Analysis and Mapping Procedures for Non-Accredited Levee Systems

New Approach

July 2013

RiskMAP
Increasing Resilience Together

Executive Summary

Background

This document outlines the new process used by the Federal Emergency Management Agency (FEMA) to analyze and map areas on the landward side of non-accredited[1] levee systems that are shown on FEMA's Flood Insurance Rate Maps (FIRMs).

Under FEMA's prior levee approach, a levee system that did not meet the National Flood Insurance Program (NFIP) requirements was analyzed and mapped as if it had no effect on the landward side of the levee system during the base (1-percent-annual-chance) flood. This was known as the "without levee" approach.

Some stakeholders expressed concern about the "without levee" approach. Members of both the U.S. House of Representatives and the U.S. Senate echoed this concern and asked FEMA Administrator Craig Fugate to consider discontinuing the "without levee" analysis and mapping approach. They suggested FEMA draw on current modeling techniques to refine the level of flood hazard reduction that non-accredited levee systems can provide, while recognizing that such modeling can never be absolutely precise.

Given recent technological advances in data collection and hydrologic and hydraulic modeling, FEMA is able to implement a more refined approach to mapping flood hazards in areas landward of levee systems. The suite of procedures discussed in this document will better meet the needs of the public and provide results that are more refined.

Recognizing that the details of the new approach would take time to finalize and that the "without levee" approach had been used in flood hazard analysis and mapping efforts for in-progress Flood Insurance Studies (FISs) and map revisions, FEMA delayed finalizing FIRMs and FIS reports for communities where levee systems did not meet accreditation requirements. This temporary delay allowed FEMA to evaluate affected levee systems using the procedures discussed in this document. In 2013, FEMA plans to gradually resume processing of FIS projects and map revisions that were delayed.

General Approach to Revised Process

FEMA designed a repeatable and flexible approach that:

- Complies with all existing statutory and regulatory requirements governing the NFIP, most notably 44CFR65.10[2];
- Leverages local input, knowledge, and data through proactive stakeholder engagement;

[1] "Non-accredited" means any levee that does not meet the requirements outlined in 44CFR65.10 .

[2] The criteria of 44CFR65.10 for accreditation of levee systems are not being changed and will remain in effect after the procedures presented in this document are implemented.

- Aligns available resources for engineering analysis and mapping commensurate with the level of risk in the areas landward of levee systems; and
- Considers, from an engineering perspective, the unique characteristics of each levee system.

FEMA established a multidisciplinary project team with representatives from FEMA, the U.S. Army Corps of Engineers, and experts from the academic and engineering communities. The FEMA-led team explored a broad spectrum of levee analysis and mapping procedures, evaluated the procedures based on a number of flooding scenarios that communities might reasonably encounter, assessed the feasibility of these procedures using several key criteria, and obtained feedback from internal and external stakeholders.

Public Review

As a part of its stakeholder engagement effort and to encourage transparency in its processes, FEMA initiated a public review and comment period to introduce the proposed approach through a report that fully described the evaluation and development of the proposed revised process.

FEMA published a notice in the FEDERAL REGISTER seeking comments on its proposed approach from December 15, 2011, until January 30, 2012. To further bolster participation in the public review process, FEMA held Web-enabled seminars to walk participants through the public review document, provide clarification, and answer questions.

In general, stakeholder comments on the proposed approach focused on the following areas:

- Economic issues (the cost of implementation to both the communities and levee owners, FEMA and other stakeholders);
- Specific need for outreach materials, particularly those that delineate the details of future studies such as who will complete them, who is responsible for data gathering, what criteria exist;
- Technical clarification around specific procedures; and
- Concerns about the impact of using Zone D[3].

Hallmark Principles of the New Levee Analysis and Mapping Process

FEMA recognizes the importance that the U.S. Congress and American public place on the need to revise the levee analysis and mapping process to assess flood hazards in areas landward of levee systems across the United States. In addressing this challenging issue, FEMA engaged in a rigorous process with a wide array of stakeholders of varying opinions and perspectives. This process led FEMA to identify four hallmark principles that would guide the process.

Interactive Stakeholder Engagement Process

The new levee analysis and mapping process include an interactive coordination process with key stakeholders, including State and community officials, officials of participating Tribes, and levee

[3] Zone D is defined as an area of undetermined, but possible, flood hazard. Properties located in Zone D areas are not subject to the federally mandated flood insurance purchase requirement.

owners. This process may include the formation of a Local Levee Partnership Team, which could include partners from the community, Tribal officials, and levee owners (for those levee systems not owned by a community or Tribal entity). Through the stakeholder engagement process, FEMA will work with stakeholders and use their input when mapping flood hazards associated with non-accredited levee systems.

More Robust Levee Analysis and Mapping Procedures

FEMA previously used the "without levee" approach to assess flood hazards associated with non-accredited levee systems. Under the "without levee" approach, Special Flood Hazard Areas (SFHAs) landward of non-accredited levees would be developed as if the levee system did not provide any level of flood-hazard reduction for the 1-percent-annual-chance flood. In essence, landward of the levee system modeling was carried out as though the levee system did not exist. Under the new approach, communities with non-accredited levee systems can provide input so that FEMA may select analysis and mapping procedures that better reflect the communities' unique circumstances and better characterize local flood hazards.

Recognition of the Uncertainty Associated with Levee Systems

FEMA will represent the uncertainty of the hazards associated with non-accredited levee systems through use of the Zone D designation. FEMA uses the Zone D designation on a FIRM to identify areas of undetermined, but possible, flood hazards. In the future, FEMA may define and adopt another zone designation through the regulatory process.

Analysis of Levee Reaches

The new levee analysis and mapping procedures recognize that levee systems have different components, and some of these components have more flood hazard reduction capability than others. In the context of the new procedures, these components are called reaches. A levee reach is defined as any continuous length of a levee system to which a single analysis and mapping procedure may be applied. There is no minimum or maximum length for a levee reach, as its definition will be primarily data dependent.

Levee Analysis and Mapping Technical Procedures

Four major components will be overlaid to develop the final flood hazard information for the FIRM: (1) a system-wide Zone D area developed using the Natural Valley Procedure; (2) a system-wide SFHA based on an interior drainage analysis developed assuming the levee system remains in place; (3) merged SFHAs determined from the appropriate levee reach procedures detailed below; (4) and the SFHA developed for the flooding source side of the levee system assuming the levee system remains in place.

A registered professional engineer must sign and seal all engineering data developed for each procedure, and this will satisfy the certification requirements of Section 65.2 and Paragraph 65.10(e) of the NFIP regulations (44CFR65.2 and 44CFR65.10(e), respectively). If required, structural, operations, maintenance, and overtopping analysis data submitted by a levee owner or community will be reviewed for completeness.

Sound Reach Procedure. A Sound Reach is defined as a continuous section of a levee system that has been designed, constructed, and maintained to withstand the flood hazards posed by a 1-percent-annual-chance flood, in accordance with sound engineering practices. A Sound Reach is beneficial in that it can be modeled assuming it will remain in place during the 1-percent-annual-chance flood and, thus, its impact will be reflected in the delineation of the final SFHA. Sound Reaches differ from an accredited levee system because they are part of a levee system that as a whole cannot meet accreditation requirements.

No reach-specific levee modeling is required for a Sound Reach. However, SFHAs from the system-wide interior drainage analysis, and/or adjacent levee reaches may still be delineated landward of Sound Reaches.

Freeboard Deficient Procedure. The Freeboard Deficient Procedure can be applied if the 1-percent-annual-chance flood is between the top of levee but it cannot meet the freeboard standard. A Freeboard Deficient Reach must meet structural analysis, Operation and Maintenance, and inspection standards. Freeboard Deficient Reaches differ from an accredited levee system because they are part of a levee system that as a whole cannot meet accreditation requirements and because they cannot meet the regulatory freeboard standard.

As with the Sound Reach Procedure, no reach-specific modeling is required for a Freeboard Deficient Reach. However, SFHAs from the system-wide interior drainage analysis, and/or adjacent levee reaches, may still be delineated landward of Freeboard Deficient Reaches.

Overtopping Procedure. The Overtopping Procedure can be applied when the 1-percent-annual-chance flood is above the levee crest for a reach, and the community or levee owner has provided appropriate technical justification that the 1-percent-annual-chance flood event will not cause structural failure. In addition to the structural standards established in 44CFR65.10, it is expected that more detailed structural analysis will be required in order to justify that the levee system can sustain the 1-percent-annual-chance flood. As with a Sound Reach and Freeboard Deficient Reach, an Operations and Maintenance Plan and documentation of inspection are required.

For an Overtopping Reach, technical analyses will be performed to determine the volume of water that will overtop the levee during the 1-percent-annual-chance flood event. This volume of water will be used to establish the SFHA.

Structural-Based Inundation Procedure. In some instances, levee systems have reaches with either structural deficiencies that are known or structural integrity that is unknown (a common occurrence for older levee systems). Levee systems with structural integrity issues may, however, provide some flood risk management benefits by impeding conveyance to some degree. For these levee reaches, FEMA will rely on modeling of breaches along the levee reach.

It is not possible to predict the exact location of a levee breach. This procedure, therefore, does not predict the probability of failure at any breach location, nor does it provide a specific determination or evaluation of the overall levee system performance or require a determination of the likely failure mechanism. The procedure instead results in the development of a levee reach-specific SFHA that might occur as a result of potential breaches along a particular levee reach during the 1-percent-annual-chance flood. To determine this SFHA, possible locations of system breaches, geometry, and failure duration will be considered.

Natural Valley Procedure. The Natural Valley Procedure will be used in two ways: first landward of the entire levee system to determine the outer limits of any Zone D areas used and second as a potential procedure applied to individual levee reaches to determine the SFHA on the landward side of the levee reach. The Natural Valley Procedure can be applied to all non-accredited levee reaches.

Below are several factors to consider when determining whether to use the Natural Valley Procedure to determine the SFHA:

- The levee reach does not significantly obstruct the flow of water;
- Data necessary for more complex methods isnot and will not be available in the near term; or
- The community (or Tribal entity, when appropriate) provides feedback that it is the acceptable procedure to use.

For riverine levee systems, the Natural Valley Procedure will reflect the levee geometry in the hydraulic model, but will allow water to flow on either side of the levee. For coastal levee systems, the Natural Valley Procedure will reflect the levee geometry, and consideration will be given as to how the levee system will impact wave propagation.

Addressing the Recommendations from the National Academies

In March 2013, the National Research Council of the National Academy of Sciences released a pre-publication version of the report *Levees and the National Flood Insurance Program: Improving Policies and Practices* (NAS Report). FEMA's new approach for modeling and mapping non-accredited levees represents an important first step towards addressing many of the conclusions and recommendations of the report. The following key themes from the NAS Report are addressed by FEMA's Risk MAP program and the new analysis and mapping approach:

- Moving Towards a Modern Risk Analysis;
- Improving Flood Risk Awareness;
- Recognizing Uncertainty in Flood Risk;
- Supporting Locally-Tailored Risk Management Strategies;
- Communicating Flood Risk behind Levees;
- Synchronizing Methodologies with the USACE; and
- Developing a Consistent Federal Message.

Steps for Continuing to Improve the Approach

FEMA will continue to work on longer term levee issues. As this work continues, FEMA will periodically issue operating guidance and standards to document updates and improvements to the approach for analyzing and mapping of non-accredited levee systems. These materials will provide the communities, levee owners, and local project sponsors with a clearer idea of how their participation will be accommodated in the new process. In addition, with the passage of the *Biggert-Waters Flood Insurance Reform Act of 2012* and the long-term conclusions and recommendations from the NAS Report, information and guidance will continue to emerge that likely will affect FEMA's approach to analyzing and mapping levee systems.

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Section 1. Introduction

This document summarizes the Federal Emergency Management Agency (FEMA) procedures for the analysis of non-accredited levee systems and the mapping of areas landward of non-accredited levee systems on Flood Insurance Rate Maps (FIRMs). A non-accredited levee system is a levee system that does not meet the requirements of Section 65.10 of the National Flood Insurance Program (NFIP) regulations (44CFR65.10), *Mapping of areas protected by levee systems.* Although non-accredited levees are physically shown on a FIRM, the area on the landward side of the levee system is shown as a Special Flood Hazard Area (SFHA), to show that the flood hazard posed by a 1-percent-annual-chance or greater flood still remains.

FEMA's mission is to support our citizens and first responders to ensure that as a nation, we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards.

A **levee** is a manmade structure, usually an earthen embankment, designed and constructed with sound engineering practices to contain, control or divert the flow of water in order to provide protection from temporary flooding.

A **levee system** is a flood hazard-reduction system that consists 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

A FEMA **accredited levee system** is a levee system that meets the requirements of 44CFR65.10 and therefore is shown on the FIRM as providing protection from the 1-percent-annual-chance flood.

FEMA has designed a cost-effective, repeatable, and flexible approach that (1) complies with all statutory and regulatory requirements governing the NFIP; (2) leverages local input, knowledge, and data through proactive stakeholder engagement; (3) aligns available resources for engineering analysis and mapping with the level of risk in the area landward of the levee; and (4) considers the unique flooding and levee characteristics, solely from an engineering perspective, of each levee system.

FEMA is replacing the former levee analysis and mapping approach—sometimes referred to by FEMA and stakeholders as the "without levee" approach—with a suite of alternative procedures. Under the former approach that was used before March 2011, FEMA modeled and mapped a non-accredited levee system to show that the entire system did not reduce flooding impacts on the landward side of the levee during the 1-percent-annual-chance flood. In essence, landward of the levee system modeling was carried out as though the levee system did not exist. A detailed explanation of the "without levee" approach is provided in Appendix C of this document.

The suite of new procedures – Sound Reach, Freeboard Deficient, Overtopping, Structural-Based Inundation, and Natural Valley – have undergone an extensive process of scientific review and public input. The new procedures are technically sound, understandable to stakeholders, and cost-effective, and they will better meet the needs of the public and provide more refined results, while at the same time recognizing that uncertainty remains. Detailed information on these procedures is provided in Subsection 4.2 of this document.

1.1 Program Overview

The U.S. Congress established the NFIP with the passage of the National Flood Insurance Act of 1968 (42 U.S.C. §§ 4001-4129). The NFIP, administered by FEMA, allows property owners and lessees in participating communities, including participating Tribes, to purchase flood insurance in exchange for State, community, and Tribal officials adopting and enforcing minimum floodplain management regulations consistent with Federal criteria.

The Act requires FEMA to identify and publish information on flood hazards nationwide and establish flood insurance zones. FEMA publishes this information on FIRMs. The primary vehicle that FEMA has used for developing the required flood hazard information is referred to as a Flood Insurance Study (FIS). The FIRMs produced by FEMA are accompanied by narrative documents referred to as FIS reports.

1.2 Levee Systems and Flood Hazard Maps

No levee system eliminates all flood hazards that can affect the people and structures located landward of the levee system. Some level of flood hazard exists in all areas within and surrounding levee systems.

FEMA does not own, operate, maintain, or inspect levee systems or develop certified levee-related data for accreditation purposes. However, as the administrator of the NFIP, FEMA creates, updates, and distributes FIRMs, including FIRMs that depict the effects that levee systems have on flooding.

For FEMA to accredit a levee system with 1-percent-annual-chance flood hazard reduction capability on a FIRM, the community, Tribe, levee owner, and/or local project sponsor must submit a package containing the required data and documentation to show that the levee system meets all design and operation requirements of 44CFR 65.10[4]. The text of 44CFR65.10 is provided in Appendix D of this document.

FEMA does not own, operate, maintain, or inspect levees or develop certified levee data for accreditation purposes. However, as the administrator of the NFIP, FEMA creates, updates, and distributes flood hazard maps, including maps that depict the effects that levee systems have on flooding.

Infrastructure alone, including levees, does not eliminate risk. Poorly designed, constructed, operated or maintained levees and floodwalls can increase risk as they may provide a false sense of security. However, levees can buy critical time for local emergency management officials to safely evacuate residents.

The development and sharing of flood hazard data and maps is key to ensuring people are aware of their risks.

[4] 44 CFR Part 65.10 was published final in 1986, after much of the mapping in the Nation had been completed. As a consequence, many levee systems were accredited that do not meet these regulations, and are being reevaluated under the Map Modernization and Risk MAP programs.

When a levee system is considered by FEMA to be accredited for NFIP mapping purposes, FEMA does not show an SFHA designation in the area landward of the levee system, other than flood hazard areas associated with interior drainage. The SFHA is the high-hazard area that would be inundated by the 1-percent-annual-chance flood (also referred to as the base flood). Flood insurance is required for buildings with federally backed mortgages within the SFHA.

Before December 8, 2011, FEMA mapped the area landward of an accredited levee system as a moderate hazard area, referred to as Zone X (shaded). Beginning on December 8, 2011, with the publication of Procedure Memo (PM) No. 66, "Flood Insurance Study Report Alignment to Digital Vision" (FEMA, 2011), FEMA symbolizes the area landward of an accredited levee system with a diagonal gray and tan hatch pattern. Both visual representations are used to identify areas of reduced risk as the result of certain flood-hazard reduction structures including levee systems. The mandatory flood insurance purchase requirements of the NFIP do not apply in these areas.

Projects built to the 1-percent-annual-chance exceedance (100-year flood) event do not entirely eliminate the risk of flooding. The 1-percent-annual-chance event, as it relates to the NFIP, is used to determine flood insurance requirements and is not a safety standard.

All levees, regardless of their level of protection, stand at risk of overtopping, breaching, or failing during a storm event that exceeds design capacity. It is prudent to consider investing in flood insurance even if it is not required.

1.3 How Flooding Occurs with Levees

Many Americans have concerns about levee failures, especially since the devastation that occurred in New Orleans following Hurricane Katrina in 2005, and the flooding along the Mississippi River and its tributaries in 2011. A large number of levees are over 100 years old, including many levees along the Mississippi River. It is important to understand that levees are designed to specific criteria; when those criteria are exceeded, the levee is likely to be unsuccessful in holding back floodwaters. Further, the frequency with which these criteria are equaled or exceeded often changes with time thereby changing the risk faced by those behind the levee system.

The exact cause of a levee failure may be difficult to determine, yet the most common causes are overtopping erosion, internal erosion, slope instability, lateral erosion, and structural instability. Aging and poorly maintained levees and control structures such as locks, gates, and pumps contribute to a higher probability of a levee failure. Exceptional events, such as a higher than designed water flow rate or water-surface elevation, also contribute to levee failures. When a levee fails, the results are often catastrophic.

1.4 Why FEMA is Revising the Former Levee Analysis and Mapping Approach

Until March 2011, FEMA identified flood hazards and produced updated FIRMs utilizing its "without levee" approach[5]. Because stakeholders expressed concern about this approach, FEMA agreed that the approach required review and further consideration. For specific detail regarding the "without levee" approach, please see Appendix C of this document.

In February 2011, members from both the U.S. House of Representatives and the U.S. Senate wrote letters requesting that FEMA discontinue the "without levee" approach for analyzing levee systems and mapping the areas impacted by the levee systems when those levee systems do not fully comply with the NFIP regulatory requirements cited at 44CFR65.10. In their letters, the Representatives and Senators requested that FEMA:

> *…discontinue the use of 'without levee' analysis in cases where a final [FEMA] determination has not been made and an affected community objects to such analysis in favor of more precise methods of flood modeling.*

At the same time, FEMA was engaged in an ongoing comprehensive review of the NFIP to identify reforms to enable FEMA to better address the flood hazards faced by Americans nationwide. FEMA included the "without levee" analysis and mapping approach issue as an important consideration in the ongoing NFIP reform efforts, yet recognized that NFIP reform is a long-term solution, and near-term changes were needed to address this issue.

Subsequent to the events of 2011, the U.S. Congress passed the *Biggert-Waters Flood Insurance Reform and Modernization Act of 2012*, which extended the NFIP for 5 years and included reforms to the NFIP. Specific to levees and associated flood control systems, the Act reinforces the approach presented in this document, which is that FEMA, along with its technical partners (including State and local governments), will identify appropriate measures and take into consideration investments in levee systems and flood-control systems. Consequently, the approach presented in this document is the first step in addressing levee-related issues. FEMA will continue to work on longer term solutions to levee-related issues.

1.5 How FEMA Developed the New Approach

In response to the congressional recommendations, FEMA suspended the issuance of final determinations for FIRMs that were based on the "without levee" approach, meaning that the FIRMs would not become effective for NFIP floodplain management and flood insurance purposes in those areas. FEMA then convened a multidisciplinary project team with representatives from FEMA, the U.S. Army Corps of Engineers (USACE), and experts from the academic and engineering communities to evaluate technical options for non-accredited levee systems.

[5] The "without levee" approach neither considered graduated risk nor provided a more granular solution in defining hazard behind non-accredited levees. Instead, it was a binary approach where the levee either met accreditation criteria or did not, with no middle ground.

The FEMA-led team explored a broad spectrum of levee analysis and mapping procedures. FEMA selected procedures for effectiveness in proof of concept case studies using a small number of theoretical scenarios that simulated real-world situations that communities might reasonably encounter. FEMA assessed the feasibility of each procedure using several key criteria, and solicited feedback from key internal and external stakeholders. FEMA then solicited public feedback on the proposed approach via a public review process (described in detail in Subsection 1.8).

Based on the results of the development, testing, review, and public comment effort, FEMA created a levee analysis and mapping approach that is flexible and will produce more refined FIRMs and supporting data where non-accredited levee systems are involved.

1.6 How FEMA will use the Approach

FEMA will use the new process discussed in this document to produce FIRMs, FIS reports, and related products for communities and Tribes impacted by non-accredited levee systems until they are replaced by longer term solutions developed through NFIP regulatory reform. Again, a core goal of the new procedures includes identifying more refined flood hazards associated with non-accredited levee systems and reflecting the results in FIRMs and related products. An important outcome of the effort is increasing the credibility of FIRMs where non-accredited levee systems exist. While FEMA strives to refine flood hazard identification, the new approach is not intended to determine the risk, level of protection, or probability of failure for specific levees or levee systems.

FEMA has not, and does not intend to, alter the NFIP regulatory requirements for levee accreditation provided in 44CFR65.10 as part of this effort. These regulatory requirements will remain in effect even after the new levee analysis and mapping process implemented.

The requirements of 44CFR65.10, 44CFR61.12, and 44CFR65.14 remain in effect. No change resulting from the proposed levee analysis and mapping approach diminishes, changes, or supersedes 44CFR65.10, 44CFR61.12, and 44CFR65.14, or any other part of the NFIP regulations.

As part of this effort, FEMA also has not revised the regulatory requirements for new construction projects that have made adequate progress toward completion provided in Section 61.12 of the NFIP regulations (44CFR61.12), *Rates based on a flood protection system involving Federal funds.* The same applies to the regulatory requirements for de-accredited levee systems that are being restored to provide 1-percent-annual-chance or greater flood hazard reduction capability provided in Section 65.14 of the NFIP regulations (44CFR65.14), *Remapping of areas for which local flood protection systems no longer provide base flood protection.* While still subject to future changes, these regulatory requirements will remain in effect after the new levee analysis and mapping process is implemented.

FEMA also has not revised, and does not intend to revise, the procedural requirements for levee systems that are new construction projects that have made adequate progress toward completion, are being restored, or are Provisionally Accredited Levee (PAL) systems. The procedural requirements for these levee systems are provided in Appendix H of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA, 2003a) and in PMs that FEMA issued to clarify the

requirements in Appendix H. Interested parties may access all procedural requirements, including Appendix H and the PMs, from dedicated pages on the FEMA Website. The regulations and procedures cited above will remain in effect after FEMA implements the new levee analysis and mapping approach.

The new process is not currently intended to be applied to non-levee embankments. The guidance for non-levee embankments documented in PM 51, "Guidance for Mapping of Non-Levee Embankments Previously Identified as Accredited" (FEMA, 2009a), is to be followed.

Finally, the process defined by this document provides better substantive information, but is not intended to alter, revise, or change existing flood insurance requirements for mapped areas of non-accredited levees or levee systems.

1.7 Stakeholder Input during Development of the Proposed Approach

To obtain external feedback from stakeholders, FEMA presented proposed procedures and solicited input from an Independent Scientific Body (ISB) and a Community Roundtable. The ISB and Community Roundtable are discussed below

After FEMA tested proof of concept case studies, FEMA coordinated with the National Institute of Building Sciences (NIBS). NIBS is a non-profit, non-governmental organization authorized by the U.S. Congress. The NIBS mission is to serve the public interest by supporting advances in building sciences and technologies for the purpose of improving the performance of our nation's buildings while reducing waste and conserving energy and resources. NIBS then convened the ISB, composed of recognized subject matter experts and registered professional engineers. Information about the ISB panel can be found at http://floodsrp.org/panels/. The Panel ID for this effort is FEMA061711. After the ISB deliberations concluded, FEMA reviewed the ISB members' comments on the documentation provided and addressed their feedback in the public review document, titled *Revised Analysis and Mapping Procedures for Non-Accredited Levees*.

