Remotely mapping stormwater ponds and roadside swales with deep learning

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Presentation to the Chesapeake Urban Stormwater Workgroup

March 17, 2026

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The Need

There is no regional, comprehensive database of stormwater management practices that **includes stormwater storage estimates** for the Chesapeake Bay watershed.

Limitations of existing databases,

- May only include facilities on public land
- Inconsistent use of naming conventions
- Limited information on the size and storage capacity of each facility

Tree box filter in Clarksburg, Maryland.

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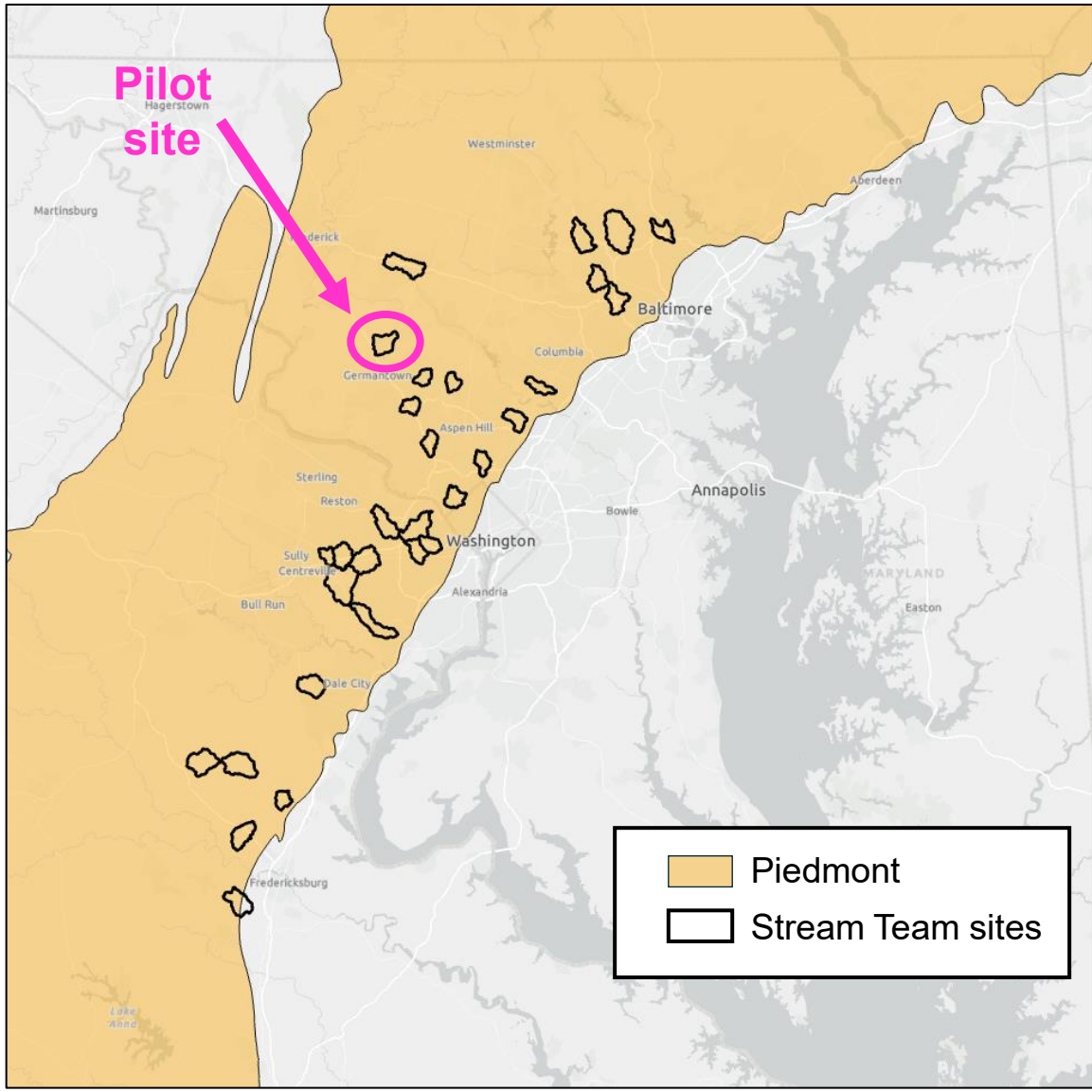
Objective

Develop an artificial intelligence / machine learning (AI/ML) deep learning model to remotely map surface stormwater facilities within 30 small suburban and urban watersheds located in the Piedmont ecoregion of the Chesapeake Bay watershed.

Dataset will include:

- Facility type
- Polygon of footprint
- Estimated surface storage



Watersheds for 30 suburban and urban Stream Team sites within the Piedmont ecoregion.

