Put Your Drainage Asset Management System to Work

Adapted from Presentation at NHEC
August 2014, Iowa City Iowa

Bonnie Peterson
MnDOT Hydraulics
Big storm + bad pipe = wrecked road

We could have fixed it cheaper, sooner
In 2014
MnDOT’s Transportation Asset Management (TAMP) committee
ranked Culverts as #1 priority
HydInfra = Hydraulic Infrastructure

MnDOT’s Culvert and Storm Drainage System Inventory and Inspection Program
HydInfra sprang from the 1986 Culvert Inspection Manual with some important differences . . .
MnDOT Hydraulic Engineers designed HydInfra in 1996

- Condition Ratings 1 – 4
- Flags and Measures record defects
- Criteria for each Material type
- Culverts less than 10 foot span
- Automated from the get-go
  - Centralized database
  - GPS
  - GIS
  - Hired a specialist for development
HydInfra Drainage Feature Types

- Pipes  – Culvert, Storm Drain, Drain Tile, Tunnels, etc.
- Structures  – MH, CB, DI
- Special Structures  – Aprons, Weirs, (catch all)
- Ponds  – Infiltration, Wet, Dry, etc.
- WQ devices  – swirling separators, skimmers etc.
- Ditches
- Discharge Points  – Outfalls (MS4) Infalls , etc.
- Illicit Discharges
- Environmental  – pH, resistivity locations
### Condition Rating Codes:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Condition Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not able to rate, not visible</td>
</tr>
<tr>
<td>1</td>
<td>Excellent – like new condition</td>
</tr>
<tr>
<td>2</td>
<td>Fair – some wear, but structurally sound</td>
</tr>
<tr>
<td>3</td>
<td>Poor – deteriorated, consider for repair or replacement</td>
</tr>
<tr>
<td>4</td>
<td>Very Poor – serious deterioration</td>
</tr>
</tbody>
</table>

*Simple ratings codes suggest repair needs*
HydInfra’s 1 – 4 ratings system came from bridge element condition ratings

**Pontis Element Condition Ratings**

Bridges are divided into separate elements, which are rated based upon the severity and extent of deterioration. There are 7 culvert elements...

- **#240**: Steel Culvert (1-4, LF)
- **#241**: Concrete Culvert (1-4, LF)
- **#242**: Timber Culvert (1-4, LF)
- **#243**: Masonry/Other Culvert (1-4, LF)
- **#388**: Culvert End Treatment (1-4, Each)
- **#421**: Culvert Footing (1-4, LF)
- **#987**: Roadway over Culvert (1-3, Each)
Pipe Materials &

- Concrete
- Corg. Steel (CSP)
- Structural Plate
- Polymeric-Coated
- Bituminous-Coated
- Aluminized Steel
- Corg. Aluminum (CAP)
- Timber
- Other

“Liner” materials describe a lined pipe:

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

Liner HDPE
Liner PVC
Perforated Plastic
Other

Concrete
Steel
Aluminum
Liner
Liner HDPE
Liner PVC
Liner Cured in Place
Liner Metal
Liner Other

Corg. Plastic (HDPE)
PVC

To track performance

“Liner” materials describe a lined pipe:
Materials differ

• Metal gets holes
• Concrete joints separate
• Plastic deforms or floats
• Odd materials require overarching criteria
Each Material type has explicit rating criteria.

