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LIST OF ACRONYMS

AHP	Analytical Hierarchy Process
AOP	Aquatic Organism Passage
ASCE	American Society of Civil Engineers
CMP	Corrugated Metal Pipe
CRC	County Road Commission
CSS	Center for Shared Solutions
CTT	Center for Technology & Training
DEQ	Department of Environmental Quality
DNR	Department of Natural Resources
DTMB	Department of Technology, Management, and Budget
FAQ	Frequently Asked Questions
FHWA	Federal Highway Administration
GIS	Geographical Information System
GPS	Global Positioning System
GUID	Globally Unique Identification
LDC	Laptop Data Collector
MiBridge	Michigan Web-based Structure Management System
MDOT	Michigan Department of Transportation
MPO	Metropolitan Planning Organizations
NBI	National Bridge Inventory
NCHRP	National Cooperative Highway Research Program
NJDOT	New Jersey Department of Transportation
Ohio DOT	Ohio Department of Transportation
PA	Public Act
PPE	Personal Protective Equipment
RCKC	Road Commission for Kalamazoo County
RPO	Regional Planning Organizations
TAMC	Transportation Asset Management Council
TAMS	Transportation Asset Management System
UTC	University Transportation Center
WAMC	Water Asset Management Council
Wisconsin DOT	Wisconsin Department of Transportation

EXECUTIVE SUMMARY

In 2018, the Transportation Asset Management Council (TAMC) Bridge Committee was tasked with managing a work plan for a pilot project for the collection of data and the evaluation of culverts owned by local transportation agencies within Michigan. The work was funded through House Bill 4320 (S-3) - Supplemental Appropriation Adjustments, which added \$2 million to the fiscal year 2018 budget from the state restricted Michigan Infrastructure Fund.

Based on recommendations made in the 21st Century Infrastructure Commission Report, the TAMC decided to use the funding for a pilot project to assist local transportation agencies with the collection of culvert data on their local road network. All work was to be completed on the pilot project before the end of fiscal year 2018 (September 30, 2018) as a condition of the funding from the Legislature. Given the relatively short timeframe, and the scope and logistics of the pilot project, the TAMC reached out to the Center for Technology & Training (CTT) at Michigan Technological University to assist with managing and facilitating the project. The CTT and the TAMC have a long-standing working relationship that, combined with the working structure that the TAMC had already established with local transportation agencies through previous projects, allowed the CTT and the TAMC to quickly initiate, launch, and complete the culvert data collection pilot project within the required timeline.

Goals

The intent of the culvert data collection pilot was to collect data on Public Act 51 Certified Roads in Michigan at a statewide level for the following goals:

- 1) Estimate the total number of culverts in the state.
- 2) Estimate the overall condition of culverts in the state using similar inspection components and rating.
- 3) Determine the range of physical characteristics (inventory information) of culverts, such as material, size, and depth, that may impact the cost to maintain or replace the asset.
- 4) Benchmark estimates of agency labor (time and materials) necessary to find and collect inventory data for culverts on a dollar per mile or other production rate basis.
- 5) Benchmark estimates of agency labor (time and materials) necessary to find and collect condition data for culverts on a dollar per mile or other production rate basis.

Project Planning

All local transportation agencies in the state were invited to participate in the *Michigan Local Agency Culvert Inventory Survey* offered between March 5-16, 2018. The goal of the survey was to assist the TAMC Bridge Committee with the completion of the project work plan, the selection of participating agencies, and the identification of appropriate culvert data to collect. All agencies that responded to the survey were eligible to participate in the culvert pilot. Based

on the survey responses, agencies that were willing to participate in the pilot were divided into tiers according to their existing level of culvert inventory and “rounds” based on their tier and geographical proximity to other responding agencies.

Given the fixed budget, the unknown number of culverts that agencies would be collecting data on, and an unknown number of participating agencies, the TAMC Bridge Committee discussed several funding options and scenarios to distribute the funding equitably. It was determined that all participating agencies were to receive a fixed mobilization reimbursement for training, purchasing of equipment to be used on the pilot, and for other pilot-related activities. County road agencies received \$10,000, and city/village road agencies received \$5,000. In addition, all local agencies were to receive \$30/per-centerline-mile where they drove to collect culvert data, not to exceed the agency’s Public Act 51 certified total centerline-miles.

It was determined that local transportation agencies would collect data on culverts ranging from 1 to <20 foot span, as culverts that span 20 feet and larger should already be included in local agencies’ bridge inventory. The TAMC Bridge Committee established a list of culvert attributes to be collected as part of the pilot, as well as six condition evaluation criteria.

