Solving Beaver Flooding Problems through the Use of Water Flow Control Devices

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ABSTRACT: Once extirpated from large parts of this country, the beaver has made a surprising comeback. However, the beaver's return to its former range is accompanied by a rising number of complaints caused by beaver-created impoundments. Highway departments, homeowners, and government officials find themselves confronting costly damage to septic systems, road infrastructures, and property as a result of the beaver's engineering ingenuity. The traditional response has been to trap and remove beavers, yet this solution is often short-term due to the continual immigration of beavers from the surrounding habitat. In addition, public attitude surveys reflect a growing desire for more humane solutions and rank animal suffering as a major determinant of which wildlife management practices are considered acceptable. To meet this growing need, two entities, The Humane Society of the United States and Beaver Solutions, Inc., established their own respective programs to help communities and homeowners resolve beaver problems through the use of water flow control devices (WFCDs), which present a relatively new, little known yet innovative concept. WFCDs are designed to control the water level, thereby preventing flooding, while allowing the beavers to remain in their habitat. This paper describes the social and ecological context for current beaver problems, how WFCDs function, gives installation and maintenance tips, and presents results of two surveys that assessed the effectiveness of WFCDs in alleviating beaver flooding problems in Connecticut and Massachusetts.

KEY WORDS: animal welfare, beaver, beaver conflicts, Beaver Deceiver, Beaver Remedies, Beaver Solutions, *Castor canadensis*, Culvert Protective Fence, humane methods, non-lethal methods, Pond Leveler, water flow control device

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INTRODUCTION

Despite almost being extirpated due to the European fur trade (Müller-Schwarze and Sun 2003), the North American beaver (*Castor canadensis*) has returned to large parts of its historic range. However, the floodplains they are returning to are now largely dominated by the human hand, and highly-developed landscapes built within floodplains have set the stage for a variety of conflicts. The conflicts range from dammed culverts to flooded roads, railways, and septic systems, destruction of valued trees, and other damage to human-built structures, infrastructure, and commercially-valued resources.

On the other hand, the benefits beavers provide to humans are numerous, such as being engineers of small, biologically rich wetlands that create vital habitat for a myriad of species, including endangered and threatened species. The wetlands created and maintained by beavers provide aquifer recharge, reduced downstream flooding, water table maintenance, erosion control, the filtration of toxins and excess nutrients, and other ecological benefits. However, despite their vital "keystone" role, conflicts with humans and human land uses have escalated in recent times.

THE CONTROVERSY

Most federal, state, and provincial wildlife agencies in North America have traditionally advocated trapping as the most sensible and economical way to resolve human-beaver conflicts (Novak 1987, Langlois and Decker 1997).

However, animal welfare advocates challenge the bases upon which agencies attempt to justify the utility of trapping. The prima facie assumption that a linear relationship exists between the abundance of an animal species and the economic and other damage it causes has been challenged and found to be lacking (Hone 1996).

Certain types of population modeling, meant to substantiate the need for trapping, have also been called into question. For example, published exponential growth figures demonstrate how, without trapping, a beaver population can grow from 2 individuals to more than 600 in just over a decade (Langlois and Decker 1997). However, the authors failed to explain that such increases were modeled on unrealistic populations into which no mortality was ever introduced (Hadidian 2003).

The assumption that indiscriminate population reduction can resolve human wildlife conflicts has been called into question. Animal welfare advocates point to the rapid recolonization of vacated niches as proof that trapping provides only temporary relief where beaver habitat remains unaltered. They stress the confounding effect of immigration, particularly of 2-year-olds who leave their natal lodge in search of new territory.

Research done at the Ames Plantation in Tennessee underscored this phenomenon. All 22 beaver colonies were trapped on the 1,619-ha study site during a 40-month period. The result was that 169 beavers were removed and eventually 162 beavers immigrated back. The researcher stated, "Potential immigration into these domains makes it probable that control programs will be as perpetual as the resource they were designed to protect" (Houston 1998).

Animal welfare advocates also assert that trapping is inhumane. Practices such as drowning and bludgeoning have been recognized by the veterinary community to be inhumane (Ludders *et al*. 1999, AVMA 2001). Kill traps are not endorsed for animals as large as beaver, and reviews of test data on them support the general conclusion that they cannot ensure a humane death for beaver (IAFWA 1997, Hadidian 2003), given the varying durations until time of death and the type and severity of injuries sustained.

