

Total Maximum Daily Loads (TMDLs): Temperature
TMDL Replacement project: **Willamette Subbasins**

March. 22, 2023, 1 p.m.

Technical Informational Webinar



Webinar purpose

- Provide background information on the technical work supporting the TMDL and TMDL allocations
- Answer questions on the technical work

Agenda

Time	Topic
1 p.m.	Welcome
1:05 p.m.	Agenda
1:10 p.m.	Zoom logistics, ground rules
1:15 p.m.	Willamette Subbasins Total Maximum Daily Load (TMDL) <ul style="list-style-type: none">• Model Setup and Calibration• Model Scenarios
2:25 p.m.	Wrap-up
2:30 p.m.	Adjourn

Zoom logistics and meeting ground rules



Raise hand to be recognized for questions or comments; please speak for yourself when recognized, let others speak without interruptions



Use chat to: Ask questions, provide informational resources



Mute when not speaking



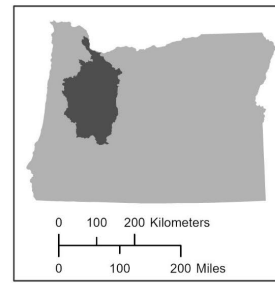
If using phone: press *9 to raise hand, *6 to mute/unmute

Temperature models

- Molalla River
- Pudding River
- Johnson Creek
- McKenzie River (Upper)
- Crabtree Creek
- Thomas Creek
- Little North Fork Santiam River
- Luckiamute River

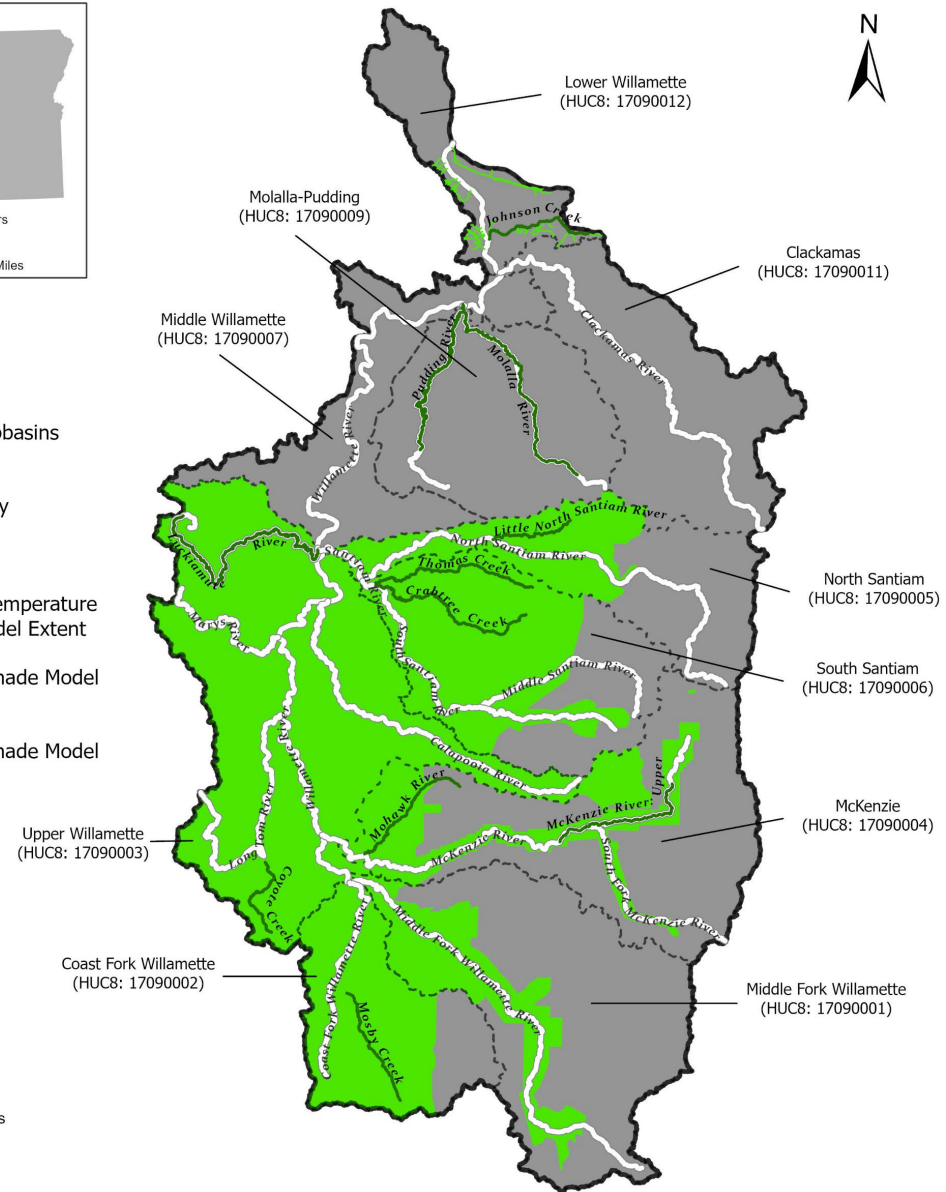
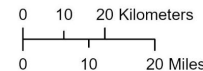
Solar models

- Lower Willamette
- Southern Willamette



Legend

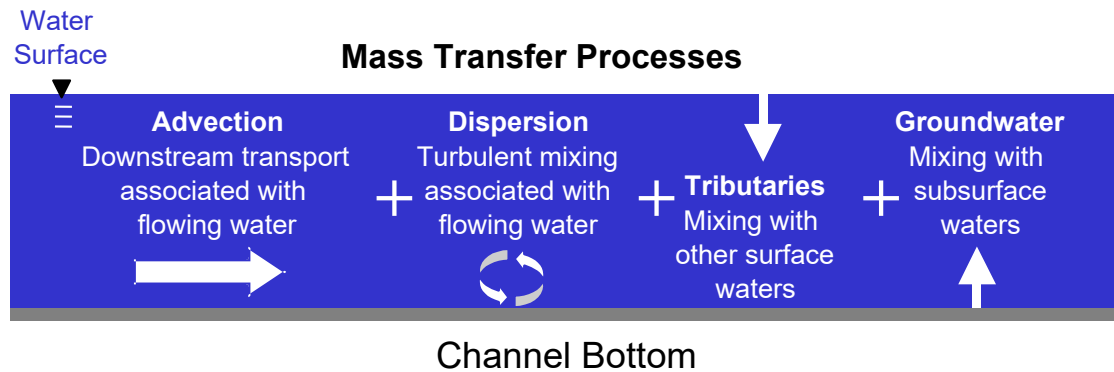
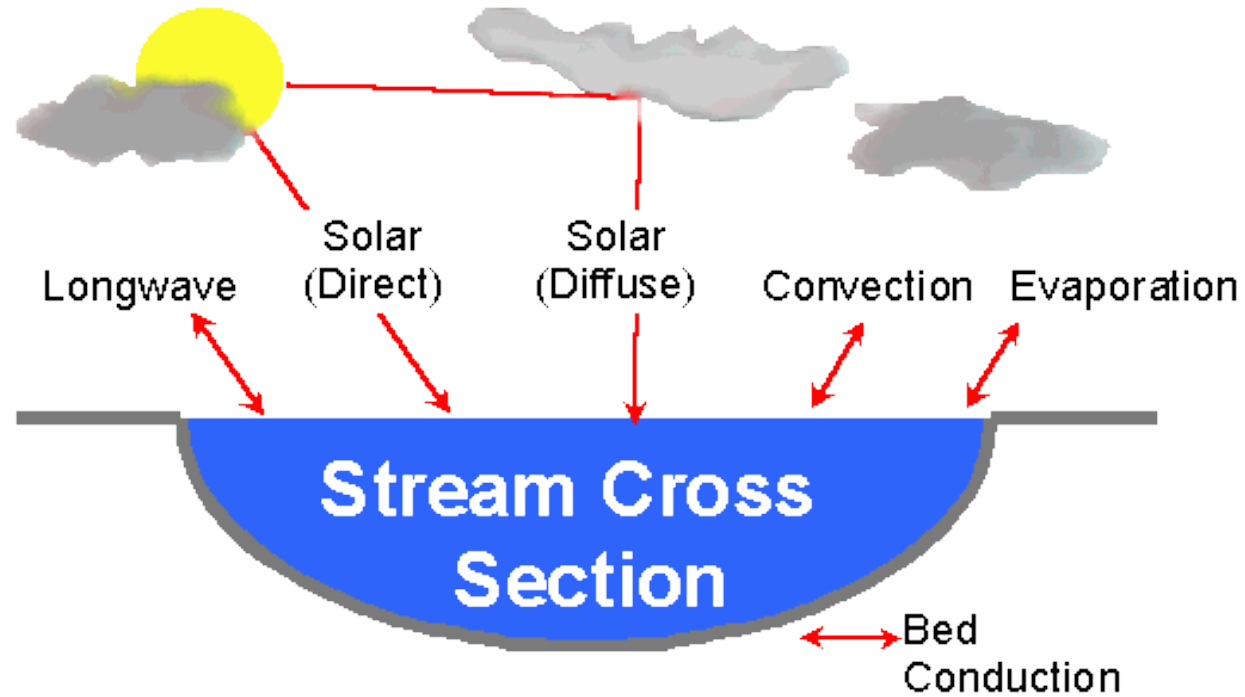
- Willamette Subbasins Boundary
- HUC8 Boundary
- Major River
- Heat Source Temperature and Shade Model Extent
- Heat Source Shade Model Extent
- Heat Source Shade Model Area



HEAT SOURCE

- Mechanistic model
- Simulates 1D open channel hydraulics, heat flux, mass transfer, and stream temperature
- Developed in 1996 at Oregon State University
- Independently peer reviewed, applied in multiple published studies all over the world.

Heat Transfer Processes



Heat Source model inputs and parameters

Land Use/Land Cover

- Height / Elevation
- Canopy Closure
- Overhang
- Topographic Shade Angles

Stream Position

- Longitude
- Latitude

Solar Modeling

Channel Morphology

- Stream Elevation
- Gradient
- Bottom Width
- Channel Angle Z

Boundary Conditions & In/Out Flows

- Stream Temperature
- Stream Flow

Met Data

- Cloudiness
- Wind Speed
- Wind Coefficients “a” & “b”
- Relative Humidity
- Air Temperature

Substrate

- Deep Alluvium Temperature
- Sediment Thermal Conductivity
- Sediment Thermal Diffusivity
- Hyporheic zone thickness
- Percent Hyporheic exchange
- Porosity

Heat Source model outputs

Temperature

- Stream Temperature
- Sediment Temperature

Flux

- Streambed Conduction
- Convection
- Evaporation

Solar Modeling

- Solar Radiation (Above Topography)
- Solar Radiation (Blocked by LULC)
- Solar Radiation (Above Stream Surface)
- Solar Radiation (Penetrating Stream)
- Effective Shade
- Thermal Radiation (Total)

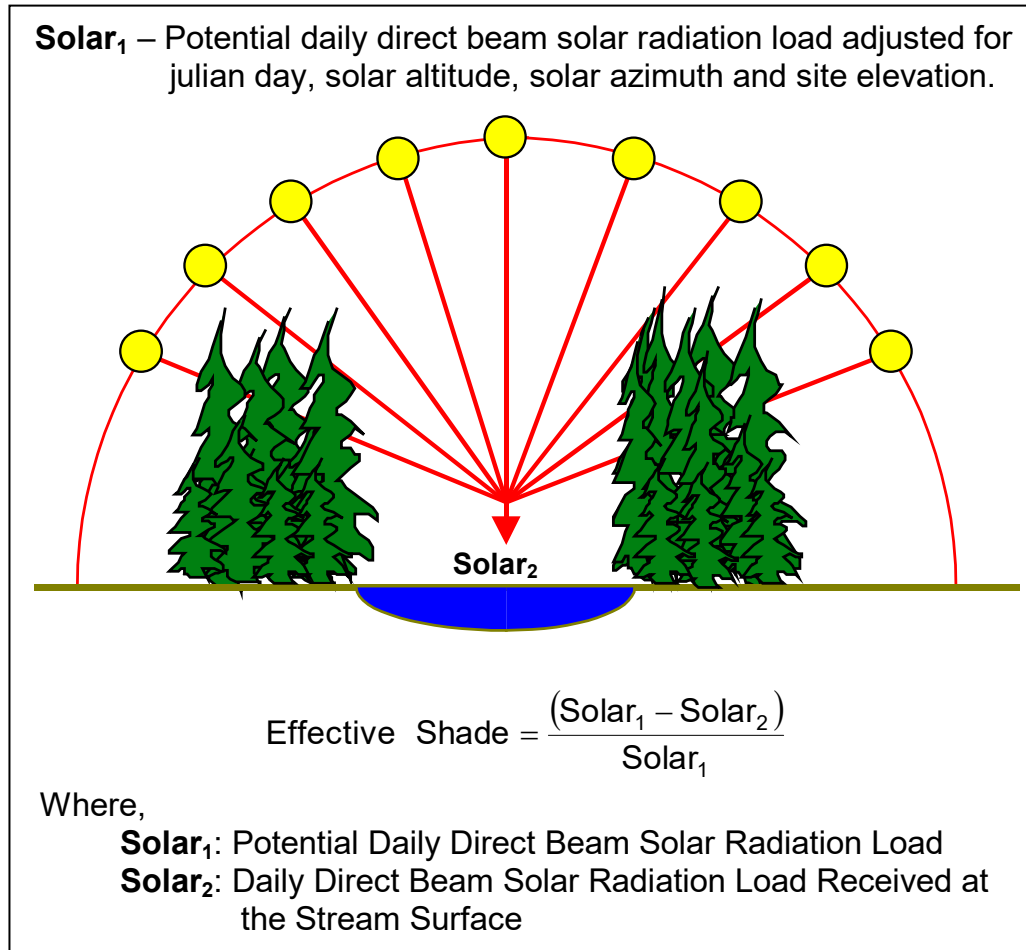
Hydraulics

- Flow Rate
- Hyporheic Exchange (cms)
- Flow Velocity
- Top Wetted Width
- Average Wetted Depth
- Maximum Wetted Depth

