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, Andy Miller, Mary McWilliams,
John Lagrosa, Nick Simeone
UMBC/CUERE
in partnership with
Kevin Brittingham, Baltimore County DEPS

Translation Slides
Greg Golden, Maryland DNR

June 21, 2023





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?

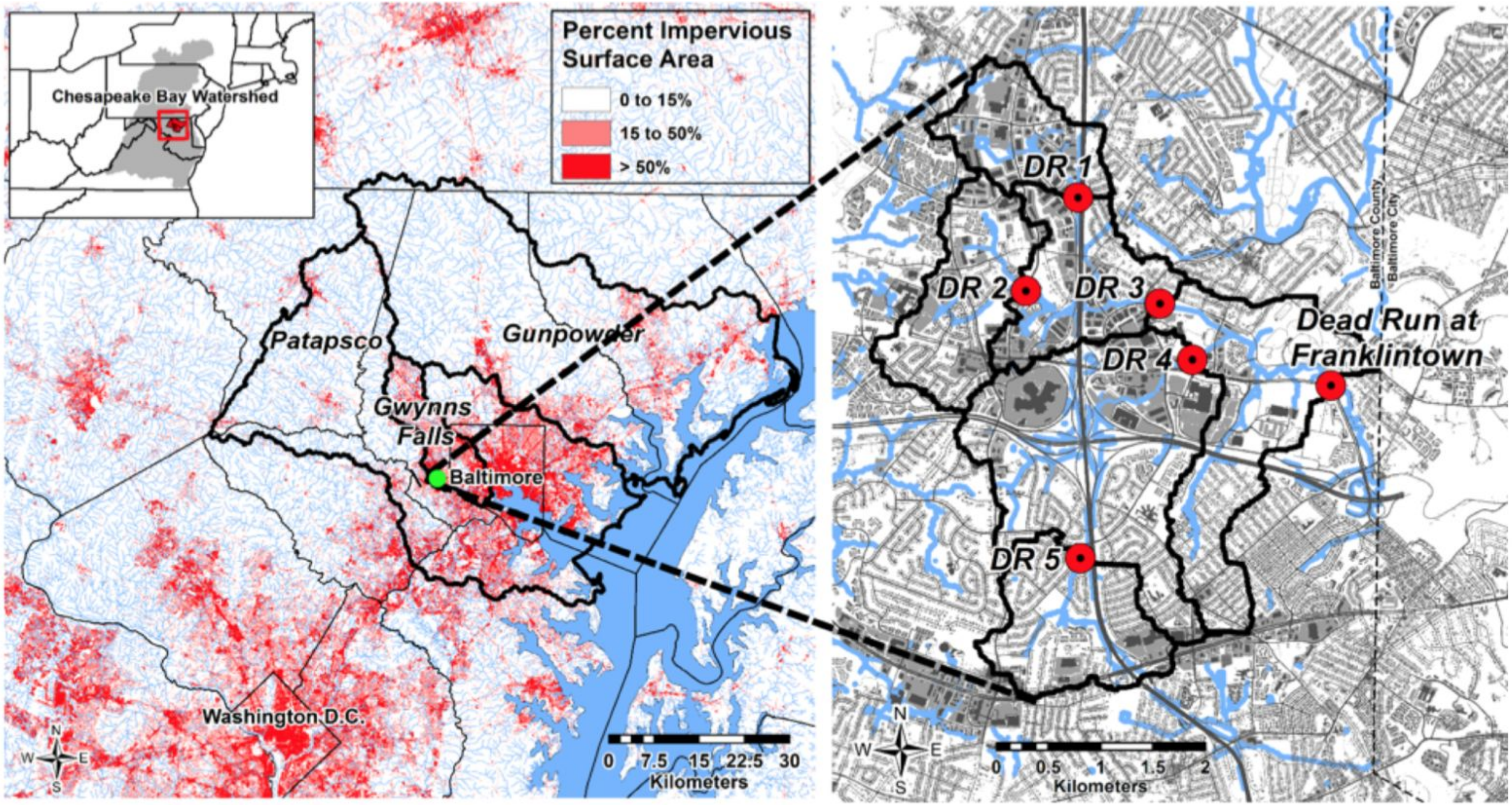
Hypotheses

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.

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



84 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

Status update

- 6 air temperature sensors deployed Oct 2021
- 169 water temperature sensors deployed Dec 2021 – March 2022
- 35 additional water temperature sensors deployed Sept 2022/ Feb 2023
- Complete downloads of data: July/Aug 2022; Jan/Feb 2023
- Next download scheduled for Nov 2023
- Video mapping workflow completed.
- Statistical analyses to be done in the coming year.

Sensor deployment design

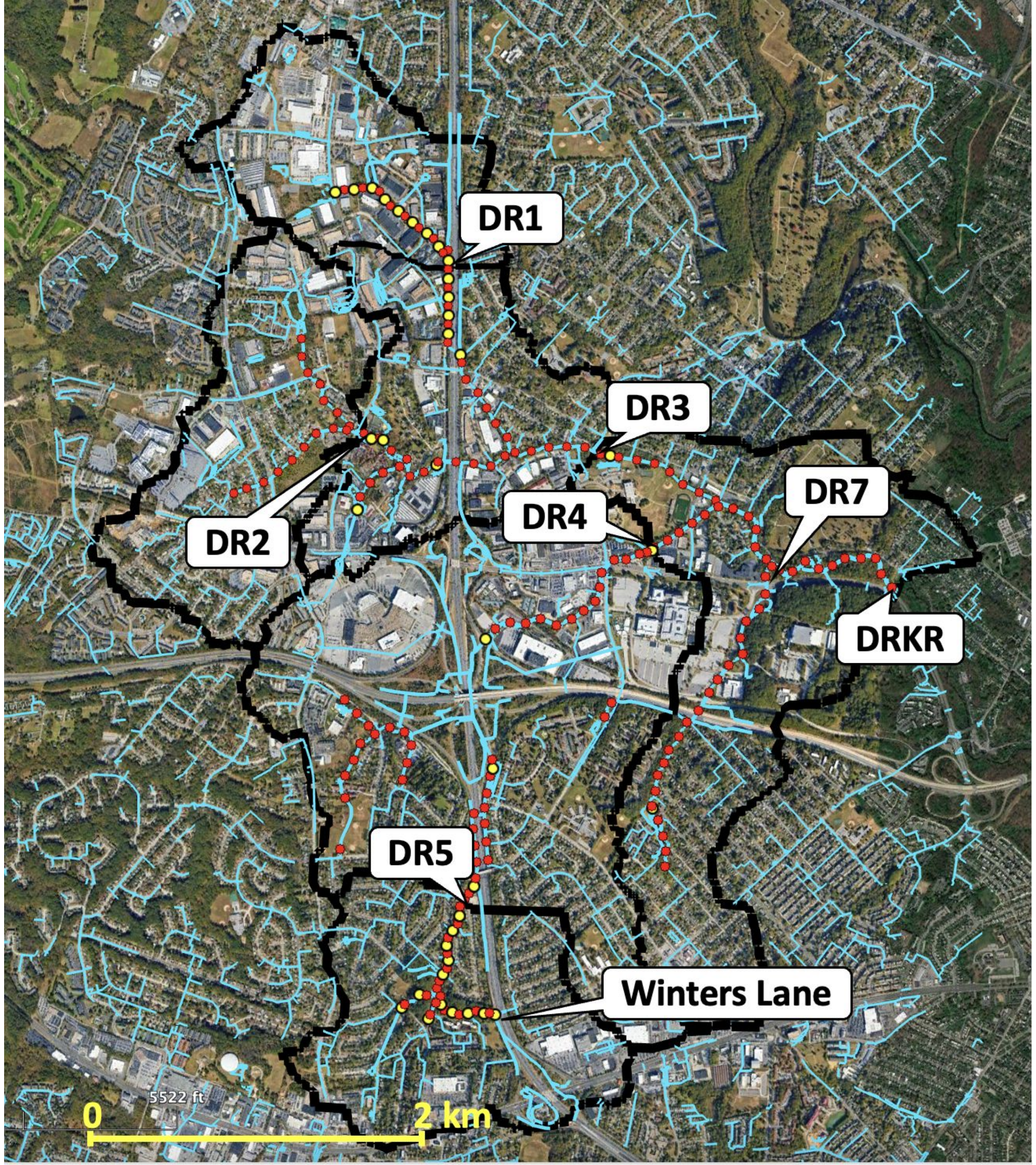
HOBO TidbiT MX 2203 temperature data loggers (stream)

