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Acronyms and Abbreviations

Acronym/Abbreviation	Spelled-Out Term
ASDSO	Association of State Dam Safety Officials
BFE	Base Food Elevation
BLM	U.S. Bureau of Land Management
BW12	Biggert-Waters Flood Insurance Reform Act of 2012
CCO	Consultation Coordination Officer
CEO	Chief Executive Officer
CFR	Code of Federal Regulations
CLOMR	Conditional Letter of Map Revision
CTP	Cooperating Technical Partners (Program)
DMA 2K	Disaster Mitigation Act of 2000
DOT	Department of Transportation
EAP	Emergency Action Plan
EM	Engineer Manual
ER	Engineering Regulation
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHBM	Flood Hazard Boundary Map
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FPA	Floodplain Administrator
GIS	Geographic information system
H&H	Hydrologic and hydraulic
HEC-ResSim	Hydrologic Engineering Center Reservoir Simulation System
HMP	Hazard Mitigation Plan
HOA	Homeowner's Association
IBWC	U.S. International Boundary and Water Commission
ICODS	Interagency Committee on Dam Safety
LOMR	Letter of Map Revision

Acronym/Abbreviation	Spelled-Out Term
MSHA	Mine Safety and Health Administration
NDSP	National Dam Safety Program
NDSRB	National Dam Safety Review Board
NEH	National Engineering Handbook
NFIP	National Flood Insurance Program
NID	National Inventory of Dams
NLD	National Levee Database
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRC	Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
O&M	Operation and maintenance
PMR	Physical Map Revision
Risk MAP	Risk Mapping, Assessment, and Planning
SFHA	Special Flood Hazard Area
SOW	Scope of Work
TMAC	Technical Mapping Advisory Council
TVA	Tennessee Valley Authority
U.S.	United States
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USC	United States Code
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WIIN	Water Infrastructure Improvements for the Nation Act
WSEL	Water-surface elevation

1.0 Overview

1.1 Introduction

This consolidated guidance document was prepared by FEMA, in support of the Risk MAP program, to promote sound and consistent implementation of National Flood Insurance Program (NFIP) regulations and mapping program standards that apply to dams/reservoirs and non-dam features.

From a FEMA flood mapping perspective, dams may be off-stream or function as obstructions located in the floodplain when they retain (or impound) floodwater by restricting outflow discharges to downstream areas. Dams may create a permanent water body or reservoir, or they may form a dry storage area used only for retarding floodwater.

For the purposes of this document, a non-dam feature is defined as a physical feature that is not designed, constructed, operated, maintained, or regulated as a flood-control structure, but may inadvertently confine flow during some flood events. Non-dam features (such as roadways and rail transit systems) cross the floodplain and restrict flow, creating incidental flood retention. They often are characterized by sizable embankments that function as dams. Some roadways are designed as dams and are subject to State dam safety regulations.

Canals that divert flow may include an embankment that is regulated as a dam or may serve as an obstruction in the floodplain that may function as a non-dam feature.

For purposes of this document, dams/reservoirs are human built as multi-purpose structures or for many primary uses, the most prominent being floodwater control, water supply, hydropower, irrigation supply, recreation, environmental protection, and firefighting. Dams may be subject to local, State, or Federal regulations. Federal agencies, such as the U.S. Army Corps of Engineers (USACE) and the U.S. Bureau of Reclamation (USBR), that own dams regulate their own dams. Several Federal agencies regulate non-Federal dams, such as the Federal Energy Regulatory Commission (FERC) and the U.S. Department of Labor, Mine Safety and Health Administration (MSHA) (mining dams). The Natural Resources Conservation Service (NRCS), which has designed thousands of dams in the United States (U.S.), does not own or operate dams. NRCS-designed dams are either privately owned and operated or are owned and operated by project sponsors, typically a quasi-governmental entity that is subject to State dam safety regulations.

Non-dam features, for the purposes of this document, may be subject to review and approval by local, State, and Federal government officials and agencies; however, they generally are not subject to permits to impound water. The non-dam features may be designed to pass a design flood frequency event based on varying flood hazards, risks, and economic criteria.

This document provides current information on the mapping of dams/reservoirs and non-dam features and associated flood hazards. This document captures current standards and practices and, therefore, does not address all topics related to the identification of flood hazards and risks associated with dams/reservoirs and non-dam features.

The primary audiences for this document are:

- Communities, regional entities, Tribal entities, and State agencies, including those participating in the Cooperating Technical Partners (CTP) Program, referred to as CTPs
- FEMA Project Teams that are formed to carry out Flood Risk Projects for FEMA Regional Offices in support of the Risk MAP program
- FEMA Regional Office and Headquarters staff
- Dam safety professionals, dam safety regulators, dam owners and operators, and various planners involved with dam safety-related efforts

The FEMA Project Teams often include representatives of the FEMA Risk MAP providers, referred to as Production and Technical Services, Community Engagement and Risk Communication, Customer and Data Services, and Program Management providers.

In this document, the use of "FEMA" refers collectively to FEMA Regional Office staff and FEMA Headquarters staff.

The guidance in this document emphasizes the Risk MAP program vision of collaborating with local, regional, State, and Tribal entities throughout a watershed or project area to deliver quality data that increase public awareness and lead to mitigation actions that reduce flood risk to life and property. To achieve this vision, FEMA transformed its historic documents for flood hazard identification and mapping efforts into a more integrated process of identifying, assessing, communicating, planning, and mitigating flood-related risks aligned with the Risk MAP vision.

To accomplish this process, the appropriate analyses, mapping, and communication of risk of dams/reservoirs and non-dam features is necessary throughout the Risk MAP Flood Risk Project lifecycle. FEMA has prepared this consolidated guidance document in keeping with the Risk MAP vision.

1.2 Objectives

This document provides guidance and recommendations on how to evaluate the impacts of flood-retarding structures (dams and non-dam features) and how to incorporate them in the Flood Insurance Study (FIS) Reports and on the Flood Insurance Rate Maps (FIRMs) produced under the Risk MAP program. The purpose of this document is to provide a consistent engineering approach to include dams and non-dam features on these FEMA regulatory products.

