DEPARTMENT OF NATURAL RESOURCES

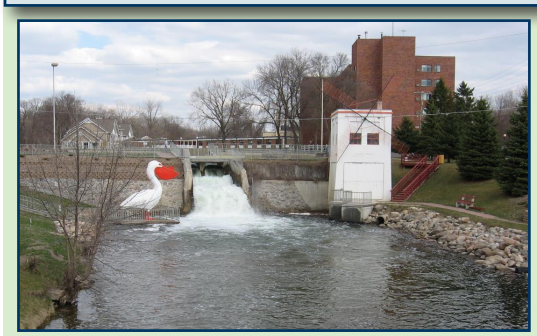
Rock Arch Rapids

What are they and why are they used?

A **Rock Arch Rapids** is used to replace or modify dams.

- Reasons to modify dams:
- Dams are aging, degrading, and at increasing risk of failure.
  - Rainfall events are becoming more intense and frequent.
  - Land use changes direct extra runoff into river networks.
  - Dam maintenance is expensive and ongoing.
- Many dams no longer serve their original purpose.
- Dams present safety concerns.
  - Hydraulic undertows are a drowning hazard.
  - Dam failure risks lives and property damage down valley.
- Dams cause great ecologic harm to river ecosystems (*see back*).

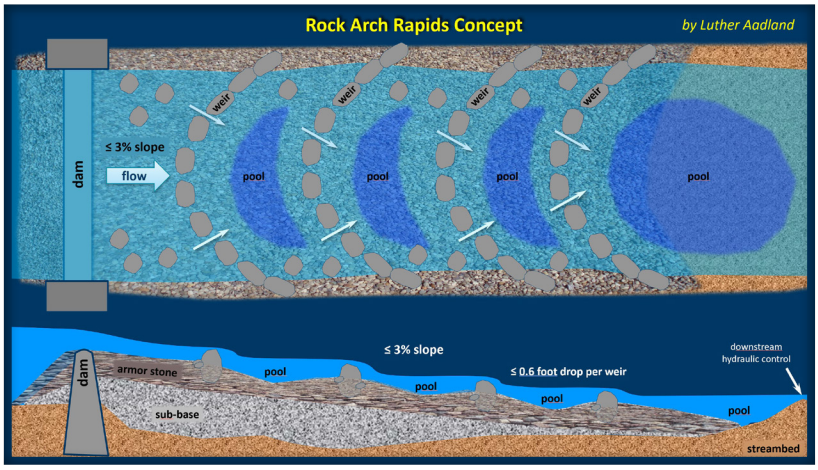
MN DNR River Ecology Unit



The deteriorating dam in Pelican Rapids, MN was modified into a Rock Arch Rapids winter 2022/2023. The ramp gradually steps down the water 5 feet over 12 arches.

Rock Arch Rapids Development and Features:

The Rock Arch Rapids (RAR) design concept was developed from years of research on natural stream features. Various naturally occurring riffle and rapids features were surveyed and analyzed for function, stability, fluid dynamics, habitat, and passability. Variations of this design have been constructed around the state (first one in 1994), studied, and refined over the years. *(Simplified graphic)*



Each RAR project is designed specifically since each river site is unique - considering total drop in water level, ramp length, flow conditions, flood size and frequency, floodplain concerns, structural constraints, fish community, etc. Each project also goes through a rigorous modeling process.

The RAR is composed of a rock ramp base that replaces the abrupt drop in water level with a gentle slope (less than 3%). The rock arches, or weirs, nested within the ramp are made of large boulders positioned in an arch with the top of the arch facing upstream and set lower than the 'legs' of the arch. This focuses the flow to the mid-line of the rapids. The large weir boulders are buried halfway or more in the rock base with the top of each boulder set at very precise elevations, to ensure less than half a foot of drop per weir. The boulders are set higher continuing towards the banks to dissipate flow energy along the banks and create slower flow areas for weaker swimming fishes. The boulders are also placed with varying sized gaps in between to create fish passage openings through the weirs. Deeper pool habitat is created between the arches for resting areas and low flow refuge.

Benefits of the **Rock Arch Rapids** design

Structural and Safety Benefits:

» structurally stable
» require minimal or no maintenance
» improve safety by eliminating hydraulic undertows or rollers known as drowning machines
» protect banks by directing flow towards mid-channel

Ecological Benefits:

- allows fish passage under all flow conditions (from spring floods to summer droughts) for fishes of all sizes and swimming abilities
- can include a low-flow channel for year-round aquatic passage
- fish species absent upstream return after dams are modified
- upstream expansion of native mussels via native fish hosts
- wildlife passage can be incorporated with bankfull flats
- creates high gradient stream habitat that is rare and crucial to the stream community that is often buried/submerged by dams
- accumulated reservoir sediments are stabilized in place
- stabilizes stream grade, or slope, preventing further up or downstream damage or degradation
- interstitial spaces in the rock ramp allow some subsurface flow through the hyporheic zone (the river's liver) that is very important to stream health and water quality
- restores natural sediment transport during higher flows through the boulder gaps and proper cross-sectional area
- design can be modified into alternating sine waves to accommodate larger, deeper pools for larger bodied fish species

Recreational Benefits:

- recreational boating opportunities for canoes, kayaks, paddle-boards, and tubing (flatter slopes are safer)
- fishing opportunities - migrating and spawning fish are drawn to this habitat and intentionally placed flat boulders can be incorporated as fishing platforms
- wildlife viewing opportunities for spawning fish and visiting birds and wildlife

Rock Arch Rapids Design Thresholds for Fish Passage:

- ramp slopes <= 3% slope (flatter slopes best, especially in large rivers)
- drops over the weirs <= 0.6 foot per weir
- pool depths >= 4 feet for small weirs; >= 6 feet in large rivers
- terraced or elliptical cross-section with gradual side slopes
- gaps between boulders sized to accommodate the range of body sizes of native fish and river flows