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Guidance for Flood Risk Analysis and Mapping

Accepting Numerical Models for Use in the NFIP

November 2021



FEMA

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Requirements for the Federal Emergency Management Agency (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) Program are specified separately by statute, regulation, or FEMA policy (primarily the Standards for Flood Risk Analysis and Mapping). This document provides guidance to support the requirements and recommends approaches for effective and efficient implementation. Alternate approaches that comply with all requirements are acceptable.

For more information, please visit the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage (<https://www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping>). Copies of the Standards for Flood Risk Analysis and Mapping policy, related guidance, technical references, and other information about the guidelines and standards development process are all available here. You can also search directly by document title at <https://www.fema.gov/resource-document-library>.

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Table of Revisions

Affected Section or Subsection	Date	Description
Section 1; Section 3.2; Section 4; Section 5.2	November 2021	Updated FEMA website URLs for access to accepted models lists and documentation. This update builds upon the previous revision from December 2020, in which guidance was revised to clarify stakeholder requirement(s) when updating a model version.

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1. Introduction

For communities and mapping partners reference and information, Federal Emergency Management Agency (FEMA) maintains website lists of numerical models meeting minimum regulatory requirements as a means of ensuring consistency in implementing Title 44, Chapter 1, of the Code of Federal Regulations (44 CFR) Paragraph 65.6(a)(6) of the National Flood Insurance Program (NFIP) regulations. Paragraph 65.6(a)(6) explains conditions under which a computer model can be used for flood hazard mapping in the NFIP.

The following list is organized into two categories by the area of responsibility of the certifying agency: Nationally Accepted Models and Locally Accepted Models. The first four model types fall under Nationally Accepted Models:

1. Coastal,
2. Hydraulic
3. Hydrologic, and
4. Statistical models.

The remaining two model types fall under Locally Accepted Models:

5. Hydraulic models developed to address particular local conditions, and,
6. Hydrologic models developed to address particular local conditions.

Locally Accepted Models are applicable only to the specific local areas for which they have been accepted and are not applicable nationwide.

To get a comprehensive list of Nationally Accepted Models and Locally Accepted Models visit <https://www.fema.gov/flood-maps/products-tools/numerical-models>. From here, you can view information for:

- **Coastal Numerical Models** - <https://www.fema.gov/flood-maps/products-tools/numerical-models/coastal>
- **Hydraulic Numerical Models** - <https://www.fema.gov/flood-maps/products-tools/numerical-models/hydraulic>
- **Hydrologic Numerical Models** - <https://www.fema.gov/flood-maps/products-tools/numerical-models/hydrologic>
- **Statistical Numerical Models** - <https://www.fema.gov/flood-maps/products-tools/numerical-models/statistical>
- **Numerical Models No longer Accepted** - <https://www.fema.gov/flood-maps/products-tools/numerical-models/no-longer-accepted>

FEMA cannot accept Flood Insurance Studies (FISs) or map revision requests that are performed with numerical models other than those on the aforementioned lists. Please visit FEMA's [website](#) for the most up-to-date versions of the lists, which are updated as needed.

2. Applicable NFIP Regulations

As Paragraph 65.6(a)(6) of the NFIP regulations states, any computer program used to perform hydrologic and hydraulic analyses in support of a flood insurance map revision must meet all the following criteria:

(6) Any computer program used to perform hydrologic or hydraulic analyses in support of a flood insurance map revision must meet all of the following criteria:

(i) It must have been reviewed and accepted by a governmental agency responsible for the implementation of programs for flood control and/or the regulation of flood plain lands. For computer programs adopted by non-federal agencies, certification by a responsible agency official must be provided which states that the program has been reviewed, tested, and accepted by that agency for purposes of design of flood control structures or flood plain land use regulation.

(ii) It must be well-documented including source codes and user's manuals.

(iii) It must be available to FEMA and all present and future parties impacted by flood insurance mapping developed or amended through the use of the program. For programs not generally available from a federal agency, the source code and user's manuals must be sent to FEMA free of charge, with fully-documented permission from the owner that FEMA may release the code and user's manuals to such impacted parties.

