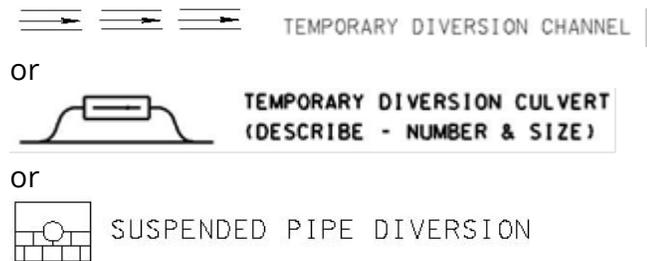




DWR – NPDES-SOP – G – 16 –Erosion Prevention and Sediment Control Handbook – 01092026
Erosion Prevention and Sediment Control Handbook

3.3.2.4 Temporary Stream Diversion



Source: TDEC

Definition and Purpose

Temporary stream diversions are implemented to redirect baseflow from active construction areas, such as bridges and culverts, allowing work to proceed in dry conditions. By isolating construction from the active flow of water, these diversions effectively minimize sedimentation and protect water quality, reducing potential environmental impacts associated with in-stream disturbances.

Appropriate Applications

Stream diversions are used where work in the stream is unavoidable and where the diversion will not cross an existing roadway where traffic is maintained (TDOT). This measure is best suited in low flow conditions. Often, a temporary stream diversion is used for smaller channels where baseflow can be entirely contained in a manmade channel or conveyed through a pipe temporarily.

Limitations and Maintenance

ALSWCC (2018) and TDOT suggest temporary diversions be constructed in drainage basins smaller than one and two square miles, respectively. Instream diversions may be better suited for larger streams (e.g., greater than one or two square miles) where conveying baseflow is more challenging.

Installing instream diversions in jurisdictional waters requires additional permits, such as an ARAP, and therefore, both the conditions of the CGP and ARAP must be followed. A Section 404 permit from USACE may also be required. If the proposed diversion is to be completed



DWR – NPDES-SOP – G – 16 –Erosion Prevention and Sediment Control Handbook – 01092026

Erosion Prevention and Sediment Control Handbook

in a TVA reservoir, a TVA 26a permit may also be necessary. Local permitting may be required in addition to state and federal permitting requirements. Consider the criteria and conditions of the necessary permits during the planning stages of the project and EPSC plans.

Inspect stream diversion channels at the end of each day to ensure flow control measures and construction material are positioned and adequately secured, thereby eliminating material waste downstream. All repairs should be made immediately. Dewatering practices used for the diversion will need to be maintained in order to function as intended (Section 4.4.12.2). Finally, stream diversion channels should be constructed such that they do not impede upstream or downstream movement of aquatic organisms whenever possible.

The maintenance for the different temporary stream diversions is type-specific:

Bypass pumps require routine maintenance to remain effective as a stream diversion. Conduct daily inspections to ensure proper pump operation, check temporary piping for leaks, and repair any damage to the impervious dike. The discharge point must be monitored for potential erosion, and flow should be confirmed as adequately diverted through the pipe. Bypass pumping may not be suitable when discharge locations cannot be stabilized, ponding to submerge the suction line is impractical, or the pump cannot handle normal flow within the stream.



Suspended pipe diversions require regular inspections of the inlet and impervious dike to confirm no damage or leakage and to confirm proper flow diversion. Regularly clear sediment and debris from behind the dike and inlet to prevent blockages. The outlet must also be checked for potential erosion and to ensure the system is functioning effectively. Additionally, the inlet should be securely anchored and sealed to maintain stability.

Piped diversions require frequent inspections for any signs of damage or malfunction. Accumulated sediment and debris must be removed from the berm and inlet to maintain unobstructed flow. Monitor the outlet for erosion potential, and any diverted flow bypassing the temporary pipe must be addressed immediately to prevent surface erosion.