- **Concrete Pipe & Special Structure**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Excellent Condition** | - Minor chipping at joints/openings  
                          - Hairline cracks  
                          - Insignificant spalling or scaling |
| **Fair Condition**     | - Joints broken or pulled apart up to 1” (anywhere along joint)  
                          - Aggregate exposed  
                          - Cracks evident with widths up to 1/8 inch  
                          - Spalling or scaling to 1/4 inch depth |
| **Poor Condition**     | - Joints broken or pulled apart 1” 2” (anywhere along the joint)  
                          - Aggregate exposed  
                          - Cracks evident with widths up to 1/8 inch  
                          - Spalling or scaling to 1/4 inch depth  
                          - Erosion or corrosion of the surface  
                          - Deformation |
| **Very Poor Condition**| - Joints pulled apart or broken (more than 3” at any point along joint)  
                          - Cracking evident with widths > 1/4 inch  
                          - Erosion or corrosion of the surface  
                          - Deformation  
                          - Cracks showing movement – pipe pieces have shifted  
                          - Pipe condition is causing soil loss beneath road surface |

**Notes:**
- Special Structures include Aprons, Slotted Drain, Headwalls, Wingwalls, open Flumes, Weirs, Expander/Reducers, Floodgates, Energy Dissipaters and other items that are not River 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.
HydInfra Condition Rating Criteria aim to **protect the roadway**

Holes or Joint Separations in pipes create **Piping and Road Voids**
With "Flags" and "Measures" we can identify and correlate problems

<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 Cavitation</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>

- Needs Repair?
- Piping
- Cracks
- Holes
- Deformation
- Misalignment
- Max Joint Separation
- # Separated Joints
- Separated Apron
- Spalling/Flaking
- Pitting/Rusting
- Infiltration
- Void in Road
- Road Distress
- Inslope Cavitation
- Erosion/Scour
- Needs Clean?
- Plugged
- Silt
- Sediment % Full
- Standing Water
Correlate sets of defects – “flags” with Material

<table>
<thead>
<tr>
<th>Material/Flag combinations that we see in MnDOT photos:</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Concrete Deformation Cracks Spalling</td>
<td></td>
</tr>
<tr>
<td>Concrete Joint Separation Road Void</td>
<td></td>
</tr>
<tr>
<td>Concrete Inslope Cavity Joint Separation</td>
<td></td>
</tr>
<tr>
<td>Concrete Joint Separation Infiltration</td>
<td></td>
</tr>
<tr>
<td>Steel Holes Road Distress</td>
<td></td>
</tr>
<tr>
<td>Steel Holes Deformation</td>
<td></td>
</tr>
<tr>
<td>Steel Holes Piping</td>
<td></td>
</tr>
<tr>
<td>Steel Holes Road Void</td>
<td></td>
</tr>
<tr>
<td>HDPE Cracks</td>
<td></td>
</tr>
<tr>
<td>HDPE Misalignment (floating)</td>
<td></td>
</tr>
<tr>
<td>Liner Deformation</td>
<td></td>
</tr>
<tr>
<td>HDPE</td>
<td></td>
</tr>
</tbody>
</table>
GPS Inspections for mapping in GIS
GIS provides context and tools
Together condition, flags, material and GIS create solutions
Put it to work
HydInfra Capabilities:

1. Performance Measures
2. Prioritize Repairs
4. Maintenance Tasks
5. Project Pre-design
6. Respond to flood damage
7. MS4 Water Quality record keeping
8. Utilities locations – “Call before you dig”
9. Research
10. Lifecycle Cost
1. Performance Measures with worthwhile goals

(If you measure it, it will happen)

- Start with inventory and inspection cycle
- Later target to reduce numbers of bad pipes

<table>
<thead>
<tr>
<th>Overall Condition</th>
<th>Recommended Inspection Frequency Years</th>
<th>Comments</th>
</tr>
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<tbody>
<tr>
<td>Very Poor</td>
<td>1</td>
<td>Pipes where</td>
</tr>
<tr>
<td>Poor</td>
<td>2</td>
<td>N/A, for</td>
</tr>
<tr>
<td>Like New and Fair</td>
<td>6</td>
<td>Least bad</td>
</tr>
<tr>
<td>Can't be Rated</td>
<td>2</td>
<td>N/A, for</td>
</tr>
<tr>
<td>Pipes with no inspections</td>
<td>2</td>
<td>Goal to inspect</td>
</tr>
</tbody>
</table>