Training

The CTT hosted an informational webinar on April 19, 2018 to outline the pilot project and solicit questions and feedback from potential participating agencies. The CTT then hosted training webinars on April 25 and 26, 2018 to go over culvert inventory data collection using the Roadsoft Laptop Data Collector (LDC), and culvert condition evaluation, respectively. Roadsoft is a roadway asset management system for collecting, storing, and analyzing data associated with transportation infrastructure. The Michigan Department of Transportation (MDOT) provides Roadsoft to local agencies at no cost as part of the statewide roadway asset management initiative spearheaded and supported by MDOT.

The CTT hosted a webinar on July 24, 2018 to instruct participating agencies on how to submit their culvert data.

Data Collection and Results

CTT staff visited nine agencies to observe their culvert data collection processes. Generally, all of the agencies visited had similar processes for data collection that varied slightly based on the tools they used.

The CTT worked closely with the Michigan Department of Technology, Management and Budget (DTMB) Center for Shared Solutions (CSS) to build additional Roadsoft functionality to enable users to upload the data directly to CSS. They also worked together to allow the five agencies not using Roadsoft to submit data.

Once the data was submitted, the CTT compiled and processed the information to provide answers for the five key objectives of the culvert pilot project.

1. Estimate the total number of culverts in the state.

After compiling the submitted culvert data and the data from the daily collection logs, the CTT calculated the estimated number of statewide local agency culverts to be between 178,939 and 213,649. The range is due to estimates or calculations using six different data subdivisions. The average of this range is 196,294 statewide local agency culverts. A breakdown of the six methods used to calculate the averages is shown in Table 1.

Table 1: Summary of statewide culvert estimation methods

Method Number	Density Factor Source	Road Network Subdivisions	Regionality	County Culverts	City Culverts	Statewide Culverts	Difference From Highest
1	Average of Collection Area	Single Network	Aggregate of Counties	164,893	19,590	184,483	86%
2	Average of Collection Area	Fed aid / NFA split	Aggregate of Counties	166,466	22,682	189,148	89%
3	Average of Collection Area	Single Network	County by region	159,349	19,590	178,939	84%
4	Average of Collection Area	Fed aid / NFA split	County by region	161,252	22,682	183,934	86%
5	Daily Logs	Single Network	Aggregate of Counties	190,839	22,810	213,649	100%
6	Daily Logs	Single Network	County by region	182,207	22,810	205,017	96%

2. Estimate the overall condition of culverts in the state using similar inspection components and rating.

Based on the submitted data, overall condition assessments indicate that the majority of the culverts inspected were in fair to good condition with 27.0% of the rated culverts holding condition ratings of 8 (good) or better, and 67.2% of the rated culverts holding conditions ratings of 6 (fair) or better. The condition rating scale for this pilot project ranged from 1 (failed) to 10 (new). Of the inventoried culverts, 69.2% included a condition rating. Of the culverts inventoried during the pilot, 78.0% had ratings collected in 2018, and 92.0% were rated in the last five years. The overall culvert condition ratings are represented in Figure 1.

