Components of a Stream

- Channel, Riparian Zone, Alluvial Aquifer
- Interactions between external drivers and these components ultimately affect stream temperature.

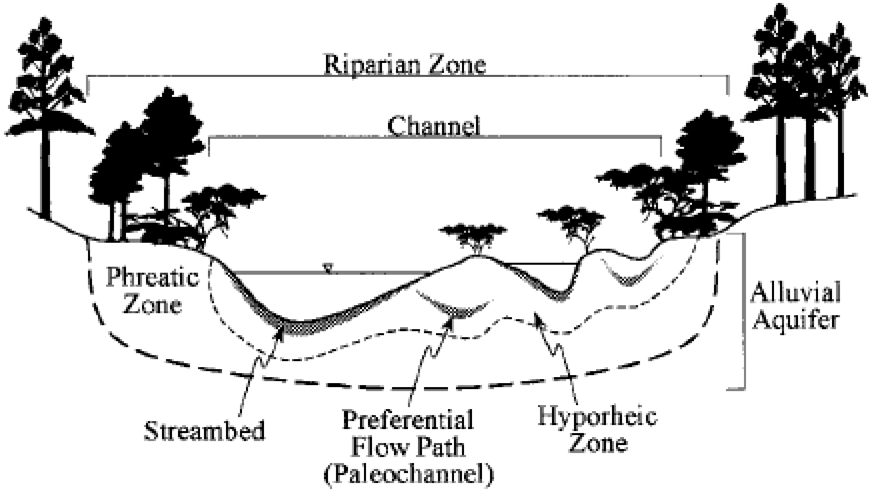


Figure 1. Structural components of a stream system (not all features exist in all streams.)

Primary Drivers

- Climatic – solar radiation, air temperature, wind speed.
- Stream Morphology – channel dimensions and configurations.
- Ground Water Influences.
- Riparian Canopy Condition.

Examples of Natural Drivers

- Topographic Shade
- Riparian and Upland Vegetation
- Precipitation, Air Temperature, Wind Speed, Cloud Cover, Relative Humidity
- Solar Angle
- Phreatic Ground Water Temperature and Discharge
- Tributary Temperature and Flow

Water Temperature ≈ Heat Energy/Water Volume

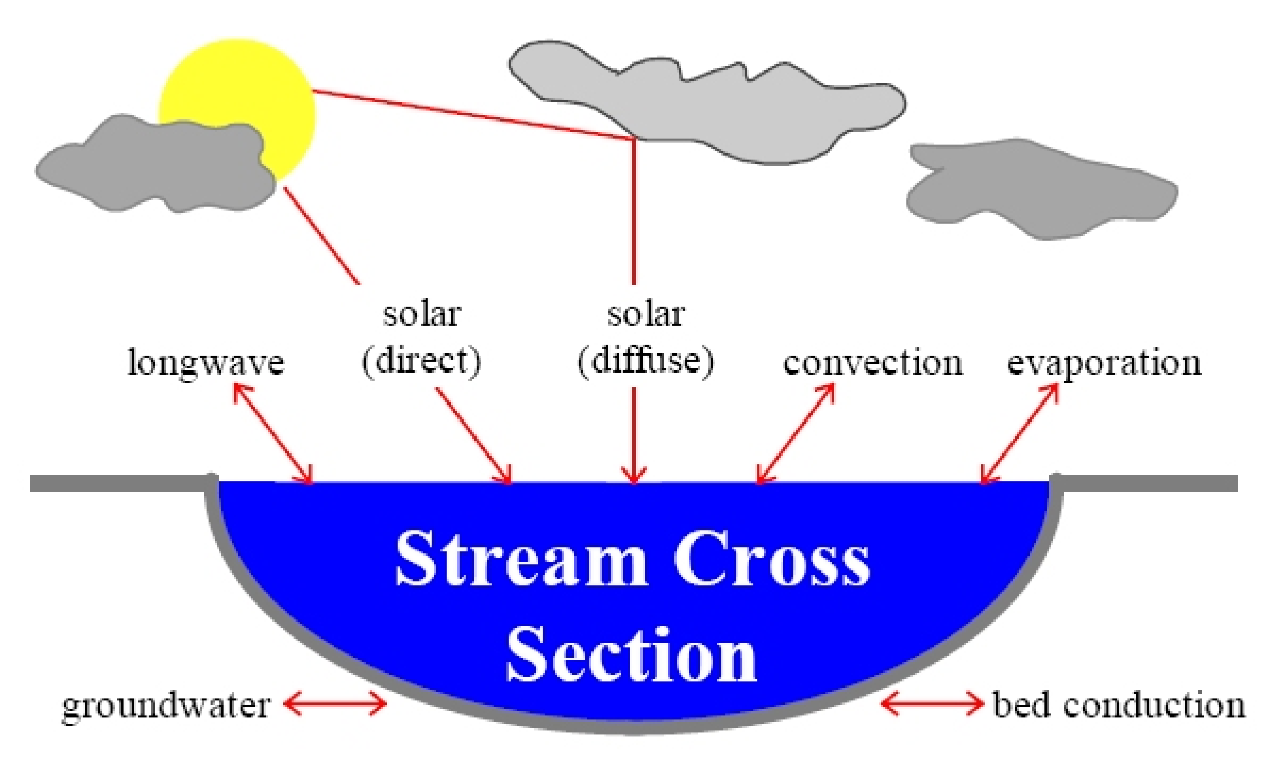
- Think of water temperature as a concentration of heat energy.
- The higher the water temperature, the higher the concentration of heat energy.
- Heat load (kWh/day) is a measure of heat energy.
- Discharge (cfs) is a measure of water volume.
- Water Temperature = Heat Load/Discharge.

