TOWN OF FRANKLIN

DEPARTMENT OF PUBLIC WORKS

257 Fisher Street

Franklin, MA 02038

January 5, 2023

Franklin Conservation Commission
355 East Central Street
Franklin, MA 02038

Re: Beaver Deceiver Installation Project - Request for Determination of Applicability
4 Abbey Lane
Franklin, MA 02308

Dear Members of the Franklin Conservation Commission:

On behalf of the Town of Franklin, I respectfully submit this Request for Determination of Applicability (RDA) for a proposed Beaver Deceiver Installation Project within Bordering Vegetation Wetland and the 200-foot Riverfront Area at the property located at 4 Abbey Lane in Franklin, Massachusetts.

The Town of Franklin Department of Public Works is tasked with ensuring the protection of publicly owned infrastructure. In recent years, a generous portion of this task has been spent mitigating beaver blockage and impacts to Town infrastructure, especially at the Forest Street culvert, Culvert 105A, conveying Dix Brook from the south.

In response to a residential inquiry, Town of Franklin Public Works personnel breached the Culvert 105A blockage, in addition to two upstream beaver dams, by hand prior to submitting this RDA. This is exempt work authorized previously by a Board of Health Emergency Authorization. Subsequently, the Town also mitigated the infrastructure hazard by lethally trapping the responsible beavers. While temporarily effective, this approach is no longer sustainable and the Town would like to find a more efficient and effective solution for the third beaver dams persisting within Dix Brook adjacent to the property located at 4 Abbey Lane. It is my opinion that installing a flow device, otherwise known as a "beaver deceiver" at this location is the best course of action. Implementing minimal-impact engineering controls will be more effective and less disruptive to the natural environment, while also successfully mitigating the hazard.

In addition to alleviating the burden of resources that have historically been dedicated to the breaching of dams, there is also a financial benefit to using engineering controls. Trapping the beavers is only a temporary solution, as the absence of beavers at any given location will once again become inhabited by other nomadic beavers. The persistent nuisance of periodically trapping beavers is not financially sound, and can be sustainably solved by installing a flow device.

The dam adjacent 4 Abbey Lane presents a direct, recognized hazard to Culvert 105A: should this beaver dam fail, it will release an uncontrolled surge of water toward the culvert. Such an occurrence creates both environmental and public safety concerns. As the surge conveys a significant amount of energy in the form of water pressure, erosion along the Bank of Dix Brook will displace soils, while simultaneously elevating and conveying dislodged fibrous vegetation (branches, logs, etc). This mass of organic and inorganic material will be channeled directly toward Culvert 105A; at which point the threat of damage to publicly-owned infrastructure becomes evident. Damage to the culvert from the aforementioned would undermine the integrity of the roadway which is supported by the culvert. This situation must (and can) be avoided by the installation of a flow device at the described upstream location.

The purpose of this Beaver Deceiver Installation Project is to install sustainable, minimal-impact engineering controls, "beaver deceivers", to prevent infrastructure damage due to beaver activities, while simultaneously promoting and encouraging the ecosystem services beavers provide to wetland ecosystems. In doing so, this Project aims to ensure the future protection and success of the local beaver population species, their ecological interactions with their surrounding environment, and the efficiency and success of local stormwater infrastructure.

An RDA is being filed because the proposed work will occur within Bordering Vegetated Wetland (BVW), Dix Brook (Perennial Stream), inland Bank, and the 200-foot Riverfront Area. These Resources are regulated under the Massachusetts Wetlands Protection Act (WPA, M.G.L. c. 131 § 40) and the Town of Franklin Wetlands Protection Bylaw (Chapter 181) and its corresponding Regulations. All of the proposed work will cause minimal disturbance within the Resource Areas with no anticipated permanent impacts. Other Resources identified adjacent the Project Area, but not within the Project Area, the 100-foot Buffer Zone to BVW and Inland Bank, and the locally regulated 25-foot No Touch Zone and 100-foot Buffer Zone to BVW and Inland Bank.

I respectfully request that the Conservation Commission issue a Negative Determination confirming that the proposed work does not run counter to the WPA and subsequently require the filing of a Notice of Intent.

This RDA application includes the following items:

- ❖ Attachment A - WPA form
- ❖ Attachment B - Figures
- ❖ Attachment C - Site Photographs
- ❖ Attachment D - Spec Sheets
- ❖ Attachment E - Best Management Practices for Pond Levelers and Culvert Protection Systems
- ❖ Attachment F - Beaver Benefits

The following text discusses the Wetland Resource Areas, proposed activities, and proposed protective measures.

Wetland Resources

Desktop and site reconnaissance and Wetland Resource Area investigations were conducted by Breeka Li Goodlander, Certified and Professional Wetland Scientist, and BeaverCorp Professional, Conservation Agent/Natural Resource Protection Manager on November 3, 2022 with collaboration from Derek Adams, Stormwater and Environmental Affairs Coordinator from Franklin Department of Public Works.

The reconnaissance was conducted in accordance with Delineating Bordering Vegetated Wetlands (BVW) under the Massachusetts Wetlands Protection Act (WPA, March 1995), the Corps of Engineers Wetlands Delineation Manual, Technical Report Y-87-1 (January 1987), and the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region Version 2.0 (January 2012). Please refer to Figure 1 in Attachment B for the locations of the Wetland Resource Areas.

Dix Brook

Dix Brook flows from the south of the proposed Project Area toward Mine Brook to the north. This stream is shown as a perennial river on the most recent USGS quadrangle and is therefore afforded jurisdictional protection under the WPA and the Franklin Wetlands Protection Bylaw.

Inland Bank

Inland Bank was not observed at this location due to a high water depth and impounded water, (e.g., beaver pond, beaver dam), however jurisdictional inland Bank is assumed.

310 CMR 1054(4) General Performance Standards

(a) None of the proposed work will impact the structural integrity of inland Bank.
(b) The proposed structure will prevent flood damage to facilities, buildings, and roads, therefore the structure may be permitted in or on the inland Bank if needed.
(c) No adverse effect on specific habitat sites of rare vertebrate or invertebrate species is proposed.

Bordering Vegetated Wetland

A Bordering Vegetated Wetland (BVW) is located at the Project location and is best described as a Freshwater Forested/Shrub Wetland (PFO1/4E;PSS14E) bordering on Dix Brook to the west.

This Wetland is regulated as BVW and is also afforded a jurisdictional 100-foot Buffer Zone under the WPA, a locally regulated 25-foot No Touch Zone, and a 100-foot Buffer Zone under the Franklin Wetlands Protection Bylaw.

Wetland Type PFO1/4E

The Cowardin wetland classification system identifies the PFO1/4E label for a wetland that consists of a palustrine basin, dominated by broad-leaved deciduous and needle-leaved evergreen woody vegetation 6 m tall or taller that is seasonally flooded and/or saturated. This means that surface water is present for extended periods (e.g. greater than a month) during the growing season, but is absent by the end of the season in most years. When surface water is absent, the substrate typically remains saturated at or near the surface.

Wetland Type PSS14E

The Cowardin wetland classification system identified the PSS14E label for a wetland that consists of a palustrine basin, dominated by scrub-shrub woody vegetation less than 6 m tall and broad-leaved deciduous and needle-leaved evergreen woody vegetation 6 m tall or taller that is seasonally flooded and/or saturated. This means that surface water is present for extended periods (e.g. greater than a month) during the growing season, but is absent by the end of the season in most years. When surface water is absent, the substrate typically remains saturated at or near the surface.

310 CMR 10.55(4) General Performance Standards

(a) This Project does not propose to destroy or otherwise impact any portion of the Resource Areas. This Project proposes to maintain the existing function of the wetland, supplemented by the local beaver population, to prevent downstream impacts on local stormwater infrastructure caused by beaver damming.
(b) No replacement or replication of BVW is proposed.
(c) No loss of BVW is proposed.

(d) No adverse effect on specific habitat sites of rare vertebrate or invertebrate species is proposed.
(e) No work is proposed within ACEC.

200-foot Riverfront Area

Dix Brook flows from the south to the north-northwest of the Project Area. Dix brook is shown as a perennial stream on the most recent USGS quadrangle and is therefore afforded a 200-foot RFA. The RFA at the Project location consists predominantly of undisturbed BVW, with a portion of the RFA consisting of upland, residential properties, and paved roadways.

310 CMR 10.58(4) General Performance Standards

(a) The proposed work meets the Performance Standards for other identified Resources (i.e., BVW).
(b) This Project is not occurring within or will have adverse impact on specific habitat sites of rare vertebrate or invertebrate species is proposed.
(c) The proposed work is a proactive, sustainable approach to mitigating beaver impacts on stormwater infrastructure and ensuring efficient functionality of said infrastructure. Alternative actions considered for this Project include a no action alternative. a lethal removal alternative, and a culvert fence alternative, A, B, and C respectively. Alternative A is ineffective as it would cause upstream flooding with a downstream surge which has the potential to significantly reduce or limit functionality of the Culvert 105A. Alternative B is equally as ineffective as it would consist of hiring a trapper to lethally remove the beaver from the BVW, subsequently losing all ecosystem benefits the beaver provides. This Alternative would also cost the Town additional funds and would require mobilization with swamp mats and machines to breach the dam within the BVW. Lastly, Alternative C is not appropriate considering that the beaver is not damming Culvert 105A, instead damming upstream. Culvert fences are ineffective against upstream damming impacts.
(d) This Project and its proposed mitigation measure will not have any significant adverse impacts on the RFA.

North American Beaver

A North American beaver (beaver), (*Castor canadensis),* community is located within the BVW complex upstream of 4 Abbey Lane and has built a beaver dam adjacent to the southern property boundary. The beaver, considered a keystone species, is a species whose importance to the ecosystem structure, composition, and function is disproportionately large relative to its abundance. This means that the beaver is the primary species for this ecosystem and has an overarching beneficial impact on the ecosystem and all biotic and abiotic communities therein and thereafter. The removal of a keystone species causes the collapse of ecosystem function, nutrient cycling, and biodiversity. Removing the existing beaver community would negatively impact the surrounding riparian and wetland ecosystem, as roughly demonstrated in Figure 1 below. Note that this Figure lacks a comprehensive list of all ecosystem services gained and lost with the placement and removal of a keystone species, respectively.

Figure 1. Trophic cascade scenario comparing the impacts of the presence of a gray wolf population, a keystone species, on the surrounding ecosystem and the absence of a gray wolf population on the surrounding ecosystem (Encyclopedia Britannica, 2020).

Through this RDA, the Project will simultaneously protect and encourage the ecological benefits of the beaver and prevent future damage and cost of mitigation at downstream infrastructure. For more information on beaver benefits, please see Attachment F.

Figure 2. A stream comes back to life (Goldfarb, 2018)

Rare Species

The Massachusetts Natural Heritage and Endangered Species Program (NHESP) Atlas (15th edition, effective August 2021) was reviewed during the preparation of this RDA. The Project Area does not fall within Priority Habitats of Rare Species or Estimated Habitats of Rare Wildlife as shown on Figure 1 in Attachment B.

Soil Survey

The Natural Resource Conservation Service (NRCS) Web Soil Survey map, which is included in Attachment B, was reviewed for information pertaining to soils within the Project Area. The Soil Survey indicated that the Project Area consists of Scarboro and Birdsall soils, 0 to 3 percent slopes (10), which is considered 100% a hydric soil. Please refer to Figure 2 in Attachment B for the mapped soils and their hydric rating.

Proposed Activities, Work Methodology, Protective Measures

Proposed activities include the hand installation of a flow device, either the Multi-Intake Leveler or the Flexible Pond Leveler. Flow devices are key tools for minimizing damage to human infrastructure and preventing degradation of riparian and wetland ecosystems by the removal of a beaver community. Installation of the Flexible Pond Leveler, applicable in less than three feet of water, or Multi-Intake Leveler, applicable in greater than three feet of water, will be determined in the field and consistent with the BeaverCoalition Best Management Practices for Pond Levelers and Culvert Protection Systems Guidebook (2022) found in Attachment E. Resource safety information for materials can be found in Attachment D.

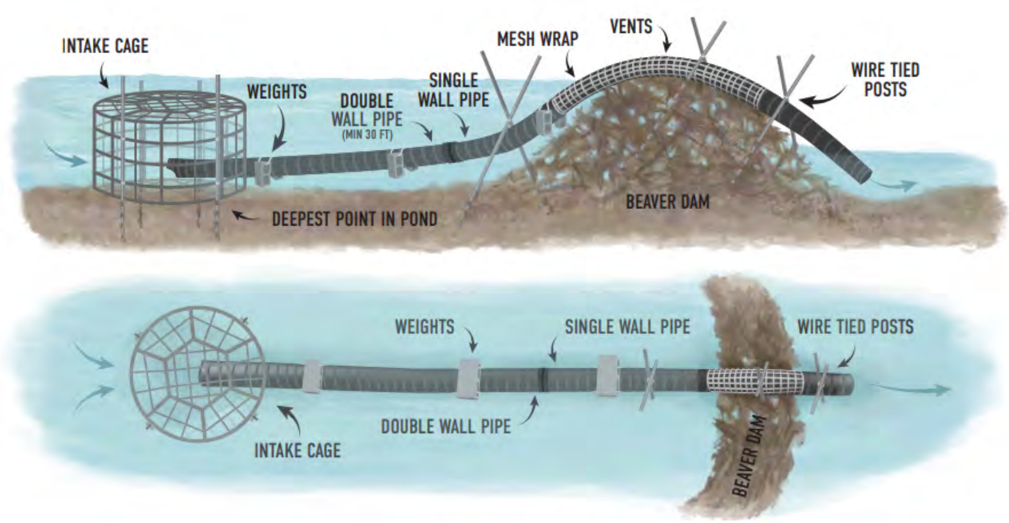


Figure 3. Standard pond lever design with no modifications (BeaverCoalition, 2022)

Access to and through the BVW on and adjacent the property of 4 Abbey Road will occur via waders by the end of spring of 2023. The scope of work conducted for this Project will be under the purview of the Town of Franklin Stormwater and Environmental Affairs Coordinator with guidance and regulatory oversight from the Town of Franklin Conservation Agent/Natural Resource Protection Manager. The physical labor will be performed by the Public Works personnel. Please see Attachment D for more information on the Multi-Intake Leveler, including installation requirements.

Summary

I look forward to having the opportunity to discuss this Beaver Deceiver Installation Project with the Town of Franklin Conservation Commission during the public hearing on January 12, 2023. I anticipate these materials are sufficient for the Commission to issue a Negative Determination, confirming that a Notice of Intent (NOI) will not be required for the proposed work to proceed.

Should you have any questions regarding this application or require additional information, please do not hesitate to contact Derek Adams at (508) 553-5545 or via email at dadams@franklinma.gov.

Sincerely,

Derek Adams
Stormwater and Environmental Affairs Coordinator

References

Beaver Coalition. Best Management Practices for Pond Levelers and Culvert Protection Systems: A guide for using flow devices to coexist with beavers. (2022) https://www.beavercoalition.org/flowdevicebmps

Encyclopedia Britannica. “trophic cascade”. (2020) https://www.britannica.com/science/trophic-cascade

Franklin GIS. (2023) https://axisgis.com/franklinma/

Goldfarb, B. Beavers, rebooted. (2018) *Science, 360*(6393), 1058-1061.

Massachusetts Department of Environmental Protection. 310 CMR 10.00: The Wetlands Protection Act. (2017) https://www.mass.gov/doc/310-cmr-1000-the-wetlands-protection-act

United States Department of Agriculture, Natural Resources Conservation Service, Data Gateway. (2023) https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

United States Fish and Wildlife Service National Wetlands Inventory. (2023) https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/

ATTACHMENTS

ATTACHMENT A
WPA FORM

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands
WPA Form 1- Request for Determination of Applicability
Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Franklin, MA
City/Town

A. General Information

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

1. Applicant:

Derek Adams
Name

dadams@franklinma.gov
E-Mail Address

257 Fisher Street
Mailing Address

Franklin
City/Town

MA
State

02038
Zip Code

508-553-5545
Phone Number

Fax Number (if applicable)

2. Representative (if any):

Firm

Contact Name

E-Mail Address

Mailing Address

City/Town

State

Zip Code

Phone Number

Fax Number (if applicable)

B. Determinations

1. I request the Franklin Conservation Commission make the following determination(s). Check any that apply:

☐ a. whether the **area** depicted on plan(s) and/or map(s) referenced below is an area subject to jurisdiction of the Wetlands Protection Act.