Following the ISB review, FEMA convened a Community Roundtable composed of a variety of community stakeholders, including levee owners and community officials, to seek feedback on the proposed levee analysis and mapping approach. The Community Roundtable participants worked through a case study of a project to get the best possible understanding of the approach and identify potential improvements and additions to the approach. At the end of the Community Roundtable session, participants agreed that the approach was "directionally correct" and provided substantial, more detailed feedback that led to further refinement of the approach.

1.8 Public Review Purpose and Process

As a part of its approach to stakeholder engagement and with the desire to be completely transparent with the process it was undertaking, FEMA established a public review and comment process on the proposed levee analysis and mapping approach. FEMA prepared a public review document that fully described the process leading up to, and the development of, the proposed revised process for the analysis and mapping of non-accredited levee systems. FEMA sought comments, questions, concerns, and suggestions for improving the technical considerations of the proposed approach, its

potential local impact, and the feasibility for community participation in the levee analysis and mapping process.

The public review document was opened for comment via the *Federal Register Notice*, (76 FR 78015) from December 15, 2011 until January 30, 2012. Respondents submitted comments through the *Federal Rulemaking Portal*; by mail to FEMA Regulatory Affairs Division Office of Chief Counsel; and the *National Flood Insurance Program (NFIP) Levees Comment website:* http://www.NFIP-levees.com. This website is no longer accessible.

To further bolster participation in the public review process, FEMA held three public online forums via webinar to present the approach on December 21, 2011, from 1:30 p.m. Eastern Standard Time (EST) to 3 p.m. EST; on January 3, 2012, from 1:30 p.m. EST to 3 p.m. EST; and on January 10, 2012, from 1:30 p.m. EST to 3 p.m. EST. The purpose of the forums was to step participants through the public review document, provide clarification, and answer questions both in document content and process for submitting comments.

1.8.1 Overview of Responses, Respondent Demographics, and Categorization

At the conclusion of the public review period, FEMA broke up any full letter responses into discrete comments for the purpose of categorization and analysis resulting in 1,441 comments.

The 1,441 comments received were from a variety of organizations as shown in Figure 1-1.

	Respondents	Comments
Local Government	59	486
Federal - USACE	38	250
Federal - FEMA Regions	13	196
Associations	12	147
State Government	15	142
Private Companies	21	135
Private Citizens	14	62
Federal - National Oceanic and Atmospheric Administration	1	22
Blank	1	1
	174	**1,441**

Figure 1-1. Total Respondents and Comments per Stakeholder Group

These comments were further grouped into the categories identified below.

1. **Economic Impact:** The cost of creating a new map/providing a new study ***or*** the impact on local homeowners from FEMA process changes.
2. **Public Impact:** The impact of FEMA process changes on the public (e.g. citizens).
3. **Insurance Impact:** The impact of FEMA process changes on insurance rates and the desire to purchase insurance policies.
4. **Real-life Impact:** The impact of real-life information on FEMA processes, as opposed to relying on simulations.

5. **Outreach:** Working with other groups to improve understanding of process changes. A particular emphasis was placed on the Local Levee Partnership Team (LLPT) process (refer to Subsection 3.8).
6. **Study Details:** The details of processing a study, including technical criteria, data requirements and availability, and which agency maintains primary responsibility for conducting the study.
7. **Technical Assistance/Process Clarification:** The desire for more specific information about the process and technical procedures and process outlined in the document.
8. **Zone D:** The impact of mapping large areas as Zone D. A particular focus was placed on creating a new zone *or* mapping these areas as Zone X (shaded).
9. **General Direction of Approach– Positive:** Comments surrounding the general approval of the direction of the approach or document.
10. **General Direction of Approach – Negative:** Comments surrounding the general disapproval of the direction of the approach or document.
11. **Non-levee Embankments:** Comments expressing a need for more information on how these structures will be mapped or included, if at all.
12. **Study Sequence:** Comments and questions regarding when new studies will be completed and what priority will be given to recently completed or pending studies.
13. **Future Efforts:** The impact of FEMA process changes on future development.
14. **Environmental:** The impact of FEMA process changes on the environment.

The three categories that received the most comments were economic impact, technical assistance/process clarification, and Zone D.

1.9 Improvements Based on Public Review Comments

FEMA carefully reviewed the 1,441 comments received. Based on the comments received and subsequent technical testing, FEMA changed and clarified the approach in many ways, as listed below.

Applicability of the New Process

- Clarified that the procedures will apply if a PAL expires and the levee is non-accredited
- Clarified how FEMA will assess whether a levee meets requirements for freeboard deficient
- Emphasized that the new approach applies only to non-accredited levees

Definition of a Levee and Non-Levee Embankment Issues

- Clarified that the non-levee structures will not be processed using the new approach
- Clarified that FEMA will review combination canals/levees on a case-by-case basis
- Provided additional guidance for how to differentiate levees from non-levee embankments
- Clarified that communities and other stakeholders may provide input into the determination of whether a flood-control structure is a levee or a non-levee embankment

Local Input

- Added information to indicate there is flexibility in determining which community participants will serve on the LLPT
- Clarified that FEMA will facilitate the LLPT. Final decisions on the appropriate approach using or informed by LLPT input, but will not provide funding to the community to participate in the LLPT
- Clarified the role of stakeholders in providing additional data

Funding

- Clarified that FEMA will not fund any efforts related to certifying data for levee accreditation or making determinations of the levee's structural conditions
- Explained that FEMA will continue to provide technical guidance relative to data collection efforts but will not fund a community's efforts to meet these requirements
- Clarified that FEMA will make data associated with levee analysis available to stakeholders

Levee Reaches

- Clarified the data requirements for each of the levee reach procedures
- Explained that Sound Reaches must consider whether adjacent levee reach failures would cause failure of the Sound Reach

Technical Analysis Issues

- Explained that the levee analysis is based on using "current" conditions
- Clarified that FEMA-approved models must be used
- Added detail to procedures for situations when there are levees on both sides of a flooding source
- Clarified circumstances under which interior drainage analysis is required
- Clarified how minimum breach width for different levee types is determined, and that the final breach parameters will be based on what breach parameters produce the most reasonable flood hazard area delineation, not necessarily the largest
- Clarified that the Natural Valley Procedure will most likely be applied to levees along flooding sources studied by approximate methods and that a community may chose the Natural Valley Procedure where appropriate

Document Structure

- Reorganized the document for more clarity
- Added an appendix focusing on Zone D

1.10 Recommendations from the National Academy of Sciences

The NAS Report made eleven recommendations and ten conclusions to improve the policies and practices related to levees and the NFIP. While the new approach for non-accredited Levee Systems

doesn't achieve all of the goals and objectives outlined in the NAS Report, it does make some important progress in achieving some of the goals, and also would allow FEMA to start piloting new approaches that would make further advances. Below is a summary of the areas where there is an existing connection to the specific recommendation and conclusion from the NAS Report. (Note, the below titles are not a directly pulled from the NAS report but are intended to address the overall theme or sub-theme of the recommendations and conclusions referenced):

Moving Towards a Modern Risk Analysis

Recommendations 1 and 3 of the NAS Report stress the importance of having a modern, detailed analysis for both understanding the risk landward of a levee system and for setting insurance rates. The new approach allows for the use of more refined analyses for determining the hazard landward of non-accredited levee systems when the appropriate data is available, but also recognizes that data and funding limitations exist for analyzing and mapping many levee systems. The new approach also enables FEMA to sub-divide a levee system into distinct reaches for analysis and mapping and tailors the analysis to specific needs, data availability, and flooding conditions of each levee reach.

Improving Flood Risk Awareness

NAS Conclusions 3, 4 and 7 point out that the current mandatory purchase program has not consistently led to the purchase of flood insurance, and by extension an awareness of flood risk. A critical aspect of FEMA's new approach for non-accredited levees is the increased collaboration with local stakeholders to increase the quality of the analysis and mapping activities and thereby increasing flood risk awareness. By better engaging stakeholders in the new approach for non-accredited levees more effective messaging will result. FEMA is also developing non-regulatory product guidance specific to levees to support this mission.

Recognizing Uncertainty in Flood Risk

Conclusion 5 of the NAS Report determined that the mandatory purchase requirements lead to the misperception that flood hazards only occur where insurance purchase is mandatory. FEMA now will designate areas within the Natural Valley footprint of non-accredited levees not subject to mandatory purchase as a possible but undetermined flood hazard using Zone D. This will allow FEMA to communicate the possibility of risk in these areas using currently available flood zone designations.

Supporting Locally-Tailored Risk Management Strategies

Conclusion 8 and Recommendation 6 of the NAS Report stress the importance of encouraging local, state, and federal involvement in developing locally focused risk management strategies. This has been an integral element of FEMA's Risk MAP vision. By considering local and state mitigation actions a measure of success under Risk MAP, FEMA recognizes the importance of advancing the concepts of risk management. Through the delineation of the area of uncertainty as a Zone D under the new approach, FEMA will be providing communities with incentive where it only existed previously in limited amounts, to recognize and manage the residual risk in these areas.

Communicating Flood Risk behind Levees

Recommendations 7, 8, and 11 all address the need for continued development of risk communication measures at all levels and the importance of evaluating the success of these activities. FEMA will engage stakeholders early in the process and will actively look for process improvement opportunities. FEMA has already established metrics for measuring "awareness" of flood risk behind levees. Through FEMA's awareness survey implemented under Risk MAP, FEMA also is able to survey the success of risk communication strategies at a national scale.

Synchronizing Methodologies with the USACE

Recommendation 9 of the NAS Report details the importance of developing common methodologies and approaches between the USACE and FEMA. FEMA and the USACE have been actively working to better align data sharing, analysis, and mapping processes as it pertains to levees. FEMA and the USACE collaborated on the development of this proposed approach to address non-accredited levees. In addition, the Flood Protection Structure Accreditation Task Force has been tasked by Congress with providing recommendations on how to improve these processes. Their final report is due this July, and the agencies have an additional year to implement these recommendations.

In addition, where it is appropriate, FEMA will utilize the USACE Levee Screening Tool during the Local Levee Partnership Team meetings to help understand and communicate the flood risk associated with the levee. Use of this tool will allow FEMA and the USACE to develop a consistent understanding of flood risks and informed decisions about future actions.

Developing a Consistent Federal Message

Conclusion 9 urges FEMA to develop a consistent federal message with open discussion and decisions about flood risk. FEMA developed this new approach for non-accredited levees in close coordination with the USACE in part to improve messaging. Also, as stated above, FEMA is working closely with the USACE on the Flood Protection Structure Accreditation Task Force to increase collaboration, eliminate duplication of efforts, and to help locals better understand available federal resources.

1.11 Continuing to Evolve the Levee Analysis and Mapping Approach

FEMA will continue to work on longer term levee issues. As this work continues, FEMA will periodically issue operating guidance and standards to document updates and improvements to the approach for analyzing and mapping of non-accredited levee systems. These materials will provide the communities, levee owners, and local project sponsors with a clearer idea of how their participation will be accommodated in the new process. In addition, with the passage of the *Biggert-Waters Flood Insurance Reform Act of 2012* and the long-term conclusions and recommendations from the NAS Report, information and guidance will continue to emerge that likely will affect FEMA's approach to analyzing and mapping levee systems.

Section 2. FEMA Levee Evaluation and Mapping Procedures during Flood Studies

To prepare FIRMs that identify the flood hazards in a community, FEMA conducts a flood hazard study, referred to as an FIS. The FIRM and accompanying report that result from the performance of an FIS are referred to as *Regulatory Products*. This section provides an overview of the FIS engineering and mapping process, which results in the development of flood hazard identification of the 1-percent-annual-chance flood. The 1-percent-annual-chance flood, also referred to as the base flood, is the basis for the flood insurance and floodplain management zones designated on FIRMs. As the definition suggests, the base flood has a 1-percent chance of being equaled or exceeded in any given year. The 1-percent-annual-chance flood is the national standard used by the NFIP for the purposes of requiring the purchase of flood insurance and regulating new development.

Detailed information on the FIS engineering and mapping process is provided in Volume 1 of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA, 2003b); in Section 1 of FEMA's *Document Control Procedures Manual* (FEMA, 2006); and in *Appeals, Revisions, and Amendments to National Flood Insurance Program Maps: A Guide for Community Officials* (FEMA, 2009d).

When appropriate as part of an FIS, FEMA evaluates data and documentation provided by the community, Tribe, levee owner, and/or local project sponsor for local levee systems to determine whether the levee systems meet the NFIP regulatory requirements of 44CFR65.10. Based on the supplied data and documentation, FEMA maps flood hazards in areas landward of the levee.

2.1 How the Flood Insurance Study Engineering and Mapping Process Works

In conducting an FIS, FEMA considers all available information. The information considered can include statistical analyses of river flow; storm surge and rainfall records; information obtained through consultation with the community; topographic and bathymetric data; surveys; and hydrologic and hydraulic analyses.

FEMA presents the results of an FIS on a FIRM and in an accompanying FIS report. The FIRM presents the occurrence or existence of the flood hazard, including flood insurance zones, flood elevations and/or flood depths, 1-percent-annual-chance floodplain boundaries, regulatory floodways, and some flood hazard reduction structures as appropriate (e.g., levees, dams); roads; culverts; and other information.

The FIS report consists of a variety of text, graphic, and tabular information, including Flood Profiles, Floodway Data Tables, summaries of storm surge elevations, summaries of flood

discharges, and descriptions of flood sources and prior flooding. The FIS report describes floodprone areas along rivers and streams, along coastal areas and lakeshores, and/or in shallow flooding areas.

FEMA employs scientifically and technically appropriate analytical methods in performing FISs. FEMA uses engineering practices that meet professional standards and result in accurate flood hazard information being shown on the FIRM and in the FIS report.

Throughout the FIS engineering and mapping process, FEMA works closely with community and Tribal officials to describe technical and administrative procedures and to obtain input. FEMA holds meetings with community officials, Tribal officials, and citizens to provide opportunities, both formal and informal, to review and comment on FEMA study findings.

Once the engineering analysis effort is complete, FEMA provides the community with preliminary versions of the FIRM and FIS report to review. After a review and comment period, FEMA conducts a formal meeting with community and Tribal officials —the Consultation Coordination Officer (CCO) meeting—to discuss the results of the FIS and to review the information shown on the preliminary version of the FIRM and FIS report. FEMA and the community and Tribal officials may also conduct Open Houses where the general public can learn more about the study outcomes and provide comments on the preliminary versions of the FIRM and FIS report.

Throughout the FIS engineering and mapping process, FEMA provides community and Tribal officials and citizens with multiple opportunities to review and comment on FEMA study findings.

By statute, FEMA provides a 90-day appeal period whenever new or modified flood elevation determinations or the designation of areas as having SFHA are proposed[6]. During the appeal period, community and Tribal officials and affected property owners have the opportunity to submit technical and/or scientific data to appeal the proposed flood hazard identification and associated determinations. FEMA also accepts comments on the base map features (e.g., road names, road configurations, corporate limits) shown on the FIRM, within the 90-day appeal period.

When the 90-day appeal period is complete and FEMA has addressed all appeals and other comments submitted during that period, FEMA sends a Letter of Final Determination (LFD) to the community Chief Executive Officer (CEO) and floodplain administrator (FPA) to finalize the FIRM and FIS report. FEMA then proceeds with publication and distribution of the new or revised FIRM and FIS report. The FIRM and FIS report become effective 6 months after the LFD date. Communities have 6 months from the LFD date to adopt the FIRM and remain eligible for participation in the NFIP.

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[6] *National Flood Insurance Act of 1968*, as amended 42 U.S.C. 4104. Biggert-*Waters Flood Insurance Reform Act* of 2012 amended Section 1363 of the NFIA (42 U.S.C. 4104) by including designations of SFHA as an appeal right. See P.L. 112-141(July 6, 2012), Section 100217. See also 44 CFR Part 67.

The CEO is the community or Tribal official who has the authority to implement and administer laws, ordinances, and regulations for the community or participating Tribe. The FPA is the community or Tribal official who is responsible for implementing and enforcing floodplain management measures and for monitoring floodplain development.

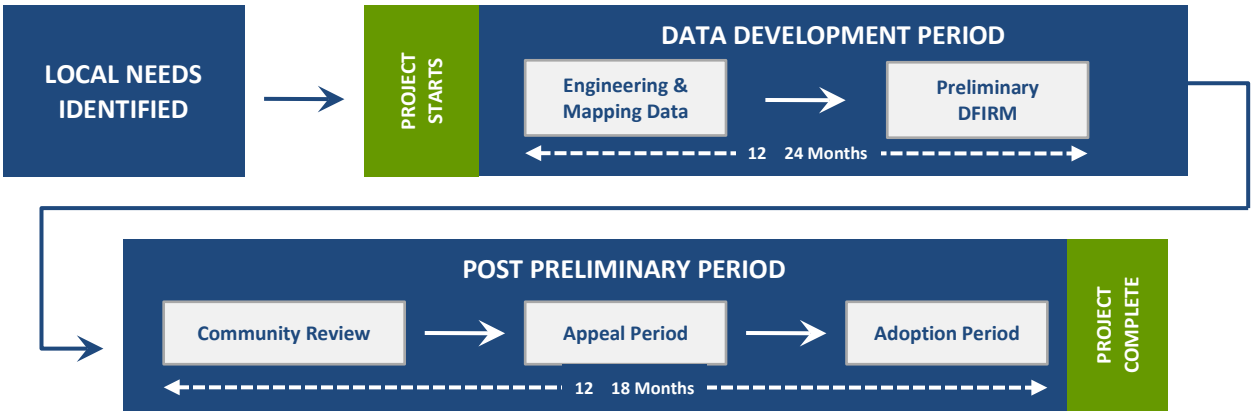

Figure 2-1. Overview of FIS Engineering and Mapping Process

2.2 Levee Evaluations during Flood Insurance Study Engineering and Mapping Process

Levees are typically earthen embankments or floodwalls that are designed to contain, control, or divert floodwaters. Furthermore, levees are generally long linear structures which are part of an overall flood-control system that may include a variety of elements, such as pump stations, floodwalls, closure devices (e.g., gates) and other drainage devices (e.g., weirs or flumes). Levee systems should be considered as chains that are only as strong as the weakest link. Therefore, during the FIS engineering and mapping process, FEMA reviews data to determine if a levee system can meet NFIP accreditation requirements.

The accreditation requirements that a levee system must meet are documented in 44CFR65.10. These requirements include such elements as freeboard, closures, embankment protection, stability, settlement, interior drainage, and operation plans and maintenance. 44CFR65.10 is provided in Appendix D of this document. It is the community's, Tribe's, levee owner's, and/or local project sponsor's responsibility to submit the data, documentation, and analyses outlined in 44CFR65.10 for FEMA accreditation of a levee system.

FEMA's role is to evaluate the information presented by the community, Tribe, levee owner, and/or local project sponsor documenting that a levee system meets the criteria in 44CFR65.10. FEMA's evaluation is used to establish appropriate flood insurance zones on the FIRM. FEMA's review does not constitute a determination as to how a structure or system will perform during an actual flood.

2.3 Former and New Levee Analysis and Mapping Approaches

Under the former "without levee" levee analysis and mapping approach, which was in effect before March 2011, when FEMA determined that a levee system could not be accredited, FEMA mapped or

represented the flood hazards in areas landward of the levee as if the levee system did not provide any hazard reduction capability during the 1-percent-annual-chance flood. The "without levee" approach is discussed in detail in Appendix C of this document.

To provide more refined flood hazard information on the FIRM in areas where levee systems are not accredited, FEMA is replacing the "without levee" approach with an approach that is made up of a suite of procedures that are technically sound, understandable to stakeholders, and cost-effective. The new suite of procedures—Sound Reach Procedure, Freeboard Deficient Procedure, Overtopping Procedure, Structural-Based Inundation Procedure, and Natural Valley Procedure—will better meet the needs of community and Tribal officials and citizens nationwide. The new procedures will not replace the need for levee owners or the associated community and/or Tribal officials to remain engaged in flood risk management activities or change the existing requirements for them to provide the required levee accreditation data and documentation as outlined in 44CFR65.10.

Additional information on the new levee analysis and mapping approach is provided in Sections 3 and 4 of this document. Section 3 provides an overview of the new levee analysis and mapping process, including the expanded data collection and stakeholder engagement effort, as documented in flowchart form (Figure 3-1). Section 4 provides detailed information on the new technical procedures.

Section 3. Overview of New Levee Analysis and Mapping Process

3.1 Introduction

This section discusses the new process to categorize a levee system, collect needed data, and engage more extensively with and involve community and Tribal officials, levee owners, and other levee stakeholders.

The flowchart in Figure 3-1 provides an overview of the new levee analysis and mapping process. To explain the steps outlined in Figure 3-1, identification numbers have been assigned to the summaries and the figure elements. The elements in gray boxes are process steps that have not changed. As indicated in Subsection 1.6 of this document, Elements 110, 120, and 500 were not within the scope of this project as they concern accredited levee systems and levee systems that are new construction projects that have made adequate progress toward completion, are being restored, or are PAL systems. The elements in blue boxes (Elements 200, 300, 400, 410, 420, 600, 610, 620, 630, 640, and 650) are process steps that are new.

This section of the document addresses Elements 10 through 400 and 700 in Figure 3-1. Section 4 describes the technical procedures, identified as Elements 610 through 650 in Figure 3-1: Sound Reach Procedure, Freeboard Deficient Procedure, Overtopping Procedure, Structural-Based Inundation Procedure, and Natural Valley Procedure.

An important part of the levee analysis and mapping process is engagement with, and involvement from community and Tribal officials, levee owners, and other levee stakeholders.

3.2 Project Includes Potential Levees (Figure 3-1, Element 10)

When an FIS is initiated for FEMA that includes levees, FEMA determines whether the levees were designed for flood control purposes by coordinating with the community, reviewing available levee documentation, and verifying that the levee system has an identified levee owner or local project sponsor (Figure 3-1, Element 20) and is operated and maintained. In making a determination about the structure, FEMA will consider the definitions for flood protection system, levee, and levee system found in Section 59.1, *Definitions*, of the NFIP regulations (44CFR59.1). The definitions of these terms are also found in Appendix B of this document.

FEMA will not apply the new process to coastal structures. Instead, FEMA will follow the existing modeling and mapping process available on FEMA's website, http://www.fema.gov/national-flood-insurance-program-0/coastal-flood-hazard-mapping-requirements.

