Conjunctive Management Modeling

In Nebraska

Association of Western State Engineers
Spring Workshop
Nebraska City, NE
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Department of Natural Resources

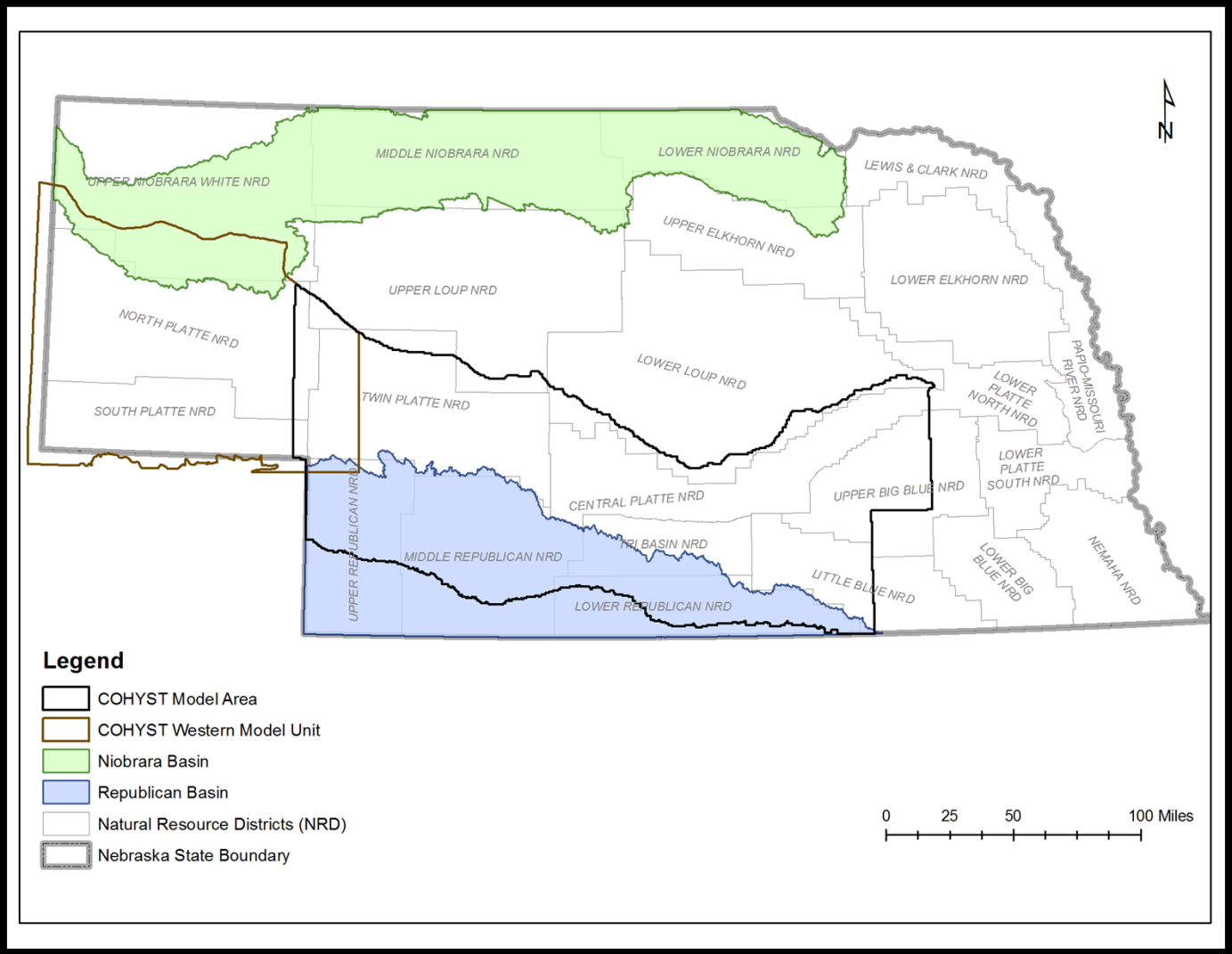
Overview

- Studies across Nebraska
- Case Study
  - Management Objectives
  - Water Budget
  - Tools
- Studies and Management
- Conclusions

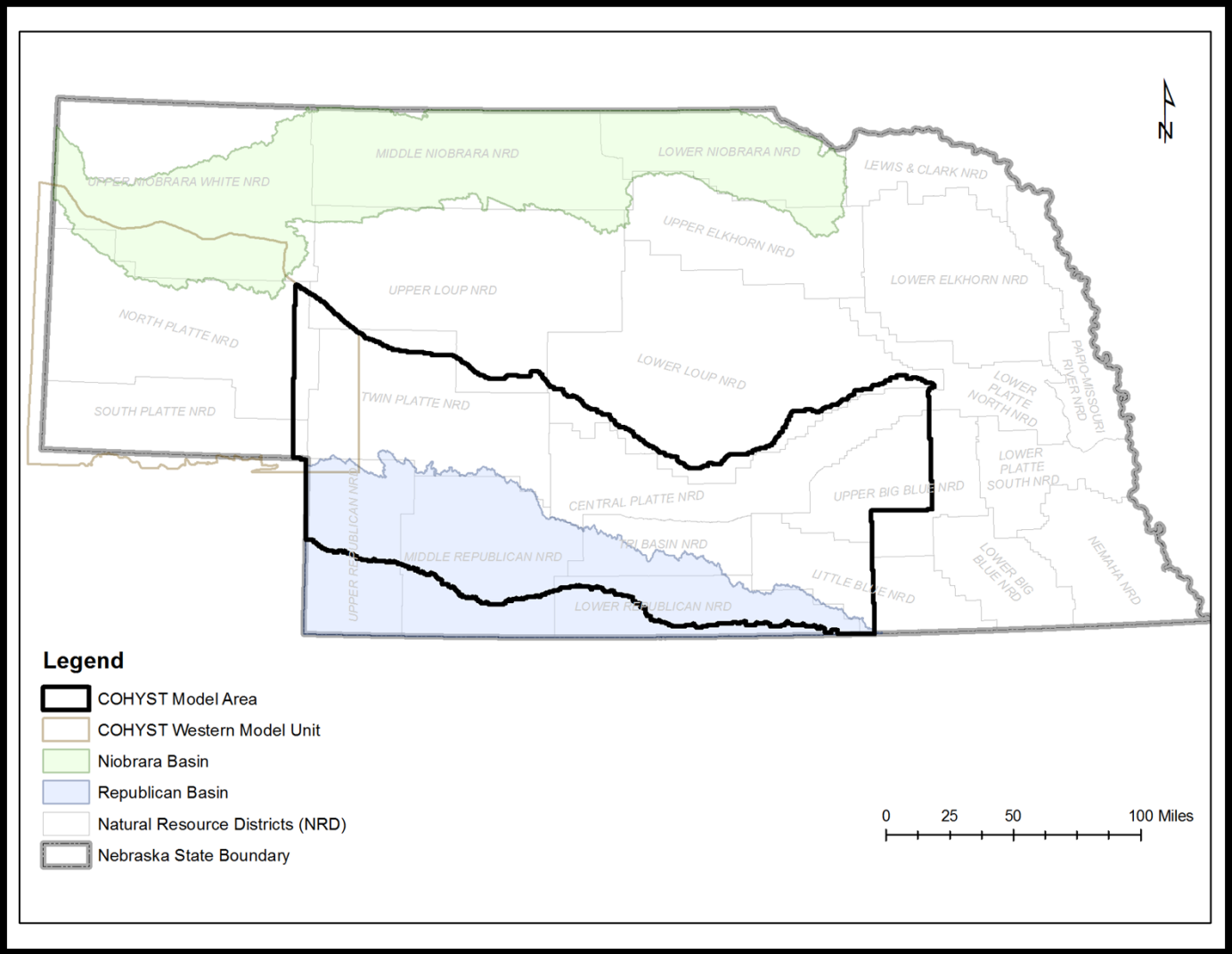
Studies

- Republican River Conjunctive Management Study
  - USBOR Basins, RRMDA
- Niobrara
  - USBOR Basins, UNWNRD
- Western Water Use
  - NPNRD, SPNRD
- Cooperative Hydrology Study (example)
  - TPNRD, TBNRD, CPNRD, CNPPID, NPPD

Studies


MIDDLE NIOBRARA NRD
LOWER NIOBRARA NRD
UPPER NIOBRARA WHITE NRD
LEWIS & CLARK NRD
UPPER ELKHORN NRD
LOWER ELKHORN NRD
UPPER LOUP NRD
NORTH PLATTE NRD
LOWER LOUP NRD
PAPIO-MISSOURI RIVER NRD
LOWER PLATTE NORTH NRD
SOUTH PLATTE NRD
TWIN PLATTE NRD
LOWER PLATTE SOUTH NRD
CENTRAL PLATTE NRD
UPPER BIG BLUE NRD
UPPER REPUBLICAN NRD
TRI BASIN NRD
MIDDLE REPUBLICAN NRD
LOWER BIG BLUE NRD
NEMAHA NRD
LITTLE BLUE NRD
LOWER REPUBLICAN NRD
N
Legend
COHYST Model Area
COHYST Western Model Unit
Niobrara Basin
Republican Basin
Natural Resource Districts (NRD)
Nebraska State Boundary
0
25
50
100 Miles

COHYST 2010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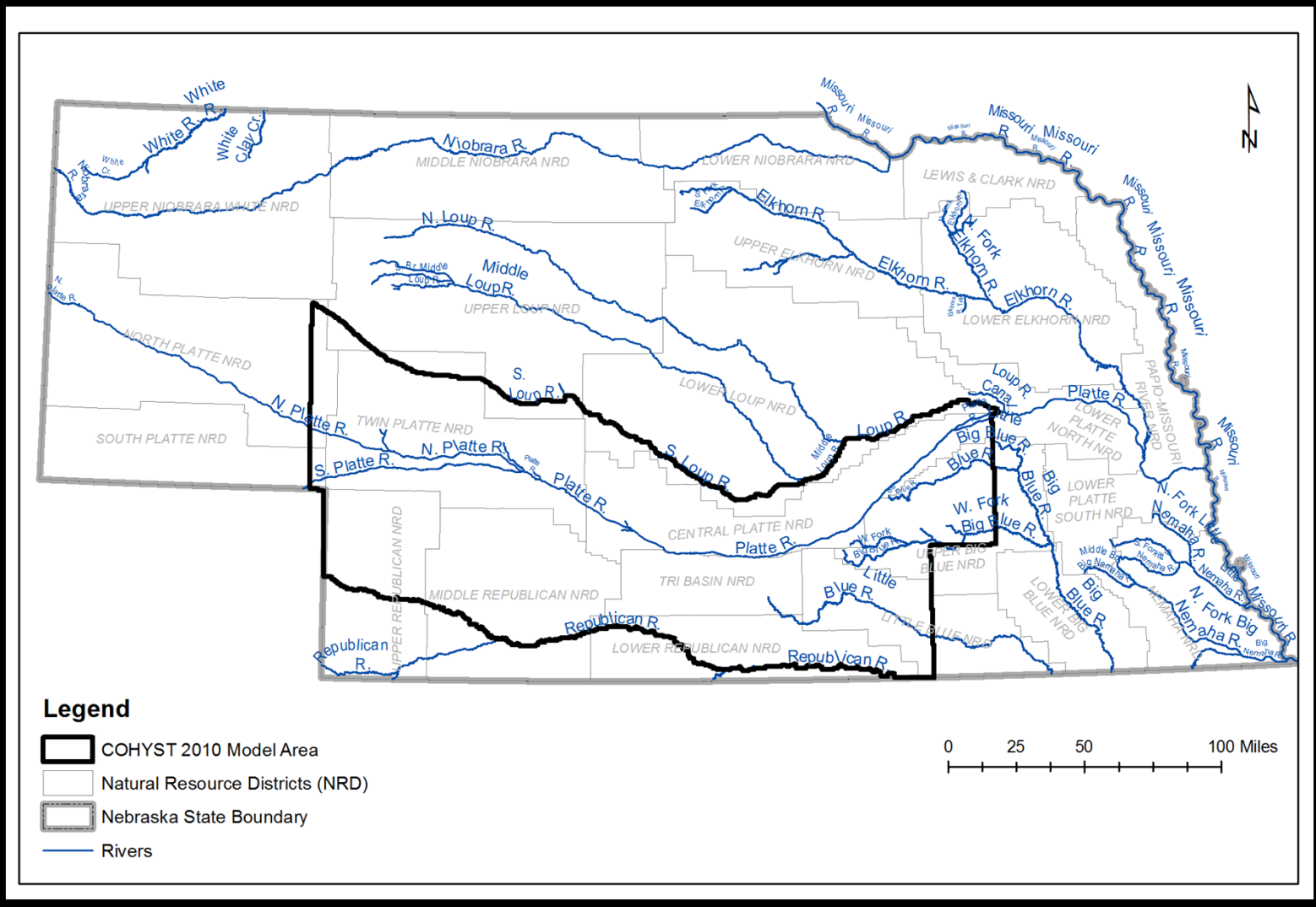
COHYST 2010 – Hydrologic Context

