

STREAM CROSSING INSPECTIONS MANUAL

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1.0 MONITORING AND MAINTAINING CROSSINGS

1.1 PREAMBLE

Environmental stewardship and safety are key considerations in stream crossing design, construction and maintenance. This is a shared responsibility among the various resource industries and the government agencies in Alberta. Due to the negative impacts that stream crossings potentially have on water quality, many stakeholders got together in 2005 and established the Foothills Stream Crossing Program. Its mandate is to:

- Monitor and improve the status of stream crossings,
- Develop and oversee the implementation of new ideas for stream crossing management in Alberta, and
- Improve the environmental record of participating companies and organizations.
- Collaborate and work together

The Foothills Model Forest promotes cooperation and shared responsibility in the improvement of sustainable land management practices and has agreed to be the coordinating agency for the Foothills Stream Crossing Program. The Alberta and Federal governments are also involved to promote integrated landscape management and conservation of watersheds.

Each stream crossing has an owner who is responsible for the initial design and construction, as well as monitoring, maintaining and de-activating the crossing as part of its stewardship commitments. This process requires a formal and timely inspection process that is based on agreed to protocols. This will help to ensure crossings are functioning effectively.

This 2006 manual is the first comprehensive treatment of inspections for the procedures in use today. Updates are planned as opportunities for improvement are identified.

In this manual we discuss how stream crossing inspections are completed, and how the data collected during an inspection is used to minimize any negative effects roads may have on water quality, fish habitat, fish migration and public safety. The protocols established by the Foothills Stream Crossing Program are widely applicable to streams within Alberta, and it is hoped all crossing owners will adopt them within their respective stewardship programs and certification protocols.



Properly installed culvert – photo courtesy of Culvert BC

Scope

The crossing inspection protocol is designed for situations where a **permanent road** crosses a **defined channel**. The inspection includes the crossing structure and the road and ditches on both approaches to the crossing. Inspections will also be performed on crossings of unmapped channels.

Crossings over intermittent streams with no channel and cross-drains through ephemeral draws are not normally inspected. In some cases stream determination is not clear. For example, short sections (e.g. – 15m) of discontinuous channel are often encountered in the field. These channel sections may result from the constriction of water flow from the crossing itself or result from gradient changes otherwise connecting flat wetland areas. Solution: When there is no channel upstream and a channel downstream walk down and determine if the downstream channel is a function of the “zone of influence” from the crossing. If it becomes an ephemeral again or runs into a sphagnum bog, etc., do not carry out the inspection. If there is a defined channel downstream that continues down slope and there is no channel upstream, carry out the assessment without the fish passage checks. When channel sections connect wetland areas, or the crossing itself connects wetland areas, assessment is recommended whenever an inflow/outflow is suspected in the system. Temporary roads often have snow bridges, drainage culverts or log fills that are removed before spring thaw, so they have little, if any, effect on stream siltation or fish migration, and thus do not normally require inspecting.

Stream crossing inspections

The inspection is designed to:

- Identify unsafe design or structural performance problems for bridge and culvert crossings
- Identify erosion and sedimentation factors
- Identify barriers to fish passage
- Record suggested remediation measures

Inspectors will consider both the crossing structure and the area that impacts the crossings (which usually means back to the height of land or to the point water does not flow to the crossing). For a list of equipment needed to complete an inspection, please refer to Appendix 2.

Inspection safety

Several hazards have been identified for stream crossing inspections. In addition to other safe practices for working on forestry roads, the following are provided. It always makes sense to work together to identify all hazards for your job, and to generate ways of preventing accidents and reducing injury.

- Be aware of traffic and park in a safe location
- Use flashing amber lights to alert drivers that you are there
- Take care negotiating steep slopes or walking on slippery rocks in streams
- Steel culverts are extremely slippery
- Never enter the stream alone, and do not wade a flooding or swiftly flowing stream

Inspection Schedules

An inspection schedule is a corporate choice, however, the following may be used as a guide:

Initial inspection - An initial inspection for a new crossing should be completed after the first season of use. Spot checks are recommended after major storms or flooding events.

Periodic inspection – Every 3 years for active crossings. Crossings tend to deteriorate over time, so older crossings, or ones with known defects may need to be inspected more often. Spot checks are recommended after major storms or flooding events.

Removed crossings – Annual inspections should be completed until the vegetation is established and the crossing site is stabilized. Spot checks are recommended after major storms or flooding events.



Reclaimed crossing

Record-keeping

The inspection form is designed for ease of data entry from paper, or using a Data Logger or similar device. A database is also used to enter, store and report information needed by the planner. Many agencies will integrate the information collected here with their corporate GIS systems to produce site-specific maps and summary information.



2.0 COMPLETING A CROSSING INSPECTION

This section covers the detailed methods of measuring and recording data during a stream crossing inspection. In order to achieve consistent measurements, and allow results from one agency to be compared with another, it is highly recommended that these procedures be applied as specified. The information to be gathered is presented here in the same order it appears on the *Stream Crossing Inspection Data Sheet* (see Appendix 4).

2.1 GENERAL SITE INFORMATION

Date:

Day-Month-Year (e.g. 14-Sep-05)

Inspector(s):

Names of inspectors

Crossing No.:

Enter crossing number assigned from the company files. It is recommended that companies develop a numbering system for their crossings to uniquely identify each crossing. Enter a new number if this is a crossing over a stream with a distinct channel that has not been mapped. For twin culverts draining the same stream giving each culvert an independent crossing number, as opposed to using a "culvert A and B" approach, helps when managing data in a database. Additionally, parameters can differ between the two culverts making it necessary to use two data sheets/data logger entry tables.

It is also recommended that the crossing number spray-painted on a nearby tree and/or on culvert for ease of locating on next visit. See photos.



Crossing Numbers are painted on the structure or a nearby tree

Crossing owner:

This name is usually supplied prior to inspecting. If not, enter “unknown.”

Name of road:

Disposition number is preferred, e.g. LOC801220, or
Road number, e.g. 104-2, or
Common name, e.g. Robb Road

GIS Location: determined in office by GIS exercise prior to heading into field.

Record projection system of coordinates (e.g. NAD 83).
UTM_Easting:
UTM_Northing:

GPS Location: determine onsite using a GPS unit

UTM_Easting:
UTM_Northing:

Name of stream:

Enter the stream name or “unnamed”

Stream category: (determined by GIS exercise)

(LP) Large Permanent
(SP) Small Permanent
(I) Intermittent
(E) Ephemeral

Fish-bearing status:

Status can be obtained prior to inspection from FMIS (the provincial Fisheries Management Information System)

(F) Fish bearing
(N) Non-fish bearing
(U) Unknown

Species (if known):

This information can be obtained prior to inspection from FMIS (the provincial Fisheries Management Information System)

Enter the standard species code, e.g. LNSC. See Appendix 3 for the full list of codes.

Fish-bearing status confirmed in field:

This is a judgement call based on visual observation during visit. FMIS does not have data for all fish-bearing streams, and therefore some streams may be of “Unknown” status. During the field visit, the inspectors should confirm whether the status is either “unknown and likely” (e.g. a small permanent or intermittent stream, or is in close proximity to a larger watercourse or lake) or “unknown and unlikely” (e.g. an ephemeral stream). If fish are observed during a visit, then the stream is considered fish-bearing, and should be recorded as such in the comments. For an unmapped small permanent stream that is not in FMIS, err on the side of caution and call it “likely” fish bearing.

If the stream is “fish-bearing” or “unknown and likely,” complete the Fish Passage section.

Likely

Unlikely



Rainbow trout captured at a crossing is evidence of fish-bearing

Length of habitat upstream (m)

A GIS system is used to measure the habitat upstream from the crossing. The GIS operator calculates the length of all tributaries upstream from the crossing. If available, the operator uses a fish probability model to obtain a length of high and medium probability habitats.

Unmapped crossing (add to database)

When an unmapped crossing is found to be crossing a stream with channel development, complete an inspection and check the box to indicate it is new to the database.

2.2 FISH PASSAGE PARAMETERS

This section is completed if the stream is “Fish-Bearing” based on FMIS data or other sources, or is “Unknown and Likely” (refer to 2.1 General Information – Fish passage confirmed in field).

See Figure 1 below for the method of determining the hang height, effective pool depth and riffle crest depth. Measure to the nearest hundredth of a meter (e.g. 0.35m).



