Multiple, static products that display flood hazard and risk in different ways that are designed for specific audiences

5. How are you interacting with *elected officials* in general? (select the best answer for how you most often interact with this audience in your primary job function)
    a. Small interactions or meetings (in person or virtual)
    b. Large interactions or meetings (in person or virtual)
    c. Through a website, where I *push* information out
    d. Through a website, where the audience *pulls* specific reports or information
    e. Through mailings or other media
    f. I do not interact with this audience in my primary job function

6. What is the purpose of your interactions with *elected officials*? (Select all that apply))

    a. To discuss or share information about the community's flood risk in general
    b. To discuss or share information about flood risk to publicly-owned buildings
    c. To discuss or share information about at-risk portions of the community in preparation for a specific rain or storm event
    d. To discuss or share information about the economic benefits and costs of reducing flood risk through mitigation
    e. To promote the need for higher standards
    f. To discuss or share flood recovery information or status after a flood event
    g. I do not interact with this audience in my primary job function

7. How are you interacting with *homeowners* in general? (select the best answer for how you most often interact with this audience in your primary job function)

    a. Small interactions or meetings (in person or virtual)
    b. Large interactions or meetings (in person or virtual)
    c. Through a website, where I *push* information out
    d. Through a website, where the audience *pulls* specific reports or information
    e. Through mailings or other media
    f. I do not interact with this audience in my primary job function

8. What is the purpose of your interactions with *homeowners*? (Select all that apply)

    a. To discuss or share information about the community's flood risk in general
    b. To discuss or share information about flood risk to a specific property
    c. To discuss or share information in preparation for a specific rain or storm event
    d. To discuss or share information about the economic benefits and costs of reducing flood risk through mitigation
    e. To discuss or share information about insurance requirements, costs, or issues
    f. To discuss or share flood recovery information after a flood event
    g. I do not interact with this audience in my primary job function

9. How are you interacting with *developers* in general? (select the best answer for how you most often interact with this audience in your primary job function)

    a. Small interactions or meetings (in person or virtual)
    b. Large interactions or meetings (in person or virtual)
    c. Through a website, where I *push* information out
    d. Through a website, where the audience *pulls* specific reports or information
    e. Through mailings or other media
    f. I do not interact with this audience in my primary job function

10. What is the purpose of your interactions with *developers*? (Select all that apply)
    a. To discuss or share information about the community's flood risk in general
    b. To discuss or share specific parameters related to development on a specific property/project
    c. To discuss or share information in preparation for a specific rain or storm event
    d. To discuss or share information about the economic benefits and costs of reducing flood risk through mitigation
    e. To discuss or share flood recovery information or requirements after a flood even

11. In a flood hazard mapping sense, what should FEMA allow State, local, Tribal, and territorial governments, private, academia, etc. stakeholders to do more of? Or to do more of independently? (free text, no character limit, no time limit)

12. How can FEMA create a more consistent flood risk message in the context of flood insurance, floodplain management, flood hazard mapping and flood mitigation? (free text, no character limit, no time limit)

13. How should FEMA utilize flood hazard mapping to enhance floodplain management and flood hazard mitigation? (free text, no character limit, no time limit)

14. Is there some topic that you think TMAC should address next year? (free text, no character limit, no time limit)

Webinar Tabular Results and Data Cleaning

There were 145 unique non-TMAC attendees to the webinars. However, there were 23 attendees that participated in polls in both webinars. These data were cleaned to (1) combine answers when some were left blank from one of the webinars (for example, if the individual answered Poll 10 in Webinar 1, but left it blank in Webinar 2, we used information from both webinars in order to get the one most comprehensive answer set from that individual). If the individual answered a poll in both webinars, the answers were checked to assure that they were the same response; if the response was different, we used the response from the first webinar (the individual may have been biased by the time of the second webinar, knowing what the questions would be, and we determined that the first set of answers would be a better comparison to 122 one-time attendees than the second answer set). .

A recording of the first webinar is located at https://youtu.be/TNrxTvL1ygk. This video was edited to remove live meeting logistics (for example, instructions on how to respond to polls) and the long silences during live polls. All content was re-used in Webinar 2.

The raw data from the webinar polls are available for download here. This information is summarized below. Note that the same method of dividing the respondents into "User" and "Producer" roles was used for this analysis.

The webinars were attended by mostly Floodplain Administrators, followed by Professional Engineers, an equal number of NFIP contractors and GIS specialists, and Other State Agency Officials ("other" meaning: not NFIP Coordinators of SHMOs). See Figure D-10 for a breakdown of webinar participants by primary job title.

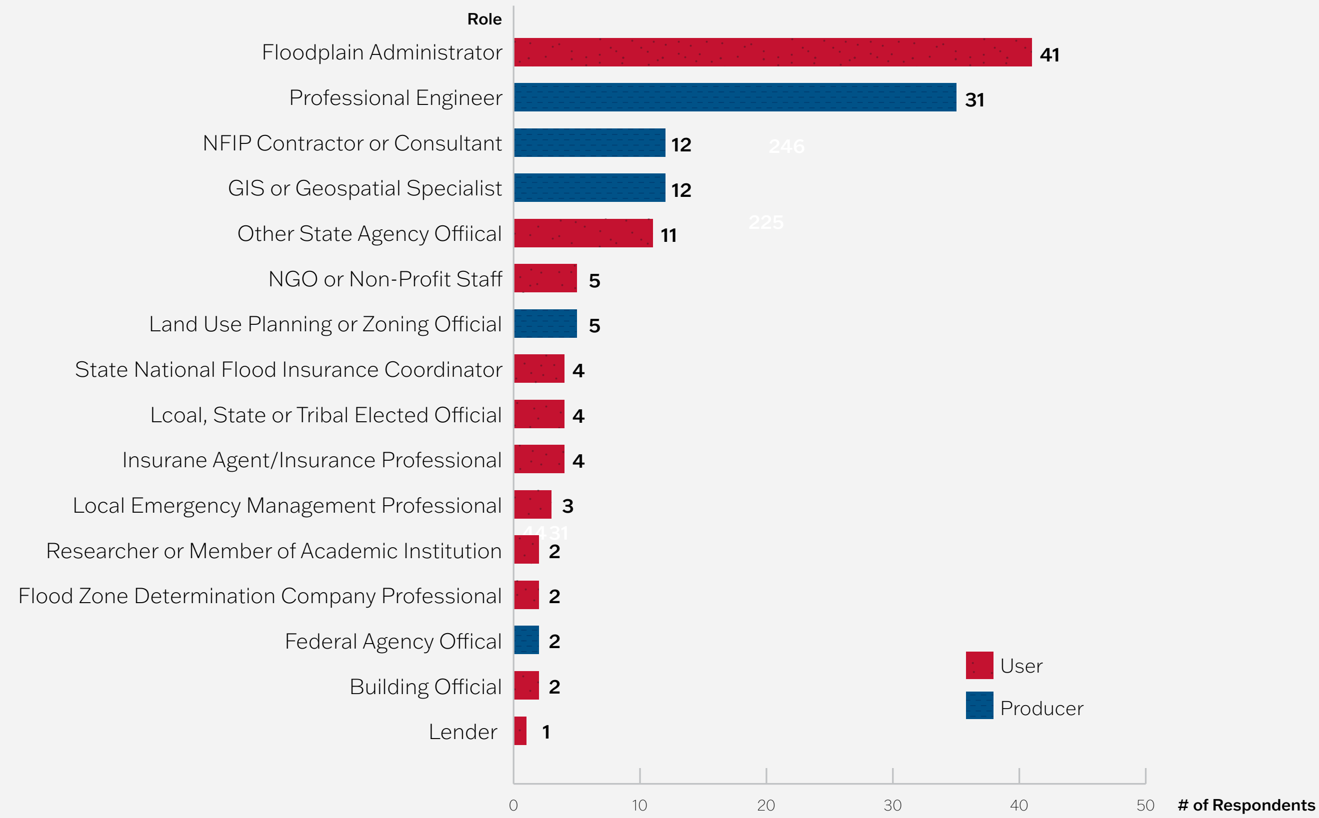


Figure D-10 / Number of Webinar Participants by Primary Job Title

Unsurprisingly, most attendees aligned themselves with the "Floodplain Management" role, followed by Flood Hazard Mapping, Flood Hazard Mitigation, and Flood Insurance. See Figure D-11 for a breakdown of participants by NFIP role alignment.

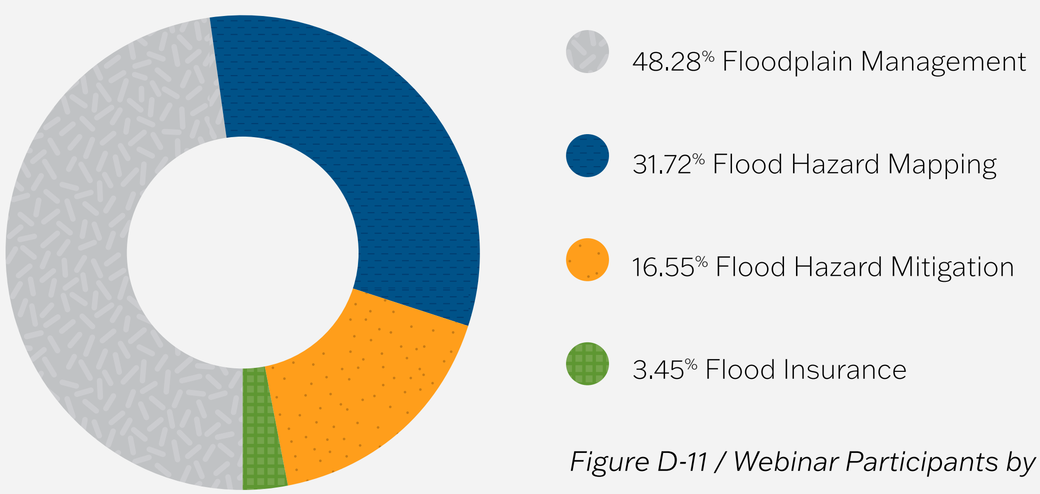


Figure D-11 / Webinar Participants by NFIP role alignment

In response to Question 3, eighteen respondents reported that they knew of a successful project or program that promotes the understanding of risk in a graduated way that they would be willing to share via follow up from a TMAC member. Those names and email addresses were shared with TMAC Subcommittee 1 members who were writing a section of this report that included the relevant information.

When asked what kinds of tools respondents need from the program, they overwhelmingly prefer a middle ground. Multiple canned or templated products developed by FEMA for use with multiple audiences scored almost as low as basic data with no formatting at all (see Figure D-12).

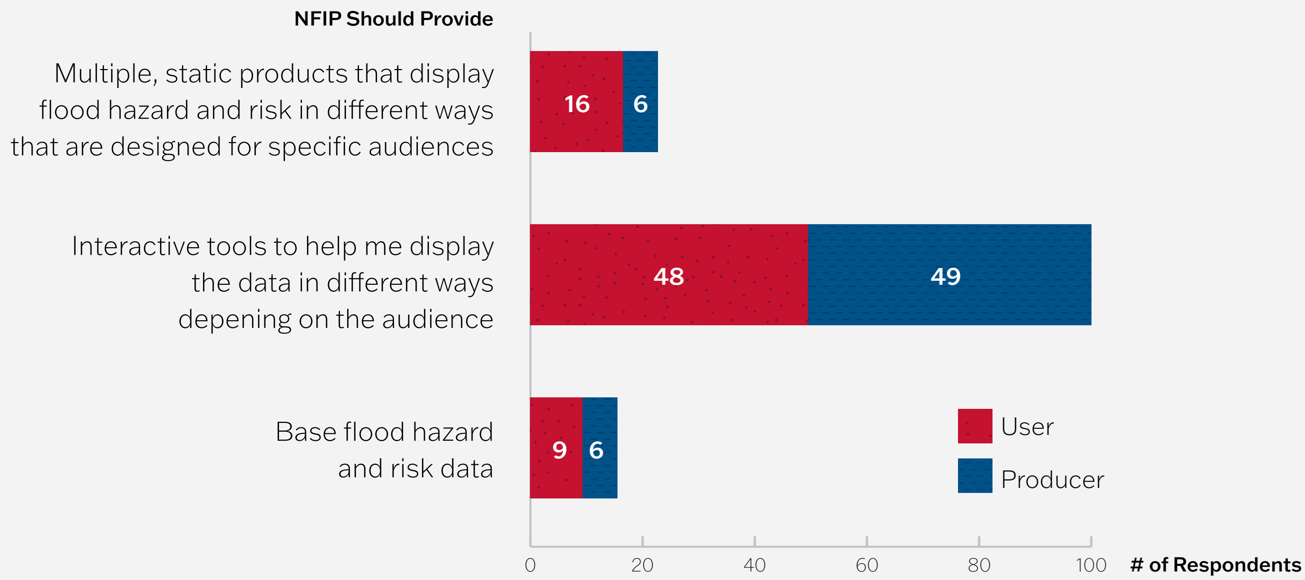


Figure D-12 / Responses to the question: "What do you believe the NFIP should provide in order to help you communicate flood risk to a wide range of audiences?"

The multiple choice webinar polls were heavily focused on how and why participants engage with other secondary stakeholders using NFIP data, tools, and products. This was prompted by an analysis of the pilot survey data, which showed that more than half of the stakeholders polled serve 4 or more secondary stakeholders, and that the majority of those stakeholders could be considered "non-technical" stakeholders. In addition, the top tool or resource noted as being needed from the program was information to help explain risk to non-technical stakeholders (see Figure D-5), then—to gain further insights—TMAC was interested in asking participants about how they engage with these audiences and the purpose of those engagements.

Figure D-13, Figure D-14, and Figure D-15 illustrate the responses to Webinar Questions 5-10, showing that stakeholders overwhelmingly engage with non-technical stakeholders in small interactions or meetings (virtual or in-person) as opposed to large interactions/meetings, media/mailings, or through websites that either push information to audiences, or where audiences pull the information they need. In addition, the top objectives of the engagement with each of the non-technical audiences identified are shown in Table D-2.

Table D-2 / Top Objectives of engagement by audience type.

