Abstract

- How often have we looked out over a river valley and wondered “Will it still look the same five years from now?”. A solid understanding of the river, plants and groundwater can provide us with some good insight to this sort of question. However, the situation is often more complicated, so that predicting changes is not straight forward. In these situations, building a computer model can serve several purposes. First, the model-building process requires capturing and organizing our understanding of the system into a collection of computer-model input files, an exercise that inevitably leads to better insight and understanding of the system and helps identify the gaps in our knowledge and/or datasets. The process also results in a tool that can be used to evaluate complex questions for a wide range of alternatives. As an example, a hydrogeologic computer model of an alluvial river valley is used to demonstrate short- and long-term impacts of proposed pumping on both river flows and groundwater levels. Key points considered include the proportion of water pulled from the river, the time it takes for the pumping to impact the river, and identifying locations where pumping may have less impact on the river system.

Using Computer Models to Predict River Valley Impacts

Gilbert Barth, Ph.D.

S.S. Papadopulos and Associates

Boulder, CO

Outline

- River-Valley Changes: Past Examples (*History Channel*)
- River Valley Hydrology (*Nature Channel*)
- Computer Model: Design/Building (*Junk Yard Wars*)
- Example: Modeling Pumping Impacts (*Myth Busters*)

River Valley Changes

Changes

- #1: Increased transbasin diversions
  - Stream flows
  - Stream seepage
  - Changes to groundwater/riparian systems
- #2: Increased groundwater pumping
  - Groundwater level/riparian systems
  - Stream seepage
  - Downstream flows

Increased Tranbasin Diversions

Moffat Firming

Windy Gap

- Develop 18,000 acre-feet per year of new, annual firm yield water delivered to the Moffat Treatment Plant
  - Water will be diverted from Fraser River
- Additional storage to ensure reliable, or “firm,” future deliveries (more wet-year diversions).
  - Wet years: water is available but Lake Granby is full, no space for storage
  - Dry years: water right too junior, no water is available to store

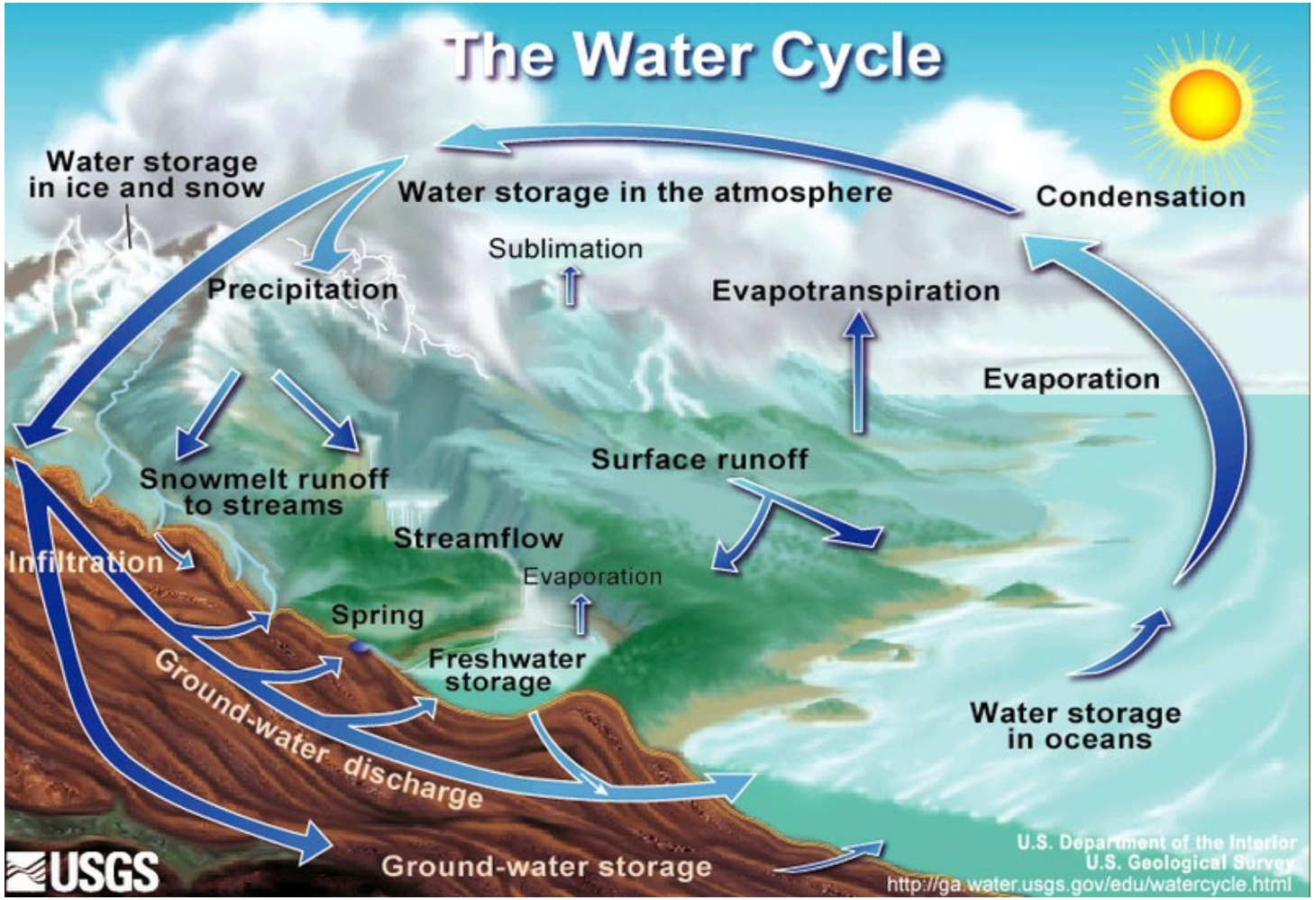
Groundwater Pumping (Kansas v. Colorado)

- 1943: Arkansas River Compact to settle disputes
- 1986: Kansas filed a complaint regarding Colorado's groundwater pumping
  - Special Master found that post-Compact increases in groundwater well pumping in Colorado had materially depleted the waters in violation of Article IV-D
  - Recommended damages be awarded to Kansas;
- Conceptual and physical expectation of impact
- Legal mechanism to account for impact

River Valley Hydrology

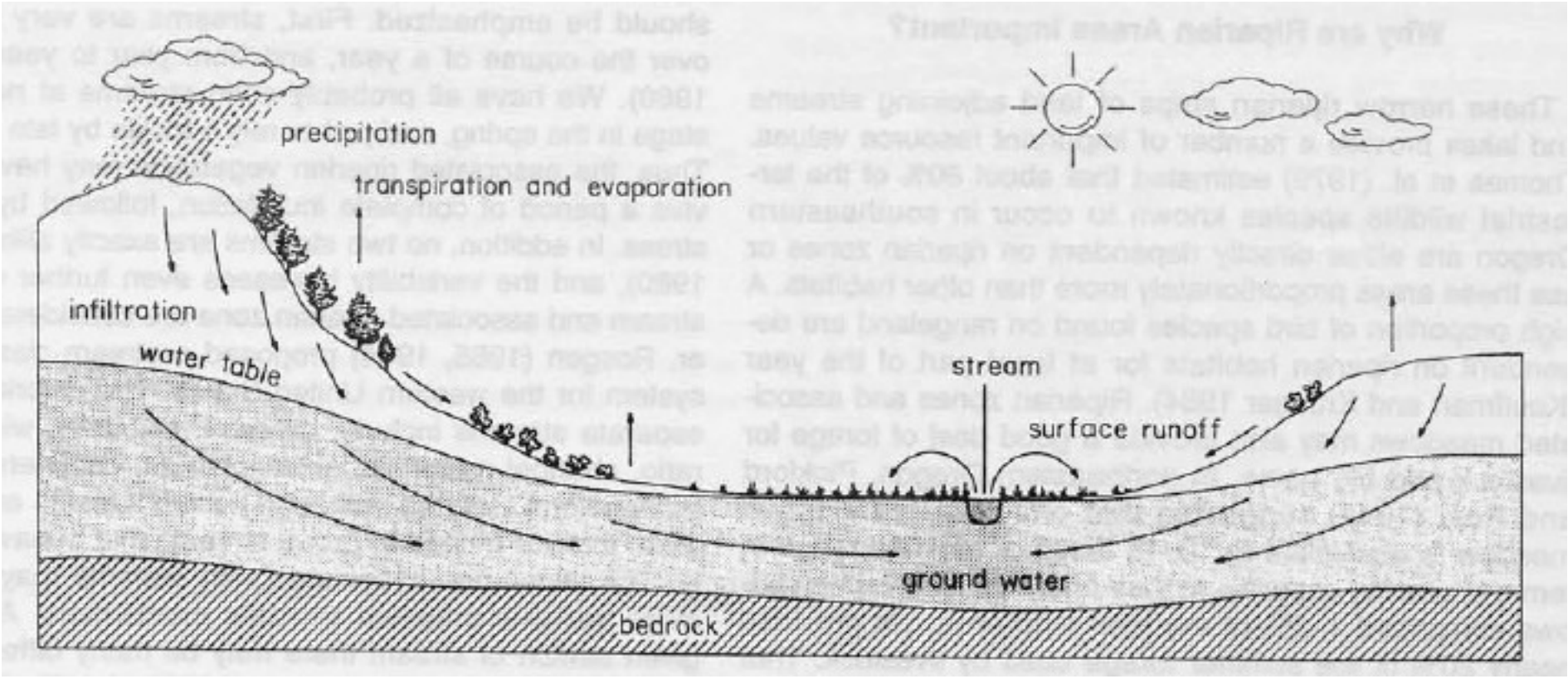
Hydrologic Cycle

- Water is always moving
- We categorize, but water is always part of the cycle
- Whatever the category, water is just responding to
  - Heat
  - Potential
  - Gravity



