4.4 Design Requirements for Crossings, Including Bridges & Major Culverts

4.4.1 Project & Design Responsibility & Considerations

A “bridge” includes the superstructure, substructure, connections, approach road fills, and scour protection works. A “major culvert” includes the culvert materials, compacted bedding and backfill, embedment materials for embedded culverts, scour protection, and the roadway.

Where pertinent in the design of any bridge or major culvert, consider:

- user safety;
- accommodation of pedestrian traffic where required;
- site selection, including assessment of stream geomorphology and geotechnical (global and local) considerations;
- environmental integrity;
- fish habitat and fish passage;
- impact of the proposed structure on the stream during and after construction;
- site revegetation requirements;
- structure alignment and location (vertical and horizontal) relative to the road and stream channel;
- complete structure combination (substructure, superstructure, connections, and scour protection);
- suitability of selected foundations for the specific site;
- design flood development;
- navigation (*Navigable Waters Protection Act*), if applicable;
- debris potential and passage;
- scour protection;
- design vehicle configuration for load and alignment;
- design traffic frequency;
- design service life influence on selection of bridge type and composition;
- construction layout, methodology, and timing; and
- economics.

The design of bridges and major culverts encompasses more than just the design of structural components. Consider the composition and interaction of all the components, as well as their relationship and impact on not only the users, but also on the road and stream components and other resources.

A key concept in a successful project is continuity of professional oversight and output reviews. The professional that is charged with retaining a close familiarity with the progress of the project, and with coordinating the various specialist inputs, is known as the Coordinating Registered Professional (CRP), who carries overall responsibility for the delivery of the professional aspects of the project.

Guidelines for Professional Services in the Forest Sector - Crossings (PDF) describes the roles and responsibilities of the CRP related to bridge planning as follows:

- confirm that the necessary assessments for the project have been completed;
- utilize specialists in the planning;
- gather site information, including the site plan and other information;
- take overall responsibility for the conceptual plan and general arrangement drawings;
- address environmental considerations in the plan;
- coordinate activities relating to the crossing project in the context of the overall development;
- understand all generally accepted uncertainties inherent in the crossing project and assumptions made in relation to the project, including assumptions made by the specialists;
- have an understanding of the roles and responsibilities of all the people involved in the planning of the crossing project; and
- consider information received from specialists and where appropriate incorporate the information into the plan.

To address these planning issues, the CRP ensures that a qualified professional has addressed the need, if any, for specialist assessments for a new bridge or a bridge replacement, including those as part of a BCTS road site plan for new construction as described in FRPA, to provide results and strategies to meet the objectives of the FSP. In practical terms for bridges and major culverts, this means a map showing the proposed road location (and approximate crossing locations) together with the results of any specialist assessments that may have been required along or adjacent to the road, such as:

- riparian;
- fisheries values;
- wildlife corridors;
- archaeological;

- terrain stability;
- soil and sediment transport;
- visuals;
- invasive plants;
- range barriers;

and how they might impact the selected road (and hence) crossing location. The CRP uses the results of the assessment information to determine:

- what if any additional information may be required for the bridge crossing; and
- how to implement the bridge project to address the assessment outcomes.

The CRP undertakes the subsequent engineering project-specific roles and responsibilities such as carrying out or overseeing the preparation of the conceptual and final design and drawings, acquisition of materials and construction of the structure. Finally, the CRP will complete the general conformance sign-off and preparation of as built drawings.

For the CRP to practice due diligence with respect to the project operations and oversight, the CRP determines that any specialists involved in the bridge project:

- are qualified to do the work;
- are used in an appropriate manner; and
- have access to any project information and to any other project personnel.

The Crossing Guidelines provide limitations as to the types of bridges (simple crossings) that may be undertaken by an RPF as the CRP. The bridge elements that may be restricted include footings, substructures and superstructure types. However, the bridge types can generally be characterized as single, simple span log stringer or other short span non-composite superstructures on cribs <4m high or interlocking concrete blocks < 2m high. The usual scenarios for bridge projects are described below. Ensure that the CRP meets the qualifications described in the skill set for simple crossings, and those additional qualifications described in the Engineering Equipment and Services (EES) Directory for more complex crossings.

