4 Mitigation Alternatives

Some dams have remaining purposes. Others do not. Some were built as mills, utility protection, or for water supply functions. Some were constructed for softer purposes, such as "beauty" dams to create what at the time were considered aesthetically pleasing flat pools of water. As dam infrastructure deteriorates, large investments may be required to create stable structures. Many communities are evaluating which needs their dams still serve, and how that relates to the cost of reconstruction. This chapter presents several alternatives being employed in various situations across Iowa and the Midwest.

Choices in dam mitigation are often presented in black and white: dams are "removed" or "saved."

Evaluating shifting demands, reconstruction and maintenance costs, original functions, current functions, and a host of available mitigation techniques yields a more honest set of choices that can be tailored to given conditions. Given the remaining key functions required in a community, perhaps the most useful questions to ask include: Can the needs be accomplished with inherently safer structures and flood reduction? Can the cost be reduced? What benefits to aquatic species may be reaped?

Stream restoration concepts in dam mitigation

Stream restoration professionals were consulted in the development of this plan, and a training that applied restoration concepts to dam problems included DNR and Iowa State University engineering, river programs, watershed improvement, and landscape archtiture staff. A salient take-away message tools was that a primary focus on dam removal as an approach to dam mitigation sets up a false choice. In fact, in some cases, dam removal may not be desirable unless issues in the former impoundment are addressed in tandem. Naturalistic structures that improve safety and reclaim stream functions can replace many locally desired functions of dams with fewer negatives. An example common to several completed or ongoing functions is the "rock arch rapids" approach replacing water supply, grade stabilization, or impoudment functions of a dam. The project results in public safety improvements and reconnects the fishery.

A personal watercraft rider(above) inspects a new rapids (right) that shored up the Vernon Springs Dam on the Turkey River near Cresco. This allowed fish to pass into the impoundment, created new habitat, and elminated the dam's "drowning machine" effect.

Removal of dams accompanied with appropriate bed stabilization and stream restoration in the former impoundment can prove beneficial for communities needing major changes. In areas where homes or businesses are flooding near the impoundment, reducing the height of the dam can reduce flood frequency. Where a formerly recreational lake-type impoundment has filled with silt, and can be predicted to do so again in the future, a community's eyesore and biologically unproductive impoundment can become a floodplain rich with trails, scenic native vegetation, and angling opportunities in a restored river. These types of shifts in recreational amenties can initially seem jarring for a community, but appear to provide a high benefit-cost ratio.

Engineered mitigation approaches

A number of engineering solutions exist to solve specifc problems, and many of them were considered in literature review for this plan. Alternatives G, H, and I include retrofits that may be useful in some very specific applicatons such as flood protection constraints, the need to maintain Asian carp barriers or hydro-electric facilities, or where dams are very wide or very tall. Other engineered approaches, in consideration of State of Iowa priorities in technical assistance and funding, tend not to solve as many public problems.

For example, a style of hinged gate controlled by air bladders can be installed after the height of a dam is reduced or to replace existing gates. If the mechanism fails, it hinges downward into the position that reduces flooding. While certainly useful, other problems outlined in Chapter 1 remain. Some communities with a vested interest in impoundments can certainly benefit from knowing more about engineered solution. However, state funding for these types of approaches is discouraged, as they tend to focus on local problems (sediment flushing, flood reduction, etc.) with un-studied success rates, while ignoring challenges common to the state's navigable streams, including public hazard reduction, fishery success, overall stream health, and navigational connections. While conventional engineering approaches can solve specific problems, they do not address most of the issues outlined in Chapter 1d, and require long-term maintenance.

Focusing on a single problem on waterbodies used by the public can present more serious problems. For example, during the 1960s, the "roller bucket" style of dam grew in prominence in engineering plans because of its ability to dissipate energy (Christodoulou, 1993). An unfortunate side effect was that dams became more effective drowning machines.

Alternatives A through F are more holistic approaches that mitigate the dam across the entire width of the river. Typically, those approaches will be considered the preferred solutions, unless other factors make them unreasonable. •

Additional resource

More information on project approaches and processes using natural channel design principles can be found in the 2010 book "Reconnecting Rivers: Natural Channel Design in Dam Removals and Fish Passage," written by Minnesota DNR stream restoration specialist Luther Aadland. It can be accessed online at this Web site:

http://www.dnr.state.mn.us/eco/streamhab/reconnecting_rivers.html

Alternative A: Dam removal with river restoration, profile view

Creating aquatic habitats, floodplains, and recreational / fitness zones

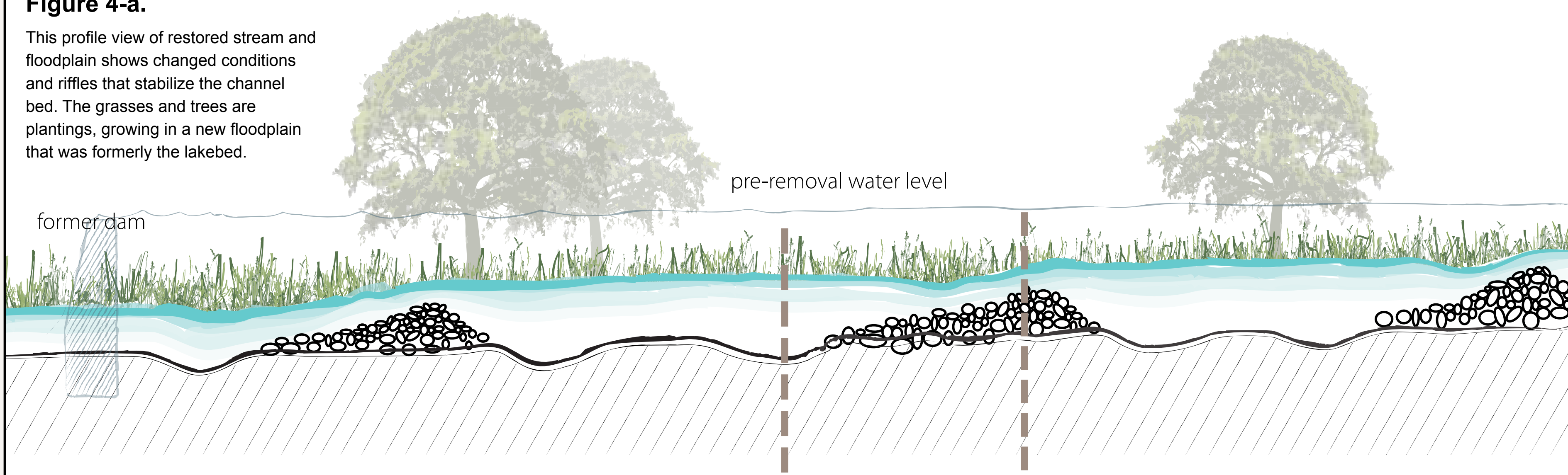
If a community tires of maintaining an aging dam for an impoundment which has decreased in quality over the years, a promising alternative can be to consider stream and floodplain restoration after the impoundment de-watered. A restored floodplain can become a park or natural area restored with native grasses, trees, and wildflowers, and provide a convenient area to develop new pedestrain or biking trails.

River impoundments often have significant community identity associated with them. Restoring a former impoundment bottom into community green space can be viable only when a community can agree it is a necessary next step. A common scenario may lead a community toward this option. Many dams are nearing their life cycle end. Damaged gates, which can be costly to replace, often precipitate local discussions about the sense of investing in a dam that may soon fail in other ways.

Certain impoundments on major rivers—especially wide, lake-like impoundments—have a frustrating tendency to fill regularly with layers of silt or sand. Some Iowa streams transport large loads of sediments even during minor floods. With a current understanding of stream systems and Iowa watersheds, lakes with ground watershed to lake surface ratios of less than 50:1 are considered restorable with watershed treatments and dredging by the Iowa DNR lake restoration and watersheds program. Lakes with greater than a 100:1 watershed to lake surface areas are considered infeasible for restoration due to sediment loads from uplands and stream channels that are impossible to control. This plan focuses on dams on streams with watersheds larger than 50 square miles with lakes in varying states of sedimentation. Wide impoundments tend to accumulate uniform silt or sand botoms, and slow velocities can provide nutrient rich water a favorable environment for algae. Periodic algael blooms may reduce dissolve oxygen. Combined, these factors tend to reduce macro invertebrate and mussel populations, which may in. Some impoundment environments favor a few "generalist" species such as carp capable of living in such an environment. All these factors can limit water quality.

Figure 4-a.

This profile view of restored stream and floodplain shows changed conditions and riffles that stabilize the channel bed. The grasses and trees are plantings, growing in a new floodplain that was formerly the lakebed.



