Attachment 1

Federal Emergency Management Agency

Washington, D.C. 20472

August 22, 2005

MEMORANDUM FOR: Regional Directors
Regions I - X

FROM: David I. Maurstad, Acting Director
Mitigation Division

SUBJECT: Procedure Memorandum 34 — Interim Guidance for Studies Including Levees

Background: Throughout the United States, levees protect numerous communities and large expanses of agricultural land from floods. Their importance in mitigating flood hazards and their relevance to the National Flood Insurance Program (NFIP) are indisputable. However, riverine and coastal levees, in the aggregate, stretch for tens of thousands of miles, and information on their location, structural integrity, and certification often is outdated or missing altogether.

Issue: To address this challenge, a Levee Coordination Committee—including representatives from FEMA, other Federal agencies, and States—is examining current levee regulations and assisting in the development of a long-term policy that protects citizens and property, while accommodating the needs of the NFIP. This memorandum helps to clarify the entities responsible for providing information on levees identified during a mapping project.

Action Taken: Until the new policy is developed, this memo provides interim guidance to minimize delays in near-term mapping studies. The attached flow chart supplements FEMA's procedure memorandums 30 and 32. This information is in conformance with Section 65.10 of the NFIP regulations.

Supplement to Procedure Memo 30—FEMA Levee Inventory System.

Mapping partners – CTPs, IDIQs, OFAs, etc. -- should continue providing information about levees located in or adjacent to study areas. Information should be provided via the FEMA Levee Inventory System (FLIS) according to Procedure Memorandum 30 and the instructions available on the FLIS Web site located at http://flis.pbsjdfirm.com. The FLIS will be accessed via the MIP after release 3.0.

Levee coordinates should be gathered at a level of detail consistent with GIS accuracy and digital Flood Insurance Rate Map (FIRM) standards. Mapping partners who do not already have access to the FLIS can contact the National Service Provider at (703) 960-8800.

Supplement to Procedure Memo 32—Levee Review Protocol.

The protocol for levee reviews, particularly the details provided in Table 1 of Procedure Memorandum 32, is revised according to the attached flow chart.

Identification of Levees

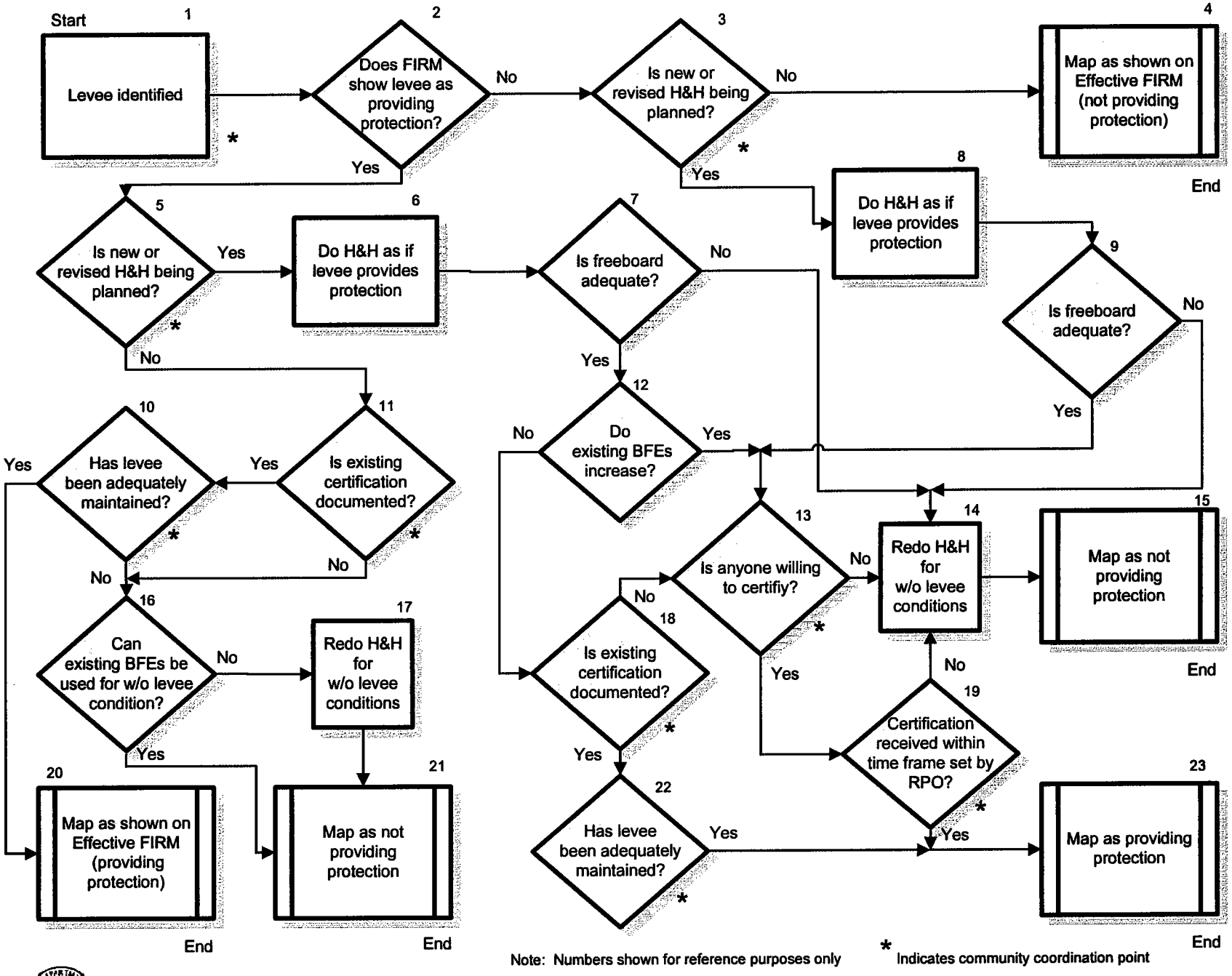
It is critical that all levees within the scope of the mapping project be identified early in the mapping project, ideally no later than the scoping meeting. The role of all mapping partners, including coordination with the State and other Federal partners (e.g., U.S. Army Corps of Engineers), related to review of levee certification should be clearly identified as part of the scoping process. When levees are identified at the scoping meeting the community must be informed of the data requirements for FEMA to recognize a levee as providing protection from the 1-percent-annual-chance flood (base flood) on the FIRM. In accordance with 44 CFR Section 65.10(a), it is the responsibility of the community or other party seeking recognition of a levee system at the time of a flood risk study or restudy to provide the data outlined in 44 CFR Section 65.10. FEMA will not be conducting detailed examinations of levees to determine how a structure or system will perform in a flood event. In addition, the community or party seeking recognition should be provided with a deadline for submitting the data and informed that if the data are not submitted by the deadline, the levee cannot be recognized as providing protection from the base flood as part of the current mapping effort. However, a revision could be initiated once data are available.

