Division of Fisheries
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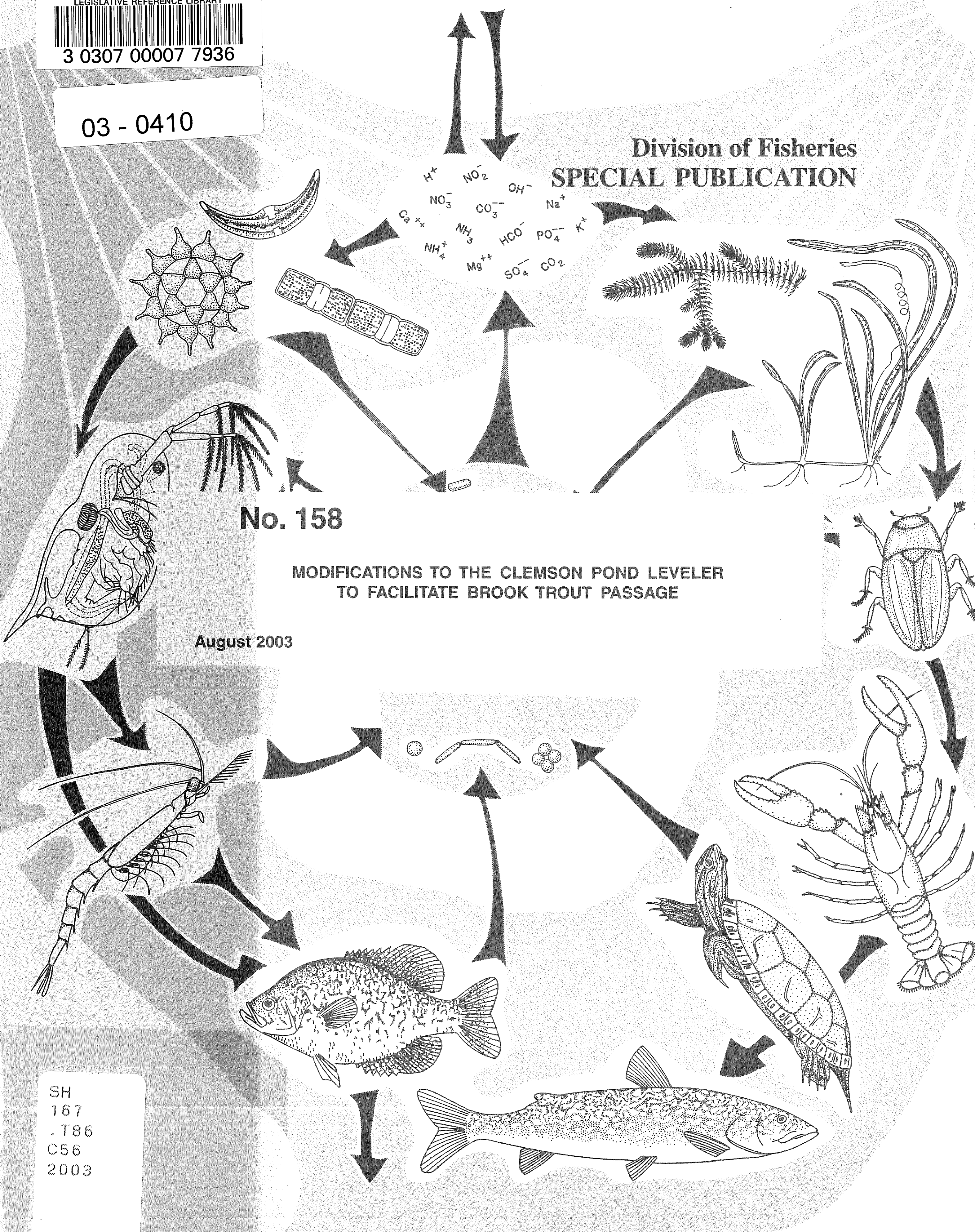


## No. 158

### MODIFICATIONS TO THE CLEMSON POND LEVELER TO FACILITATE BROOK TROUT PASSAGE

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# Modifications to the Clemson Pond Leveler to Facilitate Brook Trout Passage

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*Abstract*.--Beaver dams often preclude brook trout *Salvelinus fontinalis* from accessing thermal refugia and spawning sites but colony removal is not always an option. The Clemson Pond Leveler, developed at Clemson University, is essentially a modified culvert that effectively controls beaver pond flooding without colony abandonment. The device will not pass migrating fish as it is typically installed. We modified the intake device of a Clemson Pond Leveler by enlarging the holes and reorienting the beaver exclosure cage, and used a larger diameter discharge pipe. The modified leveler will pass fish if enough levelers are installed to reduce the water velocity in the passage leveler to $\leq 0.8\ m \cdot s^{-1}$, both ends are submerged, and the fish are properly guided to the outlet.