Others

- Hydraulic Dispersion (square meters/second)
- Evaporation Rate (mm/hour)
- View To Sky

Effective shade



Measuring effective shade



Solar pathfinder

Picture Source: Ryan Michie



hemispherical photography + analysis software

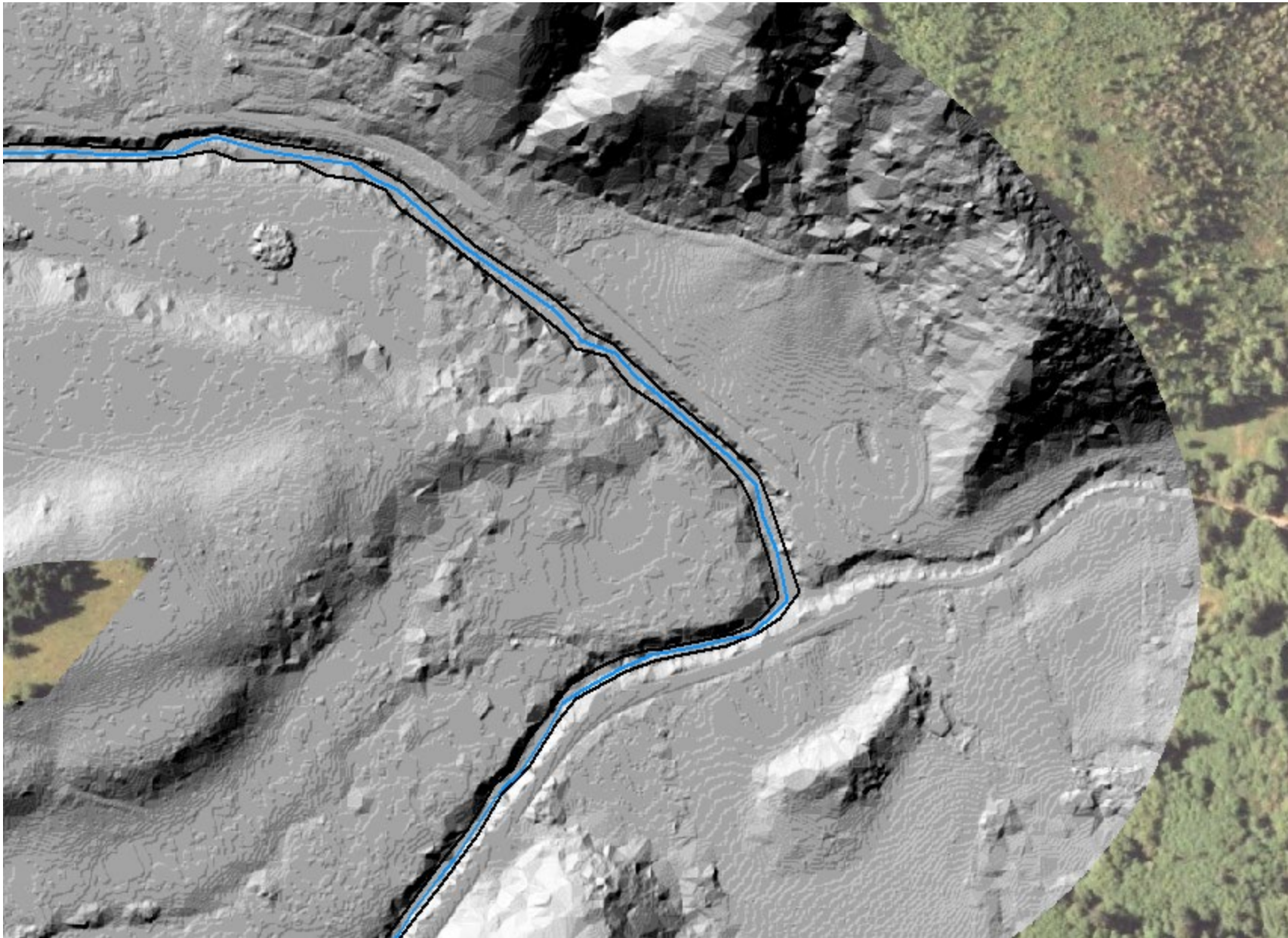


Digitize

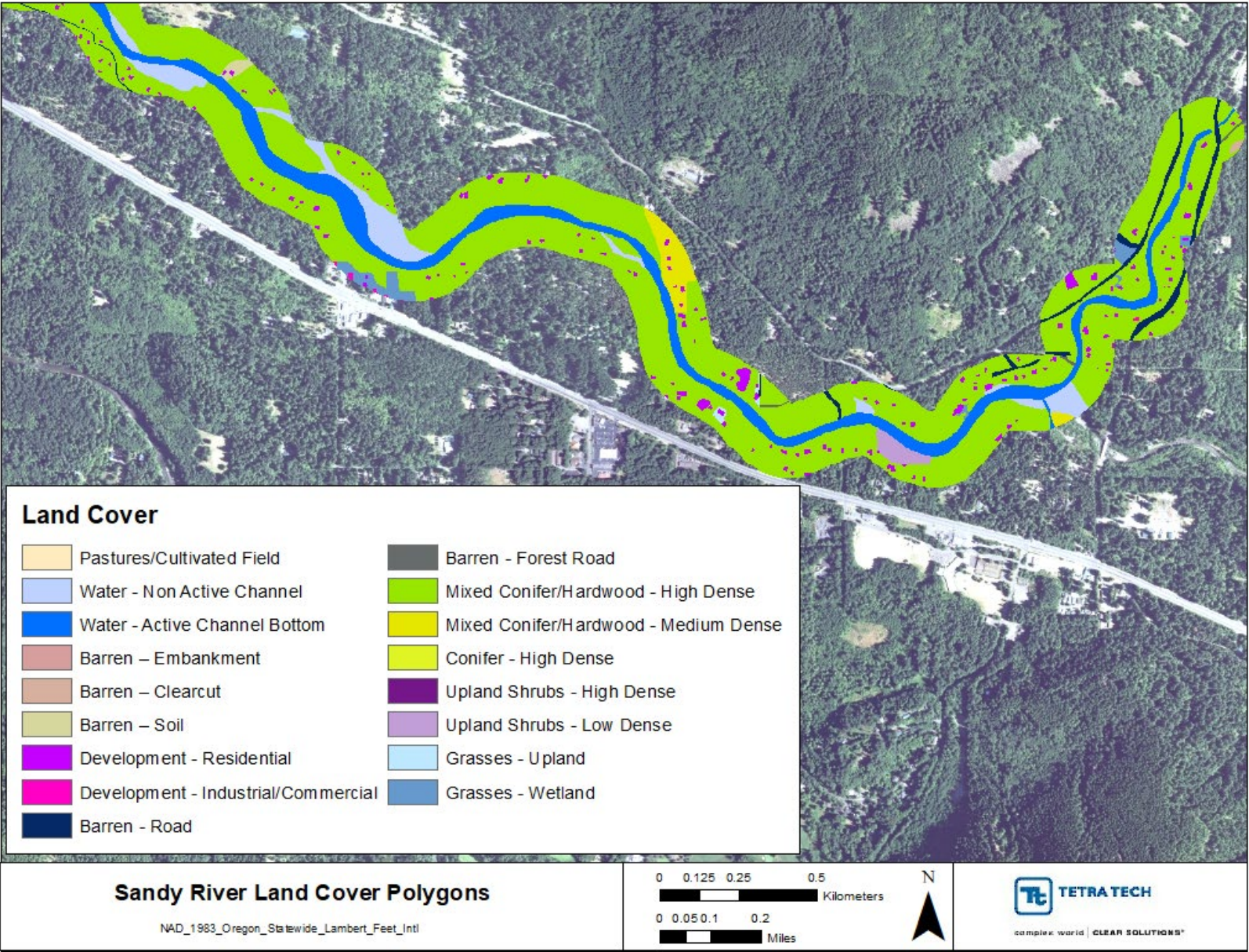
- Stream Centerline
- Left Bank
- Right Bank