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Scenario 1: Where a P.Eng will be the CRP for a bridge

The CRP has addressed the need, if any, for specialist assessments for a new bridge or a bridge replacement, or in a BCTS road site plan for new construction as described in FRPA, to provide results and strategies to meet the objectives of the FSP. A Professional of Record, who is a P.Eng and may or may not also be the CRP, carries out some or all of the subsequent engineering project-specific roles and responsibilities, including:

- the preparation of the conceptual design and general arrangement design drawings;
- quality assurance of materials fabrication;
- construction inspections;
- addressing required design revisions that become evident during construction;
- compiling materials and construction documentation; and
- preparation and sign-off of as-built drawings and statement of construction conformance.

Those items not carried out by the POR are done by the CRP, and the CRP signs off that the completed crossing structure has adequately addressed any other resource issues that were identified at the outset of the project.

Scenario 2: Where a forest professional will be the CRP for log stringer bridge superstructures

The CRP has addressed the need, if any, for specialist assessments for a new bridge or a bridge replacement, or in a BCTS road site plan for new construction as described in FRPA, to provide results and strategies to meet the objectives of the FSP.

The CRP uses design aids as required for stringer arrangement and sizing, needle beam sizing where appropriate, lashing of stringers and connections to sills or caps, placement, arrangement and sizing of crib members or concrete block sills

The CRP is responsible for:

- the preparation of the conceptual design and general arrangement design drawings;
- construction inspections;
- addressing required design revisions that become evident during construction;
- compiling construction documentation; and
- preparation and sign-off of as-built drawings and statement of construction conformance.

Scenario 3: Where a forest professional will be the CRP for re-use of portable bridge superstructures

The CRP has addressed the need, if any, for specialist assessments for a new bridge or a bridge replacement, or in a BCTS road site plan for new construction as described in FRPA, to provide results and strategies to meet the objectives of the FSP.

The CRP ensures that a professional engineer has carried out the design analysis to ensure adequacy for the intended use, and the structure has been inspected before re-use by a qualified inspector.

If any additional structural analysis is to be carried out by a professional engineer due to any potential issues raised by the inspection prior to re-use, that engineer will generally be the POR and as such will likely provide the necessary drawings, specifications, connection details, etc. for any structure that requires remedial work prior to re-use.

The CRP uses design aids as required for placement, arrangement and sizing of crib members or concrete block sills.

CRP is responsible for:

- the preparation of the conceptual design and general arrangement design drawings;
- construction inspections;
- addressing required design revisions that become evident during construction;
- compiling construction documentation; and
- preparation and sign-off of as-built drawings and statement of construction conformance.

Scenario 4: Where a forest professional will be the CRP for other short span steel girder bridge superstructures

The CRP has addressed the need, if any, for specialist assessments for a new bridge or a bridge replacement, or in a BCTS road site plan for new construction as described in FRPA, to provide results and strategies to meet the objectives of the FSP

A POR who is a P.Eng carries out (under the project oversight of the CRP) the subsequent engineering project-specific roles and responsibilities, including:

- the preparation of the conceptual design and general arrangement design drawings;
- quality assurance of materials fabrication;
- construction inspections;
- addressing required design revisions that become evident during construction;
- compiling materials and construction documentation; and
- preparation and sign-off of as-built drawings and statement of construction conformance.

Note that if the superstructure is composite, the POR or another professional engineer will necessarily become the CRP, in accordance with the Crossing Guidelines.

The CRP signs off that the completed crossing structure has adequately addressed any other resource issues that were identified at the outset of the project.

Bridge and major culvert construction drawings for any FS project (including those structures built under Road Permit (BCTS) and designated in that permit to be an FS structure to be used for harvesting after completion of the Timber Sale License) **must** be signed and sealed by one or more professionals, to clearly identify the CRP and/or Professional/Professionals of Record (POR). The POR is usually the structural/design engineer, but in some complex projects with two or more contributing engineers (such as geotechnical, river engineering, etc.), each of those participants can be designated as a POR. A POR can also be responsible for the overall general arrangement drawings, as described in Scenario 4 above.

If the CRP has prepared the conceptual design and general arrangement drawings, the CRP will sign and seal those drawings. Where a designer working for the supply/erect contractor will prepare structural drawings, that engineer will be the POR for that work. In consultation with a Ministry Engineer, consider having the professional that will carry out the field review for general conformance with the design and drawings complete and submit for review the proposed Assurance of Field Reviews FS 137 along with the construction drawings.

