Eastern Snake Plain Aquifer Model Overview

Presented to Idaho Water Resource Board

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Introduction

- Brief Modeling Introduction
- Snake Plain Model
  - Overview
  - Water Budget
  - Calibration
- Model Application
  - Scenarios
  - Tools

Why Model?

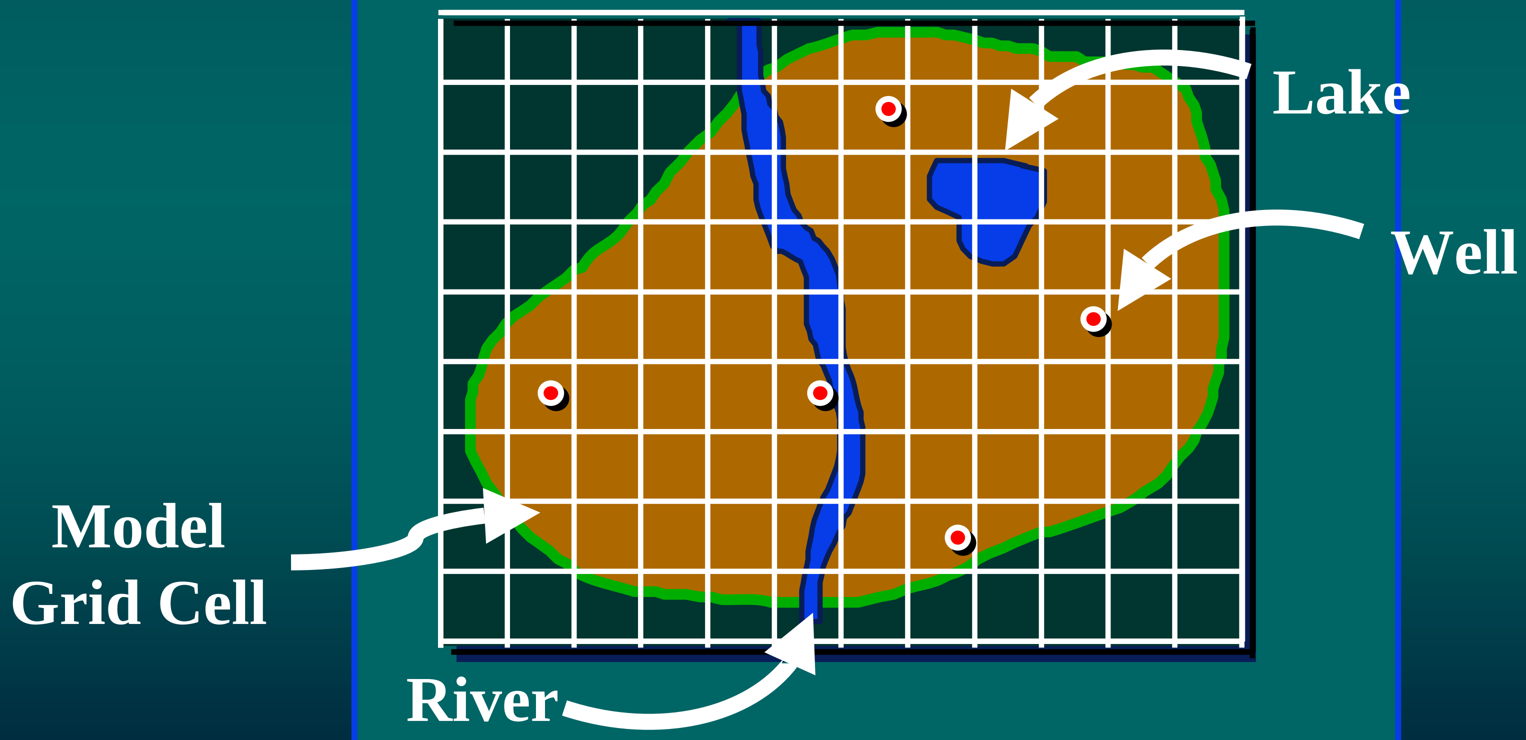
- Numerical models allow representation of very complex conditions
  - Spatial variation of hydrologic properties
  - Variation of aquifer recharge and discharge in both time and space
  - Better representation of aquifer heterogeneities than other tools

What is a Numerical Model?

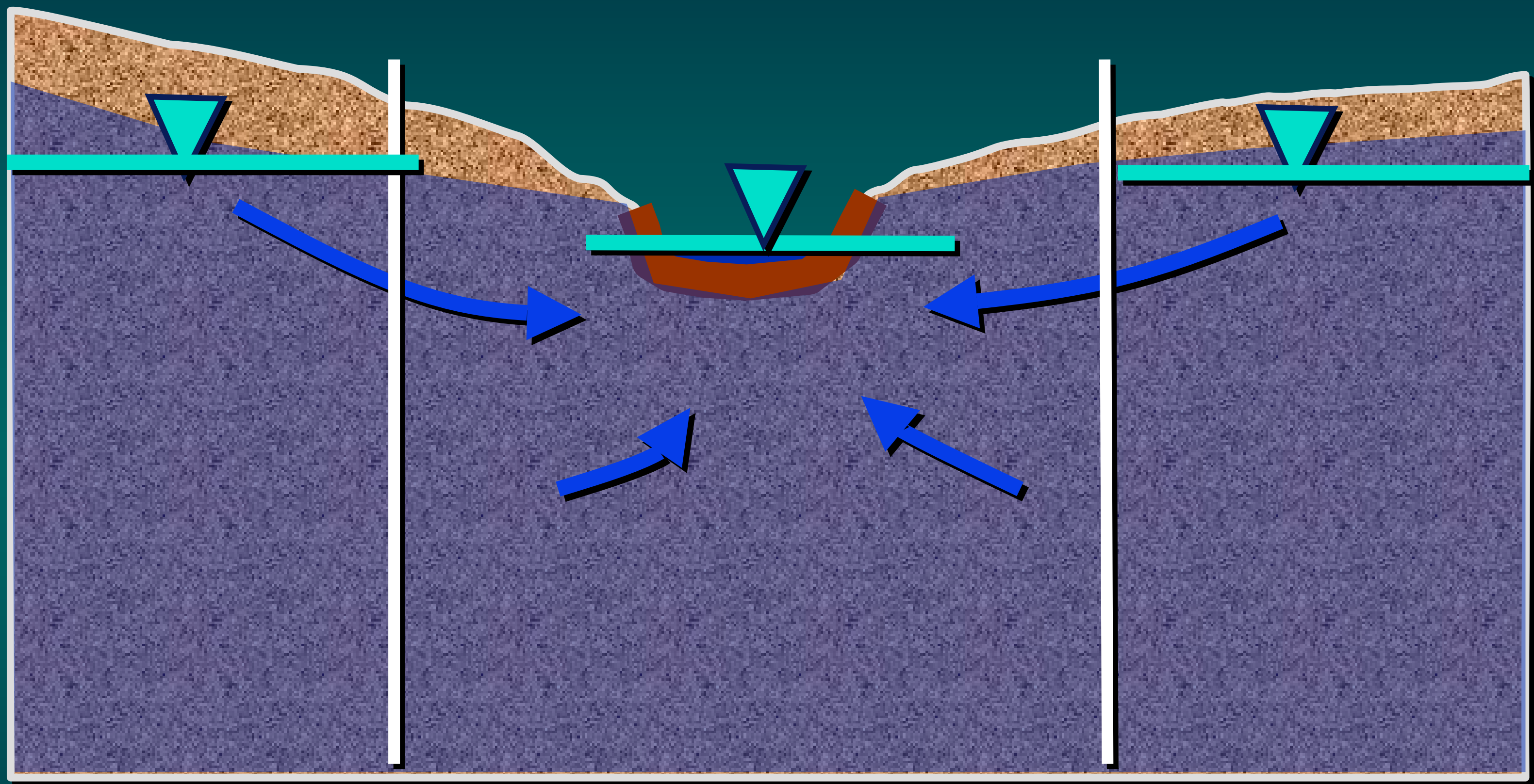
- The model area is divided (discretized) into small pieces called model cells
- Time is also discretized into time steps
- Boundaries such as mountains, rivers are identified
- A water budget (inputs and outputs) is estimated for each model cell for each time step

Model Grids and Boundaries

Example Model Grid and Boundaries



Head-Dependent River Boundary



River Leakage or Gain Varies as Aquifer Water Level Varies

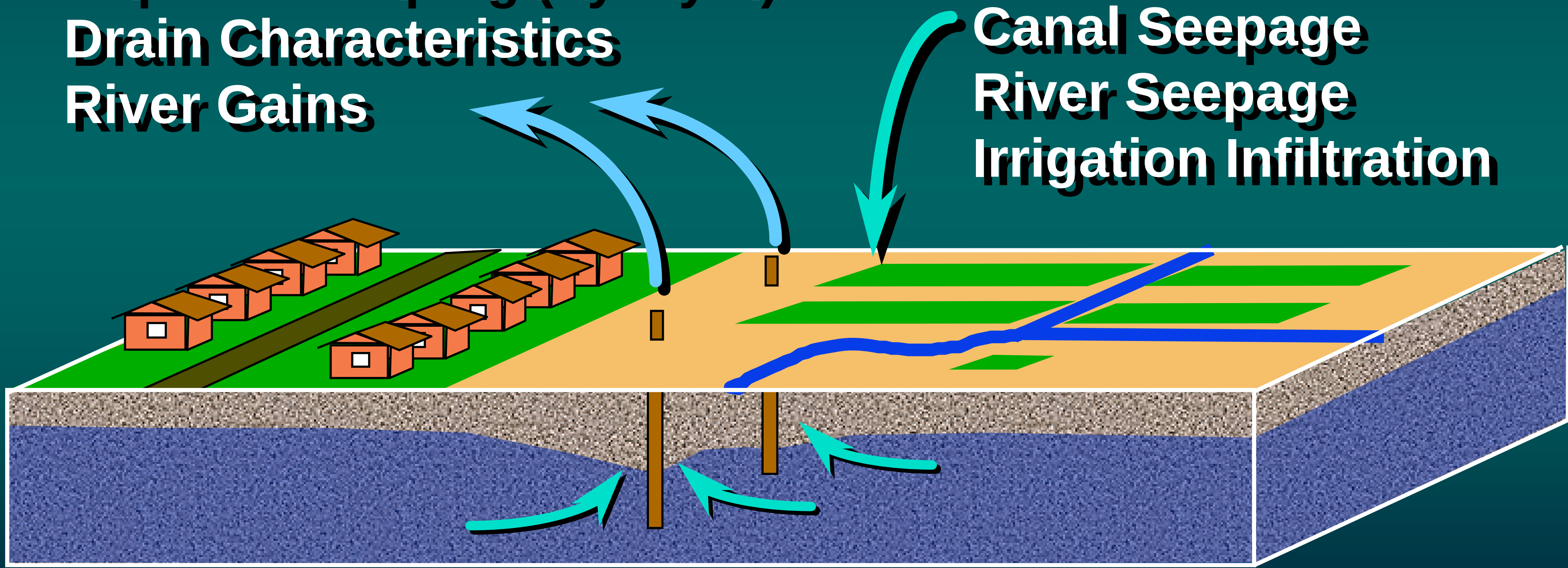
Model Input Data

Discharge Data

- Aquifer Pumping (by layer)
- Drain Characteristics
- River Gains

Recharge Data

- Precipitation
- Canal Seepage
- River Seepage
- Irrigation Infiltration



What is a Numerical Model? (cont'd)

- Mathematical equations are established to describe the flow of water into and out of each model cell
- These equations are run, representing the change in hydrologic conditions over time
- Model outputs are compared with measured aquifer water levels and river gains

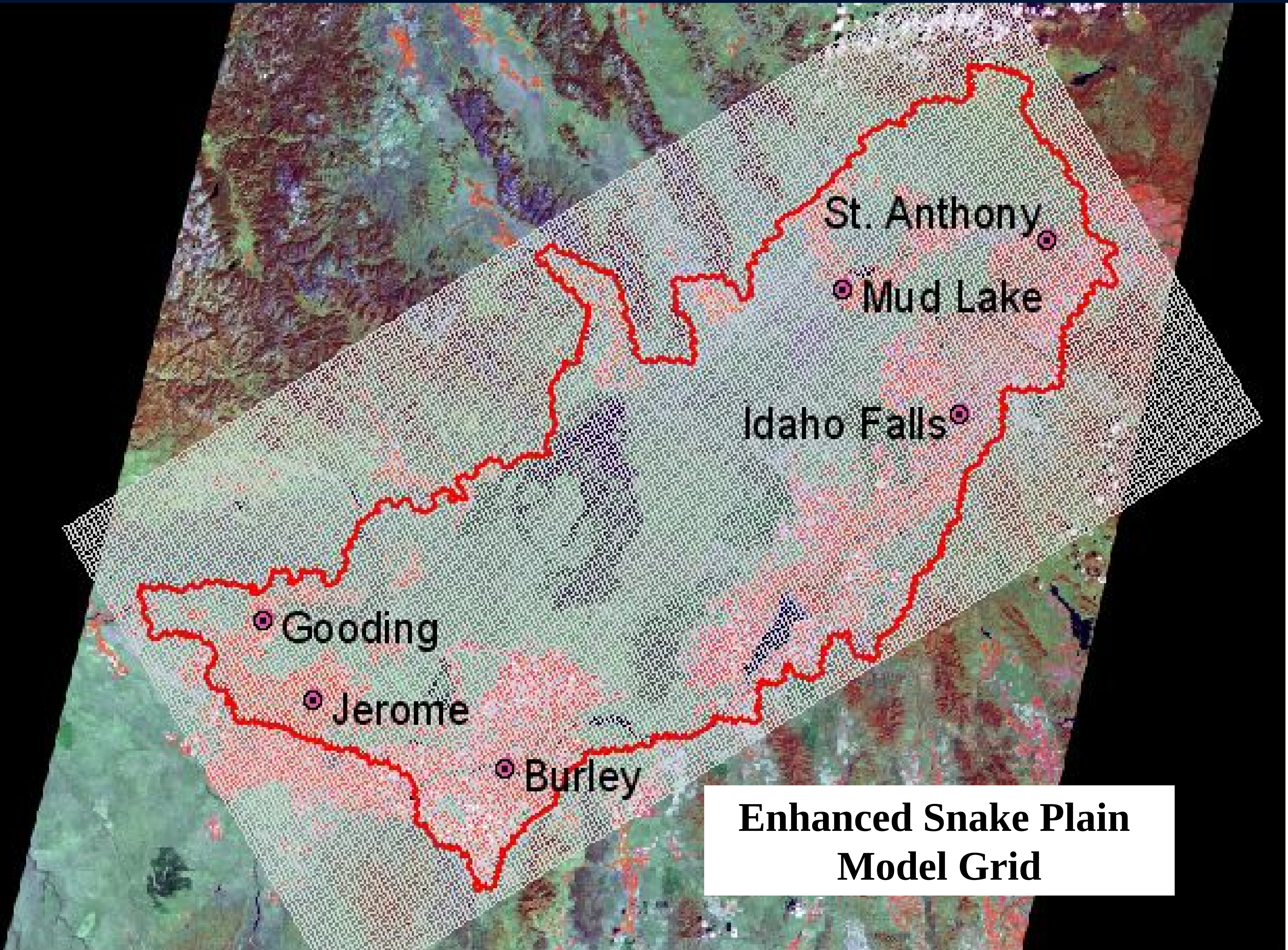
The Snake Plain Model

- Upgrade or enhancement to original ground-water model
- 22-Year Recharge/Discharge Data Set
- More Refined Grid
  - 104 Rows, 209 Columns
  - 1 mile x 1 mile
  - Approximately 10,000 Active Cells
- Better River Representation

