Modified Culvert Inventory and Assessment Protocol

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Purpose

This culvert inventory and assessment method is a modified version of the National Inventory and Assessment Procedure (NIAP; Clarkin et al 2003) developed to collect data needed to run coarse filter evaluations of fish passage (Coffman 2005)

References:

Clarkin, K., A. Connor, M. J. Furniss, B. Gubernick, M. Love, K. Moynan, and S. W. Musser. 2003. National inventory and assessment procedure for identifying barriers to aquatic organism passage at road-stream crossings. USDA Forest Service, San Dimas Technology and Development Center, San Dimas, Ca.

Coffman, J. S. 2005. Evaluation of a predictive model for upstream fish passage through culverts. Master's Thesis, James Madison University, Harrisonburg, VA

Harrelson, Cheryl C; Rawlins, C. L.; Potyondy, John P. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

Safety Protocols

- *All survey crew members must wear a safety vest and hardhat when performing surveys*
- *Felt bottom shoes are required for all survey crew members, regardless of what job you are assigned*
- *Know the hazards in and around the stream channel (slick rocks, snakes, glass, etc.)*
- *Be aware of cars, ditches, and other road hazards; set out slow cones at each survey site*
- *Hold weekly 'tailgate safety' meetings to discuss and remind crew of hazards*

Field Survey, Six Steps:

1. Navigate to site
2. Classify the crossing type
3. Record crossing attributes
4. Survey longitudinal profile and check results
5. Draw site sketch
6. Take and document photos

1. Navigate to Site

Using maps and/or GPS, navigate to the road/stream crossing.

On route to the site, record the **junction road** and **milepost** using the vehicle trip meter. Do not estimate these numbers from maps or GPS/GIS.

For each site record:

A. Stream Name
   - *as shown on USGS 1:24,000 data*

B. Road Name

C. Land Ownership
   - *FS, state, private, other*

D. Crew Members
   - *full names of all crew*

E. Junction Road
   - *road that connects with the stream crossing road*

F. Milepost
   - *distance from junction road to crossing; example 0.2 mi*

G. Quad Name
   - *as shown on USGS 1:24,000 data*

H. Date

2. Classify the Crossing Type

All sites must be classified as one of the following:

A. Natural Ford
B. Bridge
C. No Access
D. Insufficient Upstream Habitat
E. Does not exist
F. Surveyed

- *If site is classified as A-E, stop here*
- *Otherwise proceed to steps 3-6*

2A-F. Crossing Type

A. Natural Ford = no structure present and natural substrate throughout entire crossing

B. Bridge = structure spans over stream and natural substrate is present throughout entire crossing

C. No Access = cannot get to site due to private property, road too busy to safely survey site, etc; must make note in comments with reason for no access

D. Insufficient Upstream Habitat = habitat upstream of crossing unable to support aquatic life

E. Does Not Exist = crossing shown on map or GPS due to a road and stream intersecting, but in the real world they do not intersect, thus there is no crossing

2A-F continued. Crossing Type

F. Surveyed = complete steps 3-6 if the crossing is a pipe (circular or arch), box, ford, or vented ford with suitable fish habitat

3. Record Crossing Attributes

A. Flow Condition
   a. Wet (continuous flow)
   b. Isolated pools (discontinuous flow)
   c. Dry (no flow)

B. Pipe Shape
   a. Open Bottom Arch
      - *no longitudinal survey; but record pipe height and width*
   b. Circular
   c. Box
   d. Pipe Arch
   e. Ford
   f. Vented Ford

C. Pipe Material
   a. Corrugated Metal
   b. Concrete
   c. Plastic
   d. Smooth Metal
   e. Wood
   f. Unknown

D. Pipe Measurements
   a. Pipe Width (ft); example 5.2 ft
   b. Pipe Height (ft)

E. Continuous Substrate (yes/no)

3A. Flow Condition

a. Wet = continuous flow

b. Isolated pools = discontinuous flow

c. Dry = no flow

3B. Pipe Shape

a. Open Bottomed Arch = no structure material on channel bottom and natural substrate present throughout entire crossing; considered passable on all filters; *(no longitudinal survey, but record height and width measurements)*