This document either updates or supersedes applicable guidance included in Appendix C, "Guidance for Riverine Flooding Analyses and Mapping," of Guidelines and Specifications for Flood Hazard Mapping Partners, dated November 2009. Refer to Subsection 1.5.1 for additional details regarding prior guidance.

1.3 Limitations and Constraints

The guidance document contains the following limitations and constraints:

- This document focuses on evaluating the impact of dams and non-dam features on the base (1-percent-annual-chance) flood for flood hazard mapping. Risk assessment concerning the possibility of a dam break is not considered.
- This document generally applies to steady-state hydraulic modeling related to developing Base Flood Elevations (BFEs) for Flood Risk Projects. FEMA is developing guidance for incorporating the flood-retarding effects of dams and non-dam features for use in unsteady-state and two-dimensional models; that guidance will be incorporated into this document when available.
- CTPs, Project Teams (FEMA, local and State providers that partner with FEMA to develop hydrologic and hydraulic [H&H] modeling and mapping, Risk MAP providers) can access the National Inventory of Dams (NID) database through USACE at https://nid.sec.usace.army.mil/ords/f?p=105:1 when conducting the Discovery Phase of a Flood Risk Project and performing the H&H analyses.
- FEMA should be consulted for guidance to address unique or unusual modeling of flood-retarding structures not clearly addressed in this document.
- This document is not intended to address the mandate of the Technical Mapping Advisory Council (TMAC), a Federal advisory committee established to review and make recommendations to FEMA, on matters related to the national flood mapping program authorized under the Biggert-Waters Flood Insurance Reform Act of 2012 (BW12) specifically related to levees and dams. TMAC recommendations will address the FEMA regulatory requirements for dams to comply with the following provisions of BW12:

  > "Section 100216 (A) (iii), (iv), and (v) authorized FEMA to identify, review, update, maintain, and publish National Flood Insurance Program Rate Maps with respect to areas of residual risk, including areas that are protected by levees, dams, and other flood control structures, including areas that could be inundated because of the failure of a levee, dam, or other flood control structure and the level of protection provided by flood control structures."

FEMA may amend this document in the future to include guidance on quantifying risk and the TMAC recommendations.

Subsection 1.4 provides guidance on when to evaluate the flood hazard reduction effects of dams and non-dam features and how to model and map the resultant flood elevations and floodplains.

1.4 Dams and Non-Dam Features (Flood-Retarding Structures to be Included)

The FEMA Project Officer, in consultation with Project Team partners and State agencies involved in the flood risk study process, will decide when and how to include the impacts of dams and non-dam features in the H&H modeling of flood hazards for Flood Risk Projects.

FEMA may consider the level of flood hazard reduction afforded by a dam or non-dam feature on the BFEs downstream of the dam or non-dam feature, as well as the aerial extent of the flood

hazard reduction when determining whether to include the flood hazard reduction in the modeling performed for the Flood Risk Project. FEMA also may consider the cost of modeling the hydrologic impacts of a dam or non-dam feature.

The Project Team should consider the technical guidance provided below in evaluating dams and non-dam features.

The flood-retarding effects (flow reduction to the downstream areas) of dams and non-dam features may be included in the Flood Risk Project if one of the following conditions is met:

- The dam is owned or operated by an agency or corporate entity (i.e., the Tennessee Valley Authority [TVA]) of the Federal Government and was designed or can provide a level of flood control for the base flood. This includes dams and dry flood-retarding structures with a primary function of providing flood reduction for the base flood, multipurpose dams with designed flood reduction for the base flood, and dams not designed for flood reduction that provide significant incidental floodflow reduction for the base flood. The determination of significant incidental floodflow reduction is based on impacts to the areal extent of downstream flood reduction and/or the BFE to downstream areas. Questions to be considered in the determination of significant incidental floodflow reduction include:
    - Does the floodflow reduction change the flood elevation of the base flood to the degree that it results in a BFE change shown on the FIRM?
    - Is the downstream stream reach with floodflow reduction limited in areal extent due to the influences of contributing sources of floodflows?
    - Is the base flood floodplain boundary shown on the FIRM that represents the floodflow reduction coincident with the base flood boundary without floodflow reduction at the scale of the FIRM?
- The dam is owned or operated by a government entity, such as a local or State government, or by a government-sanctioned publicly funded entity, such as a drainage and flood control district, watershed authority, or public water utility. The dam and/or dry flood-retarding features were designed with a primary function of providing flood hazard reduction for the base flood, are multipurpose dams with designed flood hazard reduction for the base flood, and/or are dams not designed for flood hazard reduction that provide significant incidental flood control for the base flood. The dam is compliant with all applicable regulations of the State or Federal agencies with review authority or regulatory authority to issue permits to operate and impound water and, if required, has a current permit with a State dam regulatory legislated dam safety program or a permit with FERC. Dams not subject to State or FERC regulations must have a documented structural stability analysis during the base flood (signed and stamped by a Professional Engineer) that states the dam will function during the base flood event and not fail. In addition, an operation and maintenance (O&M) plan is required.
- The dam is owned or operated by a non-government entity, such as a private dam owner or organization, or is a dam owned by a homeowner's association (HOA). The dam was designed with a function of providing flood hazard reduction for the base flood, is a multipurpose dam with designed flood hazard reduction for the base flood, and/or is a dam

not designed for flood hazard reduction that provides significant incidental flood control for the base flood. The dam owner provides a statement that the dam is compliant with all applicable regulations of the State or Federal agencies with regulatory authority to issue permits to operate and impound water and, if required, has a current permit with a State-legislated dam safety program or a permit with the FERC. Dams not subject to State or FERC regulations must have a documented structural stability analysis during the base flood signed and stamped by a professional engineer that states the dam will function during the base flood event and not fail. In addition, an O&M plan is required.