☐ b. whether the **boundaries** of resource area(s) depicted on plan(s) and/or map(s) referenced below are accurately delineated.

☒ c. whether the **work** depicted on plan(s) referenced below is subject to the Wetlands Protection Act.

☒ d. whether the area and/or work depicted on plan(s) referenced below is subject to the jurisdiction of any **municipal wetlands ordinance** or **bylaw** of:

Town of Franklin
Name of Municipality

☒ e. whether the following **scope of alternatives** is adequate for work in the Riverfront Area as depicted on referenced plan(s).

See attached map.

C. Project Description

1. a. Project Location (use maps and plans to identify the location of the area subject to this request):

4 Abbey Lane	Franklin
Street Address	City/Town
329	018
Assessors Map/Plat Number	Parcel/Lot Number

b. Area Description (use additional paper, if necessary):

See attached.

c. Plan and/or Map Reference(s):

4 Abbey Lane	December 2022
Title	Date
Title	Date
Title	Date

2. a. Work Description (use additional paper and/or provide plan(s) of work, if necessary):

See attached.

C. Project Description (cont.)

b. Identify provisions of the Wetlands Protection Act or regulations which may exempt the applicant from having to file a Notice of Intent for all or part of the described work (use additional paper, if necessary).

See attached.

3. a. If this application is a Request for Determination of Scope of Alternatives for work in the Riverfront Area, indicate the one classification below that best describes the project.

- ☐ Single family house on a lot recorded on or before 8/1/96
- ☐ Single family house on a lot recorded after 8/1/96
- ☐ Expansion of an existing structure on a lot recorded after 8/1/96
- ☐ Project, other than a single-family house or public project, where the applicant owned the lot before 8/7/96
- ☐ New agriculture or aquaculture project
- ☐ Public project where funds were appropriated prior to 8/7/96
- ☐ Project on a lot shown on an approved, definitive subdivision plan where there is a recorded deed restriction limiting total alteration of the Riverfront Area for the entire subdivision
- ☐ Residential subdivision; institutional, industrial, or commercial project
- ☒ Municipal project
- ☐ District, county, state, or federal government project
- ☐ Project required to evaluate off-site alternatives in more than one municipality in an Environmental Impact Report under MEPA or in an alternatives analysis pursuant to an application for a 404 permit from the U.S. Army Corps of Engineers or 401 Water Quality Certification from the Department of Environmental Protection.

b. Provide evidence (e.g., record of date subdivision lot was recorded) supporting the classification above (use additional paper and/or attach appropriate documents, if necessary.)

See attached.

D. Signatures and Submittal Requirements

I hereby certify under the penalties of perjury that the foregoing Request for Determination of Applicability and accompanying plans, documents, and supporting data are true and complete to the best of my knowledge.

I further certify that the property owner, if different from the applicant, and the appropriate DEP Regional Office were sent a complete copy of this Request (including all appropriate documentation) simultaneously with the submittal of this Request to the Conservation Commission.

Failure by the applicant to send copies in a timely manner may result in dismissal of the Request for Determination of Applicability.

Name and address of the property owner:

Kevin Corrigan
Name

4 Abbey Lane
Mailing Address

Franklin
City/Town

MA
State

02038
Zip Code

Signatures:

I also understand that notification of this Request will be placed in a local newspaper at my expense in accordance with Section 10.05(3)(b)(1) of the Wetlands Protection Act regulations.

Signature of Applicant

11/30/22
Date

Signature of Representative (if any)

Date

Town of Franklin Conservation Commission

APPLICATION PROCESS SIGNATURE FORM

There are three different applications that can be submitted to undertake work in a jurisdictional area: a Notice of Intent (NOI), a Request for Determination (RDA) and a Minor Buffer Zone Activity (MBZA). All three applications have different criteria for submission and approval and the NOI and RDA are governed by both the state law and the local bylaw. The MBZA is issued under the local bylaw only.

When a potential applicant requests advice from the Conservation Agent on which application to file, the opinion of the Agent is based on the information given by the potential applicant and any other information available to the Agent, e.g. the town's GIS system. The Agent has no legal right to go onto private property at any time until after an application is filed or permission of the property owner is given.

It is important that all applicants understand that after an application is filed, additional information may come to light e.g. via a field inspection or a review of the application, that may impact the scope of the submitted application and the approval process. **Therefore, it is the ultimate responsibility of the applicant to decide which application to file.**

In light of the above, please sign below indicating an understanding of this policy and submit it with the application.

[signature] — 6 JANUARY 2023

Signature of Property Owner — Date

ATTACHMENT B
FIGURES

4 Abbey Lane

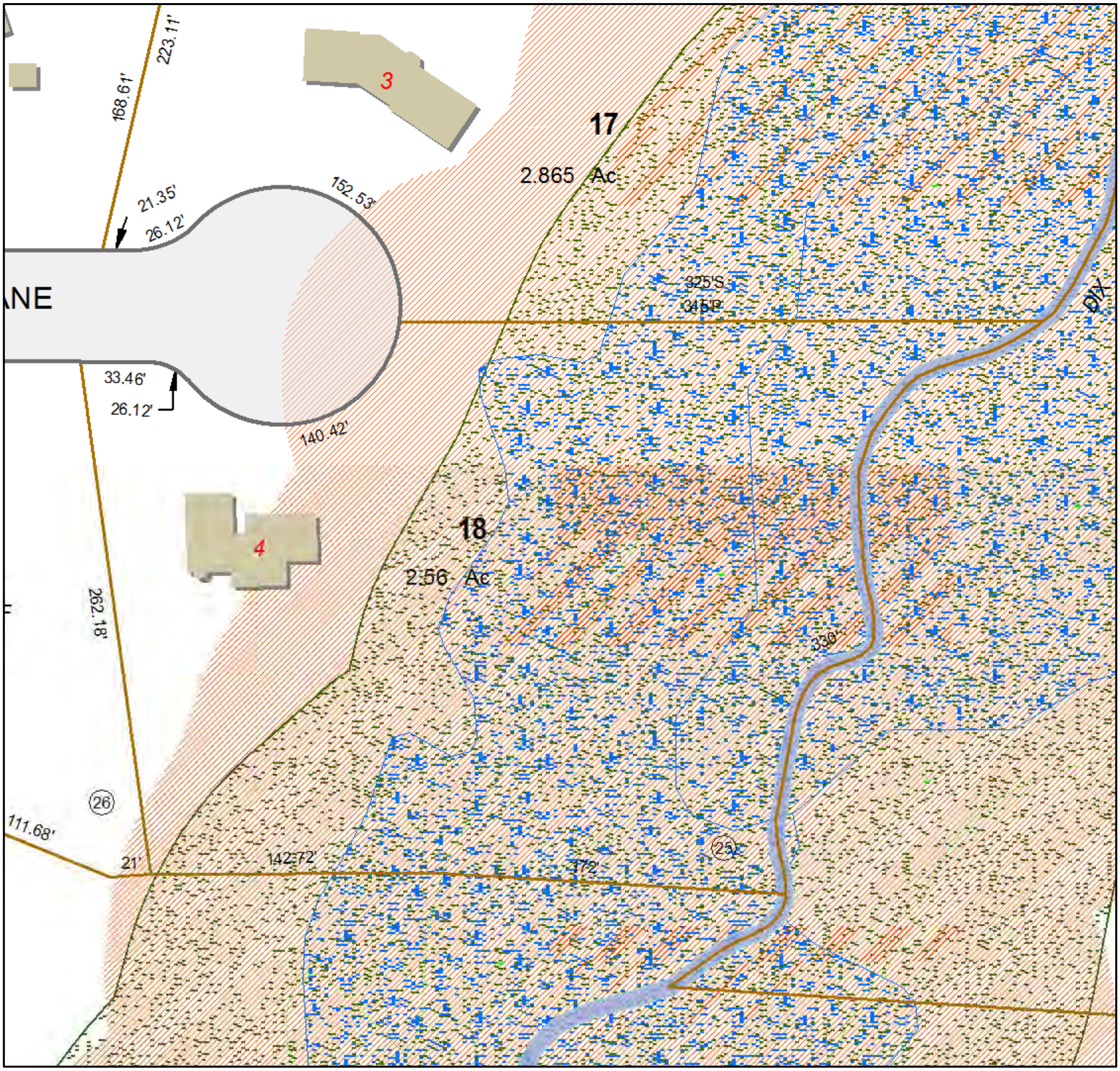
Franklin, MA

December 28, 2022

1 inch = 75 Feet

0 75 150 225

www.cai-tech.com



TownPoly	Swamp
Property Line	Wetlands 100ft Buffer
Public Road	Perennial Stream 200ft Buffer
Wetland	

This information is believed to be correct but is subject to change and is not warranted.

Hydric Soil List - All Components

This table lists the map unit components and their hydric status in the survey area. This list can help in planning land uses; however, onsite investigation is recommended to determine the hydric soils on a specific site (National Research Council, 1995; Hurt and others, 2002).

The three essential characteristics of wetlands are hydrophytic vegetation, hydric soils, and wetland hydrology (Cowardin and others, 1979; U.S. Army Corps of Engineers, 1987; National Research Council, 1995; Tiner, 1985). Criteria for all of the characteristics must be met for areas to be identified as wetlands. Undrained hydric soils that have natural vegetation should support a dominant population of ecological wetland plant species. Hydric soils that have been converted to other uses should be capable of being restored to wetlands.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2006) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and Vasilas, 2006).

Hydric soils are identified by examining and describing the soil to a depth of about 20 inches. This depth may be greater if determination of an appropriate indicator so requires. It is always recommended that soils be excavated and described to the depth necessary for an understanding of the redoximorphic processes. Then, using the completed soil descriptions, soil scientists can compare the soil features required by each indicator and specify which indicators have been matched with the conditions observed in the soil. The soil can be identified as a hydric soil if at least one of the approved indicators is present.

Map units that are dominantly made up of hydric soils may have small areas, or inclusions, of nonhydric soils in the higher positions on the landform, and map units dominantly made up of nonhydric soils may have inclusions of hydric soils in the lower positions on the landform.

The criteria for hydric soils are represented by codes in the table (for example, 2). Definitions for the codes are as follows:

1. All Histels except for Folistels, and Histosols except for Folists.
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that:
   A. Based on the range of characteristics for the soil series, will at least in part meet one or more Field Indicators of Hydric Soils in the United States, or
   B. Show evidence that the soil meets the definition of a hydric soil;
3. Soils that are frequently ponded for long or very long duration during the growing season.
   A. Based on the range of characteristics for the soil series, will at least in part meet one or more Field Indicators of Hydric Soils in the United States, or
   B. Show evidence that the soil meets the definition of a hydric soil;
4. Map unit components that are frequently flooded for long duration or very long duration during the growing season that:
   A. Based on the range of characteristics for the soil series, will at least in part meet one or more Field Indicators of Hydric Soils in the United States, or
   B. Show evidence that the soil meets the definition of a hydric soil;

Hydric Condition: Food Security Act information regarding the ability to grow a commodity crop without removing woody vegetation or manipulating hydrology.

References:

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. Doc. 2012-4733 Filed 2-28-12. February, 28, 2012. Hydric soils of the United States.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18.

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service.

Vasilas, L.M., G.W. Hurt, and C.V. Noble, editors. Version 7.0, 2010. Field indicators of hydric soils in the United States.

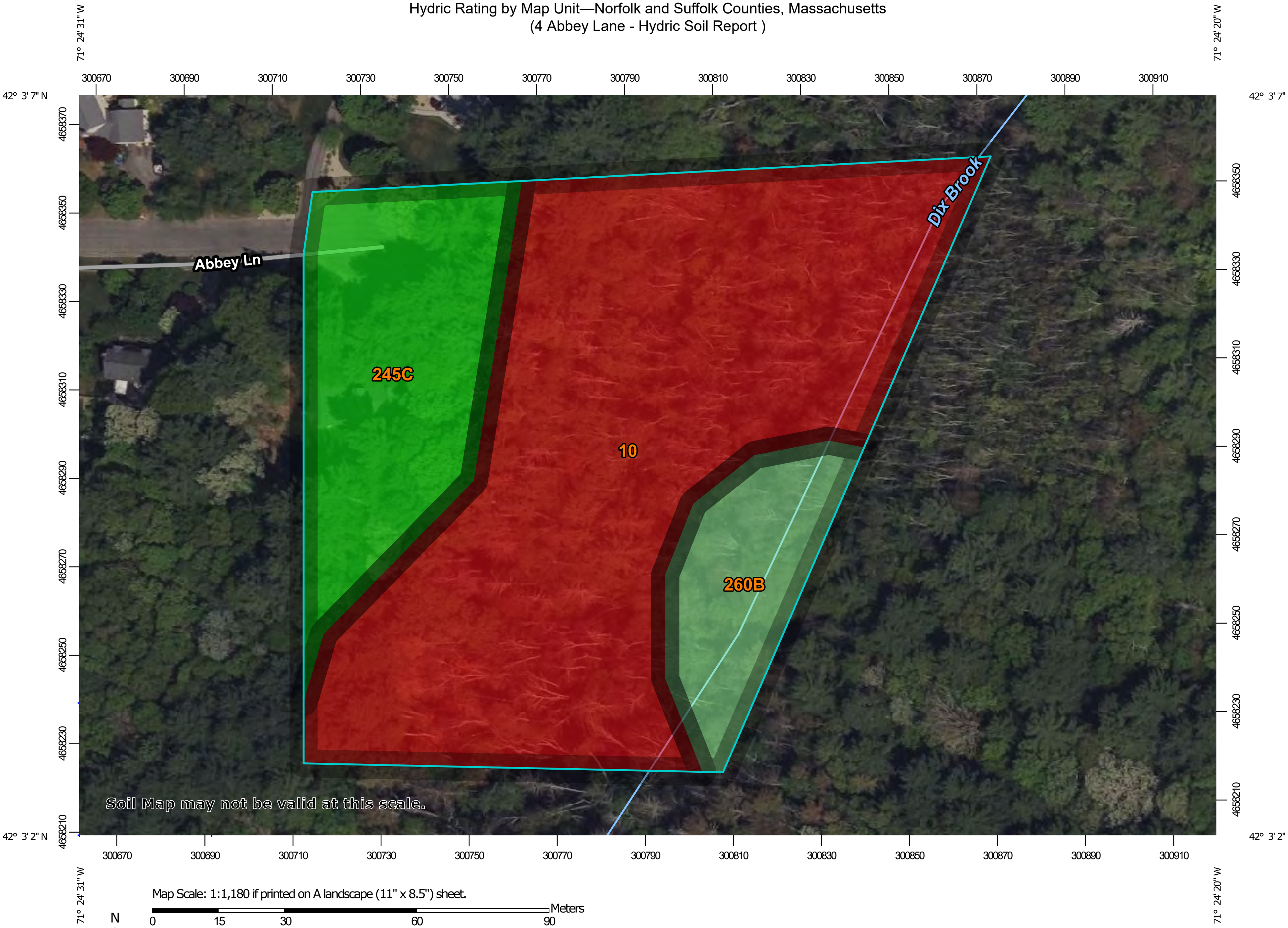
Report—Hydric Soil List - All Components

Hydric Soil List - All Components–MA616-Norfolk and Suffolk Counties, Massachusetts					
Map symbol and map unit name	**Component/Local Phase**	**Comp. pct.**	**Landform**	**Hydric status**	**Hydric criteria met (code)**
10: Scarboro and Birdsall soils, 0 to 3 percent slopes	Scarboro	65	Terraces	Yes	2,3
	Birdsall	25	Terraces	Yes	2,3
	SWANSEA	5	Bogs	Yes	1
	RAYNHAM	3	Depressions	Yes	2
	WALPOLE	2	Terraces	Yes	2
245C: Hinckley loamy sand, 8 to 15 percent slopes	Hinckley	85	Outwash deltas,outwash terraces,moraines,eskers,kames,outwash plains,kame terraces	No	—
	Windsor	5	Moraines,eskers,kames,outwash deltas,outwash terraces,outwash plains,kame terraces	No	—
	Sudbury	5	Outwash deltas,moraines,outwash plains,kame terraces,outwash terraces	No	—
	Merrimac	5	Kames,outwash plains,outwash terraces,moraines,eskers	No	—
260B: Sudbury fine sandy loam, 2 to 8 percent slopes	Sudbury	85	Outwash plains	No	—
	WALPOLE	5	Terraces	Yes	2
	MERRIMAC	5	—	No	—
	Deerfield	5	Outwash plains	No	—

Data Source Information

Soil Survey Area: Norfolk and Suffolk Counties, Massachusetts
Survey Area Data: Version 18, Sep 9, 2022

Hydric Rating by Map Unit—Norfolk and Suffolk Counties, Massachusetts
(4 Abbey Lane - Hydric Soil Report)



Map Scale: 1:1,180 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 15, 30, 60, 90

Feet: 0, 50, 100, 200, 300

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Soil Rating Lines

- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Soil Rating Points

- Hydric (100%)
- Hydric (66 to 99%)
- Hydric (33 to 65%)
- Hydric (1 to 32%)
- Not Hydric (0%)
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Norfolk and Suffolk Counties, Massachusetts
Survey Area Data: Version 18, Sep 9, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 22, 2022—Jun 5, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydric Rating by Map Unit

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
10	Scarboro and Birdsall soils, 0 to 3 percent slopes	100	2.8	67.0%
245C	Hinckley loamy sand, 8 to 15 percent slopes	0	0.9	22.1%
260B	Sudbury fine sandy loam, 2 to 8 percent slopes	5	0.5	10.9%
Totals for Area of Interest			**4.2**	**100.0%**

Description

This rating indicates the percentage of map units that meets the criteria for hydric soils. Map units are composed of one or more map unit components or soil types, each of which is rated as hydric soil or not hydric. Map units that are made up dominantly of hydric soils may have small areas of minor nonhydric components in the higher positions on the landform, and map units that are made up dominantly of nonhydric soils may have small areas of minor hydric components in the lower positions on the landform. Each map unit is rated based on its respective components and the percentage of each component within the map unit.