Hanging culverts present an obstacle to fish passage

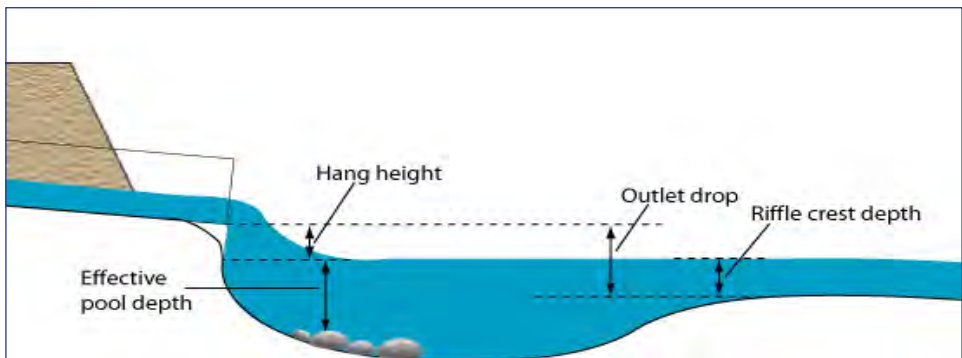


Figure 1. Measuring the hang height, effective pool depth and riffle crest depth

Hang height (m):

Hang height is measured from the bottom lip of the culvert to the surface of the water.

Riffle crest depth (m):

The riffle crest is found at the lower end of the pool, where relatively flat water starts to form riffles from the reduced stream depth.

Outfall drop (m):

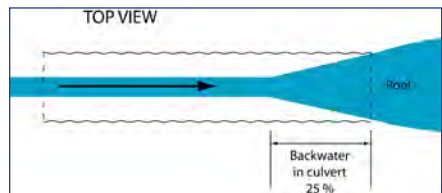
The outlet drop is the hang height plus the riffle crest depth. Outlet drops > 0.1 m may be a barrier to fish passage, depending on target fish species and swimming ability. For species-specific information, see <http://stream.fs.fed.us/fishxing/>

Effective depth of pool (m):

A fish needs a fairly deep pool to be able to get up enough swimming speed to leap into the culvert. If there are any rocks or debris at the outflow, this can limit success. Measure the effective depth of pool from the bottom or from a rock or debris to the water's surface. The pool should be measured just downstream of the turbulence created by the falling water. In the case of low/no flow, estimate this location or measure 0.3m out from the outlet culvert lip. If the water spills directly onto an erosion apron or other structure, then pool depth equals 0.

Backwater in culvert (%):

This is how far the outlet pool fills back into the culvert and is expressed as the % of the total culvert length. Choose the best category: 0, 25, 50, 75, or 100%.



Backwater does not extend through entire culvert.

Substrate in culvert %:

This is how far back into the culvert substrate can be found. It is expressed as the % of the total culvert length. Choose the best category: 0, 25, 50, 75, or 100%.

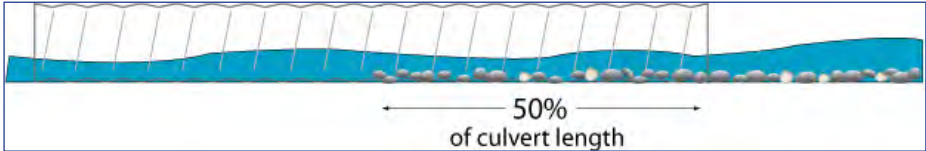


Figure 2. Substrate in culvert

Substrate type:

Substrate in the culvert helps fish passage by giving them some resting spots part way through the culvert. The larger the particle size, the better.

- (S) Sand, 0.06-2 mm
- (G) Gravel, 2-64 mm (0.08"-2.5")
- (C) Cobble, 64-256 mm (2.5"-10")
- (B) Boulder, >256 mm (10")
- (O) Other
- (N) None

2.3 VERTEX DATA

Culvert slope is an important measure for evaluating fish passage and it can be calculated from measurements taken with either a rod and level or a Forester's Vertex. In an experiment at the Foothills Model Forest, the results were comparable using both methods, however the data collection and calculation times for the Forester's Vertex were four times faster for shallow fill crossings and eight times faster for deep fill crossings. Field methods for use of the Forester's Vertex are different for shallow fill (*Figure 3*) vs. deep fill culverts (*Figure 4*).

Shallow fill:

If you are able to see "eye to eye" with your partner while standing on each end of the culvert, then it is considered to be a shallow fill. The person with the transponder should hold it at the eye level of the person holding the Vertex (*Figure 3*). If the culvert inlets and outlets are not damaged, stand on top of the pipe. With any damage or deformity, use the bottom. Take three readings and for each reading record the horizontal distance (HD) and slope (measured in degrees). These readings will be averaged in the office. Calculations are presented in Appendix 5.

Reading	SHALLOW FILL	
	HD (m)	Slope (°)
1		
2		
3		

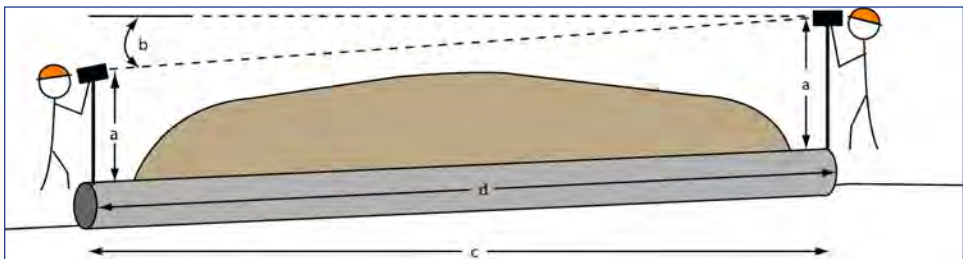


Figure 3. Measuring culvert slope at a shallow fill crossing using a Vertex.

a = height at eye level of person with Vertex, *b* = slope measured in degrees, *c* = horizontal distance.
 (modified from Keith Campbell — Campbell Forestry Consultants).

Deep fill:

If the fill is higher than the line of site from the inlet to the outlet, then the person with the Vertex should stand at a point on the road where he could see the person with the transponder at both ends of the culvert (Figure 4). The transponder is held at the same height as the Vertex. If the culvert inlets and outlets are not damaged, the person with the transponder should stand on top of the pipe. With any damage or deformity, use the bottom. Take 3 readings with the vertex for each of Horizontal Distance (HD) and Slope (degrees) from the top of the road to the culvert outlet (Foreshot), then turn around and take 3 more from the top of the road to the culvert inlet (Back shot). These readings will be averaged in the office. Calculations are presented in Appendix 5.

Reading	DEEP FILL			
	Foreshot		Backshot	
	HD (m)	Slope (°)	HD (m)	Slope (°)
1				
2				
3				

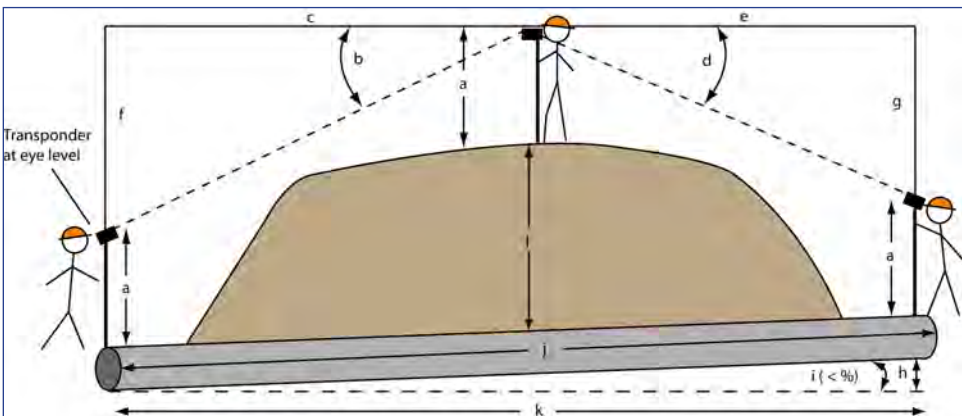


Figure 4. Measuring culvert slope at deep fill crossing using a Vertex.

a = height at eye level of person with Vertex, *b* = foreshot slope measured in degrees, *c* = foreshot horizontal distance, *d* = backshot slope measured in degrees, *e* = backshot horizontal distance.

