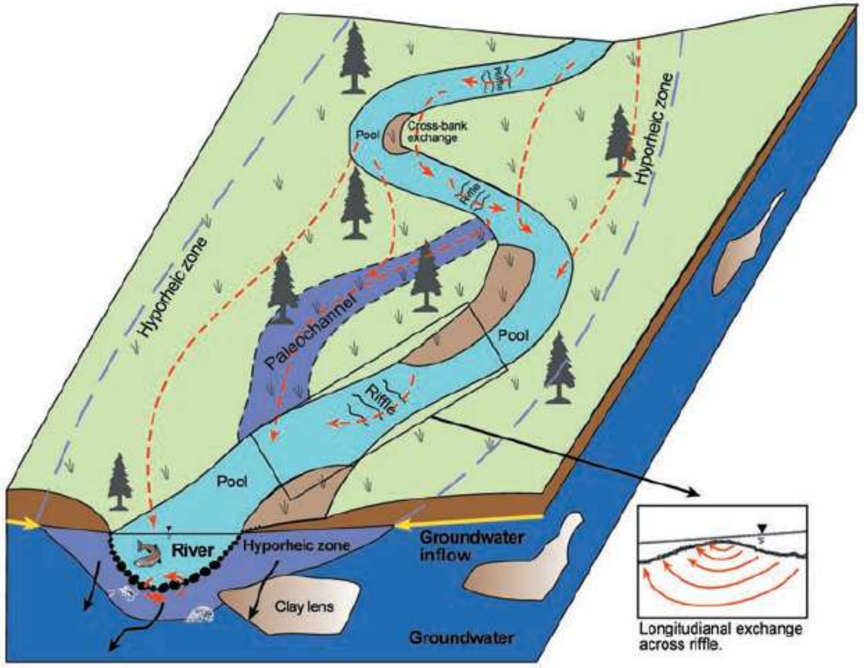
Impact of Hyporheic Exchange on Stream Temperature in Restored Systems

National Stream Restoration Conference 2023

Presented by Ethan Bauer, PE

Hyporheic Exchange

- Mixing of surface water and groundwater occurring in the saturated region along a channel
  - Extent of the exchange can be limited by topographic and geologic factors
  - Has significant influence on many biological, chemical, and physical processes
  - Is subject to seasonal variations due to groundwater fluctuation



Retrieved from Tonina and Buffingtion (2009)

Restoration Approach

- Kurtz Run Restoration at Landis Homes
  - 1,500 lf floodplain restoration (6 acres)
  - Provide stormwater management by increasing flood storage capacity and infiltration
  - Reduce sediment and nutrient loading by reducing bank erosion processes and increasing channel stability
  - Reconnect the floodplain to groundwater table by removing legacy sediment impairment across the resource

Kurtz Run at Landis Homes

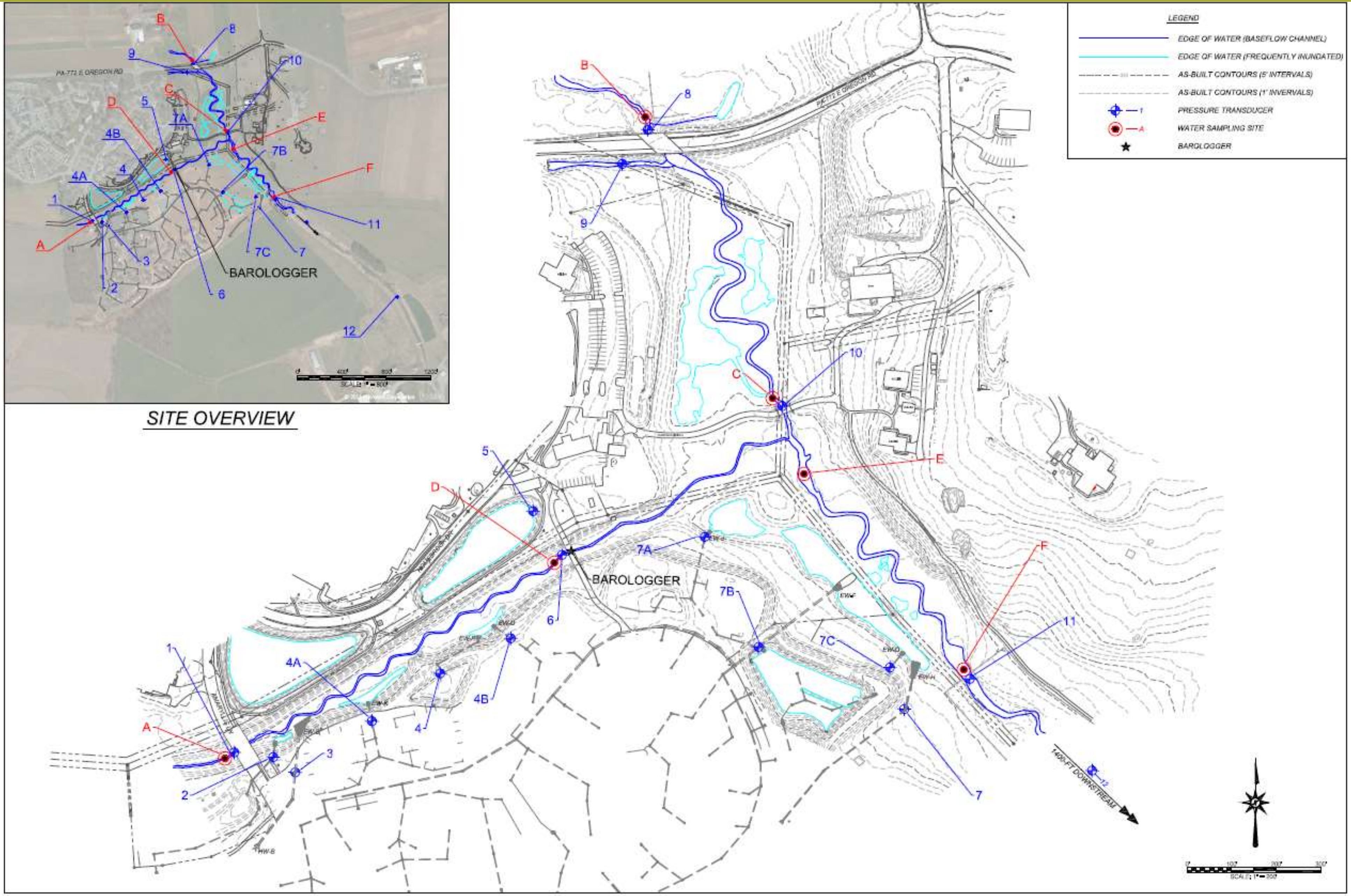
Kurtz Run Floodplain Restoration at Landis Homes

