MAPPING STREAM AQUIFER INTERACTION AT THE RIVERINE SEGMENT SCALE

Daniele Tonina
Andrea Bertagnoli
Andrew Tranmer
Charlie Luce

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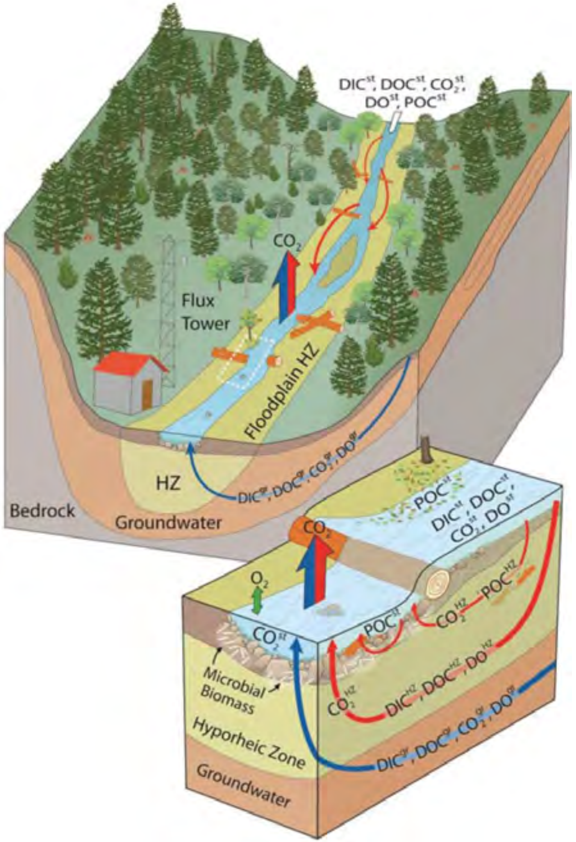
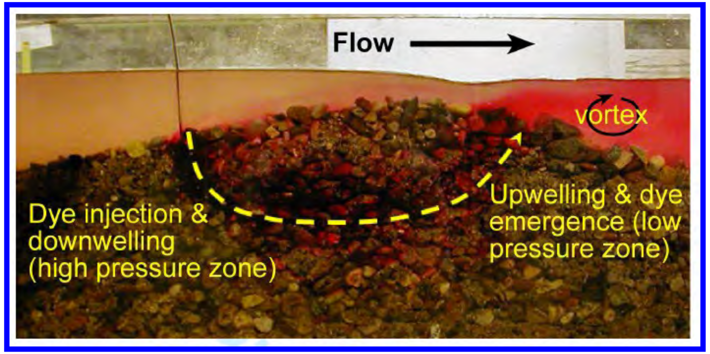
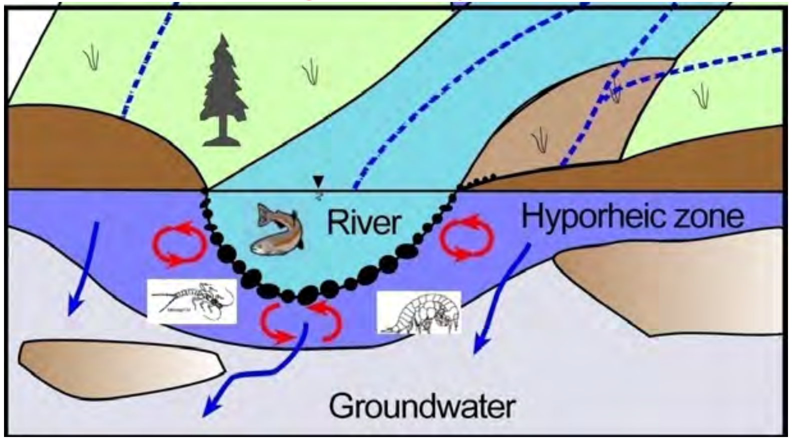
SURFACE-SUBSURFACE WATER EXCHANGE





longitudinal profile



landscape cross section

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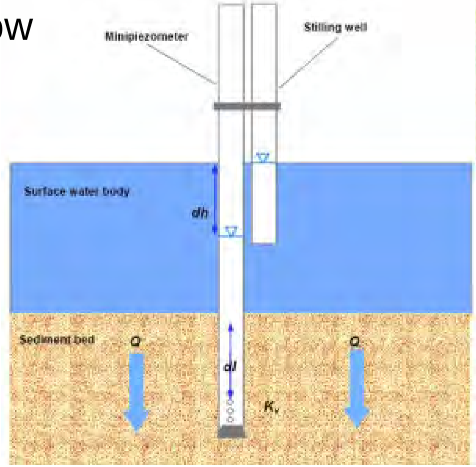
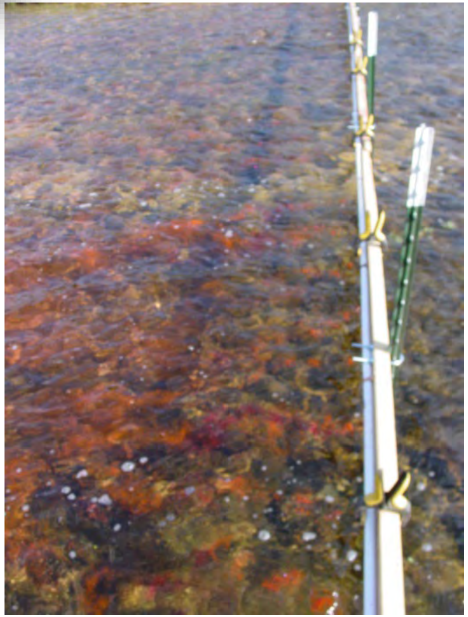
[*Tonina & Buffington,* Geography Compass, 2009]
[*Buffington & Tonina,* Geography Compass, 2009]

HOW TO MEASURE HYPORHEIC FLOW

Many ways to measure water exchange:

- Seepage meters
- Darcy's Law (q = K dh/dl) / Pressure gradients
- Incremental streamflow
- Solute tracer
- Temperature





