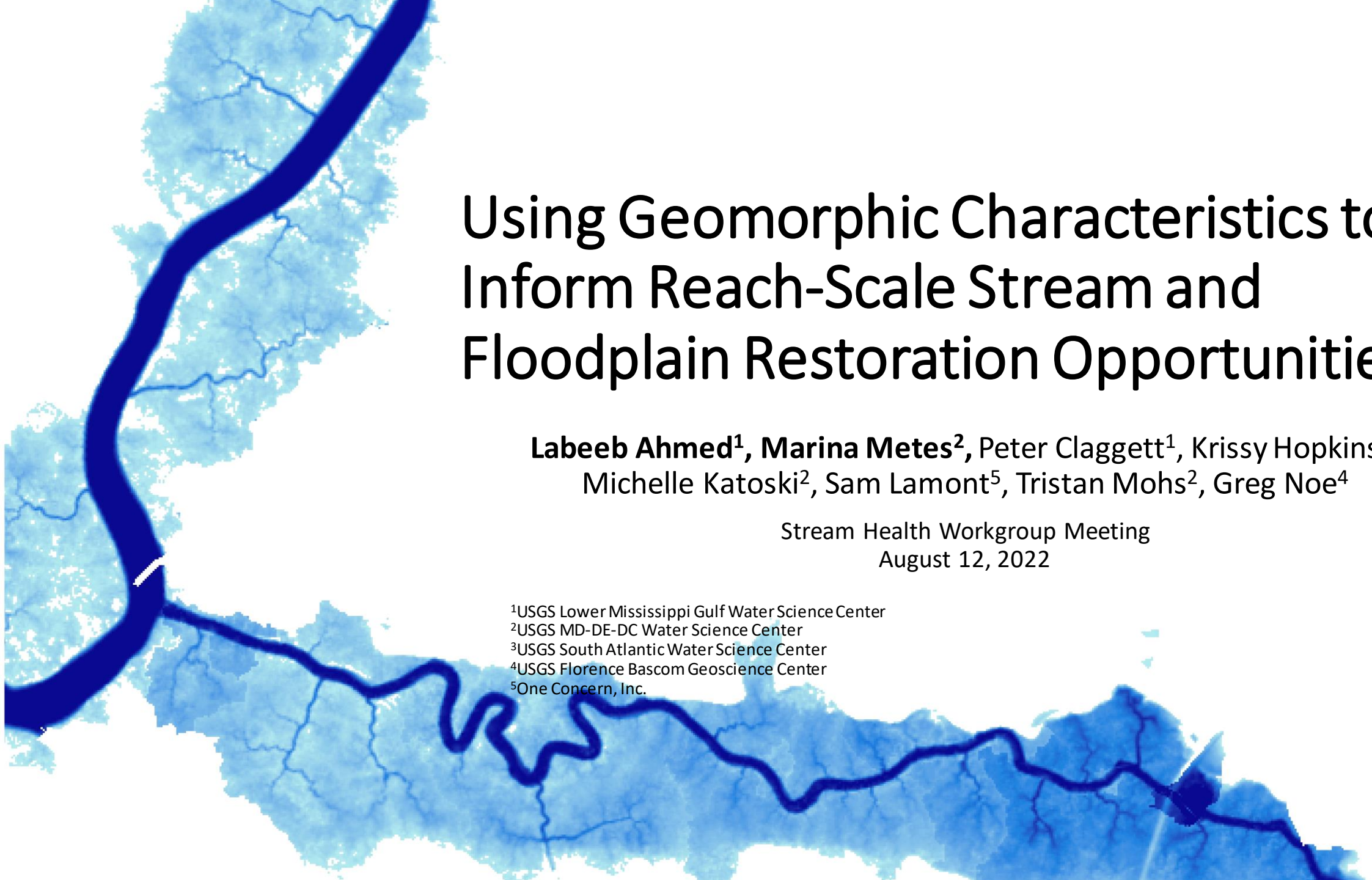

Using Geomorphic Characteristics to Inform Reach-Scale Stream and Floodplain Restoration Opportunities

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Stream Health Workgroup Meeting
August 12, 2022

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[2]USGS MD-DE-DC Water Science Center
[3]USGS South Atlantic Water Science Center
[4]USGS Florence Bascom Geoscience Center
[5]One Concern, Inc.

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Healthy vs. Impaired Stream Conditions

Connected stream-floodplain system

vs

Disconnected stream-floodplain system

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Stream Restoration

Aims to mitigate impaired streams, but often there are challenges:

- Difficult to quantify results of a stream restoration project
- Lack of consistent long-term monitoring
- Segmented restoration: site-specific and/or shifting problems downstream

Remotely Evaluating Geomorphic Conditions

We developed the Floodplain and Channel Evaluation Tool (FACET)

- An automated GIS tool to remotely measure geomorphic metrics such as channel width, bank height & active flood extent
- Requirements:
  - 3-meter or finer resolution elevation data (**preferred 1-meter**)
  - Existing stream network e.g., National Hydrography Dataset 1:24K or 1:100k
- Free and open-source tool available at code.usgs.gov/water/facet

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Seeing through the trees…

FACET Output for HUC 0206000604 in Anne Arundel County, Maryland (Coastal Plain)

