Bridge and Culvert Construction Guidelines for Stream, Riparian, and Wetland Habitats

2025

Rio Grande cutthroat trout

Note: these guidelines were partially adapted and condensed from *STREAM SIMULATION, An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings*, a publication of the USDA Forest Service Stream-Simulation Working Group (2008). Any reference of the following material should also credit the original document.

Rivers and streams are important conduits for fish and wildlife. Animals move through stream corridors to access food, shelter, mates, nesting areas, or other resources. Some movements are seasonal and are linked to the reproductive biology of the species. During the breeding season, animals move to find mates and suitable breeding habitat. For example, fish often migrate to spawning areas that have higher productivity and fewer predators, such as floodplains and headwater streams. In these areas, recently hatched fish benefit from additional resources and decreased predation pressure. Semi-aquatic and terrestrial wildlife species also use streams as travel corridors, including muskrats, otters, beavers, frogs, turtles, snakes, and migratory birds. In developed areas, rivers and streams may be the only available movement corridors for wildlife.

Animal movements are critical for maintaining aquatic and riparian wildlife populations. Barriers to movement can block the exchange of individuals among populations, eliminating gene flow and the ability of "source" populations to support smaller populations nearby. Barriers can also reduce or eliminate access to important spawning areas, nursery habitat for juvenile fish, foraging areas, refuge from predators, deep water refuges, or other seasonal habitats. Restricted access to these vital habitats can cause wildlife population declines or even local extirpations.

PROJECT GUIDELINES

The New Mexico Department of Wildlife (NMDOW) Project Guidelines provide conservation measure to minimize impacts of land use and development projects on wildlife and wildlife habitats. These Project Guidelines address stream crossing design for aquatic life move-ment. For more information on this topic, please call 505-629-7738.

The primary author of these guidelines is Malia Volke with additions from Jack Marchetti.

ERT for NM

The Environmental Review Tool (ERT) for New Mexico is a web-based system that quickly screens land use and development projects for potential impacts to wildlife and wildlife habitats. The ERT provides best management practices and guidance to mitigate these impacts. Evaluate your project with the ERT at: https://nmert.org/

EEP SECTION

The Ecological and Environmental Planning Section coordinates the Department's environmental re-view process, and works with community, private sector, state and federal government, nongov-ernmental organizations, and other project proponents to pro-tect and enhance wildlife habitats. The Section implements the Share with Wildlife program and maintains BISON-M, a database of New Mexico's wildlife species. It also participates in the develop-ment and application of wildlife-related information management and planning tools.

CONTACT

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Northern leopard frog

New Mexico meadow jumping mouse

Big Bend slider

Aquatic organisms with weak swimming abilities, and small, crawling organisms such as frogs and turtles are especially vulnerable to movement barriers. When moving upstream, these species avoid high flow velocities, high turbulence zones, and predators by moving along the stream bottom or bank edge where velocities are lower. Substandard culvert design may force semi-aquatic and terrestrial animals to move across roads, making them vulnerable to vehicle mortality. Many mussel species depend on small host fish that are typically weak swimmers. Smaller aquatic organisms including snails, worms, mites, and amphipods appear to have limited capacities for movement. The maintenance of stream bottom and bank edge habitats is important for maintaining interconnected populations of weak-swimming and crawling species.

Animal movements facilitate the upstream cycling of nutrients and organisms. Within stream systems, nutrients and organisms tend to shift downstream. The upstream movement of individuals helps counterbalance this trend and returns nutrients to upstream reaches. The movement of wildlife also helps maintain the balance between predators and prey and the distribution of food-based energy throughout the stream system.