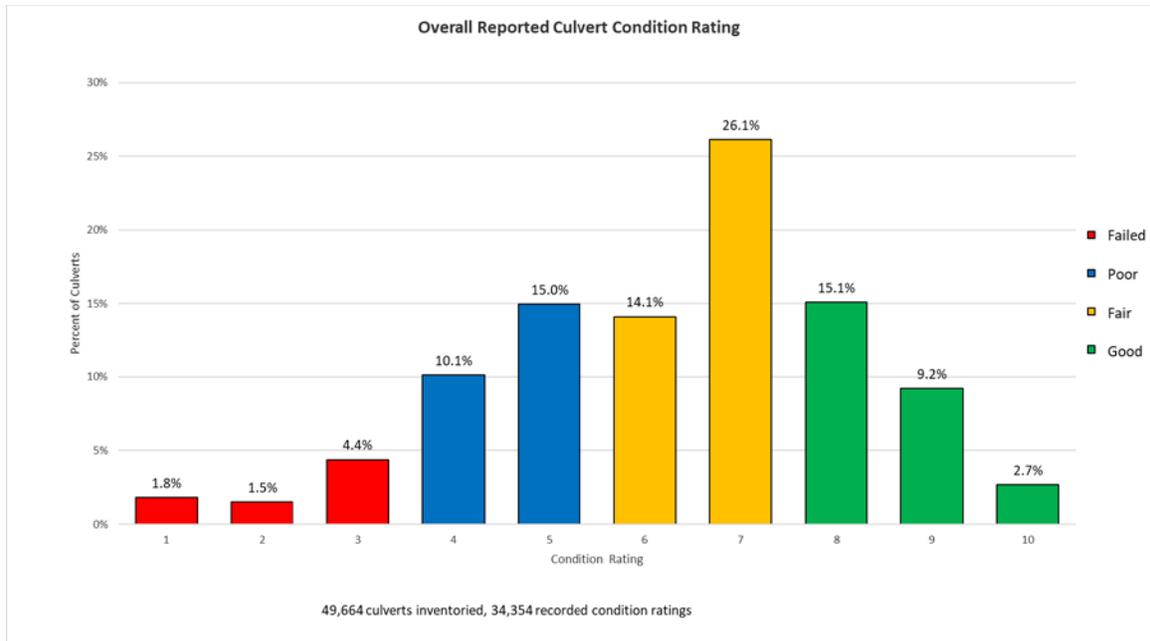


Figure 1: Overall culvert condition rating

3. Determine the range of physical characteristics (inventory information) of culverts, such as material, size, and depth, that may impact the cost to maintain or replace the asset.

Of the inventoried culverts, 69% were corrugated steel pipe, 21% were concrete, and 5% were plastic. The vast majority of reported culverts—88.8%—were circular. Of the reported circular culverts, 90% were 48 inches or less in span, 36% have 24 inches or less of cover, and 49% have between 25-72 inches of cover. The most frequent road surface type was asphalt pavement at 66%, followed by gravel at 28%. The road surface type provides important information that can be used for the estimation of replacement costs, since restoration is a significant expense.

The total volume of culverts on the locally-owned road system represent a significant asset. Local agencies own an estimated 7.3 to 9.2 million feet (1,389 to 1,756 miles) of culvert. As a basis for comparison, this is enough culvert pipe to build a single straight culvert from Houghton, Michigan to Miami, Florida. This is represented in Figure 2. It is estimated that the total replacement value of locally-owned culverts in Michigan exceeds \$1.48 billion.

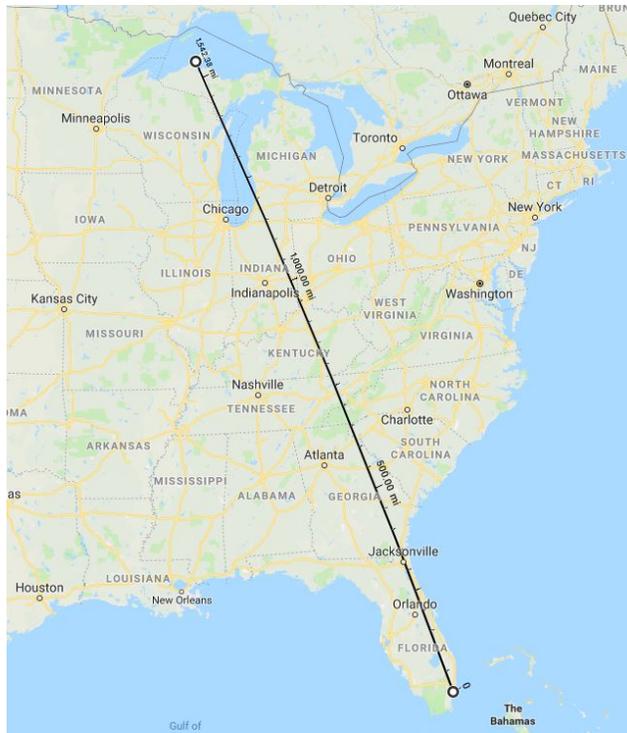


Figure 2: It is estimated that Michigan local transportation agencies own enough culvert pipe to build a single straight culvert from Houghton, Michigan to Miami, Florida

4. Benchmark estimates of agency labor (time and materials) necessary to find and collect inventory data for culverts on a dollar per mile or other production rate basis.

Estimating the expected costs to find and collect inventory data for culverts is difficult due to variables such as labor rates, culvert density, and culvert cover. Based on assumed crew size; pay; and benefit and overhead rates; the average culvert data collection labor cost is estimated to be \$39.02 per mile for county road agencies and \$69.17 per mile for cities and villages. These production rates are provided in Table 7-7 for use in estimating agency specific costs.