(modified from Keith Campbell — Campbell Forestry Consultants).

2.4 ROD AND LEVEL SURVEY DATA

The rod and level survey is a simple method that can be used as an alternative to the Vertex method for determining elevations of the inlet and outlet. For detailed surveying methods, refer to Harrelson et al. (http://www.fs.fed.us/rm/pubs_rm/rm_gtr245.pdf).

Inlet elevation (m):

Record the inlet elevation.

Outlet elevation (m):

Record the outlet elevation.

Culvert length (m):

Use a tape or laser range finder to measure culvert length.

Slope (%):

If you used a Vertex, calculate slope in the office as per Appendix 5. If you used a rod and level, confirm measurements by calculating culvert slope in the field to confirm measurements. Slope % is rise/run*100, or in our terminology:

$$\text{Slope \%} = (\text{Inlet elevation} - \text{Outlet elevation}) / \text{Culvert length} \times 100$$

2.5 CULVERT PARAMETERS

Type:

- (E) Elliptical,
- (O) Open-bottom arch,
- (R) Round

Culvert material:

- (S) Steel,
- (C) Concrete,
- (O) Other



Round steel culvert

Road surface material:

- (G) Gravel,
- (C) Clay, or mineral soil with no gravel
- (CC) Calcium carbonate - this is a white powder, often added to control dust
- (O) Other

Diameter (m):

Choose the least damaged end for the measurement. For elliptical culverts measure the widest part. Round the measured number to the nearest standard culvert size in meters.

Length (m):

Shallow fill: Measure culvert length with a laser range finder or tape.

Deep fill: Follow methods from section 2.3 - Vertex data for deep fill. See Appendix 5 for culvert length calculations.

Height of fill over culvert (m)

Estimate height of fill over culvert. For deep fills, you can also calculate fill height from your Vertex measurements for culvert length using formulas in Appendix 5.

Bankfull width of channel (m):

This is the bankfull width of the channel upstream from the crossing. The bankfull elevation can be described as the point at which the water breaches its banks and flows onto the floodplain. It is also referred to as “rooted width,” which refers to the point on a bank where the rooted, non-grass, vegetation begins. Channel width should be measured at an undisturbed section of the stream that is not affected by the right-of-way, preferably 50m upstream of crossing. Bankfull measurements should be taken 50m downstream when multiple contributing channels are present upstream. Channel width is highly variable in small streams with wider areas occurring around corners and along pools. Therefore, width should be measured in a straight section of the stream in between pools. Only one measure is taken—choose a representative site. Bankfull width, not wetted width is measured. See Figure 7 for the method of determining channel bankfull width in meters. Measure to the nearest 0.01m.



A suitable site for measuring bankfull width in a straight riffle section away from bends and pools.

Bankfull depths of channel (m):

Measure channel bankfull depths at same location as width measurement. A left, center and right depth is measured using a meter stick to the nearest 0.01 m. Right and left refer to the directions when you are looking downstream. Depth measurements should be spaced evenly along the bankfull width line of measurement (this may result in some measurements being taken on dry ground). If channel undercutting is present include an estimate of total undercutting (e.g. - 0.5m total undercutting under both banks). This will more accurately reflect the volume of water in the channel. See Figure 5 for the method of determining the three channel depths in meters. Measure to the nearest 0.01m.



Measuring bankfull depth from measuring tape elevation.

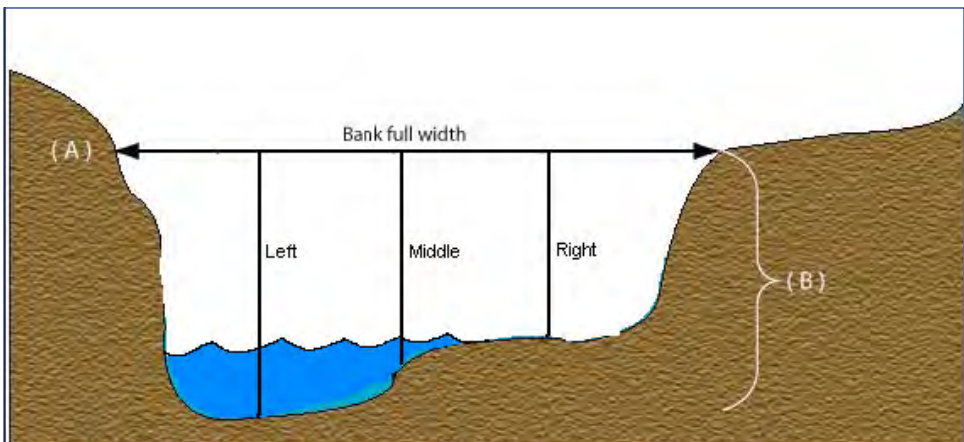


Figure 5. Measuring the bank full width (A) and 3 channel depths (B)

Armour type at inflow:

- (R) Riprap
- (G) Gabions
- (GT) Geotextile
- (V) Vegetation
- (O) Other
- (N) None



*Gabion baskets used to armour the inflow.
Note the rill erosion above the culvert*

Armour type at outflow:

- (R) Riprap
- (G) Gabions
- (GT) Geotextile
- (V) Vegetation
- (O) Other
- (N) None



Vegetation is considered armour from an erosion perspective

2.6 BRIDGE PARAMETERS



Steel bridge

Type:

Indicate the most common material used in the bridge substructure

(T) Timber

(S) Steel

(C) Concrete

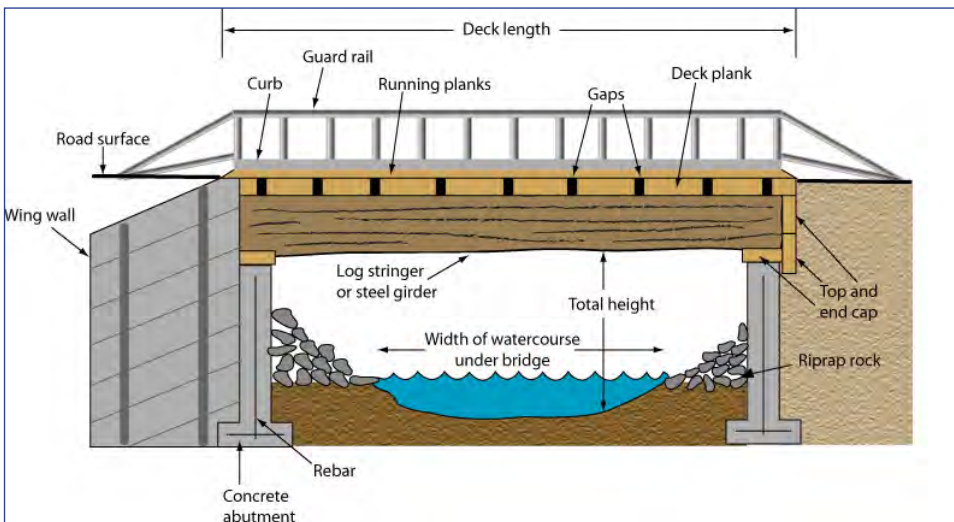


Figure 6. Bridge components

Total deck length (m):

This is the length of the bridge deck.

Deck width (# of lanes):

This is the number of lanes of traffic the bridge width will accommodate, usually one or two. If the bridge deck width is >10m then it is considered a two-lane bridge.

Decking material:

- (W) Wood,
- (C) Concrete
- (O) Other, includes steel or synthetic



*A closed decking pattern with no curb
Note the broken guard rail.*

Decking pattern:

The pattern determines whether or not dirt or other road surface materials are able to penetrate the bridge deck and fall to the stream below. If you can see through the deck it is open, if not, it is closed.

- (O) Open
- (C) Closed

Curb type:

A curb will prevent dirt or other road surface materials from falling off the side of the bridge deck to the stream below.