Datasets

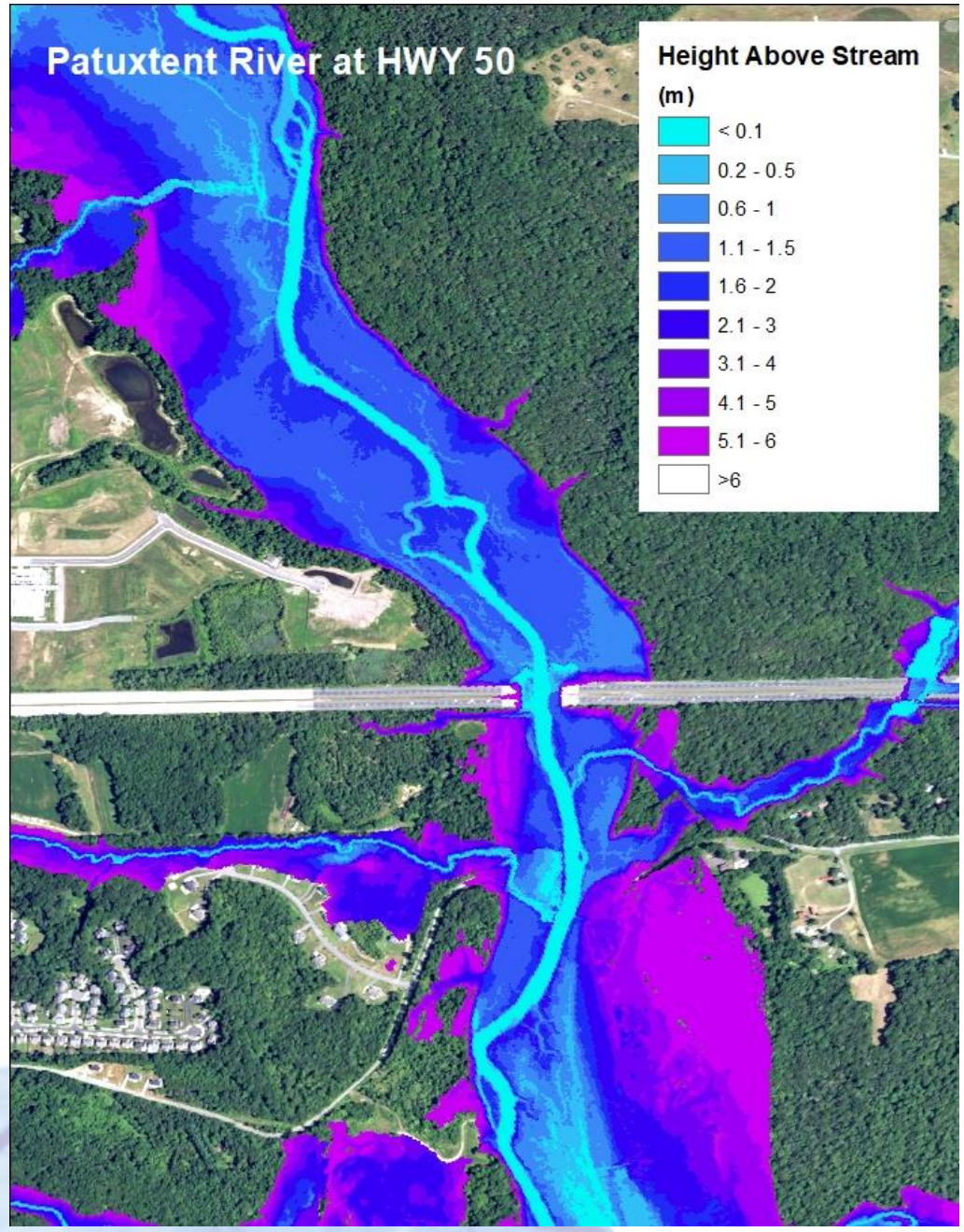
- Stream Network
- 1-D Cross Section Bank Points
- Raster-base Curvature Bank Pixels
- Floodplain Extent Raster (HAND)

Channel Cross-section Metrics

- Bank height (m)
- Bank angle, avg (deg)
- Bank angle, max (deg)
- Channel width (m)
- Channel length (m)
- Bank-full area (m^2)
- Floodplain width (m)
- Floodplain elevation, range (m)
- Floodplain elevation, sd (m)

Stream Reach Metrics

- Length (m)
- Profile slope (deg)
- Order (Strahler)
- Magnitude (Shreve)
- Upstream and downstream IDs
- Drainage area (m^2)



Data Release: Hopkins et al. 2020, https://doi.org/10.5066/P9RQJPT1

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Current Applications

- FACET-derived metrics used to model sediment and nutrient flux in the Chesapeake Bay (CB) and Delaware River (DR) watersheds (Lead: Greg Noe, USGS)
- Quantifying ecosystem services (sediment and nutrient retention, flood attenuation) provided by floodplains (Lead: Krissy Hopkins, USGS)
- FACET derived outputs:
  - 30-meter riparian buffer
  - Mapping of lotic waters and non-tidal riverine wetlands in high resolution land use/land cover

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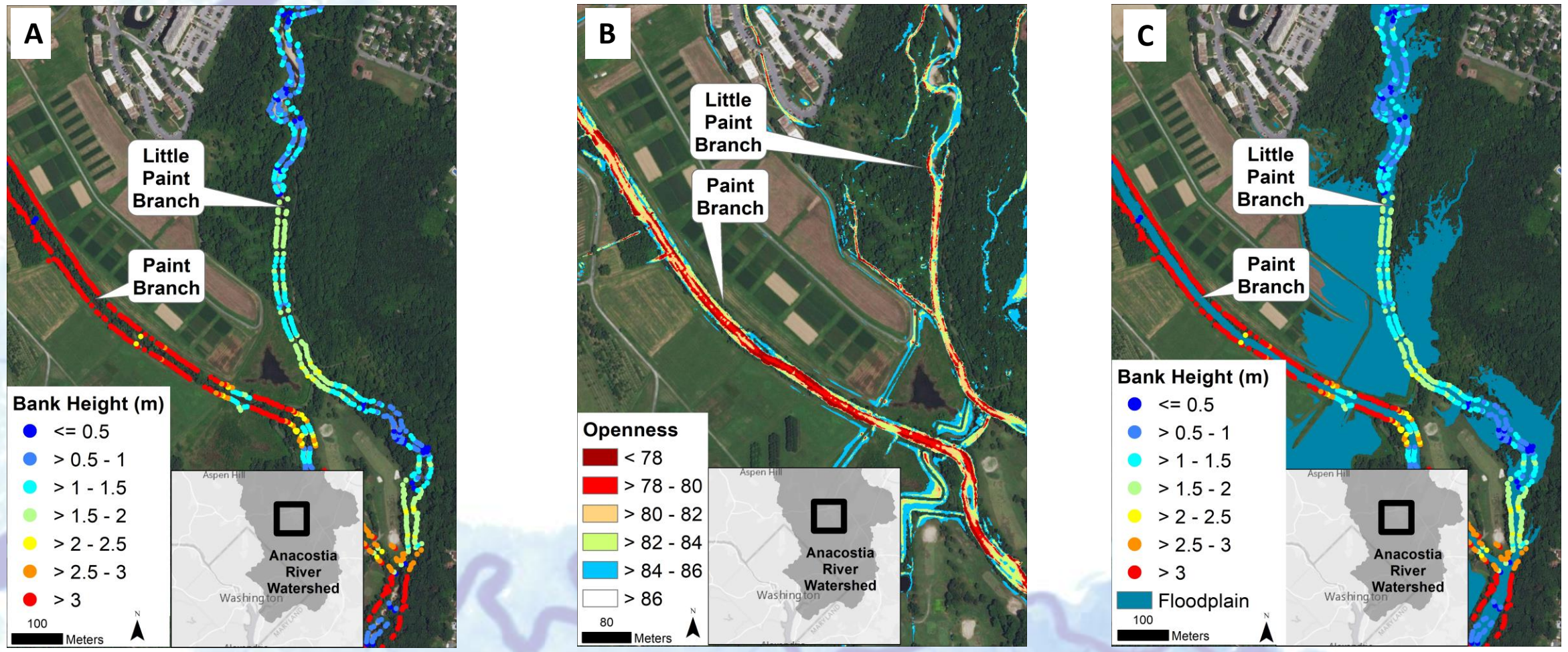
Evaluating Channel Conditions – Local Scale

Variations in bank height (A), incision (B), and floodplain extent (C) along two nearby tributaries



Source: Hopkins, K.G., Ahmed, L., Metes, M.J., Claggett, P.R., Lamont, S., and Noe, G.B, 2020, Geomorphometry for Streams and Floodplains in the Chesapeake and Delaware Watersheds: U.S. Geological Survey data release, https://doi.org/10.5066/P9RQJPT1.