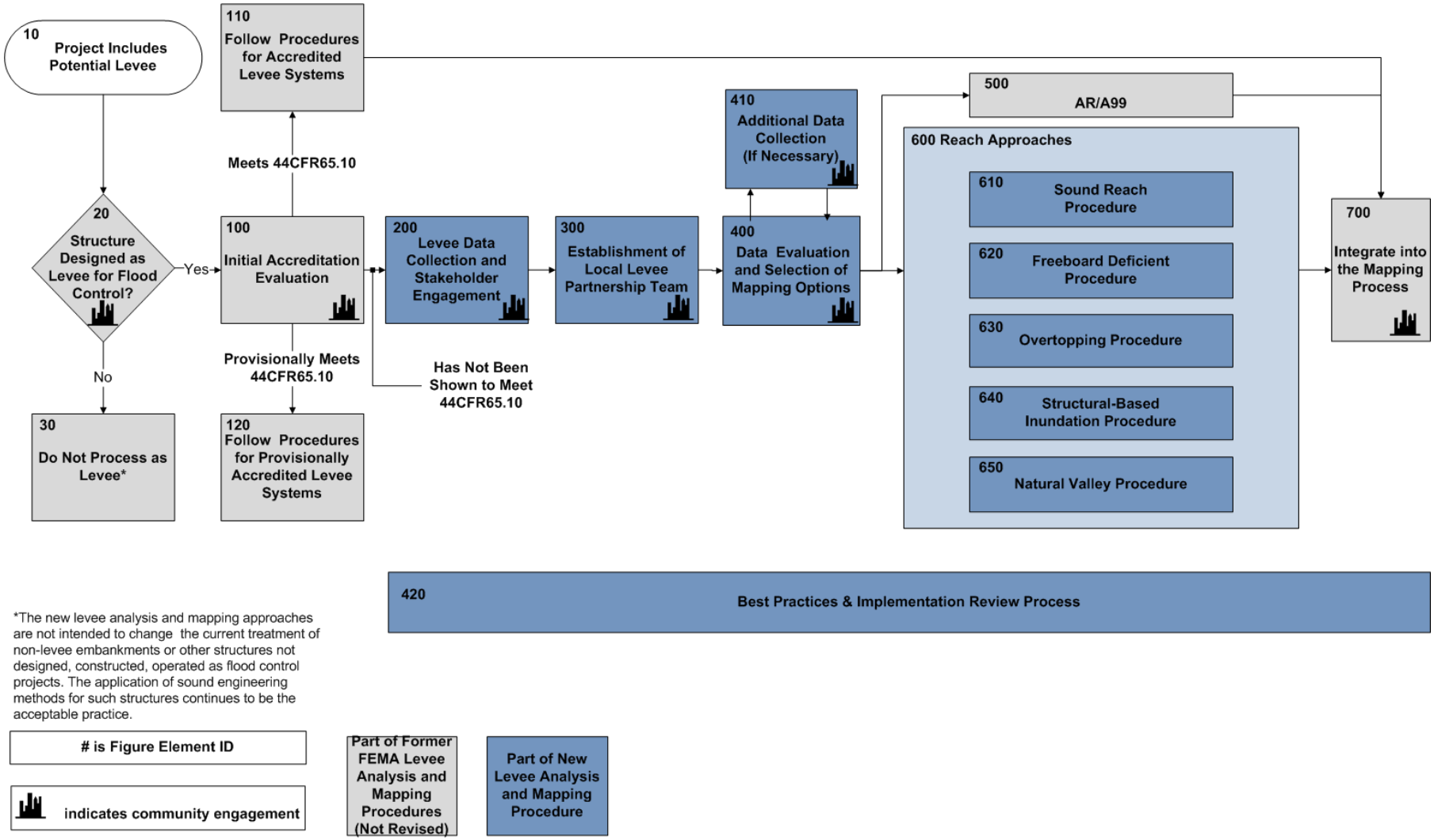

Figure 3-1. New Levee Analysis and Mapping Process

Because flood-control structures have been constructed along our nation's waterways, defining the limits of each individual levee system for accreditation purposes can be complex. To be defined as a levee system for accreditation purposes, the section of the levee must be hydraulically independent of adjacent sections. Two levees or levee reaches are considered hydraulically independent when the areas that are protected by each do not overlap and if one fails (regardless of the failure mode) the area landward of the other is not inundated. If FEMA determines that the structure is not a levee designed for flood control based on the regulatory definition (i.e., it is a road, railroad embankment, or other non-levee embankment), then the analysis proceeds to Figure 3-1, Element 30.

44CFR65.10 provides the minimum design and operation and maintenance standards levee systems must meet and continue to meet in order to be recognized as providing protection from the 1-percent-annual-chance flood on a FIRM. Levee owners must provide appropriate data and documentation to demonstrate the levee is compliant with 44CFR65.10 requirements in order for the levee to be accredited.

3.3 Do Not Process as Levee (Figure 3-1, Element 30)

If FEMA finds that a structure is not a levee designed for flood control, FEMA will not apply the new levee analysis and mapping process. This process is reserved specifically for non-accredited levees and levee systems that do not meet the requirements of 44CFR65.10.

If the levee or levee system is found to meet 44CFR65.10, FEMA will map the structure in accordance with existing procedures for accredited levees and levee systems.

The new process summarized in this section is not intended to be applied to non-levee embankments. The guidance for non-levee embankments documented in PM 51, "Guidance for Mapping of Non-Levee Embankments Previously Identified as Accredited", issued by FEMA on February 27, 2009, is to be followed. Therefore, while FEMA recognizes that non-levee embankments may in certain situations have a mitigating effect on flooding, if a structure is not designed and operated specifically to provide flood control it is not a levee and therefore is not addressed using the new process.

3.4 Initial Accreditation Evaluation (Figure 3-1, Element 100)

As mentioned in Subsection 1.6 of this document, the new levee analysis and mapping process does not change the requirements of 44CFR65.10. If the entire levee system is found to meet the requirements of 44CFR65.10, FEMA maps the levee system as accredited, using existing procedures as defined in Appendix H of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA, 2003a) and in PMs that FEMA has issued to clarify the requirements in Appendix H. Interested parties may access all procedural requirements, including Appendix H and these supporting PMs, from dedicated pages on the FEMA website. These analyses are to be based on current conditions for the levee hydrology and hydraulics.

FEMA will provide technical guidance and review of submittals to determine if levee certification requirements meet the requirements of 44CFR65.10 and will work with stakeholders for those unique situations where flood-control structures involve a combination of canals and levees. FEMA

will not fund activities related to certification/accreditation; however, FEMA may, in some situations, elect to support a community's efforts to gather additional data for flood hazard analysis and mapping activities.

When evaluating a levee system that does not meet the freeboard requirements in 44CFR65.10 (normally 3 feet), if requested by the community, FEMA will provide technical guidance to the levee owner and community/Tribal officials assessing whether the levee system meets the freeboard exception criteria in 44CFR65.10.

If the levee system has at least 2 feet of freeboard, the first step in addressing a freeboard-deficient levee system is to pursue the reduced riverine freeboard exception cited at 44CFR65.10(b)(1)(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.*

Often the approach for evaluating the uncertainty in the estimated BFE profile is the risk-based analysis procedure developed by the USACE after the publication of 44CFR65.10. The USACE risk-based approach considers the combined uncertainty in the discharge-frequency and stage-discharge relations. The role of the USACE risk-based procedure in the certification of levee systems for the NFIP is described in USACE Engineer Circular 1110-2-6067, *Engineering and Design: USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation* (USACE, 2010a).

Another approach to address the "assessment of statistical confidence limits of the 100-year discharge" that is stated in 44CFR65.10(b)(1)(ii), an analysis of the Base Flood Elevation (BFE) resulting from the lesser of the upper 5-percent confidence limit of the 1-percent-annual-chance flood discharge or the 500-year flood discharge may be submitted to support the request for freeboard exception. FEMA will recommend the use of the Interagency Advisory Committee on Water Data (IACWD) Bulletin 17B, "Guidelines for Determining Flood Flow Frequency" (IACWD, 1982), where appropriate to establish confidence limits. In addition, the community, Tribe, levee owner, and/or local project sponsor must provide an evaluation of the uncertainty in the stage-discharge relation by considering the potential and magnitude of debris, sediment, and ice accumulation as specified in 44CFR65.10. The community, Tribe, levee owner, and/or local project sponsor or other party must provide data and documentation to FEMA to show that the levee will remain structurally stable with these additional loading considerations.

All other requirements of 44CFR65.10 must also be met.

3.5 Follow Procedures for Accredited Levees (Figure 3-1, Element 110)

For levee systems that can be accredited, FEMA follows existing analysis and mapping procedures, as cited in Subsection 3.4.

3.6 Follow Procedures for Provisionally Accredited Levees (Figure 3-1, Element 120)

As mentioned in Subsection 1.6 of this document, the previously established FEMA procedures for PAL systems will not change. FEMA will follow the process and procedures documented in the following FEMA PMs regarding the mapping of PAL systems:

- PM 43, "Guidelines for Identifying Provisionally Accredited Levees" (FEMA, 2007);
- PM 45, "Revisions to Accredited Levee and Provisionally Accredited Levee Notation" (FEMA, 2008); and
- PM 53, "Guidance for Notification and Mapping of Expiring Provisionally Accredited Levee Designations" (FEMA, 2009b).

FEMA will then integrate the appropriate flood hazard information for PAL systems into the FIRM, FIS report, and related products (Figure 3-1, Element 700). FEMA will not extend the PAL expiration dates that have been established in writing with the community, Tribe, levee owner, and/or local project sponsor. The new process described in this document will apply if a PAL agreement expires and the levee is non-accredited.

3.7 Levee Data Collection and Stakeholder Engagement (Figure 3-1, Element 200)

FEMA is NOT changing the PAL process or related requirements. FEMA will NOT extend the PAL expiration dates that have already been established.

Once FEMA determines that an identified levee system does not meet the requirements of 44CFR65.10, FEMA will make additional efforts to gather data and documentation and to engage levee stakeholders. This process provides FEMA and levee stakeholders with a more comprehensive and holistic understanding of the data available.

Communities will be given the opportunity to provide data and FEMA will use any additional data or documentation collected during this process to refine the levee analysis and mapping approach. FEMA will consider community input when deciding how to apply the new levee analysis and mapping process.

This stakeholder engagement effort is designed to increase FEMA's understanding of local conditions and allow FEMA to determine the appropriate analysis and mapping procedures for the flood hazard in the areas landward of the non-accredited levee systems.

An overview of the levee data collection and stakeholder engagement process is illustrated in Figure 3-2.

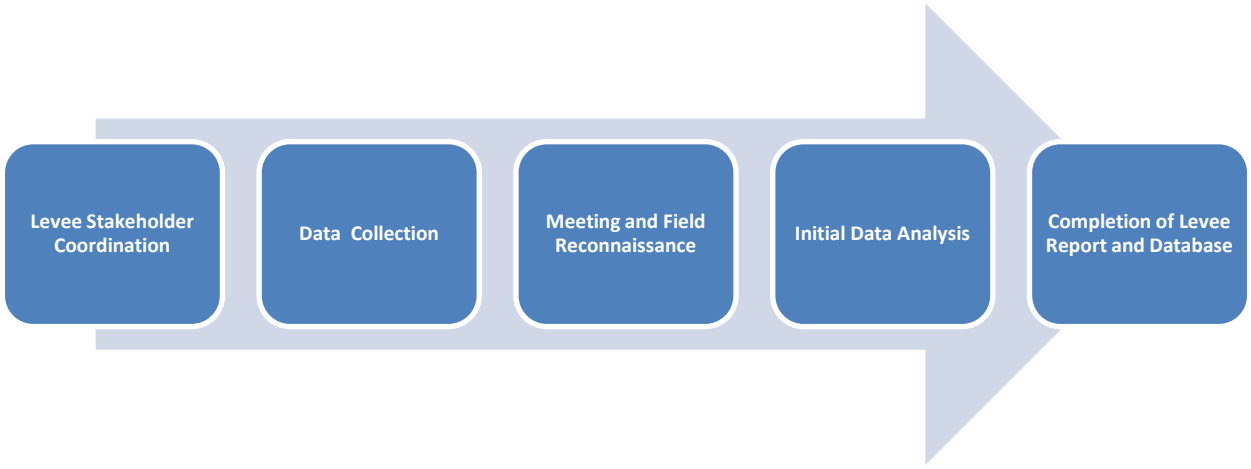

Figure 3-2. Levee Data Collection and Stakeholder Engagement Process

The initial levee stakeholder coordination and data collection steps will be required for all non-accredited levee systems. In some instances, the results of these data collection efforts may indicate that the data and documentation already collected are adequate and are sufficient to make a decision on potential analysis and mapping procedures. Where applicable, such a decision will be made by FEMA with input from the LLPT. The primary function of the LLPT will be to provide feedback, additional data, and options on levee reach selection for the system. Additional information on the LLPT is provided in Subsection 3.8. Thereafter, FEMA, through coordination with community officials, Tribal officials, levee owner(s), and/or local project sponsor(s), will proceed with modeling the levee system and mapping the flood hazards in areas landward of the levee system (Figure 3-1, Elements 500 and 600).

3.7.1 Levee Stakeholder Coordination

FEMA will coordinate with levee stakeholders to collect levee-related data and other community or Tribal information to help streamline and facilitate a meeting with stakeholders. This upfront coordination may take the form of conference calls, Web-based meetings, or other means of two-way communication. The types of levee stakeholders engaged in a levee-related project may vary by State or Region, but may include local community and Tribal officials and agencies; local economic development organizations or environmental groups; members of the local engineering community; State and regional representatives; and USACE and other Federal agencies.

3.7.2 Data Collection

FEMA will obtain available supporting data and documentation for the levee system elements from levee system owners; levee system operators; State and Federal agencies; local agencies; private individuals or corporations; FEMA data repository and online services; and USACE, including their National Levee Database (NLD). Some of this data collection may be performed prior to an initial meeting with levee stakeholders. This data collection effort before the meeting will help FEMA facilitate and encourage substantive discussion during the meeting. In addition, FEMA will obtain

available supporting documentation regarding historical performance of the levee, considering both successful performance and unsuccessful performance issues.

Data collection efforts will vary based on the potential uniqueness of each area landward of the levee. FEMA will work with different stakeholders in an effort to obtain supporting data and documentation. FEMA will not fund any efforts related to certifying data for levee accreditation or making determinations of the levee's structural conditions. FEMA will make the data and documentation available to those who request it. Levee owners may choose to perform additional data collection activities, but must do so at their own expense.

If, during the data collection effort, information is provided substantiating that the levee system may be accredited, FEMA will reconsider the accreditation determination discussed in Subsection 3.4.

3.7.3 Meeting and Field Reconnaissance

FEMA will invite levee stakeholders to the in-person meeting(s). The objectives of the in-person meeting(s) with levee stakeholders are to:

- Emphasize that the change in the mapping approach has shifted from a one-size-fits-all modeling technique, where levee stakeholders were minimally involved, to a process with a variety of options, where the stakeholders are actively engaged in the process.
- Emphasize that the goal of the levee mapping project is to apply the procedure that best reflects the flood hazard in the area landward of the levee based on available resources, data, and community needs.
- Review the available data on the levee system, confirm whether the data are accurate, and obtain stakeholders' perspectives about their flood hazards. This will help determine the appropriate procedure for modeling the levee system.
- Emphasize the importance of the stakeholders' responsibility in providing necessary data and keeping the public informed of flood hazards and the relevance of those hazards.
- Discuss the floodplain management and flood insurance implications of the use of Zone D, which is explained in detail in Appendix E of this document.
- Discuss the potential makeup of an LLPT, which is explained in Subsection 3.8.

At meetings with levee stakeholders, FEMA will explain the levee analysis and mapping approach, articulate project goals, review available data, and emphasize stakeholders' responsibility to keep the public informed about flood risks.

If requested by the levee owner or the community, FEMA may conduct a field reconnaissance of the levee system after the in-person meeting in some situations. The field reconnaissance effort may be a drive along the levee system or a walk on top of the system to view locations discussed during the in-person meeting. The type and level of field reconnaissance will depend on project needs and available resources.

The field reconnaissance is not an inspection or an attempt by FEMA to make technical conclusions on the quality or substance of the levee system. Its primary purpose is to gain a better understanding of the levee system to allow FEMA to best reflect the flood hazard information on the FIRM in areas landward of the levee. FEMA analyses for flood hazard mapping do not reflect the performance, reliability, or overall safety of a levee system and are only used to identify flood hazards associated with the levee system for NFIP purposes.

3.7.4 Initial Data Analysis

FEMA will carefully analyze the data and documentation obtained during the data collection effort to prepare for the LLPT. By performing this data review, FEMA will be prepared for specific discussions with the LLPT about levee system characteristics, modeling procedures available, flood hazards, flood hazard communications, and outreach.

During the data analysis stage, FEMA, through its mapping partners and contractors, may perform a limited data analysis of the levee system to develop baseline estimates and expected ranges of the SFHA extent and depth. The limited data analysis may include a Natural Valley analysis (described in Subsection 4.2.6 of this document), an evaluation of levee crest elevations, or the use of previously developed preliminary flood hazard zone boundaries. Any Structural-Based Inundation Procedure data that FEMA developed also may be included. FEMA will perform the analysis using readily available data, such as topographic data from the U.S. Geological Survey (USGS) National Elevation Dataset or more detailed data from the community.

FEMA will develop the Natural Valley Procedure elevations either by preparing approximate hydraulic models with the effective hydrologic study, by extending the existing flood elevations landward of the levee, or by mapping the levee crest elevation landward of the levee. FEMA will present these for discussion purposes only and will clearly inform the levee stakeholders that the final SFHA may not exactly match this "rough" flood hazard zone delineation.

During this phase, FEMA will select depth profile locations to communicate the variability in expected depths resulting from the various procedures as shown in Figure 3-3. This initial, quick analysis will provide the LLPT with an early indication of what the results from various types of analyses might provide and some indication of which procedures could most effectively depict the flood hazard.

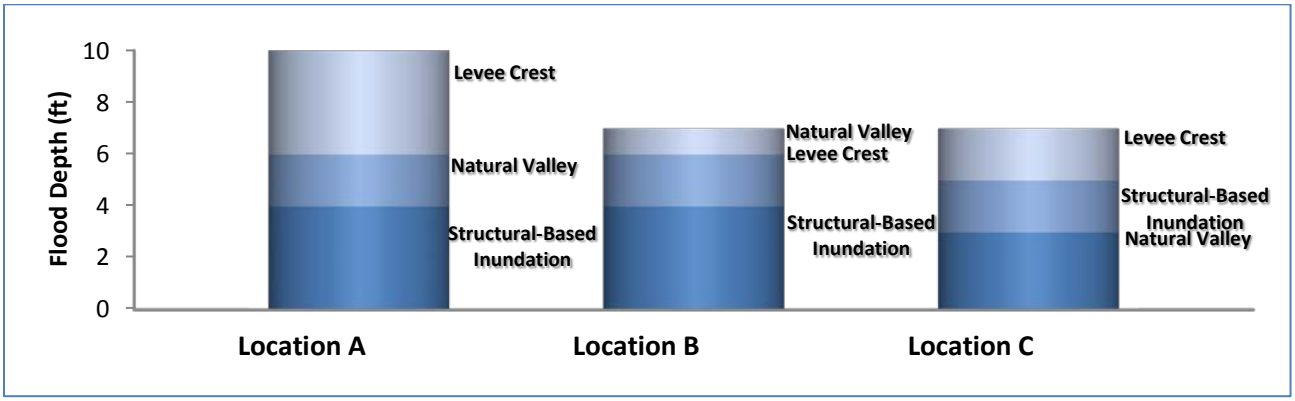

Figure 3-3. Hypothetical Results for Initial Data Analysis

FEMA will summarize the findings of the data collection and analysis effort in a draft report, database, and maps. FEMA will use the draft report and maps to aid discussions of the data and provide the levee stakeholders with an overview of levee-related data and other known available data.

3.7.5 Completion of Data Collection and Stakeholder Engagement Report and Database

FEMA will finalize a report and a database at the conclusion of the data collection and stakeholder engagement process. The report will include a section listing the data collected, when they were received, data type, and data source. This section will discuss any data that FEMA expects to receive from levee stakeholders, projected timeframe for receipt of the data, and whether funding is available to assist in the development of the data. The report will also identify potential stakeholders that could participate in the LLPT and a preliminary estimate of the expected levee reaches for the system. (The procedures used to identify levee reaches are discussed in Subsection 4.2.1 of this document.) In addition to the report, FEMA will catalogue the data collected in alignment with the database structure used for the NLD.

FEMA will provide the final version of the report and database to the levee stakeholders with whom FEMA coordinated during the process. FEMA also will provide the final version to the partners of the LLPT and make it publically available.

3.8 Establishment of Local Levee Partnership Team (Figure 3-1, Element 300)

FEMA will facilitate a LLPT when appropriate. There will be flexibility in how meeting(s) are executed including either in-person or by phone, depending on the complexity and need. FEMA or one of its representatives will participate and act as the group facilitator. FEMA will not provide funds to communities and stakeholders to cover the cost of their participation in a LLPT.

The primary function of the LLPT will be to provide feedback, additional data, and other input. FEMA's role will be to listen and gather the necessary information to effectively analyze and map the flood hazards in the area landward of the levee. The other partners will provide input on local conditions and situations. This engagement will enable FEMA to make a better-informed final decision, using local input on how the levee system will be analyzed and how the flood hazards in the area landward of the levee will be mapped.

One tool that will be used during the LLPT will be the USACE Levee Screening Tool. This process developed by the USACE combines inspection data with a preliminary engineering assessment. The tool may be utilized by the LLPT to help understand the level of risk behind the levee system and therefore the appropriate level of mapping and as a way for FEMA to nationally have a better understanding of the levels of risk behind non-accredited levees.

The makeup of the LLPT will be identified for invitation by FEMA in coordination with community and/or Tribal officials. The following are examples of individuals who could be invited to participate in the LLPT:

- Community CEO or designee (individual with decision-making authority - if not the CEO);
- Community Floodplain Administrator (FPA);

- Regional or State NFIP Coordinator;
- Levee owner (if levee is not owned by community);
- CEO or designee of participating Tribe (individual with decision-making authority);
- Local engineer/technical representative;
- FEMA Regional Office representative;
- USACE or other Federal agency representatives that could provide additional input;
- Mapping partner or contractor that is supporting FEMA in the mapping effort;
- Cooperating Technical Partner representative(s), if a regional entity or State agency other than the community has the interest and capability to be actively involved in the project; and
- Others as determined by the community and FEMA Regional Office representative.

The formation of the LLPT will begin during the levee data collection and stakeholder engagement process. FEMA will facilitate the LLPT as needed, while FEMA will ultimately make a final decision on the scope, analysis, and mapping procedures. The LLPT will provide options, and a consensus is not required; however, reasonable and valid inputs identified or provided by the group will be documented. Once the LLPT identified data and options its objectives will have been met, and the LLPT will cease formation.

3.9 Data Evaluation and Selection of Mapping Options (Figure 3-1, Element 400)

The LLPT will provide FEMA with data and inputs that will be used to select and apply the appropriate procedure to analyze and map the levee system(s) being considered. The process of selecting the procedure and modeling will be open and transparent to stakeholders. FEMA will develop additional details of this process, including recommended guidelines on a schedule acceptable to stakeholders. These details will be provided as part of FEMA operating guidance.

The new levee analysis and mapping procedures are intended and designed to be flexible, to address each situation. As discussed in Subsection 3.7, one tool that FEMA will use to assist in the initial evaluation will be rough estimates of natural valley floodplains. This information can provide an initial sense of where flooding may occur landward of the levee system. If other information is available, such as a rough estimate of a levee breach analysis/map, FEMA will also use that information. Some examples of key considerations in selecting the appropriate levee analysis and mapping procedure are as follows:

- Levee system characteristics;
- Data availability;
- 44CFR65.10 deficiency type;
- Length/size of the levee system and/or levee reach;
- Levee crest profile vs. BFEs;
- Levee performance history;
- Accreditation status of levee system on current NFIP maps;
- Flooding characteristics;

- Contributing drainage area;
- Terrain data;
- Population consequence, risk and population information; and
- Community, Tribe, levee owner, and/or local project sponsor willingness to contribute data or analyses.

FEMA may discover that a restoration project for the levee system is underway through coordination with State, community, or Tribal officials; levee owners; and/or USACE and other Federal agencies. As discussed in Subsection 1.6 of this document, FEMA has not revised the regulatory requirements provided in 44CFR61.12 for new construction projects that have made adequate progress toward completion nor the regulatory requirements provided in 44CFR65.14 for de-accredited levee systems that are being restored to 1-percent-annual-chance or greater flood hazard-reduction capability (Figure 3-1, Element 500).

3.10 Additional Data Collection (if Necessary) (Figure 3-1, Element 410)

During the data collection and stakeholder engagement process, FEMA may identify the need for additional data. When reasonable, FEMA will adjust the project schedule to include this activity. An important consideration will be how the levee analysis and mapping portion of a study impacts the overall study schedule. This additional data activity will not be used to delay a study awaiting the data necessary to meet 44CFR65.10 certification and accreditation requirements.

3.11 Best Practices and Implementation Review (Figure 3-1, Element 420)

The new levee analysis and mapping process is an improved way to address how levee systems are analyzed and how the resulting flood hazard information is presented on FIRMs. To meet the challenge of providing local flexibility while maintaining a uniform and equitable national approach, FEMA will institute a Best Practices and Implementation Review on an ongoing basis. There will be initial pilot projects of a small sample of studies throughout the nation. These pilot studies will provide input on best practices. FEMA will tailor its existing production and monitoring infrastructure to meet this new process.

FEMA will integrate the Best Practices and Implementation Review into the existing FIS engineering and mapping process to periodically update guidance as needed. This will include using feedback from appropriate subject matter experts and stakeholders.

FEMA will generate fact sheets and other outreach and training materials, including additional information on the relationship between the levee Zone D classification and NFIP regulations (discussed in Appendix E of this document). FEMA will also provide operating guidance to assist stakeholders with implementation of these new processes.

3.12 Integrate Into the Mapping Process (Figure 3-1, Element 700)

FEMA will incorporate the results of the engineering analyses into the affected regulatory products (i.e., FIRM panels, FIS report materials) as well as “non-regulatory products” that are required if a project is funded by FEMA under the Risk Mapping, Assessment, and Planning (Risk MAP)

program. Professional engineering judgment will continue to be an important element in these revised analyses and mapping. However, input from the community and the LLPT will provide additional input to FEMA and the mapping partners that are conducting the studies. In the event that a stakeholder disagrees with the final analysis and mapping procedures used to create the FIRM (Subsection 3.9), the current FEMA appeals and Scientific Resolution Panel procedures may be used. These procedures are documented in PM 58, "Implementing the Scientific Resolution Panel Process" (FEMA, 2010b).

