

# MDOT ANCILLARY STRUCTURES – MANAGING AGING CULVERTS

NICHOLAS GREEN, HNTB

# AGENDA

- Introduction to Ancillary Structures
- Ancillary Structures Innovations
  - Culvert Mix of Fixes
  - MDOT Ancillary Structure Forecasting System
- RFA Maintenance
  - I-94 North of M-59 – Crown Repair & Joint Seal Repairs
  - M-125 over Pike Swale – Partial Top Slab Replacement
  - M-79 over Fowler Drain – Jet Filter Pilot Project

# INTRODUCTION TO ANCILLARY STRUCTURES



MDOT Asset Management Program maintains a statewide inventory of 16 assets



Program is aimed to improve public safety by minimizing risk from aging and deteriorating infrastructure



Over **35000** inspections have been performed with successful resolution of over **300** RFAs since 2021



# DRAFT Ancillary Structures Program Viewer v3.0

## Component Rating Summary (All Asset Types) - MDOT Ancillary Structures Program

### Select an Asset Type

Culverts

### Select a Sub Asset Type

Culvert less than 10 feet

### Select a Region

No category selected

### Select a TSC

No category selected

### Select a Component Rating

1 - Imminent Failure, 2 - Critical, ... 10

### Number of Open Work Recs

No category selected

### Number of Open RFAs

No category selected

### Culvert Height (inches)

No number selected

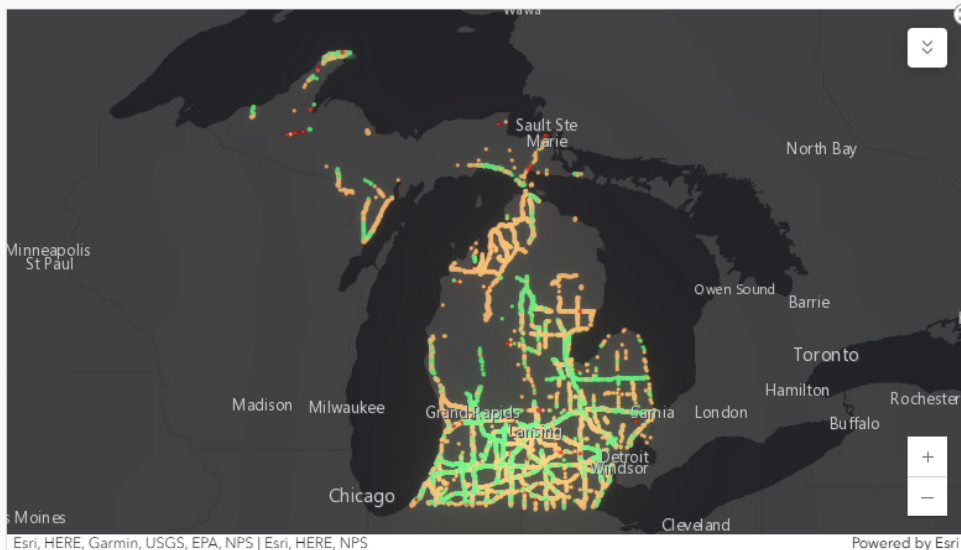
Reset

Clear

### Culvert Width (inches)

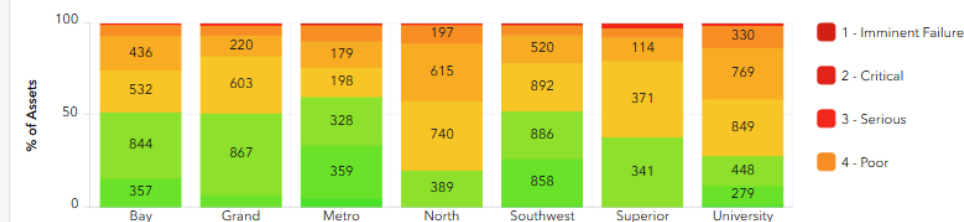
No number selected

**Note:** Select "Light Poles" or "Sign Structures" under Asset Type and then choose either "Sign Cantilever", "Sign Truss", "Frangible Pole Structure" or "Non Frangible Pole Structure" under Sub Asset Type to filter by these asset types.