AUDIENCE	TOP LEVELS OF OBJECTIVES
Elected Officials	Community-Level Flood Risk
	Promotion of Higher Standards
Homeowners	Property-Level Flood Risk
	Community-Level Flood Risk
Developers	Property-Level Development Parameters
	Community-Level Flood Risk

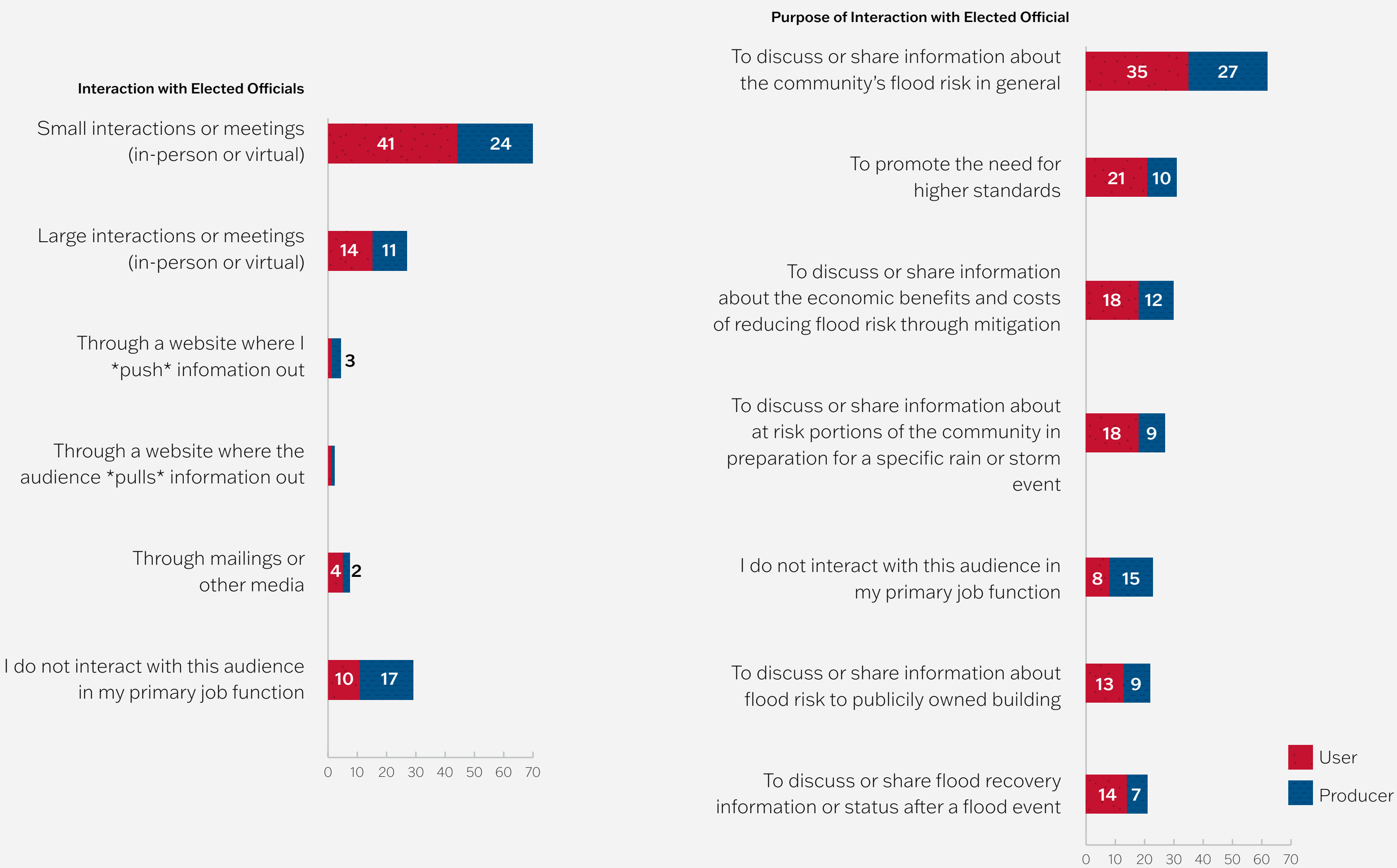


Figure D-13 / Interaction type and purpose of interactions with elected officials, by Users and Producers

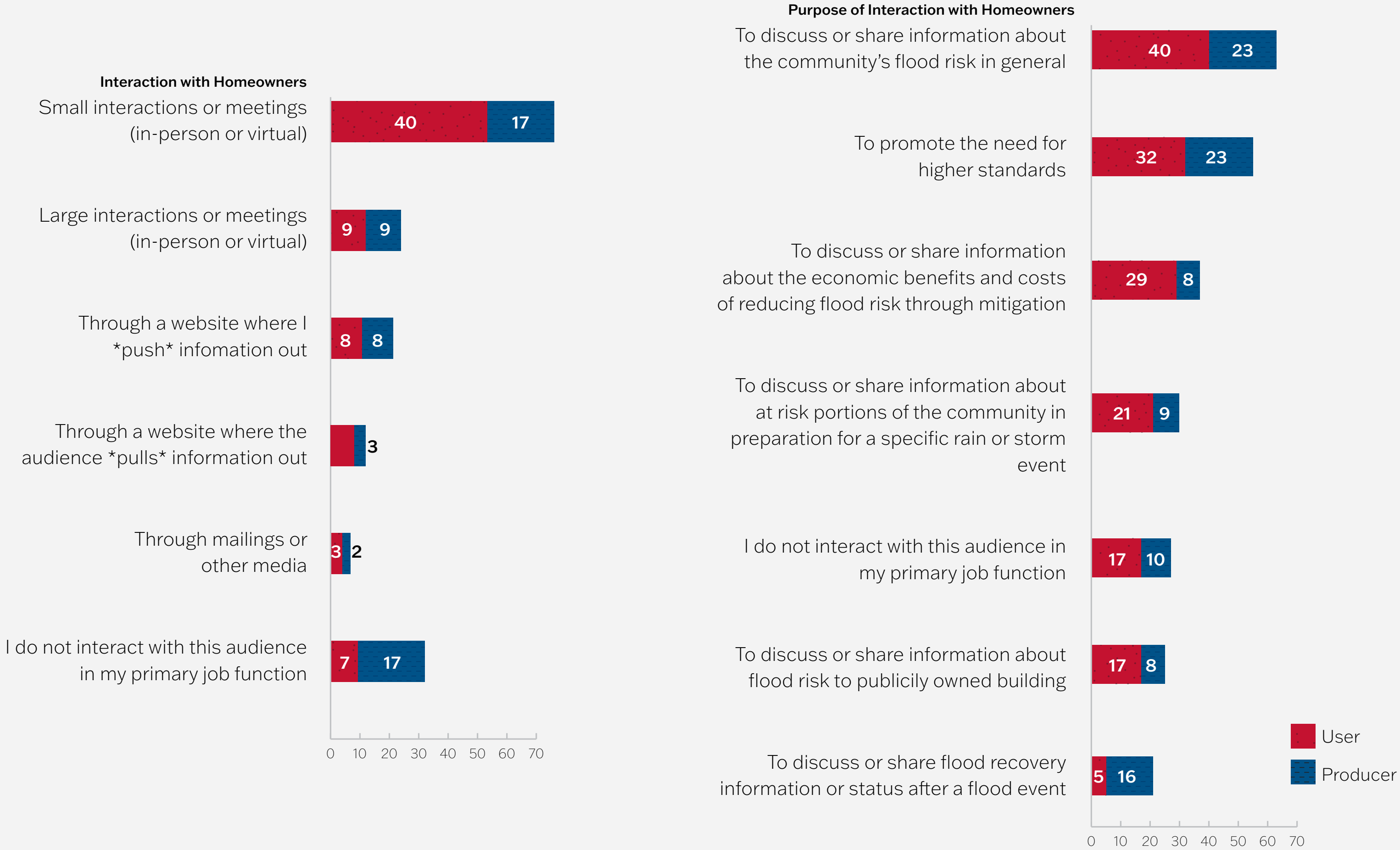


Figure D-14 / Interaction type and purpose of interactions with homeowners, by Users and Producers

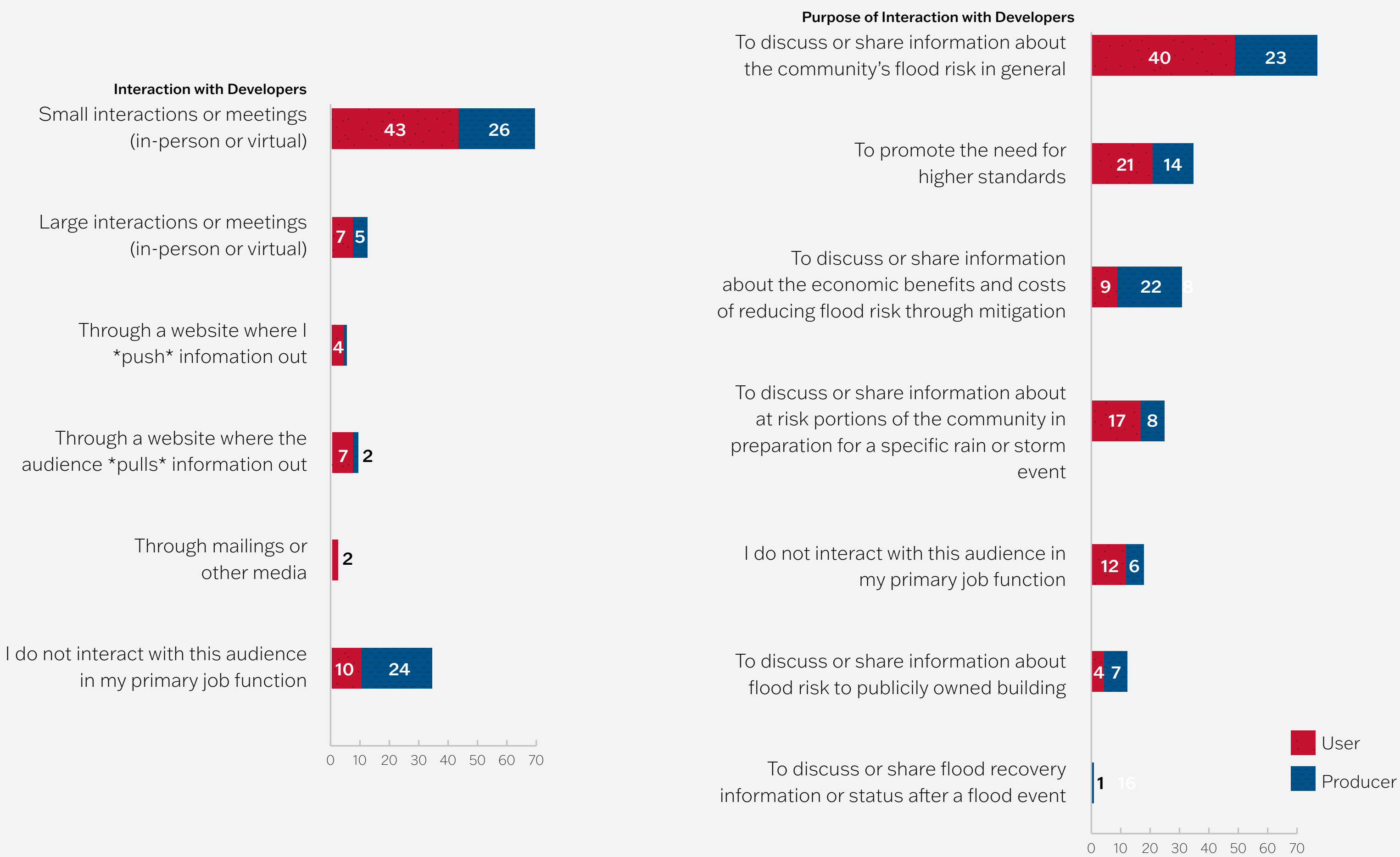


Figure D-15 / Interaction type and purpose of interactions with developers, by Users and Producers

Free Text Results

The webinars concluded with four open-ended, free text questions, for which participants were given unlimited time to answer and an unlimited character count.

Answers to the question, "*In a flood hazard mapping sense, what should FEMA allow State, local, Tribal, and territorial governments, private, academia, etc. stakeholders to do more of? Or to do more of independently?*" ranged broadly from the idea that no changes are needed because a federal mandate is required to support local enforcement all the way to the idea that FEMA should allow communities to establish their own maps, data, and standards. In general, respondents ask that FEMA listen to the local communities, streamline the update and revision process, and provide flexibility to incorporate localized data and risk conditions. Specific trends in responses to this question are summarized below:

- 24 responses requested better use of community input into the flood hazard mapping process
    - Includes data-gathering by community/technical inputs and more control of scoping decisions
    - Includes "trust" statements: "*Listen to us!*"
- 19 responses supported allowing flexibility in local data or layers on top of national-level base data; these comments included:
    - Flexibility to incorporate local standards, preferences, and anomalies into products (like new/local zones)
    - Flexibility to be able to build scenarios (SLR scenarios, mitigation scenarios, etc.)
    - Flexibility on data maintenance: "*FEMA should encourage local governments to track urban flooding issues, providing guidance and technical assistance perhaps fund through BRIC. FEMA should not try to micro manage identification and mapping of flooding due to stormsewer capacity.*"
- 13 responses supported the idea of allowing communities to map independently, including:
    - Digitization of paper-mapped areas, mapping of currently unmapped areas, and production of non-regulatory products
    - Statements about resources (from Feds or State) to do so: "*Local gov'ts might not be able to afford to pay for upgrades, but it could be something the state could plan to take on and keep control of.*"
- 13 comments were on the topic of streamlined LOMC processes and/or allowing direct community mapping updates
- 10 responses said that no changes were necessary; many of these seemed to come from CTP partners, noting that the program works, should be expanded, and CTPs seem content with

their level of autonomy

    - *"I think that partners have the opportunity to do what they need to do. I wouldn't provide more responsibility or independence."*

- 5 responses indicated that less independence is appropriate, citing that:
    - Communities rely on Feds for the "stick"
    - Communities would ignore flood risk if given the opportunity
    - Too much independence equates to inconsistencies

Answers to the question, *"How can FEMA create a more consistent flood risk message in the context of flood insurance, floodplain management, flood hazard mapping and flood mitigation?"* included:

- 49 messaging recommendations, made up of:
    - 33 messaging content ideas, including notably several related to "*pulling back the curtain*" on the mapping process, and geographic differences in messaging
    - 6 statements about consistency in messaging
    - 4 recommendations about tailoring messaging
    - 3 recommendations about messaging channels, including TV and web
    - 3 recommendations about simplifying communication
- 17 product recommendations, including expedited modeling, more funding for FEMA programs, and 11 related to updated maps
- 9 national policy/process recommendations were provided, including costs and consequences for non-compliance, consistent actions regarding flood insurance, and cohesion between insurance requirements and flood regulation
- 6 recommendations on broadening stakeholder participation, including landscape architects, other federal agency representatives, citizen scientists, and real estate agents
- 6 recommendations regarding providing interactive tools, including moving away from static products, developing interactive products for historic records, and including costs and risks associated with the different flood zones