Kurtz Run Floodplain Restoration at Landis Homes

2013

Kurtz Run Floodplain Restoration at Landis Homes

Sensor Locations

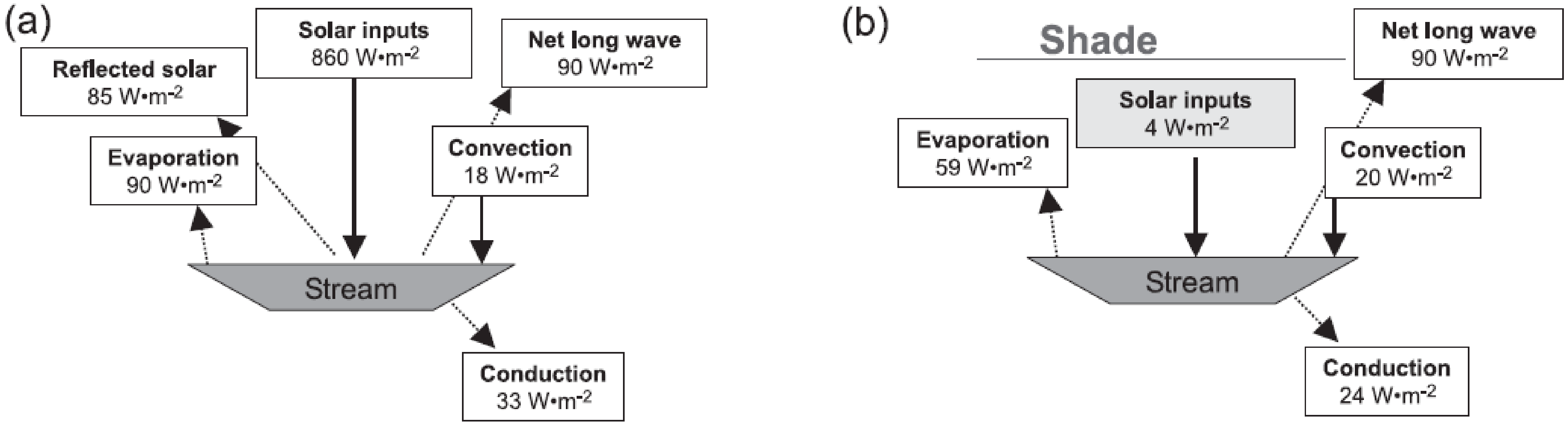


Motivation for Analysis

- Traditional thinking dictates the best way to cool a stream system is through vegetative shading
  - Substantial vegetative shading can be expensive and difficult to establish
- Factors Influencing Stream Temperatures in Small Streams (Johnson 2004)
  - 150 m of stream was shaded using black plastic sheeting
  - Hypothesis was that added shade would reduce stream temperatures throughout the reach
  - Shading proved to have little effect on reducing stream temperatures

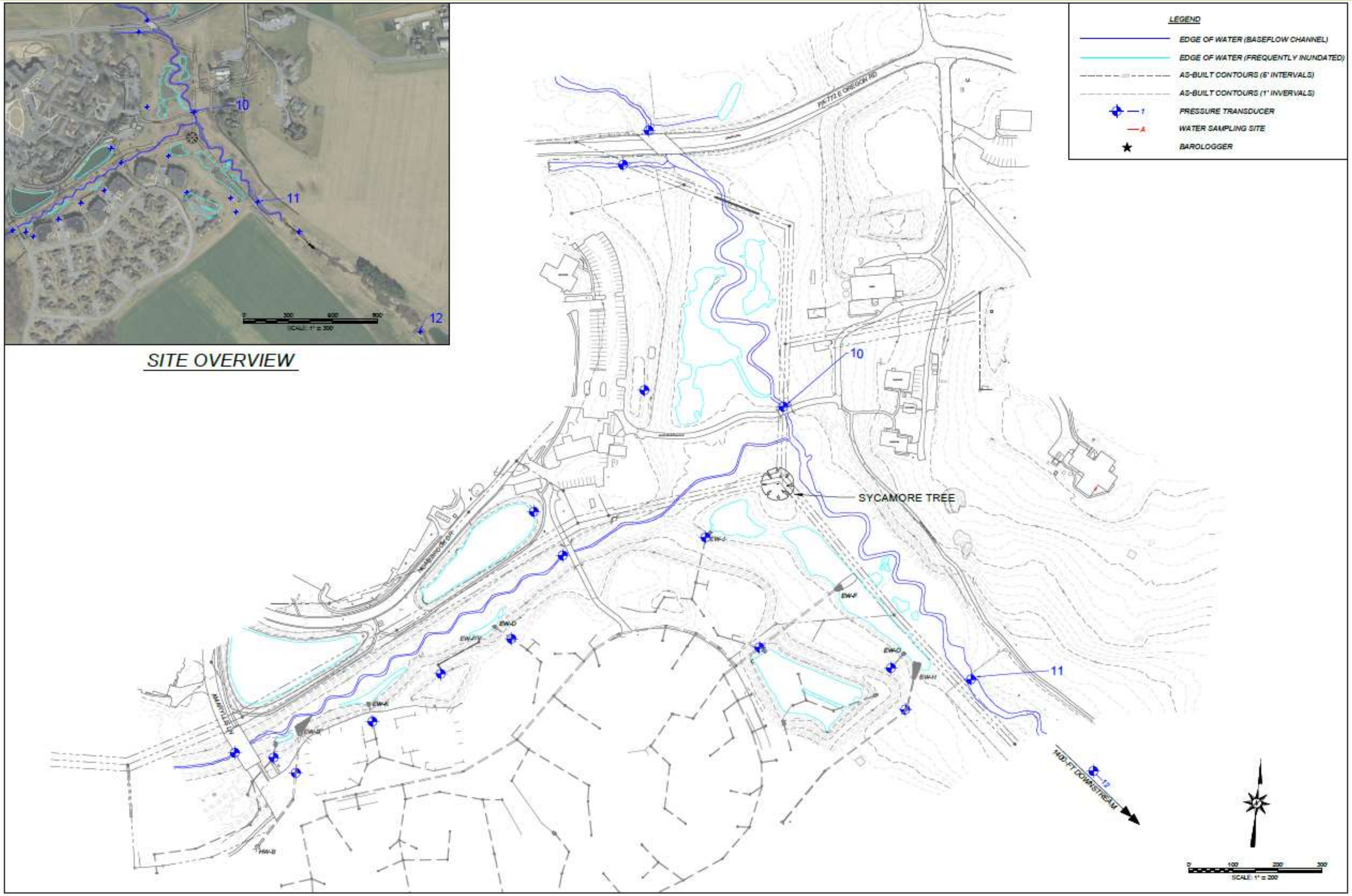
Methodology

- Johnson’s (2004) energy balance indicates solar radiation is the largest thermal energy input to streams
  - This was the basis of the decision to compare the relationship between daily maximum temperature and incident solar radiation
  - This method provides an accurate comparison of pre and post-restoration conditions and would eliminate skew from annual variations



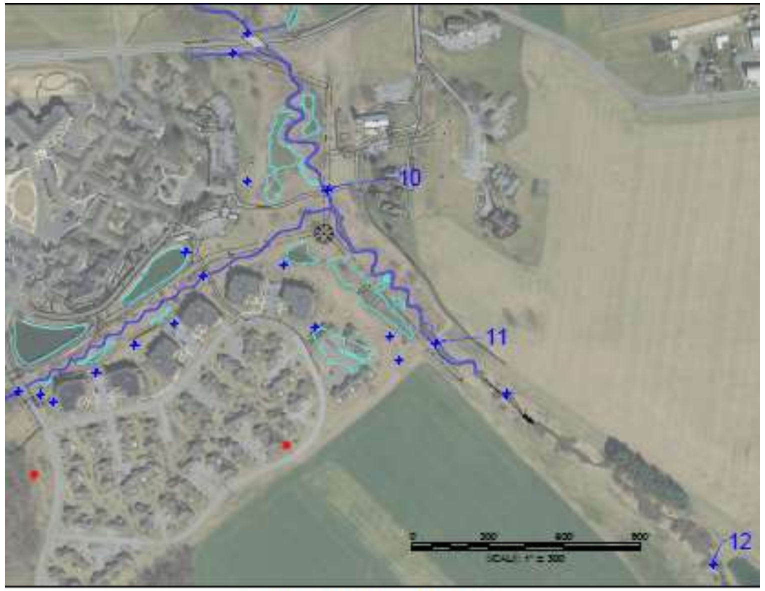
Retrieved from *Factors influencing stream temperatures in small streams: substrate effects and a shading experiment – Appendix B* (Johnson 2004)

