Review of the Interim Federal Flood Risk Management Standard (FFRMS) Flood Mapping Data Development Methodology Report

by the

Flood Resilience Interagency Working Group
FFRMS Science Subgroup

of the

NATIONAL CLIMATE TASK FORCE

White House Office of Science and Technology Policy

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About this Document

The federal government is developing multiple resources to support the implementation of the Federal Flood Risk Management Standard (FFRMS). The development of these resources is supported by the National Climate Task Force Flood Resilience Interagency Working Group, co-chaired by CEQ, FEMA, and OMB, and the Flood Resilience IWG Science Subgroup, co-chaired by HUD, NOAA, and OSTP. These resources include the Federal Flood Standard Support website (floodstandard.climate.gov), as well as the *Interim FFRMS Flood Mapping Data Development Methodology* report. The Flood Resilience IWG Science Subgroup conducted this technical review of the *Interim FFRMS Flood Mapping Data Development Methodology report* (hereafter "Methodology Report"). This review assesses the Methodology Report through a set of questions and includes suggestions for future areas of research. The Office of Management and Budget (OMB) directed the FFRMS Science Subgroup to publicly post this review to comply with best practices as outlined in OMB guidance and the goals of the Information Quality Act.

Acknowledgments

The FFRMS Science Subgroup chairs greatly appreciate the time and expertise of the Science Subgroup members – Leo Angelo Gumapas (HHS), Katherine Condon (DOE), Erin Reis (HUD), and Hamilton Smillie (NOAA) – who volunteered to be a part of the writing team for this assessment.

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FLOOD RESILIENCE INTERAGENCY WORKING GROUP

Launched in August 2021, the Flood Resilience Interagency Working Group (IWG) under the National Climate Task Force is part of the Administration's whole-of-government approach to building flood resilience. The IWG was formed in response to Executive Order (E.O.) 14030 on Climate-Related Financial Risk, which reinstated E.O. 13690 and, in doing so, reestablished the FFRMS. The Flood Resilience IWG is co-led by the Council on Environmental Quality (CEQ), the Office of Management and Budget (OMB), and the Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA) to coordinate federal agencies' implementation of FFRMS and other flood-related priorities.

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FEDERAL FLOOD RISK MANAGEMENT STANDARD (FFRMS) SCIENCE SUBGROUP

In October 2021, the Flood Resilience IWG convened an FFRMS Science Subgroup to review and update the best-available, actionable science and guidance underpinning the standard, and to facilitate development and delivery of science-based implementation resources that support consistent application of the standard by federal agencies and non-federal partners.

Subgroup Co-Chairs

- **Lauren Hayes-Knutson**, Director, Environmental Planning Division, U.S. Department of Housing and Urban Development
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Department of Defense (DOD)

Department of Energy (DOE)

Department of Health and Human Services (HHS)

Department of Homeland Security (DHS)/Federal Emergency Management Agency (FEMA)

Department of Transportation (DOT)
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U.S. Economic Development Administration (EDA)
U.S. Geological Survey (USGS)
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Table of Contents

Abbreviations and Acronyms

0.2PFA	0.2-Percent Flood Approach
BFE	Base Flood Elevation
CEQ	Council on Environmental Quality
CISA	Climate-Informed Science Approach
DHS	Department of Homeland Security
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
E.O.	Executive Order
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FFRMS	Federal Flood Risk Management Standard
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FVA	Freeboard Value Approach
GIS	Geographic information system
GSA	General Services Administration
HHS	Department of Health and Human Services
HUD	Department of Housing and Urban Development
IWG	Interagency Working Group
IQA	Information Quality Act
NASA	National Aeronautics and Space Administration
NFIP	National Flood Insurance Program
NFHL	National Flood Hazard Layer
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
OMB	Office of Management and Budget
OSTP	Office of Science and Technology Policy
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation

USDA	U.S. Department of Agriculture
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
WSEL	Water Surface Elevation

Executive Summary

Flooding is the most common and costly natural hazard in the United States, and climate change is leading to more frequent and intense floods. President Biden has taken the most ambitious climate action in history. He has been clear that in addition to cutting our greenhouse gas emissions, we must give Americans the tools they need to prepare for the growing impacts of climate change. That includes a key focus on climate resilience to help communities respond to extreme weather events like flooding.

