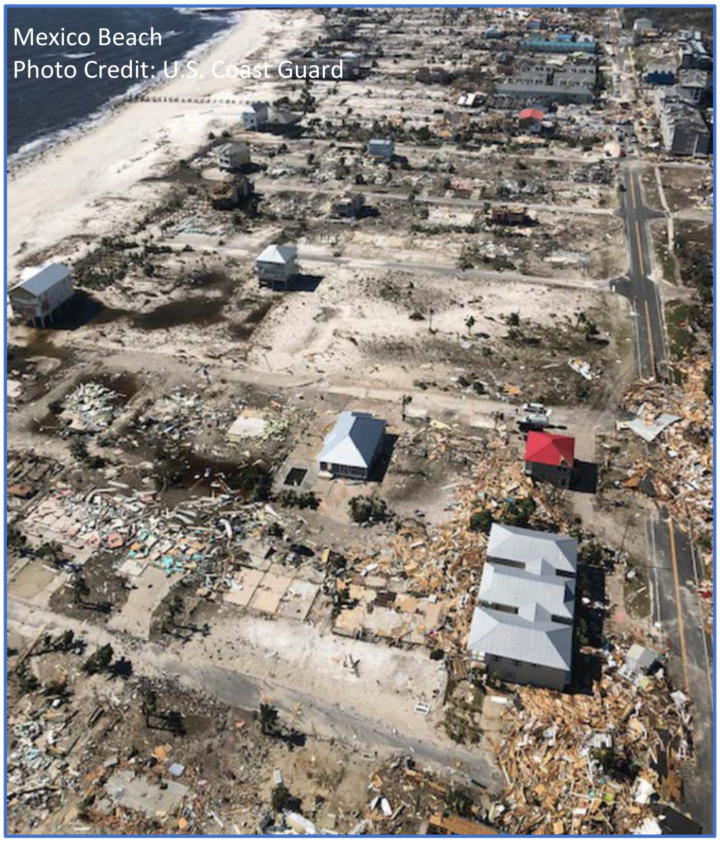
Florida Commission on Hurricane Loss Projection Methodology

Professional Team Report
2017 Flood Standards



Karen Clark & Company
KCC US Flood Reference Model Version 1.0

Remote Review
September 14-18, 2020

Additional Verification Remote Review:
November 16-18, 2020

On September 14-18, 2020, the Professional Team conducted a remote review of the Karen Clark & Company (KCC) KCC US Flood Reference Model Version 1.0. The following individuals participated in the remote review:

KCC
Christopher Burke, Ph.D., Senior Research Scientist
Karen Clark, CEO and President
Glen Daraskevich, Senior Vice President
Grant Elgin, Senior Software Engineer
Arnold Fernandes, Assistant Research Scientist
Michael Grayson, Ph.D., P.E., Consultant
Natalia Gust-Bardon, Ph.D., Research Statistician
Filmon Habte, Ph.D., Senior Wind Engineer
Nozar Kishi, Ph.D., Vice President of Model Development
Katelynn Larson, Senior Technical Writer
Marshall Pagano, Manager, Client Services
Daniel Ward, Ph.D., Senior Meteorologist
Joanne Yammine, FCAS, FCIA, Director of Actuarial Services
Yuanhao Zhao, Ph.D., Senior Hydrologist

Professional Team
Paul Fishwick, Ph.D., Computer Scientist
Tim Hall, Ph.D., Meteorologist
Chris Jones, P.E., Coastal Engineer
Mark Johnson, Ph.D., Statistician, Team Leader
Stu Mathewson, FCAS, MAAA, Actuary
Del Schwalls, P.E., CFM, Hydrologist
Shauna Urlacher, P.E., CFM, Hydrologist, observer only
Donna Sirmons, Staff

Due to the COVID-19 pandemic and State Board of Administration travel restrictions, the Professional Team conducted the traditional on-site review remotely. The remote review followed the on-site review process as detailed in the Report of Activities. The additional procedures described below applied to situations that were unique to the remote review.

KCC provided all necessary materials and data for review, whether in physical hard copy, electronic format, or virtually as agreed upon with the Professional Team members participating in the remote review (Professional Team) and Commission staff. All confidential trade secret materials and data provided by KCC directly to the Professional Team were not reproduced, recorded, copied, or duplicated in any manner by a Professional Team member. No trade secret materials or data were provided to Commission staff.

The physical hard copy documents provided to the Professional Team by KCC containing trade secret data and information were clearly designated on each page as trade secret through watermarks, footnotes, stamping or other means as appropriate.

The USB flash drives provided to the Professional Team by KCC containing electronic trade secret data and information were clearly labeled to reflect their proprietary nature.

Professional Team members only viewed, analyzed, and made edits or calculations utilizing the trade secret data and information directly on the USB flash drives provided by KCC and did not copy, duplicate, or store any electronic trade secret data and information to any other medium including personal computers or other devices.

KCC provided directly to the Professional Team, the physical hard copy materials and USB flash drives with some of the required electronic data one business day prior to the start of the remote review. Some of the information agreed upon to be provided in electronic format on a USB flash drive one business day prior to the start of the remote review was instead provided virtually prior to the commencement of the remote review. The guidelines call for the Professional Team members to ship the physical hard copy materials and USB flash drives directly to KCC via overnight delivery within one business day after completion of the remote review.

Each Professional Team member thoroughly reviewed all physical hard copy and electronic storage locations that were utilized during the remote review to ensure that all materials provided by KCC were returned or destroyed and that no record, copy, duplicate, derivative, or compilation of the information was within their possession. Each Professional Team member provided a written confirmation to Commission staff that 1) a comprehensive review was performed of all physical hard copy and electronic storage locations utilized during the remote review process, 2) all materials and information provided by KCC in support of the remote review were shipped to KCC via overnight delivery or destroyed, and 3) verified that the materials and data provided by KCC had not been reproduced, recorded, copied, or duplicated in any manner or stored on any medium including personal computers or other devices. Commission staff forwarded a copy of the written confirmations to KCC.

During the remote review, as during a traditional on-site review, the Professional Team and Commission staff restricted any note taking to a workbook prepared and provided by Commission staff or on the hard copy materials provided by KCC. At the completion of the remote review, the workbooks were shipped to KCC with the materials provided by KCC in advance of the remote review. KCC will review the remote review workbooks for notes KCC deems as trade secret information. Any workbook pages containing trade secret information as deemed by KCC are to be removed by KCC from the workbook and placed and sealed in an enveloped provided by Commission staff labeled "Contains Content Designated as Trade Secret Information by Karen Clark & Company." KCC will specifically identify what notes on a workbook page are deemed as trade secret and will be cautious not to designate as trade secret any publicly available information. KCC will send the sealed envelope and the remote review workbooks to Commission staff.

The sealed envelope will be retained by Commission staff in accordance with Florida public records law in a secure location. Commission staff will bring the sealed envelope to the Commission trade secret closed session where it will be unsealed and distributed for use during the closed session. At the end of the closed trade secret session, the notes will be placed in an envelope labeled "Contains Content Designated as Trade Secret Information by Karen Clark & Company" and sealed. The sealed envelope will be retained by Commission staff in a secure location until the retention schedule has been met at which time the sealed envelope will be destroyed and KCC informed.

Many hours and resources were dedicated by Commission staff, the Professional Team, and the KCC team in establishing the procedures and programs that were used in the remote review. The remote review would not have been possible without everyone's dedication to finding a workable solution.

The Professional Team began the remote review with an opening briefing and introductions were made. KCC discussed logistics and how materials would be presented and shared during the remote review. KCC next provided a general overview presentation on the flood model including details on the high resolution storm surge model simulating coastal flooding from tropical cyclones, the high resolution physically-based inland flood model using hydrologic and hydraulic simulation, and the building component-based engineering approach for development of the base vulnerability functions and for analysis of the effect of secondary building characteristics and mitigation measures.

The structure of the storm surge model was discussed in detail, including:

- calculation and validation of peak storm surge height
- impact of storm translation on peak surge
- calculation of the storm surge coastal profile
- amplification caused by coastal features
- inundation height and extent and validation with damage surveys
- accounting for storm surge on the exiting side of the coast and from by-passing storms.

The inland flood model was discussed in detail, including:

- defining precipitation events using historical Climate Prediction Center (CPC) data
- identifying events that lead to flooding in Florida
- calculating flood event size and shape
- accounting for the relationship between precipitation event intensity, extent, and duration
- the five distinct regions in Florida with similar climatology and the watershed boundaries
- generation of the stream network, identifying channels from the accumulated flow, and validation
- calibration of primary channels and model parameters
- distribution of excess surface water flow through a cellular-automata approach
- calibration of channel discharge and water surface levels
- validation of riverine and surface flooding
- developing the event catalog with consistent spatial coverage and selection of precipitation events and characteristics.

Inland and coastal flood vulnerability function development was discussed in detail, including:

- primary building characteristics used
- methods for estimating damage to building components
- calculation of hydrostatic and hydrodynamic loads
- estimation of wave heights
- estimation of broken, non-breaking, and breaking wave impacts on buildings

- derivation of damage functions for damage related to clean-up costs such as drying, dehumidification, sanitation, etc.
- derivation, implementation, and validation of contents vulnerability functions
- derivation, implementation, and validation of time element vulnerability functions
- secondary characteristics and mitigation measures included in the flood model.

The audit continued with a thorough review of each standards section.

During the Commission meeting to review the model for acceptability under the 2017 Flood Standards, KCC is to present the following information in the Trade Secret closed session as specified on pages 55 & 56 of the *Flood Standards Report of Activities as of November 1, 2017.*

1. Temporal evolution of coastal flood characteristics (Standard MF-4, Audit 8)
2. Temporal evolution of inland flood characteristics (Standard HHF-2, Audit 10)
3. Trade Secret Form HHF-3, Coastal Flood Characteristics by Annual Exceedance Probabilities
4. Trade Secret Form HHF-5, Inland Flood Characteristics by Annual Exceedance Probabilities
5. Trade Secret Form VF-4, Coastal Flood Mitigation Measures, Mean Coastal Flood Damage Ratios and Coastal Flood Damage/$1,000
6. Trade Secret Form VF-5, Inland Flood Mitigation Measures, Mean Inland Flood Damage Ratios and Inland Flood Damage/$1,000
7. Trade Secret Form AF-5, Logical Relationship to Flood Risk

KCC is also to address the following issue identified by the Commission during the April 28, 2020 meeting:

- Explain the disparity between actual and modeled inland flood losses.

The Professional Team additionally recommends presentation of the Trade Secret portions of SF-2 and SF-3.

Additional Verification Review – November 16-18, 2020

KCC submitted additional revisions to their submission documentation on October 23, 2020. The Professional Team conducted a remote additional verification review on November 16-18, 2020.

The following individuals participated in the additional verification review.

KCC

Christopher Burke, Ph.D., Senior Research Scientist
Glen Daraskevich, Senior Vice President
Grant Elgin, Senior Software Engineer
Natalia Gust-Bardon, Ph.D., Research Statistician
Filmon Habte, Ph.D., Senior Wind Engineer
Katelynn Larson, Senior Technical Writer
Daniel Ward, Ph.D., Senior Meteorologist
Joanne Yammine, FCAS, FCIA, Director of Actuarial Services

Yuanhao Zhao, Ph.D., Senior Hydrologist

Professional Team

Paul Fishwick, Ph.D., Computer Scientist
Tim Hall, Ph.D., Meteorologist
Chris Jones, P.E., Coastal Engineer
Mark Johnson, Ph.D., Statistician, Team Leader
Stu Mathewson, FCAS, MAAA, Actuary
Del Schwalls, P.E., CFM, Hydrologist
Donna Sirmons, Staff

As with the initial remote review, the second remote review followed the additional verification review process as detailed in the Report of Activities and the additional procedures described above for situations unique to the remote review.

KCC provided an overview of the model changes that occurred since the initial September review. The Professional Team discussed and reviewed in detail items identified in an additional pre-visit letter and outstanding open items from the September review as well as new issues that surfaced during the course of the audit.

After resolution of open items, 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 28, 2020 meeting. The deficiencies were eliminated by the established time frame, and the modifications have been verified. The page numbers below correspond to the initial February 29, 2020 submission document.

1. GF-1.C, page 15: Non-responsive. The scope is not defended in the response.

2. GF-1, Disclosure 2, page 16: Unclear and inconsistent. There is a lack of clarity and consistency on precipitation-model details. It is unclear whether precipitation rain rate or total event precipitation is being modeled for the intensity that feeds inland flooding.

3. GF-1, Disclosure 2, page 16: Incomplete. There is insufficient documentation for the following statements, (1) "…are determined from an analysis of the catalog of historical extreme precipitation events…" and (2) "…relationship derived from the historical extreme precipitation dataset." Detailed references or links to these datasets need to be provided; or, if developed in-house using other data sources, state this.

4. GF-1, Disclosure 2, page 19: Unclear. State how by-passing storms are included.

5. GF-1, Disclosure 2, page 20: Incomplete. V_{srm1} is not defined.

6. GF-1, Disclosure 2, page 21: Non-conformant. Provide a copy of the Venkatesh (1974) unpublished reference.

7. GF-1, Disclosure 2, page 22: Unclear. "…inundation depth at any point must be higher than the elevation…" Explain how the comparison of depth and elevation is done in order to generate the inundation area.

8. GF-1, Disclosure 2, page 23: Unclear. Explain how duplication of damage or increase in damage from inland flood and surge flood at the same location for the same storm is resolved.

9. GF-1, Disclosure 2, Figure 2, page 23: Non-conformant with the 2017 Flood Standards Report of Activities requirement for maps as (1) colors are incorrect, (2) legends are missing, and (3) maximum and minimum values are not present.

10. GF-1, Disclosure 2, page 23: Incomplete. Provide statistical references to support the terminology "non-parametric distributions."

11. GF-2.A, page 43: Incomplete. "Hydraulics" is a required area of expertise, yet it is not referenced.

12. GF-2, Disclosure 2.A, Table 1, pages 45-46: Incomplete. Table does not include university or relevant experience and responsibilities.

13. GF-2, Disclosure 2.A, Table 1, page 45: Incomplete. "Hydraulics" experience is not represented by team.

14. GF-3.E, page 53: Non-responsive. Response is a restatement of standard.

15. GF-3, Disclosure 1, page 53: Unclear. Explain "vulnerability regions," and how the National Flood Hazard Layer was used to generate the regions.

16. GF-3, Disclosure 8, page 55: Unclear. Explain how "flood plains" are incorporated into the Intensity Footprint Module.

17. GF-3, Disclosure 9, page 55: Incomplete. Provide the horizontal projection(s) of the data.

18. GF-3, Disclosure 9, page 55: Inconsistent. The response states that no conversions were required, yet per MF-2 Disclosure 11, the data is processed to a common coordinate system, and per HHF-2 Disclosure 3, USGS gauges referenced to NGVD29 were utilized.

19. Form GF-3, page 167: Non-conformant. Signatory of Hydrology and Hydraulics Flood Standards has no demonstrated hydraulics experience.

20. Form GF-4, page 168: Non-conformant. Signatory for Statistical Flood Standards does not have an advanced degree in statistics as required by Standard GF-2.B.

21. Form GF-5, page 169: Non-conformant. Signatory for Vulnerability Flood Standards has not demonstrated he is a licensed Professional Engineer as required by Standard GF-2.B.

22. MF-1, Disclosure 1 and Disclosure 4, pages 59-60: Inconsistent and unclear. The data range in Table 2 for Climate Prediction Center gauge-based precipitation starts in 1979, whereas the response to Disclosure 4 states it starts in 1948. Explain the contradiction, and if only data starting in 1979 were used, explain why.

