Guide for EPS Activity 453

Culvert and Soils Data Collection for Hydraulics

Purpose:

Culvert and Soils Data Collection for Hydraulics (EPS Activity 453) is often part of rehabilitation or reconstruction projects. EPS Activity 453 may include any or all the following:

- Culvert inspections
- Corrosive soils and water collection and testing
- Streambed sample collection and testing

Routine culvert inspections are generally performed by Maintenance personnel to monitor culvert conditions with the goal of catching problems before they impact the driving surface of the roadway. When a new project is initiated, a thorough survey of culvert condition, soil corrosivity, water corrosivity, in place pipe gauge, and streambed material may be requested at each culvert. This guide is intended to be used by the District Materials Lab personnel in performing the appropriate level of hydraulic materials inspections in connection with an active project to allow the Hydraulics Section to determine the necessary action, if any, in addressing existing culverts (i.e., Use-As-Is, Rehabilitation or Replacement) with the upcoming project. This guide provides the general criteria that should be used in gathering and recording the information on the Culvert Inspection Report Form.

Initiation of the Culvert and Soils Data Collection for Hydraulics:

Before any work begins, the District Materials Lab will receive notification of the need for Activity 453 from the Preliminary Field Review Report (PFR) or the Location Hydraulic Study Report (LHSR). The PFR and/or LHSR report will give information on the project such as limits, anticipated scope, as-built plans, and the anticipated level of survey necessary. The Project Manager or Hydraulic Engineer may provide supplemental information/requests, when necessary, for the initiation of the project specific Culvert and Soils Data Collection for Hydraulics activity.

The inspector should gather the following information, if available, and review thoroughly before commencing with the inspection:

- Preliminary Field Review (PFR) Report
- Location Hydraulic Study Report (LHSR)
- Additional information/needs from the Project Manager or Hydraulic Engineer
- As-built plans from when the culverts were installed and/or rehabilitated
- Limits of the project (RP's and as-built stations)
- Blank Culvert Inspection Report Form (available on the Intranet under Hydraulics Manual or Materials Forms)

Culvert Inspection:

Inspection of culverts is accomplished in a variety of ways depending on field conditions. Culverts that are large enough to walk through can be inspected thoroughly by manual/visual inspection of the culvert barrel (if not filled with water or sediment).

For smaller diameter culverts, a visual inspection from both ends may suffice, provided no major concerns are found during the inspection. If the inspector identifies concerns during the initial inspection or when requested by the Hydraulics Engineer, perform a video inspection through the culvert (CCTV) to obtain additional information.

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When inspecting culverts, the inspector needs to assess the overall condition of the culvert following the Culvert Inspection Rating System Table that is attached to this guide. The condition rating system is based on a numerical scale. A rating of "1" (Good) indicates a like-new condition, with little or no deterioration, that is structurally sound and functionally adequate. Rating numbers increase with worsening condition, up to a rating of "4" (Severe), indicating the component requires special inspection with structural evaluation or immediate maintenance. Condition ratings are based on a comparison of the existing condition with the as-designed condition. When new, a properly designed and installed culvert would have a condition rating of "1" (Good).

For the purposes of the Preconstruction Activity 453 associated with a future project, the rating system consists of one, general overall system condition rating rather than individual ratings of system components. It is recognized that while a culvert might have some components in good or fair condition, there may be other components in a poor or severe condition. Rate the culvert on the overall structural condition, ability to perform, and possible negative impacts to failure of the system. If a condition has more than one criterion for evaluation, the criterion with the poorest rating (highest number) should be used to select the condition rating for the culvert. For example, a metal culvert may receive a poor rating for localized poor shape, even if the shape is good along most of its length. A poor rating for the pipe would be appropriate because local distress can cause complete system failure.

With any rating other than "Good", it is important to make notes as to what is observed for system distress. When making comments, consider the following:

- The comments should reflect what the inspector is seeing inside and outside the pipe and be supplemented with photos.
- Provide descriptive comments that help to qualify the selected rating.
- Add comments if there is distress in the roadway pavement including a dip, sag, cracks or patching. Also note any observed voids or sink holes in the embankment above the culvert.
- If something has changed since the as-builts such as a Maintenance fix, note the change here. An example might be the culvert was lined or a repair was performed on the pipe. Be sure to include appropriate photos to relay to the Hydraulic Engineer what the physical changes are.
- If a culvert has been lined, make a note of the lining material (i.e. CSP, HDPE, CIPP, etc.) and the interior dimension of the lining.
- Any other miscellaneous information should be recorded in the Remarks section if not included under another section (i.e. metal thickness, streambed samples, other measurements, or observations, etc.)