3. Compliance with the Regulations

3.1. 44 CFR Paragraph 65.6(a)(6)(i): Model Review, Testing, and Acceptance by Certifying Agency

The following procedures should be used to add a model to FEMA's lists of "Numerical Models Meeting the Minimum Requirements." In accordance with Paragraph 65.6(a)(6)(i), any computer program used to perform coastal, hydrologic, and hydraulic analyses in support of a map revision must meet the following criteria:

- The model must be reviewed, tested, and accepted by a governmental agency responsible for the implementation of programs for flood control and/or regulation of floodplains.
- For computer programs adopted by non-federal agencies, certification by a responsible agency official must be provided which states that the program has been reviewed, tested, and accepted

by that agency for purposes of design of flood control structures or floodplain land use regulations.

FEMA does not provide technical review or testing of models. The following section provides guidance on the certification of computer programs for performing coastal, hydrologic, and hydraulic analyses for map revisions and other NFIP purposes.

Hydrologic and hydraulic models developed by federal agencies responsible for the implementation of flood control programs, floodplain regulation, and/or flood hazard analysis clearly meet the criteria stated in 44 CFR Paragraph 65.6(a)(6)(i) of the NFIP regulations. Models developed by non-federal agencies or private entities must be certified by a governmental agency responsible for the implementation of programs for flood control and/or regulation of floodplain lands. The certifying agency can be a federal agency or non-federal agency, such as a state water conservation board or regional flood control district. If the certifying agency is not a federal agency, the certifying agency must review, test, and accept the model. The requirements for certification, listed below, are more rigorous than simply applying the model for a given project.

- The certifying agency must review the model in sufficient detail to conclude that the model is scientifically correct and technically sound. The model must be based on sound hydrodynamic, hydrologic, or hydraulic principles. For this review, the certifying agency may rely on published technical papers by authors other than the model developers that demonstrate the model is technically sound. FEMA may request the certifying agency to provide the list of reviewed technical references.
- The certifying agency must test the model with measured data or compare the model to other similar models on FEMA's list of "Numerical Models Meeting the Minimum Requirements" to determine whether the model can adequately reproduce the measured data or provide results comparable to other models accepted by FEMA. A summary of the testing methods and results should be provided to FEMA.
- The certifying agency must accept the model for its use in administering programs for the design of flood control structures and/or the regulation of floodplain lands.
- With the request for approval of the model submitted to FEMA, the certifying agency must cite and describe specific examples of using the model to demonstrate the applicability of the model to the NFIP for purpose of the design of flood control structures and/or the regulation of floodplain lands.
- If necessary, FEMA may request the certifying agency to provide assistance, such as providing answers to technical questions, relative to the use of the certified model for Flood Insurance Studies and appeals in the NFIP.
- The certification must be provided by a responsible agency official who has the authority to certify the model on behalf of the agency.

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Coastal, hydrologic, hydraulic, and hydrodynamic models developed by federal agencies responsible for the implementation of flood-control programs, floodplain regulation, and/or flood hazard analysis clearly meet the criteria stated in Paragraph 65.6(a)(6)(i) of the NFIP regulations. These criteria can be extended to include federal agencies such as the U.S. Geological Survey that are not responsible for flood-control programs and floodplain regulations but are active in developing and advancing hydrologic and hydraulic models. To comply with requirements (1) and (2) discussed in this document in Section 2.0, "Applicable NFIP Regulations," models developed by non-federal agencies or private entities must be certified by a governmental agency responsible for the implementation of programs for flood control and/or regulation of floodplain lands, and such models must meet the following criteria:

- The model must be used or be planned to be used by communities for NFIP studies;
- The model must provide for new capabilities beyond any non-proprietary model on the existing accepted models lists; and
- The model must be "reviewed, tested, and accepted" with respect to its use in the design of flood-control structures or floodplain land use regulation. A written certification must be provided by the review agency to FEMA. Certification criteria are described in detail in Section 2.1 of this document, "Model Review, Testing, and Acceptance."