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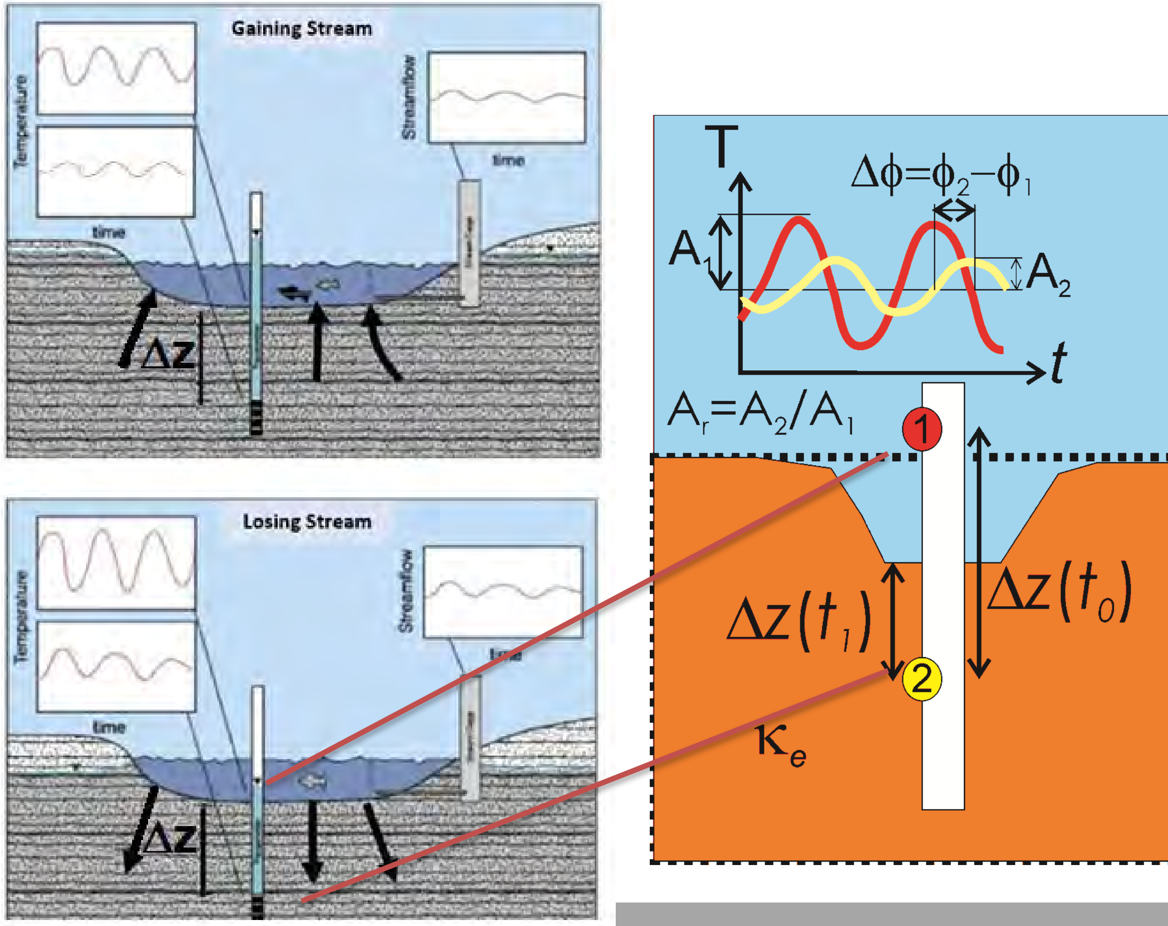
TEMPERATURE TRACER

Why temperature?

- Robust
- Relatively inexpensive



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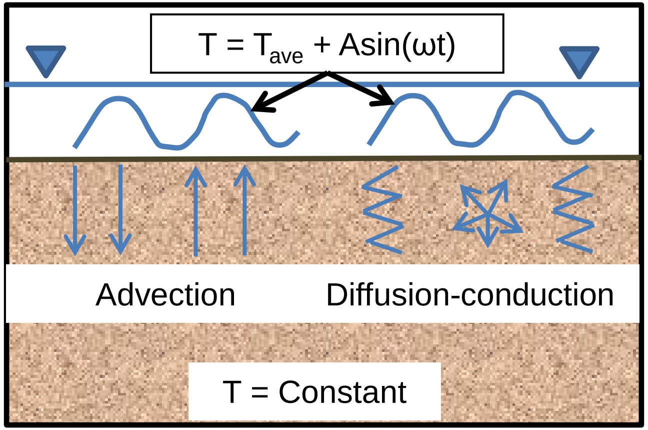
Luce & al (WRR, 2013)

BACKGROUND

1-D Advection-Diffusion Equation

$$\frac{\partial T}{\partial t} = \kappa_e \frac{\partial^2 T}{\partial z^2} - \frac{q}{\gamma}\frac{\partial T}{\partial z}$$



where:

- T: temperature (^{o}C)
- t: time (s)
- κ_e: effective thermal diffusivity ($m^2\ s^{-1}$)
- z: streambed depth (m)
- n: streambed porosity (-)
- q: Darcy flux ($m\ s^{-1}$) [related to thermal front velocity by ($q = v_{tf}\gamma$)]
- γ: ratio of bulk heat capacity (system) to water heat capacity

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BENEFITS

Solution of the flux

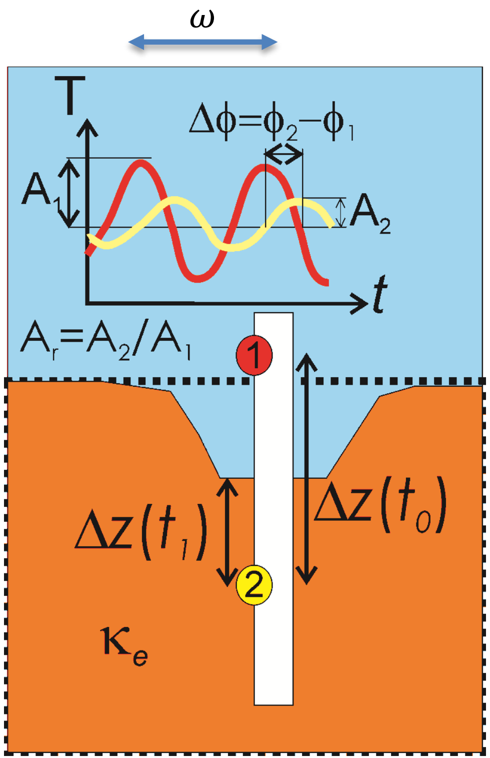
$$q(t) = f(\frac{A_2}{A_1}, \phi_2 - \phi_1, \omega, \Delta z, \gamma)$$

Solution of the sediment effective thermal properties

$$\kappa_e(t) = f(\frac{A_2}{A_1}, \phi_2 - \phi_1, \omega, \Delta z)$$

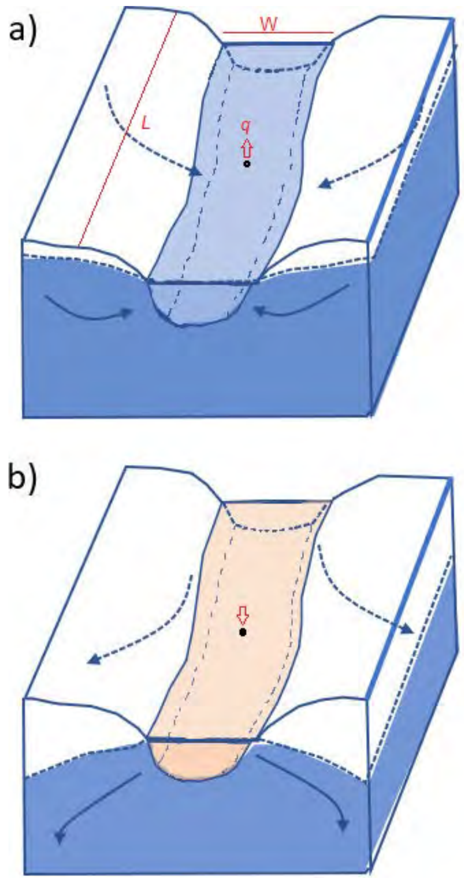
Explicit solution of streambed temporal changes

