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Rail *Safety*

Oversight and Expertise

Appendix - Guideline for Culvert Safety Management with Clarification Comments on Grey Background

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Canada

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Foreword

The objective of this Guideline is to provide railway companies with a guide for the development of their Culvert Safety Management Program (CSMP) in accordance with the *Railway Safety Management Systems Regulation (SMS)*, the *Railway Safety Act (RSA)*, and the *Track Safety Rules (TSR)*.

This Guideline is meant to promote uniformity and industry best practices with respect to the safe management of culverts and outline Transport Canada's (TC) expectations with regards to the components that should form part of a railway company's CSMP including overall design, inspection, and maintenance practices associated with culverts over which trains operate.

This Guideline is not intended to replace existing railway procedures or practices in use by railway companies. Railway companies may use alternative practices and procedures to those outlined in this Guideline, provided that they meet the intent of this Guideline. Ultimately, it is the railway company's responsibility to ensure the safety of its operation as it applies to culverts.

Part A – General

0.1 - Definitions

For the purposes of this Guideline, the terms and definitions given in the *Railway Safety Act* and the *Railway Safety Management System Regulations* apply in addition to those given below:

“culvert” means any under-grade drainage structure that forms a passageway through an embankment that is not a railway bridge. This also includes cattle and pedestrian passageways.

“Culvert Safety Management Program (CSMP)” means part of an overall railway safety management system that facilitates the management of safety risks associated with culverts.

“designate” means a technically competent person assigned to work under the direction of a Railway Engineer.

“professional engineer” means a person who is authorized under a Canadian Provincial or Territorial Engineering Act to engage in the practice of professional engineering.

“railway bridge” means any structure with a deck, regardless of length, which supports one or more railway tracks, or any other under-grade structure with an individual span length of 10 feet or more located at such a depth that it is affected by live loads.

“**railway authority**” means the railway company responsible for the maintenance of the railway right of way.

“**railway company**” means as defined in the *Canadian Transportation Act*.

“**railway right of way**” means any land on which a line of railway is situated, including yard tracks, sidings, spurs and other track auxiliary to the line of railway.

“**structural inspection**” means a documented inspection made by a Railway Engineer or his designate to identify and record any changes, defects, or repairs. It includes measuring specific defects, verifying the general conditions of a culvert, and its surroundings in order for a Railway Engineer to be able to accurately evaluate all aspects of a culvert and determine if anything reported represents a present or potential hazard to safe railway operations.

“**visual inspection**” means an inspection, that may or may not be documented, made in accordance with railway authority’s CSMP.

0.2 - Scope

This Guideline has been developed to assist a railway company in formulating a CSMP that will conform to the following:

- *Railway Safety Act (RSA)*;
- *Guidelines – Engineering Work Relating to Railway Works (Section 11 – Railway Safety Act)*;
- *Railway Safety Management System Regulations (SMS)*; and
- *Track Safety Rules (TSR)*.

It will assist a railway company in order for it to:

- a. Establish a CSMP that identifies and mitigates, to the extent possible, hazards to users and other parties who may be exposed to risks associated with culverts and related activities;
- b. Implement, maintain and continually improve a CSMP; and
- c. Determine and assess compliance with all legislative requirements and internal practices, procedures and instructions relating to safe railway operations as it applies to culverts.

Section Analysis 0.2 – Scope

This Guideline outlines the minimum components to be included in a CSMP.

0.3 - Application

This Guideline applies to a railway company to which the *Railway Safety Act* applies.

0.4 - Responsibility

The railway authority is responsible for the condition of the culverts over which it or other railway companies operate trains regardless of any agreements, division of ownership or maintenance expense. The railway authority shall¹, ensure that the track is being adequately supported and shall² be able to control, and restrict if necessary, the movement of trains on its segment of track, including the track over a culvert.

For culverts that the railway authority is responsible for with respect to inspection, evaluation, and repairs, the railway authority shall³ ensure safe railway operations are being maintained.

If a railway authority, to which this part applies, assigns responsibility for the track and culverts to another railway company, by lease or otherwise, written notification of the assignment should be provided to the appropriate TC Rail Safety Regional Office within 30 days following the assignment. The notification should be in writing and include the following:

- a. The name and address of the railway authority that is assigning responsibility;
- b. The name and address of the railway company to whom responsibility is assigned, (assignee);
- c. A statement of the exact relationship between the railway authority and the assignee; and
- d. A precise identification of the track segment.