The thematic map is color coded based on the composition of hydric components. The five color classes are separated as 100 percent hydric components, 66 to 99 percent hydric components, 33 to 65 percent hydric components, 1 to 32 percent hydric components, and less than one percent hydric components.

In Web Soil Survey, the Summary by Map Unit table that is displayed below the map pane contains a column named 'Rating'. In this column the percentage of each map unit that is classified as hydric is displayed.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2006) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and Vasilas, 2006).

References:

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

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Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service.

Rating Options

Aggregation Method: Percent Present

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

ATTACHMENT C
SITE PHOTOGRAPHS

Beaver Deceiver Installation Project
Request for Determination
4 Abbey Lane
Franklin, MA 02038

Image A: Downstream view of the Beaver Dam within Dix Brook, facing east-southeast.

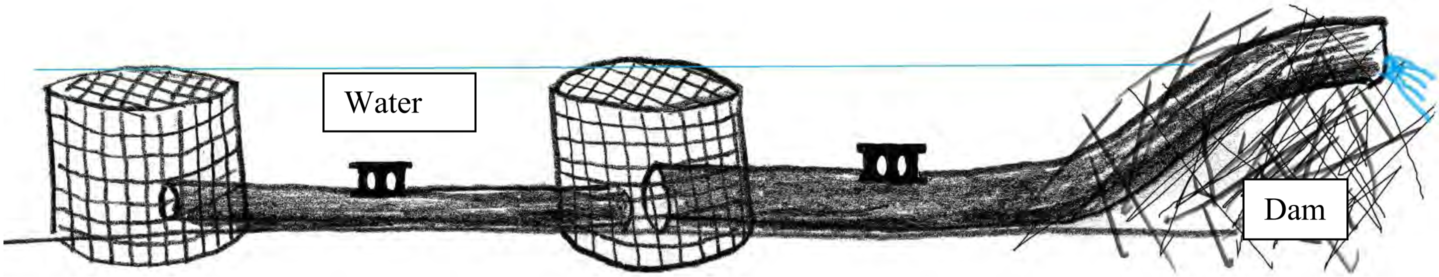

Image B: Beaver Lodge proximal to the south of the beaver dam, facing east-southeast.

Image C: Upstream view of beaver dam, with proposed Beaver Deceiver location installation.

ATTACHMENT D
SPEC SHEETS

Multi-Intake Leveler™

When flooding from a beaver dam threatens human property, health or safety, a Beaver Solutions *Multi-Intake Leveler*™ can be a very effective solution. Like our Flexible Pond Leveler™ this pipe system creates a permanent leak through the beaver dam that the beavers cannot stop.



The "*Multi-Intake Leveler*" design is based on the highly successful Flexible Pond Leveler™ which has been successful in thousands of locations. This pipe system is intended specifically for use in narrow channels or where there is inadequate depth for a standard Flexible Pond Leveler. See diagram.

Since water flows into the *Multi-Intake Leveler* pipe at two or more points it is easier to hide the flow from the beavers. A cylindrical exclusion fence at each intake point prevents beavers from getting close enough to detect and block the flow of water. Progressively larger diameter pipes to move ever larger volumes of water past a beaver dam or through a culvert protective fence without the beavers being able to detect and block the water flow into the pipes.

The pipe outlet at the dam or culvert fence is the highest part of the pipe. This height controls the pond level and it can be adjusted up or down if necessary. Water constantly flows through each section of pipe, unless the pond level drops below the peak of the pipe.

Unlike road culverts, *Multi-Intake Leveler* pipes do not need to be sized to handle catastrophic storm events because heavy storm runoff will simply flow over the top the dam. Following the storm the pipe will return the pond to its normal level.

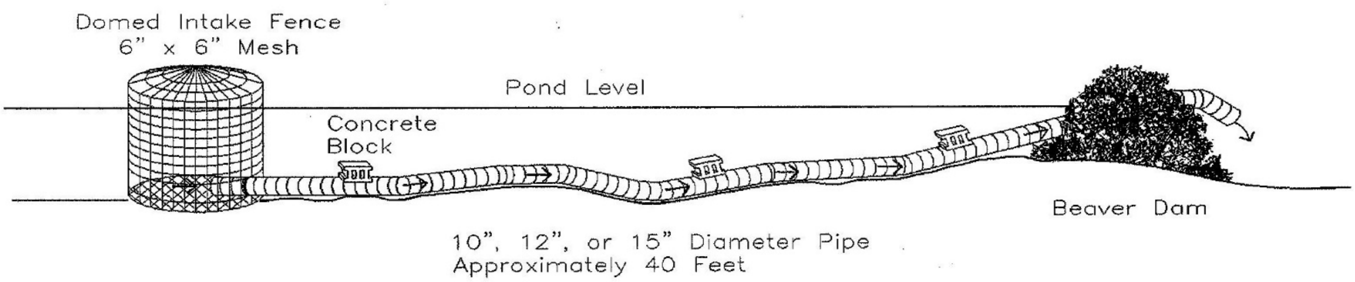
When installing this pipe system it is very important to lower the water only enough to protect human interests. Lowering the water up to one vertical foot is generally not a problem, but the more the water is lowered the more likely it is beavers will build a new downstream dam to render the pipe ineffective. New dam building in ditches is a serious concern.

A minimum water depth of 2- 3 feet is needed to prevent the beavers from detecting the flow of water into the pipes. At this depth beavers do not try to block the pipes and a steady pond level can be maintained. If a 2- 3 foot water depth cannot be tolerated, then beaver removal may be the only option.

With minimal routine maintenance this flow device will remain effective for many years, unlike beaver removal which often needs to be repeated.

Flexible Pond Leveler™

When flooding from a beaver dam threatens human property, health or safety, a Beaver Solutions Flexible Pond Leveler™ pipe system can be a very effective solution. This flow device will create a permanent leak through the beaver dam that the beavers cannot stop. This eliminates the need for repeated trapping despite the presence of beavers.



In order for these pipe systems to be effective, they must be designed so that beavers cannot detect the flow of water into the pipe. The Flexible Pond Leveler™ does this by surrounding the submerged intake of the pipe with a large cylinder of fencing which is placed in as deep water as possible. This prevents the beavers from detecting the flow of water into the pipe. As a result, the beavers do not try to clog the pipe, and a safe water level can be maintained.

The height of the pipe in the dam determines the pond level (see diagram). Water will flow through the pipe unless the pond level drops below the peak of the pipe. The pipe is set in the dam at the desired pond level, and can be adjusted up or down if necessary.

Unlike road culverts, Flexible Pond Leveler™ pipes do not need to be sized to handle catastrophic storm events because heavy storm runoff will simply flow over the top of the dam. Following the storm the pipe will return the pond to the normal level.

When installing a pipe system it is very important to lower a pond only enough to protect human interests. The more a pond is lowered the more likely it is beavers will build a new dam to render the pipe ineffective. Lowering a beaver pond by up to one vertical foot is generally not a problem.

Whenever a freestanding dam must be lowered by two feet or more, a single round of trapping may be needed prior to installing the pipe. Following trapping new beavers relocating into the area are more likely to tolerate the smaller pond without new problematic dam building because they do not have the memory of the larger pond.

With routine maintenance this flow device will remain effective for many years. Since our customer's satisfaction and our reputation are very important to us, we offer an optional low cost Maintenance Plan which is included with every Maintenance Plan at no additional cost. However, if you prefer to do the maintenance, we are always available to answer any questions at no charge because we are committed to long term success, your satisfaction and our good reputation.

ATTACHMENT E
BEST MANAGEMENT PRACTICES FOR POND LEVELERS AND CULVERT PROTECTION SYSTEMS

Best Management Practices for Pond Levelers and Culvert Protection Systems

A guide for using flow devices to coexist with beavers

December 2022

Attributions:

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Supported by:

The Beaver Coalition

Clean Water Services

Tualatin Soil and Water Conservation District

The Oregon Conservation and Recreation Fund

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Contents

Introduction

Beavers are well known for their ability to build dams which can be found in a wide variety of habitat types including wetlands, marshes, pond and lake outlets, river side-channels, and small to medium sized streams. Beavers build dams where: (1) the flow and velocity are low enough for a dam to persist, at least seasonally, and (2) where they would benefit from increasing water depth. The deeper water created from dam building helps keep beavers safe from predation both around their den and throughout their range of activity. The beavers of North America have been building dams for millions of years, and many other plants and animals have coevolved to benefit from their ecosystem engineering. The long history of beavers managing water across the landscape means that beaver-modified floodplains have a profoundly positive impact on the habitats of these other species. Beaver-modified floodplains also contribute increased water quantity and quality, carbon sequestration and vegetative evapotranspiration, and reduced severity from floods, drought, and wildfire. However, beaver dams can also negatively impact human infrastructure and land use.

> *Flow devices are key tools for minimizing both the damage to human occupied land and the degradation of riparian and wetland ecosystems that can occur if beavers are removed completely.*

Beavers often construct dams at undersized culverts, spillways, and other human infrastructure built in the channel. Beavers are instinctively attracted to the sound of trickling water, meaning infrastructure components that concentrate flow and partially constrict the stream channel can attract dam building activity. Making use of human elements can reduce the effort and time it takes for beavers to dam the stream. Even if beavers are not damming directly on or within artificial structural elements, damming activity can reroute stream water onto historic floodplain habitats which may flood adjacent infrastructure, crops, or homes. While beaver activity often facilitates better habitat for fish and wildlife, intervention to artificially diminish the footprint of beaver activity may be required due to safety concerns for human infrastructure and negative impacts to land use.

Since beavers are territorial, they quickly recognize and colonize freshly un-occupied habitat. Removing a family of beavers from an area only serves to free it up for a new beaver family. Trapping often becomes a frustrating treadmill of reactive management that degrades the habitat and depletes the local beaver population while failing to provide a robust solution. Notching a beaver dam can temporarily alleviate flooding issues, but beavers will often fix this breach with days. Habitat modification techniques, such as pond levelers and culvert protection systems, can facilitate coexistence with beavers living near human infrastructure. These techniques are often called "flow devices" and work by either limiting the area flooded by existing dams or by modifying the ability of beavers to construct dams. Flow devices are key tools for minimizing both the damage to human occupied land and the degradation of riparian and wetland ecosystems that can occur if beavers are removed completely, and have been repeatedly shown to save money over time compared to trapping.

Flow devices are immediate and cost-effective solutions that allow beavers to remain on-site, while protecting human interests. The net benefit of these coexistence solutions makes them an important tool for facilitating more beaver-managed habitat in and around human infrastructure, homes, and crops. However, these devices are not without drawbacks. By design, these devices artificially constrain the habitat beavers are attempting to make which can also constrain the benefits beaver habitat has for fish and wildlife. Proper design and installation paired

with frequent monitoring and maintenance are necessary to ensure flow device operation minimizes instream environmental impacts, especially to State sensitive, Federal Endangered Species Act listed, or Tribal culturally important native fish and wildlife species and their habitats. Flow devices are best used as an interim solution while planning for a long-term fix like culvert replacement or land use changes.

How to use this guide

The two primary categories of beaver flow device solutions are pond levelers and culvert protection systems. The following combination of design fundamentals, best management practices, and site-specific criteria form a set of standards for making, installing, monitoring, and maintaining both culvert protection systems and pond levelers as beaver coexistence solutions.

To describe these techniques, this guide uses the names pond leveler, trapezoidal culvert fence, anchor dam, pipe and fence, and pipe and dam modifications. However, various flow device designs can go by many names, including beaver bafflers, beaver deceivers, keystone fence, castor master, diversion dam, and the fence and pipe. The following best management practices (BMPs) are built on a foundation of more than 40 years of innovation. Even so, the designs and techniques for using flow devices to coexist with beavers continue to evolve. For example, experiments in Alaska are testing a culvert protection system that acts like a maze. The maze makes it difficult for beavers to get at the culvert with damming materials while allowing large bodied fish to navigate upstream without swimming through an exclusionary mesh. As innovative solutions like this are tested and new science is conducted, these BMPs should be revised.

This document is intended to empower the landowners, organizations, municipalities, and wildlife professionals who are interested in finding solutions to ongoing conflicts between human infrastructure and beaver habitat while still retaining the beavers and their benefits. If you would like to install a pond leveler or culvert protection system, use these standards to guide your planning, design, installation, monitoring, and maintenance. If you don't have the capacity to implement these BMPs, there are an increasing number of trained professionals who can assist in your project. To coordinate your installation with the applicable regulatory agencies, adhere to the state-specific, stepwise permitting process outlined in the document appendices.

Pond levelers

When to use pond levelers

Pond levelers are a coexistence solution for conflicts between beaver-facilitated wetland habitat and human infrastructure, crops, or homes. These flow devices are applicable when the landowner is willing to allow the beaver dam and pond to remain but wants to control the maximum water height. The goal of a pond leveler is to minimize the disruption to the beaver family and their habitat, so they do not abandon the site, while establishing a maximum water height and footprint which protects the landowner's assets. Pond levelers set the water surface elevation of a beaver pond by using a plastic culvert pipe to create a leak over the crest of the dam that beavers cannot repair. The intake for the leak is hidden upstream within the beaver pond and is enclosed within a cage to keep beavers from swimming near enough to sense the flowing water. Similar to an overflow drain on a bathtub which limits the water depth, a pond leveler leaks water over the crest of the beaver dam at a desired water surface height during the low flows when beavers might otherwise increase the height of the dam (Figure 1). The outlet of this pond leveler is placed downstream of the dam.

If properly constructed, installed and maintained, the use of pond levelers limits the extent of beaver ponds, minimizing flooding and potential nuisance or damage. Pond levelers permit coexistence with beavers, and the many ecosystem benefits they provide, in areas where a human tolerance for beaver facilitated habitat is limited. Flow devices can be cost-effective solutions for controlling the height of a beaver dam and the resulting footprint of the beaver pond. They can last 5-10 years or longer if properly maintained.