## Introduction

Beaver dams alter cold-water streams in ways that can negatively affect brook trout *Salvelinus fontinalis*. Dams change lotic environments to lentic environments, warming (Shetter and Whalls 1955; Avery 1962; McRae and Edwards 1994) and deoxygenating the waters (Avery 1962). Beaver dams reduce water velocities, leading to sediment deposition, restructuring the invertebrate community in favor of species that are less desirable as food (Hale 1966). In thermally marginal streams, brook trout seek cold-water seeps when water temperature rises (McRae and Edwards 1994), and beaver dams may deny them access to these thermal refugia. Brook trout lay their eggs in or near spring water upwellings (Webster and Eiriksdottir 1976; Curry and Noakes 1995) and may migrate long distances to reach them (Scott and Crossman 1973). When beaver dams deny access to these upwellings, brook trout must deposit their eggs in less desirable sites where survival is lower.

Public acceptance of trapping has declined, and reduced demand for beaver fur has lowered prices paid for beaver pelts to such an extent that harvest of beaver has steadily declined since 1986 (Berg 2000). Many landowners are less willing to allow trappers access to beaver colonies on private property because they enjoy observing the beaver and other wildlife attracted to the pond. Tools that allow brook trout passage through or around beaver dams would benefit brook trout fisheries when beaver removal is not an option.

Controlling water velocity is the key to successful fish passage if resting sites are not available within the passage device. The Clemson Pond Leveler (Figure 1), developed at Clemson University is essentially a modified culvert that effectively controls beaver pond flooding without colony abandonment (W. Berg, Minnesota Department of Natural Resources, personal communication). Work by Belford and Gould (1989) indicated that brook trout could negotiate culverts as long as 94 m with a 1.2% slope, if the water velocity was $\leq 0.8$ $m \cdot s^{-1}$. A subsequent publication by the Ontario Ministry of Natural Resources (1990) showed similar data and in both cases, almost no brook trout negotiated faster water velocities regardless of culvert length. Unfortunately, the Clemson Pond Leveler will not pass migrating fish as it is typically installed. A standard leveler will discharge a maximum of 0.042 $m^3 \cdot s^{-1}$ (Minnesota Department of Natural Resources, Division of Wildlife information brochure; water velocity $= 1.75$ $m \cdot s^{-1}$). This is lower than the typical flow in many brook trout streams, therefore a head of water will form over the intake device and water velocity in the outlet pipe will usually be near the maximum. Brook trout can traverse distances as long as the typical leveler installation if the water velocity is $\leq 0.8$ $m \cdot s^{-1}$, but water velocities are seldom slow enough to pass fish. The 5 cm holes in the intake device are too small to pass large brook trout, and the 5 cm vertical dimension of the intake device's wire beaver exclosure cage may also deter fish passage (Figure 1). Installation instructions specify that the outlet pipe should extend at least 6 m downstream from the base of the barrier and that a vertical standpipe may be used on the outlet to control water level when necessary. Migrating fish will always swim past downstream bypass flows and proceed to the face of an obstruction (Bates 1992). Furthermore, it is doubtful that fish will jump to enter a vertical pipe. During low flows, fish passage can only occur if adequate water is in the pipe, requiring some type of downstream water level control.

Beaver dams are always barriers to upstream fish movement regardless of flow, but downstream movement is possible during high flows. Our objective was to test whether a modified design would allow upstream movement of fish. A second objective was to test for low cost, using readily available materials that are light-weight and could be carried into remote locations for assembly.