- (W) Wood
- (C) Concrete
- (G) Geotextile
- (N) None – there is no curb, or the curb pattern has openings



This bridge has geotextile curbs attached to the guardrail

Road surface material:

This applies to the surface of the road at the approach to the bridge, not on the bridge deck. If it is gravel over a clay fill, select gravel

- (G) Gravel
- (C) Clay or mineral soil
- (CC) Calcium Carbonate
- (O) Other

Abutment type:

- (SP) Steel pilings
- (CP) Concrete pilings
- (LP) Log pilings
- (C) Concrete blocks
- (L) Logs
- (T) Treated lumber
- (O) Other
- (N) None

Abutment functioning:

- (Y) Yes - in good condition and no materials eroding from underneath
- (N) No - falling apart and/or materials eroding from underneath
- (N/A) No abutments present

Wingwalls functioning:

- (Y) Yes - in good condition and no materials eroding from underneath
- (N) No - falling apart and/or materials are eroding from underneath
- (N/A) No wingwalls present



Treated wood wingwalls that are failing

Armour:

Choose one or multiple types (if applicable) of armour found at crossing.

- (R) Riprap
- (G) Gabions
- (GT) Geotextile
- (V) Vegetation
- (SF) Silt fence
- (ES) Erosion socks

(O) Other

(N) None

Bankfull width of channel (m):

See Culvert Parameters

Bankfull depths of channel (m):

See Culvert Parameters

Bankfull width under bridge (m):

This is the width of the watercourse under the bridge (*see Figure 8*).

2.7 PERFORMANCE AND SAFETY

Blockage of opening (%):

This is measured at either the inflow or outflow, whichever is the greatest concern and can apply to both culverts and bridges. Measure the % of the total height that is blocked. For culverts, the total height is the diameter, for bridges it is the total height under the bridge (*see Figure 8*). Record nearest category, 0, 10, 25, 50, 75, or 100 % of total height. (Note: a blockage >10% is considered to be a barrier to fish passage.)

Cause of blockage:

- (B) Beaver
- (D) Debris
- (S) Slumping
- (R) Road material
- (O) Other
- (N) None



(B) Beaver dam under the bridge (downstream side)



Upstream pond created by beaver dam blockage under bridge

Structural problems - culverts:

- (C) Collapsing (resulting in sinkhole)
- (D) Damaged
- (SL) Slumping
- (V) Vegetation protruding
- (O) Other
- (N) None
- (U) Undersized culvert



Structural problem (C): Culvert sections have separated, creating a sink hole above and dropping fill directly into the stream, and creating an additional barrier to fish passage

Structural problems - Bridges:

- (C) Collapsing
- (D) Damaged
- (BA) Broken/separated/damaged abutments
- (RA) Rotten abutments
- (SA) Sunken deck abutments
- (DG) Damaged guardrail
- (GM) Grout missing or requires replacing
- (SL) Slumping
- (V) Vegetation protruding
- (O) Other
- (N) None



Structural problem (S): sunken deck



Structural problem (O): Pilings and rotted wingwall planks



Structural problem (C): Collapsing causing sink hole

2 COMPLETING A CROSSING INSPECTION



Structural problem (SL): Slumping caused by gully under bridge



Structural problem (RA): Log abutment beginning to rot

Bridge signs:

- (Y) Yes, sign is present
- (N) No, sign is not present
- (D) Damaged, sign is either down or needs to be replaced

Grader markers or bridge reflectors:

- (Y) Yes, markers are present
- (N) No, markers are not present
- (D) Damaged, markers are either down or need to be replaced



Markers (Y): Good bridge reflectors

2.8 EROSION AND SEDIMENTATION

Sediment from stream crossings can reduce downstream water quality, invertebrate production and fish egg survival. Inputs of sediment at a crossing may range from a negligible amount up to several tonnes per year. The amount of sediment input can be reduced by:

1. Minimizing the length of contributing ditches.
2. Establishing 100% vegetation cover on all cut and fill slopes.
3. Ensuring proper road surface runoff on approaches and at crossing.

The stream crossing inspection includes an assessment of sediment inputs from ditches and other non-vegetated sediment sources such as right of way slopes with exposed soil. Road crown condition can also affect sediment inputs at stream crossings.



When used properly, silt fences are effective in controlling sedimentation during the revegetation period

2.8.1. Preliminary Inspection

Evidence of sedimentation:

Walk along the banks of the stream upstream and downstream of the crossing to check for sediment entering the stream. Closely inspect problem areas such as the toe of the fill slopes and ditch-line outlet areas, looking for recent deposits of road-related sediment. Also, look in the stream channel for sediment fans and fresh sediment deposits along slow areas. Once identified, sediment trails can be followed uphill to locate the route and source of sediment.

Answer YES to “evidence of sedimentation?” if you see any signs of crossing-related sediment reaching the stream. Answer NO for sediment issues that are not contributing sediment to the stream (these issues can be captured in the comments section and by suggesting the “Monitor for Severity” remedial measure).

Source of Sediment:

Determine the source of sediment (Ditch, Sediment Source or External Sediment Source) and note it here. These sources are clarified on the following pages.



Road runoff-sourced sediment is spilling over silt fencing under bridge. Therefore, write “Yes” for evidence of sedimentation and “Road” or “External” for source of sediment.

2.8.2. Ditch inspection

Location *	Ditch Length (m)	Drainage improvement type
Right Downstream		
Right Upstream		
Left Downstream		
Left Upstream		

**All inspection locations are from the perspective of a person standing in the stream and facing downstream.*

Ditch length (m):

For each ditch, inspect the area where draining water will enter the channel. Look for the delivery route, indicated by recent deposits of sand or silt. For ditches that contribute sediment to the stream, measure the distance to the height of land or first properly functioning drainage structure (Figure 7).

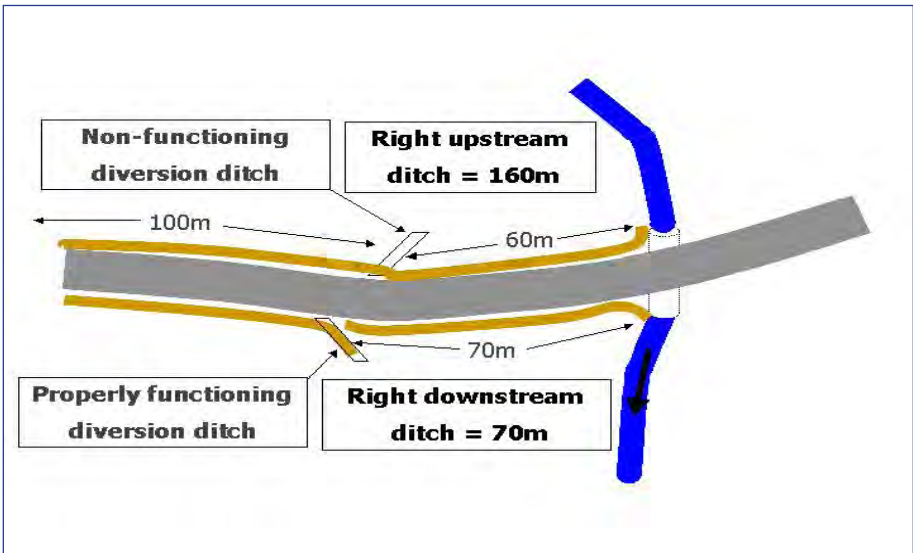


Figure 7. Measuring the length of ditch leading sediment into the channel.

Drainage improvement type:

Indicate the type of maintenance or improvement recommended for each ditch. Refer to “Remedial Measures” Options.



Blocked diversion ditch (requires Remedial Measures)

2.8.3. Sediment Source Inspection

Inspect all cut and fill slopes that connect to the stream or contributing ditches. Identify sediment source areas based on poor vegetation cover and signs of sheet, rill or gully erosion. For “Above Inlet” and “Above Outlet,” measure the contributing section of road fill above the culvert ends that bypasses the ditches and drains directly towards the channel. These areas are often bare of vegetation and are a common source of sediment. Note: Gullying from road runoff is often found in these areas but is a different problem requiring unique remedial measures, such as improving road drainage (see “*External Sediment Source*,” pg. 39). To maximize the number of remedial measure options, sediment sources draining into contributing ditches can be captured as both “Sediment Sources” and “Ditches.”

