# MN DNR Public Waters Work Permits

Culvert Design Criteria

Minnesota
DEPARTMENT OF NATURAL RESOURCES

# MN Administrative Rules

**6115.0230 BRIDGES AND CULVERTS, INTAKES AND OUTFALLS.**

**Subpart 1.**

**Goals:**

It is the goal of the department to allow crossings of public waters, including the construction of water intake and sewer outfall structures in public waters, only when less detrimental alternatives are unavailable or unreasonable, and where such facilities adequately protect public health, safety, and welfare.

# 6115.0231 SPECIFIC STANDARDS; BRIDGES, CULVERTS, INTAKES, AND OUTFALLS

- **Subp. 2.**
- **Bridges, culverts, and other crossings.**
- The construction, reconstruction, or relocation of all bridges, culverts, or other crossings over public waters shall be approved if **all** of the following criteria are met:

A. Hydraulic capacity
B. Floodplain
C. Aquatic Organism Passage
D. Navigation
E. State Trails
F. Islands

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# Hydraulic Capacity

**A.** the hydraulic capacity of the structure is established by a competent technical study. The sizing shall not be based solely on the size of existing upstream and downstream structures. If a state or federal floodplain information study exists for the area, or a United States Geological Survey gaging station is located nearby on the stream, the hydraulics of the proposed bridge/culvert design must be consistent with these data. The department may waive this requirement if:

**(1)** the department has performed a hydraulic study based upon available information and reasonable assumptions;

**(2)** the department has made a field investigation of the project site; and

**(3)** the project will not cause flood-related damages or problems for upstream or downstream interests;

# Floodplain

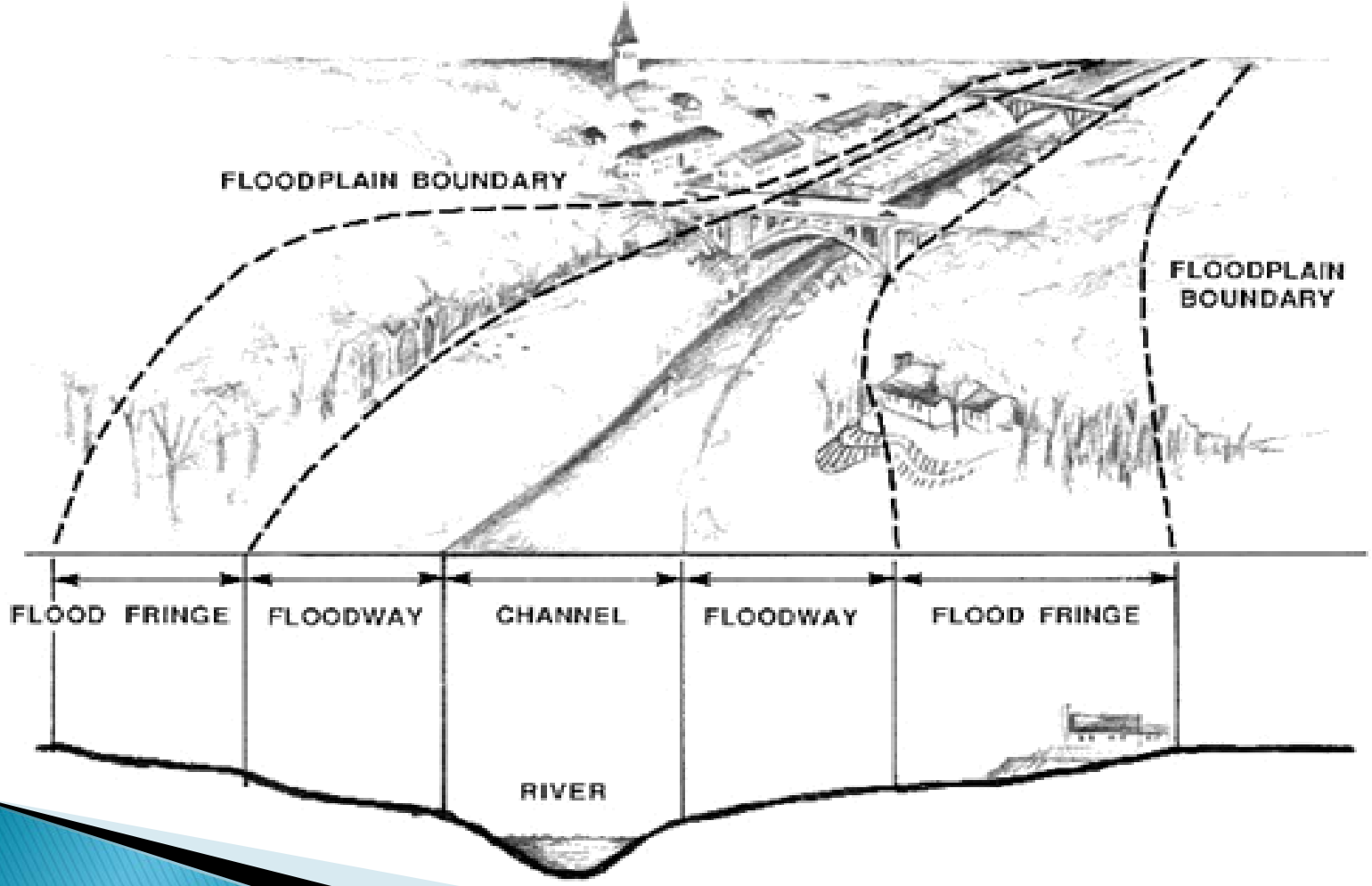
**B.** new crossings and replacements of existing crossings comply with local floodplain management ordinances, with provisions of part 6120.5700, subpart 4, item A, and with the following:

