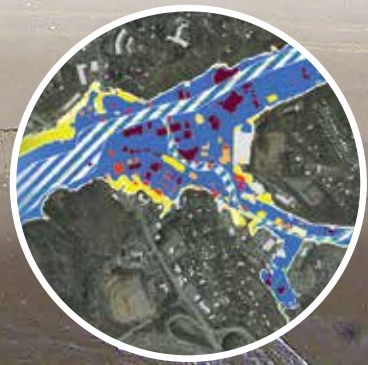
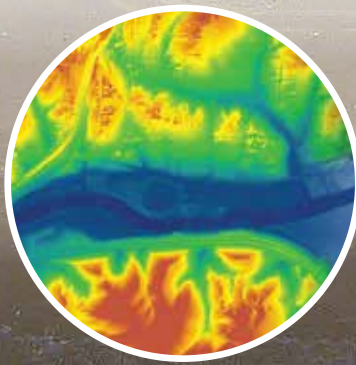


TMAC

TECHNICAL MAPPING ADVISORY COUNCIL



2018 Annual Report



TMAC

Technical Mapping Advisory Council

September 2019

Pete T. Gaynor
Acting Administrator
Federal Emergency Management Agency
500 C Street SW
Washington, DC 20472

Acting Administrator Gaynor,

As Chair of the Technical Mapping Advisory Council (TMAC), I am pleased to forward to you the TMAC 2018 Annual Report for your consideration. The 2018 Annual Report focuses on three areas: communicating uncertainty, prioritizing unmapped areas, and increasing insurance coverage. This Annual Report includes five new recommendations for FEMA to consider.

The TMAC conducted three in-person public meetings and four virtual administrative meetings between January 2018 and July 2019. Subcommittees were established and met regularly with invited subject matter experts presenting information relevant in the construction of the proposed recommendations contained in the 2018 Annual Report. Through much effort, discussions, deliberations and votes in July 2019, the TMAC concurred to submit the 2018 Annual Report.

The 2018 Annual Report would have been submitted to you much earlier than now. However, the appointments for sixteen of the TMAC members lapsed on September 30, 2018. This left only four active TMAC members and did not allow the TMAC to have a quorum to conduct business and finalize the 2018 Annual Report before now. The appointments were finally made on March 14, 2019. The cause of the delays was not with the FEMA staff supporting the TMAC. It was due to an excessive amount of time taken for vetting members – many of which were simple re-appointments of members who had been vetted before. We have two members whose vetting took over eighteen months. I encourage you to urge those performing the vetting process to be ready for the next wave of appointments and get the job done in time to avoid shuttering the TMAC again. A functioning TMAC is critical to helping both FEMA and Congress make more informed choices on potential improvements to the mapping elements of the National Flood Insurance Program.

In the short time remaining in 2019, the TMAC will respond to Mike Grimm's letter dated July 8, 2019 by reviewing previous TMAC recommendations and setting the stage for producing the 2020 annual report.

Respectfully,



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



WATCH
FOR WATER ON
ROAD

SPEED
LIMIT
35



TECHNICAL MAPPING ADVISORY
COUNCIL

TMAC 2018 Annual Report

August 2019

All illustrations in this document were created by
the Technical Mapping Advisory Council or a contractor unless otherwise noted.



Executive Summary

As we exit the Spring and enter the 2019 Hurricane season, we are reminded yet again of the devastating impacts flooding has on the US economy, its citizens, and natural landscapes. In March of this year, flooding in the Midwest damaged roads, bridges, levees and dams as it inundated millions of acres of agriculture as well as cities and towns across Nebraska, Iowa, Missouri, South Dakota, Minnesota and Wisconsin. The losses are still being tallied as this report is being finalized. In May, a storm system cut across the southern and central US where rivers rose to levels that prompted evacuations disrupting lives in Oklahoma and Arkansas. Earlier that same month the governors of Mississippi and Louisiana both declared states of emergency due to flooding.

Meanwhile, the Nation continues to struggle to recover from the unprecedented impact of 2017's hurricanes Harvey, Irma, and Maria, and the devastating flooding caused by Hurricanes Florence and Michael both making landfall towards the 2018 season. These events remind us of the importance of our mission: to provide counsel to the Federal Emergency Management Agency (FEMA) on strategies and actions that will efficiently and effectively advance the identification, assessment, and management of flood hazards and risk.

Through the National Flood Insurance Program's (NFIP) National Flood Mapping Program (Program), 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 supplying review and recommendations to FEMA on matters related to the Program as authorized and directed by the Biggert-Waters Flood Insurance Reform Act of 2012, as amended (42 U.S.C. §§ 4001–4130) (BW-12), the Homeowner Flood Insurance Affordability Act of 2014, and Agency tasking.

Since its establishment in 2014, the TMAC has delivered six reports that include 34 recommendations and 13 implementation actions to inform the FEMA Administrator's decisions to certify and develop the National Flood Mapping Program to address critical issues.

In 2018, FEMA tasked the TMAC to address three priority topics of key importance as it considers ways to improve how flood data is generated and delivered, redesigns flood risk rating for insurance, and evolves its products and services to best meet customer needs:

- Explore ways to communicate uncertainty and precision associated with data models and resulting Special Flood Hazard Areas (SFHAs) from FEMA studies without undermining risk communication and the perceived credibility of FEMA information
- Explore the appropriate criteria FEMA should consider in prioritizing unmapped areas, considering the need to create and maintain credible data for more populous areas while inspiring good mitigation practices nationally
- Examine how the FEMA national flood mapping program may take steps to increase flood insurance coverage nationally

Due to the member vetting processes the TMAC had a lapse in member appointments and reapportionments. This delayed the TMAC in delivering the 2018 TMAC annual Report. The lapse in membership prevented the TMAC from having a quorum to conduct business and finalize the Annual Report. In July 2019, the TMAC was able to discuss, deliberate and vote on the Report. In this Report, the TMAC responded to its tasking by delivering recommendations as to how FEMA may better communicate uncertainty surrounding flood hazard and its consequences, plan to address unmapped areas of the Nation, and increase flood insurance coverage nationally, as below:

Table ES-1: TMAC Recommendations 2018

TOPIC	RECOMMENDATION	
Communicating Uncertainty	AR 30	FEMA should establish upper and lower bounds for the 1%-annual-chance exceedance flood elevation using a confidence interval size of their choosing and use those limits to map the SFHA “Boundary Zone”—the area where this SFHA boundary is most likely to be. FEMA should share SFHA Boundary Zone information with the public, and other key interested parties, test how it is received, and make improvements prior to formalizing any specific standards or policy for routine map updates.
	AR 31	As part of efforts to communicate uncertainty, FEMA should periodically conduct behavioral risk audits and address the biases that characterize how individuals process information on flood risk to their property. The audits and actions taken (including language regarding the likelihood of flooding) to address biases will also help other key stakeholders, such as floodplain managers, local officials, lenders, developers, and real estate agents, to encourage property owners to invest in cost-effective mitigation measures and purchase flood insurance before the next flood occurs.
Prioritizing Unmapped Areas	AR 32	FEMA should modify its Flood Hazard Mapping Key Decision Point (KDP) Process and adopt criteria to weigh the value of providing non-regulatory projects even where the development of Flood Insurance Rate Maps (FIRMs) or Flood Insurance Studies (FISs) is not warranted.
Increasing Insurance Coverage	AR 33	Building from AR16, FEMA should share and communicate data that can help drive decisions toward purchasing flood insurance, mitigation prioritization, and reducing risk. This data should support historical, future, and probabilistic analyses of coastal, fluvial, and pluvial flood hazards. FEMA should work with other agencies to assist data collection, creation, and sharing to support integrated water resources management and encourage data sharing.
	AR 34	To increase insurance coverage, expanding on AR28, FEMA should include, as part of their non-regulatory products suite, areas previously identified as SFHAs, including information available in the Community Information System, and areas of previous flooding. This information should be easily maintained, support and communicate the actuarial rating of NFIP flood insurance, and empower informed decisions by property owners and local, regional, Tribal, and State agencies.



pittsburg, pa

Show search results for pittsburg, pa

Print Flood Map

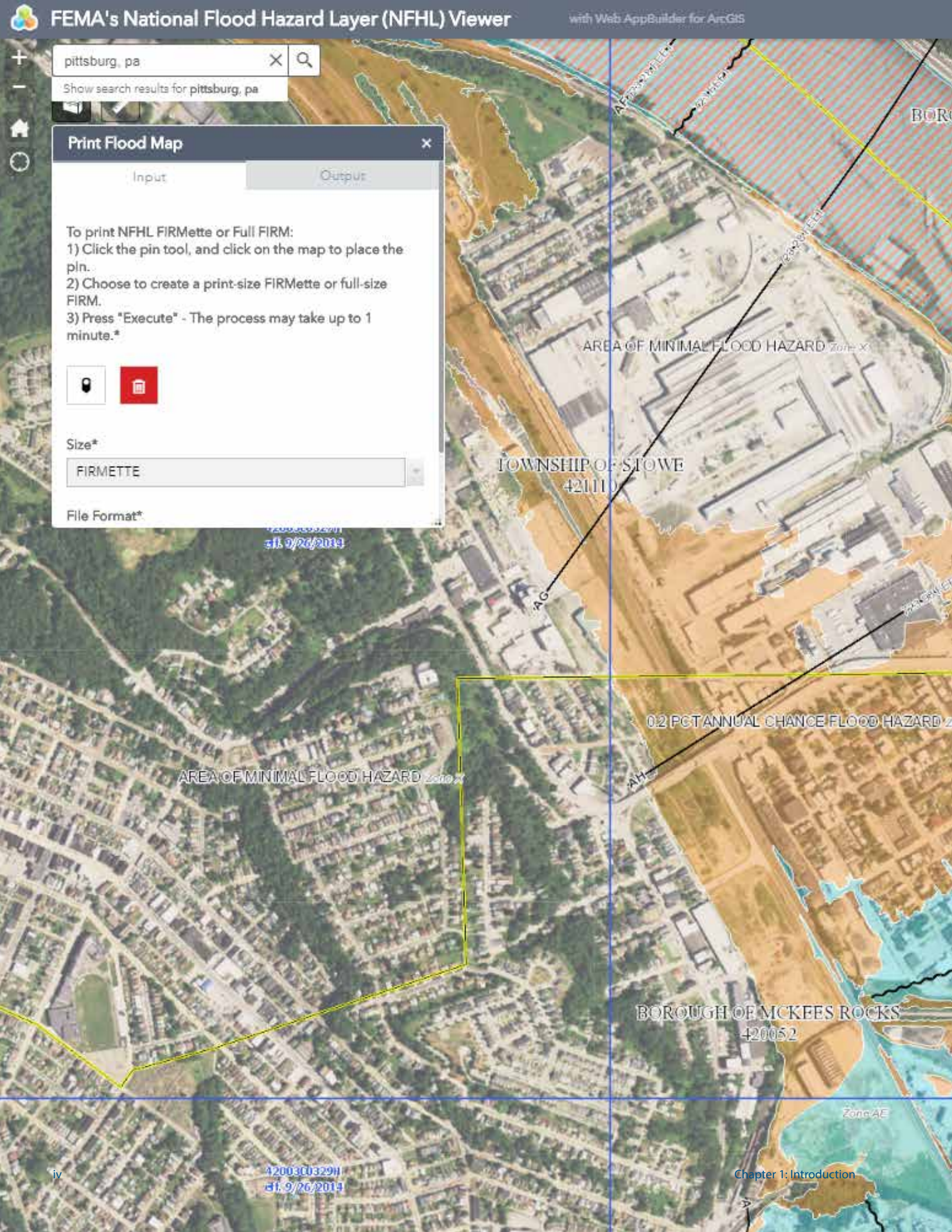
Input Output

To print NFHL FIRMette or Full FIRM:
 1) Click the pin tool, and click on the map to place the pin.
 2) Choose to create a print-size FIRMette or full-size FIRM.
 3) Press "Execute" - The process may take up to 1 minute.*

Size*
 FIRMETTE

File Format*



4200300329H
01. 9/26/2014

AREA OF MINIMAL FLOOD HAZARD Zone X

0.2 PCT ANNUAL CHANCE FLOOD HAZARD ZONE X

BOROUGH OF MCKEES ROCKS
420052

Zone AE

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Acronyms and Abbreviations

3DEP	3D Elevation Program
AAL	Annualized Average Loss
AAPL	Average Annualized Percentage of Loss
ADFO	Alternate Designated Federal Officer
BFE	Base Flood Elevation
BW-12	Biggert-Waters Flood Insurance Reform Act of 2012
CDS	Customer and Data Services
CIS	Community Information System
CNMS	Coordinated Needs Management Strategy
CTPs	Cooperating Technical Partners
DFO	Designated Federal Officer
FACA	Federal Advisory Committee Act
FEMA	Federal Emergency Management Agency
FIRMs	Flood Insurance Rate Maps
FISs	Flood Insurance Study
FOIA	Freedom of Information Act
FUB	Flood Uncertainty Band
GIO	Geospatial Information Officer
GIS	Geographic Information Systems
HFIAA	Homeowner Flood Insurance Affordability Act of 2014
HUC8	Hydrologic Unit Code 8
HWMs	High Water Marks
ICC	Increased Cost of Compliance
IWRSS	Integrated Water Resources Science and Services
KDPs	Key Decision Points
LAG	Lowest Adjacent Grade
LiDAR	Light Detection and Ranging
LiMWA	Limit of Moderate Wave Action

LOMAs	Letters of Map Amendment
LOMCs	Letters of Map Change
LOMR-F	Letters of Map Revision based on Fill
MIP	Mapping Information Platform
MS4	Municipal Separated Storm Sewer Systems
NAPA	National Academy of Public Administration
NAVD 88	North American Vertical Datum of 1988
NFHL	National Flood Hazard Layer
NFIP	National Flood Insurance Program
NHD	National Hydrography Dataset
NOAA	National Oceanic and Atmospheric Administration
NVUE	New, Valid, Updated Engineering
NWS	National Weather Service
OFA	Other Federal Agencies
PFD	Primary Frontal Dune
Program	National Flood Mapping Program
PTS	Production Technical Services
Risk MAP	Risk Mapping, Assessment, and Panning
RL	Repetitive Loss
SBA	Small Business Administration
SFHA	Special Flood Hazard Area
SLR	Sea Level Rise
SMEs	Subject Matter Experts
SOMA	Summary of Map Actions
SRL	Severe Repetitive Loss
TMAC	Technical Mapping Advisory Council
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VR	Virtual Reality
WSELs	Water Surface Elevations

1. Introduction

Flooding poses a significant threat to the economy, lives, and the natural environment. It remains the most costly natural hazard in the United States. Since 1978, the NFIP has paid over \$64 billion in claims. Further, flood damage is increasing because of sea level changes, changing climatological patterns, and increased development in floodplains (National Wildlife Federation, n.d.).

FEMA plays a crucial role in helping communities reduce the risk of loss of life and property damage from flooding by assessing flood risk through its National Flood Mapping Program and by disseminating flood risk information.

As mandated by BW-12, FEMA established the TMAC, a Federal advisory committee, to review and recommend improvements to the Program and to assess projected future conditions as they relate to flooding.

1.1 Congressional Charter

Pursuant to BW-12, the charter filed with Congress on July 29, 2013 formally established the TMAC. The TMAC was established in accordance with and operates under the provisions of the Federal Advisory Committee Act of 1972, as amended (5 U.S.C. App 2).

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

1.2 TMAC Responsibilities

The TMAC provides advice and recommendations to the Administrator of FEMA to improve the preparation of Flood Insurance Rate Maps (FIRMs) and flood hazard information. Congress has directed that the TMAC submit an annual report to the Administrator.

Among its responsibilities, the TMAC provides recommendations to FEMA on how to cost-effectively improve the accuracy, quality, ease of use, and distribution and dissemination of FIRMs and risk data as well as other requirements mandated by BW-12.

¹ BW-12 was amended by the Homeowner Flood Insurance Affordability Act of 2014 (HFIAA) (Public Law 113-89, 128 Stat. 1021-22).

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

The 2018 and 2019 TMAC members, subcommittee members, and Designated Federal Officers (DFOs) are listed in Tables 1–1, 1–2, 1–3, and 1-4 respectively.

Table 1-1: TMAC 2018 Members

TMAC MEMBER	BW 12 TMAC MEMBERSHIP REQUIREMENT
Jeffrey L. Sparrow, P.E., CFM (TMAC Chair) FEMA Market Lead, Michael Baker International	Mapping Member
Douglas A. Bellomo, P.E. (TMAC Vice Chair) Senior Technical Advisor for Flood Risk Management	U.S. Army Corps of Engineers Designee
Christopher J. Bender, Ph.D., P.E., D.CE Senior Coastal Engineer, Taylor Engineering, Inc.	Engineering Member
Richard Butgereit, GISP Chief Information Officer, Florida Division of Emergency Management	State Geographic Information System Representative
John Dorman, CFM Assistant State Emergency Management Director for Risk Management, North Carolina Emergency Management	State Cooperating Technical Partner Representative
Scott Giberson, CFM Compliance Principal, CoreLogic Flood Services	Flood Hazard Determination Firm Member
Jeffrey L. Giering, CFM State Hazard Mitigation Office, Louisiana Governor’s Office of Homeland Security and Emergency Preparedness	State Hazard Mitigation Officer
Carrie Grassi Deputy Director for Planning, New York City Mayor’s Office of Recovery and Resiliency	Local Cooperating Technical Partner Representative
Suzanne Jiwani, P.E., CFM Floodplain Mapping Engineer, Member of Association of State Floodplain Managers	Floodplain Management Member
Carey Johnson Environmental Scientist Consultant, Director’s Office, Kentucky Division of Water	State Cooperating Technical Partner Representative
Howard Kunreuther, Ph.D. James G. Dinan Professor and Co-Director, Risk Management and Decision Processes Center, Wharton School, University of Pennsylvania	Risk Management Member
Wendy Lathrop, PLS, CFM President and Owner, Cadastral Consulting, LLC	Surveying Member
Tony LaVoi Geospatial Information Officer (GIO), National Oceanic and Atmospheric Administration	National Oceanic and Atmospheric Administration/Commerce for Oceans and Atmosphere Designee
Robert Mason, P.E. Extreme Hydrologic Events Coordinator, U.S. Geological Survey	U.S. Department of the Interior Designee
Salomon Miranda, P.E. NFIP Coordinator, California Department of Water Resources, Southern Region Office	State National Flood Insurance Coordination Office Representative
Ngoc Nguyen, P.E. Interim Deputy Operating Officer, Santa Clara Valley Water District	Local Cooperating Technical Partner Representative
Luis Rodriguez, P.E. Director, Engineering and Modeling Division, Federal Insurance and Mitigation Administration, Federal Emergency Management Agency	FEMA Designee
Javier E. Ruiz Acting Director, National Geospatial Center of Excellence, Natural Resources Conservation Service	U.S. Department of Agriculture Designee
Joshua Hayes Stuckey* Chief Administrative Officer, Harris County, Texas Public Infrastructure	Regional Flood and Stormwater Management Member
Michael Tischler, Ph.D.* Director, National Geospatial Program	U.S. Geological Survey Representative

Table 1-2: TMAC 2019 Members

Jeffrey L. Sparrow, P.E., CFM (TMAC Chair) Vice President Moffat & Nichol	Mapping Member
Douglas A. Bellomo, P.E. (TMAC Vice Chair) Vice President, AECOM	Engineering Member
Scott Giberson, CFM Compliance Principal, CoreLogic Flood Services	Flood Hazard Determination Firm Member
Jeffrey L. Giering, CFM State Hazard Mitigation Office, 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, P.E., CFM Floodplain Mapping Engineer, Member of Association of State Floodplain Managers	Floodplain Management Member
Carey Johnson Assistant Director, Director's Office, Kentucky Division of Water	State Cooperating Technical Partner Representative
Carolyn Kousky Director of Policy Research and Engagement, Risk Management and Decision Processes Center, Wharton Risk Management and Decision Processes Center	Risk Management Member
Tony LaVoi Geospatial Information Officer (GIO), National Oceanic and Atmospheric Administration	National Oceanic and Atmospheric Administration/Commerce for Oceans and Atmosphere Designee
David Love Project Manager, Mecklenburg County Storm Water Services	Local Cooperating Technical Partner Representative
Robert Mason, P.E. Extreme Hydrologic Events Coordinator, U.S. Geological Survey	U.S. Department of the Interior Designee
Salomon Miranda, P.E. NFIP Coordinator, California Department of Water Resources, Southern Region Office	State National Flood Insurance Coordination Office Representative
James Nadeau Owner, Nadeau Land Surveys	Surveying Member
Ngoc Nguyen, P.E. Deputy Operating Officer, Santa Clara Valley Water District	Local Cooperating Technical Partner Representative
Luis Rodriguez, P.E. Director, Engineering and Modeling Division, Federal Insurance and Mitigation Administration, Federal Emergency Management Agency	FEMA Designee
Jonathan Smith Director, Resource Inventory Division, Natural Resources Conservation Service	U.S. Department of Agriculture Designee
Joshua Hayes Stuckey Chief Administrative Officer, Harris County, Texas Public Infrastructure	Regional Flood and Stormwater Management Member
Michael Tischler, Ph.D. Director, National Geospatial Program	U.S. Geological Survey Representative
VACANT	U.S. Army Corps of Engineers Designee
VACANT	State Geographic Information System Representative

Table 1-3: TMAC 2018 Annual Report Subcommittees

Douglas A. Bellomo, P.E. (TMAC Vice Chair) Senior Technical Advisor for Flood Risk Management	Communicating Uncertainty (Subcommittee Co-Chair)
Christopher J. Bender, Ph.D., P.E., D.CE Senior Coastal Engineer, Taylor Engineering, Inc.	Communicating Uncertainty
J. William Brown Center Director, Flood Science Center, Association of State Floodplain Managers	Increasing Coverage
Richard Butgereit, GISP Chief Information Officer, Florida Division of Emergency Management	Increasing Coverage
Rachel Hogan Carr Executive Director, The Nurture Nature Center	Increasing Coverage
John Dorman, CFM (TMAC Chair) Assistant State Emergency Management Director for Risk Management, North Carolina Emergency Management	Increasing Coverage
Scott Edelman, P.E. Senior Vice President, AECOM Water Resources	Communicating Uncertainty
Steven J. Fink, P.E. Levee Safety Program Manager, US Army Corps of Engineers	Communicating Uncertainty
Scott Giberson, CFM Compliance Principal, CoreLogic Flood Services	Communicating Uncertainty
Jeffrey L. Giering, CFM State Hazard Mitigation Office, Louisiana Governor’s Office of Homeland Security and Emergency Preparedness	Increasing Coverage
David Guignet State NFIP Coordinator, Maryland Department of the Environment	Increasing Coverage
Carrie Grassi Deputy Director for Planning, New York City Mayor’s Office of Recovery and Resiliency	Communicating Uncertainty
Suzanne Jiwani, P.E., CFM Floodplain Mapping Engineer, Member of Association of State Floodplain Managers	Prioritizing Unmapped Areas (Subcommittee Chair)
Carey Johnson Environmental Scientist Consultant, Director’s Office, Kentucky Division of Water	Increasing Coverage (Subcommittee Chair)
Christopher P. Jones, P.E. Registered Professional Engineer	Communicating Uncertainty
Carolyn Kousky Director of the Policy Research and Engagement, Risk Management and Decision Processes Center, Wharton Risk Management and Decision Processes Center	Communicating Uncertainty
Howard Kunreuther, Ph.D. James G. Dinan Professor and Co-Director, Risk Management and Decision Processes Center, Wharton School, University of Pennsylvania	Communicating Uncertainty (Subcommittee Co-Chair)
Wendy Lathrop, PLS, CFM President and Owner, Cadastral Consulting, LLC	Increasing Coverage
Tony LaVoi Geospatial Information Officer (GIO), National Oceanic and Atmospheric Administration (NOAA)	Communicating Uncertainty
David Love Project Manager, Mecklenburg County Storm Water Services	Communicating Uncertainty
Robert Mason, P.E. Extreme Hydrologic Events Coordinator, U.S. Geological Survey	Prioritizing Unmapped Areas
Salomon Miranda, P.E. NFIP Coordinator, California Department of Water Resources, Southern Region Office	Prioritizing Unmapped Areas

TMAC SUBCOMMITTEE MEMBER	SUBCOMMITTEE
Dana Moses, PE, PH, D.WRE, PMP Dam Safety Modification Mandatory Center of Expertise, U.S. Army Corps of Engineers	Communicating Uncertainty
James Nadeau Owner, Nadeau Land Surveys	Increasing Coverage
Ngoc Nguyen, P.E. Deputy Operating Officer, Santa Clara Valley Water District	Prioritizing Unmapped Areas
Luis Rodriguez, P.E. Director, Engineering and Modeling Division, Federal Insurance and Mitigation Administration, Federal Emergency Management Agency	Prioritizing Unmapped Areas
Jonathan Smith Director, Resource Inventory Division Natural Resources Conservation Service, U.S. Department of Agriculture	Prioritizing Unmapped Areas

Table 1-4: TMAC Designated Federal Officers

TMAC DESIGNATED FEDERAL OFFICER	TMAC ROLE
Michael Nakagaki Program Specialist, Federal Emergency Management Agency	TMAC Alternate Designated Federal Officer (2018) TMAC Designated Federal Officer (2019)
Mark Crowell Physical Scientist, Federal Emergency Management Agency	TMAC Designated Federal Officer (2018) TMAC Alternate Designated Federal Officer (2019)
John Ebersole Attorney, Federal Emergency Management Agency	TMAC Alternate Designated Federal Officer FEMA Legal Advisor to the TMAC
Siamak Esfandiary Program Specialist, Federal Emergency Management Agency	TMAC Alternate Designated Federal Officer (2019)
Brian Koper Emergency Management Specialist (Mitigation), Federal Emergency Management Agency	TMAC Alternate Designated Federal Officer (2019)

1.3 TMAC Mission and Guiding Principles

The TMAC’s mission is to provide counsel to FEMA on strategies and actions that will efficiently and effectively advance the identification, assessment, and management of flood hazards and risk.

