

HANDBOOK FOR ARIZONA COMMUNITIES  
On Floodplain Management and the National Flood  
Insurance Program

APPENDIX H

## FEMA LEVEE POLICY

### I. POLICY (ISSUED FEBRUARY 10, 1981)

#### Ownership

FIA will not consider privately owned, operated, or maintained levee systems unless local ordinance or state statute mandates operation and maintenance. Levee for which the community, state, or federal government has responsibility for operation and maintenance will be considered by FIA provided that the criteria discussed below are met.

#### Design Requirements

The Federal Insurance Administration has the responsibility under Public Law 90-448 to identify the special flood hazard areas of the United States. A special flood hazard area has been defined as that area subject to a 1 percent or greater annual chance of flooding. In order for FIA to remove the special flood hazard designation from an area "protected" by levees, we must be assured that the area involved does not fall within this definition.

The degree of protection afforded by a levee system is uncertain because of both the uncertainty involved in establishing the 1 percent chance flood elevations and the uncertainty involved in the structural stability of the levee itself. Common engineering practice in the construction of flood protection works, such as dams and levees, is the inclusion of a freeboard allowance above the computed water surface levels, to allow for all of the uncertainties in analysis, design, and construction that cannot be fully or readily considered in an analytical fashion. In the case of the National Flood Insurance Program, freeboard allowances must be a major factor in establishing a levee's probability of providing protection against the true 1 percent annual chance flood. FIA must be reasonably certain of this level of protection before the floodplain management, insurance purchase, and lender notification requirements under the Program can be removed from the levied area.

FIA will require a minimum levee freeboard of 3 feet, with an additional foot within 100 feet either side of

structures within the levee or where ever the flow is constricted, such as at bridges. An additional half-foot above this minimum is also required at the upst: end, tapering to the minimum at the downstream end of the levee. This standard has been generally utilized by

the Corps for levees protecting populated areas and is based on long-term experience with the success and failure of levee systems.

The above criteria will be utilized to evaluate levee systems in all ongoing and future analyses of flood hazards conducted by FIA. This includes initial identifications, studies, restudies, map revisions, LOMAs, etc. At the present time, no effort should be undertaken to revise maps for the sole purpose of implementing this policy. However, this policy shall be applied for all maps issues by FIA from the date of this memo and for which the 6 month compliance period has not yet started. Where this freeboard criteria has not been met, the opus for demonstrating that protection from the 1 percent chance flood does exist, with a lesser freeboard, will be on the levee owner. As discussed above, this will be a difficult analytical task that must address all the uncertainties involved in establishing flood discharges and the structural stability of the levee system itself. A report documenting such analyses must be submitted to, and approved by, FIA before such a levee will be credited.

#### Inspection and Evaluation

Prior to any levee system receiving credit on any future map issued by FIA, the contractor responsible for the production or revision of that map will be required to determine that the minimum design requirements itemized above have been met. In addition, a field inspection or suitable alternative, will be required to verify that the levee appears structurally sound and adequately maintained. A certification from a federal or state agency, or a registered professional engineer, that the levee meets the minimum design criteria above and that it appears, upon visual inspection, to be structurally sound and adequately maintained may be utilized in lieu of a site specific inspection by the contractor. Levees with obvious structural defects or obvious lack of maintenance will not be credited by FIA.

#### Human Intervention and Operation of Closures

In general, FIA will not recognize human intervention (e.g., capping of levees by sand bagging, earth fill,

flashboards, etc.) for the purpose of increasing a levee's design level of protection during an imminent flood situation. The levee must be designed and maintained to provide adequate 100-year protection without human supplementation. Human intervention will only be accepted for the operation of closure structures (e.g., gates, stop logs, etc.) in a levee system designed to provide at least 100-year flood protection, including adequate freeboard as described above. FIA will recognize levees with closures only under the following conditions:

1. The levee system was designed with the closure to be an integral part of the system during operation. Sand bagging of openings would not be sufficient.

