



# Design of Irish Crossing and Its Effect on Roads Management

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**Abstract:** This paper provides guidelines for the design of Low Water Stream Crossings (LWSCs) and is a synthesis and summary of previous studies reports. Results of the research on LWSCs include advantages, disadvantages, erosion and scour control, road way site geometry, recommendation during structures, traffic safety, summary and references.

**Keywords:** Low Water Crossing, Erosion, Geometry, Recommendation, Traffic, Safety

## 1. Introduction

There is an extra need for replacement of many old and unsafe bridges on low volume of traffic roads as, bridges don't adequate, and are faced with large capital expenditure for replacement structures of the same size.

From that regard, low water stream crossings (LWSCs) can provide an acceptable, low cost alternative to culverts and bridges for the light traffic roads and reduced maintenance level roads, not only that but it can be a great alternative to bridges and culverts when road use and stream flow conditions are acceptable. (Keller, 2001)

There are three common types of LWSCs: Unvented fords, Vented fords with pipes, and Low water bridges.

Selection among these depends on traffic volume, water depth, stream type, available material and budget.

### 1.1. Advantages of Low Water Crossing

- The major advantage is that a ford is not susceptible to plugging by debris or vegetation as culvert pipe may plug.
- Fords are typically less expensive structures comparing with large culverts or bridges, they may be initially more expensive than culverts or bridges, but they require less fill in the channel, and they can accommodate larger flows.
- Vented fords can be used to pass low water flows and keep vehicles out of the water, avoiding water quality degradation (Figure 1).

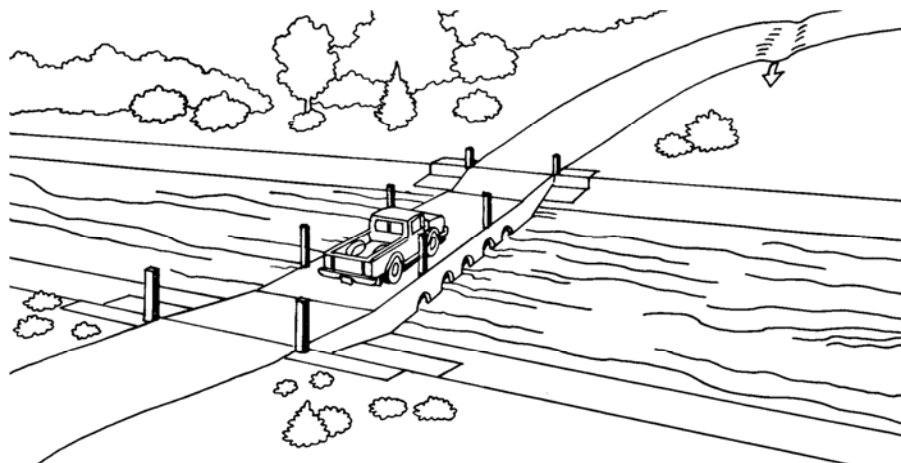


Figure 1. LWSC in low water, (sharer, 2001).

### 1.2. Disadvantages of Low Water Crossing

- Ford-type can be a cause of periodic traffic delays during the high flow of the flood (Figure 2).
- We could require high fills of replacement soil in the case of deeply incised drainages.
- Where the fords involve a dip and periodic delays, they can't be desirable for high use or high-speed roads.
- Crossing the structure can be dangerous during the period of high flow.
- Vented fords may back up the bed load in a stream channel, causing culvert plugging, requiring maintenance, and causing other channel adjustments.

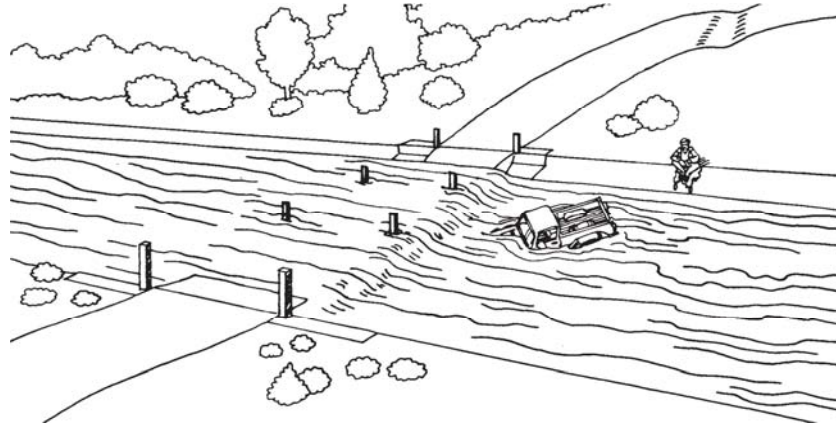


Figure 2. Crossing during high water can be dangerous! (Sharer, 2001).