Social surveys show a strong public preference for humane methods of wildlife control (Reiter *et al*. 1999), even from that sector of the public experiencing wildlife problems (Braband and Clark 1992). The public tends to equate the word "humane" with "non-lethal."

Although several social surveys have demonstrated that people's tolerance for beaver is largely based on the severity of damage experienced (Seimer *et al*. 2003, Enck *et al*. 1988), little attention has been paid in the literature to assessing the kinds of beaver damage remediation methods that the public prefers. Studies that have attempted to measure human preferences have hardly mentioned, much less described, the potential use of flow devices.

Despite the growing magnitude of the beaver problem, the published literature contains surprisingly few studies which focus on the potential utility of water flow control devices. The few studies that exist focus almost exclusively on the Clemson Leveler (Nolte *et al*. 2000, Wood and Woodward 1992). There is clearly a need for more discussion and research on this simple technology.

WHAT IS A FLOW DEVICE?

Flow devices are pipe and fence-based structures that operate by deception and exclusion. The deception part is achieved by moving water quietly through pipes so the beaver's damming instinct isn't triggered by the sound or sensation of water flow, and the exclusion part is achieved by physically preventing the beaver from blocking an intake area– such as a culvert or the inlet end of a pipe device.

There are generally two types of beaver dams– those that are freestanding in streams and brooks, and those that attached to or built in human structures, such as culverts or spillways. With the freestanding dams, the approach is to breach the dam and set PVC or ADS flex pipes through the dam at the desired water level. Some type of heavy-gauge wire mesh "cage" or "filter" is set over the inlet end of the pipe to prevent beavers from obstructing it. To remove the suction effect of moving water coming in to the pipe, an end cap is placed over the pipe and a 6-in × 2-ft notch is carved out of the underside to move water quietly from underneath. The protective cage is set below the water level to minimize water flow (Figure 1).

The inlet end of the pipe is generally run at least 20 feet from the dam, since beavers are conditioned to search for breaches in the dam at the dam itself– thus the intake should be well separated from the dam (Lisle 2003). Beavers don't tend to associate a 20-foot pipe extension with a leak in their dam.

There are a variety of commercial and non-commercial designs being used, ranging from the Clemson Pond Leveler to the Beaver Deceiver, Castor Master, Beaver Proof Add-On, Beaver Stop, Pond Leveler, and others (Anon. 2003; Lisle 2003; Wood and Woodward 1992; Callahan 2003, 2005).

The various designs are different but share a common goal of eliminating the environmental cues that cause damming. For example, the unique Beaver Deceiver, invented by wildlife biologist Skip Lisle, thwarts the beavers' instinctive habit of building dams perpendicular to stream flow. Beaver Deceivers are odd-shaped configurations (triangular, rectangular, or trapezoidal) which, when placed at the inlet end of dams/culverts, confuse the beavers and discourage damming activity (Lisle 2003). The Beaver Deceiver has been most successful when implemented along with strategies to eliminate environmental cues that stimulate damming behavior (i.e., quieting, calming, and deepening the water in front of culverts).

In addition, although not discussed in this paper, there are other ways to minimize beaver conflicts, such as by reconfiguring the culverts themselves through oversizing (Jensen *et al*. 1999).

PART I: BEAVER SOLUTIONS CLIENT SURVEY

Beaver Solutions is a Massachusetts-based company that formed in 1998 for the sole purpose of providing an ecologically sound solution for conflicts that arise between humans and beaver. Some of the services offered by this company include the installation of water flow control devices, consulting, writing of beaver management plans, educational programs, and licensed

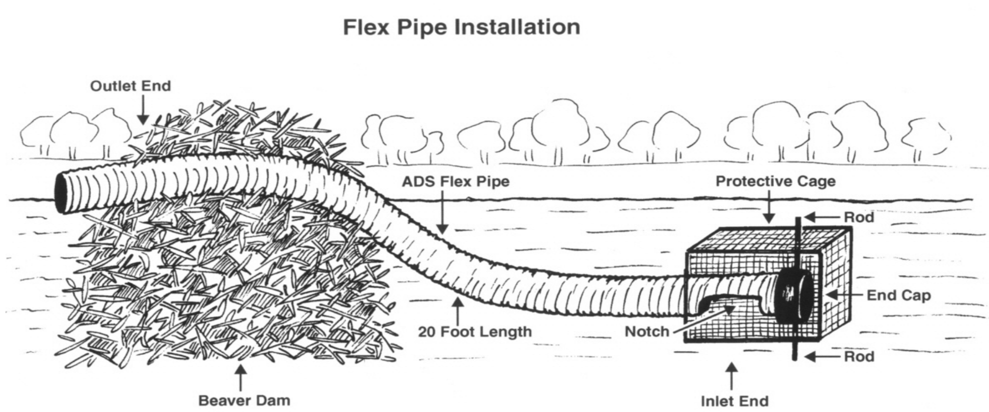

Figure 1. Flex pipe design as used by The Fund for Animals / Humane Society of the U.S.