This report reviews the methodology that FEMA used to create data to support federal agencies and their partners to make decisions to reduce flood risk. This work builds on previous federal government efforts to address flooding in the United States. In his 2015 Executive Order (E.O.) 13690, President Obama established the Federal Flood Risk Management Standard (FFRMS) to improve the country's resilience to flood risks. This E.O. was reinstated by E.O. 14030 and amended E.O. 11988 on Floodplain Management (1977), which directed federal agencies consider and manage current and future flood risks.

The FFRMS is a standard established to direct agencies to prepare for and protect federally funded buildings and other projects from current and future flood risks. __. It applies to federally funded projects, including new construction and improvements to structures that have been damaged by floods. The FFRMS directs agencies to select from several approaches to establish the flood elevation ("how high") and corresponding flood hazard area ("how wide") when siting, designing, and constructing projects. The approaches include the Climate Informed Science Approach (CISA), the Freeboard Value Approach (FVA), or the 0.2-Percent Flood Approach (0.2PFA), which are outlined in the 2015 Guidelines for Implementing E.O. 11988 and E.O. 13690.

Given the complexity of the FFRMS, the federal government is developing multiple resources to support agencies and their non-federal partners to implement this standard. In 2023, the Federal Emergency Management Agency (FEMA) released a FFRMS Floodplain Determination Job Aid. To supplement this document, in Spring 2024, the federal government released a beta version of the Federal Flood Standard Support website, which provides information and resources on flood risk management and includes the Federal Flood Standard Support Tool, which helps users determine if a federally funded project will be located within a FFRMS floodplain.

The Federal Flood Standard Support Tool uses new flood mapping data created by FEMA to support agencies in determining whether a federally funded project is in the FFRMS floodplain. The Interim FFRMS Flood Mapping Data Development Methodology report describes the processes used to create the data for the Support Tool.

This review is a technical assessment of the Interim FFRMS Flood Mapping Data Development Methodology report and was prepared by the FFRMS Science Subgroup of the National Climate Task Force Flood Resilience Interagency Working Group. This review addresses specific questions regarding how the underlying data were used, the availability of CISA data, the explanation of data limitations, and how conflicts in flood elevation are addressed in the documented methods. This review includes a discussion of opportunities for future research. The Office of Management and Budget (OMB) directed the FFRMS Science Subgroup to publicly post this review to comply with best practices as outlined in OMB guidance and the goals of the Information Quality Act.

The FFRMS Science Subgroup finds that the Interim FFRMS Flood Mapping Data Development Methodology report sufficiently describes the methods used by FEMA to create flood mapping data to support the CISA (where data are available), FVA, and 0.2PFA approaches for areas across the United States that have effective FEMA Flood Insurance Rate Maps (FIRMs). This assessment includes recommendations for clarifying issues such as where CISA data are available, how compound flooding is addressed in the methodology, and the uncertainty and limitations of the underlying data.

1. Background

The FFRMS directs federal agencies to select from several different approaches to establish the FFRMS floodplain for project siting, design, and construction. The approaches outlined in E.O. 13690 and in the 2015 Guidelines for Implementing E.O. 11988 and E.O. 13690 are:

- **Climate Informed Science Approach (CISA):** The elevation and flood hazard area that result from using best available, actionable science on climate change and other factors affecting flood risk, and considering the investment lifetime and criticality. This approach is preferred where appropriate data are available;
- **Freeboard Value Approach (FVA):** The elevation and flood hazard area that result from adding an additional 2 feet to the base flood elevation for non-critical actions and by adding an additional 3 feet to the base flood elevation for critical actions; or
- **500-year floodplain (0.2PFA):** The area subject to flooding by the 0.2%-annual-chance flood.