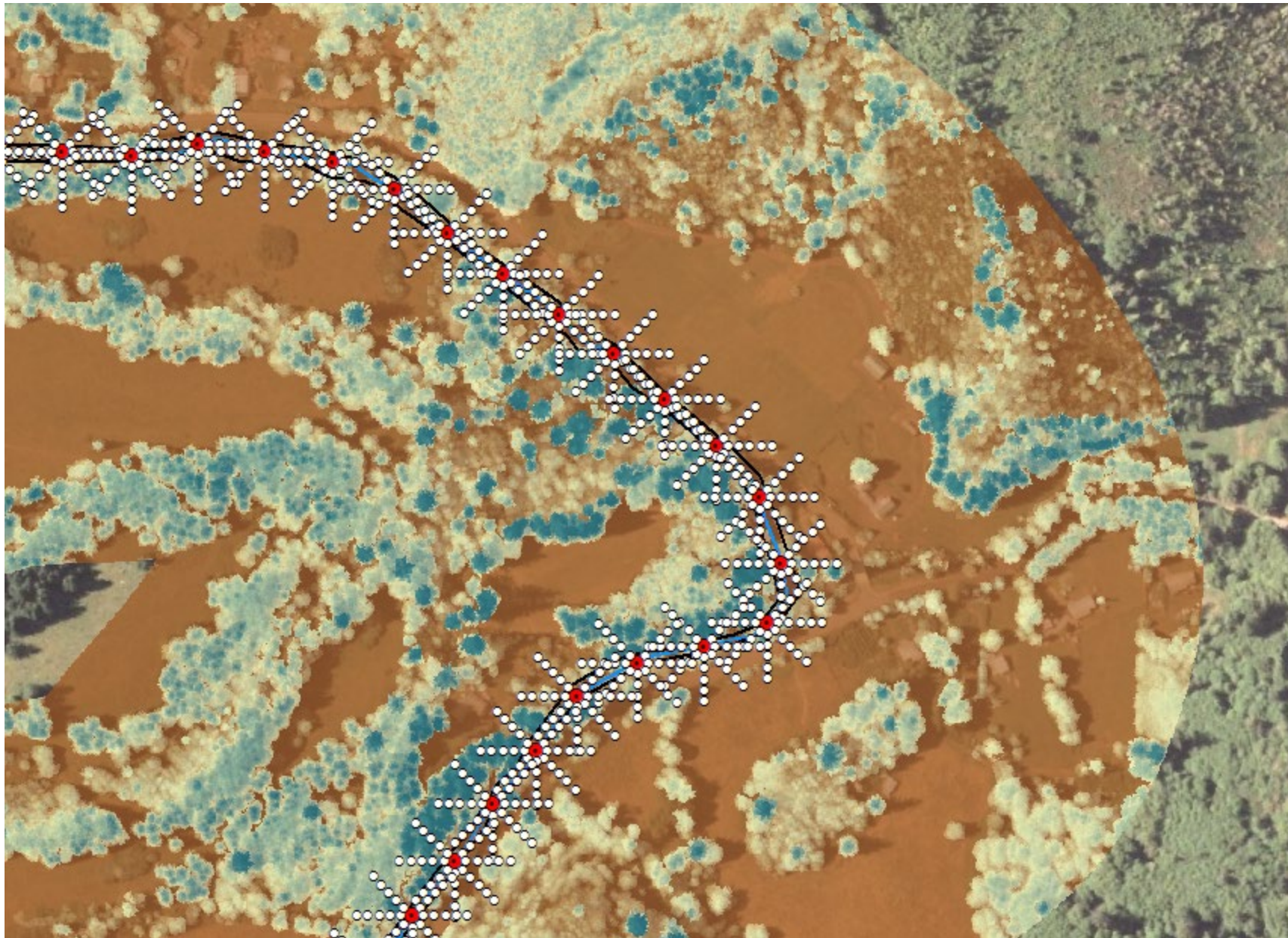
Model Node

- Stream Position
- Land Cover
- Stream Elevation
- Gradient
- Channel Shape



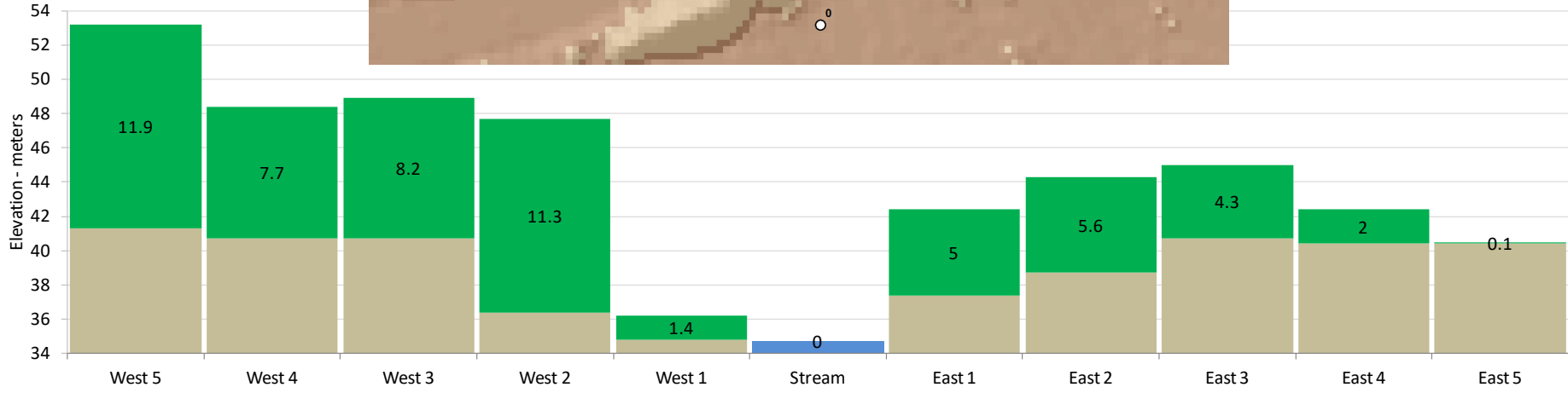
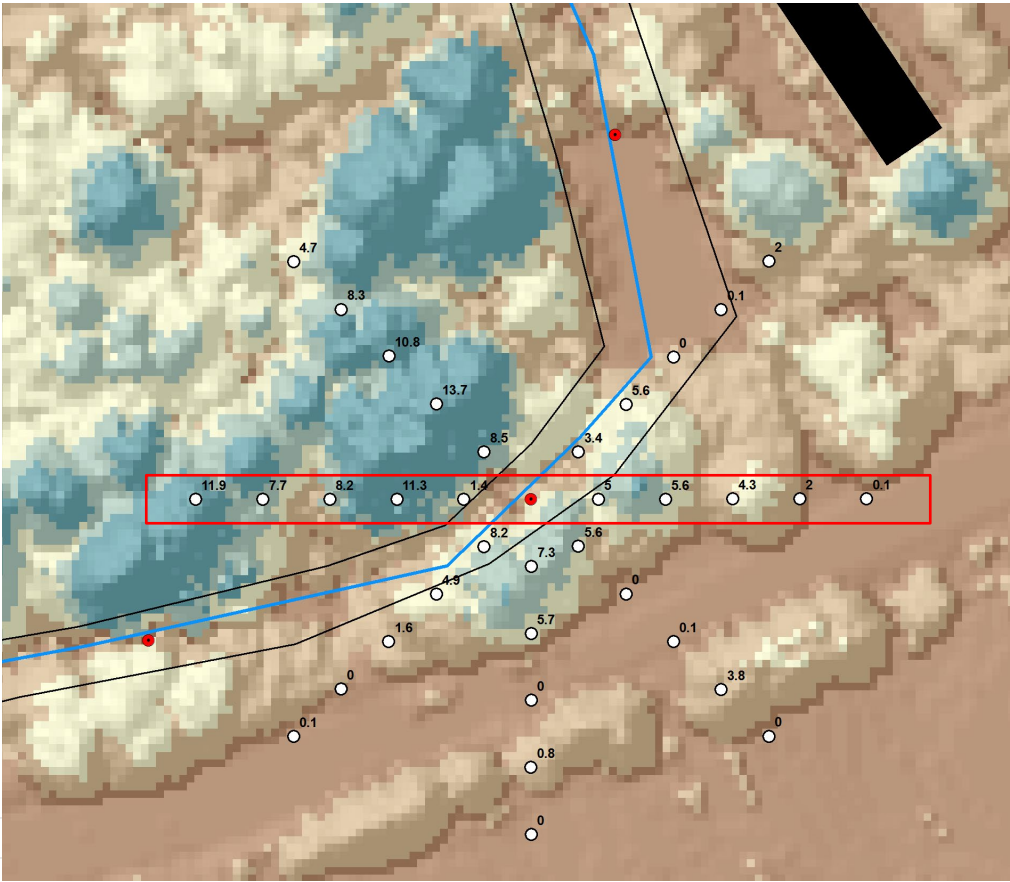
Digitize Landcover
 100 meters from each bank



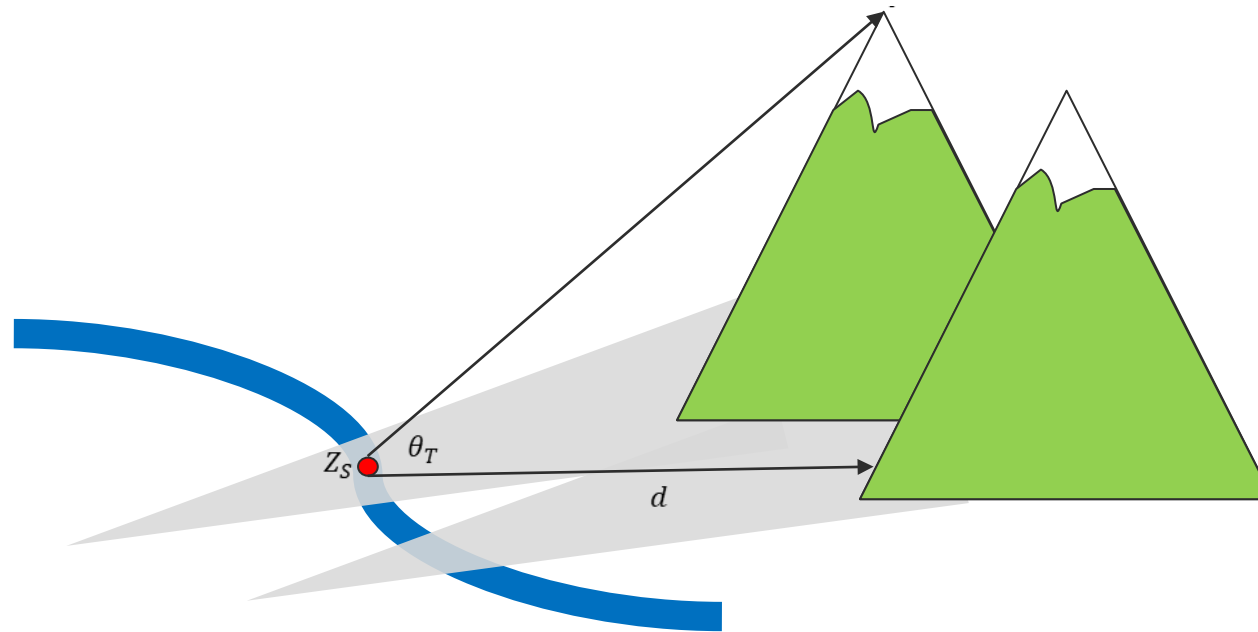
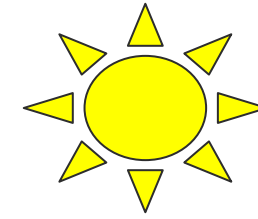


Derive vegetation height from
LiDAR

Example of model constructed land cover elevations for the West – East transect



Topographic shade angles



$$\theta_T = \tan^{-1} \left(\frac{Z_T - Z_S}{d} \right)$$

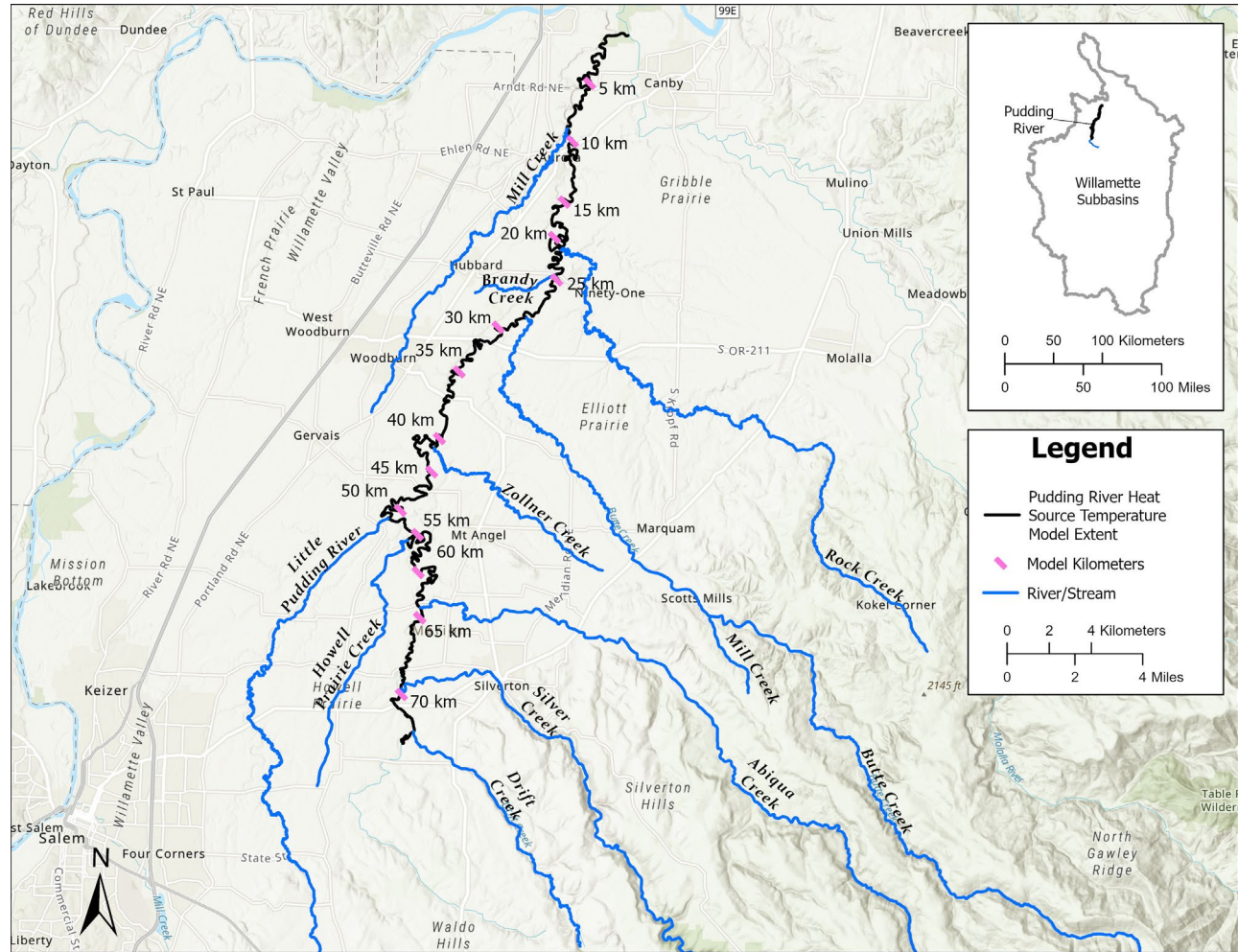
Topographic Shade Angle

where,

- $\theta_T =$ The topographic shade angle (degrees)
- $Z_T =$ The elevation (meters) at the topographic feature.
- $Z_S =$ The elevation (meters) at the stream node.
- $d =$ Horizontal distance (meters) from the stream node to the topographic feature.

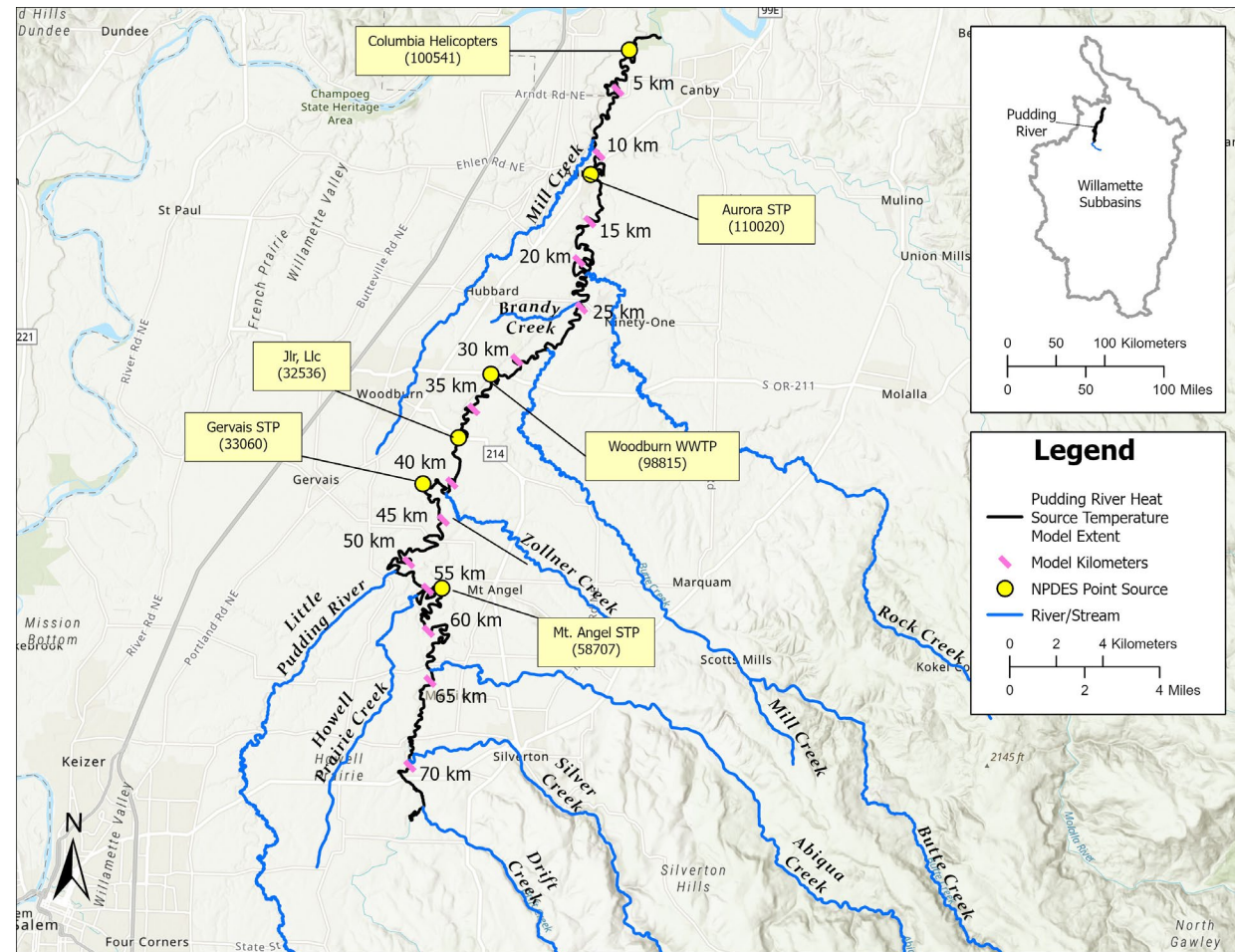
Pudding River temperature model

Model Period: August 1 to August 14, 2004
Model Extent: 84.5 km (52.4 mi)
Heat Source version 8