Early identification of levees allows the mapping partner to outline to the community, or party seeking recognition, their responsibilities and FEMA's expectations to minimize study delays. In order to aid our mapping partners in properly assessing how to handle levee mapping issues, we have generated the below flowchart.

cc: See Distribution List

Distribution List (electronic distribution only):

Office of the Mitigation Division Director
Risk Assessment Branch
Risk Identification Branch
Flood Insurance and Mitigation Divisions in FEMA Regional Offices
Office of Legislative Affairs
Office of General Counsel
National Service Provider
Systems Engineering and Technical Assistance Contractor
Map Service Center


Start
1
Levee identified
*
2
Does FIRM show levee as providing protection?
No
Yes
3
Is new or revised H&H being planned?
No
Yes
*
4
Map as shown on Effective FIRM (not providing protection)
End
5
Is new or revised H&H being planned?
Yes
No
*
6
Do H&H as if levee provides protection
7
Is freeboard adequate?
No
Yes
8
Do H&H as if levee provides protection
9
Is freeboard adequate?
No
Yes
10
Has levee been adequately maintained?
Yes
No
*
11
Is existing certification documented?
Yes
No
*
12
Do existing BFEs increase?
No
Yes
13
Is anyone willing to certifiy?
No
Yes
*
14
Redo H&H for w/o levee conditions
15
Map as not providing protection
End
16
Can existing BFEs be used for w/o levee condition?
No
Yes
17
Redo H&H for w/o levee conditions
18
Is existing certification documented?
No
Yes
*
19
Certification received within time frame set by RPO?
No
Yes
*
20
Map as shown on Effective FIRM (providing protection)
End
21
Map as not providing protection
End
22
Has levee been adequately maintained?
Yes
*
23
Map as providing protection
End
Note: Numbers shown for reference purposes only
* Indicates community coordination point

Attachment 2

water surface profile of the original hydraulic computer model. The alternate model must be then modified to include all encroachments that have occurred since the existing floodway was developed.

(ii) The floodway analysis must be performed with the modified computer model using the desired floodway limits.

(iii) The floodway limits must be set so that combined effects of the past encroachments and the new floodway limits do not increase the effective base flood elevations by more than the amount specified in §60.3(d)(2). Copies of the input and output data from the original and modified computer models must be submitted.

(3) Delineation of the revised floodway on a copy of the effective NFIP map and a suitable topographic map.

(d) *Certification requirements.* All analyses submitted shall be certified by a registered professional engineer. All topographic data shall be certified by a registered professional engineer or licensed land surveyor. Certifications are subject to the definition given at §65.2 of this subchapter.

(e) *Submission procedures.* All requests that involve changes to floodways shall be submitted to the appropriate FEMA Regional Office servicing the community's geographic area.

[51 FR 30315, Aug. 25, 1986]

§65.8 Review of proposed projects.

A community, or an individual through the community, may request FEMA's comments on whether a proposed project, if built as proposed, would justify a map revision. FEMA's comments will be issued in the form of a letter, termed a Conditional Letter of Map Revision, in accordance with 44 CFR part 72. The data required to support such requests are the same as those required for final revisions under §§65.5, 65.6, and 65.7, except as-built certification is not required. All such requests shall be submitted to the FEMA Headquarters Office in Washington, DC, and shall be accompanied by the appropriate payment, in accordance with 44 CFR part 72.

[62 FR 5736, Feb. 6, 1997]

§65.9 Review and response by the Administrator.

If any questions or problems arise during review, FEMA will consult the Chief Executive Officer of the community (CEO), the community official designated by the CEO, and/or the requester for resolution. Upon receipt of a revision request, the Administrator shall mail an acknowledgment of receipt of such request to the CEO. Within 90 days of receiving the request with all necessary information, the Administrator shall notify the CEO of one or more of the following:

(a) The effective map(s) shall not be modified;

(b) The base flood elevations on the effective FIRM shall be modified and new base flood elevations shall be established under the provisions of part 67 of this subchapter;

(c) The changes requested are approved and the map(s) amended by Letter of Map Revision (LOMR);

(d) The changes requested are approved and a revised map(s) will be printed and distributed;

(e) The changes requested are not of such a significant nature as to warrant a reissuance or revision of the flood insurance study or maps and will be deferred until such time as a significant change occurs;

(f) An additional 90 days is required to evaluate the scientific or technical data submitted; or

(g) Additional data are required to support the revision request.

(h) The required payment has not been submitted in accordance with 44 CFR part 72, no review will be conducted and no determination will be issued until payment is received.

[51 FR 30315, Aug. 25, 1986; 61 FR 46331, Aug. 30, 1996, as amended at 62 FR 5736, Feb. 6, 1997]

§65.10 Mapping of areas protected by levee systems.

(a) *General.* For purposes of the NFIP, FEMA will only recognize in its flood hazard and risk mapping effort those levee systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with the level of protection sought through the comprehensive

flood plain management criteria established by §60.3 of this subchapter. Accordingly, this section describes the types of information FEMA needs to recognize, on NFIP maps, that a levee system provides protection from the base flood. This information must be supplied to FEMA by the community or other party seeking recognition of such a levee system at the time a flood risk study or restudy is conducted, when a map revision under the provisions of part 65 of this subchapter is sought based on a levee system, and upon request by the Administrator during the review of previously recognized structures. The FEMA review will be for the sole purpose of establishing appropriate risk zone determinations for NFIP maps and shall not constitute a determination by FEMA as to how a structure or system will perform in a flood event.

(b) *Design criteria.* For levees to be recognized by FEMA, evidence that adequate design and operation and maintenance systems are in place to provide reasonable assurance that protection from the base flood exists must be provided. The following requirements must be met:

(1) *Freeboard.* (i) Riverine levees must provide a minimum freeboard of three feet above the water-surface level of the base flood. An additional one foot above the minimum is required within 100 feet in either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. An additional one-half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required.

(ii) Occasionally, exceptions to the minimum riverine freeboard requirement described in paragraph (b)(1)(i) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood elevation profile and include, but not necessarily be limited to an assessment of statistical confidence limits of the 100-year discharge; changes in stage-discharge relationships; and the sources, potential, and magnitude of debris, sediment, and ice accumulation. It must be also shown that the levee will remain structurally stable during the base flood when such additional loading considerations are imposed. Under no circumstances will freeboard of less than two feet be accepted.

(iii) For coastal levees, the freeboard must be established at one foot above the height of the one percent wave or the maximum wave runup (whichever is greater) associated with the 100-year stillwater surge elevation at the site.

(iv) Occasionally, exceptions to the minimum coastal levee freeboard requirement described in paragraph (b)(1)(iii) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood loading conditions. Particular emphasis must be placed on the effects of wave attack and overtopping on the stability of the levee. Under no circumstances, however, will a freeboard of less than two feet above the 100-year stillwater surge elevation be accepted.

(2) *Closures.* All openings must be provided with closure devices that are structural parts of the system during operation and design according to sound engineering practice.

(3) *Embankment protection.* Engineering analyses must be submitted that demonstrate that no appreciable erosion of the levee embankment can be expected during the base flood, as a result of either currents or waves, and that anticipated erosion will not result in failure of the levee embankment or foundation directly or indirectly through reduction of the seepage path and subsequent instability. The factors to be addressed in such analyses include, but are not limited to: Expected flow velocities (especially in constricted areas); expected wind and wave action; ice loading; impact of debris; slope protection techniques; duration of flooding at various stages and velocities; embankment and foundation materials; levee alignment, bends, and transitions; and levee side slopes.