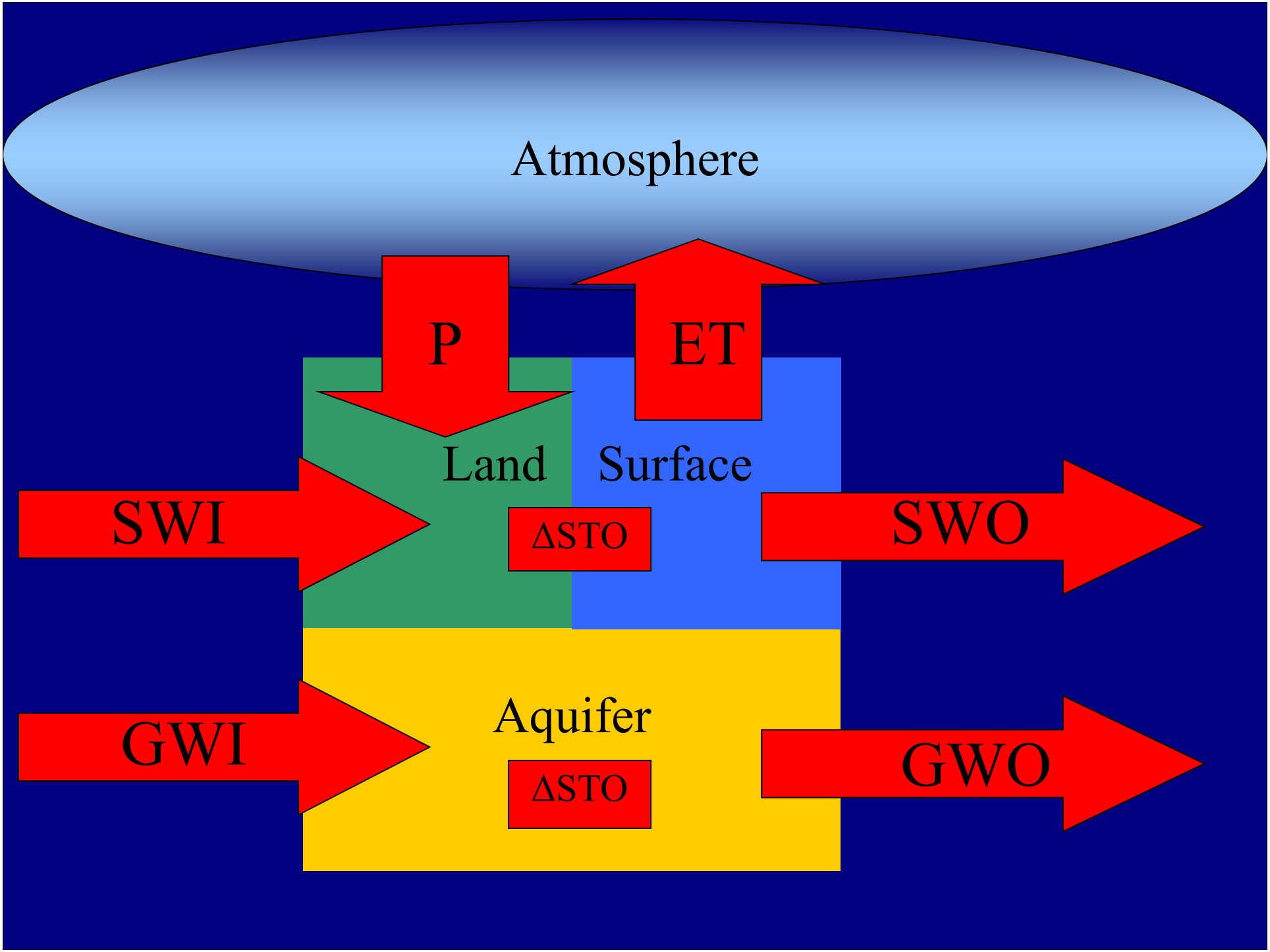


COHYST 2010

- Objectives
- Water Budget
- Develop Tools
- Adapt and Apply Tools

COHYST 2010 - Management Objectives

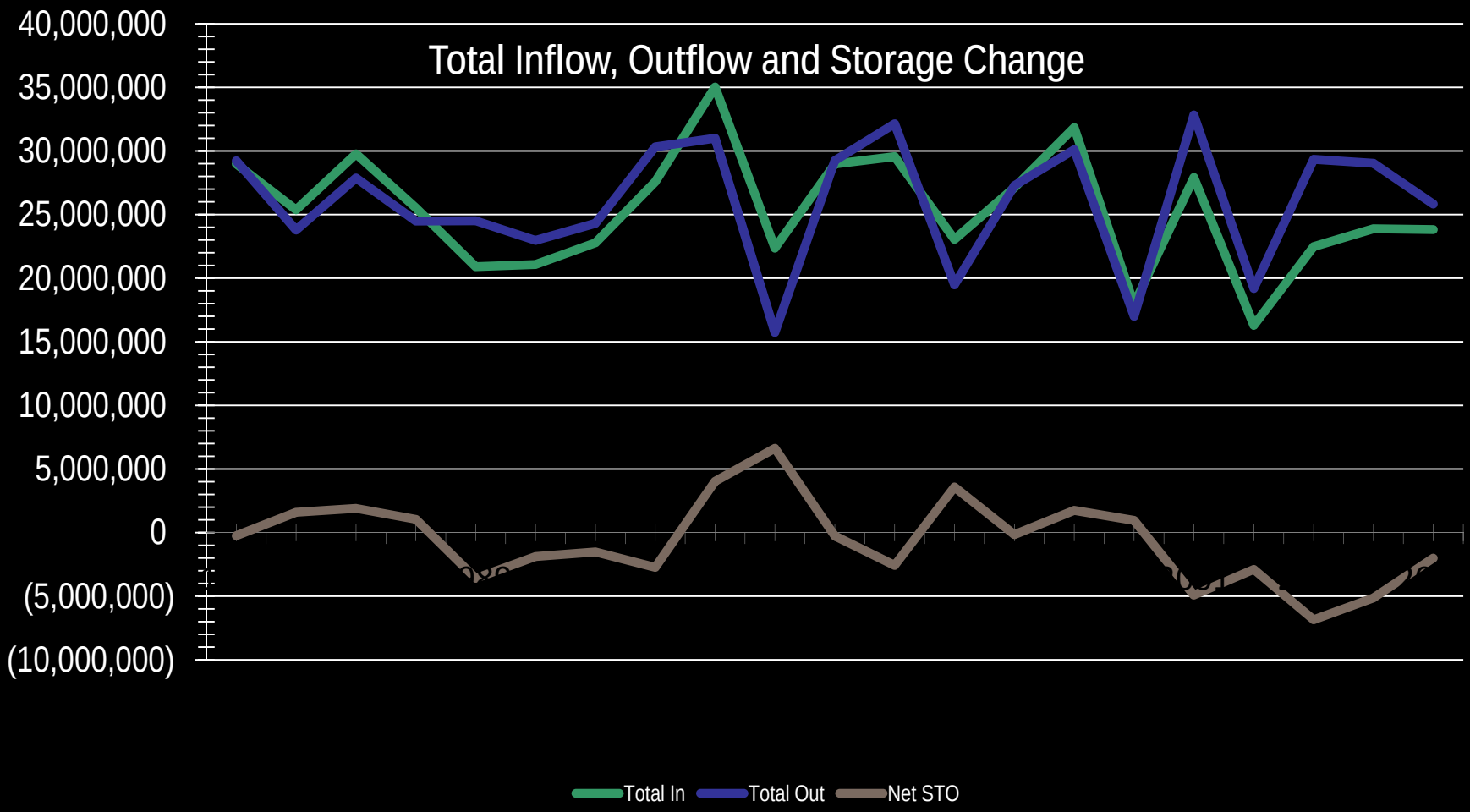
- Management tools must take into account:
  - Complete water budget
  - Temporal variability
  - Transient flow targets
- Must provide a means of Annual Tracking and Accounting
- Must incorporate surface water component


Atmosphere
P
ET
Land Surface
SWI
ΔSTO
SWO
Aquifer
GWI
ΔSTO
GWO

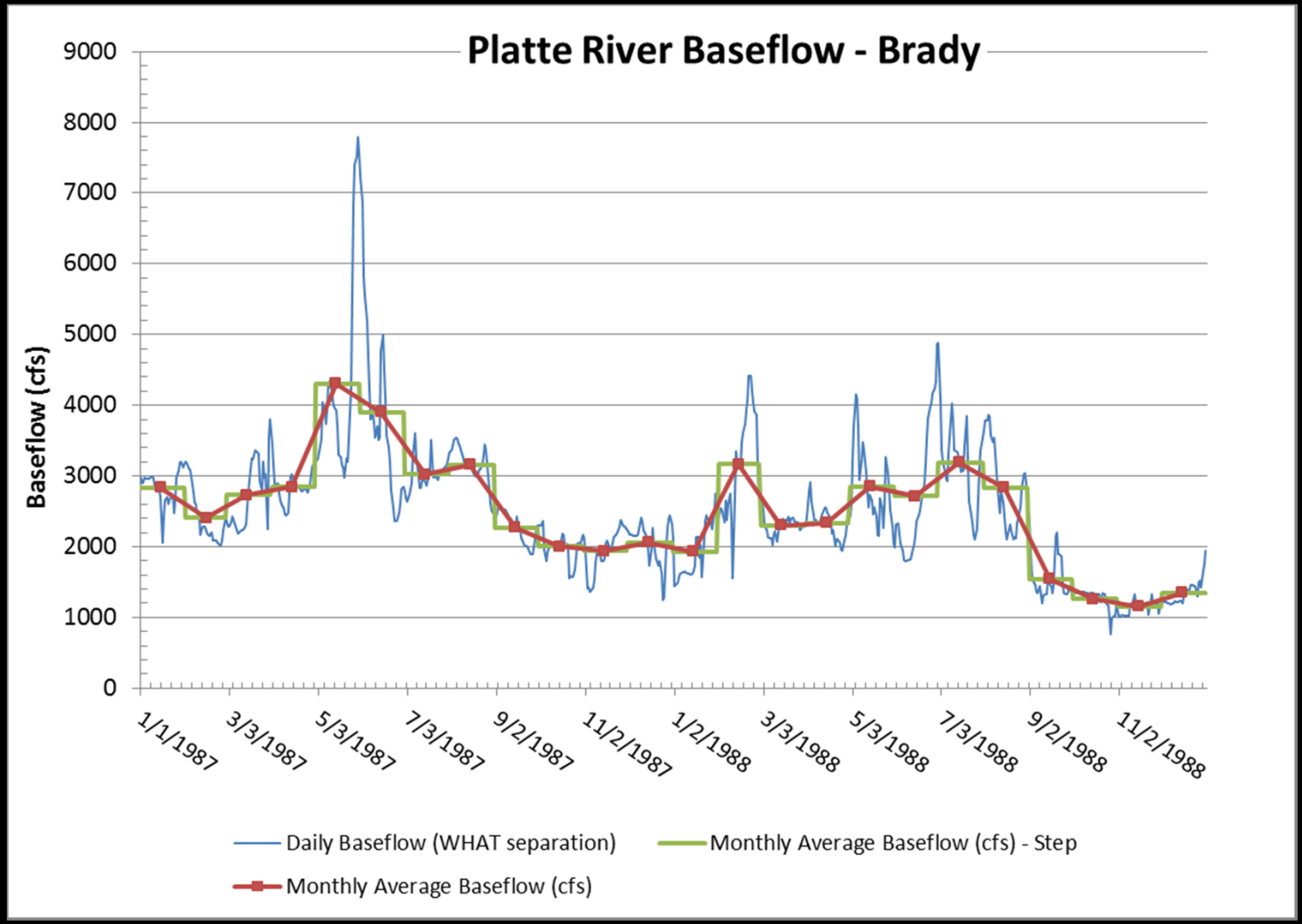
Temporal Water Budget

- Allows us to understand interrelationships
- Collection timeframes relate to the supporting data:
  - Precipitation
  - Stream gaging
  - Water table monitoring
  - Evapotranspiration
- Conceptual target = annual aggregation
- Functional targets = monthly aggregations
- Precipitation and routing data recorded daily, aggregated to monthly to help mitigate uncertainties

Temporal Water Budget – Annual In/Out +Storage



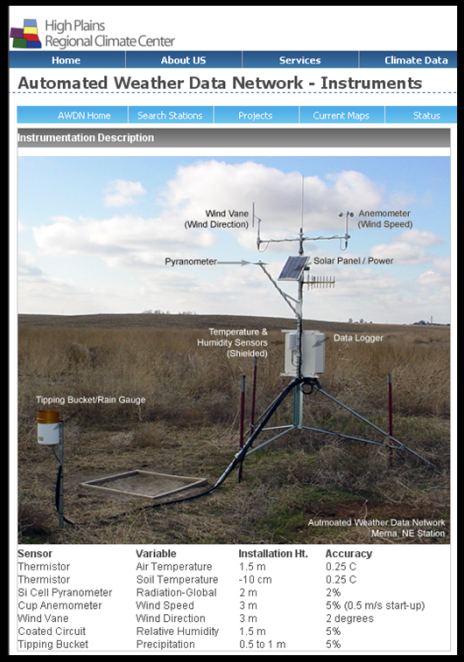
Temporal Water Budget – Daily/Monthly Streamflow



Spatial Water Budget

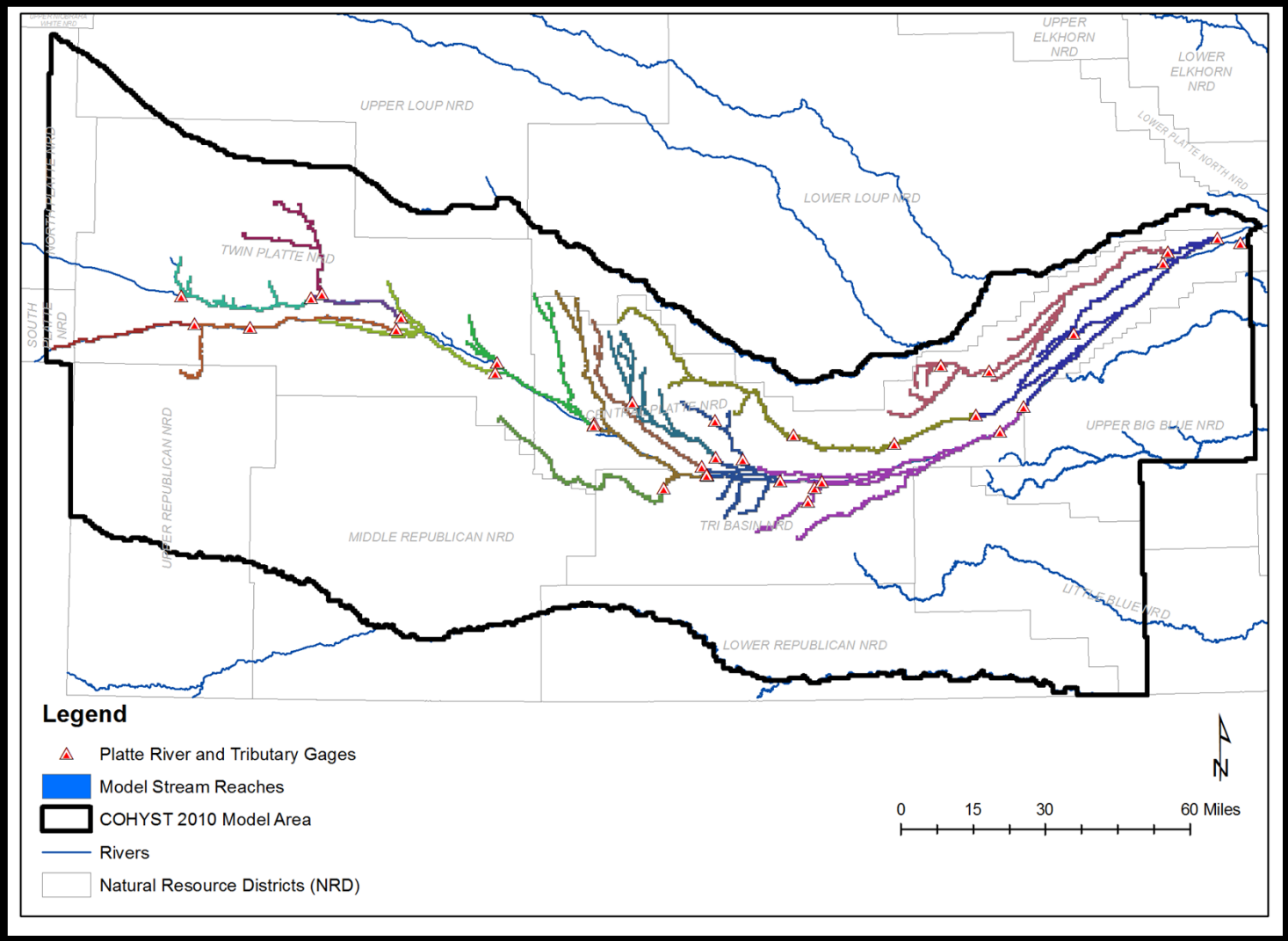
- Allows us to understand in map context
- Collection protocols vary:
  - Precipitation
  - Stream gaging/operations
  - Water table
  - Evapotranspiration*
- Values applied to grid or routing network
- Targets depend on the data, and include points, lines (reaches) and areas