Resources for Implementing the FFRMS

The federal government is developing multiple resources to support the implementation of the FFRMS. These resources include:

- **Guidelines for Implementing Executive Order 11988, Floodplain Management, and Executive Order 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input** (October 2015) – The Guidelines provide broad guidance on the implementation of E.O. 11988 and 13690 and offer a common point of reference so that each agency can issue or amend their regulations and procedures, as appropriate. The CISA Appendix (Appendix H) provides the scientific foundation of the approach, from the impacts of climate change on coastal and riverine flooding to other processes known to affect future flood risk (e.g., land use change, long-term erosion, subsidence).
- The **Federal Flood Risk Management Standard (FFRMS) Climate-Informed Science Approach State of the Science Report** (March 2023) – Developed to provide federal agencies, local officials, businesses, and others managing flood risk with information on the best-available science on current and future flood risk.
- The **FFRMS Floodplain Determination Job Aid** (August 2023) – Developed for federal agencies charged with identifying whether a federally funded action will take place in the FFRMS floodplain. The Job Aid includes case studies of various scenarios and a worksheet to capture results for floodplain determinations.
- **Federal Flood Standard Support Tool** (beta version released Spring 2024; full version to be released later in 2024) – Developed to leverage information technology and Geographic Information Systems (GIS) to visualize the FFRMS floodplain more easily, particularly where CISA data are available. For all approaches, the Federal Flood Standard Support Tool will help users locate the appropriate vertical flood elevation and corresponding horizontal FFRMS floodplain, for the action(s) under consideration. The accompanying website provides background information on the FFRMS, resources on the

incorporation of natural features or nature-based solutions into project design to reduce local flood risk and increase resilience, and relevant publications.

- **Interim FFRMS Flood Mapping Data Development Methodology report** (Spring 2024) – Developed to assist federal agencies and their non-federal partners understand the process and procedures followed by FEMA to create flood mapping data to support the FVA, 0.2PFA, and CISA (where applicable) approaches. These approaches apply to areas across the United States that have effective FEMA Flood Insurance Rate Maps (FIRMs) that contain digital, model-backed flood hazard information. FEMA intends to publish a more detailed methodology report when the Federal Flood Standard Support Tool is complete, later in 2024.

Review Process

The Federal Flood Standard Support Tool and website, and the Interim FFRMS Flood Mapping Data Development Methodology report, underwent a series of reviews as outlined below.

Federal agency experts from the National Climate Task Force Flood Resilience IWG reviewed the draft versions of the 1) Federal Flood Standard Support Tool website and 2) the Interim FFRMS Flood Mapping Data Development Methodology report circulated for interagency review. Agencies provided their input directly to NOAA and FEMA on both deliverables, and modifications to the materials were made.

Charge to the FFRMS Science Subgroup

In addition to the Flood Resilience IWG reviews described above, the FFRMS Science Subgroup conducted this review of the Interim FFRMS Flood Mapping Data Development Methodology report (hereafter "Methodology Report").

This review did not evaluate whether the approaches for implementing the FFRMS are appropriate or if other approaches should be used instead. The approaches had been previously identified, based on years of development, and were communicated in E.O. 13690 and the 2015 Implementation Guidelines, and agencies are properly seeking input on their use through notice and comment rulemaking.

The FFRMS Science Subgroup review of the Methodology Report addresses the following questions:

a. Does the Methodology Report clearly state how the underlying data were utilized?

b. Under the FFRMS, agencies may utilize one or more of the three approaches outlined in E.O. 13690 to determine the FFRMS floodplain. The Climate-Informed Science Approach (CISA) should be used where data are available and actionable. Does the Methodology Report make it clear what, and where, CISA data are available and actionable in the Federal Flood Standard Support Tool?

c. The 2015 Guidelines for Implementing E.O. 11988 and E.O. 13690, Appendix H of the Guidelines, and the 2023 FFRMS CISA State of the Science Report use the terms "best available data and science" and "actionable" in identifying what data or science should be applied in the CISA. These terms are defined in Section 1.B.1 of the 2015 Implementation Guidelines and Section 1.A.I of the Appendix H of the Guidelines. Does the methodology

described in the Methodology Report take into account best available data and actionable science?

d. Are challenges and potential solutions to data limitations clearly explained?

e. Are the methodologies outlined in the Methodology Report articulated in a way that is clear and transparent?

f. Does the Methodology Report clearly explain how conflicts in elevation outputs are or might be addressed, in particular in areas of confluence in coastal and riverine floodplains?

g. Is the methodology for utilizing topographic information and flood elevation information to delineate a FFRMS floodplain depth well-reasoned and appropriately explained?

h. What are areas of future research in flood resilience? Consider including a short paragraph outlining opportunities for future directions.