Aquatic and riparian fauna must move in response to continually changing habitat conditions in stream environments. Changes in temperature, flow velocity, or water depth may force organisms to move to areas with more favorable conditions. For example, during the summer, salmonids such as Rio Grande cutthroat trout (*Oncorhynchus clarkii virginalis*) and Gila trout (*Oncorhynchus gilae*) may move into cool headwater streams to avoid temperature stress in downstream reaches. Floodplain wetlands and side channels supported by groundwater can also provide thermal refuges during warm periods. During dry periods, fish and other aquatic organisms will move to areas with sufficient water. Extreme events, such as floods, debris flows, and droughts may force populations to move to avoid unfavorable conditions. Access to refuge habitat is particularly important in streams where natural or anthropogenic disturbances are common.

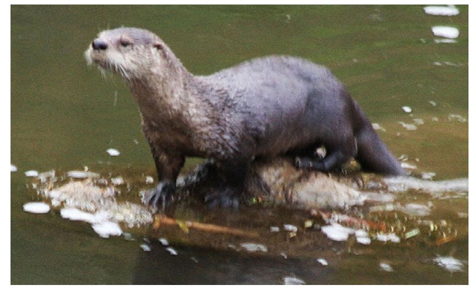
Common muskrat

Gila trout

Culverts, bridges, and other road-stream crossings can create temporary or permanent movement barriers for some or all wildlife species. Crossings that are narrower than the natural channel can back up flow above the crossing, causing the deposition of sediment and debris that blocks movement of aquatic organisms. Clogged or collapsed culverts can likewise block animal movement and divert water outside of the stream channel. Because culverts are narrower and smoother than the natural channel, flow velocities increase within a culvert, and can accelerate beyond the swimming capabilities of fish and other aquatic organisms. The surge of water flowing from the culvert outlet can scour the receiving streambed, creating a deep pool that is lower in elevation. Elevation drops can create a physical barrier for many aquatic organisms, particularly weak swimmers or jumpers, crawling organisms, and juvenile fish. The absence of bank edges within culverts may inhibit or prevent the movement of weak-swimming or crawling organisms. Crossing structures that lack a natural substrate can inhibit passage of benthic invertebrates that are confined to the streambed and can only move through appropriate substrates. Stream crossings that do not meet design requirements for larger terrestrial wildlife such as deer may increase risk of wildlife-vehicle collisions by pushing animals onto roadways (for guidance on this topic, see the Wildlife Crossing Structure Handbook, a report by the Federal Highway Administration, 2011). Barriers to some or all taxa disrupt aquatic food webs, predator-prey dynamics, competition for resources, and nutrient cycling.

Seasonal changes in stream discharge may create temporary movement barriers at stream crossings. During high flow periods, such as spring runoff, water velocities through culverts can be too high for fish passage. This can restrict access to spawning sites during the peak migration period. Conversely, low flow periods can lead to movement barriers at crossings where water depths are too shallow to allow passage of aquatic organisms. For some species, temporary or seasonal movement barriers can seriously limit reproduction or survival or within a population.