Alternative A (continued): Dam removal with river restoration, plan view

Restoring a former impoundment to a community asset

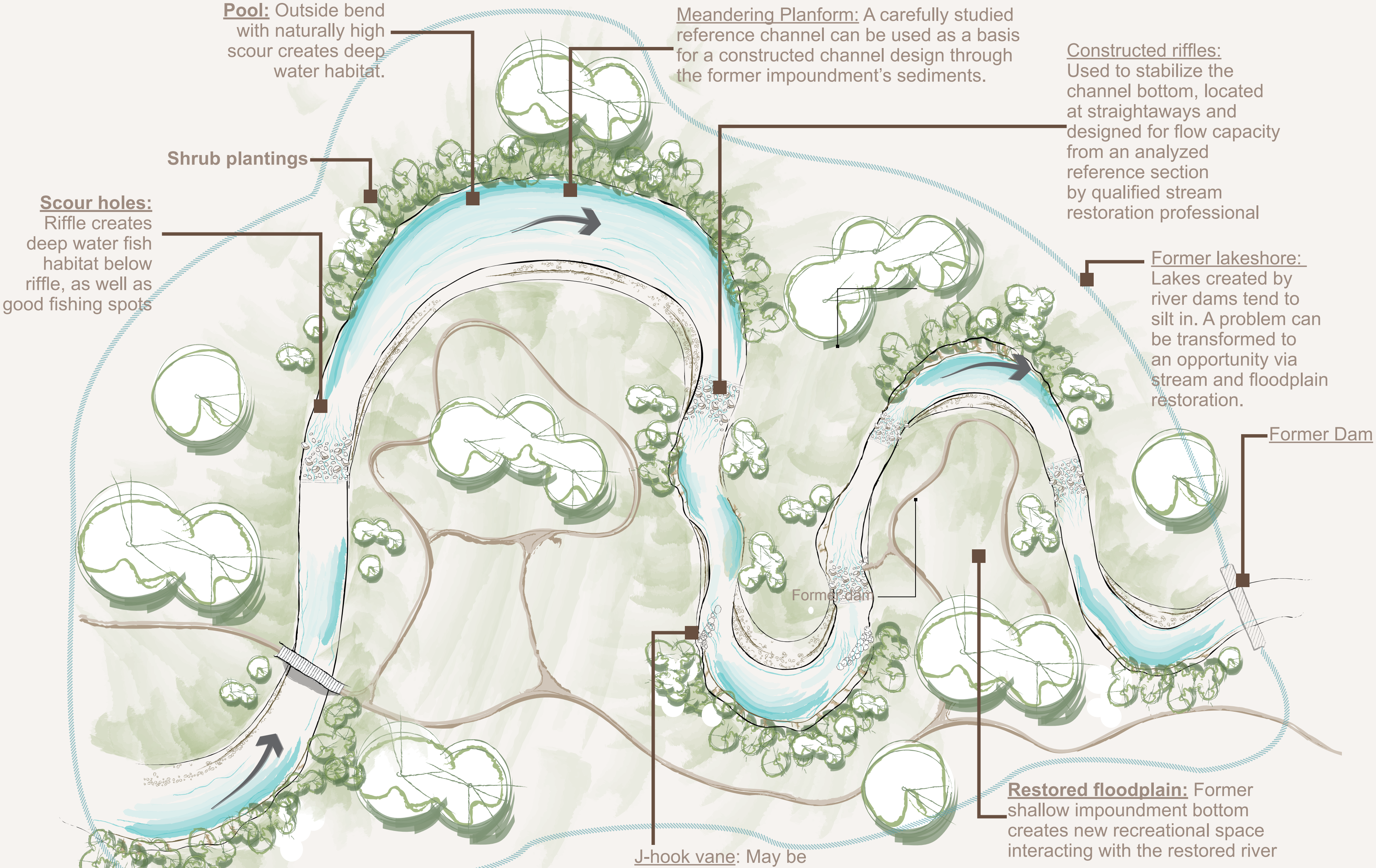


Figure 4-b.

Plan view of a dam removal with upstream river & floodplain restoration.

Alternative A (continued): Dam removal with river restoration, cross section view

Restoring a former impoundment to a community asset

Figure 4-c.
Although outside bends (pools) are high-scour areas, professional design of channels based on a reference reach and appropriate plantings result in a channel in equilibrium with good depths for varied habitat.

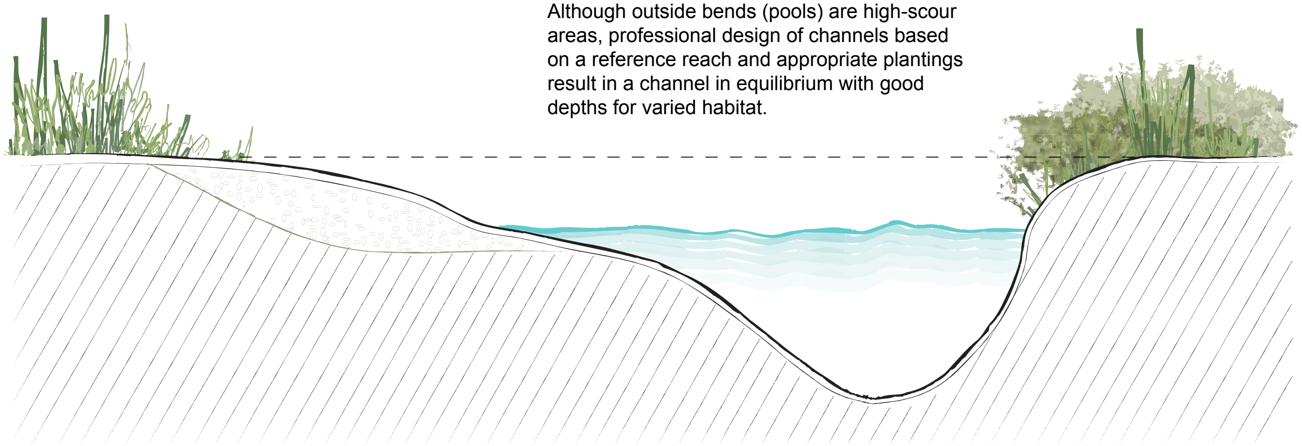
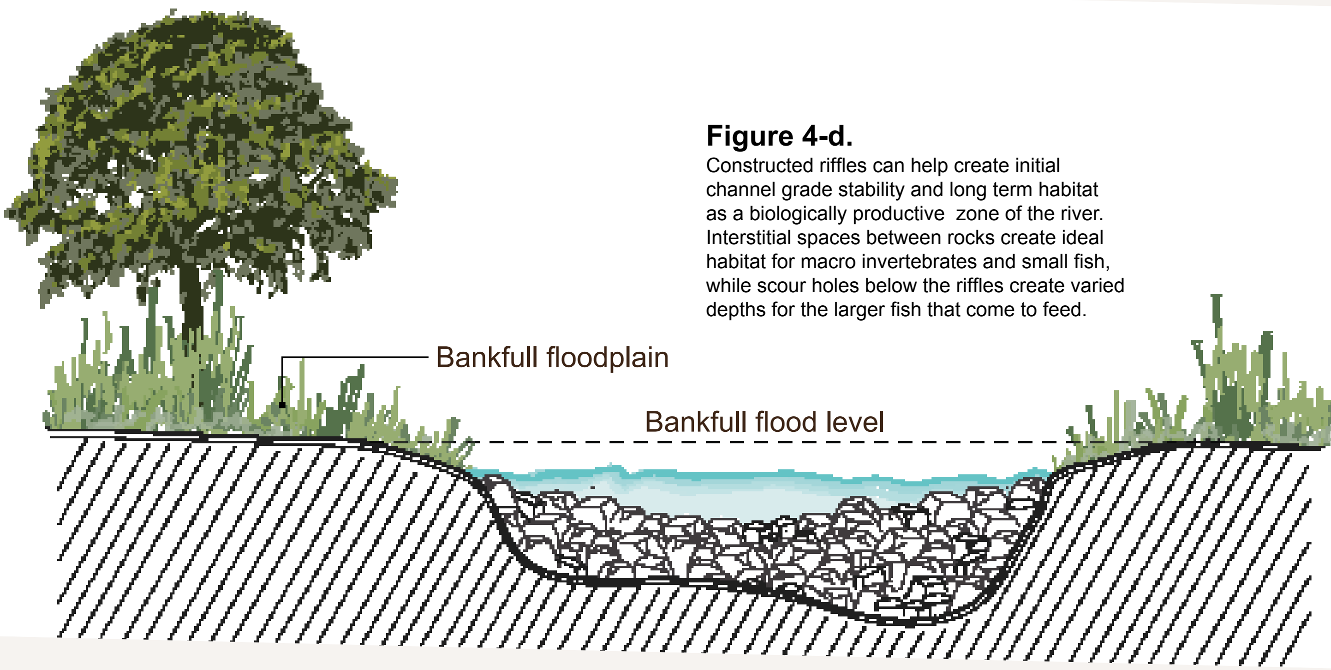