$$\Delta z(t) = f(\frac{A_2}{A_1}, \phi_2 - \phi_1, \omega, \kappa_e(t))$$



SEEPAGE DISCHARGE

$$Q_{reach} = q_i A_i = \boldsymbol{q}_i W_i L_i$$



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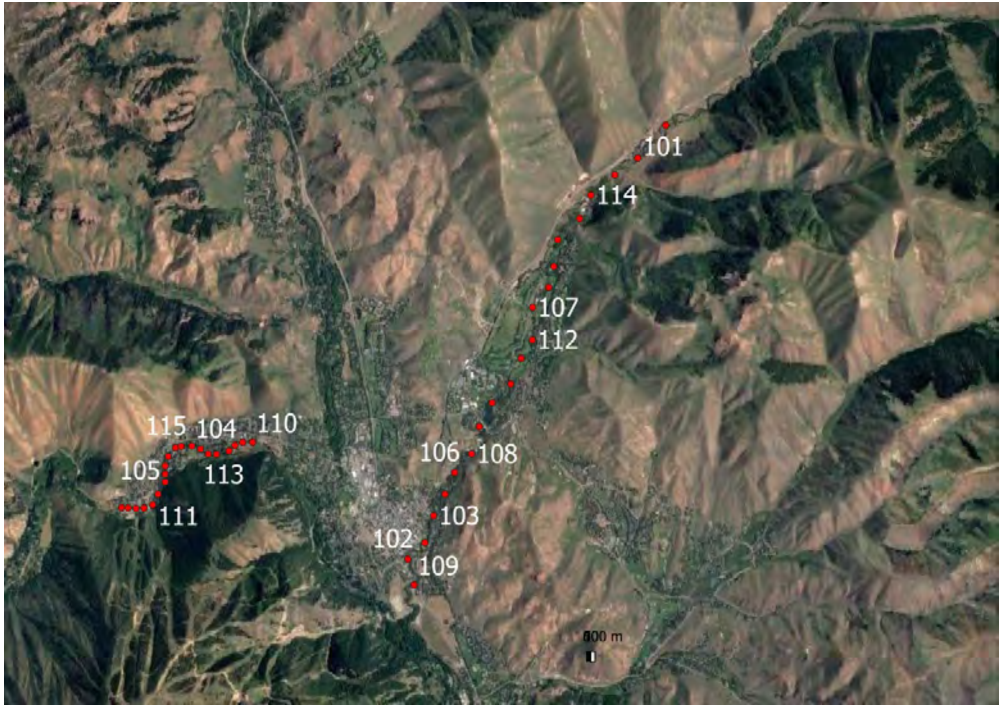
APPLICATION OF THE METHOD

(1) Have a US-GS gauging station at each ends of the reach in Warm Springs Creek (~2 miles long) and Trail Creek (~4 miles long)

(2) We have discharge measurements along Warm Springs reach from which we can quantified changes in discharge (seepage flow)



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PROBE INSTALLATION

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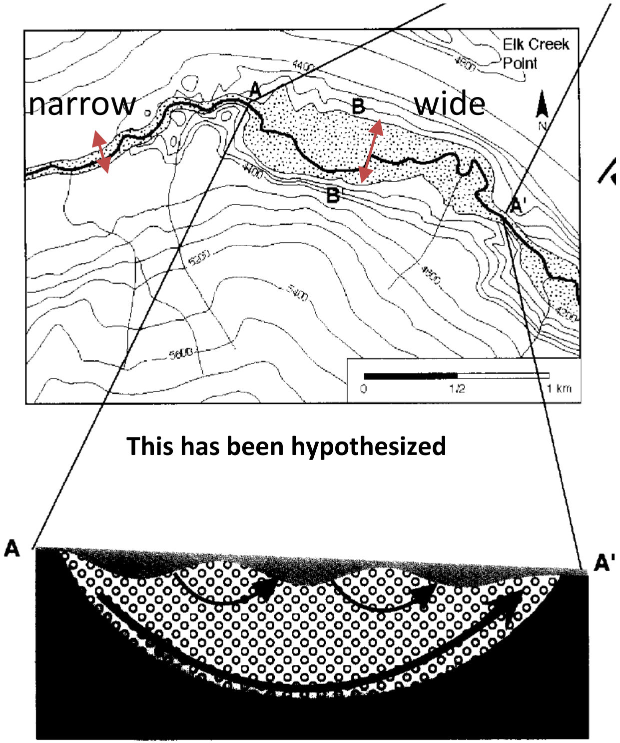
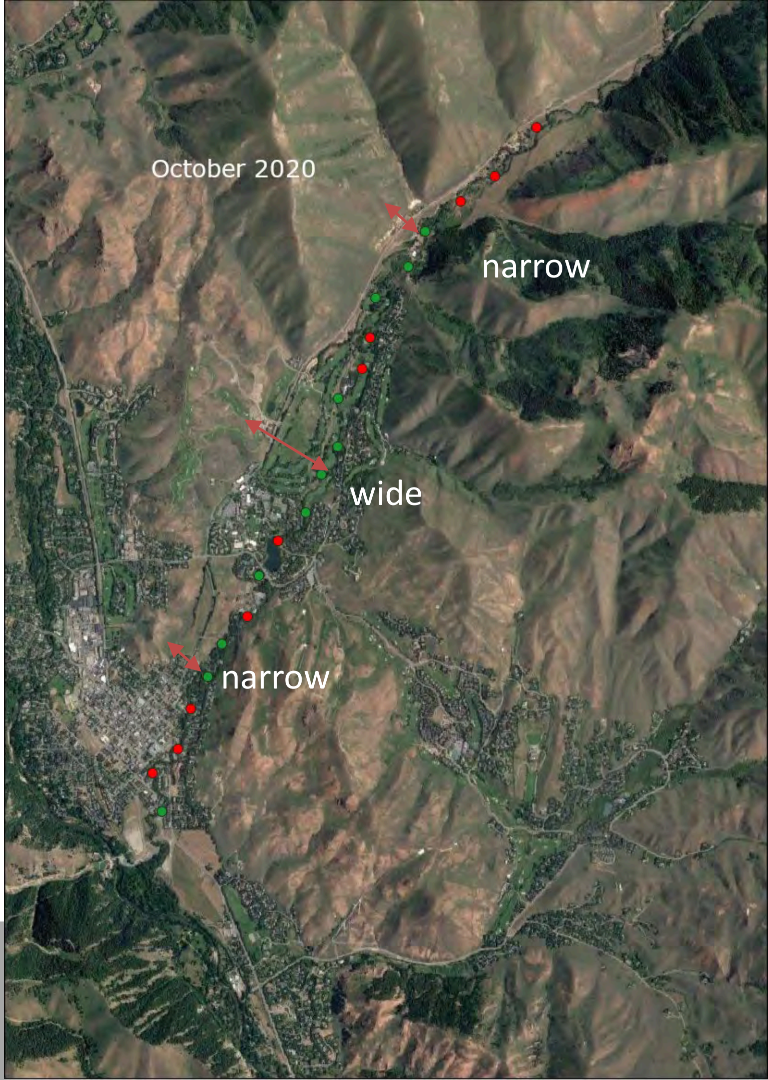
TRAIL CREEK



