ctre
Center for Transportation Research and Education

A Riverine Infrastructure Database (RIDB) for Rapid Assessment of Asset Vulnerability and Incorporating Resiliency into Agency Practices

tech transfer summary

The Riverine Infrastructure Database (RIDB) is an innovative and proactive approach to the rapid assessment of riverine locations when roadway overtopping or bridge inundation could occur.

Objectives

- Create a relational database of the Riverine Infrastructure Database (RIDB) in an enterprise geographical information system (GIS) for the rapid assessment of infrastructure
- Enable rapid assessment through the integration of flow data from the Iowa Flood Center (IFC) Hillslope Link Model (HLM)
- Provide field data collection capabilities to allow Iowa Department of Transportation (DOT) staff to collect photos and data during flooding events such as high-water marks

Background

The Iowa DOT owns approximately 2,100 bridges over streams and rivers on the primary highway system. Many of these highway bridge and roadway sites are vulnerable to flood damage and overtopping during flood events.

During flood events, it can be difficult to find relevant hydrologic and hydraulic information for assessing the vulnerability of infrastructure. In many cases, information is not available or can be very time-consuming to obtain and evaluate.

Without good information regarding the hydraulic relationship between infrastructure and flood discharges, it is difficult to be proactive regarding the protection of lives, property, and infrastructure. Too often DOTs and other infrastructure owners are reactive instead of proactive regarding flood events, resulting in unnecessary damage and risks to public safety.

Problem Statement

Starting around 2008 after extensive flooding on the Cedar River, the Iowa DOT initiated the RIDB to begin the collection of data to support the rapid assessment of infrastructure during flooding events. These data needed to be organized in a relational database within a GIS environment to be enable the assessment of infrastructure vulnerable to flood damage.

June 2024

RESEARCH PROJECT TITLE
A Riverine Infrastructure Database (RIDB) for Rapid Assessment of Asset Vulnerability and Incorporating Resiliency into Agency Practices

SPONSORS
Iowa Statewide Transportation Innovation Council
Iowa Department of Transportation (InTrans Project 20-742)
Federal Highway Administration

PRINCIPAL INVESTIGATOR
Skylar Knickerbocker, Research Engineer
Center for Transportation Research and Education, Iowa State University
sknick@iastate.edu / 515-294-7916
(orcid.org/0000-0002-0202-5872)

CO-PRINCIPAL INVESTIGATORS
Neal Hawkins, Associate Director
(orcid.org/0000-0003-0618-6275)
Zach Hans, Research Engineer
(orcid.org/0000-0003-0649-9124)
Center for Transportation Research and Education, Iowa State University

MORE INFORMATION
intrans.iastate.edu

CTRE
Iowa State University
2711 S. Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-8103

The mission of the Center for Transportation Research and Education (CTRE) at Iowa State University is to conduct basic and applied transportation research to help our partners improve safety, facilitate traffic operations, and enhance the management of infrastructure assets.

IOWA STATE UNIVERSITY
Institute for Transportation

21-SPR0-004

Research Description or Research Methodology

The initial development of the relational database under this project involved extracting all data collected by the Iowa DOT to date. The Iowa DOT provided two sources of data: a spatial database and file database. Python scripts were developed to extract relevant data from the file database for over 270 sites, with the data for each site including a site summary, a feature summary, frequency curves, and one or more rating curves.

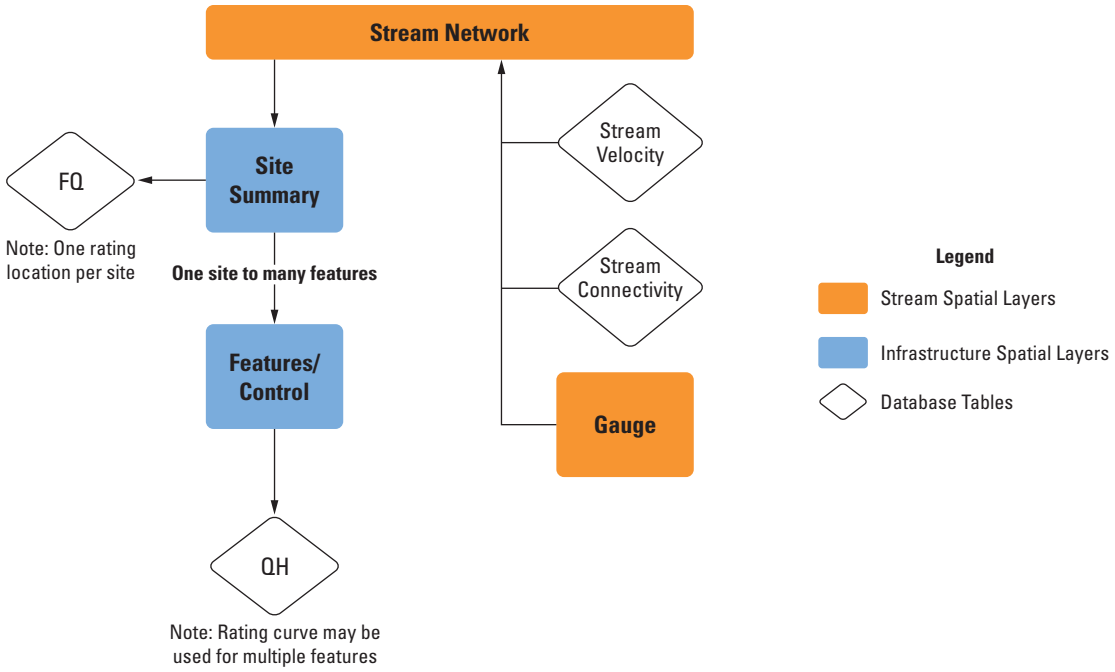
The extracted data were structured into a relational database and then populated into an enterprise GIS database. In the GIS environment, the RIDB is made up of six spatial layers and six tables that represent the stream network and infrastructure in Iowa. The layers and tables are interconnected to enable the identification of locations where flooding may have impacts across the stream network in Iowa and the corresponding infrastructure at each identified site.

Each infrastructure feature in the database has a corresponding frequency-discharge relationship (frequency curve) and a corresponding discharge-stage relationship (rating curve) that can allow for rapid assessment of potential roadway overtopping, bridge inundation, or other flood-related impacts.

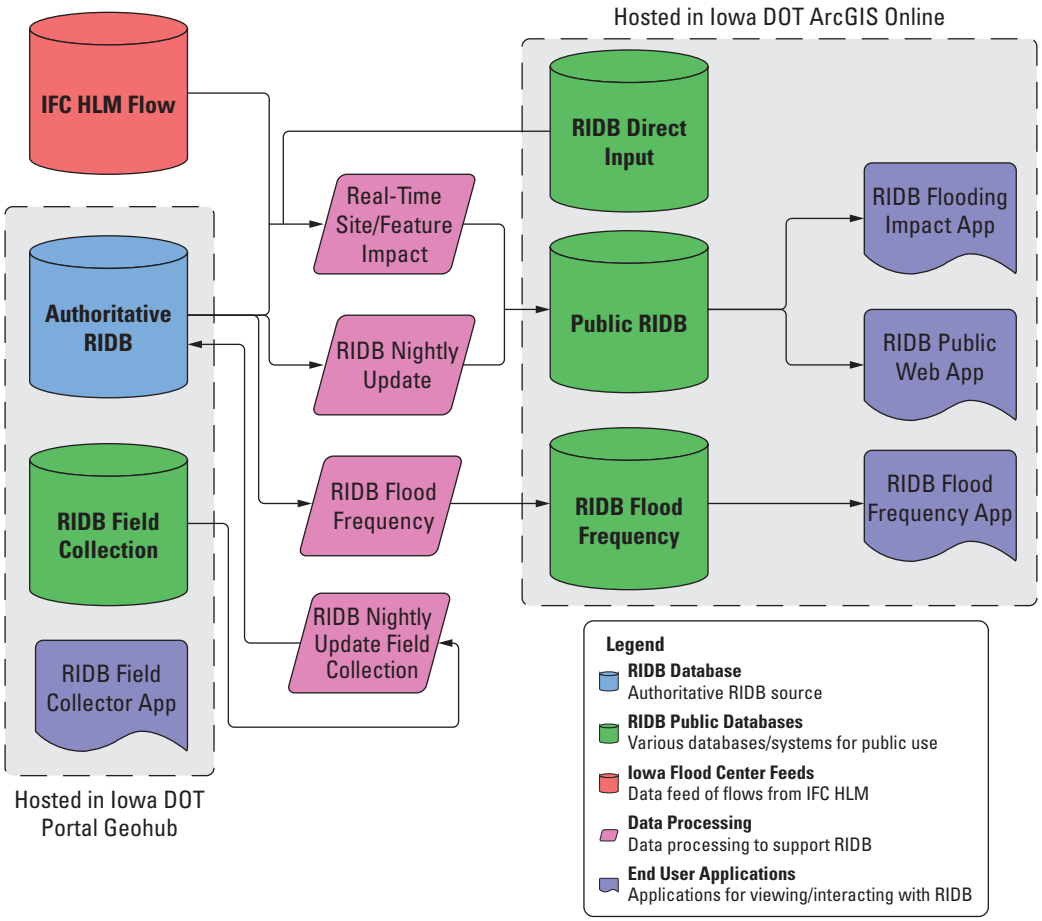
After development of the relational database, an architecture was developed for the RIDB system, including the services made available publicly and various processes developed to support the RIDB system. The various processes include nightly updates of the data, data archiving, data quality checks, updates to the flood frequency application, and hourly hydraulic analysis.

The core process developed was the capability to continuously monitor flooding impacts across the entire stream network. Using stream flows provided by the IFC's HLM, the system has the ability to utilize the rating curves for each infrastructure feature to quickly determine whether the predicted stream flows will result in features (infrastructure) or controls (e.g., dikes, levees) being overtopped or whether the flow will be over the critical discharge level that may result in scour. The system can also identify the expected start and end times of the impacts.

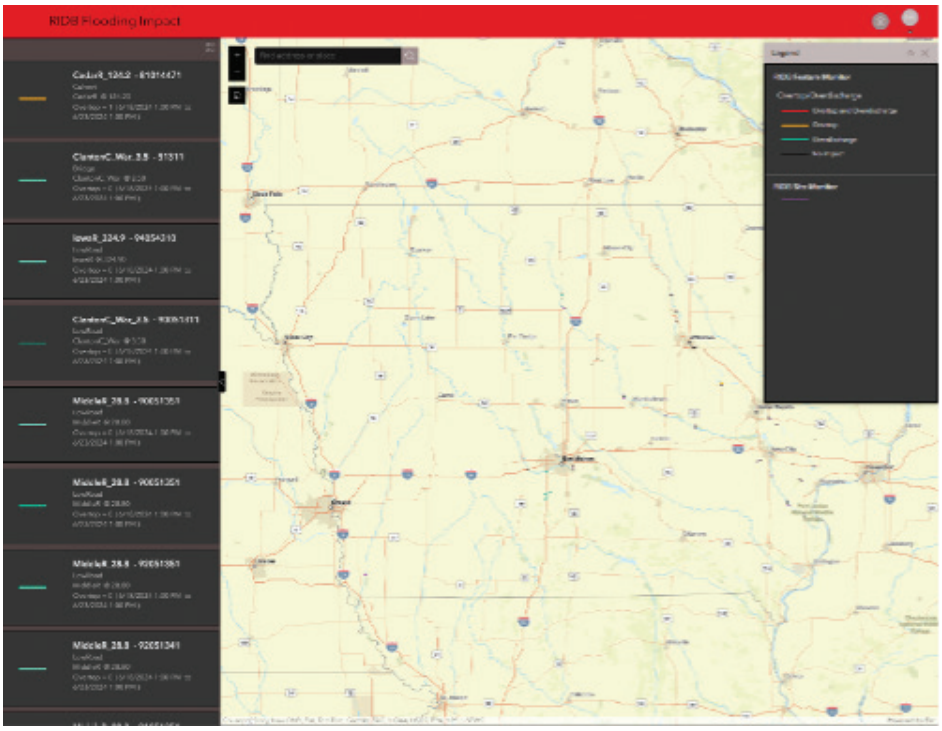
The data are published to a web map to quickly identify impacted features.



Overview of layer/table relationship in RIDB



Overview of systems architecture for RIDB



RIDB flooding impact application

Key Outcomes

The research project supported the development of a relational database of the RIDB for rapid assessment of flooding impacts on infrastructure features. The system demonstrates how maintaining a database of hydraulic and infrastructure data can support an agency's assessment of infrastructure vulnerability during high-stress flooding events.

The RIDB can also support scenario planning to allow the Iowa DOT to directly input stream flows or stage values to assess potential impacts across the network. The RIDB also supports additional resiliency analysis, as the flood frequency curves can be used to determine which types of flooding events will impact infrastructure.

Implementation Readiness and Benefits

The RIDB represents an innovative and proactive approach to assessing the vulnerability and risk of transportation projects and systems and can be utilized to provide rapid assessment of riverine locations when the potential for roadway overtopping or bridge inundation could occur.

The RIDB is operational and will continue to be maintained by the Iowa DOT. The overall goal of the Iowa DOT is to populate every site on the primary highway system in Iowa that has a drainage area of 10+ mi2 with accurate hydraulic and infrastructure information. The additional data incorporated into the RIDB will allow for the continual assessment of additional features across the state of Iowa.

The primary products from this research include the following:

- RIDB REST Service – Service providing the ability to integrate the RIDB into other systems
- RIDB Map –An interactive method of exploring hydraulic and infrastructure data in the RIDB
- RIDB Flooding Impact (Near Real-Time) – Map updated hourly that shows infrastructure impacts using stream flow data from the IFC HLM
- RIDB Flood Frequency – Map providing an interactive method of exploring how various flood frequencies impact the features across the network