4.4.2 Skill Set for CRP for Simple Crossings

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Knowledge requirements

1. be members in good standing with ABCFP or APEGBC;
2. have appropriate education, training and experience within the discipline of forestry or engineering that are congruent with CRP bridge design services;
3. have considerable recognized specialization in the layout and conceptual design of forest road bridges;
4. be familiar with forest road and bridge planning, construction considerations and techniques, design vehicle configurations and assessment, scour and scour protection, design flood hydrology determination, and bridge component properties and fabrication;
5. be thoroughly familiar with the Guidelines for Professional Services in the Forest Sector – Crossings (PDF) prepared by the Association of Professional Engineers and Geoscientists of British Columbia and the Association of BC Forest Professionals;
6. be thoroughly familiar with stream crossing requirements and procedures of the Department of Fisheries and Oceans Canada and the British Columbia Ministry of Environment;
7. have a working knowledge of related riparian and aquatic environmental issues (such as stream classification and fish passage requirements) and associated construction mitigation techniques;

8. have a working knowledge and understanding of the principles and best management practices related to stream crossings provided in the following publications:

    - Forest Practices Code of BC Forest Road Engineering Guidebook (June 2002) (PDF, 7.61 MB)
    - Forest Practices Code of BC Fish-Stream Crossing Guidebook (PDF, 4.2MB)
    - Forest Practices Code of BC Riparian Management Area Guidebook
    - Forest Practices Code of BC Fish-Stream Identification Guidebook (PDF)

Experience requirements

All CRPs require a minimum of 8 years of direct bridge experience in forestry or related industries in British Columbia within the past 10 years, including at least three years of professional experience at a level contemplated by the Crossing Guidelines. Such work experience includes:

1. Preparation of conceptual designs of forest road bridges, including analysis for log, timber, and steel components.
2. Development of general bridge arrangement drawings with consideration for:

    - design flood estimation;
    - design flood and debris passage;
    - bridge configuration alignment in relation to the road and stream;
    - road approach and alignment considerations;
    - crossing alignment to the stream;
    - scour and scour protection;
    - substructure and connection component alternatives including consideration for geotechnical conditions and construction parameters;
    - cost effectiveness of bridge options;
    - construction equipment and practices in the forest sector.

1. Preparation of reports, drawings, specifications and cost estimates.
2. Field reviews during construction of bridges to provide quality assurance and confirmation of conformance to drawings and specifications, including:

    - field monitoring of construction activities during critical phases;
    - assessing actual field conditions for consistency with design assumptions and recognized “changed conditions”;
    - assessing alternatives, and providing revisions to designs for “changed conditions”;
    - preparing as-built drawings, and providing statements of construction conformance.

4.4.3 Development & Use of Professional Engineer Forest Road General Arrangement Bridge Design Aids

Design aids may be utilized by qualified individuals producing general arrangement forest road bridge designs. The “Guidelines for Professional Services in the Forest Sector – Crossings”, Section 3.1, “Simple Crossings” requires where the Coordinating Registered Professional (CRP) is a Registered Professional Forester that - “plans **must** be prepared using structural details provided in drawings, tables, charts and other design aids that have been prepared by a Professional Engineer”.

These guidelines are applicable to: a CRP, an individual working in support of a CRP, a limited license holder with the Association of Professional Engineers and Geoscientists of BC, or anyone taking responsibility for a bridge general arrangement design and is utilizing design aids.

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Definition and content of a design aid

A design aid is a tool, produced by a professional engineer, which will provide an unambiguous result tied to clear parameters, and can be applied to a site-specific situation. An example of a design aid is a log stringer design table specifying log stringer diameters, subject to species and other identified limitations, for particular spans for specific design loads. A manual such as the FPINNOVATIONS Log Construction Handbook is not considered a design aid because a manual cannot be applied to a specific situation. However, individual stringer tables within that manual may be design aids.

When preparing design aids, a professional engineer should clearly state:

- the intended purpose, authorized users and application for the design aid;
- requirements and restrictions for those using the design aid (such as specific material or site conditions, specific aspects requiring higher level oversight, materials or connection requirements);
- assumptions made; codes referred to; and where applicable, Factors of Safety used in producing the design aid;
- limitations for application of the design aid;
- the name of the professional engineer having professional responsibility for the design aid; and
- except for those design aids in the public domain, the signature and seal of the professional engineer having professional responsibility for the design aid, the date the design aid was signed, and a date when the design aid is not longer valid (as applicable).

