

CHAPTER 10.0 CULVERTS

10.1 Introduction

This chapter provides design criteria and procedures to be used for culverts within the County. Culverts are conduits that provide conveyance of surface water underneath roadways, driveways, and other types of embankments that cross surface water drainageways.

10.2 Design Criteria and Considerations

10.2.1 Additional Requirements, References and Guidelines

In addition to the criteria and considerations outlined in this chapter, culvert design may be dictated by:

- FEMA floodplains: Culverts constructed in a regulatory floodway must demonstrate no rise in water surface elevation, or a Conditional Letter of Map Revision (CLOMR) and Letter of Map Revision (LOMR) is required.
- Drainage Areas of Interest: Culverts constructed within a Drainage Area of Interest may be required to meet more stringent requirements than other areas in the County. The County's *Bridges and Culverts* guidance document provides additional information regarding regulations for construction of crossings in Larimer County Drainage Areas of Interest. This document may be accessed on the County's website, and all technical requirements shall be met as prescribed therein.
- Master Plans: Culverts must be designed in compliance with any existing Master Plans in effect for the watershed.

No Adverse Impact

These criteria are the minimum requirements for culvert design. *All crossings, public or private, must show no adverse impact on adjacent property for the 100-year storm event.* In some cases, more stringent criteria may be required to achieve this overarching requirement.

10.2.2 Culvert Classification, Design Event, Headwater Depths

Culverts must be sized to convey the discharge from a design event based on the type of crossing that the culvert is serving (

Table 10-1), referred to as the “Culvert Classification.” Figure 10-1 shows different culvert classifications. The headwater depth criteria dictate the maximum ratio of upstream headwater to the vertical dimension of the culvert. The overtopping depth represents the maximum allowable depth measured at the crown of the roadway for the 100-year event. If a crossing does not meet one of the classifications, consult with the County Engineer for appropriate design criteria.

