Guideline for culvert safety management

October 2024

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Foreword

The objective of the *Guideline for Culvert Safety Management* is to provide railway companies with a guide for the development of their Culvert Safety Management Program (CSMP) and to promote industry best practices with regards to culvert management.

This guideline is not intended to replace existing procedures or practices in use by railway companies. It is not expected that every recommendation outlined in this guideline be contained within a single document, or that information be duplicated if it is available through other railway programs or systems. However, the location of applicable information should be incorporated into the CSMP by reference.

The railway company's railway engineer is responsible for approving their CSMP. They should take into account:

- adherence to the *Railway Safety Act*
- the best practices in this guideline
- the railway company's operation

Part A – General

0.1 – Definitions

This guideline uses the terms and definitions in the *Railway Safety Act*, plus the following:

Culvert
Any under-grade structure that forms a passageway through an embankment, supports one or more lines of track, and is not a railway bridge or a utility crossing. This also includes under-grade cattle and pedestrian passageways.

Culvert Safety Management Program (CSMP)
A program that helps manage all safety risks associated with culverts. This includes the key positions in the railway corporate structure, planning activities, responsibilities, practices, procedures, processes, standards, drawings, and personnel needed to develop, implement, achieve, review and maintain the program.

Railway bridge
Any structure with a deck, of any length, which supports one or more railway tracks, or any other under-grade structure with an individual span length of 3.05 meters (10 feet) or more located at such a depth that it is affected by live loads.

0.2 – Scope

This guideline is to help railway companies:

- formulate a CSMP that will follow the objectives of the *Railway Safety Act*
- implement and maintain a CSMP that identifies and mitigates risk as much as possible
- ensure the ongoing effectiveness of the CSMP in maintaining safe railway operations concerning culverts
- determine and assure compliance with all applicable legislative requirements, internal practices, procedures, and instructions relating to safe railway operations as it applies to culverts

0.3 – Application

This guideline is intended for railway companies to whom the *Railway Safety Act* applies.

0.4 – Responsibility

Culverts on a line where railway companies operate trains shall be inspected and maintained by the track owner or another railway company (for example, designated through a lease or other agreement), providing that the railway company knows who is responsible and the responsibilities are clearly defined.

Part B – Qualifications and designating responsible persons

1.1 – Scope

The CSMP should describe the qualification, training, or experience for people who perform functions related to the integrity and safety of culverts.

1.2 – Culvert safety management responsibility

The CSMP should identify what each position involved in the management of culvert safety is responsible and accountable for. This could be done with an organizational chart showing the chain of responsibility.

1.3 – Railway engineer

A railway engineer is a professional engineer designated by a railway company. They are responsible for and have experience in the following as they apply to their roles and responsibilities in the engineering work to be performed:

- determining the forces and stresses in culverts and their components
- prescribing safe loading conditions for culverts

- prescribing inspection, maintenance, repair, and modification procedures for culverts
- designing repairs, modifications, replacement, or installation of culverts
- performing hydrological and hydraulic analysis
- deciding the extent to which professional engineers and others are directly involved in engineering work
- supervising and retaining full responsibility for any engineering work that is assigned to technically competent people who are not professional engineers

A railway engineer should be authorized to restrict the operation of traffic over a culvert according to its current condition or state of repair.

1.4 – Culvert inspector

A culvert inspector is designated by a railway company. They can view, measure, report, and record the condition of a culvert, its individual components, and its surroundings. They are under the direct supervision of a railway engineer. The railway company may designate different classes of culvert inspectors based on the types of inspections that they are qualified to perform.

A culvert inspector should be authorized to restrict the operation of traffic over a culvert according to its current condition or state of repair.

1.5 – Designating individuals

The railway company designates railway engineers and culvert inspectors and maintains records related to the designation. The records should include the basis for the designation (qualifications and related experience). The railway company should record designations of people working on their behalf, whether they are railway employees, independent contractors, or consultants.

Section analysis 1.5 – Designation of individuals

If an independent contractor has several people performing the described functions under a contract or other engagement, then one or more people should be designated as responsible for the work performed under that engagement.

An independent contractor may provide engineering services and act as the railway engineer for the railway company. In this case, the CSMP can note that the record of designation is the signature and seal of the responsible professional engineer affixed to the documents. The basis for the designation is their licensure as a professional engineer.

