Development of a Groundwater-Surface Water Model for the Tule Basin, California

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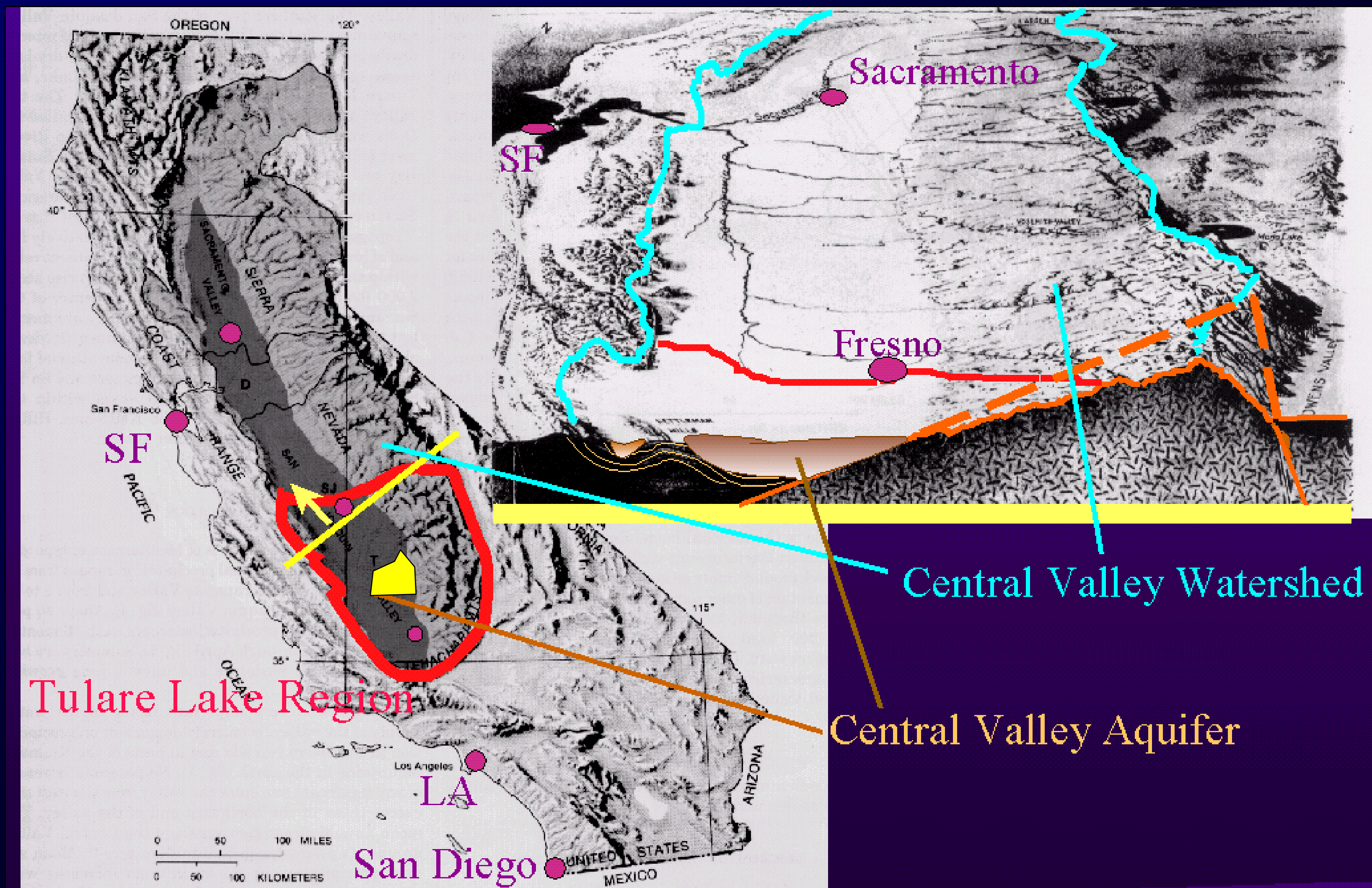
Land, Air, and Water Resources

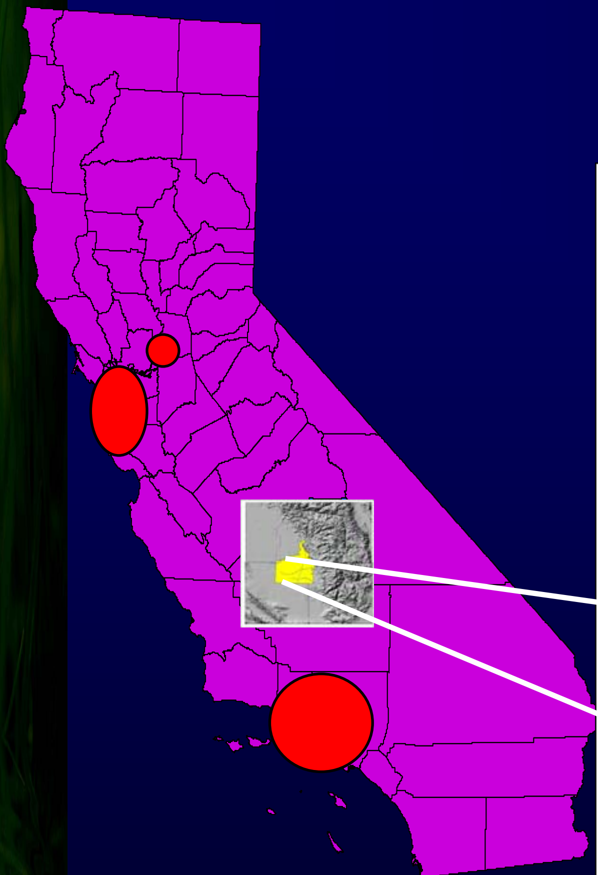
University of California, Davis

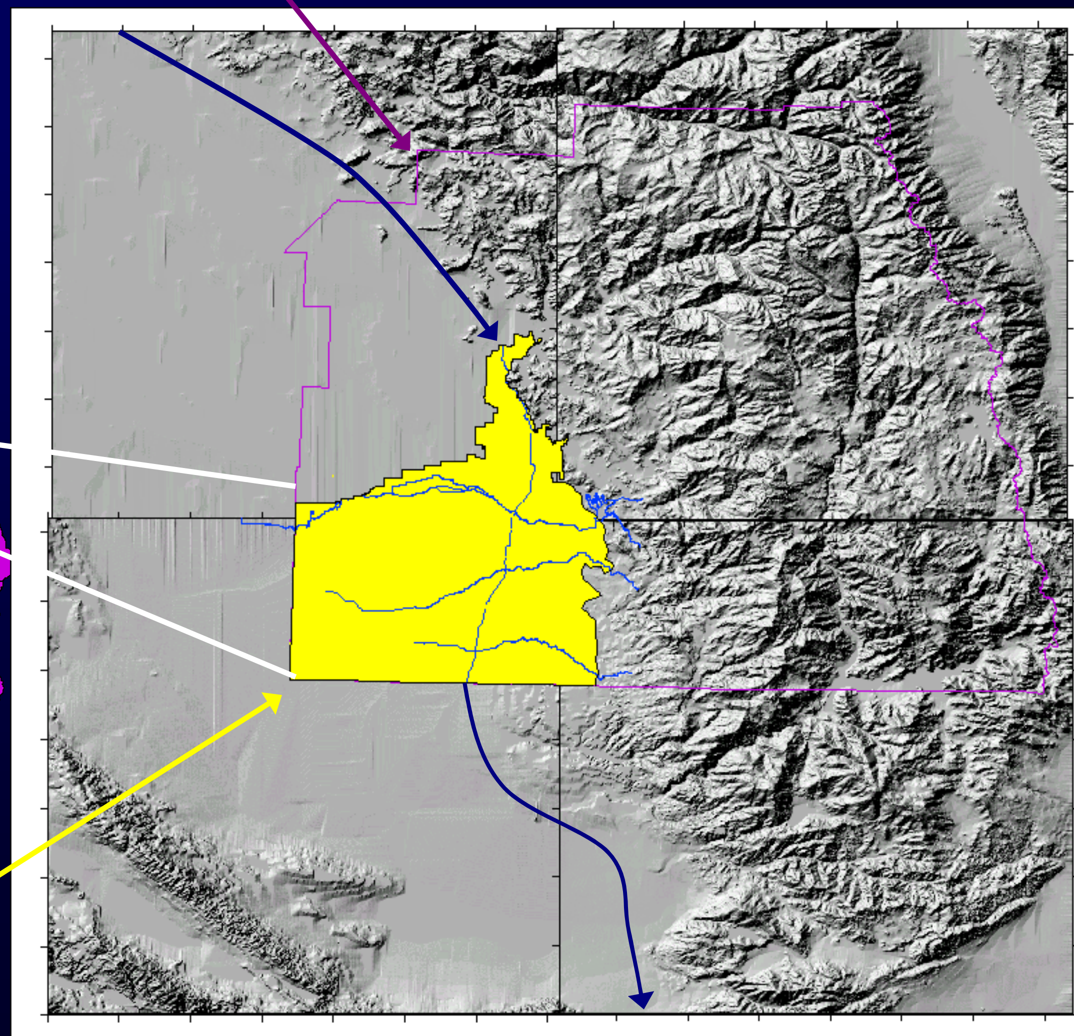
Central Valley Watershed



Project Area Location

Tulare County

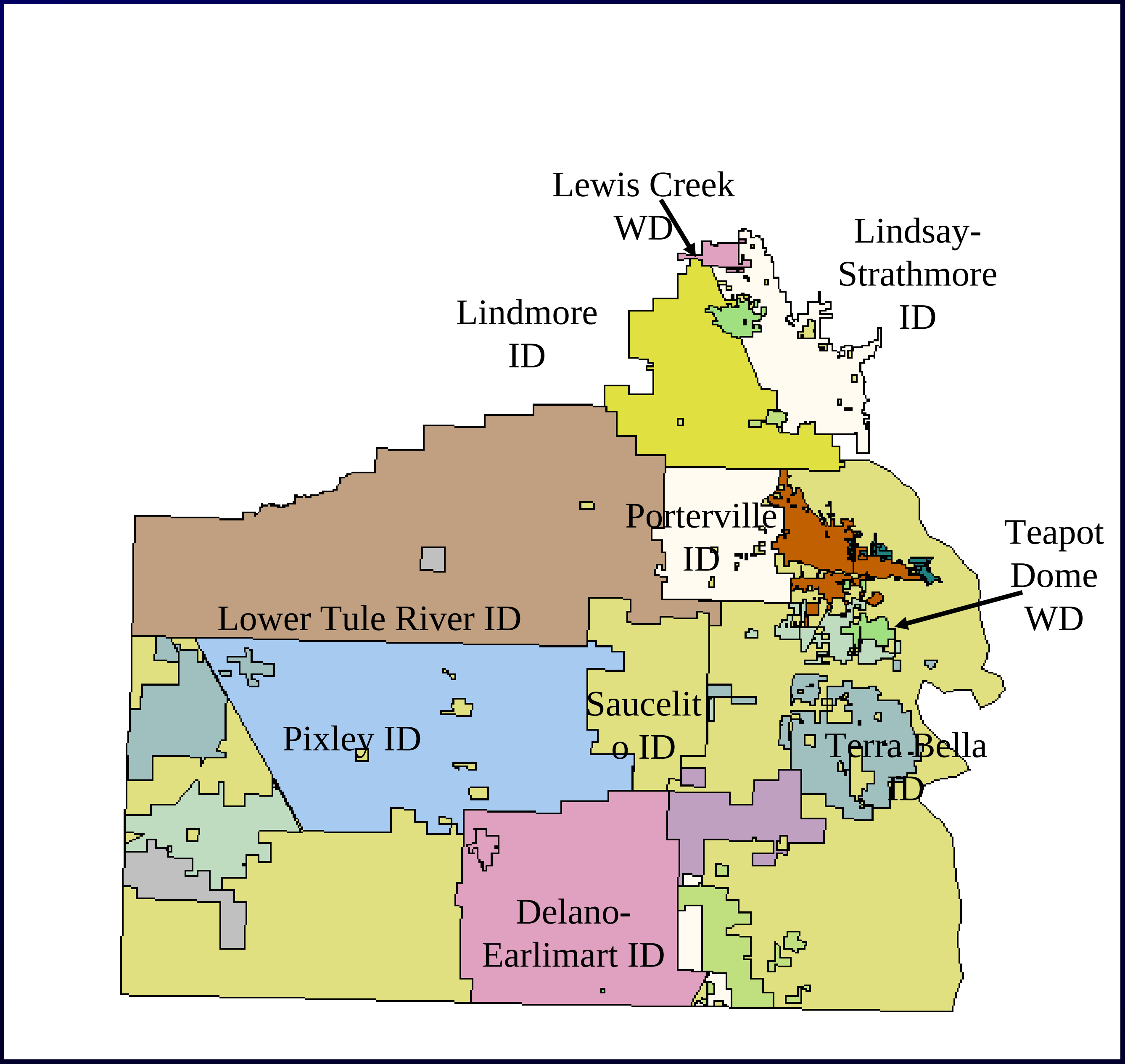




Tule Groundwater Basin
~ 2,300 km^2

nia, Davis, 2008

Irrigation, Water, and Municipal Districts in Study Area

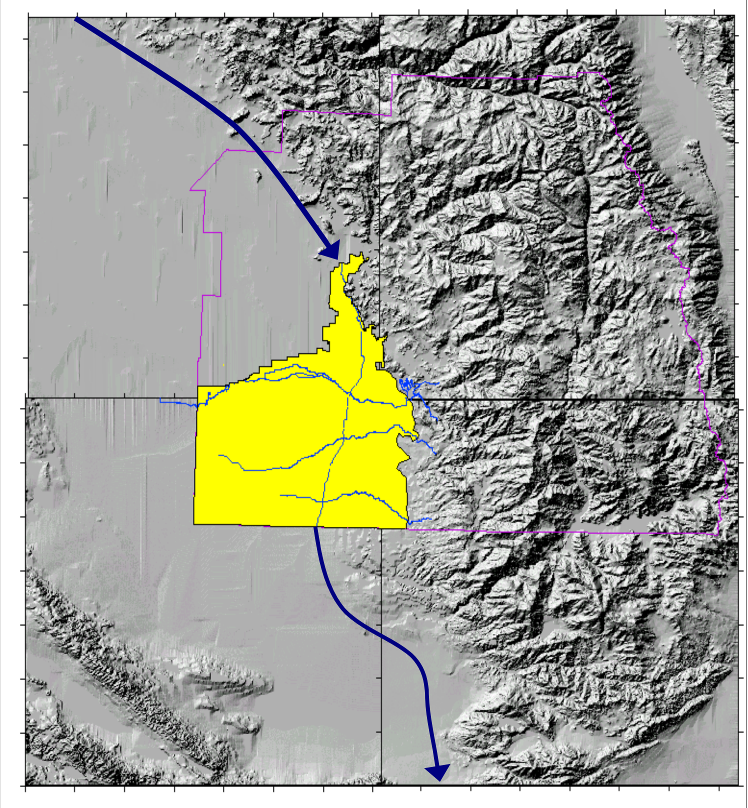


Friant Division Contractors in Study Area

District	Class 1	Class 2	Total
Delano-Earlimart ID	108,800	74,500	183,300
Lewis Creek WD	N/A (1,450)	N/A (none)	N/A (1,450)
Lindmore ID	33,000	22,000	55,000
Lindsay-Strathmore ID	27,500 (30,000)	none	27,500 (30,000)
Lower Tule River ID	61,200	238,000	299,200
Porterville ID	16,000	30,000	46,000
Saucelito ID	21,200	32,800	54,000
Teapot Dome WD	7,500	none	7,500
Terra Bella ID	29,000	none	29,000

Key Issues

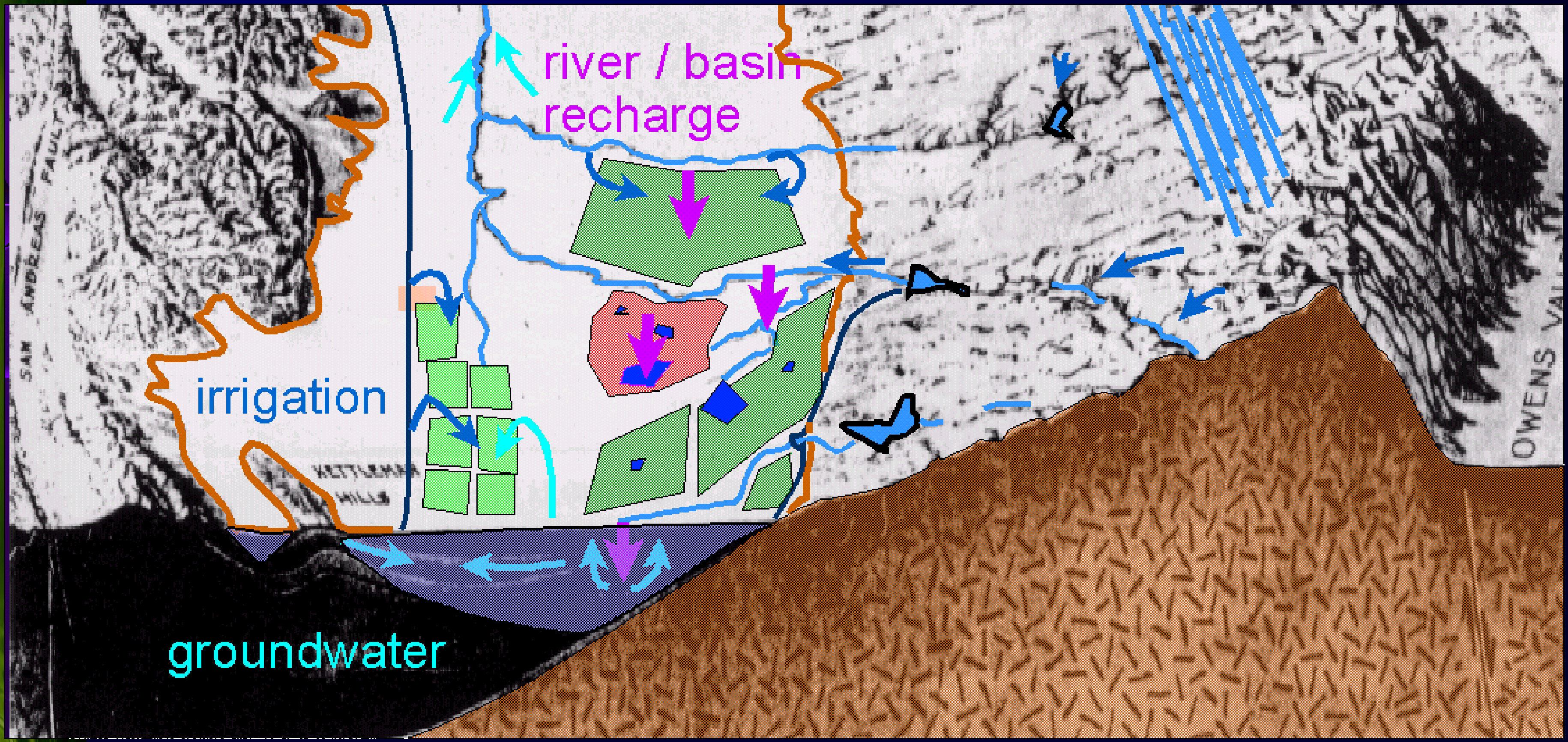
- Quantity of water delivered under renewed contracts
- Water transfers
- Tiered water pricing
- Water conservation measures
- Allocating water to fish and wildlife
- Groundwater Overdraft



