RECLAMATION

Managing Water in the West

Upper Missouri Climate Impact Assessment: Hydrologic Modeling

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Bureau of Reclamation

Outline

- **Surface hydrology model**
- **Groundwater representation**
- **Historical and projected surface water supply**

Canyon Ferry Reservoir

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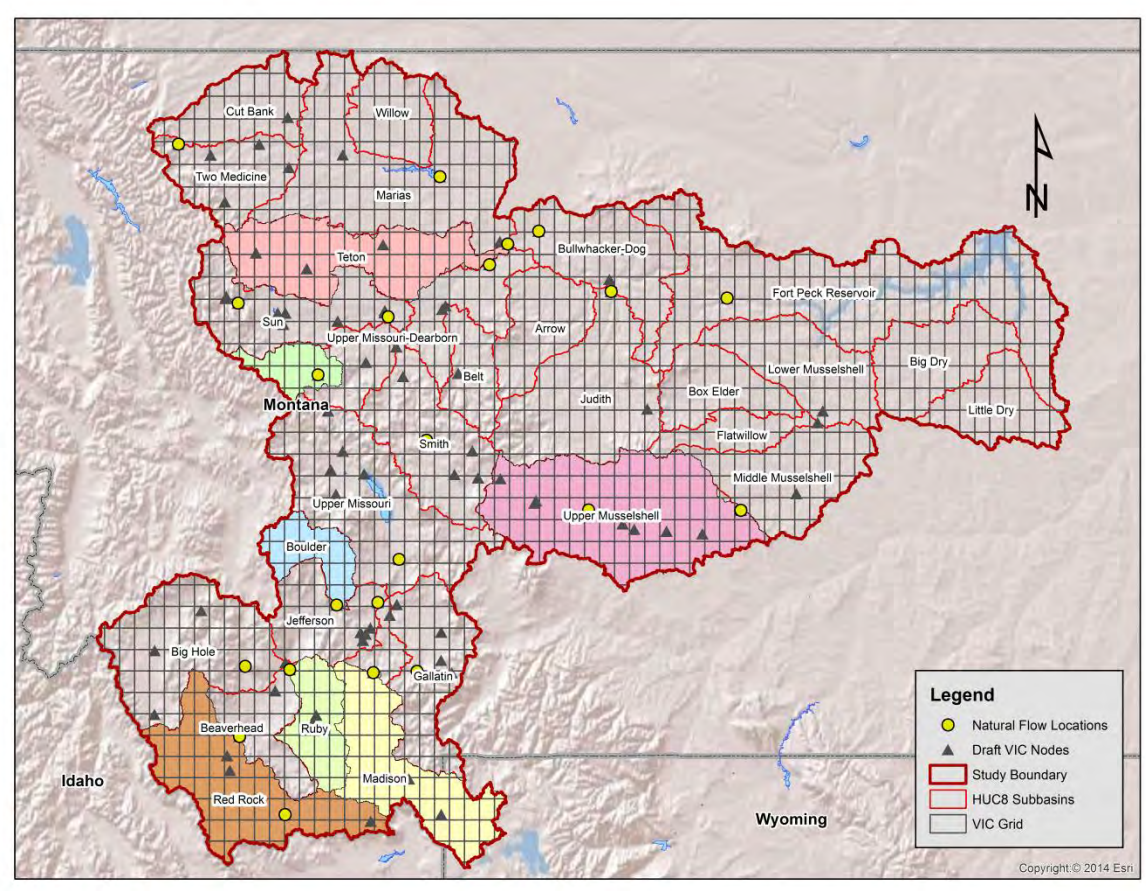
VIC Model Overview

- Simulates surface hydrology
- Model grid cells are 1/8 degree or about 8 miles per side
- Daily timestep
- Model grid cells have multiple
  - vegetation classes
  - elevation bands for simulating snow
  - infiltration/runoff parameters
- Separate streamflow routing routine