2. The levee system was designed to require human operation of closures or human backup is provided for automatic systems.

3. Sufficient flood warning time exists for the operation of all closure structures, including necessary sealing, before flood waters reach the base of the closure.

4. Operation and maintenance of closure structures are responsibilities mandated by local ordinance.

5. A formal operation plan addressing closure operation and including specific assignments of responsibility is available and capable of being implemented.

6. Periodic operation of the closure structure (at least once annually) is performed for testing and training purposes.

7. Sufficient documentation, indicating that each of the above requirements has been met, has been provided to, and accepted by, FIA.

#### Mapping of Levied Areas

Levees meeting the design, closure, and inspection requirements listed above will be credited with providing protection from the 1 percent chance flood on FHBMs and FIRMs. However, the protected area will be identified with a note on the maps stating.

This area protected from the 100-year flood by levee, dike or other structure subject to failure or overtopping

during larger floods.

All such areas will be shown as Zone B on the FIRM and as areas subject to the 300-year flood on the FBFM, to highlight the residual risk of flooding. Floodways will be delineated at the inside toe of mainline and tributary levees that are credited on a map. This will assure that no development will occur on the outside of the levee, which may jeopardize the levee's integrity, or effectiveness.

As part of all future study, restudy or map revision effort, where credit will be given to levees providing 100-year protection, the adequacy of interior drainage systems will be evaluated. Areas subject to flooding from inadequate interior drainage behind levees will be mapped using standard procedures. Often, shallow flooding zones, or even numbered A Zones, may be applicable in these instances.

For the area contained within a levee (i.e., the protected area) providing less than 100-year protection, the base flood elevation to be shown is that computed as if the levee did not exist. For the area outside of such a levee, the elevations to be shown are those obtained from the profile that would exist at the time levee overtopping begins, or from the profile computed as if the levee did not exist, whichever is higher.

This protection recognizes the increase in flood elevation in the unprotected area, which is caused by the levee itself. This procedure may result in flood elevations being shown as several feet higher on one side of the levee than the other. Both profiles should be shown in the study report and labeled as "before levee overtopping" and "after levee overtopping," respectively. Separate Floodway Data Tables should be prepared for each side of the levee and adequately labeled. The Flood Insurance Rate Map should show a gutter line, running along the levee center line, separating the areas of different base flood elevations and zones. Flood Hazard Factors and Zones should be computed independently for each area using the standard procedure.

#### Proposed and New Levees

Requests to FIA for guidance on levee construction should be addressed by referencing the minimum requirements discussed above and the Corps of Engineers' manual, "Design and Construction of Levees" (EM 1110-2-1913), for basic principles to be applied. FIA approval of design plans and as-built certifications will be

handled on a case-by-case basis. All future requests for map revisions or letters of map amendment, on the basis of newly constructed levees, will require FIA's review of as-built specifications according to the minimum standards outlined above and the principles outlined in the Corps' manual. Levees proposed for construction in an identified floodway must also be approved through the exception process outlined in Part 60.6 of the Program regulations.

## II. EXCEPTIONS TO LEVEE FREEBOARD REQUIREMENTS (AUGUST 17, 1981)

### Background

The interim levee policy issued on February 10, 1981, provides for exceptions to the minimum freeboard standard provided that the levee owner can demonstrate, to FEMA's satisfaction, that adequate protection is provided against the 1 percent chance (100-year) flood. A report documenting an assessment of the uncertainties involved in establishing the 100-year flood profile, as well as the structural stability of the levee, was required in order for FEMA to make an adequate technical evaluation.

This provides further guidance on the nature of the required report and essential elements that must be addressed. It is not intended to set forth the specific criteria with which these elements will be evaluated. This evaluation must be made on a case-by-case basis after a thorough review of the exception request report by FEMA's engineering staff or consultants familiar with the design of levee systems. The elements outlined below pertain to the evaluation of freeboard exception requests only; additional factors may require consideration in the comprehensive evaluation of other aspects of a levee system.

