Great Lakes Stream Crossing Inventory Instructions

8/26/2020

Photo Credit: Ottawa National Forest, Sucker Creek @ Gogebic County Road 206

This protocol was developed, reviewed, and tested by the following organizations: Michigan DNR, U.S. Forest Service, Trout Unlimited, Wisconsin DNR, U.S. Fish & Wildlife Service, Huron Pines, Conservation Resource Alliance, Michigan Technological University, and road commissions.

Funding for development and testing was provided by the U.S. Forest Service, U.S. Fish & Wildlife Service, and The Nature Conservancy.

The original version (5/6/2011) was updated 8/26/2020.

This document is a guide to completing the *Stream Crossing Data Sheet* (new version forthcoming) and the Great Lakes Stream Crossing Inventory Survey, a Survey 123 application. Please use the below link to MI DNR ArcGIS HUB site or contact Mike Rubley (RubleyM1@michigan.gov) for access to the Survey 123 application. Careful attention to this guidance will ensure consistent crossing assessments, which is critical for identifying problems and prioritizing remediation.

Equipment Check List

- ☐ Maps with crossing locations
- ☐ Stream crossing data sheets (or electronic data recorder)
- ☐ Clip board
- ☐ Pens/pencils
- ☐ GPS Unit
- ☐ Tape measure (100 ft)
- ☐ Survey pins
- ☐ Tile road/sharpshooter/rebar
- ☐ Folding rule (6 ft)
- ☐ Survey rod (16 ft telescoping)
- ☐ Hand level
- ☐ Camera w/ extra batteries
- ☐ Compass
- ☐ Flow meter (or floating object, such as an orange and a stopwatch)
- ☐ Waders, hip boots, wading shoes (try to avoid felt-soled wader boots as they can be hard to sterilize and clean from aquatic invasive species).
- ☐ Safety vests
- ☐ Traffic cones
- ☐ Brush clearing tools
- ☐ Hardhat
- ☐ Safety glasses
- ☐ Flashlight or headlamp
- ☐ First aid kit

Safety

Streams can be hazardous places to work, so take care to sensibly evaluate risks before you begin to survey stream crossings. These surveys will work best with two people to make measurements easier, but also to provide help if needed.

Crews should be aware of road and traffic safety when parking their vehicles and crossing over the road for measurements. Take measurements carefully and estimate if necessary. Avoid wading into even small streams at high flows, pools of unknown depths, or scaling steep and rocky embankments. There are usually ways to make effective estimates of structure dimensions without risking harm. Using an accurate laser rangefinder is one way to measure with less risk. Other approaches include measuring culvert lengths over the top of the roadway instead of through the structure, and measuring an approximate pool width from the roadway, aligning ends of the tape measure with the outside edges of the pool perpendicular to the road.

Clean Your Equipment

The following simple precautions will help prevent the spread of invasive species among survey sites. Follow this protocol between every site, but be particularly careful when moving among watersheds.

1. Inspect your equipment and remove any aquatic plants, animals, and mud.
2. Using a bleach solution and a brush, scrub all equipment free of debris **and** rinse thoroughly with clean tap water. Take special care to clean equipment that was in contact with stream water, including flow meters, tape measures, rulers, and waders.
3. Drain water from all equipment.
4. At the end of the day, store all equipment where it will dry thoroughly before the next field trip.

Instructions for Filling Out Data Sheet

The following instructions are organized in the same order as the data sheet. **The single most important piece of guidance in this document is to completely fill out the data sheet at each site.** After a survey is complete, it can be difficult to determine whether a blank field means that the item was not assessed, or whether it was not applicable. **Instead of leaving a blank, record "NA" for items that you assessed, but were not present or applicable.**

All length measurements should be made in feet and recorded to the nearest 0.1 foot. Do not record inches, even for measurements that are less than one foot. For example, record 0.5 feet instead of 6 inches. Measurements longer than 20 feet may be rounded to the nearest foot if you are not confident in the precision of the measurement (e.g., when you have to lay the tape over the road when measuring the length of a culvert).

Do not conduct this inventory if in-stream or ground conditions are such that necessary observations of the stream bed, stream banks, road surface, ditches, embankments, are concealed by snow or high flows. If streams are flowing near or over their banks do not conduct this inventory. Aquatic passability measurements of depth and velocity are designed to be collected at or near low flow conditions. Ratios used in determining the aquatic passability at the site will be skewed if depth and velocity are measured during high flow conditions.

Finally, methods and terminology used in this protocol require some level of training or experience. If training is required, see local contacts listed at the bottom of the page at this site for a list of professionals in your area that can assist: https://great-lakes-stream-crossing-inventory-michigan.hub.arcgis.com/.

Location Information

Delete Site: If a new survey is replacing the existing site, or if the existing inventory data no longer exists, select Yes.

GPS Waypoint: Record waypoint name/number from the GPS (Global Positioning System) unit. It is convenient to use the Site ID as the GPS waypoint. Record the position as close to the middle of the road above the structure as is safely possible.

Set your GPS unit to:

- Map Datum = WGS84
- Location Format = hddd.ddddd (decimal degrees)
- On a Garmin unit, Set INTERFACE FORMAT = GARMIN
- Time: TIME ZONE=CENTRAL, DAYLIGHT SAVINGS = AUTO

Bearing: Take a bearing using a compass from the upstream inlet of the culvert or crossing to the downstream outlet of the culvert or crossing.

Site ID: Record the Site ID from the watershed map, if the site has been previously inventoried. If the site has not been inventoried, either give the site a unique Site ID consistent with the naming convention your organization uses and agreed to by management or record NA.

Additional Crossing Identification Information (Optional): to be filled out if applicable:

Structure ID
Facility Identifier
Culvert Station Number
Fixed Asset Number
Legacy ID for the asset
DEQ Permit Number
DTMB Tag Number
Fishwerks Barrier ID obtained from https://greatlakesconnectivity.org/

Stream Name: Record the name of the stream, generally relying on names from U.S. Geological Survey topographic maps. Use "Unnamed" if the waterway is not named, or "Unknown" if you are not sure. If a different local name exists, record it in parentheses.

Stream Flow Type: Options: Perennial (if flowing during the time of assessment), intermittent (if channel is dry but has obviously flowed recently, appears to flow annually), ephemeral (if channel is dry and appears to flow only after heavy rains, may be covered in organic debris indicating it has not flowed recently), or concentrated wetland flow.

Reach Code: Record the USGS Reachcode from the National Hydrography Dataset (NHD)

Crossing Name: Record the name or number of the road or crossing. If the road does not have a name, use "Unnamed" or describe the road, like "Connor's Driveway" or "Dirt road off Hwy 23". For National Forest roads, identify both the Forest Road number (ie. FR 2131) and the Town Road name where applicable, like "FR 2131, Peshtigo River Road".

Observer Name: Record full names or first initials and last names of survey crew.

Data Source / Affiliation: Enter the Name of your organization, group, or agency.

Inventory Date: Record the date that the site was surveyed (in the form mm/dd/yy).

GPS Lat/Long: Record coordinates in decimal degrees for the waypoint from the GPS unit. Record all decimal places (do not round).

State/Territory: Record the name of the state or territory where the crossing is located.

County: Record the name of the county where the crossing is located.

Township/Range/Section (Optional): If you are unable to record GPS coordinates, record the township, range, and section where the crossing is located.

Adjacent Landowner Information: Record any relevant information about adjacent landowners, such as name or contact information.

Utilities: Are utilities visible at the site (Yes, No, Unknown). If yes, describe in additional comments below. Options could include: buried lines (flagging) for telephone, gas, or fiber optic, overhead lines, or municipal lines near cities (sometimes secured under or along side of bridges).

Additional Comments: Record any additional relevant site information.

Road / Crossing Owner: Select the option that best describes the owner/manager of the road. Provide a description for Other in comments. Options: Federal, State, County, Township, Tribal, Private, Other.

Crossing Information

Road / Crossing Surface: Circle the type of road surface present. Options include: Paved (blacktop or cement), Gravel (rotten granite or crushed rock), Sand, and Native Surface (native soil without any additions, other than sand).

Road / Crossing Surface Condition: Indicated the condition of the road surface present. Options include: for paved surfaces (New pavement, old pavement, or broken pavement), for gravel, sand and native surfaced roads (well graded, rutted, ponding, rilled/gullied, impassible).

Road Core Integrity: The road core, also called the road prism, encompasses all aspects of the road (fill, road surface, embankments, stream crossing structures). Indicate the condition of the road core. Options: Good (no symptoms of lack of integrity), Fair (some of the symptoms may be present, but not to an extent posing high risk to the crossing), Poor (one or more symptoms are present and are compromising the integrity of the crossing).

<u>Symptoms of compromised road core integrity</u>

Sink holes directly over the culvert

Undermining/subsurface erosion (severe piping)

Slumping of the fill

Piping

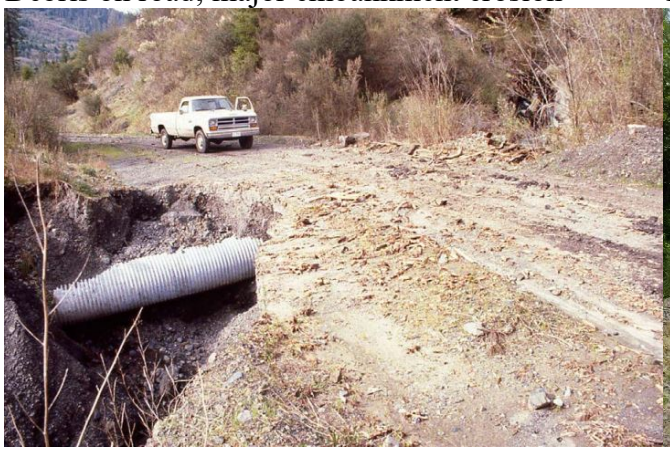
Undercutting

Severe embankment erosion, mass wasting

Frequent Road Overtopping: Is there evidence of stream flows overtopping the road crossing? Options: Yes (clearly observed evidence), No (no evidence), Unknown (unclear evidence)

<u>Evidence of road overtopping</u>

Debris on road; major embankment erosion



Rills parallel to stream flow

Photo credit: Handbook for Forest, Ranch, and Rural Roads, 2014, by PWA.

