

Culvert Replacement

Cofferdam systems are the most common method for separation in-water construction sites from flowing stream. Cofferdam systems enclose a work area to reduce the transport of sediment pollution generated from construction activities beyond the work site. Typical cofferdams are installed to keep water out of the work area by blocking surface and subsurface flow both upstream and downstream of the work area. Although the area between the cofferdams is 'dewatered' or 'pumped dry,' they are typically are not completely water tight. The intent is to minimize the amount of leakage under, through and around the cofferdam. As long as the water level between the cofferdams is kept low, the water pressure from the outside of the cofferdam will ensure that dirty water does not escape the work site and reach the stream resource. Cofferdams will not be used for pile driving activities.

Cofferdams may include, but are not limited to; small sandbags, industrial, one cubic yard sandbags, jersey barriers, sheet piles, and proprietary/manufactured devices (e.g., inflatable cofferdams). Sandbag cofferdams are the most cost effective option but are generally limited to water depths less than 6 feet. Sandbag cofferdams are placed on the streambed and therefore do not block subsurface flow. A better "seal" is achieved between the sandbag cofferdam and the streambed if any large rocks are moved by hand prior to sandbag placement. If a project requires excavation of more than ~2 feet (e.g., to embed a large culvert) sheetpiles may be driven into the substrate to block subsurface flows in the channel, thereby creating a more structurally sound/safer work area. From past construction experience, MaineDOT estimates that sandbags are used 95 % of the time and sheetpiles are used 5 % of the time for crossing replacements that are less than 30 feet in width. For crossing replacements larger than 30 feet, sheet piles have been used 60 % of the time and sandbags used 40 % of the time. Greater water depths (> 6 feet) at larger crossings (e.g., large bridges) typically require the use of sheetpiles.

The following section (1-7) describes a typical cofferdam installation using an upstream sandbag cofferdam and a pump bypass or diversion channel to divert stream flow around a work site.

1. The upstream cofferdam is installed first. Thick mil poly sheeting is laid along the streambed before the sandbags are placed.
2. The excess plastic is then folded over the sandbags in the upstream direction and another layer of sandbags is placed on the plastic to help seal the dam from infiltration. The plastic is then extended along the stream bottom as far upstream as practicable to increase the flow length of the subsurface flow. This helps prevent flow from going beneath the sandbag cofferdam.
3. When industrial sandbags are used, additional small sandbags may be placed in between the large sandbags to help seal the work area.
4. Once the upstream cofferdam is secured, the contractor will begin diverting upstream flows around the cofferdam area using a bypass pump. This water will be discharged directly into the stream channel below the downstream cofferdam. At the outlet of the pumps, high velocity (>5 fps) water is being discharged back into the stream. This water has the potential to erode the stream substrate and cause a turbidity release. The contractor will implement scour prevention measures at the discharge site to reduce energy at the point of discharge and prevent elevated turbidity levels.

5. The downstream cofferdam will then be installed in the same manner as the upstream cofferdam. The downstream cofferdam acts as a safeguard against a failure of the upstream cofferdam and to control downstream backwater situations.
6. Once both cofferdams have been installed, the contractor will begin to dewater the area between the cofferdams. If the water is turbid from disturbance caused by installation of the cofferdams, the water will be pumped to a temporary sediment basin to allow filtration to occur. If the water inside of the cofferdam visually appears to be as turbid as the water flowing into the upstream cofferdam it will be pumped to downstream of the downstream cofferdam.
7. The inside of the cofferdam is then dewatered using pumps to create a “dry” work area. This process is explained in detail below.
8. Most cofferdams leak to a small degree, so a pump will be placed in the work area to catch and evacuate accumulating water to the “Dirty Water” Treatment System



A dewatered work area with a small pump to maintain the dry work area.

At crossing replacements with deep scour pools on the downstream side of a culvert, the cofferdam will typically be placed at the downstream end of the scour pool to ensure the water can be properly controlled on the site. Attempting to install a cofferdam in deep scour pool can be problematic due to cofferdam leakage and increased water pressure exerted by the deep

water. The downstream pool will be dewatered to a depth that allows fish evacuation if required.