Sensor Locations



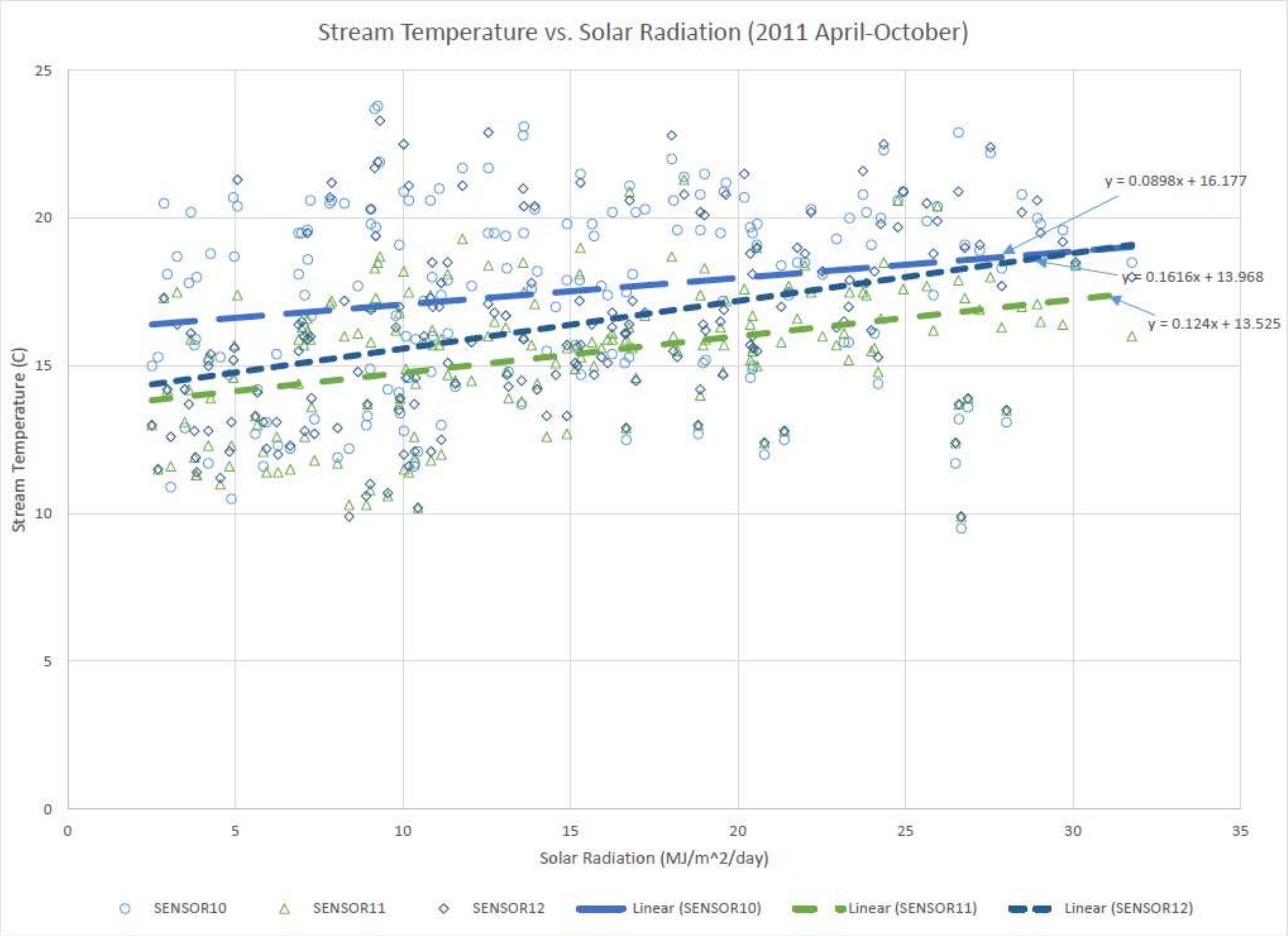
Methodology

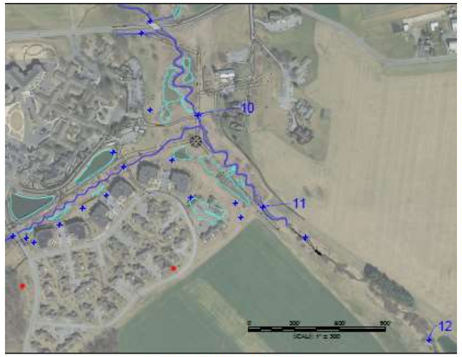
- Maximum daily stream temperature vs. total daily solar radiation
  - 5-minute recording interval for temperature
  - Three locations along the restored mainstem
- 1 year of pre-restoration data and 5 years post
- April through October