Vegetation bent over

Fresh road gravel downstream

Fresh road gravel and sand downstream in floodplain, but not upstream.

Diversion Potential: A stream crossing has a diversion potential if, when the culvert plugs, the stream would ovetop the road and flow down the road or ditch, away from the stream channel, rather than over the road crossing and back into the natural drainage channel. If the culvert were to plug would flow divert into the ditch, down road (away from stream), or back into its natural drainage path?

Stream crossing with diversion potential

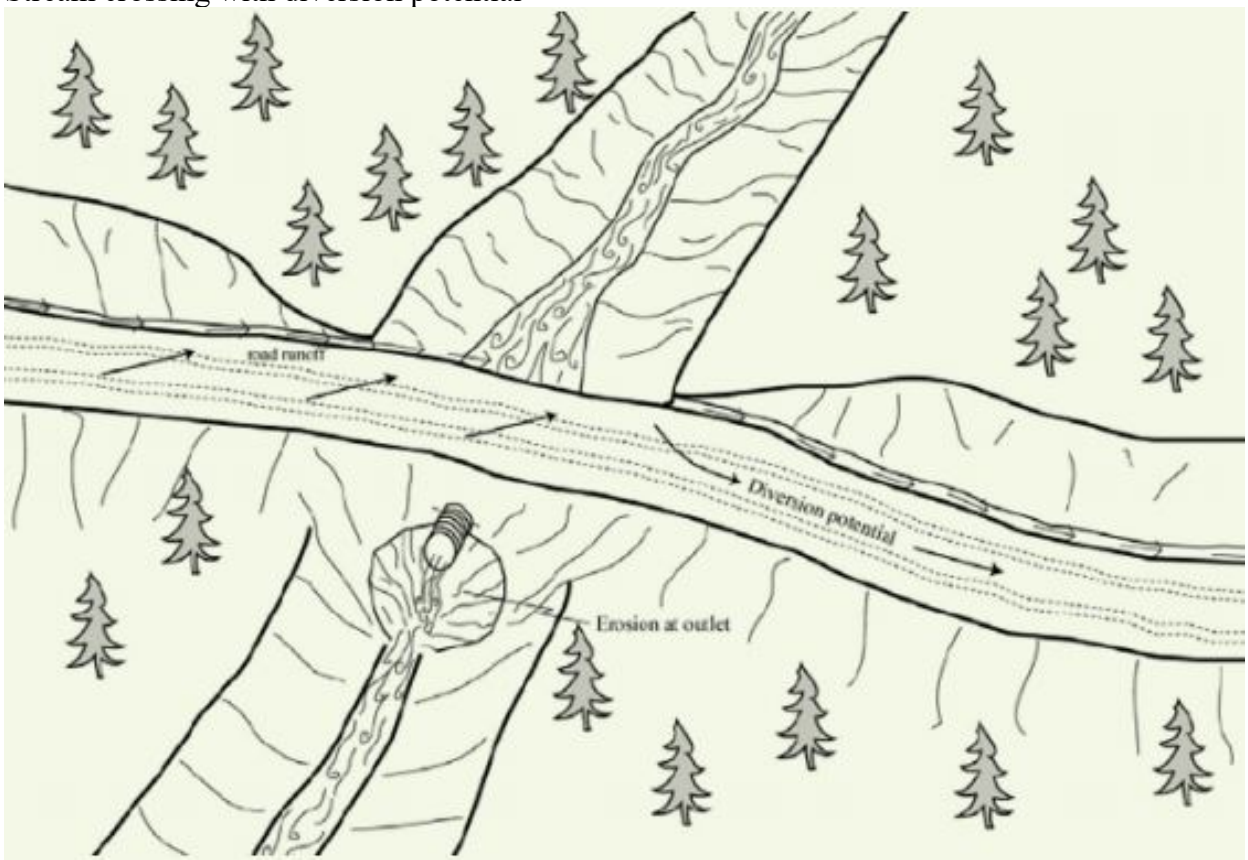


Image credit: Handbook for Forest, Ranch, and Rural Roads, 2014, by PWA

Stream crossing with diversion potential

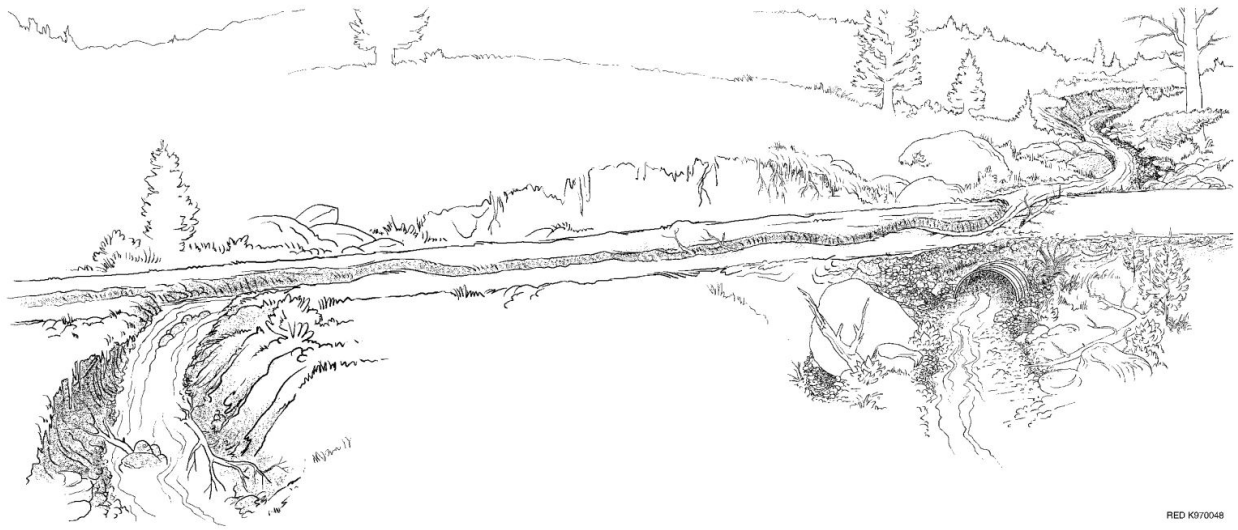


Image credit: Handbook for Forest, Ranch, and Rural Roads, 2014, by PWA

Stream crossing with diversion potential prevented

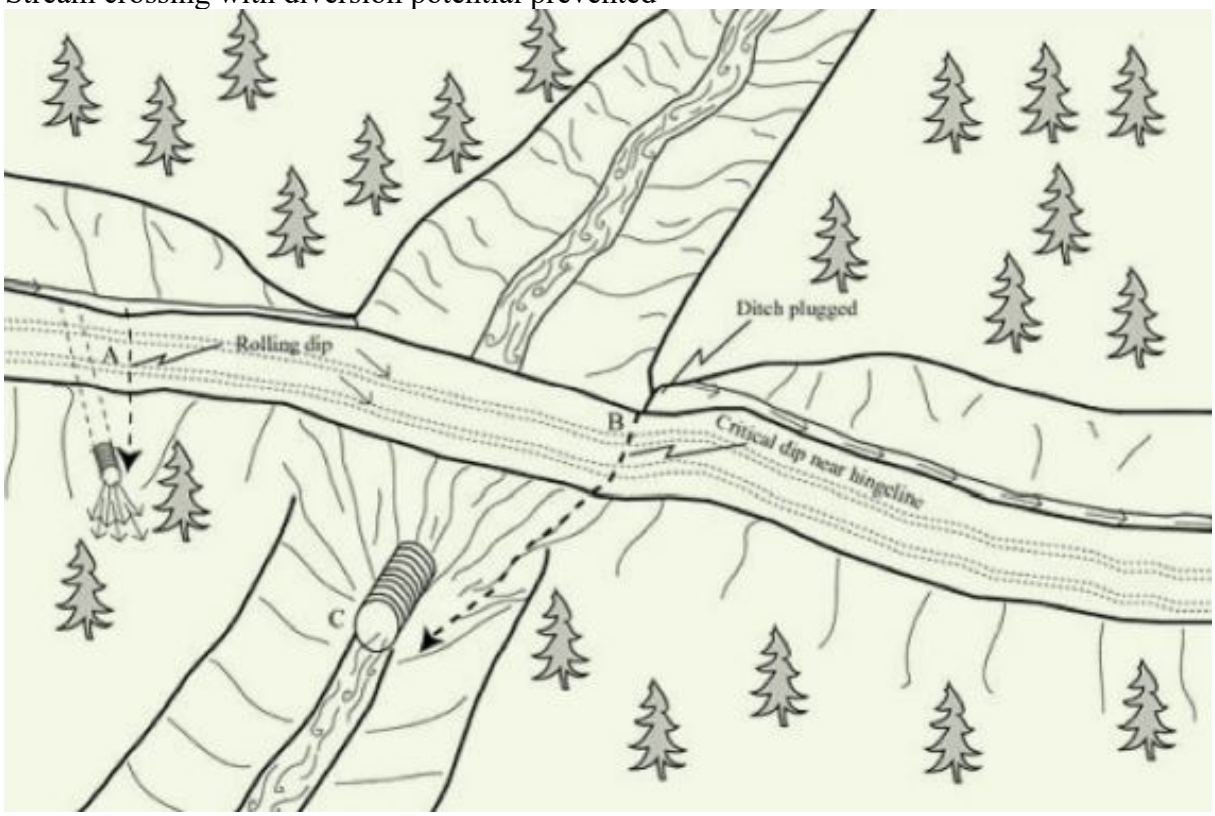
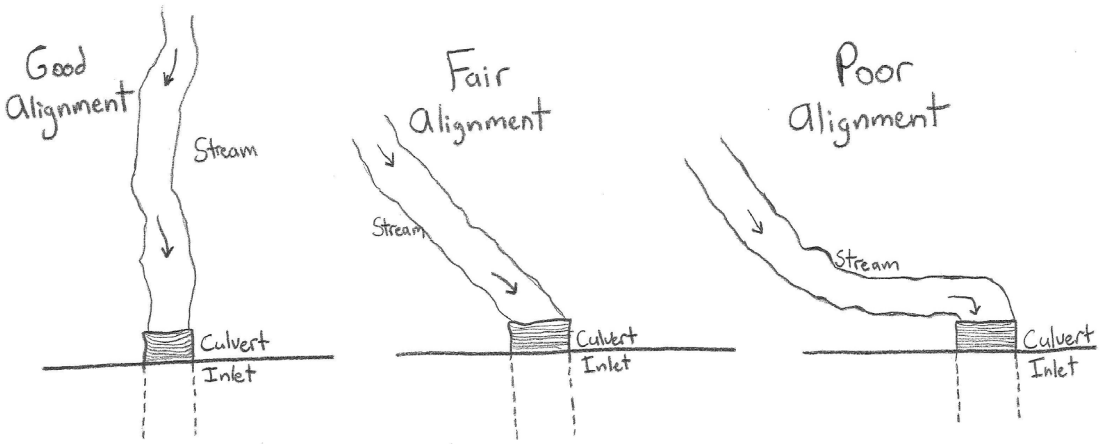


