Forest Practices Board

Bridge Planning, Design and Construction

Special Investigation

FPB/SIR/38

March 2014

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Board Commentary

The Forest Practices Board is concerned with the growing number of non-compliances showing up in recent audit reports,[i] and is very concerned about how many of those non-compliances involve unsafe bridges. Based on these audit results, the Board undertook a special investigation of bridge planning, design and construction. Over the 2013 field season, the Board examined 216 bridges built on resource roads since January 2010 in five districts around the province.

The investigation focused on safety, protection of the environment and planning. Results were variable across the five districts and amongst builders.

Of significant concern to the Board are the poor safety results. Nineteen bridges were obviously unsafe and investigators had serious safety concerns with a further 13 bridges. Overall, only 85 percent of these new bridges were deemed safe. Investigators informed all affected licensees about these unsafe bridges. The Board expects these licensees to be diligent and ensure these known bridge deficiencies are corrected prior to any further industrial use, as required by legislation.[ii]

While most builders are adequately protecting the environment, there were problems found with planning. Plans must be complete and accurate and a qualified professional must take responsibility for a bridge. Only 60 percent of bridges had complete plans and there was no professional assurance that 73 bridges were planned and built adequately.

This is unacceptable.

Both professional engineers and professional foresters may be involved in planning and constructing bridges on resource roads. In exchange for the right to practice, these professionals must comply with the law and with professional practice guidelines to ensure that they fulfill their professional obligations to protect the safety, health and welfare of the public and the environment. This is called professional reliance.

The professional associations have provided professional practice guidelines for bridge planning, design and construction to their members, but not all licensees and professionals are following it.

In accordance with section 131(2) of the *Forest and Range Practices Act*, the Board is making the following recommendation:

> The Board requests that the Joint Practices Board of the Association of BC Forest Professionals and the Association of Professional Engineers and Geoscientists of British Columbia advise it of the steps planned or taken to address the professional practice issues identified in this report by October 31, 2014.

The Board views these findings as a reasonable sample of what is happening throughout the province and it expects all licensees to exercise due diligence to ensure that resource road bridges are safe. Based on these findings, the Board also expects that the Compliance and Enforcement Branch of the Ministry of Forests, Lands and Natural Resource Operations will increase its attention to the integrity of bridges.

This report is a wake-up call to those who are not complying with the law or the professional practice guidelines. Due to the potentially significant consequences, there are no corners to cut when it comes to bridge design, planning and construction. The public and government expect and deserve high safety, environmental and professional standards, but those standards are not currently being met.

Introduction

Bridges are an essential part of British Columbia's resource road network. Each year, government, resource industries and utilities build bridges on Crown land. These bridges are used by both industry and the public to access resources and recreational opportunities and to connect remote communities.

Through the Board's annual compliance audits, many new bridges are assessed each year. While the majority of these bridges are well designed and well constructed, some are not.

A well-constructed bridge.

A poorly constructed bridge identified in a Forest Practices Board audit.

Over the past several years, the Board has identified significant safety and environmental issues with newer bridges through its audits. A summary of the more recent issues with bridges built since January 2010 appears in Appendix 1.

In early 2013, the Board, in collaboration with the Joint Practices Board (JPB) of the Association of BC Forest Professionals (ABCFP) and the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC), decided to conduct a special investigation of bridge planning, design and construction.[1] The investigation examined whether the parties who plan, design and construct bridges are meeting legislated requirements and conforming to standards of professional practice. In other words, the Board set out to determine if new[2] bridges are safe for industrial use and if forest resources such as water, soil and fish are being protected.

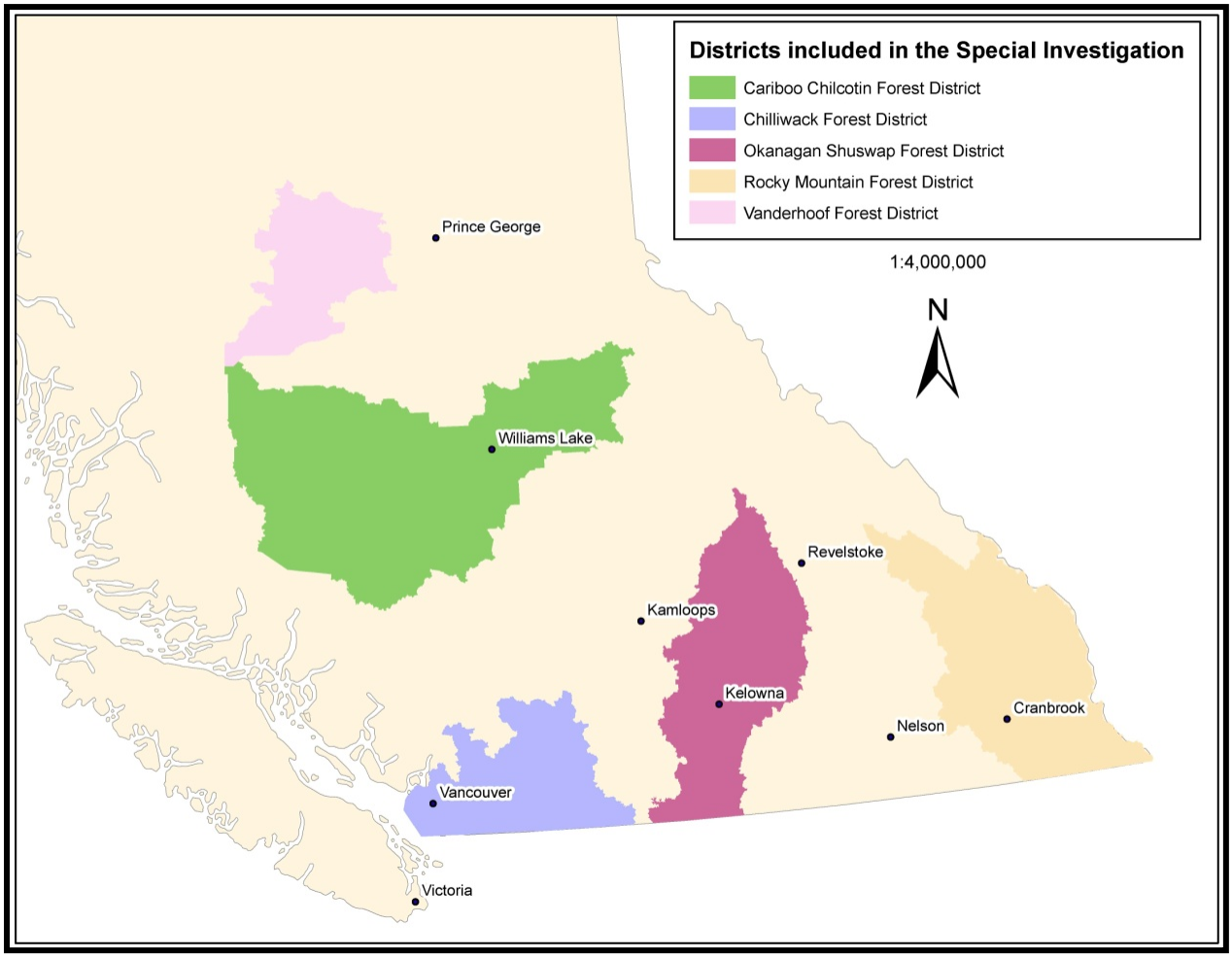
This is the Forest Practices Board's report on the results of the investigation.

