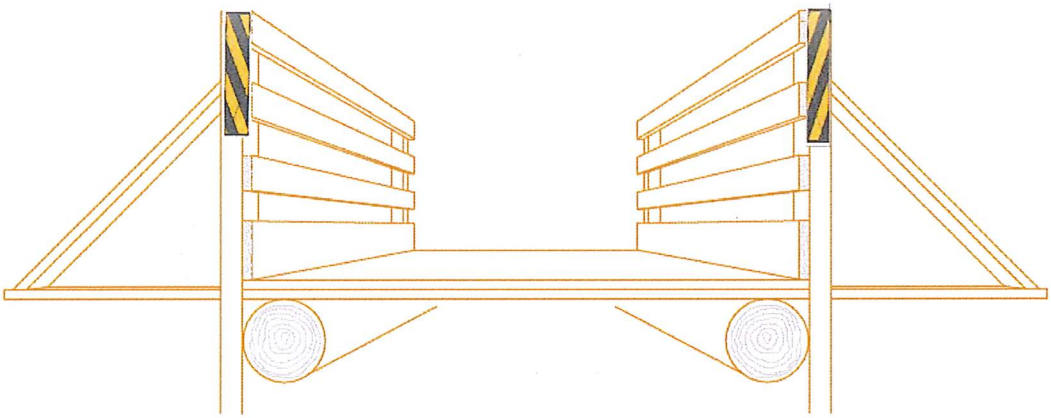
Bridge Guidelines

For New and Replacement Snowmobile and All-Terrain Vehicle Bridges



WISCONSIN
DEPT. OF NATURAL RESOURCES

PUB-CF-005 2017

TABLE OF CONTENTS

INTRODUCTION 1
About this guide 1
How to use this guide 1
Department rule 1
Bridge plan review 2
Water Regulatory Review 3
GENERAL BRIDGE DESIGN 5
General Bridge Design Considerations 5
Wearable Surfaces 5
About Railings 5
Bridge Design 6
Engineering Design Requirements 6

ILLUSTRATIONS 8
Wood Pole Bridges (40' or less) 9
Steel 'I' Beam Bridges (40' or less) 10
APPENDIX 11
Capital Improvement Ownership Acknowledgement 12
Easement 13
Cost Saving Ideas 14

INTRODUCTION

About this guide

Bridges are the fuses in the circuit of any snowmobile or all-terrain vehicle trail system. In time, these bridges may need repair or may need total replacement. This guide was assembled to help counties, clubs and trail groups through the process of repairing or reconstructing these vital components of a trail system. The bridges designed and built using this guideline are not meant for over the road vehicles, other than those associated with periodic maintenance or repair related work.

Project Sponsor

The ***project sponsor*** for the snowmobile program is a county. For the all-terrain vehicle program, the project sponsor may be a city, village, town or county. Cooperating snowmobile or all-terrain vehicle clubs or associations are not considered an eligible project sponsor.

Due to the variable nature of existing conditions (topography, stream flow, soil conditions, snow load, etc.) and the variety in type of bridge structures (designed and prefabricated), **this document should NOT be used as a sole bidding document**, but as a reference document only.

How to use this guide

This guide is arranged in four major sections.

- General information about bridge review
- Engineering design requirements
- Illustration for various design features
- Appendix containing helpful hints and sources

Department rule

The Department of Natural Resources is required by law to review all new and replacement bridge structures and culverts constructed in or over navigable waters to assure compliance with state statutes and codes. Adequate clearances and flood flow design requirements are necessary to prevent obstruction to navigation, and to protect human life and minimize property loss in periods of high water.

Counties interested in constructing new or replacement structures should arrange to review the proposed water crossing with the appropriate Water Management Specialist. This review will determine the need for a permit. If a permit is necessary, the permit application will outline the necessary type of information needed for further review by the Water Management Specialist.

Bridges are made up of three major components (see the following illustrations)

1. Deck (Wearing surface; transfers loads (live and dead) to other bridge components
2. Superstructure (Includes all components that support the deck system and loads applied to the deck; transfers loads to substructure) Bridges are often named for their specific type of superstructure (timber, steel, truss, prefabricated, arch, etc.)
3. Substructure (Includes all elements that support the superstructure; transfers loads to the foundation/earth – abutments, piles, piers, bents, etc).