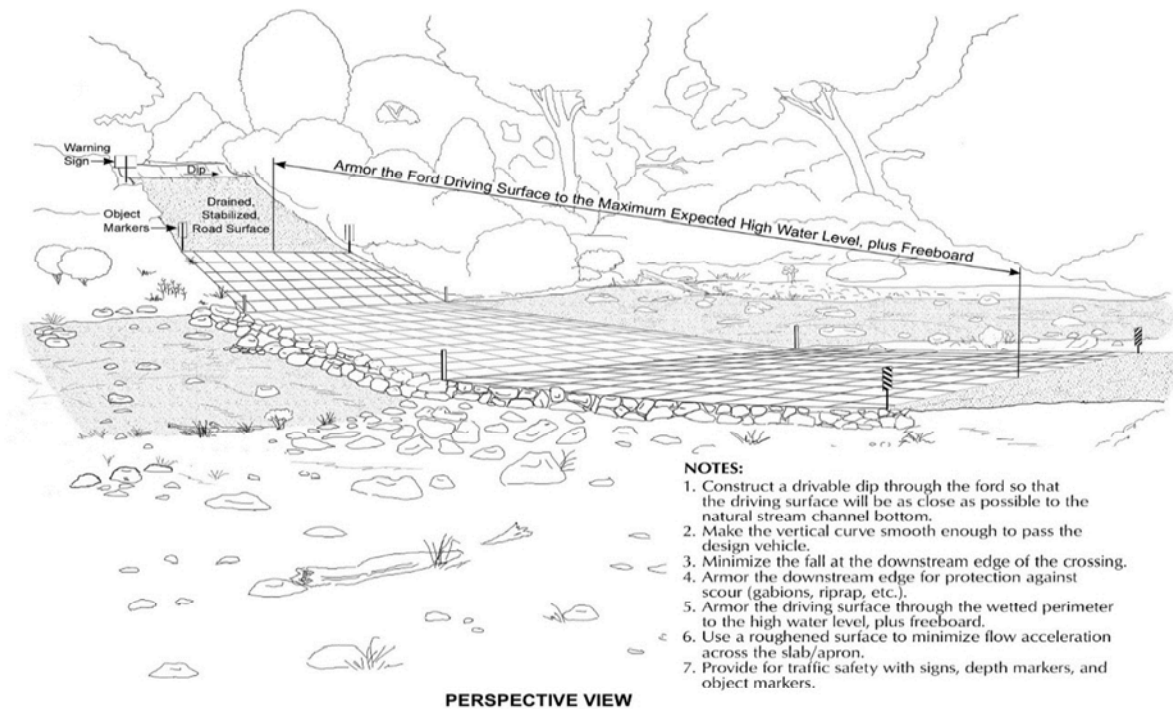
## 2. Methodology

### 2.1. Roadway and Site Geometry

Roadway geometry must be adequate for safe passage of the design vehicle, hence we have to build a structure that fits the site, with a vertical and horizontal alignment that will be safe and will allow the design vehicle to pass over the

crossing, select a site with a relatively straight road alignment and locate a crossing at a straight reach of the stream.

Moreover the road profile should conform to the shape of the natural channel as much as possible and use a vertical curve dip through the ford, sufficiently gentle not to catch the bumper or undercarriage of vehicles passing through the ford (Figure 3).



### KEY DESIGN COMPONENTS FOR AN UNVENTED, IMPROVED LOW-WATER FORD CROSSING AN EPHEMERAL STREAM

Figure 3. Unvented ford geometric design and its component. (Sharer, 2001).

