Impact of Hyporheic Exchange on Stream Temperature in Restored Systems
NGWA Groundwater Summit 2017
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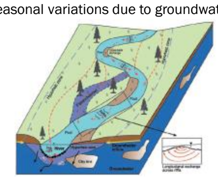
Hyporheic Exchange

LandStudies

- Mixing of surface water and groundwater occurring in the saturated region along a channel
  - Extent of the exchange can be limited by topographic and geologic factors
  - Has significant influence on many biological, chemical, and physical processes
  - Is subject to seasonal variations due to groundwater fluctuation



Retrieved from Tonina and Buffingtion (2009)

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Restoration Approach

LandStudies

- Kurtz Run Restoration at Landis Homes
  - 1,500 lf floodplain restoration (6 acres)
  - Provide stormwater management by increasing flood storage capacity and infiltration
  - Reduce sediment and nutrient loading by reducing bank erosion processes and increasing channel stability
  - Reconnect system to groundwater table by removing legacy sediment

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Kurtz Run at Landis Homes

LandStudies

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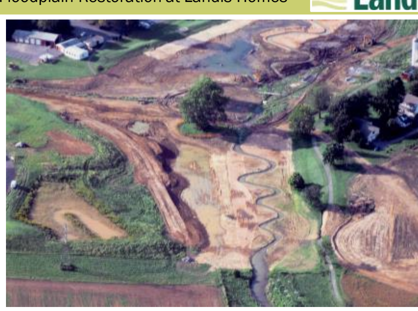
Kurtz Run Floodplain Restoration at Landis Homes

LandStudies



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Kurtz Run Floodplain Restoration at Landis Homes

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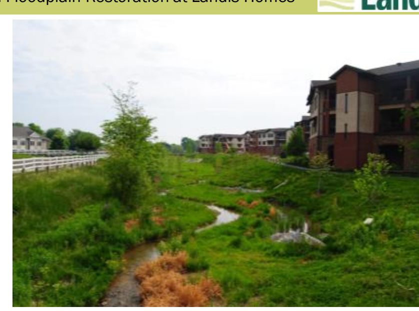

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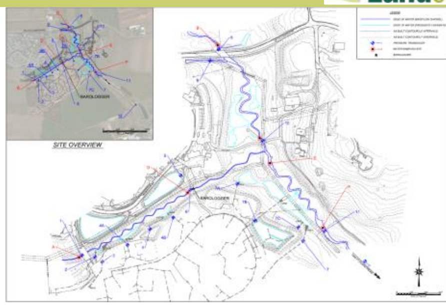
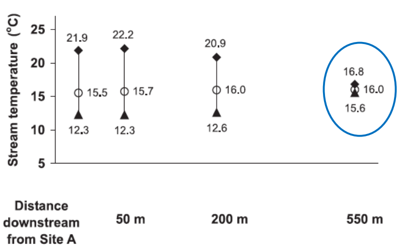
Kurtz Run at Landis Homes



Motivation in the Literature

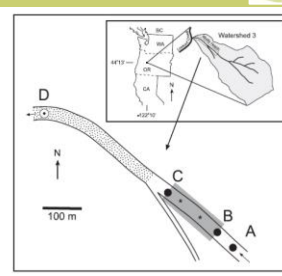
- Traditional thinking dictates the best way to cool a stream system is through vegetative shading
  - Substantial vegetative shading can be expensive and difficult to establish
- Factors Influencing Stream Temperatures in Small Streams (Johnson 2004)
  - 150 m of stream was shaded using black plastic sheeting
  - Hypothesis was that added shade would reduce stream temperatures throughout the reach
  - Shading proved to have little effect on stream temperature

Motivation in the Literature



Retrieved from *Factors influencing stream temperatures in small streams: substrate effects and a shading experiment* (Johnson 2004)

Motivation in the Literature



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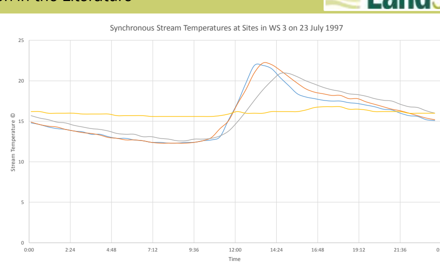

