Extension
UNIVERSITY OF WISCONSIN–MADISON

# 2018 Dam Failures in the Coon Creek and West Fork Kickapoo Watersheds in Southwestern Wisconsin

**A Summary of NRCS Technical Reports**

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## *Purpose and Context*

This summary provides an overview of the condition, performance, and safety concerns of the flood-control dams in the Coon Creek and West Fork Kickapoo Watersheds, drawing on recent Natural Resources Conservation Service (NRCS) technical investigations and planning documents to highlight factors affecting their future safety and management. This summary is largely based on official NRCS project documents developed in collaboration with local partners:

- **NRCS (2024).** Final Watershed Plan – Programmatic Environmental Impact Statement. U.S. Department of Agriculture, Natural Resources Conservation Service.
- **NRCS (2023).** Cultural resource investigations for the West Fork Kickapoo River Watershed in Monroe and Vernon Counties, Wisconsin (Technical Memo No. TM2023-0494; UWM-CRM Project No. 2023-0292). U.S. Department of Agriculture.
- **NRCS (2019).** Investigation Report for Coon Creek Watershed Structures 21, 23, and 29, and West Fork Kickapoo Watershed Structures Mlsna and 1. U.S. Department of Agriculture, Natural Resources Conservation Service.

These sources include detailed hydrologic and geologic analyses, breach investigations, engineering assessments, and planning information that collectively document past and existing conditions, the 2018 dam failures, and future hazards under evolving climate and rainfall conditions. In addition to these sources, this summary includes additional hydrologic and engineering judgements from its authors.

## *Key Takeaways*

- The 2018 flood event in the Coon Creek and West Fork Kickapoo watersheds showed that a short-lived very intense rainstorm can rapidly create high-risk conditions at multiple dams at the same time.
- Even when a dam does not immediately break, extreme flows and overtopping can place major stress on the dam's structures. Aging infrastructure and geologic weaknesses increase the risk that a dam could be damaged or fail once it is pushed beyond its capacity to safely pass flow. Geologic weaknesses can threaten dam stability on their own, even during less extreme events.
- Updated rainfall analyses indicate that storms once considered unusually large are becoming more likely, meaning dams in the Coon Creek and West Fork Kickapoo watersheds are increasingly likely to experience inflows beyond their original design assumptions.
- During moderate floods, dams may reduce peak flows downstream, and removing a dam could cause modest increases in natural flood peaks. However, during rare extreme floods, a dam breach can produce a sudden, damaging surge that may be more severe than natural flooding.
- Overall, the watershed-scale evaluation finds that selective decommissioning provides the strongest long-term public safety benefit in the Coon Creek and West Fork Kickapoo watersheds, and that proactive actions can reduce risks to downstream communities.

## *Key Terms*

- **Breach:** a failure where a section of the dam erodes or collapses, allowing stored water to escape rapidly and uncontrollably.
- **Earthfill dam:** a dam constructed primarily from compacted soil rather than concrete, making it more vulnerable to erosion when uncontrolled water flows over or through it.
- **Emergency (auxiliary) spillway:** a secondary overflow channel intended to carry water only during very large floods when the principal spillway cannot pass incoming flows.
- **Filter:** a layer of engineered material within a dam designed to allow water to pass through while preventing soil from being carried out, helping reduce the risk of internal erosion.
- **Geologic vulnerability:** weaknesses in the foundation or surrounding rock and soil that can allow water to erode or undermine the dam.
- **Grout curtain:** a subsurface barrier created by injecting grout into cracks or voids in bedrock or soil beneath or alongside a dam to reduce seepage and strengthen the foundation.
- **Hydrologic failure:** situations where floodwaters exceed the dam's ability to safely pass water through its spillways.
- **Internal erosion:** a process where flowing water gradually removes soil from within the dam or its foundation, potentially leading to sudden failure.
- **Overtopping:** when water flows over the top of the dam rather than through a designed spillway, creating a high risk of erosion and damage.
- **Principal spillway:** the dam's main outlet structure, designed to safely release water during typical floods.
- **Seepage:** the movement of water through the dam or its foundation, which can weaken materials and contribute to erosion if not properly controlled.
- **Structural failure:** physical damage to the dam itself, such as erosion, cracking, or collapse.