23. MF-1, Disclosure 4, page 60: Incomplete. Insufficient justification provided on bilinear interpolation for downscaling gridded precipitation. Explain why such interpolation doesn't underestimate local extremes.

24. MF-2, Disclosure 1, page 61: Incomplete. Not all parameters for coastal flooding from GF-1 Disclosure 2 are listed; e.g., shoaling factors (bathymetry, coastal geometry) and amplification factors.

25. MF-2, Disclosure 2, page 62: Incomplete. The relationships among event precipitation, event duration, and event extent as developed by KCC require justification and description of methods.

26. MF-2, Disclosure 2, page 63: Incomplete. Provide the lower bound allowed for D.

27. MF-2, Disclosure 4, page 63: Unclear and incomplete. (1) Statements need to be clearer for the coastal parameters about stochastic versus fixed for R_{max} and translation direction. (2) Unclear how daily values of zero precipitation are treated with the continuous distribution being fit.

28. MF-2, Disclosure 8, page 65: Unclear. Explain whether and how tides were incorporated into the storm surge model. Was the "average tide height" an initial model condition or were all storm surge simulations made assuming a constant tide level?

29. MF-2, Disclosure 10, page 65: Unclear. Regarding the functional relationship between wave height and inundation depth, are waves taken to be depth-limited everywhere?

30. MF-2, Disclosure 11, page 65: Unclear. Explain the use of NAVD83.

31. MF-3.B, page 66: Non-responsive. Response is a restatement of the standard.

32. MF-3.C, page 66: Inadequate. Additional detail is needed. Explain what is meant by "the entire life of an event." Starting at what point in the storm's life cycle?

33. MF-3, Disclosure 6, page 68: Unclear. Justification is unclear for excluding non-tropical cyclones, as the significant event mentioned in NOAA 1994 was the March 1993 storm that produced record storm surge tide near Cedar Key, Florida.

34. MF-3, Disclosure 8, page 68: Non-responsive. Surge magnitude convergence as a function of simulation off-shore duration cannot be accommodated in this approach.

35. MF-4.A, B, and D, page 69: Non-responsive. Responses are a restatement of the standard.

36. MF-4, Disclosure 1, Figures 7, 8 & 9, pages 69-70: Non-conformant with the 2017 Flood Standards Report of Activities requirement for maps as (1) colors are incorrect, (2) legends are missing, and (3) maximum and minimum values are not present.

37. MF-4, Disclosure 2, page 70: Inconsistent. Treatment of waves is inconsistent compared to VF-1 Disclosure 5.

38. MF-4, Disclosure 3, page 70: Inconsistent. How the model accounts for velocity is inconsistent compared to VF-1 Disclosure 6a.

39. MF-4, Disclosure 5, page 71: Unclear. Explain the box in Figure 10, "Deduct elevation from surge depth to calculate inundation depth."

40. MF-4, Disclosure 10, page 73: Unclear. Explain the functional relationship between wave height and inundation depth and the extent to which waves are depth-limited.

41. MF-5.A and B, page 74: Non-responsive. Responses are a restatement of the standard.

42. MF-5.C, page 74: Unclear. Provide more detail on the functional relationship between wave height and inundation depth.

43. MF-5, Disclosure 2, page 74: Unclear. The distribution governing the occurrence frequency of precipitation events, as opposed to intensity, is not provided. Explain how the occurrence frequency is related to the Poisson flood frequency distribution shown in SF-1 Disclosure 5.

44. MF-5, Disclosure 2, page 75: Unclear. (1) "The variability in observed event duration relative to the expected duration based on the relationship with the precipitation amount is modeled as a random variable following a lognormal distribution," needs to be written clearly. (2) "The variability in the size of observed precipitation events relative to the size expected from the relationship with the precipitation amount is modeled as a random variable following a lognormal distribution," needs to be written clearly.

45. MF-5, Disclosure 3, page 75: Unclear and incomplete. Figure 12 is difficult to read; fonts are too small. Explain how the extrapolation is performed, why only the 20-year and 50-year return periods were provided, and why only at two sites. Text and Figure 12 legends indicate the tide gauge data are from NOAA whereas the figure caption indicates USGS. Provide a reference to the data source.

46. HHF-1, Disclosure 2, page 76: Non-responsive. Surface water flooding is not based on a "channel" or "stream." Explain how the analyses are segmented or the network is developed.

47. HHF-1, Disclosure 3, page 76: Unclear. The second sentence says the initial river discharge "of the model" is the mean yearly discharge. The next paragraph says that for historical simulations the initial and boundary conditions are the "minimum values observed" and are calibrated using 7-year windows.

48. HHF-1, Disclosure 3, page 76: Incomplete. There is no discussion of tides as a boundary condition.

49. HHF-2.C, page 79: Non-responsive. Response is a restatement of the standard.

50. HHF-2, Disclosure 1, Figures 13, 14 & 15, pages 80-81: Non-conformant with the 2017 Flood Standards Report of Activities requirement for maps as (1) colors are incorrect, (2) legends are missing, and (3) maximum and minimum values are not present.

51. HHF-2, Disclosure 1, page 80: Unclear. Explain “NA” in Figure 13.

52. HHF-2, Disclosure 2, Figure 16, page 82: Non-conformant with the 2017 Flood Standards Report of Activities requirement for maps as (1) colors are incorrect, (2) legend is missing, and (3) maximum and minimum values are not present.

53. HHF-2, Disclosure 3, pages 83-85: Unclear. Provide Figures 17-22 with the time scales shortened to highlight the specific events. Define HRR in Figures 17, 19, and 21.

54. HHF-2, Disclosure 5, page 86: Unclear and inconsistent. Explain how FEMA (2011) velocity approximation pertains to inland flood flow as the FEMA approximation was developed for overland storm surge flow. Text in GF-1 Disclosure 2, Intensity Footprint Module (page 18) states that inland flow velocity is based on the Manning equation and flood depth.

55. HHF-2, Disclosure 6, page 86: Incomplete. Provide more detail concerning initial and boundary conditions for riverine and lacustrine flooding, including initial flood stages.

56. HHF-3, Disclosure 1, page 88: Non-responsive. In addition to the data sources, provide a list of major flood control measures in Florida used in the model.

57. HHF-3, Disclosure 5, page 89: Unclear and non-conformant. Figure number is mislabeled and missing from the Table of Contents. The previous figure was labeled Figure 22. Indicate the location of the L-31 East levee in the figure. Non-conformant with the 2017 Flood Standards Report of Activities requirement for maps as (1) colors are incorrect, (2) legends are missing, and (3) maximum and minimum values are not present.

58. HHF-4.A, B, C, and D, page 90: Non-responsive. Responses are a restatement of the standard.

59. HHF-4, Disclosure 2, page 94: Incomplete. Address the logical relationship between the coincidence of storm tide and inland flooding with flood extent and depth.

60. HHF-4, Disclosure 2, page 94: Unclear. Explain “R” defined as “wet parameter.” In the next to last paragraph, there is either a missing word or incorrect comma placement, resulting in multiple interpretations.

61. Form HHF-1, Figures 47-54, pages 175-181: Non-conformant with the 2017 Flood Standards Report of Activities requirement for maps as (1) colors are incorrect, (2)

some legends are missing and those provided are too small to read, and (3) maximum and minimum values are not present in all the figure panels.

62. Form HHF-2, Figures 55-57, pages 183-184: Non-conformant with the 2017 Flood Standards Report of Activities requirement for maps as (1) colors are incorrect, (2) some legends are missing and those provided are too small to read, and (3) maximum and minimum values are not present.

63. Form HHF-4, Figures 58-62, pages 186-187: Non-conformant with the 2017 Flood Standards Report of Activities requirement for maps as (1) colors are incorrect, (2) some legends are missing and those provided are too small to read, and (3) maximum and minimum values are not present.

64. SF-1, Disclosure 3, page 96: Incomplete. Assessments of uncertainty using confidence intervals or other scientific characterizations of uncertainty are not provided.

65. SF-1, Disclosure 5, page 96: Unclear. In Figure 26 there appears to be mass at event number less than 0, and while the data are discrete, the modeled fit is difficult to assess.

66. SF-1, Disclosure 5, page 97: Inadequate. Provide information on the historical events used in the evaluation.

67. SF-1, Disclosure 5, page 97: Unclear. Explain what is meant by Pearson's test on the independence of residuals and cite a reference. Explain how this test demonstrates agreement with historical observations. The same issues exist for discharge and peak surge.

68. SF-2, Disclosure 1, pages 100-102: Incomplete. Document the references to the sensitivity analysis as was done in Form S-5 for the hurricane model submission.

69. SF-3, Disclosure 1, pages 103-105: Incomplete. Document the references to the uncertainty analysis as was done in Form S-5 for the hurricane model submission.

70. SF-5, Disclosure 1, pages 110-111: Unclear. Explain why there is a much greater disparity between modeled and actual flood loss for inland floods than coastal floods.

71. VF-1.D, page 112: Unclear. Explain how lateral and vertical hydrostatic, hydrodynamic, and wave forces are accounted for in the model.

72. VF-1.E, page 112: Unclear. Clarify how the model defines "lowest floor elevation" for inland and coastal flood: (1) are they the same or different, and (2) are they the same as the NFIP and Florida Building Code (FBC) definition for A zones (top of floor) and V zones (bottom of lowest horizontal member supporting floor). Explain how vulnerability functions account for any differences in lowest floor definitions.

73. VF-1, Disclosure 2, page 113: Unclear. Indicate if the building components listed (i.e., walls, openings, wall-to-foundation connections, foundation, and roof) are the complete

list. Indicate if other building components subject to damage when wet (e.g., interiors, equipment) are addressed by vulnerability functions, and if so, how.

74. VF-1, Disclosure 2, page 113: Unclear. Explain what is meant by "direct" damage, "progressive" damage, and "functional" damage. Explain how vulnerability functions account for damage to structural and non-structural elements.

75. VF-1, Disclosure 2, page 113: Unclear. Explain how individual component vulnerabilities are combined.

76. VF-1, Disclosure 2, page 114: Unclear. Clarify the relationship of first floor height to lowest floor.

77. VF-1, Disclosure 2, page 114: Unclear. Explain what is meant by the phrase, "thereby reducing the total building load" in the penultimate sentence in the third paragraph.

78. VF-1, Disclosure 3, page 114: Unclear. Explain how "flood zone" was used in the comparison of actual (claims) and modeled flood damage.

79. VF-1, Disclosure 3, page 114: Unclear and inconsistent. Fourteen events are noted while Table 5 (SF-5 Disclosure 1) contains thirteen events.

80. VF-1, Disclosure 3, page 115: Incomplete. Refinements made to vulnerability functions as a result of claims data comparison not provided.

81. VF-1, Disclosure 5, page 115: Unclear. Explain what is meant by the term "elevated," since some of the "not-elevated" foundations do in fact elevate the floor above the ground.

82. VF-1, Disclosure 5, page 115: Inconsistent. Classification of hydrodynamic loads (including velocity and wave) is different than the classification of hydrodynamic in VF-1.D and VF-1 Disclosure 2 (velocity only, no waves), and elsewhere in VF-1 Disclosure 5.

83. VF-1, Disclosure 5, page 115: Incomplete. Explain the effect of the depth-limited wave assumption on validation of vulnerability functions with claims data corresponding to claims subject to less-than-depth-limited wave conditions.

84. VF-1, Disclosure 6.a, page 116: Unclear. Explain how velocity is calculated from FEMA (2011), which provides lower and upper bound estimates, and how velocity is incorporated into vulnerability function development.

85. VF-1, Disclosure 7.b, page 117: Unclear. Explain how pre- and post-FIRM (Flood Insurance Rate Map) buildings are designated and indicate which FIRM is used to make such a designation.

86. VF-1, Disclosure 7.b, page 117: Incomplete. Provide the origin of Table 7 relating First Floor Height (FFH) and foundation type.

87. VF-1, Disclosure 7.b, page 117: Unclear. Explain the column heading “Coastal A Zone” in Table 7 and its consistency with FBC and FEMA use of the term. Explain the implications of the KCC usage of the term for assumed foundation types and FFHs.

88. VF-1, Disclosure 7.b, page 117: Unclear. Explain how all post-FIRM V Zone foundations listed are used by the flood model, as several are not compliant with NFIP or FBC V Zone requirements. Explain how using all the post-FIRM V Zone foundations would affect designation of foundation type for unknown foundations, vulnerability function validation, or model loss predictions.

89. VF-1, Disclosure 7.c, Table 8, page 118: Unclear. Describe how unreinforced and reinforced masonry are weighted.

90. VF-1, Disclosure 7.c, page 118: Unclear. Indicate if manufactured home tie-down assumptions are the same or different in Disclosures 7.c and 7.d.

91. VF-1, Disclosure 7.c, Table 9, page 119: Incomplete. Explain how different editions of the FBC exceeded minimum NFIP requirements and how different FBC editions were incorporated into flood vulnerability functions.

92. VF-1, Disclosure 9, page 120: Unclear. Explain how the NFIP’s Community Rating System has been factored into building characteristics, vulnerability zones, and vulnerability function development.

93. VF-1, Disclosure 9, page 120: Incomplete. Explain how different editions of the FBC exceeded minimum NFIP requirements.

94. VF-1, Disclosure 9, page 121: Unclear. Explain whether Florida’s Coastal Construction Control Line or Coastal Building Zone requirements have been factored into building characteristics tied to year-built bands.

95. VF-2, Disclosure 4, page 124: Unclear. Explain how “flood zone” was used in the comparison of actual (claims) and modeled flood damage.

96. VF-2, Disclosure 4, page, 124: Incomplete. Refinements made to vulnerability functions as a result of claims data comparison not provided.

97. VF-2, Disclosure 7, page 125: Unclear. Explain how contents vulnerability functions are set for cases where there is no structural damage.

98. VF-3, Disclosure 8, page 128: Inconsistent and unclear. Disclosure 8 says time element vulnerability functions do not explicitly distinguish between direct and indirect loss, yet VF-3 Disclosure 2, page 127 says time element losses can be divided into direct and indirect losses. Explain how direct and indirect time element losses are combined.

99. VF-4, Disclosure 2, Table 13, page 130: Unclear. Explain how vulnerability functions account for utility equipment.

100. AF-1, Disclosure 1, page 133: Incomplete. Provide a sample calculation for determining property value.

101. AF-2, Disclosure 5, page 141: Inconsistent. AF-1, Disclosure 3 includes water intrusion per s.627.715 FS.

102. AF-4.A-F, page 144: Non-responsive. Responses are a restatement of the standard.

103. Form AF-1, Figures 65-67, pages 206-207: Unclear. Make the minimum and maximum location and values legible.

104. Form AF-2, page 212: Incomplete. Provide the missing entries in Table 22 for Hurricanes Irma and Michael.

105. Form AF-3, Figure 72, page 226: Unclear. Make the minimum and maximum location and values legible.

106. Form AF-4.F, page 258: Non-responsive. No response given.

107. CIF-5, Disclosure 3, Table 16, page 159: Explain the verification approaches for the externally acquired data provided in Table 16.

Professional Team Pre-Visit Letter

The Professional Team's pre-visit letter questions are provided in this report under the corresponding standards. The first pre-visit letter with questions 1-83 was sent on April 30, 2020. After KCC submitted a revised submission in response to the deficiencies, a second pre-visit letter with questions 101-126 was sent on June 25, 2020. After KCC submitted a revised submission following the initial remote review, a third pre-visit letter with questions 201-210 was sent on October 30, 2020. Following is the preamble included in the combined pre-visit letters.