### Elements Required

The purpose of a freeboard allowance is to provide for those factors that cannot be rationally accounted for in design flood profile computations. When exceptions to the freeboard standard are sought, the levee owner must demonstrate that those factors that have not been directly considered in the 100-year profile computations are of insignificant consequences and do not appreciably increase the probability that the levee will overtop or fail during the true 100-year event. The elements that must be addressed in an exception request are discussed below.

## 1. Uncertainty in the Design Flood Profiles

Ideally, a levee system that is credited with providing 100-year flood protection would have no chance of overtopping or failure during the true 100-year flood, or a smaller event. This can never be the case because of the uncertainties associated with estimating the 100-year flood and the uncertainties in the structural stability of the levee itself. The freeboard allowance is an important factor in increasing the probability that protection from the true 100-year flood does exist, as an earth levee built only to the estimated 100-year flood profile has less than a 50 percent chance of providing true 100-year flood protection.

a. Hydrologic uncertainty. An exception request from the standard freeboard requirement must evaluate the variance in the estimated 100-year discharge, which could result in an underestimation of the magnitude of the true 100-year flood. In general, ungaged streams, or streams with a short period of gage record, have flood estimates with greater variance. Thus, there is less certainty that the established 100-year discharge will fall within reasonable limits of the true value. The exception request should include a computation of the 100-year discharge with the expected probability adjustment. The approximate confidence limit at which levee overtopping begins should also be identified in the report. Where confidence limits or the expected probability adjustment cannot be computed directly from statistical analysis of gaged records, they should be estimated by some reasonable method that is documented in the report.

b. Hydraulic uncertainty. Uncertainty in flood discharge can be translated into corresponding uncertainty in flood profiles using standard hydraulic techniques. Stream reaches with a high degree of hydraulic sensitivity (i.e., relatively great changes in stage result from a relatively small change in discharge) would have a greater tendency for levee overtopping than a less sensitive stream. The freeboard exception request should include a profile developed using the 100-year flood discharge with the expected probability adjustment. It should also include a profile run at the discharge where levee overtopping just begins and an assessment of the approximate confidence limit corresponding to that discharge. Where a high degree of uncertainty exists in the 100-year discharge and the stream reach is hydraulically sensitive to changes in discharge, reduction in the freeboard requirement would not be warranted.

Other factors that must be assessed in the evaluation .

the hydraulic uncertainty are the potential and magnitude of debris or hydraulic uncertainty are the potential and magnitude of debris or sediment accumulation or ice jamming during the 100-year discharge event. Sources of debris, sediment, and ice in upstream areas should be considered, as well as any historical evidence of ice or debris blockage or sediment deposition. The behavior of such materials within the leveed reach, and particularly at bends or constrictions, should be addressed. Where such problems are common, the expected level of flood protection from a levee system designed considering only free-flow events can be greatly reduced. A reduction in the standard freeboard requirement would not be warranted in this situation.

## 2. Uncertainty in Levee Structural Stability

a. Seepage Levees work primarily on the principle of providing a mass of material large enough to prevent shear failure by the hydrostatic and hydrodynamic forces acting on the levee embankment and foundation. Because of the construction costs involved, levees rarely contain the impervious cores or drainage layers common to earth dams. Since levee embankments are actually flooded for relatively short periods of time, such expenditures are usually not warranted. Thus, levee mass is substituted for other design features that would control seepage. This is necessary, because, once the levee embankment becomes completely saturated during a period of high water, seepage emerges on the landslide slope and failure probability through loss of slope stability and internal erosion increases greatly.

For given levee top widths and side slopes, the mass of a levee section is determined by the levee height. Thus, the freeboard above the 100-year flood level is a good indication of the relative mass of the levee section and the length of the seepage path before saturation occurs. Whenever freeboard lower than the standard is being proposed, this usually implies a levee of lower mass. In this situation, other factors that influence the rate and degree of levee embankment and foundation saturation must be addressed.

