

Guidance for Repair, Replacement, and Clean-up of structures in Streams and Waterways of Puerto Rico and US Virgin Islands

In Puerto Rico (PR) and US Virgin Islands (USVI), flooding caused by heavy rainfall events, tropical storms, and hurricanes can damage stream crossings (bridges, culverts, low-water crossings, etc.) and in-stream structures (piers, docks, etc.), and create debris jams. Many streams in PR and USVI support an array of aquatic species, including anadromous and catadromous native fish and a suite of native shrimp. Repair and clean-up activities in streams have the potential to adversely affect these species and their habitat, causing sedimentation in areas downstream of the project and disruption of sediment transport leading to channel instability.

This guidance applies to repair, replacement, and clean-up projects related to storm damage or natural processes. The guidance applies to creeks, rivers, and tidally-influenced waters in PR and USVI. All projects in aquatic habitats should be considered with the following conditions below.

General Guidance for Road Crossing Structures:

Road-Stream Crossing Removal and Associated Channel Restoration

If a temporary crossing structure will be removed, the affected area should be restored to a natural state. Following structure removal, the stream channel should be reconstructed to match natural bankfull (i.e., channel shape from effective discharge or channel forming discharge [Figure 1]) width, channel slope and active floodplain dimensions, which exist upstream and downstream of the structure being removed. This activity should occur to restore physical and biological aquatic habitat connectivity, most notably, passage for aquatic and terrestrial organisms.

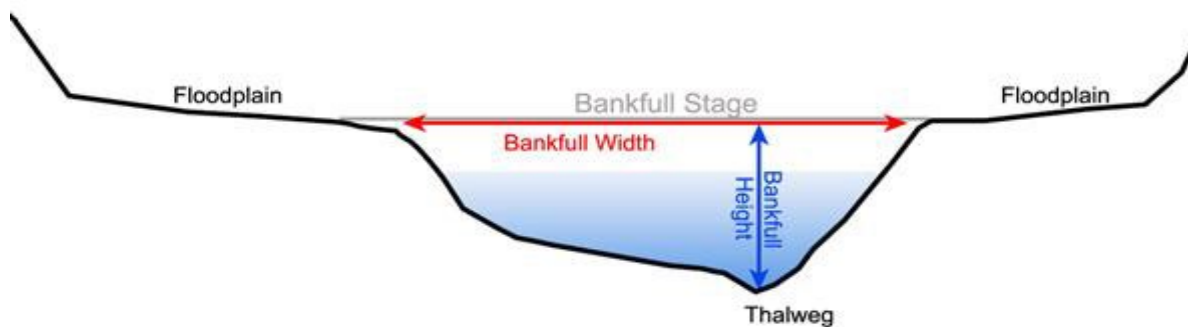


Figure 1. Bankfull Cross Section.

Road-Stream Crossing Replacement Structure

Replacement with a culvert or open-bottomed structure. Culvert refers to a variety of closed-bottomed metal and concrete structures. Open-bottomed structures include arches, three-sided boxes and bridges. Structure widths should be at least 1.2 times bankfull width with stable bank rocks on both sides. Structures should be constructed in a manner that accommodates 100-year flows, (Figures 2 and 3) and allows for natural stream processes including sediment and woody debris transport to the greatest degree possible given the structure dimensions. Flood relief culverts (Figure 4) on unconfined floodplains may be used. Crossings with large unconfined floodplains may require additional capacity or may include floodplain relief structures.

