Culvert Condition Assessment Manual

2019 Edition
This document provides guidance for completing the Culvert Condition Assessment Form. The information collected will assist in the identification of culverts for repair or replacement. The assessment data form is to be used for an entire road-stream crossing, which may include single or multiple culverts or multiple cell bridges. The top of the form (see page 22) contains general information about the crossing and the bottom half of that page is for specific data on the condition of the crossing. The form is designed for a rapid assessment by trained lay observers (not necessarily engineers) for purposes of flagging crossings that should be examined more closely for potential structural deficiencies. It is essential to gather all of the data required for each structure for accurate assessment of the entire crossing. This assessment module is one of several develop and maintained by the North Atlantic Aquatic Connectivity Collaborative (NAACC). Data collected through use of this Culvert Assessment Form will be stored in the NAACC online database on the NAACC website: https://www.streamcontinuity.org/
Safely conducting the Culvert Assessment is of the utmost importance. The conditions under which assessments can be done should require the following items for a team of two assessors. Assessments requiring advanced safety equipment (i.e. climbing rope, air monitoring devices) should not be done unless conducted by people with the proper safety training and equipment.

List of Culvert Sites and Map
Assessment Guide
Blank Assessment Forms
Clipboards and Writing Implements
2 Waterproof Flashlights and/or Headlights
4 28” Orange Collapsible Safety Cones with Reflective Bands
2 Class II Safety Vests
2 Safety Glasses
2 Work Gloves and/or Heavy Rubber Gloves
Camera
Hand Held GPS
2 Chest Waders
2 Cell Phones and/or Portable Radios
Bug Spray
First Aid Kit with Blood Stop

Snake Bite and Poisonous Vegetation Kits
Pruning Shears or Machete
A Pocket Rod
Chipping Hammer
Duct Tape
Gallon Size Ziploc Bags
5 Gallon Bucket (to carry items)
100’ Reel Tape (measurements should be in feet and Tenths of feet)
Telescoping Stadia Rod
Measuring Wheel
Small Round Point Shovel
Small Iron Rake (7” wide)
Wasp and Hornet Spray
Probing Rod or Walking Stick
Before heading to the field, plan a route and discuss a strategy to most efficiently assess the maximum number of culverts within the time allowed. Make sure you have everything in your vehicle that you will need for the entire time you plan to stay in the field. When you arrive at the site, identify a safe location to park the vehicle. If it is on the shoulder of the road, place the orange safety cones in a manner to alert traffic as to its presence. Ideally the vehicle is parked off the roadway as not to interfere with traffic. Don your personnel protective equipment, scan the site for potential hazards and collect your forms and tools.

Start by completing all general information on the Culvert Assessment Form such as Date, Lead Observer, Location, Time, Weather, etc... If any information is unknown, leave the space blank.

Position yourself on the road as close to the midpoint of the culvert as is safely possible to determine and record the GPS coordinates in decimal degrees. A GPS device is required for this step. GPS devices should be set to WGS84 datum.

Starting with the outlet side of the culvert and record the pertinent data in the boxed sections of the form. If there is a circumstance or area of concern that is not covered on the form, record the information in the “Notes” section. Take as many photographs as is necessary to properly record the condition of the culvert and appurtenances. Identify the photographs by number and description in the shaded area at the bottom of the form.

Safely move to the inlet side of the culvert, record the pertinent data in the boxed sections of the form. If there is a circumstance or area of concern that is not covered on the form, record the information in the “Notes” section. Take as many photographs as is necessary to properly record the condition of the culvert and appurtenances. Identify the photographs by number and description in the shaded area at the bottom of the form.

Observe the condition of the pavement or soil above the culvert and note any holes or cracks which could indicate a void underneath.

In the field assess each aspect of the culvert (including appurtenances) as “Adequate,” “Poor,” or “Critical.” Aspects that are new, excellent, very good or good are all classified as “Adequate” for purposes of this assessment. The manual describes, in text and photographs, characteristics of culverts that would lead to assessments of adequate, poor and critical. If you are unsure of any terminology on the form, please refer to the glossary on page 24.

It is necessary to complete a Culvert Assessment Form for each culvert. For example, if two culverts are side by side and have identical characteristics, two culvert forms must still be completed. Standing at the inlet of a crossing with multiple culverts looking downstream, the culvert on the left will be #1. Continue numbering the culverts sequentially going from left to right.