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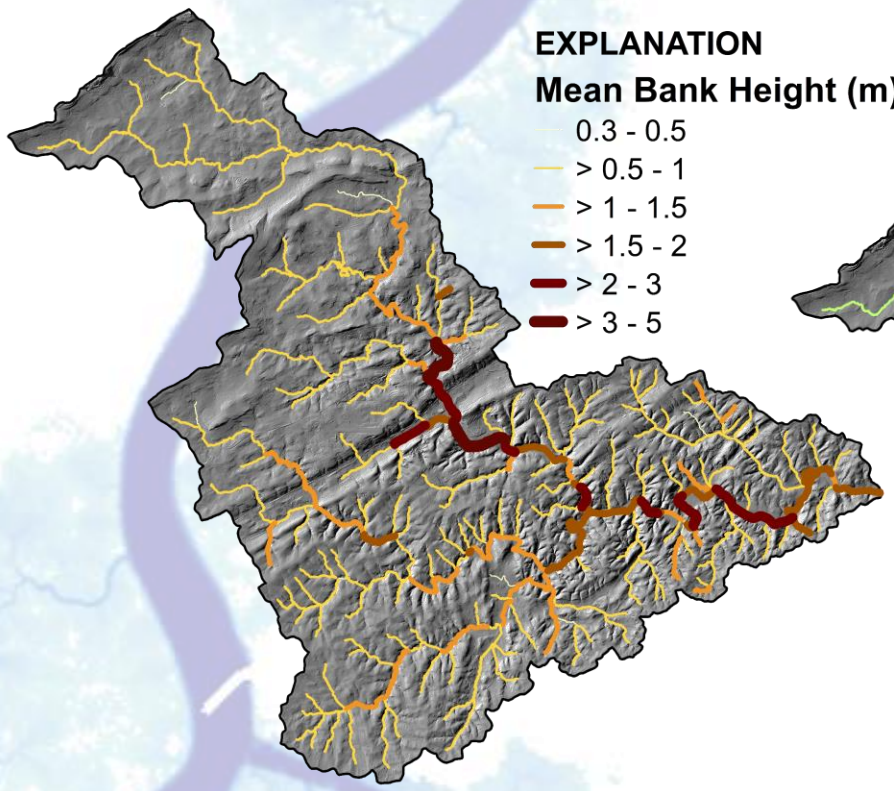
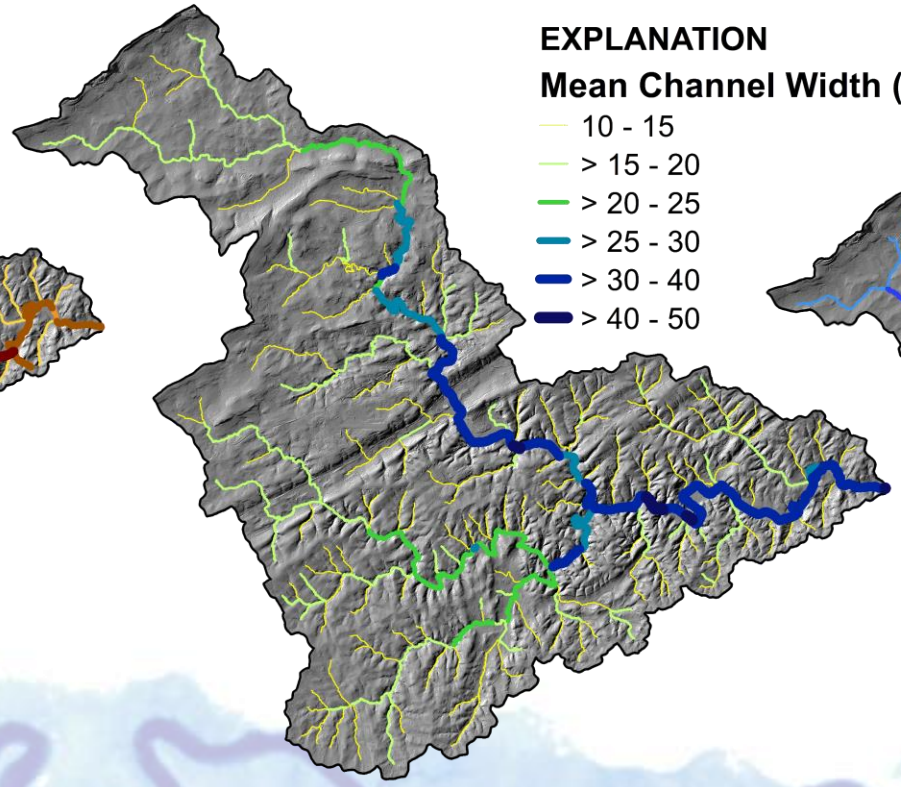
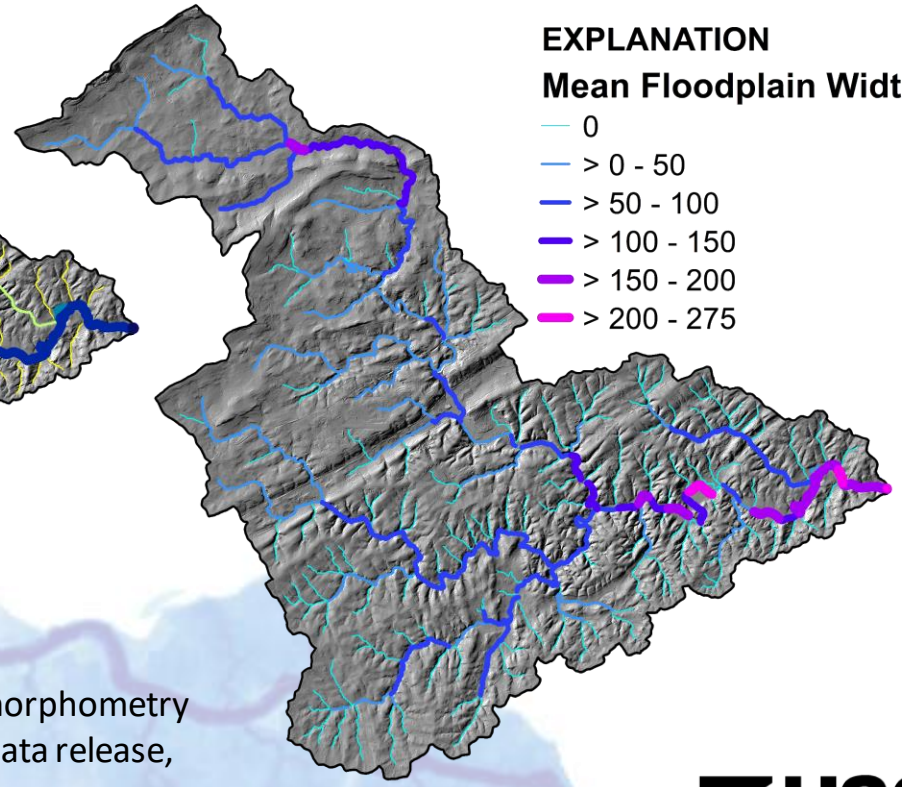
Evaluating Channel Conditions – Reach & Watershed Scale