[1] Information obtained through the course of this investigation regarding the standards of professional practice identified on specific sites will be compiled by the JPB representative and any further follow-up regarding professional practice will be at the Associations' discretion.

[2] While structures may be newly installed, some components may be reused.

Scope

The investigation included all bridges constructed since January 1, 2010, by government and licensees in five districts – Chilliwack, Vanderhoof, Rocky Mountain, Okanagan Shuswap and Cariboo Chilcotin.



Approach

In spring 2013, the Board informed licensees and government within the five districts about the investigation and compiled a list of bridges built since January 1, 2010. The Board then requested any available planning documents, record drawings (formerly called as-built drawings)[3] and crossing assurance documents for those bridges.

Board staff reviewed all available documentation and then teams consisting of a professional forester and a professional engineer visited the bridges during the summer and fall. The teams evaluated compliance with regulatory requirements and also conformance with applicable professional practice guidelines. The criteria used to evaluate the requirements are explained below.

[3] A record drawing is a record of what was built at the site, including any revisions made to the original plan.

Legislative Framework and Standards of Professional Practice

Bridge planning, design and construction on resource roads are governed by legislation and are overseen, in most cases, by professional engineers and professional foresters. The *Forest and Range Practices Act* (FRPA), the *Forest Planning and Practices Regulation* (FPPR) and the *Woodlot Licence Planning and Practices Regulation* (WLPPR) specify certain requirements for the planning, design and construction of bridges. In general, these requirements are aimed at ensuring bridges are safe for industrial users and that forest resources such as water, soil and fish are protected.

The JPB of the ABCFP and the APEGBC has developed guidelines for professional practice for bridge projects. These *Guidelines for Professional Services in the Forest Sector–Crossings*[4] were first released in 2005 and revised in 2008. These guidelines are currently under review by the JPB and a new version is expected shortly after release of this report.

The general requirements of the legislation and the professional practice guidelines are discussed below.[5]

Legislation

The FPPR sets out the requirements that must be met for bridge planning, design and construction for resource road bridges on Crown land. The requirements ensure safety for industrial users and protection of forest resources.

The FPPR requirements examined in this investigation are:

- S.39 – natural surface drainage patterns must be maintained
- S.55 – the stream channel and banks must be protected
- S.56 – fish passage must be maintained
- S.57 – activities must not harm fish or damage habitat
- S.72 – bridges must be safe for industrial users
- S.73 – bridges must be designed to meet or exceed applicable standards
- S.74 – bridges must be designed to pass the highest expected peak flows
- S.77 - certain records and as-built/record drawings must be retained

Standards of Professional Practice

The *Guidelines for Professional Services in the Forest Sector–Crossings* are intended to establish standards of practice that members should meet to fulfill professional obligations, including the duty to protect the safety, health and welfare of the public and the environment. Delivery of professional services for a *Crossing* can involve the practice of professional forestry and professional engineering. The *Foresters Act* includes, within the definition of the practice of professional forestry, "planning, locating and approving forest transportation systems including forest roads". The *Engineers and Geoscientists Act* includes, within the definition of the practice of professional engineering, "design or directing the

[4] A crossing is defined as a forest road bridge or an engineered culvert. A bridge includes the superstructure, substructure, connections, approach road fills, and scour protection works and is greater than six metres in length.

[5] For exact requirements, please refer to the *Forest Planning and Practices Regulation* available at http://www.canlii.org/en/bc/laws/regu/bc-reg-14-2004/latest/bc-reg-14-2004.html and the Guidelines for Professional Services in the Forest Sector – Crossings, available at https://www.apeg.bc.ca/getmedia/65c13c6c-6b68-4d74-aed3-a08965b8558f/APEGBC-Guidelines-for-Forest-Sector-Crossings.pdf.aspx

construction of public utilities, industrial works, railways, bridges ...". There is long-standing historical involvement of *Members* of each profession with respect to *Crossing* projects.

Although these guidelines are not legal requirements, they do set out general standards of professional practice that members of APEGBC and ABCFP must meet. Failure to meet the intent of the guidelines could be evidence of unprofessional conduct. The guidelines also set out standards and responsibilities with respect to qualifications and competencies in the design and construction of bridges in the forest sector.

A key feature of the guidelines is the concept of a *simple crossing*, which recognizes that the design and construction of certain simpler bridges does not always need the specialized expertise of a professional engineer. An appropriately qualified and experienced professional forester may design and build a simple bridge, using design aids prepared by a professional engineer. Although a simple crossing may be less complex than a non-simple crossing, it still must meet the same standards of planning and documentation, including, but not limited to, general arrangement drawings, hydrological flow determinations and channel stability assessments, assessment of the design bearing pressure for the applicable ground conditions and final as-built/record drawings and crossing assurance statements. Detailed structural designs or design aids for the superstructure (either logs or steel) and, in some cases, the substructure must be prepared, signed and sealed by a professional engineer, and these drawings must be referenced in the bridge plan as applicable.