Part C – Culvert inspection

2.1 – Scope

The CSMP should provide for an effective culvert inspection program. The railway company should clearly define and document the different types of culvert inspections to be undertaken, including the frequencies of these inspections in its CSMP.

Section analysis 2.1 – Scope

Types of inspections include but are not limited to:

- visual
- detailed
- scour
- hydraulic
- underwater
- special

A culvert with undetected or unreported damage or deterioration can present a severe risk to safe railway operations. Evaluating a culvert requires the application of engineering principles by a professional engineer, who is usually not present during the inspection. For this reason, an inspection report should show any conditions on the culvert that might lead to a reduction in capacity, initiation of repair work, or a more detailed inspection of the condition.

2.2 – Culvert inventory

The railway company is expected to maintain an inventory of all culverts on its right of way and at a minimum, include the following information:

- location (such as subdivision and mileage)
- geo-referenced coordinates (such as longitude and latitude)
- obstacle being crossed (such as stream, pedestrian walkway, cattle pass)
- height of cover (measured from the top of the culvert to the bottom of a tie)
- total length
- number of tracks
- culvert material and type
- culvert dimensions (such as span, rise, and number of the cell)
- year installed (if available)

2.3 – Types of inspections

2.3.1 – Visual inspection

A visual inspection is a documented inspection made by a railway engineer or a culvert inspector. A visual inspection should be detailed enough to verify that the condition of

the culvert does not impair its ability to function as intended and include a mechanism to initiate further action when substandard conditions are identified.

Visual inspection of culverts should be completed in addition to visual track inspections required by the Rules Respecting Track Safety.

2.3.2 – Detailed inspection

A detailed inspection is a documented inspection made by a railway engineer or a culvert inspector. It identifies and records any changes, defects, or repairs to culverts. It includes measuring specific defects and verifying the general conditions of a culvert and its surroundings. This allows a railway engineer to accurately evaluate all aspects of a culvert and determine if anything reported is or could be a risk to safe railway operations.

2.3.3 – Special inspection

The CSMP should include a procedure to protect traffic after an accident or during and after a significant natural event that may have affected the structural integrity of a culvert. There should also be a procedure for inspecting a culvert after a significant natural event.

A significant natural event may include but is not limited to:

- flood
- fire
- ice flows
- debris flows
- sub-grade instability
- rock instability
- beaver dam failure
- earthquake

2.3.4 – Submerged culvert inspection

The CSMP should include provisions for underwater inspections to detect the deterioration of submerged components of the culvert, or where the culvert cannot be inspected due to the depth of water or poor visibility.

The railway company’s underwater inspection program should:

- identify the culverts to inspect
- include markers to identify culvert locations in the field
- include a list of items to inspect and the frequency to inspect them

Section analysis 2.3.4 – Submerged culvert inspection

The condition of underwater culvert components is usually not evident from above. Determining their condition might be as simple as using a measuring rod or might need periodic or special diving inspections. Advanced technology might also be able to determine underwater conditions.

Not all culverts need an underwater inspection. Not every part of a culvert underwater needs an underwater inspection. If a railway engineer determines a culvert to be susceptible to conditions that will need underwater inspections, then appropriate provisions and procedures are put in place.

Underwater inspection equipment can be ineffective due to murky water conditions. In this case, a railway engineer may consider a diving inspection for a larger diameter culvert to determine its condition. For smaller diameter culverts, the railway company could monitor the track and embankment on an ongoing basis and look for any signs of culvert failure as soon as it occurs. This monitoring should also include a documented inspection at the companies' required frequency.

2.4 – Culvert inspection procedures and frequency

A CSMP should include culvert inspection procedures from a railway engineer that**:**

- specify or reference the procedures for inspecting different types and sizes of culverts
- are designed to detect, report, and protect deteriorations and deficiencies of the culvert before they are a risk to the railway
    - This includes the channel conditions, hydraulic capacity and the surrounding fill material
- prescribe a visual inspection for each culvert in service at least once every calendar year
- prescribe a detailed inspection at least once every 5 years
- contain the requirements for special inspections and submerged culvert inspections
- require that any culvert that has not been in service and has not been inspected be inspected and the report reviewed by a railway engineer before it is put back into service

2.5 – Culvert inspection records

The railway company should keep a record of each inspection.