## *History of the Dams*

In the late 1950s, federal and local partners began constructing a series of flood-control dams across the Coon Creek and West Fork Kickapoo Watersheds. By the early 1970s, 23 structures—14 in Coon Creek and 9 in West Fork Kickapoo—had been completed under the PL-566 Watershed Protection and Flood Prevention Program to protect farmland and downstream communities from recurring floods (Figure 1). These projects were a continuation of major soil and water conservation efforts in the region dating back to the original Coon Creek Demonstration Project, a nationally significant watershed management initiative. The dams were designed and permitted as Low Hazard structures, consistent with the rural land uses and limited downstream development at the time of construction. The structures were planned with a functional life of approximately 50 years. Now more than six decades later, most dams have exceeded that intended service life. In addition, development and infrastructure growth downstream since the 1960s mean that consequences of failure are now greater in many cases.

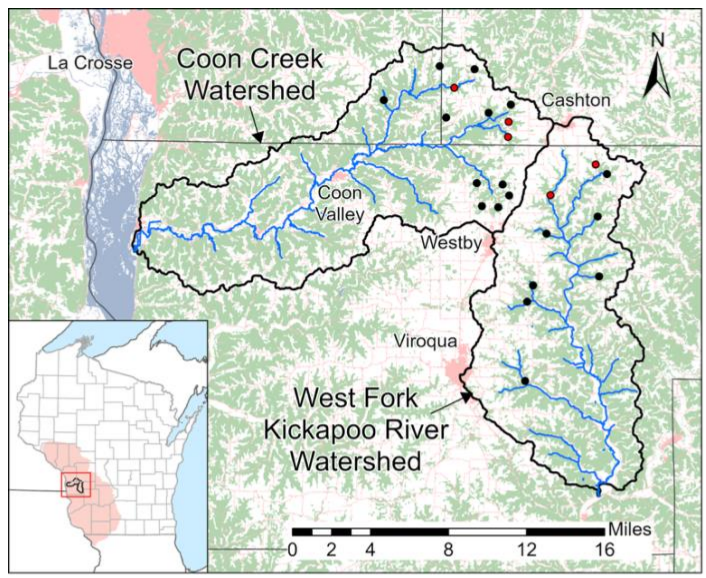


**Figure 1.** The Coon Creek and West Fork Kickapoo watersheds and the locations of dams (filled circles). Dams that failed during the 2018 flood event are shown as red circles.

## *Known Vulnerabilities Prior to 2018*

Before 2018, multiple performance concerns had been identified. The dams had operated far beyond their intended service life, and their design reflected standards and watershed conditions of the early 1960s. Several issues contributed to increased vulnerability:

- **Aging infrastructure:** Original design assumptions and materials have degraded over more than 60 years in service.
- **Geologic concerns:** Foundation seepage and springs were documented at multiple West Fork Kickapoo dams, leading to grout curtain installations and continued monitoring of abutment stability (Figure 2).
- **Internal erosion risk:** Filter and drain systems predate modern criteria and may not provide adequate protection against internal erosion under high hydraulic stress.
- **Hydrologic undersizing:** Principal spillways were designed for approximately 4.6 inches (Coon Creek) and 3.9 inches (West Fork Kickapoo) of rainfall in six hours—estimates considered ~50–100-year storms based on mid-20th-century rainfall science.

**Figure 2.** Close-up of exposed bedrock at the right abutment of West Fork Kickapoo Dam 1 after the dam failed during the 2018 flood. Fractures in the bedrock and large exposed cavities show geological weaknesses in the dam foundation and provide an example of geological problems present at failed dams in the watershed (NRCS, 2019).

- **Earthen emergency (auxiliary) spillways:** Emergency spillways were constructed as unarmored soil channels (e.g., not concrete-lined), making them inherently vulnerable to rapid erosion if heavily engaged during extreme floods (Figure 3).

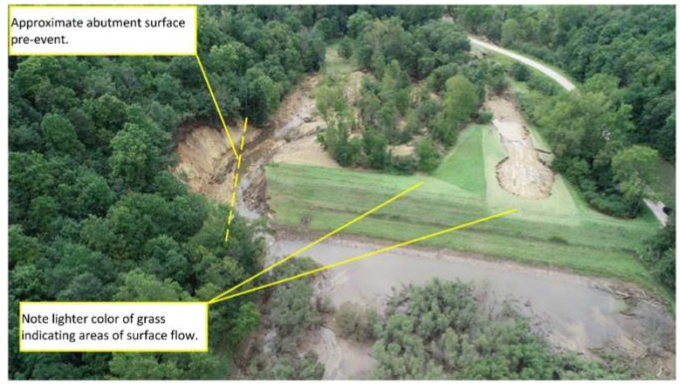


**Figure 3.** Aerial view of the eroded earthen emergency spillway (right side of the dam) at Coon Creek Dam 29. This spillway is representative of the unarmored soil emergency spillways, which are vulnerable to rapid erosion when activated by large floods (NRCS, 2019).

- **Increased downstream exposure:** Development, recreational use, and transportation infrastructure downstream of several dams mean the consequences of potential failure are now greater than at the time of construction.