b. Circular = height and width of pipe are equal

c. Box = square or rectangular shaped

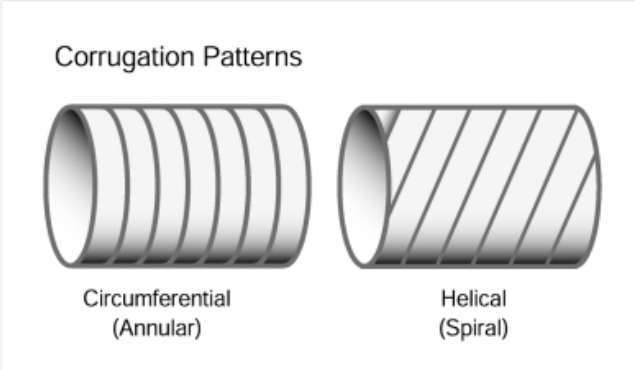
d. Pipe Arch = similar to circular pipe but height and width are not equal

3B continued. Pipe Shape

e. Ford = can be constructed in various manners including slated (often concrete or wooden), paved, or any method that alters the natural substrate

f. Vented Ford = ford surface with any pipe or culvert underneath; each pipe and the ford itself must be surveyed

3C. Pipe Material



a. Corrugated Metal = can have helical or concentric corrugations; may or may not have rust line, may be made a single piece or multiple plates bolted together

b. Concrete = used in many box and some circular and arch culverts

3C continued. Pipe Material

c. Plastic = made of plastic (PVC or HDPE), may or may not have corrugations

d. Smooth Metal = metal pipe with no corrugations

e. Wood = wood and logs are used to make log stringers, log box culverts, and circular culverts

f. Other = an unknown material or one not listed above; make a note in the comments field about the pipe material

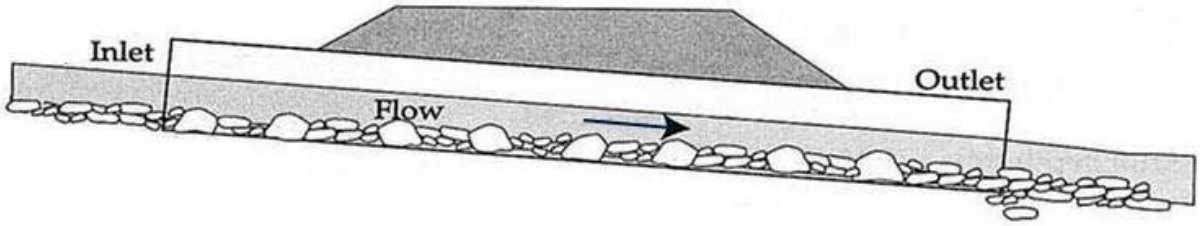
3D. Pipe Measurements

a & b. Pipe Width and Height (ft) = the inside height and width of each pipe is measured using a stadia rod or tape measure; measure at the widest and highest point of the pipe; dig down through substrate to pipe if necessary

3E. Continuous Substrate

D. Continuous Substrate = each pipe needs to be checked for continuous substrate; the substrate must fully run the length of the culvert, be wide enough to provide a natural substrate for fish; and be representative of the stream bed

Note: if pipe is full of gravel to the point where it is somewhat plugged (i.e. blocking flow & restricting fish passage) it is NOT considered continuous substrate; in this case make a note in the comments



4. Survey Longitudinal Profile and Check Results

Survey the following points:

A. BM
- bench mark; using marking paint, mark a spot that will not move during the course of the survey and has a good view of the stream corridor

B. P2
- edge of culvert or ford inlet

C. P3
- road surface near middle of culvert; mark spot with marking paint that will not move during the course of the survey

