Private Bridges, Culverts and Low Water Crossings

MITIGATION IDEAS
Some Considerations Before You Build or Rebuild

Region III

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Table of Contents

I. Disclaimer

II. Introduction

III. Obtaining a Permit

IV. Water Crossings

V. Bridges

VI. Culverts

VII. Low Water Crossings

VIII. Examples

IX. Definitions
I. Disclaimer

The designs in this booklet address the necessity for careful consideration of a number of issues to gain or regain, and to maintain, safe ingress and egress over water bodies utilizing private crossings.

Because each land and water site is unique, and the type of materials and the quality of construction will vary, mechanisms must be customized to each location, it is not possible or desirable to attempt to present or address all considerations. FEMA therefore does not warrant the completeness, inclusiveness or comprehensiveness of the discussion that follows.

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II. Introduction

It is imperative that all watercourse crossings, including bridges, low water crossings and culverts be properly designed and constructed to perform safely and adequately under varying natural conditions. Any watercourse crossing has the potential to alter or disrupt the waterway characteristics from the low to high flow conditions. Improper installations can result in extensive loss and damage to public and private property, danger to human life, as well as damage to the environment as a result of flooding, erosion and washouts. Maintaining the overall integrity of the waterway is of the utmost importance.

In selecting or evaluating a crossing site, the characteristics listed below should be considered. The chosen location should enable construction of a crossing that is economical to both construct and maintain.

Waterway crossing sites should be selected using the following criteria:

- Where there are fairly level and sufficiently long approaches with gentle grades
- Where there are firm and stable soil conditions
- Where the crossing will be at right angles to the waterway
- At a site of relatively shallow water depth and low velocity during floods
- Away from fish spawning areas, water intakes and lake outlet sites
- Where a minimum of scouring and sediment displacement will occur
- With adequate space for entering the public highway at right angles
Construction should be performed during dry weather and not prolonged. This will minimize risks to both the project and the environment. Installation should not be done in frozen ground.

Structural design should be based on maximum anticipated water depth and velocity in addition to the intended use of the crossing. Longer and higher bridges are often more economical because they will sustain less damage in future flood events.

The actual design and installation of the crossing needs to be coordinated with all persons who may be involved in the project: owner, engineer, contractor and governing agencies (local, state and federal).

III. Obtaining a Permit

All construction of waterway crossings require permits from at least one if not multiple local, state and federal agencies before any work can begin. Permits may also be required for any or all of the following: alterations, enlargements, repairs, maintenance and removal of bridges, culverts or low water crossings. No matter where you live, there exists some form of permitting process required for any watercourse encroachment or alteration. Very often a local Soil Conservation District Agency works along with the United States Army Corps of Engineers, Federal and State Clean Water Act representatives, Department of Natural Resources, Environmental Protection Agency, United States Fish and Wildlife Service, State Division of Highways and a local Floodplain Administrator.

Assurances or verification must be given to the Floodplain Manager that the flood carrying capacity within the altered area of the stream in question will be maintained. If hydrologic and hydraulic analyses are required, qualified personnel shall perform them.

Building techniques that may be required to present a “best practice” in the construction of a bridge, culvert or low water crossing may include: wing walls, trash grates and the sizing of openings to carry anticipated future increases in flood heights.

The design or redesign and the actual construction of a waterway crossing are separate parts of the total project often handled by different persons. If so, it is important that installation procedures are considered during the design phase of the crossing. Communication and coordination between designer, builder and regulating agencies is necessary to achieve a quality-finished product with a minimum of environmental alterations and a minimal amount of time spent in the actual water channel.

The builder usually is responsible for obtaining the necessary permits and ensuring the day-to-day construction practices follow all local, state and federal regulations, specifications and guidelines. Each waterway crossing is unique and requires well-planned construction methods.

Failure to follow the local permitting process and obtaining approval from all authorities having jurisdiction can result in a delay of your installation or an order to stop construction and formal enforcement actions, including financial penalties.
IV. Water Crossings

This manual places crossings in three categories: bridges, culverts and low water crossings. Specific information about each follows.