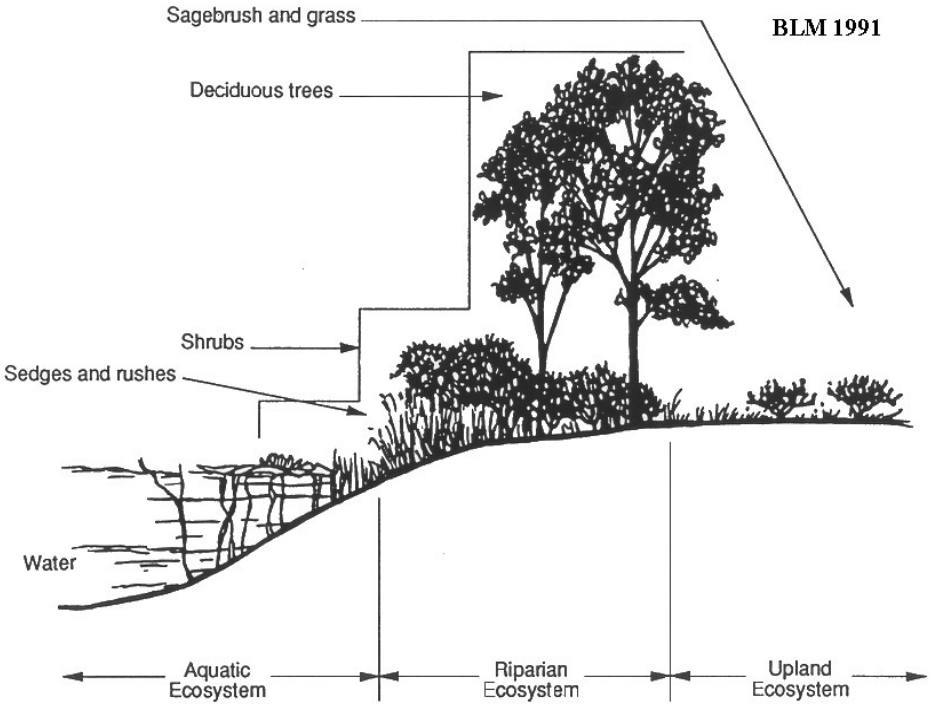
River Valley Cross Section

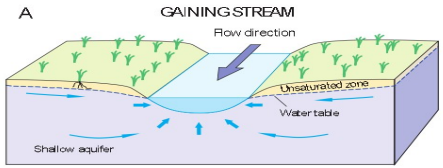
- Water movement in a slice across the valley

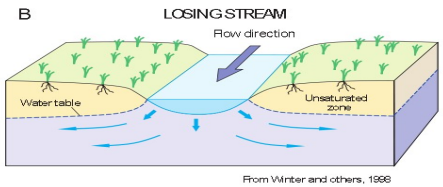


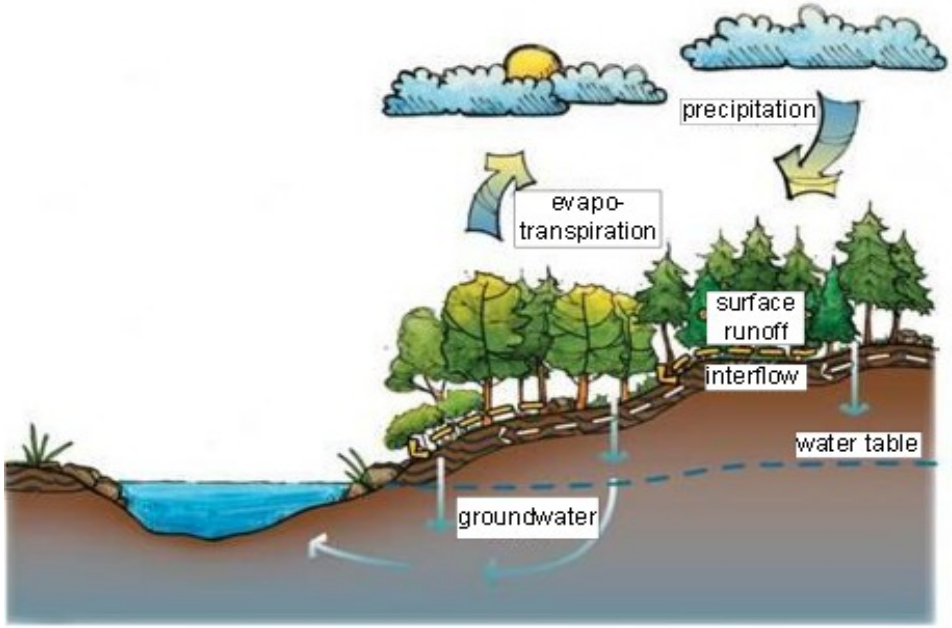
Along the River Corridor

- Include features impacted by change
- Spatial Components
  - Aquatic
  - Riparian
  - Upland
- Temporal Components
  - Gaining/losing
  - ET rates
  - Hydrographs



