Florida Commission on Hurricane Loss Projection Methodology

Professional Team Report

2021 Flood Standards

Hurricane Michael, Bay County

Hurricane Irma, Osceola County

Impact Forecasting

On-Site Review: June 10-14, 2024

Additional Verification Review: Sept 23-26, 2024

On June 10-14, 2024, the Professional Team conducted an on-site review of the Impact Forecasting (IF) Florida Flood Model (FCHLPM) Version 3.0 on ELEMENTS Version 18.0. The following individuals participated in the review.

IF
Nans Addor, Ph.D., Principal Hydrologist, Fathom
Sushma Bhat, Director, Software Development
David Colbus, Director
William Dong, Ph.D., Associate Director and Tech Lead, Software Development
Radovan Drinka, Global Head of Tropical Cyclone Model Development
Xian He, Ph.D., Associate Director
Anmol Khanna, Senior R&D Consultant
Yuliia Khmurovska, Ph.D., Catastrophe Model Developer
Yujin Liang, Ph.D., P.E., Director, Catastrophe Model Development
Chris Long, Director, Software and Analytics
Molly Markey, Ph.D., Associate Director, Product Manager, U.S. Wind and Flood
Minchong Mao, FCAS, CCRMP, MAAA, Senior Managing Director, Actuary, Aon Reinsurance Solutions
Ricardo Wong Montoya, Catastrophe Model Developer
Andres Paleo, Ph.D., Associate Director, Research and Development
Purvish Patel, Director, Software Quality Assurance
Sri Harshitha Polamuri, Ph.D., Senior Scientist
Ankit Prashnani, Senior Consultant
Petr Puncochar, Ph.D., Head of Flood Model Development
Niall Quinn, Ph.D., Principal Modeler, Fathom
Venkatesh Ramaiah, Associate Director
Dan Rees, Director, U.S. Flood Model Development
James Savage, Ph.D., Principal Hydraulic Model Developer, Fathom
Elham Sharifineyestani, Ph.D., Senior Scientist, Research and Development
Corbin Tucker, Senior Analyst
Vipin Unnikrishnan, Ph.D., Principal Research Consultant
Chad Xu, Catastrophe Actuarial Analyst, Aon Reinsurance Solutions

Professional Team
Jenni Evans, Ph.D., Meteorology
Paul Fishwick, Ph.D., Computer/Information
Mark Johnson, Ph.D., Statistics, Team Leader
Chris Jones, P.E., Vulnerability, virtual
Steve Kolk, ACAS, MAAA, Actuarial, observer
Stu Mathewson, FCAS, MAAA, Actuarial
Chris Nachtsheim, Ph.D., Statistics, observer
Del Schwalls, P.E., CFM, Hydrology and Hydraulics
Donna Sirmons, Staff

The Professional Team began the review with an opening briefing and introductions. IF provided thorough, detailed presentations on the exposure and industry exposure database, and on the hazard, vulnerability, and financial components of the flood model, including:

- Third-party exposure data at a location level and distributions by coverage, county, ZIP Code, flood zone, occupancy and construction, and flood hazards
- Development of the flood vulnerability functions based on rational structural analysis, post-event site investigation, technical literature, and expert opinion
- Hydro-grid module and dataset covering the hydraulic-related components
- Calculation of first-floor height (FFH)
- Processing of base-floor elevation (BFE), flood zones, and geospatial datasets
- Stochastic event set addressing tropical cyclone induced flooding (fluvial, pluvial, and storm surge) from the hurricane model
- Stochastic event set addressing non-tropical system induced pluvial (precipitation) and fluvial (riverine) flooding
- Tropical cyclone rainfall modeling
- Inundation modeling for the fluvial and pluvial components
- Storm surge modeling based on the Sea, Lake and Overland Surge from Hurricanes (SLOSH) model developed by the National Oceanic and Atmospheric Administration (NOAA)
- Flood defenses
- Vulnerability tiers (regions) and primary characteristics: occupancy classes, construction classes, year-built bands (for non-manufactured homes and manufactured homes), number of stories, foundation type, and FFHs
- Vulnerability water intrusion module, mechanical failure module for inland and coastal flood, structural failure module, cost module for building, contents, and time element
- Derivation of relativity-based vulnerability functions and vulnerability functions for structures with one or more unknown characteristics
- Secondary modifiers and mitigation measures
- Consideration of waves in vulnerability functions
- ELEMENTS data import, insurance processing features, and analysis setup and processing
- Software development process and testing

IF discussed the partnership with Fathom in developing the flood hazard component due to flood hazard modeling challenges and the capability to provide flexibility with event set generation. Discussed the high-resolution models developed by Fathom and considerations for hazard validation. There is also direct coupling between the flood and hurricane model including a common demand surge model, and the event set split into tropical cyclone induced flooding and non-tropical cyclone system flooding.

The audit continued with a review of each standards section.

On April 18, 2024, IF informed the Commission that work was being performed to ensure the horizontal and vertical datums underlying all hazards were the same. The storm surge hazard was re-processed to the World Geodetic System 1984 (WGS84) horizontal datum and Earth Gravitational Model 2008 (EGM08) vertical datum. This change resulted in revisions to Forms HHF-1, HHF-2, SF-2, AF-1, AF-2, AF-3, AF-4, and AF-8 in addition to revisions to figures and statements provided for many disclosures. Revised submission materials were provided on May 10, 2024. IF provided further details on the changes made to ensure consistency among the datums.

On May 31, 2024, IF informed the Commission that significant errors were discovered in the development of Form AF-4. IF provided further details on the problem detected in generating the flood output ranges in Form AF-4. All standards associated with the impacted forms could not be verified pending review of those forms.

During the opening briefing, IF informed the Professional Team of additional corrections to disclosures in the May 10, 2024, revised submission. These corrections were reviewed during the audit and are explained under the applicable standards.

During the on-site review, errors were detected by the Professional Team in Form AF-3. IF provided details on the error and a corrected form was reviewed.

In addition to the standards not verified due to the Form AF-4 error, several additional standards were not verified due to open items, and an additional verification review was anticipated. Discussed with the Modeler options as provided in the Report of Activities Acceptability Process.

On June 18, 2024, the Modeler requested an additional verification review with resolution of pending open items and revised documentation due on September 3, 2024. The Commission Chair granted the same extension courtesy to IF as was provided to FIU. An additional verification review was held on September 23-26, 2024. Comments related to the additional verification review are provided under the applicable standards proceeded with "September Additional Verification Review Comments:".

The Professional Team recommends the following trade secret data and information be presented to the Commission during the trade secret session of the meeting to review the model for acceptability under the 2021 Flood Standards.

1. MF-3, Audit 4 animation of the overland evolution of the wind and pressure field from Hurricane Ian (2022) and its impact on the simulated storm surge depth.

September Additional Verification Review Comments:

IF submitted a revised submission on September 3, 2024. The Professional Team completed an additional verification review on September 23-26, 2024.

The following individuals participated in the additional verification review.

IF

Nans Addor, Ph.D., Principal Hydrologist, Fathom
Ted Amdur, Senior Scientist
Sushma Bhat, Director, Software Development
David Byrne, Ph.D., Postdoctoral Researcher – Climate Risk, Woodwell Climate Research Center
David Colbus, Director
Neandro DeMello, Senior Scientist
William Dong, Ph.D., Associate Director and Tech Lead, Software Development
Radovan Drinka, Global Head of Tropical Cyclone Model Development
Xian He, Ph.D., Associate Director
Anmol Khanna, Senior R&D Consultant
Yuliia Khmurovska, Ph.D., Catastrophe Model Developer
Yujin Liang, Ph.D., P.E., Director, Catastrophe Model Development
Maria Lomelo, Managing Director, Global Program Director
Chris Long, Director, Software and Analytics
Minchong Mao, FCAS, CCRMP, MAAA, Senior Managing Director, Actuary, Aon Reinsurance Solutions
Ricardo Wong Montoya, Catastrophe Model Developer
Andres Paleo, Ph.D., Associate Director, Research and Development
Purvish Patel, Director, Software Quality Assurance
Sri Harshitha Polamuri, Ph.D., Senior Scientist
Petr Puncochar, Ph.D., Head of Flood Model Development
Niall Quinn, Ph.D., Principal Modeler, Fathom
Venkatesh Ramaiah, Associate Director
Dan Rees, Director, U.S. Flood Model Development
James Savage, Ph.D., Principal Hydraulic Model Developer, Fathom
Elham Sharifineyestani, Ph.D., Senior Scientist, Research and Development
Radek Solnicky, Senior Scientist
Corbin Tucker, Senior Analyst
Vipin Unnikrishnan, Ph.D., Principal Research Consultant
Chad Xu, Catastrophe Actuarial Analyst, Aon Reinsurance Solutions

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Jenni Evans, Ph.D., Meteorology
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Mark Johnson, Ph.D., Statistics, Team Leader
Chris Jones, P.E., Vulnerability, virtual
Stu Mathewson, FCAS, MAAA, Actuarial
Del Schwalls, P.E., CFM, Hydrology and Hydraulics
Donna Sirmons, Staff

Changes in the September 3, 2024, submission were reviewed. Open items from the initial June on-site review and from the September additional verification review were reviewed and resolved.

All standards are now verified by the Professional Team.

Report on Deficiencies

The Professional Team reviewed the following deficiencies cited by the Commission at the April 4, 2024, meeting. The deficiencies were eliminated by the established time frame, and the modifications have been verified.

1. Figure 16 (page 94), Figure 97 (page 293), Figure 98 (page 294), Figure 106 (page 302), Figure 124 (page 314), Figure 125 (page 315), and Figure 127 (page 317): Incomplete. The maximum is omitted from the figures.

2. GF-1.2, page 19: Incomplete. The use of the Tropical Cyclone Rainfall (TCR) model is not mentioned until MF-1.7 (page 60) and not described until MF-2.6 (page 72). The TCR model should be included in the summary of the model.

3. GF-1.6, pages 26-42: Incomplete. Compo et al. 2009 (page 61), Leopold 1994 (page 69), Schureman 1958 (page 74), and England 2019 (page 107) references not included in list of references.

4. GF-2.B, page 43: Non-responsive. Response does not address the standard and is the same response as given for GF-1.B.

5. MF-2.C, page 63: Incomplete. Justification is not given for the inland model resolution.

6. MF-5.2, page 106: Incomplete. Rationales for Translational/Forward Speed and Heading Angle/Direction are not provided. GDP tails and Laplace margins are not defined.

7. HHF-1.2, pages 112-116: Unclear. Figure numbering on pages 115-116 needs to be resolved, including the corresponding discussion.

8. HHF-1.4, page 117: Incomplete. Provide documentation on the sensitivity of the flood model results based on assumptions relevant to flooding conditions in Florida, including lake level and tide height, rather than assessments of the model sensitivity in semi-arid and snow-dominated areas.

9. HHF-1.14, pages 123-124: Incomplete. Indicate the units of the variables in Equations 10 and 11.

10. HHF-2.A, page 128: Non-responsive. Response does not specifically address flood extent.

11. HHF-2.1, page 128: Non-responsive. There is no discussion regarding removing Unnamed Storm in East Florida (May 2009) and adding Hurricane Hermine (2016). Moreover, the discussion that was provided contradicts the discussion in HHF-2.2, page 129.

12. HHF-2.2, page 129: Non-responsive. Tropical Storm Fay (2008) cannot be replaced due to a lack of data by Hurricane Ian (2022) which does not provide data for validation.

13. HHF-2.3, page 138: Incomplete. Figure 36 incorrectly repeats information for Hurricane Irma (2017) rather than Hurricane Hermine (2016) as stated in the figure caption.

14. Form HHF-1, page 301, Figure 105: Incomplete. The inland flooding map for Hurricane Eta (2020) is omitted.

15. AF-6.A, page 253: Non-responsive. Response does not mention flood loss costs.

16. Form SF-1, page 330: Incomplete. Identify the specific Pearson Type distribution being used.

17. Form AF-1.B, page 346: Incomplete. No response is provided.

Professional Team Pre-Visit Letter

The Professional Team's pre-visit letter questions are provided in the report under the corresponding standards. The April 5, 2024, pre-visit letter preamble is provided first followed by the May 29, 2024, pre-visit letter addendum opening.

The purpose of this pre-visit letter is to outline specific issues unique to Impact Forecasting's model submission under the 2021 flood standards, and to identify lines of inquiry that will be followed during the on-site review in order to allow time for adequate preparation. Aside from due diligence with respect to the full submission, various questions that the Professional Team will ask during the on-site review are provided herein. This letter does not preclude the Professional Team from asking for additional information during the on-site review that is not given below or discussed during an upcoming conference call to be held if requested by Impact Forecasting. The goal of a potential conference call is to address your questions related to this letter or other matters pertaining to the on-site review. The overall intent is to help expedite the on-site review and to avoid last minute preparations that could have been undertaken earlier.

It is important that all material prepared for presentation during the on-site review be provided to the Professional Team and presented using a medium that is readable by all members of the Professional Team simultaneously.

The Professional Team will begin the review with an opening briefing. Impact Forecasting should then proceed with thorough, detailed presentations on each model component. Afterwards, a review of the flood standards in the *Flood Standards Report of Activities as of November 1, 2021,* will commence. Each flood standard should be addressed beginning with responses to the pre-visit letter questions for that specific standard followed by responses to all of the audit items for that standard.

If changes have been made in any part of the model or the modeling process from the descriptions provided in the initial January 28, 2024, submission, provide the Professional Team with a complete and detailed description of those changes, the reasons for the changes (e.g., an error was discovered), and any revised forms. For each revised form, provide an additional form with cell-by-cell differences between the revised and the original submitted values.

Refer to the On-Site Review chapter of the *Flood Standards Report of Activities as of November 1, 2021*, for more details on materials to be presented and provided to the Professional Team. Particular attention should be paid to the requirements under Presentation of Materials.

In addition to the 6 items listed under Presentation of Materials, provide copies of:

1. Flowchart standard documents if internally developed, or references to published standards, and

2. Software engineering practice and coding guidelines if internally developed, or references to published standards.

In an effort to reduce the time and cost involved in producing hard copy materials, only 8 printed copies of the presentations (printed two slides per page and duplexed), and the Form AF-6 graphical summaries, color-coded contour or high-resolution map of the flood loss costs for slab foundation owners frame buildings, and the scatter plot of the flood loss costs against distance to closest coast for slab foundation owners frame buildings need to be provided. While the *Report of Activities* specifies 6 printed copies, additional Professional Team members will be in attendance as observers only.

All documentation should be easily accessible from a central location in order to be reviewed electronically.

The following pre-visit questions are arranged by flood standard groups.

Following is the May 29, 2024, pre-visit letter addendum opening.

After reviewing the May 10, 2024, revised submission, the Professional Team revised questions from the original pre-visit letter which are shown in track changes below, and added additional questions. For the additional questions, we have started the question numbering at 101 in order to distinguish the additional questions from the original questions sent on April 5, 2024. Page numbers below refer to the May 10, 2024, track changes submission document.

101. Provide an annotated list of all revisions made to the original January 28, 2024, submission.

GENERAL FLOOD STANDARDS – Mark Johnson, Leader

GF-1 Scope of the Flood Model and Its Implementation*

*(*Significant Revision)*

A. The flood model shall project loss costs and probable maximum loss levels for primary damage to insured personal residential property from flood events.

B. A documented process shall be maintained to assure continual agreement and correct correspondence of databases, data files, and computer source code to presentation materials, scientific and technical literature, and modeling organization documents.

C. All software, data, and flowcharts (1) located within the flood model, (2) used to validate the flood model, (3) used to project modeled flood loss costs and flood probable maximum loss levels, and (4) used to create forms required by the Commission in the Flood Standards Report of Activities shall fall within the scope of the Computer/Information Flood Standards and shall be located in centralized, model-level file areas.

D. Differences between historical and modeled flood losses shall be reasonable, given available flood loss data.

E. Vintage of data, code, and scientific and technical literature used shall be justifiable.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

1. GF-1.2, pages 18-19: Explain in detail the approach for the non-tropical event set.

   Discussed that the non-tropical event set utilizes a statistical model fitted to historical reanalysis data to provide a synthetic event set to supplement the synthetic tropical cyclone model event set. The key components of the non-tropical cyclone model are data collection, event clustering, dependence, modeling, and synthetic event generation.

   Reviewed the underlying pluvial and fluvial data.

Discussed spatial filtering of the data to create precipitation and discharge input.

Discussed that the two event sets are tropical cyclones which include hurricanes and tropical storms, and the non-tropical cyclone set that includes all other flood producing storms. Candidate events for the non-tropical cyclone event set are filtered to remove historical tropical storms and hurricanes.

Reviewed a schematic of the steps in event clustering. Discussed that inland flooding sites are processed independently with clusters linked based on spatiotemporal overlaps.

Reviewed the process for synthetic event generation.

Reviewed a graphical example of the impact of residual terms sampled on the conditioning site's Laplace distribution.

2. GF-1.2, pages 18-19: Explain the "derivative" of the Heffernan & Tawn multivariate extreme value model. Identify the random variables in play as derived from the synthetic event set, and their dependence structure. Explain how the results from Fathom, Multi-Source Weighted-Ensemble Precipitation (MSWEP), Framework for Understanding Structural Errors (FUSE), and mizuRoute are incorporated into the derivative model. Explain the subsequent progression in the model framework to include semi-empirical and Laplace distributions. Provide the Year Loss Table.

   Discussed the Hefferman and Tawn (2004) model, the use of semi-empirical marginal and Laplace distributions, and the random variables and their dependencies within the statistical model.

   Reviewed an example Year Loss Table for tropical cyclone and non-tropical cyclone model output.

3. GF-1.2, page 20: Provide the return periods referenced in the sentence, "The initial forcing for the pluvial simulation are the one-, six-, and 24-hour precipitation intensities associated with several return periods of extreme precipitation."

   Discussed that the return periods explicitly simulated were the 1 in 10, 20, 50, 75, 100, 200, 250, 500, and 1000 year. The interpolated return periods were 1 in 15, 30, 40, 150, 350, and 750 year.

4. GF-1.2, page 25: Elaborate on the demand surge functions for the TC and non-TC components of the model.

   See comments under AF-4, PVL #88.

5. GF-1.3, page 25 (May 10 revised submission page 26): Explain why the lacustrine modeling component is not included in the Figure 1 flowchart.

   Discussed the reasons for not including the lacustrine modeling component in the Figure 1 flowchart.

   Reviewed a revised Figure 1 to include the flowchart updated during the on-site review to conform to flowchart standards.

6. GF-1.6, page 28 (May 10 revised submission page 29), Meteorological References: The Benson, M.A., 1958 article has been superseded. Explain if and how the update in the literature has been taken into account.

   Discussed that no changes based on updates to the Benson (1958) reference were considered.

Discussed that the fluvial model simulates river flows directly in river channels and includes rivers with an upstream catchment greater than 500 sq km. Discussed that the pluvial model simulates rainfall directly onto DEM (digital elevation model) and captures flood risk along small streams and rivers not represented in the fluvial model as well as surface water flooding away from streams. The pluvial model also includes sub-grid channels with an upstream catchment area greater than 50 sq km.

Audit

1. Automated procedures used to create forms will be reviewed.

   Discussed the automated procedures to create the various submission forms.

   Reviewed the script for producing Form AF-8.

   Discussed the coding errors discovered in the scripts for generating Form AF-3 and Form AF-4.

2. All primary scientific and technical literature that describes the underlying flood model theory and implementation (where applicable) should be available for review in hard copy or electronic form. Modeling-organization-specific publications cited must be available for review in hard copy or electronic form.

   All references were available electronically and were reviewed as necessary.

3. Compliance with the process prescribed in Flood Standard GF-1.B in all stages of the flood modeling process will be reviewed.

   Reviewed the documented process for assuring continual agreement and correct correspondence of databases, data files, and computer source code to slides, and technical papers. Reviewed several examples throughout the course of the audit.

   Discussed the source control software and error tracking systems used to maintain accuracy.

4. Items specified in Flood Standard GF-1.C will be reviewed as part of the Computer/ Information Flood Standards.

   Discussed that all data used to develop and validate the model, project loss costs, and to create submission forms are stored in centralized, model-level file areas.

   Discussed the underlying issues relative to the errors in generating Forms AF-3 and AF-4, error discovery and timeline, error fixes and testing, and mitigation measures.

5. Maps, databases, and data files relevant to the modeling organization's submission will be reviewed.

   All maps, databases, and data files were available for review. Reviewed samples throughout the course of the audit.

   Discussed that model and software code, including R&D software code, source code for the ELEMENTS platform which includes the financial component, and code used to generate submission forms, is maintained in Microsoft Team Foundation Server (TFS) and is version controlled.

6. Justification for the differences in modeled versus historical flood losses will be reviewed, recognizing that flood loss data may be limited to internal or proprietary datasets.

   Reviewed comparisons of modeled versus historical losses under the Statistical Flood Standards.

   Discussed that differences between historical and modeled flood losses are due to different sample sizes of historical events and the various uncertainties within the data.

   See additional comments under SF-5 Audit 3.

7. Justification for the vintage of data, code, and scientific and technical literature used will be reviewed.

   Discussed the evaluation of and justification for the vintage of model component data, code, and technical literature.

   Discussed the process and data Fathom uses to develop and improve its flood models and data.

   Reviewed several Fathom academic peer-reviewed research papers published in scientific journals.

8. The modeling-organization-specified, predetermined, and comprehensive exposure dataset used for projecting personal residential flood loss costs and flood probable maximum loss levels will be reviewed.

   Reviewed the development and key elements of the IF comprehensive exposure dataset.

   Reviewed the distribution of Florida residential exposure data by coverage and a summary of the exposure dollar values.

   Reviewed geographical maps of the exposure database by county, by ZIP Code, and by flood zone.

   Reviewed distribution of exposure by flood depth for coastal and inland flooding.

9. The following information related to changes in the flood model, since the initial submission for each subsequent revision of the submission, will be reviewed.
   A. Flood model changes:
      1. A summary description of changes that affect, or are believed to affect, the personal residential flood loss costs or flood probable maximum loss levels,
      2. A list of all other changes, and
      3. The rationale for each change.
   B. Percentage difference in average annual zero deductible statewide flood loss costs based on a modeling-organization-specified, predetermined, and comprehensive exposure dataset for:
      1. All changes combined, and
      2. Each individual flood model component and subcomponent change.
   C. For any modifications to Form AF-4, Flood Output Ranges, since the initial submission, a newly completed Form AF-5, Percentage Change in Flood Output Ranges, with:
      1. The initial submission as the baseline for computing the percentage changes, and
      2. Any intermediate revisions as the baseline for computing the percentage changes.
   D. Color-coded maps by rating area or zone reflecting the percentage difference in average annual zero deductible statewide flood loss costs based on the modeling-organization-

specified, predetermined, and comprehensive exposure dataset for each flood model component change, between:

1. The currently accepted flood model and the revised flood model,
2. The initial submission and the revised submission, and
3. Any intermediate revisions and the revised submission.

Reviewed the updates to the storm surge hazard to align the vertical and horizontal datums with inland flood datums included in the May 10, 2024, revised submission. The datum update resulted in a 1.4% increase in loss costs, with the storm surge loss component increasing by 1.8%.

Discussed that these changes varied systematically throughout the state.

Reviewed maps depicting the percentage differences in total modeled gross loss and the percentage differences in the storm surge modeled loss by county.

September Additional Verification Review Comments:

Discussed the rationale for not implementing the improvements given in Bulletin 17-C (U.S. Geological Survey Techniques and Methods for determining flood flow frequency).

