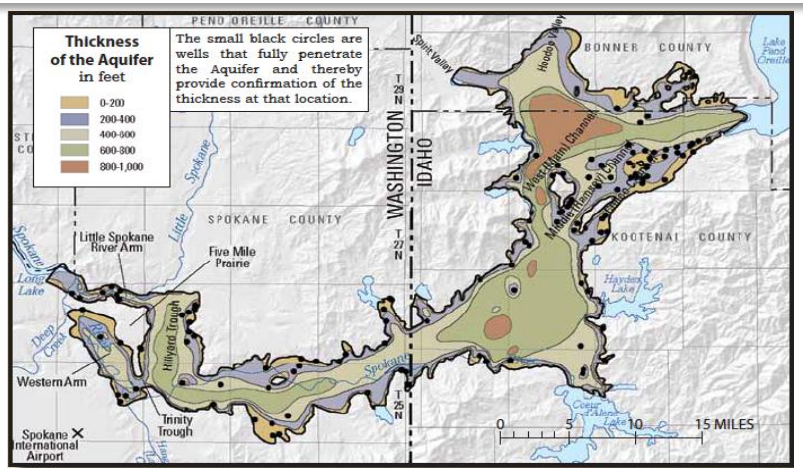
WISDM

Watershed Integrated System Dynamics Modeling

Allyson Beall King and Melanie Thornton



Spokane River Watershed and Spokane Valley Rathdrum Prairie Aquifer

WASHINGTON STATE UNIVERSITY

CERE

USDA

NSF

State of Washington Water Research Center

BioEarth

Biosphere-relevant earth system model

Purpose of Collaborative Modeling and Stakeholder Engagement

- Value added research that benefits the public
- Provides opportunity for discussion and collaboration
  - Express individual interests
  - Develop a mutually acceptable solution to complex problems
  - Work together

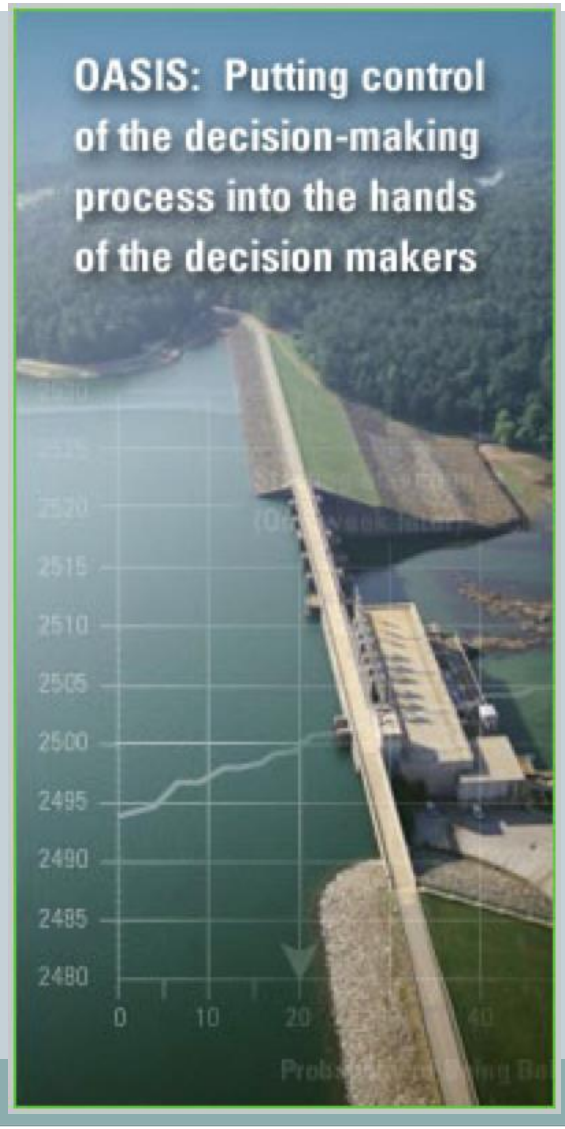
Collaborative Modeling: OASIS

- Working with HydroLogics Inc
- Water Management Issues
  - Analysis
  - Planning
  - Conflict resolution
- OASIS
  - Computer modeling program

http://www.hydrologics.net/oasis.html

Why **OASIS** Hydrologic Model?

- Used for water resources planning on 20% of nation's water supply
- It is capable of modeling virtually any water system in the world
  - From small and simple to large and complex.



OASIS Hydrologic Modeling

- Utilizes historic data and MODFLOW
- Water balance model
- River flow and aquifer levels
- "What-if" scenarios

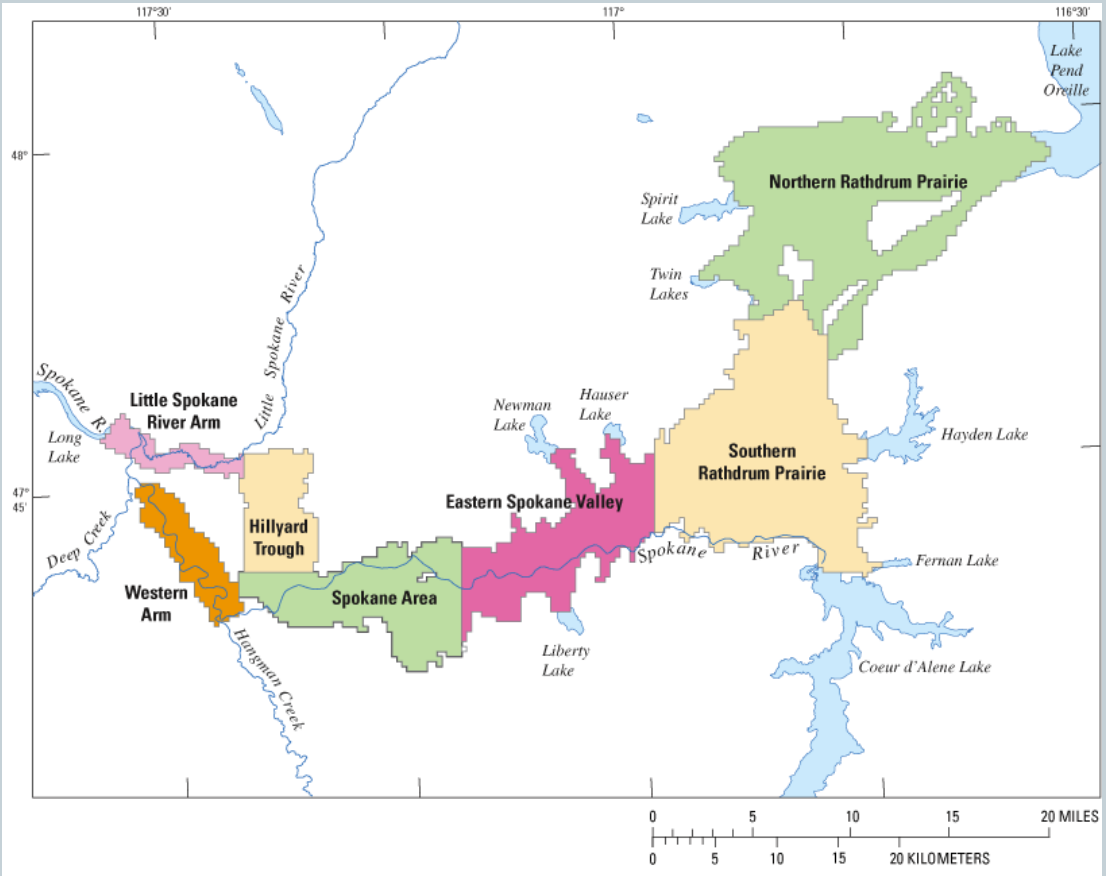
What if the climate changed?