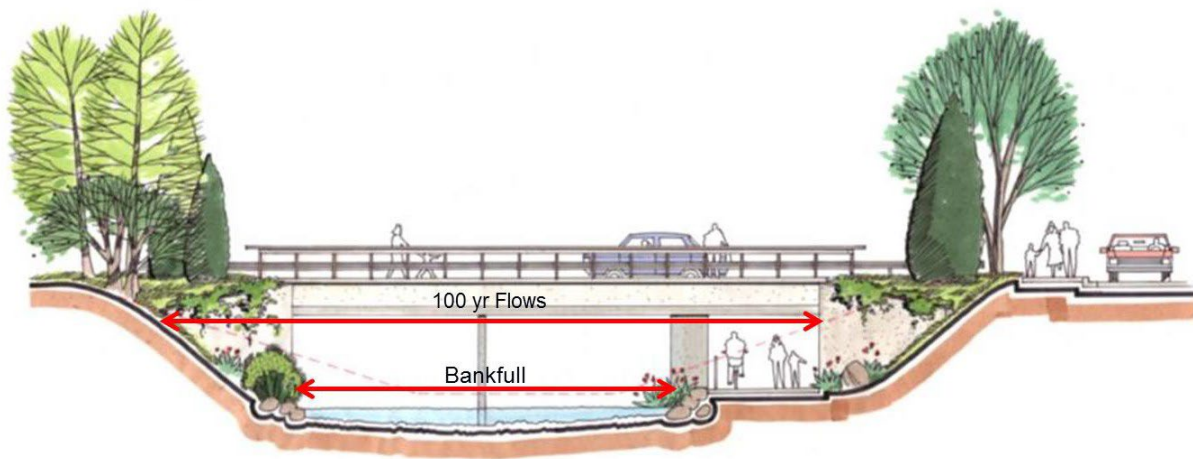


Figure 2. 100 yr Flow Design.



Figure 3. Bridge with Floodplain and Height Capacity for 100 yr Flows.



Figure 4. Bankfull Channel Culvert with Flood Relief Culverts at Floodplain Elevation.

Design Criteria

Stream crossing designs are intended to replicate the natural stream processes within and immediately adjacent to a culvert or opened-bottom structure. Aquatic organism passage, sediment transport and flood and wood conveyance within the structure are intended to imitate the stream conditions upstream and downstream of the crossing, as close to natural conditions as the structure type allows (Figures 5 and 6). Culverts and open-bottomed structures, when properly sized and designed, can accomplish these natural stream processes. Culverts should be partially filled with material

that simulates the natural streambed. Open-bottomed structures should contain substrate that matches the natural stream channel.



Figure 5. Poor design has resulted in scour and degradation below culvert and obstruction to fish passage.



Figure 6. Bankfull Bottomless Arch Culvert with Floodplain Relief Drain.

Implementation of a replacement project requires a high level of information and site-specific data regarding stream hydrology and geomorphology, as well as engineering and construction expertise. Project design criteria include several components as described below.

Structure Width

The width of structures (at bankfull or top of bank elevation) should be equal to or greater than 1.2 times bankfull channel width. A single structure span of the width is preferred but multiple culverts are allowed, and should be accompanied with flood relief drains. The minimum structure width of a culvert should be five feet to allow placement of substrate material. The width of the structures within the vertical adjustment potential should be equal to or greater than 1.2 times bankfull channel width. No piers, footers, piles, or abutments should be within 1.2 times bankfull width, unless there are constraints in placement and design criteria which then should allow for a minimum amount of structures.

Structure Alignment

The structure should achieve optimal orientation relative to both the road and stream channel. Replacement structures are sometimes shifted to achieve better alignment with the natural stream channel pattern at the crossing location. Skew angle should be in line with stream channel orientation.

Structure Capacity

The structure should accommodate a 100-year flood flow without significant change in substrate size and composition. To meet this requirement, unconstrained channel types may require structures wider than 1.2 times bankfull or additional flood relief structures. The headwater depth to structure height ratio should not exceed 0.8:1 for 100-year flows in order to allow for additional vertical clearance for woody debris and sediment transport.

Channel Slope

The culvert structure slope should match an appropriate reference reach of the natural stream (assessed at a minimum of approximately 20-30 times the channel width upstream and 20-30 times the channel width downstream of the site, though a suitable reference reach could be located further upstream or downstream). The maximum slope should not exceed 3.5 percent because of difficulties in retaining substrate within the structure at higher gradients, increasing both costs and design complexity. Bridges do not have a maximum slope range.

Embedment

If a culvert is used, the bottom of the culvert should be buried into the streambed not less than 20 percent of the culvert height.

Elevation

For open-bottomed structures, the footings or foundation should be designed to be stable for the maximum scour depth. The structure should also provide a low flow channel.

Substrate

Material in structures should match the natural stream channel. Bed materials should match natural stream bed mobility characteristics. Bank and other key bed structural elements (e.g. steps, weirs, ribs, etc.) should be stable at the 100-year flow.

Geotechnical analysis

Structure design and construction methods may be influenced by soil composition and subsurface conditions including, but not limited to, the presence of bedrock and clay. The need for geotechnical analysis is determined on a project-specific basis and is not always necessary.