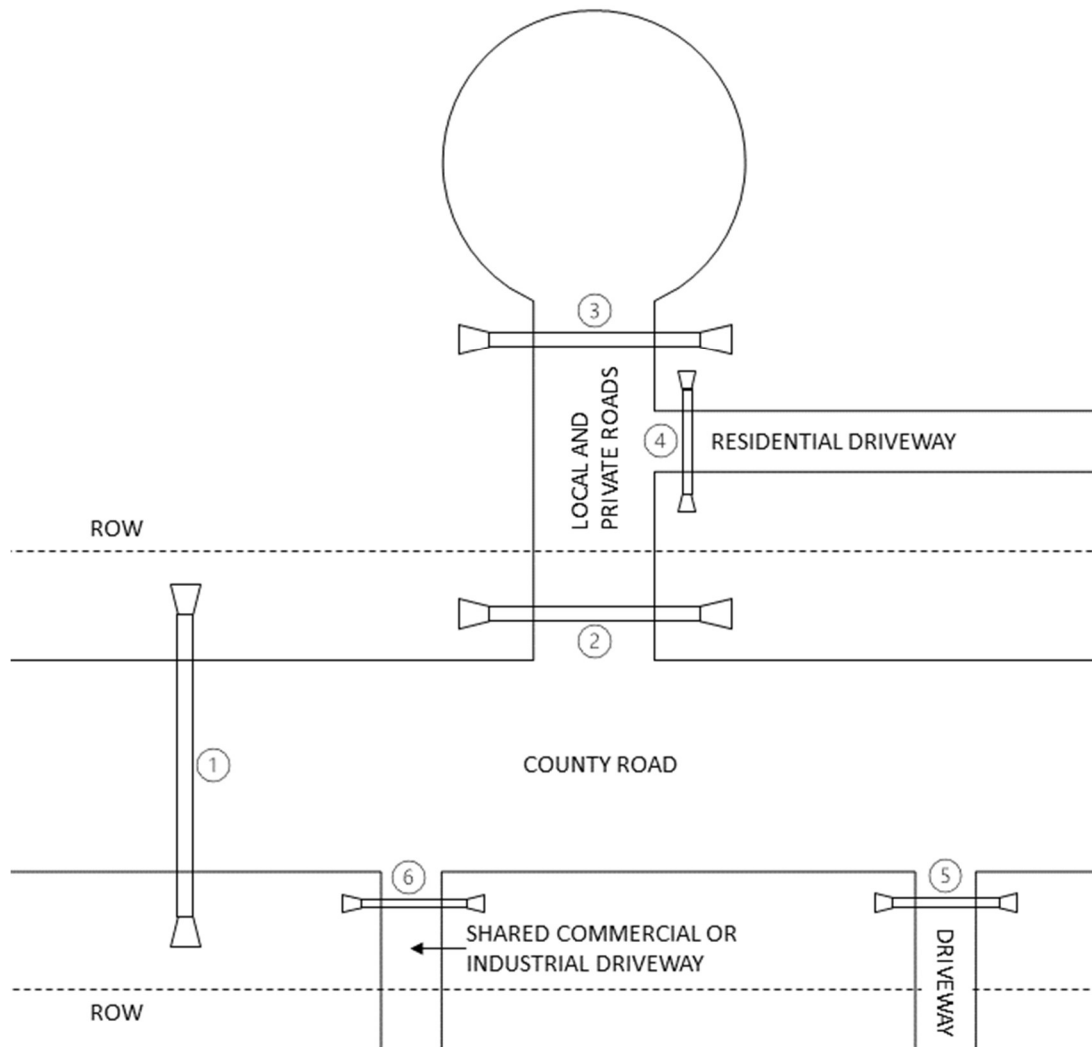


Figure 10-1. Culvert Classification Diagram

Table 10-1. Design Event, Maximum Headwater Depth and Overtopping Depth Criteria*

Culvert Classification	Road Classification/Description	Minimum Design Event	Headwater to Depth Ratio	Maximum Allowable Overtopping Depth for 100-Year Event
1	Public, Local	10-year	$H_w/D \leq 1.5$	6 inches
1	Public, Minor Collector	25-year	$H_w/D \leq 1.5$	6 inches
1	Public, Major Collector	100-year	$H_w/D \leq 1.5$	Not allowed
1	Public, Arterial	100-year	$H_w/D \leq 1.5$	Not allowed
2	Private, Local (in ROW)	10-year	$H_w/D \leq 1.5$	n/a**
3	Private, Local (not in ROW)	10-year	$H_w/D \leq 1.5$	n/a
4	Private, Driveway (Local, Private Rd Access)	10-year	$H_w/D \leq 1.5$	n/a
5	Private, Driveway (County Rd Access)	10-year	$H_w/D \leq 1.5$	n/a
6	Private, Driveway (Shared Access)	10-year	$H_w/D \leq 1.5$	n/a

*Design criteria are subject to all applicable floodplain regulations, adopted storm drainage master plans and demonstration of no adverse impacts to adjacent property.

**n/a = not applicable

10.2.3 Culvert Size and Material

Table 10-2 presents the minimum size and materials that are allowed based on the culvert classification.

If a non-circular culvert will be used, then the opening area shall be at least equivalent to the opening area of the corresponding minimum diameter circular culvert. Single-walled HDPE pipe and fiberglass end sections are prohibited. CMP should be 16-gauge or heavier and RCP should be Class 3 or above.

Table 10-2. Culvert Size and Material Requirements

Culvert Classification	Road Classification/Description	Minimum Size	Material
1	Public, Local	18"	RCP
1	Public, Minor Collector	18"	RCP
1	Public, Major Collector	18"	RCP
1	Public, Arterial	18"	RCP
2	Private, Local (in ROW)	18"	RCP
3	Private, Local (not in ROW)	18"	RCP, HDPE, CMP
4	Private, Driveway (Local, Private Rd Access)	15"	RCP, HDPE, CMP
5	Private, Driveway (County Rd Access)	15"	RCP, HDPE, CMP
6	Private, Driveway (Shared Access)	15"	RCP, HDPE, CMP

10.2.4 Inlet and Outlet Design

All culverts shall have a flared end section, headwall and/or wingwalls at both the upstream and downstream ends to protect against piping and erosion. Refer to the *Hydraulic Structures* chapter of the MHFD Manual for design guidance for these types of end treatments. Figure 10-2 provides an example end section design for a reinforced concrete circular pipe from the Colorado Department of Transportation. Flared-end sections are generally most appropriate for culverts 36 inches diameter or less.