The TMAC believes the following guiding principles should underpin the future of the Program:

- Credible products
- Effective leveraging
- Efficient implementation
- Financial stability
- Stakeholder acceptance

1.4 TMAC Reports

The reports the TMAC has submitted to FEMA since 2015 provide recommendations on a broad range of NFIP topics and are interrelated.

TMAC REPORTS, 2015 TO 2017

The reports the TMAC submitted to FEMA from 2015 to 2017 are listed below.

TMAC 2015 Annual Report (TMAC, 2015b) (hereafter referred to as 2015 Annual Report) includes 22 recommendations on improvements to the following aspects of the Program:

- Framework data management plan
 - Effective communications of flood hazards and risk
 - Maintenance methodology for the national 5-year flood hazard and risk assessment plan
 - Flood hazard identification and risk assessment process
 - Geodatabase-derived digital display implementation plan
 - Transition from 1-percent-annual-chance flood determination to location-specific flood frequency and structure-specific flood risk determination
 - Cooperating Technical Partners (CTPs): Metrics, process, and delegation methodology
 - Advancing future conditions modeling and mapping

TMAC Future Conditions Risk Assessment and Modeling (TMAC, 2015a) (hereafter referred to as Future Conditions report) includes 7 recommendations and 37 sub-recommendations to help FEMA ensure that FIRMs incorporate the best available climate science to assess flood risks and ensure that FEMA may use the best available methodology to consider the impact of the rise in sea level and future development on flood risk.

TMAC National Flood Mapping Program Review (TMAC, 2016b) (hereafter referred to as 2016 Program Review) provides a review of the national flood mapping program with regard to its ability to provide technically credible flood hazard information, when the program is implemented as designed, in areas where FIRMs are prepared or updated. It also includes 14 recommendations to FEMA to assist the agency to provide technically credible flood hazard data into the future. Recommendation 2 of this report is to implement all of the recommendations in the Future Conditions report.

TMAC 2016 Annual Report (TMAC, 2016a) purpose of the 2016 Annual Report was threefold: (1) prioritize the recommendations already provided in the above-referenced three reports, (2) give FEMA further suggestions on how to implement the TMAC's recommendations by proposing 28 implementation actions, and (3) provide two new recommendations. The new recommendations are related to flood risk-rated insurance and how flood hazard and risk data, models, and methodologies tie into the NFIP.

TMAC 2017 Annual Report (TMAC, 2018) the purpose of the 2017 Annual Report is to give further suggestions on how to implement TMAC's recommendations, provide clarification and guidance in response to the 2017 Tasking Memo received from FEMA. FEMA requested clarification and guidance in three specific topic areas: (1) floodplain management, (2) residual risk (also known as structure-specific rating), and (3) future conditions. The TMAC responded by developing five recommendations and nine implementation actions intended to further strengthen FEMA's evolving national flood mapping program, reduce risk, and help keep the nation safe.

TMAC 2018 ANNUAL REPORT

The purpose of the TMAC 2018 Annual Report is to provide FEMA with recommendations related to the following requests from FEMA: (1) evaluate how the FEMA National Flood Mapping Program can take steps to increase flood insurance coverage nationally, (2) explore ways to communicate uncertainty and precision associated with data models and resulting Special Flood Hazard Area (SFHA) from FEMA studies without undermining risk communication and the perceived credibility of FEMA information, and (3) explore the appropriate criteria that the program should consider in prioritizing unmapped areas, while inspiring good mitigation practices nationally.

The requests are detailed in the Tasking Memo, which is provided in Appendix C.



Friendly Area Neighbors



Map of the Friendly Area Neighbors
List of locations in the neighborhood
that are within a 5-minute walk
of the neighborhood center.

- Grocery & Markets
- City Hall
- Fire Station
- Police Station
- Clinic
- Hospital
- Activity Centers
- The Arts
- Community Center
- Library
- Museum
- Recreation Center
- Schools
- Elementary School
- High School
- University

Parks and Open Space
Community Garden
Bikeway
Off-Street Path-Bike path, Soft path
Railroad

Friendly Area Neighbors
Community
Map

2. Communicating Uncertainty

FEMA's strategic plan is to create a better prepared and more resilient Nation by encouraging communities to undertake responsible, cost-effective protective measures to reduce their future disaster losses. In this regard, FEMA has an interest in and opportunity to improve the communication of flood risk uncertainties so the consequences of flooding (impacts on people, property, and the environment) can be better assessed and managed.

This chapter highlights the technical and behavioral challenges and opportunities in communicating flood risk uncertainties to key stakeholders who include, but are not limited to, property owners and renters, business owners, floodplain managers, local officials, lenders, developers, and real estate agents.²

FEMA asked the TMAC to help tackle the challenge of administering the NFIP National Flood Insurance Program which has a legal mandate to publish floodplain boundaries as a tool for implementing minimum floodplain management regulations (44 CFR parts 59 through 72) and to enforce the mandatory flood insurance purchase requirement. FEMA has compiled an extensive and impressive floodplain dataset within the U.S. which identifies land where the probability of flooding is 1% or greater in any given year. These areas are often referred to as “the floodplain” or Special Flood Hazard Area (SFHA).

Flood insurance is required by law for structures in SFHAs that have federally backed mortgages. In addition, communities that participate in the NFIP are required to carry out minimum floodplain management functions in SFHAs. From an administrative and legal perspective, a structure is either in the SFHA and subject to the insurance and floodplain management requirements or outside the SFHA and not subject to them. These administrative necessities have resulted in a pervasive misconception that inside the SFHA flooding is possible and outside the SFHA, flooding is not possible or very unlikely. This fundamental misunderstanding about the nature of flooding and the uncertainties associated with quantifying it, combined with documented decisionmaker biases has led to inaction and surprise—particularly in areas outside the SFHA. Inaction and surprise will likely continue without a concerted effort to improve flood risk communication – including information and open discussion about the uncertainties associated with identifying the SFHA and the certainty that larger floods than that used to administer the NFIP will occur. While this chapter focuses solely on the uncertainty with the SFHA delineation, TMAC emphasizes that larger magnitude floods occur. It is imperative that inundation likelihood be included in any flood risk communication and related uncertainty with the public.

FEMA asked the TMAC to:

Explore ways to communicate uncertainty and precision associated with data models and resulting SFHA from FEMA studies without undermining risk communication and the perceived credibility of FEMA information.

This chapter is focused on communicating the uncertainties associated with delineating the SFHA boundary given the important legal and administrative role that line plays in carrying out the NFIP. Though they exist and can be of considerable size, this chapter does not examine other uncertainties such as those associated with estimating damage to assets exposed to flood hazards.

²Although the challenges and opportunities relate to many other stakeholder groups, this report is focused on the listed key stakeholders with the intent that the recommendations herein may be applicable to others.

The first step in addressing this challenge is understanding what experts know about modeling floods. Section 2.1 highlights some of the technical aspects of a probabilistic flood hazard analysis, which uses statistical techniques to determine uncertainty in flood hazards in riverine and coastal environments. Tables in Appendix G highlight the sources of the uncertainty from atmospheric, land, riverine, and coastal sources. This section also proposes creating an SFHA Boundary Zone addition to the current sharp demarcation between SFHA and non-SFHA, which is necessary for administrative and legal purposes. Introducing the notion of uncertainty in identifying the 1 percent-annual chance floodplain is an important first step in improving communication about the unpredictable nature of flood hazards—particularly to those who live or work in or near the SFHA. Further, it may provide additional room for dialogue regarding potential losses to life and property that goes beyond a simple binary view of the hazard (“in/out”, “yes/no”).

Behavioral issues in communicating uncertainty to key stakeholders are covered in Section 2.2. Developing a strategy for communicating uncertainty requires an understanding of the difference between how interested parties perceive flood risk and how experts perceive the hazard and its consequences. Systematic biases can influence decision-making when there is uncertainty in low probability events such as severe flooding. Section 2.2 suggests ways of addressing these biases using a behavioral risk audit and illustrates how property owners in floodplains and other interested parties can use the tool.

Section 2.3 covers mitigating future losses from flood-related disasters and the role key stakeholders can play in encouraging investments in mitigation. The stakeholders concerned with this challenge include floodplain managers, local officials, lenders, developers, and real estate agents.

Section 2.4 summarizes the key findings of the chapter and presents recommendations on how to improve the communicating flood risk uncertainties.

2.1 Special Flood Hazard Area Boundary Zone

As previously noted, out of administrative and legal necessity, FEMA develops flood mapping products that display the 1-percent-annual-chance floodplain or SFHA as a defined line on a FIRM. Technically, this line is delineated using a single point estimate (the mean) along a probability distribution, or family of possible 1-percent-annual-chance flood elevations. Unlike in the past, when maps were drawn on paper, FEMA's current state-of-the-art mapping procedures allow users to determine with much greater precision where on the surface of the earth the SFHA boundary is. This, coupled with the use of a single point estimate of the 1-percent-annual-chance flood, can lead users to a false sense of certainty regarding the potential extent of flooding during 1-percent-annual-chance events.

Given FEMA's use of modern mapping techniques, once established digitally, the location of the SFHA boundary can be determined on the ground precisely, despite the fact that there is uncertainty associated with the information used to establish the boundary given the random (aleatory) nature of flooding as well as remaining knowledge-based (epistemic) uncertainties. Knowledge-based uncertainties can be reduced through added investments in learning and measuring whereas random natural uncertainties cannot be reduced with additional investments and therefore must be accepted as a characteristic of what is being studied. It is possible, however, to determine upper and lower flood elevation estimates with varying levels of confidence using well established statistical techniques. However, these upper and lower bounds are based in part on assumptions associated with flooding through culverts and under bridges as well as the performance

of water related structures (such as dams and levees). For example, FEMA flood hazard computations assume culverts and bridges are not obstructed by debris during the base flood, that storm surge and rainfall events are statistically independent, and that key variables are stationary (e.g., probability density function properties can be estimated from instrument records alone). Further, once published, the maps are simply a snapshot in time. Physical changes to the landscape during map production and after its publication, both natural (e.g., wildfires, shoreline erosion and accretion) and manmade (e.g., development) can impact flood extents. The use of improved science and new technologies can also change the results, and additional flood, storm, and rainfall records can shift computed flood probabilities. While the SFHA boundary zone proposed in this chapter will not address all the above noted sources of uncertainty, it will address some, and is an important first step at introducing the notion of uncertainty thus providing an opportunity to greatly improve the way flood risk is communicated and managed going forward.

The assumptions that go into flood hazard analyses and the dynamic nature of flooding mean that any computed and published line defining the SFHA has uncertainty associated with it and while it is mathematically possible to determine the upper and lower ranges of the floodplain boundary, exactly how those bounds are established and communicated should, in part, be a function of their purpose.

Probabilistic analysis methods and standardized processes have been developed in recent years that incorporate uncertainty as an integral part of characterizing flood hazards. Stakeholders, such as floodplain managers or community officials, working to develop innovative products or higher standards may want these uncertainty estimates (e.g., confidence intervals) for their decision-making processes. Others, such as real estate agents, lenders and developers, may only want the mean estimate so they can quickly determine mandatory insurance purchase and minimum floodplain management requirements. Regardless, these stakeholders if armed with information about the uncertain nature of flooding, could become powerful advocates for improving flood risk management practices, as discussed in Section 2.3. Alternatively, communicating the uncertainty associated with flood hazard areas could lead to calls for lowering floodplain management standards, reducing the area where flood insurance is mandated, or subsidizing federal flood insurance prices – all of which would lead to greater flood risk to individuals, businesses, communities, states, and the nation as a whole. It will be important to keep in mind the purpose of sharing uncertainty estimates is to improve the public's understanding of the nature of flood hazards so flood risks can be more effectively avoided, reduced, transferred, or accepted.

Though significant advancements have been made to reduce uncertainties in flood hazard analyses and mapping, the remaining uncertainties are a real part of the two key elements that determine the size, shape, and location of the SFHA. The two key elements are:

- The computed mean 1-percent-annual-chance flood elevation (e.g., the average size flood that has a 1 percent chance of being equaled or exceeded in any given year), which is important in understanding how much water is anticipated
- Ground elevation measurements used to identify land exposed to the flooding source and below the computed mean 1-percent-annual chance flood elevation, which gives us the size, shape, and extent of the SFHA

Uncertainties in estimating 1-percent-annual-chance flood elevations for riverine flood sources can be generalized into two major categories: the flow magnitude and the resulting water surface elevation at a given location. There are typically limited observations for estimating the flow-frequency relationship in the range of

the 1-percent-annual-chance flood elevation. Uncertainty in estimating the flow magnitude of the 1 percent-annual-chance flood elevation event can be reduced in some circumstances by using datasets from similar streams in regions with comparable weather characteristics; although a large portion of the uncertainty will remain irreducible based on limitations in sample size and the random nature of flooding. Similarly, the ability to predict the flow characteristics of extreme floods is limited by observations used to calibrate and validate hydraulic models. There can also be changes to the flow characteristics that result from physical phenomena such as channel erosion during the flood, debris blockages, dam or levee failures, and ice jams, which today remain difficult to estimate and are typically not included in the development of the 1-percent annual-chance flood elevation.

For coastal areas, the dynamic nature of the environment makes estimation of low-frequency (less likely) water levels and waves accompanying them challenging for several reasons. Detailed analysis of coastal water levels and waves requires detailed representations of the land elevations and existing vegetation and development conditions in the study area; however, the quality and resolution of coastal conditions data varies by location and conditions are constantly changing. The historical record for strong storm systems (both tropical and extra-tropical) provides critical information on storm parameters that influence storm strength for the study area; however, the historical record is not sufficient to help us understand the likelihood all possible storm conditions. In addition, some locations have a scarcity of strong historical storms to evaluate.

As coastal storm-generated wave and water level conditions differ for the Pacific, Atlantic, Great Lakes, and Gulf of Mexico shorelines, recent FEMA studies have applied different methodologies designed to capture the forcing relevant to the 1-percent annual-chance flood elevation. As a recent example along the Gulf of Mexico and Atlantic (up to New York) coastlines, application of state-of-the-art coupled hydrodynamic and nearshore wave models allows inclusion of the land conditions and storm forcing to develop the water level and wave conditions for a suite of relevant storms. Implementation of computer codes that allow parallel processing (which greatly increase computational efficiency) and access to high-performance computing clusters (designed for parallel processing) has allowed recent studies to include both refined detail in the land conditions and storm suites with approximately 200 to 400 representative storms. Each of these representative storms has an associated probability, which allows estimation of the stillwater level and wave conditions. With additional modeling, total water level (including runup and dune erosion) can be estimated for the 1-percent-annual-chance exceedance probability. Despite the recent advancements in methodologies, uncertainty in the final coastal hazard estimates persists. These uncertainties relate to imperfect models of the extremely complex physical processes that occur from powerful storm systems and with insufficient historical records to capture the range of storm conditions expected to occur over longer time periods. In addition, state-of-the-art modeling systems include many important coastal processes, but cannot capture all of them, such as storm-induced erosion, rainfall, run-off, and storm-water effects.

Appendix G contains tables that identify recent advancements in reducing uncertainties for both riverine and coastal systems while identifying areas of future improvement in further reducing and communicating the uncertainty that remains.

Of the two main variables that make up the size, shape, and location of the SFHA (flood stage and ground elevation), the uncertainty in flood stage cannot be eliminated given its natural variability, and it will be highest in areas where flood records are short or where flooding events are rare. Regardless, FEMA has and continues to take advantage of new data and improved methods for establishing flood elevations, specifically the Base Flood Elevation (BFE). The base flood is the 1-percent-annual-chance flood.

Uncertainties in ground elevation measurements are better known today than they were at the inception of the NFIP. Early in the program, there was widespread use of U.S. Geological Survey (USGS) topographic quadrangle maps for establishing the SFHA. Often these maps were developed using aerial images flown decades earlier using techniques that resulted in ground elevation accuracies of five vertical feet (half a 10-foot contour interval) or more for many parts of the country. FEMA's recent investment in and use of high-resolution elevation data (i.e., USGS 3DEP LiDAR) as it becomes available has significantly reduced the uncertainty in ground elevation measurement. Today, FEMA consistently employs minimum accuracy standards of typically one to two vertical feet depending on the area being studied and the resources available.

It is important to note that no matter the advancements that have been made, it is not possible to eliminate all uncertainty in determining the size, shape, and location of the 1-percent-annual-chance exceedance flood area. Though this may not be comforting to those who wish to predict exactly when, where, and how deep the next flood will be, it is important to be honest and clear about what is known and what remains uncertain. The fact is, while uncertainties have been reduced, they remain high in some areas for reasons beyond FEMA's control. The technical credibility of FEMA's mapping program should not be judged by the amount of uncertainty associated with estimates of the BFE or SFHA. Importantly, knowing uncertainties remain, the TMAC stated in our 2016 Program Review report:

TMAC finds the National Flood Mapping Program, when applied as designed, supplies technically credible flood hazard data in areas where FIRMs are prepared or updated.

That said, it does make it even more critical that uncertainties are clearly communicated as part of the program— in ways that are meaningful and actionable.

PROPOSAL: ESTABLISH A SPECIAL FLOOD HAZARD AREA BOUNDARY ZONE

Although it is not possible to know the exact size and shape of the next 1-percent-annual-chance flood given the random nature of flooding as well as existing knowledge-based uncertainties, it is possible to estimate the amount of uncertainty by determining minimum and maximum extents using proven statistical techniques. It is also possible to communicate the uncertainty while demonstrating fairness in establishing the SFHA boundary using the mean of the computed range, as FEMA currently does.

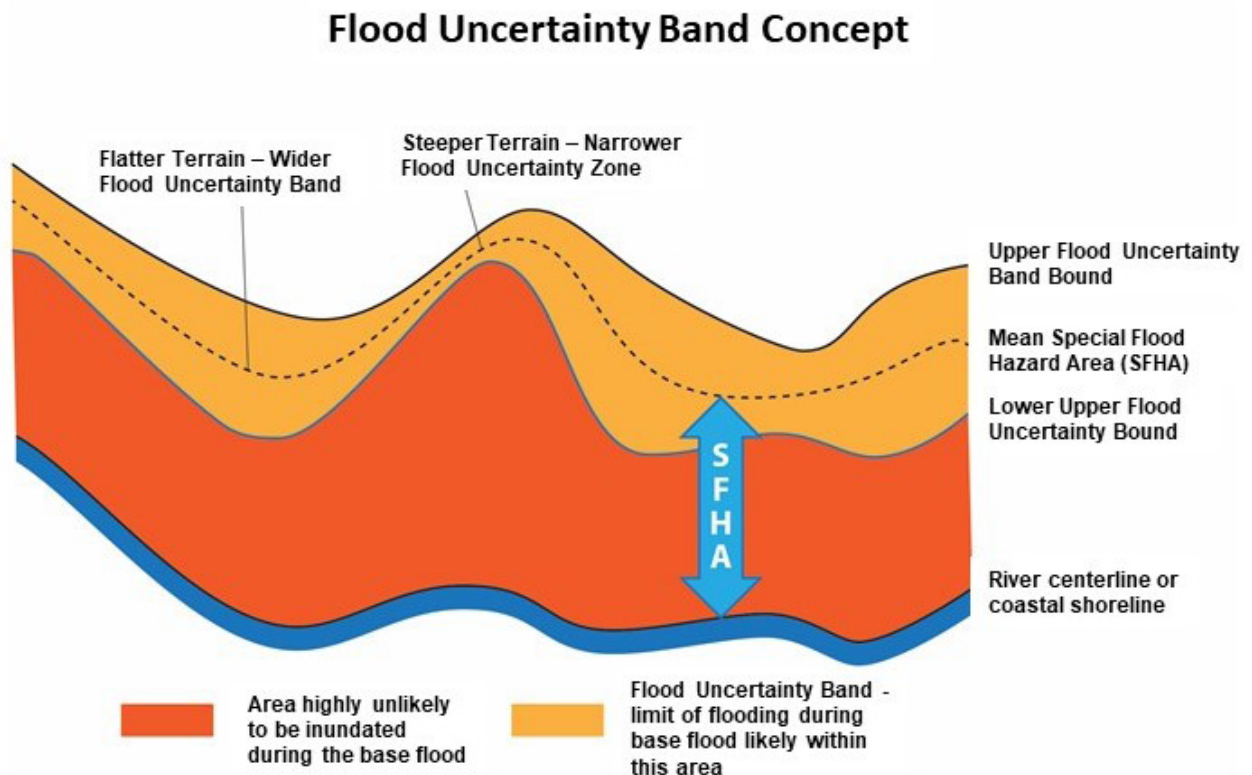
RECOMMENDATION 30

FEMA should establish upper and lower bounds for the 1 percent annual chance exceedance flood elevation using a confidence interval size of their choosing, and use those limits to map the SFHA "Boundary Zone" the area where this SFHA boundary is most likely to be. FEMA should share SFHA Boundary Zone information with the public, and other key interested parties, test how it is received, and make improvements prior to formalizing any specific standards or policy for routine map updates.

The intent of introducing uncertainty around the SFHA boundary is to inform decision making by key stakeholders regarding investing in flood risk mitigation, flood insurance purchase, and new development in flood-prone areas. To effectively communicate the uncertainty surrounding the SFHA boundary, it is proposed that FEMA use a uniform shading to represent this boundary, with the mean denoted as a line bisecting that area and that the SFHA between the flooding source and the lower bound of the SFHA be shaded differently and noted as being highly likely to be inundated during a 1-percent-annual-chance flood. FEMA may choose to assign this area a name that denotes its meaning, such as a “flood uncertainty band (FUB)” or another appropriate name. For the purposes of the rest of this chapter, the term FUB is used as an example name for this new zone. See Figure 2-1 as an example of how to display this information. In steep coastal areas, or areas where wave action or wave runup drive the location of the inland limit of the SFHA, FEMA may need to consider alternative SFHA boundary zone schemes. This chapter discusses the uncertainty of the SFHA boundary, not to be confused with establishing design elevations for a community. A broader discussion of risk and how design elevations should be developed are within the 2015 TMAC Future Conditions Risk Assessment and Modeling Report, chapter 3, section 3.4 pages 3-32 to 3-38.

Importantly, FEMA should take care in communicating that the upper extent of the FUB does not represent the extent of possible flooding. Floods larger than the 1-percent-annual-chance exceedance event depicted in Figure 2-1 remain possible and become more likely when timeframes greater than 1 year are considered. For example, the probability of a home flooding that is built right on the SFHA boundary is not 1 in 100 (1%) over the life of a 30-year mortgage; rather it exceeds 1 in 4 (greater than 25%).

Figure 2-1. Depiction of the SFHA Boundary Zone concept



COMMUNICATIONS EXAMPLE

Using Figure 2-1 as a notional example, FEMA could use the key messages listed in Table 2-1 when proposing updated flood boundaries.

CONCLUSION

Despite the fact that uncertainties exist in estimating and mapping flood inundation areas (including the 1 percent-annual-chance floodplain or SFHA), the current legal construct of the NFIP demands discrete lines and zones be drawn for administrative purposes. This administrative necessity can lead to a misunderstanding regarding the possibility of flooding and potential damages that could result. Further, it exacerbates the binary perception of risk—one where people and property are safe or unsafe, in or out of harm's way, where insurance and floodplain management standards are required or not. This mapping structure leads people to think nothing needs to be done, or that what is minimally required is all that is needed to protect themselves against flood damage.

Table 2-1. SFHA Boundary Zone Key Messages

KEY MESSAGE	SUPPORTING STATEMENTS
Though efforts are made to reduce it, uncertainty exists in this flood hazard depiction, which is the reason for the FUB noted here.	<ul style="list-style-type: none"> FEMA has worked hard to reduce uncertainties associated with its methods for computing flood elevations and the measurements used as input to those models; however, there is an inherent randomness in flooding that makes it impossible to evaluate or eliminate all sources of uncertainty for a flood event. The objective of displaying the FUB on the map is to better communicate that there are many factors which make flooding estimates uncertain.
We are X% confident that when the flood on which we base our national program occurs, the area it impacts will be within the area shown on this boundary zone.	<ul style="list-style-type: none"> However, floods of greater magnitude [such as the<insert local event reference> flood] are possible and would extend damage well beyond this SFHA Boundary Zone.
Within the FUB, there is a line that depicts the limits of the area where flood insurance and other requirements are mandatory	<ul style="list-style-type: none"> As a matter of policy, FEMA feels that using the expected flood elevation and communicating the uncertainty associated with its determination is honest, equitable, and transparent. This line, called the FUB, is developed out of administrative and legal necessity. As a matter of practicality and fairness, FEMA uses the mean 1% annual chance flood elevation to establish the Base Flood Elevation which is then used to set the SFHA boundary.
Properties inside the boundary zone line have a higher risk of flooding than those beyond that limit.	<ul style="list-style-type: none"> Those just outside the SFHA boundary must understand that even though there is no requirement to purchase insurance, there remains a very real possibility of flooding – particularly during events larger than the -percent-annual chance flood. FEMA encourages people both inside and outside the SFHA boundary limit to contact their insurance agents and voluntarily purchase insurance and take other steps to lower their risk. Further, FEMA strongly encourages those responsible for managing flood risk at the state and local level, to establish floodplain management standards beyond the SFHA. Doing this will help ensure property is protected from damages during a 1-percent-annual-chance flood while also mitigating against floods of larger magnitude.
This map is Preliminary right now, but an appeal period is scheduled for XX [time period].	<ul style="list-style-type: none"> FEMA has an appeal procedure in place so those who feel that there are specific errors can provide alternative scientific information, judgments, or assumptions that result in a different flood elevation than that to develop the map before it is finalized. Appeals that result in flood elevations that are within one standard deviation of the average flood elevation—the elevation on which the SFHA boundary lies—will be considered as confirming the proposed estimate given the inherent uncertainties in this type of work. Appeals resulting in flood elevations outside that range will be considered statistically significant and may warrant changes to the proposed flood elevations and the resulting SFHA boundaries.
Even after this map is finalized, it can be revised at any time.	<ul style="list-style-type: none"> Because of data limitations, uncertainty, and changing conditions with time, FEMA has procedures in place so that anyone with better or more current data can, at any time, can request the SFHA and other map features be changed using better or more current data.

