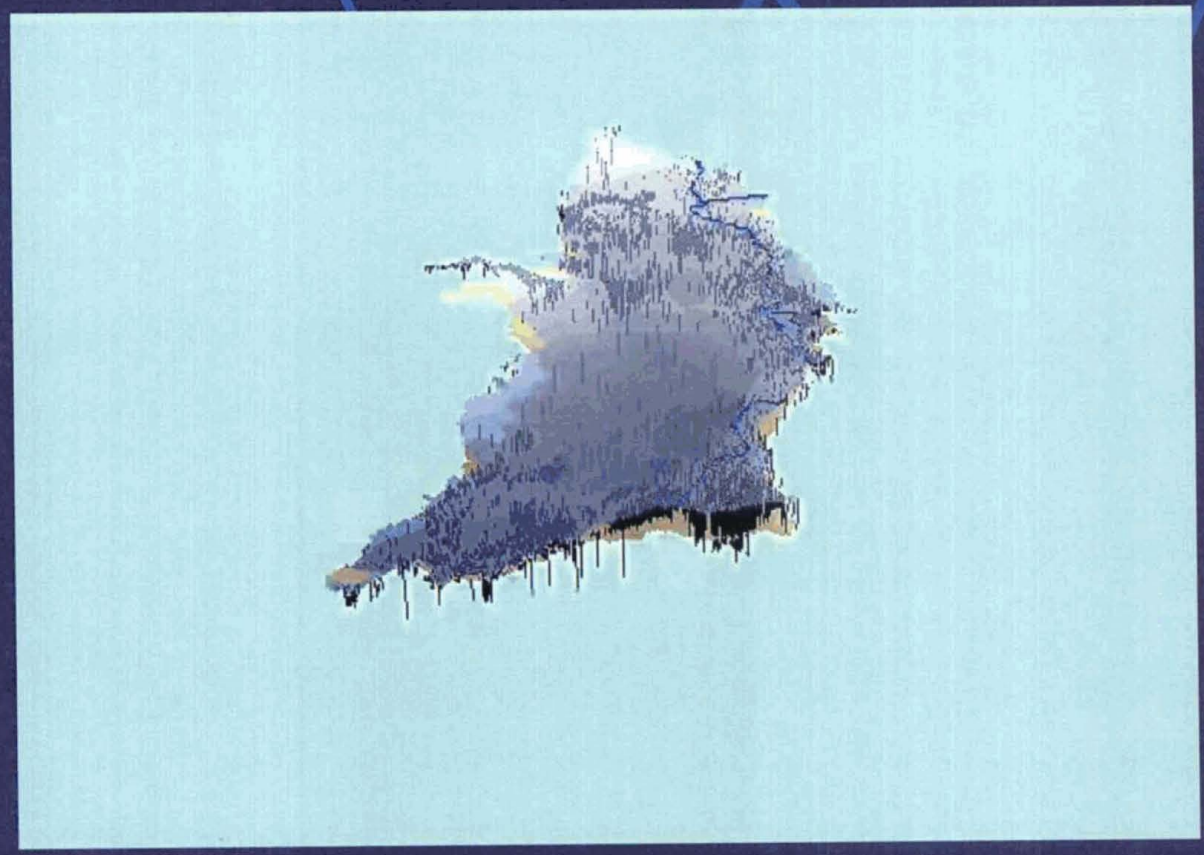
Eastern Snake Plain Aquifer Model



Outline

- ESHMC
- Background
- Introduction to the Model
  - Model Inputs
  - Model Structure
  - Calibration Targets
- How the Model is Used

Eastern Snake Hydrologic Modeling Committee

- Comprised of professionals working on Idaho water issues on the eastern Snake Plain
- Agency representative
  - IDWR, BOR, USGS, US Fish and Wildlife Service
- Industry Representative
  - Idaho Power Co
- Researchers
  - U of I, IWRRI
- Consultants
  - Surface water users, ground water users, spring users

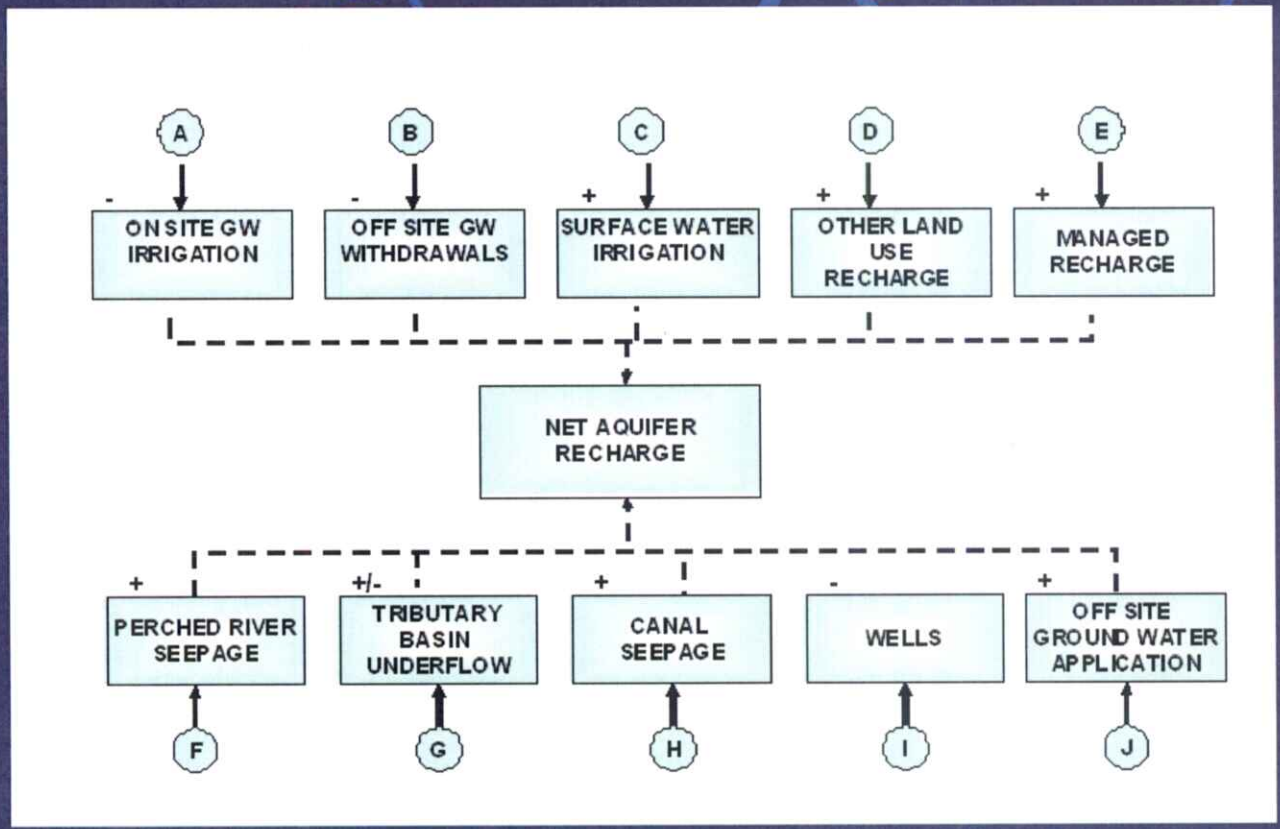
Background

- ESPA
  - Basalt Aquifer
  - Composed of many small coalescing and overlapping flows
- Volume of water in aquifer comparable to Lake Erie
- Hosts 17% of the springs in the U.S. over 100 cfs

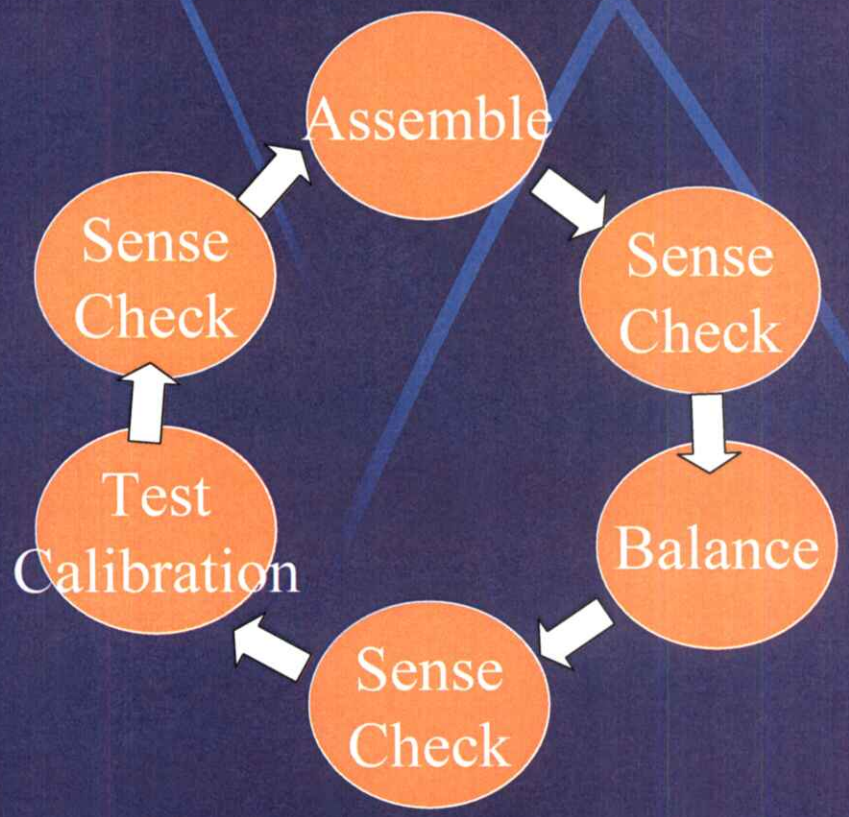
Model Inputs

- Identify Budget Components
  - Hydrogeologic processes
  - Prior studies
  - Input from ESHMC

Formalize Representation of Budget Components



Assemble & Test Budget

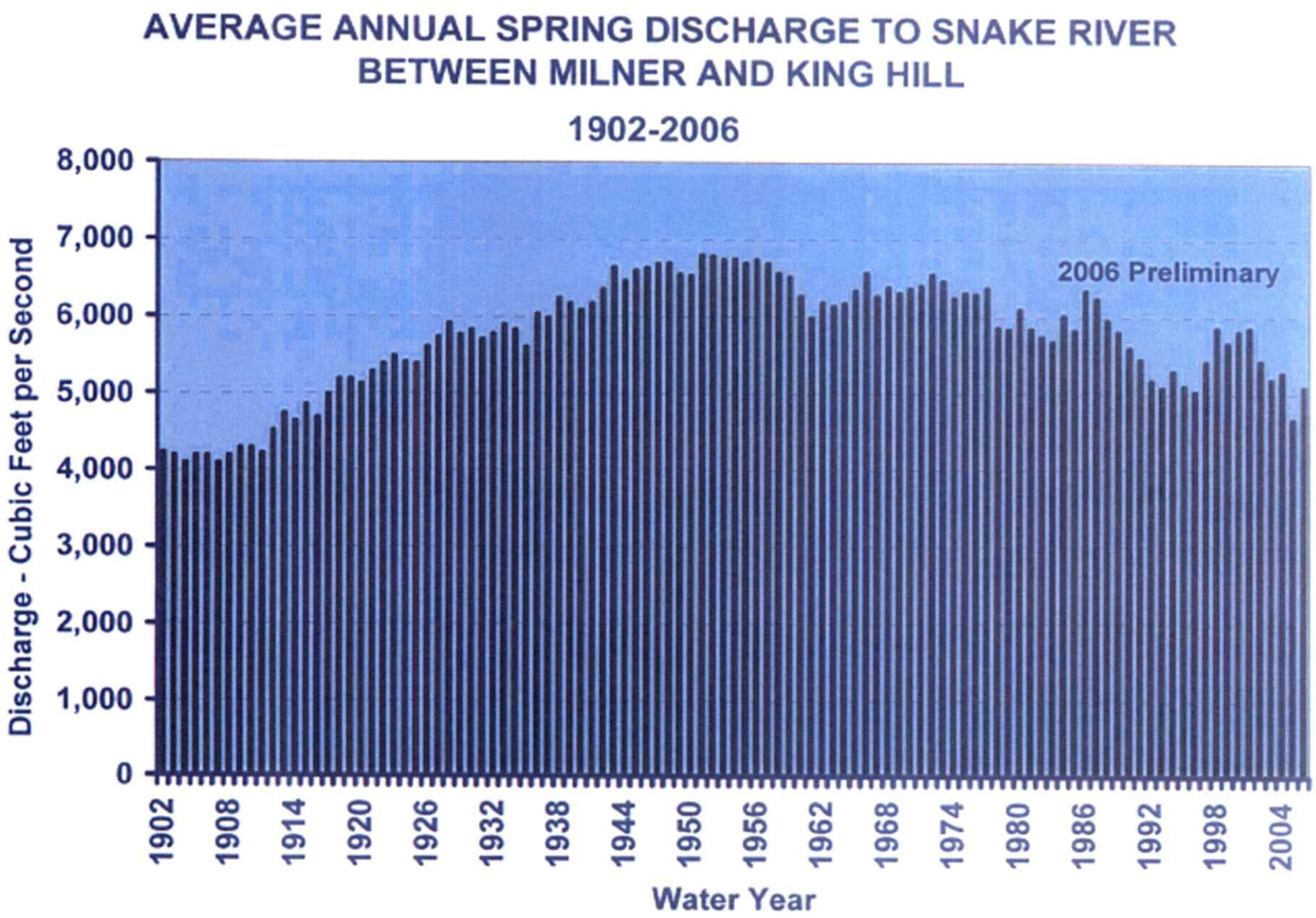


Final Water Budget

• Incidental recharge from surface water irrigation on the plain	3.4 MAF
• Precipitation	2.2
• Underflow from tributary basins	0.9 MAF
• Losses from Snake River & tributaries	1.0 MAF
ANNUAL GAINS TO AQUIFER	**7.5 MAF**
• Discharges from aquifer	5.5 MAF
• Ground water pumping	2.0 MAF
ANNUAL LOSSES FROM AQUIFER	**7.5 MAF**

