South Platte Decision Support System

a joint effort by CWCB and DWR

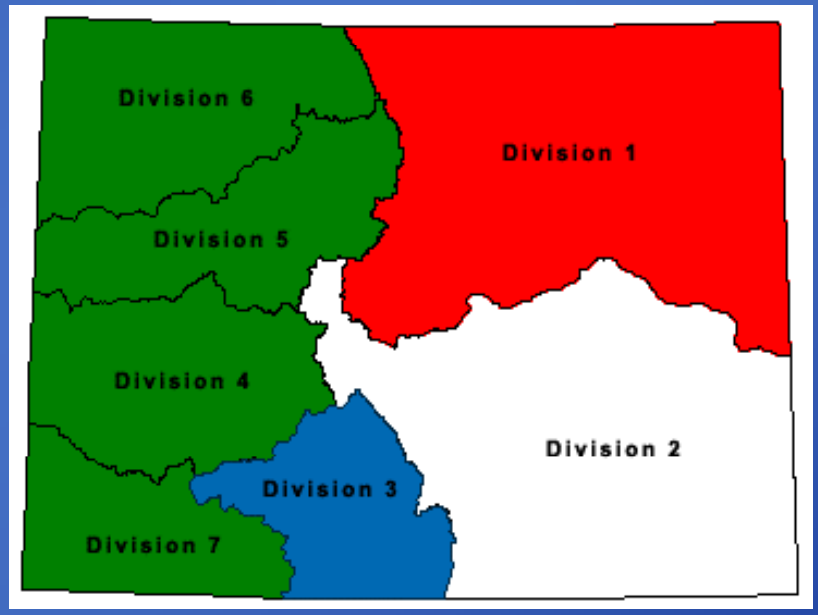
Groundwater Component

Peer Review Committee
Meeting 5

December 18, 2008

Presentation Outline

- Introductions & Meeting Purpose
- Background Information
- StateCU Update
- Model Stress Input Update
- Model Calibration
- Discussion
- Action Items/Upcoming Meetings/Closing Remarks



Meeting Purpose

- Review Model
- Update on Model Inputs
- Feedback from PRC
- Status on Model Calibration

Background Information (Refresher)

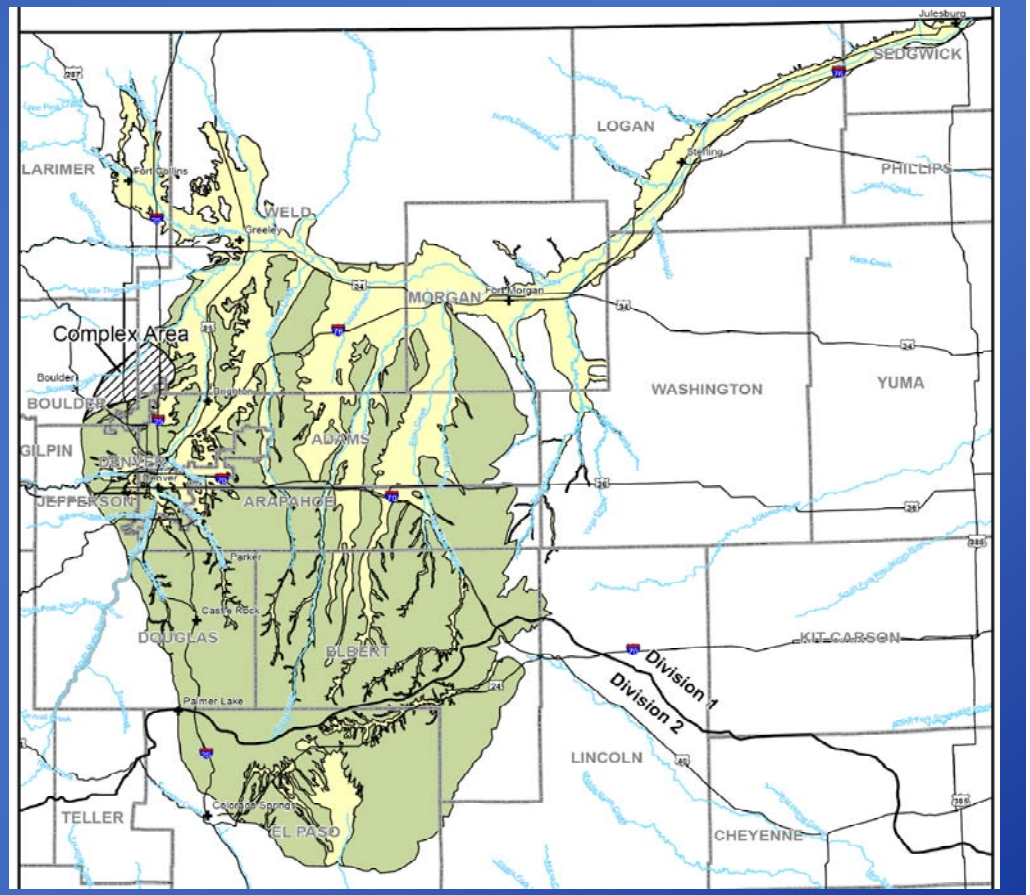
- PRC Meetings and Feedback
- Summary of Previous Meeting
- Follow-up from PRC Comments
- Overview of the Alluvial Groundwater Model