Spiny softshell turtle



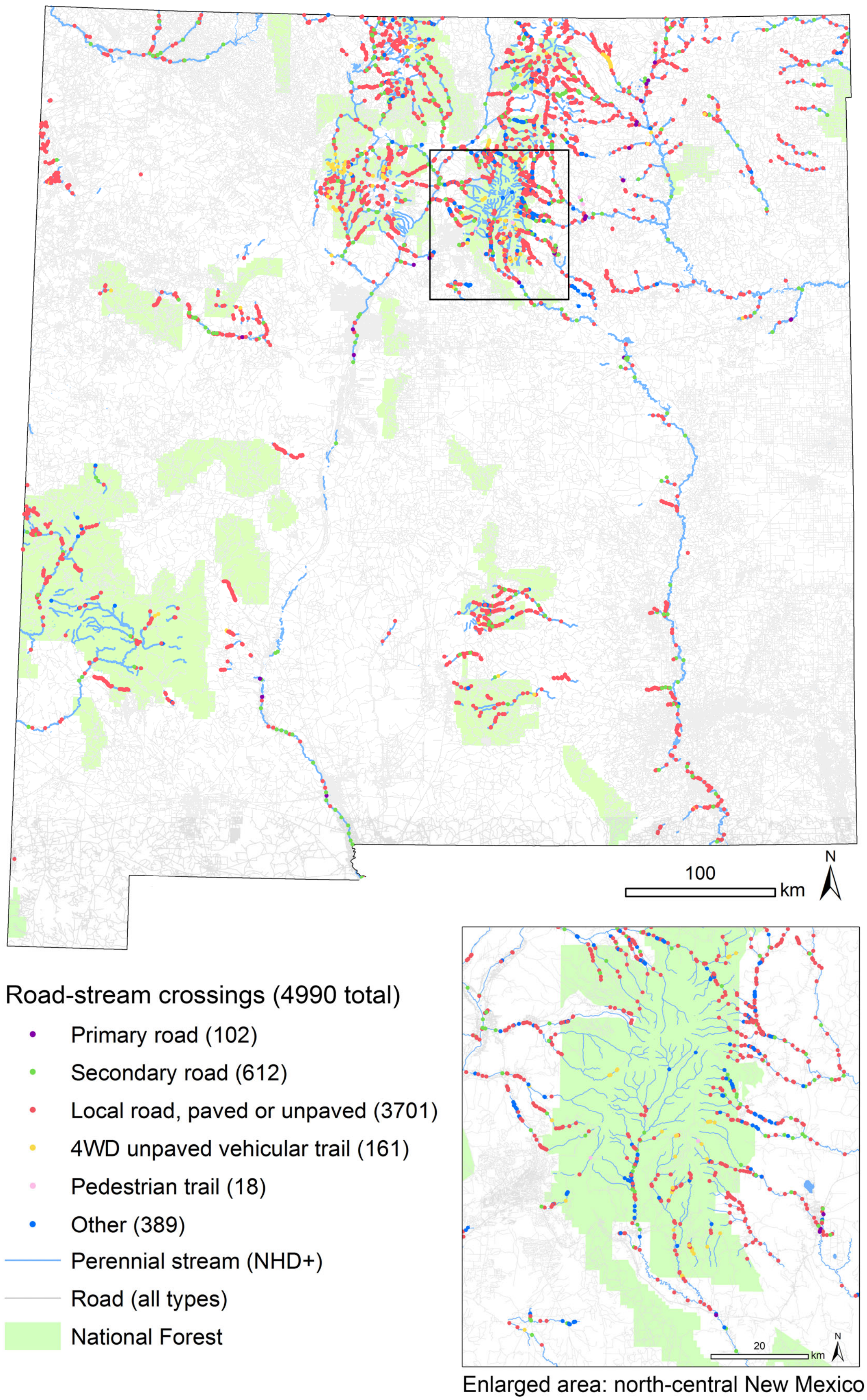
North American river otter

Narrow-headed garter snake

White Sands pupfish

Flathead chub

Noel's amphipod



An estimated 4,990 road crossings occur along perennial streams in New Mexico, based on National Hydrography Dataset Plus (NHD+) and TIGER roads (2017) data. The enlarged area shows the southern extent of the Sangre de Cristo Mountains, including portions of the Santa Fe National Forest and Carson National Forest in north-central New Mexico.

In addition to creating barriers for fish and wildlife movement, stream crossings often degrade or diminish aquatic, riparian, and wetland habitats. Replacement of the natural channel with an artificial crossing structure causes direct habitat loss, and culverts themselves have very little habitat value. Stream crossings also disrupt fluvial processes that create and maintain stream habitats, such as transport, erosion, and deposition of sediment and woody debris. Much of this habitat creation occurs during higher flows, which are often constrained by crossing structures. Disruptions to the hydrologic and sediment regimes limit the creation and renewal of diverse channel and floodplain habitats, such as side channels and debris accumulations.

Stream crossing structures commonly cause increased rates of erosion and sedimentation. This is often a concern during the construction period, but can also be an issue throughout the life of the structure. Ongoing erosion of the banks and streambed can cause channel degradation, disconnecting the channel from its floodplain and dewatering adjacent wetlands. Excess sediment increases turbidity and alters downstream substrates and channel geometry. Increased turbidity can adversely affect visual predators and filter feeders that are adapted to clear water environments. Accelerated rates of erosion and sedimentation at stream crossings can thus have significant local or cumulative effects on stream, riparian, and wetland habitats.