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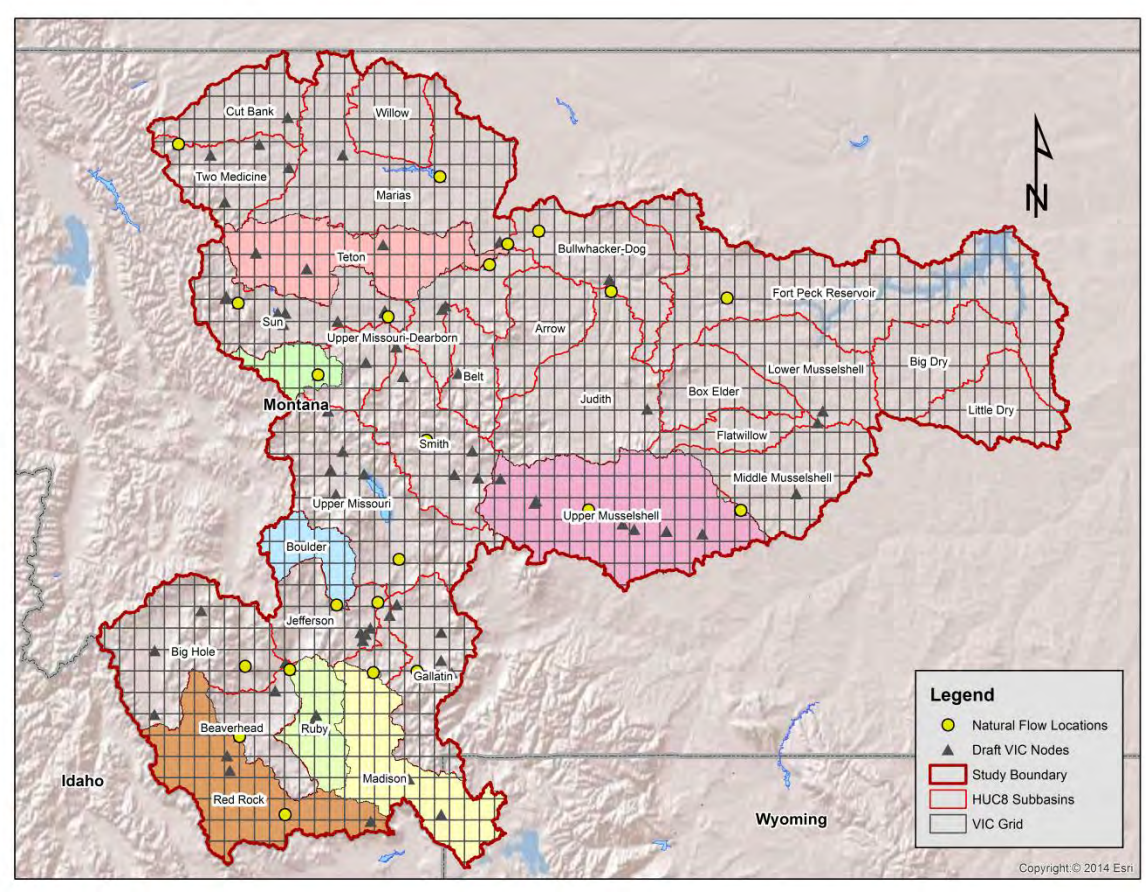
VIC Model Overview

- **Historical simulation period, water years 1951-1999**
- **Meteorological data (precipitation and temperature) used to drive the model is documented by Maurer et al. 2002**



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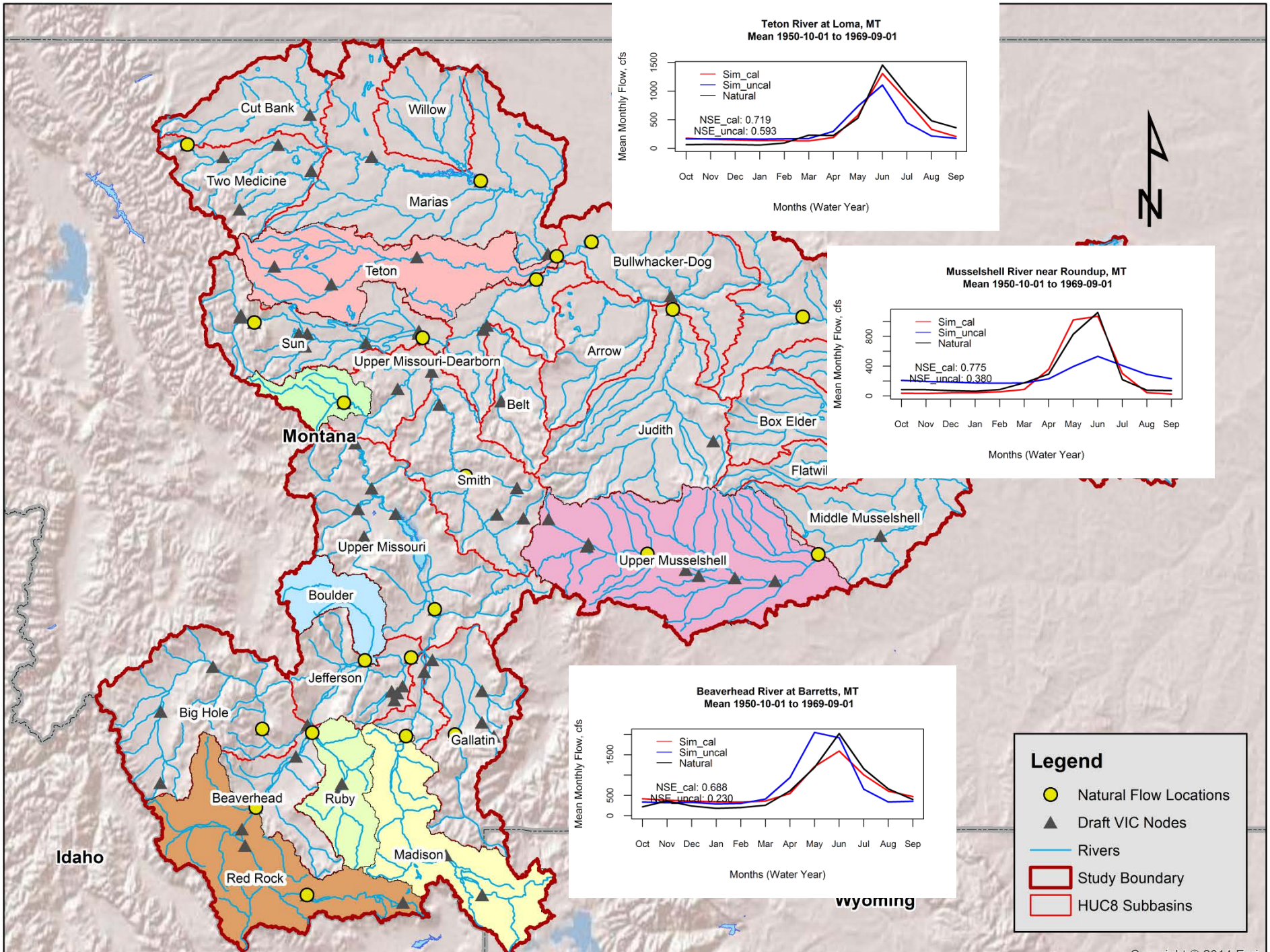
Teton River at Loma, MT
Mean 1950-10-01 to 1969-09-01
Mean Monthly Flow, cfs
0
500
1000
1500
Sim_cal
Sim_uncal
Natural
NSE_cal: 0.719
NSE_uncal: 0.593
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Months (Water Year)
Musselshell River near Roundup, MT
Mean 1950-10-01 to 1969-09-01
Mean Monthly Flow, cfs
0
400
800
Sim_cal
Sim_uncal
Natural
NSE_cal: 0.775
NSE_uncal: 0.380
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Months (Water Year)
Beaverhead River at Barretts, MT
Mean 1950-10-01 to 1969-09-01
Mean Monthly Flow, cfs
0
500
1500
Sim_cal
Sim_uncal
Natural
NSE_cal: 0.688
NSE_uncal: 0.230
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Months (Water Year)
Cut Bank
Willow
Two Medicine
Marias
Teton
Bullwhacker-Dog
Sun
Upper Missouri-Dearborn
Arrow
Belt
Montana
Judith
Box Elder
Smith
Middle Musselshell
Upper Missouri
Upper Musselshell
Boulder
Jefferson
Big Hole
Gallatin
Beaverhead
Ruby
Madison
Idaho
Red Rock
Wyoming
Legend
Natural Flow Locations
Draft VIC Nodes
Rivers
Study Boundary
HUC8 Subbasins