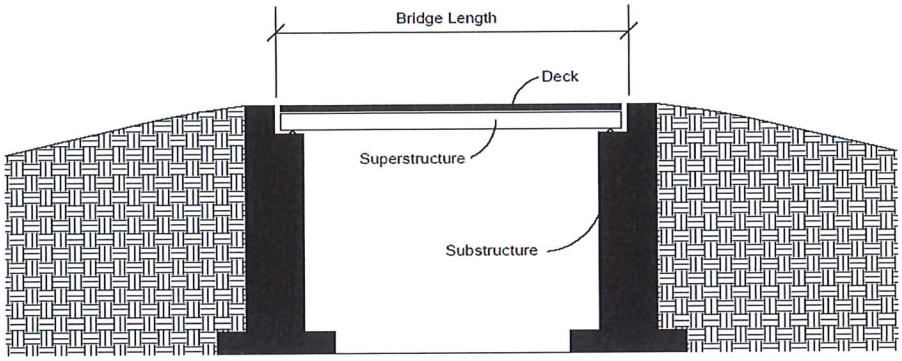


ILLUSTRATION A

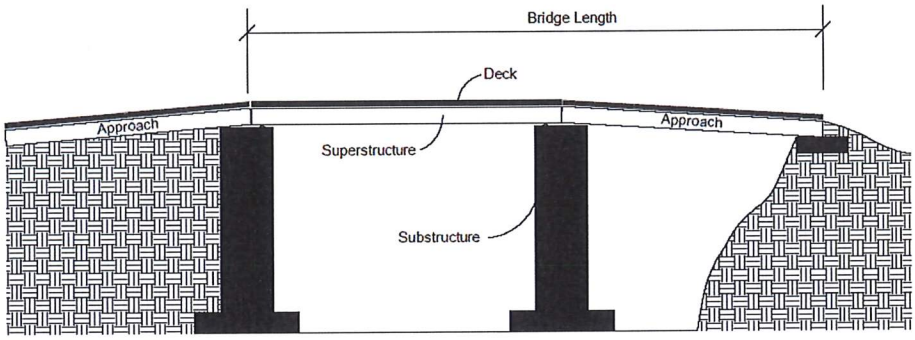


ILLUSTRATION B

Bridge Plan Review

Bridge Engineering

1. As with any public-use facility, it is necessary that the appropriate documentation and responsibility be noted. All bridges designed or built using this guide must have a designer-of-record associated to the site-specific design.

2. The bridge length is defined as the total distance being spanned (not fully earth supported); in some cases this may include the approaches and in most cases is simply the distance from one abutment to the other (see above illustrations).

3. It is the sponsor's responsibility to verify the structural adequacy of the structure. Adequacy of the structures strength can be provided by the methods listed below:
   a) Provide an engineered stamped drawing.
   b) Provide a manufactures certification for factory built or component bridges.

Water regulatory review Requirements

Be aware that the Department's water regulatory program requires submittal and review of construction plans for all bridges as required by S. 30.123, Stats. Contact the local Water Management Specialist for details.

Please Note!

Due to the varying nature of bridge designs, retrofits, soil conditions, varying degrees of degradation and changes in loading situations, etc., it is the project sponsor's responsibility to determine what should be required for submittal as detailed above in regards to soil information, substructure and loading calculations. A site visit by the project sponsor to verify all conditions is highly recommended.

Easement language

Sponsors are strongly urged to put language into easements for the abutments that give the sponsor the rights to maintain, repair, operate, inspect, replace and remove the bridge structure and have the rights of ingress and egress for the same purposes.

The following conditions will be inserted into all agreements on private lands to explain this. Both parties need to sign the document and send it back with signed agreement.

As a condition to receipt of this grant, Sponsor agrees not to convert or approve conversion of capital improvements (Grant Capital Improvement) that have been constructed using grant monies from the Department to any use inconsistent with the type of use for which the grant was awarded, during the useful life of the project determined pursuant to NR 50.09(8), Wis. Admin. Code. Such Grant Capital Improvements include but are not limited to bridges, culverts, gates, buildings, and shelters.