The analyses supporting the request for exception from the standard freeboard requirement should demonstrate that saturation through the levee foundation and embankment will not occur during the 100-year flood, or that the levee is designed for stability against loading conditions for case IV as defined in the Corps of Engineers manual, "Design and Construction of Levees" (EM 1110-2-1913, Chapter 6 Section II). The following factors should be addressed in these analyses:



1. Depth of flooding
2. Duration of flooding
3. Embankment geometry and length of seepage path at critical locations
4. Embankment and foundation materials
5. Embankment compaction
6. Other design factors affecting seepage (e.g. drainage layers)
7. Other design factors affecting embankment and foundation stability (e.g. berms)

Where seepage control is critical and stability problems are likely, an exception to the standard freeboard requirement would not be warranted.

**b. Surface Erosion.** As with seepage control, most levees rely primarily on greater mass to compensate for loss of levee material through erosion caused by flow velocity and wave wash. Requests for exception from the standard freeboard requirements should demonstrate that no appreciable erosion of the levee embankment can be expected during the 100-year flood, as a result of either stream currents or waves, or that anticipated erosion would not result in failure of the levee embankment or foundation directly or indirectly through reduction of the seepage path and subsequent instability.

The following factors should be addressed in these analyses:

1. Expected flow velocities, especially in constricted areas.
2. Expected wind and wave action
3. Slope protection techniques
4. Duration of flooding at various stages and velocities
5. Embankment and foundation material
6. Levee alignment, bends, and transitions
7. Levee side slopes

Where erosion potential is significant, an exception to the standard freeboard requirement will not be made.

**c. Settlement** Levee constructed with minimal or no compaction, or where embankment or foundation materials are undrained or composed of materials of high compressibility, will often experience a significant amount of post-construction settlement. This settlement can result in losses of freeboard as large as 15 percent of the total levee height. An exception request from the standard freeboard requirement must evaluate the potential and magnitude of future losses of freeboard

a result of levee settlement and assess the following factors:

1. Embankment loads
2. Compressibility of embankment soils
3. Compressibility of foundation soils
4. Age of levee system
5. Construction compaction methods

For new or recently enlarged levee systems where minimal or no compaction was utilized in construction or where foundation soils are undrained or of high compressibility, a detailed settlement analysis must be made using procedures such as those described in the Corps of Engineers manual, "Soil Mechanics Design--Settlement Analysis" (EM 1110-2-1904). For established levee systems (more than 10 years old), the exception request should address the above 5 factors, the amount of settlement that has occurred since construction, and the amount and rate of expected future settlement. Where additional loss of freeboard due to expected future settlement could contribute significantly to the probability of levee overtopping or structural failure during the 100-year flood, an exception to the standard freeboard requirement will not be granted.

#### Procedure

Upon a determination that a levee system does not meet the minimum freeboard requirements as established in the February 10, 1981, policy memo, the levee owner may appeal FEMA's determination to designate the leveed area as flood-prone. The sole basis for the appeal shall be the demonstration that adequate protection from the 100-year flood exists. This demonstration will be accomplished through a technical report submitted by the levee owner that addresses each of the above elements. The report must be certified by a registered professional engineer to be correct and accurate to the best of his or her knowledge. The same registered professional shall also certify that the levee system is adequately designed and maintained to protect against the 100-year flood.

Upon receipt of this report and certification, FEMA will review the report either in-house, through another federal agency, or through a consultant familiar with the design and construction of levee systems. During this review, the levee owner may be required to provide

additional data and certifications necessary to complete the review.

Upon completion of the review, FEMA will revise the appropriate community map or inform the levee owner why the levee system was found to be deficient. Maps will not be revised while either the levee system of REMA's review is incomplete. The exception request, technical backup report, and certifications will be retained by FEMA as documentation for the exception.