trapping services. The client base includes highway departments, public utilities, major railroads, state and federal agencies, private businesses and property management, and conservation and humane groups.

A two-part study assessed the efficacy of both water flow control devices and trapping to control beaver problems at 482 conflict sites. Results were first collected in April 2003 and then expanded upon in April 2005, and subsequently reported (Callahan 2003, 2005). This study represents the largest-scale study to date in which both water flow control devices and trapping were utilized to mitigate beaver problems and their success evaluated over a 7-year time span.

Data collection was done by Mike Callahan of Beaver Solutions, Inc., with assistance from Ruth Callahan and Donald LaFountain of Integrated Wildlife Control. Between 30% and 40% of the sites were under annual maintenance contracts with Beaver Solutions. All conflict sites in this study were located in New England or New York, with the majority (98%) of the study sites being in Massachusetts.

Methods

The beaver conflict sites in this study consisted of either blocked culverts or high water levels and/or flooding resulting from freestanding beaver dams. One of two interventions (installation of flow device or trapping) was chosen, and then the sites were monitored to assess the success of the intervention.

Success was defined as complete resolution of the identified problem. For each site, the customer identified the issue(s) of concern before the installation of a flow device or trapping, and Beaver Solutions staff provided an agreed-upon solution intended to resolve the problem. In addition, Beaver Solutions may have suggested methods to remediate other potential issues before undertaking a project.

Culverts

Blocked culverts were manually cleared of beaver damming materials, and then a Culvert Protective Fence (Figure 2) was installed either with or without a Pond Leveler Pipe (Figure 3). Criteria for installing a fence alone included: a) sites containing an open area of water in front of the culvert where a fence could be surrounded by water, b) very high stream flow where the cost for sufficient pipe capacity would be very high, or c) if ponding could not be tolerated in front of the culvert.

Criteria for installing a Culvert Protection Fence and Pond Leveler Pipes together included: a) sites containing a small area in front of the culvert which preclude a fence, b) if there was the capacity for some ponding in front of the culvert, c) if it was desirable to elevate the water level upstream to reduce the risk of other problematic dams upstream, or d) at those sites where beavers had already dammed a poorly-designed fence and were now “fence trained”.

Dams

High water levels from a free-standing beaver dam were lowered with one or more Pond Leveler pipes inserted through the dam (Figure 3), the number of pipes being dependent on water volume and desired level of flowage.

Materials

The materials used to install pipe levelers and fences include Advanced Drainage Systems (Hilliard, OH) polyethylene black plastic corrugated pipe, 20-ft lengths, 6- to 24-inch diameter, single- and double-wall pipes. The pipes are encased with 6-gauge concrete reinforcing wire with 6 × 6-inch mesh that comes in 5 × 10-ft sheets. Concrete blocks are used to weigh down the leveler pipes. Hog rings, copper fasteners, and 9-gauge galvanized wire are used to secure the devices together. The fences are

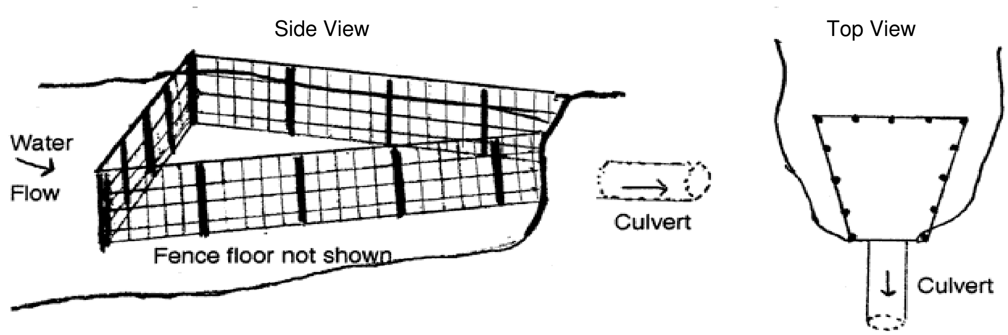

Figure 2. Culvert Protective Fence.

