



Considering the Residual Risk from Dams in Flood Risk Products

During a flood mapping project, to properly assess and communicate a complete view of the flood risk both upstream and downstream of a dam, it is critical to consider the effects of dams and their associated residual risk. Many large reservoirs are operated with outflow controls that include gates to regulate the flow through outlet structures. They are typically operated according to established rules determined by the relationship between inflow, outflow, storage, and water demand. The primary purpose of approximately 16,000 dams out of the 90,000+ dams in the National Inventory of Dams is flood control. However, dam outlet control structures can affect flow rates downstream regardless of the dam's purpose. Even when dams perform as they are designed, there will always be a level of flood risk remaining, or "residual risk." For example, a storm event that is more severe than the design-storm can result in overtopping, inundation upstream of the dam, or failure of the dam or spillway, potentially resulting in rapid water release.

RISKS IN DESIGNED OPERATION: In August 2017, in the midst of the rainfall associated with Hurricane Harvey, the U.S. Army Corps of Engineers (USACE) was faced with the decision of whether to release water from the Addicks and Barker dams due to rapidly rising water elevations. If they did not release storage from the dams, the volume of uncontrolled water around the dams would be higher and increase the risk to surrounding communities. With confidence that the structures would continue to perform as designed, the USACE coordinated floodwater releases with the Harris County Flood Control District. Even though dam failure was not an immediate concern, communities both upstream and downstream of the dam were at risk.

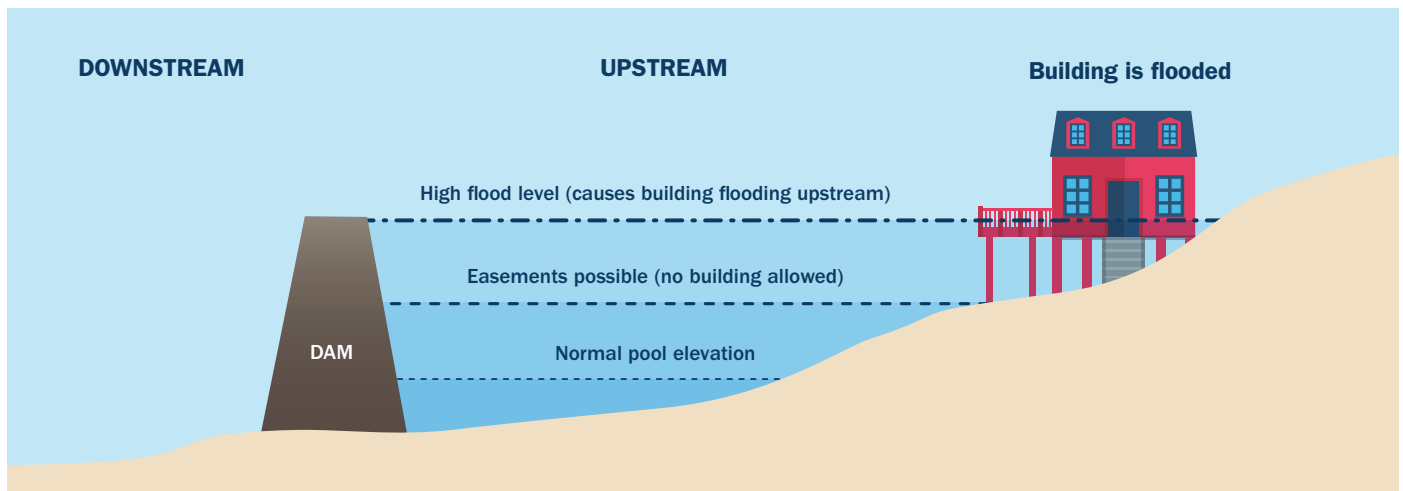
WHAT IS A DAM?

Though Federal, State, and local dam safety partners may define a dam a bit differently, FEMA defines a dam as "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)

FORMS OF RESIDUAL RISK: As a dam reaches capacity, areas upstream of the dam can become inundated and pose a risk to the communities there. Spillway releases can pose a "non-breach risk," which is the risk of flooding due to spillway flow without a breach of the dam, or the risk due to overtopping without breach of the dam structure. For example, in 2016 during Hurricane Matthew in North Carolina, local governments coordinated evacuations downstream of the Lake Wilson Dam, which was overtopping and releasing water at an uncontrolled rate. Despite that uncontrolled release, the dam structure was not breached.

