Electrical Imaging of the Changes in Hyporheic Exchange from Channel-Spanning Logjams

COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT

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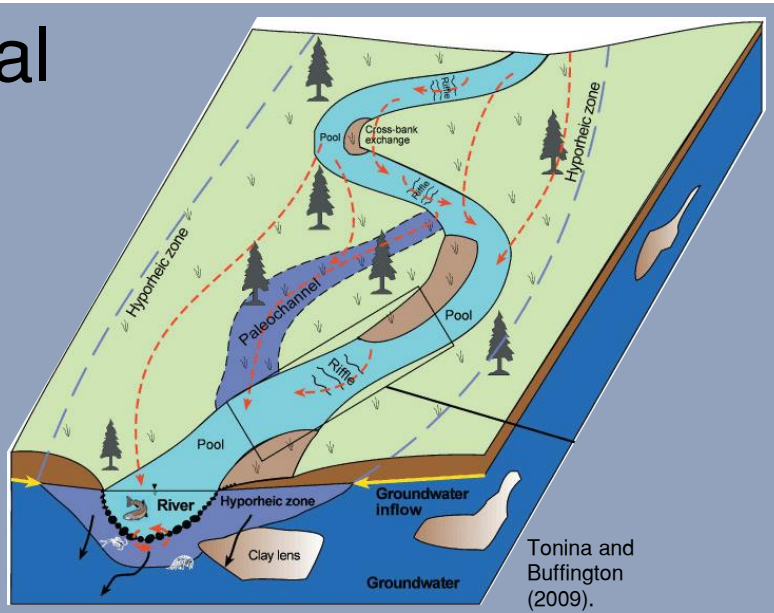
2

Background

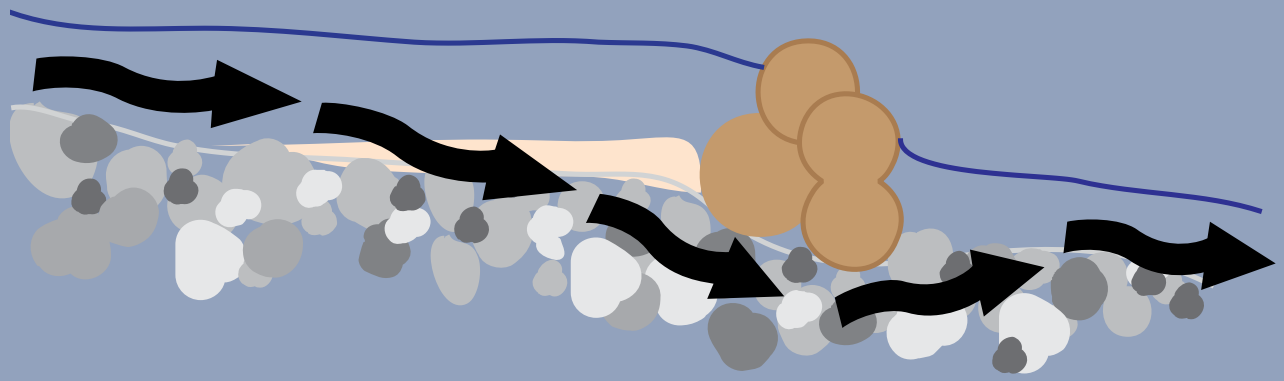
- Human impacts alter natural processes and features of streams
  - Timber harvesting
  - Stream engineering
  - Beaver removal
  - Urbanization
- Natural heterogeneity is important for sediment transportation and healthy ecosystems



Tonina and Buffington (2009).

Logjams

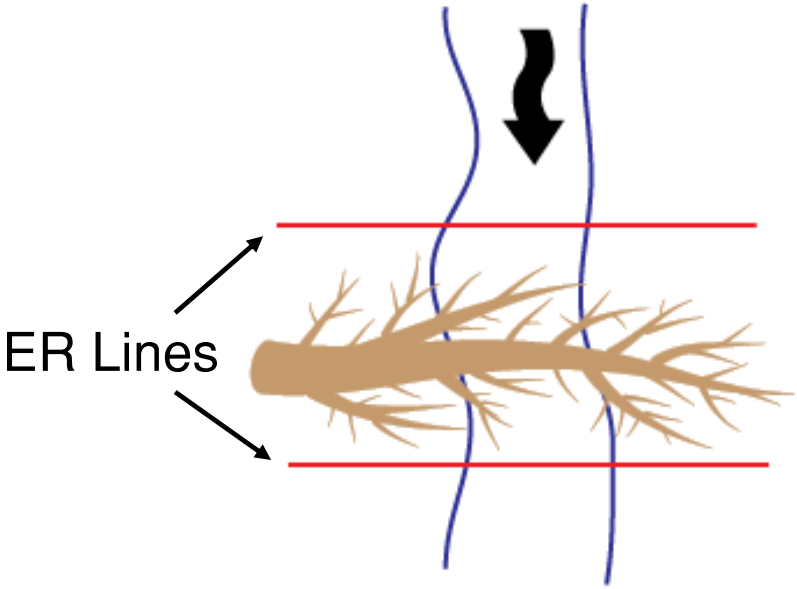
- Logjams increase hydraulic resistance and create pressure gradients driving hyporheic exchange flow
  - Transfers dissolved oxygen, solutes, and nutrients
  - Regulates temperature fluctuations
  - Creates diverse habitats



