Adding wood to the Raging River: Looking for effects on habitat and temperature

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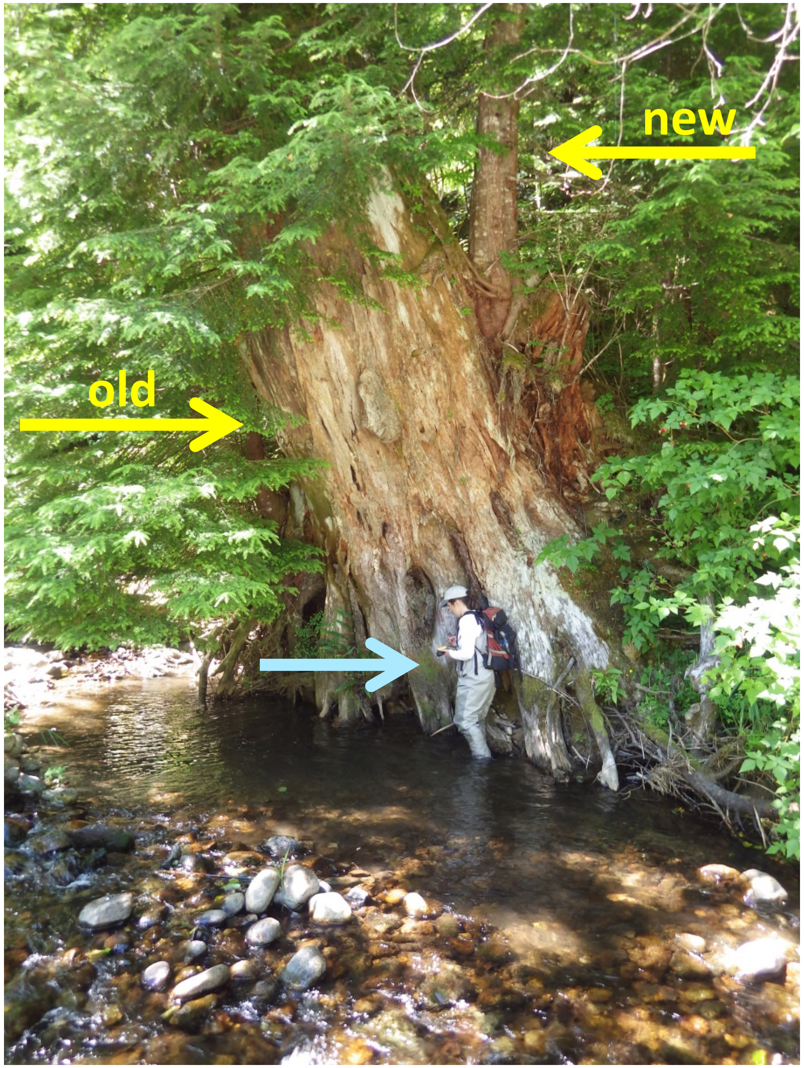
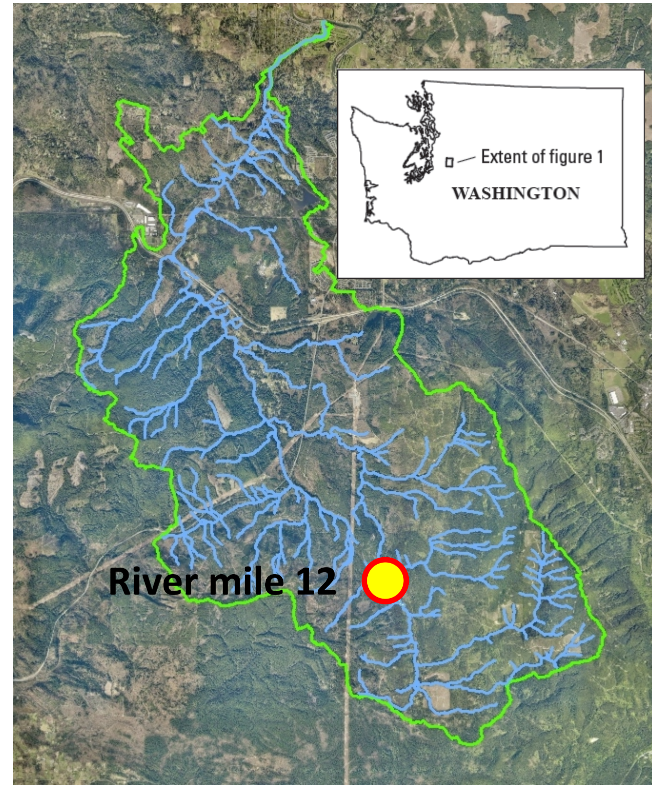
Wood in Pacific Northwest Streams

- Important
  - sediment dynamics
  - channel configuration
  - habitat
- Wood large and abundant in undisturbed systems
- In others, wood rare and small
- Restoration often includes adding wood



Raging River

- 93 logs added in 2009
- Chinook salmon stream
- Mitigation for work downstream
- Logs unanchored
- All within 300 m



Added wood:
Mean length = 25 feet
Mean diameter = 14 inches

Increase in wood density:
>10x in the 300-m reach
~2x in the 1-km reach

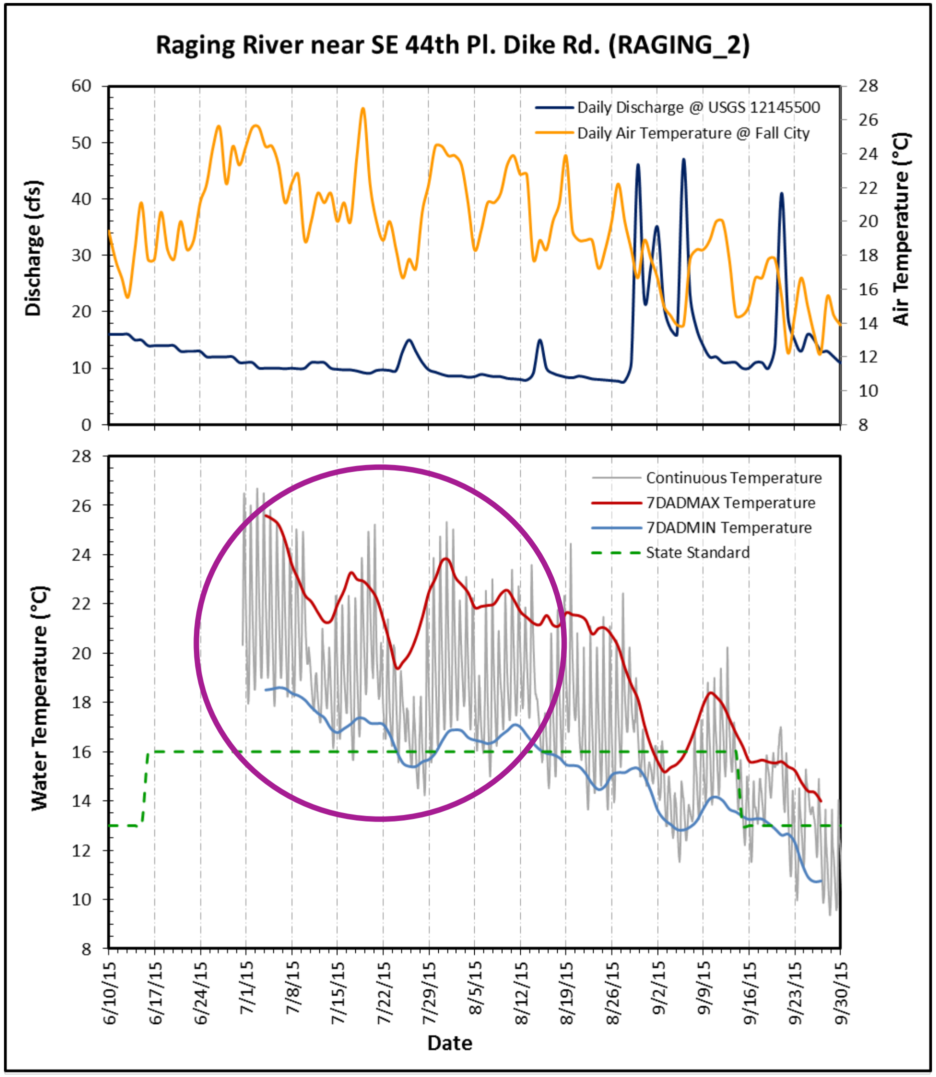
Questions: In 2015…

- Greater complexity associated with wood?

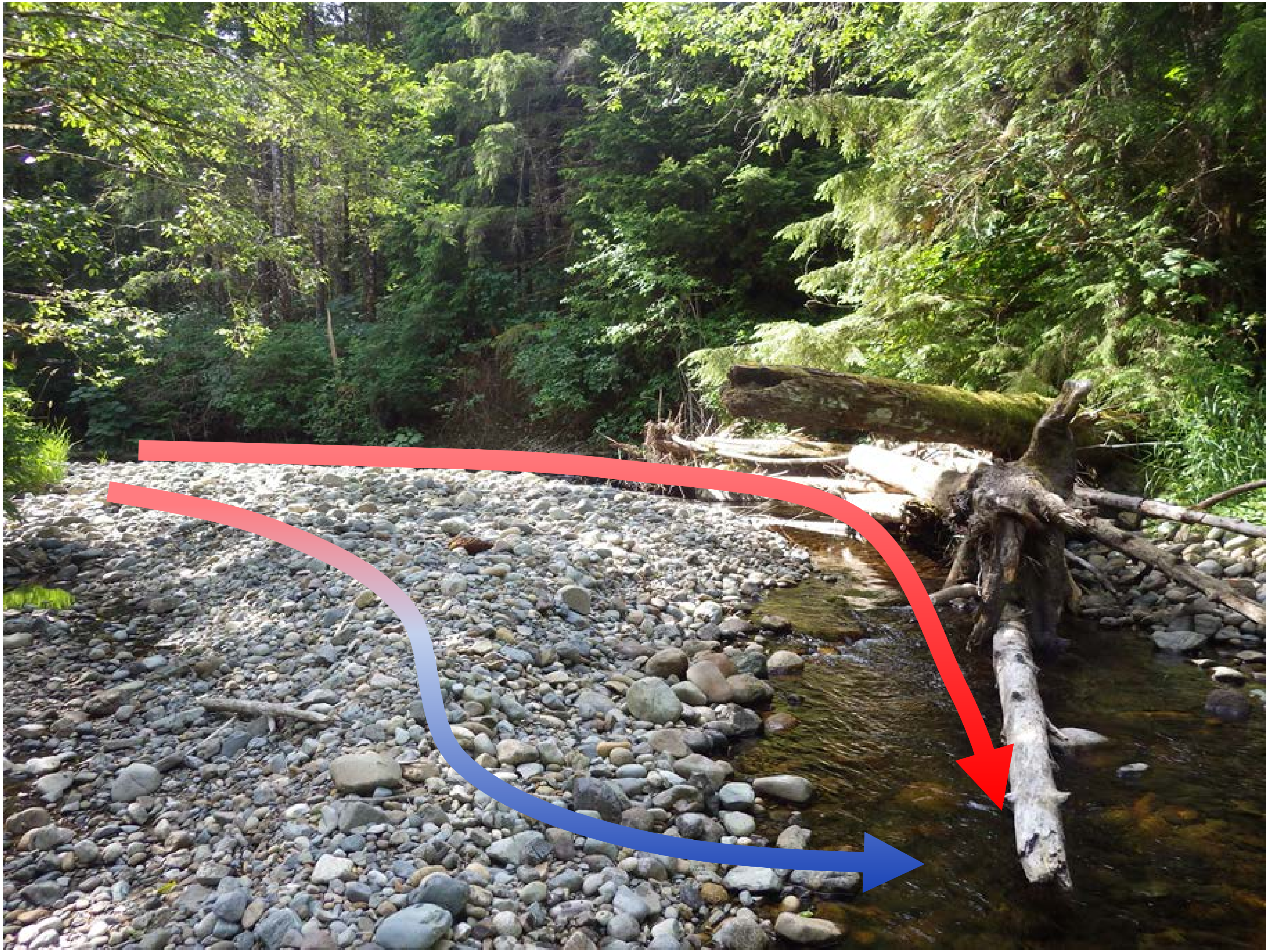
- Any cooling associated with wood?