If the contractor chooses a sheet pile cofferdam, sheets will be driven in pairs across the stream to block flow. Each sheet, approximately 24 inches wide, will be driven into the substrate adjacent to the shoreline to ensure the flow of water is sealed off from the construction site. The length of the sheet piles used will vary based on soil conditions, presence of rocks or ledge, and water depths. The sheets will need to be driven deep enough to cut off subsurface flow while still being tall enough to isolate the work area. Sheet piles are normally installed with a vibratory hammer. The process of cofferdam installation and water control with sheet pile mirrors the process described for sandbags. The only different being poly sheeting is not placed on the stream bottom for a seal since the subsurface flow length is increased vertically from the sheet piles rather than horizontally from the poly sheeting. Small sandbags may still be placed outside of the sheet piles to help seal water flow from entering the work area.

Dewatering

As discussed above, the work area will be dewatered to allow construction work to occur “in the dry”. Water inside of a newly constructed cofferdam system is often turbid. Because streamflow is cut off by the cofferdams and pumped around the work site, very fine-grained sediments tend to stay in suspension for periods of time greater than 4 hours. In order to dewater the work area, this turbid water is pumped to a temporary sediment basin BMP that will filter much of the suspended sediments out of the water and allow the water to flow through a vegetated buffer prior to entering the stream.

Temporary Sediment Basin

After the cofferdams have been installed, it is necessary to dewater the work area. This water is then pumped into a temporary sediment basin for filtration.

1. The temporary sediment basin will be installed according to MaineDOT’s Best Management Practices (BMP) Manual (2008).
2. The sediment basin will be comprised of hay bales and non-woven Geotextile filter fabric. Filter fabric is used to line the inside of the hay bale basin to filter sediment. Sediments accumulated inside the basin will be disposed of at a location away from the stream to prevent future erosion and transport of the sediments back into the stream.
3. Proprietary products such as ‘dirt bags’ can also be used. A ‘dirt bag’ is a large bag made of filter fabric that will filter turbid water in a way similar to the sediment basin.
4. The sedimentation basin will be located close to the work site with adequate vegetation between it and the stream to provide additional filtration.
5. Pumping dirty water to the sediment basin:

- a. Hoses will be setup between the sediment basin and the work area between the cofferdams to be dewatered.
 - b. The “dirty water” pump(s) will then be started and the water will be pumped to the sediment basin.
6. Once fish are evacuated from the work area, it will be pumped as dry as possible.
 7. If there is leakage around the cofferdam or upwelling in the work area, pockets will be excavated in the work area to collect the water. This water will be pumped into the sediment basin for filtration, prior to its release back into the stream. Clean crushed stone is often placed around this pump intake to further minimize suspended sediments from being pumped in the sediment basin.



Hay bales and geotextile fabric used as part of a dirty water treatment system.

Types of Cofferdams

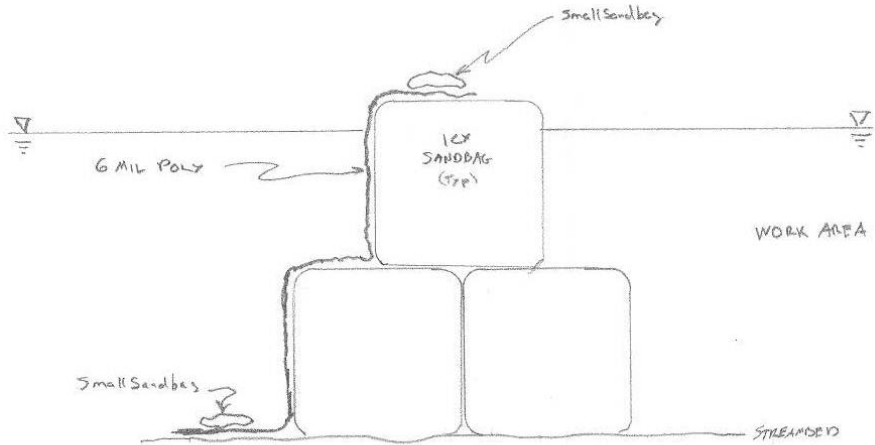
Industrial Sandbags

The contractor may use industrial sandbags for all or some portion of a cofferdam system (see below). These are large, 1-cubic yard capacity sandbags made of a heavy poly material and are effective at stopping water flow. Each bag is filled with sand and then lowered in place with heavy equipment. A sheet of plastic is often incorporated under and in front of the sandbag enclosure to aid in sealing and to prevent leakage. Industrial sandbags may be stacked on top of one another where water depths are greater and/or when greater stability is needed to hold back deeper water.