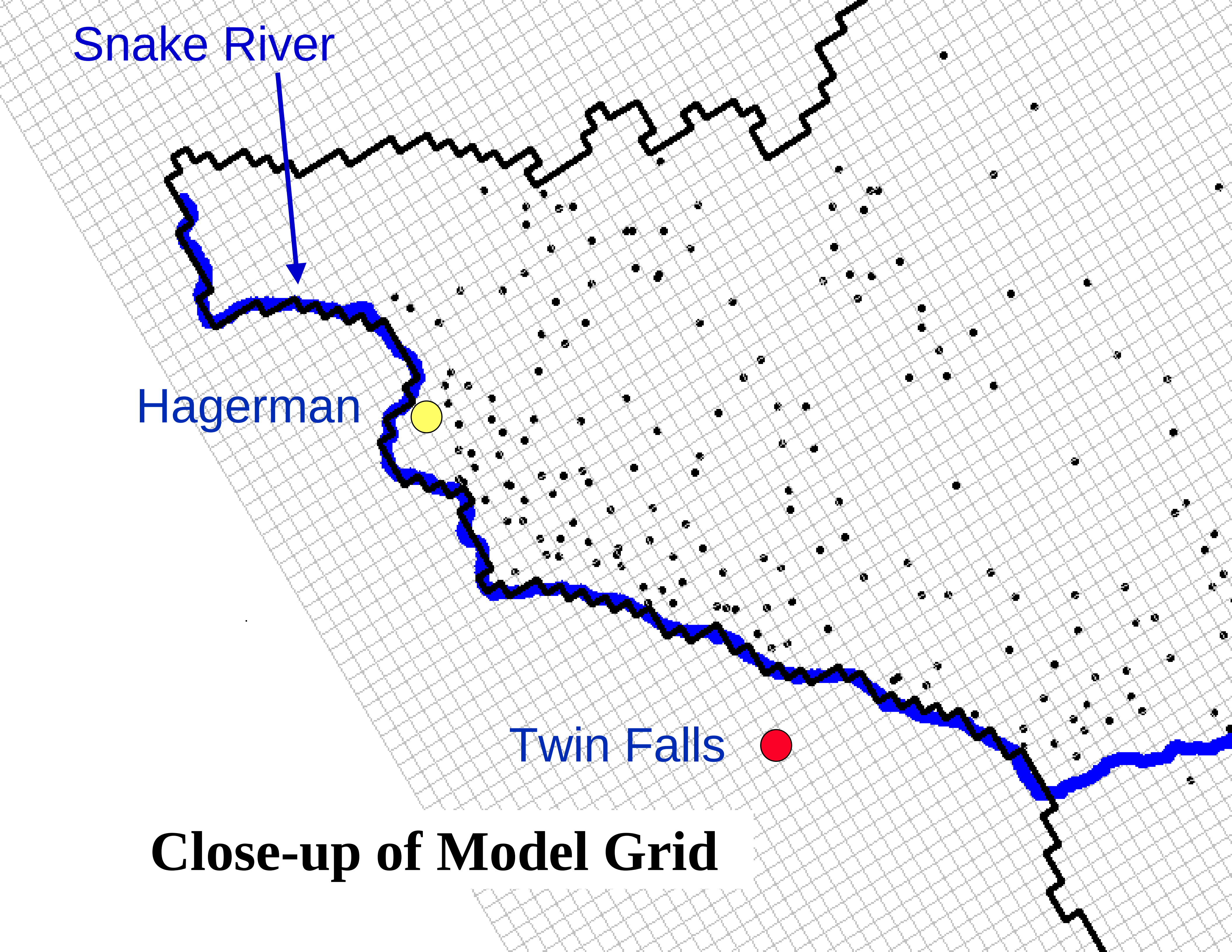
Unique Model Development Method

- Eastern Snake Hydrologic Modeling (ESHM) Committee participated in model re-development
  - Group comprised of experts representing various water use interests
  - Major design decisions discussed in ESHM group
  - Not always total agreement, but general consensus

- Unique method for model development
  - Attempt to gain consensus on science
- Group kept well informed through meetings and design documents
  - Approximately 30 interim reports available on IWRRI web site
- Collaboration resulted in better, more error-free model

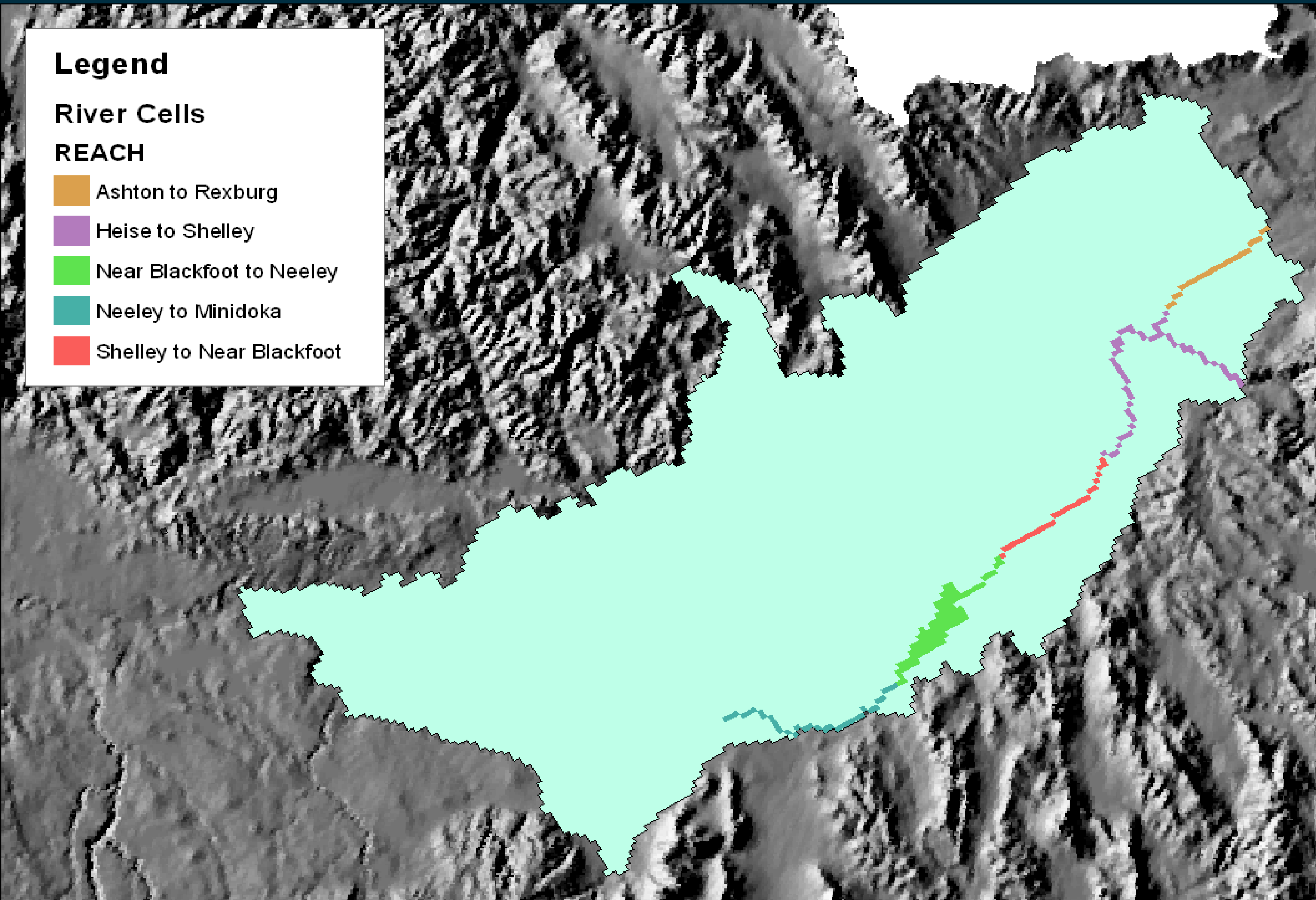


Enhanced Snake Plain Model Grid

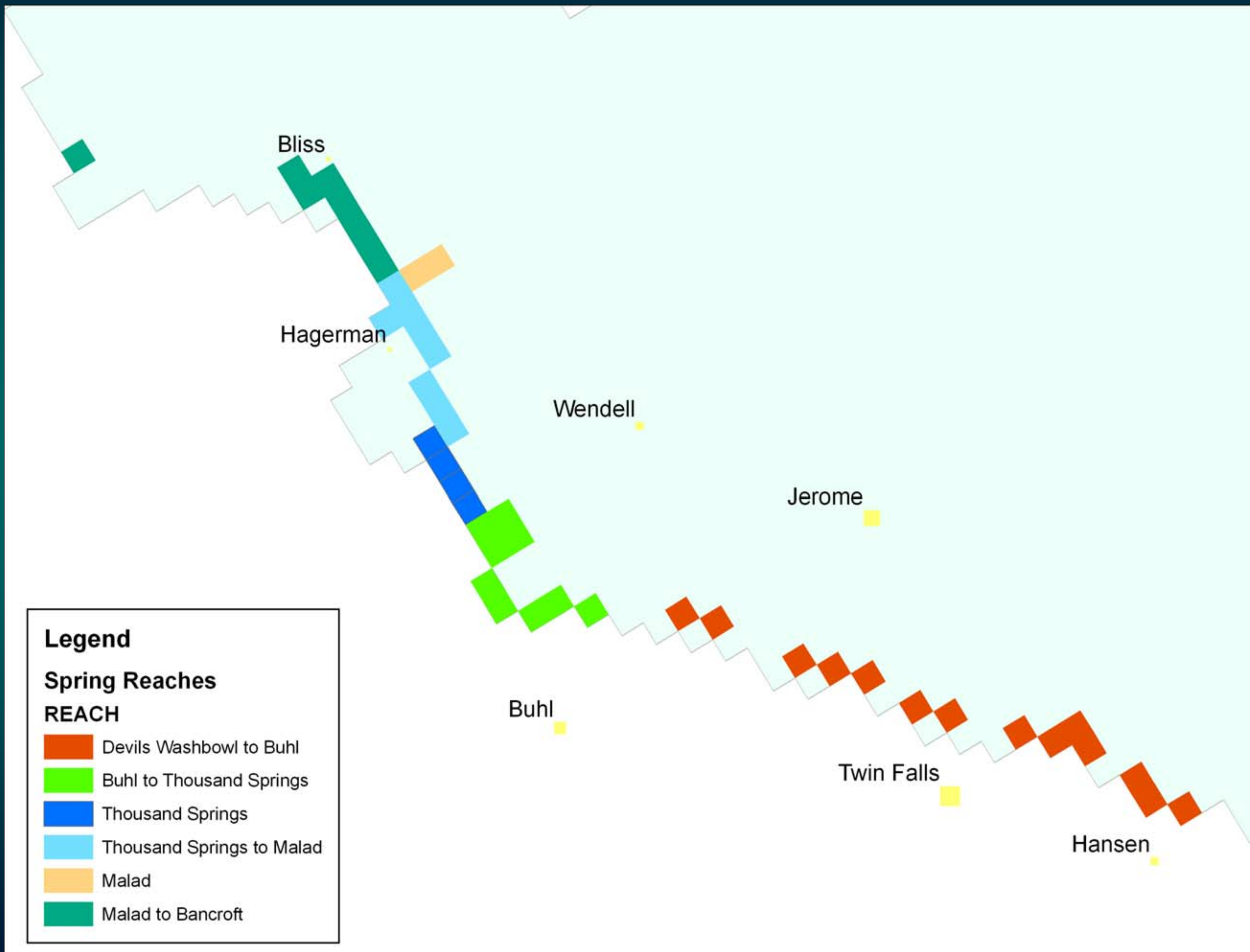


Close-up of Model Grid

Snake River Representation



Spring Representation



- Model Water Budget

Model Ins and Outs

Aquifer Recharge
- Precipitation
- Canal Seepage
- Surf.Water Irrigation
- Streams
- Tributary Valleys

Aquifer Discharge
- Pumping
- Spring discharge

Computer Model

Aquifer Head

Exchange With Surface Water

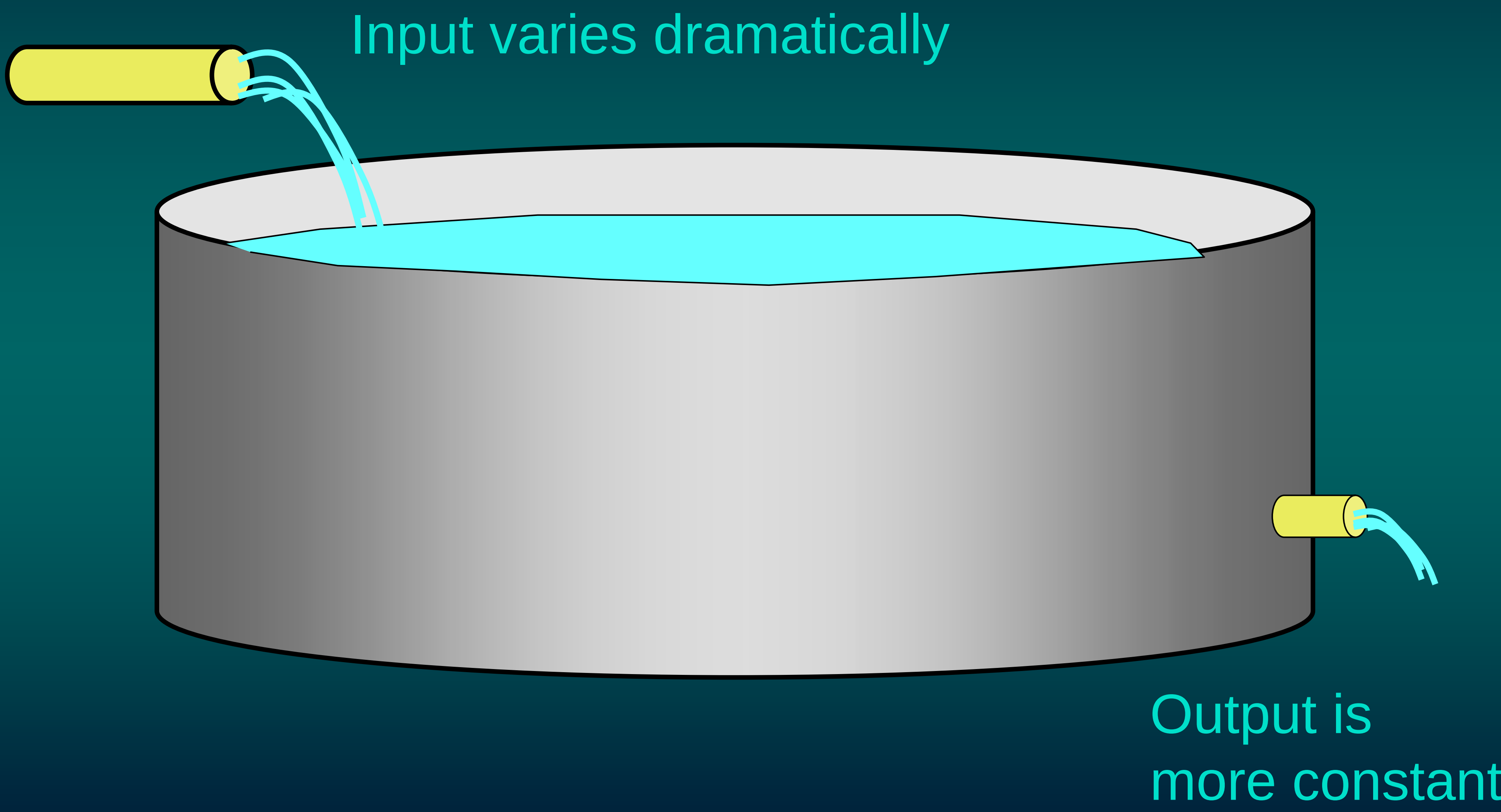
Model Water Budget

- Representation of all water coming and going from the aquifer over time
- One of the most important aspects of a numerical model
- Water budget drives the numerical model