Groundwater Representation

- **Three areas were identified for including groundwater demands and impacts within the study area**
  - **Helena Valley, Gallatin Valley, Beaverhead River Basin (Clark Canyon to Beaverhead Rock)**
- **Groundwater use is represented in terms of how it has historically impacted streamflow**
  - **Lagged diversions from their surface sources (Helena Valley and Gallatin)**
  - **Supplemental source and associated depletions/returns to the river (Beaverhead)**
  - **Return flow routing partitioned between GW and SW in RiverWare model**

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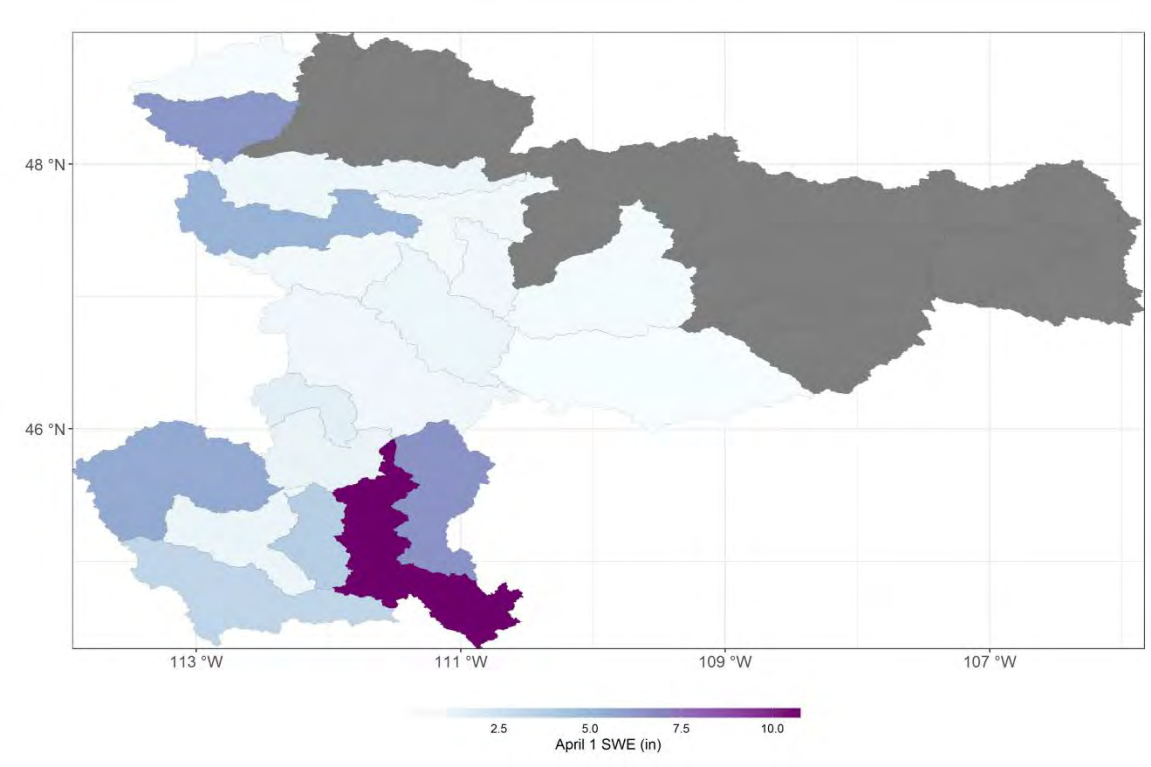
Sample VIC Model Results
Mean April 1 Snow Water Equivalent

- SWE is natural water storage
- SWE shown for HUCs with more than 1/8 inch
- Historical simulated range from 0.4 inches to 11 inches (HUC subbasin averages)