Due to their low erodibility, areas of bedrock and riprap are not considered sediment sources. Once the measurements are complete, they will be used to estimate relative soil loss based on a simplification of the Revised Universal Soil Loss Equation:

$$\text{Soil loss (t/year)} = R * VM * \text{Area}$$

R = the rainfall factor with a value of 700 for Alberta Foothills region

VM = the vegetation management factor based on vegetation cover class

Area = the source size in hectares

Location*	Sediment Source	Sediment Source	Veg. Cover Class	Remediation Type
	Length (m)	Width (m)	(1-5)	
Right Downstream				
Right Upstream				
Left Downstream				
Left Upstream				
Above Inlet				
Above Outlet				

**All inspection locations are from the perspective of a person standing in the stream and facing downstream.*

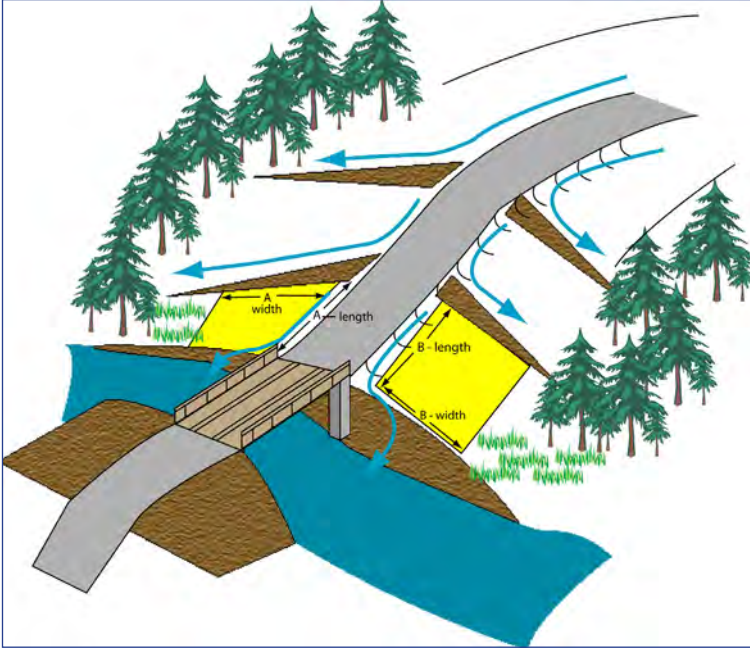


Figure 8. Measuring sediment source area

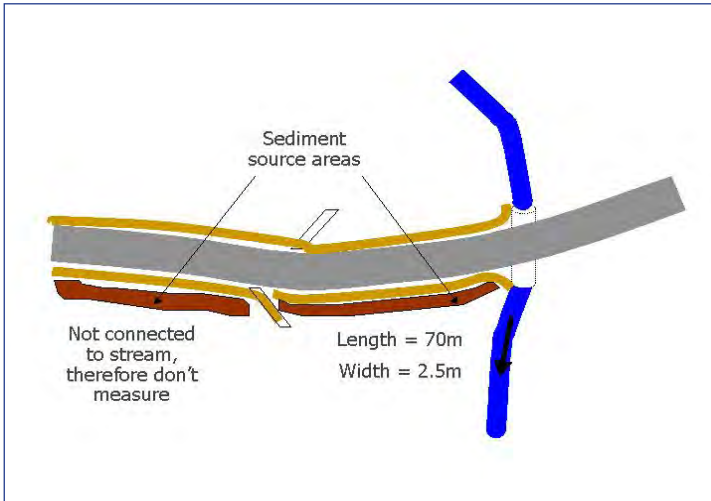


Figure 9. Measuring sediment sources.

Sediment source length (m):

Measure the length of the sediment source areas that are connected to the stream. Do not include sediment source areas that drain into functioning diversion ditches. (Figure 8 and Figure 9).

Sediment source width (m):

Measure the width of the sediment source areas that are connected to the stream. Do not include sediment source areas that drain into functioning diversion ditches. (Figure 8 and Figure 9).

Vegetation cover class:

Estimate the vegetation cover class:

- 1 – % cover 0-10, vegetation management factor (VM) of 0.4
- 2 – % cover 10-30, vegetation management factor (VM) of 0.2
- 3 – % cover 30-50, vegetation management factor (VM) of 0.1
- 4 – % cover 50-95, vegetation management factor (VM) of 0.05
- 5 – % cover 95-100, vegetation management factor (VM) of 0.003

Remediation type:

Recommend method(s) of remediation. Refer to “Remedial Measures” options.

2.8.4 External Sediment Source Inspection

Some sediment sources, such as bridge decks and road surfaces, are difficult to capture quantitatively. Bridge deck-sourced sediment results from factors such as: open deck, missing curbs, heavy traffic and loose road surface materials. While road-sourced sediment is usually captured as a “Ditch” issue, this is not possible when road sediment bypasses the ditches. This is often the case when road sediment moves down fill slope gullies near the inlet and outlet culvert ends. In addition, while a fill slope gully can be captured as a “Sediment Source,” the gully area measurement underestimates the true contributing area of sediment. The inspector can capture these sources by estimating the severity of the problem using a high, medium or low rating. Capturing road runoff is illustrated in the following examples:

Example criteria of a low severity road runoff problem include:

- Absence of gullying above inlet/outlet and no signs of sedimentation.
- A properly crowned/graded road directing road runoff into ditches.
- Flat road approaches not directing water towards crossing.

Example criteria of a high severity road runoff problem include:

- Gullying above inlet/outlet reaching the stream and contributing sediment.
- A poorly crowned/graded road directing road runoff towards inlet/outlet.
- Steep road approaches directing water towards crossing.

Note that road sediment reaching the stream via ditches can be captured as an “External Sediment Source” and/or a “Ditch,” depending on management objectives.



Fill slope erosion due to road surface runoff (requires Remedial Measures)

2.9 SUMMARY REMARKS

Emergency repair required:

The two situations that can be considered an emergency are when the road or crossing is in a state that public safety is at risk or that the crossing has failed or failure is imminent.

(Y) Yes, describe the problem briefly and/or choose repair options from “Remedial Measures.”

(N) No



A large sinkhole near the bridge presents a high risk of an accident—emergency repair is warranted

Suggested remedial measures or follow-up:

Choose one or more “Remedial Measures” (see *Appendix 4*).



Remedial measures:

C7 - Remove beaver dam blockage and

C8 - Requires debris/beaver grates



Remedial measures:

4 - Requires vegetation cover seeding and

8 - Stabilize and repair grade fill slumping or gullyng



Remedial measures:

- C1 - Requires sediment barriers on both sides of this crossing,*
- 7 - Requires ditch blocks, and*
- 5 - Requires diversion ditches*



Remedial measures:

- 1 - Requires rip rap armour and 8 - Stabilize and repair grade fill slumping or gullyng*

2.10 PHOTOS

Six digital photos are normally taken for each inspection. Placing a unique frame number here will maintain the “photo number-crossing number” link. Photos should also be downloaded to a computer for back up on a frequent basis. A photo numbering system should be established so that they can be easily filed and found when needed.

Frame number	Description
	Inflow
	Outflow
	Upstream of crossing (fish habitat)
	Downstream of crossing (fish habitat)
	View from crossing to road approach on LDB
	View from crossing to road approach on RDB
	Other

3 IDENTIFYING PRIORITIES FOR REMEDIAL ACTION

Inspection data will be evaluated using specific criteria, which are detailed in the following three subsections. The rating for each subsection is then applied to the crossing overall, based on the highest rating on any given subsection.

3.1 FISH PASSAGE EVALUATION

Utilize Figure 12 to determine how the crossing is likely to affect fish passage. The diagram is interpreted as follows:

- Green:* Obstruction of fish migration is not an issue at this crossing. Future monitoring should be conducted to check for debris blockages, formation of an outlet drop, changes in substrate, and backwater within the culvert.
- Yellow:* The crossing may impede passage of some species or life stages at various times of the year. A detailed fish passage assessment is recommended.
- Red:* The crossing presents a fish migration concern. A remediation or replacement design is recommended at this site.