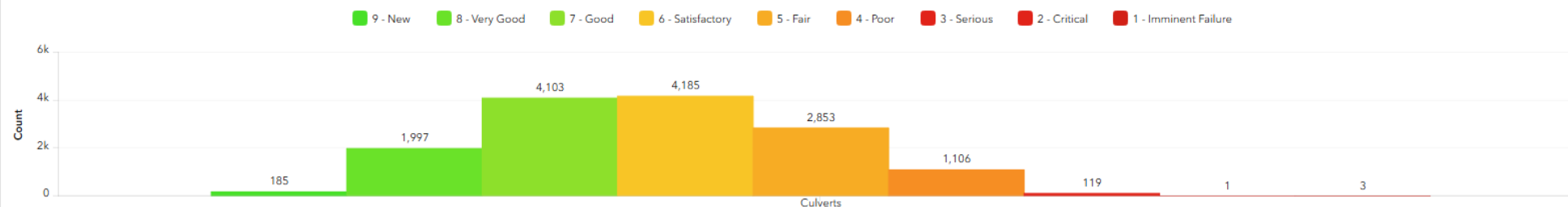
Structure Number	Sub Asset Type	MDOT Region	MDOT TSC	Main Route	Last Component Rating	Last Inspection Date	Number
CULV-000320	Culvert less than 10 feet	Southwest	Marshall	M-66	6 - Satisfactory	Jan 11, 2022	
CULV-000328	Culvert less than 10 feet	North	Gaylord	M-119	6 - Satisfactory	May 20, 2024	

### Asset Condition Rating Distribution by Region



Note: Only rated counts are listed in this chart.

### Statewide: Asset Condition Rating Distribution by Asset Type



**Notes:** (1) Only rated counts are listed in this chart, (2) Cantilever and Truss are listed as "Sign Structures" and Frangible/Non-Frangible are Listed as "Light Poles" when viewing all asset types in the chart above and (3) When filtering using the "Select an Asset Type" Cantilever and Truss are listed as "Sign Structures" and Frangible/Non-Frangible are Listed as "Light Poles" when viewing all asset types in the chart above.

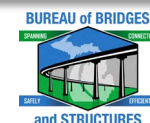
Rating by Asset Type (% of Assets)

Rating by Asset Type (Count)

Overall Component Rating



## ANCILLARY STRUCTURES PROGRAM







# DRAFT Ancillary Structures Program Viewer v3.0

## Component Rating Summary (All Asset Types) - MDOT Ancillary Structures Program

Select an Asset Type

Culverts

Select a Sub Asset Type

Culvert less than 10 feet

Select a Region

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Select a TSC

No category selected

Select a Component Rating

1 - Imminent Failure, 2 - Critical, ...

Number of Open Work Recs

No category selected

Number of Open RFAs

No category selected

Culvert Height (inches)

No number selected

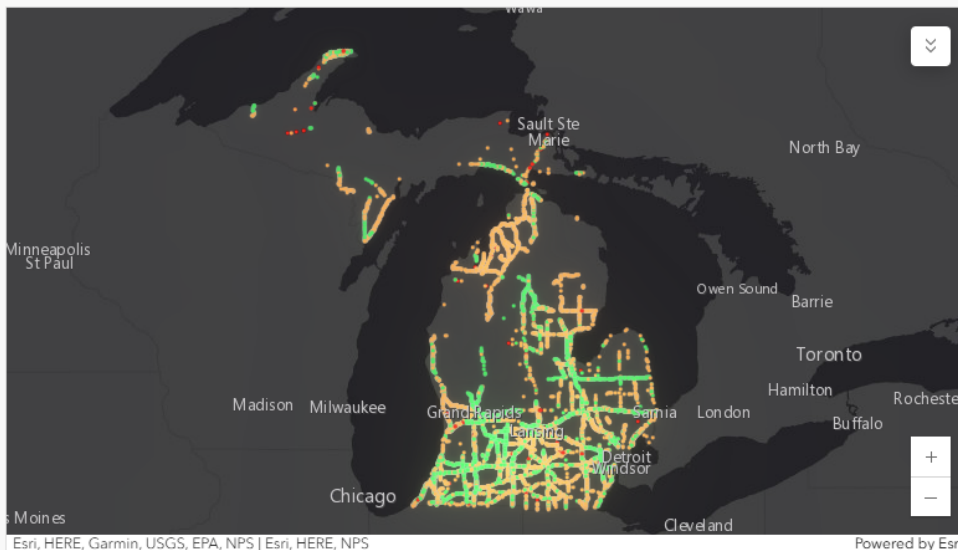
Reset

Clear

Culvert Width (inches)