Water Budget

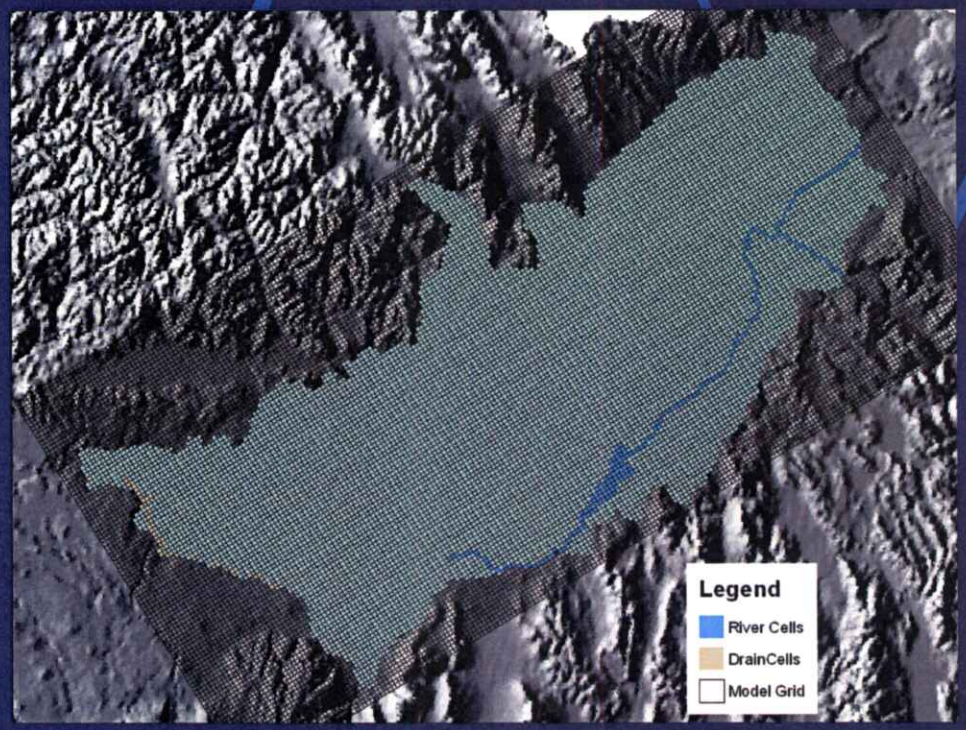
- Surface water irrigators become more efficient during a drought resulting in less incidental recharge
- Due to less incidental recharge, aquifer doesn't recover before next drought
- Not as much water stored for next drought, so surface water irrigators forced to become even more efficient
- 1980 to 2002 discharge about equal to recharge
  - Does not mean aquifer is in balance


AVERAGE ANNUAL SPRING DISCHARGE TO SNAKE RIVER
BETWEEN MILNER AND KING HILL
1902-2006
Discharge - Cubic Feet per Second
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2006 Preliminary
1902
1908
1914
1920
1926
1932
1938
1944
1950
1956
1962
1968
1974
1980
1986
1992
1998
2004
Water Year

Model Structure

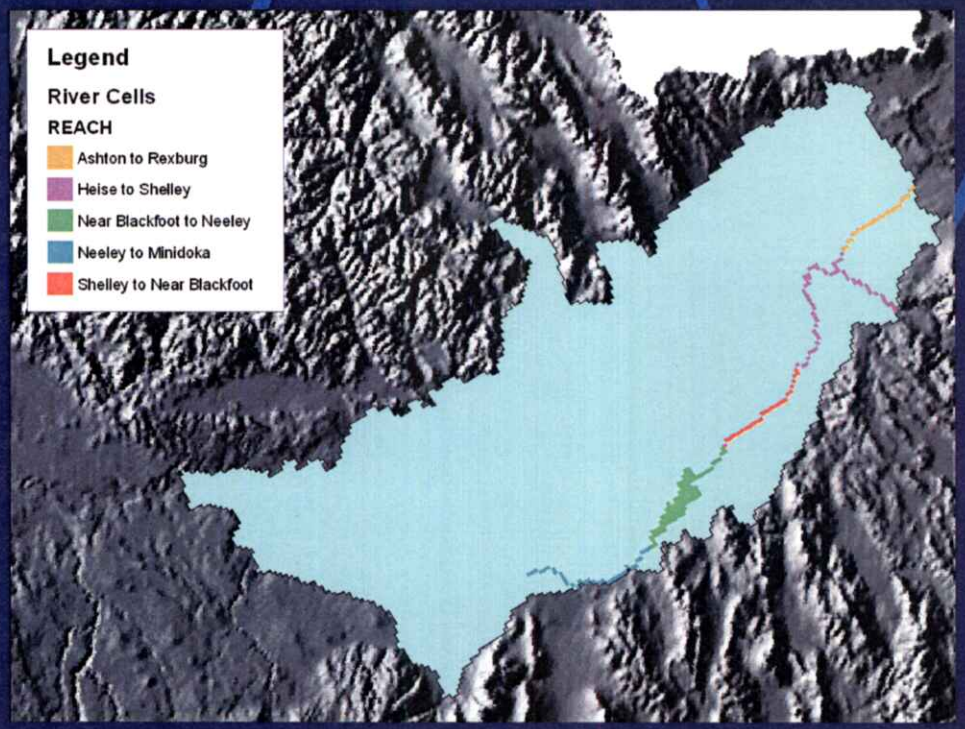
- Numerical model - MODFLOW
- Grid
  - Number of rows, number of columns, number of layers
- River representation
- Springs representation
- Data
  - Water table elevation
  - Snake River
    - Compute ground water contribution to river or river contribution to ground water
      - Gains or losses

Grid



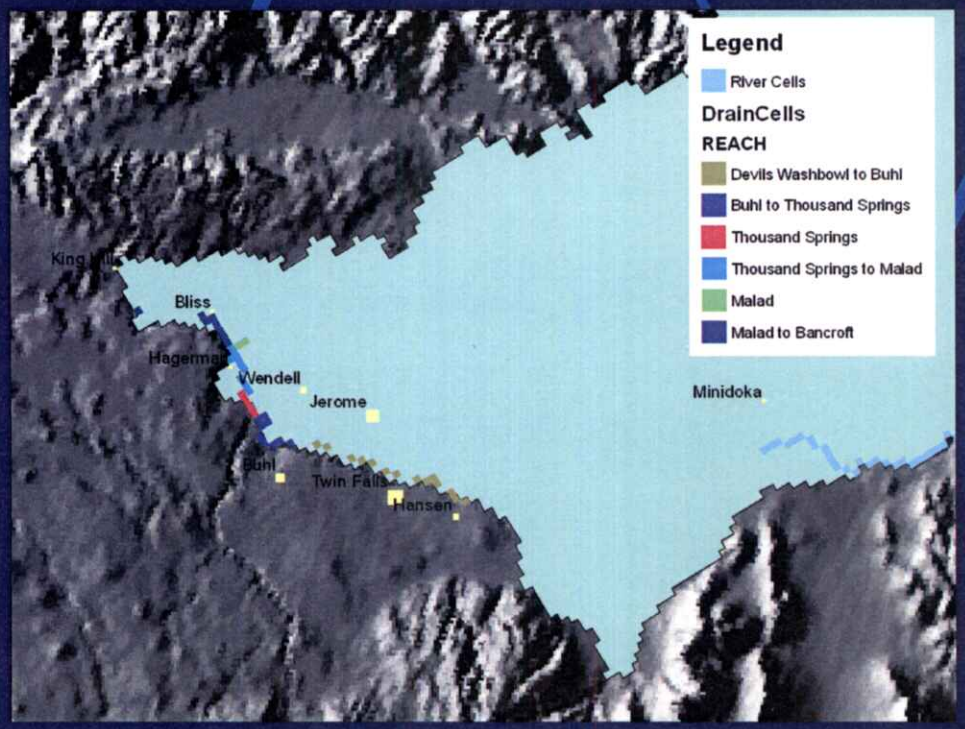
- Rotation 31.4° counter clockwise
- 104 rows
- 209 columns
- 1 mi by 1 mi
- 1 layer

Snake River



- 5 river reaches above Minidoka
  - Ashton to Rexburg
  - Heise to Shelly
  - Shelly to nr Blackfoot
  - Nr Blackfoot to Neeley
  - Neeley to Minidoka
  - Minidoka to Milner
    - Gains not statistically significant

Springs



- 6 Spring reaches
  - Devils Washbowl – Buhl
  - Buhl – Thousand Springs
  - Thousand Springs
  - Thousand Springs – Malad
  - Malad
  - Malad – Bancroft
- 45 drain cells

Calibration

- Coupled steady state and transient
- 22-year period of calibration
  - 6-month stress periods
- PEST parameter estimation software

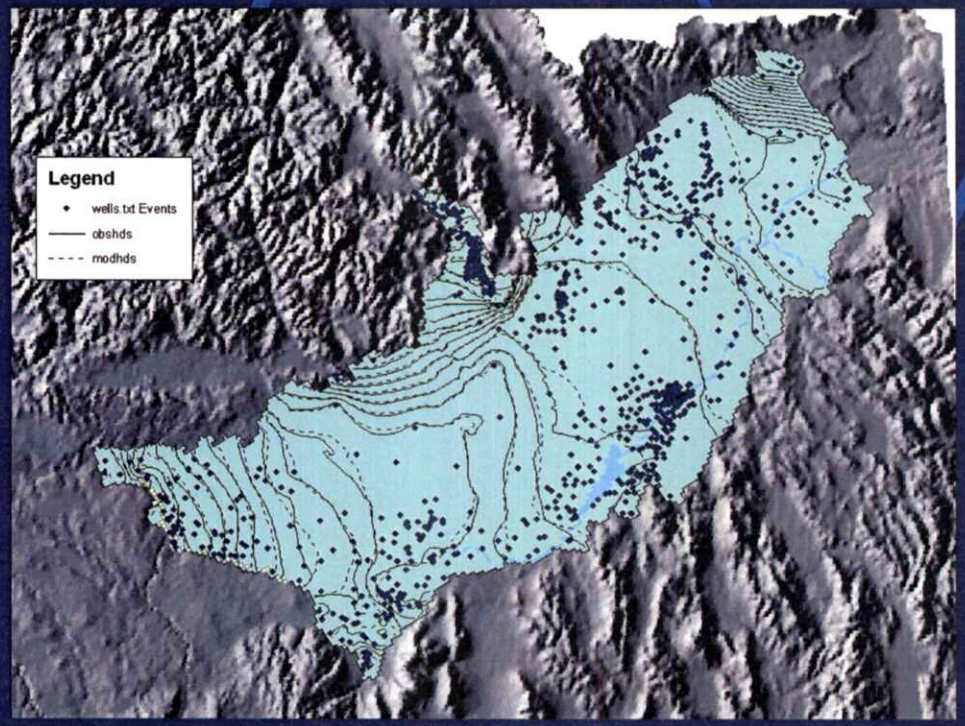
Calibration Targets

- Water table elevation data
  - USGS data
  - IDWR data
- Reach gain and loss data
  - IDWR reach gain and loss program
    - USGS gauging station data
    - Water master diversion data

