1 Introduction

Aging dams and intense storms with subsequent floods have led to at least ten structural failures at Iowa dams in the past three years. This presents serious challenges, but also provides a chance to correct a legacy of problems not anticipated three to four generations ago when many small dams were constructed. New frameworks for low-head dam mitigation provide exciting opportunities to usher in a new legacy of enjoyment, respect, and care for the navigable waters of Iowa. *Solving Dam Problems: Iowa's 2010 Plan for Dam Mitigation* provides an updated inventory, new naturalistic approaches to enhance rivers in dam mitigation projects, perspectives on flood reduction, and cost effective methods of reducing deaths at dams.

1a. The Role of Iowa's 2010 Plan for Dam Mitigation

In 2008, the Iowa Department of Natural Resources was instructed to develop statewide plans for the newly formed water trails low-head dam public hazard programs. Elements were to include an inventory of low-head dams, various mitigation design templates and construction guidelines for working in and along rivers and recommendations for volunteers, communities, water trail developers, and dam owners. Experts in engineering, stream restoration, and fisheries were consulted to develop recommendations for alternatives that create fewer life-cycle problems than traditionally designed low-head dams.

In July of 2010, as this plan was being finalized, a catastrophic breach occured at the Lake Delhi Dam. Techniques outlined in this plan were put to use in Maquoketa riverbed stabilization projects necessitated by the failure of that large dam. Lessons learned in that disaster have been incorporated into this plan.

The resulting 2010 dam mitigation plan relates the function and historical importance of dams to today. The plan also inventories Iowa's dams, provides design templates for mitigating hazards and improving fish passage and lays out a general statewide strategy and action steps to improve river connectivity over the next ten years. Two companion documents to this plan were developed:

1. A fully illustrated manual *Developing Water Trails in Iowa* for water trails developers, including planning guidance, standardized signage design, and incorporation of stream restoration and stormwater management concepts in access construction.
2. The state water trails plan *Iowa Water Trails: Connecting People, Water and Resources*, documenting the historic and present day importance of Iowa's navigable waters, with comparisons of relevant data and strategies for adding value to Iowa's system.

The low-head dam public hazard program within the Iowa DNR was established in 2008 to reduce fatalities at traditionally designed dams. The Iowa DNR has a separate dam safety program tasked with assuring Iowa's dams are constructed and maintained per a hazard classification system based on risks downstream of the dam; however, this program does not specifically address the hazard posed by low head dams to recreational users. Reducing what to date have been more numerous Iowa deaths due to traditional "low-head" dam design was a main consideration in creating the newer public hazard program. This plan broadens the set of goals for mitigation to improve river ecology and enhanced recreation.

Taken together, this plan responds to increased demand in Iowa for safer water-based recreation, improving water quality, conserving Iowa's aquatic resources, and developing opportunities to enhance resilience of aquatic life by improving stream connectivity. Together, these factors are expected to contribute to economic vitality and a higher quality of life for Iowans. •

1b. The Vision for Low-Head Dam Mitigation

Iowa's vision was developed using a thoughtful process involving thousands of Iowans.

Social assessment tools developed both through public input meetings and questionnaires show evolving attitudes about dams. Protecting and restoring rivers and watersheds and reducing the number of dam-related drownings were the top priorities identified with various tools, including internet stakeholder surveys, a statewide mail survey, a livery owners mail survey, and a mail survey of the owners of dams.

Nearly 1,000 Iowans participated in an internet-based survey developed by Iowa State University's Department of Landscape Architecture to construct strategies and goals for water trail and dam mitigation programs. Stakeholders included anglers, paddlers, natural resource agency staff, economic development staff, and the general public. This survey helped set early direction when all stakeholder groups clearly articulated that a balanced mix of safe avoidance, warning signage, and modification or dam removal should be considered. Habitat improvements were considered valid impetus for mitigation, and physical mitigation at deteriorating dams was considered most appropriate. Only 10 percent of research participants indicated they were strongly in favor of dam removal as a blanket solution to dam problems.