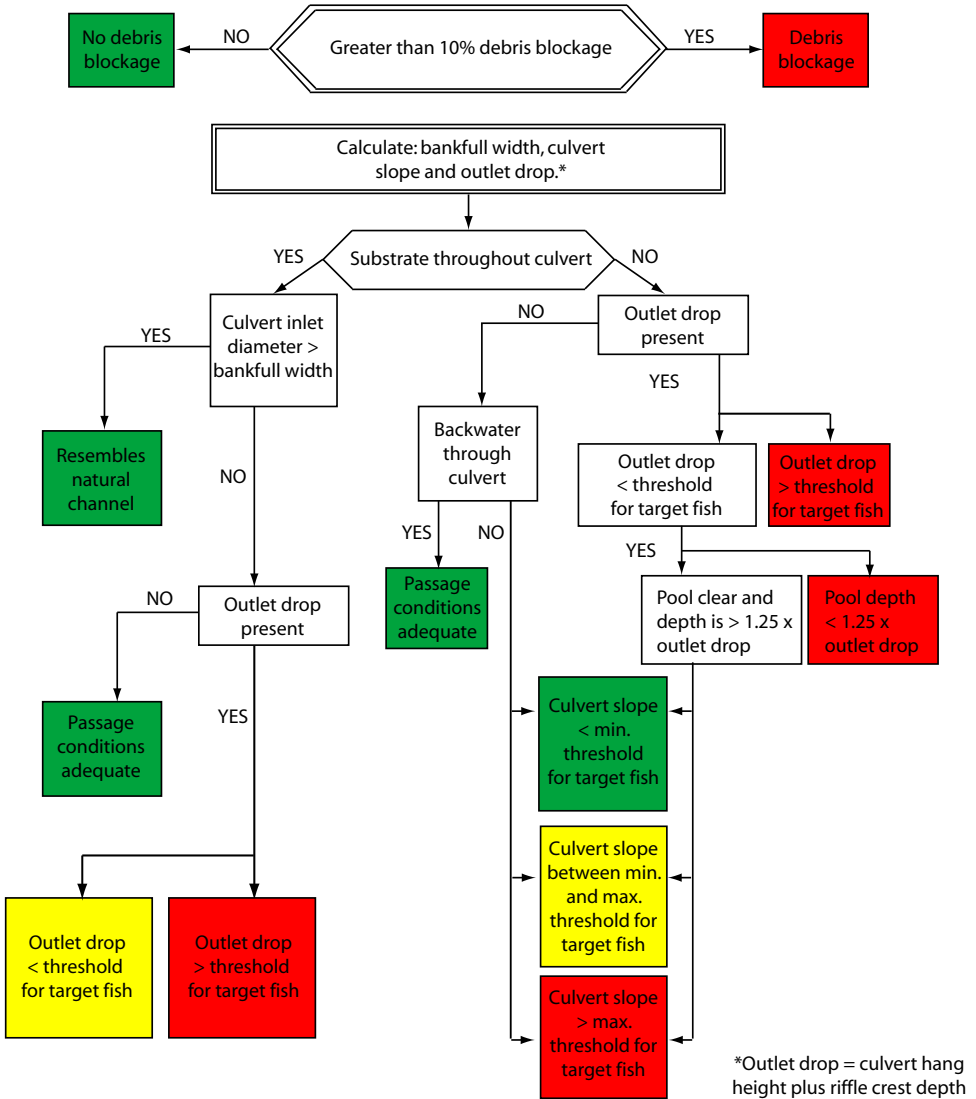


Figure 12. Fish passage evaluation with culvert slope and outlet drop criteria for juvenile rainbow trout (based on Clarkin, K. et al. May 2003. National Inventory and Assessment Procedure. Appendix B. 7 Jan 2006. <http://www.stream.fs.fed.us/publications/PDFs/NIAP.pdf>)

3.2 SAFETY AND PERFORMANCE EVALUATION

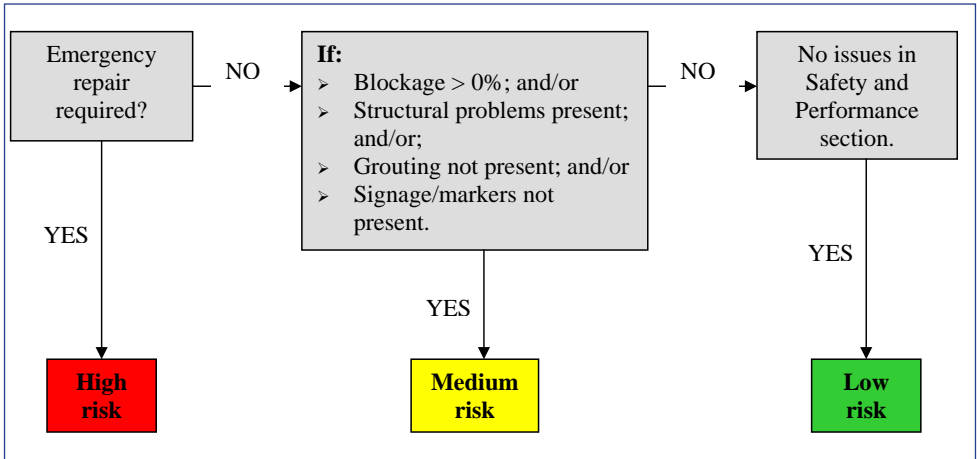


Figure 13. Safety and performance evaluation

3.3 EROSION AND SEDIMENTATION EVALUATION

The inspection findings are summarized for each crossing (Table 1). The cut-off values for total ditch length and estimated sediment yield should be adjusted based on field calibrations. Additional categories could also be added based on management objectives.

Table 1. Erosion inspection summary procedure.

Total Ditch Length (m)*	Soil Loss Index (m ³)*	Estimated (external) Sediment Source	Rating
>100m	≥20	High	High
30-100m	10-19.9	Medium	Medium
<30m	<10	Low	Low

* Threshold values for high, medium and low to be set according to objectives and actual observations.

To summarize each crossing, use the maximum rating for each of the three components to produce an Overall Erosion/Sedimentation Rating (Table 2).

Table 2. Example erosion inspection summary.

Crossing #	Component 1: Total Ditch Length	Component 2: Soil Loss Index	Component 3: External Sediment Source	Overall Rating
3001	Low	Low	Low	Low
3002	Low	Low	High	High
3003	Medium	Medium	Low	Medium

3.4 CROSSING EVALUATION SUMMARY

Refer to the previous sections (3.1, 3.2, and 3.3) to determine the summarized fields below. The overall rating of a stream crossing should be based on the priorities of each company using this protocol.

Table 3. Summary Evaluation

Summary Evaluation	3.1 Fish Passage Evaluation	3.2 Safety and Performance Evaluation	3.3 Sedimentation Evaluation	Overall Rating
High risk	Red	Emergency repair required.	High	Based on individual company priorities.
Medium risk	Yellow	Any of: <ul style="list-style-type: none"> • Blockage • Structural problem(s) • Grout not present • Signage/markers not present 	Medium	Based on individual company priorities.
Low risk	Green	No Issues	Low	Based on individual company priorities.

APPENDIX 1

GLOSSARY

Active channel means those parts of the bed and banks of a water body that are without terrestrial vegetation;

Deleterious means anything that has the potential to harm or alter fish or fish habitat. This could be wood debris, oil, fuel, mud, or dirt from the banks of the watercourse.

Emergency means a situation where there is an imminent risk to the aquatic environment, public health or safety, or an imminent risk of structural failure to a watercourse crossing;

Erodibility is a characteristic of the material subject to erosion that denotes susceptibility to erosive agents. Sands are generally more erodible than silts, and silts than clays, but no fully satisfactory way to predict soil erodibility has been found. Changing conditions of the soil (soil wetness, soil frost, recent tillage or compaction) change the erodibility of soil. Angular soil particles are more interlocking than rounded particles; soil colloids cement particles together; compaction increases total surface contact among particles. All of these tend to reduce erodibility. Another important factor is whether water is infiltrating or exfiltrating the soil surface while detachment under water is taking place; the filtration force reduces erodibility in the first instance but increases it in the second. Gullies often begin along midslopes where water exfiltrates during rainfall.

Erosion is the process by which soil and minerals are detached and transported by water, wind, gravity, ice and man's activities. Physical energy, chiefly in the form of gravity or kinetic energy, and chemical energy, chiefly as a weathering process, underlie erosion in all its forms. This text is concerned mainly with water, gravity and man's activities as erosive agents. However, wind has reshaped land in desert and "dust-bowl" areas throughout time and ice is locally important in high mountains. Historically, ice and ice melt shaped much of the land, lakes and rivers north of continental glaciation.

Fish means fish used for domestic, sport and commercial purposes, and fish of special concern, including but not limited to rare, endangered, threatened or vulnerable species.