Overall Target: 80% of Highway Pipes meet Recommended Inspection Frequency

Condition 4: 1 or 2 years
Condition 3: 4 years
Condition 2: 6 years
Condition 1: 6 years
Condition 0: 2 years
2. **Prioritize** based on today’s requirement

Choose your biggest, worst culverts that have piping and road voids with shallow cover, and highest ADT (and highest price tag)
Or Prioritize based on today’s funds

Choose the pipes that Maintenance can repair now with little cash:

Resets, Paved Inverts, Joint Repair
3. **Automate State-wide Repair Estimates with Pipe Suggested Repair Method**

Bad pipes are sorted into Repair Methods from traits.
Suggested Repair sorting process covers the most common problems.
Web-based HydInfra Report selects bad pipes for 7 potential repairs

## Suggested Repair Method
Condition 3 and 4  Concrete or Steel Pipes
District 6, May 30, 2012

<table>
<thead>
<tr>
<th>Pipe ID</th>
<th>Hwy</th>
<th>Ref Pt</th>
<th>Material</th>
<th>Road Type</th>
<th>Shape</th>
<th>Span</th>
<th>Rise</th>
<th>Units</th>
<th>Length</th>
<th>Units</th>
<th>Cover</th>
<th>Span Ft</th>
<th>Cond R</th>
<th>Repair Under Road</th>
<th>Repair Under Road</th>
<th>Refl</th>
<th>Holes</th>
<th>Parking</th>
<th>Mismatch</th>
<th>Inclin Separation</th>
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<tbody>
<tr>
<td>732154</td>
<td>14</td>
<td>161.625</td>
<td>Concrete</td>
<td>Centerline</td>
<td>Round</td>
<td>24</td>
<td>24</td>
<td>Inches</td>
<td>70 Feet</td>
<td>2 - 6 Feet</td>
<td>2.00</td>
<td>4</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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</tr>
<tr>
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<td>36</td>
<td>Inches</td>
<td>24 Feet</td>
<td>2 - 6 Feet</td>
<td>3.00</td>
<td>4</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>732157</td>
<td>14</td>
<td>161.751</td>
<td>Corg. Steel (CSP)</td>
<td>Centerline</td>
<td>Round</td>
<td>30</td>
<td>30</td>
<td>Inches</td>
<td>31 Feet</td>
<td>2 - 6 Feet</td>
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<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
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<tr>
<td>732155</td>
<td>14</td>
<td>161.752</td>
<td>Corg. Steel (CSP)</td>
<td>Centerline</td>
<td>Round</td>
<td>30</td>
<td>30</td>
<td>Inches</td>
<td>31 Feet</td>
<td>2 - 6 Feet</td>
<td>2.50</td>
<td>3</td>
<td>Y</td>
<td>N</td>
<td>N</td>
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<td>24</td>
<td>Inches</td>
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<td>2.00</td>
<td>4</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
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<td>24</td>
<td>Inches</td>
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<td>0 - 2 Feet</td>
<td>2.00</td>
<td>3</td>
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<td>Y</td>
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<td>N</td>
<td>Y</td>
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<td>482231</td>
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<td>24</td>
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<td>Inches</td>
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<td>4</td>
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<td>N</td>
<td>Y</td>
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<td>70 Feet</td>
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<td>2.00</td>
<td>4</td>
<td>Y</td>
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<td>N</td>
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<td>Inches</td>
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<td>3.00</td>
<td>4</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
</tbody>
</table>
Statewide Pipe Repairs Cost Estimate from Suggested Repair Report