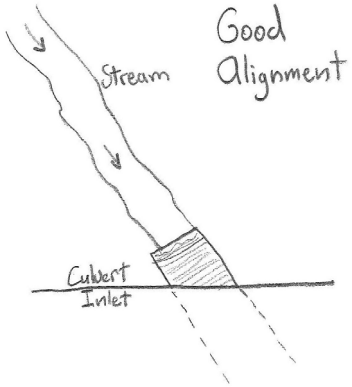
Image credit: Handbook for Forest, Ranch, and Rural Roads, 2014, by PWA

Stream crossing with diversion potential prevented

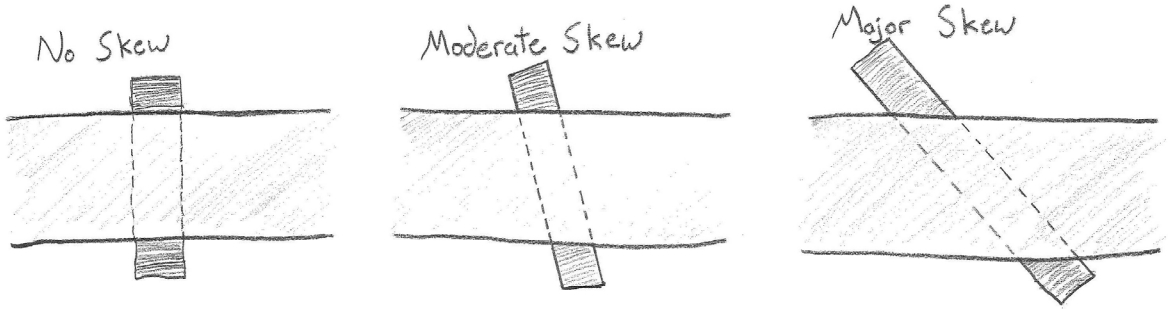
Image credit: Handbook for Forest, Ranch, and Rural Roads, 2014, by PWA

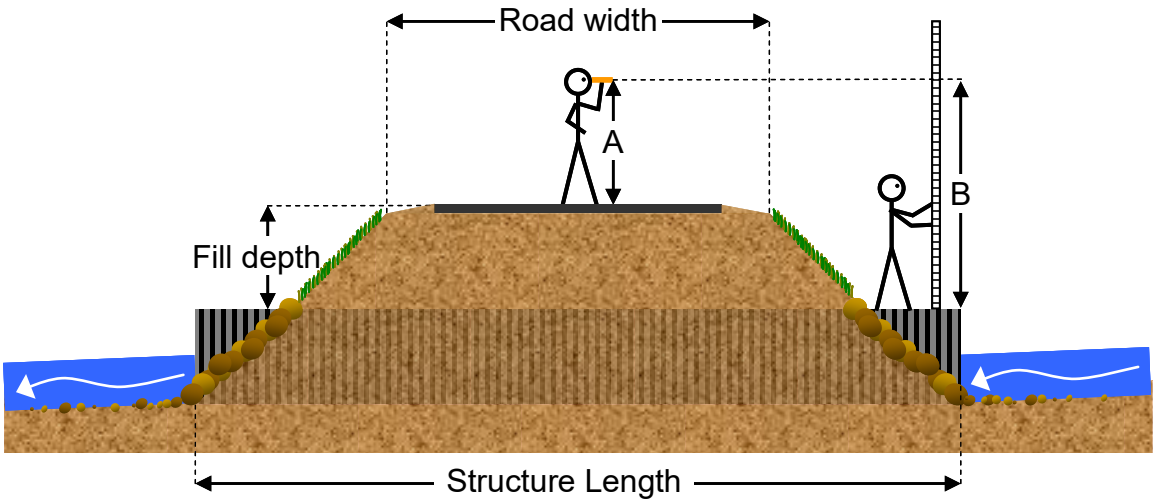
Structure/Stream Alignment: Visually estimate how well the stream and culvert inlet (or upstream bridge deck) are aligned to one another. Options: Good Alignment, Fair Alignment, Poor Alignment.





Culvert Skew: Visually estimate if the culvert is skewed. Options: No skew (culvert is nearly perpendicular to the road), Moderate skew (less than 45° from perpendicular), Major skew (more than 45° from perpendicular).



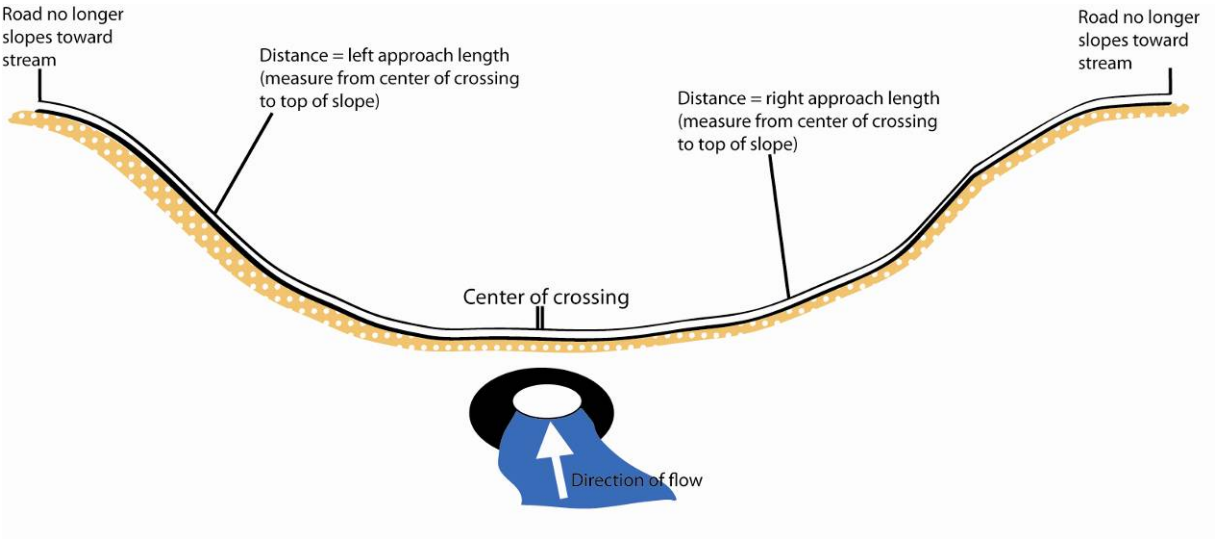


Road / Crossing Width (ft): Measure and record the width of the road to the nearest 0.1 foot. Measure the road width from the outside edge of one road shoulder to the outside edge of the other shoulder. The road shoulder ends, and the ditch (or crossing embankment) begins, when the surface starts to slope away from the road.

Structure Length: Measure the structure length to the nearest 0.1 foot (see diagram above). If a culvert has mitered ends, measure the length at the bottom. The structure length can be measured by stretching the tape across the road surface. If the crossing is large enough to walk through, the measurement can also be taken there, but do not put yourself in any dangerous situations.

Location of Low Point: Record whether the lowest point on the road surface that is in the vicinity of the crossing is where the stream passes under it or offset some distance from the stream. Options: At stream, Other.

Runoff Path: Does the grading of the road near the crossing indicate that runoff from the road runs along the road or into the ditch? Options: roadway, ditch.



Left Approach Length (ft): *(Erosion Estimate Automatically Calculated for Approach Lengths. If approach length exceeds 1,000 ft, erosion estimate will be based on 1000 ft approach length)* Measure, pace or otherwise estimate the distance from the structure to the top of the slope leading down towards the structure. This is the distance that water would drain down the road to the structure.

Left Approach Slope: Measure slope using the hand level and rod, slope enabled range finder, or clinometer. When using a level and rod, take measurement A as above. Measurement B is some distance away along the approach, ideally at the top of the approach or a distance sufficient to represent the average slope. Slope = (A-B)/horizontal distance.

Left Approach Ditch Vegetation: Options:
None – ditch has been recently graded and is bare of vegetation.
Partial – ditch has some vegetation and some bare, eroding places.
Heavy – ditch is fully vegetated or rip-rapped with no signs of erosion.

Right Approach Length (ft): *(Erosion Estimate Automatically Calculated for Approach Lengths. If approach length exceeds 1,000 ft, erosion estimate will be based on 1000 ft approach length)* Measure, pace or otherwise estimate the distance from the structure to the top of the slope leading down towards the structure. This is the distance that water would drain down the road to the structure.