Figure 4-d.
Constructed riffles can help create initial channel grade stability and long term habitat as a biologically productive zone of the river. Interstitial spaces between rocks create ideal habitat for macro invertebrates and small fish, while scour holes below the riffles create varied depths for the larger fish that come to feed.



Removed. A dam removal project with limited river restoration needs began in late 2010 on the Yellow River in Allamakee County.

Alternative B: Rock ramps

Rock ramps create a sloping mass of loose stone downstream of a dam, and are sometimes used as an alternative to removing dams. They offer benefits of breaking up recirculating currents, eliminating the "drowning machine" effect, and can also provide an aestheically pleasing replacement feature in a community. Stability and maintenance can be a problem when this type of structure is not designed by a stream restoration professional.

Rock arch rapids

Appropriately designed rock arch rapids have proven to be remarkably resilient structures on various streams across the Midwest after monitoring through major floods. It has more recently been employed in several Eastern rivers. This style of design was originally developed by Luther Aadland, a Minnesota DNR stream restoration specialist. The rock arch rapids places careful emphasis on material quality, channel capacity, sizing, quantity, slope, and placement. It also incorporates arching buttresses of large boulders that create a riffle-pool sequence. Long-term monitoring data available documenting its permformance makes this the preferred method when a rock ramp is determined to be the most suitable project. This structure can also replace a dam's function, if needed.

Grouted rock rapids

Due to poor availabilty of adequate size and hardness of stone in portions of Iowa, grouting -- injecting masonry mix into gaps between stones -- may be considered in some cases. Design parameters of the rock arch rapids should still be considered in design. This type of design will require future maintenance, as grout may crack over time, allowing undersized materials to separate and move.

Figure 4-e.
Rock arch rapids, plan view.

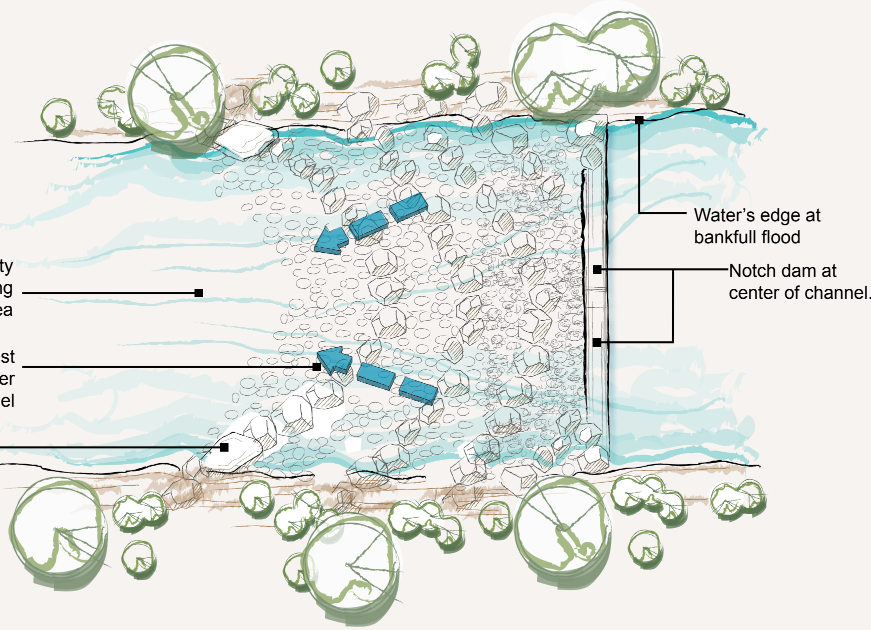
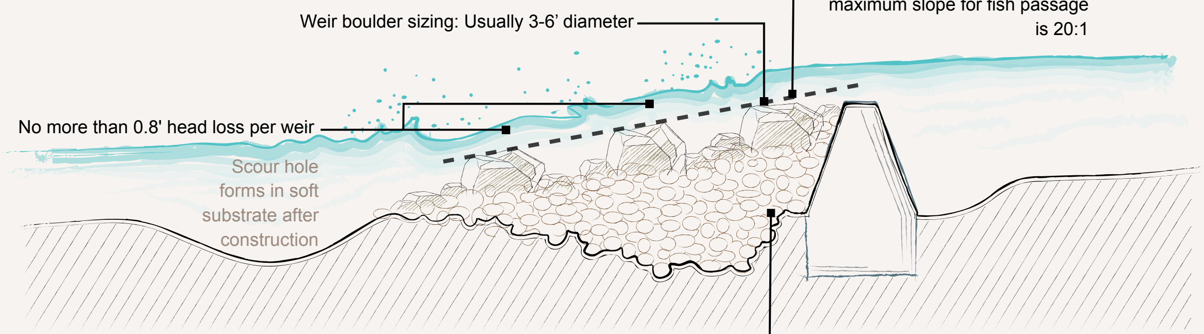