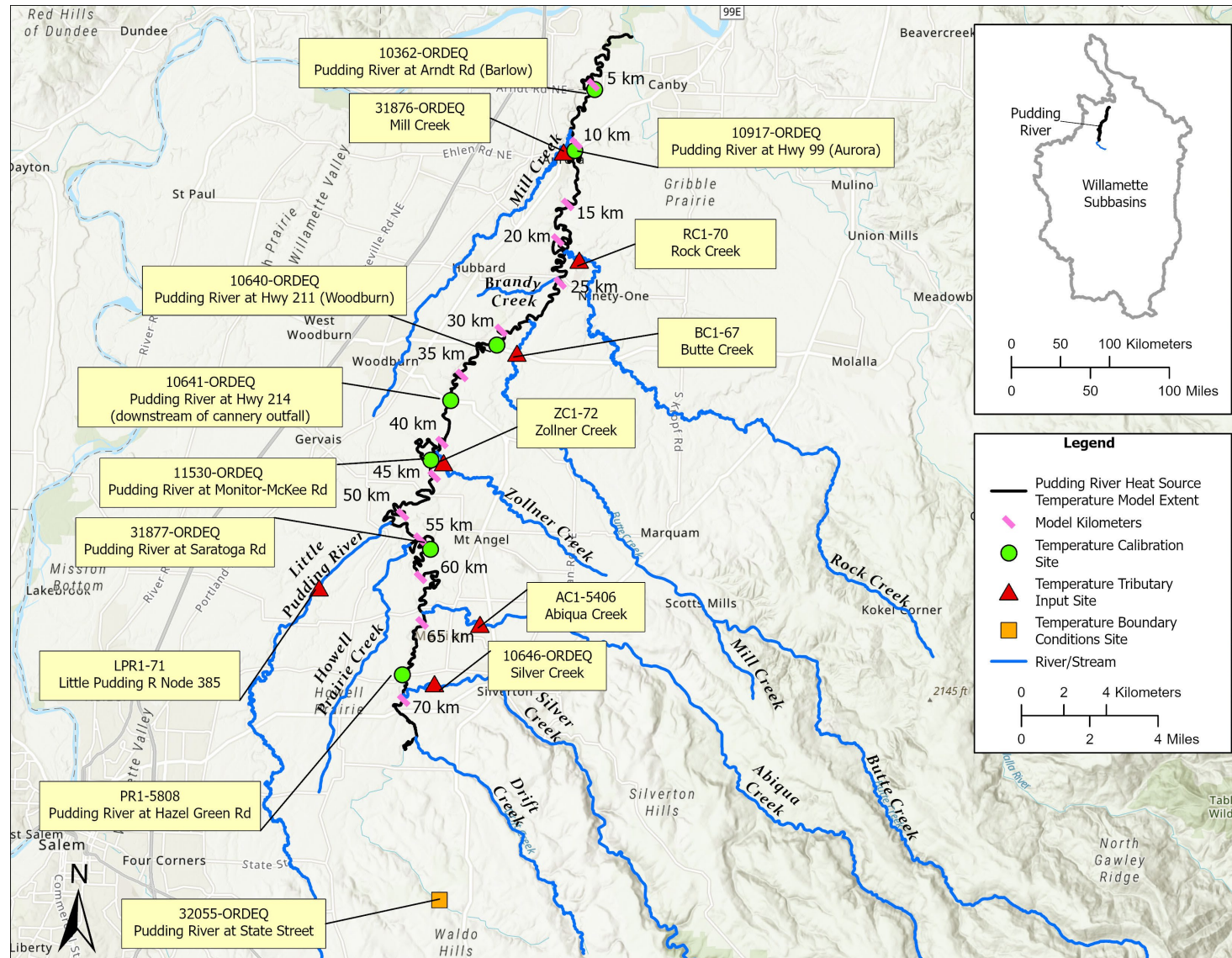


Pudding River NPDES permittees

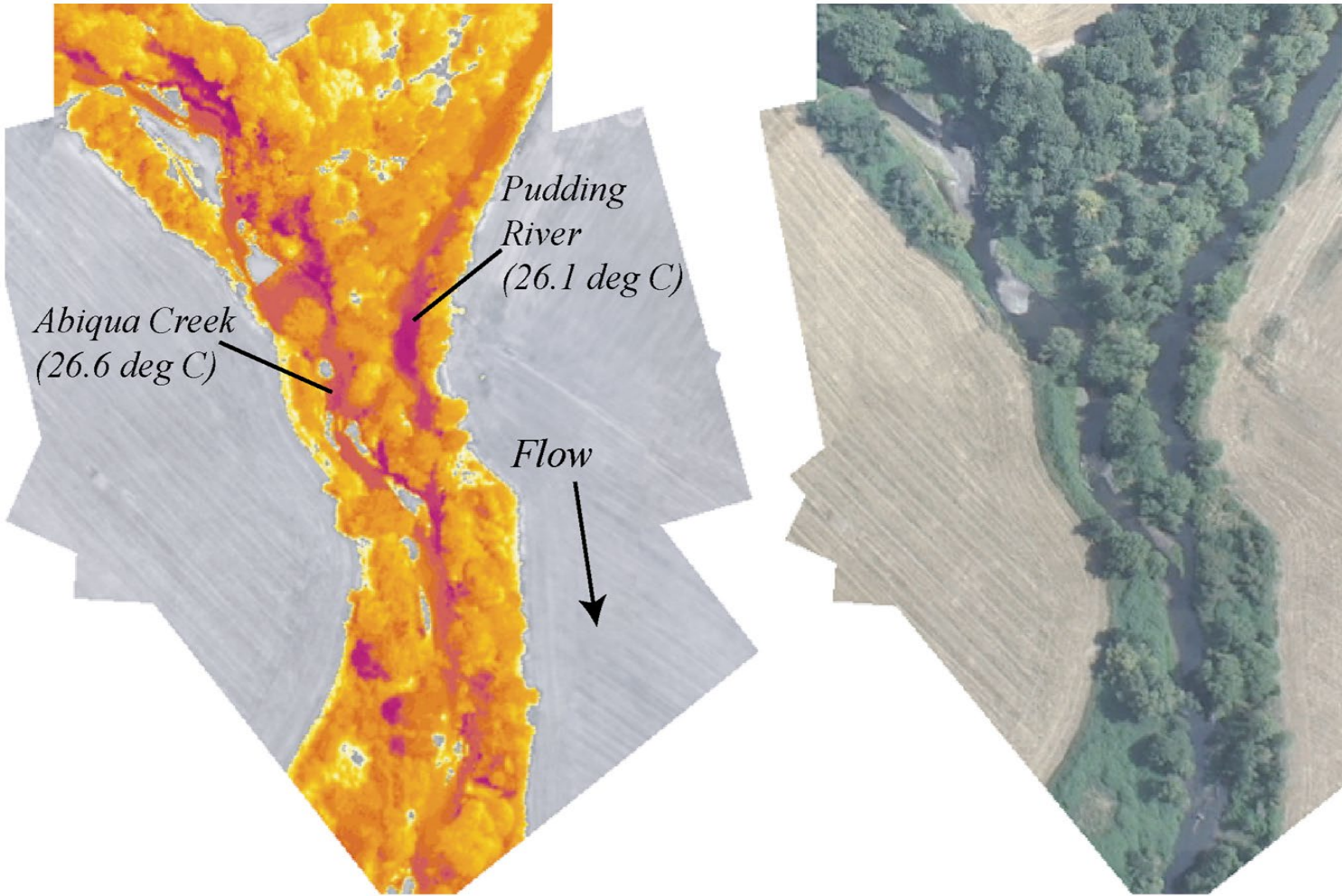
- Aurora STP
- Woodburn WWTP
- JLR
- Gervais STP
- Mt Angel



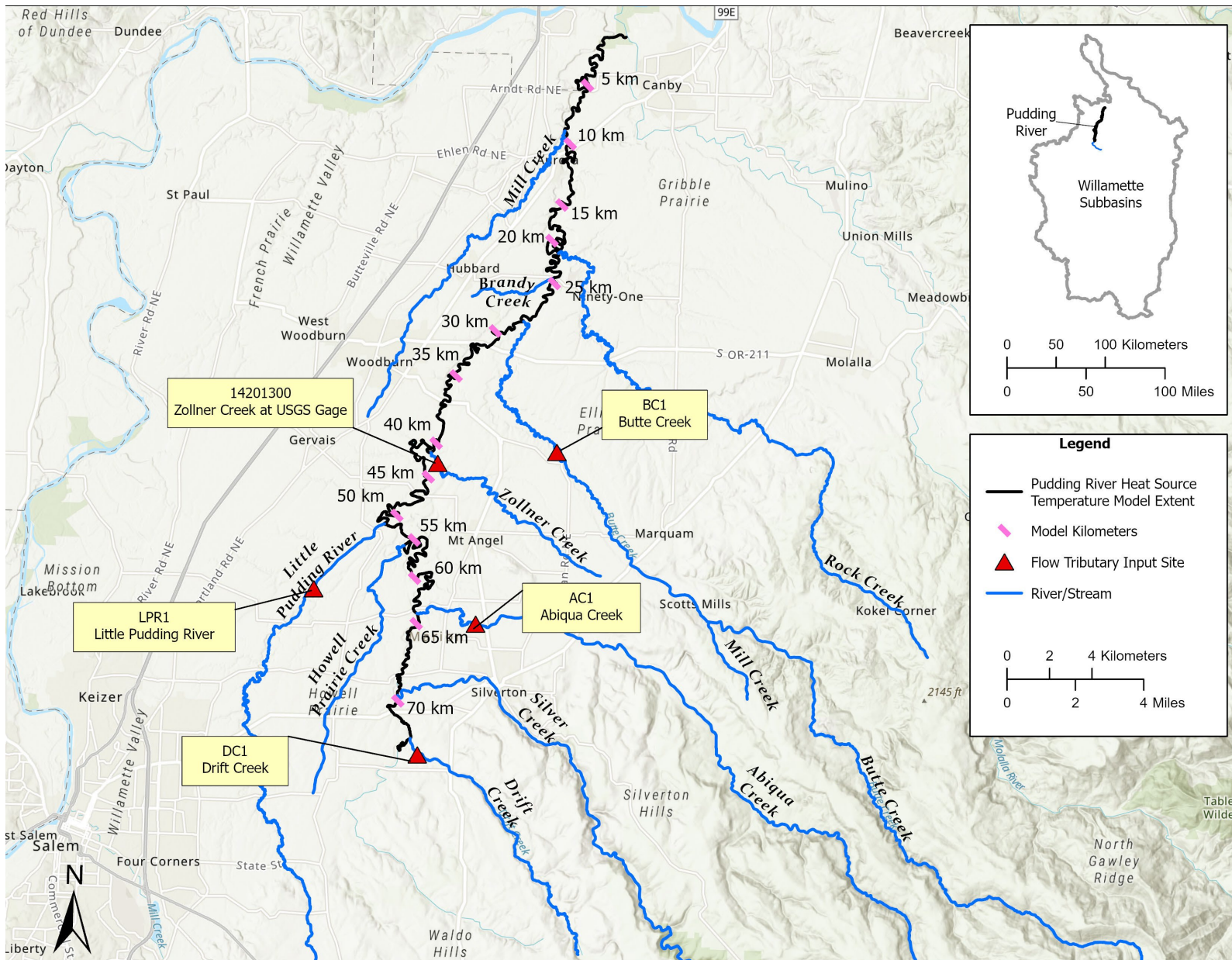
Temperature inputs and calibration sites



Degrees C



Thermal Infrared Radiometry (TIR)
August 11, 2004



Flow inputs

- Measured data
- Flow mass balance
- Accounted for points of diversion and withdrawals

