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#### RESEARCH PROJECT TITLE

Demonstrating the Use of Small Uncrewed Aircraft Systems (Drones) Capabilities and Data for Iowa Transportation and Infrastructure Work

#### SPONSORS

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The Program for Sustainable Pavement Engineering and Research (PROSPER) is part of the Institute for Transportation (InTrans) at Iowa State University. The overall goal of PROSPER is to advance research, education, and technology transfer in the area of sustainable highway and airport pavement infrastructure systems.

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**IOWA STATE UNIVERSITY**  
Institute for Transportation

## Demonstrating the Use of Small Uncrewed Aircraft Systems (Drones) Capabilities and Data for Iowa Transportation and Infrastructure Work: **Pilot Project No. 3 – Use of Small Uncrewed Aircraft Systems for Erosion and Sediment Control Device Monitoring**

tech transfer summary

High-resolution sUAS imagery can support faster and safer condition assessments of erosion and sediment control devices on construction sites.

### Objective

This pilot study aimed to evaluate the feasibility of using small uncrewed aircraft systems (sUAS) for detecting and assessing erosion and sediment control devices (ESCDs) on construction sites. The study also sought to develop a prototype workflow for rapidly delivering processed sUAS data and extracting ESCD features for condition assessment.

### Background

The use of sUAS, commonly referred to as drones, has expanded rapidly across transportation engineering applications, particularly in remote sensing and infrastructure monitoring. The Iowa Department of Transportation (DOT) initiated a research project to demonstrate the usefulness of sUAS for infrastructure applications through five pilot projects. The third pilot project, described in this summary, focused on the detection and assessment of ESCDs.

ESCD monitoring relies primarily on traditional field inspections, where inspectors conduct routine site visits and perform close-range assessments. This approach is inefficient on large construction projects, where devices are spatially distributed across complex terrain. Field inspections are also time-consuming and labor-intensive and can expose inspectors to challenging or unsafe site conditions.

Remote sensing technologies such as sUAS can address these limitations by enabling rapid site-wide data collection and device monitoring. Processed outputs from sUAS imagery, including digital elevation models (DEMs), orthophotos, and multispectral imagery, provide detailed spatial information that can support device identification and condition assessment.



Examples of ESCDs: silt fence (left), check dam (middle), wattle (right)

## Problem Statement

To address the limitations of manual field inspections, there is a need for efficient monitoring approaches that can support faster and safer assessment of ESCD conditions.

Relatively few investigations have explored the use of sUAS for automated feature extraction and condition assessment of ESCDs. Developing workflows that enable efficient data collection, processing, remote analysis, and rapid data sharing is essential to support the practical adoption of sUAS for ESCD monitoring in construction environments.

## Research Description

With the understanding that traditional field inspections are typically conducted on a weekly basis, the research activities were organized into two major components:

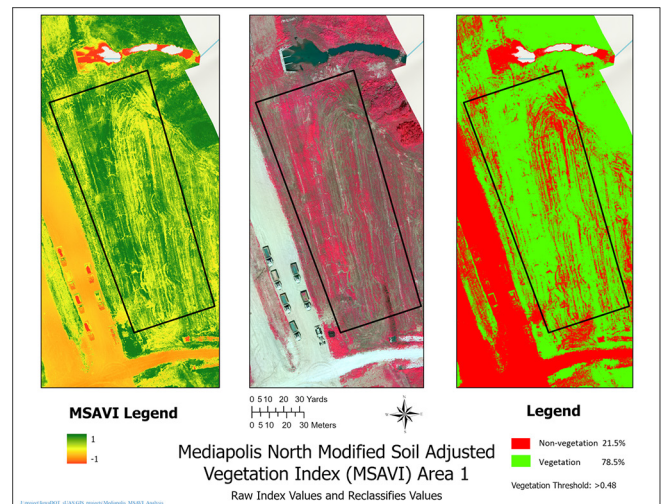
1. Development of a rapid and seamless sUAS data collection and processing workflow for efficient digital delivery
2. Feature extraction from processed data for the quantitative and qualitative assessment of the overall conditions of ESCDs

The research team visited three grading project sites in Iowa: (1) two sites located in Mediapolis, Des Moines County and (2) one site located in Oskaloosa, Mahaska County. Before sUAS data collection, preliminary site visits were conducted to understand ongoing construction activities, site terrain, and barriers such as overhead powerlines.