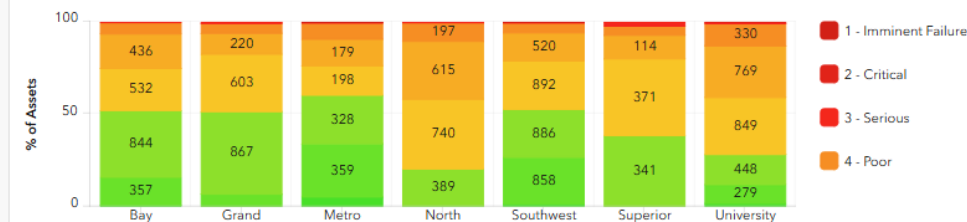
No number selected

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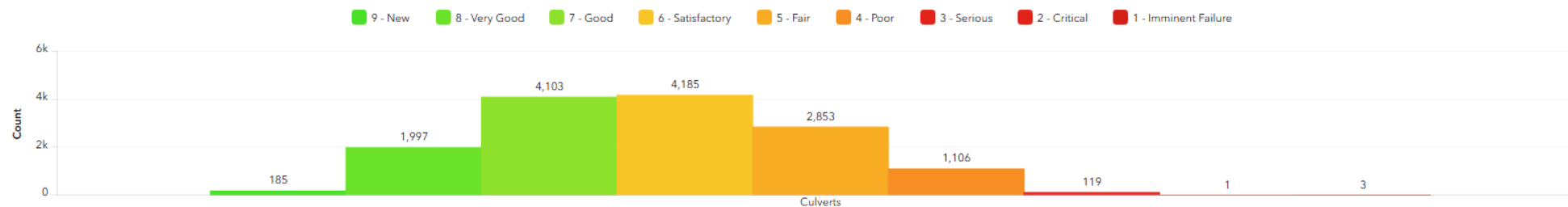
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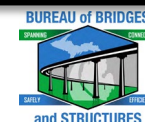
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Rating by Asset Type (Count)

Overall Component Rating



## ANCILLARY STRUCTURES PROGRAM

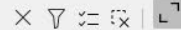




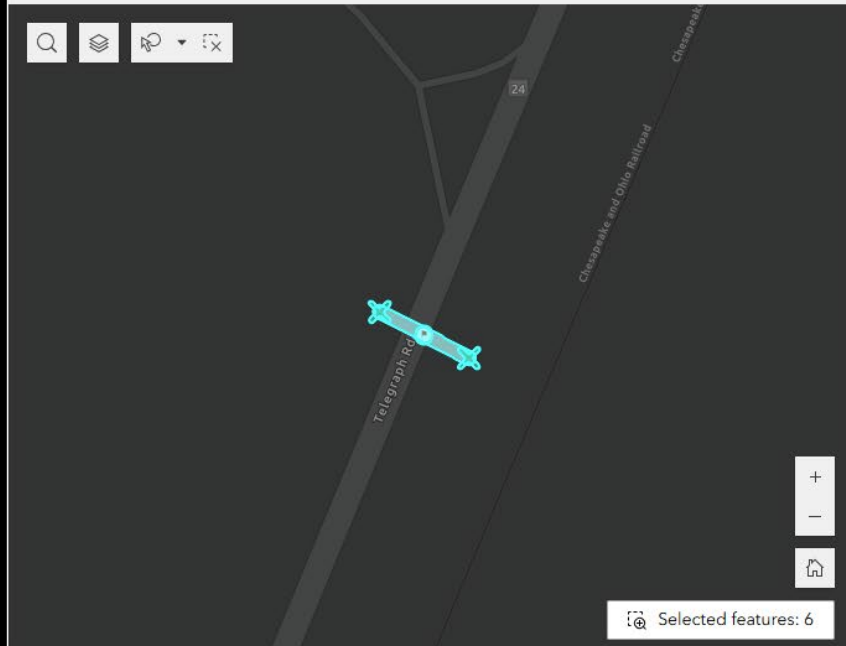
# DRAFT Ancillary Structures Program Viewer v3.0

## Culvert Less Than 10 Foot Span Inspection Viewer

Q CULV-012993



CULV-012993 - University



Esri Community Maps Contributors, Province of Ontario, SEMCOG, © OpenStreetMap, Microsoft, Esri, T... Powered by Esri



Inventory - CULV-012993

[Inventory Details](#)



Work Rec - 349102

[Work Rec Details](#)



Inspection - 7/26/2023, 12:49 PM

[Inspection Details](#)



RFA - 96433

[RFA Details](#)



# ANCILLARY STRUCTURES PROGRAM



## Projected Condition

28,737  
25,863  
22,990  
20,116  
17,242  
14,369  
11,495  
8,621  
5,747  
2,874  
0