Right Approach Slope: Measure slope using the hand level and rod, slope enabled range finder, or clinometer. When using a level and rod, take measurement A as above. Measurement B is some distance away along the approach, ideally at the top of the approach or a distance sufficient to represent the average slope. Slope = (A-B)/horizontal distance.

Right Approach Ditch Vegetation: Options:
None – ditch has been recently graded and is bare of vegetation.
Partial – ditch has some vegetation and some bare, eroding places.
Heavy – ditch is fully vegetated or rip-rapped with no signs of erosion.

Pictures: Record a photo of the left approach and right approach.

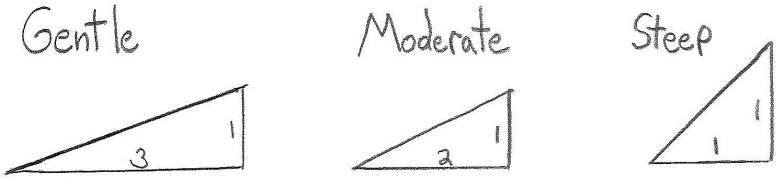
Left Approach

Right Approach

Upstream Fill Depth (ft): Measure and record the depth of road fill above the crossing (i.e. from the top of the culvert to the surface of the road) to the nearest 0.1 foot. The simplest way to record this measurement is to use a survey rod and hand level, which requires two people. First, both people stand on level ground a few feet away from each other. The person with the hand level takes a reading on the survey rod – this is measurement A. Then one person goes to one end of the culvert and places the base of the rod on the top of the culvert. The other person stands on the road surface and reads the level height of the rod with the hand level – this is measurement B. Fill depth = B-A. See diagram on page 12.

Upstream Embankment Slope: Estimate the slope of the embankments and indicate which slope category most closely represents the embankments. A slope ratio of 2:1 means 2' horizontal distance to 1' vertical drop. Options:

Gentle: 3:1 or 15° or 33%
Moderate: 2:1 or 22.5° or 41%
Steep: 1:1 or 45° or 100%
Vertical: 0:1 or 90°



Inlet Armoring / Rip-rap: What type of armoring is present on the embankment slope on the inlet side of the road? Options: None, Gravel, Rock, Concrete, Metal, Woody Vegetation, Other.

Inlet Armoring Functionality: Indicate how well the road embankment fill is armored around the inlet. Options: Good (large rip rap, concrete or aluminum headwall/wingwalls), Fair (undersized or incomplete rip rap, woody vegetation), Poor (unprotected embankment slopes, non-woody vegetation)

Embankment Armoring examples

Good (large rip rap covers entire flood prone area)

Good (aluminum headwall and wingwalls)

Fair (partial armoring)

Fair (woody vegetation)

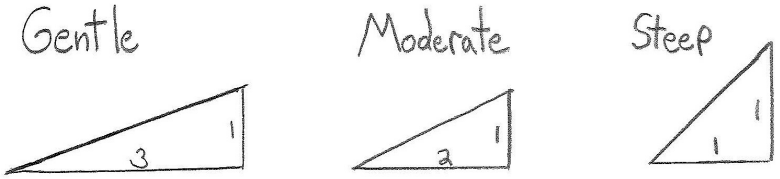
Poor (unprotected embankment slopes)

Poor (non-woody vegetation)

Downstream Fill Depth (ft): Measure and record the depth of road fill above the crossing (i.e. from the top of the culvert to the surface of the road) to the nearest 0.1 foot. The simplest way to record this measurement is to use a survey rod and hand level, which requires two people. First, both people stand on level ground a few feet away from each other. The person with the hand level takes a reading on the survey rod – this is measurement A. Then one person goes to one end of the culvert and places the base of the rod on the top of the culvert. The other person stands on the road surface and reads the level height of the rod with the hand level – this is measurement B. Fill depth = B-A. See diagram on page 12.

Downstream Embankment Slope: Estimate the slope of the embankments and indicate which slope category most closely represents the embankments. A slope ratio of 2:1 means 2' horizontal distance to 1' vertical drop. Options:

Gentle: 3:1 or 15° or 33%
Moderate: 2:1 or 22.5° or 41%
Steep: 1:1 or 45° or 100%
Vertical: 0:1 or 90°

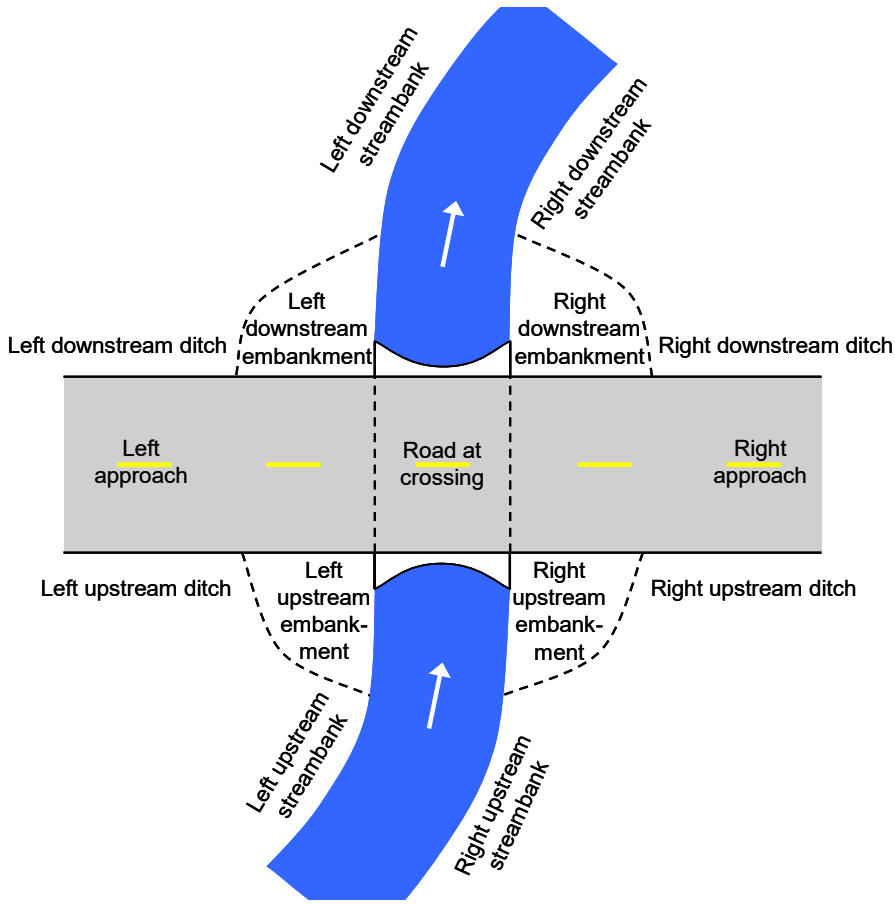


Outlet Armoring / Rip-rap: What type of armoring is present on the embankment slope on the inlet side of the road? Options: None, Gravel, Rock, Concrete, Metal, Woody Vegetation, Other.

Outlet Armoring Functionality: Indicate how well the road embankment fill is armored around the inlet. Options: Good (large rip rap, concrete or aluminum headwall/wingwalls), Fair (undersized or incomplete rip rap, woody vegetation), Poor (unprotected embankment slopes, non-woody vegetation)

For records of additional erosion other than the above captured approach erosion, use the below procedure. Note prominent streambank erosion within 50 feet of the crossing.

Location of Erosion: Record the location of each distinct eroding area using the terms in the diagram below. Left and right are facing downstream. The road approach extends to where it no longer slopes toward the crossing. Road shoulders are considered part of the road or approach, not the ditch. The boundary between an embankment and a ditch is generally where the slope and/or material of the grading changes.



Erosion Dimensions: Measure the length, width and depth of eroded areas to the nearest 0.1 foot.

Eroded Material Reaching Stream: For each eroded area, circle "Yes" or "No" to indicate whether the eroded material appears to be reaching the stream.

Material Eroded: Indicate soil type(s) which best describes the eroded sediment. Options include: "Sand", "Silt", "Clay", "Gravel", "Loam", "Sandy Loam", and "Gravelly Loam".

If there is erosion occurring, can corrective actions be installed? Circle "Yes" or "No" to indicate whether there are any corrective actions that can be installed to address the erosion problems. In the "Erosion Notes" section, provide more detail on the correction action options.

Extent of Erosion: Circle the word that best describes the overall extent of erosion near the crossing. Options: Minor, Moderate, Severe, Very Severe, Stabilized.

Erosion Image: If particularly noteworthy, record a picture of the erosion.

Structure Information

Crossing Type: Circle the type of stream crossing structure that is present (see descriptions and photos below). If "Culvert(s)" is circled, indicate the number of culverts present. Provide a description for "Other". If the crossing is too wide to measure at the inlet or outlet, or if it is too dangerous, estimate the width from the top of the crossing. In the following instructions, the term "structure" is used as a general term for the crossing structure, which may be any of the following.

Culvert - Culverts are the most common type of crossing. They come in various shapes and material types. If there are multiple culverts at the crossing, record measurements for the primary culvert (the one that carries the most stream flow) in the "Crossing Information" section, "Culvert 1". Number additional culverts from left to right, facing downstream, in your site sketch and record their characteristics in the "Multiple Culverts/Spans" box.

Bridge - Bridges can span the entire stream width ("a clearspan bridge") or they may have multiple spans with support columns located in the stream. If there are multiple spans, number them from left to right, facing downstream, in your site sketch and record their characteristics in the "Multiple Culverts/Spans" box.

Ford - Fords are low-water crossings where vehicles drive across the streambed. Gravel, rocks or concrete planks may be added to the streambed to help support traffic.

Dam - A dam is a barrier constructed across a waterway to control the flow or raise the level of water.