Heat Load

- When cool water is added to a warmer stream, heat energy is not lost but diluted.
- When water is taken out, the concentration of heat load does not change so temperature stays the same (until more load is added).
- Evaporation is exception because water absorbs more energy as it evaporates.

Heat Load

- Heat energy is transferred from the sun to the stream directly via radiation.
- Atmospheric heat reaches stream surface via convection, conduction and advection; and then moves into the channel via conduction.



Stream Temperature

- Temperature of phreatic aquifer is generally baseline for stream temperature (after snowmelt).
- In the absence of Insulating and Buffering influences, stream temperature trends away from baseline towards atmospheric temperatures in the downstream direction.
- Inputs from ground water tend to moderate channel temperature, inputs from tributaries tend to pull temperature towards that of the incoming water.

Insulating Processes

- Influence the rate of heat flux into and out of the stream.
- Channel Width – narrow and deep
- Riparian vegetation height, density, proximity

Buffering Processes

- Can heat or cool the stream.
- Store heat as opposed to adding or removing.
- Integrate variation in discharge and temperature over time.
- Alluvial exchange or Hyporheic flow (most important buffer)

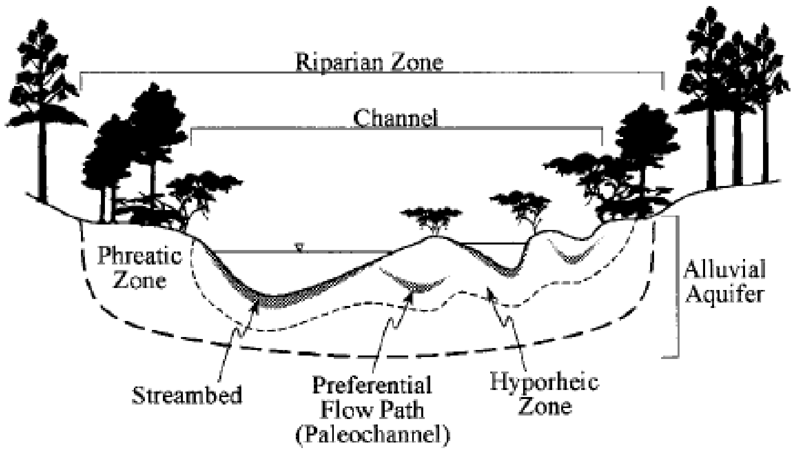


Figure 1. Structural components of a stream system (not all features exist in all streams.)

Human Influence

- Changing the timing or magnitude of amount of heat energy delivered to the channel or the amount of water delivered to the channel.
- Changing physical structure of a stream can influence heat load and stream's ability to withstand a given heat load.
- Size matters – streams with different structural characteristics will differ in their sensitivity to human influence.

Stream Size

Table 3. Relative influence of stream characteristics on temperature in small, medium, and large streams

Stream Order	Stream characteristics: Riparian shade	Stream discharge	Tributaries	Phreatic groundwater	Hyporheic groundwater
1–2	High	Low	Moderate	High	Low–Mod
	Riparian shade and lateral phreatic groundwater inputs provide thermal stability. Lateral tributaries can frequently affect overall stream temperature. Large wood stores sediments and creates streambed complexity, driving hyporheic flow. (However, hyporheic influence is high and shade moderate in alpine meadow systems.)				
3–4	Moderate	Moderate	High	Moderate	Mod–High
	Temperature of lateral tributaries has strong influence on stream temperature. Effects of riparian shade modest. Thermal inertia due to larger flows becomes more important. Where floodplains form, channels patterns become more complex, and alluvial aquifers are well developed, hyporheic influence can be high. Large wood creates habitat complexity and forms channel-spanning jams that may provide significant shade to the stream.				
5+	Low	High	Low–Mod	Low–Mod	Mod–High
	Complex floodplain morphology creates a diversity of surface and subsurface flow pathways with differential downstream flow rates allowing for stratification, storage, insulation, and remixing of waters with differential temperatures. The resulting mosaic of surface and subsurface water temperatures continually remix to buffer channel temperature and create thermal diversity. The thermal inertia of large water volumes allows the stream to resist changes in temperature. Where side channels exist, shade from vegetation can be important.				