Every bridge must have a coordinating registered professional (CRP) who takes overall responsibility for the coordination of all of the services required for the crossing project. For a simple crossing, the CRP may be a registered professional forester or a professional engineer. For all other crossings, the CRP must be a professional engineer. Regardless of the type of bridge, the CRP should have a good understanding of all facets of planning and designing the bridge.

General arrangement drawings must be signed and sealed by the CRP in all cases and must be defendable and may be subject to peer review. A complete set of plans generally consists of the general arrangement drawings supplemented with the superstructure and substructure details, design parameters and any construction specifications. The CRP must determine that suitable field reviews have been carried out in order to provide the necessary as-built/record drawings and, finally, must sign and seal a crossing assurance statement. The intent is that the assurance statement be finalized prior to vehicles using the bridge. All documentation must be retained and available for review.

Evaluation Criteria

To determine if a bridge met legislative and professional practice requirements, the teams reviewed all available documentation and recorded structural and site conditions on a field inspection form.

S. 39 natural surface drainage patterns: Natural surface drainage patterns were maintained if the bridge and rip rap did not constrict and/or divert the natural channel.

S. 55 protection of banks and channel: Stream banks were adequately protected if they were vegetated and undisturbed or armoured with rock. Disturbance included channel constrictions, increased sediment delivery into the stream and damaged banks and vegetation.

S. 56 maintenance of fish passage: Fish passage was maintained if the bridge did not physically block the stream.

S. 57 protection of fish habitat: In addition to sections 39, 55, and 56 requirements, fish habitat was considered protected if the bridge did not contribute sediment to the stream.

S. 72 safe for industrial use: Teams reviewed the bridge and documentation to ensure the bridge was designed and built to handle the anticipated loads, approaches were safe and the structural components were in good condition. Evidence of abutment erosion, inadequate clearance, inadequate guard rails (also called bull rails) or unsafe approaches were noted as potential safety issues, depending on the severity or risk.

S. 73 bridge design: Designs were reviewed to determine whether they met the applicable standards as well as any indications that the site conditions for foundations and substructures were accounted for (allowable bearing pressures, etc.). Structural components such as stringers, decking and abutments were examined to ensure they met applicable standards.

S. 74 peak flow: Designs were reviewed to ensure that peak flow was considered. In the field, teams assessed the adequacy of the bridge to pass expected peak flows based on observable high water indicators compared to the design information, measured the opening size (underside of the bridge to the channel bed) and reviewed the upstream and downstream channel conditions.

S. 77 records: In addition to having designs that meet standards, a person who builds a bridge must maintain records of the construction, crossing assurance statements and produce an as-built/record drawing which depicts the actual condition of the bridge, as opposed to the general arrangement drawings or proposed conditions.

Population

Overall, the Board examined 216 bridges as part of the investigation. Tables 1 and 2 show the breakdown by district and by builder type.

Table 1. Population by District

District	No. of Bridges
Cariboo - Chilcotin	36
Chilliwack	53
Okanagan -Shuswap	36
Rocky Mountain	56
Vanderhoof	35
Total	**216**

Table 2. Population by Builder

Bridge Builder*	No. of Bridges
BCTS - FSR	16
MFLNRO - FSR	45
Major - FSR	26
Major - RP	105
Other	24
Total	**216**

*BCTS - FSR Built by BC Timber Sales on a forest service road (FSR).
MFLNRO – FSR Built by Ministry of Forests, Land and Natural Resource Operations on a forest service road.
Major - FSR Built by a major licensee on a forest service road.
Major - RP Built by a major licensee on a road permit road.
Other Built by a woodlot licensee, timber sale licence holder, non-replaceable forest licence holder, a holder of a forest licence issued under section 47.3 of the *Forest Act*, or an independent power producer.

Results

The Board chose to show the results of this investigation by district and type of builder, rather than attribute findings to individual licensees. Table 3 shows overall compliance and compliance by geographic district. Table 4 shows overall compliance and compliance by type of builder. Detailed results are provided in Appendix 2. Green indicates above average compliance and red indicates below average compliance.

Table 3 – Overall Results – Compliance by District

		COMPLIANCE BY DISTRICT (%)				
	Overall Compliance (%)	Cariboo - Chilcotin	Okanagan - Shuswap	Rocky Mountain	Vanderhoof	Chilliwack
PLANNING						
Complete plans (s. 73, 77 FPPR)	60	50	92	50	63	53
As-built prepared (s. 77 FPPR)	72	58	78	91	86	47
Accurate as-built (s. 77 FPPR)	84	100	93	82	77	72
Crossing assurance statement (conformance)	66	33	78	89	91	38
Peak flow (s. 74 FPPR)	64	61	58	86	60	49
ENVIRONMENT						
Natural surface drainage maintained (s. 39 FPPR)	89	100	100	68	91	91
Protected banks and channel (s. 55 FPPR)	89	97	100	70	91	91
Sediment control (s. 57 FPPR)	86	94	86	77	89	83
Fish passage maintained (s. 56 FPPR)	99	100	100	95	94	98
SAFETY						
No abutment erosion (s. 72 FPPR)	89	97	97	77	89	85
Safe approaches and alignment (s. 72 FPPR)	93	100	97	77	100	96
Adequate clearance (s. 72 FPPR)	94	100	100	84	94	83
Safe and sound (s. 72, 73 FPPR)	85	89	92	71	86	85

Green = above average, Red = below average

Table 4 – Overall Results – Compliance by Builder

		COMPLIANCE BY BUILDER (%)				
	Overall Compliance (%)	BCTS on FSR	MFLNRO On FSR	Major Licensee on FSR	Major Licensee RP	Other
PLANNING						
Complete plans (s. 73, 77 FPPR)	60	75	87	65	48	46
As-built prepared (s. 77 FPPR)	72	67	87	81	75	25
Accurate as-built (s. 77 FPPR)	84	90	97	71	80	83
Crossing assurance statement (conformance)	66	94	93	81	56	25
Peak flow (s. 74 FPPR)	64	87	93	65	52	46
ENVIRONMENT						
Natural surface drainage maintained (s. 39 FPPR)	89	94	98	96	84	83
Protected banks and channel (s. 55 FPPR)	89	100	98	92	86	79
Sediment control (s. 57 FPPR)	86	87	98	96	80	79
Fish passage maintained (s. 56 FPPR)	99	94	100	100	100	96
SAFETY						
No abutment erosion (s. 72 FPPR)	89	94	93	100	88	75
Safe approaches and alignment (s. 72 FPPR)	93	100	98	88	90	92
Adequate clearance (s. 72 FPPR)	94	100	98	96	94	83
Safe and sound (s. 72, 73 FPPR)	85	87	98	85	81	79