Reviewed comparisons of the flood frequency analysis results for several United States Geological Survey (USGS) stations demonstrating no significant difference in the results between using Bulletin 17-B and
Bulletin 17-C.

Reviewed maps illustrating the changes in loss costs at the ZIP Code level in North, South, and Central Florida due to the datum conversion for storm surge flooding, storm surge plus tropical cyclone inland flooding, and storm surge plus tropical cyclone and non-tropical cyclone inland flooding.

GF-2 Qualifications of Modeling Organization Personnel and Consultants Engaged in Development of the Flood Model*

*(*Significant Revision)*

A. Flood model construction, testing, and evaluation shall be performed by modeling organization personnel or consultants who possess the necessary skills, formal education, and experience to develop the relevant components for flood loss projection methodologies.

B. The flood model and flood model submission documentation shall be reviewed by modeling organization personnel or consultants in the following professional disciplines with requisite experience: hydrology and hydraulics (advanced degree or currently licensed Professional Engineer, with experience in coastal and inland flooding), meteorology (advanced degree), statistics (advanced degree or equivalent experience), structural engineering (currently licensed Professional Engineer, with experience in the effects of coastal and inland flooding on buildings), actuarial science (Associate or Fellow of Casualty Actuarial Society or Society of Actuaries), and computer/information science (advanced degree or equivalent experience and certifications). These individuals shall certify Expert Certification Forms GF-1 through GF-7 as applicable.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

7. GF-2.2.A, pages 45-47 (May 10 revised submission pages 46-48): Provide, electronically only, resumes of personnel listed in Table 1.

   Reviewed resumes of personnel and consultants involved in the flood model.

   - Nans Addor, Ph.D. in Hydrology and Climate Change Impacts, University of Zurich, Switzerland; M.S. in Environmental Sciences with Major in Atmosphere and Climate, ETH Zurich, Switzerland; B.S. in Environmental Sciences and Engineering, École polytechnique fédérale de Lausanne (EPFL), Lausanne, Switzerland

   - Sushma Bhat, B.S. in Computer Technology, University of Bombay, Mumbai, India; B.S. in Physics, University of Bombay, Mumbai, India; Honors Diploma in Systems Management, National Institute of Information Technology, Bombay, India

- David Colbus, M.A. in Climate and Society, Columbia University, New York, NY; B.A. in Anthropology with Minors in Biology, Psychology, and Creative Writing, University of Miami, Coral Gables, FL

- William Dong, Ph.D. in Engineering with Concentration in Computer Simulation of Construction Operations, University of Nebraska, Lincoln, NE; M.S. in Construction Engineering and Management, Illinois Institute of Technology, Chicago, IL

- Radovan Drinka, M.S. in Physics, Comenius University, Bratislava, Slovakia

- Xian He, Ph.D. in Civil Engineering, University of Illinois, Urbana-Champaign, IL; M.S. in Civil Engineering, University of Illinois, Urbana-Champaign, IL; B.S. in Civil Engineering, Tongji University, Shanghai, China

- Yuliia Khmurovska, Ph.D. in Civil Engineering (Building and Structural Engineering), Czech Technical University, Prague, Czechia; M.S. of Civil and Industrial Engineering, National Academy of Environmental Protection and Resort Development, Simferopol, Ukraine

- Alec Killoran, B.A. in English Language and Literature with Minor in History, University of California, Santa Barbara, CA

- Yujin Liang, Ph.D. in Structural Engineering, University of Illinois, Chicago, IL; M.S. in Water Conservancy and Hydropower Engineering Architecture, Tsinghua University, Beijing, China; B.S. in Water Conservancy and Hydropower Engineering Architecture, Hohai University, Nanjing, China

- Chris Long, M.A. in Economics, Tufts University, Medford, MA; B.A. in Economics, University of Chicago, Chicago, IL

- Minchong Mao, M.S. in Computer Science, University of Missouri, Columbia, MO; M.S. in Chemistry, Eastern Illinois University, Charleston, IL; B.S. in Chemical Engineering, Beijing University of Chemical Technology, Beijing, China

- Ricardo Wong Montoya, B.S. in Civil Engineering, Pontifical Catholic University, San Miguel, Peru

- Nehal Naik, M.S. in Computer Application, South Gujarat University, India; B.S. in Electronics, Gujarat University, India

- Andres Paleo, Ph.D. in Civil Engineering (Structures), University of Florida, Gainesville, FL; M.S. in Civil Engineering (Structures), Autonomous University of Yucatan, Mexico; B.S. in Civil Engineering, Autonomous University of Yucatan, Mexico

- Purvish Patel, B.S. in Mathematics and Computer Science, Business Administration, Wayne State College, Wayne, ME; Certificate in System Engineering, University of Kansas, Lawrence, KS

- Ankit Prashnani, M.Tech in Geomatics, CEPT University, India; B.Tech in Civil Engineering, Pandit Deendayal Energy University, India

- Petr Puncochar, Ph.D. in Hydrology and Open-Channel Hydraulics, Czech Technical University, Prague, Czechia

- Niall Quinn, Ph.D. in Geography and Oceanography, University of Southampton, UK; M.S. in Geography, University of Southampton, UK; B.S. in Geography, University of Southampton, UK

- Venkatesh Ramaiah, M.S. in Computer Science, Birla Institute of Technology and Science, Pilani, India, B.E. in Computer Science and Engineering, Visvesvaraya Technology University, Belgaum, India

- Daniel Rees, M.A. in Geographic Information Science, Clark University, Worcester, MA; B.A. in Geography, Clark University, Worcester, MA

- Christopher Sampson, Ph.D. in Hydrology, Willis Research Network and University of Bristol, UK; M.S. in Geographic Sciences, University of Bristol, UK

- James Savage, Ph.D. in Hydraulic Modeling, University of Bristol, UK; M.S. in Geographical Sciences, University of Bristol, UK

- Elham Sharifineyestani, Ph.D. in Civil Engineering, Old Dominion University, Norfolk, VA; M.S. in Environmental Engineering, Sharif University of Technology, Iran; B.S. in Civil Engineering, University of Arak, Iran

- Radek Solnicky, M.S. in Probability, Mathematical Statistics and Econometry, Charles University, Prague, Czechia

- Shruthi Srikantegowda, Bachelor of Electronics and Communication Engineering, Visvesvaraya Technological University, India; PGD Information Technology, Symbiosis Pune, India

- Corbin Tucker, M.S. in Applied Mathematics: Actuarial Science, University of Illinois, Urbana-Champaign, IL; B.S. in Mathematics, Tennessee Technological University, Cookeville, TN

- Vipin Unnikrishnan, Ph.D. in Civil Engineering, Louisiana State University, Baton Rouge, LA; M.S. in Civil Engineering, Indian Institute of Technology, Madras, India; B.T. in Civil Engineering, University of Kerala, India

- Chad Xu, M.S. in Actuarial Science, Temple University, Philadelphia, PA; M.S. in Finance, Dayton University, Dayton, OH; B.S. in Applied Mathematics, Jiangsu Second Normal University, Nanjing, China

Audit

1. The professional vitae of personnel and consultants engaged in the development of the flood model and responsible for the current flood model and the submission will be reviewed. Background information on the professional credentials and the requisite experience of individuals providing testimonial letters in the submission will be reviewed.

   See above for resumes reviewed.

   Discussed the peer-reviewed letters from Dr. Holly Widen who reviewed the hazard and vulnerability components (see Appendix D), and Dr. Eduardo Reinoso who reviewed the vulnerability component (see Appendix C).

2. Forms GF-1, General Flood Standards Expert Certification, GF-2, Meteorological Flood Standards Expert Certification, GF-3, Hydrological and Hydraulic Flood Standards Expert Certification, GF-4, Statistical Flood Standards Expert Certification, GF-5, Vulnerability Flood Standards Expert Certification, GF-6, Actuarial Flood Standards Expert Certification, GF-7, Computer/Information Flood Standards Expert Certification, and all independent peer reviews of the flood model under consideration will be reviewed. Signatories on the individual forms will be required to provide a description of their review process.

   Reviewed the signed expert certifications. Discussed the review process followed by the signatories.

   Interviewed the Statistical Flood Standards signatory. Discussed his process for reviewing the statistical contents of the submission.

   Discussed with Dan Rees and Xian He, General Flood Standards signatories, their modeling experience.

3. Incidents where modeling organization personnel or consultants have been found to have failed to abide by the standards of professional conduct adopted by their profession will be discussed.

   Discussed that there were no departures of personnel attributable to violations of professional standards.

4. For each individual listed under Disclosure 2.A, specific information as to any consulting activities and any relationship with an insurer, reinsurer, trade association, governmental entity, consumer group, or other advocacy group within the previous four years will be reviewed.

   Reviewed a summary table of the professional relationships for IF personnel involved in the development and implementation of the model and the submission.

September Additional Verification Review Comments:

Reviewed resume of new IF team member:

- David Byrne, Ph.D. in Physical Oceanography, University of Liverpool, UK; M.Sc. in Operational Research, University of Edinburgh, UK; B.Sc. in Mathematics, University of Liverpool, UK

GF-3 Insured Exposure Location*

*(*Significant Revision)*

A. ZIP Codes used in the flood model shall not differ from the United States Postal Service publication date by more than 48 months at the date of submission of the flood model. ZIP Code information shall originate from the United States Postal Service.

B. Horizontal location information used by the modeling organization shall be verified by the modeling organization for accuracy and timeliness and linked to the personal residential structure where available. The publication date of the horizontal location data shall be no more than 48 months prior to the date of submission of the flood model. The horizontal location information data source shall be documented and updated.

C. If any flood model components are dependent on databases pertaining to location, a logical process shall be maintained for ensuring these components are consistent with the horizontal location database updates.

D. Geocoding methodology shall be justified.

E. Use and conversion of horizontal and vertical projections and datum references shall be consistent and justified.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

Revised Question #8 in PVL Addendum:

8. GF-3.E, pages 52-53 and GF-3.9, page 55: The final storm surge footprint is converted from horizontal datum North American Datum of 1983 (NAD83) and vertical datum North American Vertical Datum of 1988 (NAVD88) to World Geodetic System 1984 (WGS84) and Earth Gravitational Model (EGM08), respectively. However, the storm surge footprint is a horizontal extent. Discuss how the vertical component of the elevations is accounted for in the conversion. During LiDAR (Light Detection and Ranging) pre-processing (MF-2.11, page 82), the LiDAR datasets were converted to horizontal projection EPSG:4326 and EGM08. Discuss reconciling the WGS84 horizontal datum of the inland flood model and the EPSG:4326 datum of the LiDAR datasets.

Discussed that this issue was addressed in the May 10, 2024, resubmission by converting storm surge vertical datum from NAVD88 to EGM08. All data within the flood model with a vertical component now uses EGM08 as its vertical datum and WGS84 as its horizontal datum.

9. GF-3.5, page 53 (May 10 revised submission page 54): For locations with provided latitude/longitude coordinates, explain how the system determines the horizontal datum of the data. Explain how non-WGS84 data is converted to WGS84.

   Discussed that the model is designed to process exposure on a location level, assigning coordinates to each location based on street address information or latitude and longitude coordinates.

Audit

1. Geographic displays of the spatial distribution of insured exposures will be reviewed. The treatment of any variations for populated versus unpopulated areas will be reviewed.

   Reviewed maps of the spatial distribution of insured exposures by county, by ZIP Code, and by flood zone. Reviewed the total insured value by flood zone.

2. Third party vendor information, if applicable, and a complete description of the process used to create, validate, and justify geographic grids will be reviewed.

   Discussed the review and validation of the third-party ZIP Code data.

3. The treatment of exposures over water or other uninhabitable terrain will be reviewed.

   Discussed the methodology used to ensure no exposure points fall over water or other uninhabitable terrain. Discussed that exposures in wetland areas are preserved.

4. The process for geocoding complete and incomplete street addresses will be reviewed.

   Reviewed examples of the geocoder process when enough information is not provided to match locations. Discussed the process for geocoding locations that fail to import and are not modeled.

5. Flood model geocode location databases will be reviewed.

   Discussed the Precisely (former Pitney Bowes) geo-address service to convert street addresses into location coordinates in the WGS84 coordinate system. Reviewed the geocode API (Application Programming Interface). Reviewed treatment of ZIP Code 33141. See comments under AF-6, PVL #90.

GF-4 Independence of Flood Model Components

The meteorology, hydrology and hydraulics, vulnerability, and actuarial components of the flood model shall each be theoretically sound without compensation for potential bias from other components.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. The flood model components will be reviewed for adequately portraying flood phenomena and effects (damage, flood loss costs, and flood probable maximum loss levels). Attention will be paid to an assessment of (1) the theoretical soundness of each component, (2) the basis of the integration of each component into the flood model, and (3) consistency between the results of one component and another.

September Additional Verification Review Comments:

Verified after resolution of outstanding issues from other standards.

Reviewed the theoretical soundness, integration of components, and consistency across components throughout the course of the two audits.

There was no evidence to suggest that one component of the model was deliberately adjusted to compensate for another component.

GF-5 Editorial Compliance

The flood model submission and any revisions provided to the Commission throughout the review process shall be reviewed and edited by a person or persons with experience in reviewing technical documents who shall certify on Form GF-8, Editorial Review Expert Certification, that the flood model submission has been personally reviewed and is editorially correct.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. An assessment that the person who has reviewed the flood model submission has experience in reviewing technical documentation and that such person is familiar with the flood model submission requirements as set forth in the *Flood Standards Report of Activities as of November 1, 2021* will be made.

   Discussed the experience of David Colbus, the editorial compliance signatory, who reviewed the submission document, and the process followed for reviewing and ensuring the submission is accurate.

2. Attestation that the flood model submission has been reviewed for grammatical correctness, typographical accuracy, completeness, and no inclusion of extraneous data or materials will be assessed.

   IF confirmed that the flood model submission was reviewed throughout the development process for grammatical correctness, typographical accuracy, completeness, and no inclusion of extraneous data or materials.

3. Confirmation that the flood model submission has been reviewed by the signatories on the Expert Certification Forms GF-1 through GF-7 for accuracy and completeness will be assessed.

   IF confirmed that subject matter experts reviewed all submitted materials for completeness and accuracy.

4. The modification history for flood model submission documentation will be reviewed.

   Discussed the process for preparing, reviewing, revising, and tracking revisions to the submission documentation. Reviewed the submission documentation modification history.

5. A flowchart defining the process for form creation will be reviewed.

   Reviewed a flowchart of the process for submission form creation.

6. Form GF-8, Editorial Review Expert Certification, will be reviewed.

   Reviewed Form GF-8.

Editorial items noted by the Professional Team in the pre-visit letter, the pre-visit letter addendum, and during the on-site review were satisfactorily addressed during the audit. The Professional Team has reviewed the submission per Audit item 3, but cannot guarantee that all editorial difficulties have been identified. The Modeler is responsible for eliminating such errors.

September Additional Verification Review Comments:

Verified after review of revisions made in the September 3, 2024, revised submission and revisions made during the additional verification review.

METEOROLOGICAL FLOOD STANDARDS – JENNI EVANS, LEADER

MF-1 Flood Event Data Sources*

*(*Significant Revision)*

A. The modeling of floods in Florida shall involve meteorological, hydrological, hydraulic, and other relevant data sources required to model coastal and inland flooding.

B. The flood model shall incorporate relevant data sources in order to account for meteorological, hydrological, and hydraulic events and circumstances occurring either inside or outside of Florida that result in, or contribute to, flooding in Florida.

C. Coastal and inland flood model calibration and validation shall be justified based upon historical data consistent with peer reviewed or publicly developed data sources.

D. Any trends, weighting, or partitioning shall be justified and consistent with current scientific and technical literature.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

10. MF-1.1, page 59 (May 10 revised submission page 61): Provide the 17 return periods used for the Fathom Hazard catalog.

    Discussed that the return periods used from the Fathom hazard catalog were the 1 in 10, 15, 20, 30, 40, 50, 75, 100, 150, 200, 250, 350, 500, 750, and 1000-year events. Fathom indicated most of these return periods were computed directly with a handful by interpolation.

102. MF-1.3, page 62: Discuss how a change in sea level of 0.24 m (9 in) is “not significant enough to alter the loss estimates a lot” compared to changes in storm surge footprints and loss costs.

    Discussed that sea-level rise is not considered, and that losses are modeled under current conditions, exposure, and meteorological and hydrological conditions.

Audit

1. The modeling organization's data sources will be reviewed.

   Reviewed the key datasets for tropical cyclone induced coastal and inland flooding, and non-tropical cyclone induced inland flooding.

2. Changes to the modeling organization's data sources from the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the IF flood model.

3. Justification for any modification, partitioning, or adjustment to historical data and the impact on flood model parameters and characteristics will be reviewed.

   Discussed that the historical data was not modified when developing the tropical cyclone induced coastal and inland flooding events.

   Discussed the methodology for creating the non-tropical cyclone induced inland flooding event set.

   Discussed that tropical storms are included in rainfall calculation and also storm surge.

4. The method and process used for calibration and validation of the flood model, including adjustments to input parameters, will be reviewed.

   Discussed the calibration of storm surge elevation and validation of modeled storm surge footprints for historical events. Reviewed comparisons of flood extent and elevation/depth with observed data provided in MF-4.1 and Form HHF-1.

   Discussed that modeled return period storm surge maps are validated against National Flood Insurance Program (NFIP) extents for stochastic events. Reviewed validation of the return period storm surge elevation at several NOAA tidal stations provided in MF-5.3.

   Discussed that the hydraulic and inland flood statistical models are uncalibrated. Reviewed validation examples of the hydraulic model provided in Form HHF-1 and in MF-5.3.

   Reviewed validation related to the non-tropical event set for the inland statistical model provided in SF-1.5.

   Discussed that spatially uniform parameter values are used for the FUSE (Framework for Understanding Structural Errors) hydrological model and the MizuRoute rainfall-runoff routing model. Reviewed Figure 38 in HHF-2.3 illustrating the ability of the model to differentiate between events.

Reviewed comparison of Hurricane Matthew (2016) observed and modeled peak flow.

5. Any treatment of projected changes in sea level, precipitation, and storm characteristics will be reviewed.

   Discussed that the flood model does not include treatment of projected changes in sea level, precipitation, or other storm characteristics.

September Additional Verification Review Comments:

Discussed how storms with multiple landfalls are treated in the model. Reviewed example of Hurricane Ivan (2004).

Reviewed an illustration of the different basin activation points. Reviewed the steps for basin selection.

Reviewed the storm surge and rainfall induced flood distributions for Hurricane Sally (2020) and Hurricane Eta (2020) impacts on Florida.

Reviewed animations for surge-induced flooding and maximum depth for Hurricane Sally (2020) and Hurricane Eta (2020).

MF-2 Flood Parameters (Inputs)*

*(*Significant Revision)*

A. The flood model shall be developed with consideration given to flood parameters that are scientifically appropriate for modeling coastal and inland flooding. The modeling organization shall justify the use of all flood parameters based on information documented in current scientific and technical literature.

B. Differences in the treatment of flood parameters between historical and stochastic events shall be justified.

C. Grid cell size(s) used in the flood model shall be justified.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

11. MF-2.C, page 63 (May 10 revised submission page 65): Explain how the various grid sizes (e.g., 1°x1°, 0.1°x0.1°, 1 arc second, 30m) work in tandem throughout the model.

    Reviewed the various grid sizes chosen to represent the most appropriate spatial resolution while considering computation requirements. Discussed how resolution is defined and implemented.

    Discussed that the storm surge component is independent of the inland and hydrological models, and that the storm surge resolution chosen is from the smallest applicable SLOSH basin grid.

    Discussed that the FUSE model is independent of the hydraulic model and feeds into the routing mizuRoute model. See comments under HHF-1 PVL #40 for transferring water from FUSE to mizuRoute.

    The Modeler confirmed that data can be computed at different resolutions and then combined without introducing any resolution induced problems.

12. MF-2.1, page 68 (May 10 revised submission page 70): Elaborate on the timeseries given in the response.

    Discussed that the time series relate to the pluvial and fluvial reanalysis datasets and that spatiotemporal events are extracted for use in the non-tropical statistical model.

13. MF-2.2, page 69 (May 10 revised submission page 71): Provide data and analysis that shows "the modeled Rmax has general agreement."

    Reviewed the modeled relationship between central pressure and Rmax, and their changes. Discussed that Rmax decreases with increase in storm intensity.

    Reviewed goodness-of-fit test results for Rmax.

14. MF-2.4, page 72 (May 10 revised submission page 74): Provide the fixed values in the non-TC synthetic event set model: the event definition threshold, the spatio-temporal window parameters, and the generalized Pareto distribution threshold, and fitted parameters used in the marginal distribution creation.

    Reviewed the spatiotemporal parameter values. Reviewed histograms of the distributions.

15. MF-2.6, page 72 (May 10 revised submission page 74): Discuss how infiltration effects are applied to the boundary conditions for fluvial flooding (GF-1.2, page 20), versus how rainfall is reduced to account for soil infiltration (MF-1.7, page 61, May 10 revised submission page 63). Discuss how the relevant adjustable parameters in the FUSE model related to infiltration and surface storage are utilized in the modeling (MF-2.1, page 68, (May 10 revised submission page 70).

    Discussed that infiltration is inherently represented by the use of a gauge-based approach to determine extreme flows in the fluvial hydraulic model.

    Discussed that infiltration is considered in the pluvial hydraulic model by calculating the amount that infiltrates and deducting that volume from the rainfall. The remaining rainfall generates runoff.

    Discussed that precipitation is split between surface runoff and infiltration in the FUSE model.

    Reviewed the calculation of flood model FUSE parameters and values.

16. MF-2.6, page 72 (May 10 revised submission page 74): Provide more details on the Tropical Cyclone Rainfall (TCR) model. In particular, explain how saturation specific humidity is modeled, what vertical level(s) is/are used, and how the vertical velocities are modeled. Describe how output from the TCR model is used in flood calculation.

    Reviewed details of the TCR model. Reviewed the rainfall calculation associated with tropical cyclones. Reviewed equation for estimating vertical velocity.

    Reviewed the key steps for producing event flood maps.

    Reviewed the non-proprietary code for calculating rainfall and rain rate in the TCR model.

    Reviewed the code for calculating accumulated rainfall along the storm track.

    Reviewed an example for a stochastic storm in the TCR model code.

103. MF-2.6, pages 74-75: Describe how environmental data (saturation specific humidity, vertical velocity) are assigned for stochastic storms.

    Discussed the process for assigning environmental parameters for the stochastic tropical storm set.

17. MF-2.8, page 74 (May 10 revised submission page 76): Discuss how tide is adjusted for step #3 as the storm approaches land.

    Discussed the process for accounting for tide and storm surge through shallow areas and over land.

104. MF-2.8, page 76: Clarify the first sentence in the third paragraph, "…with cells that wet and dry."

    Reviewed an example illustration of dry and wetted grid squares. Reviewed a rewording of the referenced sentence for clarification.

18. MF-2.11, page 76 (May 10 revised submission page 78): In the response addressing Inland Flood, clarify the available coverage of LiDAR data in Florida.

    Reviewed map of LiDAR coverage for Florida.

105. MF-2.11, page 78: Explain how the underlying Copernicus DEM relates to the USGS National Elevation Dataset (NED) in the fluvial component of the model.

    Discussed that the use of FABDEM (Forest and Buildings removed Copernicus DEM) provides a consistent and better-quality terrain dataset than some of the other available datasets.

106. MF-2.12, pages 82-84: Clarify how the changes in datum relevant to storm surge are reflected in the text or in the revised Figure 9 (page 83).

