Evaluation of watershed-scale impacts of stormwater management facilities on thermal loads to a Maryland Class IV stream using a high-frequency sensor network

Claire Welty, UMBC
Andy Miller, UMBC
in partnership with
Kevin Brittingham, Baltimore County DEPS
June 16, 2022

Research question to be addressed

What best management practice design and siting methods will reduce thermal impacts to Maryland's Use III and IV streams?

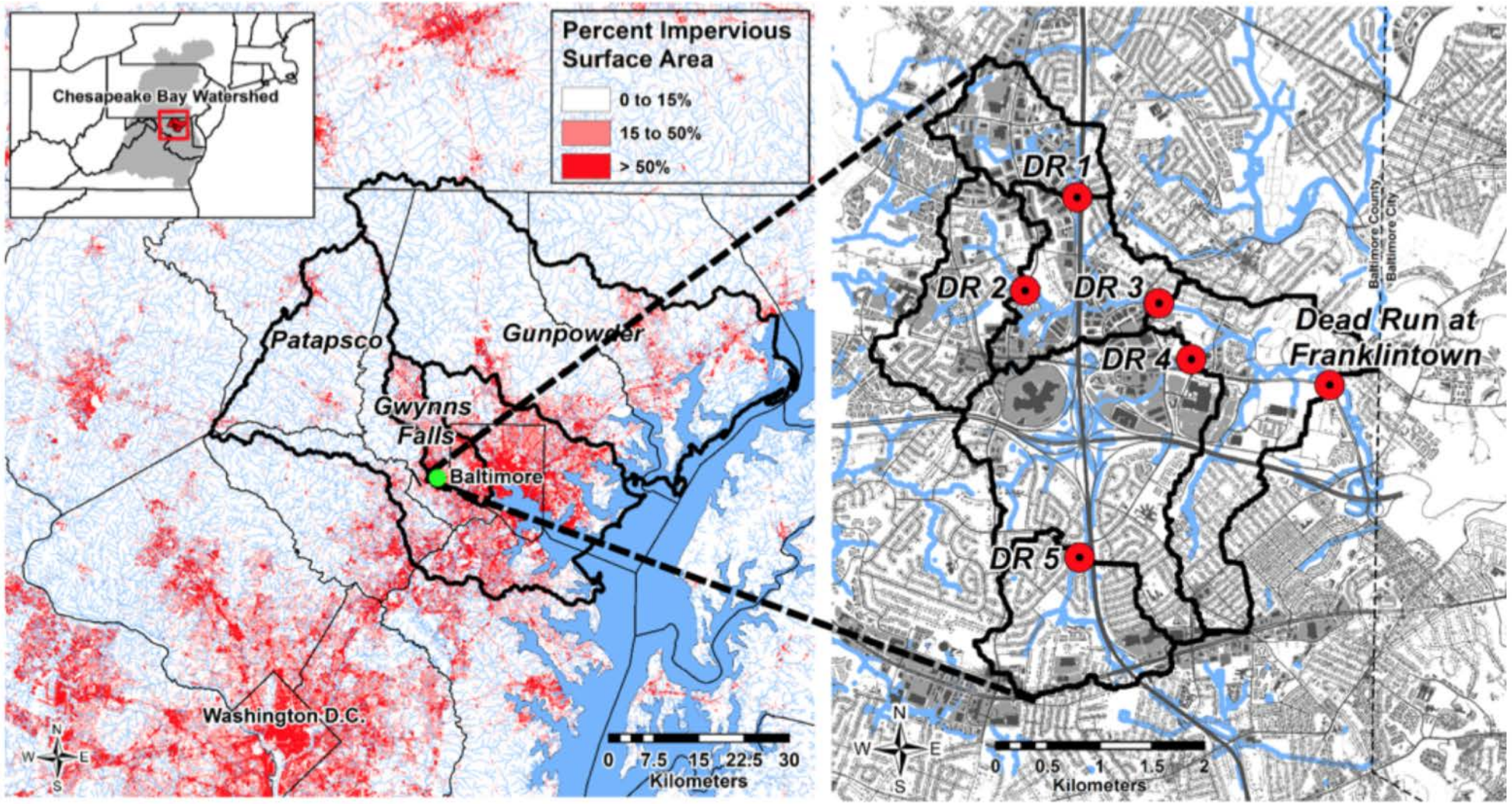
Hypotheses

H1 High spatial- and temporal-resolution observations of stream water temperature reveal patterns of influence on thermal loading associated with land cover and stormwater management features.