Section 4. Levee Analysis and Mapping Technical Procedures

Until March 2011, FEMA used a single method to model and map the SFHA for non-accredited levee systems. FEMA is replacing this former "without levee" levee analysis and mapping procedure with five technical procedures described in this section. Through the early phases of the new levee analysis and mapping process, described in Section 3 of this document, FEMA has added stakeholder engagement and coordination steps to gather data and input from levee stakeholders and to develop a situation-specific procedure for each levee system.

For each system, three major components will be layered together to develop the final flood hazard information to be presented on the FIRM.

The first major component will be the flood hazards evaluated at the system level. This includes a Zone D flood hazard determined using a natural valley analysis, discussed in Subsection 4.2.6, for the entire levee system. The delineated Zone D area reflects the possible 1-percent-annual-chance flood hazard that exists because the levee system is not accredited, and is intended to communicate the uncertainty of the prediction of the potential flood hazards associated with levee systems. Layered on top of the Zone D area, also evaluated at the system level, will be any SFHA associated with interior drainage elements.

The second major component will be based on the concept of dividing the levee system into reaches to develop more refined assessments of the flood hazard associated with the individual levee reaches within a levee system. The SFHAs resulting from the analysis of individual levee reaches will be superimposed on each other to create a composite delineation that represents the flood hazard associated with the entire system as a whole. Therefore, the flood elevations on this layer are not necessarily associated with one mode of failure at a particular location.

The third major component will be based on the evaluation of the flood hazard on the flooding source side of the levee system. This will be modeled assuming the levee system remains in place, referred to as the "with levee" approach in Appendix H of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA, 2003a). The final landward layer shown on the FIRM often may consist of a Zone D area on the landside of the levee resulting from the system-wide natural valley analysis and the SFHA based upon the combination of flooding results from each independently analyzed reach, any interior drainage flooding of the system and ponding against the landside of the levee. The flooding source side will have SFHA and flood elevations from the "with levee" analysis.

4.1 Flood Hazards Evaluated at the System Level

4.1.1 Reflecting the Possible Flood Hazard of a Non-Accredited Levee System

For areas that fall within the natural valley floodplain of the levee system, but are not designated as an SFHA, the Zone D designation will be used to reflect the possible 1-percent–annual-chance flood hazard that exists because the levee system is not accredited. This area will be determined using the Natural Valley Procedure, discussed in Subsection 4.2.6. This is similar to the process used to

determine the Zone X (shaded) areas for accredited levee systems. The Zone D designation is used for non-accredited systems instead of the Zone X (shaded) designation because the flood hazard potential is higher and more uncertain than with accredited levee systems. As mentioned earlier in this document, Zone D is used by FEMA to designate areas with possible, but undetermined, flood hazards. Properties in Zone D areas are not subject to the Federal mandatory flood insurance purchase requirement. Further detailed discussion of Zone D is included in Appendix E of this document. If there are levee systems on both sides of a flooding source, or multiple systems that overlap, the extent of the Zone D area for each system will be analyzed independently assuming the other systems remain in place.

4.1.2 Special Flood Hazard Area Resulting from Interior Drainage Flooding

For non-accredited levee systems, the adequacy of the interior drainage systems will be evaluated and an SFHA will be mapped for the 1-percent-annual-chance flood in these locations. Interior drainage systems associated with levee systems usually include storage areas, gravity outlets, pumping stations, contributing water courses, or a combination thereof. The interior drainage will be analyzed assuming that all sections of the levee and associated structures will remain intact in their current condition and the components of the drainage system function as designed and planned.

The level of effort required for the analysis of the interior drainage systems will depend on the procedure chosen for the levee reaches within the system. Engineering judgment will be used to determine if the interior drainage systems need to be analyzed. The decision to model and map interior drainage will be made by FEMA after consultation with the community, Tribe, levee owner, and/or local project sponsor, and the mapping partners.

If the potential for measurable flooding exists on the landward side of the levee, an interior drainage analysis should be done. If the Natural Valley or Structural-Based Inundation Analysis Procedure is used for the entire system, no additional interior drainage analysis should be required. The extent of the SFHA used to depict this hazard will depend on the depth and type of flooding that occurs.

4.2 Flood Hazards Evaluated at the Reach Level

In addition to the system-wide hazard mapping discussed in Subsection 4.1, the levee system will be divided into levee reaches to develop a more refined evaluation of the flood hazard. If there are levee systems on both sides of a flooding source or multiple systems that overlap, each system will be analyzed independently, assuming the others remain in place, to determine the flood hazards for each levee reach.

4.2.1 Division of Levees into Reaches

A levee reach is defined as any continuous length of a levee system to which a single technical procedure may be applied. There is no minimum or maximum length for a levee reach. The FEMA determination on the procedure to be applied, which will consider inputs made by the LLPT, will be based primarily on available data, hydraulic conditions, community needs, and funding availability. A summary of the data requirements for each procedure is included in Figure 4-1. All engineering data submitted must be signed and sealed by a registered professional engineer. The registered

professional engineer's signature and seal has the same meaning as the certification required in 44CFR65.2 and 44CFR65.10(e).

	Sound	Freeboard Deficient	Overtopping Approach	Structural-Based Inundation	Natural Valley
Elevation Information for the Levee Crest and Toe	Required	Required	Required	Required	–
BFE + Freeboard Less than Levee Crest	Required	–	–	–	–
BFE Less than Levee Crest	Required	Required	–	–	–
Operations and Maintenance Plan	Required	Required	Required	*Recommended*	–
Structural Design Requirements	Required	Required	Required	*Recommended*	–
Inspection Reports	Required	Required	Required	*Recommended*	–
Evaluation of Overtopping Erosion Potential	–	–	Required	–	–

Figure 4-1 .Summary of Levee Reach Data Requirements

It is the responsibility of the community, Tribe, levee owner, and/or local project sponsor to provide the documentation to support the standards in Figure 4-1 for the levee reach if that approach is to be applied.

Analyzing and mapping levee reaches separately allows the final analysis and mapping to better refine the SFHA around those reaches of a levee system that can be shown to provide some level of flood-hazard reduction capability during the 1-percent-annual-chance flood. This subsection details how, under the new levee analysis and mapping procedures, a non-accredited levee system may be divided into multiple reaches, with each levee reach being modeled and mapped separately using one of five procedures:

Under the new levee analysis and mapping approach, a non-accredited levee system may be divided into reaches, with each modeled and mapped separately.

- Sound Reach Procedure;
- Freeboard Deficient Procedure;
- Overtopping Procedure;
- Structural-Based Inundation Procedure; and
- Natural Valley Procedure.

Figure 4-2 shows an example of a levee system that has been divided into reaches.

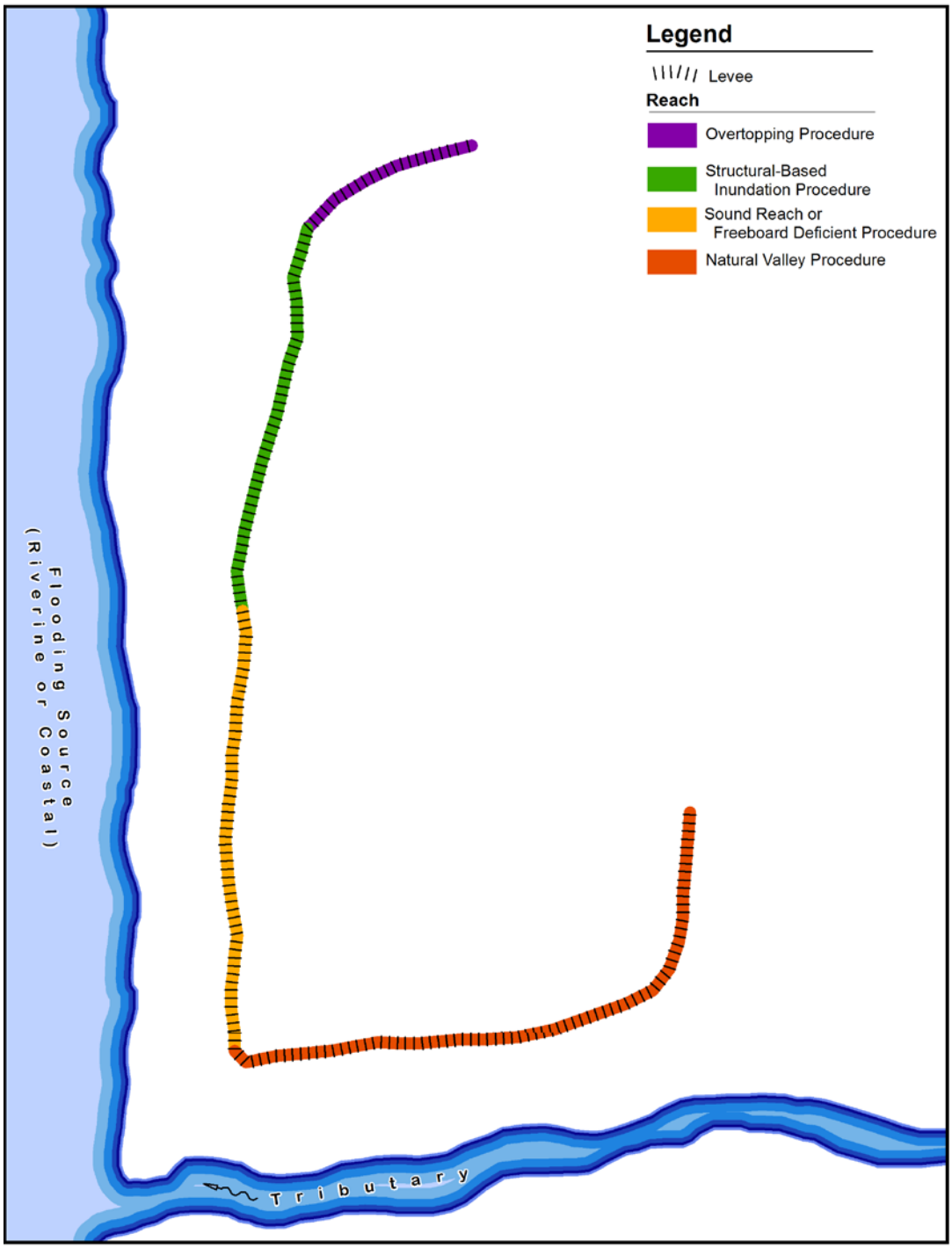

Figure 4-2. Example of Segmentation of a Levee System

Each procedure, except for the Sound Reach Procedure, may be applied at both the system and reach levels. The flooding that results from the analysis of each individual levee reach with all other levee reaches intact, will be merged with that of the flooding that the results from the analyses of the other reaches within the system, along with any interior drainage flooding of the system. Combining the flood hazards from all reaches will result in a final SFHA delineation landward of the levee system. Developing the final SFHA delineation based on the reach division is discussed further in Subsection 4.2.7.

4.2.2 Sound Reach Procedure

A Sound Reach is a levee reach that has been designed, constructed, and maintained, in accordance with sound engineering practices, to withstand and reduce the flood hazards posed by a 1-percent-annual-chance flood. A Sound Reach is beneficial in that it can be modeled assuming it will remain in place and thus its impact will be reflected in the final SFHA. Determining hydraulic independence is discussed in Subsection 3.2 of this document. If the entire system addresses all elements of 44CFR65.10, the current procedures for accredited levee systems will be followed. Figure 4-3 is an illustration of a cross section view of the Sound Reach conditions.

A **Sound Reach** is a levee reach that has been designed, constructed, and maintained, in accordance with sound engineering practices, to withstand and reduce the flood hazards posed by a 1-percent-annual-chance flood.

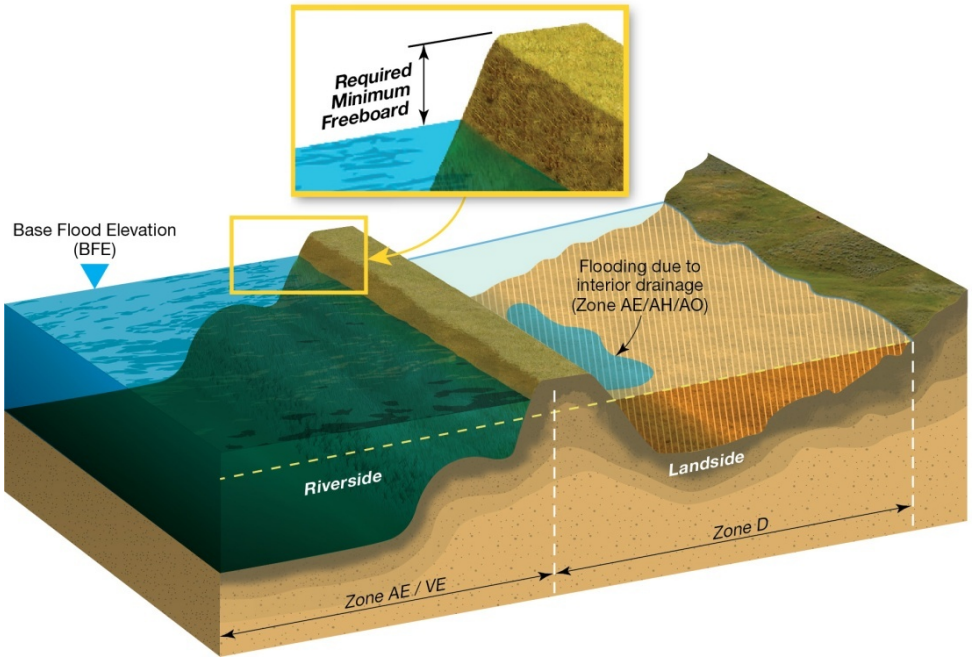

Figure 4-3. Sound Reach Cross Section View

4.2.2.1 Data Requirements

Sound Reaches differ from an accredited levee system because they are part of a levee system that as a whole cannot meet accreditation requirements; because they are only a component of a levee system, they cannot be considered a hydraulically independent system. To designate a levee reach as a Sound Reach, technical data must be provided that demonstrates that the levee reach will withstand the forces of the 1-percent-annual-chance flood, and reasonably account for uncertainty. To accomplish this, documentation to meet the following standards from 44CFR65.10 must be submitted to FEMA:

- *Freeboard*. The levee reach must meet the minimum freeboard standards in 44CFR 65.10(b)(1).
- *Operations and Maintenance Plan*. Details of the operations and maintenance standard are in 44CFR65.10(c).
- *Structural design standards*. Structural design should meet minimum design standards including data regarding closures in 44CFR65 (b)(2), embankment protection in 44CFR65.10(b)(3), embankment and foundation stability in 44CFR65.10(b)(4), settlement in 44CFR65.10(b)(5), and any other design standards as detailed in 44CFR65.10(b)(6). The structural design documentation should also include a discussion if the structural integrity could be affected by the failure of an adjacent levee reach if that adjacent levee reach is not categorized as Sound or Freeboard Deficient.
- *Inspection reports*. The standard for documentation of inspection is in 44CFR65.10(c)(1)(iii) and 44CFR65.10(c)(2)(iv).
- Elevation information for the levee crest and toe
- All items must be signed and sealed by a registered professional engineer.

Sound reaches differ from an accredited levee system because they cannot meet the definition of a hydraulically independent system

FEMA will review the submittal in accordance with the appropriate sections of PM 63 (FEMA, 2010a).

4.2.2.2 Technical Procedures

No levee reach-specific modeling is required for a Sound Reach. However, it is important to note that the SFHAs from the system-wide interior drainage analysis and/or adjacent levee reaches may still be present landward of Sound Reaches as illustrated in Figure 4-3. This will depend on the presence of interior ponding areas and other terrain features on the landward side of the levee.

4.2.3 Freeboard Deficient Procedure

For NFIP purposes, freeboard refers to the vertical distance between the top of the levee and the 1-percent-annual-chance flood elevation. Freeboard requirements are established in acknowledgement of the uncertainty with flood hazards, including analysis uncertainty of both the hydraulic variables

and the flood discharge, blockage of nearby bridge openings, and potential for unforeseen performance or operational issues.

Given the potentially catastrophic consequences of a levee system overtopping and failing, freeboard is an important design standard. For the purposes of the NFIP, in riverine situations, 3feet of freeboard is the minimum requirement with additional freeboard required at transitions and structures. Under certain circumstances, a lower freeboard may be approved with the proper supporting data and analyses, but not less than a minimum of 2 feet. In coastal areas, freeboard for the purposes of the NFIP is 1 foot above the height of the 1-percent-annual-chance wave or the maximum wave runup (whichever is greater).

The difference between a Sound Reach and Freeboard Deficient Reach is that a Freeboard Deficient Reach does not have enough freeboard to meet the freeboard standards outlined in 44CFR65.10. Figure 4-4 is an illustration of a cross section view of the Freeboard Deficient conditions.

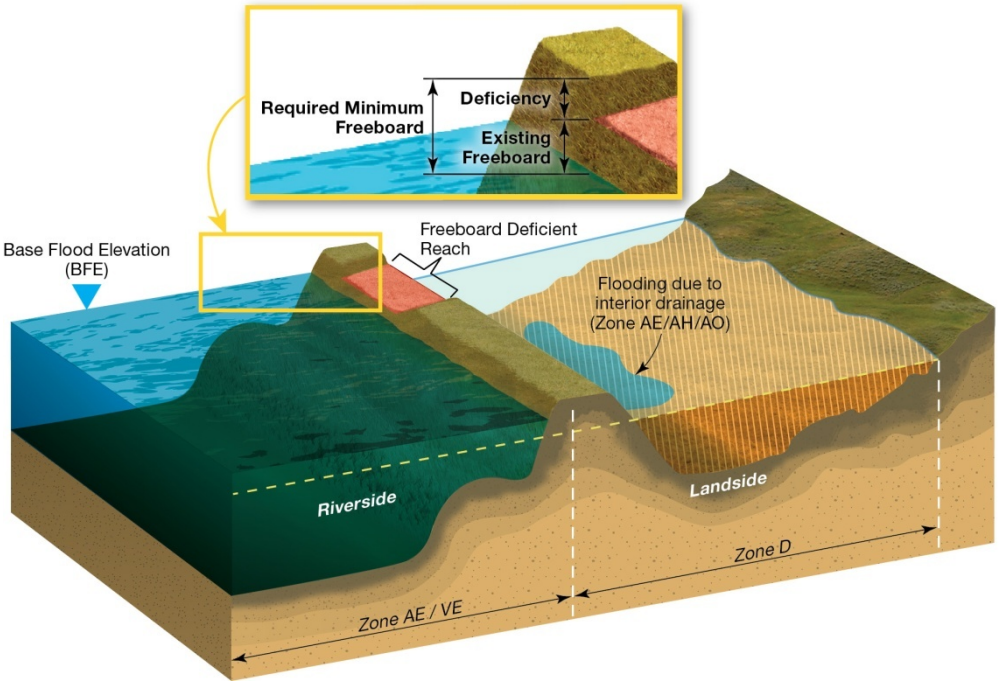

Figure 4-4. Freeboard Deficient Cross Section View

4.2.3.1 Data Requirements

To designate a levee reach as a Freeboard Deficient Reach, documentation to meet the following standards from 44CFR65.10 must be submitted to FEMA:

- The top of the levee crest and closure structures along the entire reach must be above the BFE.
- *Operations and Maintenance Plan*. Details of the operations and maintenance standard are in 44CFR65.10(c).

- *Structural design standards*. Structural design should meet minimum design standards including data regarding closures in 44CFR65 (b)(2), embankment protection in 44CFR65.10(b)(3), embankment and foundation stability in 44CFR65.10(b)(4), settlement in 44CFR65.10(b)(5), and any other design standards as detailed in 44CFR65.10(b)(6). The structural design documentation should also include a discussion if the structural integrity could be affected by the failure of an adjacent levee reach if that adjacent levee reach is not categorized as Sound or Freeboard Deficient.
- *Inspection reports*. The standard for documentation of inspection is in 44CFR65.10(c)(1)(iii) and 44CFR65.10(c)(2)(iv).
- Elevation information for the levee crest and toe
- All items must be signed and sealed by a registered professional engineer.

FEMA will review the submittal in accordance with the appropriate sections of PM 63 (FEMA, 2010a).

4.2.3.2 Technical Procedures

Similar to the Sound Reach Procedure, no levee reach-specific modeling is required for a reach to which the Freeboard Deficient Procedure is applied. However, it is important to note that the SFHAs from the system-wide interior drainage analysis and/or adjacent levee reaches where different procedures have been applied may still be present landward of Sound Reach Procedure reaches. The final delineation of the SFHA also will need to reflect the presence of interior ponding areas and other terrain features on the landward side of the levee.

4.2.4 Overtopping Procedure

In some instances, levee systems have locations that have been specifically armored to sustain overtopping flows or the rate of overtopping flow is small enough or of short enough duration that the system does not fail during the overtopping event. To recognize this level of hazard reduction capability, FEMA developed a procedure for modeling and mapping levee reaches within these systems. Figure 4-4 is an illustration of a cross section view of the overtopping conditions.

The Overtopping Procedure can be applied when the BFE is above the levee crest for a reach, but it can be demonstrated that the 1-percent-annual-chance flood event will not cause structural failure of the overtopped levee reach. As distinguished from the Freeboard Deficient Procedure, the Overtopping Procedure is applicable when the 1-percent-annual-chance flood level is higher than the top-of-levee elevation. The Freeboard Deficient Procedure applies if the 1-percent-annual-chance flood is below the top-of-levee elevation, but the levee system has less than the minimum required freeboard.

The Overtopping Procedure can be applied when the BFE is above the levee crest for a reach, but it can be demonstrated that the 1-percent-annual-chance flood will not cause structural failure.

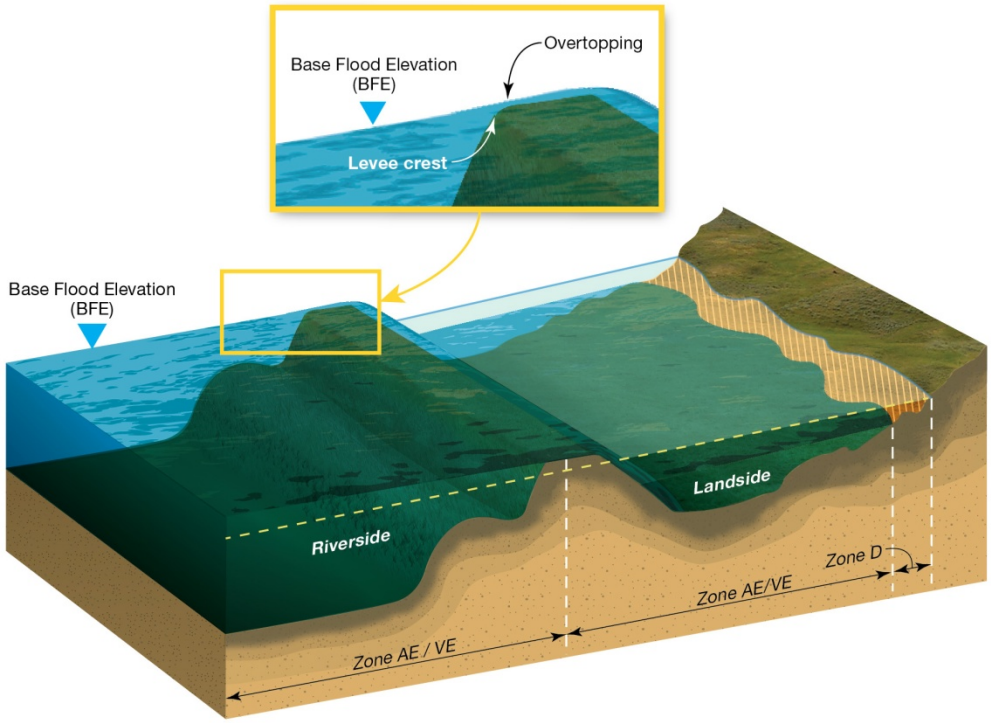

Figure 4-5. Overtopping Cross Section View

4.2.4.1 Data Requirements

To designate a levee reach for evaluation using the Overtopping Procedure, analysis, signed and sealed by a registered professional engineer, indicating that no appreciable erosion of the levee crest, toe, embankment, or foundation occurs during the overtopping of the 1-percent-annual-chance flood event. This erosion could be as a result of either currents or waves and must not result in structural failure (i.e., breach of the levee), directly or indirectly, through loss of embankment material due to erosive forces or the reduction of the seepage path or piping and subsequent instability. Also, documentation to meet the following standards from 44CFR65.10 must be submitted to FEMA:

- Operations and Maintenance Plan;
- Structural design standards;
- Inspection reports; and
- Elevation information for the levee crest and toe.