	Current	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
9	452	456	262	155	98	71	64	71	87	117	160
8	2522	2619	2645	2561	2423	2259	2084	1909	1743	1599	1483
7	6463	6679	6536	6363	6165	5939	5680	5391	5078	4772	4481
6	9443	9354	9139	8962	8803	8654	8505	8348	8176	7986	7783
5	5687	5614	5682	5753	5821	5883	5937	5980	6007	6017	6010
4	1944	1807	2032	2253	2465	2672	2878	3082	3285	3465	3619
3	150	134	350	559	768	981	1205	1444	1698	1951	2196
2	6	6	22	63	129	221	343	499	694	924	1192
1	2	0	1	3	8	16	29	45	67	93	124
0	0	0	0	0	0	0	0	0	0	0	0

# CULVERT MIX OF FIXES

## DRAFT Preliminary Repair, Rehabilitation, and Replacement Options for Consideration for Culverts

HNTB

Prepared by HNTB Corporation

**Ancillary Structures Program**

**Table 1: Culvert Less than 10-foot Span Work Recommendations**

Number	Description of Work Recommendation	Material Involved	Quantity/Unit
1	Channel - Install/Repair Scour Countermeasures	Rock or Artificialized Concrete Block (ACB)	Cubic Foot
2	Channel - Monitor Scour	N/A	N/A
3	Substructure - Repair Abutment/Wingwall Headwall	Concrete	Cubic Foot
4	Repair/Replace End Treatment	End Treatment Material, as needed	Each
5	Repair Washouts/Erosion	Stone or Other, as needed	Square Foot
6	Approach Pavement Repair	Asphalt	Cubic Yard
7	Brush Cut	Sediment	Cubic Foot
8	Culvert Cleanout	Concrete	Square Foot
9	Clean and/or Paint/Re-seal Concrete for Graffiti Removal	Joint Sealer	Linear Foot
10	Seal Barrel	Crack Sealer	Linear Foot
11	Seal Cracks	Barrel Material, as needed	Square Foot
12	Barrel Repair	Liner	Linear Foot
13	Install Culvert Liner	Culvert	Linear Foot
14	Replace Culvert		
99	Other		

Source: MASIM, September 2023, Table 8.2.16.

**2.2 Definitions**

For the purpose of this report, the terms of repair, rehabilitation, and replacement were modified from the National Cooperative Highway Research Synthesis 303 Assessment and Rehabilitation of Existing Culverts (2002). The definitions in the Minnesota DOT (MnDOT) Culvert Repair Best Practices, Specific Provisions - Best Practices Guidelines (2014). Routine and preventative maintenance activities are defined differently between agencies. However, the definitions included below may be defined differently between agencies. However, the definitions included below may be defined differently between agencies. However, the definitions included below may be defined differently between agencies.

A repair is a maintenance task that is aimed at ensuring a culvert consistently remains in a good and safe condition. This type of maintenance includes clearing debris or sediment from a culvert.

- Routine maintenance** is designed to address specific defects and is responsive to specific situations rather than being planned. Routine maintenance includes clearing debris or sediment from a culvert.
- Preventative maintenance** is a cyclical maintenance approach that addresses early-stage deterioration and to stop it from worsening.



### Ancillary Structures Program

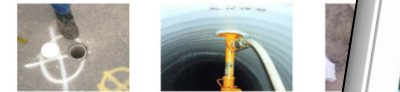
Figure 8: Spirally Wound Liner: Stationary (left) and Mobile (right) Winding Machines



Source: NCHRP, 2010

Tightly-fitted liners (expandable diameter liners) typically do not require grouting or joints in the host culvert pipe. When grouting is required, it can be accomplished by installing from the surface before liner winding, drilled through the installed liner, or through the bulkhead (Figure 9). According to NCHRP (2010), the standards ASTM F1735 outline the specifications and testing procedures for materials, dimensions, stiffness factor, extrusion quality, and a form of marking for extruded PVC profile automated production of spirally wound pipe liners. ASTM F1697 provides table of profile strip dimensions showing waterway wall thickness ranging from 0.040 in. representing typical thickness of this type of liner.

Figure 9: Spirally Wound Liner: Surface Grouting (left), Grouting Through Liner Through Bulkhead (right)



Source: NCHRP, 2010

Spiral winding presents key advantages, such as excavation elimination, installation, and it can efficiently handle bends and diameter changes. It avoids chemical processes and potential contamination. The method, which can be a limitation of this method.