(4) *Embankment and foundation stability.* Engineering analyses that evaluate levee embankment stability must be submitted. The analyses provided shall evaluate expected seepage during loading conditions associated with the base flood and shall demonstrate that seepage into or through the levee foundation and embankment will not jeopardize embankment or foundation stability. An alternative analysis demonstrating that the levee is designed and constructed for stability against loading conditions for Case IV as defined in the U.S. Army Corps of Engineers (COE) manual, "Design and Construction of Levees" (EM 1110–2–1913, Chapter 6, Section II), may be used. The factors that shall be addressed in the analyses include: Depth of flooding, duration of flooding, embankment geometry and length of seepage path at critical locations, embankment and foundation materials, embankment compaction, penetrations, other design factors affecting seepage (such as drainage layers), and other design factors affecting embankment and foundation stability (such as berms).

(5) *Settlement.* Engineering analyses must be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained within the minimum standards set forth in paragraph (b)(1) of this section. This analysis must address embankment loads, compressibility of embankment soils, compressibility of foundation soils, age of the levee system, and construction compaction methods. In addition, detailed settlement analysis using procedures such as those described in the COE manual, "Soil Mechanics Design—Settlement Analysis" (EM 1100–2–1904) must be submitted.

(6) *Interior drainage.* An analysis must be submitted that identifies the source(s) of such flooding, the extent of the flooded area, and, if the average depth is greater than one foot, the water-surface elevation(s) of the base flood. This analysis must be based on the joint probability of interior and exterior flooding and the capacity of facilities (such as drainage lines and pumps) for evacuating interior floodwaters.

(7) *Other design criteria.* In unique situations, such as those where the levee system has relatively high vulnerability, FEMA may require that other design criteria and analyses be submitted to show that the levees provide adequate protection. In such situations, sound engineering practice will be the standard on which FEMA will base its determinations. FEMA will also provide the rationale for requiring this additional information.

(c) *Operation plans and criteria.* For a levee system to be recognized, the operational criteria must be as described below. All closure devices or mechanical systems for internal drainage, whether manual or automatic, must be operated in accordance with an officially adopted operation manual, a copy of which must be provided to FEMA by the operator when levee or drainage system recognition is being sought or when the manual for a previously recognized system is revised in any manner. All operations must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP.

(1) *Closures.* Operation plans for closures must include the following:

(i) Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists for the completed operation of all closure structures, including necessary sealing, before floodwaters reach the base of the closure.

(ii) A formal plan of operation including specific actions and assignments of responsibility by individual name or title.

(iii) Provisions for periodic operation, at not less than one-year intervals, of the closure structure for testing and training purposes.

(2) *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 on NFIP maps for flood protection purposes only if the following minimum

criteria are included in the operation plan:

(i) Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists to permit activation of mechanized portions of the drainage system.

(ii) A formal plan of operation including specific actions and assignments of responsibility by individual name or title.

(iii) Provision for manual backup for the activation of automatic systems.

(iv) Provisions for periodic inspection of interior drainage systems and periodic operation of any mechanized portions for testing and training purposes. No more than one year shall elapse between either the inspections or the operations.

(3) *Other operation plans and criteria.* Other operating plans and criteria may be required by FEMA to ensure that adequate protection is provided in specific situations. In such cases, sound emergency management practice will be the standard upon which FEMA determinations will be based.

(d) *Maintenance plans and criteria.* For levee systems to be recognized as providing protection from the base flood, the maintenance criteria must be as described herein. Levee systems 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 when recognition is being sought or when the plan for a previously recognized system is revised in any manner. All maintenance activities must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP that must assume ultimate responsibility for maintenance. This plan must document the formal procedure that ensures that the stability, height, and overall integrity of the levee and its associated structures and systems are maintained. At a minimum, maintenance plans shall specify the maintenance activities to be performed, the frequency of their performance, and the person by name or title responsible for their performance.

(e) *Certification requirements.* Data submitted to support that a given levee system complies with the structural requirements set forth in paragraphs (b)(1) through (7) of this section must be certified by a registered professional engineer. Also, certified as-built plans of the levee must be submitted. Certifications are subject to the definition given at §65.2 of this subchapter. In lieu of these structural requirements, a Federal agency with responsibility for levee design may certify that the levee has been adequately designed and constructed to provide protection against the base flood.

[51 FR 30316, Aug. 25, 1986]

§65.11 Evaluation of sand dunes in mapping coastal flood hazard areas.

(a) *General conditions.* For purposes of the NFIP, FEMA will consider storm-induced dune erosion potential in its determination of coastal flood hazards and risk mapping efforts. The criterion to be used in the evaluation of dune erosion will apply to primary frontal dunes as defined in §59.1, but does not apply to artificially designed and constructed dunes that are not well-established with long-standing vegetative cover, such as the placement of sand materials in a dune-like formation.

(b) *Evaluation criterion.* Primary frontal dunes will not be considered as effective barriers to base flood storm surges and associated wave action where the cross-sectional area of the primary frontal dune, as measured perpendicular to the shoreline and above the 100-year stillwater flood elevation and seaward of the dune crest, is equal to, or less than, 540 square feet.

(c) *Exceptions.* Exceptions to the evaluation criterion may be granted where it can be demonstrated through authoritative historical documentation that the primary frontal dunes at a specific site withstood previous base flood storm surges and associated wave action.

[53 FR 16279, May 6, 1988]

Attachment 3

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, D.C. 20314-1000

ER 1105-2-101

CECW-P
CECW-E

Regulation
No. 1105-2-101

3 January 2006

Planning
RISK ANALYSIS FOR FLOOD DAMAGE REDUCTION STUDIES

1. Purpose. This regulation provides guidance on the evaluation framework to be used in Corps of Engineers flood damage reduction studies. It is jointly promulgated by Planning and Engineering.

2. Applicability. This regulation is applicable to all HQUSACE elements, major subordinate commands, districts, laboratories and field operating agencies (FOA) having civil works responsibilities. It applies to all implementation studies for flood damage reduction projects.

3. Distribution Statement. Approved for public release; distribution is unlimited.

4. References.

a. ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies.

b. EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies.

c. ETL 110-2-556, Risk-based Analysis in Geotechnical Engineering for Support of Planning Studies.

5. Background.

a. Risk and uncertainty are intrinsic in water resources planning and design. All measured or estimated values in project planning and design are to various degrees inaccurate. Invariably the true values are different from any single, point values presently used in project formulation, evaluation, and design.

b. The Corps develops best estimates of key variables, factors, parameters, and data components in the planning and design of flood damage reduction projects. These estimates are considered the "most likely" values. They are frequently based on short periods of record, small sample sizes, and measurements subject to error. Prior to risk analysis, sensitivity analysis had been the primary tool for considering uncertainty in project planning and design. Sensitivity analysis, however, frequently presumes that the appropriate range of values is identified and that all values in that range are equally likely. In addition, the results of this analysis are typically reported as a single, most likely value that is treated by some as if it were perfectly accurate.

This Engineer Regulation supercedes ER 1105-2-101 dated 1 March 1996.

c. Risk analyses can be advantageously applied to a variety of water resources planning and design problems. The approach captures and quantifies the extent of the risk and uncertainty in the various planning and design components of an investment project. The total effect of uncertainty on the project's design and economic viability can be examined and conscious decisions made reflecting an explicit tradeoff between risks and costs. Risk analysis can be used to compare plans in terms of the variability of their physical performance, economic success, and residual risks.

d. Budget constraints, increased customer cost sharing, and public concern for project performance are issues that must be addressed in the assessment of Federal water resources investments. Explicit consideration of risk and uncertainty can help address these issues and improve investment decisions.