Maintenance means the repair, partial replacement or structural restoration of a watercourse crossing that results or may result in the disturbance or alteration of the bed or banks or active channel of a water body;

Sedimentation is the process by which materials carried in water are deposited. Materials are considerably mixed, sorted and segregated by size during the process; coarse particles move relatively short distances and finer particles move longer distances. Very fine clay in suspension will move to the nearest body of still water, where it may form a fine layer uniformly over the bottom.

Uncoded water body means a mapped water body that does not have a class symbol specified on a map listed in Schedule 6 - Codes of Practice.

Unmapped water body means a water body that does not appear on a map listed in Schedule 6 - Codes of Practice.

UTM coordinates means coordinates that use the Universal Transverse Mercator grid to identify or plot the specific location of a site or object.

Watercourse refers to rivers, brooks, creeks or other natural water channel and the bed along which this flows. Ephemeral draws (runoff channels) and intermittent streams are included.

Watercourse crossing means a crossing or temporary crossing and any associated permanent or temporary structures that are or will be constructed to provide access over or through a water body, including but not limited to a Type 1 crossing, Type 2 crossing, Type 3 crossing, Type 4 crossing or a Type 5 crossing, and structures and measures to isolate the location of the works, erosion protection structures, and sedimentation management structures.

Watershed is an area of land that drains downhill to a body of water, such as a stream, lake, river or wetland.

APPENDIX 2

EQUIPMENT NEEDED TO DO AN INSPECTION

- Digital camera
- GPS unit (Global Positioning System)
- Laser level, receiver, tripod, and rod
- Forester's vertex
- Rangefinder
- 50m measuring tape
- Meter/scale stick
- Field forms on waterproof paper with clipboard or hand held computer (e.g. Datalogger)
- Field notebook
- Stream Crossing Manual for reference
- Map(s) and map case
- Pens, pencils
- Satellite phone
- First aid kit
- Visi-vests (safety); Cruise vest
- Rubbermaid tote for gear

APPENDIX 3

STANDARD FISH SPECIES NAME CODES

Species Code	Species Common Name	Species Scientific Name
ARGR	Arctic Grayling	<i>Thymallus arcticus</i>
BKTR	Brook Trout	<i>Salvelinus fontinalis</i>
BLTR	Bull Trout	<i>Salvelinus confluentus</i>
BNTR	Brown Trout	<i>Salmo trutta</i>
BRST	Brook Stickleback	<i>Culaea inconstans</i>
BURB	Burbot	<i>Lota lota</i>
CISC	Cisco	<i>Coregonus artedi</i>
CTTR	Cutthroat Trout	<i>Oncorhynchus clarki</i>
FLCH	Flathead Chub	<i>Platygobio gracilis</i>
FNDC	Finescale Dace	<i>Phoxinus neogaeus</i>
GOLD	Goldeye	<i>Hiodon alosoides</i>
IWDR	Iowa Darter	<i>Ethostoma exile</i>
LKCH	Lake Chub	<i>Couesius plumbeus</i>
LKTR	Lake Trout	<i>Salvelinus namaycush</i>
LKWH	Lake Whitefish	<i>Coregonus clupeaformis</i>
LNDC	Longnose Dace	<i>Rhinichthys cataractae</i>
LNSC	Longnose Sucker	<i>Catostomus catostomus</i>
MNWH	Mountain Whitefish	<i>Prosopium williamsoni</i>
NRDC	Northern Redbelly Dace	<i>Phoxinus eos</i>
NRPK	Northern Pike	<i>Esox lucius</i>
PGWH	Pygmy Whitefish	<i>Prosopium coulteri</i>
PRDC	Pearl Dace	<i>Margariscus margarita</i>
RNTR	Rainbow Trout	<i>Oncorhynchus mykiss</i>
SLSC	Slimy Sculpin	<i>Cottus cognatus</i>
SPSC	Spoonhead Sculpin	<i>Cottus ricei</i>
TRPR	Trout Perch	<i>Percopsis omiscomaycus</i>
WALL	Walleye	<i>Stizostedion vitreum</i>
WHSC	White Sucker	<i>Catostomus commersoni</i>
YLPR	Yellow Perch	<i>Perca flavescens</i>
UNKN	Unknown	

APPENDIX 4

STREAM CROSSING INSPECTION DATA SHEET

APPENDICES

STREAM CROSSING INSPECTION FORM

GENERAL SITE INFORMATION									
Date	Inspector(s)	Crossing No.	Crossing owner	Name of road	Legal Description	Unmapped Crossing?	GPS UTM_E	GPS UTM_N	
Name of stream	Stream category	Fish-bearing status	Species (if known)	Fish-bearing status confirmed in field	Length of habitat upstream (m)	GIS UTM_E	GIS UTM_N		
				Likely	Unlikely				
FISH PASSAGE PARAMETERS									
Hang height (0.01m)	Riffle Crest depth (0.01m)	Outlet drop (0.01m)	Effective depth of pool (0.01m)	Backwater in culvert (%)	Substrate in culvert (%)	Substrate Type	Culvert slope uniform?	Fish barrier present?	
VERTEX DATA									
Reading	SHALLOW FILL		STEEP FILL				LASER LEVEL DATA	Inlet Elevation (m)	Outlet Elevation (m)
	HD (m)	Slope (°)	Foreshot (towards outlet)		Backshot			Culvert Length (m)	Slope (%)
1			HD (m)	Slope (°)	HD (m)	Slope (°)			
2									
3									
CULVERT PARAMETERS									
Type	Culvert Material	Road surface material	Diameter (0.01m)	Length (m)	Height of fill over culvert (m)	Bankfull channel width (0.01m)	Bankfull channel depths (0.01m)	Armour Inflow	Armour Outflow
BRIDGE PARAMETERS							PERFORMANCE AND SAFETY		
Type	Total deck length (m)	Deck Width (# of lanes)	Decking material	Decking pattern	Curb type	Road surface material	Blockage of opening (%)	Cause of blockage	Grader markers/Bridge reflectors
Abutment type	Abutment functioning?	Wingwalls functioning?	Armour	Bankfull channel width (0.01m)	Bankfull channel depths (0.01m)	Bankfull width under bridge (0.01m)	Bridge signs	Structural problems	
EROSION AND SEDIMENTATION									
1. Preliminary Inspection					3. Sediment Source Inspection				
Evidence of sedimentation?	Source of Sediment				Location	Length	Width	Veg. cover class	Remediation type
					R. Dwnstrm				
					R. Upstrm				
					L. Dwnstrm				
2. Ditch Inspection									
Location	Length	Drainage Improvement type			L. Upstrm				
R. Dwnstrm					Above Inlet				
R. Upstrm					Above Outlet				
L. Dwnstrm									
L. Upstrm									
4. External Sediment Sources (road, bridge deck, etc.)									
					Rating:	Source/Action:			
SUMMARY REMARKS					PHOTOS				
Immediate Attention Required? (If yes, describe.)					Frame #	Description			
						Inlet			
						Outlet			
						Upstream of crossing (fish habitat)			
						Downstream of crossing (fish habitat)			
						View of road left (LDB)			
						View of road right (RDB)			
						Other -			
Comments									

APPENDICES

STREAM CROSSING INSPECTION FORM

REFERENCE TABLE

GENERAL SITE INFORMATION

Stream Category: (LP) Large Permanent, (SP) Small Permanent, (I) Intermittent

Fish-bearing status: (F) Fish bearing, (N) Non-fish bearing, (U) Unknown

FISH PASSAGE PARAMETERS

Backwater in culvert (%): 0,25,50,75,100%

Substrate in culvert (%): 0,25,50,75,100%

Substrate type: (S) Sand; (G) Gravel; (C) Cobble; (B) Boulder; (O) Other; (N) None

CULVERT PARAMETERS

Type: (E) Elliptical, (O) Open-bottom arch, (R) Round; (RC) Reclaimed

Culvert Material: (S) Steel; (C) Concrete; (O) Other

Road surface material: (G) Gravel; (C) Clay or mineral soil with no gravel; (CC) Calcium carbonate; (O) Other

Armour: (R) Riprap; (G) Gabions; (G) Geotextile; (V) Vegetation; (O) Other; (N) None