Case Histories are as follows:

1/16/2025



### Ancillary Structures Program

The Caltrans Design Information Bulletin 83.04 Caltrans Supplement to FHWA Culvert Repair and Practices Manual (2014) outlines the folded and re-formed PVC liner strategy. Lining with folded and re-formed PVC liner involves the insertion of a continuously extruded, folded PVC liner into the host pipe. After that, the new pipe is reformed to adapt to the shape of the host pipe. This is achieved without excavation. Back when the bulletin was originally published, there was uncertainty about the durability and abrasion resistance of PVC compounds of this type. Also, the use of this intervention was limited to pipes with diameters of 24 inches or less. The liners are made of PVC compounds that are modified from those used in PVC pipes, and they are used for direct burial (e.g., standard ribbed PVC pipes).

#### 4.2.3 Deform-Reform Liner

##### National Cooperative Highway Research Program (NCHRP)

The NCHRP's Culvert Rehabilitation to Maximize Service Life While Minimizing Direct Costs and Traffic Disruption (2010) outlines the deform-reform liners strategy.

Deform-reform liners are HDPE pipes that are initially manufactured in a round shape with their memory set to remain round through cooling. Then, they undergo reheating with warm water, below the manufacturing temperature, and are deformed into a "U" shape using a former or a "heart" shape to the job site (Figure 14, left). The flexible liner is temporarily maintained by a sleeve or plastic bands (Figure 14, middle). Following the folding process, the pipe is coiled on large vertical drums for transport by applying pressure (Figure 15, left). The flexible liner is unwound from the coil and pulled into the host pipe using a winching mechanism (Figure 15, right). Once pulled into the culvert, the liner is reformed by releasing the bands, allowing it to revert to its original shape (Figure 16). This re-rounding process can use pressurized steam, a combination of steam-generated heat and pressure, or hot water. The installation cannot be performed in line flow conditions. Liner thickness is determined based on the ASTM F1533, covering requirements and test methods for deformed polyethylene (PE) liner for the rehabilitation of gravity flow and non-pressure pipes.

Figure 14: Deform-Reform Liner: "Heart" Shape of Folded HDPE Liner (left), Plastic Bands to the Shape (middle), and Coiled Pipe to Transport (right)



Source: NCHRP, 2010

1/16/2025



### Ancillary Structures Program

Figure 18: Installation of Centrifugally Cast Liner



Source: Bechtel, 2010

##### National Cooperative Highway Research Program (NCHRP)

NCHRP's Culvert Rehabilitation to Maximize Service Life While Minimizing Direct Costs and Traffic Disruption (2010) outlines the centrifugal casting strategy.

In some centrifugal casting systems, additional towelling or surfacing may not be necessary. For small diameter pipes, the equipment is remotely operated (Figure 19). For large diameter pipes, an operator can enter the pipe to control the remotely operated machine head (Figure 19). The centrifugal casting device moving through the pipe evenly applies a continuous, thin layer of cement mortar (typically ranging from 0.25 in. to 0.5 in. thick, and up to 2 in. thick when multiple layers are applied) onto the interior of a deteriorated culvert pipe.

Figure 19: Spincast System Applies Material to Pipe Walls Using Centrifugal Force for Small Diameter Pipes (left) and for Large Diameter Pipes (right)



Source: NCHRP, 2010

1/16/2025



MDOTANCILLARYSTRUCTURES.ORG



# I-94 NORTH OF M-59 – EXISTING CONDITIONS



- 83" x 53" Concrete horizontal elliptical culvert
- Constructed in 1962 and extended in 1997
- Asset defects include:
  - Joint separation with active water & soil infiltration
  - Barrel Failure
- Culvert Crosses 8 lanes of traffic

# I-94 NORTH OF M-59 – EXISTING CONDITIONS

## Barrel Failure (Interior)





# I-94 NORTH OF M-59 – EXISTING CONDITIONS

## Barrel Failure (Exterior)





# I-94 NORTH OF M-59 – EXISTING CONDITIONS

## Joint Separation with Infiltration



# I-94 NORTH OF M-59 – REPAIR OPTIONS


## Repair Option #1



- Open Cut Excavation of I-94 Left Shoulder
- Remove & Replace of damaged 83"x53" Pipe
- 0.5 square mile drainage area to be maintain through bypass pumping
- Estimated Cost: \$510,000