Raging River is HOT!
(for a river in the Pacific NW)

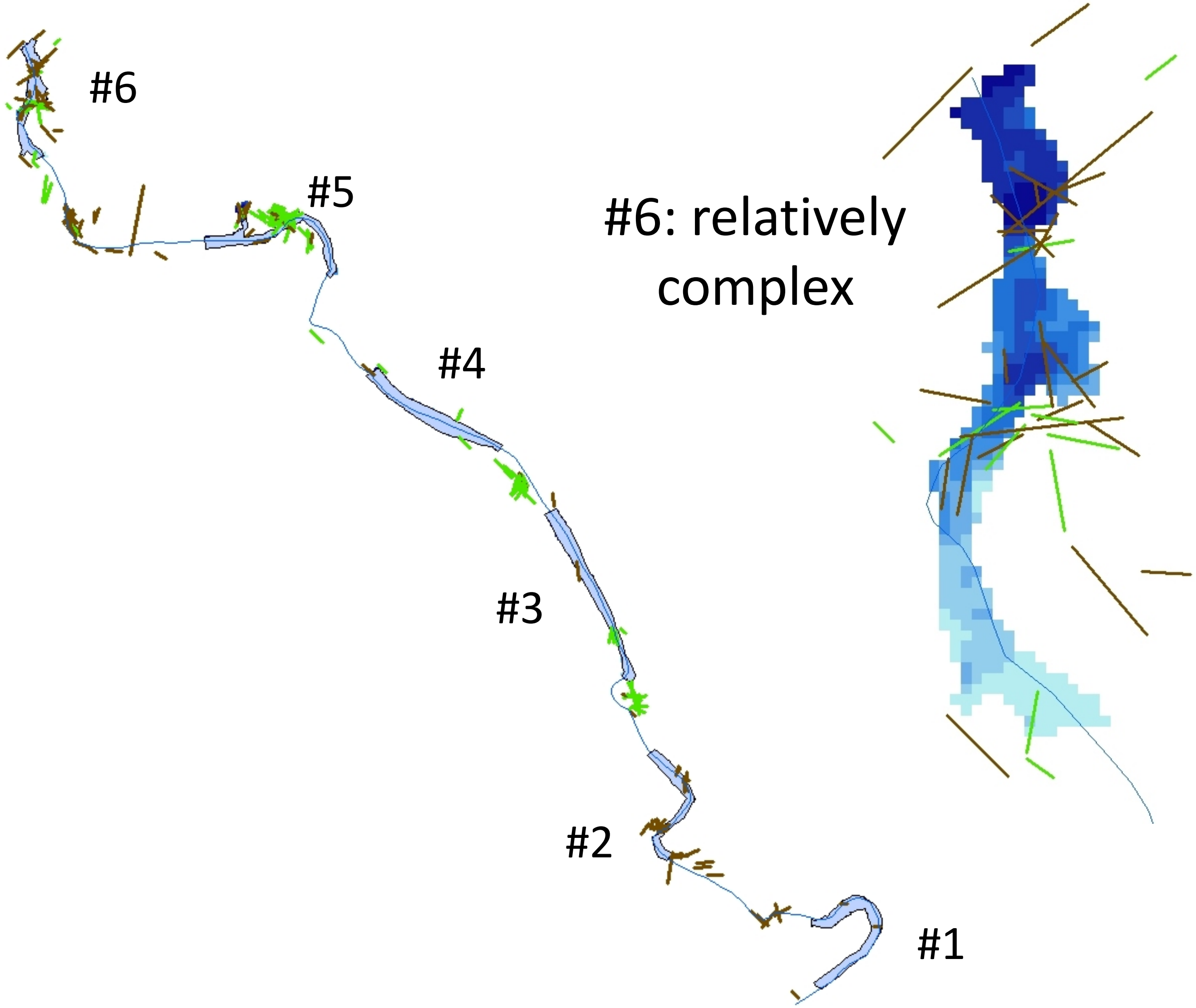
- In 2015, at the mouth:
  - Daily minimum >16°C
  - Max =26°C
- River at base flow in July due to drought



King County 2016. *Hot Water and Low Flow: The Summer of 2015 in the Snoqualmie River Watershed.*



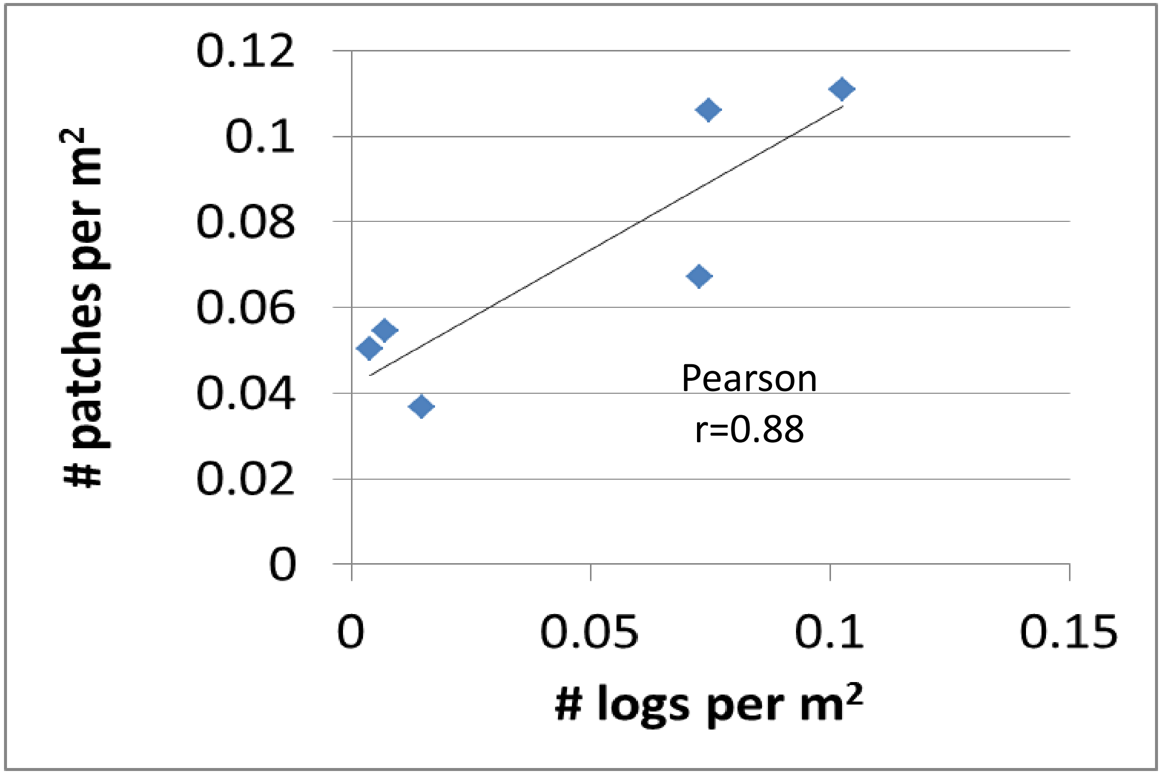
- Reach ~1 km
- Salt tracer reaches ~100 m
- Distributed temperature sensor ~1 m
- Piezometers ~<1 m



#6
#5
#4
#3
#2
#1
#6: relatively complex

Wood and Complexity

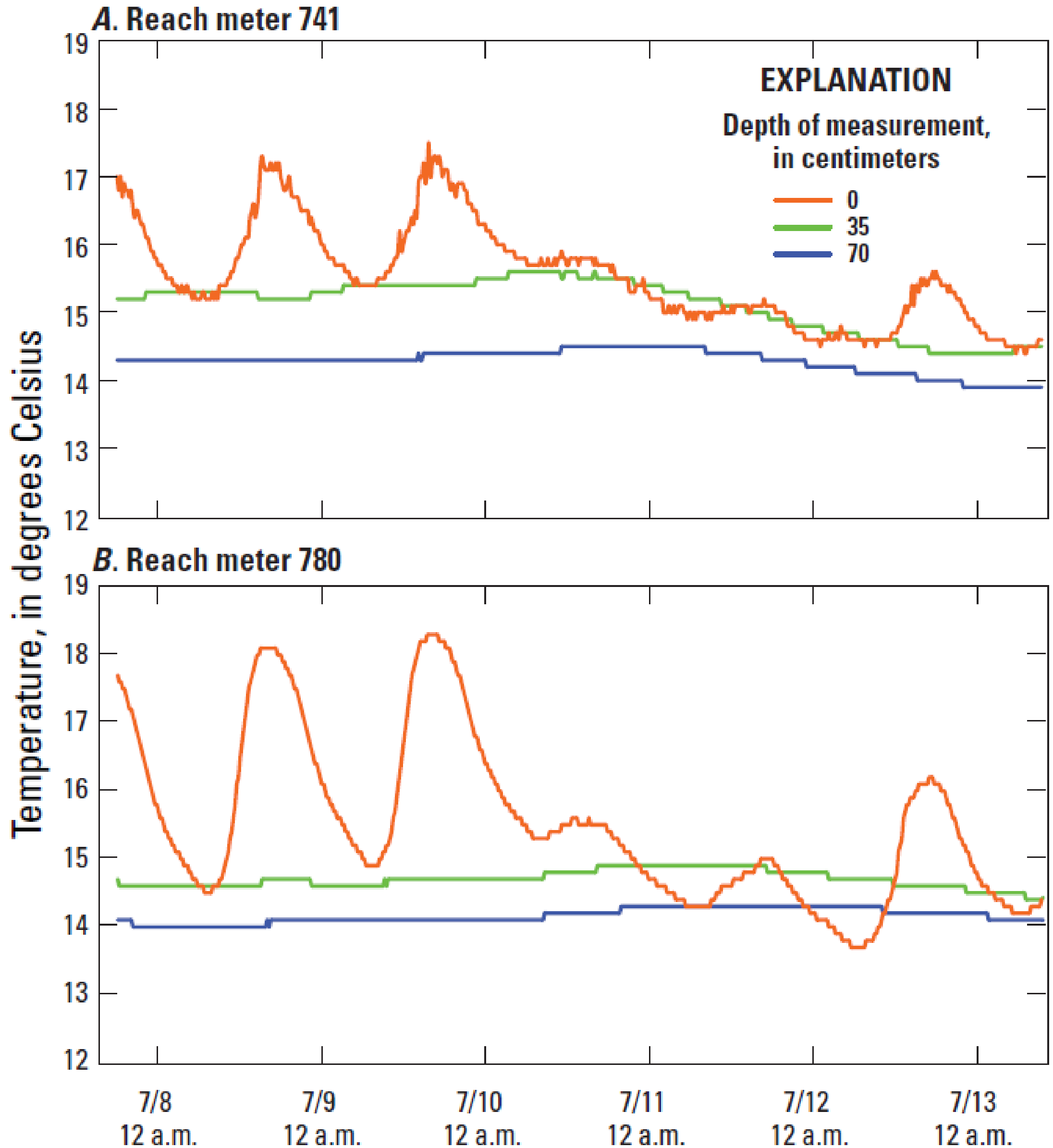
- Wood and complexity correlated
- Greater transient storage in reaches with wood



Questions: In 2015…

- Greater complexity associated with wood?
  - *Yes, wood and complexity correlated*
- Any cooling associated with wood?