TMAC Recommendation 30 proposes the establishment and depiction of a FUB. The purpose of this band is to introduce the concept of uncertainty while meeting administrative mandates and more transparently communicating what is known and unknown about the flood hazard. Sharing this information will help improve communications and FEMA's credibility (e.g., actual 1-percent-annual-chance floods are not as likely to extend beyond the FUB as they are to extend beyond the SFHA) while facilitating actions that go beyond minimum federal insurance purchase and floodplain management requirements.

2.2 Behavioral Risk Audit for Addressing Systematic Biases

Theoretical and empirical research over the past 50 years has revealed that decision-makers exhibit systematic biases that characterize intuitive thinking. This type of thinking is guided by emotional reactions and personal experience in dealing with the uncertainty of the flood hazard and its consequences as shown in Table 2-2. These biases, some of which are discussed here, impact how individuals process information on risks they face and suggest ways that we can communicate uncertainty more effectively. Note that these are only a few of the many biases discussed in the behavioral science literature that have been selected as examples for the purposes of this chapter.

Table 2-2. Systematic Biases Impacting Uncertainty

SYSTEMATIC BIAS	DEFINITION
Myopia	The tendency to focus on overly short future time horizons in dealing with investing in mitigation measures
Optimism	The tendency to be overly optimistic and underestimate the likelihood that losses will occur from future hazards
Inertia	The tendency to ignore uncertainty by maintaining the status quo
Simplification	A tendency to focus on one element of the risk (e.g. likelihood or consequences) when there is uncertainty associated with all the elements

Source: Meyer and Kunreuther (2017)

A behavioral risk audit provides ways for key stakeholders to address these systematic biases by focusing attention on how individuals perceive the likelihood and consequences of the hazards differently from the way experts do. Strategies are then proposed that work with rather than against people’s perceptions and systematic biases by framing choices in ways that lead individuals to pay attention to the risk. By coupling the framing of the risk with short-term economic incentives, one can encourage investments in cost-effective mitigation measures now rather than waiting for the disaster to occur.

The following subsections outline how the biases in Table 2-2 can be addressed by residents exposed to flood hazards. Section 2.3 indicates how the behavioral risk audit can be designed. The communication process will be most successful if the behavioral risk audit utilizes a combination of the proposals for each of the systematic biases outlined below.

MYOPIA

Many individuals make decisions using relatively short time horizons. Some flood mitigation measures, however, only have a positive payback period if evaluated over longer timeframes. Individuals are normally certain of the upfront costs of these loss prevention measures and view their benefits as being highly uncertain given the low probability of a flood causing damage to their property next year. One way to address this myopia bias is to adopt a financing policy that focuses attention on economic savings in the very near-term. One such possibility could be coupling a loan for mitigation to premium reductions on flood insurance. If the premium reduction was greater than the cost of the loan (something that would need to be evaluated for specific mitigation measures), the homeowner could see a financial savings annually.

OPTIMISM

People tend to believe that they are immune from threats such as flooding because it has a low probability of occurring next year. By stretching the time horizon when presenting information on the likelihood of a flood occurring (e.g., a greater than 1 in 4 chance of suffering flood damage over the next 30 years rather than a 1-percent-chance of flood damage next year), property owners may pay more attention to its consequences rather than treating the flood as below their threshold level of concern.

INERTIA

People often do not undertake protective measures to reduce future losses, but instead prefer to stick with the status quo rather than forging new paths of action, particularly when there is considerable uncertainty as to whether a change will result in a gain or a loss. One way to deal with this problem of inertia is to make economically preferred flood mitigation and financing strategies default options so they require little additional burden of change on the consumer. For example, if flood coverage was included in standard homeowners' policies for residents outside of the SFHA, they may be more likely to keep the coverage than if they had to do the extra work to buy a separate NFIP flood insurance policy as they currently have to do. Of course, given the challenges with doing this on the part of insurers and the often-high costs of flood coverage, it is an open research question whether this design is feasible and what the overall impact would be on take-up rates.

SIMPLIFICATION

Individuals often simplify their decision-making by focusing attention on only one aspect of a decision. For example, they may pay attention to either the low probability of a flood occurring or the consequences of the event, but not both. If they treat the low probability of a flood as below their threshold level of concern, then they will not want to consider any form of protection now. One way to address the simplification bias is to develop worst case scenarios should a flood occur so as to divert attention from the low probability of its occurrence. Worst case scenarios, however, are not appropriate for all decision-making contexts, so evaluation would be needed.

2.3 Enabling Mitigation

As mentioned in Section 2.2, the administrative necessity that a single 1-percent-annual-chance hazard line be determined can lead to a misunderstanding regarding the uncertainties associated with flooding. To encourage mitigation by developers, homeowners, and renters as well as the community at large, it will be important for the relevant stakeholders to clearly and consistently communicate the uncertainties associated with flood hazards and their potential property damage and related consequences.

FEMA defines mitigation as "the effort to reduce loss of life and property by lessening the impact of disasters" (FEMA, 2018). Mitigation can occur at a Federal, State, Tribal, regional, local, or a property level. According to the National Institute of Building Sciences, for every \$1 spent on disaster mitigation, the public saves \$6 in disaster costs (National Institute of Building Sciences, 2017). Mitigation will only occur when hazard and risk assessment information is sufficiently compelling and comprehensible to result in action such as when the flood risk, coupled with economic incentives, is communicated to individuals in ways that encourage them to consider investing in protection prior to the next flood.

While there is no guarantee that the proposed FUB or similar approach would result in increased propensity for communities, property owners, and others to take steps to reduce their risk, TMAC believes that communicating uncertainty could be a first step in helping better prepare those individuals whose land or structures are in the floodplain to undertake cost-effective mitigation measures. In addition to FEMA, other key stakeholders—namely, floodplain managers, local officials, lenders, developers, and real estate agents—can play an important role in communicating to the property owner or renter the nature of their flood hazard and risk even if the property is beyond the SFHA line, so property owners and renters become interested in considering how to mitigate the impact of flood-related disasters.

PRINCIPLES FOR EFFECTIVELY COMMUNICATING FLOOD RISK

In the 2016 Annual Report, TMAC described the need for effective communication of flood hazard and flood risk in order to improve public and personal safety and to establish more resilient communities. The 2016 TMAC report examined various core stakeholder groups, their uses of flood hazard information, and their interaction with the larger public. While communicating uncertainty was not explicitly mentioned in either the 2015 or 2016 TMAC Annual Reports, the principles of effective communication were outlined in the 2015 report and should be adhered to. These principles are that in the guidance and tools coming from FEMA, information should:

- Be delivered at the local level
- Be tailored to individual households, communities, and other stakeholders
- Be delivered from credible and trusted sources
- Be long term
- Have consistent, clear, and non-conflicting content
- Encourage and motivate some behavior by recognizing systematic biases
- Account for the values of target audiences or communities
- Use various modes of communication
- Be provided through repeat messaging

It is important that messages communicated by the key stakeholders use consistent terminology, transparent data, and include an open discussion about flood risk.

Challenges and Opportunities for Communicating Uncertainty to Key Stakeholders

In the 2016 Annual Report, TMAC described the need for effective communication of flood hazard and flood risk in order to improve public and personal safety and to establish more resilient communities. Below is a summary of the challenges and opportunities related to communicating uncertainty to the property owners and renters by the relevant stakeholders who interact with them. It should be noted that Chapter 4 of this 2018 Annual Report, which discusses increasing flood insurance coverage nationally, focuses on products that communicate to homeowners, landowners, and renters. The present section focuses more on stakeholders that can assist in communicating to these audiences the impact that cost-effective mitigation measures can have on reducing their flood-related losses.

Floodplain Managers

State, Tribal, and Local officials are front-line communicators of FEMA's flood hazard and flood risk products given their regulatory authority to review and permit compliant development in flood hazard areas. The NFIP sets minimum standards that all NFIP-participating communities must enforce in order to maintain eligibility for the program, but communities are encouraged to go beyond these standards. One example of the challenges in this regard is the minimum elevation versus recommended freeboard requirement. The NFIP requires that the lowest floor of structures built in SFHAs be at or above the (1-percent-annual-chance) BFE. While BFEs reflect probabilistic estimates of flood risk, there is uncertainty that can cause flood heights to rise above this elevation, as noted in Section 2.1. Additional freeboard provides a margin of safety against this uncertain flood risk as well as additional protection against more severe events, or conditions unacknowledged in the BFE. These risks include debris blockage, structure failure (e.g., dams, levees), natural or manmade changes to the watershed (e.g., wildfires, upstream development that impacts the hydrology) and sea level rise due to climate change. In addition, freeboard has the added benefit of reducing risk-based flood insurance premiums.

Similarly, floodplain managers want tools to communicate the uncertainty associated with the extent of the flood risk due to data limitations or future conditions. The Flood Uncertainty Band proposed in Section 2.1 would help those responsible for managing flood risk at the state and local levels to voluntarily regulate new development and other activities in the area between the SFHA boundary and the upper-end estimate of the SFHA Boundary Zone.

As discussed in Section 2.2, individuals often do not consider mitigating the flood hazard due to the likelihood of experiencing damage as being below their threshold level of concern as a result of the simplification bias. One approach in combating this would be to not only discuss the likelihood of an event occurring but to communicate the financial impact of experiencing severe flood damage without insurance coverage or without investing in cost-effective loss reduction measures.

Another tool that TMAC has recommended in the past (2016 Annual Report, Chapter 4) is to digitally map historical flood events. This provides an opportunity to have a discussion between FEMA and the community, or the community floodplain manager with its residents about the reality that floods larger than the 1-percent annual-chance flood have happened in the past and could happen again.

Local Elected Officials

Local officials have an economic incentive to make their community more resilient with respect to flood damage, but may have concerns if they feel that flood risk information curtails economic development and reduces property values, thus possibly lowering the community's tax base. From 2010 to 2015, FEMA administered the National Flood Risk Awareness Survey (FEMA, n.d.; FEMA, 2018c), a national survey of local officials to better understand their beliefs and experiences around flood risk and the proactive actions they have taken to reduce risk.

In all 6 years of the survey, the majority of local officials who responded believed that their community was either at risk or vulnerable to flooding. In 2015, 73 percent agreed that flood risk can change over time due to new weather patterns, development, and other factors; and 78 percent agreed that their community depends on the local government for flood risk information to protect themselves and their properties from flooding. However, only 50 percent agreed that there are many available resources, both technical and financial, that can be used to reduce a community's flood risk. This data suggests that local officials who are informed about the community's flood risk,

despite its uncertainties, are interested in and motivated to take action, but may not be doing so because of a lack of access, real or perceived, to available resources.

An awareness of the behavioral risk audit described in Section 2.3 can inform messaging about flood risk. For example, to address the optimism bias, in discussing the risks associated with a 1-percent-annual chance flood, providing a message in a timeframe that property owners can relate to is important, such as characterizing the “100-year flood event” as one that has a 26 percent chance of occurring at least once over the life of a 30-year mortgage. FEMA has recently recognized the importance of communicating the flood risk in this manner by indicating that the chances of homeowners experiencing a 1-percent-annual-chance flood sometime in the next 30 years is greater than 1 in 4. Recent experimental research indicates that extending the time horizon in this way has a positive impact on individuals’ decision to purchase flood insurance (Chaudhry et al., 2018).

Lenders

Financial institutions are mandated by law to require flood insurance on loans secured by buildings in the SFHA and face monetary penalties for non-compliance. Compliance helps ensure that homes and businesses at a high risk of flooding are protected by flood insurance in the event of a flooding event. The Standard Flood Hazard Determination Form must be completed for each loan to indicate whether the loan is subject to the mandatory purchase of flood insurance requirement. The form has the following yes/no question about the property that is serving as the collateral for the loan: “Is the Building/Mobile Home in Special Flood Hazard Area?”³

While the form and this central question are important for compliance purposes, without additional information these requirements can reinforce tendencies towards the simplification bias as customers purchasing a home with a mortgage may focus on the “Yes/No” response as to whether or not federal regulations require flood insurance instead of recognizing the more complex and uncertain aspects of the flood hazard and associated risk to the home being purchased. To address this bias, FEMA could implement the Flood Uncertainty Band. Through the use of FEMA flood maps delineating the Flood Uncertainty Band, lenders and their customers can have access to information about the uncertainty around the mapping of the 1-percent-annual-chance floodplain and the potential for flooding in areas outside of the SFHA and beyond the Flood Uncertainty Band.

There is currently no Federal requirement for purchasing flood insurance as a condition for a federally related mortgage if the building is outside of the SFHA. Recent events, namely Hurricane Harvey, provide sufficient reminders that floods larger than the 1-percent-annual-chance flood do occur and extend beyond the edge of the mapped SFHA. Many property owners with mortgages living outside of this area believe that there is certainty and security associated with the fact that their mortgage company did not require flood insurance as a condition for the loan. In practice, some lenders may provide a voluntary notice to customers seeking a mortgage on a building outside the SFHA. These messages include its proximity to an SFHA, the potential for flooding, and the availability of flood insurance. With the implementation of a Flood Uncertainty Band, lending institutions, investors, and even the Federal Regulatory Lending Agencies would have more incentive to provide additional information to potential homebuyers beyond the strict requirements of the law and potentially require the purchase of flood insurance as a condition of the loan in the Flood Uncertainty Band.

If available, by including flood insurance as an optional or potential rider on a homeowners’ policy, property owners living in or near the Flood Uncertainty Band may be encouraged to purchase flood coverage, as noted in Section 2.2. While discussions on insurance occur between property owners and insurance agents, if lenders indicate that the rider will provide protection against both wind and flood damage from hurricanes, many individuals near the coast, for example, may decide to purchase and maintain a flood insurance rider on their

³FEMA, “Standard Flood Hazard Determination Form (SFHDF),” OMB Control No. 1660-0040 (expires October 31, 2018). https://www.fema.gov/media-library-data/1469556176499-3fb6b6e3f04108ff34fdd56f007ac05d/FEMA_Form_086_0_32_06_2016.pdf.

homeowners' policy. As many homeowners seem to be under the misimpression that water damage from floods is covered by their current homeowners' policy. This discussion between the lender and property owner would likely lead to a productive dialog about risk and availability of flood insurance coverage and maybe even encourage the use of home equity loans to reduce risk.

Developers

Developers seek opportunities for land acquisition or for improvements to existing development, while minimizing risks or exposures associated with these transactions. Among the considerations for certain projects are the regulations governing community floodplain management and bank financing. Areas in or partially in the SFHA are subject to floodplain regulations for communities participating in the NFIP. If land acquisition, subdivision, or real estate development is being financed, banks may obtain a Standard Flood Hazard Determination Form even though the federal regulations do not apply if the loan is not for construction of structures. Banks may elect to obtain a flood determination in order to understand the downstream requirements for homebuilders and homebuyers such as a flood insurance requirement.

For land developments partially or wholly within the SFHA, developers face requirements based on local ordinances and may pursue projects to analyze and mitigate the flood hazard. While costs associated with significant engineering efforts to mitigate future losses may be significant, to overcome the myopia bias these developers could foresee that such up-front investment in capital can be rewarded with a higher sales price and reduced flood risk exposure following the sale.

Although the use of a Flood Uncertainty Band may not alter local requirements or financing conditions, it can provide information that developers could utilize in making decisions on new construction or whether to purchase land. By understanding the uncertainty associated with the SFHA, developers could invest in additional studies or analyses to better understand the hazard, including possible future changes in the hazard based upon the development itself.

Real Estate Agents

Real estate agents work to ensure their clients—buyers and sellers of real estate—have the information required to make a decision regarding the transaction. In this capacity, many agents find disclosures to be useful provided the information is based upon facts rather than interpretation. Real estate agents' activities in the context of a transaction can be subject to common law as well as federal and state laws that govern licensing, disclosures, sales contracts, and professional practices.

With respect to the flood hazard and the risk to life and property associated with this hazard, there is no federal law or regulation governing the real estate transaction. Instead, many states have passed laws requiring the disclosure of information related to the location of the property relative to a floodplain, the flood loss history of the building, drainage issues on the property and any requirement for flood insurance. According to the National Association of Realtors, as of 2019, more than 30 states had state flood hazard disclosure requirements with one or more disclosure requirements (NAR, 2019). Some of the states currently include variations on the question as to whether the property is in the mapped SFHA.

These real estate disclosures could include information on whether or not the property is within the SFHA boundary zone. Adding this information could provide value if combined with the risk associated with the hazard, the uncertainty of the hazard, the reason for the Flood Uncertainty Band, the potential costs of flood insurance in various areas and for this property, and the potential costs of future damage to the property over time as conditions change in the future. The disclosure could provide the recipient with a website where

additional information on the hazard and risk would be available. In this manner, if coupled with disclosures based upon facts and actual knowledge, such as whether the property has previously been damaged by flooding or whether the current owner is required to pay for flood insurance, real estate agents can effectively serve as facilitators of information without being put into the position of being expected to have expertise on flood maps or flood risk.

With respect to the biases discussed in Section 2.2, real estate agents can use a behavioral risk audit in several different ways. They can address the optimism bias by highlighting the likelihood of at least one flood causing damage to the house over a 30-year period. In dealing with the simplification bias they can highlight the consequences of a flooding event to a property owner who is outside the SFHA if they do not have flood insurance and have not invested in cost-effective mitigation measures. To encourage the adoption of these measures on existing homes, real estate agents can help overcome the myopia bias by working with financial institutions to finance the upfront costs through a loan tied to the mortgage. Annual insurance premiums may decrease more than the annual loan costs given lower claims costs from flood losses in the future.

PROPOSAL: BEHAVIORAL RISK AUDIT

Given the systematic biases that impact how individuals process risk information, the principles laid out here for effectively communicating flood risk, and known challenges and opportunities for communicating uncertainty to key stakeholders, the TMAC proposes that a behavioral risk audit would be helpful to FEMA in communicating uncertainty.

RECOMMENDATION 31

As part of efforts to communicate uncertainty, FEMA should periodically conduct behavioral risk audits and address the biases that characterize how individuals process information on flood risk to their property. The audits and actions taken (including language regarding the likelihood of flooding) to address biases will also help other key stakeholders, such as floodplain managers, local officials, lenders, developers, and real estate agents, to encourage property owners to invest in cost effective mitigation measures and purchase flood insurance before the next flood occurs.

2.4 Conclusion

It is not possible to know the exact depth and shape of the 1-percent-annual-chance flood. However, it is possible using proven statistical techniques to determine reasonable minimum and maximum extents of a mean 1% annual chance flood elevation, and this information could be used to show uncertainty to a wide variety of stakeholders. TMAC recommends that FEMA establish, test, and implement a Flood Uncertainty Band—the area where the floodplain boundary is most likely to be.

In addition, there are several systematic biases that impact how individuals process information on their risk, and there are known principles for effectively communicating flood risk given these biases. The TMAC also recommends that a behavioral risk audit would be helpful to residents and property owners in the SFHA, and other key stakeholders in communicating uncertainty so they will purchase flood insurance and undertake mitigation measures to reduce their losses prior to the next disaster. TMAC encourages FEMA to include stakeholder outreach prior to formal implementation to ensure the intent of these recommendations is met.

3. Prioritizing Unmapped Areas

In its March 8, 2018, Tasking Memo to the TMAC, FEMA requested that the TMAC focus on exploring and providing insight concerning prioritization of unmapped areas. Specifically, the letter requested that the TMAC:

Explore the appropriate criteria that the program should consider in prioritizing unmapped areas, considering the need to create and maintain credible data for more populous areas while inspiring good mitigation practices nationally.

3.1 Prior Related Recommendations and Implementation Actions

Issues related to prioritizing studies, which may be relevant to unmapped areas, are identified generally in some of the TMAC’s previous recommendations and implementation actions (see Table 3-1). Several of the recommendations and implementation actions included in Table 3-1 are directly related to FEMA’s request (specifically AR 2, AR 2.2, and AR 3, and PR 11 and PR 12), while those remaining are related to the topic in general and should be considered when addressing this topic. This chapter discusses unmapped areas and not residual risk areas, which were addressed in the TMAC 2017 Annual Report.

Table 3-1. Previous Recommendations and Implementation Actions

NO.	DESCRIPTION
AR2	Develop National Program 5-Year Plan. FEMA should develop a national 5-year flood hazard and risk assessment plan and prioritization process that aligns with program goals and metrics (see Recommendation 3). This should incorporate a rolling 5-year plan to include the establishment and maintenance of new and existing studies and assessments in addition to a long-term plan to address the unmapped areas (emphasis added). Mapping and assessment priorities should be updated annually with input from stakeholders (e.g., Multi-Year Hazard Identification Plan). The plan should be published and available to stakeholders.
IA2.2	Prioritizing flood hazard and risk assessment studies. FEMA should develop, with input from stakeholders, a list of factors to be used for prioritizing flood hazard and risk assessment studies across the country.
AR3	Develop National Program Goals and Metrics: FEMA should develop National Flood Hazard and Risk Assessment Program goals that include well-defined and easily quantifiable performance metrics. Specifically, the program goals should include metrics for the following: <ul style="list-style-type: none"> a. Maintaining an inventory of valid (verified), expiring, unverified, and unknown flood hazard miles; b. Addressing the non-modernized areas of the Nation <i>and unstudied flood hazard miles</i> (emphasis added); c. Conducting flood risk analysis and assessments on the built environment; and d. Counting population having defined floodplains using a stream level performance indicator for a better representation of study coverage.
PR11	Evaluate Program Metrics: FEMA should evaluate the current metrics to better measure the efficient production, valid inventory, and stakeholder acceptance of the National Flood Mapping Program. TMAC recommends that FEMA should: <ul style="list-style-type: none"> a. Discontinue the current Deployment and Mitigation Action metrics and replace them with more effective measures, and b. Focus revised metrics on measuring the quality and quantity of flood hazard and risk products delivered to communities.
PR12	Include an Inventory Metric: FEMA should have an inventory metric that reports quantity, quality, and time aspects on national, regional, tribal, state, and watershed levels: <ul style="list-style-type: none"> a. Quantity: Quantity should be tracked through the life of a floodplain from no study through to detailed study. Statistics should be provided annually. b. Quality: Quality should be measured by retaining the existing NVUE metric of the current inventory and adding an NVUE metric for coastal flood hazard miles. c. Time: Timing should be measured from Discovery to the issuance of Preliminary maps and from the issuance of Preliminary maps to Effective maps for active projects.

AR = TMAC Annual Report (2015, 2016, or 2017)

PR = TMAC National Floodplain Mapping Program Review (TMAC, 2016b)

3.2 New Recommendation

The TMAC 2015 Annual Report considered problems associated with unmapped areas and expressed concern about the lack of a plan to prioritize and address these areas. FEMA evaluates the need for new and updated flood-risk mapping projects against criteria to allocate the limited flood-mapping resources to address needs in areas with the greatest population and developmental demands, and where maps do not meet current standards, working in collaboration with communities to understand their needs. FEMA's current standards have different mapping tolerances based on population, density of floodplain development and anticipated development growth.

While TMAC acknowledges that this approach has produced flood maps that service 98 percent of the population, the approach also precludes consideration of a substantial number of unmapped miles of streams. Of the 3.5 million miles of streams in the US, flood hazards have yet to be mapped on approximately 1.4 million (40 percent of the total.) By prioritizing high population, highly developed areas, low population rural areas are denied the opportunity to use FIRMs and FEMA non-regulatory products to assess flood risks in planning for future development, emergency events, agricultural and resource management, and other uses not directly related to flood insurance.

Thus, the TMAC recommends the following:

RECOMMENDATION 32

FEMA should modify its Flood Hazard Mapping Key Decision Point Process and adopt criteria to weigh the value of providing non regulatory products even where the development of FIRMs or FISs is not warranted.

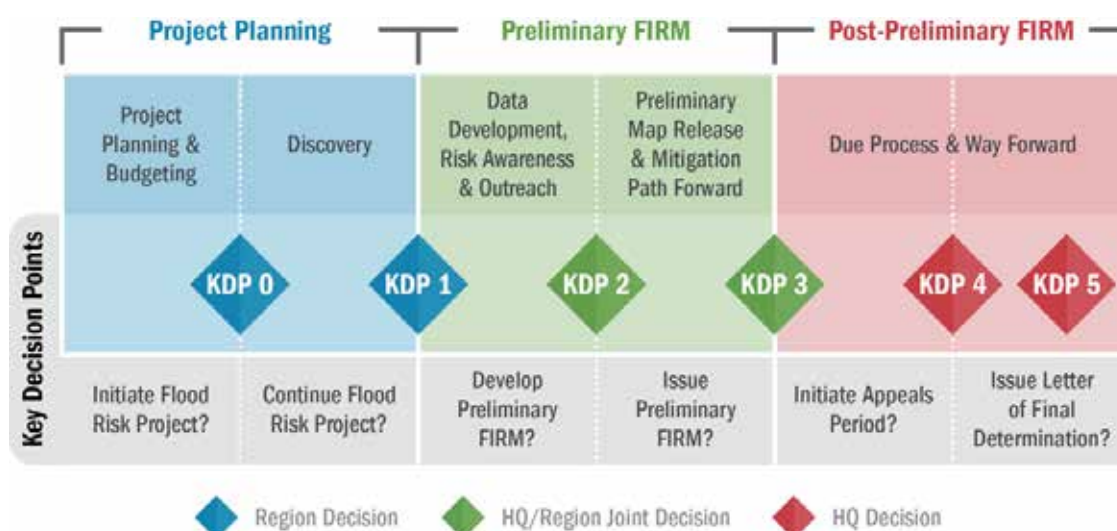




3.3 Incorporating Options for Unmapped Miles into the FEMA Flood Hazard Mapping Key Decision Point Process

FEMA asked TMAC to explore and recommend appropriate criteria that the FEMA Flood Hazard Mapping Program should include in prioritizing unmapped areas, considering the need to create and maintain credible data for more populous areas, while inspiring good mitigation practices nationally. The resulting criteria and optional product selections developed by TMAC are intended to be used within the existing FEMA evaluation framework (Figure 3-1) at known Key Decision Points (KDPs). These criteria can support decisions to produce standard regulatory products (i.e., FIRM), or secondary, nonregulatory products that, while lacking some detail, may be used by tribes and local communities to improve flood-risk mitigation, emergency planning, and/or land use decision-making.