SITE OVERVIEW

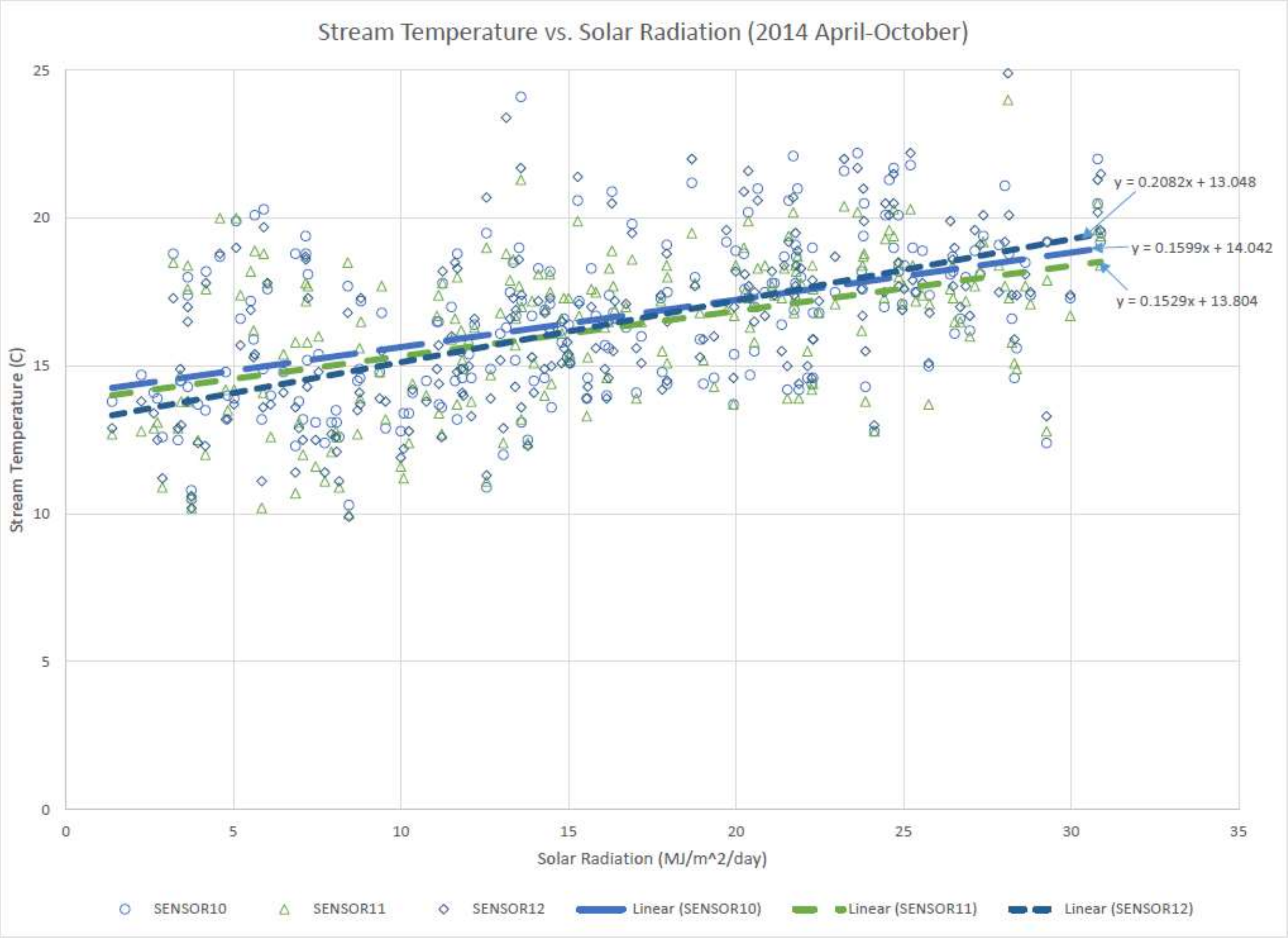
Pre-Restoration (2011)

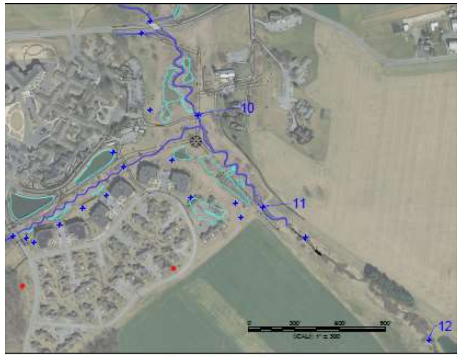




SITE OVERVIEW

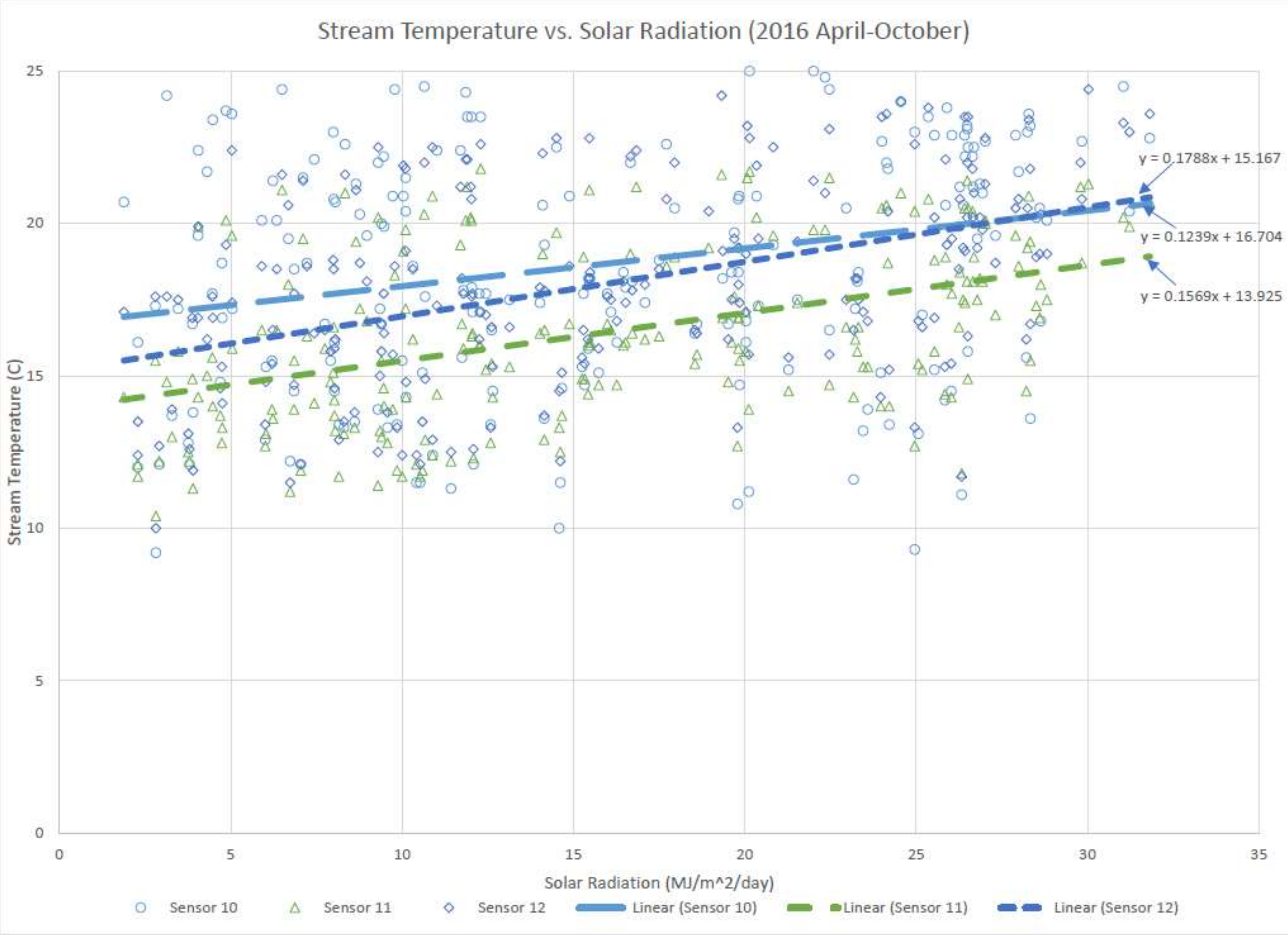
Post-Restoration (2014)