Spatial Water Budget - Precipitation

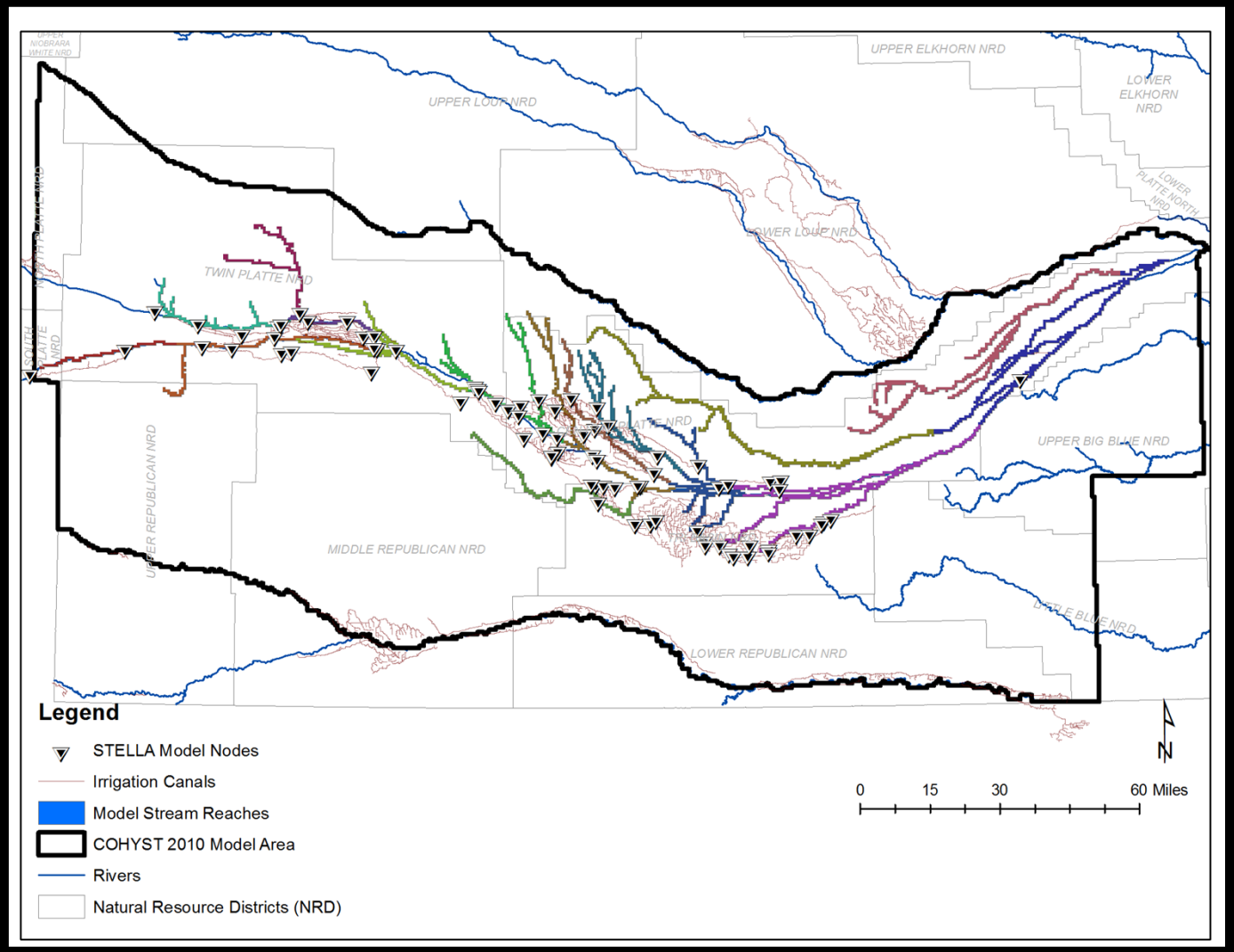


- Data from multiple automated weather data network stations (AWDN stations)

Spatial Water Budget – Stream Reaches

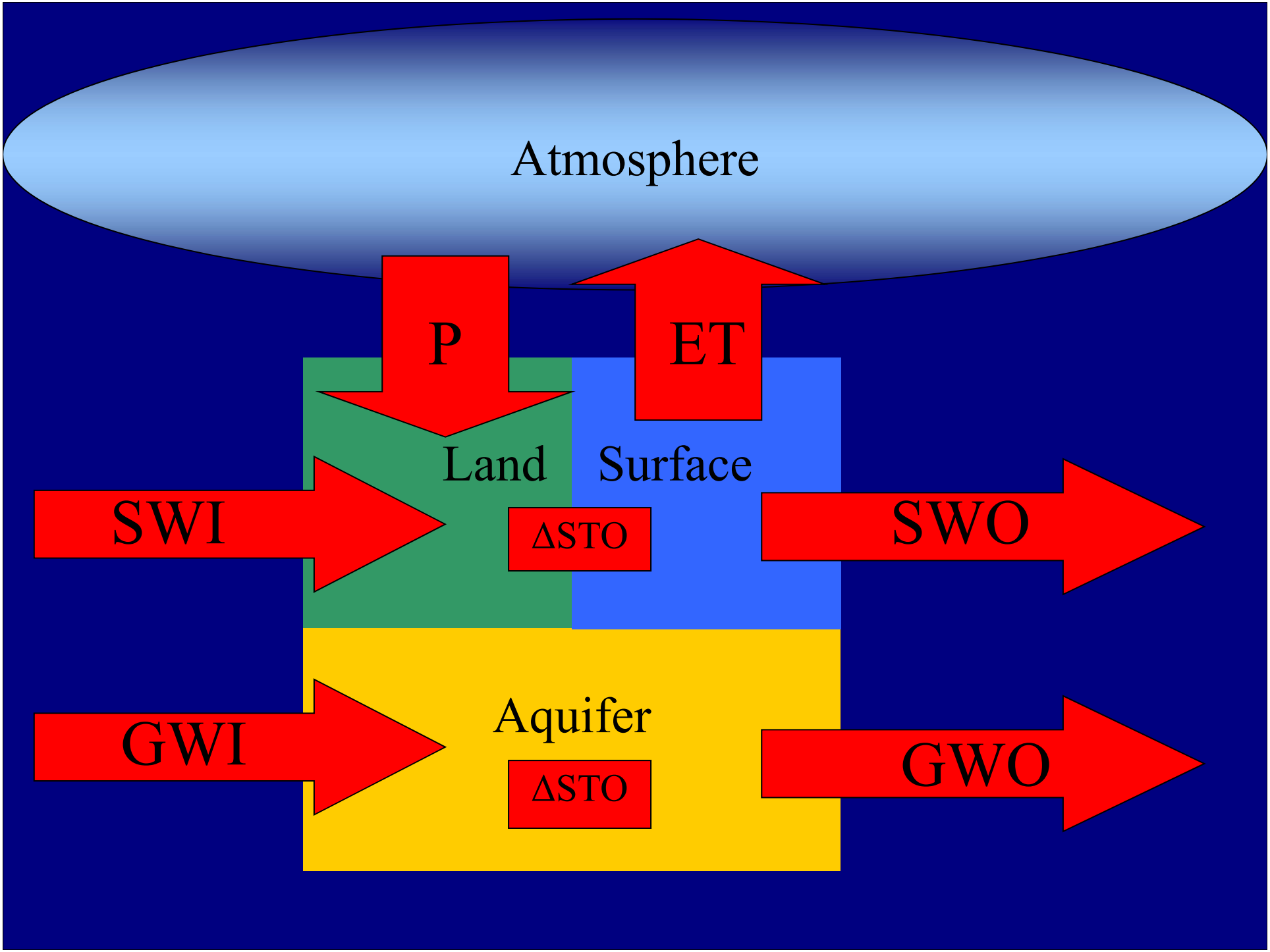


Spatial Water Budget – Canal Operations



Tools

- Given: Spatial distribution and temporal scales of collected data is variable in time, location and completeness
- We can design tools to various temporal and spatial scales and calibrate to available data
- Data and models are more valid and defensible when aggregated to appropriate scales
- COHYST 2010 was designed according to these considerations, resulting in three tools…


Atmosphere
P
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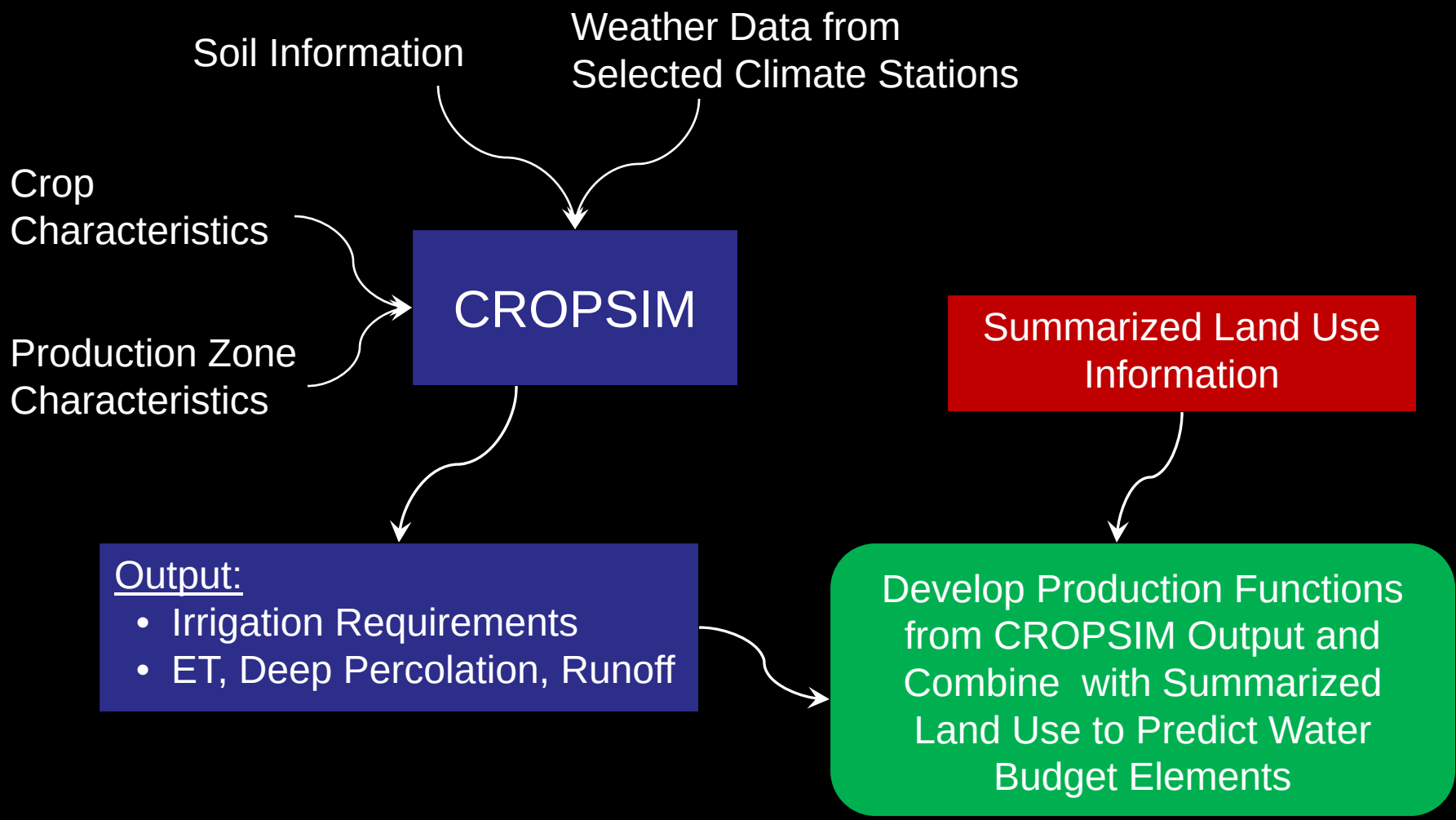
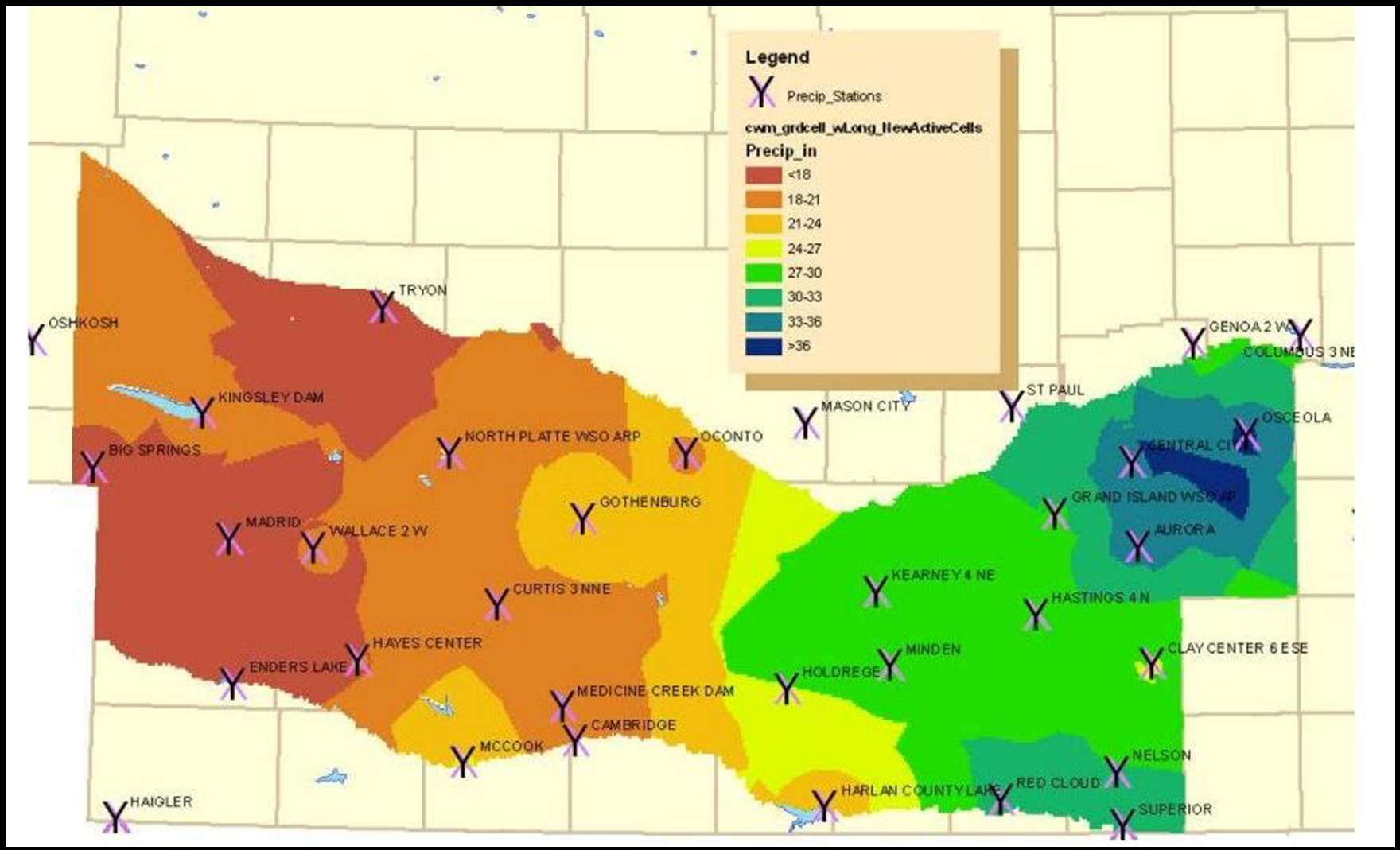
Watershed Tool – Approach



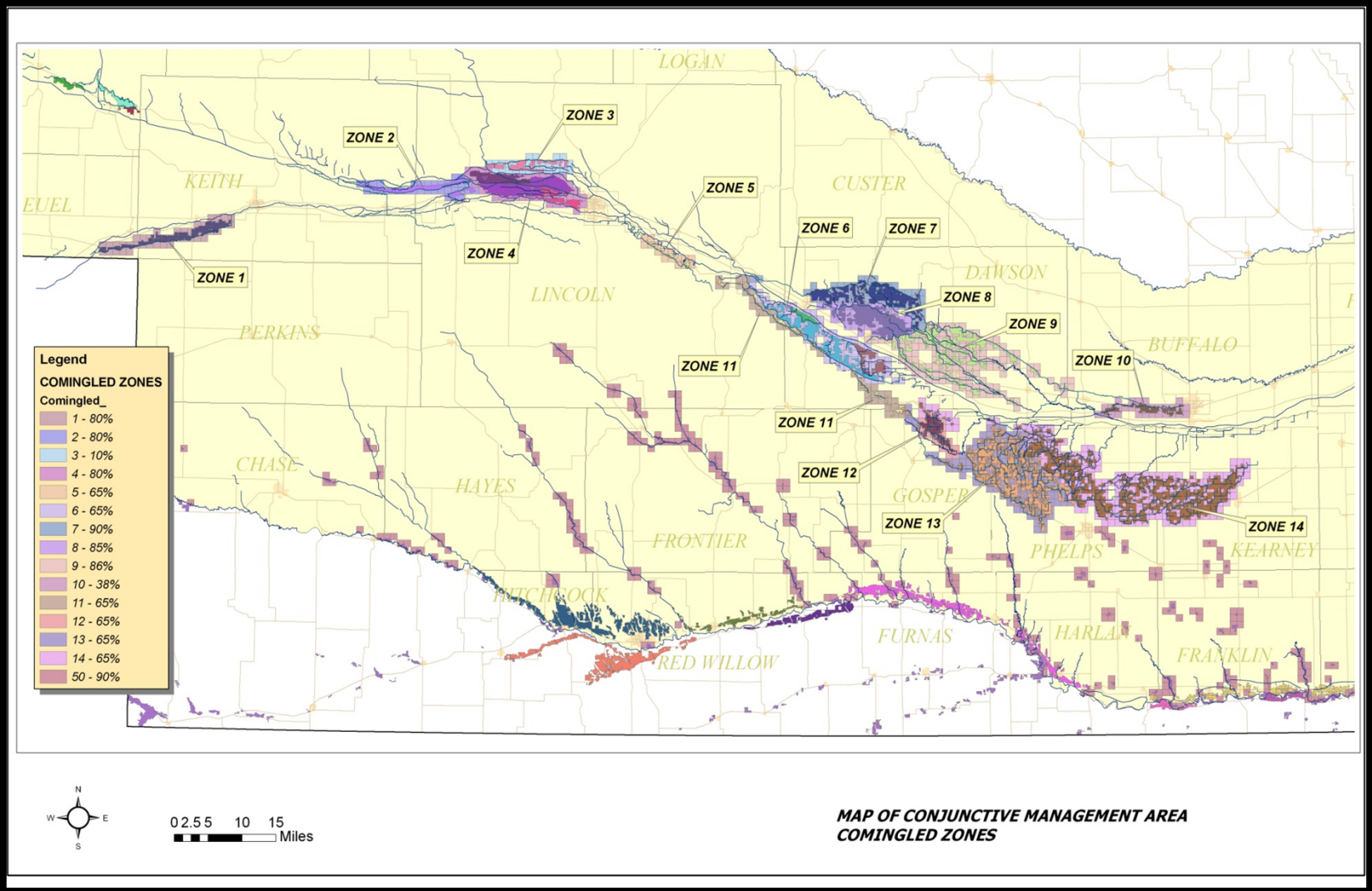
Watershed Tool

- Incorporates:
  - Precipitation/climate data
  - Land/soil/crop characteristics