What if pumping doubled in Washington? Idaho?

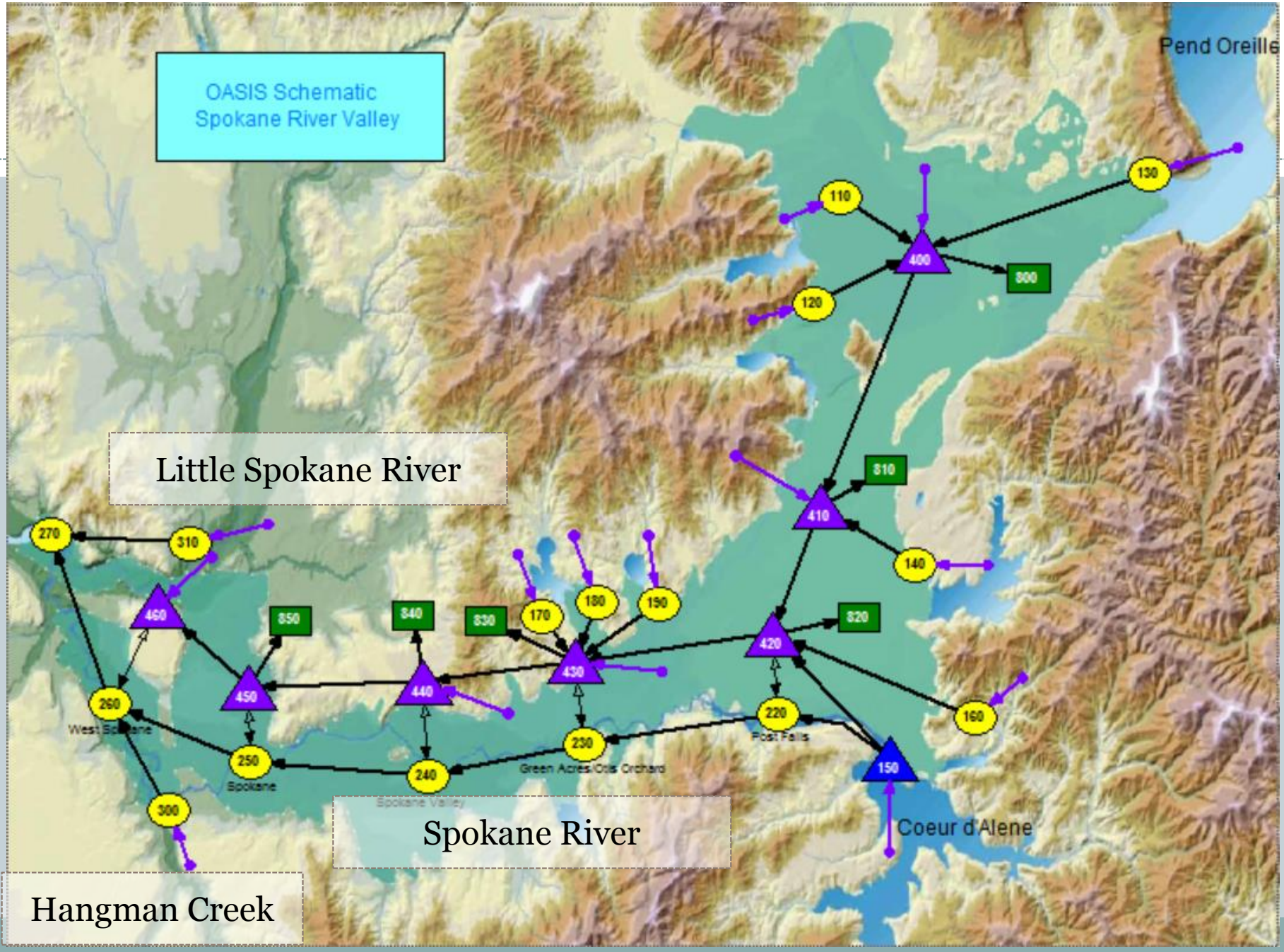
What will have the most beneficial use of unused water allocations?

Technical Collaboration

- Collaborating with
  - Guy Gregory
  - John Covert
  - Dale Ralston
  - Mike Hermanson
  - Pat Maher
  - Bob Hirsch
  - Mike Barber
  - Gary Johnson



Sub-regions of the SVRP aquifer for water-budget calculations (Figure from: USGS)