Water Table Elevation

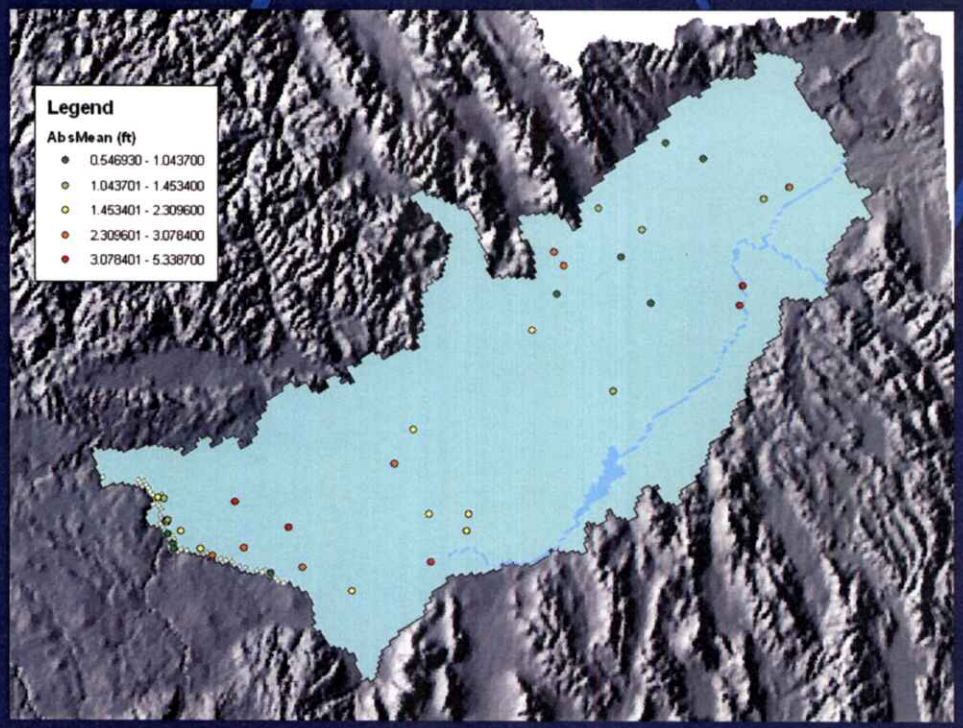
- Average Condition (steady state)
  - No change in magnitude or direction of ground water flow
    - Rarely occurs in nature,
    - important in modeling
- Water Levels over time (transient)
  - Seasonal
  - Mass measurement
  - Trend

Steady State



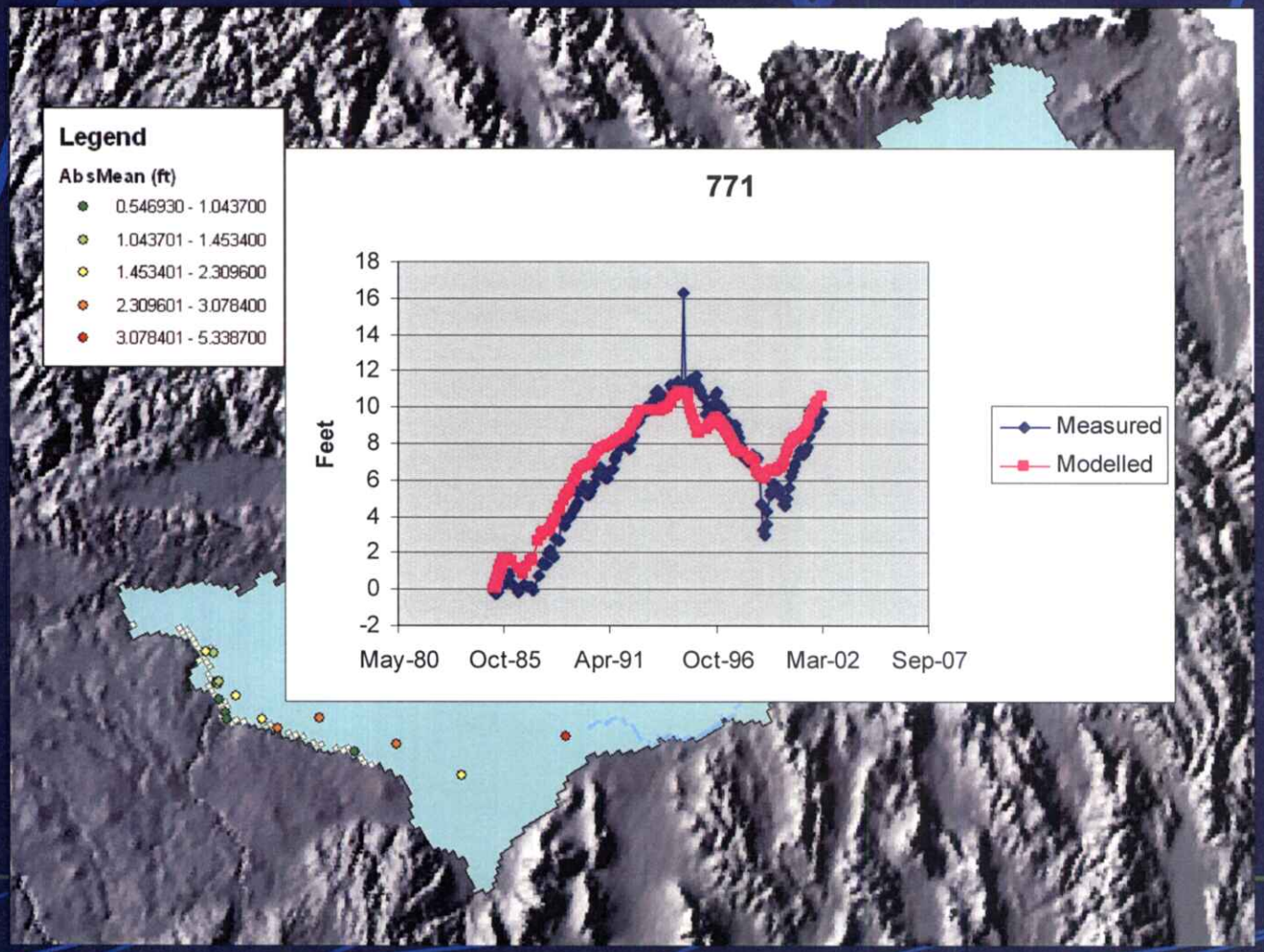
- May1 1982 to November 1, 2000
- All water table elevation observations averaged
  - 1,008 observations

Seasonal Data Set

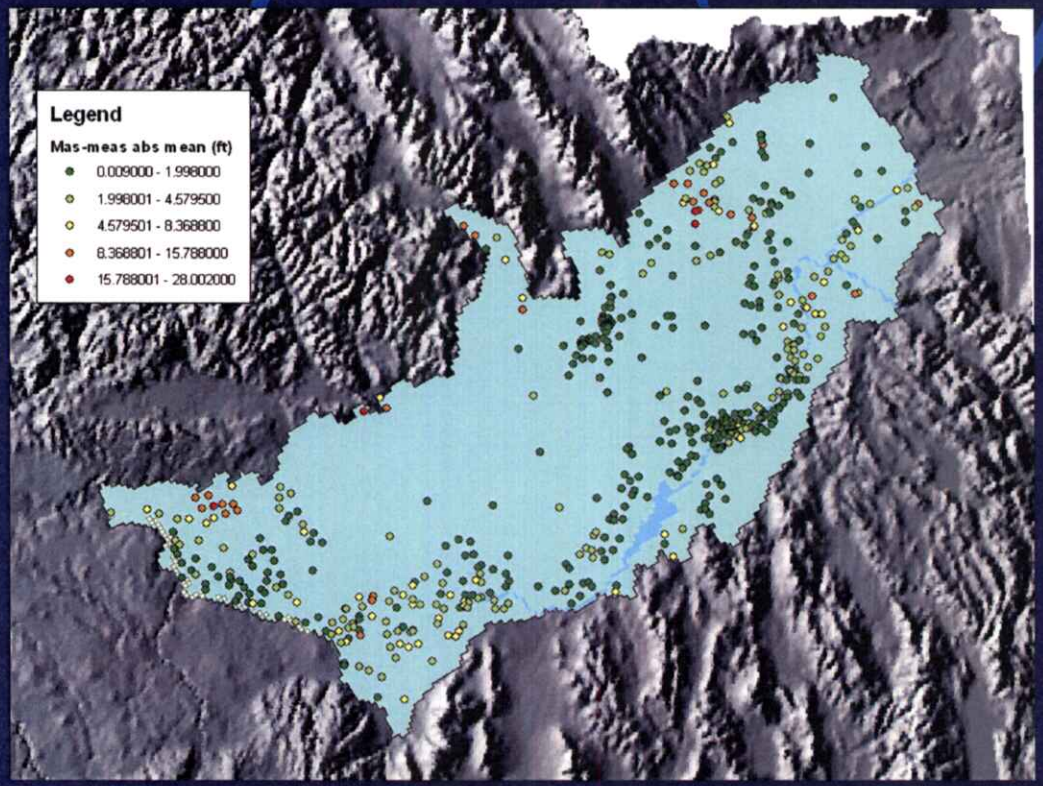


- Hundreds to thousands of observations
  - Lots of data
  - Limited spatial coverage
  - 9,548 observations in 39 wells