For maintenance purposes, the Performance Problems Requiring Action section should be completed and the appropriate agencies notified of any areas of concern.

Complete and store the Culvert Assessment Form(s) and then head safely to the next crossing location.
Culvert Reference Material

A glossary of terms used in the Culvert Condition Assessment Form may be found on page 25 of this manual. The Culvert Assessment Reference Chart which contains detailed descriptions of Culvert Shapes and Dimensions can be found on page 23.
Invert Deterioration

Adequate
Minor corrosion and pitting, no holes or distortion. Cannot penetrate metal with sharp point of chipping hammer. Minor isolated spalls in concrete.

Poor
Perforations visible and/or connection hardware failing (metal). Heavy abrasion and scaling with exposed steel reinforcement (concrete). Heavy abrasion or scour damage (plastic). Displaced mortar and/or blocks, holes in invert area (masonry).

Critical
Holes or section loss with extensive voids beneath invert and/or embankment/roadway damage. Holes and gaps with extensive infiltration of soil, bedding, or backfill material (masonry).
Joints & Seams

Adequate
Minor separation of joints and seams up to 1”, minor backfill infiltration.

Poor
Significant separation of joints and seams between 1” to 3”; infiltration of backfill into culvert; voids visible in fill through offset of joints.

Critical
Severe separation of joints and seams greater than 3”; infiltration of backfill into culvert; large voids visible in fill through offset of joints.
Structural Integrity of Barrel (Concrete)

**Adequate**
Longitudinal cracks less than 1/8” in width, spalls up to 1/4” deep.

**Poor**
Longitudinal cracks between 1/8”-1/4” in width, spalls larger than 1/2” deep, and spalls have exposed rebar.

**Critical**
Severe cracking and spalls greater than 1/2” on culvert walls, sections of culvert are partially collapsed, major corrosion of rebar.
**Structural Integrity of Barrel (Metal)**

**Adequate**
Minor cracking around bolt holes or seams at isolated sections.

**Poor**
Significant cracking and/or deterioration along bolt holes and isolated seams of plates.

**Critical**
Severe cracking and or deterioration along bolt holes and along seams of plates.
Adequate
Minor isolated rip or tear caused by debris less than 6” in length and 1/2” in width. Minor cuts or gouges to end sections from maintenance or construction activities.

Poor
Cracking, splits or tears over 6” in length and up to 3/4” in width. Openings in pipe causing loss of backfill material.

Critical
Cracking, splits, punctures, or tears over 6” in length and over 1” in width. Openings in pipe causing loss of backfill material.
**Headwall/Wingwall**

**Adequate**
Minor spalls and cracks less than 1/8” in width. No exposed rebar or surface evidence of rebar corrosion. Minor settlement of the wall.

**Poor**
Significant spalls and cracks between 1/8” to 1/4” in width. Exposed rebar with corrosion. Significant settlement of the wall.

**Critical**
**Apron**

### Adequate
Some minor undermining of culvert and small scour hole. Some deterioration of joint between apron and headwall.

### Poor
Significant undermining of culvert and evidence of scour hole. Significant deterioration of joint between apron and headwall.

### Critical
Extensive undermining of culvert and development of a large hole under a structural element of the culvert. Substantial deterioration of joint between apron and headwall.
Armoring

Adequate
Streambed and streambanks are reinforced with a protective covering of rocks or engineering materials.

Poor
Significant displacements, undermining or deterioration affecting the performance of the culvert structure.

Critical
Partially or totally failed, significantly affecting performance and/or causing embankment/roadway damage or undermining of the culvert barrel or footings.
**Embankment Piping**

**Fair**  
Embankment moist only in areas surrounding culvert barrel. No evidence of flow or sediment transport observed.

**Poor**  
Evidence of seepage through the embankment along the outside of the culvert barrel, sediment transport not observed.

**Critical**  
Evidence of flow through embankment along the outside of culvert barrel. Evidence of sediment transport, “voids” or sink holes observed.
**Adequate**
Minor distortions isolated within the pipe resulting in flattening of invert and/or crown. Isolated sections are slightly non-symmetrical. Span dimension is within 5-15% of design.