OASIS Schematic
Spokane River Valley
Pend Oreille
Little Spokane River
Spokane River
Hangman Creek
Coeur d'Alene
Post Falls
Green Acres/Otis Orchard
Spokane
Spokane Valley
West Spokane
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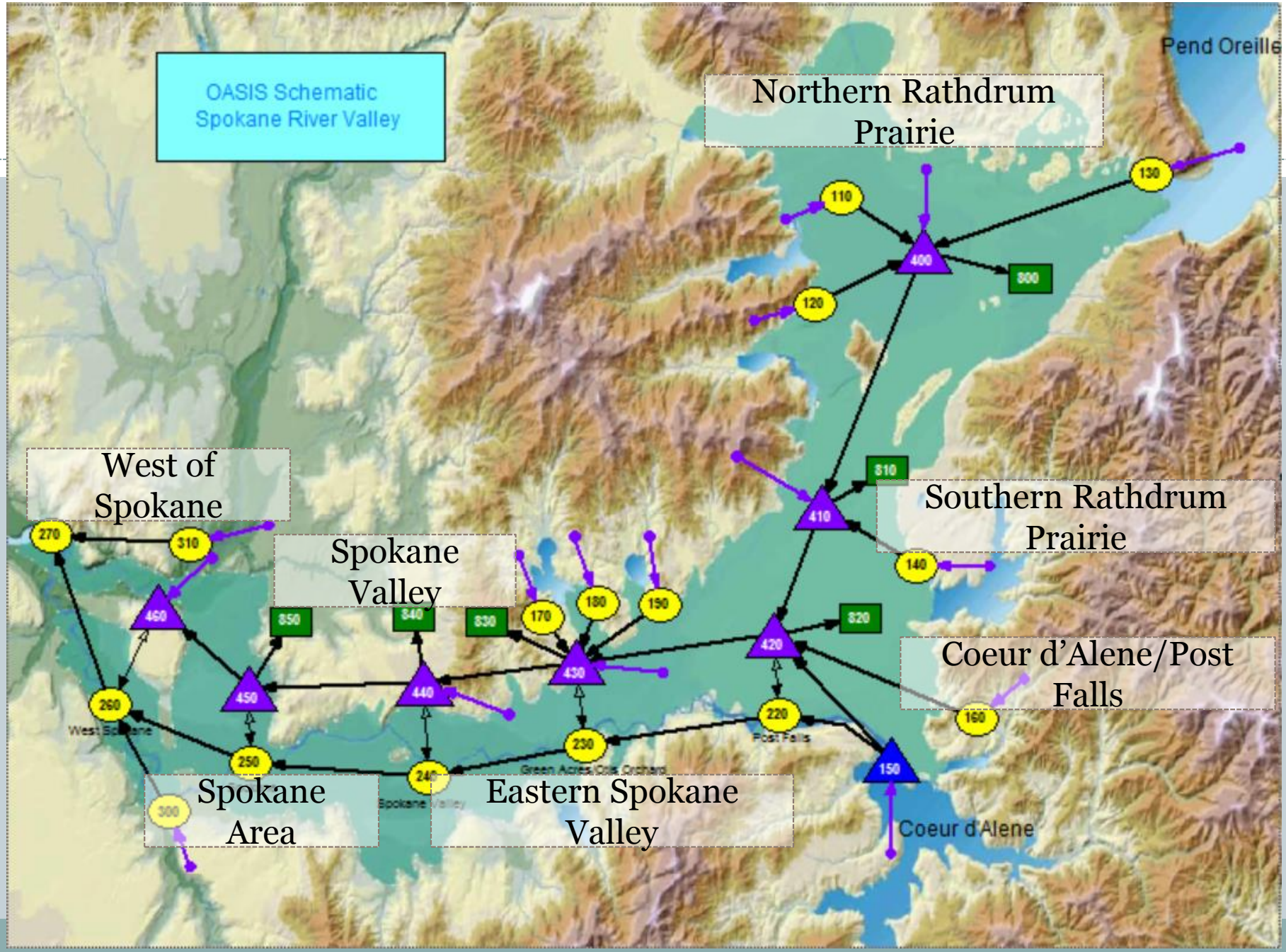
OASIS Schematic
Spokane River Valley
Northern Rathdrum Prairie
Pend Oreille
West of Spokane
Spokane Valley
Southern Rathdrum Prairie
Coeur d'Alene/Post Falls
Spokane Area
Eastern Spokane Valley
Coeur d'Alene
West Spokane
Post Falls
Green Acres/Otis Orchards
Spokane Valley
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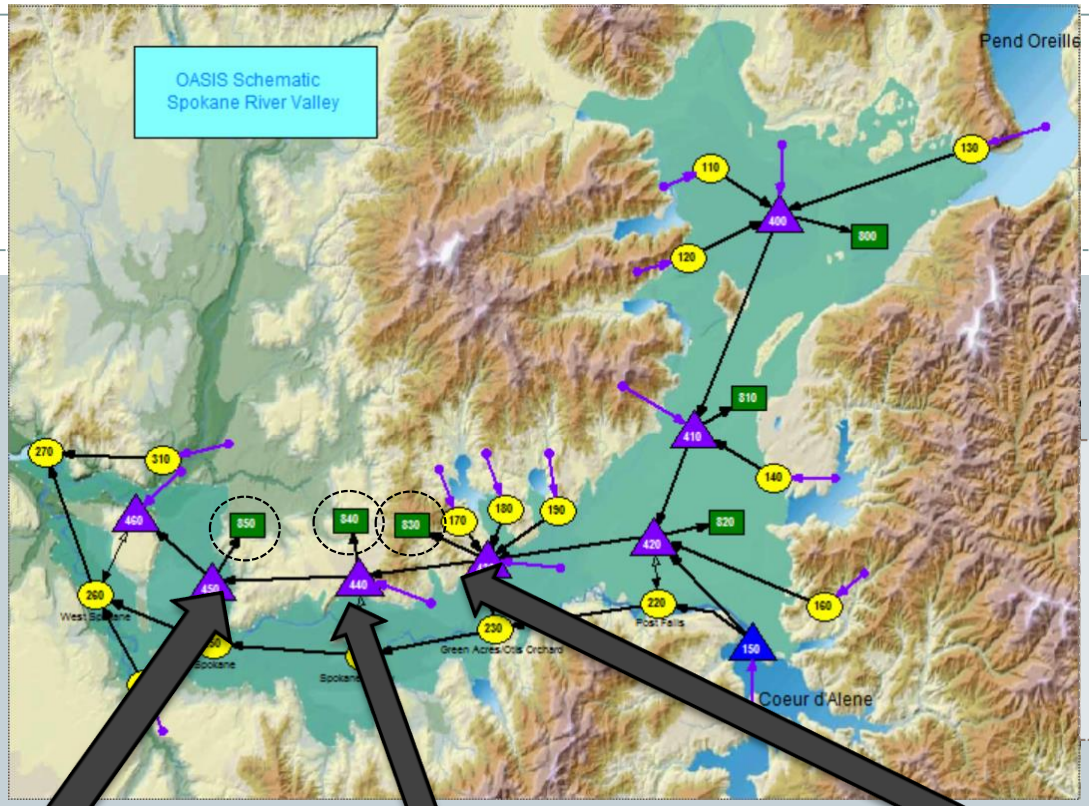
WA Public Supply



Spokane Area

- City of Spokane
- Spokane Business
- North Spokane ID
- Whitworth
- Fairchild AFB
- Rivervale Water Assc.

Spokane Valley

- Spokane County WD
- Millwood WD
- E Spokane WD
- Irvin WD
- Model ID
- Modern Electric
- Carnhope ID
- Pasadena Park ID
- Hutchinson ID

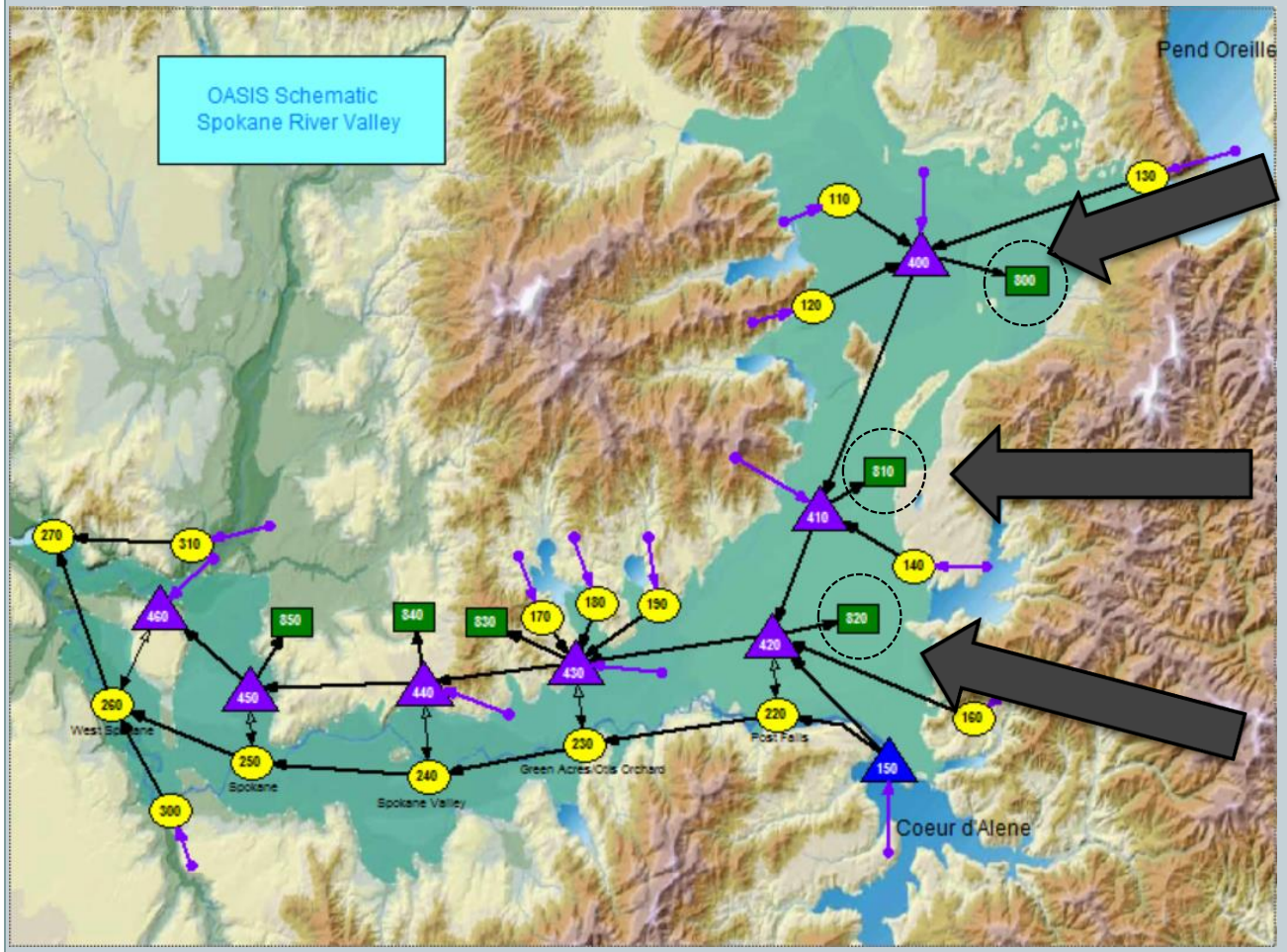
Spokane Valley (con'td)