Green = above average, Red = below average

Planning

Inadequate planning is the biggest issue revealed by this investigation. Only 60 percent of the bridges had complete plans; 64 percent of designs considered expected peak flows; and only 72 percent had as-built/record drawings, of which only 84 percent were accurate. From a professional practice perspective, crossing assurance statements were not prepared for a full one-third of bridges. This means that a professional has not taken overall responsibility for the bridge and assured industry and the public that it is safe for use and protects the environment.

Bridge builders in the Okanagan Shuswap, Rocky Mountain and Vanderhoof Districts were above average in meeting planning requirements. Those in the Cariboo-Chilcotin and Chilliwack performed below average.

Compliance with planning requirements was above average for bridges built on forest service roads (FSRs) by either government, BCTS or major licensees. Performance by major licensees on road permit roads and by "Other" licensees was below average.

Environment

In general, builders are complying with the requirements and protecting the environment when installing bridges. The Rocky Mountain district showed below average results, which may be partially explained by the extreme rain event of June 20, 2013 (see Appendix 3). Once again, bridges built on FSRs by government, BCTS and major licensees were above average in terms of maintaining natural surface drainage, protecting banks and channels, controlling sediment and maintaining fish passage.

Safety

The Rocky Mountain and Chilliwack districts showed below average performance with respect to safety issues. Certainly the June 20, 2013, storm event in the Kootenays contributed to eroded abutments and foundation failures, but that was not the only safety issue. Some bridges are being classified as temporary by builders and designed and built to a lower standard, which is not permitted by the legislation (see Appendix 4). The "Other" category of builder showed the poorest results with only 69 percent of bridges considered safe and sound. Bridges on FSRs had the fewest safety concerns.

Overall, 32 bridges had safety issues –19 bridges were not safe and sound and investigators had significant safety concerns with a further 13 bridges.

Conclusion

This investigation set out to determine if new bridges are safe for industrial use and if forest resources such as water, soil and fish are being protected.

Generally, bridge builders are protecting the environment by maintaining natural surface drainage patterns and fish passage, controlling sediment and protecting banks and channels. Some exceptions are noted in this report.

However, safety is an issue. Safety starts with good planning. Bridges must be planned, designed and built to accepted standards by qualified professionals. Complete plans and professional assurance that a bridge was built in accordance with those plans gives users confidence that a bridge is safe to use.

This investigation examined 216 bridges and found:

- incomplete plans for 40 percent of bridges.
- one-third of bridges did not have a professional seal of approval in the form of a crossing assurance statement.
- designers did not consider the ability of a bridge to pass the expected peak flow of water for 36 percent of bridges.
- 15 percent of bridges were not safe and sound, meaning there were obvious safety issues.

The Board is concerned with the number of unsafe bridges found in this investigation. The issue is not that the legislation and guidance are lacking, but that a significant number of professionals are not following them. Complying with the law and conforming to the professional practice guidelines is not necessarily an expensive or difficult task—licensees of all types and in all locations are doing it. It takes the right mindset and systems to ensure that records are prepared and retained, and qualified professionals are involved at the right time.

The professional practice guidelines give flexibility to builders in exchange for properly planning and constructing bridges. When these requirements are not followed, public confidence and trust in professionals is eroded, much like poorly protected abutments.

This rate of non-compliance and non-conformance requires immediate attention.

[i] Forest Practices Board Road and Bridges Special Report – February 2013 – link:
http://www.fpb.gov.bc.ca/SR43_Road_and_Bridge_Practices_Audit_Findings_2005-2011.htm

[ii] Forest Planning and Practices Regulation – Section 75 – Structural Defects
http://www.canlii.org/en/bc/laws/regu/bc-reg-14-2004/latest/bc-reg-14-2004.html

Appendix 1: Previous Audit Work

During the 2011, 2012 and 2013 field seasons, in six separate audits across British Columbia, Board auditors assessed 70 new bridges and noted 7 bridges, built since January 2010, that were significantly non-compliant with legislation. A short summary of the issues noted and the relevant section of legislation are listed below. For greater detail on each finding, refer to the reports noted below which can found on the Board website.

BRIDGE	ISSUES	NON-COMPLIANCE	LICENSEE
1. ***Forestry Audit: BC Timber Sales – Squamish District, Chinook Business Area*** *(February 2012)*	• Inadequate and incorrect consideration and calculations of peak flows. • Bridge was constructed without sufficient clearance to pass expected peak flow. District manager not notified of construction on an FSR.	s. 74 and s. 79 - FPPR Non-conformance with professional practice guidelines.	BCTS – FSR (TSL holder on FSR)
2. ***Forestry Audit: BC Timber Sales – Prince George Business Area, Mackenzie District*** *(April 2012)*	• Bridge construction outside of in-stream work window.	s. 57 - FPPR	BCTS - FSR
3. ***Audit of Timber Harvesting, Road Construction, Deactivation and Maintenance, and Wildfire Protection on 606546 B.C. Ltd, FL A19202*** *(February 2013)* (two bridges)	• No plans or as-built drawing. • No crossing assurance statement.	s. 77 - FPPR Non-conformance with professional practice guidelines.	Major - RP
4. ***Forestry Audit: BC Timber Sales and Timber Sale Licence Holders – Stuart-Nechako Business Area, Fort St. James District*** *(May 2013)*	• Bridge unsafe - stringer undersized and no lashing. • No plans or as-built drawing. • Inadequate crossing assurance statement.	s. 72, s. 73 and s. 77 - FPPR Non-conformance with professional practice guidelines.	Other
5. ***Forestry Audit: BC Timber Sales and Timber Licence Holders – Prince George Business Area, Prince George District*** *(March 2014)*	• No as-built drawing. • Inadequate bearings • Guard logs ineffective. • Crossing introducing sediment to the stream. • No crossing assurance statement.	s. 72, s. 73 and s. 77 - FPPR Non-conformance with professional practice guidelines.	Other
6. ***Audit of Forest Planning and Practices: South Island District Woodlot – Woodlot Licence W0033*** *(March 2014)*	• Bridge unsafe - improper lashing, no guard rails. • Inadequate bearings. • No plans or as-built drawing. • No crossing assurance statement.	s. 61, s. 62 and s. 66 - WLPPR Non-conformance with professional practice guidelines.	Other