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Sand filters

Bioretention

Features to be mapped

Roadside swales

Dry/wet ponds

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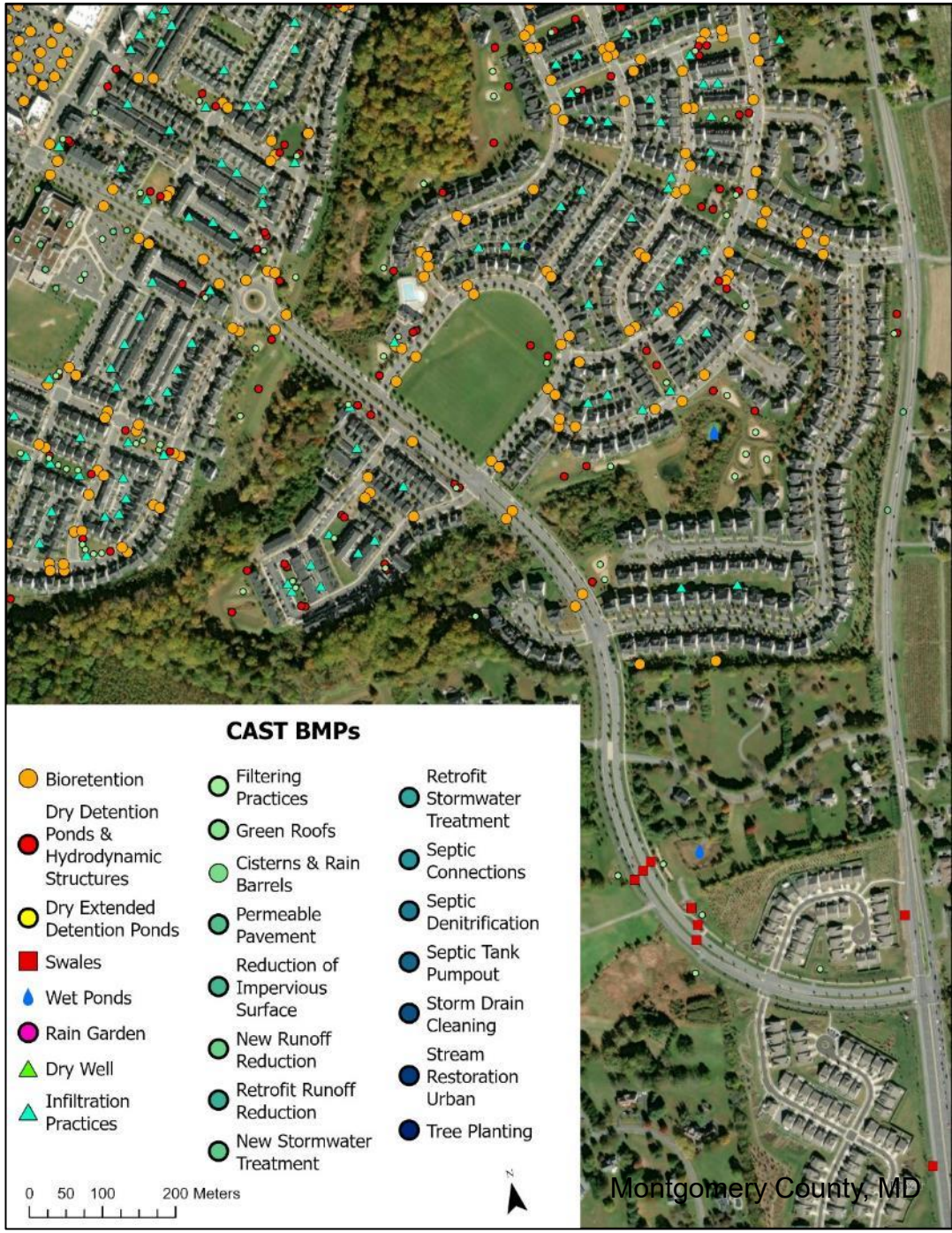
Pilot Site in Little Seneca Creek