Discussed that Figure 9 was revised due to the change in size of the figure for formatting.

19. MF-2.13, page 82 (May 10 revised submission page 84): Clarify whether the National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRM) or Flood Insurance Study (FIS) data are used given the statements on page 82 (May 10 revised submission page 84) and the process provided in Figure 21 (page 100, May 10 revised submission page 103).

See comments under PVL #13.

Discussed that the flood model hazard components do not have dependency on NFIP flood insurance rate maps or FIS data. The vulnerability component incorporates BFE and flood zone.

Audit

1. All flood parameters used in the flood model will be reviewed.

Discussed the different parameters used in the storm surge model, the inland hydraulic model, the inland statistical model, the FUSE hydrological model, and the mizuRoute routing model.

Reviewed the regression parameters and residual terms for the inland statistical model.

Reviewed the number and landfall frequency of tropical storm events per year.

2. For explicit representation of precipitation, data sources, calibration, and evaluation will be reviewed.

Discussed that precipitation is explicitly modeled utilizing a physics-based tropical cyclone rainfall (TCR) model. Reviewed the key inputs for the TCR model. Reviewed modeler process for determining and testing inputs and outputs to the TCR model. Reviewed examples from two historical storms.

Discussed how rainfall is modeled in the pluvial hydraulic simulations. Reviewed the spatial and daily temporal resolutions used.

Discussed the calibration parameters and validation of the TCR model. Reviewed a scatter plot of observed to modeled accumulated rainfall.

3. For implicit representation of precipitation, justification, data sources, method, and implementation will be reviewed.

   Discussed that non-tropical cyclone precipitation events are generated implicitly in the inland statistical model. Reviewed the data and synthetic generation of precipitation in the statistical model.

4. Graphical depictions of flood parameters as used in the flood model will be reviewed. Descriptions and justification of the following will be reviewed:
   a. The dataset basis for any fitted distributions, the methods used, and any smoothing techniques employed,
   b. The modeled dependencies among correlated parameters in the flood model and how they are represented, and
   c. The dependencies between the coastal and inland flooding analyses.

   Reviewed graphical depictions of central pressure, Rmax, and surface drag coefficient in the storm surge model. Reviewed the value assigned for wind friction coefficients.

   Reviewed the generalized Pareto distribution (GPD) threshold and fitted parameters in the non-tropical statistical rainfall model.

   Reviewed the dataset basis used to model the tropical cyclone wind parameters in the storm surge model.

   Discussed that the inland statistical model parameters are fit to historical data and that the events per year is an empirical distribution.

   Reviewed equations for the Rmax to central pressure deficit and the wind friction coefficients.

   Reviewed the hydraulic model parameters provided in MF-2.1.

   Discussed that if a location is flooded by both inland flood and coastal flood, the losses are calculated separately, and the maximum loss is used for that location.

   Discussed the validation process of simulated wind and pressure fields to historical storms.

5. Scientific and technical literature cited in Flood Standard GF-1, Scope of the Flood Model and Its Implementation, may be reviewed to determine applicability.

   Meteorological references were available electronically and were extensively reviewed as necessary.

6. The initial and boundary conditions for coastal flood events will be reviewed.

   Reviewed the process for using the four boundary conditions in the SLOSH model.

September Additional Verification Review Comments:

   Discussed that the windfield used in the SLOSH model for storm surge is the default, not the windfield used in the hurricane model.

7. The basis or dependence of flood model parameters on NFIP FIRM or other FIS data will be reviewed.

   Discussed that the flood model hazard parameters are not based on and do not depend on NFIP FIRM or other FIS data.

   Discussed that the vulnerability functions are distinguished between pre-FIRM and post-FIRM effective year.

   Discussed how and when base flood elevation is considered.

September Additional Verification Review Comments:

Reviewed changes to central pressure prior to and after landfall for Hurricane Irma (2017) and Hurricane Michael (2018) addressing the pressure decay influences of storm surge. Reviewed maps of storm surge height changes for both storms for intensity held constant at landfall compared to the decay rate implemented in the model.

Reviewed comparison of Hurricane Irma (2017) accumulated rainfall footprints with and without pressure decay.

Discussed that the relationship between central pressure and Vmax is defined in the hurricane wind model.

MF-3 Wind and Pressure Fields for Storm Surge*

*(*Significant Revision)*

A. Modeling of wind and pressure fields shall be employed to drive storm surge models due to tropical cyclones.

B. The wind and pressure fields shall be based on current scientific and technical literature or developed using scientifically defensible methods.

C. Physically-based simulation of atmosphere-ocean interactions resulting in storm surge shall be conducted over a sufficiently large domain that storm surge height has converged.

D. The features of modeled wind and pressure fields shall be consistent with those of historical storms affecting Florida.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

107. MF-3.1, page 86: Clarify the impact of a constant shape parameter in the wind distribution for all tropical cyclones.

Discussed the comparison of modeled and observed storm surge heights for winds in gradient wind balance and Equation (3) for cyclostrophic balance. Discussed that Equation (1) remains the wind distribution used in the SLOSH model to generate storm surge.

Audit

1. All external data sources that affect the modeled wind and pressure fields associated with storm surge will be identified and their appropriateness reviewed.

   Reviewed the historical data sources used to generate the wind and pressure fields.

2. Calibration and evaluation of wind and pressure fields will be reviewed. Scientific comparisons of simulated wind and pressure fields to historical storms will be reviewed.

   Discussed that the default SLOSH wind and pressure field model is used for storm surge modeling.

3. The sensitivity of flood extent and depth results to changes in the representation of wind and pressure fields will be reviewed.

   Reviewed the sensitivity analyses results of the storm surge loss costs regarding variation of the wind and pressure fields input variables as provided in SF-2.1.

4. The over-land evolution of simulated wind and pressure fields and its impact on the simulated flooding will be reviewed.

   Reviewed an example animation of the overland evolution of the wind and pressure fields from Hurricane Ian (2022) and the impact on the simulated storm surge depth.

   Discussed that multiple events need to be presented in order to verify the standard.

5. The derivation of surface water wind stress from surface windspeed will be reviewed. If a sea-surface drag coefficient is employed, how it is related to the surface windspeed will be reviewed. A comparison of the sea-surface drag coefficient to coefficients from current scientific and technical literature will be reviewed.

   Reviewed the equation for surface water wind stress that is modeled using the SLOSH model.

6. The uncertainties in the factors used to convert from a reference windfield to a geographic distribution of surface winds and the impact of the resulting winds upon the storm surge will be reviewed and compared with current scientific and technical literature.

   Discussed that the SLOSH model's surface wind and pressure fields incorporate storm translation.

September Additional Verification Review Comments:

Reviewed the storm characteristics modeled and the calculation of the storm surge and inland flooding for Hurricane Eta (2020) and Hurricane Sally (2020).

Discussed the method for determining Rmax for Hurricane Charley (2004) at landfall.

MF-4 Flood Characteristics (Outputs)*

*(*Significant Revision)*

A. Flood extent and elevation or depth generated by the flood model shall be consistent with observed historical floods affecting Florida.

B. Methods for deriving flood extent and elevation or depth shall be scientifically defensible and technically sound.

C. Methods for modeling or approximating wave conditions in coastal flooding shall be scientifically defensible and technically sound.

D. Modeled flood characteristics shall be sufficient for the calculation of flood damage.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

108. MF-4.1, page 91: Provide storm surge footprints for Hurricane Betsy (1965) and Hurricane Wilma (2005). Discuss how their maximum surge height has changed with the DEM update since the original January 28, 2024, submission.

Reviewed comparisons of storm surge depth footprints for Hurricane Betsy (1965) and Hurricane Wilma (2005) using the old datum (NAD83 and NAVD88) and using the new datum (WGS84 and EGM08). Reviewed the changes in maximum depth. Discussed whether these changes influenced the changes in Form AF-2 loss costs between the January and May submissions.

20. MF-4.1, pages 90-97, Figures 12-19 (May 10 revised submission pages 93-100): Discuss the model maximum flood depth compared to the nearest observations. Provide Figures 12, 14, 16, and 18 with the storm tracks plotted. Provide Figures 13, 15, 17, and 19 with the vertical datum.

Reviewed maps of the maximum flood depth compared to the nearest observations for Hurricane Dorian (2019), Hurricane Opal (1995), Hurricane Sally (2020), and Hurricane Charley (2004).

Reviewed Figures 12, 14, 16, and 18 with the storm tracks plotted, and Figures 13, 15, 17, and 19 with the vertical datum. Discussed the large values of maximum modeled depth.

21. MF-4.1, page 91 (May 10 revised submission page 93): Provide the data in Figure 13 in an Excel file.

Reviewed the underlying data for Figure 13.

109. MF-4.1, page 93: Provide a new Figure 13, Hurricane Opal (1995), consistent with revised Figure 12.

Reviewed a new Figure 13 for Hurricane Opal (1995) consistent with revised Figure 12 using the new EGM08 vertical datum.

22. MF-4.1, page 93 (May 10 revised submission page 95): Provide the data in Figure 15 in an Excel file.

Reviewed the underlying data for Figure 15.

110. MF-4.1, page 97: Discuss Figure 17, Hurricane Dorian (2019), with respect to revised Figure 16.

Reviewed a new Figure 17 for Hurricane Dorian (2019) consistent with revised Figure 16 using the new EGM08 vertical datum. Discussed the root mean square error (RMSE) of the observed compared to modeled elevation.

23. MF-4.1, page 96 (May 10 revised submission page 99): Provide Figure 18 in a format where observations can be seen.

Reviewed the storm surge footprint for Hurricane Sally (2020) in Figure 18. Discussed how the change in the DEM datum since the original submission resulted in a change in the storm surge footprint.

111. MF-4.7, page 102, Figure 20: Discuss how SLOSH basins are selected independently of the storm track.

Reviewed the process for selecting SLOSH basins.

Reviewed a revised flowchart in Figure 20 corrected during the on-site review to reflect how SLOSH basins are selected depending on the tropical cyclone track and to conform to flowchart standards.

112. MF-4.7, page 102, Figure 20: Discuss how DEM adjustment in the revised submission relates to the step for mapping of SLOSH grid to IF grid or calculation of surge depth (DEM subtraction) and how this impacts loss costs.

Discussed that the step for mapping the SLOSH grid to the flood model grid did not change due to the update in the DEM.

Reviewed a flowchart revised during the on-site review to add the additional datum conversion step.

24. MF-4.10, pages 102-104 (May 10 revised submission pages 105-107): Discuss how Rmax is an appropriate scale for storm surge with reference to observed and National Hurricane Center (NHC) simulations of Sea, Lake, and Overland Surges from Hurricanes (SLOSH) for Hurricanes Katrina (2005) and Dennis (2005).

Discussed the Rmax and storm surges for Hurricane Dennis (2005), a small hurricane with limited extent of impacts closer to the storm track, and for Hurricane Katrina (2005), a large hurricane which affected most of the U.S. Gulf Coast.

Audit

1. The method and supporting material for determining flood extent and elevation or depth for coastal flooding will be reviewed.

   Discussed that the SLOSH model is used to determine the storm surge extent and elevation.

2. The inland propagation of coastal flood and the effect of coastal flood propagation on inland flood will be reviewed.

   Discussed that coastal and inland flood are modeled separately and there are no effects of coastal flood propagation on inland flood, and vice versa.

3. Any modeling-organization-specific research performed to calculate the flood extent and elevation or depth and wave conditions will be reviewed, along with the associated databases.

   Discussed that the storm surge model uses the SLOSH model to calculate coastal flood extent and elevation.

   Discussed that the tropical cyclone storm tracks are drawn from the hurricane wind model that was developed from HURDAT2 and are used as input into the SLOSH model.

   Discussed that waves are addressed in the vulnerability functions.

4. Historical data used as the basis for the flood model flood extent and elevation or depth will be reviewed. Historical data used as the basis for the flood model flood velocity, as available, will be reviewed.

   Discussed the historical data used by the storm surge model and the inland statistical model.

Reviewed modeled flood extent and depth comparisons with observed data provided in MF-4.1 and Form HHF-1. Reviewed validation of return period storm surge elevation at NOAA tidal stations provided in MF-5.3.

Discussed that flood velocity is considered in developing the vulnerability functions. Discussed the descriptions provided in VF-1.8.

See comments under PVL #1 and HHF-1.14 for the pluvial and fluvial historical data in the inland statistical model.

Discussed that historical rainfall and river gauge data are used for validation of the hydraulic model.

5. The comparison of the calculated characteristics with historical flood events will be reviewed. The selected locations and corresponding storm events will be reviewed to verify sufficient representation of the varied geographic areas. If a single storm is used for both coastal and inland flooding validation, then its appropriateness will be reviewed.

Discussed that modeled historical storm surge footprints are compared to historical observed high-water marks and extents. Reviewed comparisons of flood extent and depth with historical observation data provided in MF-4.1 and Form HHF-1.

Reviewed comparisons of observed and simulated flood flow for historical events at USGS river gauges provided in Figures 29-37 in HHF-2.3. Discussed Modeler assessments of limitations in the data.

Reviewed Figure 38 illustrating the model analysis to differentiate between events and to capture a range of peak flows across a wide range of river sizes.

6. Consistency of the flood model stochastic flood extent and elevation or depth with reference to the historical flood databases will be reviewed. Consistency of the flood model stochastic flood velocity, as available, with reference to the historical flood databases will be reviewed.

Reviewed comparison of the modeled 100-year flood footprint with historical maximum storm surge elevation.

Reviewed comparisons of the modeled accumulated rainfall and gross loss for stochastic events to the accumulated rainfall for Hurricane Ian (2022), Hurricane Irma (2017), and Hurricane Frances (2005).

7. Form HHF-2, Coastal Flood Characteristics by Annual Exceedance Probability, and Form HHF-3, Coastal Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item), will be reviewed.

   Reviewed Form HHF-2 and discussed the results.

8. Modeled frequencies will be compared with the observed spatial distribution of flood frequencies across Florida using methods documented in current scientific and technical literature. The comparison of modeled to historical statewide and regional coastal flood frequencies as provided in Form HHF-2, Coastal Flood Characteristics by Annual Exceedance Probability, and Form HHF-3, Coastal Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item), will be reviewed.

   Reviewed comparisons of the modeled storm surge elevation exceedance probabilities at a location on land closest to several NOAA tidal station locations with observed frequencies provided in MF-5.3 and Form HHF-2.

9. Comparison of 0.01 and 0.002 annual exceedance probability flood extents produced by the flood model with those from the Federal Emergency Management Agency (FEMA) will be reviewed.

   Reviewed comparisons of the modeled flood extent corresponding to the 0.01 and 0.002 annual exceedance probabilities with NFIP flood extents provided in Forms HHF-2 and HHF-3.

   Reviewed comparison of the modeled 0.01 and 0.002 annual exceedance probability flood extents for inland flood with NFIP flood extents in Form HHF-5.

10. Temporal evolution of coastal flood characteristics will be reviewed. (Trade Secret Item to be provided during the closed meeting portion of the Commission meeting to review the flood model for acceptability.)

    Reviewed examples of the temporal evolution of storm surge elevation and depth, windspeed, central pressure difference, and Rmax. These examples will be shown to the Commission during the Trade Secret session.

11. Comparisons of the flood flow calculated in the flood model with records from United States Geological Survey (USGS) or Florida Water Management District (FWMD) gauging stations will be reviewed.

    Reviewed comparisons of modeled peak flows to USGS gauge site data from Hurricane Ivan (2004) and Hurricane Irma (2017). Reviewed examples provided in HHF-2.2.

12. Calculation of relevant characteristics in the flood model, such as flood extent, elevation or depth, and waves, will be reviewed. The methods by which each flood model component utilizes the characteristics of other flood model components will be reviewed.

    Discussed that coastal flood extent and elevation is calculated using the SLOSH model.

    Discussed the process for calculating the total flood extent from all flood models.

    Discussed that wave effects are accounted for in the vulnerability functions.

13. The modeled coincidence and interaction of inland and coastal flooding will be reviewed. If it is not modeled, justification will be reviewed.

    Discussed that coastal (storm surge) and inland flooding are modeled separately. Impacts of flooding at locations affected by both coastal and inland flood are accounted for in the financial component of the model.

14. The basis or dependence of modeled flood characteristics on NFIP FIRM or other FIS data will be reviewed.

    Discussed that the vulnerability functions are distinguished between pre-FIRM and post-FIRM effective year and that the vulnerability tiers are designed based on FEMA flood zones.

September Additional Verification Review Comments:

Reviewed map comparisons of the modeled and NFIP flood extents for different exceedance probabilities in Brevard, Broward, Levy, Pinellas, Wakulla, Charlotte, and Escambia Counties.

Reviewed the temporal evolution of storm surge depth for Hurricane Wilma (2005) and Hurricane Ivan (2004) that will be presented to the Commission during the trade secret session.

Reviewed maps of the historical storm events in Form HHF-1 with the gauge locations added in revised Figures 30-38.

MF-5 Flood Probability Distributions

A. ***Flood probability, its geographic variation, and the associated flood extent and elevation or depth shall be scientifically defensible and shall be consistent with flooding observed for Florida.***

B. ***Flood probability distributions for storm tide affected areas shall include tropical, and if modeled, non-tropical events.***

C. ***Probability distributions for coastal wave conditions, if modeled, shall arise from the same events as the storm tide modeling.***

D. ***Any additional probability distributions of flood parameters and modeled characteristics shall be consistent with historical floods for Florida resulting from coastal and inland flooding.***

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

25. MF-5.2, page 107 (May 10 revised submission page 110): Provide details on the threshold chosen. Explain how the methodology of Varty et al. comes into play.

    Discussed the threshold selection process and the approach followed in Varty et al. (2021).

    Reviewed the marginal and Laplace distributions in the flood statistical model.

    Reviewed the distributions of fitted generalized pareto distribution thresholds for sites in Florida separated for pluvial and fluvial flooding. Reviewed QQ plots for each site.

26. MF-5.2, page 107 (May 10 revised submission page 110): Explain how the Generalized Extreme Value (GEV) and Generalized Pareto (GP) distributions are used as part of the Regionalized Flood Frequency Analysis (RFFA) to calculate extreme streamflow.

    Discussed that the GEV and GP distributions are applied to calculate growth curves for clusters of gauged locations. Discussed the process for matching ungauged locations.

    Discussed the process to calculate extreme flows for any location on any river in Florida.

27. MF-5.2, page 108 (May 10 revised submission page 111): Discuss the modeled inland flood probabilities relative to observations. In particular, discuss why higher probability events tend to bias toward lower flows compared to historical records, while lower probability events bias toward higher flows compared to historic.

    Discussed issues with estimating extreme flows using only gauge data. Discussed the Modeler's explanations for the biases observed in Figure 23 which was published in Bates et al. (2021).

28. MF-5.3, page 110, Table 10 (May 10 revised submission page 113): Discuss how inland flood validation metrics of Iowa Flood Center data are relevant to inland flood in Florida.

    Discussed that the main validation of the flood models in the submission has been done with data in Florida.

Audit

1. The consistency in accounting for similar flood parameters and characteristics across Florida and segments in adjacent states will be reviewed.

   Reviewed illustration of the basins covering Florida extending into adjacent states with overlaps to ensure a continuous footprint.

   Discussed that the hydraulic model is simulated over 1°x1° tiles that extend beyond the Florida border with a buffer region to ensure consistency across state boundaries.

2. The method and supporting material for generating stochastic coastal and inland flood events will be reviewed.

   Discussed that the flood model uses the same tropical cyclone event set and storm tracks as used in the current accepted hurricane model. The tropical cyclone tracks are used as input to the SLOSH model to generate storm surge.

   Discussed that the inland flood stochastic event set generates tropical events and non-tropical events. Tropical event characteristics are defined using the TCR tropical precipitation model and routing through the hydrological models. Non-tropical event characteristics use precipitation and discharges from the hydrological models.

   Reviewed details of the tropical cyclone event set derived from the wind model, including storm track generation, annual number of storms, storm genesis parameters, translational speed and heading angle, central pressure, and Rmax.

3. Any modeling-organization-specific research performed to develop the functions used for simulating flood model characteristics or to develop flood databases will be reviewed.

   Discussed that no modeling-organization-specific research was performed to develop the functional forms used for simulating coastal flood model characteristics. Coefficients were derived through linear regressions on the historical data.

4. Form SF-1, Distributions of Stochastic Flood Parameters (Coastal, Inland), will be reviewed.

   The coastal and inland flooding distributions for stochastic flood parameters in Form SF-1 were reviewed under the Statistical Flood Standards.

5. Comparisons of modeled flood probabilities and characteristics for coastal and inland flooding against the available historical record will be reviewed. Modeled probabilities from any subset, trend, or fitted function will be reviewed, compared, and justified against this historical record. In the case of partitioning, modeled probabilities from the partition and its complement will be reviewed and compared with the complete historical record.

   Reviewed comparison of modeled to observed annual landfall frequency provided in MF-2.7.

   Reviewed comparison of modeled to observed coastal flood elevation frequencies provided in MF-5.3.

   Reviewed inland flood characteristics by annual exceedance probabilities provided in Form HHF-4. Reviewed validation of flood probabilities provided in MF-5.2 and MF-5.3.

September Additional Verification Review Comments:

Discussed that Vmax is an input from the hurricane model and is not calculated in the inland flood model.

HYDROLOGICAL AND HYDRAULIC FLOOD STANDARDS – DEL SCHWALLS, LEADER

HHF-1 Flood Parameters (Inputs)*
*(*Significant Revision)*

A. Treatment of land use and land cover (LULC) effects shall be consistent with current scientific and technical literature. Any LULC database used shall be consistent with the National Land Cover Database (NLCD) 2016 or later. Use of alternate datasets shall be justified.

B. Treatment of soil effects on inland flooding shall be consistent with current scientific and technical literature.

C. Treatment of watersheds and hydrologic basins shall be consistent with current scientific and technical literature.

D. Treatment of hydraulic systems, including conveyance, storage, and hydraulic structures, shall be consistent with current scientific and technical literature.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

29. HHF-1.2, page 113, Figure 25 (May 10 revised submission page 116): Provide examples of fluvial and pluvial basin boundaries compared to the topographic data used in the model. Discuss the procedures for verifying basin boundaries.

    Reviewed examples of combining fluvial and pluvial inundation masks. Discussed the process of combining masks to ensure the maximum lacustrine extent.

30. HHF-1.2, page 114, Figure 26 (May 10 revised submission page 117): Discuss in detail the data represented in (c) and the different recurrence intervals identified, and how that translates to a combined map in (d). Discuss the process of extracting flood maps for a catchment unit where no overlapping is allowed for a given flood event depicted in Figure 26.

    Discussed that Figure 26 (c) shows a series of catchments, each with a return period value attributed to them, obtained from the stochastic event. The catchment map shows the fluvial depths associated with the 1-in-150-year fluvial hazard layer cut to that catchment polygon. Figure 26 (d) provides an extension where the process is applied across all catchments and perils, retaining the resulting maximum depth in each cell.

Discussed the process of hazard layer selection and sampling.

31. HHF-1.3, page 116 (May 10 revised submission page 119): Discuss the time steps used in rainfall modeling, hydrologic modeling, and hydraulic modeling, and their relationships. Discuss how the selected time steps are sufficient to capture peak flooding, including for short duration, high-intensity rainfall events (e.g., 2 in/hr).

    Discussed how the daily time step captures peak flooding from an 8-hour storm.

    Reviewed the temporal resolution for the FUSE hydrological model.