Appendix 2: Detailed Summaries

Planning – Bridge and Major Culvert Design

Legal Requirement

Section 73 of the *Forest Planning and Practices Regulation* requires a person who builds a bridge to ensure that the design and fabrication of the bridge meets or exceeds applicable standards established by the Canadian Standards Association, Canadian Highway Bridge Design Code, CAN/CSA-S6 and soil properties, as they apply to bridge piers and abutments, as established by the Canadian Foundation of Engineering Manual. Bridge designs must also take into account the effect of logging trucks with unbalanced loads and off-centre driving.

Why is this requirement important?

The design and fabrication of a bridge must meet established standards to ensure that it can safely support the design load. A properly designed bridge protects both public safety and environmental values.

What Were Our Assessment Criteria?

Plans and designs were complete if they included a conceptual design/general arrangement drawing supplemented with the detailed superstructure and substructure drawings, as well as other fabrication, material and construction specifications, signed and sealed by a professional engineer, or a professional forester if applicable for simple bridges.

What Did We Find?

Sixty percent (129 of 216) of the bridges examined had complete bridge designs. Thirty percent had partial, and therefore inadequate, plans and no plans were provided[6] for 10 percent of the bridges. Overall, planning was inadequate for 40 percent of the bridges.

Performance in the Okanagan Shuswap district was particularly good, where 92 percent of plans were complete. Bridges built on forest service roads were more likely to have complete plans than those built on road permit roads.

Planning – Records and As-Built Drawings

Legal Requirement

Section 77 of the *Forest Planning and Practices Regulation* specifies the information that must be prepared or obtained for a crossing, including: pile driving records, mill test certificates, in-plant steel fabrication drawings, concrete test results, soil compaction results, and other relevant field and construction data. A person must also prepare as-built[7] drawings of the bridge or major culvert. This information must be kept until the bridge is removed or the person is no longer required to maintain the road. As-built drawings document any significant changes to the design made during construction, or confirm that the bridge was built in general conformance with the conceptual design.

[6] Investigators initially requested bridge design information in April 2013. Each licensee who did not provide the requested information was asked several times. When no design information was made available to investigators by December 31, 2013, it was deemed to not exist.

[7] As-built drawings are also called record drawings.

Why is this requirement important?

Relevant field and construction information and the as-built drawings provide a record of what was actually installed at the site.

What Were Our Assessment Criteria?

The investigation team reviewed the available documentation to ensure that relevant field and construction information was complete. They considered as-built drawings to be adequate if they accurately reflected what was built and were signed and/or sealed by a professional engineer or professional forester.

What Did We Find?

Documentation was complete and as-built drawings were prepared for 72 percent (155 of 216) of bridges examined. Of those, 130 were accurate while 25 were not, meaning significant visible aspects of the built bridge were missing or inaccurate in the documentation.

Government and licensees in the Rocky Mountain district performed better than average in preparing as-built drawings and those in Chilliwack district performed worse than average. Among licensees, "Other[8]" tenures were least likely to prepare as-built drawings.

There were no significant differences in the accuracy of as-built drawings between licensees or districts.

Planning – Crossing Assurance Statement (CAS)

Professional Practice Guideline

The coordinating registered professional must give an assurance that a crossing has been built in general conformance with the plans and supporting documents.

Why Is A Crossing Assurance Statement Important?

A CAS demonstrates that a qualified professional was responsible for the planning or design and field reviews required for the crossing. The professional assures that the significant aspects of the construction work generally conformed to the plans and supporting documents, including revisions.

What Were The Assessment Criteria?

This guideline was met if a crossing assurance statement was signed by a coordinating registered professional.