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

The Professional Team will also be considering material in response to the deficiencies and the issue designated by the Commission during the April 28, 2020 conference call meeting. After review of the new material submitted in response to the deficiency letter, the Professional Team may have additional questions to be sent in a subsequent pre-visit letter.

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

The on-site schedule is tentatively planned to proceed in the following sequence: (1) thorough, detailed presentations on each model component; (2) section by section review commencing within each section with pre-visit letter responses; (3) responses to flood standards in the *Flood Standards Report of Activities as of November 1, 2017*; and (4) responses to the audit items for each flood standard in the *Flood Standards Report of Activities as of November 1, 2017*.

If changes have been made in any part of the model or the modeling process from the descriptions provided in the original February 29, 2020 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 all revised forms where any output changed. For each revised form, provide an additional form with cell-by-cell differences between the revised and originally submitted values.

Refer to the On-Site Review section of the *Flood Standards Report of Activities as of November 1, 2017* 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 on pages 76-77. These requirements are reproduced at the conclusion of this letter.

For your information, the Professional Team will arrive in business casual attire.

The pre-visit comments are grouped by flood standards sections.

June 25, 2020: After reviewing the May 29, 2020 revised submission in response to the deficiencies identified by the Commission, the Professional Team has additional pre-visit letter questions which have been inserted in blue text under the applicable standard section starting with number 101. The page numbers in the new questions refer to the May 29, 2020 track changes submission document.

October 30, 2020: In keeping with the numbering format from the previous letters, questions start with number 201. The page numbers refer to the October 23, 2020, track changes submission document.

Editorial Items

Editorial items were noted by the Professional Team in the pre-visit letters for correction prior to the start of the remote review in order to facilitate efficiency during the review and to avoid last minute edits. Additional editorial items were also noted during the remote review.
The Professional Team reviewed the following corrections to be included in the revised submission to be provided to the Commission no later than 10 days prior to the meeting to review the model for acceptability. Page numbers below correspond to the revised May 29, 2020 submission document.

1. Table of Contents, List of Figures, page 13: Label for Figure 66 missing “for” after exposure; Figures 77 and 78 misnumbered
2. Table of Contents, List of Tables, page 17: Table 24 as given on page 237 missing from list; Tables 24 and 25 misnumbered
3. GF-1, Disclosure 2, pages 21-22: Definition and equation inconsistency with “I” versus “*i*” and “w” versus “W”
101. GF-1, Disclosure 2, page 24: Missing return right after V_{srm1} definition in non-track change revised document.
4. GF-1, Disclosure 2, page 27: Unanwa misspelled in 4^{th} paragraph; non-parametric distributions changed to empirical distributions
5. GF-1, Disclosure 4, page 33: Correct alphabetical order of Agel reference
6. GF-1, Disclosure 4, page 35: In Guidolin reference, “weighed” should be “weighted”
7. GF-1, Disclosure 4, page 38: Correct alphabetical order of Angus and Andrews references
8. GF-1, Disclosure 4, page 41: Caraballo-Nadal et al. 2006 reference duplicated
9. GF-1, Disclosure 4, page 43: “Management” misspelled in FEMA 2011 reference; correct alphabetical order of reference
10. GF-1, Disclosure 4, page 46: In Mitchell reference, “hiller” should be capitalized
102. GF-2, Disclosure 1.A, page 57: Zhao experience, “…Zhao has completed courses…”
11. MF-2, Disclosure 2, page 76: Definition and equation inconsistency with “*Extent*” versus “Extent”
103. MF-5.C, page 91: Remove boldface in response and add a return before part D as evidenced in the non-track changes document.
12. MF-5, Disclosure 2, page 91: For R_{max}, insert “increasing” before each of V_{max} and latitude to make it clearer
13. HHF-4, Disclosure 1, Table 3, page 114: In County column, “Dade” should be “Miami-Dade”
14. HHF-4, Disclosure 2, page 118: Insert “in” after “increase” in penultimate paragraph
104. SF-1, Disclosure 5, page 123: New Table 5 was added. Table numbers have been updated in Table captions, but many Table references in text are incorrect.
15. SF-4, Disclosure 1, page 135: “TD” not in list of acronyms; “F” should be “FS” as provided in acronym list
105. VF-1, Disclosure 2, page 142: “…similar to the lowest floor definition…”
16. VF-3, Disclosure 1, Figure 41, page 156: In top box, “element” is missing, should be “building-to-time element damage ratio”
17. VF-4, Disclosure 2, Table 14, page 161: In Description column for Wet Floodproofing, “inside of outside” should be “inside or outside”
18. AF-1, Disclosure 5, page 167: Unbold first paragraph in response
106. AF-4.F, page 174: Typo in last sentence.
19. CIF-3.B, Figure ~~45~~42, page 183: In box below START, “Files(s)” should be “File(s)”
20. CIF-4, Disclosure 1, page 185: In DotNetZip bullet, period is missing between Zip and dll
107. Form GF-3, page 197: Correct “M.S.”
21. Form GF-4, page 198: Should Joanne Yammine’s credentials be “B.S.” or “B.M.”?
22. Form GF-6, page 203: In item 1, “vulnerability” should be “actuarial” and should Joanne Yammine’s credentials be “B.S.” or “B.M.”?
108. Form HHF-2, page 220: The text statement above Figure 52, “The following maps have been created with RiskInsight’s default color scheme…” is no longer relevant.
23. Form HHF-2.B, page 220: In Figure ~~55~~52 caption, “St. Lucia County” should be “St. Lucie County”

24. Form HHF-2.B, page 222: In Figure ~~57~~54 caption, "St. John's County" should be "St. Johns County"
25. Form HHF-4.B, Figure 58, page ~~187~~226: In caption, "(top)" should be "(left)" and "(bottom)" should be "(right)"
26. Form VF-1.D, page 236: Figure 63 caption not the same as given in Table of Contents
27. Form VF-2.D, page 239: Figure 64 caption not the same as give in Table of Contents
28. Form AF-1.C, page 250: Period missing at end of sentence
29. Form AF-4, pages 294-344: Column title "Hurricane Loss Costs" should be "Flood Loss Costs"
30. Appendix G: Acronyms, page 370: FGDL, FWMD, NCEP, and NGVD29 omitted; NAVD/NAVD88 and NAD/NAD 83 incomplete; defined North American Datum of 1983 incorrectly identified as NAVD83
31. Appendix G: Acronyms, page 370: In FCHLPM, "Methodologies" should be "Methodology"
32. Appendix G: Acronyms, pages 371-372: ILS, M.A., M.B.A., and M.S. duplicated
33. Appendix G: Acronyms, page 372: P definition incomplete; Precipitation parameter including what?

Submission revisions made and reviewed during the September remote review:

1. GF-1, Disclosure 2, page 20: Corrected number of locations covering the basins that affect Florida
2. GF-1, Disclosure 2, page 24: Clarification added on peak storm surge calculation
3. GF-1, Disclosure 2, page 27: Non-parametric distributions changed to empirical distributions
4. GF-1, Disclosure 4, page 34: DeWitt et al. (2015) and Feng & Beighley (2020) hydrological/hydraulic references added
5. GF-1, Disclosure 4, page 38: Zhang et al. (2019) and Zhao & Beighley (2016) hydrological/hydraulic references added
6. GF-1, Disclosure 4, page 39: Southwest Florida Water Management District (2005) hydrological/hydraulic reference added
7. GF-3, Disclosure 5, page 67: Corrected clustering algorithm to k-means
8. GF-3, Disclosure 9, page 68: Clarification added on datum conversions
9. HHF-3, Disclosure 1, page 110: Clarification added on Florida major dams and levees resources
10. SF-1, Disclosure 5, page 121: Figure 26 revised
11. SF-3, Disclosure 1, pages 133-134: Figures 32 & 33 revised
12. VF-1, Disclosure 5, page 144: Clarification added on breaking and non-breaking waves
13. VF-1, Disclosure 7.b, page 146: Clarification added on foundation type
14. Form SF-1, page 231: Spatial extent and duration distributions revised

Submission revisions made and reviewed during the November remote additional verification review:

1. GF-1, Disclosure 2, page 19: Updated precipitation events discussion to include duration
2. GF-1, Disclosure 2, page 26: Updated text for consistency with updated methodology
3. GF-1, Disclosure 4, pages 39-41: Finger (2013), Muhlbauer et al. (2009), and Yellowlees et al. (2016) statistical references added

4. HHF-4.D, page 115: Clarification added on the method accounting for coastal and inland flooding overlap
5. HHF-4, Disclosure 2, page 122: Text corrected on the method accounting for coastal and inland flooding overlap
6. SF-1, Disclosure 5, page 127: *E* values corrected in Table 5
7. Form SF-1, page 238: Rmax, spatial extent, and duration distributions corrected
8. Form AF-6, pages 363-364: Form revised

GENERAL FLOOD STANDARDS – Mark Johnson, Leader

GF-1 Scope of the Flood Model and Its Implementation

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. The modeling organization shall maintain a documented process to assure continual agreement and correct correspondence of databases, data files, and computer source code to slides, technical papers, and modeling organization documents.

C. All software and data (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.

Audit

1. All primary technical papers that describe 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.

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

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

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

5. 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.

6. 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. 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:
   1. Between the initial submission and the revised submission, and
   2. Between any intermediate revisions and the revised submission.

7. 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.

Pre-Visit Letter

1. GF-1, Disclosure 2, page 16 (revised page 19): Provide basin map indicating the rainfall locations used in the inland flood model, and the basins affecting Florida which they cover.

2. GF-1, Disclosure 2, pages 17-21 (revised pages 20-24): Provide a table or list of where each equation is further documented and implemented (e.g., the file names).

3. GF-1, Disclosure 2, page 17 (revised page 20): Given the 60-minute time step for simulating peak flood stages in surface water/riverine flooding, explain how the model accounts for missing peaks occurring between the 60-minute time step, which could underestimate flooding, especially in urban/neighborhood areas with intense-rainfall driven surface water flooding. Explain how this time step is associated to the 5-minute interval in the surge model.

4. GF-1, Disclosure 2, page 17 (revised page 20): Provide sub-basin map for modeled surface water flooding, including supporting topographic information.

5. GF-1, Disclosure 2, Coastal, pages 19-22 (revised pages 22-26): The storm-surge modeling approach is based on techniques and publications from the 1960s and 1970s. This does not constitute the "current scientific and technical literature" required by Standard MF-2.A. In-house research and development could, in principle, make up for a lack of relevant current literature, but such development is not sufficiently reported in the submission. It is therefore expected that much more in-house research and development has occurred than is reported in the submission that adapts these older techniques to current data and raises their performance to levels comparable to modern techniques. This in-house research and development will be reviewed in detail. Two key examples are:
   a) Peak Storm Surge formula: Jelesnianski (NOAA report, 1972) describes an approach similar to that described in the submission, but it does not supply a regression relation equivalent to the peak surge equation. Therefore, the peak-surge equation needs to be justified as independent research. What data were used? How good is the fit? How are the approaches of the referenced studies further refined by KCC?
   b) The surge modification for translation speed, direction, bathymetry, coastal geometry (shoaling), and local amplification: Provide extensive detail on these developments, including the methodology, data sources, and quantitative analysis on the fits to observations.

6. GF-1, Disclosure 2, Inland, pages 16-18 (revised pages 19-22): Substantial additional detail needs to be provided. Explain how a precipitation "event" is defined in the KCC Event Catalog in terms of total rain, duration, or area. Are events spatially correlated? Do events translate in space? The Inland Event description does not mention translation, but modeling of Tropical Storm Fay (2008) indicates rainfall throughout Florida (HHF-2 Disclosure 1, Figure 13), as if following Fay's track. Relatedly, is precipitation and associated flooding from surge-and-wind producing hurricanes treated differently

than other inland flood events? If so, is there correlation between surge and precipitation-driven flood events?

7. GF-1, Disclosure 2, Inland, pages 16-18 (pages 19-22): Provide more detail on the occurrence probability of events. The Pareto distribution analysis of Papalexiou et al. (2013) is mixed type (i.e., given a non-dry day, provide the rain amount). It provides the probability of the event intensity, given an event, but what is the first step that provides the probability of having an event of any intensity? Figure 26 in SF-1 Disclosure 5 indicates a Poisson event frequency, and a Poisson event distribution is indicated in Form SF-1. What is the threshold in the historical data analysis that defines a rain event?

101. GF-1, Disclosure 2, page 20: Provide the model fits and underlying data associated with the regression analysis of extent and total precipitation.

201. GF-1, Disclosure 2, page 21: Provide an explanation for channel discharge method and calculation.

8. GF-1, Disclosure 2, page 19 (revised page 22): Explain how isolated ponding in Digital Elevation Model (DEM) cells is addressed in inland model compared to method in surge model?

9. GF-1, Disclosure 2, page 21 (revised page 24): Provide a copy of Rao and Majumdar (1966) in the "Indian Journal of Meteorology and Geophysics," which is hard to access online.

102. GF-1, Disclosure 2, page 27: Explain how Wasserman (2006) addresses the terminology issue, as "non-parametric distributions" is not mentioned in this cited reference.

10. GF-1, Disclosure 6, page 42 (revised page 47): Describe in detail the development of the modeler exposure dataset.

Verified: ~~**NO**~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed the documented process assuring agreement and correspondence of databases, data files, and computer source code to slides, technical papers and KCC documents illustrated throughout the audit, especially with regard to key equations.

Reviewed table of equations and revisions made in corresponding documentation. Reviewed table of equations and corresponding variables cross reference.

Reviewed the KCC centralized, model-level file areas associated with the model, its validation, projections of modeled flood loss costs and probable maximum loss levels, and generation of Commission required forms.

Discussed the basis for a 60-minute time step for capturing precipitation accumulation and modeling inland flood. Discussed the time steps used for inland and coastal flood analysis.

Reviewed the regression fits of spatial extent and total precipitation.

Discussed the treatment of ponding.

Reviewed the following maps, databases and data files:

- Basin map with rainfall locations used in the inland flood model and the basins affecting Florida which they cover
- Sub-basin map for modeled surface water flooding and topography
- Sub-basin map with surface roughness
- ZIP Code centroid maps
- NFIP redacted policies dataset
- FEMA National Flood Hazard Layer (NFHL)
- KCC's comprehensive exposure dataset
- Intensity footprints, results from post-event damage surveys, NOAA imagery, storm data, USGS high water marks, stream gauge datasets, and SLOSH
- Hydraulic network riverine and lacustrine flood map
- Hydraulic network surface water map
- Basins map at 1 arc-second resolution
- NOAA Storm Events Database for water levels and locations
- Map with NOAA flood depths superimposed
- Validation maps for Hurricanes Andrew (1992), Ivan (2004), Jeanne (2004), and Wilma (2005)
- Major flood control measures map
- Map defining the regions for event precipitation in the model
- Damage/exposure ratios for each of the 8 reference structures used in Forms VF-1 and VF-2
- Table of 1,000 years of Form AF-6 events showing the value of each event for each year.

Reviewed differences in modeled versus historical flood losses in Forms AF-1, AF-2, AF-3, and AF-4 and explanations for the differences.