Photo/Video:
Photos of all pipe inspections are required. Additional photos of the distress areas should also be included to augment the inspection comments. For each culvert inspection, use the following list to identify what photos/videos are needed:

- Every inspection should have photos associated with it. Clearly number the photos on the inspection form with the associated culvert.

- Photos should show the interior condition of the pipe including inverts, top of pipe, joints, perforations, or other areas of concern to aid Hydraulics in estimating the remaining useful life of the pipe.
- Also include photos showing the inlet and outlet end treatments and any erosion/scour present. Multiple photos may be necessary including taking photos far enough back to show the surrounding ground condition, scour, and to clearly see the culvert end treatment and condition.
- Photos looking upstream or downstream from above the culvert when it would help visualize erosion or scour issues.
- Also, take photos to show the road fill height/amount of cover over the culvert, if not already clearly shown in one of the other photos taken.
- Take photos of any pavement distress (dip, sag, cracks or patching).
- Photos of any sink holes or voids in the embankment above the culvert.
- Include video inspection when requested or if there are concerns that cannot be vetted out through visual inspection from either pipe end.

Metal Thickness:
There are times when the in-place metal thickness of existing pipes is requested to be measured; these are at the discretion of the Hydraulic Engineer. When requested, either with the initial culvert inspection or in a follow-up after the inspection, obtain existing metal pipe thicknesses at locations through the pipe as specified by the Hydraulic Engineer. The most common and by far the best practice to obtain pipe thickness includes the use of an Ultrasonic Thickness Meter (D-meter). This is a non-destructive way of obtaining metal thickness at multiple locations in the pipe. A less desirable method would be to physically remove several coupon samples of the pipe.

Unless otherwise specified by the Hydraulics Engineer, D-meter readings of metal thickness should be taken using the following general guidance. Adjustments can be made to spacing, but this provides a starting point if no guidance is provided in the request.

- Take readings at 25-ft. intervals through the pipe.
- Obtain measurements at the 12 o'clock, 2, 4, 6, 8 and 10 o'clock positions at each 25-ft. interval.
- Provide one calibration measurement at the inlet top of the pipe, preferably where both sides of the metal are exposed to air. The goal is to get a reading from a location where the metal does not see water runoff or have soil on the outside of the pipe. This measurement will help to confirm the original pipe thickness that was installed. It will also help calibrate the measurements within the pipe.
- Be sure readings are NOT taken where two sections of pipe come together, either at a band or splice joint in the case of structural plate pipe.
- Record all readings in a table format. Note direction along the pipe the readings were taken (i.e. started at inlet or outlet, measurements taken as if looking towards outlet or inlet, etc.). Include calibration measurement and where it was taken.

Other:
For additional inspection information, photographs, and guidelines on performing culvert and storm drain inspections, the publication by AASHTO titled "Culvert & Storm Drain System Inspection Guide" is a good resource. MDT personnel have access to an online only version of this guide from the MDT Library.

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Corrosion Samples:

The corrosive water and soil tests data are used to determine the acceptable pipe materials for the new pipe or to determine if existing pipes have the required remaining design life. Refer to the LHSR or PFR for specific sampling requests. If none are provided, by these reports or through a separate request by the Hydraulic Engineer, perform corrosive samples at all pipe crossings as follows:

- Soil and water samples should be taken from all existing pipe crossings and channel bottoms at bridge locations to determine pH, marble pH, resistivity, and percent sulfates (SO4) of the soil and water.
- Take soil samples at both upstream and downstream culvert ends of all pipe crossings. Collect soil samples, not less than 2.5-lbs., for corrosive testing in accordance with MT 232 and place them in sealed containers.
- Whenever water is present at the pipe, include a water sample as well. Collect water samples, not less than 1 quart, for corrosive testing in accordance with MT 232 and place in sealed containers.
- Record the sample number, route, and reference post or station on the form for each sample.
- Include the corrosion sample numbers on the culvert inspection form for each pipe that samples were taken from.