As a condition to receipt of this grant, Sponsor shall enter into a written agreement (the Agreement) with the landowner or landowners, and all successive landowners, over which the Grant Capital Improvement rests or to which the Grant Capital Improvement is installed (Landowner), that specifies the sponsor as the owner of the Grant Capital Improvement. The Agreement must also allow for the removal of the Grant Capital Improvements if permission for the placement of the Grant Capital Improvement is withdrawn by the Landowner, or if the Grant Capital Improvement is used in a manner inconsistent with the type of use for which the grant was awarded, during the useful life of the project determined pursuant to NR 50.09(8), Wis. Admin. Code.

If conversion or approval of conversion to any use inconsistent with the type of use for which the grant was awarded by the Sponsor occurs, the Sponsor shall reimburse the Department for the pro rata value of the remaining life of the Grant Capital Improvement.

If the Grant Capital Improvement cannot be removed upon withdrawal of placement permission from the Landowner during the useful life of the project determined pursuant to NR 50.09(8), Wis. Admin. Code, the Sponsor shall reimburse the Department for the pro rata value of the remaining life of the Grant Capital Improvement.

If the Grant Capital Improvement is used in a manner inconsistent with the type of use for which the grant was awarded during the useful life of the project determined pursuant to NR 50.09(8), Wis. Admin. Code, the Sponsor shall reimburse the Department for the pro rata value of the remaining life of the Grant Capital Improvement.

GENERAL BRIDGE DESIGN

General bridge design considerations

Permanent bridges should be site-specific designed to meet the appropriate minimum loading requirements specified below. Anticipated maintenance and grooming needs should be considered when the bridge is being designed. Normally bridges designed for snowmobiling and all-terrain recreation purposes vary from 8 to 12 feet in width depending on the equipment used, the span of the bridge, and whether the bridge is in conjunction with an abandoned railroad grade.

Wearable Surfaces

In cases where excessive deck wear may occur as a result of studded tracks, it is advisable that a wearable/replaceable surface be applied to the deck to protect the integrity of the structure. These surfaces can vary from a removable (temporary) surface like conveyor belt material, to nominal 2" thick (i.e.: 2x8, 2x10, or 2x12) material running along the travel paths of the deck surface to a more permanent solution like a redundant deck system, placed on the existing supporting deck.

Please Note!

Construction and placement of removable bridges may be approved by the Department. These bridges must be attached securely to one footing with a flexible type connection to prevent loss during flooding conditions. Consult your local Water Management Specialist for permit details.

Existing bridges such as logging, old highway, or farm bridges may be utilized for snowmobiling or all-terrain vehicle purposes. The project sponsor is responsible for approving the structural adequacy of the bridge structure. Bridges should be at least eight feet wide for two-way traffic. These bridges must be signed in accordance with Department trail signing guidelines.

Where possible, bridges should be sited so that existing banks are not substantially altered in the construction of the bridge approach.

Winter ice crossings may be allowed by the Department with due consideration for user safety and the environment. Determination by department regional staff will be based on factors such as depth of water, stream bottom materials, approaches to the stream, and nature of the stream freeze/flow cycle.

About railings

Under circumstances where depth of water, fast current, or vertical drop from bridge to water surface dictate, railings will be required on either permanent or removal bridges. Similarly, railings may be necessary for culverts under these conditions.

Where railings are judged necessary by the project sponsor, they must be a minimum of 42 inches in height above the deck surface and designed to prevent the passage of an object with a diameter greater than 6 inches. The minimum design loading for the railing shall be 50 pounds per lineal foot (plf), transversely and vertically, acting simultaneously on each longitudinal member. Rail members located more than 5 feet above the deck surface are excluded from this loading requirement. Railing extensions may be highly desirable depending on the type of approach to the bridge.

On bridges where railings are not judged to be necessary **"kicker plates"** or other low retaining devices must be fastened to the deck. These plates shall be at least of a nominal 2"x6" material and run the entire length of the deck surface on both sides as to provide guidance within the deck surface.

Bridge Design

Generally, when a permanent bridge is open for off-season pedestrian use, railings should be provided. If the bridge is closed to off-season use, properly signed, and barricaded, railings may not be necessary.