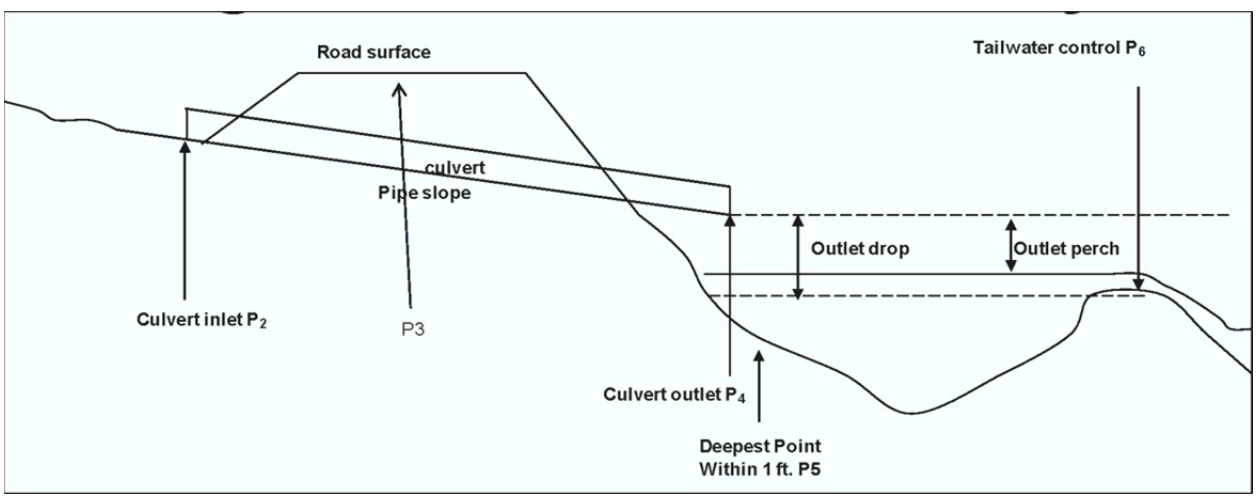
D. P4
- edge of culvert or ford outlet

E. P4b
- edge of outlet apron, when present place stadia rod at the lowest point on the apron

F. P5
- deepest point within one foot of P4, or within one foot of P4b if an apron is present

G. P6
- tailwater control; take elevation measurement from average lowest spot in the hydraulic control between outlet pool and riffle

Note: If P2 and/or P4 are embedded and substrate in the pipe is discontinuous or doesn't appear permanent, you must dig down to find the bottom of pipe for elevation reading. If substrate appears permanent, then measure P2 and P4 elevations from top of substrate; no need to dig down.



4. Longitudinal Survey Points

A. Bench Mark (BM) = initial reference (or starting) point of the survey, mark with paint and place stadia rod on a point that will not move during the survey; examples of locations to mark: road surface, a rock, guardrail, top of the culvert

B. Culvert Inlet (P2) = used for determining culvert slope; if inlet is embedded place stadia rod on top of substrate, otherwise place on corrugation of pipe

Note: If P2 is embedded and substrate in the pipe is discontinuous or doesn't appear permanent, you must dig down to find the bottom of pipe for elevation reading. If substrate appears permanent, then measure P2 elevation from top of substrate; no need to dig down.

B2. Ford Inlet (P2) = used for determining ford slope; place stadia rod on upstream edge of ford at deepest location

C. Road Surface (P3) = used to determine head-water depth for flood capacity as well as road-fill volume calculations; mark with paint and place stadia rod near middle of road close to center of culvert on a spot that will not move during the course of the survey; if working on a wetted ford and can't use marking paint, mark P3 with a rock by scrapping algae away or on unique spot on ford

4 continued. Longitudinal Survey Points

D. Culvert Outlet (P4) = used to determine culvert slope and outlet perch; if outlet is embedded place stadia rod on top of substrate, otherwise place on corrugation of pipe

