Synthesis Element 7/8

Impacts of BMPs and Habitat Restoration on Water Temperature: Prospects for Mitigating Rising Water Temperatures

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- Draft Summary of Synthesis is Available
- General Approach
- Evaluation of Key Urban Findings
- Key Forestry Findings
- Jamboard Discussion Questions

Simple Stream Warming Model

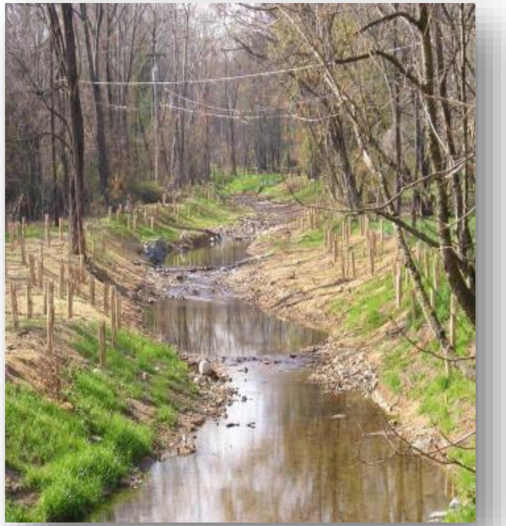
[Stream Temp Δ] =

$$\sum [\Delta \text{ Land Use}] + [\text{Upland BMP } \Delta] + [\text{Stream Corridor } \Delta] + [\text{Corridor BMP } \Delta] + [\text{Riverine } \Delta]$$

- *Land Use* Temp Effect: as influenced by heat island effect: Forest << Pasture/Crops << Suburban <<< Urban. The cumulative land use effect is generally + relative to the baseline.
- *Upland BMP* Effect: reflects how ponding, infiltration or filtration of runoff modifies baseflow and runoff temps (+ or - or no change, relative to the land use baseline)
- *Stream Corridor* Effect: reflects the *current* presence or absence of riparian cover along the corridor (+ or -)
- *Corridor BMP* Effect: Whether new BMP installed in the corridor influence temps, relative to the historical corridor baseline. (+ or -)
- *Riverine/Reservoir* Effect: the increase in stream temp as it moves from headwaters thru rivers and is warmed by reservoirs and impoundments along the way, until it reaches head of tide (+).

Classification for BMP Temp Effect

1. Known Heaters
2. Suspected Heaters
3. Shaders
4. Shade Removers
5. Known Coolers
6. Suspected Coolers
7. Thermally-Neutral
8. Uncertain or Unknown

Known Heaters

- Upland BMPs that increase downstream temperatures due to surface ponding via detention or retention of runoff, to a depth of up to 10 feet.

- Examples include wet ponds, created wetlands, dry ED ponds, farm ponds and CAFO lagoons

- Increase from 2 to 10 degrees F from the land use baseline.

- No engineering techniques exist to mitigate heating, except for deep-water release from much deeper reservoirs and impoundments.

Known and Suspected Coolers

- Urban BMPs such as infiltration, permeable pavement and bioretention

- Designed to move surface runoff back into shallow groundwater, where it may reside for hours or several days before reaching streams.

- Cooling effect can range from 2 to 5 degrees F, depending on site soils and presence of underdrains

- BMPs are NOT Refrigerators – cannot compensate for land use effect – or meet coldwater temp standards

The cumulative impact of BMP on stream temperature

Can be expressed as the relative fraction of ("cool" BMPs * treated BMP acres) vs. ("heater" BMPs * treated BMP acres)

Scenario 1: Whether historic BMP implementation from 1970 to 2020 cumulatively increased, decreased or had no impact on stream temperatures discharged to the Bay.

Scenario 2: Whether a different mix of BMPs built in future years could potentially mitigate stream warming caused by climate change post-2020 and/or compensate for any heating by historic BMPs prior to 2020.

Evaluation: *How good is the data?*

- While significant gaps remain, there is enough data for urban and forestry practices to get a general sense of their impact of historic and future BMPs on stream temperatures in the watershed.