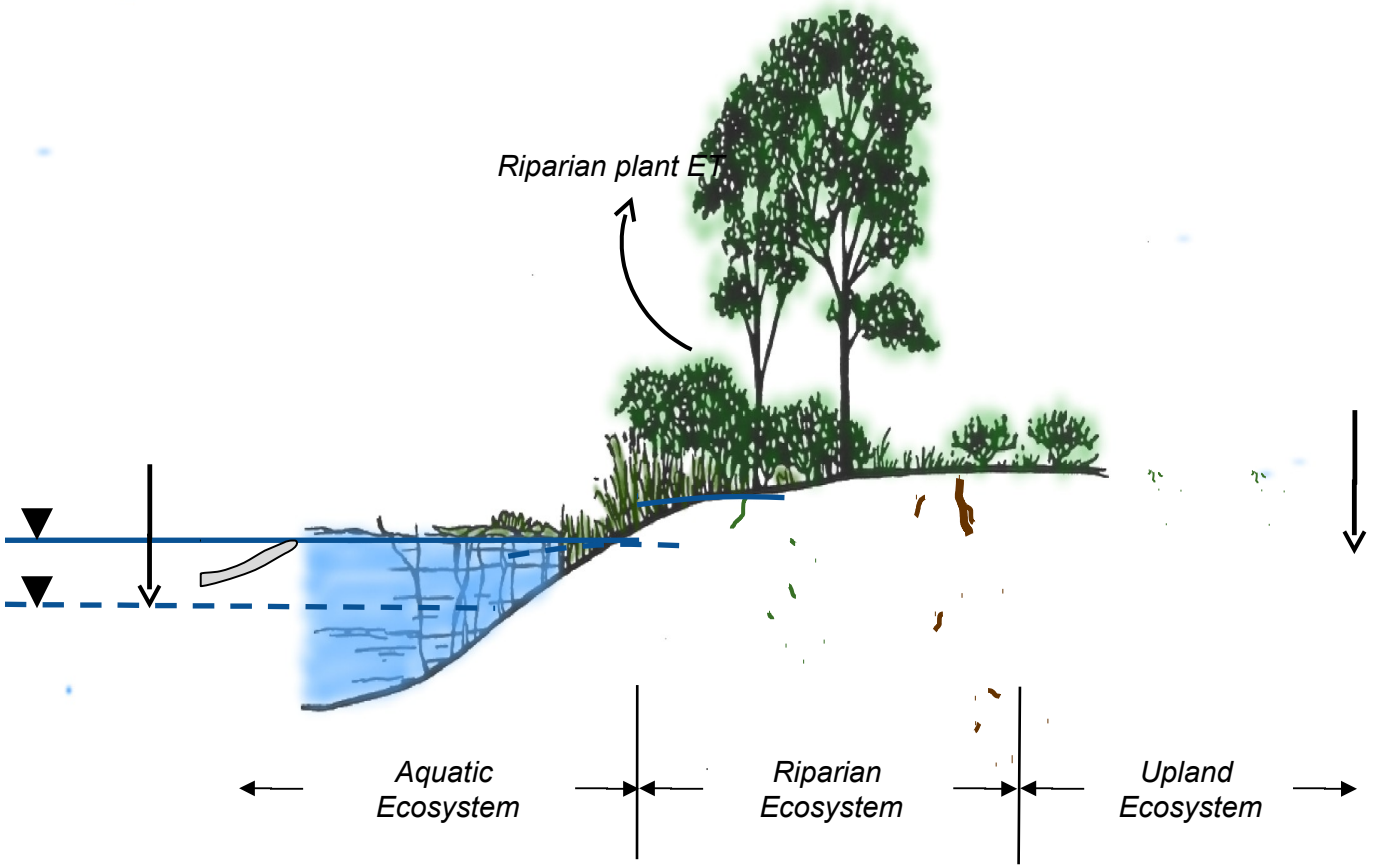






Water Budgets and Capture/Interception

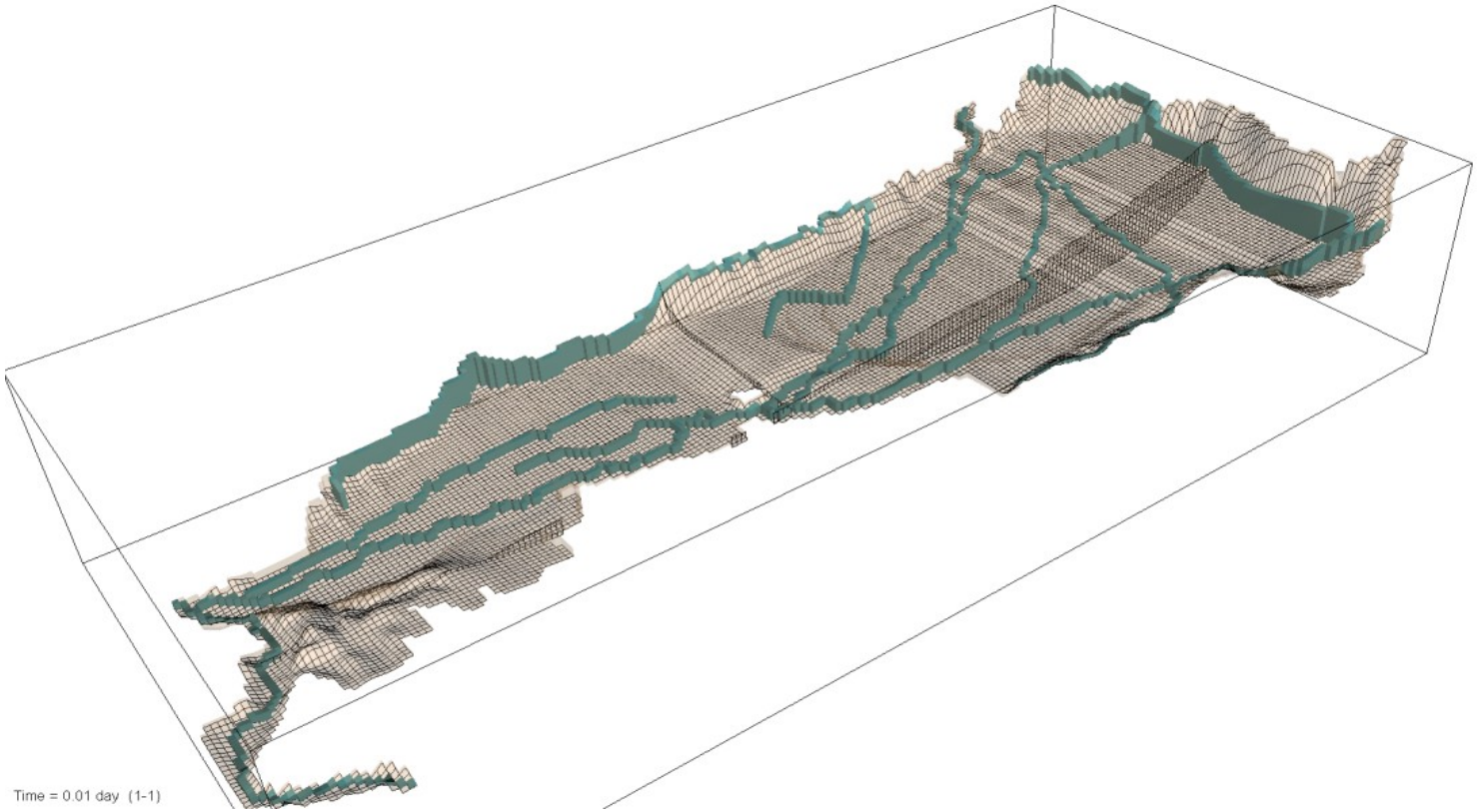
- Water sources/sinks
  - Rivers/canals
  - Groundwater (Storage)
  - Mountain front recharge
  - Percolation
  - Evapotranspiration
- Impact of changes
  - Water levels
  - River seepage
  - **Capture and/or Interception**



Model Building

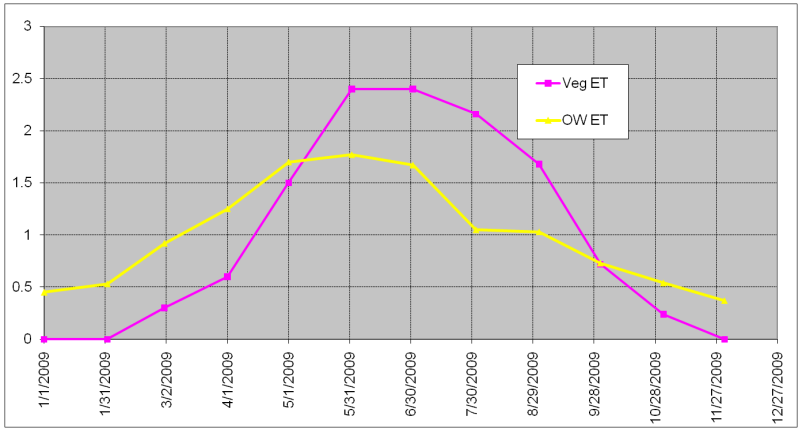
Model Design: Extent and Features

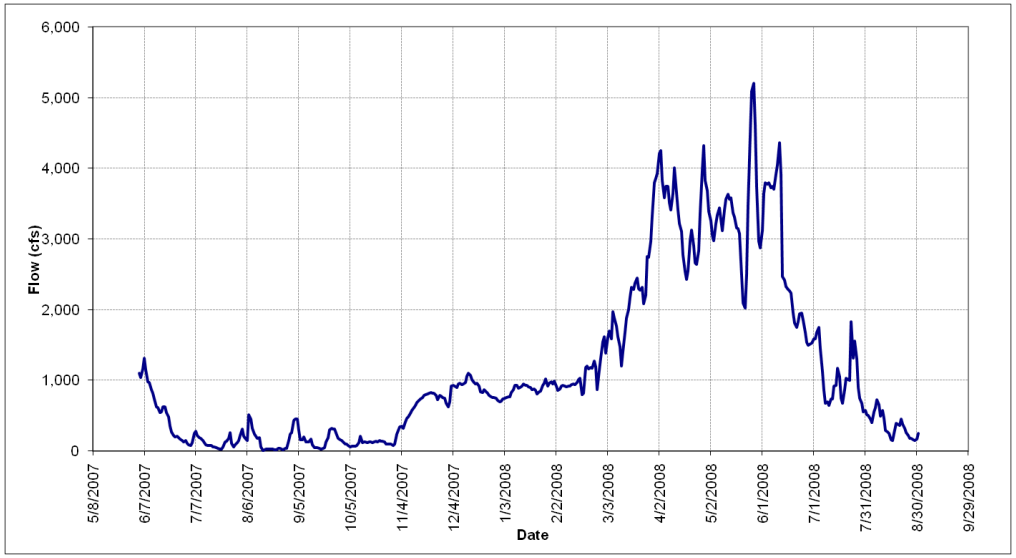
- Represent big features
- Natural boundaries
- Details as needed
- Vertical can be important