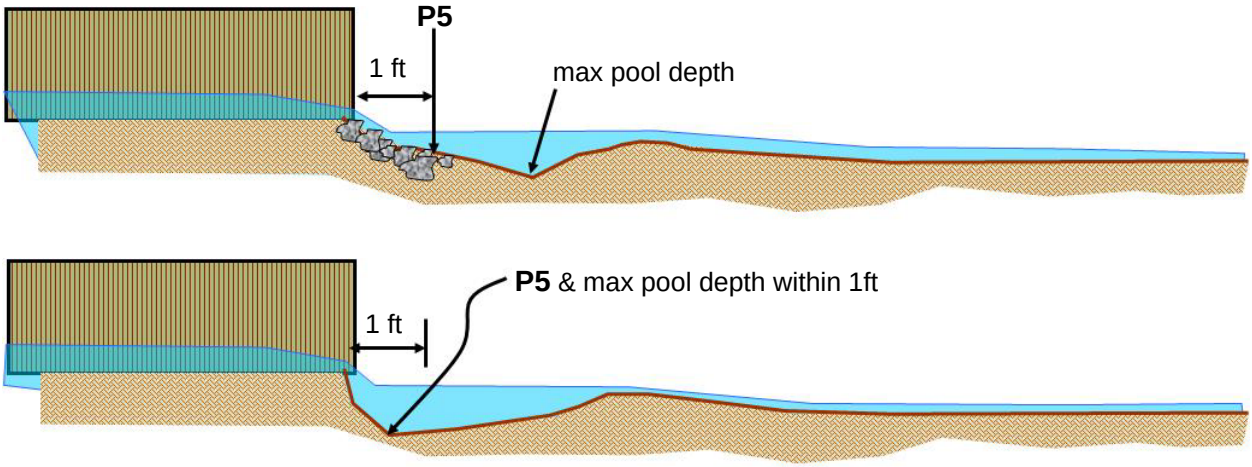
Note: If P4 is embedded and substrate in the pipe is discontinuous or doesn't appear permanent, you must dig down to find the bottom of pipe for elevation reading. If substrate appears permanent, then measure P4 elevation from top of substrate; no need to dig down.

D2. Ford Outlet (P4) = used to determine ford slope and outlet perch; place stadia rod on downstream edge of ford

4 continued. Longitudinal Survey Points

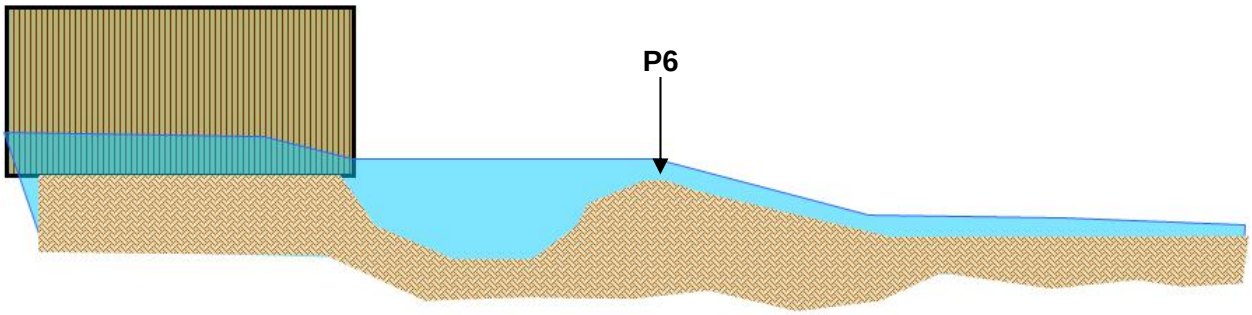
E. Outlet Apron (P4b) = a hardened surface (often concrete) at the pipe outlet intended to dissipate scouring; not every pipe has an outlet apron; when present place the stadia rod on the average lowest point of the downstream edge of the apron to take an elevation reading

F. Deepest Point within 1ft (P5) = place stadia rod at the lowest streambed elevation within the leaping distance of the fish species (1 ft); if an apron is present place stadia rod within 1 ft of P4b



4 continued. Longitudinal Survey Points

G. Tailwater Control (P6) = used to determine perch, residual inlet depth, and residual pool depth; P6 is the hydraulic control between outlet pool and riffle; if there is no outlet pool then there is no tailwater control; when present place stadia rod at the lowest average elevation of the stream bottom



Survey Set-Up Instructions

1. Using marking paint, mark the bench mark and P3 on surfaces that will not move during the survey
2. Run measuring tape from just above P2 to below P6; it is preferable to run the tape through the pipe, however if not possible then tape can be run on road surface
3. Set up level in a safe spot where all the points are visible and where the level will not have to be moved during the survey
4. Shoot elevations and stations of all points
5. Check that results seem correct by comparing calculated values to what you visually observe at the crossing (if not, redo survey); calculate backwatered, outlet drop, and pipe slope

   A. Backwatered Calculations
   1. BM Rod Read + 100 = Height of Instrument (HI)
   2. HI – P6 Rod Read = P6 Elevation
   3. HI – P2 Rod Read = P2 Elevation
   4. P6 Elevation – P2 Elevation = Positive or Negative Value
      - *Positive = Backwatered*
      - *Negative = Not Backwatered*