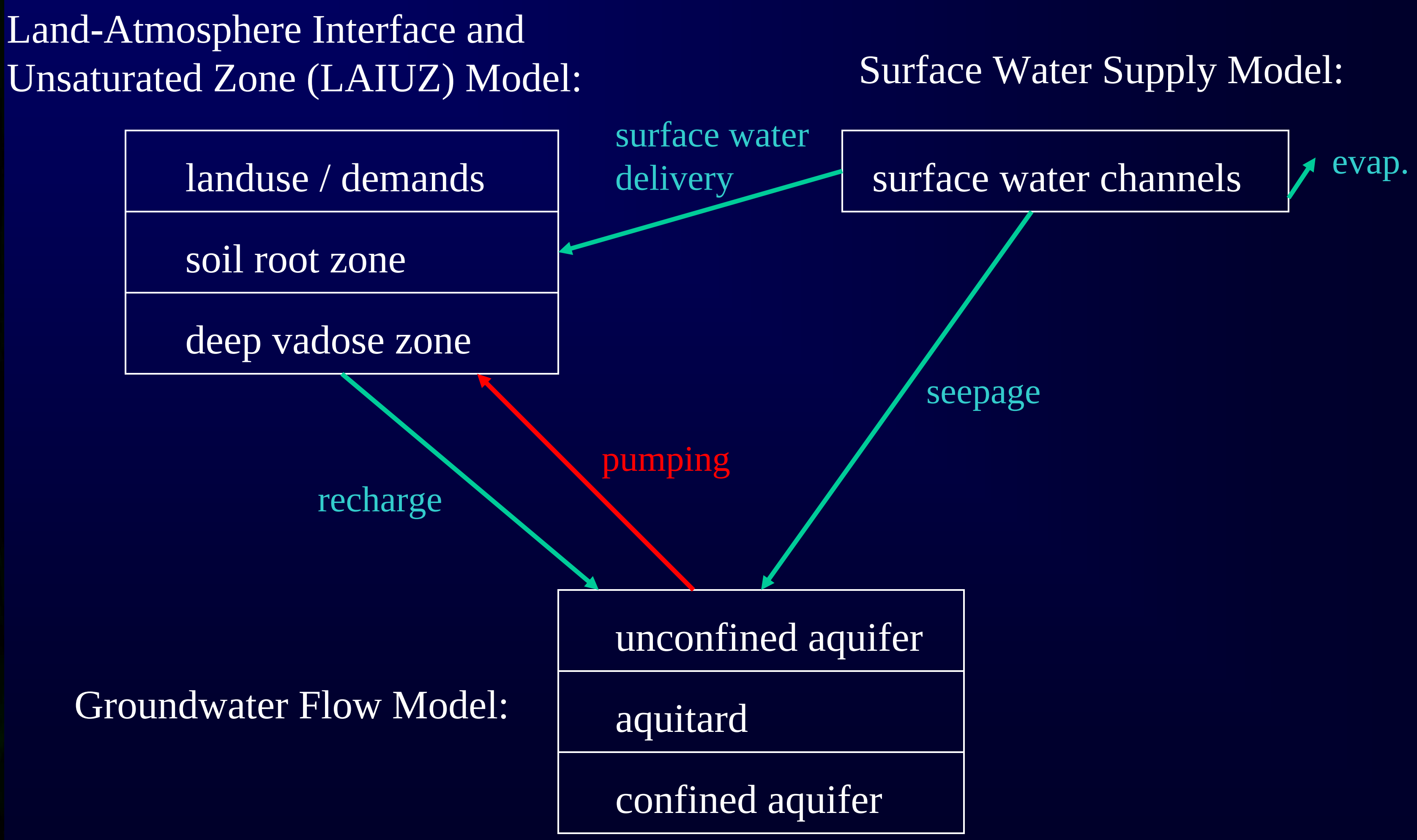
Project Objectives

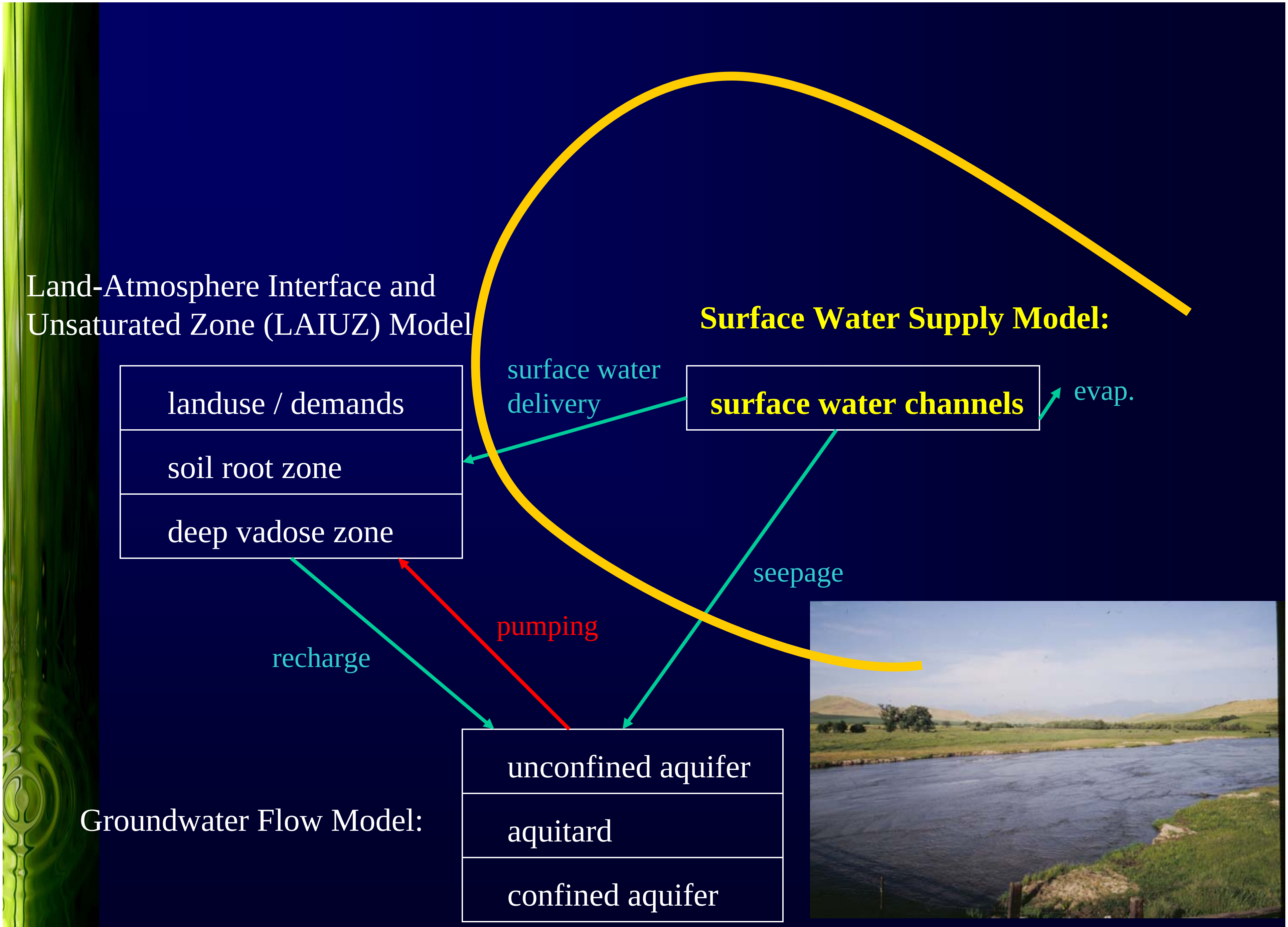
- Develop a conjunctive use groundwater-surface water model for the Tule Groundwater Basin area.
- Create a comprehensive, user-friendly database of the project area hydrology and hydrogeology using GIS
- Develop and assess the response of the groundwater basin to several future conjunctive use management alternatives

Water in California's Central Valley

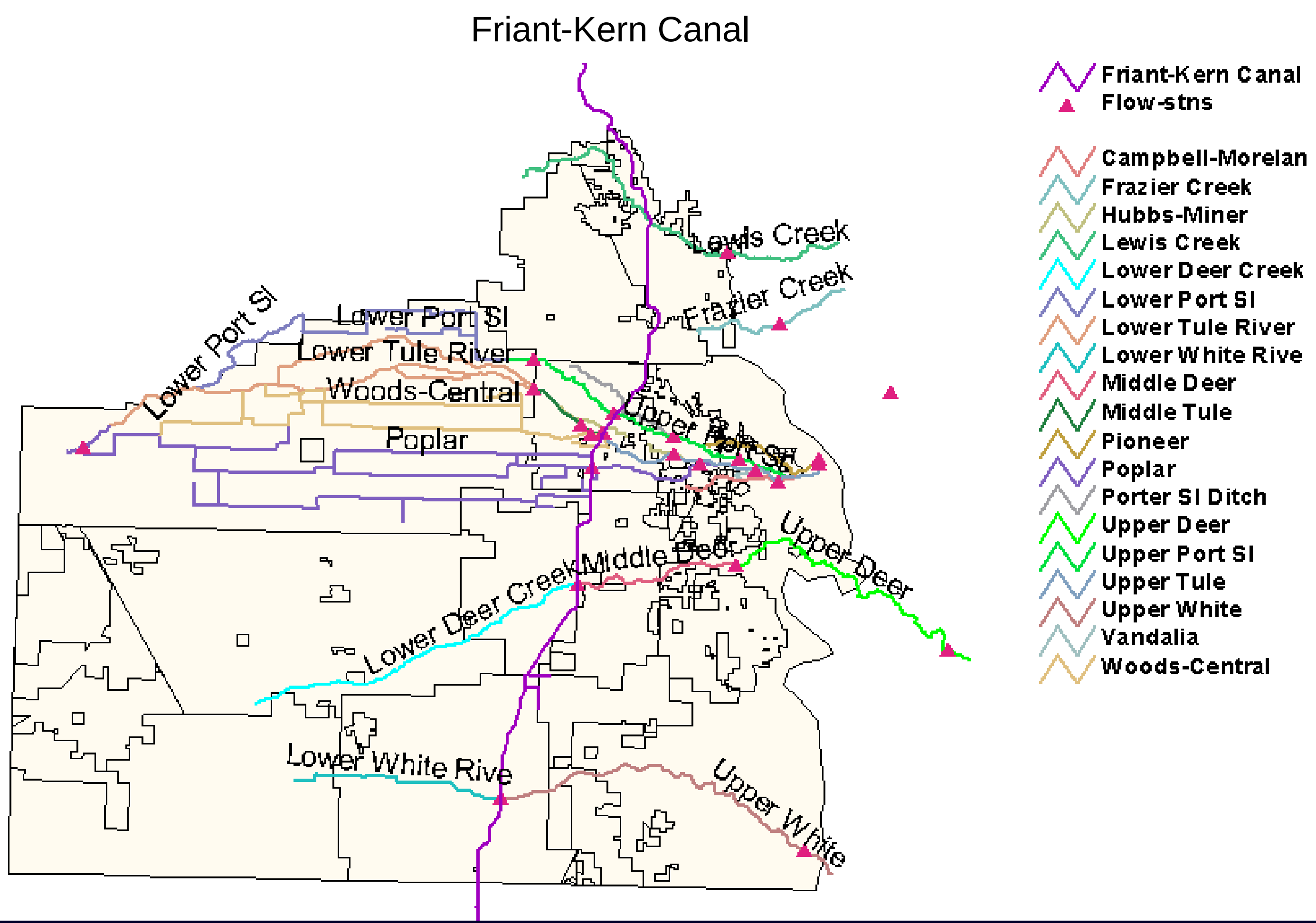


Interaction of Surface Water Supply, Land-Atmosphere and Unsaturated Zone (LAIUZ), and Groundwater Flow Models

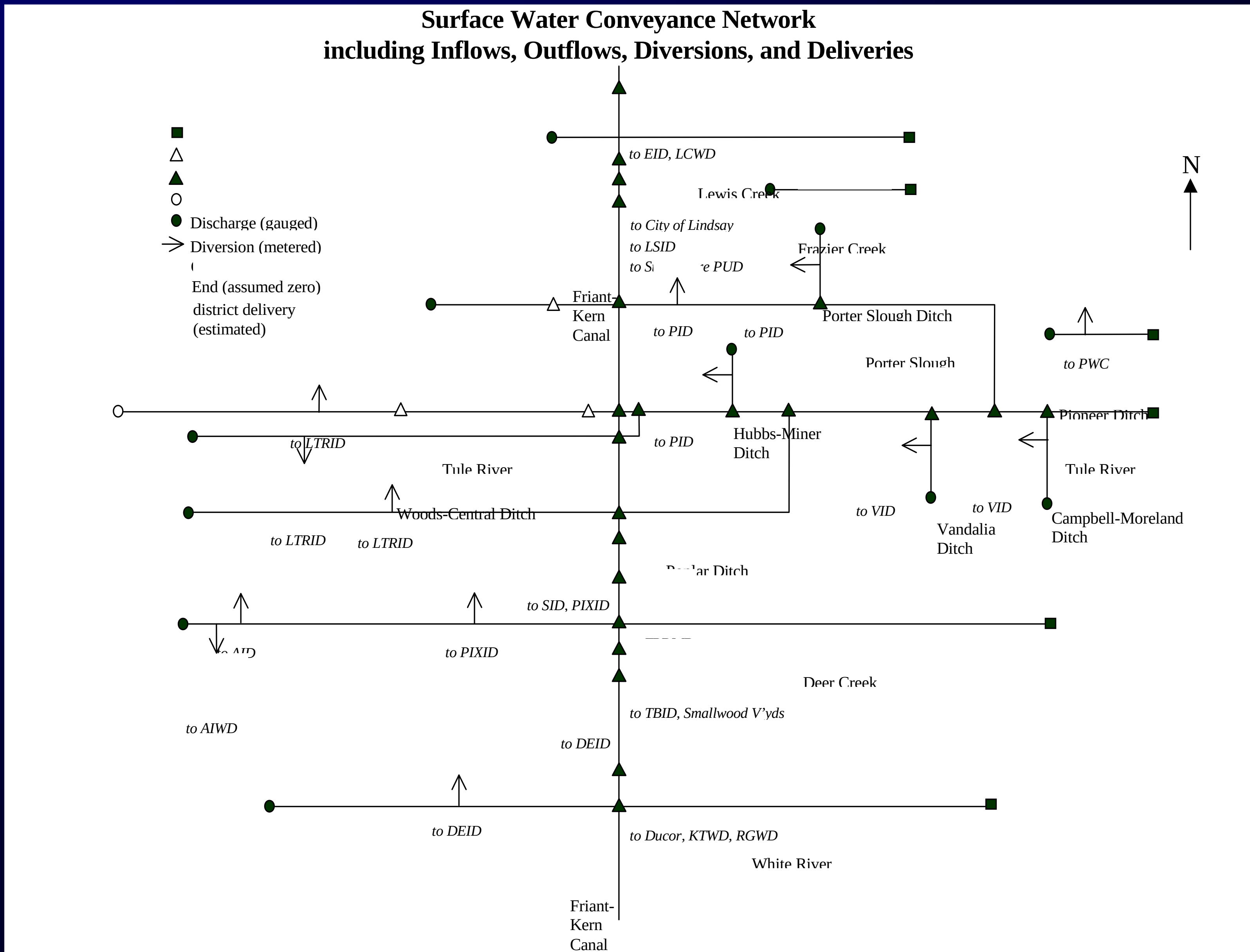



Land-Atmosphere Interface and
Unsaturated Zone (LAIUZ) Model
landuse / demands
soil root zone
deep vadose zone
Surface Water Supply Model:
surface water channels
surface water
delivery
evap.
seepage
recharge
pumping
Groundwater Flow Model:
unconfined aquifer
aquitard
confined aquifer