# Floodplain

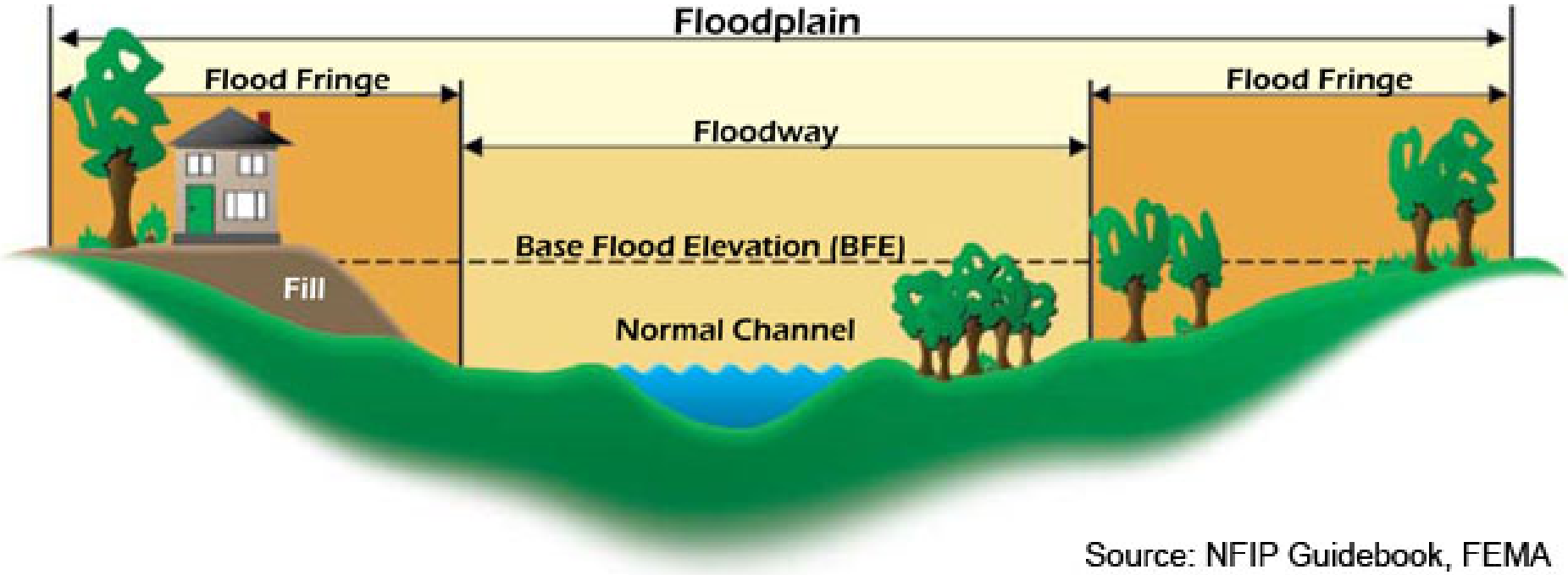
**B.** new crossings and replacements of existing crossings comply ~~with local floodplain management ordinances~~, with provisions of part 6120.5700, subpart 4, item A, ~~and with the following~~:

**6120.5700, subp. 4, A.** The limits of the floodway shall be designated so that permissible encroachments on the floodplain will not cause an increase in stage of the regional flood of more than 0.5 feet in any one reach or for the cumulative effect of several reaches of a watercourse. If the increase in flood stage will materially increase the flood damage potential, the commissioner may require that such increases be less than 0.5 feet. The commissioner may authorize increases greater than 0.5 feet where studies show that further increases in flood stages will not materially increase the flood damage potential.

# Floodway


FLOODPLAIN BOUNDARY
FLOODPLAIN BOUNDARY
FLOOD FRINGE
FLOODWAY
CHANNEL
FLOODWAY
FLOOD FRINGE
RIVER

## Characteristics of a Floodplain




Source: NFIP Guidebook, FEMA

# Floodplain

**B.** new crossings and replacements of existing crossings comply with local floodplain management ordinances, with provisions of part 6120.5700, subpart 4, item A, and with the following:

**(1)** for new crossings, no approach fill for a crossing shall encroach upon a community designated floodway. When a floodway has not been designated or when a floodplain management ordinance has not been adopted, increases in flood stage in the regional flood of up to one-half of one foot shall be approved if they will not materially increase flood damage potential. Additional increases may be permitted if: a field investigation and other available data indicate that no significant increase in flood damage potential would occur upstream or downstream, and any increases in flood stage are reflected in the floodplain boundaries and flood protection elevation adopted in the local floodplain management ordinance;

# Floodplain

**B.** new crossings and replacements of existing crossings comply with local floodplain management ordinances, with provisions of part 6120.5700, subpart 4, item A, and with the following:

**(2)** for replacement of existing crossings, if the existing crossing has a swellhead of one-half of one foot or less for the regional flood, the replacement crossing shall comply with the provisions for new crossings in subitem (1). If the existing crossing has a swellhead of more than one-half of one foot for the regional flood, stage increases up to the existing swellhead shall be allowed if field investigation and other available data indicate that no significant flood damage potential exists upstream from the crossing based on analysis of data submitted by the applicant. The swellhead for the replacement crossing may exceed the existing swellhead if it complies with the provisions for new crossings found in subitem (1)

# Floodplain

**B.** new crossings and replacements of existing crossings comply with local floodplain management ordinances, with provisions of part 6120.5700, subpart 4, item A, and with the following:

**(3)** the decks and approaches to bridges or culverts on major transportation routes and on roads that provide access to development at urban densities shall be no lower than two feet below the flood protection elevation as defined in part 6120.5700, subpart 5, unless it can be shown that alternative routes or access can be provided during the regional flood

# Aquatic Organism Passage

**C.** the structure provides for game fish movement, unless the structure is intended to impede rough fish movement or the stream has negligible fisheries value

# Barriers to Fish Passage

- Hanging Outlets
  - Downstream Scour
  - Pipe set above grade
- Velocity in Pipe
- Depth in Pipe
- Length of Pipe

# Fish Passage Design Criteria

1) Maximum Velocity: do not exceed a specified flow velocity at a specified flow representing conditions during periods of upstream movement
2) Minimum Depth: maintain a minimum depth for fish movement at low flow conditions when fish may be moving
3) Gradient: maintain channel elevation between stream bed and pipe at inlet and outlet through which fish can easily pass (no excessive drops)

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# Stream Stability

**Stream Equilibrium Condition** occurs when water flow, sediment and woody debris are transported in a watershed in such a manner that the stream maintains its dimension, pattern and profile without unnaturally aggrading or degrading at the river reach or valley segment scales. Benefits of managing streams toward equilibrium conditions include the reduction of flood damages, the naturalizing of hydrologic and sediment regimes, improved water quality through reduced sediment and nutrient loading and restoration of the structure and function of aquatic and riparian habitat.