- The non-dam feature is a roadway, railroad, lock, gate, or other structure, such as an irrigation canal, that incorporates earthen embankments into the water conveyance system that restricts the base flood and provides incidental flood control effects. The following factors will be considered when determining whether to include the incidental flood control effects in the H&H modeling for a Flood Risk Project:
    - The feature does not overtop during the base flood unless designed with overtopping protection to guard against failures.
    - The feature was designed hydrologically and hydraulically in such a way that may have resulted in flood hazard reduction for structures, such as a roadway and conveyance structures designed per State Department of Transportation (DOT) guidelines or the guidance of the U.S. Department of Transportation Federal Highway Administration (FHWA) Publication No FHWA-HIF-12-026, Hydraulic Design Series Number 5. The feature also has a documented structural/ geotechnical stability analysis that shows it will not fail during the base flood event. Or, the FEMA Project Officer makes the case-by-case decision based on engineering judgement that certain features, such as multilane interstate highways, have sufficient mass, designed conveyance systems, or have historical information to impact the base flood for the anticipated duration of ponding.
    - A covenant or agreement has been exercised by the non-dam feature owner and the local government with jurisdictional authority under the NFIP that ensures that the conveyance system will not be enlarged, thus reducing the flood storage, unless mitigated, and thereby increasing the base flood discharge downstream.
    - The non-dam feature will be adequately maintained to ensure it will function as intended and as included in the H&H modeling. O&M plans for State-owned and operated roadways that are subject to system operation and maintenance are not required to be provided. For other private non-dam features, a covenant or agreement has been exercised by the non-dam feature owner and the local government with jurisdictional authority under the NFIP that ensures that the feature will be maintained by the local government if not maintained by the private owner.

For dam and non-dam features for which flood hazard reduction is included in the hydrologic analysis, the flood elevations downstream of the dam or non-dam feature will be established based on the attenuated floodflow. The flood elevations upstream of the dam or non-dam feature are to be established at the routed flood elevation. The regulatory floodway upstream of the dam or non-dam feature should be modeled consistent with Subsection 3.2, “Storage Considerations,” Floodway Analysis and Mapping, dated November 2016.

For all other structures that do not meet the previously mentioned conditions and for which flood hazard reduction is not included in the hydrologic analysis, the flood elevations are to be established as follows:

- The backwater effects upstream of the structure may be established based on the routed elevations from a hydrologic model unless no hydrologic model routing was performed or the structure overtops during the base flood. If no hydrologic model routing was performed or the structure overtops during the base flood, the backwater effects are to be established assuming the structure remains in place and the top of the structure functions as a weir.
- Flood discharge reduction downstream of the structure is not to be included in the hydraulic modeling.

1.5 Prior Guidance and Historical Practices

1.5.1 Prior Guidance

The consolidation of work that guided users through decades of dam-related procedures implemented during flood hazard mapping projects was incorporated into this document. This is intended to promote sound and consistent implementation of policies, regulations, and standards for dam-related flood hazard identification. This guidance enhances compliance with the NFIP regulations as cited in the Code of Federal Regulations (CFR) at Title 44, Chapter 1, Part 65 (44 CFR Part 65), incorporating portions of previous guidance documents and FEMA standards to facilitate implementation during Flood Risk Projects. FEMA has prepared this document to expand on and supersede guidance provided in the previously referenced Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix C, dated November 2009 and the following Risk MAP Flood Risk Analysis and Mapping guidance documents:

- Floodway Analyses and Mapping, Subsection 3.2, dated November 2016
- Base Flood Elevation Mapping Guidance, dated November 2014
- General Hydrologic Considerations, dated May 2016
- General Hydraulics Considerations, dated November 2016

More details for each superseded guidance document are provided in each chapter of this document.

This document supersedes any other existing dam guidance document for NFIP flood hazard mapping.

1.5.2 Historical Practices

Based on general program knowledge and past historical practices, most H&H models have been one-dimensional steady-state models. Hydrologic analysis performed using stream gage data or based on the statistical analyses of regional stream gage data has been preferred over more labor-intensive rainfall-runoff models. Still, many dams and non-dam features have been hydrologically modeled using rainfall-runoff models to reflect flood storage. The decisions to do so were made on a case-by-case basis by FEMA in consultation with a FEMA mapping provider.

Typically, if the dam or non-dam feature was considered to have a significant hydrologic effect on downstream areas and existing rainfall-runoff model data could be leveraged, the mapping provider modeled the dam or non-dam feature in the hydrologic rainfall-runoff model to derive peak discharges that were transferred and applied to the hydraulic model. For other, older cases, the mapping provider adjusted the hydrologic effect using a gage analysis or modified regression equation. For some lakes and reservoirs, the mapping provider used the flood elevation from the hydrologic routing at the dam, and generally the mapping provider hydraulically modeled the dam or non-dam feature as an obstruction in the floodplain. If the base flood overtopped the embankment, the mapping provider assumed the embankment would function as a weir, stay in place, and not fail, mapping the higher hazard by showing the backwater effect to upstream areas.

Generally, the downstream peak flows from the dam usually were handled in one of two ways (options):

- Option One. If the dam or non-dam feature likely would be overtopped or fail during the base flood event, the mapping provider set the downstream peak flows to the same peak flows entering the reservoir (no reduction of peak flows due to retention upstream of the structure). This option was used most often for non-dam features and dams that were not significantly related to the base flood event (smaller dams).
- Option Two. If the mapping provider determined (based on engineering judgement, design information, field reconnaissance, etc.) that the embankment would remain in place during the base flood event, was being properly maintained, and had an operation plan (if applicable) that provided for dedicated flood storage in the reservoir, then the mapping provider based the downstream flows on the routed outflow from the hydrologic model. This option was used less often because getting the certified engineering data to support this option was difficult if not impossible.

This document advises when the storage behind the non-dam feature should be included in the Flood Risk Project and how it should be modeled.

Historically, the needs and specifications for dams have been more stringent than for levees due to the typical use of dams. However, no previous national guidance has been available on how best to model dams. To better explain why this guidance is needed, specific examples of the differences between dams and levees are shown in Table 1.