All Items must be signed and sealed by a registered professional engineer. In addition to the standards detailed in 44CFR65.10, more expansive structural and operational and maintenance will be required for these reaches to certify the overtopping analysis. These are detailed in this subsection.

The documentation submitted is to include the hydrologic and hydraulic analyses used to determine the duration and extent of overtopping expected during the 1-percent-annual-chance flood event. FEMA will review the submittal package for completeness as discussed in PM 63 (FEM, 2010a).

The purpose of this process is not to dictate design standards or strict requirements for supporting data other than the hydrologic and hydraulic modeling that is required to demonstrate whether the levee reach will appreciably erode. It is the responsibility of the community, Tribe, levee owner, and/or local project sponsor, based on a signed and sealed engineering analysis conducted in accordance with sound engineering practice, to determine if the required armoring will prevent appreciable erosion during the 1-percent-annual-chance flood. However, FEMA has identified possible items, discussed below, for community, Tribe, levee owner, and/or local project sponsor and their consulting engineers to consider when developing the data.

Loading Conditions Used for Evaluation

For the loading conditions used for evaluation, the professional engineer will use the 1-percent-annual-chance flood event plus a factor of safety, such as an elevation freeboard, that takes into account uncertainty in the data. The factor of safety used will depend on the levee reach and engineering judgment. For example, the factor of safety will vary when unique tie-in conditions exist or control structures are present. Because of the uncertainty in depth and duration of the overtopping flows, a factor of safety will typically be applied when considering the structural stability of the levee reach.

Determining Need for Armored Surfacing

A community, Tribe, levee owner, and/or local project sponsor, based on the certified engineering analysis submitted, may be able to demonstrate that armoring is not required for a levee reach to fall within this scenario. However, in most cases, armoring will be expected. Some of the reasons for armored surfacing include:

- Some indication that flow along the levee reach may cause some erosion that will initiate levee breaching;
- A lack of proper and continuous maintenance that would result in a non-continuous, non-uniform surface. The lack of proper and continuous maintenance could include the lack of irrigation, fertilization and annual inspections;
- Concerns about localized irregularities, which lead to flow anomalies, since available survey data may not be indicative of localized conditions along the levee reach;
- Local conditions, on the landward side of the levee, include the presence of dips, depressions, or protrusions, including trees, posts, or other surface anomalies;
- Traffic rutting along the levee crest that induces non-uniform crest conditions, in terms of both levee profile and structural condition;
- Difficulty in establishing and properly maintaining a dense and continuous grass cover (in semi-arid and arid regions);
- Debris carried by flood flow may induce damage to the protective surfacing;

- A small amount of damage to a dry or cracked embankment, leading to a catastrophic failure during overtopping; and
- Risk reduction in high-impact areas.

Items to Consider When Determining Viability of an Armored Surface

The items below should be considered when determining the viability of an armored surface, when applicable.

- *History of events*. Flood levels, overtopping locations, damage assessments, and maintenance records can be considered to evaluate the damage that occurred during past overtopping events, especially if depth and duration can be established and evidence shows minor to no damage occurred. If the levee has experienced piping or sand boils, the stability of the levee should be questioned. These data will not be used to change the accreditation determination made at the beginning of the levee analysis and mapping process (Figure 3-1, Element 100).
- *Potential freeboard loss due to subsidence or localized settlement*. Frequent, accurate surveys are critical to ensure that an adequate safety factor is maintained in an area where long-term settlement and regional subsidence are common.
- *Overtopping height and overtopping flow rate (cubic feet per second)*. Velocity and tractive-force calculations are key considerations to assess erosion potential. Engineer Circular 1110-2-6067, *Engineering and Design: USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation* (USACE, 2010a) discusses overtopping flow rates as they apply to grass-covered levees.
- *Overtopping duration*. Levee design discharge or stage hydrographs indicating minutes, hours, or days of anticipated overtopping are especially critical for grass-covered levees.
- *Uplift potential and maximum induced shear stress along the interface between the armored surfacing and the overtopping flow*. Adequacy of the selected armoring scheme must be demonstrated for given site conditions.
- *Resiliency of levee material.* Granular and sandy soils will require surface armoring for small rates and depths of flow.
- *Flow concentration potential.* Surface discontinuities and irregularities can lead to irregular hydraulic flow patterns. Armoring should be provided if gullies, tire tracks, access roads, fences, utility poles, animal burrows, cattle paths, roads, and bike trails, or other conditions may exist that will concentrate flow. For grass-lined levees, the downstream slope can be evaluated to determine if it is uniform from crest to toe, with no interruptions or irregularities such as dips, depressions, or protrusions (e.g., trees, posts, or other surface anomalies).
- *Effect of debris on flow patterns.* Armored levee reaches can be subject to damage from flood-borne debris.
- *Levee toe protection*. This is especially required at the location of eddies, groins, and hydraulic jumps. The depth and thickness of toe protection need to be considered.

- *Levee armoring alternatives*. Alternatives include soil cement, articulated concrete blocks, roller-compacted concrete, gabions, geocells, and rock chutes. Each alternative will have placement thickness recommendations and associated components/feature design considerations (e.g., tieback levees, subdrainage, anchoring requirement).
- *Wind and wave action*. This includes the impact of breaking waves over the levee.
- *Cavitation potential.* The evaluation of how overtopping flows will affect armored surfacing.
- *Levee height.* Low levees may be more tolerant to overtopping.
- *Interior side slopes.* Flatter slopes (i.e., > 4H: 1V) are more tolerant. This is especially important for grass-covered levees.
- *Inspections*. Inspection frequency is especially important for grass-covered levees or after historical events where overtopping occurs or the levees have been stressed.
- *Validity of the Operations and Maintenance Plan.* Confidence is required in emergency planning that minimizes the effects of overtopping, including the impact at overtopping location(s) and interior drainage.
- *Filter capability and free-draining bedding.* Filter materials should be protected from high rates of flow.

Additional Considerations for Levees Subject to Coastal Flood Forces

A levee reach subject to coastal flood forces will need to include adequate embankment protection, foundation, and embankment stability. The levee reach will need to resist wave effects (potentially including wave overtopping and storm surcharge to resist erosion). This needs to be documented in the design, construction, operation, and maintenance of the levee reach.

Armored surfacing should be considered on both the seaward and landward sides of the levee, including the crest, to ensure that the levee reach can withstand the wave forces to which the levee is subjected. Further discussion about armoring coastal levees is presented in USACE Coastal Engineering Research Center (CERC) CERC-89-15, *Criteria for Evaluating Coastal Flood Protection Structures* (USACE, 1989).

4.2.4.2 Technical Procedures

If the appropriate data are provided as detailed above, the flooding source hydrograph will be routed over the levee reach. The resulting hydrograph landward of the levee reach will be modeled according to the techniques discussed in Subsection 4.4.2 to establish the SFHA.

Figure 4-6 shows an example of the Overtopping Procedure applied to a reach of a non-accredited levee system.

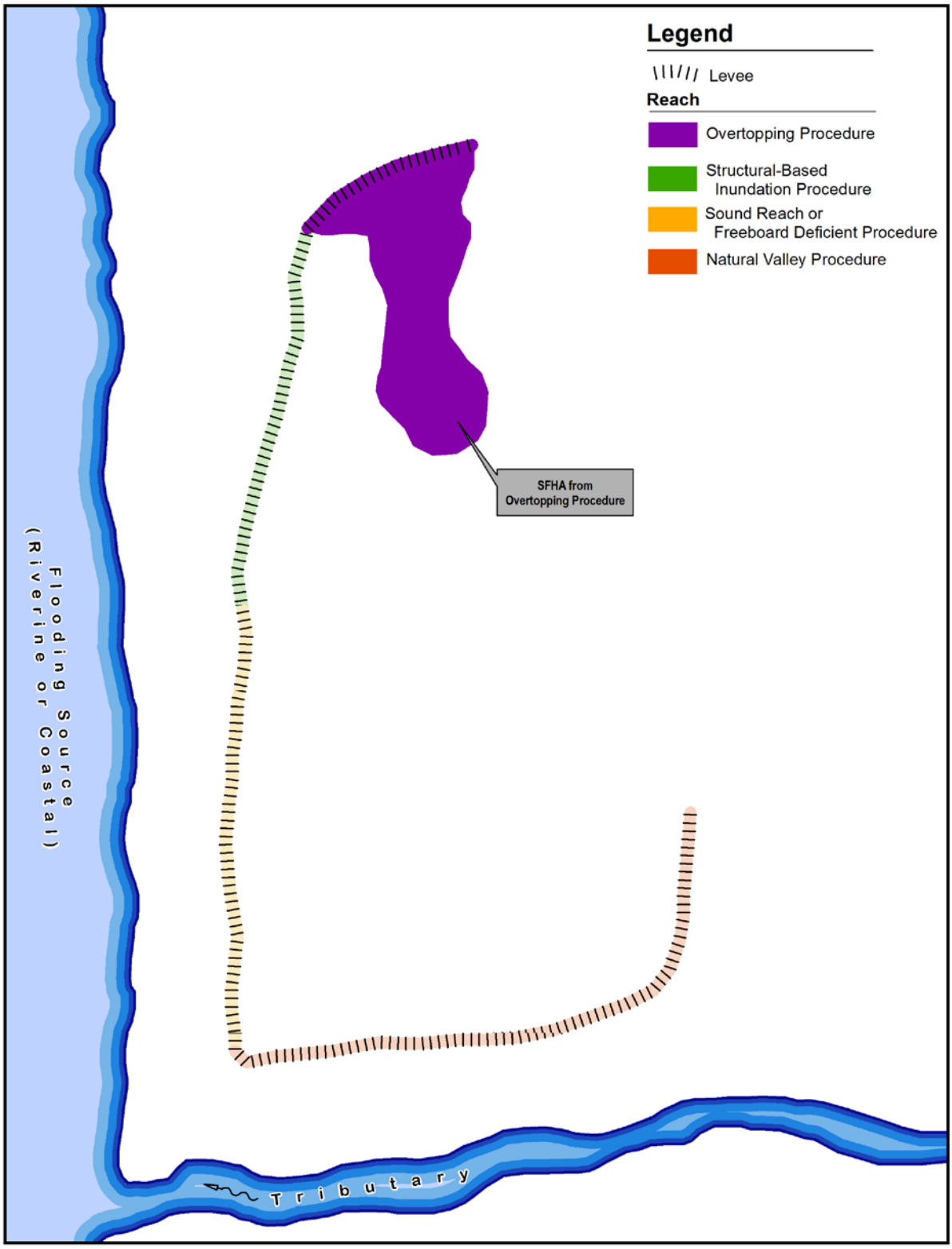

Figure 4-6. Overtopping Procedure

4.2.5 Structural-Based Inundation Procedure

In some instances, levee systems have reaches with either known structural deficiencies or a lack of data to support one of the other procedures. For levee reaches that fall into this category, FEMA developed a standardized procedure to identify the limits of the 1-percent-annual-chance flood that may result from potential levee failure. This procedure relies on the modeling of levee breaches along the levee reach. In Figure 4-7, a sample levee breach is illustrated.

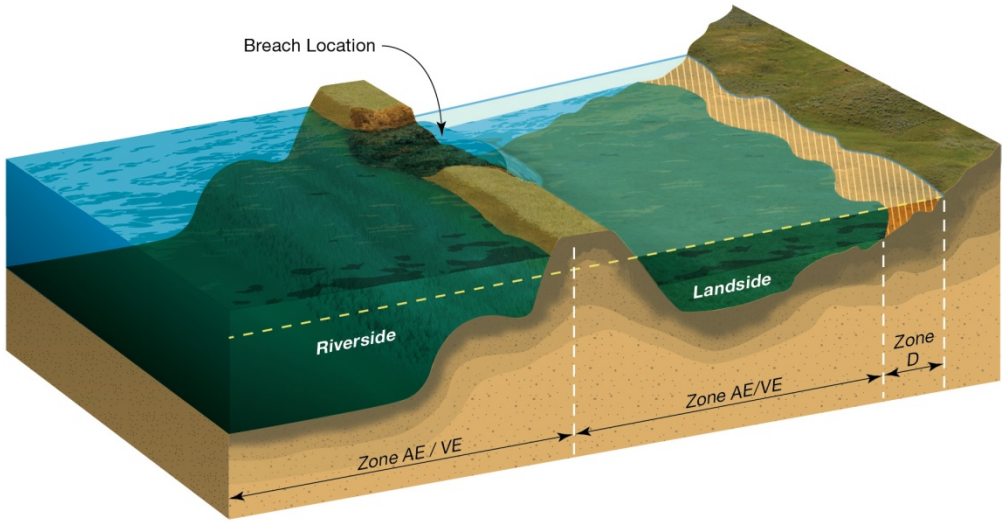

Figure 4-7. Structural-Based Inundation Cross Section View

Predicting the exact timing and location of a levee or floodwall breach is not possible unless it is a design feature of the system. This procedure, therefore, does not predict the probability of failure at any breach location nor does it provide a specific determination or evaluation of the overall levee system performance or require a determination of the likely failure mechanism. The procedure instead develops an SFHA that might occur due to potential breaches along a particular levee reach during the 1-percent-annual-chance flood.

4.2.5.1 Data Requirements

The data requirements for the Structural-Based Inundation Procedure will vary depending on the final flood hazard zone that will be mapped. In most cases, a flood hydrograph of the flooding source will be required.

Structural-Based Inundation Reaches differ from an accredited levee system because they only require that all items available be signed and sealed by a registered professional engineer. The only mandatory data requirement is an accurate depiction of the top-of-levee and toe-of-levee elevations. However, in certain circumstances, it may be necessary to submit the following information to FEMA to support the analyses following the standards from 44CFR65.10:

- *Operations and Maintenance Plan*. Details of the operations and maintenance plan standard in 44CFR65.10(c).

- *Structural design standards*. Structural design should meet minimum design standards including data regarding closures in 44CFR65.10(b)(2), embankment protection in 44CFR65.10(b)(3), embankment and foundation stability in 44CFR65.10(b)(4), settlement in 44CFR65.10(b)(5), and any other design standards in 44CFR65.10(b)(6).
- *Inspection reports*. The standard for documentation of inspection in 44CFR65.10(c)(1)(iii) and 44CFR65.10(c)(2)(iv).

No freeboard or water-surface elevation requirements apply to the Structural-Based Inundation Procedure. Therefore, this procedure can be applied when the levee crest is lower than the 1-percent-annual-chance flood level but high enough to impede flow.

4.2.5.2 Technical Procedures

Methods to identify possible locations of system breaches, modes of failure, geometry, failure triggers, and failure duration for use in mapping the 1-percent-annual-chance flood resulting from the breaches are described below. Given the number and nature of assumptions inherent in this procedure, FEMA will allow some flexibility in its utilization to enable the use of engineering judgment. In rural settings, where levee systems protect primarily agricultural lands, yet the levees are hydraulically significant, simplification of the approach may be warranted to limit analysis costs that would not result in significantly different flood hazard mapping.

Determination of Modeled Breach Locations

The locations of possible levee and floodwall breaches can be determined using the methods described below.

1. Select initial breach locations for each levee reach, one representing a breach location near the downstream end of the levee reach and another near the upstream end of the levee reach.
2. Determine the breach hydrograph associated with the 1-percent-annual-chance flood as though it occurs independently and combine the results into a composite SFHA delineation.
3. Make an initial judgment, through examination of the terrain landward of the levee and/or preliminary modeling results, on whether the selected breach locations will result in a reasonable identification of the flood hazard. The flood hazard will be considered to have been reasonably identified when all potential storage areas and flow paths that can be reached by breach flows reflect the potential flood hazard.
4. Add additional breach locations to the initial locations if additional breaches can change the flood elevations or the extent of the composite floodplain significantly.

The breach locations generally should be placed to correctly capture the full flood hazard on the landward side of the levee. Exact locations should be based on breach potential indicators, such as greatest overtopping depth, past breach locations, encroachment or known seepage locations, or changes in levee material or shape.

Time of Breach Initiation

The time that a breach is assumed to be triggered will impact the peak flow and volume through the breach. The time that produces the most reasonable case should be chosen using sound engineering judgment. For an overtopping breach, a sensitivity analysis should be conducted as described in the "Sensitivity Analysis" subsection below to estimate the breach initiation time that produces the most reasonable SFHA. For an internal failure analysis, the breach failure should initiate at the peak flood stage, unless information that suggests a different breach initiation time is appropriate.

Another option to consider when determining at what point to initiate the breach is the point in time when the water rises to an elevation at which the levee fails to meet all standard engineering criteria. This will be prior to peak stage in many cases.

Breach Shape and Development Time

A rectangular shape extending vertically from the levee crest to the flood-side toe elevation will be adequate to describe the breach shape, unless additional analysis determines breach side slopes are important and necessary for accurate modeling of the breach. The minimum breach width will be 100 feet for clay levees and 500 feet for sand levees. This is based on a qualitative review of historic breach width information. The breach width estimates may be based on empirical or physical methods, although empirical methods will likely be far more common. The breach width estimation may consider levee embankment height, levee material, crest width, depth and duration of overtopping, longitudinal river velocity, area protected by the levee, and duration of river stage. The method to estimate breach width will be based on sound engineering judgment, adjusted by comparing to historical documented levee breaches.

Empirical Methods:

*Dam breach equations***.** Empirical equations have been developed by several authors to estimate breach size, shape, and failure time for dam breaches. The equations are based on examination of historical data for dam breaches. Levee failures generally end with much wider breach bottom widths than dams, relative to the height of the levee/dam. The wide breach width may be caused in part by the erosive shear force of flood flow parallel to levees and in part by the tendency for the hydraulic head over the breach to remain elevated for a longer period of time. Dam breach parameter empirical equations may be applicable to levees in some situations, but justification for their use will be needed if they are chosen for the levee breach width computation.

Historical levee breach information. If available, historic levee breach information is an important tool in determining breach shape and development time. Currently there is no nationwide compendium of historic breach information to reference.

Physically Based Models:

Where appropriate information is available to do so, physically based breaching models may be used. These models are based on erodibility of the levee and levee foundation, levee and levee foundation soil type, levee vegetative cover, flood stage, and flood duration. The model chosen must be on the list of FEMA's approved models, found on http://www.fema.gov/national-flood-insurance-program-flood-hazard-mapping/numerical-models-meeting-minimum-requirements.

Breach Hydrograph Development

Given a flooding source 1-percent-annual-chance hydrograph and breach parameter, a breach hydrograph will be estimated to determine the landward flow. Both basic breach hydrograph methods and advanced breach hydrograph techniques may be used.

Basic Breach Hydrograph Methods:

Basic breach hydrograph methods do not require the data demands or modeling software capabilities of advanced methods, but they may include assumptions that are more conservative than advanced hydrograph methods or assumptions that are not appropriate for some levee failure scenarios.

Advanced Breach Hydrograph Techniques:

Advanced breach hydrograph techniques develop breach hydrographs by modeling the breach within unsteady-state hydraulic models. Unsteady-state hydraulic models, which route hydrographs through the flooding source while modeling the development of breach geometry, are capable of modeling levee breach effects that are not included within all of the basic hydrograph development methods. Breach hydrographs developed from unsteady-state hydraulic models include the impacts of breach development and lowering of flooding source elevations.

Sensitivity Analysis

A sensitivity analysis will be conducted to evaluate the effects that varying the levee breach width, failure initiation time, and time of breach formation will have on the resulting flood hazards, within reasonable limits. It is expected that breach width will be the most widely tested parameter during the sensitivity analysis. This sensitivity analysis will include widening and narrowing the levee breach width and investigating the impacts of different breach initiation times and times of breach formation. The breach width is not expected to vary below the minimums discussed in the "Breach Shape and Development Time" subsection. As the parameters are varied, the impacts to the peak discharge, volume through the breach, and the SFHA will be noted. In general, the final parameters chosen will represent the most reasonable flood hazard area.

To test the impact of failure initiation time, a calculation initiating the breach at the point of overtopping of the levee on the ascending or rising limb of the river flood hydrograph will be conducted. Also, a breach calculation will be performed at the time to peak of the river, but not greater than 2 hours after overtopping begins. The duration of overtopping may be extended if technical calculations are provided by the community, Tribe, levee owner, and/or local project sponsor that indicates the levee can withstand additional overtopping without failure.

Mapping

The SFHA shown on the FIRM will be based on a composite of the 1-percent-annual-chance flood hazard zone delineations developed at each breach location. Figure 4-8 shows an example of the Structural-Based Inundation Procedure applied to a reach of a non-accredited levee system.

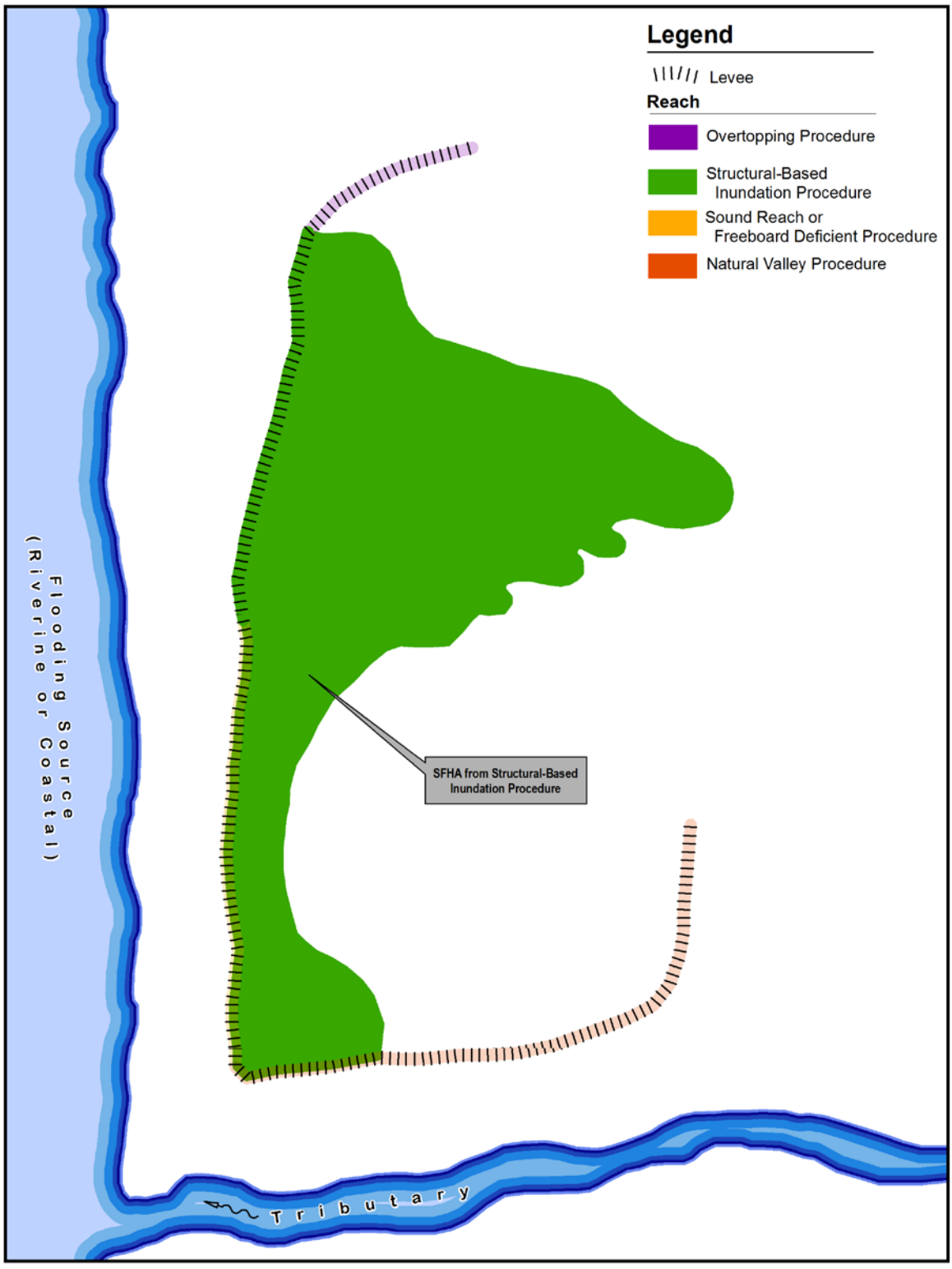

Figure 4-8. Structural-Based Inundation Procedure

4.2.6 Natural Valley Procedure

The Natural Valley Procedure can be used in two ways: as discussed in Subsection 4.1.1, landward of the entire levee system to determine the Zone D area, and, as discussed in this section, as a potential procedure applied to individual levee reaches to determine the SFHA on the landward side of the levee reach. The Natural Valley Procedure can be applied to all non-accredited levee reaches. Below are several factors to consider when determining whether to use the Natural Valley Procedure to determine the SFHA:

- *Hydraulic significance of the levee reach.* In some cases, a levee reach is so significantly overtopped during the peak of the 1-percent-annual-chance flood event that the existence of the levee does not have a noticeable effect on the water-surface elevation (WSEL). Techniques and items to consider for this situation are included in the Technical Procedure section below.
- *Availability of data.* Because of the minimal data requirements of the Natural Valley Procedure, if no data are available to support the other procedures, the Natural Valley Procedure will be developed using FEMA funds. In some locations the effective mapping on the flooding source on the flooding source side of the non-accredited levee system is approximate and therefore the SFHA is designated as Zone A or Zone V. In these locations, FEMA will evaluate the need for more detailed modeling of the flooding source and levee system. If the need does not exist, the flooding source mapping will remain approximate and most likely the Natural Valley Procedure will be used for the levee reach.
- *Needs of the community.* Because of the more limited data requirements and resources required to analyze a levee reach using the Natural Valley Procedure, a community may prefer to use this method. The community may also request to use the Natural Valley Procedure.

