Culvert Inspection and Repair

We could have fixed it cheaper, sooner!

Bonnie Peterson, HydInfra Coordinator
Minnesota Department of Transportation
APWX Mpls 2016
Big storm + bad pipe = wrecked road

We could have fixed it cheaper, sooner.
Identify failing culverts by learning the common mechanisms of culvert deterioration in culverts less than 10 foot span and storm drain pipes.
Pipe with Holes causes Piping and Road Void

Road fill washes away at each burst of rain

CMP Storm Drain on Hadley Avenue at MnDOT Oakdale Office in 2015
This is what piping looks like – water leaves the pipe at holes or joint separations and flows along the outside.
Typical Culvert Failure has a pavement patch.

Water flows along the outside of pipe carrying road fill away.

MN 95 2015 Eric Brenna
Pipe Repair is too late when the road surface reflects condition of pipe

MN 95 near MP 89, near Marine on the St. Croix
While some steep slopes are prone to failure leaking pipes lubricate the slide

US Highway 8, April 2016  Photos by MnDOT Oakdale Surveys
Pavement may span the **void** for awhile until it doesn’t.

Holes in 6’ x6’ box culvert allowed road fill to wash out but pipe did not collapse
Inspect and Repair
to interrupt
culvert deterioration
before the road is affected
(cheaper)
A good inspection system tells you which culverts to fix before the paving project (not after).

HydInfra Project Design Report has inspection details for pipes, structures and special structures.
HydInfra = Hydraulic Infrastructure

MnDOT’s
Culvert and Storm Drainage System
Inventory and Inspection Program

(Culverts less than 10 foot span and storm drain features)
117,000 HydInfra Pipes in MnDOT’s inventory

Blue dots are pipes in good condition

July 2016
HydInfra Inspectors record drainage features with GPS devices

Inspectors use Trimble GPS with Terrasync or ArcPad. District Key Experts guide Inspectors and process field data with Pathfinder Office. Process will change in 2018 when Agile Assets software is implemented.
3-part rating system tracks **Materials** for Lifecycle Cost Analysis.
Track many **Materials** for Lifecycle costs

<table>
<thead>
<tr>
<th>Pipe Materials &amp;</th>
<th>to track performance</th>
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- **Concrete**
- **Corrugated Steel (CSP)**
- **Structural Plate**
- **Polymeric-Coated**
- **Bituminous-Coated**
- **Aluminized Steel**
- **Corrugated Aluminum (CAP)**

- **Corrugated Plastic (HDPE)**
- **PVC**
- **Perforated Plastic**
- **Polypropylene**
- **SRPE (Steel Reinforced PolyEthylene)**

**“Liner” materials describe a lined pipe:**

- **Liner HDPE**
- **Liner PVC**
- **Liner Cured in Place**
- **Liner Metal**
- **Liner Other**
Intuitive Condition Rating Codes suggest the need for repair

HydInfra Inspection Manual
Culvert and Storm Drainage Systems

Condition Rating Codes:

1. Excellent – like new condition
2. Fair – some wear, but structurally sound
3. Poor – deteriorated, consider for repair or replacement
4. Very Poor – serious deterioration
0. Not able to rate, not visible
Flags and Measures describe the defects

**Condition Indicators**
- Needs Repair?
- Piping
- Cracks
- Holes
- Deformation
- Misalignment
- Max Joint Separation
- # Separated Joints
- Separated Apron
- Spalling/Flaking
- Pitting/Rusting
- Infiltration

**Roadway Indicators**
- Void in Road
- Road Distress
- Inslope Cavity
- Erosion/Scour

**Not in Condition Rating**
- Needs Clean?
- Plugged
- Silt
- Sediment % Full
- Standing Water
Each Material Type has explicit rating criteria.

Road Void is always Condition 4.

### Concrete Pipe & Special Structure

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
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<tr>
<td>1 Excellent</td>
<td>Minor chipping at joints/openings, Hairline cracks, Insignificant spalling or scaling</td>
</tr>
<tr>
<td>2 Fair</td>
<td>Joints broken or pulled apart up to 1&quot; (anywhere along joint), Aggregate exposed, Cracks evident with widths up to 1/8 inch, Spalling or scaling to 1/4 inch depth</td>
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<tr>
<td>3 Poor</td>
<td>Joints broken or pulled apart 12-30&quot; (anywhere along the joint), Cracks evident with widths &gt; 1/4 inch, Reinforcement fully exposed in places, Eroded holes through concrete or bottom gone, Deformation, Cracks showing movement, Pipe pieces have shifted</td>
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<tr>
<td>4 Very Poor</td>
<td>Joints pulled apart or broken (more than 3&quot; at any point along joint), Cracking evident with widths &gt; 1/4 inch, Reinforcement fully exposed in places, Eroded holes through concrete or bottom gone, Deformation, Cracks showing movement, Pipe pieces have shifted, Pipe condition is causing soil loss beneath road surface</td>
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**Notes:**

Special Structures include Aprons, Slotted Drain, Headwalls, Wingwalls, open Flumes, Weirs, Expander/Reducers, Floodgates, Energy Dissipaters and other items that are not Pipes, Structures, SPCDs (Structural Pollution Control Devices), Ponds or Ditches.