H2 The thermal impact of surface stormwater facilities is comparable to that of directly-connected impervious surfaces at the watershed scale. The relative importance depends on drainage ratio of connected impervious to drainage area treated by stormwater management.

H3 Discharge from underground stormwater management facilities better mitigates thermal impacts to streams compared to drainage from surface stormwater facilities.

Dead Run watershed study area - Use Class IV stream network



Proposed tasks to be undertaken

- Water temperature sensors to be deployed at high spatiotemporal resolution at watershed scale
- Air temperature sensors to be deployed at USGS stream gages
- Data to be recorded every 5 minutes for 2 years/ all flow regimes
- Data to be downloaded periodically
- Spatiotemporal mapping of data at watershed scale to be done
- Statistical analysis of data to be carried out

Deployment design

HOBO TidbiT MX 2203 temperature data loggers (water)

- 160 sensors
  → Every 100 m along all accessible stream segments of the Dead Run, 16 km total
- 140 sensors
  → Longitudinal transects of temperature sensors at ~2-5-10-50 m intervals downstream ~30 stormwater management facilities

HOBO MX2305 temperature sensors (air)

- 6 sensors
  → At 6 USGS stream gaging stations

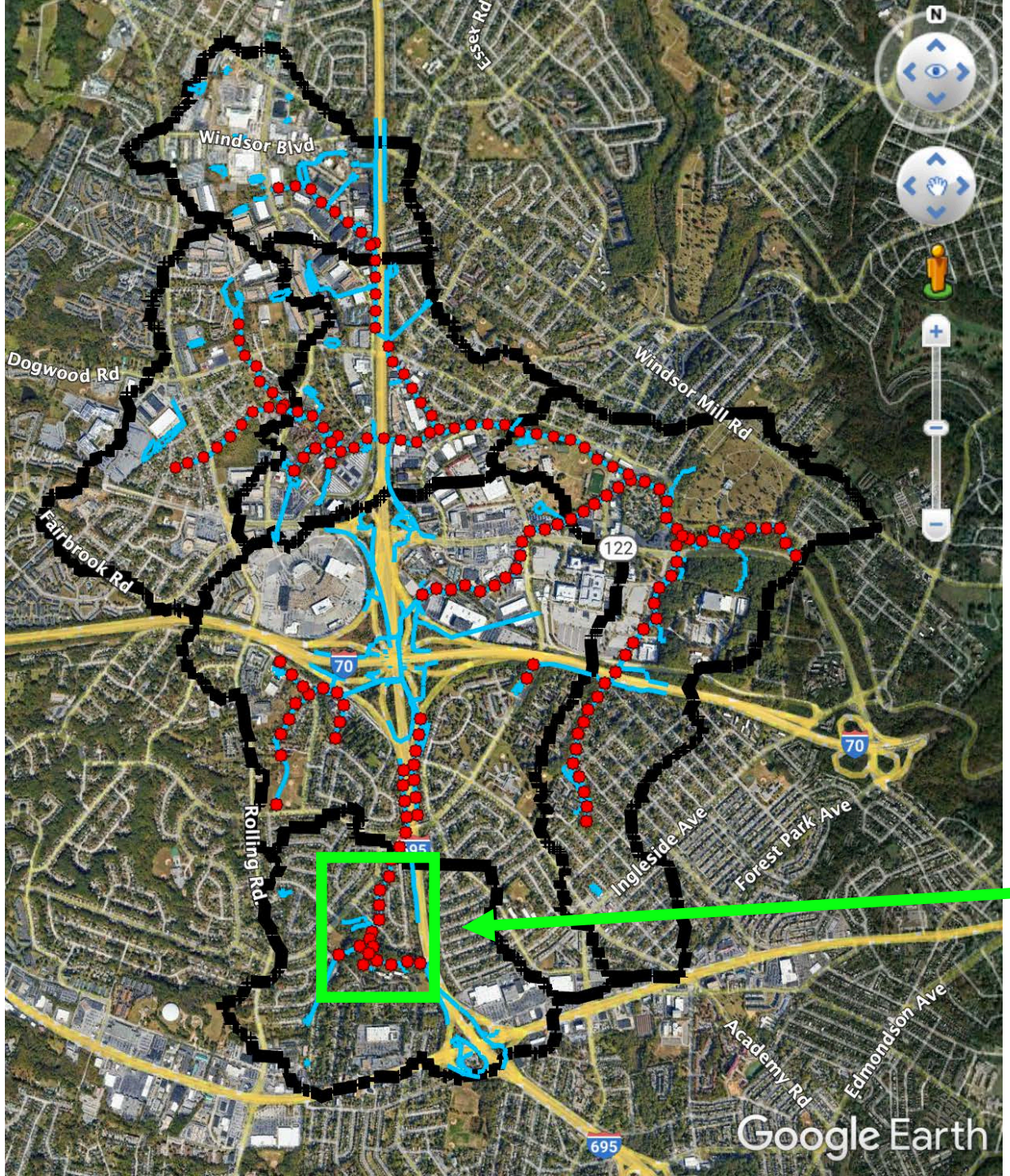
Status update

- Project started 7/15/2021; sensors ordered immediately
- Sensors arrived Oct 2021 owing to “supply chain issues”
- Air temperature sensors deployed Oct 2021
- 169 water temperature sensors deployed Dec 2021 – March 2022
- Trial download conducted in Jan 2021 for one subwatershed
- First download of all data to be carried out July 2022
- Finer-scale deployments will be made based on watershed-scale data

Deployment challenges

- Bluetooth downloadable sensors will not work through water
- Needed to devise a scheme for secure deployment yet quick release
- Need to be able to find sensors upon return visits
- Stream channel is particularly difficult to navigate owing to downed Ash trees
- Necessary to hike 16 km twice – once for reconnaissance; once for deployment
- Icy weather conditions owing to order delay