5. Definitions. To describe effectively the concepts of risk analysis for flood damage reduction studies, this document uses the following terminology:

a. "Risk" is the probability an area will be flooded, resulting in undesirable consequences.

b. "Uncertainty" is a measure of imprecision of knowledge of parameters and functions used to describe the hydraulic, hydrologic, geotechnical, and economic aspects of a project plan.

c. "Risk Analysis" is an approach to evaluation and decision making that explicitly, and to the extent practical, analytically, incorporates considerations of risk and uncertainty in a flood damage reduction study.

d. "Annual Exceedance Probability (AEP)" is the probability that flooding will occur in any given year considering the full range of possible annual floods.

e. "Residual Risk" is the flood risk that remains if a proposed flood damage reduction project is implemented. Residual risk includes the consequence of capacity exceedance as well.

6. Variables in a Risk Analysis. It is recognized that the true values of planning and design variables and parameters are frequently not known with certainty and can take on a range of values. One can describe, however, the likelihood of a parameter taking on a particular value by a probability distribution. The probability distribution may be described by its own parameters, such as mean and variance for a normal distribution, or minimum, maximum, and most likely for a triangular distribution. Risk analysis combines the underlying uncertainty information so that the engineering and economic performance of a project can be expressed in terms of probability distributions.

A variety of planning and design variables may be incorporated into risk analysis in a flood damage reduction study. Economic variables in an urban situation may include, but are not necessarily limited to, depth-damage curves, structure values, content values, structure first-floor elevations, structure types, flood warning times, and flood evacuation effectiveness. Other variables may be important for other types of projects. For example, in agricultural areas, seasonality of flooding and cropping practices may be important. The uncertainty of these variables may be due to sampling, measurement, estimation, and forecasting. For hydrologic and

hydraulic analysis, the principal variables are discharge and stage. Uncertainty in discharge and stage exists because record lengths are often short or do not exist where needed, and the effectiveness of flood flow regulation measures is not precisely known. Uncertainty in discharge also comes from estimation of parameters used in rainfall runoff computations, such as precipitation and infiltration. Uncertainty factors that affect stage might include conveyance roughness, cross-section geometry, debris accumulation, ice effects, sediment transport, flow regime, bed form, and others. For geotechnical and structural analysis, the principal source of uncertainty is the structural performance of an existing levee. Uncertainty in structural performance occurs due to a levee's physical characteristics and construction quality. Uncertainty in the operating performance of planned structures due to the difficulties related to locating and installing temporary barriers in a timely manner or variations in retention structure flood control operations may also be important considerations for certain flood damage reduction projects. In addition to uncertainty in the variables noted above, uncertainty arises from imprecise analysis methods (i.e. mathematical computations do not perfectly represent natural processes).

7. Policy and Required Procedures.

a. All flood damage reduction studies will adopt risk analysis as described herein. The risk analysis approach and results shall be documented in the principal decision document used for recommending authorization and/or construction. The types of documents involved are feasibility reports, general design memorandums, and general reevaluation reports. For reconnaissance phase, the proposed feasibility study risk analysis will be developed to the task level and included in the Project Management Plan. The plan will describe the methods to be used to quantify the uncertainties of the key variables, parameters, and components and the approach to combining these uncertainties into higher-level measures of overall economic and engineering performance. In cases where a general reevaluation report is proposed and standard freeboard assumptions or other engineering standards were used that are critical to sizing and/or performance of project features, a reformulation of the project using risk analysis, as described herein, shall be undertaken to determine the appropriate project for construction recommendation.

b. The ultimate goal is a comprehensive approach in which the values of all key variables, parameters, and components of flood damage reduction studies are subject to probabilistic analysis. Not all variables are critical to project justification in every instance. In progressing toward the ultimate goal, the risk analysis and study effort should concentrate on the uncertainties of the variables having a significant impact on study conclusions. At a minimum, the following variables must be explicitly incorporated in the risk analysis:

- the stage-damage function for economic studies (with special emphasis on structure first floor elevation, depth-percent damage relationships, and content and structure values for urban studies); for studies in agriculture areas, other variables (e.g., time of year, crop type and costs of production) will be key and should be used in the economic analysis;

- discharge associated with exceedance frequency for hydrologic studies;

- conveyance roughness and cross-section geometry for hydraulic studies; and

- structural and geotechnical performance of existing structures.

c. The Standard Project Flood (SPF) is defined in several legacy Engineer Regulation (ER) and Engineering Manual (EM) guidance documents. In the context of ER 1105-2-100 and risk analysis guidance, the SPF is no longer a valid design target, having been superceded by more current guidance. Instead, a full range of floods, including those that would exceed the SPF, is to be used in formulation and evaluation of alternatives. It is noted, however, in certain regions of the United States, there is a significant history of projects that were planned, designed, and constructed based on the SPF, and strong local identification with the concept continues to be prevalent. As a consequence, while current guidance on project formulation and selection governs, the SPF may have a useful role for application in risk analysis, for comparing new project proposals with nearby existing projects that were based on the SPF, and as a check and validation of floods computed from statistical frequency analysis.

d. The National Economic Development (NED) plan will be the scale of the flood damage reduction alternative that reasonably maximizes expected net benefits, (expected benefits less expected costs). It will be calculated explicitly including uncertainties in the key variables. Consideration of increments in project scale beyond the NED plan is permissible to improve project performance and to manage residual risks to people and property. Existing policy governing project increments beyond the NED plan must, however, be followed. Flood damage reduction projects may be part of a Combined NED/National Ecosystem Restoration (NER) Plan as described in ER 1105-2-100. Specific procedures for formulating and evaluating combined plans are described in Engineer Circular 1105-2-404.

e. The estimate of net NED benefits and benefit/cost ratio will be reported both as a single expected value and on a probabilistic basis for each planning alternative. The probability that net benefits are positive and that the benefit/cost ratio is at or above 1.0 will be presented for each planning alternative.

f. The flood protection performance will be presented. The risk analysis will quantify the performance of all scales of all alternatives considered for final recommendation. The analysis will evaluate and report residual risk, which includes consequence of project capacity exceedance. This requires explicitly considering the joint effects of the uncertainties associated with key hydrologic, hydraulic, and geotechnical variables. This performance will be reported in the following ways:

(1) the annual exceedance probability with associated estimates of uncertainty,

(2) the equivalent long-term risk of exceedance over 10-, 30-, and 50-years, and

(3) the ability to contain specific historic floods.

g. The distribution of residual flood damage and other relevant aspects of residual risks shall also be displayed. The residual risk shall be reported as the expected annual probability of each alternative being exceeded. For comparison purposes, the without-project risk in terms of the annual probability of flood damages occurring and the annual probability of other property

hazards (fire, wind, etc.) will be displayed. Residual human health and safety risks will be displayed. To aid this display and to improve the understanding of the residual risk, inundation maps showing flood depths, should the project be exceeded, shall be provided. In addition, a narrative scenario for events that exceed the project design shall be provided. Both the inundation map and the narrative scenario shall be provided for each alternative considered for final selection.

h. All project increments comprise different risk management alternatives represented by the tradeoffs among engineering performance, economic performance, and project costs. These increments contain differences in flood damage reduced, residual risk, and local and Federal project cost. It is vital that the local sponsor and residents understand these tradeoffs in order to fully participate in an informed decision-making process.

i. Special Guidance.