Attributes such as crack width and spalling depth won't be measured in most cases—inspectors must estimate sizes based on what they see.
Pipe size, shape and material, plus defect flags point to Repair Methods

Cluster of suggested Joint Repairs indicates joint separations along Highway 61

Suggested Repair Report sorts bad pipes to estimate repair needs
# Statewide Pipe Repairs Cost Estimate from Suggested Repair Report

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Culvert Repair Methods used by MnDOT Maintenance:

- Trench New Pipe
- Slipline
- Replace Aprons
- Reset
- Extension
- Joint Repair
- Hole Repair
- Paved Invert
- Fill Voids

Images:
- Trench New Pipe
- Joint Repair
- Paved Invert
Culverts of different materials have different failure modes that progress through stages that end in road failure.
Pipe Material and its Environment
determine Lifespan

• **Avoidable defects** – Design or installation-caused problems, includes manufacture, construction or design

• **Random Events** – A culvert in the ground can be damaged by random events and forces – *huge rainfall, frost heave, etc.*

• **Gradual Deterioration** – A chunk of good pipe material in the ground may degrade gradually, influenced by its environment – manufacturer’s projected lifespan
Most Steel pipe gradually deteriorates through a series of defects shown by inspection flags:

1. Pitting/Rustling
2. Spalling/Flaking
3. Holes
4. Piping
5. Road Void
6. Deformation

HydInfra data shows that about 10% of MnDOT’s steel pipe has holes.
Joint Separation and Misalignment is rare in Steel pipe and may indicate a slope failure.
Repair Steel Pipe

Pave the invert, install a liner or replace the culvert before piping and road voids occur when inspection shows Flaking Rust or a Hole less than 1 inch.
1971 Paved Invert repair still looks good in 2015
– Bergstrand, Duluth
Concrete pipe fails most often when Joint Separation and Piping causes Road Void

HydInfra data shows about 7% of MnDOT’s concrete pipes have separated joints
Void in Road may occur through Joint Separation 1 inch or greater

Concrete jacked pipe with 1 ½ in joint separation creates road void, shown by survey range pole in hole in the pavement.  27SEP2011 – Rob Coughlin
Joint gaps are less likely with Gasketed Concrete Pipe

Non-Gasketed joint

JOINTS IN
NON-GASKETED PIPE
STD. PLATE 3000

1"

Gasketed joint

JOINTS IN
GASKETED PIPE
STD. PLATE 3006

1"

24" pipe example
Pipe tie bolts are standard on new concrete culverts but won’t hold under stresses.

District 1 photo shows broken pipe tie pointing to joint separation in Concrete arch pipe.
Concrete Joint Separation may be worse in western Minnesota. Inspection flags show hotspots for Joint Separation.

This 2011 map was created after Highway Culvert inventory was completed but before most Districts were focused on repairing pipes.
Concrete abrasion, acid attack and bad manufacture are far less common

Abrasion from rocks
District 1 Duluth

Acidic factory discharge,
I-94 St. Paul

Metro District

Bad concrete mix in alternating pipe sections, District 3
Baxter
Acid attack looks similar to bad concrete mix but alternating good - bad pipe sections suggest bad material.

MN Highway 36 culvert in Roseville alternated many good and a few bad pipe sections.
Porous weeping patches indicate bad concrete material.

The pipe photo shows water trickling down the inside wall through perforations or honeycombing.

D7 MN Highway 22, 2014
Repair Concrete Pipe

Repair joints or install liner or replace the culvert before piping and road voids occur when inspection shows Joint Separations 1 – 3 inches.
Joint Repair in large Concrete culvert
There are many varieties of Plastic Pipe but we have information on HDPE.

HydInfra data shows about 5% of HDPE pipes have visible deformation.
Random grass **fire** burned this HDPE
It has Flaking, Holes and Deformation
Pipe was re-routed across road inslope with too little cover (about 6 inches). High water or frost heave can cause the pipe to “float”.

Hydrostatic Uplift Due to a High Water Table

Buoyancy becomes an issue in buried pipe when the groundwater encroaches into the pipe zone. For projects where a high groundwater table or water surrounding the pipe is expected, precautions should be taken to prevent the floatation of HDPE pipe. Under the right conditions and when increased cover heights are possible, providing a minimum amount of cover will help prevent floatation.
Bad Resin 1996 HDPE pipe shows Deformation and Misaligned and Separated Joints

HydInfra ID 36918 has manufacturing defect in pipe material
1996 bad resin HDPE has patterned surface and cracks in 2006

Resin Specs have been changed since this pipe was manufactured
Repair Plastic Pipe

Replace pipe or repair cracks before piping and road voids occur

or when inspection shows Cracks, Misalignment or Deformed 10%
HDPE cracks were repaired by manufacturer

- 2006 repair on 1996 HDPE
- Drill hole to stop cracking
- Patched by manufacturer’s crew with their material
Better inspections lead to better repair recommendations.

Begin Part 2
Kris Langlie and Rob Coughlin