Answers to the question, *"How should FEMA utilize flood hazard mapping to enhance floodplain management and flood hazard mitigation?"* included the following themes:

- 24 responses on connecting the 4 legs of the NFIP "stool" Mapping, Mitigation, Floodplain Management, Insurance) with probabilistic data
    - Including global connection statements (6), specific connections to floodplain management standards (3), insurance connections (1), and most notably, connecting the mapping data to mitigation (13)
        - *"Show the effects of various flood mitigation strategies"*
        - *"Help inform local governments/stakeholders about where mitigation can be useful"*
- 20 responses about providing online, interactive tools to help portray/visualize risk to multiple audiences
    - Includes improving the MSC, tools that allow for scenario-building, depicting risk from many sources
    - *"Emergency managers would benefit from having layers that show critical facilities, define areas of repetitive flooding based on rep loss data but not specifically calling out reop loss structures, and marking overtopped roadways or restrictive structures based on the FIS profile data and mapping Discovery data. Basically creating an equivalent to the National Flood Hazard Layer viewer called something like the National Flood Hazard Mitigation viewer."*
- 12 specific technical recommendations, including:
    - future conditions (5), channel migration, past flood events, and other inclusions or recommendations
- 6 comments on better use of community-provided data, including:
    - Partnering for LiDAR updates, local data in general, and urban flooding information being more local
- 6 mapping resources concerns—how will FEMA finish the job of upgrading data for unmapped and non-digital communities, do away with Zone A areas completely, update H&H where digital conversion only; all while continuing to maintain Risk MAP and implementing a new program
- 7 recommendations about using the mapping process to support other activities, including:
    - Enhancing local agency connections; local capability building for flood risk management; product tailoring to fit community needs; obtaining buy in for things like CRS, ordinance improvements; and supporting local spearheading of communications/outreach

- Expand non-regulatory products (2)
    - BLE, more non-regulatory products in general: "I believe the non-regulatory products created under Risk MAP are the answer, maybe enhance the program for all communities."

Answers to the last question, *"Is there some topic that you think TMAC should address next year?"* included the following themes:

- 13 specific technical topics, including:
    - Erosion, modeling software, 2D modeling, channel migration, and other technical topics
- 10 recommendations that TMAC take on the next steps on probabilistic/graduated, including:
    - CRS connections, mitigation and floodplain management aspects, changing data collection needs, and communication and outreach
- 7 future conditions-related recommendations, including future conditions, sea level rise, and the impact of these factors on mapping
- 4 mapping resource recommendations, including encouraging the completion of mapping for unmapped areas, providing guidance on mapping priorities, evaluating the mapping inventory, and developing/assisting on a national flood mapping program data management strategy
- 4 recommendations on connecting the 4 legs (Mapping, Mitigation, Floodplain Management, Insurance) of the NFIP stool, including:
    - how best to use data for emergency management, better connections between mapping and insurance and floodplain management, how FEMA might permit a set of projects that work together to mitigate flood risks
    - *"I'd like to see the TMAC expand its scope or collaborate with similar groups in other aspects of floodplain management within FEMA to take this holistic deep dive into the topic and develop a strategic plan for real reform that will create a long term sustainable program that has a real impact on flood risk reduction."*
- 3 specific studies were recommended, including:
    - impacts to socioeconomically disadvantaged communities; flooding and homelessness; and dam/levee impact assessments

- 3 recommendations on changes to Mapping Program elements were received, including:
    - Reducing the timeline for post-preliminary processing, mapping some areas as being off limits to development, and doing away with LOMCs entirely
- 3 recommendations about more/continued engagement, including finding success stories and best practices
- 2 recommended changes to 44 CFR, including regulations allowing 2D modeling and regulations around non-regulatory products

Focus Groups

Five focus groups were put together based on the NFIP role alignment information obtained from the survey:

- 1 Floodplain Management and Flood Hazard Mitigation
- 1 Flood Insurance
- 1 Flood Hazard Mapping
- 2 cross-role alignment Focus Groups

Focus group participants were selected based on their response to a question posed during the survey asking whether they would be willing to participate in follow-on stakeholder engagement opportunities. Those individuals who responded 'yes' or 'maybe' were grouped in alignment with the four discipline areas (Floodplain Management, Flood Hazard Mitigation, Flood Insurance, Flood Hazard Mapping), and through a random selection process using a function in Excel, participants were selected. TMAC determined the number of participants per focus group and the sub-disciplines/areas of interest to be represented. Table-D3 shows the composition of the three discipline-specific focus groups:

Table D-3 / Focus Group Member Categories and Attendees

FLOOD HAZARD MAPPING FOCUS GROUP			
PARTICIPANT NO.	TITLE/ CATEGORY	NO. OF POSITIONS ON FOCUS GROUP (PLANNED)	ATTENDED FC MEETING? (Y/N)
1	Coastal Engineer	1	N
2	Engineering Geologist	1	N
3	Estuary Program Director	1	N
4	Flood Risk Manager	1	Y

FLOOD HAZARD MAPPING FOCUS GROUP

PARTICIPANT NO.	TITLE/ CATEGORY	NO. OF POSITIONS ON FOCUS GROUP (PLANNED)	ATTENDED FC MEETING? (Y/N)
5	Hydraulic/Environmental Engineer	1	N
6	Inundation Modeling/Risk Analysis SME	1	Y
7	River Scientist	1	N
8	State Floodplain Mapping Coordinator	1	Y

FLOOD INSURANCE FOCUS GROUP

PARTICIPANT NO.	TITLE/ CATEGORY	NO. OF POSITIONS ON FOCUS GROUP (PLANNED)	ATTENDED FC MEETING? (Y/N)
1	NFIP Coordinator	2	Y
2	ISO/CRS Professional	2	Y
3	Insurance Claims Manager	1	Y
4	Real Estate Professional	1	Y
5	Lending Professional	1	Y

FLOODPLAIN MANAGEMENT/MITIGATION FOCUS GROUP

PARTICIPANT NO.	TITLE/ CATEGORY	NO. OF POSITIONS ON FOCUS GROUP (PLANNED)	ATTENDED FC MEETING? (Y/N)
1	Building Official/Code Enforcement	1	Y
2	Community Rating System Coordinator	1	N
3	Floodplain Manager	2	Y
4	Mitigation Planner	1	Y
5	Land Use Planner/Zoning Official	2	Y
6	Sustainability/Resilience Manager	1	N
7	Tribal Watershed Manager	1	Y

Once the random selection process was completed, focus group members were contacted to outline the process and share calendar information. A Designated Federal Officer (DFO) representative was also identified to participate in each meeting as per Federal Advisory Committee Act (FACA) requirements.

The initial plan was to conduct three focus group meetings for each discipline area:

- Meeting 1: Introductions, Goals and Objectives, and Ground Rules
- Meeting 2: Facilitated Discussion
- Meeting 3: Validation of Results

However, after the first set of focus groups with the Floodplain Management and Mitigation Planning representatives, it was decided Meetings 1 and 2 could be combined, which was the approach for the subsequent Flood Insurance and Flood Hazard Mapping Focus Groups. Two cross-section focus groups were conducted once the first three sets of discipline-specific focus groups were completed; the purpose of these cross-section focus groups was to present consolidated outcomes, validate the results, and reach general consensus on important recommendations, resource needs, obstacles, and other feedback. Table D-4 shows the final focus group schedule, with nine successfully completed at the conclusion of the process:

Table D-4 / Focus Group Meeting Schedule

MEETING DESCRIPTION	DATE	TIME
Group No. 1: Floodplain Management/Mitigation Element		
Meeting No. 1: Introduction and Ground Rules	04-Nov-20	2-3 pm ET
Meeting No. 2: Facilitated Discussion	05-Nov-20	2-4 pm ET
Meeting No. 3: Summarize and Consensus	10-Nov-20	11 am-12 pm ET
Focus Group No. 2: Insurance Element		
Meeting No. 1/2: Introduction and Facilitated Discussion	13-Nov-20	11 am-1pm ET
Meeting No. 3: Summarize and Consensus	18-Nov-20	4 pm-5 pm ET
Focus Group No. 3: Flood Risk Mapping Element		
Meeting No. 1/2: Introduction and Facilitated Discussion	24-Nov-20	1 pm-3 pm ET
Meeting No. 3: Summarize and Consensus	30-Nov-20	2 pm-3 pm ET
Focus Group No. 4a: Non-homogeneous Cross-Section		
Meeting No. 1: Summarize and Consensus	02-Dec-20	11 am-1 pm ET
Focus Group No. 4b: Non-homogeneous Cross-Section		
Meeting No. 1: Summarize and Consensus	02-Dec-20	3 pm-5 pm ET

Note: *Personally identifiable information (PII) for focus group members was protected in several ways, including the use of a password-protected spreadsheet of contact information that the team used to coordinate focus group participation.*

To ensure maximum participation, the team sent initial notification emails, followed by individual emails with information to register for each of the focus group sessions. This was augmented with follow-up phone calls and a final reminder email several days prior to the scheduled focus group. In cases where participants indicated they would not have the ability to attend, the team revisited the list of randomly selected participants and contacted the next individual on the list until a replacement was identified.

Free Text Responses

The team prepared materials for each focus group meeting to ensure consistent delivery of information across all focus groups. This included the development of a series of questions to be posed to each focus group to ensure participant responses met the information needs of TMAC through the stakeholder engagement process. Open-ended questions were developed to promote discussion and engagement among participants. The number of questions was generally limited to no more than seven, which included prompts to drill down to further level of detail in the response. Provided as Attachment A are the questions posed to each focus group.

The team prepared white boards for each focus group meeting, which were conveyed using the WebEx platform. This provided a means of interactive engagement with participants who had a number of tools at their disposal to communicate their responses. In addition to verbal responses to questions posed, participants were able to annotate their input in writing on slides as they were presented. They were also able to use the chat function in WebEx to further communicate with the team. Each presentation was recorded, and files of the annotated slides and their input via the chat function were made. Importantly, at the onset of each meeting, participants were notified that the discussions were being recorded.

Focus Group Presentation of Results

The final meeting of each set of focus groups provided an opportunity for participants to validate the outcome of their discussions during the facilitated engagement portion of the process. Additionally, the team prepared a consolidated summary of outcomes, which was validated during the final set of cross-section focus group meetings. These meetings were attended by both a randomly selected group of participants representing a cross-section of practitioners impacted by the transition from binary to graduated flood risk. Participants from the three sets of previously conducted focus groups also were invited to attend.

Exhibit 1. NFIP stakeholders aligned with Flood Hazard Mitigation/Floodplain Management, Flood Insurance, and Flood Hazard Mapping **currently** engage in many practices to reduce flood risk or contribute to flood hazard data accuracy. Stakeholders feel certain that some of these activities will change or improve with the shift from binary to graduated (green). Other areas represent uncertainty or knowledge gaps about future changes (orange).

	Mitigation/Floodplain Management	Flood Insurance	Flood Hazard Mapping
Activities shared by all stakeholder groups	Risk identification (multiple sources: pluvial, flood control structures, future conditions, coastal, riverine, special hazards, etc.) (green)		
	Promote risk understanding/awareness (green)		
	Promote better connections between program elements (mitigation, floodplain mgmt., mapping, flood insurance) (green)		
	CRS program participation and support		
Activities shared by both Insurance and Mit/FPM stakeholders	Adopt or promote freeboard (green)		
	Address risk beyond the Special Flood Hazard Area (green)		
	Promote the inclusion of future conditions (including climate change) (green)		
	Work through mitigation options/scenarios with others (green)		
	Manage or connect others to grants/funding		
Activities reported by only one stakeholder group	Enforce minimum standards *	Training (clients, lenders, communities)	Obtain or manage local mapping inputs
	Adopt higher standards	Professional Development	Data collection, maintenance, or validation *
	Mitigate flood risk	Mandatory purchase and associated activities *	Mapping quality activities (e.g., QRs, G&S, etc.) *

(green) Activities that stakeholders feel are certain to change by the shift from binary to graduated

* Areas of uncertainty/knowledge gaps regarding the shift from binary to graduated

Exhibit 2. NFIP stakeholders said **it was clear** that some current practices will change as the program transitions from a binary view of flood hazards to a graduated understanding of flood risk. ***These represent stakeholder expectations regarding the shift.***

Activity	*ID All Sources of Flood Risk*	*Include Future Conditions*	*Promote Risk Understanding*	*Risk Beyond SFHA*	*Promote Better Connections*	*Freeboard*	*Mitigation Options/ Scenarios*
How stakeholders feel these activities will change with program shift	Better risk visualization of flood risk from all sources		Better communication of risk		Better understanding of mitigation options and opportunities		
	Better risk categorization (e.g., risk from pluvial can be separated from risk from riverine)		Conversations go beyond mandatory purchase requirement		More responsible development outside of SFHA		
	Input accuracy/quality control will be more important		Better understanding of consequences of flooding (depth-damage information)				
	More inputs = more uncertainty		New tools can promote more risk tolerance discussions				
	Mitigation/FPM drives future products (vs. Insurance)		Insurance pricing discussions held *before* development occurs				
	Interpretation and use of maps/products will change						

Exhibit 3. NFIP stakeholders said there were **areas of uncertainty and gaps in understanding about the future** as the program transitions from a binary view of flood hazards to a graduated understanding of flood risk. ***These represent unknowns that the program should seek to answer as part of the shift.***

Activity	*Mandatory Purchase and Associated Activities*	*Data Collection, Maintenance and Validation*	*Mapping Process Quality Measures*	*Enforce Minimum Standards*
Area of uncertainty or knowledge gap	How will all elements of the program be connected (mitigation, floodplain management, mapping, insurance)?			
	Will mandatory purchase change? Where will insurance be mandatory in the future?	What will the new products look like? What will be involved in making them?		What will minimum standards be and how will they be tied to new products?
	How will the program track changes/authoritative sources for mandatory purchase as shift occurs?	Will there be dynamic models responsive to continual local inputs and changes?		
	Will the shift include addressing affordability including connecting people to funding and mitigation support?	Can new products support more "losses avoided" discussions and outputs?		
	What mitigation credits will be available to reduce insurance rates, and how will new products reflect them?			