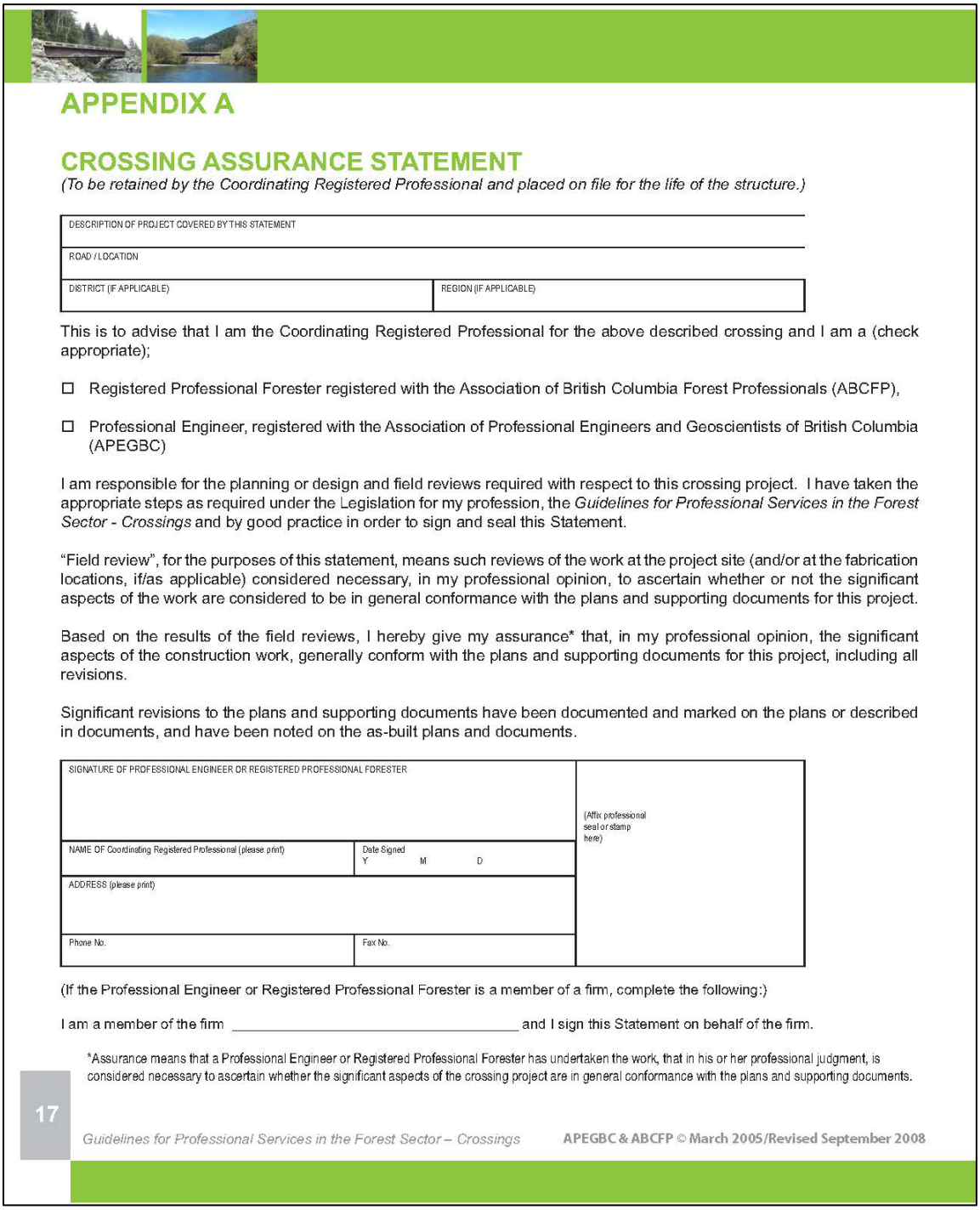
What Did The Investigation Find?

A coordinating registered professional signed a CAS for 66 percent (142 of 216) of the bridges.[9] Government and licensees in the Rocky Mountain, Okanagan-Shuswap and Vanderhoof districts performed better than average in preparing crossing assurance statements, while those in the Chilliwack and Cariboo Chilcotin districts performed below average.

[8] Other tenures are woodlot licences, timber sale licences, non-replaceable forest licences, and forest licences issued under section 47.3 of the *Forest Act*, or an independent power producer.

[9] One bridge was under construction at the time of the field visit and it was too soon to expect a CAS.

Builders of bridges on forest service roads were more likely to complete crossing assurance statements. Licensees in the "Other" category were least likely to prepare crossing assurance statements, with only 1 of 18 completed.



APPENDIX A

CROSSING ASSURANCE STATEMENT

(To be retained by the Coordinating Registered Professional and placed on file for the life of the structure.)

DESCRIPTION OF PROJECT COVERED BY THIS STATEMENT	
ROAD / LOCATION	
DISTRICT (IF APPLICABLE)	REGION (IF APPLICABLE)

This is to advise that I am the Coordinating Registered Professional for the above described crossing and I am a (check appropriate);

☐ Registered Professional Forester registered with the Association of British Columbia Forest Professionals (ABCFP),

☐ Professional Engineer, registered with the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC)

I am responsible for the planning or design and field reviews required with respect to this crossing project. I have taken the appropriate steps as required under the Legislation for my profession, the *Guidelines for Professional Services in the Forest Sector - Crossings* and by good practice in order to sign and seal this Statement.

"Field review", for the purposes of this statement, means such reviews of the work at the project site (and/or at the fabrication locations, if/as applicable) considered necessary, in my professional opinion, to ascertain whether or not the significant aspects of the work are considered to be in general conformance with the plans and supporting documents for this project.

Based on the results of the field reviews, I hereby give my assurance* that, in my professional opinion, the significant aspects of the construction work, generally conform with the plans and supporting documents for this project, including all revisions.

Significant revisions to the plans and supporting documents have been documented and marked on the plans or described in documents, and have been noted on the as-built plans and documents.

SIGNATURE OF PROFESSIONAL ENGINEER OR REGISTERED PROFESSIONAL FORESTER		(Affix professional seal or stamp here)
NAME OF Coordinating Registered Professional (please print)	Date Signed Y M D	
ADDRESS (please print)		
Phone No.	Fax No.	

(If the Professional Engineer or Registered Professional Forester is a member of a firm, complete the following:)

I am a member of the firm _____ and I sign this Statement on behalf of the firm.

*Assurance means that a Professional Engineer or Registered Professional Forester has undertaken the work, that in his or her professional judgment, is considered necessary to ascertain whether the significant aspects of the crossing project are in general conformance with the plans and supporting documents.

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Guidelines for Professional Services in the Forest Sector – Crossings APEGBC & ABCFP © March 2005/Revised September 2008

Planning – Peak Flow

This bridge has adequate clearance for expected flows.

Inadequate clearance. Debris is trapped under bridge.

Inadequate clearance.

Erosion of the sill on the same bridge due to inadequate clearance.

Legal Requirement

Section 74 of the *Forest Planning and Practices Regulation* requires a person who builds a bridge to ensure that it can pass the highest peak flow expected while the bridge is in place.

Why is this requirement important?

If a bridge is not designed and constructed to be able to handle the expected peak flow, it could wash out or be damaged, posing a significant risk to public safety and the environment.

What Were The Assessment Criteria?

This requirement was met if the design considered the peak flow to be expected over the life of the bridge. Typically this included a calculation of watershed area, average and peak flows.

What Did The Investigation Find?

Licensees and government considered peak flow for 64 percent (138 of 216) of the bridges.

Ministry designs for bridges on forest service roads were particularly good, with 39 of 42 considering peak flow. Licensees in the "Other" category performed below average, with peak flow considered for 10 of 18 bridges.

Licensees in the Rocky Mountain district considered peak flow for 49 of 56 bridges, which is above average performance.