While culvert installations and some low water crossings alter natural flow, it is preferred that watercourse crossings be appropriately designed to minimize the disturbance of streambeds and flow velocities. If designed and constructed properly, bridges are preferred to culverts and low water crossings.

V. Bridges

Quality designed and constructed bridges can maintain the original natural watercourse channel bed without any alteration or disturbance. Other types of structures tend to restrict and obstruct the normal and above normal flow of the waterway. Clear-span bridges do not require infilling or restrict the area of water flow as culverts or multi-span bridges do. Bridges also reduce or eliminate channel disturbance during construction.

Bridges provide better capacity to accommodate high flows while creating better inlet and outlet conditions that allow debris to pass through without blockage.

Flood damage to bridges includes floodwaters overwhelming the deck and superstructure as a result of inadequate attention paid to the hydraulic capacity of the bridge, erosion as well as damage from the impact and accumulation of debris.
Design considerations for bridges should include:

- Span the entire water channel without altering the water banks or bed and having the abutments or piers encroaching into the channel.

BRIDGE PIER IN CHANNEL CREATES SCOURING AND DEBRIS CATCH

BRIDGE ABUTMENTS ENCROACHING INTO THE STREAM
• Adequately handle storm water runoff from the roadway.
• Utilize a ‘perched’ bridge design with low roadway approaches to sacrifice the roadway and save the bridge under severe flood conditions.

PERCHED BRIDGE AND LOW WATER CROSSING

• Install wing walls to direct the water flow into the bridge opening to eliminate potential erosion.
LACK OF WING WALLS AND A SHORT BRIDGE SPAN CAUSED LOSS OF BRIDGE APPROACH DURING HIGH WATER

- Avoid the direct contact of uncured concrete and pentachlorophenol-treated wood with the water to avoid the toxic reaction to aquatic life.
- Handrails or guardrails should be installed where necessary.

BRIDGE WITH HANDRAILS AND UNOBSSTRUCTED WATER FLOW
BRIDGE WITH A SHORT APPROACH CREATES LACK OF SPACE FOR A LONGER BRIDGE SPAN AND CAUSES ABUTMENT ENCROACHMENT

- Stabilize the disturbed areas with native vegetation whenever possible vs. using structural solutions: bulkheads, riprap and other structural solutions.

The bridge design below has been successfully used where the stream banks are firm enough to prevent erosion and support the abutments. No concrete is needed. The stringers are welded to the steel abutment members that sit directly on the soil.
VI. Culverts

Culverts can be used for a watercourse crossing where the installation of a bridge is not feasible and the impact on fish and other aquatic life is minimal. Culverts are appropriately used for access across drainage ditches, intermittent streams and small waterways. Culverts often fail to accommodate high water flows. This results in washouts, erosion and flow blockage by debris buildup.

Commonly available culverts are made of corrugated steel, polyethylene or reinforced concrete. Multiple culverts are not recommended due to the trapping of debris. If a waterway is too wide or large for a single culvert, then the design should be changed to a bridge. To correctly install gang culverts, a thorough hydraulic and hydrologic analysis is needed. A minimum distance of 2 feet is needed between culverts and infill must be properly compacted. This fill must be protected from washing out by installing an end wall or armoring at the inlet and outlet areas. A debris guard is also needed.

The culvert must have a large enough opening to handle peak runoff. Ideally, a properly designed culvert’s simulated bed will reflect the natural streambed where water flow conditions inside the culvert are much like the conditions at the upstream and downstream sites of the crossing.
Design considerations for culverts should include:

- Wing walls may be used to aid in directing the flow of water at the outlet and directly into the inlet to help prevent erosion.

- The culvert must provide for proper road width and side slopes.
- Headwalls can prevent washouts at steep slopes and unstable fill sites.
HEADWALL AT CULVERT INLET

- Install the culvert so that the existing waterway slope/gradient is not changed.
- The culvert should be aligned with the waterway, with no changes in water flow direction at the upstream or downstream area of the crossing.
- Culverts should never be installed with bends in them.
- Recess the bottom of the culvert to a depth at least 12 inches below the existing streambed or to the projected scour depth of the natural channel.