DWR – NPDES-SOP – G – 16 –Erosion Prevention and Sediment Control Handbook – 01092026

Erosion Prevention and Sediment Control Handbook

Fabric-lined diversion channels require regular inspection for stability under normal flow conditions and following all rainfall events. Signs of displacement or failure must be addressed promptly. It is essential to ensure that earthen material does not come into direct contact with the water body to prevent contamination and maintain water quality.



Planning and Design Considerations

All diversions must not impede aquatic organism passage. Disturbance within the confines of stream banks is required to be conducted during dry weather or separate from flowing water. The operation of excavation equipment is not to take place in flowing waters. Minimize the duration of the instream work as well as the clearance of the stream-bed and banks. During construction, all excavated material must be stabilized and stored outside the 100-year floodplain unless otherwise authorized. Any water pumped from the worksite must be discharged through an approved sediment filtration device, such as a sediment basin (Section 4.4.7) or filter bag (Section 4.4.12.6), to prevent contamination of downstream waters. Energy dissipation measures (Section 4.3.4) must be installed at the pipe outlet to prevent scour and erosion.

Common temporary stream diversions include bypass pumping, suspended pipe diversions, piped diversions, and fabric-lined diversion channels. Diversions that use impervious dikes or berms require methods to eliminate or reduce sediment from potential stormwater entering the construction area, such as pumping stormwater from the work area to a sediment filter bag (Section 4.4.12.6). Consider placing the EPSC measure outside of the designated buffer zone or at least the minimum buffer distance required in the CGP. Regardless of the type of stream diversion chosen, ensure the dimensions of the diversion can adequately convey the bankfull capacity of the stream (ALSWCC, 2018) or the required design flow, which is specified by either the CGP or local standards.

Use bypass pumping during low-flow conditions to minimize land disturbance. This method involves using a bypass pump along with an impervious dike or berm to redirect water from an upstream section to a downstream section through controlled pumping. Since this process transfers water directly from one point to another, it is crucial to discharge at a low flow rate to prevent erosion at the outlet. Bypass pumping is most effective for short-duration construction activities that do not require prolonged water diversion. Construction specifications include:



DWR – NPDES-SOP – G – 16 –Erosion Prevention and Sediment Control Handbook – 01092026

Erosion Prevention and Sediment Control Handbook

- Set up bypass pump and hose. Place the hose outlet in such a way as to minimize erosion at the discharge site or provide temporary energy dissipation measures. Consider anchoring the pump and hose;
- Construct outlet protection if needed for the diverted water so as not to create erosion;
- Construct an impervious dike or berm upstream of the work area to impound water for the bypass pump intake. Consider using a floating intake for pumps;
- Construct an impervious dike or berm downstream to isolate the work area;
- Check the operation of the pump system. Have an operation plan in place for when the pump will be run and who will manage it if it is not automatic; and
- Upon completion of construction, stabilize the work area in the stream and then remove the impervious dikes or berms, bypass the pumping system.

Temporary pipes are used to divert the small flows around the work area without the use of pumping operations. While the cost is higher for this operation than for an open plastic-lined channel, the probability of sediment loss is much lower than with an open diversion channel. Use this practice where adequate slope and space exist between the upstream and downstream ends of the diversion. The diversion pipe material should be high-density polyethylene (HDPE) or equivalent and extend at least one foot beyond the upstream and downstream toes of the diversion to provide adequate durability. Pipes must be properly secured using sandbag plugs at both the upstream and downstream ends, ensuring that the top of the plugs extends at least as high as the natural channel banks. If elbows are used to connect the pipe to the natural stream, they must be anchored using sandbags and sealed with polyethylene sheeting to create a watertight connection. A minimum cover of 24 inches must be maintained over the pipe to protect against structural damage and ensure stability. For circular pipes, the diameter of the pipe can be calculated from a reformulation 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. Construction specifications include:

- Install a temporary pipe adjacent to the work area. Excavation may be required to provide a positive drainage slope from the upstream to the downstream side;
- Connect the downstream temporary pipe to the existing downstream channel. Place the outlet of the pipe to minimize erosion at the discharge site or provide temporary energy dissipation measures;
- Connect the upstream temporary pipe to the upstream existing channel;