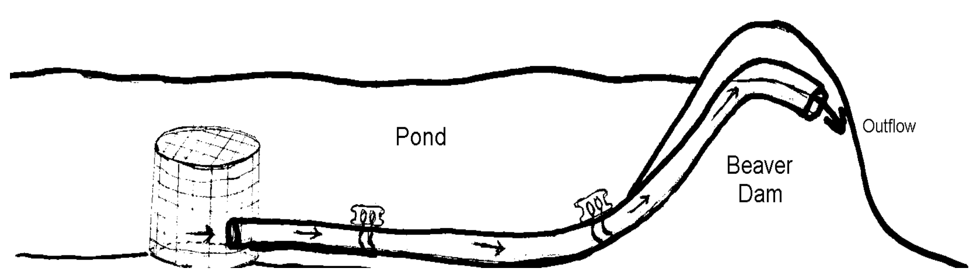

Figure 3. Pond Leveler pipe diagram.

Table 1. Beaver management study overview.

Management Method	Total Sites	Total Successful	Total Failed	Failed <1 Yr	Failed 1-2 Yrs	Failed >2 Yrs
Culvert Devices	227	220 (97%)	7 (3%)	5	2	0
Pond Levelers	156	135 (87%)	21 (13%)	21	0	0
Cylindrical Fences	30	18 (60%)	12 (40%)	9	0	3
Trapping Only	69	8 (16%)	43 (84%)	3	34	6
Total	**482**					

note: follow-up data was not available for 18 of the 69 *Trapping Only* sites

attached to heavy-duty steel fence posts, 5 to 8-ft lengths.

As shown in Figures 2 and 3, flow devices are designed to eliminate environmental cues that trigger the beaver's damming instinct. This can be accomplished by submerging the outlet end of the pipe and surrounding it with protective heavy-gauge wire mesh to prevent the beaver from plugging it with debris (Figure 3), or by minimizing damming by creating a culvert protector in a triangular or trapezoidal shape that frustrates the beavers' instinct to dam in a perpendicular direction to water flow (Figure 2). Even if the beaver dams one side of the fence, this design allows for ample water flow to occur on the other sides.

Trapped Sites

Some sites (69) were selected for trapping as the management intervention. The trapped sites were those where:

- *Topography/logistical issues*: The topography or development of an area presents so many potential conflicts if beavers are permitted to stay, it would be cost-prohibitive to "beaver-proof" with flow devices. An example of a problematic logistical setting includes man-made, uniform channels such as long agricultural drainage ditches or canals. The uniformity of the parallel embankments create an infinite number of places where the beavers can dam, versus the more natural waterways, where most streambeds are not parallel and instead afford beavers particular outcroppings or pinch points at which to start their dams.
- *Zero tolerance for any water level changes*: Areas where human health, property, or safety would be threatened with even a minor water level elevation. Reservoirs are one example of this kind of area. Sometimes septic systems, houses, wells, and other human constructs are built in such close proximity and on such a low plane relative to the natural stream that beavers are unable to build even a small dam without causing a conflict with people. Essentially, in these cases, there is no middle ground where beavers can have enough pond depth to survive while at the same time human health, safety, or property values are protected.
- *Zero tolerance for beaver*: Landowner states a firm, non-negotiable preference for trapping over installing a flow device or protecting trees, and simply won't allow the presence of beavers.

There were 8 additional sites where the water level needed to be lowered over 1 vertical foot where trapping preceded the installation of Pond Leveler pipes in order to prevent the potential for downstream damming.

Results

All 482 beaver conflict sites evaluated by the author between November 1998 and February 2005 were included in this study. A total of 413 sites were managed with flow devices and 69 sites were selected for trapping (Table 1).

The flow devices were in place for an average of 36.6 months with a range of 3 months to 75 months. This represents 15,104 months (or 1,259 years) of total flow device operations.

Flow device success rates were observed at 97% for culvert devices and 87% for Pond Leveler Pipes in free-standing beaver dams. Cylindrical fences were installed on 30 culverts in 1999 and 2000. However, due to a much higher failure rate (Table 1), this design was abandoned by 2000. The reasons why other flow devices failed can be seen in Table 2. These reasons included a new dam, insufficient pipe capacity, no maintenance, dammed fencing, and vandalism.