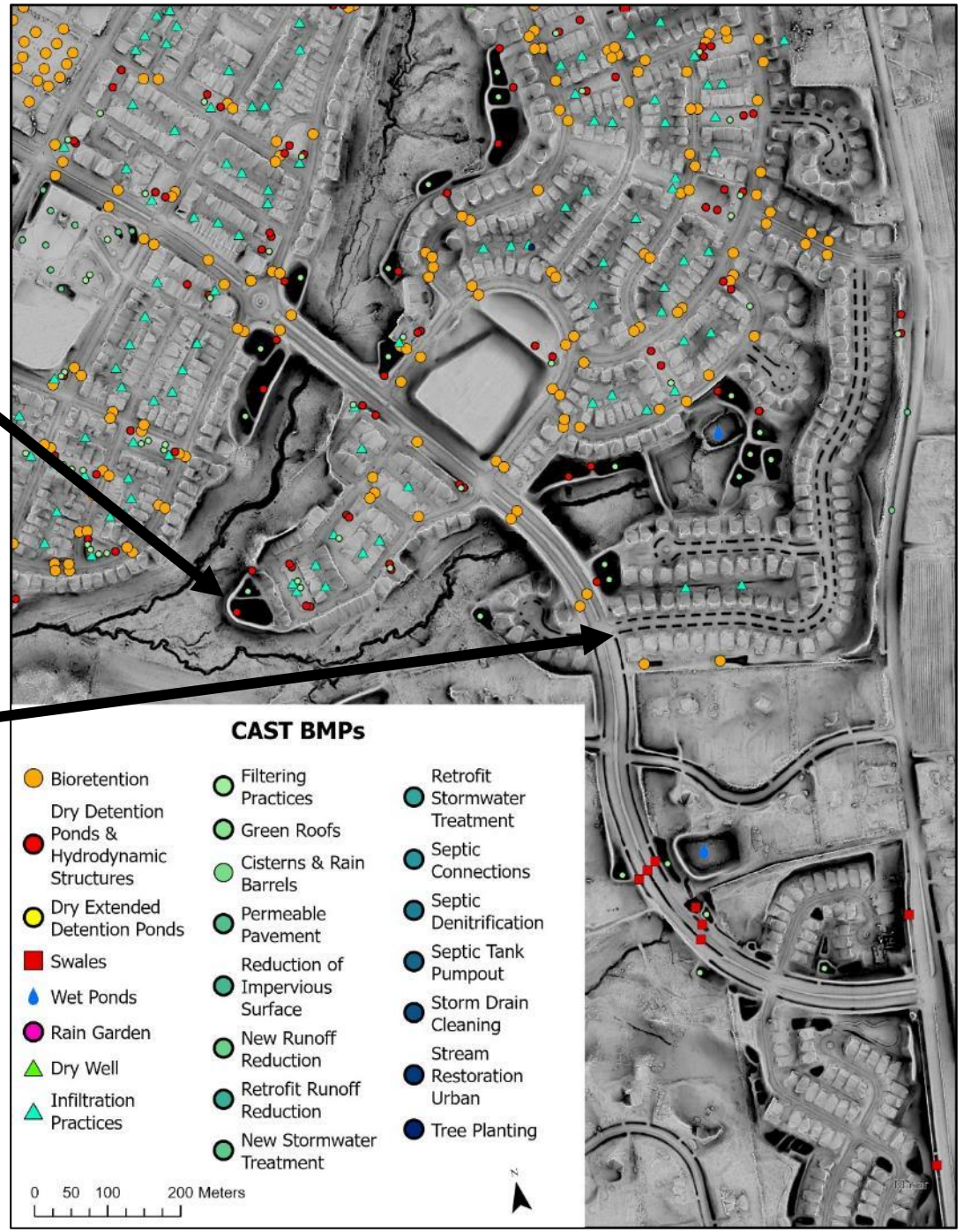
Selected due to research team's history of working in the Clarksburg Special Protection Area and availability of necessary datasets

Chesapeake Assessment Scenario Tool (CAST) shows many stormwater practices in the Clarksburg Special Protection Area.