(1) The use of freeboard or similar buffers to account for hydrologic, hydraulic, and geotechnical uncertainties will no longer to be used in levee planning and design.

(2) Certification of levees must follow current guidelines described in the Federal Emergency Management Agency/USACE memorandum on Levee Certification for the National Flood Insurance Program. See CECW-CP for the current guidance, which describes levee performance criteria that must be reported when levee certification is requested.

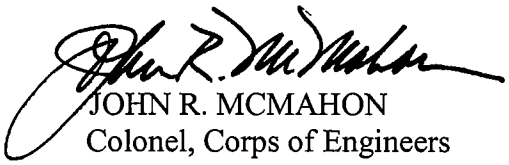
(3) Project performance will be described by annual exceedance probability and long-term risk rather than level-of-protection.

(4) Analysis to assure safe, predictable performance of the project will be included. Such analysis will formulate features to manage capacity exceedence at the least damaging or other planned location. For levees and floodwalls, this may include providing superiority at pumping stations and other critical locations. The analysis of these features will consider their contribution to the project's performance and cost.

8. Example Displays of Risk Analysis Results. Appendix A, Tables A-1a through A-6 and Figures A-1 through A-8, to this regulation represents example displays of engineering and economic performance information. This information can be useful in aiding decisions by local

sponsors, stakeholders and Federal officials by helping to increase their understanding of the risk inherent in each alternative.

FOR THE COMMANDER:



JOHN R. MCMAHON
Colonel, Corps of Engineers
Chief of Staff

1 Appendix
App A - Example Displays of Project Engineering and Economic Performance Results from Risk Analysis

Appendix A

Example Displays of Project Engineering and Economic Performance Results from Risk Analysis

Table A-1a: Expected Value and Probabilistic Values of EAD and EAD Reduced

	Expected Annual Damage ($'000)		Damage Reduced ($'000)		EAD Reduced that is Exceeded with Specified Probability ($'000)		
Plan	Without Plan	With Plan	Mean	Standard Deviation	0.75	0.50	0.25
20 foot levee	575	220	355	57	316	353	393
25 foot levee	575	75	500	77	451	503	555
30 foot levee	575	5	570	98	502	573	626
channel	575	200	375	65	328	370	415
detention basin	575	250	325	93	263	325	388
relocation	575	220	355	61	313	353	396

Table A-1b: Expected Value and Probabilistic Values of Costs

	Annual Cost ($'000)		Cost that is Exceeded with Specified Probability ($'000)		
Plan	Mean	Standard Deviation	0.75	0.50	0.25
20 foot levee	300	40	273	300	327
25 foot levee	400	45	370	400	430
30 foot levee	550	60	510	550	590
channel	300	30	280	300	320
detention basin	275	10	268	275	282
relocation	250	20	237	250	263

Table A-2: Expected Value and Probabilistic Values of Net Benefits

	Expected Annual Benefit and Cost ($'000)		Net Benefits ($'000)		Prob. Net Benefit is > 0	Net Benefit that is Exceeded with Specified Probability ($'000)		
Plan	Benefits	Cost	Mean	Std. Dev.		0.75	0.50	0.25
20 foot levee	355	300	55	68	0.80	8	54	99
25 foot levee	500	400	100	88	0.88	45	104	164
30 foot levee	570	550	20	116	0.55	-62	14	91
channel	375	300	75	74	0.83	19	72	120
detention basin	325	275	50	96	0.70	-17	50	113
relocation	355	250	105	63	0.97	62	100	145

Table A-3: Expected Value and Probabilistic Values of Benefit/Cost Ratios

Plan	Expected Benefit/Cost Ratio		Probability B/C > 1	B/C Ratio Value that is Exceeded with Specified Probability		
	Mean	Standard Deviation		0.75	0.50	0.25
20 foot levee	1.21	0.26	0.80	1.03	1.19	1.35
25 foot levee	1.28	0.24	0.88	1.11	1.26	1.43
30 foot levee	1.05	0.22	0.55	0.89	1.03	1.17
channel	1.26	0.27	0.83	1.06	1.24	1.41
detention basin	1.19	0.35	0.70	0.94	1.18	1.42
relocation	1.44	0.27	0.97	1.25	1.40	1.60

Table A-4: Performance Described by AEP and Long-term Risk

Plan	Annual Exceedance Probability	Long-term Risk (Probability of Exceedance Over Indicated Time Period)		
		10 Years	30 Years	50 Years
Without	0.250	0.94	1.00	1.00
20 foot levee	0.020	0.18	0.45	0.64
25 foot levee	0.010	0.10	0.26	0.39
30 foot levee	0.001	0.01	0.03	0.05
channel	0.015	0.14	0.36	0.53
detention basin	0.030	0.26	0.60	0.78
relocation	0.020	0.18	0.45	0.64

Alternative Display
Table A-4: Performance Described by AEP and Long-term Risk

Plan	Annual Exceedance Probability (AEP)	Long-Term Risk (Chances of Exceedance Over Indicated Time Period)		
		10 Years	30 Years	50 Years
Without	0.250	1 in 1.1	1 in 1.0	1 in 1.0
20 foot levee	0.020	1 in 5.5	1 in 2.2	1 in 1.6
25 foot levee	0.010	1 in 10.5	1 in 3.8	1 in 2.5
30 foot levee	0.001	1 in 100	1 in 33.8	1 in 20.5
channel	0.015	1 in 7.1	1 in 2.7	1 in 1.9
detention basin	0.030	1 in 3.8	1 in 1.7	1 in 1.3
relocation	0.020	1 in 5.5	1 in 2.2	1 in 1.6

Table A-5: Annual Exceedance Probability Uncertainty

Plan	Annual Exceedance Probability (AEP)		AEP of Plan that is Exceeded with Specified Probability		
	Mean	Std. Dev.	0.75	0.50	0.25
Without	0.250	0.140	0.155	0.249	0.344
20 foot levee	0.020	0.016	0.008	0.017	0.029
25 foot levee	0.010	0.008	0.004	0.008	0.013
30 foot levee	0.001	0.003	0.000	0.001	0.002
channel	0.015	0.010	0.008	0.013	0.020
detention basin	0.030	0.021	0.015	0.025	0.040
relocation	0.020	0.015	0.010	0.019	0.030

Table A-6: Risk Comparison

Plan	Annual Exceedance Probability
Without	0.250
20 foot levee	0.020
25 foot levee	0.010
30 foot levee	0.001
channel	0.015
detention basin	0.030
relocation	0.020
Comparable Property	
Fire Damage	0.001
Wind Damage	0.005
Earthquake	0.001