An abrupt drop at a culvert outlet restricts upstream animal movement. *M. Volke.*

Low flow conditions along with improperly designed culverts block the movement of White Sands pupfish, a State Threatened species, at Holloman Air Force Base near Alamogordo. *M. Watson.*

Debris accumulation at a culvert impedes animal movement. *M. Volke.*

An improperly designed low water crossing on the Tularosa River creates a barrier to aquatic life movement, including the Federally Endangered loach minnow. *M. Volke.*

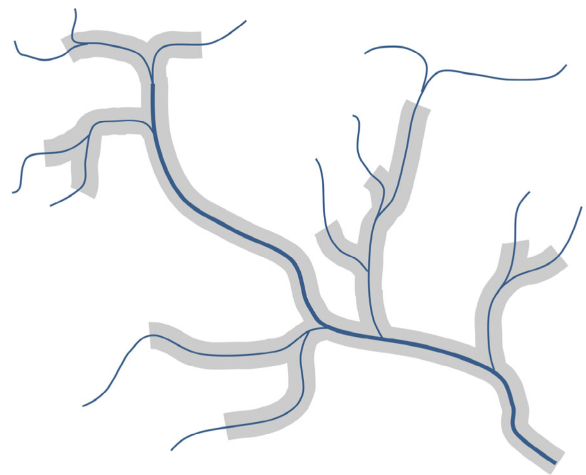
How crossings can impede movement

- Physical barriers (collapsed culverts)
- Abrupt change in elevation at crossing inlets or outlets
- Sediment/debris accumulation
- High flow velocities exceed swimming ability
- Excessive turbulence
- Insufficient water depth
- Discontinuity of channel substrate
- Absence of bank edge areas

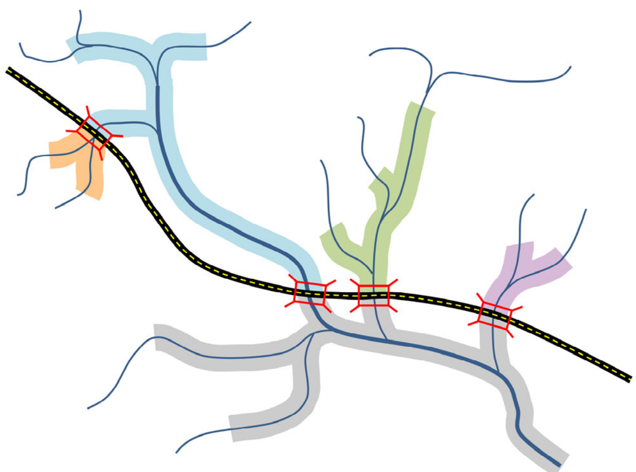
This large culvert provides a seamless transition between the natural stream and artificial structure, along with a natural substrate through the entire crossing, enabling aquatic life movement. *M. Volke.*

Before: A potential barrier to aquatic life movement along the Rio San Antonio on the Carson National Forest. *M. Volke.*

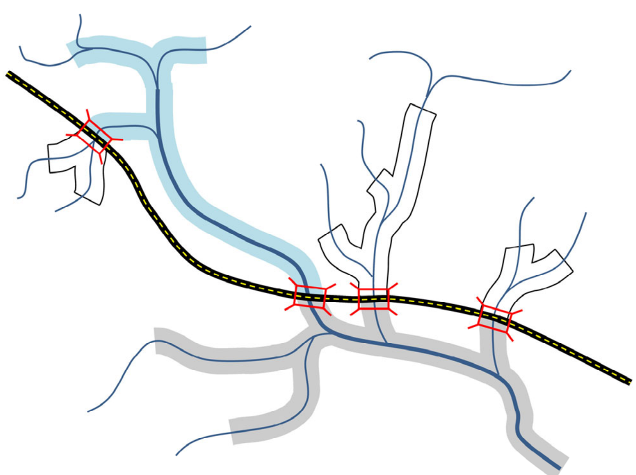
After: Aquatic life movement is much improved following replacement of the old crossing structure with a bridge. *M. Volke.*



(A) A stream network provides continuous habitat for swimming and crawling species.