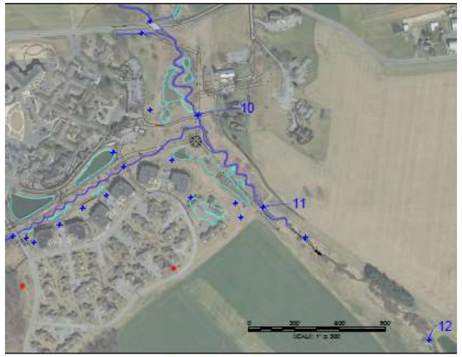




SITE OVERVIEW

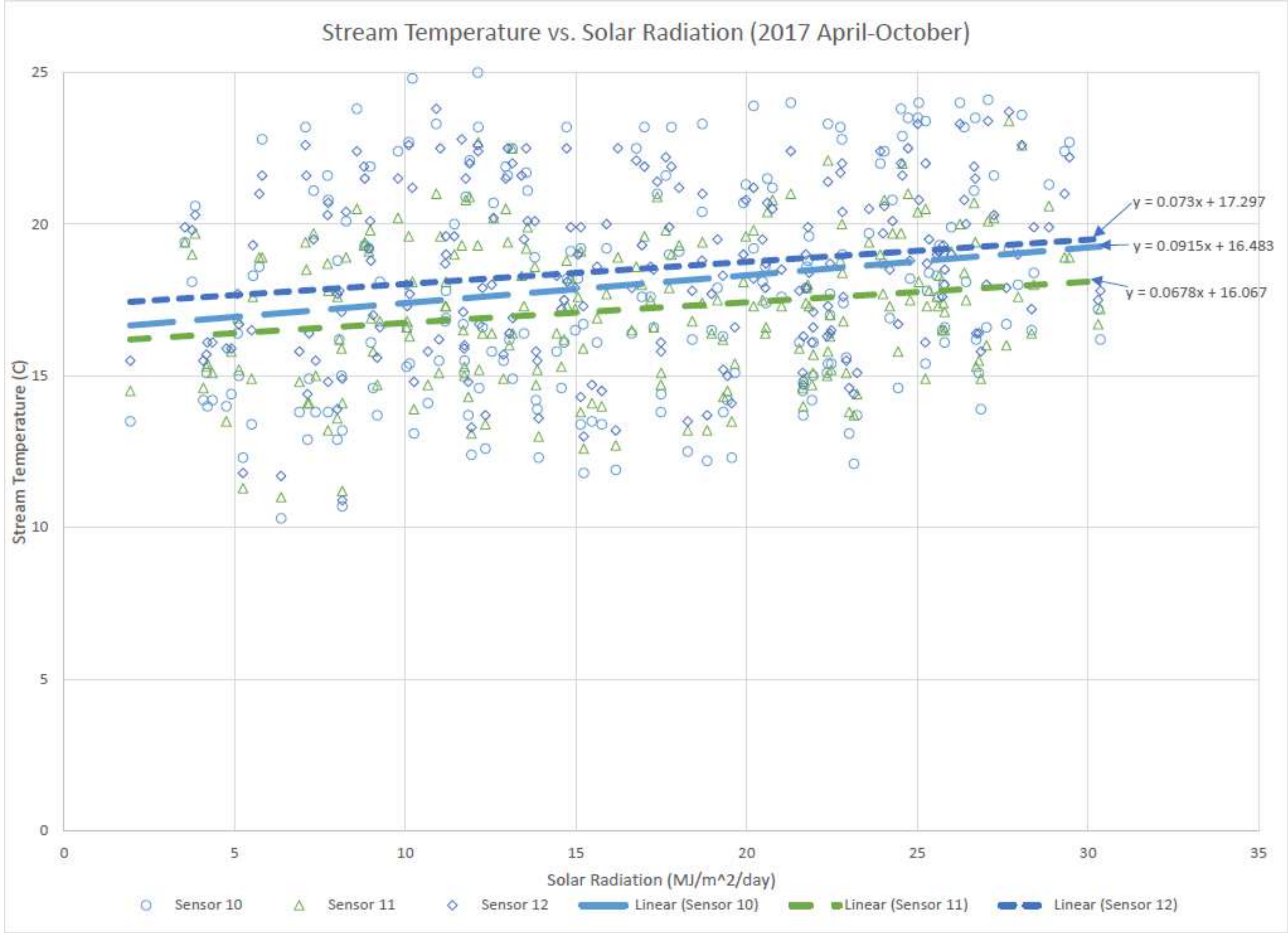
Post-Restoration (2016)

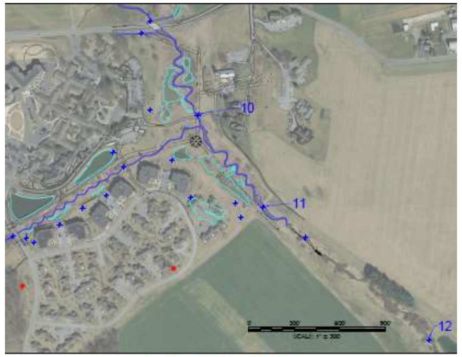




SITE OVERVIEW

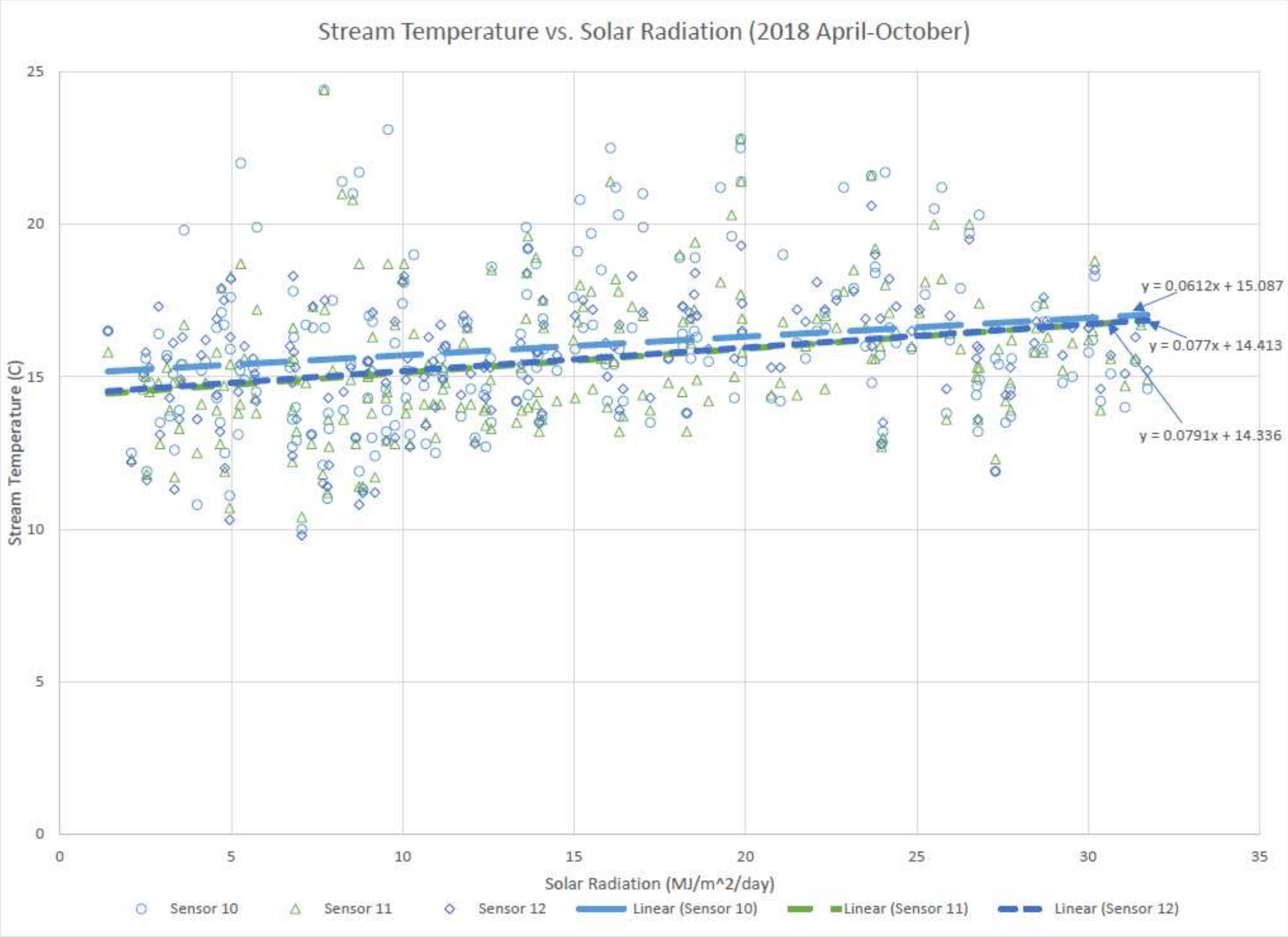
Post-Restoration (2017)

