

# Map MODERNIZATION

Federal Emergency Management Agency



**FEMA's Flood Hazard Mapping Program**

# Guidelines and Specifications *for* Flood Hazard Mapping Partners

*Appendix H: Guidance for Mapping of  
Areas Protected by Levee Systems*



**FEDERAL EMERGENCY MANAGEMENT AGENCY**

[www.fema.gov/fhm/dl\\_cgs.shtm](http://www.fema.gov/fhm/dl_cgs.shtm)

**April 2003**

All policy and standards in this document have been superseded by the FEMA Policy for Flood Risk Analysis and Mapping. However, the document contains useful guidance to support implementation of the new standards.

## **Summary of Changes for Appendix H, Guidance for Mapping of Areas Protected by Levee Systems**

The Summary of Changes below details changes that have been made to Appendix H subsequent to the initial publication of the *Guidelines* in February 2002. These changes represent new or updated guidance for Flood Hazard Mapping Partners.

| <b>Date</b> | <b>Affected Section(s)/ Subsection (s)</b> | <b>Summary of Changes</b>                               |
|-------------|--|---|
| April 2003  | H.2, H.4.2                                 | Updated to reflect the new FEMA Levee Inventory System. |
| April 2003  | H.2  | Clarified levee freeboard requirement language.         |

## Appendix H

# Guidance for Mapping of Areas Protected by Levee Systems

This Appendix describes the Federal Emergency Management Agency (FEMA) requirements and procedures for evaluating earthen levee systems and mapping the areas affected by those systems. Procedures for evaluating concrete dikes, floodwalls, seawalls, and other structures are not covered herein and shall be coordinated with and approved by the FEMA Regional Project Officer (RPO) or the Project Officer (PO) at FEMA Headquarters (HQ). Mapping Partners also must contact the RPO or PO to obtain the appropriate criteria for analyzing agricultural levees.

Specific guidance for the evaluation of coastal structures and the mapping of areas affected by these structures is contained in Appendix D of these Guidelines.

### H.1 Levee System Component Terminology [February 2002]

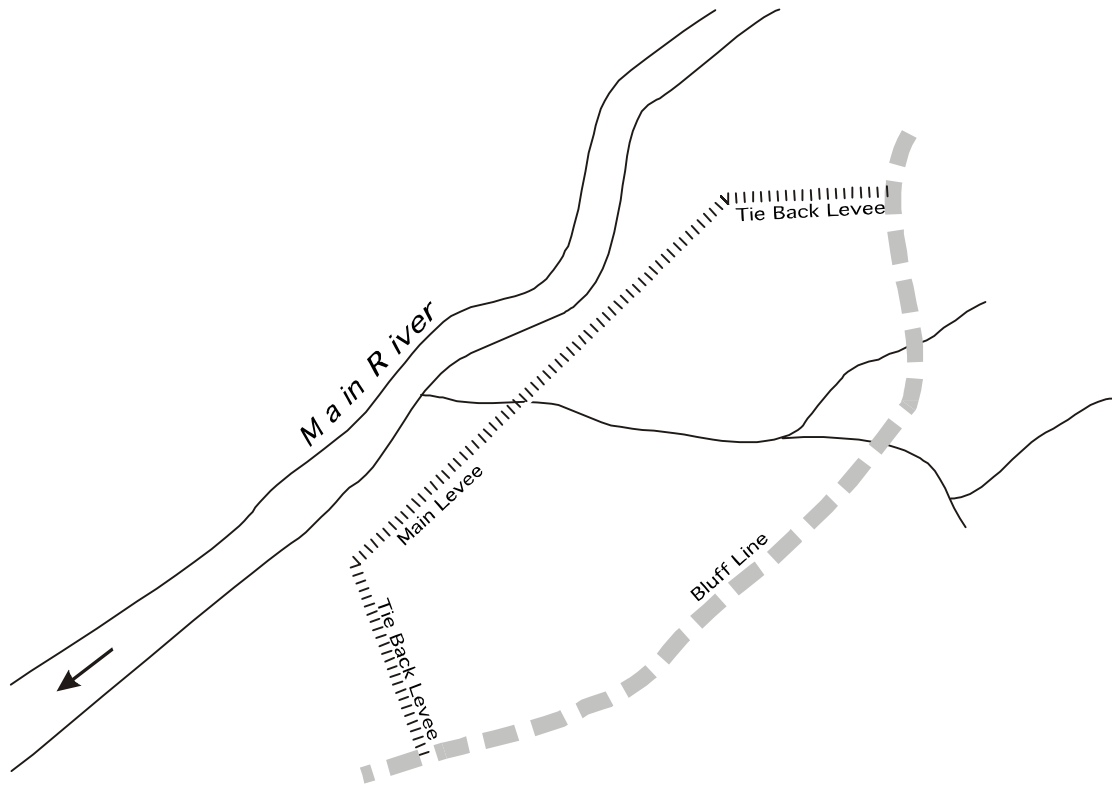
A levee system usually consists of a main levee, tie back levees, a gravity outlet, and pumps. Some levee systems may also include pressure conduits, closure structures, ring levees, setback levees, sublevees, and spur levees. The most common components are defined below.