Environment – Maintaining Natural Surface Drainage Patterns

This bridge spans the channel and the rip-rap does not encroach on the stream. Natural surface drainage is maintained.

This bridge is too short for the stream and the rip-rap is constricting the channel. Natural surface drainage is not maintained.

Legal Requirement

Section 39 of the *Forest Planning and Practices Regulation* requires a person who builds a road to maintain natural surface drainage patterns both during and after construction.

Why is this requirement important?

Altering the natural flow of water can adversely affect public safety, infrastructure, water quality and timing of flow, fish and fish habitat. Constriction of the channel can also increase the potential for erosion of the abutments, which is a safety concern. Bridges and culverts must be designed with adequate consideration for channel hydraulics to mitigate potentially adverse impacts.

What Were The Assessment Criteria?

Natural surface drainage patterns were maintained if the bridge and rip rap did not constrict and/or divert the natural channel. Typically a channel is constricted when a bridge is too short for the channel.

What Did The Investigation Find?

Natural surface drainage patterns were maintained at 89 percent (192 of 216 bridges) of the bridges. The Rocky Mountain district had below average performance, where 16 of the 24 bridges with issues were located. Performance was relatively equal amongst licensee type.

Environment – Protection of Fish Habitat, Stream Banks and Channels

Protected and undisturbed banks. Vegetated banks help to reduce erosion.

Unprotected and disturbed banks.

Good sediment control. This sump allows sediment to settle out of the water.

Poor sediment control. Sediment from the cutbank in the background can wash into the stream affecting water quality.

Legal Requirements

Section 55 of the *Forest Planning and Practices Regulation* requires a person who builds a stream crossing to protect the stream channel and stream bank immediately above and below the stream crossing, and mitigate disturbance to the channel and banks at the crossing.

Section 57 of the *Forest Planning and Practices Regulation* requires a person installing a bridge to do so at a time and in a manner that is unlikely to harm fish or destroy, damage or harmfully alter fish habitat.

Why are these requirements important?

The installation of stream crossing structures involves the removal or disturbance of trees, shrubs and soil immediately within and adjacent to the stream channel. As a result, it is necessary to mitigate this disturbance, ensuring that the channel is sufficiently stable and can withstand expected water flows.

Fish require clean water for feeding and breathing and habitat for spawning, rearing and overwintering. The construction, maintenance or deactivation of roads, particularly near and across streams, has the potential to affect these requirements. The excessive disturbance of stream channels at a bridge location can damage or alter fish habitat directly. A lack of planning and implementation of erosion and sediment control during bridge structure installation, deactivation and long-term road use, can cover spawning gravels and affect the ability of fish to feed and breathe.

What Were The Assessment Criteria?

Stream banks were adequately protected if they were vegetated and undisturbed or armoured with rock. Sediment control was adequate if the bridge and approaches did not contribute excessive sediment to the stream.

What Did The Investigation Find?

Stream banks were adequately protected at 89 percent (193 of 216) of the bridges. Performance was relatively equal amongst licensee type. Licensees in the Rocky Mountain district performed below average, with inadequate bank protection at 14 of the 23 bridges with issues. Sediment control was adequate at 86 percent (186 of 216) of the bridges. Sediment control on bridges built on forest service roads was particularly good.

Environment – Fish Passage

This bridge does not hinder fish passage.

This bridge is resting on logs in the channel of a fish stream. It was supposed to be removed before spring but was in place in late July. It is blocking fish passage.

Legal Requirement

Section 56 of the *Forest Planning and Practices Regulation* requires a person to ensure that they do not cause a material adverse effect on fish passage.

Why is this requirement important?

A bridge should span the area above the natural high water mark of a stream or river channel. This ensures the bridge can accommodate peak flows and, if located on a fish stream, the bridge will not damage fish habitat or affect the movement of fish through the site. If the channel banks are narrowed to accommodate a bridge that is too short or the bridge is set below the high water mark, the

hydraulic effects can include increased water velocity, channel scour, aggradation (deposited sediment and gravel raise the stream bed) and altering the natural movement of bed load and woody debris. If this happens, the channel can become partially blocked and the water velocity can increase, making fish passage through the area for the purposes of feeding or spawning more difficult.

What Were The Assessment Criteria?

Fish passage was maintained if the bridge did not physically block the stream.

What Did The Investigation Find?

Fish passage was maintained at 99 percent of the bridges. In general, bridges and arches do not impede fish passage. However, there were two cases where fish passage was impeded. In one situation, a portable bridge was laid over a fish stream (S3) in the winter. It was supposed to be removed before freshet but was not, and it blocked the stream. In another case, a culvert that was part of a bridge design was installed on a fish stream adjacent to the main bridge. Corrugated metal pipes are generally not passable by fish.

Safety

Examples of Safe Bridges

This bridge has concrete "no-posts" on the approaches to direct traffic onto the bridge deck.

The steel superstructure is bolted to the timber cap and the deck panels are properly attached.

This bridge abutment is well armoured and placed outside of the stream channel to prevent scour.

This bridge was designed and built to pass the peak flow expected every 100 years.

This log stringer bridge was lashed tightly with steel cable.

This bridge has safe approaches and the channel and abutments are protected with rip-rap.

Legal Requirement

Section 72 of the *Forest Planning and Practices Regulation* states that a person who constructs or maintains a road must ensure that the road and the bridges, culverts, fords and other bridges associated with the road are structurally sound and safe for use by industrial users.

Why is this requirement important?

An unsound bridge could lead to loss of life, equipment and damage the environment.

What Were The Assessment Criteria?

Teams reviewed the bridges for safe use by industrial and public users. This involved a review of the built bridge on site. Using professional judgment the investigators specifically evaluated:

- horizontal and vertical alignment of approaches;
- stability of the approaches (considering the proposed vehicle configurations);
- clearance of the bridge related to existing channel morphology;
- superstructure and substructure conditions; and
- design load ratings with respect to the anticipated loads.

Note that concerns about abutment erosion, alignment and clearance did not necessarily mean that the bridge was unsafe. For example, abutment erosion could become a safety concern over time if allowed to continue, but may not be a serious safety issue at the time of inspection.