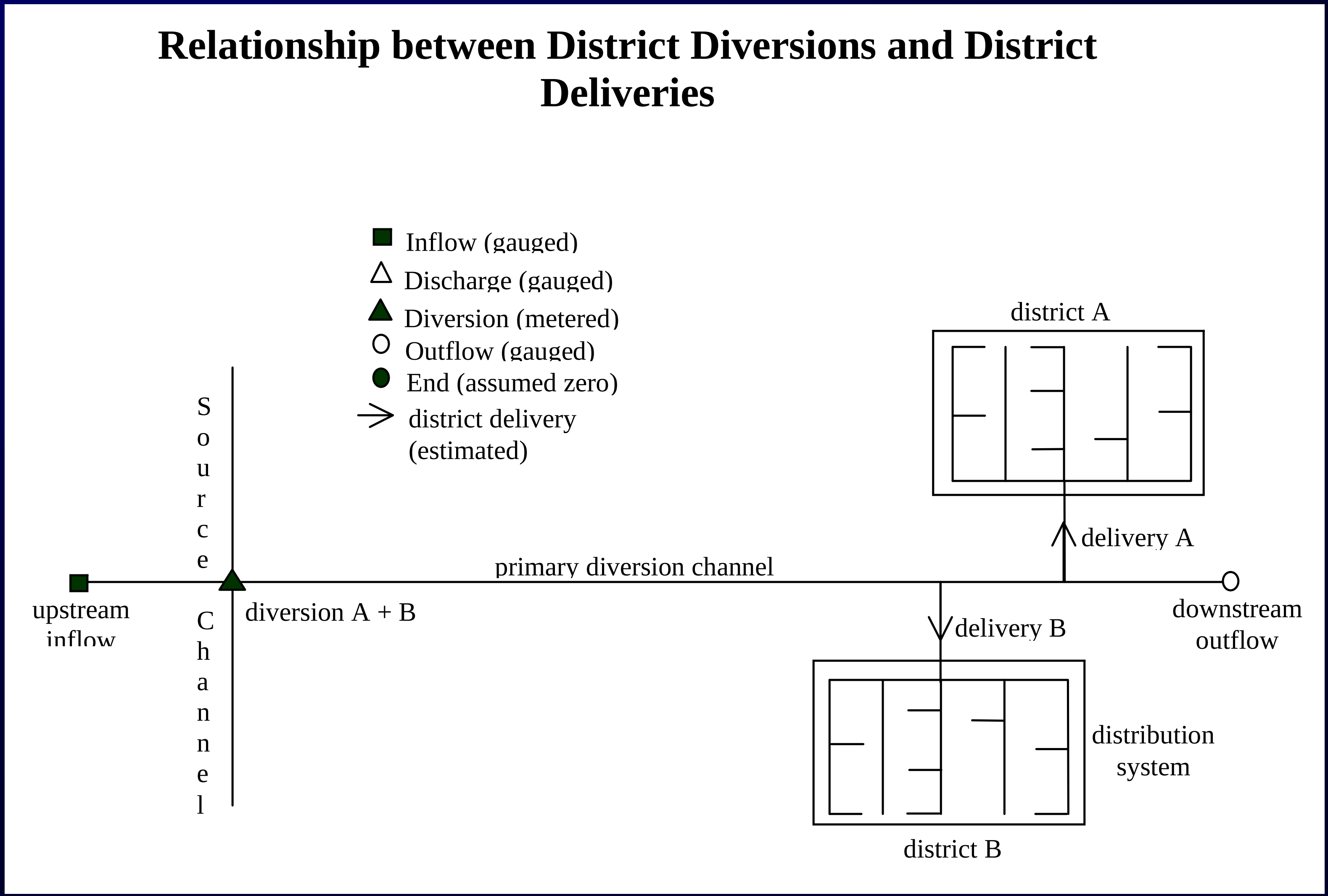
Surface Water Conveyance Network



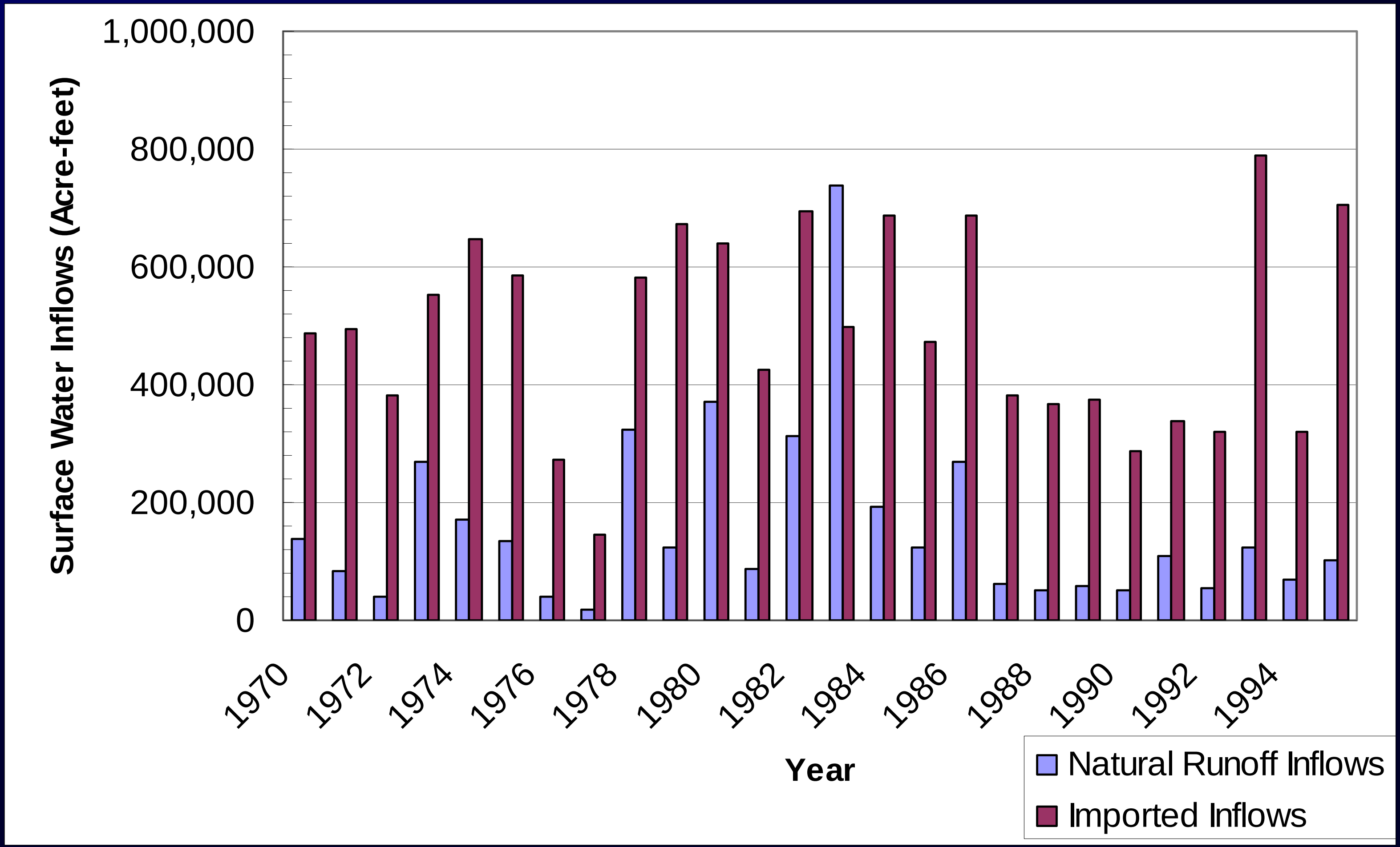
Channel Network Implementation



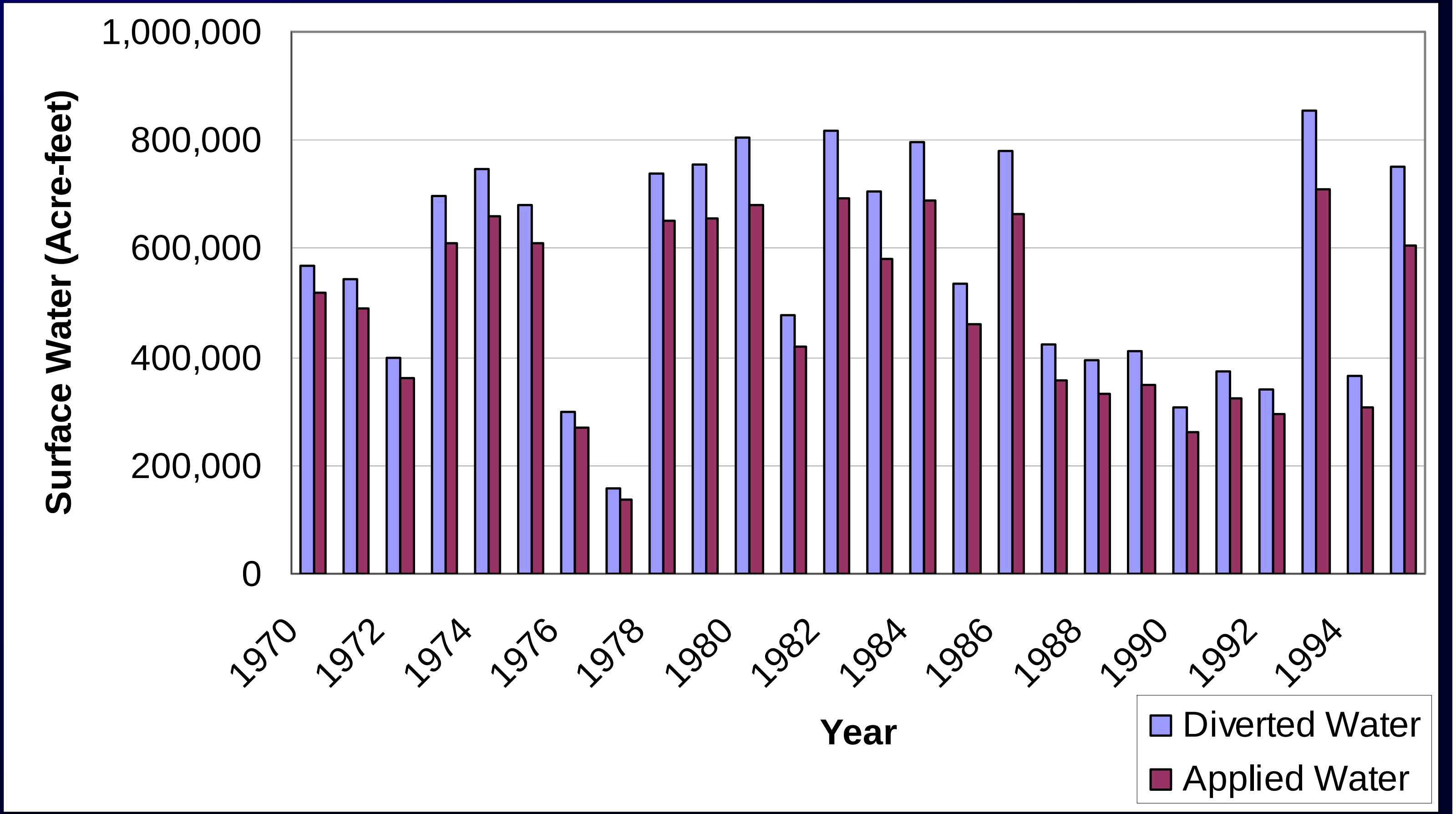
Handling Seepage and Evaporation



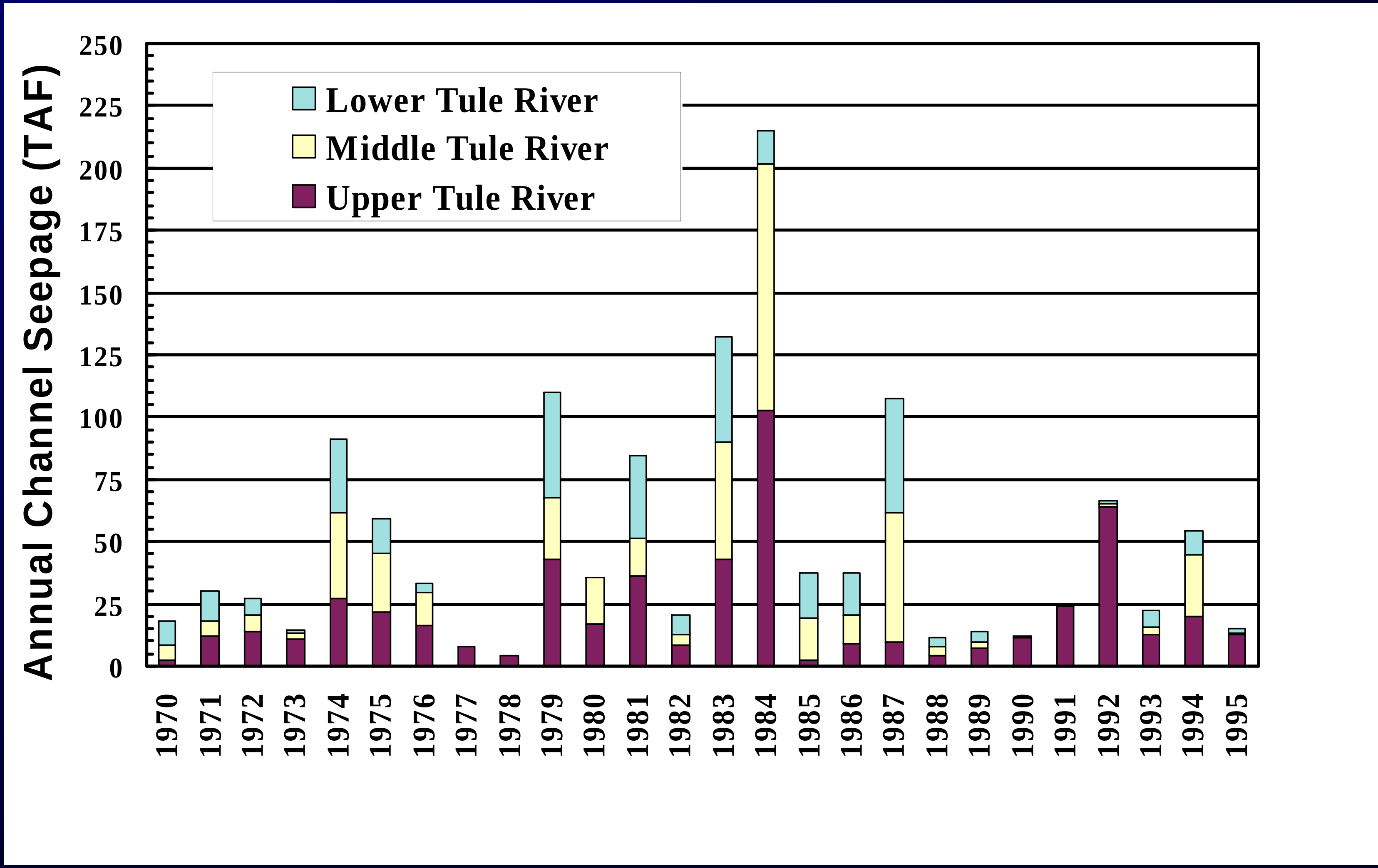
Surface Water Deliveries (1970-95): Input



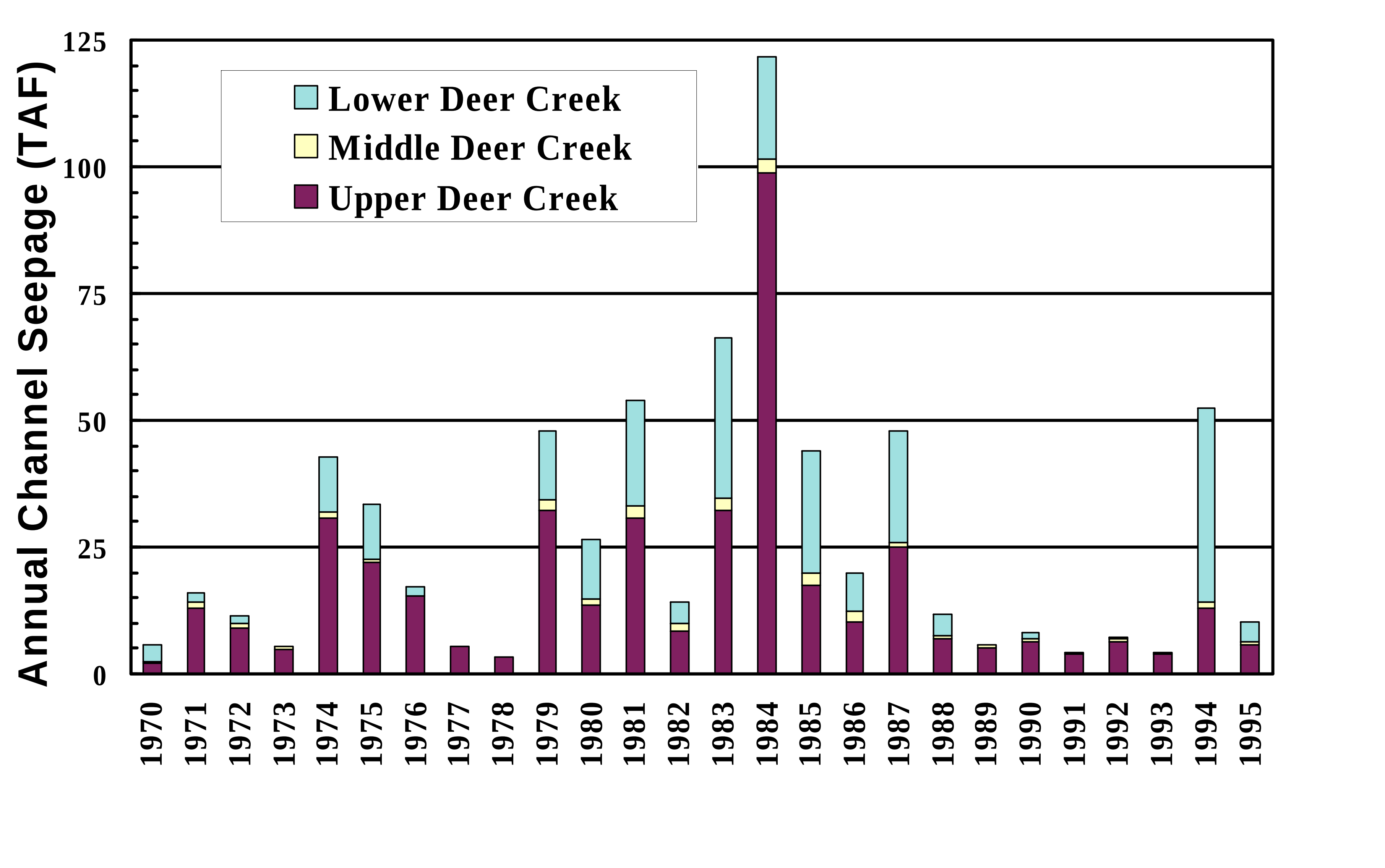
Surface Water Deliveries (1970-95): Output



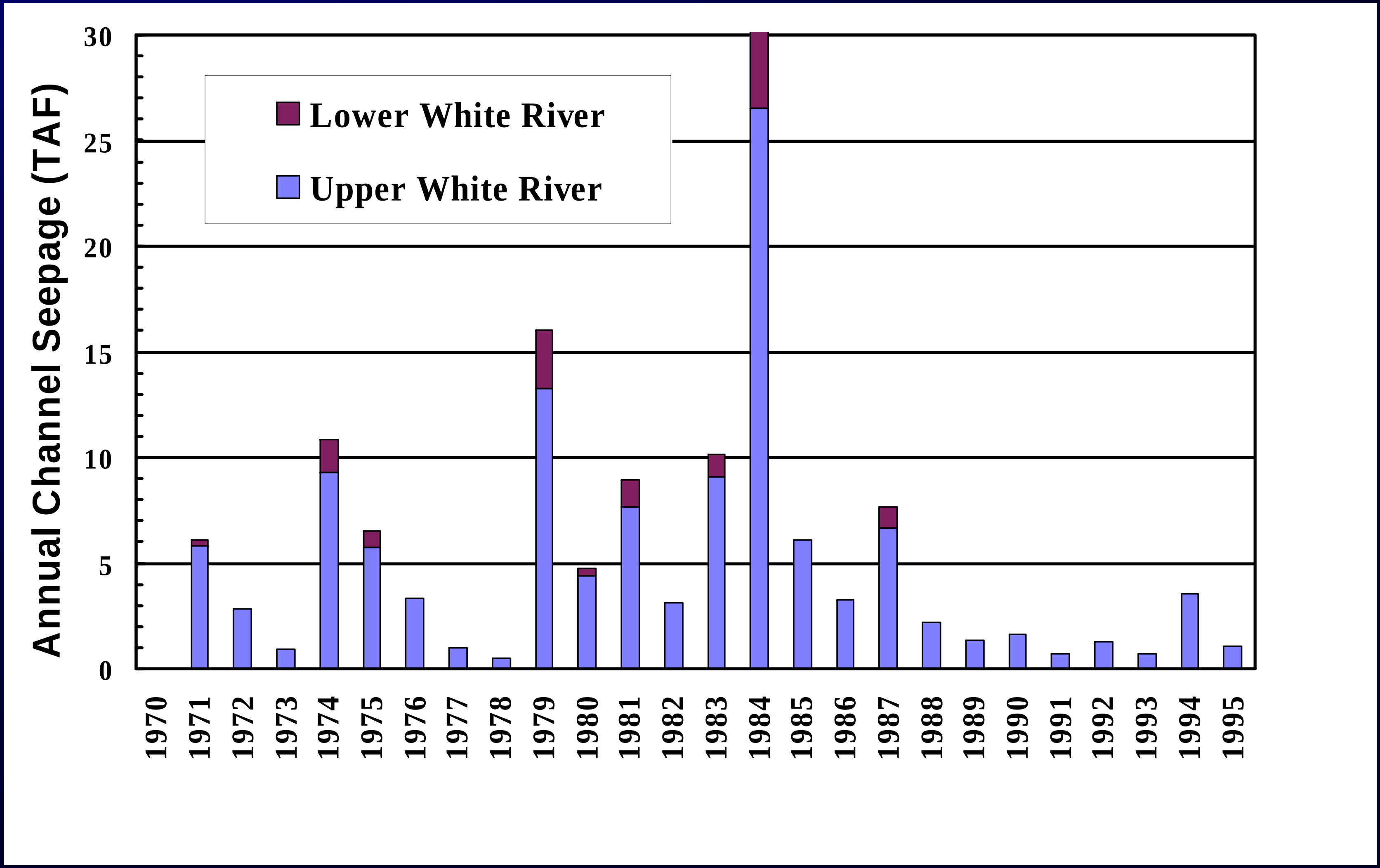
Annual Channel Seepage from the Tule River



Annual Seepage from the Deer Creek



Annual Seepage from the White River



River Recharge Modeling Approach

river recharge line coverage

↓

Line River Recharge Information Layer
Argus ONE MODFLOW/MT3D PIE

export template: converts the line river recharge layer into a grid of surface recharge stresses