This has been hypothesized

Baxter and Hauer, Can J Fish Sci 2000



WARM SPRINGS CREEK

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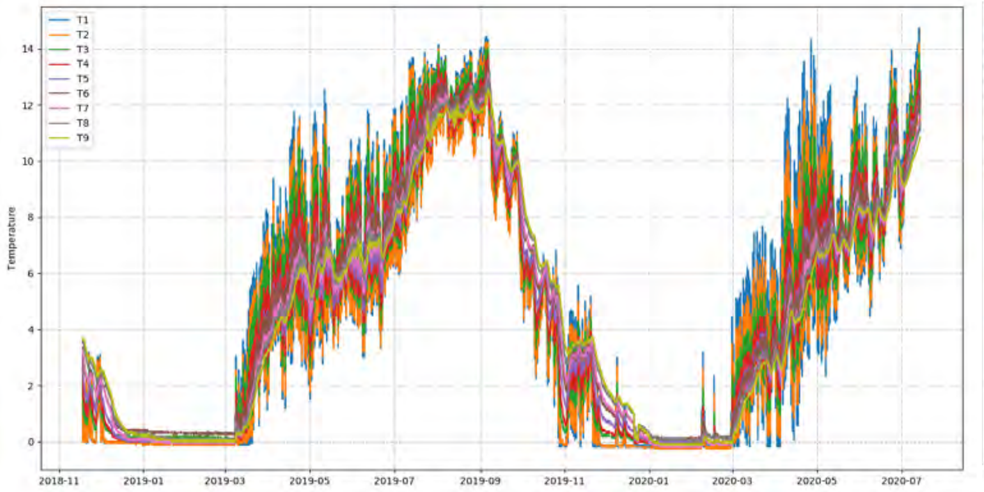
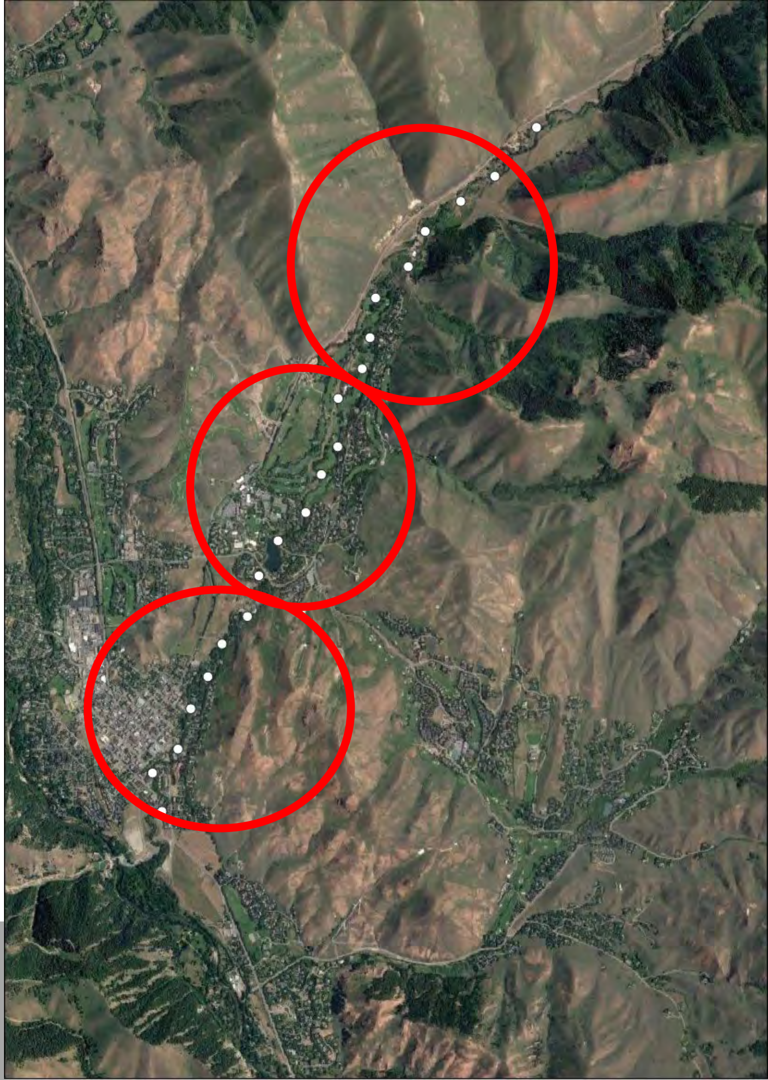
TRAIL CREEK





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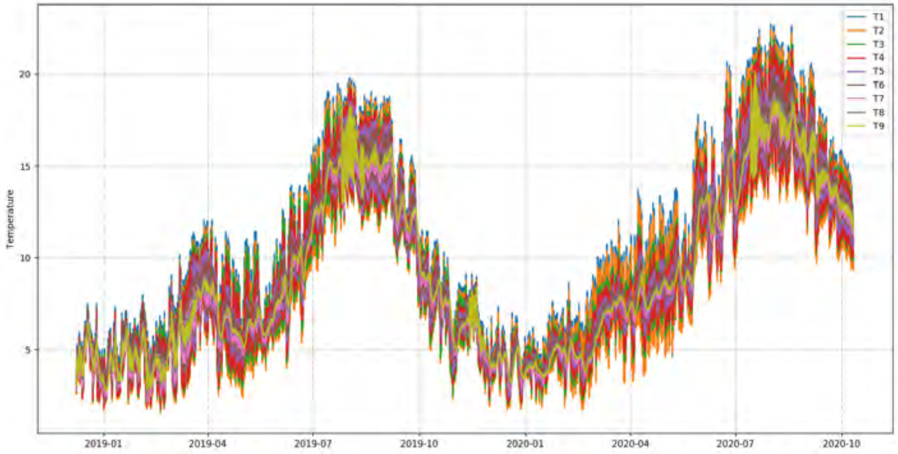
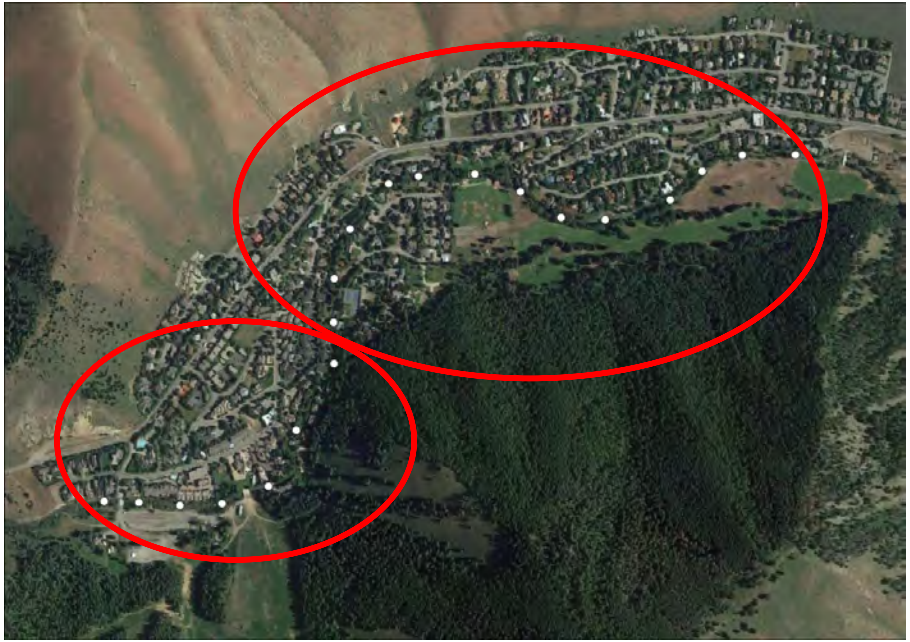
WARM SPRINGS CREEK