Crossing Use: What is the primary use of the crossing? Options: Road, Railroad, Farm Crossing, Trail, Driveway, Decommissioned Road, Other-specify in comments.

Additional Crossing Use: Select a secondary use of the crossing if applicable. Options: Not applicable, Wetland equalization / cross drainage, High water relief, Portable bride, Engineered structure, Other-specify in comments.

Structure Shape: Circle the term that best describes the shape of the structure.

Round

Square/Rectangle – typically concrete, with floor (may be covered with natural stream substrate).

Open Bottom Square/Rectangle – the walls of the crossing are buried and the stream bottom is undisturbed.

Pipe Arch – similar to a round pipe, but bottom is flattened.

Native Bottom Arch – pipe bottom is not observable, natural stream bed inside.

Ellipse – oval or “squashed pipe”.

Structure Material: Is the structure made out of metal, concrete, plastic, or wood?

Structure Interior: Record whether the interior of the crossing is smooth or corrugated.

Are there multiple culverts/spans at the crossing?: Options: 1 Structure, 2 Structures, 3 or more structures.

If one culvert/span is present, enter the width and height of the structure in the fields below. If there are two culverts/spans, enter the width and height of the primary flow structure below and then "Add New Records" for each additional culvert/span further below. If two culverts/spans are passing equal flow volumes, enter the height and width of the most left culvert (looking downstream at the inlet) below first, and then "Add New Records" for the additional cuvlerts/spans further below.

Structure Width: Measure the structure width to the nearest 0.1 foot. If the crossing is too wide to measure at the inlet or outlet, or if it is too dangerous, estimate the width from the top of the crossing. For culverts, measure at the widest point. For pipe arches, this will be near the bottom or under water. If there are multiple culverts/spans at a crossing, record their dimensions separately in the "Add New Records" box. For bridges, do not record the overall top deck span, rather, measure the width under the bridge between constricting features (abutments or inner slope protecting material).

Structure Height: Measure the structure height to the nearest 0.1 foot. For bottomless structures, height is measured from the streambed to the ceiling of the structure. For structures with bottoms, height is measured from the floor to the ceiling, including the depth of substrate, if present. If the water is too deep to wade, use the survey rod to measure from the top of the crossing. For bridges, measure the height between the streambed and the bottom of the bridge.

Substrate in Structure: Is there natural stream bed material in the structure? If so, is it mostly sand, gravel, rock, or a mixture of particle sizes?

Stream Flow: Circle the term which best describes the stream flow conditions during the survey. (See definition of bankfull flow in the Representative Reach Information section.)

- None – The streambed is dry and there is no water flow.
- < ½ Bankfull – The stream channel is less than half filled with water.
- < Bankfull – The stream channel is more than half filled with water, but is not full.
- = Bankfull – Water has filled completely filled the stream channel, but is not flowing onto the floodplain.
- > Bankfull – Water had filled the stream channel and is flowing onto the floodplain.

Is the crossing affected by a dam or impoundment? Options:
Not affected by an impoundment.
Yes, by an upstream dam or impoundment.
Yes, by a downstream dam or impoundment.

Inlet Type: Circle the term(s) that best describe the inlet (upstream end) of the crossing structure.

Projecting – end of culvert protrudes from embankment.

Apron – extension of culvert floor beyond end of pipe.

Mitered – end of culvert cut at an angle, usually sloping back toward road

Wingwall – walls (various materials) that are built out at angles from the inlet (Circle 10-30 or 30-70 degrees from parallel with culvert walls).

Headwall – concrete, gabion (wire mesh filled with rocks), masonry, or timber wall built around inlet.

Trash Rack – mesh cover or gate over inlet to prevent floating debris from entering culvert.

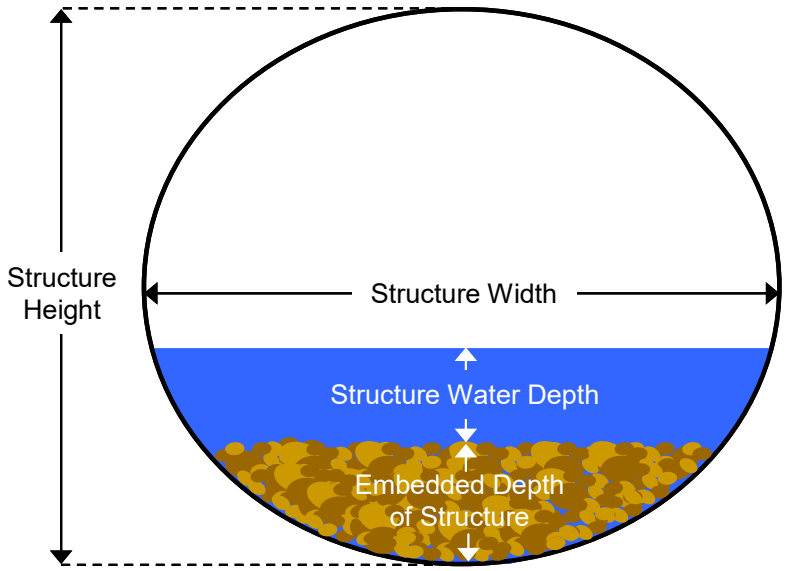
Headwall and wingwall

Image credit: Contech Engineered Solutions, 2012

Wingwall Material: Options: Not applicable, Wood, Logs, Concrete, Steel, Other-specify in comments

If multiple structures are present, record water depth, embedded depth, and water velocity at the inlet and outlet of the culvert/span carrying the most flow. If there are multiple structures with apparently equal flow volumes, measure water depth, embedded depth, and velocity at the left-most culvert/span (facing downstream looking at the inlet).

Inlet Water Depth: Measure the structure water depth to the nearest 0.1 foot at the inlet of the structure. Measure from the stream bed (if filling the bottom of the pipe) or culvert bottom to the water surface. If the water depth varies in the section of the structure you can reach at each end, find the structure cross section with the shallowest maximum depth and record the deepest point at this cross section. If you can walk through the structure safely, find the structure cross section from the entire length that has the shallowest maximum depth and record the deepest point at this cross section. The depth at this point is the limiting depth for fish passage. If the water is too deep to wade, use the survey rod to measure from the top of the crossing.

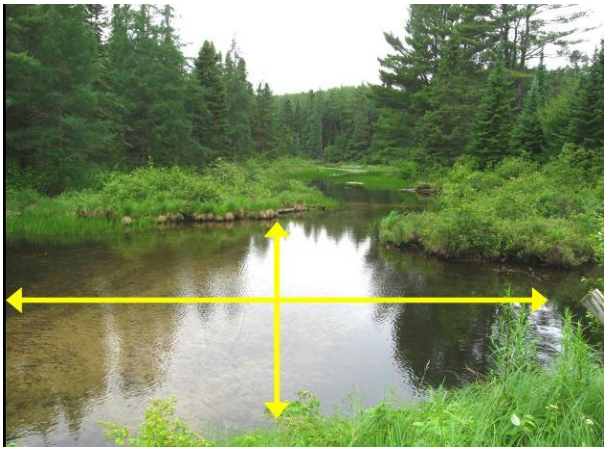


Inlet Embedded Depth: Using the tile probe/sharp shooter/rebar measure the depth of streambed substrate to the nearest 0.1 foot just inside the inlet of the structure. If the depth appears to vary substantially, take multiple measurements and record the average. If depth is substantial and embedded depth could not be determined, enter 2, but do not spend more than 5 minutes probing/excavating to determine embedded depth of the structure.

Inlet Water Velocity: If you have a current meter, measure the water velocity at the inlet and outlet of the structure. If the maximum water depth is less than 0.4 feet, measure the velocity at the midpoint of the water depth at the deepest point. If the maximum water depth is greater than 0.4 feet, measure the velocity at 0.2 feet above the substrate at a few points that are deeper than 0.4 feet and record the lowest velocity.

If you do not have a current meter, drop an orange, bobber, or other floating object into the water at the inlet of the crossing and time how long it takes to float through the structure. Calculate the velocity by dividing the length of the structure by the time it took the item to float through the structure. Be sure to retrieve the item floated through the culvert.

Upstream Pond Present?: If the stream channel is noticeably wider directly above the crossing than in other sections of the stream, this is a pond that is created by a crossing structure that is too small or set at a higher elevation than the natural stream bed.
If an upstream pond is present, measure its length and width to the nearest 0.1 foot. If the length and width cannot be measured due to water depth or other reasons, the length and width can be estimated from the crossing or measured with a range finder. If the crossing does not have an upstream pond, record "NA". In the summary comment field, indicate the cause of the ponding, if observable.



Upstream Sediment Wedge: In high gradient scenarios, a pond may not form, but a noticeable deposition (or wedge) of sediment could form within 100' of the crossing inlet. This could look like an island, a sand or gravel bar, or just an obvious accumulation of sediment due to an undersized culvert or one set too high. Do you observe an upstream sediment wedge? Options: Yes, No.

Inlet Image: Record a picture of the inlet looking downstream.

Upstream Conditions Image: Record a picture of the stream conditions upstream of the crossing, standing on the road or culvert inlet.

Outlet Image: Record a picture of the culvert outlet looking upstream.

Downstream Conditions: Record a picture of the stream conditions downstream of the crossing, standing on the road or culvert outlet.

Outlet Type: Circle the term(s) that best describe the outlet (downstream end) of the crossing structure.

At Stream Grade – bottom of culvert is at or below the elevation of the stream bed.