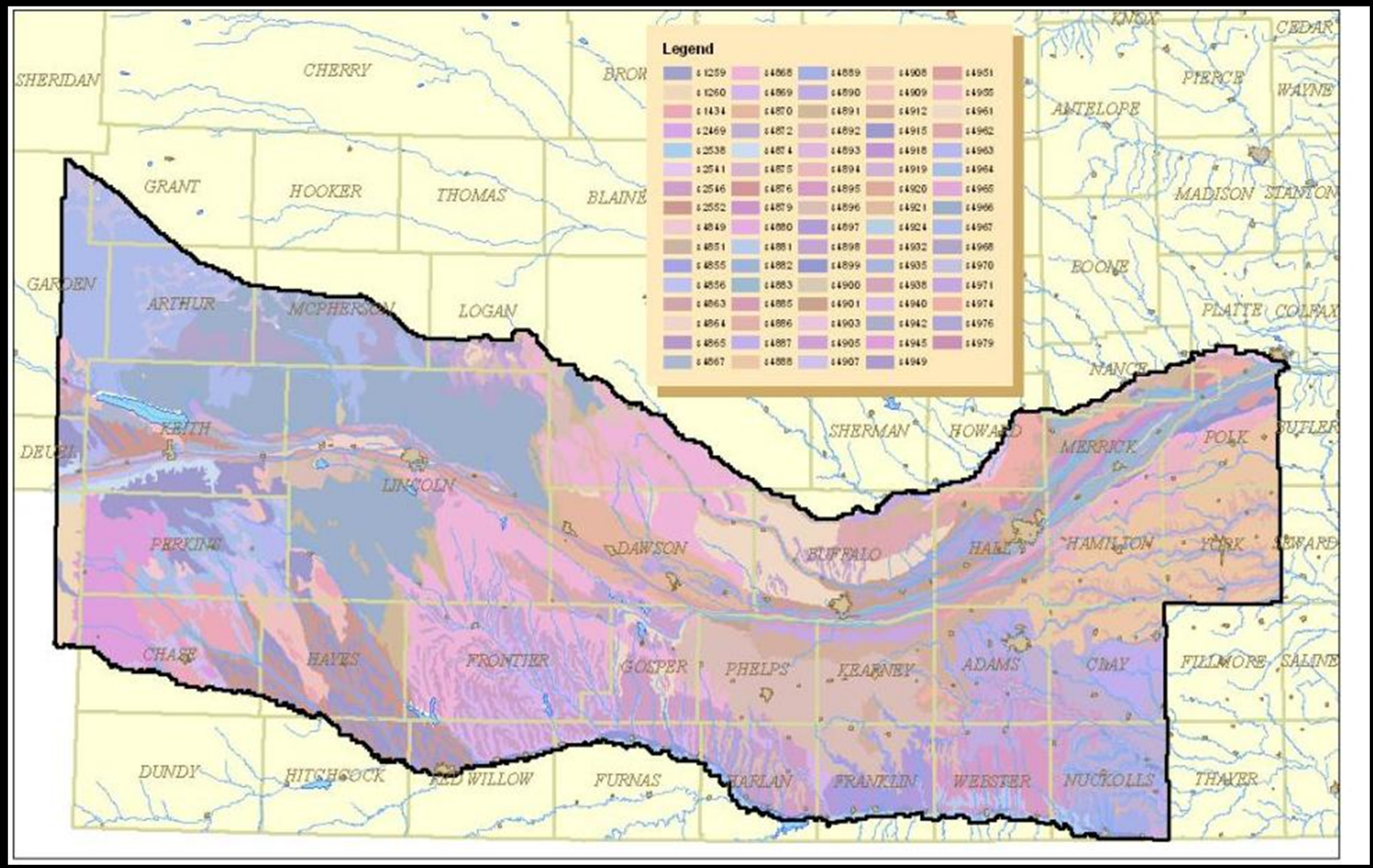
Watershed Tool – Precipitation



Watershed Tool – Land Use



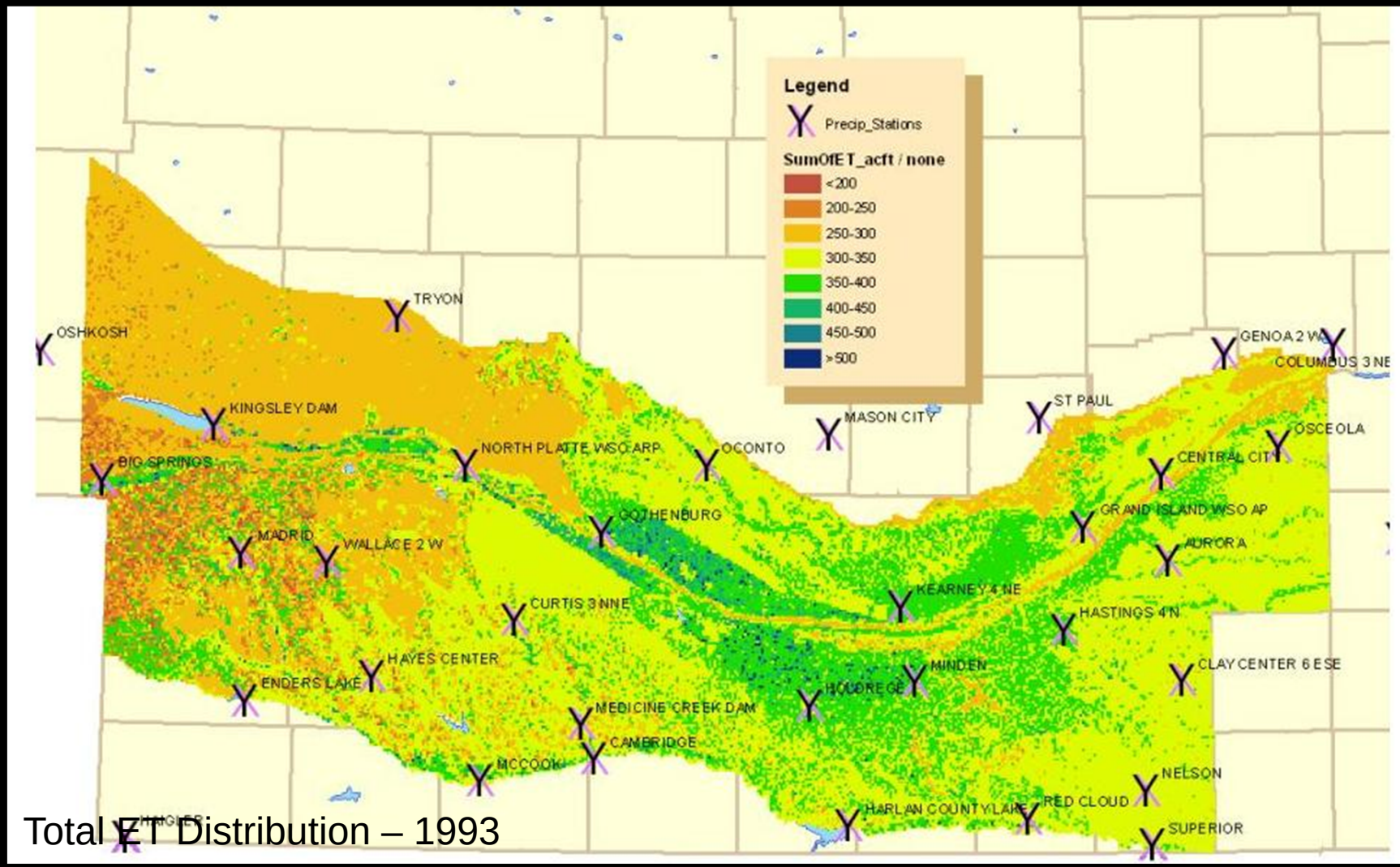
Watershed Tool – Soil



Watershed Tool

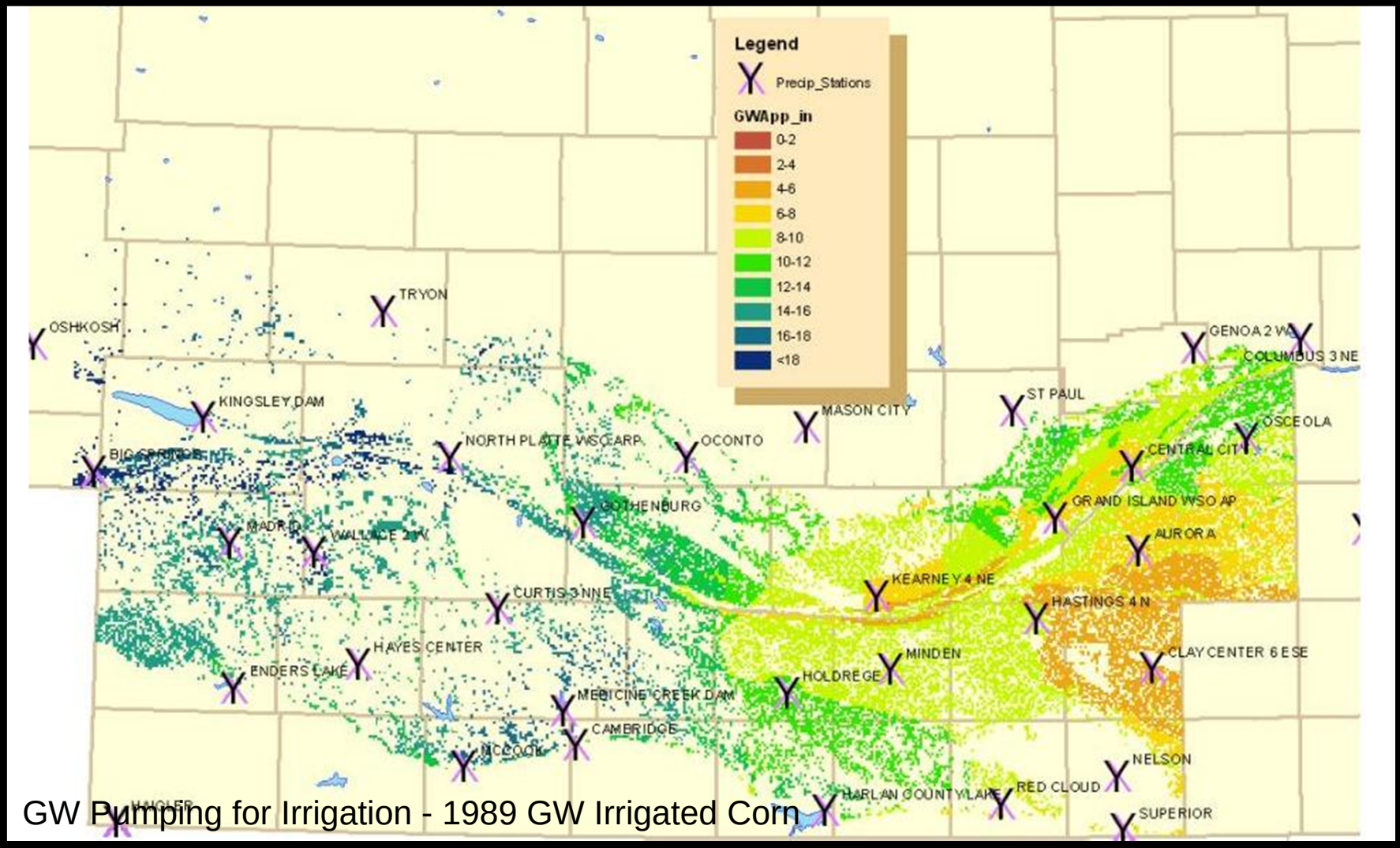
- Produces:
  - Evapotranspiration
  - Irrigation requirements
  - Deep percolation
  - Field/watershed scale runoff