    Discussed that the hydraulic model uses an adaptive timestep for both the pluvial and fluvial model simulations.

32. HHF-1.3, pages 116-117 (May 10 revised submission pages 119-120): Describe how current event storm footprints are scaled to the Hurricane Katrina (2005) reference footprint.

    Discussed the rationale for extracting initial conditions from historical simulations.

    Discussed that the soil moisture and river levels from (or recorded) a few days before Hurricane Katrina (2005) made landfall were used as the initial conditions for the stochastic tropical cyclone rainfall. River flows which determine the footprint are then computed using the tropical cyclone rainfall for each event. Discussed that FUSE and mizuRoute compute flow based on FUSE runoff, and that the footprint of each event is determined by simulation.

    Discussed the process for including non-tropical rainfall events.

33. HHF-1.4, page 117 (May 10 revised submission page 121): Discuss how the sensitivity studies referenced are relevant to floods due to tropical storms.

    Discussed the rationale for using a range of initial conditions from tropical cyclone footprints.

    Discussed the process for including non-tropical rainfall events.

34. HHF-1.5, page 118 (May 10 revised submission pages 121-122): Discuss how data from the different sources cited here are combined.

    Discussed the process for combining LiDAR coverage and FABDEM data. Reviewed maps illustrating the areas covered by each type of data.

Reviewed an anomalous feature in the terrain and the Modeler's process for quality control of the final Manning's distribution.

35. HHF-1.10, page 120 (May 10 revised submission pages 123-124): Justify the specific choices made for Manning coefficients given that many of the primary sources in the literature provide ranges for the various land use codes.

    Discussed the process and rationale for applying lower Manning's roughness coefficients in urban areas appropriate for a wide variety of land cover.

36. HHF-1.10, page 121 (May 10 revised submission page 124): Discuss the process and metrics by which the 10-year drainage level of protection is related to a rainfall amount. Include the level of protection that must be achieved by the model (e.g., no flooding, isolated flooding, shallow flooding), consideration of regional standards, variations considered across urban areas, and age of urban areas.

    Discussed the process and rationale for using a 10-year return period for stormwater capacity.

37. HHF-1.13, page 122 (May 10 revised submission page 126): Since no hydraulic structures other than levees are included in the model, discuss how the inland flooding extents of large rivers (e.g., St. Johns River, Peace River) are affected by the presence of large roadway crossings of these rivers, and how the model treats these constrictions in flow.

    Discussed the methodology to ensure that channel flow is not affected by the presence of any blocking features that may exist in the DEM.

    Discussed that any restrictions of flow caused by roadways crossing rivers are not represented in the hydraulic model.

38. HHF-1.14, page 124 (May 10 revised submission page 128): Provide a more detailed description of how the parametrization (1D small river) is implemented into 2D shallow water equations (SWE) model on 1°x1° grid to produce modeled flows.

    Discussed the process for using a 1-arc second sub-grid channel that provides the geometry of the river channel. Discussed that this is in a larger 1°x1° tile domain.

    Reviewed an example sub-grid channel discretization.

39. HHF-1.14, page 124 (May 10 revised submission page 128): Discuss how implementation and validation of this model in Florida are affected by the four different modeling structures: 1D only, 2D only, coupled 1D/2D, and 2D sub-grid. Provide a comparison of results for these four approaches.

    Discussed the implementation and validation of the Florida flood model. Discussed that only the sub-grid model approach was used.

40. HHF-1.14, page 125 (May 10 revised submission page 129): Provide an example of how mizuRoute is distributing flow from FUSE.

    Reviewed illustration of the flow resulting from a tropical cyclone and routed by mizuRoute through the MERIT-Hydro (Multi-Error-Removed-Improved-Terrain-Hydro) network.

    Reviewed illustration of the MERIT-Hydro river network.

    Discussed the process to distribute and route FUSE runoff and to compute the river flow resulting from tropical cyclone rainfall.

41. HHF-1.14, page 126 (May 10 revised submission page 130): Describe how gauge data are merged with ERA5 reanalysis (climate reanalysis dataset), and the benefit to the flood model calculation.

    Discussed the precipitation dataset and the process for merging of observations from a global dataset of rain gauges.

    Discussed the rationale and benefits of the approach.

    Reviewed relevant references.

42. HHF-1.14, page 126 (May 10 revised submission page 130): Discuss how the data sites for "semi-empirical" fitting of inland flood distributions are selected, how many are in Florida or adjacent states, and the process used for the fitting.

    Discussed the site selection process and the marginal model fitting to the site data.

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. The initial and boundary conditions for flood events will be reviewed.

   Discussed the boundary conditions for the fluvial model, the pluvial model, the hydrological model, and the event set.

   Reviewed the four sets of boundary conditions in the SLOSH model used for the surge model.

2. The topographic representation will be reviewed.

   Reviewed map of the LiDAR and Fathom DEM coverage for Florida.

   Discussed the process for converting the LiDAR and Fathom DEM datasets to the EGM08 vertical datum.

3. Any modeling-organization-specific methodology used to incorporate LULC information into the flood model will be reviewed.

   Discussed that the LULC dataset is the 2019 NLCD.

   Reviewed the methodology defining the spatially varying Manning's roughness coefficients in the hydraulic model simulations provided in MF-2.1.

   Reviewed the methodology for identifying developed locations with urban drainage provided in MF-2.6, and the resulting reduction in rainfall used in the model as a proxy for infiltration.

4. Any modeling-organization-specific research performed to develop the soil infiltration and percolation rates or soil moisture conditions used in the flood model will be reviewed, if applicable.

   Discussed that no modeling-organization-specific research was performed to develop the soil infiltration and percolation rates or soil moisture conditions.

5. The watershed and hydraulic basin boundaries in the flood model, and the methods for developing these boundaries, or any equivalent assumptions, will be reviewed.

   Discussed that the watershed and hydraulic basins are two independent datasets for fluvial and pluvial flooding. Reviewed the process for creating fluvial masks.

6. The hydraulic network and treatment of hydraulic structures in the flood model will be reviewed.

   Discussed the hydraulic network and the hydrological connectivity of river reaches.

   Discussed the modeling of hydraulic structures, such as levees in the National Levee Database (NLD).

7. The hydrologic and hydraulic mathematical models used will be reviewed.

   Discussed the equations and numerical models for the hydrological and routing models, the hydraulic model, and the storm surge model.

   Discussed use of a variety of FUSE configurations to select variable infiltration capacity (VIC) based model.

8. Any modeling-organization-specific research performed to develop hydrologic and hydraulic equations used in the flood model, and the variables and constants used in these equations, will be reviewed.

   Discussed that no unpublished research was applied to develop hydrologic and hydraulic equations.

9. The input files for the hydrologic and hydraulic components of the inland flood model will be reviewed.

   Reviewed an example input file for the FUSE hydrological model.

   Reviewed examples of fluvial and pluvial boundary conditions.

   Reviewed an example sub-grid channel.

   Reviewed a DEM example and a spatially varying Manning's example.

10. The relationships between time steps used in the hydrologic and hydraulic components of the flood model will be reviewed, if applicable.

    See comments under PVL #31 for the hydraulic model.

Discussed that the FUSE and mizuRoute are run at a daily time resolution.

11. The basis or dependence of flood parameters on NFIP FIRM or other FIS data will be reviewed, if relevant.

    Discussed that there is no dependence between the HHF model parameters and any NFIP FIRM or FIS data.

Discussed new text added in the submission to HHF-1, Disclosures 3 and 4 addressing non-tropical rainfall events.

Reviewed the Geographic Information System (GIS) data for the 10, 50, 100, and 500-year return period mapping in Washington County.

HHF-2 Flood Characteristics (Outputs)*
*(*Significant Revision)*

A. Flood extent and elevation or depth generated by the flood model shall be consistent with observed historical floods affecting Florida.

B. Methods for deriving flood extent and depth shall be scientifically defensible and technically sound.

C. Modeled flood characteristics shall be sufficient for the calculation of flood damage.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

43. HHF-2.1, page 128 (May 10 revised submission page 132): Provide comparisons of the modeled and historical flood extents and elevations or depths for the storm events listed in Form HHF-1.

    Reviewed comparisons of modeled and historical storm surge footprints and the location of the maximum storm surge depth for Hurricane Andrew (1992), Hurricane Ivan (2004), Hurricane Frances (2004), Hurricane Wilma (2005), Hurricane Matthew (2016), Hurricane Hermine (2016), Hurricane Irma (2017), Hurricane Michael (2018), Hurricane Eta (2020), and Hurricane Ian (2022).

    Discussed the storm surge in the St. Johns River from Hurricane Matthew (2016) and Hurricane Ian (2022).

    Reviewed comparisons of modeled and historical inland flood footprints and the location of the maximum flood depth for Hurricane Matthew (2016), Hurricane Hermine (2016), Hurricane Michael (2018), Hurricane Eta (2020), and Hurricane Ian (2022).

    Reviewed validation scatter plots for the storms listed above. Discussed the shift in the revised scatter plots due to the change in DEM datum.

113. HHF-2.1, page 132: Discuss data sources reviewed for available observations of extent and intensity for the May 2009 event.

    Discussed the data sources reviewed for Unnamed Storm in East Florida (2009).

44. HHF-2.2, page 129 (May 10 revised submission page 133): Hurricanes Hermine (2016) and Eta (2020) have paths that do not impact the areas affected by the rainfall-driven flooding from Unnamed Storm in Panhandle (2013) and Unnamed Storm in East Florida (2009). Discuss how the geographic variation for modeling inland flooding represented by the removed storms is maintained by the substituted storms.

    Discussed that the text in the submission was incorrect. Hurricane Hermine (2016) was not used. Hurricane Eta (2020) was used to replace the Unnamed Storm in Panhandle (2013).

    Discussed that Hurricane Matthew (2016) was chosen to replace the Unnamed Storm in East Florida (2009) due to the similarity in observed rainfall intensity and extent.

    Discussed that the substituted storms replaced non-tropical storms with tropical storms.

    Determined that the Modeler needs to demonstrate cases for both tropical and non-tropical events in order to verify the standard.

    Reviewed table comparing the maximum 24-hour rainfall amounts and NOAA return periods at multiple sites between Hurricane Matthew (2016) and Unnamed Storm in East Florida (2009).

    Reviewed table comparing the mean and maximum daily precipitation for drainage sub-basins that were impacted by both the Unnamed Storm in Panhandle (2013) and Hurricane Eta (2020).

45. HHF-2.2, page 129 (May 10 revised submission page 133): Provide justification for validation using any historical events not specified in Form HHF-1.

    See comments under PVL #44.

46. HHF-2.3, pages 130-140 (May 10 revised submission pages 134-145): Provide justification for the suitability of substituted storms.

    See comments under PVL #44.

47. HHF-2.3, page 130 (May 10 revised submission page 134): Discuss how realistic mean annual flow (MAF) data in arid regions is relevant to MAF data in Florida.

    Discussed the process for selecting USGS river gauges used to evaluate simulations for the historical events in HHF-2.3.

48. ~~HHF-2.4, page 141: Identify all hydrological and hydraulic variables that affect the flood extent and characteristics, and provide units for the variables.~~

    No longer applicable after receiving the revised May 10, 2024, submission.

49. HHF-2.5, page 141 (May 10 revised submission page 146): Reconcile the description of the inland flood model with VF-1.8, specifically, the inclusion of flood-borne debris and velocity in loss calculations.

    Discussed that explicit modeling of flood-borne debris was not considered for most types of buildings. The effects of flood-borne debris were implicitly accounted for in the vulnerability functions. The assessment of flood-borne debris effects was specifically taken into account for buildings equipped with breakaway walls.

    Discussed that the link between inundation depth and flood velocity as given in FEMA (2011) is applied in the vulnerability component.

    Reviewed the lower and upper bounds in FEMA (2011) as the basis for modeled coastal and inland flood velocities.

    Reviewed the beta distribution for flow velocity for a given flood depth.

50. HHF-2.7, page 142 (May 10 revised submission page 147): Under the second bullet, the submission states, "The same limitations as above apply for FIS maps." Discuss what is meant by this statement, since the FIRM are the maps, and the FIS is the report. Discuss how the FIS was used to check the flood protection measures.

    Reviewed a revised statement in the submission correcting "FIS maps" to "FIS reports."

56. Form HHF-1, pages 288-313 (May 10 revised submission pages 299-347): Provide Figure 97 adjusted to show all of the state and to move the inset to not block other areas of the state. Provide Figures 97-107 with the storm tracks plotted. Provide Figures 108-123 with the vertical datum.

    Reviewed Figures 97-107 with storm tracks plotted, and Figures 108-123 with vertical datum.

57. Form HHF-1, page 290 (May 10 revised submission page 304), Figure 94: Explain the storm surge in portions of Walton County protected by a barrier island, yet no storm surge on the barrier island itself.

    Reviewed the storm surge elevation map for Hurricane Ivan (2004) showing storm surge on the barrier islands in Escambia and Walton Counties.

58. Form HHF-1, page 299 (May 10 revised submission page 323), Figure 103: Discuss the modeled maximum storm surge for Hurricane Michael (2018) occurring in the Santa Rosa Island area rather than the Mexico Beach area.

    Open item from the June on-site review. See comments below under September Additional Verification Review Comments.

59. Form HHF-1, page 303 (May 10 revised submission page 333), Figure 107 (May 10 revised submission Figure 108): Justify the maximum value of 60.20 feet for Hurricane Ian (2022), as well as the other storm cases with high values in Figures 93-106 (pages 289-302, May 10 revised submission pages 302-329).

    Reviewed satellite imagery of the 60-ft maximum inland flood depth location for Hurricane Ian (2022). Reviewed the ground elevation and inundation depth horizontal profiles. Reviewed histograms of depth values for Hurricane Ian (2022).

    Reviewed satellite imagery of the 30-ft maximum inland flood depth location for Hurricane Michael (2018). Reviewed the ground elevation and inundation depth horizontal profiles. Reviewed histograms of depth values for Hurricane Matthew (2018).

    Reviewed satellite imagery of the maximum storm surge flood depth locations for Hurricane Ian (2022), Hurricane Sally (2020), Hurricane Matthew (2016), and Hurricane Hermine (2016). Reviewed the corresponding inundation depth horizontal profiles. Reviewed histograms of flood depth values for the storms.

60. Form HHF-1, page 308 (May 10 revised submission page 340), Figure 116 (May 10 revised submission Figure 117): Discuss removing one of the listed inland flooding storms due to a lack of observed data, and replacing it with Hurricane Hermine (2016) with only 2 inland flooding validation points, and Hurricane Eta (2020) with 0 inland flooding validation points.

    Discussed that data is available for Hurricane Ian (2022) and that the text in the submission will be revised.

    Reviewed inland flood footprints with maximum inundation depth and scatter plots of observed versus modeled water surface elevation for Hurricane Hermine (2016) and Hurricane Eta (2020).

61. Form HHF-1, page 309 (May 10 revised submission page 342), Figure 118 (May 10 revised submission Figure 119): Explain the apparent model bias for Hurricane Irma (2017).

    Discussed the results shown in the scatter plot of observed-versus-modeled water surface elevation for Hurricane Irma (2017). Reviewed comparison of the modeled gross loss to trended observed NFIP loss.

114. Form HHF-1, page 338, Figure 115; page 340, Figure 117; page 344, Figure 121: Discuss why the inland flood observed water surface elevations and the root mean square error (RMSE) changed, when the modeling and datum for inland flood did not change.

    Discussed that the observed water surface elevations changed due to the shift in datum from NAVD88 to EGM08 used for elevations.

115. Form HHF-1, page 342, Figure 119: Discuss why four observation points were removed.

Discussed that the four points removed in the revised submission scatter plot were mistakenly filtered out. Reviewed a corrected scatter plot with all 60 points of the EGM08 datum which will be included in the revised submission.

62. Form HHF-1.E, page 312 (May 10 revised submission page 347): Explain the root-mean-square-error (RMSE) always less than 1 meter whereas several RMSE values exceed 1 meter for Figures 108-123 (pages 304-312).

Discussed that the root-mean-square-error in the scatter plots is less than 1 meter for all events except inland flood scatter plots for Hurricane Frances (2004) and Hurricane Hermine (2016) which is due to insufficient inland flood observation data.

63. Form HHF-1.F, page 312 (May 10 revised submission page 347): Discuss how observations used in evaluating modeled scenarios are selected and quality controlled.

Discussed the inland flood observation data used and the process for evaluating inland flood events.

Discussed the storm surge observation data used and the process for evaluating coastal flood events.

64. Figures 12-19 (pages 90-97, May 10 revised submission pages 93-100), Figures 93-107 (pages 289-303, May 10 revised submission pages 302-331 and Figures 93-108), and Figures 129-132 (pages 322-324, May 10 revised submission pages 363-365, Figures 130-133): The Inundation Depth range upper limit of ">10ft" in the maps is much lower than the Maximum Modeled Depths. Provide Figures 12-19, 93-107 (May 10 revised submission Figures 93-108), and 129-132 (May 10 revised submission Figures 130-133) with additional inundation depth intervals above 10ft.

Reviewed revised figures with additional inundation depth intervals above 10ft.

65. Figure 14 (page 92, May 10 revised submission page 95), Figure 18 (page 96, May 10 revised submission page 99), Figure 95 (page 291, May 10 revised submission page 306), Figure 99 (page 295, May 10 revised submission page 315), and Figure 101 (page 297, (May 10 revised submission page 319): Explain the contradiction where the maximum is in Hillsborough Bay at Tampa, yet the storm surge footprint is located elsewhere in the state.

Reviewed storm surge footprints and the maximum storm surge location for Hurricane Charley (2004), Hurricane Sally (2020), Hurricane Frances (2004), and Hurricane Hermine (2016).

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. The method and supporting material for determining flood extent and elevation or depth for inland flooding will be reviewed.

   Reviewed the methodology for determining flood extents and elevations/depths for inland flooding.

2. Any modeling-organization-specific research performed to calculate the inland flood extent and elevation or depth will be reviewed along with the associated databases.

   Discussed that no unpublished research was applied to calculate the inland flood extent and elevation or depth.

   See comments under PVL #29, PVL #30, and HHF-1 Audit 5 for event footprint construction.

3. Any modeling-organization-specific research performed to derive the hydrological characteristics associated with the topography, LULC distributions, soil conditions, watersheds, and hydrologic basins for the flood extent and elevation or depth will be reviewed.

   Discussed that no unpublished research was applied to derive hydrological characteristics.

4. Historical data used as the basis for the flood model flood extent and elevation or depth will be reviewed. Historical data used as the basis for the flood model flood flow and velocity, if applicable, will be reviewed.

   See comments under GF-1, PVL #1.

5. The comparison of the calculated characteristics with historical inland flood events will be reviewed. The selected locations and corresponding storm events will be reviewed to verify sufficient representation of the varied geographic areas.

   Reviewed comparisons of observed and modeled flood depth for Hurricane Ian (2022) with ICEYE satellite data.

6. Consistency of the flood model stochastic flood extent and elevation or depth with reference to the historical flood databases will be reviewed. Consistency of the flood model stochastic flood flow and velocity, if applicable, with reference to the historical flood databases will be reviewed.

   See comments under HHF-1, PVLs #29 and #30.

7. Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps, will be reviewed.

   Reviewed updated maps and scatter plots provided in revised Form HHF-1.

8. For the historical flood events given in Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps, the flood characteristics, including temporal and spatial variations contributing to modeled flood damage, will be reviewed.

   Reviewed the spatial variations in Form HHF-1 maps.

9. Form HHF-4, Inland Flood Characteristics by Annual Exceedance Probability, and Form HHF-5, Inland Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item), will be reviewed.

   Reviewed Forms HHF-4 and HHF-5.

   Discussed the study areas and the criteria for their selection for each of the five Florida regions used in Forms HHF-4 and HHF-5.

10. Modeled frequencies will be compared with the observed spatial distribution of flood frequencies across Florida using methods documented in current scientific and technical literature. The comparison of modeled to historical statewide and regional inland flood frequencies as provided in Form HHF-4, Inland Flood Characteristics by Annual Exceedance Probability, and Form HHF-5, Inland Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item), will be reviewed.

    Reviewed the different annual exceedance probabilities in Form HHF-4 and Form HHF-5 inland flood maps.

11. Comparison of 0.01 and 0.002 annual exceedance probability flood extents produced by the flood model, including both inland and coastal flood, with the flood extents from FEMA will be reviewed.

    Reviewed comparison of the 0.01 and 0.002 annual exceedance probability flood extents for coastal flooding in Form HHF-3, and for inland flooding in Form HHF-5.

12. The basis or dependence of flood characteristics on NFIP FIRM or other FIS data will be reviewed, if relevant.

    Discussed that modeled flood characteristics do not depend on NFIP FIRM or other FIS data.

13. Temporal evolution of inland flood characteristics will be reviewed, if applicable. (Trade Secret Item to be provided during the closed meeting portion of the Commission meeting to review the flood model for acceptability.)

    Discussed that the inland flood model hazard component does not contain a temporal component.

14. Calculation of relevant characteristics in the inland flood model, such as flood extent and elevation or depth, will be reviewed. The methods by which each flood model component utilizes the characteristics of other flood model components will be reviewed.

    Reviewed the calculations of relevant characteristics in the inland flood model, including flood extent and elevation. See disclosures HHF-1.13 and HHF-1.14.

15. The selected time steps representing peak flood extents and elevations or depths referenced in Flood Standard HHF-1, Flood Parameters (Inputs), Disclosure 14, will be reviewed, if applicable. Any assumptions used to account for peak flood extents and elevations or depths for flood events with shorter durations than the selected time steps will be reviewed.

    Discussed that the inland flood model hazard component does not contain a time series of intensities.

Additional September Additional Verification Review Comments:

Reviewed maps of the historical storm events in Form HHF-1 with the gauge locations added in revised Figures 30-38.

Reviewed comparisons of modeled versus observed accumulated rainfall for Hurricane Ian (2022), Hurricane Irma (2017), and Hurricane Frances (2004).

Reviewed comparisons of modeled versus observed for the non-tropical cyclone events Panhandle Storm (2013) and East Florida Storm (2009) with fluvial selected as the key driver for event selection and location/subbasin selection. Reviewed pluvial results for the same event. Reviewed results for the peak pluvial event for the same location.

Reviewed satellite imagery and the digital terrain model (DTM) for the maximum flood depth locations for Hurricane Andrew (1992) and Hurricane Hermine (2016).

Reviewed satellite imagery and the DTM for the maximum inland flood depths from Hurricane Michael (2018) and Hurricane Ian (2022).

Reviewed satellite imagery and the DTM for the maximum flood depth location and observed value in the Florida Keys for Hurricane Wilma (2005).

Discussed possible source(s) of the storm surge in the St. Johns River from Hurricane Matthew (2016) and from Hurricane Ian (2022). Reviewed temporal evolution footprint maps for both storms.

Reviewed the value changes for the observed data in the revised Form HHF-1 inland validation scatter plot for Hurricane Michael (2018) due to the change in datum.

Reviewed the top 10 historical storms producing the highest amounts of inland flood loss. Reviewed the storm tracks, central pressure, Rmax, and translation speeds for the top 10 storms.

Discussed the ground elevation values where ground elevations are negative for storm surge, and where ground elevations are below normal water level for inland flood. Discussed how locations for a set of storms coincide with these negative elevations. Discussed exposures and their insured value associated with negative ground elevations.

Discussed process and safeguards in place to prevent model users from placing exposures into non-inland or wet points.

Reviewed comparisons of modeled to observed fluvial footprints for the non-tropical East Florida Storm (2009).