- Pinecroft MHP
- Hutton Settlement
- Orchard Ave ID

Eastern Spokane Valley

- Vera Water
- Liberty Lake W&S
- Moab WD
- Consolidated ID
- Trentwood ID
- Green Ridge Estates
- Pioneer Water Co.
- Timberline MHP

Idaho Public Supply
Water Purveyors in each sub-region



Northern Rathdrum Prairie

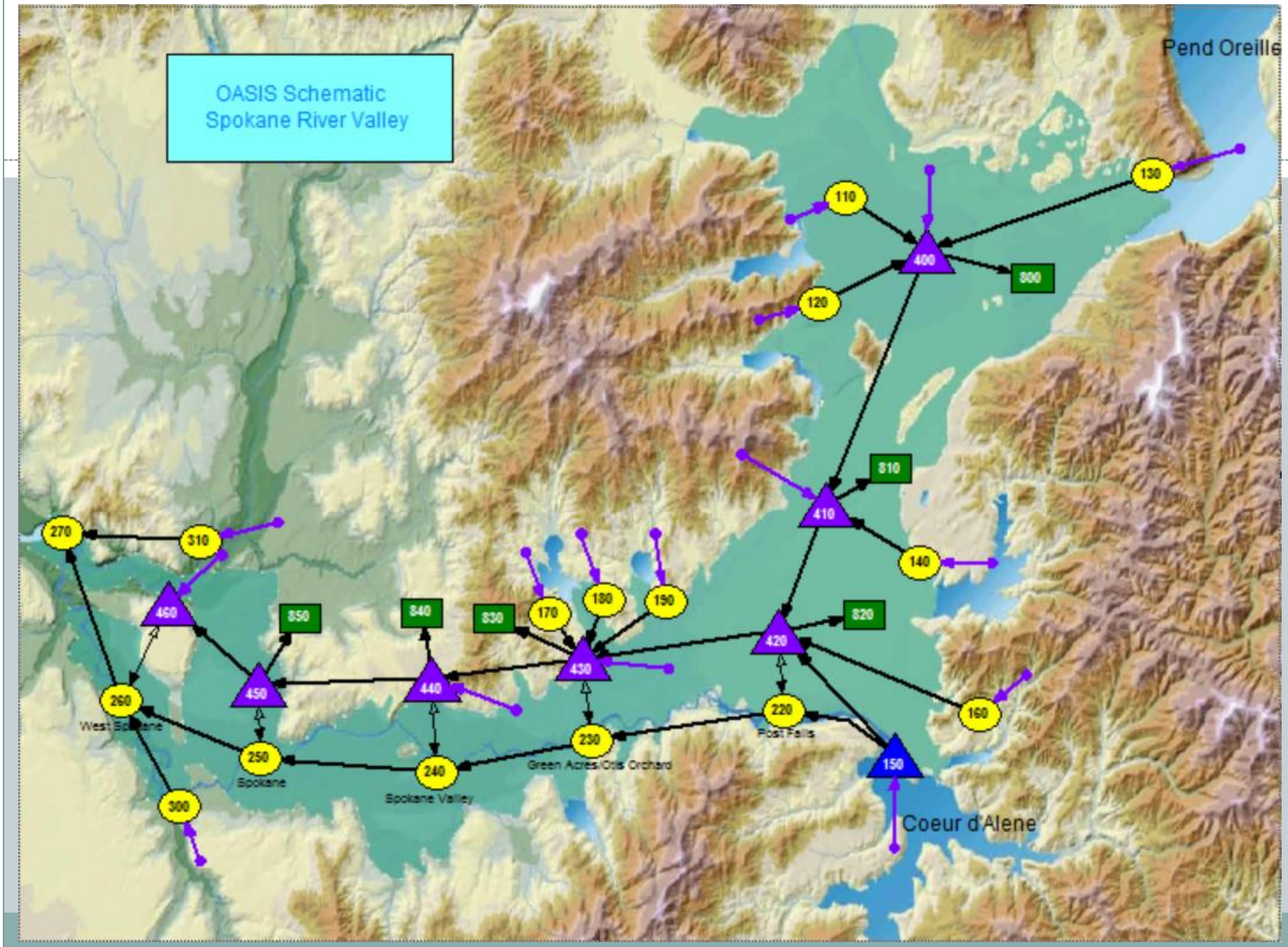
- Athol
- North Kootenai ID

Southern Rathdrum Prairie

- Rathdrum
- Avondale
- Hayden Lake ID

Coeur d'Alene/Post Falls

- Coeur d'Alene
- Post Falls
- East Greenacres Water District


OASIS Schematic
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Pend Oreille