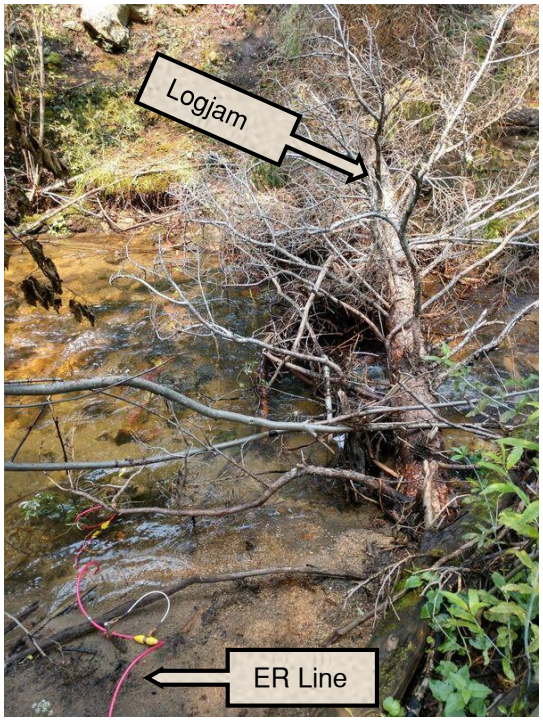
Field Site: Little Beaver Creek

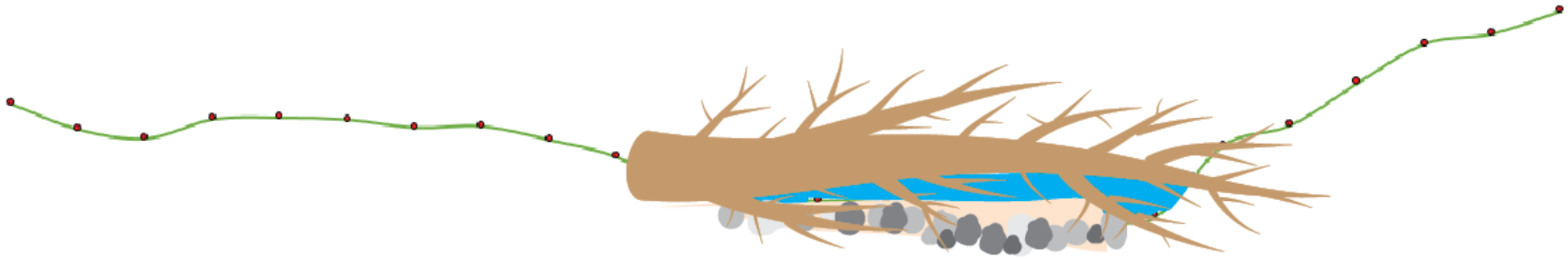
- Drainage Area: 40 km^2
- Third-order tributary to the South Fork of the Cache la Poudre River
- Montane Forest (1,840-2,740 m elevation)
- Snowmelt Dominated
- Abundant logjams and minimum human alteration