Discussed the storm substitutions of Hurricane Hermine (2016) and Hurricane Eta (2020) for non-tropical East Florida Storm (2009) in Form HHF-1.

Discussed that the East Florida Storm (2009) was a record-setting event.

Reviewed interactive GIS map of coastal and inland flooding return periods at high resolution for a selection of locations.

HHF-3 Modeling of Major Flood Control Measures

A. The flood model's treatment of major flood control measures and their performance shall be consistent with available information and current state-of-the-science.

B. The modeling organization shall have a documented procedure for reviewing and updating information about major flood control measures and if justified, shall update the flood model flood control databases.

C. Treatment of the potential failure of major flood control measures shall be based upon current scientific and technical literature, empirical studies, or engineering analyses.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

51. HHF-3.A, page 145 (May 10 revised submission page 150): Discuss sources of additional information on flood control measures beyond the United States Army Corps of Engineers (USACE) National Levee Database and how these are implemented in the hydrodynamic model.

    Reviewed several external sources of flood protection data. Discussed the lack of information and tasks performed to evaluate suitable information.

52. HHF-3.C, page 145 (May 10 revised submission page 150): Discuss the impact of the model not accounting for failure of major flood control measures.

    Discussed that the model does not account for the dynamic effect of broken or failed flood control measures. Once the standard of protection is exceeded, the model generates flood loss on the protected zone.

53. ~~HHF-3.5, pages 148-150 (May 10 revised submission pages 153-155): Provide an example of the flood extent and elevation due to the potential impact of a major flood control measure failure.~~

    No longer applicable after receiving the revised May 10, 2024 submission.

54. HHF-3.5, page 149 (May 10 revised submission page 154), Figure 41: Demonstrate how the flooding impacts outside the protected area are impacted by the intact levee, and how the modeling connectivity of the flooding from the northeast to the southwest occurs with the intact levee.

    Discussed the satellite image of the Arbuckle Creek Levee provided in Figure 41 and the limitations for modeling. IF explained the attributes of the levee system and landscape with maps of the levee and nearby areas.

55. HHF-3.5, page 150 (May 10 revised submission page 155), Figure 43: Discuss how the model determines that L-31 East Levee provides storm surge protection to areas outside of the levee, including decreasing the storm surge depths northeast of the levee.

    Discussed the differences in the events shown in the middle and right images in Figure 43. The middle image depicts an event where the storm surge water surface elevation does not overtop the levee. The right image depicts an event where the storm surge water elevation does overtop the levee.

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. Treatment of major flood control measures incorporated in the flood model will be reviewed.

   Discussed that the USACE National Levee Database (NLD) is the primary source for major flood protection measures in the flood model.

   Discussed the process to identify flood control measures not included in the NLD and for integrating the datasets.

   Reviewed maps of two levee systems in Florida affected by coastal flooding.

2. The documented procedure addressing the updating of major flood control measures as necessary will be reviewed.

   Discussed major flood control measures are anticipated to be updated in the next version of the flood model.

3. The methodology and justification used to account for the potential failure or alteration of major flood control measures in the flood model will be reviewed.

   Discussed that the model does not account for flood defense failure (erosion or displacement) but does account for overtopping.

4. Examples of flood extent and depth showing the potential impact of major flood control measure failures will be reviewed.

   Reviewed an example of the storm surge depth footprint when the levee system was overtopped during Hurricane Andrew (1992).

   Reviewed satellite image comparisons of a levee system with defended and undefended 40-year flood maps.

   Reviewed examples of flood defenses application on fluvial flooding in Marion and Indian River Counties.

5. If the flood model incorporates major flood control measures that require human intervention, the methodology used in the flood model will be reviewed.

   Discussed that the model does not incorporate major flood control measures that require human intervention.

HHF-4 Logical Relationships Among Flood Parameters and Characteristics*
*(*Significant Revision)*

A. At a specific location, water surface elevation shall increase with increasing terrain roughness at that location, all other factors held constant.

B. Rate of discharge shall increase with increase in steepness in the topography, all other factors held constant.

C. Rate of discharge shall increase with increase in imperviousness of LULC, all other factors held constant.

D. Inland flood extent and depth associated with riverine and lacustrine flooding shall increase with increasing discharge, all other factors held constant.

E. The coincidence of storm tide and inland flooding shall not decrease the flood extent and depth, all other factors held constant.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. The analysis performed to demonstrate the logical relationships will be reviewed.

   Reviewed the analysis results demonstrating logical relationships. Reviewed the areas selected for the analysis. Reviewed 1 in 100-year fluvial hazard maps for the selected locations.

2. Methods (including any software) used in verifying the logical relationships will be reviewed.

   Reviewed graphs demonstrating the logical relationships of the effects of 1) increased roughness on water surface elevation, 2) increased steepness in topography on rate of discharge, 3) increased imperviousness of LULC on the rate of discharge, 4) increased discharge on inland flood extent and depth in the Panhandle, North Florida, Southwest Florida, East Florida, and Southeast Florida.

STATISTICAL FLOOD STANDARDS – MARK JOHNSON, LEADER

SF-1 Modeled Results and Goodness-of-Fit*

*(*Significant Revision)*

A. The use of historical data in developing the flood model shall be supported by rigorous methods published in current scientific and technical literature.

B. Modeled results and historical observations shall reflect statistical agreement using current scientific and statistical methods for the academic disciplines appropriate for the various flood model components or characteristics.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

66. SF-1.5, page 174 (May 10 revised submission page 179): Explain the bias in Figure 55.

Discussed that the cause of the bias in the return period magnitudes remains undetermined. Discussed the analysis performed to examine the bias and the rationale for the Modeler being comfortable with the results.

67. SF-1.5, page 177 (May 10 revised submission page 182): Explain the Chi metric attributed to Coles.

Discussed that the Chi statistic represents the probability of one variable being extreme given that another variable is extreme.

68. SF-1.5, page 185 (May 10 revised submission page 190), Figure 70: Justify the reasonableness of 0-1 feet given 0.01 *p*-value. Justify the reasonableness of 6-10 feet given 0.00 *p*-value.

Discussed that statistical tests and mean comparisons are used to determine the reasonableness of the modeled and claims losses. Discussed the tests at the lowest flood depth bin and for higher flood depth bins.

116. SF-1.5, page 190: Explain the large changes in Figure 70 due to the DEM change. For example, *p*-value for 5-6 going from 0.46 to 0.00, *p*-value 4-5 going from 0.50 to 0.05, substantial increases in claims counts.

Discussed that in addition to the DEM change, the comparison in Figure 70 was changed to compare multi-story modeled to 2-story claims data rather than to 1-story claims data as there were more 2-story claims data available.

Discussed the 5-6ft flood depth change relative to the damage ratios.

117. SF-1.5, pages 190-191: Provide an Excel file with the underlying data for Figure 70 (page 190) and Figure 71 (page 191).

Reviewed the underlying data used to create the storm surge Figures 70 and 71.

69. SF-1.5, page 185 (May 10 revised submission page 192), Figure 72: Justify the inland flood building damage function with four of the six *p*-values being 0.

Discussed the use of *p*-values to justify reasonableness of modeled losses for coastal and inland flooding. Discussed the results at lower flood depth bins and at higher flood depth bins.

Audit

1. Forms SF-1, Distributions of Stochastic Flood Parameters (Coastal, Inland), and SF-2, Examples of Flood Loss Exceedance Estimates (Coastal and Inland Combined), will be reviewed. Justification for the distributions selected, including for example, citations to published literature or analyses of specific historical data, will be reviewed. Justification for the goodness-of-fit tests used will also be reviewed.

Reviewed each of the distributions given in Form SF-1 with respect to selection, estimation, goodness-of-fit, and basis in scientific literature.

Reviewed the number and landfall frequency of tropical storm events per year.

Discussed that the use of "uniform" when describing the generation of storm genesis parameters is not appropriate.

2. The modeling organization characterization of uncertainty for damage estimates, annual flood loss, flood probable maximum loss levels, and flood loss costs will be reviewed.

Discussed that the uncertainty in damage estimates is captured in the vulnerability functions.

3. Regression analyses performed will be reviewed, including for example parameter estimation, graphical summaries and numerical measures of the quality of fit, residual analysis and verification of regression assumptions, outlier treatment, and associated uncertainty assessment.

   Reviewed the regression analyses for central pressure.

   Reviewed the equation to model storm relative intensity.

   Reviewed the equation to calculate relative intensity.

   Reviewed scatter plots of modeled and observed central pressures assessing the degree of agreement.

   Reviewed histograms of the residuals obtained from regression analysis.

September Additional Verification Review Comments:

Reviewed comparison of the 5-6ft flood depth damage ratio to other flood depths damage ratios. Discussed the impact of the datum change, the inclusion of 1 and 2-story claims, and the inclusion of Hurricane Ian (2022) data in the claims dataset.

Discussed the process and the use of random sampling for storm genesis location.

Reviewed comparisons of historical to modeled inland decay rates for landfalling storms on the Florida Gulf Coast and Florida Peninsula Coast. Reviewed the historical storms included in the comparisons.

Reviewed the coefficients underlying the standard and robust regression analyses used to compute central pressures for modeling storm relative intensity.

SF-2 Sensitivity Analysis for Flood Model Output

The modeling organization shall have assessed the sensitivity of temporal and spatial outputs with respect to the simultaneous variation of input variables using current scientific and statistical methods in the appropriate disciplines and shall have taken appropriate action.

Verified: YES

Professional Team comments are provided in black font below.

Pre-Visit Letter

70. SF-2, pages 187-194 (May 10 revised submission pages 193-201) and SF-3, pages 195-197 (May 10 revised submission pages 202-204): Given that far field pressure (FFP) contributes greatly to sensitivity and uncertainty, justify treating it as a constant in the model.

    Discussed the rationale for using FFP as a constant.

Audit

1. The modeling organization's sensitivity analysis for the flood model will be reviewed in detail. Statistical techniques used to perform sensitivity analysis will be reviewed. The results of the sensitivity analysis displayed in graphical format (e.g., contour or high-resolution plots with temporal animation) will be reviewed.

   Reviewed the sensitivity analyses performed for storm surge loss costs based on the equivalent of Form S-6 used in the hurricane reviews which was adapted for the flood model. The analyses showed that the most sensitive aspects of the storm surge component are far field pressure, Rmax, and central pressure depending on the category of storm.

SF-3 Uncertainty Analysis for Flood Model Output

The modeling organization shall have performed an uncertainty analysis on the temporal and spatial outputs of the flood model using current scientific and statistical methods in the appropriate disciplines and shall have taken appropriate action. The analysis shall identify and quantify the extent that input variables impact the uncertainty in flood model output as the input variables are simultaneously varied.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The modeling organization uncertainty analysis for the flood model will be reviewed in detail. Statistical techniques used to perform uncertainty analysis will be reviewed. The results of the uncertainty analysis displayed in graphical format (e.g., contour or high-resolution plots with temporal animation) will be reviewed.

   Reviewed the uncertainty analyses performed for storm surge loss costs based on the equivalent of Form S-6 used in the hurricane reviews which was adapted for the flood model. For Category 1 storms, the far field pressure is the major contributor to the uncertainty in storm surge loss costs. For Categories 3 and 5, Rmax has the greatest impact.

SF-4 Flood Model Loss Cost Convergence by Geographic Zone

At a modeling-organization-determined level of aggregation utilizing a minimum of 30 geographic zones encompassing the entire state, the contribution to the error in flood loss cost estimates attributable to the sampling process shall be negligible for the modeled coastal and inland flooding combined.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. An exhibit of the standard error by each geographic zone will be reviewed.

   Reviewed map of the relative standard error percentage by county for inland and coastal flooding.

   Discussed the values for Lee and DeSoto Counties.

September Additional Verification Review Comments:

Discussed the reasons for the standard error values given for Lee and DeSoto Counties.

Reviewed map of the standard error as a percentage of the loss cost by county.

SF-5 Replication of Known Flood Losses

The flood model shall estimate incurred flood losses in an unbiased manner on a sufficient body of past flood events, including the most current data available to the modeling organization. This standard applies to personal residential exposures. The replications shall be produced on an objective body of flood loss data by county or an appropriate level of geographic detail.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

71. SF-5.1, pages 201-202 (May 10 revised submission pages 208-209): Explain the differences across modeled losses and observed NFIP loss.

    Discussed that the differences between the modeled losses and the NFIP observed losses are attributed to numerous factors that lie in the model's ability to fully resolve the physical processes that underlie the meteorological, hydrological, hydraulic, and mechanical processes that occur during modeled events.

    Discussed that building stock, NFIP take up rates, and the built environment were analyzed to determine how each assumption contributes to the differences between modeled and observed NFIP losses.

118. SF-5.1, page 208: Explain why the relative changes in loss costs reported in Form AF-2 for Hurricane Andrew (1992, 19.2%) and Hurricane Wilma (2005, 12.2%) are not reflected in Table 28.

    Discussed the differences in losses for Hurricane Andrew (1992) and Hurricane Wilma (2005) as given in Form AF-2 and those given in Table 28. Reviewed a corrected Table 28 provided at the start of the on-site review that eliminated the differences.

Audit

1. The following information for each flood event in Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps, will be reviewed:
    a. The validity of the flood model assessed by comparing projected flood losses produced by the flood model to available flood losses incurred by insurers at both the state and county level,

b. The version of the flood model used to calculate modeled flood losses for each flood event provided,
c. A general description of the data and its sources,
d. A disclosure of any material mismatch of exposure and flood loss data problems, or other material consideration,
e. The date of the exposures used for modeling and the date of the flood event,
f. An explanation of differences in the actual and modeled flood parameters,
g. A listing of the differences between the modeled and observed flood conditions used in validating a particular flood event,
h. The type of coverage applied in each flood event to address:
    1. Personal residential structures
    2. Manufactured homes
    3. Condominiums
    4. Contents
    5. Time element,
i. The treatment of demand surge or loss adjustment expenses in the actual flood losses or the modeled flood losses, and
j. The treatment of wind losses in the actual flood losses or the modeled flood losses.

Discussed that there was no material mismatch of exposure and flood loss data.

Discussed that the flood model does not include wind losses.

Discussed that coverage terms for all construction and occupancy combinations are based on NFIP policy terms.

Discussed that loss adjustment expenses are not estimated by the flood model or included in the claims used from the NFIP loss database.

Discussed data and sampling uncertainties.

2. The following documentation will be reviewed:
    a. Publicly available documentation and data referenced in the flood model submission in hard copy or electronic form,
    b. Modeling-organization-specific documentation and data used in validation of flood losses,
    c. An analysis that identifies and explains anomalies observed in the validation data, and
    d. User input data for each insurer and flood event detailing specific assumptions made with regard to exposed personal residential property.

All publicly available documentation was available electronically and reviewed as necessary.

Reviewed NFIP claims analysis under the Vulnerability Flood Standards.

Discussed that user input data was not used, that only the IF industry exposure data was used.

3. The confidence intervals used to gauge the comparison between historical and modeled flood losses will be reviewed.

   Reviewed the 95% confidence interval for the difference between historical and modeled losses.

4. The results for more than one flood event will be reviewed to the extent data are available.

   Reviewed comparisons of modeled to actual results from ten different hurricanes.

September Additional Verification Review Comments:

Discussed the hazard and loss data sources used for validating the model.

VULNERABILITY FLOOD STANDARDS – CHRIS JONES, LEADER

VF-1 Derivation of Building Flood Vulnerability Functions*

*(*Significant Revision)*

A. Development of the building flood vulnerability functions shall be based on two or more of the following: (1) rational structural analysis, (2) post-event site investigations, (3) scientific and technical literature, (4) expert opinion, (5) laboratory or field testing, and (6) insurance claims data. Building flood vulnerability functions shall be supported by historical and other relevant data.

B. The derivation of building flood vulnerability functions and the treatment of associated uncertainties shall be theoretically sound and consistent with fundamental engineering principles.

C. Residential building stock classification shall be representative of Florida construction for personal residential buildings.

D. The following flood characteristics shall be used or accounted for in the derivation of building flood vulnerability functions: depth above ground, and in coastal areas, damaging wave action.

E. The following primary building characteristics shall be used or accounted for in the derivation of building flood vulnerability functions: lowest floor elevation relative to ground, foundation type, construction materials, number of stories, and year of construction.

F. Flood vulnerability functions shall be separately derived for personal residential buildings and manufactured homes.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

72. VF-1.E, page 204 (May 10 revised submission page 211): Provide a copy of the Ashley M. Gordon, 2019 reference. Explain how the reference is relevant to Florida construction.

Reviewed the Gordon (2019) reference. Discussed its relevance to Florida construction.

73. VF-1.2, page 205 (May 10 revised submission page 212): Discuss the validation and calibration process using NFIP claims data. Explain “pass calibration” and “pass validation” in Figure 83. Explain how the NFIP claims subsets used for calibration and validation are determined.

Discussed the validation and calibration process using NFIP claims data. Discussed that the IF methods use the claims data differently for validation and calibration.

Reviewed a calibration process example for a residential single family, 1 story building without basement.

Reviewed the rationale for the calibration passing criteria.

Reviewed box plot of water depth above FFH versus damage ratios with NFIP claims for inland flooding, coastal flooding, and a weighted average.

Discussed the goodness-of-fit tests used for validation. Reviewed table of statistical significance tests of storm surge building damage functions for different flood depths. Reviewed a box plot of storm surge depth versus damage ratios with NFIP claims.

119. VF-1.3, page 213: Provide details on the component-based methodology. Explain if and how the components are aggregated into major categories (e.g., foundation, walls). Using a representative building, show how the associated vulnerability function is developed using the component-based methodology.

Discussed the component-based methodology used in the structural failure module and the water-contact modules.

Reviewed the assignment of cost for components in the cost module.

Reviewed the component-wise damage distribution for coastal flooding.

74. VF-1.6, page 207 (May 10 revised submission page 214): Discuss the site investigations used to calibrate and validate the damage functions. Explain how it relates to the process shown in Figure 83 (page 205).

Discussed site investigations that were broadly used in calibrating and validating the vulnerability functions.

Reviewed examples of vulnerability function validation by visual comparison of building damage with predicted damage ratios from Hurricane Irma (2017).

75. VF-1.7, page 208 (May 10 revised submission page 215): Where there is coastal inundation, identify locations that experience waves.

    Reviewed maps illustrating different storm surge return periods where wave action is considered.

Revised Question #76 in PVL Addendum

76. VF-1.12, page 217 (May 10 revised submission page 224): In Table 34, for Tier Primary Modifier, define coastal A zone and how you identify it. Define Zone A and indicate how wave conditions are addressed in Zone A. Explain if and how waves are addressed in non-special flood hazard area (SFHA) areas subject to coastal flooding. Explain how dates are associated with flood zones.

    Reviewed the definition of FEMA flood zones. Discussed that vulnerability tiers are based on December 2022 National Flood Hazard Layer.

    Reviewed maps of the Florida flood zones.

    Reviewed map of Tier 3 storm surge flood extent for a 100-year return period.

    Discussed that coastal flooding inundation will be accompanied by waves in the vulnerability model.

77. VF-1.15, page 220 (May 10 revised submission page 227): Explain how dates are associated with each tier.

    Discussed that buildings are grouped into year-built bands that represent distinct points when meaningful building code changes occurred. The year-built bands are assigned consistently to each tier.

    Reviewed year-built bands representing important changes in Florida Building Code (FBC)-Building and FBC-Residential.

    Reviewed important changes in the Community Rating System (CRS) and its impact on FFH.

    Reviewed the default FFH assignment when FFH is unknown. Discussed that the model assigns a default site FFH based on type of foundation, flood zone, construction, and year built.

    Reviewed illustration of lowest floor elevation.

    Discussed that the Modeler uses FEMA flood zones to identify tiers.

82. Form VF-1, page 336 (May 10 revised submission page 377): Provide plots and tables comparing Mean Damage Ratio (MDR) versus Flood Depth for each of the 8 reference structures.

    Reviewed comparison of coastal flood depth versus damage ratio for the eight reference structures prescribed in Form VF-1, and the corresponding table of values.

83. Form VF-2, page 339 (May 10 revised submission page 380): Provide plots and tables comparing MDR versus Flood Depth for each of the 8 reference structures.

    Reviewed comparison of inland flood depth versus damage ratio for the eight reference structures prescribed in Form VF-2, and the corresponding table of values.

Audit

1. All building and manufactured home flood vulnerability functions will be reviewed. The magnitude of logical changes among these for given flood events and validation materials will be reviewed.

   Discussed details of vulnerability functions development.

   Reviewed a sample of non-manufactured home and manufactured home vulnerability functions for inland and coastal flooding.

   Discussed the methodology for estimating damage for both inland and coastal flooding.

   Reviewed comparisons of coastal and inland flood Mean Damage Ratios (MDR) for a reinforced masonry building, 2-story, slab on grade foundation with 1-ft FFH above grade, and for a single-family wood frame building, slab on grade foundation with 1-ft FFH above grade.

   Reviewed comparisons of coastal and inland flood MDR for a residential reinforced masonry multi-family building, slab on grade foundation with 1-ft FFH above grade.

   Reviewed comparisons of coastal and inland flood MDR year-built band relativities for a residential single-family reinforced masonry building, 2-story, slab on grade foundation with 1-ft FFH above grade.

   Reviewed comparisons of coastal and inland flood MDR FFH relativities for a residential single-family wood frame building, 2-story, with a pile foundation.

   Reviewed comparisons of coastal and inland flood MDR construction class relativities for a residential single-family building, 1-story, dry stack concrete foundation, 3-ft FFH above grade.

Reviewed comparisons of coastal and inland flood MDR year-built band relativities for a residential single-family mobile home tied down, dry stack concrete foundation, 3-ft FFH above grade.

Reviewed comparisons of coastal and inland flood MDR FFH relativities for a mobile home tied down, dry stack concrete foundation.

Discussed the Report of Activities distinction between water infiltration (rain) and water intrusion (flood).

Reviewed the code for estimation of building components damage due to coastal flood load. Reviewed calculation of forces and moments from breaking waves on walls.

Reviewed the equation for hydrodynamic load. Reviewed the flood velocity unit conversion from metric to imperial units.

Reviewed the code for breaking wave loads on elevated structures and the wave slam coefficient.

Reviewed calculation for breaking wave loads on vertical piles and vertical walls.

Reviewed the dynamic pressure coefficient.

Reviewed the code for frame structure connection failures.

Reviewed terminology for wave height and wave crest elevation.

2. Comparison of building flood vulnerability functions for Form VF-1, Coastal Flood with Damaging Wave Action, reference structures will be reviewed. Comparison of building flood vulnerability functions for Form VF-2, Inland Flood by Flood Depth, reference structures will be reviewed.

   See comments under PVLs #82 and #83. Additional insight into modeling for PVLs #82 and #83 was provided for manufactured homes.

3. If the flood model uses component-based vulnerability functions, comparisons of the overall building flood vulnerability functions and the individual component-based vulnerability functions will be reviewed for each of the reference structures in Form VF-1, Coastal Flood with Damaging Wave Action, and Form VF-2, Inland Flood by Flood Depth (16 comparisons total, eight for each form).

   Reviewed comparisons of coastal flooding inundation depth versus damage ratio and comparisons of inland flood inundation depth versus damage ratio for:
   1) wood frame, one story, crawlspace, 4-ft FFH,
   2) wood frame, two story, 1-ft FFH,

3) wood frame, two story, timber pile, 9-ft FFH,
4) masonry, one story, 1-ft FFH,
5) masonry, two story, 1-ft FFH,
6) masonry, two story, concrete pile, 9-ft FFH,
7) manufactured home, dry stack masonry pier,4-ft FFH, and
8) manufactured home, reinforced masonry pier, 7-ft FFH.