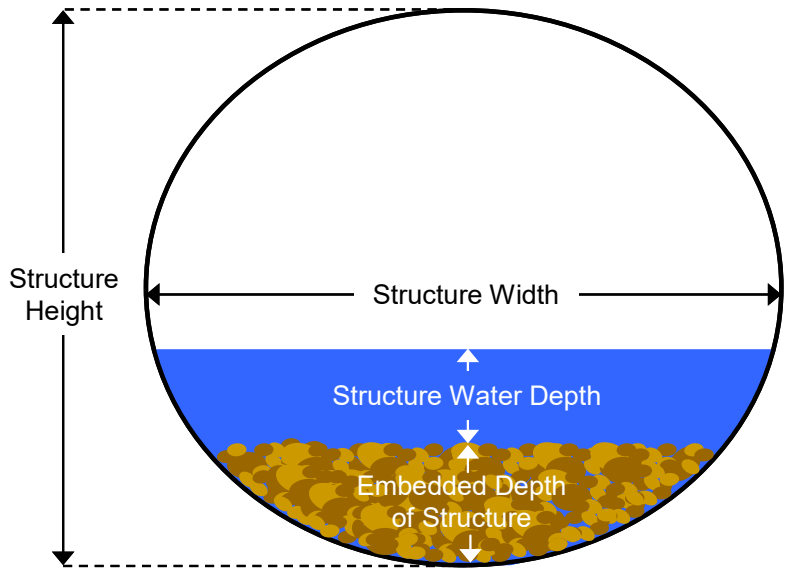
Freefall onto Riprap

Cascade over Riprap

Outlet Apron – extension of culvert floor beyond end of pipe.

Freefall into Pool

Outlet Water Depth: Measure the structure water depth to the nearest 0.1 foot at the outlet of the structure. Measure from the stream bed (if filling the bottom of the pipe) or culvert bottom to the water surface. If the water depth varies in the section of the structure you can reach at each end, find the structure cross section with the shallowest maximum depth and record the deepest point at this cross section. If you can walk through the structure safely, find the structure cross section from the entire length that has the shallowest maximum depth and record the deepest point at this cross section. The depth at this point is the limiting depth for fish passage. If the water is too deep to wade, use the survey rod to measure from the top of the crossing.



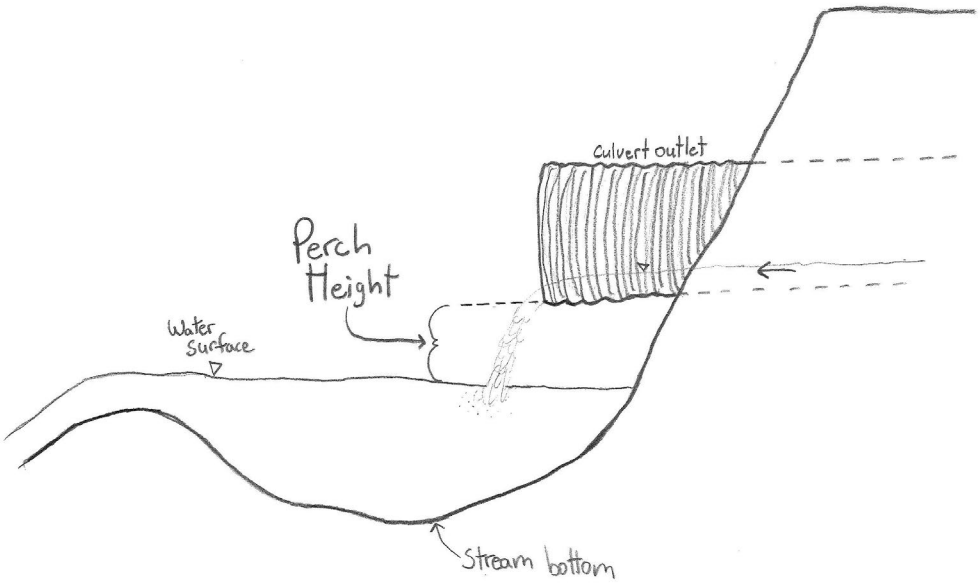
Outlet Embedded Depth: Using the tile probe/sharp shooter/rebar measure the depth of streambed substrate to the nearest 0.1 foot just inside the outlet of the structure. If the depth appears to vary substantially, take multiple measurements and record the average. If depth is substantial and embedded depth could not be determined, enter 2, but do not spend more than 5 minutes probing/excavating to determine embedded depth of the structure.

Outlet Water Velocity: If you have a current meter, measure the water velocity at the inlet and outlet of the structure. If the maximum water depth is less than 0.4 feet, measure the velocity at the midpoint of the water depth at the deepest point. If the maximum water depth is greater than 0.4 feet, measure the velocity at 0.2 feet above the substrate at a few points that are deeper than 0.4 feet and record the lowest velocity.
If you do not have a current meter, drop an orange, bobber, or other floating object into the water at the inlet of the crossing and time how long it takes to float through the structure. Calculate the velocity by dividing the length of the structure by the time it took the item to float through the structure. Be sure to retrieve the item floated through the culvert.

Velocity Measured With: Options: Float Test, Flow Meter

Velocity Measurement Depth (ft): Record the depth the water velocities were taken at from the surface (0 ft) of the water down. If the water velocity was completed using the Float Test method, record 0 as the depth.

Perch Height: If the crossing is perched (outlet elevated above downstream water surface), measure the vertical distance from the downstream water surface to the bottom of the stream crossing structure to the nearest 0.1 foot interval. If the outlet of the crossing is not perched, enter 0.



Scour Pool: If the stream channel is noticeably wider and deeper directly below the crossing than in other sections of the stream, this is a scour pool that is created by high velocity water during high flow events. If a scour pool is present, measure its length and width to the nearest 0.1 foot. If the length and width cannot be measured due to water depth or other reasons, the length and width can be estimated from the crossing or measured with a handheld range finder. If the crossing does not have a scour pool, record “NA”.

Road Sediment Deposition: Sediment can collect downstream of a road stream crossing if significant erosion is occurring or if the road frequently washes out or overtops. The most obvious indicator is the presence of road gravel (similar size, shape, color as the road surfacing) in the channel or on the floodplain downstream. Do you observe road sediment deposition downstream? If yes and the cause is obvious and observable, record it in the summary comment field.

Plugged: A crossing may be plugged by beaver activity, debris washed downstream, or by man-made barriers such as rock piles (often to raise upstream water levels). Estimate the percentage of structure that is plugged to the nearest 20% and indicate whether the material is mostly in the inlet, outlet, or inside the structure. Indicate location of plugged area on site sketch and in the comments.

Crushed: Estimate the percentage of the structure that is crushed to the nearest 20% and indicate whether the crushed area is mostly at the inlet, outlet, or inside the structure. Indicate location of crushed area on site sketch and in the comments.

Rusted Through: Record whether or not the structure is rusted through. Indicate location of rust on site sketch. Surface rust that is not causing structural failure should not be noted here, but will be used in evaluation of general condition.

Structure Condition: Thoroughly examine the culvert. Look at the inlet and outlet, pay special attention to the condition of the invert if possible. Using a high-powered flashlight look into the culvert looking for segment disconnection, distortion, settling, rust, and indentations. Select the most appropriate rating code to describe the existing condition of the culvert. Do not spend more than 5 minutes assessing this factor.

Code	Description
9	New structure.
8	Not new, but no noticeable corrosion, abrasion, chipping, spalling, or cracking. No shape changes such as barrel distortion (bowing, bending, warping), bulging, inlet or outlet damaged.
7	Light superficial corrosion or abrasion or chipping or spalling or cracking. No shape changes (described above).
6	Moderate deterioration from corrosion or abrasion (small rust flakes or indication that rust is slightly deeper than the surface level) or cracking or spalling or chipping (few minor cracks or localized chipping in the concrete). OR minor shape changes (described above).
5	Moderate to major deterioration from corrosion or abrasion (less than 5% of the structure has small holes or is nearly rusted through) or cracking or spalling or chipping (several small cracks or moderate chipping in the concrete) OR Moderate shape changes (described above).
4	Major deterioration from corrosion or abrasion (5-10% of the structure is rusted through) or cracking or spalling or chipping (medium sized cracks, widespread chipping, exposed metal reinforcement). OR Major shape changes (described above) reducing the capacity of the structure by less than 30% OR segment disconnection (segments of concrete or metal culvert disconnecting internally) but no evidence of water piping.
3	Major deterioration from corrosion or abrasion (10-50% of the length of structure is rusted through) or cracking or spalling or chipping (large chunks sloughing off, large cracks, exposed metal reinforcement) OR Major shape changes (described above) reducing the capacity of the structure by up to 50%. OR segment disconnection with evidence of water piping under or around the culvert.
2	Severe deterioration from corrosion or abrasion (more than 50% of the structure is rusted through) or cracking or spalling or chipping (more than 50% of the structure is compromised). Or Major shape changes (described above) reducing the capacity of the structure by greater than 50%. OR Segment disconnect causing major subsurface erosion/piping and/or partial fill failure and/or sink holes in the fill.
1	Deterioration, shape changes, or segment disconnection more severe than the previous category to the extent that the road manager should be contacted to determine if the road should be closed.
0	Road closed. Impassible. Partial or full crossing failure.

Modified from FHWA, NBI, Chapter 14, Figure 14.2.24

Representative Reach Information

Riffles are sections of natural stream channels that have relatively shallow and fast flowing water compared to other sections of the stream. They can also be recognized by steeper water surfaces than pools, which have a nearly flat water surface. In most streams, the substrate in a riffle is composed of larger particles (e.g., gravel or cobbles) than other sections of the stream. Measurements of stream channel and flow characteristics at a "representative riffle" are used to describe the most challenging conditions that fish face in natural reaches of the stream. While the channel width in riffles can range from narrow to wide, you should choose a representative riffle that strikes a balance between the wider and the narrow reaches. The bankfull (defined below) channel width in an average riffle is used as a standard for evaluating whether the crossing structure is wide enough to carry high stream flows.