Exhibit 4. For **mandatory purchase of flood insurance and affordability topics**, NFIP stakeholders provided **recommendations** for the program as it transitions from binary to graduated flood risk.

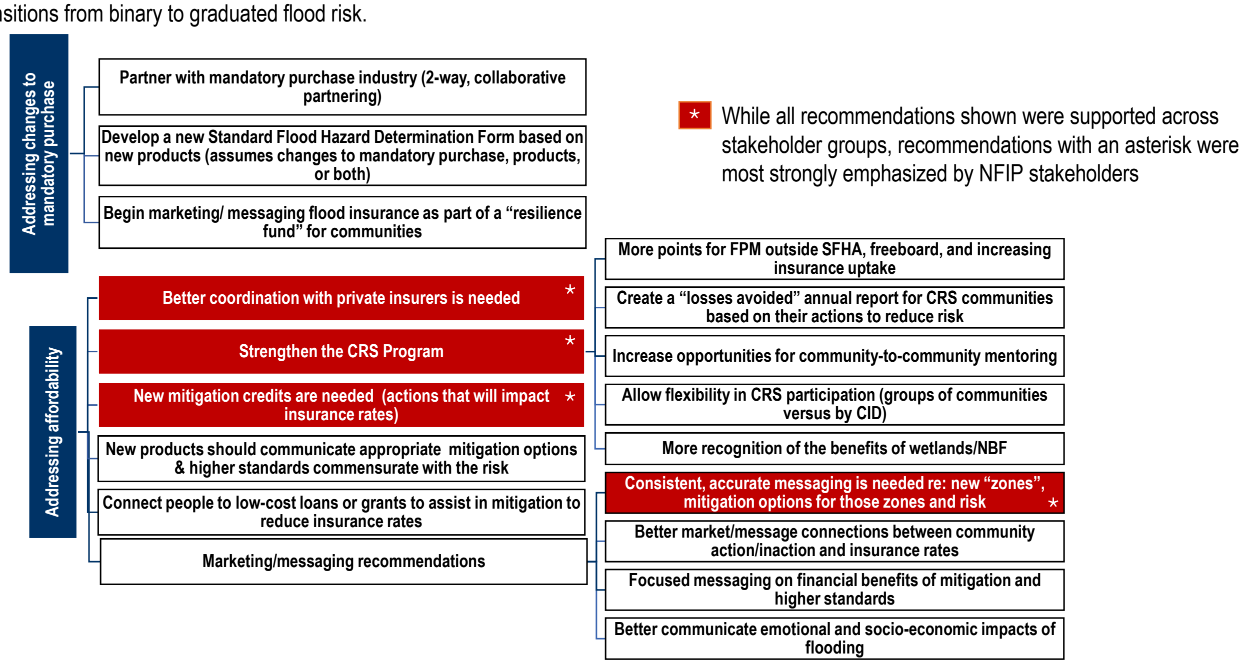
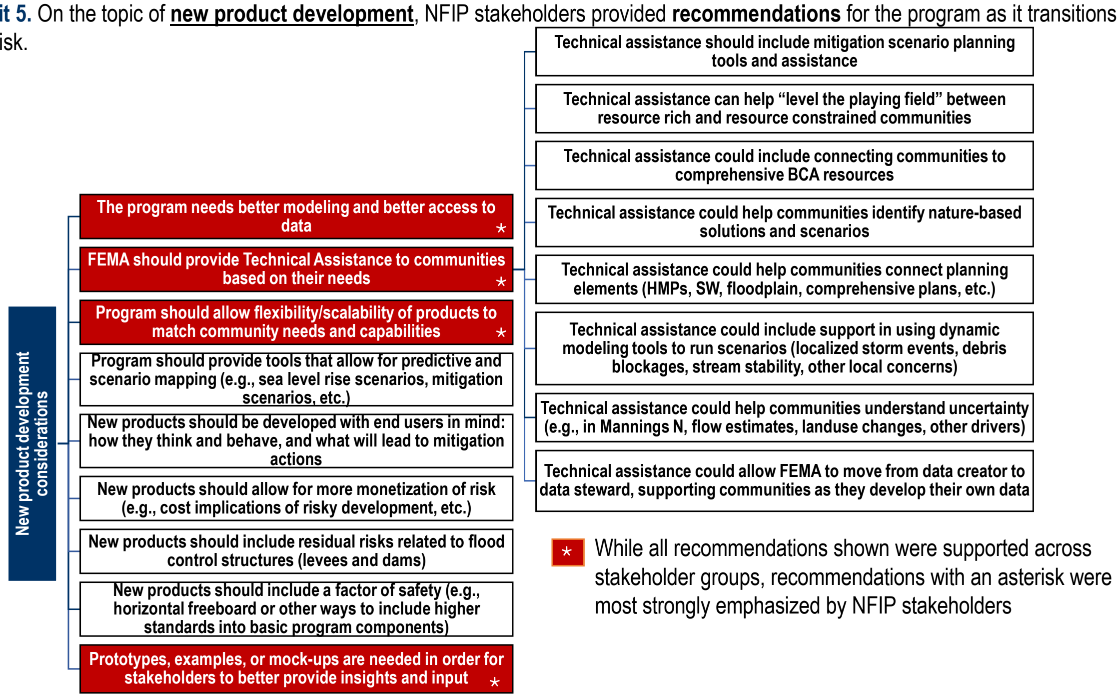
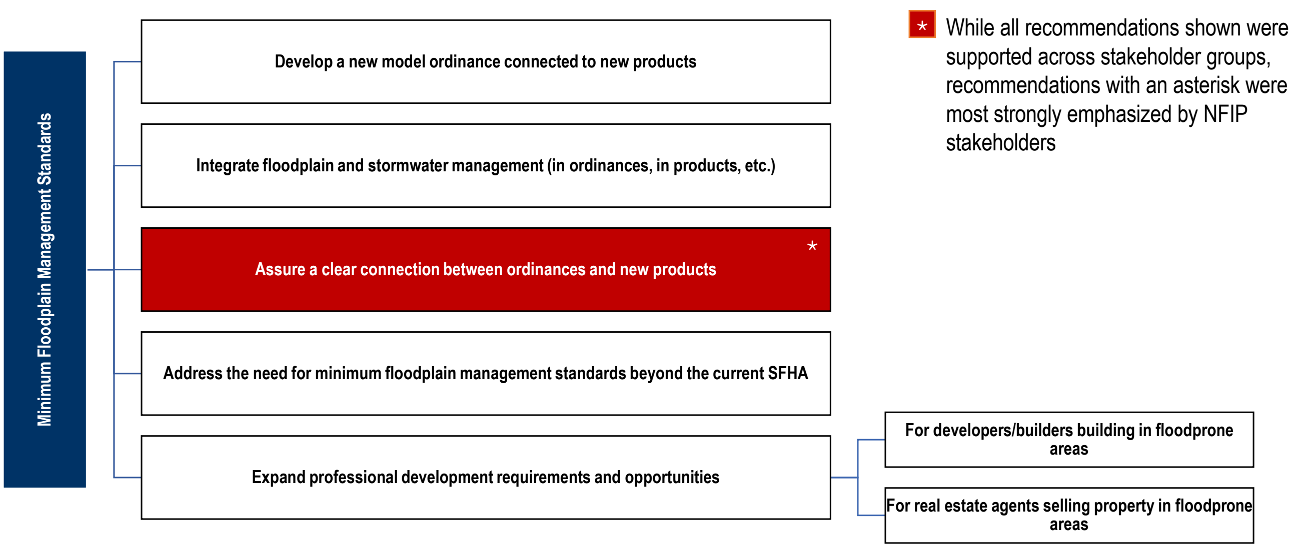


Exhibit 5. On the topic of **new product development**, NFIP stakeholders provided **recommendations** for the program as it transitions from binary to graduated flood risk.



TMAC 5

Exhibit 6. On the topic of **minimum floodplain management standards**, NFIP stakeholders provided **recommendations** for the program as it transitions from binary to graduated flood risk.



TMAC 6

Exhibit 7. Focus group discussions resulted in recommendations for improving existing incentives or implementing new ones to facilitate mitigation actions leading to reducing risk.

ICC	CRS	Monetization of Risk	Grants	Insurance	NFIP Participation	Private Investment
▪ More flexibility (used as match for grants, use pre-claim for mitigation) ▪ Increase amount available ▪ Promote cumulative substantial damage	▪ More points for certain elements (see exhibit 4) ▪ More mentoring between communities ▪ Messaging changes (see exhibit 4)	▪ Message insurance as a "resilience fund" ▪ Losses avoided messaging/ reporting ▪ Products that provide "life of structure" analysis and discussions ▪ Products that promote mitigation option/ scenario discussions	▪ Provide >100% market value for retreat or other national mitigation priorities ▪ No longer aligned to "SFHA"	▪ Consider changes to program that eliminate incentives for building in risky areas ▪ Establish maximum lifetime payout that, once hit, requires mitigation as the only option	▪ Allow flexibility in jurisdictional oversight and mapping (e.g., regional or watershed governmental levels instead of being based on CID)	▪ Find ways to encourage and incentivize private sector ▪ Incentivize banks to provide low-interest loans tied to mortgage to address affordability

Exhibit 8. The main concerns of NFIP stakeholders regarding the shift from binary to graduated risk.

Communities Adapting to Changes

- Level of effort in already stressed communities (multiple priorities, level of modeling knowledge)
- Explaining changes to public
- Understanding mitigation credits and options
- Connection to regulatory elements
- What will Congress do? "Too much too fast"

Level of Change on the Horizon

- Will 44 CFR 60.3 be revised?
- Will mandatory purchase change?
- How granular will new "zones" and rates be? How complex?
- How difficult will it be to communicate new "zones"?
- (How) will Future Conditions including climate change be incorporated?
- Affordability: how will low income/vulnerable populations be addressed?

Connections Between NFIP Elements

- How will mitigation, insurance, mapping, and FPM work together as Risk Rating 2.0 rolls out? How will affordability be addressed?
- How will new products align to mitigation options and FPM standards (minimum and higher standards)?

Clear Plan for Transition

- Messaging at each stage will be important
- What will the phase-in of new products look like?
- How will FEMA juggle finishing current program while transitioning to new? A phased approach should be adopted (case by case based on status of current maps)
- Need to clearly define "graduated risk" and provide examples and prototypes

Exhibit 9: General consensus was reached by NFIP focus group members that FEMA should prioritize five key things as the transition from a binary approach to flood risk to a more graduated approach occurs.

- **Better models and data, inclusive of multiple aspects of flood risk (future conditions, flood control structures, pluvial, etc.)**
- **A clear connection to floodplain management ordinances**
- **A plan is needed for phase-in of new program elements and shift from current to new**
- **Provide Technical Assistance (see exhibit 5)**
- **Risk communication to increase risk awareness and understanding, and promote mitigation actions**

Appendix E/ TMAC Administrative and Public Meetings – Report Year 2020

MEETING DATE	MEETING TYPE	LOCATION	BUSINESS PURPOSE
February 26, 2020	Administrative	Virtual	The purpose of the TMAC Administrative Meeting was to kick off the 2020 TMAC by reviewing the 2020 TMAC Tasking Memo and conducting the ethics briefing.
April 14 - 15, 2020	Public	Virtual	The purpose of the meeting was to elect a new Chair, provide updates from FEMA, discuss the 2020 TMAC Report document structure, and to report out from the subcommittee meetings.
July 27 - 28, 2020	Public	Virtual	The purpose of the meeting was to: (1) receive briefings from Ed Kearns of First Street Foundation and John Dorman of North Carolina's flood mapping program; (2) receive a briefing about the TMAC survey and Stakeholder Engagement Plan; 3) deliberate and vote on the Vision Statement for the 2020 TMAC Report; and 4) receive briefings from each subcommittee on their sections of the 2020 TMAC Report.
October 29 - 30, 2020	Public	Virtual	The purpose of the meeting was to: (1) make progress on the 2020 TMAC Annual Report; (2) review the results of the stakeholder engagement effort; (3) receive an update on Risk Rating 2.0; (4) go through each subcommittee's draft sections; and (5) discuss TMAC's next steps and discuss what recommendations to make to FEMA regarding the 2021 Tasking Memo.
December 17, 2020	Administrative	Virtual	The purpose of the meeting was to: (1) receive updates from Subcommittees 1 and 2 on their progress towards completion of the 2020 TMAC Annual Report; (2) receive a presentation on the feedback gathered from the stakeholder engagement focus groups; and (3) solicit a call for members to submit nominations for the next TMAC Chair.
January 19 - 20, 2021	Public	Virtual	The purpose of this meeting was to discuss revisions to the draft TMAC Annual Report and vote on recommendations to submit to FEMA in the Annual Report.
March 1 - 2, 2021	Public	Virtual	The purpose of this meeting was to: (1) review the final report; (2) hold a vote to submit the final report to the FEMA Administrator; (3) introduce the 2021 TMAC Tasking Memo; and (4) vote to appoint a new chair for 2021.