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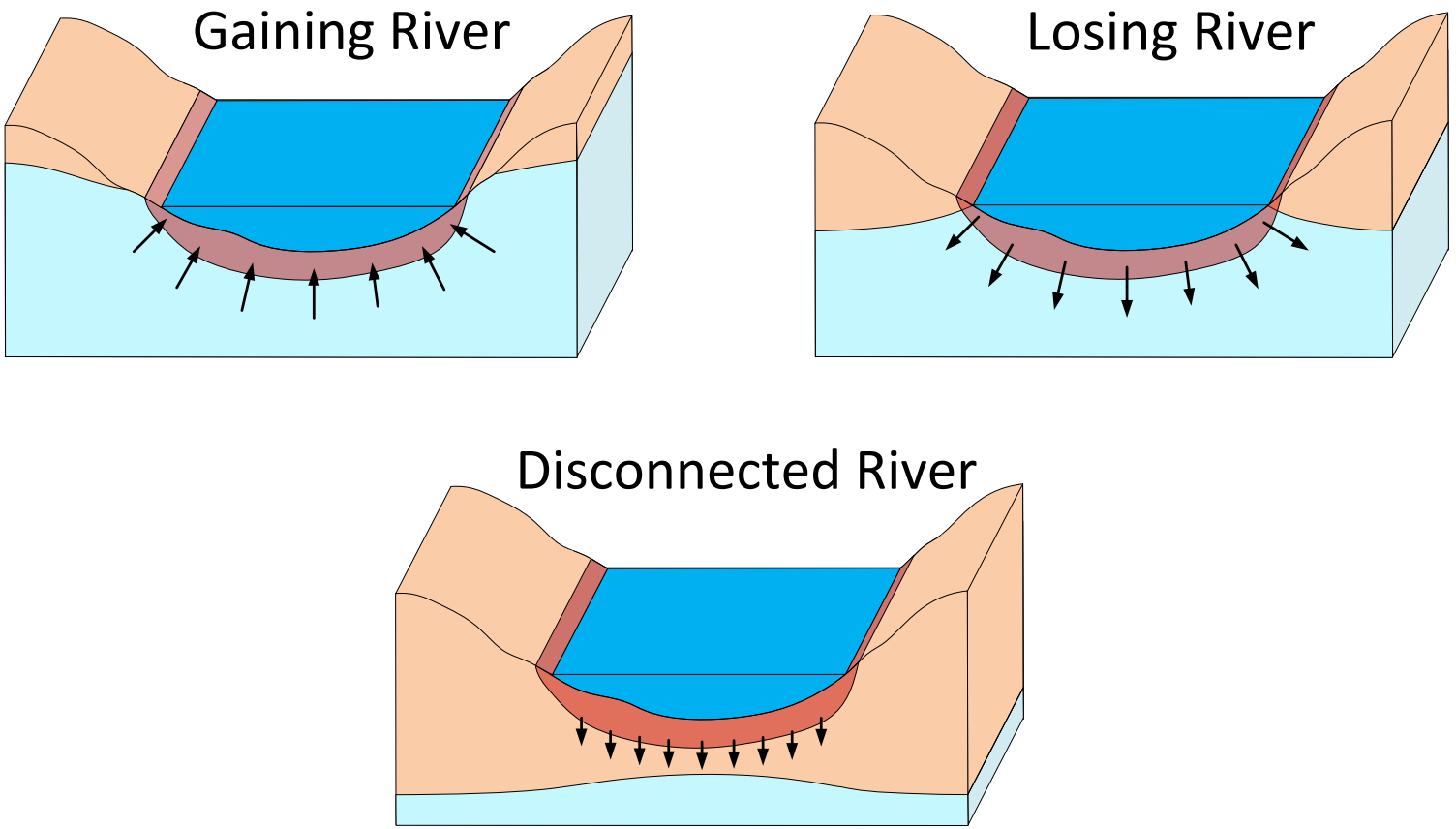
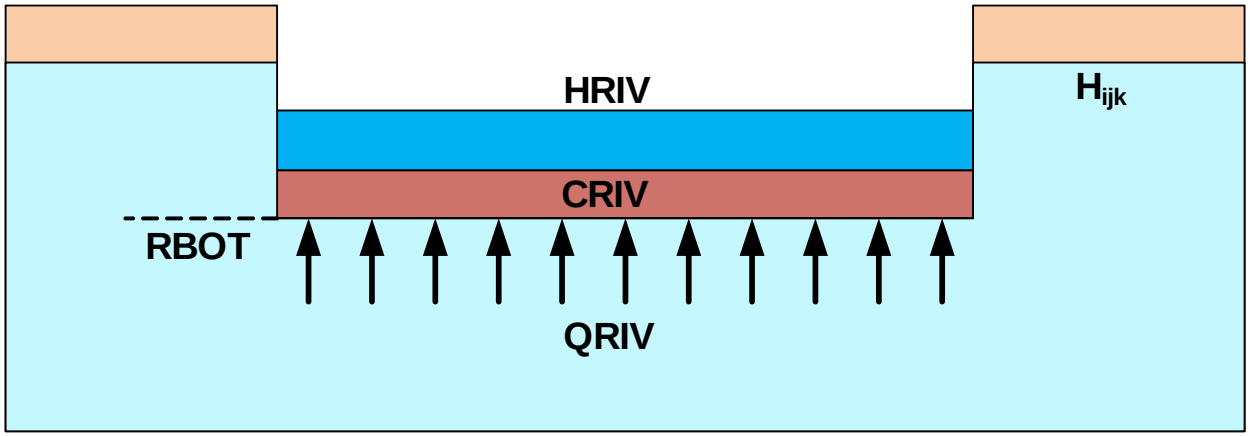
Modeling the Spokane Valley Rathdrum Prairie Aquifer and the Spokane River

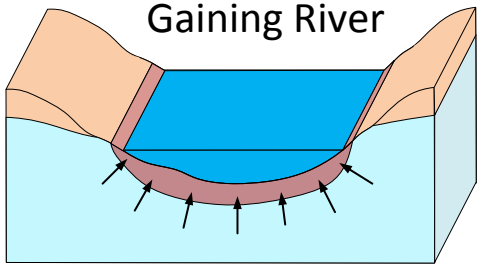
THE TECHNICAL PART: GOVERNING EQUATIONS

River-Aquifer Dynamics



Case #1 - Aquifer Head Above River Stage

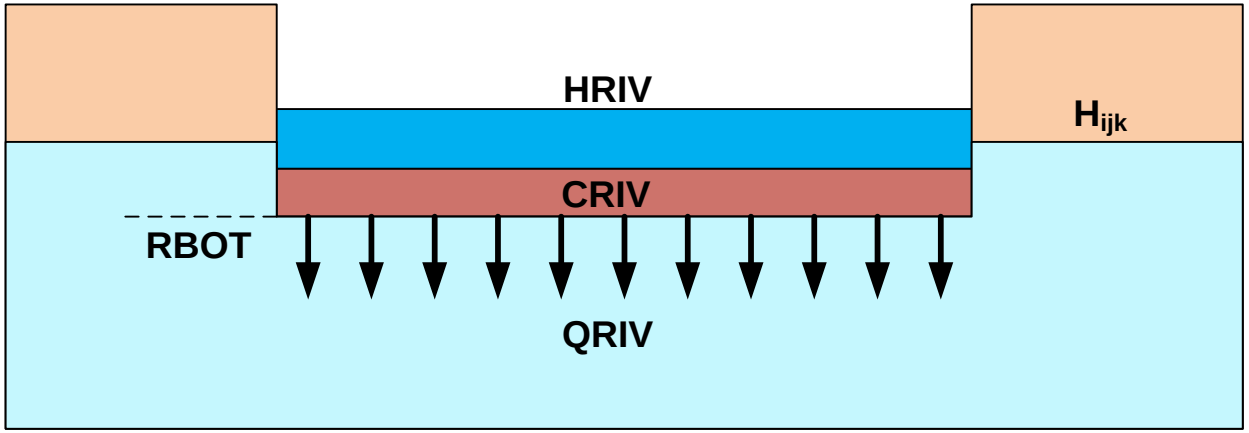


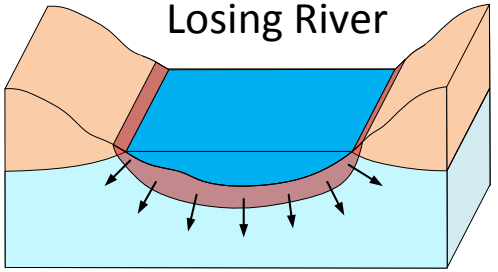


$$QRIV = CRIV * (HRIV - H_{ijk})$$

H_{ijk} = Head in groundwater node
HRIV = Stage in river
CRIV = Conductance of river bottom sediments
RBOT = Elevation of bottom of sediments
QRIV = Flow between aquifer and river