Use of design aids

A person should undertake the following best professional practices when using a design aid produced by others:

- are authorized by the “owner” of the design aid to use the design aid (note that some tables such as FPINNOVATIONS or Ministry log stringer tables are in the public domain; otherwise, the design aid is usually proprietary and often intended to be used only for client- specific applications);
- have discussed the design aid with the professional engineer that created the design aid to ensure that the individual using the design aid understands the limitations of the design aid and to ensure that they have the latest applicable version of the design aid;
- reference the specific design aid(s) in drawings and documentation when used for specific projects;
- provide copies of the design aid(s) used (that are not in the public domain) with the design documentation provided to the client; and
- seek specialist assistance (usually from a professional bridge engineer) when applicability of the design aid is in question or unforeseen circumstances make the design aid not applicable or questionable.

4.4.4 Typical Bridge Design Approach

Bridge and major culvert designs and construction approaches for FSRs have evolved into industry standards. Typical details and arrangements are described in the Forest Service Bridge Design and Construction Manual and in guidelines and requirements for ministry bridges. The most common components have been structurally pre-engineered and are well known by bridge designers, fabricators, and erectors.

Ensure that practitioners in bridge and major culvert design for FSRs meet established skill sets. Refer to the skill set for simple crossings and the Engineering Equipment and Services (EES) Directory for more complex crossings.

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Forest Service Bridge Design & Construction Manual

The Forest Service Bridge Design and Construction Manual drawings include ministry-approved component configurations and details. Detailed designs for various components, such as concrete decks, slab girders, and various footing arrangements, are also provided in

the manual.

As well, the manual lists proprietary bridge components (consisting of conceptual drawings with minimal details) that have been approved by the ministry. Proponents whose proprietary systems have been accepted by the ministry have provided proof that their components will meet the stringent requirements laid out in the manual for structural integrity, durability, and other relevant aspects pertaining to the product's usage.

Design implementation process

Where the maintainer of an industrial use FSR will replace a bridge or major culvert on that road under a Road Use Permit, ensure that the District Manager, in the conditions for that crossing structure:

- provides mandatory site specific design and construction requirements to the maintainer; and
- directs the maintainer to submit the completed construction drawings for review and approval prior to commencing construction.

For most other situations, utilize the following bridge or major culvert design implementation process:

- in consultation with a Ministry Engineer, determine the design parameters for a bridge or major culvert structure (see Appendix 4.3 DESIGN CHECKLIST) and determine whether the conceptual designer will be the Ministry Engineer or a consultant professional engineer retained by BCTS/District; as described earlier, this person will normally be the CRP;
- convey the design parameters and the performance requirements for the crossing to the conceptual designer;
- have the conceptual designer conduct a site visit and make note of the physical site parameters, including observations on design flood hydrology, foundation evaluation, vertical and horizontal alignment and crossing location opportunities, and construction limitations (such as equipment and materials access);
- have the conceptual designer evaluate the options for the crossing given the available information and make a recommendation for the development of a site plan and oversee its completion (generally a detailed site plan for all but the simplest crossings [see Site Data & Survey Requirements for Bridges & Major Culverts].

Note that in the above scenario, the Ministry Engineer may undertake the conceptual design and become the CRP for the project, should time and resources permit.

Conceptual design / general arrangement drawings

A conceptual design illustrates how the proposed crossing structure addresses the site-specific operational requirements. Typically, the general arrangement drawings consist of one or more drawings showing the components and configuration of the proposed bridge or major culvert crossing, as well as construction details overlain on a site plan and profile [see Construction Drawings & Specifications], making reference to specific ministry standard drawings and details laid out in the Forest Service Bridge Design and Construction Manual.

Ensure that the conceptual designer signs and seals the General Arrangement drawings.

Detailed structural design

For all but the most complex structures, a detailed structural design is typically not completed as part of the development of general arrangement designs. The final superstructure arrangement is best left to the fabricator or erection contractor, who can provide the most cost-effective and efficient design based on their materials availability and erection schemes. As part of the design/build process for the typical, simply supported forest road bridge structures, the detailed structural design of the superstructure components are completed by the bridge fabricator or the contractor who is the successful bidder to construct the bridge. In such cases, the contractor's or fabricator's engineer will normally be the structural POR, and the professional that prepared the conceptual design will be the Coordinating Registered Professional (CRP) as described earlier in this chapter.

4.4.5 Design Opening

Base the design flood requirements for bridges and major culverts on the anticipated life of the structures. Structures to be in place for a relatively short life pose reduced risks (compared with those expected to have longer life), and thus reduced design flood concerns can be considered.

In addition to design flood passage, make allowances for anticipated debris. For bridges, incorporate freeboard above the design highwater to allow for passage of floating debris. In the case of major culverts, also accommodate debris (floating or submerged) in the design process.