Figure 3-1. FEMA’s flood hazard mapping key decision point process



The FEMA Flood Hazard Mapping KDP process is a formal method for evaluating whether a flood risk mapping project should advance through six points in the workflow process and documents the rationale for each decision. Community engagement and feedback are integrated throughout FEMA’s decision-making process. This process is described in detail in FEMA’s KDP guidance (FEMA, 2018b). The criteria developed by TMAC to assist in prioritizing unmapped areas may best be applied to KDP0, KDP1 and KDP2. KDP0 addresses the question “should FEMA initiate a flood risk project?” Here, FEMA relies on information such as state multi-year plans, community engagement feedback, and Coordinated Needs Management Strategy (CNMS) data to assess whether a project should be initiated, which should include considerations for unmapped areas. KDP1 addresses the question “Is FEMA ready to continue this flood risk project?” By considering data development, risk awareness, and information gained through the discovery phase following a decision to proceed in KDP0. KDP2 addresses the question “Is FEMA ready to develop a preliminary FIRM and Flood Insurance Study (FIS) for this flood risk project?”

At KDP2, alternate production paths that lead to non-regulatory products but still provide great value to unmapped communities could be introduced as a means of implementing Recommendation 32. These alternative non-regulatory products would render unnecessary the expense in both time and financial resources associated with FIRM production, while providing valuable information to assist communities facing flood hazards with no data upon which to act.

3.4 Screening Criteria for Unmapped Miles

SFHAs are shown on FEMA FIRMs. However, because not all flood hazards have been determined, not all areas at risk of flooding are shown on FIRMs. FEMA and CTPs usually focus on preparation of flood maps for populated areas that can face potential significant loss of life and/or damage to property or include critical infrastructure. The Zone D designation is used for areas where flooding is deemed possible but flood hazards have not been determined. Zone D can include either or both urban and rural areas. TMAC also defines “unmapped areas” as including areas designated as Zone d and areas for which no maps have been developed. Some of these areas may also include unstudied urban flood hazards that may be Zone X (shaded and unshaded).

Recommended criteria to be considered during KDP0 to assign a higher priority for mapping flood hazards include:

- (1) Current unmapped areas that include urban land use or areas experiencing or expected to experience active land use changes (including decommissioned or abandoned federal facilities) and growth in population in the near future, such as in the next 10 years
- (2) Include critical facilities and infrastructure. Critical facilities and infrastructure, as discussed here, covers physical structures where flooding would result in a significant effect on public health and safety. Critical facilities and infrastructure can include but are not limited to police stations, fire stations, emergency operation centers, hospitals, schools, airports, electrical power stations, drinking water treatment plants, wastewater treatment plants, bridges, freeways, dams, etc.
- (3) Area downstream of an unmapped area or area subject to comingled flooding from upstream unmapped areas.
- (4) Have repeated flood insurance claims or disaster area payments whether federal, state, or local.
- (5) Have high risks to loss of life and/or damage to property but have low population and density. This should include facilities that could have potentially significant environmental impacts if flooded, such as concentrated animal feeding operations.
- (6) Have strong local support such as leveraged data or proposed local mitigation actions.

CNMS is a system for inventorying flood hazard mapping needs for the NFIP. CNMS has a Geographic Information Systems (GIS) layer that includes unmapped miles. FEMA should consider intersecting this layer with data reflecting the factors listed above to help identify unmapped streams that should be considered a priority.

3.5 Non-regulatory Products for Unmapped Areas

FEMA has developed, through its Risk Mapping, Assessment, and Planning (Risk MAP) program, non-regulatory products (e.g., Discovery maps, Changes Since Last FIRM, depth and risk analysis grids, Flood Risk Reports and Flood Risk Databases, Base Level Engineering) to enhance flood risk communication, improve the acceptance of identified flood hazard data, and to enhance mitigation plans and actions.

The information and data provided by the non-regulatory products are used by different users and for different reasons, as follows:

Floodplain management. Base level engineering and other non-regulatory products are used as best available data to make informed decisions to reduce future flood losses in areas not mapped on the FIRMs.

Emergency management. Non-regulatory products are used by Federal, State, Tribal, and local emergency management professionals for emergency management planning and exercises.

Mitigation. States, Tribes, and communities undertake mitigation planning to identify a range of actions that will reduce risk from hazards that threaten people, property, critical infrastructure, and natural resources. Non-regulatory products can inform mitigation planning.

Public. Flood hazard and risk data products are used to mitigate against the risk. This includes purchasing flood insurance, elevating structures or critical building systems to protect assets and property, and choosing not to purchase or develop property in flood-prone areas. Non-regulatory products can inform mitigation planning.

Agriculture. Flood hazard information for rural areas would be useful for the crop insurance program in identifying potential loss areas and estimating pay outs.

Resource management. State, local, and tribal governments often rely on FEMA's mapped SFHAs to establish setbacks, support ordinances, and to issue permits to protect habitat and natural resources. Non-regulatory products can inform mitigation planning.

Both the regulatory and non-regulatory Risk MAP products use the flood risk database developed before KDP2 (see Figure 3-1) in the KDP process. Normally, projects passing KDP2 move on to regulatory product development. Modifying the KDP2 process to have two decisions evaluated – 1) should regulatory maps be developed, and 2) should non-regulatory products be developed – would allow use of the flood risk database for developing non-regulatory unmapped miles in areas that do not meet FEMA's criteria for updating the regulatory data. The KDP2 criteria for developing only Risk MAP products should consider data needed for Zone D or unmapped areas, risk avoidance, hazard mitigation plan development, and/or mitigation action projects. There are unmapped areas that need data for these purposes, but do not have sufficient population density to warrant regulatory map development.

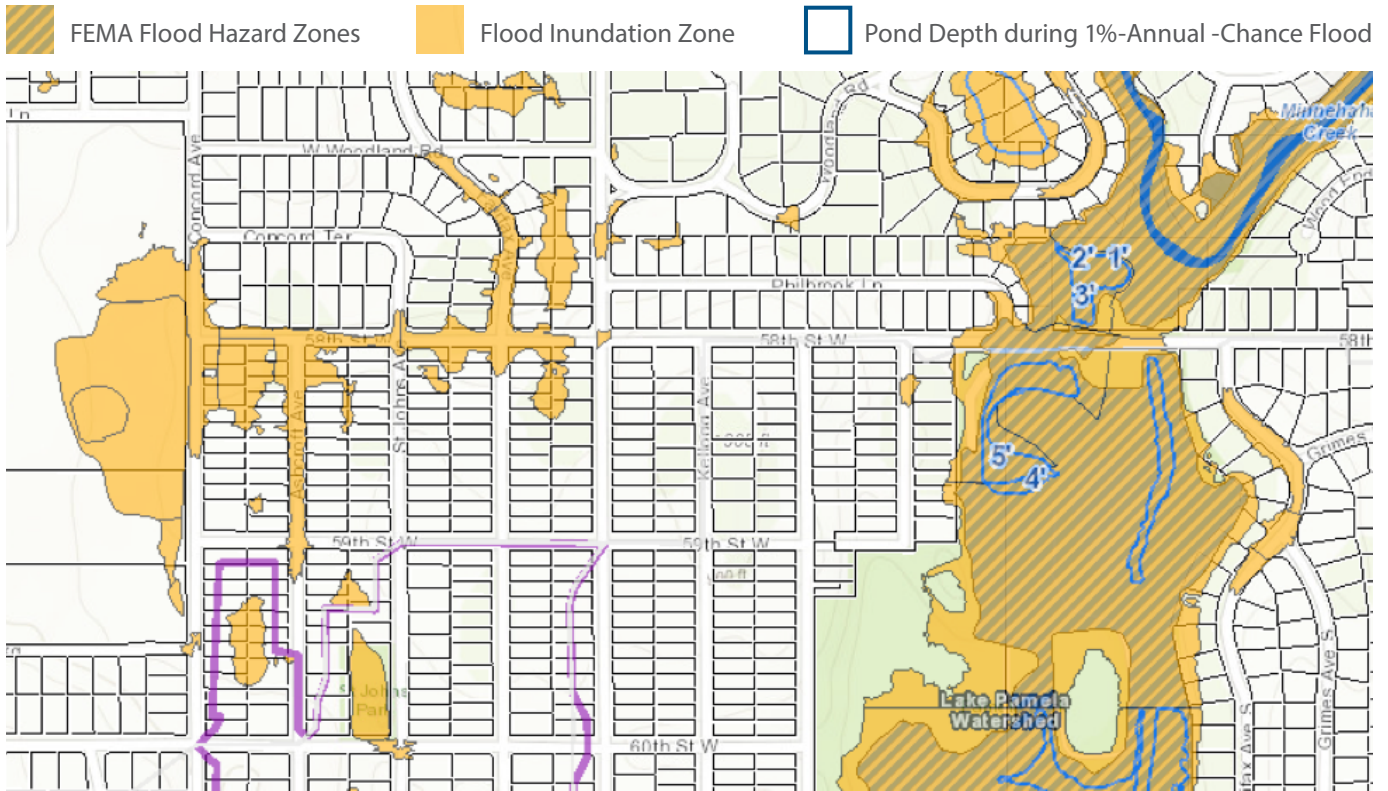
3.6 Unmapped Urban Flood Hazards

Unmapped urban areas, often labeled as Zone X (unshaded) on the FIRM, have different concerns. Flooding in these areas from intense rainfall can overwhelm urban stormwater systems or the infiltration capacity of the ground. This pluvial flooding can form sheet flows or pooling of water in areas that are beyond the reach of larger flooding sources. The modeling techniques required to estimate the extent and probability of pluvial flooding are more data intensive and complex, and thus generally more uncertain and expensive to develop than the models used for riverine flood hazards.

Some communities are reluctant to share pluvial flood hazard information with FEMA given the uncertainties associated with the results, possible added costs for bringing the information into compliance with FEMA technical specifications, the perceived impact on property values, the potential flood insurance purchase requirements and associated cost implications, and the potential impact on new development in the form of floodplain management requirements. Figure 3-2 is an example of an urban community's interactive map. The map provides information on urban flooding hazards. This service provides both FEMA flood hazard zones (hatched areas) and their own flood inundation areas (orange shading), which includes pluvial flood hazards. The gold shading portrays flooding during the critical duration 1 percent-chance event. The critical duration event is the duration of rainfall that produces the greatest flow rate or ponding depth/area. The cross-hatched area is the

FEMA 1 percent-annual-chance floodplain. The non-FEMA information is used for risk communication purposes on the community’s website.

Figure 3-2. Community interactive map for the City of Edina, MN



FEMA is considering developing a Risk MAP viewing platform that incorporates flood risk data from other sources. This platform could link to community websites displaying flood risk such as that shown on the map in Figure 3-2. In order to implement such a viewing platform, there would need to be standards for what data would be acceptable for inclusion on the site.

There is a need to link flood risks and stormwater management to enable improved community planning and flood-risk mitigating behavior. The National Academy of Sciences Urban Flooding Study report was completed in March 2019. This study and FEMA’s Risk Rating 2.0 initiative highlight the need for evaluating methods to identify pluvial flood risk for communication purposes and to ensure insurance rates reflect the actual risk. Information coming out of these two initiatives could be useful in developing the standards for acceptable data to be displayed on a future viewing platform.

Communicating the potential hazards beyond the mapped SFHAs is complicated. The public frequently believes these areas are safe from flooding despite the fact that there is uncertainty in the flood hazard identification process, floods larger than those computed by FEMA remain possible, and that intense rainfall events can cause pluvial flooding.

Generally, local governments do not design storm water systems to handle the 1% annual-chance exceedance rainfall event. Nonetheless, it is important they work with FEMA and others to communicate flood risks and promote best management practices in areas not designated as SFHAs.

3.7 Conclusion

FEMA's current process for prioritizing mapping projects relies on criteria that result in allocating limited flood-mapping resources largely to areas of moderate to high population densities. While TMAC acknowledges that the current mapping inventory covers the vast majority of the current population, nearly 40 percent of the stream miles in the country remain unmapped, most in undeveloped, rural areas as well as urban areas subject to pluvial flooding.

There are significant benefits of providing flood hazard risk information to these unmapped areas to assist with planning for future development, emergency events, and uses not directly related to flood insurance. Therefore, TMAC recommends FEMA modify its flood hazard mapping KDP process and adopt criteria to weigh the value of providing non-regulatory projects to current unmapped areas, even where the development of FIRMs or FISs is not warranted or not possible due to available resources.

4. Increasing Flood Insurance Coverage

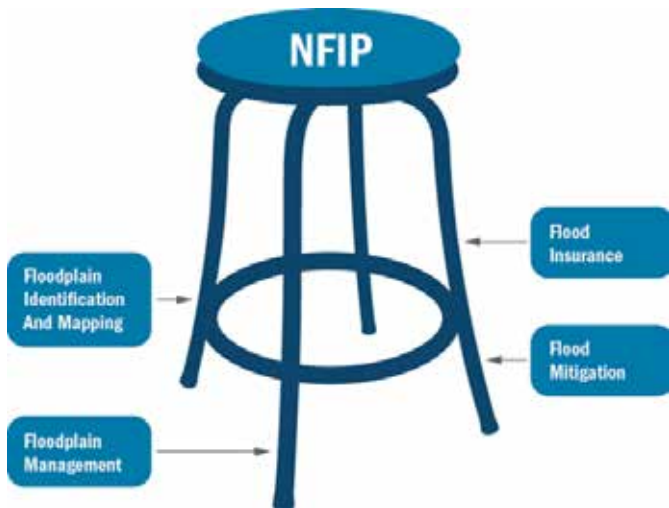
In 2017, FEMA developed a new strategic plan (FEMA, 2018b) highlighting three goals: (1) Build a Culture of Preparedness, (2) Ready the Nation for Catastrophic Disasters, and (3) Reduce the Complexity of FEMA. Within the strategic plan, FEMA identified two objectives under Goal 1 within the NFIP: Incentivizing investments that reduce risk and closing the insurance gap (see figure 4 1).

Figure 4-1. Objective 1.1 and 1.2 of the 2019 FEMA Strategic Plan



FEMA requested that the TMAC evaluate how the FEMA National Flood Mapping Program (under Risk MAP) can take steps to increase flood insurance coverage nationally. The subcommittee formed to address this topic is focusing on how to leverage and enhance current flood hazard and risk products and associated outreach initiatives to support flood insurance rating, flood risk communication, and increase the flood insurance pool through various means. The three tasks assigned to TMAC in 2018 are inherently related. Unmapped areas for which there is no publicly available flood hazard and risk information translates to uncertainty in these areas and provides another opportunity for expansion of the NFIP policy base. The concept of communicating the social and technical aspects of uncertainty in flood hazard mapping has also been addressed by TMAC in Chapter 2 of this Annual Report and correlates well with the discussion provided on “increasing coverage.” While “unmapped” generally refers to a complete lack of flood hazard and risk data, Chapter 3 of this 2018 Annual Report addresses the need to define flood hazards in a way to better express risk and include areas not identified by “traditional” flood mapping methodologies. Additionally, many datasets are available to FEMA that may be used to help communicate the general concept of flood risk that may be used to enhance the NFIP policy base. Finally, an expansion (and possible clarification) of previous TMAC recommendations, such as for areas below dams and behind levees, will also help FEMA achieve its strategic goal of doubling flood insurance coverage nationwide by 2022.

Figure 4-2. NFIP four-legged stool



Global weather-related disaster losses exceeded \$300 billion in 2017, which made 2017 the costliest year on record and continues a long-term upward trend (Swiss re, 2017). The impacts of flooding often go far beyond direct damages to assets and infrastructure. Social and environmental impacts, in addition to economic losses resulting from business disruption, welfare effects, and supply chain shocks can at times equal or exceed direct flood damage (Hallegatte, 2008).

The NFIP is often represented by a four-legged stool with each leg representing the main programs that support flood risk management and reduction (Figure 4-2). One of the four tools the NFIP uses to reduce the financial impact of flood damage is to provide flood insurance to the citizens of the Nation (42 U.S.C. § 4001).

Flood insurance provides policyholders with a means to recover expenses related to damaged structures and personal property losses. Unfortunately, flood insurance generally carries a negative connotation despite years of public outreach and diligent insured payouts after flood events. As the NFIP marks 50 years of existence in 2018, recent data indicate that the number of flood insurance policies have generally been on the decline in most states since 2012 (FEMA, 2017).

Figure 4-3. NFIP payouts (building, contents, and ICC), FY2012 through FY2018 (YTD)

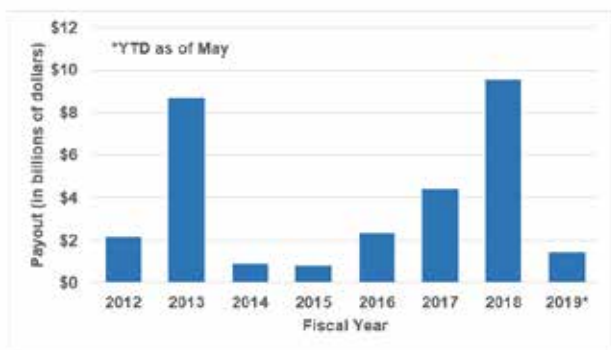


Figure 4-3. NFIP payouts (Building, Contents, and ICC) FY 2012 through FY 2019 (YTD)

However, flood insurance is the most expedient and thorough flood-related recovery method, especially when compared to federal disaster assistance and loans. The payouts (building, contents, and increased cost of compliance [ICC]) shown in Figure 4-3 are based on claims with a **date of loss within the fiscal year**. The data are as of July 2018 and are the most recent validated information. Subsequent payments on claims (including ICC payments) are included in the fiscal year of the loss regardless of the date of payments.

For structures with federally backed mortgages in the SFHA, flood insurance is mandatory to obtain and retain the loan. Flood insurance is not required for structures outside SFHAs unless a lender requires it, even though approximately 30 percent of NFIP flood insurance claims come from these areas. That said, relatively few property owners buy flood insurance unless they are required to do so and only 20 to 30 percent of homes without mortgages in SFHAs have flood insurance (Dixon et al., 2017). Additionally, preliminary studies have indicated only 25 to 45 percent of the flooded one- to four-family homes in Houston had flood insurance coverage to recover from Hurricane Harvey in 2017 (Dixon and Clancy, 2017).

Convincing individuals and business owners to purchase and maintain flood insurance can be difficult due to the challenge of communicating risks associated with flooding, misconceptions about how flood insurance works, and perceptions regarding the value and affordability of insurance coverage. While this chapter does not directly address affordability concerns of the NFIP or the behavioral aspects of understanding flood risk, current research indicates that flood insurance costs are burdensome for many households (Dixon and Clancy, 2017) and assumptions about peoples' risk-reducing behavior, willingness to relocate, and access to information play a key role in the decision to purchase insurance (Haer et al., 2017). Recently, various social media platforms, especially twitter, have gained traction as novel sources of information on disaster events. Many tweets may now be geo-referenced in order to locate flood events around the world and potentially provide timely and accurate information about ongoing events, which are crucial for relief organizations seeking to effectively respond to disasters (de Bruijn et al., 2018). These tools can be leveraged to work in tandem with comprehensive community flood analyses to create a real-time depiction of flood risks that will be useful in disaster planning and response and will potentially assist FEMA in realizing its goal of doubling flood insurance policies.

TMAC's charter, as established by BW-12 (42 u.s.c. § 4101a), directs the TMAC's attention to the national flood mapping program rather than to the NFIP. Considering this, the discussion, recommendations, and implementation actions in this Annual Report focus on approaches related to mapping, mapping products, and outreach recommendations. However, the TMAC encourages FEMA to look beyond its current outreach efforts and NFIP flood insurance product offerings to reach all types of property owners and consumers, including renters (both residential and non-residential), realtors, developers, real estate buyers and sellers, and insurance agents who may not realize their options or be aware of the vast amount of flood risk information that is available to assist them. FEMA should create specific tools tailored to educate new and existing property owners about their risk, the inherent uncertainty associated with flood events, and the value of mitigating flooding risk through flood insurance. These tools and tailored outreach will help to educate new owners as well as real estate and insurance industries assisting in transactions. To better understand what outreach and map products could reduce flood insurance attrition, FEMA should engage individuals who decide to drop their flood insurance policies. The "endowment effect" in social psychology suggests that what one owns is valued highly simply because it is their own, and that an owner is typically more averse to relinquishing what they own than someone who values the acquisition of a product they do not currently possess (Kahneman et al., 1990). Outreach to those who relinquish their flood insurance policies may provide key information about decision-making processes and insight into what products and resources were or were not used. This key information can drive the creation of better mapping and outreach products to limit attrition of the current customer pool.

In light of a paradigm shift in one major component of the NFIP, flood insurance, a concurrent paradigm shift in another major component, flood hazard mapping, is anticipated. Leveraging previous TMAC recommendations and implementation actions, FEMA should engage partners and stakeholders in a broad outreach and marketing campaign for flood insurance. This campaign should focus on three key areas that have specific functions toward the goal of increasing flood insurance coverage. These areas are: new customer creation, current customer retention, and expansion of flood insurance product availability. Some potential outreach opportunities for these areas are identified in Table 4-1.

Table 4-1. Potential outreach opportunities that may be used to increase flood insurance coverage.

AREA OF INTEREST	INITIATIVES
New Customer Creation	<ul style="list-style-type: none"> • Point of Real Property Sale Outreach Initiatives • First Time / First Year Policy Buyer Incentives • Incentive Programs for Write Your Own, Lenders, Home Builders, and Real Estate Industry • Market Barrier Reduction such as Escrow, Monthly Payment Options, and Rider to Homeowner’s Policies
Customer Retention	<ul style="list-style-type: none"> • Outreach and Polling Initiatives • Incentive Programs for Return Customers • Risk Change Updates
Expansion of Flood Insurance Product Availability	<ul style="list-style-type: none"> • Reclaimed Property from a LOMR-F; LOMAs Based on Low Differential Between LAG and BFE or Freeboard Height • Other Areas of Residual Risk (Such as Proximity to Structural Flood Control Projects) • Areas Within 0.2-percent-annual-chance floodplain or other flood hazard areas

Aggressive engagement in targeted marketing, including using social media, is needed to increase flood insurance coverage nationwide. Flood hazard and risk communication should be a top priority that works in concert with expanding the NFIP policy base through programmatic, insurance and flood risk product enhancements, regulatory, and possibly legislative approaches.

TMAC is pleased to learn that FEMA is undertaking a transformative approach to redesign flood insurance policies, forms, and risk rating. Risk Rating and Policy Forms Redesign highlights FEMA’s Strategic Plan’s objectives of closing the insurance gap and reducing the complexity of FEMA. The new process is being designed to deliver flood insurance rates that are fair, clear, and use current technology and data while using policy forms that are simple and align with insurance industry standards. The flood insurance policies will have an actuarial rating, be based on community flood risk, and will be able to identify likely mitigation actions that may contribute to lower flood risk scores, and thus lower flood insurance premiums.

Communicating that insurance is simply transferring risk from an individual or business to the respective insurance carrier is a valid strategy. Flood insurance products that correlate more closely to current technology and industry standards are a significant improvement over traditional flood insurance offerings from FEMA. Ultimately, TMAC envisions two overarching goals of doubling flood insurance coverage:

- How can insurance be used to transfer flood risk?
- How can the current culture, discussion, and thinking of the NFIP transition from an “in versus out of the SFHA” mentality to “what is my flood risk and what can I do to mitigate it?”

In Risk MAP, considerable time and resources are spent on precise outputs where streamflow and other climatic data generally possess considerable uncertainties. Flood hazards should be depicted in various ways so that users of varied scientific prowess throughout all sectors of our society can easily understand them. Regulatory flood mapping requirements will always have their place, but communicating flood risk should be much more than an exercise in a regulatory process. Previous TMAC recommendations call for flood risk to be determined at the structure level; this will be a monumental improvement in determining flood risk for structures, but will likely do little to help most citizens understand flood risk.

Property owners should be empowered to make sound decisions about the hazards impacting their assets and be able to understand their flood risk by using FEMA flood hazard products. The FEMA Map Service Center (<https:// msc.FEMA.gov>) quickly provides flood hazard data for the 1 percent-annual-chance flood

(and sometimes the 0.2 percent-annual-chance flood) but very little communication about flood risk. A more encompassing view of community flood risk that leverages data from various sources is needed and may include:

- Multiple flood recurrence intervals, including probabilistic flood modeling
- Pluvial flood risks
- Areas of significant and/or repetitive stormwater/urban flooding
- Catastrophic flood events
- Areas of historical flood claims and repetitive losses, including disaster-related Individual assistance
- Areas where Letters of Map Change (LOMCs) have been issued; mainly Letters of Map Amendment (LOMAs) and Letters of Map Revision based on Fill (LOMR-Fs)

FEMA's flood risk awareness and education efforts to increase resiliency should include research of changing weather patterns and the resultant datasets that are used for model inputs. Much of the nation's flood hazard datasets are using the latest and greatest terrain data and hydraulic computations, but climatic science updates are direly needed in some areas of the nation. Investments should be made to update and keep climactic data as current as possible. This will likely require a strategic implementation approach among many stakeholders but data such as National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall indices, probable maximum precipitation, peak flow analyses, and depth/damage functions should be assessed and updated, if warranted. Additionally, maintaining and updating these datasets will also allow agencies such as USGS, U.S. Army Corps of Engineers (USACE), and NOAA to continue developing products such as the National Water Model (<http://water.noaa.gov/about/nwm>) and Flood Inundation Map libraries (https://water.usgs.gov/osw/flood_inundation/) and to conduct alternative analyses to mitigate flood risks. The fact that a significant portion of NFIP insured losses come from outside identified SFHAs further justifies the need to maintain and update climatic datasets. In fact, research has indicated that the nation's flood maps may underestimate flood exposure by a factor of 3 (Wing et al., 2018). This relates not only to the concepts described in the Communicating Uncertainty chapter of this 2018 Annual Report, but also the fact that many of the data inputs (e.g., precipitation, stream flow) used in flood hazard mapping are becoming outdated and in need of update.