# I-94 NORTH OF M-59 – REPAIR OPTIONS

## Repair Option #2

Owner: Michigan Department of Transportation		 Corby Energy Services, Inc.		Contractor: Corby Energy Services, Inc.		<div>Proposal</div> Date of service: Date: 07/08/2024 Invoice Number: CES job #:8033-xxxx		
Address: 425 W. Ottawa Street Lansing, MI 48933				Address: PO Box 970 Belleville, MI 48112				
ATTN: Michelle O'Neal, PE				ATTN: Troy Freed				
Region: Metro				Title: Project Manager				
TSC:				Mobil: 989-213-4408				
Address: 6333 Lansing Road Lansing, MI 48917				Email: tfreed@corbyenergy.com				
ATTN: Michelle O'Neal, PE								
MDOT Contract #: 200000000843								
MDOT DO#:								
Region	Section	Line Item	Description	U/M	Quantity	Unit Price	Price	Location
			Culvert Rehabilitation					I-94 / M-59
Metro	K	Misc.	Mobilization	LS	1	\$ 11,500.00	\$ 11,500.00	
			DCP Testing					Included
			83" x 53" Elliptical RCP					
	M	Mechanical seals	66" Joint Internal Joint Seals	EA	31	\$ 6,700.00	\$ 207,700.00	Install Joint Seals
	K	Misc.	Soil injection / fill voids	PD	3100	\$ 8.00	\$ 24,800.00	Estimated quantity
			Pipe repair					
	CO10	6	Pipe repair	LS	1	\$ 5,000.00	\$ 5,000.00	8 hour minimum/Port to Port
	CO7	11	Hydro excavate	HR	8	\$ 395.00	\$ 3,160.00	
	CO8	7	Concrete special	CY	1	\$ 8,500.00	\$ 8,500.00	
			Traffic					
	K	Misc.	Lane shoulder closure	Day	1	\$ 1,500.00	\$ 1,500.00	EB
	K	Misc.	Lane shoulder closure	Day	1	\$ 1,500.00	\$ 1,500.00	WB
	K	Misc.	Lane shoulder closure	Day	1	\$ 1,500.00	\$ 1,500.00	Ramp
	K	Misc.	TMA-1	Day	1	\$ 1,460.00	\$ 1,460.00	EB
	K	Misc.	TMA-2	Day	1	\$ 1,460.00	\$ 1,460.00	WB
	CO8	16	Misc. Traffic Devices	LS	1	\$ 7,500.00	\$ 7,500.00	
						\$ 275,580.00		Sub-total
Exclusions: Guardrail remove and replace								
Pricing assumes all work to be completed								

- Crown Repair
  - Fabricated stainless steel crown to match unique culvert size and configuration
- Internal Joint Seals
- Soil Injection for site stabilization



# I-94 NORTH OF M-59 – REPAIR

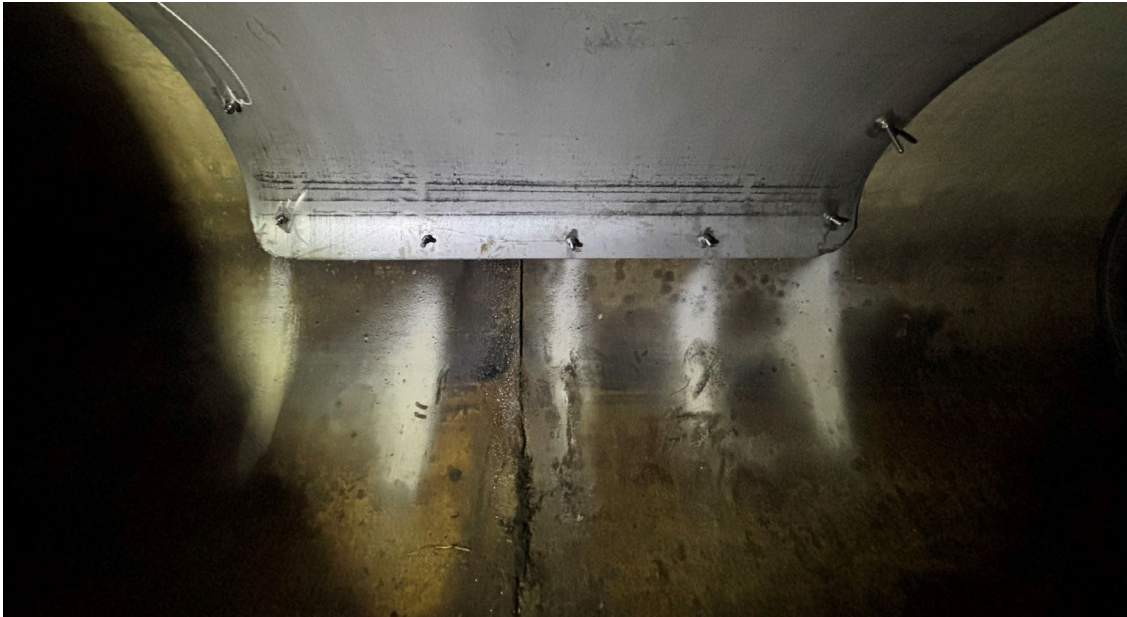
## Crown Repair





# I-94 NORTH OF M-59 – REPAIR

## Crown Repair



# I-94 NORTH OF M-59 – REPAIR



- **Joint Repair**

- Internal Joint Seals installed at 30 joints to mitigate separation & infiltration
- DCP testing revealed soft areas of soil to be addressed through soil injection