(B) After construction of a road with substandard culverts, species populations are fragmented into five smaller and more isolated populations.



(C) Smaller and more isolated populations are more vulnerable to genetic changes and local extinctions due to chance events. Over time, as these smaller populations fail, species are eliminated from a significant portion of the suitable habitat available in this drainage.

Hypothetical example of barrier culverts that isolate populations. Isolation can occur from failure to provide aquatic organism passage, or disruptions in hydrology that cause discontinuities in suitable aquatic or riparian habitats.

Recommendations

CROSSING DESIGN PHASE

To avoid adverse impacts to fish, wildlife, and their habitats, stream crossings should be designed to closely simulate the natural stream channel. Project proponents should consult with the New Mexico Department of Wildlife (NMDOW) early in the project development phase to ensure that the project design minimizes adverse impacts to fish, wildlife, and their habitats. For agencies using federal funds, consultation with NMDOW is a requirement of the Fixing America's Surface Transportation (FAST) Act.

General design recommendations:

- Crossings should be sited outside of hazardous areas such as steep, wet, or unstable slopes. High value habitats such as wetlands or critical spawning areas should be avoided.
- Projects should not alter the natural stream channel size or shape (width, depth, gradient, direction, or meander pattern), water flow capacity, flow velocity, or sediment regime.
- Crossings should be sized to accommodate the full range of stream flows and geomorphic processes. Structures should be at least as wide as the natural channel, and be able to accommodate a 100 year flood.
- The constructed channel should ensure adequate water depth during low flow periods and resist scour during floods.
- The widest part of a round culvert should be placed at or above the highest potential bed elevation to maintain flood and debris flow capacity.
- The transition between the natural stream and artificial structure should be as seamless as possible. The structure should present no more of an obstacle to aquatic animals than the adjacent natural channel. Avoid unnatural barriers, such as inlet or outlet drops, and ensure that the crossing structure is aligned with the natural channel.
- Design the structure to accommodate channel movement as much as possible.
- Consider installing permanent rock structures within culverts to increase roughness and accommodate the movement abilities of weak-swimmers and crawling animals. The natural stream bed and bankline can be simulated with irregularly placed rock secured with filler material.
- Plan for extreme events and crossing failure. Determine where the water will go if the culvert becomes clogged. The design should prevent diversions down the road if water overtops the structure. A dip over or down grade of the crossing structure will prevent the stream from running down the road. Ensure that the downstream end of the relief dip is well-armored.

Recommendations

CROSSING DESIGN PHASE (continued)

- Check your culvert design with FishXing Software, a simple program designed to assist engineers, hydrologists, and fish biologists evaluate the design of culverts for fish passage. It is available as a free download.

- If terrestrial wildlife passage is desired, ensure that crossings meet design requirements (refer to the Wildlife Crossing Structure Handbook).

Bridges and open-bottom, arch culverts are generally the best options for wildlife passage and maintenance of stream ecosystem processes. These structures are more open and maintain natural stream beds, allow unrestricted flow during normal conditions, and typically allow the passage of some woody debris. Bridges are usually the best option for active floodplain locations and debris flow areas where high clearance is necessary. While initially more expensive, bridges, arch culverts, and larger structures are less prone to flood damage and debris plugging, and are thus likely to be more self-sustaining and lower in maintenance costs over the long-term. **Stream crossings that utilize bridges or arch culverts are generally compliant with the above recommendations for aquatic life movement.**

A successful bottomless arch culvert over Big Blue Creek (a tributary to Coyote Creek) along NM Highway 434 in northeast New Mexico. *M. Volke.*