**Poor**
Significant distortions within the pipe resulting in flattening of invert and/or crown of pipe. Span dimension is within 15-20% of design.

**Critical**
Severe distortions and deflection within the pipe; flattening of the crown or invert; structure is partially collapsed. Span dimension is greater than 20% of design.
Adequate
Minor isolated distortions and dimpling within the pipe. Pipe deflection 5-10% from original shape.

Poor
Significant distortions; wall buckling; flattening of invert/crown throughout the pipe. Pipe deflection 10-15% from original shape.

Critical
Severe distortions; wall buckling; flattening of invert/crown throughout the pipe; cracking/tearing present. Pipe deflection greater than 20% of original shape.
**Structural (Longitudinal) Alignment**

**Adequate**
Minimal horizontal or vertical misalignment of the pipe.

**Poor**
Significant horizontal or vertical misalignment of the pipe (Note: do not confuse this with constructed pipe bends).

**Critical**
Significant misalignment resulting in deformation of pipe or embankment/roadway damage.
Channel Alignment

Adequate
Angle measured from upstream channel to centerline of culvert barrel is from 0-45 degrees.

Poor
The stream channel approaches the crossing at an angle of 45-70 degrees from the centerline of the structure.

Critical
The stream channel approaches the crossing at an angle of 70-90 degrees from the centerline of the structure.
Adequate
Minor to moderate deterioration. Concrete - moderate cracking, scaling or leaching (minor delamination or spalling). Masonry - moderate weathering (minor joint deterioration). Slight settlement or undermining. Minor footing exposure.

Poor
Extensive deterioration. Concrete - extensive cracking, scaling or leaching (delamination or spalling may be prevalent). Masonry - extensive weathering (significant joint deterioration). Significant settlement or undermining. Footing exposed and undermined.

Critical
Severe or critical deterioration. Function or structural capacity of the culvert has been severely impacted - immediate repairs or structural analysis may be required. Concrete - severe cracking, scaling, delamination, or spalling. Masonry - severe weathering (failed joints or displaced masonry blocks) Severe settlement or undermining.
Level of Blockage

**Adequate**
Blockage is 10-30% of opening.

**Poor**
Blockage is 30-75% of opening.

**Critical**
Blockage is >75% of opening.
Adequate
Minor cracking, deterioration, or deformation. Minor undermining.

Poor
Significant cracks, piping or undermining affects >50% of appurtenance. End crushed or separated from barrel.

Critical
Deterioration is significantly affecting performance and/or causing embankment and/or roadway damage.
Buoyancy or Crushing

Adequate
Hydraulic uplift is overcome by a combination of the weight of the pipe, weight of the fill material over the pipe and weight of the water in the pipe.

Poor
Light to moderate denting or deformation of inlet and/or outlet end of flexible pipe culvert. The invert of the inlet is at the streambed elevation (no uplift).

Critical
Invert of inlet bent upward above stream bed or mitered edges crumpled inward.
Culvert Assessment Form

**CROSSING DATA**

For multiple culvert crossings use one sheet per culvert. Go from left to right, standing at inlet looking downstream.

<table>
<thead>
<tr>
<th>Crossing Code:</th>
<th>Local ID: (Optional)</th>
<th>Date Observed:</th>
<th>Lead Observer:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Culverts:</td>
<td>Culvert of</td>
<td>Stream:</td>
<td>Road:</td>
</tr>
<tr>
<td>Location: (St. #, Pole #, Etc.)</td>
<td>Town:</td>
<td>County:</td>
<td>State:</td>
</tr>
<tr>
<td>GPS Coordinates:</td>
<td>N Latitude</td>
<td>W Longitude</td>
<td>Time:</td>
</tr>
<tr>
<td>Crossing Type:</td>
<td>Embankment Piping</td>
<td>Apron</td>
<td>Armoring</td>
</tr>
<tr>
<td>Culvert Material:</td>
<td>Metal</td>
<td>Concrete</td>
<td>Plastic</td>
</tr>
<tr>
<td>Length of Culvert:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**INLET**