In several previous instances, FEMA has reviewed and tested a proprietary model for possible inclusion in the Accepted Models lists. However, as of August 16, 2004, FEMA does not review and test any proprietary model. Another government agency that is familiar with the model should be contacted to certify its use. FEMA will provide necessary assistance to the certifying agency upon request. The certifying agency must review and test the model to determine whether the model is scientifically correct and technically sound, and whether the model can provide adequate information to support NFIP study and mapping. While federal agencies can certify a model for nationwide use, state and regional agencies can certify a model for use within their jurisdiction. The certification document must be provided by an agency official with authority to certify the model on behalf of that agency. FEMA will review and evaluate the certification materials provided by the certifying agency to make the final determination on whether the model meets the minimum requirements of the NFIP.

3.2. 44 CFR Paragraphs 65.6(a)(6)(ii) and (iii): Model Documentation and Availability

With regard to requirements in Paragraphs 65.6(a)(6)(ii) and (iii), FEMA understands that many models developed by private entities, such as software developers, are often proprietary in nature. The conditions listed are not meant to infringe upon the software developer's rights. Under Paragraph 67.8(e) of the NFIP regulations, FEMA is obligated to ensure that parties affected by floodplain mapping have the right to appeal map actions. Computed Base (1-percent-annual-chance) Flood Elevations (BFEs) can be appealed only if they are believed to be scientifically or technically incorrect. As part of an appeal resolution, it may be necessary that the source codes and user's

manuals for the computer program used to develop or amend the BFEs be made available to affected parties who can demonstrate the need to review the model. This is necessary to allow the affected parties to evaluate the methodology used to compute the BFEs.

FEMA has developed two sample disclosure agreements that both protect the interests of software developers and meet the procedural and technical guidelines of Parts 65 and 67 of the NFIP regulations. The disclosures do not need to be notarized, but they may be. The first, entitled "Conditional Permission to Disclose Source Code and User Manual," is a general agreement between FEMA and a model developer, stating that the model developer will release the source code and user's manual to any appellant who demonstrates the need to review the model. This agreement is concluded before a model is added to one of the aforementioned lists. The second, entitled "Disclosure Agreement Between Model Developer and Impacted Party," is an agreement between the model developer and an appellant that provides for release of the source code and user's manual to the appellant and requires the appellant to protect the proprietary rights of the model developer. This second agreement is used only when an appeal is received.

The "Conditional Permission to Disclose Source Code and User Manual" document and the "Disclosure Agreement Between Model Developer and Impacted Party" are available by contacting FMIX using https://floodmaps.fema.gov/fhm/fmx_main.html.

If these and the criteria outlined in 44 CFR Paragraphs 65.6(a)(6)(ii) and (iii) are met, FEMA will accept the model and include it on the list of "Numerical Models Meeting the Minimum Requirements of the National Flood Insurance Program" located at <https://www.fema.gov/flood-maps/products-tools/numerical-models>. The area of applicability of the model will be consistent with the area of responsibility of the certifying agency (i.e., local, regional, or national).

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4. Maintenance of the Accepted Models lists

4.1. FEMA Acceptance Letter and Website Update

Once FEMA agrees a model complies with the regulations, FEMA will issue a letter of acceptance addressed to the certifying agency. This acceptance letter is used as the basis for updating FEMA's list of accepted models; therefore, as we make updates to our lists on FEMA.gov, please reference and include the FEMA acceptance letter in any NFIP mapping projects (studies or revision requests) using the model. You can visit the FEMA.gov website for the most up-to-date version of the lists, as it will be updated as necessary.

4.2. Version Updates to An Accepted Model

Model version updates are relatively routine in the software field of a model developer. When a new version of an accepted model is available, and the certifying agency/model developer requests to have the new model version accepted, data and documentation must be submitted to FEMA. In general, the submittal must describe how/why this new version is different, and what (if any) differences in output may be expected compared to the previous already accepted version. FEMA will

review this submitted data and documentation to determine whether the updated model version can be accepted. Regarding testing/development model versions (e.g., beta phase), final production model versions must be used for regulatory NFIP mapping products.