Watershed Tool – Evapotranspiration



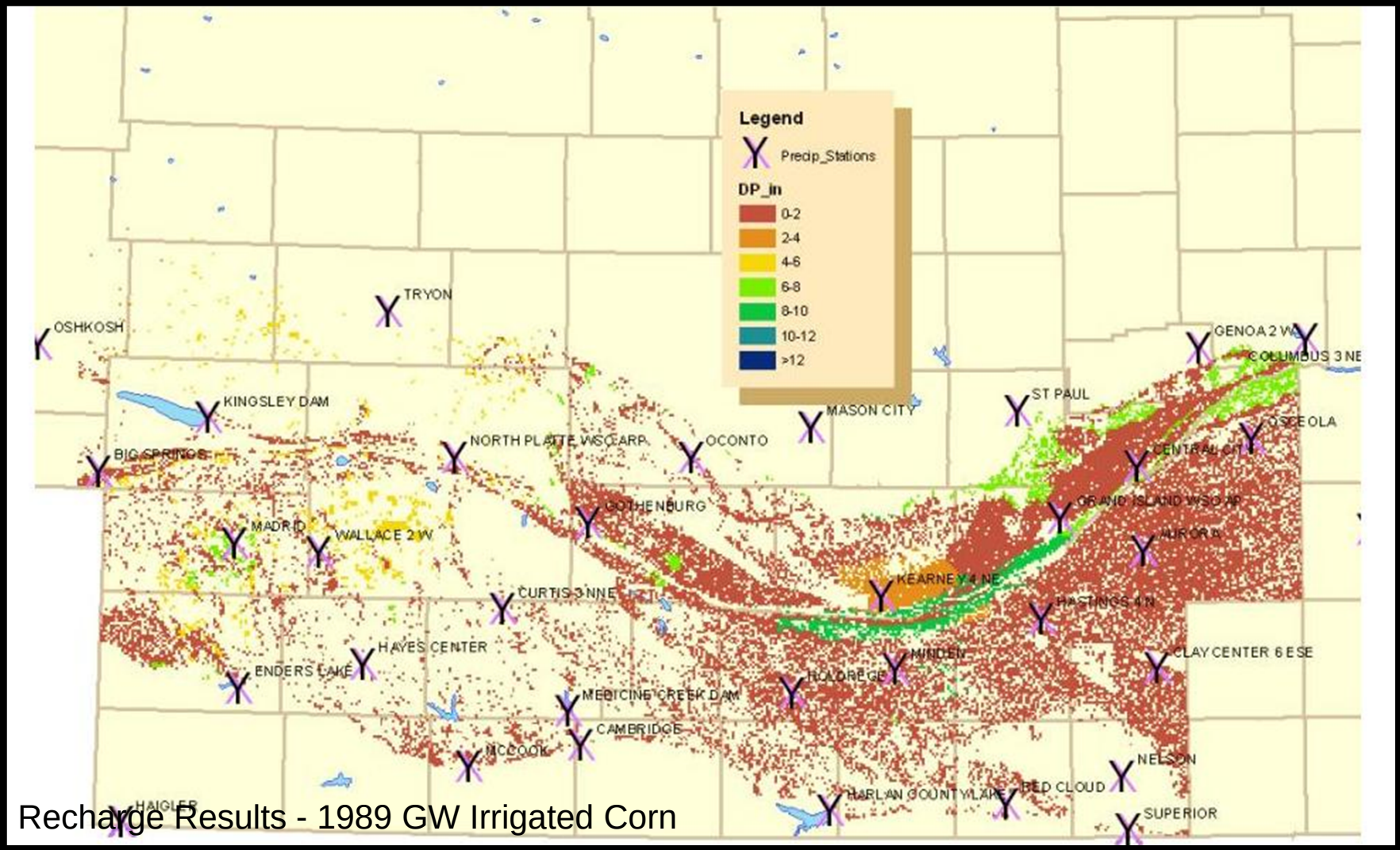
Total ET Distribution – 1993

Watershed Tool – Irrigation



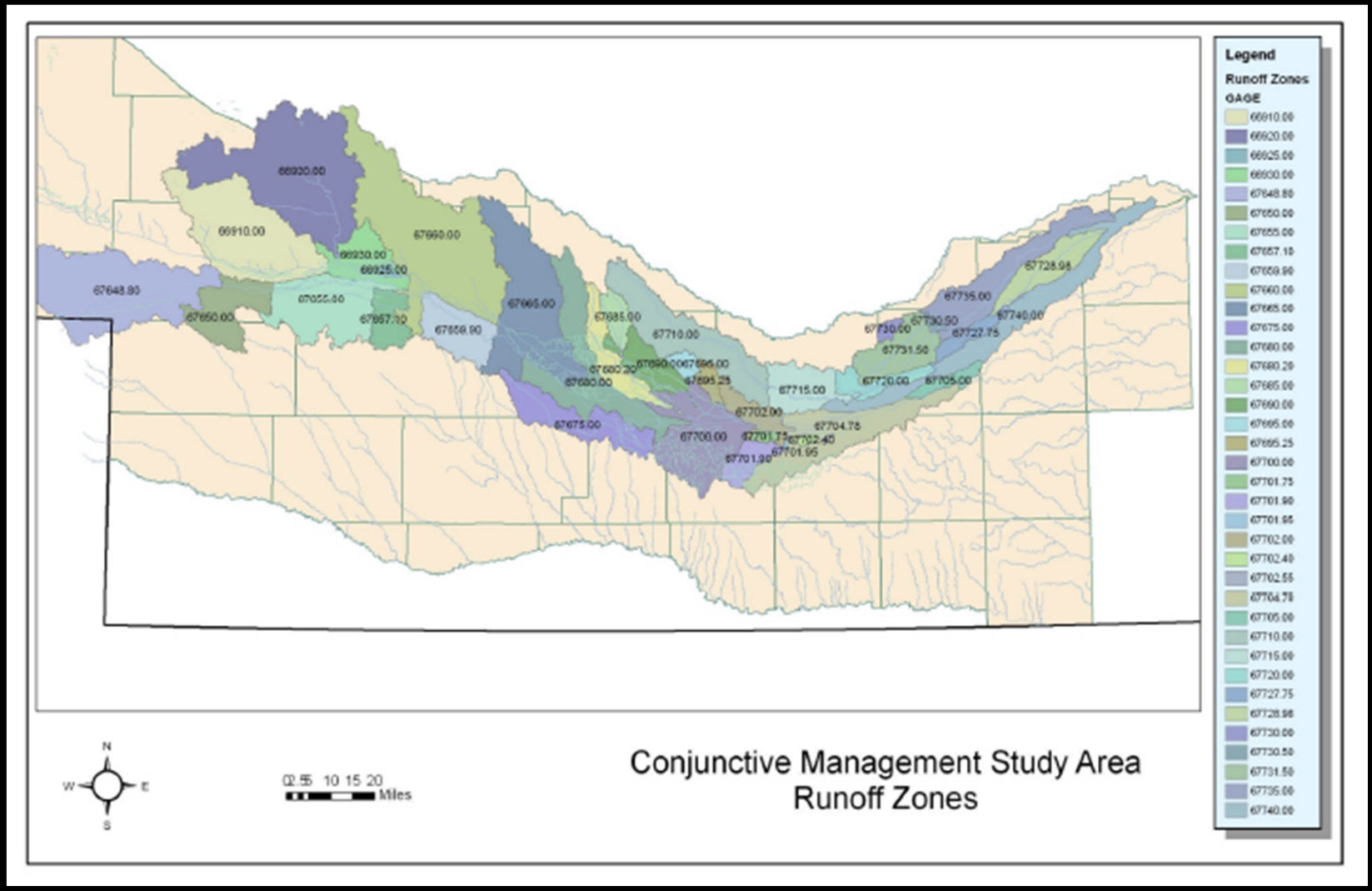
GW Pumping for Irrigation - 1989 GW Irrigated Corn

Watershed Tool – Percolation



Recharge Results - 1989 GW Irrigated Corn

Watershed Tool - Runoff



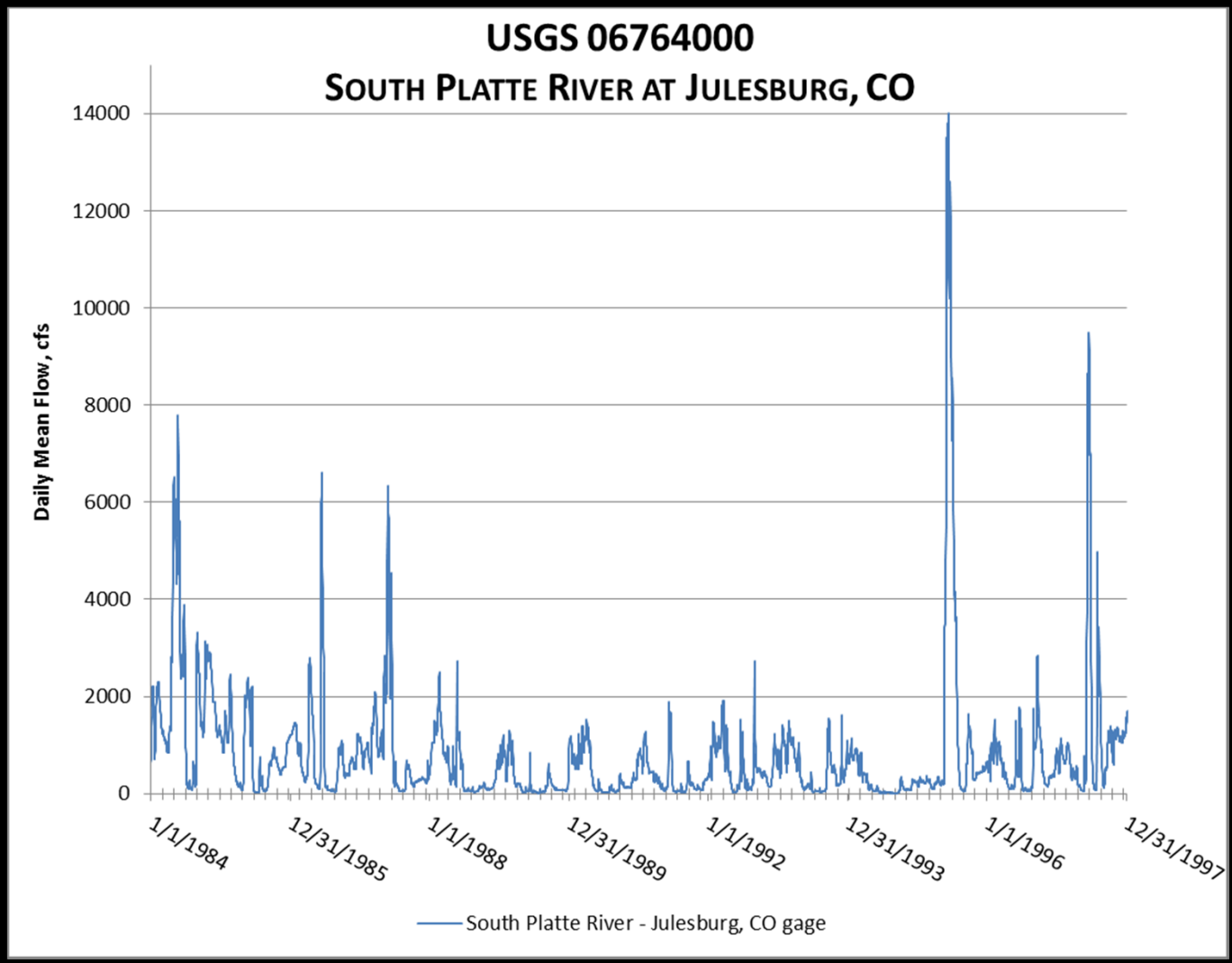
Surface Water Tool

- Surface Water Operations Model – STELLA
- Object oriented network:
  - Reservoirs
  - Streams, Diversions, and Returns
  - Canals
  - Losses and Gains
  - Hydropower
- Rules and operations customized
  - Water Rights and Priorities
  - Natural Flows and Storage Flows

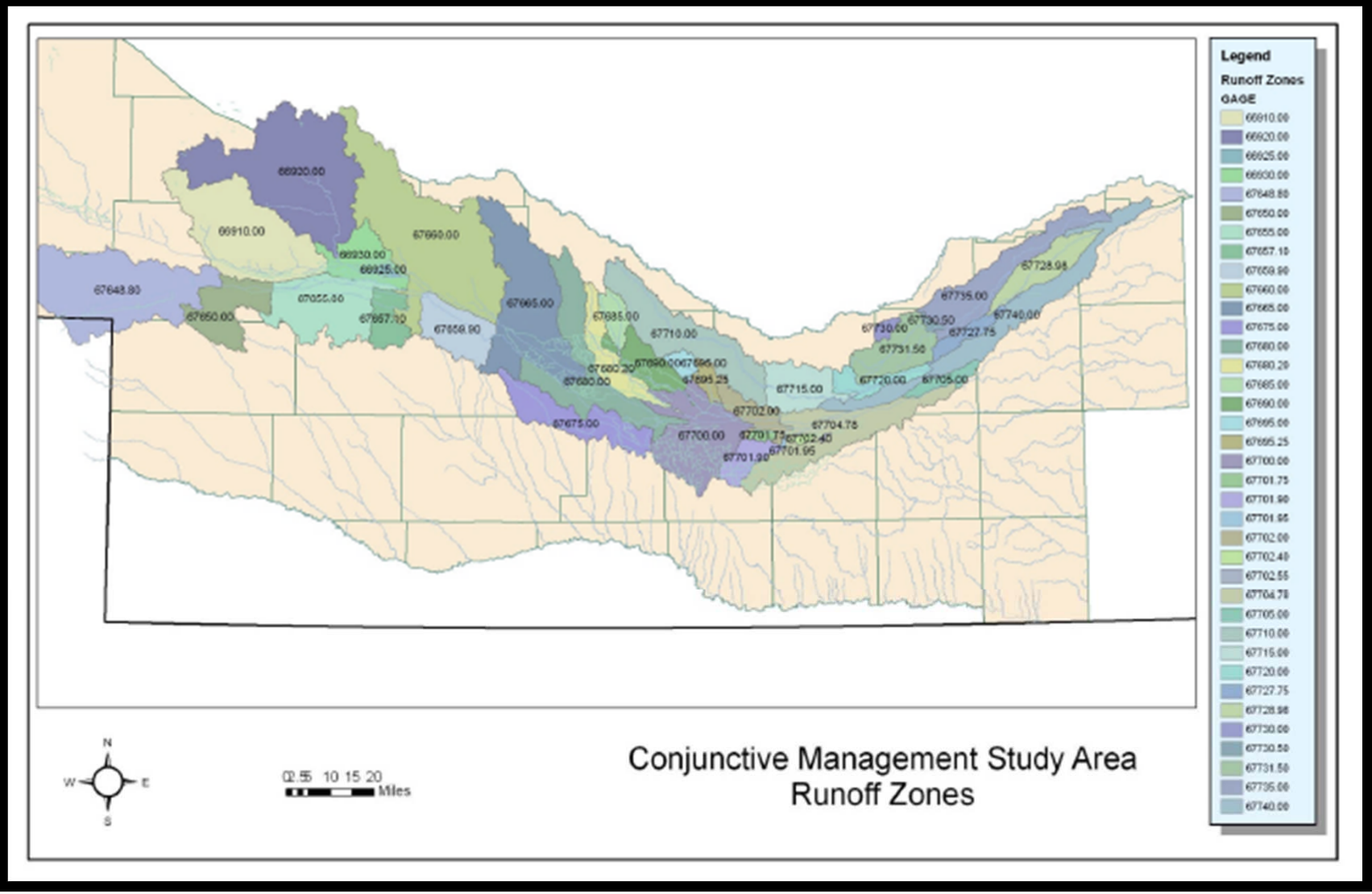
Surface Water Tool

- Incorporates:
  - Surface water inflow
  - Watershed scale runoff
  - Baseflow component of streamflow
  - Irrigation district demands

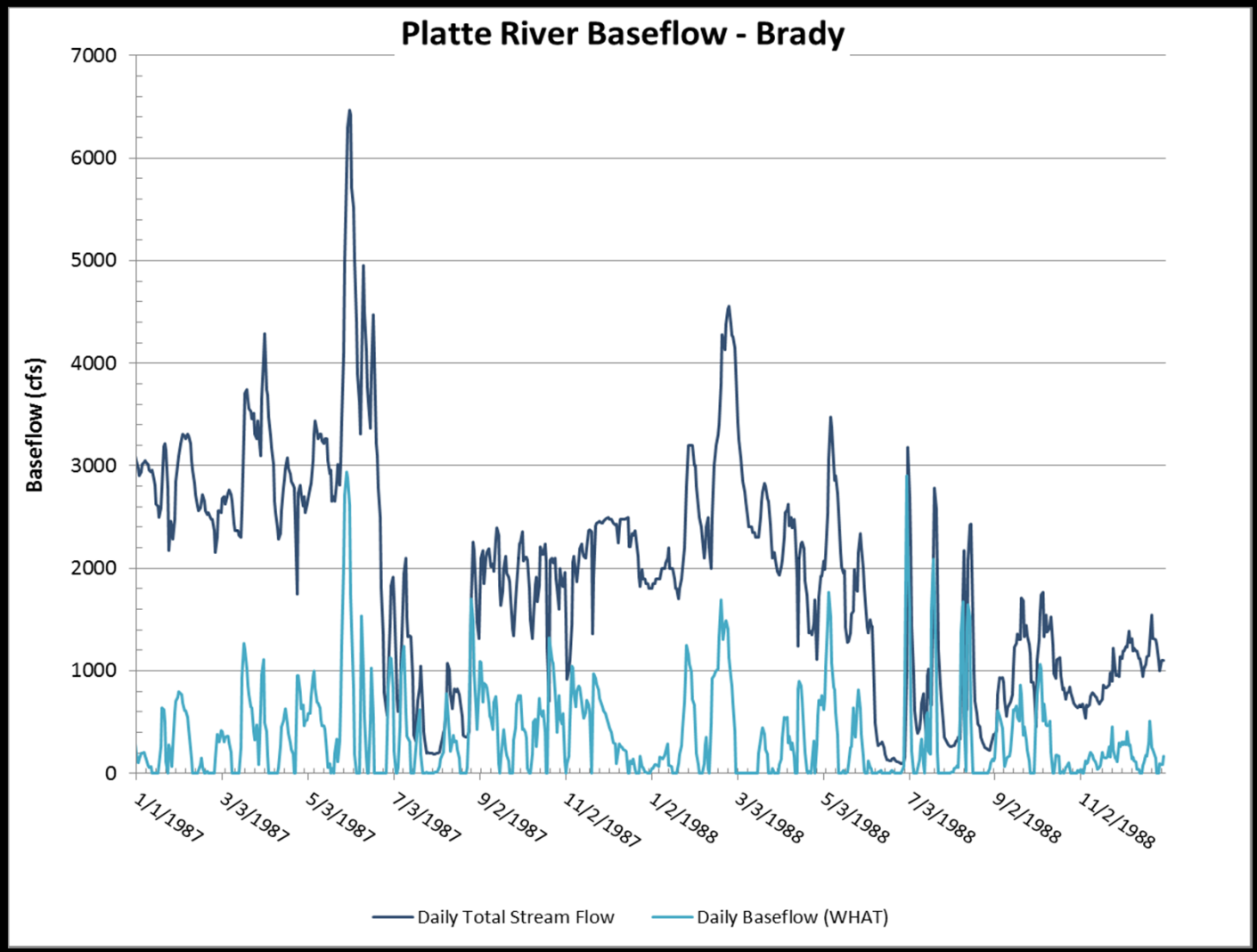
Surface Water Tool – Surface Water Inflow