- 204 sensors
  - Every 50-100 m along all accessible stream segments of Dead Run, 16 km total
  - ~2 m downstream of all stormwater management facilities

HOBO MX2305 temperature sensors (air)

- 6 sensors
  - At 6 USGS stream gaging stations

https://www.onsetcomp.com/



Sensor station map

- 204 locations over 16 km
- Red markers: 100 m spacing
- Yellow markers: 50 m spacing
  + 2 m downstream of SWM facilities



Stream temperature animation using GIS and video editing software

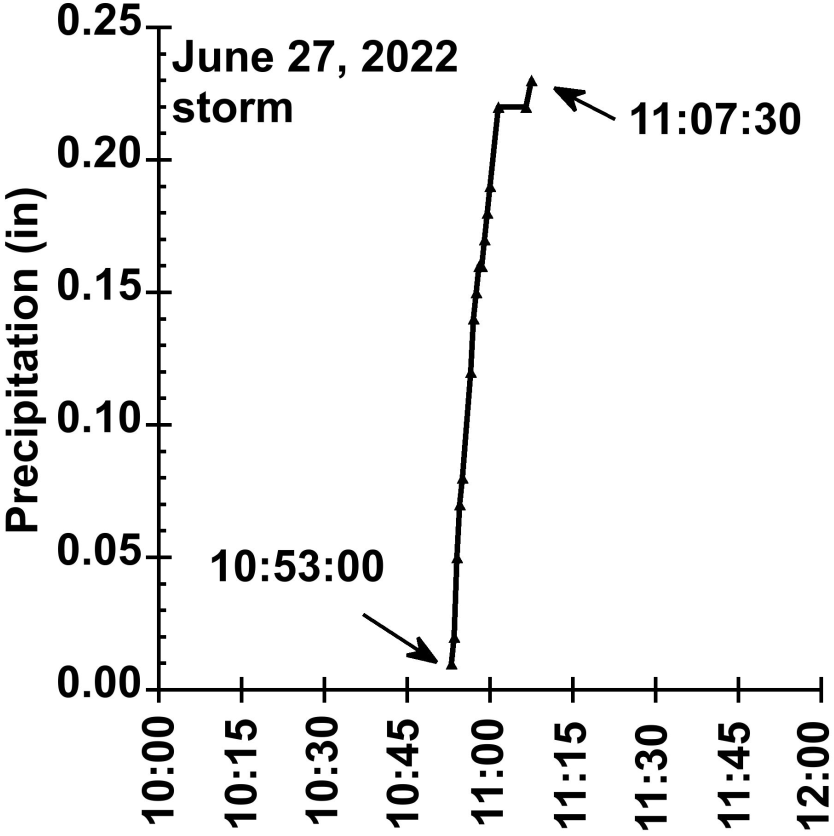
- Example animation: June 27, 2022 storm, 10:53 – 11:07 AM
  - Animation for 24 hours surrounding storm (@ 5 min time step)
  - 288 data snapshots = 288 maps

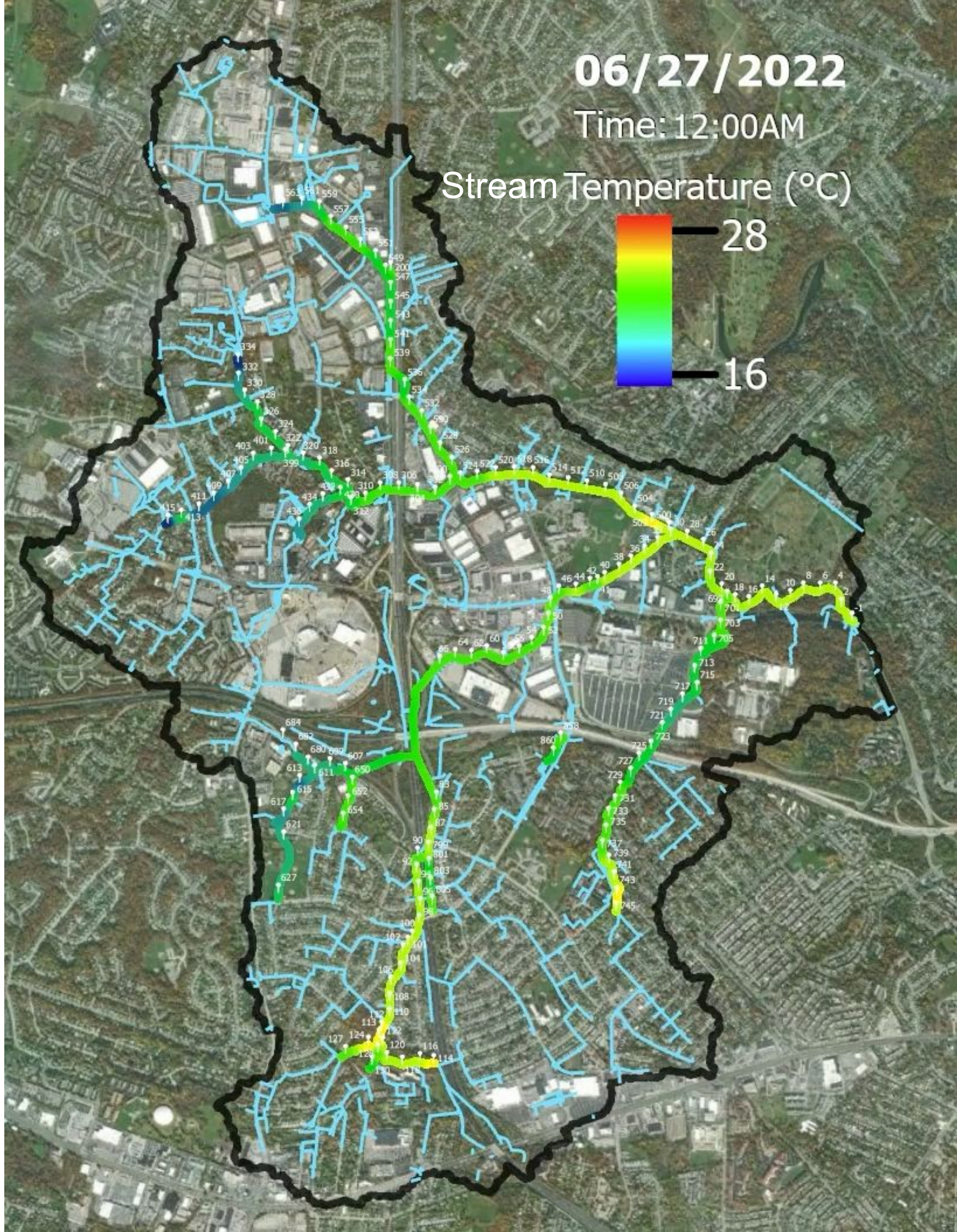
- We constructed a GIS model that automates map creation
  - Each map shows temperatures for all sensors in a “view” at a single snapshot in time.
  - The model then iterates for all 288 maps in one day.
  - We can do this for any view (e.g. one stream segment or all) and for any time period for which we have data.