Section Analysis 0.4 - Responsibility

The responsibility for safe railway operations over any culvert lies with the railway authority. The railway authority is responsible for complying with the Scope of this Guideline, Part A – General. If a culvert supports tracks owned by two or more railway companies, then the railway companies are jointly responsible for compliance with this part.

If during a visual inspection there is a situation noted that could impact safe railway operations, the railway authority is to notify the party responsible and ensure that effective remedial action has been carried out. If required, TC can be notified as well of the safety issue in order to help facilitate a resolution to the issue, particularly in the event when one of the parties fails to recognize their responsibilities.

¹ Track Safety Rules part I 6

² Track Safety Rules part I 6

³ Section 11 of the Railway Safety Act

Part B – Culvert Safety Assurance

1.1 - Safety Management Systems (SMS)

Under the *Railway SMS Regulations*, a railway company is required to implement and maintain systems to manage the safety of all aspects of railway operations. The CSMP shall⁴ form part of and be referenced in the railway company's SMS.

Section Analysis 1.1- Safety Management Systems

When a railway company is not the railway authority for the track over which it operates, that railway company must implement and maintain a system to ensure that the railway authority, over who's track they operate, demonstrates conformance with its CSMP and that safe railway operations are maintained with respect to culverts. This may include, but not be limited to, a review of the railway authority's internal safety audit for culverts.

Part C – Qualifications and Designation of Responsible Persons

2.1 – Scope

A railway authority's CSMP shall⁵ describe the qualification, training and designation of persons who perform safety critical functions that affect the integrity and safety of culverts.

2.2 – Culvert Safety Management Responsibility

A railway company's CSMP shall⁶ identify clear authorities, responsibilities, and accountabilities for the management of culvert safety.

2.3 – Railway Engineer

A Railway Engineer is a professional engineer, designated by a railway authority, who is responsible for, and has related experience in the following functions as they apply to the particular engineering work to be performed:

- a. Determine the forces and stresses in culverts;
- b. Prescribe safe loading conditions for culverts;
- c. Prescribe inspection, maintenance, repair and modification procedures for culverts;
- d. Prepare designs and specifications for the repairs, modifications, replacement, or installation of culverts; and
- e. Perform hydrological and hydraulic analysis.

⁴ Section 2 of the Railway Safety Management System Regulations

⁵ Section 2(h) Railway Safety Management System Regulations

⁶ Section 4(1)(e) Railway Safety Management System Regulations

A Railway Engineer shall⁷ decide to which extent professional engineers shall⁸ be directly involved in the engineering work related to culverts.

A Railway Engineer should be authorized to restrict the operation of traffic according to the immediate condition or state of repair of a culvert.

Section Analysis 2.3 - Railway Engineer

A Railway Engineer is responsible for the development of all inspection procedures, reviews inspection reports, and determines whether culverts are being inspected according to the applicable procedures and frequency, and reviews any items noted by an inspector as required. He/she shall⁹ also take responsibility for design, construction, evaluation or alteration work and procedures to be followed in association with a railway work that affects safety of culverts.

2.4 – Culvert Inspector

A Culvert Inspector is a person who is designated by a railway authority, and deemed to be technically competent to view, measure, report, and record the condition of a culvert along with its surroundings under the direction of the Railway Engineer.

A Culvert Inspector should be authorized to restrict the operation of traffic according to the immediate condition or state of repair of a culvert.

Section Analysis 2.4 –Culvert Inspector

This section proposes the qualifications that a Culvert Inspector should meet. Effective inspection of culverts is essential to preserving their integrity and serviceability. Culvert Inspectors must be able to understand and follow the inspection procedure, including accessing inspection points on a culvert, measuring components and any changes, describing conditions found in a standard, unambiguous manner, and detecting the development of conditions that are critical to the safety of the culvert. Culvert Inspectors should have a good understanding of how each type of culverts (i.e. rigid culverts e.g. concrete or steel pipes and flexible culverts e.g. corrugated steel pipes, plastic pipes such as PVC, etc.) function hydraulically and structurally. It is essential that a Culvert Inspector who detects a potential hazard to the safe railway operations should be authorized by the railway authority to place appropriate restrictions on the operation of traffic pending review as necessary by a Railway Engineer. A Railway Engineer should ensure that there is a process in place, which may include audits, field trips and training of a Culvert Inspector, to assure the quality of the inspections reported.