Logjam Site



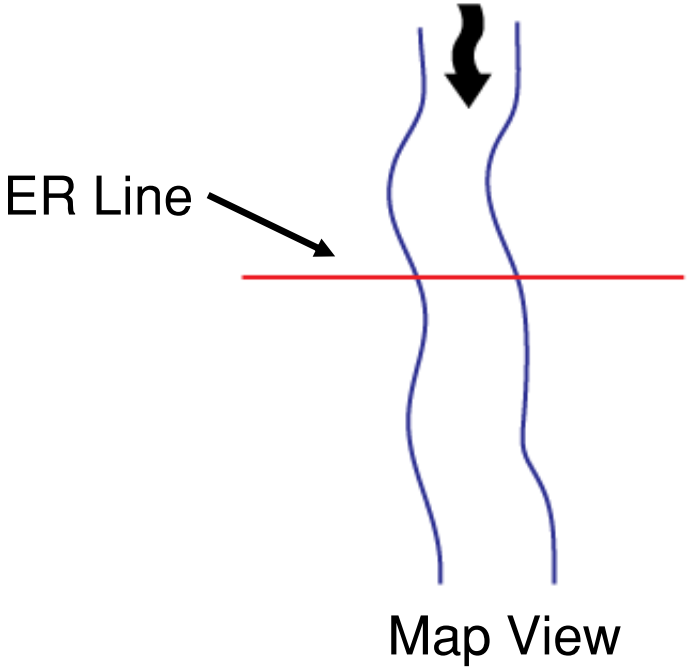
Map View



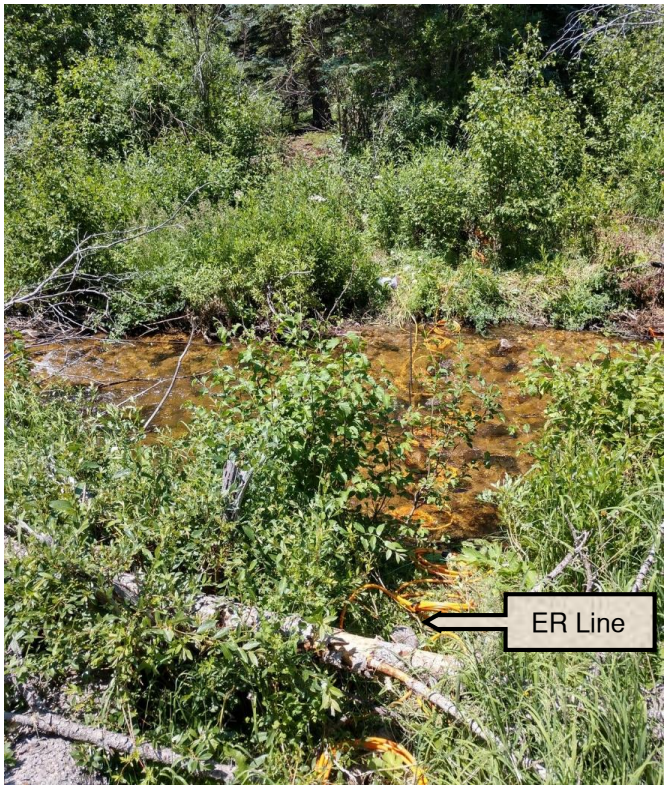


Cross-Section

Control Site



Map View



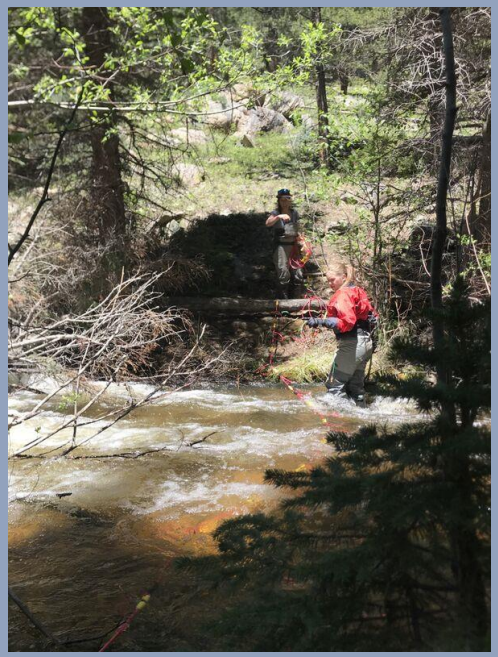
Cross-Section

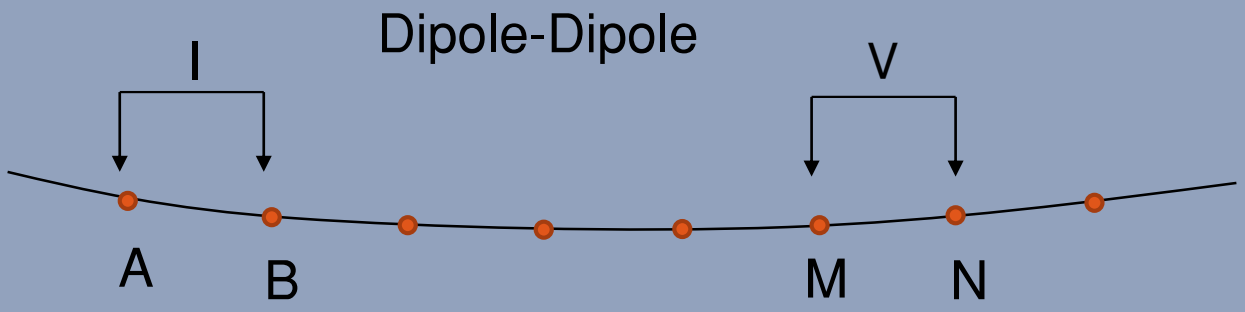
Field Methods

- 4-hour injection of a salt tracer
  - NaCl is highly conductive
- In-stream and ER monitoring for 24 hours
- 24 electrodes with 1 to 0.5 meter spacing