Mailed surveys and telephone interviews implemented by Iowa State University's Center for Agriculture and Rural Development (CARD) tracked Iowan's river use and preferences from 4,775 participants. CARD estimates that nearly half of all Iowans logged at least one trip to an Iowa river in the past year. Economic effect estimates of river use patterns will be developed in the near future.

Numerous experts in stream restoration, engineering, environmental education, law enforcement, fisheries, aquatic invasive species, water quality, public land management, tourism, and economic development also contributed insights and knowledge. Statewide committee members provided insight into the vision. Iowa's river corridors appear to be both highly valued and well-used according to all sets of studies.

Iowa's vision for the future of major river dam mitigation links multiple benefits and avoids setting up conflicts. It's about the importance of listening to and communicating with Iowans, and putting the spotlight on problem solving. It's about improving recreation, aqatic habitats and water quality, and it's about finding economic opportunities. The vision is also about rekindling the connection between people's interactions with the landscape and their respect and understanding of resource conditions and functions. •

IOWA'S FUTURE FOR DAM MITIGATION WILL …

... respond to aging dam infrastructure

... be grounded in listening to local interests and dam owner concerns

… strive to reduce dam-related deaths through education, warning signage, guidelines for access areas near dams, and structural mitigations such as removal or rapids conversions

… balance ecological benefits of fish passage with the need to block or slow the spread of invasive species at some of the largest dams

… consider recreational benefits from new features created at former dam sites

… blend benefits to aquatic species, angler access, recreational safety, navigation improvements, economic development, and tourism when prioritizing structural dam mitigations

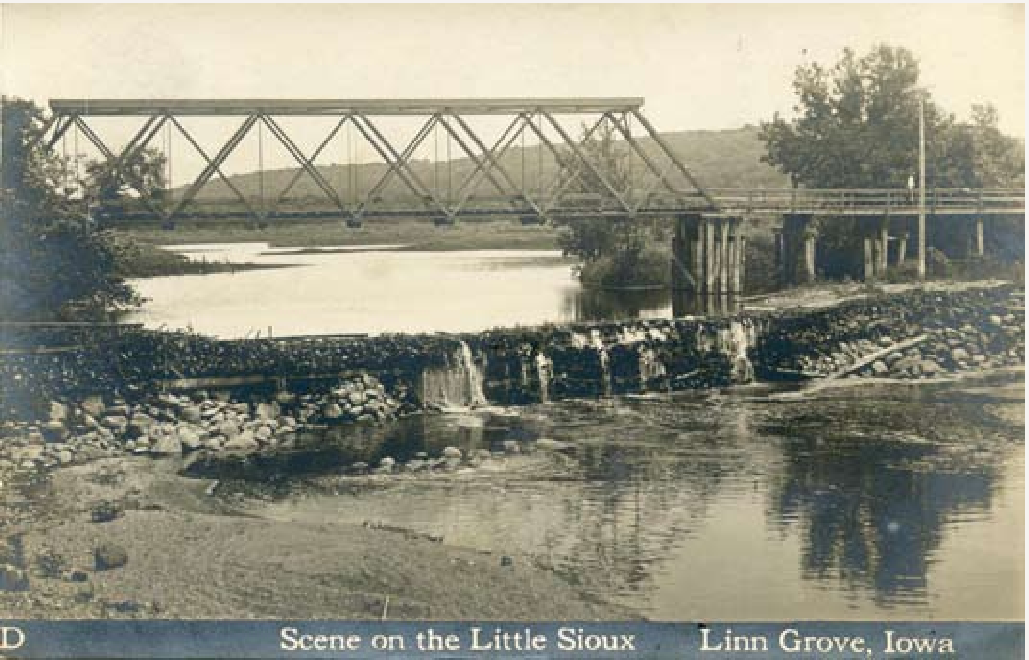
1c. History of Iowa Dams: Why They Are Here

The first recorded dam on an Iowa stream was built on the Yellow River in 1829 to refurbish Fort Crawford with newly sawn lumber for its rotting palisade. For a time, a young lieutenant named Jefferson Davis (who later led the Confederacy during the Civil War) operated the sawmill. Throughout the 1830s and throughout the settlement of Iowa, the milling industry relied primarily on Iowa's rivers. Most of those created a head of water with small rock or crib dams. These dams helped power grist, woolen, or saw mills. According to the first census in 1840, there were 118 mills operating in Iowa employing 154 settlers. "By 1870 the Federal census enumerated 502 flour and gristmills and 545 sawmills — or more than a thousand mills in the Hawkeye State" (Petersen, 1941:20). There were as many as 40 mills alone on the Upper Iowa River (Knudson, 48), and as many as 80 operating along Des Moines River (Swisher, 1940:14) by the 1880s. (Swisher, 1940: 15-16). Mill operation reached its zenith in the 1890s.