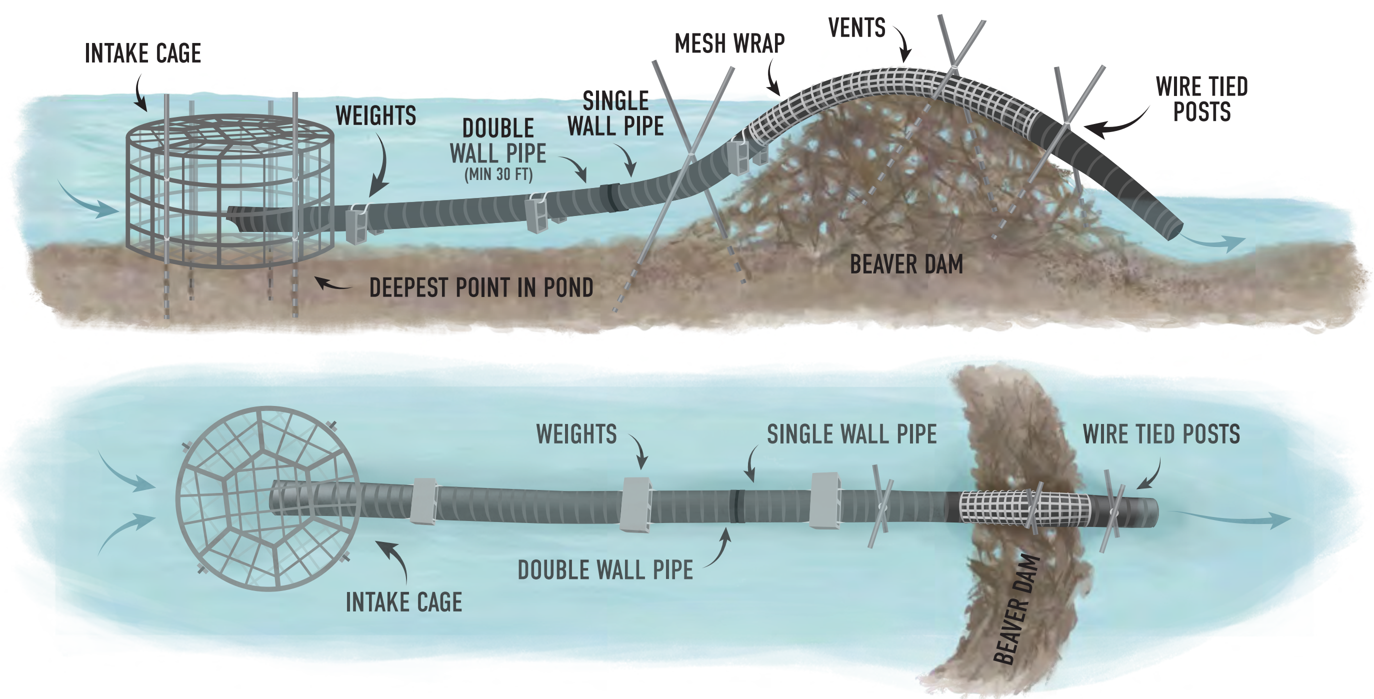


Figure 1. Standard pond leveler with no modifications.

Design fundamentals

Pond leveling devices control the height of a beaver dam by using a plastic culvert pipe and a caged intake located upstream within the beaver pond to hide a leak at the dam. Beavers will be unable to regulate the impoundment depth by adding height to the dam, and since they generally won't raise the dam height unless water is running over the top, the physical height of the dam will be constrained along with the water level. Artificially constraining the extent of beaver-facilitated habitat can impact the fish and wildlife that rely on beaver-managed ecosystems. As such, pond levelers should only be installed after careful consideration and every effort should be made to maintain the maximum possible extent of the beaver pond.

Essential design components of pond leveling systems

- **Minimize adverse impacts to habitat:** The installation of a pond leveler will decrease habitat for beavers and other native fish and wildlife. In order to minimize adverse impacts to habitat:
    - » Maximize the footprint of the beaver pond by lowering the dam crest elevation only as much as is required to alleviate human flooding concerns. Maintaining maximum water depth over the openings to the beaver den or lodge is vital to prevent abandonment and/or the construction of new dams upstream or downstream of the flow devices.
    - » Minimize fish and wildlife interaction with the pond-leveling system, particularly regarding impairing or preventing fish passage and the entrapment of other species such as turtles, waterfowl, or even larger mammals. Sharp edges that fish and wildlife could come into contact with should be smoothed, beveled, or tucked away and there should be no artificial protrusions into the flow path of the pond leveler. Pond levelers should not dewater the stream or otherwise artificially restrict instream flows. Fish passage design components may be required for the device. Reference the Appendices for state-specific criteria.
    - » Consider the long-term plan for the site. Infrastructure changes like upgrading culverts or moving critical infrastructure away to give the aquatic and riparian ecosystems more room are the best long-term coexistence solutions.
- **An upstream intake:** While beavers will quickly fix any leak in the upstream surface of their dam, hiding the intake of the pond leveler 30' to 60' upstream removes it from the proximity of the dam where beavers tend to search for the leak.
- **A caged intake:** The intake must be caged to prevent beavers from swimming close enough to the pipe to feel or hear running water. If this exclusionary cage is too small and beavers sense the leak, they will mobilize enough debris to encapsulate the entire intake cage in days. The cage must have openings small enough that a beaver cannot fit through. The size of the cage must correspond with the size of the pipe used, so that when fully flowing there is no discernible flow through the fence.

- **Eliminated "trickling" sound and feel:** Beavers can detect leaks by hearing and feeling them. It is essential to eliminate the sensations of flowing water within the pond leveling system upstream of the beaver dam. Beavers are adapted to cascading water on the downstream side of their dam and will generally not attempt to repair leaks from this side. This outlet can be further protected with a domed lattice of sticks or mesh.

- **Dispersed intake flow:** The uniform, circular lip of the intake pipe must be disrupted to prevent the intake flow coupling with the pond surface (a whirlpool) if the intake cage is positioned in less than 4' of water. One effective method is to cut a half-circle of pipe material out of the bottom lip of this opening (Figure 2).

- **Stabilized flow device:** Staking the intake cage is only necessary where the intake cage is subjected to discernible flows. At these sites, firmly stabilize the intake cage and pipe to keep beavers from moving it and to minimize the need for adjustment after high-flow events. The pipe can be held in place at the dam using steel posts and the intake cage and pipe can be held in place with either steel posts or weights (Figure 1).

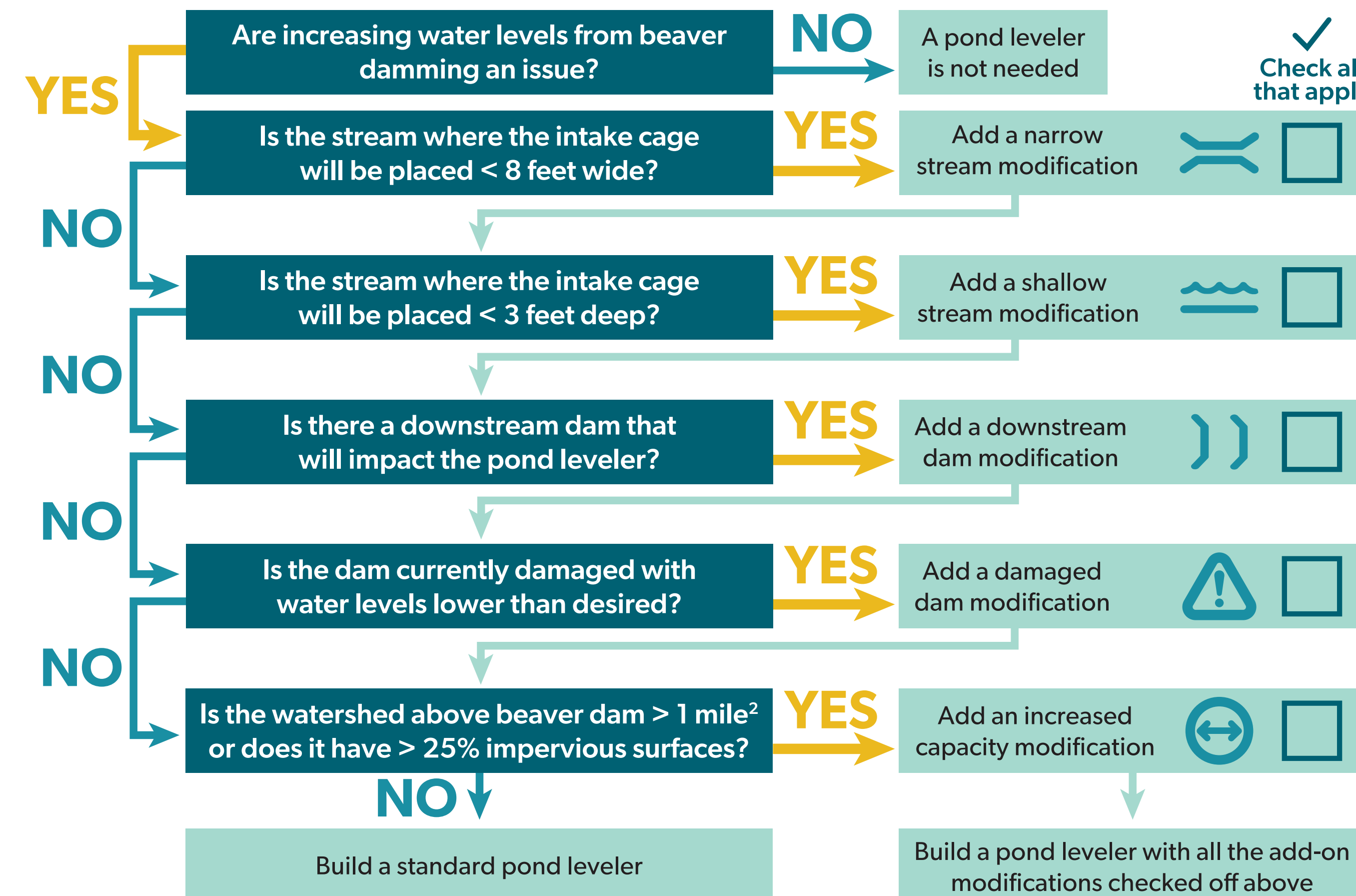
- **Vented pipe:** Small vent holes or slits must be cut into the top surface of the submerged pipe to release gas trapped in the pipe or within the pipe wall. These holes are essential to minimize air entrapment and keep the pipe from floating. The size of holes must be kept to a minimum to avoid attracting the attention of a beaver and to avoid potentially trapping fish, amphibians, or other wildlife.

- **Rugged construction:** It is important to construct a pond leveling system with high quality materials that can withstand normal environmental forces over time. For the pipe, use High Density Polyethylene, which is often called HDPE, and henceforth "plastic culvert pipe" in this guide. This pipe is available as single wall or double wall construction. Double wall is more robust and its smooth interior is quieter, but it lacks flexibility. Single wall is flexible, but not as quiet. Metal products like wire mesh, tie wire, screws and steel posts should all be heavy duty products that will last for a reasonably long period while being exposed to the elements.

- **Appropriately sized pipe:** Determining the appropriate pipe size for your site can be tricky, and requires considering the size of the watershed, its land-use, the percentage of impervious surface, and the permeability of the beaver dam itself. The porosity of the beaver dam depends on the materials used in the dam and can fluctuate seasonally, or even daily, as beaver add fresh mud and other materials to maintain the dam. Except where there are concerns with fish passage, use a pipe size that will carry the majority of flows moving over the beaver dam. Pipe size, material and gradient will change how much water (usually measured in cubic feet per second) can flow through your pond leveler. Look up the flow calculations for your pipe (usually available from the manufacturer) and estimate based on a 1% gradient. For reference, at 1% slope a 12" double wall pipe will move 3.8 cubic feet per second (CFS), while a 12" single wall pipe will move 2.7 CFS. A 15" double wall pipe will move 7.0 CFS, while a 15" single wall pipe will move 4.2 CFS.

Best Management Practices for Pond Levelers
and Culvert Protection Systems

Choosing pond leveler modifications



Best management practices

Pond leveling systems can successfully facilitate human/beaver coexistence for many years provided they are planned, installed, and maintained correctly. Adhering to the following Best Management Practices and modifications applicable to your site will provide the highest chance of long-term success.

Site planning

1. Prepare and submit a project plan to the applicable local, state, and/or federal permitting authority. Follow your state-specific project plan review process outlined in the document appendices.

2. Determine the new water height of the pond. If the pond contains a beaver den or lodge, find the elevation of the entrance tunnel. The water surface elevation of the pond must not drop below the top of the underwater entrance tunnel. This elevation marks the lowest possible pond elevation that can be used in the design. If the water level is lowered below the top of the burrow entrance, beavers may relocate

to adjacent stream reaches or build a new dam (often downstream), or freeze to death in cold winter climates. If beavers abandon the dam, the investment in designing and installing a pond leveler is lost. If the target dam does not contain a lodge or den, it is still important to only lower the water height the minimum amount needed to meet the coexistence objectives.

3. Develop a site plan by creating rough sketches of installation based on site layout, including expected impact up and downstream of target dam. Create two sketches with one viewing the site from above and the second viewing the site from one side.

4. Determine pipe size needed at your site. The two most common sizes are either 12" or 15" diameter. The standard design for these best management practices assume a 12" pipe is appropriate. The increased capacity modification (pg. 15) accounts for sites where a 15" pipe is needed. Generally, a 15" pipe should be used if the watershed above the beaver dam is over one square mile or has over 25% impervious surfaces. If the site has very little tolerance for natural pond level fluctuation, it is better to opt for an oversized pipe.

    » The online USGS tool StreamStats can be used to determine relevant attributes. Select the point that represents the beaver dam location, then select parameters including the area that drains to that stream point (DRNAREA) and the area percentage of impervious surfaces (LC11IMP).

5. Refer to the Design Fundamentals when designing the pond leveler and determine if the site requires any of the listed modifications.

6. Develop adaptive management plans for beaver or environmental disturbance to the site. These may include excessive debris accumulation, streamflow dropping below the intake cage, beaver modification of intake cage area, and construction of additional beaver dams up or down stream.

7. Collect the materials and tools that will be required for the installation day. Plan to use hand tools only. The use of heavy equipment can trigger additional permitting requirements. Hand tools can include rakes, shovels and saws to modify the beaver dam, a post pounder or sledge hammer for installing posts, and a small boat, kayak, or paddle board if the pond is too deep for chest waders.

8. Plan to conduct the entire installation within a single day during an appropriate in-water work window.

Installation

1. Minimize on-site micro-plastic contamination by cutting vent holes in plastic culvert pipes in an area where debris can be contained and properly disposed.

2. Select the upstream location for the intake cage. Prioritize maximum water depth, pond width, and the distance from the dam (in that order). Install the intake cage at the deepest point in the upstream pond as far from the beaver dam as the site allows (Figure 1). If possible, place in a sheltered area (like the inside bend of a stream channel slightly outside the thalweg) to minimize debris accumulation during high flow events.

3. Incrementally remove material from the beaver dam to the desired height before installing the pipe through the dam at this elevation.

4. Float the intake cage into place using pontoons. Simple pontoons can be made with 6-8' lengths of capped 6" or 8" PVC pipe and temporarily fastened under the intake cage with rope and a quick-release knot. Orienting the pontoons perpendicular to the pipe will increase stability during installation.

5. Stake the pipe and intake cage in place where possible with steel posts. Where the water is too deep or substrate is too hard (or soft), weigh pipe and intake cage down with concrete blocks or steel weights (Figure 1).

6. Wrap any exposed single wall pipe on the crest of the beaver dam with a wire mesh wrap, typically hardware cloth, to dissuade beavers from chewing into the pipe (Figure 1). Double wall pipe does not need to be wrapped.

7. Cover the exposed pipe with woody debris and mud to help camouflage it, and to help prevent beavers from chewing on the exposed pipe. Notch a small leak in the dam away from the pond leveler to give the beavers something to fix after the disruption of installation and lowering the water.

Maintenance

Check the pond leveling system regularly (minimum yearly) for any weather or beaver related damage. Before and after the typical peak-flow seasons are good periods to conduct maintenance. In many regions, these periods are in the fall before the winter precipitation and in spring after the last of the high-flows. Use only hand-tools for maintenance. Maintenance activities should include:

- Removing any accumulated debris from the intake cage. Some pond levelers, like those submerged deep in a pond or lake, may accumulate little or no debris and require minimal maintenance. Other pond levelers, like those installed in three feet of water within an active stream channel, may accumulate floating debris quickly and require monthly maintenance during certain times of the year.

- Making adjustments to the pipe outlet as necessary to meet original design criteria.

- Monitor the water level over the entrance tunnel to the beavers' den and look for potential new damming activity upstream and downstream of the device. Adaptively managing for changing site conditions. If necessary, modify the pond leveler to meet the initial objective while remaining within the construction guidelines.