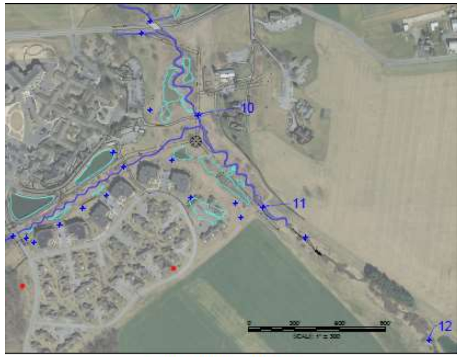




SITE OVERVIEW

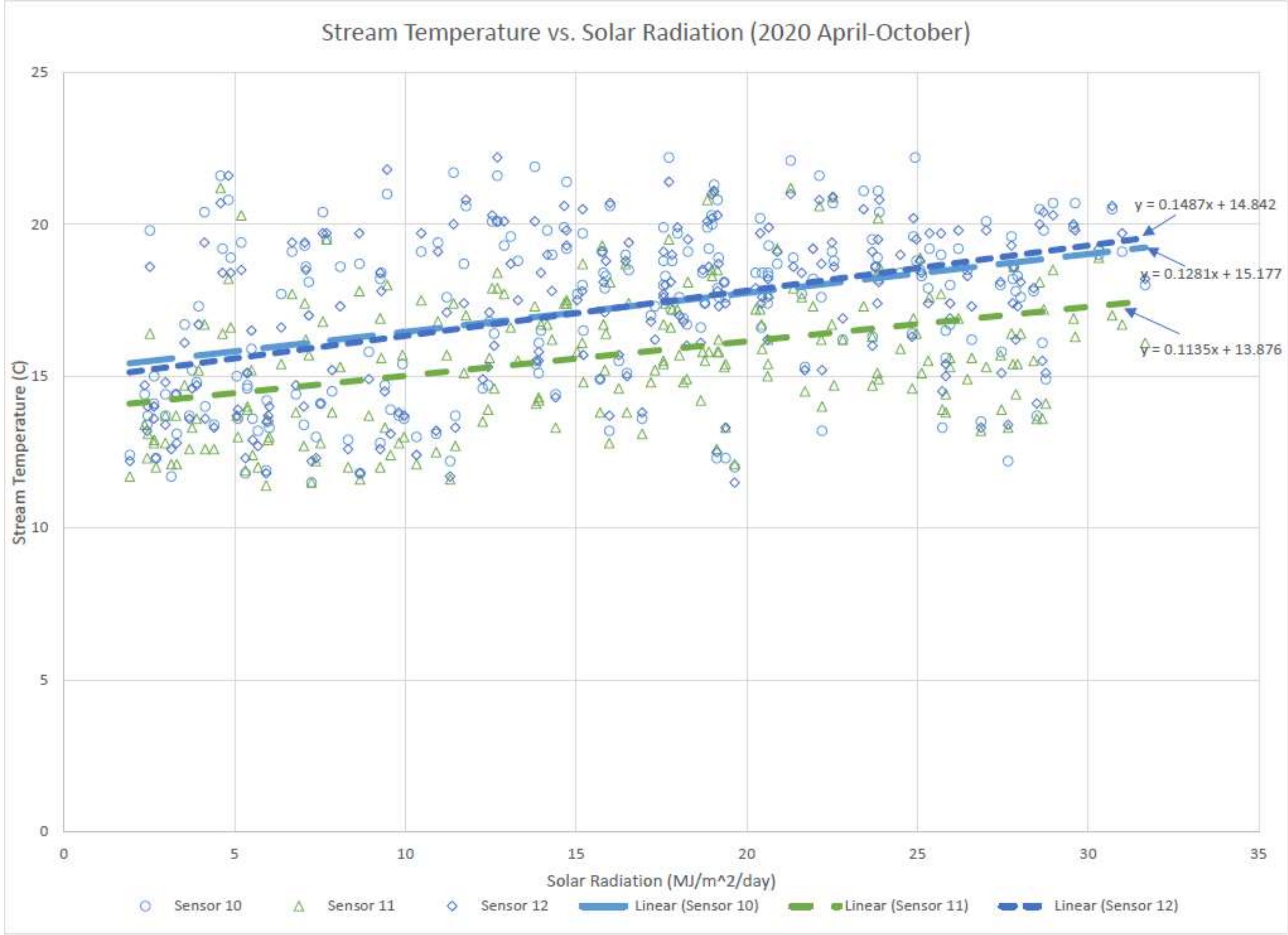
Post-Restoration (2018)