- We have little or no temperature data for agricultural and habitat restoration practices.

- We lack detailed data to needed to accurately model past and future changes in stream temperatures at the scale of the Bay watershed…especially in response to future BMP implementation scenarios.

Evaluation: What do we know about the watershed impact of Urban BMPs on stream temperatures?

- Urban BMPs have a mixed effect, but it appears that we have historically installed more "heaters" than "coolers", at least in terms of treated acreage.
- When combined with upland and corridor tree clearing and urban drainage, it is likely we have exacerbating stream warming, well beyond the land use effect
- Widespread use of LID practices can reduce the BMP effect on downstream temperatures in the future

Special issues with forestry and habitat restoration BMPs

Shaders

• Upland or corridor forestry practices that maintain or increase forest canopy/forest cover
• Upland BMPs: tree planting, tree pits, foundation planters -- greatest cooling effect occurs over impervious cover.

• Corridor BMPs: riparian forest buffers and some forms of floodplain restoration

Shade Removers

- Land development activities, farming and stream corridor practices that remove riparian forests from the stream corridor, relative to the historic baseline year for actual cover.
- Examples may include: farm buffers that have expired, some forms of stream channel restoration, and construction site clearing during new land development

What do we know about the impact of Shaders/Shade Removers on water temperature in the riparian corridor?

- Riparian forests effectively cool streams by reducing incoming shortwave radiation, reducing maximum temperatures and overall temperature variability, and through evapotranspiration
- Greatest cooling benefits are for smaller, narrower streams
- Type and structure of riparian forest can influence cooling benefits
- Even relatively small areas of riparian forest (300M- 1km) can provide local cooling benefits and act as thermal refugia for coldwater species
- Newly planted trees will require a decade or more to effectively shade streams -> Very important to conserve mature forests!

What do we know about the impact of Shaders/Shade Removers on water temperature in upland areas?

- Floodplain forests can also help reduce water temperature via reductions in ambient air temperature
- Upland forests can help cool runoff, especially when located over impervious surfaces
- Forests have high infiltration rates that aid groundwater recharge important for summer low flows.
- Conversion of upland forest to development can have significant water temperature implications
- Impacts of forest harvesting on water temperature can be effectively mitigated by maintaining riparian forest buffers

Evaluation: *What more needs to be done before the workshop?*

- Add more research on the temperature impacts of agricultural, forestry and habitat restoration practices