5. Benchmark estimates of agency labor (time and materials) necessary to find and collect condition data for culverts on a dollar-per-mile or other production rate basis.

The daily data collection logs did not contain a large enough data set to directly determine the time needed to collect condition rating information on known culverts. However, the daily logs show the average time per culvert to collect inventory data only was approximately 8 minutes faster than collecting inventory and condition rating data. This difference in average collection rate is likely the result of the added task of performing the condition rating activity.

Conclusions

This pilot project revealed that the tools, business processes, and relationship building that the TAMC initiated for the collection of Pavement Surface Evaluation and Rating (PASER) road

condition data has created a strong framework for the rapid collection of other asset data on the local agency road system. This is apparent from the significant capabilities that pilot participants demonstrated with their ability to collect a large volume of high-quality asset inventory and condition data on nearly 50,000 culverts in approximately three months. This number constitutes about 24% of the approximately 196,000 total local agency culverts in the state.

The pilot project also identified that a significant level of effort is required to inventory and rate local agency-owned culverts. It will take an estimated \$10 million and over 131,000 collection team hours to complete the initial data collection of local agency culverts. Annual training expenses are estimated at \$250,000 - \$500,000 for development, provision, and participation in the training.

As part of an ongoing five-year condition evaluation cycle, the estimated annual cost will be approximately \$2.1 to \$2.25 million (in today's dollars) for continued training and data collection of culvert inventory and condition evaluation moving forward. This assumes 1/5 of all culverts will be inspected each year as part of a five-year repeating cycle where every culvert is inspected once every five years. Therefore, the five-year costs associated with training and data collection for a culvert inventory and condition evaluation program are estimated at \$10.5 to \$11.25 million. These estimates do not include costs associated with development and implementation of asset management programs for culverts. There will be additional unknown expenses for training, equipment, and data handling.

All participants were invited to participate in a follow-up survey. Many respondents indicated their intent to use the data gathered to advance their culvert asset management programs. Many also indicated they plan to use the condition evaluations to either add to, or create, a maintenance plan for addressing culverts in need of replacement. Of special note was that many indicated that they intend to continue to collect inventory and condition data on the culverts in their network even though the culvert pilot project is over. Aside from the value of the data that was collected and the conclusions that can be drawn from it, having practical, actionable outcomes that participants intend to continue using should not be overlooked.

1. BACKGROUND

The TAMC was appointed by the State Transportation Commission on September 26, 2002 as required in Public Act (PA) 499. Their mission as defined by this act is to report the condition of the Michigan public road network to the Michigan Legislature [1]. The TAMC's mission is taken directly from PA 499 and states:

“In order to provide a coordinated, unified effort by the various roadway agencies within the state, the transportation asset management council is hereby created within the state transportation commission and is charged with advising the commission on a statewide asset management strategy and the processes and necessary tools needed to implement such a strategy beginning with the federal-aid eligible highway system, and once completed, continuing on with the county road and municipal systems, in a cost-effective and efficient manner.”

To this end, TAMC has successfully adopted an existing condition assessment system—Pavement and Surface Evaluation Rating, or PASER—for the paved road network in Michigan. The TAMC has successfully set up the data systems; funding mechanisms; collection and data handling methods; and data collection infrastructure to collect pavement condition data on the entire paved federal-aid system (approximately 39,000 centerline miles) in Michigan. In 2017, the TAMC expanded to provide for a system of condition assessment on unpaved roads.

The TAMC Bridge Committee was tasked with managing a work plan for the collection of data and the evaluation of culverts located within Michigan. The FY 2018 budget provided for \$2,000,000 from the state restricted Michigan Infrastructure Fund to inspect and inventory culverts on the local road system. *House Bill 4320 (S-3) - Supplemental Appropriation Adjustments*, which spells out the appropriation, can be viewed at:

<http://www.legislature.mi.gov/documents/2017-2018/billanalysis/House/pdf/2017-HLA-4320-361480C1.pdf>

This project is related to a recommendation made by the 21st Century Infrastructure Commission in their *21st Century Infrastructure Report* that was published in November, 2016. More information about the 21st Century Infrastructure Commission can be found at:

https://www.michigan.gov/snyder/0,4668,7-277-61409_78737---,00.html

The transportation recommendations, including recommendations related to culverts made in the *21st Century Infrastructure Report*, can be found at:

https://www.michigan.gov/documents/snyder/Ch_6_-_Transportation_Recommendations_551285_7.pdf

The TAMC intended for the majority of this funding to pass down to cities, villages, and county road commissions (local agencies) to collect their data via a reimbursement, based on mobilization and centerline miles travelled. All work was to be complete on this pilot before the

end of FY18 (September 30, 2018) as a condition of the funding from the Michigan Legislature. A schedule for this pilot was created to fit this deadline and is shown in Table 1-1.