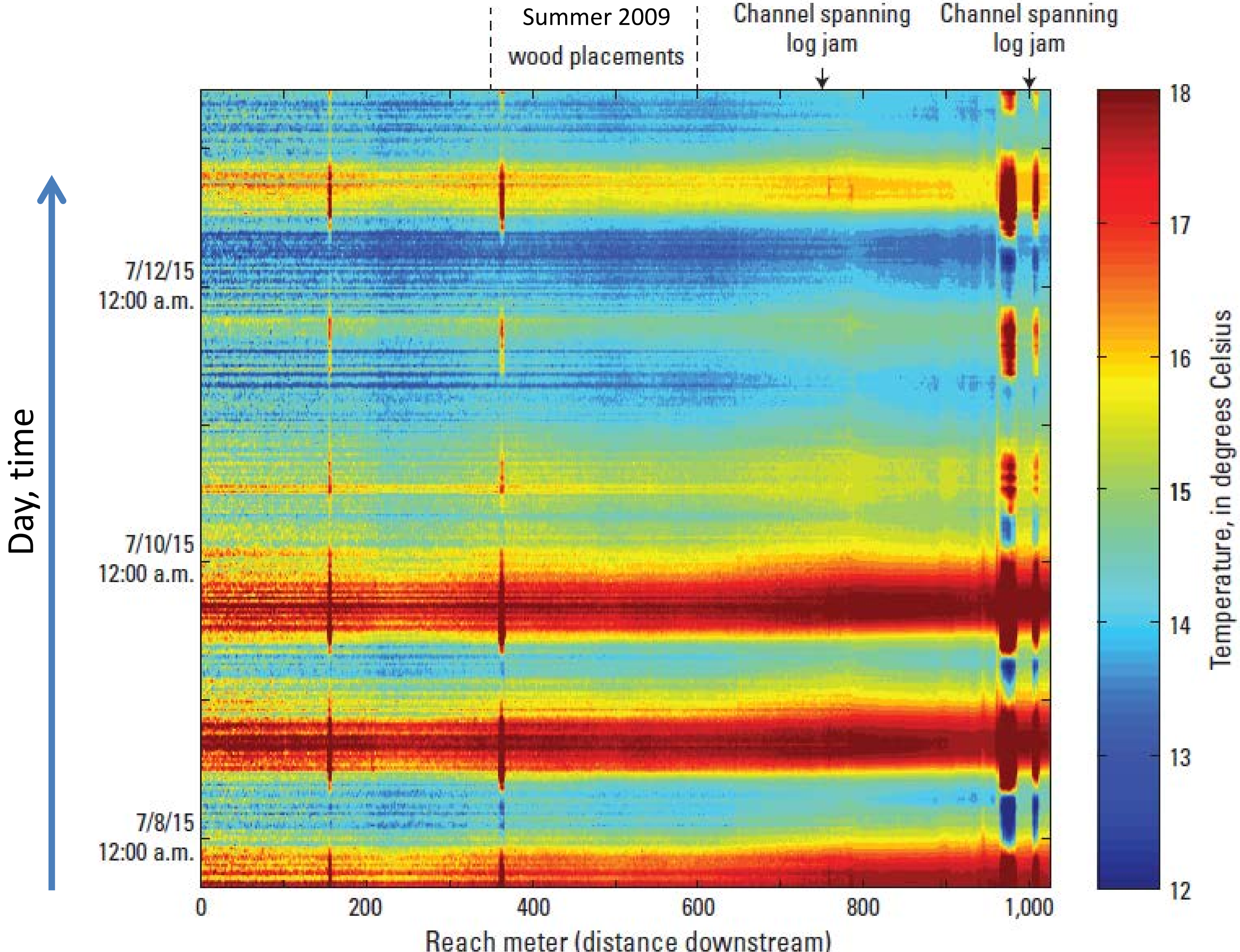
Upwelling of cool water in some piezometers



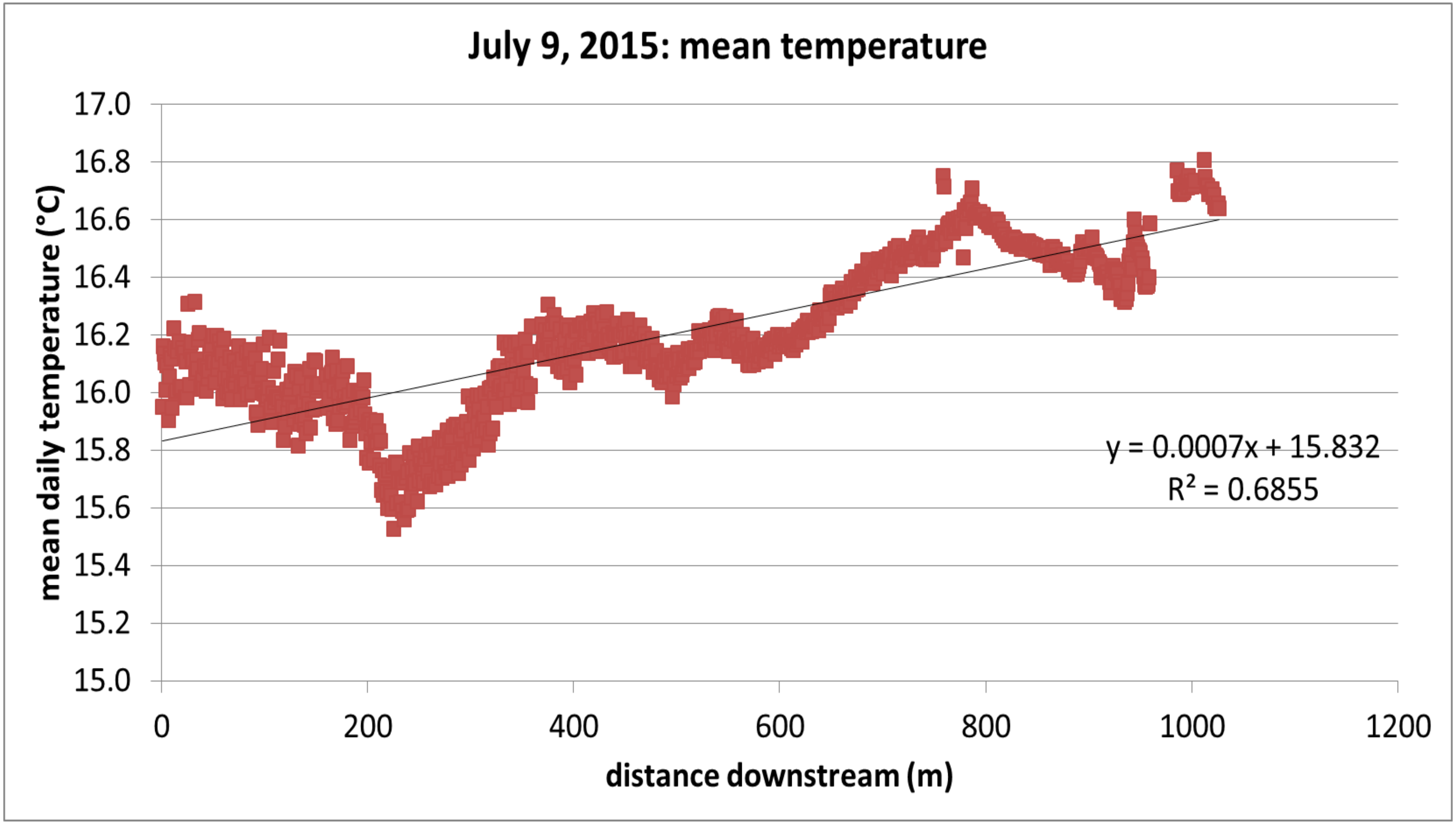
Gendaszek and Optaz 2016

Fiber optic distributed temperature sensor (FO-DTS)

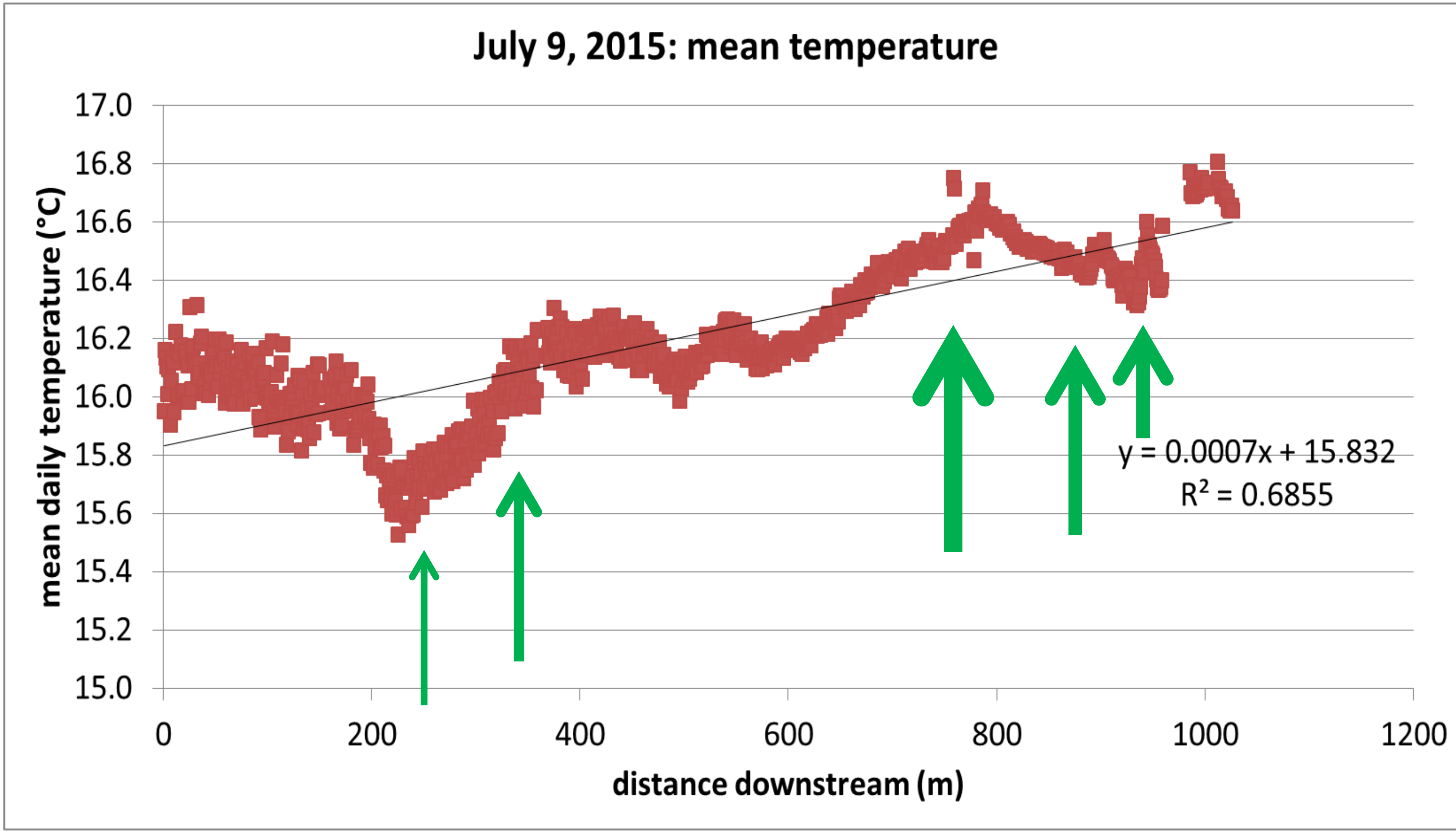
- Deployed for 1 week
- Recorded temp each meter, every 30 minutes
- Covered ~1-km reach