Schedule of PRC Meetings

Mtg 1	Data Collection Status	Nov ‘05
Mtg 2	Data Analysis Status/Model	Feb ‘07
Mtg 3	Model Overview	Jan ‘08
Mtg 4	Stress Inputs	April 21
Mtg 5	Modeling Update	Dec 18
Mtg 6	Calibration Progress	TBD
Mtg 7	Draft Report	TBD

Summary of Previous PRC Meeting:

- Discussed
  - modeling goals
  - model domain
  - model stress inputs
  - data-centered process and tools
  - calibration approach
- Received comments



LRE Presentation

(30 Minutes)

Alluvial Groundwater Model - Overview

- Model Goals and Potential Applications
- Modeling Process
- Model Description
  - Domain, Grid, Stress Periods
  - Initial Aquifer Properties
  - Simulated Flows
  - Updated Stress Inputs
- Calibration Process and Current Status

Alluvial Groundwater Model: Goals and Potential Applications

Goals:

- Enhance understanding of regional groundwater flow in the study area (drawdown, stream depletion)
- Identify and prioritize data gaps
- Develop a tool to assist in planning and evaluation of various water resources activities

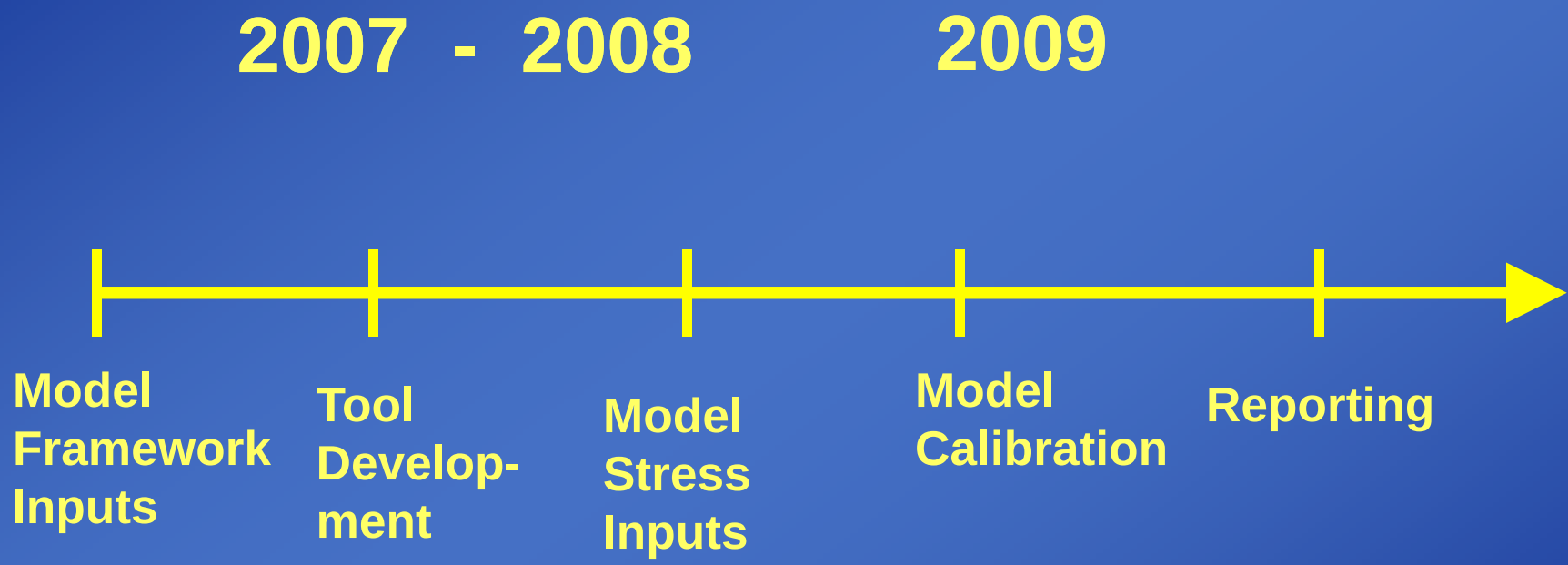
Potential Applications:

- Effects of pumping and recharge
- Effects of changes in irrigation efficiency
- Effects of water transfers

SPDSS Modeling Process

- Use data from earlier SPDSS tasks to develop inputs
- Use tools developed under the RGDSS & SPDSS to automate the model input file development
- Incorporate other information provided by SPDSS contractors
  - agricultural pumping
  - recharge
  - groundwater evapotranspiration
- Run and calibrate the model

SPDSS Modeling Process (cont'd)