Figure 4-9 is an illustration of a cross section view of the Natural Valley Procedure.

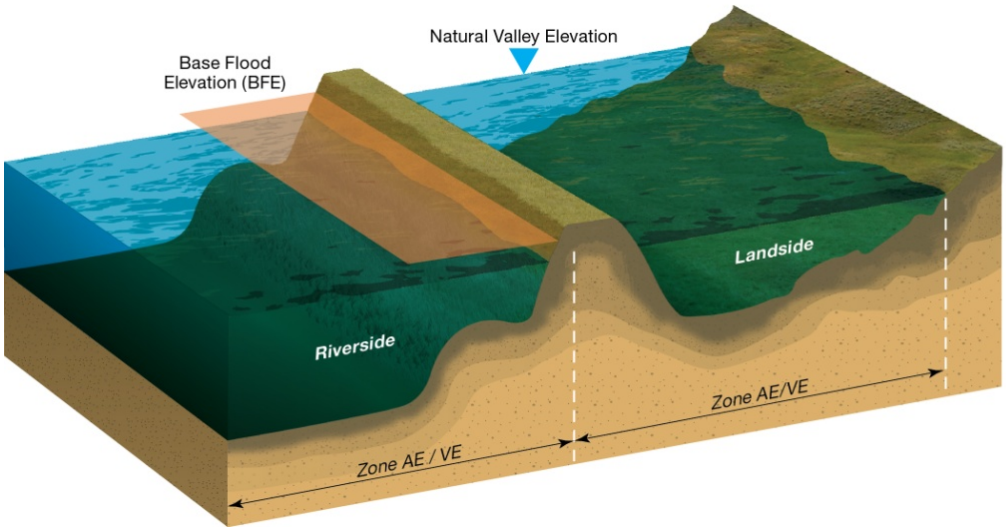

Figure 4-9. Natural Valley Cross Section View

4.2.6.1 Data Requirements

No structural data are required from the community, Tribe, levee owner, and/or local project sponsor to proceed with the Natural Valley Procedure.

4.2.6.2 Technical Procedures

Testing the Hydraulic Significance of the Levee Reach for Riverine Levees

Characteristics of the levee reach that may indicate the levee is not hydraulically significant include:

- Levee/floodwall is fully submerged and landward conveyance is in the direction of the river flow.
- Lateral exchange of flow across a levee that is overtopped is insignificant or does not exist because the water level on the land side of the levee equalizes with the flooding source
- Height of the levee/floodwall is low compared to the WSEL over the crest of the levee/floodwall for the majority of the length of the levee/floodwall, as outlined in the following section.

Modeling the Natural Valley Procedure on Levees Subject to Riverine or Lacustrine Flood Forces

The Natural Valley Procedure will be modeled for riverine levee reaches by leaving the topographic features of the levee in the model, but allowing the discharge to flow on either side of the levee, as shown in Figure 4-9. The levee will be modeled as not impeding conveyance.

Figure 4-10 shows an example of the Natural Valley Procedure applied to a reach of a non-accredited levee system.

Modeling the Natural Valley Procedure on Levees Subject to Coastal Flood Forces

Non-accredited levees subject to coastal flood forces will be fully intact within the storm surge model setup to determine peak storm-surge elevations seaward of the levees. In these situations, consideration will be given as to how the levee system will impact wave propagation. A steady-state condition will then be assumed landward of the levee, and the 1-percent-annual-chance WSEL will be extended landward of the non-accredited levee until it intersects the ground elevation, or the levee on the opposite side, in the case of a ring levee. A similar procedure may be applied when a detailed storm surge model is not available.

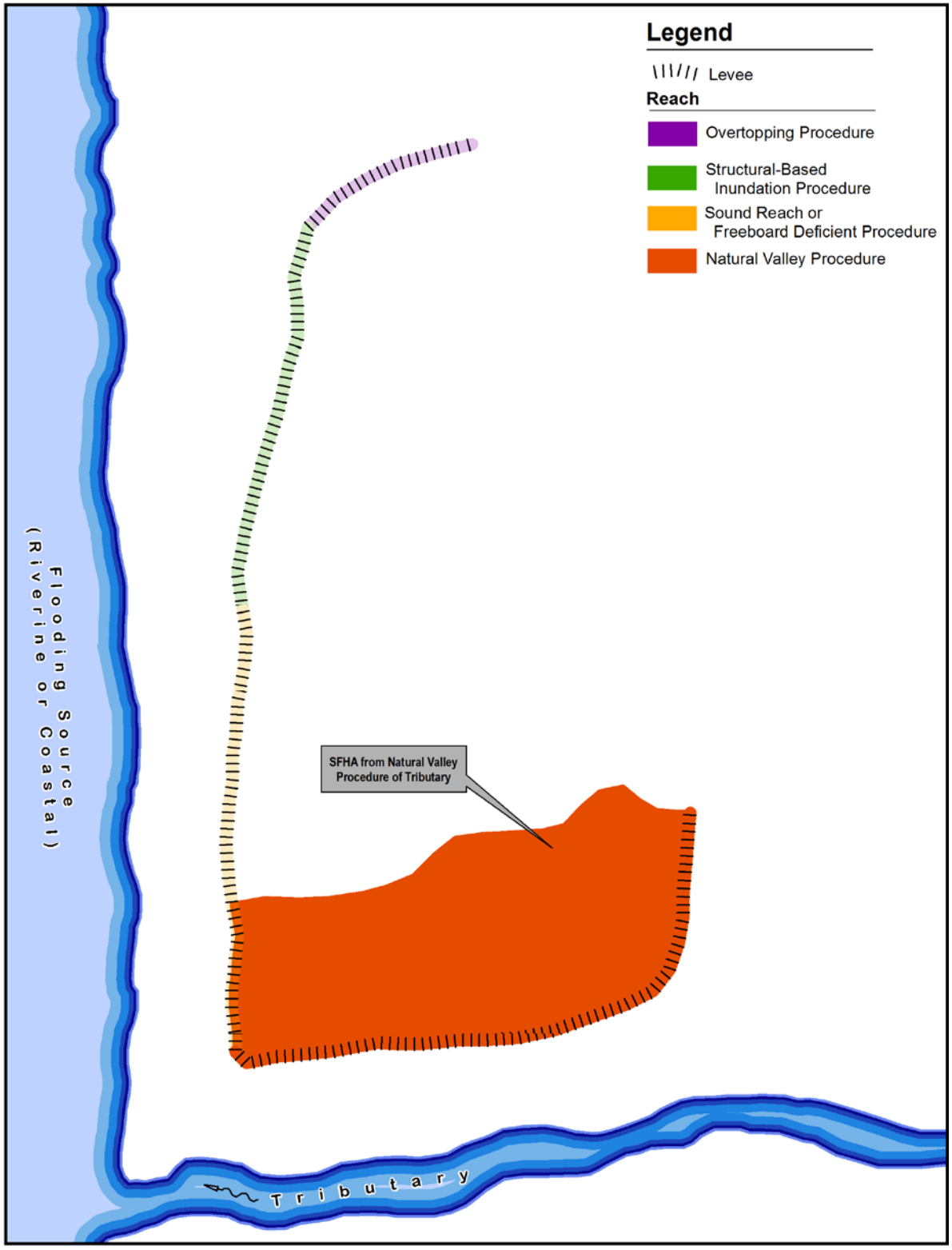

Figure 4-10. Natural Valley Procedure

4.2.7 Special Flood Hazard Area Resulting from Levee Reach Procedures Chosen

For each individual levee reach, the SFHA extent will be determined by the procedure chosen. These individual polygons will be merged to produce the final SFHA.

When the Structural-Based Inundation Procedure is used, the SFHA for that levee reach will be a composite of each independently analyzed breach location. In addition, the final SFHA will reflect that a breach could occur at any location along the levee reach. To achieve this, it may be acceptable to extrapolate breach analysis results to areas that were not analyzed separately. This will most often occur in situations where breach flows seek a flow path or storage area that is not directly adjacent to the levee. The final mapping will not reflect the analyzed breach locations, just the composite flood hazards resulting from all breach analyses conducted.

The input data requirements to map BFEs on the FIRM for the Overtopping and Structural-Based Inundation Procedures follow existing FEMA guidelines outlined in Appendix C of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA, 2009c). Therefore, field-surveyed cross sections and field-surveyed hydraulic structures such as bridges and culverts will be required on the landward side of the levee if BFEs will be shown on the FIRM. For the Natural Valley Procedure, BFEs can be shown as long as the flooding source was studied with the required level of detail.

4.3 Flood Hazards Evaluated by Flooding Source

4.3.1 Flooding Source Modeling and Mapping

The new methods for levee analysis and mapping generally do not impact the modeling and mapping of the BFE on the flooding source side of the levee. Existing procedures for determining the BFEs on the flooding source side of the levee are to be followed. Therefore, the BFEs on the flooding source side of the levee should be determined assuming the levee remains in place. If there are levees on both sides of the flooding source, both will be assumed to be in place when determining the BFE on the river side of the levees.

If the levee system includes locations where the 1-percent-annual chance WSEL is higher than the levee crest, the levee will be overtopped assuming no failure in order to determine the appropriate base flood elevation on the flooding source side of the levee. The residual 1-percent-annual-chance discharge that overtops will be modeled and mapped similar to the procedures outlined for split or diverted flow in Appendix C of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA, 2009c). Therefore even if the Structural-Based Inundation Procedure is used, the flow lost through the breach will not necessarily change the flow modeled on the riverside of the flooding source.

4.3.2 Flooding Source Floodway Determination

Under the new procedures, FEMA typically will map the regulatory floodway at the riverward toe of the levee. Exceptions may occur when hydraulic calculations demonstrate a floodway is warranted elsewhere or when a community specifically requests otherwise. Per 44 CFR 60.1(d), the criteria of

the NFIP are minimum standards and that any floodplain management regulations adopted by a State or community that are more restrictive than the NFIP criteria are encouraged and take precedence.

The regulatory floodway is a community tool and the final approach to determining the regulatory floodway will be made in conjunction with the impacted communities and the levee owner. Also, when the State and local jurisdictions along either side of a flooding source are different, coordination among those State and local jurisdictions and the FEMA Regional Office(s) will need to take place before the floodway modeling approach is finalized. Additional guidance for determining the regulatory floodway under the new procedures will be included in Operating Guidance.

4.4 Additional Analysis and Mapping Considerations

4.4.1 Hydrograph Development

4.4.1.1 Riverine Hydrograph Development

Traditionally, studies conducted for flood insurance purposes have only calculated peak-flow or peak-surge elevation. Both Structural-Based Inundation and Overtopping Procedures will often require a 1-percent-annual-chance flood hydrograph[7] to complete the modeling, making the development of a flood hydrograph necessary. Computing and selecting a representative hydrograph shape with an appropriate volume is an important step. For many systems, the hydrograph shape and volume will be a key parameter influencing the resultant SFHAs. A cost-effective method is needed to estimate flood hydrographs for studies where only peak discharges/surge elevations are currently available, where a rainfall-runoff model or storm surge model is not available, or where funding is not sufficient to develop a rainfall-runoff or storm surge model. A summary of these procedures is included below and specifics will be detailed further in operating guidance, as appropriate.

Options for developing hydrographs include:

- For flooding sources with gaging stations near the study location, the hydrograph could be estimated by scaling a major (10-percent-annual-chance peak discharge or greater) observed flood hydrograph or by developing a balanced synthetic flood hydrograph using peak discharges and N-day volumes;
- For ungaged watersheds, existing rainfall-runoff models (either the model used to develop the FIS discharges or locally adopted rainfall runoff models) can be used or scaled to achieve the desired percent chance hydrograph;
- If no rainfall-runoff model is available, it may be feasible to develop a simplified rainfall-runoff model for a single watershed area with no subdivision and no channel/reservoir routing or model calibration. The flood hydrographs from this model could be scaled to be consistent with peak discharges determined from other methods;

[7] The term hydrograph is used in this document to denote both a time series of flow rate (for riverine analysis) and the time series of water-surface elevation associated with a storm surge event (for coastal analysis).

- The desired-percent-chance peak discharge for rural and urban ungaged watersheds may be estimated from USGS regression reports or from other regression equations developed for the study area. The basin lag time may be estimated by regression equations given in USGS reports on dimensionless hydrographs, many of which are summarized in Appendix B of Ries (USGS, 2007), and other regression equations developed for basin lag time. The basin lag time as used in the USGS dimensionless hydrograph approach is the time from the center of mass of rainfall excess to the center of mass of runoff.

Using rainfall-runoff data for 81 watersheds in Maryland, Thomas and others (Transportation Research Board, 2000) demonstrated that the basin lag time used to define the USGS dimensionless hydrograph was, on average, only 5 percent less than the watershed time of concentration. Therefore, basin lag time as defined above may be approximated by the time of concentration as estimated by the NRCS (1986) travel time method.

The balanced synthetic hydrograph method described above for gaged streams may also be applied to ungaged streams by:

- estimating N-day volumes (e.g., 1-day, 3-day, 7-day) at gaging stations in the vicinity of the ungaged stream;
- developing regression equations for estimating the desired-percent-chance N-day volumes for the ungaged stream; and
- Constructing a balanced synthetic hydrograph with the desired-percent-chance N-day volumes.

This method is more time consuming, but it may be used if the dimensionless hydrograph method does not provide reasonable results or in areas where the dimensionless hydrograph method may not be applicable.

4.4.1.2 Coastal Hydrograph Development

For coastal analyses, one way to create a synthetic storm surge hydrograph is using procedures in the Federal Highway Administration (FHWA) publication, *Highways in the Coastal Environment* (FHWA, 2008) if data from a detailed coastal model are not available. The required variables for the method are the half storm duration (D), peak surge elevation (S_p), forward speed of the storm (f), and the radius of maximum winds (R). S_p is given directly from the published 1-percent-annual-chance water level noted in the FIS, while a range of values for both R and f are possible for a given location.

Coastal FISs based on modern methods involving Joint Probability Method (JPM) analysis contain enough information about the range of storm parameters that a representative R and f to associate with the value of S_p can be calculated directly. For studies where the FIS does not employ a JPM approach for determining the 1-percent-annual-chance water level, these values may need to be estimated by examining historical storms in the region.

Pilot tests suggest that the ultimate extent of flooding landward of a breached or overtopped coastal levee is not highly sensitive to the shape of the synthetic hydrograph, and so the exact choice for f

and D may not be a critical factor. The peak surge and width of failure in a breaching condition is of primary importance within this analysis.

4.4.2 Hydraulic Modeling Landward of the Levee

This subsection presents recommended guidance to be used for the mapping of the landward flood hazard area for levee reaches that fit within the Overtopping or Structural-Based Inundation Procedures. For these procedures, often an unsteady flow will be required. While Appendix C of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA, 2009c) discusses both one- and two-dimensional unsteady-flow modeling, this subsection provides additional guidance specific to levees.

The flood hazard area created by levee overtopping or breach is assumed to be subject to the same annual-chance flooding as the exterior flooding source. For example, if a levee is breached by the 1-percent-annual-chance flood, the inundated area will be assigned a 1-percent-annual-chance exceedance probability and delineated as an SFHA on the FIRM.

Hydrologic or hydraulic analyses are necessary to compute the flood elevations created by the inflow. Reservoir routing and pump operation will be the features generally applied to determine flood elevations for hydrologic analyses.

One-dimensional (1D), two-dimensional (2D) steady flow, and unsteady flow solution methods are the hydraulic analysis methodologies applicable to compute flood elevations. The applicability and data requirements for these methodologies are summarized below.

4.4.2.1 Hydrologic Flow Routing

Hydrologic flow routing is applicable when floodplain storage, not conveyance, is the dominant factor determining the flood elevation. This will generally be applicable if the inflow is for a limited duration and the interior floodplain has the capability to store the volume of flow entering the protected area. A stage-inflow hydrograph of the exterior flooding source is essential to determine the duration and rate of the inflow, and to conduct a hydrologic flow routing. Depending on the mode of failure, inflow hydrographs can be computed by applying appropriate hydraulic computations. Most hydrologic flow routing models also have the capability to reflect flow evacuation features, such as pumping stations.

4.4.2.2 Hydraulic Modeling

A hydraulic approach is applicable when an alternate flow path is created landward of the levee for floodwater to flow downstream. Conveyance and floodplain storage along the flow path are the dominant factors controlling the flood elevations. For general floodplain analyses based on the formulation of basic equations of motion, four types of solutions procedures are available. They are categorized as 1D steady flow, 1D unsteady flow, 2D steady flow, and 2D unsteady flow solutions. Where groundwater is close to ground level, it may be appropriate to account for groundwater interaction.

Any hydraulic analysis software accepted by FEMA for flood hazard area development can be selected for hydraulic modeling. General data requirements and applicability of the different types of hydraulic flow modeling are listed below.

One-Dimensional Steady Flow Analysis

One-dimensional steady flow analyses are applicable where flow is limited to defined flow paths. Inflow would be peak flow rates generated from the subject levee failure conditions – overtopping, segment failure, dynamic breach, or final breach condition. Weir and split flows are two commonly used options.

Inflow discharges due to overtopping can be computed by applying lateral weir flow computations. For weir flow assumptions to be applicable, the flow crossing the crest profile of the levee or flood wall must not be submerged landward of the levee. The weir flow method is also applicable if the final breach geometry creates weir flow conditions.

When overtopping flow accumulated on the floodplain creates a fully submerged condition landward of the levee, split flow becomes applicable. When a breached levee fails to the natural ground level, inflow may be computed as split-flow conditions in the vicinity of the breach location. The breach or overtopping flow may return to the same river downstream, join another flooding source, or flow into a large water body whose WSEL will not noticeably change despite receiving the inflow from levee failure. In addition, most steady flow analyses can also reflect constant pumping rates.

One-dimensional steady flow models are generally not applicable in coastal situations.

One-Dimensional Unsteady Flow Analysis

Unsteady flow analyses are most suitable if the flow is limited to defined flow paths and defined storage areas are present in the overbank. However, unsteady flow models using link-node concepts to represent flow have the capability to model a larger number of flow paths and offline floodplain storage. Unsteady flow analyses have the capability to simulate online floodplain storage and dynamic impacts of pumping activities.

Unsteady flow analyses can be applied to a variety of downstream boundary conditions. Flow may rejoin the same river downstream, at other flooding sources, travel to storage/ponding areas, or reach an ocean impacted by daily tide level variations.

Unsteady 1D numerical models also may be applied to model the hydraulics for coastal levee overtopping and breach scenarios. In selecting an appropriate model, consideration is to be given to models that include modules for incorporating flow-control structures and supercritical flow. Models developed with modules accounting for dam-break scenarios may also be applied to levee breach scenarios. Models that are applicable to coastal flooding sources and include wave overtopping also exist and can be used.

Two-Dimensional Flow Analysis

Two-dimensional flow routing is most applicable to natural floodplains with flat terrain or urban floodplains where flow directions are dictated by streets, storm drain alignments, and obstructions

caused by buildings. When levee breach or overtopping occurs, inflow from the channel may be modeled as 1D flow near the breach and develop into 2D flow, either forming flow paths or remaining as sheet flow to spread over the floodplain. A typical 2D model can model levee, flow paths, street flow, or shallow flow conditions.

Generally, 2D models have the capability to provide unsteady flow solutions. A hydrograph and can be generated outside of the 2D model and provided as input. Inflow hydrographs can be computed using methodologies described for 1D unsteady flow analysis. Some 2D software accepted for flood study development can also model levee overtopping, piping, and slope stability failure as well as flow routing on the adjoining floodplain.

Two-dimensional analyses provide a convenient method to simulate multiple modes of failure at different locations without significant additional effort. Two-dimensional analysis is also applicable to simulate flood ponding in areas between two levees or areas protected by ring levees. When a breach occurs in one of the levees, areas between two levees will be inundated until the ponding elevation reaches the equivalent elevation of the flooding source side or overtops the other levee. In the latter situation, the ponding elevation is to be mapped as the elevation of levee being overtopped. Pumping and other flood mitigating features may be reflected in most 2D models through rating curves.

The storm surge modeling system most prevalently used in coastal flood hazard studies includes the ADCIRC 2D circulation model, which is then coupled with a 2D wave model (STWAVE or UnSWAN).

A 2D model will have varying levels of complexity. A simple 2D model using terrain data may be easily produced. In comparison, a complex 2D model that includes detailed hydraulic structures and streets may be time-consuming to prepare.

Combination of One-Dimensional and Two-Dimensional Models

Increasingly, 1D unsteady flow and 2D software developers have provided the capability to link 1D and 2D solutions as needed. Users have the capability to use the appropriate solutions for appropriate locations. Some such models also have options to model the levee breach process. The channel flow is typically modeled as 1D, using cross sections. Landward flow from a levee breach or overtopping is routed using 2D grids or finite element mesh.

The selected analysis methodology should be able to reflect flow conditions adequately and develop reliable flood elevations and flood hazard area boundaries for the area landward of a levee that does not meet the 44CFR65.10 criteria. Decision factors include the consequences of levee failure, nature of the terrain, complexity of the levee systems, mode of failure mechanisms, data availability, and availability of funds.

4.4.3 Flood Hazard Mapping

The final mapped flood hazard boundaries landward of non-accredited levee systems will be a worst-case combination of three main sources:

- The composite SFHA resulting from the levee reaches evaluated by the Overtopping, Structural-Based Inundation, or Natural Valley Procedures for each levee reach (Sound and

Freeboard Deficient Reaches will not have a SFHA associated with the individual reach analysis);

- The SFHA resulting from the interior drainage analysis; and
- The area developed using the Natural Valley Procedure, which will be used to depict the potential 1-percent-annual-chance flood hazard that exists landward of a non-accredited levee system in areas where an SFHA has not been identified. This Zone D will be shaded on the FIRM differently than a typical Zone D to clarify the difference in how the two zones are developed.

This concept is illustrated in Figure 4-11. If BFEs are to be shown on the FIRM, they will be based on the highest elevation of the composite mapping.