2.5 - Designation of Individuals

Each railway authority's CSMP should designate individuals or class of individuals qualified as Railway Engineers and Culvert Inspectors. For each class of individuals designated, the records should include the basis for the designation in effect.

⁷ Section 11 of the Railway Safety Act

⁸ Section 11 of the Railway Safety Act

⁹ Section 11 of the Railway Safety Act

Section Analysis 2.5 - Designation of Individuals

This section proposes that each railway authority designate class of individuals as qualified Railway Engineers and Culvert Inspectors, and provide a recorded basis for each designation in effect. The railway authority should record designations of each class of individuals, whether employees, consultants or contractors. If a consultant or contractor has several individuals performing the described functions under a contract or other engagement, then one or more individuals should be designated as being responsible to the railway authority for the work performed under that engagement, with the others working under the responsible charge of that individual.

Part D – Culvert Design

3.1 - Scope

Each railway authority's CSMP should include requirements to ensure that culverts are sized to accommodate the normal flows, and that they have sufficient structural capacity to handle the applied loads.

3.2 - Design and Installation of New Culverts

Each railway authority's CSMP should specify procedures for the design and installation of new culverts. The culvert design and specifications shall¹⁰ be prepared under the direction of a Railway Engineer considering site requirements and using appropriate engineering methods and standards. A Railway Engineer or his designate should ensure that the work is completed in conformity with the design and specifications.

3.3 - Replacement and Repair of Existing Culverts

Each railway authority's CSMP should specify 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, by a Railway Engineer or his designate to its design flow and determine its adequacy when considering available repair or replacement options. Consideration should always be given to inlet and outlet improvements to address any increased scour potential as a result of a culvert repair or replacement.

A procedure for assessing the requirement for culverts that are not found should be developed. Assessments shall¹¹ be performed under the direction of a Railway Engineer or his designate and the results should be documented.

¹⁰ Section 11 Railway Safety Act

¹¹ Section 11 Railway Safety Act

Section Analysis 3.2 and 3.3 – Design and Installation of New Culverts and Replacement and Repair of Existing Culverts

This section is not intended to be all-inclusive. The intent of this section is to highlight the importance of design and installation of new or replacement culverts. Railway companies should consult manufacturer's installation instructions pertaining to their individual products. Additionally, industry standards or guidelines, such as AREMA, are available to assist railway companies in the design and installation of culverts.

Culverts are primarily constructed to convey water through a railway or other embankment. A culvert that does not perform this function properly may jeopardise safe railway operations, cause excessive property damage, or even loss of life. The hydraulic requirements of a culvert usually determine the size, shape, slope, inlet and outlet treatments of a culvert. Culvert hydraulics can be divided into two general design elements. The first is a hydrological analysis to determine the design discharge or the amount of runoff the culvert should be designed to convey. The second is a 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. It is imperative that the culvert installation crew is knowledgeable and skilful of sound culvert installation techniques and equipped with proper material(s) and equipment(s). It is important that railway companies provide proper training to their culvert installation crew.

Part E – Culvert Inspection

4.1 - Scope

Each railway authority's CSMP should provide for an effective culvert inspection program.

A railway authority's CSMP should clearly define the different types of culvert inspections to be undertaken, including the frequencies of these inspections.

Section Analysis 4.1 – Scope

Types of inspections include but are not limited to visual, detailed, scour, hydraulic, underwater, special, etc.

4.2 – Culvert Inventory

Each railway authority's CSMP should include an inventory of all culverts over which trains operate and at a minimum, include the following information:

- a. Location (i.e. subdivision and mileage);
- b. Number of tracks;
- c. Culvert type;
- d. Culvert Dimensions (i.e. span, rise, and number of cells);
- e. Total length;

- f. Height of Cover (measured from the top of the culvert to the bottom of tie);
- g. Year installed, if available;
- h. Geo-referenced coordinates (i.e. longitude, latitude); and
- i. Type of crossing (i.e. stream, pedestrian walkway, cattle pass etc.).