<table>
<thead>
<tr>
<th>District</th>
<th>Repair method</th>
<th>Unit Price</th>
<th>Contract average bid</th>
<th>Contract Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CIPL</td>
<td>$93.22 foot</td>
<td>$183,973</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grout</td>
<td>$77.387</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jack</td>
<td>$968.165</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paved Invert</td>
<td>$40.212</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trench</td>
<td>$2,260.010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CIPL</td>
<td>$533</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grout</td>
<td>$597</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jack</td>
<td>$1,552.383</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Paved Invert</td>
<td>$323.374</td>
<td></td>
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<tr>
<td></td>
<td>Trench</td>
<td>$2,260.010</td>
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</tr>
<tr>
<td>3</td>
<td>CIPL</td>
<td>$129.65</td>
<td>$518,691</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grout</td>
<td>$23,009</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jack</td>
<td>$1,025,585</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paved Invert</td>
<td>$2,715</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Trench</td>
<td>$29,643</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

District 1:
- CIPL: 3637 feet, $183,973
- Grout: 644 feet, $577.387
- Jack: 1286 feet, $968.165
- Paved Invert: 152 feet, $40.212
- Trench: 1633 feet, $2,260.010

District 2:
- CIPL: 3362 feet, $533
- Grout: 644 feet, $597
- Jack: 1286 feet, $1,552.383
- Paved Invert: 152 feet, $323.374
- Trench: 1633 feet, $2,260.010

District 3:
- CIPL: 3637 feet, $518,691
- Grout: 644 feet, $23,009
- Jack: 1286 feet, $1,025,585
- Paved Invert: 152 feet, $2,715
- Trench: 1633 feet, $29,643
4. Improve response time on day-to-day Maintenance issues with HydInfra + Mobile Mapping

Inspector calls in
HydInfra ID
Highway
Milepost location
5. Predesign for Construction Projects

Stimulus projects and construction scoping get a head start with HydInfra inventory and inspection data.
Know which pipes to fix before the paving project (not after).
Use GIS to identify culverts for fish passage or **environmental permits**

Find MnDot-DNR Permit best practices
6. **Respond to flood damage**
when heavy rains wash out culvert

- Roadway is out
- Culvert data is known
- FEMA disaster declared
- special forms and records
- Asset Management to find spare parts
7. Map storm drain networks for MS4 Water Quality and Hazardous Spills
8. Storm utility locations for “Call before you dig”
9. Research Pipe Materials

Inspection flags show **hotspots** for Joint Separation in Concrete Pipe.
10. Lifecycle Cost capture started with “Wildly Important Goal”

- Maintenance captures culvert repair costs with Mobile App

- Construction costs are being estimated
Mobile App captures Culvert Repair Cost
Preliminary Repair Costs for Trench New Pipe are coming in

<table>
<thead>
<tr>
<th>Repair Made</th>
<th>Total Cost</th>
<th>Culvert Type (Roadway)</th>
<th>Highway/Not Highway</th>
<th>Material</th>
<th>Width (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trench New Pipe</td>
<td>$2,924</td>
<td>Entrance</td>
<td>Not Highway</td>
<td>Corg. Plastic (HDPE)</td>
<td>24.00</td>
</tr>
<tr>
<td>Trench New Pipe</td>
<td>$19,163</td>
<td>Centerline</td>
<td>Highway</td>
<td>Corg. Plastic (HDPE)</td>
<td>24.00</td>
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<tr>
<td>Trench New Pipe</td>
<td>$10,058</td>
<td>Field Entrance</td>
<td>Not Highway</td>
<td>Corg. Steel (CSP)</td>
<td>36.00</td>
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<tr>
<td>Trench New Pipe</td>
<td>$0</td>
<td>Centerline</td>
<td>Highway</td>
<td>Corg. Plastic (HDPE)</td>
<td>24.00</td>
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<td>Trench New Pipe</td>
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<td>Entrance</td>
<td>Not Highway</td>
<td>Corg. Steel (CSP)</td>
<td>8.00</td>
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<tr>
<td>Trench New Pipe</td>
<td>$8,197</td>
<td>Field Entrance</td>
<td>Not Highway</td>
<td>Corg. Plastic (HDPE)</td>
<td>36.00</td>
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<tr>
<td>Trench New Pipe</td>
<td>$4,423</td>
<td>Field Entrance</td>
<td>Not Highway</td>
<td>Corg. Steel (CSP)</td>
<td>18.00</td>
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<tr>
<td>Trench New Pipe</td>
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<td>Farm Entrance</td>
<td>Not Highway</td>
<td>Corg. Steel (CSP)</td>
<td>18.00</td>
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<tr>
<td>Trench New Pipe</td>
<td>$6,311</td>
<td>Other</td>
<td>Not Highway</td>
<td>Corg. Steel (CSP)</td>
<td>24.00</td>
</tr>
</tbody>
</table>
MnDOT will choose Asset Management Software this Fall.