Stream temperature animation using GIS and video editing software

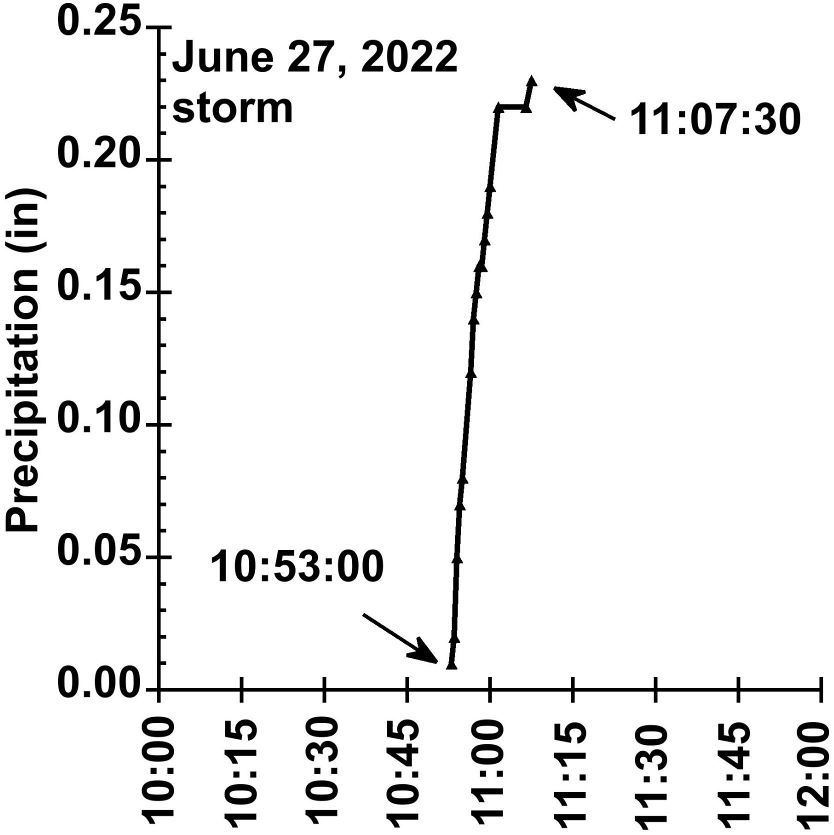
- Temperatures are displayed using an interpolated color gradient
- The collection of maps is then arranged
  - in sequence
  - for a set duration
  - analogous to a digital version of flip-books children play with