- *Levees*: Manmade structures, usually earthen embankments, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding.
- *Levee systems*: Flood protection systems that consist of a levee, or levees, and associated structures, such as closure and drainage devices, which are constructed and operated in accordance with sound engineering practices.
- *Main and tributary levees*: Levees that lie along a main stream and its tributaries, respectively.
- *Tie back levees*: Levees that extend from the main levees along rivers, lakes, or coasts to bluff lines (high ground) and are part of the line-of-protection.
- *Ring levees*: Levees that completely encircle or “ring” an area subject to inundation from all directions.
- *Setback levees*: Levees that are built on the land side of existing levees, usually because the existing levees have suffered distress or are in some way being endangered, as by river migration.

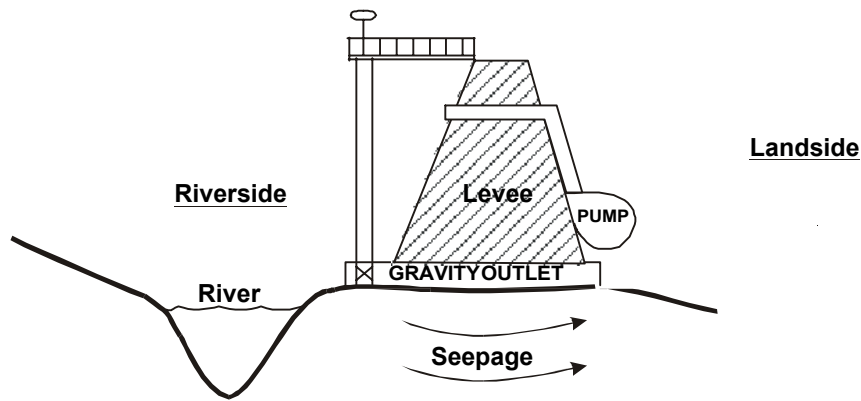
- *Sublevees*: Levees built for the purpose of underseepage control. Sublevees encircle areas behind main levees, which are subject, during high-water stages, to high uplift pressures and possibly the development of sand boils. Sublevees normally tie into the main levees, thus providing a basin that can be flooded during high-water stages, thereby counterbalancing excess head beneath the top stratum within the basin. Sublevees are rarely employed as the use of relief wells or seepage berms make them unnecessary except in emergencies.
- *Berms*: Horizontal strips or shelves of material built contiguous to the base of either side of levee embankments for the purpose of providing protection from underseepage and erosion, thereby increasing the stability of the embankment or reducing seepage. Berms can be located on either side of levees, depending upon their purpose.
- *Spur levees*: Levees that project from the main levee and serve to protect the main levee from the erosive action of stream currents. Spur levees are not true levees; they are training dikes.
- *Dikes*. Embankments constructed of earth or other suitable materials to protect land from overflows or to regulate water.
- *Floodwalls*: Concrete walls constructed adjacent to streams for the purpose of preventing flooding of property on the landside of the wall; normally constructed in lieu of or to supplement levees where the land required for levee construction is more expensive or not available.
- *Lines-of-protection*: Locations of levees or walls that prevent floodwaters from entering an area.
- *Pressure conduits*: Closed conduits designed to convey interior flows through the line-of-protection under internal pressure. The inlet to a pressure conduit that discharges interior flows by force of gravity must be at a higher elevation than the river stage against which it functions. Some pressure conduits may serve as discharge conduits from pumping stations.
- *Pumping stations*: Pumps located at or near the line-of-protection to discharge interior flows over or through the levees or floodwalls (or through pressure lines) when free outflow through gravity outlets is prevented by high exterior stages.
- *Gravity outlets*: Culverts, conduits, or other similar conveyance openings through the line-of-protection that permit discharge of interior floodwaters through the line-of-protection by gravity when the exterior stages are relatively low. Gravity outlets are equipped with gates to prevent riverflows from entering the protected area during time of high exterior stages.

