# MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 23-501 (project 692) | July 2023

## A Risk-based Framework for Optimizing Inspection Planning of Utah Culverts

## the ISSUE

The Utah Department of Transportation intends to classify culverts as tier 1 assets because of the high number of culverts, the potential disruptions to roadways, and property damage that could result from poorly maintained culverts. Despite having more than 47,000 culverts, UDOT's current inventory only has complete information for 272 culverts. Consequently, UDOT needs to develop a comprehensive culvert management system (CMS) to maintain them systematically.

## the RESEARCH

Researchers developed a robust framework to enhance culvert inspection planning in Utah as the first step in developing the CMS. The objective of this study is to assist UDOT in establishing a comprehensive CMS by creating a Utah culvert management manual. To achieve this, the researchers identified the culvert deterioration curves based on historical data from Utah, Colorado, and Vermont. These curves are then employed by a risk-based framework for life cycle analysis to estimate the frequency of culvert inspections and service life. The proposed method for determining culvert deterioration curves and enhancing inspection planning involves using machine learning algorithms, including support vector regression (SVR) and random forest regression (RFR), as well as a risk assessment approach. The culvert life cycle was analyzed for risk assessment to consider associated risks during the culvert life cycle and estimate future risks. The developed solution is intended to be integrated into the Atom software, which is used to manage assets and maintenance for UDOT.

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## Project Title

A Risk-based Framework for Optimizing Inspection Planning of Utah Culverts

## Sponsors | Partners

Utah DOT, Division of Maintenance

USDOT, Research and Innovative Technology Administration

## the FINDINGS

The final deterioration curves were formulated using SVR and RFR algorithms, utilizing culvert inventories from Colorado, Utah, and Vermont. Given the theoretical understanding and the data limitations, the curve forms appeared reasonable. Despite the limited data, the models developed for the Colorado, Vermont, and Utah datasets achieved between 60% and 80% accuracy, which is deemed acceptable. The model developed using the consolidated dataset also performed well, with 71% accuracy for the SVR model and 79% for the RFR model. All associated risks were considered and estimated during the life cycle analysis to better prepare for future risks.

## the IMPACT

The expectation is that using this manual will enable UDOT to enhance its culvert network's functioning while reducing maintenance costs. By adopting this method, UDOT may be able to save both money and time, compared with traditional approaches. According to the case study results, UDOT should focus on only 10% of its inventory rather than spending a substantial amount of money inspecting all culverts regularly. Another potential use for Utah's final culvert deterioration curve is proactive maintenance, which can significantly improve the culvert network system's performance and reduce potential disruptions. Moreover, it could prevent significant harm to Utah's transportation infrastructure and safeguard its users' lives.

Researchers also drafted a Culvert/Storm Drain Management System Manual for Utah. The manual was developed after reviewing multiple culvert maintenance and inspection manuals issued by the federal government and other state DOTs. The manual was designed specifically for Utah's culverts and utilized UDOT's inspection rating system. It also amalgamates content from several manuals tailored for Utah's culverts and focuses on key aspects such as culvert inspections, data inventory, and maintenance.

For more information on this project, download the Main report at https://www.ugpti.org/resources/reports/details.php?id=1129


For more information or additional copies, visit the Web site at www.mountain-plains.org, call (701) 231-7767 or write to Mountain-Plains Consortium, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.