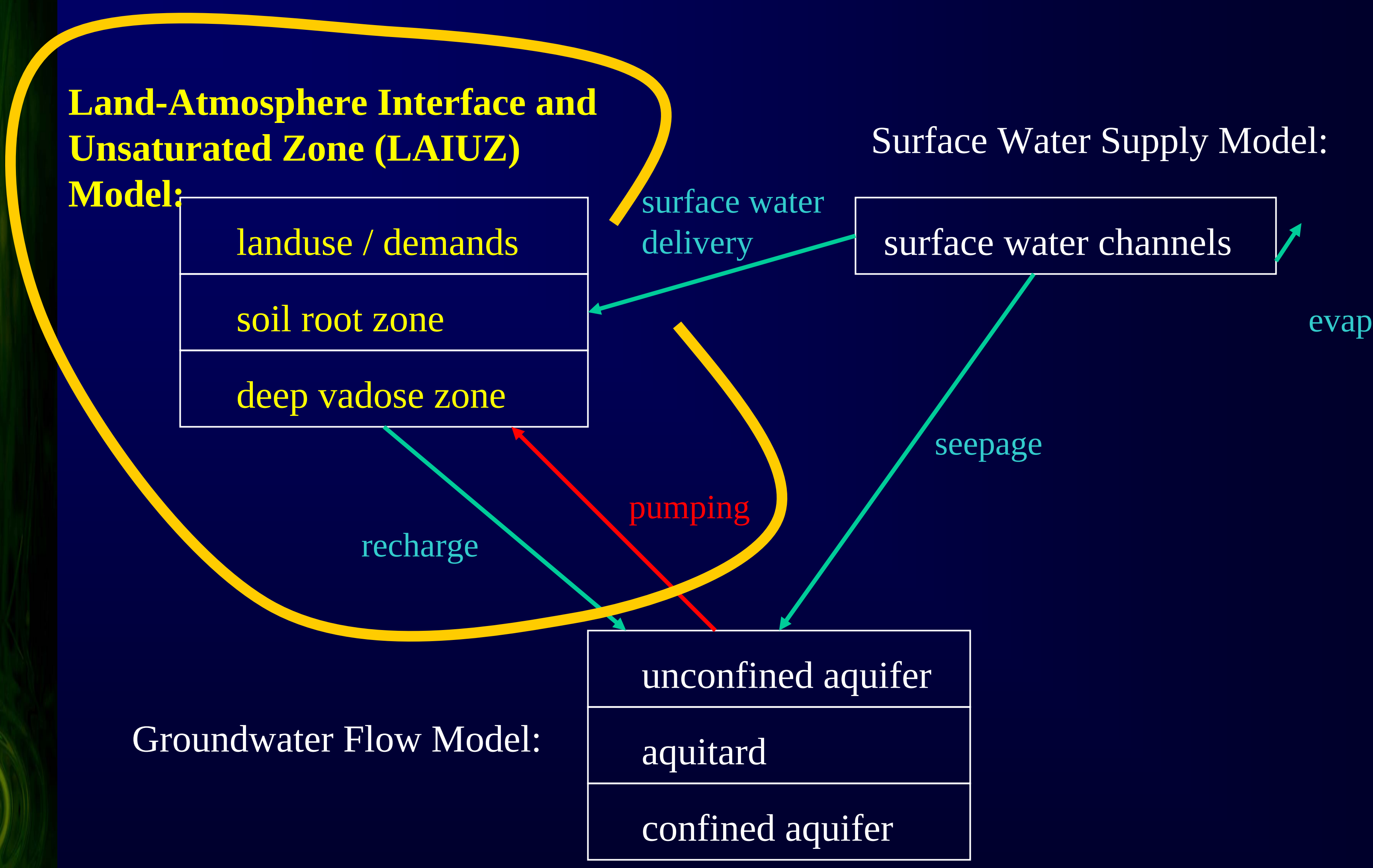
↓

MODFLOW recharge package input file

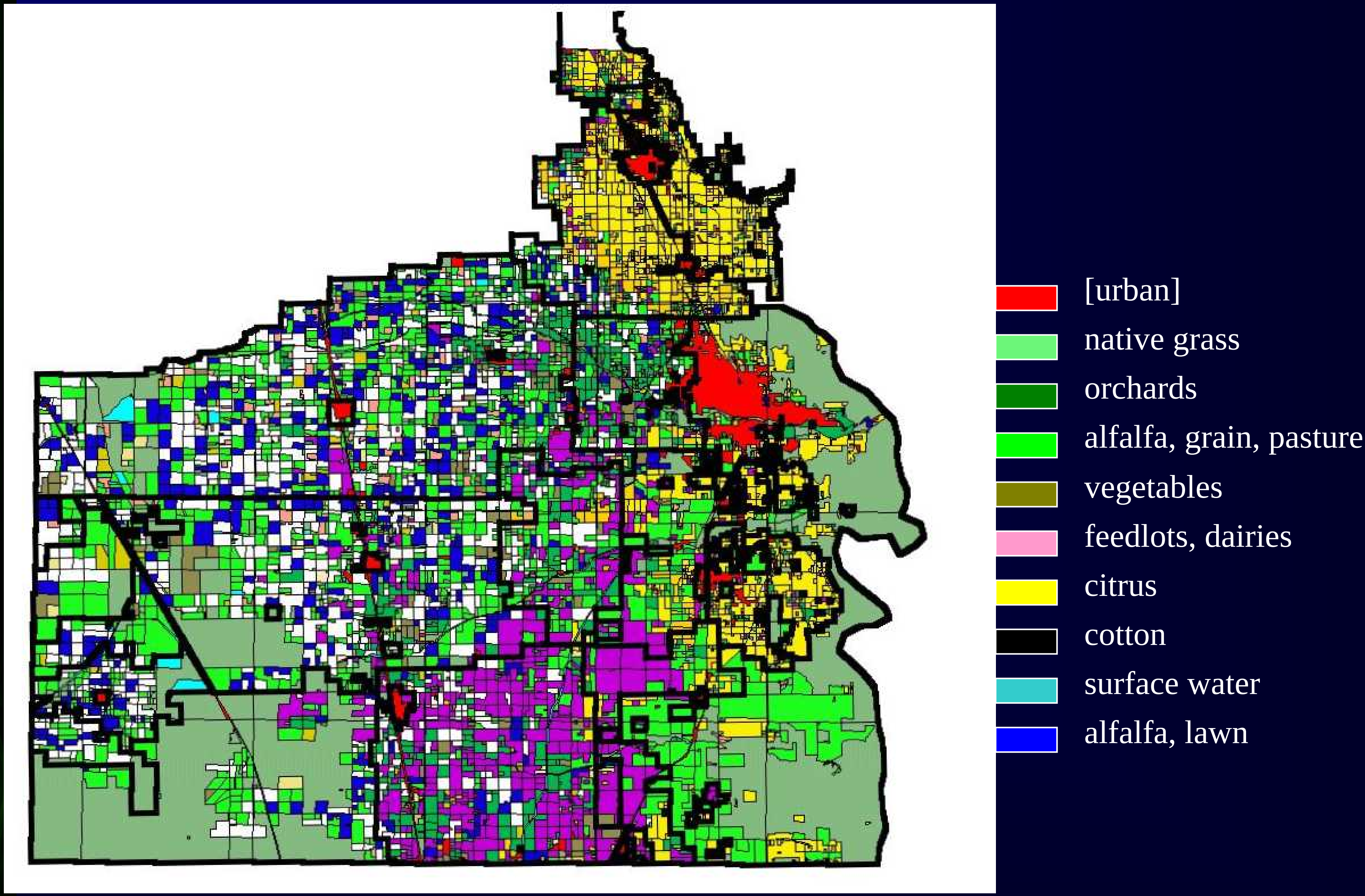
↓

MODFLOW

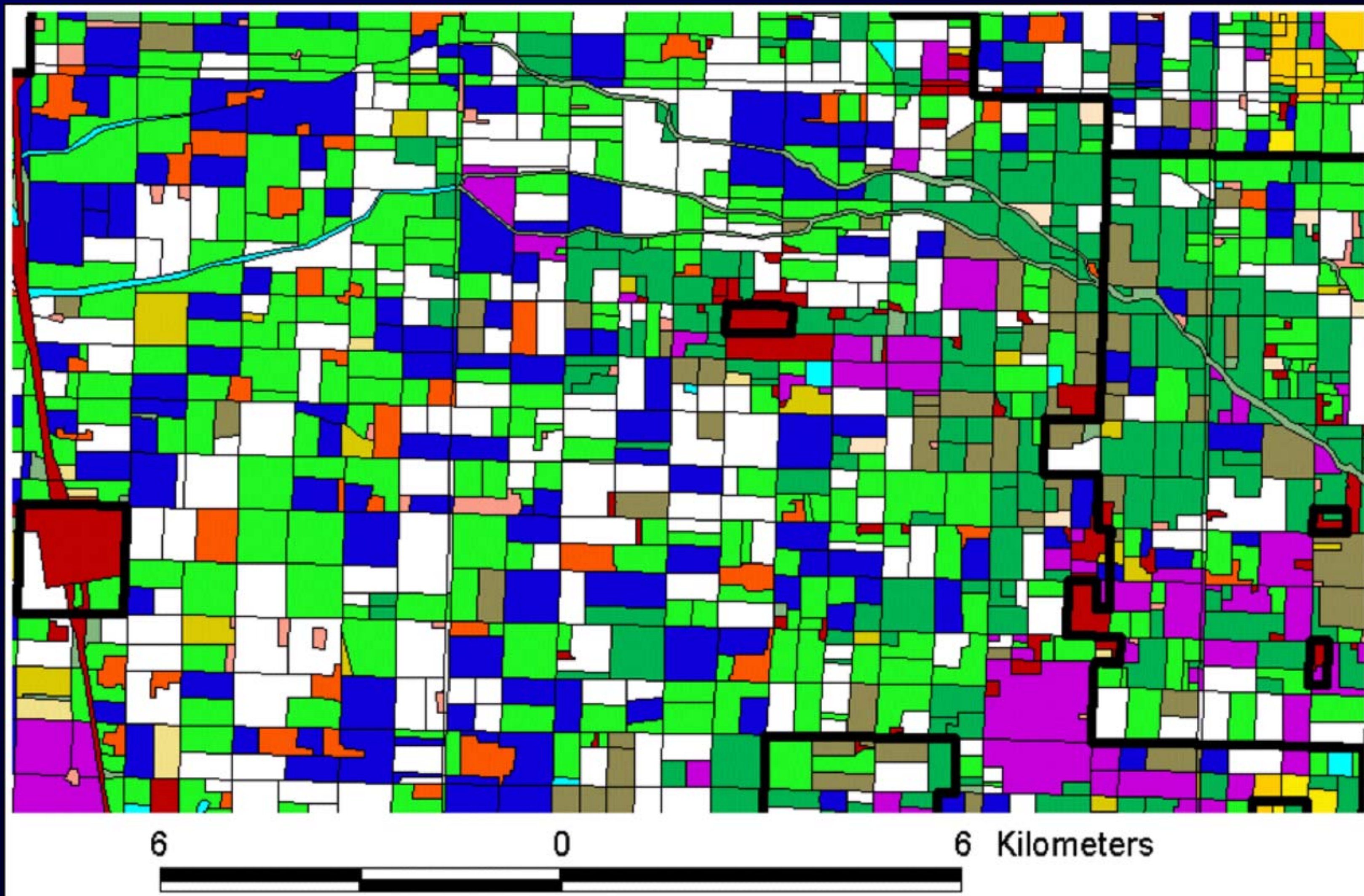
→ Simulated Water Balance Response


Land-Atmosphere Interface and Unsaturated Zone (LAIUZ) Model:
landuse / demands
soil root zone
deep vadose zone
surface water delivery
Surface Water Supply Model:
surface water channels
evap.
seepage
pumping
recharge
Groundwater Flow Model:
unconfined aquifer
aquitard
confined aquifer

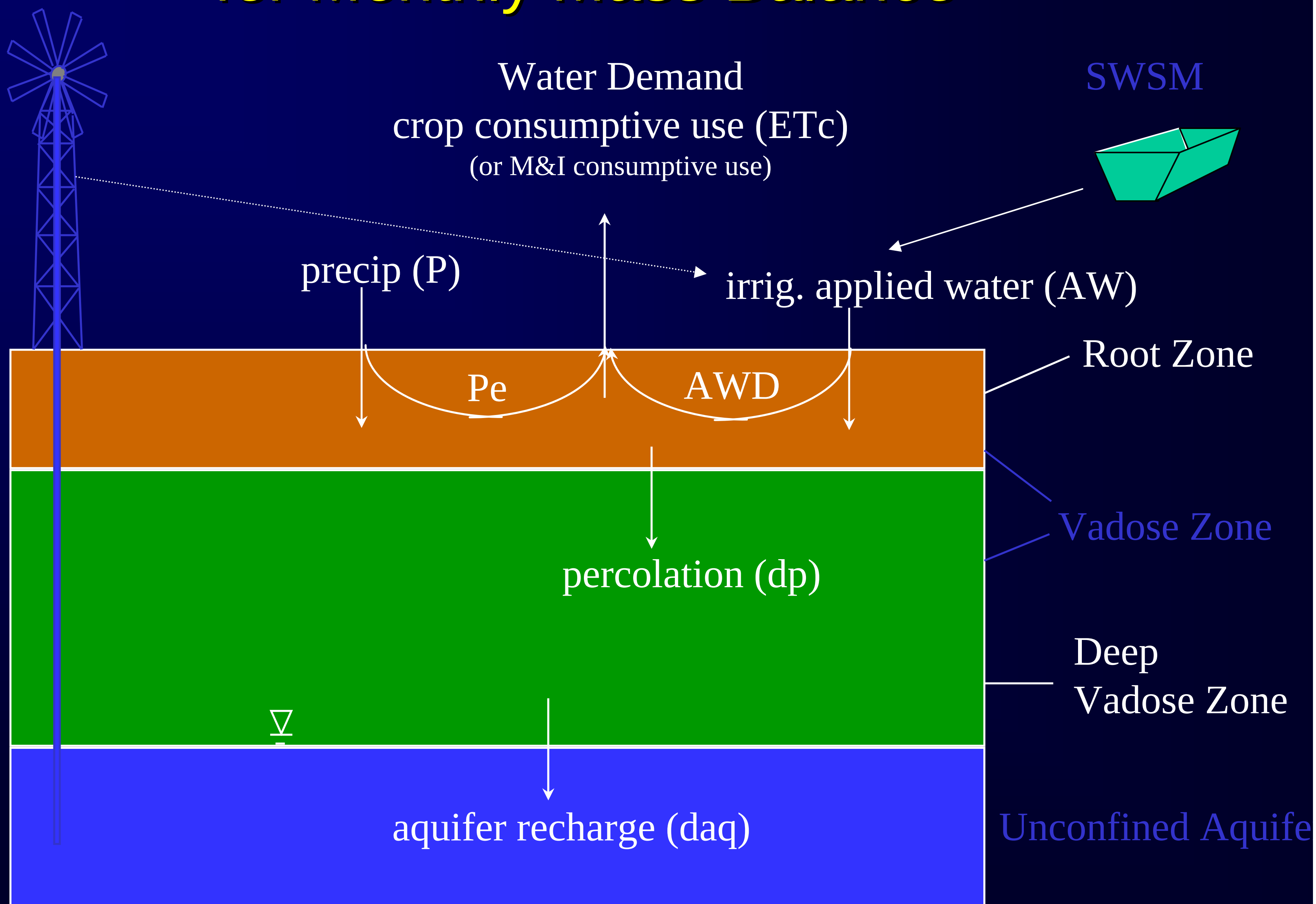
Major Crop Types / Landuse Areas



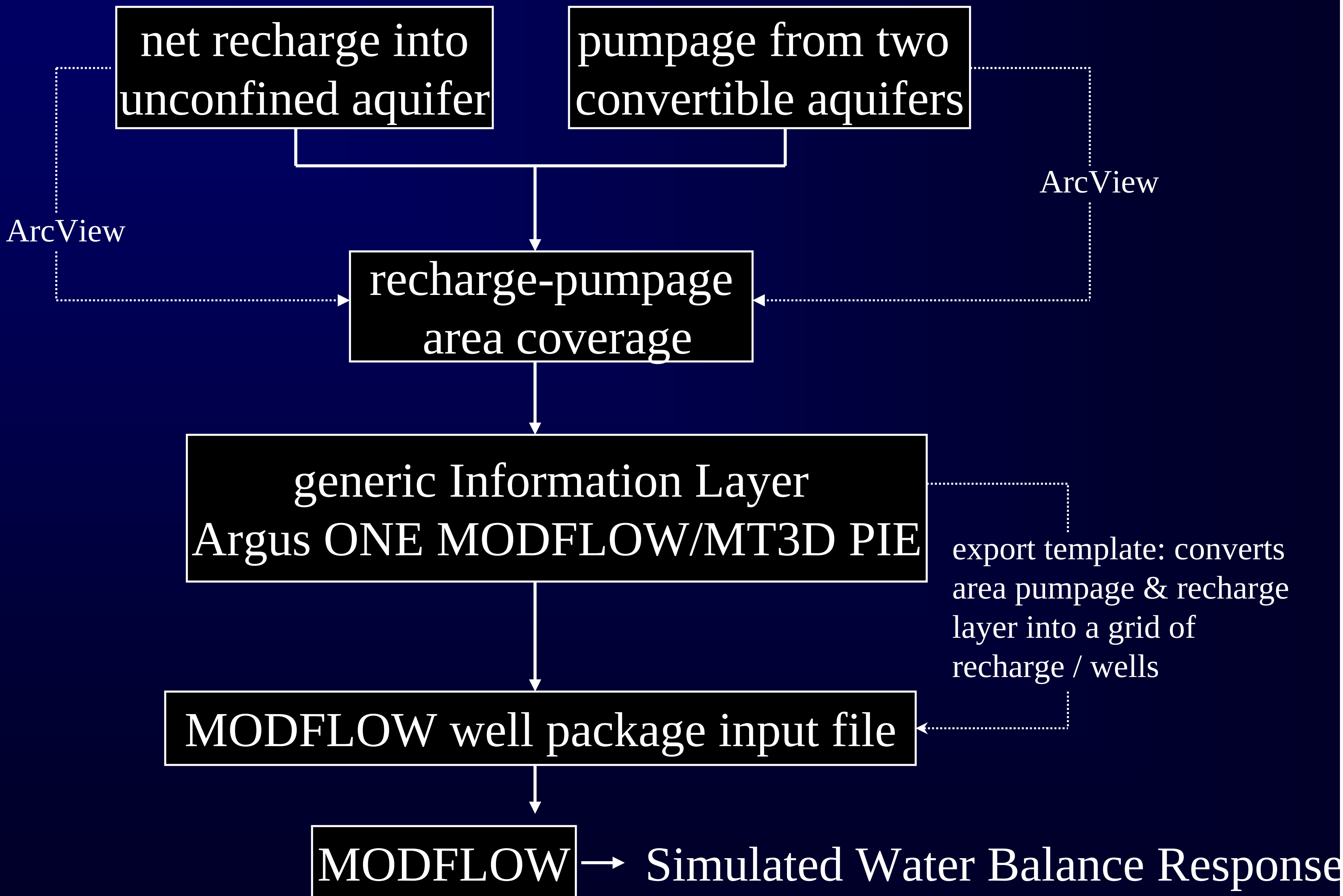
Details of Landuse Coverage



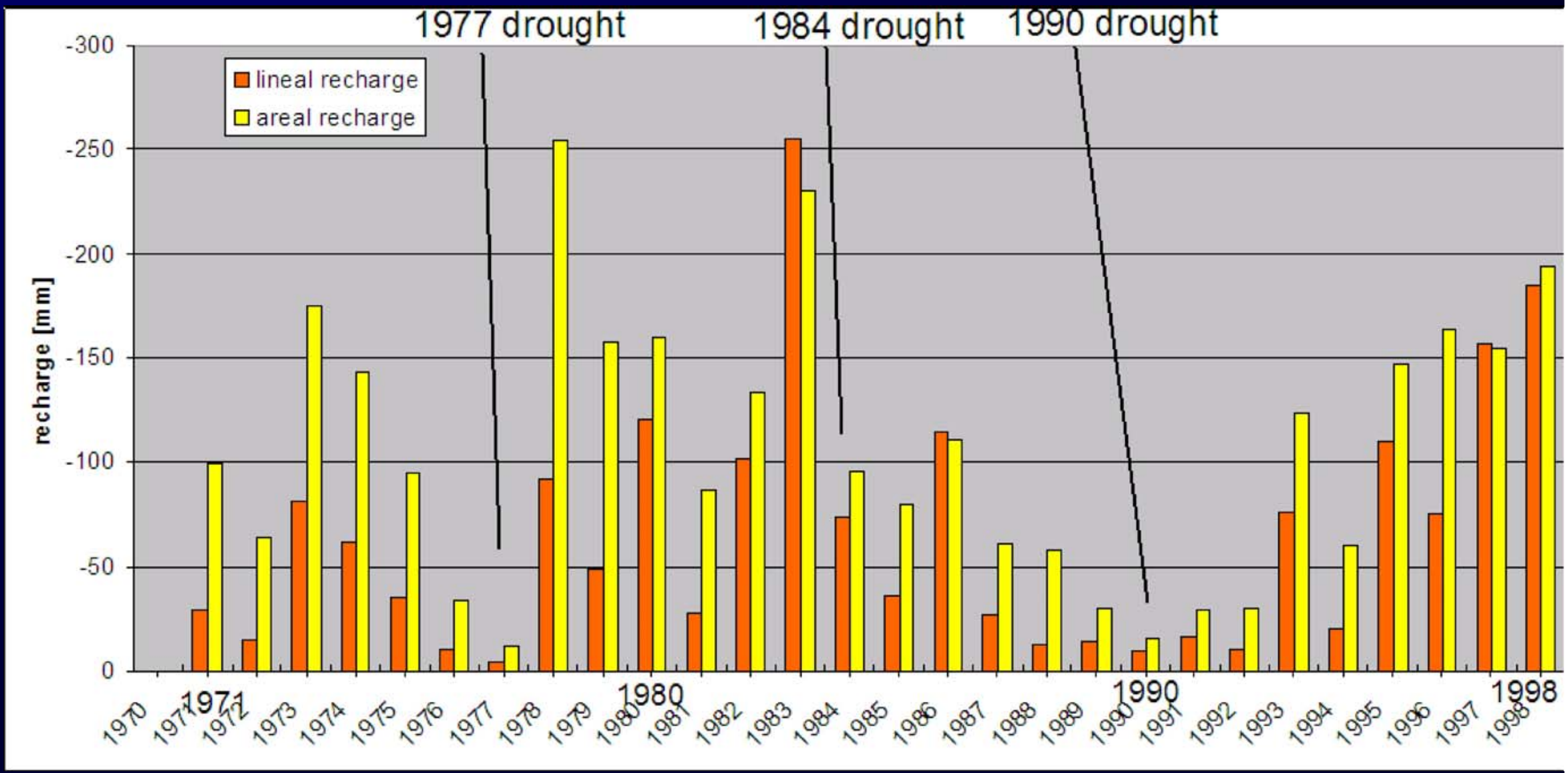
LAIUZ: Model Components for Monthly Mass Balance