Appurtenance: Headwall | Wingwalls | Headwall & Wingwalls | Mitered To Slope | Projecting | Flush | Recessed | Other | None
| Inlet Shape: | Outlet Grade: |
| Outlet Dimensions: | A. Width: | B. Height: | C. Substrate/Water Width: | D. Water Depth: | E. Abutment Height: |
| Structural (Longitudinal) Alignment |
| Channel Alignment |
| Level of Blockage |
| Flared End Section |
| Invert Deterioration |
| Buoyancy or Crushing |
| Cross-Section Deformation |
| Structural Integrity of Barrel |
| Joints and Seams |
| Footings |
| Headwall/Wingwalls |
| Armoring |
| Apron |
| Embankment Piping |

**OUTLET**

Appurtenance: Headwall | Wingwalls | Headwall & Wingwalls | Mitered To Slope | Projecting | Flush | Recessed | Other | None
| Outlet Shape: |
| Outlet Grade: |
| Outlet Dimensions: | A. Width: | B. Height: | C. Substrate/Water Width: | D. Water Depth: | E. Abutment Height: |
| Structural (Longitudinal) Alignment |
| Channel Alignment |
| Level of Blockage |
| Flared End Section |
| Invert Deterioration |
| Buoyancy or Crushing |
| Cross-Section Deformation |
| Structural Integrity of Barrel |
| Joints and Seams |
| Footings |
| Headwall/Wingwalls |
| Armoring |
| Apron |
| Embankment Piping |

**Performance Problems Requiring Action**

- Debris/Veg Blockage > 1/3 of rise
- Sediment Blockage > 1/2 the opening
- Buoyancy or Crushing-Related Inlet Failure
- Poor Channel Alignment
- Local Outlet Scour
- Previous and/or Frequent Overtopping
- Embankment Piping
- Channel Degradation/Headcut
- Embankment Slope Instability
- No Access/Ends Totally Buried/Submerged
- Aggressive Abrasion/Corrosion/Chemical
- Exposed Footing (Open-Bottom Culvert Only)

**Notes:**

**Photo #:** Description:

**Photo #:** Description:

**Photo #:** Description:

**Photo #:** Description:

**Photo #:** Description:

*To provide additional feedback on performance problems use the optional second sheet*

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2019
Culvert Assessment Reference Chart

**CULVERT SHAPE & DIMENSIONS**

1. **Round Culvert**
   - Diameter
   - Height
   - Water Level

2. **Pipe Arch/Elliptical Culvert**
   - Height
   - Width
   - Water Level

3. **Open Bottom Arch Bridge/Culvert**
   - Height
   - Width
   - Water Level
   - Water Surface

4. **Box Culvert**
   - Height
   - Width
   - Depth

5. **Bridge with Side Slopes**
   - Length
   - Height
   - Water Level

6. **Box/Bridge with Abutments**
   - Length
   - Height
   - Width

7. **Box/Bridge with Abutments and Side Slopes**
   - Length
   - Height
   - Width

**CULVERT CONDITION REFERENCE**

**Structural (Longitudinal) Alignment**
- **Poor:** Significant horizontal or vertical misalignment of the pipe (Note: do not confuse this with constructed pipe bends).
- **Critical:** Significant misalignment resulting in deformation of pipe or embankment/roadway damage.

**Channel Alignment**
- **Poor:** The stream channel approaches the crossing at an angle of 45-70 degrees from the centerline of the structure.
- **Critical:** The stream channel approaches the crossing at an angle of 70-90 degrees from the centerline of the structure.

**Level of Blockage**
- **Poor:** Debris/sediment/vegetation blocks 1/3 of more of the inlet/outlet opening.
- **Critical:** Sediment blocks more than 1/3 the inlet/outlet opening (and not designed that way for aquatic organism passage).

**Flared End Section**
- **Poor:** Significant cracks, piping or undermining affects >50% of section. End crushed or separated from barrel.
- **Critical:** Deterioration is significantly affecting performance and/or causing embankment/roadway damage.

**Invert Deterioration**
- **Poor:** Perforations visible and/or connection hardware failing (metal). Heavy abrasion and scaling with exposed steel reinforcement (concrete). Heavy abrasion or scour damage (plastic). Displaced mortar and/or blocks, holes in invert area (masonry).
- **Critical:** Holes or section loss with extensive voids beneath invert and/or embankment/roadway damage. Holes and gaps with extensive infiltration of soil, bedding or backfill material (masonry).