What Did The Investigation Find?

Ninety-three percent (200 of 216) of bridges had safe approaches and alignments. Eighty-nine percent (193 of 216) showed no erosion of abutments, and 94 percent (204 of 216) had adequate clearance (the ability of the bridge to pass expected peak flows.)

Overall, 85 percent of bridges were safe and sound. Nine percent of (19 of 216) bridges were not safe and sound, and investigators had significant safety concerns with a further 6 percent (13 of 216) of bridges.

Generally, ministry-built bridges on forest service roads performed well while the "Other" category of licensee showed below average performance.

Licensees in the Rocky Mountain district had below average performance with respect to safe approaches and alignment and clearance. This could reflect the June 2013 storm event discussed in Appendix 3.

Examples of Unsafe Bridges

Abutment erosion resulting from inadequate foundations installed well above creek scour depth, constructed within stream channel. An improperly supported substructure could ultimately result in structural failure of the bridge.

Close-up of same bridge. Extensive scour under the foundation after a major storm event.

Abutment erosion. The abutment (log sills) washed away and the bridge settled 75 cm below the road surface.

A close-up view of the settling due to abutment erosion.

Unstable and erodible fill in the approach is a safety issue and also contributes sediment to the stream.

This curb log is undersized, unsecured and does not meet WorkSafe BC regulations.

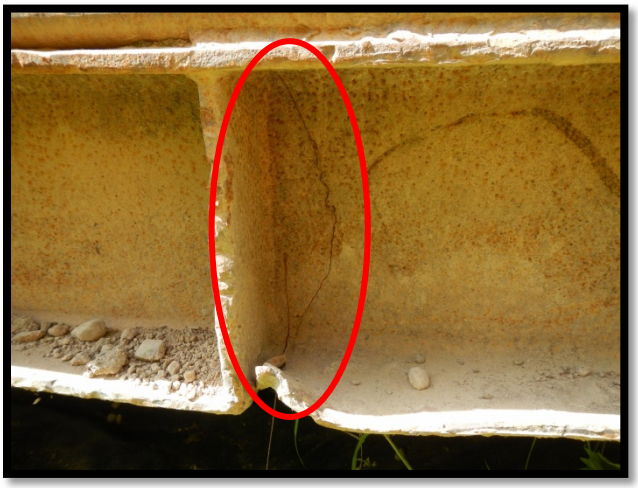
These curb logs are not attached to the bridge and are ineffective if struck by a vehicle. Potential for a vehicle to accidentally drive off the bridge.

Superstructure attached improperly to round sill and bearing plate is not fully supported and aligned on the sill.

No approach logs or approach flares to direct traffic onto bridge deck prevent vehicles from dropping off road prism edge.

Crack in underside of I-beam of portable bridge. Expanded under live load.

Structural fatigue evident on portable bridge by bearing stiffener.



Same portable bridge indicating I beam fatigue that expanded under live load.

Unstable channel above bridge with no consideration of channel geomorphology or anticipated flows. No information provided by licensee.

There was no professional assurance that this portable superstructure is safe for re-use at this site.

Deck panels have shifted because they are not attached to the girders.

Deck rotten/ damaged and a significant gap between running surface and the guard rail could catch a wheel.

Deck panels differ in width. Narrow panel shows damage from a vehicle.

Concrete slab bridge missing guard rail.

Undersized and improperly located sill log does not adequately support superstructure. Girder stiffener and bearing plate does not align with center of sill

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Bridge located at the bottom of a hill, on a curve and there are no guard rails. Superstructure was not lashed or pinned properly to the foundations. No consideration for unbalanced loads or off-centre driving. This bridge was examined during a 2013 audit.

Appendix 3: East Kootenay Storm Event

On or about June 20, 2013, large and intense storms hit parts of the East Kootenays. These were the same storm systems that caused widespread flooding in Alberta. Unprecedented levels of precipitation fell in a number of river valleys, including the White, Bull and Elk Rivers. Weather stations in the Cranbrook area recorded over 100 millimetres of rainfall. The extreme rainfall combined with a high snow pack caused significant flood events on streams and rivers throughout the East Kootenays.

Over 40 bridges were damaged or destroyed as a direct result of the extreme flood levels. The storms were estimated to be a 1 in 100-year event to a 1 in 500-year event. This highlights the need for proper peak flow calculations when designing major bridges, especially in the mountainous regions of British Columbia.

FSR bridge over the White River destroyed by June storm event.

Insufficient clearance after a storm event due to aggradation (deposited sediment and gravel).

Appendix 4: Temporary Structures

During the investigation, we examined bridges identified as 'temporary' structures either on the general arrangement plans or in discussion with the builders. There is no definition of temporary in the legislation.[10] In these situations, temporary generally means for short-term use. But short term can vary from weeks to years depending on the circumstances.

In several cases, bridges were under-designed and/or under-built based on the fact that the bridge was considered temporary by the licensee. For example, banks were not armoured or peak flow calculations were not done.

The requirements of the *Forest Planning and Practices Regulation* apply, regardless of the period the bridge will be in place. For example, banks must be protected and bridges must accommodate the expected peak flow over the period they are to be in place (s. 74(1)). However section 74(2) provides flexibility to a bridge builder. It states that a person may build a bridge that will not conform to the requirements of s. 74(1) if:

(a) the bridge will pass peak flows that will occur during the period the bridge remains on site,
(b) the construction of the bridge occurs during a period of low flow, and
(c) the bridge, or a component of the bridge that is vulnerable to damage by high flow, is removed before any period of high flow begins

This does not mean that a builder does not have to consider peak flow because the bridge is temporary. The builder has to consider expected flows during the period the bridge will remain on site.

If a bridge is designed to a lower standard, the coordinating registered professional should state on the design the reasoning for the reduced standards, the anticipated risks, and clearly indicate the design life of the bridge including deactivation and a site remediation action plan.

Simply indicating that the bridge is temporary does not relieve a professional of professional practice requirements or the legislation.

[10] The Ministry of Forests, Lands and Natural Resource Operations engineering manual defines a temporary bridge as having stringers or girders, or abutments, comprised of temporary materials (untreated logs or untreated timbers).

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