## Methods

I first calculated the maximum discharge through 30.5 cm and 25.4 cm diameter pipes that could be reached without exceeding 0.8 $m \cdot s^{-1}$ using Manning's equation. The discharge was estimated as $Q = V \cdot A$, where $Q =$ discharge ($m^3 \cdot s^{-1}$), $A =$ total cross sectional area ($m^2$) of the pipes, and $V =$ velocity ($m \cdot s^{-1}$). A 30.5 cm diameter leveler will pass 0.058 $m^3 \cdot s^{-1}$ and a 25.4 cm diameter leveler will pass 0.041 $m^3 \cdot s^{-1}$ at a level pipe water velocity low enough to pass brook trout at temperatures near 0° C. A set of one 25.4 cm and two 30.5 cm pipes could thus pass 0.157 $m^3 \cdot s^{-1}$ before exceeding the threshold, if velocities were equal in each pipe. The site selected for leveler installation was a dam with apparent beaver activity located in the Two Island River, Cook County, Minnesota. In October 2002, discharge was estimated using the method of partial sections (MNDNR 1978) and found to be 0.142 $m^3 \cdot s^{-1}$. The set of three pipes with diameters as specified above could pass this discharge with an expected velocity of 0.72 $m \cdot s^{-1}$, suggesting the velocity would not exceed the 0.8 $m \cdot s^{-1}$ threshold at base flow.