Figure 4-f.
Rock Arch Rapids, profile view



Alternative C: Simple dam removal or staged dam removal

Certain dams can be physically removed without additional restoration. Low dams with narrow impoundments or dams that have been breached for several years are the best candidates. In all cases, the impoudment needs to be carefully studied for potential release of sediments and compared to the river's annual sediment transport rate.

If volumes are significant, analysis of sediment for toxic contaminants may also be required in permits to assess potential harm to aquatic life downriver if sediments were released.

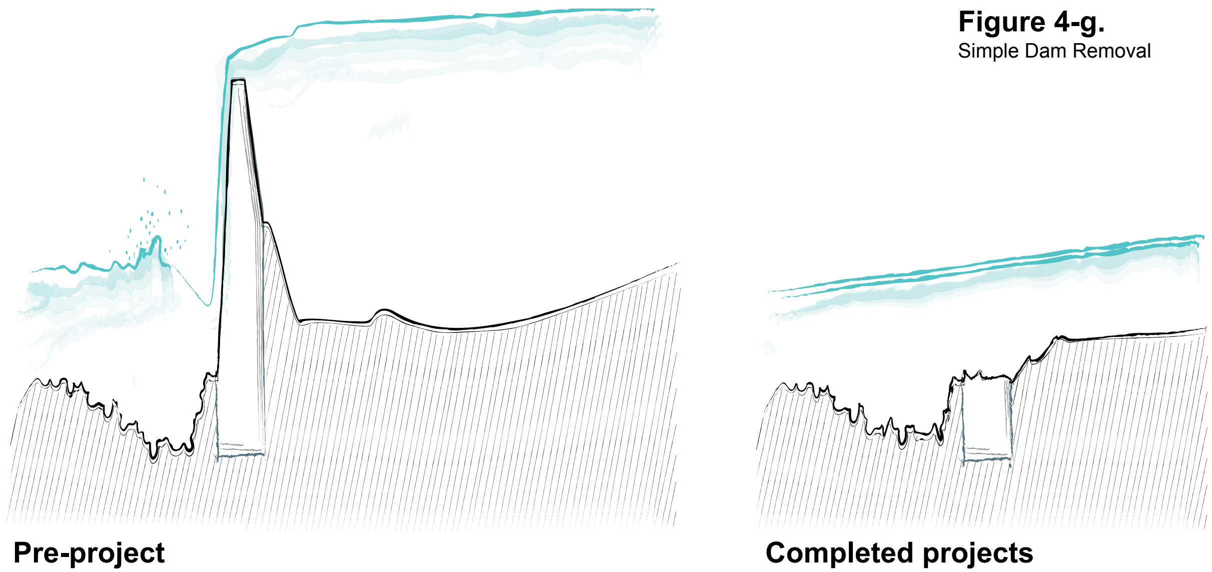


Figure 4-g.
Simple Dam Removal

Simple dam removal: As is implied, the dam is removed to the natural river bed level in one step. This is only an option at where survey and analyis shows limited sediment release not expected to harm aquatic life downstream

