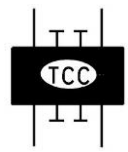
3.3.2.7 Temporary Culvert Crossing



TEMPORARY CULVERT CROSSING

Source: TDEC

Definition and Purpose

A temporary culvert crossing consists of pipes or culverts placed within a flowing stream or watercourse and covered with clean stone or riprap to provide site access for construction vehicles. As the most common type of stream crossing, culverts are cost-effective, readily available, and capable of supporting heavy equipment. They are an effective means to stream crossings without causing damage to the stream bed, channel, or banks during use; however, they may contribute to erosion during installation and removal.

Appropriate Applications

Temporary culvert crossings can be installed where construction traffic cannot be routed around a stream. Culvert crossings are an ideal measure for crossings with heavy machinery, where many crossings occur throughout the workday, and when the channel is too wide for normal bridge construction (VDEQ, 2024).

Limitations and Maintenance

Storms larger than the design event may yield significant damage to the crossing such as wash outs, blockages, overtopping, or loss of materials. Larger streams may not be suitable to have temporary culvert crossings, due to the amount of drainage area and flow that is draining to that point.

Inspect the crossing after every rainfall and at least twice a week during required inspections. Repair any damage to the crossing as soon as possible. Unstable stream banks require lining with conventional riprap or appropriate stabilization measures.

Installing temporary culvert crossings in jurisdictional waters requires additional permits, such as an ARAP, and therefore, both the conditions of the CGP permit and ARAP must be followed. A Section 404 permit from USACE may also be required. If the proposed crossing is to be completed in a TVA reservoir, a TVA 26a permit may also be necessary. Consider the criteria and conditions of the necessary permits during the planning stages of the project and EPSC plans. Temporary culvert(s) may not be permitted in streams with sensitive or endangered aquatic life. Culverts may create hydraulic jumps or fish barriers, thereby preventing passage (see example photograph) if they are not installed correctly. Temporary culverts should only be constructed when necessary as they create the greatest obstructions to flood flow and aquatic habitat (GSWCC, 2016).


Source: GSWCC (2016)

Planning and Design Considerations
The culverts used for the temporary culvert crossing can vary in shape, size, and material (GSWCC, 2016; VDEQ, 2024). The design of the temporary culvert crossing requires hydrologic and hydraulic analysis to ensure they can safely convey expected flow rates and velocities. This is necessary to compute the ideal number, diameter, and length of pipe. Include all design specifications in the EPSC plans.

There are various planning and design considerations to be aware of before constructing temporary culvert crossings. The crossings need to be protected from washout during periods of high flows. This can be achieved by diverting high flows around or over the structures. To limit disturbances and preserve the local ecosystem to the maximum extent possible, implement the following (TDOT):

- Limit the clearing or riparian vegetation as much as possible;
- During installation, divert the flowing water around the structure;
- Design the crossing perpendicular to the stream to impede flow as little as possible;
- Design the crossing to support the maximum anticipated loads such that maintenance burdens are not repeatedly observed;
- Place culverts on the streambed to minimize fish blockages and hydraulic jumps; and
- Extend the culverts at least one foot beyond the upstream and downstream toe of placed aggregate.

The culverts need to be sized to convey the peak flow from the designated design storm: either the 2-year, 24-hour, or 5-year, 24-hour, depending on the quality of the stream. Further, recurrence intervals may be different per local regulations. The minimum pipe size suggested is 18 inches (TDOT). The diameter of *circular pipes* can be computed following a reformulated version of Manning's Equation (Eqn 15):

$$D = 16 \times \left(\frac{q_p \times n}{\sqrt{S}}\right)^{3/8} \quad \text{(Eqn 15)}$$

where D is the pipe diameter (inches), q_p is the peak flow rate (cubic feet per second), n is Manning's roughness coefficient (unitless), and S is the pipe slope (feet per foot). Round the computed pipe diameter up to the next common size. Rounding up the pipe diameter changes the peak flow capacity, hydraulic radius, wetted perimeter, etc., and therefore, also the peak velocity (V_P) in the pipe.

A single culvert may result in a pipe diameter too large for the channel dimensions. In such cases, Table 3.3.2.6-A provides the equivalency of pipe capacities. For example, a 36-inch pipe has the capacity of three 24-inch pipes. When multiple culverts are desired, they should be separated by one-half the diameter of the culvert or 12 inches, whichever distance is greater.