2. Response to Charge Questions

The FFRMS Science Subgroup agencies were invited to respond to each of the questions in the charge. The below replies summarize the responses received from across the agencies.

a. Does the Methodology Report clearly state how the underlying data were utilized?

Yes, the Methodology Report clearly states how the underlying data (namely, the National Flood Hazard Layer and The National Map (for elevation) were utilized. However, there are three areas that would benefit from additional discussion:

- Estimation of water levels in locations subject to both coastal and riverine hazards is unclear. Additional discussion of the overlap of riverine and coastal areas is needed describing how the overlap was handled and including further explanation on which base flood elevation (BFE) should be utilized if a riverine or coastal area BFE is simultaneously reported in the Federal Flood Standard Support Tool.

- The uncertainties with the data and models and how these uncertainties may affect the outcome of the floodplain determination are not addressed. Consider including a short paragraph outlining the uncertainties in the data.

b. Under the FFRMS, agencies may utilize one or more of the three approaches outlined in E.O. 13690 to determine the FFRMS floodplain. The Climate-Informed Science Approach (CISA) should be used where data are available and actionable. Does the Methodology Report make it clear what, and where, CISA data are available and actionable in the Federal Flood Standard Support Tool?

It is not entirely clear what and where CISA data are available and actionable in the Federal Flood Standard Support Tool; however, this information is easier to find in the Federal Flood Standard website.

For example, the report includes a list of databases and shapefiles to be "used to support the public facing Federal Flood Standard Support Tool," but the reader is left to infer that these are the data actually available in the Federal Flood Standard Support Tool. Some of the datasets discussed are

relevant to CISA and others are relevant only to the freeboard value approach (FVA), so the reader has to refer to other sections of the text to understand that the 0-10 foot freeboard rasters are intended to be used in conjunction with the 2022 Interagency Sea Level Rise Technical Report sea level scenarios to generate coastal CISA flood maps. The spatial availability of these data is not discussed in this section, so the reader has to refer to other sections to understand how the coastal data availability differs for the Pacific and Great Lakes coasts versus the Atlantic and Gulf Coasts. The concept of actionability is mentioned but not discussed.

In addition, the regional availability and "actionability" of data and models for CISA implementation in coastal zones is not discussed nor is there any discussion of data quality, completeness, or record length criteria that must be met for CISA to be implemented. The Methodology Report, or any update, should consider emphasizing that more complex analysis may be required in other areas to determine the CISA floodplain. Related, the reference to the Sweet et al. (2022) report in the footnote on page 4 mentions "containing up-to-date sea level rise projections available for U.S. states and territories," but does not explicitly state whether the sea level rise scenarios in the Sweet et al. report are "actionable" for using CISA in all coastal areas in the country.

Finally, the Methodology Report should clarify that the methodology described for using CISA uses "simplified CISA" as outlined in the FFRMS Floodplain Determination Job Aid and in the 2015 Implementation Guidelines (p. 54-55). CISA, as defined in the E.O. 13690, is described as the approach that uses "the best-available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science." The FFRMS states that for coastal flood hazards, agencies should use interagency global mean sea level rise adjusted to local relative sea-level conditions combined with surge, tide, and wave data using state-of-the-art science in a manner appropriate to policies, practices, criticality, and consequences (risk). By comparison, "simplified CISA" is explained as adding sea level rise projections for coastal areas to the effective base flood elevation. This should be explicitly stated in the Methodology Report.