Computer Model Inputs

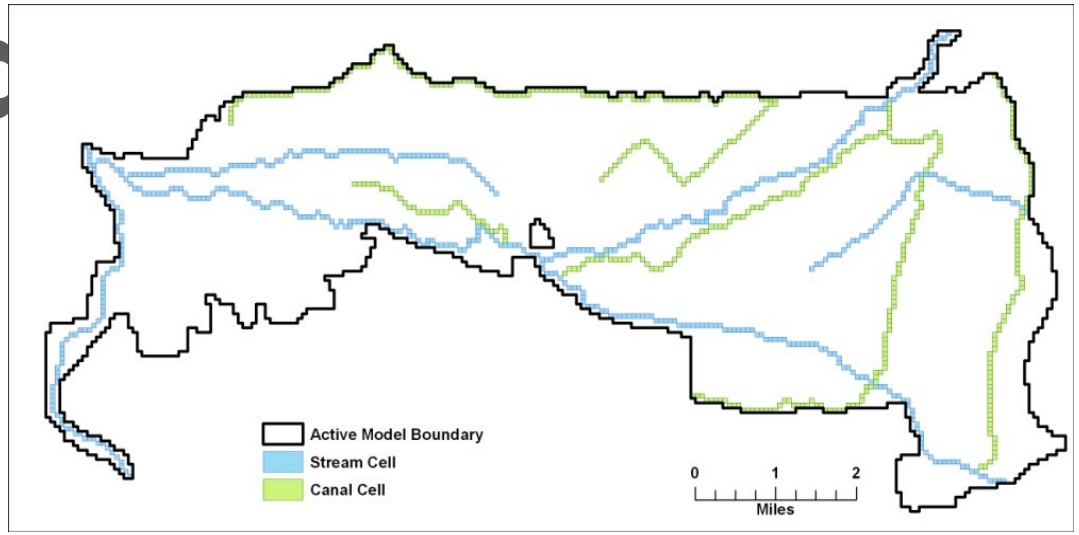
- Information
  - River flows
  - Diversions
  - Irrigation
  - Crop consumption
  - Percolation
  - Evapotranspiration
  - Boundaries (seepage to/from other formations)

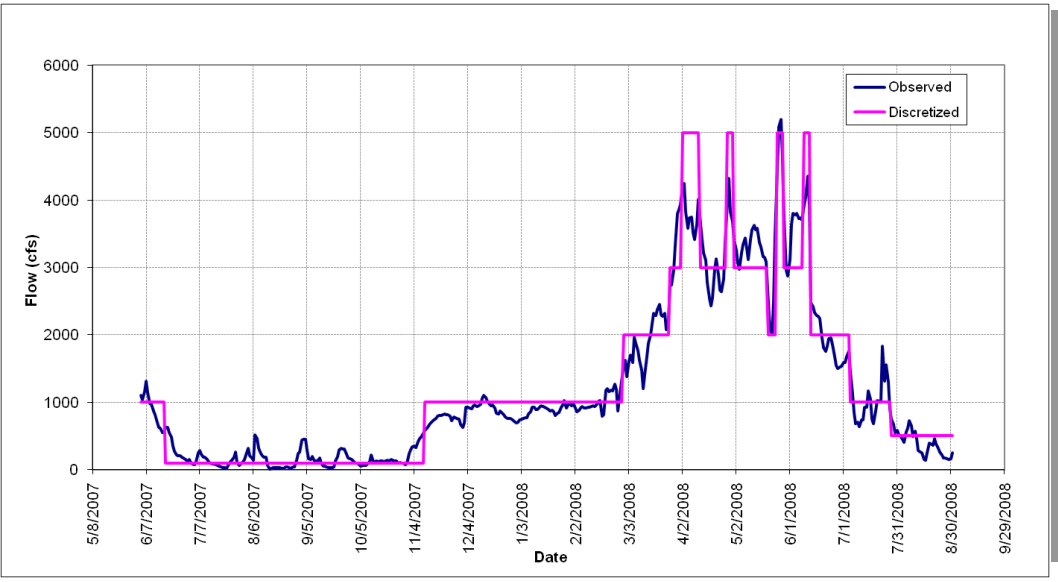


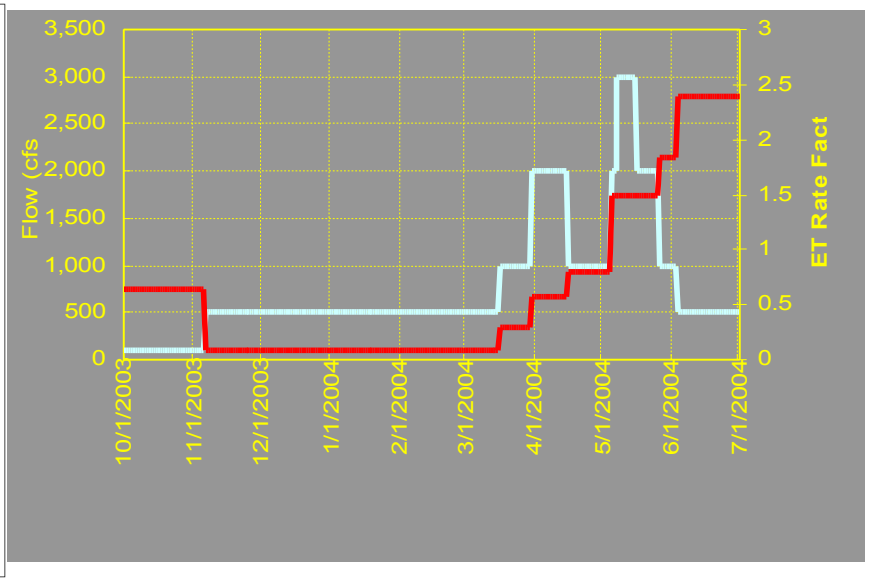


Flow mod

- Start building files that incorporate
  - Distribution
  - Quantities
  - Timing