- *Closure devices*: Any movable and essentially watertight barrier, used in flood periods to close an opening in a levee, securing but not increasing the levee design level of protection.
- *Stop logs*: Logs, planks, cut timber, steel, or concrete beams fitting into end guides between walls or piers to close openings in levees, floodwalls, dams, or other hydraulic structures. The stop logs are usually handled or placed one at a time.
- *Street gates*: Closure gates used during flood periods to close roadway openings through levees or floodwalls.

The diagrams in Figure H-1 provide plan view and sectional view schematics of a standard levee system.



PLAN VIEW SCHEMATIC



SECTIONAL VIEW SCHEMATIC

Figure H-1. Plan View and Sectional View Schematics of Standard Levee System

## **H.2 Levee System Evaluation Criteria**

**[April 2003]**

Mapping Partners shall evaluate the ability of levee systems not already documented in the FEMA Levee Inventory System (FLIS) to provide protection from the 1-percent-annual-chance flood. (See Volume 3, Subsection 3.2.7.3 for further details regarding the FLIS.) In doing so, Mapping Partners shall use the criteria outlined in Section 65.10 of the National Flood Insurance Program (NFIP) regulations and the step-by-step procedures as summarized on the following pages. Mapping Partners shall **always** initiate analyses by evaluating the levee freeboard and maintenance plan and shall only proceed with further analyses if these requirements are met.

1. Freeboard. Mapping Partners shall evaluate the freeboard provided by the levee. Riverine levees must provide a minimum freeboard of 3 feet above the 1-percent-annual-chance flood elevation. An additional 0.5 foot above that minimum is required along the length of the upstream tieback levee and at the upstream end of the main levee (see Figure H-1). The amount of required freeboard along the main levee tapers to no less than 3 feet above the 1-percent-annual-chance flood elevation at the downstream end. The downstream tieback levee must also provide 3 feet of freeboard along its length. An additional 1 foot of freeboard above the 3-foot minimum is required within 100 feet of either side of structures within the levee (e.g., closure structures) or wherever the flow is constricted (e.g., at bridges). Freeboard criteria are detailed in Paragraph 65.10(b)(1) of the NFIP regulations.
2. Structural Design Analyses. Mapping Partners shall review the structural analyses, which address closures, embankment protection, embankment and foundation stability, and settlement. The structural analyses must meet the criteria detailed in Paragraphs 65.10(b)(2), (3), (4), and (5) of the NFIP regulations.
3. Interior Drainage. Where credit will be given to levees providing protection from the 1-percent-annual-chance flood, Mapping Partners shall evaluate the adequacy of interior drainage systems. Interior drainage systems associated with levee systems usually include storage areas, gravity outlets, pumping stations, or a combination thereof. These drainage systems will be recognized by FEMA as providing flood protection from the 1-percent-annual-chance flood only if they meet the criteria outlined in Paragraphs 65.10 (b)(6) and (c)(2) of the NFIP regulations.
4. Operations. In general, Mapping Partners shall not consider human intervention (e.g., capping of levees by sandbagging, earthfill, or flashboards) for the purpose of increasing a levee's design level of protection during an imminent flood in the levee evaluation. Only in exceptional cases where no practicable alternative exists and technical justification is provided will FEMA permit sandbagging to satisfy freeboard requirements. The assigned Mapping Partner shall coordinate all such cases with the FEMA RPO. Human intervention will normally only be accepted for the operation of closure structures (e.g., gates, stoplogs) and manual backup for pumping stations in a levee system designed to provide at least 1-percent-annual-chance flood protection, including adequate freeboard as described earlier. Where levee closures and/or pumping stations are involved, an officially adopted operations plan that meets all the criteria set forth in Paragraphs 65.10(c)(1) and (2) of the NFIP regulations is required.