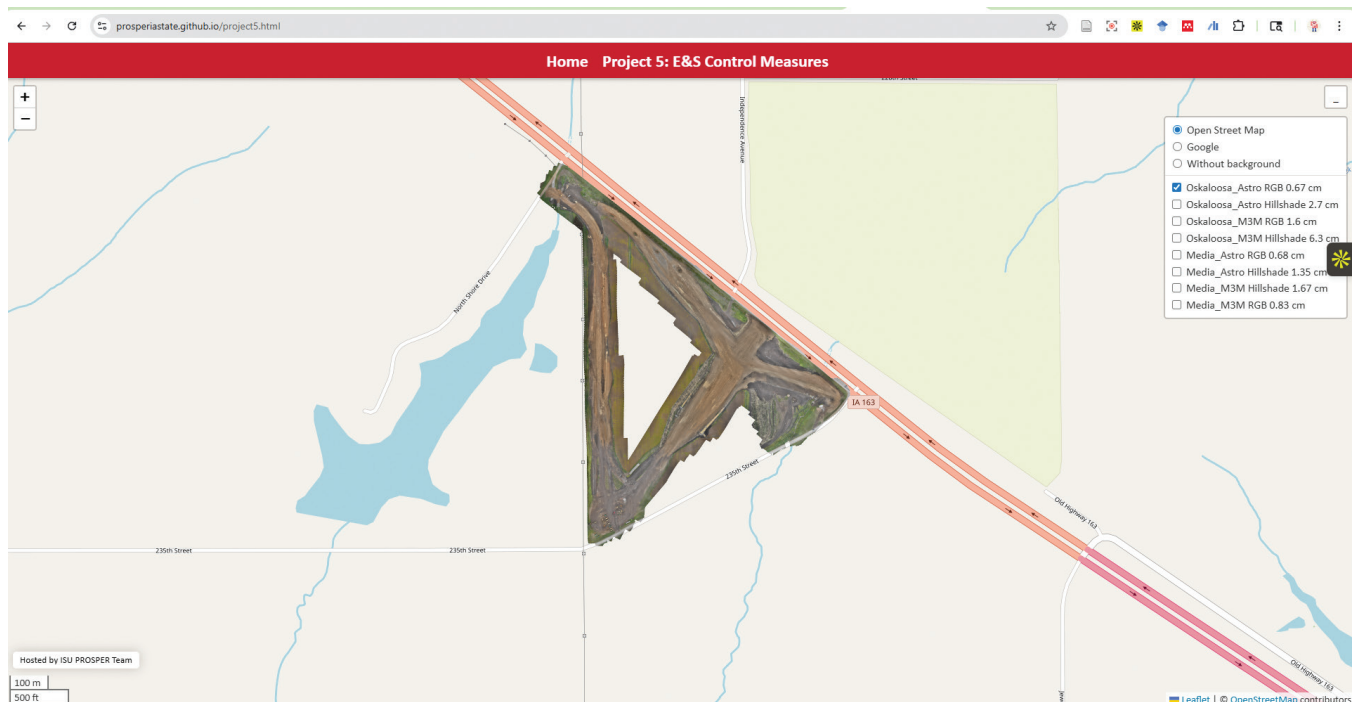
Following data collection at the three sites, sUAS data were processed into orthophotos, DEMs, and hillshade models. The processed data are viewable in any ArcGIS software or in the platform-agnostic web application developed for this project.

Automatic feature extraction toolboxes for rapid condition assessment were developed in ArcGIS Pro for five types of ESCDs:

1. **Vegetation:** To determine vegetation coverage within an area, Normalized Difference Vegetation Index (NDVI) and Modified Soil Adjusted Vegetation Index (MSAVI) values were calculated from processed multispectral orthophotographs.



*Output of MSAVI calculations*



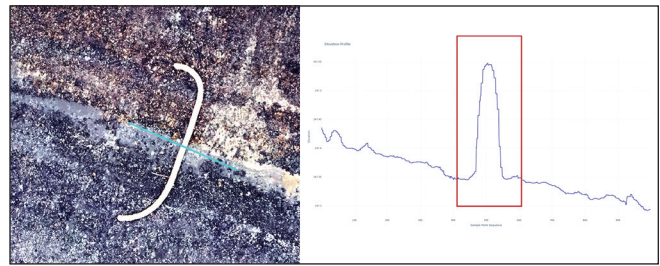
*Web-based data viewing platform*

2. **Rock Check Dams:** To assess sediment buildup at rock check dams, elevation features were extracted from DEMs to conduct profile analyses of the dams' upstream and downstream regions. In addition, red-green-blue (RGB) imagery was used to analyze the rock within the dams.

3. **Silt Fences:** Three methods were used to assess the condition of silt fences: (1) profile analysis from DEMs to indicate profile slope patterns, (2) multispectral image analysis to quantify accumulated sediment, and (3) use of the 3D viewing feature in ArcGIS Pro, which tilts 2D imagery into a 3D scenic view.

4. **Wattles:** Similar to the assessment of silt fences, two methods were used to assessing wattles: (1) profile analysis from DEMs and (2) 3D viewing.