Trapping was the sole intervention methods used at 69 sites. However, the failure rate was high (84%) due to the fact that 43 of the sites were re-colonized, some within 1 year of intervention (7%), with the majority of sites (79%) being re-colonized within 1-2 years.

Table 2. Reasons for flow device failure.

Reason for Failure	Culvert Devices	Pond Levelers
Total Sites	**257**	**156**
New Dam	0	11 (7%)
Insufficient Pipe Capacity	0	6 (4%)
No Maintenance	4 (1.6%)	2 (1%)
Dammed Fencing	2 (0.8%)	2 (1%)
Vandalism	1 (0.4%)	0
Total Failure Rate	**7 (2.7%)**	**21 (13%)**

Cost Analysis

Beaver-related flooding has been known to cause significant economic damage to roads, railroads, septic systems, agricultural lands, and buildings. In addition, repeated opening of blocked culverts with heavy equipment usually leads to culvert damage, expensive replacements, and continual manpower costs. Preventing these recurring expenses becomes very important for budget-conscious towns, departments of transportation, and railroad companies.

The costs for various flow devices are provided in Table 3. While these methods do have a significant initial installation cost, when averaged over 10 years, these annualized costs drop considerably to several hundred dollars per year.

Table 3. Flow device cost analysis.

	Average Cost	Annual Maintenance	Annualized Cost (10 yr)
Culvert Fence	$750	$200	$275
Culvert Fence and Pipe	$1,400	$150	$290
Flexible Leveler Pipe	$1,000	$100	$200

PART II: FUND FOR ANIMALS CLIENT SURVEY

The Fund for Animals (FFA) established a Beaver Remedies program in 1999 to help homeowners, city officials, and highway department resolve problems caused by beavers. The program provides consulting services and the actual installation of water flow control devices. The program was taken over by the HSUS in January 2005 after a merger between the two organizations.

Methods

The basic flow device designs utilized by the HSUS Beaver Remedies program is similar to those used by Beaver Solutions, therefore a description of the devices and their installation will not be repeated here. Figure 1 is an illustration of the basic design utilized.

A customer satisfaction survey was conducted by phone between April 9-13, 2002. An intern from the Yale School of Forestry and Environmental Studies conducted most of the interviews and was assisted by a Fund for Animals employee. Thirty-six "customers" were interviewed, representing 16 town or agency staffers and 20 private homeowners. Because multiple devices were installed for some respondents, this survey represented the performance of 54 water flow control devices. An attempt was made to reach all clients for whom flow devices were installed since 1998, yet some could not be reached by phone (despite multiple attempts) or had moved. The overall response rate was 86%.

The following survey questions were asked in a phone interview of all respondents:

1) Is the water flow control device still working?
2) Are you satisfied with the device? (very satisfied, satisfied, unsatisfied)
3) Has the device kept the water level where you want it?
4) How often do you do maintenance on the device each year?
5) How long does each maintenance event take, on average?
6) Was there any trapping done at the site before the device was installed or after it was installed?
7) Has the device ever been vandalized?
8) Have you modified the device at all? (If yes, ask reason why/type of modification needed)
9) Would you use a water flow control device again?
10) Would you recommend a flow device to others as a way to resolve beaver flooding problems?

Results

The results of the survey are described below, grouped together under the relevant topical headings. The survey represents 36 customer opinions of 54 installations.

Customer Satisfaction

Respondents' satisfaction level with flow devices was high (89%) and was closely linked to whether or not they perceived the device to be working. Of the 32 "satisfied" respondents, 69% (22) reported being "very satisfied." Although the water level wasn't exactly where 6 respondents wanted it to be, 2 considered themselves still satisfied while 4 were unsatisfied. When asked if they would use a flow device again, the majority of respondents (89%) said "yes," although 4 respondents attached qualifiers to their yes responses such as "if it can be made to work," "with improvements," "with more pipes." Similarly positive results were achieved when respondents were asked if they would recommend a flow device to others. Ninety-four percent said "yes," although 4 respondents attached qualifiers such as "as long as it was maintained," "if more pipes were added," "once the device was fixed," or "worth a try."

Failure Rate

Device failure was defined in two ways: either 1) customers expressed dissatisfaction with the device, or 2) the device didn't work properly after 3 attempts to fix it. Six devices met one or both of these conditions, which amounted to an 11% failure rate.