4.3 - Scheduling of Culvert Inspections

In addition to visual inspection requirements of culverts contained in the Track Safety Rules, a railway authority shall¹² have a CSMP that:

- a. Should include a documented structural inspection at a minimum of once every five years. Should any culvert inspection indicate that the culvert is at a minimum acceptable condition (advance deterioration evident but still functioning as intended), the culvert should be scheduled for a more frequent visual documented inspection, as determine by a Railway Engineer; and
- b. Should include an inspection of any culvert that has not been in railway service and has not been inspected in accordance with this section. The inspection report shall¹³ be reviewed by a Railway Engineer prior to the resumption of railway service.

Section Analysis 4.3 – Scheduling of Culvert Inspections

a. The railway authority should conduct regular comprehensive structural inspections of each culvert at least once every five years, and maintain records of those inspections that include the date on which the inspection was performed, the precise identification of the culvert inspected, the items inspected, an accurate description of the condition of those items, and a narrative of any inspection item that is found by an inspector to be a potential problem.

A culvert should be inspected more frequently than the period referenced in paragraph above when a Railway Engineer or his designate determines that such is necessary. The responsibility for adequate inspection remains with the railway authority, with the conditions prescribed by a Railway Engineer. The inspection regime for every culvert should be determined from its condition, configuration, environment and traffic levels.

b. Any culvert that has not been in railway service and has not been inspected in accordance with this section should be inspected and the inspection report reviewed by a Railway Engineer prior to the resumption of railway service. The inspection frequency requirements of paragraph (a) do not apply to culverts that are not in service, but that does not relieve a railway authority from responsibility for any damage to outside parties that might be caused by the condition of a culvert.

¹² SMS Regulations

¹³ Section 11 Railway Safety Act

4.4 – Culvert Inspection Procedures

- a. Each railway authority's CSMP should specify the procedure to be used for inspection of various types and sizes of culverts.
- b. The culvert inspection procedures should be specified by a Railway Engineer or his designate. The inspection procedures should incorporate the methods, means of access, and level of detail to be recorded for the various types and sizes of culverts.
- c. The culvert inspection procedures should ensure that the level of detail in the inspection procedures is appropriate for the size and configuration of the culvert and conditions found during previous inspections.
- d. The culvert inspection procedures should be designed to detect, report, and protect deteriorations and deficiencies of the culvert, the channel conditions, hydraulic capacity and the surrounding fill material before they present a hazard to safe railway operations.

Section Analysis 4.4 – Culvert Inspection Procedures

Each railway authority's CSMP should specify the procedure to be used for inspection of different sizes and types of culverts, including safe work procedures for inspection personnel (i.e. confined space, etc.). A Railway Engineer or his designate should specify the culvert inspection procedures. The culvert inspection procedures should provide reasonable assurance that the level of detail is appropriate for the size and configuration of the culvert. Additionally, the culvert inspection procedures should be designed to detect, report, and protect deterioration and deficiencies before they present a hazard to safe railway operations. The responsibility for adequate inspection remains with the railway authority, with the conditions prescribed by a Railway Engineer or his designate.

4.5 - Special Inspections

Each railway authority's CSMP should include a procedure for the protection of traffic and for the inspection of any culvert that might have been damaged by an unusual event including but not limited to flood, fire, ice flows, debris flows, sub-grade instability, beaver dam failure, earthquake, derailment, and vandalism.

Section Analysis 4.5 - Special Inspections

It is essential that traffic be protected from possible culvert failure caused by damage from an unusual event. The railway authority should have in place a means to receive notice of such an event and a procedure to conduct an inspection following such an event.

A Railway Engineer may be required to supplement his/her competencies with outside expertise to provide for a reasonable level of culvert safety, (e.g. geotechnical, hydraulic, hydrological or underwater inspection).

4.6 – Submerged Culverts

Each railway authority's CSMP should include provisions for underwater inspections to detect the deterioration of culvert components that are submerged, or where the culvert cannot be inspected due to the depth of water.

In order to provide reasonable assurance of the culvert's integrity, the railway authority should have in place an underwater inspection program that:

- Identifies the culverts to inspect;
- Includes markers for the identification of culvert locations in the field; and
- Includes a list of items to inspect, and the frequency of inspections.