Table 1-1: Schedule of pilot activities

Task	Feb		Mar		Apr			May			Jun			Jul			Aug			Sep												
	19	26	5	12	19	26	2	9	16	23	30	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	3	10	17	24
	Contract and Funds Disbursement																															
Task 1	Literature Review of Best Practices																															
Task 2	Local Agency Survey - Data Availability and Extent																															
Task 3	Selection of Data Collection and Storage Methods																															
Task 4	Develop and Conduct Pilot Training																															
Task 5	Selection of Participating Agencies																															
Task 6	Pilot Data Collection																															
Task 7	Pilot Centralized Data Storage Solution																															
Task 8	Evaluation of Pilot																															
Task 9	State-wide Collection Cost Estimate																															
Task 10	Final Report																															

Culverts, for the purposes of this pilot, are defined as linear drainage conduits underneath a public roadway that are not considered “bridges” by the Federal Highway Administration (FHWA). In general, the FHWA considers a “bridge” as having a combined span of more than twenty feet, which would include listing on the National Bridge Inventory (NBI). Culverts are differentiated from storm sewers in that they are straight-line conduits that are open at each end, and do not include intermediate drainage structures (manholes, catch basins etc.). Only culverts found within PA 51 Certified Roads are eligible for collection as part of this data collection effort; culverts found beneath private driveways or commercial drives are not eligible for inclusion or reimbursement.

The goal is to ensure the TAMC has a strategy that can be used across the state to further streamline and standardize the collection of culvert data and to develop best practices for the asset management of culverts in the state. Obtaining local culvert inventory and condition evaluation data in a representative group of local agencies will help determine the level of effort and cost to advance a similar effort statewide in the coming years.

2. INTRODUCTION

Asset management is crucial to planning and executing maintenance operations and replacing roadway assets in the most efficient and cost-effective manner. In order to effectively draw conclusions and make decisions, a complete inventory with regular condition evaluations is crucial to asset management. Agencies have created effective, standardized inventory and condition assessment programs for bridges and road surfaces for the purpose of asset management, but culvert inventory and condition assessment programs are often not executed with the same sophistication, or they are not established at all.

The need for culvert asset management is clear; there have been numerous documented culvert collapses in recent years that have led to damage and injuries, costing agencies significant money in emergency repairs and public safety concerns. In the early morning of June 17, 2018, Houghton County experienced an extreme rainfall (1000-year event) causing widespread damage in which many culverts failed, resulting in damage to surrounding areas, as depicted in Figure 2-1 and Figure 2-2. These culverts failed due to an extreme event that could not have been prevented through sound asset management, but they are representative of the roadway damage that can occur from culvert failures.



Figure 2-1: Culvert failure in Houghton, Michigan leading to roadway damage



Figure 2-2: Houghton county culvert failure in Ripley, Michigan

Culvert inventory and condition assessment programs assist in mitigating culvert problems before their condition becomes critical and allows culvert work to be coordinated with road work: saving money and maintaining public safety. Many of Michigan’s local agencies do not have an established culvert inventory and condition assessment program. Of the local agencies that do have a program, there is little consistency between local agencies in how the programs operate, and many inventories are incomplete. The TAMC Local Agency Culvert Pilot seeks to provide standardization between local agencies by providing guidance on the inventory and condition evaluation of culverts.

This document serves as the final report for the TAMC pilot program implementing the inventory and condition evaluation of culvert assets owned by Michigan’s local agencies. The intent of the pilot was to collect data to be used in generating the following information on PA 51 Certified Roads in Michigan at a statewide level:

- 1) Estimate the total number of culverts in the state.
- 2) Estimate the overall condition of culverts in the state using similar inspection components and rating.
- 3) Determine the range of physical characteristics (inventory information) of culverts, such as material, size, and depth, that may impact the cost to maintain or replace the asset.
- 4) Benchmark estimates of agency labor (time and materials) necessary to find and collect inventory data for culverts on a dollar per mile or other production rate basis.
- 5) Benchmark estimates of agency labor (time and materials) necessary to find and collect condition data for culverts on a dollar per mile or other production rate basis.