Seasonal Data Set

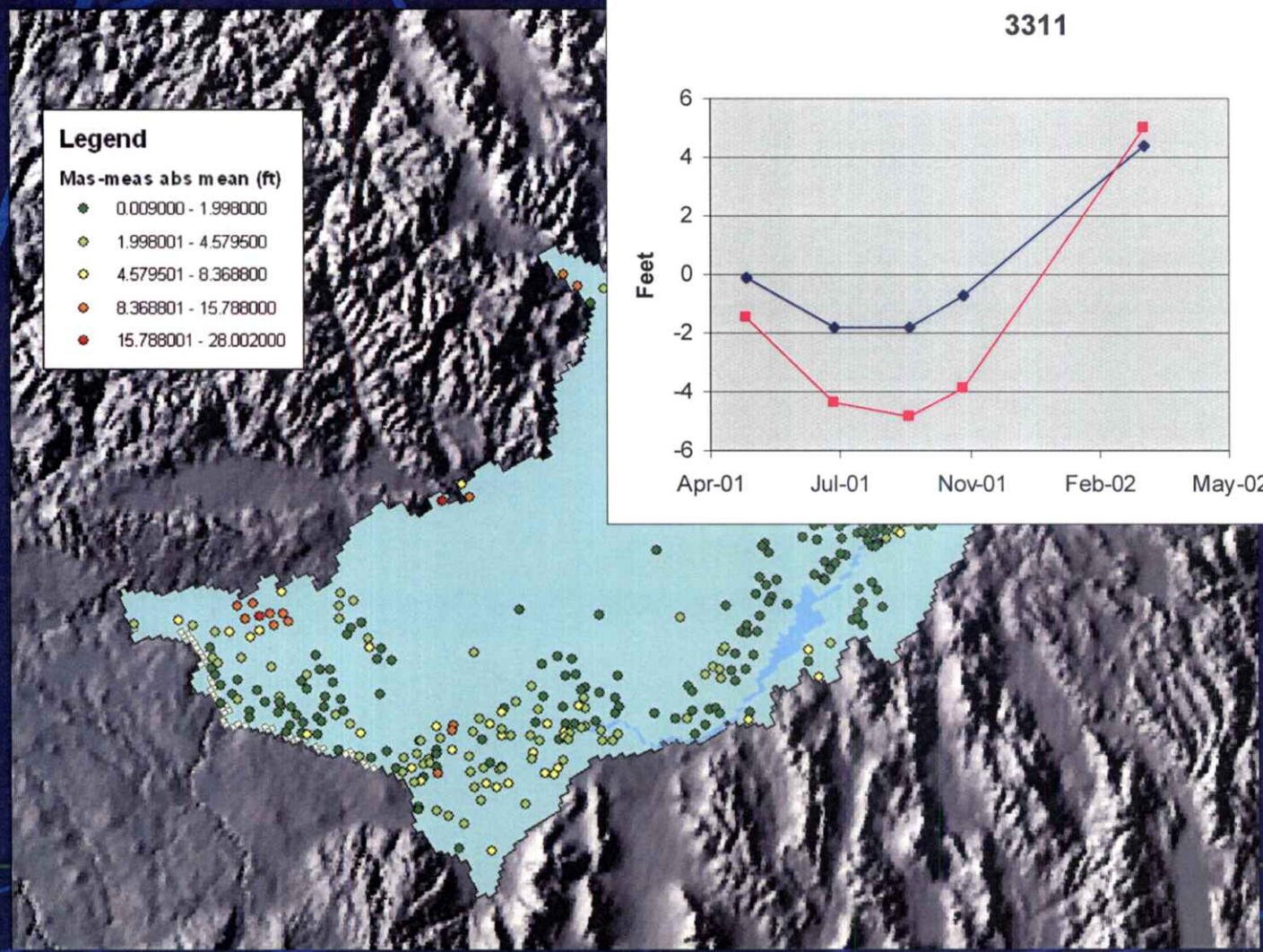


Mass Measurement

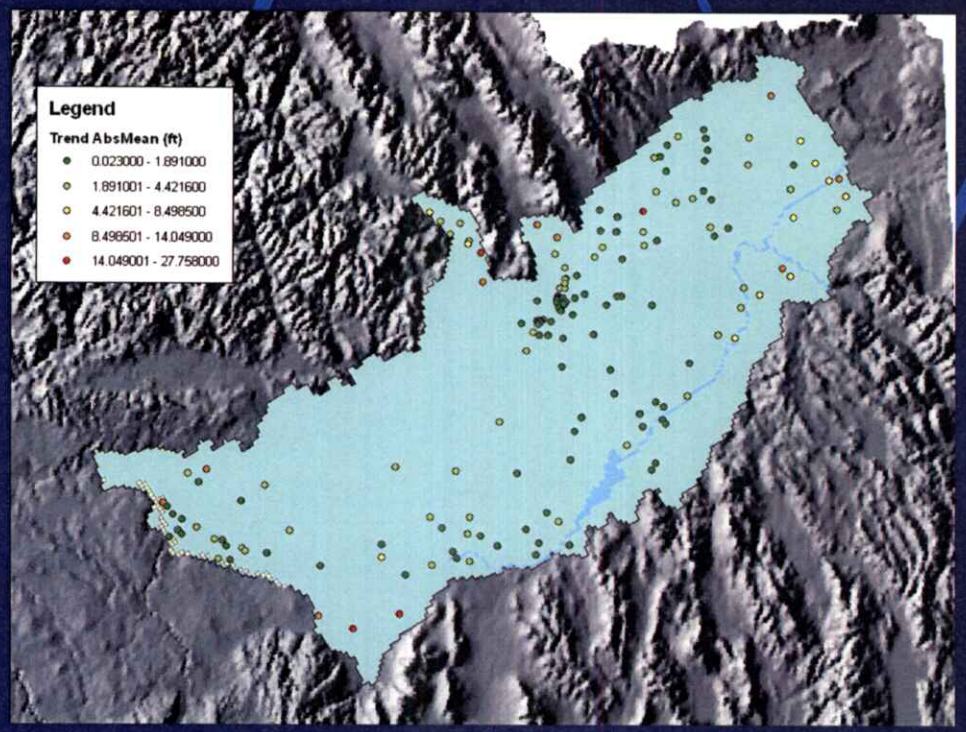


- Observations collected on behalf of this modeling effort
  - 3/1/2001 – 5/8/2002
  - 1,766 observations in 601 wells

Mass Measurement

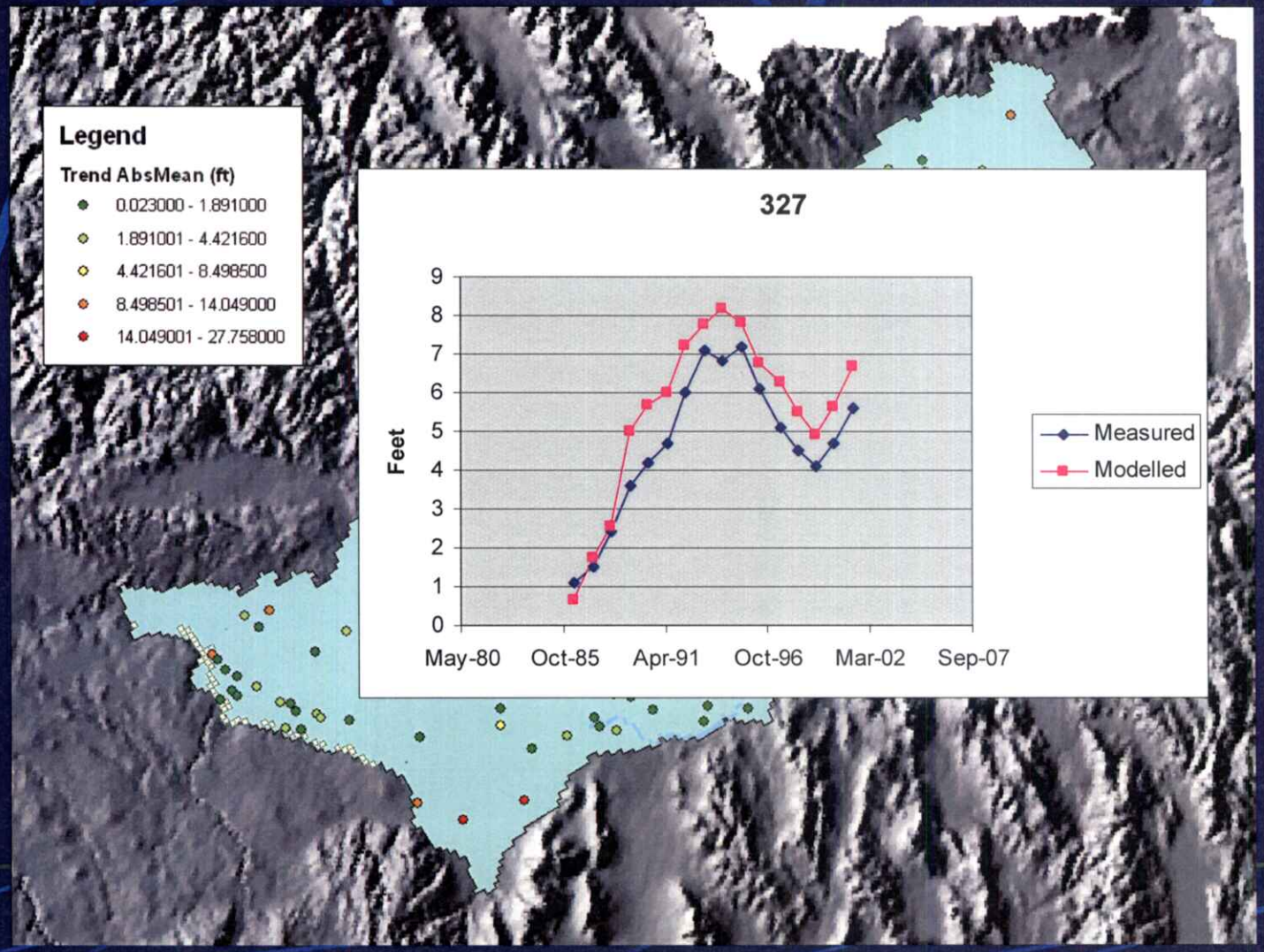


Trend

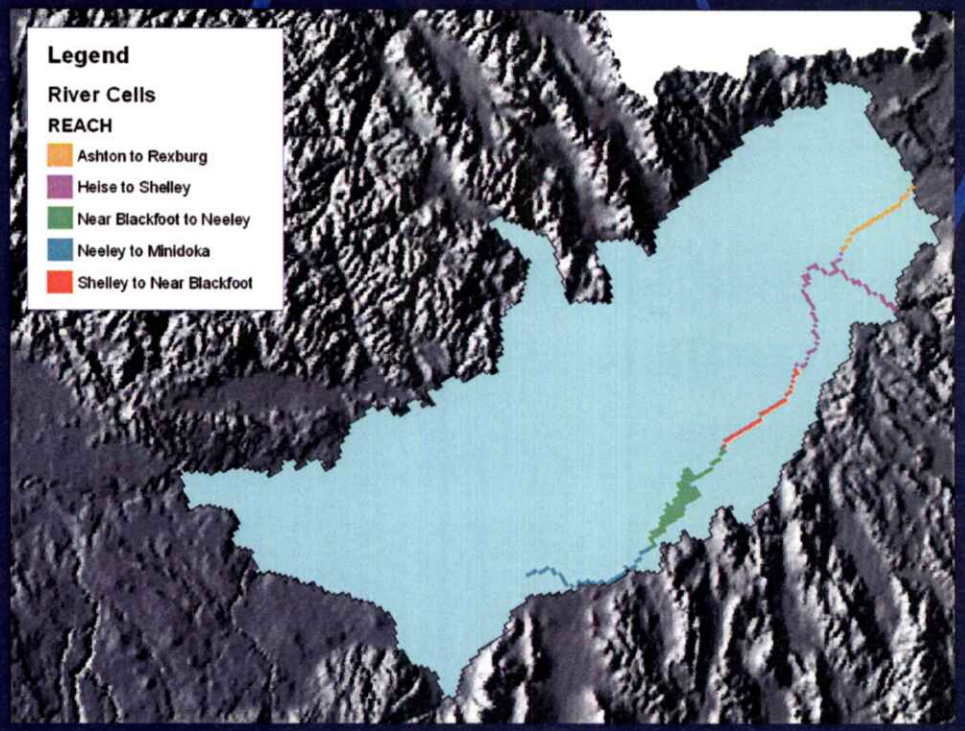


- Annual observations in wells
  - 1,403 observations in 173 wells

Trend

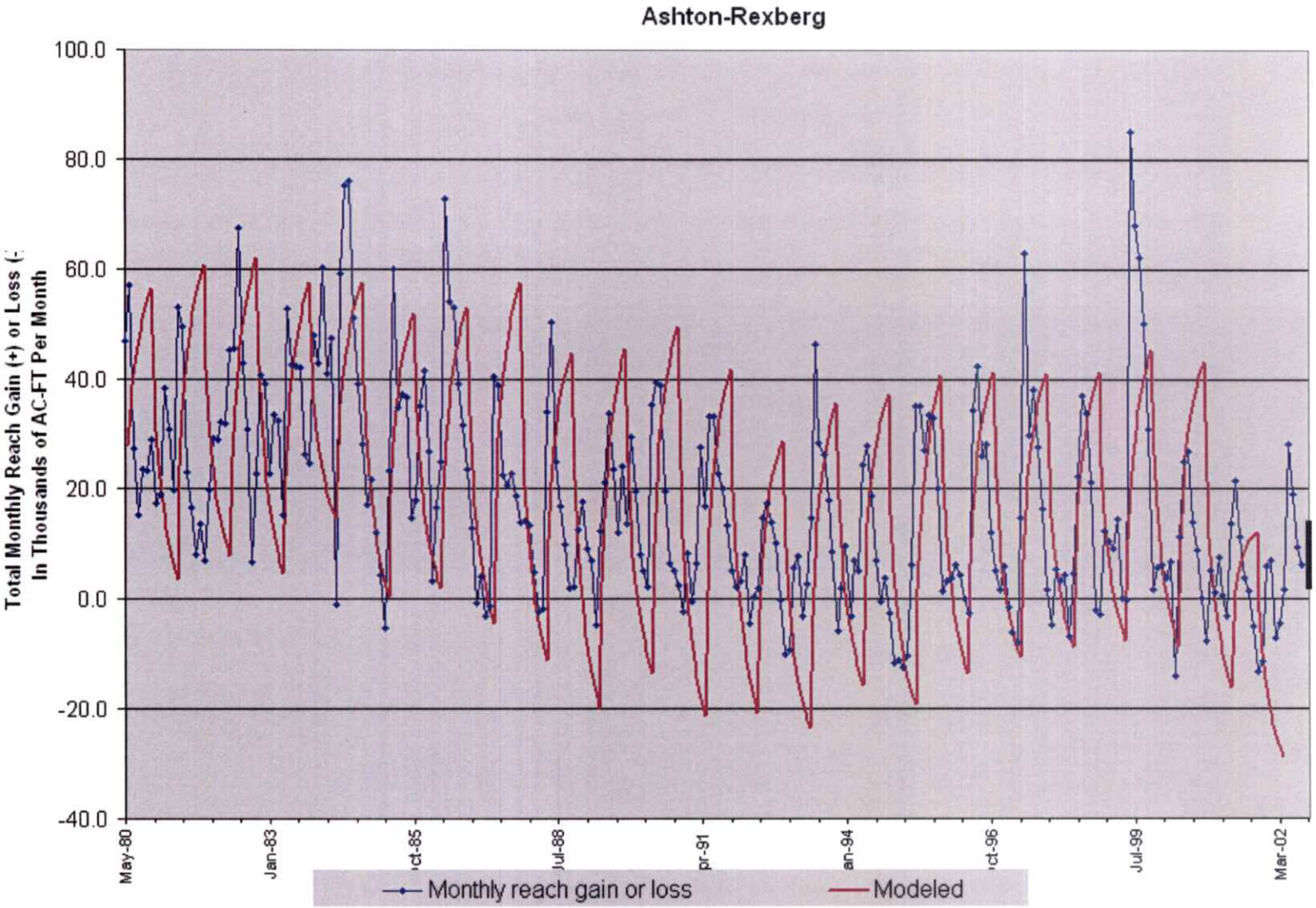

Legend
Trend AbsMean (ft)
0.023000 - 1.891000
1.891001 - 4.421600
4.421601 - 8.498500
8.498501 - 14.049000
14.049001 - 27.758000
327
Feet
0
1
2
3
4
5
6
7
8
9
May-80
Oct-85
Apr-91
Oct-96
Mar-02
Sep-07
Measured
Modelled