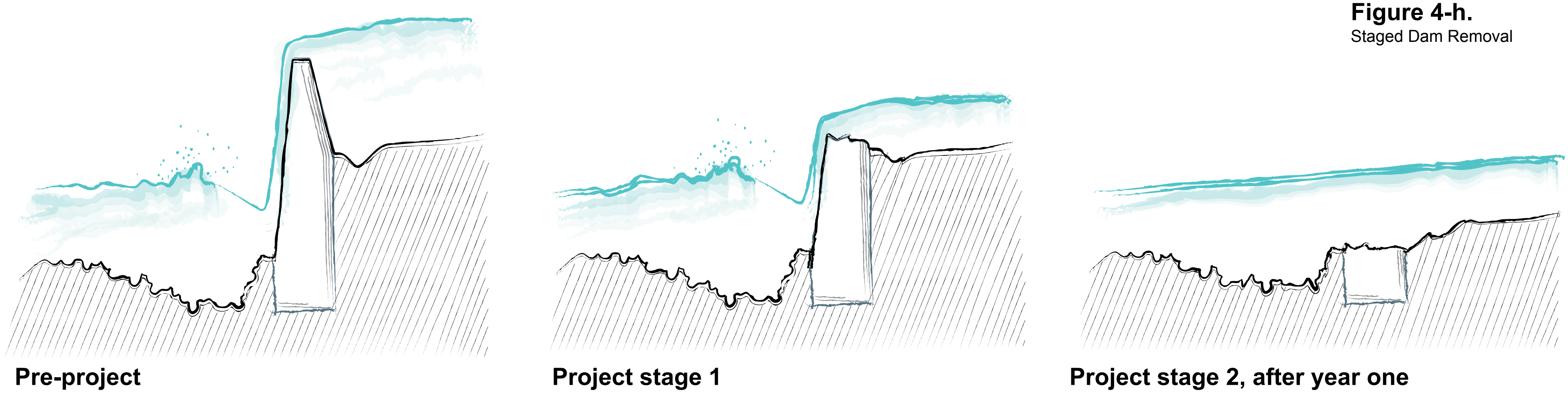


Figure 4-h.
Staged Dam Removal

Staged dam removal: The top section of a dam is lowered by a prescribed number of feet over a lenght of time, usually years, in order to control volumes of sediment released in a single event (Morris & Fan). Similar effects can be created by breaching the dam, or leaving existing gates open for a long period of time to gradually release sediments.

Alternative D: Recreational attractions

Several national engineering firms design highly recreational structures that can transform an old dam into an amenity for both locals and tourists, and add to an overall attractive setting. These can range from a mildly adventurous section of water friendly to children on innertubes (right) to a highly technical Olympic whiteater course, such as one constructed in Wausau, Wisconsin.

Construction of the first Iowa example began in Charles City in the fall of 2010 funded by local hotel / motel taxes, Iowa DNR's low-head dam public hazard program, and Iowa Great Places funding. Note in the photograph (FIGURE 4-j) that a portion of the channel is smooth and steep-sloped. That portion of the channel will provide a recreational wave for surfing by kayaks or river surf boards.

Recreational Makeover. Recreational chutes, pools, and boulders replaced a low-head dam, as hazard for innertubers in San Marcos, Texas. The area reamains popular for innertubing, with added swimming and kayaking opportunities.

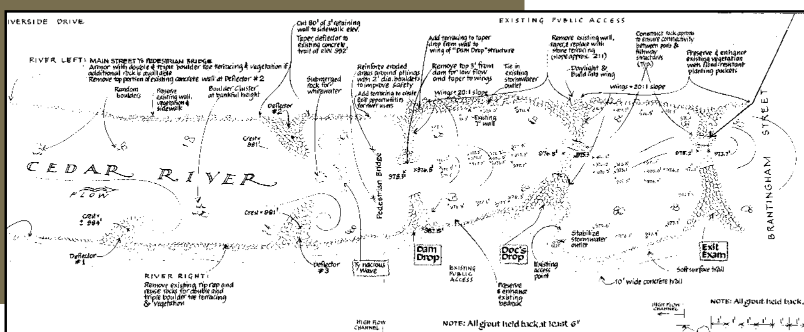


Figure 4-i. The design (Recreational Engineering and Planning) for the Charles City whitewater park uses large natural quarry boulders with grouting injected betwen them in a series of freestanding weirs. The project will result in similar features to the San Marcos park (photos, above).

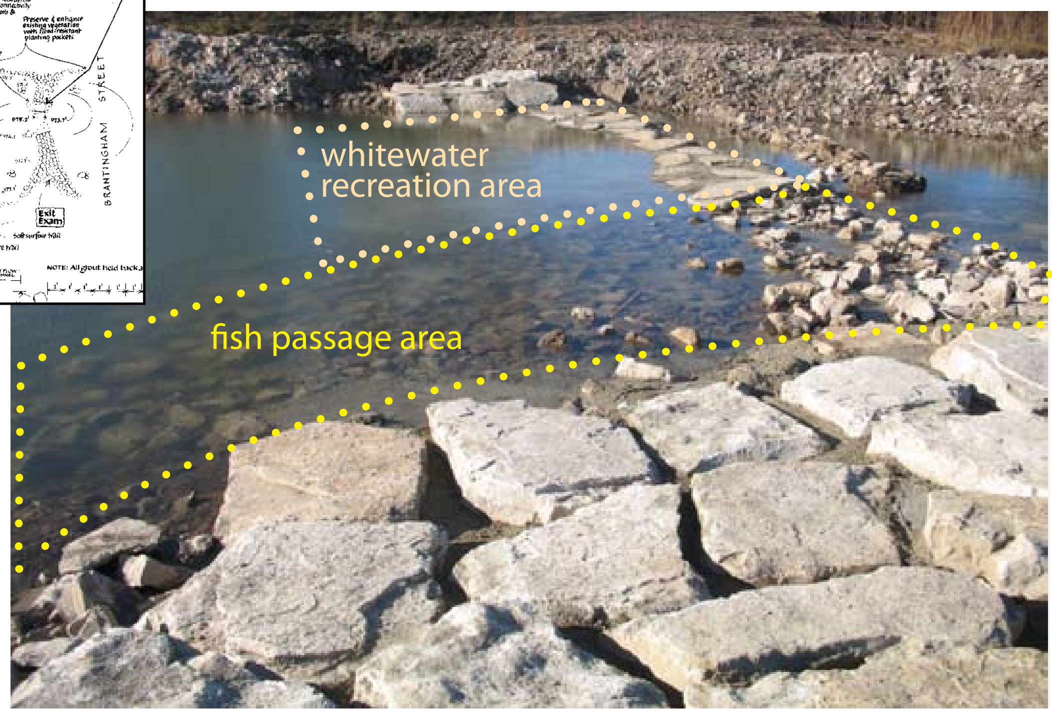


Figure 4-j. Iowa Code 481A.14 requires new in-channel stuctures to provide fish passage. Fish passage is a key for both mussels and fish to access various portions of streams. The roughened, gently sloping portion of the channel at the Charles City whiteater park is designed to maintain velocities and flow patterns fish can use to work up the rapids.