HydInfra will be perfected!
Sad Reality:

**Competing needs** edge out culvert repairs

Legislature granted $$ for Maintenance to repair pavement.

Money has to be used this year, or it’s gone.

So, culvert repairs waited because Maintenance forces were fixing pavement instead.
States sharing databases to improve Lifecycle performance
Repair is too late when road voids have occurred

**Cause:** Bad Pipe

**Effect:** Bad Road

Piping: water runs outside the pipe causing void in road
The road had collapsed. The culvert was still standing.

Concrete pavement will span a road void for awhile, before it collapses.
Use it – HydInfra Tasks:

• Provide condition rating codes everyone can understand and use
• Record drainage feature inventory data
• Track multiple inspections over time
• Track repairs or maintenance tasks and other activities
• Track tasks to comply with water quality, required by MS4
• Track performance measures for inspection cycle or condition targets
• Assist with project scoping and pre-design
• Speed response to capture hazardous spills
• Prioritize repairs based on feature attributes, roadway type and location
• Automate estimating for statewide repair needs and costs (costs in development)
• Track and research pipe materials’ failure modes and performance over time (Correlations -- map materials’ attributes to find patterns)
• Assist in flood/storm recovery
• Track and sum lifecycle costs over time (in development)
Set up Drainage Asset Management System:

1. **Condition ratings** that everybody can understand
   - 1-4 rating is self-clear,
   - Ratings suggest maintenance action needed, or not

2. **Explicit criteria** describe failure modes
   - Avoid words like “Moderate” or “Excessive”
     - (no one knows what those words mean)
   - Include measureable, or estimate-able criteria
     - Like Holes, or maximum joint separation
   - Odd materials require an overarching criteria

3. **Pipe Materials** differ and defects need to be described
   - Metal gets holes
   - Concrete joints separate
   - Plastic deforms or floats

4. **Drainage feature types**
   - Pipes, Structures, Ponds, Water Quality devices, Ditches, Special Structures, Discharge Points, etc
   - Rate all features with similar criteria, based on materials

5. **Use GPS and GIS** to identify features
   - Map it and you understand the context

6. **Hydraulics and Maintenance** people are in this together
   - Flow of ideas helps us ask the right questions
   - Maintenance Performance Measures for Culverts caused it to happen

7. **User support people** get continuous feedback from Users and develop improvements
Use it – HydInfra Tools:

– Web-based data access
  • Reports
  • Data upload (internal and external access)
  • Map service for information in the field
  • GIS data access tools simplify access in the office
  • Mobile App for Maintenance’ Repairs
HydInfra Credentials:

- 2005 Federal Highway Administration Transportation Asset Management Case Studies “Culvert Management Systems Alabama, Maryland, Minnesota, and Shelby County”
- 2014 MnDOT Map21 TAMP Federal study with MN, Louisiana and NY.
- 2010 Federal Lands Highways’ Chapter 2 - Culvert Assessment Tool of the “FHWA FLH CULVERT ASSESSMENT GUIDE” borrowed elements from HydInfra condition rating criteria
- Currently NCHRP 14-26 Culvert Inspection Manual panel member