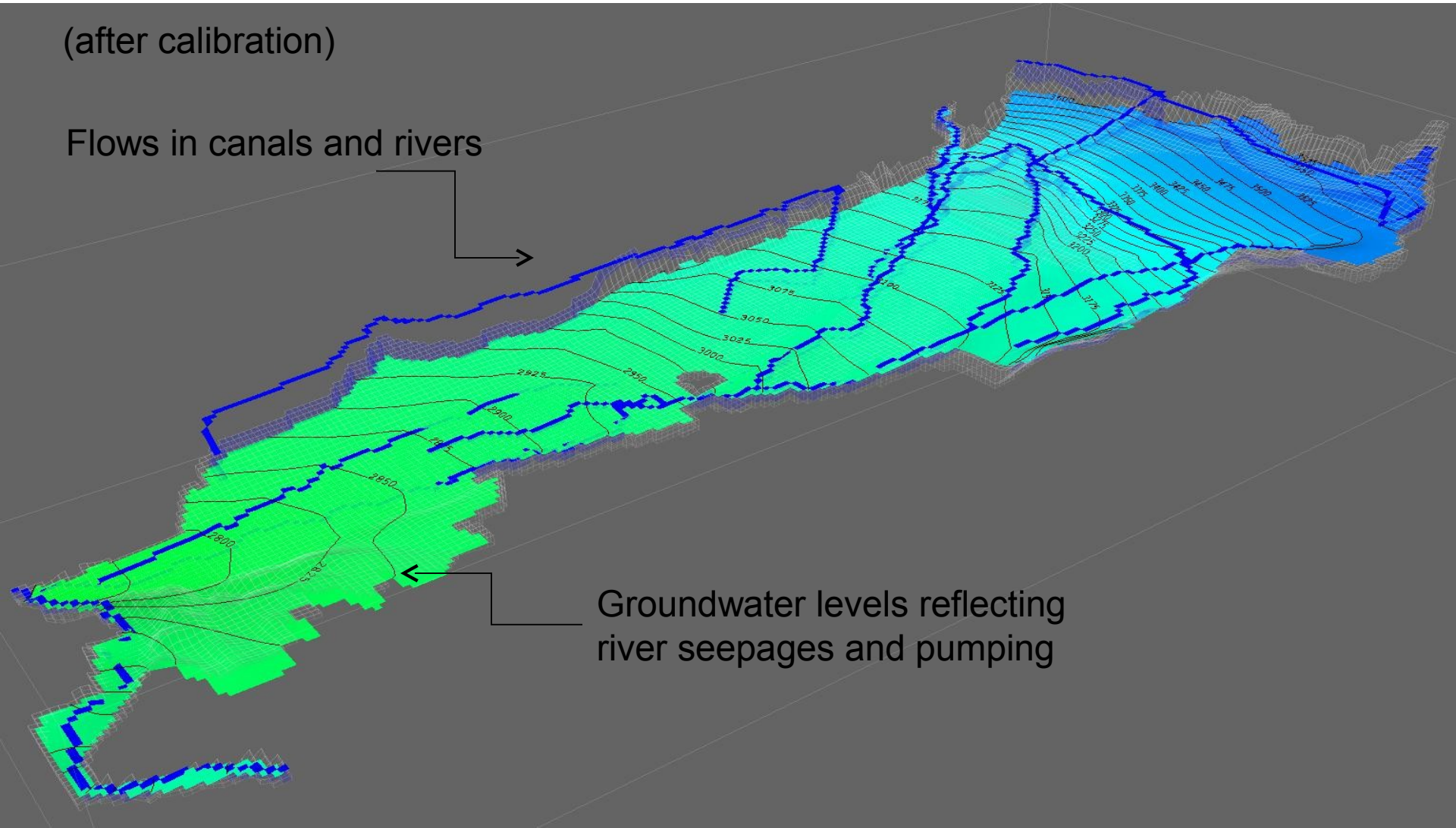






Simulated Conditions

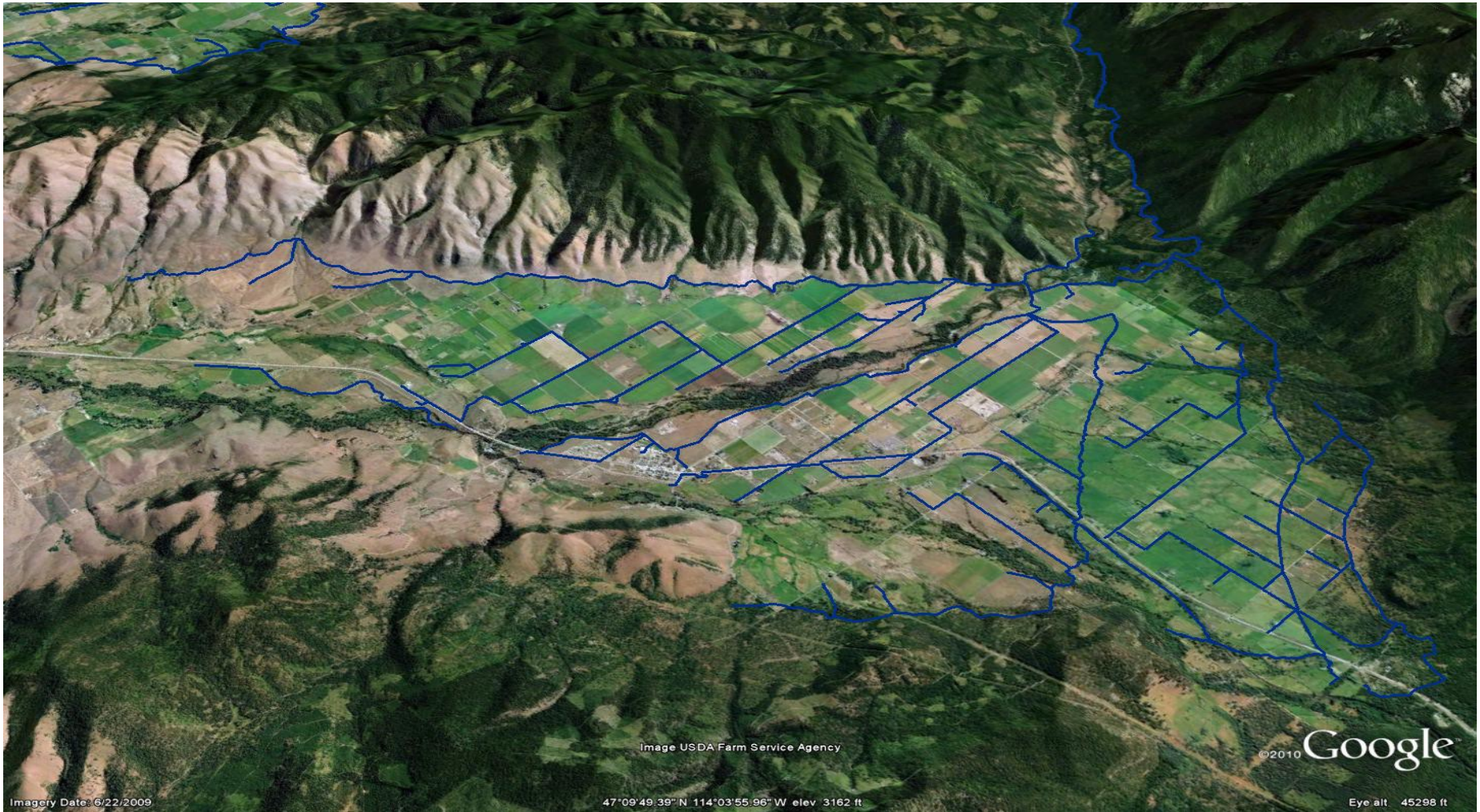
(after calibration)