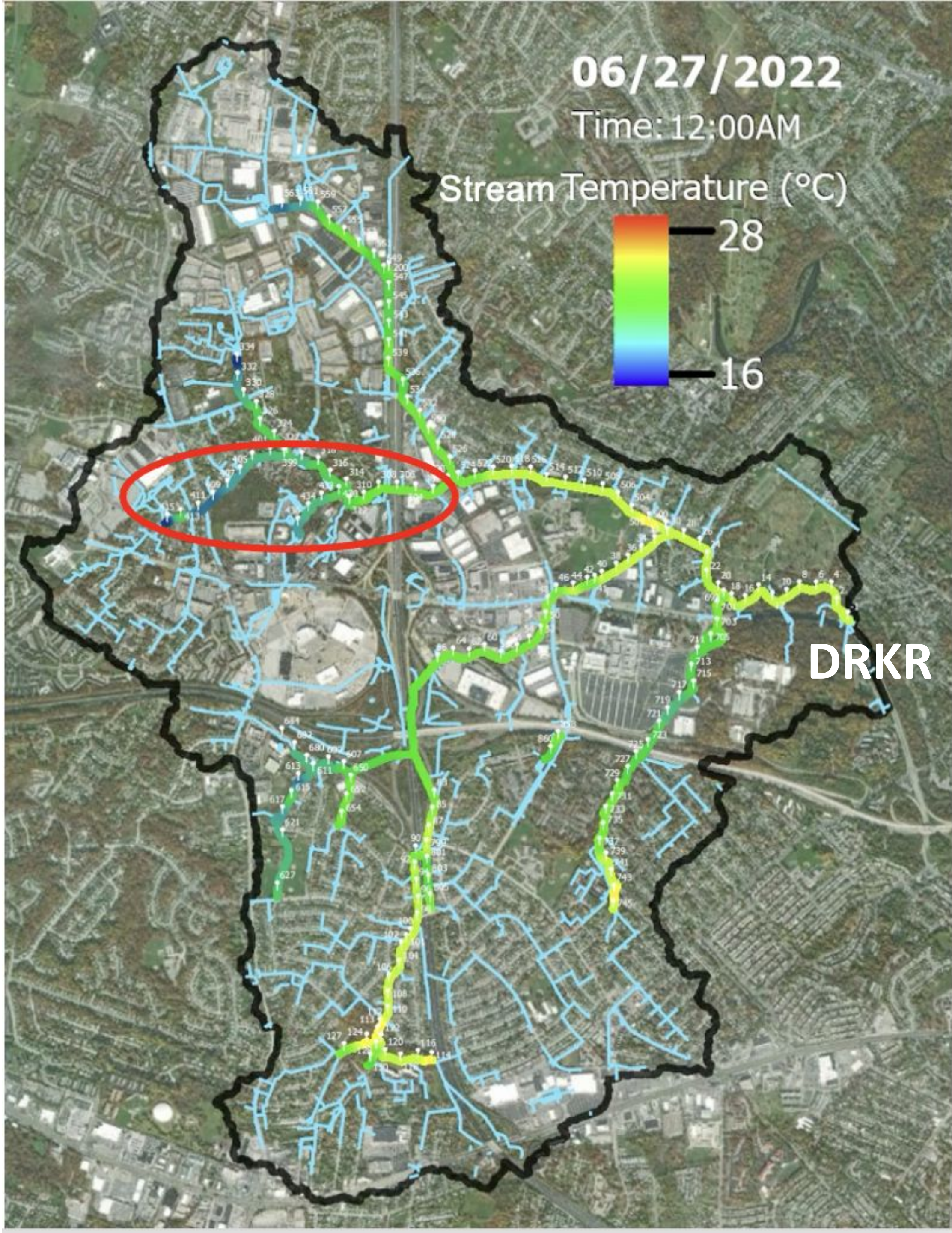
Example animation: June 27, 2022 storm



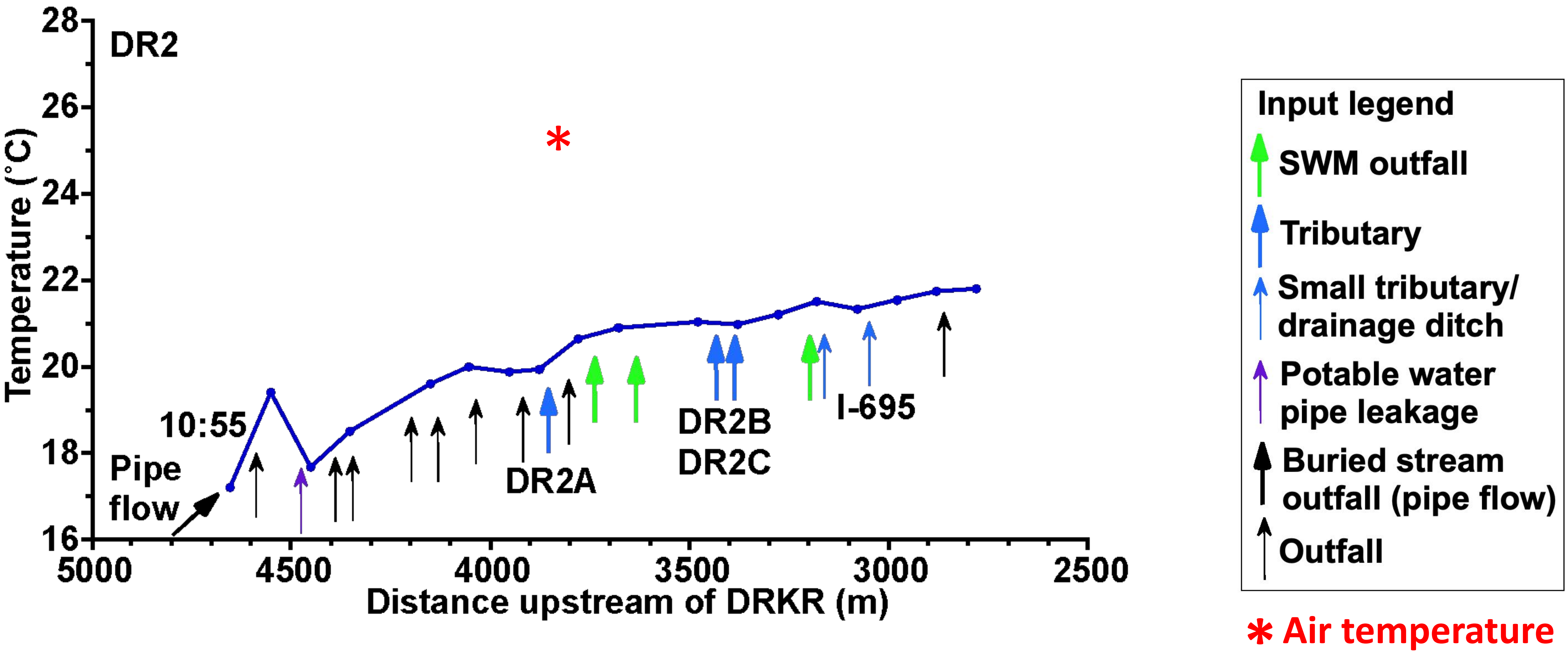


Example animation: June 27, 2022 storm

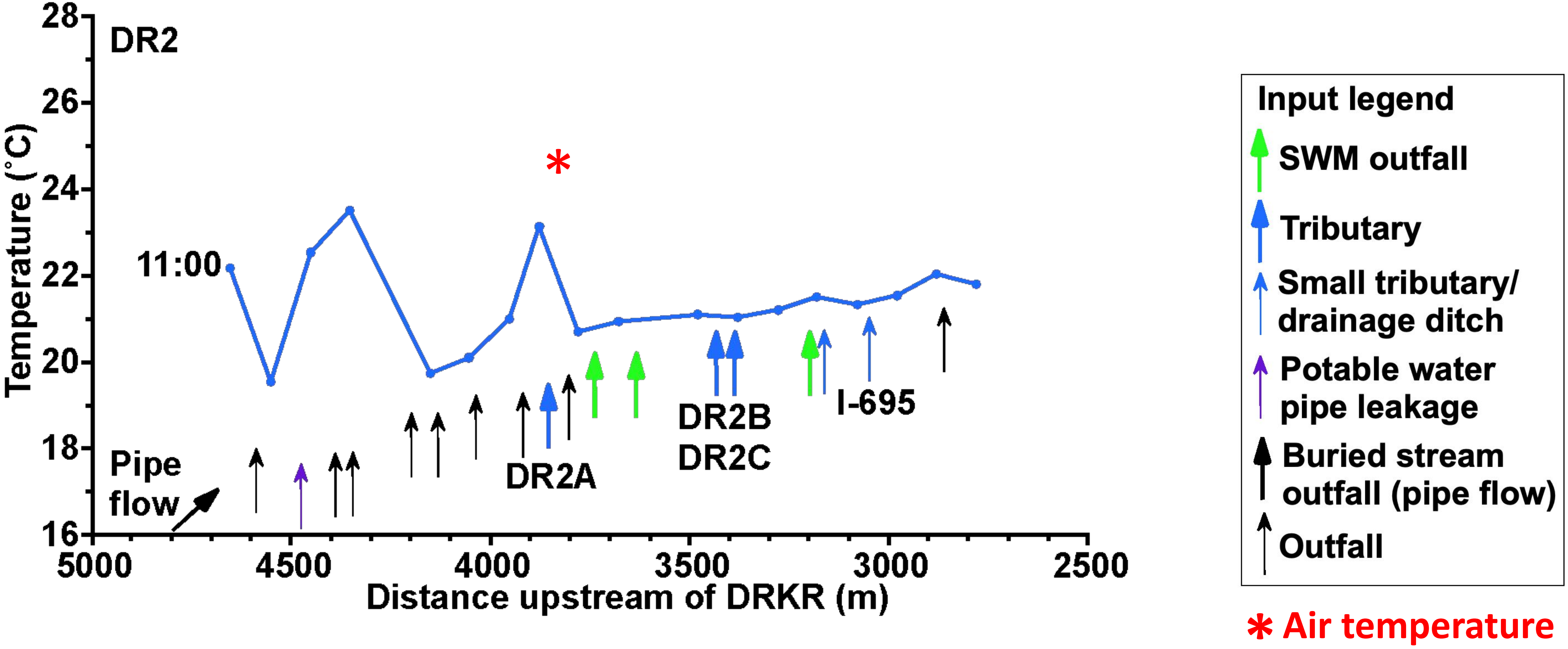




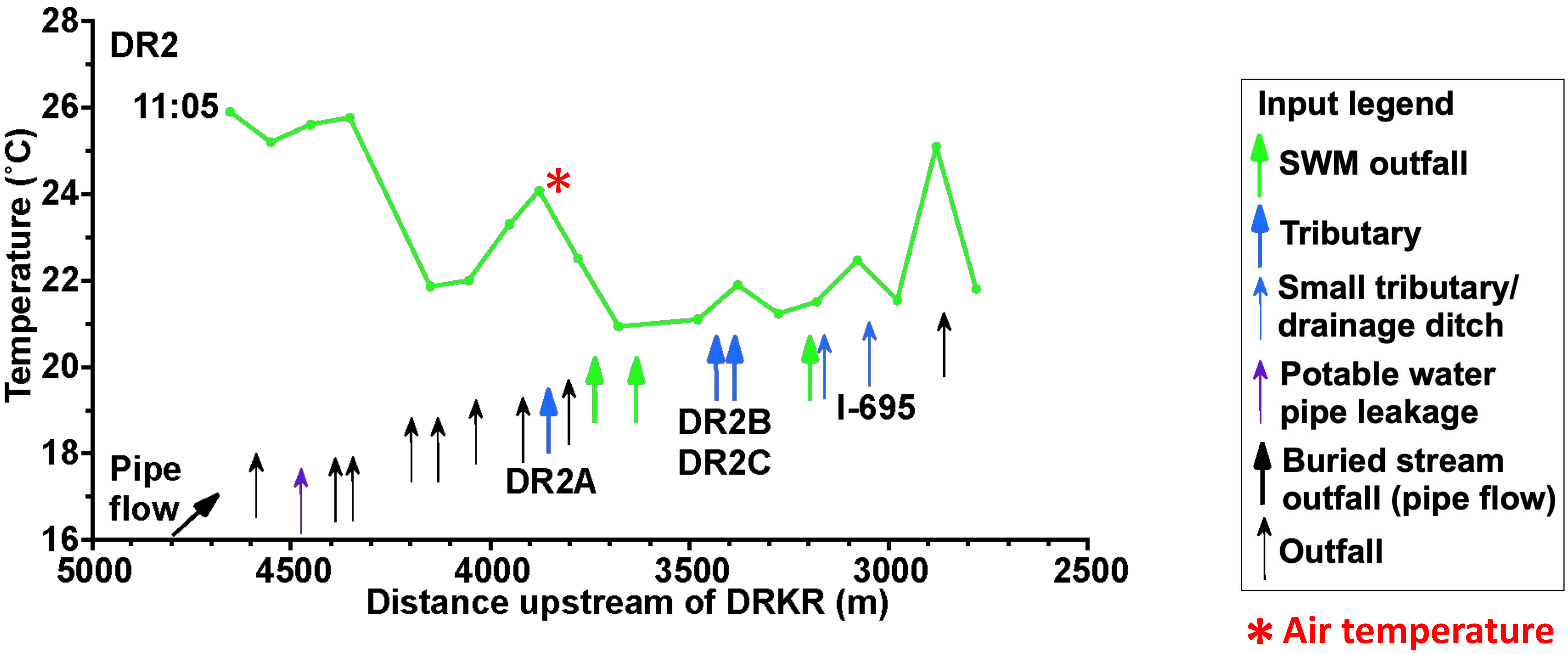
Example plots: June 27, 2022 storm



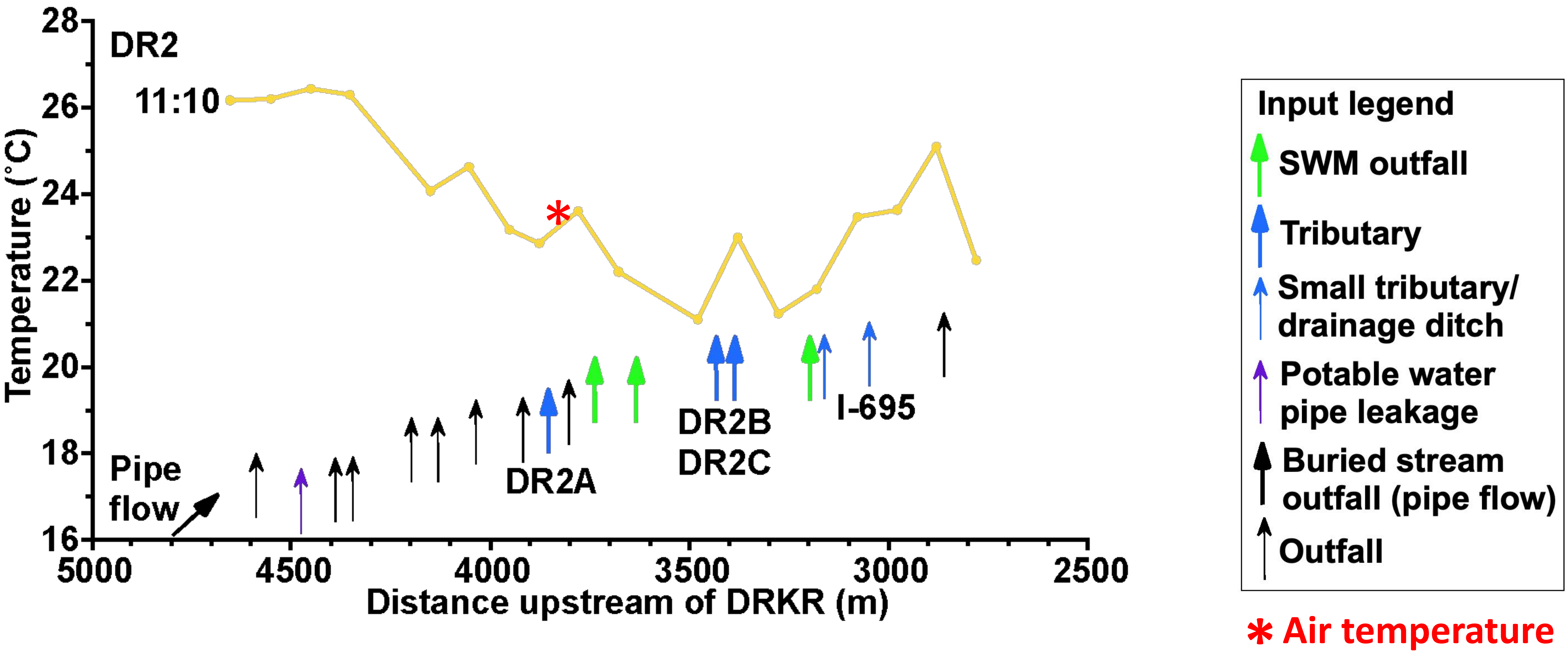
Example plots: June 27, 2022 storm



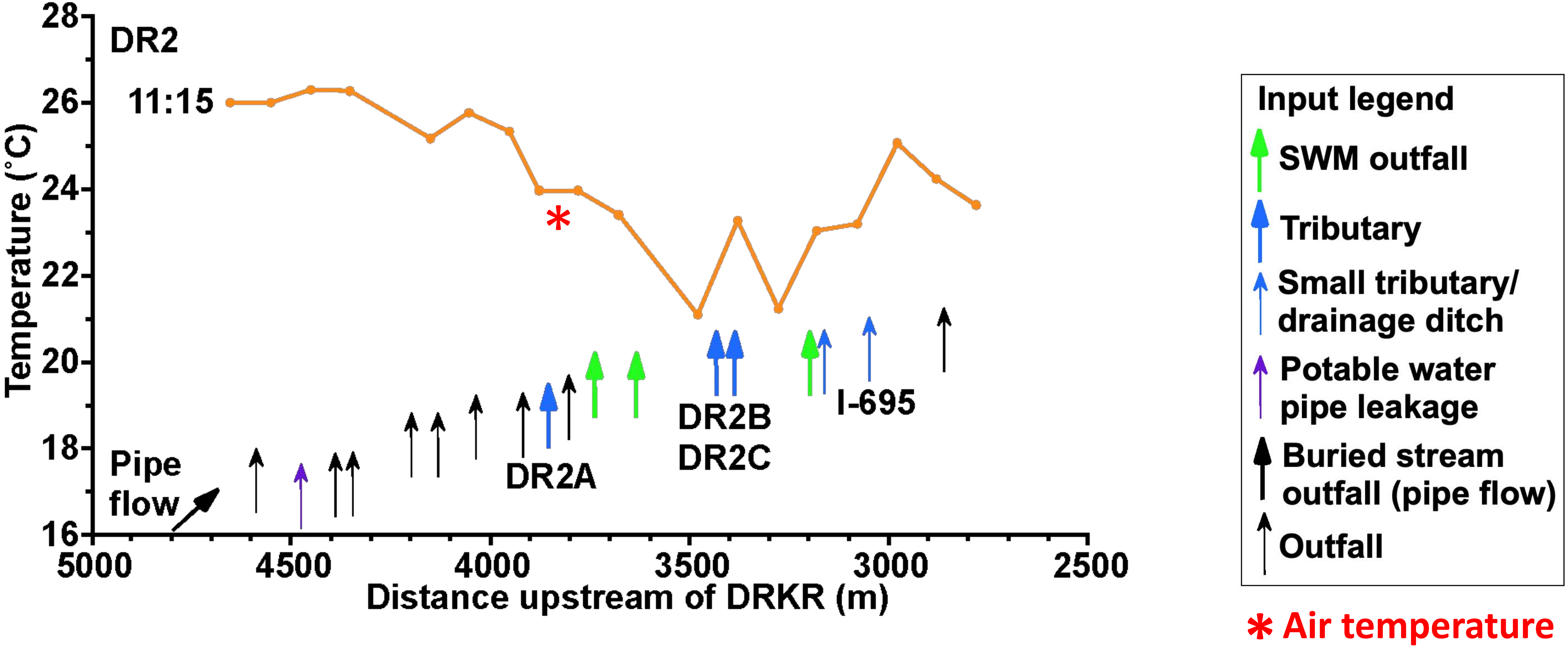
Example plots: June 27, 2022 storm



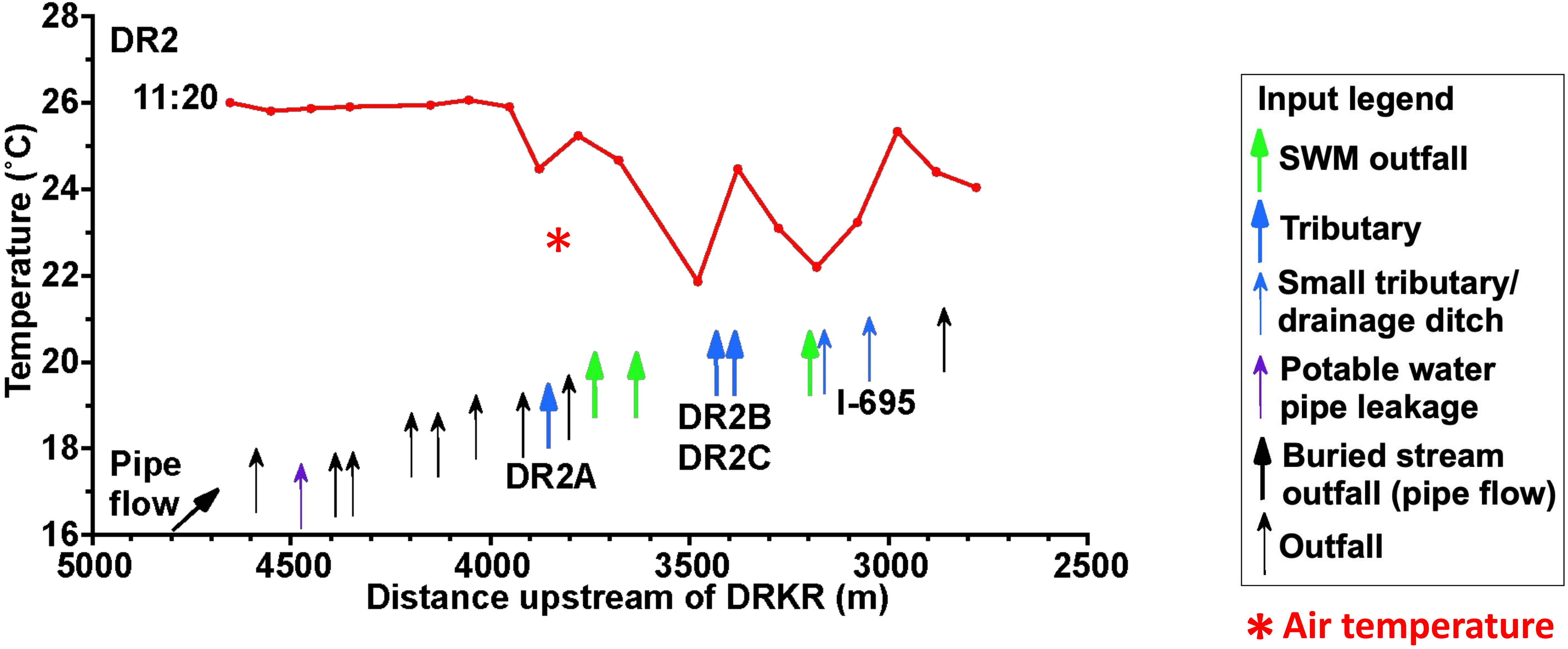
Example plots: June 27, 2022 storm



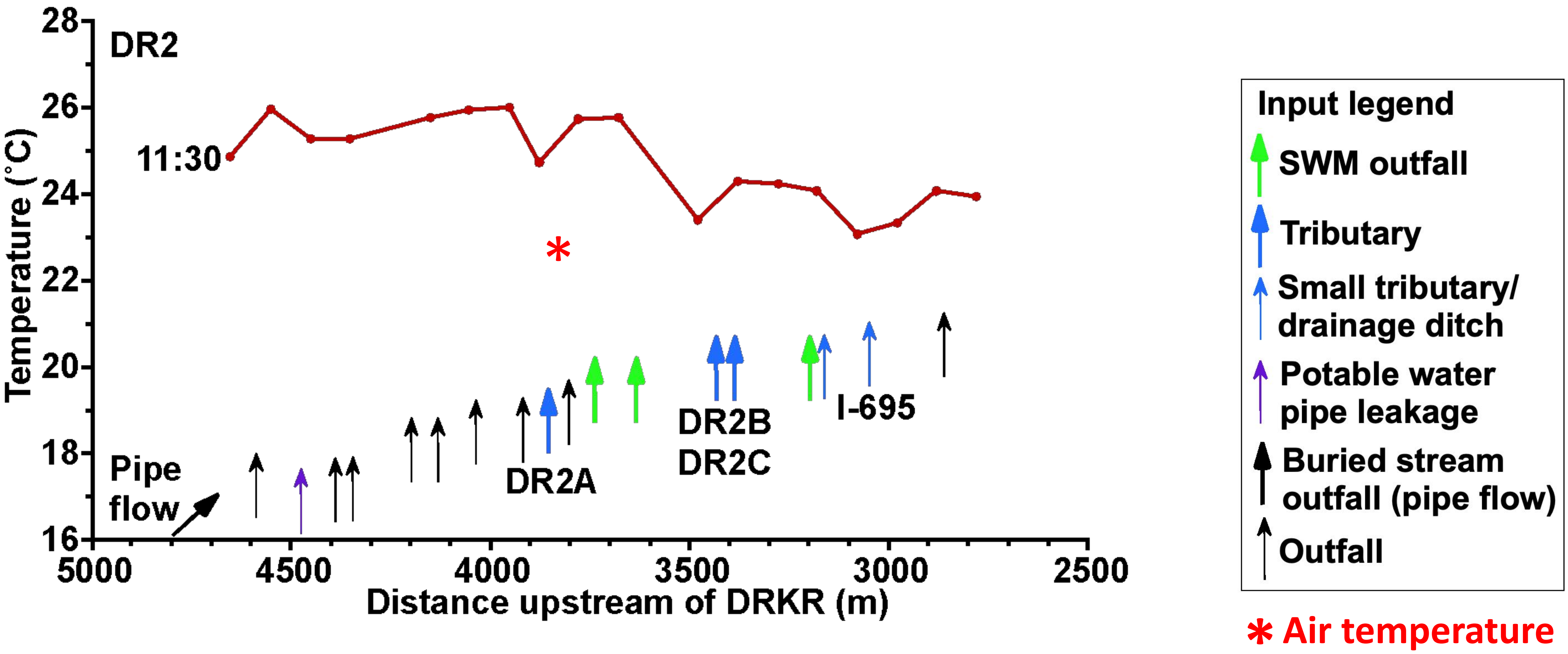
Example plots: June 27, 2022 storm



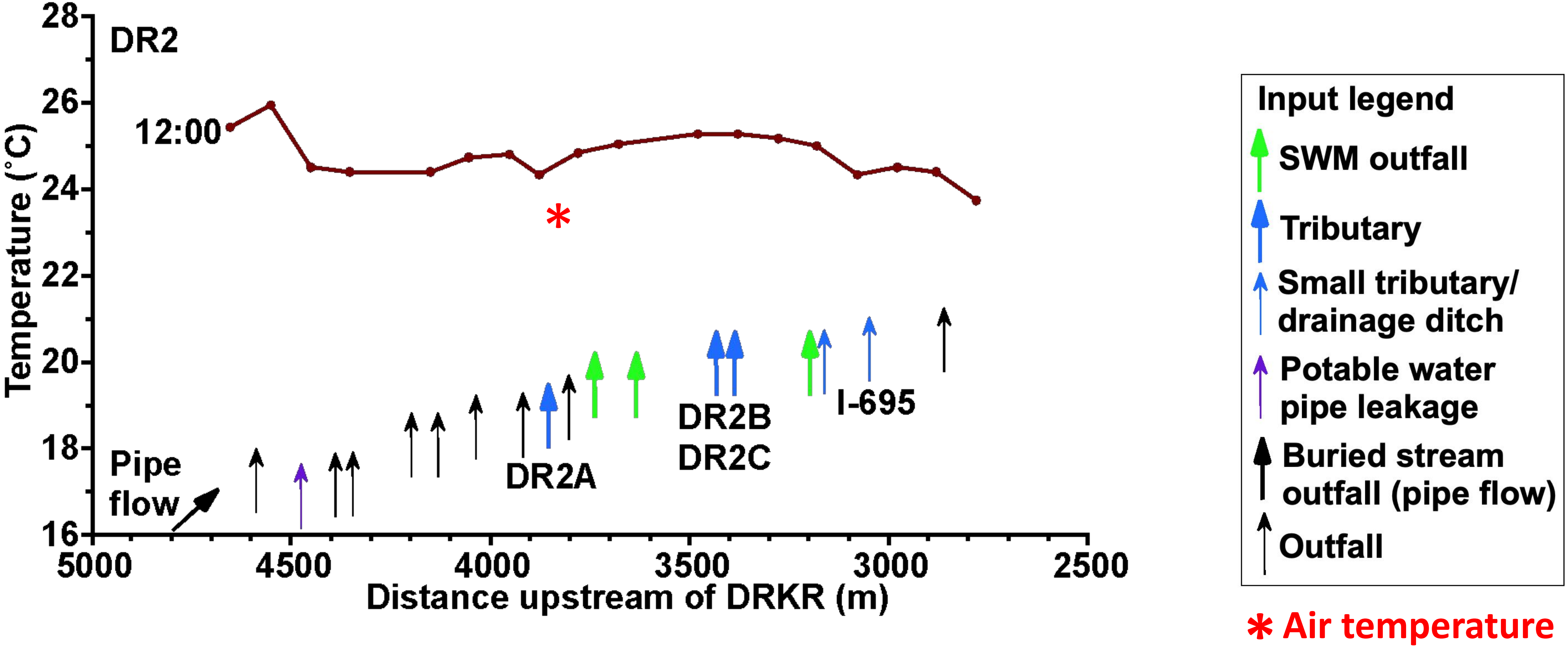