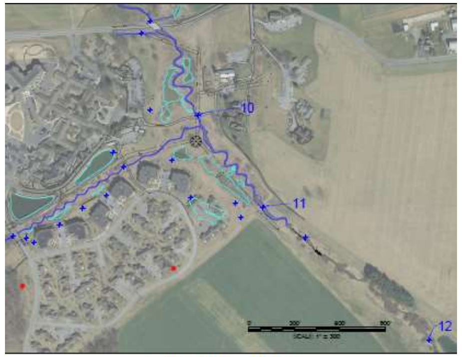




SITE OVERVIEW

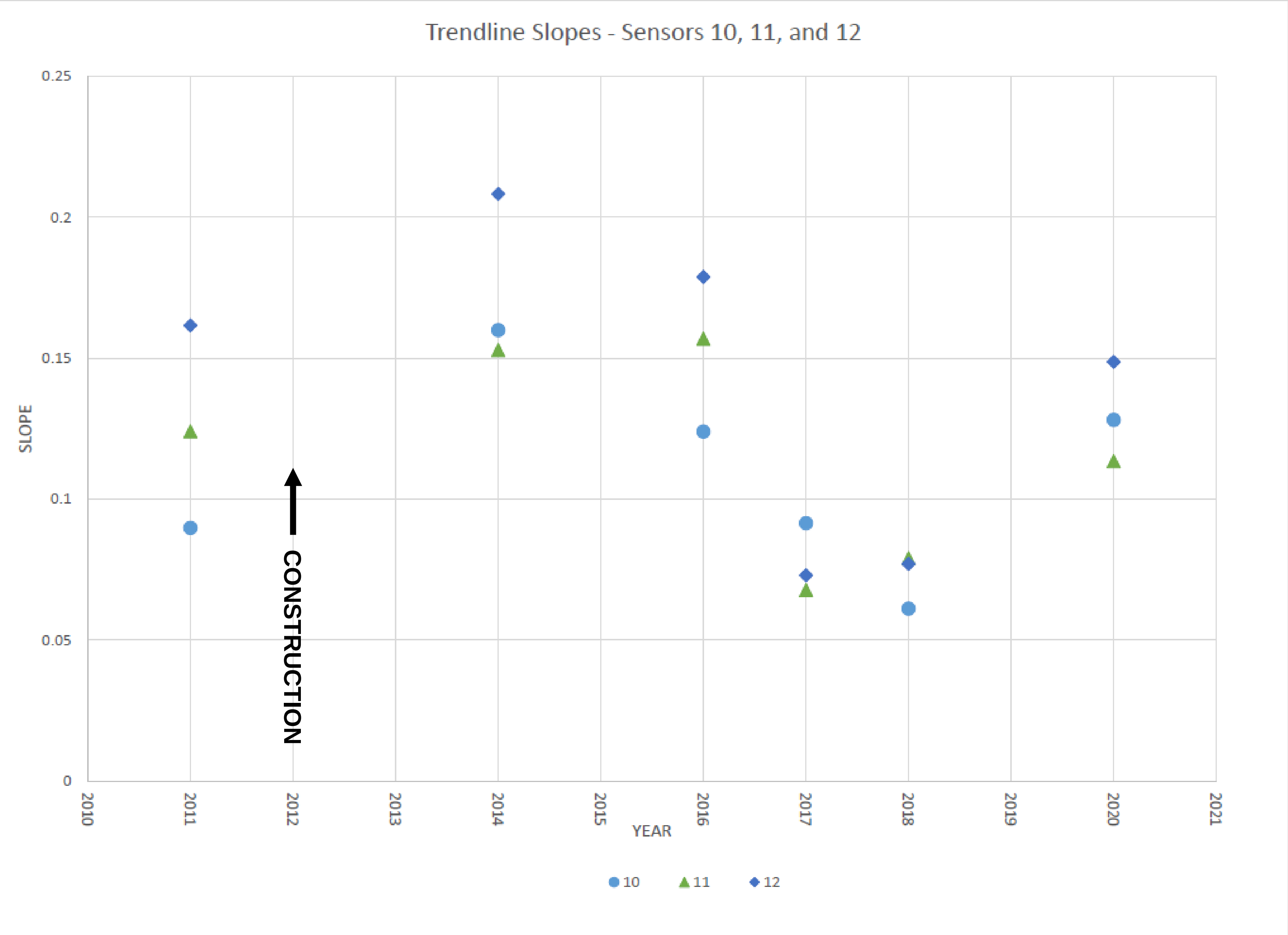
Post-Restoration (2020)