Gendaszek and Optaz 2016



July 9, 2015: mean temperature
mean daily temperature (°C)
17.0
16.8
16.6
16.4
16.2
16.0
15.8
15.6
15.4
15.2
15.0
0
200
400
600
800
1000
1200
distance downstream (m)
y = 0.0007x + 15.832
R² = 0.6855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17.0
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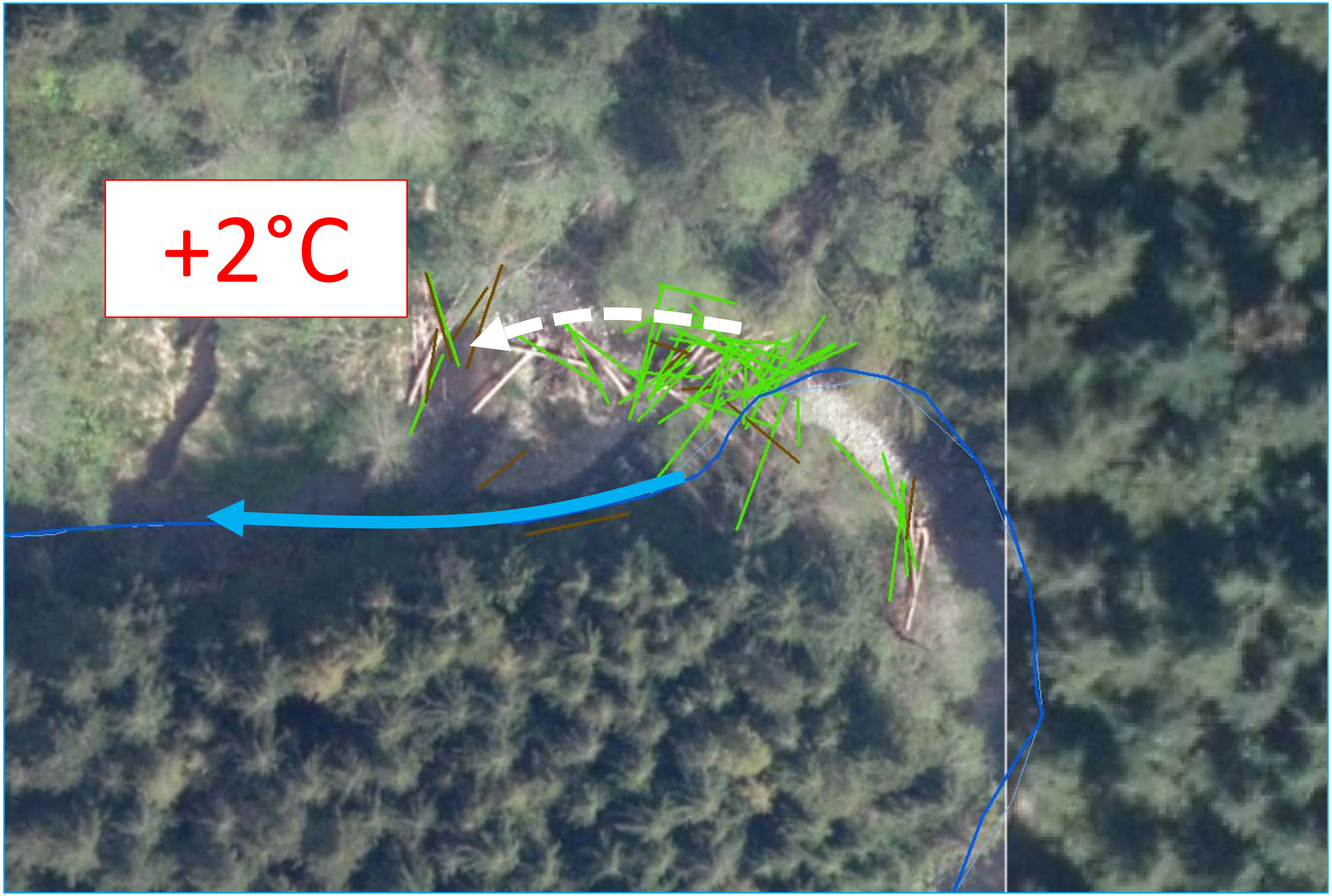
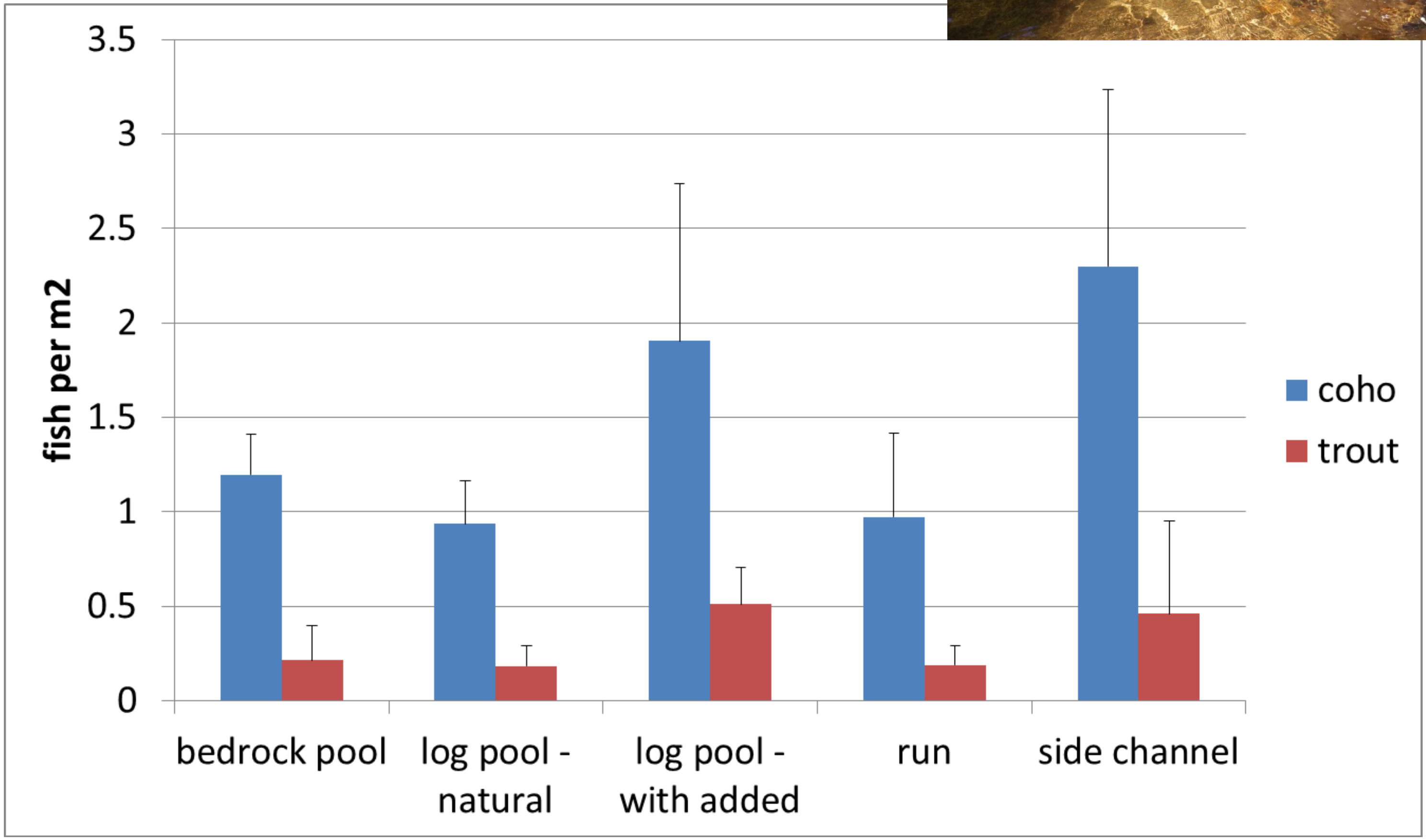
15.2
15.0
0
200
400
600
800
1000
1200
distance downstream (m)
y = 0.0007x + 15.832
R² = 0.6855

Temps rise in pools and side channels



Coho and trout densities



Questions: In 2015…

- Greater complexity associated with wood?
  - *Yes, wood and complexity correlated*
- Any cooling associated with wood?
  - Isolated upwelling of cool water
  - Some cooling along sections of reach
  - But cooling not associated with wood
  - Warming in pools and side channels
  - Other factors (bedrock geology) more likely affecting hyporheic exchange

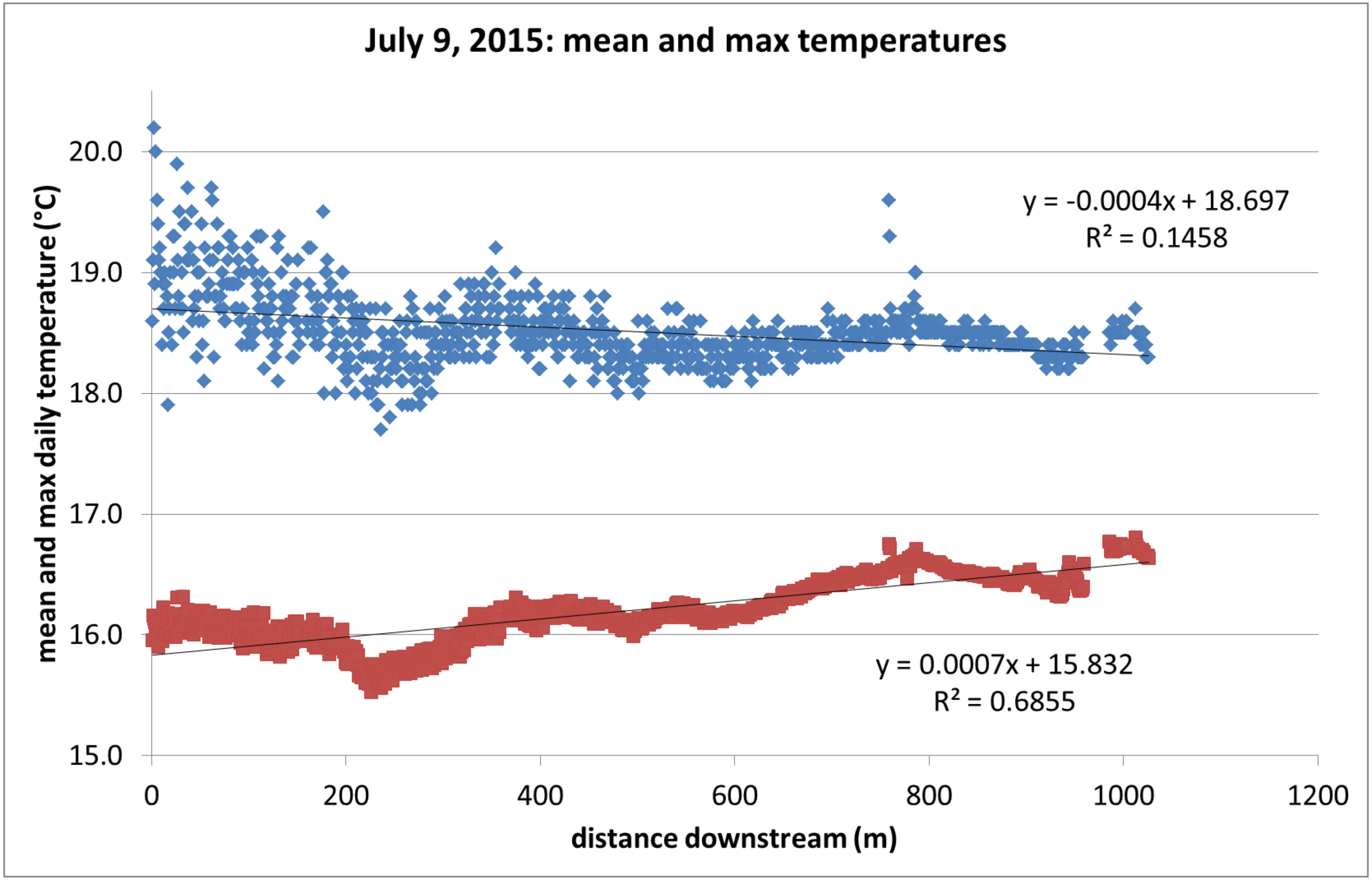
Implications

Adding wood may increase habitat complexity but will not likely cool the Raging River substantially