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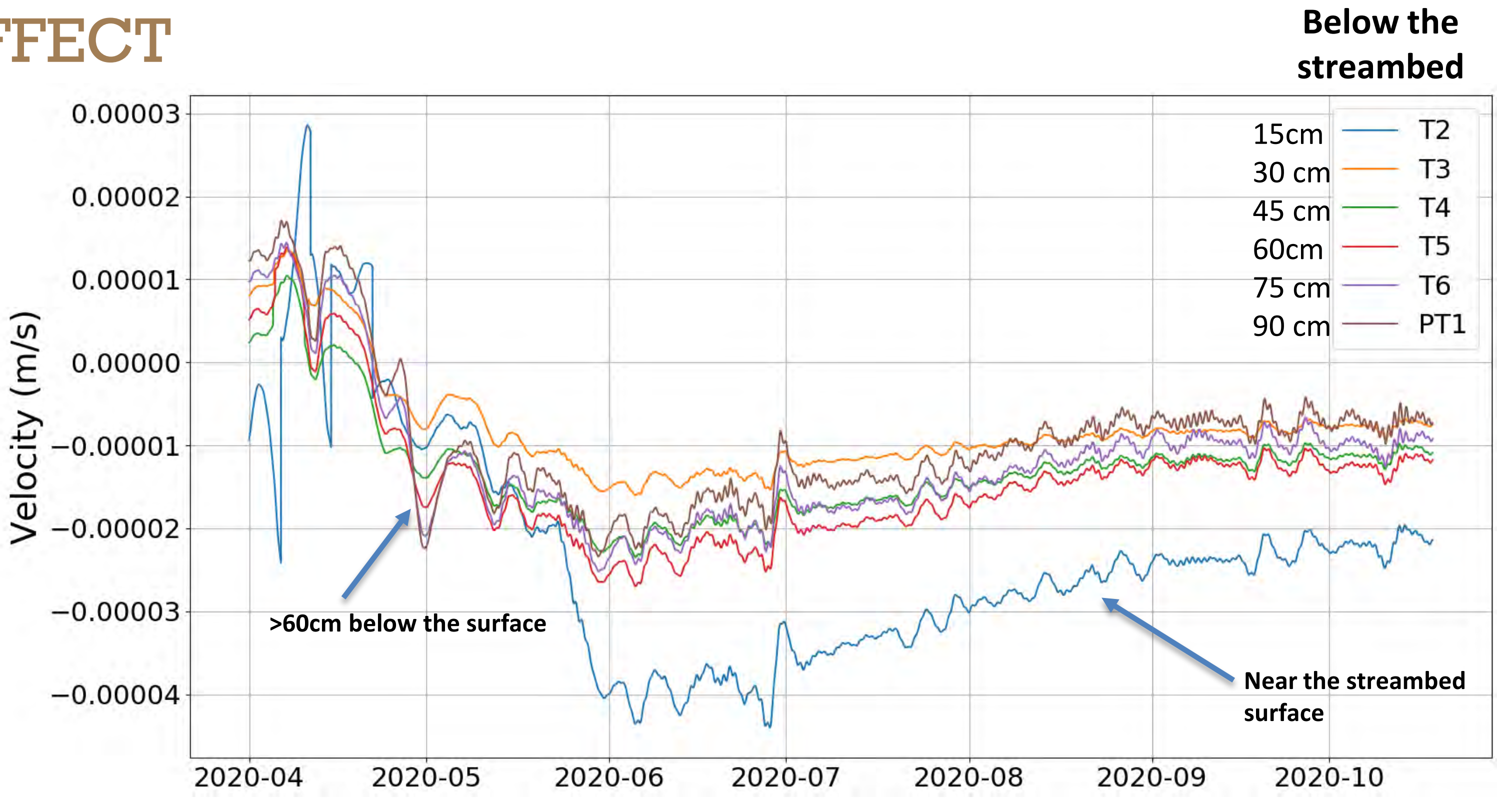
DEPTH EFFECT



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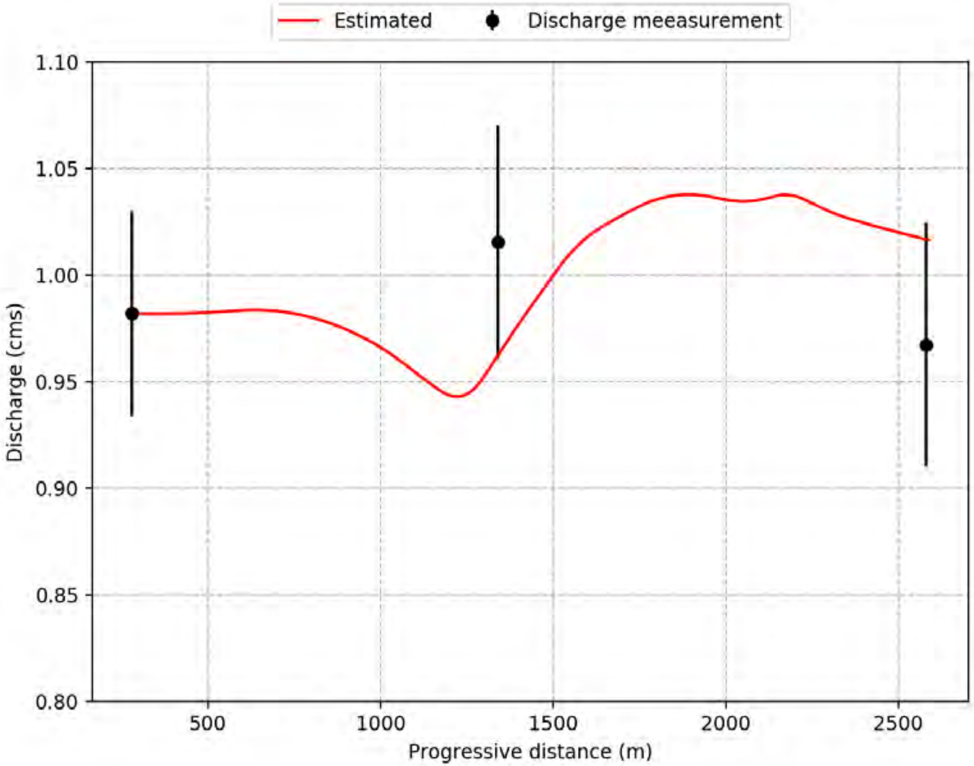
WARM SPRINGS CREEK SEEPAGE OCTOBER 30, 2019