Meteorological data

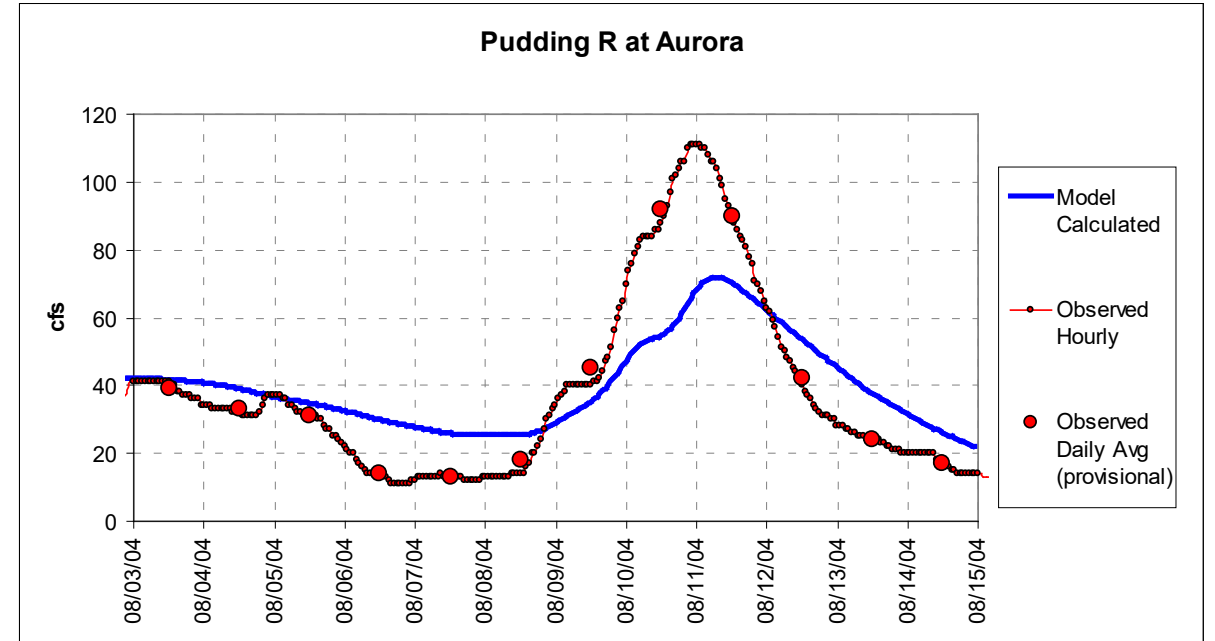
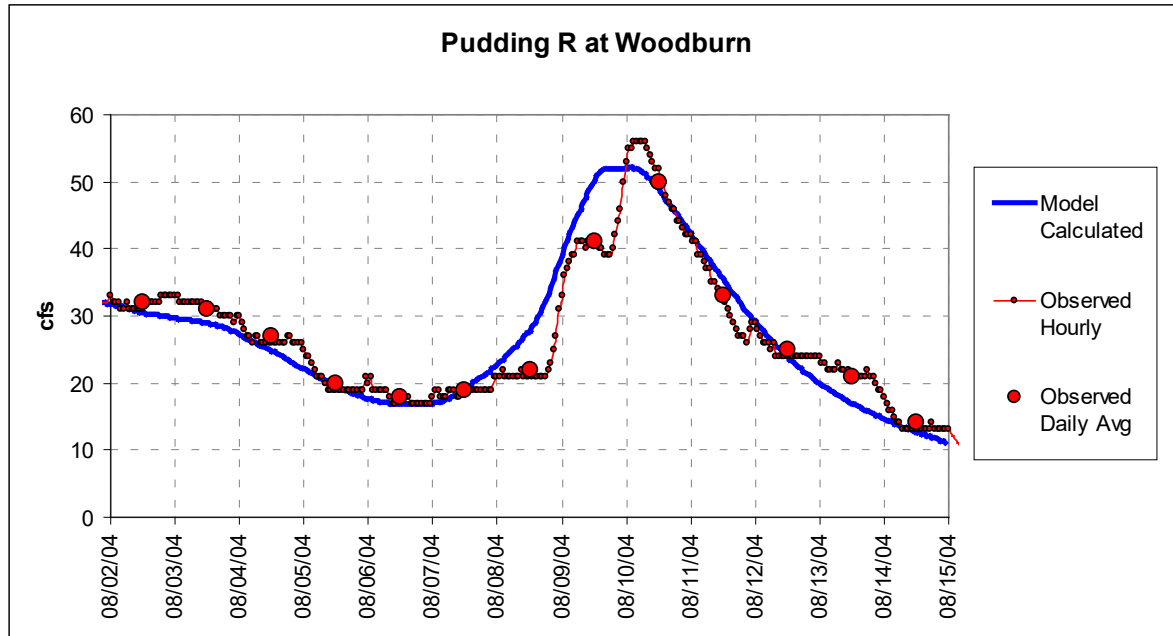
AgriMet – Aurora ARAO

- Air Temperature
- Wind Speed
- Relative Humidity

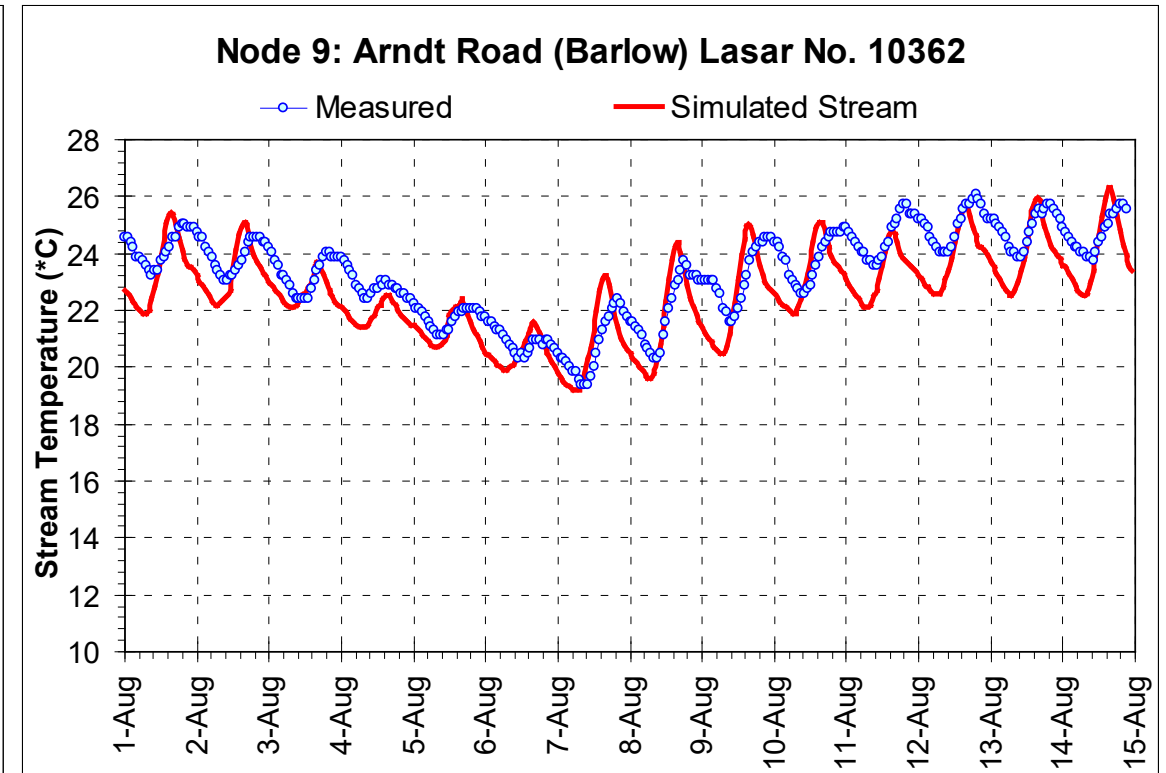
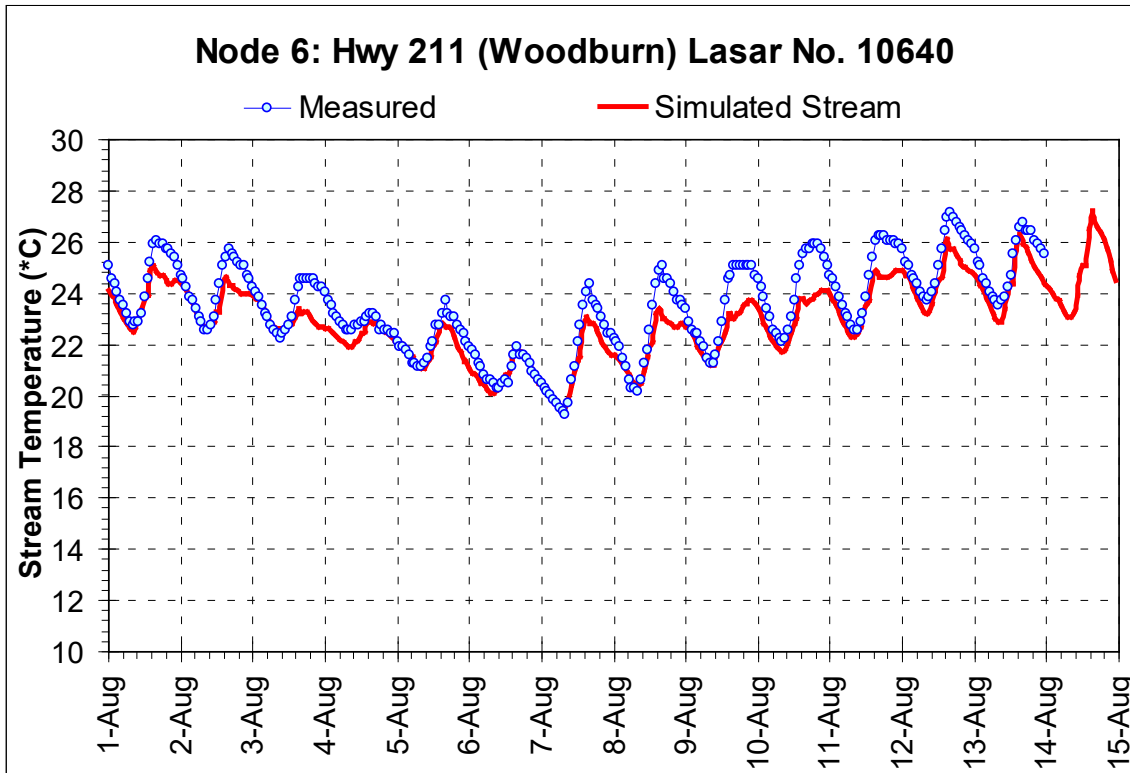
Aurora State Airport (NWS)

- Cloudiness

Flow calibration results



Temperature calibration results



Temperature calibration results

Hourly Temperatures

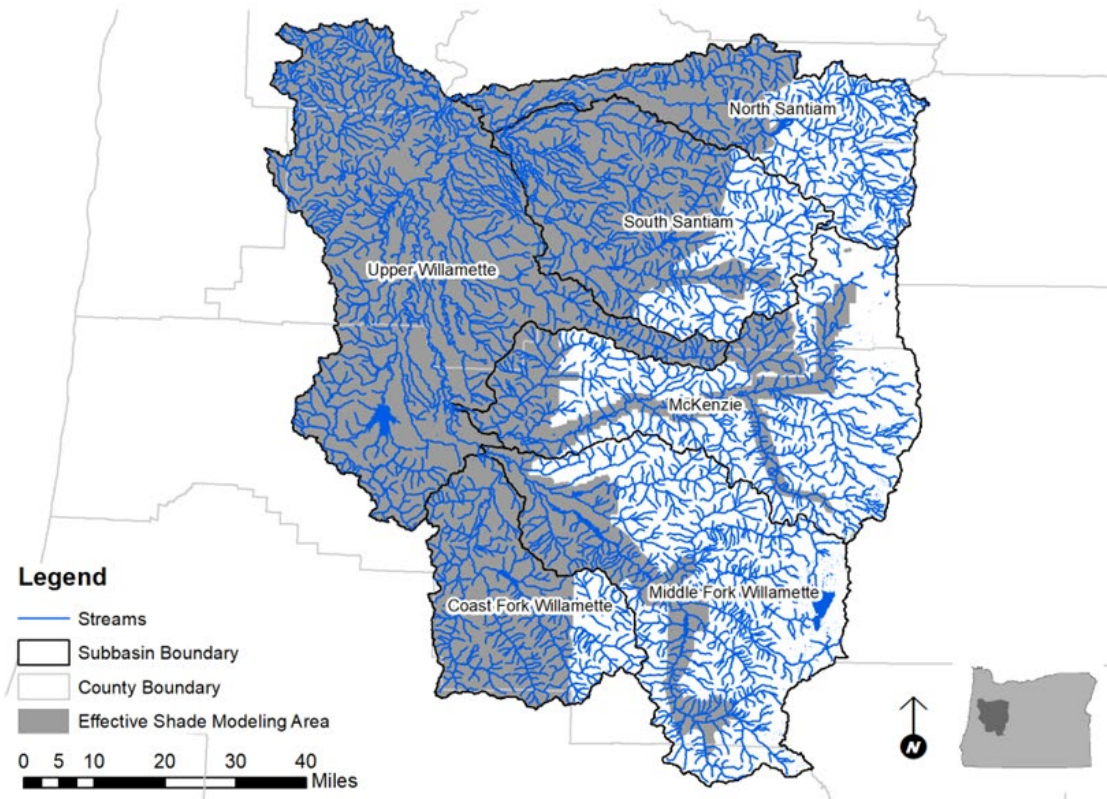
Station	Location (model km)	Mean Error	Mean ABS Error	RMS Error
Node 3: Saratoga Road DEQ Laser No. 31877	66.3	1.8	2.1	2.5
Node 4: Monitor-McKee Rd DEQ Laser No. 11530	51.7	-0.5	0.8	0.9
Node 5: Hwy 214 DEQ Laser No. 10641	43.7	-0.5	0.8	0.9
Node 6: Hwy 211 (Woodburn) DEQ Laser No. 10640	36.2	-0.6	0.7	0.8
Node 8: Hwy 99E (Aurora) DEQ Laser No. 10917	12.4	-0.1	0.8	1.0
Node 9: Arndt Road (Barlow) DEQ Laser No. 10362	7.7	-0.7	1.0	1.2