- Additional maintenance and reporting requirements may be required. Reference the Appendices for state-specific criteria.

Site-specific criteria

Every site with beaver activity is unique. The stream morphology, hydrology, native fish and wildlife presence, beaver use, and objectives of the flow device installation can all vary between sites. It is essential to modify the design of a pond leveler to meet site-specific conditions.

The standard design criteria are broadly applicable to most sites. Site specific modifications can be added to the standard design depending on site features. In all cases, the application of the design criteria are meant to keep beavers actively using the dam and pond. The core goal of the design is not to install a pond leveler. The goal of the design is to maximize beaver habitat by keeping beavers at the site and minimize disruption to human infrastructure, without impairing passage for all the species and life stages of anadromous and resident fish using the aquatic resource.

Site features for a standard design

- An active and intact beaver dam is the direct source of the problematic water surface elevation.
- There is a suitable location within the upstream pond for the intake cage that is 30'-60' from the beaver dam with a width of 8' or more and depth of 3' or more during low flow periods at the target elevation.
- There are no downstream beaver dams that impact the ability for a pond-leveling system to lower the water surface elevation to the desired level.
- Site is appropriate for 12" pipe size (see Site Planning).

Design criteria

1. Use 12" diameter plastic culvert pipe.
2. Use at least 10' of double wall plastic culvert pipe at the intake cage.
3. Install pipe intake in the center of an intake cage, at least 12" above its wire floor. The diameter of this intake cage must be a minimum of 5' wide. The pipe should be secured in place using 9-gauge (or heavier) corrosion-resistant wire. Products with zinc or copper should be avoided as these are toxic to aquatic life.
4. Cut a half-circle out of the bottom lip of the intake pipe at its mouth approximately 6" deep and 8" wide (Figure 2).
5. The cage must be constructed with 6-gauge welded wire (or heavier) and should have a maximum of 6" by 6" openings (a beaver can pass through larger mesh sizes). When passage of fish species is a concern, mesh openings or migration pathways within the structure must be large enough to accommodate passage of the target species and life stages. Reference the Appendices for fish specific and state-specific criteria.
6. Use double wall plastic culvert pipe where possible. Single wall can be substituted if double wall is not available.
7. Use single wall plastic culvert pipe where flexibility is needed. If single wall pipe is not available, coupling 10' lengths of double wall pipe can provide some flexibility.
8. Maximize the distance between the beaver dam and intake, with a minimum of 30' and ideal range of 40'-60'. Install intake cage in the deepest part of the upstream pond and a minimum of 4' away from either bank. Maximize the distance between the stream banks and the cage to allow for passage of fish and wildlife.
9. Connect segments of plastic culvert pipe with split couplers secured with zip-ties and ceramic coated or stainless screws (no longer than necessary so as not to protrude into the interior of the pipe).
10. Cut small holes or slits (1/8 inch) at the crest of every rib in the single wall culvert pipe at 11, 12 and 1 o'clock in orientation (Figure 2). Running a portable circular saw down the length of the pipe with the blade set at an appropriate depth is a quick and efficient technique. Capture and dispose of the plastic debris.
11. Cut small holes or slits (1/8 inch) at the crest of every rib in the double wall culvert pipe at 4, 8, 11, 12 and 1 o'clock in orientation (Figure 2). Cut through only the outer wall to allow air trapped between the ribbed exterior layer and smooth interior layer of plastic to escape. Capture and dispose of the plastic debris.
12. Secure the pipe in place with weights and/or steel posts every 10'-20', using 9-gauge (or heavier) corrosion-resistant wire. Products with zinc or copper should be avoided as these are toxic to aquatic life.
13. Run the pipe downstream of the dam a minimum of 4' or into the downstream pool (Figure 1).

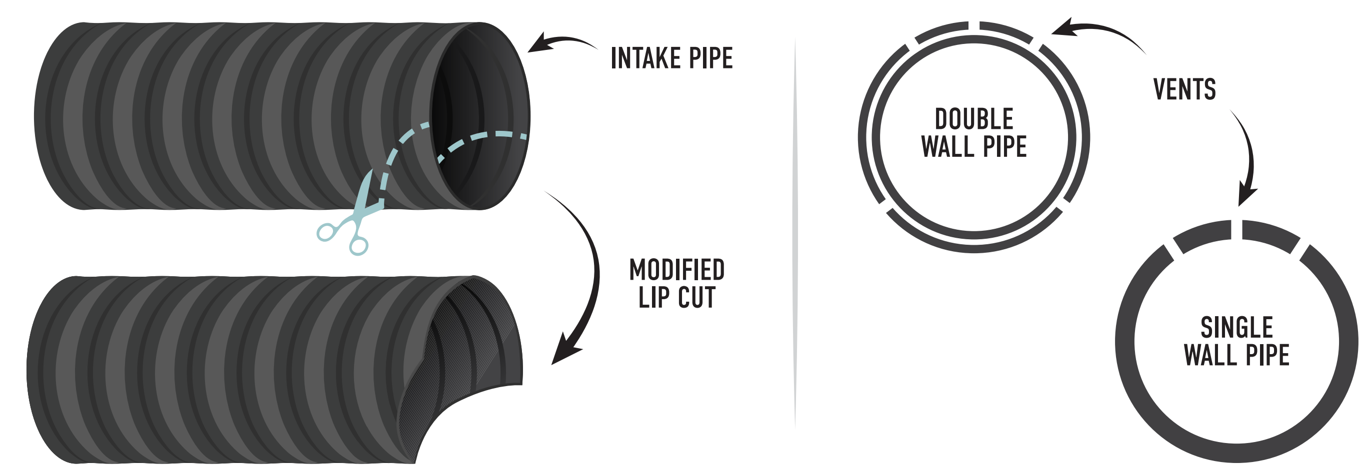


Figure 2. Modification to intake pipe and locations for pipe vent cuts.

Narrow channel modification

Narrow channels, such as severely incised streams, present an extra challenge to pond leveling systems. Pond levelers work because the cage around the intake excludes beavers from swimming near the intake of the pipe where they can sense the moving water. If the intake cage isn't adequately sized, beavers will discover and plug the device. However, if a 5' standard design intake cage takes up most of a narrow stream and there isn't adequate space for beavers to maneuver around it, they are likely to use the cage as a dam anchor and begin building directly on the intake structure. The closest intake cage must be a minimum of 30' from the beaver dam.

In streams with potential beaver habitat, these narrow, deep characteristics often represent a temporary degraded state. Beaver dams will begin the process of restoring habitat to a more functional state, through collecting sediment and reconnecting the floodplain. This natural, process-based restoration can contribute to more active floodplain habitat in the future and the intake cages may be more prone to sedimentation. Plan accordingly.

When pond levelers are deployed in areas with an active channel of less than 8' in width, the following design criteria aim to:

- Distribute intake flow over two or more points to reduce potential beaver attraction.
- Minimize the profile of the intake cage and maximize the area of unobstructed channel, without sacrificing the buffer the cage provides.

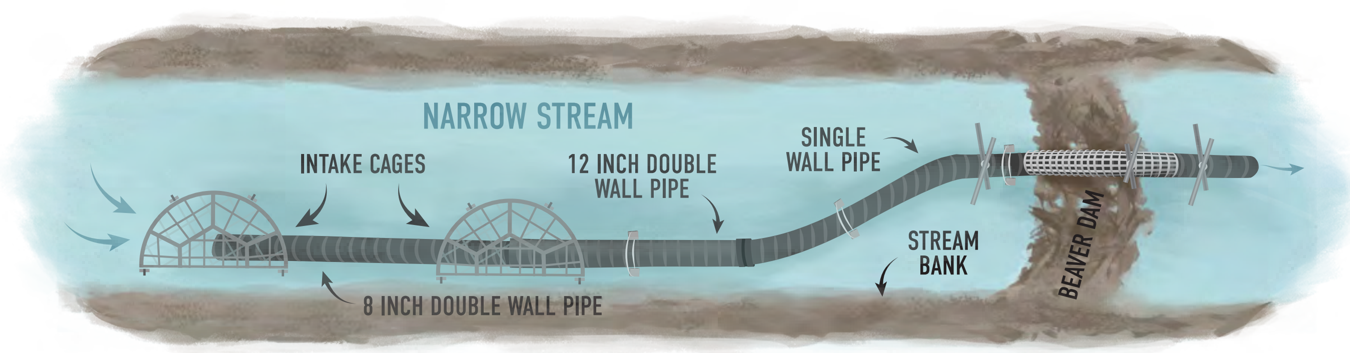


Figure 3. Overhead view of dual intake pond leveler modification for narrow streams using half-circle intake cages.

Narrow channel design criteria

Follow design criteria #5-13 from the standard design.

14. Construct a dual intake pond-leveling system with the intake flow distributed over two cages, spaced at a minimum of 20' from each-other (Figure 3).
15. Construct two half-circle intake cages with a radius of 4' each using a minimum 6-gauge wire thickness.
16. Split the intake flow between the two intake cages by nesting an 8" double wall pipe into the mouth of a 12" double wall pipe (Figure 4).
17. Cut a half-circle out of the bottom lip of the mouth of an 8" intake pipe and install with the intake positioned at the midpoint along the flat side of the cage (Figure 2).
18. Cut a half-circle out of the bottom lip of both the 8" and 12" intake pipes and secure the smaller pipe within the larger one, such that the opening area is roughly the same as the other intake (Figure 4). Use ceramic coated or stainless screws (no longer than necessary so as not to protrude into the interior of the pipe) and/or 9-gauge corrosion resistant wire. Products with zinc or copper should be avoided as these are toxic to aquatic life.
19. Install the opening of the nested pipes in the second cage at the midpoint along the flat side (Figure 3).
20. Install both intake cages with their flat sides tight along the stream bank to prevent beavers from swimming between the bank and the intake cages. Maximize the distance between the opposite stream bank and the intake cages to allow beaver (and other fish and wildlife) passage. Sometimes this requires using a shovel to shape the shore so the cage rests snugly against the bank.

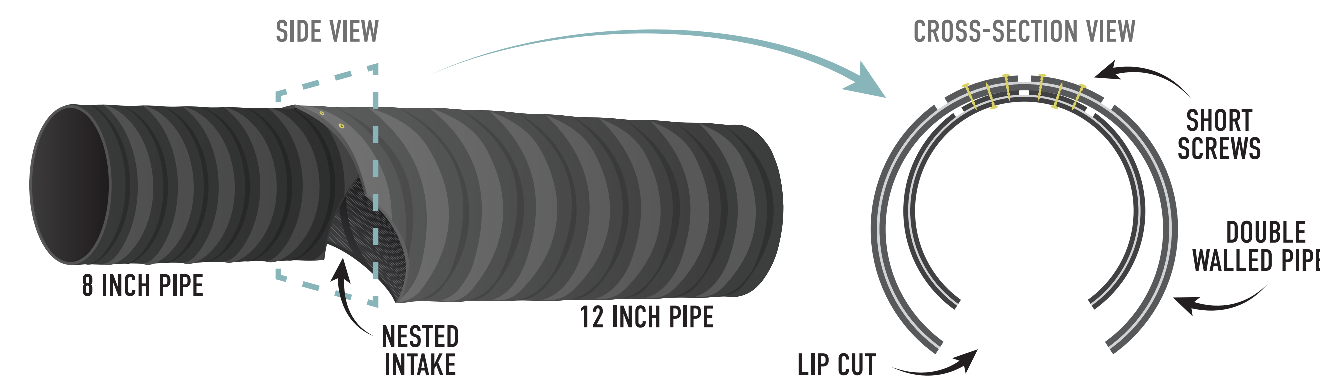


Figure 4. Nested pipe configuration used when constructing a dual-intake pond leveler.

Shallow channel modification

Pond leveler systems work because the cage around the intake excludes beavers from swimming close enough to the intake pipe to sense moving water. In shallow channels or if water around the cage drops, the flow per area into the cage is concentrated, increasing the chances that beavers will discover the intake pipe. When pond leveling devices are deployed in areas with a water depth of 1-2', the flow per area into the intake cage(s) must be minimized to diminish potential beaver attraction. The closest intake cage must be a minimum of 30' from the beaver dam.

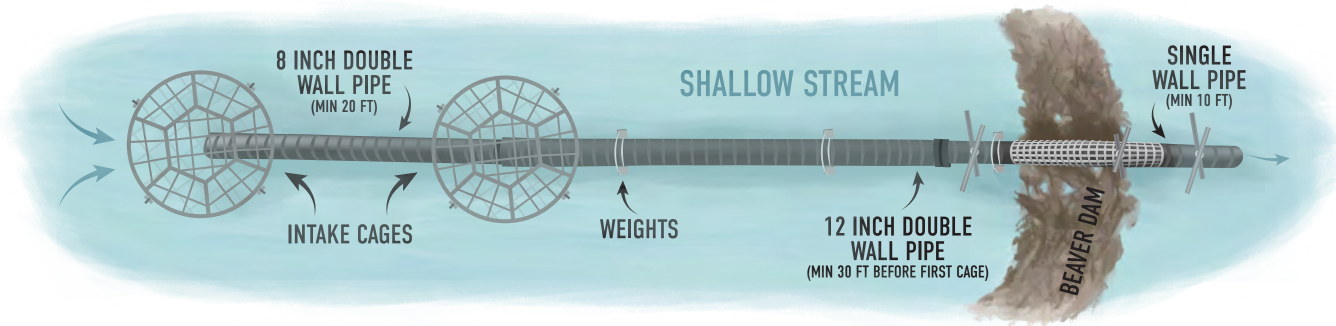


Figure 5. Dual intake pond leveler modification for shallow streams.

Shallow channel design criteria

There are two options for a shallow site:

- A single intake system with a larger cage
- A dual intake system (Figure 5)

For a single intake system

Follow design criteria #1, and #3-13 from the standard design.

14. Install pipe intake in the center of an 8' diameter intake cage.
15. Install intake cage in the deepest part of the upstream pond and a minimum of 4' away from either bank. Maximize the distance between the stream banks and the cage to allow for passage of fish and wildlife.

For a dual intake system

Follow design criteria #5-13 for a standard design, and #20, 22 and 24 from the narrow channel modification.

25. Construct two round, 6' intake cages using a minimum wire thickness of 6-gauge.
26. Cut half-circle out of the bottom lip of an 8" intake pipe at its mouth and install in the center of upstream cage (Figure 2).
27. Install cages in the deepest part of the upstream pond and a minimum of 4' away from either bank. Maximize the distance between the stream banks and the intake cages to allow for passage of fish and wildlife.

Best Management Practices for Pond Levelers
and Culvert Protection Systems

Downstream dam modification

Sometimes beavers will build an additional dam downstream of a pond-leveling system which can flood the original dam and flow device. Large downstream dams have the potential to increase water levels above the maximum set by the pond leveler. The risk of downstream dam construction can be minimized through adherence to the best management practices during installation, particularly by retaining an adequate pond depth for the beavers. However, if an additional dam is constructed less than 50' away, the downstream pond can be controlled by extending the pipe from the outlet of the existing pond leveling system across the downstream dam (Figure 6).

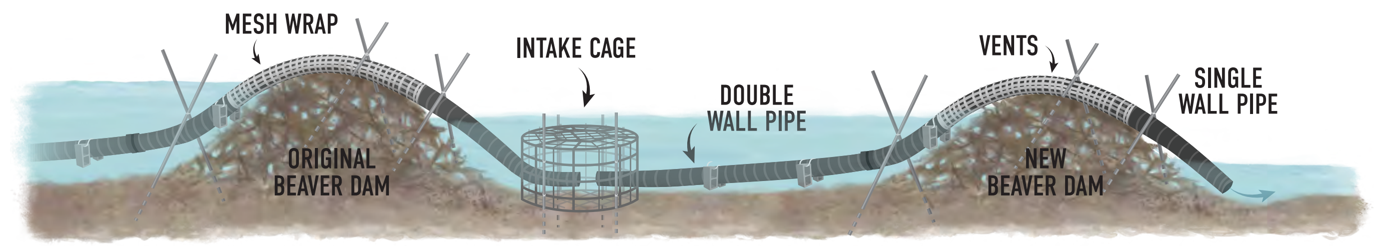


Figure 6. Pond leveler extension to accommodate additional downstream beaver dams.