Many of Iowa's natural rapids and falls were preferred places to build dams because fewer materials were needed for construction. Cedar Falls, Cedar Rapids, and Iowa Falls are all named after natural river features. Immediate negative effects to upstream fisheries were observed (see Chapter 3).

The first hydropower dams

Water-powered mills declined as the economic base shifted throughout the late 1800s from wheat production to corn, cattle, and hogs. Dams resurged in importance in the early 1900s with the invention of the light bulb and other devices. Some old mill dams were repurposed to hydroelectric generation, while other dams were newly constructed to generate electricity. During the same time, rapids on the Mississippi River at Keokuk and Rock Island were considered navigational problems, and plans were laid for the first locks and dams. The Rock Island rapids was submerged when the Moline Lock opened in 1907, and the Des Moines rapids at Keokuk was submerged 1913 with a dam that also became one of the world's largest hydroelectric facilities of the time. As floods were known to regularly wipeout rock-and-crib style dams, dam owners began slathering concrete caps over older dams, using Portland cement as a primary material for new constructions. Thus, the"low-head" style of dam was born in Iowa. By the 1920s, however, the power generated by smaller hydroelectric dams could not meet demand; coal burning power plants soon took over as the primary source of energy production, and hydroelectricity generation declined (Swisher, 1940).



1930s dams

In the 1930s, about 50 dams were constructed, most of them in the name of conservation (despite earlier observations that fishing declined for upstream communities) and work development. Construction of some dams employed work-hungry men through the Civilian Conservation Corp, the Work Progress Administration, and the state's Civil Works Administration (CWA). Local conservation leagues also built a number of dams in Iowa. These projects provided temporary work for scores of otherwise unemployed Iowans. However, the purpose of the dams themselves was not economic.

Many were called "beauty dams" and others were billed as "recreational improvements" at places that were often already popular angling areas or picnic sites. As new dams were constructed as uniform concrete walls across rivers with abutment walls along the banks, local populations were quickly educated about the forces involved. For example, the Iowa Conservation Commission authorized construction of a CWA dam at Littleton in 1933; the first victims drowned in 1936 and 1937.

The Rivers and Harbors Act of 1930 also led to the construction of present-day locks and dams on the Mississippi River to create a 9-foot navigation channel.

A historical postcard of the dam in Littleton, Iowa, on the Wapsipinicon River. Built in 1933, a young teenage boy drowned here in 1936, and a second drowning occured in 1937.

The Redfield Dam on the Middle Raccoon River.

Fairbank Dam on the Little Wapsipinicon River

The old mill at Fort Dodge.