7DADM Temperatures

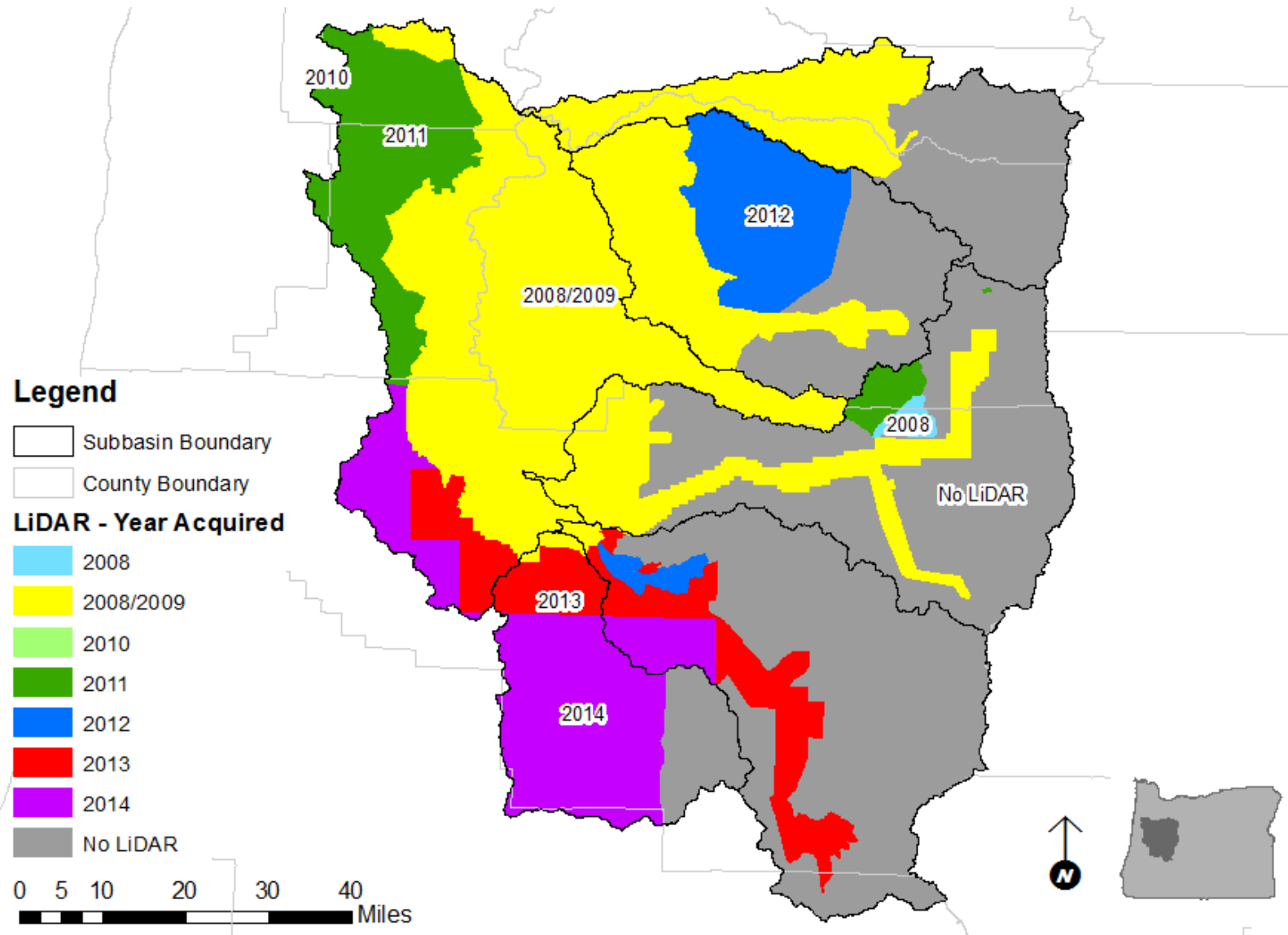
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Node 6: Hwy 211 (Woodburn) DEQ Laser No. 10640	36.2	-1.1	1.1	1.1
Node 8: Hwy 99E (Aurora) DEQ Laser No. 10917	12.4	0.5	0.5	0.5
Node 9: Arndt Road (Barlow) DEQ Laser No. 10362	7.7	0.1	0.1	0.1

Southern Willamette shade model

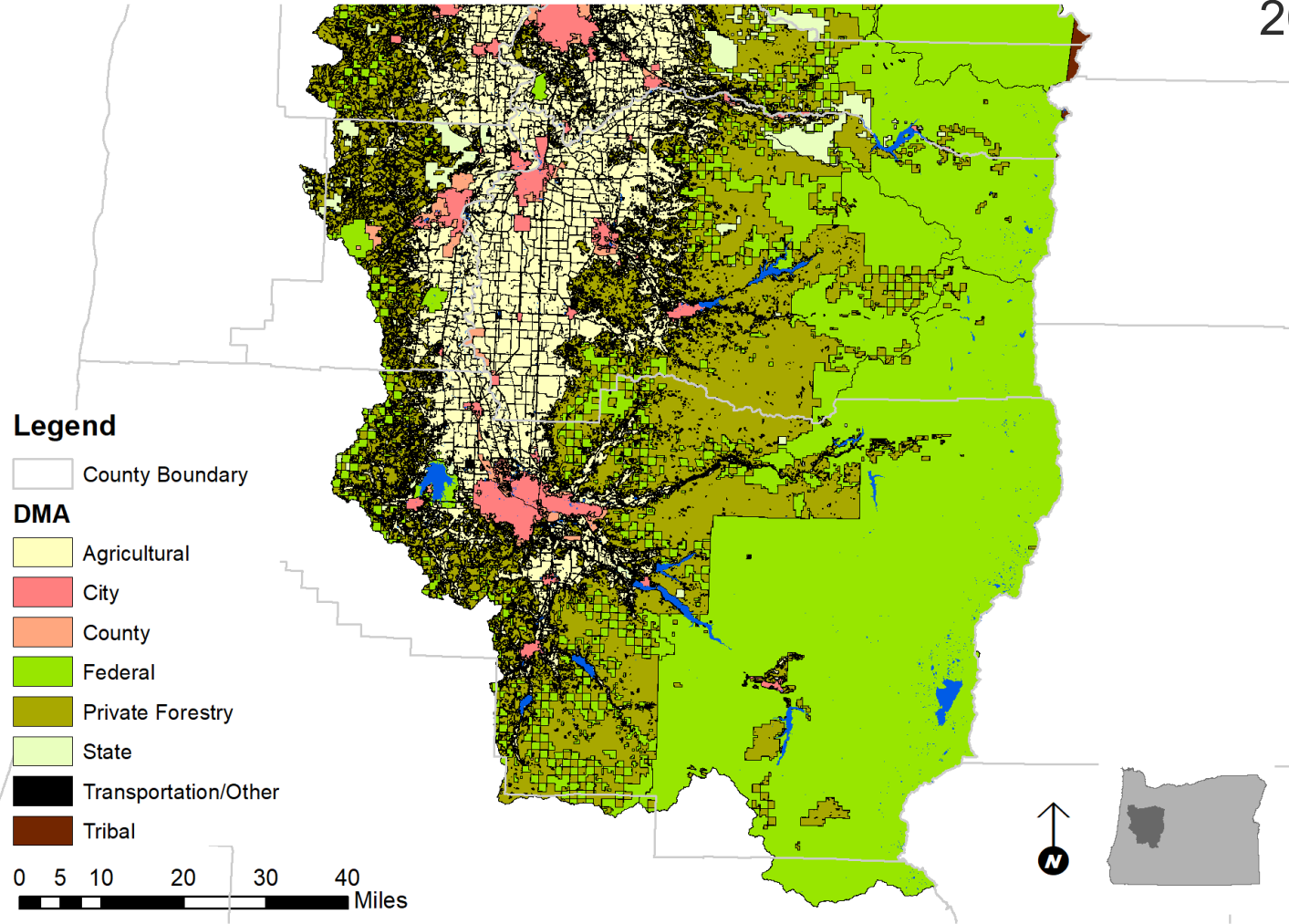
Model Period August 15, 2014
Distance Step: 200 meters
Stream Position: NHD



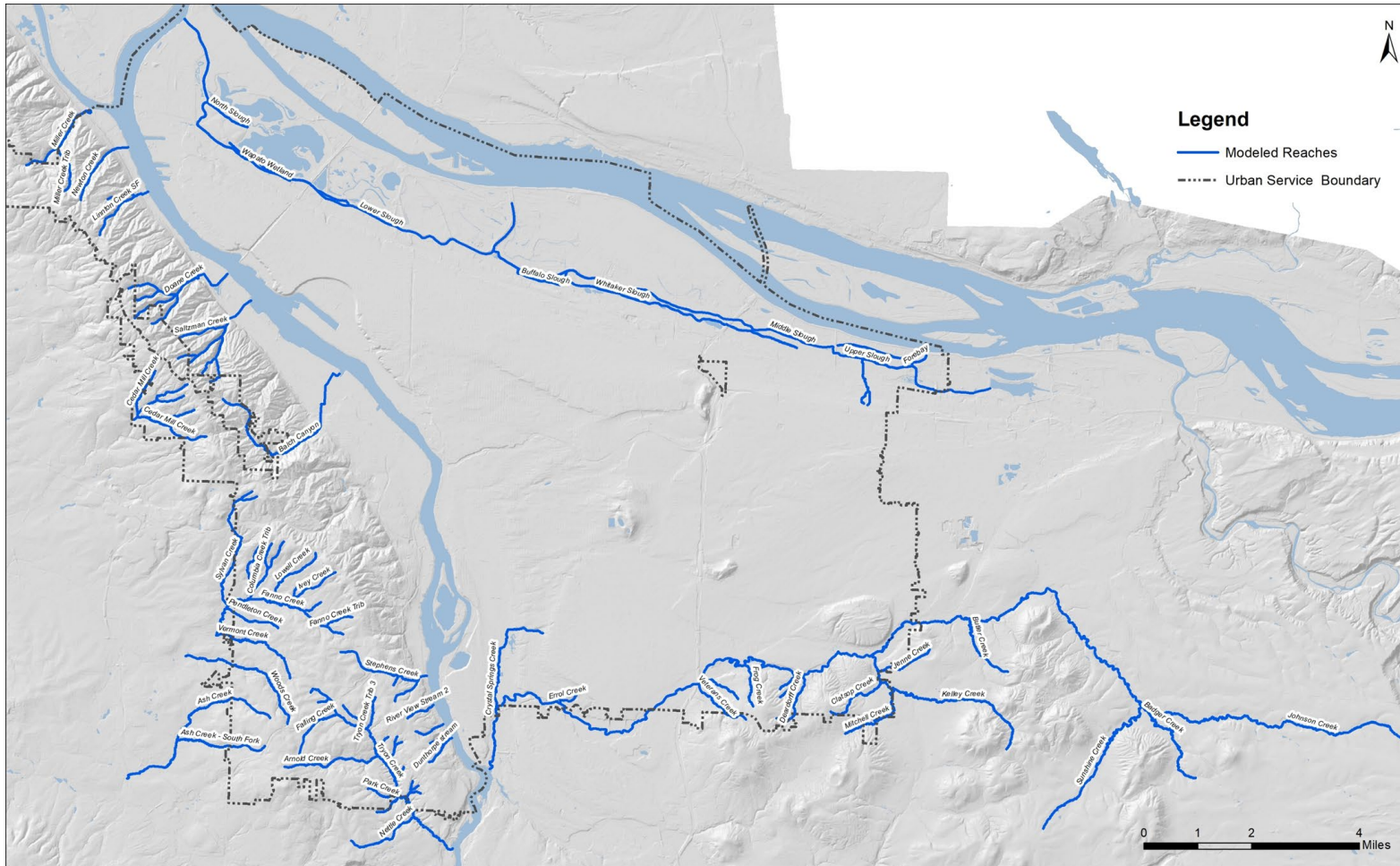
Available LiDAR



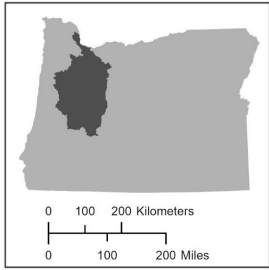
Ownership and Jurisdiction Mapping 2019 County Taxlot Records



Lower Willamette shade model

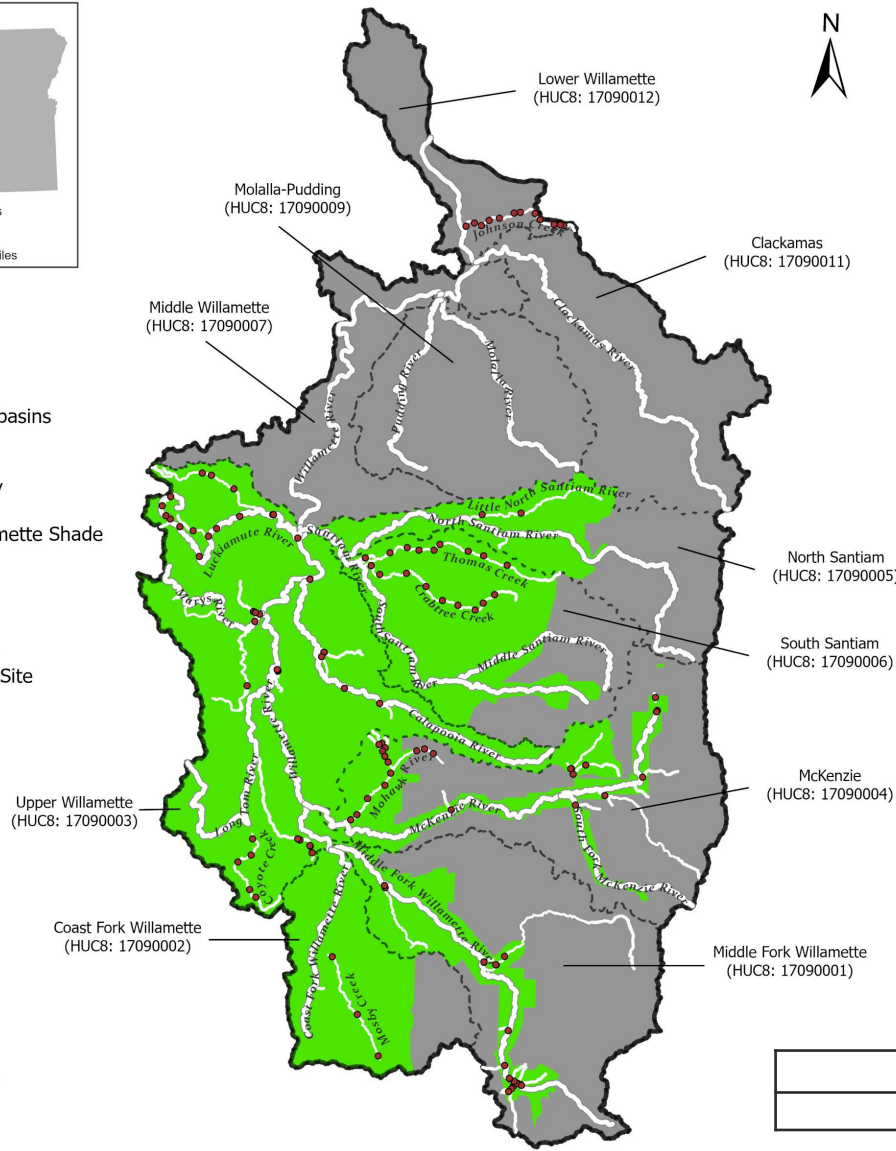


Model Period July 1 – August 31,
2007, 2014, 2019
Distance Step: 25 meters
Stream Position: Metro
Model by City of Portland