4. Modifications to the building vulnerability component of the flood model since the currently accepted flood model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications, and their impacts on the building vulnerability functions.

   Not applicable as this is the first submission of the IF flood model.

5. Comparisons of the building flood vulnerability functions with the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the IF flood model.

6. Building vulnerability functions that incorporate waves or wave proxies will be reviewed. Thresholds for damaging wave action will be reviewed. The area over which building flood vulnerability functions for damaging waves or wave proxies are applied will be reviewed.

   Discussed that waves and wave loads are considered wherever coastal flooding occurs.

   Reviewed comparison of coastal and inland flood vulnerability functions, the former incorporating wave action.

   Reviewed maps of the storm surge flood extent for different return periods where wave action was considered.

September Additional Verification Review Comments:

Audit items 7-21 were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

7. Validation of the building flood vulnerability functions and the treatment of associated uncertainties will be reviewed.

   Reviewed the t-tests conducted to validate the storm surge vulnerability functions.

   Reviewed box plot of storm surge depth versus MDR with NFIP claims for 1 and 2 story non-manufactured homes.

   Reviewed the t-tests conducted to validate the inland flooding vulnerability functions.

Reviewed box plot of inland flood depth versus MDR with NFIP claims for 1 and 2 story non-manufactured homes.

Discussed that the building flood vulnerability functions were developed using a component-based approach.

Reviewed the probability distributions for uncertainty in the damage ratios.

8. Historical data in the original form will be reviewed with explanations for any changes made and descriptions of how missing or incorrect data were handled. For historical data used to develop building flood vulnerability functions, the goodness-of-fit of the data will be reviewed. Complete reports detailing flooding conditions and damage suffered for any laboratory or field-testing data used will be reviewed. A variety of different personal residential building construction classes will be selected from the complete rational structural analyses and calculations to be reviewed. Laboratory or field tests and original post-event site investigation reports will be reviewed. Other scientific and technical literature and expert opinion summaries will be reviewed. Insurance claims data will be reviewed.

Discussed that the building vulnerability functions were calibrated and validated using NFIP redacted claims data. Reviewed the number of building policies and exposure value by construction type in the claims data. Discussed how missing or incorrect data were handled. Reviewed the damage function calibration and validation, and the NFIP Claims Data Analysis Methodology documentation.

Reviewed an example calibration box plot and an example validation box plot of storm surge depth versus MDR with NFIP claims.

Discussed the process for flood loading, calculation of flood resistance of load-bearing components, and calculation of flood damage of the load-bearing components.
Reviewed examples of post-event site investigation reports used in the development of the vulnerability functions.

Discussed how the wave assumption (that depth-limited waves exist throughout the storm surge footprint) could lead to conservative damage estimation.

Reference papers and technical literature were available electronically and reviewed as necessary.

9. All scientific and technical literature, reports, and studies used in the continual development of the building flood vulnerability functions must be available for review in hard copy or electronic form.

All references were available electronically and were reviewed as necessary.

10. Justification for the personal residential building construction classes and characteristics used will be reviewed.

    Reviewed the Industry Exposure Data (IED) statistics by construction class.

Additional September Additional Verification Review Comments:

Reviewed the IED evaluation process to validate the quality and accuracy of Florida exposures. Reviewed an example study conducted of claims associated with Hurricane Ian (2022).

11. Documentation and justification for the effects on the building flood vulnerability functions due to local and regional construction practices, and statewide and local building codes, floodplain management regulations, and their enforcement will be reviewed. If year of construction or geographical location of the building is used as a surrogate for building code, floodplain management regulation, and their enforcement, complete supporting information for the number of year of construction groups used as well as the year-bands and geographical regions of construction that separate particular groups will be reviewed.

    Discussed that vulnerability functions were developed by year-built and geographical tier as a surrogate for building code requirements, construction practices, and code enforcement.

    Reviewed the tier-based building categorization and the geographical tier map for Florida.

    Reviewed the code enforcement and construction practices by year-built band for non-manufactured homes and for manufactured homes.

12. Describe in detail the breakdown of new flood claims data into number of policies, number of insurers, dates of flood loss, amount of flood loss, and amount of dollar exposure; separated into personal residential and manufactured homes. Indicate whether or not the new flood claims datasets were incorporated into the flood model. Describe research performed and analyses on the new flood claims datasets and the impact on flood vulnerability functions.

    Discussed the acquisition date of the NFIP claims data used to calibrate the building vulnerability functions, the total exposure amount, and the total loss amount.

13. How the claim practices of insurance companies are accounted for when flood claims data for those insurance companies are used to develop or to verify building flood vulnerability functions will be reviewed. Examples include the level of damage the insurer considers a loss to be a total loss, claim practices of insurers with respect to concurrent causation, the impact of public adjusting, or the impact of the legal environment.

    Discussed that only NFIP claims data were used for calibration and validation of the vulnerability functions, and that claims practices are accounted for implicitly in the data.

14. The percentage of damage at or above which the flood model assumes a total building loss will be reviewed.

    Discussed that the model does not have a damage threshold at which the flood model assumes a total building loss.

15. The treatment of law and ordinance in building flood vulnerability functions will be reviewed.

    Discussed that law and ordinance is not explicitly considered in the flood model.

16. Documentation and justification for the method of derivation and data on which the building flood vulnerability functions are based will be reviewed.

    Reviewed the Flood Vulnerability Functions Development and Flood Vulnerability Simulator documentation.

17. If modeled, the treatment of water intrusion in building flood vulnerability functions will be reviewed.

    Reviewed the calculations for inside water level as a function of outside water level.

    Reviewed illustrations of the methodology for water intrusion without envelope breach and after envelope breach.

18. The basis or dependence of building flood vulnerability functions on NFIP FIRM or other FIS data will be reviewed.

    Discussed that some inputs of building vulnerability functions are based on information provided by NFIP FIRM data (e.g., vulnerability tier). The vulnerability functions are distinguished between pre-FIRM and post-FIRM effective years. The vulnerability tiers are based on FEMA zones. BFE and foundation type are used to estimate FFE where FFE is not given in the exposure data.

    Reviewed fluvial vulnerability functions for different tiers.

    Reviewed fluvial vulnerability functions for pre-FIRM and post-FIRM effective years.

    Discussed that there is no basis or dependence on other FIS data.

19. The process to account for FEMA's change in flood insurance premium rating to Risk Rating 2.0 will be reviewed, if applicable.

    Discussed that the flood model does not directly account for FEMA's Risk Rating 2.0 premium rating system.

20. Form VF-1, Coastal Flood with Damaging Wave Action, will be reviewed.

Reviewed Form VF-1. See comments under PVL #82.

21. Form VF-2, Inland Flood by Flood Depth, will be reviewed.

Reviewed Form VF-2. See comments under PVL #83.

Additional September Additional Verification Review Comments:

Reviewed revisions in the submission to correct the misuse of the term wave height.

Reviewed text added to the submission to state that, for pier or pile supported buildings, the greater of breaking wave loads or hydrodynamic loads are applied to the first row of piers/piles and hydrodynamic loads are applied to all other piers/piles.

Reviewed schematic representation of inland flood velocity force action on a building on piles and on a building on a slab/crawlspace foundation, under intact envelope and breached conditions.

VF-2 Derivation of Contents Flood Vulnerability Functions*

*(*Significant Revision)*

A. Development of the contents flood vulnerability functions shall be based on some combination of the following: (1) post-event site investigations, (2) scientific and technical literature, (3) expert opinion, (4) laboratory or field testing, and (5) insurance claims data. Contents flood vulnerability functions shall be supported by historical and other relevant data.

B. The relationship between building and contents flood vulnerability functions shall be reasonable.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

78. VF-2.B, page 221 (May 10 revised submission page 228): Provide a comparison of structure and contents vulnerability functions for a representative building.

    Reviewed comparison of structure and contents vulnerability functions for a residential single-family, unreinforced masonry construction, 1-story, unknown year built, slab on grade foundation, 1-ft FFH structure.

    Discussed when contents vulnerability functions reach the 100% damage ratio.

79. VF-2.10, page 224 (May 10 revised submission page 231): Provide a comparison of fresh and saltwater contents vulnerability functions for a representative building.

    Reviewed a comparison of coastal and inland contents vulnerability functions for a residential single-family, unreinforced masonry construction, 1-story, unknown year built, slab on grade foundation, 1-ft FFH structure.

    Discussed that contents failure is due to contact with the flood water inside the building.

    Discussed the difference between the inland and coastal contents vulnerability functions.

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. Modifications to the contents vulnerability component of the flood model since the currently accepted flood model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications and their impact on the contents vulnerability functions.

   Not applicable as this is the first submission of the IF flood model.

2. Comparisons of the contents flood vulnerability functions with the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the IF flood model.

3. All contents flood vulnerability functions will be reviewed.

   Reviewed examples of coastal and inland flood contents vulnerability functions.

4. Contents flood vulnerability functions that incorporate waves or wave proxies will be reviewed. Thresholds for damaging wave action will be reviewed. The area over which contents flood vulnerability functions for damaging waves or wave proxies are applied will be reviewed.

   Discussed that the contents flood vulnerability functions are tied to the building vulnerability functions, and therefore account for wave action.

   Reviewed a schematic representation of pressure forces on the building envelope in inland flooding and coastal flooding.

   Reviewed comparison of coastal and inland flood contents vulnerability functions incorporating wave action.

   Reviewed maps of the storm surge flood extent for different return periods where wave action was considered.

5. Validation of the contents flood vulnerability functions and the treatment of associated uncertainties will be reviewed.

   Reviewed the t-tests conducted to validate the coastal flooding contents vulnerability functions.

Reviewed box plot of contents versus building damage ratios with NFIP claims.

Reviewed the t-tests conducted to validate the inland flooding contents vulnerability functions.

6. Documentation and justification of the method of derivation and underlying data or assumptions related to contents flood vulnerability functions will be reviewed.

   Discussed that the contents vulnerability functions were developed using the IF damage simulator and also based on engineering analysis and judgement.

   Reviewed the Flood Vulnerability Functions Development and Flood Vulnerability Simulator documentation.

7. Historical data in the original form will be reviewed with explanations for any changes made and descriptions of how missing or incorrect data were handled. For historical data used to develop contents flood vulnerability functions, the goodness-of-fit of the data will be reviewed. Complete reports detailing flood conditions and damage suffered for any test data used will be reviewed. Original post-event site investigation reports will be reviewed. Other scientific and technical literature and expert opinion summaries will be reviewed. Insurance claims data will be reviewed.

   Discussed that the contents vulnerability functions were calibrated and validated using redacted NFIP claims data. Reviewed the number of building policies and exposure value by construction type in the claims data.

   Reviewed an example calibration box plot and an example validation box plot of storm surge depth versus MDR with NFIP claims.

   Reviewed examples of post-event site investigation reports used in the development of the contents vulnerability functions.

   Reference papers and technical literature were available electronically and reviewed as necessary.

8. Justification for changes from the currently accepted flood model in the relativities between flood vulnerability functions for building and the corresponding flood vulnerability functions for contents will be reviewed.

   Not applicable as this is the first submission of the IF flood model.

9. Documentation and justification of the method of derivation and underlying data or assumptions related to contents flood vulnerability functions will be reviewed.

   See Audit 6.

10. The basis or dependence of contents flood vulnerability functions on NFIP FIRM or other FIS data will be reviewed.

    Discussed that the contents vulnerability functions are tied to the building vulnerability functions due to conditions such as envelope breach and building structure failure.

    Discussed that the contents flood vulnerability functions distinguish between pre-FIRM and post-FIRM effective years.

    Discussed that the contents flood vulnerability functions have no basis or dependence on other FIS data.

11. All scientific and technical literature, reports, and studies used in the continual development of the contents flood vulnerability functions must be available for review in hard copy or electronic form.

    All references were available electronically and were reviewed as necessary.

Reviewed the code for contents damage in the water infiltration model.

VF-3 Derivation of Time Element Flood Vulnerability Functions*

*(*Significant Revision)*

A. Development of the time element flood vulnerability functions shall be based on one or more of the following: (1) post-event site investigations, (2) scientific and technical literature, (3) expert opinion, (4) laboratory or field testing, and (5) insurance claims data.

B. The relationship among building, contents, and time element flood vulnerability functions shall be reasonable.

C. Time element flood vulnerability functions derivations shall consider the estimated time required to repair or replace the property.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

80. VF-3.B, page 226 (May 10 revised submission page 233): Explain and demonstrate the consistent pattern among the building, contents, and time element flood vulnerability functions.

    Reviewed comparison of building, contents, and time element vulnerability functions for a residential single-family, unreinforced masonry construction, 1-story, unknown year built, slab on grade foundation, 1-ft FFH structure.

81. VF-3.3, page 227 (May 10 revised submission page 234): Describe how emergency response time (ERT) and required restoration time (RRT) vary with storm characteristics and other factors.

    Discussed that the time element flood vulnerability functions depend on emergency response time, which is linked to the stillwater level, and required restoration time, which is linked to the building components damage.

    Reviewed the emergency response time function based on flood depth.

    Reviewed the time element coastal and inland flood vulnerability functions for a residential single family wood frame construction, 1-story, unknown year built, crawlspace foundation, and 3-ft FFH structure.

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. Modifications to the time element vulnerability component of the flood model since the currently accepted flood model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications and their impact on the time element vulnerability functions.

   Not applicable as this is the first submission of the IF flood model.

2. Comparisons of the time element flood vulnerability functions with the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the IF flood model.

3. All time element flood vulnerability functions will be reviewed.

   Reviewed examples of coastal and inland flood time element vulnerability functions.

4. Time element flood vulnerability functions that incorporate waves or wave proxies will be reviewed. Thresholds for damaging wave action will be reviewed. The area over which time element flood vulnerability functions for waves or wave proxies are applied will be reviewed.

   Discussed that the time element flood vulnerability functions are tied to the building vulnerability functions, and therefore incorporate wave action.

   Reviewed schematic representations of flood forces on the building envelope in both inland and coastal flooding.

   Reviewed comparison of coastal and inland flood time element vulnerability functions.

5. Validation of the time element flood vulnerability functions and the treatment of associated uncertainties will be reviewed.

   Discussed that the time element vulnerability functions were validated using comparisons to functions used by FEMA’s Hazus (Hazards United States).

   Discussed that damage uncertainty derived for building damage functions is transferred to the time element functions as part of the required restoration time.

Reviewed comparisons of time element vulnerability functions with FEMA time element functions.

6. Documentation and justification of the method of derivation and underlying data or assumptions related to time element flood vulnerability functions will be reviewed.

   Reviewed the Time Element Flood Vulnerability Functions Development documentation.

7. Historical data in the original form will be reviewed with explanations for any changes made and descriptions of how missing or incorrect data were handled. To the extent historical data are used to develop time element flood vulnerability functions, the goodness-of-fit of the data will be reviewed. Complete reports detailing flooding conditions and damage suffered for any test data used will be reviewed. Original post-event site investigation reports will be reviewed. Other scientific and technical literature and expert opinion summaries will be reviewed. Insurance claims data will be reviewed.

   Discussed that no historical insurance claims data was used in the development of the time element vulnerability functions.

8. If included, the methodology and validation for determining the extent of infrastructure flood damage and governmental mandate and their effect on time element flood vulnerability will be reviewed.

   Discussed that infrastructure flood damage and governmental mandates are not explicitly modeled.

   Discussed that the time element vulnerability functions consider required restoration time and emergency response time.

9. Justification for changes from the currently accepted flood model in relativities between flood vulnerability functions for building and the corresponding flood vulnerability functions for time element will be reviewed.

   Not applicable as this is the first submission of the IF flood model.

10. Documentation and justification of the method of derivation and underlying data or assumptions related to time element flood vulnerability functions will be reviewed.

    See Audit 6.

VF-4 Flood Mitigation Measures*
*(*Significant Revision)*

A. Modeling of flood mitigation measures to improve flood resistance of buildings, and the corresponding effects on flood vulnerability and associated uncertainties shall be theoretically sound and consistent with fundamental engineering principles. These measures shall include design, construction, and retrofit techniques that affect the flood resistance or flood protection of personal residential buildings.

B. The modeling organization shall justify all flood mitigation measures considered by the flood model.

C. Application of flood mitigation measures that affect the performance of personal residential buildings and the damage to contents shall be justified as to the impact on reducing flood damage whether done individually or in combination.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

84. Form VF-3, page 344 (May 10 revised submission page 385): Explain the results contained in the form.

    Discussed the results given in Form VF-3.

    Discussed that structure elevation is the most effective mitigation measure.

    Discussed the differences in wet and dry floodproofing.

    Discussed the effect of flood openings on crawlspace foundations.

    Reviewed comparisons of flood depth versus damage ratios for coastal and inland flood for elevation of the reference structure for mitigation measures 1-ft, 2-ft, and 3-ft high.

    Discussed the multiplicative approach for combining secondary modifiers.

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. Flood mitigation measures used by the flood model, whether or not referenced in Form VF-3, Flood Mitigation Measures, will be reviewed for theoretical soundness and reasonability.

   Reviewed the secondary characteristics and mitigation measures included in the flood model.

2. Modifications to flood mitigation measures in the flood model since the currently accepted flood model will be reviewed in detail, including the rationale for the modifications, the scope of the modifications, the process, the resulting modifications, and their impacts on the flood vulnerability component.

   Not applicable as this is the first submission of the IF flood model.

3. Comparisons of flood mitigation measures in the flood model with the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the IF flood model.

4. Procedures, including software, used to calculate the impact of flood mitigation measures will be reviewed.

   Reviewed the Secondary Modifiers Development Methodology documentation. Noted that this and other documentation requires versioning and dates.

   Discussed the multiplicative methodology used when multiple secondary characteristics and mitigation measures are provided by the user.

5. Form VF-3, Flood Mitigation Measures, Range of Changes in Flood Damage, and Form VF-4, Differences in Flood Mitigation Measures, will be reviewed.

   Reviewed Form VF-3. See comments under PVL #84.

6. Implementation of flood mitigation measures will be reviewed as well as the effect of individual flood mitigation measures on flood damage. Any variation in the change in flood damage over the range of flood depths above ground for individual flood mitigation measures will be reviewed. Historical data, scientific and technical literature, expert opinion, or insurance company claims data used to support the assumptions and implementation of flood mitigation measures will be reviewed. How flood mitigation measures affect the uncertainty of the vulnerability will be reviewed.

   Reviewed comparison of damage ratios versus flood depth for flood secondary characteristics and mitigation measures.

7. Implementation of multiple flood mitigation measures will be reviewed. The combined effects of these flood mitigation measures on flood damage will be reviewed. Any variation in the change in flood damage over the range of flood depths above ground for multiple flood mitigation measures will be reviewed.

   Reviewed implementation of multiple flood secondary characteristics and mitigation measures, which vary with flood depth.

ACTUARIAL FLOOD STANDARDS – STU MATHEWSON, LEADER

AF-1 Flood Model Input Data and Output Reports*

*(*Significant Revision)*

A. Adjustments, edits, inclusions, or deletions to insurance company or other input data used by the modeling organization shall be based upon generally accepted actuarial, underwriting, and statistical procedures.

B. All modifications, adjustments, assumptions, inputs and input file identification, and defaults necessary to use the flood model shall be actuarially sound and shall be included with the flood model output report. Treatment of missing values for user inputs required to run the flood model shall be actuarially sound and described with the flood model output report.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

85. AF-1.4, page 236 (May 10 revised submission page 243): Provide an electronic copy of the ELEMENTS Input Data Format document.

    Reviewed the ELEMENTS Input Data Format document.

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. Quality assurance procedures, including methods to assure accuracy of flood insurance or other input data, will be reviewed. Compliance with this standard will be readily demonstrated through documented rules and procedures.

   Reviewed the Actuarial Forms Exposure Generation Plan documentation that outlines the procedures and methods to assure accuracy of insurance and other input data for generating submission forms.

2. All flood model inputs and assumptions will be reviewed to determine that the flood model output report appropriately discloses all modifications, adjustments, assumptions, and defaults used to produce the flood loss costs and flood probable maximum loss levels.

   Discussed the general procedures for treatment of data during import as provided in AF-1.7.

   Reviewed sample output reports disclosing assumptions, post import summaries, and model settings.

3. Explanation of the differences in data input and flood model output for coastal and inland flood modeling will be reviewed.

   Discussed that there is no difference in data input or flood model output for coastal and inland flood modeling.

4. The human-computer interface relevant to input data and output reports and corresponding nomenclature used in Florida rate filings will be reviewed.

   Reviewed the Florida rate filing interface screen where only compliant analysis options are permitted when "FCHLPM rate filing compliance" is selected.

   Reviewed an exported analysis output report for a Florida rate filing model run.

   Discussed that any analysis using the "FCHLPM rate filing compliance" setting contains a highlighted note in the exported analysis output report: "Special Note: Selected analysis settings are suitable for Florida rate filing."

Additional September Additional Verification Review Comments:

Reviewed the steps involved for a Florida rate filing. Reviewed the model output analysis report indicating the selections and input data for the model simulation are valid for Florida rate filings.

Reviewed model user documentation provided to clients.

AF-2 Flood Events Resulting in Modeled Flood Losses*
*(*Significant Revision)*

A. Modeled flood loss costs and flood probable maximum loss levels shall reflect insured flood related damages from both coastal and inland flood events impacting Florida.

B. The modeling organization shall have a documented procedure for distinguishing flood-related losses from other peril losses.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

86. AF-2.B, page 243 (May 10 revised submission page 250): Provide an electronic copy of the documented procedure for distinguishing flood losses from other peril losses.

    Reviewed the documented procedure for distinguishing flood losses from other peril losses.

    Started a review of a live demonstration of the model execution.

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. The flood model will be reviewed to evaluate whether the determination of flood losses in the flood model is consistent with this standard.

   Discussed that the calculation of flood loss costs and flood probable maximum loss (PML) levels for Florida reflect all insured flood-related damages from tropical and non-tropical precipitation flood events impacting Florida.

   Discussed that the flood model does not account for wind losses related to coastal and inland flooding.

   Reviewed the documented procedure to distinguish flood-related losses from other peril losses.

2. The flood model will be reviewed to determine that meteorological or hydrological and hydraulic events originating either inside or outside of Florida are modeled for flood losses occurring in Florida and that such effects are considered in a manner which is consistent with this standard.

   Discussed that all events in the flood model have sufficient overlap in the event set domains even though the two event sets are modeled separately.

3. The flood model will be reviewed to determine whether and how the flood model takes into account any damage resulting directly and solely from wind and water infiltration.

   Discussed that the flood model calculates losses from coastal and inland flooding separately.

   Reviewed the Flood Model Suite Selection Document demonstrating how flood loss is determined in portfolio import and analysis settings.

4. The flood model will be reviewed to determine how flood losses from water intrusion are identified and calculated.

   Discussed that the flood model only provides users the option to model flood losses and that water intrusion is not included in the model.

5. The documented procedure for distinguishing flood-only losses from other peril losses will be reviewed.

   See Audit 3.

   Discussed that the flood model only provides users the option to model flood-only losses.

6. The effect on flood loss costs and flood probable maximum loss levels arising from flood events that are neither inland nor coastal flooding will be reviewed.

   Discussed that the model does not account for events that are neither inland nor coastal flooding events.

AF-3 Flood Coverages*

*(*Significant Revision)*

A. The methods used in the calculation of personal residential structure flood loss costs, including the effect of law and ordinance coverage, shall be actuarially sound.