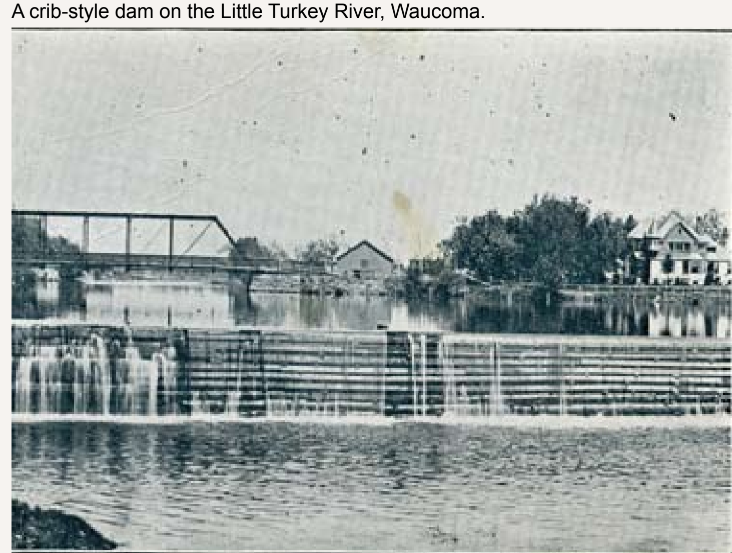
Modern low-head dam era

Additional low-head dams, were constructed from the 1950s to the 1980s for various purposes, including water supply, grade stabilization for down-cutting streams, and for recreation. In this era, many dams were constructed with “roller buckets” or a small curving lip that magnified upward water forces to dissipate energy and reduce downstream scour (Forester, 1949). The U.S. Army Corps of Engineers constructed the first large earthen dams to create large impoundments during the 1960s and 1970s for flood control. These reservoirs (Red Rock, Saylorville, Coralville, and Rathbun) are managed by the USACE. These dams provide a number of recreational opportunities, including trails, campgrounds, shelter houses, and motorboat ramps. Iowa DNR and county conservation boards created a number of smaller recreational lakes on smaller stream systems. In several decades of experience, watershed area to lake surface area ratios for newly constructed lakes have become decidedly lower to avoid rapid sedimentation problems experienced on large main-stem rivers. (Hoyer, McGhee, personal communication)

The latest major cycle of dam building on major streams came as southwestern Iowa rivers and creeks unexpectedly began to rapidly downcut due to downstream channelization of main-stem tributaries of the Missouri River. This had been done to create more productive land and in the name of flood control. Channelization creates high energy gradients, resulting in head-cuts upstream. In highly erodible loess soils, streams that formerly meandered peacefully toward the Missouri began tearing gullies through fields and pastures in an upstream march of head-cuts. Many channels suddenly looked like canyons. More than $1 billion in infrastructure damage to bridges and roads led to mobilization of efforts. After the creation of the Hungry Canyons Alliance, numerous check dams were installed throughout the 1990s and 2000s, with a present-day total of more than 157. The most common type are sheet-pile low-head dams. Some are rock riffles, and some of the low-head dams have had rock ramps installed downstream to aid fish passage.

Social attitudes about dams in the past decade have evolved. In many cases, a broader range of concerns are being incorporated when dams are in need of repair or reconstruction. In 2010, eight projects to mitigate legacy problems with dams were either ongoing or complete. •

A crib-style dam on the Little Turkey River, Waucoma.



1a. Problems associated with dams on major rivers

Dams in Iowa were exceedingly important to the early economic development of the state. Many have important ongoing economic value, such as water supply and hydroelectrical power generation. However, negative factors related to dams on major rivers have not been thoroughly explored until recently.

Problems associated with low-head and other dams on major rivers are numerous. They include:

1) **Dam infrastructure is failing rapidly.** This can cause downstream flooding and excessive sediment releases may elevate downstream turbidty for months or even years.

2) **Periodic fatalities** related to the recirculating hydraulic that forms, particularly at moderately high flows.

3) **Blocked fish passage**, and other interruptions to biological connectivity resulting in streams that are not meeting their biological potential for anglers and diversity of aquatic habitat.

4) **Fine-particle sediment accumulation** upstream of the dam can create poor uniform habitat and poor-quality recreation.