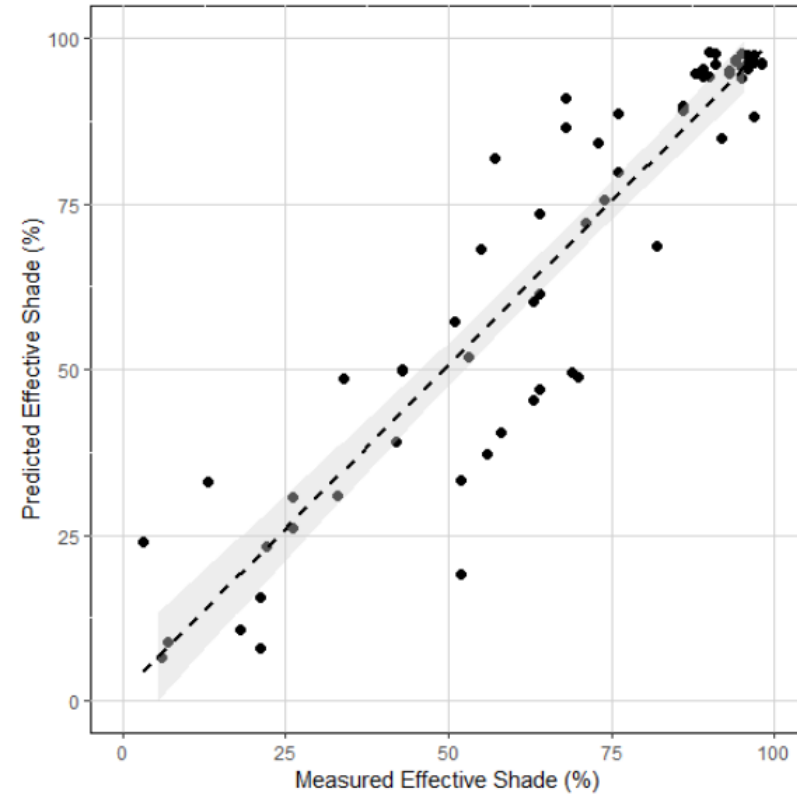


Legend

- Willamette Subbasins Boundary
- HUC8 Boundary
- Southern Willamette Shade Model Area
- River/Stream
- Effective Shade Measurement Site



65 effective shade measurements for the Southern Willamette



n	R ²	ME	MAE	RMSE
65	0.87	0.5	7.8	11



Model scenarios

- No point sources
- Point sources at waste load allocations
- Restored Vegetation
- Protected Vegetation

Pudding River Waste Load Allocations (WLA) modeling assumptions

JLR (formerly known as Agripac/Brucepac)
Allocated HUA: 0.01 C

Gervais STP
NPDES permit condition of no discharge is maintained.
Allocated HUA: 0.0 C

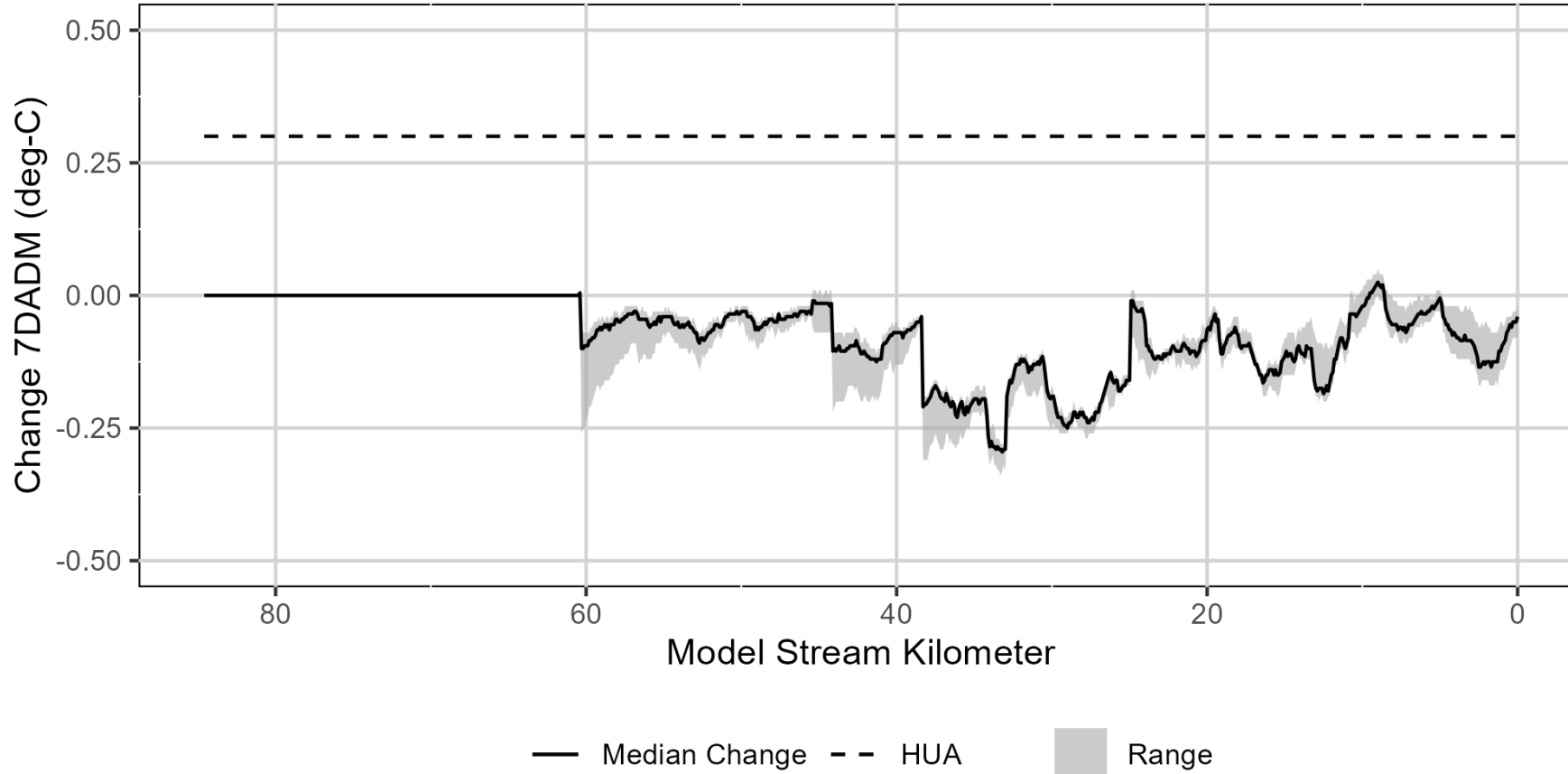
Woodburn WWTP
Allocated HUA: 0.20 C

Aurora STP
NPDES permit condition of no discharge is maintained.
Allocated HUA: 0.0 C

Mt. Angel STP
NPDES permit condition of no discharge is maintained.
Allocated HUA: 0.0 C

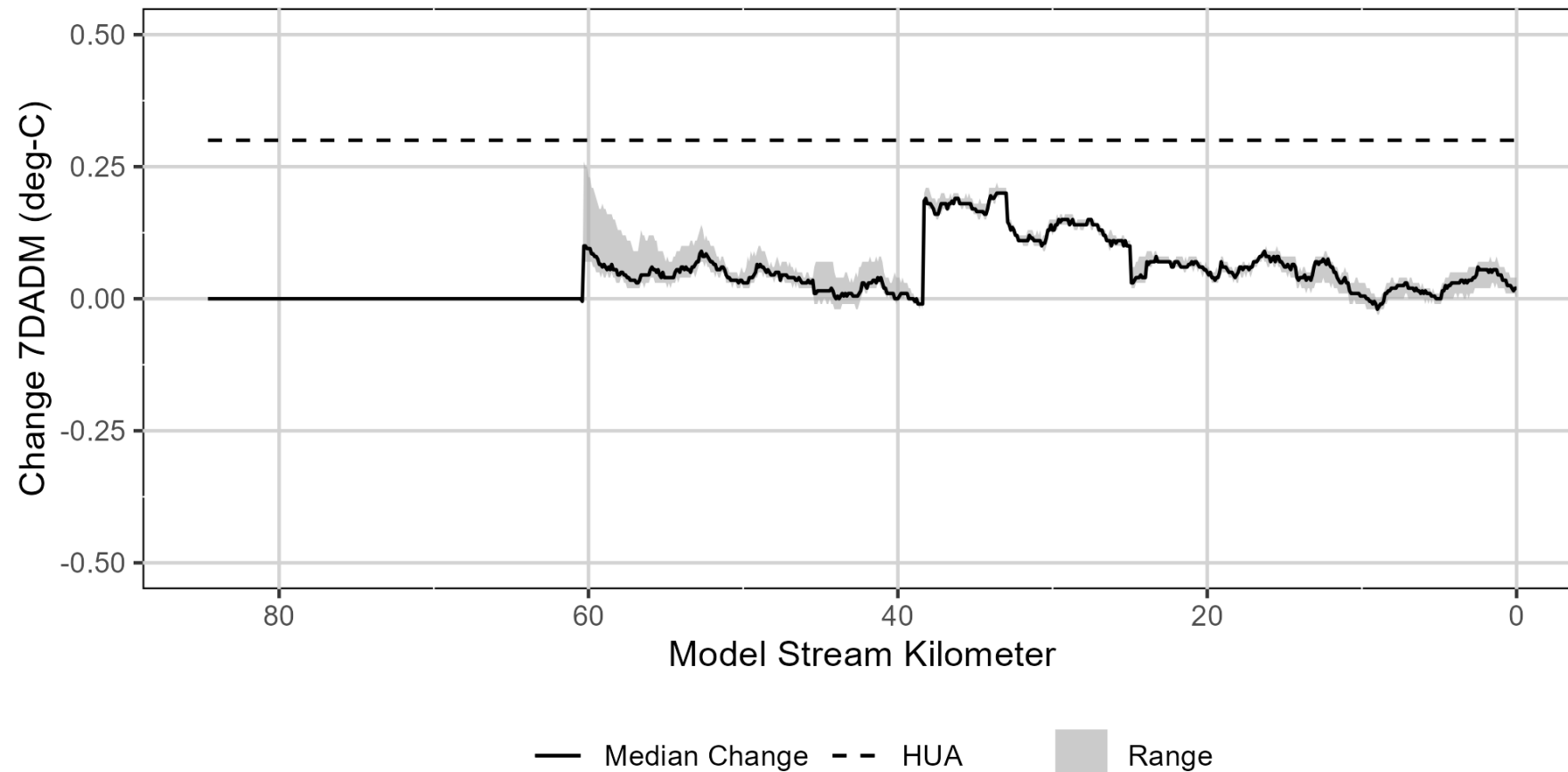
Model results: Pudding River

Point source Waste Load Allocations impacts relative to No Point Source conditions



