AQUATIC ORGANISM PASSAGE, CULVERT
DESIGN PROCEDURES
(396DP)

BACKGROUND

The following information applies specifically to trout and Topeka shiner and was obtained from Natural Resources Conservation Service technical references in Colorado and South Dakota. It provides useful information for evaluating or designing culverts to allow for aquatic organism passage from one stream reach or water body to another. Target fish species for most small streams in Nebraska will consist of either trout (brook, brown, or rainbow) or small minnow-like species, such as the Topeka shiner, which are endangered, threatened, or at-risk. The criteria for the Topeka shiner are expected to be representative for other similar species. Planning and implementation should be in accordance with the 396 Aquatic Organism Passage Standard.

The design procedures detailed in this document are broken into three sections as follows:

- No Slope / Stream Simulation Method
- Water Velocity and Depth in the Culvert
- Vertical Jump Height and Depth of Jump Pool

NO SLOPE / STREAM SIMULATION METHOD

The preferred method to address aquatic organism passage through culverts is to use the No Slope or Stream Simulation design criteria. It provides more suitable conditions for most fish species yet does not require extensive hydrology analysis, engineering design, or survey work. All of the following criteria must be met:

- Width of culvert must be equal to or greater than the average channel bed width at the elevation the culvert meets the streambed.
- Gradient of culvert is the same as the stream gradient, not to exceed a 1% grade.
- Downstream invert of culvert is countersunk below the channel bed by a minimum of 20% of the culvert diameter or rise.
- Upstream invert of culvert is countersunk below the channel bed by a maximum of 40% of the culvert diameter or rise.
- Substrate (silt, sand, gravel, etc.) is either placed or deposited by stream flow into the base of culvert in a manner that mimics the adjacent steam bed.

This method, if installed correctly and functioning as intended, will eliminate the need to address water velocity and depth in the culvert as well as vertical jump height and depth of jump pool at the outlet of the culvert. Those parameters are addressed in the following sections for situations when the No Slope / Stream Simulation method cannot be used or to evaluate existing culverts for aquatic organism passage.

WATER VELOCITY AND DEPTH IN THE CULVERT

The velocity of the water in the culvert should be based upon 50 percent of the capacity of the channel at bank-full conditions. Water velocities within the culvert should not exceed critical swimming speeds noted in the table below. Fish must be able to pass through the culvert in five minutes or less. Time required for passage is calculated by dividing the length of the culvert by the net velocity of the fish (darting speed minus water velocity in the culvert).

Table 1. Swimming speeds for trout and Topeka shiner.

Species (Adult)	Cruising Speed (1)	Sustained Speed (2)	Darting Speed (3)
Topeka Shiner		1.0 – 1.3 fps	1.3 – 2.5 fps
Trout	< 2 fps	2 – 6 fps	6 – 14 fps

(1) Cruising speed can be maintained for hours and is used for migration
(2) Sustained speed can be maintained for 2 – 200 minutes and is used for passage through difficult areas.
(3) Darting speed can be maintained for seconds up to 2 minutes and is used for feeding and escape from predators.

Adult trout need 8 inches of water in the culvert in order to successfully use the passage. For juvenile trout or smaller species, shallowness of water may be offset with baffles, deeper corrugations, or other devices to create depth and/or resting areas.

VERTICAL JUMP HEIGHT AND DEPTH OF JUMP POOL

The maximum jump height should be 6 inches for juvenile trout and up to 1 foot for adult trout. Depth of the jump pool (below the culvert outlet) should be a minimum of 2 feet. The Topeka shiner is not well adapted to negotiate any amount of jump height distance.

PRIMARY REFERENCES

Natural Resources Conservation Service – Colorado. 2001. Fish Passages. Biology Technical Note 29.

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