Recommendations

CONSTRUCTION AND MAINTENANCE PHASE

Erosion and Sediment Control

- Avoid disturbance to vegetation and minimize bare ground.
- Limit vehicle and equipment traffic to existing roads and rights-of-way. Locate staging areas in previously disturbed sites.
- Use protective measures (e.g., silt fences, hay bales, mats, coir logs) to prevent excavated material from entering surface waters.
- Manage turbid water during excavation with vegetative buffers, sediment basins, geotextile filter bags, or other appropriate materials.
- Stabilize exposed soils with vegetation as soon as possible to prevent excessive erosion.
- All topsoil removed for construction should be stockpiled and used as surface fill in reclamation of the project area. Any additional fills should consist of permeable materials that do not disrupt the existing sub-surface hydrology.

Dewatering

Minimize the extent and duration of hydrologic disruption.

Consider using bypass channels for maintaining some stream connectivity during construction to provide for aquatic life movement and minimize erosion and turbidity.

Prevent fish from entering the construction site by placing block nets at the upstream and downstream ends of the dewatered section.

Restrict in-channel work to periods of no or lowflow. The low flow period in New Mexico generally occurs during late fall and winter. However, some sites may support fall-spawning fish or wintering wildlife (eg., bald eagles, waterfowl). Consult with NMDOW to identify site-specific constraints for project timing.

Salvage aquatic organisms (e.g.,fish, mussels) stranded during dewatering. To avoid stranding, stressing, or killing aquatic organisms, dewater gradually, capture the organisms, and relocate them to the best available habitat above or below the construction site.

Recommendations

CONSTRUCTION AND MAINTENANCE PHASE (continued)

Pollution Control

- Pressure wash or steam clean heavy equipment before entering the project area to remove any petroleum products and weed propagules.
- Inspect equipment daily for leaks.
- Keep appropriate spill clean-up materials such as booms and absorbent pads on-site at all times during construction.
- Store fuel, oil, hydraulic fluid, lubricants, and other petrochemicals outside of the floodplain and other sensitive areas.
- Minimize instream equipment activity, with no refueling, maintenance, or cleaning of equipment (e.g., ready-mix concrete trucks) in or near the watercourse. Contain any poured concrete in forms and prevent introduction of uncured concrete into surface or ground waters.
- Ensure that gravel, riprap, and other bank stabilizing materials are free of fines and chemical contaminants.
- During bridge work, use tarpaulins or other catchment devices to prevent debris, wastes, and toxic compounds from entering the stream.

Re-vegetation

- Following construction, revegetate disturbed areas using native plant species appropriate for the site. Plant materials should consist of local ecotypes whenever possible.
- Consider using high density pole plantings of cottonwood and willow at sites where they occur naturally. To improve establishment success, harvest and plant poles during the winter dormant season following complete leaf-off. Ensure that poles are planted to the depth of the water table.
- Seed mixes may be used to revegetate disturbed areas. All seed mixes should be native and certified as weed-free. Seed establishment may be improved by roughening the soil surface to help collect seeds and water, applying a light mulch on top of the seeds, and supplemental watering.
- To enhance initial erosion control, sterile triticale (*Triticum aestivum* X *Secale cereale* 'Quickguard') may be a desirable component of the seed mix.
- Contact native plant nurseries and seed producers in the early stages of project planning to ensure that the appropriate plant species and ecotypes are available in anticipated quantities for plantings.

CONSTRUCTION AND MAINTENANCE PHASE (continued)

Beaver Coexistence and Damage Prevention (where beavers are known or expected to occur)