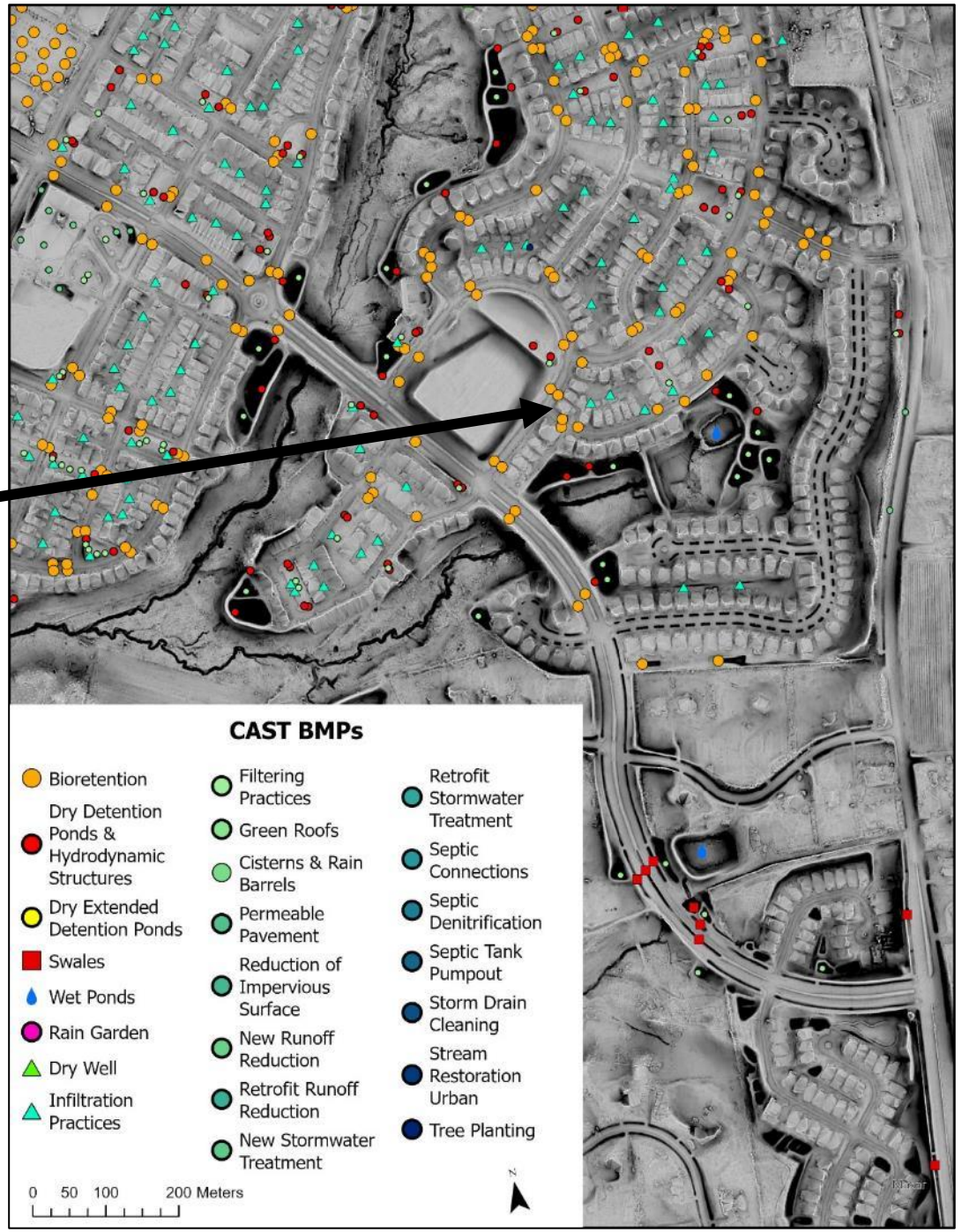
Limitations of CAST

- No information on area or volume
- Point represents polygon feature
- Many swales are missing



Limitations of remote mapping

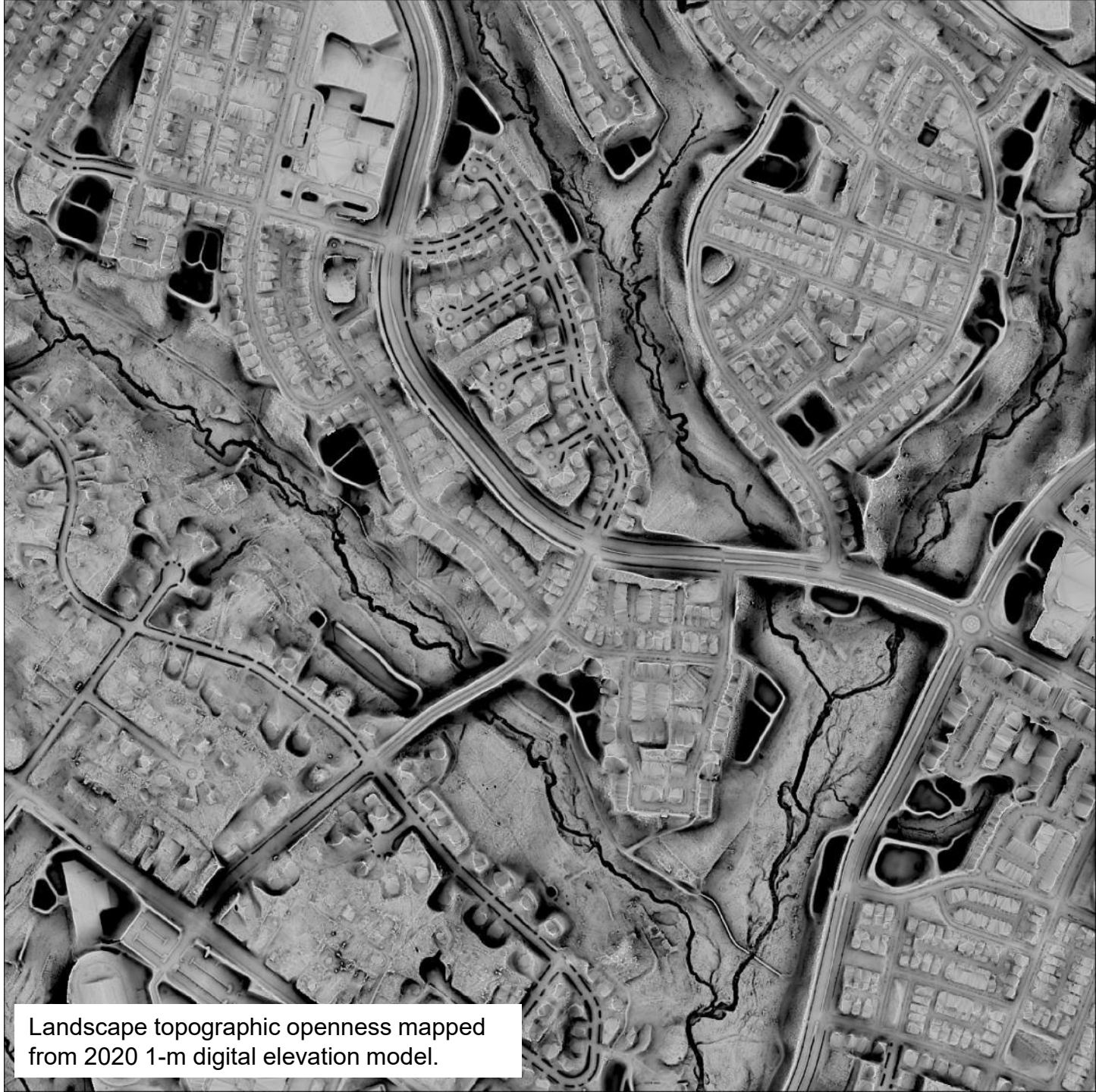
- Some surface features are not detectable from elevation data
- Subsurface features (e.g., infiltration facilities) will not be mapped



Certain stormwater facilities are visible in the 1-m lidar data

Goal: Develop an AI/ML model to map these features across Stream Team Typology 4 (urban Piedmont) sites to enhance our information on stormwater practices at a watershed-scale.