5. Maintenance. For a levee system to be recognized as providing 1-percent-annual-chance protection, the system must be maintained in accordance with an officially adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the levee system. The specific requirements of the maintenance plan are detailed in Paragraph 65.10(d) of the NFIP regulations. Note that a governmental agency must assume ultimate responsibility for maintenance plans.
6. Certification Requirements. All levee systems must be certified in accordance with Paragraph 65.10(e) of the NFIP regulations.
7. Exception Procedures. FEMA will accept certification from another Federal agency that an existing levee system is designed and constructed to provide 1-percent-annual-chance flood protection in lieu of the requirements outlined in Paragraphs 65.10(b)(1) through (7) of the NFIP regulations. Under certain circumstances, FEMA may also grant exceptions to the requirements itemized above or approve alternate analysis techniques.



## **H.3 Crediting Criteria for Flood Maps**

**[February 2002]**

The Mapping Partner responsible for performing the hydrologic and hydraulic analyses shall follow the steps listed below in determining a levee system's ability to provide 1-percent-annual-chance flood protection. The final decision concerning the creditability of the levee system must be made by the RPO before the Mapping Partner proceeds with further hydraulic analyses.

1. The Mapping Partner shall identify the levee system to be studied, including all "levee elements" (e.g., main levee, tieback levee, railroad or highway embankment), interior drainage elements and any other elements required to form a stand-alone flood-control structure.
2. The Mapping Partner shall determine the ownership of each system element via telephone contact with community officials and/or appropriate State and Federal agencies.
3. The Mapping Partner shall determine the status of all system elements (i.e., credited or unaccredited, detailed or approximate study), as presently reflected on the effective Flood Insurance Rate Map (FIRM).
4. The Mapping Partner shall obtain all available supporting documentation from the system element owner, operator (i.e., local agency, State agency, Federal agency, private individual, corporation), and/or the appropriate FEMA data repository, including but not limited to the following:
  - As-built plans;
  - Survey data;
  - Geotechnical reports;
  - Structural analyses;
  - Interior drainage analyses;
  - Inspection reports; and
  - Operation and maintenance plans.
5. The Mapping Partner shall obtain written confirmation of any previous certification by the agency responsible for design and construction that the levee system or elements thereof are Federal projects that provide protection from the 1-percent-annual-chance flood, when appropriate.
6. The Mapping Partner shall make an individual inventory of data received for the levee system.

7. The Mapping Partner shall perform hydraulic analyses of the 10-, 2-, 1-, and 0.2-percent-annual-chance floods, assuming the levee system to be in place if these hydraulic analyses are not available. Otherwise, the Mapping Partner shall assess the available computations for present-day application and modify them, if necessary.
8. The Mapping Partner shall use available as-built levee profiles or topographic data and the 1-percent-annual-chance water-surface profile obtained from the hydraulic analysis conducted with the levee in place to make a determination of the available freeboard of each system element.
9. If any element of the levee system is found to provide less than the required freeboard, the Mapping Partner shall inform the RPO of the level of freeboard deficiency. Based on the information provided by the Mapping Partner and the availability of other design data, the RPO may request more detailed surveys of the levee profile or a risk analysis of the levee design elements.
10. The Mapping Partner shall review the available operation and maintenance plans to determine whether the plans meet the requirements of Paragraphs 65.10 (c) and (d), and document any noted deficiencies in writing to the RPO. The RPO shall provide guidance on any supplemental evaluation necessary to ascertain the adequacy of operation and maintenance plans.
11. The Mapping Partner shall summarize the results and conclusions of the levee evaluation in a final letter report to the RPO and include the following as attachments and/or references:
  - All correspondence and reports of telephone conversations with and among the RPO; local, State, and Federal entities; and levee owners;
  - Inventories of available data; and
  - Field inspection reports and photographs.
12. The Mapping Partner shall summarize the actions taken in the levee evaluation, the ownership of each system element, and the outcome of the evaluation for inclusion in the Flood Insurance Study report.

## **H.4 Review Responsibilities**

**[February 2002]**

This section addresses the independent review responsibilities of the Mapping Partner responsible for preparing the Preliminary version of the Flood Insurance Study report and FIRM (hereinafter referred to as reviewing Mapping Partner).