Snake River

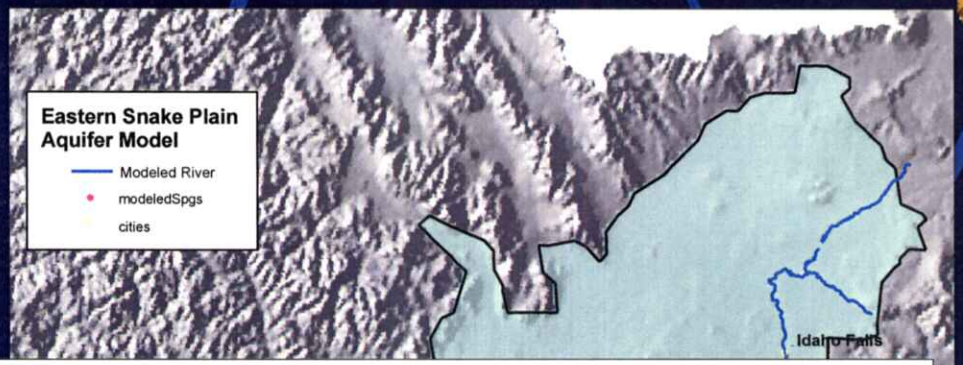


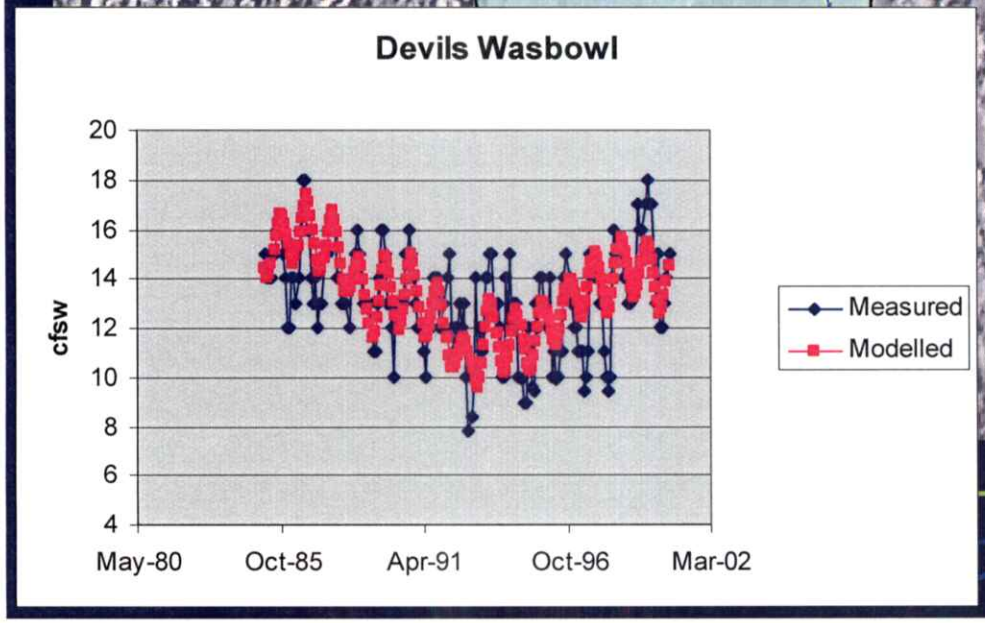
- Snake River reaches
- Monthly gains and losses for five river reaches

Snake River


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

Springs





- Nine springs with significant time series

The Model

- Steady state
  - 1,008 water table elevation observations
  - 5 Snake River gain and loss observations
  - 6 spring observations
- Transient
  - 12,717 water table elevation observations
  - 725 Snake River gain and loss observations
  - 1,526 spring discharge observations

Model Use

- 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
  - Repeats 22-year calibration period
- Curtailment scenario
  - Demonstrate that the model could be used to simulate a curtailment of ground water users
- A&B scenario
  - Identify sources of drawdown within A&B service area
- Managed recharge scenario
  - Simulate increases in river gains if we had been recharging between 1980 and 2002
- No surface water changes scenario
  - If surface water irrigation practices had not migrated to sprinkler systems, what would conditions be like today

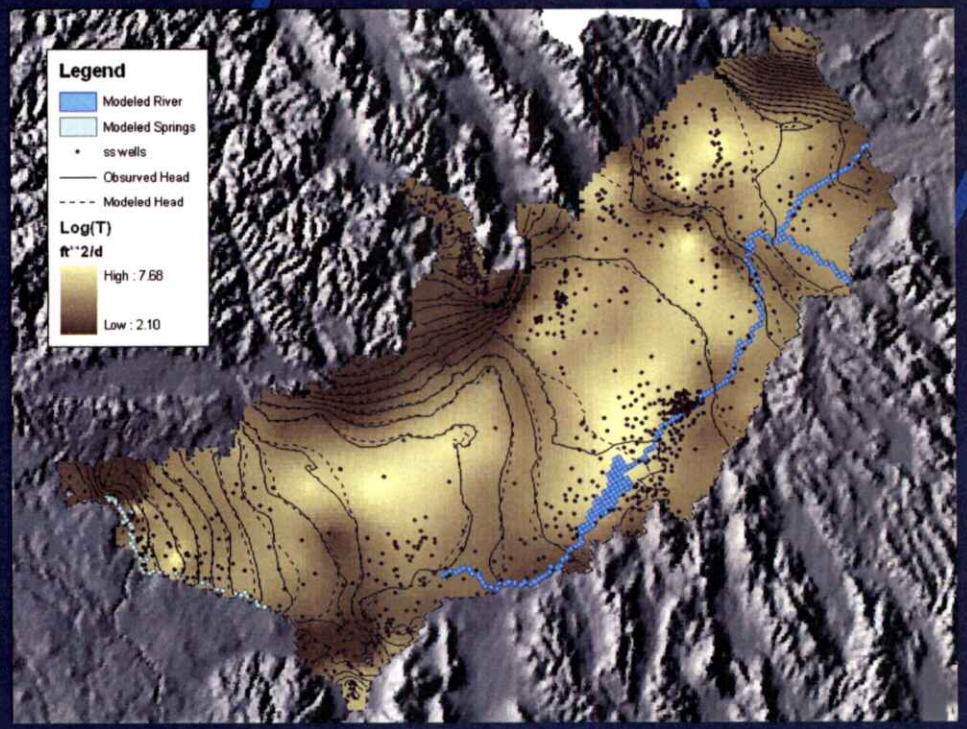
How the Model Is Used

- Spreadsheet tools
  - CREP
    - Used to simulate effect of taking land out of production
  - Managed recharge
    - Simulate effect of proposed recharge projects
  - Conversion
    - Simulate effects of converting land from ground water to surface water irrigation
  - Water rights transfers
    - Between wells

A Curtailment Scenario

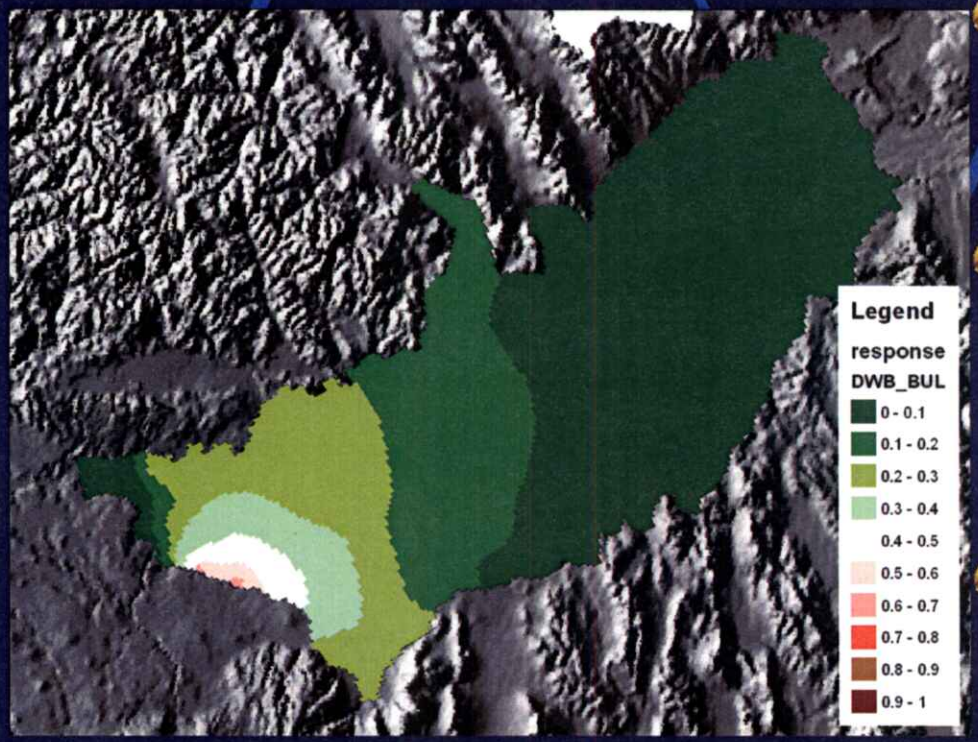
- Uncertainty
- Response functions
- Model grid
- Irrigated lands
- Water rights data base

Uncertainty



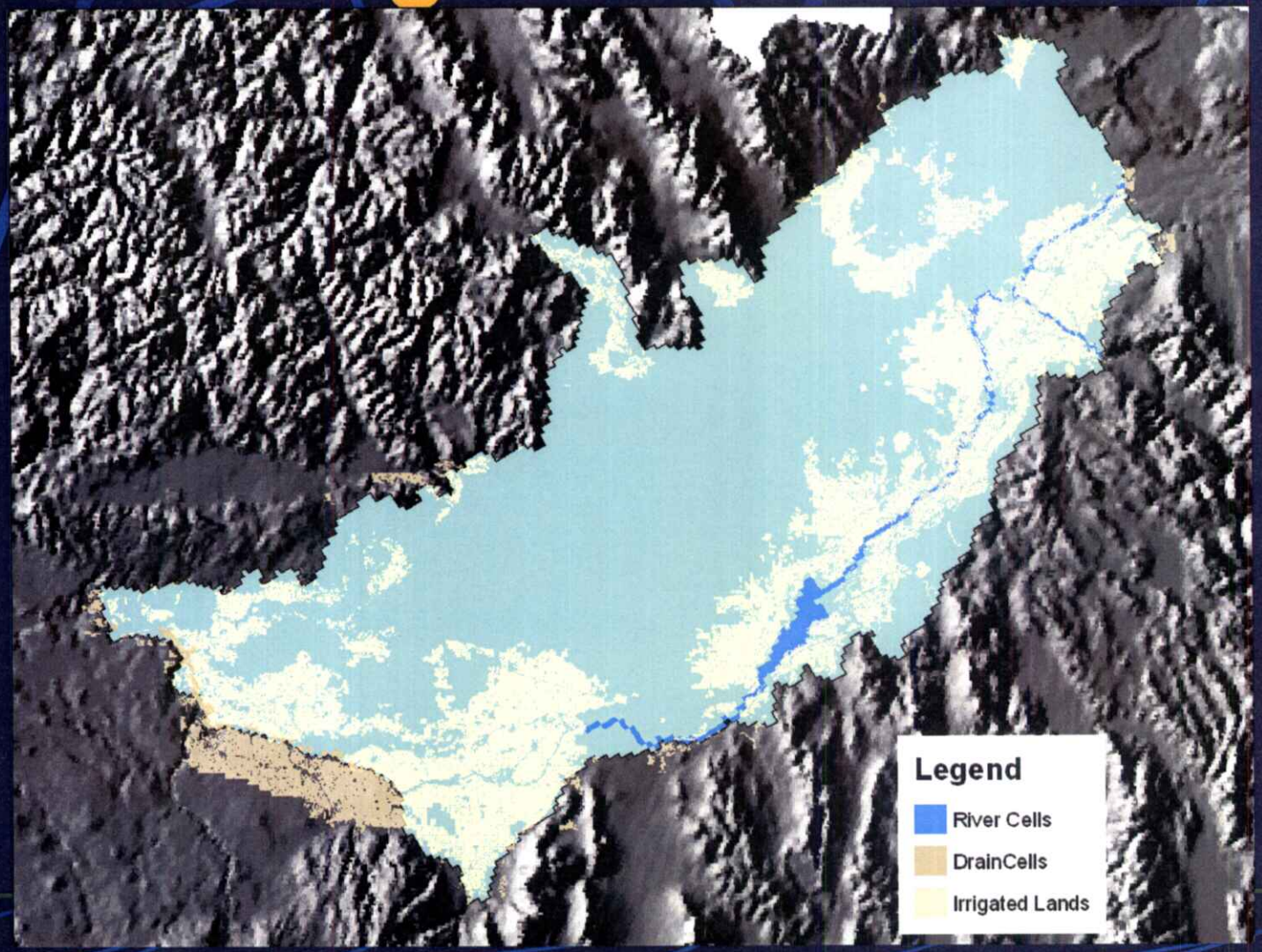
- Model is simulation
- Model misfit
  - Standard error less than 20 ft
  - Water level change about 4,000 ft
- Measurement uncertainty
  - Largest is river gains