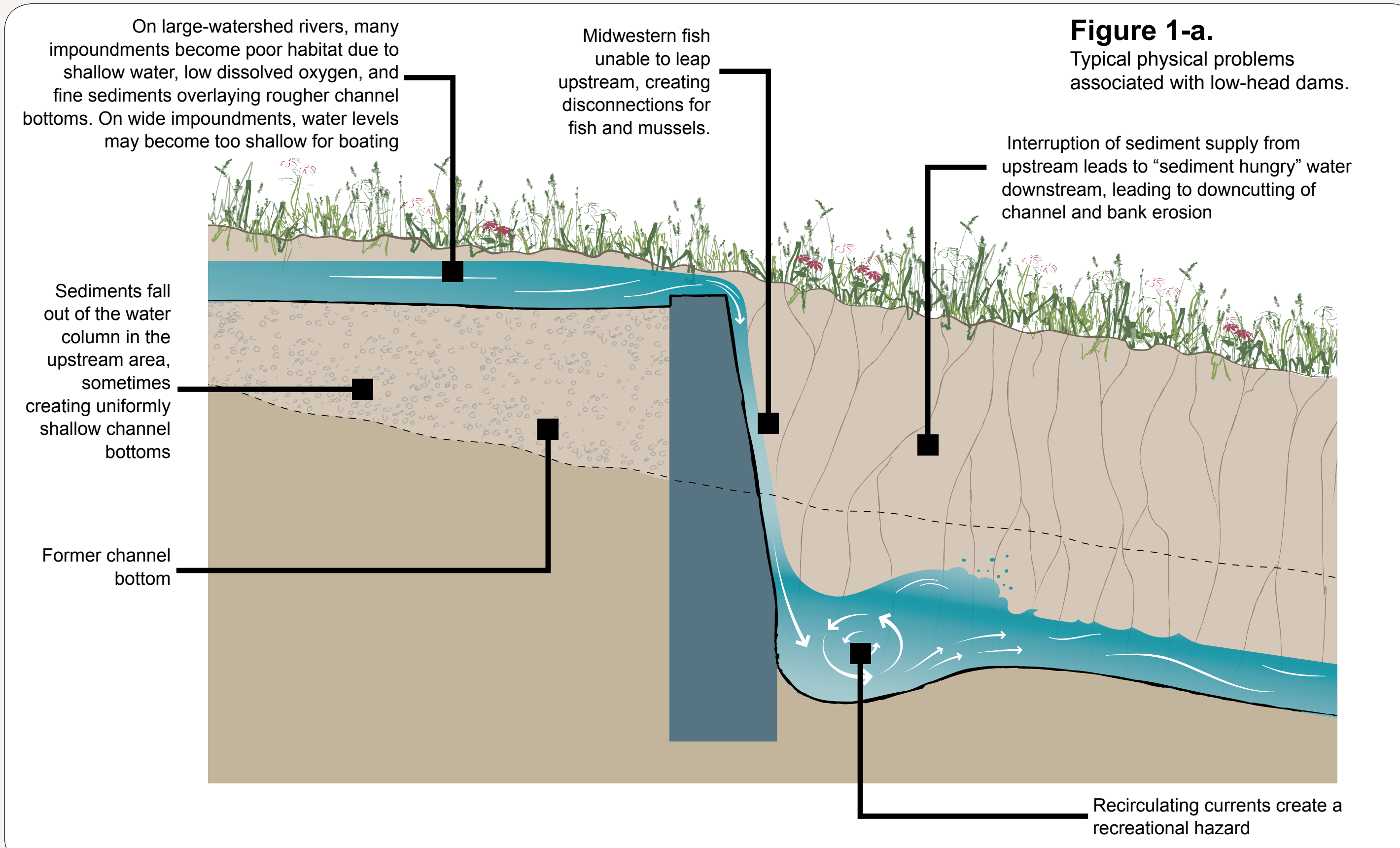
5) Downstream of the dam, **high scour** and sediment disequilibrium create bank erosion and streambed downcutting.

6) Some dwellings and businesses near impoundments are flooded more frequently than necessary because of a dam's high crest **contributes to upstream flooding**, while run of the river dams do nothing to reduce downstream flooding.

7) **Liability issues** related to dam ownership and a greater awareness has led to increased interest in dam removal or divestment.

This section explores various issues confronted dam owners and the public related to dams on major rivers. •

Figure 1-a.
Typical physical problems associated with low-head dams.



River dams with failures or structural problems

A strong majority of Iowa dams on major rivers are well past their deisgn life cycles. Flooding in 2008 exposed a wave of structural problems statewide, and more flooding in 2010 reinforced the point. Visible structural problems were noted at the following dams:

Lower Dam, Upper Iowa River

Charles City, Lower Dam, Cedar River

Yellow River Ford / Dam

Klondike Dam, Big Sioux River

Littleton Dam, Wapsipinicon River

Boone Waterworks Dam, Des Moines River

Nora Springs Dam, Shell Rock River

Rockford Dam, Shell Rock River

Fort Dodge Hydroelectric Dam, Des Moines River

Lake Delhi Dam, Maquoketa River

Quaker Mill Dam, Maquoketa River

Costs to replace damaged or underperforming gates can range from $500,000 to several million dollars. Debris accumulation can also worsen upstream flooding.