The reviewing Mapping Partner shall review levees, and structures intended to serve as levees for their effect on the 1-percent-annual-chance flood, to verify that they have been properly analyzed. The Mapping Partner shall conduct this review to ensure that minimum design criteria requirements have been met before any levee system is credited on the FIRM as providing 1-percent-annual-chance flood protection. The Mapping Partner shall document any deviations or exceptions fully and ensure a technical basis for exceptions is provided. This independent review shall assess the conclusions reached by the Mapping Partner performing the hydrologic and hydraulic review and shall facilitate establishing appropriate flood insurance risk zone determinations for the FIRM, and does not constitute a determination as to how a structure or system will perform during a flood event.

### **H.4.1 Review Criteria**

**[February 2002]**

The reviewing Mapping Partner shall conduct this review to ensure that the analysis was performed in accordance with the requirements detailed in Sections H.3 and H.4 and in conformance with Section 65.10 of the NFIP regulations.

FEMA will not consider privately owned, operated, or maintained levee systems as providing 1-percent-annual-chance flood protection unless local ordinances or State statutes mandate operation and maintenance. Levee systems for which a community, State, or Federal agency has responsibility for operation and maintenance will be considered by FEMA if they meet, and continue to meet, minimum design, operation, and maintenance standards. These standards must be consistent with the level of protection sought through the comprehensive floodplain management criteria established in Section 60.3 of the NFIP regulations.

The reviewing Mapping Partner must review the levee system to ensure it meets all minimum design requirements (i.e., freeboard, closures, embankment protection, embankment and foundation stability, settlement, interior drainage, and other design criteria required by FEMA). The reviewing Mapping Partner shall review the detailed engineering analyses performed under each category to ensure that they comply with Paragraph 65.10(b) of the NFIP regulations. The level of effort to be expended by the reviewing Mapping Partner in reviewing levee structural design criteria shall be decided by the PO at FEMA HQ or his/her designee on a project-by-project or community-by-community basis.

For a levee to be credited on the FIRM as providing 1-percent-annual-chance flood protection, the operation plans must comply with FEMA regulations as outlined in Paragraph 65.10(c) of the NFIP regulations. When required, the reviewing Mapping Partner shall review the plans to ensure compliance with FEMA regulations, particularly in the areas of closures and interior drainage systems.

The final criterion for levee certification is a functional maintenance plan that complies with Paragraph 65.10(d) of the NFIP regulations. The designated Mapping Partner shall review the plan to ensure that, at a minimum, it specifies the maintenance activities to be performed, the frequency of performance, and the person(s) by name or title responsible for the performance.

As mentioned earlier in this Appendix, FEMA will accept certification from another Federal agency that an existing levee system is designed and constructed to provide 1-percent-annual-chance flood protection in lieu of the requirements outlined in Paragraphs 65.10(b)(1) through (b)(7) of the NFIP regulations. In addition, under certain circumstances, FEMA may also grant exceptions or approve alternative analysis techniques on a case-by-case basis.

## **H.4.2 Levee Inventory**

**[April 2003]**

In addition, to the responsibilities detailed above, the reviewing Mapping Partner shall ensure that all levees in or adjacent to identified floodplains are documented and inventoried in accordance with the guidance for recording levees in the FLIS, provided in Volume 3, Subsection 3.2.7.3 of these Guidelines.

## **H.5 Floodplain Mapping and Flood Profiles [February 2002]**

If the levee satisfies the appropriate requirements, as verified by the RPO, the protected area (landward side of the levee) is to be designated as shaded Zone X or the appropriate zone determined by the interior drainage analysis (e.g., Zone AH). If an interior drainage analysis does not exist or has been determined to be insufficient in the levee investigation, further analysis and investigation of the residual flood risk associated with interior drainage shall be coordinated with the RPO. The RPO may opt to authorize additional analyses or make a recommendation for the flood hazard mapping on the protected side of the levee.

If the subject levee does not meet the requirements stated in Section 65.10 of the NFIP regulations, as verified by the RPO, the Mapping Partner shall recompute the 1-percent-annual-chance flood elevations as if the levee did not exist. None of the subject levee will be recognized as providing 1-percent-annual-chance flood protection unless there are portions of the levee system that can meet requirements of Section 65.10 of the NFIP regulations independent of the remaining levee system. The Mapping Partner shall consider the 1-percent-annual-chance flood levels on the unprotected side (river side) of the levee to be equal to the 1-percent-annual-chance water-surface elevations computed with the levee in place.

If the 1-percent-annual-chance flood level, with the levee in place, is higher than the top of the levee, the Mapping Partner shall use either the computed 1-percent-annual-chance flood levels on the riverside of the levee or the top-of-levee elevation, if appropriate. The 1-percent-annual-chance flood levels shall then be recomputed for the landward side of the unrecognized levee as if the levee did not exist.