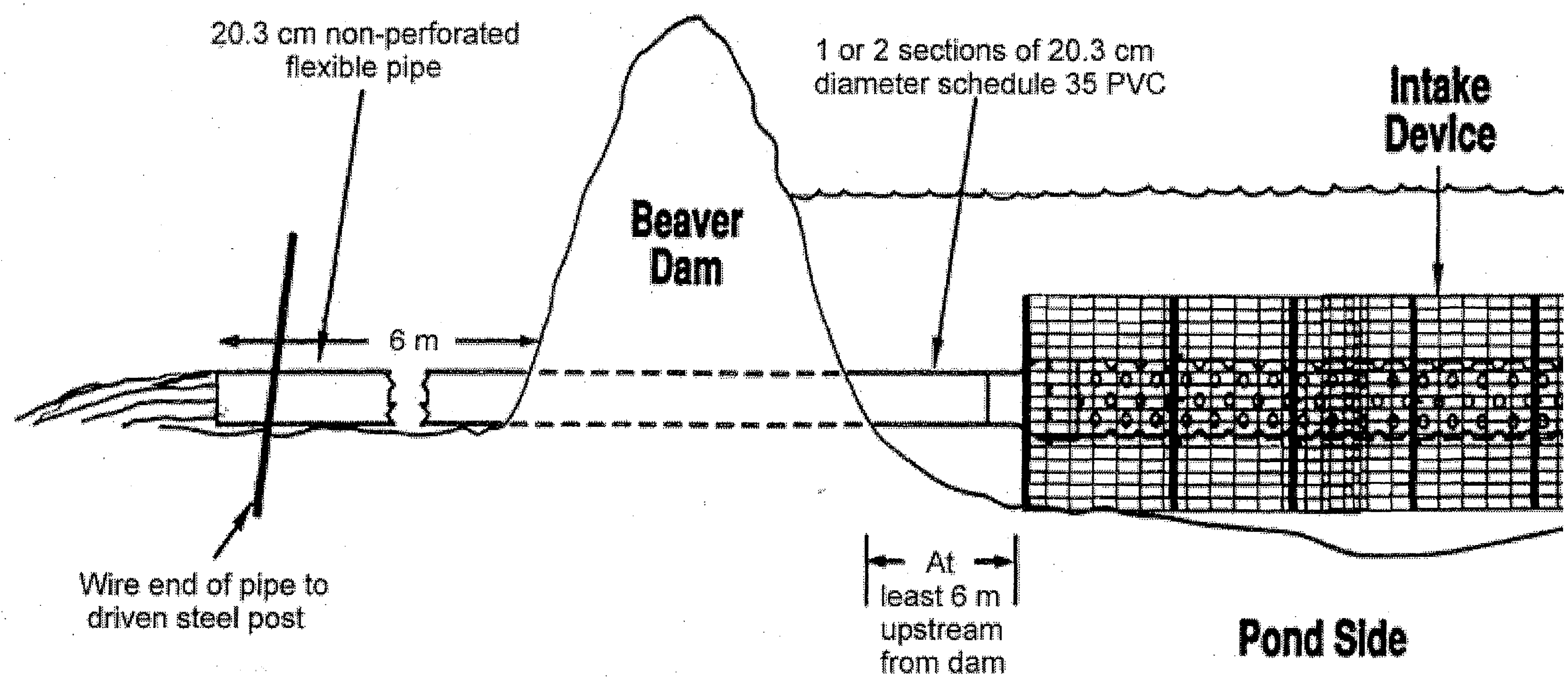


Figure 1. Typical unmodified Clemson Leveler installation during a high flow. The 5 X 10 cm openings in the exclosure cage are oriented parallel to the long axis of the pipe. The intake device has 5 cm diameter holes, a 25.4 cm to 20.3 cm reducer, and an end cap.

Three pond leveler intake devices were constructed, one for fish passage and two for water bypass, each with larger diameters than the pipes in the original design. The intake device for fish passage was made from a 3 m section of 25.4 cm (10 inch) diameter polyvinyl chloride (PVC) air duct. Six rows of 5 X 10 cm (2" x 4") rectangular slots were cut along the pipe with the slots oriented perpendicular to the long axis of the pipe. No end cap was used. The intake pipe was enclosed in a cylindrical wire cage made of 5 X 10 cm, 12 gauge welded wire (Figure 2). Openings in the exclosure cage were oriented perpendicular to the long axis of the pipe and the pipe was positioned in the cage as in Figure 2 (lower). Two intake devices designed for bypass flow were made of 30.5 cm (12 inch) diameter PVC air duct with the standard 5 cm hole array and an end cap. We did not enclose the bypass intakes with wire cages.

The beaver dam was opened and the three intake devices were installed side by side. Three 3 m sections of 25.4 cm (10 inch) diameter single wall high density polyethelene (HDPE) culvert were connected to the downstream end of the fish passage intake device to pass water though the dam. Several saw cuts about 10 cm (4 inches) in length were made in the belled end of the culvert, forming several flaps that were overlapped on the intake device to form a snug fit. The flaps were secured to the intake device using 6.35 mm diameter hex head lag screws. Three 3 m sections of 30.5 cm diameter single wall HDPE culvert were similarly connected to the downstream end of each bypass leveler except that the ends were not belled so the saw cuts were not necessary. After the levelers were installed, it was evident that the beaver dam was no longer active so the breach in the dam was plugged with sand bags.

The downstream end of the culvert from the passage leveler was inserted into a 1.8 m X 1.2 m X 0.9 m crib so that we could confirm that fish had moved through the leveler (Figure 3). The crib frame was constructed from 1.25 cm PVC pipe and covered with 1.25 cm mesh polyethelene netting. A hole was cut in the upstream end of the crib and the culvert was snugly secured in the opening with cable ties.

Ten wild brook trout were collected with backpack electrofishing gear and placed in the crib to determine if they would swim through the passage leveler. The first four fish, ranging from 156-185 mm total length were released into the crib on 17 October 2002 when the discharge was 0.144 $m^3 \cdot s^{-1}$ and the water velocity in the fish passage leveler was 0.65 $m \cdot s^{-1}$. On 22 October, six more fish, ranging from 151-218 mm total length were released into the crib. The water velocity in the fish passage leveler was 0.86 $m \cdot s^{-1}$. Water temperature on both dates was 0.28° C. The crib lid was sealed with cable ties after each group was introduced to the crib to insure that the fish were not removed by people or animal predators.

## Results

On 24 October 2002, no brook trout remained in the crib or leveler, indicating that all had successfully passed through the device. The water velocity in the passage leveler was 0.75 $m \cdot s^{-1}$ and the water temperature was 0.28° C.

The cost of materials in 2002 to build one 30.5 cm (12 inch) diameter leveler with four 3 m sections of outlet culvert was approximately $241: PVC air duct $52; PVC end cap $12; HDPE single wall culvert (4 x $40) $160; welded wire $7; Flexible PVC pipe $10. Additional inexpensive materials included lag screws, #12 copper wire, eyebolts, nuts, washers and tools. The 30.5 cm diameter air duct and culvert were the heaviest components, weighing 16 kg (35 lbs.) each.