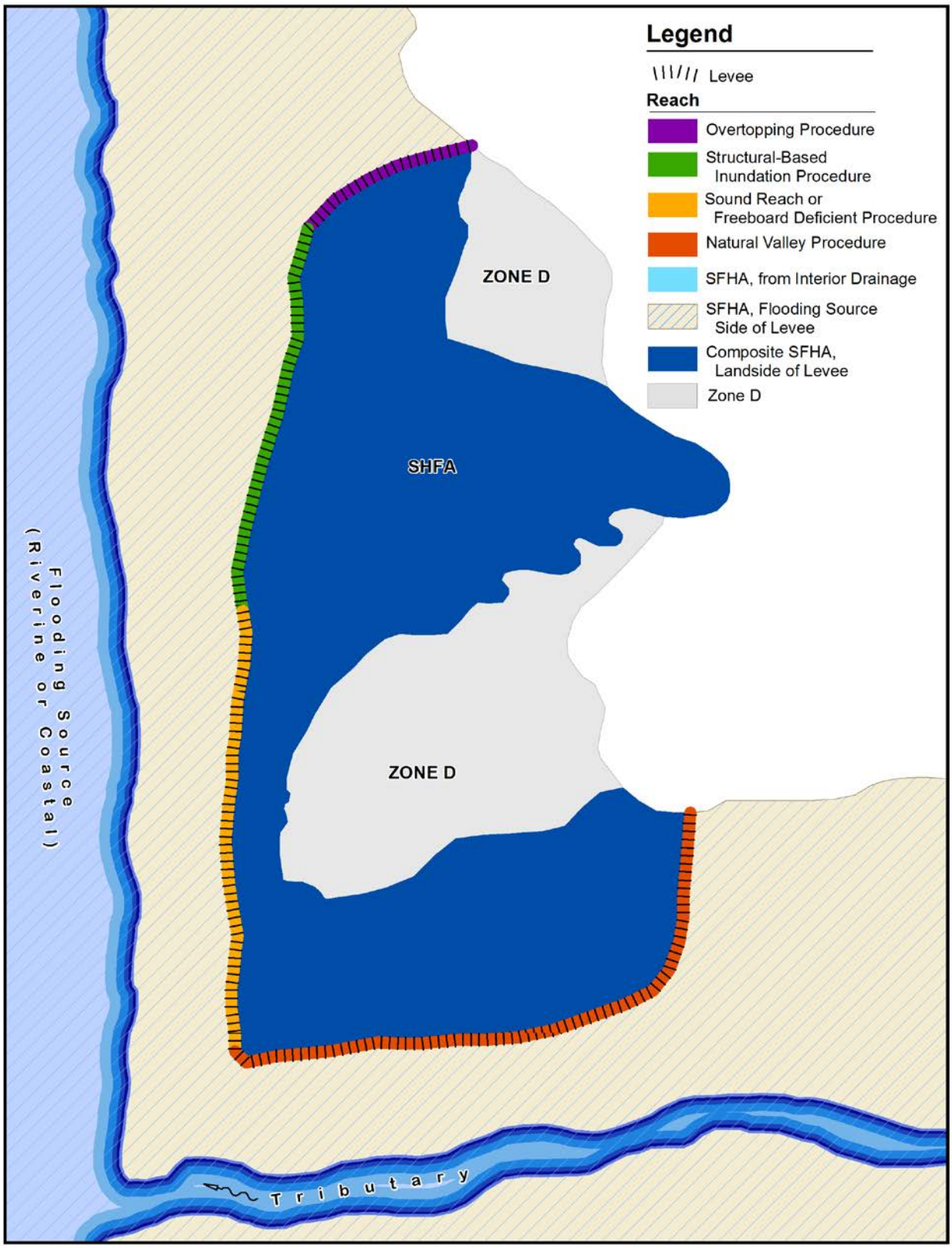

Figure 4-11. Composite Flooding for the Levee System

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Appendix A. List of Levee-Related Acronyms

The acronyms below have been used in this report or will be encountered in other levee-related FEMA resources. A more comprehensive list of levee-related acronyms and abbreviations is available from the FEMA Library.

- ADCIRC – Advanced Circulation (computer model)
- BFE – Base Flood Elevation
- BIA – Bureau of Indian Affairs
- CCO – Consultation Coordination Officer
- CEO – Chief Executive Officer (community official)
- CERC – Coastal Engineering Research Center (USACE)
- CFR – Code of Federal Regulations
- CTP – Cooperating Technical Partner
- DHS – Department of Homeland Security
- EC – Engineer Circular (USACE)
- EM – Engineer Manual (USACE)
- EP – Engineer Pamphlet (USACE)
- ER – Engineer Regulation (USACE)
- ESA – Endangered Species Act
- FEMA – Federal Emergency Management Agency
- FHWA – Federal Highway Administration
- FIMA – Federal Insurance and Mitigation Administration
- FIRM – Flood Insurance Rate Map
- FIS – Flood Insurance Study
- FPA – Floodplain Administrator
- GIS – Geographic Information System
- HEC – Hydrologic Engineering Center (USACE)
- HEC-SSP – HEC Statistical Software Package (USACE)
- ISB – Independent Scientific Body
- JPM – Joint Probability Method
- LFD – Letter of Final Determination

- NCLS – National Committee on Levee Safety
- NED – National Elevation Dataset
- NFIP – National Flood Insurance Program
- NIBS – National Institute of Building Sciences
- NLD – National Levee Database
- NLSP – National Levee Safety Program
- NRCS – Natural Resources Conservation Service
- NSS – National Streamflow Statistics (computer program)
- O&M – Operations and Maintenance (Plan)
- PAL – Provisionally Accredited Levee
- PM – Procedure Memorandum
- Risk MAP – Risk Mapping, Assessment, and Planning (Program)
- SFHA – Special Flood Hazard Area
- STWAVE – Steady State Irregular WAVE (computer model)
- SWSTAT – Surface-Water Statistics (U.S. Geological Survey computer program)
- USACE – U.S. Army Corps of Engineers
- USBR – U.S. Bureau of Reclamation
- USGS – U.S. Geological Survey
- WSEL – Water-Surface Elevation

Appendix B. Glossary of Levee Terms

The terms below have been used in this document and will be encountered in other levee-related FEMA resources. Additional terms are provided in the glossary of frequently used terms available from the FEMA Library.

0.2-Percent-Annual-Chance Flood – The flood that has a 0.2-percent chance of being equaled or exceeded in any given year (also known as the 500-year flood).

1-Percent-Annual-Chance Flood – The flood that has a 1-percent chance of being equaled or exceeded in any given year (also known as the 100-year flood).

44CFR65.10 Requirements – See Section 65.10 Requirements**.**

Accredited Levee System– A levee system that FEMA has shown on a FIRM that is recognized as reducing the flood hazards posed by a 1-percent-annual-chance or greater flood. This determination is based on the submittal of data and documentation as required by 44CFR65.10 of the NFIP regulations. The area landward of an accredited levee system is shown as Zone X (shaded) on the FIRM except for areas of residual flooding, such as ponding areas, which are shown as Special Flood Hazard Area (SFHA).

ADCIRC Coastal Circulation and Storm Surge Model – A system of computer programs for solving time-dependent, free surface circulation and transport problems in two and three dimensions. These programs utilize the finite element method in space allowing the use of highly flexible, unstructured grids.

Adequate Progress Determination – A written determination issued by FEMA to the Chief Executive Officer of a community that has provided sufficient information for FEMA to determine that substantial completion of a flood protection system has been effected because: (1) 100 percent of the total financial project cost of the completed flood protection system has been authorized; (2) at least 60 percent of the total financial project cost of the completed flood protection system has been appropriated; (3) at least 50 percent of the total financial project cost of the completed flood protection system has been expended; (4) all critical features of the flood protection system, as identified by FEMA, are under construction, and each critical feature is 50 percent completed as measured by the actual expenditure of the estimated construction budget funds; and (5) The community has not been responsible for any delay in the completion of the system.

Adoption/Compliance Period – The period that begins with the issuance of a Letter of Final Determination and ends when a new or revised Flood Insurance Rate Map FIRM) becomes effective. During the compliance period, usually lasting 6 months, a community must enact and adopt new or revised floodplain management ordinances required for participation in the NFIP.

Appeal – A formal objection to FEMA's proposed flood hazard determinations shown on a new or revised FIRM.

Appeal Period – The 90-day period, beginning on the date of second publication of FEMA's proposed flood hazard determination notice in a local newspaper, during which certain community officials or owners or lessees of real property within the community meeting statutory appeal requirements may submit formal objections to the proposed flood hazard determinations by submitting data to show that the proposed flood hazard determinations are scientifically or technically incorrect.

Approximate Study – An engineering study that results in the delineation of floodplain boundaries for the 1-percent-annual-chance flood, but does not include the determination of Base Flood Elevations or base flood depths.

Base Flood – The flood that has a 1-percent chance of being equaled or exceeded in any given year.

Base Flood Elevation (BFE) – The elevation of a flood having a 1-percent chance of being equaled or exceeded in any given year.

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, erosion, or increase the stability of the slopes of the earthen embankment, thereby increasing the stability of the embankment or reducing seepage.

Certification –As stated in 44 CFR 65.2(b), certification of analyses is a statement that the analyses have been performed correctly and in accordance with sound engineering practices. Certification of structural works is a statement that works are designed in accordance with sound engineering practices to provide protection from the base flood. Certification of "as built" conditions is a statement that the structure(s) has been built according to the plans being certified is in place, and is fully functioning.

Chief Executive Officer (CEO) – The official of a community who has the legal authority to implement and administer laws, ordinances, and regulations for that community.

Closure Devices – Any movable and essentially watertight barriers, used during flood periods to close openings in levee systems, securing but not increasing the levee systems' design level of protection.

Coastal Levees - Structures that are designed to provided low-lying coastal areas with total protection during the 1-percent flood. The costal levee must be substantial enough to prevent any flooding or wave overtopping landward of the levee crest. The crest elevation of the levee must be elevated at least two feet above the 1-percent Stillwater elevation, and above the elevation of the 1-percent wave height or the maximum wave runup elevation. (whichever is greater).

Code of Federal Regulations (CFR) – The codification of the general and permanent rules published in the FEDERAL REGISTER by the Executive Departments and agencies of the Federal Government. NFIP regulations are published in Parts 59 through 77 of Title 44 of the CFR.

Community – Any State or area or political subdivision thereof, or any Indian Tribe or authorized tribal organization, or Alaska Native village or authorized native organization, which has the

authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction.

Consultation Coordination Officer (CCO) – The individual on the FEMA Regional Office staff who is responsible for coordinating with a community on activities related to the NFIP.

CCO Meeting/Open House – The term used to describe a formal meeting with community officials and select stakeholders and subsequent open house for the public for flood risk projects carried out under the FEMA Risk Mapping, Assessment, and Planning Program. The CCO Meeting/Open House focuses on the release of the Preliminary version of the FIRM and FIS report and the process for reviewing and adopting the FIRM prior to the FIRM effective date.

Cooperating Technical Partner (CTP) – A participating NFIP community, regional entity, or State agency that has the interest and capability to become a more active participant in the FEMA Flood Hazard Mapping Program and has signed a Partnership Agreement with FEMA under the Cooperating Technical Partners Program.

De-Accredited Levee System – A levee system that was once shown on the FIRM as reducing the flood hazards posed by a 1-percent-annual-chance or greater flood, but is no longer accredited with providing this flood hazard reduction because FEMA has not been provided with sufficient data and documentation to determine that the levee system continues to meet the NFIP regulatory requirements cited at 44CFR65.10. The impacted area landward of a de-accredited levee system is shown on a new FIRM as an SFHA, labeled Zone A or Zone AE, depending on the type of engineering study that was performed for the area.

Detailed Study – An engineering study that, at a minimum, results in the delineation of floodplain boundaries for the 1-percent-annual-chance flood and the determination of BFEs and/or base flood depths.

Effective Base Flood Elevations (BFEs) – The BFEs that are shown on the FIRM that is in effect for a community for flood insurance and floodplain management purposes.

Effective Date – The date of issuance of the NFIP map for a community and the date when compliance to the NFIP begins.

Effective Map – The NFIP map issued by FEMA, usually a FIRM, that is in effect as of the date shown in the title block of the map as "Effective Date," "Revised," or "Map Revised" and is to be used by the community and others for flood insurance and floodplain management purposes.

Erosion –The process of the gradual wearing away of land masses. This peril is not per se covered under the National Flood Insurance Program

Federal Emergency Management Agency (FEMA) – The component of the U.S. Department of Homeland Security that oversees the administration of the NFIP.

Federal Insurance and Mitigation Administration (FIMA) – The component of FEMA Headquarters that, among other responsibilities, administers the NFIP. FIMA works with partners at

the Federal, State, and local level to facilitate efforts toward achieving resilience from natural hazards. FIMA works to reduce risk to life and property damage through a variety of grant programs.

Federal Register – The document, published daily by the Federal Government, that presents regulation changes and legal notices issued by Federal agencies.

Flood – A general and temporary condition of partial or complete inundation of normally dry land areas from (1) the overflow of inland or tidal waters or (2) the unusual and rapid accumulation or runoff of surface waters from any source.

Flood Insurance Rate Map (FIRM) – The insurance and floodplain management map produced by FEMA that identifies, based on detailed or approximate analyses, the areas subject to flooding during a 1-percent-annual-chance flood event in a community. Flood insurance risk zones, which are used to compute actuarial flood insurance rates, also are shown. In areas studied by detailed analyses, the FIRM shows BFEs and/or base flood depths to reflect the elevations of the 1-percent-annual-chance flood. For many communities, when detailed analyses are performed, the FIRM also may show areas inundated by 0.2-percent-annual-chance flood and regulatory floodway areas.

FIRM Effective Date – The date on which the NFIP map for a community becomes effective.

Flood Insurance Study (FIS) Report – A document, prepared and issued by FEMA, that documents the results of the detailed flood hazard assessment performed for a community. The primary components of the FIS report are text, data tables, photographs, and Flood Profiles.

Floodplain Administrator (FPA) – The community official who is responsible for implementing and enforcing floodplain management measures and for monitoring floodplain development.

Flood Protection System – Those physical works for which funds have been authorized, appropriated, and expended and which have been constructed specifically to modify flooding in order to reduce the extent of the area subject to a "special flood hazard" and the extent of the depths of the associated flooding. These systems typically include hurricane tidal barriers, dams, reservoirs, levees, or dikes.

Floodwall – Concrete wall constructed adjacent to shorelines for the purpose of reducing flooding of property on the landward side of the wall. Floodwalls are normally constructed in lieu of or to supplement levees where the land required for levee construction is too expensive or not available.

Floodway – See regulatory floodway.

Freeboard –The vertical distance between the top of a levee and the water level that can be expected during the 1-percent-annual-chance flood.

Geographic Information System (GIS) – A system of computer hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems.

Hazard – An event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, and other types of loss or harm.

Hydraulic Analysis – An engineering analysis of a flooding source carried out to provide estimates of the elevations of floods of selected recurrence intervals.

Hydraulic Computer Model – A computer program that uses flood discharge values and floodplain characteristic data to simulate flow conditions and identifies flood elevations.

Hydraulic Independence - Two levees or levee reaches are considered hydraulically independent when the areas that are protected by each do not overlap and if one fails (regardless of the failure mode) the area landward of the other is not inundated.

Hydraulic Methodology – Analytical methodology used for assessing the movement and behavior of floodwaters and determining flood elevations and regulatory floodway data.

Hydrograph – A graph showing stage, flow, velocity, or other properties of water with respect to time.

Hydrologic Analysis – An engineering analysis of a flooding source carried out to establish peak flood discharges and their frequencies of occurrence.

Hydrology – The science encompassing the behavior of water as it occurs in the atmosphere, on the surface of the ground, and underground.

Independent Scientific Body (ISB) – An independent group composed of recognized experts and, convened by the National Institute of Building Sciences to review and provide comments on the proposed levee mapping approach developed by FEMA.

Interior Drainage – Natural or modified outflow of streams within a area landward of the levee for the conveyance of runoff.

Interior Drainage Systems – Systems associated with levee systems that usually include storage areas, gravity outlets, pumping stations, or a combination thereof.

Letter of Final Determination (LFD) – The letter in which FEMA announces its final determination regarding the flood hazard information presented on a new or revised FIRM and FIS report, including (when appropriate) new or modified BFEs, base flood depths, SFHAs, zone designations, or regulatory floodways.

Levee – A manmade structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to reduce flood hazards posed by temporary flooding.

Levee Breach – A rupture, break, or gap in a levee system that causes flooding in the adjacent area and whose cause has not been determined.

Levee Failure Breach – A rupture, break, or gap in a levee system that causes flooding in the adjacent area and for which a cause of failure is both known and occurred without overtopping. An investigation is usually required to determine the cause.

Levee Overtopping – Floodwater levels that exceed the crest elevation of a levee system and flow into areas landward of the levee landward of the levee system.

Levee Overtopping Breach – A rupture, break, or gap in a levee system that causes flooding in the adjacent area and whose cause is known to be a result of overtopping.

Levee Owner – A Federal or State agency, a water management or flood control district, a local community, a levee district, a nonpublic organization, or an individual considered the proprietor of a levee.

Levee Reach – Any continuous section of a levee system to which a single analysis and mapping procedure may be applied.

Levee Saturation – Soil saturation that has occurred in an earthen levee because of floodwaters remaining above flood stage for extremely long periods of time. This condition can lead to catastrophic failure of the levee.

Levee System – A flood hazard-reduction system that consists 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**.**

LiDAR – An airborne laser system, flown aboard rotary or fixed-wing aircraft, that is used to acquire x, y, and z coordinates of terrain features that are both manmade and naturally occurring.

Local Levee Partnership Team – A work group that can be facilitated by FEMA when a non-accredited levee system in a community or project area will be analyzed and the areas landward of the levee system will be mapped. The primary function of this group is to share information/data and identify options based on stakeholder roles and knowledge.

Lowest Adjacent Grade (LAG) – The lowest natural elevation of the ground surface next to a structure.

Mitigation – A sustained action taken to reduce or eliminate long-term risk to people and property from flood hazards and their effects. Mitigation distinguishes actions that have a long-term impact from those are more closely associated with preparedness for, immediate response to, and short-term recovery from specific events.

Mitigation Planning– A ***process*** for State, local, and Indian Tribal governments to identify policies, activities, and tools to implement sustained actions to reduce or eliminate long-term risk to life and property from a hazard event. The mitigation planning process has four steps: (1) organizing resources; (2) assessing risks; (3) developing a mitigation plan; and (4) implementing the plan and monitoring progress.

National Elevation Dataset (NED) – The primary elevation data product of the U.S. Geological Survey. The NED is a seamless dataset with the best available raster elevation data of the conterminous United States, Alaska, Hawaii, and territorial islands.

National Flood Insurance Program (NFIP) – A voluntary federal program under which floodprone areas are identified and federal flood insurance is made available to the owners of the property in participating communities. The NFIP is Federal program created by Congress to mitigate future flood losses nationwide through sound, community-enforced building and zoning ordinances and to provide access to affordable, federally backed flood insurance protection for property owners. The NFIP is designed to provide an insurance alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods. Participation in the NFIP is voluntary and based on an agreement between local communities and the Federal Government that states that if a community will adopt and enforce a floodplain management ordinance to reduce future flood risks to new construction in Special Flood Hazard Areas (SFHAs), the Federal Government will make flood insurance available within the community as a financial protection against flood losses.

National Levee Database (NLD) - The focal point for comprehensive information about our nation's levees. Authorized by Congress in 2007, the database contains information to facilitate and link activities, such as flood risk communication, levee system evaluation for the National Flood Insurance Program (NFIP), levee system inspections, flood plain management, and risk assessments. The NLD continues to be a dynamic database with ongoing efforts to add levee data from federal agencies, states, and Tribes.

Non-Accredited Levee System – A levee system that does not meet the requirements spelled out in the NFIP regulations at Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations (44CFR65.10), *Mapping of Areas Protected by Levee Systems*, and is not shown on a FIRM as reducing the flood hazards posed by a 1-percent-annual-chance or greater flood.

Operating Guidance Documents – Documents issued by FEMA to assist FEMA Regions, CTP Program participants, and FEMA contractors in the effective implementation of various program elements associated with flood hazard mapping (and related NFIP products) and flood risk assessment. Operating guidance documents provide best practices for FEMA's Risk MAP Program. Operating guidance documents are posted on the FEMA Website

Participating Community – Any community (including any Indian Tribe, authorized tribal organization, Alaska Native village, or authorized native organization) that voluntarily elects to participate in the NFIP by adopting and enforcing floodplain management regulations that are consistent with the standards of the NFIP. The sale of flood insurance under the NFIP is authorized in a participating community.

Partnership Agreement – An agreement signed by FEMA and a community, regional entity, or State agency that wishes to participate in the FEMA Cooperating Technical Partners Program. The Partnership Agreement is a broad statement of principle, emphasizing the value of the NFIP's three components: insurance, floodplain management, and mapping.

Piping – The phenomenon where seeping water progressively erodes and washes away soil particles, leaving large voids in the soil. Removal of soil through sand boils by piping or internal erosion damages levees, their foundations, or both, which may result in settlement and has the potential to cause catastrophic failures of levees.

Ponding – The result of runoff or flows collecting in a depression that may have no outlet, subterranean outlets, rim outlets, or manmade outlets such as culverts or pumping stations. Impoundments landward of manmade obstructions are included in this type of shallow flooding as long as they are not backwater from a defined channel or do not exceed 3.0 feet in depth.

Post-FIRM Structure – A structure that was built after the first FIRM was adopted for the community in which the structure is located.

Preferred Risk Policy (PRP) – A flood insurance policy that offers low-cost coverage to qualified owners and tenants of eligible structures located in moderate-risk areas (i.e., Zone B, Zone C, Zone X, Zone X (shaded)) on the current effective FIRM.

Pre-FIRM Structure – A structure that was built before December 31, 1974, or before the first FIRM was adopted for the community in which the structure is located, whichever is later.

Preliminary FIRM – The NFIP map that reflects the initial results of a FEMA study/mapping or flood risk project. The Preliminary FIRM is provided to CEOs and FPAs of all affected communities before a 90-day appeal period is initiated.

Preliminary FIS Report – The report that reflects the initial results of a FEMA study/mapping or flood risk project. The Preliminary FIS report is provided to CEOs and FPAs of affected communities before the 90-day appeal period is initiated.

Preliminary Flood Hazard Information– The flood hazard information, including BFEs, base flood depths, SFHAs, and regulatory floodways that are shown on the Preliminary version of the FIRM and in the Preliminary FIS report before the 90-day appeal period begins.

Procedure Memorandum (PM) **–** A memorandum issued by FEMA to clarify mapping-related procedures, particularly procedures documented in FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners*.

Profile baseline – A horizontal distance along the Flood Profile as represented on the FIRM and shown in the Floodway Data Table. The profile baseline represents the distance between cross sections or nodes in a one-dimensional model. The profile baseline may be the same as the stream centerline, which is the channel configuration shown on the base map.

Provisionally Accredited Levee (PAL) – A designation for a levee system that FEMA has previously accredited with reducing the flood hazards associated with a 1-percent-annual-chance or greater flood on an effective FIRM, and for which FEMA is awaiting data and/or documentation that will demonstrate the levee system's compliance with the NFIP regulatory criteria cited at 44CFR65.10.

Public Sponsor – A public entity that is a legally constituted public body with full authority and capability to perform the terms of its agreement as the non-Federal partner of the U.S. Army Corps of Engineers for a project, and able to pay damages, if necessary, in the event of its failure to perform. A public sponsor may be a State, county, city, town, federally recognized Indian Tribe or

tribal organization, Alaska Native Corporation, or any political subpart of a State or group of states that has the legal and financial authority and capability to provide the necessary cash contributions and lands, easements, rights-of-way, relocations, and borrow and dredged or excavated material disposal areas necessary for the project.

Regional Offices (ROs) – The FEMA offices located in Boston, Massachusetts; New York, New York; Philadelphia, Pennsylvania; Atlanta, Georgia; Chicago, Illinois; Denton, Texas; Kansas City, Missouri; Denver, Colorado; San Francisco, California; and Bothell, Washington.

Regulatory Floodway – A floodplain management tool that is the regulatory area defined as the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the base flood discharge can be conveyed without increasing the BFEs more than a specified amount. The regulatory floodway is not an insurance rating factor.

Residual Flooding Area – The area of 1-percent-annual-chance flooding that is shown as an SFHA on a FIRM in the impacted area landward of an accredited or provisionally accredited levee system; the source of residual flooding is usually local drainage or flooding from a source that is not controlled by the levee system.

Risk Mapping, Assessment, and Planning (Risk MAP) Program – A program developed by FEMA to leverage the successes of earlier flood map modernization efforts and further enhance the usability and value of flood hazard mapping. The Risk MAP program combines flood hazard mapping, risk assessment tools, and mitigation planning into one seamless program. The intent of this integrated program is to encourage beneficial partnerships and innovative uses of flood hazard and risk assessment data in order to maximize flood loss reduction.

Sand Boils – The volcano-like cones of sand that that are formed on the landward side of a levee system when the upward pressure of water flowing through soil pores under a levee (underseepage) exceeds the downward pressure from the weight of the soil above it.

Seepage – See underseepage.

Scientific Resolution Panel (SRP) –A three- to five-member independent review body composed of technical experts that will review appeals of proposed flood hazard determinations. The panel members are experts in surface-water hydrology, hydraulics, coastal engineering, and other engineering and scientific fields that relate to the creation of FIRMs and FIS reports. The SRP process is managed by the National Institute of Building Sciences (NIBS), a non-profit organization independent from FEMA.

Scientifically Incorrect Information – The flood hazard information (including BFEs, base flood depths, SFHAs, and regulatory floodways) determined through analyses in which the methodologies used and/or assumptions made are inappropriate for the physical processes being evaluated or are otherwise erroneous.

Section 65.10 Requirements – The NFIP regulatory criteria for the evaluation and mapping of areas impacted by levee systems, which are published at Title 44, Chapter I, Section 65.10 of the Code of Federal Regulations.

Shallow flooding – Flat areas where a lack of channels prevents water from draining away easily. Shallow flood problems fall into three categories: sheet flow, ponding and urban drainage. For the

purposes of the NFIP, shallow flooding is distinguishable from riverine or coastal flooding because it generally occurs in area where there is no channel or identifiable flow path.