Table 1: General Differences between Dams and Levees

Item Considered	Dams	Levees
Design Criteria	Dams are designed in general to a higher standard than levees.	Levee design is similar, but more simplified, because levees only hold back temporary flooding and generally are lower in height.

Item Considered	Dams	Levees
Freeboard	Freeboard is set by the design flood hydrographs that will affect the dam and reservoir and standard engineering practice as defined by State standards or, in the absence of State standards, by Federal publications such as the Design of Small Dams from the USBR; Chapter 4, "Hydrology," of the National Engineering Handbook from the NRCS; and other standards.	Freeboard requirements for NFIP accreditation are cited in the NFIP regulations at 44 CFR §65.10 and the standards provided in USACE Engineer Manual (EM) 1110-2-1913 and EM 1110-2-299.
Structural Requirements	Structural requirements generally are more stringent for dams due to higher embankment heights, often larger engineering loads to consider, and long-term saturation of the embankments.	Structural requirements are less stringent than dams because levee embankments are subject to shorter-term flood inundation and generally have lower embankment heights.
Original Design Intent	Dams are designed for multiple reasons, but can include providing storage for water supply, fire protection, power generation, and recreational uses. Dams may provide either designed or incidental flood control.	Levees are designed mainly to prevent temporary flooding of areas for agricultural purposes or flood hazard reduction, but usually are not designed to have any (planned or measurable) impact on downstream peak flows.
Regulatory Responsibility	For dams that meet the State criteria for regulation (usually set based on height and/or storage), States typically have authority for permitting; requiring or performing inspections; enforcing non-compliance; and regulating their construction, maintenance, operation, rehabilitation, alteration, repair and removal. Dams that are not subject to State regulatory requirements then may be the responsibility of the local government jurisdiction to comply with development or other permit requirements to protect the public. FEMA application forms for map revisions (MT-2 forms) will help identify dams falling under either the jurisdiction of the State or Federal agency, so that stakeholders can coordinate with the appropriate responsible agencies for design review, including H&H, structural, etc. For a dam not regulated by a Federal agency or State, FEMA would require the local government agency to perform a design review.	For levees to be accredited by FEMA, if they are designed and constructed by another Federal agency responsible for design and construction of levees, and they certify the levee meets 44 CFR §65.10 requirements, FEMA would accept their certification and map the areas landward of the levee as Zone X (shaded) and provide credit for the flood hazard reduction. For any other levees, a registered professional engineer is required to provide the 44 CFR §65.10 information, with FEMA, or their providers, reviewing the data for completeness.

1.6 Regulatory Requirements

FEMA has congressional authorizations related to dams as part of the NFIP, the National Dam Safety Program (NDSP), and BW12.

2.0 Key Definitions

2.1 General Definitions

Table 2 presents the key definitions used in this document. For a complete list of terms, see Section 6.0, Definitions.

Table 2: Definitions

Term	Definition
Dam	An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water.[1]
Non-dam feature	A physical feature that is not designed, constructed, operated, maintained, or regulated as a flood-control structure, but may inadvertently confine flow during some flood events. Non-dam features (such as roadways and rail transit systems) cross the floodplain and restrict flow, creating incidental flood retention.
Levee	Per 44 CFR §59.1, 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 to reduce flood hazards posed by temporary flooding.
Reservoir	A body of water impounded by a dam and in which water can be stored. In the case of mine tailings facilities, it can include the solids as well as the water retained.[1]

[1]Reference: Selecting and Accommodating Inflow Design Floods for Dams, FEMA P-94 (August 2013)

2.2 Dam versus Levee Definition

During a Flood Risk Project, the function and/or classification of a flood-control structure sometimes can be questioned. That is, does this structure qualify as a dam or levee under the NFIP flood hazard mapping program? When dams are built, auxiliary or appurtenant structures exist that could be considered a dam or a levee. If the structure is upstream in the reservoir area, within the pool, around the pool, etc., the FEMA Project Team should ask: Would this levee/embankment/dike/etc. exist if there was not a dam/reservoir? If the answer is yes, it is most likely a levee and should follow the guidance in Levees, which is accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage. If the answer is no, then it is associated with the dam that is enabling the reservoir pool to be used and/or it is needed for the reservoir regulation and should be managed as a dam.[1] Generally, that structure would follow the FEMA guidance for dams.

[1] Engineering Regulation (ER) 1110-2-1156. Engineering and Design, Safety of Dams—Policy and Procedures, U.S. Army Corps of Engineers, Washington, DC, 31 March 2014

When an assigned Project Team considers this guideline unclear or not applicable to a structure, that member should discuss the issue with the FEMA Project Officer. (See Table 1, General Differences between Dams and Levees, for more information on the design differences between dams and levees.)

3.0 Flood Hazard Study and Revision Process for Dams and Non-Dam Features

As part of the Risk MAP program, FEMA works with Federal, State, Tribal, and local partners across the nation to identify flood hazards and promote informed planning and development practices to help reduce flood risk. The Risk MAP program provides high-quality maps, information, and tools to better assess flooding risks, as well as planning and outreach support to help communities act to reduce (or mitigate) flood risk. Each Flood Risk Project or map revision process should be tailored to the needs and capabilities of each affected community and may involve different steps, products, and services.

The following subsections provide general descriptions of the flood hazard analysis and mapping study and map revision process that would apply to both dams and non-dam features. Details addressing the flood hazard analyses and mapping of dams and non-dam features are provided in Section 4.0 of this document.