   B. Outlet Drop Calculations (only when P6 present)
   1. HI – P4 Rod Read = P4 Elevation
   2. P4 elevation – P6 elevation = Positive or Negative Value
      - *Positive = Height (ft) Fish Must Jump to Enter Pipe*
      - *Negative = No Outlet Drop Present*

   C. Perch Calculations (only when P6 absent)
   1. Hi – P5 Rod Read = P5 Elevation
   2. P5 Elevation + Water Depth at P5 = Water Surface (WS)
   3. P4 Elevation – WS = Perch

   D. Pipe Slope Calculations
   1. P2 Elevation – P4 Elevation = Rise
   2. P4 Station – P2 Station = Length
   3. Rise / Length = Slope
   4. Slope X Length = Slope X Length

6. **Repeat for each pipe**; don't forget to repeat for ford surface on vented fords
7. Move level to change its elevation for the closing procedure
8. Shoot to bench mark and P3

9. Check that survey closes (within ±0.02 inches); follow the 'survey close calculations' below

Survey Close Calculations

1. BM Rod Read + 100 = Height of Instrument (HI)
2. HI - P3 Rod Read = Known Elevation for P3
3. Move Level
4. New P3 Rod Read
5. New P3 Rod Read + Known Elevation for P3 = New HI
6. New BM Rod Read
7. New HI - New BM Rod Read = New Elevation
8. 100 - New Elevation = Error (must be within ±0.02)

10. If survey does not close or results don't make sense, the survey must be repeated

Notes for multiple pipe, dry stream, and no outlet pool scenarios:

Multiple Pipes

- Pipes are counted from left to right when looking downstream
- All information for steps 3 and 4 must be collected for each pipe
- Check results for each pipe before closing survey
- It is possible for multiple pipes to have an individual P6 for each pipe; however, often all pipes will share one outlet pool and therefore have the same P6

Dry Streams

- Dry streams are surveyed in the same manner as streams with water
- Record water depth at P5 = 0
- Make note in comments that stream is dry

No Outlet Pool

- If there is no outlet pool, there will be no P6
- Make note in comments that P6 is not present

No Outlet Pool and a Dry Stream

- If there is no outlet pool, there will no P6
- If stream is dry record water depth at P5 = 0
- Make note in comments that stream is dry and P6 not present