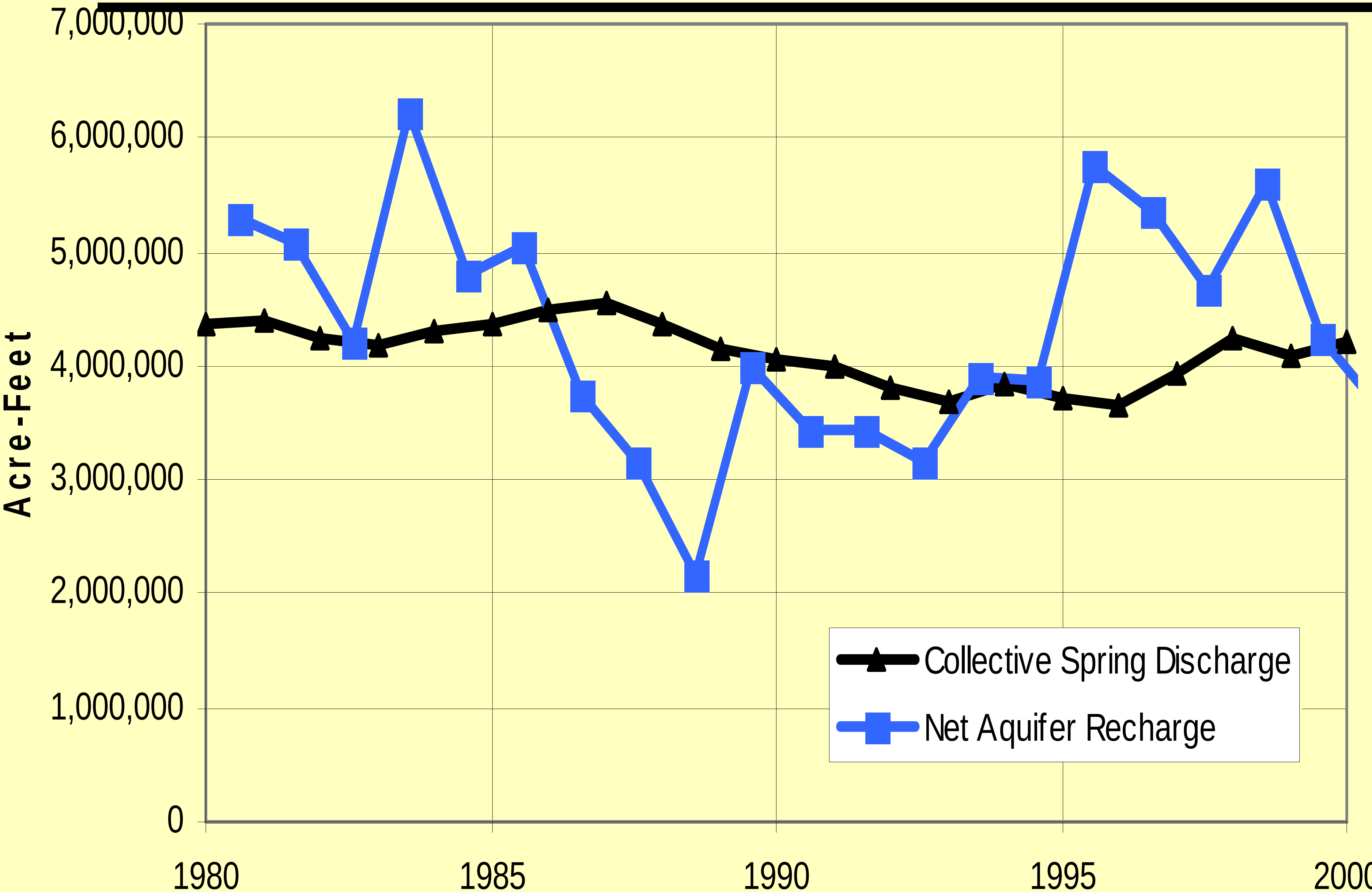
Aquifer Recharge and Discharge

- Recharge mechanisms
  - Surface water irrigation application (less ET)
  - Canal seepage
  - Subsurface flow from tributary valleys
  - Precipitation directly on the plain
  - River losses
- Discharge mechanisms
  - Springs and river gains
  - Ground water pumping

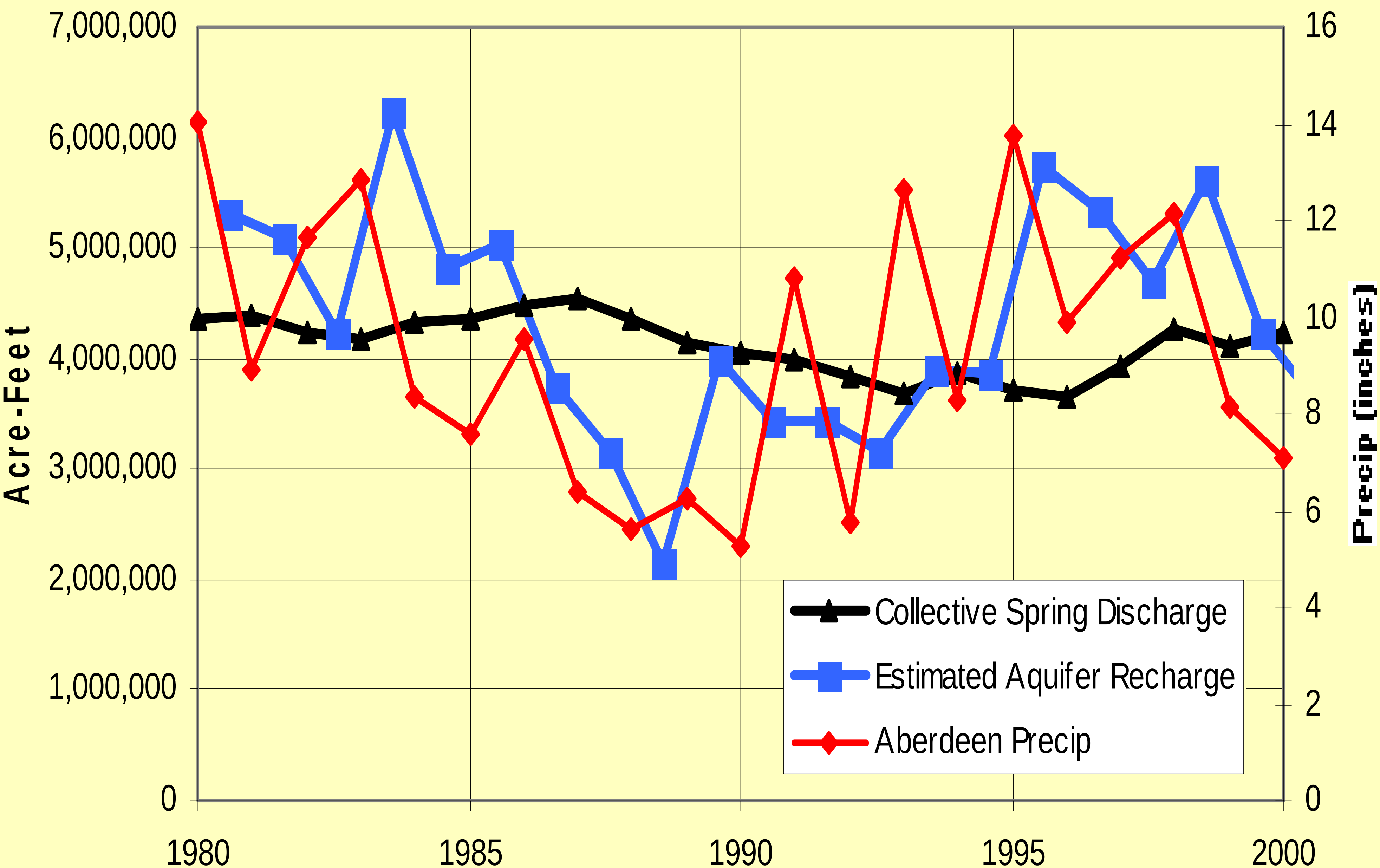
The aquifer is a large, leaky tank filled with rocks

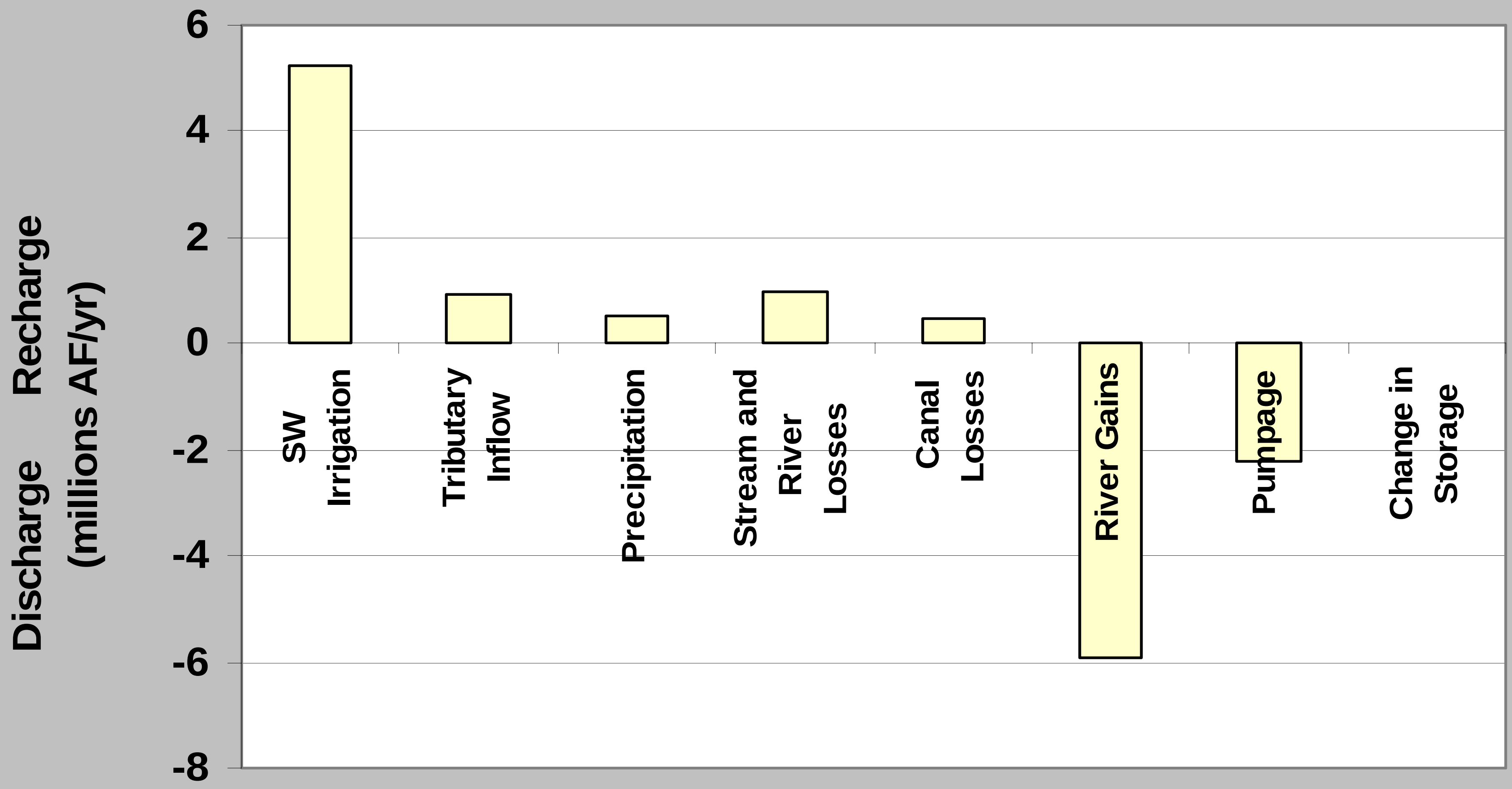


Recharge Variation With Time

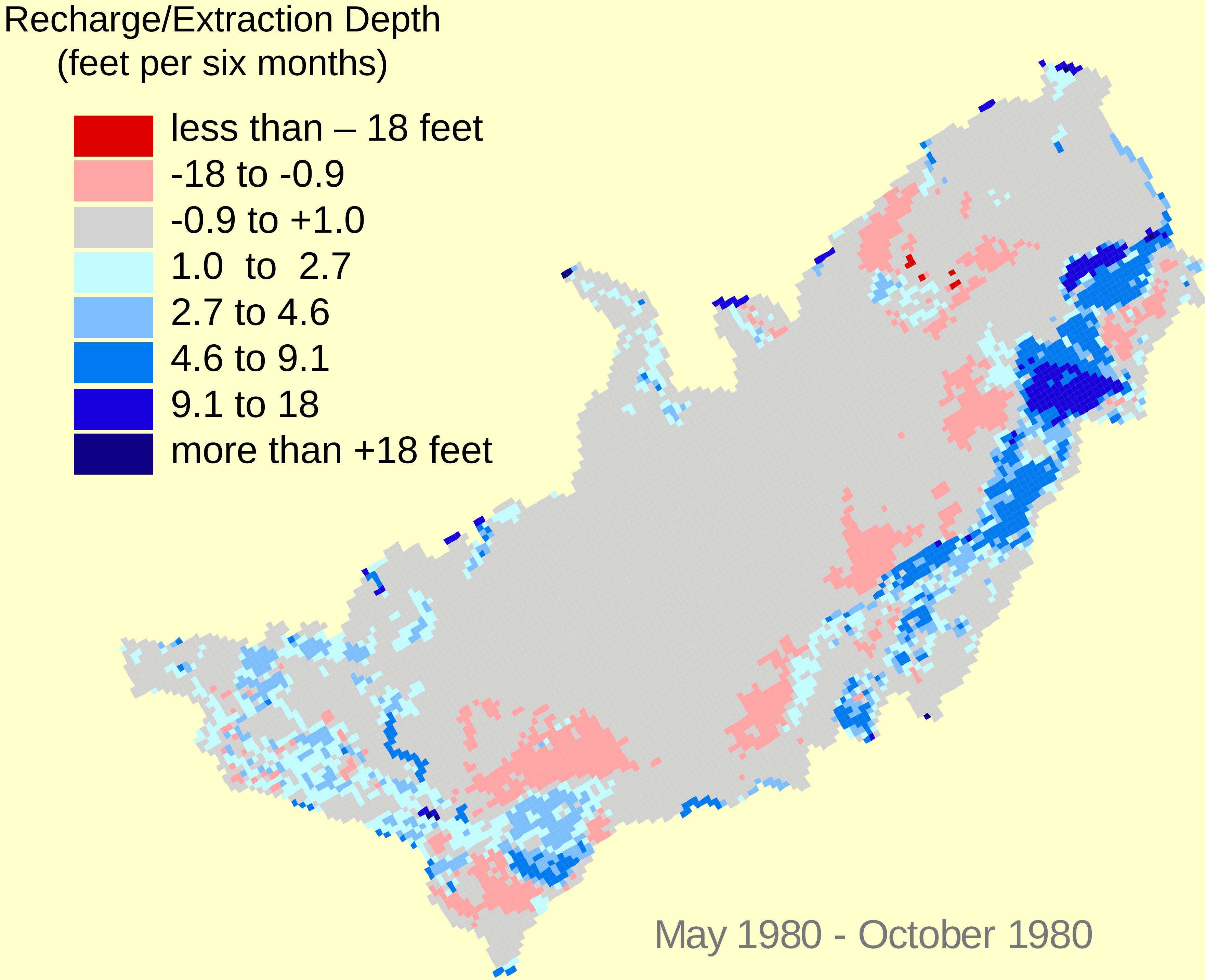


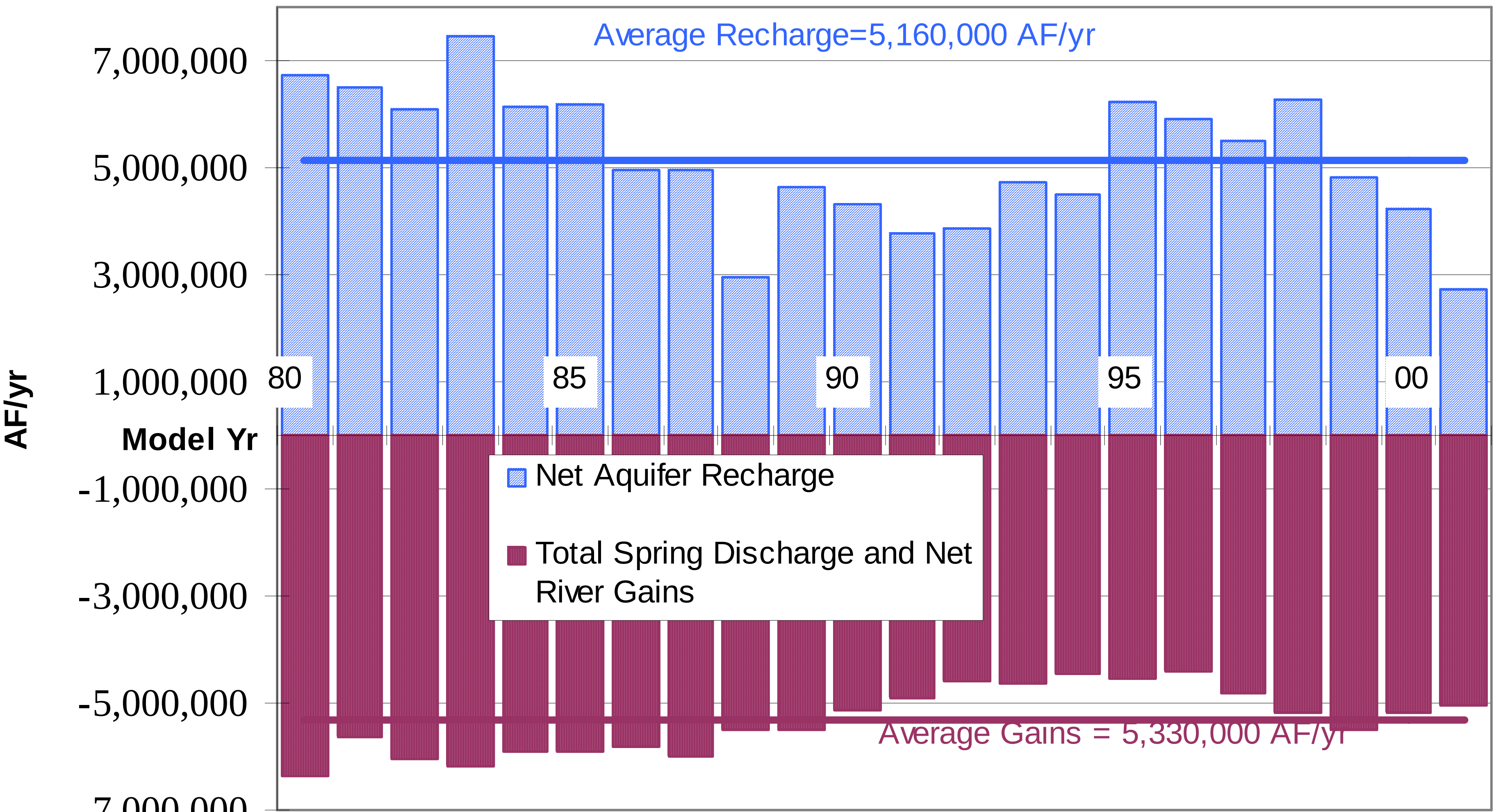
Precipitation Exerts Control





Components of recharge averaged for model period.