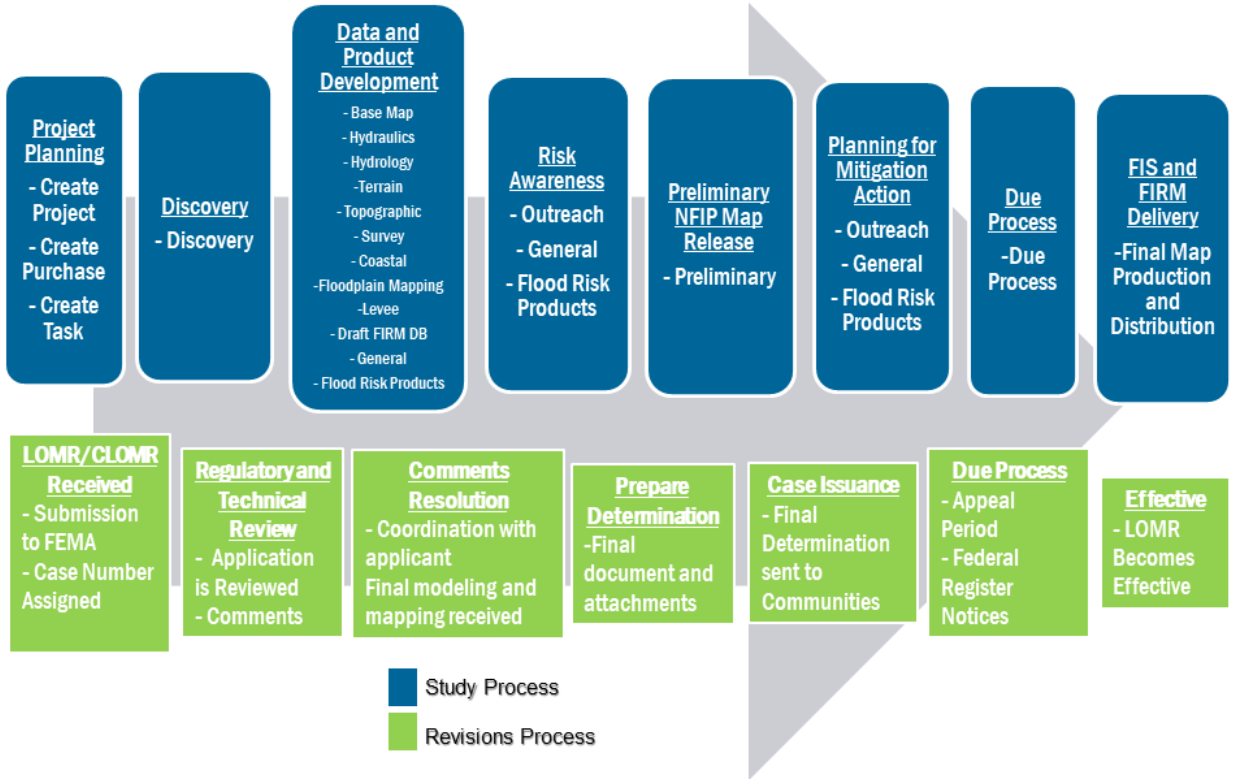
3.1 Flood Hazard Study Process

The flow diagram shown in Figure 1 provides an overview of the Risk MAP study process and the revisions process outlined in Subsection 3.2 of this document. During each phase, consideration and incorporation of data on dams or non-dam features will be evaluated. Dams or non-dam features within each phase of the study process are explained in more detail in the following subsections.

3.1.1 Project Planning

As part of the overall program planning effort, FEMA Regional Offices must develop and select individual projects that are aligned with and meet overarching program objectives. The presence of dams and non-dam features may impact the project scope of work. The FEMA Regional Office may select several project types to initiate. For example, to make progress toward deploying projects that deliver quality data, FEMA Regional Offices should consider how to annually initiate the appropriate quantities of flood hazard data updates to balance inventory decline with available resources and critical framework data (e.g., high-quality Light Detection and Ranging data).

Figure 1: Studies and Revision Business Flow Diagram



FEMA evaluates many other factors and data considerations to enable informed decisions to be made on project selection to achieve the program objectives. These factors help to organize the project planning and prioritization process into four major categories: Risk, Need, Equity, and Data. Dams and non-dam features contribute to these categories in the following ways:

- **Risk** - Consider the risk, defined generally as a probability of a threat/event times consequence. For example, consider the population below a dam. Larger population counts below the dam may increase project prioritization. Also, consider population growth, as this may require changes to the dam's hazard classification. If existing flood hazard analyses do not reflect current risks, then they need to be updated, which could increase project priority.
- **Need** - Consider Hazard Mitigation Plan (HMP) status, as areas with no HMPs, or with long-expired HMPs, may receive increased priority. These areas may not have key inputs needed to understand risk and act on it. Also consider the stream's New, Validated, and Updated Engineering status, as unverified streams increase project priority.
- **Equity** - Consider areas that do not have digital flood hazard data and place a higher priority on these areas. These areas may have dams to be considered.
- **Data** - Consider availability of quality data to contribute to the project. Higher priority project areas are those with unavailable quality data. Owners of dams may have H&H analyses available to enhance the flood hazard data.

Engagement with both internal and external stakeholders is strongly encouraged and is necessary to achieve success during the Project Planning Phase of a Flood Risk Project. While more thoroughly discussed in the Stakeholder Engagement Guidance: Project Planning and Discovery Process, specific partners to consider engaging for dam and non-dam features include:

- Dam owners and operators, which may include Federal agencies, State agencies, quasi-governmental organizations (i.e., watershed districts), HOAs, or private owner districts
- State dam safety officials
- FEMA NDSP personnel
- NFIP-participating communities
- Other watershed stakeholders

FEMA should initiate the contact with the owner of the dam. Then, upon mutual understanding, the FEMA Project Team can engage with the owner of the dam under the agreed-upon direction from the FEMA Project Officer. Successful stakeholder engagement during the Project Planning Phase should result in a clearer understanding of the project activities that a watershed/project area may benefit from most; a clearer understanding of State preferences and priorities for Risk MAP project scopes; and strengthened relationships, a sense of partnership, and shared objectives between FEMA and community officials.

