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.
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.
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

### Pipe Materials & Material Type

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Corg. Plastic (HDPE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corg. Steel (CSP)</td>
<td>PVC</td>
</tr>
<tr>
<td>Structural Plate</td>
<td>Perforated Plastic</td>
</tr>
<tr>
<td>Polymeric-Coated</td>
<td>Polypropylene</td>
</tr>
<tr>
<td>Bituminous-Coated</td>
<td>SRPE (Steel Reinforced PolyEthylene)</td>
</tr>
<tr>
<td>Aluminized Steel</td>
<td>“Liner” materials describe a lined pipe:</td>
</tr>
</tbody>
</table>

- Liner HDPE
- Liner PVC
- Liner Cured in Place
- Liner Metal
- Liner Other

<table>
<thead>
<tr>
<th>Timber</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitrified Clay</td>
<td>Other</td>
</tr>
</tbody>
</table>

**MATERIAL TYPE**

- **CONCRETE**
- **STEEL**
- **PLASTIC**
- **ALUMINUM**
- **OTHER**

**to track performance**
Intuitive Condition Rating Codes suggest the need for repair

**HydInfra Inspection Manual**
Culvert and Storm Drainage Systems

**Condition Rating Codes:**

- **Like new**
  - 1: Excellent – like new condition
- **Still okay**
  - 2: Fair – some wear, but structurally sound
- **Fix in project**
  - 3: Poor – deteriorated, consider for repair or replacement
- **Fix it sooner**
  - 4: Very Poor – serious deterioration
- **Unknown**
  - 0: Not able to rate, not visible
Flags and Measures describe the defects

<table>
<thead>
<tr>
<th>Condition Indicators</th>
<th>Roadway Indicators</th>
<th>Not in Condition Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Needs Repair?</td>
<td>- Void in Road</td>
<td>- Needs Clean?</td>
</tr>
<tr>
<td>- Piping</td>
<td>- Road Distress</td>
<td>- Plugged</td>
</tr>
<tr>
<td>- Cracks</td>
<td>- Inslope Cavity</td>
<td>- Silt</td>
</tr>
<tr>
<td>- Holes</td>
<td>- Erosion/Scour</td>
<td>- Sediment % Full</td>
</tr>
<tr>
<td>- Deformation</td>
<td></td>
<td>- Standing Water</td>
</tr>
<tr>
<td>- Misalignment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Max Joint Separation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- # Separated Joints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Separated Apron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Spalling/Flaking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pitting/Rusting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Infiltration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Infiltration
- Pitting/Rusting
- Infiltration
- Pitting/Rusting
- Infiltration
- Pitting/Rusting
- Infiltration
Each Material Type has explicit rating criteria.

Road Void is always Condition 4.
Pipe size, shape and material, plus defect flags point to **Repair Methods**

Suggested Repair Report sorts bad pipes to estimate repair needs

Cluster of suggested Joint Repairs indicates joint separations along Highway 61
**Statewide Pipe Repairs Cost Estimate from Suggested Repair Report**

<table>
<thead>
<tr>
<th>District</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Repair method</td>
<td>Cost</td>
<td>Cost</td>
</tr>
<tr>
<td>District 1</td>
<td>CIPL</td>
<td>$183,973</td>
<td>$323,374</td>
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<tr>
<td></td>
<td>Grout</td>
<td>$77,387</td>
<td>$1,025,585</td>
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<tr>
<td></td>
<td>Jack</td>
<td>$968,165</td>
<td>$1,593</td>
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<tr>
<td></td>
<td>Paved Invert</td>
<td>$40,212</td>
<td>$725.00</td>
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<tr>
<td></td>
<td>Slipline</td>
<td>$2,260.010</td>
<td>$3562</td>
</tr>
<tr>
<td></td>
<td>Trench</td>
<td>$365,255</td>
<td>$1,893,341</td>
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<tr>
<td>District 2</td>
<td>Slipline</td>
<td>$93.22 foot</td>
<td>$2,449.80</td>
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<tr>
<td></td>
<td>Trench</td>
<td>$65.37 foot</td>
<td>$26,362.84</td>
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<tr>
<td>District 3</td>
<td>CIPL</td>
<td>$129.65 foot</td>
<td>$5,644</td>
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<tr>
<td></td>
<td>Grout</td>
<td>$32.48 foot</td>
<td>$1286</td>
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<tr>
<td></td>
<td>Jack</td>
<td>$16.24</td>
<td>$29,643</td>
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<tr>
<td></td>
<td>Paved Invert</td>
<td>$1029</td>
<td>$3833</td>
</tr>
<tr>
<td></td>
<td>Slipline</td>
<td>$1848</td>
<td>$27</td>
</tr>
</tbody>
</table>
Culvert Repair Methods used by MnDOT Maintenance:

- Trench New Pipe
- Slipline
- Replace Aprons
- Reset
- Extension
- Joint Repair
- Hole Repair
- Paved Invert
- Fill Voids
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/Rusting
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.
Paved Invert Repair
for steel pipes 3 foot height or larger

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
congrete pipes have separated joints
Void in Road may occur through Joint Separation 1 inch or greater

Concrete jacked pipe with 1½ 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

24” pipe example

**Gasketed joint**

JOINTS IN
GASKETED PIPE
STD. PLATE 3006
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
 Aciddic 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
Too little cover – Construction change caused Floated HDPE

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 flotation of HDPE pipe. Under the right conditions and when increased cover heights are possible, providing a minimum amount of cover will help prevent flotation.

Flotation Technical Note TN 5.05 February 2007
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