BRIDGE PARAMETERS

Type: (T) Timber; (S) Steel; (C) Concrete; (RC) Reclaimed

Decking material: (W) Wood, (C) Concrete, (S) Steel, (O) Other, includes Synthetic

Decking pattern: (C) Closed; (O) Open

Curb type: (W) Wood, (C) Concrete, (G) Geotextile, (N) None

Road surface material: (G) Gravel; (C) Clay; (CC) Calcium carbonate; (S) Sand; (O) Other

Abutment type: (SP) Steel pilings, (CP) Concrete pilings; (LP) Log pilings; (C) Concrete blocks; (L) Logs; (T) Treated lumber; (O) Other; (N) None

Abutments functioning? (Y) In good condition, no eroding materials; (N) Falling apart and/or materials eroding from behind structure; (N/A) Not applicable

Wingwalls functioning? (Y) In good condition, no eroding materials; (N) Falling apart and/or materials eroding from behind structure; (N/A) Not applicable

Armour: (R) Riprap; (G) Gabions; (G) Geotextile; (V) Vegetation; (SF) Silt fence; (ES) Erosion socks; (O)ther; (N)one

PERFORMANCE AND SAFETY

Blockage of opening: 0,10, 25,50,75,100%

Cause of blockage: (B) Beaver; (D) Debris; (I) Intentional; (S) Slumping; (R) Road material; (O) Other; (N) None

Structural problems - *Culverts*: (C) Collapsing; (D) Damaged; (SL) Slumping; (U) Undersized; (V) Vegetation protruding; (O) Other; (N) None

Structural problems - *Bridges*: (C) Collapsing; (D) Damaged; (BA) Broken/separated/damaged abutments; (RA) Rotten abutments; (SA) Sunken abutments; (DG) Damaged guardrail; (GM) Grout missing; (SL) Slumping; (V) Vegetation protruding; (O) Other; (N) None

EROSION AND SEDIMENTATION

2. **Ditch Inspection** Drainage improvement type: *Refer to "Remedial Measures" options.*

3. **Sediment Source Inspection** Vegetation Cover Class: (1) 0-10 % cover; (2) 10-30% cover; (3) 30-50% cover; (4) 50-95% cover; (5) 95-100% cover

Remediation type: *Refer to "Remedial Measures" options.*

4. **External Sediment Sources** Rating: (H) High; M (Medium); L (Low) - *see manual for clarification*

Action: *Refer to "Remedial Measures" options.*

SUMMARY REMARKS

Emergency repair required? If Yes, choose repair options from "Remedial Measures."

Suggested Remedial Measures or Follow-up - *Bridges*

B1 - Requires abutments/pilings	B10 - Remove/clean mud build-up from deck	B18 - Build up wing walls
B2 - Replace/repair abutment or wing wall cribbing	B11 - Enclose open deck	B19 - Repair bridge deck
B3 - Raise sunken bridge structure	B12 - Concrete deck requires re-grouting	B20 - Other (Describe)
B4 - Stabilize/armour scouring under bridge	B13 - Replace worn running surface	
B5 - Requires longer bridge span	B14 - Repair damaged guard rails	
B6 - Remove tree debris from under bridge	B15 - Repair/replace guard rail curbs	
B7 - Install missing warning signs	B16 - Enclose open guard rails with curbs	
B8 - Install missing safety reflectors	B17 - Tie Wingwalls into abutments	

B9 - Requires deck corner barrier plates to prevent road material buildup into stream

Suggested Remedial Measures or Follow-up - *Culverts*

C1 - Requires sediment barriers/markers (from road grading)	C7 - Remove beaver dam blockage
C2 - Requires replacement - undersized diameter and/or length	C8 - Pipe requires baffles
C3 - Requires replacement - internal structural problems	C9 - Requires fish presence check
C4 - Requires pipe extensions - short pipe	C10 - Requires fish habitat assessment
C5 - Repair separated joint	C11 - Install debris/beaver grates
C6 - Repair washout	C12 - Other (explain)

Applies to both bridges and culverts

1 - Requires rip rap armour	8 - Stabilize and repair gullying/slumping on fill slopes	15 - Requires geotextile material
2 - Requires silt fence	9 - Repair sink hole and associated structural problems	
3 - Requires erosion socks	10 - Remove beaver dam	
4 - Requires vegetation cover seeding	11 - Remove and reclaim	
5 - Requires diversion ditches	12 - Monitor for increase in severity	
6 - Requires cross-drain	13 - Requires ditch(es)	
7 - Requires ditch blocks	14 - Repair/maintain silt fence	

APPENDIX 5

CALCULATING CULVERT PERCENT SLOPE AND LENGTH FROM VERTEX MEASUREMENTS.

PART 1. SHALLOW FILL CULVERTS

1. To convert the slope measure from degrees to percent slope, use:

$$\text{Percent \%} = \text{TAN (RADIANS}(b)\text{)*100.}$$

2. To calculate culvert length use:

$$d = \text{SQRT}(((\text{run}*\text{percent slope})^2+(\text{run}*\text{run})))$$

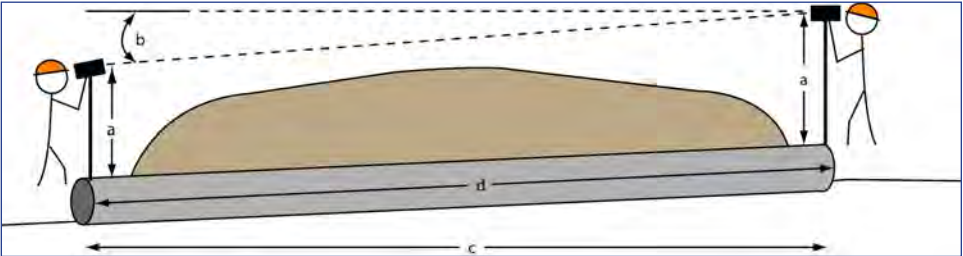


Figure 1. Measuring culvert slope at a shallow fill crossing using a Vertex.

a = height at eye level of person with Vertex

b = slope measured in degrees

c = horizontal distance or run

d = culvert rise

e = culvert length.

PART 2. DEEP FILL CULVERTS

Calculations:

$$f \text{ (outflow elev)} = c * (\text{TAN}(\text{RADIANS}(b)))$$

$$g \text{ (inflow elev)} = e * (\text{TAN}(\text{RADIANS}(d)))$$

$$h \text{ (culvert rise)} = f - g$$

$$i \text{ (% slope)} = h / (c + e) * 100$$

$$j \text{ (culvert length)} = \text{SQRT}(j^2 + h^2)$$

$$k \text{ (culvert run)} = c + e$$

$$l \text{ (fill height)} = (f + g) / 2$$

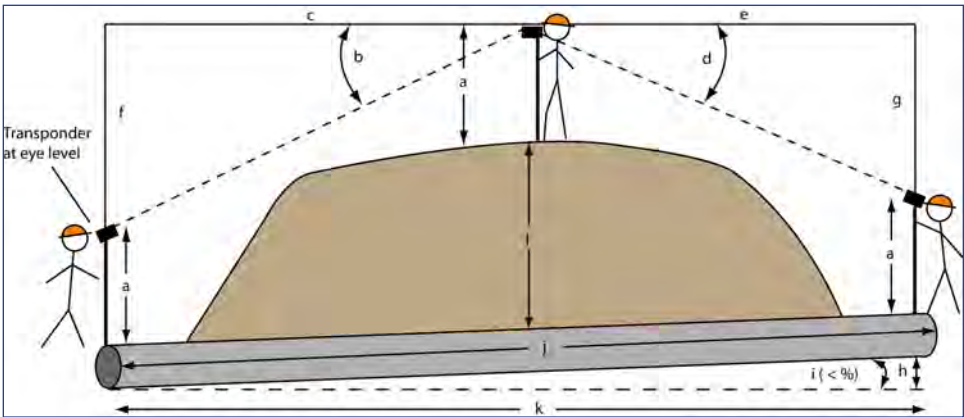


Figure 2. Measuring culvert slope at deep fill crossing using a Vertex.

a = height at eye level of person with Vertex

b = foreshot slope measured in degrees

c = foreshot horizontal distance

d = backshot slope measured in degrees

e = backshot horizontal distance

f = outflow elevation

g = inflow elevation

h = culvert rise

i = total culvert slope in percent

j = culvert length

k = total run

l = fill height