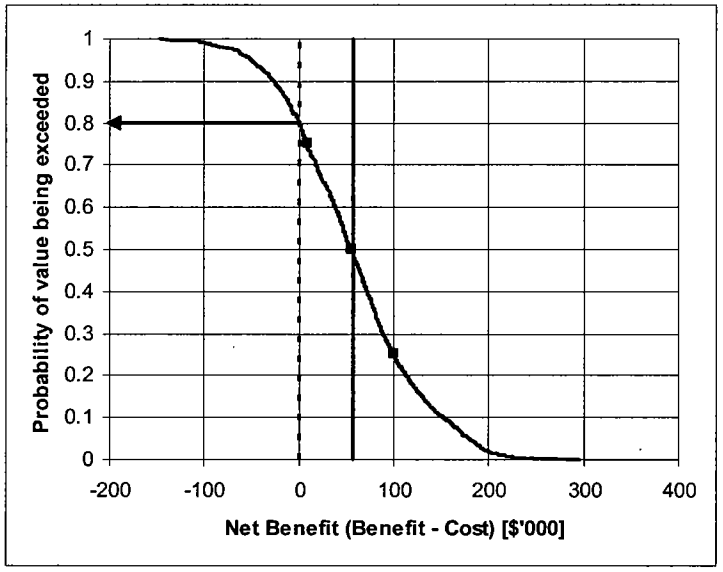


Figure A-1. Cumulative Distribution Function of Net Benefit for 20' Levee

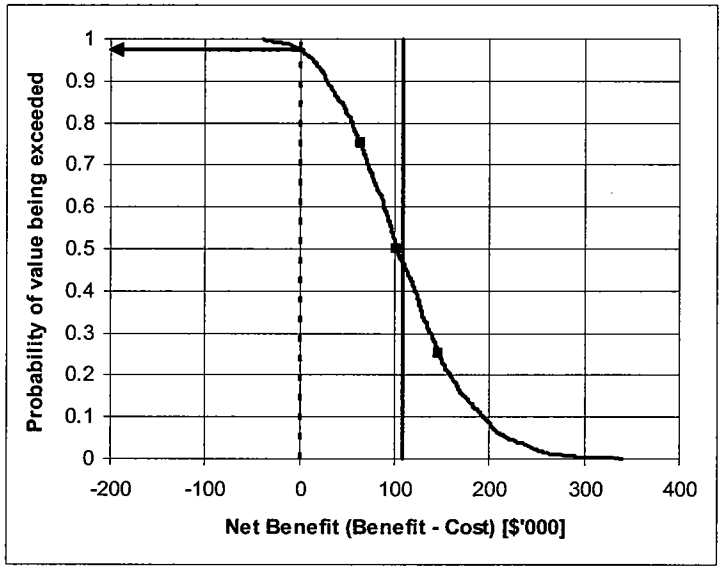


Figure A-2. Cumulative Distribution Function of Net Benefit for Relocation

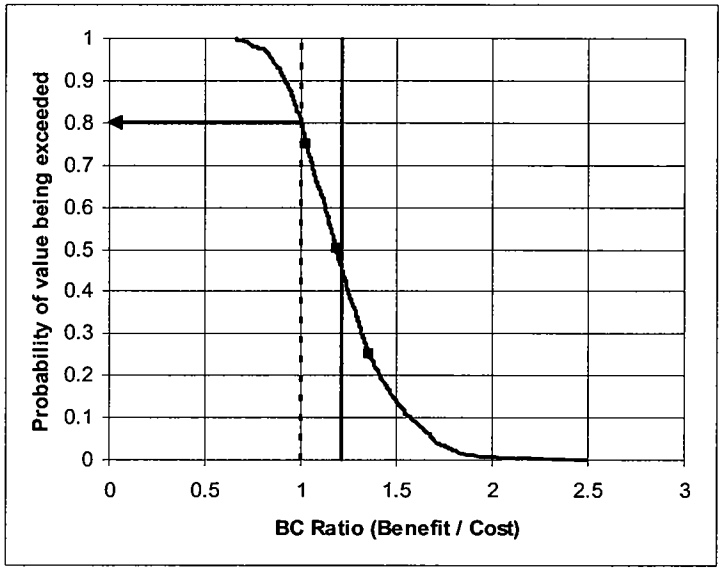


Figure A-3. Cumulative Distribution Function of BC Ratio for 20' Levee

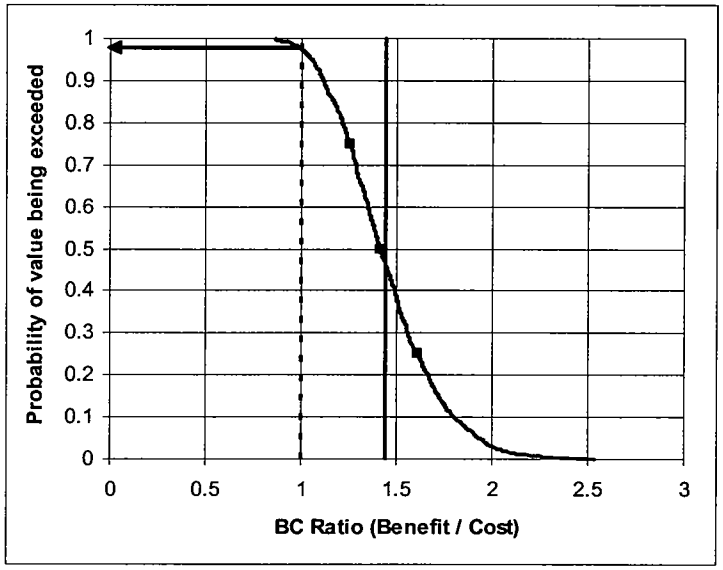


Figure A-4. Cumulative Distribution Function of BC Ratio for Relocation

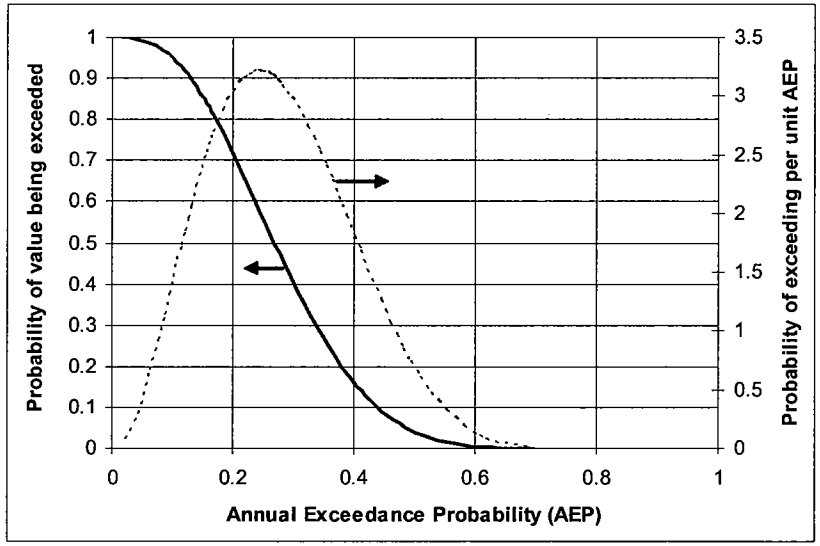


Figure A-5. Distribution Functions of AEP for Without Project

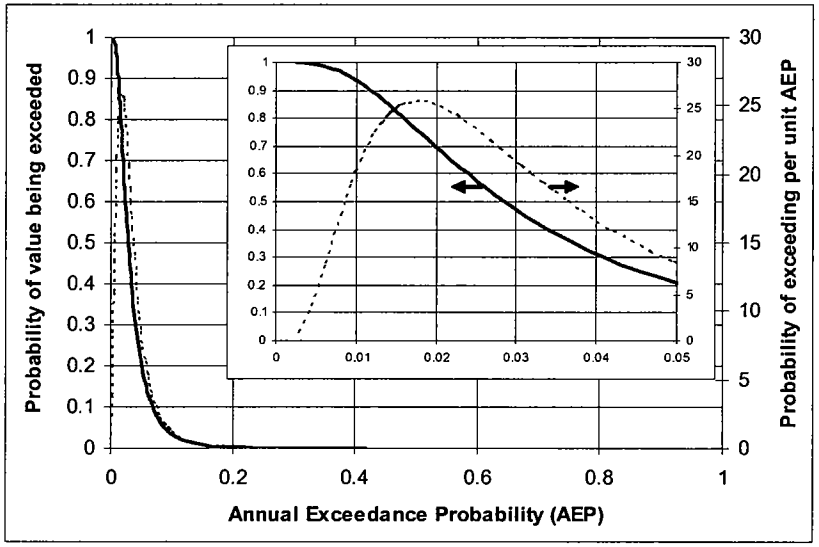


Figure A-6. Distribution Functions of AEP for 20' Levee

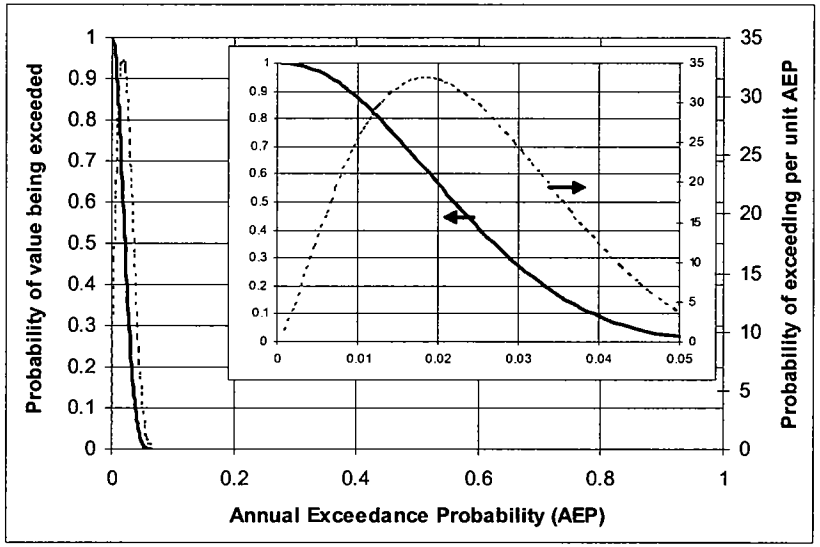


Figure A-7. Distribution Functions of AEP for Relocation

Should the levees protecting My City south of the Your River be threatened, residents could attempt to move to nearby higher ground. The depth of flooding in the protected neighborhoods in this area would generally not exceed that at the river's edge although a few areas would experience flooding of more that 10 feet. New Town, other the other hand, is ringed by levees so that residents trying to leave the area would have to find their way across the main highway system to areas of higher ground. Moreover, because New Town is in a depression, a third of the area would flood to depths over 10 feet. Some areas would flood to as much as 35 feet. Because of the lengthy duration of flooding and the lack of natural drainage from this area, flood water would likely remain in New Town for 2 weeks or more. With the proposed levee, New Town is subject to a 1 in 100 chance of being flooded in any year but a 1 in 2.5 chance in 50 years. Therefore, the probability of a catastrophic event within the lifetime of most residents is nearly the same as flipping a fair coin and getting heads.

SOURCE: Adapted from: National Research Council. 1995. Flood Risk Management and the American River Basin: An Evaluation. Washington, DC: National Academy Press.

Figure A-8. Example Scenario

Attachment 4

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
WASHINGTON, D.C 20314-1000

10 APR 1997

REPLY TO
ATTENTION OF:

CECW-P/CECW-E

MEMORANDUM FOR ALL MAJOR SUBORDINATE COMMANDS

SUBJECT: Guidance on Levee Certification for the National Flood Insurance Program

1. Use of risk-based analysis by the U.S. Army Corps of Engineers in flood damage reduction project formulation studies has created a disconnect between the Corps analysis and the Federal Emergency Management Agency's (FEMA) levee certification policy. FEMA's policy requires that levees be structurally sound, properly maintained, and have at least three feet of freeboard above the 100-year flood profile elevations before FEMA will recognize that the levees provide protection. The Corps risk-based analysis eliminates the concept of arbitrary freeboard by incorporating risk and uncertainty throughout the formulation process.