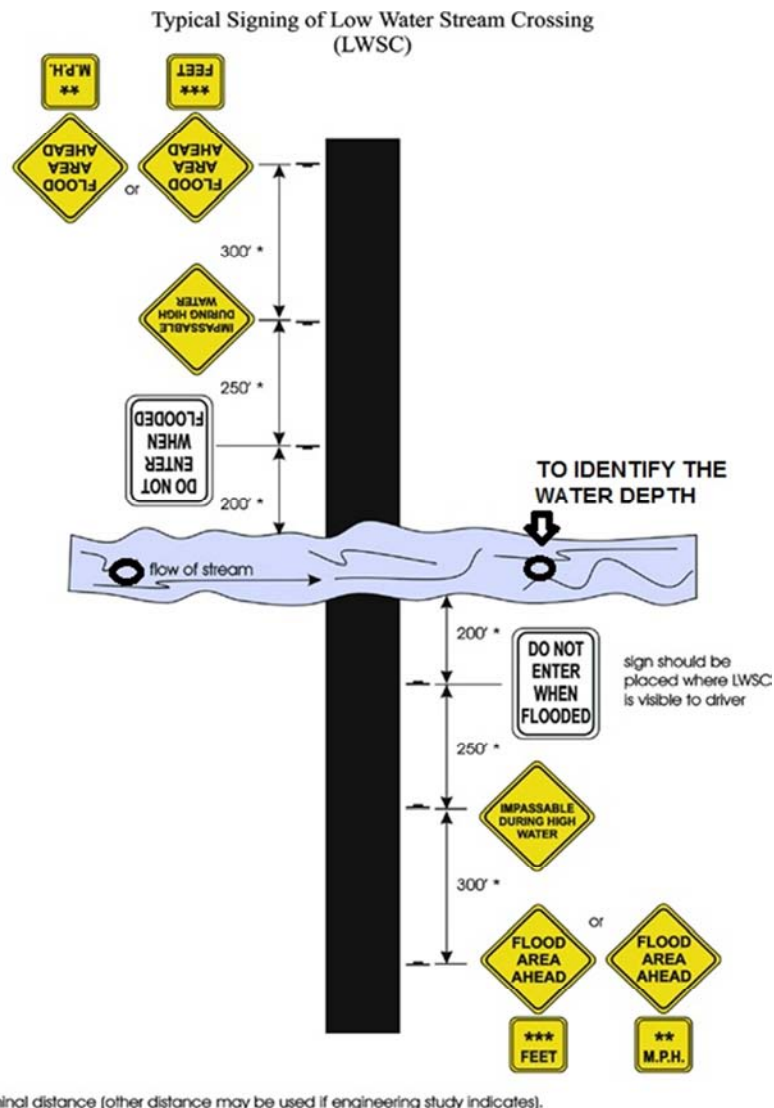
To minimize damming of the channel, any elevated structure should maintain as high percentage of open area as possible. Low-water crossing structures are designed with a vertical sag, or dip, in the middle of the structure to concentrate overtopping flow to the mid channel, and minimize flow against channel banks.

## 2.2. Erosion Control Measures for Fords Include the Following

- Netting, vegetation, and ground cover for any disturbed areas such as work areas, storage areas, materials sources, and exposed earthwork, both during and after construction.
- Controlling water in ditches flowing into the crossing and across disturbed or denuded earthwork areas.
- Trapping sediment in catchment basins, behind silt fences, or in channel with sediment mattresses.
- Minimizing sedimentation from construction in-channel.
- Protecting exposed overflow areas.

## 2.3. Traffic Control and Safety

- You must locate low-water stream crossings at sites where the road is straight to improve the sight distance exists.
- To define the roadway and keep traffic on the structure you have to build 6- by 10-inch wood or 15-inch-high concrete curbs.
- To define each entrance of the structure, Place object markers along the road at each corner of the structure.
- Install warning signs to identify the approaching ford places and warn drivers of flooding and possible traffic delays. (Figure 4).
- Use marker posts that indicate the depth of flow.
- Consider making the ford extra wide for traffic safety, and wherever possible, using 4:1 or flatter fore slopes on embankments.
- If site evaluation determines that a ford would be unsafe, choose a conventional structure such as a culvert or standard bridge. (Iowa DOT, 2003).



**Figure 4.** Typical layout for signing of a low water stream crossing. (Carstens and Woo 1981, reprinted in Gu 2003.).

## 2.4. Structural Design of Driving Surface

Design low-water crossings to support the design vehicle for the onsite soil conditions.