Table 3.3.2.6-A: Number of smaller diameter culverts (top row) required to achieve the same flow capacities as larger diameter culverts (first column). Source: Wisconsin Tubing.

Diameter (in)	18	24	30	36	42	48	54
18	1						
24	2	1					
30	3	2	1				
36	5	3	2	1			
42	7	4	3	2	1		
48	10	5	3	2	2	1	
54	13	7	4	3	2	2	1
60	16	8	5	4	3	2	2
66	20	10	6	4	3	2	2
72	25	12	8	5	4	3	2
84	35	18	11	7	5	4	3

Before placement of the pipe culvert(s) and aggregate, place a geotextile fabric on the stream- bed and banks to prevent subgrade sediment migration. Ensure the geotextile covers the streambed and extends a minimum of six inches and a maximum of one foot beyond the end of the culvert and bedding material. Cover the culvert(s) with clean small, riprap, such as Class A-1, such that the depth of conventional riprap above the top of the culvert is one-half the diameter of the culvert or 18 inches, whichever is greater. Use a geotextile fabric to separate the Class A-1 riprap from No. 57 stone, which is to be used as the top six inches of the crossing. For sites that are crossing an ETW or waters with unavailable parameters for siltation, use a nine inch layer of Class A-3 riprap instead of the six inches of 57 stone. Crown the top of the culvert crossing in the center of the crossing above the channel banks and grade down to each approach. Extend the conventional riprap past the top of bank of each approach to prevent potential erosion. Ensure the top width of the crossing does not exceed 20 feet.

Provision to prevent construction road runoff from entering the stream is necessary. The preferred method for accomplishing this is to provide low approaches which will form “sag” points on either side of the stream channel (TDOT). Direct runoff into these “sag” points into erosion-resistant areas adjacent to the access road. These low approaches will also facilitate the safe passage of flood flows greater than the design flow rate. If possible, construct the “sag” points such that they are no lower than the crown of the temporary culvert. Where “sag” points cannot be constructed, low berms, six inches high with 5H:1V side slopes may be placed on either side of the channel to divert flows.

The culverts, rock, and geotextile should be removed immediately after construction is finished, and the stream- bed and banks must be stabilized and restored to pre-construction conditions.

Example Application

-Example courtesy of TDOT-

Given:

A temporary culvert crossing is to be constructed across a stream in Wilson County, TN (Type II rainfall distribution) which has the following characteristics:

- Drainage Area = 120 acres (0.1875 square miles)
- Slope of stream at site = 2.0%
- Channel bottom width = 8 feet
- The channel side slopes are 3.5 feet high at a slope of 1.5H:1V
- Runoff Curve Number CN=75 Wilson County, TN
- Time of Concentration, T_c =1 hour
- Assume no pond and swamp areas, F_p =1.

Determine:

The temporary culvert crossing design for this site and compute the required quantities.

Solution:

Step 1- Determine the design flow rate: The design flow rate should be based on the 2-Year, 24-hour storm. The Rational method may be applicable to estimate the design flow rate based on professional judgement (Chapter 2); however, the NRCS method is more appropriate. For a 2-year, 24 hour storm the rainfall depth, P = 3.64 in. Compute the various variables required in Eqn 10 from Section 2.1.3.

a.) Runoff depth, Q_{CN}, Eqns 1-3 from Section 2.1.1:

$$S = 1000 / CN - 10 = 3.33$$

$$I_a = \lambda \times S;\ \text{assume } \lambda = 0.2$$

$$I_a = 0.2 \times 3.33 = 0.667 \text{ in}$$

$$Q_{CN} = \frac{(P - I_s)^2}{P - I_a + S} = \frac{(3.64 - 0.667)^2}{3.64 - 0.667 + 3.33} = 1.4 \text{ in.}$$

b.) Unit peak discharge, q_u:

$$I_a / P = 0.667 / 3.64 = 0.183$$

$$q_u = 340 \text{ csm/in (Exhibit 4-II or 5-II, NRCS, 1986)}$$

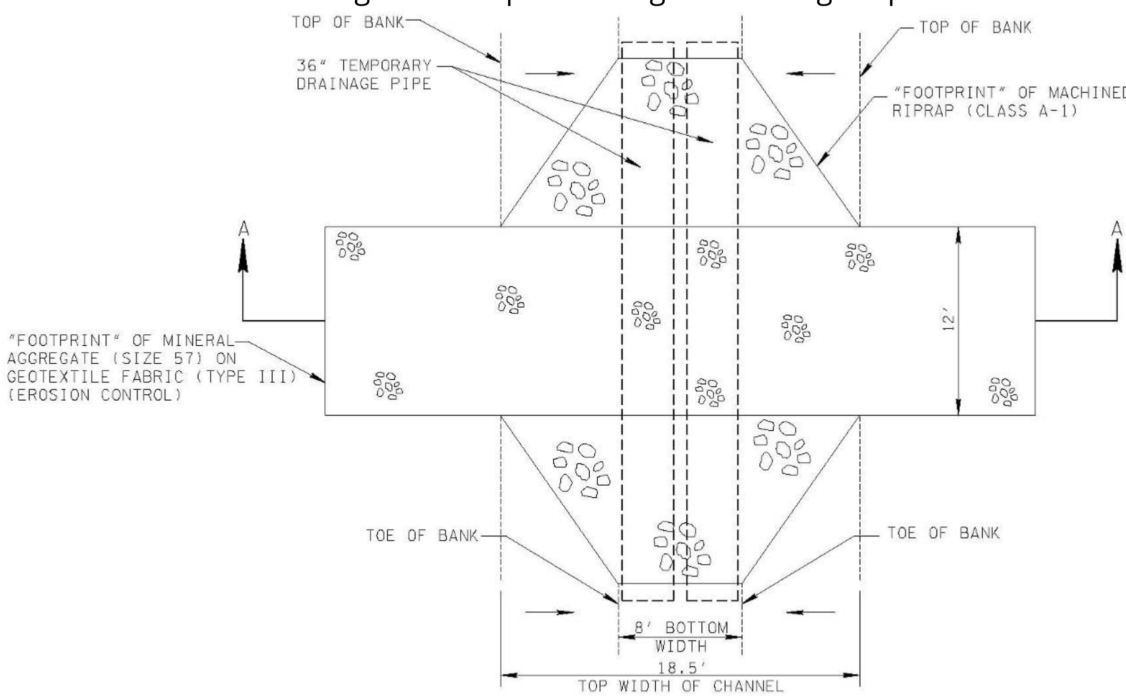
c.) Peak discharge, q_p:

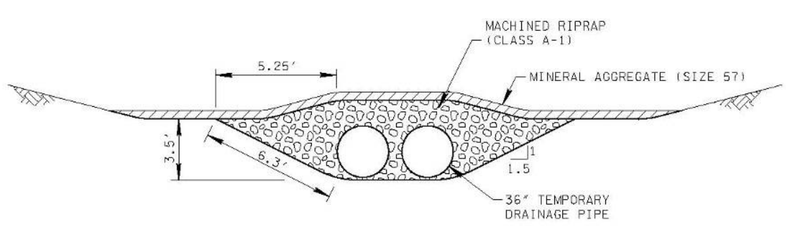
$$q_p = q_u \times A_m \times CN \times F_p = 340 \times 0.1875 \times 1.4 \times 1 = 89.3 \text{ ft}^3/\text{s}$$

Step 2- Select pipe size and number: Using Eqn 15 shown herein, the diameter pipe (assuming corrugated metal; n = 0.022) required to convey 89.3 cubic feet per second can be calculated:

$$D = 16 \times \left(\frac{q_p \times n}{\sqrt{S}}\right)^{3/8} = 16 \times \left(\frac{89.3 \times 0.022}{\sqrt{0.02}}\right)^{3/8} = 42.9 \text{ inches}$$

Thus, the smallest diameter pipe that can convey 89.3 cubic feet per second of water is 48 inches. However, as indicated on the standard drawing, this pipe would require two feet of cover in addition to six inches of mineral aggregate (size 57). Thus, the total height of this structure would be 6.5 feet, which is judged to be too large to fit into the channel height. As an alternative, twin 36-inch pipes are considered to handle the same flow rate (Table 3.3.2.6-A). The spacing between the pipes should be 1.5 feet for a total width of 7.5 feet, which can be accommodated in the channel bottom. Further, these pipes require 1.5 feet of cover, which combined with 6 inches of mineral aggregate (size 57), results in a total height of 5.0 feet. This height is judged to be a much better fit compared to the channel height, and twin 36-inch pipes are selected for the crossing. An example drawing of the design is presented.





SECTION A-A

References

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