B. The methods used in the calculation of personal residential appurtenant structure flood loss costs shall be actuarially sound.

C. The methods used in the calculation of personal residential contents flood loss costs shall be actuarially sound.

D. The methods used in the calculation of personal residential time element flood loss costs shall be actuarially sound.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. The methods used to produce personal residential structure, appurtenant structure, contents, and time element flood loss costs will be reviewed.

   Discussed the process for calculating flood loss costs for building, contents, and time element coverages.

   Reviewed the IF Financial documentation.

2. The treatment of law and ordinance coverage will be reviewed, including the 25% and 50% coverage options for personal residential policies.

   Discussed that law and ordinance coverage is not explicitly considered in the model.

AF-4 Modeled Flood Loss Cost and Flood Probable Maximum Loss Level Considerations*

*(*Significant Revision)*

A. Flood loss cost projections and flood probable maximum loss levels shall not include expenses, risk load, investment income, premium reserves, taxes, assessments, or profit margin.

B. Flood loss cost projections and flood probable maximum loss levels shall not make a prospective provision for economic inflation.

C. Flood loss cost projections and flood probable maximum loss levels shall not include any explicit provision for wind losses.

D. Damage caused from inland and coastal flooding shall be included in the calculation of flood loss costs and flood probable maximum loss levels.

E. Flood loss cost projections and flood probable maximum loss levels shall be capable of being calculated from exposures at a geocode (latitude-longitude) level of resolution including the consideration of flood extent and depth.

F. Demand surge shall be included in the flood model's calculation of flood loss costs and flood probable maximum loss levels using relevant data and actuarially sound methods and assumptions.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

87. AF-4.1, page 248 (May 10 revised submission page 255): Provide, in Excel, tables of 1,000 years descending from the Top Event corresponding to Form AF-8. For each year, show the value of each event separately.

    Reviewed the tables of 1,000 years descending from the Top Event which showed agreement with Form AF-8.

88. AF-4.3, page 249 (May 10 revised submission page 256): Explain in detail the demand surge model. Provide a copy of the documented procedure, and its implementation in the code.

Reviewed the documented procedure for demand surge in the tropical cyclone and non-tropical cyclone models.

Reviewed the methodology for calculating and applying demand surge factors.

Discussed that the demand surge methodology in the tropical cyclone model is the same as for the current accepted hurricane model.

Reviewed the methodology for determining demand surge for the non-tropical cyclone model.

Discussed the level of loss when demand surge is observed for a non-tropical cyclone storm.

89. AF-4.5, page 250 (May 10 revised submission page 257): Explain how the trending factor from Collins and Lowe is applied to post-2001 losses.

Discussed the sources used for creating values for the housing index, fixed real tangible wealth growth index, and gross domestic product growth. Discussed that insurance utilization is assumed to have held steady post-1995, so the index value post-1995 is constant at 1.

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. How the flood model handles expenses, risk load, investment income, premium reserves, taxes, assessments, profit margin, economic inflation, and any criteria other than direct property flood insurance claim payments will be reviewed.

   Discussed that the flood losses and PML levels generated by the flood model do not include expenses, risk load, investment income, premium reserves, taxes, assessments, or profit margins.

2. The method of determining flood probable maximum loss levels will be reviewed.

   Reviewed the methodology for determining flood PML. Discussed that the basic methodology is the same as for the hurricane model.

3. The uncertainty in the estimated annual flood loss costs and flood probable maximum loss levels will be reviewed.

   Reviewed the methodology for calculation of uncertainty intervals.

4. The data and methods used to incorporate individual aspects of demand surge on personal residential coverages for coastal and inland flooding, inclusive of the effects from building material costs, labor costs, contents costs, and repair time will be reviewed.

   See comments under PVL #88.

5. How the flood model accounts for economic inflation associated with past insurance experience will be reviewed.

   Discussed the methodology used to develop and validate flood loss costs and flood PMLs using past insurance experience.

   See comments under PVL #89.

6. The treatment of wind losses in the determination of flood losses will be reviewed.

   Reviewed the documented procedure for distinguishing flood losses from other peril losses.

7. How the flood model determines flood loss costs associated with coastal flooding will be reviewed.

   Reviewed the methodology for calculating flood loss costs for residential structure coverage.

8. How the flood model determines flood probable maximum loss levels associated with coastal flooding will be reviewed.

   Reviewed the methodology for calculating PML at an occurrence level and at an aggregate level.

9. How the flood model determines flood loss costs associated with inland flooding will be reviewed.

   Discussed that the same methodology to calculate loss costs applies for both coastal and inland flooding.

10. How the flood model determines flood probable maximum loss levels associated with inland flooding will be reviewed.

    Discussed that the same methodology to calculate PML levels applies for both coastal and inland flooding.

11. The methods used to ensure there is no systematic over-estimation or under-estimation of flood loss costs and flood probable maximum loss levels from coastal and inland flooding will be reviewed.

    Discussed that the flood model event sets are developed and validated using historical datasets, and that the modeled loss outputs are validated using historical claims data.

12. All referenced scientific and technical literature will be reviewed, in hard copy or electronic form, to determine applicability.

    All references were available electronically and were reviewed as necessary.

Additional September Additional Verification Review Comments:

Reviewed the demand surge application to event losses that populate the event loss table.

Reviewed the methodology for determining demand surge for the non-tropical cyclone model and implementation in the code.

AF-5 Flood Policy Conditions*

*(*Significant Revision)*

A. The methods used in the development of mathematical distributions to reflect the effects of deductibles, policy limits, and flood policy exclusions shall be actuarially sound.

B. The relationship among the modeled deductible flood loss costs shall be reasonable.

C. Deductible flood loss costs shall be calculated in accordance with s. 627.715, F.S.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. The extent that historical data are used to develop mathematical depictions of deductibles, policy limits, policy exclusions, and loss settlement provisions for flood coverage will be reviewed.

   Discussed that historical claims data were not used to develop mathematical depictions of deductibles and policy limits. Discussed how policy deductibles and policy limits are developed, and how policy exclusions, loss settlement and other exclusions are handled.

2. The extent that historical data are used to validate the flood model results will be reviewed.

   Discussed the analysis performed of the input industry exposure database and the NFIP policy and claims datasets that are used for validation of event level losses.

3. Treatment of annual deductibles will be reviewed, if applicable.

   Discussed that the flood model does not account for annual deductibles.

4. Justification for the changes from the currently accepted flood model in the relativities among corresponding deductible amounts for the same coverage will be reviewed.

   Not applicable as this is the first submission of the IF flood model.

AF-6 Flood Loss Outputs and Logical Relationships to Risk*

(Significant Revision)

A. The methods, data, and assumptions used in the estimation of flood loss costs and flood probable maximum loss levels shall be actuarially sound.

B. Flood loss costs shall not exhibit an illogical relation to risk, nor shall flood loss costs exhibit a significant change when the underlying risk does not change significantly.

C. Flood loss costs cannot increase as the structure flood damage resistance increases, all other factors held constant.

D. Flood loss costs cannot increase as flood hazard mitigation measures incorporated in the structure increase, all other factors held constant.

E. Flood loss costs shall be consistent with the effects of major flood control measures, all other factors held constant.

F. Flood loss costs cannot increase as the flood resistant design provisions increase, all other factors held constant.

G. Flood loss costs cannot increase as building code enforcement increases, all other factors held constant.

H. Flood loss costs shall decrease as deductibles increase, all other factors held constant.

I. The relationship of flood loss costs for individual coverages (e.g., personal residential structure, appurtenant structure, contents, and time element) shall be consistent with the coverages provided.

J. Flood output ranges shall be logical for the type of risk being modeled and apparent deviations shall be justified.

K. All other factors held constant, flood output ranges produced by the flood model shall in general reflect lower flood loss costs for personal residential structures that have a higher elevation versus those that have a lower elevation.

L. For flood loss costs and flood probable maximum loss level estimates derived from and validated with historical insured flood losses or other input data and information, the assumptions in the derivations concerning (1) construction characteristics, (2) policy provisions, and (3) contractual provisions shall be appropriate based on the type of risk being modeled.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

Revised Question #90 in PVL Addendum

90. Form AF-1, pages 387-393: Explain the difference in Owners rates, by ZIP Code, between the low of less than 0.01 (33141) and the high of about 90.0 (34139).

Discussed that the loss cost value in ZIP Code 34139 is due to the high frequency of storm surge and inland events that impact the exposures within the ZIP Code.

Reviewed satellite imagery of the exposures in ZIP Code 33141 compared to the 250-year inland flood footprint.

Additional September Additional Verification Review Comments:

Discussed that in the revised Form AF-1 both ZIP Codes 33141 (Miami-Dade County) and 34139 (Collier County) remained the same.

Revised Question #91 in PVL Addendum

91. Form AF-1, pages 387-393: Explain the difference in Manufactured Homes rates, by ZIP Code, between the low of 0.0001 (32343) and the high of 115.5 (34139).

Discussed that the low values in the original Form AF-1 have zero value in the revised form because there is no residential exposure within the ZIP Codes.

Reviewed satellite imagery of the exposures in ZIP Code 34139 compared to the 20-year surge depth footprint.

Discussed that the 0.0001 loss cost value in ZIP Code 32343 is due to the position of the single exposure in the ZIP Code located on the edge of the modeled maximum flood extent.

Revised Question #92 in PVL Addendum

92. Form AF-1, pages 387-393: Explain the difference in Frame Owners rates, by County, between the low of about 0.252 in Indian River County and the high of about 23.2 in Collier County.

Discussed that the differences in average loss costs is caused by the spatial allocation of hazard and exposure and the FFH assumptions based on year built and FIRM effective date.

Additional September Additional Verification Review Comments:

Discussed that in the revised Form AF-1 the high loss cost values for Frame Owners remain in Collier County and the lowest in Miami-Dade County.

Reviewed the differences in loss costs between the original and revised Form AF-1.

Revised Question #93 in PVL Addendum

93. Form AF-1, pages 387-393: Explain the difference in Manufactured Homes rates, by County, between the low of about 0.004 in Hendry County and the high of about 33.4 in Collier County.

Discussed that the difference in manufactured homes rates is due to the minimum FFH assumed for manufactured homes and the maximum modeled flood depth above the minimum in Hendry and Collier Counties.

Revised Question #94 in PVL Addendum

94. Form AF-1, pages 387-393: Explain the zero rates for Owners and Manufactured Homes in several ZIP Codes (e.g., 32099, 32403, 33448, 33620, 33848, 33855, 34979).

Discussed that the zero values are due to no exposure in the IF industry exposure data for five of the listed ZIP Codes, and that two of the ZIP Codes have no hazard in the stochastic storm sets.

Reviewed satellite imagery of ZIP Code 32099 with no residential exposures.

Additional September Additional Verification Review Comments:

Discussed that the comments above remain valid for the revised Form AF-1.

Revised Question #95 in PVL Addendum

95. Form AF-1, pages 387-393: Explain why more than half of the Manufactured Homes losses per 1,000 by ZIP Code are lower than Wood Frame. Also, explain why the ratio of Manufactured Homes to Frame Owners rates ranges from 0.011 in Palm Beach County (33473) to 149.5 in Monroe County (33001).

Discussed that the difference in minimum FFH assumed for manufactured homes compared to a minimum FFH for wood frame homes results in manufactured homes being less vulnerable to low flood depths that are common for high frequency events.

Reviewed plot of FFH in Monroe County for a wood frame single family structure.

Additional September Additional Verification Review Comments:

Discussed the cases where Manufactured Homes loss costs are greater than Wood Frame loss costs in the revised Form AF-1.

120. Form AF-1, pages 387-394: Explain why this form shows overall increases from the original January 28, 2024, submission in most counties, some quite large, while Form AF-4 shows very small differences.

Not applicable with new Form AF-4.

96. Form AF-2, pages 352-355 (May 10 revised submission pages 396-400): Describe in detail the modeling-organization-specified, predetermined and comprehensive exposure dataset. Provide the total value of the exposures and the number of exposures by type (frame, masonry, manufactured homes).

Reviewed the IF industry exposure dataset breakdown by coverage. See comments under GF-1, Audit 8.

97. Form AF-2, pages 352-355 (May 10 revised submission pages 396-400): Explain the Hurricane Donna (1960) losses compared to other storms, especially Tampa Bay (1921).

Discussed that the track of Hurricane Donna (1960) along Southwest Florida caused storm surge to impact more properties than Hurricane Tampa Bay (1921).

Additional September Additional Verification Review Comments:

Reviewed loss costs by ZIP Code for Hurricane Donna (1960) and the Hurricane TampaBay06 (1921) storms. Reviewed maps of the flood loss cost per $1,000 by County for both storms.

121. Form AF-2, pages 396-400: Comparing to the original January 28, 2024, submission, explain the large increases for Hurricane Betsy (1965) and Hurricane Andrew (1992), and the large decreases for Hurricane Opal (1995) and Hurricane Dennis (2005). Explain why there was no change for the two unnamed storms.

Reviewed maps of storm surge footprints for Hurricane Betsy (1965), Hurricane Andrew (1992), Hurricane Opal (1995), and Hurricane Dennis (2005).

Discussed that the large increases and decreases in the losses of the storms are due to the datum change in the storm surge footprint.

Reviewed plot of the impact on gross loss for the storm surge historical event loss datum change.

122. Form AF-3, page 402: Explain why the table provided in the Excel file has not changed since the original January 28, 2024, submission, although Form AF-2 shows significant changes for these storms.

Discussed that an incorrect table for Form AF-3 was provided in the May 10, 2024, revised submission. Reviewed a corrected Form AF-3 provided during the on-site review.

Revised Question #98 in PVL Addendum

98. Form AF-3, page 417, Figure 146: Explain the losses in southwest Florida for this panhandle storm.

Discussed that historical events boundaries are defined by the same clustering algorithm as used to define stochastic events.

See comments under GF-1, PVL #1 for a description of the methodology.

Reviewed visual examples of the process for local peak clustering.

Revised Question #99 in PVL Addendum

99. Form AF-4, pages 424-438 (September 3 revised submission pages 483-518): Explain the multiple zeros (0) for Low throughout the form for Frame Owners (e.g., Hernando Low).

PVL Addendum revised question not reviewed during the June on-site review due to errors in Form AF-4.

September Additional Verification Review Comments:
Discussed that the zeros are caused by the requirement for loss costs to be rounded to three decimal points.

100. Form AF-4, pages 369-375 (May 10 revised submission pages 425-431, September 3 revised submission pages 483-493), 0% Deductible: Explain the zeros for Manufactured Homes, Renters, and Condo Units (e.g., Brevard County Low).

Original PVL question not reviewed during the June on-site review due to errors in Form AF-4.

September Additional Verification Review Comments:
Discussed that the zeros are caused by the requirement for loss costs to be rounded to three decimal points.

Revised Question #101 in email sent to IF on 9/10/24

101. Form AF-4, pages 483-493, 0% Deductible: Explain the differences in Average loss costs between the highest county (Dixie) and the lowest counties (Indian River, Okeechobee). The high county shows a loss cost of 9.25, while the low counties are less than 0.25.

Original PVL question not reviewed during the June on-site review due to errors in Form AF-4.

September Additional Verification Review Comments:
Discussed that the differences in average loss costs are caused by the spatial allocation of hazard and exposure as well as the FFH assumptions based on year built and FIRM effective date.

Revised Question #102 in email sent to IF on 9/10/24

102. Form AF-4, pages 483-493, 0% Deductible: Explain, in general, the wide swings in relativities of Average loss costs as shown below:
    a. The ratio of Masonry Owners to Frame Owners rates that range from 0.036 (Collier) to 3.83 (St. Johns), and most show Masonry Owners rates greater than Frame Owners,
    b. The ratio of Manufactured Homes to Frame Owners rates that range from 0.046 (Hendry) to 8.96 (Monroe), and more than half of the Manufactured Homes rates are less than Frame Owners, and
    c. The ratio of Masonry Renters to Frame Renters and Condo Owners rates that range from 0.006 (Gilchrist) to 21.0 (Suwanee) and more than half of the Masonry Renters are greater than Frame Renters.

Original PVL question not reviewed during the June on-site review due to errors in Form AF-4.

September Additional Verification Review Comments:

Discussed that the differences in loss cost are caused by the relationship between the spatial allocation of each construction type and the spatial allocation of hazard. The masonry structures and manufactured homes experience a higher average intensity than the frame structures within the same county.

103. Form AF-4, page 371 (May 10 revised submission page 427, September 3 revised submission page 483): With Form AF-1 having only two ZIP Codes for Glades County (33471 and 33944), explain the values given in Form AF-4 in Glades County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.

Not reviewed during the June on-site review due to errors in Form AF-4.

September Additional Verification Review Comments:

Discussed that the high and low loss costs for counties represent the highest and lowest loss costs calculated for each individual flood risk and that ZIP Code values are not relevant.

Discussed how cases where ZIP Code boundaries that are not aligned with a county boundary are handled.

~~104. Form AF-4, page 371: With Form AF-1 having only two ZIP Codes for Gulf County (32456 and 32465), explain the values given in Form AF-4 in Gulf County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.~~

No longer relevant.

105. ~~Form AF-4, page 372: With Form AF-1 having only one ZIP Code in Lafayette County (32066), explain the values given in Form AF-4 in Lafayette County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.~~

No longer relevant.

106. ~~Form AF-4, page 373: With Form AF-1 having only two ZIP Codes for Okeechobee County (34972 and 34974) with similar loss costs, explain the values given in Form AF-4 in Okeechobee County Low, Average, and High for Frame Owners, Masonry Owners, and Manufactured Homes.~~

No longer relevant.

123. ~~Form AF-4, pages 424-438: Explain why the form in the submission has not been updated to agree with the Excel version of the form (contrary to the D. Rees letter dated May 10, 2024).~~

No longer relevant.

124. Form AF-4, pages 425-431 (September 3 revised submission pages 483-518), 0% Deductible: Explain the differences in Average Manufactured Homes loss costs between the highest county (Collier) and the lowest counties (Hendry, Glades). The high county shows loss costs about 35.0, while the low counties are less than 0.122.

Not reviewed during the June on-site review due to errors in Form AF-4.

September Additional Verification Review Comments:
Discussed the FFH assumption for Manufactured Homes and the number of Manufactured Homes that can experience flood above the FFH.

125. Provide Form AF-5 as required in the Acceptability Process (see Report of Activities, page 58, IV.d).

Not reviewed during the June on-site review due to errors in Form AF-4.

September Additional Verification Review Comments:
Form AF-5 was provided with the September 3, 2024, revised submission. Reviewed the comparisons in Form AF-5 between the original submitted Form AF-4 and the new, corrected Form AF-4.

107. Form AF-8, page 391 (May 10 revised submission pages 447-448): Discuss the methodology used to calculate the 10% and 90% uncertainty ranges. Explain why the ranges are very narrow.

Reviewed the methodology for calculating the 10% and 90% uncertainty levels in Form AF-8.

Discussed that the ranges are narrow due to the number of records in the IF industry exposure database.

126. Form AF-8, pages 447-448: Explain why the tables show significant decreases for all PML levels while Form AF-4 shows very little change in the loss costs.

Not reviewed due to errors in Form AF-4.

September Additional Verification Review Comments:
Discussed the difference in using ground up loss in Form AF-8 versus gross loss in Form AF-4 that led to the mismatch of results.

127. Form AF-8, pages 447-448: Explain the methodology for calculating the uncertainty levels and why the range of uncertainty is so narrow.

Reviewed the methodology for calculating uncertainty levels in Form AF-8.

Discussed that the ranges are narrow due to the number of records in the IF industry exposure database.

September Additional Verification Review Comments:

New Question #128 in email sent to IF on 9/10/24

128. Form AF-4, pages 483-518: Explain why Form AF-4 was wrong in the original submission and what has been done to prevent a recurrence.

Discussed the issues discovered in Form AF-4. Reviewed the old and corrected codes used to generate Form AF-4. Discussed how the errors were discovered, the solutions to correcting the errors in the form generation process, and steps implemented for consistency testing between scripts that generate loss costs.

Reviewed a revised actuarial form quality assurance (QA) plan to ensure the updated procedures have been integrated into a timeline that allows enough time to review, check, and reproduce actuarial form results.

Audit

Audit items were not reviewed during the June initial on-site review and were listed as open items to be reviewed during the September additional verification review.

September Additional Verification Review Comments:

1. The data and methods used for flood probable maximum loss levels for Form AF-8, Flood Probable Maximum Loss for Florida, will be reviewed. The Top Event and Conditional Tail Expectations will be reviewed.

   See comments under PVL #107.

   Reviewed graph of the conditional tail expectation of the yearly loss.

   Reviewed the storm surge footprint of the top loss stochastic event. Reviewed the storm characteristics, the surge elevation, and surge depth of the maximum modeled depth for this event.

   Reviewed the inland flood footprint of the top loss stochastic event.

   Discussed how Lake Okeechobee is handled in the inland flood model.
2. The frequency distribution and the individual event severity distribution, or information about the formulation of events, underlying Form AF-8, Flood Probable Maximum Loss for Florida, will be reviewed.

   Discussed that the event set consists of 200,000 years of simulation and that the annual number of storms follow a negative binomial distribution.

   Discussed that the uncertainty captures the variation of loss due to uncertainty in the flood vulnerability functions.

   See comments under PVL #107.

3. All referenced scientific and technical literature will be reviewed, in hard copy or electronic form, to determine applicability.

   All references were available electronically and were reviewed as necessary.

4. Graphical representations of flood loss costs by rating areas and geographic zones (consistent with the modeling-organization grid resolution) will be reviewed.

   Reviewed graphical representations of flood loss costs by ZIP Code provided in Form AF-1.

5. The procedures used by the modeling organization to verify the individual flood loss cost relationships will be reviewed. Methods (including any software) used in verifying Flood Standard AF-6, Flood Loss Outputs and Logical Relationships to Risk, will be reviewed. Forms AF-1, Zero Deductible Personal Residential Standard Flood Loss Costs; AF-2, Total Flood Statewide Loss Costs; AF-3, Personal Residential Standard Flood Losses by ZIP Code; and AF-6, Logical Relationships to Flood Risk (Trade Secret Item); and AF-7, Percentage Change in Logical Relationships to Flood Risk, will be reviewed to assess flood coverage relationships.

   Reviewed the Actuarial Forms QA Plan document outlining the procedures to verify the individual flood loss cost relationships.

6. The flood loss cost relationships among deductible, policy form, construction type, coverage, year of construction, foundation type, number of stories, and lowest floor elevation will be reviewed. For coastal flooding, the flood loss cost relationship with distance to the closest coast will be reviewed.

   Reviewed Form AF-6 graphical representations of the flood loss costs relationships and confirmed reasonability.

   Discussed the error discovered in Form AF-6, Notional Set 6 Foundation Type generation process and the revised values in the form table and revised graph after correcting the error. Reviewed a new step added to the Form AF-6 QA plan to test for this type of error in the future.

7. The total personal residential insured flood losses provided in Forms AF-2, Total Flood Statewide Loss Costs, and AF-3, Personal Residential Standard Flood Losses by ZIP Code, will be reviewed.

   Reviewed revised Form AF-2 provided in the May 10, 2024, revised submission, and corrected Form AF-3 provided during the June on-site review.

8. Form AF-4, Flood Output Ranges, and Form AF-5, Percentage Change in Flood Output Ranges, will be reviewed, including geographical representations of the data where applicable.

   Discussed the reasons for the “significant errors” discovered in the Form AF-4 code, why the QA checks did not catch the errors, and what has been implemented to prevent a recurrence of the error.