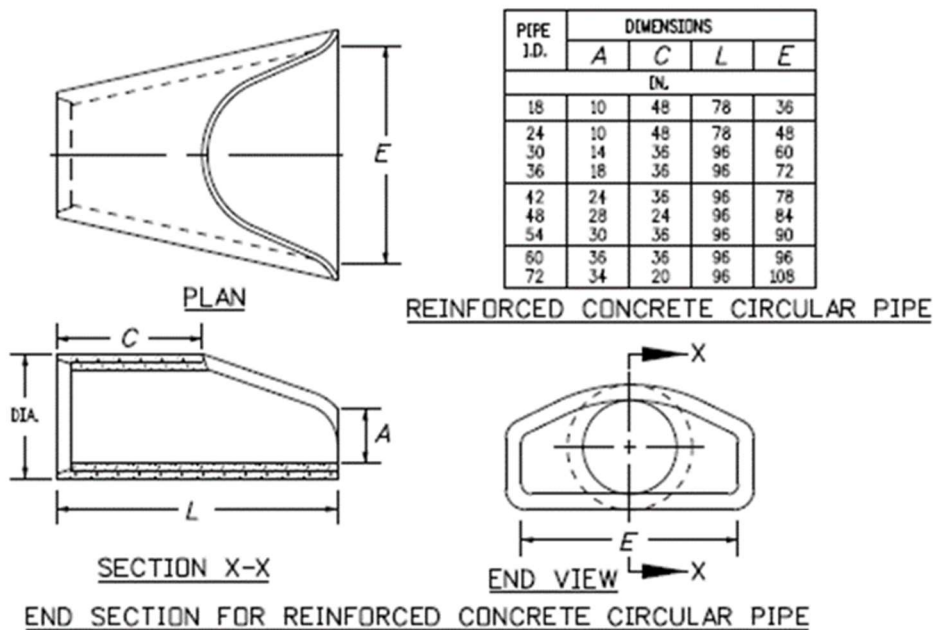


Figure 10-2. Example End Section for Reinforced Concrete Circular Pipe from CDOT Standard Plan No. M-603-10

10.2.5 Cover Depth

The cover depth above the crown of the culvert shall be a minimum of 12 inches for any culvert beneath a public roadway (e.g., Culvert Classification 1). The minimum cover depth for culverts under driveways directly accessing a County roadway shall also be 12 inches, unless otherwise allowed at the discretion of the County Engineer.

10.2.6 Velocity and Outlet Protection

Culverts shall be designed with a minimum velocity of 3 feet per second for the design flow to reduce sediment and debris accumulation. Outlet protection (typically rip-rap aprons) is required when velocities exceed 5 feet per second for the design discharge. For larger culverts a stilling basin may be required. The *Hydraulic Structures* chapter of the MHFD Manual contains design guidance for rip-rap aprons and other erosion protection measures located at culvert outlets.

10.2.7 Debris Control (Post-Fire Areas)

The engineer should consider if a new culvert may be impacted by recent wildfires in the contributing area upstream and take appropriate actions as necessary. These areas will produce higher than usual runoff rates and may also be subject to debris flows that can clog and damage culverts. The “Debris Control Structures Evaluation and Countermeasures” document from the Federal Highway Administration (FHWA, 2005) provides guidance for design of debris control structures.

10.3 Design Procedures

The engineer shall use the design procedures outlined in the *Culverts and Bridges* chapter of the MHFD Manual and/or methods presented in the “Hydraulic Design of Highway Culverts Manual” by the Federal Highway Administration (FHWA, 2012). These documents provide guidance on using capacity charts, nomographs and computer applications. The County encourages the use of either the MHFD-Culverts (formerly UD-Culverts) spreadsheet program or the FHWA HY-8 Culvert Analysis Program for computer applications. The use of other software programs for culvert design and analysis must be approved by the County Engineer.

10.4 Submittal Requirements

Submittal documents will vary based on the method and design procedures used. Capacity chart calculations may use the culvert design form provided in the *Culverts and Bridges* chapter of the MHFD Manual, or similar. All submittals shall include at least the following items:

- Headwater and tailwater depth/elevation,
- Embankment/roadway crown elevation,
- Design discharges,
- Culvert size, shape, and material,

- Inlet/outlet loss coefficients,
- Manning's n values,
- Minimum and maximum velocities,
- Printouts of inputs and outputs for all computer applications.

10.5 Permits

Culvert construction may require one or more permits from the County and other organizations. The applicant shall contact the County prior to providing any submittals to determine what permits will be required. Below is a list of some of the permits that may be required for culverts.

- Building Permit – Larimer County,
- Floodplain Development Permit – Larimer County,
- Right-of-Way Work Permit – Larimer County,
- Access Permit – Larimer County,
- Private Road Construction Permit – Larimer County,
- Development Construction Permit – Larimer County,
- Wild & Scenic Rivers – U.S. Forest Service,
- Section 404 Permit – Army Corps of Engineers,
- Native Endangered and Threatened Species – U.S. Fish and Wildlife Service,
- Water Quality Permits related to stormwater management and dewatering – Colorado Department of Public Health & Environment.

10.6 References

Bradley, J.B., Richards, D.L., and Bahner, C.D., 2005, "Debris Control Structures – Evaluation and Countermeasures", Hydraulic Engineering Circular No. 9, Third Edition, FHWA-IF-04-016, Federal Highway Administration, Washington, D.C.

Schall, J.D., Thompson, P.L., Zerges, S.M., Kilgore, R.T., and Morris, J.L., 2012, "Hydraulic Design of Highway Culverts", Hydraulic Design Series No. 5, Third Edition, FHWA-HIF-12-026, Federal Highway Administration, Washington, D.C.