Water flowing under the Klondike Dam on the Big Sioux River after undermining. The dam's water supply function will be replaced with a rapids that will create a similar pool upstream.

Fractures in this dam at Charles City would eventually have widened, but the dam was removed and replaced with a recreational feature instead. (See Chapter 4, Alternative D)

Quaker Mill Dam. A dike breached in 2008's Maquoketa River flood, dewatering the mill pond and dam. After repairs were completed, the dike breached again in 2010 flooding.

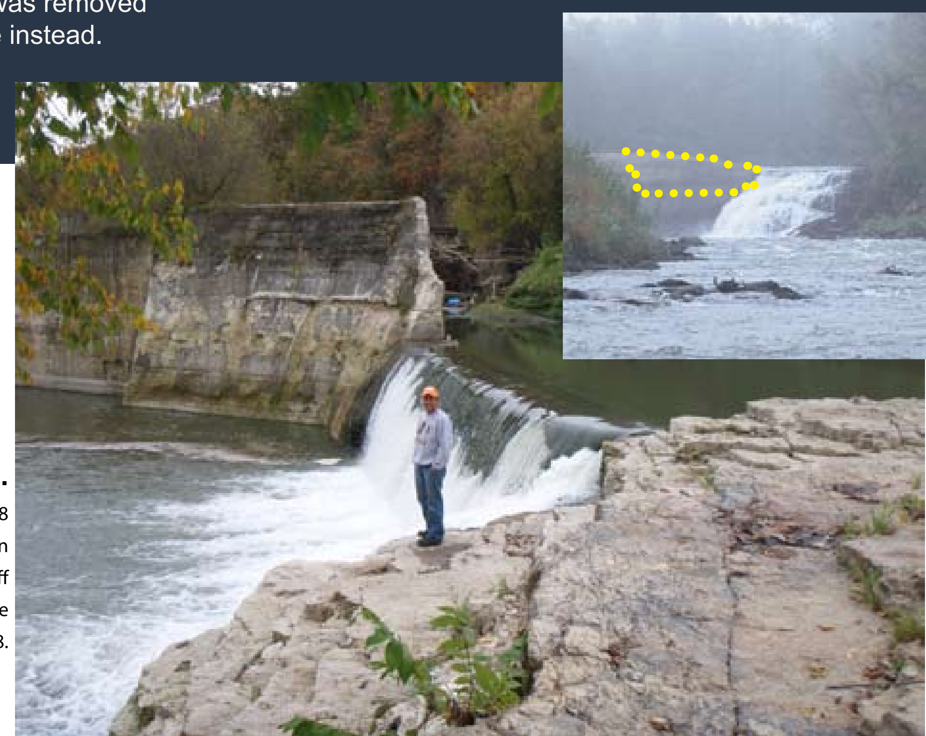


Figure 1-b. Post-flood and pre-2008 photo showing a portion of Lower Dam shorn off during flooding on the Upper Iowa River in 2008.

Head cut after the Delhi Dam breach

Immediate flood damage to downstream commmunities Hopkinton and Monticello after the Lake Delhi Dam breached was widely reported. For several months after the floodwaters subsided, a lesser known ecological emergency continued. Decades of silt trapped by the impoundment gradually built the lakebed higher and higher. Post-breach, water had to fall over silt to reach the lower riverbed. The scouring force undermined the silt as it fell, sending energy upstream. More than 200,000 cubic yards of silt was released as the resuting “head cut” moved up lakebed silts a total of two miles.

Figure 1-c. Headcut progress after the breach.

Stabilizing the channel bed after the breach.

Temporary rock riffles were constructed at two sites to add stability to a shifting channel bed contributing massive silt loads to the Maquoketa River. One riffle at the breach(left) stabilized a remnant of the dam. Another was built near the bridge 2-miles upstream to intercept the head cut.