# Hydraulic Capacity

**A.** the hydraulic capacity of the structure is established by **a competent technical study**. The sizing shall not be based solely on the size of existing upstream and downstream structures. If a state or federal floodplain information study exists for the area, or a United States Geological Survey gaging station is located nearby on the stream, the hydraulics of the proposed bridge/culvert design must be consistent with these data. The department may waive this requirement if:

**(1)** the department has performed a hydraulic study based upon available information and reasonable assumptions;

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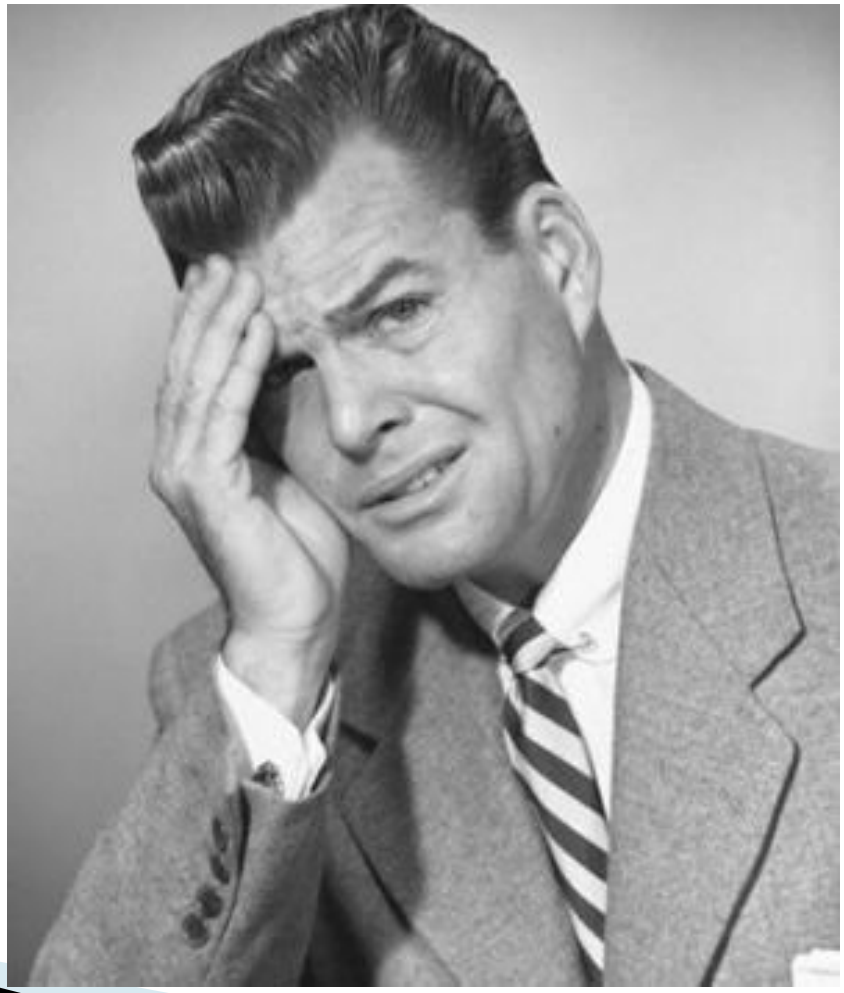
# What is a “competent technical study”?



Traditionally, culvert design was based on hydrologic and hydraulic models that predict peak runoff from a watershed, with the culvert sized accordingly to pass a specified design storm. Fish passage was not always addressed with these designs.

Alternative designs or simulation techniques inherently take fish passage into account by addressing issues of low flow, hydraulic variability and sediment transport. Currently a variety of design techniques are increasingly being implemented in Minnesota, commonly where fish passage is a concern.

# Competent Technical Study

- Design Flow: pass the design peak flow event
  - Risk Tolerance
- Floodplain considerations
  - Based on 100-year Flow Event
- Fish Passage
  - Velocity, Depth, Length
- Stream Stability
  - Pass Water AND Sediment + Debris

# Best Practices Manual
# Best Practices for Meeting DNR General Public Waters Work Permit GP 2004-0001

- http://www.dnr.state.mn.us/waters/watermgmt_section/pwpermits/gp_2004_0001_manual.html

# Culvert Design Approaches

- **Open bottom span:** Open bottom structures are not considered as restricting flow or impinging upon the channel cross sectional area. These structures are not considered an impediment to fish movement.