Downstream dam design criteria

Follow design criteria #9-13 from the standard design.

14. Extend the pipe from the original pond leveler into an exclusion cage at the toe of the original dam and then through and over the new dam downstream. Build the new cage using criteria #3-5. Extend a new pipe from the downstream side of this cage, leaving either 6" between the two pipe ends within the cage.
15. Use flexible single wall plastic culvert pipe to extend the existing pipe into the new cage downstream of the original beaver dam, and over the new beaver dam. Use double wall plastic culvert pipe to extend between the beaver dams along the flat stream bottom.
16. Install the pond leveler through the downstream beaver dam at least 6" lower in elevation than the original dam.

Damaged dam modification

Sometimes a dam has been removed or reduced below the desired crest elevation prior to the planned installation of a pond leveler. If an immediate need to reduce flooding is required, reducing the beaver dam height will provide a temporary solution while assessing the options for beaver coexistence at a site. If the dam is still below the desired crest elevation when you are ready to install the pond leveler, either: (1) wait for the beavers to increase the dam's height to the target elevation or (2) install the pond leveler above the dam at the desired elevation (it will not flow until the beaver dam is built back to that point).

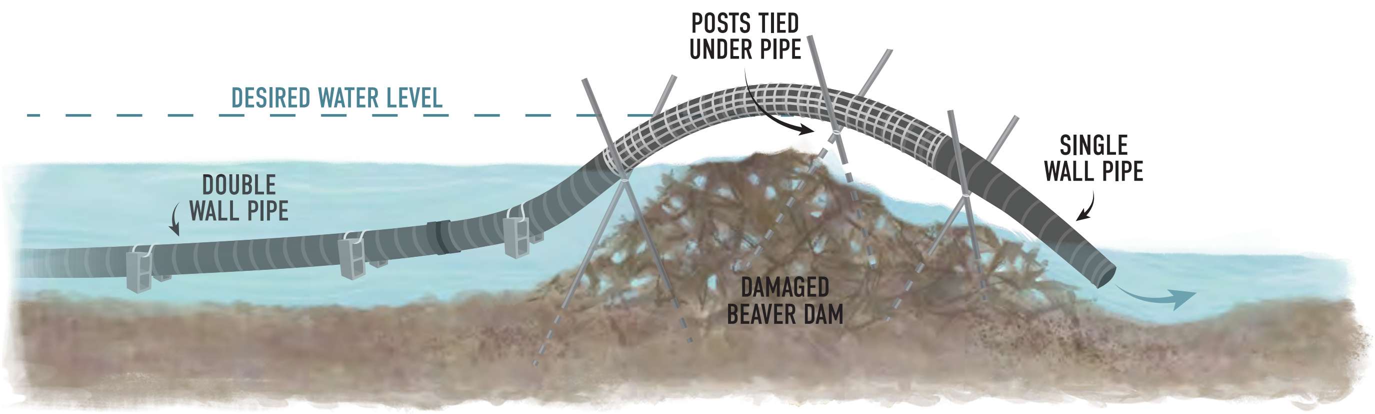


Figure 7. Installing or adjusting pond leveler to account for dam damage.

Damaged dam design criteria

Follow design criteria #1-12 from the standard design.

13. Position the single wall plastic culvert pipe at the desired maximum dam elevation and secure suspended in place with steel posts directly over the dam crest (Figure 7). Fasten the pipe to the steel posts using a minimum wire thickness of 9-gauge.

14. Wrap exposed pipe with a corrosion-resistant wire mesh wrap, typically hardware cloth, securing with hog-rings or wire. Products with zinc or copper should be avoided as these are toxic to aquatic life.

⊖ Increased capacity modification

A 12" pipe is generally sufficient for most sites. However, in special cases where the watershed above the beaver dam is over one square mile or has over 25% impervious surfaces, additional capacity may be required.

Increased capacity design criteria:

Follow design criteria #1, 3, and 5-13 from the standard design.

14. Install pipe intake in the center of a 7' diameter intake cage.

15. Use 15" plastic culvert pipe. This pipe can convey almost 2x the flow rate of a 12" pipe.

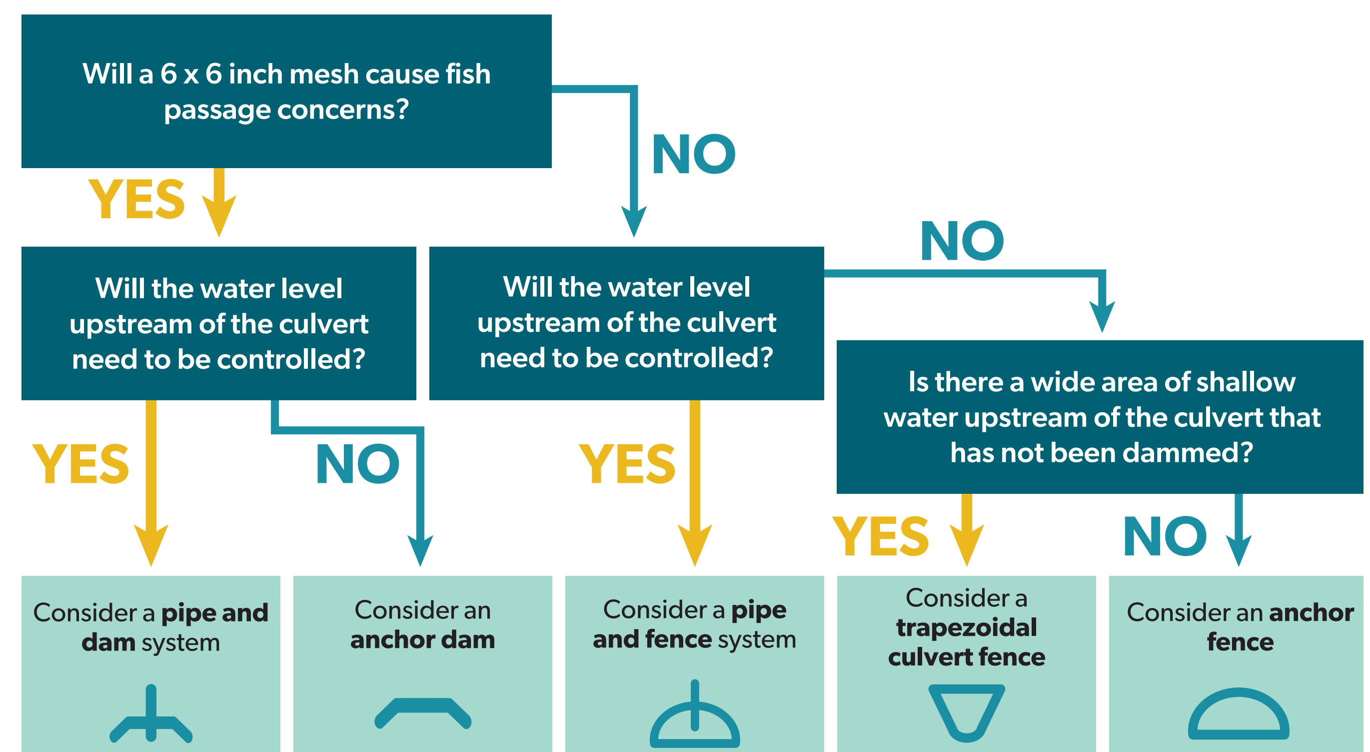
Culvert protection systems

When to use a culvert protection system

Culverts, spillways and similar human infrastructure can be protected from beaver damming while preserving their function. Many of the culverts where beaver damming occurs are undersized and may present fish passage issues. If possible, replace the culvert with a structure that is properly sized and designed.

If financial, logistical, and time critical responses prevent immediate culvert replacement, a properly constructed, installed and maintained culvert protection system can provide a cost-effective solution that can last 5-10 years or longer if properly maintained. A culvert protection system is designed to protect infrastructure while allowing beavers to remain in their habitat. It is vital that the addition of a culvert protection system does not further impact the passage of target fish species or life stages of concern.

Choosing a culvert protection system



Design fundamentals

Culvert protection designs work by either physically excluding beavers from the culvert or spillway or by altering the cues that promote dam building activity. Primary tactics include:

A **trapezoidal culvert fence** (Figure 8) protects the culvert by physically excluding beavers from the area around the culvert inlet using wire fencing. The shape of the fence also alters the physical and auditory cues that promote dam building. Beavers will often start to construct a dam along the two sides of the fence exclosure nearest to the culvert, but generally abandon the dam building as the angle of the fencing pushes them out into still water where they no longer detect the sensations of flowing water. As a result, a majority of the fence remains unobstructed.

An **anchor fence** (Figure 9) directly protects the culvert's mouth with a semi-circle of fencing. Beaver damming activity is still allowed at the culvert mouth, but the location of the dam is controlled by the fence structure. By relocating the damming activity upstream, flow through the culvert is unimpeded. This design can be modified to accommodate a pond leveler through the anchor fence if the elevation or extent of the upstream beaver pond must be limited. The modification of adding a pond leveler to an anchor fence is often called a **pipe and fence** culvert protector (Figure 10).

An **anchor dam** (Figure 11) is a similar strategy used to protect culverts at sites where fencing should not be used in the stream. This tactic includes construction of a Beaver Dam Analog (BDA) reinforced with steel posts—just upstream of the culvert mouth. While this tactic does not exclude the beavers from the infrastructure, it can divert them into investing and improving upon the reinforced BDA as their new dam, leaving the culvert open. This design can be modified to accommodate a pond leveler through the reinforced BDA if the extent of the upstream beaver pond must be limited. The modification of adding a pond leveler to an anchor dam is often called a **pipe and dam** culvert protector (Figure 12).

Create a long-term plan for site that includes infrastructure changes such as upgrading culverts or moving critical infrastructure away from riparian habitat. The best long-term coexistence solution for beaver-human conflicts is to give the aquatic and riparian ecosystems more room to facilitate natural processes and build ecosystem resilience.

Essential design components of culvert protection systems

- Beaver exclusion from the culvert: Unless constructing an anchor dam or pipe and dam, beavers should be excluded from the area around the culvert using heavy gauge wire that is small enough that both adult and sub-adult beaver cannot pass through.
- Provide fish passage: It is essential that designs minimize passage obstruction or delay of fish species and life stages of concern. When passage of fish species is a concern, mesh openings or migration pathways within the structure must be large enough to accommodate passage of the target species and life stages. Reference the Appendices for fish specific criteria.
- Start with a clean culvert: During the appropriate time of year, remove all the aggregated damming materials from within the culvert and upstream area of work. Take appropriate safety precautions when removing dams that are retaining large quantities of water. This activity can be quite dangerous since the force behind the flowing water increases exponentially as the dam is lowered, the risk of a sudden dam collapse increases, and a person could be swept into the culvert and drowned.
- Stabilize flow device in place: It is important to stabilize the anchor fence in place with steel posts and/or untreated cedar lumber (as needed), to minimize the need for major readjustment after high flows.
- Rugged construction: It is important to construct the culvert protection system with high quality materials that can withstand the forces of nature in a streambed. Metal products like wire mesh, tie wire, screws, and steel posts should all be of quality construction that will hold up over time and exposure.
- Facilitate wildlife passage: Leave an opening in the exclusionary fence that runs up onto dry land to provide an exit for other wildlife that may use the culvert to move up and down the stream (Figure 8).
- Minimize adverse impacts to habitat by:
    - » Minimizing sediment mobilization and turbidity when removing damming material from the culvert and during installation and maintenance
    - » Reduce the footprint of the beaver pond only as much as is necessary to address human concerns.

Best management practices

It is vital that culvert protection systems be planned, installed, and maintained correctly to successfully facilitate human-beaver coexistence for many years. The following Best Management Practices should be adhered to when implementing these coexistence methods:

Site planning

1. Contact your state fish and wildlife agency to determine if the site must consider passage of target fish species and life stages in the design. Discuss any concerns using the recommended 6" by 6" mesh spacing may cause. Follow the specific guidelines in the Appendices for developing and submitting your project plan to the appropriate state agencies.
2. Determine the footprint of the wetted stream channel upstream of the culvert or spillway during low flow in the absence of beaver damming. If there is a wide area of shallow water upstream of the culvert (without the influence of a beaver dam), consider a trapezoidal culvert fence. If there is not an adequate, shallow, upstream wetted area adjacent to the culvert's inlet, then consider an anchor fence or an anchor dam.
3. Determine the human infrastructure tolerance for upstream impoundment. If the culvert capacity remains open, how high can a beaver dam be built? If the beavers can be allowed to naturally set the height of their dam, consider an anchor fence or anchor dam. If there is a maximum dam height that must be enforced, consider installing a pipe and fence or a pipe and dam flow device.

4. Develop a site plan by creating rough sketches of installation based on site layout, including the expected up and down stream impact. Create two sketches with one viewing the site from above and the second viewing the site from one side.

5. Develop maintenance and adaptive management plans for beaver or environmental disturbance to the site. Disturbances can include, but are not limited to, excessive debris accumulation, intake cage stranding due to low flow (when the water around the intake cage decreases below 2' deep), beaver modification of intake cage area, construction of additional beaver dams upstream, downstream, or within the culvert.

6. Adhere to the Design Fundamentals in designing the culvert protection solution.

Installation

- Remove all the aggregated damming materials from within the culvert and the upstream area of work immediately before flow device installation. Remember to take appropriate safety precautions when removing dams that are retaining large quantities of water.
- Use only hand-tools for culvert system installation and conduct within a day if possible.
- Stabilize with heavy duty steel posts firmly driven into the streambed and spaced close enough to resist damming and flooding.
- Reinforce with steel or untreated wood. Do not use treated wood.

Maintenance

- Check the fence system regularly (minimum quarterly) for weather or beaver related damage.
- Remove any accumulation of debris from the fencing of a trapezoidal culvert fence and from the intake cage for a pipe and fence flow device.
- Adjust the fence, pipe, or outflow as necessary to meet original design criteria or to adaptively manage for changing site conditions.
- Adaptively manage for changing site conditions. If necessary, modify the installation to meet the initial objective while remaining within the construction guidelines.
- Use only hand-tools for maintenance.

Site-specific criteria

Every site with beaver activity is unique, making it essential to modify the design of a culvert protection system to the site specific conditions. The following standard design criteria are broadly applicable, and the subsequent examples provide site specific modifications to the standard design in response to variations in site features. In all cases, the design criteria are intended to allow beaver to actively use adjacent stream reaches while allowing the protected culvert to function normally.

Trapezoidal culvert fence — standard site

Site features

- Active beaver damming within infrastructure that creates a flow constriction point, such as inside a culvert or spillway.
- Shallow stream channel upstream of the culvert mouth (assessed during low flow without beaver activity) with open water that is less than 3' deep, greater than 3 times the width of the culvert, and longer than 16'. A trapezoidal culvert fence needs to accommodate at least 2' (laterally) of open water on all sides between the fence and the bank.