Source: Hopkins, K.G., Ahmed, L., Metes, M.J., Claggett, P.R., Lamont, S., and Noe, G.B, 2020, Geomorphometry for Streams and Floodplains in the Chesapeake and Delaware Watersheds: U.S. Geological Survey data release, https://doi.org/10.5066/P9RQJPT1.

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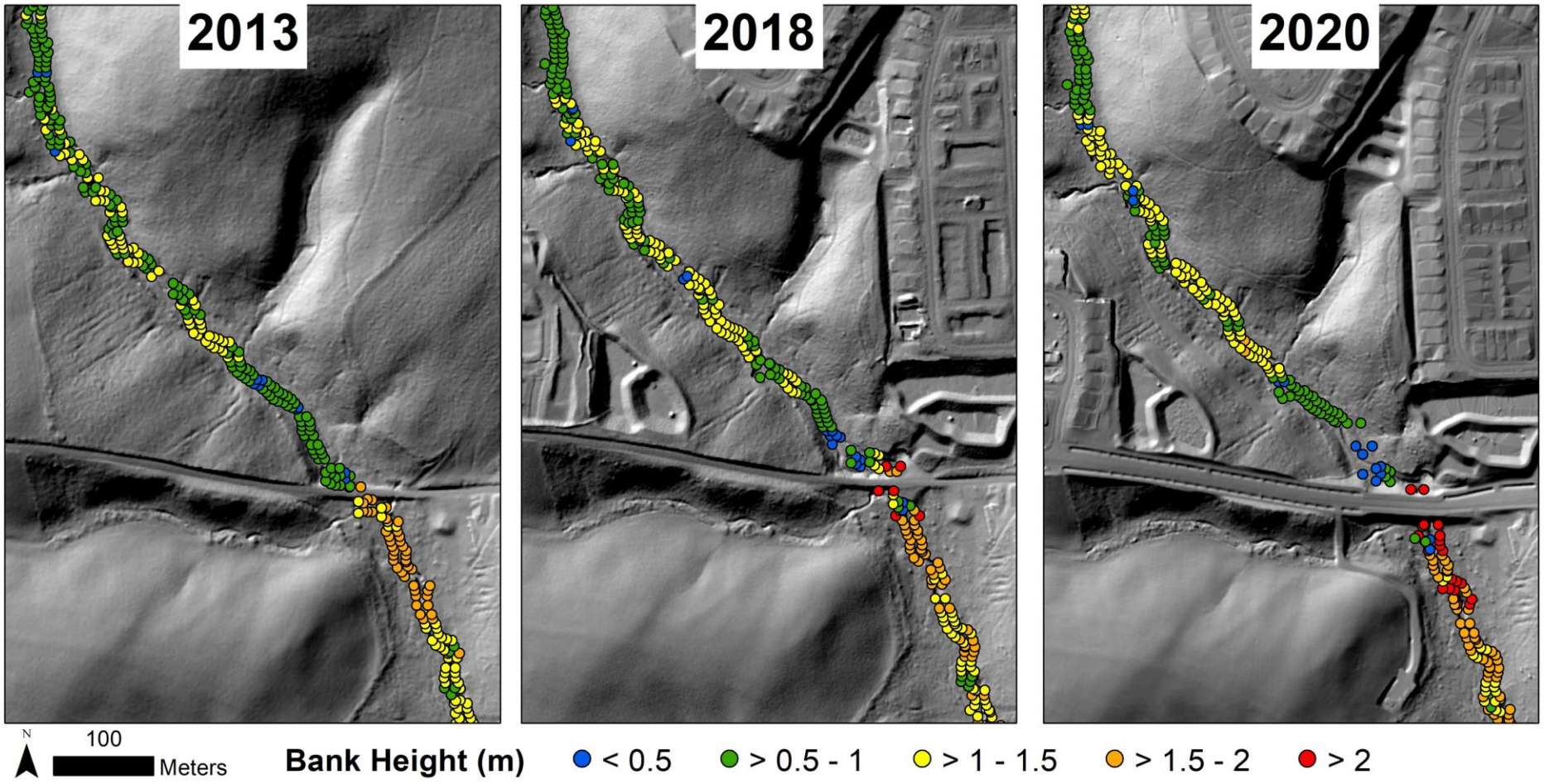
Evaluating Geomorphic Change with Repeat Lidar



Site: Urbanizing **headwater** stream

Change: channel **deepening** between 2013 and 2020

Sources: Hopkins, K.G., Ahmed, L., Metes, M.J., Claggett, P.R., Lamont, S., and Noe, G.B, 2020, Geomorphometry for Streams and Floodplains in the Chesapeake and Delaware Watersheds: U.S. Geological Survey data release, https://doi.org/10.5066/P9RQJPT1.; Metes, M.J. and Jones, D.K., 2021, Lidar-derived digital elevation models in Clarksburg, MD representing the years 2002, 2008, 2013, and 2018: U.S. Geological Survey data release, https://doi.org/10.5066/P9YQFR17.