2. To ensure that levee certification to FEMA is performed by the Corps in a consistent manner, the enclosed guidance has been developed for use by all Major Subordinate Commands (MSC). This guidance has been reviewed and accepted by FEMA, and establishes Corps-wide standard procedures applicable to all future levee certification decisions.

3. It is recognized that levee certification commitments based on existing FEMA regulations have been made to non-Federal sponsors for some projects in progress. Exceptions to the new guidance will be considered for uncertified projects for which levee certification commitments already have been made. Each MSC should submit a list of projects that fall into this category, along with a justification for the exception, to CECW-EH by NLT 30 April 1997.

4. Points of contact for this guidance are Mr. Earl Eiker, telephone (202) 761-8500, or Mr. Ken Zwickl, telephone (202) 761-1855.

FOR THE COMMANDER:

Encl

RUSSELL L. FUHRMAN
Major General USA
Director of Civil Works

DISTRIBUTION: See next page.

CECW-P/CECW-E **25 March 1997**

edited to reflect current terminology and intent 03 January 2006

GUIDANCE ON LEVEE CERTIFICATION FOR THE NATIONAL FLOOD INSURANCE PROGRAM

1. **PURPOSE AND APPLICABILITY:** This document provides guidance to be used for certifying levees to the Federal Emergency Management Agency (FEMA) for their administration of the National Flood Insurance Program (NFIP). This guidance does not affect plan formulation and evaluation procedures. It is intended to provide a consistent methodology for levee certification by the Corps of Engineers. This guidance applies to all Corps District and Division offices. Note that levee certifications are provided to FEMA at the District/Division option and within available funds.

2. **BACKGROUND:** By letter dated 21 March 1996, FEMA, requested that the Corps review its criteria for levee certification in order to ensure consistency in administration of the NFIP by FEMA. This concern has arisen as a result of the Corps application of Risk Analysis *(RA)* in flood damage reduction project formulation studies. FEMA's policy requires that levees be structurally sound, properly maintained, and have at least 3 feet of freeboard above the 100-year flood profile elevations before FEMA will recognize that the levees provide protection from the 100-year flood. The FEMA requirements are fully explained in 44 CFR, Chapter 1, Part 65.10 of the Code of Federal Regulations. The FEMA requirements include data and analysis submission requirements for design criteria (freeboard, closures, embankment protection, embankment and foundation stability, settlement, interior drainage), operations plans and maintenance plans. 44 CFR Part 65.10 also states that in lieu of the structural requirements and data and analysis requirements, a Federal agency with responsibility for levee design may certify that a levee has been adequately designed and constructed to provide 100-year protection.