Response Function

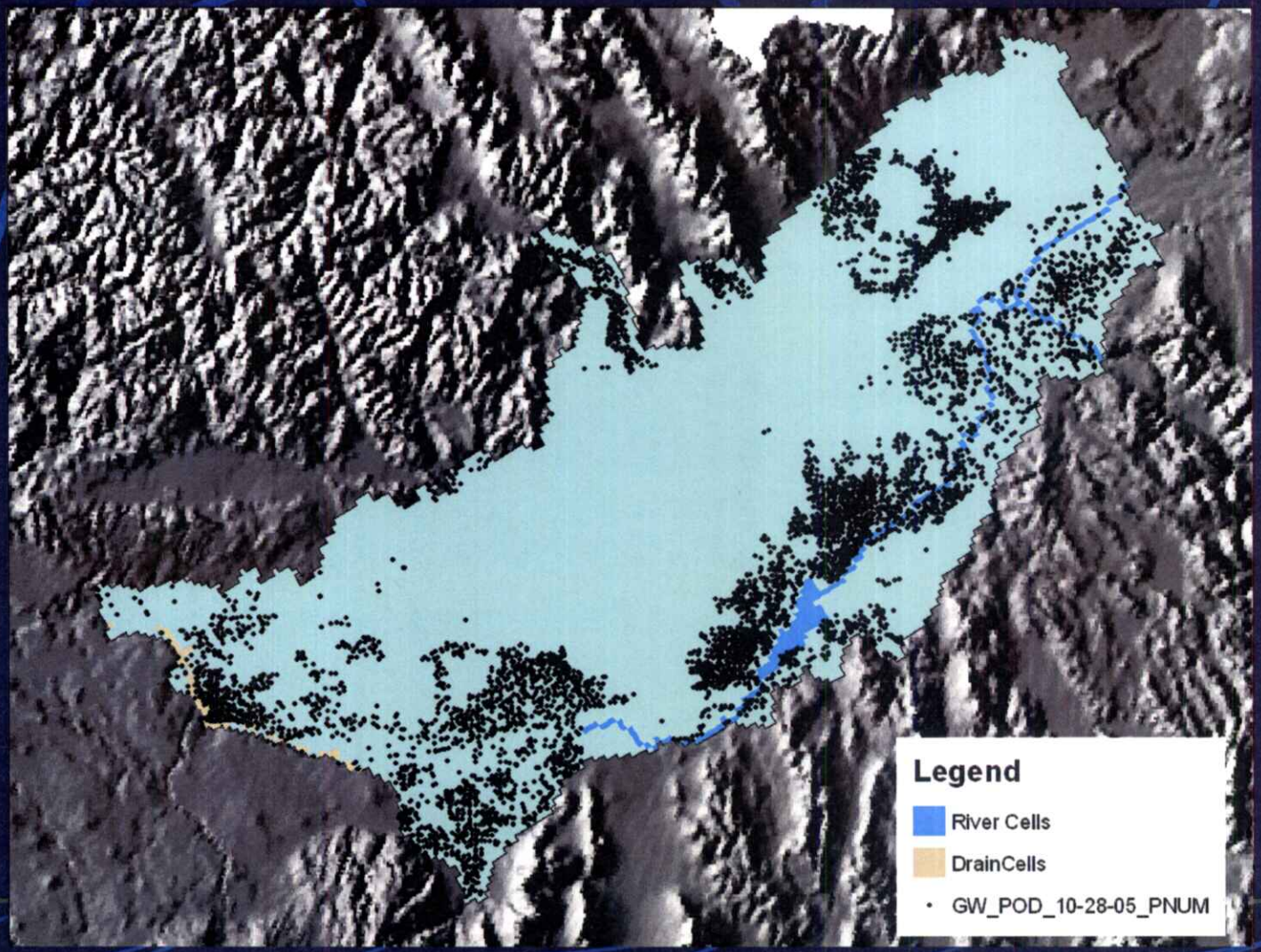


- If left alone all aquifer water will discharge into the Snake River
- Water pumped from anywhere in the aquifer would discharge to the Snake River
- Impact from pumping spreads out radially from pumping center