- a. Unless otherwise indicated, design all elevated structures (slabs, box culverts, or pipes) and bridges to support an 80,000 pound, HS-20-44 "legal" design load, in accordance with AASHTO "Standard Specifications for Highway Bridges" requirements.
- b. Provide at least 1-foot compacted soil cover over culverts, or a concrete slab (typically at least 6 to 8 inches thick) over box culverts, based upon manufacturers' requirements or structural analysis.
- c. Construct the roadway driving surface with material durable enough or heavy enough to resist the shear stresses or lateral forces of the water flow.
- d. Protect the entire "wetted perimeter" of the ford (the area of the entire high flow), plus freeboard (typically 2 to 4 feet of additional height).
- e. Remove soft or organic subgrade soils and replace the soil with select, structurally sound material in a layer thick enough that will support the traffic without deformation.

## 2.5. Vehicle Characteristics

Static: mass, length, width, height.

- a. In general, the maximum allowed are 80000 lb, 2.59 m wide, 14.63 m long for trailers, These values might vary by location, some agencies allow larger vehicle.
- b. Truck weight is a critical issue weight per axle that does the most damage to the roadway.

Most fords should be designed to pass a minimum legal 80,000-pound load, often designated as an HS 20-44 legal load (highway semi, 44-ton limit).

If there is a load restriction on the road, post the weight limit at the ford. If overloads are anticipated, such as yarders or special construction equipment, the design (or temporary supports) must support those loads.

Elevated structures such as box culverts, other vented fords, and low water bridges should meet the same structural requirements as a normal structure designed for that site and span.

For corrugated metal pipe structures, use a 1-foot minimum soil cover,

Unless the manufacturer recommends otherwise. Concrete pipe may require 18 inches of cover.

When designing structures for lower load limits and lighter design vehicles, post the crossing (particularly if it is an elevated platform) for the allowable load limit.

For at-grade structures on granular soils, a legal load can usually be accommodated with a layer of aggregate 6- to 12-inches thick.

The ford surface needs to resist the forces of low-water flow so we recommend a relatively coarse 1.5- to 2-inch minus, well-graded aggregate.

To prevent displacement at high flows, place this surfacing

aggregate over a layer of small to medium size riprap.

Using the curve for a 12:1 or bottom slope. Geocells can be used to confine the aggregate, provide structural support, and prevent the aggregate from washing away. The geocells are typically covered with an additional 4 to 6 inches of aggregate to prevent damage to the cells.

Compact any surfacing aggregate, and replace it periodically after high-flow events.

A stockpile of extra aggregate can be stored near the ford for periodic replacement. (Iowa DOT 2003)

Box structures and low-water bridges must have appropriate footings or foundations to support the traffic and dead load of the structure and to spread the load across the encountered soil or rock conditions.

Reinforced concrete slabs, 6 to 8 inches thick, are commonly used on small box structures for the deck and abutment. In some cases, designers support the slab or vent on spread footings at least 2 feet wide and deeper than the expected depth of scour.

Structures must have durable driving surfaces, curbs, and other features that can survive periods of inundation and have debris both hit them and go over them. Structural design should be based upon structural analysis and meet the current AASHTO bridge design requirements for the anticipated loads.

Soft subgrade soils, such as silts, clay, and organic deposits, usually require over excavation and backfilling with aggregate or select material for a 1- to 2-foot thickness.

Very soft soils may require a subsurface investigation and site-specific design. Imported backfill material and/or the top foot of native material are often compacted to at least 90 percent of their AASHTO T-99 maximum density to provide adequate load-bearing support.

Where a road crosses an active flood plain the road surface should be very low or preferably at-grade with the flood plain to prevent obstructing or funneling flood flows.

For structural support on fine or organic meadow soils, it may be necessary to over excavate the roadway footprint and backfill it with select structural material, coarse rock, or aggregate.

Place geotextile between the fine meadow soil and the roadway material to separate the materials and prevent contamination of the aggregate.

## 2.6. Recommendation for Site Construction

To satisfy safety factors and water-quality concerns, incorporate standard erosion and sediment control practices (BMPs) into all projects as needed.