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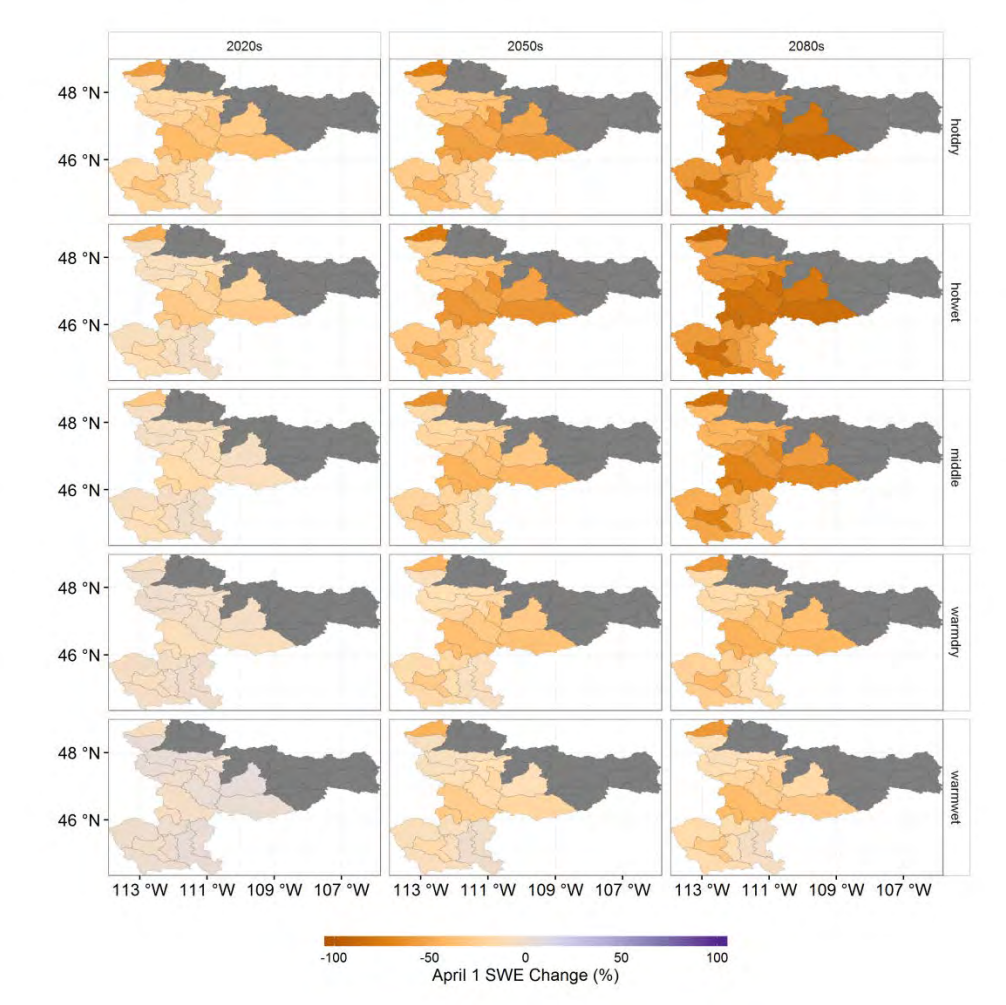
Sample VIC Model Results
Projected Change April 1 SWE (2050s)

- **Range of projections indicate decreasing April 1 SWE**
  - **-8% to -32% across the study area**



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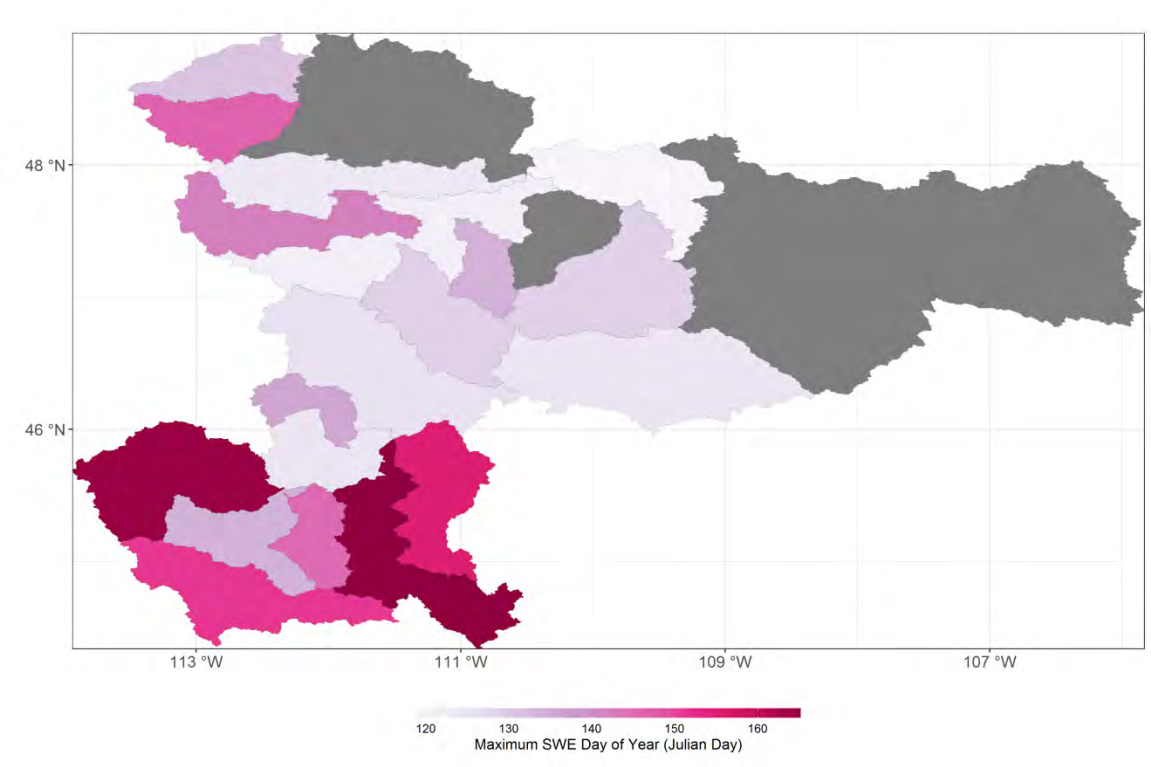
Sample VIC Model Results
Mean Day of Maximum SWE