3.1.2 Discovery

The Discovery Phase of a Flood Risk Project is essential to locating the dams or non-dam features (i.e., dams, roadway embankments, railroad embankments) that may potentially affect the flood risk in the study area. The features may be located within the watershed upstream or downstream of the study area. When a dam or non-dam feature is identified, the Project Team, led by FEMA, should engage stakeholders to collect applicable information, which may include, but is not limited to, the following:

- Dam Name and NID and/or State Dam Inventory ID number.
- Date of construction or major repair/rehabilitation, if known. If not known, document that it is unknown.
- Who owns the flood-retarding structure?
- What is the primary purpose of the dam? Is there documentation that it was designed for flood control?
- Is the structure regulated by the local, State, or Federal government?
- Does the structure have an O&M plan?
- Does the structure have a documented structural/geotechnical stability analysis associated with it?
- Do as-built plans exist?
- Do design H&H data/calculations/models exist? If a design H&H analysis does exist for the facility, then:

    - Does a computer model exist, such as the USACE Hydrologic Engineering Center Reservoir Simulation System (HEC-ResSim)?
    - Is the full operation plan of the dam with all the dependencies on the gate operations available to code into a model?
    - What is the typical pool history or an assumption of where to start the pool, based on a pool elevation below which the dam is required to keep?
- Does it overtop during the base flood event? If so, by how much does it overtop?
- What is the inflow design flood event for the dam?
- Does a base flood pool easement exist?
- Is it a regulated dam or a non-dam flood-retarding structure?
- Is the dam in sequence with other dams? If so, what are the names and NID ID or State ID of the other dams? Is there a watershed management plan for these sequenced dams?
- Is (are) the dam(s) mentioned in the current effective FIS Report or named on the current effective FIRM panel? Are they named as a dam or as some other name, such as a culvert?
- What is the hazard potential classification for the dam(s) within the NID and the State inventory database? Is there a difference in the classification between the NID database and the State inventoried database? If so, what is the difference and why?

Using the data collected above, the Project Team will assess the data for possible flood-retarding structures. Based on the specifics of each possible flood-retarding structure, the FEMA Project Officer will make an initial decision regarding the study approach for each dam and non-dam feature for inclusion in the Flood Risk Project. Possible study approaches include, but are not limited to, the following:

- A full enhanced study, including the hydrologic routing of flows through the structure and the hydraulic modeling of routed flows upstream and downstream of the facility.
- A study that does not include any hydrologic routing through the structure, but instead shows the structure as a hydraulic obstruction.
- A study that does not include any H&H calculations and ignores the presence of the structure. This study approach should only be applied to the following situations:
    - When preparing automated approximate studies where the work scope involves the exclusion of the hydraulic modeling of stream crossings.
    - When minor structures, such as footbridges, private roads, fords, and small embankment stream crossings, are deemed to not be hydraulically significant during a base flood event. In some cases, a dam or non-dam feature so significantly overtops during the peak of the base flood event that the existence of the feature does not have a noticeable effect on the water-surface elevation (WSEL).
- No study of the structure since the effective FIS Report and FIRM appropriately depicts the flood hazards and validity of the effective study.

For structures determined to be flood-retarding, the starting water surface for available storage may be based on a variety of data. For structures with a designed and documented flood control function, the starting WSEL for hydrologic routings may be set at the normal pool or based on the approved operation plan for the structure, whichever results in the higher hazard.

For dams with the primary function of water supply, energy generation, or other non-flood control purposes, the Project Team should set the WSEL for hydrologic routings based on the normal pool. If reservoir water level elevations are not available, the routings are to be started at the crest of the lowest overflow auxiliary or emergency spillway. In addition, the Project Team should review the O&M plans for these dams to determine what, if any, impact they may have on the flows.

Non-dam embankments with a standing water body may use the normal pool as the starting water surface elevation. For non-dam features that do not have a normal pool, the stage-volume rating curve is to be set based on the best topographic data available. If available, the Project Team must consider outlet structures in a hydrologic routing model.

4.3.3.3 Storm Duration

The Project Team should use an appropriate storm duration for the routings in the modeling in line with the FEMA guidance Hydrology: Rainfall-Runoff Analysis, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage. Each State dam safety regulatory agency or authority may have its own specific requirements that the Project Team should consult when determining storm duration.

4.3.3.4 Subbasin Computations

In hydrographs, the Project Team must include subbasin responses, which are outflows from subbasins as a function of time. The team will compute the subbasin responses in conjunction with infiltration as rainfall losses, rainfall data, time concentrations, input hydrographs if applicable, land use and soil types, or channel routings.

The Project Team must fully document the elevation-storage-outflow relationship if it is used, including sources of data on reservoir operation; the outlet structure; and methods, sources, and measurements of data used to define the relationship.

4.3.3.5 Hydrologic Review

The Project Team member that reviews hydrologic routing models for dams and non-dam features must comply with the quality control process specified in the FEMA technical guidance in General Hydrologic Considerations and Hydrology: Rainfall-Runoff Analysis, which are accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

4.3.4 Hydraulic Modeling

The Project Team will determine hydraulic effects of a dam or non-dam feature using a FEMA-approved model (https://www.fema.gov/hydraulic-numerical-models-meeting-minimum-requirement-national-flood-insurance-program). In addition, the team will use the hydraulic modeling guidance specific to dams discussed in Subsections 4.3.4.1 and 4.3.4.2.

4.3.4.1 Hydraulic Structures

The Project Team should compute flood elevations at the dam or non-dam feature through hydrologic routing.

For dams where the flood-retarding effects will be included in the hydraulic modeling, the regulatory floodway upstream of the dam will be coincident with the base flood pool elevation unless there is a more restrictive easement that the community and the FEMA Regional Office approve.

For dams where the pool is not protected by a permanent easement or a storage floodway, the Project Team must adjust the elevation-storage relationship for the flood-retarding pool in the hydrologic model to eliminate the storage volume in the floodway fringe. This modeling exercise will likely be an iterative process.

For dams where the flood-retarding effects (flow reduction to downstream areas) will be included in the hydraulic modeling, the Project Team should model the regulatory floodway downstream of the dam using the reduced flows.

4.3.4.2 Hydraulic Review

The Project Team member that reviews hydraulic models associated with dams and non-dam features must comply with the quality control process specified in the General Hydraulics Considerations, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage.