Example

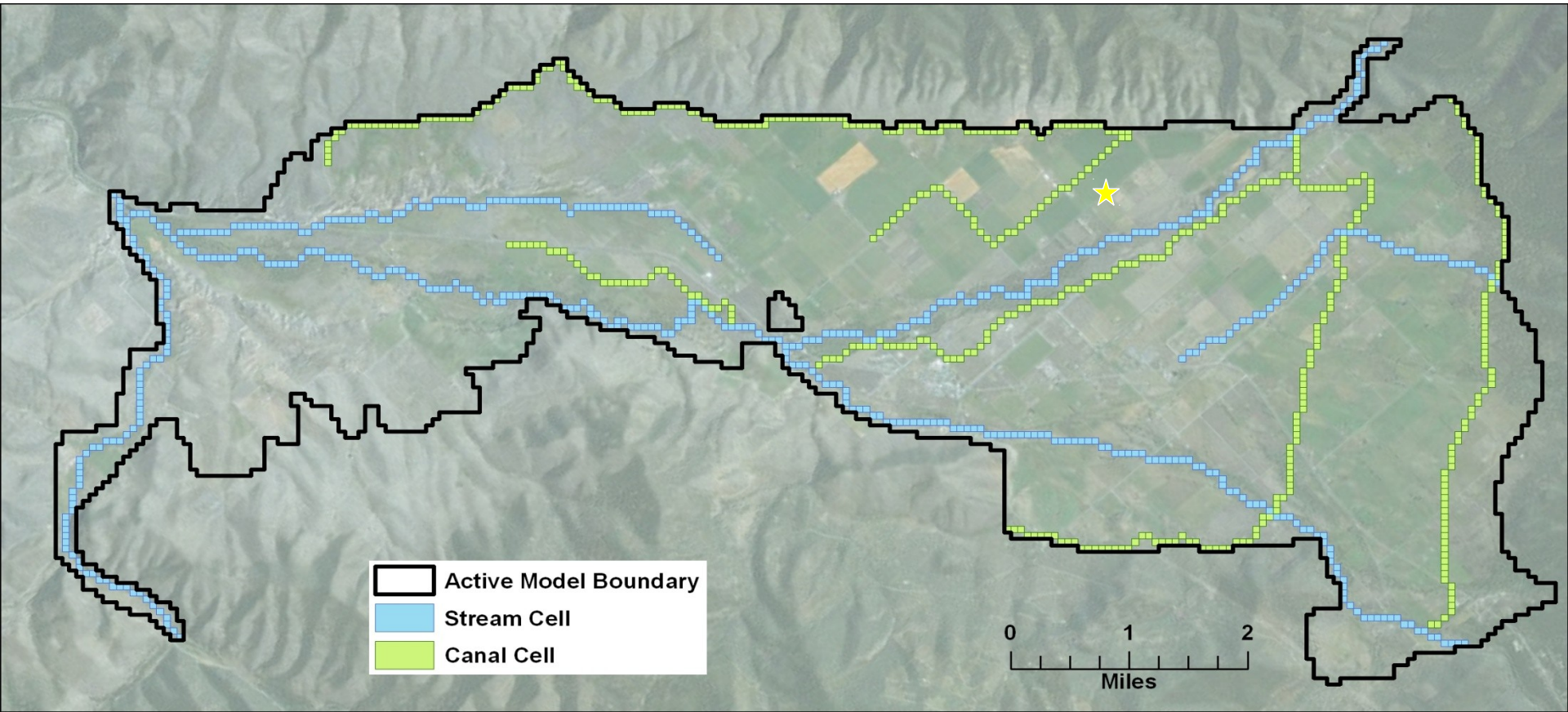
Alluvial river valley

- Fat Aspen Valley

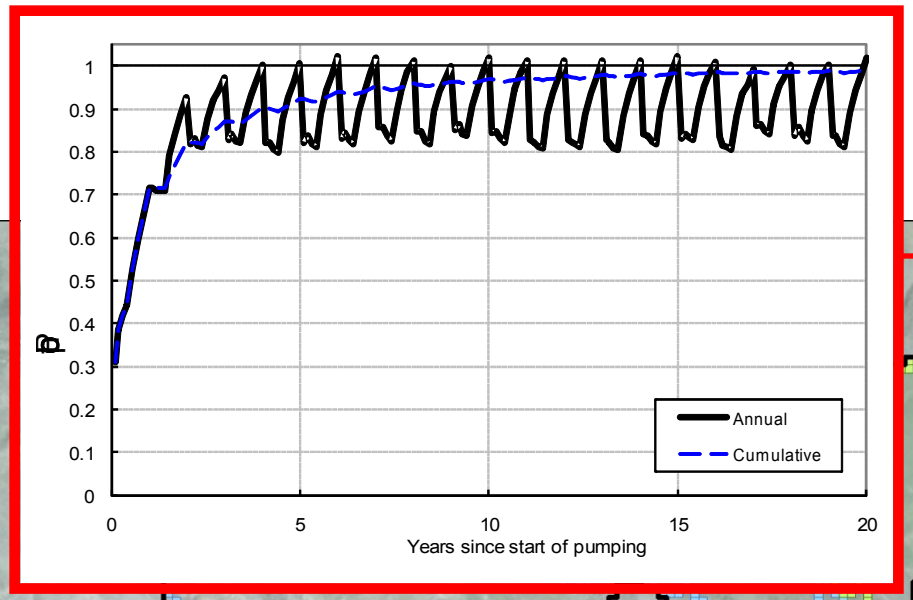


Using the Model: Pumping Impacts

- If a new well starts pumping
  - When will it start intercepting “river water” (not just storage)?
  - How long until it is pumping only “river water”?

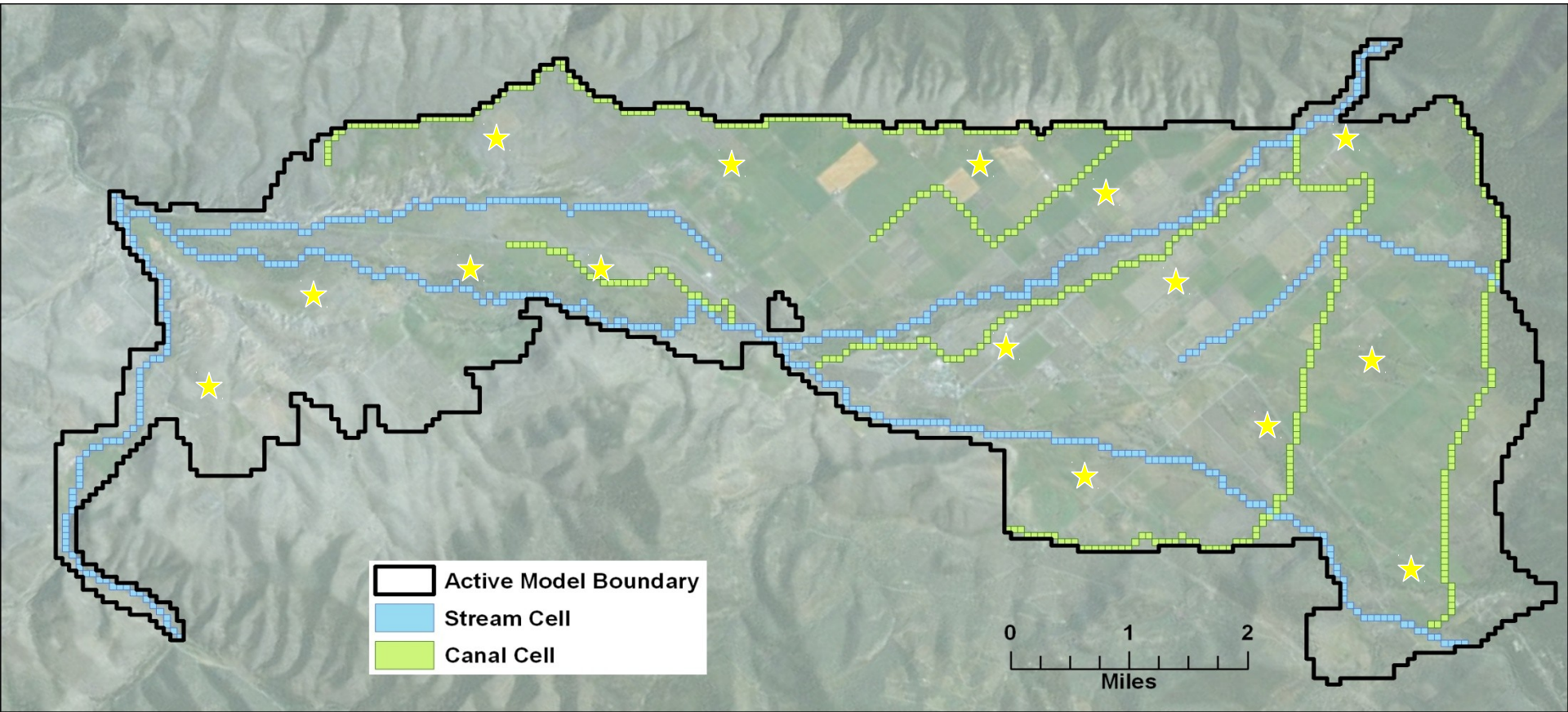


is Intercepted Water?



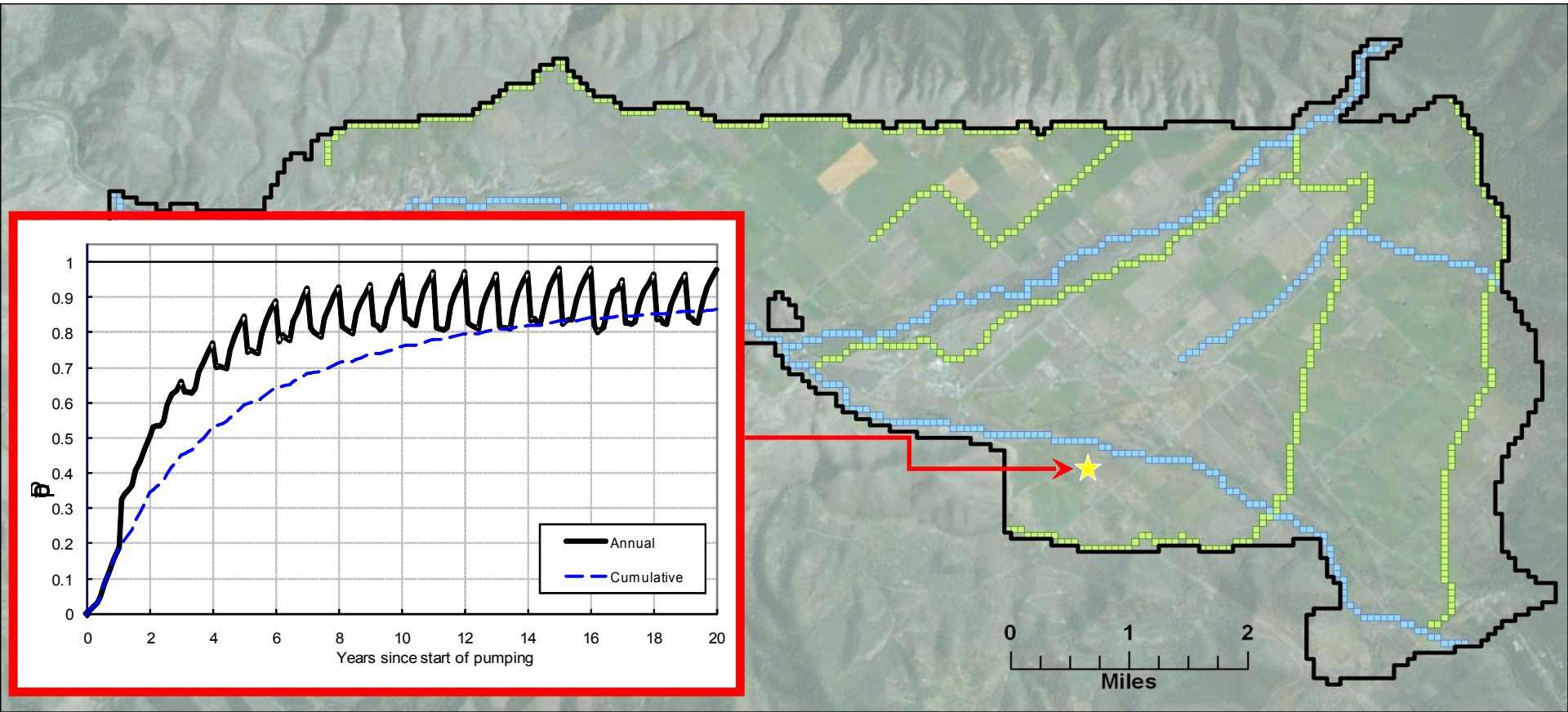
- After just 2 years, pumping is mostly from river (direct or intercepted)

What about other locations?