Throughout our discussions, TMAC has emphasized the need for mitigation to avoid as much future damage as possible. Beyond simply increasing the flood insurance policy base, TMAC believes that the impetus behind the current task is to improve mitigation efforts to reduce flood risks throughout the Nation. Effective adaptation to increasing flood risk requires a diversified approach, which may include structural flood protection measures, early warning systems, risk-informed land planning, nature-based solutions, social protection, and risk financing instruments (Aerts et al., 2014). The right mix of mitigation measures will always vary from community to community, subject to levels of risk, funding, and political will. It is imperative to view flood insurance as a mitigation measure and to view the transfer of financial risk from property owners to insurance companies as a vital tool in the mitigation toolbox.

TMAC is aware of a variety of options and considerations that have been discussed by others in the pursuit of better flood preparedness through insurance. For example, the RAND Corporation's Center for Catastrophic Risk Management and Compensation has argued the most effective strategy to increase flood insurance coverage would be to extend the mandatory purchase requirement to all homes in high-risk flood zones, regardless of mortgage. The authors of the rand study also propose extending the mandatory purchase requirement to the 0.2-percent-annual-chance floodplain (or moderate risk flood zone), perhaps with a reduced flood insurance coverage requirement. Also relevant to this topic, the Wharton Risk Management and Decision Processes Center recently completed a report assessing the increasing role and impacts of private insurance relating to the NFIP

(Kousky et al., 2018). The Wharton report includes discussion of mitigation and the need for cooperative private and public sector roles in achieving adequate flood protection, but data is currently lacking as to whether an increase in private policies is currently replacing or supplementing NFIP policies. The report points out that private insurers have marketed flood insurance to residents in the floodplain in which flood insurance is not a federal requirement. They have been successful in convincing homeowners to add this coverage to their homeowner’s policy. In this regard, FEMA could interact with lenders to give homeowners an option to provide a homeowner’s policy with an NFIP policy as part of the overall insurance coverage. In the spirit of the inertia bias and the behavioral risk audit discussed in Section 2, this default option may increase coverage as demonstrated by many previous empirical studies.⁴

4.1 Discussion of TMAC Recommendations

TMAC began addressing the “increasing coverage” task in prior reports to FEMA, as shown in the recommendations and implementation actions listed in Table 4-2.

Table 4-2. Previous Recommendations and Implementation Actions

AR 10	<p>FEMA should transition from identifying the 1-percent-annual-chance floodplain and associated Base Flood Elevation (BFE) as the basis for insurance rating purposes to a structure-specific flood frequency determination and associated flood elevations.</p> <p>AR 10.1: FEMA should develop a strategy for obtaining the building footprints and relevant building elevations of properties throughout the Nation to be used in determining structure-based flood risk.</p> <p>AR 10.2: FEMA and its partners should identify data needs and standards for developing and maintaining accurate, location-specific flood frequency information, including associated flood conditions (e.g., velocity, waves, erosion, duration), for both present and future flood conditions.</p> <p>AR 10.3: FEMA should perform a demonstration(s) to learn from and document data requirements, processes, and standards necessary for nationwide implementation for structure-based risk assessment.</p>
AR 15	<p>FEMA should leverage opportunities to frame and communicate messages to stakeholders in communities so they understand the importance of addressing the flood risk today and consider long-term resilience strategies. Messages should be complemented by economic incentives, such as low-interest loans and mitigation grants, that lead community leaders and individuals to undertake cost-effective risk reduction measures.</p>
AR 16	<p>FEMA should transition from the current panel-based cartographic limitations of managing paper maps and studies to manage NFIP data to a database-derived, digital-display environment that are fully georeferenced and relational, enabling a single digital authoritative source of information and database-driven displays.</p>
AR 23	<p>FEMA should develop, in conjunction with others in the public and private sectors, flood risk-rated insurance premiums for all structures within and outside the identified Special Flood Hazard Area (SFHA). These premiums should be based on the nature and severity of the flood hazard, structure elevation, and other characteristics, as well as structure damage functions and vulnerability.</p>
AR 24	<p>FEMA should communicate to the property owner and other interested parties the cost of risk-rated insurance today and over time for new and existing structures to make the risk transparent. These data should include the benefits and cost that mitigation measures will have on these premiums.</p>
AR 25	<p>As FEMA transitions away from the 1-percent-annual-chance line, a risk score for existing and proposed structures should be developed. Each structure should be assigned a current conditions risk score and a future conditions risk score.</p>
AR 28	<p>FEMA should develop a series of mapping prototype products aimed at more effectively communicating residual flood risk related to levees, dams, and event-driven coastal erosion. Products developed should incorporate end user and stakeholder testing, and FEMA should develop standards for routine production and presentation, if applicable.</p>
FC 1	<p>Provide future conditions flood risk products, tools, and information for coastal, Great Lakes, and riverine areas. The projected future conditions should use standardized timeframes and methodologies wherever possible to encourage consistency and should be adapted as actionable science evolves.</p>
PR 9	<p>FEMA should move to a database-derived display, as outlined in the TMAC 2015 Annual Report Recommendation Number 16.</p>
PR 10	<p>For non-accredited levees, FEMA should replace the Zone D designation in levee-protected areas with risk zones that are more appropriate for the level of risk.</p>

40 ⁴ See Thaler and Sunstein (2018) and Meyer and Kunreuther (2017) for more information.

AR = TMAC Annual Report (2015, 2016, or 2017)

FC = TMAC Future Conditions Risk Assessment and Modeling Report (2015)

PR = TMAC National Floodplain Mapping Program Review (2016)

While this 2018 Annual Report is focused primarily on the programmatic aspects of increasing flood insurance through the national flood hazard mapping program, FEMA should acknowledge and assess many options to increase flood insurance coverage, whether from a product and rating, legislative, regulatory, or programmatic standpoint.

A recent study by the National Institute of Building Sciences indicates that for every dollar invested in flood hazard mitigation, \$6 are saved (National Institute of Building Sciences, 2017). A significant part of accomplishing the task of increasing flood insurance coverage is related to better public understanding of risk. In doing so, communication tools become key to success. Throughout their tenures, both this TMAC and the predecessor TMAC from 1996 to 2000⁵ have made recommendations to FEMA to operate the NFIP within an all-digital, database-driven environment and emphasized that collaboration, communication, and coordination between FEMA and its stakeholders be more effective and efficient. TMAC applauds the improvements implemented by FEMA in recent years. We hope to capitalize on that progress with our discussion, recommendations, and implementation actions.

Risk is often a difficult concept for many people to grasp. In the context of floodplain management, “risk” is quantified as the likelihood or probability of experiencing flooding multiplied by the consequences of flooding, including the suffering and damages from such an event (TMAC 2017 Annual Report). While we can plan for the probability of certain flood events, damaging consequences of floods of other magnitudes still exist. “residual risk” refers to the risk remaining after mitigation measures have been taken. TMAC believes that “residual risk” should be defined to incorporate additional conditions and circumstances that have not been previously addressed by TMAC.

In its 2017 Annual Report, TMAC addressed the topic of residual risk to address delivery, display, and communication of hazards that drive credible risk assessment in areas impacted by levees, dams, and event-driven coastal erosion (TMAC, 2017). TMAC has noted that beyond flood control structures and coastal erosion, other forms of residual risk exist but are not given much attention within Risk MAP. Examples include the possibility of floodwaters rising above mapped regulatory elevations, flood damages to structures outside of mapped SFHAs, urban (stormwater) flooding areas, and historic events, such as flood claims and disaster payments. Placing emphasis on creating products previously recommended by TMAC, in addition to new products recommended in this 2018 report, will support active engagement of community stakeholders so that residents and business owners have a sense of ownership of their flood risk.

As with any form of insurance, the public often makes decisions based on immediate costs and perceived benefits. As noted in our introduction to this section, TMAC believes that additional insurance products, marketing, and outreach could increase insurance coverage. The public will need to understand their exposure to risk prior to making a decision on whether or not to purchase flood insurance. This requires innovative mapping and flood risk product creation, which the three sections of this Annual Report work together to address.

In light of “evaluate[ing] how the FEMA National Flood Mapping Program can take steps to increase flood insurance coverage nationally,” TMAC makes the following recommendations with associated narrative.

⁵The first Technical Mapping Advisory Council to FEMA was established for 5 years under the National Flood Insurance Program Reform Act of 1994.

RECOMMENDATION 33

Building off AR16, FEMA should share and communicate data that can help drive decisions toward purchasing flood insurance, mitigation prioritization, and reducing risk. This data should support historical, future, and probabilistic analyses of coastal, fluvial, and pluvial flood hazards. FEMA should work with other agencies to assist data collection, creation, and sharing to support integrated water resources management and encourage data sharing.

Individual investments in flood hazard data are unlikely to move the dial much on the purchase of flood insurance, but collectively, enhancing the outputs of flood hazard and risk identification will build a climate of better understanding that is much more likely to lead to an increase in flood insurance coverage. TMAC reinforces the need to provide flood risk products that are clear, concise, and credible.

RECOMMENDATION 34

To increase insurance coverage, expanding on AR28, FEMA should include as part of their non regulatory products suite, areas previously identified as SFHAs, including information available in the Community Information System, and areas of previous flooding. This information should be easily maintained, support and communicate the actuarial rating of NFIP flood insurance, and empower informed decisions by property owners and local, regional, Tribal, and State agencies.

FEMA has made significant investments in precise terrain data over the past several years; similar investments, in cooperation with other federal, state, regional, tribal, and local agencies, should be made in acquiring data to support creating comprehensive and collective views of community flood risk (e.g., rainfall, streamflow, infrastructure characteristics, depth/damage functions, etc.) That support FEMA's updated flood risk rating procedures.

TMAC has identified the following areas for improved data creation, communication, and education regarding residual risk that will ultimately lead to increased flood insurance coverage. The following section is subdivided into two subsections: (1) a discussion of previous TMAC recommendations and FEMA efforts and (2) a discussion of 2018 recommendations and proposed implementation actions. The discussion below is not intended to duplicate any previous TMAC recommendations, but to clarify their applicability under the auspices of increasing flood insurance coverage.

PREVIOUS TMAC RECOMMENDATIONS AND FEMA EFFORTS

Dams, Levees, and Event-driven Coastal Erosion Residual Risks (as Identified in AR 28)

As noted in the TMAC 2017 Annual Report, present FEMA flood hazard and risk products do not adequately inform the general, non-technical public about the most commonly described forms of residual flood risks. Flood control and water storage structures often lead property owners behind levees and downstream of dams to believe that they are "risk free." But levees and dams are often susceptible to overtopping or failure and explaining these types of risk to the public can be extremely difficult but also significant in improving understanding of residual risks. There are also risks associated with storm-induced coastal erosion that may result from wave energy. These residual risks are not fully addressed in the current Risk MAP and floodplain management standards. Expedited efforts to create hazard and risk data for these residual risk areas should be considered. Applicable marketing and outreach must also be created to work in tandem so that there is no disconnect between the floodplain management, insurance, mapping, and mitigation aspects of the NFIP in the minds of the public.

Future Conditions (as Identified in FC 3 and 4)

TMAC previously recommended that all future conditions flood risk information be non-regulatory with the caveat that communities should be allowed—and encouraged—to adopt future conditions flood hazard products, tools, and information for local decision-making purposes. The flood risk products, tools, and information created should help provide communities usable guidance for managing and mitigating future flood risks.

Expedited efforts to create datasets and products recommended previously by TMAC should be considered.

Flood Depth, Analysis Grids, and Datasets for Communities and Watersheds

The general public often misunderstands probability and varying flood recurrence intervals and therefore does not understand the risk of inundation when relying on traditional FEMA flood hazard products (1 percent and 0.2 percent- annual-chance flood hazard areas). The message needs to be communicated that risk is real, no matter the annual chance probability of flooding. Significant steps have been taken through risk map to create valuable products that communicate flood risk. Products such as flood depth grids, percent chance of flooding over a period of time, and flood severity (depth and velocity) are available (e.g., FEMA, 2018b), but their use should be expanded.

Historical Floods and High Water Marks (HWMs) Available to Stakeholders

Records of historic floods and information about high water marks provide context for stakeholders to understand the possibility and extent of flooding. Tracking the number of people affected by historic floods in specific years sharply illustrates increases in potential dangers as population grows. Online flood inundation maps, leveraging flood gauges, compiled by the USGS and National Weather Service (NWS) often in partnership with the USACE (USGS, 2016), are easily understood visual tools. These products provide “real life” information and may differ from the water surface elevations for the frequencies used in FEMA flood mapping, but paint a comprehensive picture of community flood risk that can be integrated into a variety of public platforms issued by FEMA, states, communities, conservation groups, natural resource agencies, etc. Flood elevations (base flood, historic floods, floods important to the community, etc.) should continue to be reported in reference to North American Vertical Datum of 1988 (NAVD 88) and accepted updates, depth of flooding, and stage/height of flooding where data (USGS stream gauge or other) are available—at the gauge’s datum.

High water marks convey additional impact that can spur property owners and potential property purchasers to insurance protection and mitigation, be used to calibrate engineering models, and may be leveraged for Community Rating System credit.

DISCUSSION OF 2018 TMAC RECOMMENDATIONS

The discussion provided below expands on the 2018 recommendations provided by the TMAC regarding non-regulatory fluvial, pluvial and coastal flood hazard and risk products.

Areas with Letters of Map Change, Specifically Amendments and Revisions Based on Fill

Letters of Map Amendments (LOMAs) and Letters of Map Revision Based on Fill (LOMR-Fs) are presently issued on the basis of lowest elevation of a structure or parcel of land being at or above the BFE. This federally mandated flood insurance requirement is unrelated to the level of accuracy or precision of the data collection and analysis involved in the creation of a FIRM. This means that structures in areas affected by letters of map change (LOMCs) are subject to residual flood risks of which their owners may be unaware. Even ground marginally above BFE without elevation

by fill is subject to this kind of residual risk. FEMA should create awareness products and implement program updates related to these LOMCs that include inherent uncertainties in floodplain mapping (and leverages the findings in Section 2 of this Annual Report). A potential best practice relating to areas “reclaimed” through LOMAs or LOMR-Fs could be to require property owners to include them with deeds for the affected land along with notice for local officials to check land use regulations (local, state, tribal, and federal) relating to areas with affected by LOMCs. Including both the LOMC and the notice would also give local officials an opportunity to further interact with and inform property owners, realtors, and potential developers of flood hazards and risks.

Repetitive Loss (RL), Severe Repetitive Loss (SRL) Structures, Historical Flood Insurance Claims, Individual Assistance Payments, and Small Business Administration (SBA) Loan Areas

FEMA should consider identifying and communicating previous flood loss information via disaster assistance or flood insurance such as the number of times structures have been damaged, amount of damages sustained, and disaster claims or loans associated with structures and neighborhoods. Personally-identifiable information should be removed from such data to protect privacy, but the data itself is important for a spectrum of stakeholders. “Heat-maps” omitting street addresses for a “general” flood risk depiction may be used to reveal varying levels of flood risk. Note: In October 2018, FEMA introduced OpenFEMA “to execute federal open data machine readable policies and standards, and to promote a culture and empower open government within FEMA.” This data release includes much of the data mentioned above, including a redacted NFIP claims dataset.

Number of Flood Insurance Policies in Force, Amount of Flood Insurance Coverage, Number of Paid Losses, and Total Losses Paid – Data Available in FEMA Community Information System (CIS)

FEMA should enhance visualization tools of data readily available in the FEMA CIS database. Recognizing that people often emulate what their neighbors will do, a means of identifying how many policies are in place in a given area (zip code) could stimulate insurance and mitigation measures. TMAC recognizes that there are privacy concerns with such information (as there would be with repetitive loss, past-claims, Individual Assistance payments, etc.), but the data underscores local flood vulnerabilities and should be shared broadly. It is also important to note that providing information at the zip code level isn’t always particularly helpful for community-wide comparisons. Again, Heat-maps may be used to depict general flood risk and to reveal varying levels of flood risk.

Limit of Moderate Wave Action (LiMWA)

Areas beyond Zone V flood hazard zones are subject to wave actions that cause different kinds of damages from those experienced from overbank flooding. Zone V is defined by coastal flooding with wave heights 3 feet or higher. However, wave actions continue beyond Zone V and are generally only characterized by the LiMWA. The general lack of awareness of wave action beyond Zone V and the LiMWA often results in citizens and community officials who are unprepared for such impacts. LiMWAs represent a non-regulatory flood hazard boundary line indicating the inland limit of the area expected to receive 1.5-foot or greater breaking waves during the 1-percent-annual-chance flood event. LiMWAs help communicate risks that are infrequently designated on community FIRMs. Public awareness and understanding of coastal wave action could be enhanced by creating a separate non-regulatory zone designation such as “AEC – Zone AE Coastal” for coastal flood hazard zones and other designations on the landward side of the LiMWA where wave action can still occur. Educating coastal stakeholders of impacts outside Zone V would likely improve insurance coverage by effectively communicating the currently unidentified hazard and mitigation efforts, such as building permit processes that more appropriately address this hazard.

Stormwater/Urban (Pluvial) Flood Hazards

The connection between stormwater management and floodplain management is critical. Management of flood hazards requires us to take into account the quantity, location, and quality of that water, in addition to characteristics such as current and future land use, soils, and slope. Managing and mitigating stormwater runoff affects floodplain management, so the two practices should be more closely intertwined.

Comprehensive planning efforts should integrate floodplain and stormwater management within communities. FEMA should create flood risk products highlighting pluvial flooding risks, particularly in urban areas with stormwater issues. A 2016 white paper developed by the Pennsylvania Association of Floodplain Managers (Debarry, 2016) provides background and recommendations to accomplish the reintegration of stormwater and floodplain management. Among other recommendations, that report suggests supporting better flood forecasting by refined modeling that includes stormwater control features and their designed release or retention rates.

TMAC suggests that for better mitigation and floodplain management we need finer-scale flood-resolution than the current 1 square-mile threshold of identifying flood hazards. Currently, local communities may choose to implement a smaller watershed threshold to identify flood hazards and risks, but in general, finer resolution of stormwater modeling, such as 2-D base level engineering (BLE) analyses, could greatly increase understanding of pluvial flood risks and thus could increase the flood insurance pool. Increased insurance would then encourage more mitigation measures, further improving community resilience. FEMA should encourage and incentivize mapping stormwater systems through Municipal Separated Storm Sewer Systems (MS4) programs to create a focal point for leveraging federal, state and local resources and logically reconnect water quantity with water quality programs and activities. This should not be misconstrued as an intent to identify regulatory SFHAs beyond the current 1 square-mile standard but should be presented as an option for communities to implement.

Identify Resilience Measures and Depict Mitigation Actions that Have Decreased Flood Vulnerability

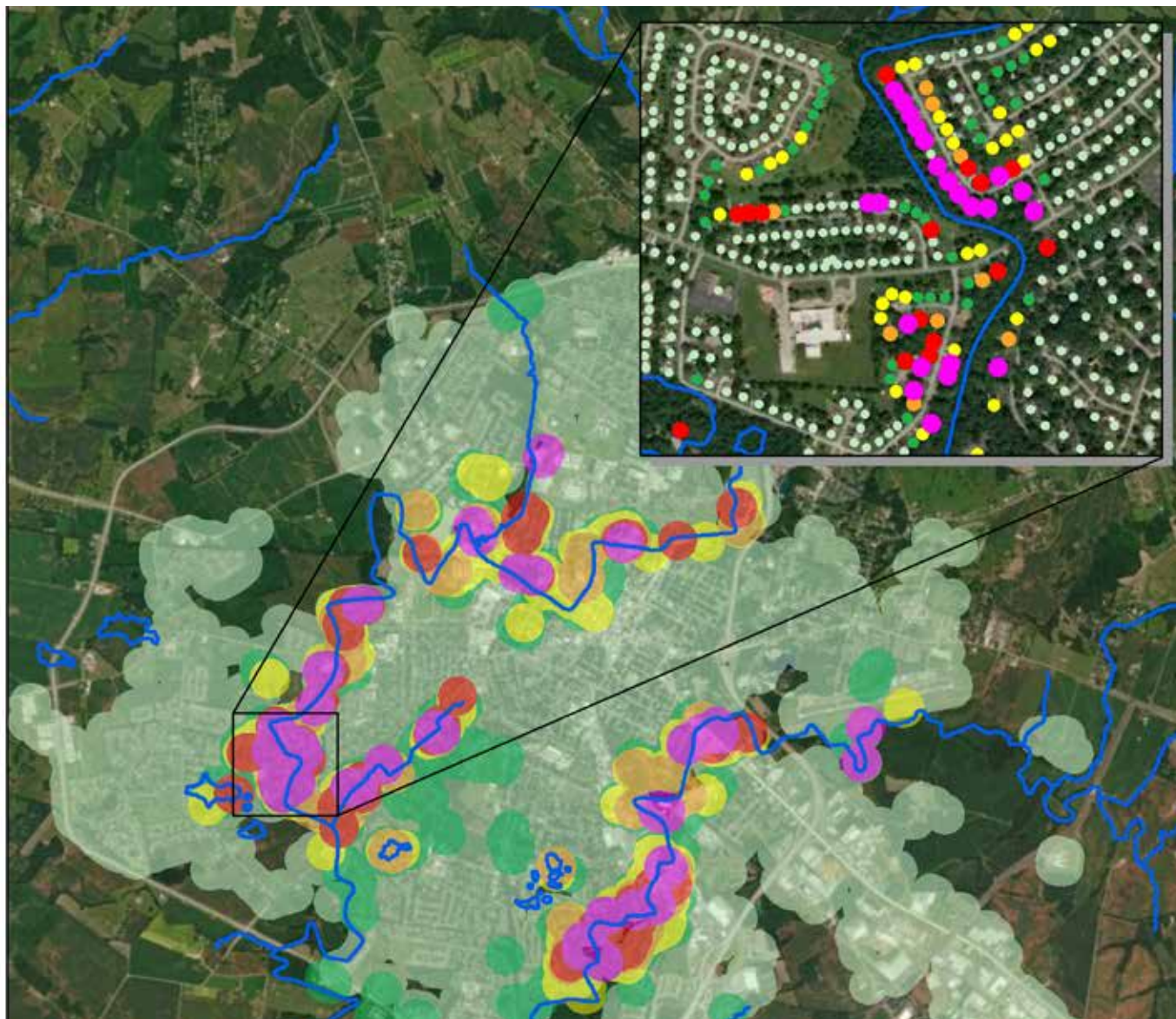
FEMA should assess previous investments in hazard mitigation measures, with a particular emphasis on flooding. A comprehensive review of past projects and projects currently underway will assist in developing data that will enhance the risk score concept of risk rating review and redesign discussed previously. These data may also be used as an educational tool to depict reduced flood risk resulting from mitigation actions, triggering more mitigation and flood insurance investments.

Expanding the Public's Understanding of the Variability of Flooding and Its Causes by Developing and Articulating Information to Technical and Non-technical Stakeholders

The 2018 TMAC Annual Report highlights the needs to better articulate flood risks on a broad scale. From discussing the inherent uncertainties of flood hazard mapping to prioritizing currently unmapped areas to increasing flood insurance coverage, a common theme remains: most individuals and business owners are not properly informed of their flood risk. Considerable challenges remain in simplifying flood hazard messaging and communication, but much of this may be accomplished by improving visualization tools. For this reason, FEMA should assess creating a "broad brush" risk depiction that leverages the products previously discussed. The depiction could (and should) leverage structure-based risk assessments, historical, future, probabilistic, and pluvial analysis of community flood hazards, and unique community flood hazard characteristics. These simple, non-regulatory products could increase awareness of pluvial, fluvial, and coastal (as applicable) community flood risks to spur greater flood insurance coverage and mitigation. This approach could also aid FEMA in

developing means of articulating to lower-risk property owners that they may still have risk of losses, and that flood insurance in combination with mitigation measures is a sound approach to self-protection. It should be noted that any products like this should be tested to ensure the deliverables are usable and easily understood by the intended audiences, similar to the NWS’s hazard simplification efforts (<https://www.weather.gov/hazardsimplification/>). Figures 4.4 – 4.6 depict sample non-regulatory products that may be utilized by FEMA’s national flood mapping program to accomplish enhanced flood hazard and risk visualization.

Figure 4-4 (a). Non-regulatory structure-based flood risk non-regulatory product example



Understanding Flood Risk Categories					
LATENT RISK					
Outside of Mapped Special Flood Hazard					
Flooding Still Possible	1 - MARGINAL	2 - MODERATE	3 - HIGH	4 - VERY HIGH	5 - EXTREME
Flooding Still Possible					

Figure 4-4(b). Non-regulatory structure-based flood risk non-regulatory product example.