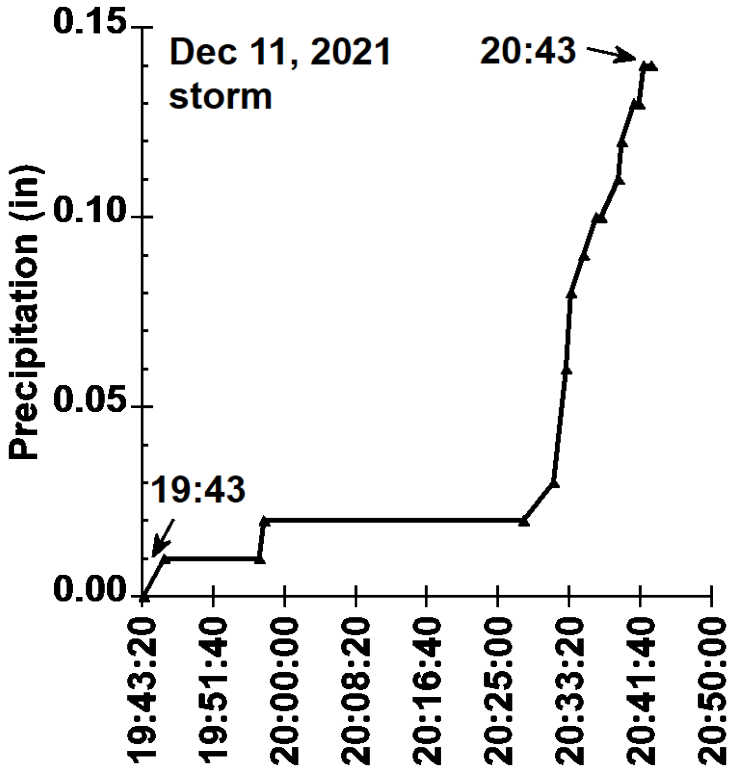
Deployment solution



Deployment achieved:
169 locations over 16 km

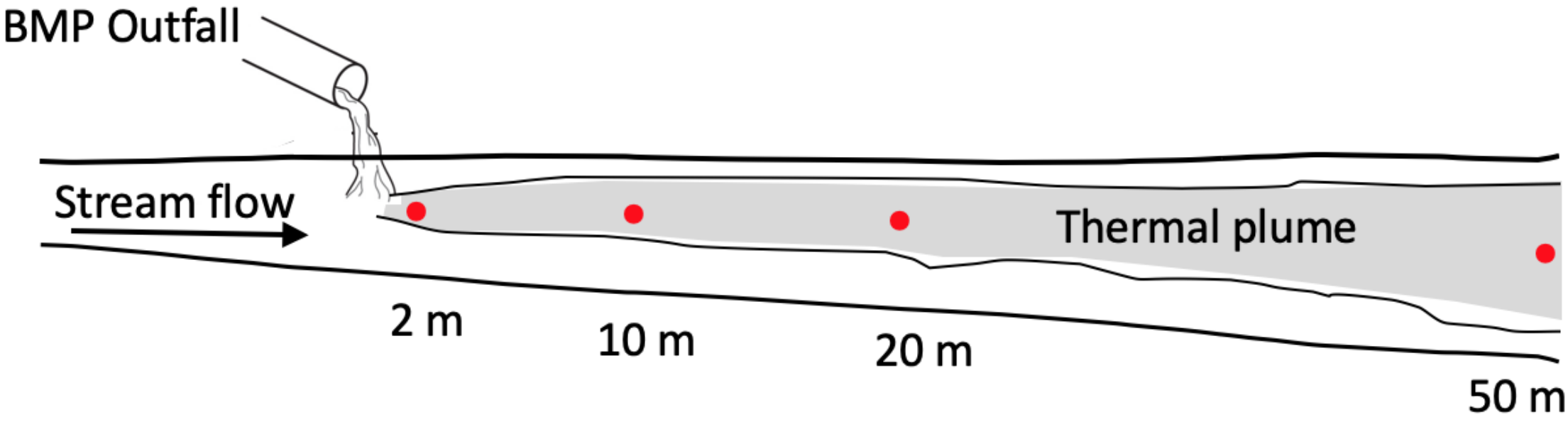
Trial download

Stream temperature response to storm runoff



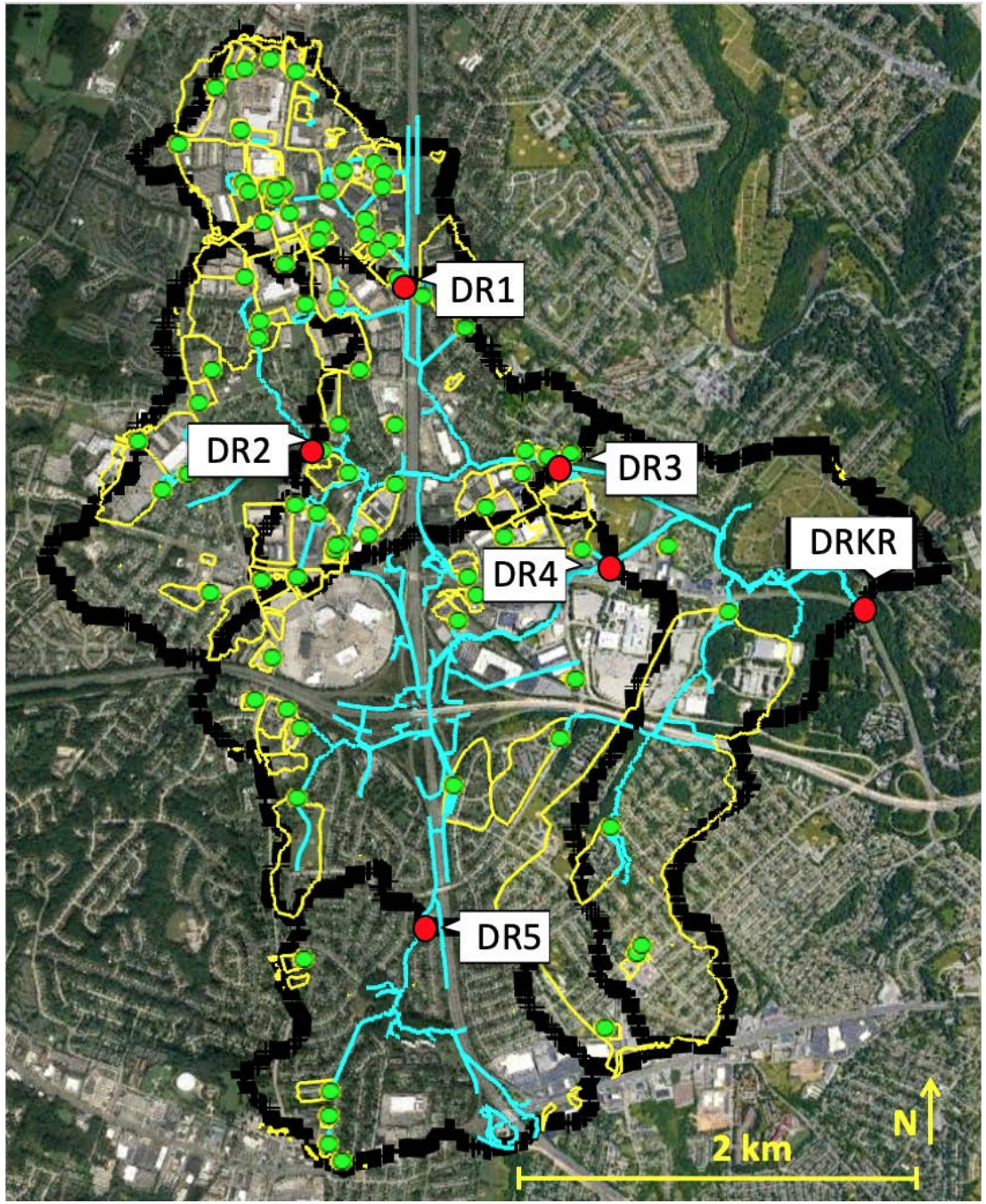
Next steps

- Download of entire stream network
- Selection of stormwater facilities for finer-scale deployments



Locations of stormwater management facilities in Dead Run

30 sites to be selected for denser stream temperature instrumentation



Stormwater facilities permitted by Baltimore County located in Dead Run watershed

Facility type	Number
Bioretention	1
Detention structure (dry pond)	21
Extended detention structure, dry	34
Infiltration basin	1
Infiltration trench	1
Microbioretention	2
Oil grit separator	5
Permeable pavement	3
Sand filter	7
Shallow marsh	1
Submerged gravel wetland	1
Underground filter	1
Wet pond/wetland	2
Other	4

Acknowledgments