Placement of plastic sheeting under sandbag cofferdam.

SANDBAG COFFERDAM



Detail of typical sandbag cofferdam using industrial-sized sandbags. Water flow is moving left to right in the drawing above. The area labeled 'Work Area' will be dewatered.

Jersey Barrier Cofferdams

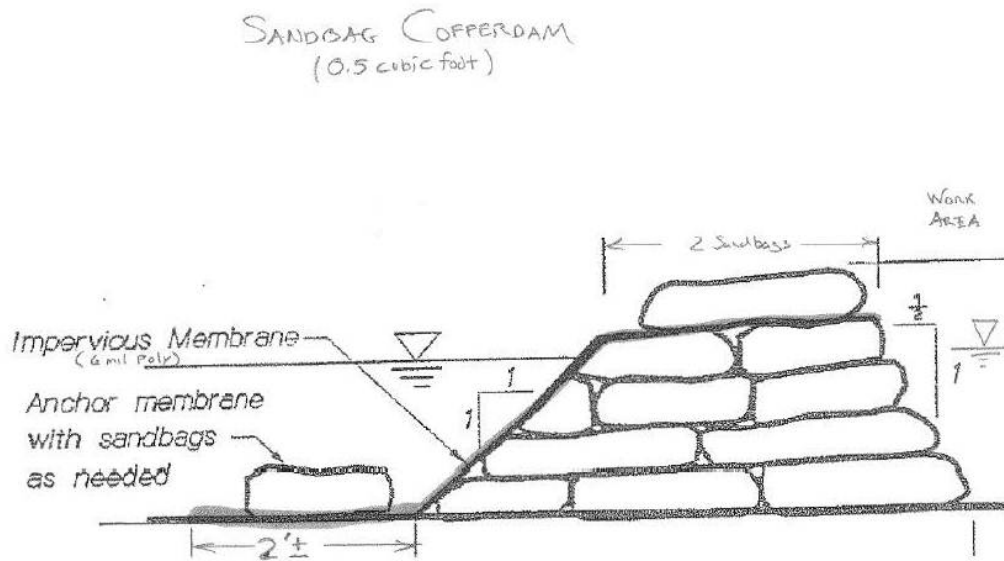
In some instances, jersey barriers are used as the structure element of the cofferdam. They are lined with plastic to create a seal.



Cofferdam made of sandbags and jersey barriers draped with plastic sheeting. Pump intake in the photo is maintaining water levels in the work area.



Cofferdam made of industrial sandbags. Bypass pump intake upstream of the cofferdam.



Detail of sandbag cofferdam using small sandbags. Water flow is moving left to right in the drawing above. The area labeled 'Work Area' will be dewatered.



Example of a cofferdam constructed of small sandbags.

Sheetpiles

Sheet piles are used as an earth retention and excavation support technique that retains soil and reduces groundwater inflow using steel sheet sections with interlocking edges. Sheet pile retaining walls are typically used in soft soils and tight spaces. Sheet pile walls are made out of steel which is driven into the ground. Sheet piles is usually driven $\frac{2}{3}$ of their length into the ground, with $\frac{1}{3}$ extending above ground, but this may be altered depending on the environment and substrate at the project site.



Sheet pile used as a cofferdam (upstream of work area).



Sheet pile used as a cofferdam (upstream of work area).

Maintenance of water flow

Stream flow must be maintained at all times in the downstream reaches of the stream below the project. Not only is this important to downstream aquatic biota, but it is necessary for construction as water flow that is blocked will eventually over top cofferdams and cause damage to the work area and surrounding property. A pump diversion and a bypass channel are the two different techniques that MaineDOT used to maintain water flow. Pump diversions are the most common method used to maintain downstream flow and are utilized on ~90 % of small stream crossing replacement projects. Bypass channels are limited by the topography of the site. If the channel has steeply sloping banks and surrounding topography, it is challenging to dig a channel down to an elevation to match the existing stream. Also, bypass channels must be design to allow continued traffic flow during the project.