## Discussion

Larger diameter pipes would pass more water, so fewer levelers may be needed, thus reducing construction costs. However, heavier pipes may be impractical to transport to remote sites. We used PVC air duct for the intake devices because it is considerably lighter than schedule 35 PVC, but we were unable to readily obtain pipe larger than 30.5 cm (12 inch). Air duct as large as 38 cm (15 inch) is available but we were not able to purchase it in small quantities and HDPE pipe is not manufactured in that diameter. Manning's equation (White 1979) (see page 2) can be used to estimate stream discharge to determine if water velocities in the levelers will be slow enough to pass fish.

Migrating fish must be lead to the passage leveler outlet. The downstream entrance to the passage leveler must be at the face of an obstruction or fish will swim past it and proceed to the face of the dam. A fence of small mesh will suffice but it will require periodic cleaning and maintenance following freshets. A sandbag, rock or plank weir is also feasible, but if discharge is higher than the levelers can handle, the weir should be a barrier itself or fish will jump over it and become stranded in the impounded pool. If multiple leveler outlets are at the same location, all should have passage leveler intake devices. This strategy has another advantage in that the larger holes in the intakes will reduce weight and make transport to remote locations easier.

The air duct in the passage leveler intake may need an end cap and the bypass intakes may require enclosure in a welded wire cage. Beaver repair breaches in their dam by responding to the feel and sound of flowing water. Dr. Gene Wood, developer of the leveler, stated that the end cap and wire cage are necessary to prevent beaver from detecting the flow and attempting to plug the leveler (personal communication). The water velocities in our passage scenario, however, are considerably slower than through the standard leveler, reducing the probability of detection by the beaver. The detection velocity threshold is unknown.

The natural dam-repair response by beaver may be used to fill the dam breach following leveler installation. Raising and securing the downstream ends of the flexible HDPE culvert above the original water level in the pond will temporarily direct all flow through the breach and the beaver will fill it quickly.

Water level must be controlled so that the intake and outlet of the passage leveler(s) are submerged or nearly so. The water level in the upstream pond can be controlled in two ways. If all levelers include the welded wire exclosures, the position of the intake pipe in the wire cage will control water level to some extent. In our experiment, we positioned the intake pipe at the bottom of the cage to lower the upstream pond to its pre-impoundment level. In time, the flow through a pipe in this position may decline from sediment deposition. Additional control can be obtained by raising or lowering the end of the outlet culvert(s). In our experiment, the beaver dam was positioned near the middle of a large pool that controlled the water level, submerging both ends of the passage leveler. In other situations, the water may need to be impounded downstream from the passage leveler outlet(s) (Figure 4). This can be accomplished by restricting the flow with rocks or sand bags since fish can swim through very high water velocities in short bursts (Beamish 1978).