Example plots: June 27, 2022 storm



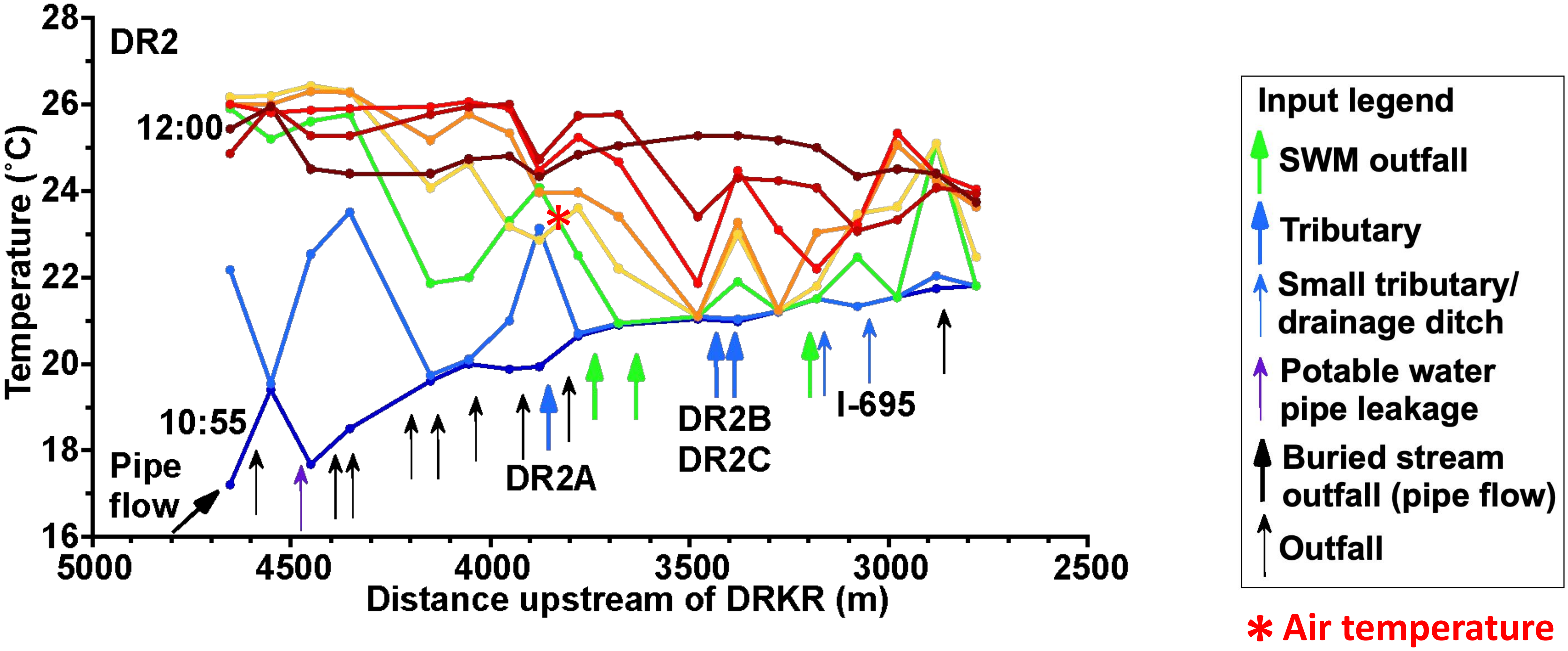
Example plots: June 27, 2022 storm



Example plots: June 27, 2022 storm



Example plots: June 27, 2022 storm



Summary

- High-density, high frequency temperature sensor network successfully deployed along 16 km of stream length.
- State-of-the-art GIS video mapping enables qualitative evaluation of stream-network thermal response to inputs from stormwater runoff.
- Example analysis points toward uncontrolled runoff contributing substantially to thermal impacts to the stream system.
- Comprehensive analysis of data across many storms and SWM facilities will be carried out next.