- Day of Maximum SWE shown for HUCs with more than 1/8 inch
- Results based on water year (October 1=day 1)
- Historical simulated range from 120 (January 28) to 165 (March 14)



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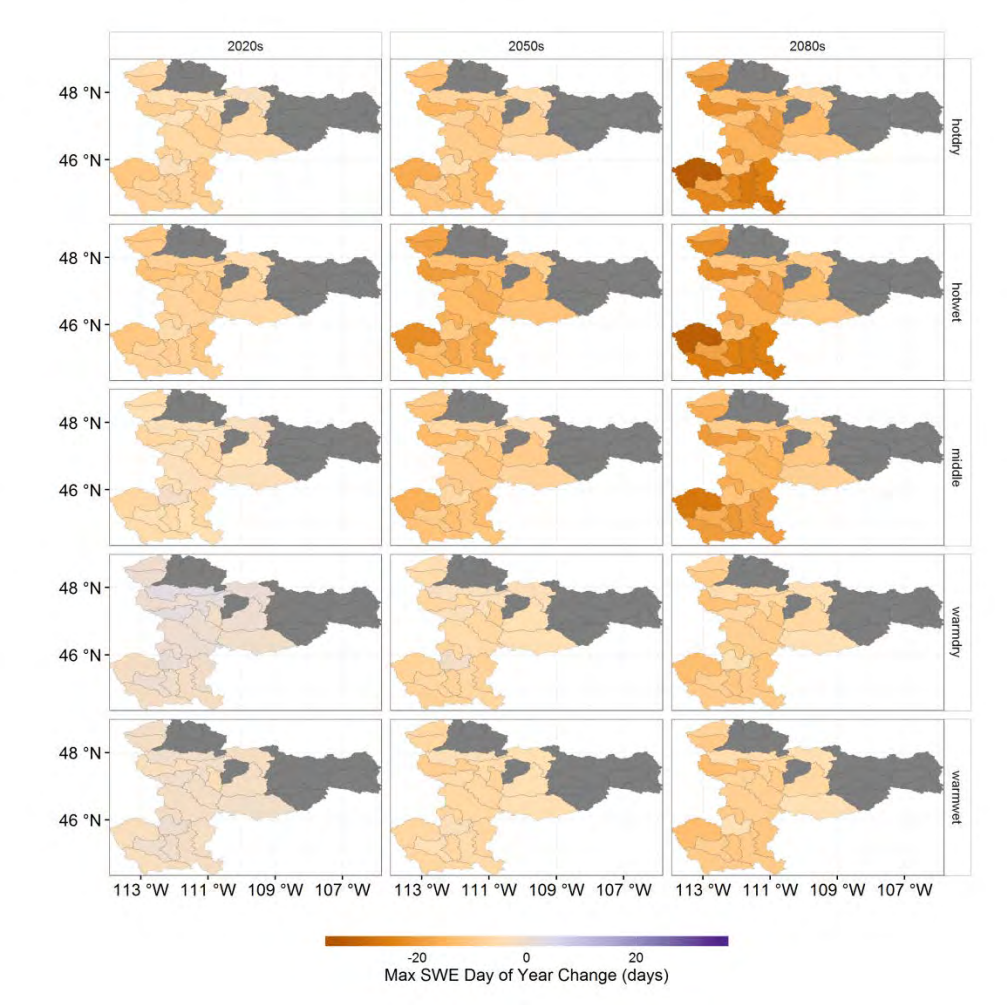
Sample VIC Model Results Projected Change Day of Maximum SWE (2050s)

- **Range of projections indicate shift toward earlier day of maximum snowpack**
  - **-2 to -23 days, depending on scenario and location**