Trapping

One-third of the respondents (33%, 12/36) said that their sites had been trapped prior to the flow device being installed; however, the number of respondents allowing trapping dropped to 3.7% (2/36) after the installation of the water flow control device. Some respondents commented that they no longer had sites trapped because the flow device solved their flooding problem.

Vandalism

Thirteen percent of the devices (7/54) were vandalized. Three respondents commented that they knew who the vandals were, and that the vandals misperceived the pipe devices to be giant beaver traps, and had vandalized them because of that misconception. To avoid this problem, HSUS now recommends that landowners put up educational signs at high visibility sites to explain what a flow device is and what it does.

Adjustments Needed

Seventy-six percent of the devices (41/54) did not require any modification after installation. However, 24% (13/54) required some kind of adjustment, which was separated out into 2 categories: one-third of those needing adjustment were to fix human-induced damage such as vandalism (20%) or a backhoe damaging the device (10%), while two-thirds of the needed adjustments were to fix problems that arose more naturally, such as ice damage, pipes being knocked out of place, or damaged fencing which resulted in the device being either replaced (15%), the fencing or intake filter being repaired (15%), or the pipe height adjusted or additional pipes added (40%).

Device Maintenance

Half of the respondents reported maintaining their devices (18/36), and FFA staff monitored an additional 10 devices periodically. Respondents reported checking devices at varying intervals during the year. Sixty-one percent (17/28) reported that routine maintenance took 15 minutes or less, and 93% (26/28) reported that maintenance took a half hour or less (Figure 4).

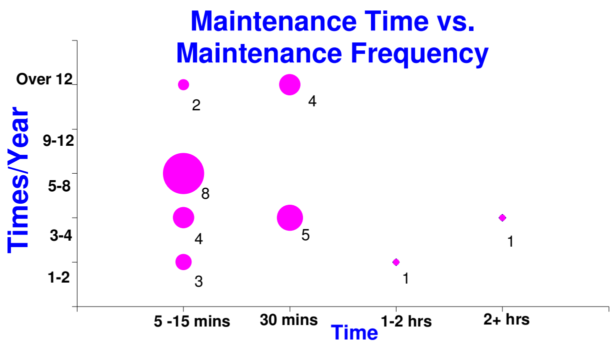

Figure 4. Survey responses on flow device maintenance.

DISCUSSION

Overall, these two surveys revealed both high customer satisfaction ratings and high efficacy levels resulting from the use of water flow control devices to control beaver flooding. Based on these findings, we conclude that flow devices are a cost-effective, long-term, and ecological way to manage most beaver-human conflicts.

Beaver trapping may be the only course of action for those occasional conflict sites where a flow device is either not feasible or fails, the water level needs to be drastically lowered, or the landowner will not tolerate any beavers or any water level fluctuation on their property. However, as the Callahan survey demonstrated, the trapped sites were usually recolonized within a year, thus the effect of trapping was relatively short-lived. Trapping was largely abandoned by clients as a flood control measure on most of the trapped sites in the FFA survey once flow devices were installed and proved successful.

The results of these two studies run completely contrary to statements appearing in agency literature, such as "One significant drawback is that very few beaver problems (only 4.5% in Massachusetts, 3% in New York) can actually be solved with a water level control device" (Langlois and Decker 1997), and that "It is important to choose a site carefully because a lot of time and money is required to build, install and maintain it" (Hamlin *et al.* 1997). In contrast, the two studies conducted by Beaver Solutions and The Fund for Animals found that flow devices demonstrated high success rates, minimal maintenance requirements, a relatively low cost, and that flow devices were applicable to the vast majority of problem sites.

One may wonder if installation errors are to blame for the low success and applicability rates reported in state agency literature. However, the basis for their assertions was neither cited nor found via an extensive research effort, so no firm conclusion can be drawn due to the lack of any citable data or research protocol.

Although devices did require some alteration after installation in less than a quarter of the FFA installations, the vast majority of respondents seemed to find this amount of maintenance to be acceptable.

Overall, this paper provides strong evidence that water flow control devices such as Culvert Protective Fences and Pond Leveler Pipes are the most cost-effective, long-term, humane, and ecological methods to manage most beaver-human conflicts while preserving wetland values. Given the short-term and limited effect of trapping, it is imperative that wildlife damage professionals turn more attention towards research and development of flow devices and their applicability in a variety of ecological contexts.

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