Reviewed model changes from the February 29, 2020 submission to the May 29, 2020 submission:

- Adjusted historical precipitation rate within the uncertainty in the rate for specific events
- Addition of a levee
- Modifications to the inland flood footprints in response to anomalies identified after the initial submission that resulted in changes to the modeled results
  - ♦ Closing of channel gaps in riverine flooding
  - ♦ Correcting negative DEM values in the USGS data
  - ♦ Refined surface flooding in the Peace River/Tampa basin
  - ♦ Updated the stochastic precipitation event set with new regression relationships.

Reviewed the development of the KCC comprehensive exposure dataset.

Discussed handling of discrepancies among flood datasets.

Reviewed rainfall map from Tropical Storm Fay (2008) and discussed how the impact of translating rain events are captured in the rain event set.

Reviewed an example of a stochastic rain event with extent similar to Tropical Storm Fay (2008).

Reviewed footprint comparison of modeled stochastic rainfall events to historical events on several barrier islands.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed model changes implemented since the initial review in September:

- Inland Flood Model
    - ♦ New regression models for event duration and precipitation amount, and spatial extent and precipitation amount impacting event parameter values
    - ♦ A modeled basin was revised to improve model validation to historical events
    - ♦ A modeled basin and channel network was updated
- Coastal Flood Model
    - ♦ Coastal event set updated to be consistent with the updated hurricane model event set
- Updated methodology for estimating damage for locations impacted by both inland and coastal flood during a single event

Reviewed the impact on modeled loss costs as a result of each model change.

Reviewed the channel discharge method and calculation using the Muskingum-Cunge routing method.

Reviewed scientific references supporting the modeling of the total event precipitation and duration relationship.

Reviewed methodology to remove ponding in coastal flood.

Reviewed revised flowchart required by Audit Item 2.

Verified after resolution of open issues.

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

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 licensed Professional Engineer(s) with experience in coastal and inland flooding), meteorology (advanced degree), statistics (advanced degree), structural engineering (licensed Professional Engineer(s) with experience in coastal and inland flooding), 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.

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.

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.

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.

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.

Pre-Visit Letter

11. GF-2, Disclosure 2.A, Table 1, pages 45-46 (revised pages 50-57): Provide resumes for every individual involved in the development and implementation of the model.

Verified: YES

Professional Team Comments:

Reviewed resumes of modeling personnel:

- Kioumars Afshari, Ph.D. in Geotechnical Earthquake Engineering, Statistics and Structural Engineering minors, University of California, Los Angeles, CA; M.Sc. in Geotechnical Engineering, Sharif University of Technology, Tehran, Iran; B.Sc. in Civil Engineering, Sharif University of Technology, Tehran, Iran

- Vivek Basrur, M.S. in Management Sciences, University of Waterloo, Waterloo, Ontario, Canada; Continuing research towards a Ph.D. in Water Resources Management and Operations Research, Harvard University and MIT, Cambridge, MA; Graduate research towards Ph.D. in Water Resources Management and Operations Research, Indian Institute of Technology, Delhi, India; B. Technology in Civil Engineering/Structures, Indian Institute of Technology, Delhi, India

- Christopher Burke, Ph.D. in Physics, Tufts University, Medford, MA; M.S. in Physics, Tufts University, Medford, MA; B.S. in Physics, Lehigh University, Bethlehem, PA

- Karen Clark, M.B.A. and M.A. in Economics, Boston University, Boston, MA

- Adrian Corman, Ph.D. in Physics, University of Missouri, Columbia, MO; B.S. in Physics and Mathematics, College of Charleston, Charleston, SC

- Glen Daraskevich, M.S. in Information Systems, Boston University Questrom School of Business, Boston, MA; M.S. in Environmental Engineering, University of New Haven, West Haven, CT; B.S. in Civil Engineering, University of Connecticut, Storrs, CT

- Adam Dimanshteyn, B.A. in Economics and Mathematics, Boston University, Boston, MA

- Grant Elgin, Boston University MET computer science fundamentals, discrete math, data structures and algorithms course work, Boston, MA; University of Alabama, Civil Engineering course work, Tuscaloosa, AL; Suffolk University, Electrical Engineering course work, Boston, MA

- Arnold Fernandes, M.A. in Earth Sciences, Boston University, Boston, MA; M.S. in Geology, University of Mumbai, India; B.S. in Geology with Minors in Physics and Mathematics, University of Mumbai, India

- James Michael Grayson, Ph.D. in Civil Engineering, Clemson University, Clemson, SC; M.S. in Civil Engineering, Clemson University, Clemson, SC; B.S. in Civil Engineering, Clemson University, Clemson, SC

- Natalia Gust-Bardon, Ph.D. in Economics, University of Szczecin, Szczecin, Poland; M.S. in Statistics and Data Science, University of Texas at San Antonio, San Antonio, TX

- Filmon Habte, Ph.D. in Civil, Structural/Wind Engineering, Florida International University, Miami, FL; M.Sc. in Civil/Structural Engineering, Florida International University, Miami, FL; B.Sc. in Civil Engineering, University of Asmara, Asmara, Eritrea

- Nozar Kishi, Post-Doctoral Fellowship 1992 Earthquake Engineering, University of California, Los Angeles, CA; Ph.D. in Earthquake Engineering, Kyoto University, Kyoto, Japan; M.Sc. in Structural Dynamic, Kyoto University, Kyoto, Japan; B.Sc. in Structural Engineering, Sharif University of Technology, Tehran, Iran

- Katelynn Larson, B.A. in English/Communications Literature and Creative Writing, Massachusetts College of Liberal Arts, North Adams, MA

- Linshou Li, M.S. in Information Technology, Worcester Polytechnic Institute, Worcester, MA

- Marshall Pagano, B.S. in Mathematics, Quantitative Economics, Tufts University, Medford, MA

- Daniel Ward, Ph.D. in Atmosphere Science, Colorado State University, Fort Collins, CO; M.S. in Atmospheric Science, Colorado State University, Fort Collins, CO; B.S. in Agricultural and Life Sciences with concentration in Atmospheric Science, Cornell University, Ithaca, NY

- Joanne Yammine, FCAS, B.S. in Mathematics with concentration in Actuarial Science, Université de Montréal, Montreal, Quebec, Canada

- Yuanhao Zhao, Ph.D. in Civil Engineering, Northeastern University, Boston, MA; M.S. in Water Resources Engineering, Marquette University, Milwaukee, WI; B.E. in Civil Engineering, South China University of Technology, Guangzhou, China

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

Reviewed Forms GF-1 through GF-7.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed revised Forms GF-1 through GF-7.

GF-3 Insured Exposure Location

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 hazard or any flood model vulnerability components are dependent on databases pertaining to location, the modeling organization shall maintain a logical process 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.

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.

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.

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

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

5. Flood model geocode location databases will be reviewed.

Pre-Visit Letter

12. GF-3.B, page 53 (revised page 66): Provide evidence that the ZIP Code centroids are within their boundaries (e.g., via visual inspection).

13. GF-3.C, page 53 (revised page 66): Explain the logical process to ensure consistency and updating of databases.

14. GF-3, Disclosure 1, page 53 (revised pages 66-67): Discuss the quality control review measures performed on the NFIP Redacted Policies Dataset (2020). What is the process used to resolve records

in the dataset where claims data incorrectly indicates wind damage that was actually surge damage (e.g., Hurricane Michael (2018), Mexico Beach)?

15. GF-3, Disclosure 1, page 53 (revised pages 66-67): Discuss the quality control review measures performed on the FEMA National Flood Hazard Layer (NFHL) dataset.

103. GF-3, Disclosure 1, page 67: Explain how the non-NFIP, non-CRS, and CRS Class 10 communities were assessed in the vulnerability regions.

16. GF-3, Disclosure 2, page 54 (revised page 67): Provide a detailed explanation of the process for “is found to be invalid,” regarding ZIP Codes or geocodes.

17. GF-3, Disclosure 4, page 54 (revised page 67): When an exact match to the street number cannot be found and a geocode for the entire street is returned, explain how KCC ensures the resulting geocode is representative of the actual location, especially with roads that cross multiple riverine flooding sources and flood zone boundaries, or cross ZIP Code boundaries.

18. GF-3, Disclosure 5, page 54 (revised page 67): Explain the basis for the cluster analysis approach and the use of the k-nearest neighbor algorithm. Explain in more detail the development and contents of the KCC dataset.

104. GF-3, Disclosure 9, page 68: Identify the horizontal datums that are associated with the various datasets and how they were converted to a consistent datum.

Verified: **YES**

Professional Team Comments:

Reviewed spatial distributions of insured exposures.

Reviewed ZIP Code boundaries and centroids for the entire state. Reviewed the quality check process to ensure no exposures fall over water or other uninhabitable terrain. Checked displays for geo-points over water or in uninhabitable terrain.

Reviewed the process to ensure consistency and updating of databases.

Discussed the use of the Community Rating System (CRS) to classify Florida into regions with different levels of flood vulnerability.

Discussed the process for geocoding complete and incomplete street addresses. Discussed the process for handling invalid address data or geocodes. Reviewed a stress test example showing how incomplete input data are resolved.

Reviewed geocode location databases.

Reviewed quality control review measures for the NFIP Redacted Policies Dataset. Discussed the assumption that the NFIP paid claims data is due to flooding and that wind losses are not included.

Reviewed quality control review measures performed on the FEMA National Flood Hazard Layer datasets.

Reviewed explanation of invalid ZIP Codes or geocodes.

Reviewed the cluster analysis approach in the exposure dataset development.

Reviewed horizontal projections and datums, and vertical datums associated with various datasets and their conversions to a consistent system.

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.

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.

Verified: ~~NO~~ **YES**

~~Pending resolution of open issues~~

Professional Team Comments:

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

Discussed the process for developing, validating, and implementing the different model components. Reviewed flowchart for model development, software development, and exposure and loss processing identifying personnel involved at each step.

Reviewed flowcharts of model software components.

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

*****Additional Verification Review – November 16-18, 2020*****

Throughout the course of the two reviews, there was no evidence to suggest that one component of the model was deliberately adjusted to compensate for another component.

Verified after resolution of open issues.

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.***

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, 2017* will be made.

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.

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.

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

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

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

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed the staff and editorial processes used in preparing the submission document.

Reviewed the modification history for the flood-model submission documentation.

Reviewed flowchart and the process for form creation. Reviewed revisions made to the flowchart during the review.

Reviewed Form GF-8.

Editorial items noted in the pre-visit letters and during the remote review by the Professional Team 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.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the modification history for the submission documentation.

Verified after review of open items.

METEOROLOGICAL FLOOD STANDARDS – Tim Hall, Leader

MF-1 Flood Event Data Sources

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.

Audit

1. The modeling organization's data sources will be reviewed.
2. Justification for any modification, partitioning, or adjustment to historical data and the impact on flood model parameters and characteristics will be reviewed.
3. The method and process used for calibration and validation of the flood model, including adjustments to input parameters, will be reviewed.

Pre-Visit Letter

19. MF-1, Disclosure 4, page 60 (revised page 73): Provide an example of downscaling rainfall from 0.25° to 0.08° grids.

Verified: **YES**

Professional Team Comments:

Reviewed an example of bilinear interpolation of the Climate Prediction Center (CPC) rainfall data from its native 0.25° grid to a 0.08° grid. Discussed data issues related to the CPC dataset. Discussed and reviewed application of CPC data to inland event generation.

Discussed the hurricane data (HURDAT2, Extended Best Track).

Reviewed the flood-event data sources.

Discussed that no modifications, partitioning, or adjustments were made to the historical data used in development of the model flood climatology.

Reviewed the peak surge calculation and comparison of the modeled peak surge to historical observations.

Reviewed the treatment and discussed the scientific references for bay amplification and shoaling for peak surge. Reviewed the data for assigning amplification factors.

Reviewed the storm surge coastal profile shape developed using historical storm tide data.

Reviewed calibration and validation of the channel discharge and water surface elevation. Reviewed a graphical representation of the USGS gauge locations in the Florida basins. Reviewed plots comparing modeled channel discharge and water surface elevation to observed flood parameters at a specific USGS gauge location.

Reviewed modeled inland flood footprint comparison to USGS high water mark data for Hurricane Irma (2017) and to NOAA storm data for Tropical Storm Fay (2008).

MF-2 Flood Parameters (Inputs)

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.

Audit

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

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

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

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.

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

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

Pre-Visit Letter

105. MF-2, Disclosure 2, page 76: Provide the dataset underlying the logarithmic relationship for event duration versus total precipitation for each of north and south Florida. Describe how spatial extent is calculated.

202. MF-2, Disclosure 2, pages 77-78: Provide the underlying data from which the total precipitation and event duration model was obtained, including parameter estimates and associated fit summaries for the overall dataset and the individual North and South Florida subsets. Likewise, provide analogous information for the spatial extent and total precipitation model.

20. MF-2, Disclosure 3, page 63 (revised page 77): Discuss how the model handles the coincidence of rainfall and coastal storm surge.

203. MF-2, Disclosure 4, page 79: Provide the underlying data, parameter estimates, and goodness-of-fit details associated with the updated translation speed Weibull distribution.

21. MF-2, Disclosure 6, page 64 (revised page 78): Explain how short, high-intensity, small rainfall events (<100 mm; e.g., 2 in/hr) are accounted for in the precipitation model, especially in urban areas.

22. MF-2, Disclosure 6, pages 64-65 (revised page 78): Provide a map indicating the 300 rainfall locations used in the inland model, and the basins affecting Florida which they cover. Indicate how these 300 locations are related to the 40 locations of GF-1 Disclosure 2 (page 16).

23. MF-2, Disclosure 8, page 65 (revised page 79): Justify the use of "average astronomical tide height" for each event. Explain why this does not lead to a bias in the tail of the storm-tide distribution. The frequency of large events would seem to be underestimated, because the effect of strong surge during high tide is neglected. Tidal amplitudes can be several feet in Florida (e.g., Miami Beach NOAA Tides and Currents site indicates approximately 3 feet minimum-to-maximum March 10, 2020).

24. MF-2, Disclosure 11, page 65 (revised page 79): Explain how the impact of the relative vertical accuracy of the DEM of 0.81 m (2.65 ft) was addressed.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed the procedure to determine spatial extent of rainfall-event ellipses in the stochastic catalog and its relationship with rainfall amount in the historical data.

Reviewed the procedure to determine spatial extent, orientation, and eccentricity of rainfall-event ellipses in the stochastic catalog. Reviewed the climatological maps of orientation and eccentricity.

Reviewed the procedure for determining the decline in precipitation intensity with distance from event centers.

Discussed event probabilities determined from analysis of CPC historical precipitation data. Discussed the thresholds for defining extreme precipitation events. Reviewed frequency of maximum precipitation for historical Florida floods.

Discussed how the model handles the coincidence of rainfall and coastal storm surge. Reviewed comparisons of coastal flood and inland flood for Hurricane Earl (1998), Hurricane Frances (2004), and Hurricane Irma (2017).

Reviewed map of the rainfall event-center locations used in the inland model covering all basins affecting Florida.

Discussed the impact of using mean tide for storm surge estimation. Reviewed sensitivity tests on the impact.

Reviewed the modeled peak-surge exceedance return-period curve.

Discussed the use of USGS gauge data to adjust the inaccuracies in the Digital Elevation Model (DEM). Discussed the process for ensuring accuracy of the DEM.

Discussed that topography and elevation data are based on the USGS 3D Elevation Program (3DEP).

Reviewed distributions for Vmax, Rmax, forward speed, and track direction. Reviewed the relationship between Rmax and Vmax. Reviewed frequency histogram of forward speed. Reviewed track direction at landfall.