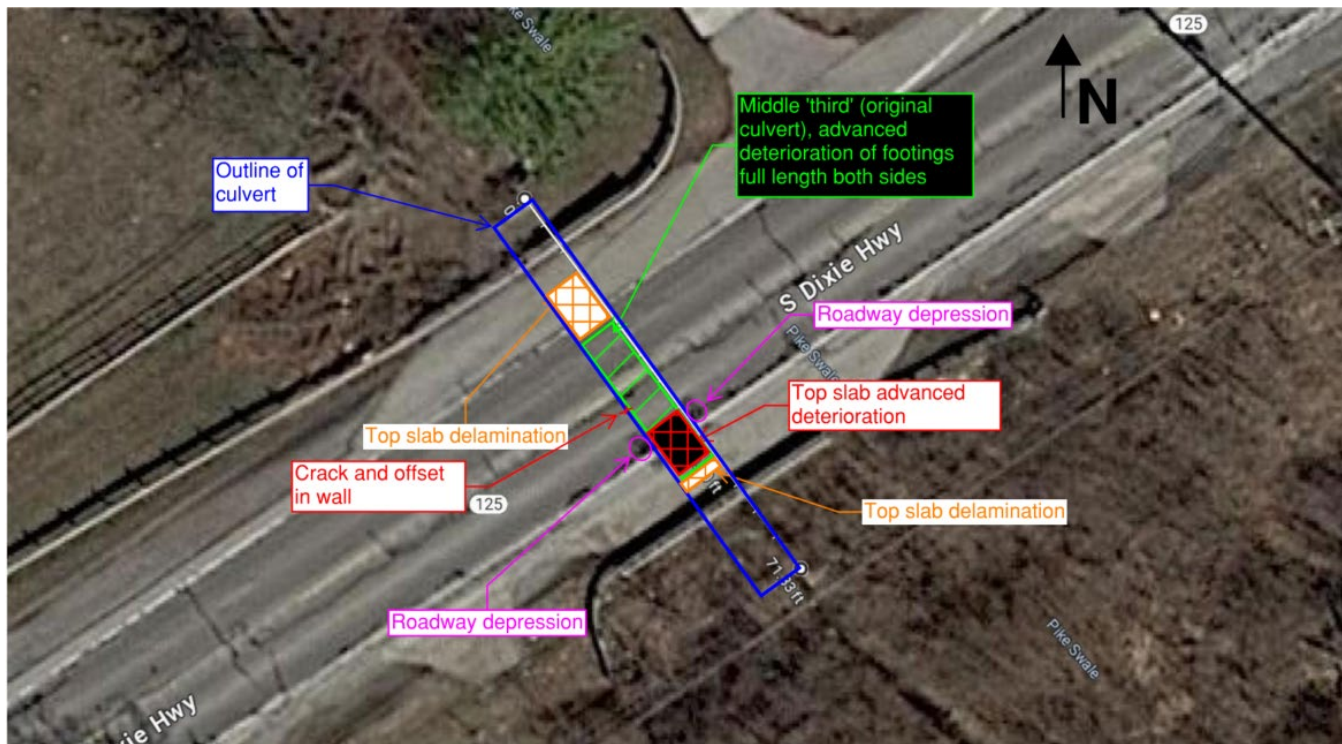


# I-94 NORTH OF M-59 – REPAIR



- Soil Injection
  - Injection ports spaced at 5' increments in in left shoulders, left lanes, and median.
  - Over 2700 lbs of two-part foam injected into the voids

# M-125 OVER PIKE SWALE – EXISTING CONDITIONS



- 48" x 72" Three-Sided Concrete Culvert
- Constructed in 1930s
- Asset defects include:
  - Structural cracking
  - Deterioration of concrete footings
  - Spalling of culvert soffit exposing reinforcement
  - Depression in roadway above soffit deterioration
- Deemed RFA Priority Level 1 in February 2024