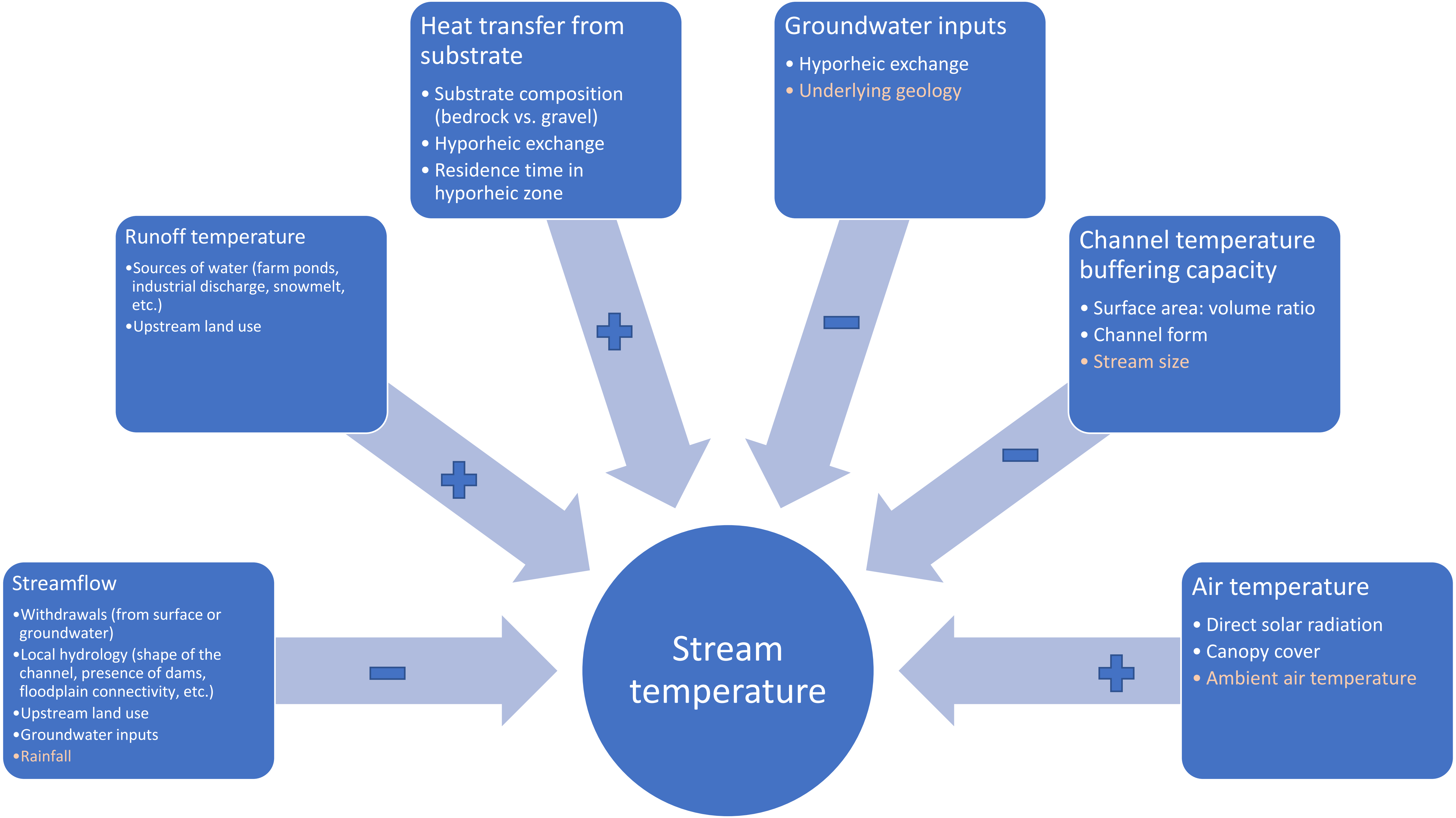
- Check out BMP pollutant removal database to see if there are any more urban BMP temperature "efficiency" data to analyze.

- Derive watershed-wide of the total treated acreage of BMPs for each temperature category, using input data from the Phase 6 CBWM. This could be used to make a back of the envelope estimate of whether or not there are more BMP heaters than BMP coolers in the watershed.

- Use existing mapping data to calculate the total headwater stream mileage of the Bay watershed that potentially could be reforested.

Jamboard Discussion Questions

- What are some key opportunities to use BMPs more strategically to mitigate rising water temperatures?
- What are some messages we could use to communicate about these opportunities to managers, planners, and policy makers?
- How can we further enhance the cooling benefits of forestry and habitat restoration practices?
- What additional research and analysis is needed to refine our synthesis prior to the fall workshop?


Heat transfer from substrate
Substrate composition (bedrock vs. gravel)
Hyporheic exchange
Residence time in hyporheic zone
Groundwater inputs
Hyporheic exchange
Underlying geology
Runoff temperature
Sources of water (farm ponds, industrial discharge, snowmelt, etc.)
Upstream land use
Channel temperature buffering capacity
Surface area: volume ratio
Channel form
Stream size
Streamflow
Withdrawals (from surface or groundwater)
Local hydrology (shape of the channel, presence of dams, floodplain connectivity, etc.)
Upstream land use
Groundwater inputs
Rainfall
Stream temperature
Air temperature
Direct solar radiation
Canopy cover
Ambient air temperature