Public navigational and recreational safety

Memorials at the Reasoner Dam in Humboldt (left) on the Des Moines River and at Alden (above, and top right) on the Iowa River.

Small craft and navigation

A rise in small craft (kayaks, canoes, innertubes, angling float tubes, small motorized kayaks, etc.) recreation has increased navigation of Iowa's rivers in the past decade. Rapid expansion in innertube, canoe, and kayak rental services contributes to the accessibility of these activities, as does a wider commercial availability of various types of craft. Dams are often popular places to fish, oftentimes by wading anglers. Because low-head dams create recirculating hydraulics that may be unrecognizeable at times, drownings and injuries tend to be more concentrated at dam sites than other areas on rivers.

- Dam-related deaths occurrd at a rate of approximately 1.5 per year from 1998 to 2010.

- Not all low-head dam owners are actively implementing warning signage, which can be a critical education point for new river users.
- Dams may not be harmful at all flow levels, leading the public into complacency.
- Business opportunities may be limited when liveries are prevented from expansion by dams (Des Moines River at Boone, Maquoketa River at Monticello, Turkey River at Clermont).
- Low-quality impoundments at some dams are not popular for recreation or navigation.

Angling at dams

Dams are often attractive places to fish. Fish tend to congregate at or near them while trying to move upstream, and scour below dams can create deep water habitat with highly oxygenated water. Wading anglers, however, are vulnerable to drowning after being swept off their feet.

Figure 1-d.
The two photos to the right, both of the Mon-Maq Dam on the Maquoketa River near Monticello, illustrate how a dam may not recirculate significantly at low flows. However, at high flows, the river's flow direction is upstream from the boil line (yellow dotted line), holding debris against the dam's face.

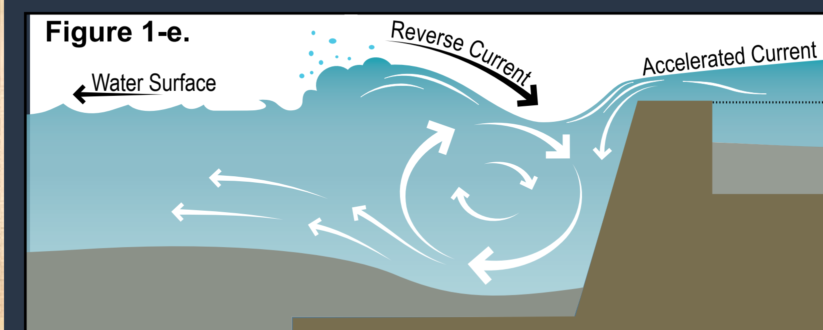
Hard to see. Falling a few feet, Little Dam in Fort Dodge can be difficult to see from upstream. From the side, it's danger is readily apparent.


TODAY
Low-down, mean 'drowning machines'

"Drowning machines" are not a new problem

The "drowning machine" effect has been publicized by rescue and safety personnel nationwide since a rash of drownings among rescuers in the 1970s and 1980s. This 1985 Des Moines Register article explains the hazard of the low-head dam, a dam which is like a wall across a river that creates upward force. This results in a mound of water (the boil line), from which water flows upstream toward the dam.

Figure 1-e.



Dams are often thought of for their value in flood control. For a few of Iowa's notable dams, namely U.S. Army Corps of Engineers reservoir dams, this is the case for areas downstream. However, most of Iowa's dams are "run of the river" dams. These dams simply pass over water at the same rate it arrives from upstream. Low-head dams, rock dams, crossings, and even some large impoudnment dams fit this description.

For areas upstream of a run-of -the-river dam, the height of the dam becomes the lowest river bottom throughout the entire impounded reach upstream. Until the dam is submerged by restrictions from downstream, the dam is the main limiting factor in the area. Where a dam is still impounding water while infrastructure is being flooded (see photo, bottom right), flooding could be lessened if the dam's height were reduced to an optimal level, or if the dam were removed entirely.

Some dams are fitted with tainter gates that are opened during floods to reduce problems with upstream flooding. Sometimes, gates are confused as being flood-control features, when in fact they only mitigate problems that occur due to the presence of the dam. When gates are damaged and stuck closed, or filled with debris, they no longer reduce upstream flooding problems.