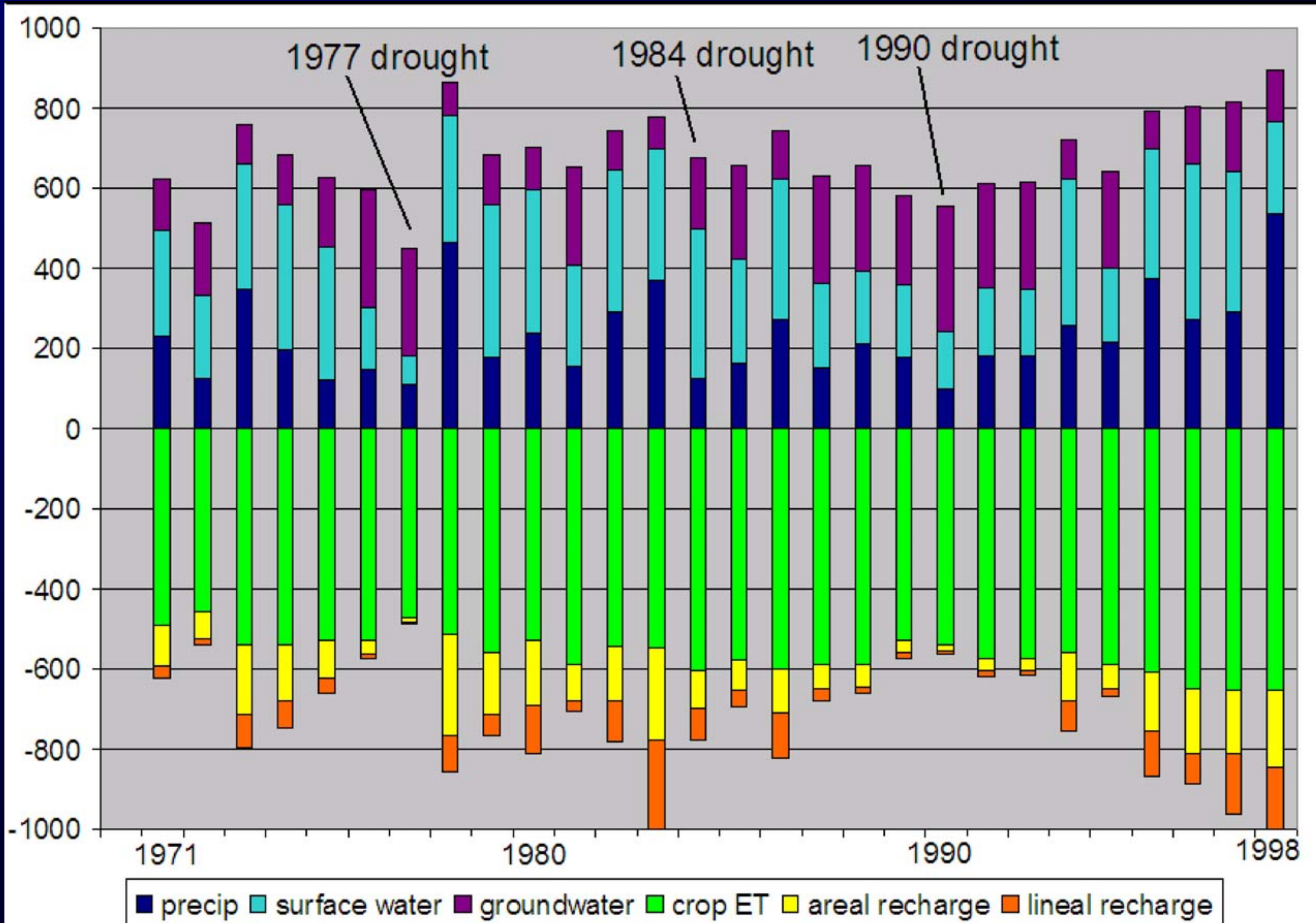
Recharge and Pumpage Modeling Approach



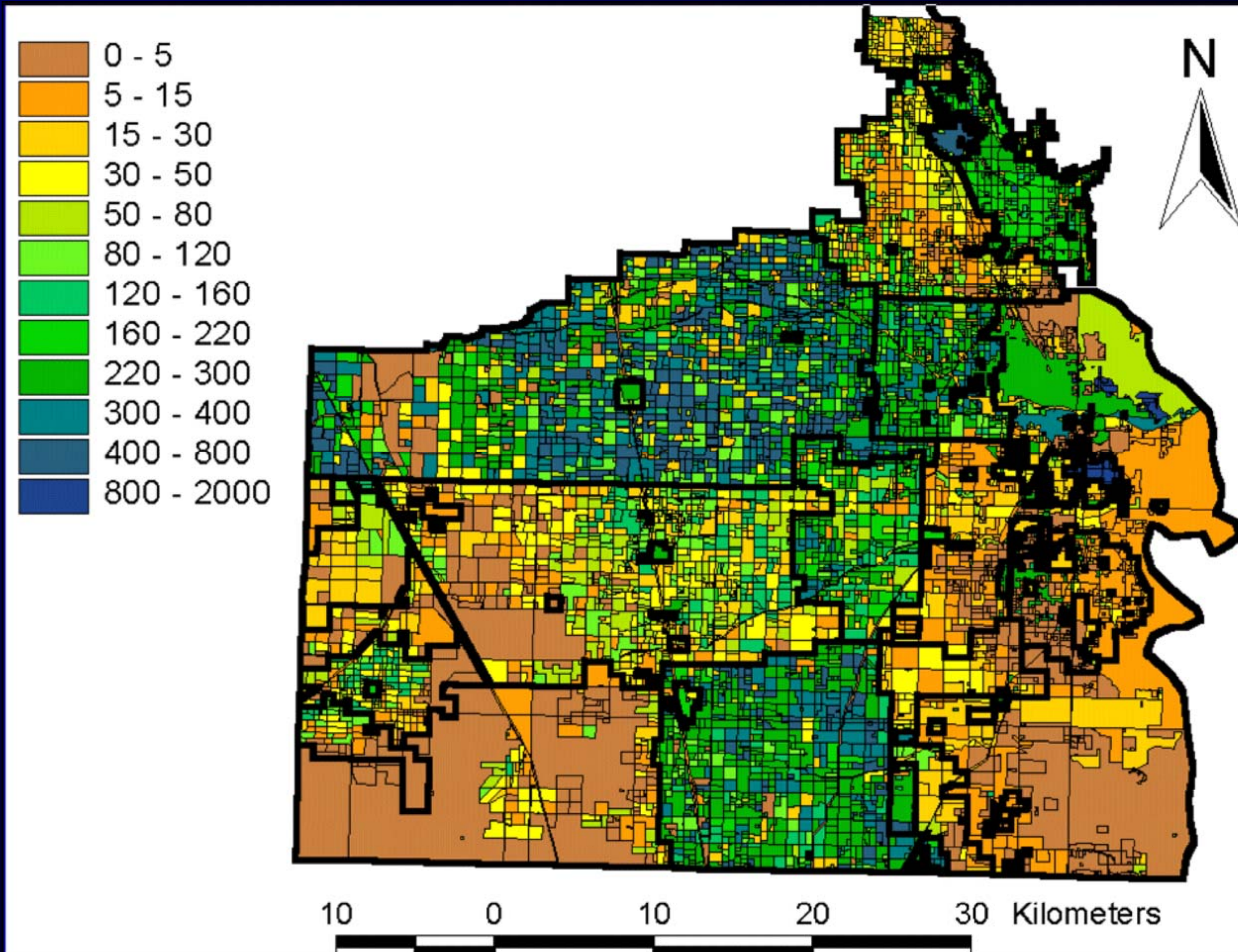
Lineal (Stream) vs. Diffuse Recharge



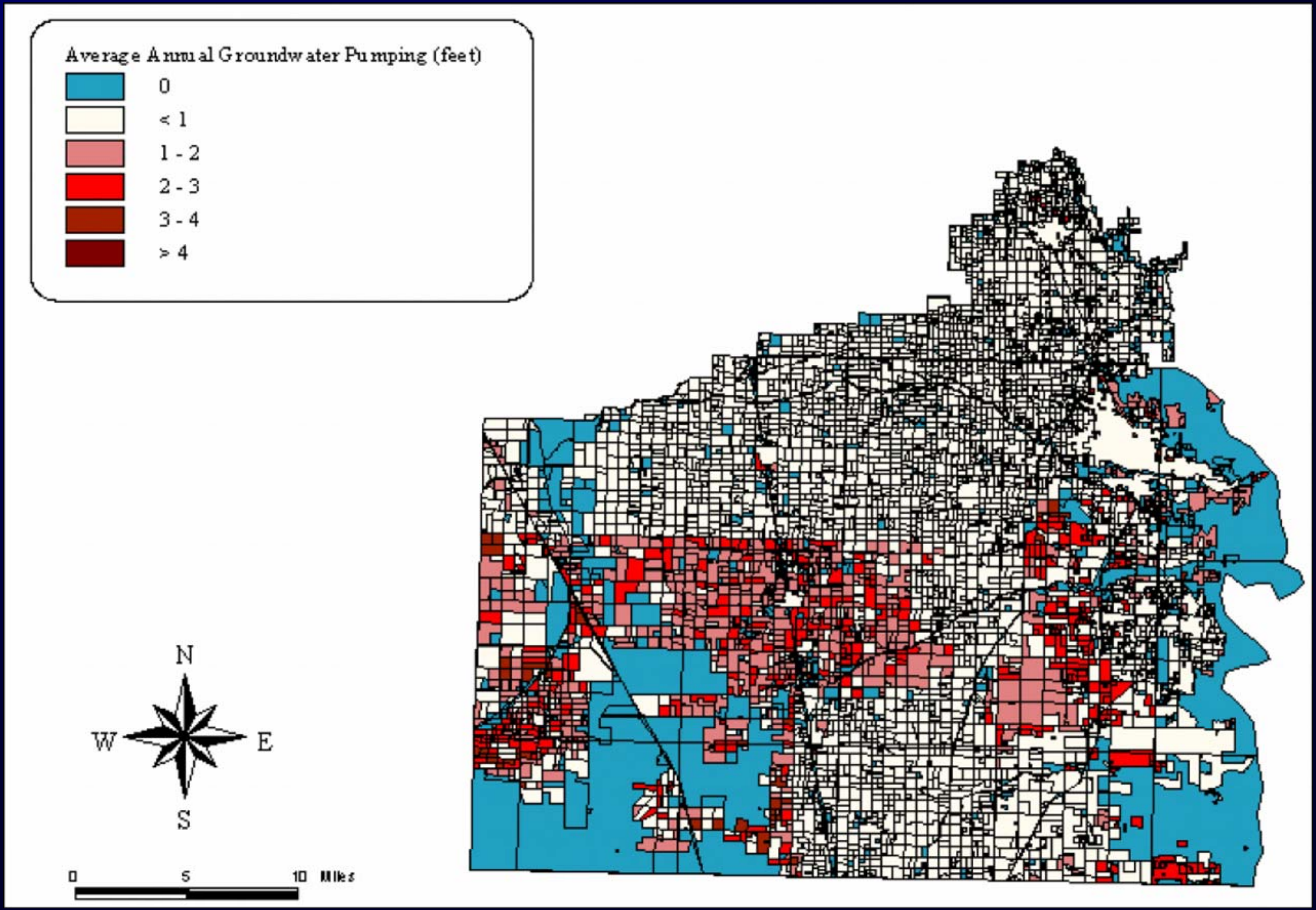
Project Area Hydrologic Budget



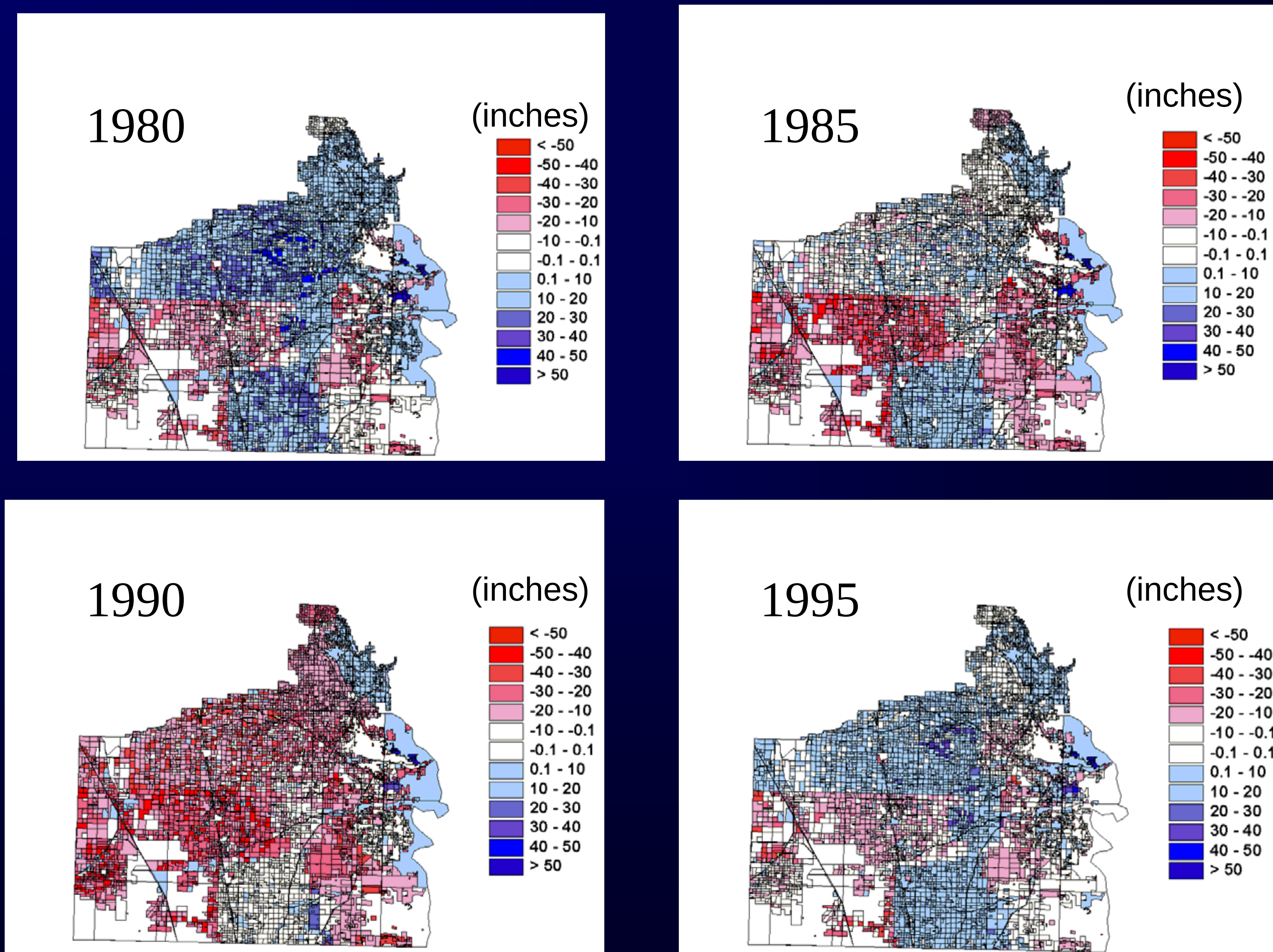
Average Recharge [mm/yr], 1970 - 2000



Average Pumping [ft/yr], 1970 - 2000

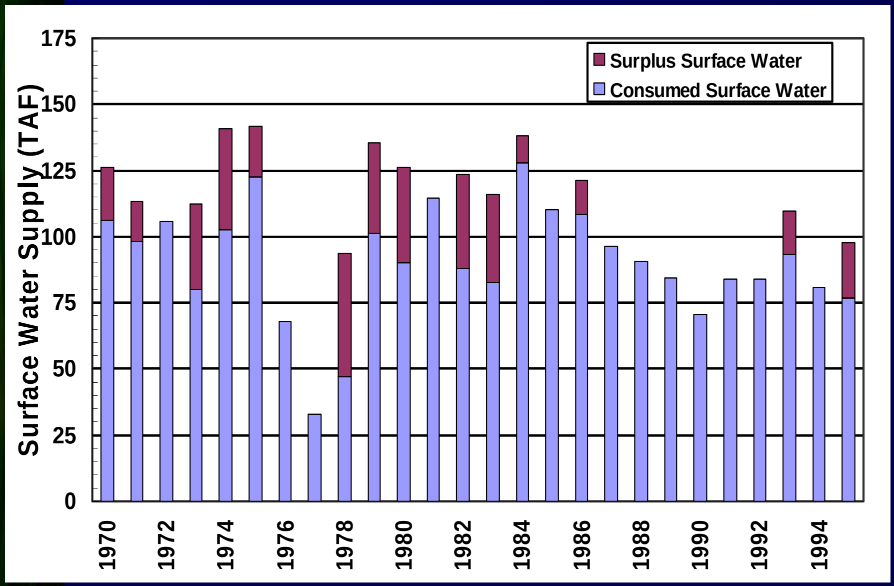


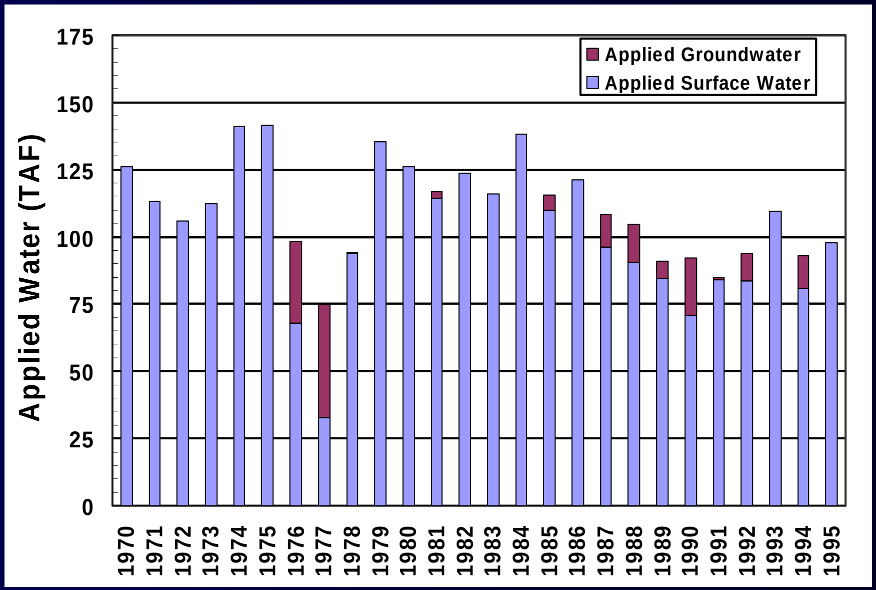
Annual Net Aquifer Recharge

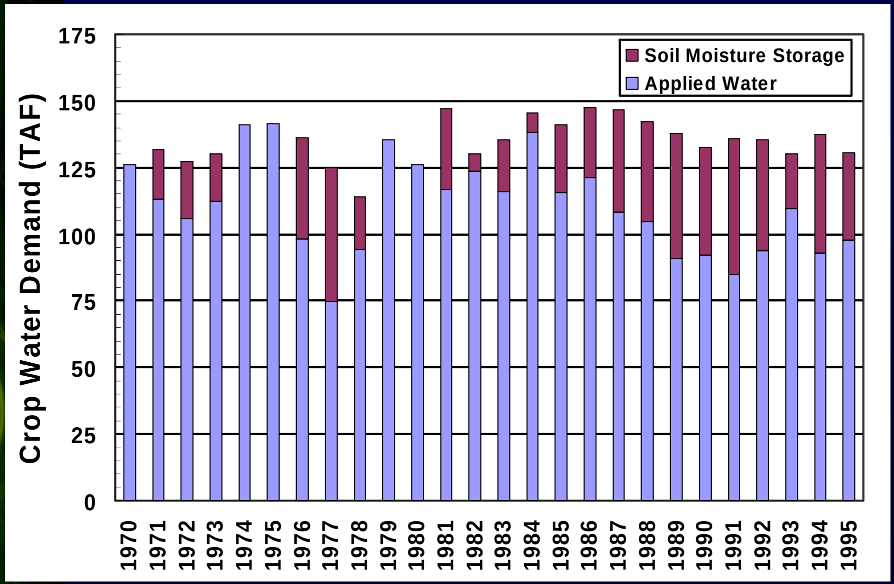