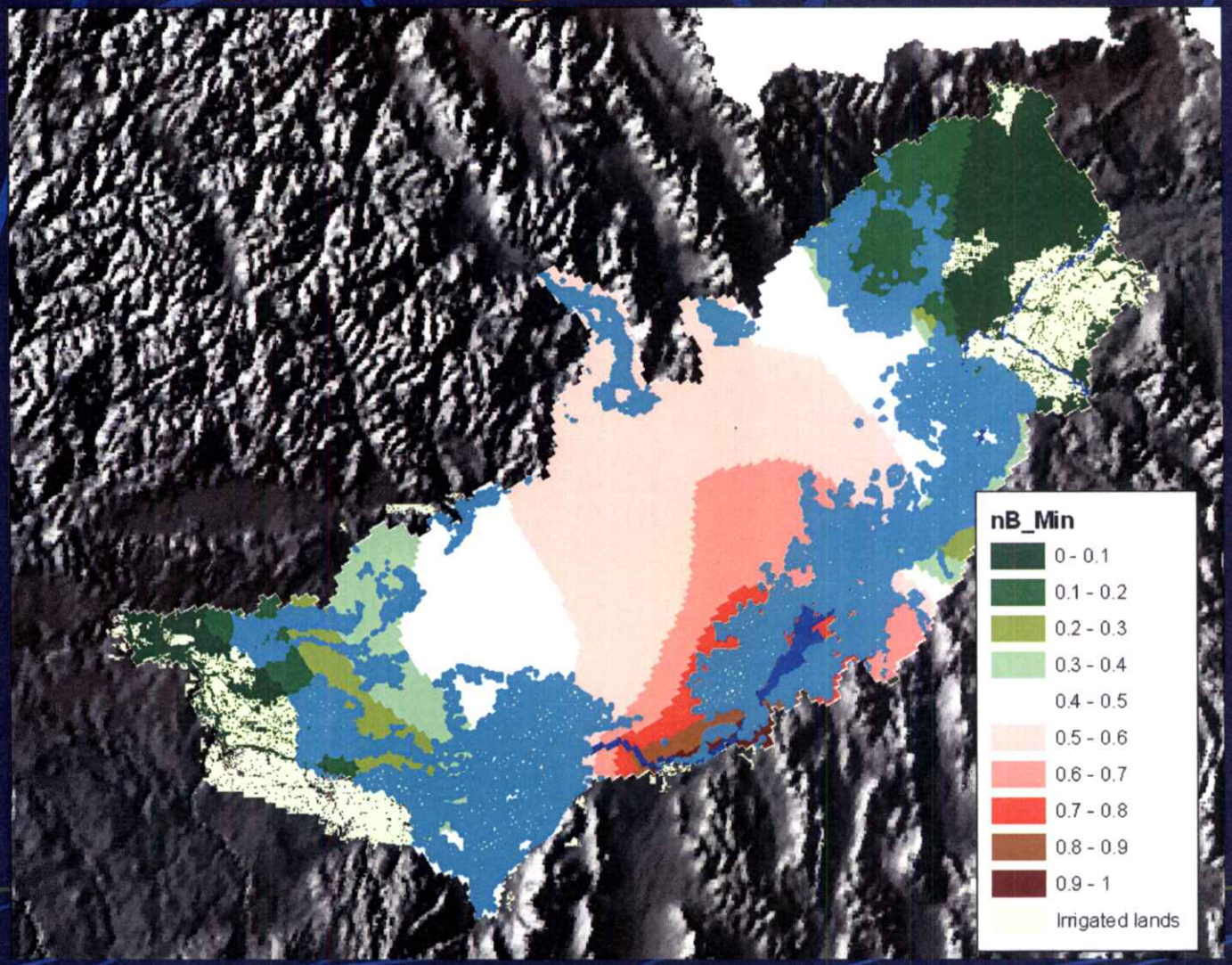
Irrigated Lands



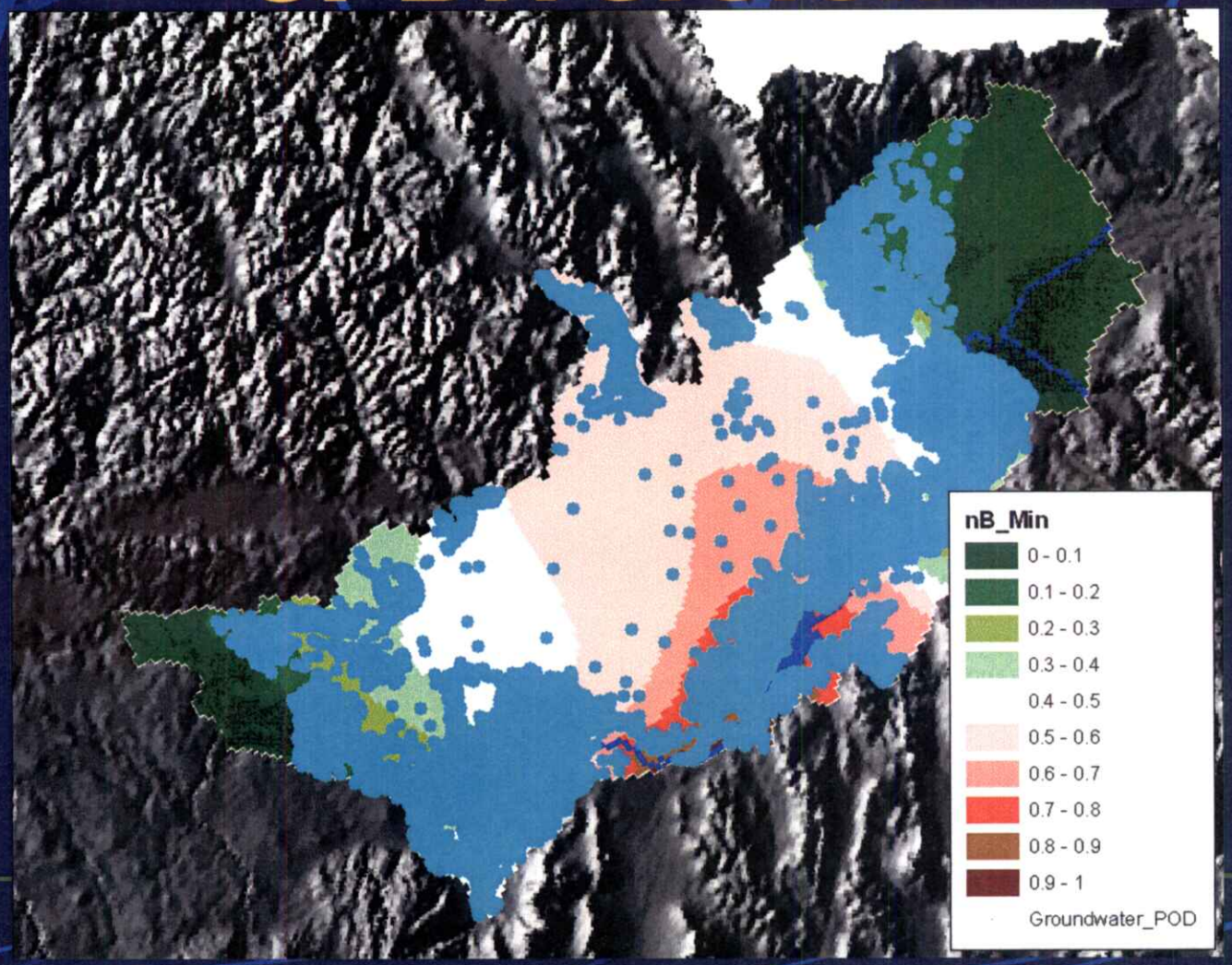
Ground Water Irrigation Wells



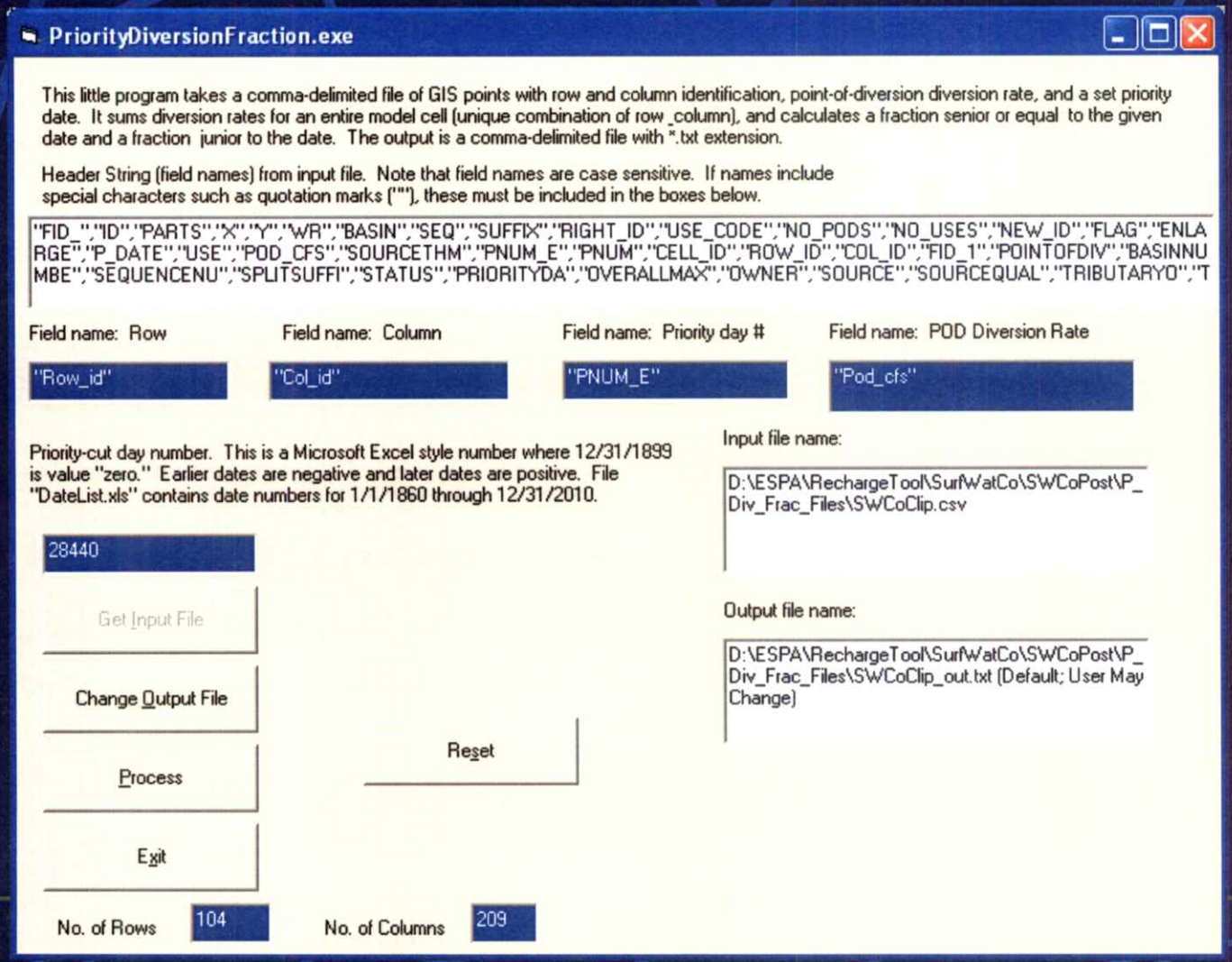
Clip Irrigated Lands



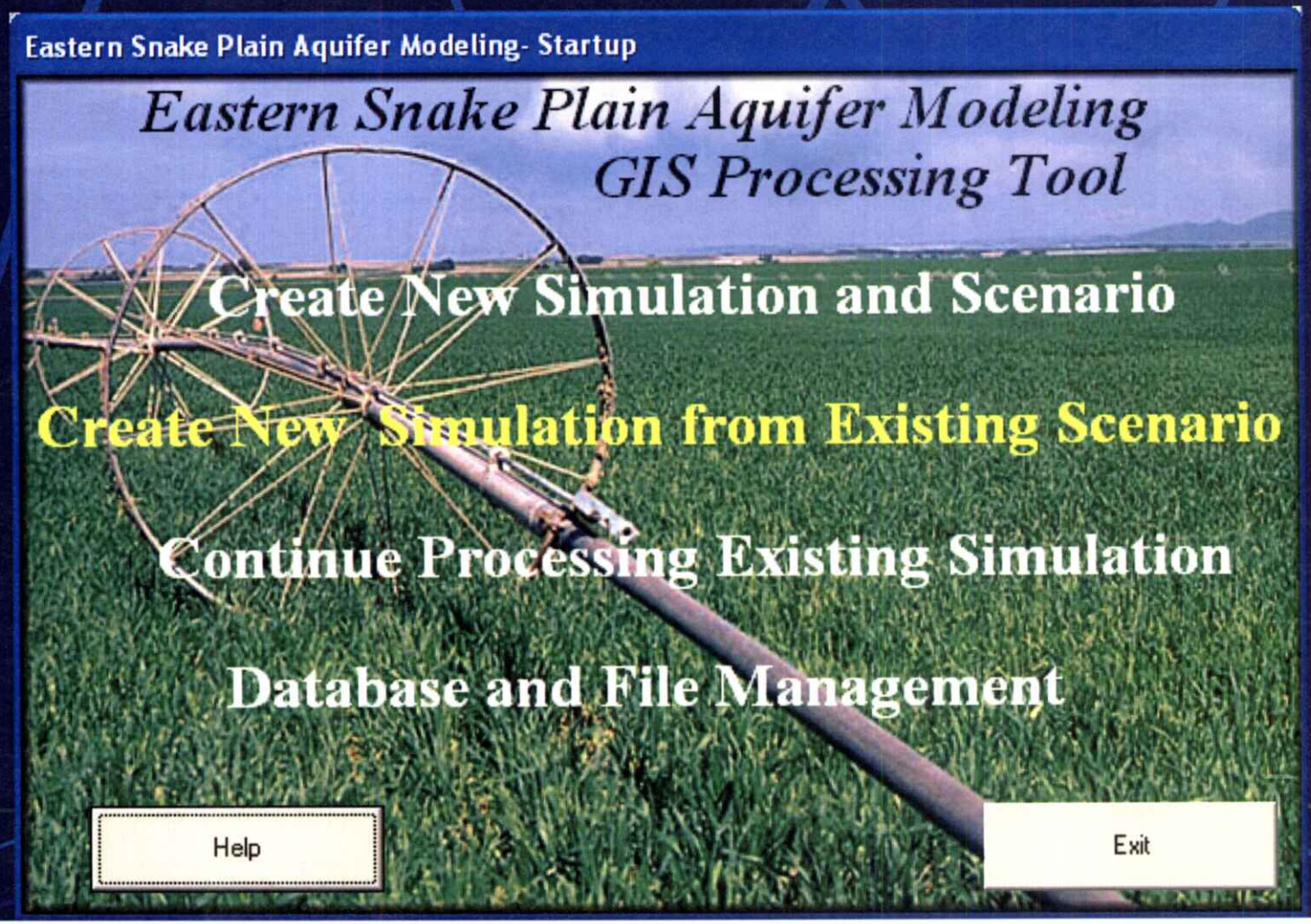
Clip Groundwater Points of Diversion



Select Priority Date



Compute Consumptive Use



Run Model to Determine Impact

irr_area		Depleation		ft/ac/yr
491,805,019	m^2	29,635,472	ft^3/d	2.044744
121,527	ac	248,492	ac-ft/y	
reach	**cf/d gain**	**cfs gain**	**ac-ft/y**	
A-R	2598813	30.1	21,791	
H-S	1590866	18.4	13,339	
S-B	5125720	59.3	42,979	
B-N	1.36E+07	157.9	114,367	
N-M	1902839	22.0	15,955	
DWB-BUL	2606376	30.2	21,854	
BUL-KSP	949287.9	11.0	7,960	
KSP	595295.5	6.9	4,992	
KSP-MLD	64425.26	0.7	540	
MLD	541656.7	6.3	4,542	
MLD-BAN	20635.8	0.2	173	
sum	29,635,473	343	248,492	

- End

The three most important things

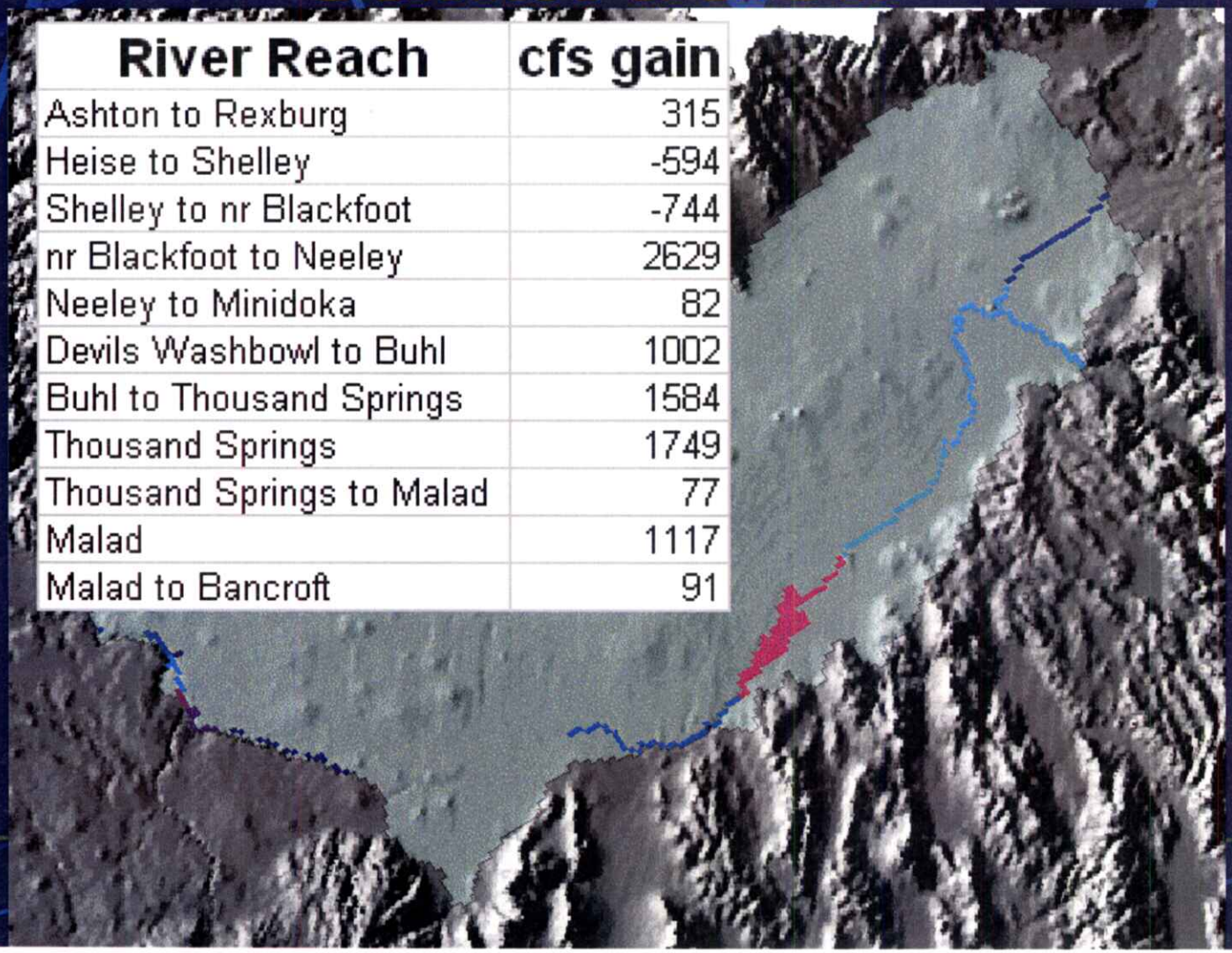
- The river reaches
  - Control model veracity
- The river reaches
  - Control model calibration
- The river reaches
  - Control model predictions

Control model veracity

- The model is good to the extent that the river gain and loss targets actually represent river and aquifer interaction
  - River gain and loss calculation
    - Difference up and down river gages
    - Account for diversions and returns
      - Returns not historically measured