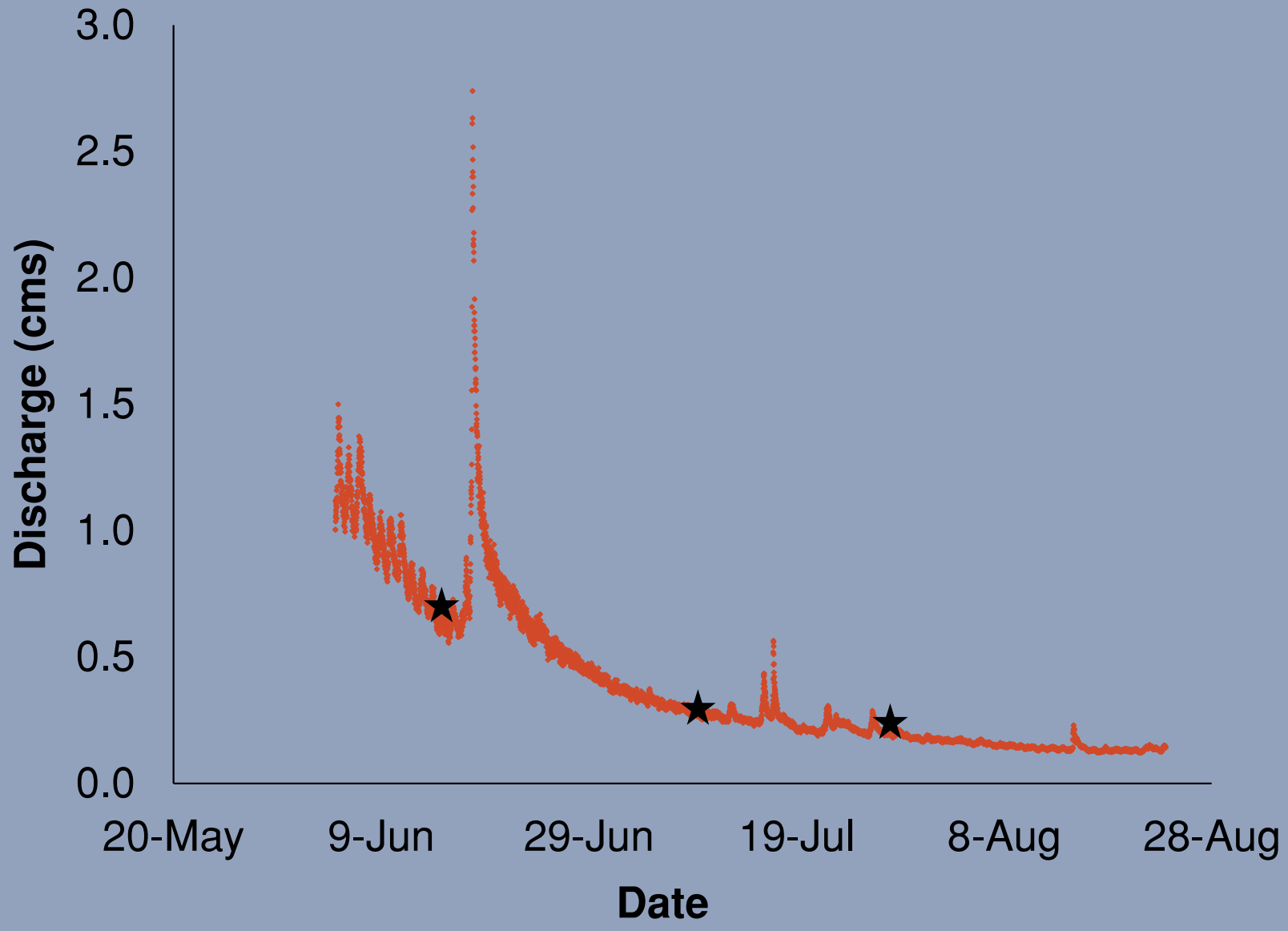
Field Methods: Electrical Resistivity

- ER passes low-frequency alternating current along the lines
- Typical solute monitoring methods (i.e. wells and in-stream) are insufficient to capture hyporheic exchange
- ER provides spatial and temporal data