Levee certification for NFIP purpose can best be explained as follow. FEMA may request a "levee certification" from the Corps by letter directly to the Corps District office. The letter normally contains language such as:

> "...Please provide this office with current certification as to whether the design and maintenance of this levee are adequate to credit it with 100-year flood protection. Please note that such a statement does not constitute a warranty of performance, but rather the Corps current position of the levee system's design adequacy..."

3. **POLICY:** The Corps will continue to work with FEMA to ensure that Risk Analysis provides improved information for levee certification decisions. The following guidance and decision tree should be used until further notice.

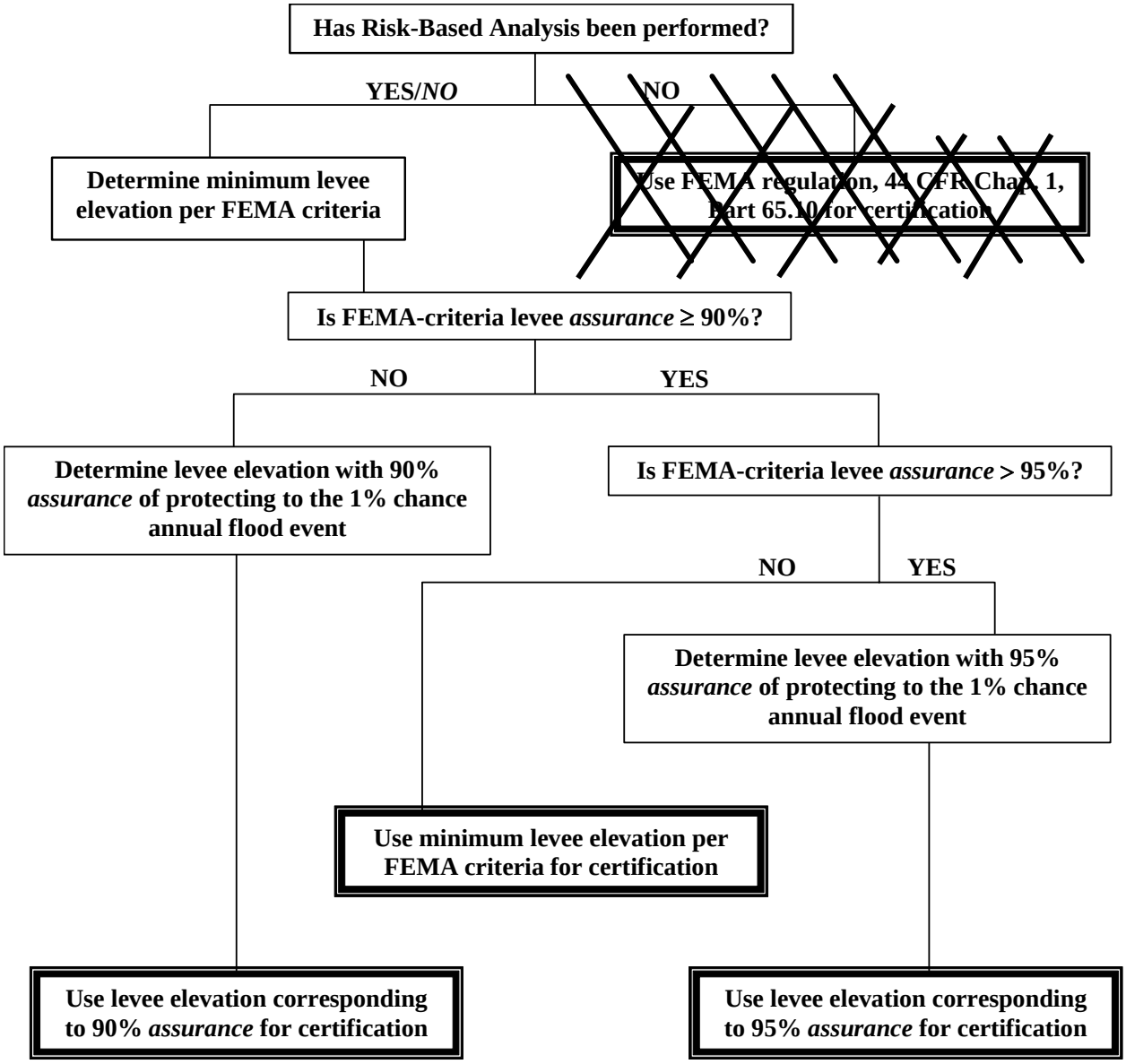
GUIDANCE ON LEVEE CERTIFICATION
FOR THE NATIONAL FLOOD INSURANCE PROGRAM

a. **Existing Levees, No Risk-Based Analysis Available**: For certification purposes, the Corps should evaluate the levees based primarily on FEMA criteria contained in 44 CFR Chapter 1, Part 65.10. Thus, the general rule will be that if a levee will contain the median one percent chance flood, with three feet of freeboard, it should be certified as being capable of passing the FEMA base flood, as long as it is adequate based on a geotechnical and structural evaluation, as described below. Exceptions to the three feet of freeboard requirement may be pursued, based on the FEMA policy of permitting other Federal agencies responsible for levee construction to certify that levees will pass the FEMA based flood. Such exceptions should be based on careful evaluation of the hydrologic, hydraulic, structural and geotechnical uncertainties, and current levee conditions as discussed blow.

a. **Existing and Proposed Levees, Risk Analysis *Required*:** In these cases, output on project performance from the Risk Analysis should be used to arrive at a decision regarding levee certification for FEMA. Existing and proposed levees will be certified as capable of passing the FEMA base flood if the levees meet the FEMA criteria of 100-year flood elevation plus three feet of freeboard, with two exceptions, as follows. When the FEMA criteria results in a "Conditional Percent Chance Non-exceedance" (*Assurance*) of less than 90% the minimum levee elevation for certification will be that elevation corresponding to a 90% chance of non-exceedance. When the FEMA criteria results in a*n assurance* of greater than 95%, the levee may be certified at the elevation corresponding to a 95% chance of non-exceedance. For existing levees, the certification decision is also contingent upon a structural and geotechnical evaluation, as described below. For proposed levees, the geotechnical and structural issues are assumed to be accounted for during design and construction of the levees.

b. **Engineering Evaluation:** A geotechnical and structural evaluation will be used to determine the water elevation at which the levee is not likely to fail. In some cases, this water level will be the determining factor in the decision to certify the levee system. The procedures to be used in the evaluation of a levee system for NFIP levee certification should consist of an engineering evaluation to determine if the levee system meets the Corps design construction, operation and maintenance standards, regardless of levee ownership or responsibility. The District will examine available existing information and data, such as original design, surveys of levee top profile, levee cross-sections, records of modifications and changes, performance during past flood events, and remedial measures. It will also include a field inspection of the levee, structures, closure devices and pumping stations to evaluate the adequacy of maintenance. The engineering analysis should examine the project with respect to embankment stability, under seepage, through seepage, and erosion protection. Existence of closure devices will necessitate a review of the adequacy of flood warning time for the complete operation of all closure structures.

Levee Certification Decision Tree



FEMA Criteria = 1% chance median annual flood event plus three feet of freeboard
~~RELIABILITY~~ ASSURANCE= percent chance non-exceedance given the 1% chance annual event occurs.

Note: Diagram was edited 03 January 2006 to reflect current terminology ('reliability' replaced with *assurance*) and to remove branch of tree that previously accommodated non-risk analysis studies, now inappropriate.