4.3. Removing Models from List(s)

A model will be removed from the lists if it meets one of the following conditions:

- The model is no longer supported by the agency that developed, supported, or certified the model;
- The model has not been used for an NFIP study or revision for five years, and no effective NFIP study is based on the model; or
- The model is no longer supported by current computer hardware or operating systems.

4.4. Local Model Acceptance by Certifying Agency

FEMA has developed a certifying agency certification letter template, which communities may use to achieve acceptance of locally applied models.

5. Use of HEC RAS in the NFIP

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The U.S. Army Corps of Engineers (USACE) is a leading federal agency in the development of hydrologic and hydraulic computer modeling programs. These programs have been used throughout the history of the NFIP for flood hazard mapping and the creation of FISs and Flood Insurance Rate Maps (FIRMs). The HEC-2 computer model is one specific model that has been used extensively throughout the history of the NFIP for hydraulic calculations to determine BFEs.

5.1. Development of HEC-RAS

The Hydrologic Engineering Center of the USACE released the River Analysis System, HEC-RAS, to replace the HEC-2 hydraulic model; none of the hydraulic routines from HEC-2 were used in the HEC-RAS software. The following information provides guidance for the use of HEC-RAS to replace HEC-2 models for flood hazard mapping in the NFIP.

The majority of detailed FISs and FIRMs in existence today have used the HEC-2 model to calculate BFEs. Paragraph 65.6(a)(8) of the NFIP regulations states that "...Unless the basis of the request is the use of an alternative hydraulic methodology or the requestor can demonstrate that the data of the original hydraulic computer model is unavailable or its use is inappropriate, the analysis shall be made using the same hydraulic computer model used to develop the BFEs shown on the effective FIRM and updated to show present conditions in the flood plain. Copies of the input and output data from the original and revised hydraulic analyses shall be submitted." Since the USACE no longer supports the use of the HEC-2 model, FEMA must determine when it is appropriate to use HEC-RAS when the original study used HEC-2 to determine BFEs.

FEMA issued a policy statement on March 14, 1997, that explained the appropriate uses of HEC-RAS. Briefly, it stated that HEC-RAS could be used for a map revision request or restudy when one of the following conditions had been met:

- The entire stream was rerun using HEC-RAS; or
- The stream reach remodeled using HEC-RAS was hydraulically independent from the rest of the stream, e.g., the stream was restudied from the downstream confluence with the receiving stream (or other hydraulic control section) upstream to a dam or other hydraulic control section.

5.2. Application of HEC-RAS to Flood Insurance Studies

Given that the USACE replaced HEC-2 with HEC-RAS, FEMA subsequently revised its policy statement on April 30, 2001, to encourage the use of HEC-RAS when appropriate, using the following guidance.

5.2.1. NEW DETAILED FLOOD INSURANCE STUDIES

For new detailed Flood Insurance Studies that have not yet been started, and for streams for which there is not an effective detailed study, FEMA encourages the use of HEC-RAS rather than HEC-2. Note that other computer models may also be used; FEMA's complete list of acceptable computer models can be accessed at <https://www.fema.gov/flood-maps/products-tools/numerical-models>. HEC-2 is still considered an acceptable hydraulic model; however the use of HEC-RAS instead of HEC-2 is strongly encouraged.

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5.2.2. REVISIONS TO EFFECTIVE FLOOD INSURANCE STUDIES

For revisions to or restudies of detailed-study streams, where the effective model is HEC-2, the conversion to HEC-RAS is encouraged. The following guidelines must be followed to convert an effective HEC-2 model to HEC-RAS.