Bridge and culvert crossings should be signed with the standardized reflective black and yellow hazard markers. Used in pairs, the hazard markers delineate an opening through which the trail user must pass. Markers should be placed on each end rail of the bridge or on separate posts if the bridge is not railed. Each hazard marker of the pair is placed with alternate black and yellow 45 degree diagonal stripes facing down and in toward the center of the bridge or culvert. (Please consult page 10 of the Trail Signing Handbook for examples)

Engineering Design Requirements

The following are engineering design requirements for bridge structures that are placed on approved snowmobile or all-terrain vehicle trail systems. The guide is intended to apply to bridges that are not a part of highway/vehicular road systems. This guide is to apply equally to all bridge types and construction materials, including steel, concrete and wood. This guide allows for the use of the *Service Load Design, Strength Design (Load Factor Design) or Load Resistance Factor Design Methods*:

Design Methods

Footings/substructure

- Bridge footings must be designed to support design deck (live) loads and structure (dead) loads.
- Footings shall extend a minimum depth of below frost penetration and preferably below stream bed level. Footing design may vary with soil types.

Design Loads

Dead Loads (DL):

- Loads respective to the bridge system/superstructure

Live Loads (LL):

Pedestrian Load (PL):

- For Main and Secondary Members

This load shall be applied to those areas as to produce the maximum stress in the member being designed.

- PL = 60 psf

Snow Load (SNL):

This load will vary depending on geographical location and required trail "snow pack":

- Columbia County to WI/ILL border = 30 psf
- Waushara County to Columbia County = 40 psf
- Marathon County to Waushara County = 50 psf
- Bayfield County to Marathon County = 60 psf

Vehicle Load ("design vehicle", VL):

- These bridges shall be designed for an occasional single maintenance vehicle load, also know as the "design vehicle".
- **Design Vehicle**: This is the design load expected on the bridge deck due to routine trail/bridge maintenance and use. Loadings shall be based on "typical" equipment *train weight* (using individual weight, width and wheel or track spacing loading). The agency accepted design vehicle load shall be **14,000 lbs**.

LOAD COMBINATIONS FOR DESIGN

Wind Load:

- The bridge must be designed to withstand a horizontal wind force of 20 pounds per square foot (psf) applied on the net projected vertical surface.

Combination of Loads for design:

- The two load combination formulas to be used for design are below. ***The designer must use the formula*** *that will create the maximum stress in the member or members being designed:*

DL + .80 * (PL + SNL + WL)

OR

DL + .75 * (SNL + WL + VL)

Design Details

- The allowable deflection of the bridge spans due to uniform live load shall be L/360 for any bridge type. This specified deflection value is more liberal than highway or even AASHTO pedestrian bridge value, recognizing the actual live load needed to approach or achieve the maximum deflection will be infrequent and applied far more gradually than typical vehicular loads.

- Minimum Metal Thickness: Closed structural tubular members shall be a minimum of ¼".

- Welded Tubular Connections: Welded tubular connections shall be designed in accordance with the Structural Welding Code – Steel ANSI/AWS D1.1

- Bridges constructed above the 100 year flood elevation should be anchored to the footing securely enough to prevent shifting due to the wind loading given above.

- Bridges constructed that extend below the 100 year flood elevation should be anchored to the footing securely enough to prevent shifting due to the wind loading given above plus the loading caused by flood water flowing past the bridge. The force due to the water flowing past the bridge can be figured using the formula.

  Force (in pounds) = $3.9\ AV^2$
  Where A = projected vertical bridge area in flow and
  V = velocity of water in feet per second

Please Note!

These requirements do not release the project sponsor from the potential for failure of a bridge structure due to the use of improper construction techniques or inadequate or substandard construction materials. The bridge shall comply with all applicable Floodplain and Shoreland Zoning standards. It is advisable to consult your local County Zoning office prior to applying for grants.