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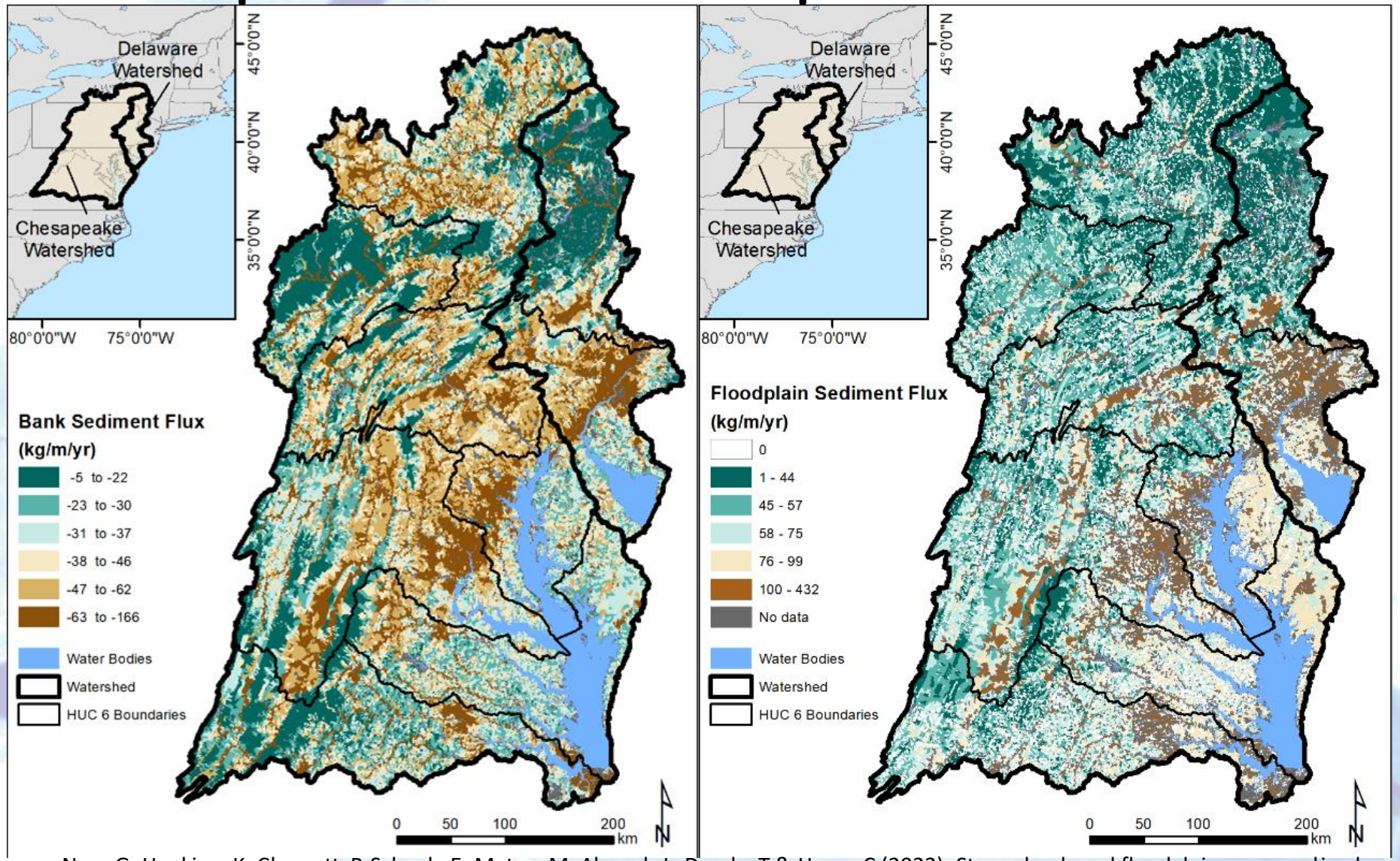
Using FACET outputs to model streambank erosion and floodplain sediment deposition across the Mid-Atlantic



We can use this information to assess an **entire watershed** and identify areas more **prone to erosion or deposition.**

This information might potentially be useful in **targeting** areas in need of **floodplain restoration** or floodplain **conservation** to **mitigate flooding** downstream.

Source: Noe, G, Hopkins, K, Claggett, P, Schenk, E, Metes, M, Ahmed, L, Doody, T & Hupp, C (2022). Streambank and floodplain geomorphic change and contribution to watershed material budgets. *Environmental Research Letters*, *17*(6), 064015.

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Next Steps: Incorporate USGS streamgage data to better calibrated FACET channel and floodplain measurements (FY-23)

- Currently we have limited sites (62) for calibration and validation, based on “geomorphically active” floodplain extent
- Field data surveys are costly and time consuming
- Geomorphic data are available in the field data collected regularly by field technicians at USGS streamgage sites
- Automate workflow to access geomorphic data for calibrating predictive models to map flood-prone areas at various recurrence intervals in ungaged reaches using lidar

Cross-sectional Surveys

Two primary methods for collecting high flow discharge measurements:

- Acoustic Doppler Current Profiler (ADCP)
- High Water Marks (HWMs) identified for indirect flow measurements

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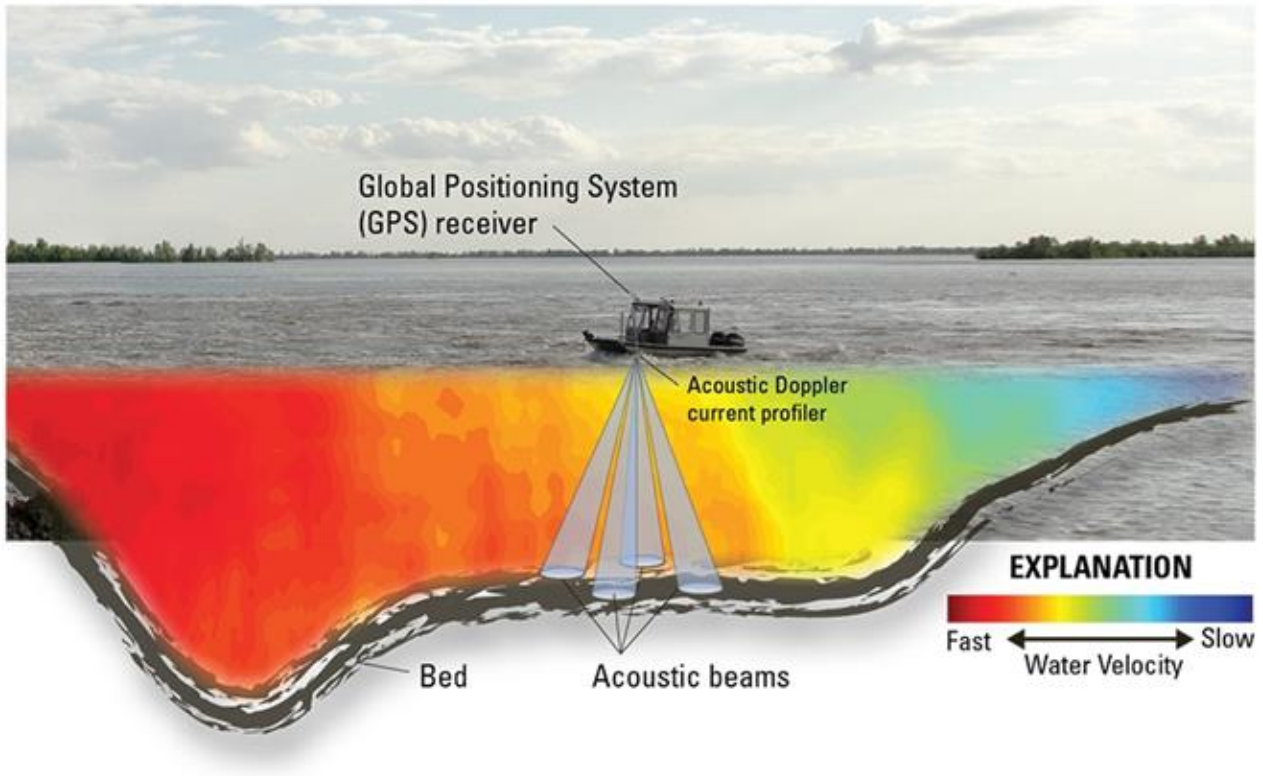
ADCP