Polygon-based representations of ponds and swales allows us to estimate potential water storage volume.



Landscape topographic openness mapped from 2020 1-m digital elevation model.

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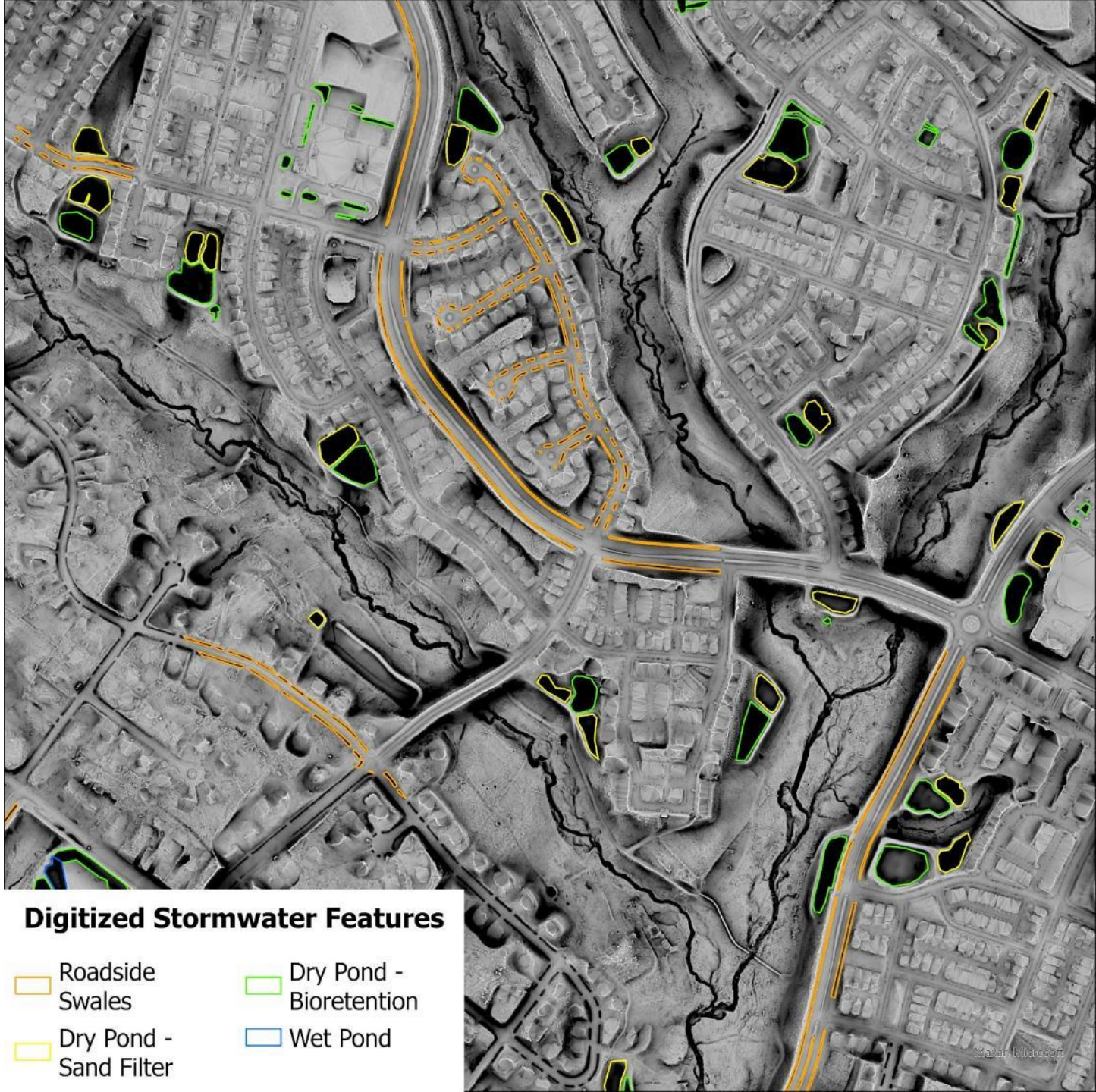
Developed training dataset

Hand-digitized stormwater features by Nathaniel Rosenbloom, USGS MD-DE-DC WSC.