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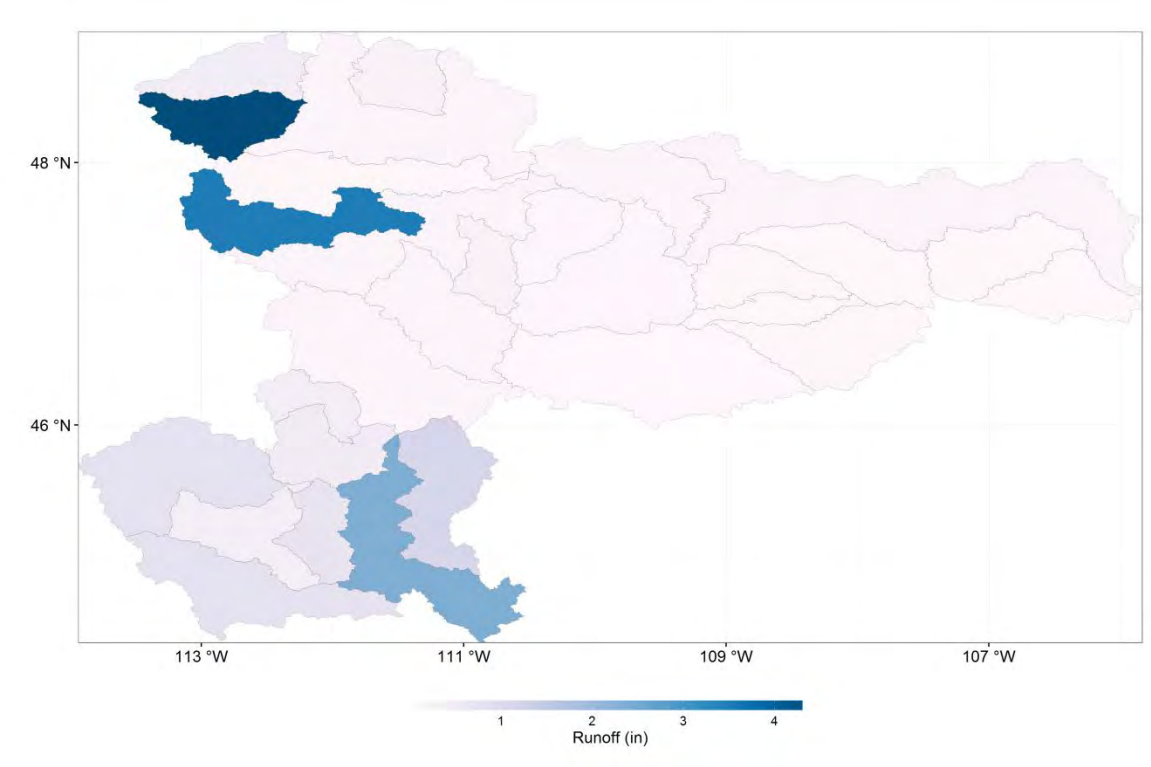
Sample VIC Model Results
Mean Annual Runoff

- **Historical simulated range from <1 inches to 4.5 inches (HUC subbasin averages)**



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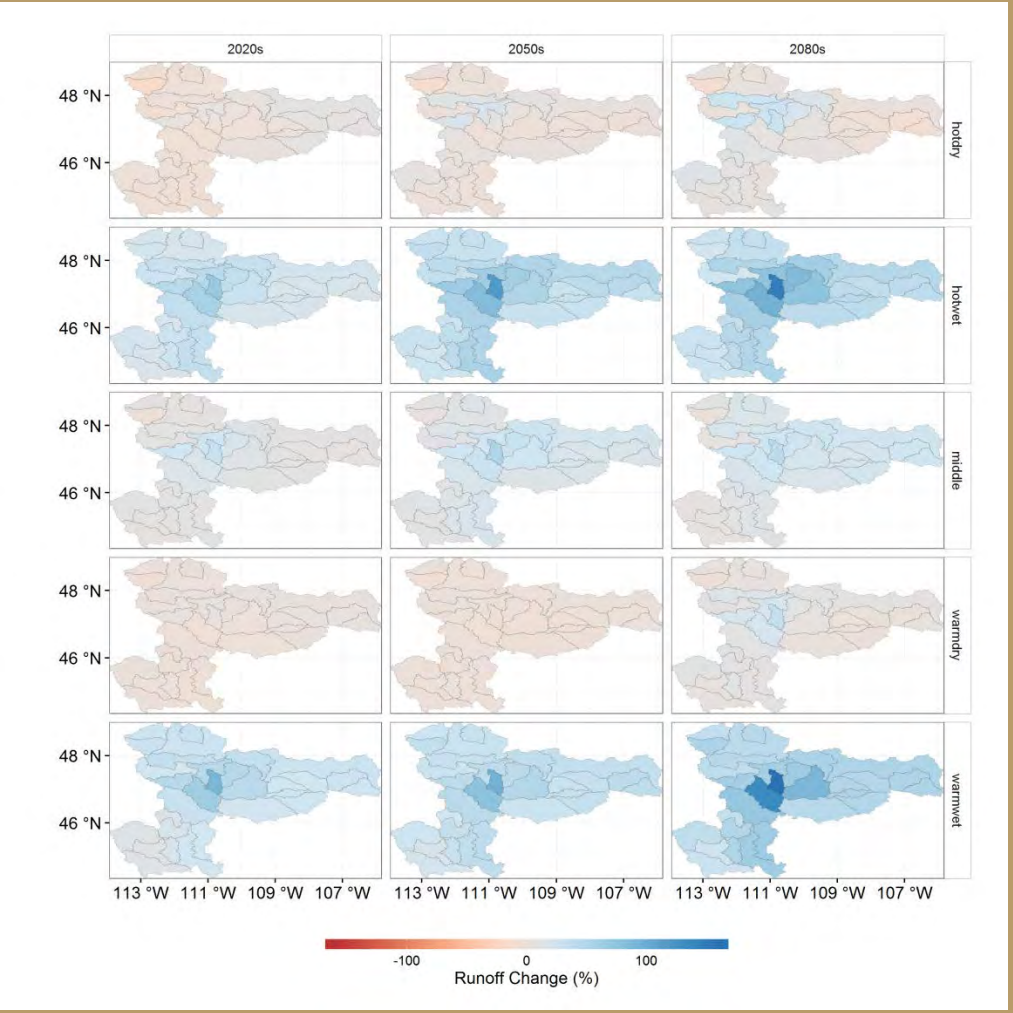
Sample VIC Model Results
Projected Change Annual Runoff (2050s)