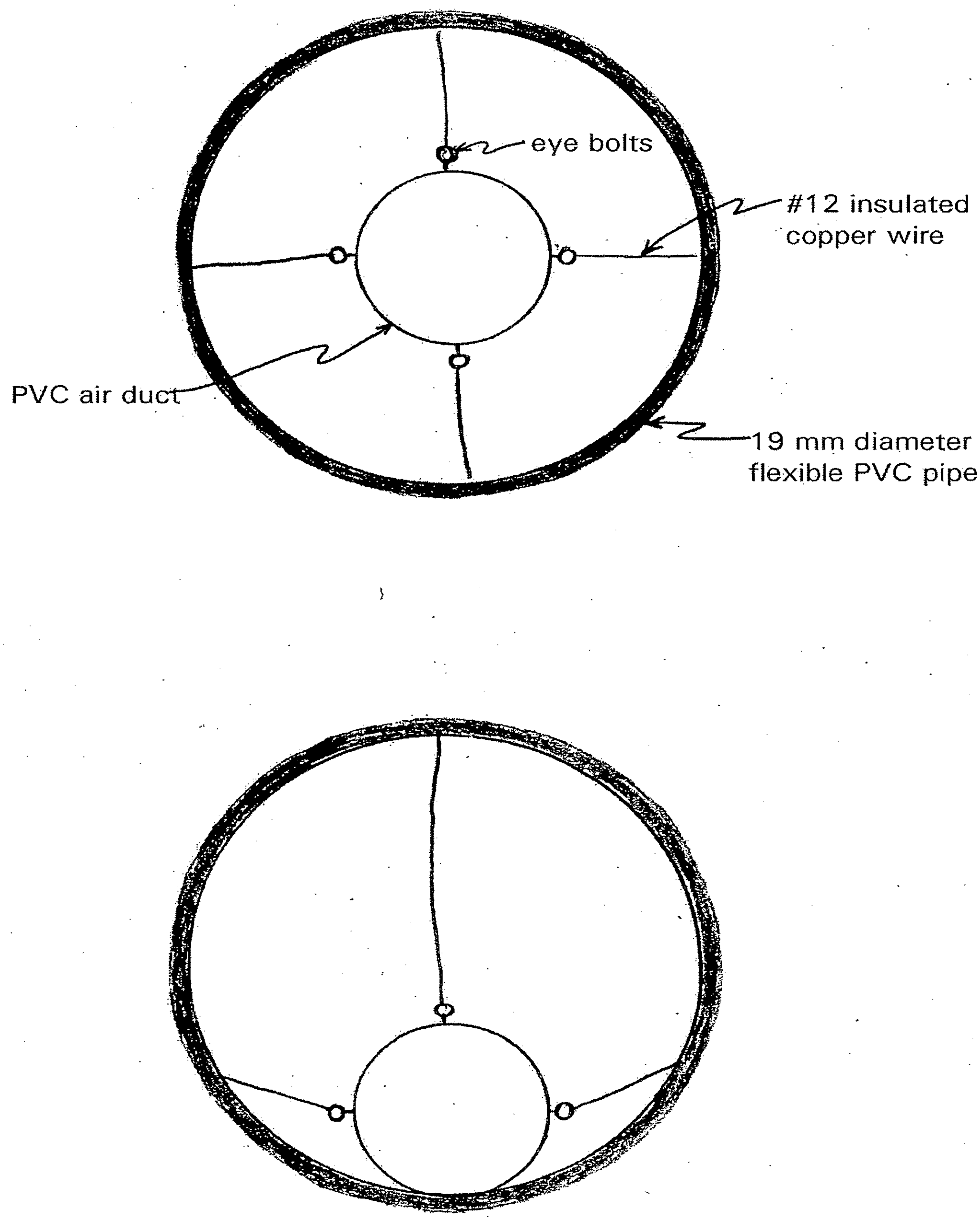


Figure 2. End views of the standard Clemson Pond Leveler intake device (upper) and the modified version (lower).