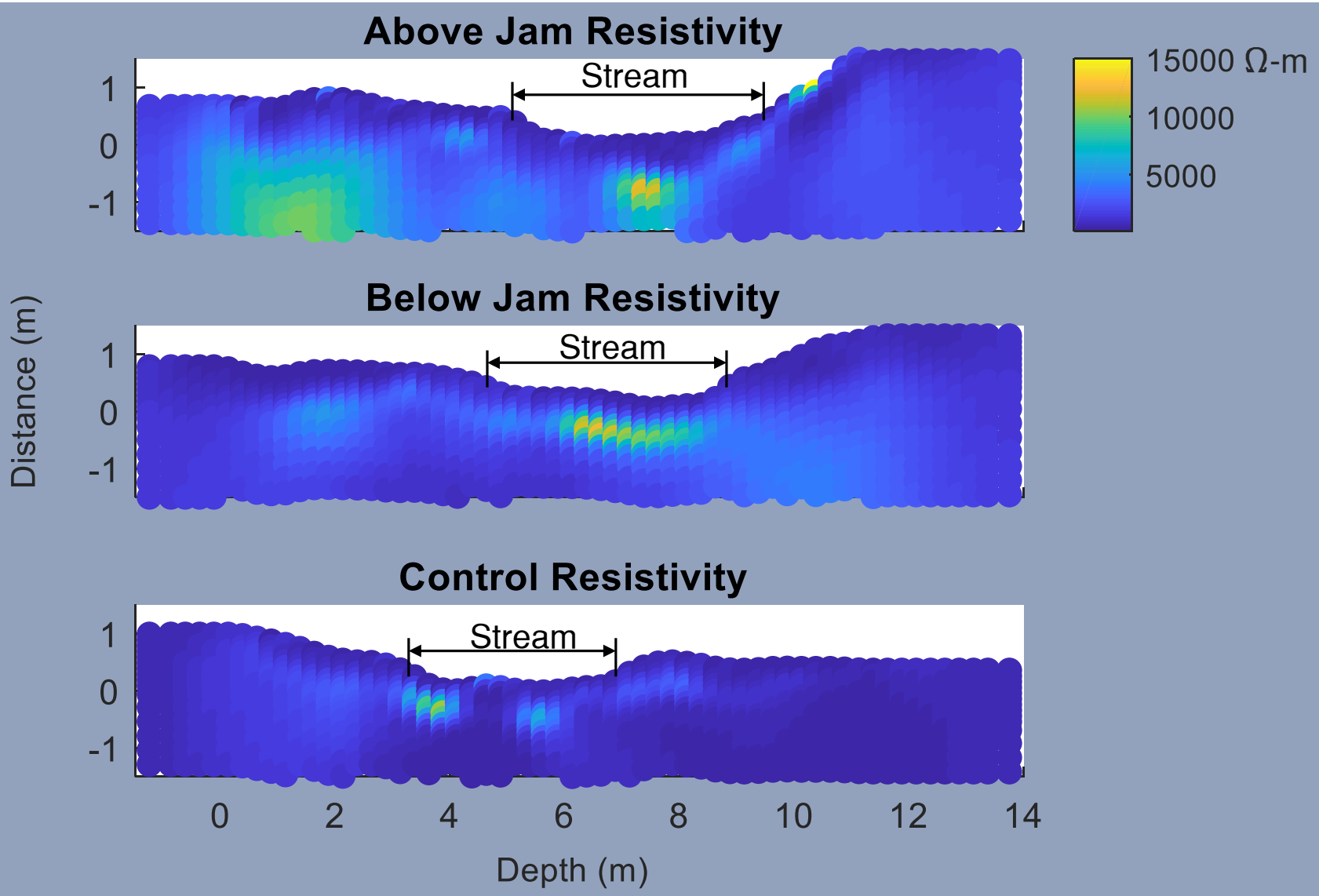




Calculated Discharge (cms) Based on Rating Curve

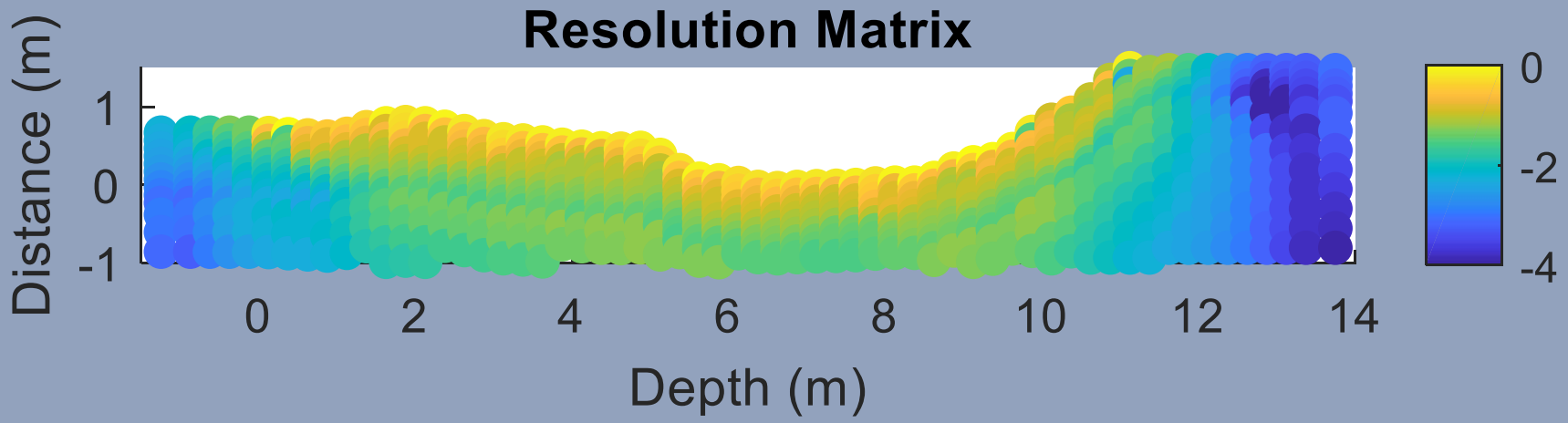


Background Resistivity



Background Fluid Resistivity : 416 Ω-m (EC: 24 uS/cm)