Recharge/Extraction Depth
(feet per six months)
less than – 18 feet
-18 to -0.9
-0.9 to +1.0
1.0 to 2.7
2.7 to 4.6
4.6 to 9.1
9.1 to 18
more than +18 feet
May 1980 - October 1980



Annual Net Aquifer Recharge and River Gains

- Managing changes in water budget provides opportunity for adjusting supply and demand
- Some elements out of our control
  - Precipitation
  - Tributary underflow
- Some elements can be managed
  - Consumptive use
  - Irrigation diversions, return flows, canal leakage
  - Ground-water pumping
  - Managed recharge

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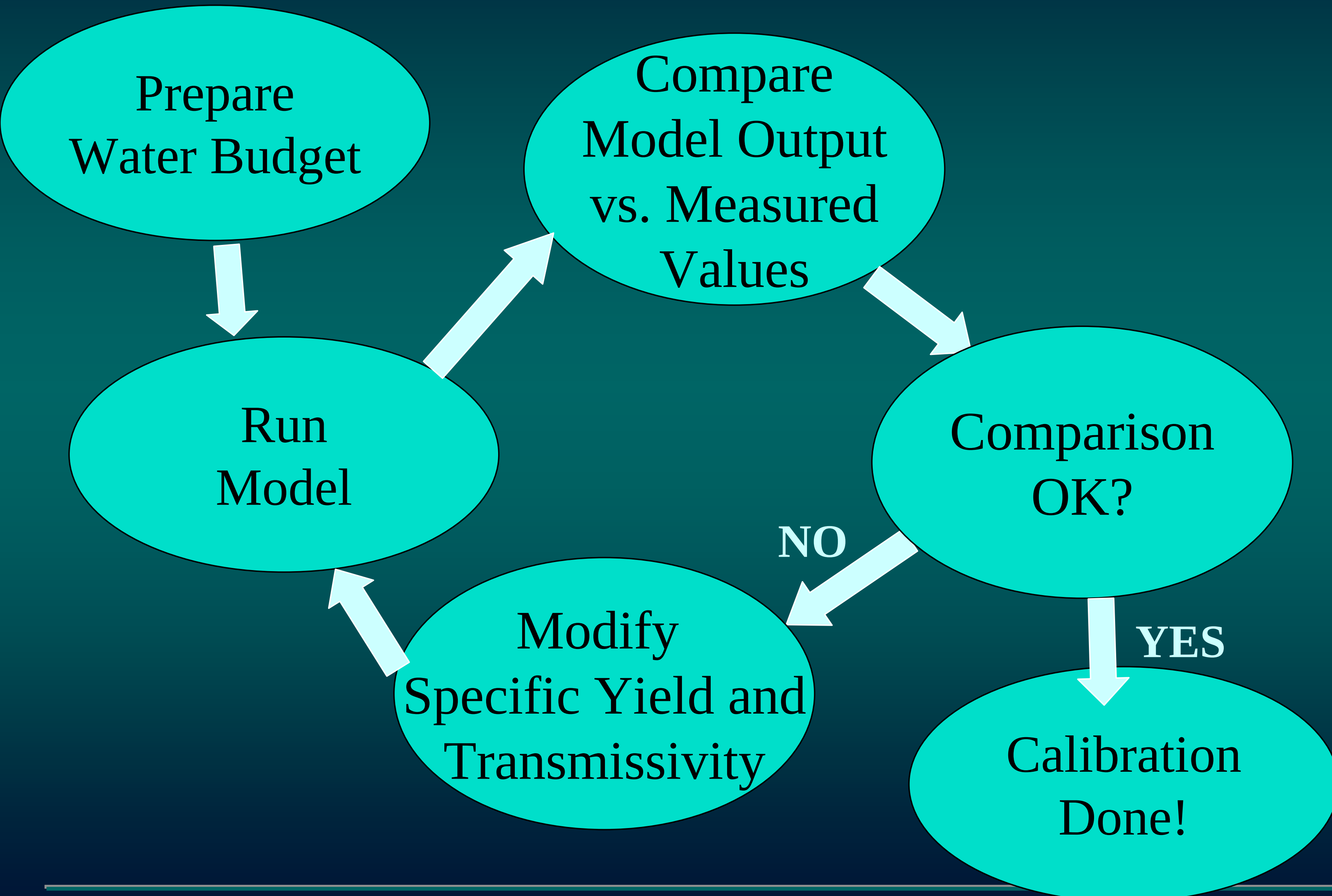
- Model Calibration

Model Calibration



Model Calibration

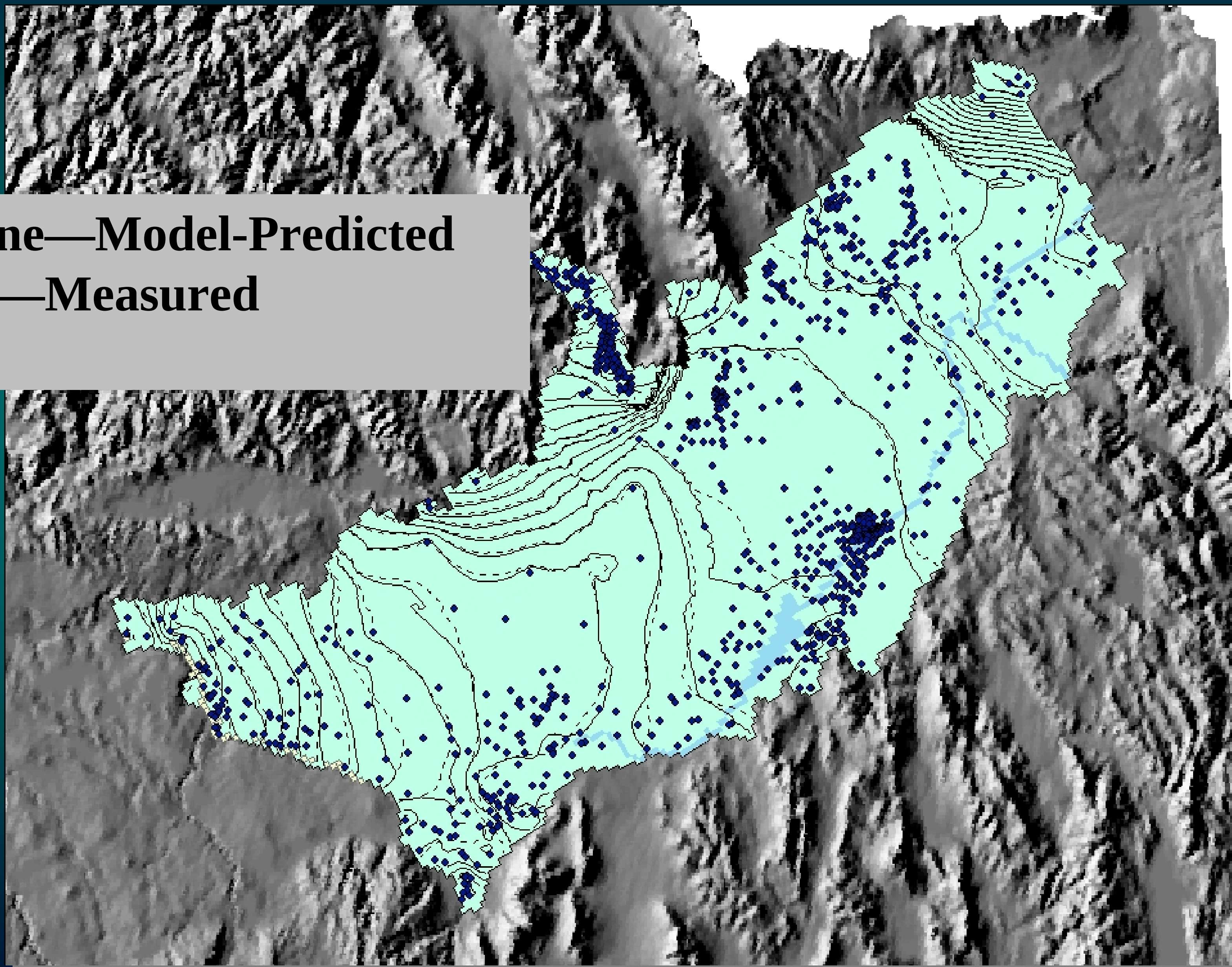
- Model calibrated using automated tools
- Thousands of model runs, looking for best fit to field measurements
  - Aquifer water levels
  - Spring discharges
  - River gains/losses

Measured Data for Calibration

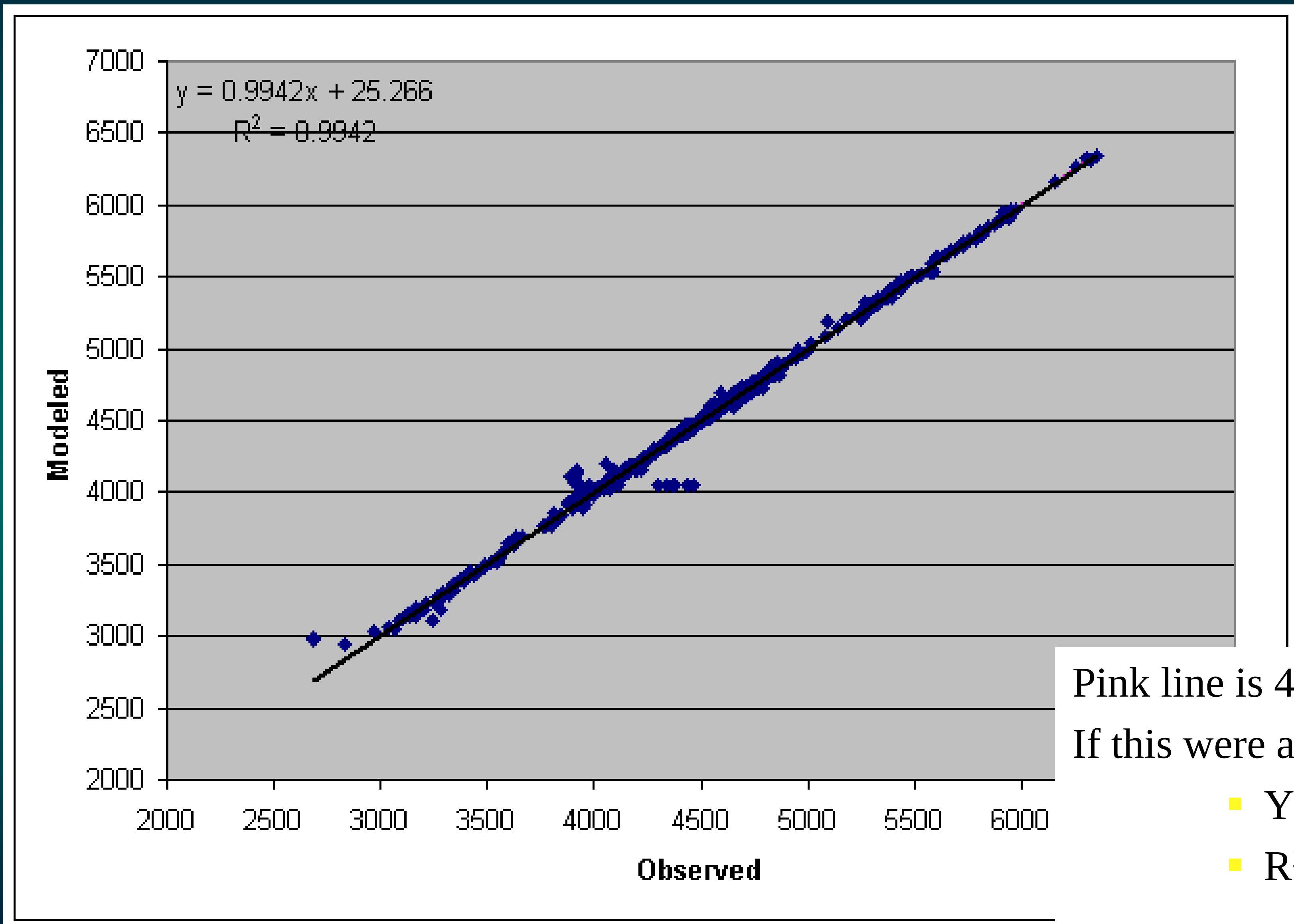
- Water table elevation data
  - USGS data
  - IDWR data
- Reach gain and loss data
  - IDWR reach gain and loss program
    - USGS gaging station data
    - Water master diversion data
- Spring Discharge
  - USGS data
  - Idaho Power data