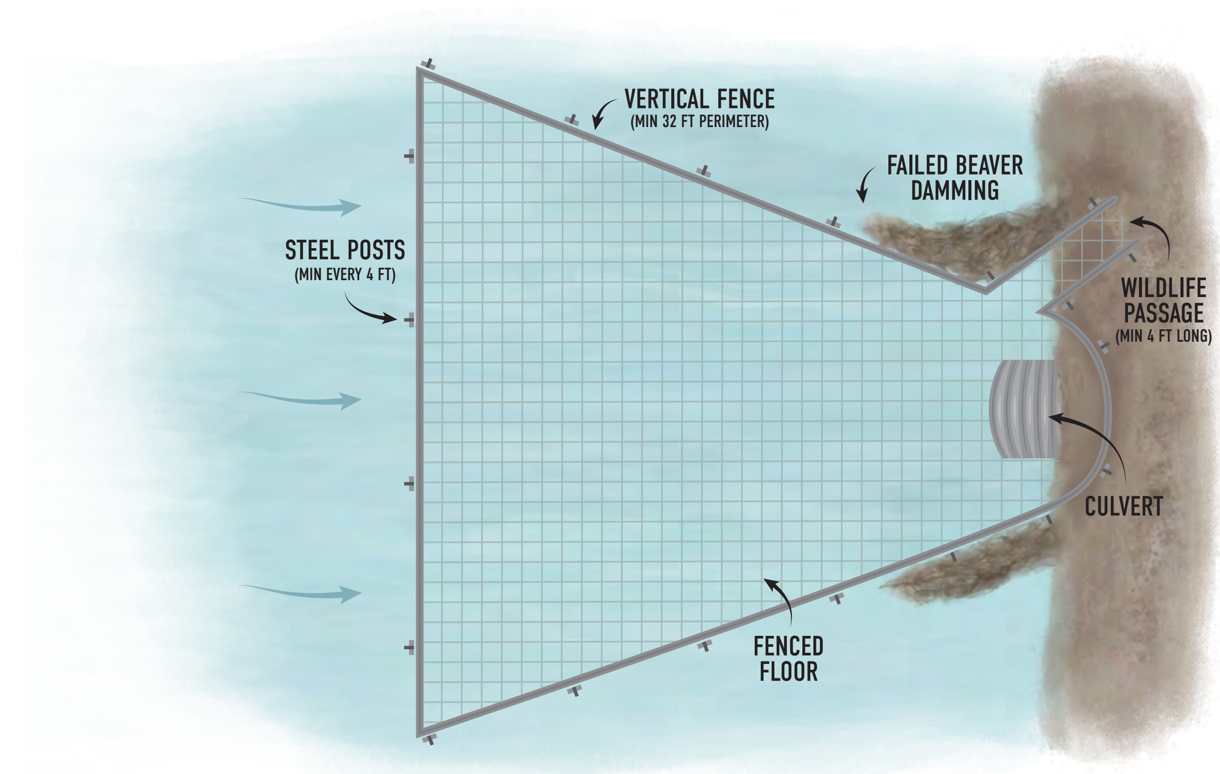


Figure 8. Trapezoidal culvert fence.

Trapezoidal culvert fence design criteria

1. Design the trapezoid with a minimum perimeter length of 32' and at least 2' of open water around all sides between the fence and the bank. The typical length of the trapezoid's sidewalls should be 12' and its face should be at least double the width of the culvert's opening (i.e. 12' for a 6' culvert). These measurements are flexible per site requirements as long as minimum surrounding water and perimeter length are maintained. If the perimeter length is too short, beavers may treat the structure like an anchor fence and dam around the perimeter.

2. Construct the fence using welded wire with a minimum thickness of 6-gauge.

3. The fencing should be constructed using 6" by 6" openings between wires. Do not construct an opening size less than 4" by 4" to avoid accumulating too much floating debris. When passage of fish species is a concern, mesh openings or migration pathways within the structure must be large enough to accommodate passage of the target species and life stages. Reference the Appendices for fish specific criteria.

4. Attach wire panels together with a minimum overlap of one cell and fasten with one hog ring on each of the parallel overlapping wires.

5. Create a fenced floor using a mesh resting horizontally on the streambed. The mesh must run all the way to the culvert's mouth, allowing no place for beavers to tunnel underneath.

6. Extend fencing a minimum of 18" (ideally 24") above the water surface elevation at low flow conditions. In general, the total height of the wall should equal the stream depth plus 2 feet.

7. Extend fencing, including the floor, onto the road bank to completely surround the culvert.

8. Construct one opening with side walls in the trapezoid's perimeter that extends a minimum of 4' long across dry ground onto the road bank. Extend a floor in this terrestrial wildlife passage from the floor of the flow device to the end of the passageway (Figure 8) and infill with small rocks and other on-site materials to provide solid footing. Build this passage minimum of 16" wide and minimize exposed sharp wire ends for both wildlife and human safety.

9. Stabilize with heavy-duty steel posts at least every 4 feet and firmly driven into the streambed. Angle bracing the upright posts with additional steel posts is recommended for streams with heavy flows (see bracing in Figure 9). Untreated 2" by 6" timber can be used for additional bracing around the entire top of the fence. Use heavy gauge wood staples to secure the wire mesh to the wood and heavy duty lag bolts to attach the cross bracing at the corners.

10. Fasten the trapezoidal culvert fence to steel posts using a minimum wire thickness of 9-gauge.

Anchor fence — standard site

Site features

- Beavers can be allowed to manage upstream habitat and the extent of upstream beaver impoundment does not require control.

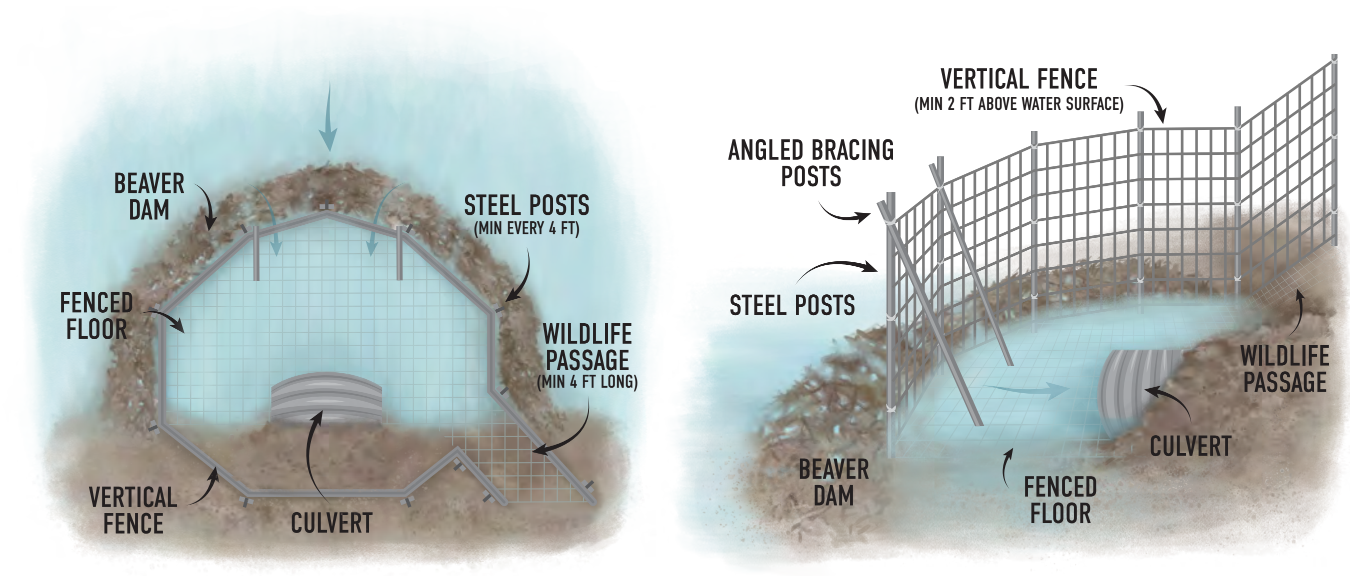


Figure 9. Standard anchor fence shown from above (left) and side (right).

Anchor fence design criteria

1. Construct a half-circle of fencing to protect the culvert or spillway, with the top of the arc facing upstream (Figure 9). Allow for 6-8 feet of radial space between the fencing and the culvert.

2. Construct the fence using welded wire with a minimum thickness of 6-gauge.

3. The fence should be constructed to have a maximum of 6" by 6" openings between wires.

4. Attach wire panels together with a minimum overlap of one cell and fasten with one hog ring on each of the parallel overlapping wires.

5. Fenced floor must run all the way to the culvert's mouth, allowing no place for beavers to tunnel underneath.

6. Extend fencing a minimum of 18" (ideally 24") above the water surface elevation at low flow conditions. In general, the total height of the wall should equal the stream depth plus 2 feet.

7. Extend fencing onto the road bank to completely surround the culvert (unless there are concrete walls that surround the culvert, or another such surface, that you can run the fencing up against so that beavers cannot dig around the fencing).

8. Construct one opening in the exclusion fence perimeter adjacent to one side of the culvert mouth that extends to the dry bank with side walls for a minimum of 4' long across dry ground. Extend a floor in this terrestrial wildlife passage from the floor of the flow device to the end of the passageway (Figure 9) and infill with small rocks and other on-site materials to provide solid footing. Build this passage minimum of 16" wide and minimize exposed sharp wire ends for both wildlife and human safety.

9. Stabilize with heavy-duty steel posts at least every 4 feet and firmly driven into the streambed. Angle bracing the upright posts with additional steel posts is recommended for streams with heavy flows.

10. Secure the anchor fence to steel posts using a minimum wire thickness of 9-gauge.

Anchor fence — pipe and fence modification

Site features

- Beavers cannot be allowed to freely control upstream habitat and its water surface elevation. The extent of upstream beaver impoundment requires control, and a maximum elevation must be set for the beaver dam at the exclusion fence using a pond leveler.

Pipe and fence design criteria

Construct an anchor fence in accordance with the standard design #1-10.

11. Construct and install a pond leveler in accordance with the standard pond leveler Design Fundamentals, Best Management Practices, and Site specific Criteria.

12. Install the overflow pipe through the fencing of the anchor fence (Figure 10) at the desired maximum dam crest elevation and secure in place with corrosion-resistant wire (minimum of 9-gauge or heavier) and heavy-duty steel posts. Products with zinc or copper should be avoided as these are toxic to aquatic life.

Best Management Practices for Pond Levelers
and Culvert Protection Systems

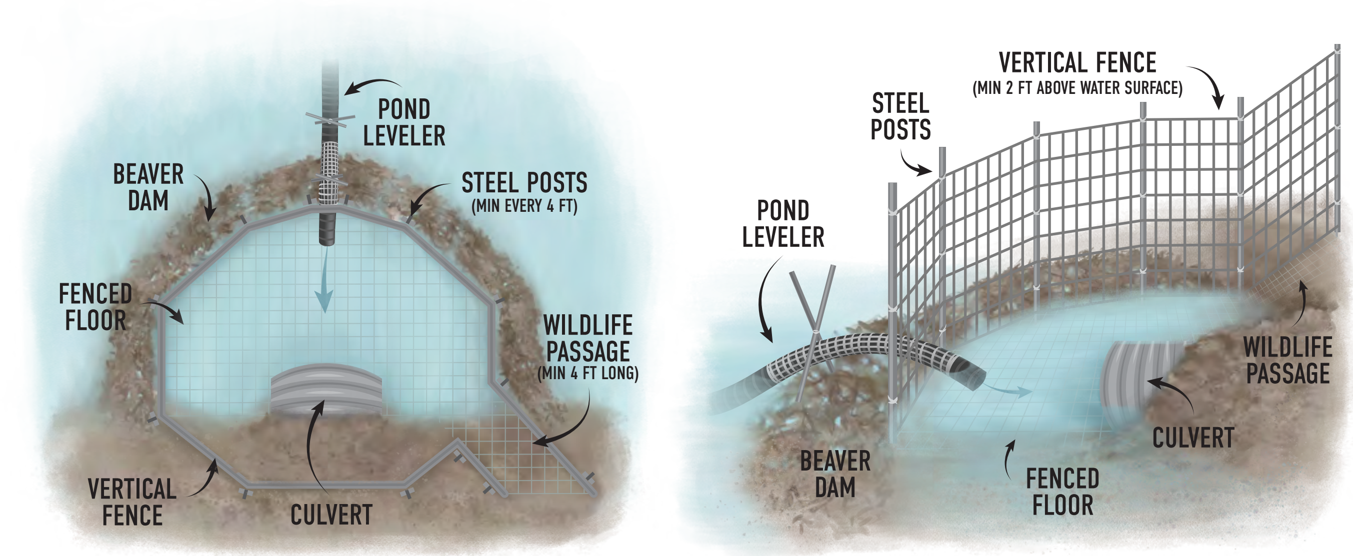


Figure 10. The combination of an anchor fence and pond leveler to create a pipe and fence culvert protection system shown from above (left) and side (right).

Anchor dam — standard site

Site features

- Beavers can be allowed to manage upstream habitat. The extent of upstream beaver impoundment does not require control.
- Stream is less than 1.5' deep 6-8' upstream of the spillway.
- A fence with 6" by 6" openings is not appropriate for the site.

Anchor dam design criteria

1. Construct a Beaver Dam Analogue (BDA) 6-8 feet upstream of the culvert or spillway. Adhere to the best management practices for a "post-less BDA" in Chapter 4, Appendix E of the Low-Tech Process-based Restoration of Riverscapes: Design Manual (Wheaton et al. 2019).
2. Stabilize with heavy-duty steel posts, firmly driven into the streambed no less than 12" apart (Figure 11).

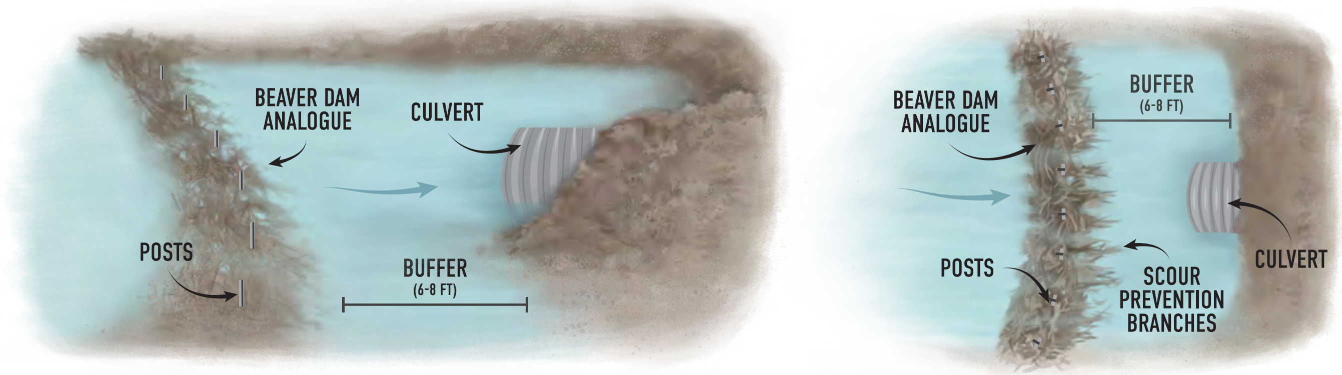


Figure 11. Anchor dam using a post-less BDA that is reinforced with steel posts.

Anchor dam — pipe and dam modification

Site features

- Beavers cannot be allowed to freely control upstream habitat. The extent of upstream beaver impoundment requires control, and a maximum elevation must be set for the beaver dam using a pond leveler.
- A fence with 6" by 6" openings is not appropriate for the site.

Pipe and dam design criteria

Construct an anchor dam in accordance with design criteria for a standard design #1-2.

3. Construct and install a pond leveler in accordance with the standard pond leveler Design Fundamentals, Best Management Practices and Site specific Criteria.

4. Position the overflow pipe over the anchor dam, using the same procedure outlined for a natural beaver dam (Figure 12).

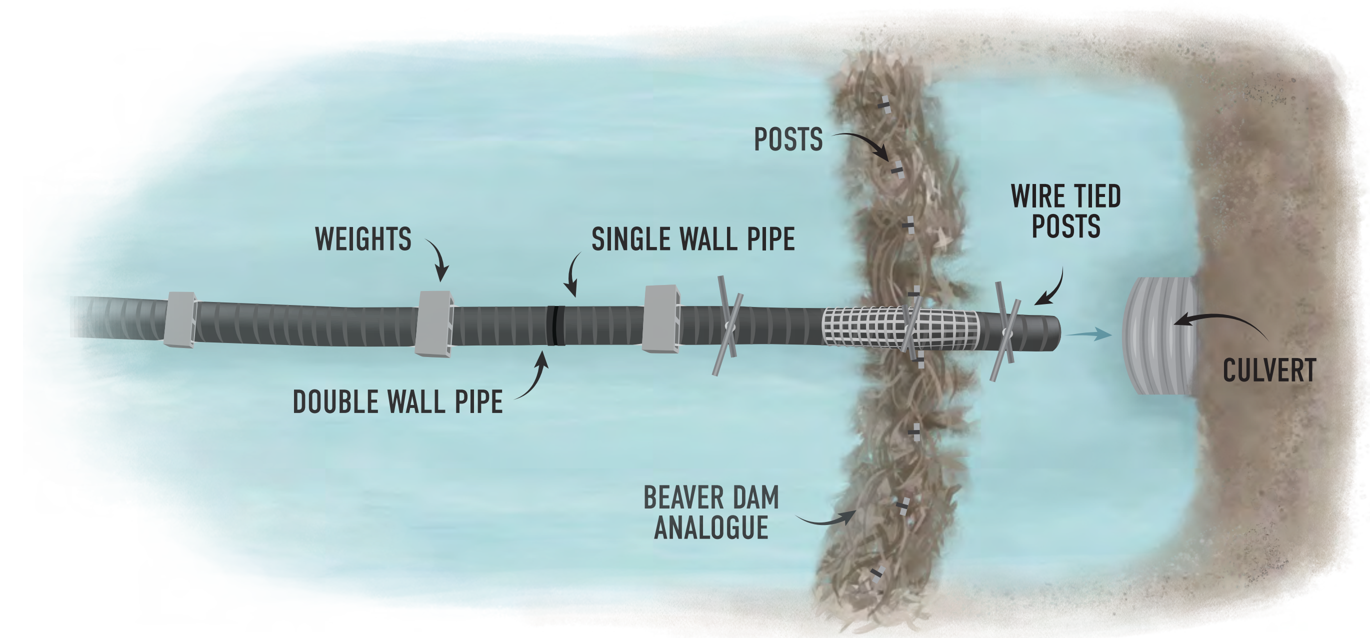


Figure 12. Combination of an anchor dam and pond leveler to create a pipe and dam culvert protection system.