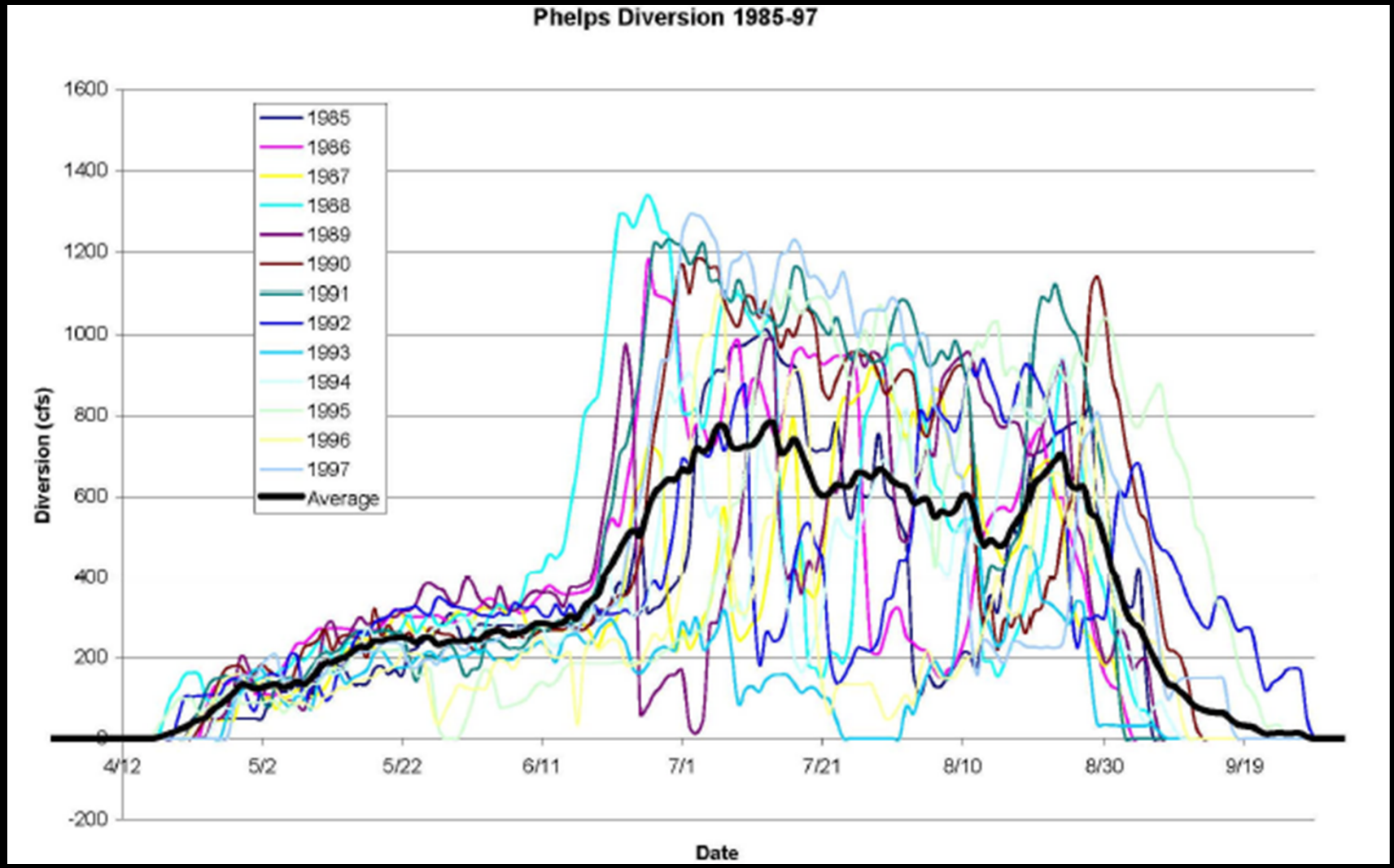
Surface Water Tool - Runoff



Surface Water Tool - Baseflow



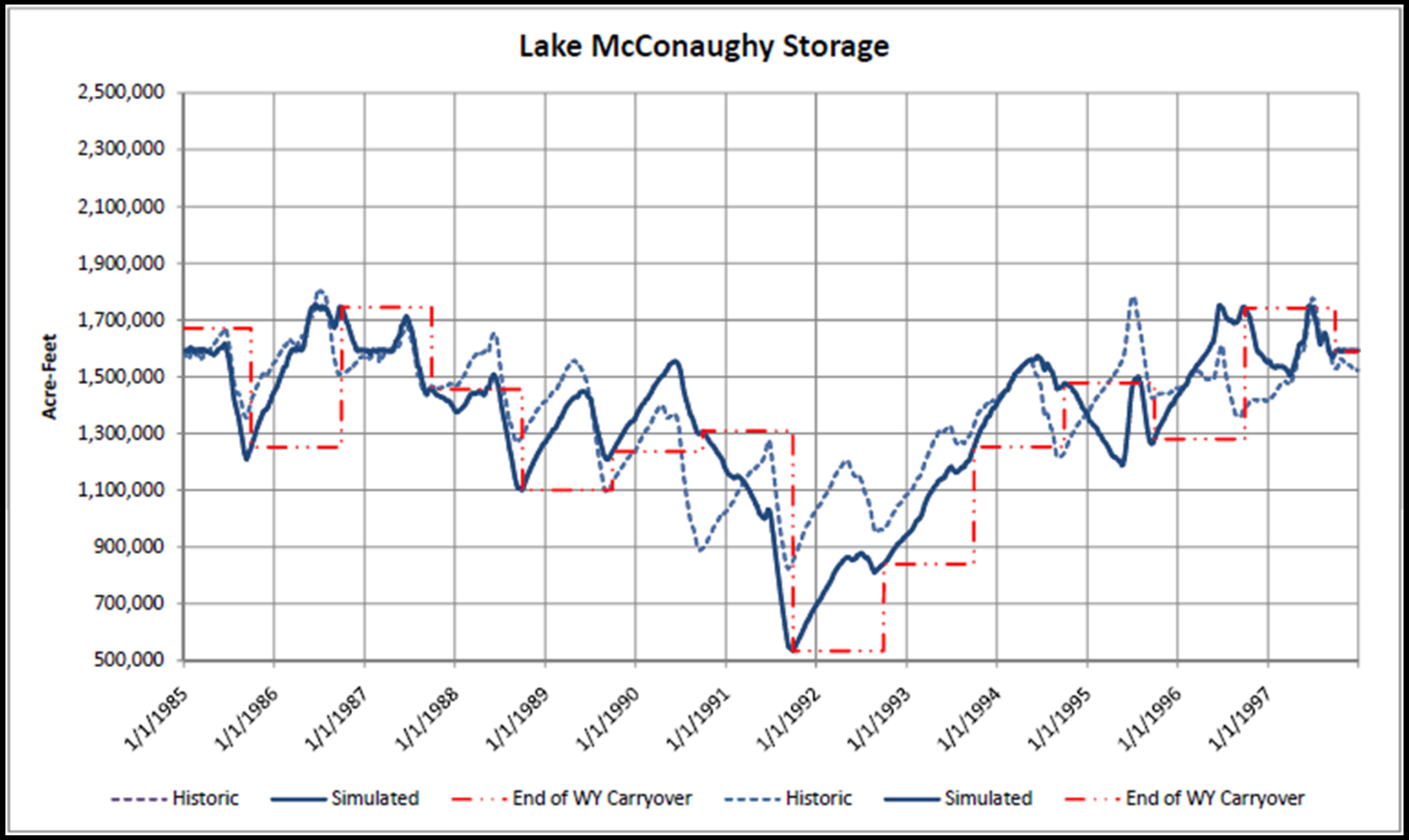
Surface Water Tool - Irrigation District Demands



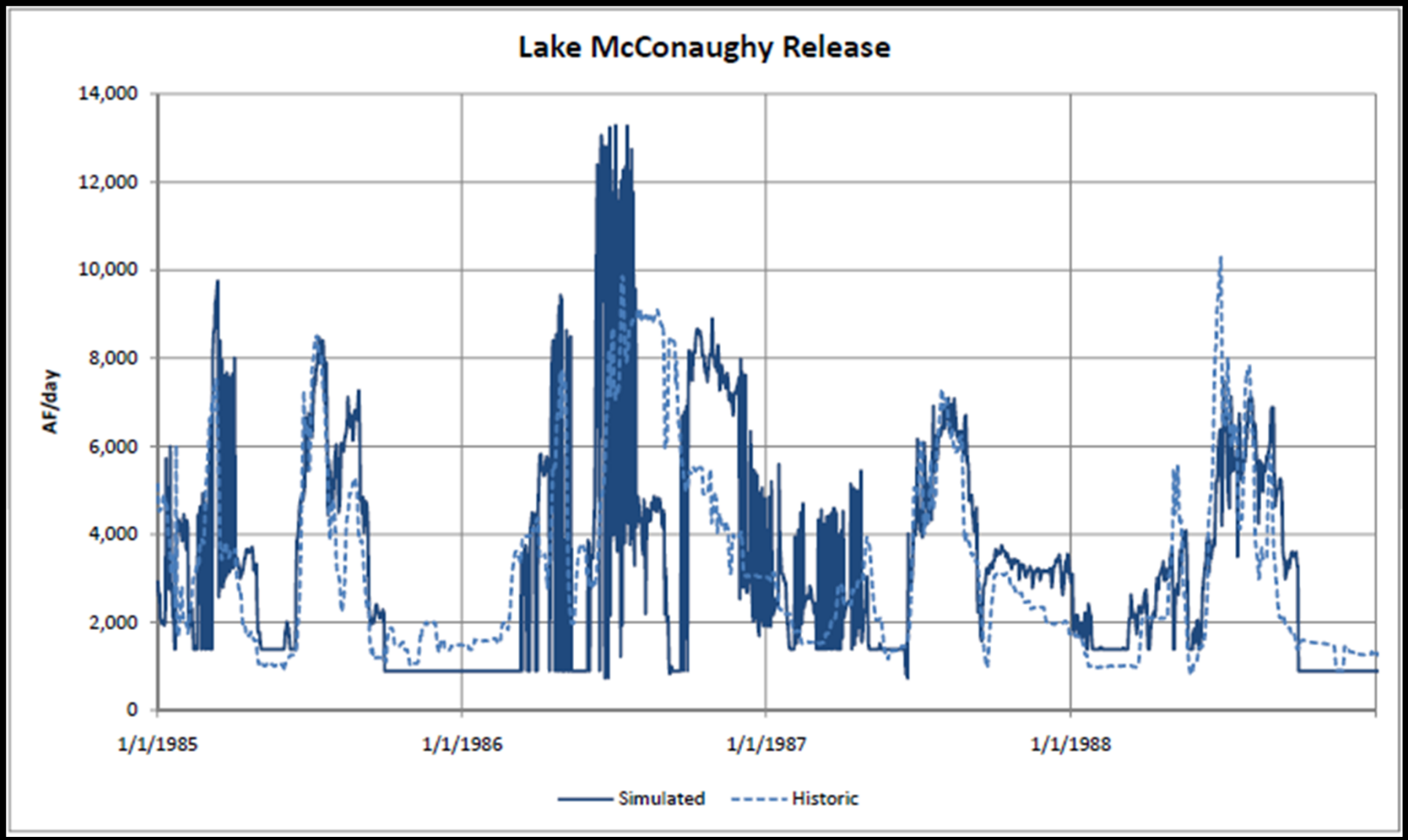
Surface Water Tool

- Produces:
  - Changes in surface water storage
  - Routed surface flow through the system
  - Canal recharge

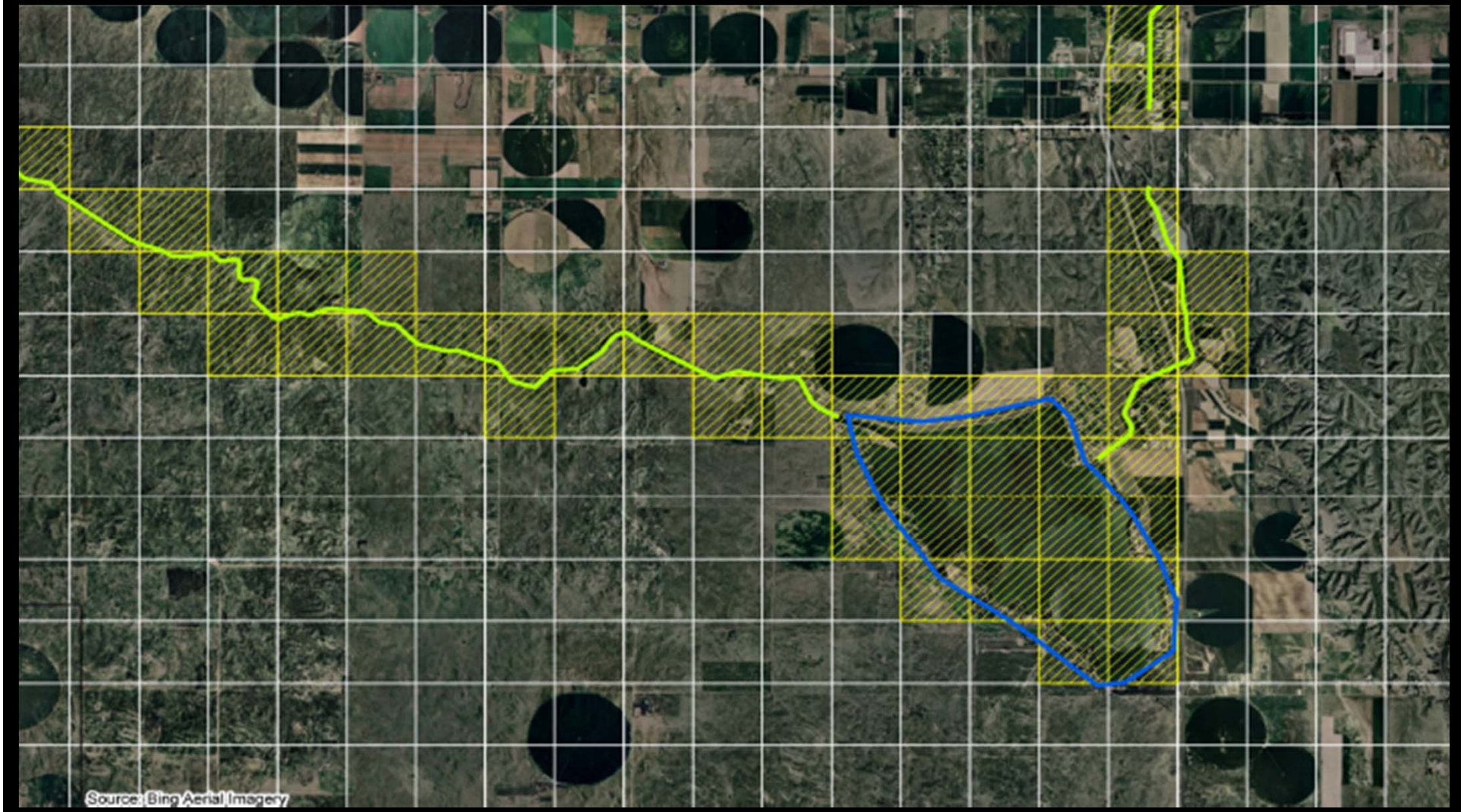
Surface Water Tool – Surface Water Storage