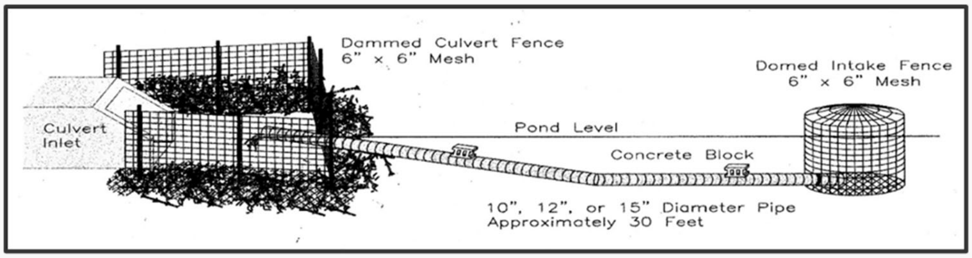
- Install culvert protective fencing to prevent beavers from damming the culvert openings. Protective fencing should be installed on the upstream end to keep beavers back from the opening. This protective fencing should extend 10-12 feet away from the culvert inlet, ideally in a trapezoidal shape (see image below). Culvert fencing should extend 1-2 feet above the water surface and should include a floor to prevent beavers from burrowing beneath the fence.

- Use heavy gauge fencing (e.g., 4 to 6 gauge) with a large mesh size (6x6 or 6x8 inch) to allow for the passage of fish and aquatic wildlife.

- Design culverts with a large opening. Beavers are less likely to dam culverts with a large inlet opening (e.g., bottomless arch culverts) compared to culverts with small inlet openings (e.g., pipe culverts).

- A fence-and-pipe system, where culvert fencing is used in combination with a pond leveler (also called flexible pond levelers or water level control devices), may be required in situations where cul-vert fencing is blocked by beaver damming or flood debris, thus restricting water flow into the culvert and resulting in ponding upstream. This ponding can pose a flood risk to adjacent infrastructure or property. The fence-and-pipe system uses a pipe to move water from the ponded area, through the blockage and fence, and into the culvert.

An example of culvert fencing. *S. Boyle*.



Fence-and-pipe system (photo left and diagram right) with a pipe running from above the obstruction and fencing to the culvert inlet downstream. *P. Planer, RangeWorks LLC.*

ADDITIONAL RESOURCES

New Mexico Environment Department

New Mexico Environment Department – Surface Water Quality Bureau

New Mexico 401 Water Quality Certification (New Mexico Environment Department)

US Army Corps of Engineers (Albuquerque District)

404 Permits (US Army Corps of Engineers)

Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings (US Forest Service)

Culvert Design for Aquatic Organism Passage (US Department of Transportation)

National Fish Passage Program (US Fish and Wildlife Service)

FishXing Software (US Forest Service). Software that is intended to assist engineers, hydrologists, and fish biologists evaluate the design of culverts for fish passage. It is available as a free download.

StreamStats (US Geological Survey). A web application that provides access to an assortment of Geographic Information Systems (GIS) analytical tools that are useful for water-resources planning and management, and for engineering and design purposes. Users can obtain basin characteristics and estimates of flow statistics for selected sites.

Wildlife Crossing Structure Handbook (Federal Highway Administration)

NMDOW Habitat Guidelines, Restoration and Management of Native and Non-native Trees in Southwestern Riparian Ecosystems. Includes a list of vendors to help land managers find local sources of native plant materials.

Con-Arch Engineering. A supplier of open-bottom, arch culverts

Blocked Culverts and Drains (The Beaver Institute)

Non-lethal Options for Mitigating the Unwanted Effects of Beaver (US Fish and Wildlife Service; Chapter 9 in the Beaver Restoration Guidebook)

Landowners' Guide to Non-lethal Beaver Solutions (Animal Protection New Mexico)

Beaver Coexistence and Cost Share Brochure (Defenders of Wildlife)

ADDITIONAL RESOURCES (continued)

Resolving Beaver Conflicts Humanely (Animal Protection New Mexico)

Wildlife photo credits

Golden stonefly

J. Caldwell:	Rio Grande cutthroat trout
T. Brennan:	narrow-headed garter snake
D. Salmon:	Gila trout
T. Kennedy:	flathead chub
B. Lang:	Noel's amphipod
J. Stuart:	northern leopard frog, New Mexico meadow jumping mouse, Big Bend slider, common muskrat, spiny softshell turtle, North American river otter