- Discharge measurement
- "boat" collects discharge velocity and distance along the water column
- Provides cross-sectional profile of the channel
- Collected during high flows and baseflow in larger streams



Courtesy: P. Ryan Jackson, USGS Central Midwest Water Science Center

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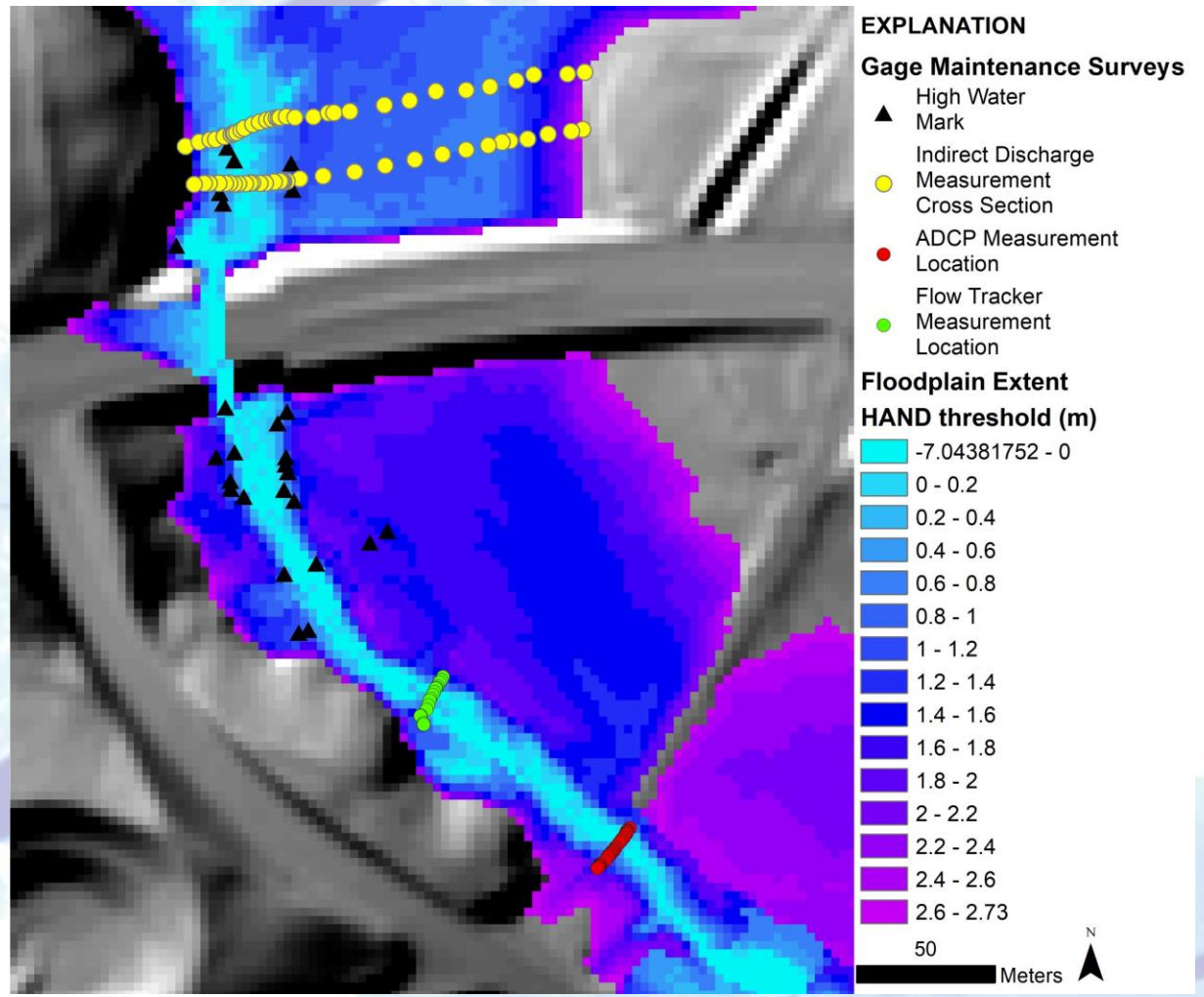
High Water Marks