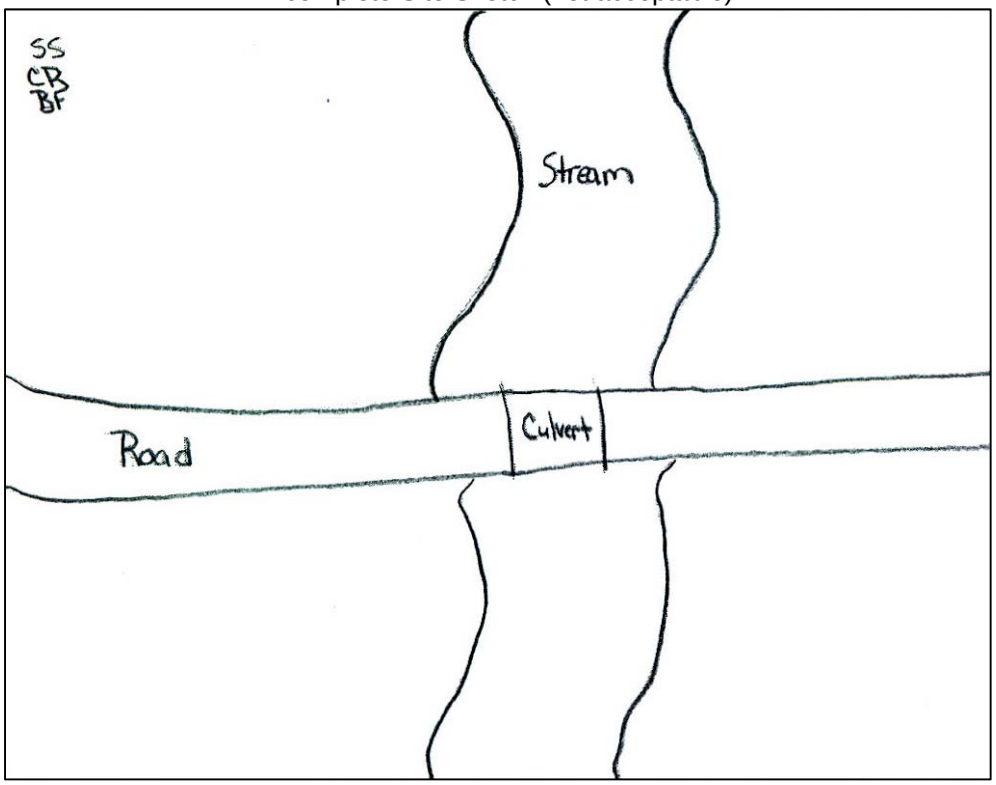
5. Draw Site Sketch

The site sketch must include:

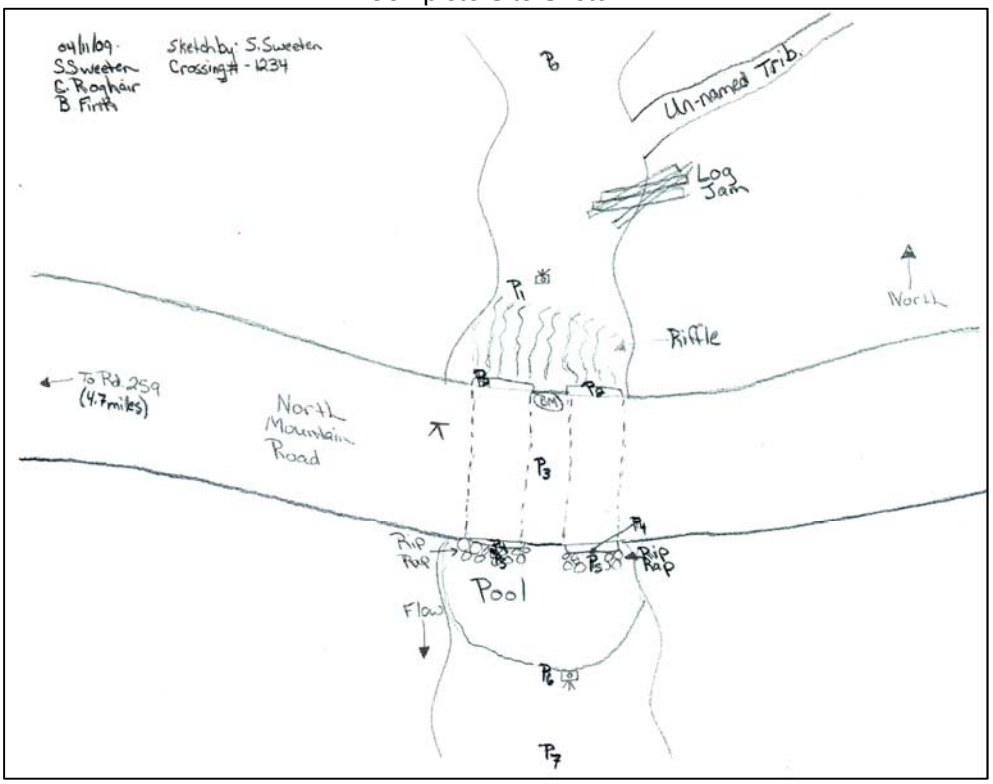
A. Crew members (full names)
B. Date
C. Crossing ID
D. Note person who drew sketch
E. North arrow
F. Direction of flow
G. Road name
H. Junction road name
I. Milepost
J. Stream name
K. Photo locations
L. Location of P points
M. Location of benchmark
N. Location of level
O. Pipe number for multiple pipes (pipe 1 on left looking downstream)
P. Outlet apron
Q. Debris jams
R. Depositional bars
S. Tributaries (include name if named)
T. Features unique to site (buildings, landmarks, etc.)
U. Damages/obstacles inside structure
V. Location of riprap or bank armoring
W. Any additional comments

5. Site Sketch

Incomplete Site Sketch (not acceptable)



Complete Site Sketch



6. Take and Document Photos

Photo Requirements:

Take a photo of the whole inlet and outlet at each site. Try to include all pipes in photos if possible. Also photograph any unique features of the site.