Specific recommended changes to improve clarity:

- Include an explicit statement on where CISA data are and are not available at this time, noting this can/will change over time.
- Add note that the method developed uses simplified CISA.
- Include a table or map showing which counties are currently included in CISA and which ones are expected to have CISA data available over what timeframe.
- Add a statement regarding which of the listed datasets are included in or integrated into the Federal Flood Standard Support Tool and note if all datasets are used for all approaches, or if some are specific to CISA vs FVA.

c. The 2015 Implementation Guidelines, Appendix H of the 2015 Implementation Guidelines and the 2023 FFRMS CISA State of the Science Report use the terms "best available data and science" and "actionable" in identifying what data or science should be applied in the CISA. These terms are defined in Section 1.B.1 of the 2015 Implementation Guidelines and Section 1.A.I Appendix H of the 2015 Implementation Guidelines. Can the methodology described in the Methodology Report take into account best available data and actionable science?

In general, yes. This said, "best available information" is briefly mentioned, but the Methodology Report would benefit from expanding this to explain and reference these terms and how the methodology complies with this requirement. Specifically:

- Regarding Digital Effective FIRMs, the decision was made to utilize "datasets that have gone through a full public comment and appeal period as the basis for this effort". This should be highlighted elsewhere in the Methodology Report, including the reasoning behind that decision explained in greater depth.

- The Methodology Report should explain some of the limitations to taking into account best available data and actionable science, including:
    - Using whole-foot increments of freeboard from 0 to 10 feet on the Atlantic and Gulf Coasts does not allow for the full application of the CISA in planning beyond the year 2100, when the highest 2022 Interagency Sea Level Rise Technical Report scenario yields over 12 feet of global sea level rise by 2150.

    - Applying the best available science in areas subject to future relative sea level *fall*, such as the southeast coast of Alaska, is not included because the lowest available projection is zero change.

    - Modeling the floodplain under existing conditions then superimposing linear increments of freeboard on top of the modeled surface can omit the nonlinear effects of sea level change on coastal floods. This can include amplified depth-limited waves that result in increased storm surge through wave setup effects. These effects may cause the future floodplain elevation to increase by more than the increase in sea level alone. The workflow described in the FFRMS CISA State of the Science Report on page 11 for assessing future coastal flooding calls for assessing sea level projections before determining still water heights, rather than adding them on afterward.

    - Flooding in areas that are subject to both riverine and coastal flood hazards. In areas subject to both coastal and riverine hazards, the two hazards were mapped separately and may overlap. The Federal Flood Standard Support Tool does not distinguish between coastal and riverine flood hazard, only providing one result each for the freeboard value and simplified CISA approaches, so it is unclear whether the freeboard value output represents the riverine or the coastal hazard or the maximum of the two. In either case, even the maximum of the two surfaces can seriously underestimate flood risk in the transition zone as demonstrated in numerous studies (e.g., Moftakhari et al. [2019] specifically address this aspect of the FEMA mapping approach https://doi.org/10.1016/j.advwatres.2019.04.009). As with the linear superposition described above, this method may be a necessary simplification due to resource constraints but probably cannot be considered the state of the actionable science. The FFRMS CISA State of the Science Report specifically mentions this method on page 66 as not recommended for implementation of the CISA or FFRMS.

  - The spatial limitations of available FIRM maps and/or the limitations to these data in accounting for variability in factors such as soil type, recent wildfire or land cover changes, and other factors that may affect flooding.

- Language should be added to explain if and how the Federal Flood Standard Support Tool will be updated as new FIRMs are completed and introduced through the public comment and appeal period (and more broadly, additional information on update frequency would be useful to include).

d. Are challenges and potential solutions to data limitations clearly explained?

In general, yes. However, the Methodology Report should include more resources and point to suggested methods for how to address areas where data are not available. While many limitations are raised, the discussion of potential solutions is quite limited, such as the one on compound riverine-coastal flooding in estuaries. The greatest concern is that some key limitations are not presented front and center to potential users.

e. Are the methodologies outlined in the Methodology Report articulated in a way that is clear and transparent?