Appendix F/ TMAC 2020 Subcommittee Meetings – Report Year 2020

Subcommittee 1

MEETING DATE	MEETING PURPOSE
April 2, 2020	Identify approaches for stakeholder engagement, SME gaps, and future program alternatives
April 8, 2020	SME briefing on the probabilistic approach
April 30, 2020	Report section assignment, brainstorm best practices, stakeholder engagement planning
May 11, 2020	Receive SME briefing on Mecklenburg County decision model and Iowa Flood Information System; discuss vision statement and stakeholder engagement
May 27, 2020	SME briefing on value of probabilistic by USACE and coastal PFRA by FEMA
June 17, 2020	Review ASFPM survey results, takeaways from conferences, and the subcommittee report
June 23, 2020	SME briefing on European flood mapping and review the Subcommittee report
July 15, 2020	Discuss TMAC updates, plan for webinars, and review draft of Subcommittee report
July 22, 2020	Review and discuss the Subcommittee report
August 14, 2020	Conduct a webinar to engage with stakeholders
September 16, 2020	Review and discuss the Subcommittee report; Discuss TMAC membership, TMAC upcoming meeting, planned Focus Groups, and path beyond October
September 24, 2020	Conduct a webinar to engage with stakeholders
October 7, 2020	Review and discuss the Subcommittee report
October 20, 2020	Discuss TMAC updates, stakeholder engagement, and review draft of Subcommittee report
November 4, 2020	Conduct Focus Group #1 – Floodplain Management/Mitigation Element: Introduction and Ground Rules
November 5, 2020	Conduct Focus Group #1 – Floodplain Management/Mitigation Element: Facilitated Discussion
November 10, 2020	Conduct Focus Group #1 – Floodplain Management/Mitigation Element: Summarize and Consensus

MEETING DATE	MEETING PURPOSE
November 13, 2020	Conduct Focus Group #2 – Insurance Element: Introduction and Facilitated Discussion
November 17, 2020	Discuss TMAC updates, stakeholder engagement, and review draft of Subcommittee report
November 18, 2020	Conduct Focus Group #2 – Insurance Element: Summarize and Consensus
November 24, 2020	Conduct Focus Group #3 – Flood Risk Mapping Element: Introduction and Facilitated Discussion
November 30, 2020	Conduct Focus Group #3 – Flood Risk Mapping Element: Summarize and Consensus
December 2, 2020	Conduct Focus Group #4a – Non-homogeneous Cross-Section: Summarize and Consensus
December 2, 2020	Conduct Focus Group #4b – Non-homogeneous Cross-Section: Summarize and Consensus
December 8, 2020	Review and discuss proposed Subcommittee recommendations
December 15, 2020	Discuss TMAC updates and stakeholder engagement, and review the Subcommittee report
January 5, 2021	Kick-off the finalization of the 2020 TMAC report
January 8, 2021	Discuss and address comments on Subcommittee chapters
January 13, 2021	Discuss and address comments on Subcommittee chapters
February 4, 2021	Discuss the final draft of Subcommittee chapters
February 11, 2021	Discuss the final draft of Subcommittee chapters

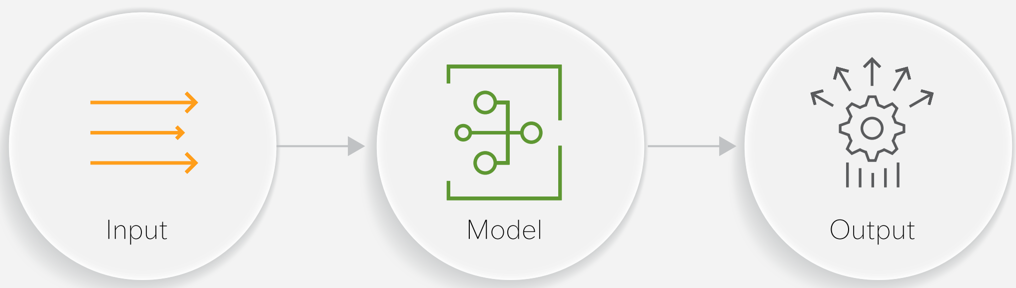
Subcommittee 2

MEETING DATE	MEETING PURPOSE
March 13, 2020	Subcommittee 2 kick-off meeting
March 27, 2020	Author progress reports and working call
April 10, 2020	Pre-official meeting check-in
April 24, 2020	Author progress reports and working call
May 8, 2020	Author progress reports and working call
May 22, 2020	Author progress reports and working call
June 30, 2020	Author progress reports and working call
July 20, 2020	Pre-official meeting check-in
July 31, 2020	Author discussion and next steps post-official meeting
August 3, 2020	Focus call to define path forward
August 14, 2020	Review tasking and brainstorm ideas for report sections
August 28, 2020	Assign writers to report sections and discuss questions
September 25, 2020	Consolidate and review draft report
October 16, 2020	Review comments from draft report and data from stakeholder surveys
November 13, 2020	Report Draft Working Call
December 2, 2020	Report Draft Working Call and check-in
December 8, 2020	Discuss revisions to draft report
December 15, 2020	Report Draft Working Call
January 8, 2021	Address comments and consolidate report
January 11, 2021	Address comments and consolidate report
February 5, 2021	Address comments and consolidate report
February 11, 2021	Pre-finalization check-in call

Appendix G / Probabilistic Methods

G.1 / Deterministic Analysis

Deterministic analysis represents a sort of analysis where a single number represents the solution. Producing that single number can be incredibly complex, requiring many computations and input values; but in the end, it is boiled down to a single number that represents a best answer for a given question. Typically, the inputs represent best available information or expert judgment, and this can culminate in an estimate that reflects an incomplete picture of the complexity of the system under analysis.



G.2 / The Problem

In natural resources sciences we strive to profess truth, and our attempts at such a profession lead us towards a representation that is black or white. Either our answer is truth, or it is not truth. In such an environment, the practice has evolved a culture of producing a result or a number that best encapsulates our ability to describe truth. This answer typically is associated with our "best guess" at some natural phenomenon. A way to describe this would be to attempt to estimate the maximum flow in a stream next year. To achieve that end, we would collect information on all of the historic maximum stream flows in that stream for as long as our recorded history would allow—in this sample, we would naturally see a variation of maximum annual flows. As a natural scientist trying to best articulate truth, we have a choice to make—how do we estimate from this data the likely annual maximum flow in the river next year? We could take the average of all of those annual maximum flows to represent the central tendency of that dataset of annual maximum flows. Reasonably, we could suggest that the most likely value to occur next year would be the average value. For many, this represents our best guess at answering the question as truthfully as possible. This answer (or many other single number representations of the data) represents a deterministic estimate of the most likely annual maximum flow in the river next year. In statistics we learn that the likelihood of that value occurring next year is infinitesimally small. Dr. Charlie Yoe proclaims, "the single number answer is a lie," appealing to our ethical obligation to profess truth.

This dissonance with truth will continue until we establish a range of values to describe our answer. Suggesting that we would have a 50 percent likelihood (assuming symmetrical data) that the value would be less than or equal to the average given our sampled historical data allows us the opportunity to express a range of values, and acknowledge that our system varies naturally. Suggesting that we would have a 50 percent likelihood that our value is greater than or equal to the average given, our historic data is a better approximation of truth. Other tools in our statistical toolbox allow us to describe data, and its variation, in a more complete way. An example of this is the five-number summary, which allows expression of a minimum, 25 percent exceedance value, 50 percent exceedance value, 75 percent exceedance value and maximum value that describes the full data and their variability. This is truth, though it might be a complex truth to profess.

G.3 / Deterministic 1-Percent-Annual-Chance Event

Instead of evaluating the annual maximum flow in the river next year, we could approximate the flow that will only be exceeded 1 percent of the time. In order to do this, we look at our data and rank it. In the case of the data (Figure G-1), with 89 events, we have not observed 100 years of annual maximum series data, which means we have no historical precedence for estimating a flow that will only be exceeded 1 percent of the time. We could use all 89 years of data and say that the 89th record flow is only going to be exceeded 1 percent of the time, but this would be an approximation based on limited data. Unfortunately, in this case we do not know what the 1-percent-annual-chance event is based on our observations of data and must use other methods to estimate that value. In this case, our five-number summary as described above is still insufficient to explain the potential variation when relying simply on empirical evidence. A strategy to overcome this limitation is to provide a numerical solution for record extension by fitting a continuous statistical distribution. We can take the data we have, fit it to a statistical distribution, and from that distribution compute the 1-percent-annual-chance event. The line in black in the image represents that fitted distribution. However, selection and fitting of the distribution itself introduces a new source of error into our system: model selection error. Nevertheless, we can now explain with our numerical model our best estimate for the 1-percent-annual-chance event—a flood flow with a magnitude of approximately 447,000 cubic feet per second (Figure G-2). In fact, this flow estimate is not as high as the highest observed flow, which implies that our highest observed flow will recur less frequently than the 1-percent-annual-chance flow event. This is still a deterministic estimate that reflects our knowledge of the natural variation in the stream over our period of data collection.

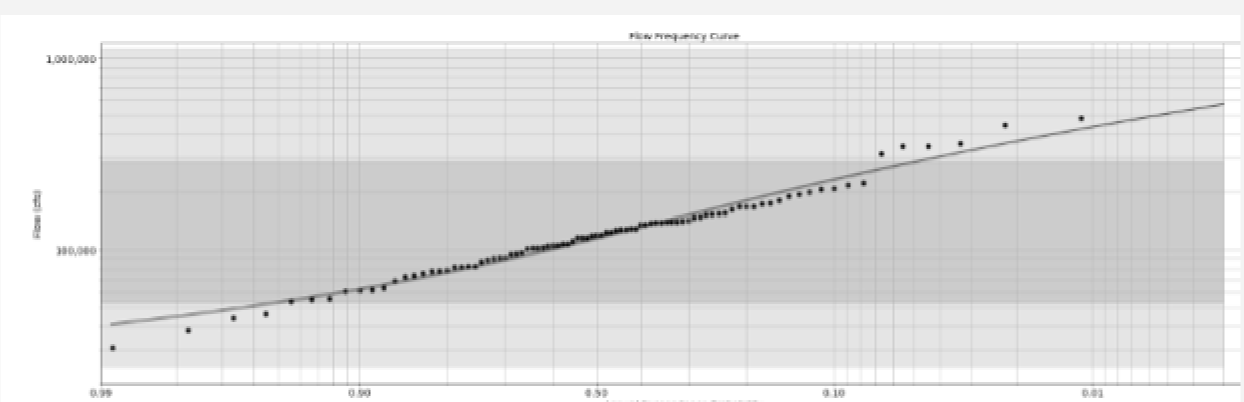


Figure G-1 / 89 ranked annual flood observations Fitted to an LPIII distribution at USGS Gage ID 016465000

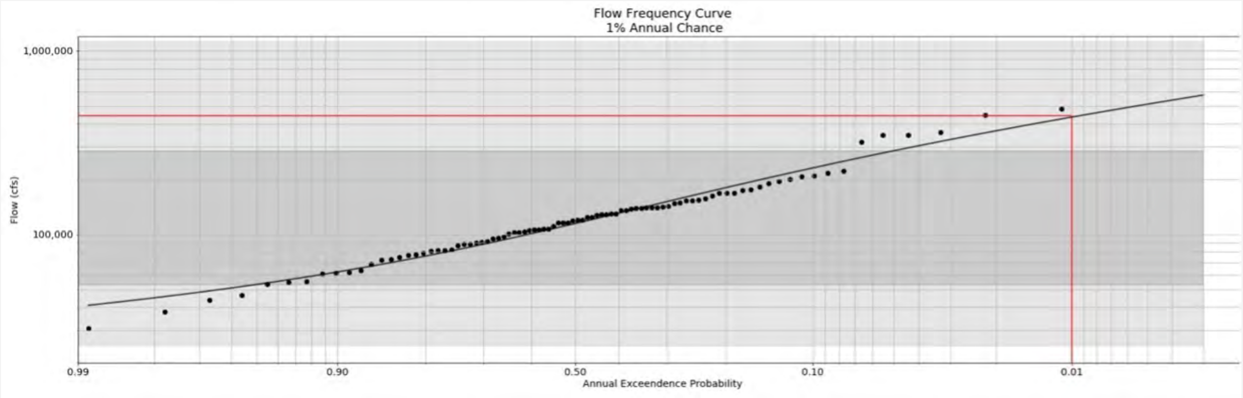


Figure G-2. / The 1% Annual Chance Flow based on the fitted LPIII distribution at USGS gage ID 016465000

Yet with this approach, we still face other practical limitations to our ability to truthfully answer the question of the likely annual maximum flow next year in a stream. If we simply take the data we have observed and declare that it fully encompasses the potential variability in the stream, we are suggesting that we have seen all possible flows in that river. Sadly, however, this is not generally the case. If our sample is made up of 5 observations, it would be less likely to describe the full variability of the system than a dataset with 50 observations. In the case that we have been describing, we have 89 records, so we have even more certainty about the data, but not enough to accurately describe the 1 percent event. As a result, we introduce a new limitation in our ability to describe a natural phenomenon, our lack of knowledge due to limited data. In this case, we do not know if our data represent the full range of possible outcomes, because we have limited information. In the image below, the historic data represented by the black dots is sampled with replacement, a methodology called bootstrapping. In a bootstrap shown in Figure G-3, we sample 89 (commensurate with the number of values in our historic data) values with replacement from the original data as a representative subsample of our historic data. This process is repeated many times (in the image we repeat this process 4,000 times). Each subsample describes our sample in the same relationship as our sample represents all of the possible storms that could occur across all time—in essence, our sample of historic data is a subsample of the true population of data. The range of empirical frequency curves created by our 4,000 bootstrap samples represents our knowledge uncertainty due to the data we have observed. The range of the historic data defines our Natural Variability, whereas the spread of our bootstraps describes our Knowledge Uncertainty. It should be noted that our knowledge uncertainty is much larger than the model error presented with our numerical fitting discussion above.

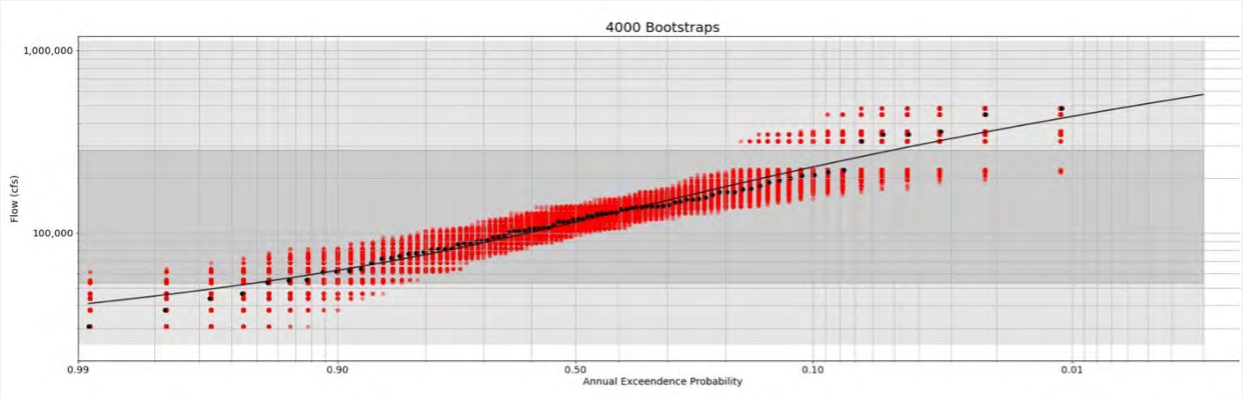


Figure G–3. / 4,000 empirical bootstrap samples describing the knowledge uncertainty around a historic sample

Alternatively, the process of bootstrapping can be completed using the analytical fitted distribution as shown in Figure G-4. This parametric bootstrapping capability allows us to extend our analysis beyond our observed historic record with statistical distributions built to describe the natural processes at play, thus keeping our extrapolation within the general bounds of reality.