**Bouyancy or Crushing**
- **Poor:** Light to moderate denting or deformation of inlet and/or outlet end of flexible pipe culvert. The invert of the inlet is at the streambed elevation (no uplift).
- **Critical:** Invert of inlet bent upward above streambed or mitered edges crumpled inward.

**Cross-Section Deformation**
- **Poor:** Significant perceptible deformation. Deformation with accompanying longitudinal cracking (concrete).
- **Critical:** Excessive deformation resulting in significant reduction of available flow area, and/or extensive infiltration of soil, voids, structural failure or embankment/roadway damage.

**Headwall/Wingwalls**
- **Poor:** Cracking or breaking off of flakes or chips affecting >50% of area and/or exposed steel reinforcement. Gap >4” between barrel and wall. Footing exposed and undermined.
- **Critical:** Partially or totally collapsed with damage to embankment/roadway.

**Armoring**
- **Poor:** Significant displacements, undermining or deterioration affecting the performance of the culvert structure.
- **Critical:** Partially or totally failed, significantly affecting performance and/or causing embankment/roadway damage or undermining of the culvert barrel or footings.

**Apron**
- **Poor:** Significant cracking affects >50% of apron. Significant piping or undermining.
- **Critical:** Partially or totally collapsed, significantly affecting performance and/or causing embankment/roadway damage.

**Embankment Piping**
- **Poor:** Slight pavement cracking above the culvert, perhaps with a noticeable bump/depression when driving, but no evidence of holes in the embankment or soil infiltration in the culvert barrel.
- **Critical:** Partially or totally failed, significantly affecting performance and/or causing embankment/roadway damage or undermining of the culvert barrel or footings.

**Joints and Seams**
- **Poor:** Open or displaced with significant infiltration of soil and/or leakage of water and voids visible. Missing mortar or displaced blocks (masonry).
- **Critical:** Open or displaced with significant infiltration of soil and accompanying embankment/roadway damage.