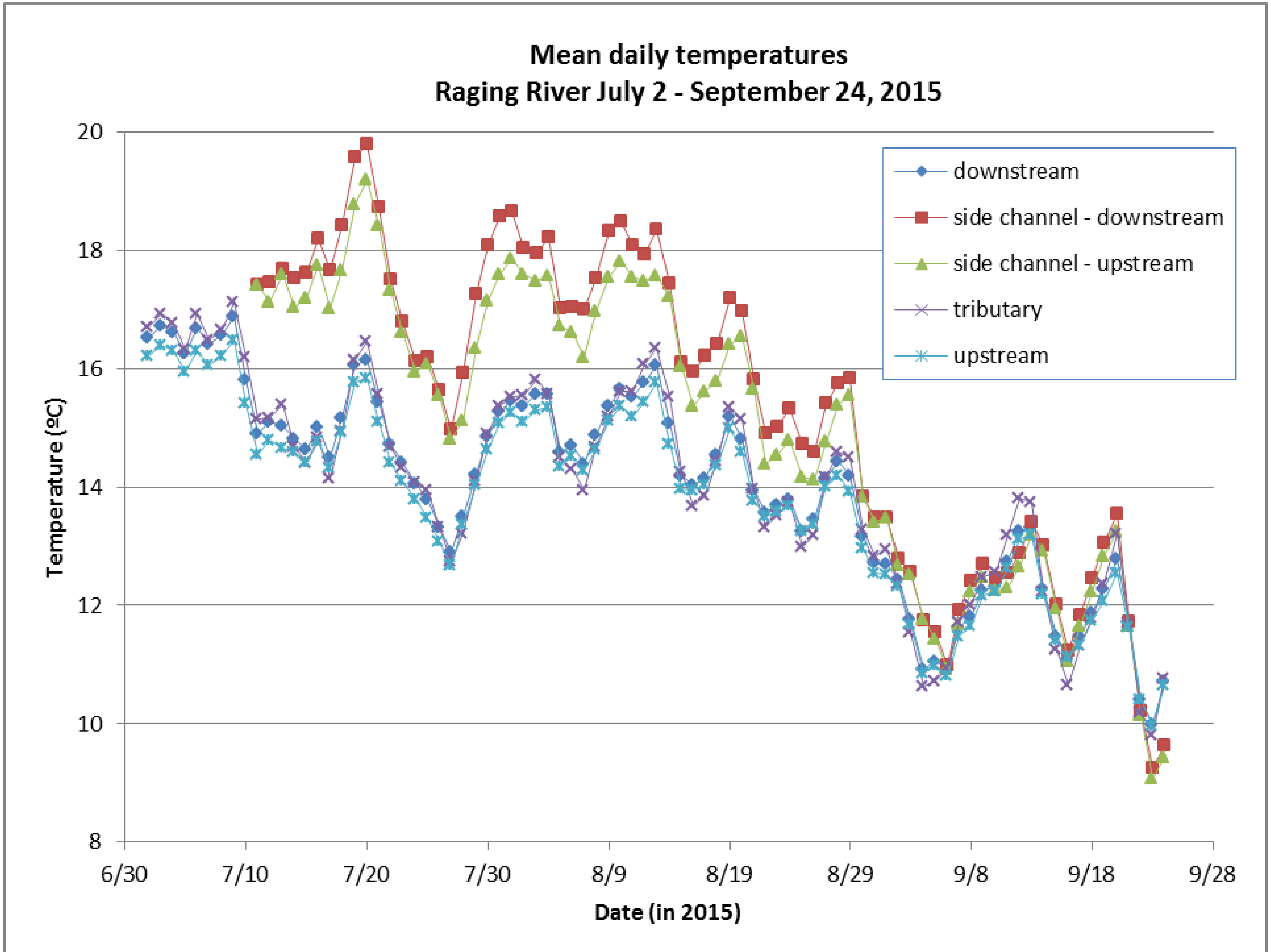
Thank You!

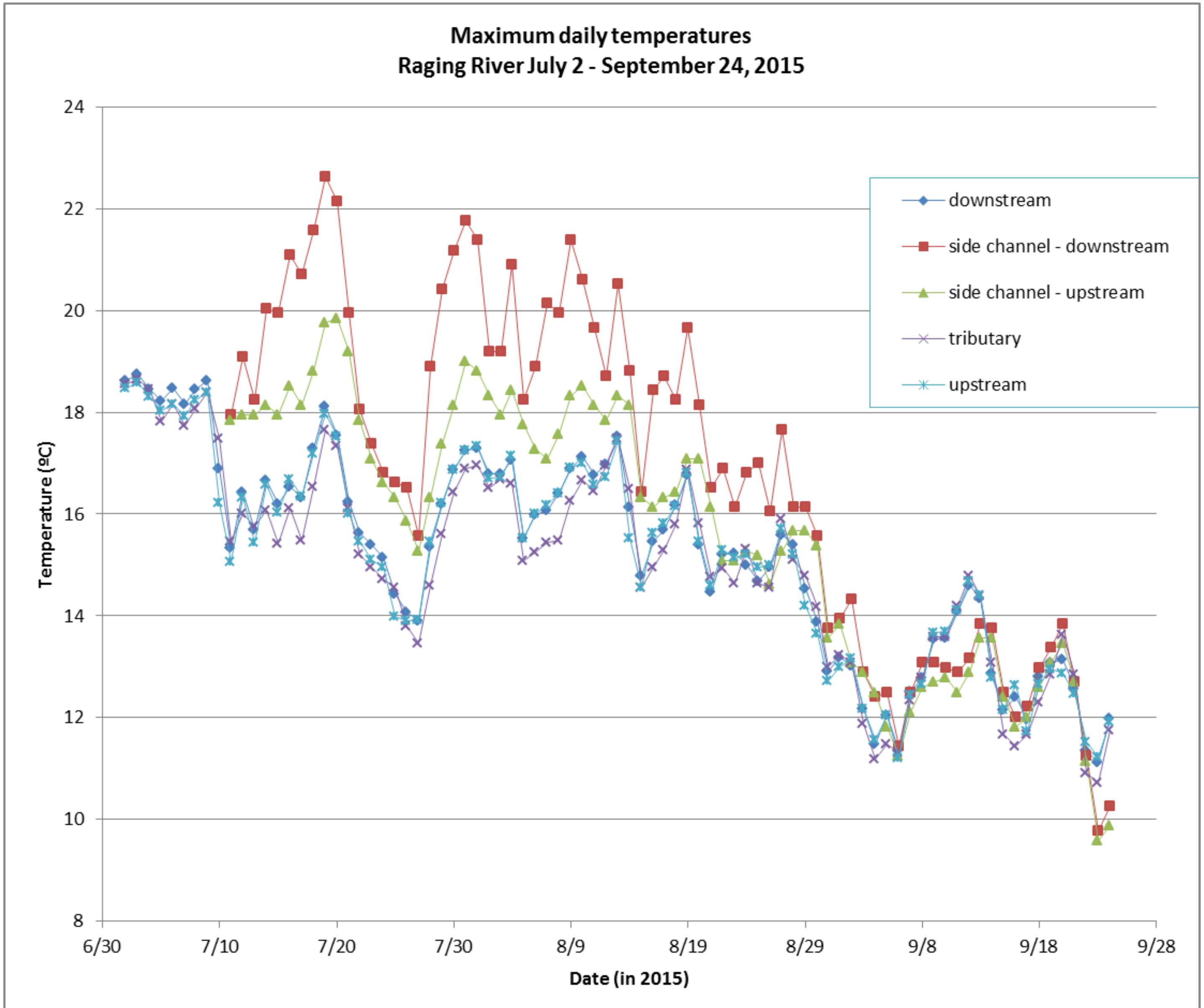
- **This work was funded by the Snoqualmie Watershed Forum through CWM grant funds and the USGS Cooperative Water Program.**

- **Many hands make light work:**
- **King County**
  - **Bob Pendergast, Chris Gregersen, Dan Lantz, Josh Kubo, Ken Rauscher, Andrew Miller, Kay Kitamura, Jo Wilhelm, Chris Knutson**
- **USGS**
  - **Chad Opatz**



July 9, 2015: mean and max temperatures
y = -0.0004x + 18.697
R² = 0.1458
y = 0.0007x + 15.832
R² = 0.6855
mean and max daily temperature (°C)
20.0
19.0
18.0
17.0
16.0
15.0
0
200
400
600
800
1000
1200
distance downstream (m)

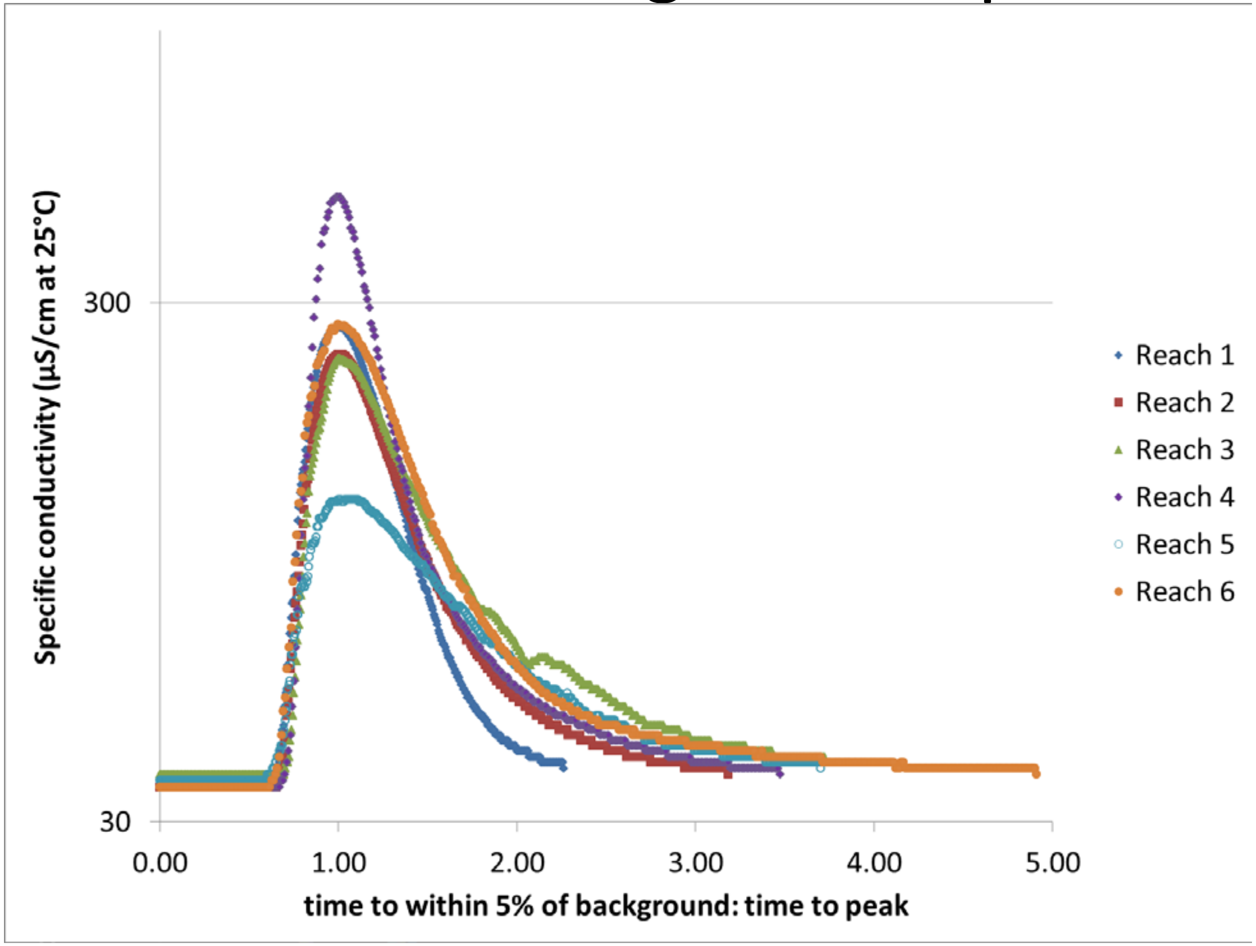

Mean daily temperatures
Raging River July 2 - September 24, 2015
Temperature (ºC)
20
18
16
14
12
10
8
6/30
7/10
7/20
7/30
8/9
8/19
8/29
9/8
9/18
9/28
Date (in 2015)
downstream
side channel - downstream
side channel - upstream
tributary
upstream