- **Projections indicate a wide range of change in mean annual runoff**
  - **15% decrease to 115% increase for the 2050s, depending on scenario and location**



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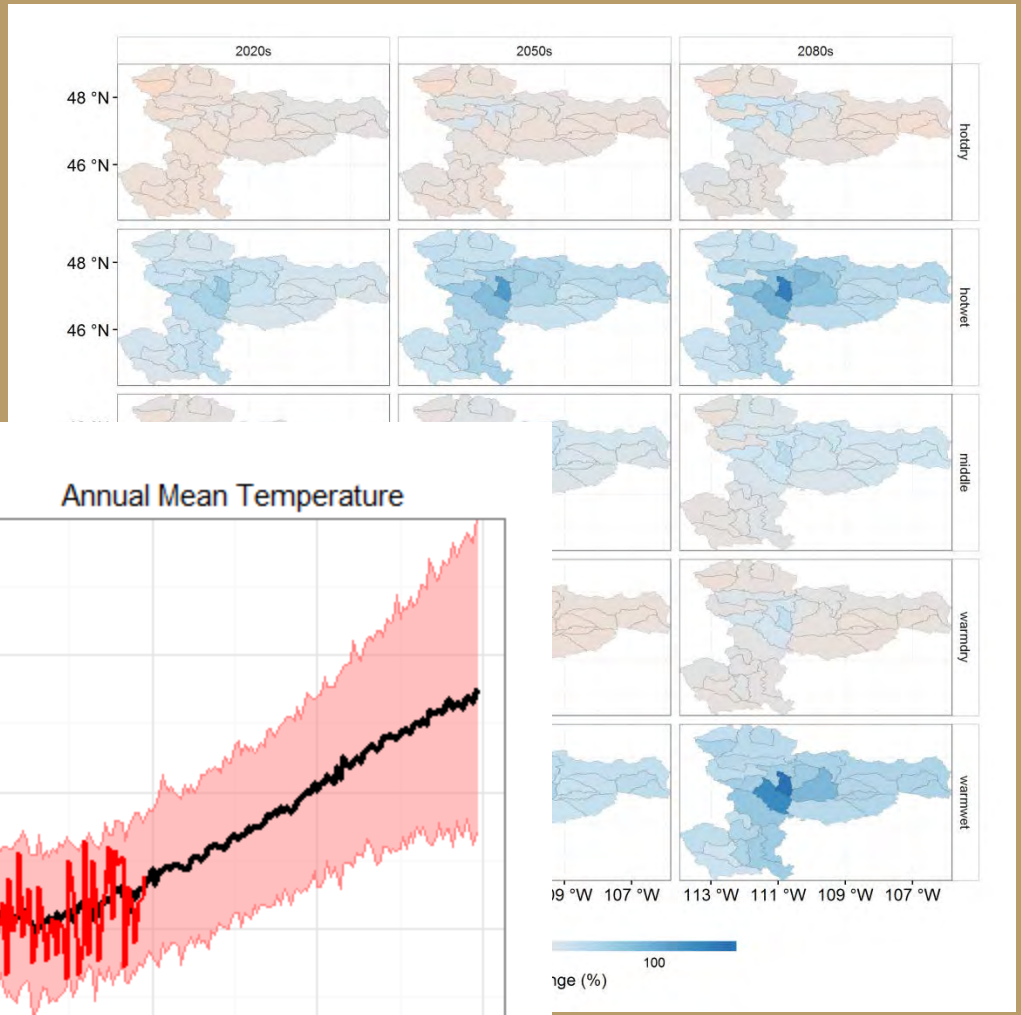