Average Aquifer Water Levels May 1, 1982 through October 31, 2000

Dashed Line—Model-Predicted
Solid Line—Measured



Average Water Level Matches

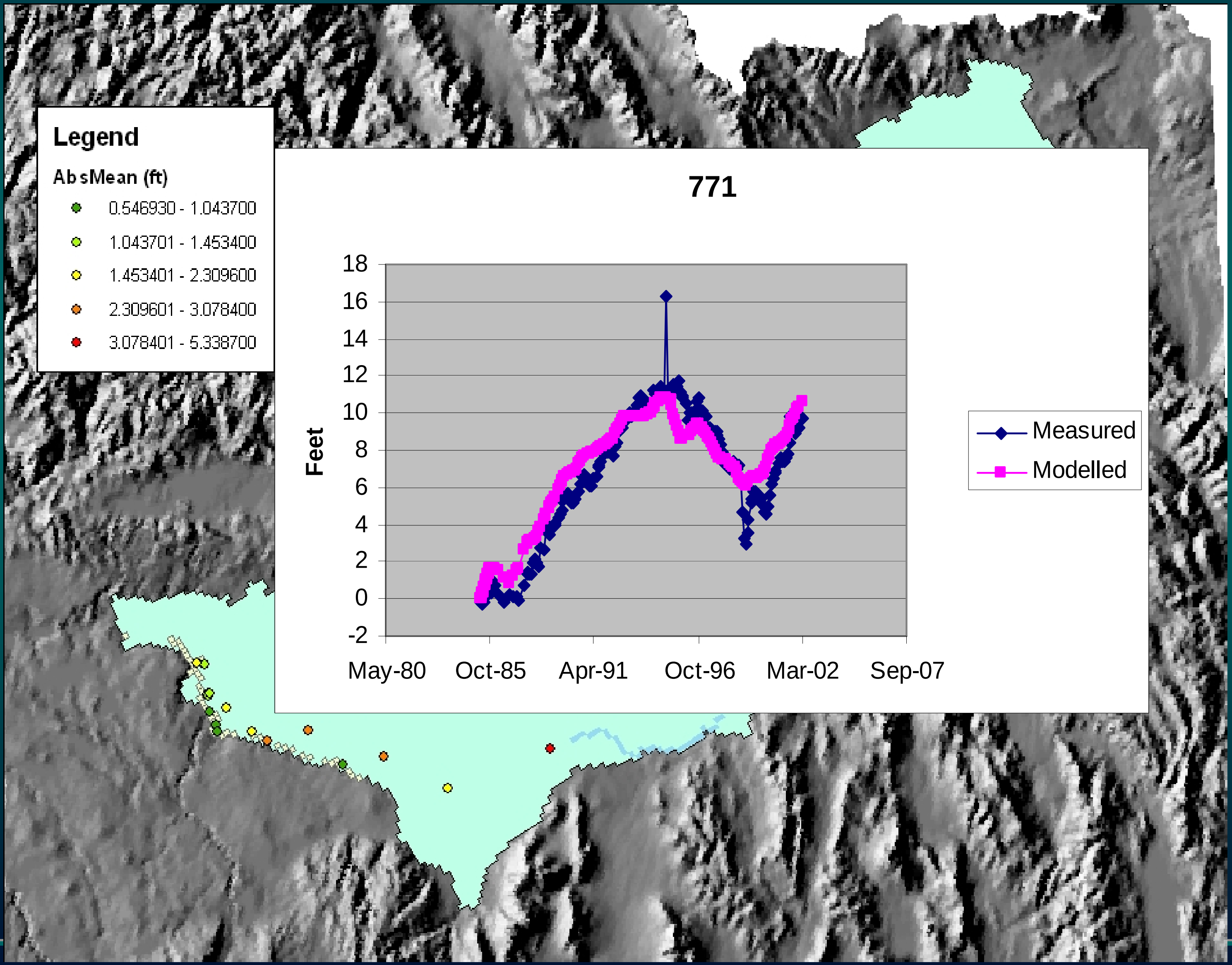


Pink line is 45º

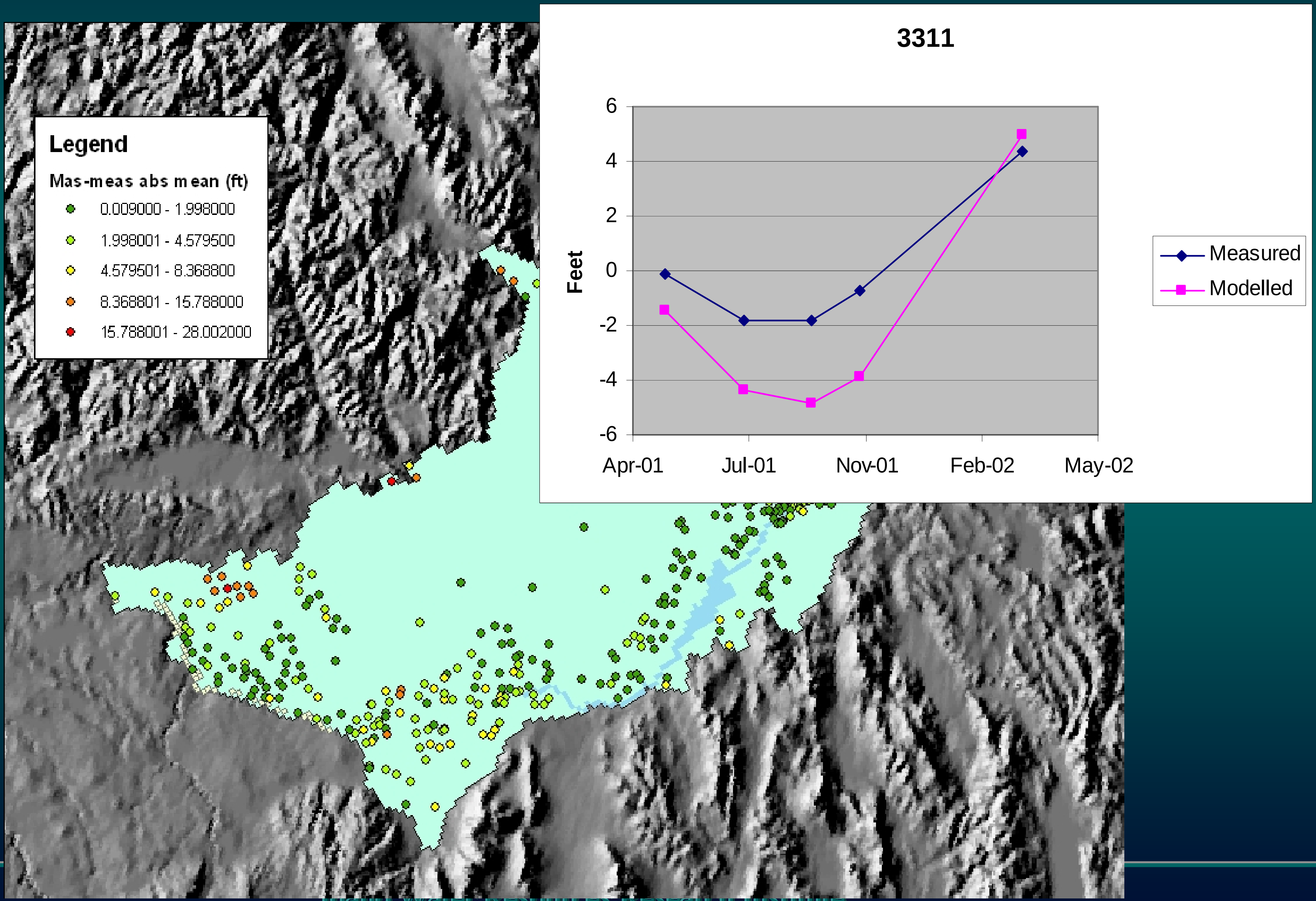
If this were a perfect match

- Y=1x + 0
- $R^2 = 1$

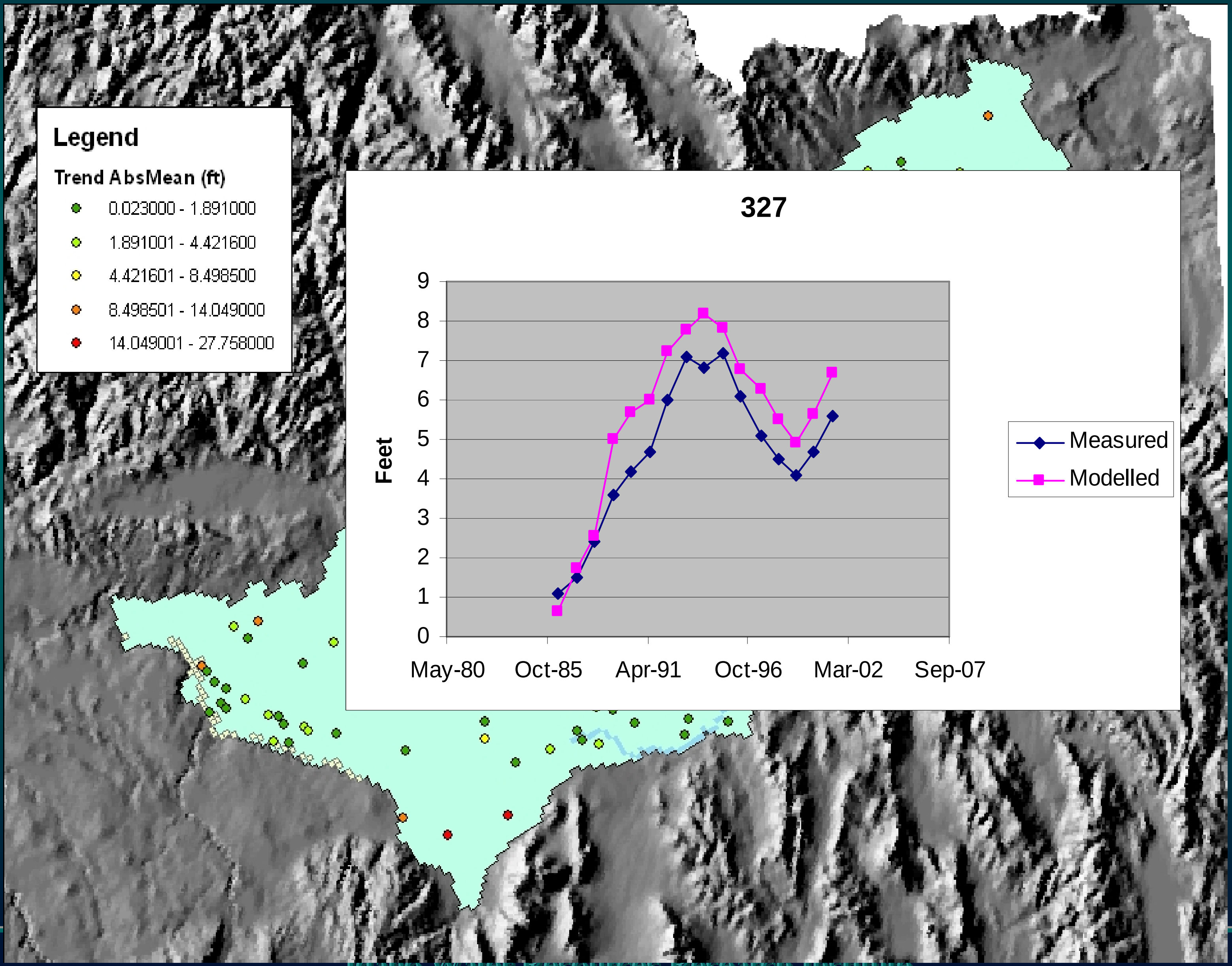
Aquifer Water Level Match Over Time



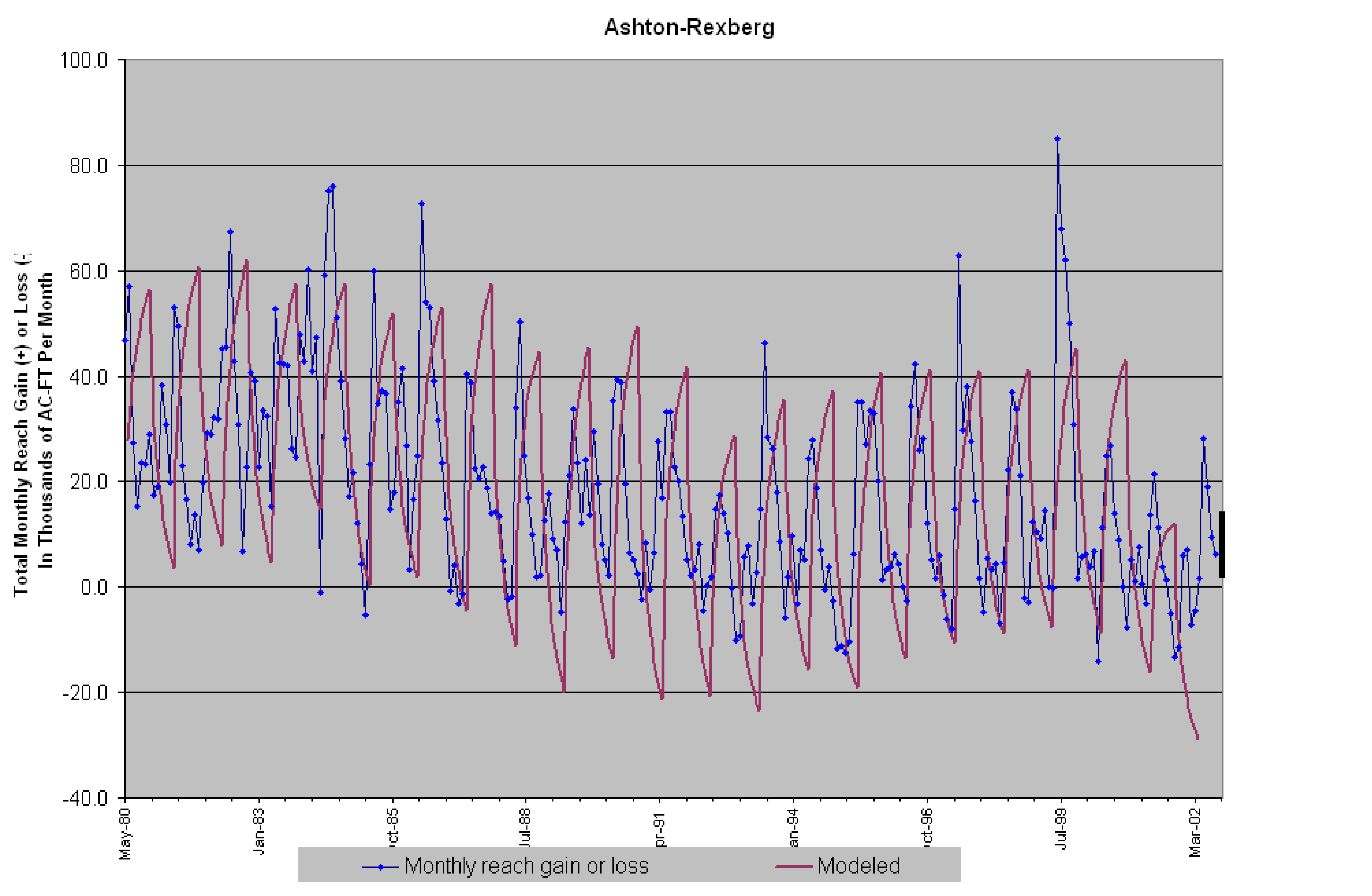
Aquifer Water Level Match Over Time



Aquifer Water Level Match Over Time



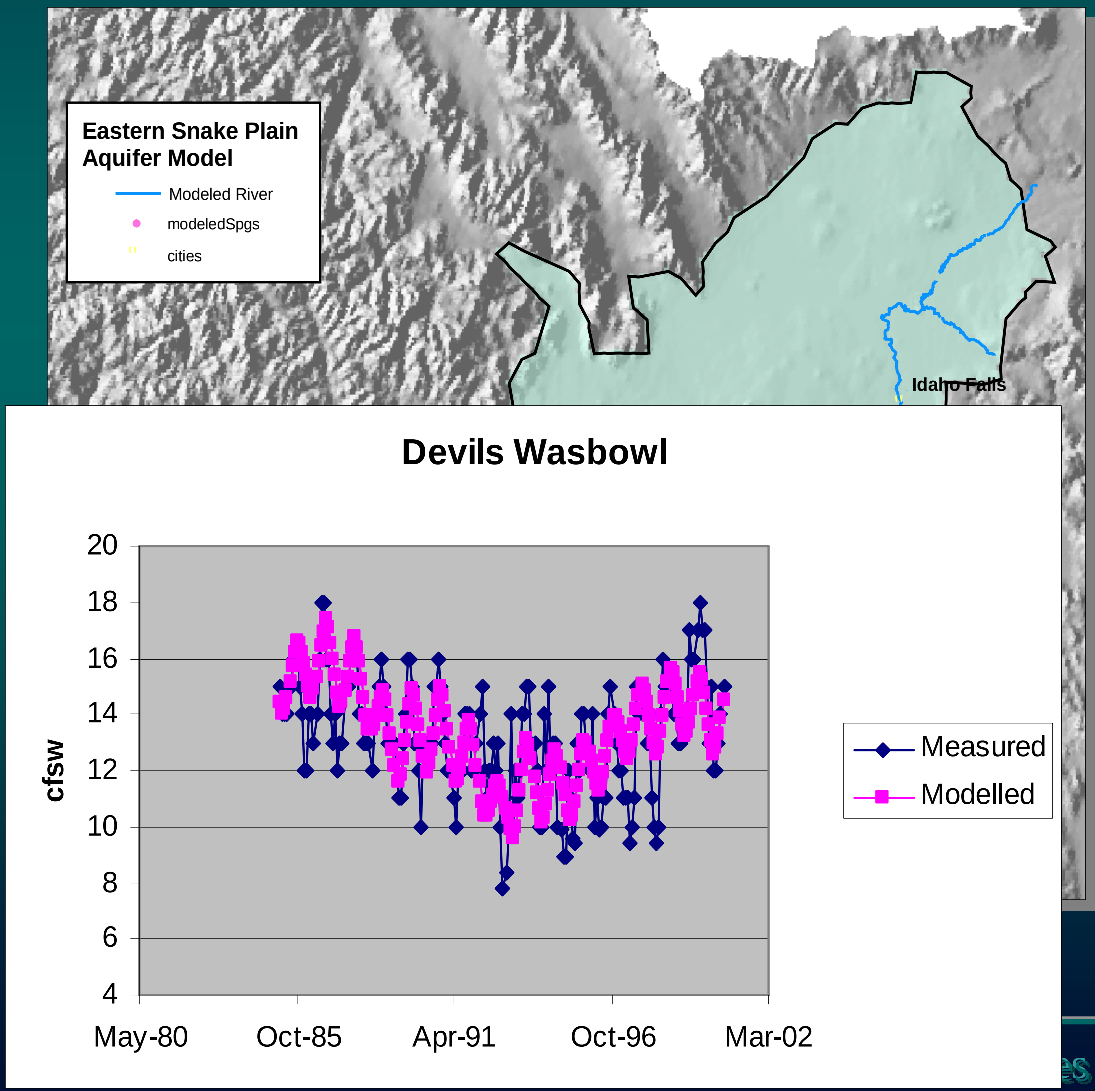
Snake River



Ashton-Rexberg
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-40.0
Total Monthly Reach Gain (+) or Loss (-)
In Thousands of AC-FT Per Month
May-80
Jan-83
Jul-88
Jul-99
Mar-02
Monthly reach gain or loss
Modeled

Springs

- Nine springs with significant time series



Calibration Summary

- Average Aquifer Measurements
  - 1008 water table elevation measurements
  - 5 Snake River gain and loss measurements
  - 6 spring measurements
- Aquifer Measurements Over Time
  - 12717 water table elevation measurements
  - 725 Snake River gain and loss measurements
  - 1526 spring discharge measurements
- Model Calibrated to over 15,000 measurements!