4.4 Floodplain/Floodway Mapping

If the Project Team determines that the floodplain/floodway boundaries need to be developed or revised, the team must follow the procedures listed in existing FEMA standards and current guidance documents, including (at the time of this publication) the following guidance documents, all of which are accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage:

- Mapping Base Flood Elevations on Flood Insurance Rate Maps
- Riverine Mapping and Floodplain Boundaries Guidance
- Floodway Analysis and Mapping

Special concerns related to the floodplain/floodway mapping around dams are fully documented by existing FEMA guidance and standards.

The Project Team should base floodplain and floodway analysis on the regulatory modeling scenario. For dams credited for flood storage, the regulatory floodplain mapping floodway analysis should be based on the reduced flows downstream. The storage area must be designated as a regulatory floodway.

4.5 FIRM and FIS Report Guidance

4.5.1 FIRM Panels

The Project Team should show and label all dams that are being modeled on the FIRM panels under development. For dams shown in the FIS Report on a Flood Profile, the labeled dam name and NID ID or State ID number must match what is shown on the Flood Profile. The dam name should be taken from the dam regulatory agency first, then from the NID second, as the State inventories generally are more accurate than the NID. The team should store modeled dam and non-dam features in the FIRM database, with the STRUCT_NM field correctly matching the Flood Profile in the FIS Report and the label on the FIRM Panel. The guidelines presented in the FIRM Panel Technical Reference, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage, should be followed for mapping of dam and non-dam features.

SFHAs upstream of a dam represent the base flood hazard and should be labeled with a BFE on the FIRM. These elevations may be represented as a static BFE value or stored within cross-section or BFE lines in the FIRM database.

4.5.2 FIS Report

The Project Team should list dams (with names, NID ID, and State ID) and non-dam features in the FIS Report regardless of their use in H&H modeling. Features not used for hydraulic modeling are to be listed in the Non-Levee Flood Protection Measures table, and the team should capture them in the FIRM database. Important dam-specific information to capture could include NID ID or a State-specific ID, the year built, length, height, storage volume, construction type, drainage area, Hazard Potential Class, etc.

Dams used in detailed hydrologic and/or hydraulic models should be represented on the Flood Profile or Summary of Non-Coastal Stillwater Elevations, as appropriate for the study reach. The dam name and ID on the Flood Profile should correspond to the FIRM and the FIRM database. The Project Team should include a description of how dams were modeled in the FIS Report. Refer to the guidelines presented in the FIS Report Technical Reference, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage, for specific formatting and usage.

Published sources of data for dam information used in the Flood Risk Project should be listed in the Bibliography and References section of the FIS Report.

4.5.3 Flood Risk Products

Dam-Specific Flood Risk Products have been developed to effectively communicate risk to a broad audience. FEMA and Project Team members should use discretion when considering whether to produce these dam datasets and where to apply them as part of a Flood Risk Project. Dam-Specific Flood Risk Datasets can increase the community's risk awareness and/or lead them to mitigation actions. However, multiple factors must be considered before including these datasets in the project. Refer to Dam-Specific Non-Regulatory Flood Risk Datasets, accessible through the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage, for specific usage of these non-regulatory products.

6.0 Definitions

Table 4 presents definitions of terms that are commonly used in the field of dam mapping and their definitions.

Table 4: Terms and Definitions

Term	Definition	Source
1-percent-annual-chance floodplain	The floodplain inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year.	Adapted from FEMA website https://www.fema.gov/flood-zones
1-percent-annual-chance flood	The flood having a 1-percent chance of being equaled or exceeded each year. The 1-percent-annual-chance flood also is referred to as the base flood or 100-year flood.	Adapted from FEMA website https://www.fema.gov/flood-zones
Acre-foot	A unit of volumetric measure that would cover 1 acre to a depth of 1 foot. It is equal to 43,560 cubic feet.	FEMA 148
Backwater	Backwater occurs when ineffective flow pools at the downstream end of incoming tributaries. Backwater from the receiving stream or other water body is represented as a static elevation at the downstream end of the profile. The backwater elevation is represented as a horizontal line using the applicable line type for each recurrence interval. The backwater is projected upstream until it intersects the corresponding modeled profile. If the receiving water body does not have a regulatory BFE, backwater is not displayed on the profile and a limit of study label is placed at the downstream location on the tributary where the approximate 1-percent-annual-chance profile would be greater than the tributary stream 1-percent-annual-chance profile and identified with a note reading "1-percent-annual-chance-backwater effects from [name of main stream]."	FEMA, Flood Profiles (November 2016)
Base Flood	The flood having a 1-percent chance of being equaled or exceeded in any given year.	44 CFR §59.1

Term	Definition	Source
Conveyance	The movement of a stream of water and/or other mobile substances from place to place.	Adapted from NRCS "Flow" https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/wapmctn6333.pdf
Covenant	An agreement, a legally binding contract	
Dam	An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water.	FEMA 148 and FEMA P-94
Dam failure	Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water or the likelihood of such an uncontrolled release.	Adapted from FEMA 148
Dam safety	The art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment.	Adapted from FEMA 148
Embankment	A raised structure of earth, rocks, or gravel, usually intended to retain water or carry a roadway.	USACE ER-1110-2-1156
Emergency Action Plan	A plan of action to be taken to reduce the potential for property damage and loss of life in an area affected by a dam failure or large flood.	FEMA 148
Erosion	The wearing away of a surface (bank, streambed, embankment, or other surface) by floods, waves, wind, or any other natural process.	FEMA 148
Flood Hazard Boundary Map	An official map of a community, issued by the Federal Insurance Administrator, where the boundaries of the flood, mudslide (i.e., mudflow), or related erosion areas having special hazards have been designated as Zones A, M, and/or E.	44 CFR § 59.1
Flood Insurance Rate Map	An official map of a community, on which the Federal Insurance Administration has delineated both the Special Flood Hazard Areas and the risk premium zones applicable to the community.	IS-9, Managing Floodplain Development Through the NFIP