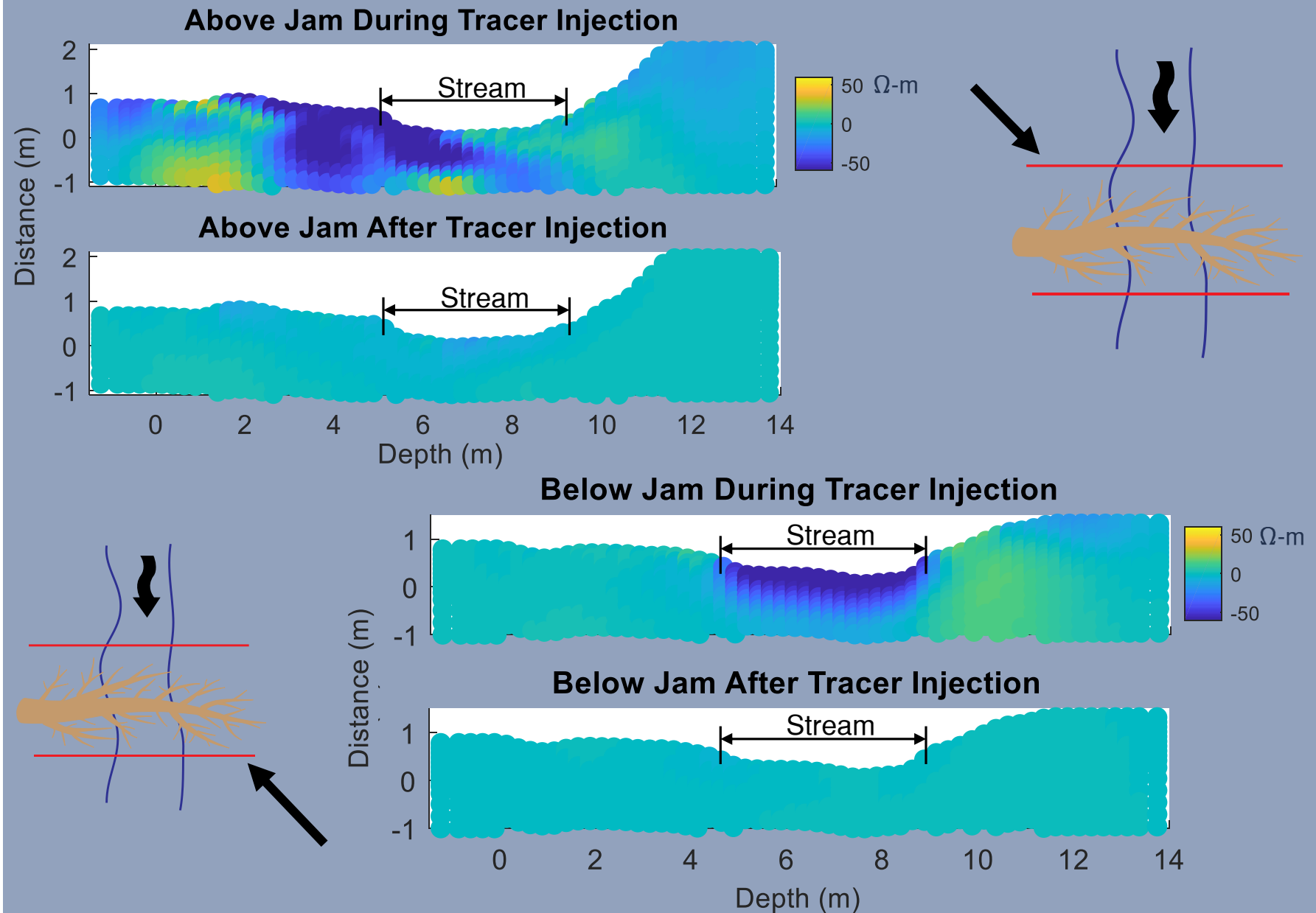
Resolution Matrix



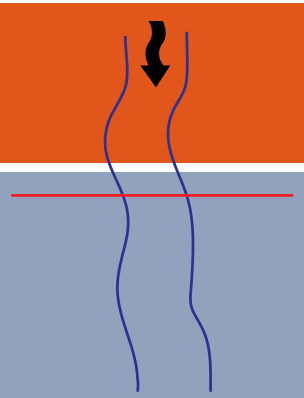
Log10(diagonal of resolution matrix)

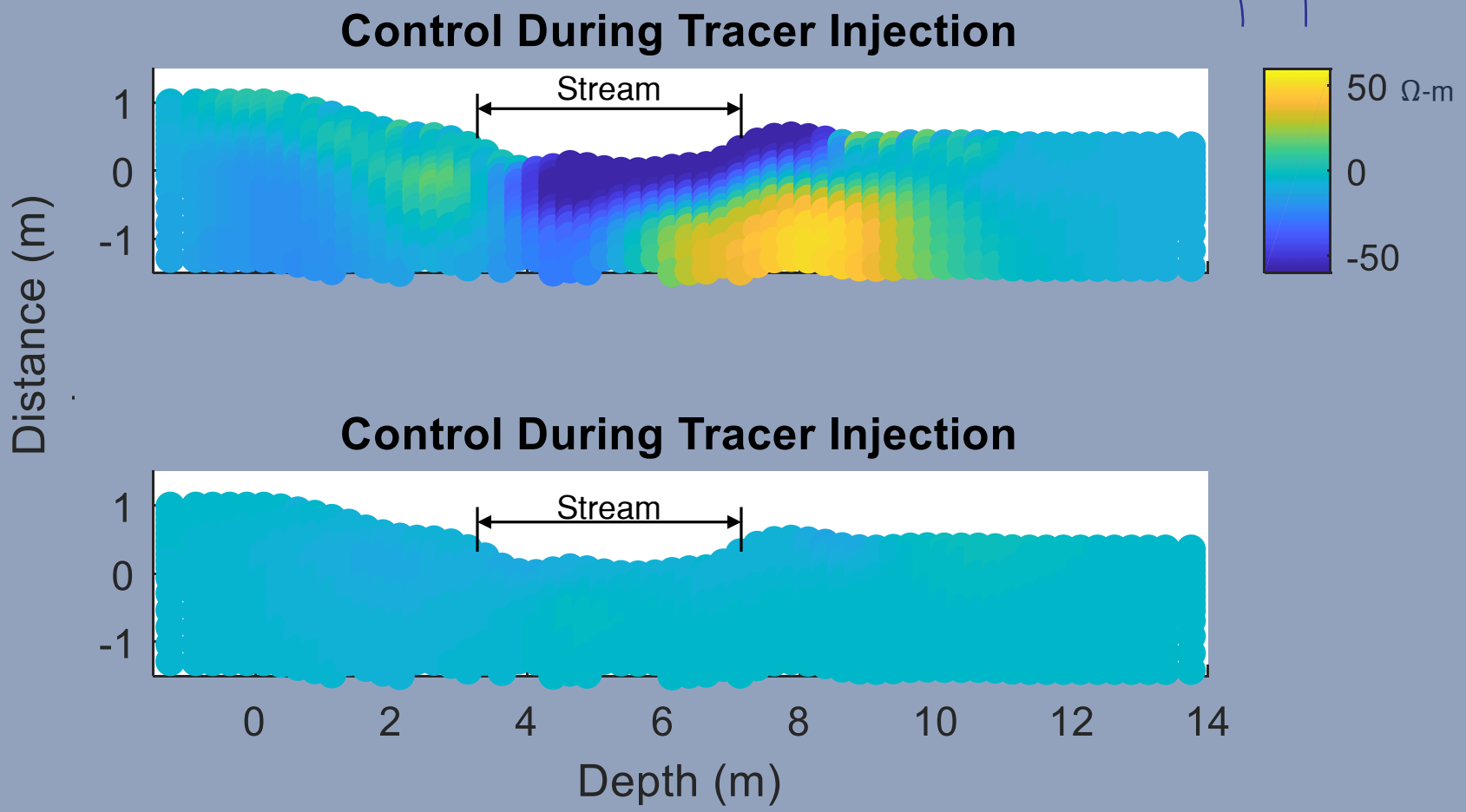
- Pixels equal to log(1) = 0 have perfect resolution
- Pixels less than 1 (negative in log space) have less than perfect resolution