Control model calibration

River Reach	cfs gain
Ashton to Rexburg	315
Heise to Shelley	-594
Shelley to nr Blackfoot	-744
nr Blackfoot to Neeley	2629
Neeley to Minidoka	82
Devils Washbowl to Buhl	1002
Buhl to Thousand Springs	1584
Thousand Springs	1749
Thousand Springs to Malad	77
Malad	1117
Malad to Bancroft	91



Control model predictions

- River reaches can be added but not divided
  - Senior user can get water entering upstream reach
  - Model not calibrated finer than current reach scale
- Spring reaches can not be added or divided
  - Water arriving at a spring not available to others
  - Spring reaches smaller to increase odds of getting water to the injured party
    - Larger reach ~ more gain
    - Smaller reach ~ less gain

It's the reaches

- Calibration targets control how sensitive reach is to changes in the aquifer
  - Veracity of targets important
  - More gain = more sensitive
- River reaches can be added
- No reach can be divided

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

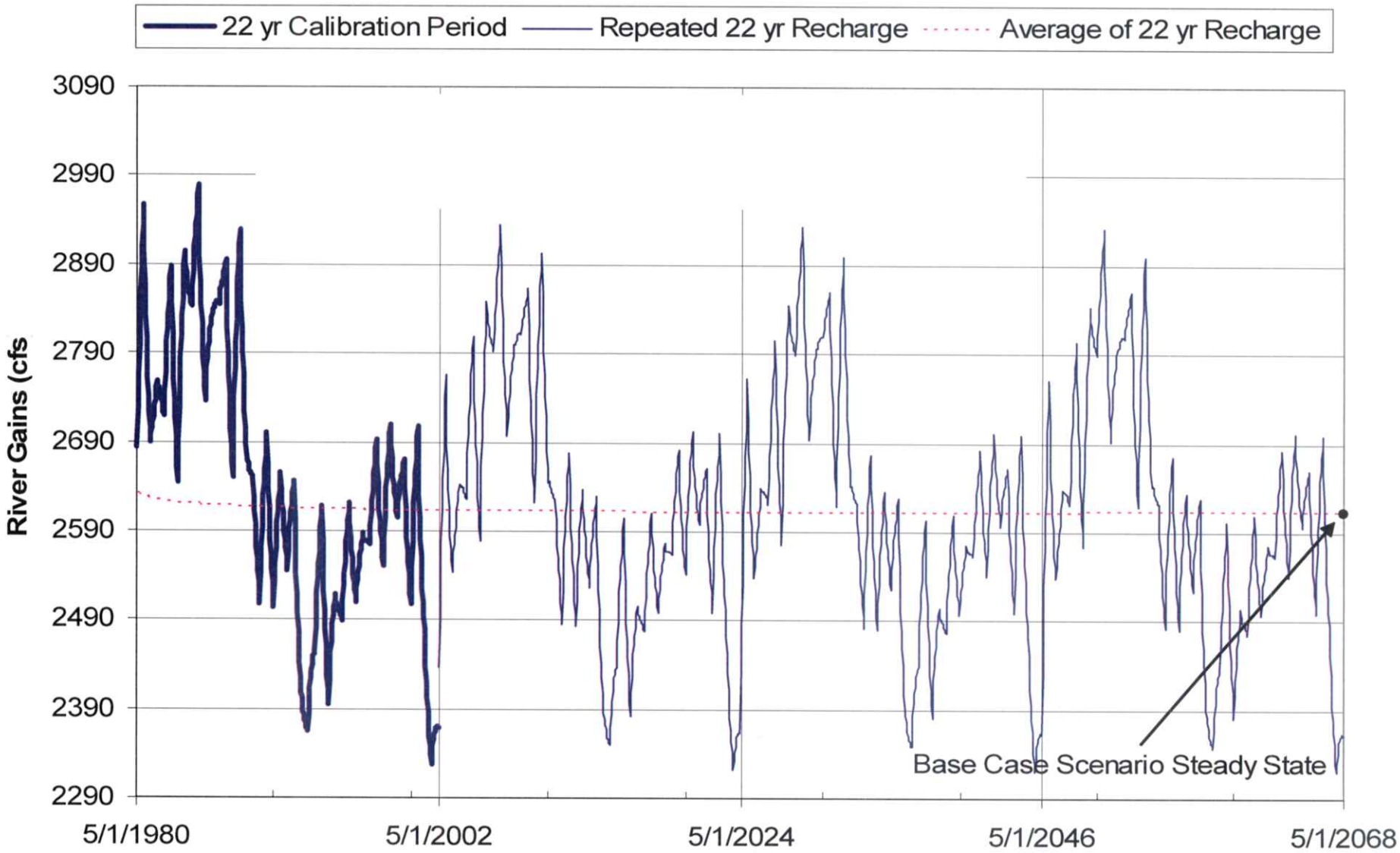


Figure 9. Simulation Results for the near Blackfoot to Neeley Reach (ESPAM v1.1)

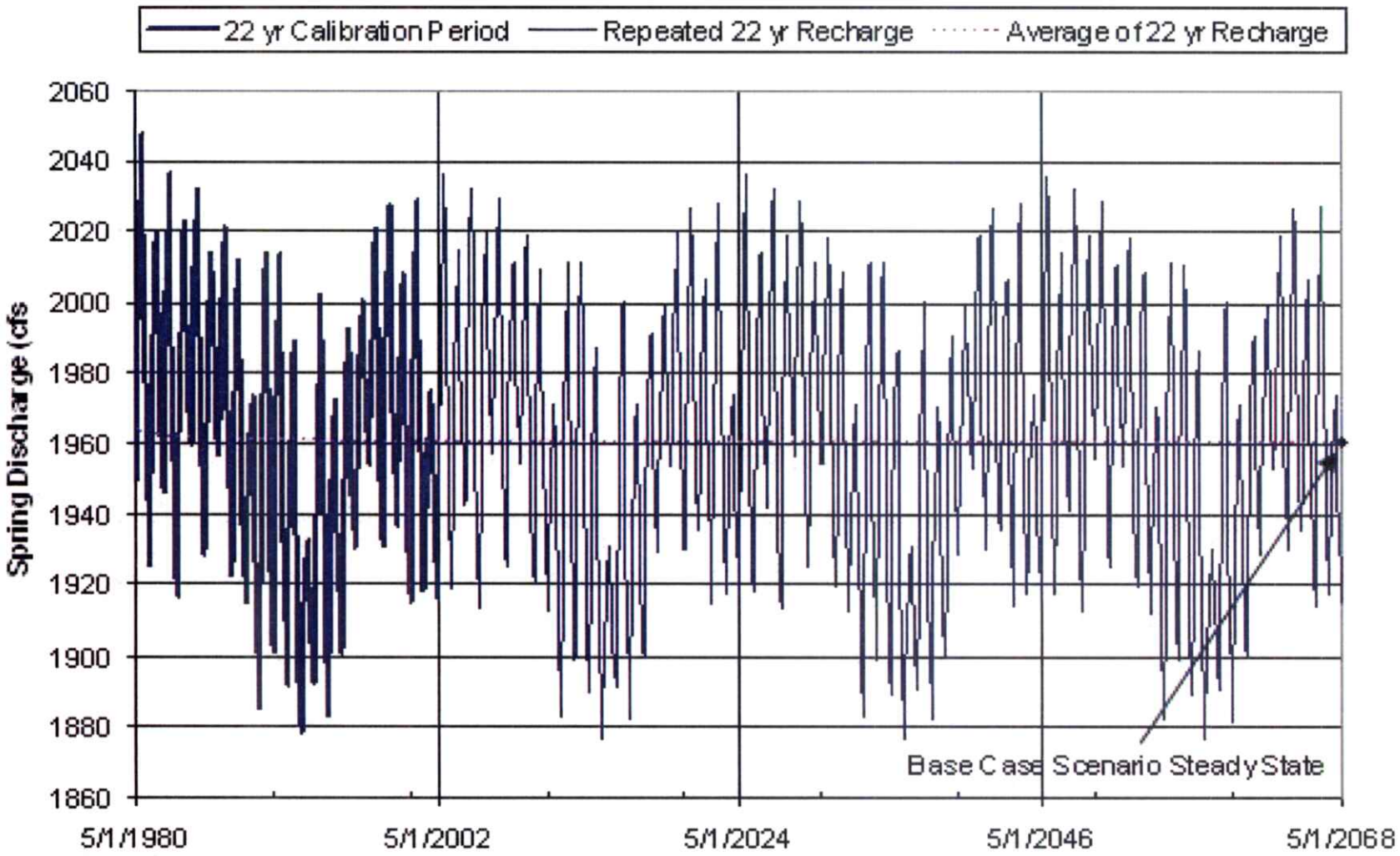
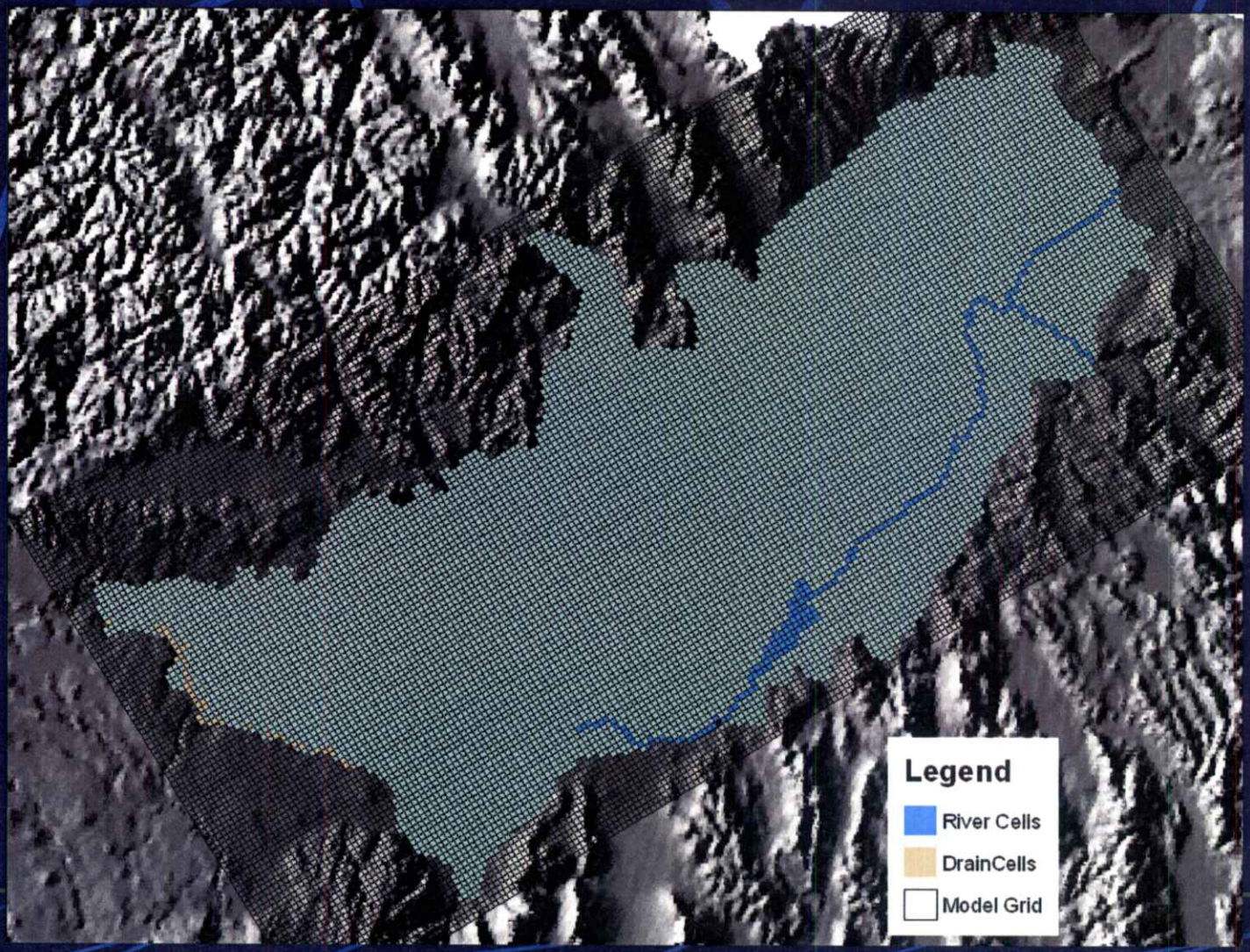


Figure 13. Simulation Results for the Thousand Springs Reach (ESPAM v1.1)

Model Grid



How The Model Is Used

- Clip irrigated lands to response function greater than 10%
- Clip ground water points of diversion to response function greater than 10%
  - Use only irrigation wells
- Select wells junior to priority date
- Compute consumptive use
- Run in model to determine impact on target reach