Downstream, rapid flow changes and sudden flooding conditions can occur because of "incremental risk," or the risk associated with dam breach, overtopping and breach, and dam component malfunction or faulty operation.

Each dam is a unique structure and has potential impacts upstream and downstream of the dam. If the outlet control structure is not accounted for in the mapping and the structure is designed to route the 1-percent-annual-chance flood event without overtopping, the flood risk may not be properly represented, either upstream or downstream, based on the assumptions made. If the dam outlet structure is not designed to route the 1-percent-annual-chance flood event and the dam would likely fail catastrophically during such an event, the floodplain would be affected both upstream and downstream. These modeling assumptions should be used to determine the residual risk related to dams and be reflected in the resulting flood mapping products.



FLOOD MAPPING CONSIDERATIONS: To properly assess hazards as a part of a Risk Mapping, Assessment, and Planning (Risk MAP) project, it is important to account for the effects dams could have on the hydraulic and hydrologic assumptions within a flood hazard analysis or product, and to seek information within the Risk MAP flood risk products on the risk posed by dams. Review the Operation and Maintenance Plan for the dam, if available. If the plan shows that the dam would fail at a certain water-surface elevation or that the dam provides storage up to the 1-percent-annual-chance flood event, it is taken into consideration during flood modeling. If no Operation and Maintenance Plan is available, engineering judgement should be used to evaluate the dam's performance.

Standard practices adjust over time: the Biggert-Waters Act (2012) changed requirements for Flood Insurance Rate Maps (FIRMs) with respect to areas of residual risk associated with dams, levees, and other flood hazard reduction structures.* Flood Risk Products may also reflect information related to residual risk, but these products are not required to be used and are purely voluntary for those communities that wish to use them. If a community is concerned about residual risk issues (such as a high flood level in a lake that affects upstream properties), Flood Risk Products provide an opportunity to visualize and communicate that risk.

FLOOD RISK PRODUCTS: FEMA's Flood Risk Products were introduced as part of the Risk MAP program to assist in the mitigation of flood risk. They can help communities and local officials better understand their flood risk and prompt people to consider their level of risk (low, moderate, or high), instead of simply being identified as "in" or "out" of a Special Flood Hazard Area. Residual risk for dams can be collected and included in these products through coordination with the State dam safety program and the local community, and that information can help inform planning efforts related to dams. Dam safety is a shared responsibility; State and local officials can use these plans to better prepare for and mitigate against residual risk from dams and then respond to and recover more effectively from the effects should they fail.

The Flood Risk Database (FRD) product is the primary collection of dam-specific information for a given area or watershed. The FRD Technical Reference provides additional information on these items and the FRD overall. Flood Risk Products are intended to help people visualize flood risk differently than on the traditional FIRM, but all FRD raster datasets must align with the model information used to develop the associated regulatory products. All other FRD database elements must align with regulatory products if they are developed from them.

Two optional Flood Risk Products, the Flood Risk Map (FRM) and Flood Risk Report (FRR), are flexible and can be customized to meet the needs of stakeholders. Refer to their respective guidance documents for additional information on how to include this information.

*Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures, FEMA P-946

REFERENCES:

[FEMA DR-SC-4241 South Carolina White Paper on Dam Risk \(2015\)](#)

[FEMA P-1090 Hurricane Matthew in North Carolina Dam Risk Management Assessment Report \(2017\)](#)

[FEMA P-1069 National Dam Safety Program Fact Sheet \(2015\)](#)

[FEMA P-1025 Federal Guidelines for Dam Safety Risk Management \(2015\)](#)

[FEMA Flood Risk Database Technical Reference \(2018\)](#)

[FEMA Guidance: Flood Risk Database \(2018\)](#)

[FEMA Guidance: Flood Risk Map \(2018\)](#)

[FEMA Guidance: Flood Risk Report \(2018\)](#)

[USACE 1110-2-1156 Safety of Dams – Policy and Procedures \(2014\)](#)

[USACE “Corps Releases at Addicks and Barker Dams to Begin”](#)

[National Inventory of Dams Website](#)

[Association of State Dam Safety Officials \(damsafety.org\)](#)

[FEMA Dam Safety Fact Sheets 1, 3, and 4 of 4 by Region IV](#)

[FEMA Technical Advisory 2: Risk Exposure and Residual Risk Related to Dams - North and South Carolina; Hurricane Matthew DR-4285 and DR-4286](#)

[FEMA Dam Safety Fact Sheet Series \(8 fact sheets total\)](#)



This Dam Safety Fact Sheet was developed by FEMA Region IV.