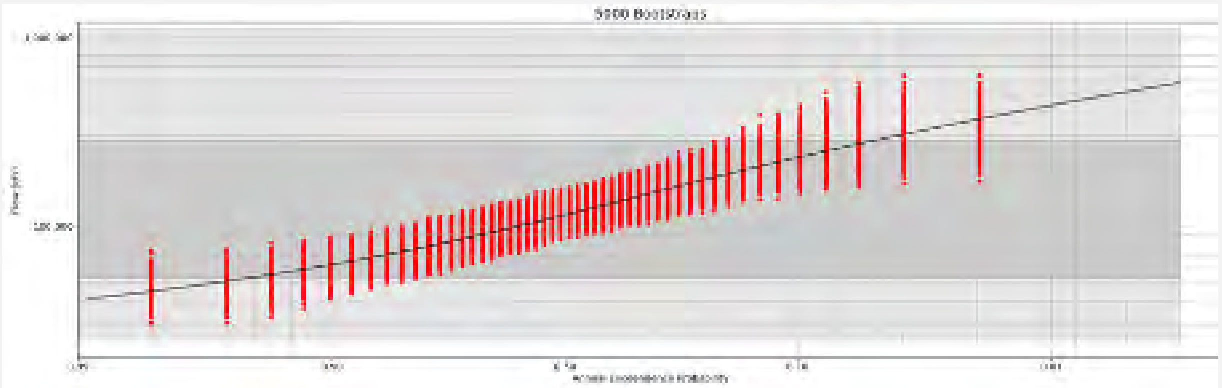


Figure G-4. / 5,000 analytical bootstrap samples describing the knowledge uncertainty around a historic sample

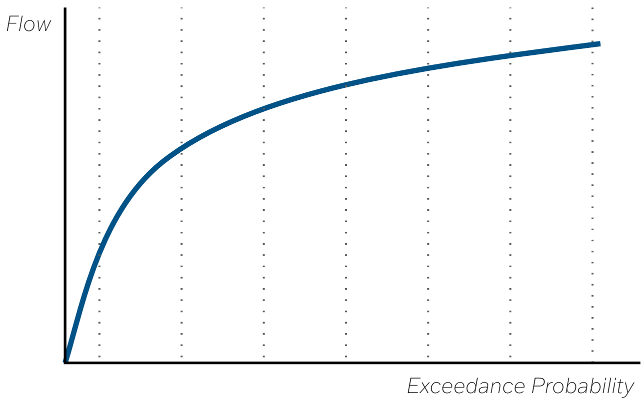
Variability and uncertainty are two concepts that are important to consider when modeling natural phenomena. Variables in our system vary naturally, and we are uncertain if our data capture that variability completely due to our lack of knowledge. In the scientific community, these are generally described as Natural Variability (Aleatory Uncertainty) and Knowledge Uncertainty (Epistemic Uncertainty). Properly addressing these two sources of uncertainty in our systems is crucial to a full representation of a natural phenomenon. Using the techniques outlined in Bulletin 17C, we have the ability to describe the impact of our lack of knowledge on our ability to estimate the 1-percent-annual-chance flow. Here we can describe the range of possible flows that might represent the 1-percent-annual-chance flow given our uncertainty regarding our dataset representing the full range of variability that could occur in the river from year to year.

How does Graduated Hazard Relate to Probabilistic Methods?

In Figure G-5 we see a probability flow relationship, sometimes called a flow frequency curve. It is depicted as a Cumulative Density Function (CDF). This represents our best estimate of the range of possible flows. This range of possible flows is based on our understanding of historic data, and reflects the natural variability of our historic information. Fitting the raw data (as seen in Figure G-1) to a known distribution such as the Log Pearson Type III distribution provides a way to extend our ability to estimate the extreme events that have not yet been observed based on our limited data. Sampling values off of this relationship can be done using random sampling, or stratified and importance sampling, or simply by pulling specified exceedance probabilities from the distribution. Regardless of the technique, this only represents the natural variability of our best estimate—this way of representing systems is not capable of describing knowledge uncertainty.

Taking into consideration the problem that our limited historic information limits our ability to know if our observations fully represent the range of possible flows, we seek to use uncertainty bounds (as shown in Figure G-6) to represent our limited knowledge. Figure G-6 expresses a confidence interval around the best estimate frequency curve, which represent our uncertainty in our best estimate.

Flow Probability Relationships



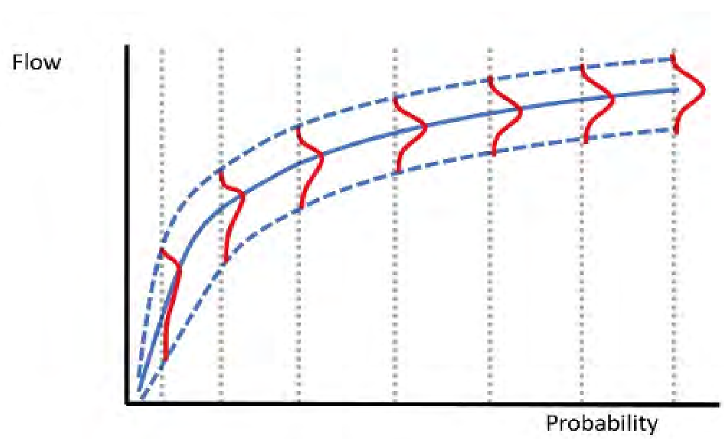
Deterministic Relationship

1. Describes our best estimate
2. Reflects Natural Variability
3. Based on Historical Data
4. Can be based on a fitted distribution
5. Must be confined between 0 and 1

Figure G-5 / An illustrative deterministic flow frequency relationship

There are many strategies for sampling frequency curves with uncertainty. For example when looking forward, Figure G-9 shows the process of nested looping of sampling the knowledge uncertainties first, and then performing the composition through the systems as a second procedural step. The use of bootstrapping for the knowledge uncertainty allows for the variation of the shape, scale, and location of the underlying distribution(similar to leveraging the EMA and bootstrapping outlined in Bulletin17-C). Alternatively, curve sampling techniques (similar to leveraging the non-central distribution outlined in Bulletin 17-B) can be used to sample the uncertainty without manipulating the skew of the distribution. The second stage can be performed with naïve sampling or stratified and importance sampling. There are issues with stratification and importance sampling if hydrologic memory of the watershed extends beyond a year, and there is auto-regressive correlation where the analysis is interested in the lifecycle of a watershed. There are issues with random sampling if the

Flow Probability Relationships With Uncertainty



Probabilistic Relationship

1. Acknowledges Uncertainty
2. Provides range of outputs for given probability
3. Uncertainty is dependent upon available data
4. Reflects Natural Variability
5. Based on Historical Data
6. Can be based on a fitted distribution
7. Must be confined between 0 and 1

Figure G-6 / An illustrative deterministic flow frequency relationship objective is the extreme ends of the frequency curve because the computational burden becomes excessive. The choice of stratification is important, and must be developed with the objectives of the analysis in mind.

G.4 / Probabilistic Methods

Probabilistic methods provide a more robust toolset for describing the impact of natural variability and knowledge uncertainty on our ability to estimate the range of potential hazards posed by natural phenomena. In the section above we described deterministic methods as utilizing a set of input parameters to drive a series of complex equations to produce a single best estimate. Probabilistic methods produce a range of estimates that express the uncertainty in the outputs of a complex system. This is done by sampling many sets of input parameters that span the range of possible input parameter combinations as shown in Figure G-7. The truth is that our best way to describe these systems is to acknowledge that there is no single number answer, but rather a range of answers that likely encapsulate a fuller picture of the truth.

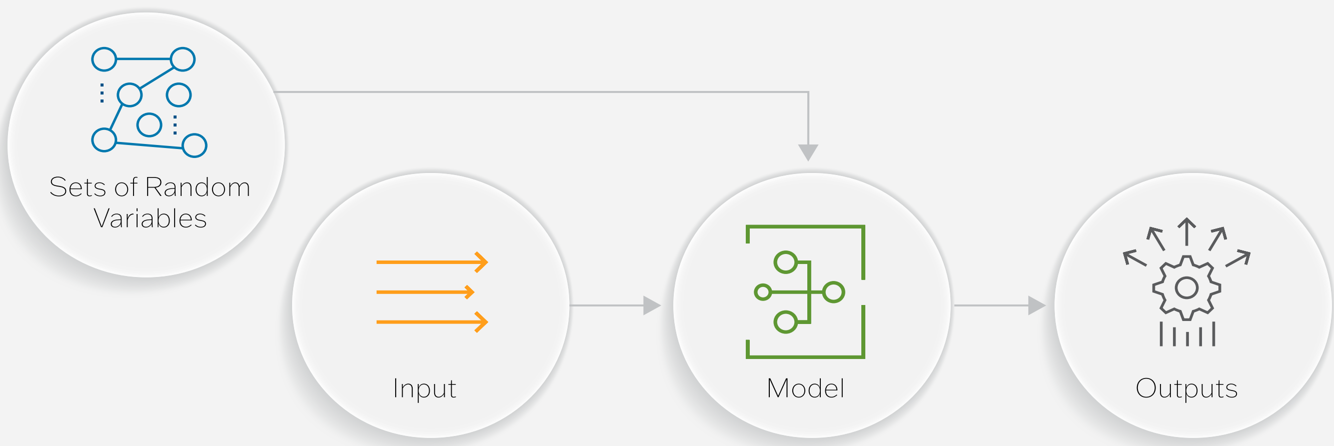


Figure G-7. / A Depiction of a probabilistic system with one set of inputs and many sets of random variables producing many outputs

When thinking about probabilistic methods, there are many steps in the chain that each have their own set of uncertainties. In the previous examples we focused on flow frequency. Flow frequency is governed by many parameters. Assuming a constant input of precipitation, the flow in the river could vary based on many conditions. The moisture in the ground prior to the event impacts how much rainfall is converted into flow rather than absorbed by the ground. The temperature impacts whether the precipitation falls to the ground as accumulated snow, rainfall on the ground, or rainfall on snow. The associated flow for a given precipitation is not known because there is uncertainty in the conditions of the watershed at the time of the precipitation making landfall.

Likewise, the stage resulting from a given flow is impacted by the amount of debris in the channel at the time of the event; sedimentation from previous events may change the channel geometry; failures of infrastructure like levee breaches may also impact the stage related to a given flow. There is not a simple functional relationship that can determine the probability-precipitation, precipitation-flow, flow to stage, or stage to damage relationships.

Within the input parameters that influence our estimates of flood outcomes, we have Natural Variabilities and Knowledge Uncertainties. Some of these parameters are easy to classify, while others are more complex to classify. One major difference between Natural Variability and Knowledge Uncertainty is that Knowledge Uncertainty is reducible; for instance, leveraging paleo flood records to extend streamflow observations can reduce our uncertainty in the error around the frequency curve. Investing in strategies such as data collection reduces our uncertainties and provides us more defensible estimates of decision metrics and their potential impact on mitigative actions. Table G-1 provides some basic parameters that illustrate the separation.

Table G-1 / *Parameters that contribute natural variability or knowledge uncertainty for different disciplines*

CATEGORY	NATURAL VARIABILITY	KNOWLEDGE UNCERTAINTY
Hydrologic Modeling	Annual Maximum Flow	Error around the flow frequency curve
	Snowmelt	
	Forecasted Flow	
Reservoir Modeling	Starting Storage	Storage Elevation relationship
	Power and Water Demands	Release capacity
Hydraulics Modeling	Sedimentation profile	Weir, Gate, Bridge Coefficients
	Manning's n	Manning's n
	Ice Thickness	Terrain Data
	Bridge Debris	
	Breaches	
Consequence Modeling	Foundation heights of all Single Family Residential structures	Foundation height of a specific Single family residential structure
	Damage Relationships	Structure Value
	Fatality Rates	Content Value

These sources of variability and uncertainty must be sampled properly to account for the uncertainty in the expected values of our decision metrics such as a specific Annual Chance Exceedance or an Average Annualized Loss. Figure G-8 seeks to illustrate the general flow of the process from sampling flow to computing damage estimates.

In the Deterministic methodologies, the process would follow the image. A probability representing the annual exceedance value for a flow would be sampled as step 1. Step 2 converts the probability to flow, step 3 uses a stage frequency relationship (or numerical model) to compute stage, step 4 converts that stage to a damage through the best estimate damage—frequency relationship—and that damage value is associated with the probability of the sampled flow in step 5. Ultimately, this is repeated for multiple probabilities and the curve in the lower quadrant is integrated to compute an average annualized loss.

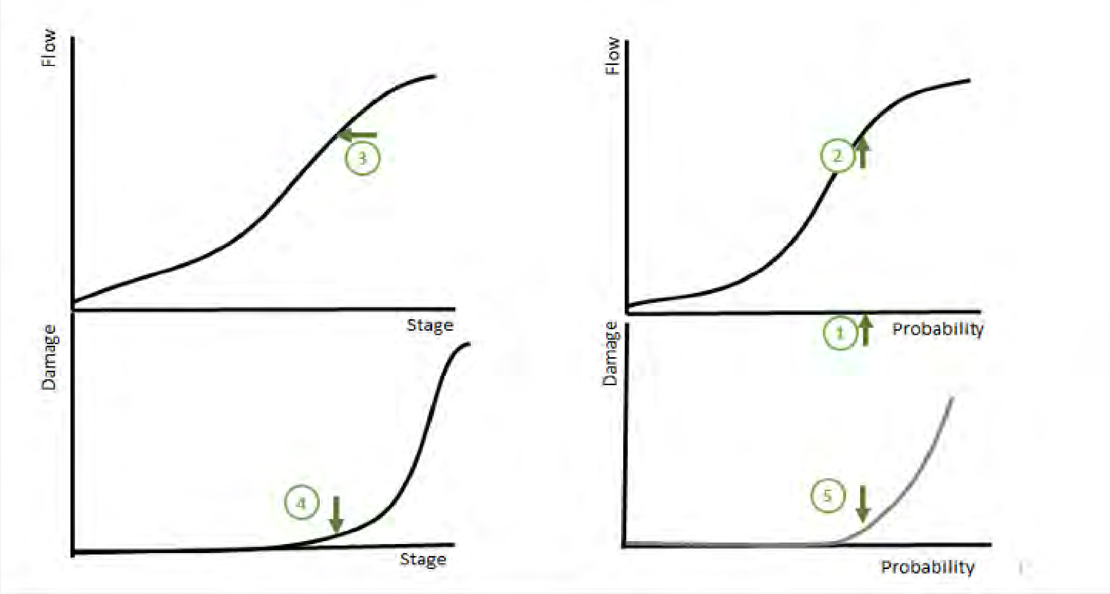


Figure G-8. / Sampling values off of deterministic relationships to produce a deterministic result

Converting this deterministic system to a probabilistic system requires the same basic workflow with three generalized additional steps as described in Figure G-9. First the uncertainties that influence the flow frequency relationship are sampled to create a new flow frequency relationship in step 1, then uncertainties are sampled in our flow stage relationship (or numerical model) to create a new relationship for flow and stage in step 2, then a damage stage relationship is sampled to reflect our uncertainties in stage damage representing a new stage damage relationship in step 4. Steps 4 through 8 are repeated (as in the example above) to span the full probability range of natural variabilities, and ultimately our damage probability curve is integrated to create an estimate of average annualized losses. Following this estimate, steps 1 through 3 are repeated to create a new set of curves (from our originals with our uncertainty distributions) and a new estimate of average annualized losses is computed. This process will continue until the distribution of our decision metrics are stabilized.

