THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

Technical Memorandum FY25RU2

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Flood Assessment System for TxDOT: Update on Research in FY25

Contents

Introduction

The Flood Assessment System for TxDOT (FAST) is a set of map layers which show flooding conditions on TxDOT roads and bridges. These layers were built with emergency response in mind, helping TxDOT to proactively plan for and respond to flood threats.

FAST forecasts flooding across 200,000 miles of streams and rivers in Texas to predict flood risk on 470,000 miles of public roads and 12,000 bridges. The forecasts come from the National Weather Service's Short-Range model, which looks 18 hours ahead and updates every hour.

To improve accuracy, FAST uses 80 radar flood gauges installed on TxDOT bridges. These gauges measure water level and flow velocity, and the data is used to adjust the model, so the predicted flows match what's happening on the ground. This correction process spreads through the stream network using a statistical method called data assimilation.

FAST is a research level system, meaning it needs more testing and fine-tuning before it can be used in real flood operations. A continuing research program supports its development and adds new improvements over time.

The report comprises three sections summarizing FAST:

1. **Online Data Layers** for flood information
2. **Flood Gauges** which provide flood measurement
3. **Research,** which details the research efforts undertaken to support the FAST project during FY25 (1 September 2024 to 31 August 2025.

In addition, this report summarizes the status of the FAST project as of August 2025. It builds upon three detailed technical reports submitted earlier this year:

- Report P2B: Flood Map Services[1]
- Report P3B: Flood Decision Support Gauge Network[2]
- Report P5B: Flood Data Services[3]

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1 https://www.caee.utexas.edu/prof/maidment/FAST/Documents/ReportP2BProject0_7095_01Amended.pdf

2 https://www.caee.utexas.edu/prof/maidment/FAST/Documents/ReportP3BProject0_7095_01Amended.pdf

3 https://www.caee.utexas.edu/prof/maidment/FAST/Documents/ReportP5BProject0_7095_01.pdf

FAST Layers

The FAST layers can be ingested and displayed via a web map to show flood conditions, as seen in Figure 1. This example highlights the Mustang Creek watershed near Taylor, Texas, with three layers showing the worst-case conditions expected over the next 18 hours:

- **Flood Inundation** – shows the maximum extent of flooding.
- **Bridge Warnings** – points indicating the highest expected water level at each bridge, grouped into categories based on how close the water is to the low chord.
- **Flooded Roads** – red lines highlighting roads expected to flood, categorized by roadway type.

The Bridge Warnings layer includes a link to a graphic that appears when you click on a bridge point. Figure 2 shows an example from a bridge in the Dallas District. The chart has a slider bar along the bottom that lets you see the forecasted water level over time. The colors indicate how close the water is to the low chord of the bridge:

- **Green** – more than 5 feet below
- **Yellow** – 2 to 5 feet below
- **Red** – 0.5 to 2 feet below
- **Purple** – less than 0.5 feet below
- **Black** – roadway overtopped

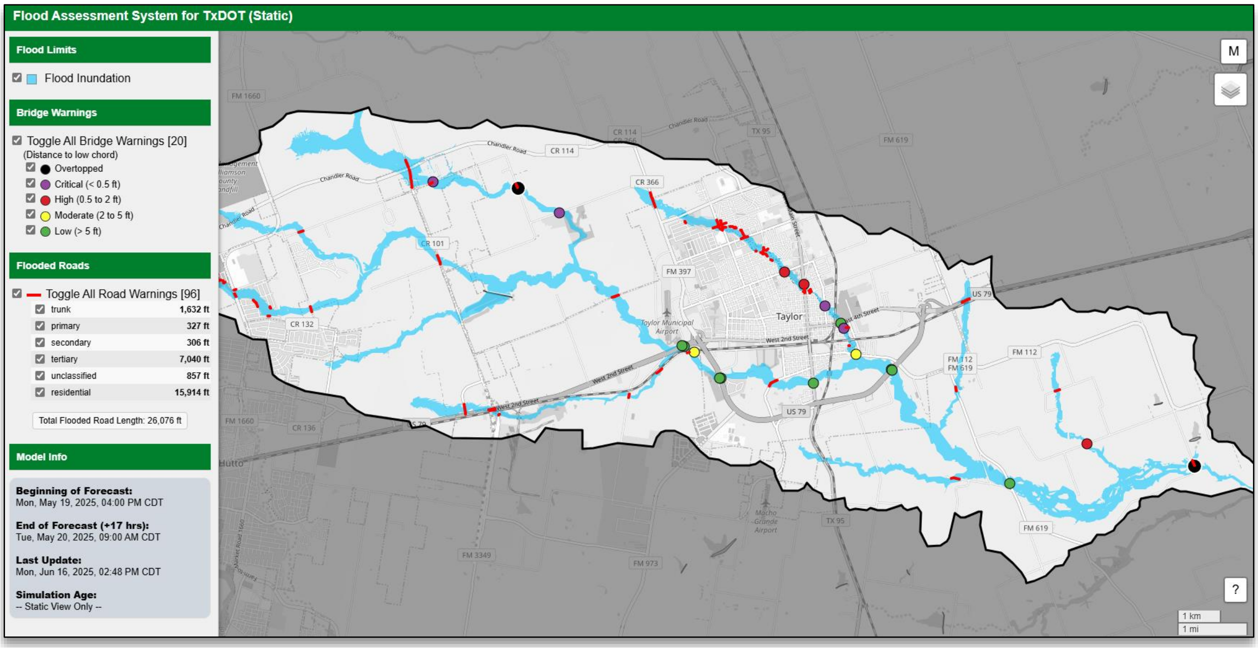


Figure 1. FAST map layers for flooded roads, bridges and inundation extent

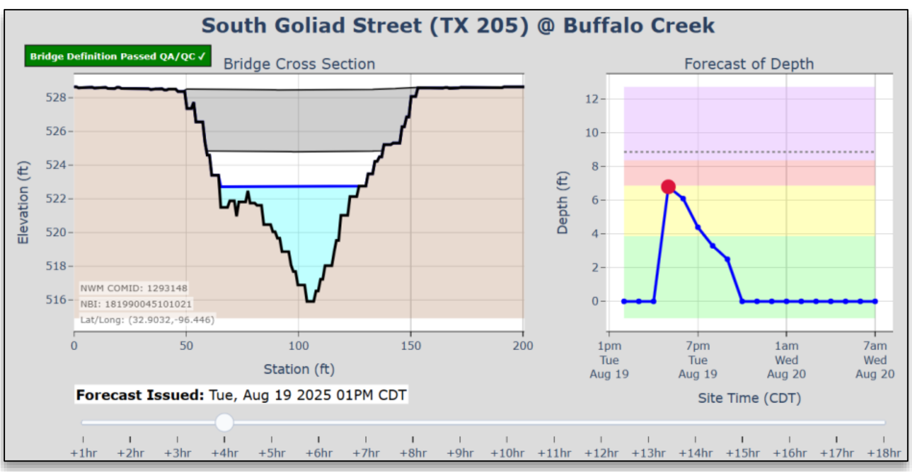


Figure 2. Bridge warning graphic

To access the FAST layers, there are two versions: District Level or State-Wide. The District level was our initial launch through which testing of access, performance, and status was conducted. The state-wide option was created after our initial testing was completed and the datasets were moved from our Amazon Web Services server to the KISTERS server.

The District and Statewide versions are available at https://bridges.txdot.kisters.cloud/fast_v4/ . The site (see Figure 3) shows the flood layers for each TxDOT District and gives a summary of how many bridge warnings and flooded road segments are expected in each District. It also shows the time of the most recent update, which is usually about 30 minutes after the latest forecast and observed data are received.

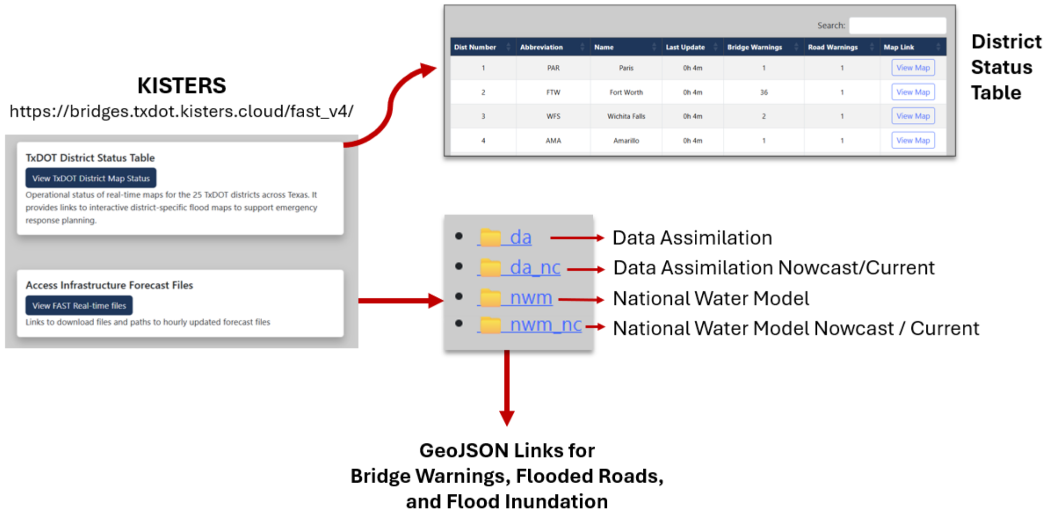


Figure 3. https://bridges.txdot.kisters.cloud/fast_v4/ landing page, with access points to district status, GeoJSON links, and production status.

The FAST State-Wide links, which can be viewed in ArcGIS Online or other applications, can be found using the links below:

State-Wide FAST Layers

NWM Statewide

- Bridge Warnings: https://knatempstorage.s3-us-west-1.amazonaws.com/fast_realtime/nwm/TXFull/bridge_warning_pnts.geojson
- Flooded Roads: https://knatempstorage.s3-us-west-1.amazonaws.com/fast_realtime/nwm/TXFull/flood_road_trim_ln.geojson
- Flood Inundation: https://knatempstorage.s3-us-west-1.amazonaws.com/fast_realtime/nwm/TXFull/flood_ar.geojson

Data Assimilation Statewide

- Bridge Warnings: https://knatempstorage.s3-us-west-1.amazonaws.com/fast_realtime/da/TXFull/bridge_warning_pnts.geojson
- Flooded Roads: https://knatempstorage.s3-us-west-1.amazonaws.com/fast_realtime/da/TXFull/flood_road_trim_ln.geojson
- Flood Inundation: https://knatempstorage.s3-us-west-1.amazonaws.com/fast_realtime/da/TXFull/flood_ar.geojson

State-Wide FAST Layers Status

- **S3 Status Dashboard**

Flood Gauges

The flood discharge forecasts contained in the FAST layers are validated against all available gauges, including 80 radar-based instruments mounted on TxDOT bridges (example in Figure 4). These gauges measure both surface water level and velocity using radar sensors, a data logger, and data transmission via cellular communications. Each unit is powered by a solar panel, has a compact footprint, and is designed for easy removal if bridge repairs or reconstruction are required. To verify elevations, USGS field staff also use traditional wire-weight gauges as a reference check.

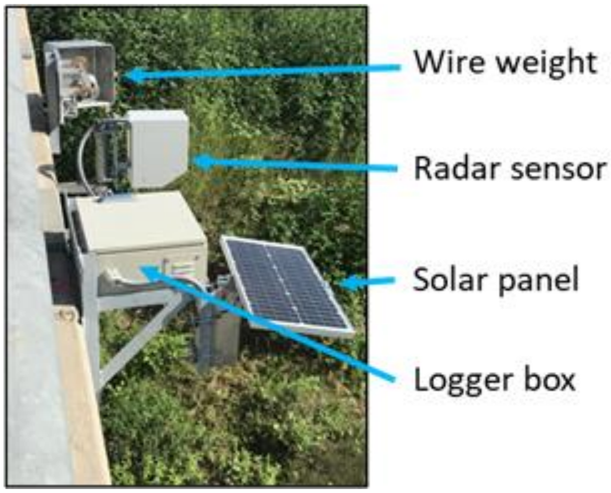
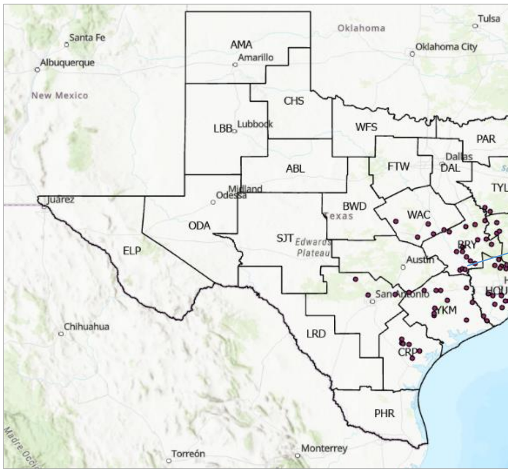
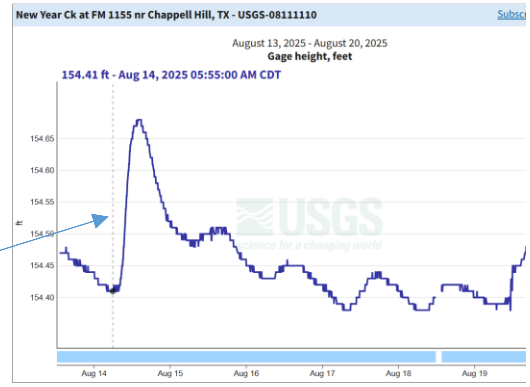


Figure 4. Picture of a standard Streamflow III gage installation on a TxDOT bridge.

USGS operates and maintains this radar gauge network and identified the 80 site locations to reduce data gaps and ensure appropriate sites for velocimetry were selected. As shown in Figure 5, the installations are distributed across inland and coastal basins where conventional gauging was relatively sparse. Their addition effectively doubles stream-gauge density in these areas relative to the traditional USGS network.





[New Year Ck at FM 1155 nr Chappell Hill, TX - USGS Water Data for the Nation]()

Figure 5. Locations of TxDOT radar gauges and water levels recorded at a gauge.

As shown in Figure 6a, each RQ-30 gauge measures water level (h) with a vertical radar beam and surface velocity (Vs) with an angled beam that applies Doppler shifts from water-surface ripples. Discharge is then computed by calibrating surface velocity against cross-sectional mean velocity obtained with Acoustic Doppler Current Profiler (ADCP) measurements (Figure 6b).

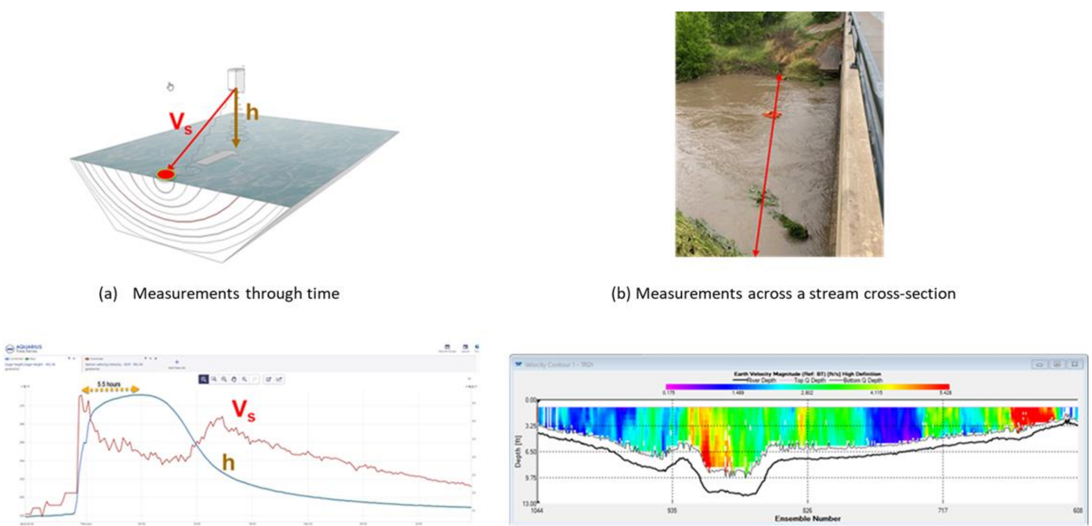


Figure 6. Measurements through time and at a stream cross-section.

Typically, two to three targeted ADCP field measurements at key stages have proved sufficient to provide a reliable calibration. Discharge calibration relies on the k-factor method, which relates radar-measured surface velocity to channel mean velocity. This relationship is sensitive to cross-sectional geometry and flow conditions (in-bank vs. out-of-bank). Over the past year, USGS field crews expanded calibration activities by collecting acoustic Doppler current profiler (ADCP) data at additional RQ-30 radar streamgage sites, particularly in basins with limited historical coverage. Since October 1, 2024, more than 150 site visits have been completed to perform essential tasks such as routine maintenance, level runs, troubleshooting equipment, and discharge measurements. On average, each RQ-30 site was visited twice during this period. In addition, 37 streamflow measurements were obtained at 25 Streamflow III sites. These efforts increased the number of calibration-quality sites to 34 (Figure 7), with discharge measurements strategically collected during moderate- and high-flow conditions to maximize hydrologic value and strengthen rating development.

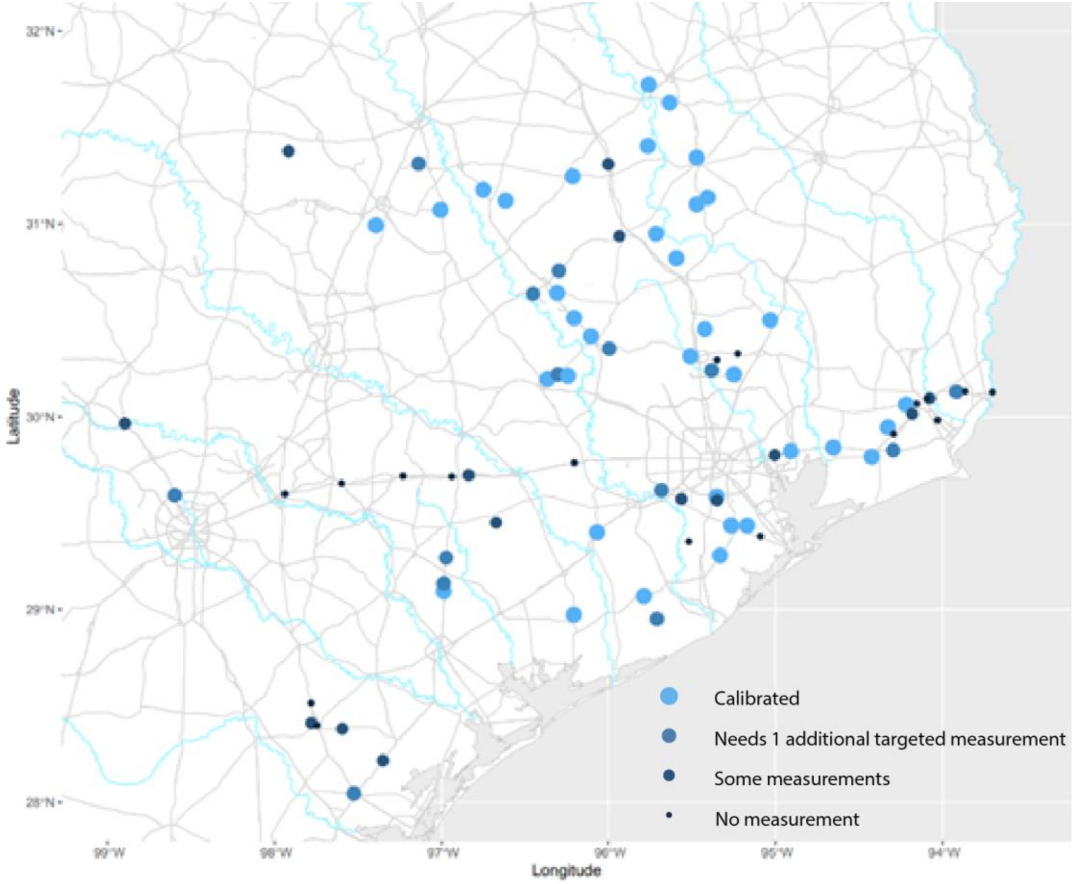


Figure 7. Map showing calibration status of the Streamflow III sites.

Over the past year, 77 of 80 radar streamflow gauges remained operational, with high-frequency stage and velocity data generally available in near real time. Although the system has proven durable, three gauges are currently offline: one permanently removed after repeated vandalism, one temporarily decommissioned due to bridge construction, and one inaccessible because of an equipment malfunction and site safety concerns. The remaining 77 units are operational and transmitting, though site-level interruptions and intermittent gaps may occur due to telemetry or local conditions typical of field deployments. Over the past year, USGS crews visited all gauges to inspect equipment, service power systems, clean solar panels, collect discharge measurements, and verify elevations, applying corrections as needed to ensure reliable referencing.

This effort represents the largest radar stream-gauge network in the United States, now encompassing 268 station-years of data—averaging 3.5 years per gauge. The dataset provides a strong basis to evaluate the feasibility of large-scale radar-based streamflow monitoring. While not universally applicable across all sites or flow conditions, several major advancements have been demonstrated, including improved discharge accuracy in backwater conditions, detection of channel changes such as scour, and insights into stage–velocity relationships.

On July 4, 2025, a flash flood occurred on the Guadalupe River where the nearest TxDOT radar gauge, located at Comfort, recorded the data shown in Figure 8. The time series reveals a distinct "velocity spike" that preceded the peak stage of the hydrograph. This behavior likely reflects the early arrival of the flood wave front, as velocity is more immediately responsive to hydraulic gradient and momentum transfer than stage. Although the precise stage–velocity relationships under extreme flow conditions require additional study, the observed signal underscores the potential utility of velocity as an early indicator of flood onset.

Early detection is especially critical for flash floods, which are among the most dangerous hydrologic hazards due to their rapid onset and limited lead times that are often less than an hour in steep headwater catchments such as those in the Texas Hill Country. Timely warnings can provide emergency managers and the public with crucial minutes needed to take protective action, potentially saving lives. Because the Comfort gauge is located downstream of Kerrville where a tragic loss of life occurred during this flood, it did not provide actionable information for that community. Nonetheless, this case demonstrates the potential value of a distributed radar gauge network: by detecting velocity changes in upstream reaches, it may be possible to anticipate subsequent stage rises and significantly enhance the predictive skill and lead time of flash flood warning systems in the region.

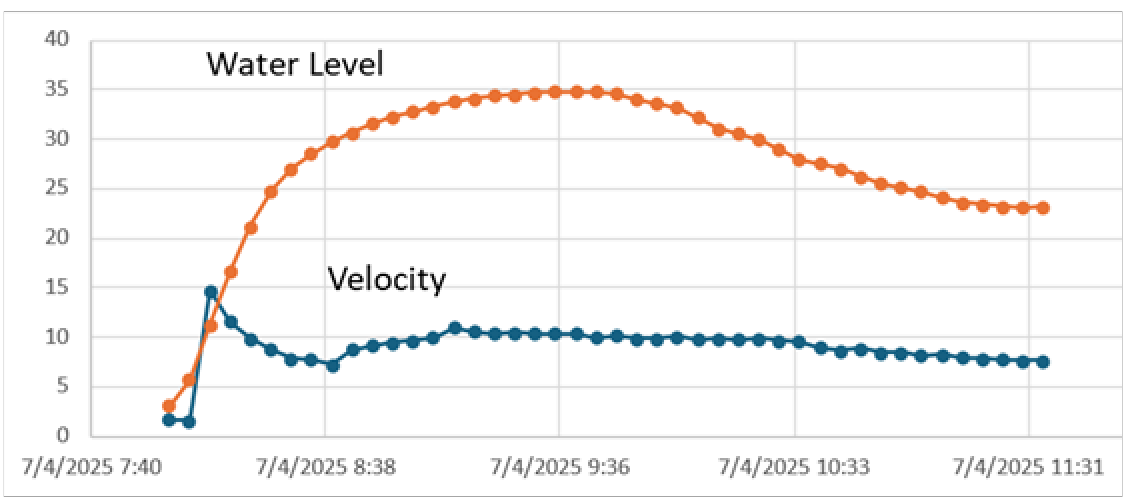


Figure 8. Water level (ft) and velocity (ft/s) from TxDOT radar gauge on Guadalupe River at Comfort on 4 July 2023 (USGS Provisional Data).

Research

The research component of the FAST project creates methodologies to support the FAST system. In particular, these focus on flood data analytics – assessing the errors in flood forecasts and using data from the radar flood gauge network to reduce those errors. Two papers were published this year from this research:

Timilsina, S., and P. Passalacqua (2025), A comparative analysis of national water model versions 2.1 and 3.0 reveals advances and challenges in streamflow predictions during storm events, Journal of Hydrology: Regional Studies, Volume 58, https://doi.org/10.1016/j.ejrh.2025.102196

Oh, J. and M. Bartos (2025), Flood early warning system with data assimilation enables site-level forecasting of bridge impacts, Nature Partner Journals: Natural Hazards, 2, Article 64, https://doi.org/10.1038/s44304-025-00116-0

Timilsina and Passalacqua (2025) assess the performance of two versions of the National Water Model in Texas and show that the newer version 3.0 is significantly more accurate than the earlier version 2.1. They did not find spatial patterns in the error across Texas – in other words, the errors are not significantly different in the drier or wetter parts of the state. They did find, however, that the National Water Model under-predicted flooding during some severe storm events because of under prediction of storm rainfall.

Oh and Bartos (2025) describe a scheme for improving flood forecasts through Data Assimilation. This scheme combines observed data at TxDOT and USGS stream gauges with National Water Model forecasts to produce adjusted streamflow forecasts that are more accurate than those produced by the National Water Model alone. The Data Assimilation framework uses a Kalman Filtering scheme to adjust and reroute the flows through the stream network so that observed and forecast flows better match the values reported by stream gauges. Evaluating the proposed framework over the San Antonio and Guadalupe river basins showed that the new data assimilation approach resulted in increased forecasting skill over all lead times considered (from 1 to 12 hours) compared to the National Water Model, with more pronounced improvements at longer lead times.

The Data Assimilation scheme is incorporated within FAST at the state-wide level so that two versions are available for testing – flood forecasting with and without Data Assimilation.

Current research is focused on assessing the spatial correlation of rainfall and streamflow, and on using Data Assimilation on a densified stream network. The goal of the spatial correlation analysis is to quantify the distance over which streamflow is similar and integrate that information in the Data Assimilation workflow to further improve hydrological predictions. We have performed this analysis using a tool from geostatistics called the variogram, that measures the similarity of a variable at pairs of locations in a network. The distance can be taken in any direction (isotropic variogram) or along stream lines (topological variogram). We find that the correlation length (the distance over which streamflow is similar) increases during storms to about 50-60 km (Figures 9, 10 below) and is related to the distance over which rainfall is similar. Integrating this information into the Data Assimilation scheme shows improvements in hydrological predictions of streamflow and a wider extent of the network over which the Data Assimilation is able to adjust the streamflow values.

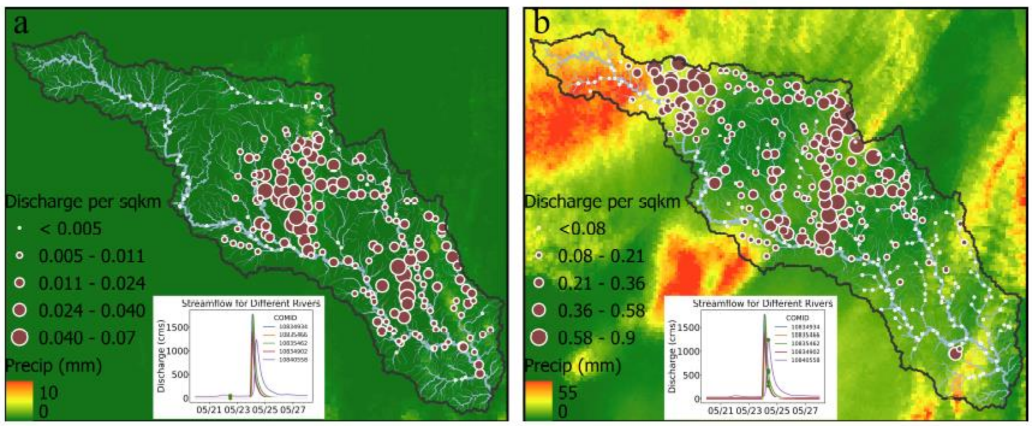


Figure 9 (a) San Antonio basin before the 2015 storm: Precipitation (May 22, 00-12 hours) and normalized discharge (cms per sqkm) for 2015-05-22 12:00 hrs (b) San Antonio basin during the 2015 storm: Precipitation (May 24, 06-09 hours) and normalized discharge (cms per sqkm) for 2015-05-24 09:00 hrs. The inset hydrograph shows streamflow over the storm, with the green dot indicating the specific time shown in the corresponding main map.

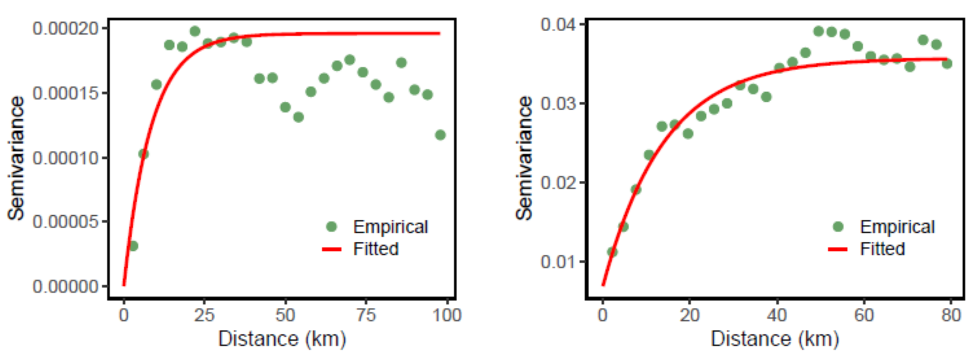


Figure 10. Variograms of normalized discharge in the San Antonio Basin for (a) 2015-05-22 12:00 and (b) 2015-05-24 09:00. The correlation length (the length at which the red curve levels off) increases to 50-60 km during the storm and that is consistent across watersheds and storms.

Another major effort towards improving flood forecasts has been the densification of the stream network model used for discharge predictions (see Figure 11). The current operational model used by FAST simulates flow at roughly 70,000 streamlines throughout the state of Texas, using the same stream network topology as the National Water Model. However, the resolution of this stream network model is not sufficient to capture flooding at all NBI bridges, and often does not capture flow at low water crossings in urban areas.

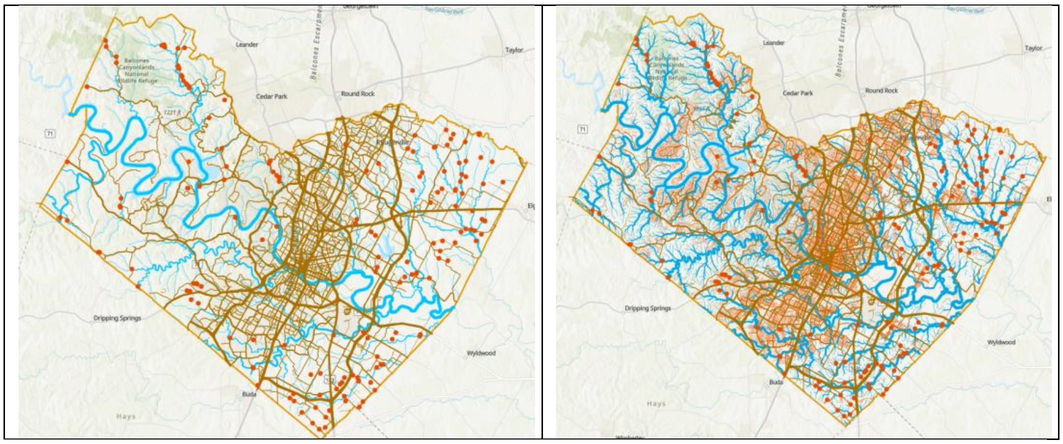


Figure 11. (Left): Travis County as represented in the current FAST system, with 2,621 miles of roads (orange), 1018 miles of streams (blue) and 92 low water crossings captured (red). (Right): Travis County as represented in the high-resolution model, with 6,684 miles of roads, 2,528 miles of streams, and 140 low water crossings captured.

To correct this problem, we have created and tested a methodology for densifying the FAST stream network model and generating high resolution streamflow predictions. High-resolution streamlines are first obtained from either nationally-available GIS layers (NHDPlusHR, USGS Streamstats) or from local surveyed data, depending on the best available data source. Next, runoff forcings from the National Water Model are partitioned to each high-resolution streamline based on their fractional contributing areas as determined from high-resolution digital elevation models. Runoff is then routed through the high-resolution model using the Muskingum routing code described in Oh and Bartos (2025).

Our initial test case focuses on Travis County, where the stream network resolution has been increased from 916 reaches to 63,455 reaches. With this increased stream resolution, the number of low water crossings captured by the model has increased from 92 to 140 in Travis County (out of a total of 163 low water crossings). Figure 12 shows a comparison of the modeled discharges under the current model resolution (left) and the high-resolution model (right) for Travis County for a storm event occurring on 4/21/2023. Future work will extend the coverage of the high-resolution models across the state of Texas using streamlines obtained from the USGS Streamstats database, pending the public release of this dataset.

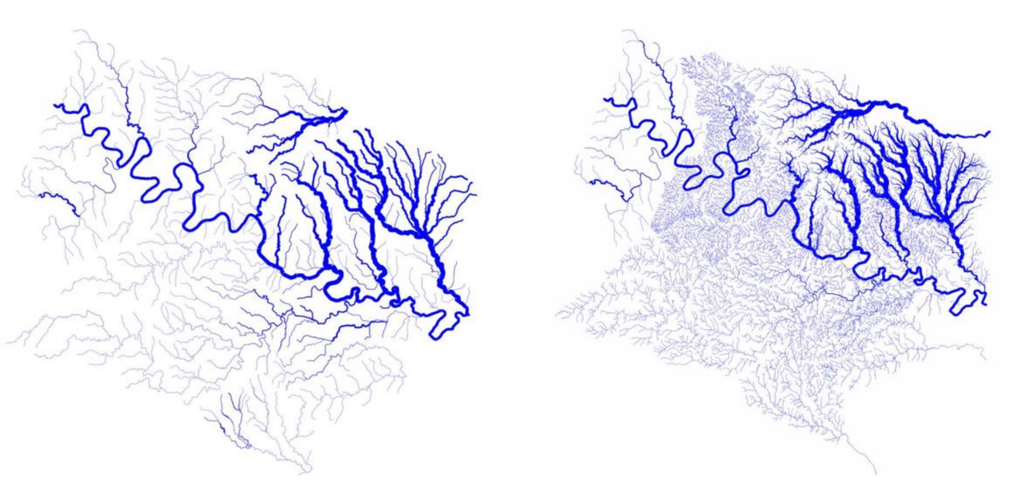


Figure 12. Streamflow in Travis County under a storm event occurring on 4/21/2023. (Left): Original resolution model. (Right): High-resolution model.

Conclusion

The **FAST (Flood Assessment System for TxDOT)** project aims to provide accurate, timely information about flooding on Texas roads and bridges. Originally based on complex research, it has evolved into an easy-to-use tool accessible across the TxDOT agency.

Recent progress includes developing practical and user-friendly FAST layers and streamlining the production workflow. Currently hosted on **Roadflood.com** (as a temporary platform), the system is set to be integrated into an internal TxDOT site.

FAST offers a **real-time, hourly-updating map** that shows current and forecasted flooding (up to 18 hours ahead) on roads and bridges. Key features include:

- **Flooded roads** marked in red, scaled by flood extent.
- **Bridges** shown as colored dots, changing from green to black based on flood severity.
- **Dynamic hourly updates** to reflect changing conditions.
- **Archivable data** to review past flooding impacts.

The system supports TxDOT District offices, Maintenance Sections, and emergency management by enhancing situational awareness and response during flood events. FAST is a research level system, meaning it needs more testing and fine-tuning before it can be used in real flood operations. A continuing research program supports its development and adds new improvements over time.

FAST is supported by a network of 77 radar flood gauges mounted on TxDOT bridges that measure water surface elevation and velocity. These gauges are installed and maintained by the US Geological Survey, and are the largest operational network of such gauges in the United States. The USGS has developed a method for calibrating the radar gauges using Acoustic Doppler Current Profiler measurements across the stream cross-section. This method has been applied to calibrate 34 gauges.

On 4 July 2025, a catastrophic flood occurred at Kerrville on the Guadalupe River. The nearest TxDOT radar gauge is located in Comfort, downstream of Kerrville, and it recorded a distinct velocity "spike" right at the beginning of the flood rise about 90 minutes before the peak flood depth at this site. The measurement of both velocity and water surface elevation at TxDOT radar gauges may offer a possibility of advanced flood warning during flash flood conditions.

The data analytics component of the FAST research has created a Data Assimilation methodology that knits together the forecast discharge in the stream network with the discharge measurements at the TxDOT radar gauges, adjusting the discharge over the stream network to create more accurate predictions of road and bridge flooding.