- Model Use

Model Use—Scenarios and Tools

- Scenarios pose ‘what if’ questions
  - What if nothing changes in water use?
  - What if the drought continues?
- Tools use the model for estimating the impacts of proposed changes
  - CREP
  - Water rights transfers

Scenarios

- Base Case Scenario
- Curtailment Scenario
- Drought Scenario
- Managed Recharge Scenario
- A&B Scenario
- Continued Conversion to Sprinkler Scenario
- No Changes to Surface Water Practices Scenario

- We will show example results for Curtailment, Base Case and Managed Recharge Scenarios

Scenarios (cont'd)

- Scenarios estimate impacts to river reaches due to changes in hydrologic conditions or practices
- Some scenarios require large assumptions
  - Drought scenario—future drought conditions
  - Base Case Scenario—future water supply and use
  - Managed Recharge Scenario—future excess water availability

Scenarios (concluded)

- Primary reason for running scenarios is to ascertain how the hydrologic system responds to changes in water supply or practices
- Scenarios best evaluated in terms of changes in river gains—not absolute gains
- No one scenario defines the whole system
  - Best to evaluate the scenarios as a group

- Some example scenarios

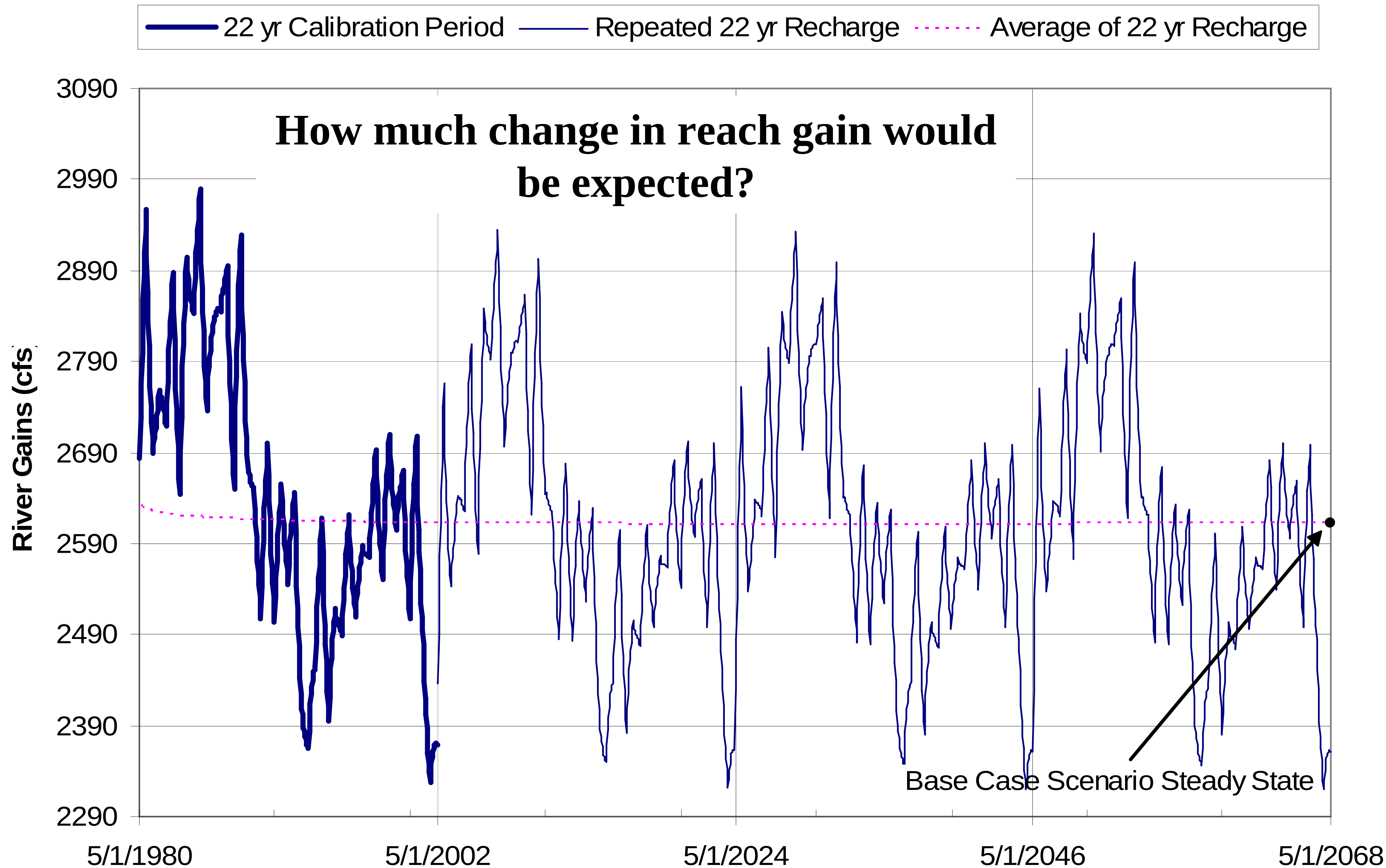
Base Case Scenario

"If current land and water use practices continue and if the 22-year period from 1980 to 2002 represents future water supply conditions, what will be the effect on spring discharge and Snake River gains and losses?"

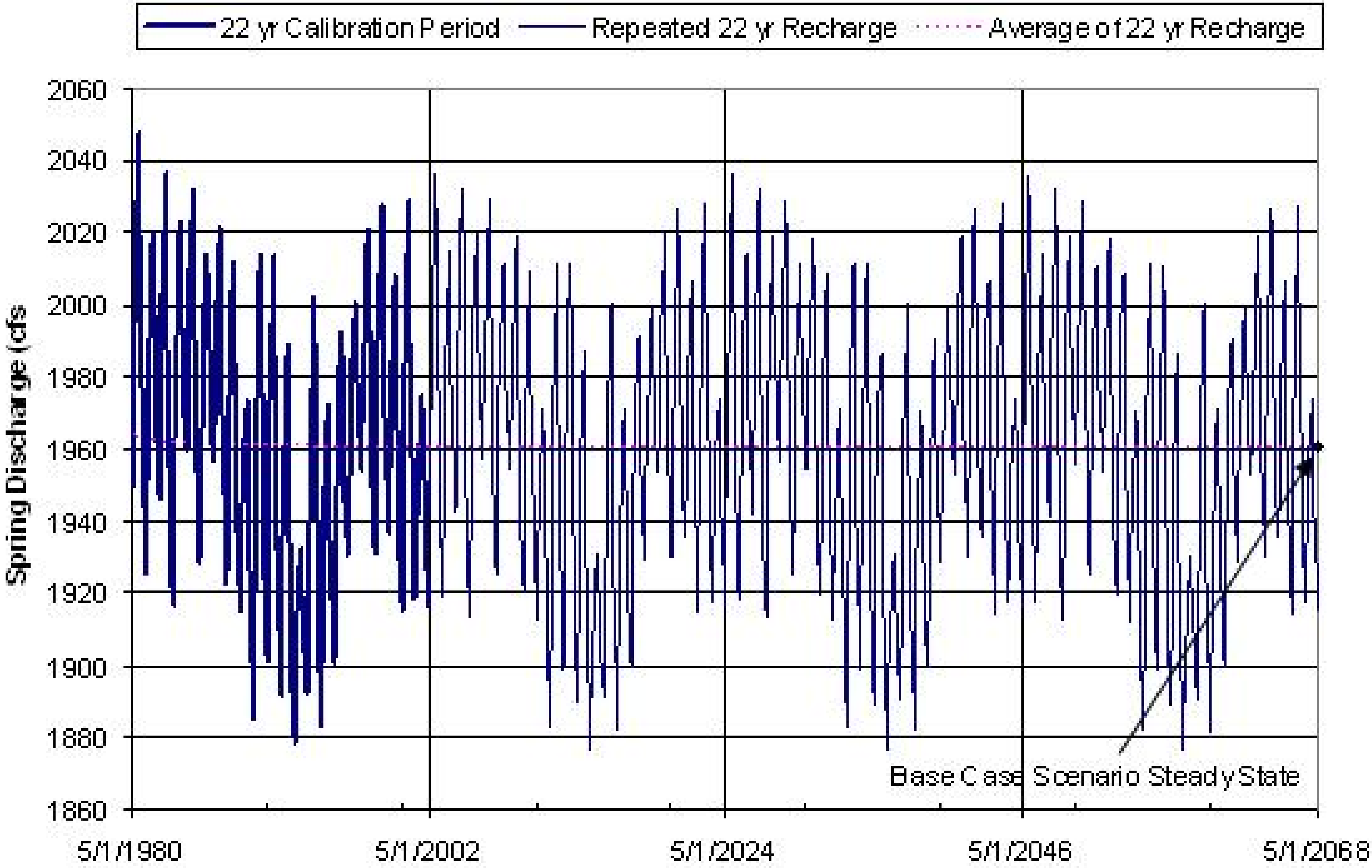
- Method—repeats past 22 years of water supply and practice multiple times in the future

Base Case Scenario (cont'd)

- Major assumptions
  - Future water supply identical to last 22 years
  - Evolution of water use practices identical to last 22 years
- Not realistic, but useful for determining whether we are yet to experience a huge impact from past activities



Base Case Scenario predicted impacts—Near Blackfoot to Neeley Reach



Base Case Scenario predicted impacts—Thousand Springs Reach

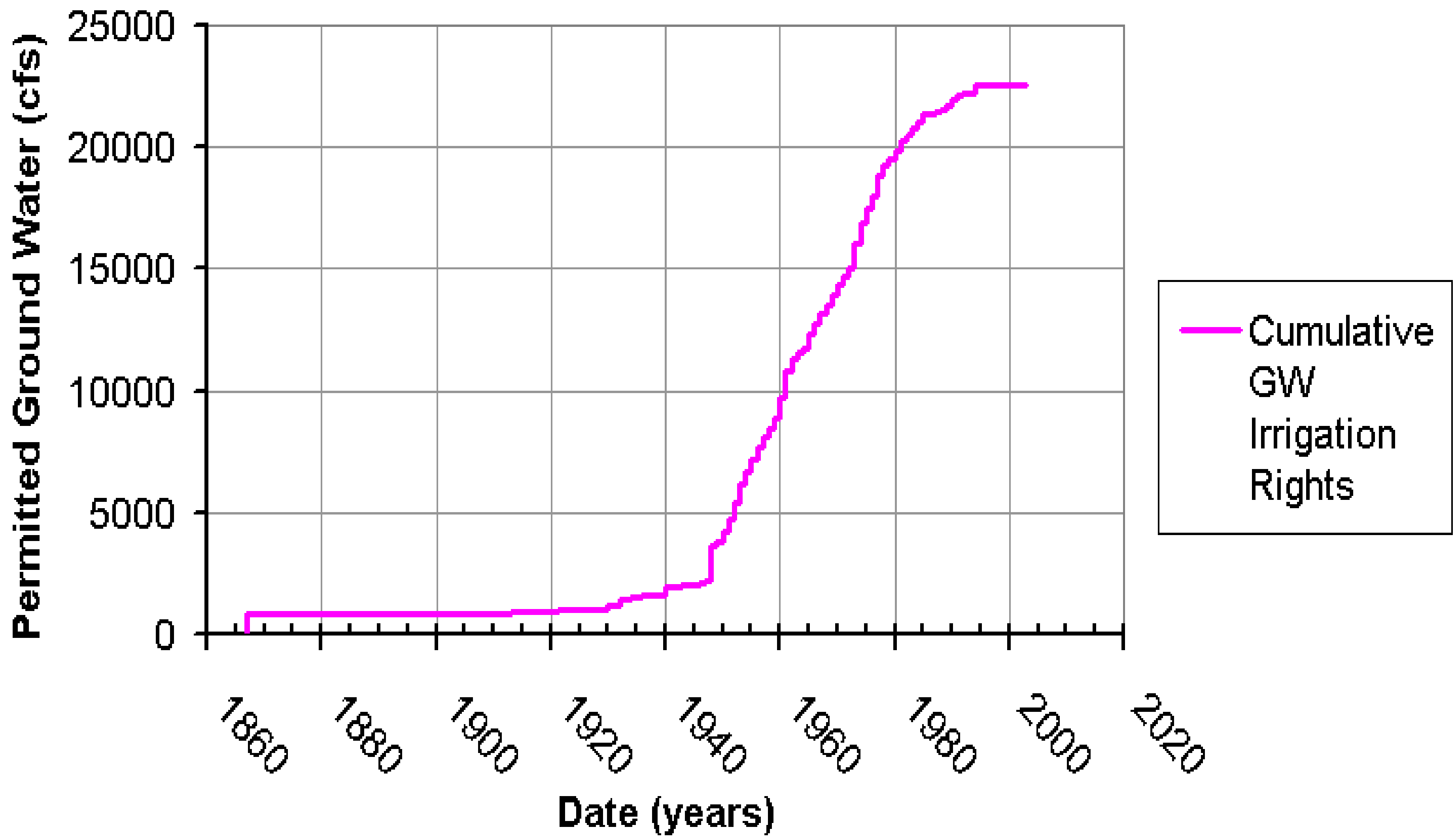
Curtailment Scenario

"If ground water pumping junior to a specified priority date were to be curtailed, what would be the effect on spring discharge and Snake River gains and losses?"

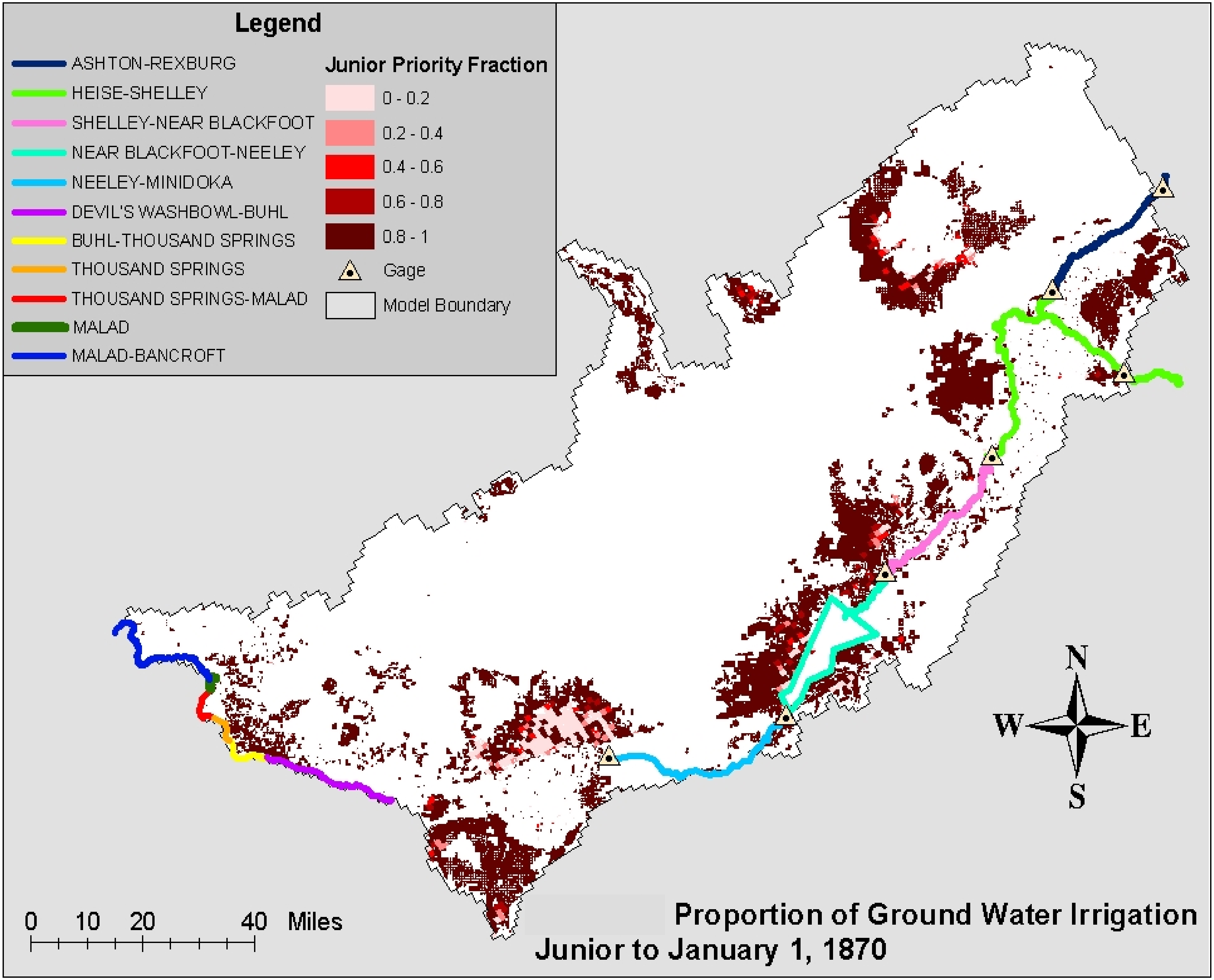
- Method—evaluates impact to the river reaches of curtailing ground-water pumping junior to each of 5 cut-off priority dates
  - Ground-water use associated with each date is determined
  - Impacts to river due to that use are evaluated