Reviewed distributions of the maximum precipitation amount and the fits to historical data for the precipitation regions affecting Florida.

Reviewed the event-duration and spatial-extent regression analyses.

Reviewed the initial and boundary conditions for coastal flood events. Reviewed map for spacing of coastal locations and map examples of bay amplification and shoaling adjustments.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the underlying data and distribution fits for spatial extent, duration, forward speed, Rmax, landfall frequency, Vmax, and track direction.

Reviewed historical Rmax data for generating residuals and confirmed inclusion of recent data.

Reviewed the revised regression relationships between event-duration and total precipitation and spatial-extent and total precipitation. Reviewed sensitivity to thresholds employed in the analyses. Reviewed erroneous precipitation data events dropped from analysis.

Reviewed references relevant to event duration relationship with total precipitation and associated thresholds.

Reviewed scatter plots for spatial extent in South and North Florida.

Verified after resolution of open issues.

MF-3 Wind and Pressure Fields for Storm Surge

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. The modeling of wind and pressure fields that drive coastal flood models shall be conducted over a sufficiently large domain that storm surge height is converged.

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

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.

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.

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

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

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.

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.

Pre-Visit Letter

204. MF-3, Disclosure 1, page 82: Provide the underlying data, parameter estimates, and goodness-of-fit details associated with the updated Rmax residuals Normal distribution.

Verified: YES

Professional Team Comments:

Reviewed the historical data sources that affect the modeled wind and pressure fields associated with storm surge.

Reviewed the dependence of peak surge on central storm pressure.

Reviewed the decline of surge magnitude along the coast from the peak-surge location and its dependency on Rmax.

Discussed the over-land weakening based on Kaplan and DeMaria (1995).

Reviewed the dependence of central pressure on Rmax with Vmax.

Reviewed the time series animation of overland coastal surge estimates for Hurricane Michael (2018).

MF-4 Flood Characteristics (Outputs)

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.

Audit

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

2. 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.

3. 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.

4. 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.

5. 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.

6. 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.

7. 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.

8. 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.)

9. 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.

10. 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.

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

Pre-Visit Letter

25. MF-4, Disclosure 1, pages 69-70 (revised pages 83-86): Provide the data underlying Figures 7, 8, and 9 in an Excel file for use by the Professional Team on-site to verify the historical versus modeled surge values.

26. MF-4, Disclosure 4, page 71 (revised page 87): Discuss how astronomical and storm tides are considered in the boundary conditions of the inland flood model.

27. MF-4, Disclosure 6, page 72 (revised page 89): Present the material described in paragraph 1.

28. MF-4, Disclosure 9, page 72 (revised page 89): Provide justification for neglect of the surge-size relationship. There is good evidence that peak surge increases with R_{max}, other factors being equal (e.g., Irish et al. 2008). What is the impact of neglecting this dependency?

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed the underlying storm surge data for Hurricane Wilma (2005), Hurricane Ivan (2004), and Hurricane Jeanne (2004) and discussed the treatment of tides in model-observational comparisons of coastal flooding for these storms.

Discussed the mean sea level boundary condition for inland flood.

Reviewed the data sources used to validate inundation depth and extent for coastal and inland flooding. Reviewed validation examples of modeled intensity footprints using various datasets.

Reviewed references on the relationship between peak surge and Rmax, as well as modeler analysis of this relationship.

Reviewed the methodology for coastal flood inundation depth. Discussed the scientific references and sources for the relationship between peak surge and central pressure.

Reviewed calculation for peak storm surge, documentation with variable definitions, and implementation in the code.

Discussed modeling-organization work performed to calculate the flood extent and depth from storm surge.

Reviewed the equation for track direction factors and shoaling adjustment factors based on Jelesnianski (1972).

Reviewed scatter plot of modeled peak surge height compared to historical storm surge observations. Discussed the number and type of storms included in the comparison.

Reviewed the equation for the storm surge coastal profile shape.

Reviewed the coastal spatial resolution and the time step for surge inundation. Discussed factors that affect surge attenuation inland.

Reviewed procedure to remove ponding in surge simulations.

Reviewed scatter plots and footprint comparisons of modeled versus observed coastal inundation for Hurricane Ivan (2004) and Hurricane Jeanne (2004).

Reviewed comparisons of NOAA Storm Events Database to modeled inland flood inundation for Hurricane Irma (2017) and Tropical Storm Fay (2008).

Reviewed comparison of the historical peak surge to modeled annual frequency of peak surge for Florida.

Reviewed comparisons of modeled 100-year flood extents with the FEMA 100-year flood extents for Washington, Miami-Dade, and Martin Counties.

Reviewed comparisons of the modeled 10-year flood extents from historical and stochastic events for Martin County.

Reviewed 0.1, 0.02, 0.01, and 0.002 annual exceedance probability maps for several counties.

Reviewed animation of the temporal evolution of coastal inundation depth from Hurricane Michael (2018).

Reviewed comparisons of modeled discharge to USGS data.

Discussed inland flooding from riverine sources and calculation of the flood extent from each channel location. Reviewed flood footprint along the Suwannee River from Tropical Storm Fay (2008).

Discussed the cellular-automata methodology for modeling surface water flow and reviewed associated equations.

Discussed the treatment of coincidence of inland and coastal flood in the modeled results.

Reviewed Forms HHF-2 and HHF-3.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed example of stochastic rain-driven flood event in Florida Keys.

Reviewed updated comparisons of modeled 100-year flood extents with the FEMA 100-year flood extents for Washington, Miami-Dade, and Martin Counties.

Reviewed updated 0.1, 0.02, 0.01, and 0.002 annual exceedance probability maps for several counties.

Verified after resolution of open issues.

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.

Audit

1. The consistency in accounting for similar flood parameters and characteristics across Florida and segments in adjacent states will be reviewed.
2. The method and supporting material for generating stochastic coastal and inland flood events will be reviewed.
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.
4. Form SF-1, Distributions of Stochastic Flood Parameters (Coastal, Inland), will be reviewed.
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.

Pre-Visit Letter

29. MF-5, Disclosure 2, page 75 (revised pages 91-92): Provide evidence for establishing the Initial Water Balance using a random variable following a gamma distribution to model the precipitation rate during spin-up, with corresponding goodness-of-fit tests.

205. MF-5, Disclosure 2, page 94: Provide the underlying data, parameter estimates, and goodness-of-fit details associated with the updated translation speed Weibull distribution.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed the spin-up period used to generate initial water balance conditions for a flood event and the distribution fit for climatological precipitation used for model initialization.

Reviewed the goodness-of-fit test on a sample of values from the full initial-precipitation dataset.

Reviewed model event distribution by landfall location and track direction at landfall.

Discussed that shoaling adjustment factors represent the effects of local bathymetry and extend beyond Florida to neighboring states.

Discussed that model coastal flood footprints are generated from the 50,000-year stochastic event catalog hurricane tracks.

Reviewed the process for selecting model flood events using a joint probability method with a ternary tree structure. The hierarchy of the ternary tree is determined through the results of sensitivity tests. Reviewed the criteria defining events in the model event catalog.

Reviewed a sample of the stochastic event catalog list and discussed the file naming conventions.

Reviewed process for creating model inland flood footprints. Reviewed maps of example precipitation events in different Florida regions.

Reviewed selected distributions and goodness-of-fit tests for model parameters:

- Vmax
- Rmax
- track direction
- forward speed
- landfall frequency
- precipitation amount
- precipitation spatial extent
- precipitation event duration
- initial precipitation
- annual extreme precipitation event frequency.

Reviewed comparison of modeled to historical coastal flood exceedance probabilities for Ft. Myers and Cedar Key.

Reviewed comparison of inland 100-year modeled flood depth to historical data.

Reviewed the fitted distribution for the 100-year flood discharge. Reviewed comparison of the 100-year modeled flood discharge to historical data.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the updated model event distribution by landfall location and track direction at landfall.

Reviewed updated plot of annual landfall frequency.

Reviewed updated goodness-of-fit tests for Vmax, Rmax, track direction, forward speed, landfall frequency, event duration, and spatial extent parameters.

Reviewed the method for generating stochastic inland and coastal flood events. Reviewed impact of revised probability distributions on nodes in the ternary tree hierarchical structure.

Reviewed modifications in ternary-tree node selections rules and discussed impact on extreme events.

Verified after resolution of open issues.

HYDROLOGICAL AND HYDRAULIC FLOOD STANDARDS – Del Schwalls, Leader

HHF-1 Flood Parameters (Inputs)

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) 2006 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.

Audit

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

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

3. 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.

Pre-Visit Letter

30. HHF-1, Disclosure 1, page 76 (revised page 94): Provide a map of the hydraulic network used in the riverine and lacustrine flood analyses.

31. HHF-1, Disclosure 2, page 76 (revised page 94): Provide a map of the hydraulic network used in surface water flood analyses.

32. HHF-1, Disclosure 3, page 76 (revised pages 94-95): Justify the decision to base initial and boundary conditions on the historical minimum values.

106. HHF-1, Disclosure 3, page 95: Explain the inconsistency between historical event simulations using mean yearly river discharge for initialization while stochastic simulations use climatological precipitation. Explain how climatological precipitation produces mean annual discharges.

33. HHF-1, Disclosure 4, page 77 (revised page 95): Provide a map showing the six basins used in the model including the stream network.

Verified: **YES**

Professional Team Comments:

Reviewed maps of the regions covering the hydraulic networks in Florida by modeled basin for riverine and lacustrine flood and for surface water flood.

Reviewed map of USGS gauges in each modeled basin. Discussed the initial and boundary conditions.

Discussed the hydraulic boundary conditions for inland flood.

Discussed the river discharges used for initialization for historical and stochastic event generation.

Reviewed stream network and catchments datasets.

Reviewed map of major waterbodies in Florida (lakes and reservoirs).

Reviewed data files for channel properties, catchment properties, precipitation, and time series data from USGS.

Reviewed the process for incorporating LULC information into the model. Reviewed validation map comparing modeled surface roughness to NLCD (2016).

Reviewed methods for incorporating the effect of soils and soil parameters on inland flooding.

HHF-2 Flood Characteristics (Outputs)

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.

Audit

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

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.

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

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.

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.

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.

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

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.

9. 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.

10. 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.)

11. 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.

Pre-Visit Letter

34. HHF-2, Disclosure 1, page 79 (revised pages 97-100): Provide additional detail on the water level and locations estimated from the NOAA Storm Events Database. The NOAA reports are qualitative, often based on newspaper sources, providing none or only vague water-level values. Also, the locations are not given in equal size grid squares. Explain how the blue squares in Figures 13 & 14 are determined. For example, for Unnamed East Florida May 2009, the Figure 14 table entry 29.3N -81.1W seems to correspond to a NOAA Storm Events Entry May-19 for Volusia County location "1SW-Deltona" (lat/lon range 28.8893/-81.2357 to 29.2531/-81.4554 called 29.1 -81.3 in Figure 14 table). The report says "several feet of standing water in many areas of eastern Volusia County." Explain how this translates to 12-36 inches.

35. HHF-2, Disclosure 1, pages 80-81 (revised pages 98-100): Relate the lat/lon locations given in the tables to locations on the maps in Figures 13-15.

107. HHF-2, Disclosure 1, page 99: Explain in Figure 13 the absence of non-blue colors (inundation depth great than 1 ft) in spite of the maxima being 5.8 (surface flood) and 8.2 (river flood).

36. HHF-2, Disclosure 3, page 85 (revised pages 101-107): Provide a graphical comparison of KCC modeled to recorded water surface elevation for Unnamed Storm in Peace Tampa Region (August 2017).

108. HHF-2, Disclosure 6, page 108: Clarify contradiction between new text reference of 90-day model spin-up compared to other references of 60-day model spin-ups.

37. Form HHF-1, pages 175-181 (revised pages 208-218): Provide maps that can be zoomed in and reviewed in detail for Figures 51-53. Provide the validation data for Figures 47-50 and Figure 54.

Verified: ~~**NO**~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Discussed method for location estimation derived from NOAA Storm Events Database. Discussed how intensity footprints are validated using NOAA storm data.

Reviewed validations of modeled flood depth to observed NOAA storm data for Tropical Storm Fay (2008), Unnamed Storm in East Florida (May 2009), and Unnamed Storm in Panhandle (July 2013).

Reviewed maps of maximum riverine flood and maximum surface flood extent and depth.

Reviewed comparison of modeled discharge and water surface elevation to USGS observations for Unnamed Storm in Peace Tampa Region (August 2017).

Discussed time steps used in rainfall, riverine, and surface water flooding analyses.

Discussed the reasons for using a 90-day model spin-up time in generating historical events versus a 60-day model spin-up time for stochastic event generation.

Reviewed Form HHF-1 maps for storm surge and inland flood. Reviewed the historical flood events footprints.

Reviewed in detail the methodology and equations for determining flood extent and depth for inland flooding.

Reviewed hillslope and channel flow equations.

Reviewed the method for establishing surface flooding extents from model output.

Discussed how the model analyzes a series of lakes, including major waterbodies, connected by a series of channels.

Reviewed historical discharge and water surface elevation data from USGS for riverine flooding and the NOAA historical database for surface flooding.

Reviewed comparisons of modeled discharges and water surface elevations to USGS gauge observations.

Reviewed map comparing the modeled 100-year flood depths with USGS gauge data.

Reviewed scatter plot comparison of modeled water surface elevations for 100-year flood discharges to USGS observations.

Reviewed comparisons of the modeled 10-year flood extents from stochastic and historical events for Washington, Martin, and Miami-Dade Counties.

Reviewed comparisons of modeled 100-year flood extents with the FEMA 100-year flood extents for Washington, Martin, and Miami-Dade Counties.

Reviewed validation maps for surface water flood and riverine flood from Tropical Storm Fay (2008), Unnamed Storm in East Florida (May 2009), and Unnamed Storm in Panhandle (July 2013).

Reviewed temporal evolution of inland flood of the Suwannee River in Dixie and Gilchrist Counties from Tropical Storm Fay (2008).

Discussed the threshold for modeled precipitation events.

Discussed the extent of modeled inland flooding.

Reviewed Forms HHF-4 and HHF-5.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the updated catchments and channel network.

Reviewed updated comparisons of the modeled 10-year flood extents from stochastic and historical events for Washington, Martin, and Miami-Dade Counties.

Reviewed updated comparisons of modeled 100-year flood extents with the FEMA 100-year flood extents for Washington, Martin, and Miami-Dade Counties.

Reviewed comparison of inundation depths and model parameters in Martin County. Discussed the process for determining the maximum inundation depth by county.

Further reviewed in detail the methodology and equations for determining flood extent and depth for inland flooding.

Reviewed revised Forms HHF-3, HHF-4 and HHF-5.

Verified after resolution of open issues.

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.

Audit

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

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

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.

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

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

Pre-Visit Letter

38. HHF-3, Disclosure 1, page 88 (revised page 110): Discuss how determination is made for which dams and levees are "major." Provide maps showing the location of major flood control measures incorporated in the flood model.

109. HHF-3, Disclosure 1, page 110: Provide the complete list of major flood control measures incorporated in the model.

39. HHF-3, Disclosure 4, page 89 (revised page 111): Discuss which major flood control measures are evaluated for failure and how that selection is determined.

40. HHF-3, Disclosure 4, page 89 (revised page 111): Demonstrate and explain in detail how a dam/levee failure is executed in the model, including the location and duration of the failures.

Verified: YES

Professional Team Comments:

Reviewed list of dams and levees in the model.

Reviewed maps indicating location of all dams and levees included in the model.