Design Vehicle Load Signage

All new, replacement or structurally modified bridges shall have a sign posted as to their *greatest load carrying capability* at both ends of the structure a minimum of 4 feet from the ground. ***An example:*** *A bridge designed using the 14,000 lb design load* ***and*** *the overload provision of 20,000 lb – shall be posted at 20,000 lbs.*

ILLUSTRATIONS

Illustrations

The following pages contain tables and diagrams that deal with:

- 40' (or less) Wooden bridges with clear (unsupported) spans up to 20 feet in length
- 40' (or less) Steel clear (unsupported) span bridges using wide flange "I" beams for the superstructure.

Please Note!

It is the project sponsor's responsibility to verify the structural adequacy of these bridges and their corresponding bridge components (abutments, piers, railings, etc.) and the existing or modified conditions (soil types, stream bank, etc.) or if deemed appropriate, contract for such professional services.

Wood Pole Bridges (40' or less)

Based on the loading requirements specified within this guide

8' Wide Bridges

**Span	2 pole	3 pole	4 pole	5 pole	6 pole
10'	*10" diameter	8"	8"	7"	7"
12'	11"	9"	9"	8"	7"
14'	11"	10"	9"	9"	8"
16'	13"	11"	10"	9"	9"
18'	14"	12"	11"	10"	9"
20'	15"	13"	11"	10"	10"

10' Wide Bridges

**Span	3 pole	4 pole	5 pole	6 pole
10'	*9" diameter	8"	8"	7"
12'	10"	9"	9"	8"
14'	11"	10"	9"	9"
16'	12"	11"	10"	9"
18'	13"	12"	11"	10"
20'	14"	12"	11"	11"

12' Wide Bridges

**Span	3 pole	4 pole	5 pole	6 pole
10'	*10" diameter	9"	8"	8"
12'	11"	10"	9"	9"
14'	12"	11"	10"	9"
16'	13"	12"	11"	10"
18'	14"	12"	11"	11"
20'	15"	13"	12"	11"

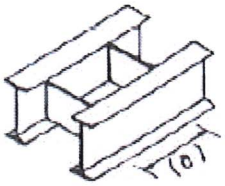
* Diameter dimension: is the smallest measurable dimension along the entire pole length
** Span = ***Longest*** unsupported length, not necessarily total bridge length

Note: 2 layers of decking material used:

- Top coarse as a wear course only (2" nominal thickness)
- Bottom coarse to be support related (2" Full thickness)

Steel "I" Beam Bridges (40' or less)

Based on the loading requirements specified within this guide



Example: 8W10
8: indicates the depth of the beam, this case: 8"
10: indicates the weight in pounds per foot, this case: 10 lbs/foot
(a): indicates maximum spacing (in feet) for lateral support of "I" beams (limit buckling, etc)

8' Wide Bridges

**Span	2 beam	3 beam	4 beam
20'	12W14 (3.5)	10W11.5 (3.8)	8W10 (4.2)
25'	12W19 (4.2)	12W14 (3.5)	10W11.5 (3.8)
30'	12W22 (4.3)	12W16.5 (4.1)	12W14 (3.5)
35'	14W26 (5.3)	12W19 (4.2)	12W16.5 (4.1)
40'	14W30 (7.1)	14W22 (5.3)	12W19 (4.2)

10' Wide Bridges

**Span	2 Beam	3 Beam	4 Beam	5 Beam
20'	12W16.5 (4.1)	12W11.8 (2.7)	10W11.5 (3.8)	8W10 (4.2)
25'	12W22 (4.3)	12W16.5 (4.1)	12W14 (3.5)	10W11.5 (3.8)
30'	14W26 (5.3)	12W19 (4.2)	12W16.5 (4.1)	12W14 (3.5)
35'	14W30 (7.1)	14W22 (5.3)	12W19 (4.2)	12W16.5 (4.1)
40'	18W35 (6.3)	14W26 (5.3)	12W22 (4.3)	12W19 (4.2)

12' Wide Bridges

**Span	2 Beam	3 Beam	4 Beam	5 Beam	6 Beam
20'	12W19 (4.2)	10W19 (4.2)	10W15 (4.2)	6W25 (6.4)	6W20 (6.4)
25'	14W26 (5.3)	14W22 (5.3)	12W19 (4.2)	12W14 (3.5)	8W21 (5.6)
30'	16W31 (5.8)	14W26 (5.3)	14W22 (5.3)	12W22 (4.3)	10W22 (6.1)
35'	18W35 (6.3)	14W34 (7.1)	14W30 (7.1)	12W26 (6.9)	14W22 (5.3)
40'	18W46 (6.4)	14W48 (7.2)	14W38 (7.1)	14W30 (6.0)	14W26 (5.3)