Acknowledgments

CBT/DNR – Pooled Monitoring Fund

UMBC/CUERE staff

Samantha Volz, Amalie Rebstock, Hanna Donovan

USGS - Sarah Queen

Translation Slides

What are the take home points?
What does this mean for me?

Translation Slides by Greg Golden, Environmental Review Program,
MD Department of Natural Resources

What does this mean for me?

- Only in recent years has it been feasible to study stream thermal regime and thermal influences at this high level of resolution.
- Data sets and analysis are now feasible; this is among the earliest documentation in Maryland at this resolution.
- Preliminary analysis is revealing importance of temporal sequences and spatial / locational influences.
- Stormwater retrofits, riparian buffer improvement, and even development planning are better informed by this analysis.

What do I take from this if I am a practitioner:

- Off-the-shelf new & retrofit SWM designs and approaches for thermal protection are a start, but this study's data and analysis will be demonstrating that tuning designs to specific watershed factors will provide optimal resource protection opportunities.

- Practitioners can be preparing to address future thermal regime watershed management decisions by local governments, which have been informed by such watershed-specific data analysis.

What do I take from this if I am a regulator:

- Future protection of stream thermal regimes ideally will take into account watershed characteristics and stream continuum (temporal and spatial profile) factors and data.

- Riparian buffers, SWM strategies and retrofits, untreated runoff sources, and impervious surface management all matter to stream thermal regimes, and now have better data collection and analysis tools available.


Claire Welty weltyc@umbc.edu
Andy Miller miller@umbc.edu
Mary McWilliams mmcwill1@umbc.edu
John Lagrosa jl@umbc.edu
Nick Simeone wn95497@umbc.edu
Greg Golden greg.golden@maryland.gov