You must adapt all BMPs to site-specific conditions, particularly during construction

Hence, review project design to ensure appropriate BMPs are incorporated into the design and construction requirements.

Monitoring the implementation and effectiveness of BMPs is also necessary for resource and structure protection and for identifying additional maintenance needs.

*The following is a partial list of typical BMPs that apply to the construction of low-water crossings:*

a. Stream Crossing Location

Like all stream crossings, locate low-water crossings perpendicular to the channel on a straight stretch, whenever possible to improve sight distance and minimize structure length.

Although difficult when retrofitting old crossings or working with certain landforms, this positioning will reduce the effects of stream flow energy on the structure itself as well as impacts resulting from the redirection of flow against channel banks.

b. Timing of Construction Activities

When feasible, schedule activities in and near the channel during the dry season, or for a time period when precipitation and runoff are unlikely to be in the safe mood.

Stop construction during times when soils are too wet for equipment stabilization to operate without damaging the soil resource and increasing the potential for water quality degradation.

c. Erosion Control Plan

Create this plan before starting the project. Include the specific practices to be implemented for controlling erosion and preventing management caused sediment from reaching the drainage. Ensure compliance by frequent inspections.

d. During Construction of Stable Embankments

Construct approaches and road surfaces with adequate strength to support the road way, shoulders, subgrade, and traffic loads. When fills are required, stabilize embankments with retaining walls, confinement systems, plantings, or a combination, as needed. Adequately compact all road surfaces.

e. Servicing and Refueling Construction Equipment

Equipment must have a stable area to move so keep service and refueling areas well away from wet areas, surface water, and drainages.

Minimize soil contamination potential by using berms around these sites, and using impermeable liners or other techniques to contain spills.

f. Control of Road Drainage

There are many methods can help reduce the effects of increased runoff and sediment transport caused by low-water stream crossings and road ditches.

These methods include dips that shunt water off the road near the crown of the approach, culverts that carry water from a road ditch and disperse it on the other side away from the channel, paved approaches, and armored ditches.

In areas without sufficient distance for safely dispersing road and ditch water, slow the flow by using sediment basins, check dams, contour trenching in the discharge area, or other similar methods.

g. Controlling In-Channel Excavation

Heavy equipment should cross or work in and near streams only under specific protection requirements.

Excavation in these areas should follow all of the following minimum water quality protection requirements:

1. Do not excavate outside of caissons, cribs, cofferdams, or sheet pilings, unless previously authorized.

2. Do not disturb natural streambeds adjacent to the structure.

3. Keep disturbance of banks to a minimum, and stabilize any banks that are disturbed.

h. Specifying Riprap Composition

Size and install riprap to reduce the power of sliding flood and resist erosive water velocities.

Do not include any material such as weakly structured rock, organic material, or soil that might add to the sediment load.

To prevent undermining, it may be necessary to use filter blankets or other methods.

i. Diversion of Flows around Construction Sites

To prevent damaging to the site during construction we have to divert stream flow around construction sites hence, return it to the natural stream course as soon as possible after construction, or before the wet season which are closer.

Stabilize all disturbed areas before the wet season or as needed.

j. Structure Maintenance

Structures and approaches may suffer deterioration from either large runoff events or normal use.

Provide the basic maintenance to protect the structure and prevent damage to resources.

*(Keller, 2001)*

### 3. Summary and Conclusion

Low water crossings can be a low-cost solution for drainage structure requirements with low level of traffic, drainage remediation and new site development.

Unvented fords are less expensive than culverts or bridges as material of the unvented fords can be equal 2500 per m<sup>2</sup>, they may be initially than culverts, as they require less fill in channel, and they accommodate larger flows

Unvented fords can be a great offer when the normal stream flows less than 6 inches in depth for no more than two weeks per year and the water velocity less than 3 m/sec with respect of the delay expected to the crossing vehicles.

Must ensure that the time of travel for the alternative road don't exceed 1 hour.

Line of gabions or large break concrete are required to integrate the structure into the surrounding environment while protecting the edges of the system from scour and erosion and to slowdown the power of sliding water.

Use small rock or gravel to provide a smooth driving surface. This small rock will have to be periodically maintained and replaced.

Hydraulic design is of a primary importance because most damage to the structure results directly from the scour.

Use well placed sturdy depth signs at fords to advise traffic of dangerous water depths and the availability of passing.