When a dam has reached its life-cycle end, considering these factors through professional analysis and modeling can help a community reduce flooding by predictable amounts. With what appears to be increasing flood frequency in Iowa, reducing height of dams may be valuable to explore. •

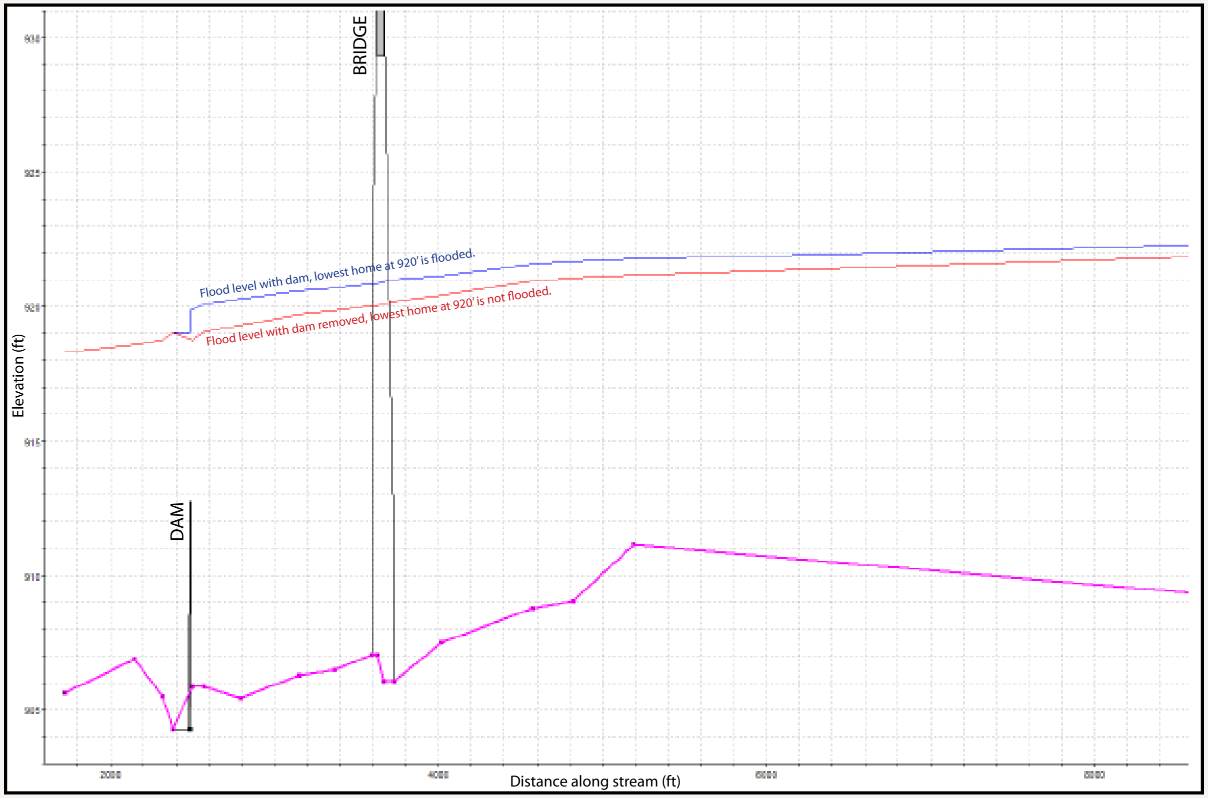


Figure 1-f. A HEC RAS model depicts water surface with a dam and no-dam scenario on the Wapsipinicon River upstream of the Littleton Dam, at a discharge of 10,000 cubic feet per second, or the relatively frequent 5-year flood event. The lowest habitable structures on the impoundment begin to flood when the water surface elevation is 920 feet. (Modeling by Interfluve, Inc.)

Manchester, Flood of 2010. When a dam's influence is clearly visible during a flood, like the dam below the bridge in Manchester, the dam likely contributes to upstream flooding. (Photo from AP video footage.)