DWR – NPDES-SOP – G – 16 –Erosion Prevention and Sediment Control Handbook – 01092026

Erosion Prevention and Sediment Control Handbook

- Construct an impervious dike or berm at the upstream side of the existing channel to divert the existing channel into the temporary pipe;
- Construct an impervious dike or berm at the downstream side of the bypass pipe to isolate the work area; and
- Upon completion of construction, stabilize the disturbed area, then remove the impervious dikes or berms and temporary pipe.

Use the suspended bypass pipe where an existing pipe or culvert is extended and is large enough to accommodate the bypass pipe. This bypass pipe is constructed inside the existing pipe or culvert to divert the watercourse through the construction area, thereby keeping the work area dry. Construction specifications include:

- Install a temporary pipe through the existing pipe or culvert to be extended. Place the outlet of the temporary pipe to minimize erosion at the discharge site or provide temporary energy dissipation measures;
- Construct an impervious dike or berm upstream of the work area to divert flow through the temporary pipe. Anchor and seal the temporary pipe securely at the inlet;
- Construct an impervious dike or berm at the downstream side of the bypass pipe to isolate the work area; and
- Upon completion of the culvert or pipe extension and once the work area is stabilized, remove the impervious dikes or berms and the temporary pipe.

A fabric-lined temporary diversion channel is used to divert normal stream flow and small storm events around the work area without the use of pumping operations. The temporary diversion channel is typically constructed adjacent to the work area and is stabilized by lining with a geotextile fabric (Type III) to minimize the potential for erosion within the temporary diversion channel (TDOT). Ensure the selected lining can withstand design velocities per Tables 3.3.2.1-A and 3.3.2.1-B, as well as per manufacturer specifications (ALSWCC, 2018). Geotextile linings alone may not be sufficient to prevent erosion. In cases where design velocities exceed two and a half feet per second, consider the use of conventional riprap or other structural linings in addition to geotextiles (TDOT). Use this practice where adequate space and slopes exist adjacent to the work area. Avoid creating steeper slopes than preexisting natural conditions. Consider alternative methods in summer months, as plastic linings can thermally enrich stream water. Though this is not a CGP requirement, many aquatic species in Tennessee are sensitive to thermal fluctuations. Construction specifications include:

- Excavate the diversion channel without disturbing the existing channel. Ensure the dimensions of the channel can convey the design flow. Refer to Section 3.3.2.3 to adequately size a channel;



DWR – NPDES-SOP – G – 16 –Erosion Prevention and Sediment Control Handbook – 01092026

Erosion Prevention and Sediment Control Handbook

- Place poly-fabric liner in the diversion channel with a minimum of four feet of material overlapping the channel banks. Secure the overlapped material using at least one foot of fill material. Ensure the liner and fill material can withstand the velocity of water during the design flow. Refer to Section 4.2.6.1 to adequately line a channel;
- Connect the downstream diversion channel into the downstream existing channel and secure the poly-fabric liner at the connection;
- Connect the upstream diversion channel into the upstream existing channel and secure the poly-fabric liner at the connection;
- Construct an impervious dike or berm in the existing channel at the upstream side to divert the flow into the diversion channel;
- Construct an impervious dike or berm in the existing channel at the downstream side to isolate the work area and capture any construction stormwater;
- Dewater the work area of any construction stormwater through a sediment filter bag or similar, as needed;
- Upon completion of construction and stabilization of the work area, remove the impervious dikes or berms and divert the channel back into the newly constructed reach or culvert;
- Remove the poly-fabric liner and fill in the diversion channel to the previous grade unless new elevations are shown on the plans; and
- Establish vegetation on all disturbed areas.