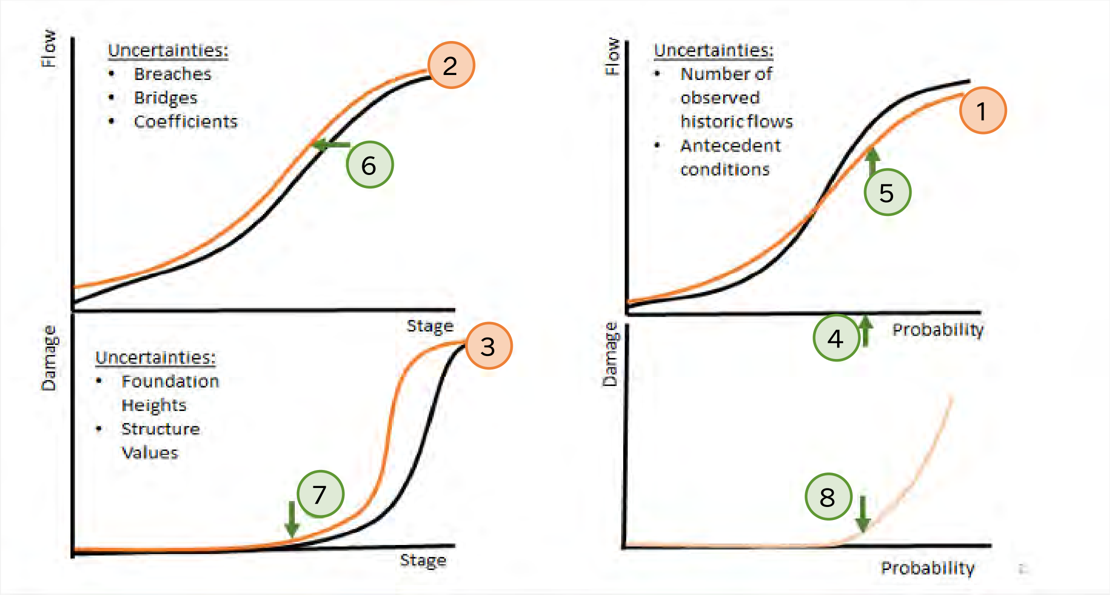


Figure G-9. / Sampling off of relationships with uncertainty using a nested loop to separate natural variabilities from knowledge uncertainties

While the example above focuses on the distribution of estimates of average annualized losses, the same process could be performed for any intermediate computed metric at any spatial scale. Therefore, this process could create a map of annualized stage-exceedance probability across the floodplain as shown in Figure G-12.

G.5 / Common Probabilistic Methods in Water Resources

USGS: Bulletin 17c attempts to describe uncertainty around the flow frequency relationship, with newer, more complete methods for handling non-traditional data sources and improving our ability to account for the uncertainty in the skew estimate, a major parameter defining the flood-frequency distribution at stream gages; its predecessor Bulletin 17b has been providing uncertainty using the non-central T distribution since 1982.

Principles and Guidelines 1983: Supplement III States "Uncertainty and Variability are inherent in water resources planning." Although the language differs in their descriptions from the common practice of today, the principles are there almost 40 years ago. Principles and Guidelines 1983 have been adapted to policy for USACE in practical guidance through ER 1105-2-101, Risk Assessment for Flood Risk Management; and EM 1110-2-1619 (1996), Risk-Based Analysis for Flood Damage Reduction Studies, which were originally written around 1996, and have had multiple updates to keep up with the state of the science. These regulations and manuals have been governing USACE application of probabilistic methods for over 20 years. In section G3, an excerpt from NRC Report 2000 is described, which reviewed the original documents from 1996 and requested their updates to formalize language and to provide guidance on the importance of separating natural variability from knowledge uncertainty. The Nuclear Regulatory Commission (NRC) is investigating Probable Flood Hazard Analysis for inland (including the influence of system-wide dam failures) and coastal storms (including compound flooding)—seeking to address both natural variability and knowledge uncertainty.

G.6 / NRC Report from 2000

In WRDA 96 from the 104th Congress of the United States, Public Law 104-303 of WRDA 96 stated the following (Section 202h):

> The Secretary (Army) shall enter into an agreement with the National Academy of Sciences to conduct a study of the Corps of Engineers' use of risk-based analysis for the evaluation of hydrology, hydraulics, and economics in flood damage reduction studies.

The National Research Council appointed a Committee on the Risk Based Analysis for Flood Damage Reduction. An evaluation WAS completed with a book published by the NRC in 2000. The following comments come from the recommendations of the committee:

- The committee recommends that the Corps' risk analysis method evaluate the performance of a levee as a spatially distributed system.
- The committee recommends that the corps calculate the risks associated with flooding, and the benefits of flood damage reduction project structure by structure rather than conducting risk analysis on damage aggregated over groups of structures in damage reaches.
- The committee thus recommends that the Corps adopt a consistent vocabulary for describing

risk analysis concepts, specifically distinguishing between risk, natural variability, knowledge uncertainty, and measures of system reliability.

- The committee recommends that the federal levee certification program focus not upon some level of assurance of passing the 100-year flood, but rather upon "annual exceedance probability—the probability that an area <mitigated> by a levee system will be flooded by any potential flood. This annual exceedance probability of flooding should include uncertainties derived from both natural variability and knowledge uncertainty.

G.7 / What is Risk?

Risk is described in many ways by many fields, each bring their own unique perspectives that are beneficial to the conversation. ISO 31000 describes risk as "the impact of uncertainty on meeting objectives." If our objective is to reduce flood risk, our uncertainty is having a significant impact on our ability to meet the objective—that is a beneficial construct that should be considered. In engineering circles, Risk is generally described as a functional combination of the probability of a hazard with the significance of the consequence. This view is commonly adopted across many fields in one form or another. Some fields break the description into further components such as exposure, performance, vulnerability, and infrastructure performance, but ultimately the same basic notion exists.

Risk can be used to describe the current condition or some future state, or a combination of both. Risk can be managed through evidence-based approaches targeted at probability reduction or consequence reduction. Risks can be transferred through mitigative measures like insurance, or they can be transformed by changing the nature, likelihood, or consequences of a hazard (this can happen to intensify or reduce risks). Residual risk measures the remaining risk in the floodplain after measures, or with no measures, and it can also be used to describe the remaining risk after some risk management activity has been taken in the future.

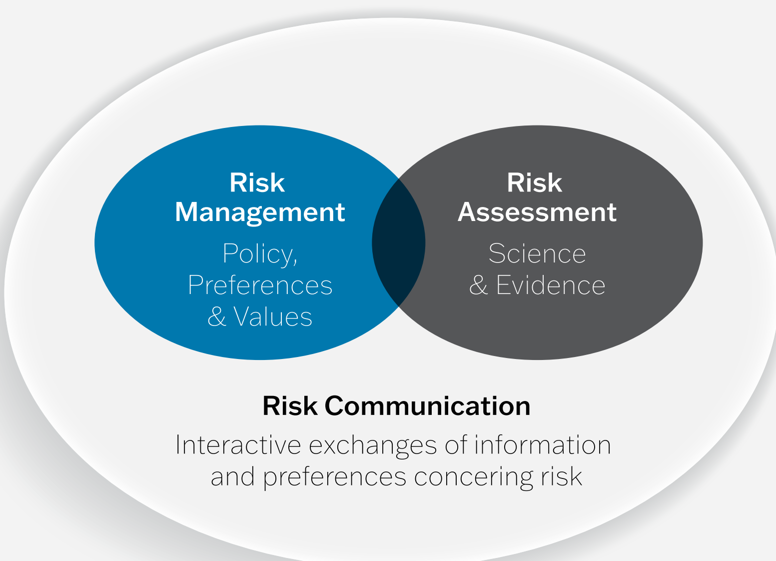


Figure G-10. / The tasks of risk management, risk assessment, and risk communication

G.8 / Risk Analysis

Risk Analysis is composed of related processes (see Figure G-10). This graphic is from a recent report by USACE (Moser 2017) that is an adaption from Moser 2007—which cites the graphic as an adaption from WHO 2007. It depicts Risk analysis as an activity that is composed of Risk Management, Risk Assessment, and Risk Communication.

G.9 / Risk Assessment

Risk assessment in Figure G-11 is the activity associated with evaluating the risks within a context. In the realm of flood risk, one context might be the expected losses at a structure.

"Risk is often described by the following simple equation:

(1.1) Risk = Probability x Consequence

This is not a literal formula for calculating risks. Most risk calculations are more complex. It is instead a conceptual model that helps us think about risk. What it tells us is that there are two essential elements to a risk. If a loss or opportunity of any consequence has no probability of occurring, there is no risk. Likewise, no matter how probable an event, if there is no consequence or undesirable outcome, there is no risk." (Principles of Risk 2017 Yoe Moser).

This definition lends itself to either Qualitative or Quantitative risk assessment processes. In this document, we are discussing quantitative methods that are born of this conceptual framework applied to flood risk. It is important to note the impact of opportunities when considering risk assessment. Properly aligning incentives for healthy activities in the floodplain presents an enormous opportunity that has a probability of success—this in itself should be first in our minds when considering the application of risk analysis in flood risk management.

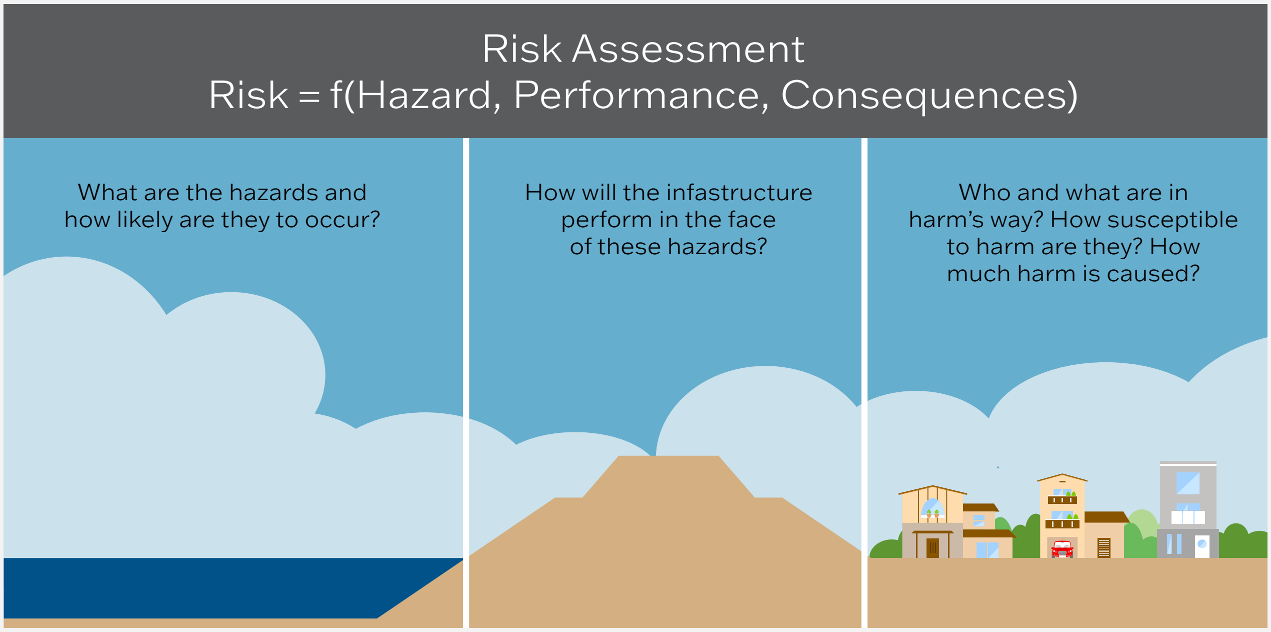


Figure G-11. / Risk equation adopted by many flood risk management activities

Other Risk Formulas

Peter Sandman uses a different equation for risk:

Risk = Hazard + Outrage

This framework can be very important to think through when dealing with public responses to catastrophic disasters. When catastrophe is at hand, the public is not interested in risk as a function of probability and consequences, they are outraged at the consequences of a hazard, and the significance of their plight must be understood before any technical language is used to discuss risk.

In general, the expected losses depend on the likelihood and severity of a hazard occurring at a structure. In the presence of mitigative measures, the performance of the mitigative measures (levees, structure elevations, flood proofing) needs to be evaluated. The hazard is then combined with some characterization of the vulnerability of the structure to a flood and the value of the structure to determine the magnitude of the consequences. This evaluation culminates in a numerical combination of these variables to represent some metric. A common metric is the expected annualized damage or average annualized losses at a structure. As described above, using a single value to represent the risk characterization at a structure is an incomplete characterization of the truth. The Average Annualized Loss (AAL) at a structure should represent the full range of natural variability impacting that structure, scaled by the significance of the consequences. A distribution around this value (a distribution of average annualized losses) should represent our uncertainty in what the true AAL at a structure might be. A risk analysis is the numerical calculation of these sorts of metrics and their distributions.

Monte Carlo simulation is a common approach to this analysis. Monte Carlo analysis is a numerical technique that facilitates integration across relationships where direct functional forms are not necessarily known. A nested Monte Carlo simulation is a common variant used to separate the impact of natural variabilities from the knowledge uncertainties influencing the computed metrics.