Maximum daily temperatures
Raging River July 2 - September 24, 2015
Temperature (ºC)
24
22
20
18
16
14
12
10
8
6/30
7/10
7/20
7/30
8/9
8/19
8/29
9/8
9/18
9/28
Date (in 2015)
downstream
side channel - downstream
side channel - upstream
tributary
upstream

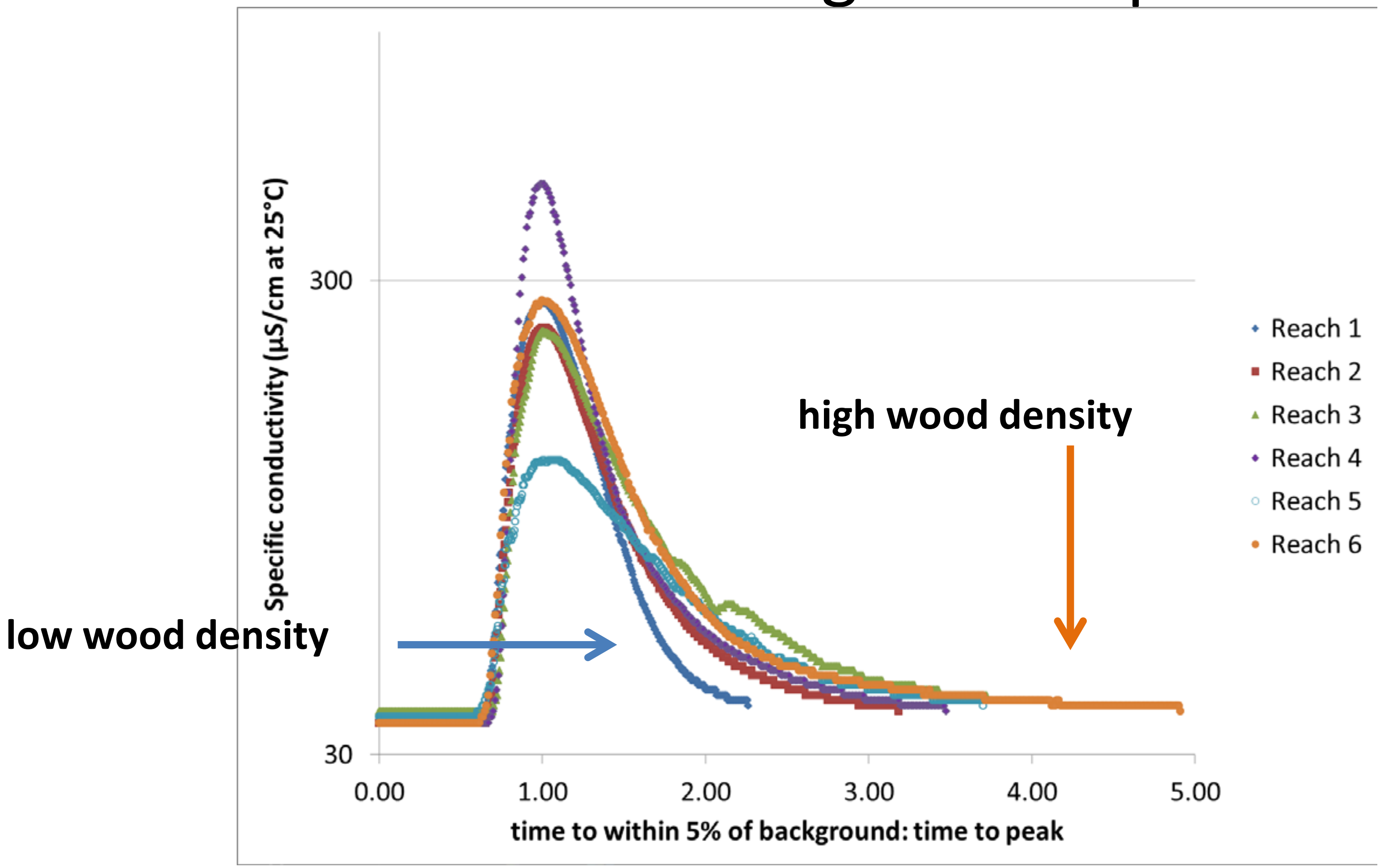
Wood and Complexity

- Greater transient storage in complex reaches



Wood and Complexity

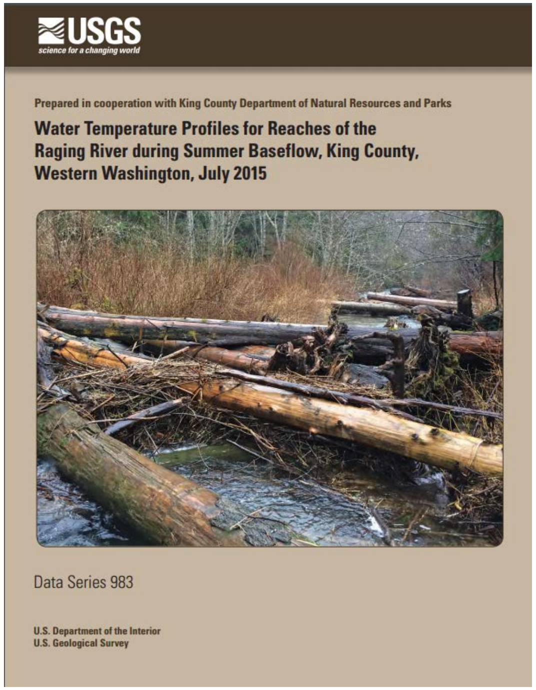
- Greater transient storage in complex reaches



Between 2009 and 2015:
- Logs moved
- Formed new jams
- Recruited to existing jams

Longitudinal and Vertical Stream Temperature Profiles during Summer Baseflow (2015)

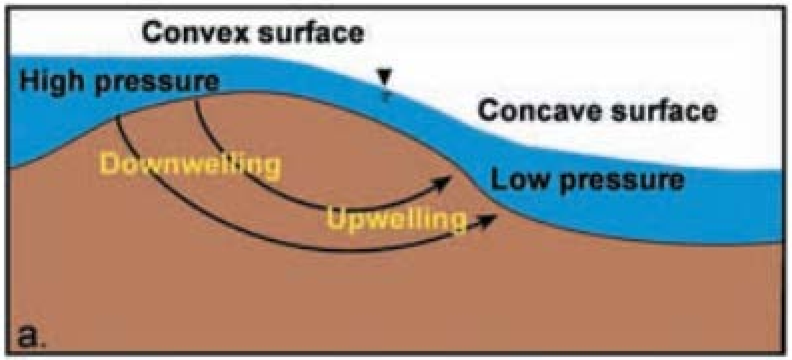
- Longitudinal profiles of stream temperature continuously measured for ~ 1 week using a >1,000-m Fiber-Optic Distributed Temperature Sensor
- Vertical profiles of surface and subsurface temperatures measured along pool-riffle sequences



Gendaszek and Opatz (2016)
https://pubs.er.usgs.gov/publication/ds983

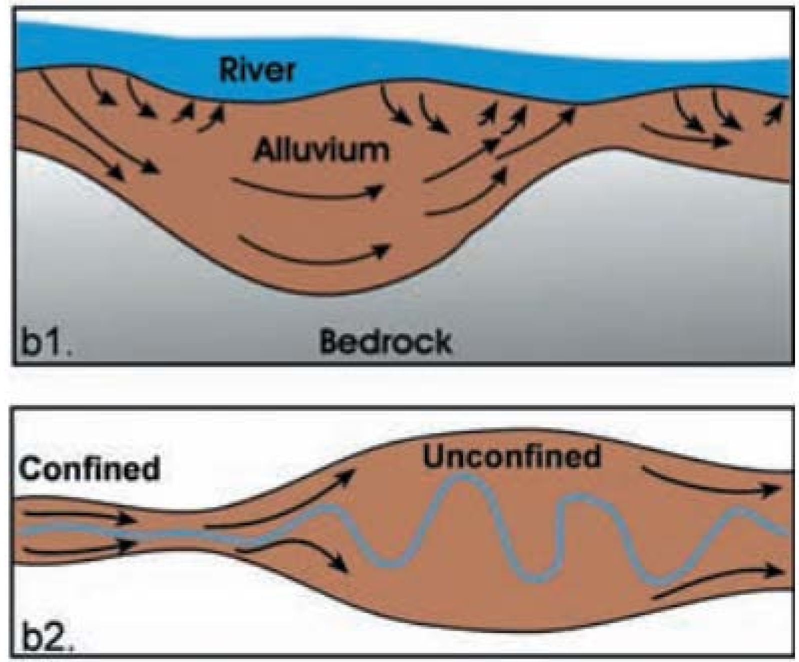
Geomorphic Influences on Hyporheic Exchange

Pool-Riffle Sequences



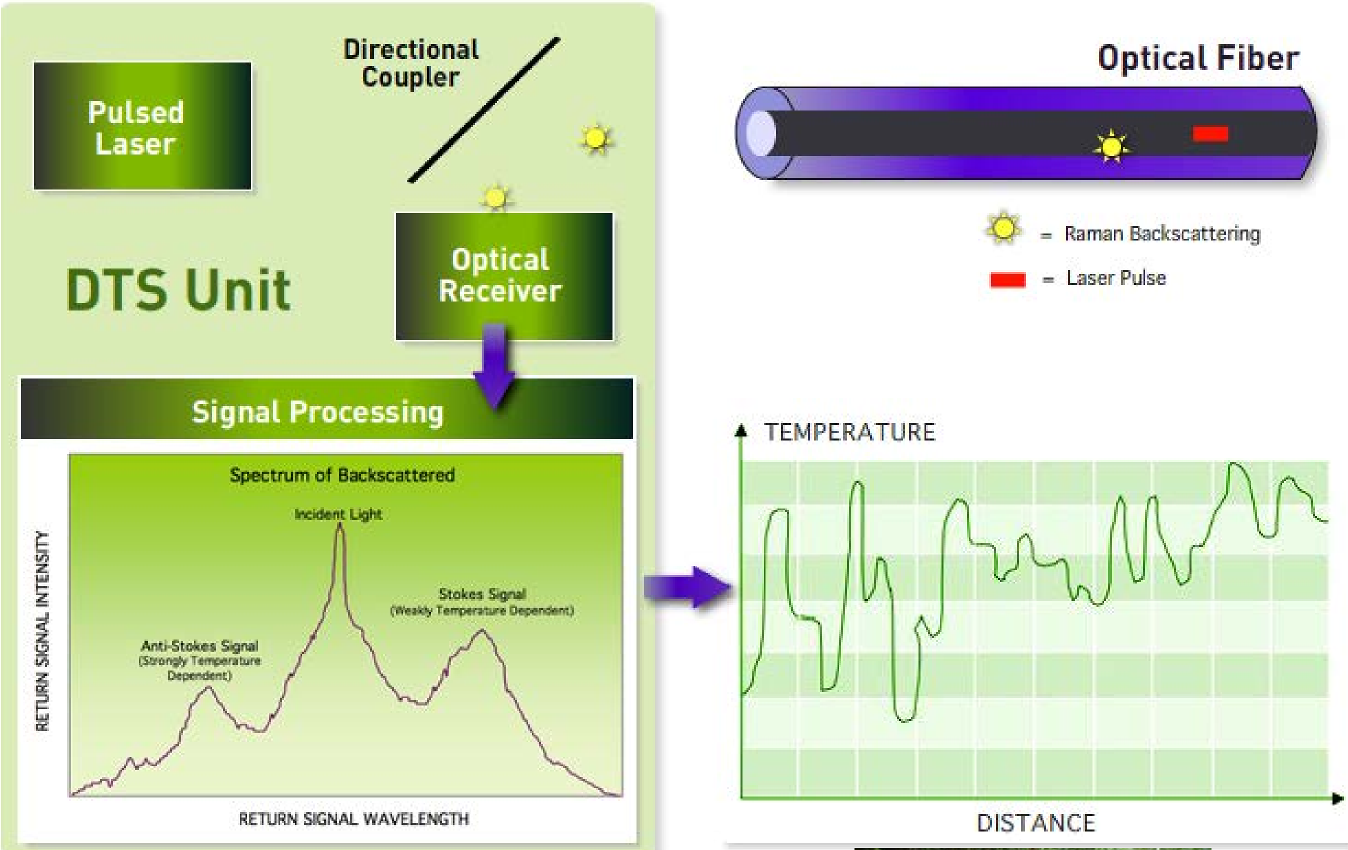
- Hyporheic processes vary across spatial scales as a result of geomorphic and geologic conditions
- During summer, hyporheic water is cooler than surface water and has less diurnal variability