Curtailment Scenario (concluded)

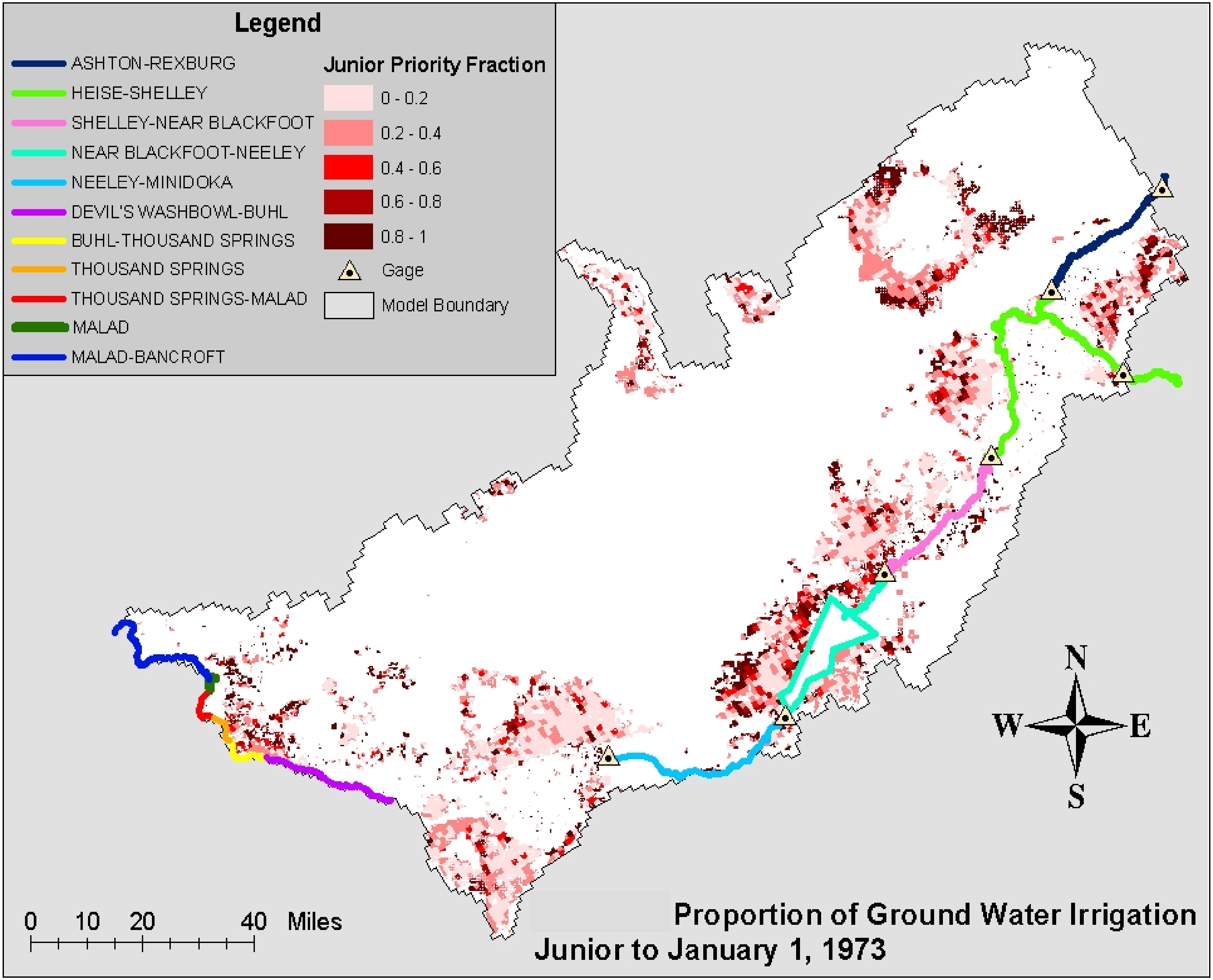
- Benefit depends on location of river reach
  - Highly dependent on location of curtailed acres
  - Takes long time for benefit to accrue
- Scenario predicts that ground water pumping accounts for approximately 50% of measured decline in Thousand Springs area
  - Balance of declines due to changes in surface water practices and drought



Ground water priorities on the eastern Snake River Plain.

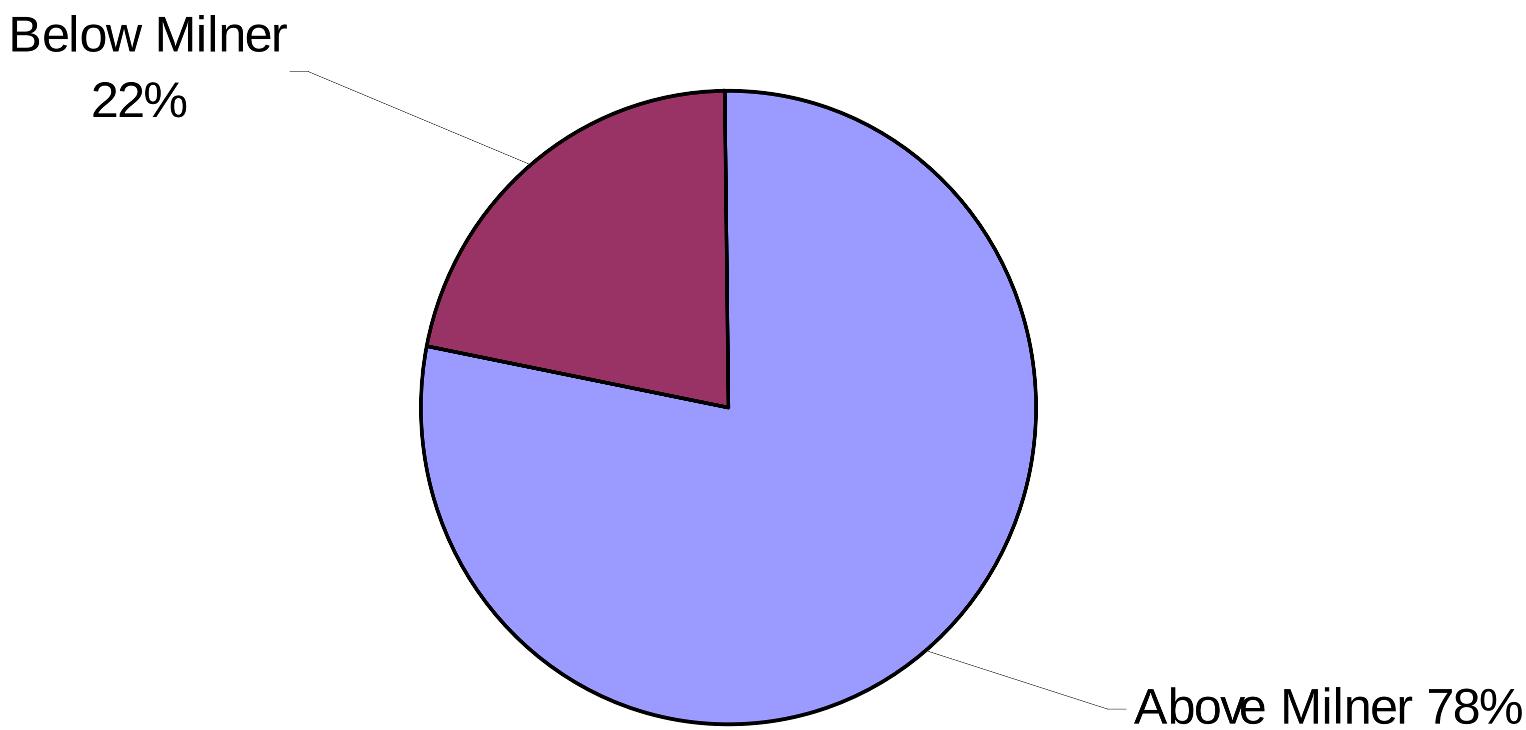


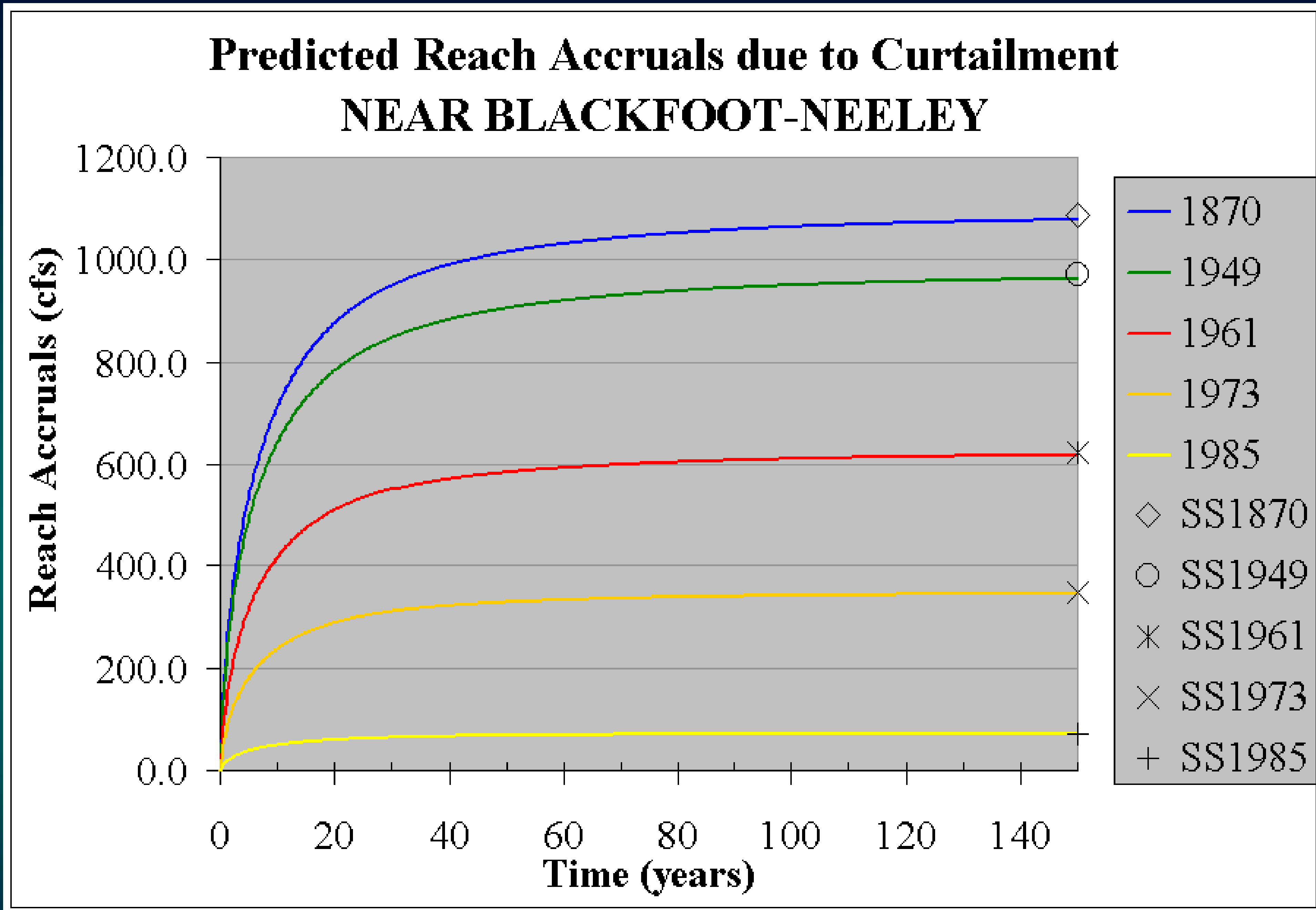
Legend
ASHTON-REXBURG
HEISE-SHELLEY
SHELLEY-NEAR BLACKFOOT
NEAR BLACKFOOT-NEELEY
NEELEY-MINIDOKA
DEVIL'S WASHBOWL-BUHL
BUHL-THOUSAND SPRINGS
THOUSAND SPRINGS
THOUSAND SPRINGS-MALAD
MALAD
MALAD-BANCROFT
Junior Priority Fraction
0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
Gage
Model Boundary
N
W
E
S
0 10 20 40 Miles
Proportion of Ground Water Irrigation
Junior to January 1, 1870



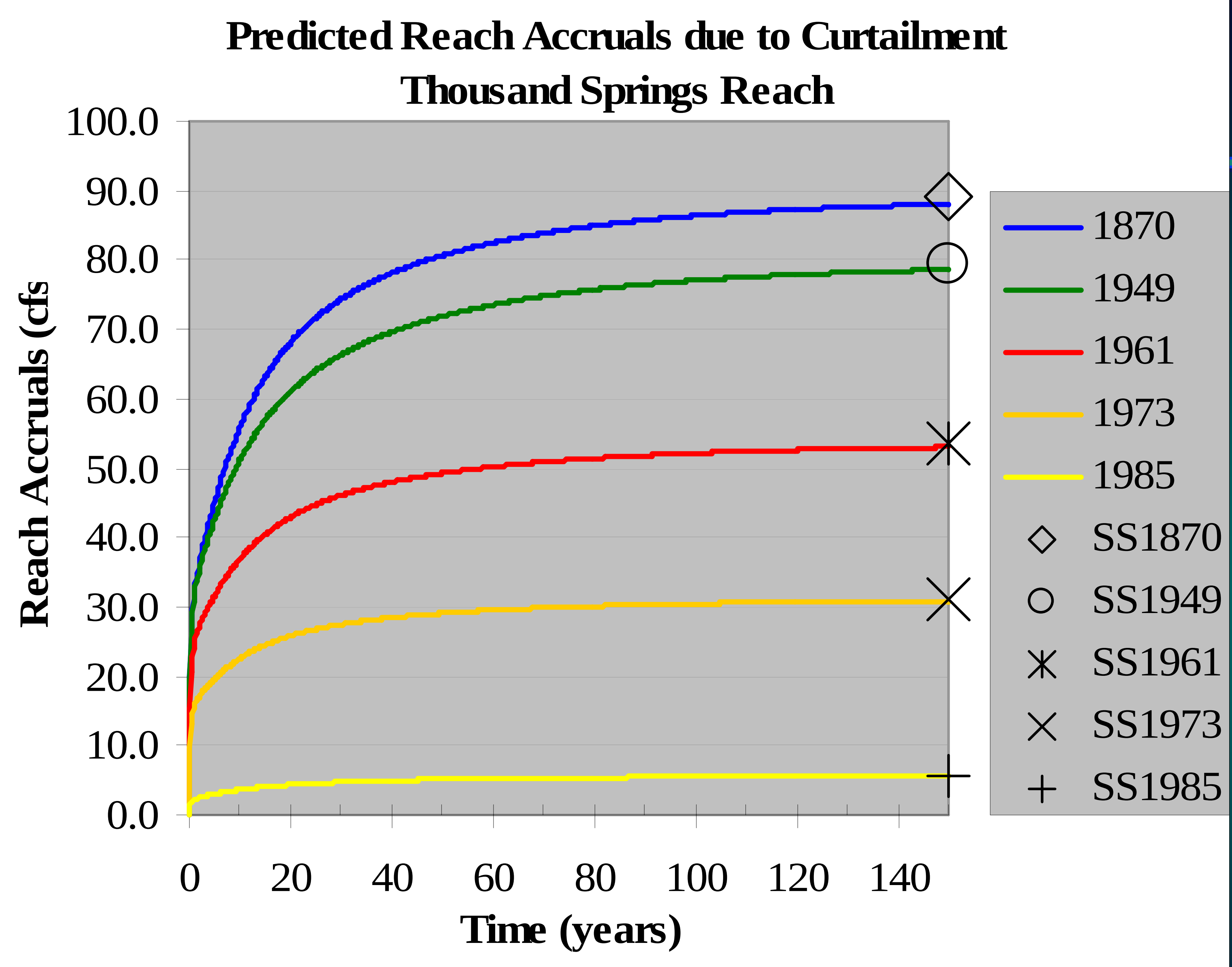
Proportion of Ground Water Irrigation Junior to January 1, 1973

Impact of 1973 Curtailment (916 cfs Total)





Predicted Reach Accruals due to Curtailment for Near Blackfoot-Neeley Reach.



Predicted Reach Accruals due to Curtailment for Thousand Springs Reach.