Case #2 - Groundwater Head Below River Stage but Above River Bottom

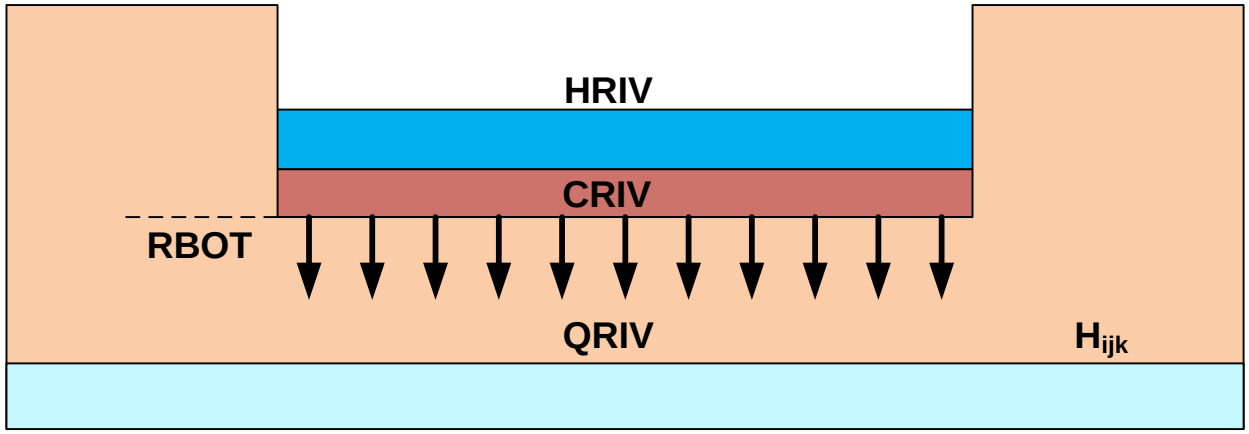


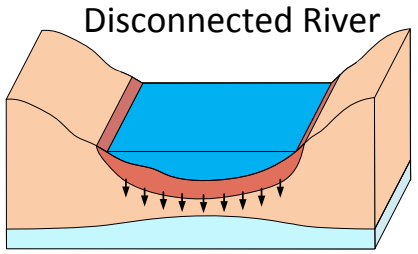


$$QRIV = CRIV * (HRIV - H_{ijk})$$

H_{ijk} = Head in groundwater node
HRIV = Stage in river
CRIV = Conductance of river bottom sediments
RBOT = Elevation of bottom of sediments
QRIV = Flow between aquifer and river

Case #3 - Head Below River Bottom





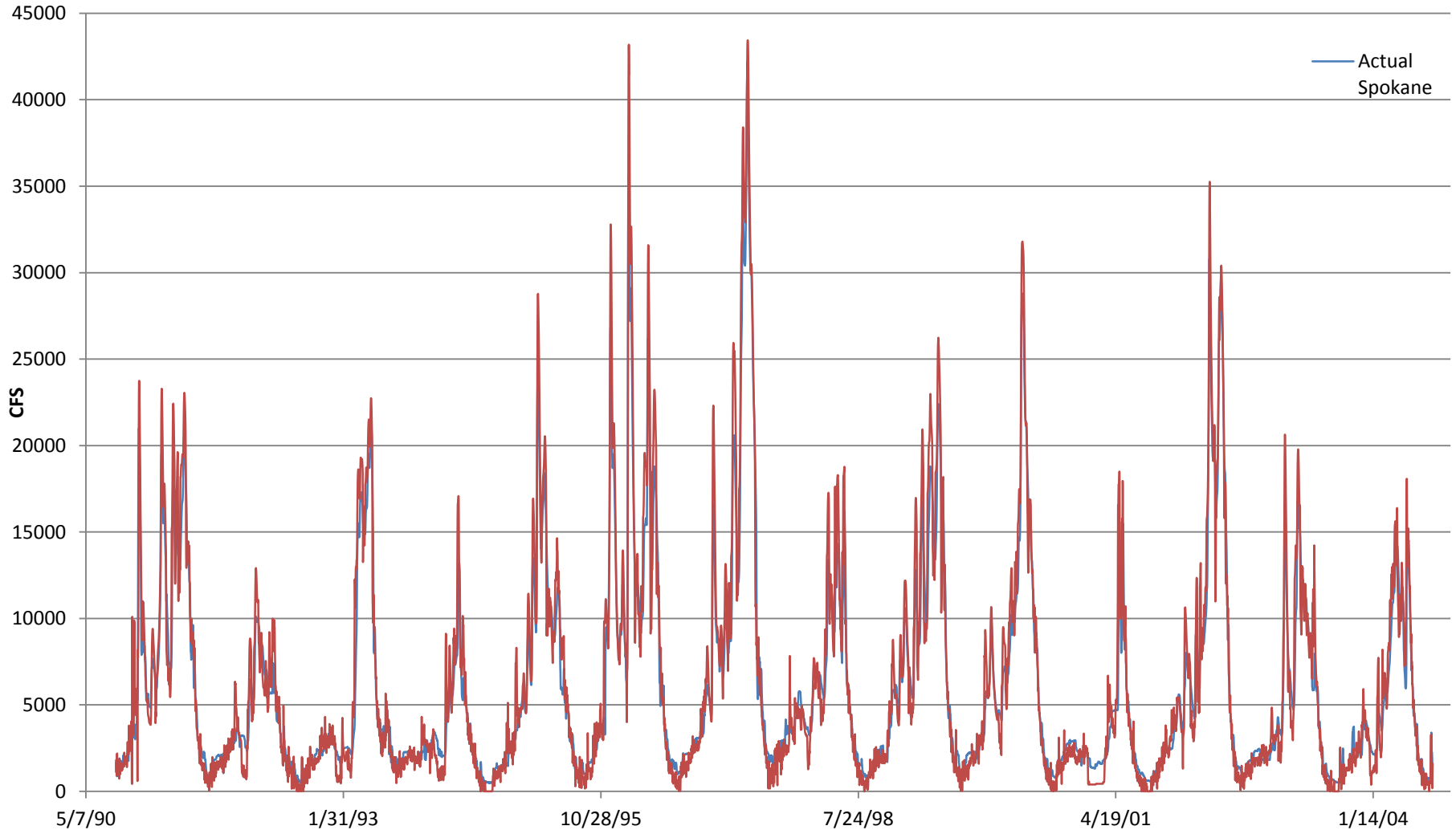
QRIV = CRIV * (HRIV - RBOT)

H_{ijk} = Head in groundwater node
HRIV = Stage in river
CRIV = Conductance of river bottom sediments
RBOT = Elevation of bottom of sediments
QRIV = Flow between aquifer and river