Surface Water Tool – Routed Surface Flow



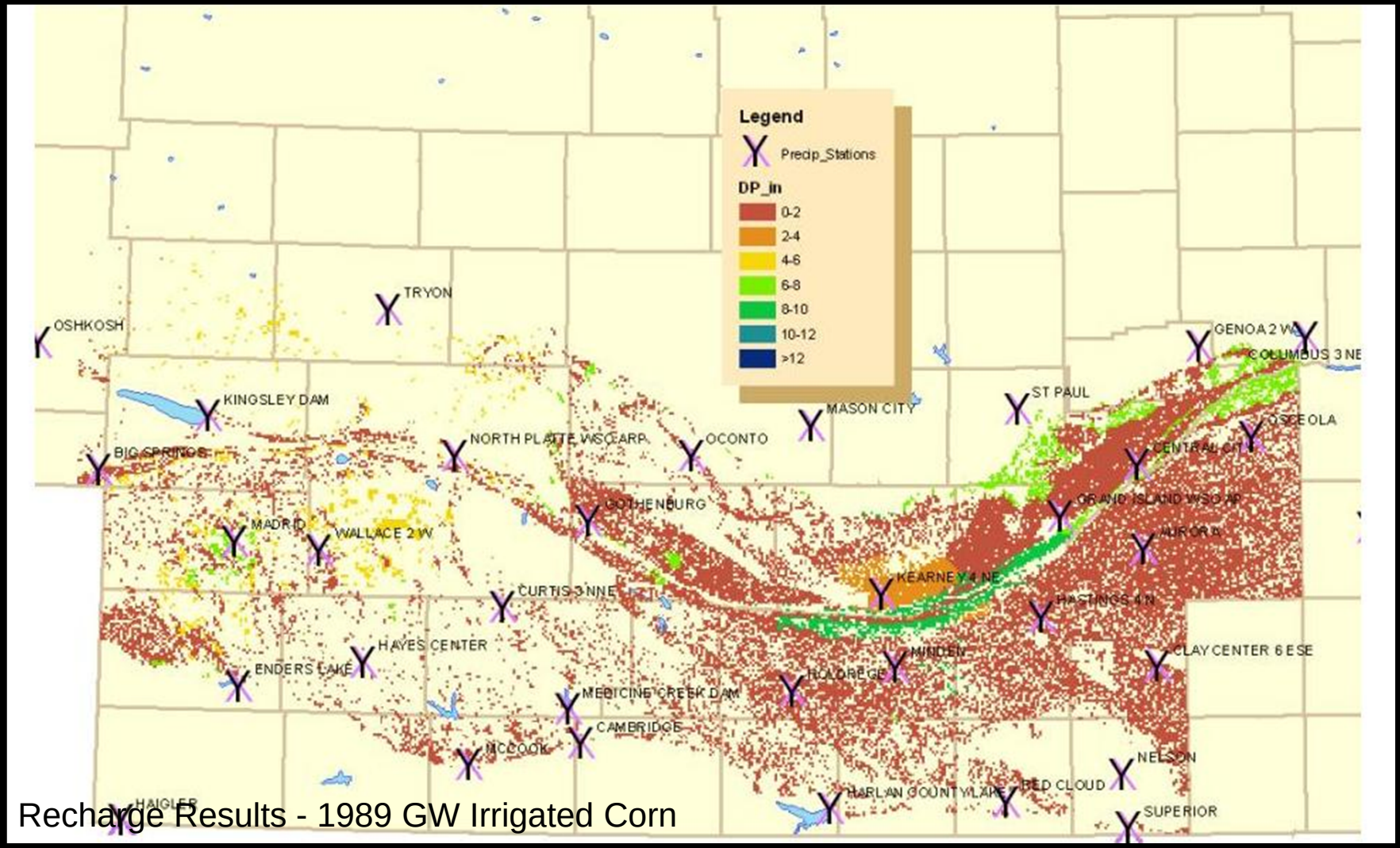
Surface Water Tool – Canal Recharge



Groundwater Tool

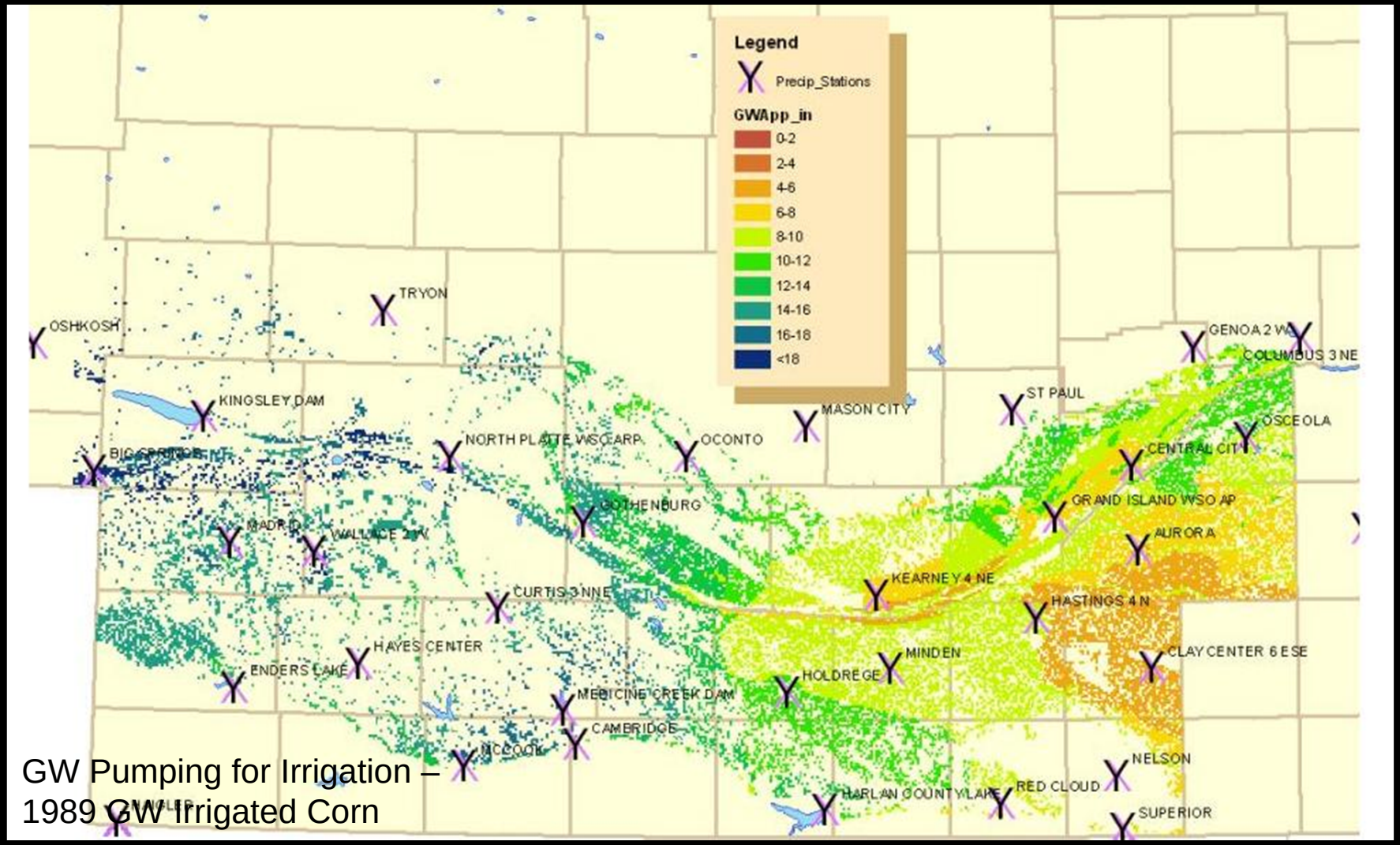
- Incorporates:
  - Recharge and pumping from watershed tool
  - Recharge from surface water tool

Groundwater Tool – Recharge



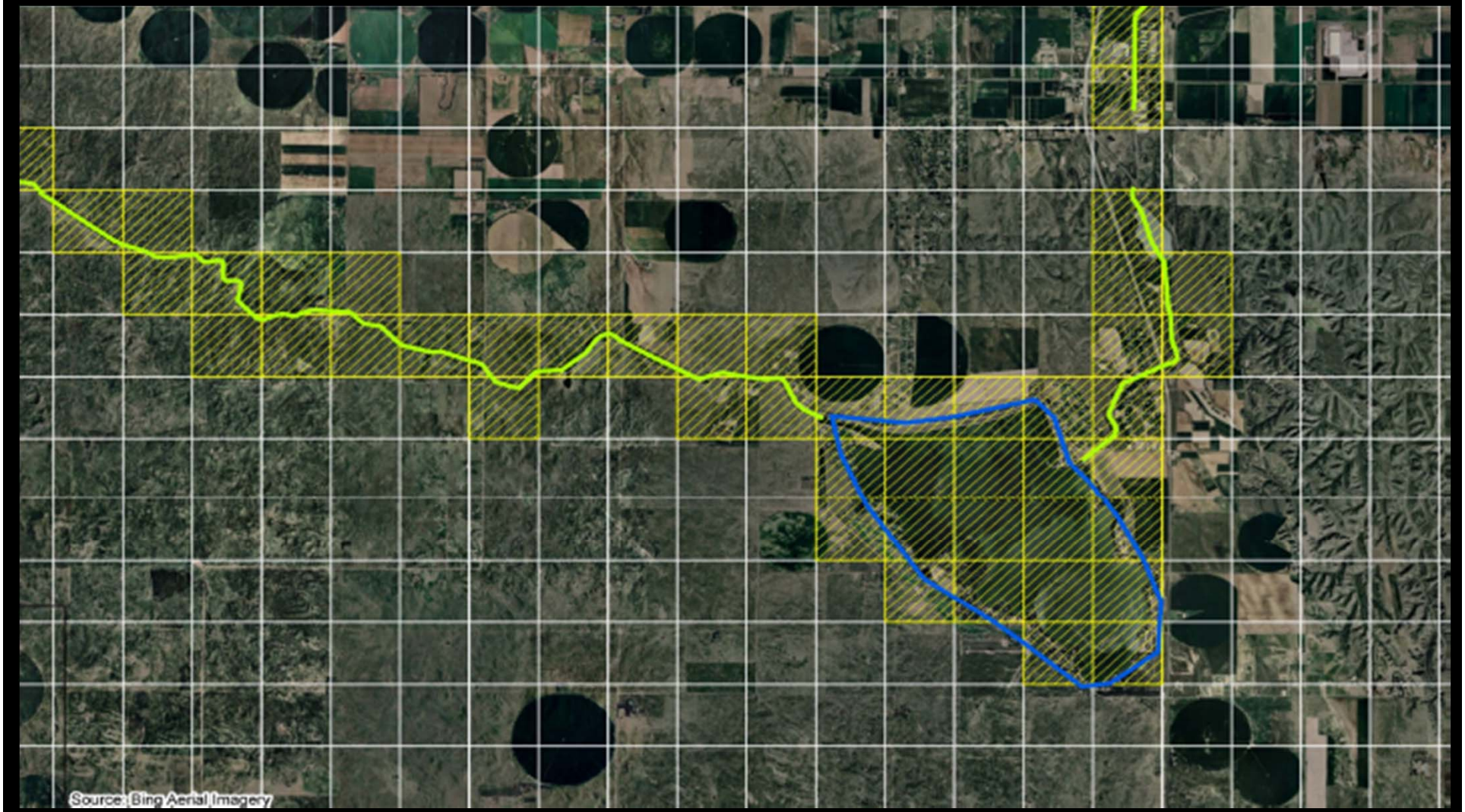
Recharge Results - 1989 GW Irrigated Corn