CBT/DNR – pooled monitoring fund

UMBC/CUERE staff

Mary McWilliams, John Lagrosa, Hanna Donovan

USGS - Sarah Queen

Translation Slides

Greg Golden, MD DNR
Karl Berger, MWCOG

What are the take-home points?

- The study will develop addition insight on site conditions and SWM BMP thermal sensitivity that can be considered when designing SWM approaches or retrofits in regulated coldwater systems.
- We can expect useful stream system data and observations that can also be used in stream and riparian restoration efforts.
- Preliminary results from the trial storm on 12/11/2021 show the deployment system's ability to record fine differences in temperature.
- Study holds great promise for detailing rapid differences in temperature during stormflows.

What are the take-home points?

- Specific site and design cases are important tools for the thermal review field, and several will be developed in this study.
- Reviewers should gain further thermal insight into SWM BMP types, potentially into certain unique design features and options found on specific BMP sites, and for watershed/tributary/riparian condition and influence.
- The study results can be applied to both future specific project reviews, and also will help to identify additional technical details and watershed conditions for further study or observation in coldwater regulatory review.

What does this mean for me?

- Need data like this if we are to mitigate increasing stream temperatures
  - → Whether voluntarily or through regulation
- Effort should be expanded to other watersheds
  - → Need to determine how much we can mitigate high temperatures based on watershed characteristics
  - → The study can inspire more work on not only coldwater system thermal review, but also possible nuanced thermal effects to warmwater aquatic species, and level of thermal influence on restoration ecological uplift potential