Stream Diversion

Stream diversion is the process of maintaining stream flow at a work site using pumps and hoses or bypass channels. MaineDOT provides the contractor with stream flow data so that adequate diversion pump capacity will be available to convey expected stream flows during the proposed construction period (typically the in-stream work window; July 15-September 30). Steps in the stream diversion process are described below:

1. Prior to in-stream work, a temporary culvert will be placed under the road and away from the stream to house a diversion hose that convey stream flow. The temporary culvert protects the diversion hose during the construction activities and also allows traffic flow to continue (unless there is a traffic detour). Another common way of doing this is by running the diversion hose over the road and using wood blocks to protect the hose from traffic.
2. The intake hose will be placed just above the upstream cofferdam. To minimize impact on the streambed, the end of the hose is placed in a bucket and/or the stream bottom will be lined with geotextile fabric. A screen is often placed at the hose intake to prevent injury to fish and entrapment within the work area.
3. The gasoline diversion pumps will be setup as far away from the stream as possible to prevent the risk of contamination of the waterbody. The pump systems are contained and generally pose little to no risk of contamination. The number and size of pumps used varies depending on the volume of stream flow at the time work is being conducted.
4. Non-woven geotextile fabric or plastic sheeting will be laid along the streambed at the discharge point of the diversion hose (downstream of the work site) to protect the streambed from scour caused by the high velocity flow.



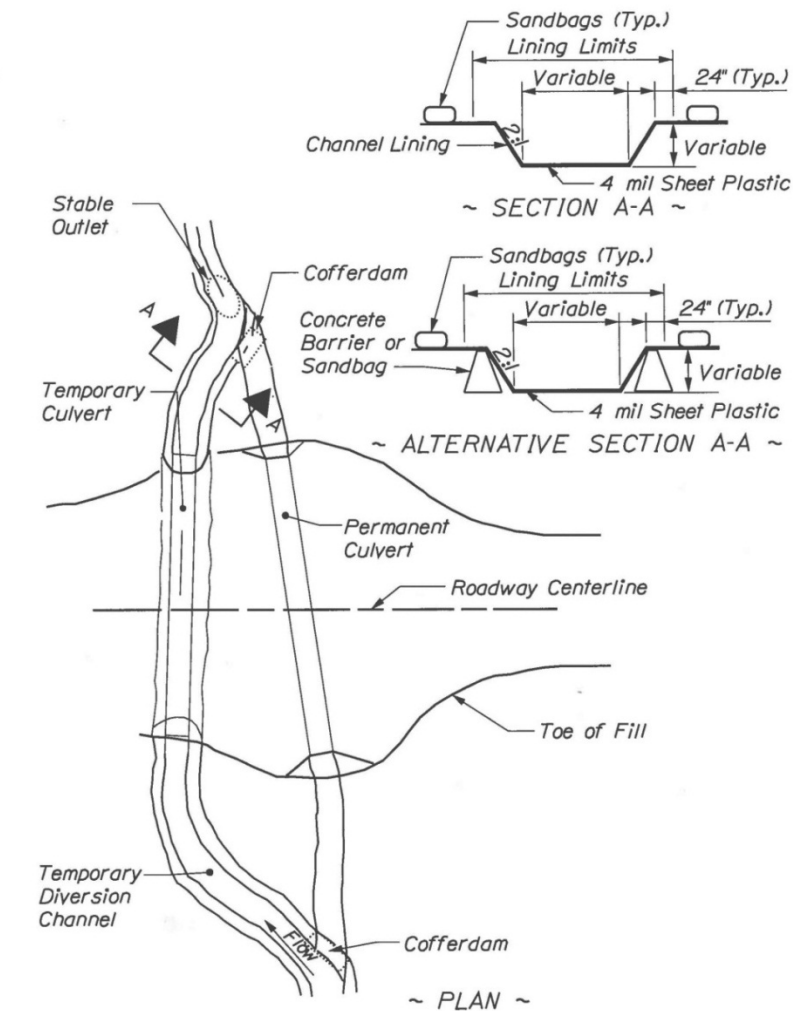
Poly and Hay Bales used for a pump outlet or the outlet of a bypass channel

Temporary Stream Diversion or Bypass Channel

A temporary stream diversion or bypass channel is used for large streams or small rivers where neither pump nor hose diversions are practical and the road is closed to traffic for the duration of construction. The typical process used to divert flow through a temporary culvert or bypass channel installed next to a stream is described below. MaineDOT provides the contractor with stream flow data so the size and capacity of the temporary culvert or bypass channel can accommodate the expected stream flows during the construction period.