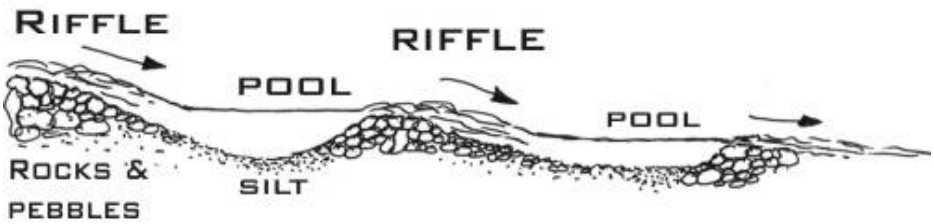


Image credit: Field Studies Council, Life in Freshwater

Choose a reference that is far enough from the crossing that its characteristics are not affected by the crossing. This may be as little as 50 feet from the crossing on a very small stream or as much as several hundred feet on a large stream or river. You may select a representative riffle that is upstream or downstream of the crossing. Generally, if the culvert is ponding water upstream, the best representative reaches are downstream. If the road has failed in the past and has deposited significant sediment downstream, often upstream will provide the vest representative reaches. In very low gradient streams, sometimes riffles do not exist or are not obvious. The water surface can appear to remain flat throughout. In these systems, measure bankfull width on a straight representative reach. Avoid measuring bankfull width at a significant bend. Once you have identified a suitable representative riffle (or straight reach), make the following measurements:

Location: Is the representative reach up stream or downstream?
Approximately how far from the culvert (to the nearest 100')?

Bankfull Width: Measure the bankfull width of the stream, perpendicular to the direction of flow, to the nearest 0.1 foot. Bankfull width is the channel width at the point where water has filled the principal stream channel and just begins to flow onto the active floodplain. Most streams only fill their bankfull channels about once per year. The point that defines the edge of the bankfull channel is typically defined by a sharp transition from a vertical or sloping bank to a horizontal floodplain. Woody vegetation rarely grows in the bankfull channel, although tree roots may be exposed below the bankfull elevation. **Bankfull width is one of the most important parameters in this inventory. Training or experience is required to correctly measure bankfull width in the field.**

Where to measure bankfull width:

- In the most representative reach of the natural channel.
- The most reliable indicator is a near-channel, flat depositional surface. Be it a wide floodplain, the top of a point bar, or a small bench within an entrenched channel.
- At a change in bank slope.
- At a change in vegetation (not as reliable):
    - Woody vegetation rarely grows in the bankfull channel.
    - Annual vegetation can grow in the bankfull channel, especially point or mid channel bars.
- At scour features:
    - Moss line on boulders or bedrock.
    - Exposed root hairs of perennial vegetation.
- In over-widened entrenched river systems, sometimes the tops of mid-channel bars is the best indicator.

Where NOT to measure bankfull width:

- Logjams.
- Near tipped trees.
- Manmade impacts: walls, riprap, pipes.
- Braided channels.
- Near a tributary or spring.
- Within the influence of the road stream crossing.
- Hard meander bends.

Bankfull width in non-entrenched scenarios

In (most) cases where streams are not entrenched, bankfull width will occur at the top of the stream bank, at the point where stream flood waters will overflow and begin occupying the floodplain as shown in the figures and photo below.

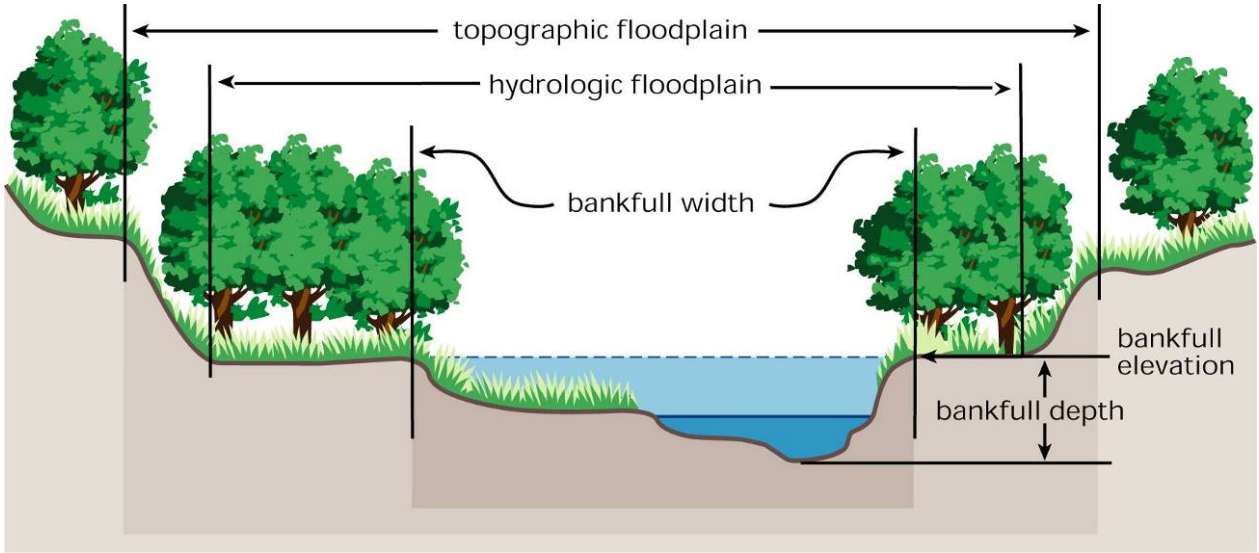


Image credit: Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG).

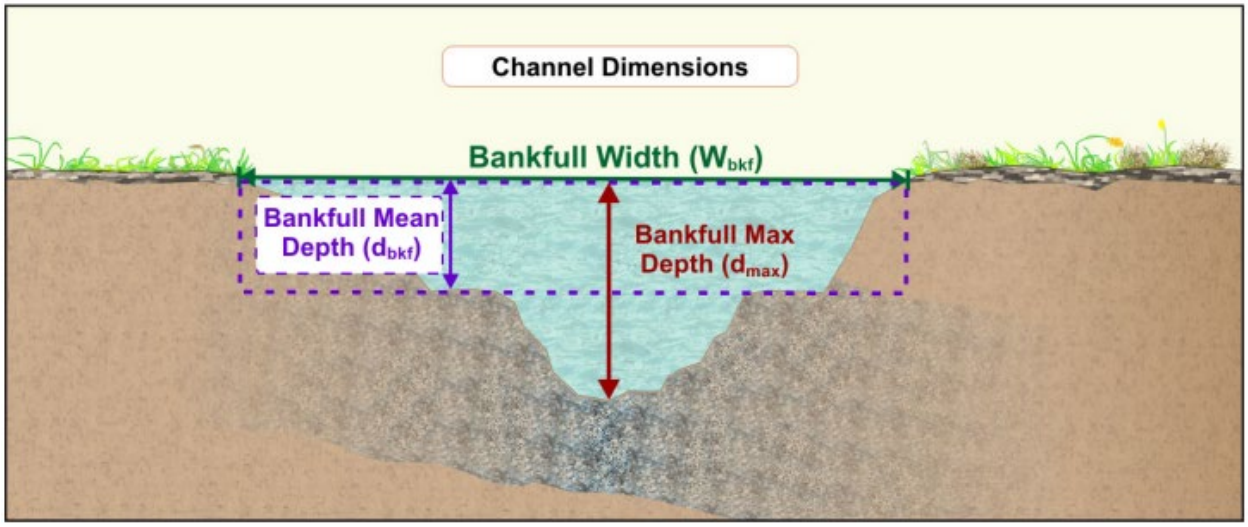


Image credit: Wildland Hydrology, 2018.

<u>Bankfull width in entrenched scenarios</u>

However, in an incised stream system (lowering it's elevation), bankfull width should not be measured between the previous banks, rather, look for any indication of a new depositional surface or "mini-bank" being formed within the incised gully.

Image Credit: Timmons Group, 2020

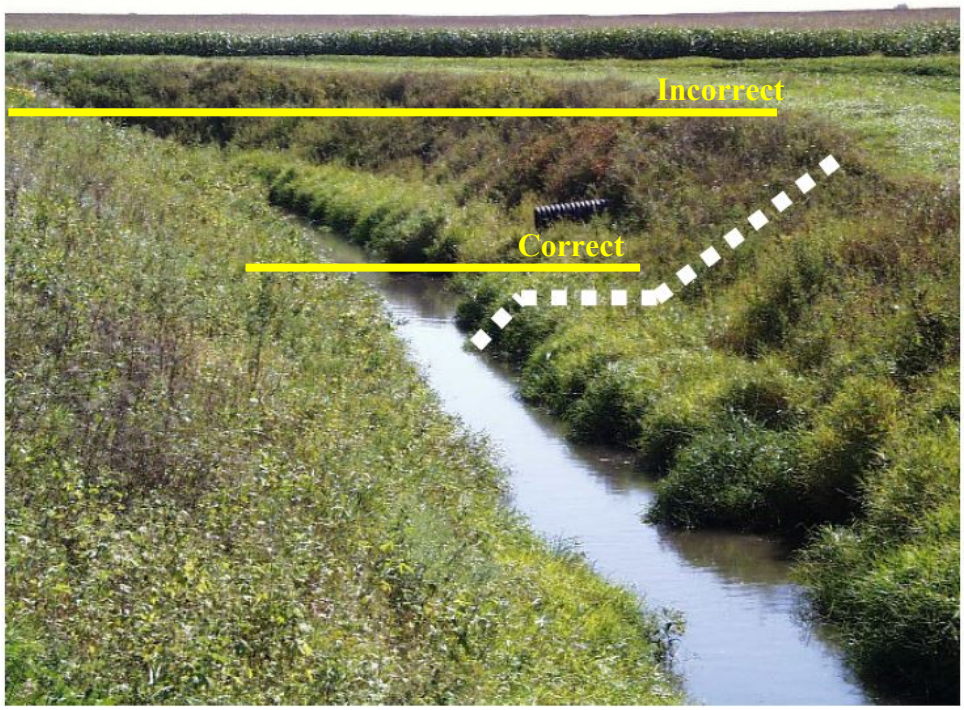


Image Credit: Huron Pines

Wetted Width: Measure the wetted width of the stream, perpendicular to the direction of flow, to the nearest 0.1 foot. Wetted width is the distance between the edges of the water at the time of the measurement.