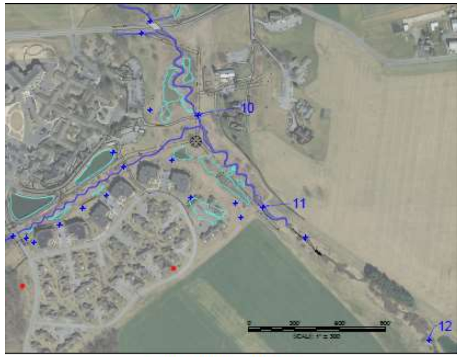




SITE OVERVIEW

Trends Across the Data





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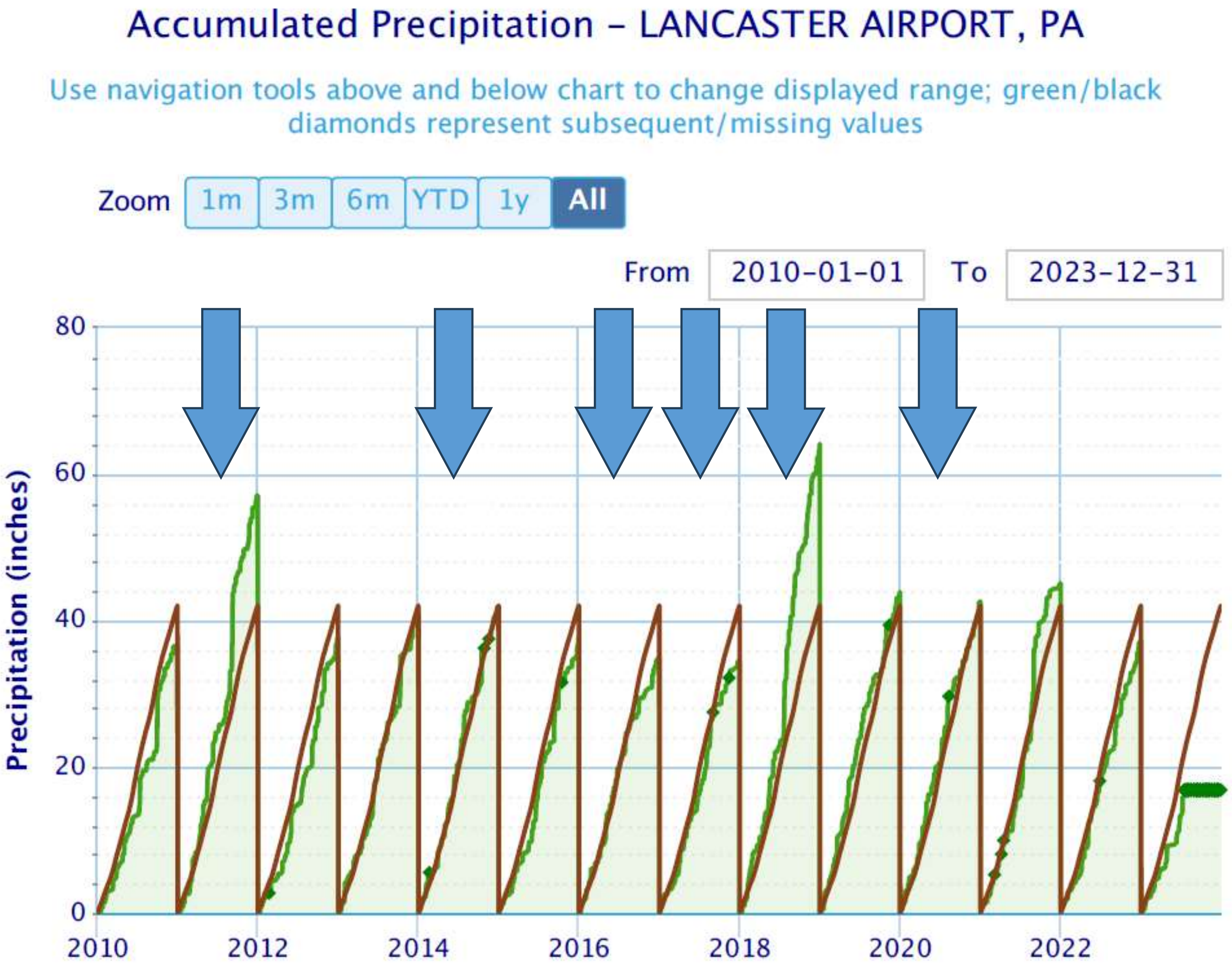
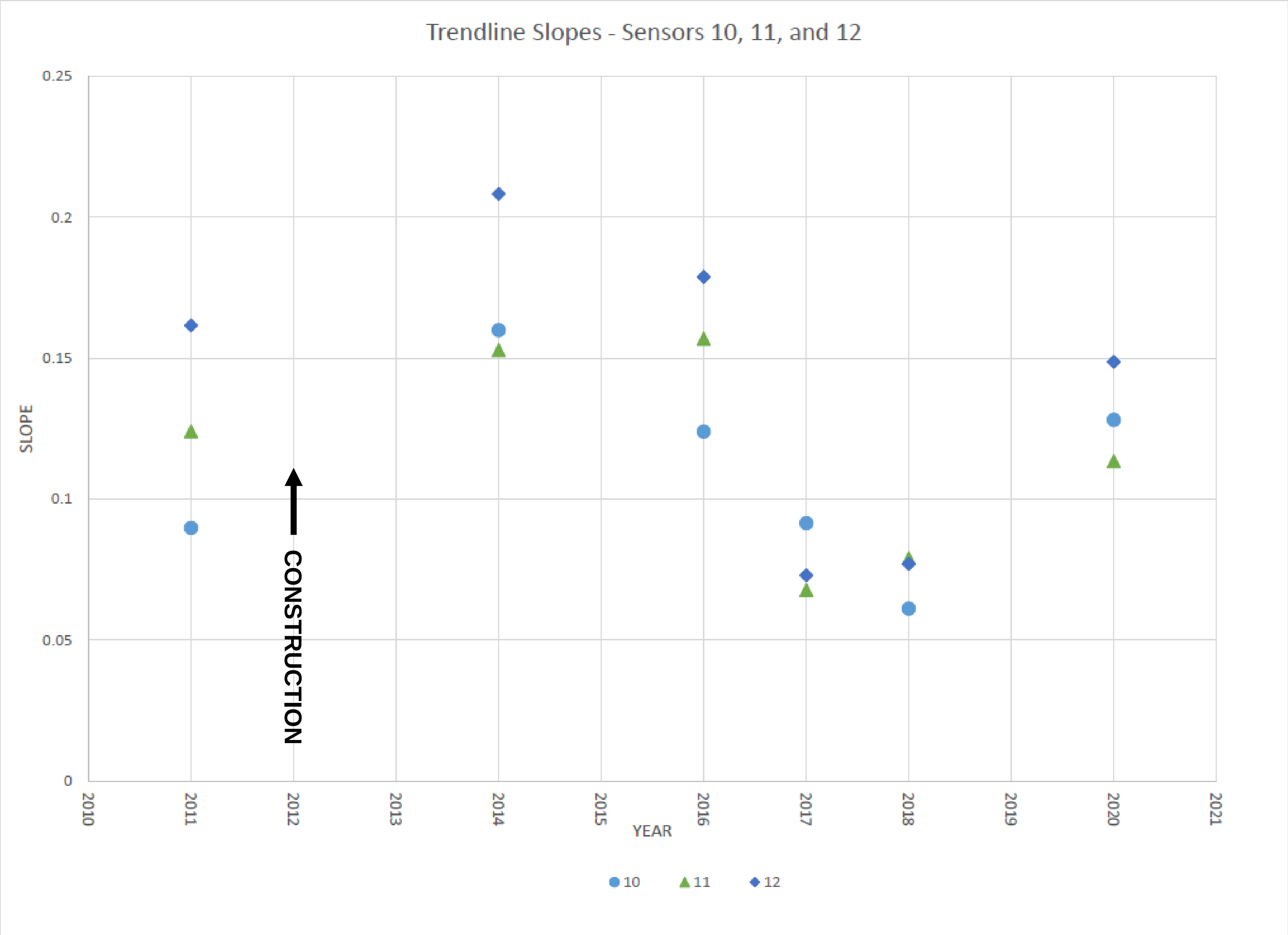
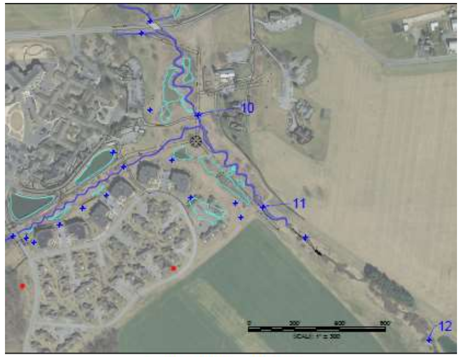
Kurtz Run at Landis Homes



Retrieved from National Weather Service

Trends Across the Data

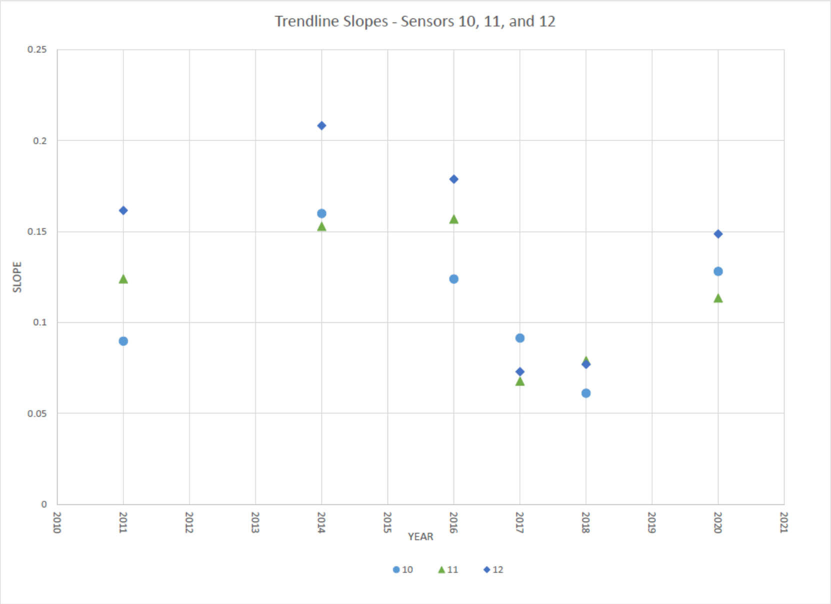




SITE OVERVIEW

Results

- An increased response to solar radiation was observed immediately post-construction
- As the restoration matures and develops, a buffering effect becomes apparent
- Groundwater levels will impact exchange effects in the system



Conclusions

- Increasing hyporheic exchange provides durable long-term benefit in buffering stream temperatures
  - Residual impact seen downstream
- Hyporheic exchange and groundwater inputs must be accounted for when examining stream temperature dynamics
  - These processes are complex and highly variable based on site conditions
- Multiple benefits can coexist without diminishing the value of other benefits
- Shading does provide benefit by limiting energy inputs into the system, but it is only part of the picture

References

- Johnson, S. L. (2004, July 24). Retrieved 6 21, 2016, from Oregon State University: http://forestry.oregonstate.edu/cof/fe/watershd/fe538/StreamTemperature/johnson_factors_effecting_stream_temp_CJOF04.pdf
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- Tonina, D., & Buffington, J. M. (2009). Hyporheic Exchange in Mountain Rvers I: Mechanics and Environmental Effects. *Geography Compass*, 1063-1086.

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