Individually, these factors posed potentially manageable operational concerns. Combined, they indicated that the system was increasingly at risk if faced with a short-duration, high-intensity rainfall event.

## *The August 27–28, 2018 Extreme Rainfall Event*

On the night of August 27–28, 2018, a highly localized convective storm system stalled over the upper portions of the Coon Creek and West Fork Kickapoo watersheds, producing 6–7 hours of intense rainfall. Maximum 6-hour precipitation totals for both watersheds are presented in Figure 4. Point rainfall depths exceeding 9 inches in Coon Creek and 8 inches in West Fork Kickapoo far surpassed the mid-20th-century principal spillway design thresholds (4.6 inches and 3.9 inches, respectively). As a result, the principal outlets could not pass the inflow, and the emergency spillways were activated at the affected sites. In the Coon Creek watershed, storm magnitudes were also large enough to exceed emergency spillway design thresholds and ultimately challenged freeboard limits, leading to overtopping and embankment erosion at multiple structures. At WFK-1, the rainfall exceeded emergency spillway design capacity without reaching the crest, forcing substantial uncontrolled flow through the earthen emergency spillway. The breach then initiated within the emergency spillway on the left abutment side of the dam, where seepage and foundation weaknesses had previously been identified.

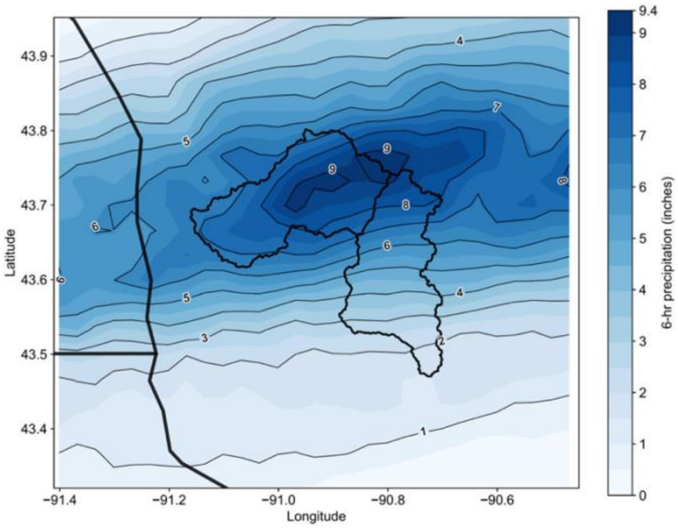


**Figure 4.** Six-hour precipitation (inches) during the 9 PM–3 AM period of the 27–28 August 2018 storm. The left watershed is Coon Creek and the right watershed is West Fork Kickapoo. Rainfall amounts are shown using both color shading and contour lines. Precipitation data are from the Analysis of Record for Calibration (AORC).

Because these peak intensities were concentrated directly over some of the smallest upstream reservoirs, water levels rose rapidly, and the dams transitioned from normal operation into emergency flow conditions within a short window of time.

## *Hydrologic and Structural Failure Outcomes*

As inflows rose faster than outlet works could release water, multiple dams transitioned from normal operation to emergency conditions. Principal spillway capacity was exceeded at multiple dams, requiring flow through the unarmored emergency spillways. In several cases, water levels continued to rise beyond emergency spillway design limits, leading to overtopping of the dam crest.

The observed failure outcomes during the 2018 event were as follows:

- Fifteen dams exceeded their principal spillway capacity, resulting in flow through the emergency spillway.
- Nine of these fifteen then exceeded emergency spillway capacity and overtopped the embankment crest, indicating a loss of controlled flow.
  - Five overtopped but remained structurally intact
  - Four overtopped and subsequently breached: CC-21, CC-23, CC-29, and WFK-Mlsna
- WFK-1 breached without overtopping, although overtopping could still have occurred if the spillway had continued functioning under rising inflows.
- In total, five dams breached during the event.

Both hydrologic failure and geologic vulnerabilities were critical factors leading to structural failure and breaches. In every case where a breach occurred, the dam had already exceeded its hydrologic design limits, either through emergency spillway flow beyond capacity or, in the most severe cases, overtopping. The fact that nine dams overtopped suggests that the dam system as a whole struggled to safely pass the volume of water generated during this event. Because earthfill dams can be highly susceptible to erosion when uncontrolled flow occurs over or around the embankment, any exceedance of spillway capacity places these structures at significant risk of failure. Taken together, these observations underscore that hydrologic design exceedance, when combined with unresolved geologic weaknesses, leaves earthfill dams highly vulnerable to catastrophic failure during extreme floods.