# M-125 OVER PIKE SWALE – EXISTING CONDITIONS

## Footing Deterioration





# M-125 OVER PIKE SWALE – EXISTING CONDITIONS

## Footing Deterioration





# M-125 OVER PIKE SWALE – EXISTING CONDITIONS

## Soffit Spalling





# M-125 OVER PIKE SWALE – EXISTING CONDITIONS

## Roadway Depression



**Cross Section of Barrel**

The diagram illustrates the cross-section of a barrel structure with the following dimensions and details:

- Overall Dimensions:**
  - Top width: 1'-4" (left), 7'-6" (center), 1'-4" (right)
  - Top slab thickness: 6'-0"
  - Internal width: 1'-3" (left), 6'-0" (center), 1'-3" (right)
  - Bottom width: 3'-7" (left), 4'-0" (center), 3'-7" (right)
  - Left side height: 1'-9" (bottom), 1'-6" (middle), 4'-8" (top)
  - Right side height: 6'-0" (bottom), 1'-4" (middle), 1'-6" (top)
- Reinforcement and Structural Details:**
  - Top Slab:** 6 SL-C bars @ 12" ctra.
  - Internal Slab:** 5L-A bars, 4" x 1/2" Key.
  - Side Walls:** 5/16" Field Weld all around, Typ.
  - Bottom Chords:** 2" pipe drains @ 6', 10" x 2" Key.
  - Reinforcement Labels:** A5-C bars, A5-L bar, A5-C bars, FA bar.
  - Adhesive:** EA04 Adhesive, 12" Spacing.
  - Concrete Removal:** Concrete Removal Limits, Typ. Surface of vertical wall to be intentionally roughened prior to installation of proposed slab.
  - Excavation Limits:** Excavation limits, Typ.



# M-125 OVER PIKE SWALE – SOFFIT REPAIR





# M-125 OVER PIKE SWALE – SOFFIT REPAIR





# M-125 OVER PIKE SWALE – SOFFIT REPAIR





# M-125 OVER PIKE SWALE – SOFFIT REPAIR





# M-79 OVER FOWLER DRAIN- EXISTING CONDITIONS



- 72" Circular Concrete Culvert
- Asset defects include:
  - Joint Separation with active water & soil infiltration



# M-79 OVER FOWLER DRAIN- EXISTING CONDITIONS

## Joint Separation & Infiltration





# M-79 OVER FOWLER DRAIN – JOINT REPAIRS

## Concrete Coring



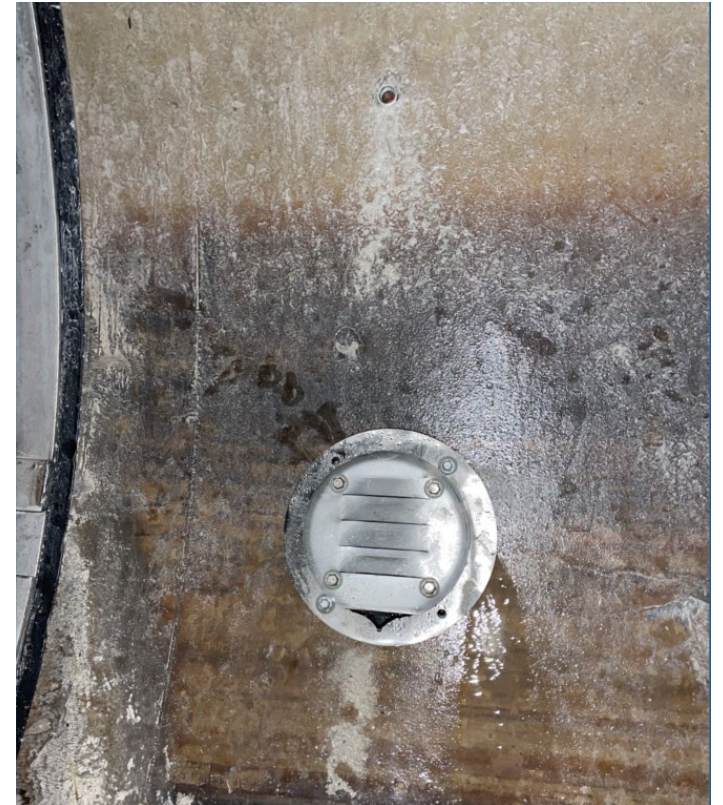


# M-79 OVER FOWLER DRAIN – JOINT REPAIRS

Core



Jet Filter Install





# M-79 OVER FOWLER DRAIN – JOINT REPAIRS





# THANK YOU