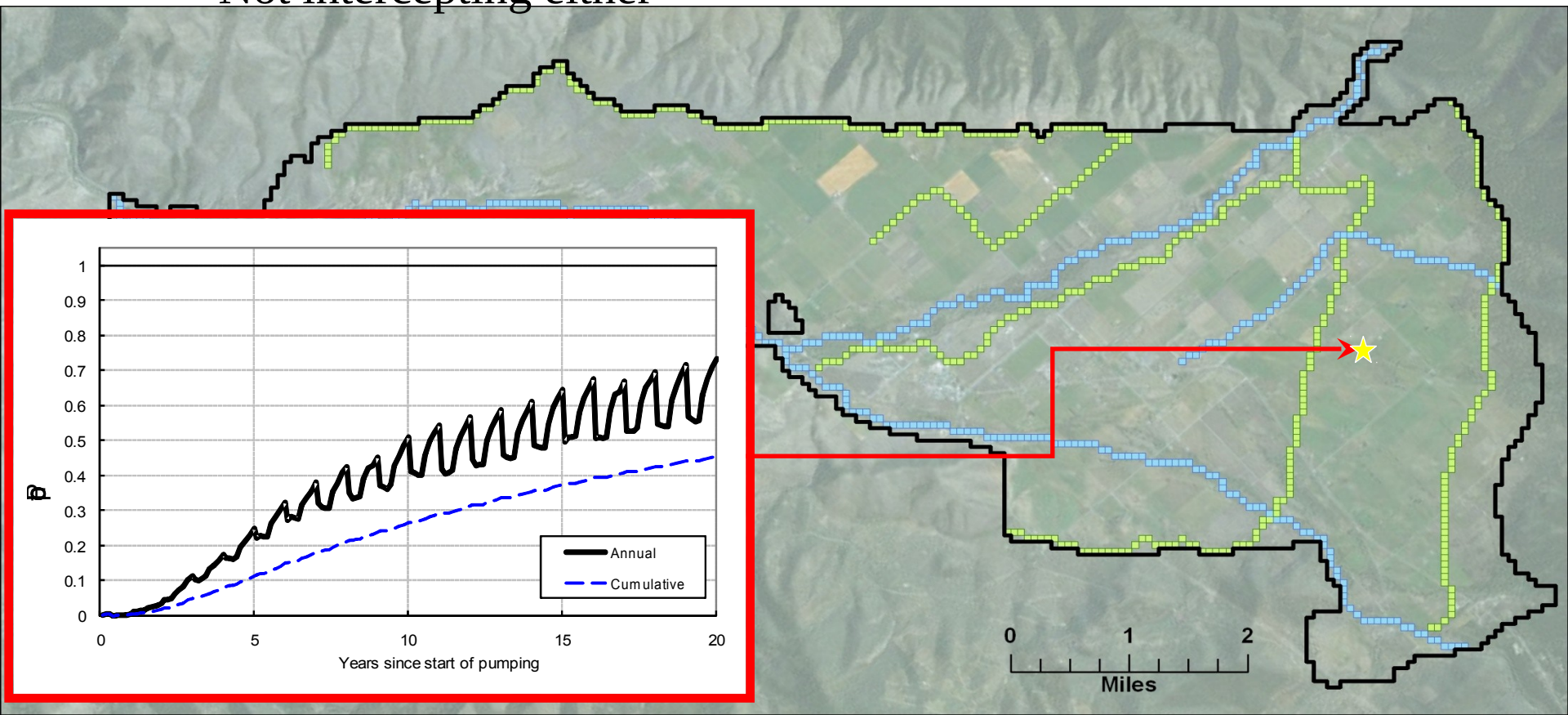
Different Location, Different Impact

- After 4 years, about 80% intercepted
- After year 10, mostly intercepted



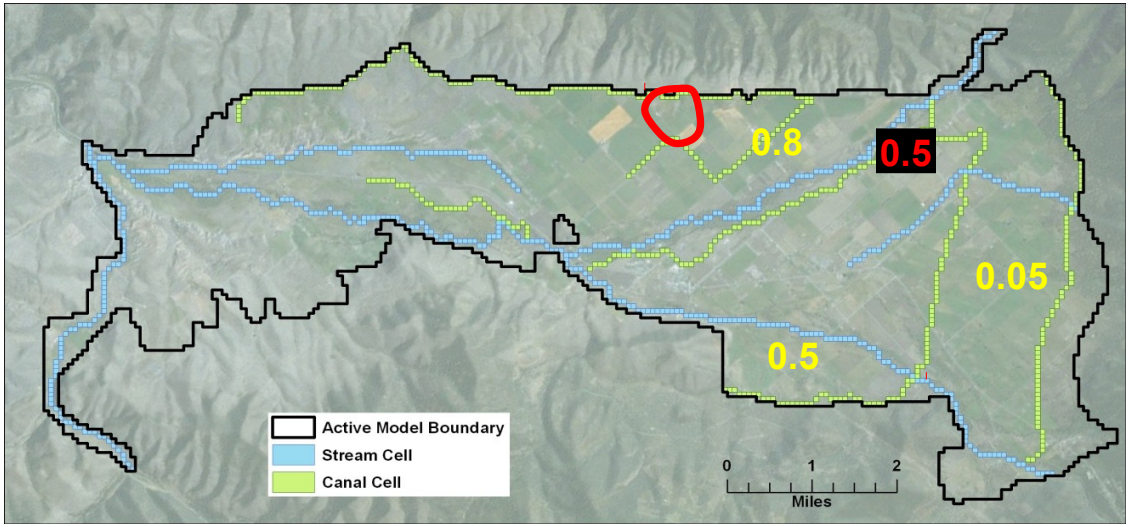
Streams: Different Impact

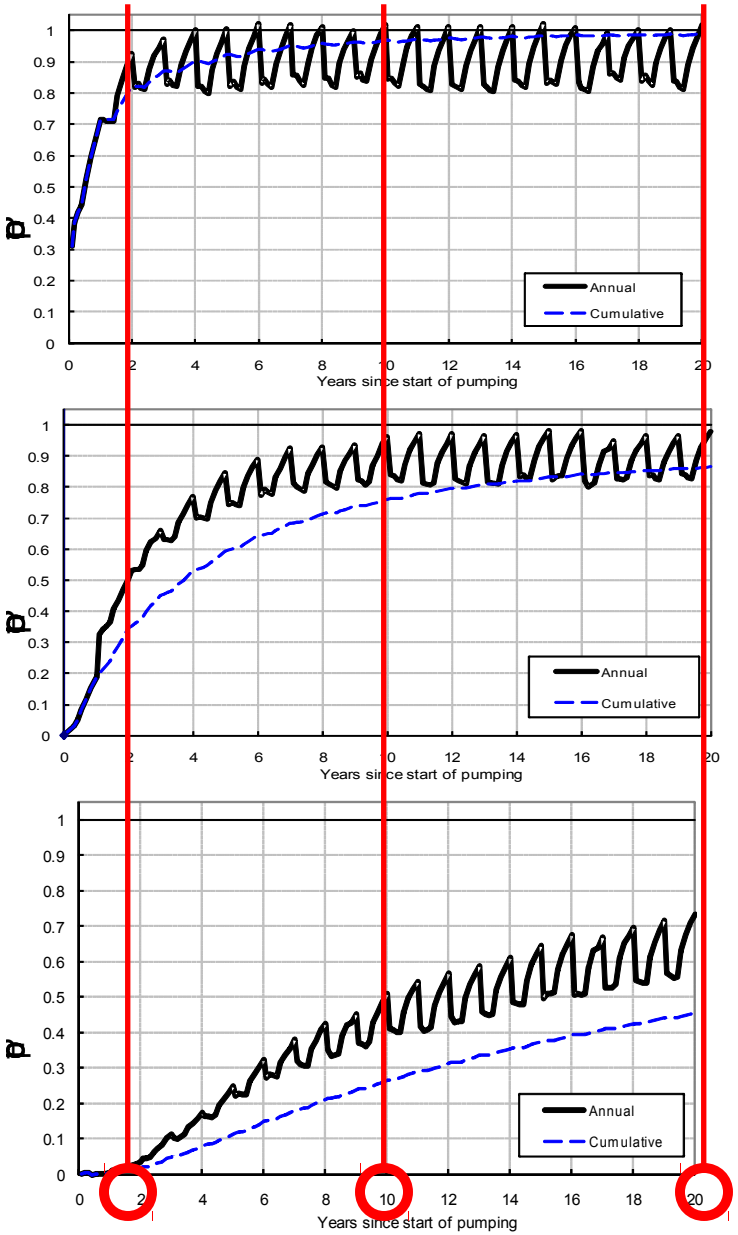
- 20 Years and still not 100%
- Distance from river, and proximity to other sources
- Not intercepting either