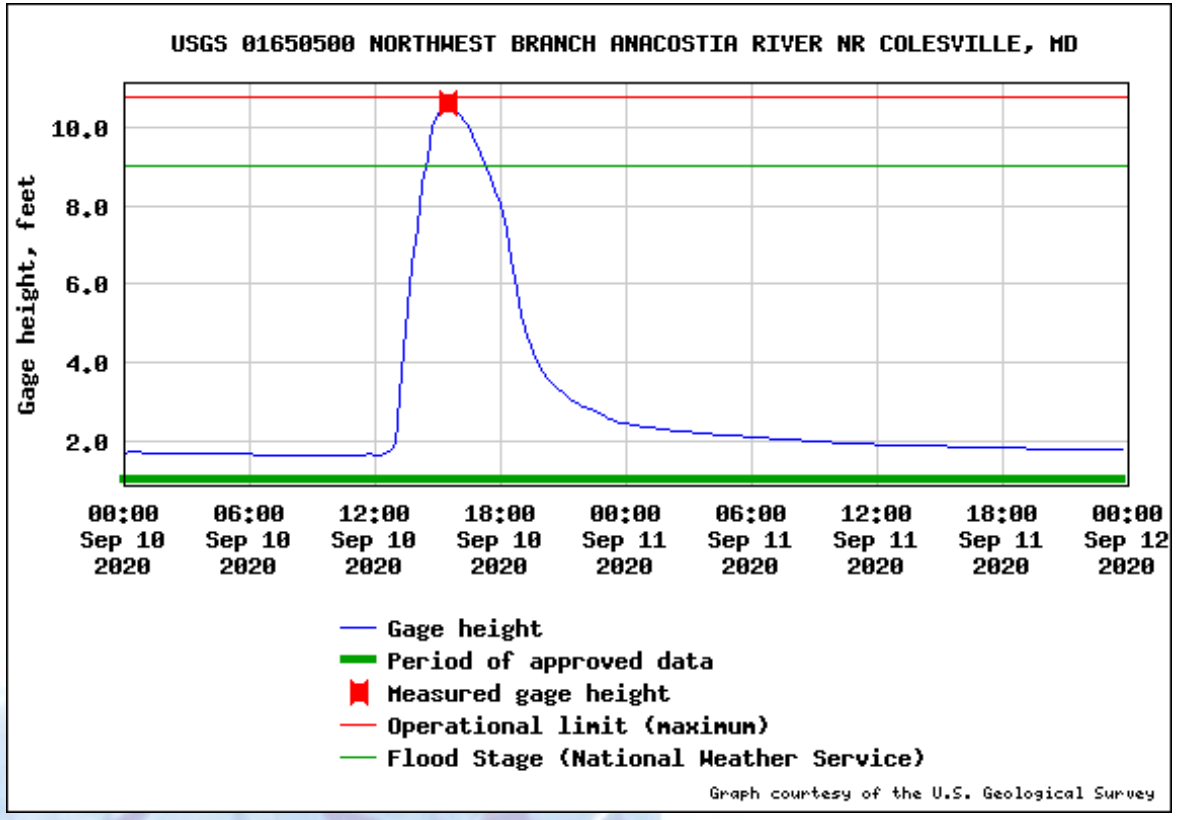
- Indirect flow measurements (IFMs) collected after storm events near the streamgage
- HWM: highest elevation of floodwaters
- Cross-section profile of the channel and the floodplain extent

Sources/Usage: USGS. Public Domain.

Calibrate Floodplain with High Water Mark Data

Pilot site: NW Branch Anacostia at Colesville, MD





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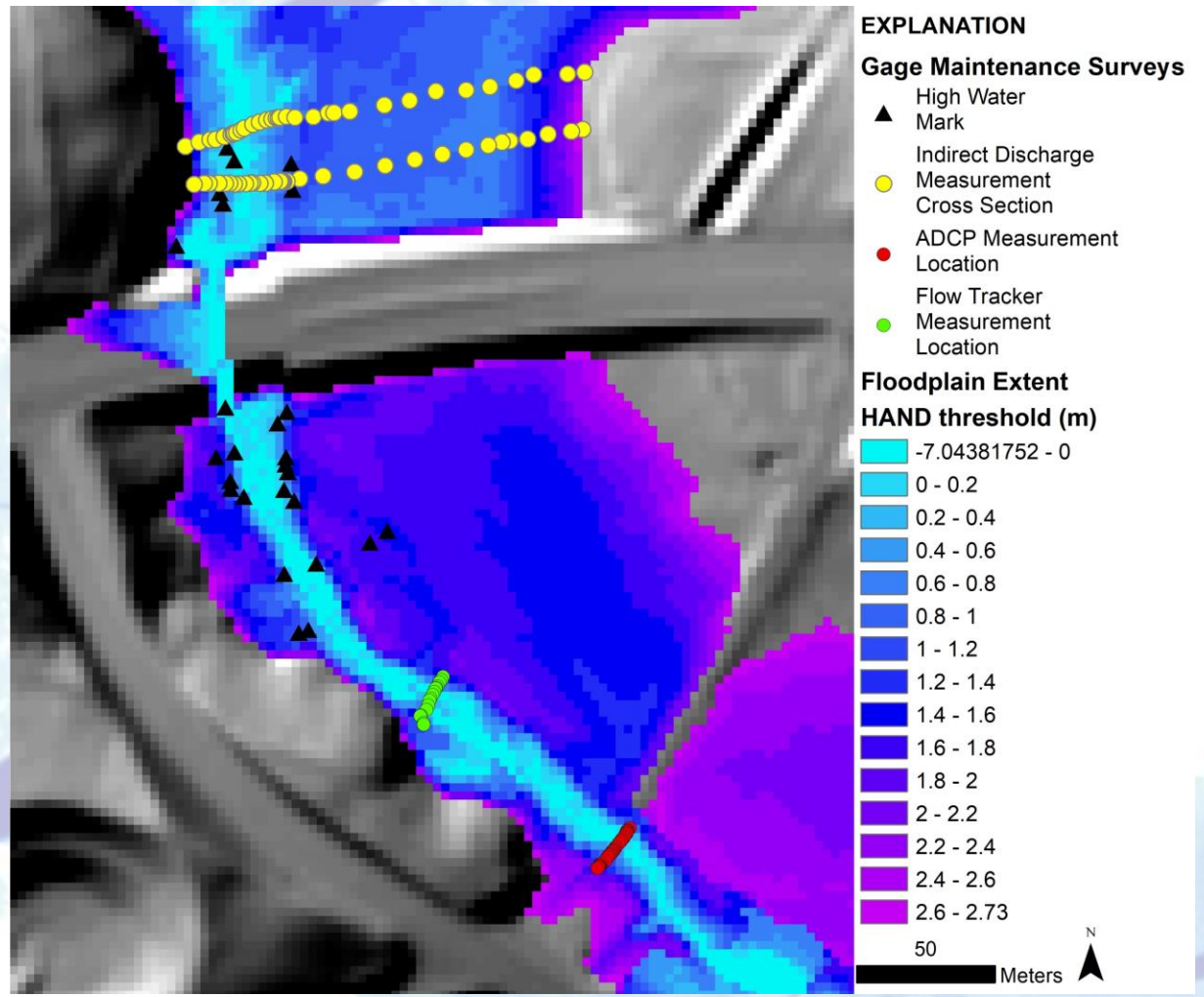
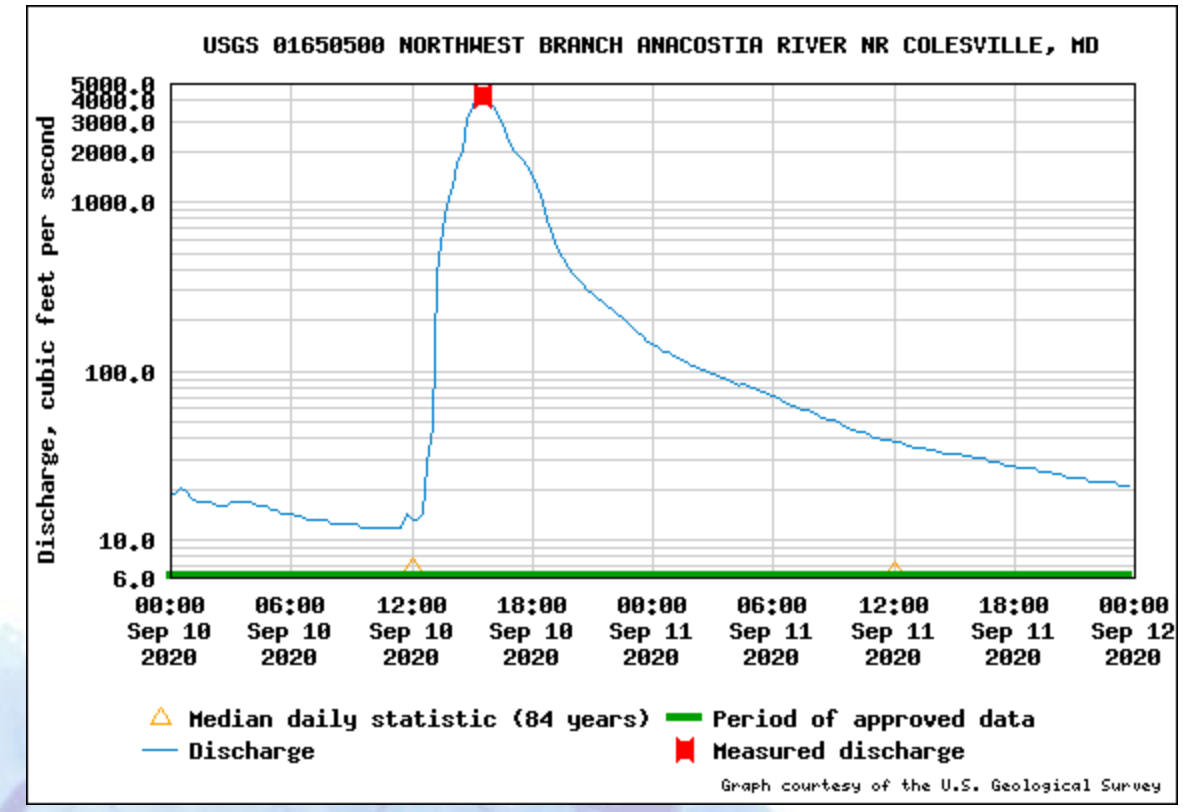