- **Conventional Design:** Culverts sized to pass a specified design storm (e.g., 10 years peak flow) with no consideration given to fish passage needs.

- **Hydraulic Design:** Techniques that create water depths and velocities to meet the swimming abilities of target fish populations. This approach considers the flow requirements (eg: maximum velocity, sustained velocity, flow depth, etc) needed by specific species. The goal is to keep the velocity below a set of thresholds corresponding to a fish's maximum swim speed, sustained swim speed, and related measures. This is a common method for meeting the frequent DNR requirement of: 'Velocities of the 2-year 24-hour event shall not exceed 2 feet per second".

- **Hydraulic Simulation:** Design approaches that simulate natural hydraulics of streams by adding rock or roughness elements to simulate natural hydraulic variation within or adjacent to the culvert. Typically these include placement of rock on the floor of the culvert or placement of rock rapids below the outlet to create pools and riffles, etc. This is an intermediate design method (between geomorphic simulation and hydraulic design).

- **Geomorphic Simulation:** Design approaches that simulate natural channel morphology and sediment transport. In Minnesota this technique is commonly referred to as 'MESBOAC'. It was developed in the northern forested region of Minnesota for the US Forest Service and is based on principles of fluvial geomorphology rather than individual fish swimming ability.

# Competent Technical Study:

- The DNR will consider the use of any of the above methods, or combination thereof, as long as fish passage requirements for the specific site are met.

# Geomorphic Simulation Technique MESBOAC

- MESBOAC stands for:
- **Match culvert width to bankfull stream width.**
- **Extend culvert length through the side slope toe of the road.**
- **Set culvert slope the same as stream slope**
- **Bury the culvert**
- **Offset multiple culverts.**
- **Align the culvert with the stream channel.**
- **Consider headcuts and cutoffs.**

# MESBOAC

- MESBOAC aims to match the culvert width with natural stream dimensions, while maintaining sediment balance (sediment in = sediment out). MESBOAC has the advantage of not requiring analysis of fish passage flows. It assumes that since the natural flow characteristics are maintained, fish passage will occur.

# MESBOAC

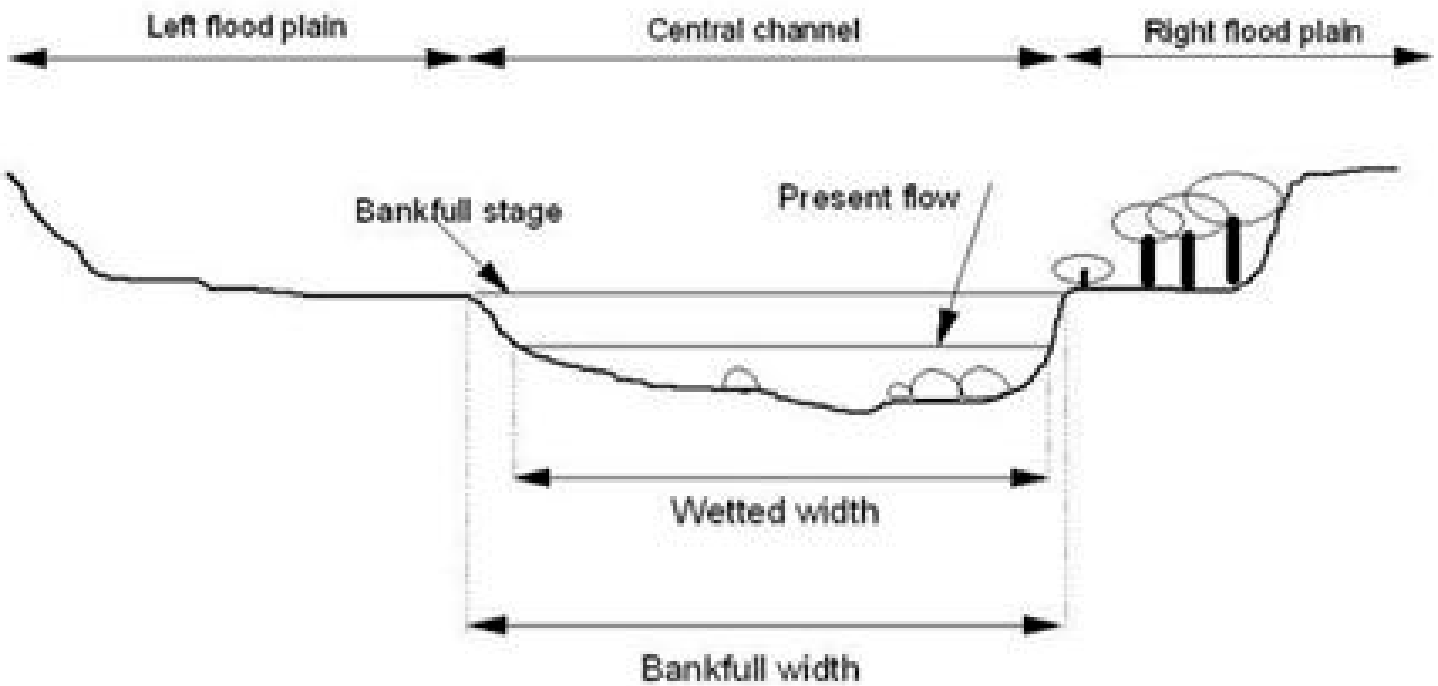
- Advantages:
  - Hydrologic  & Hydraulic Modeling not required
  - Bedload movement accounted for
  - Fish passage presumed
  - Reduced maintenance (minimizes scour & aggredation)