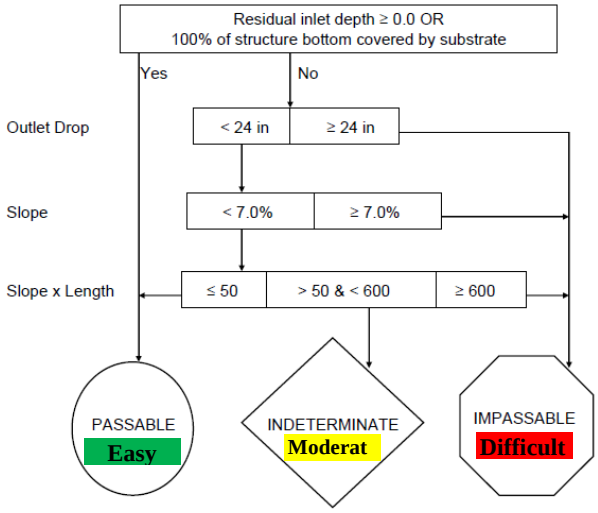
A. Stadia rod, crew member, and whiteboard must be in each photo
B. Identify site with proper site ID on whiteboard
C. All pipes should be visible
D. Channel should be included
E. Get as much of the crossing and stream in the photo as possible
F. Whiteboard should be upright, legible, and clear in photo
G. Make sure there is no glare on whiteboard
H. Check each photo before moving to next site
I. Record the photo identifier numbers for images taken

Common Photo Problems:

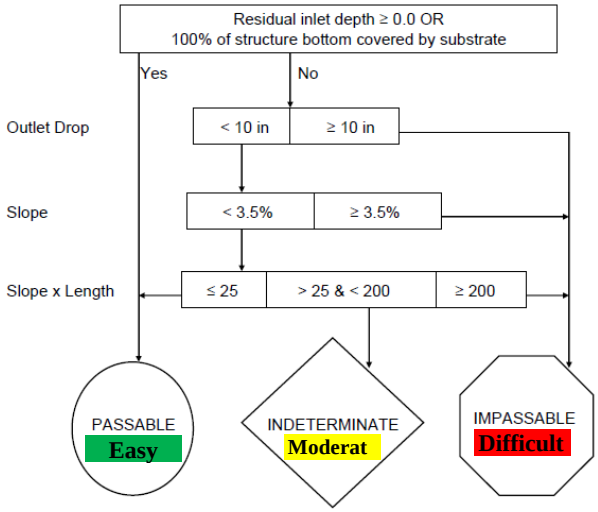
- Blurriness
- Zoomed in too far
- Zoomed out too far
- Cannot see whiteboard
- Stadia rod not included
- Cannot see all the pipes
- Light reflecting off the whiteboard
- Incorrectly labeled whiteboard

Coffman Models

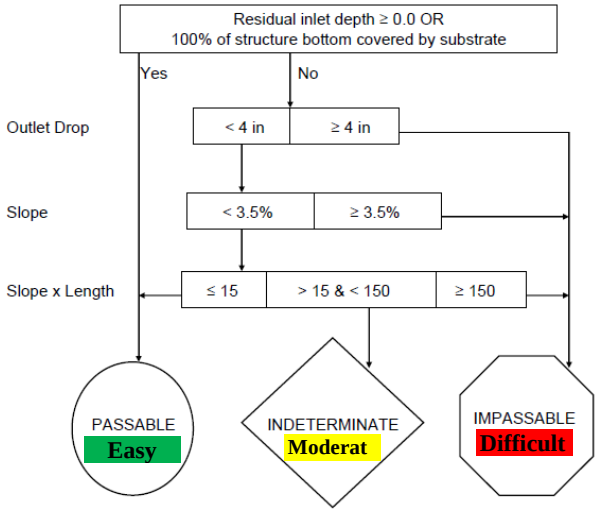
Filter A
Application: strong swimmers and leapers
Example: adult brook trout



Filter B
Application: moderate swimmers and leapers
Examples: adult minnows, age-0 brook trout



Filter C
Application: weak swimmers and leapers
Examples: darters, sculpins



Source: Coffman, J. S. 2005. Evaluation of a predictive model for upstream fish passage through culverts. Master's Thesis, James Madison University. Harrisonburg, VA. Bold color is our interpretation of status.