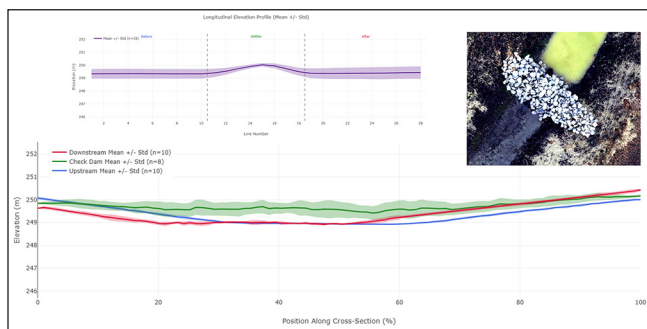
5. **Stormwater Basins:** Stormwater basin conditions were assessed directly from 2D orthophotographs, which indicated coloration, inflow conditions, and overflow into the surrounding area. In addition, changes in basin area can be assessed if subsequently captured data are available for the same site.



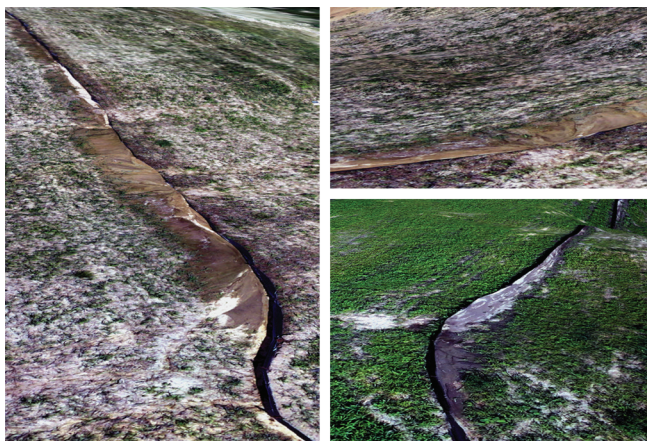
*Elevation profile of a wattle*



*2D orthophotos showing stormwater basins*



*Upstream and downstream elevation profile of a check dam*



*Close-up 3D view of a silt fence*

## Key Findings

- This pilot project developed practical sUAS data collection strategies and a workflow for remotely monitoring the condition of ESCDs at active construction sites.
- Critical factors for achieving a rapid and seamless workflow from sUAS data collection to data visualization include the following:
  - Optimal placement of ground control points (GCPs) and the use of a real-time kinematics (RTK) module
  - Use of high-resolution sensors to enable higher flight altitudes while maintaining image quality, reducing flight time, and improving operational efficiency
  - Proper resource planning, including additional batteries and charging equipment, to ensure uninterrupted sUAS operations
  - Weather condition monitoring to ensure safe sUAS operations and avoid unfavorable conditions such as high winds, rain, and/or poor visibility
  - Sufficient computing resources, including high-performance computers or cloud-native data processing software, to allow large-scale processing in a timely fashion
  - Prior authorization from the Federal Aviation Administration and remote pilot certification

- The proof-of-concept toolboxes developed for the ESCDs included in this study are capable of feature extraction from processed sUAS data.
- Suitable analysis methods were developed for remote monitoring of the ESCDs covered in this study.
- Additional benefits may arise from the routine use of sUAS for ESCD inspections. Because data collection typically requires flying over large portions of a site, additional information on completed earthwork and other ongoing construction activities can also be captured. Repeated site surveys, therefore, create a digital repository of construction progress that can support future decision-making and project monitoring.

## Limitations and Future Research

The limitations of this study included the following:

- sUAS operations can be affected by sudden changes in weather conditions during or close to the times of data collection. Even with routine weather monitoring before flight operations, sUAS deployment is limited to periods of suitable weather.
- While a wide range of ESCDs are typically found on construction sites, only five types were assessed in this study. Future investigations should include additional ESCD types to evaluate suitable feature extraction methods and better understand the potential of sUAS for comprehensive ESCD monitoring.
- Processing sUAS image data from large construction sites requires substantial computational resources to enable timely digital data delivery. Without adequate computing capability, the transition from raw imagery to final analysis may become slow and inefficient.

- The sites visited for data collection featured little to no active construction. More complex scenarios, such as fast-moving construction sites, may create additional challenges for drone teams.

Future research can address these limitations and capitalize on the early outcomes of this pilot study. Promising areas for future work include visits to multiple sites with varying terrain and site conditions; further testing of the digital delivery workflow, including by the Iowa DOT and local agencies; and evaluation of the feature extraction toolboxes across different ESCD types.

## Implementation Readiness and Benefits

The use of sUAS for the remote assessment of ESCD conditions has the potential to enhance the speed, safety, and productivity of data collection and analysis. The workflow developed in this study has achieved preliminary success in demonstrating the remote monitoring and condition assessment of ESCDs on construction sites.

Further development is needed to enhance the framework begun in this project, including additional data collection from a variety of sites featuring a broader range of ESCDs and end-user testing of the digital delivery workflow.