Upstream and downstream transition lengths should be one and one and a half times the channel width, respectively, when the ratio of the radius of curvature to channel width is greater than or equal to three. When the radius of curvature to channel width ratio is less than three, utilize Figure 4.2.3-A to determine transition lengths. When using Figure 4.2.3-A, the hydraulic radius, r , can be calculated utilizing Fang (2007), as specified in Section 2.1.2.



DWR – NPDES-SOP – G – 16 –Erosion Prevention and Sediment Control Handbook – 01092026
Erosion Prevention and Sediment Control Handbook

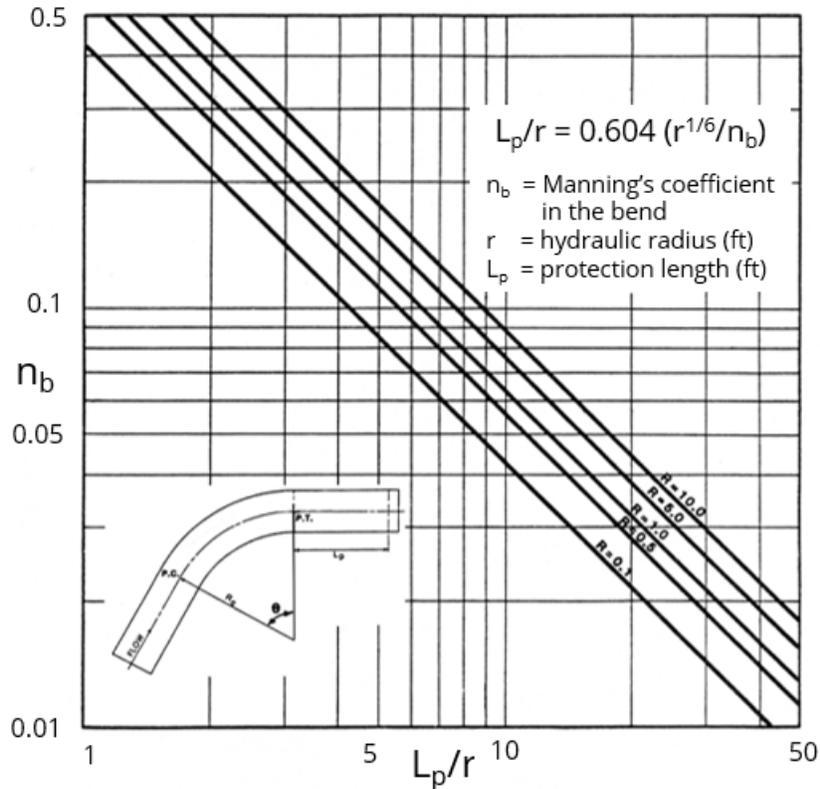


Figure 4.2.3-A: Protection Length (L_p) downstream of a channel bend, in this case, a channel transition for a diversion. Amended from: TDOT.

Example Application

For designing a fabric-lined diversion channel, refer to Section 3.3.2.3 for an example regarding the sizing of the channel and Section 4.2.6.1 for lining the channel.

-Example courtesy of TDOT-

Given:

A firm is designing a culvert replacement on an existing roadway that crosses a small stream in rural southwest Tennessee, Fayette County (CN=75). The roadway consists of two 12-foot lanes, with six-foot shoulders. The replacement structure will consist of a 12-foot × 4-foot box culvert, 100 feet long. In order to allow this project to be constructed in the dry, a temporary diversion culvert will be used. The drainage area at the site is 120 acres, with a time of concentration of 0.70 hours, and the stream slope is 0.5%. The area is Hydrologic Area 4.

Determine:

The required design and quantities for a temporary diversion culvert.