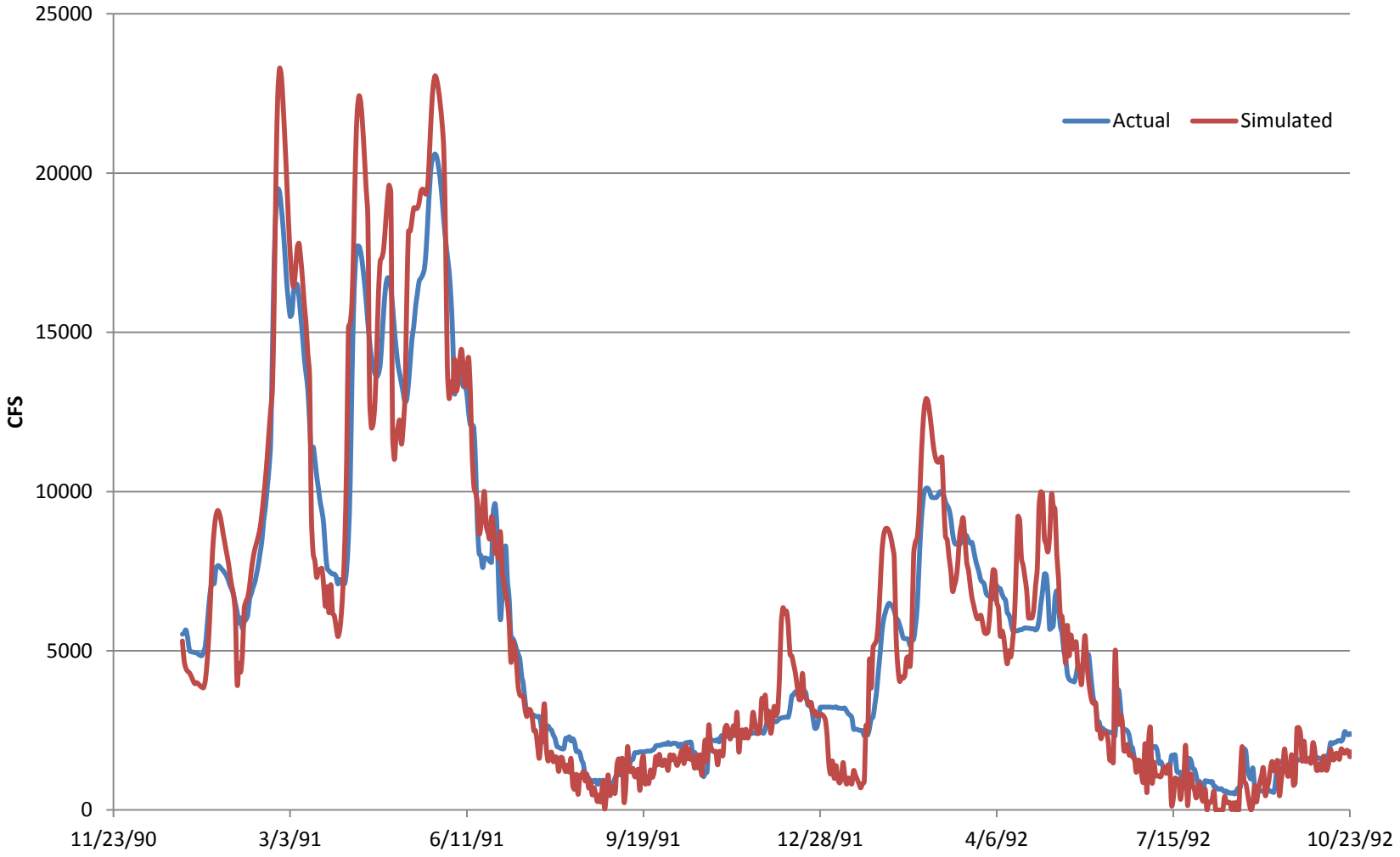
OASIS modeled outputs compared to actual data

SOME EXAMPLES

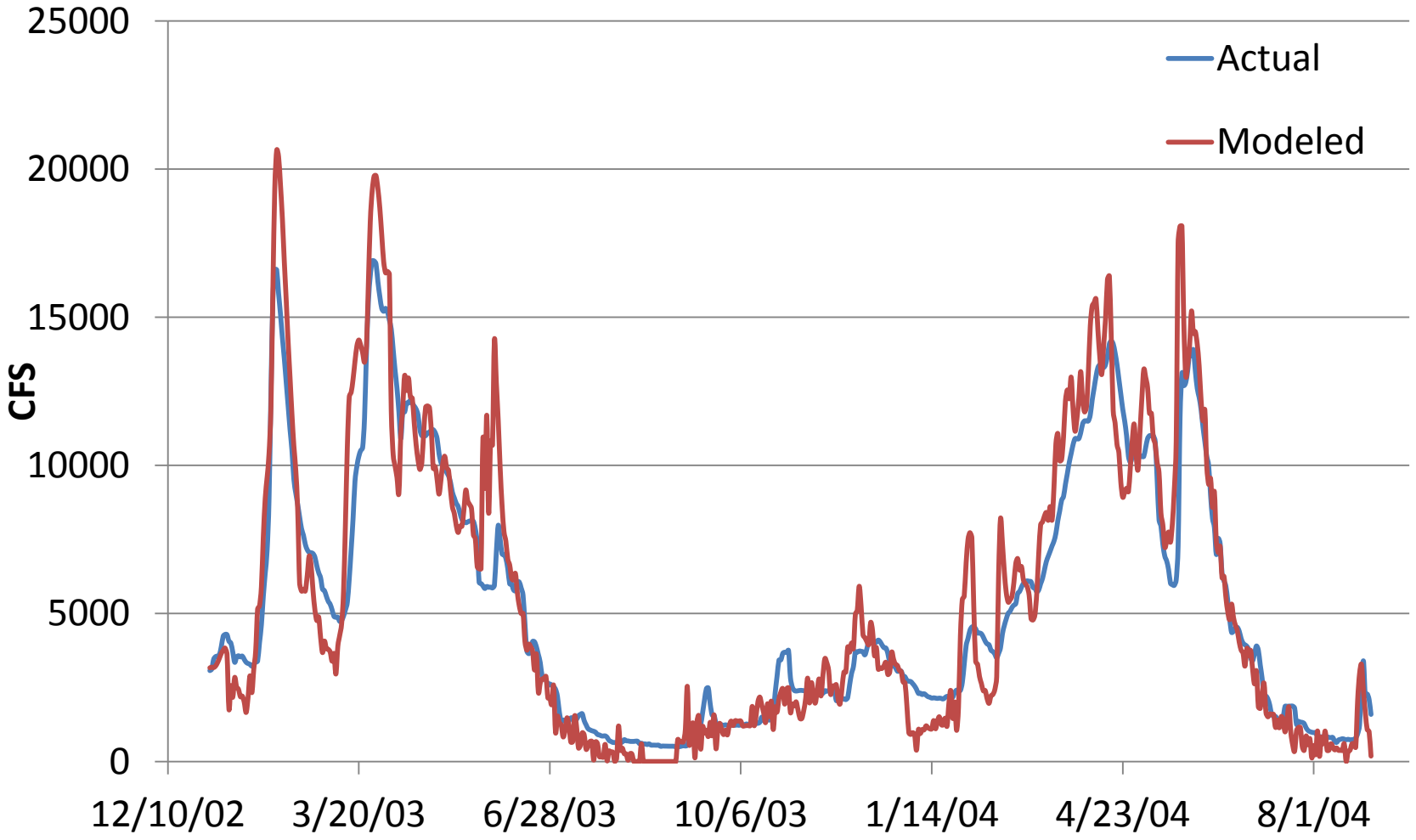
Streamflow at Spokane Gage 1990-2004
Modeled (red) vs Actual (blue)