Lateral and Vertical Extent of Bedrock



Tonina and Buffington (2009)

Longitudinal Temperature Profile: Fiber- Optic Distributed Temperature Sensor (FO-DTS)

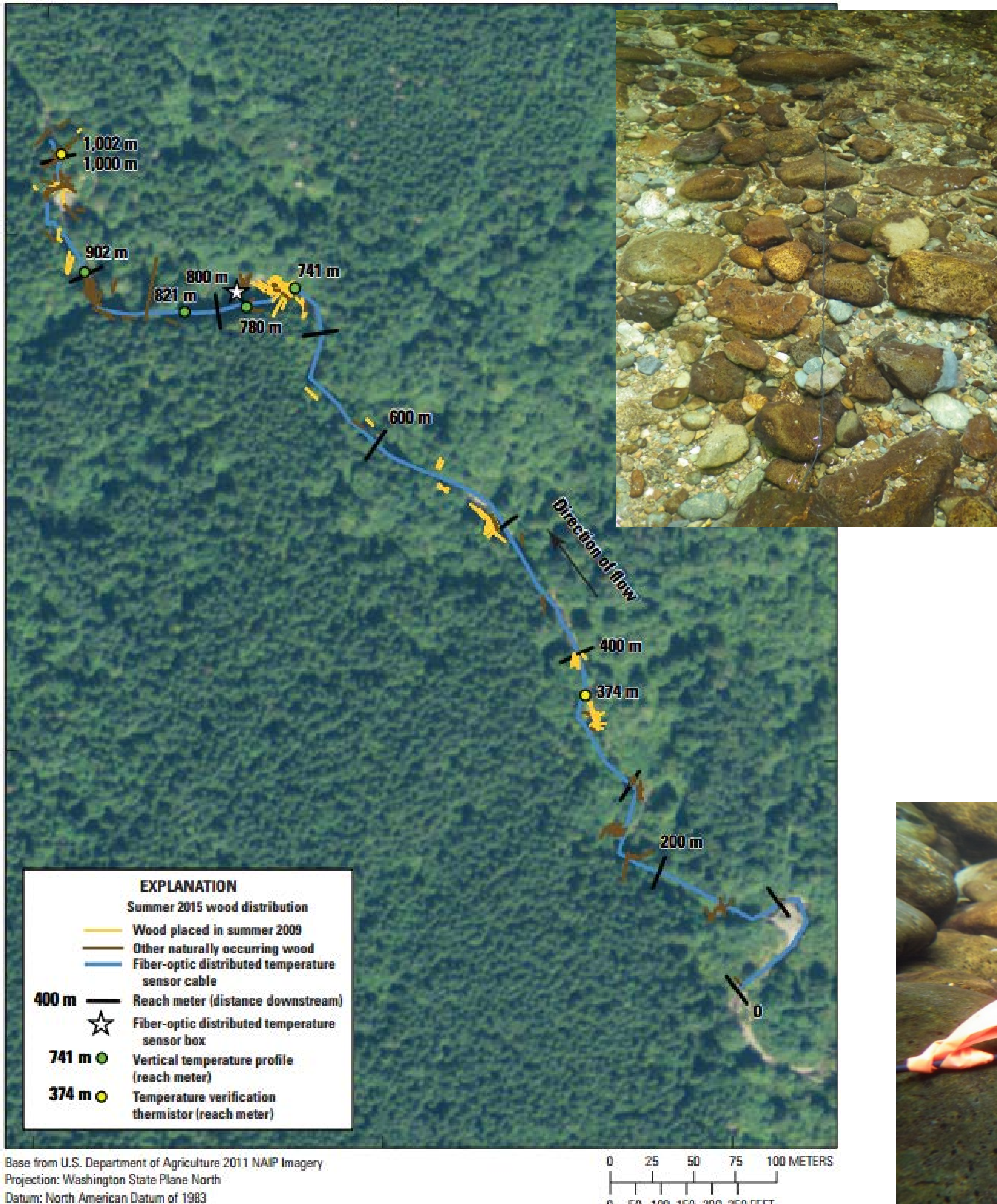


Temperature calculated from Anti-Stokes: Stokes Ratio

~ 0.1° C accuracy

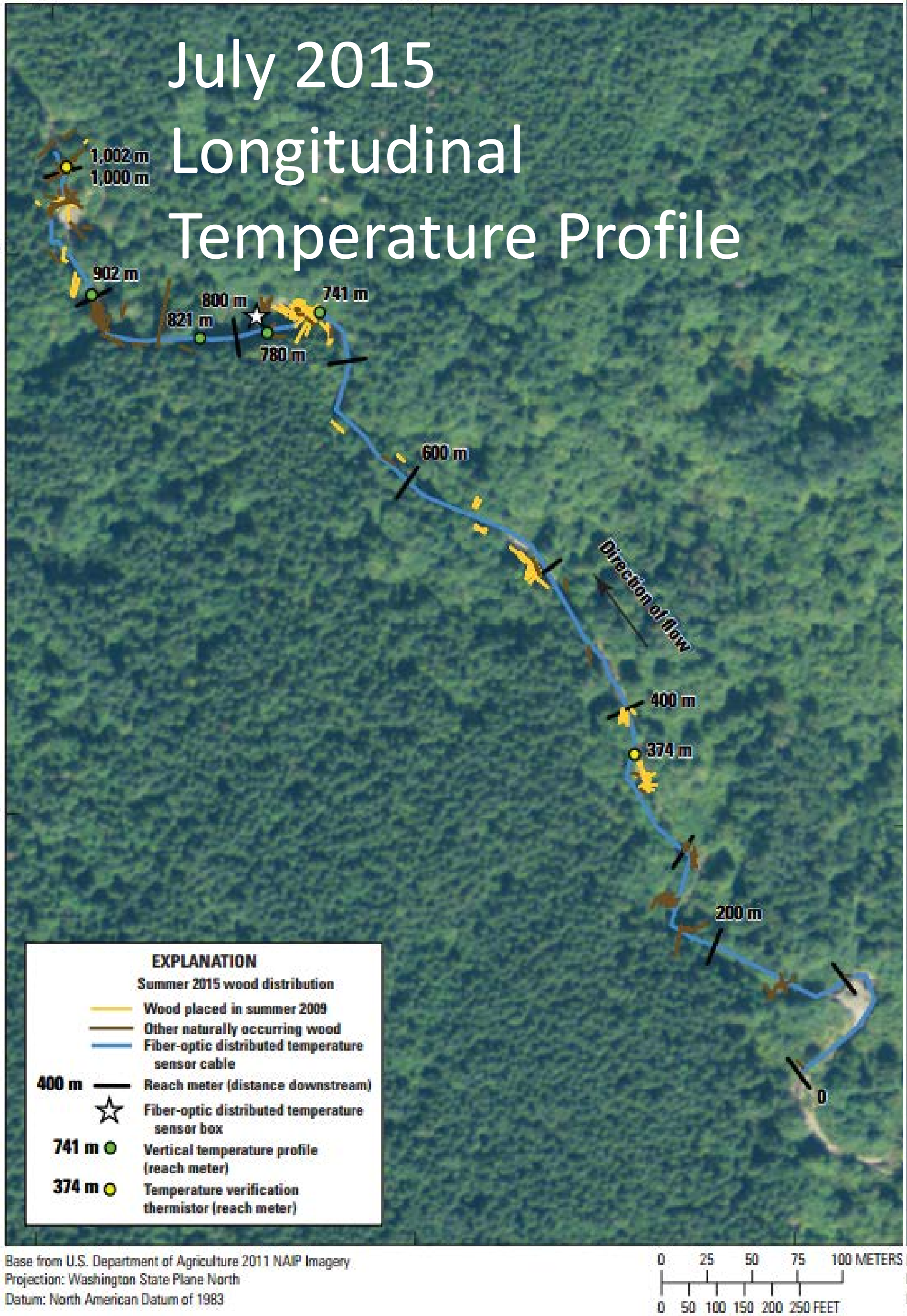
~ 1-meter resolution

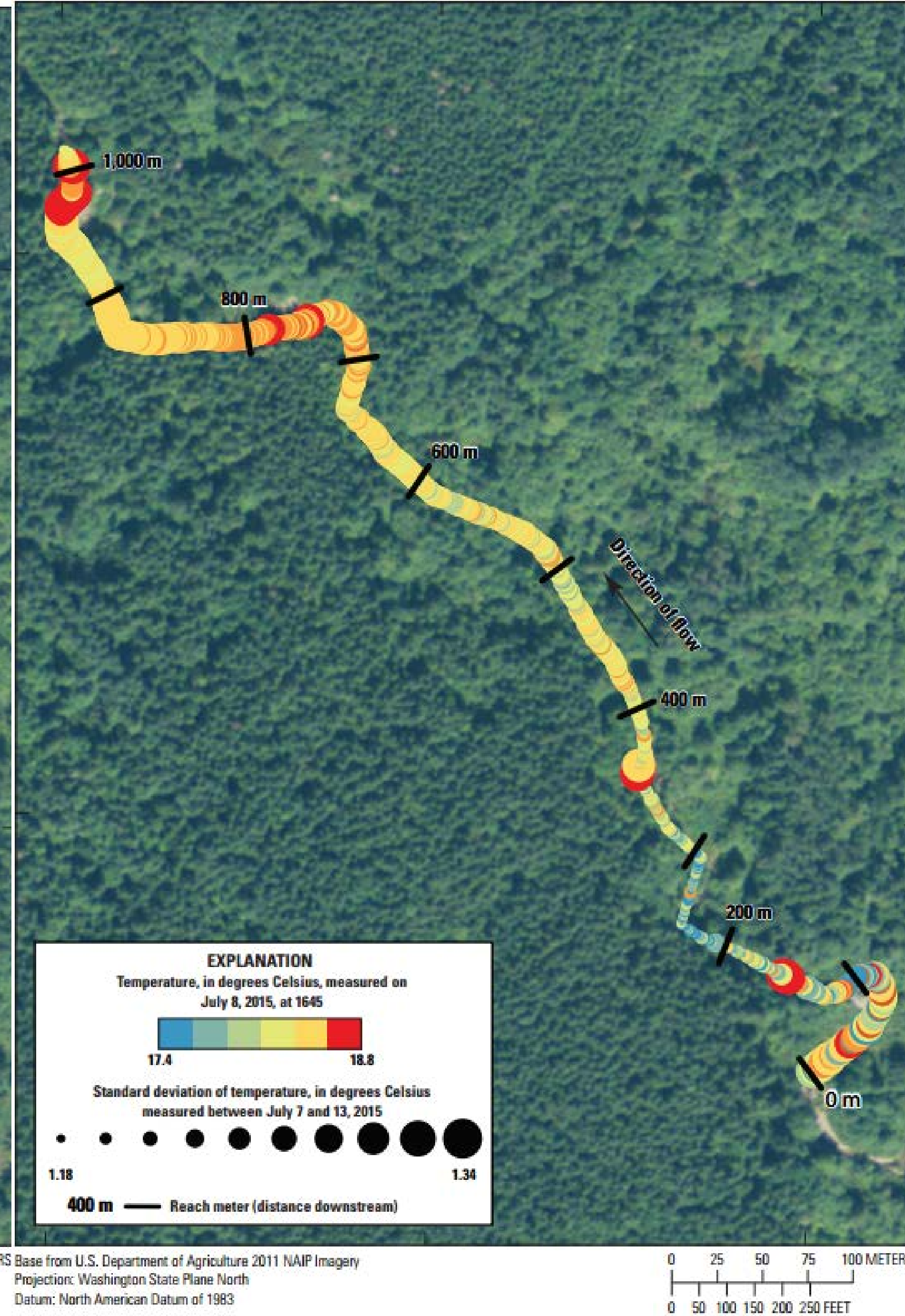
Deployment in the Raging River



- Deployed for 1 week
- Recorded temp each meter, every 30 minutes
- >1,000-m reach