Smaller diameter culverts should include documented monitoring program that includes the frequency and items to be consider, as determined by the Railway Engineer.

Section Analysis 4.6 - Submerged Culverts

Each railway authority's CSMP should provide for the detection of deterioration of culvert components that are submerged or subject to water flow. The condition of culvert components located under water is usually not evident from above. A means to determine their condition might be as simple as using a measuring rod, or might call for periodic or special diving inspections. Advanced technology might also provide devices that can be used to determine underwater conditions.

It is recognized that not all culverts require an underwater inspection. The intent in this section is that if a culvert is deemed by a Railway Engineer to be susceptible to conditions that will require underwater inspections, provisions and procedures should be put in place to satisfy this section of the Guideline. Where underwater inspection equipment is ineffective due to murky water conditions, a Railway Engineer may consider a diving inspection for a larger diameter culvert to determine its condition. For smaller diameter culverts the railway authority 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 yearly documented inspection.

4.7 – Inspection of Drainage Channel Conditions

- a. Each railway authority's CSMP shall¹⁴ include provisions to ensure each drainage facility or culvert under or immediately adjacent to the roadbed is maintained and kept free of obstruction, in order to accommodate expected water flow for the area concerned.

4.8 - Culvert Inspection Records

- a. Each railway authority's CSMP should keep a record of each inspection that has been performed on culverts.
- b. Each record of an inspection under the CSMP described in this part should be prepared from notes taken on the day(s) the inspection is made, supplemented with sketches and photographs as needed.
- c. Each railway authority's CSMP should specify that every culvert inspection include, as a minimum, the following information:
 1. An identification of the culvert inspected;

¹⁴ Track Safety Rules part II B.I

2. The date (i.e. month, year) on which the inspection was completed;
 3. The identification of the inspector;
 4. The type of inspection performed;
 5. An indication on the report as to whether any item noted thereon requires a expedited or critical review by a Railway Engineer or his designate, and any restrictions placed at the time of the inspection; and
 6. The condition of components inspected, which may be in a condition-reporting format, together with any narrative description or photographs, as necessary, for the correct interpretation of the report.
- d. Each railway authority's CSMP should specify the retention period and location of culvert inspection records.

Section Analysis 4.8 – Culvert Inspection Records

a. Each railway authority to which this part applies should keep a record of each inspection that is performed on those culverts under this part.

b. A culvert inspection has little value unless it is recorded and reported to the individuals who are responsible for the ultimate determination of the safety of the culvert. Culvert Inspectors may use a variety of methods to record their findings as they move about the culvert. These include, but are not limited to, notebooks, voice recordings, having another individual transcribe notes, and photographs. These notes and other items are usually compiled into a prescribed report form at the end of the day or at the conclusion of the inspection.

c. Delineates the essential elements that should be addressed and reported in any culvert inspection report.

4.9 - Review of Culvert Inspection Reports

Each railway authority's CSMP should specify the manner and timeline in which culvert inspection reports are to be reviewed by a Railway Engineer, or his designate, to:

- a. Determine whether inspections have been performed in accordance with the relevant schedule and specified procedures;
- b. Evaluate whether any items on the report represent a present or potential hazard to safe railway operations;
- c. Require any modifications to the inspection procedures or frequency for that particular culvert; and
- d. Schedule any repairs or modifications to the culvert that are required to maintain its structural integrity and hydraulic capacity.
- e. Ensure that inspection reports are reviewed in accordance with the timeline identified in the railway authority's CSMP.

Section Analysis 4.9 - Review of Culvert Inspection Reports

A Railway Engineer or his designate should review inspection reports and determine whether culverts are being inspected according to the applicable procedures and frequencies, and review any items noted by a Culvert Inspector as exceptions.

4.10 – Culvert Hazard Identification and Risk Assessment

Railway companies are required to implement and maintain processes for the identification of safety issues and concerns,¹⁵ evaluating and classifying risks by means of a risk assessment¹⁶, and implement necessary risk control strategies¹⁷.