Term	Definition	Source
Flood Insurance Study Report	A report published by FEMA for a community in conjunction with the community's FIRM. The report contains background data that includes the base flood discharges and WSELs that were used to prepare the FIRM.	Adapted from IS-9, Managing Floodplain Development Through the NFIP
Flood Retention	The storage of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel.	Adapted from FEMA 148 “Flood Storage”
Floodplain	An area adjoining a body of water or natural stream that may be covered by floodwater. Also, the downstream area that would be inundated or otherwise affected by the failure of a dam or by large floodflows. The area of the floodplain is generally delineated by a frequency (or size) of flood.	Adapted from FEMA 148
Freeboard	A factor of safety usually expressed in feet above a flood level for purposes of floodplain management. “Freeboard” tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge openings, and the hydrological effect of urbanization of the watershed. At times, overbuild to account for long-term settlement and incrementing the height to ensure maintenance access during flood events is referred to as freeboard as well. For dams and purposes of the NFIP, this is the vertical distance between a specified stillwater (or other) reservoir surface elevation and the top of the dam, without camber.	Adapted from Levees and FEMA 148

Term	Definition	Source
Hazard Potential	The possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or misoperation of the dam or appurtenances. Impacts may be for a defined area downstream of a dam from floodwaters released through spillways and outlet works of the dam, or from waters released by partial or complete failure of the dam. An area upstream of the dam also may be impacted by the effects of backwater flooding or landslides around the reservoir perimeter.	Adapted from FEMA 148
Hydraulic Analysis	An engineering analysis of a flooding source carried out to determine how floodwaters will move within the system in response to differing discharge quantities.	Levees
Impoundment	Body of water created by a dam or non-dam feature.	USBR Glossary, https://www.usbr.gov/library/glossary
Lake	A water-filled basin with restricted or no outlet. Includes reservoirs, tidal ponds, and playas.	NRCS, https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/wapmctn6333.pdf
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 to reduce flood hazards posed by temporary flooding.	44 CFR § 59.1
Mapping Partner	A local, State, or regional entity (e.g., participating NFIP community, State agency/authority, local or regional conservation district, regional watershed entity, or CTP) that has established a relationship and agreement with FEMA to be a more active participant in the FEMA flood hazard mapping program and take on responsibility for development of Flood Hazard Risk Products in partnership with FEMA (.	

Term	Definition	Source
National Inventory of Dams (NID)	An inventory that contains information on more than 90,000 dams throughout the U.S. that are more than 25 feet high, hold more than 50 acre-feet of water, or are considered a significant hazard if they fail. The NID is maintained and published by USACE with information from all 50 States, Puerto Rico, and 16 Federal agencies. The NID is available at: https://nid.sec.usace.army.mil	Adapted from USACE ER1110-2-1156
National Levee Database (NLD)	A dynamic, searchable inventory of information, developed by USACE in cooperation with FEMA, is for all levee systems in the U.S. The NLD contains information to facilitate and link activities, such as flood risk communication, levee system evaluation for the NFIP, levee system inspections, floodplain 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.	Levee Guidance
Non-Dam Feature	A physical feature that is not designed, constructed, operated, maintained, or regulated as a flood-control structure, but may inadvertently confine flow during some flood events. Non-dam features (such as roadways and rail transit systems) cross the floodplain and restrict flow, creating incidental flood retention.	
Regulatory Floodway	The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water-surface elevation more than a designated height.	44 CFR § 59.1
Reservoir	A body of water impounded by a dam and in which water can be stored. In the case of mine tailings facilities, it can include the solids as well as the water retained.	FEMA P-94

Term	Definition	Source
Residual Risk	The risk that remains after all mitigation actions and risk reduction actions have been completed. With respect to dams, FEMA defines residual risk as “risk remaining at any time” (FEMA, 2015, page A-2). It is the risk that remains after decisions related to a specific dam safety issue are made and prudent actions have been taken to address the risk. It is the remote risk associated with a condition that was judged to not be a credible dam safety issue.	USACE ER-1110-2-1156
Risk	The product of the likelihood of a structure being loaded, adverse structural performance (e.g., dam failure), and the magnitude of the resulting consequences.	High Hazard Potential Dams Notice of Funding Opportunity for FY 2019
Risk Assessment	A broad term that encompasses a variety of analytic techniques that are used in different situations, depending on the nature of the risk, the available data, and needs of decision makers. A risk assessment is a systematic, evidence-based approach for quantifying and describing the nature, likelihood, and magnitude of risk associated with the current condition and the same values resulting from a changed condition due to some action. Risk assessment includes explicit acknowledgment of the uncertainties in the risk. As applied to dam safety, the process of identifying the likelihood and consequences of dam failure to provide the basis for informed decisions on a course of action.	USACE ER-1110-2-1156

Term	Definition	Source
Special Flood Hazard Area	The land in the floodplain within a community subject to a 1-percent or greater chance of flooding in any given year. The area may be designated as Zone A on the FHBM. After detailed ratemaking has been completed in preparation for publication of the FIRM, Zone A usually is refined into Zones A, AO, AH, A1-30, AE, A99, AR, AR/A1-30, AR/AE, AR/AO, AR/AH, AR/A, VO, or V1-30, VE, or V. For purposes of these regulations, the term "special flood hazard area" is synonymous in meaning with the phrase "area of special flood hazard."	Adapted from 44 CFR § 59.1, "Area of special flood hazard"
State	Any State of the United States, the District of Columbia, Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.	44 CFR § 59.1
State Dam Safety Agency	A State agency that has regulatory authority over the safety of non-Federal dams.	33 USC § 467(14)
Storage	The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel.	FEMA 148
Watershed	The area drained by a river or river system or portion thereof. The watershed for a dam is the drainage area upstream of the dam.	FEMA 148

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Related Templates Associated with this Guidance

The following templates will help practitioners comply with the guidance contained in this document and will help with overall Risk MAP program consistency. When they have been reviewed and comments have been addressed, the templates will be stored individually on the fema.gov Flood Risk Analysis and Mapping webpage under the "Templates and Other Resources" link (http://www.fema.gov/media-library/assets/documents/32786?id=7577). They are merely provided here to aid in the consolidation of review comments to one document.