Bigger Picture

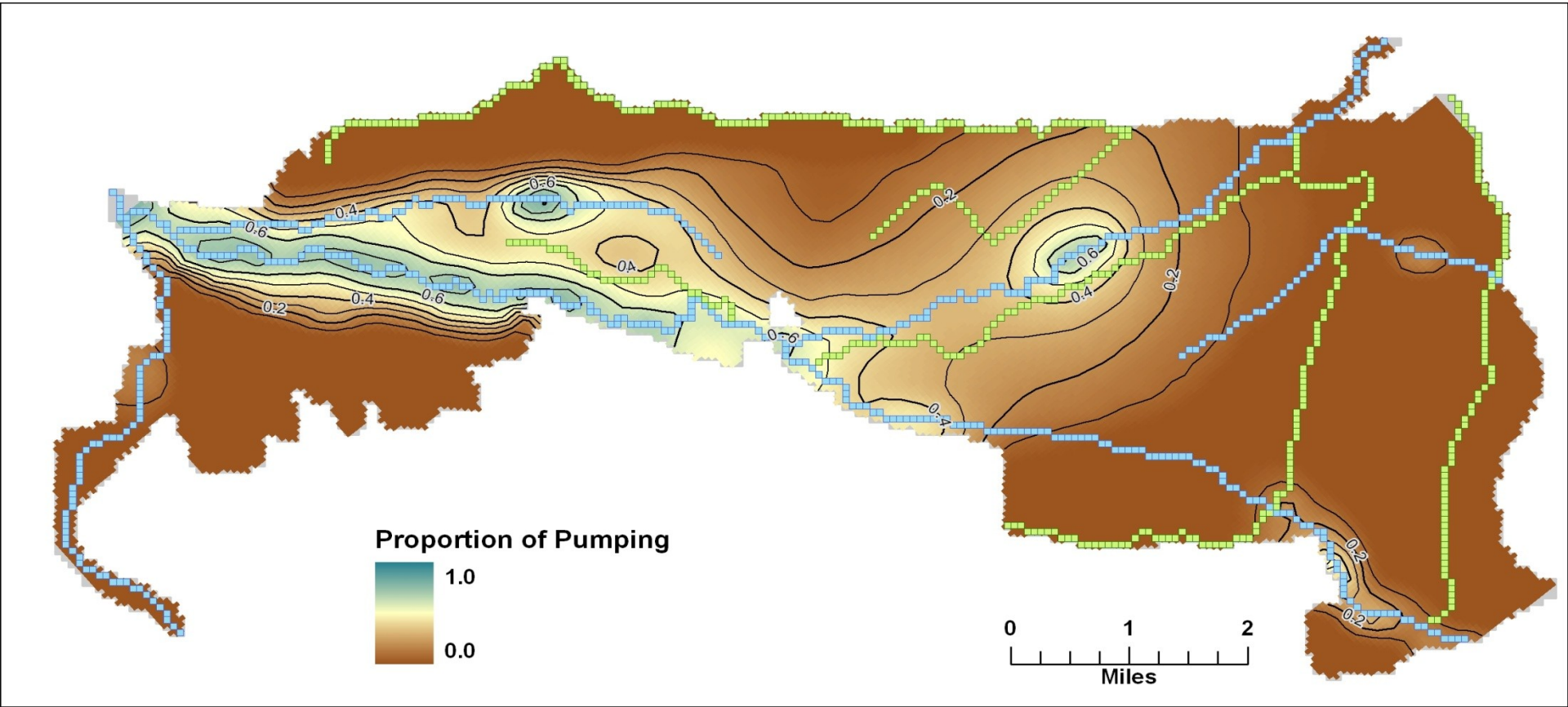
- Can we get a picture of the entire valley at 2, 10 and 20 years?
- Use our 3 graphs to demonstrate
- Pick results from each graph at a 2, 10 and 20 years
- Put values on map
- Draw a contour





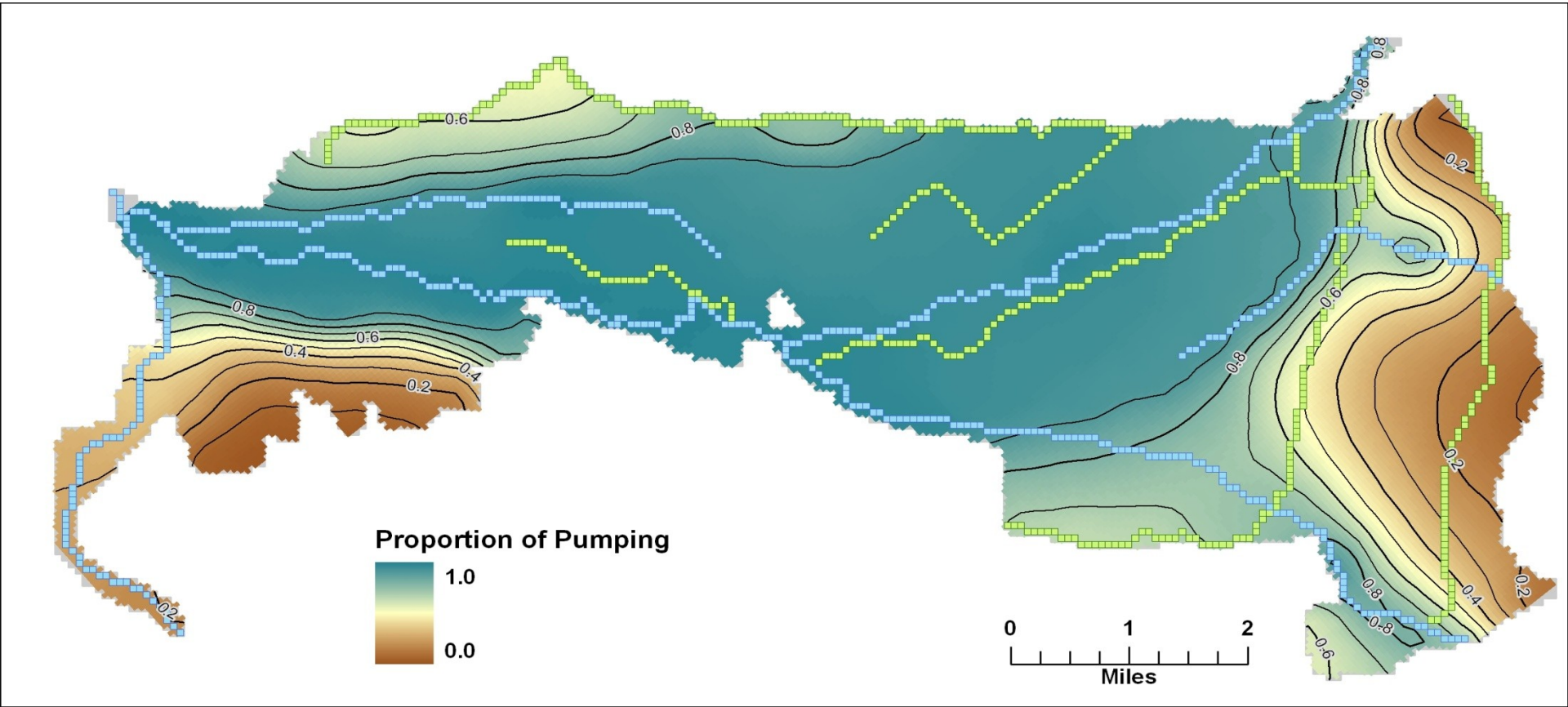
Pumping Impacts after One Month

- Repeat the analysis for 1000's of locations
- Combine results to map out when each part of the valley will start to have big river impacts
- Proportion of pumping coming from the river after 35 days



What Happens in the Long-Term

- Proportions after 10 years of pumping
- Areas with lower proportions are either further from the river, draw from another source, or both.



Summary

- Water is always on the move
- Develop a clear conceptual model
- Do the water-budget accounting
  - Refine conceptual model?
- Design/Build the model
  - Simplest model that can represent the impacts of changes
- Test ideas
  - Refine conceptual/numerical models?
- Use results, and look for new questions to ask!

Questions?