Discussed the process to verify all levees in the National Levee Database were included in the DEM data.

Reviewed the treatment of major flood control failure in the model.

Discussed the procedure for updating the latest DEM data and validating the presence of major dam and levees in the data.

Discussed that the model does not include human intervention on major flood control measures.

HHF-4 Logical Relationships Among Flood Parameters and Characteristics

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

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

Audit

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

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

Pre-Visit Letter

110. HHF-4.A and C, page 113: Explain the relationship between a change in cross sectional area and the resulting change in water surface elevation.

41. HHF-4.D, page 90 (revised page 113): Explain how the model accounts for coincidence of storm tide and inland flooding.

42. HHF-4, Disclosures 1 and 2, pages 90-94 (revised pages 113-118): Discuss how the logical-relation tests were implemented. Explain why the slope experiments are conducted over only a few days, while roughness and discharge are conducted over a year. For slope in Figure 24, explain why the results for steep slope lead the results for shallow slope in one case (Panhandle), while the opposite occurs in another case (Southeast).

Verified: YES

Professional Team Comments:

Reviewed calculation for channel width and the relationship between a change in cross section area and water surface depth.

Discussed that inundation is the maximum from either coastal flood or inland flood and precludes the coincidence of storm tide and inland flooding. Reviewed footprints of coastal flood and inland flood for Hurricane Earl (1998) and Hurricane Irma (2017).

Reviewed slope sensitivity analysis results.

Reviewed the equations demonstrating the relationships between roughness, channel slope, and discharge in the model.

Reviewed the relationship between increased roughness on water surface elevation.

Reviewed the relationship between increased channel slope on discharge.

Reviewed the relationship between increased precipitation on discharge.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the updated methodology for estimating damage and losses for locations impacted by both inland and coastal flooding during a single event.

Reviewed validation analysis results based on Hurricane Irma (2017) loss data.

STATISTICAL FLOOD STANDARDS – Mark Johnson, Leader

SF-1 Modeled Results and Goodness-of-Fit

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.

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.

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.

Pre-Visit Letter

43. SF-1, Disclosure 1, page 95 (revised page 119, Form SF-1 is pages 230-232): If there are stochastic components to the flood control failure analysis, then additional entries in Form SF-1 may be required.

44. SF-1, Disclosure 5, pages 96-97 (revised pages 120-124): Provide the underlying data for Figures 26 and 27 for use by the Professional Team on-site.

111. SF-1, Disclosure 5, page 121: Both the historical data and modeled fit in Figure 26 are discrete entities so that the axis labeled "density" is inappropriate. As depicted, it is not clear as to the historical data in Figure 26 with vertical lines above each of the number of events per year (except for 1 event). Provide on-site a table of the historical and fitted values and a revised Figure 26.

112. SF-1, Disclosure 5, page 122: Note that years 1948-2018 were used with maximum precipitation per event, anywhere in one of the four regions. Define the 4 regions and their relationship to the 5 regions as given in the Report of Activities (page 137).

206. SF-1, Disclosure 5, Table 5, page 127: Explain the large changes in the Water Elevation r and E values with the new r value representing perfect agreement while the Nash-Sutcliffe value is short of perfect. Explain the change in E values for Peak Surge while the r value was unchanged (other than potential rounding).

113. Form SF-1, pages 230-232: Provide detailed evidence of the goodness-of-fit test associated with each of the stochastic flood functions or variables reported in this form. Provide the underlying data sets on-site.

207. Form SF-1, page 239: Provide the underlying data, parameter estimates, and goodness-of-fit details associated with the updated annual landfall frequency Empirical distribution.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

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

Reviewed the results given in Form SF-1 using underlying datasets provided by KCC.

Reviewed Flood Loss Exceedance Estimates in Form SF-2.

Reviewed the characterization of uncertainty for damage estimates, annual flood loss, probable maximum loss levels, and flood loss costs.

Reviewed the occurrence probability modeled as a Pareto distribution.

Reviewed the relationship between extent and total precipitation.

Reviewed the logarithmic relationship for event duration versus total precipitation.

Reviewed the historical versus modeled storm surge values depicted in Figures 7, 8, and 9.

Reviewed the gamma distribution fits to the spin-up precipitation rate with corresponding goodness-of-fit tests.

Reviewed fits for inland flood events per year (Figure 26) and precipitation per event (Figure 27).

Reviewed revised Figure 26.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the relationships between event duration and total precipitation amount and event spatial extent and total precipitation amount. Reviewed scatter plots of the regression distribution fits for North and South Florida.

Reviewed the new empirical distribution used for landfall frequency.

Reviewed the uncertainty interval differences from the previous submission for the top loss event.

Reviewed the revised exhibit for inland flood events per year.

Reviewed implementation of the probability distribution function for the Rmax normalized residuals.

Reviewed the annual number of model landfall events.

Reviewed revised Forms SF-1 and SF-2.

Verified after resolution of open issues.

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.

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.

Pre-Visit Letter

45. SF-2, Disclosure 1, pages 101-102 (revised pages 125-128): Provide in advance of the on-site review the supporting data files in Excel that underlie Figures 31-33.

208. SF-2, Disclosure 1, pages 130-132: Provide in advance of the remote review the supporting data files in Excel that underlie Figures 28-30. Explain the change from the May 29, 2020 submission.

Verified: YES

Professional Team Comments:

Reviewed the sensitivity analyses performed based on the equivalent of Form S-6 used in the hurricane reviews adapted for the flood model. In particular, reproduced the results given in Figures 28-30 using the underlying datasets provided by KCC.

Reviewed the input variables used for the coastal flood sensitivity analysis and the input variables used for the inland flood sensitivity analysis. Discussed the exposure set used for both analyses.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the updated sensitivity analyses performed after the model updates. Reviewed time-series simulations of inland and coastal flooding.

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.

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.

Pre-Visit Letter

46. SF-3, Disclosure 1, pages 104-105 (revised pages 130-134): Provide in advance of the on-site review the supporting data files in Excel that underlie Figures 34-36.

209. SF-3, Disclosure 1, page 135-138: Provide in advance of the remote review the supporting data files in Excel that underlie Figures 31-33. Explain the change from the May 29, 2020 submission.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed the uncertainty analyses performed based on the equivalent of Form S-6 used in the hurricane reviews adapted for the flood model. In particular, reproduced the results given in Figures 31-33 using the underlying datasets provided by KCC.

Reviewed the input variables used for the coastal flood uncertainty analysis and the input variables used for the inland flood uncertainty analysis. Discussed the exposure set used for both analyses.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the revised uncertainty analyses performed after the model updates. Discussed the change in number of events generated and analyzed for testing the uncertainty of each parameter.

Verified after resolution of open issues.

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.

Audit

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

Pre-Visit Letter

47. SF-4, Disclosure 2, page 109 (revised page 137): Discuss how the 286,614 events are spread throughout the 100,000-year stochastic catalog and the breakdown between inland and coastal flooding events.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

*****Additional Verification Review – November 16-18, 2020*****

Reviewed maps of the standard error by county for inland and coastal flooding.

Verified after resolution of open issues.

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.

Audit

1. The following information for each flood event 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.

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.

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

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

Pre-Visit Letter

210. SF-5, Disclosure 1, pages 138-139: Explain why some, but not all, modeled losses were changed from the May 29, 2020 submission.

Verified: ~~NO~~ **YES**

~~Pending resolution of open issues~~

Professional Team Comments:

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the updated historical events impacted by the changes to the model footprint generator.

Reviewed the confidence interval analysis comparing historical and modeled flood losses.

Reviewed modeled footprint comparisons to historical inland flood events June 22, 2012 and August 27, 2017.

Reviewed modeled footprint comparison to Hurricane Irma (2017) with combined inland and coastal flooding.

Reviewed the differences between actual and modeled inland flood losses.

Verified after resolution of open issues.

VULNERABILITY FLOOD STANDARDS – Chris Jones, Leader

VF-1 Derivation of Personal Residential Structure Flood Vulnerability Functions

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

B. The derivation of personal residential structure flood vulnerability functions and their 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 structures.

D. The following flood characteristics shall be used in the derivation of personal residential structure 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 personal residential structure vulnerability functions: lowest floor elevation relative to ground, foundation type, construction materials, and year of construction.

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

Audit

1. All personal residential structure flood vulnerability functions will be reviewed.

2. Vulnerability functions for waves or wave proxies will be reviewed. Modeling organization thresholds for damaging wave action will be reviewed. The area over which vulnerability functions for damaging waves or wave proxies are applied will be reviewed.

3. Validation of the personal residential structure flood vulnerability functions and associated uncertainties will be reviewed.

4. 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 personal residential structure 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 structure 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 technical literature and expert opinion summaries will be reviewed. Insurance claims data will be reviewed.

5. All papers, reports, and studies used in the continual development of the personal residential structure flood vulnerability functions must be available for review in hard copy or electronic form.

6. Multiple samples of personal residential structure flood vulnerability functions for personal residential structures and manufactured homes will be reviewed. The magnitude of logical changes among these items for given flood events and validation materials will be reviewed.

7. Justification for the personal residential structure construction classes and characteristics used will be reviewed.

8. Documentation and justification for all modifications to the personal residential structure flood vulnerability functions due to statewide and county building codes, floodplain management regulations, and their enforcement will be reviewed. If year of construction and/or geographical location of the personal residential structure 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(s) and/or geographical region(s) of construction that separates particular group(s) will be reviewed.

9. The effects on personal residential structure flood vulnerability from local and regional construction characteristics, statewide and county building codes, and floodplain management regulations will be reviewed, including whether current statewide and county building codes are reflected.

10. How the claim practices of insurance companies are accounted for when claims data for those insurance companies are used to develop or to verify personal residential structure 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, or the impact of public adjusting.

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

12. Documentation and justification for the method of derivation and data on which the personal residential structure flood vulnerability functions are based will be reviewed.

13. If modeled, the treatment of water intrusion in personal residential structure flood vulnerability functions will be reviewed.

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

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

Pre-Visit Letter

48. VF-1, Audit 1: Provide a glossary of key terms as used in the February 29, 2020 submission (including, but not limited to: vulnerability region, flood plain, inundation depth, lowest floor, first floor height, direct damage, progressive damage, functional damage, structural damage, elevated foundation, hydrostatic loads, hydrodynamic loads, wave loads).

49. VF-1, Audit 1: Provide definition sketches for inland flood and coastal flood showing a building cross-section, ground, foundation, lowest floor, first floor height, stillwater level, wave crest (if present), and flood forces or pressures.

50. VF-1, Audit 1: Provide plots and tables comparing damage/exposure ratios for each of the 8 reference structures used in Form VF-1 and Form VF-2.

51. VF-1, Audit 1: Explain how KCC vulnerability functions compare with FEMA and USACE Depth Damage Functions (DDFs), considering similar buildings subject to inland freshwater flood or coastal saltwater flood with waves.

114. VF-1, Disclosure 2, pages 141-142: Provide a complete list of building components used to develop vulnerability functions.

115. VF-1, Disclosure 3, pages 142-143: Discuss how the date of the flood zone was selected for each building. Explain how flood zone was used to develop vulnerability functions, assign flood characteristics, model flood losses, and compare modeled flood losses with flood claims.

116. VF-1, Disclosure 3, page 143 and VF-2, Disclosure 4, page 153: Provide a complete set of refinements to vulnerability functions based on claims analyses.

52. VF-1, Disclosure 5, pages 115-116 (revised pages 143-144): Provide a sketch to accompany the text describing the calculation of wave height and wave crest elevation.

117. VF-1, Disclosure 5, pages 143-144: Provide a comprehensive description of the calculation and treatment of waves. Explain (1) how the presence of breaking versus non-breaking waves is determined, (2) how non-breaking wave loads are calculated, (3) what wave height specification (i.e., significant wave height or controlling wave height or otherwise) is used by the model, and (4) how breaking versus non-breaking wave condition is assigned to each flood claim comparison.

118. VF-1, Disclosure 7.b, pages 145-146: Provide a comprehensive explanation of how foundation type and foundation height are determined, including for buildings with unknown foundation characteristics. Explain (1) how the following affect foundation type and height: flood zone, pre-FIRM versus post-FIRM, building code (FBC-residential or FBC-building), ASCE 24, local floodplain regulations (freeboard), (2) what is meant by A Zone Coastal in Table 8 heading (FEMA and FBC have different definitions of the term), and (3) how A Zone Coastal definition affects foundation selection.

119. VF-1, Disclosure 7.c, pages 146-147: Clarify the use of the two manufactured home tie-down requirements listed (HUD and Florida).

120. VF-1, Disclosure 7.d, page 148: Provide a comprehensive explanation of how different editions of the Florida Building Code (Building and Residential volumes) and ASCE 24 are used to develop and implement vulnerability functions. Explain (1) how the model determines which codes and editions to apply; and (2) how local building code amendments to flood provisions (primarily freeboard) affect development and use of vulnerability functions.

121. VF-1, Disclosure 9, page 150: Discuss how the date of the CRS Class was selected for each building.

122. VF-1, Disclosure 9, pages 149-150: Explain how Coastal Construction Control Line (CCCL) foundation, floor elevation, and other building requirements are implemented by the model, given that CCCL requirements pre-date FBC.

Verified: ~~NO~~ **YES**

~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed flowchart and process for development of residential structure vulnerability functions. Discussed the derivation, underlying data, and validation of the different residential structure vulnerability functions.

Reviewed the building components used to develop inland and coastal flood vulnerability functions.

Reviewed the primary building characteristics used for vulnerability functions development and their definitions:

- Construction type
- Occupancy type
- Number of stories
- First floor height
- Year built bins
- Vulnerability region.

Discussed how vulnerability functions vary by community and year built. Discussed how major changes in building code requirements are used by the model. Reviewed the year-built groupings for site-built homes and manufactured homes.

Reviewed flowchart to determine first floor height.

Reviewed the different construction types used in the model for site-built homes and manufactured homes.

Reviewed diagrams illustrating building cross-section, ground, foundation, first floor height, still water level, breaking and non-breaking waves, and hydrostatic and hydrodynamic pressures for inland and coastal flood.

Reviewed estimation of flood loads on building components for inland and coastal flooding.

Reviewed diagram illustrating the different wave loads and their treatment in calculating coastal flood damage. Discussed the effect of wave load treatment on modeled losses.

Discussed the use of post disaster survey observations, technical literature, expert opinion, and flood vulnerability functions from the U.S. Army Corps of Engineers and FEMA to develop vulnerability functions.

Reviewed plots of the relationship between building mean damage ratios and flood depth above ground for coastal and inland flood.

Reviewed table of total number of flood-model vulnerability functions by building type.

Reviewed map of the model vulnerability regions by NFIP's Community Rating System (CRS). Reviewed the CRS class effective date used to assign communities to different vulnerability regions. Discussed the effect of CRS assumptions on modeled losses.

Discussed how flood zone is used by the model and for validation to flood claims data.

Discussed the process for comparing modeled mean damage ratios to claims mean damage ratios for building vulnerability validation.

Discussed the process for determining foundation type and height for buildings with unknown data. Discussed the impact of building codes, floodplain management regulations and Coastal Construction Control Line requirements on building characteristics.

Discussed how differences in flood design requirements in the different editions of the Florida Building Code and ASCE 24 are accounted for in the vulnerability functions.

Reviewed mapping of year built and U.S. Department of Housing and Urban Development (HUD) requirements for manufactured homes.

Reviewed comparison table of modeled and historical losses.

Discussed processing and handling of flood claims data.