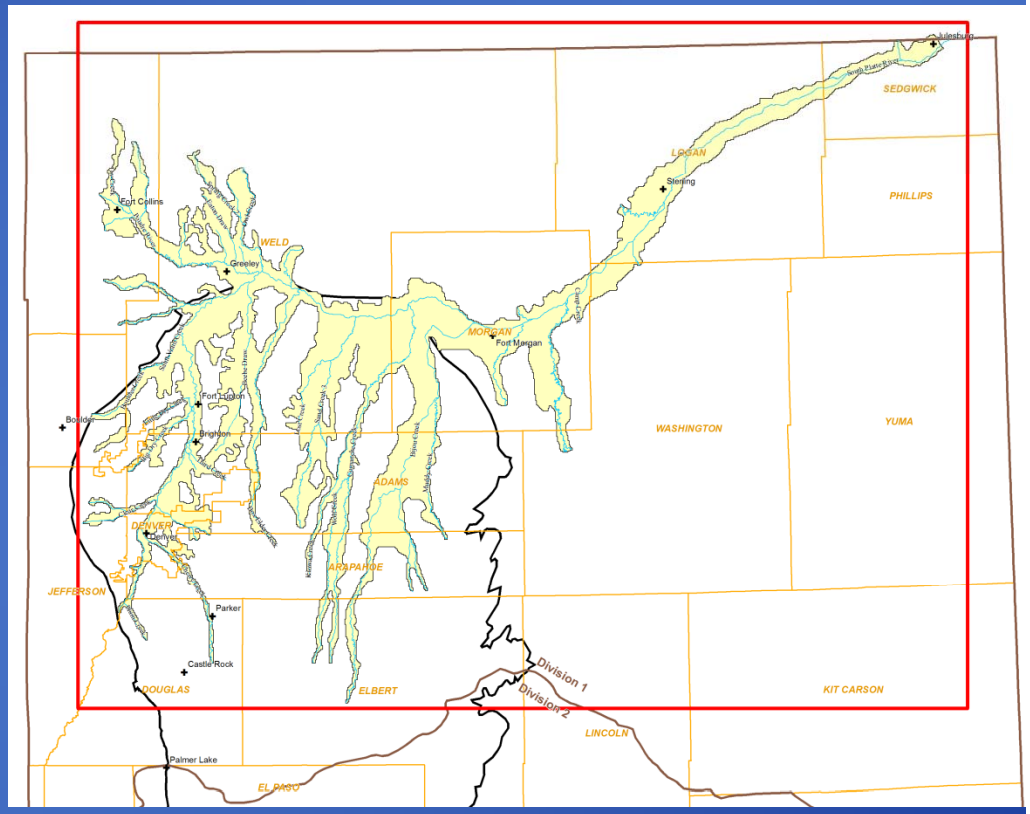
Model Description

Alluvial Model Domain

- 1,000 ft uniform grid spacing (~ 23 acres)
- One layer model
- Active domain defined by saturated thickness >10 ft and 2 model cells wide
- Active area 2500 sq. miles