- The record should be prepared from notes taken during the inspection, including sketches and photographs as needed
- The railway company should specify the location where inspection records are kept are kept; and
- Keep inspection records for 5 years after the inspection, or until after the next 2 inspections of the same type, whichever is greater

The record should include:

- an identification of the culvert inspected
- the date of the inspection
- the identification of the inspector
- the type of inspection performed, as per the inspection types in the CSMP
- an indication of if any item in the report needs an immediate review by a railway engineer
- any restrictions placed during the inspection
- the condition of components inspected with any narrative description or photographs needed to interpret the report
    - this may be in a condition-reporting format set out in the CSMP

2.6 – Review of culvert inspection reports

The CSMP should include how a railway engineer should review culvert inspection reports. The purpose of this review is to:

- make sure that inspections followed procedures and were at the required frequency
- evaluate if any items on the report are a present or potential safety risk
- require any modifications to the inspection frequency or procedures for that culvert
- schedule any repairs or modifications to the culvert that are required to maintain its structural integrity and hydraulic capacity;
- assess if culverts that were not found during inspections are required
- determine if a higher-level review is needed

2.7 – Higher level review

A higher-level review under 2.6 should be conducted by a railway engineer to ensure that a culvert is safe for its intended use. The review may include an assessment of all existing culvert inspections, evaluations, reports, information, and circumstances relating to a culvert. Additional inspections or evaluations may be required to complete a higher-level review.

Records of a higher-level review should identify, at a minimum:

- the culvert evaluated
- the date of the evaluation
- the responsible railway engineer
- the conclusions and recommendations of the higher-level review

2.8 – Culvert risk identification

The railway company should develop, implement, and maintain processes to identify safety issues and concerns, evaluate risks, and implement risk control strategies.

Section analysis 2.8 – Culvert risk identification

Safety issues and concerns associated with culverts include, but are not limited to:

1. Waterway adequacy

Evaluate the stream channel and drainage area for:

- changes in stream channel alignment, which may reduce hydraulic capacity or cause scour
    - a change in the direction of flow or its velocity can contribute to culvert failures
    - wing walls and barrels can break off due to settlement caused by scour
- changes in upstream land use may change the peak flow rates and stream stability
    - these include clearing, deforestation, significant construction and new development, channel improvements, and removal of dams
    - obstructions downstream that back water up to the culvert may also affect the performance of the culvert or cause saturation of the roadbed
- excessive bank erosion, stream channel aggradation/degradation that may indicate a change in water flow
- high water marks which indicate that a culvert may be inadequately sized
    - this increases the potential for flooding damage or track flooding
    - check culverts during or immediately after peak flows to determine if water has ponded, adjoining properties are flooded, or the track is flooded
- water should flow in and out of a culvert smoothly and without interference or obstruction
    - channel obstructions such as deposits of debris, ballast, driftwood, mudslides, beaver dams, and organic growth affect the hydraulic capacity of a culvert

If any of the above conditions exist, the railway company should consider an analysis to determine if a culvert is adequately sized.

2. Beaver activity

Beaver dams located upstream and downstream from the track represent a potential hazard to the track structure. The primary hazard caused by beaver activity is washouts. It also causes gullying or seepage erosion of the railway grade. Railway companies should regularly inspect for beaver dams and take appropriate actions if conditions are hazardous. An aerial survey of beaver dams may be required in the spring and fall of each year to support ground inspections.

3. Debris and sediment blocking culverts

The culvert must be able to handle the design flow. If the culvert is blocked with deposits of debris, driftwood, organic growth (including beaver dams) or sediment, the culvert may be unable to handle design flows. This may cause excessive ponding, flooding of nearby properties, and washouts of track and embankment. Accumulations of debris and sediment in the stream may cause scour of the stream banks and embankments or changes in the channel alignment. Thus, it is imperative that railway companies remove deposits of debris and sediment if they threaten safe railway operations and property.

4. Snow and ice conditions blocking culverts

Snow and ice can prevent proper drainage by blocking a culvert and impeding flow. Railway companies should take appropriate actions to protect safe railway operations in these conditions.

5. High water condition

Some areas frequently or historically experience high or rapidly moving water conditions, such as flash floods. These areas may be protected with detection devices to sense the rise or velocity of water in or near culverts, which may be unable to carry the total storm runoff. The track bed may be washed away or flooded, which can cause significant damage. When such conditions are imminent, washout protection devices will provide sufficient warning to stop all nearby trains.