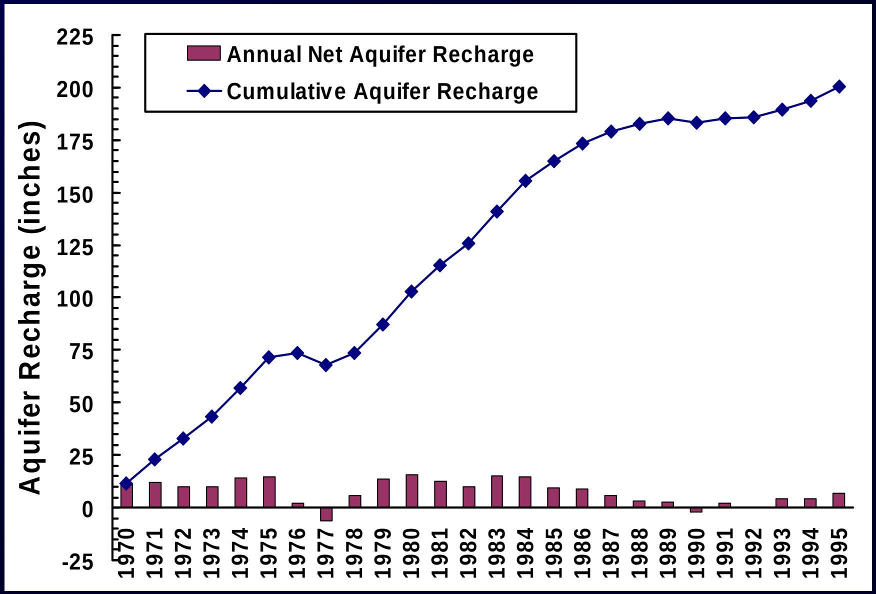
Delano-Earlimart Irrigation District

irrigated acreage (Tulare Co. only): 45K



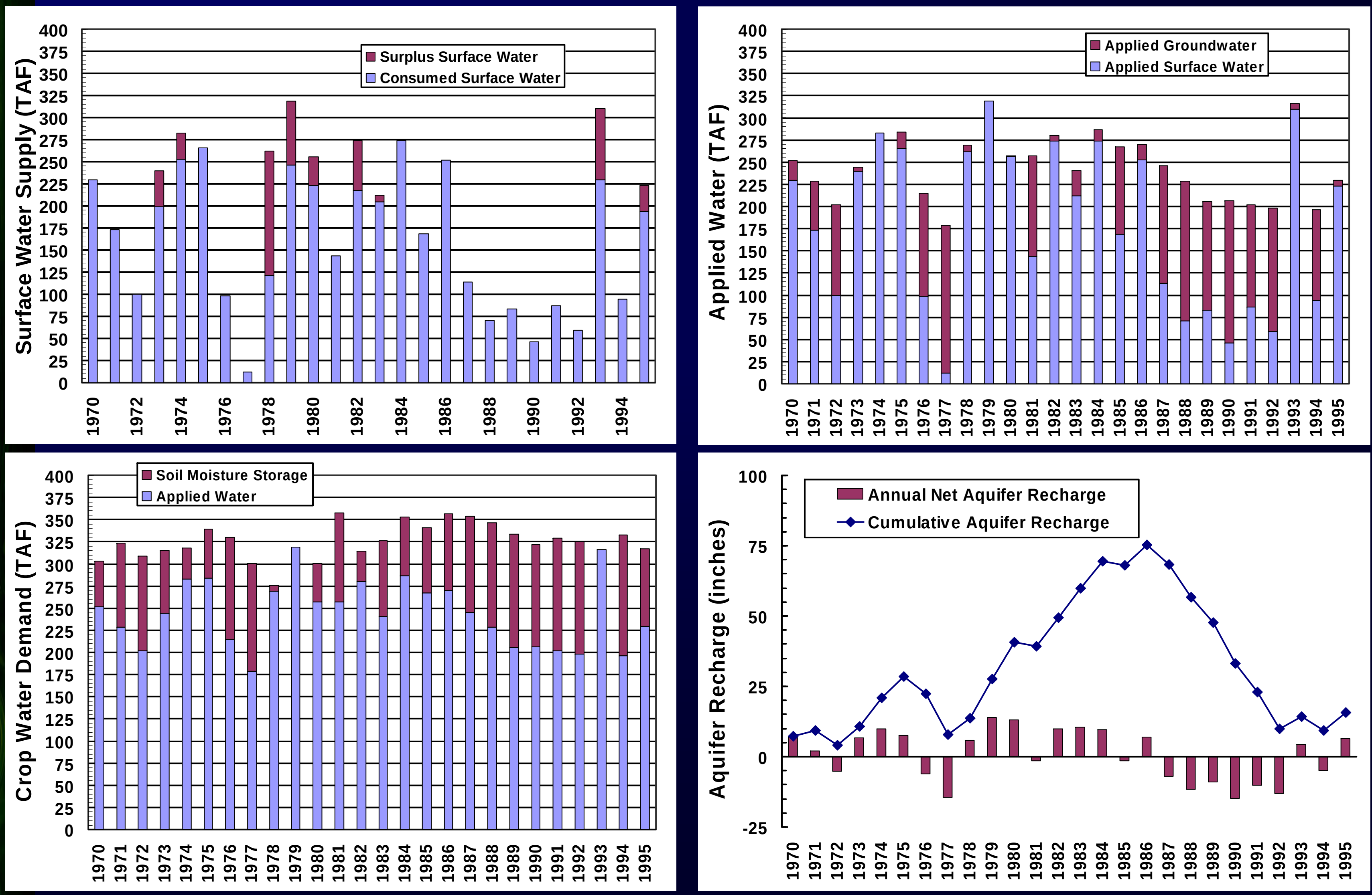






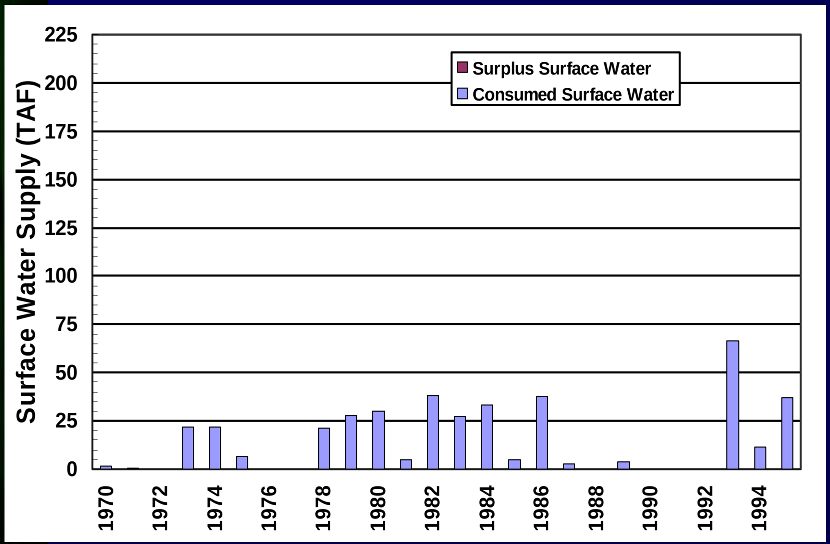
Lower Tule River Irrigation District

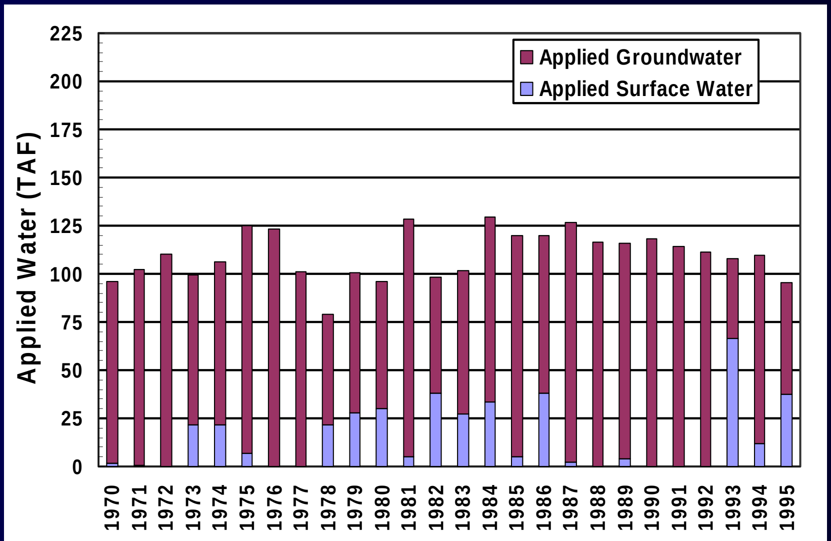
irrigated acreage: 82K

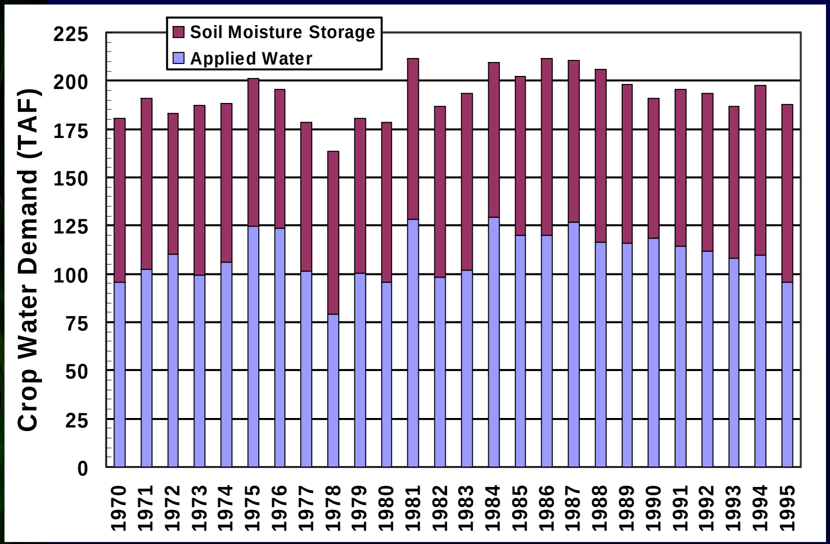


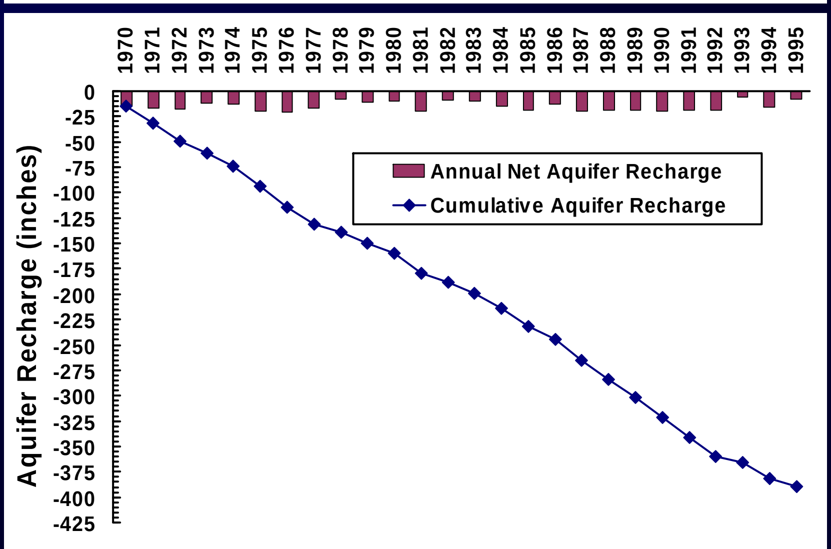
Pixley Irrigation District

irrigated acreage: 52K



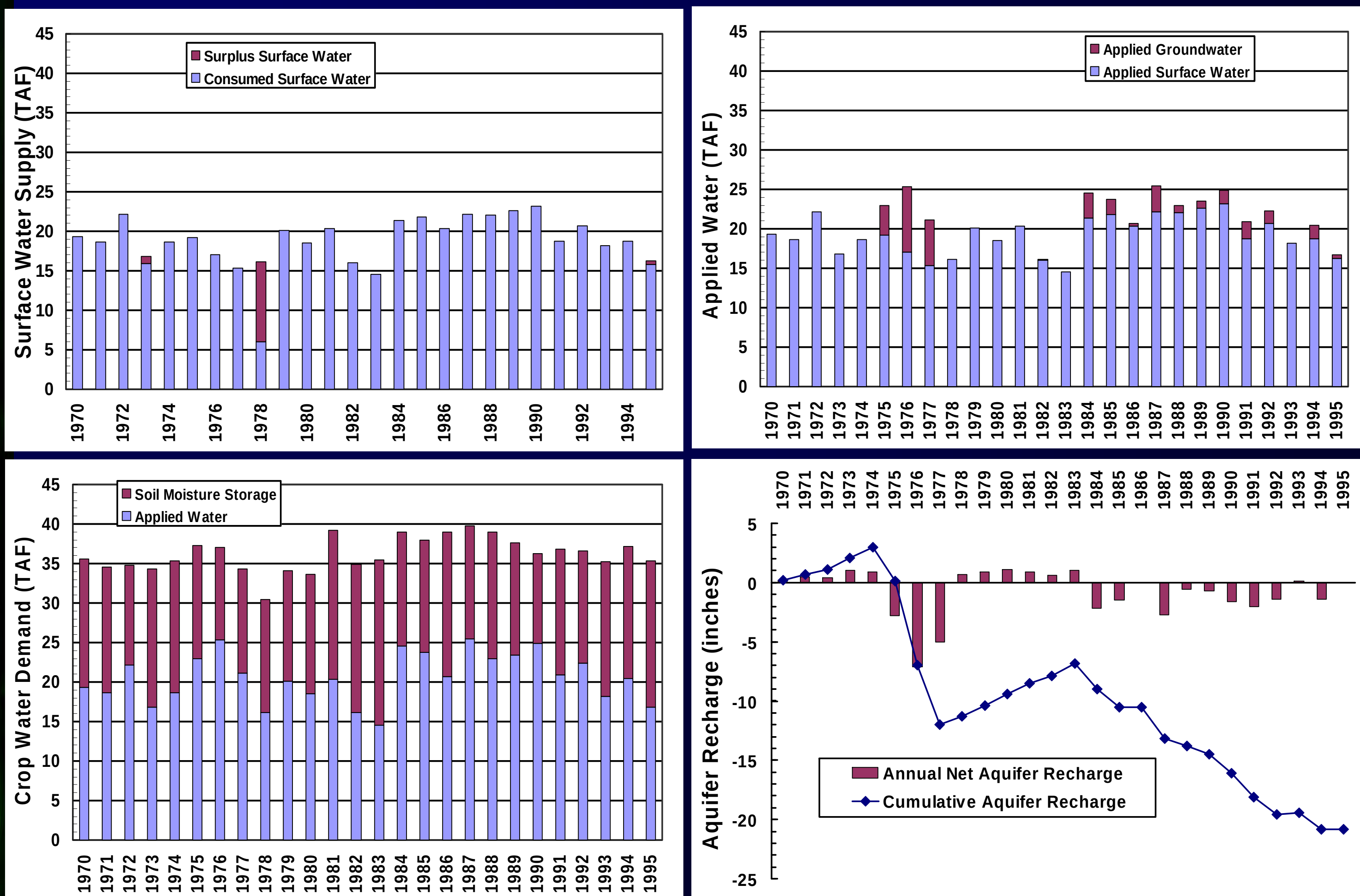