These recommendations promote the use of the U.S. Forest Service's Stream Simulation approach for designing road-stream crossings, an approach which our agencies have successfully used on previous projects to support recovery of anadromous and catadromous fishes by restoring stream habitat.

Specific Conditions for Road-Stream Crossings:

A. Bridge and Culvert Repair, Replacement, or Upgrade to a Higher Preference Order

All bridge and culvert projects should follow the guidelines below and the General Conditions in D. General design drawings and recommendations are shown in Appendix A. Stream crossing structures are listed in order of preference from 1 (most preferred) to 4 (least preferred). Bridges that fully span the stream and have no in-stream pilings are preferred over other crossing types and should be used whenever possible as they minimize impacts to listed species and critical habitat, and reduce the need for future repairs.

Order of Preference	Structure	Project Description	Conditions
N/A	Bridge	Repair/reinforcement	Follow the General Conditions listed in D. below.
		Repair/reinforcement with new rip rap	<i>Placement of new rip rap in-stream should be consulted on with the Service on a case-by-case basis for specific recommendations.</i>
1	Bridge – no in-stream pilings	Replacement or upgrade	1) Remove all remnants of the damaged structure from the stream channel and dispose of in an off-site disposal area. 2) Follow the General Conditions listed in D. below.
2	Bridge – with in-stream pilings	Replacement or upgrade	<i>All bridge replacements and upgrades that require in-stream supports should be consulted on with the Service on a case-by-case basis for specific recommendations.</i>
3	Culvert – bottomless	Replacement or upgrade	1) Culvert width should be 1.2 times bankfull width. 2) Multiple culverts are needed when the maximum culvert width available is reached, but bankfull width has not been reached. 3) Culvert slope should match channel grade. 4) It is recommended that floodplain relief drains be installed in road approaches.
4	Culvert – box, elliptical or round (in order of preference for minimization of impacts)	Replacement	1) Culvert width should be 1.2 times bankfull width. 2) Culvert should be counter sunk below substrate to a depth of 20% of the culvert diameter (round) or rise (elliptical, box). 3) Multiple culverts are needed when the maximum culvert width available is reached, but bankfull width has not been reached. 4) Culvert slope should match channel grade. 5) It is recommended that floodplain relief drains be installed in road approaches.

B. Demolition and Removal of Damaged Structures

- Conduct activities in a manner that minimizes disturbance to the stream bottom and banks.
- The structure should be lifted or floated out of the stream, not dragged on the bottom.
- Wooden pilings should be cut or pinched off at the substrate level.

- Remove all remnants of the damaged structure from the stream channel and dispose of in an off-site disposal area.
- In addition, follow the General Conditions listed in D. below.

C. Debris Removal

- When feasible and safe, natural woody debris should remain in the stream.
- Conduct activities in a manner that minimizes disturbance to the stream bottom and banks.
- Debris should be lifted or floated out of the stream, not dragged on the bottom.
- In addition, follow the General Conditions listed in D. below.

CI. General Conditions for all Projects

1. Keep in-stream work to a minimum.
2. Conduct work activities from atop a stable streambank or reinforced platform, when feasible, and in a manner that does not degrade or destabilize the streambank.
3. Install erosion and sediment control devices before any work is performed, and closely monitor and maintain for the life of the construction project. Implement the appropriate best management practices for preventing and minimizing erosion and sediment outlined in the following manuals: https://www.fema.gov/sites/default/files/documents/fema_4339-guide-nnbs-job-aids-streambank-puerto-rico.pdf, <https://www.drna.pr.gov/documentos/guia-para-el-manejo-de-rios-en-puerto-rico-2/>.
4. Keep land clearing to the minimum level necessary for project completion. Stream bank vegetation should be left intact to the extent practicable. Cutting vegetation is preferred to root grubbing near streams.
5. Cover disturbed areas with erosion controls mats and revegetated promptly with native grasses.
6. Locate debris collection sites, borrow sites, fill dirt stockpiles, and equipment staging areas at least 200 feet from stream channels to minimize the potential of sediments and contaminants entering the waterway.

CII. Low Water Crossings-Fords

1. All recommendations for Low Water Crossings-Fords can be found in the U.S. Forest Service Publications Number 0625 1808—SDTDC Titled “Low-Water Crossings: Geomorphic, Biological, and Engineering Design Considerations”.

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Appendix A

General Design Drawings for Fish Passage Structures