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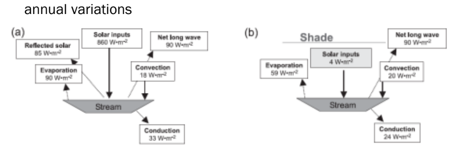
Analysis Methodology

- Johnson's (2004) energy balance indicates solar radiation as the largest thermal input to streams
  - This was the basis of the decision to compare the relationship between daily maximum temperature and incident solar radiation
  - This method provides an accurate comparison of pre and post-restoration conditions and would eliminate skew from seasonal and annual variations



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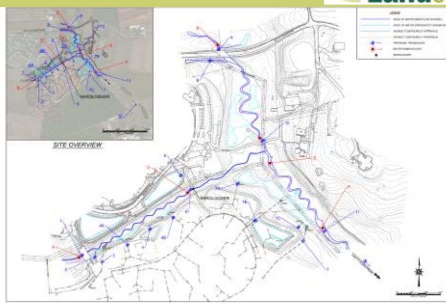
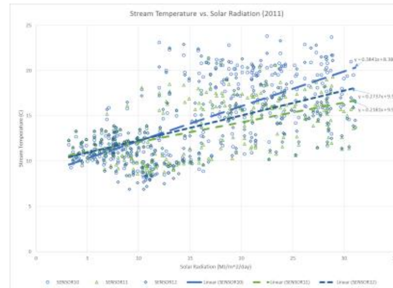
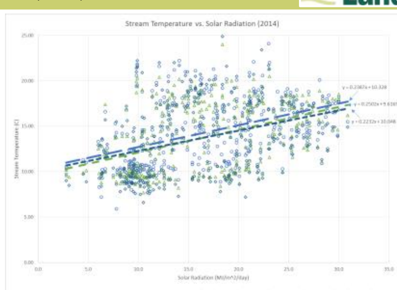
Kurtz Run at Landis Homes



Pre-Restoration (2011)



Post-Restoration (2014)



Descriptive Statistics

2011 Temp Data			
	Sensor 10	Sensor 11	Sensor 12
Maximum	23.80	21.30	23.30
Minimum	8.20	8.40	6.90
Mean	14.51	13.40	13.93
Median	13.15	12.85	13.15
Range	15.60	12.90	16.40
Correlation Coefficient	0.69	0.56	0.55
r^2	47.52%	31.53%	30.50%

2014 Temp Data			
	Sensor 10	Sensor 11	Sensor 12
Maximum	26.00	24.00	24.90
Minimum	5.90	7.70	6.60
Mean	14.25	13.73	13.71
Median	14.00	13.70	13.75
Range	20.10	16.30	18.30
Correlation Coefficient	0.43	0.44	0.36
r^2	18.58%	19.56%	13.26%

Results

- Variation in stream temperature was determined to be statistically significant – not due to natural variation
  - Variation in solar radiation was determined to be statistically insignificant
- 53% reduction in influence of solar radiation on daily maximum stream temperature
  - This reduction is attributed to the restoration activities – no other significant change occurred in the system during this time period

Conclusions

- Establishing hyporheic exchange can provide long term benefit with faster turnaround than attempting to establish vegetative shading
  - Even when successfully established, the potential benefit that shading can provide is limited
- Hyporheic exchange should be accounted for when examining stream temperature dynamics
- It is possible to design restoration efforts to increase surface-groundwater interaction while achieving other goals
  - Multiple benefits can coexist without diminishing the value of other benefits

References

- Johnson, S. L. (2004, July 24). Retrieved 6 21, 2016, from Oregon State University: http://forestry.oregonstate.edu/cof/fe/watershd/fe538/StreamTemperature/johnson_factors_effecting_stream_temp_CJOF04.pdf
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- Tonina, D., & Buffington, J. M. (2009). Hyporheic Exchange in Mountain Rvers I: Mechanics and Environmental Effects. *Geography Compass*, 1063-1086.

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