Understanding Flood Risk Categories					
LATENT RISK Outside of Mapped Special Flood Hazard Flooding Still Possible Flooding Still Possible	1 - MARGINAL	2 - MODERATE	3 - HIGH	4 - VERY HIGH	5 - EXTREME

The figures depict flood risk determined at an individual structure level by establishing each structure’s finished floor elevation and flood depth grids for the 10-, 4-, 2-, 1-, and 0.2-percent-annual-chance flood events. The resulting multi-frequency flood depth grids were used to determine the Depth of Flooding at each structure for each flood event. USACE depth vs. damage curves were then utilized to generate damage estimates for each structure. Damage estimates (by percent of the structure) were calculated for both the structure and its contents. The damage estimates were aggregated to calculate a flood risk score based on the Average Annualized Percentage of Loss (AAPL) for each structure. AAPL provides a simple approach for determining annualized losses, Using the best available structure-related elevation data (surveyed or estimated) and flood hazard data. Annualized Average Loss (AAL) values may also be easily determined using AAPL by simply multiplying the AAPL value by the structure’s value.

Additional consideration and feedback are needed to establish flood risk categories (Latent – Extreme) based on AAPL values. The color scheme for flood risk categories in figures 4.4 (a) and 4.4 (b) align with the risk categories established by the national weather service at <https://www.spc.noaa.gov/misc/about.html>

Figure 4-5 (a). Rain on grid flood hazards from 2d modeling

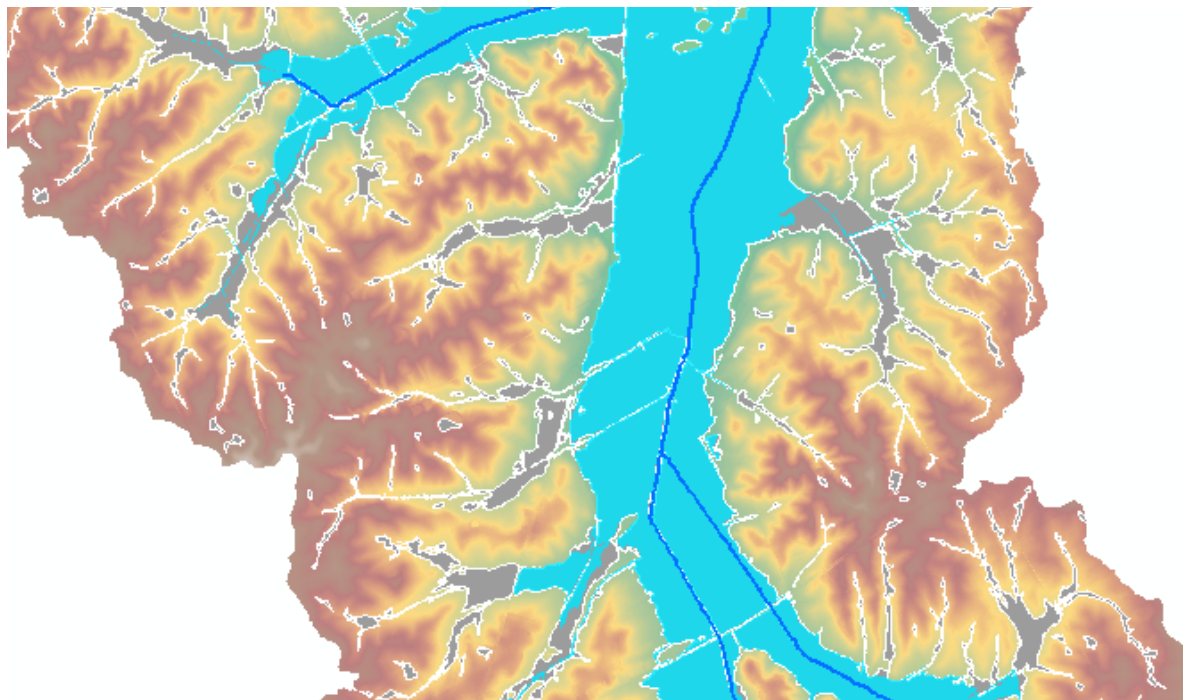


Figure 4-5 (b). Rain on grid flood hazards from 2D modeling



Legend

- Stream
- 1% Annual Chance NFHL
- 2D Model 1% Annual Chance Max Water Surface

Discussion of figures 4.5 (a) - 4.5 (b)

Historically, SFHA identification has been performed within predetermined study extents and generally up to a one square mile watershed area in riverine settings – although there are many examples nationwide of SFHAs identified beyond a one square mile watershed area. By conducting engineering analyses on predetermined watershed limits only the flooding caused by specifically studied streams is evaluated. In contrast, 2D flood hazard modeling, – specifically rain-on-mesh analyses – generates flood hazards along every stream, ditch, and swale throughout an entire watershed. The 2D model outputs provide flood hazard information on the “regulated” stream as well as the other contributing areas of the watershed. Identifying watershed-based maximum water surface outputs using 2D modeling as a non-regulatory flood hazard product, without the one square mile watershed limit, may provide a more holistic understanding of community flood hazards.

Figure 4-6. Using Virtual Reality to communicate flood risk. Virtual Reality (VR) is an innovative way to communicate flood risk by immersing users in a specific environment using digital tools. Figure 4.6 provides an example where a VR user may view an area without a flood hazard present and compare that to the same area when it has been inundated by a 1% annual change flood



4.2 Conclusion

In order to increase flood insurance coverage nationwide, and specifically in areas where it is most needed, FEMA should support comprehensive data collection and create flood hazard and risk products that communicate past, present, and future community flood risks. Specific emphasis should be placed on partnerships that allow for enhanced coastal, fluvial, and pluvial flood hazard analyses and may include (1) probabilistic and catastrophic flood risk assessments, (2) climatic and technical data collection and generation, (3) satellite and aerial data products, and (4) anecdotal evidence such as road closures and photos. The data collected should support FEMA’s Risk Rating and Review initiative and eventually support real-time flood forecasting and event-driven inundation mapping. This will provide FEMA additional opportunities to leverage data and programmatic efforts from other partner agencies (e.g., USGS, NOAA-NWS, USACE), and also includes data from citizen science sources such as the community collaborative rain, hail and snow network to highlight collaborative efforts. These efforts also tie in well with state or watershed-level water resources planning initiatives similar to the USACE Silver Jackets program, which emphasizes State-led flood risk management and reduction opportunities. Comprehensive community-based flood hazard data should be coordinated, collected and maintained at the state and/or local levels. This will allow for the collaborative communication of flood risk that will likely enhance flood insurance uptake.

Many agencies have made significant institutional shifts to discussing “impact-based” weather and warning messages. Sharing the impacts of flood hazards, rather than solely scientific or technical details, is a concept that could easily inform FEMA’s flood hazard mapping efforts and pave the way toward increased flood insurance coverage nationwide.

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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 \$1,100,000 for FY2017 and \$800,000 for FY2018. This includes surge support for all direct and indirect expenses. Three staff directly support the TMAC. One full-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 an Alternate DFO. 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 Composition:

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 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;
- 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). 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).

The sixteen appointed members serve terms of office of two years. However, up to half (eight) of those initially appointed to the Council may serve one-year terms to allow for staggered turnover. Appointments may be renewed by the FEMA Administrator for up to an additional one- or two-year period. A member appointed to fill an unexpired term shall serve the remainder of that term and may be reappointed for up to an additional one- or two-year term. The Administrator has the authority to extend reappointments for up to an additional one- or two-year period as deemed necessary. In the event the Council terminates, all appointments to the Council will terminate.

13. 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.

14. Subcommittees:

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. Recordkeeping:

The records of the TMAC, formally and informally established subcommittees, or other subgroups of the Council, shall be maintained and handled in accordance with General Records Schedule 26, Item 2 or other approved agency records disposition schedule.

16. Filing Date:

July 29, 2017
 Department Approval Date

July 31, 2017
 CMS Consultation Date

August 03, 2017
 Date Filed with Congress



Appendix B: TMAC Bylaws



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 TMAC 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 TMAC provides advice and recommendations to the Administrator of FEMA to improve the preparation of flood insurance rate maps (FIRM). Among its specified statutory responsibilities, TMAC will examine performance metrics, standards and guidelines, map maintenance, delegation of mapping activities to State and local mapping partners, interagency coordination and leveraging, and other requirements mandated by the authorizing BW-12 legislation. In addition, TMAC 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 TMAC 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 TMAC members may request SMEs, by expertise or skillset, to appear before the TMAC, as needed. Member requests will be made to the Chair for consideration and consultation with the TMAC 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 TMAC 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 of the TMAC may serve terms of office of two years; however, up to half of those initially appointed TMAC members may be appointed to serve one-year terms to allow for staggered turnover. The FEMA Administrator or his designee may reappoint serving members for additional terms. When the TMAC terminates, all appointments to the TMAC shall terminate.

Section 4. Certification of Non-Lobbyist Status.

All members of the TMAC 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 TMAC. Members who register as a lobbyist after their appointment or re-appointment will be replaced on the Council.

Section 5. Members' Responsibilities.

Because the TMAC's membership 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 TMAC'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 TMAC 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 TMAC, individual members may not petition or lobby Congress for or against particular legislation or encourage others to do so.
- c) Members of the TMAC 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 TMAC. If requested to testify before Congress, members of the TMAC:
 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. TMAC Leadership.

TMAC 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 either a one or two year term, based on their initial appointment. Appointments may be renewed for up to an additional

one-year term. No Chair or Vice Chair shall serve longer than three years, unless 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. In the event that the DFO determines that such an extension is necessary, such extension shall not extend the Chair or Vice Chair's appointment for a period in excess of six months. 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 TMAC;
- b) Works with the DFO to develop meeting agendas;
- c) Sets and maintains a schedule for TMAC activities (e.g., report development);
- d) Works with the TMAC 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 quarterly TMAC meetings.

Section 2. Designated Federal Officer.

The DFO serves as FEMA's agent for all matters related to the TMAC and is appointed by the FEMA Administrator. In accordance with the provisions of the FACA, the DFO 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.

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.

TMAC will meet in plenary sessions approximately once or twice per quarter, 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. TMAC 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 552b of title 5, U.S.C.

Section 2. Agenda.

Meeting agendas are developed by the DFO in coordination with the TMAC 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 in the Federal Register.

FEMA will publish the meeting notice and agenda in the Federal Register at least 15 calendar days prior to each TMAC 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 TMAC is the presence of 50-percent plus one of the Council members currently appointed. In the event a quorum is not present, the TMAC 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 TMAC 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 TMAC 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 TMAC 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 or 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 TMAC 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.

TMAC 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 TMAC 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 TMAC 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 TMAC 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 TMAC or subcommittee members convened solely to gather information, conduct research, or analyze relevant issues and facts in preparation for a TMAC meeting or to draft position papers for consideration by the TMAC.

ARTICLE VI EXPENSES AND REIMBURSEMENTS

Expenses related to the operation of the TMAC 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 TMAC 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 TMAC 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: TMAC subcommittees may consist of TMAC members and non-TMAC members as limited below. TMAC members may be named to serve on a specific subcommittee and may contribute to others as requested.

Subcommittees will not function independently of the TMAC or provide advice or recommendations directly to FEMA. Subcommittees (standing and ad-hoc) must present all advice, recommendations, and reports to the full TMAC 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-TMAC individuals to serve on the subcommittee, as necessary. Only TMAC 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 TMAC membership or from Federal staff. All such requests shall be made to the DFO who will facilitate the process to obtain 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 TMAC members currently appointed to the Subcommittee; and (2) TMAC 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 TMAC Subcommittee members present. Members may vote on draft reports and recommendations that will be presented to the full TMAC. 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 TMAC through discussion as an entire body. The DFO will determine focus areas in consultation with the TMAC 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 TMAC 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 TMAC. The DFO will supply the requested materials to the TMAC subcommittee upon request and resource availability.

ARTICLE IX RECOMMENDATIONS AND REPORTING

P.L. 112-141 directs TMAC 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.

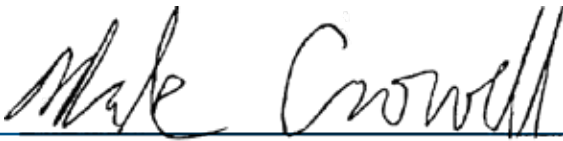
Once the TMAC achieves consensus on a report and recommendations, the TMAC Chair is responsible for providing a final version of the report to the FEMA Administrator. The final report and any accompanying memoranda will be posted on the TMAC website.

ARTICLE X RECORDKEEPING

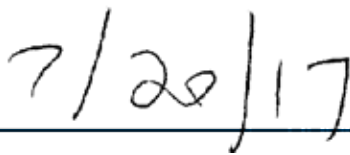
The DFO maintains all records of the advisory Council in accordance with FACA and FEMA policies and procedures. All documents, reports, or other materials presented to, or prepared by or for the Council, constitute official government records and are available to the public upon request.

ARTICLE XI BYLAWS APPROVAL AND AMENDMENTS

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



Mark Crowell
Designated Federal Officer



Date Approved:

Appendix C: FEMA 2018 TMAC Tasking Memo



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



FEMA

March 8, 2018

Jeffrey Sparrow, P.E., CFM
Chair, Technical Mapping Advisory Council
3601 Eisenhower Avenue
Alexandria, VA 22304

Dear Mr. Sparrow,

The Federal Emergency Management Agency appreciates the hard work of the Technical Mapping Advisory Council (TMAC) to date and the work that it will continue to perform. We value the continued engagement with TMAC as FEMA considers ways to improve how flood data is generated and delivered, redesigns flood risk rating for insurance, and evolves its products and services to best meet customer needs.

In 2018, FEMA would like the TMAC to provide insight on three specific mapping-related topics, which will position FEMA to continue to evolve the National Flood Insurance Program (NFIP). These are informed by suggestions that the TMAC forwarded for consideration and input provided by the FEMA National Flood Mapping Program.

My request is that the TMAC specifically focus the TMAC 2018 Annual Report on exploring and providing insight on the following three topics:

1. Evaluate how the FEMA National Flood Mapping Program can take steps to increase flood insurance coverage nationally.
2. Explore ways to communicate uncertainty and precision associated with data models and resulting Special Flood Hazard Areas (SFHA) from FEMA studies without undermining risk communication and the perceived credibility of FEMA information.
3. Explore the appropriate criteria that the program should consider in prioritizing unmapped areas, considering the need to create and maintain credible data for more populous areas while inspiring good mitigation practices nationally.

I appreciate the Council's continued dedication to sharing its knowledge and insight for FEMA to further strengthen our evolving flood mapping program, reduce risk, and help keep our Nation safe.

Sincerely,

A handwritten signature in blue ink, appearing to read "Roy E. Wright", written over a circular stamp.

Roy E. Wright
Deputy Associate Administrator for
Insurance and Mitigation

ATTACHMENT

This attachment provides additional context for the issues that FEMA is asking the TMAC to address in 2017.

Issue 1: Floodplain Management and Mitigation impacts of transitioning away from the 1-percent-annual-chance flood hazard

Context:

Today, national flood insurance is available in more than 22,000 participating communities across the United States. In exchange, those communities have agreed to adopt and enforce minimum land use standards and building codes. Flood hazard mapping is an important part of the National Flood Insurance Program (NFIP), as it is the basis for insurance ratings and the minimum floodplain management standards.

One of the greatest strengths of the NFIP is this partnership with communities, which includes their efforts to mitigate and reduce flood risks through floodplain management and building codes. While the NFIP sets minimum Federal standards, those are intended to be a launching place for more aggressive standards and mitigation by the community, based on the risks they face.

While tremendous mitigation and resiliency benefits are associated with having minimum Federal standards, the situation also presents some challenges. Currently, the NFIP's flood mapping program is structured around a binary Base (1-percent-annual-chance) Flood Elevation (BFE) line on a flood map, and a property is either inside or outside of that line. If the owners are within that line and have a Federally backed mortgage, they have to buy insurance. This "in or out" perspective gives property owners and policyholders a false sense of risk and doesn't communicate the full spectrum of risk. The way we've historically mapped flood hazards, and the mandatory purchase associated with the 1-percent BFE delineation, make it difficult for our policyholders to understand their risk.

Consistent with the TMAC's recommendations, we are laying the foundational framework for transforming our flood mapping program to provide structure-specific flood frequency determinations. As we work to evolve the mapping program to transition away from the 1-percent-annual-chance flood hazard as the basis for insurance ratings, we must also understand and address the cascading impacts of this change, particularly on floodplain management.

From a floodplain management perspective, the 1-percent-annual-chance flood hazard and associated floodway on the Flood Insurance Rate Maps are used as the basis for establishing and enforcing floodplain management standards in the community. As the NFIP and flood mapping program evolve into a structure-specific, risk-based program, is the floodway concept still relevant? If we no longer mapped the floodway, how would floodplain management standards be enforced?

Request to TMAC:

As FEMA moves away from mapping the 1-percent-annual-chance flood hazard and evolves the flood mapping program to provide structure-specific risk, what are the cascading impacts, issues, and opportunities that FEMA should consider from a floodplain management and mitigation perspective? What mapping tools will be needed to support floodplain management? Is the floodway concept still relevant? If we no longer mapped the floodway, how would floodplain management standards be enforced?

Issue 2: The National Flood Mapping Program must purposely and strategically enhance, replace, and add flood hazard mapping products in the coming years in order to support a redesign of the flood risk rating structure for the NFIP and to enhance understanding of risk at a more granular level. The most significant gaps are currently in areas affected by levees, dams, and other embankments, as well as areas subject to event-driven erosion.

Context:

FEMA is undertaking an effort to redesign risk rating for the NFIP. Essential to this effort is ensuring that the National Flood Mapping Program efficiently produces flood hazard data for a risk-based analysis to improve understanding and/or ownership of flood risk at a given location or structure and supporting transformative change in how the program reflects gradation of flood risk for flood insurance rating and risk communication.

Currently, the flood risk products and hazard information that FEMA delivers focus on specific likelihoods of the flood hazard, with a particular focus on the 1-percent exceedance level for NFIP rating and floodplain management. As the TMAC, National Academies, FEMA actuaries, and others have pointed out, FEMA should adopt a risk-based approach that considers the full range of flood hazards and the resulting outcomes. To that end, FEMA is considering how to better reflect risk from routine flooding to low-probability but high-consequence events. FEMA is actively working to develop next-generation coastal and riverine studies to support a risk-based approach, but gaps remain.

First, the 2016 TMAC National Flood Mapping Program Review noted that FEMA does not currently account for critical hazard conditions specific to areas affected by dams, levees, or other manmade structures. BW-12 calls for FEMA to begin to identify such hazards as part of the NFIP defined in statute.

Second, the 2015 Annual Report's Recommendation 9 calls for FEMA to review and update coastal event-based erosion methods for open coasts, and to develop event-based erosion methods for other coastal geomorphic settings. Additionally, it is noted that FEMA's use of the Primary Frontal Dune (PFD) to identify Coastal High Hazards Areas does not lend itself to a multiple-frequency determination. The program would welcome input on how to evolve FEMA's assessment of erosion so that it is consistent with the state of the science, applies to the many types of coastlines, and does not inhibit the ability of the NFIP to evolve with a more effective risk rating design. We are also interested in learning the TMAC's perspective on the continued utility of the PFD designation or if the NFIP can, or should, function without it.

Request to TMAC:

As FEMA takes on the challenge of delivering flood hazard data that support more robust flood risk rating, how can FEMA more effectively deliver, display, and communicate the hazards that drive credible risk assessments in the following areas?

- Residual risk impacted by dams, levees, or other manmade structures; and
- Areas of changing risk due to event-driven coastal erosion

What related work of other Federal or State agencies and the private sector should be considered or should inform FEMA's approaches?

Issue 3: The TMAC's 2015 Future Conditions Risk Assessment and Modeling (Future Conditions report) raised significant issues and opportunities. Many players exist in the development and dissemination of future conditions information, including Federal agencies, non-governmental organizations, States, and others. Perspective on the role of all players in the field of future conditions and gaps that remain in the development and dissemination of this information to stakeholders of the NFIP is needed.

Context:

In January 2016, the TMAC delivered its Future Conditions report. This statutorily mandated report included seven overarching recommendations and numerous sub-recommendations. The TMAC's recommendations and sub-recommendations provide substantial input and guidance into how FEMA may generate some future conditions data and information.

Over the past decade, the amount of information being provided to States and communities concerning future conditions flooding and erosion hazards has dramatically increased. This is especially true for sea level rise (SLR) projections and SLR planning information. At present, multiple Federal agencies (including the U.S. Army Corps of Engineers, the National Atmospheric and Oceanic Administration, the U.S. Geological Survey, and the Environmental Protection Agency), nationally scoped non-governmental organizations (e.g., The Nature Conservancy, Climate Central, and the National Research Council), and various State and regional bodies are producing and disseminating this information.

In this crowded space, FEMA seeks to avoid unnecessary redundancies and overlaps with these ongoing efforts. This is for several reasons. First, many communities, especially coastal ones, are not able to absorb and act on the vast amounts of data already available, especially if they seem to conflict due to uncertainty in the science. Second, the cost to produce the datasets as described in the Future Conditions report is significant; therefore, if similar data are already available, this cost should be avoided. Third, before any data is produced, FEMA wishes to ensure that it is data that are actually needed by our customers and that it is provided in a way that is most useful to them. Given this, FEMA would like to better understand the TMAC's perspective on the unmet needs or gaps in this field that the TMAC envisions FEMA's participation could fill.

To give these recommendations the full weight of the consideration that they are due and to design and implement an effective future conditions program in response to them, FEMA would like to continue working with the TMAC in 2017 to better understand the role this agency should play in providing communities with future conditions information. We want to ensure that we fully understand the need that is not being met by other Federal, or non-Federal, resources as we develop new products.

Request to TMAC:

Given the current datasets and tools currently being produced by various Federal agencies and non-Federal entities, what additional tools, data and resources can FEMA provide with respect to Future Conditions that would be useful to our customers and stakeholders?



Appendix D: Summary of Previous TMAC Goals, Recommendations, and Implementation Actions

GOAL 1: ACCURATE DATA, MODELS, AND RISK ASSESSMENTS

- AR 2**
Develop national program 5-year plan.
- AR 3**
Develop national program goals and metrics.
- AR 4**
Work with partners to ensure topo data is collected to Federal standards.
- AR 5**
Document horizontal and vertical accuracy of topo data.
- AR 6**
Review updated statistical models (Bulletin 17C).
- AR 7**
Develop guidance for selection and use of riverine and coastal models.
- AR 8**
Develop guidance related to coastal two-dimensional storm surge modeling.
- AR 9**
Update coastal event-based erosion methods.
- FC 1**
Provide future conditions flood risk products using standardized timeframes.
- FC 2**
Identify and quantify accuracy and uncertainty of data.
- FC 3**
Provide flood hazard products for coastal areas that includes erosion and sea level rise (SLR) using scenario approach.
- FC 4**
Provide flood hazard products for riverine areas that include future conditions.
- FC 5**
Generate future conditions data to frame and communicate messages.
- FC 6**
Perform demonstration projects.
- FC 7**
Future conditions should be consistent with existing conditions analysis and future conditions scenarios.
- PR 1**
Adopt AR15 recommendations that relate to the technical credibility of the program.
- PR 2**
Adopt FC report recommendations 1-7.
- PR 3**
Complete implementation of the statutory requirements of the National Flood Mapping Program.
- PR 4**
Enhance communication and transparency with stakeholders.
- PR 5**
Investigate offering multi-year program management grants to Cooperating Technical Partnerships (CTP).

GOAL 1 (continued)

- PR 6**
Facilitate, partner, and leverage high-resolution topo data.
- PR 7**
Work with partners to examine ways to shorten the study process.
- PR 8**
Move to database-driven, digital display of flood hazard data.
- PR 9**
Identify residual risk associated with levees, other flood control structures, and dams.
- PR 10**
Replace Zone D designation for non-accredited levees with more appropriate risk zones.
- PR 11**
Evaluate program metrics to better measure efficient production, valid inventory and stakeholder acceptance.
- PR 12**
Include an inventory metric that reports quantity, quality, and time aspects for all levels of geography.
- PR 13**
Include a metric that shows progress towards the digital platform.
- PR 14**
Evaluate benefits and costs and value to the Nation as a result of different funding levels of the National Flood Mapping Program.
- AR 23**
Develop, flood risk-rated insurance premiums for all structures based on the nature and severity of the flood hazard, structure elevation, and other characteristics.
- AR 24**
Communicate the cost of risk-rated insurance today and over time, including the benefits and cost that mitigation measures will have on premiums.
- AR 28:**
Develop a series of stakeholder-tested mapping prototype products aimed at more effectively communicating residual flood risk related to levees, dams, and event-driven coastal erosion.
- AR 29:**
Initiate stakeholder needs assessments to identify end users' highest priority needs for future conditions products and services that support its current flood-related programs and their evolution over time.

GOAL 2: TIME AND COST-EFFICIENT GENERATION OF DATA

- AR 11**
Update the Mapping Information Platform (MIP) to add greater flexibility.
- AR 12**
Determine cost impact due to new program requirements.
- AR 13**
Integrate process for mass LiDAR-based Letters of Map Amendment (LOMA).

GOAL 3: UTILIZATION OF COST-EFFICIENT TECHNOLOGIES

AR 16

Transition to a database-derived, digital display environment.

GOAL 4: INTEGRATED FLOOD RISK MANAGEMENT FRAMEWORK

AR 10

Transition to structure-specific flood frequency determination.

AR 14

Transition to structure-specific risk assessment.

AR 25:

As FEMA transitions away from the 1-percent-annual-chance line, a current and future conditions risk score for existing and proposed structures should be developed.

AR 26:

Coordinate with floodplain managers and mitigation planners to identify and test data and tools needed to support floodplain management and mitigation as it moves away from the 1-percent-annual-chance line.

AR 27:

Develop, in coordination with stakeholders, a transition plan for moving away from the 1-percent-annual-chance line.

GOAL 5: AWARENESS OF FLOOD HAZARD AND RISK DATA

AR 1

Implement a process to assess the needs of users.

AR 15

Communicate messages that consider long-term resilience strategies.

GOAL 6: ADDED VALUE PARTNERING AND LEVERAGING

AR 17

Consider National Academy of Public Administration (NAPA) recommendations on agency cooperation and federation.

AR 18

Partner to ensure availability of accurate water level and stream flow data and enhance the National Hydrography Dataset (NHD).