Section Analysis 4.10 – Culvert Hazard Identification and Risk Assessment

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

a. Waterway adequacy;

The stream channel and drainage area should be evaluated for the following:

- 1. 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 failures of a culvert. Wing walls and barrels can break off due to settlement caused by scour.*
- 2. Changes in upstream land use such as clearing, deforestation, significant construction and new development, channel improvements and removal of dams may change the peak flow rates and stream stability. Similarly, obstructions downstream from a culvert that back water up to the culvert may also affect the performance of the culvert or cause saturation of the road bed.*
- 3. Excessive bank erosion, stream channel aggradation/degradation may be indicative of a change in water flow.*
- 4. A high water marks indicate that a culvert may be inadequately sized, which increases the potential for flooding damage or track flooding. Culverts should be checked during or immediately after peak flows -to determine whether water has ponded, adjoining properties are flooded, or the track is flooded.'*
- 5. 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, affects the hydraulic capacity of a culvert.*

If any of the above condition exists railway authority should perform hydrological and hydraulic analysis to determine if a culvert is adequately sized.

b. Slope stability/Ground Hazardous;

This inspection should be conducted by a geotechnical engineer to identify, assess and monitor ground hazards. Ground hazards include but not limited to landslides, subsidence, snow and ice conditions as well as hydraulic erosion hazards. Frequency and locations to be inspected is dependent on the current conditions and the assessed likelihood and severity of the ground hazard. If conditions warrant, helicopter inspections should be conducted to inspect and assess potential hazards such as but not limited to rock falls, debris flows, earth flows, avulsions (shifted streams) and river erosion hazards. Railway authority should take appropriate action as directed by the geotechnical engineer if emergent conditions are identified; immediate action should be taken to mitigate the threat.

¹⁵ Section 2(e)(i) of Safety Management System Regulations

¹⁶ Section 2(e)(ii) of Safety Management System Regulations

¹⁷ Section 2(f) of Safety Management System Regulations

c. Beaver activity;

Railway authorities should implement a beaver control program where warranted to mitigate hazards imposed by beaver activity. Beaver dams located upstream and downstream from the track, in streams that flow under or near the track represent a potential hazard. The primary hazard caused by beaver activity is washouts. It also results in gullying or seepage erosion of the railway grade. Railway authorities 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.

d. Debris and sediment blocking culverts;

It is essential that the culvert 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 inadequate to handle design flows. This may result in excessive ponding, flooding of nearby properties, and washouts of track and embankment. Accumulations of debris sediment in the stream may cause scour of the stream banks and embankments, or could cause changes in the channel alignment. Thus it is imperative that railway authorities remove deposits of debris and sediment blockings if it poses a threat to safe railway operations and property.

e. Snow and ice conditions blocking culverts;

Similarly snow and ice can prevent proper drainage by blocking a culvert and impeding flow. Railway authorities should take appropriate actions when such conditions warrant to protect safe railway operations.

f. High water condition;

Areas subjected to frequent or historic conditions of high or rapidly moving water, such as flash floods, may be protected with detection devices to sense the rise or velocity of water in or near culverts, which may be inadequate to carry the total storm runoff. The track bed may be washed away or flooded and in such cases significant damage could occur. When such conditions are imminent, washout protection devices would provide sufficient warning to stop all nearby trains.

Similar in nature to washout protection is the high water detection device, which detects the rate-of-rise and absolute level of water around particularly vulnerable locations such as culverts, which could face inundation by rapid storm runoff conditions. Conventional rain gages could also be utilized to provide early warning of impending high water conditions.

g. Severe weather conditions;

Railway authorities should monitor weather conditions and weather warnings and 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 any adverse situation.

Railway authorities should remain vigilant of events, including but not limited to heavy precipitation, spring runoff, high river levels and/or higher than normal flow conditions, etc. When such conditions exist, inspections should be performed and appropriate measures taken before and after the event to protect safe railway operations. Culverts should be re-evaluated to confirm both structural integrity and the ability to effectively accommodate water flow under the track.

h. Highly corrosive and abrasive environments;

Water and soil related corrosion and abrasion are the two main forms of deterioration experienced by culvert materials.

Certain soil and water conditions have a strong relationship to accelerated culvert deterioration. Metal culverts are subject to corrosion in certain aggressive environments. The pH and electrical resistivity of soil and water provide an indication of the likelihood of corrosion. Railway authorities should establish guidelines in terms of pH and resistivity that are based on local conditions and performance.