Yes, however, the Methodology Report requires the reader to combine information from several sections to fully understand the methodology. More explicit language to clarify the connection among multiple sections would be useful, for example, describing the intention that the 0 to 10 foot freeboard increments are to be combined with the 2022 Interagency Sea Level Rise Technical Report sea level scenarios to generate CISA coastal floodplain elevations. The samples of quality-control checklist items are appreciated, but an appendix or link to the full list would enable the full reproduction of the workflow used to generate these inundation maps, should it ever be necessary.

f. Does the Methodology Report clearly explain how conflicts in elevation outputs are or might be addressed, in particular in areas of confluence in coastal and riverine floodplains?

While the Methodology Report mentions that both floodplains may overlap in these areas, and many densely populated settlements are in areas subject to riverine-coastal "compound" flooding, additional discussion is needed to address this issue. Including more detail, as well as including recommended next steps at the end of the Methodology Report would be useful. The 2023 FFRMS CISA State of the Science Report chapter on compound flooding may be a useful reference for content (see p. 62, VI. Assessing Future Compound Flooding)

There is concern that presenting overlapping coastal and riverine flood hazard zones that "do overlap in many instances" could confuse users substantially and lead to maladaptive decisions. In adding detail, additional discussion to answer questions such as the following would be useful:

- How were zones subject to compound riverine-coastal flooding addressed in CISA coastal flood calculations?
- For the FVA, how does the National Flood Hazard Layer (NFHL) account for riverine-coastal compound flooding?

- The Methodology Report reads as if coastal and riverine flood zones are computed using entirely separate processes and they may happen to overlap in some areas. Would this lead to two different water levels for a flood with a given recurrence interval?
- If neither the CISA nor the FVA adequately considers the compound nature of flood hazards at estuarine locations, would it be possible to merely identify areas subject to such compound flooding and then note that engineers and other qualified experts need to carry out a more rigorous assessment?
- It looks like the NFHL already has a designation for areas with complex hydrology. Could that be used? If a project team needs to display some elevation data, could they add a highly visible disclaimer about the limitations of the methods used and the need for future applications with methods better suited for compound flood hazards?

In general, the Methodology Report would benefit from a short "Next Steps" section at the end of the report. This could include future work to refine overlapping coastal and riverine hazard zones, planned improvements to the methodology, and the anticipated availability of additional data.

g. Is the methodology for utilizing topographic information and flood elevation information to delineate a FFRMS floodplain depth well-reasoned and appropriately explained?

Yes. The basic approach is explained well, especially the GIS procedures. The attention paid to levees and backwater fingers is appreciated.

One related issue is that the NFHL's rules for using 1-D and/or 2-D models in specific locations are unclear. Does the NFHL attribute database contain such information? Another issue that may arise in projecting future flood hazards with 1-D (2-D) models is that the cross-sections (raster grids) used to model them may not reach the water surface elevation of future floods (more likely with 1-D models). The flow chart could also use some reorganization that would indicate the use of DEMs for coastal zones more clearly.

The Methodology Report would benefit from some additional details on the age of the underlying flood elevation hydraulic and hydrologic information (i.e., FIS Study), and how this may impact analysis (e.g., an FFRMS floodplain based on 1980s baseline BFE data may underestimate the hazard (within the past 10 to 15 years). Section 1.4.2 (Data Challenges) may be a good place for this.

h. What are areas of future research in advancing flood resilience?

The most pressing areas of future research include improved representation of the non-linear effects of sea level change on coastal flood heights and more realistic treatment of compound flood hazards in areas subject to both coastal and riverine floods. Consider including an explicit statement to this effect in the Methodology Report.

Beyond this, the Methodology Report itself reasonably identifies areas where future work is needed to increase the coverage of CISA, refine the accuracy of calculated elevations, etc., which provides a good starting point for future work.

The Methodology Report should point to the FFRMS CISA State of the Science Report (2023), which identifies many short-, medium-, and long-term tasks that could be organized into a roadmap to guide the ongoing implementation of the FFRMS.