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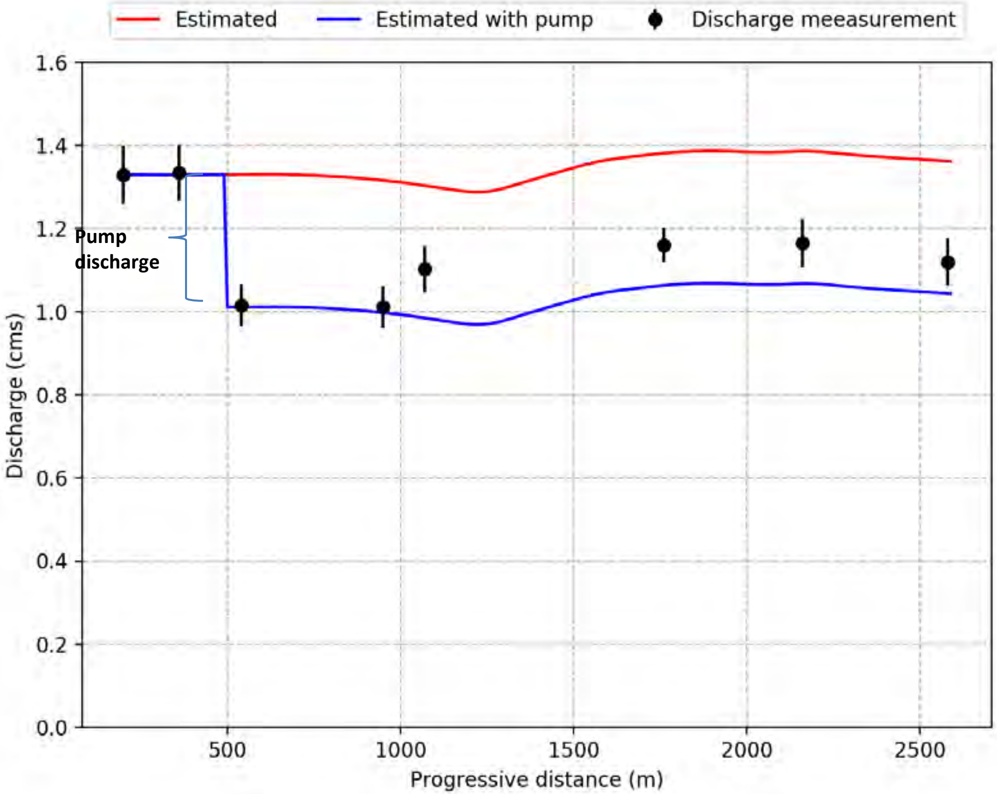
WARM SPRINGS CREE SEEPAGE OCTOBER 3 2019

Snow Pump
11.2477 cfs
0.3185 cms



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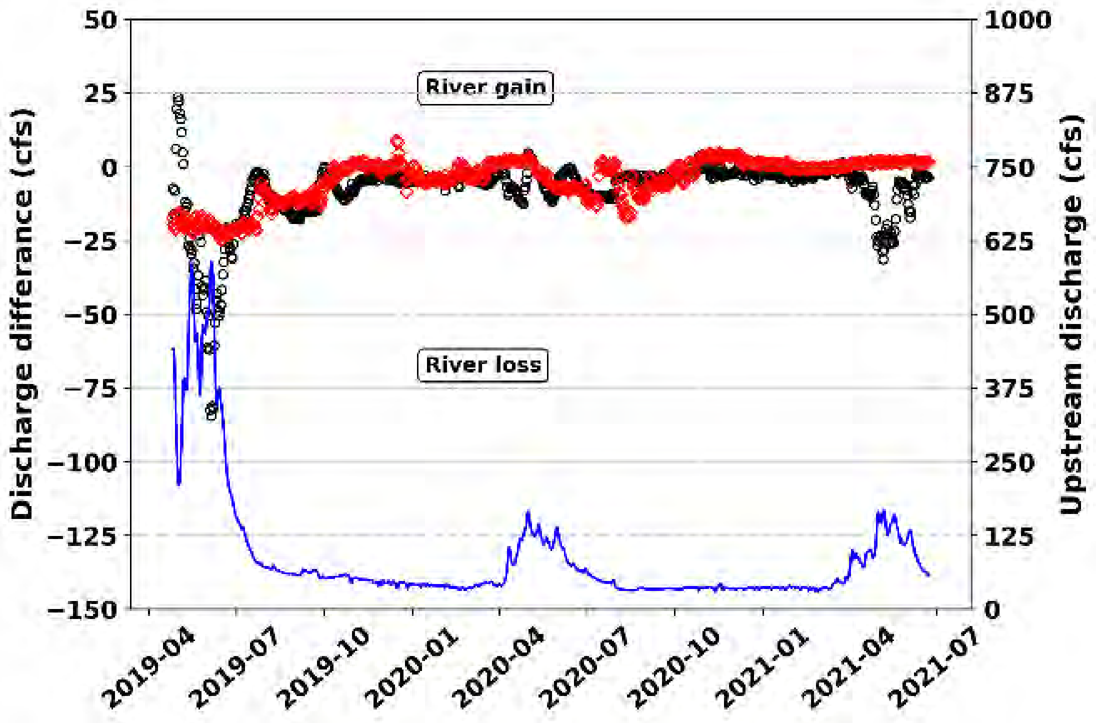
WARM SPRINGS CREEK SEEPAGE-USGS GAGING STATION COMPARISON



Total yearly seepage volume (over ~2 miles)

Qs = -6,420,00 m^3 in 2019

-1,197,00 m^3 in 2020

Overall, a losing stream recharging the groundwater

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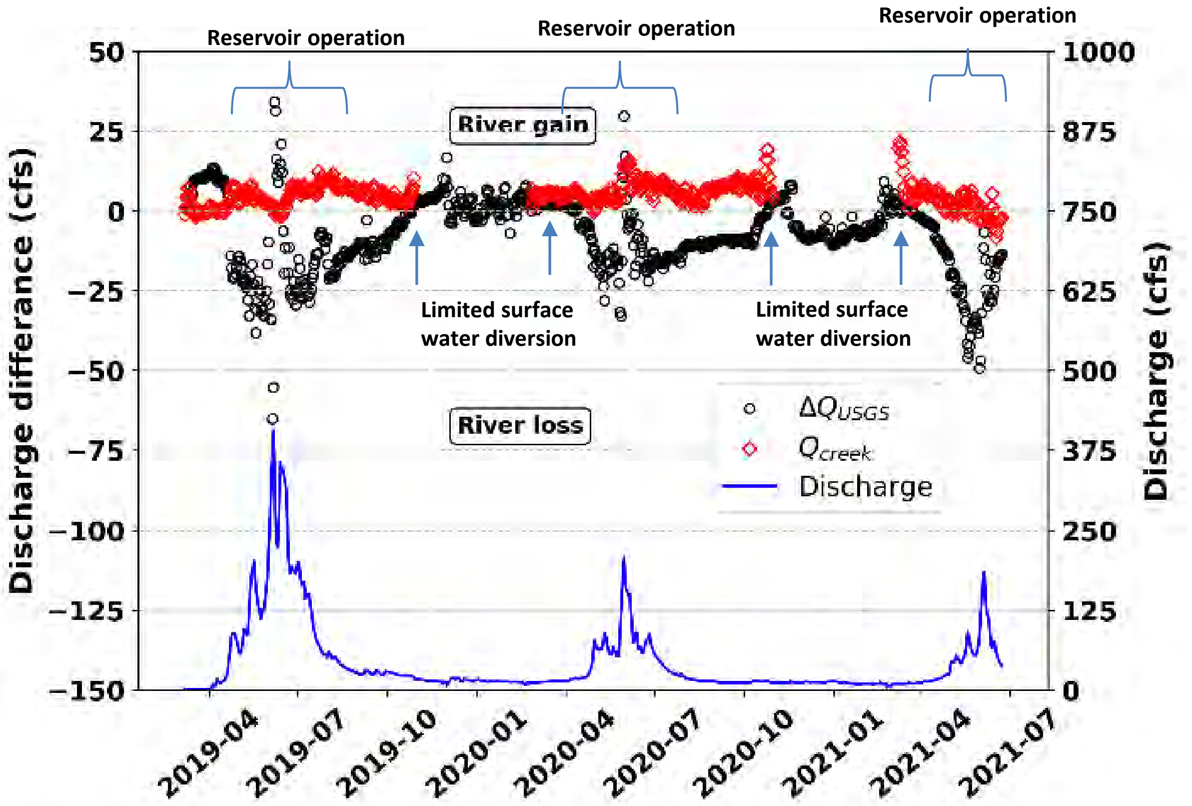
TRAIL CREEK SEEPAGE-USGS GAGING STATION COMPARISON