- The effective HEC-2 model should be rerun on the requestor's computer in HEC-RAS to create the duplicate effective model. The differences in water-surface elevation between the effective model and the duplicate effective model must be fully documented and thoroughly explained. Most differences in water-surface elevation can be attributed to the (1) differences in bridge/culvert modeling routines, (2) method of conveyance calculations, (3) critical depth default, and (4) floodway computations. The HEC-RAS User's Manual and the HEC-RAS Hydraulics Reference Manual provide details on computational differences between the two models and guidance on simulating HEC-2 results; these manuals should be consulted to explain the differences between the effective and duplicate effective models.
- Once the duplicate effective model has been established, the corrected effective, existing conditions, and post-project conditions models can be created in HEC-RAS, using the duplicate effective HEC-RAS model as the basis.

- As a reminder, unless it is demonstrated that it would not be appropriate, the revised HEC-RAS model must match the effective water-surface profile within 0.5 foot at the upstream and downstream ends of the revised reach, in compliance with Paragraph 65.6(a)(2) of the NFIP regulations.

6. Automation Tools and Their Relationship to Accepted FEMA Models

Geographic Information Systems (GIS), enhanced hydrologic and hydraulic modeling tools, and computer software can be used to efficiently develop and update flood hazard information for the NFIP. These automated tools facilitate model building, perform data processing and storage tasks, improve graphics and visualization, and provide user-friendly graphical interfaces.

A wide variety of automation tools have been developed to facilitate hydrologic and hydraulic modeling. These tools range from simple graphical user interfaces that help input model parameters to highly advanced GIS-based tools that contain state-of-the-art software and modeling approaches with fully-integrated data processing, graphics, and visualization capabilities. The most commonly used automation tools are organized into three categories below based on their relationship to accepted FEMA models.

6.1. Category 1 **This Document Has Been Superseded.**

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These automation tools can be either pre-processing or post-processing. Pre-processing tools are independent modules that perform input data pre-processing tasks to estimate model input parameters and/or help build hydrologic and hydraulic model input files. Post-processing tools are independent modules that perform model output data post-processing tasks to help plot, display, visualize, or manipulate hydrologic and hydraulic model results. They may simply be graphical user interfaces (GUIs) designed to help format, analyze, or display modeling input and output data. Additionally, they may be GIS- or CAD-based, have data storage capabilities and animation techniques, or help integrate a variety of different modeling components. In all cases, they function in conjunction with, but separately from, the executable file of a computer model that is on FEMA's accepted models list.

The tools in this category are considered acceptable for use in the flood hazard mapping program because they are not computer models themselves, but are used to prepare data for input to the model or process data output from the model. Since they function independently from a computer model already on the accepted models list, and are not the basis for map revisions, they are acceptable. FEMA will not maintain a list of tools that fall into this category.

When map revision requests or flood insurance studies are submitted to FEMA for review that utilize one of these "Category 1" tools for hydrologic and hydraulic modeling, all required model input and output must be made readily available. This would include all input model parameters and output

data, which is required for QA/QC purposes in reviewing, maintaining, and revising the modeling data.

6.2. Category 2

These software tools are computer models that perform modeling routines that emulate a model on FEMA's accepted model list; however, their source code has been re-written to perform these tasks, instead of using the accepted model's source code. For example, they may reproduce basic HEC-1 hydrology functions, but do not use the HEC-1 executable computer code. In general, they usually provide additional functionality, such as data pre-and post-processing, enhanced graphics, GUIs, or visualization techniques. They are considered computer models because they perform hydrologic and hydraulic calculations similar to other accepted FEMA models. Therefore, Category 2 software tools need to meet 44 CFR Paragraphs 65.6(a)(6)(i), (ii), and (iii) of the NFIP regulations. If accepted, these models will be added to FEMA's acceptable model list.

6.3. Category 3

These software tools use new hydrologic and hydraulic modeling methods and/or models not currently on the FEMA accepted numerical models list. They may add pre-or post-processing functions similar to the other categories of tools as well. Therefore, since these software tools use new modeling methods, they are considered new computer models, and Category 3 software tools need to meet 44 CFR Paragraphs 65.6(a)(6)(i), (ii), and (iii) of the NFIP regulations. If accepted, these models will be added to FEMA's acceptable model list.

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