Alternative E: Height reduction with rock ramp

Fully removing a dam is oftentimes neither necessary or desirable. Too much sediment may be released, or the dam owner may not be in control of the upstream area for restoration to occur. At the same time, applying the rock arch rapids design to tall structures can be cost prohibitive or technically infeasible. Lastly, rock arch rapids do not address impoundment problems such as low dissovled oxygen, fine sediment accumulation, and sediment transport interruptions.

Some advantages of stream restoration can be realized in this balanced approach. Reducing the height of a dam can begin to normalize sediment transport while reducing project cost. The bulk of sediments can become a bankfull floodplain across much of the former impoundment bed. However, the channel will likely be wide and shallow until vegetation becomes well established on its own. This may take years or even decades.

Height reduced. The height of the Hopkinton Dam was reduced, with a riffle installed downstream, similar to the Figure 4-l.

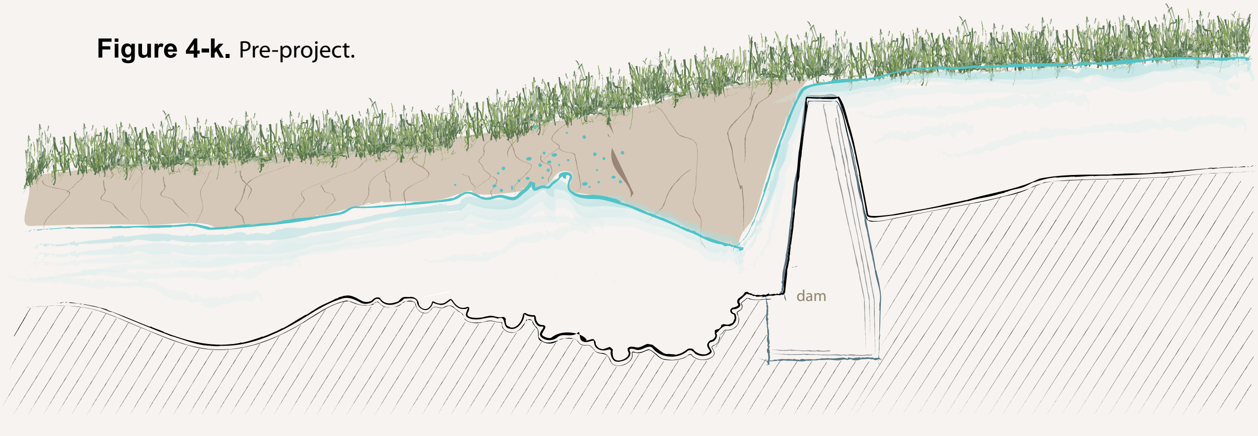


Figure 4-k. Pre-project.

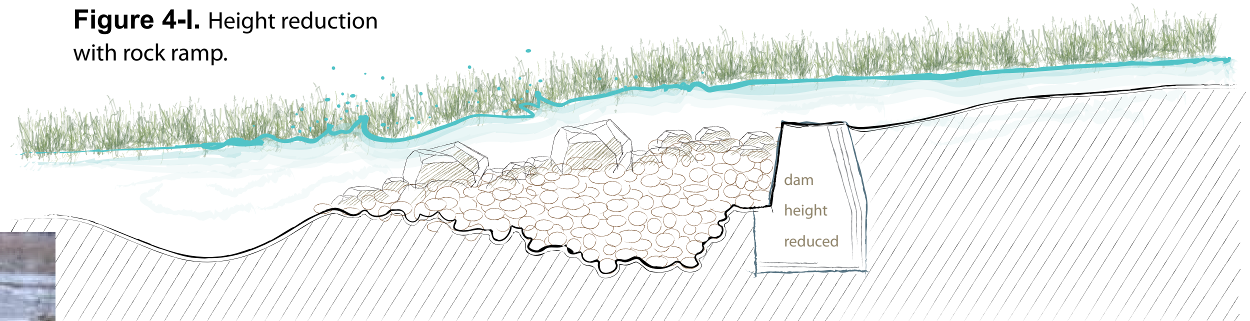


Figure 4-l. Height reduction with rock ramp.

Alternative F: Replacing a dam with a rock-arch rapids

When a pool needs to be maintained for infrastructure reasons, but the dam is not in the optimal position for rock sizing and slope considerations, a dam's impounding function can be replaced by a free-standing rock arch rapids. A 4:1 backslope becomes necessary.