# MESBOAC

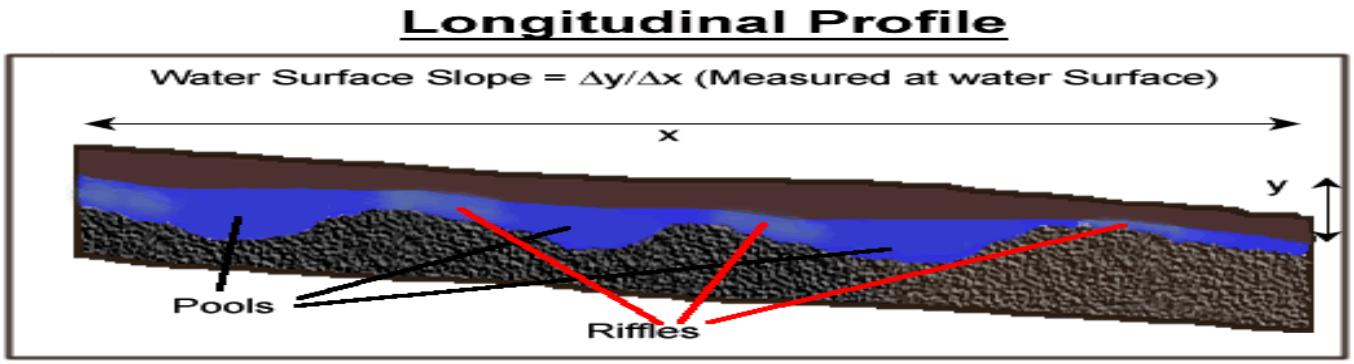
- Disadvantages:
  - Not appropriate in detailed floodplain areas
  - Typically requires larger culverts than conventional culvert design
  - Precise identification of bankfull width required
  - Channel slope must be accurately identified

# Bankfull Width

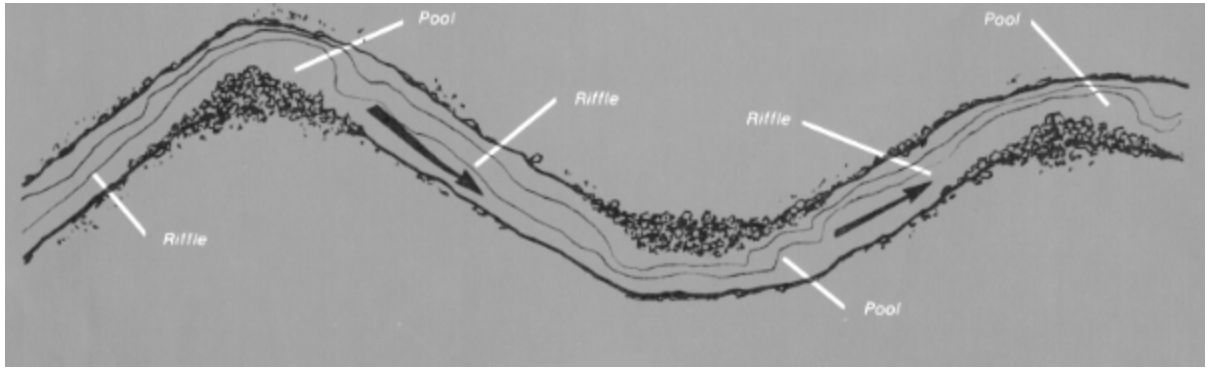
- Measure at riffles not pools
- Measure at multiple riffles to ensure accurate identification