HEADWALLS NEEDED, FLOW RESTRICTED AND INSUFFICIENT COVER
• When a debris barrier/ trash grate is used to catch debris, the grate should be installed with a low incline to prevent floating debris from being held against the grate by the flow. This can cause washouts.
• Culverts should be inspected after heavy rainstorms and flood events.
• Height restrictions may require the use of a horizontally elongated culvert, which result in better low flow characteristics.

VII. Low Water Crossings

Low water crossings have limited application due to continued disturbance of the streambed and frequent inundation. Do not use a low water crossing to serve occupied dwellings where no alternate emergency access is available. They are more suitable for low volume roads with no inhabitable dwellings where the normal volume of water flow is relatively low.

The more stable the streambed and banks are with bedrock and the lower the existing bank slopes and grades are, the more suitable the site is for a low water crossing. Approach grades should be less than 10%. Sites that consist mostly of sand and/or silt are not appropriate for fording.

Two types of low water crossings are the unvented ford and the vented ford.

Unvented fords are constructed of riprap, gabions, or concrete to provide a stream crossing without the use of pipes where streams are dry most of the year and crossing use is temporary. Water depth flow over an unvented ford should not exceed 6 inches.

Vented fords use pipes under the crossing to allow low flows to pass through without regularly passing over the crossing. The pipes or small culverts may be placed in aggregate, riprap, gabions or concrete.
Low water crossings can be useful for infrequently crossed waterways that experience flash floods, since it would be uneconomical to construct a bridge or culvert. Debris problems and other maintenance are minimized. Proper signs should be used warning of the dangers of high water.

IX. Definitions

**Abutment**: Support structure that supports the end of a span.

**Aquatic Life**: All forms of living things found in water, ranging from bacteria to fish and rooted plants. Insect larva and zooplankton are also included.

**Armoring**: A facing layer (protective cover), or riprap, consisting of very large stones placed to prevent erosion or the sloughing off of an embankment.

**Best Practice**: The optimum construction method put into practice at a particular place and time.

**Bridge**: A watercourse crossing that can maintain the original natural watercourse channel bed without any alteration or disturbance. This crossing structure is built so that people can get from one side to the other.
**Conduit:** Any pipe, tube, or drain tile through which water is conveyed.

**Conveyance:** Floodwater carrying capacity in a passage area of a watercourse.

**Culvert:** A closed conduit, which allows water to pass through a roadway prism.

**Debris:** Any material including floating woody materials and other trash, suspended sediment, or bed load moved by a flowing stream.

**Filter fabric:** Geotextile erosion fabric used to cover and stabilize topsoil for use with riprap and ground cover.

**Floodwaters:** Water flows that have risen above the stream bank and flow over adjoining lands.

**Headwall:** A wall at the end of a drainage structure designed to prevent erosion of the embankment at its entrance or outlet.

**Infilling:** Soil, rock, gravel or a combination placed in a depression or ditch to fill the void. Used in conjunction with a culvert.

**Low water crossing:** A fording site of a waterway.

**Perched bridge:** Style of bridge elevated or raised at both ends to avoid floodwaters and create low roadway approaches.

**Pier:** A vertical structure (column or pile), which supports the ends of a multi-span superstructure at a location between abutments.

**Piping:** Washing out or erosion between and around culverts.

**Riprap:** Rock placed on embankment slopes to prevent erosion.

**Sediment:** Stone, gravel or cobbles that originate from the weathering of rocks and is transported by, suspended in, or deposited by water.

**Scour:** The result of an erosive action of flowing water in waterways, excavating and carrying away material from the bed and banks.

**Trash Grate:** A debris guard or screen placed at the upstream entrance of a culvert, which stops heavy floating debris away from the culvert entrance during high velocity flow.

**Watercourse:** Any natural or artificial channel through which water flows; a lake, river, creek, stream, wash, arroyo, channel or other topographic feature on or over which waters flow at least periodically.

**Wing wall:** The sidewalls of a structure (bridges and culverts) used to prevent sloughing of banks or channels and to direct and confine the flow.