Reviewed comparison of inland vulnerability functions for different construction types to NFIP claims data. Reviewed sample comparisons of mean damage ratio uncertainty.

Reviewed vulnerability functions by construction type, number of stories, first floor height, year built, vulnerability region, and building occupancy.

Discussed the process for addressing water intrusion.

Reviewed a glossary of key terms used in the submission.

Reviewed Form VF-1 (coastal flood) and Form VF-2 (inland flood). Reviewed plots and tables comparing flood damage/exposure ratios for each of the 8 reference structures used in the forms.

Reviewed model documentation and code related to vulnerability function development and implementation.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed revised text describing wave conditions. Reviewed diagrams illustrating building cross-section, ground, foundation, first floor height, and flood conditions (still water depth, flow velocity, and breaking, broken and non-breaking waves). Reviewed diagrams illustrating flood loads for coastal and inland flood conditions.

Reviewed flood vulnerability functions for a reference structure and its components.

Reviewed revised model documentation and code related to flood loads, damage calculation, and vulnerability function implementation.

Verified after resolution of open issues.

VF-2 Derivation of Personal Residential Contents Flood Vulnerability Functions

A. Development of the personal residential contents flood vulnerability functions shall be based on some combination of the following: (1) post-event site investigations, (2) 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 personal residential structure and contents flood vulnerability functions shall be reasonable.

Audit

1. All personal residential contents flood vulnerability functions will be reviewed.

2. Validation of the personal residential contents flood vulnerability functions and associated uncertainties will be reviewed.

3. Documentation and justification of the following aspects or assumptions related to personal residential contents flood vulnerability functions will be reviewed:
   a. The method of derivation and data,
   b. Variability of personal residential contents flood damage by personal residential structure classification and characteristics,
   c. Variability of personal residential contents flood damage by flood characteristics, and
   d. Personal residential contents flood damage for various occupancies.

4. 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 personal residential 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 technical literature and expert opinion summaries will be reviewed. Insurance claims data will be reviewed.

5. All papers, reports, and studies used in the continual development of the personal residential contents flood vulnerability functions must be available for review in hard copy or electronic form.

Pre-Visit Letter

53. VF-2, Audit 1: Explain how KCC contents vulnerability functions compare with FEMA and USACE contents DDFs, considering similar buildings subject to inland freshwater flood or coastal saltwater flood with waves.

Verified: **YES**

Professional Team Comments:

Reviewed flowchart of process for contents vulnerability function development. Discussed the derivation, underlying data, and validation of contents vulnerability functions.

Reviewed comparison of the modeled contents to building damage relationship for residential buildings and for condo units and the mean damage ratios from claims data.

Reviewed comparison of modeled coastal mean damage ratios for inundation above ground to United States Army Corps of Engineers (USACE) depth-damage functions.

Reviewed comparison of modeled inland mean damage ratios for inundation above ground to Federal Insurance Administration (FIA) and USACE depth-damage functions.

VF-3 Derivation of Personal Residential Time Element Flood Vulnerability Functions

A. Development of the personal residential time element flood vulnerability functions shall be based on one or more of the following: (1) post-event site investigations, (2) technical literature, (3) expert opinion, (4) laboratory or field testing, and (5) insurance claims data.

B. The relationship among personal residential structure, contents, and time element flood vulnerability functions shall be reasonable.

Audit

1. All personal residential time element flood vulnerability functions will be reviewed.

2. Validation of the personal residential time element flood vulnerability functions and associated uncertainties will be reviewed.

3. Documentation and justification of the following aspects or assumptions related to personal residential time element flood vulnerability functions will be reviewed:
   a. The method of derivation and underlying data,
   b. Variability of personal residential time element flood vulnerability by personal residential structure classification and characteristics,
   c. Variability of personal residential time element flood vulnerability by flood characteristics,
   d. Personal residential time element flood vulnerability for various occupancies, and
   e. The methods used to estimate the time required to repair or replace the property due to flooding.

4. 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 personal residential 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 technical literature and expert opinion summaries will be reviewed. Insurance claims data will be reviewed.

5. If included, the methodology and validation for determining the extent of infrastructure flood damage and governmental mandate and their effect on personal residential time element flood vulnerability will be reviewed.

Pre-Visit Letter

54. VF-3, Audit 1: Explain how KCC time element loss functions compare with FEMA and USACE functions, considering similar buildings subject to inland freshwater flood or coastal saltwater flood with waves.

Verified: **YES**

Professional Team Comments:

Reviewed flowchart for time element vulnerability function development. Discussed the derivation, underlying data, and validation of time element vulnerability functions.

Reviewed comparison of the modeled time element to building damage relationship for residential buildings and for condo units and the mean damage ratios.

Reviewed comparisons of building damage ratio to event-related time and repair time.

Reviewed the relationship between time element and building mean damage ratios for residential buildings and condo units.

VF-4 Flood Mitigation Measures

A. Modeling of flood mitigation measures to improve flood resistance of personal residential structures, the corresponding effects on flood vulnerability, and their 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 structures. The modeling organization shall justify all flood mitigation measures considered by the flood model.

B. Application of flood mitigation measures that affect the performance of personal residential structures and the damage to contents shall be justified as to the impact on reducing flood damage whether done individually or in combination.

Audit

1. Flood mitigation measures used by the flood model will be reviewed for theoretical soundness and reasonability.

2. Form VF-3, Flood Mitigation Measures, Range of Changes in Flood Damage, Form VF-4, Coastal Flood Mitigation Measures, Mean Coastal Flood Damage Ratios and Coastal Flood Damage/$1,000 (Trade Secret Item), and Form VF-5, Inland Flood Mitigation Measures, Mean Inland Flood Damage Ratios and Inland Flood Damage/$1,000 (Trade Secret Item), will be reviewed.

3. 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 over the range of flood depths above ground for individual flood mitigation measures will be reviewed. Historical data, technical literature, expert opinion, or insurance 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.

4. 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 over the range of flood depths above ground for multiple flood mitigation measures will be reviewed.

Pre-Visit Letter

55. Form VF-3, page 202 (revised page 242): Explain the results contained in the form. Provide a form completed for aggregated coastal only and a form for aggregated inland only.

Verified: **YES**

Professional Team Comments:

Reviewed secondary characteristics and mitigation measures included in the model:

- elevate structure
- elevate or protect utilities
- dry flood proofing

- wet flood proofing
- building enclosure
- floor of interest
- presence of basement
- building-to-foundation connection type.

Reviewed relationships between mean damage ratio, secondary characteristics and mitigation measures versus flood depth for different building types at varying heights above ground.

Reviewed plot of building utility damage functions and the relationship between mean damage ratios and water depth above first floor height.

Reviewed the process for grouping and combining multiple secondary characteristics.

Reviewed Forms VF-3, VF-4, and VF-5.

ACTUARIAL FLOOD STANDARDS – Stu Mathewson, Leader

AF-1 Flood Modeling Input Data and Output Reports

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.

Audit

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.

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.

3. Explanation of the differences in data input and flood model output for coastal and inland flood modeling will be reviewed.

Pre-Visit Letter

123. AF-1, Disclosure 1, page 163: Explain how the underinsured adjustment is handled in the model input process.

56. AF-1, Disclosure 3, page 133 (revised page 163): Explain how the flood model addresses each of the flood policies mentioned in s. 627.715 FS (i.e., standard policy, preferred policy, customized policy, flexible policy).

Verified: YES

Professional Team Comments:

Reviewed how the underinsured adjustment is handled in the model input process.

Reviewed how the model addresses all of the flood policy types in the Florida flood insurance statute.

Reviewed the Exposure Data Processing Guide and the Exposure Import User's Guide.

Reviewed the input and output forms detailing the necessary specifications of analysis. Reviewed an example analysis output report. Discussed that a model user can only make adjustments to the type of output requested.

Discussed that there are no differences in data input for coastal and inland flood modeling.

Discussed that the inland and coastal models are independent and are not run in combination.

AF-2 Flood Events Resulting in Modeled Flood Losses

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.

Audit

1. The flood model will be reviewed to evaluate whether the determination of flood losses in the flood model is consistent with this standard.
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.
3. The flood model will be reviewed to determine whether the flood model takes into account any damage resulting directly and solely from wind. Flood losses associated with flooding will be reviewed to determine the treatment of wind losses.
4. The flood model will be reviewed to determine how flood losses from water intrusion are identified and calculated.
5. The documented procedure for distinguishing flood-related losses from other peril losses will be reviewed.
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.

Pre-Visit Letter

57. AF-2.B, page 141 (revised page 171): Provide a copy of the documented procedure for distinguishing flood losses from other peril losses.

58. AF-2, Disclosure 3, page 141 (revised page 171): There is no overlap accounted for between the storm surge and inland flood models. Will there be double counting in some areas?

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed the documented procedure for distinguishing flood losses from other peril losses.

Discussed the treatment of coincidence of inland and coastal flood in the modeled results.

Reviewed the definition of an inland and a coastal flood event in the model. Discussed the inundation depth level at which the model begins to estimate flood-related damage.

Reviewed graph of modeled events by Florida landfall location and hurricane intensity.

Reviewed map of modeled basins and precipitation events.

Discussed that the inland and coastal flood models only calculate flood-related insured losses. Discussed that the independence of the two models precludes any damage resulting directly and solely from wind.

Reviewed the process for identifying and calculating water-intrusion flood losses.

Discussed that the model does not account for events that are neither inland nor coastal flooding events.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the updated model event distribution by landfall location.

Reviewed the model change addressing the correlation and potential overlap of inland and coastal flooding.

Verified after resolution of open issues.

AF-3 Flood Coverages

A. The methods used in the calculation of personal residential structure flood loss costs 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.

Audit

1. The methods used to produce personal residential structure, appurtenant structure, contents, and time element flood loss costs will be reviewed.

2. The treatment of law and ordinance coverage will be reviewed. If it is not modeled, justification will be reviewed.

Pre-Visit Letter

59. AF-3.B, page 142 (revised page 172): Explain how calculation of appurtenant structure flood loss costs are similar to the methods used for building flood loss costs.

Verified: YES

Professional Team Comments:

Reviewed loss cost calculations for appurtenant structure and building flood loss costs. Discussed that the calculations are the same for all coverages.

Discussed the treatment of law and ordinance coverage in the model.

AF-4 Modeled Flood Loss Cost and Flood Probable Maximum Loss Level Considerations

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.

Audit

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.

2. The method of determining flood probable maximum loss levels will be reviewed.

3. The uncertainty in the estimated annual flood loss costs and flood probable maximum loss levels will be reviewed.

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.

5. How the flood model accounts for economic inflation associated with past insurance experience will be reviewed.

6. The treatment of wind losses in the determination of flood losses will be reviewed.

7. How the flood model determines flood loss costs and flood probable maximum loss levels associated with coastal flooding will be reviewed.

8. How the flood model determines flood loss costs and flood probable maximum loss levels associated with inland flooding will be reviewed.

9. 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.

10. All referenced literature will be reviewed, in hard copy or electronic form, to determine applicability.

Pre-Visit Letter

60. AF-4, Disclosure 1, page 144 (revised page 175): Provide, in Excel, tables of 1,000 years descending from the Top Event corresponding to Form AF-6. For each year, show the value of each event separately.

61. AF-4, Disclosure 3, page 145 (revised page 175): Explain in detail the demand surge model. Provide a copy of the documented procedure and its implementation in the code.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed the tables of 1,000 years descending from the Top Event corresponding to Form AF-6.

Reviewed the basis for demand surge implemented in the model.

Discussed that there are no assumptions for any criteria other than direct property flood insurance claims payments.

Reviewed the methods of determining probable maximum loss levels.

Discussed the method for calculating uncertainty intervals.

Discussed that there are no adjustments made for economic inflation when validating the model using claims data.

Reviewed the process for ensuring there is no systematic over-estimation of flood loss costs and flood probable maximum loss levels.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the uncertainty intervals calculated using 10,000 stochastic simulations.

Reviewed revised comparison of modeled losses to actual flood losses for coastal, inland, and combined events.

Verified after review of open issues.

AF-5 Flood Policy Conditions

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.

Audit

1. The process used to determine the accuracy of the insurance-to-value criteria in data used to develop and validate the flood model results will be reviewed.

2. To the extent that historical data are used to develop mathematical depictions of deductibles, policy limits, policy exclusions, and loss settlement provisions for flood coverage, the goodness-of-fit of the data to fitted models will be reviewed.

3. To the extent that historical data are used to validate the flood model results, the treatment of the effects of deductibles, policy limits, policy exclusions, coinsurance, and loss settlement provisions for flood coverage in the data will be reviewed.

4. Treatment of annual deductibles will be reviewed.

Pre-Visit Letter

62. AF-5, Disclosure 2, page 146 (revised pages 176-177): Explain the formula used, since it is a formula that was superseded in the currently approved hurricane model submission.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Discussed that the model makes no insurance-to-value assumptions.

Discussed that no mathematical depictions of deductibles, policy limits, policy exclusions or loss settlement provisions are used in the model.

Discussed that policy terms in the historical data used for validation were processed in accordance with industry practices.

Reviewed the calculation for annual aggregate deductibles.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the updated formula used to calculate expected insured loss.

Verified after resolution of open issues.

AF-6 Flood Loss Outputs and Logical Relationships to Risk

A. The methods, data, and assumptions used in the estimation of 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.

Audit

1. The data and methods used for flood probable maximum loss levels for Form AF-6, Flood Probable Maximum Loss for Florida, will be reviewed. The Top Event and Conditional Tail Expectations will be reviewed.

2. The frequency distribution and the individual event severity distribution, or information about the formulation of events, underlying Form AF-6, Flood Probable Maximum Loss for Florida, will be reviewed.

3. The first and second moments of the Annual Aggregate and Annual Occurrence distributions underlying the tables in Form AF-6, Flood Probable Maximum Loss for Florida, will be reviewed.

4. The first and second moments of the frequency and severity distributions, or similar information about the event distributions, underlying the flood probable maximum loss levels shown in Parts A and B in Form AF-6, Flood Probable Maximum Loss for Florida, will be reviewed.

5. All referenced literature will be reviewed, in hard copy or electronic form, to determine applicability.

6. Graphical representations of flood loss costs by rating areas and geographic zones (consistent with the modeling-organization grid resolution) will be reviewed.

7. Color-coded maps depicting the effects of topography and flood control measures on flood loss costs by rating areas and geographic zones (consistent with the modeling-organization grid resolution) will be reviewed.

8. 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 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 Loss Costs by ZIP Code, and AF-5, Logical Relationship to Flood Risk (Trade Secret Item), will be reviewed to assess flood coverage relationships.

9. The flood loss cost relationships among deductible, policy form, construction type, coverage, year of construction, foundation type, condo unit floor, 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.

10. The total personal residential insured flood losses provided in Forms AF-2, Total Flood Statewide Loss Costs, and AF-3, Personal Residential Standard Flood Loss Costs by ZIP Code, will be reviewed.

11. Form AF-4, Flood Output Ranges, will be reviewed, including geographical representations of the data where applicable.

12. Form AF-4, Flood Output Ranges, will be reviewed to ensure appropriate relativities among deductibles, coverages, and construction types.

13. Apparent anomalies in the flood output ranges and their justification will be reviewed.

Pre-Visit Letter

63. Form AF-1: Explain the Zero entries (e.g., ZIP Code 32697).

64. Form AF-1, pages 206-207 (revised pages 246-249): Explain the loss costs in the areas to the west and northwest of Lake Okeechobee in Figures 65-67.

