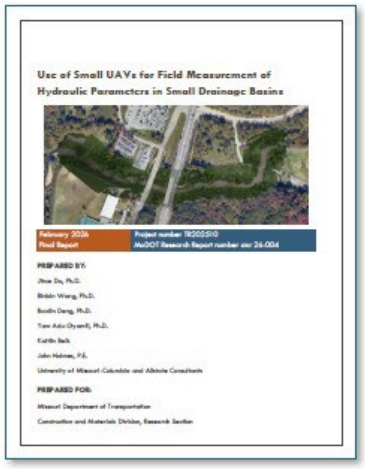
For more information contact: Scott Breeding (573) 526-4325

Research Summary

Use of Small UAVs for Field Measurement of Hydraulic Parameters in Small Drainage Basins


Use of Small UAVs for Field Measurement of Hydraulic Parameters in Small Drainage Basins

This project evaluated the feasibility, accuracy, and operational practicality of using small unmanned aerial vehicles (UAVs) to measure hydraulic parameters, water surface elevation, surface velocity, bathymetry, and stream discharge, in small to medium Missouri drainage basins. Traditional field methods such as wading, current metering, or ADCP surveys can be hazardous, slow, or impractical during high-flow conditions. UAV-based remote sensing offers a non-contact alternative capable of rapidly acquiring spatially continuous data while reducing personnel risk.

The objectives of this project were to (1) conduct an in-depth literature review of past and current research on UAV-based measurements of key hydraulic parameters, including water surface elevation, flow velocity, bathymetry, and discharge; (2) identify best practices through field surveys and data processing for UAV-based measurements in small drainage basins across different hydrologic regions of Missouri; and (3) demonstrate the effectiveness of UAV-based hydraulic measurements in the field, developing a step-by-step procedure manual, and presenting methods and results.

An in-depth literature review was conducted covering studies published between 2010 and 2024. The reviewed publications focused on river applications of UAVs for studies of directly relevant hydraulic parameters. River application studies were further grouped into four subcategories for analysis: water surface elevation, bathymetry, surface velocity, and discharge measurements.

The literature review and analysis show that UAV-based methods can measure key river characteristics with useful accuracy. The review covers the details of using UAVs to estimate water-surface elevation, riverbed shape, surface flow velocity, and stream discharge using a variety of sensors and image-based techniques. While accuracy varies among methods, overall results indicate that UAVs provide reliable hydraulic information when traditional field measurements are difficult, time-consuming, or unsafe.

"UAV-based measurements offer a safer and more efficient way to collect hydraulic data when traditional field methods are difficult or hazardous."

For this project, twelve potential field locations were reviewed, and five representative sites were selected for detailed UAV data collection. These sites represent a range of channel sizes and flow conditions, with drainage areas spanning approximately 20 to 300 square miles and stream

discharges ranging from about 20 to 170 cubic feet per second, while allowing safe and consistent UAV operations. At each site, UAV imagery and sensor data were used to evaluate water-surface elevation, surface velocity, bathymetry, and discharge using both geometry-based and velocity-based approaches.

Results indicate that UAV-based discharge estimates are generally comparable to standard reference methods, typically within about 25%. Geometry-based approaches can perform well when channel shape and roughness are well characterized, but they may be sensitive to site conditions. Surface-velocity-based approaches tend to produce more consistent results across different sites and flow conditions, making them well suited for rapid field deployment.

Based on field experience, several practical recommendations are provided. Particle Tracking Velocimetry (PTV) is preferred in clear-water conditions with seeding particles, while Particle Image Velocimetry (PIV) is more robust in turbid or flooded conditions where sufficient surface texture or tracer density is present. The use of biodegradable seeding materials improves measurement quality for both methods, and automating data processing workflows, such as surface-velocity extraction and discharge estimation, improves efficiency, reduces operator workload, and enhances consistency.

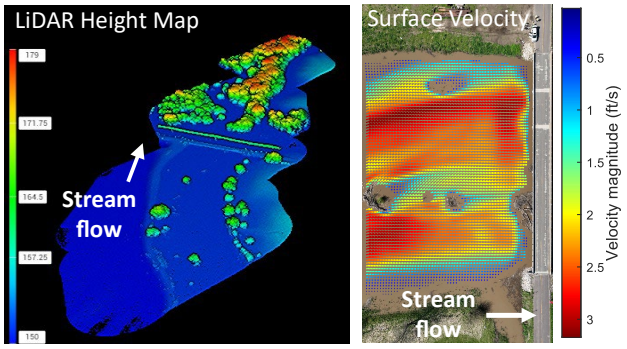


Figure 1 Examples of UAV-based hydraulic measurements. Water surface height mapped using UAV LiDAR (left). Surface flow velocity estimated from UAV imagery (right).

Project Information

PROJECT NAME: TR202510—Use of Small UAVs for Field Measurement of Hydraulic Parameters in Small Drainage Basins

PROJECT START/END DATE: December 2024-February 2026

PROJECT COST: $299,999

LEAD CONTRACTOR: University of Missouri-Columbia and Allstate Consulting

PRINCIPAL INVESTIGATOR: Binbin Wang and John Holmes

REPORT NAME: Use of Small UAVs for Field Measurement of Hydraulic Parameters in Small Drainage Basins

REPORT NUMBER: cmr 26-004

REPORT DATE: February 2026

Project Manager

CONTACT INFORMATION:

Scott Breeding
Senior Research Analyst
Missouri Dept. of Transportation
1617 Missouri Blvd.
Jefferson City, MO 65109
(573) 526-4325
Scott.Breeding@modot.mo.gov