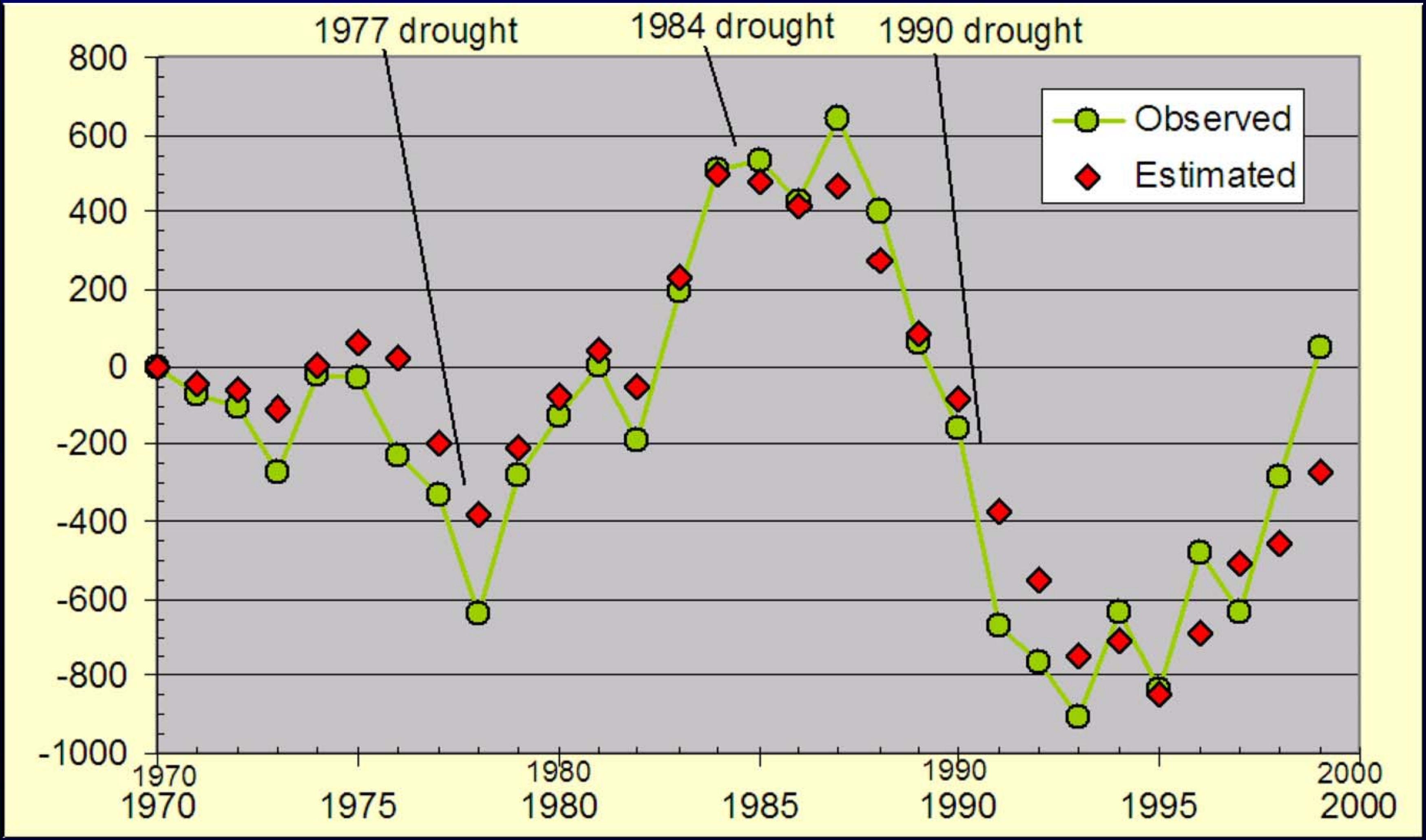


Terra Bella Irrigation District

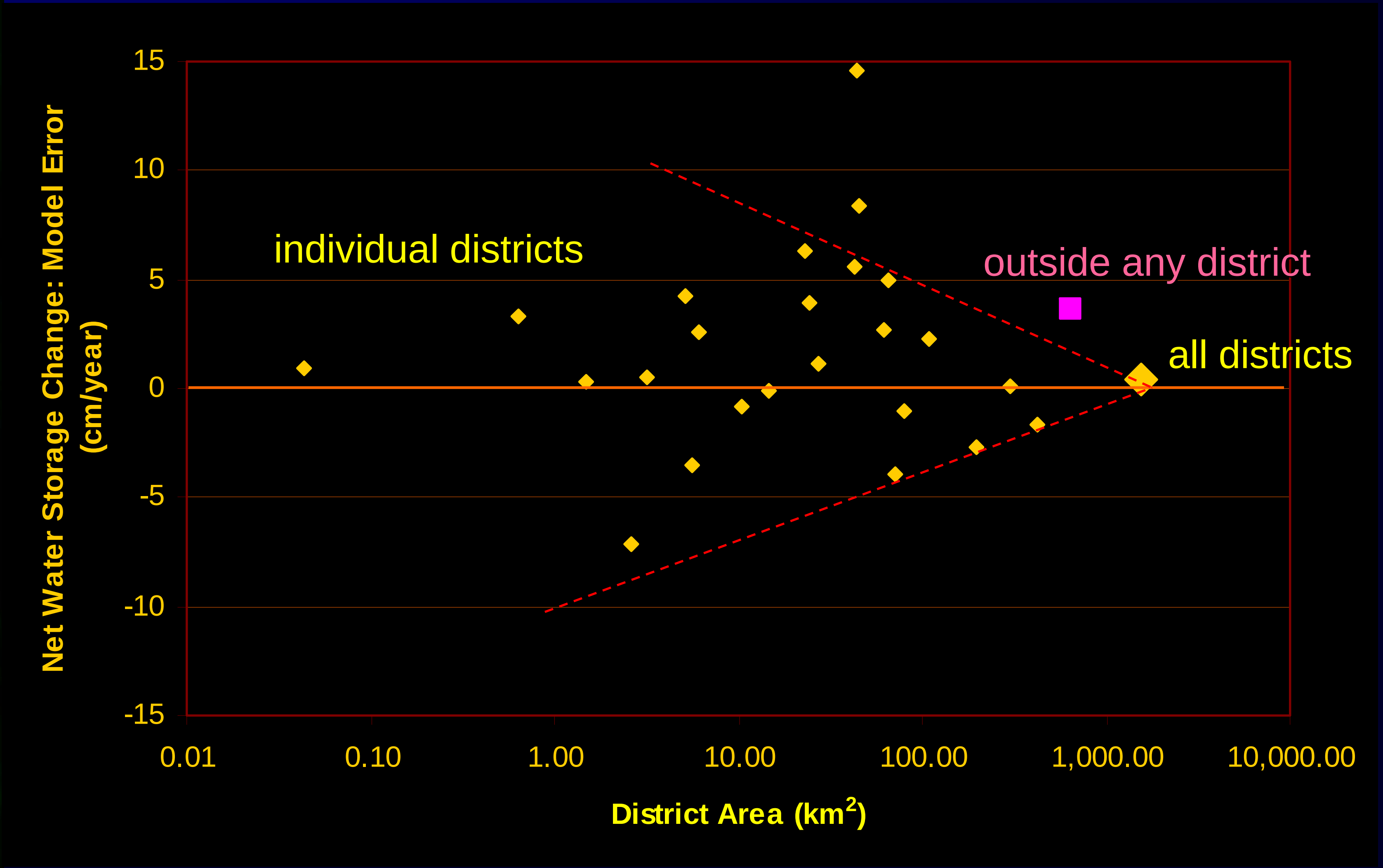
irrigated acreage: 11K

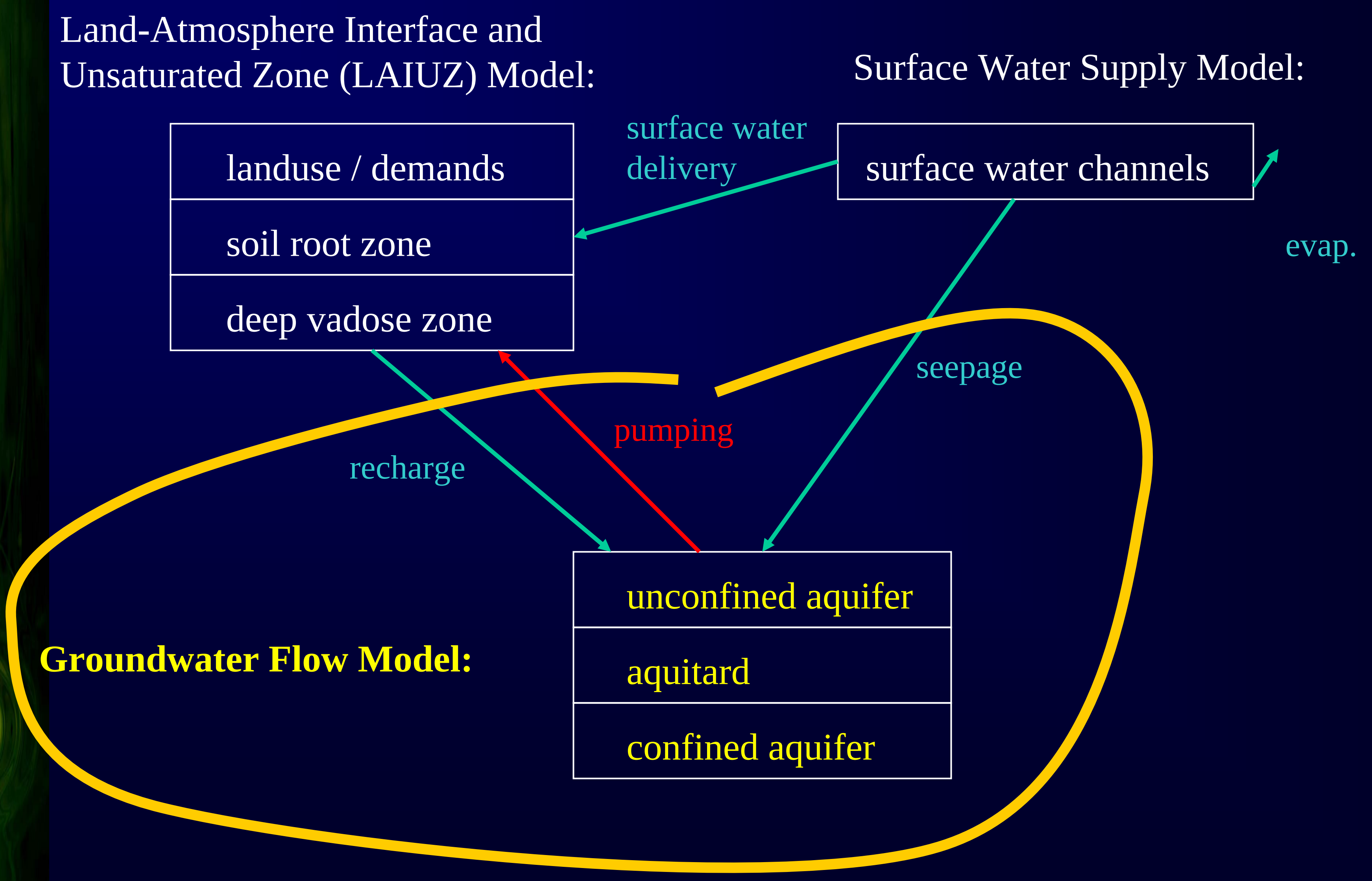


Observed vs. Computed Net Budget



measured groundwater storage change minus calculated water budget (avg. 1970 - 1986)




Land-Atmosphere Interface and
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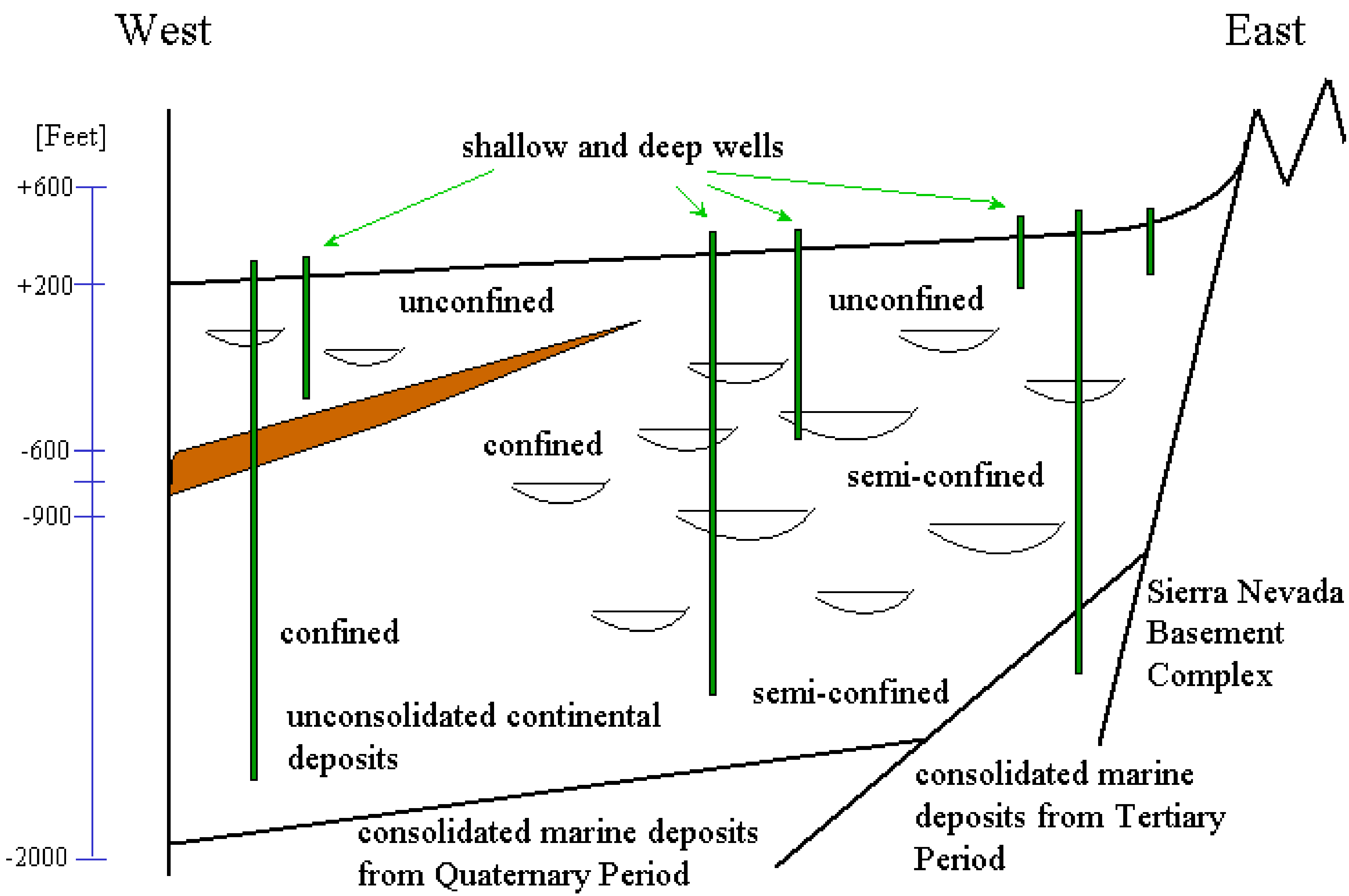
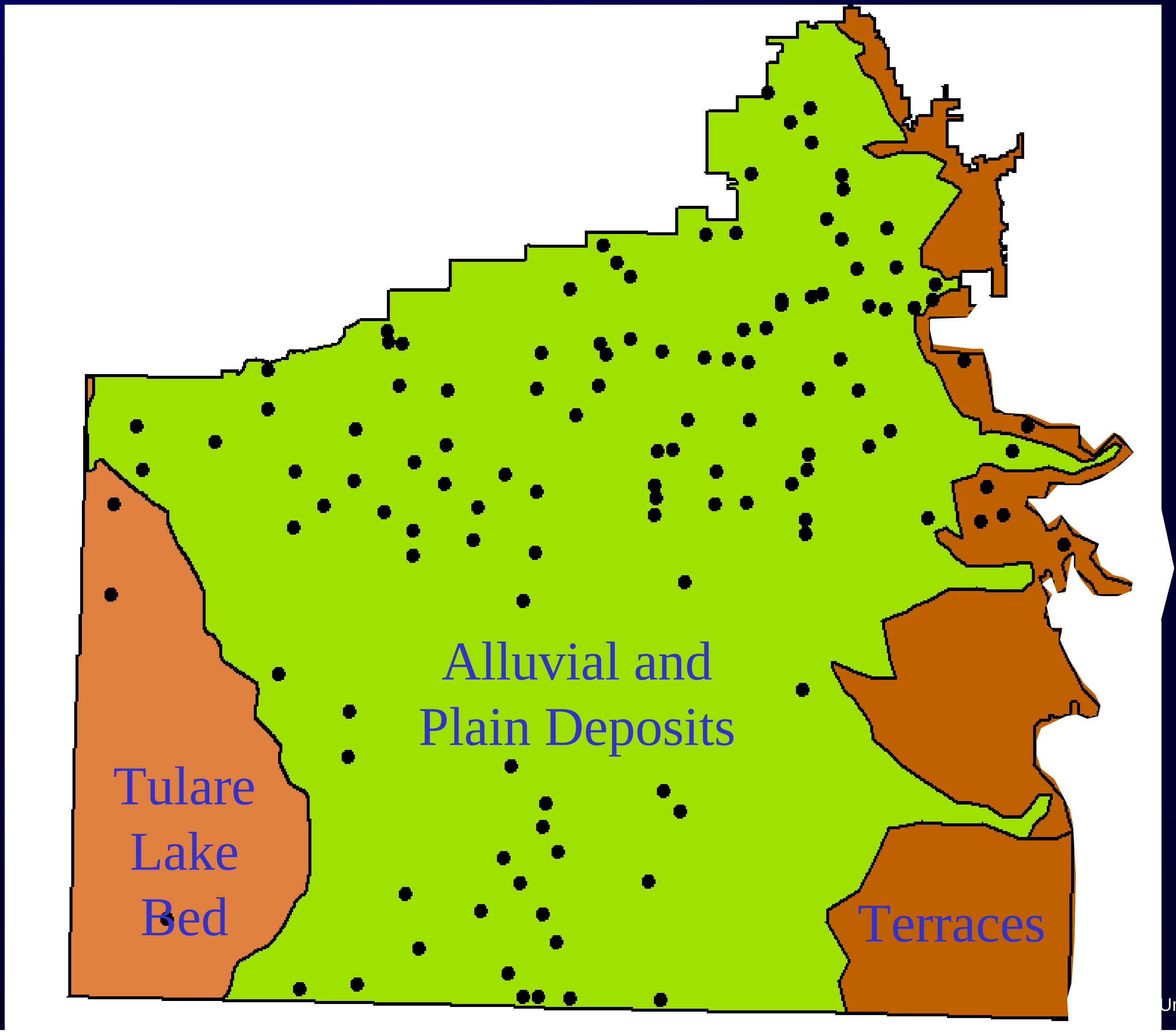
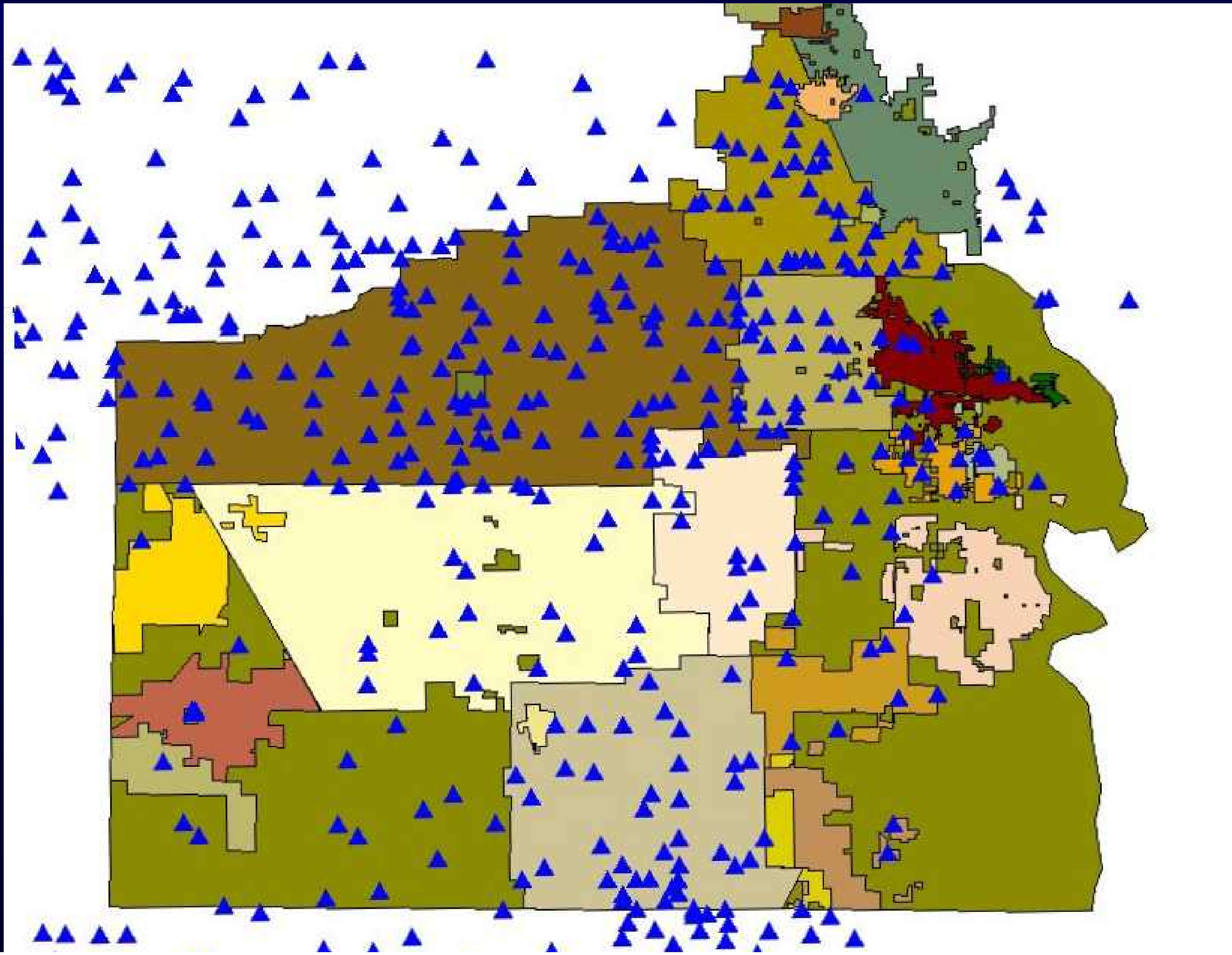