1. The contractor will dig a trench directly adjacent to the crossing structure to be replaced. The inlet and outlet of the trench is left intact (or blocked) so water flow is only allowed in the bypass channel after its construction is mostly complete.
2. The bypass channel allows water to flow continuously and provide passage for aquatic organisms. The elevation of the bypass channel is set to ensure water can freely flow around the work area during construction.

- The channel is lined with a poly material to ensure that erosion of soils from the bed of the constructed channel is minimized. The poly material is weighted down by sand bags or other inert materials to hold it in place. It is layered from the upstream to downstream direction to ensure that water flow does not lift the material and allow for soil erosion.



REF: Best Management Practice for Erosion and Sedimentation Control -
Temporary Stream Diversion

TEMPORARY STREAM DIVERSION
802(14)

Typical layout and cross-section of a bypass channel used for temporary stream diversion.

After the bypass channel is constructed and the stream diverted around the work area, the work area between the cofferdams will be dewatered. This water will be pumped into a temporary sediment basin for filtration.

Crossing Replacement

Once the stream flow is diverted and the work area is dewatered, the crossing removal and installation process can commence. At this point, the crews are working within the contained work area and there is no sediment being released into the stream. All pumps, hoses, dams, and the sediment basin are monitored closely and maintained throughout the construction period. The old culvert will be removed and the new one replaced in the dry. When the culvert and riprap installation is complete, all headwalls, disturbed areas, and permanent drainage ditches are stabilized with final treatments, utilizing temporary erosion control BMPs as necessary.

Construction Sequence

A stream-crossing replacement project will follow the process explained below, which includes a typical cofferdam installation) and structure replacement process. The photos below illustrate some of the scenarios for replacing crossing structures.

1. Remove the old crossing structure.
2. Excavate and place fill for the foundation of new crossing structure.
3. Construct/install new crossing structure.
4. Construct riprap scour pads at the ends (inlet and outlet) of the new culvert crossing. (Only if necessary)
5. Place backfill into the new structure and over rip rap scour pads.
6. Wash fine sediment material into new backfill to ensure water flow remains on top of the newly placed stream substrate.
7. Stop pumps, restore flow, and then remove cofferdams.



Concrete box culvert being set.



Crossing structure being 'bedded'.



Concrete box structure being backfilled and receiving bedload.

Project Completion

Once construction is complete, contractors will remove the entire cofferdam and concrete seal. The cofferdam will slowly fill with water by either turning off the maintenance pump or by removing a portion of one pair of sheets. Sheet piles are typically driven to a depth greater than 25 feet, requiring a vibratory extractor to remove the sheet piles. Once the cofferdam is breached and flooded, remaining sheet piles and bracing are removed. In rare instances, construction plans will include cutting the cofferdam sheet piles to a specific elevation and leaving in-place to aid in scour reduction or to minimize ice damage to abutments or piers.

Cofferdam Removal

After all work that requires isolation from the stream environment is complete, the cofferdam can be removed to restore stream flow through the structure. Cofferdams that are placed across the entire stream are removed as followed.

1. The diversion pump system will be stopped and the upstream cofferdam will slowly be breached. The first flush of dirty water will be captured by the downstream “dirty water” pump, which will then pump the water into the sediment treatment system.
2. When the water behind the remaining intact cofferdam is visually similar, that dam will be breached as well.
3. The remainder of the upstream cofferdam and the diversion pump system will then be removed.
4. Sandbag cofferdams will be removed by hand, if they are small, or by an excavator working from the stream banks if they are the large industrial-sized sandbags.

Post Construction Site Stabilization

Once water flow is restored to the area inside of the new culvert or bridge and the in-water portion of stream crossing replacement is complete, restoration of the construction site will begin. The contractor will complete final stabilization treatments, restoration of any temporary work areas, and rebuild the roadway on top of the new crossing structure.

Final stabilization treatments

Some final stabilization treatments are part of the design completed by the contractor, and others are reviewed as part of the SEWPCP plan.

Rip rap is used to stabilize areas steeper than 2:1 where long term slope stability is necessary.

Vegetated slope stabilization is implemented on slopes that are more gradual (shallower) than 2:1. This includes placement of a seed mix that will allow for rapid growth and stabilization as well as plants that have substantial root systems for stabilization that take longer periods to be established.