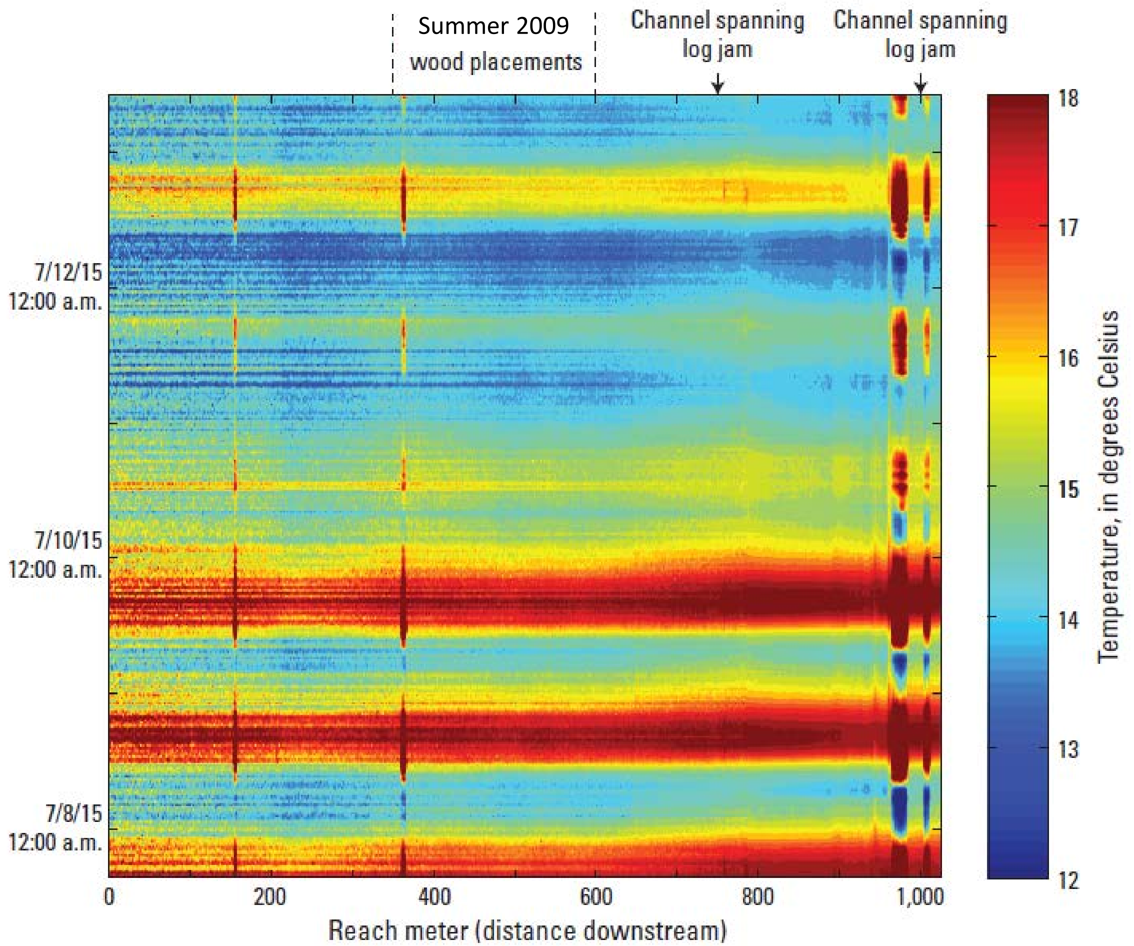
July 2015 Longitudinal Temperature Profile

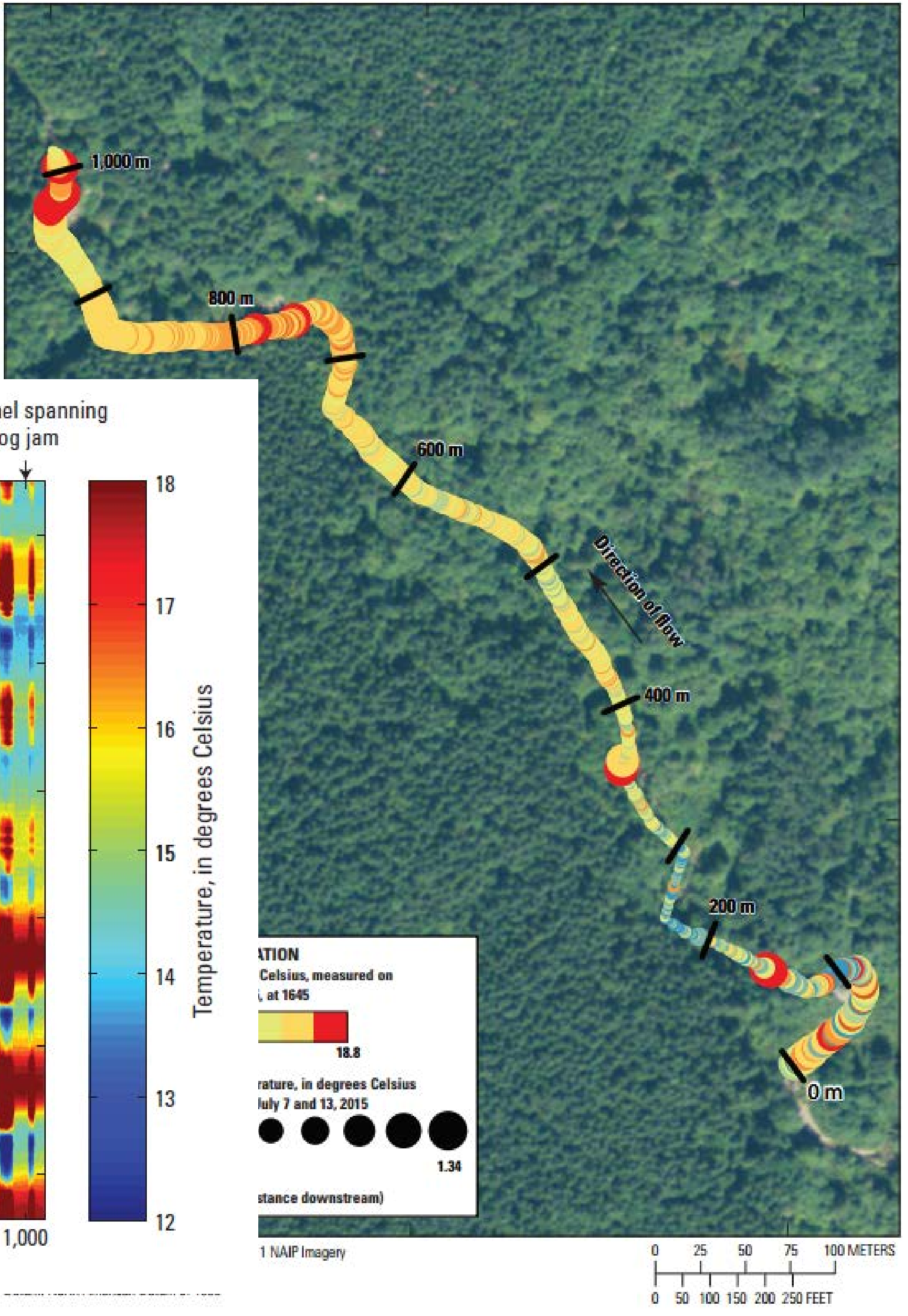




Gendaszek and Optaz (2016)

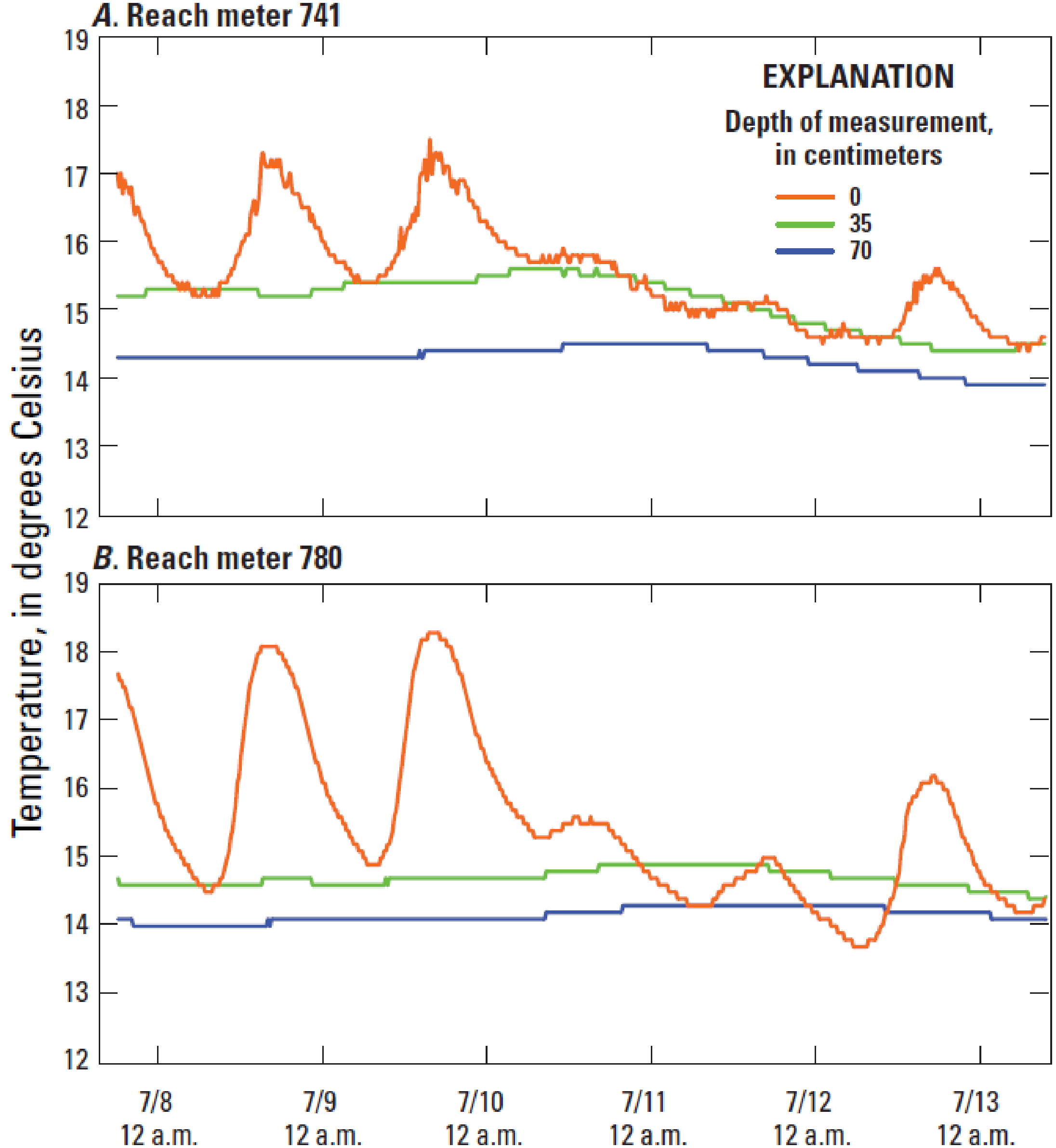
July 2015 Longitudinal Temperature Profile





Vertical Temperature Profiles

Upwelling of consistently cool water in some piezometers…



Gendaszek and Opatz (2016)

Vertical Temperature Profiles

… but not in others.