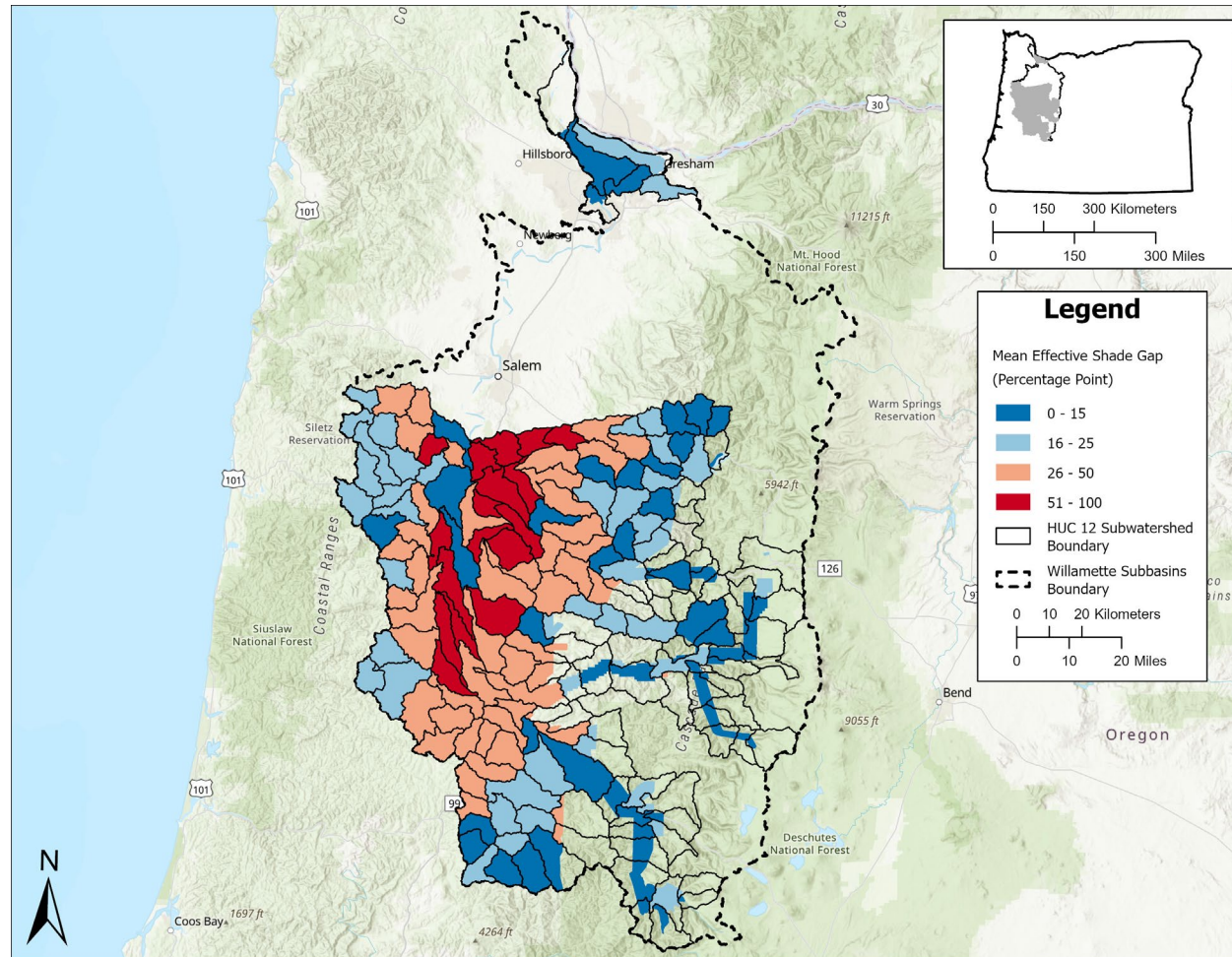
Model results: Pudding River

Point source Waste Load Allocations impacts relative to current conditions

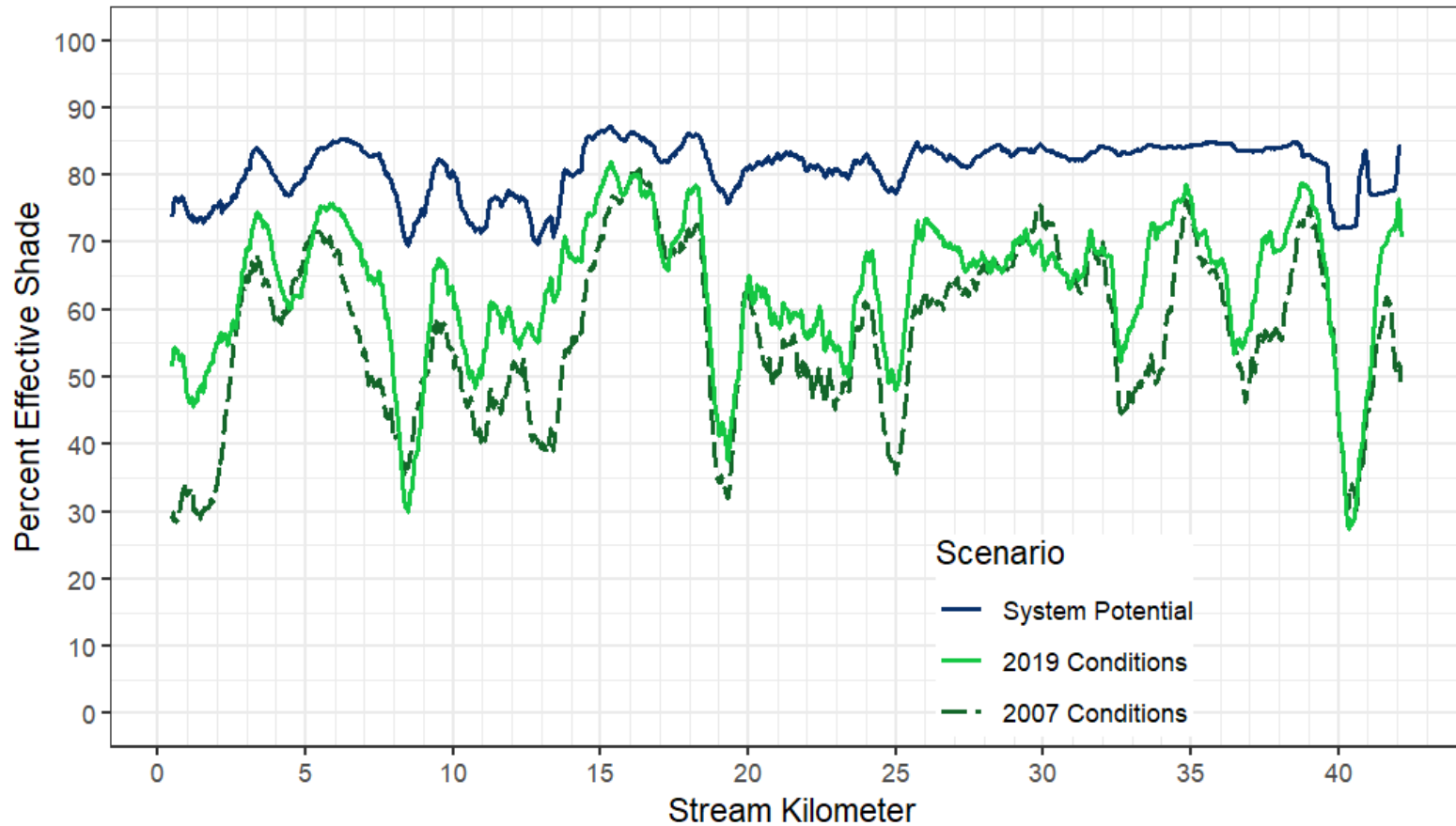


Southern Willamette shade gap

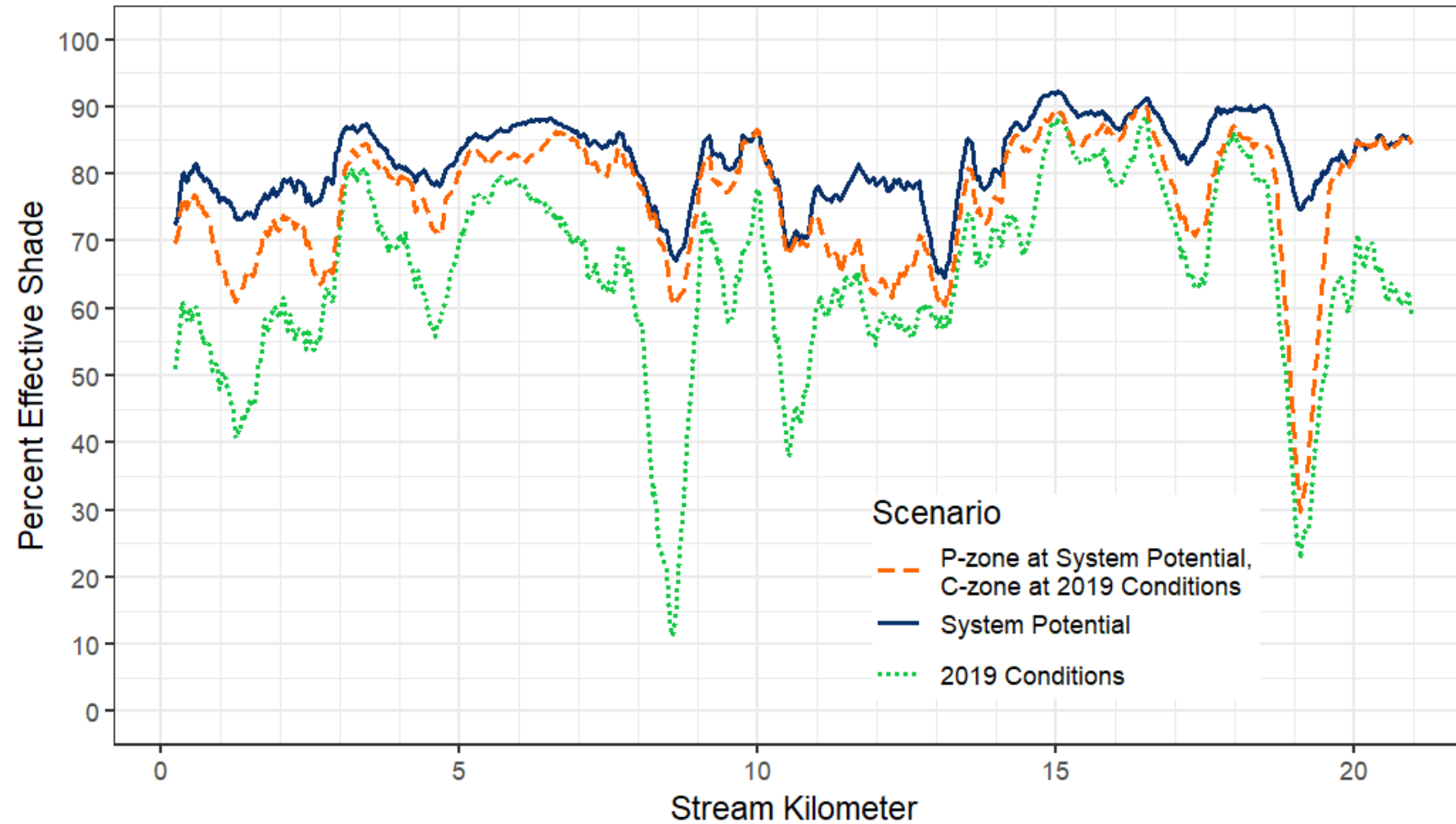
Restored minus Current

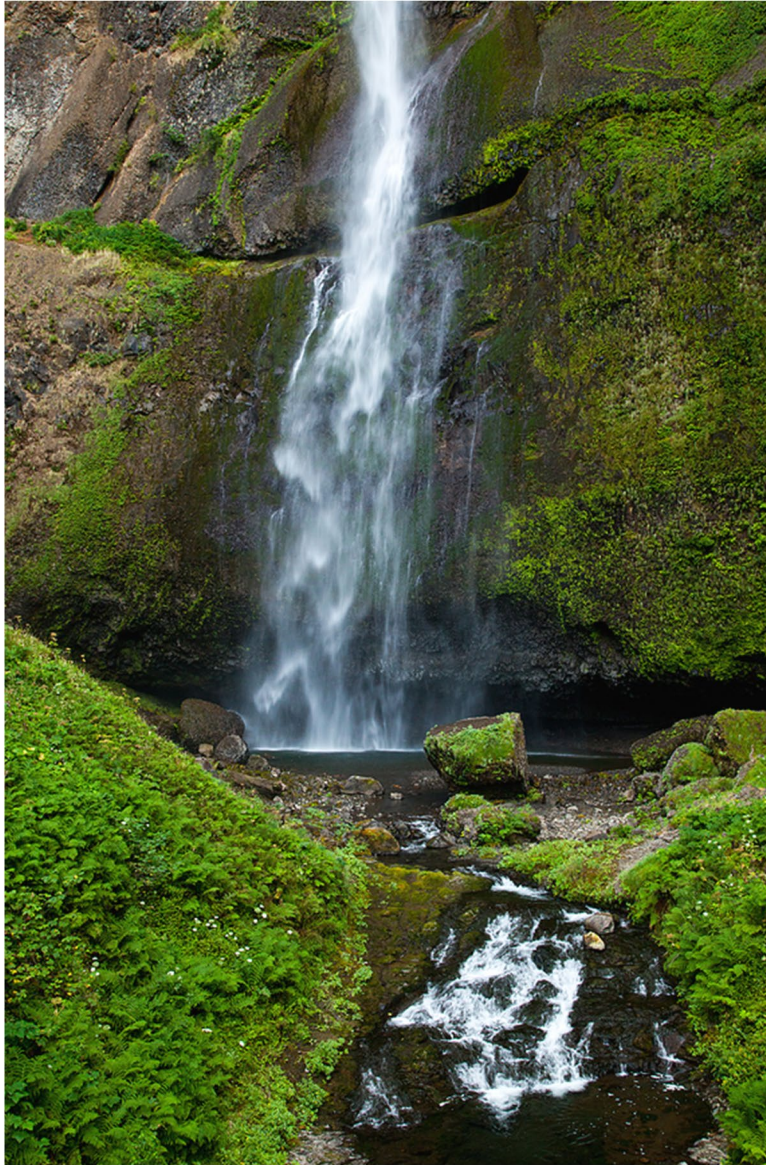


Lower Willamette current and restored vegetation (Johnson Creek)



Protected vegetation scenario (Johnson Creek)





Contacts and resources

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Priscilla Woolverton, Basin Coordinator Priscilla.woolverton@deq.oregon.gov

Web pages (links to rulemaking pages, Quality Assurance Project Plans, more)

Project page:

<https://www.oregon.gov/deq/wq/tmdls/Pages/tmdlRwillamette.aspx>

Rulemaking page:

<https://www.oregon.gov/deq/rulemaking/Pages/willamettetempTMDL.aspx>

Committee input and rulemaking email:

Willamette.TemperatureTMDL@DEQ.oregon.gov

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