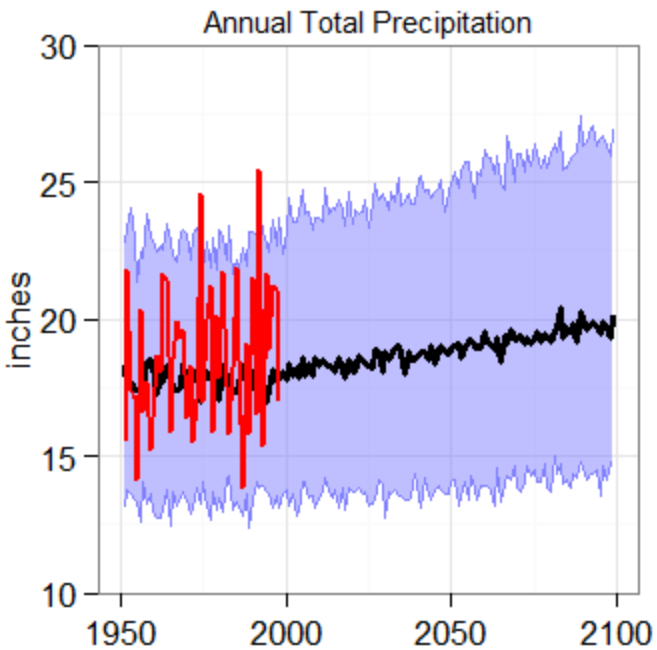

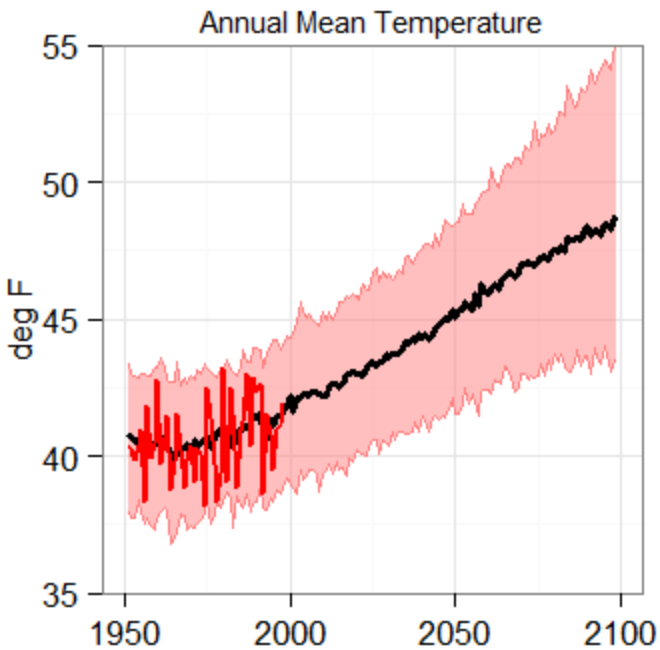

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Questions?

Swift Current Creek

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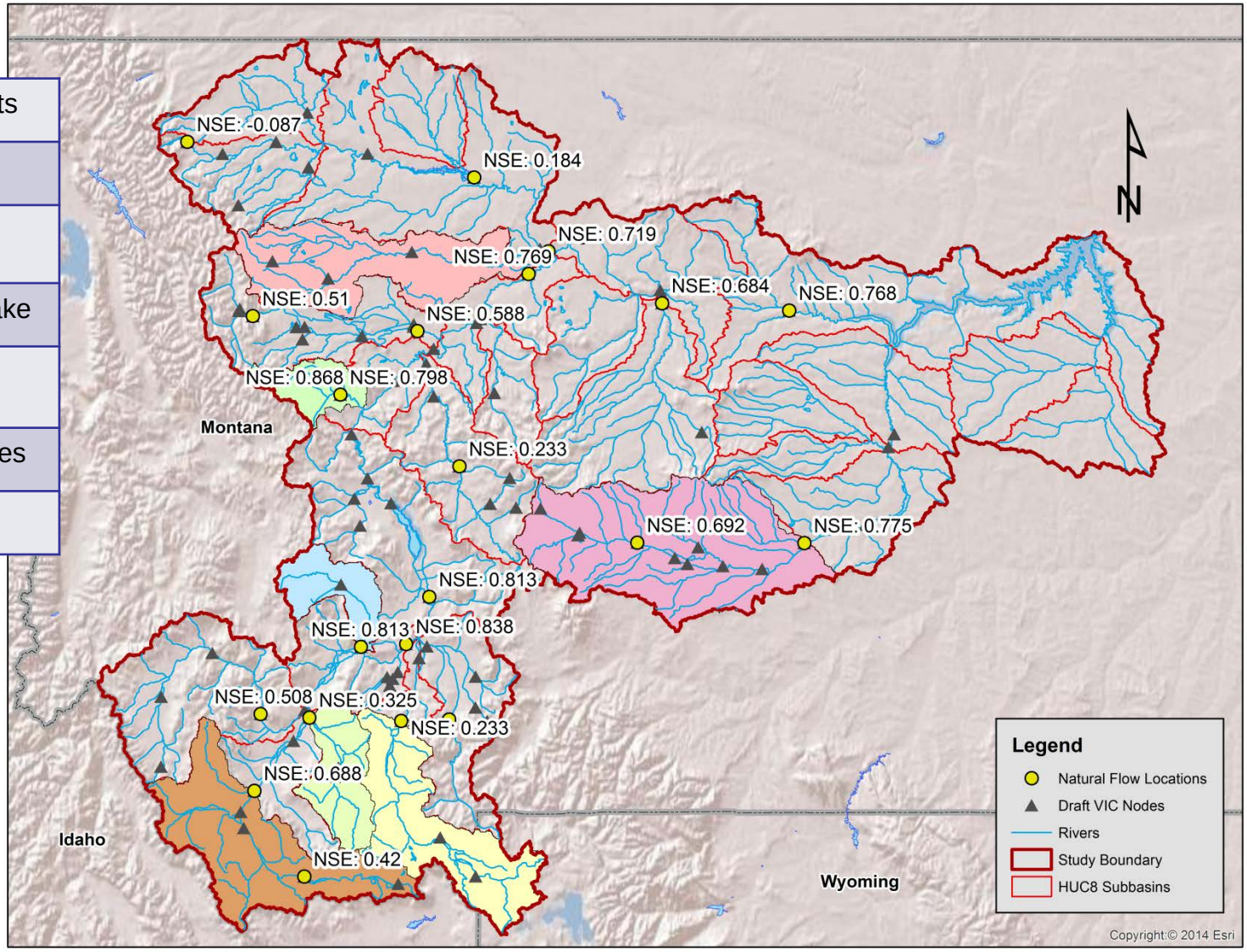
Resulting Calibration Statistics (Nash Sutcliffe Efficiency)

Beaverhead River at Barretts
Boulder River near Mouth
Dearborn River near Mouth
Madison River blw Ennis Lake
Musselshell River near Roundup
Ruby River near Twin Bridges
Teton River at Loma