Total yearly seepage volume (over ~5 miles)

Qs = 4,661,000 m^3 in 2019

7,359,660 m^3 in 2020

Overall, a gaining stream recharged by the groundwater



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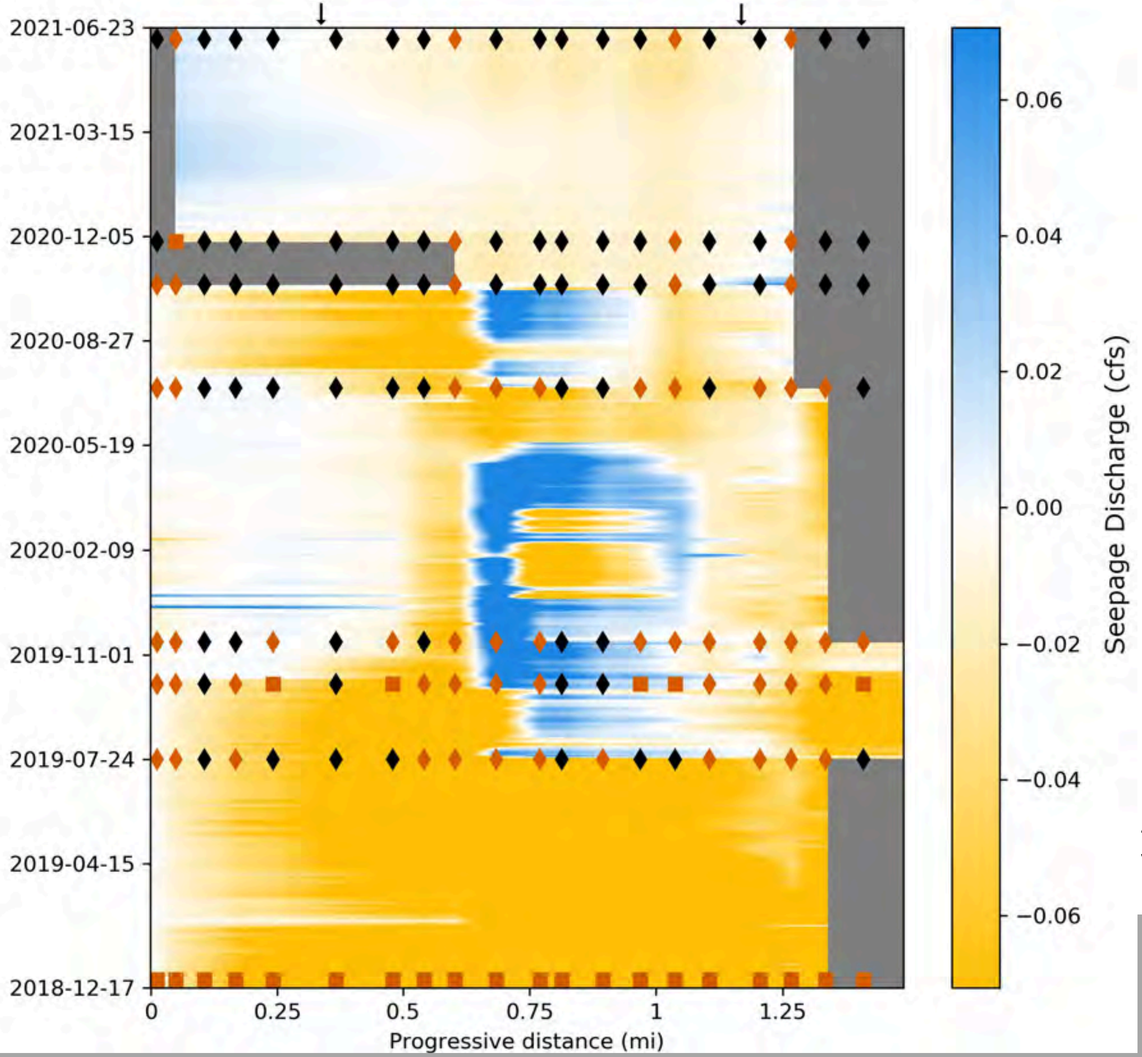
WARM SPRINGS CREEK SEEPAGE DISTRIBUTION

Mainly downwelling



Dry year

Average year

↓ Well location

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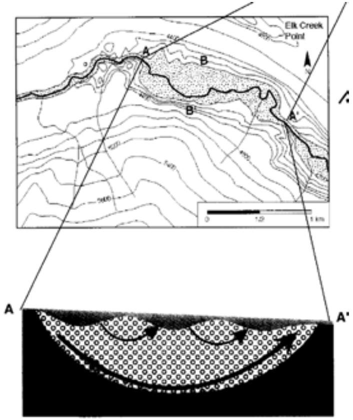
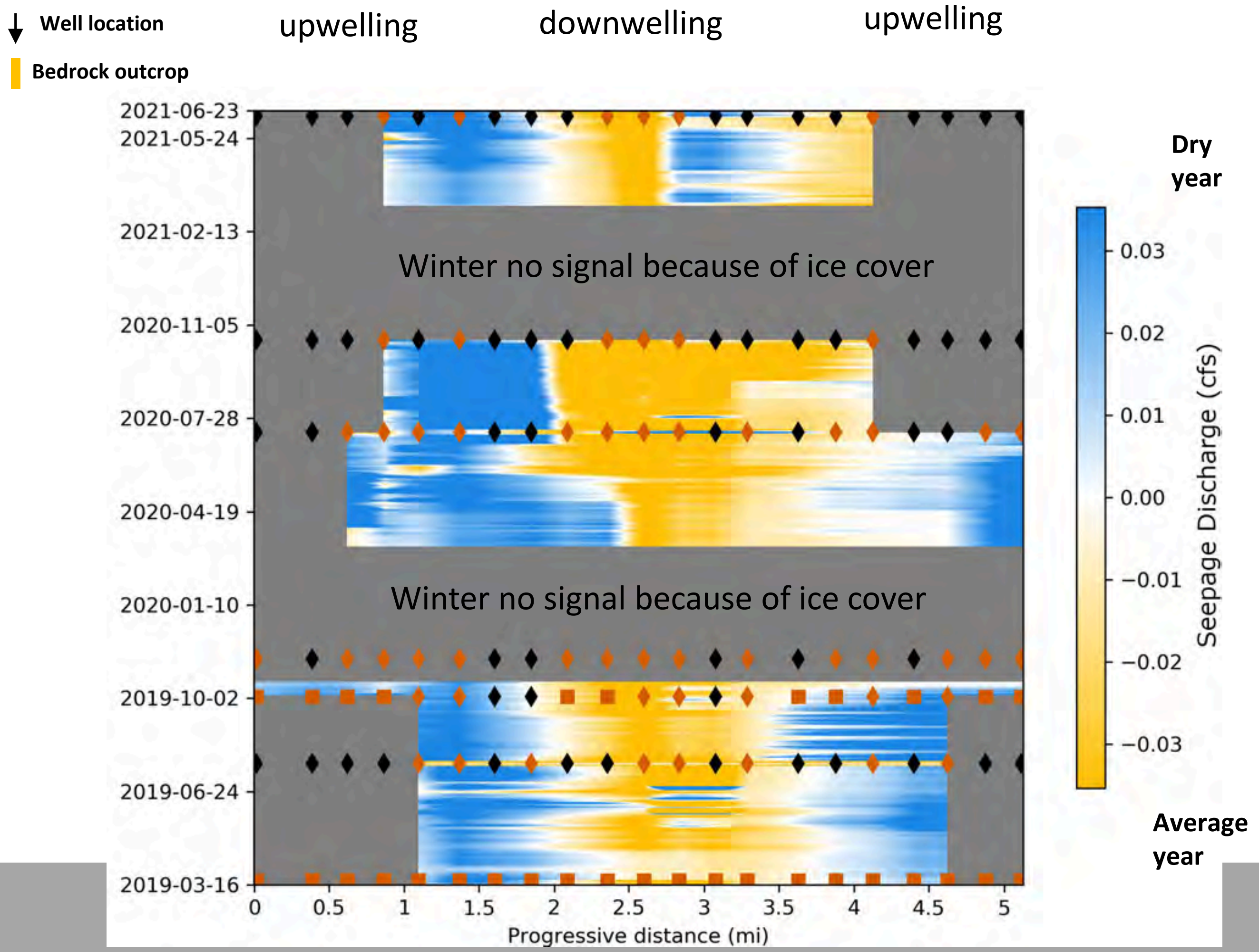
TRAIL CREEK SEEPAGE