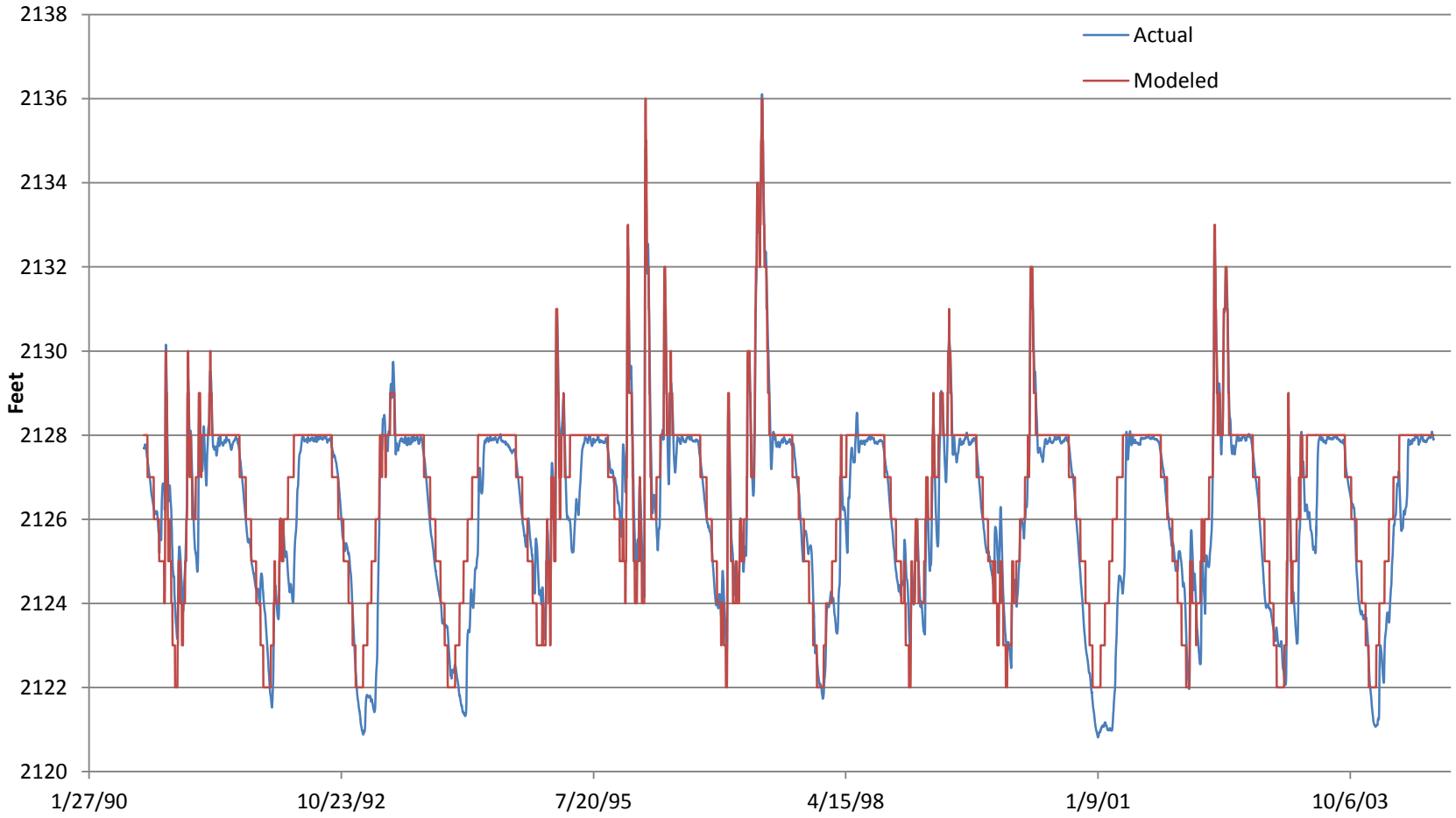
Streamflow at Spokane Gage: Modeled (red) vs Actual (blue) Snapshot: 1991-1992



Streamflow at Spokane Gage: Modeled (red) vs Actual (blue) Snapshot: 2003-2004



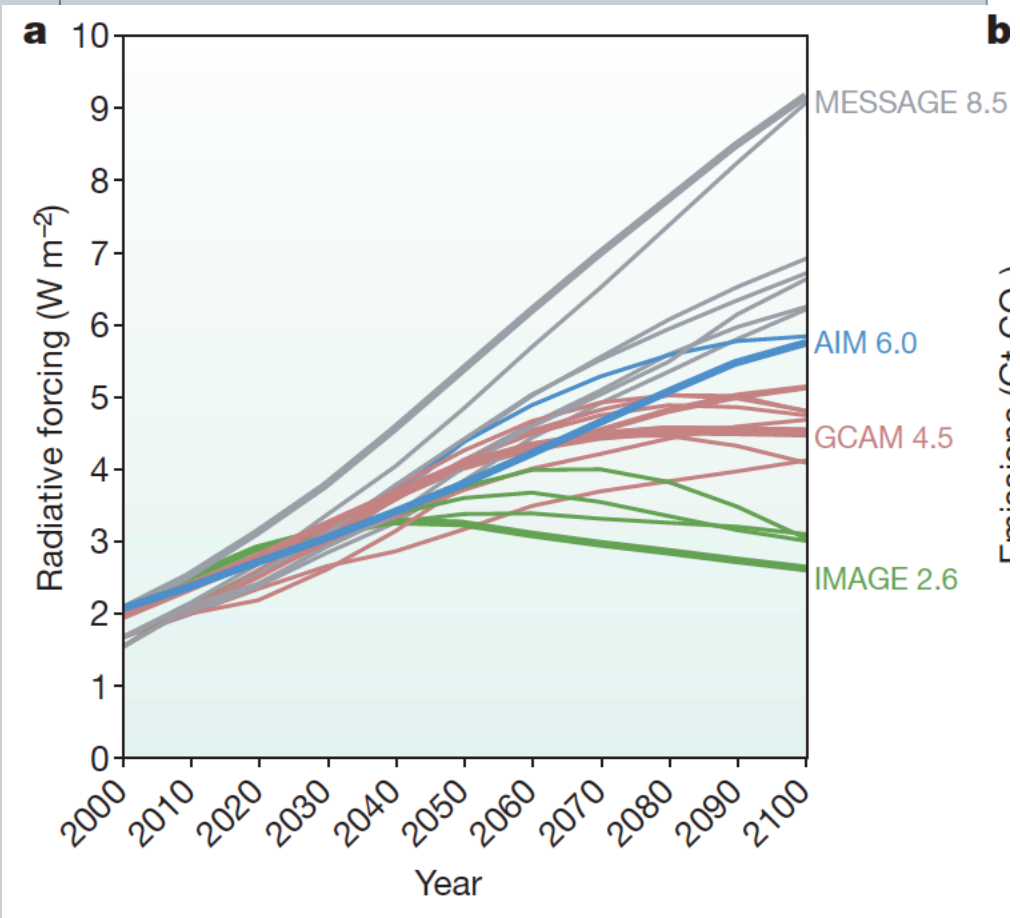
Coeur d'Alene Lake Elevation (ft) Modeled (red) vs Actual (blue)



Scenario Development

Climate Scenarios and Impact on Hydrology (from WSU MODFLOW/PRMS Model)

- No Climate Policy Future (BAU)
  - RCP8.5
  - > 8.5 W/m² in 2100
- Adapt to Risk Scenario
  - RCP6
  - ~ 6 W/m² in 2100
- Moderate Mitigation & Climate Policy
  - RCP4.5
  - 4.5 W/m² in 2100
- Aggressive Climate Policy & Carbon Sequester and Capture Technology
  - RCP2.6
  - Peak 3 W/m² before 2100



Example: Scenario Development

- What would an increase in growth scenario look like?
  - Would you expect growth to occur in such a way that it would impact areal *recharge*?
    - Currently precipitation on the land surface of the aquifer (and urban storm-water runoff) is ~15% of the total aquifer recharge
  - How should we include water conservation?

Your Input!

Your Input: What do you care about?

- What are the criteria that you would use to evaluate the performance of this system?
- We call these criteria: performance measures
  - It's a way to compare alternatives for one or more management objectives

What do you care about?

- Examples of model outputs
  - River flow at Spokane gage
  - Aquifer water level
  - Per capita water use
    - Impacts of conservation
  - Coeur d'Alene Lake levels
  - Streamflows for fish habitat

Thank you!