Appendix

> *Note: We are working with the applicable regulatory authorities in varies states to green-light the permitting process for flow devices. State-specific guidance will be published here as we finalize those appendices. If you would like to support this effort, please contact The Beaver Coalition.*

THE BEAVER COALITION

ATTACHMENT F
BEAVER BENEFITS

Beaver Institute, Inc.

14 Mountain Road
Southampton, MA 01073
www.beaverinstitute.org

BI Beaver Primer

The North American beaver, *Castor canadensis*. This animal means different things to different people, including: a nuisance rodent, cute animal, water rat, destructive tree killer, Canada's national animal, road flooder, dam builder, ugly swamp creator, or environmental savior. Whereas, Native Americans thought of beavers as "Little People" in part because they are second only to man in their ability to change their environment to serve their own needs[i]. They revered the beaver as a totem animal and lived in harmony with them.

Today however, most people have limited exposure to the natural world, and beavers typically only make the news when problems occur. So our talk about this furry, aquatic mammal can be quite polarizing. Fortunately, as you'll soon learn, this polarization is unnecessary.

Historical Perspective

Beavers have lived in North America for millennia. An estimated 60 - 400 million beavers lived in North America when Europeans first arrived here.[ii] [iii] Over many millennia countless species evolved on this continent to take advantage of the ecological niches beavers created. Due to the myriad of species that began to rely on beaver created habitats, beavers became a Keystone species,-responsible for supporting biodiversity in North America. Biologists call them a Keystone species because like a keystone in a stone arch, the ecosystem collapses if you remove the beaver.

Native Americans had sustainably trapped and hunted beaver for thousands of years. In stark contrast, Europeans had eliminated nearly all the beavers in Europe to make fashionable top hats made of felt. They highly coveted beaver fur because it made the best felt. So upon discovering more beaver in the New World this new fur supply was greedily exploited.

Beaver trappers were usually the first white people to explore this continent, leading the white man's westward settlement. Trading with natives for furs was common. Beaver pelts were so valuable that they were used as currency by early pioneers, and frontier wars were even fought over furs. By the time most settlers arrived all the beavers were gone.

Since beavers were eliminated in advance of most white settlers, towns, roads, farms, etc. were all established in the absence of beavers. As we'll soon see, this historical fact creates serious problems for us today.

Beavers Return

Top hats and furs eventually went out of fashion, but by then the only surviving beavers were in remote areas. No longer hunted and often protected by wildlife managers who recognized the eco-system values that beavers offered, throughout the 20th century these resilient animals slowly rebounded[iv].

Probably the most dramatic and innovative reintroduction program occurred Idaho. In 1948 to establish beaver colonies in remote areas without roads, Idaho Fish and Game biologists dropped a total of 76 beavers from planes inside parachuted wooden crates! The first parachuted beaver was named Geronimo. Amazingly, all but one of the beavers survived their landings and successfully established colonies in the remote wilderness.[v]

Beaver recolonization in most of North America was less dramatic but also successful, both because many farms had reverted to forest, and beaver pelts were no longer valuable so interest in trapping beavers was limited.

The Beaver Cycle

As beavers returned, so did an important natural cycle that had been missing from our landscape.

When beavers open the forest canopy by damming streams and cutting down trees they create new ecological niches and transition zone habitats where various species thrive. Many of our threatened and endangered species require these vanishing habitats at some stages of their lives.[vi] Beaver activity creates “Mosaic Habitats” (a mix of habitats), even as they continue to disappear elsewhere from development, negatively impacting species that are declining in numbers, such as turtles, bats, and grouse.[vii]

So while killing trees in and around a beaver pond appears destructive, these dead trees actually create critical habitats for honeybees, wood ducks, swallows, herons, and others, and also allow grasses, sedges, bushes and saplings to grow on the perimeter of the pond. These plants provide habitat variety, food and cover for foraging animals.

Since beavers prefer not to travel far from the water, eventually they exhaust their woody food supply. When this happens the beavers will move to a new location. Then their dams develop leaks and the ponds drain out. The rich pond sediment gives rise to a lush, grassy meadow. Eventually shrubs and trees become established, and after 10 -15 years there is enough woody vegetation to attract new beavers and the process starts over. This natural beaver cycle creates a repeating series of successional habitats that support biodiversity.

Opening the tree canopy creates valuable land-based habitats, and it also allows sunlight reach the water where it triggers an explosion of aquatic biological activity. Algae and aquatic plants grow in the sun-drenched, nutrient rich water. This organic material supports microscopic organisms, which are eaten by a variety of invertebrates. These become food for fish, birds and mammals. An entire food chain is created which is why beaver ponds become magnets for wildlife. The biodiversity that exists due to beaver activity makes beavers our prototypical Keystone species and nature’s ecosystem engineers.[viii]

Each Keystone species is critically important for biodiversity, yet there is another Keystone species that relies on beavers, salmon! More beavers mean more salmon, and more salmon mean even more biodiversity!

Scientific research by Pollock, Wheaton, Kemp, and many others shows that streams with beaver dams actually produce larger and more numerous native trout and salmon.[ix] It turns out that beaver dams create ponds that serve as ideal nurseries for juvenile fish by creating complex edge habitat, increasing the invertebrate and insect food supply, putting beneficial woody debris in the water, reducing fish energy needs by providing slow water refuge, and increasing winter survival of salmonids. It is believed that having more beaver ponds could help some salmon be taken off the threatened species list!

Why Give a DAMn?

As if biodiversity and salmon recovery weren't enough, there are many other benefits to having beavers on our landscape.

Beaver dams actually *improve* stream flow and water quality[x]. Dangerously high stream flows are moderated by dams that function as natural sponges to reduce damaging peak flows and erosion during high runoff events, and increase low stream flows during droughts by slowly releasing stored water.

Water quality is also improved by the algae, plants and sediment in the ponds. How? They remove suspended particles, process organic wastes, and capture toxic heavy metals, pesticides and fertilizers from runoff in streams. These wetlands serve as the "Earth's Kidneys".[xi]

Want more benefits? Beaver ponds also recharge our drinking water aquifers, stabilize the water table, and help repair incised streams. Therefore, beavers are currently being relocated in western states such as WA, OR, ID, CO and UT for their stream restoration, water storage, and salmon and trout restoration services. Plus beavers provide all these valuable services for free, saving taxpayers millions of dollars!

Where erosion has cut a very deep stream channel the water table will drop, killing the surrounding vegetation, and making the area inhospitable to beavers. When this occurs Beaver Dam Analogs[xii] made from wooden posts and woven branches, are being successfully installed across streams to promote sediment deposition to raise the stream bed and water table. Beaver Dam Analogs reverse severe channel incision damage and ultimately make the area hospitable to beavers who will move in and complete the restoration work.

Beaver Problems

Remember all our infrastructure that was built in the absence of beavers? That is a big reason why beaver problems arise today.

As beavers returned, they entered a highly altered landscape due to human development. So when they began to dam their ancestral streams, conflicts with humans sometimes occurred and our two species would butt heads.

Initially problematic beavers could be relocated to uninhabited areas, and this continues in many western states with low beaver populations and large rural areas. However, in the late 20th century as the number of these isolated sites diminished in some states, lethal control became the primary management tool. In many states lethal beaver management remained the only viable beaver control method for decades. However, over the past 20 years great strides have been made to resolve beaver - human conflicts nonlethally in order to maximize the benefits of beavers.

That being said, nonlethal management is not feasible everywhere. In the Beaver Institute's experience beaver trapping remains the most viable option in up to 25% of beaver-human conflicts. However, new beavers will be always be attracted and relocate to good habitat, so if trapping is chosen it will need to be done indefinitely. This is one of several reasons we recommend that beaver removal only be used as a last resort.

There are many advantages of using non-lethal beaver management tools. First and foremost, properly designed and installed flow devices are extremely effective at limiting the size of beaver ponds and protecting human infrastructure. Second, they allow us to safely maximize valuable wetland and mosaic habitat acreage. Third, nonlethal beaver management is usually the most cost-effective method to manage beavers since the solutions are long-term, versus the typical short-term success of trapping.[xiii] [xiv] Fourth, in many states it is illegal to relocate wildlife, so all trapped beavers must be killed making nonlethal management more humane. And finally, where feasible, coexistence with beavers promotes a culture of respect, balance and proper stewardship for our environment.

Effective Nonlethal Methods

Understanding how and why beavers do what they do is necessary to properly manage them.

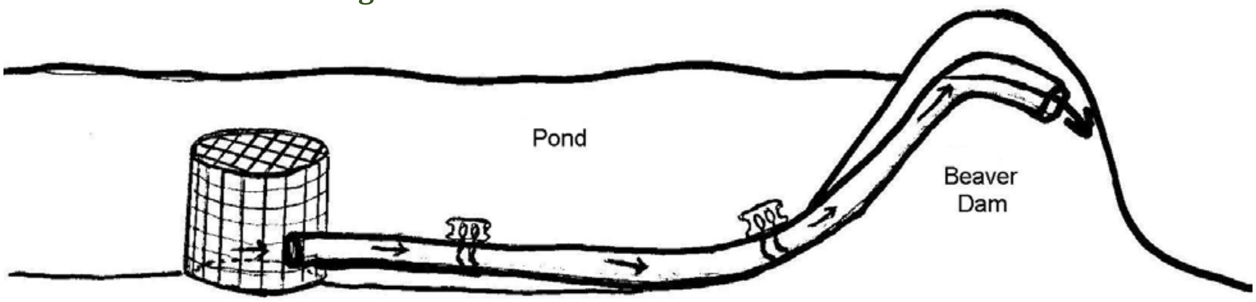
There are currently a wide variety of devices that can effectively prevent infrastructure damage from beavers at road culverts and manmade dam spillways, and there are effective pipe systems that can be installed through freestanding beaver dams to control ponds at safe levels. Thousands of successful water control devices have been installed across North America. These successful water control devices are commonly known as flow devices, Beaver Bafflers, or Beaver Deceivers.[xv]

Blocked road culverts are a very common beaver problem. To a beaver, a culvert pipe through a roadbed looks like a hole in a dam. With a little work they can "repair' the hole and turn the roadbed into a large dam. Good for the beaver, but bad for us because a blocked road culvert can quickly cause serious health and safety issues, damage to infrastructure and create major expenses and headaches for highway departments.

Fortunately, it is rare that a road culvert cannot be protected from beavers. Depending upon the site characteristics, different culvert protective devices can be used, such as Diversion Dams, Large Culvert Fences, or Fence and Pipe flow devices. When designed and installed professionally, all these devices exceed a 95% success rate and can be guaranteed effective. These flow devices can also be successfully used on other manmade structures such as manmade dam spillways and retention ponds. Many examples and testimonials can be found on our website at: www.beaverinstitute.org.

Flooding problems from freestanding beaver dams are managed differently. Often a device called a Flexible Pond Leveler pipe system can lower and maintain a beaver pond at a level that will not threaten human interests. See diagram.

Flexible Pond Leveler Diagram



Created by Michel LeClair in Canada, the Flexible Pond Leveler pipe system works because the fencing on the pipe intake keeps the beavers far enough from the inlet so they do not feel or hear water flowing into the pipe. If the beavers cannot detect the flow of water into the pipe, they do not try to block it. The pipe is placed through a trench dug in the dam. The height of the pipe in the dam controls the pond level.

Another common beaver complaint is tree chewing. Fortunately, valuable specimen trees or other mature trees that people value can be readily protected from beaver chewing with simple and inexpensive methods such as tree trunk fencing or a paint-sand mixture applied to the base of the tree. Again, successful techniques with instructions and pictures can be found on our website at: https://www.beaverinstitute.org/management/tree-protection/.

Beaver Institute, Inc.

The Beaver Institute, Inc. is a charitable 501(c)3 nonprofit whose Mission is to be a catalyst for advancing beaver management and watershed restoration by providing technical and financial assistance to public and private landowners experiencing beaver conflicts, supporting scientific research, training mitigation professionals, and increasing public appreciation of the beaver's critical role in creating wetland ecosystems. Our Vision is to resolve all beaver-human conflicts in a science-based manner in order to maximize the many benefits that beavers contribute to the environment. Please consider joining our Beaver Believer Volunteer Krew[xvi], or support us with a tax deductible donation.

There is a wealth of useful information and many other resources on our website that can successfully guide you how to resolve beaver conflicts with proven techniques, or you can find a professional Beaver Management expert in your area at: https://www.beaverinstitute.org/management/installer-locator/.

Conclusion

Although these four-legged "Little People" can present serious challenges, they are a critical Keystone species and cost-effective, long-term, environmentally-friendly and humane management options exist to resolve conflicts.

We all have an important role to play by educating others about the many benefits of beavers, and advocating for coexistence with beavers wherever feasible. This enlightened approach can protect human property and interests, save taxpayer money, and preserve and improve the natural environment that we and all living things rely upon.

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[i] www.animalfactsencyclopedia.com/Beaver-facts.html

[ii] https://en.wikipedia.org/wiki/Beaver

[iii] http://www.ohiohistorycentral.org/w/American_Beaver

[iv] B. Baker and E. Hill, (2003) Wild Mammals of North America: Biology, Management, and Conservation. 2nd ed., Johns Hopkins University Press, Baltimore, MD, pp. 288-310.

[v] http://boisestatepublicradio.org/post/parachuting-beavers-idahos-wilderness-yes-it-really-happened#stream/0.

[vi] https://www.epa.gov/wetlands/why-are-wetlands-important

[vii] K. Wagener, *The Habitat*, CACIWC Newsletter, (2017) Vol. 29, No. 4, p.6.

[viii] https://en.wikipedia.org/wiki/Ecosystem_engineer

[ix] https://www.beaverinstitute.org/research/library/

[x] Terry. N & Bañuelos, G. (2000) Phytoremediation of contaminated soil and water. CRC Press LLC

[xi] https://blog.epa.gov/blog/2014/06/wetlands-earths-kidneys/

[xii] https://www.beaverinstitute.org/management/stream-restoration/

[xiii] Mitigating infrastructure loss from beaver flooding: A cost–benefit analysis, Hood, G. et. al. (Dec. 2017) Human Dimensions of Wildlife, pp. 1-14.

[xiv] An Analysis of the Efficacy and Cost of Flow Devices along Roadways in Virginia, (2008) Boyles, S and Savitzky, B, Univ. of Calif. Davis, pp.47 – 52.

[xv] The "Beaver Deceiver", a trapezoidal fence designed to protect road culverts was invented and trademarked by Skip Lisle at Beaver Deceivers International.

[xvi] https://www.beaverinstitute.org/about/support/

Why Beavers Matter

Beaver dams

- Filter sediment and pollutants & reduce silt load, improving overall water quality
- Restore streams and regulate flow, reducing erosion

Beaver ponds

- Replenish aquifers, elevate/stabilize the water table, and drought-proof the landscape
- Mitigate large-scale flooding
- Store groundwater for agricultural use
- Slow/extinguish wildfires and provide refuges for other wildlife
- Increase biodiversity, providing habitat for many other species

Beaver behavior

- Foraging promotes plant growth
- Channel-digging provides habitat for fish and amphibian eggs and larvae

Learn more at www.coexistwithbeavers.org

Human-Beaver Coexistence Fund