## *Decisions Following the 2018 Failures*

After the 2018 dam breaches, NRCS and local sponsors began a watershed-wide evaluation of the remaining structures. Through the Programmatic Environmental Impact Statement (PEIS) process, multiple alternatives were assessed, including repair, rehabilitation, relocation, replacement, conversion to smaller ponds, and full decommissioning.

The evaluation determined that the dams have exceeded their original 50-year design life and that many share similar geologic vulnerabilities. Analyses also showed that upgrading the dams to meet current safety and hydrologic standards would require substantial and costly modifications, while providing limited flood-damage reduction benefits under modern rainfall conditions.

Based on these findings and stakeholder input, NRCS and project sponsors selected decommissioning as the preferred approach for most of the remaining structures. Implementation planning and phased dam removals are now advancing to address long-term public safety and watershed resilience.

## *Updated Rainfall Science and Elevated Risk*

Investigations following the 2018 floods show that short-duration, high-intensity storms like the August 2018 event are more likely today than when the dams were originally designed. This reflects improved scientific understanding of rainfall extremes in the region.

However, increased likelihood does not mean that a storm of this scale will occur within any specific timeframe. Extreme rainfall is driven by complex and variable atmospheric processes, and each year's weather is largely independent of the next. Because of this natural variability, a storm similar to the 2018 event could occur multiple times over the coming decades—or might not occur again for a long period. What has changed is the overall chance of such an event occurring during the remaining life of these dams. In other words, while we cannot say when a similar storm will strike again, the probability of experiencing a severe rainfall event that challenges or exceeds dam design limits is now considered higher than it was when the structures were constructed.

## *Implications for Flood Safety and Watershed Management*

The 2018 floods demonstrated that a single, short-duration extreme rainfall can lead to widespread hydrologic failures and structural breaches within hours. When inflows rise more quickly than the dams can safely pass water downstream—whether due to limited reservoir storage, undersized outlet performance relative to extreme inflows, or reduced efficiency in aging structures—the potential for uncontrolled flow increases. Once water moves into areas not intended for prolonged conveyance, such as over the crest or through emergency spillways, existing seepage pathways and foundation weaknesses can further increase the likelihood of breach.

The combined effect of:

- limited hydrologic performance relative to high-intensity inflows
- aging infrastructure operating beyond its intended service life
- geologic vulnerabilities that increase the risk of breach
- growing potential for more frequent and intense storms than considered in original designs

indicates a system-wide vulnerability across these watersheds. The 2018 event showed that these dams, as a group, can be pushed beyond their operational limits during extreme rainfall, and that failure mechanisms can develop rapidly once hydrologic control is lost.

## *Modelling and Decommissioning Considerations*

Planning studies for Coon Creek and West Fork Kickapoo evaluated several alternatives, including keeping the existing dams, significant rehabilitation, and full removal. Modeling efforts compared flows and downstream impacts under both retained and decommissioned dam scenarios across a range of flood magnitudes. Results indicate that for moderate floods, dam removal would slightly increase natural peak flows but within manageable ranges along restored channels. However, during rare extreme floods, if existing dams fail, they could produce abrupt releases that are significantly larger than what would occur in a naturally routed system. Considering these findings, along with the dams' aging condition and hydrologic and geologic vulnerabilities, decision-makers concluded that the risk of catastrophic failure with dams in place outweighs the incremental increase in flood peaks expected after decommissioning. As a result, the decommissioning alternative was selected as the preferred action in the NRCS Record of Decision for the Coon Creek and West Fork Kickapoo watersheds.

## *Conclusions*

The technical investigations lead to several key conclusions regarding dam safety and future management needs in the Coon Creek and West Fork Kickapoo watersheds:

- The 2018 event demonstrated that a short-duration extreme storm can trigger a system-wide hydrologic failure, posing serious risks of structural failure at multiple dams simultaneously.
- Hydrologic failure alone can place substantial stress on dam structures. Aging conditions and geologic vulnerabilities can increase the likelihood of structural failure once hydrologic control is lost. At the same time, geologic issues remain concerning on their own, even in the absence of hydrologic failure.
- Updated rainfall analyses indicate that storms of a magnitude once considered exceptional are now more probable, meaning that existing dams are more likely to encounter inflows beyond their original design thresholds.
- For moderate floods, dams can provide some attenuation; decommissioning may modestly increase natural peaks. For rare extreme events, however, if dams fail, sudden releases can be far more damaging than naturally routed flows. Overall, the watershed-scale evaluation concludes that decommissioning provides the greatest long-term safety benefit.
- Proactive risk-reduction measures, including selective decommissioning, can improve public safety and lower the potential for future flood damage.

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