Streambed Samples:

- The gradation test results from the streambed material samples are used to calculate the scour potential at existing and proposed bridge sites or as part of the design for Aquatic Organism Passage (AOP). When requested in the LHSR or directly by the Hydraulic Engineer, take representative streambed samples from one or more bridge/culvert lengths upstream of the drainage crossings identified. If sampling at a bridge, also take a sample under the bridge. The samples should be within the streambed and be a representative sample of the streambed material. If present, gravel bars are an easy location to take the sample. If gravel bars are not present, take several shovels full of stream bed material while walking across the channel. Submit sample with Materials Gradation Analysis form F123E. Note on the forms which sample was taken upstream of the bridge and which sample was taken under the bridge.
- Sample information should be entered into a sample record in AASHTOWare using the Material Code **PC 8 – Pre-Construction Streambed Sample**.
- The MDT Lab will complete a gradation analysis.
- When testing is complete the District Materials Supervisor will send the Sample Record Test Results Report to the District Hydraulic Engineer.

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Culvert Inspection Report Form:

The Culvert Inspection Report form (available on the Intranet under Hydraulics Manual or Materials Forms) is an Excel spreadsheet that is intended to be filled in electronically. However, it can also be printed out and filled in manually. Add additional rows to the form as needed. For each culvert included in the Hydraulics Materials Survey limits, perform the field inspection, and fill out the Culvert Inspection Report Form using the following guidance:

- Sta. and/or RP:
  - Provide the as-built station of each culvert, whenever possible.
  - Provide the Reference Post (RP) for each culvert.

- Culvert Description:
  - Dia. / Span x Rise: Provide the diameter of round shaped culverts. Provide the Span x Rise of all arch and box culverts. Provide units of measurement as appropriate. Verify measured dimension against as-built's information, note any discrepancies found.
  - Length: Record the length of the culvert using either as-built information or field measured data. Verify any as-built data used with field observations. Record the dimension in feet.
  - Material Type: Record the culvert material type (i.e. CMP, RCP, RCB, etc.). For metal pipes, also provide the apparent coating (i.e. Galvanized, Bituminous, Polymeric, etc.).

- Condition Rating:
  - Using the Culvert Inspection guide above and the Culvert Inspection Rating System Table (attached), record the observed condition of the culvert rating. Place an "X" in the field that best describes the condition of the culvert.

- Corrosion Samples:
  - Record the sample number for each soil and water sample taken at each culvert where applicable. If no samples taken, leave blank.

- Photo/Video:
  - List the photo numbers used for each culvert inspection. If a video was taken, note the video number taken as well. All photos/videos should be numbered electronically and zipped into a single file for transferring to server or DMS.

- Remarks / Comments:
  - Refer to the Culvert Inspection section above for a detailed list of data that should be entered into this field.
  - Use this field for any relevant information that would be useful to the Hydraulic Engineer in understanding the overall condition of the pipe.

After completing the Culvert Inspection Form, upload the form and any photos or videos to PCMS, and then send the Hydraulic Engineer an email with a link to the uploaded file(s).