** Span = ***Longest*** unsupported length, not necessarily total bridge length

APPENDIX

The following pages contain a list of:

- Capital Improvement Ownership Acknowledgement Agreement Example
- example of an Access Easement
- sample easement description
- capital improvement ownership acknowledgement
- cost saving ideas

Example - **Capital Improvement Ownership Acknowledgement** - Example

I, _____, as landowner, agree that the Capital Improvement
(name)

described as _____, that is proposed to be installed by
(bridge, culvert, etc.)

_____ on land owned by me, described as
(name of installer)

located on the _____, in the _____1/4 of the _____1/4
(waterbody)

of Section _____, Township _____ (N), Range _____ (E, W), Town

of _____, _____ County,
(Town name) (County name)

is owned by _____ County.

_____ _____
(Landowner or Representative) (Date)

_____ _____
(Representative of the County) (Date)

Example - **EASEMENT** - Example

KNOW ALL MEN OF THESE PRESENTS, that the undersigned, _____, for One Dollar and other good and valuable consideration, the receipt of which is hereby acknowledged, does hereby grant, sell and convey unto _____ County, Wisconsin, its successors and assigns, a permanent easement to maintain, repair, replace and/or remove a bridge used for recreational vehicles to cross _____ that is located on the property described as follows:

[LEGAL DESCRIPTION]

It is intended by these presents to grant unto the County of _____ the perpetual right to maintain, repair, operate, inspect, replace and remove a the aforementioned bridge located on the above described property with the right of ingress and egress to and from the same, to make such repairs, changes, alterations, improvements, removals from, substitutions and additions to said bridge as Grantee may from time to time deem advisable.

IN WITNESS WHREOF, _____ have set their hands and seals this

_____ day of _____, 20__.

_____ Typed Name

_____ Typed Name

ACKNOWLEDGEMENT

STATE OF WISCONSIN)
) SS
COUNTY OF _____)

I, _____, a Notary Public in and for the above County and State, hereby certify

that on this _____ day of _____, 20___, before me personally appeared

_____ to me well known to be the person who executed the foregoing

instrument and acknowledge the same.

_____

Notary Public, _____ County, WI

My Commission Expires: _____

THIS INSTRUMENT DRAFTED BY ATTORNEY PAUL B. MILLIS
Courtesy of Jackson County Forestry

Cost Saving Ideas

- Look thoroughly up-stream and down-stream for the best crossing location. The original site might not be the best.
- Consider culverts instead of bridges in locations with intermittent, small or medium stream flows. Long term maintenance can be minimized with proper culvert sizing and installation. Blockage of culverts by beaver is a potential problem.
- Have your DNR Water Management Specialist look at the proposed site and agree on how the project should be done before you start detailed planning, before you request a water permit and before you apply for funding. A clear span bridge and no stream or bank disturbance is preferred (their viewpoint is parallel to the stream while yours may be parallel to the trail).
- Build bridges with club labor. Use local contractor assistance, if needed. Use the skills of local club members and keep it simple and safe.
- Eliminate or minimize engineering costs by using pre-engineered plans, pre-engineered kits, prefabricated bridges and non-concrete supports.
- Abutments can be constructed from treated wood instead of concrete.
- Wood bridge supports are easier to remove if the bridge is relocated to another site.
- Prefabricated metal bridges are pre-engineered and are available in long single spans.
- Pre-engineered wood bridge kits, using steel beams are available for on-site assembly.
- Pre-cut, all wood, bridge kits are pre-engineered and require on-site assembly.
- Use rough sawn, pressure treated lumber which is full dimensioned and therefore much stronger than smooth finished nominal dimensioned lumber. The bending strength of 2 inch rough sawed material is over twice as strong as nominally sized 2 inch planed material.
- Rough sawn hardwood such as white oak is tougher and longer lasting than treated pine.