   Reviewed a corrected Form AF-4 and a Form AF-5 with the percentage differences from the initial submission of Form AF-4.

9. Justification for all changes in flood loss costs from the currently accepted flood model will be reviewed.

   Not applicable as this is the first submission of the IF flood model.

10. Form AF-4, Flood Output Ranges, will be reviewed to ensure appropriate relativities among deductibles, coverages, and construction types.

    See comments under Audit #8.

11. Apparent reversals in the flood output ranges and their justification will be reviewed.

    See comments under PVLs #95 and 102.

12. Details on the calculation of uncertainty intervals and their justification will be reviewed.

    See comments under PVL #127.

Additional September Additional Verification Review Comments:

Discussed the errors discovered in the Form AF-1 generation process. Discussed that the errors were discovered while reviewing and preparing responses for Pre-Visit Letter items. Discussed the solutions implemented to correct the errors. Reviewed the updated Form AF-1 QA plan with additional testing and mitigation steps. Reviewed the updated Form AF-1 QA test script.

Reviewed the loss costs by ZIP Code for Hurricane Donna (1960) and Hurricane TampaBay06 (1921). Reviewed map comparisons of the loss costs.

COMPUTER/INFORMATION FLOOD STANDARDS – PAUL FISHWICK, LEADER

CIF-1 Flood Model Documentation*

*(*Significant Revision)*

A. Flood model functionality and technical descriptions shall be documented formally in an archival format separate from the use of correspondence including emails, presentation materials, and unformatted text files.

B. A primary document repository shall be maintained, containing or referencing a complete set of documentation specifying the flood model structure, detailed software description, and functionality. Documentation shall be indicative of current model development and software engineering practices.

C. All computer software (i.e., user interface, scientific, engineering, actuarial, data preparation, and validation) relevant to the flood model shall be consistently documented and dated.

D. The following shall be maintained: (1) a table of all changes in the flood model from the currently accepted flood model to the initial submission this year, and (2) a table of all substantive changes in the flood model since this year's initial submission.

E. Documentation shall be created separately from the source code.

F. A list of all externally acquired currently used flood model-specific software and data assets shall be maintained. The list shall include (1) asset name, (2) asset version number, (3) asset acquisition date, (4) asset acquisition source, (5) asset acquisition mode (e.g., lease, purchase, open source), and (6) length of time asset has been in use by the modeling organization.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

108. CIF-1.F, page 259 (May 10 revised submission page 266): Provide the list of all externally acquired flood model-specific software and data assets as described and required by Standard CIF-1, Audit item 6.

Reviewed the list of all externally acquired flood model-specific software and data assets. The list was updated during the review to add the externally acquired proprietary TCR code.

Audit

1. The primary document repository, containing or referencing full documentation of the software in either electronic or physical form, and its maintenance process will be reviewed.

Discussed the use of Microsoft Team Foundation Server (TFS) as the primary code repository, and Microsoft SharePoint as the primary document repository. Discussed that documents are version controlled and history is maintained by SharePoint.

Reviewed all software development related documents stored online. Discussed that access is to authorized users only. Discussed that contents of the site are backed up regularly in compliance with Aon's security policy.

2. All documentation should be easily accessible from a central location in order to be reviewed.

See comments under Audit 1.

3. Complete user documentation, including all recent updates, will be reviewed.

Reviewed examples of documentation in the course of the audit.

4. Modeling organization personnel, or their designated proxies, responsible for each aspect of the software (i.e., user interface, quality assurance, engineering, actuarial, verification) should be present when the Computer/Information Flood Standards are being reviewed. Internal users of the software will be interviewed.

All subject matter experts and personnel involved in software implementation were available and participated throughout the review.

5. Verification that documentation is created separately from, and is maintained consistently with, the source code and data will be reviewed.

Discussed that architecture, design, and technical notes along with requirement specifications are created and stored separately from the source code.

Reviewed examples of the ELEMENTS application architecture, design, and technical notes in ELEMENTS DCF Architecture Design.

Reviewed examples of Model Requirements Specification for ELEMENTS in R&D Model Requirements Documentation and Florida Flood (FCHLPM) Model Implementation documentation.

Discussed that source code is maintained using Visual Studio within TFS.

6. The list of all externally acquired flood model-specific software and data assets will be reviewed.

   See comments under PVL #108.

7. The tables specified in Flood Standard CIF-1.D that contain the items listed in Flood Standard GF-1, Scope of the Flood Model and Its Implementation, Disclosure 8 will be reviewed. The tables should contain the item number in the first column. The remaining five columns should contain specific document or file references for affected components or data relating to the following Computer/Information Flood Standards: CIF-2, Flood Model Requirements, CIF-3, Flood Model Organization and Component Design, CIF-4, Flood Model Implementation, CIF-5, Flood Model Verification, and CIF-7, Flood Model Maintenance and Revision.

   Reviewed the table of changes for the change in the tropical cyclone model that was updated to bring its vertical and horizontal datums to align with the inland flood model.

8. Tracing of the flood model changes specified in Flood Standard GF-1, Scope of the Flood Model and Its Implementation, Disclosure 8 and Audit 9 through all Computer/Information Flood Standards will be reviewed.

   Not applicable as this is the first submission of the IF flood model.

September Additional Verification Review Comments:

Reviewed documentation for the Tropical Cyclone Rainfall (TCR) model.

Reviewed documentation for the vulnerability component. Reviewed the vulnerability component equation and variable mapping documentation.

Reviewed an updated list of externally acquired flood software and data assets. Reviewed the document used to track external assets, which was updated and revised during the additional verification review to add dates for asset versioning.

CIF-2 Flood Model Requirements*

*(*Significant Revision)*

A complete set of requirements for each software component, as well as for each database or data file accessed by a component, shall be maintained. Requirements shall be updated whenever changes are made to the flood model.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. Maintenance and documentation of a complete set of requirements for each software component, database, and data file accessed by a component will be reviewed.

   Reviewed requirements for software components.

   Reviewed data files and databases.

   Reviewed development operations for tracking tasks.

September Additional Verification Review Comments:

Verified after verification of other standards.

CIF-3 Flood Model Organization and Component Design*

*(*Significant Revision)*

A. The following shall be maintained and documented: (1) detailed control and data flowcharts and interface specifications for each software component, (2) schema definitions for each database and data file, (3) flowcharts illustrating flood model-related flow of information and its processing by modeling organization personnel or consultants, (4) network organization, and (5) system model representations associated with (1)-(4) above. Documentation shall be to the level of components that make significant contributions to the flood model output.

B. All flowcharts (e.g., software, data, and system models) in the submission or in other relevant documentation shall be based on (1) a referenced industry standard (e.g., UML, BPMN, SysML), or (2) a comparable internally-developed standard which is separately documented.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

109. CIF-3.B, page 261 (May 10 revised submission page 268): Provide the documents for flowcharting standards.

Reviewed the flowchart standards followed by the Modeler. Discussed that the flowchart standards follow ISO 5807, BPMN, and UML.

Audit

1. The following will be reviewed:
   a. Detailed control and data flowcharts, completely and sufficiently labeled for each component,
   b. Interface specifications for all components in the flood model,
   c. Documentation for schemas for all data files, along with field type definitions,
   d. Each network flowchart including components, sub-component flowcharts, arcs, and labels,
   e. Flowcharts illustrating flood model-related information flow among modeling organization personnel or consultants (e.g., BPMN, UML, SysML, or equivalent technique including a modeling organization internal standard), and

f. If the flood model is implemented on more than one platform, the detailed control and data flowcharts, component interface specifications, schema documentation for all data files, and detailed network flowcharts for each platform.

Reviewed the flowchart for ELEMENTS data import, hazard and loss processing.

Reviewed an example UML-based database schema illustrating relationships among data components.

Reviewed an example network architecture.

Reviewed workflow of IF professionals involved in development of the flood model.

Discussed that the flood model is only available in the ELEMENTS application, and on Microsoft Windows machines.

Reviewed the flowchart for model data quality check and validation testing within the ELEMENTS application.

Reviewed the flowchart for development of the flood vulnerability functions.

Reviewed the flowchart for structural failure or non-failure in the vulnerability simulator.

Reviewed the flowchart for water contact loss in the vulnerability simulator.

Reviewed the flowchart for submission form creation.

Reviewed the flowchart for interactions among flood model components which was revised during the on-site review to conform to the flowchart standards.

Reviewed loading representations of coastal flood loads on elevated structures including breaking wave loads on vertical piles and on vertical walls.

Reviewed flowchart for the flood model vulnerability simulation engine.

2. A flood model component custodian, or designated proxy, should be available for the review of each component.

All subject matter experts and personnel involved in software implementation were available and participated, as needed, throughout the review.

3. The flowchart reference guide or industry standard reference will be reviewed.

See comments under PVL #109.

Discussed that IF is to conduct an internal examination to ensure all flowcharts follow the IF flowchart standards in order for the standard to be verified.

September Additional Verification Review Comments:

Reviewed the flowchart for the tropical cyclone rainfall model which was revised during the review to conform to the ISO 5807 standard and to accurately reflect the order for calculating the rainfall rate.

Discussed that the Modeler reviewed all flowcharts in the submission to confirm conformance to flowchart standards.

Reviewed numerous revised flowcharts that were redesigned to conform to IF's flowchart standards.

Reviewed flowchart for the vulnerability simulator modules.

Reviewed new diagram created of the network organization that will replace Figure 3 in the final revised submission.

Reviewed revised business workflow diagram that will replace Figure 4 in the final revised submission.

Reviewed a functional block diagram for all of the major model components used in the flood model submission.

Reviewed a flowchart for model handover.

Reviewed the database schema with definitions and diagrams for the flood model damage functions.

Reviewed flowchart for model data quality check and validation testing within the ELEMENTS platform revised to conform to flowchart standards.

CIF-4 Flood Model Implementation*

(Significant Revision)

A. A complete procedure of coding guidelines consistent with current software engineering practices shall be maintained.

B. Network organization documentation shall be maintained.

C. A complete procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components shall be maintained.

D. All components shall be traceable, through explicit component identification in the flood model representations (e.g., flowcharts) down to the code level.

E. A table of all software components affecting flood loss costs and flood probable maximum loss levels shall be maintained with the following table columns: (1) component name, (2) number of lines of code, minus blank and comment lines, and (3) number of explanatory comment lines.

F. Each component shall be sufficiently and consistently commented so that a software engineer unfamiliar with the code shall be able to comprehend the component logic at a reasonable level of abstraction.

G. The following documentation shall be maintained for all components or data modified by items identified in Flood Standard GF-1, Scope of the Flood Model and Its Implementation, Disclosure 8 and Audit 9:

1. A list of all equations and formulas used in documentation of the flood model with definitions of all terms and variables.

2. A cross-referenced list of implementation source code terms and variable names corresponding to items within G.1 above.

H. Flood model code and data shall be accompanied by documented maintenance, testing, and update plans with their schedules. The vintage of the code and data shall be justified.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

110. CIF-4.H, page 264 (May 10 revised submission page 271): Provide the information as noted.

Reviewed examples of MatLab and R code stored in TFS.

Reviewed the source control system and secured share path for software code, testing plans and test cases, and data.

Audit

1. Sample code and data implementations will be selected and reviewed, for at least the meteorology, hydrology and hydraulics, vulnerability, and actuarial components.

Reviewed the original code for generating Form AF-4 and the corrected code. Discussed the errors in the code and when they were discovered. Discussed the testing process and why the errors were not detected earlier. Reviewed updated procedures established to perform advance testing and mitigation to eliminate similar errors in the future.

Reviewed comments added to the corrected Form AF-4 code.

Reviewed the original code for generating Form AF-3 and the corrected code. Discussed the errors in the code, the testing process, and why the errors were not detected earlier. Reviewed updated procedures established to perform advance testing and mitigation to eliminate similar errors in the future.

Reviewed the code for estimation of building components damage due to coastal flood loads. Reviewed the equation and variable mapping for hydrodynamic loads.

Reviewed the code for breaking wave loads on elevated structures, the wave slam coefficient, and the dynamic pressure coefficient. Reviewed the associated equations and variable mappings.

Reviewed code for frame structure connection failures.

Reviewed the non-proprietary portions of the tropical cyclone rainfall model code.

Reviewed the code for calculating accumulated rainfall along the storm track.

Reviewed a live demonstration on the development server for simulating inland flood (pluvial and fluvial) and coastal flood (storm surge) separately and selecting the maximum loss.

Reviewed a live demonstration on the development server of the storm surge and inland flood model interaction.

2. The documented coding guidelines, including procedures for ensuring readable identifiers for variables, constants, and components, and confirmation that these guidelines are uniformly implemented will be reviewed.

   Reviewed the coding guidelines documentation that covers numerous programming languages, and the common coding guidelines.

3. The procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components will be reviewed.

   Discussed the processes and procedures for automated and manual validation of flood model development in the data verification process document.

   Reviewed flowchart for model data quality checks and validation testing within the ELEMENTS application.

4. The traceability among components at all levels of representation will be reviewed.

   Reviewed the process used to ensure traceability among model components.

5. The following information will be reviewed for each component, either in a header comment block, source control database, or the documentation:
   a. Component name,
   b. Date created,
   c. Dates modified, modification rationale, and by whom,
   d. Purpose or function of the component, and
   e. Input and output parameter definitions.

   Reviewed examples of comments in the different source codes reviewed.

6. The table of all software components as specified in Flood Standard CIF-4.E will be reviewed.

   Reviewed the code analyzer report.

   Reviewed table of line counts with and without comments.

7. Flood model components and the method of mapping to elements in the computer program will be reviewed.

   Reviewed the ELEMENTS Design Document.

   Reviewed a diagram for mapping model components.

8. Comments within components will be reviewed for sufficiency, consistency, and explanatory quality.

   Comments in selected source codes were reviewed.

9. Unique aspects within various platforms with regard to the use of hardware, operating system, and essential software will be reviewed.

   Discussed that the flood model is available only on the ELEMENTS platform which is only available on Windows platform.

10. Network organization implementation will be reviewed.

    Reviewed the network organization diagram for ELEMENTS.

11. Code and data maintenance plans, testing plans, update plans, and schedules will be reviewed. Justification for the vintage of code and data will be reviewed.

    Reviewed the master test plan documentation.

    Reviewed sample test cases for hydrogrid test plan and secondary modifiers test plan.

    Reviewed sample Spring planning and tracking tasks documentation.

    Reviewed the vintage of code branching strategy.

    Discussed the use of Agile and Scrum for software development.

September Additional Verification Review Comments:

Reviewed implementation of the tropical cyclone rainfall model. Reviewed the equation variable mapping documentation for the tropical cyclone rainfall model.

Discussed that all scripts utilized for the development of the vulnerability component have been revised to change hard-coded numbers to named variables. Reviewed an example of the flood vulnerability simulator code.

Reviewed the methodology and implementation of non-tropical cyclone demand surge.

Reviewed the code for contents damage in the water infiltration model.

Reviewed the inland decay rate equations, formula mapping, and implementation in the code.

Reviewed implementation of flood loading.

Reviewed the methodology and implementation on the interaction of the inland flood model components to generate combined flood depth values.

Reviewed the Code Metrics table revised during the review to add a data dictionary and to add a column for the number of comment lines.

CIF-5 Flood Model Verification*

(Significant Revision)

A. General

For each component, procedures shall be maintained for verification, such as code inspections, reviews, calculation crosschecks, and walkthroughs, sufficient to demonstrate code correctness. Verification procedures shall include tests performed by modeling organization personnel other than the original component developers.

B. Component Testing

1. ***Testing software shall be used to assist in documenting and analyzing all components.***
2. ***Unit tests shall be performed and documented for each updated component.***
3. ***Regression tests shall be performed and documented on incremental builds.***
4. ***Integration tests shall be performed and documented to ensure the correctness of all flood model components. Sufficient testing shall be performed to ensure that all components have been executed at least once.***

C. Data Testing

1. ***Testing software shall be used to assist in documenting and analyzing all databases and data files accessed by components.***
2. ***Integrity, consistency, and correctness checks shall be performed and documented on all databases and data files accessed by the components.***

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. Procedures for unit conversion verification will be reviewed.

   Reviewed the flood velocity unit conversion from metric to imperial units.

2. The components will be reviewed for containment of sufficient logical assertions, exception-handling mechanisms, and flag-triggered output statements to test the correct values for key variables that might be subject to modification.

   Reviewed an example of source code showing exception handling.

3. The testing software used by the modeling organization will be reviewed.

   Reviewed examples of unit testing and automation testing.

   Discussed the process and repository for the testing scripts.

   Reviewed the Quality Assurance (QA) plan updated during the on-site review to include timelines for checking results of actuarial forms. Discussed the Modeler's plan to migrate to project management.

4. The component (unit, regression, integration) and data test processes and documentation will be reviewed including compliance with independence of the verification procedures.

   Reviewed documentation of the testing strategy.

   Reviewed documentation for various testing tasks and matrix:
   - Unit Testing
   - Hydrogrid Test Plan
   - Secondary Modifiers Test Plan
   - Regression Test Report
   - Florida Flood Model Master Test Plan

   Reviewed testing of the proprietary TCR model code.

5. Fully time-stamped, documented cross-checking procedures and results for verifying equations, including tester identification, will be reviewed. Examples include mathematical calculations versus source code implementation, or the use of multiple implementations using different languages.

   Reviewed an example of cross checking.

6. Flowcharts defining the processes used for manual and automatic verification will be reviewed.

   Reviewed the flowchart for manual and automatic verification.

   Reviewed the insurance loss calculation test.

   Reviewed testing flowcharts in the ELEMENTS Software QA Process.

7. Verification approaches used for externally acquired data, software, and models will be reviewed.

   Reviewed the Precisely (formerly Pitney Bowes) geocoder testing and verification documentation.

September Additional Verification Review Comments:

Reviewed testing completed on the tropical cyclone rainfall model output. Reviewed comparisons of modeled to observed rainfall footprints for Hurricane Isabel (2003) and Hurricane Irene (2011).

Reviewed testing of the calculation of contents damage in the water infiltration model.

Reviewed the geocoding testing on the GIS data provided by a third-party geocoder.

Reviewed the manual calculations of modeled PML, average annual loss (AAL), and quantiles used for validation.

Reviewed an improvement plan for resolving problems with topographic datasets. The improvement plan included a testing plan and a data testing process with a Gantt chart for implementation of the plan.

CIF-6 Human-Computer Interaction*

*(*New Flood Standard)*

A. Interfaces shall be implemented as consistent with accepted principles and practices of Human-Computer Interaction (HCI), Interaction Design, and User Experience (UX) engineering.

B. Interface options used in the flood model shall be unique, explicit, and distinctly emphasized.

C. For a Florida rate filing, interface options shall be limited to those options found acceptable by the Commission.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Pre-Visit Letter

111. CIF-6.A, page 271 (May 10 revised submission page 278): Provide the human interface guidelines.

Reviewed the human interface guidelines documentation for designing the ELEMENTS user interface.

112. CIF-6.C, page 271 (May 10 revised submission page 278): Provide and explain the analysis options related to Florida rate filings.

Reviewed the user story, wireframe design, and technical notes for the FCHLPM rate filing interface options.

Discussed the flood model peril options available for selecting the dataset used in a Florida flood rate filing.

Started a review of a live demonstration of the model execution.

Audit

1. External and internal user interfaces will be reviewed.

Started a review of a live demonstration of the model execution.

Reviewed a live demonstration on the development server for simulating inland flood used to calculate damage ratios, connect flood depth to exceedance probability, and calculate average annual losses and PML event losses.

Discussed that Structured Query Language (SQL) Server Management Studio is the external user interface to extract additional data or analyses.

2. Documentation related to HCI, Interaction Design, and UX engineering will be reviewed.

   Reviewed the ELEMENTS User Interface HCI Guidelines.

   Reviewed the use of wireframes for user interface design.

3. The decision process specifying the logic of interface option selections, when an acceptable flood model is selected, will be reviewed.

   Reviewed the interaction diagram showing logic of interface option selection when an acceptable Florida flood model is selected.

September Additional Verification Review Comments:

Reviewed the Florida rate filing interface code.

Reviewed a live demonstration of a model run.

CIF-7 Flood Model Maintenance and Revision*

*(*Significant Revision)*

A. A clearly written policy shall be implemented for review, maintenance, and revision of the flood model and network organization, including verification and validation of revised components, databases, and data files.

B. A revision to any portion of the flood model that results in a change in any Florida personal residential flood loss cost or flood probable maximum loss level shall result in a new flood model version identification.

C. Tracking software shall be used to identify and describe all errors, as well as modifications to code, data, and documentation.

D. A list of all flood model versions since the initial submission for this year shall be maintained. Each flood model description shall have an unique version identification and a list of additions, deletions, and changes that define that version.

Verified: ~~NO~~ YES

Professional Team comments are provided in black font below.

~~Not verified pending resolution of open items.~~

Audit

1. All policies and procedures used to review and maintain the code, data, and documentation will be reviewed. For each component in the system decomposition, the installation date under configuration control, the current version identification, and the date of the most recent change(s) will be reviewed.

   Reviewed software development and testing processes documentation.

   Discussed the use of internal build versioning for tracking software changes.

   Discussed that the model version number was not updated due to the post-model processing errors in Forms AF-3 and AF-4.

2. The policy for flood model revision and management will be reviewed.

   Reviewed the model and platform versioning management documentation.

3. Portions of the code will be reviewed.

   Code reviews were conducted as listed under CIF-4.

4. The tracking software will be reviewed and checked for the ability to track date and time.

   Source code and documents available on SharePoint were reviewed during the course of the audit.

   Discussed the use of TFS for storing and maintaining code and the use of SharePoint for storing and maintaining documentation.

5. The list of all flood model revisions as specified in Flood Standard CIF-7.D will be reviewed.

   Reviewed the document to track model changes since the initial submission. The document was revised during the on-site review to add dates of model versioning and model changes.

September Additional Verification Review Comments:

Reviewed the model and platform revision management documentation.

Reviewed the document used to track model changes since the initial submission, which was updated and revised during the additional verification review to add dates for model versioning and model changes.

CIF-8 Flood Model Security*

*(*Significant Revision)*

Security procedures shall be implemented and fully documented for (1) secure access to individual computers where the software components or data can be created or modified, (2) secure operation of the flood model by clients, if relevant, to ensure that the correct software operation cannot be compromised, (3) anti-virus software installation for all machines where all components and data are being accessed, and (4) secure access to documentation, software, and data in the event of a catastrophe.

Verified: YES

Professional Team comments are provided in black font below.

Audit

1. The written policy for all security procedures and methods used to ensure the security of code, data, and documentation will be reviewed.

   Reviewed data and network security documentation. Discussed the security measures taken.

   Discussed that there have been no known security breaches.

2. Documented security procedures for access, client flood model use, anti-virus software installation, and off-site procedures in the event of a catastrophe will be reviewed.

   Discussed that IF follows data retention and recovery protocols defined by the Aon Information Technology (IT) group.

   Reviewed the IF Security in the Aon IT documentation.

3. Security aspects of each platform will be reviewed.

   Discussed that the flood model can only be used with the ELEMENTS application which is only available on Windows platform.

   Discussed that ELEMENTS uses domain security groups to grant access to the application.

   Reviewed ELEMENTS architecture and deployment documentation.

4. Network security documentation and network integrity assurance procedures will be reviewed.

Reviewed network security documentation addressing secured physical access to the data center, secured computer access, secured access to flood model components, and secured access to documentation and source code.

Discussed that all IF hardware resources are monitored and patched by Aon IT groups.