Number of digitized stormwater features

- 776 swales
- 214 sand filters
- 409 bioretention ponds
- 69 wet ponds



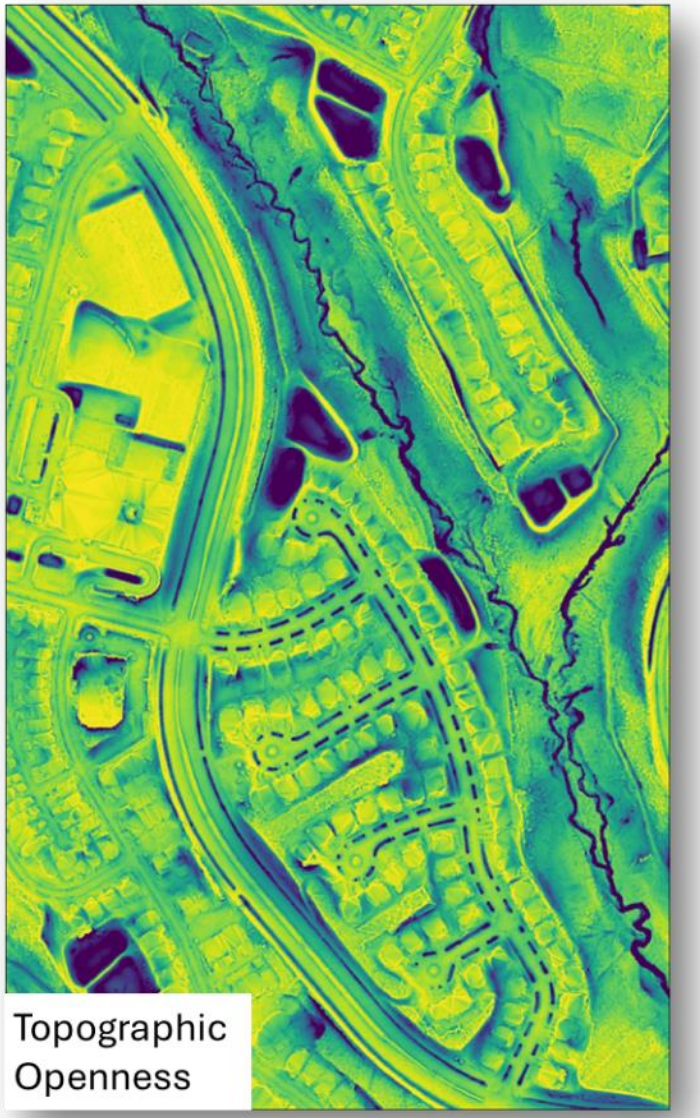
Preliminary model inputs

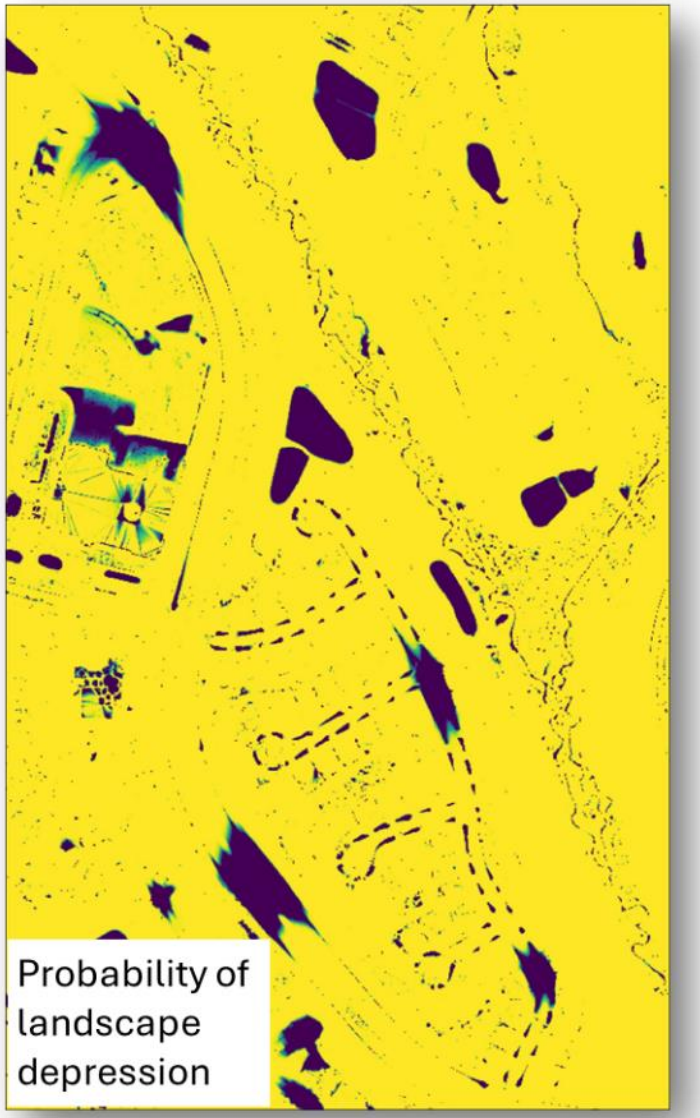
More enclosed relative to surroundings

1

0

Less enclosed relative to surroundings





1

0

Higher probability of cell being in a depression

Lower probability of cell being in a depression

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Preliminary deep learning model output

Roadside swales and detention features

Preliminary roadside swales.

Preliminary detention features.