**Footings**
- **Poor:** Top portion of footing exposed, but no cracking or breaking off of flakes or chips.
- **Critical:** Footing exposed with signs of cracking or breaking off of flakes or chips. Bottom of footing exposed and/or undercut.
<table>
<thead>
<tr>
<th>Glossary</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appurtenance</td>
<td>Structures, such as aprons, flared end structures, headwalls and wingwalls, that give support to the culvert end or header.</td>
</tr>
<tr>
<td>Apron</td>
<td>Erosion protection at the inlet or outlet consisting of rip rap or concrete.</td>
</tr>
<tr>
<td>Armoring</td>
<td>Artificial surfacing of a channel bed, bank, or embankment slope to resist scour or erosion.</td>
</tr>
<tr>
<td>Bridge</td>
<td>Deck supported by abutments (or stream banks). It may have more than one cell or section separated by one or more piers.</td>
</tr>
<tr>
<td>Buoyancy</td>
<td>Water exerting upward pressure on the culvert.</td>
</tr>
<tr>
<td>Buried Stream</td>
<td>Segment of stream that flows within a pipe extending well beyond the road crossing. The planned crossing site does not include an inlet and/or outlet, likely because a stream previously in this location has been rerouted, probably underground.</td>
</tr>
<tr>
<td>Cascade</td>
<td>The outlet of the structure is raised above the stream bottom at the outlet such that water flows very steeply downward across rock or other hard material when flowing from the structure.</td>
</tr>
<tr>
<td>Channel Alignment</td>
<td>Indicates the alignment of the crossing structure relative to the stream at the inlet. Compare the crossing centerline to a centerline of the stream where it enters the crossing.</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Deterioration and rusting of metal through oxidation.</td>
</tr>
<tr>
<td>Crossing Code</td>
<td>A unique ID for each crossing in the database provided by the assigning authority (NAACC xycode).</td>
</tr>
<tr>
<td>Culvert</td>
<td>A culvert consists of a structure buried under some amount of fill. Culverts can be made of stone, brick or masonry.</td>
</tr>
<tr>
<td>Delamination</td>
<td>Splitting or separating of concrete or asphalt in the culvert.</td>
</tr>
<tr>
<td>Flush</td>
<td>The end of the culvert is not recessed nor does it extend beyond the headwall.</td>
</tr>
<tr>
<td>Ford</td>
<td>A ford is a shallow, open stream crossing, in which vehicles pass through the water. Fords may be armored to decrease erosion, and may include pipes to allow flow through the ford (vented ford).</td>
</tr>
<tr>
<td>Free Fall</td>
<td>The outlet of the structure is above the stream bottom such that water drops vertically when flowing out of the structure.</td>
</tr>
<tr>
<td>Free Fall onto Cascade</td>
<td>The outlet of the structure is raised above the stream bottom at the outlet such that water drops vertically onto a steep area of rock or other hard material, then flows very steeply downward until it reaches the stream.</td>
</tr>
<tr>
<td>Headwall</td>
<td>A structure at either end of the culvert whose purpose is to hold back the embankment, retain the culvert and prevent erosion.</td>
</tr>
<tr>
<td>Inlet</td>
<td>The in-flow end of the culvert.</td>
</tr>
<tr>
<td>Inlet Drop</td>
<td>Water in the stream has a near-vertical drop from the stream channel down into the inlet of the structure. This usually occurs because sediment has accumulated above the inlet.</td>
</tr>
<tr>
<td>Lead Observer</td>
<td>Person responsible for data collection and data quality.</td>
</tr>
<tr>
<td>Leaching</td>
<td>Water that is penetrating through the culvert and traveling along the outside of the barrel.</td>
</tr>
<tr>
<td>Local ID</td>
<td>Identification code assigned by local agency or organization.</td>
</tr>
<tr>
<td>Location</td>
<td>Description that will allow another person to locate the culvert using only the supplied information.</td>
</tr>
<tr>
<td>Mitered to Slope</td>
<td>The end of the culvert is cut at an angle to match that of the topography.</td>
</tr>
<tr>
<td>Multiple Culvert</td>
<td>Two or more adjacent culverts at a single crossing.</td>
</tr>
<tr>
<td>No Crossing</td>
<td>A crossing that exists on a map that does not exist in the field.</td>
</tr>
<tr>
<td>No Upstream Channel</td>
<td>Areas where water crosses a road through a culvert but no road-stream crossing occurs because there is no channel up-gradient of the road. This can occur at the very headwaters of a stream or where a road crosses a wetland that lacks a stream channel (at least on the up-gradient side).</td>
</tr>
<tr>
<td>Outlet</td>
<td>The out-flow end of the culvert.</td>
</tr>
<tr>
<td>Overtopping</td>
<td>When the amount of flowing water exceeds the capacity of the culvert and flows over the road surface.</td>
</tr>
<tr>
<td>Perched</td>
<td>When the outlet is above the level of the stream bottom causing water leaving the culvert to form a waterfall or cascade.</td>
</tr>
<tr>
<td>Recessed</td>
<td>The end of the culvert does not protrude through the headwall, nor is it flush with the headwall.</td>
</tr>
<tr>
<td>Removed Crossing</td>
<td>A crossing apparently existed previously at the site but has been removed, so the stream now flows through the site with no provision for vehicles to cross over it.</td>
</tr>
<tr>
<td>Scaling</td>
<td>Loss of concrete in thin, plate-like pieces, lamina, or flakes that peel off from a surface due to freeze/thaw.</td>
</tr>
<tr>
<td>Scour</td>
<td>Removal of sediment such as sand and gravel from a channel bed or bank caused by swiftly moving water.</td>
</tr>
<tr>
<td>Soil Infiltration</td>
<td>Soil entering a culvert through a joint or hole.</td>
</tr>
<tr>
<td>Spalling</td>
<td>Breaking or splitting off of surface concrete in chips or bits.</td>
</tr>
<tr>
<td>Stream Grade</td>
<td>Elevation at which the water flows.</td>
</tr>
<tr>
<td>Substrate/Water Width</td>
<td>The widest width of the water or substrate within a culvert, whichever is wider.</td>
</tr>
<tr>
<td>Structural (Longitudinal) Alignment</td>
<td>Pertaining to the horizontal or vertical alignment of the pipe. (Note: do not confuse this with constructed pipe bends).</td>
</tr>
<tr>
<td>Wingwall</td>
<td>A short section of wall connected to the side of a headwall used as a retaining wall and to stabilize abutment and guide stream into culvert.</td>
</tr>
</tbody>
</table>