Plan and schedule all construction activities to prevent erosion and sedimentation and provide an easy method for maintenance.

Review project design to ensure appropriate BMPs are incorporated into the design construction requirements.



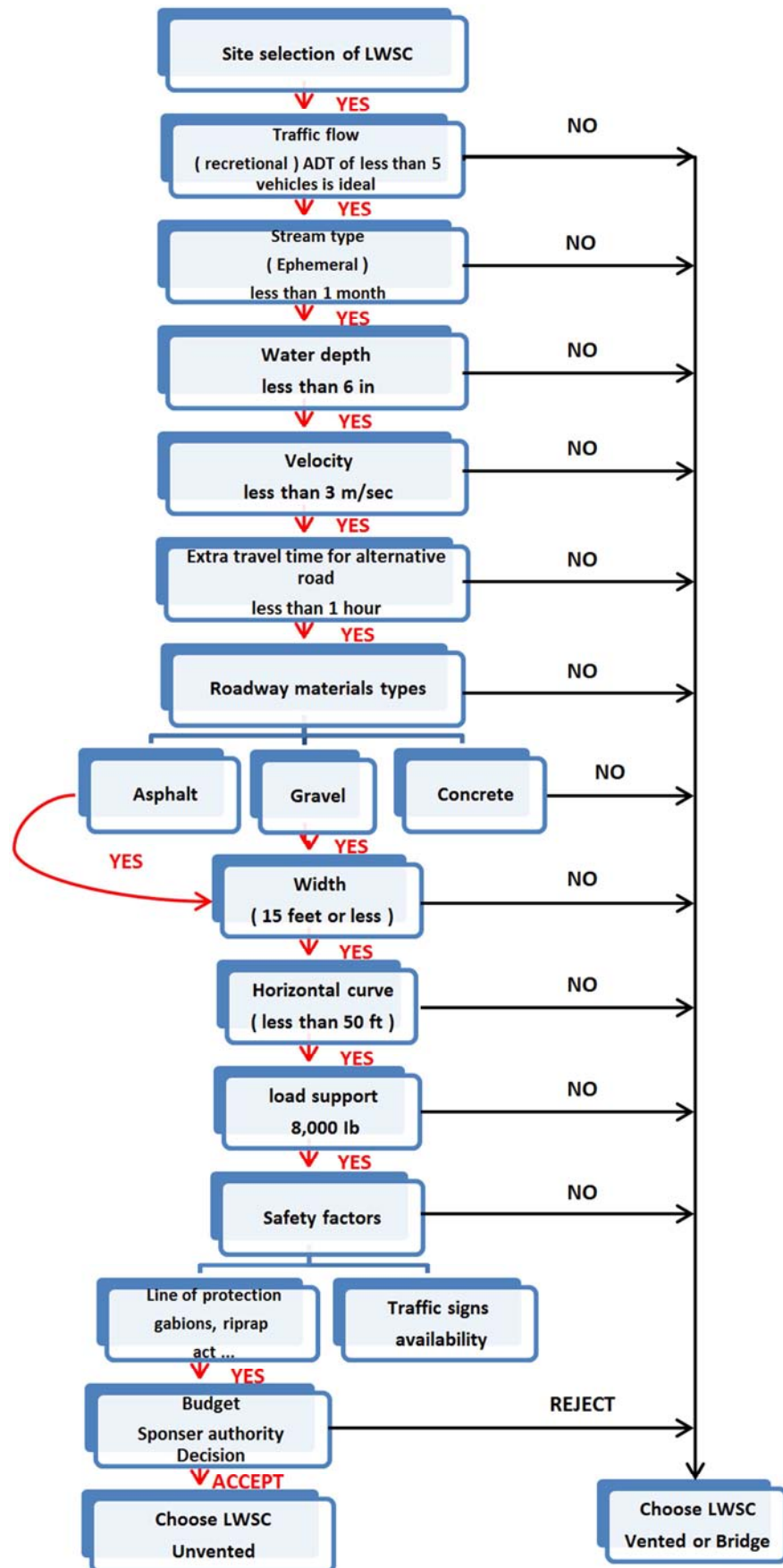


Figure 5. General flow chart for choosing LWSC type Ahmed Erfan, Irish crossing 2015.

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