Water Depth: Measure the water depth from the streambed to the water surface to the nearest 0.1 foot. Select a location that represents the average stream depth.

Representative Reach Velocity: If you have a current meter and are in a representative riffle, measure the water velocity at the deepest point of the riffle. If the water depth is less than 0.4 feet, measure the velocity at the midpoint of the water depth. If the water depth is greater than 0.4 feet, measure the velocity at 0.2 feet above the substrate.

If you do not have a current meter, drop an orange, bobber, or other floating object into the water at the head of the riffle and time how long it takes to float to the bottom of the riffle. Calculate the velocity by dividing the length of the riffle by the time it took the item to float that distance. Be sure to retrieve the item floated down the stream.

If the representative reach does not have a riffle (ie in very low gradient streams) measure water velocity at a location representative of the highest velocity naturally occurring in the channel. This will likely occur in straight sections. Do not measure representative reach water velocity directly below a natural log jam outlet as these are temporary and localized structures.

Water Velocity Measured With: Options: Float Test, Flow Meter

Dominant Substrate: Circle the word that best describes the material on the bed of the reference riffle.

- Cobble – baseball-sized or larger rocks
- Gravel – rocks between the size of a pinhead and a baseball
- Sand – particles are smaller than a pinhead and feel gritty between fingers
- Silt – very fine particles that don't stick together
- Clay – very fine particles that stick together
- Organics – decomposing plant material
- Bedrock – solid slabs of rock

Representative Reach Image: Record a photo of the representative reach.

Morphological Assessment

Overall Channel Stability:

Background

The current form (morphology) of a natural channel is a result of watershed inputs of sediment and flow, the local landforms and valley types, and disturbances which can be both human-caused and natural. Over time and void of significant disturbance, channels find a balance between the erosive forces of water, the erosion resistance of vegetation, and the quantity of sediment they must transport. This balance is called equilibrium. Significant changes to the input of sediment, flow, or disturbance regime will cause the stream channel to adjust, either by aggradation or degradation. Aggradation is the net accumulation of sediment on the channel bed causing it to rise over time. Degradation is the net loss of sediment from the bed causing it to be lower over time. Whether a channel is degrading, or aggrading can have an effect on the long-term stability of a road stream crossing over time.

Instructions

The degree to which a channel is degrading, aggrading, or at equilibrium can be assessed based on field indicators. Visually assess the stream channel outside of the influence of the stream crossing. DO NOT consider the stream reaches that are influenced by the stream crossing (ponded or subject to road sediment deposition). Complete this section after the representative riffle data has been collected, and the stream system has been observed to the full extent possible. Look as far upstream and downstream as possible to assess the indicators. Compare the conditions observed at the site to those described in the below worksheet, and ultimately indicate the dominant condition (equilibrium, aggradation, degradation) even if indicators from multiple conditions are observed.

Condition	Field Indicators (check all existing conditions)
Indicators of Channel Equilibrium	☐ The channel has a well-defined bankfull contour that clearly demarcates an obvious, well connected floodplain near the bankfull elevation throughout most of the reach. In sand bed systems, there is often fresh sand deposition on or forming this bank. ☐ Perennial riparian vegetation is abundant and well established along the bankfull contour, but not below it. ☐ There is leaf litter, thatch, or wrack in most pools (if pools are present) ☐ The channel contains embedded woody debris of the size and amount consistent with what is naturally available in the riparian area. ☐ There is little or no active undercutting or burial of riparian vegetation. ☐ If mid-channel bars and/or point bars are present, they are not densely vegetated with perennial vegetation. ☐ There are channel pools, the spacing between pools tends to be regular and the bed is not planar (flat or uniform gradient) through the reach. ☐ The larger bed material supports abundant mosses or periphyton.

Indicators of Active Degradation	☐ The channel is characterized by deeply undercut banks with exposed living roots of trees or shrubs. ☐ There are abundant bank slides or slumps. ☐ The lower banks are uniformly scoured and not vegetated. ☐ The channel elevation below the road is much lower in elevation than above the road. The road has stopped a headcut from progressing up stream (all other factors should be assessed away from the road). ☐ Riparian vegetation is declining in stature or vigor, or many riparian trees and shrubs along the banks are leaning or falling into the channel (do not consider trees from outside of the bank that have fallen into the channel or an occasional wind-tipped bank tree). ☐ An obvious historic floodplain has recently been abandoned, as indicated by the age structure of its riparian vegetation. ☐ The channel bed appears scoured to bedrock or dense clay. ☐ Head cuts, "nick points" are present. ☐ In stream infrastructure such as bank stabilization structures or fish habitat structures are exposed or being undercut by the stream.
Indicators of Active Aggradation	☐ There is an active floodplain with fresh splays of coarse sediment (sand and larger that is not vegetated) deposited in the current or previous year. ☐ There are partially buried living tree trunks or shrubs along the banks. ☐ Perennial terrestrial or riparian vegetation is encroaching into the channel or onto channel bars below the bankfull contour. ☐ There are avulsion channels on the floodplain or adjacent valley floor.
Overall	☐ Equilibrium ☐ Degradation ☐ Aggradation

Adapted from: California Rapid Assessment Method, Riverine Field Book ver. 6.1. 2013.

Examples

Degradation

Aggradation

Equilibrium – cedar swamp

Equilibrium – sedge meadow

Equilibrium – higher gradient

Image Credit: Coleman Egertson

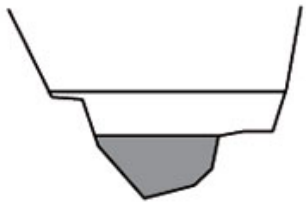
Equilibrium – tag alder

Entrenchment: Entrenchment describes the relationship of the river to its valley and landform features. Streams can be entrenched naturally due to a narrow valley type (typically in steeper landforms) or as a result of degradation. Visually estimate which of the three broad classes of entrenchment the reach near the road stream crossing exhibits. If the downstream reach is different from the upstream reach, indicate the state of the upstream reach. For entrenched and moderately entrenched systems, indicate in the comment field if the cause appears to be degradation or just a natural confinement.

Entrenched

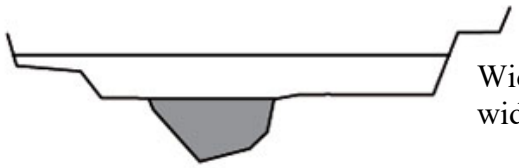
Width of the floodplain is close to the stream bankfull width.

Moderately Entrenched



Width of the floodplain is somewhat wider than the stream bankfull width.

Slightly Entrenched



Width of the floodplain is much wider than stream bankfull width.

W_{fp} = **Flood plain Width**

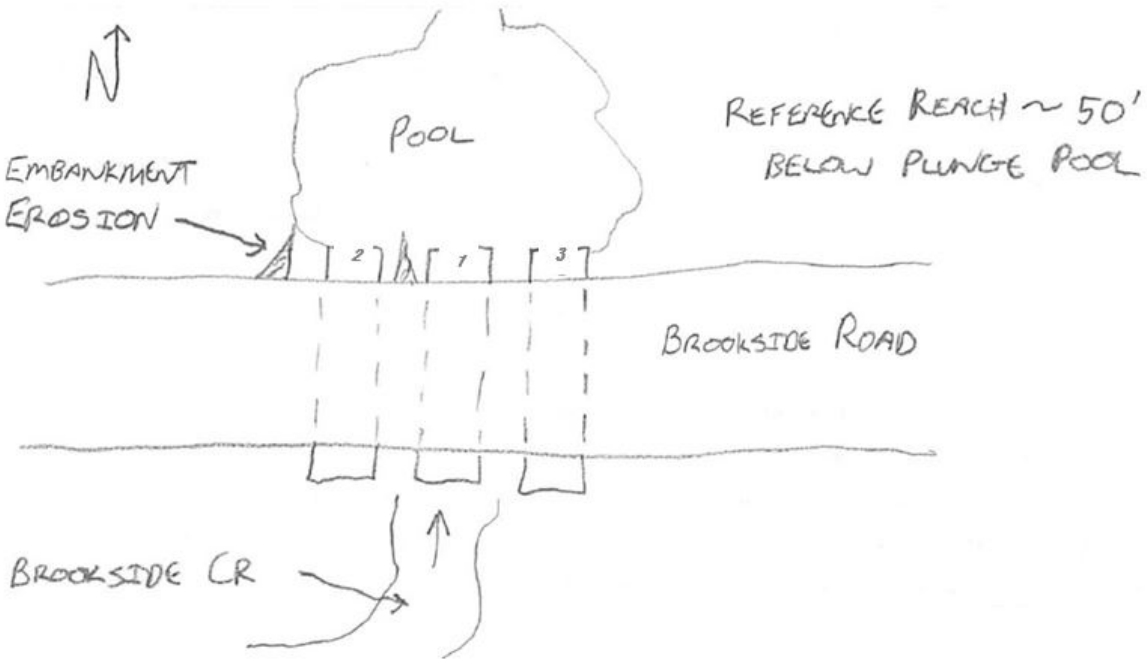
W_{bf} = **Bankfull Width**

Summary Information

Do you believe there is a time-sensitive maintenance need at the site? (Y/N)
Comments: Describe the needed maintenance at the site.

Were any non-native invasive species observed at the site? Record the names of any invasive species you observe. If you are not sure about a species identification, take a picture or save a specimen.

Site Comments: Describe any site factors or context unique to the site not capture in the above protocol. Record the cause of any of the issues noted above (plugging, ponding, sediment deposition, etc…). If upstream sediment deposition is observed, please indicate here. Factors unique to fords should be recorded here: wetted width across the ford, approach armoring, streambed armoring.

Site Sketch (optional):

Draw an overhead sketch of crossing. Be sure to mark North on the map and to indicate the direction of flow. Include major features documented on form, such as erosion sites, multiple culverts, scour pool, impounded water, etc. Here is an example: