



TECHNICAL SUMMARY

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LRRB PROJECT COST:

\$60,678



Steel pipes are commonly used for entrance and side culverts in Minnesota, but corrosion can be a problem.



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Mapping the Service Lives of Steel Culverts in Minnesota

What Was the Need?

To allow water to flow beneath roads and other structures, engineers use culverts, typically constructed of concrete, steel or plastic. Steel culverts, commonly used in Minnesota for entrances and side culverts, corrode over time and their service lives depend on the properties of the soil in which they are placed. Two important soil properties affecting steel culvert longevity are pH (a measure of the soil's acidity and corrosiveness) and resistivity (a measure of how much the soil resists the flow of electricity, which is usually related to the cohesiveness of the soil, but also to moisture and temperature).

Because these and other soil properties vary significantly across Minnesota, engineers must select the appropriate type of steel pipe material for the expected environmental conditions. Steel pipe differs in gage, or wall thickness, and in the coatings used to reduce corrosion, which are either aluminum, zinc or polymeric coated. While aluminum coating provides superior corrosion protection compared to the zinc coating of galvanized pipes, it is also more expensive, but may still be the most cost-effective choice.

To choose the most cost-effective type of pipe that still meets the desired service life for a given project, engineers may use the [California Method](#), commonly employed across the United States to estimate the expected service lives of steel pipes based on the pH and resistivity of the soil in which they will be placed. However, this method sometimes requires that engineers take field measurements of soil pH and resistivity, which can be impractically expensive or time-consuming. This often leads to use of a default minimum thickness for culvert steel pipes, which may result in premature deterioration. Research was needed to make soil pH and resistivity data available for locations throughout Minnesota.

What Was Our Goal?

The goal of this project was to determine soil resistivity and pH properties throughout Minnesota and use this data to create service-life maps for galvanized and aluminized steel pipes of various gages.

What Did We Do?

During the summer of 2014, researchers tested more than 560 soil samples for resistivity and pH—50 to 90 per MnDOT district—along embankments of state trunk and county highways, excluding multilane major highways because of their lower frequency of steel culverts. They also made concurrent observations of soil texture, surrounding landscape, roadway type and water presence. Where water was present, researchers measured its pH and conductivity, and used conductivity to calculate the water's resistivity.

Researchers used this data to validate existing soil data sets as well as observations from district and county engineers. With a few exceptions, field-measured soil pH data was highly consistent with that from the Natural Resources Conservation Service's [STATSGO database](#). Because this database includes more measurements than those taken by researchers, they decided to use this data to develop maps with a greater resolution than otherwise possible. They also used STATSGO soil texture data to estimate soil resistivity

The steel pipe service-life maps developed in this project will help MnDOT and local engineers make more cost-effective decisions about the particular steel pipe materials chosen for culverts in different parts of the state.

“This project was eye-opening, showing that you can double the service lives of steel culverts just by changing the coating of the pipe at little extra expense.”

—Andrea Hendrickson,
State Hydraulic Engineer,
MnDOT Office of Bridges
and Structures

“The maps generated by this project will provide a good reference for county engineers as they try to determine what type of steel pipe to put in the ground, making their decisions about gage and coating much easier.”

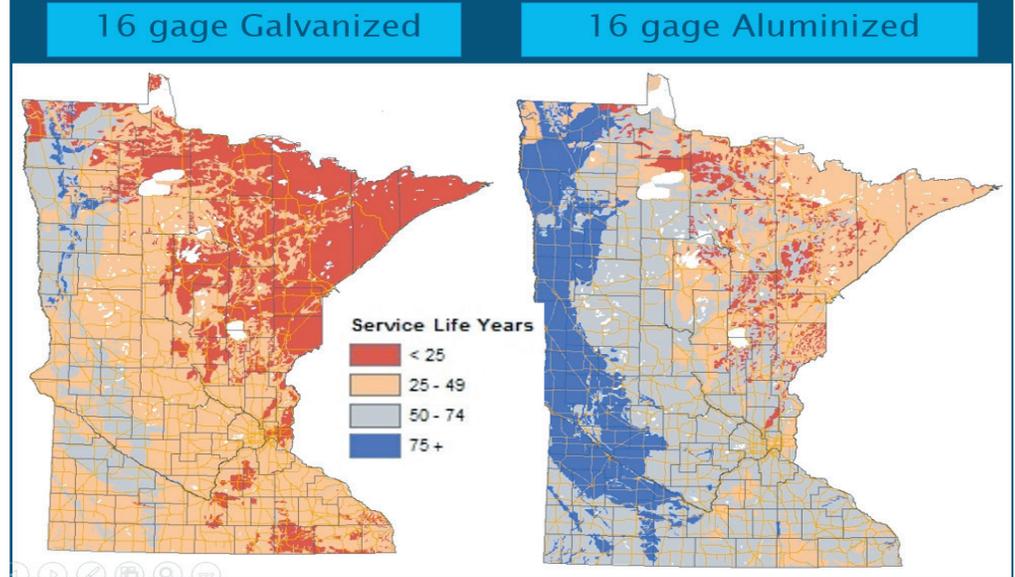
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Service Life Comparison



Service-life comparisons for galvanized and aluminized pipes show that while 24-inch aluminized pipes cost 17 percent more, in most of Minnesota their use doubles the service lives of culverts (assuming they are dry with little to no abrasion potential).

values because they found resistivity field measurements to be unreliable and consistently higher than anticipated.

What Did We Learn?

Overall, researchers found no significant relationship between land use and soil pH or resistivity. Soils were more acidic within 10 miles of wetlands and lakes.

Researchers used pH and resistivity data sets to calculate and develop maps of the service lives for 18-, 16-, 14-, 12-, 10- and 8-gage galvanized and aluminized steel pipe in locations across Minnesota. They also created a pipe selection table that allows engineers to quickly determine the expected (90th percentile) service lives for various gages and types of steel pipes, depending on the geographic zone in which they will be used. It is important to note that these estimates do not take into account factors that can significantly decrease the service lives of steel pipe culverts, including proximity to wetlands, volume of water flowing through the pipes, abrasion caused by sediment in flowing water, and the effects of soil moisture and deicing chemicals. Engineering judgment is still needed to determine if the equations are applicable and that any risk of premature failure is acceptable.

What's Next?

MnDOT will use the results of this project to update Chapter 2 of the [MnDOT Drainage Manual](#) and is currently sharing steel pipe service-life maps with MnDOT and county maintenance personnel. It has also funded further research into the use of video cameras for culvert inspection. The maps developed in this project will help engineers improve their choice of materials when designing steel culverts so that agencies can save on costs while developing longer lasting infrastructure.

This Technical Summary pertains to the LRRB-produced Report 2015-31, “Minnesota Steel Culvert Pipe Service-Life Map,” published June 2015. The full report can be accessed at mndot.gov/research/TS/2015/201531.pdf.