Groundwater Tool – Groundwater Pumping



GW Pumping for Irrigation –
1989 GW Irrigated Corn

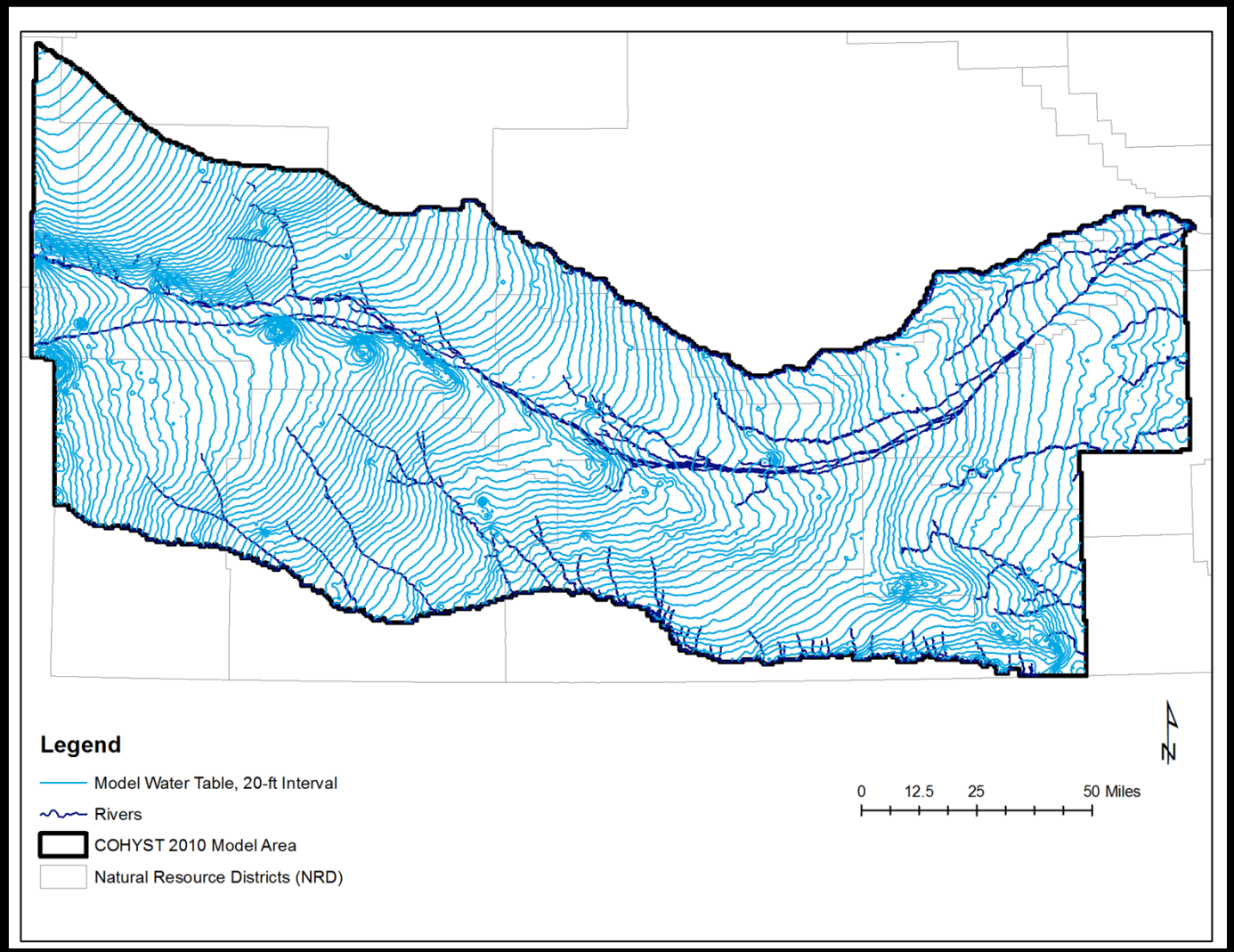
Groundwater Tool – Canal Recharge



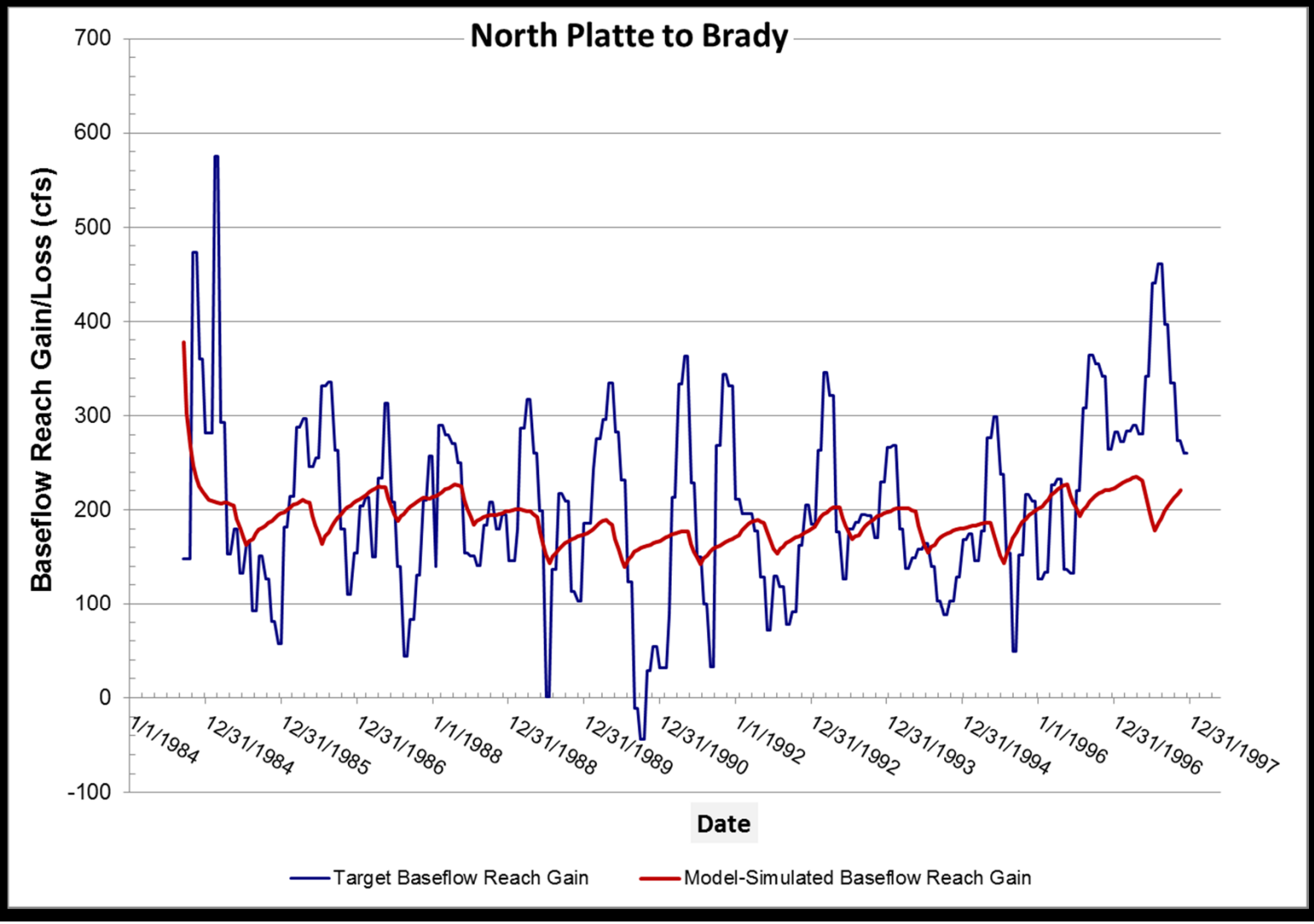
Groundwater Tool

- Produces:
  - Water table configuration
  - Baseflow component of streamflow
  - Propagates stresses through the aquifer in time and space

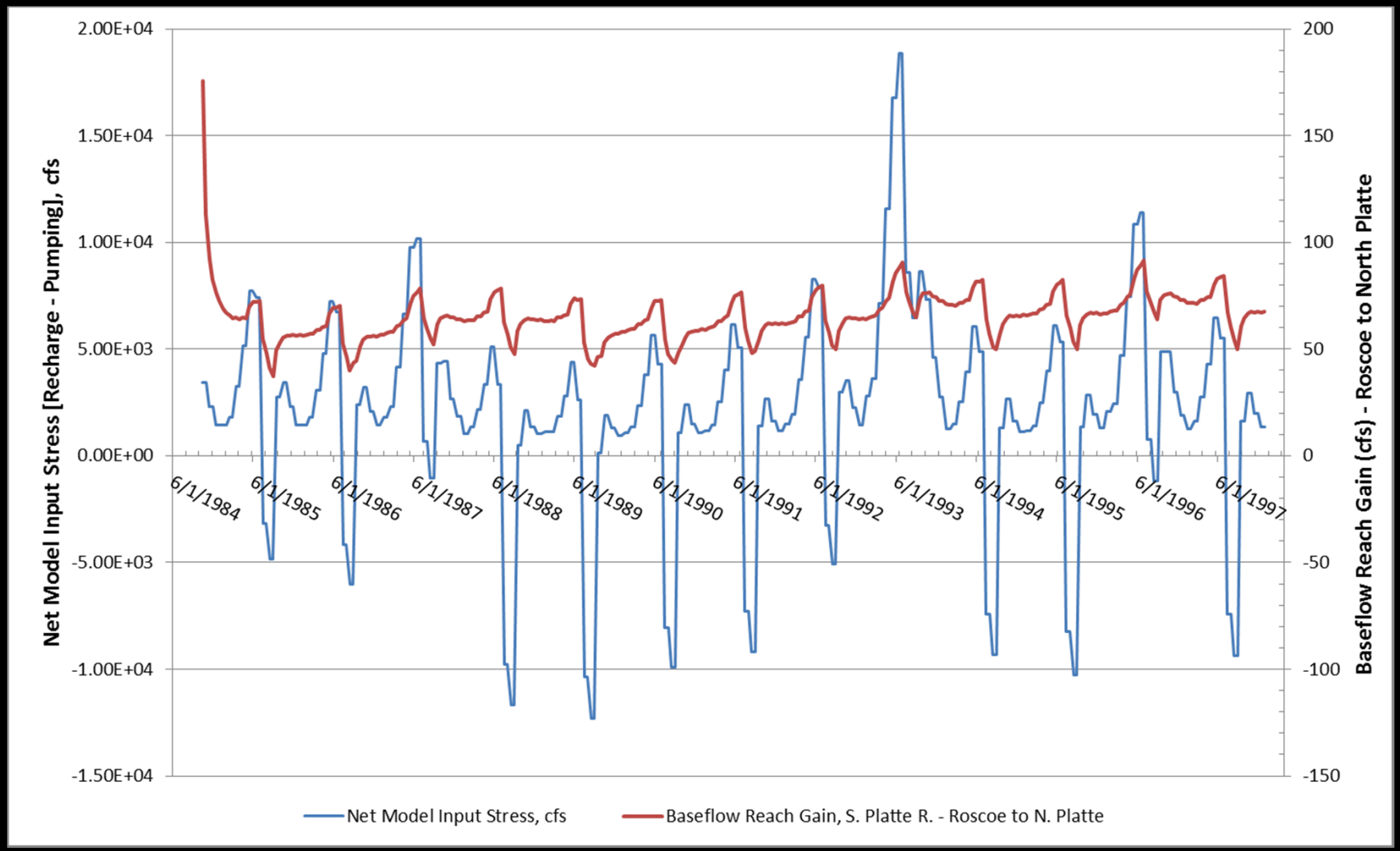
Groundwater Tool – Water Table Configuration

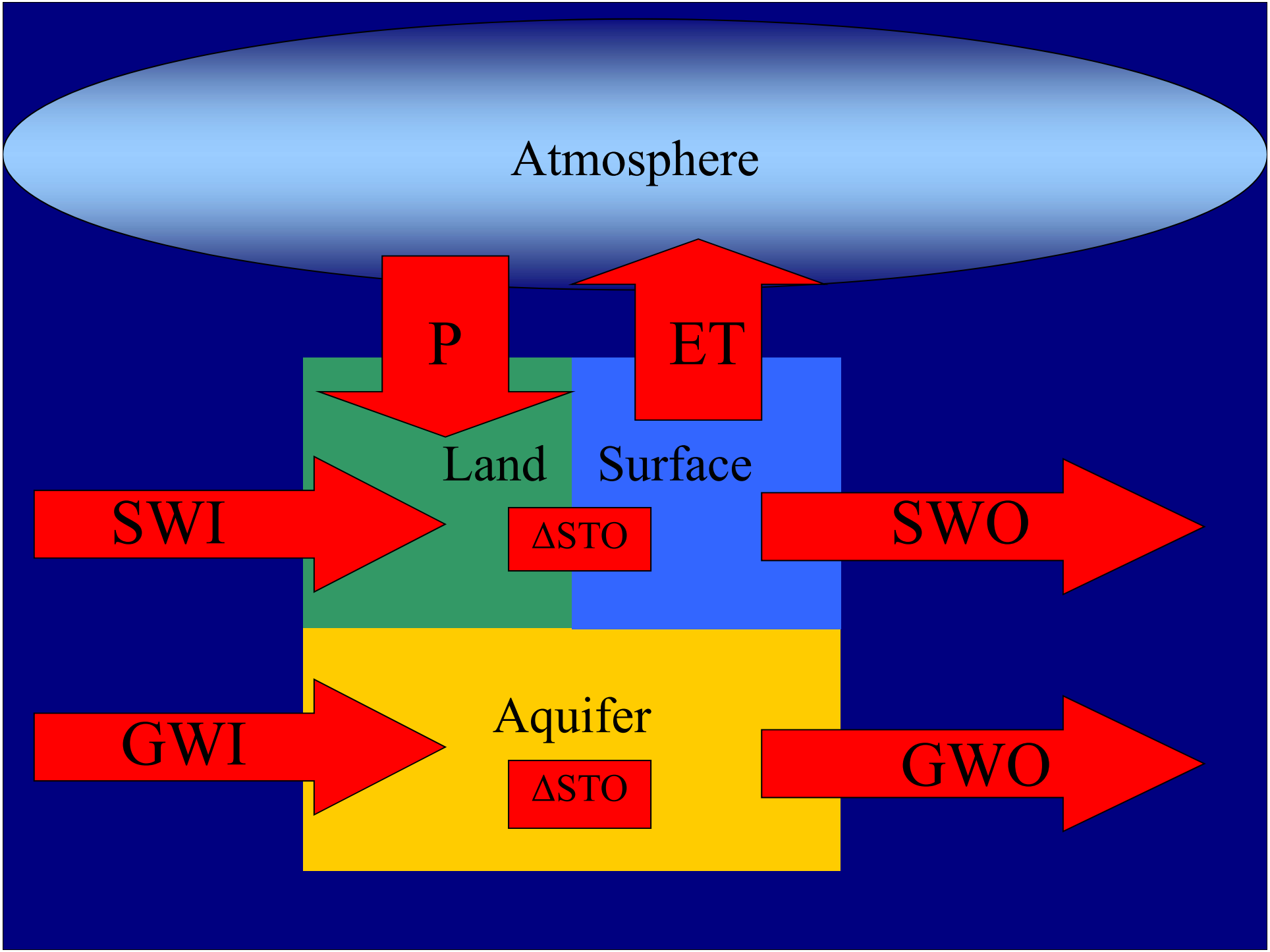


Groundwater Tool – Baseflow Component of Streamflow



Groundwater Tool – Propagate Stresses

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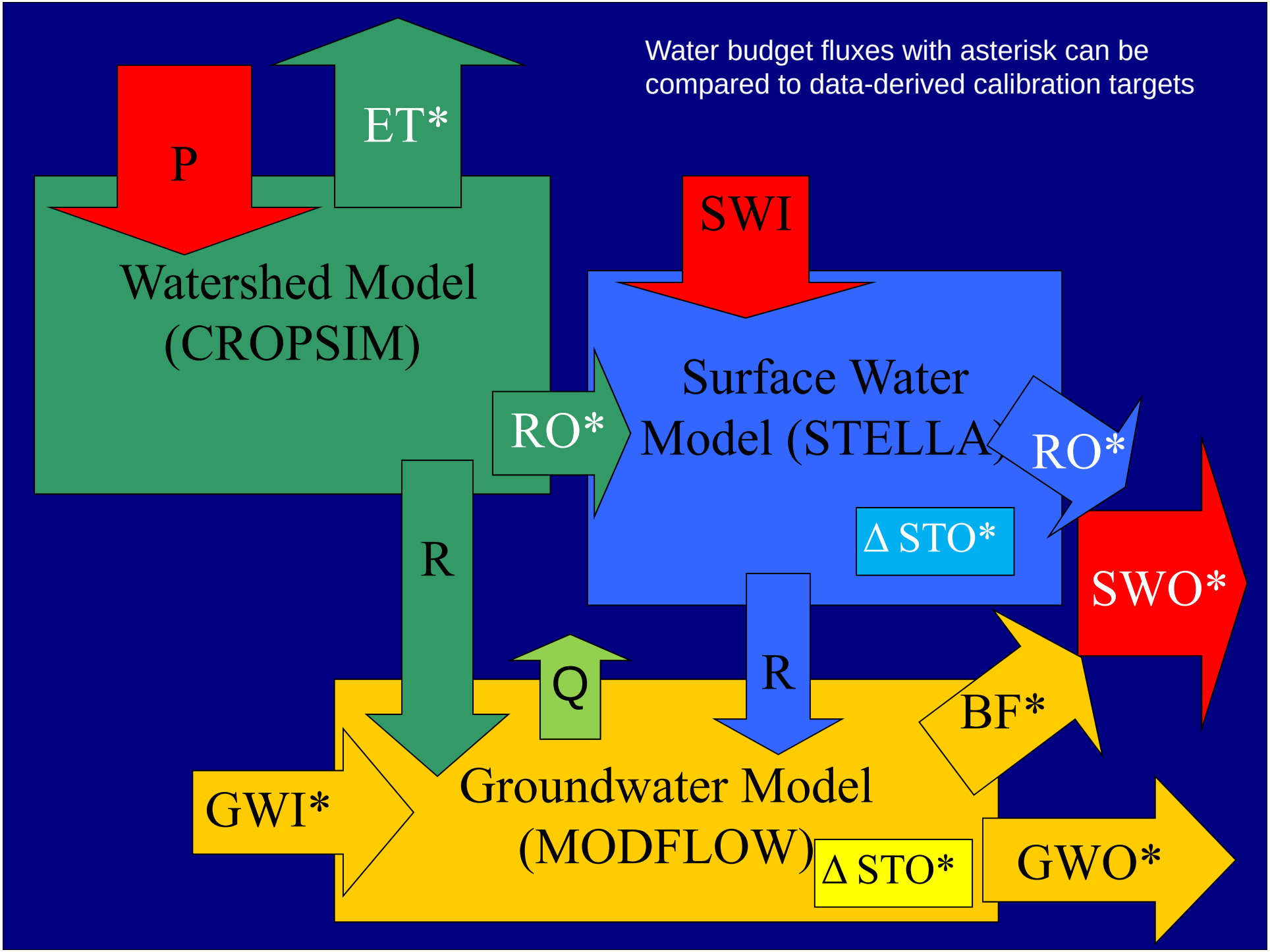
Water budget fluxes with asterisk can be compared to data-derived calibration targets
P
ET*
Watershed Model (CROPSIM)
SWI
RO*
Surface Water Model (STELLA)
RO*
Δ STO*
SWO*
R
Q
R
BF*
GWI*
Groundwater Model (MODFLOW)
Δ STO*
GWO*

Studies – Primary Concerns

- Republican River Conjunctive Management Study
  - Compact and IMPs, allocation, acres retirement, augmentation
- Niobrara
  - Economics and IMPs, climate, limited supply, small volume flows, hydropower shortages
- Western Water Use
  - PRRIP and IMPs, highly regulated, imported/contracted water, commingled uses, allocation
- Cooperative Hydrology Study (example)
  - IMPs, Highly regulated, diverse uses, acres retirement

Conclusions

1. Individual NRDs have location specific concerns and preferred management approaches
2. The state has an obligation to protect existing users and provide for sustainable economic development, while protecting the riparian ecosystem in support of federal and state initiatives
3. The concept of conjunctive management will take many forms in Nebraska, but all will be variations on the central theme of integrated water management outlined here

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