Similar to washout protection, a high water detection device detects the rate-of-rise and absolute level of water around vulnerable locations such as culverts. These locations could be inundated by rapid storm runoff conditions. Conventional rain gages could also provide early warning of high water conditions.

6. Severe weather conditions

Railway companies should watch for events, including but not limited to heavy precipitation, spring runoff, high river levels, and/or higher than normal flow conditions. When such conditions exist, inspections should be performed, and appropriate measures taken before and after the event to protect safe railway operations. Re-evaluate culverts to confirm both structural integrity and the ability to accommodate water flow under the track adequately.

In locations where railway companies and road authorities share a drainage basin, it is essential that they have communication protocols for sharing information relating to the protection of the infrastructure, especially during severe weather events.

Railway companies should monitor weather conditions and weather warnings. They should follow-up with special patrols for culvert inspections, including drainage assessments for the specific warning areas. Weather monitoring is an effective way to plan for adverse situations.

When identifying hazards related to culverts, railway companies should consider:

- identification of culverts which are susceptible to scour or lateral stream migration
- identification of areas subject to flooding or high flows
- identification of culverts that have been damaged by a previous event
- identification of critical culverts to determine whether, when, and where projected flooding or high flows might be consequential
- awareness of snowpack conditions and impact on spring runoff
- awareness of the effects of ice flow dams and other debris accumulation on the substructure
- developing and implementing methods to protect culverts before, during, and after a flood or high flow event
- developing and implementing monitoring technologies that could provide advance warning of pending failures due to the effects of an event
- use sonar, sensors, and other smart technologies to monitor scour-critical culverts
- defining qualification and training requirements for inspectors to monitor culverts during an event
- developing processes to monitor severe weather events
- defining the frequency and scope of inspections during a flood or high flow event

7. Highly corrosive and abrasive environments

Water and soil-related corrosion and abrasion are the 2 main ways culvert materials deteriorate. Certain soil and water conditions have a strong link to accelerated culvert deterioration. Metal culverts corrode in certain aggressive environments. The pH and electrical resistivity of soil and water indicate the likelihood of corrosion. Railway companies should create pH and resistivity guidelines based on local conditions and performance.

Abrasion may remove any protective coating on the metal. This exposes the core material to chemical and further abrasive attack. Corrosion may weaken the structural capacity of the pipe by creating perforations from either the water or soil side. Material and water moving through these holes may create voids around the culvert pipe. This undermines the supporting backfill material and further weakens its structural integrity.

The effects of water-side abrasion and corrosion are visible and easy to assess. However, soil side corrosion is not as visible; corroded fasteners or rust emanating from the seams may indicate soil side corrosion. Corrosion and abrasion of corrugated metal culverts can be a serious problem with adverse effects on structural performance.

Railway companies should be aware of aggressive environments. They should have a plan in place to monitor, address, and implement special inspection methods in those environments.

8. Buried culverts (culverts “not found” but which exist on the railway company’s inventory)

Culvert inspectors should report any inventoried culverts they are unable to locate to the railway engineer. A railway engineer is responsible for determining the effect this may have on drainage in the area and safe railway operations.

Buried culverts may cause inadequate drainage or culvert failure, which could impact safe railway operations. Railway companies should make every effort to locate such culverts and update their inventory.

9. Deferred work

A railway engineer should perform an evaluation and risk analysis before deferring any culvert work.

10. Inadequate culvert length

Culvert extension may be required because of proposed bank widening, stream deepening, track lift, or other work.

Part D – Designing, constructing, and maintaining culverts

3.1 – Scope

The CSMP should outline procedures for designing, constructing, and maintaining culverts. The railway company should include requirements to ensure that culverts are sized to accommodate the expected flows and that they have sufficient structural capacity for the applied loads.

3.2 – Procedures for designing, constructing, and maintaining culverts

The railway company documentation should include:

- standards or drawings for designing, constructing, and maintaining existing and new culverts
- procedures to ensure design, construction, and maintenance work follows standards and procedures
- procedures to ensure maintenance activities that affect load carrying capacity of a culvert are assessed, recorded and approved by a railway engineer before being deferred
- procedures to ensure on-site construction changes are recorded and approved by a railway engineer

3.3 – Replacing and repairing existing culverts

The CSMP should include procedures for assessing the structural and hydraulic adequacy of existing culverts when signs of distress are observed or where they regularly show an inability to handle normal flows.