Culvert Inspection Rating System Table

	1	2	3	4
	GOOD	**FAIR**	**POOR**	**SEVERE**
General Condition	• Like new, with little or no deterioration, structurally sound and functionally adequate.	• Some deterioration but appears to still be structurally sound and functionally adequate.	• Significant deterioration, functional inadequacy, or both. • Pipe needs maintenance or repairs to restore function.	• Very poor condition. • Structural integrity is in question and possibility of failure very likely.
Metal Barrel Condition	• No dents or other localized damage. • Isolated areas of freckled rust may be present. • The coating is generally in good condition with no damage due to abrasion; slight coloring on galvanization is ok. • Curvature of pipe is smooth with deformation being less than 5% of the original interior dimensions.	• Small dents or impact damage to pipe wall or end section with no wall breaches. • Freckled rust and/or corrosion of pipe wall material. Some loss of section may be starting, but no through-wall penetration from corrosion exists. • Some limited or local abrasion of pipe surface may exist. • Only localized minor breaches in the coating with no severe corrosion present. • Top half of pipe is smooth in shape. • Only localized minor bulges may be present. • Only localized minor flattening of the bottom may be present. • Deformation is no more than 10% of the original inside dimensions.	• Any perforation through the pipe wall, but perforations no larger than over one corrugation width by 6" long. • Large dents or impact damage to pipe wall or end section. • Widespread corrosion of the pipe is very evident. • Widespread section loss of the pipe wall may be present, but the section loss is no greater than 10% of the original wall thickness. • Localized deep pitting with several holes less than or equal to 1" diameter. Penetration possible with hammer pick strike. • Widespread abrasion of protective coating with breaches exposing the pipe wall material and allowing through-wall penetration during probe with hammer pick strike. • Significant shape distortions or flattening. Lower third of pipe may be kinked. Deformation between 10% and 15% of the original inside dimensions. • Visibly out-of-shape.	• Dents or damage present that warrant engineering evaluation. • Through-wall holes greater than one corrugation width over a length of more than 6", allowing unimpeded soil infiltration. • Extensive corrosion present with widespread wall penetration. Invert is missing in localized sections. Holes due to corrosion are greater than 1" diameter or there are many smaller holes grouped closely. • Abrasion has worn large holes through the metal pipe. areas greater than one corrugation in length by more than 6" around the circumference. • Large sections of coating are gone. • Extreme distortion of shape throughout the pipe with local areas of reverse curvature and kinks. Deformation greater than 15% of the original inside dimensions. Significantly out-of- shape.

Culvert Inspection Rating System Table

	1	2	3	4
	GOOD	**FAIR**	**POOR**	**SEVERE**
Concrete Barrel Condition	• No measurable cracking, scaling, abrasion, spalling, or other surface deterioration present.	• Some minor cracking and localized spalling visible, but no re-bar is exposed. • Longitudinal cracks are less than 0.05" wide (thickness of a dime) and some circumferential cracking may also be present, but there is no water infiltration evident through cracks. • Efflorescence present, but no signs of rust staining emanating from cracks. • Light to moderate scaling and/or abrasion present (typically less than ¼", with or without exposed aggregate, over less than 20% of pipe surface.)	• Cracking and spalling is more prevalent, but no re-bar is exposed. • Longitudinal cracks are between 0.05" and 0.1" wide and circumferential cracks present with water infiltration. • Efflorescence and/or rust staining emanates through cracks. • Moderate to severe scaling and/or abrasion present (typically between 0.25" and 0.5" deep with clearly exposed aggregate over more than 30% of pipe surface.)	• Cracking, spalling, slabbing and deterioration visibly extensive. • Longitudinal cracks are greater than 0.1" wide with exposed re-bar, significant water infiltration and/or soil migration. • Large areas of rust staining emanate through cracks. - Widespread spalling greater than 0.75" in depth or delamination with exposed rebar present. • Extensive surface damage and aggregate pop-out. • Complete invert deterioration and loss of pipe wall section.
Joint Condition	• All joints are intact and tight together.	• Joints are all still functional. May be minor joint separation, but with no loss of material through the joints.	• Some joints may be partially separated, allowing material loss into pipe.	• Severe joint separation with faulting and material loss into the pipe evident.
Inlet / Outlet Condition	• Functioning well with no visible signs of erosion or distress.	• May be some minor scour and/or sediment issues present near the inlet and/or outlet of the pipe, but still fully functional.	• Significant scour and/or sediment issues are present at the inlet and/or outlet of the pipe. • Functionality of the pipe has begun to suffer.	• Serious scour and/or sediment issues are present at the inlet and/or outlet of the pipe affecting the integrity of the pipe.
Road / Embankment	• No dip, sag, cracking, or patches in pavement above culvert. • No visible sink holes or voids in the embankment above the culvert.	• Slight or minor cracking in pavement above culvert. • No dip, sag, or patches in pavement above culvert. • No visible sink holes or voids in the embankment above the culvert.	• Minor dip, sag, or cracking in pavement above culvert. • No patches in pavement above culvert. • No visible sink holes or voids in the embankment above the culvert.	• Significant dip, sag, or cracking in pavement above culvert with skid marks. • Patches in pavement above culvert. • Visible sink holes or voids in the embankment above the culvert.