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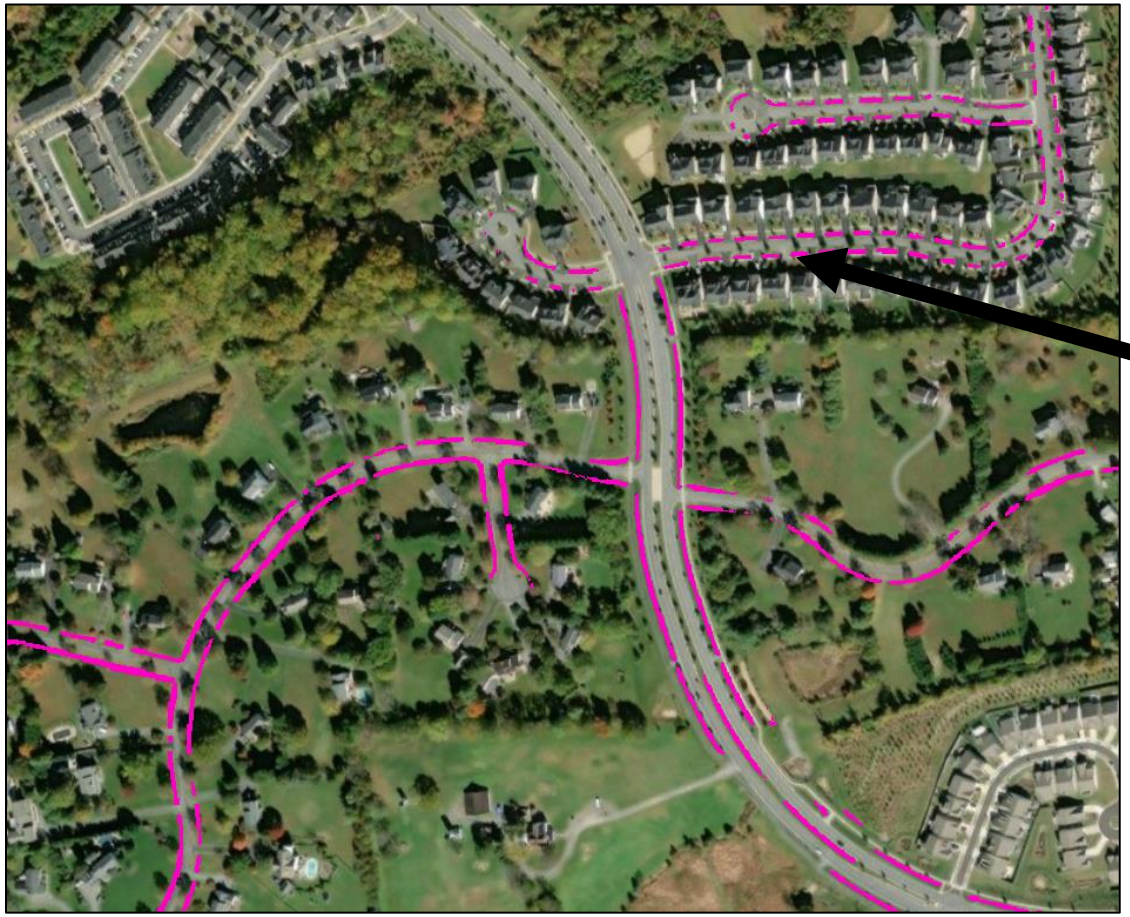
Preliminary deep learning model output

Roadside swales and detention features



Preliminary roadside swales.

The model identified swales between driveways.
Photo credit: Google Street View.

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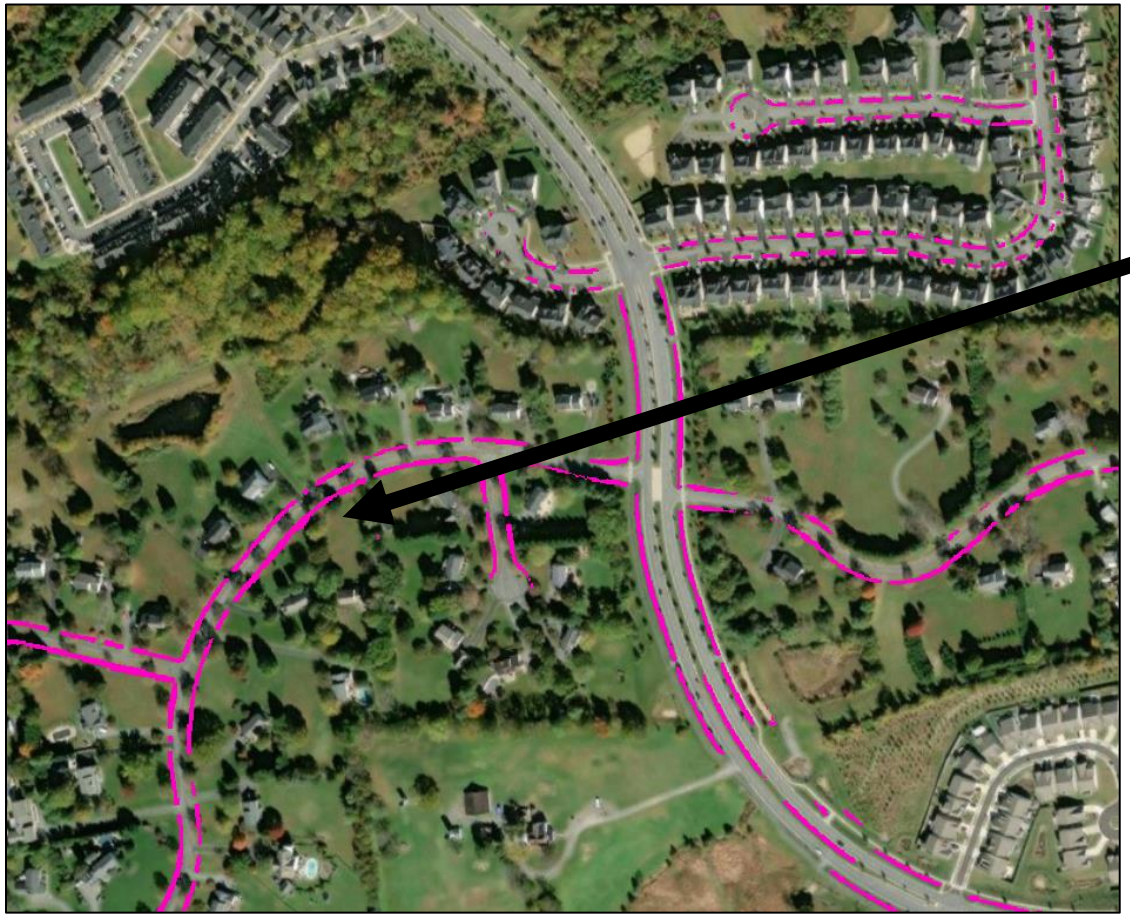
Preliminary deep learning model output