If water-surface elevations of the 10-, 2-, and 0.2-percent-annual-chance floods on the river side of the levee are higher than the top-of-levee elevations, the Mapping Partner also shall consider those elevations to be equal to the top-of-levee elevations. If those elevations are lower than the top-of-levee elevations, the Mapping Partner shall use the elevations as computed on the Flood Profile. The Mapping Partner shall not make further analyses for the conditions without the levees shall not be made for floods with frequencies less than the 1-percent-annual-chance flood.

For the levees that do not satisfy the minimum requirements, the Mapping Partner might draw a maximum of five Flood Profiles on the profile sheet, representing the 10-, 2-, and 1-percent-annual-chance floods with levee elevations, and the 1- and 0.2-percent-annual-chance floods without levee elevations.

If the "with levee" base (1-percent-annual-chance) flood elevations (BFEs) are higher than the "without levee" BFEs, the Mapping Partner shall show a line running along the levee centerline, separating the areas of different BFEs, on the FIRM. Otherwise, the Mapping Partner shall show only "without levee" BFEs on the FIRM.

If the levees do not meet the requirements of Section 65.10 of the NFIP regulations, the Mapping Partner shall compute the regulatory floodway widths for the without levee condition using the equal conveyance reduction method. In the "Regulatory" column in the Floodway Data table, the Mapping Partner shall include two BFEs, representing river side and land side conditions, if

the former elevation is higher than the latter elevation. Otherwise, the Mapping shall show without levee BFEs in the Floodway Data table. At a tributary confluence with the main stream, the Mapping Partner shall show the BFEs from the main stream as the regulatory elevations if they are higher than the river side or land side BFEs of the tributary.

The above procedures for the determination of BFEs and regulatory floodways also apply to the conditions where levees exist on both sides of the stream. In these cases, the evaluation shall include the possibility of simultaneous levee failure, failure of only the left side, and failure of only the right side, and shall consider simultaneous levee failure for both the BFE and regulatory floodway computations. The Mapping Partner shall contact the RPO for guidance on the evaluation of levee systems under these circumstances.

Regulatory floodway boundaries are to be delineated at the landside toe of mainline and tributary levees that are credited with providing 1-percent-annual-chance flood protection on a FIRM. Thus, the community's floodplain management ordinance must prohibit encroachment on the levee, which could jeopardize levee integrity or effectiveness. It may also be appropriate to place regulatory floodways at levees providing a lower level of protection if encroachment on the river side of the levee is of concern to the community. The Mapping Partner that is performing the analysis shall consult with community officials and the RPO to resolve this situation.

For levee systems where an area of land may be totally or partially surrounded by levees or where two or more flooding sources join that have levees on both sides of the stream, the Mapping Partner that is performing the analysis shall contact the RPO before proceeding with any analyses for levee failures. For these complex situations, the flood hazard in the area that would have been protected by the non-failed levee(s) must be based on selection of failure scenarios that yield the highest BFE or flood hazard.

## **H.6 Flood Control Restoration Zones**

**[February 2002]**

When the Mapping Partner evaluating a levee system determines that a community is in the process of restoring the system to provide 1-percent-annual-chance flood protection, that Mapping Partner shall follow the procedures outlined in Section 65.14 of the NFIP regulations and obtain the information required by FEMA. If the criteria of Section 65.14 are met, the Mapping Partner shall coordinate with the RPO or the PO at FEMA HQ to determine whether the FIRM should be revised to designate the temporary flood hazard areas as a flood control restoration zone (Zone AR). The Mapping Partner also shall coordinate with the RPO or the PO at FEMA HQ to determine whether the flood hazard areas shown on the effective FIRM shall be designated as “dual” flood insurance rate zones (i.e., Zone AR/AE, Zone AR/AH, Zone AR/AO, Zone AR/A).

When the Mapping Partner evaluating a flood protection system for FEMA determines that a restoration project has been completed and all required certifications and evidence have been submitted, that Mapping Partner shall coordinate with the RPO or the PO at FEMA HQ to determine whether the flood control restoration zone designation should be revised to Zone A99 on the FIRM. The criteria outlined in Paragraph 65.14(h) of the NFIP regulations shall be the basis for this determination.

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