# Channel Slope




- Measure two – three riffle/pool segments upstream and downstream of culvert location




- Read elevations in the thalweg of riffles

# Design Achieves:

- Hydraulic Capacity
- Sediment Movement
- Fish Passage
- Floodplain regulations (if necessary)

- Then . . . . .

# Success!


Minnesota
DEPARTMENT OF NATURAL RESOURCES

**PUBLIC WATERS WORK GENERAL PERMIT**

**GENERAL**
**Permit Number**
2001-1172

Pursuant to Minnesota Statutes, Chapter 103G, and on the basis of statements and information contained in the permit application, letters, maps, and plans submitted by the applicant and other supporting data, all of which are made a part hereof by reference, **PERMISSION IS HEREBY GRANTED** to the applicant to perform the work as authorized below:

| | |
|---|---|
| **Public Water**<br>All Public Waters | **County**<br>All |
| **Name of Permittee**<br>Governmental Subdivisions and the General Public | **Telephone Number (Include Area Code)**<br>N.A. |
| **Address (No. & Street, RFD, Box No., City, State, Zip Code)**<br>Various | |
| **Authorized Work:**<br>Upon notice to and approval by the DNR Ecological and Water Resources Area Hydrologist, replacement or repair of damaged bridges, culverts, shore protection measures, structures, stream channels, or other facilities in areas that have been declared a disaster by the Federal Government, or when localized conditions exist and the DNR Ecological and Water Resources Director or Regional Manager authorizes the use of this permit. Fill authorized by this permit is allowed subject to Conditions 14 and 15 and all other requirements of this permit. Work may not commence unless or until the Notice and Verification Form (Attachment A) is completed and signed by the Area Hydrologist. | |
| **Purpose of Permit:**<br>Repair of structures and facilities damaged by flooding | **Expiration Date of Permit**<br>June 1, 2016 |
| **Property Described As:**<br>Various. The permittee must own, control, or have permission to access and use all lands on which the repair or replacement is located. | |

This permit is granted **subject to** the following **CONDITIONS:**

1. The **permittee** is not released from any rules, regulations, requirements, or standards of any applicable federal, state, or local agencies; including, but not limited to, the U.S. Army Corps of Engineers, Board of Water and Soil Resources, MN Pollution Control Agency, watershed districts, water management organizations, county, city and township zoning. This permit does not release the **permittee** of any permit requirement of the St. Paul district, U.S. Army Corps of Engineers, Army Corps of Engineers Centre, 190 Fifth Street East, St. Paul, MN 55101-1638.

2. This permit is not assignable by the **permittee** except with the written consent of the Commissioner of Natural Resources.

3. The **permittee** will notify the Area Hydrologist at least five days in advance of the commencement of the work authorized hereunder and notify him/her of its completion within five days. The Notice of Permit issued by the Commissioner will be kept securely posted in a conspicuous place at the site of operations.

4. The **permittee** will make no changes, without written permission previously obtained from the Commissioner of Natural Resources, in the dimensions, capacity or location of any items of work authorized hereunder.

5. The **permittee** will grant access to the site at all reasonable times during and after construction to authorized representatives of the Commissioner of Natural Resources for inspection of the work authorized hereunder.

6. This permit may be terminated by the Commissioner of Natural Resources at any time deemed necessary for the conservation of water resources of the state, or in the interest of public health and welfare, or for violation of any of the conditions or applicable laws of this permit, unless otherwise provided in the conditions.


That's all Folks!