Logjam Site: Changes in ER

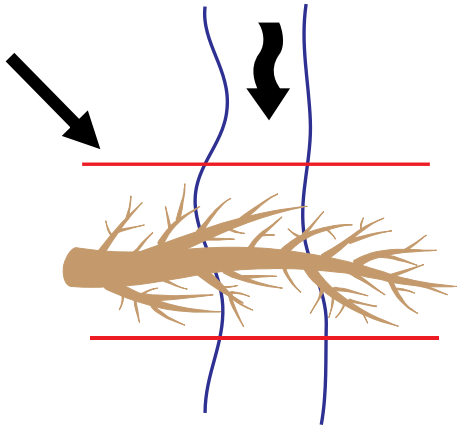


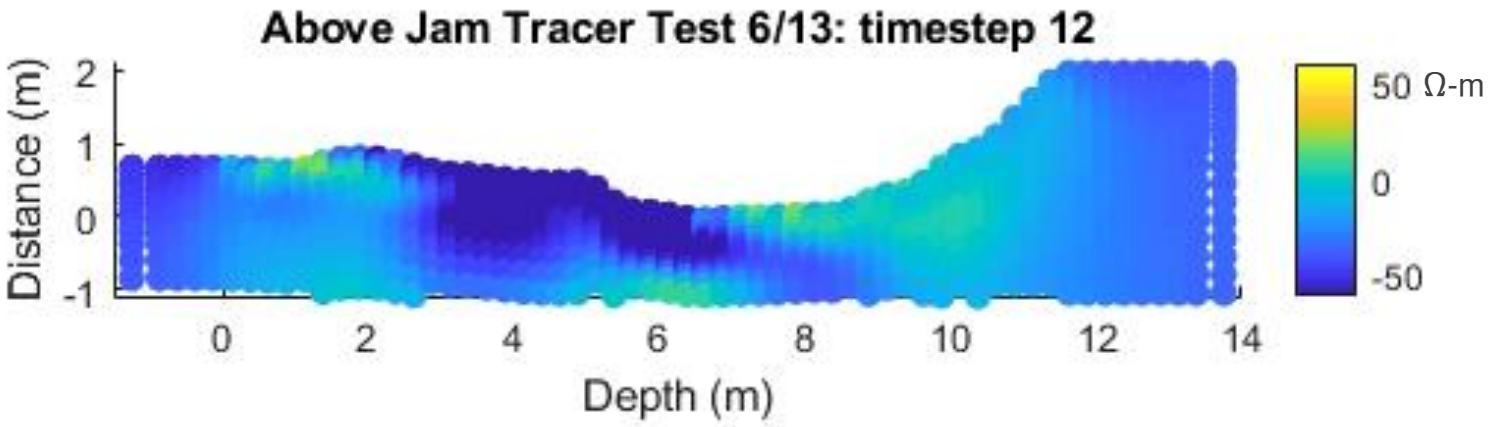
Control Site: Changes in ER





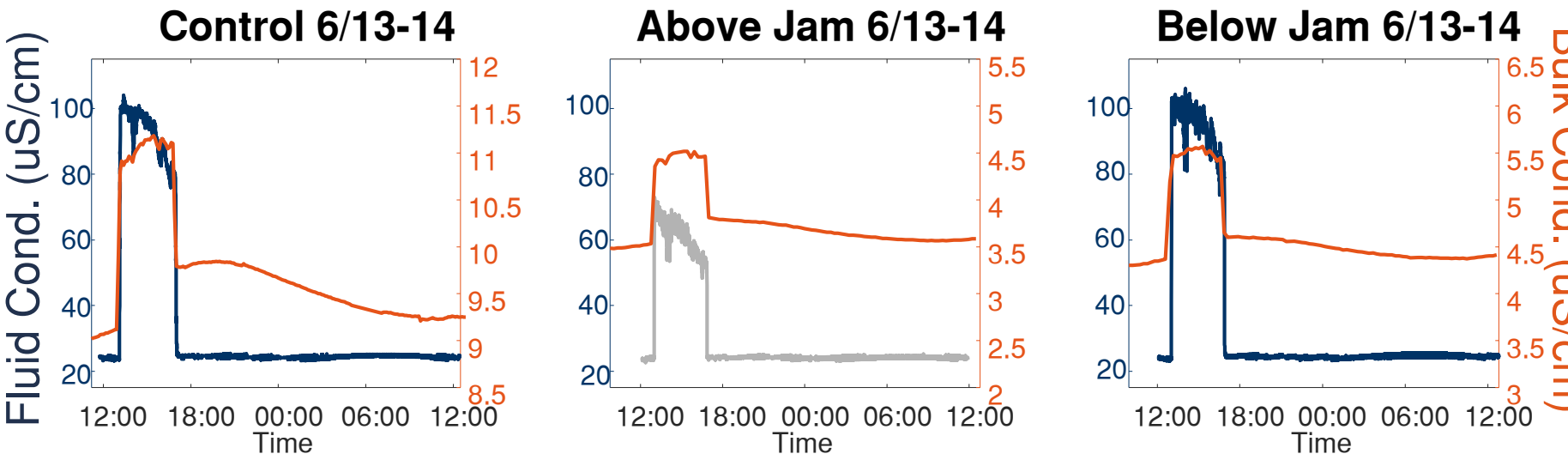
Changes in ER Above Logjam Over Time





Tracer Test 6/13-14

Fluid vs Bulk Electrical Conductivity

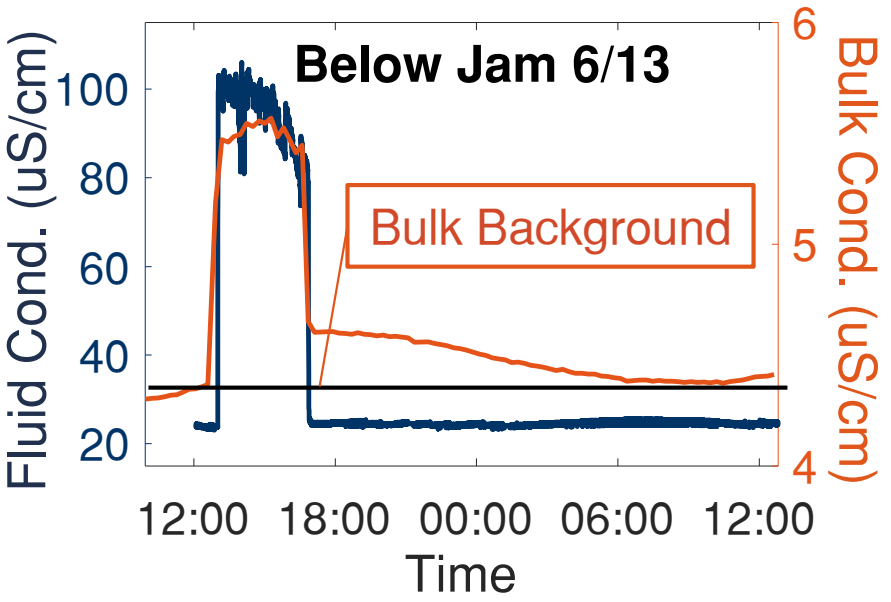


Tracer 6/13-14	Control		Above Jam		Below Jam	
Mean Arrival Time (hr)	7	2	6	3	6	2
Variance (hr^2)	36	5	36	15	34.0	10
Skewness (hr^3)	**220**	**57**	**254**	**188**	**271**	**135**

Flow Comparisons

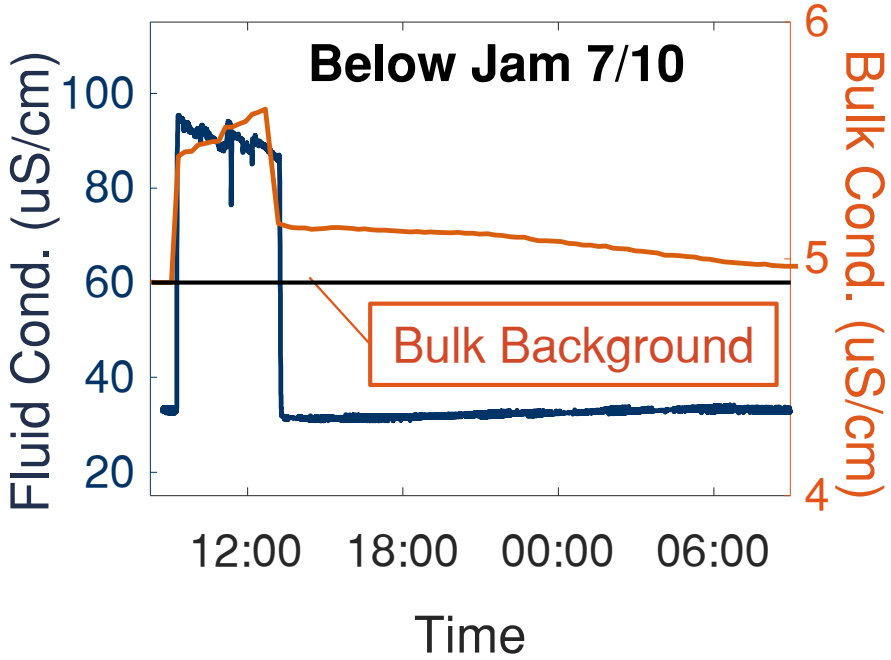
Tracer 6/13-14	Bulk	Fluid
Mean Arrival Time (hr)	6	2
Variance (hr^2)	34	10
Skewness (hr^3)	**271**	**135**

Discharge: 0.86 cms



Tracer 7/10-11	Bulk	Fluid
Mean Arrival Time (hr)	7	2
Variance (hr^2)	40	9
Skewness (hr^3)	**193**	**135**

Discharge: 0.17 cms



Conclusions

- ER improves measurements of the hyporheic zone
- Logjams increase hyporheic exchange flow
- Higher discharge rates increase hyporheic exchange flow

Applications

- Characterize human impacts on stream functions
- Improve water quality
- Advance stream restoration and conservation efforts

Acknowledgements

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Questions?