Before replacing or repairing an existing culvert, consideration should be given to its design flow and determine its adequacy when choosing repair or replacement options. Always consider inlet and outlet improvements to address any increased scour potential as a result of a culvert repair or replacement.

Section analysis 3.2 and 3.3 – Designing and installing new culverts and replacing and repairing existing culverts

Railway companies should consult the manufacturer's installation instructions for each of their products. Industry standards or guidelines, such as American Railway Engineering and Maintenance of Way Association, are also available to assist railway companies in the design and installation of culverts.

The hydraulic requirements of a culvert usually determine its size, shape, slope, inlet, and outlet treatments. Culvert hydraulics can be divided into 2 general design elements:

1. hydrological analysis to determine the design discharge or the amount of runoff the culvert should be designed for
2. hydraulic analysis to select a culvert or evaluate whether an existing culvert is capable of adequately conveying the design discharge

Good quality backfill material, proper placement technique, and adequate compaction are of critical importance when installing a culvert. The culvert installation crew should have adequate training, experience, be knowledgeable of sound culvert installation techniques, and equipped with proper materials and equipment.

Part E – Documentation, records and evaluation of CSMP

4.1 – Scope

The CSMP should provide for the verification of the effectiveness of the program and the accuracy of the resulting information, including the validity of culvert inspection reports and culvert inventory data.

4.2 – Monitoring and evaluating the CSMP

The railway company should implement and maintain procedures for periodic internal monitoring and evaluations of its CSMP to determine if it:

- meets the intent of this guideline
- has been properly implemented and maintained
- continues to effectively manage culvert safety

4.3 – Verifying culvert inspections

The CSMP should incorporate provisions for on-site evaluation of a representative sampling of culverts to determine if the inspection reports accurately describe the condition of the culverts.

Section analysis 4.3 – Verifying inspections

One of the most important ways to determine if a CSMP is effective is comparing recent culvert inspection reports against actual conditions found at the culverts. It is recommended that the railway engineer carries out inspection verification on a yearly basis.

4.4 – Documents and records

The CSMP documents and records shall be made available to Transport Canada's railway safety inspector upon request in the course of an inspection, as soon as reasonably practicable.

Where possible, the railway company should retain relevant drawings for as long as they own the culvert. They should keep inspection records as per Section 2.5 of this guideline.

When the railway company assigns maintenance responsibilities for track and culverts to another railway company, the other railway company should be given access to relevant culvert documents and drawings.

Part F – Requirements of Section 11 – *Railway Safety Act*

5.1 – Scope

Section 11 of the *Railway Safety Act* states:

"(1) All work relating to railway works — including, but not limited to, design, construction, evaluation, maintenance and alteration — must be done in accordance with sound engineering principles.

(2) All engineering work relating to railway works must be approved by a professional engineer."

5.2 – Engineering work related to culverts

Engineering work related to culverts includes, but is not limited to:

- preparing culvert designs and specifications
- developing construction, repair and modification procedures
- developing inspection and evaluation procedures
- reviewing culvert inspection reports and conducting the higher-level review
- evaluating proposed maintenance deferrals
- verifying that construction, repair, and modification work is completed following the design and specifications
- conducting hydrological and hydraulics analysis

5.3 – Engineering work performed by persons who are not Professional Engineers

A railway engineer may assign aspects the engineering work described in this guideline to technically competent people who are not professional engineers. Such work must be performed under the direct supervision of the railway engineer. The railway engineer continues to be responsible for all aspects of the engineering work.

The railway company must be able to demonstrate how their CSMP meets the requirements of Section 11 of the *Railway Safety Act.*

Section analysis 5.3 – Engineering work performed by persons who are not Professional Engineers

In Canada it is common practice for professional engineers to assign engineering work to competent people who are not professional engineers, provided that they are working under the "direct supervision" of the professional engineer taking responsibility for the work. "Direct supervision" implies that a reasonable level of supervision is provided to ensure that the work meets the same standards of professional conduct and competence as if the professional engineer had performed the work personally. It does not require the supervising engineer to monitor every aspect of the work that is being performed.

Further guidance on acceptable professional practice can be found from Engineers Canada and the applicable provincial or territorial Engineering Associations.

First Issued: January 2012
Revision 1: October 2024