Soil Saturation – A condition in soil in which all spaces between the soil particles are filled with water. Such conditions normally occur after prolonged periods of rainfall and/or snowmelt.

Sound Reach – A reach that has been designed, constructed, and maintained to withstand the flood hazards posed by a 1-percent-annual-chance flood, in accordance with the standards in 44CFR65.10 of the NFIP regulations.

Special Flood Hazard Area (SFHA) – The area delineated on a FIRM as being subject to inundation by the 1-percent-annual-chance flood. SFHAs are determined using statistical analyses of records of riverflow, storm tides, and rainfall; information obtained through consultation with a community; floodplain topographic surveys; and hydrologic and hydraulic analyses.

Stillwater Flood Elevation – The projected elevation that floodwaters would reach in the absence of waves resulting from wind or seismic effects.

Structures – For floodplain management purposes, walled and roofed buildings, including gas or liquid storage tanks that are principally above ground, as well as manufactured homes. For flood insurance purposes, walled and roofed buildings, other than gas or liquid storage tanks, that are principally above ground and affixed to permanent sites, as well as manufactured homes on permanent foundations

Surge – The rise of the ocean surface that occurs in response to barometric pressure variations (the inverse barometer effect) and to the stress of the wind acting over the water surface (the wind setup component).

Underseepage – The upward pressure on the land landward of a levee system that is exerted by groundwater, under pressure from the flooding source, when the elevation of the floodwaters is higher than the elevation of the land.

Unnumbered A Zones – Flood insurance risk zones, designated “Zone A” on an FHBM or FIRM, that are based on approximate studies.

Water-Surface Elevations (WSELs) – The heights of floods of various magnitudes and frequencies in the floodplains of coastal or riverine areas, in relation to a specified vertical datum.

Wave – A ridge, deformation, or undulation of the water surface.

Wave Crest Elevation – The elevation of the crest of the wave.

Wave Height – The vertical distance between the wave crest and the wave trough.

Wave Runup – The rush of wave water up a slope or structure.

Wave Runup Depth – The vertical distance between the maximum wave runup elevation and the eroded ground elevation.

Wave Runup Elevation – The elevation, referenced to NGVD29, NAVD88, or other datum, reached by wave runup.

Wave Setup – The increase in the still water surface near the shoreline, due to the presence of breaking waves.

Zone A - Areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations (BFEs) or flood depths are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.

Zone A99 - Areas subject to inundation by the 1-percent-annual-chance flood event, but which will ultimately be protected upon completion of an under-construction Federal flood protection system. These are areas of special flood hazard where enough progress has been made on the construction of a protection system, such as dikes, dams, and levees, to consider it complete for insurance rating purposes. Zone A99 may only be used when the flood protection system has reached specified statutory progress toward completion. No Base Flood Elevations (BFEs) or depths are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.

Zone AE and A1-30 - Areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. Base Flood Elevations (BFEs) are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.

Zone AH - Areas subject to inundation by 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between one and three feet. Base Flood Elevations (BFEs) derived from detailed hydraulic analyses are shown in this zone. Mandatory flood insurance purchase requirements and floodplain management standards apply.

Zone AO - Areas subject to inundation by 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between one and three feet. Average flood depths derived from detailed hydraulic analyses are shown in this zone. Mandatory flood insurance purchase requirements and floodplain management standards apply. Some AO zones have been designated in areas with high flood velocities such as alluvial fans and washes. Communities are encouraged to adopt more restrictive requirements for these areas.

Zone AR - Areas that result from the decertification of a previously accredited flood protection system that is determined to be in the process of being restored to provide base flood protection. Mandatory flood insurance purchase requirements and floodplain management standards apply.

Zone B - Area of moderate flood hazard, usually depicted on Flood Insurance Rate Maps as between the limits of the 1-percent-annual-chance and 0.2-percent-annual-chance floods. B Zones are also used to designate base floodplains of little hazard, such as those with average depths of less than 1 foot.

Zone C - Area of minimal flood hazard, usually depicted on Flood Insurance Rate Maps as above the 0.2-percent-annual-chance flood level. B and C Zones may have flooding that does not meet the criteria to be mapped as a Special Flood Hazard Area, especially ponding and local drainage problems.

Zone D - Area of undetermined but possible flood hazard.

Zone V - Areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations (BFEs) or flood depths are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply

Zone VE and V1-30 - Areas subject to inundation by the 1-percent-annual-chance flood event with additional hazards due to storm-induced velocity wave action. Base Flood Elevations (BFEs) derived from detailed hydraulic analyses are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.

Zone X - Newer Flood Insurance Rate Maps show Zone C (see above) as Zone X.

Zone X (shaded) - Newer Flood Insurance Rate Maps show Zone B (see above) as Zone X (shaded)

Appendix C. Former Non-Accredited Levee System Evaluation and Mapping Approach

FEMA is replacing the former approach to evaluating levee systems and mapping areas landward of the levee that is specified in Appendix H of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (Guidelines and Specifications) (FEMA, 2003a). Under the former approach, when a levee system did not meet the National Flood Insurance Program (NFIP) requirements cited in the Code of Federal Regulations (CFR) at Title 44, Chapter 1, Section 65.10 (44CFR65.10), FEMA classified the levee system as non-accredited, which changed the extent of the flood hazards in areas landward of the levee on the Flood Insurance Rate Map (FIRM) as if the levee system did not divert the flow or impede the conveyance. In these instances, the FIRM did not reflect the levee system as providing any hazard-reduction unless portions of the levee system satisfied the regulatory requirements of 44CFR65.10 and were hydraulically independent of the portions of the levee system that did not meet the requirements of 44CFR65.10. This is then used as the basis for setting flood insurance rates under the NFIP and for flood plain management in these areas.

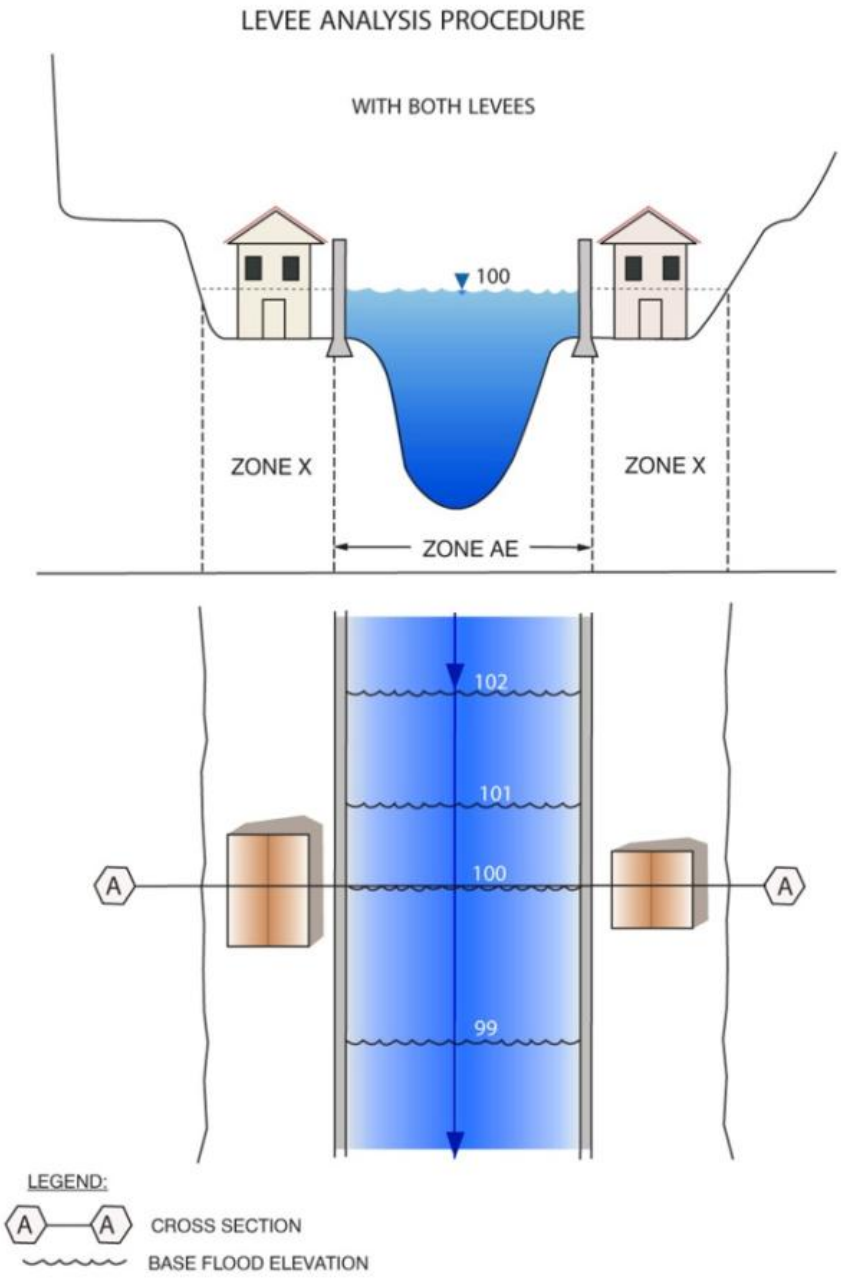
Use of the former approach to evaluate and map areas with non-accredited levees generated considerable concern from community and Tribal officials and their representatives in the U.S. Congress. Some believe the former approach to be too broad a stroke when determining an area's flood hazard. Therefore, in response to correspondence from the U.S. Congress, in March 2011, FEMA suspended the processing of all FIRMs and Flood Insurance Study reports for communities and Tribes with levee systems that could not be accredited because they did not meet the requirements of 44CFR65.10.

Because FEMA establishes and maps the 1-percent-annual-chance and 0.2-percent-annual-chance floods on FIRMs, a non-accredited levee system can only be considered as having no hazard-reduction under existing policies and procedures. However, FEMA recognized that even if a levee system cannot be accredited, it may still impede the flow of floodwater and have some impact on the flooding process,

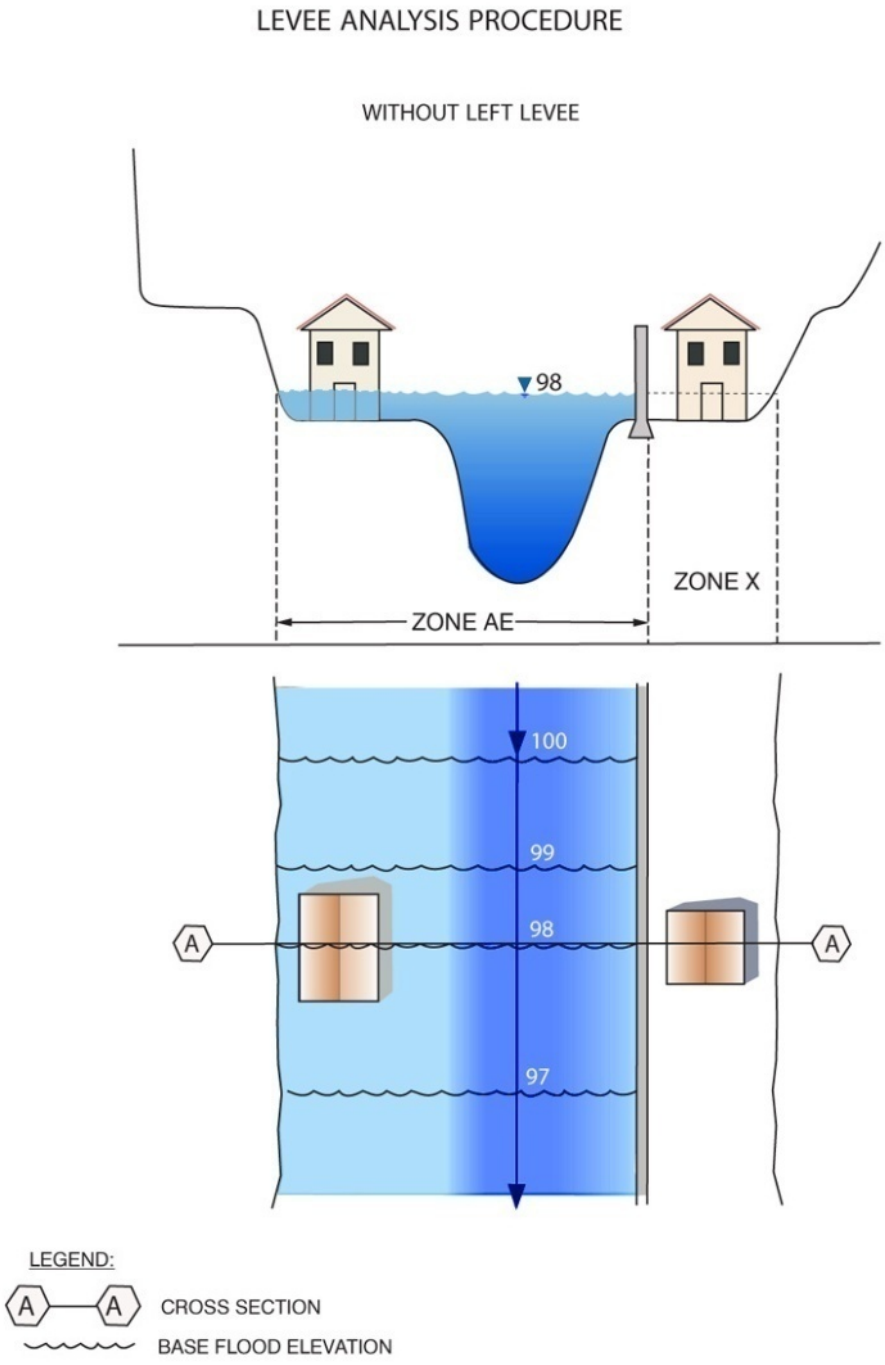
Below is a step-by-step graphical depiction of how FEMA typically mapped Base Flood Elevations (BFEs) and Special Flood Hazard Areas using the former approach when levees on both sides of a river or other flooding source could not be accredited with reducing the flood hazards posed by a 1-percent-annual-chance or greater flood.

Floodways under the former approach were determined using equal conveyance reduction based on the "without levee" condition and simultaneous failure when both sides had levees.

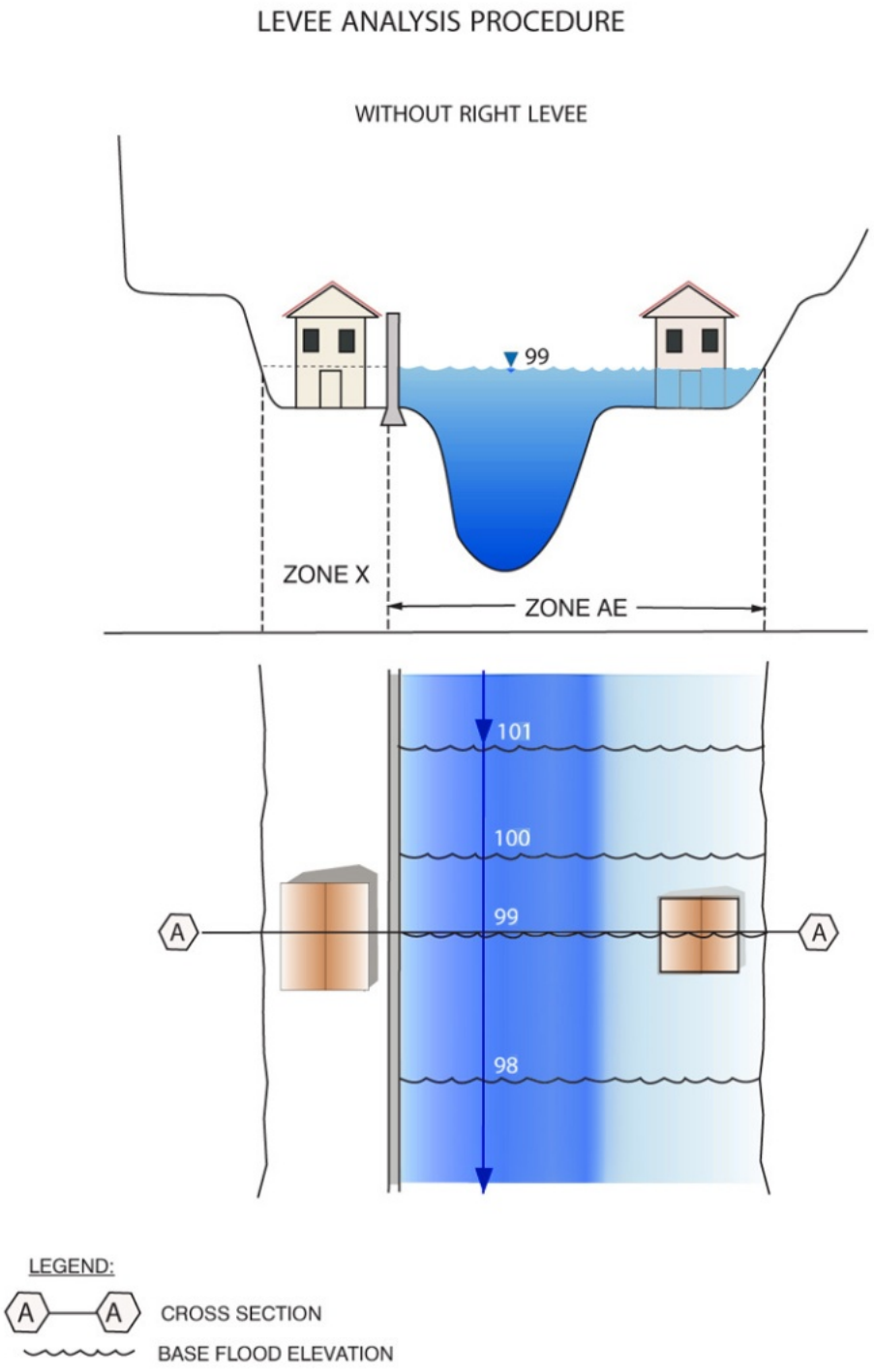
Step1: Compute the riverward BFE with both levees in place.



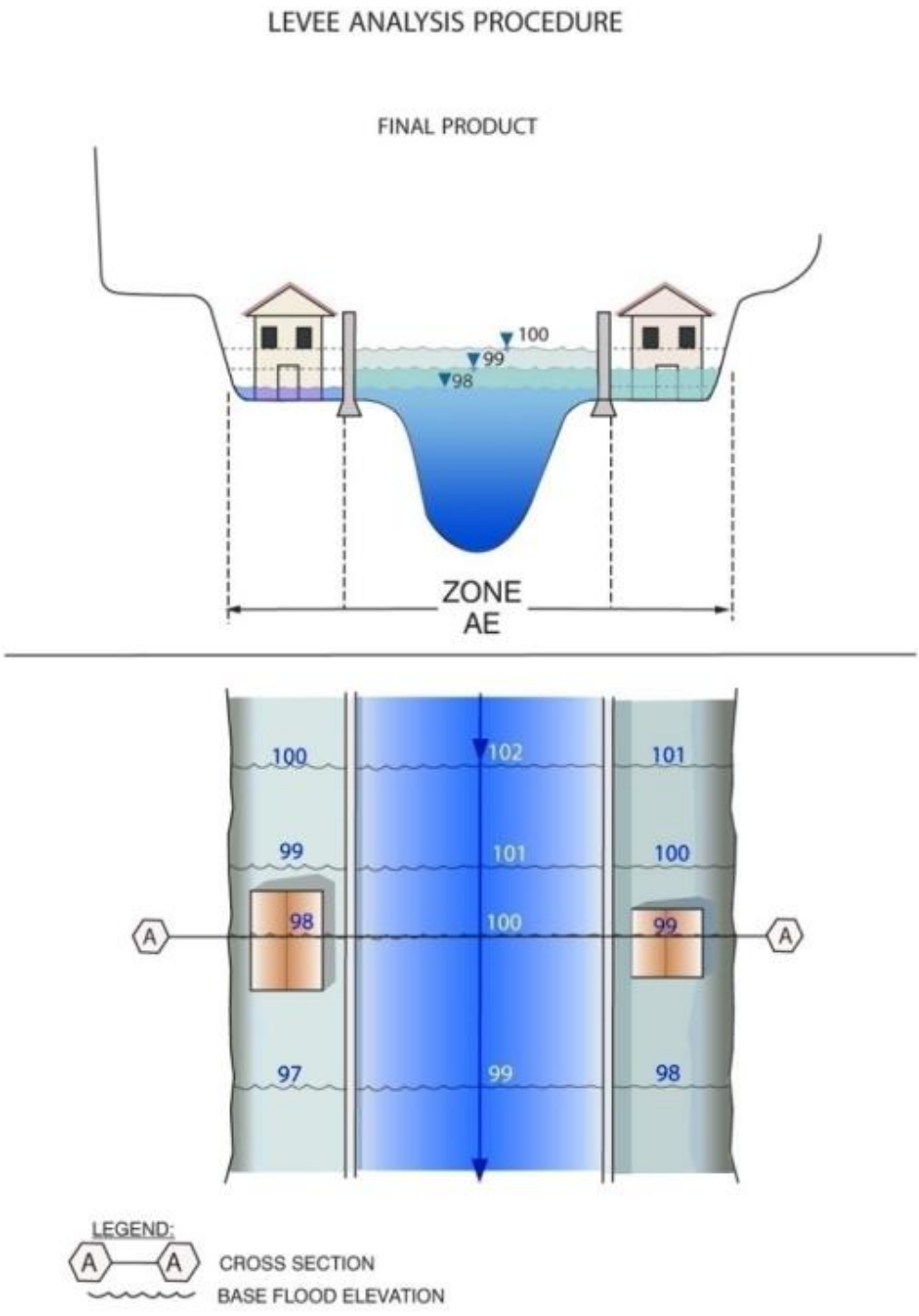
Step 2: Compute the left-side BFE by removing the levee on the left side of the river from the analysis.



Step 3: Compute the right-side BFE by removing the levee on the right side of the river from the analysis.



Step 4: Map the results of Steps 1, 2, and 3.



Appendix D. Section 65.10 of the NFIP Regulations

The National Flood Insurance Program (NFIP) regulatory criteria for the evaluation and mapping of areas protected by levee systems are presented in the Code of Federal Regulations at Title 44, Chapter 1, Section 65.10. These NFIP regulatory criteria are provided in their entirety below as they appear in the FEDERAL REGISTER.

Section 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 Sec. 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 Sec. 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.

Appendix E. Zone D

The National Flood Insurance Program (NFIP) defines Zone D as an area of possible, but undetermined, flood hazards. Historically, FEMA has used the Zone D designation in areas where a flood hazard analysis has not been completed. When analyzing and mapping areas landward of non-accredited levee systems, FEMA will use Zone D to designate the possible 1-percent–annual-chance flood inundation on Flood Insurance Rate Maps (FIRMs). Zone D will supplement the SFHAs developed through the procedure(s) applied to individual levee reaches. The size and location of the Zone D areas will vary and be based on the results of the composite SFHA analysis that results from the Natural Valley Procedure. The natural valley analysis is hydraulically modeled for riverine levee reaches by retaining the topographic features of the levee in the model, but allowing the discharge to flow on either side of the levee, assuming that the levee does not impede conveyance.

E.1. Flood Insurance in Zone D

Flood insurance is available in Zone D; however, properties located in Zone D areas are not subject to the federally mandated flood insurance purchase requirement. A lender may, however, require insurance coverage for properties located landward of levee systems regardless of the zone designation, as a condition of a loan.

E.2. Zone D Floodplain Management

It is important to note that FEMA views the analysis of the non-accredited levee systems as an intermediate step in the possible process leading to full levee accreditation. Because Zone D is not considered an SFHA, SFHA regulations do not apply. Floodplain management requirements are applied at the discretion of local officials as long as the community complies with the minimum standards of the NFIP regulations cited at 44CFR60.3(a).

The Zone D area landward of the levee system will be depicted on the FIRM with a different symbology than the traditional Zone D area. The Zone D landward of the levee system is to be accompanied by a note in the Notes to Users portion of the FIRM communicating the distinction between the two Zone D types. The differentiation between Zone D types will allow various stakeholders to identify Zone D areas landward of the levee system for use in determining flood insurance requirements, enforcing floodplain management and mitigation, and communicating risk.

If the community chooses to enforce elevation requirements in Zone D areas landward of the levee for new construction, local officials could require development to take place at a set height above grade, taking an approach similar to floodplain management in an SFHA with established Base Flood Elevations (BFEs). Tools that FEMA would make available to communities to aid in the enforcement of elevation requirements include flood depth grids and water-surface elevations derived from the Zone D natural valley analysis. These tools would provide flood depths and elevations to which a community could regulate new construction. The data could be provided to the community upon completion of the non-accredited levee analysis.