~ 5% AEP or 20-year flood (based on USGS StreamStats)



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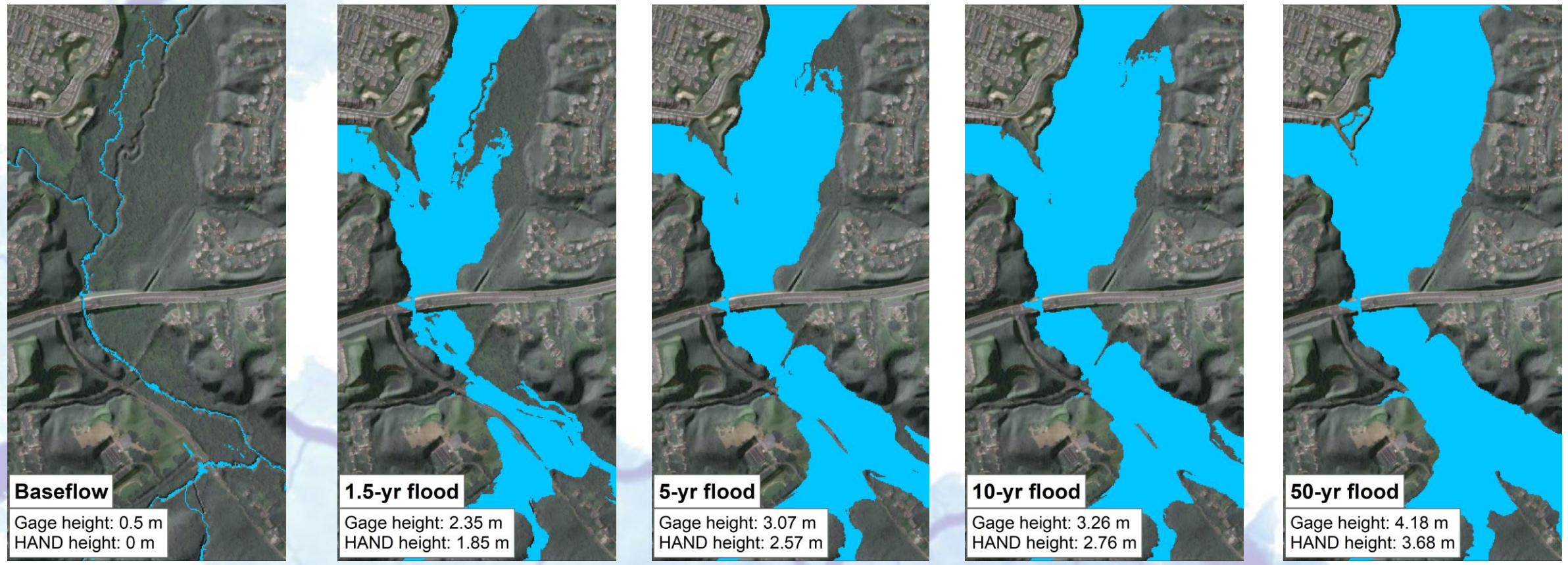
Calibrate Floodplain with High Water Mark Data

Pilot site: NW Branch Anacostia at Colesville, MD

Calibrating floodplain extent to various flood recurrence intervals



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Challenges

ADCP

- Some cross-section profiles have gaps
- Random collections near gaged sites

HWMs

- Smaller sample size
- Offline storage at water science centers
- Not spatially referenced to an established datum

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Summary and Discussion

- Project Priorities:
  - Development of geomorphic metrics that assess stream impairment
  - Develop remotely sensed methods for long-term stream restoration monitoring using FACET
  - Improve floodplain mapping capability in FACET
- Questions for audience:
  - How do practitioners want to use the data to make management decisions?
  - What types of data and metrics, and at what scale?
  - Important flood recurrence intervals for practitioners: 5, 10, 20, 50 (year)?
  - Potential GIT project ideas to support workgroup's goals and priorities

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Resources and Contacts

- Data: **https://doi.org/10.5066/P9RQJPT1**
- Code: **https://code.usgs.gov/water/facet**
- Online Viewer: **https://www2.usgs.gov/water/southatlantic/projects/floodplains/**
- Contacts:
  - Labeeb Ahmed (lahmed@usgs.gov or lahmed@chesapeakebay.net)
  - Marina Metes (mmetes@usgs.gov)

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