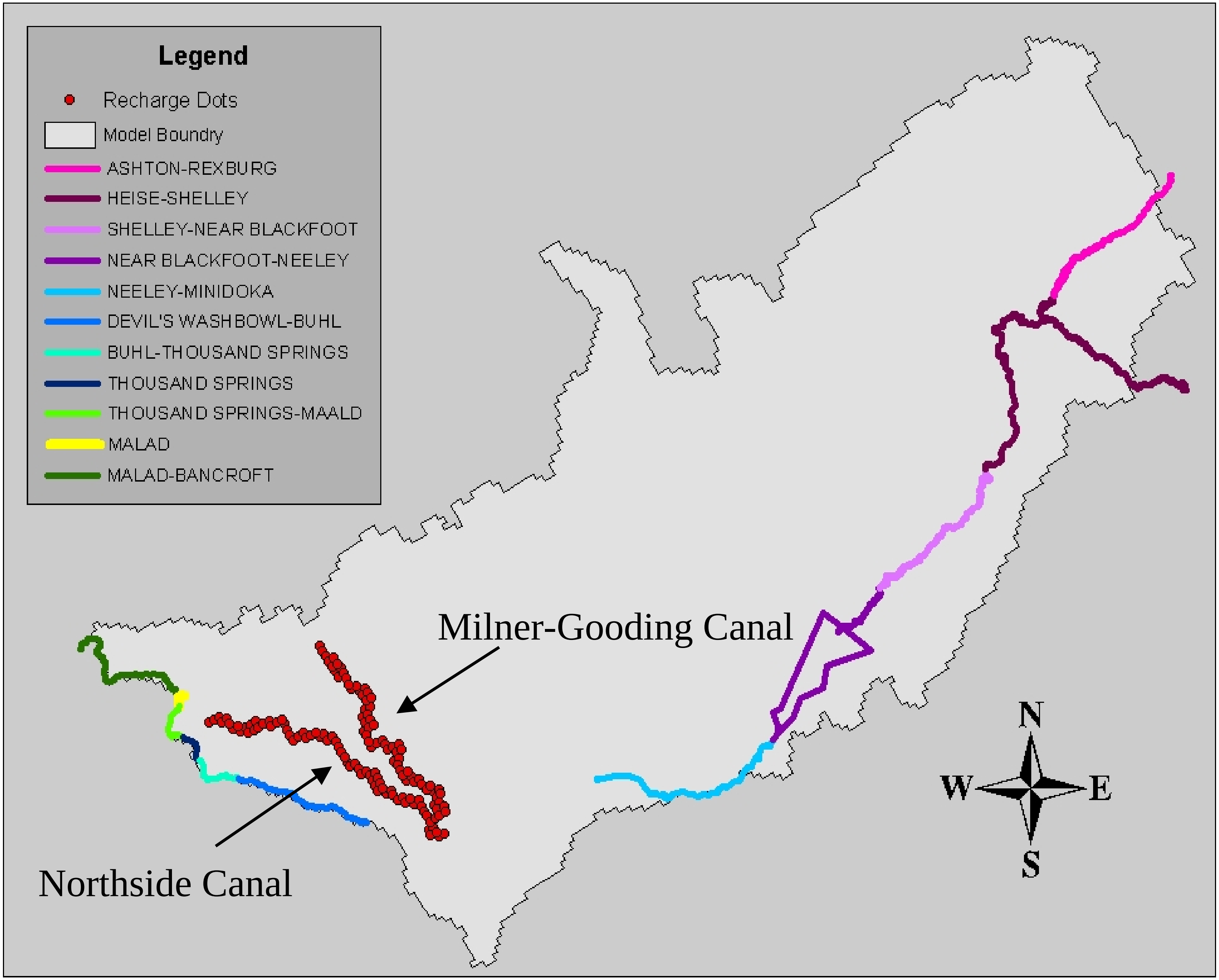
Managed Recharge Scenario

"If we had been recharging in the Milner-Gooding and Northside Canal recharge sites during the past 22 years using all available water and canal capacity, what would be the expected increases in discharges to the river as a result of the managed recharge?"

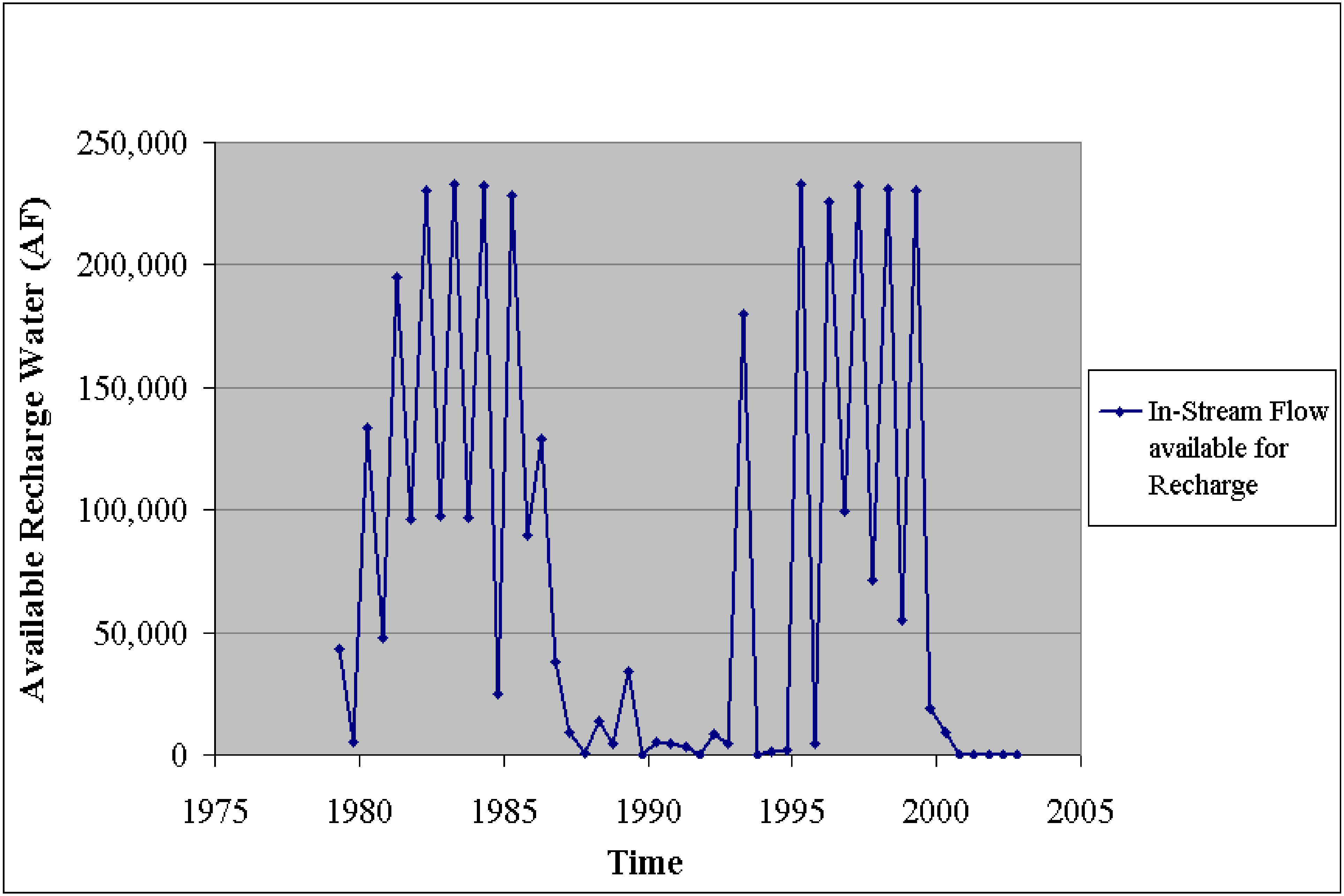
- Method—evaluates impact to the river reaches due to intentionally recharging the aquifer with excess water during the past 22 years

Managed Recharge Scenario (concluded)

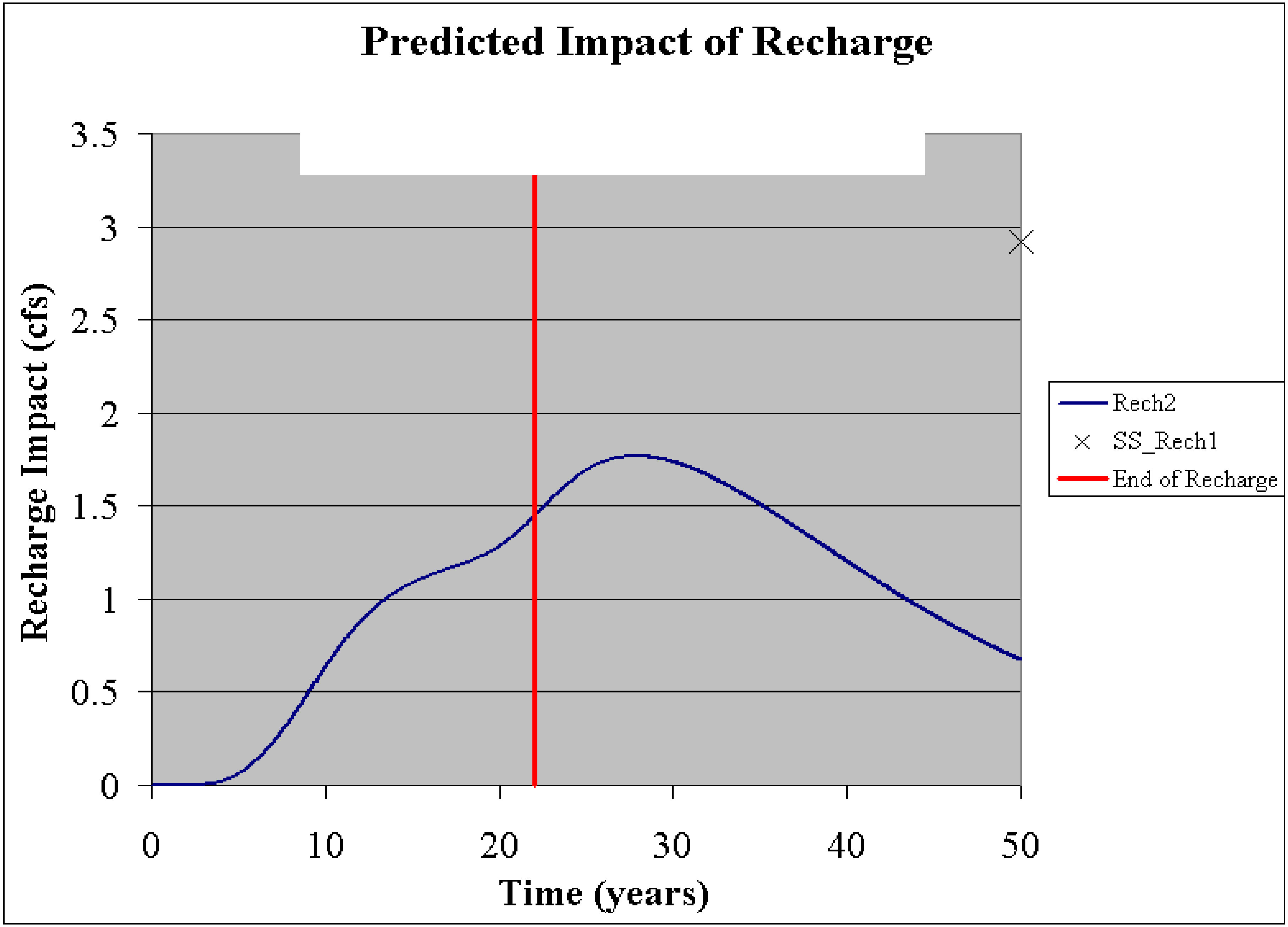
- Evaluated excess water for each of the past 22 years
- Evaluated canal carrying capacity during same period
- Used model to estimate the impacts to the river of conducting managed recharge with the excess water



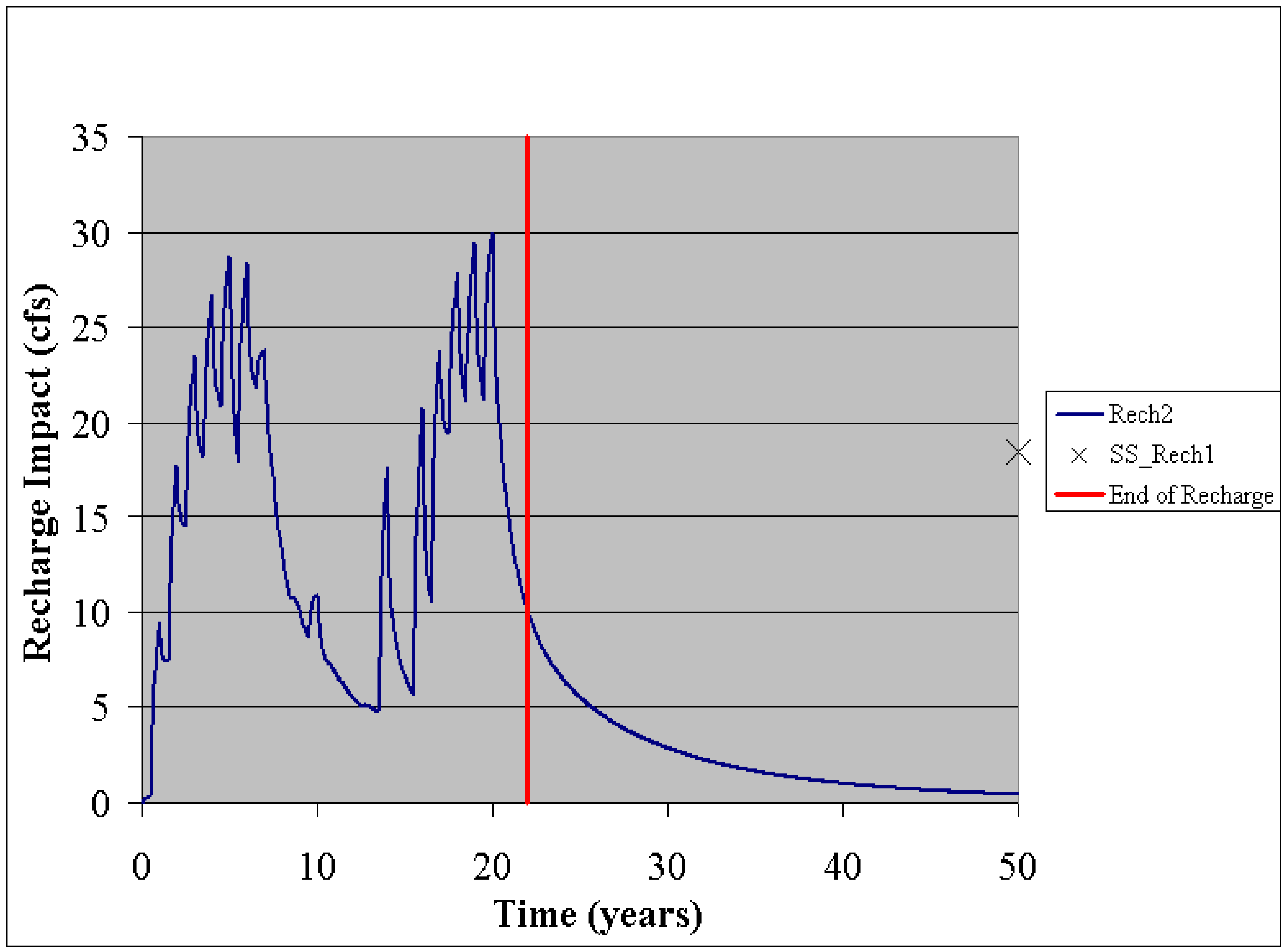
Location of Milner-Gooding and Northside Canals relative to hydraulically connected river reaches.



In-Stream flow available for managed recharge by 6-month stress period assuming 750 ft^3/sec past Milner.



Predicted impact to Ashton-Rexburg reach due to managed recharge in Milner-Gooding and Northside Canals.



Predicted impact to Thousand Springs reach due to managed recharge in Milner-Gooding and Northside Canals.

Tools

- Facilitate use of ground-water model
- Spreadsheets based on model results
- Examples of tools
  - Water Rights Transfer Tool
  - CREP Evaluation Tool
  - Managed Recharge Tool
  - Water Use Conversion Tool

Tools (cont'd)

- User inputs parameters
  - CREP: number of acres of CREP land in a specific county
  - Managed recharge: number of acre-feet of water to be recharged at a specific location
- Tools estimate impacts to nine river reaches resulting from the input parameters

Tools (concluded)

- Allow non-modeler to use model results
- Very useful when evaluating proposed changes in water use

Conclusions

- Model best science and tool available
- Objective model—developed with input from water user group experts
- Water budget major driver for model
  - Near balanced for 22-year calibration period
- Model calibrated to 15,000 measurements
- Scenarios provide assessment of specific questions
- Tools available for assessing proposed management activities

Contact Us?

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- IWRRI Web Page (model, documents, scenarios, etc)
  - http://www.if.uidaho.edu/~johnson/ifiwrri/projects.html