The process can follow a sequence as described by the subsequent images. A statistical representation of the hazard is developed through Monte Carlo sampling of the weather. This weather is promulgated through the system to produce flood flows across the watershed. Infrastructure governing the movement of water (levees, dams, nature-based features) change the way water moves through the system and are also modeled. Damage-driving parameters are produced (i.e., maximum depth in the floodplain for a series of events). Those values are tracked across the entire simulation and a statistical representation of these depth grids is produced to describe the annual exceedance probability grids. Figure G-12 describes the Annual Exceedance Probability Grid for an area behind a levee, including levee breaching characteristics sampled at random. This is commensurate with the products that were produced with the PFRA process deployed by FEMA in FY 20. This is a hazard-based metric that could represent a significant shift towards a graduated view of the flood hazard.

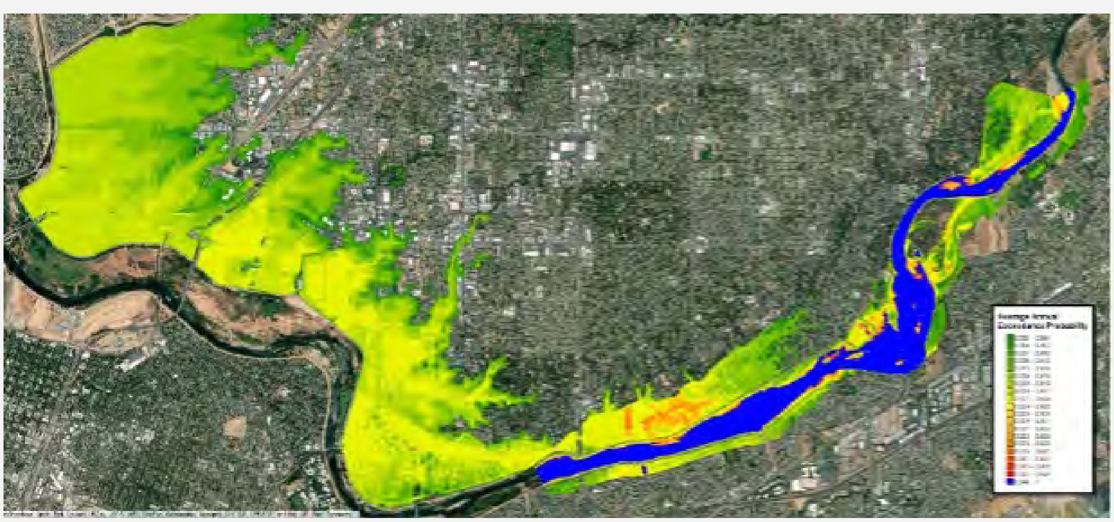


Figure G-12 / An Annual Exceedance Probability map describing the likelihood of flooding behind a levee with breaches
For ADA accommodation for this figure, please contact the TMAC DFO at FEMA-TMAC@fema.dhs.gov

Production of other useful metrics is possible. For example, using the depths produced to evaluate the number of times a structure is wet above the first floor can be a meaningful metric for describing the likelihood a hazard may impact a home. This is a hazard-based metric that is site specific and can be a useful emergency management and communication tool (Figure G-13).

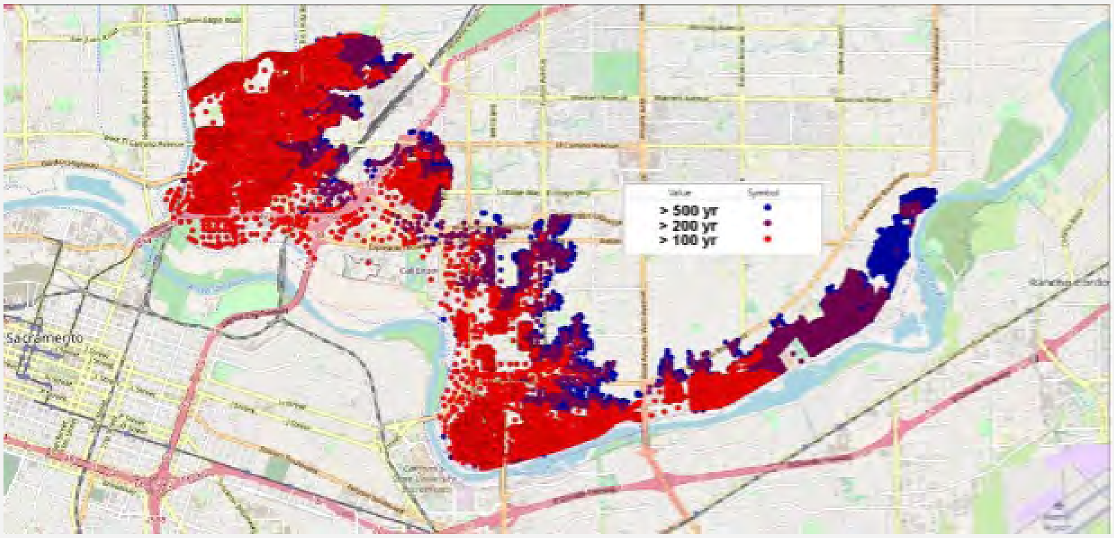


Figure G-13 / Annual Exceedance Probabilities at structures representing the likelihood of flooding above the first floor elevation
For ADA accommodation for this figure, please contact the TMAC DFO at FEMA-TMAC@fema.dhs.gov

Scaling the depth estimates to a nonlinear depth-damage relationship (by structure classification) and then by structure value represents a transformation of hazard information into a risk metric. Figure G-14 represents a deterministic view of the Average Annual Losses at all structures in the modeled area. Average Annual Losses are not represented by a linear relationship with the likelihood a structure gets wet above its first floor. Rather, the loss is scaled by the nonlinear relationship of the depth damage relationship with further spatial disaggregation of the risk due to the valuation of the structures. This makes maps of AAL not follow the intuitive graduated view that AEP maps (Figure G-12) present.

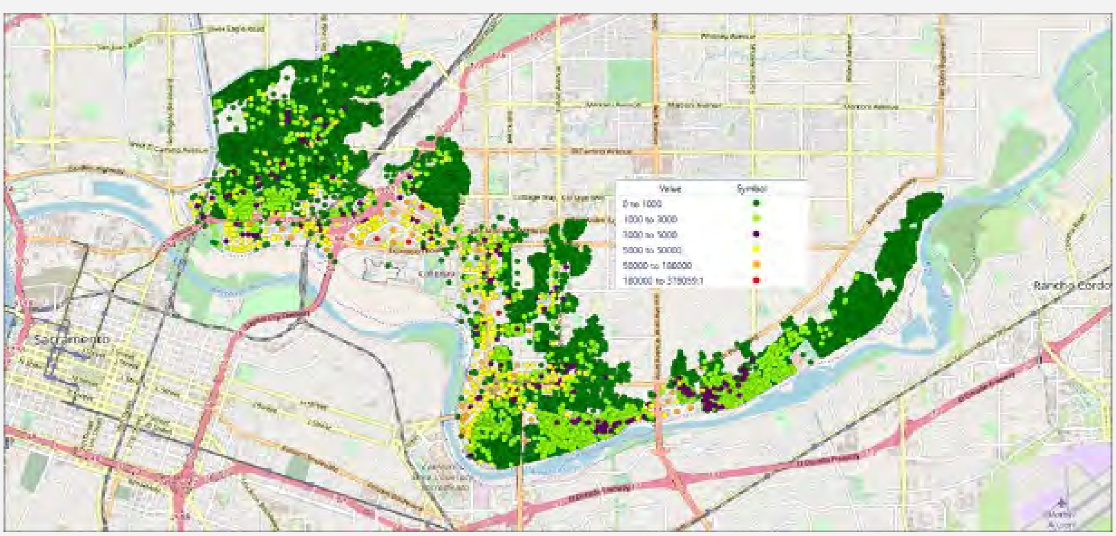


Figure G-14 / A map of Average Annualized Loss (AAL) at all of the structures in the modeled area
For ADA accommodation for this figure, please contact the TMAC DFO at FEMA-TMAC@fema.dhs.gov

Scaling the depth estimates to a nonlinear depth-damage relationship (by structure classification) and then by structure value represents a transformation of hazard information into a risk metric. Figure G-14 represents a deterministic view of the Average Annual Losses at all structures in the modeled area. Average Annual Losses are not represented by a linear relationship with the likelihood a structure gets wet above its first floor. Rather, the loss is scaled by the nonlinear relationship of the depth damage relationship with further spatial disaggregation of the risk due to the valuation of the structures. This makes maps of AAL (Figure G-14) not follow the intuitive graduated view that AEP maps (Figure G-13) present.

G.10 / Risk Management

Risk-based metrics created through a probabilistic risk assessment methodology can yield information useful for managing risk. The metrics can be compared to some standard, or to a relative measure of acceptable risk.

For example, in continuing the theme of AALs, a risk assessment would include comparing that analyzed value to some objective to support a decision. If the analyzed value is less than a threshold that describes some measure of acceptable risk, the risk is assessed to be acceptable. If the analyzed risk is above the threshold, it represents a risk that is no longer acceptable. Risk Assessment frameworks can be simple or complex. In the example so far, we have focused on a system expressed in terms of the economic value of risk. Other agencies and stakeholders consider other value systems in addition to economic systems. The risk management stage of risk analysis must be able to support multiple decision criteria across multiple metrics of differing value systems.

Building mitigative measures such as levees to remove a statutory requirement for flood insurance may reduce economic losses estimated for the events up to the requirement, but events beyond the requirement have no significant risk transfer (such as insurance) to provide a buffer for the citizens behind the system. This does not include the relationship of building moratoriums associated with statutory requirements that allow for reckless construction in areas reclaimed by structural mitigative measures. In this instance, a decision based on an economic value system has introduced consequence creep, which intensifies the significance of future economic losses and life safety issues. Considering the economic impacts alone in justification of mitigation activities is troublesome. Neglecting to acknowledge the impact on future life safety consequences cuts against the very core of the code of ethics for most professional engineering societies, which hold paramount the safety of the public. The risk management practices deployed by FEMA must acknowledge the impacts across other value streams than simple economics.

The evaluation of risk in a quantitative framework as described above can provide valuable decision metrics across the range of possible events and possible consequences. This information can be used to inform risk mitigation activities across multiple decision criteria. To best leverage the information, the objectives of the risk management activities must be clearly articulated. The ISO definition of Risk as the impact of uncertainty on meeting objectives is a much better way to think about risk at this stage in the risk management process. When faced with the difficult vision of creating a more flood-resilient nation, the strategic objectives need to be crystal clear. Is the flood resiliency only pertaining to the ability for people to recover? What about businesses? What about ecosystems? Clearly identifying strategic goals that help achieve the stated objective (with a shared understanding of the objective) is critical to any risk management framework.

Each of these strategic goals must be associated with clear metrics that describe the ability for the system to continue to exist, to operate at a reduced capacity, and to operate at an acceptable capacity. These are typically referred to as the risk capacity, risk tolerance, and risk appetite. For each strategic objective, a description of the capacity, tolerance, and appetite must be defined in such a way as to support minimizing the variance associated with meeting the strategic objective that supports the vision of a more flood-resilient nation.

To clarify the importance of clearly stated goals, the following example is provided (Figure G-15). Suppose a diabetic has a young daughter. Diabetics have many possible negative outcomes associated with poor management of their disease state. One of the first significant failures is the loss of vision. If the diabetic wished to manage the risk associated with the disease enterprise, risk management would suggest setting strategic objectives with measurable metrics to reduce the variability in meeting outcomes. The first step would be to define strategic outcomes. The goal "I wish to be at my daughter's wedding" is remarkably different than "I wish to see my daughter's wedding" regarding the setting of risk capacities, tolerances, and appetites on the metric A1C (a description of 3-month running average of blood sugar levels).

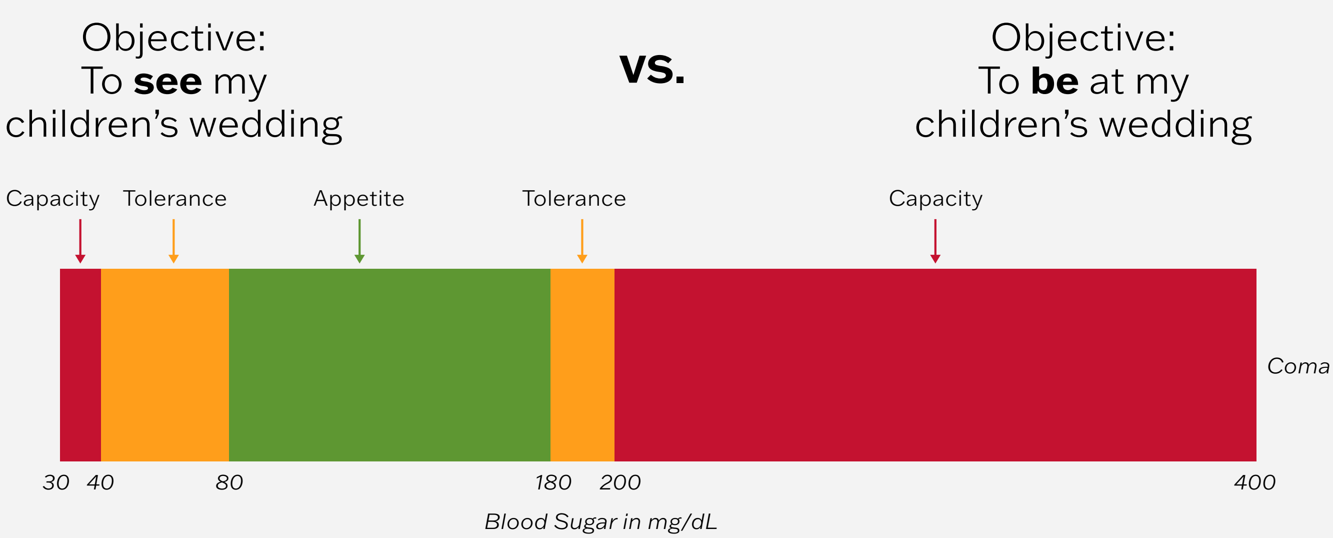


Figure G-15. / An example describing a hypothetical Appetite, Tolerance, and Capacity for a diabetic, and objectives that may drive different outcomes on the setting of appetites and tolerances

There are many aspects here to consider when thinking about risk management activities to produce a more flood-resilient nation. A metric that could be developed, measured, and evaluated would be the count of flood policies by state, which could associate directly with the strategic objective of reducing the insurance gap. The metrics can be from probabilistic analysis, or from empirical collection of data, pre- or post-storm. Each objective must have criteria for capacity, tolerance, and appetite, and clear and actionable mitigation plans for each goal that are triggered based on metrics being in the tolerance or capacity range.