AR 19

Implement strategies to incentivize stakeholders to increase partnerships.

AR 20

Develop measures to evaluate CTP capabilities and competencies and increase responsibilities.

AR 21

Establish a National Flood Hazard Risk Management Coordination Committee.

GOAL 7: PERMANENT, SUBSTANTIAL PROGRAM FUNDING

AR 22

Define financial needs to implement recommendations.

KEY

Recommendation Sources:

AR	TMAC 2015 Annual Report or TMAC 2016 Annual Report
FC	TMAC Future Conditions Risk Assessment and Modeling (2015)
PR	TMAC National Flood Mapping Program Review (2016)

Acronyms:

CTP	Cooperating Technical Partner
KDP	Key Decision Point
LiDAR	Light Detection and Ranging
LOMA	Letter of Map Amendment
MIP	Mapping Information Platform
NAPA	National Academy of Public Administration
NFIP	National Flood Insurance Program
NHD	National Hydrography Dataset
SLR	Sea Level Rise



Transformation of Mapping

INITIATIVES

Structure Based Risk Assessments



BENEFIT: Transform the National Flood Insurance Program (NFIP) to protect current and future generations

National Program 5 Year Plan



BENEFIT: Increase transparency and leveraging of Federal funds

Future Conditions



BENEFIT: Stop building future problems

RECOMMENDATION / IMPLEMENTATION ACTION	
<p>AR 1 (2015)</p>	<p>FEMA should establish and implement a process to assess the present and anticipated flood hazard and flood risk products to meet the needs of various users. As part of this process, FEMA should routinely:</p> <ul style="list-style-type: none"> a) Conduct a systematic evaluation of current regulatory and non-regulatory products (data, maps, reports, etc.) to determine if these products are valued by users, eliminating products which do not cost-effectively meet needs; b) Consider user requirements prior to any updates or changes to data format, applications, standards, products, or practices are implemented; c) Proactively seek to provide authoritative, easy to access and use, timely, and informative products and tools; and d) Consider future flood hazards and flood risk. <p>Former Numbering IA16 2.1 (New Numbering AR 1.1) FEMA should construct and implement, and measure the effectiveness of public communication strategies that reflect how individuals acquire and process information on low-probability, high-consequence events. The strategies would include:</p> <ul style="list-style-type: none"> • Using a variety of media to illustrate and communicate flood hazard and risk information to different audiences and generational groups; • Illustrating location-specific inundation levels by working with private-sector mapping companies and other partners to integrate street-level photos with overlays of flood levels at multiple return intervals into FEMA’s mapping platform; • Working with real estate listing services to display flood hazard and risk information data for their customers; and • Displaying historical flood information, including flood boundaries and depths, where available.
<p>AR 2 (2015)</p>	<p>FEMA should develop a national five-year flood hazard and risk assessment plan and prioritization process that aligns with program goals and metrics (see Recommendation 3). This should incorporate a rolling five-year plan to include the establishment and maintenance of new and existing studies and assessments in addition to a long-term plan to address the unmapped areas. Mapping and assessment priorities should be updated annually with input from stakeholders (e.g., Multi-Year Hazard Identification Plan). The plan should be published and available to stakeholders.</p> <p>Former Numbering IA16 1.1 (New Numbering AR 2.1) FEMA should publish the State Geographic Information System (GIS) Standard Operating Procedures on a graphical web interface so that sources of local geospatial information are readily available to everyone.</p> <p>Former Numbering IA16 3.1 (New Numbering AR 2.2) FEMA should develop, with input from stakeholders, a list of factors to be used for prioritizing flood hazard and risk assessment studies across the country.</p>
<p>AR 3 (2015)</p>	<p>FEMA should develop National Flood Hazard and Risk Assessment Program goals that include well-defined and easily quantifiable performance metrics. Specifically, the program goals should include metrics for the following:</p> <ul style="list-style-type: none"> a) Maintaining an inventory of valid (verified), expiring, unverified, and unknown flood hazard miles; b) Addressing the non-modernized areas of the Nation and unstudied flood hazard miles; c) Conducting flood risk analysis and assessments on the built environment; and d) Counting population having defined floodplains using a stream-level performance indicator for a better representation of study coverage. <p>Former Numbering IA16 3.2 (New Numbering AR 3.1) FEMA should merge the Coordinated Needs Management Strategy (CNMS) and Risk Mapping, Assessment, and Planning (Risk MAP) Progress websites so users can see in one place what needs updating and what is being updated.</p> <p>Former Numbering IA16 3.3 (New Numbering AR 3.2) FEMA should evaluate whether adding the number or density of Light Detection and Ranging (LiDAR)-based Letters of Map Amendment (LOMAs) to Secondary Element contributes to the CNMS metric effectiveness.</p>
<p>AR 4 (2015)</p>	<p>FEMA should work with Federal, State, local, and Tribal partners to ensure topographic, geodetic, water-level, and bathymetry data for the flood mapping program is collected and maintained to Federal standards. Future FEMA topographic and bathymetric LiDAR acquisition should be consistent with 3D Elevation Program (3DEP) and Interagency Working Group on Ocean and Coastal Mapping standards, and all geospatial data for the flood mapping program should be referenced to current national datums and the National Spatial Reference System. Water level gage datums for active gages should be referenced to current national datums and the National Spatial Reference System and, to the extent practical, datums for inactive gages should be converted to meet these standards.</p>
<p>AR 5 (2015)</p>	<p>FEMA should document the horizontal and vertical accuracy of topographic data input to flood study models and the horizontal and vertical accuracy of topographic data used to delineate the boundaries of the flood themes. These data should be readily available to users, and clearly reported with products.</p>

RECOMMENDATION / IMPLEMENTATION ACTION	
AR 6 (2015)	FEMA should periodically review and consider use of new publicly available statistical models, such as the proposed Guidelines for Determining Flood Flow Frequency, Bulletin 17C, for flood-frequency determinations.
AR 7 (2015)	<p>Riverine. FEMA should develop guidelines, standards, and best practices for selection and use of riverine models appropriate for certain geographic, hydrologic, and hydraulic conditions.</p> <ul style="list-style-type: none"> a) Provide guidance on when appropriate models would be 1-D vs. 2-D, or steady state vs. unsteady state, b) Support comparative analyses of the models and dissemination of appropriate parameter ranges; and c) Develop quality assurance protocols. <p>Coastal. FEMA should develop guidelines, standards, and best practices for selection and use of coastal models appropriate for certain geographic, hydrologic, and hydraulic conditions.</p> <ul style="list-style-type: none"> a) Provide guidance on when appropriate models would be 1-D vs. 2-D, b) Support comparative analyses of the models and dissemination of appropriate parameter ranges, and c) Develop quality assurance protocols.
AR 8 (2015)	FEMA should develop standards, guidelines, and best practices related to coastal 2-D storm surge modeling in order to expand the utility of the data and more efficiently perform coastal flood studies.
AR 9 (2015)	FEMA should review and update existing coastal event-based erosion methods for open coasts, and develop erosion methods for other coastal geomorphic settings.
AR 10 (2015)	<p>FEMA should transition from identifying the 1-percent-annual-chance floodplain and associated Base Flood Elevation (BFE) as the basis for insurance rating purposes to a structure-specific flood frequency determination and associated flood elevations.</p> <p>Former Numbering IA16 1.2 (New Numbering AR 10.1) FEMA should develop a strategy for obtaining the building footprints and relevant building elevations of properties throughout the Nation to be used in determining structure-based flood risk.</p> <p>Former Numbering IA16 6.1 (New Numbering AR 10.2) FEMA and its partners should identify data needs and standards for developing and maintaining accurate, location-specific flood frequency information, including associated flood conditions (e.g., velocity, waves, erosion, duration), for both present and future flood conditions.</p> <p>Former Numbering IA16 6.4 (New Numbering AR 10.3) FEMA should perform a demonstration(s) to learn from and document data requirements, processes, and standards necessary for nationwide implementation for structure-based risk assessment.</p>

RECOMMENDATION / IMPLEMENTATION ACTION	
AR 11 (2015)	<p>FEMA should modify the current workflow production process and supporting management system, the Mapping Information Platform (MIP), to reduce unnecessary delays created by redundant tasks and the inflexibility of the system. The process and system are not currently designed to properly manage non-regulatory products or products that do not fit predefined footprints. FEMA should modify the system to enable flexibility in project scope and size, such as the choice of watershed size, not limiting projects to only the hydrologic unit code 8 (HUC8).</p> <p>Former Numbering IA16 4.1 (New Numbering AR 11.1) FEMA should develop a process for reviewing various aspects of the Flood Insurance Study (FIS) workflow and procedures to ensure that:</p> <ul style="list-style-type: none"> • Workflow efficiencies and cost-effectiveness, including during the Key Decision Point (KDP) process, are encouraged; • Complementary reporting systems are integrated; • Revisions to the FIS workflow and procedures incorporate a dynamic, digital display environment system; • All internal paperwork required for publishing the notice in the Federal Register is reviewed; • Best Management Practices are incorporated; and • Guidance from FEMA HQ and/or Regional offices is documented and shared. <p>Former Numbering IA16 4.2 (New Numbering AR 11.2) FEMA should take into consideration the following items at the next review of the MIP system:</p> <ul style="list-style-type: none"> • Integrate the MIP and KDP process into one system. • Provide mapping partners more visibility on Data Validation Tasks (i.e., who is responsible for these tasks at the Regional office) and ensure more proactive coordination is implemented before and after the data validation tasks. • The MIP should take into account the uniqueness of Cooperating Technical Partners (CTPs) and enable more flexibility in all areas of the flood production process, including product upload, geographic areas, metadata requirements, and Quality Assurance/Quality Control (QA/QC) reviews. • Transition the MIP to a geodatabase system, similar to the CNMS, in which information is saved geospatially and used to run customized queries and reporting for Regional offices, mapping partners, and CTPs. • Enhance functionality to create auto-generation of template correspondence (e.g., Summary of Map Actions [SOMA] letters). • Provide greater flexibility in user controls. • Provide additional user access to related information. • Add risk product workflows. • Integrate an efficient solution to seamless mapping or HUC or State geographic areas. <p>Former Numbering IA16 4.3 (New Numbering AR 11.3) FEMA Regions should clearly document and communicate MIP workflow validation and QA/QC procedures, correspondence protocols and approvals, documentation requirements, and other Region-specific guidance expectations of the flood study process. Additionally, FEMA Regions should regularly update partners with staff changes and roles and responsibilities for the Regional staff.</p> <p>Former Numbering IA16 4.4 (New Numbering AR 11.4) FEMA Headquarters (HQ) should develop additional guidance and training for mapping partners related to the Code of Federal Regulations (CFR) requirements for due process and Federal Register notifications. Regions should also be encouraged to create addendums that communicate their specific requests and internal timelines for their coordination activities with Production Technical Services(PTS) contractors and CTPs.</p> <p>Former Numbering IA16 4.5 (New Numbering IA 11.5) The TMAC recommends that FEMA work with the Customer and Data Services (CDS) contractor to evaluate the ability to migrate the MIP into a relational database system that can access data from other components of the flood insurance study program, such as a revised version of the Flood Insurance Rate Map (FIRM) database. Further efficiencies in reporting, data integration, and archival processes can occur if both a MIP database and FIRM database systems can relate to one another.</p>
AR 12 (2015)	<p>FEMA, in its update of guidance and standards, should determine the cost impact when new requirements are introduced and provide guidance to consistently address the cost impact for all partners.</p>
AR 13 (2015)	<p>FEMA should develop guidelines and procedures to integrate a mass LiDAR-based LOMA process into the National Flood Hazard and Risk Assessment Program. As part of this process, FEMA should also evaluate the feasibility of using parcel and building footprint data to identify eligible “out as shown” structures as an optional deliverable during the flood mapping process.</p>

RECOMMENDATION / IMPLEMENTATION ACTION	
<p>AR 14 (2015)</p>	<p>FEMA and its mapping partners, including the private sector, should transition to a flood risk assessment focus that is structure-specific. Where data are available, FEMA and its partners should contribute information and expertise consistent with their interests, capabilities, and resources toward this new focus.</p> <p>a) A necessary prerequisite for accurate flood risk assessments is detailed flood hazard identification, which must also be performed to advance mitigation strategies and support loss estimations for insurance rating purposes.</p> <p>b) FEMA should initiate dialogue with risk assessment stakeholders to identify potential structure-specific risk assessment products, displays, standards, and data management protocols that meet user needs.</p> <p>c) FEMA and its partners should develop guidelines, best practices, and approaches to implementing structure-specific risk assessments.</p> <p>Former Numbering IA16 6.2 (New Numbering AR 14.1) FEMA and its partners should identify data needs and standards for developing and maintaining accurate structure characteristics needed for risk estimation. Included in this should be a review of building characteristics data in existing flood risk estimation models, projects, programs, and databases.</p> <p>Former Numbering IA16 6.3 (New Numbering AR 14.2) FEMA and its partners should review and, if needed, modify flood damage functions to better capture structure-specific damage resulting from various flood hazards.</p>
<p>AR 15 (2015)</p>	<p>FEMA should leverage opportunities to frame and communicate messages to stakeholders in communities so they understand the importance of addressing the flood risk today and consider long-term resilience strategies. Messages should be complemented by economic incentives, such as low-interest loans and mitigation grants, that lead community leaders and individuals to undertake cost-effective risk reduction measures.</p>
<p>AR 16 (2015)</p>	<p>FEMA should transition from the current panel-based cartographic limitations of managing paper maps and studies to manage NFIP data to a database derived, digital-display environment that is fully georeferenced and relational, enabling a single digital authoritative source of information and database-driven displays. Towards this transition, FEMA should:</p> <p>a) Prepare a multi-year transition plan to strategically transition all current cartographic and/or scanned image data to a fully georeferenced enterprise relational database.</p> <p>b) Update required information for map revisions (MT-2 application forms) and Letter of Map Change (LOMC) applications to ensure accurate geospatial references, sufficient data to populate databases, and linkages to existing effective data.</p> <p>c) Adopt progressive data management approaches to disseminate information collected and produced during the study and revision process, including LOMCs.</p> <p>d) Ensure that the data management approach described in (c) is sufficiently flexible to allow efficient integration, upload, and dissemination of NFIP and stakeholder data (e.g., mitigation and insurance data that are created and maintained by Other Federal Agencies(OFA)), and serve as the foundation for creating all digital display and mapping products.</p> <p>e) Provide a mechanism for communities to readily upload jurisdictional boundary data, consistent with requirements to participate in the NFIP, as revised, allowing other stakeholders access.</p> <p>Former Numbering IA16 5.1 (New Numbering AR 16.1) FEMA should implement the following features into a future, dynamic, database-derived, digital display environment to manage the update, maintenance, and dissemination of all flood hazards and risk data across the country:</p> <ul style="list-style-type: none"> • Data are geospatial and captured in a relational geodatabase. • Data can be dynamically queried and displayed (point and click). • Develop a new website that features user-specific inputs, and where data provide one access point for multiple sources of flood hazard data and risk assessment information. • Products are developed on-the-fly using dynamic data calling features. • The new website and database support scalability, based on data availability, population, flood frequency and population impacted, and flood insurance penetration. <p>Former Numbering IA16 5.2 (New Numbering AR 16.2) FEMA should perform a demonstration(s) to learn from and document data requirements, processes, and standards necessary for nationwide implementation of a geodatabase-derived, digital display environment.</p> <p>Former Numbering IA16 5.3 (New Numbering AR 16.3) FEMA should utilize the National Flood Hazard Risk Management Coordination Committee to implement the TMAC’s vision, including the new database-derived, digital display environment.</p>
<p>AR 17 (2015)</p>	<p>FEMA should consider National Academy of Public Administration (NAPA) recommendations on agency cooperation and federation (6, 7, 8, 9, 13, and 15) and use them to develop more detailed interagency and intergovernmental recommendations on data and program-related activities that can be more effectively leveraged in support of flood mapping.</p>

RECOMMENDATION / IMPLEMENTATION ACTION	
AR 18 (2015)	FEMA should work with Federal, State, local, and Tribal agencies, particularly the U.S. Geological Survey (USGS) and the National Ocean Service, to ensure the availability of the accurate water level and streamflow data needed to map flood hazards. Additionally, FEMA should collaborate with USGS to enhance the National Hydrography Dataset to better meet the scale and resolution needed to support local floodplain mapping, while ensuring a consistent national drainage network.
AR 19 (2015)	FEMA should develop and implement a suite of strategies to incentivize communities, nongovernment organizations, and private sector stakeholders to increase partnering and subsequent contributions for flood hazard and risk updates and maintenance. Former Numbering IA16 7.2 (New Numbering AR 19.1) FEMA should investigate opportunities and obstacles to implementing multi-year funding cooperative agreements that complement the five-year CTP Plan. Former Numbering IA16 7.3 (New Numbering AR 19.2) FEMA should facilitate and fund demonstration projects for CTPs to incentivize program innovation and efficiencies.
AR 20 (2015)	FEMA should work with CTPs to develop a suite of measures that communicate the project management successes, competencies, and capabilities of CTPs. Where CTPs demonstrate appropriate levels of competencies, capabilities, and strong past performance, FEMA should further entrust additional hazard identification and risk assessment responsibilities to CTPs. Former Numbering IA16 7.1 (New Numbering AR 20.1) FEMA should evaluate the LOMC Review Partnership pilot program and develop clear program requirements, responsibilities, and performance metrics. This information should be used to formally establish the LOMC Review Partnership program, and increase the number of designated communities, where appropriate.
AR 21 (2015)	To ensure strong collaboration, communication, and coordination between FEMA and its CTP mapping partners, FEMA should establish a National Flood Hazard and Risk Management Coordination Committee. The role of the committee should be focused around the ongoing implementation of the five-year Flood Hazard Mapping and Risk Assessment Plan. FEMA should add other members to the committee that have a direct bearing on the implementation of the plan.
AR 22 (2015)	FEMA should define the financial requirements to implement the TMAC's recommendations and to maintain its investment in the flood study inventory.
AR 23 (2016)	FEMA should develop, in conjunction with others in the public and private sectors, flood risk-rated insurance premiums for all structures within and outside the identified Special Flood Hazard Area (SFHA). These premiums should be based on the nature and severity of the flood hazard, structure elevation, and other characteristics, as well as structure damage functions and vulnerability.
AR 24 (2016)	FEMA should communicate to the property owner and other interested parties the cost of risk-rated insurance today and over time for new and existing structures to make the risk transparent. These data should include the benefits and cost that mitigation measures will have on these premiums.
AR 25 (2017)	As FEMA transitions away from the 1-percent-annual-chance line, a risk score for existing and proposed structures should be developed. Each structure should be assigned a current conditions risk score and a future conditions risk score. AR 25.1 FEMA should perform pilot projects utilizing risk scores to determine the best data and methods to accurately calculate structure-specific risk for floodplain management for existing and new structures.
AR 26 (2017)	FEMA should coordinate with floodplain managers and mitigation planners to identify and test data and tools needed to support floodplain management and mitigation as it moves away from the 1-percent-annual-chance line. AR 26.1 FEMA should perform pilot projects to understand the implications and opportunities for floodplain management in regard to moving to risk scores and determine other relevant data. AR 26.2 FEMA should perform pilot projects to determine possible alternatives or modifications to the floodway concept.
AR 27 (2017)	FEMA should develop, in coordination with stakeholders, a transition plan for moving away from the 1-percent-annual-chance flood line.

RECOMMENDATION / IMPLEMENTATION ACTION	
<p>AR 28 (2017)</p>	<p>FEMA should develop a series of mapping prototype products aimed at more effectively communicating residual flood risk related to levees, dams, and event-driven coastal erosion. Products developed should incorporate end user and stakeholder testing, and FEMA should develop standards for routine production and presentation, if applicable.</p> <p>AR 28.1 FEMA should conduct pilot projects with communities and other stakeholders to evaluate how effective the prototypes are at communicating residual risk.</p> <p>AR 28.2 Once prototypes are developed and evaluated, FEMA should leverage the existing flood study process and other community engagement touchpoints to communicate residual risk.</p> <p>AR 28.3 FEMA should refine existing non-regulatory products and develop new non-regulatory products to clarify coastal flood risks in the vicinity of erodible features, and highlight the spatial areas affected by event-driven coastal erosion and Primary Frontal Dune (PFD) delineation. Possible products include:</p> <ul style="list-style-type: none"> • Delineation of model results in the vicinity of the eroded PFD • Representation of the regulatory flood zones in the absence of an erodible dune feature
<p>AR 29 (2017)</p>	<p>FEMA should initiate stakeholder needs assessments to identify end users’ highest priority needs for future conditions products and services that support its current flood-related program and the program’s evolution over time.</p> <p>AR 29.1 FEMA should engage a broad array of Federal, State, Tribal, and community-level stakeholders, private-sector stakeholders, and partners throughout the design, planning, execution, and interpretation of the Needs Assessment.</p> <p>AR 29.2 FEMA should ensure that the Needs Assessment collects information on users’ intended applications and addresses key analytical variables, such as relevant timeframe(s), spatial resolution, level of study, future conditions scenarios (e.g., land use, erosion, sea level rise), product type, uncertainty, and visualization preferences.</p> <p>AR 29.3 FEMA should integrate an ongoing future conditions needs gathering step as part of the standard flood study process and during other local community engagement touchpoints, and use the information gained to adapt FEMA’s products to respond to evolving user needs and advancements in science and technology.</p>
<p>FC 1 (2015)</p>	<p>Provide future conditions flood risk products, tools, and information for coastal, Great Lakes, and riverine areas. The projected future conditions should use standardized timeframes and methodologies wherever possible to encourage consistency and should be adapted as actionable science evolves.</p> <p>Former Numbering 3-4 (New Numbering FC 1.1) FEMA should define a future population metric that uses a standard future population database along with various budget scenarios for keeping the data current to predict the percent of the population covered at various points in the future.</p> <p>Former Numbering 3-5 (New Numbering FC 1.2) FEMA should take into account future development (excluding proposed flood control structures for the base condition/scenario) for future conditions mapping. An additional scenario can be generated that does include future flood control structures.</p> <p>Former Numbering 3-6 (New Numbering FC 1.3) FEMA should use population growth as an indicator of areas with increased potential flood risk.</p> <p>Former Numbering 4-4 (New Numbering FC 1.4) FEMA should develop guidance for how local zoning and land use planning can be used to identify where and how land use will change in the future, and incorporate that into local hazard and risk modeling.</p> <p>Former Numbering 4-11 (New Numbering FC 1.5) FEMA should develop a policy and standards on how to consider and determine erosion zones that are outside of the SFHA as they ultimately affect flooding and environmental conditions within the SFHA.</p> <p>Former Numbering 5-2 (New Numbering FC 1.6) FEMA should use a scenario approach for future conditions flood hazards calculation and mapping that will allow users to evaluate the robustness of proposed solutions to a range of plausible future conditions, including uncertain land use and climate change impacts.</p>
<p>FC 2 (2015)</p>	<p>Identify and quantify accuracy and uncertainty of data and analyses used to produce future conditions flood risk products, tools, and information.</p> <p>Former Numbering 3-2 (New Numbering FC 2.1) FEMA should use future risk assessments to take into account the likelihood of events occurring and their impacts, as well as the associated uncertainties surrounding these estimates.</p> <p>Former Numbering 3-7 (New Numbering FC 2.2) FEMA should publish multiple future conditions flood elevation layers that incorporate uncertainty so as to provide a basis for building designs that lower flood risk.</p>

RECOMMENDATION / IMPLEMENTATION ACTION	
FC 3 (2015)	<p>Provide flood hazard products and information for coastal and Great Lakes areas that include the future effects of long-term erosion and sea/lake level rise. Major elements are:</p> <ul style="list-style-type: none"> • Provide guidance and standards for the development of future conditions coastal flood risk products; • Incorporate local relative sea/lake level rise scenarios and long-term coastal erosion into coastal flood hazard analyses; and • Consider the range of potential future natural and man-made coastal changes, such as inundation and coastal erosion. <p>Former Numbering 4-1 (New Numbering FC 3.1) FEMA should use a scenario approach when considering shoreline location for the estimation of future conditions flood hazards. At least two scenarios should be evaluated, one in which the shoreline is held at its present location, and another in which the shoreline is eroded according to the best available shoreline erosion data.</p> <p>Former Numbering 4-6 (New Numbering FC 3.2) FEMA should develop guidance for incorporating future conditions into coastal inundation and wave analyses.</p> <p>Former Numbering 4-8 (New Numbering FC 3.3) FEMA should develop consistent methods and models for long-term coastal erosion hazard mapping.</p> <p>Former Numbering 5-4 (New Numbering FC 3.4) FEMA should use Parris, et. al., 2012, or similar global mean sea level scenarios, adjusted to reflect local conditions, including any regional effects (Local Relative Sea Level) to determine future coastal flood hazard estimates. Communities should be consulted to determine which scenarios and time horizons to map, based on risk tolerance and criticality.</p> <p>Former Numbering 5-5 (New Numbering FC 3.5) FEMA should work with other Federal agencies (e.g., National Oceanic and Atmospheric Administration [NOAA], U.S. Army Corps of Engineers [USACE], USGS), the U.S. Global Change Research Program (USGCRP), and the National Ocean Council to provide a set of regional sea level rise scenarios, based on the Parris, et al., 2012 scenarios, for the coastal regions of the United States out to the year 2100 that can be used for future coastal flood hazard estimation.</p> <p>Former Numbering 5-7 (New Numbering FC 3.6) FEMA should prepare map layers displaying the location and extent of areas subject to long-term erosion and make the information publicly available. Elements include:</p> <ul style="list-style-type: none"> • Establishing the minimum standards for long-term erosion mapping that will be used by FEMA that must be met by partners/communities if it is to be incorporated into the FEMA products. • Working with Federal, State, and local stakeholders to develop these minimum standards via pilot studies. • Securing funding that can support sustained long-term erosion monitoring and mapping by allowing for periodic updates. <p>Former Numbering 5-9 (New Numbering FC 3.7) FEMA should support additional research to characterize how a changing climate will result in changes in Great Lakes and ocean wave conditions, especially along the Pacific Coast. The relative importance of waves on this coast makes this an important consideration.</p> <p>Former Numbering 5-10 (New Numbering FC 3.8) For the Great Lakes, the addition or subtraction of future lake level elevations associated with a changing climate is not recommended at this time, due to current uncertainty in projections of future lake levels.</p> <p>Former Numbering 5-11 (New Numbering FC 3.9) FEMA should build upon the existing current conditions flood hazard analyses prepared by FEMA for the NFIP to determine future coastal flood hazards.</p> <p>Former Numbering 5-12 (New Numbering FC 3.10) FEMA should incorporate local relative sea-level rise scenarios into the existing FEMA coastal flood insurance study process in one of the following ways:</p> <ul style="list-style-type: none"> • Direct Analysis: Incorporate sea level rise directly into process modeling (e.g., surge, wave setup, wave runup, overtopping, erosion) for regions where additional sea level is determined to impact the base flood elevation (BFE) non-linearly (e.g., 1FT Sea Level Rise (SLR) = 2FT or more BFE increase). • Linear Superposition: Add sea level to the final calculated total water level and redefine BFE for regions where additional sea level is determined to impact the BFE linearly (e.g., 1FT SLR = 1FT BFE increase). • Wave effects should be calculated based on the higher Stillwater, including sea level rise. <p>Former Numbering 5-13 (New Numbering FC 3.11) Maps displaying the location and extent of areas subject to long-term coastal erosion and future sea-level rise scenarios should be advisory (non-regulatory) for Federal purposes. Individuals and jurisdictions can use the information for decision making and regulatory purposes if they deem appropriate.</p>