Additional areas of future work for the flood resilience community to consider as these resources evolve include:

- noting the FFRMS GIS products may be of use to other flood mapping practitioners;
- calling out opportunities for collaboration and future integration, for example with USGS StreamStats or post-wildfire flooding and debris mapping tools—or more broadly, creating the opportunity for users to add in layers of other data;
- making the rasters available for download for use in project site selection and design;
- including wave effects (including infragravity waves) on flood extents, as these may be important in some coastal areas;
- addressing areas with rapid vertical land movement, such as Louisiana and Alaska. In such areas, there could be a large temporal mismatch between the time of the latest topographic survey and the time when the floodplain was modeled, yielding misleading floodplain depths if both are assumed to be static and referenced to NAVD88 when the water surface is superimposed on the DEM. (Instead, it may be helpful to specify the year of analysis in such areas, so that the user can assess whether the mapped areas are still applicable or should be considered for updated analysis.); and
- adding data for areas that have not historically flooded but may flood in the future based on climate projections, including variables such as soil type, recent wildfire or land cover change, and heavy precipitation events.

3. Discussion

The FFRMS Science Subgroup writing team discussed the agency responses to the charge questions. While the agency responses are summarized in the above text, there were several instances where issues beyond the scope of this review arose. These are summarized below for future reference as additional resources to support the implementation of the FFRMS are developed. While the focus of this review was intended to be solely on the Methodology Report itself, several comments were made regarding enhancements to the Federal Flood Standard Support Tool. The comments were forwarded to the team developing the tool and will be assessed for inclusion in future enhancement to the tool and associated website.

The complete version of the Federal Flood Standard Support Tool is currently targeted for release later in 2024 and with it, a more in-depth and detailed Methodology Report. The longer report should include:

- More detail on the GIS software, processing steps, and specific tools used to develop the data. In general, consider adding appendices with GIS steps, full Quality Control (QC) checklists, and other process documents to enable users to more fully understand the methodology behind the Federal Flood Standard Support Tool.

- A map or visual to illustrate areas where CISA data is available and actionable, recognizing this data availability will change over time.

The Methodology Report describes limitations of data availability as well as some of the challenges in determining the FFRMS floodplain given these limitations. This highlights the opportunities for future work as the science and the tools for implementing the FFRMS evolve over time. Specifically:

- Future refinements in the methodology that use physics to determine the water surface elevations (WSELs) of the waterways will reduce uncertainty and yield more reliable results. Currently, not using physics creates an issue especially where backwater occurs (e.g., bridges); as even using digital mapping as a baseline (via FEMA FIRMS) only captures (at best) the energy and momentum of the discharge producing that base flood event and extent. The energy and momentum associated with those other increments (1 2, 3 feet) are likely not going to be the same values or characteristics and may represent varying discharges for any given locations; e.g., a 1-foot increase at location (A) might represent a climate change projected discharge increase of (say) 10% and at location (B), using the same climate science, a projected discharge increase of (say) 5%. Future work should incorporate complexities like these, and continue expanding the use of CISA as recommended by the FFRMS CISA State of the Science Report.

- The availability of FIRMs and the relative income status of a community seem to be correlated. There are many rural underserved and Tribal communities not participating in the NFIP. As this method is only available to communities participating in the NFIP, there remains an additional burden on those other non-NFIP communities in implementing FFRMS. Future work will benefit from addressing these data gaps to improve equity in data availability and application.

4. Conclusion

The Interim FFRMS Flood Mapping Data Development Methodology report sufficiently describes the methods used by FEMA to create flood mapping data to support the CISA (where applicable), FVA, and 0.2PFA approaches for areas across the United States that have effective FEMA Flood Insurance Rate Maps that contain digital, model-backed flood hazard information. As described in Section 2 of this assessment, the Methodology Report would benefit from additional language to clarify issues such as where CISA data are available, how compound flooding is addressed in the methodology, and the uncertainty and limitations of the underlying data. The FFRMS Science Subgroup will work with FEMA on integrating this additional language in this Methodology Report, and recognizes that some of the recommended changes may require additional time and will be addressed in the more in-depth Methodology Report to be released later in 2024.

The FFRMS Science Subgroup appreciates the opportunity to provide this review and looks forward to contributing to future resources that are developed to support the implementation of the FFRMS and improve flood resilience across the United States.