Abrasion may remove any protective coating on the metal, exposing the core material to chemical and further abrasive attack. Corrosion forces may perforate the pipe from either the water or soil side, weakening its structural capacity. Also, exfiltration or infiltration of material and water through these holes may create voids around the culvert pipe, undermining the supporting backfill material and further weakening its structural integrity.

The effects of water-side abrasion and corrosion are easy to assess (since they are visible); however, soil side corrosion is not as apparent (since they are not 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 authorities should be cognisant of aggressive environment and should have a plan in place to monitor, address, and implement special inspection methods in those environments.

i. Buried culverts (culverts “not found” but exist on Railway Company’s inventory);

Culvert Inspectors should report any inventoried culverts they are unable to locate and report these locations 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.

Culverts that are not found may result in inadequate drainage or culvert failure, which could impact safe railway operations. Railway authorities should make every effort to locate such culverts and update their inventory.

j. Deferred work;

A Railway Engineer should perform an evaluation and risk analysis prior to deferring any culvert work.

k. Inadequate culvert length.

Culvert extension may be required as a result of proposed bank widening, stream deepening, track lift, etc.

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

5.1 - Scope

Pursuant to Section 11 of the *Railway Safety Act* “All engineering work relating to railway works, including design, construction, evaluation or alteration, shall be done in accordance with sound engineering principles. A professional engineer shall take responsibility for the engineering work”.

5.2 - Engineering work related to Culverts

Engineering work includes but is not limited to:

- Culvert design;

- Installation and maintenance procedures;
- Inspection and review procedures;
- Deferred maintenance procedures;
- Procedure for maintenance and replacement work completed; and
- Hydrological and hydraulics analysis.

Part G – Documentation, Records and Audit of Culvert Safety Management Programs

6.1 - Scope

Each railway authority's CSMP should include a process for the verification of the effectiveness of the program and the accuracy of the resulting information.

6.2 – Audits, General

A Railway company shall¹⁸ implement and maintain procedures for periodic internal safety audits, reviews by management, monitoring, and evaluations of its CSMP to determine whether it:

- a. Meets the requirements of this Guideline;
- b. Has been properly implemented and maintained; and
- c. Is effective in continually reducing the risk associated with culverts.

Section Analysis 6.2 - Audits, General

To verify the effectiveness of a CSMP, it is necessary to have processes for, and conduct, internal audit.

Internal audit should include:

- a. *Each railway authority's CSMP should incorporate provisions for an inspection audit to determine whether the inspection provisions of the program are being followed, and whether the program itself is effectively providing for the continued safety of the subject culverts.*
- b. *The inspection audit should include an evaluation of a representative sampling of culvert inspection reports and determine whether the reports accurately describe the conditions of the culvert inspected.*

6.3 - Documents and Data Management

Each railway authority should document their CSMP and keep records under this part. The CSMP documents and records should be made available to Transport Canada, in Canada, upon request, as soon as reasonably practicable.

The railway authority should retain, where possible, pertinent drawings for as long as they are responsible/own the culvert and inspection records as per Section 4.8 of this Guideline.

¹⁸ Section 2(J) of the Safety Management System Regulations

When maintenance responsibilities for track and culverts are assigned to another railway company, it should be assigned or given access to pertinent culvert documents and drawings.

Section Analysis 6.3 - Documents and Data Management

Each railway authority should keep records (standards, procedures, drawings, inspection reports, evaluations, etc.) under this part and make those documents and records available for inspection and reproduction upon request. Access to the documents and records of the CSMP is required for carrying out regulatory oversight.

6.4 - Electronic Record Keeping

A railway authority should make it known to Transport Canada, upon request, whether they are maintaining paper or electronic records, or a combination thereof.

A railway authority may create and maintain any of the records required by this part through electronic storage. To qualify as electronic storage the following conditions should be met:

1. The system used to generate the electronic record meets all requirements of this part;
2. The electronically generated record contains the information required by this part;
3. The railway authority should train its employees who use the system on the proper use of the electronic record keeping system; and
4. The railway authority maintains an information technology security program adequate to ensure the integrity of the system, including the prevention of unauthorized access to the program logic or individual records.