Roadside swales and detention features



Preliminary roadside swales.

The model identified roadside swales in areas with older development.
Photo credit: Google Street View.

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Preliminary deep learning model output

Roadside swales and detention features

The model identified sand filters and dry ponds.

Preliminary detention features.

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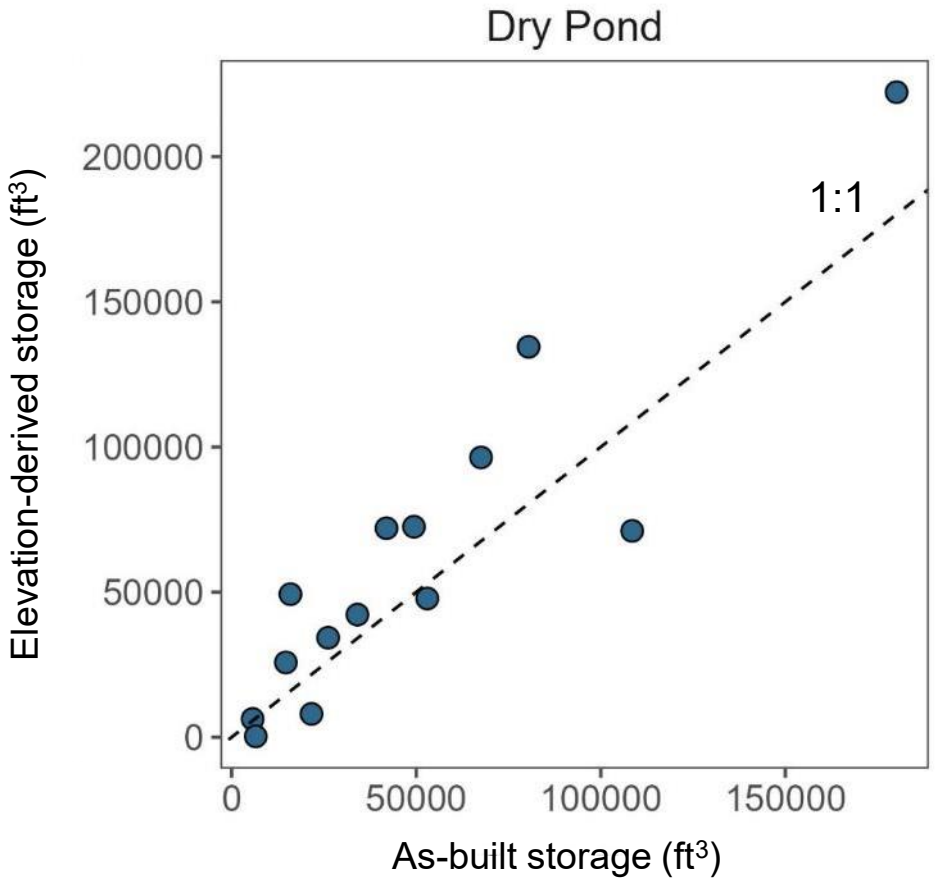
Estimating stormwater surface storage

Surface stormwater storage estimates based on elevation depths within each stormwater feature.



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Deep learning model performance

Swales

Precision	Recall	F1
0.787	0.555	0.651

Preliminary roadside swales

Ponds

Precision	Recall	F1
0.875	0.674	0.761

Preliminary detention features

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Translating measures in metrics

Outputs from this remote mapping effort will be converted into watershed metrics.

Possible metrics include:

- Surface water storage per watershed area
- Surface water storage per impervious area
- Proportion of roadways lined with swales

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Could this support maintenance?

Aerial imagery could be combined with stormwater practice footprints to assess changes in vegetation and water ponding over time.

Example for a sand filter.

Google Earth, 5/25/2013 | 9/10/2015 | 9/19/2017 | 4/10/2021 | 5/13/2023

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Next steps

- Expand to all Urban Typology sites (FY26)
- Journal article on methods (FY27)
- Integrate into Stream Team Urban Typology Study (FY27)

Project Webpage https://www.usgs.gov/centers/chesapeake-bay-activities/science/remotely-mapping-stormwater-facility-footprints-and

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