65. Form AF-1, pages 206-207 (revised pages 246-249): Explain why most of the manufactured home losses per $1,000 are lower than wood frame. Given that, explain the ZIP Code in Dixie County (32680) that indicates manufactured homes have higher loss costs per $1,000 than wood frame or masonry.

124. Forms AF-1, AF-2, and AF-3, pages 246-293: Explain the reason for the changes in modeled results from the original submission, as shown in these forms.

125. Form AF-1, Figures 62-64, pages 246-249: In particular, explain the large changes in the Panhandle and North Florida. For example, Hamilton, Putnam, Wakulla, and Madison Counties.

66. Form AF-3, page 223 (revised pages 255-273): Explain why the totals for storms do not match those given in Form AF-2.

67. Form AF-3, Figure 70, page 225 (revised Figure 67, page 287): Explain the high losses in Southwest Florida (Sanibel Island and surrounding areas) for Hurricane Jeanne (2004).

126. Form AF-4, pages 294-349: Explain the difference in the output ranges compared to the original submission.

68. Form AF-4, page 230 (revised page 294): Explain why there are so many Zeros (e.g., Brevard County Low).

69. Form AF-4, pages 231-232 (revised pages 295-296): Explain the weighting procedure used to determine the county averages for DeSoto and Gulf Counties.

70. Form AF-4, page 232 (revised page 296): With Form AF-1 having only two ZIP Codes for Glade 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.

71. Form AF-4, 0% Deductible, pages 230-237 (revised pages 294-301): Explain, in general, how apparent anomalies were resolved. In particular, explain the following cases where Frame loss costs are less than Masonry loss costs:
    Owners: Brevard Average, Pasco Average, Sumter Average
    Renters: Leon Average, St. Lucie Average
    Condo Unit: Brevard Average, Miami-Dade Average

72. Form AF-4, page 232 (revised page 296): 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.

73. Form AF-4, page 233 (revised page 297): 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.

74. Form AF-4, page 235 (revised page 299): With Form AF-1 having only two ZIP Codes for Okeechobee County (34972 and 34974) with “close” 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.

Verified: ~~NO~~ **YES**

~~Pending resolution of open issues~~

Professional Team Comments:

Discussed the explanation for the Zero entries in Form AF-1. Reviewed map of cluster centroids plotted against the 100-year flood catalog.

Discussed the loss costs in the areas west and northwest of Lake Okeechobee in Figures 65-67. Reviewed the 100-year map for inland flood.

Reviewed calculation for unknown first floor height. Reviewed a comparison of loss costs for manufactured homes to single-family frame and masonry homes.

Reviewed the model changes since the initial February submission and the effects on modeled loss costs for coastal and inland flood. Reviewed maps of the resulting modeled loss costs changes February to May. Reviewed inland flood footprint comparisons between February and May.

Reviewed maps of the changes to riverine flooding in the Panhandle and North Florida.

Discussed the differences in losses between Forms AF-2 and AF-3.

Discussed the losses in Southwest Florida for Hurricane Jeanne (2004).

Discussed the explanation for the Zero entries in Form AF-4. Reviewed maps of the 100-year inland flood inundation and the 500-year storm surge inundation for a particular ZIP Code centroid.

Reviewed the weighting procedure to obtain the average annual loss cost by county.

Reviewed the process for applying the weighting procedure in counties having only two ZIP Codes and how counties with only one ZIP Code are handled.

Reviewed maps of the top events from an occurrence level and from an aggregate level.

Reviewed the first and second moments of the annual aggregate and annual occurrence in Form AF-6.

Reviewed maps of flood loss costs by ZIP Code and County for frame owners, masonry owners, and manufactured homes.

Reviewed maps representing the effect of terrain slope on inland flood loss costs.

Reviewed map representing the impact of flood control measures on loss costs.

Reviewed the series of checks performed to verify the individual loss cost relationships in Form AF-5 for reasonability. Reviewed scatter plots of the different flood loss cost relationships.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed Forms AF-1, AF-2, AF-3, AF-4, AF-5, and AF-6 for consistencies in relativities and rationale for changes from previous submission.

Reviewed the updated maps of flood loss costs by ZIP Code and by County for frame owners, masonry owners, and manufactured homes.

Reviewed revised maps of the top events from an occurrence level for both inland and coastal flood, and from an aggregate level.

Reviewed the first and second moments of the annual aggregate and annual occurrence in revised Form AF-6.

Reviewed the loss costs in revised Form AF-5 for relative consistencies. All apparent anomalies were resolved. In particular, reviewed the building to contents vulnerability relationship.

Verified after resolution of open issues.

COMPUTER/INFORMATION FLOOD STANDARDS – Paul Fishwick, Leader

CIF-1 Flood Model Documentation

A. Flood model functionality and technical descriptions shall be documented formally in an archival format separate from the use of letters, slides, and unformatted text files.

B. The modeling organization shall maintain a primary document repository, 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 modeling organization shall maintain 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. The modeling organization shall maintain a list of all externally acquired currently used flood model-specific software and data assets. 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.

Audit

1. The primary document repository, in either electronic or physical form, and its maintenance process will be reviewed. The repository should contain or reference full documentation of the software.

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

3. Complete user documentation, including all recent updates, will be reviewed.

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.

5. Verification that documentation is created separately from, and is maintained consistently with, the source code and data will be reviewed.

6. The list of all externally acquired flood model-specific software and data assets will be reviewed.

7. The tables specified in CIF-1.D that contain the items listed in Standard GF-1, Scope of the Flood Model and Its Implementation, Audit 6 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 Architecture and Component Design, CIF-4, Flood Model Implementation, CIF-5, Flood Model Verification, and CIF-6, Flood Model Maintenance and Revision.

8. Tracing of the flood model changes specified in Standard GF-1, Scope of the Flood Model and Its Implementation, Audit 6 through all Computer/Information Flood Standards will be reviewed.

Pre-Visit Letter

75. CIF-1.D, page 151 (revised page 181): Provide the table of all substantive changes in the flood model since the February 29, 2020 submission, if any.

76. CIF-1.F, page 151 (revised page 181): Provide the list of all externally acquired software and data assets.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Discussed that the overall software engineering process is the same for all perils.

Reviewed the summary of changes between the February and May 2020 submissions.

Reviewed the list of all external acquired flood model-specific software and data sources.

Confirmed there were no model software changes since the May 29, 2020 revised submission.

Reviewed a plan the modeler will implement to improve the process to mitigate problems with inconsistency between different forms of documentation and implementation. Reviewed an updated flowchart of the revised process.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed the updated review process to mitigate inconsistency between different forms of documentation and implementation, including the addition of documentation review details and accountability requirements for reviewers through completion of a documentation review checklist.

Reviewed the updated documentation reflecting changes in the methodology for determining regression relationships and residual analyses for event duration and spatial extent.

Reviewed the summary of changes documentation outlining all changes since the February 2020 initial submission.

Reviewed vulnerability code mapping documentation.

Reviewed the inland flood event catalog generation documentation.

Verified after resolution of open issues.

CIF-2 Flood Model Requirements

The modeling organization shall maintain a complete set of requirements for each software component as well as for each database or data file accessed by a component. Requirements shall be updated whenever changes are made to the flood model.

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.

Pre-Visit Letter

77. CIF-2, page 152 (revised page 182): Provide the highest-level requirements documentation for the model.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed requirements documentation for precipitation, inland flood, storm surge, vulnerability, and model definition.

*****Additional Verification Review – November 16-18, 2020*****

Verified after resolution of open issues.

CIF-3 Flood Model Architecture and Component Design

A. The modeling organization shall maintain and document (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, and (4) system model representations associated with (1)-(3). 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) shall be based on (1) a referenced industry standard (e.g., Unified Modeling Language (UML), Business Process Model and Notation (BPMN), Systems Modeling Language (SysML)), or (2) a comparable internally-developed standard which is separately documented.

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, and
    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).

2. A flood model component custodian, or designated proxy, should be available for the review of each component.

3. The flowchart reference guide or industry standard reference will be reviewed.

Pre-Visit Letter

78. CIF-3, page 153 (revised page 183): Provide a description of procedures used to ensure that the diagrams are verified as being compliant with ISO 5807.

79. CIF-3.A, page 153 (revised page 183): Provide the documents that describe the flow of data between all relevant components of the software as well as the schema of the databases that host the exposures and results and the supporting API.

Verified: ~~NO~~ **YES**

~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed flowchart for model development, software development, and exposure and loss processing identifying personnel involved at each step.

Reviewed flowchart of the model software components.

Reviewed flowchart for form creation. Reviewed revisions made to the flowchart during the review.

Reviewed flowchart for building vulnerability function development.

Reviewed flowchart for determining first floor height.

Reviewed flowchart for contents vulnerability function development.

Reviewed flowchart for time element vulnerability function development.

Reviewed flowchart of the project kick-off process.

Reviewed flowchart of the project review and update process.

Reviewed documents describing the flow of data between all relevant software components, the schema of the databases, and the supporting application programming interface (API).

Reviewed list of detailed flowcharts for all model components.

Reviewed flowcharts for creating, loading and validating exposure data.

Reviewed flowchart for estimating ground up and gross losses.

Reviewed flowchart for model output report generation.

Reviewed flowchart of model definition dataflow.

Reviewed detailed list of interface specifications for all model components.

Reviewed documentation for data file schemas.

Reviewed flowchart of network organization.

Discussed that the ISO 5807 standard was followed for creating all flowcharts.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed flowchart of the updated project review process.

Verified after resolution of open issues.

CIF-4 Flood Model Implementation

A. The modeling organization shall maintain a complete procedure of coding guidelines consistent with current software engineering practices.

B. The modeling organization shall maintain a complete procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components.

C. All components shall be traceable, through explicit component identification in the flood model representations (e.g., flowcharts) down to the code level.

D. The modeling organization shall maintain a table of all software components affecting flood loss costs and flood probable maximum loss levels 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.

E. 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.

F. The modeling organization shall maintain the following documentation for all components or data modified by items identified in Standard GF-1, Scope of the Flood Model and Its Implementation, Audit 6:

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 F.1 above.

Audit

1. The interfaces and the coupling assumptions will be reviewed.

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.

3. The procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components will be reviewed.

4. The traceability among components at all levels of representation will be reviewed.

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.

6. The table of all software components as specified in CIF-4.D will be reviewed.

7. Flood model components and the method of mapping to elements in the computer program will be reviewed.

8. Comments within components will be reviewed for sufficiency, consistency, and explanatory quality.

Pre-Visit Letter

80. CIF-4.D, page 154 (revised page 184): Provide the table of all software components affecting flood loss costs and probable maximum loss levels.

81. CIF-4.F, page 154 (revised page 184): Provide the list of equations and formulas used in the flood model documentation with definitions of all terms and variables. Provide the cross-referenced list of implementation source code terms and variable names.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed table of all software components affecting flood loss costs and probable maximum loss levels.

Reviewed list of equations with cross-referenced links to source code.

Reviewed that documented equations could be traced through the design and implementation phases.

Reviewed documentation files for several flood model calculations.

Reviewed coding guidelines documentation.

Reviewed an example code used for model validation. Discussed that the model is validated before allowing it to be used for loss analysis.

Reviewed the procedure for creating, deriving, or procuring and verifying databases or data files accessed by model components.

Reviewed the process to ensure traceability among model components.

Discussed that the source code for the RiskInsight platform is under Microsoft Team Foundation Server (TFS) source control.

Reviewed the table listing the number of lines of code by project for all software components.

Reviewed an example from the model definition file that provides the primary means of mapping damage functions, hazard events, and other model details.

Reviewed examples of code comments for methods and descriptive comments for statements in the code.

Reviewed channel data and code implementation.

Reviewed catchment data and code implementation.

Reviewed load equations and code implementation.

*****Additional Verification Review – November 16-18, 2020*****

Reviewed updated coding guidelines.

Reviewed Manning equation and Muskingum-Cunge equation code implementation.

Reviewed revised model documentation and code related to rainfall volume, and the corresponding water balance implementation.

Reviewed example of single-family vulnerability function code for inland and coastal flood.

Verified after resolution of open issues.

CIF-5 Flood Model Verification

A. General

For each component, the modeling organization shall maintain procedures 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. The modeling organization shall use testing software to assist in documenting and analyzing all components.

2. Unit tests shall be performed and documented for each component.

3. Regression tests shall be performed and documented on incremental builds.

4. Aggregation 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. The modeling organization shall use testing software to assist in documenting and analyzing all databases and data files accessed by components.

2. The modeling organization shall perform and document integrity, consistency, and correctness checks on all databases and data files accessed by the components.

Audit

1. 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.

2. The testing software used by the modeling organization will be reviewed.

3. The component (unit, regression, aggregation) and data test processes and documentation will be reviewed including compliance with independence of the verification procedures.

4. 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.

5. Flowcharts defining the processes used for manual and automatic verification will be reviewed.

6. Verification approaches used for externally acquired data, software, and models will be reviewed.

Pre-Visit Letter

82. CIF-5.C2, page 157 (revised page 187): Provide documentation for integrity, consistency, and correctness checks on all databases and data files accessed by flood model components.

83. CIF-5, Disclosure 3, Table 16, page 159 (revised Table 17, pages 188-189): Explain how National Flood Hazard Layer information is factored into selection of vulnerability function and loss calculations. Explain how the claims data is verified.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed documentation for defensive coding practices, tracking and diagnostic reports to facilitate locating any problems in the code. Reviewed examples of defensive coding.

Discussed the origination of the flood zone used to select a vulnerability function.

Discussed the unit, regression, and aggregation tests performed. Reviewed an example of each test.

Reviewed a general overview of the process for code development to implementation.

Reviewed flowcharts of automated and manual test processes.

Discussed the general data verification process.

Reviewed the QA process used to review and process NFIP claims data.

*****Additional Verification Review – November 16-18, 2020*****

Verified after resolution of open issues.

CIF-6 Flood Model Maintenance and Revision

A. The modeling organization shall maintain a clearly written policy for flood model review, maintenance, and revision, 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. The modeling organization shall use tracking software to identify and describe all errors, as well as modifications to code, data, and documentation.

D. The modeling organization shall maintain a list of all flood model versions since the initial submission for this year. Each flood model description shall have an unique version identification and a list of additions, deletions, and changes that define that version.

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.

2. The policy for flood model revision and management will be reviewed.

3. Portions of the code will be reviewed.

4. The tracking software will be reviewed and checked for the ability to track date and time.

5. The list of all flood model revisions as specified in CIF-6.D will be reviewed.

Verified: ~~NO~~ **YES**
~~Pending resolution of open issues~~

Professional Team Comments:

Reviewed the procedures to ensure complete and accurate completion of development projects including code reviews, testing, and documentation.

Reviewed code review example and code review check-in requirements.

Reviewed the KCC protocol for flood model changes, including review, revisions, or maintenance. Discussed that there was no change in the protocol across perils.

Reviewed example of platform components and revision history on the Microsoft Team Foundation Server (TFS) online source control documentation system.

Reviewed modeler policy for model maintenance and revision.

*****Additional Verification Review – November 16-18, 2020*****

Verified after resolution of open issues.

CIF-7 Flood Model Security

The modeling organization shall have implemented and fully documented security procedures 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.

Audit

1. The written policy for all security procedures and methods used to ensure the security of code, data, and documentation will be reviewed.
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.

Verified: YES

Professional Team Comments:

Reviewed modeler policies for Security Procedures and Antivirus & Malware.

Reviewed modeler IT Disaster Recovery Plan.

Confirmed there have been no known security breaches.