West
East
[Feet]
+600
+200
-600
-900
-2000
shallow and deep wells
unconfined
unconfined
confined
semi-confined
confined
semi-confined
Sierra Nevada Basement Complex
unconsolidated continental deposits
consolidated marine deposits from Tertiary Period
consolidated marine deposits from Quaternary Period

Major Geomorphic Units and Spatial Pattern of Water Level Observation Wellbores



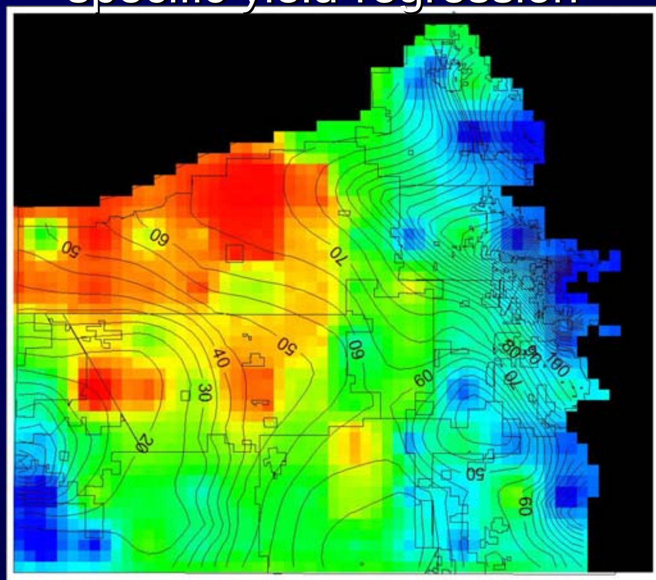
Distribution of Wells (for Calibration) by District



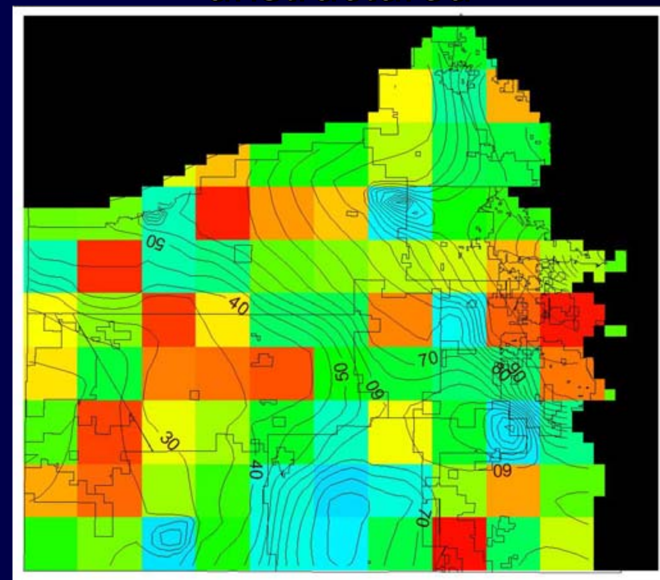
vis, 2008

K Calibration Concept Models

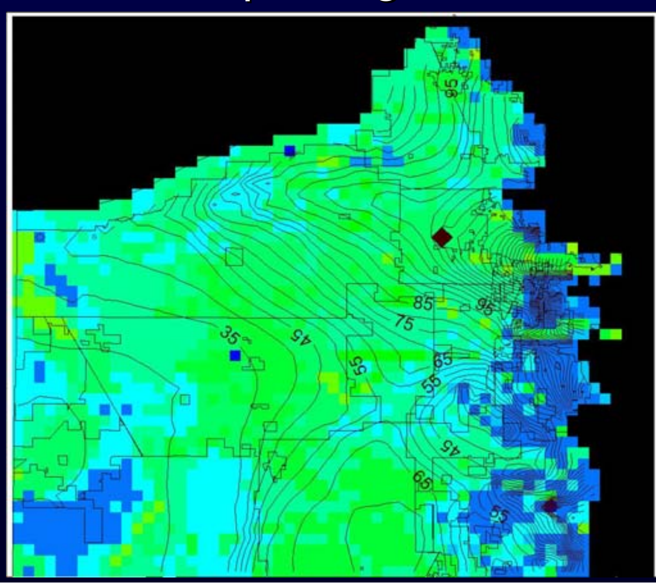
specific yield-regression



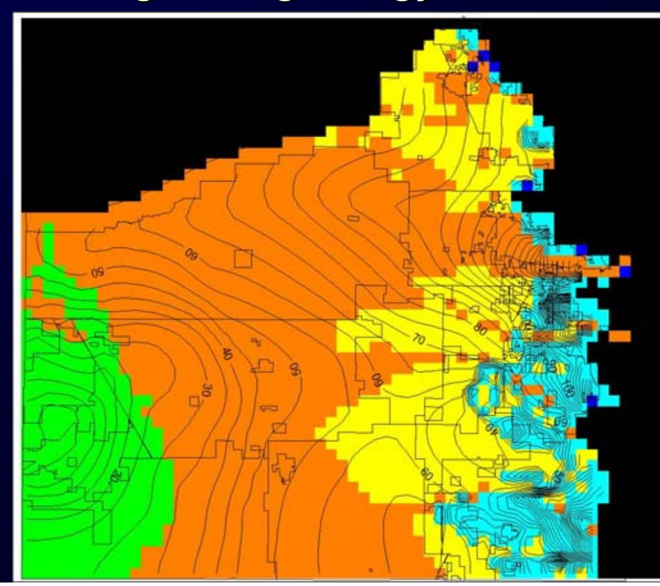
unstructured



soil map K-regression

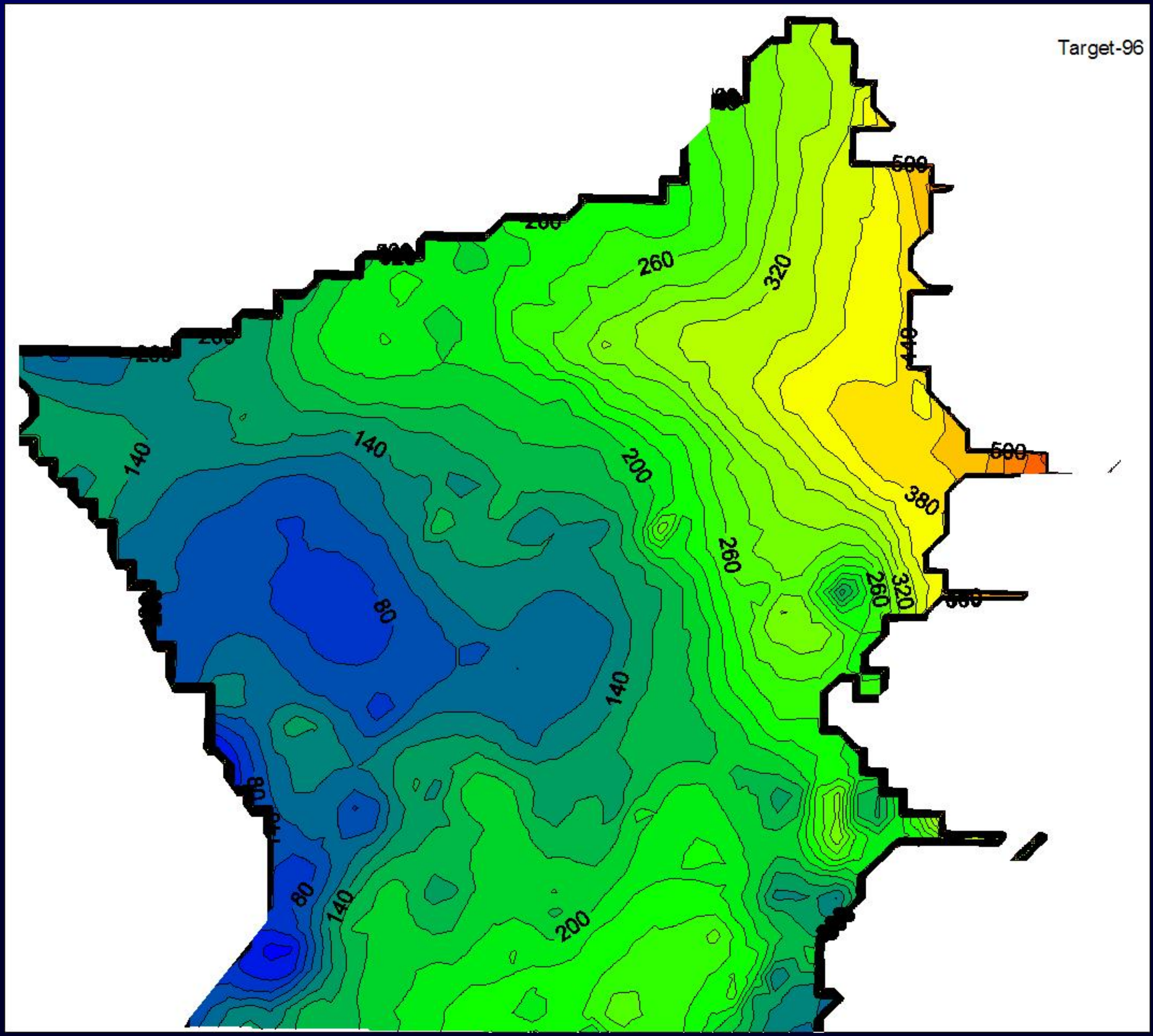


regional geology-based

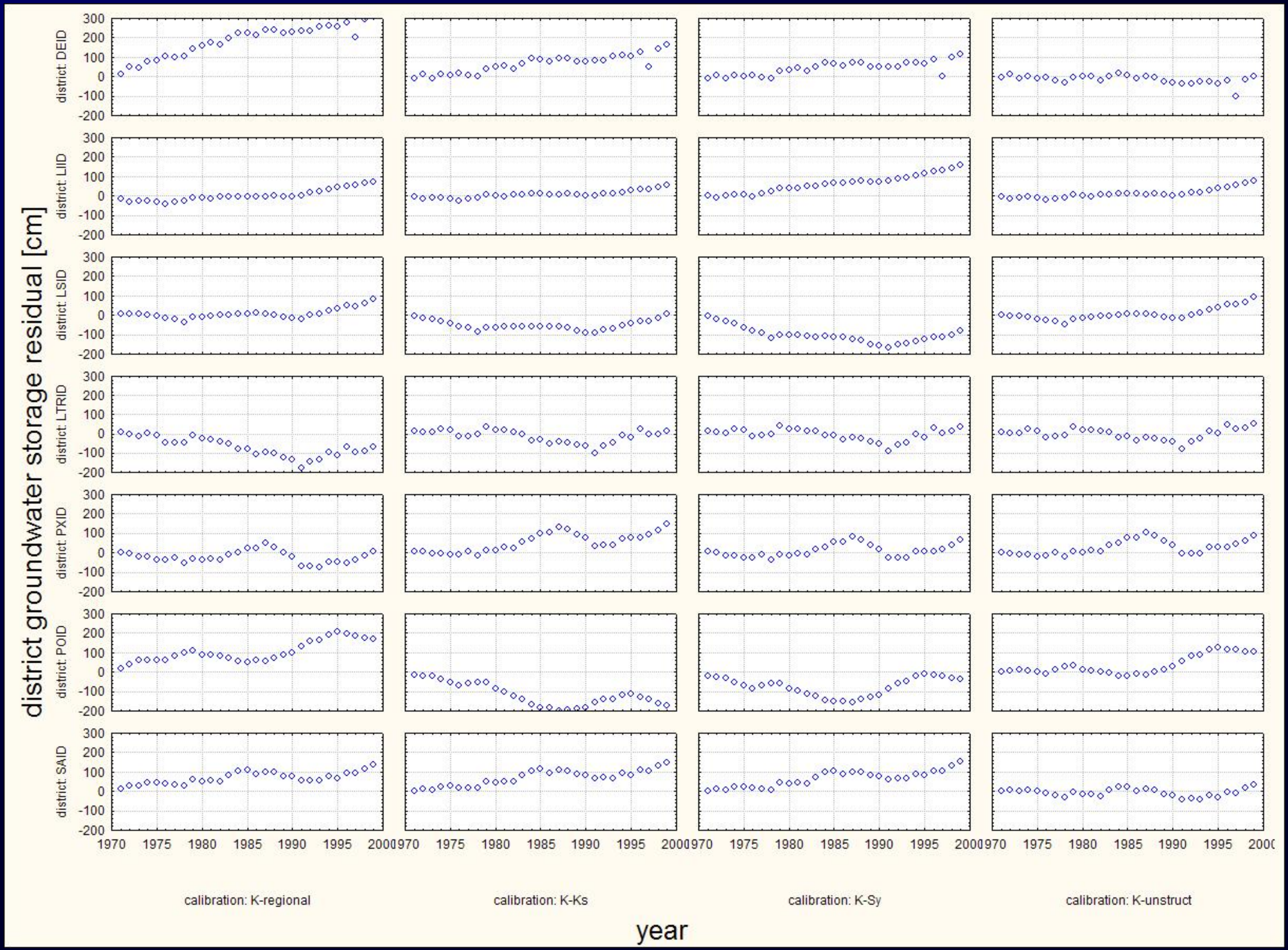


ornia, Davis, 2008

Typical Target Head Distribution



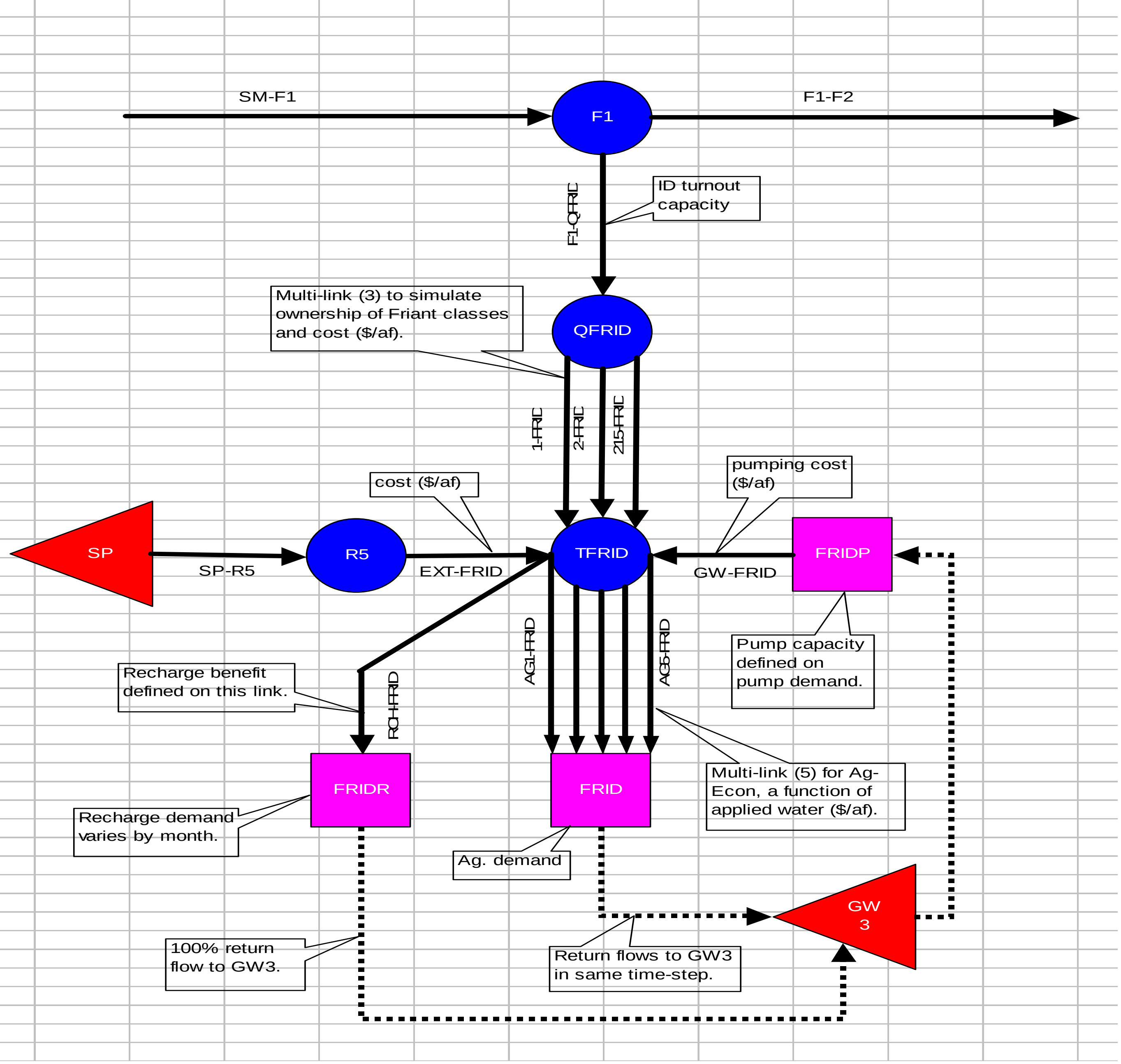
Calibration Residuals [cm]



Every district has sources and demands.

MODSIM Representation of a Friant Deman

Example: Fresno Irrigation District, FRID



Economics Driven

- Each district has an agricultural production model of water use.
- A district's sources of water have different economic costs.
- FredSim allocates water to maximize agricultural profits.
- Link to groundwater model: exchange between groundwater "boxes"

FredSim Results

- Results from FredSim include:
  - Flows to each district from each source for each year in the model simulation period.
  - Reservoir and groundwater levels for each year in the model simulation period.
  - Economic costs and benefits to farmers of changes in water allocations and operations.
  - Prediction: Higher surface water costs lead to increased groundwater pumping / overdraft

Conclusion

- demonstrate interaction between surface water supply vs. groundwater level
- better understanding of groundwater dynamics
- Estimates of temporal & spatial recharge distribution
- Estimates of temporal & spatial pumping distribution
- planning tool for conjunctive management “what-if” scenarios (=> Fredsim project by Dr. Lund)
- educational/planning resource

http://groundwater.ucdavis.edu