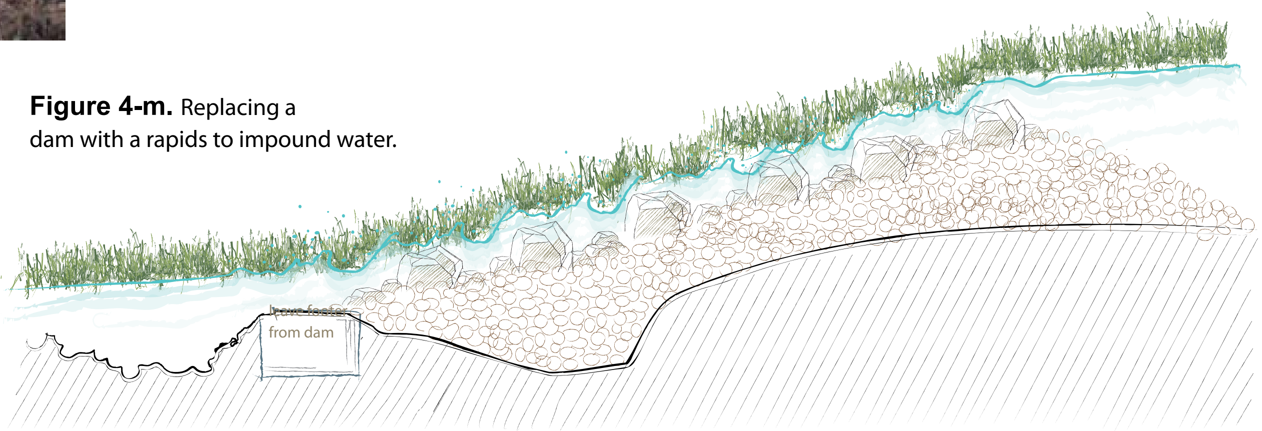


Figure 4-m. Replacing a dam with a rapids to impound water.

Alternative G: Hazard retrofits

Structures that do not enhance fish passage, but are likely to reduce fatalities by breaking up recirculating hydraulics, may play a role in several situations. Figure 3-d in chapter 3 shows dams where fish passage is biologically undesireable because these dams play a role in preventing invasive Asian carp from moving upriver. In other cases, where rivers are wide and dams will be retained, safety-only treatments may be considered for part of the channel width alongside fish and boat passage chutes and side channels.

Step dams

Step dams (Figure 4-n) have been used across North America as a way to reduce recirculating hydraulics. They have probably reduced drownings, but may not be 100 percent effective. Rock structures that disrupt uniform flow patterns may be more successful at dissipating hydraulics than uniform concrete construction. Installing step dams can be fairly costly, and don't offer additional benefits.

Trailing vanes and floating slides

Recently developed engineering techniques can reduce the "roller hydraulic" effect of dams and leave a dam intact by installing adjustable or self-adjusting slides and vanes (Figures 4-o, 3-p). These may be more cost effective than step dams in some situations. However, these new technologies have not been broadly applied and field tested.

Alternative H: Partial channel chutes

A chute uses a portion of the width of a dam to convert it into either a fish passage, boat chute, or both. It requires a wall be constructed to divide the chute from the main channel. Unlike preceding mitigation approaches desribed, it does not reduce hazard across the entire width of a dam. Because it also draws recreation close to the dam, it should be paired with a hazard retrofit from Alternative G. Expense of the combined approaches mean this alternative will likely be deployed at wide dams in urban settings.

Chute with step dam. Denver's Confluence Park has an example of partial channel chute (boating). The remainder dam of the dam was retrofitted into a step dam for safety reasons.

Alternative I: Side passages

Side channel passages, also known as diversions, require excavation of a small channel around the dam. They have been used both for fish passage and boat passages in Europe and North America. Some communities developing whitewater courses prefer this method because flows to the diversion can be controlled. Burried utilities and development near dams can make this approach a challenge, and it tends to be one of the most costly approaches. In addition, it does not remove the hazard. Fish sometimes have a difficult time finding the mouth of the fish passage for migration, because they are attracted to the louder noise of water spilling over the dam.

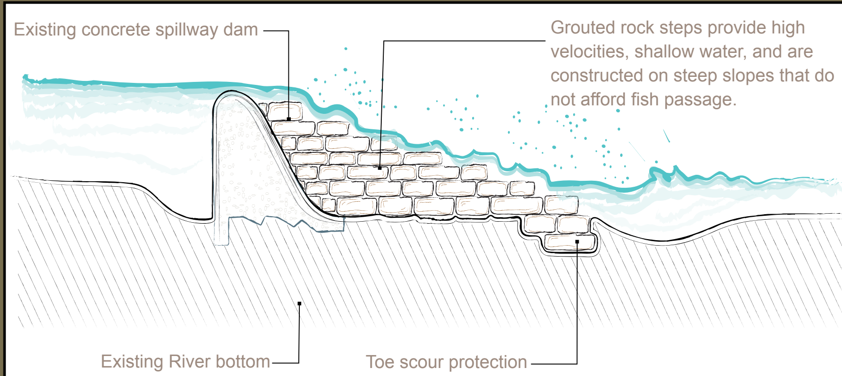


Figure 4-n.
Step dams can reduce recirculating hyraulics by creating a chaotic, rather than uniform, flow pattern.

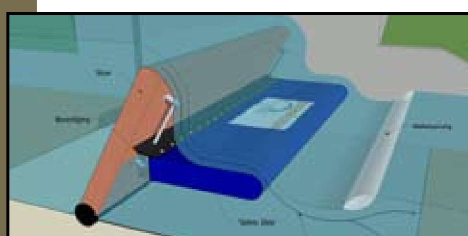


Figure 4-o.
Safety slide, patent pending by Oranjewoud, The Netherlands.

Floating slide. Recirculation eliminated with floating slide in a Dutch canal

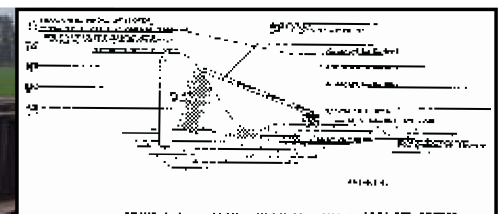


Figure 4-p. Trailing vane proposed for a Fort Dodge dam. Patent by McLaughlin Whitewater Engineering.