RECOMMENDATION / IMPLEMENTATION ACTION	
<p>FC 4 (2015)</p>	<p>Provide future conditions flood risk products and information for riverine areas that include the impacts of: future development, land use change, erosion, and climate change, as actionable science becomes available. Major elements are:</p> <ul style="list-style-type: none"> • Provide guidance and standards for the development of future conditions riverine flood risk products. • Future land use change impacts on hydrology and hydraulics can and should be modeled with land use plans and projections, using current science and build upon existing model study methods where data are available and possible. • Future land use should assume built-out floodplain fringe and take into account the decrease of storage and increase in discharge. • No actionable science exists at the current time to address climate change impacts to watershed hydrology and hydraulics. If undertaken, interim efforts to incorporate climate change impacts in flood risk products and information should be based on existing methods, informed by historical trends, and incorporate uncertainty based upon sensitivity analyses. • Where sufficient data and knowledge exist, incorporate future riverine erosion (channel migration) into flood risk products and information. <p>Former Numbering 4-7 (New Numbering FC 4.1) FEMA should evaluate previously issued guidance for future conditions land use and hydrology to incorporate best practices and lessons learned from communities that have implemented the guidance since 2001.</p> <p>Former Numbering 4-9 (New Numbering FC 4.2) FEMA should determine long-term riverine erosion hazard areas for areas subject to high erosion and provide it to the public in a digital layer.</p> <p>Former Numbering 4-10 (New Numbering FC 4.3) FEMA should utilize a national standard for riverine erosion zone delineations that reflects geographic variability.</p> <p>Former Numbering 5-6 (New Numbering FC 4.4) FEMA should take the impacts of future development and land use change on future conditions hydrology into account when computing future conditions for riverine areas.</p> <p>Former Numbering 5-8 (New Numbering FC 4.5) FEMA should implement riverine erosion hazard mapping (E Zones that define channel migration zones), leveraging existing data, models, and approaches that reflect site-specific processes and conditions.</p> <p>Former Numbering 5-15 (New Numbering FC 4.6) FEMA should use observed riverine trends to help estimate what future conditions might look like. In watersheds where floods of interest may decrease in magnitude and frequency, FEMA should use existing riverine study results as the basis for flood hazard mapping. In watersheds where floods exhibit increases in magnitude or frequency, then use best available science to determine future hydrology and flood hazards.</p> <p>Former Numbering 5-16 (New Numbering FC 4.7) FEMA should work with other Federal agencies via the Advisory Committee on Water Information’s Subcommittee on Hydrology to produce a new method to estimate future riverine flood flow frequencies. This method should contain ways to consistently estimate future climate-impacted riverine floods and address the appropriate range of flood frequencies needed by the NFIP.</p> <p>Former Numbering 5-17 (New Numbering FC 4.8) FEMA should produce, and should encourage communities to adopt, future conditions products to reduce flood risk.</p>
<p>FC 5 (2015)</p>	<p>Generate future conditions data and information such that it may frame and communicate flood risk messages to more accurately reflect the future hazard in ways that are meaningful to and understandable by stakeholders. This information should enable users to make better-informed decisions about reducing future flood-related losses.</p> <p>Former Numbering 3-3 (New Numbering FC 5.1) FEMA should frame future risk messages for future conditions data and information such that individuals will pay attention to the future flood risk. Messages may be tailored to different stakeholders as a function of their needs and concerns.</p>
<p>FC 6 (2015)</p>	<p>Perform demonstration projects to develop future conditions data for representative coastal and riverine areas across the Nation to evaluate the costs and benefits of different methodologies or identify/address methodological gaps that affect the creation of future conditions data.</p> <p>Former Numbering 3-1 (New Numbering FC 6.1) FEMA should perform a study to quantify the accuracies, degree of precision, and uncertainties associated with respect to flood studies and mapping products for existing and future conditions. This study should include the costs and benefits associated with any recommendation leading to additional requirements for creating flood-related products.</p> <p>Former Numbering 5-3 (New Numbering FC 6.2) FEMA should conduct future conditions mapping pilots to continue to refine a process and methods for mapping and calculating future flood hazards, and capture and document best practices and lessons learned for each.</p> <p>Former Numbering 5-14 (New Numbering FC 6.3) FEMA should support research for future conditions coastal hazard mapping pilots and case studies using the latest published methods to determine the best means to balance the costs and benefits of increasing accuracy and decreasing uncertainty.</p>

RECOMMENDATION / IMPLEMENTATION ACTION	
FC 7 (2015)	<p>Data and analysis used for future conditions flood risk information and products should be consistent with standardized data and analysis used to determine existing conditions flood risk, but also should include additional future conditions data, such as climate data, sea-level rise information, long-term erosion data; and develop scenarios that consider land use plans, planned restoration projects, and planned civil works projects, as appropriate, that would impact future flood risk.</p> <p>Former Numbering 4-2 (New Numbering FC 7.1) FEMA should support expanded research and innovation for water data collection, for example using Doppler radar.</p> <p>Former Numbering 4-3 (New Numbering FC 7.2) FEMA should use a scenario approach to evaluate the impacts of future flood control projects on future conditions flood hazards.</p> <p>Former Numbering 4-5 (New Numbering FC 7.3) FEMA should support research on future conditions land use effects on future conditions hydrology and hydraulics.</p> <p>Former Numbering 4-12 (New Numbering FC 7.4) FEMA should develop guidance for evaluating locally-developed data from States and communities to determine if it is an improvement over similarly-available national datasets and could be used for future conditions flood hazard analyses.</p> <p>Former Numbering 4-13 (New Numbering FC 7.5) FEMA should develop better flood risk assessment tools to evaluate future risk, both population-driven and climate-driven. Improve integration of hazard and loss estimation models (such as Hazus) with land use planning software designed to analyze and visualize development alternatives, scenarios, and potential impacts to increase use in local land use planning.</p> <p>Former Numbering 5-1 (New Numbering FC 7.6) Future flood hazard calculation and mapping methods and standards should be updated periodically as we learn more through observations and modeling of land surface and climate change, and as actionable science evolves.</p>
PR 1 (2016)	<p>FEMA should adopt the TMAC's 2015 recommendations that relate to the National Flood Mapping Program's technical credibility from the TMAC 2015 Annual Report.</p>
PR 2 (2016)	<p>FEMA should adopt the future conditions recommendations from the <i>2015 TMAC Future Conditions Risk Assessment and Modeling</i> report.</p> <p>Former Numbering IA16 8.1 (New Numbering PR 2.1) FEMA should identify and summarize relevant future conditions-related modeling and mapping projects nationwide (Federal or non-Federal sources) that have technical relevance to the NFIP's mapping program, and capture any data standards, modeling and mapping methods, and/or best practices that can inform FEMA's future conditions mapping program.</p> <p>Former Numbering IA16 8.2 (New Numbering PR 2.2) FEMA should review existing State-level riverine erosion hazard mapping programs to determine what data standards, modeling and mapping methods, and/or best practices are transferable (i.e., broadly applicable) for potential nationwide implementation of riverine erosion hazard mapping. FEMA should also capture those standards and methods that are applicable to specific geographies or physical settings (analogous to the coast-specific models and guidance used in FEMA's current coastal flood study process).</p> <p>Former Numbering IA16 8.3 (New Numbering PR 2.3) FEMA should include consideration of both SLR and long-term coastal erosion in the modeling and mapping of flood hazards in all new coastal future conditions pilots.</p> <p>Former Numbering IA16 8.4 (New Numbering PR 2.4) FEMA should leverage completed FEMA pilot studies and other relevant coastal and riverine future conditions projects and programs nationwide to prepare a gap analysis that captures outstanding data standards and methodological elements critical to implementing future conditions mapping nationwide.</p> <p>Former Numbering IA16 8.5 (New Numbering PR 2.5) FEMA should use the existing body of knowledge gained through completed future conditions pilots, evaluation of existing future conditions-related programs, and other relevant Federal and non-Federal efforts to commence development of future conditions modeling and mapping standards and guidelines.</p> <p>Former Numbering IA16 8.6 (New Numbering PR 2.6) FEMA should convene stakeholders and subject matter experts in the initial scoping, development, and review of new future conditions modeling and mapping standards and guidelines (Implementation Action 8.5). This effort should begin as soon as possible to inform the gap analysis and gap prioritization (Implementation Action 8.4), and enable use of any near-term pilots to address critical information needs.</p> <p>Former Numbering IA16 8.7 (New Numbering PR 2.7) FEMA should develop and test multiple approaches for visualizing future conditions flood risk in one or more future mapping pilots, drawing on relevant social science expertise and lessons learned from prior pilots and other completed mapping projects.</p>
PR 3 (2016)	<p>FEMA should complete the implementation of the statutory requirements of the National Flood Mapping Program.</p>
PR 4 (2016)	<p>FEMA should continue to enhance communication and transparency with program stakeholders by, for example, including organizational and contact information on the Internet.</p>

RECOMMENDATION / IMPLEMENTATION ACTION	
PR 5 (2016)	FEMA should investigate offering multi-year program management grant periods (versus annual) to Cooperating Technical Partnerships (CTPs).
PR 6 (2016)	FEMA should facilitate, partner, and leverage current high resolution topographic data (e.g., Light Detection and Ranging [LiDAR] data, other new and emerging technologies).
PR 7 (2016)	FEMA should work with the Congress and other partners to examine ways to shorten the study process, including the time added to the mapping process by QRs, KDPs, and legislated due process, as identified in TMAC’s 2015 Goal 2 Annual Report Recommendation Number 11.
PR 8 (2016)	FEMA should move to a database-derived display, as outlined in the TMAC 2015 Annual Report Recommendation Number 16.
PR 9 (2016)	FEMA should work to identify residual risk areas behind levees and other flood control structures and downstream of dams.
PR 10 (2016)	For non-accredited levees, FEMA should replace the Zone D designation in levee-protected areas with risk zones that are more appropriate for the level of risk.
PR 11 (2016)	FEMA should evaluate the current metrics to better measure the efficient production, valid inventory, and stakeholder acceptance of the National Flood Mapping Program. TMAC recommends that FEMA should: <ul style="list-style-type: none"> • Discontinue the current Deployment and Mitigation Action metrics and replace them with more effective measures, and • Focus revised metrics on measuring the quality and quantity of flood hazard and risk products delivered to communities.
PR 12 (2016)	FEMA should have an inventory metric that reports quantity, quality, and time aspects on national, regional, Tribal, State, and watershed levels: <p>a) Quantity: Quantity should be tracked through the life of a floodplain from no study through to detailed study. Statistics should be provided annually.</p> <p>b) Quality: Quality should be measured by retaining the existing New, Valid, Updated Engineering (NVUE) metric of the current inventory and adding an NVUE metric for coastal flood hazard miles.</p> <p>c) Time: Timing should be measured from Discovery to the issuance of Preliminary maps, and from the issuance of Preliminary maps to Effective maps for active projects.</p>
PR 13 (2016)	FEMA should have a metric that shows progress towards meeting a digital platform goal by area of the Nation to compliment FEMA’s current population metrics. This metric could include the total area of the country, as well as progress towards Goal 3 and Recommendation 16 in the TMAC 2015 Annual Report.
PR 14 (2016)	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.

AR = TMAC Annual Report (2015), TMAC 2016 Annual Report, or TMAC 2017 Annual Report, PR = TMAC National Flood Mapping Program Review (2016), FC = TMAC Future Conditions Risk Assessment and Modeling (2015), IA = Implementation A

Appendix E: TMAC Administrative and Public Meetings —Fiscal Year 2018



MEETING DATE	MEETING TYPE	LOCATION	BUSINESS PURPOSE
December 6, 2017	Public	Virtual	The TMAC reviewed, deliberated on, and approved final TMAC 2017 Annual Report content for production and submission to the FEMA Administrator.
January 31, 2018	Administrative	Virtual	The TMAC selected a new TMAC Chair.
March 15, 2018	Administrative	Virtual	The TMAC conducted an administrative meeting to receive the TMAC 2018 tasking memo, organize into subcommittees, and review a proposed schedule for the TMAC 2018 Annual Report development.
May 15-16, 2018	Public	3101 Wilson Blvd., Arlington, VA	The TMAC discussed the 2018 TMAC topics. The council received briefings from subject matter experts, and produced topic outlines for full council review.
July 23 and 26, 2018	Administrative	Virtual	The TMAC conducted an administrative meeting to achieve consensus on the 2018 key insights and recommendations and report draft content direction for the TMAC 2018 Annual Report
September 25-26, 2018	Public	U.S. Geological Survey, Reston, VA	The TMAC reviewed, deliberated on, and approved final TMAC 2018 Annual Report content for production and submission to the FEMA Administrator.
April 10, 2019	Administrative	Virtual	The TMAC conducted an administrative meeting to introduce new TMAC members.
July 31 - August 1, 2019	Public	3101 Wilson Blvd, Arlington, VA	The TMAC reviewed, deliberated on, and approved the TMAC 2018 Annual Report. The TMAC received 2019 Tasking Memo.

Appendix F: TMAC 2018 Subcommittee Meetings —Fiscal Year 2018



Increasing Coverage Subcommittee Meetings

MEETING DATE	BUSINESS PURPOSE
April 16, 2018	Kickoff Meeting. Discuss the tasking.
May 7, 2018	Discuss the subcommittee’s tasking.
March 16, 2018	Discuss the topic and produced an outline identifying lead authors and assignments.
June 28, 2018	Discuss subcommittee report writing.
July 2, 2018	Discuss subcommittee report writing.
July 9, 2018	Discuss subcommittee report writing.
April 10, 2018	Discuss subcommittee report writing.
July 23, 2018	Discuss the subcommittee’s progress, reviewed the annotated topic outline, and reviewed draft key insights/recommendations and content.
July 30, 2018	Discuss subcommittee report writing.
August,13, 2018	Discuss subcommittee report writing.
August 20, 2018	Discuss subcommittee report writing.
May 3, 2019	Discussed the draft report
May 10, 2019	Discussed edits to draft report

Communicating Uncertainty Subcommittee Meetings

MEETING DATE	BUSINESS PURPOSE
May 7, 2018	Discussed the objectives of the subcommittee.
May 16, 2018	Discuss the topic and produced an outline identifying lead authors and assignments.
May 24, 2018	Reviewed and commented on the draft outline.
June 20, 2018	Reviewed and commented on the draft report.
July 25, 2018	Discuss the subcommittee’s progress, reviewed the annotated topic outline, and reviewed draft key insights/recommendations and content.
August 6, 2018	Discussed the draft report.
April 30, 2019	Discussed edits to draft report.

Prioritizing Unmapped Areas Subcommittee Meetings

MEETING DATE	BUSINESS PURPOSE
May 4, 2018	Kickoff Call. Discuss objective, schedule, and SME needs.
May 16, 2018	Discuss the topic and produced an outline identifying lead authors and assignments.
June 4, 2018	SME briefing to subcommittee on BLE.
June 18, 2018	SME briefing to subcommittee on IWRSS.
June 25, 2018	SME briefing to subcommittee on urban flooding.
June 11, 2018	SME briefing to subcommittee on CNMS.
July 25, 2018	Discuss the subcommittee’s progress, review the annotated topic outline, and review draft key insights/recommendations and content.
July 27, 2018	Discuss comments on draft report.
April 26, 2019	Discussed final edits to draft report.

BLE = Base Level Engineering

IWRSS = Integrated Water Resources Science and Services

CNMS = Coordinated Needs Management Strategy

SME = subject matter expert

Appendix G: Advancements and Areas for Future Improvement in Reducing Uncertainty in Flood Hazard Analysis

Uncertainty		Recent Advancements in Reducing Uncertainty	Areas for Future Improvement in Reducing Uncertainty
Type	Source		
Associated with the land	Land cover	<ul style="list-style-type: none"> National landcover datasets have been developed that provide great increase in resolution and coverage compared to data available for previous studies 	<ul style="list-style-type: none"> Land use is always changing; therefore, frequent updates to imagery are needed. The resolution of the natural system is greater than the resolution of current models
	Levee response to flooding	<ul style="list-style-type: none"> Levee fragility has been incorporated into the flood hazard assessment and mapping for select riverine NFIP products 	<ul style="list-style-type: none"> Routine incorporation of levee fragility evaluation in the development of NFIP products and Levee Accreditation
	Riverine erosion		<ul style="list-style-type: none"> Incorporation of long term changes in stream channel section and short-term changes during large floods; especially in engineered reaches adjacent to levees
	Storm-induced coastal erosion	<ul style="list-style-type: none"> Coastal erosion caused by storms is considered in the overland portion of coastal storm surge and water level and wave analyses 	<ul style="list-style-type: none"> Advancements in computational models and computing resources could allow storm surge modeling to apply a moveable bed model so storm-induced dune and beach erosion are considered in physical processes within storm surge modeling (step before overland modeling)
	Wildfire hydrology		<ul style="list-style-type: none"> Incorporation of the probability and effects of wildfire events on hydrology and flooding
	Long-term coastal erosion		<ul style="list-style-type: none"> Long-term coastal erosion, or accretion, could be included in storm surge and coastal risk modeling
Meteorological	Rainfall depth-area-duration	<ul style="list-style-type: none"> Improved statistical approaches in making hydrologic predictions for rainfall 	<ul style="list-style-type: none"> Incorporating climate change and trends Use stochastic storm generation to evaluate various storm types and patterns
	Rainfall-runoff modeling	<ul style="list-style-type: none"> Software improvements that increase the capability of evaluating uncertainty in model parameters 	<ul style="list-style-type: none"> Routine incorporation of stochastic storm generation and Monte Carlo analysis to evaluate model uncertainty
	Including rainfall effects in coastal storm surge modeling		<ul style="list-style-type: none"> Couple storm surge, wave, and rainfall/runoff models to account for effects of rainfall caused by tropical and extra-tropical events on coastal storm surge. This coupling requires understanding and estimates of how much rainfall tropical and extra-tropical storms produce.
Riverine	Riverine channel geometry	<ul style="list-style-type: none"> Geometry Data Improvements Lidar datasets for topography Enhanced bathymetry datasets 	<ul style="list-style-type: none"> Include estimates of hydraulic geometry changes due to channel aggradation or degradation
	Riverine structure geometry		<ul style="list-style-type: none"> Include the increase in WSELs due to debris at bridges and other encroachments Include additional 2-Dimensional and Computational Fluid Dynamics modeling at Bridges and other Encroachments
	Streamflow information (hydrologic predictions)	<ul style="list-style-type: none"> More precise stream flow measurements National Streamflow Datasets Additional years of streamflow data for statistical fitting 	<ul style="list-style-type: none"> Quantify error associated with observed flow events Monte Carlo analysis of coincident flow at locations such as riverine/ tide and at major confluences Remote sensing of snow covered area and snow melt methods in hydrologic modeling

Uncertainty		Recent Advancements in Reducing Uncertainty	Areas for Future Improvement in Reducing Uncertainty
Type	Source		
Riverine	Impact of reservoirs	<ul style="list-style-type: none"> Advanced analysis techniques for reservoir impacts on streamflow predictions 	<ul style="list-style-type: none"> Increase computational ability to improve the estimate of reservoir impact on streamflow predictions
	Future conditions		<ul style="list-style-type: none"> Incorporation of future land use and development activities in the floodplain such as major land use changes that affect roughness characteristics
	Hydraulic modeling	<ul style="list-style-type: none"> More efficient computation Efficient 2-Dimensional Modeling Computational Fluid Dynamics for detailed bridge/encroachment analysis 	<ul style="list-style-type: none"> Monte Carlo analysis to evaluate parameter uncertainty and determine a mean WSEL Increased efficiency of Computational Fluid Dynamic Modeling And determine a mean WSEL uncertainty Increased efficiency of Computational Fluid Dynamic Modeling
	Impact of reservoirs	<ul style="list-style-type: none"> Advanced analysis techniques for reservoir impacts on streamflow predictions 	<ul style="list-style-type: none"> Increase computational ability to improve the estimate of reservoir impact on streamflow predictions
Coastal	Model mesh/grid	<ul style="list-style-type: none"> LiDAR datasets for topography Enhanced bathymetry datasets National landcover datasets National datum conversion tools (VDatum) 	<ul style="list-style-type: none"> Advancements in computer algorithms and computational resources to speed up processing Automated meshing tools Improved resolution and detail of landcover data
	Wind modeling (wind speed/direction)	<ul style="list-style-type: none"> Improved models to develop wind/pressure representations of historical and synthetic tropical storms and extra-tropical storms Increased data sets and data products related to interaction of strong winds and ocean surface (wind drag coefficients) 	<ul style="list-style-type: none"> Advancements in meteorological data collection Improved understanding of wind and pressure interactions with water and land during power storms
	Historical storm database	<ul style="list-style-type: none"> Additional historical storm data to work with (1980s and 1990s) versus prior studies 	<ul style="list-style-type: none"> Development of rapidly deployed water level, wave, and meteorological sensors Data from future storms allow better understanding of tropical and extra-tropical storm parameters
	Hydrodynamic modeling	<ul style="list-style-type: none"> Flexible mesh option to allow resolution concentrated in area of interest Option for assigning multiple physical features to each model node to relate to physical processes of friction, wind stress, wind sheltering at highly refined scale Validation to multiple recent tropical and extra-tropical storms with thorough review Parallelized codes that allow for efficient simulation on high performance computers 	<ul style="list-style-type: none"> Improved understanding of physical process (including wind/water/sediment interaction) Advancements in model validation and understanding of uncertainty with increased storm databases and measured post-storm data Advances in computer science and algorithms can improve model efficiency
	Wave modeling	<ul style="list-style-type: none"> Ability to directly couple with hydrodynamic model for real-time calculation of wave-induced water level changes (wave setup) Flexible mesh and nested grid options to allow resolution concentrated in area of interest Validation to multiple recent tropical and extra-tropical storms with thorough review in recent FEMA studies and published journal articles 	<ul style="list-style-type: none"> Apply 2-d wave modeling instead of transect-based overland wave modeling phase to coastal storm surge studies Application of 2-d wave heights within a multi-frequency approach to defining risk to coastal structures

Uncertainty		Recent Advancements in Reducing Uncertainty	Areas for Future Improvement in Reducing Uncertainty
Type	Source		
Coastal	Overland wave modeling	<ul style="list-style-type: none"> • Development of GIS-based tools to increase efficiency of transect development and model execution • Tightly spaced transects removes the amount of interpolation required • Access to statistical water level and wave results in sheltered waters to inform starting wave conditions 	<ul style="list-style-type: none"> • Dune Erosion included based on general average erosion rate for coastal storms* • Advances for processing of inland areas with limited inundation during storms (edge of wet area)* • Application of 2-d wave model results could remove need for separate overland analysis
	Interaction between tides and storm surge	<ul style="list-style-type: none"> • Recent studies have applied advanced methods to handle tide and storm surge interaction depending on tide amplitude and storm surge features where some prior studies did not link the processes 	<ul style="list-style-type: none"> • Advance statistical treatments of how tides interaction with both extra-tropical storm surge (long duration events) and tropical storm surge
	Damage curves for structures related to water levels, waves, and erosion	<ul style="list-style-type: none"> • Post-storm field reconnaissance provides important information on how water levels, waves, and erosion interact with structures during strong storms 	<ul style="list-style-type: none"> • Develop structure-specific risk assigned with multi-frequency depth/damage curves • Execute focused studies to develop datasets necessary to understand how structures interact with water levels, waves, and erosion • Develop datasets to document structure characteristics
	Inclusion of structure damage within analysis procedure	<ul style="list-style-type: none"> • Increased access to data on building construction methods, types • Increased access to data on structure first floor elevation • Increased access to data on damage curves for water, waves, and wind 	<ul style="list-style-type: none"> • Advancements in modeling methods to provide robust wave parameters required for damage calculations • Continued increase in coastal structure data related to construction methods, elevations, conditions • Addition of structural damage estimates to standard FEMA hazard study procedures so uniform data sets are available.
	Future sea level and climate conditions	<ul style="list-style-type: none"> • New measurement techniques (including satellite-based) • Additional monitoring stations for sea level and coastal data • Data collected from recent storms that supplement historical record • Advancements in climate models applied to predict future scenarios 	<ul style="list-style-type: none"> • Development of analysis techniques, including probabilistic approaches, to include sea level change in future damage predictions • Application of new data and models to refine potential future scenarios