DWR – NPDES-SOP – G – 16 –Erosion Prevention and Sediment Control Handbook – 01092026
Erosion Prevention and Sediment Control Handbook

Solution:

Step 1- Determine the design flow rate: Though temporary diversions are typically designed for short-term use and not intended to convey stormflow, for the purposes of this example, it will convey stormflow. The design flow rate should be based on the 2-Year, 24-hour storm. Since the drainage area at this site is greater than 100 acres, the TR-55 Graphical Peak Discharge Method will be used (Eqn 10, Section 2.1.3). The design flow rate is computed as follows:

- 2-year, 24-hour rainfall: $P = 3.98$ in (NOAA)
- Initial abstraction: $I_a = 0.667$ in (Eqns 2 and 3, Section 2.1.1)
- Compute $I_a / P = 0.1679$
- Unit peak discharge coefficient, $q_u = 440$ csm/in (NRCS, 1986)
- Runoff depth, $Q_{CN} = 1.653$ inch (Eqn 2, Section 2.1.1)
- Assuming a ponding factor, $F_p = 1$, the peak discharge, q_p , is calculated to be 136.4 cfs (Eqn 10).

Step 2- Select the culvert size and diversion type: The smallest single (circular) pipe capable of conveying the 2-year flow rate can be calculated with Eqn 15.

$$D = 16 \times \left(\frac{q_p \times n}{\sqrt{S}} \right)^{3/8}$$
$$D = 16 \times \left(\frac{136.4 \times 0.024}{\sqrt{0.005}} \right)^{3/8} = 67.4 \text{ inches}$$
$$D = 72 \text{ inches} = 6 \text{ feet}$$

Since the site offers eight feet of clearance between the existing channel bottom and the profile grade of the roadway, there will be sufficient cover, and this size will be acceptable. Due to the diameter of the selected pipe, it is judged that the connection between the diversion culvert and the natural channel should be provided by means of excavated channel transitions, rather than by providing pipe elbows.

Step 3- Design the upstream channel transition: Based on examination of the plans, it is determined that the existing channel bottom is approximately six feet wide. Thus, the excavated channel transitions will also have a bottom width of six feet. It is also determined that the average depth of the channel transition will be four feet, with 2H:1V side slopes.

Based on inspection of the site layout, it is determined that this transition should be 30 feet long and that it should have a radius of curvature of 25 feet. Riprap erosion protection should extend past the end of the curved channel transition into the natural channel. Since the radius of curvature for this transition is more than three times the bottom width, the upstream riprap should extend 1.0 times the channel bottom width, or six feet from the end of the diversion channel. Thus, the total length of this transition will be 36 feet (refer to TDOT standards presented in Section 5.05.7



DWR – NPDES-SOP – G – 16 –Erosion Prevention and Sediment Control Handbook – 01092026

Erosion Prevention and Sediment Control Handbook

for these details). The procedure provided in Sections 3.3.2.1 – 3.3.2.3 of this manual is used to determine normal depth for the design flow rate in the natural channel. Based on a trapezoidal cross-section with a six-foot bottom width, 2H:1V side slopes, and stream slope of 0.005 ft/ft, it is found that the normal depth would be 2.86 feet, at a velocity of 4.07 feet per second. Since the velocity at the design flow rate is less than 5 fps, machined riprap Class A-1 will be suitable for this transition (Table 3.3.2.1-A).

Step 4- Design the downstream channel transition: The main portion of the proposed diversion channel will be 100 feet long in order to match the length of the proposed permanent structure. However, since the diversion channel is located on one side of the permanent structure, additional channel length will be necessary to connect the main portion of the diversion channel to the natural stream channel.

Based on inspection of the site layout, it is determined that these transitions should be 30 feet long at each end of the channel, and that they should have a radius of curvature of 25 feet. The riprap transition lining should extend past the ends of the curved transitions. Since the radius of curvature for these transitions is more than three times the bottom width of the channel, the downstream riprap should extend one and a half times the channel bottom width, or nine feet, from the end of the diversion channel. Thus, according to the specifications in TDOT Section 5.05.7, the minimum downstream length of riprap should be 39 feet. V_p , the velocity at which water is discharged from the pipe, was found to be 6.43 feet per second (using methodologies discussed in Section 4.3.4); thus, machined riprap Class B is required for this transition (Table 3.3.2.1-A). An energy dissipator (Section 4.3.4) is required at the outlet.

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