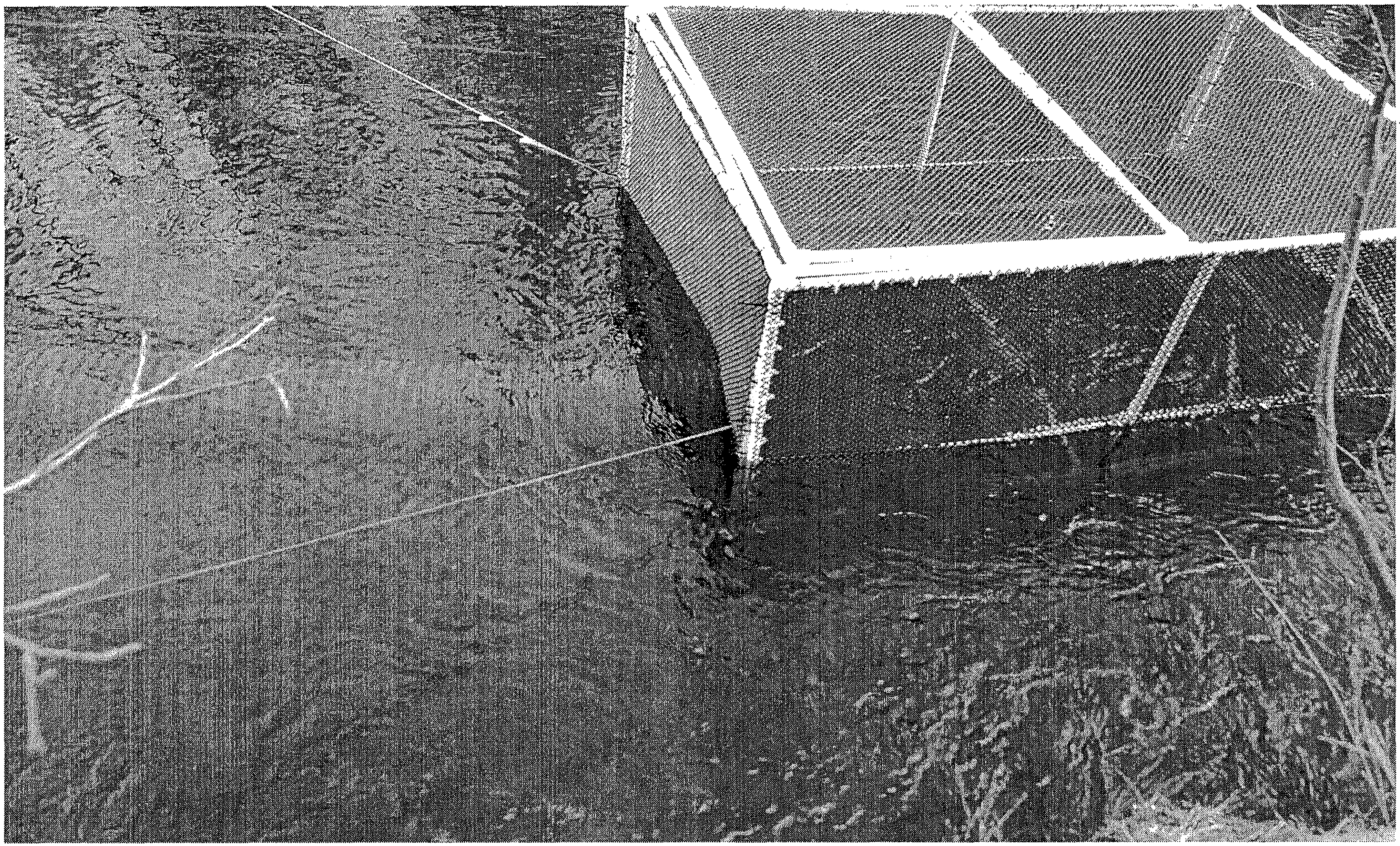

Figure 3. Enclosed outlet of the fish passage leveler, Two Island River.

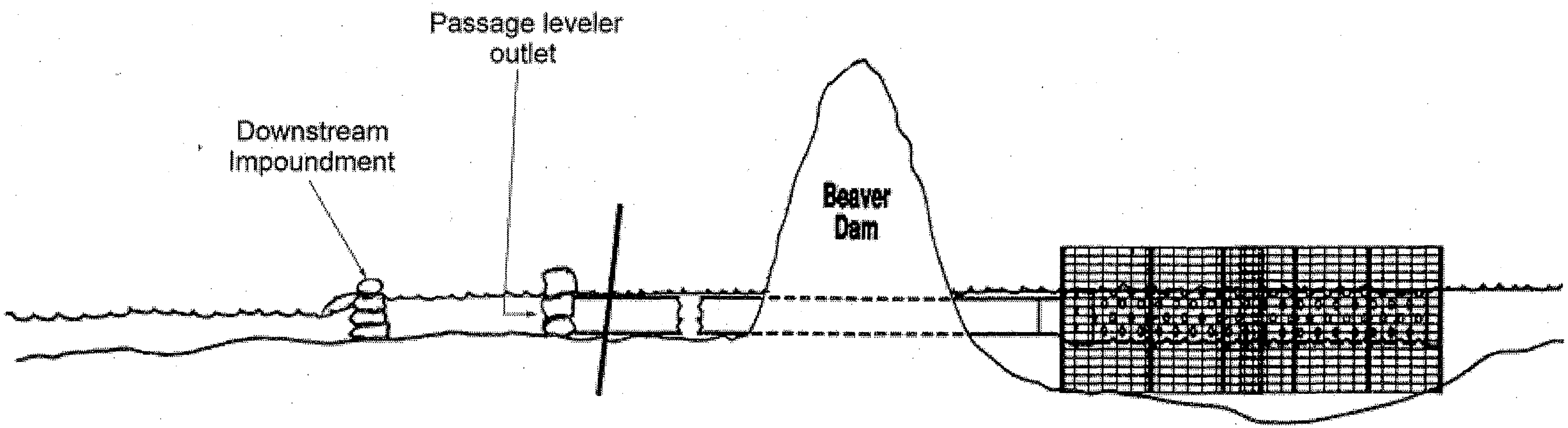


Figure 4. A leveler installation showing the down stream impoundment to submerge the outlet and control the upper pond water level.

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