Water year gets drier



Baxter and Hauer, Can J Fish Sci 2000



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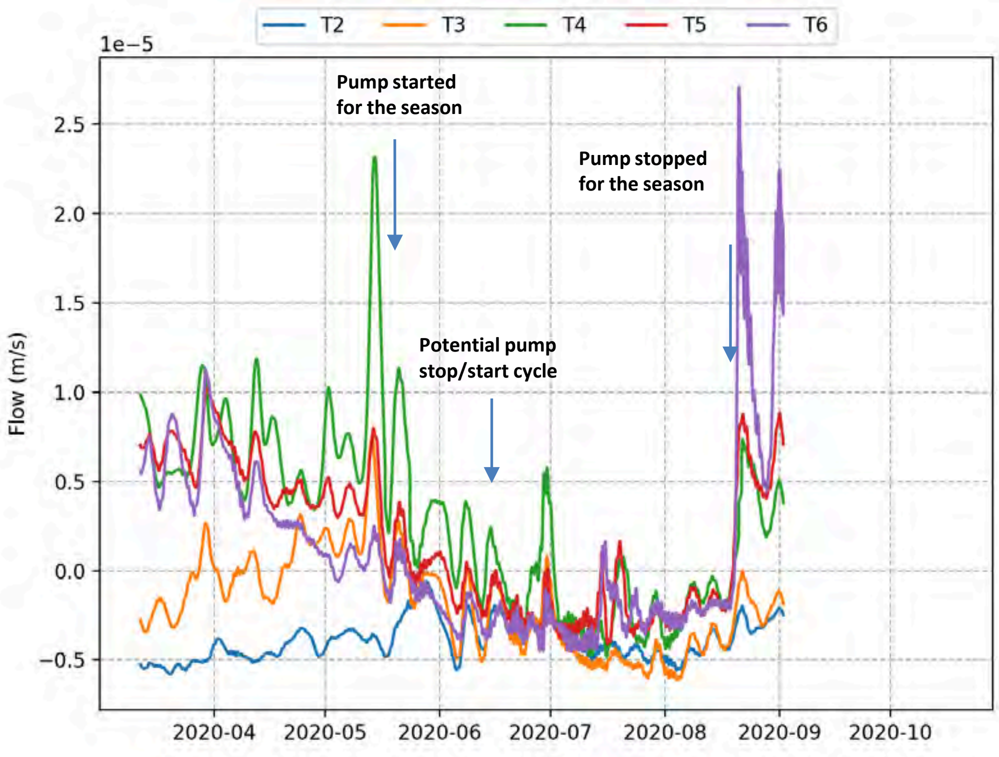
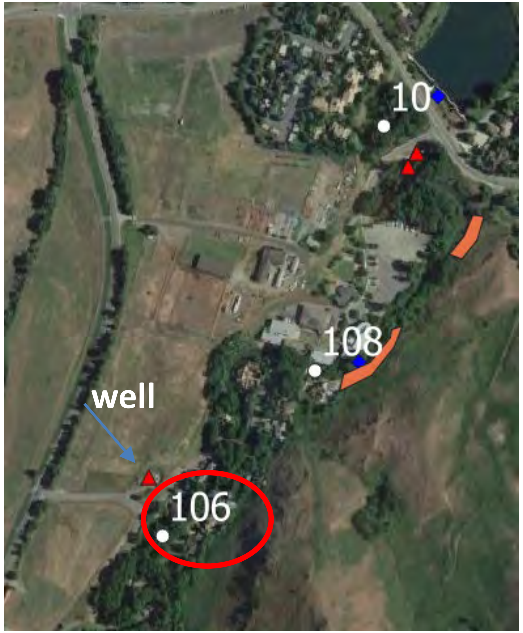
PROBE 106 - FLUX





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CONCLUSIONS

- The thermal method provides good agreement when surface diversions are not present.
- This method can measure local fluxes that may otherwise be lost in the differential gaging method.
- The method provides from daily to yearly seepage discharges from the reach to entire river segment scale

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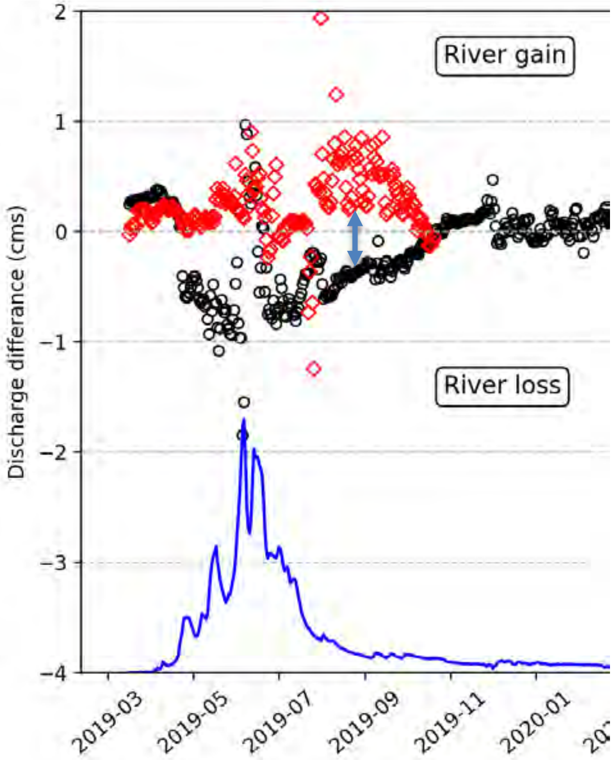
CONCLUSIONS

- Warm Springs Creek is a losing stream while Trail Creek is a gaining stream
- In a dry year Warm Springs Creek loses less water and Trail Creek gains more water than a wet year
- The stream-groundwater interaction maintains water in the stream.
- Streambed elevation changes were not detectable during the study period

CONCLUSIONS

Monitoring seepage discharge provides better understanding of water resource availability because in gaining and losing reaches, the actual diverted water could be different from that quantified by the surface water discharge difference between upstream and downstream ends because of the groundwater contribution.



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QUESTIONS

Acknowledgements

- Idaho Department of water Resources
- Hatch Program IDA01722

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