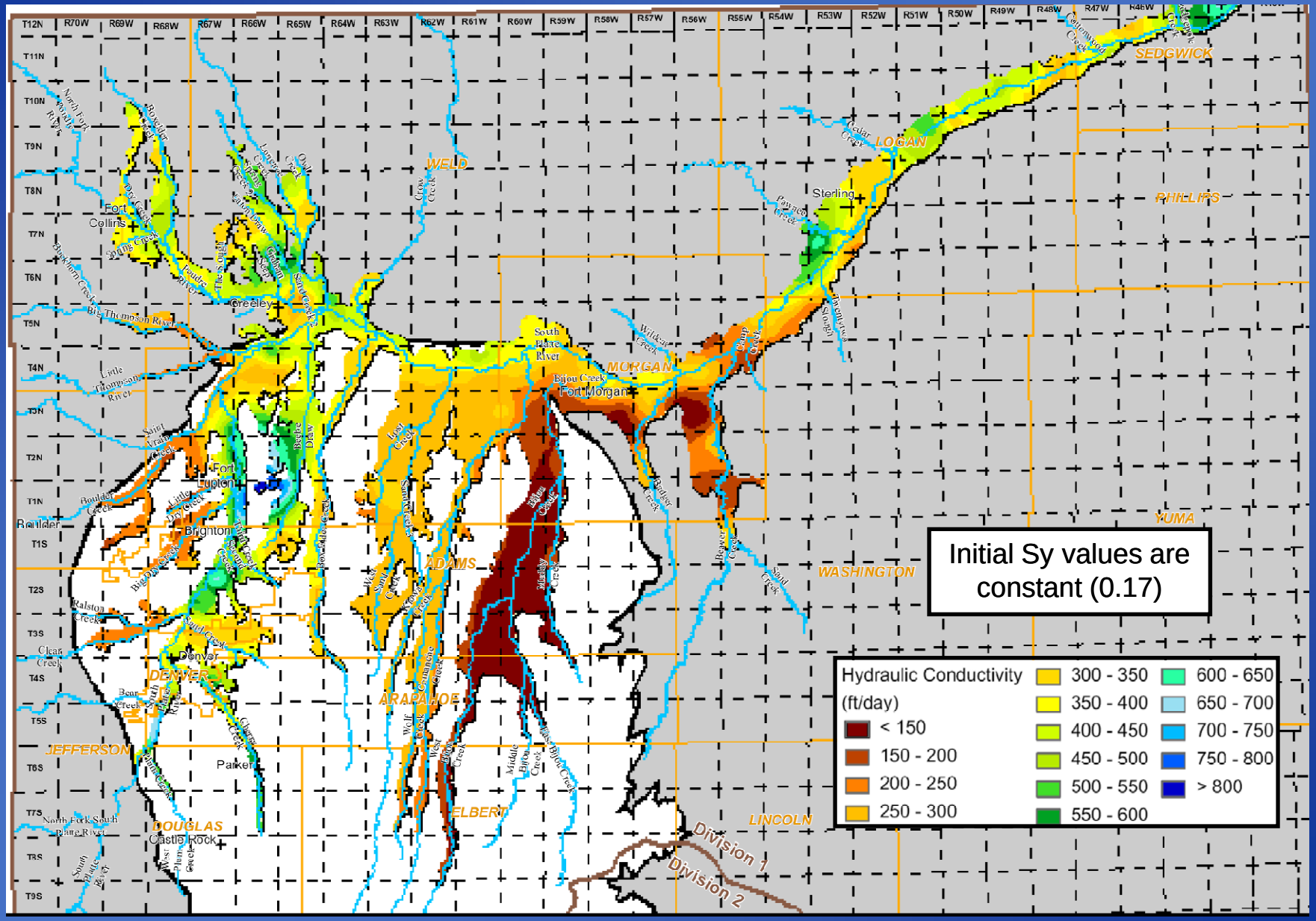
Model Time Periods

- Simulation Period is 1950 – 2006
- Monthly Stress Periods



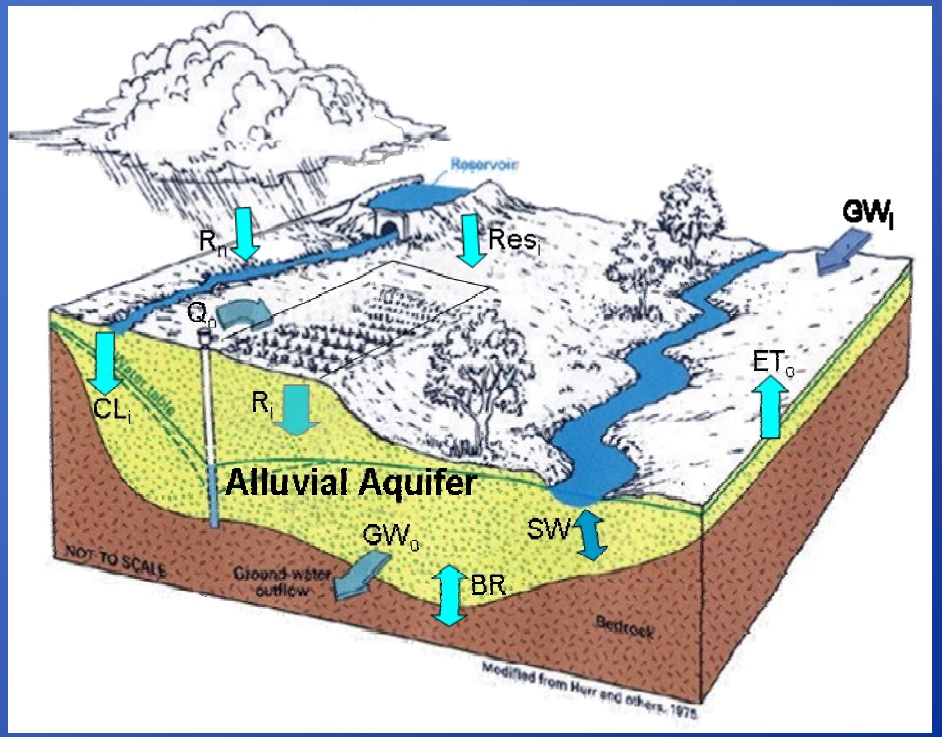
SPDSS Alluvial Aquifer Model Area and Active Domain

Initial Aquifer Properties (Task 43.3)



Simulated Flows (model stresses)

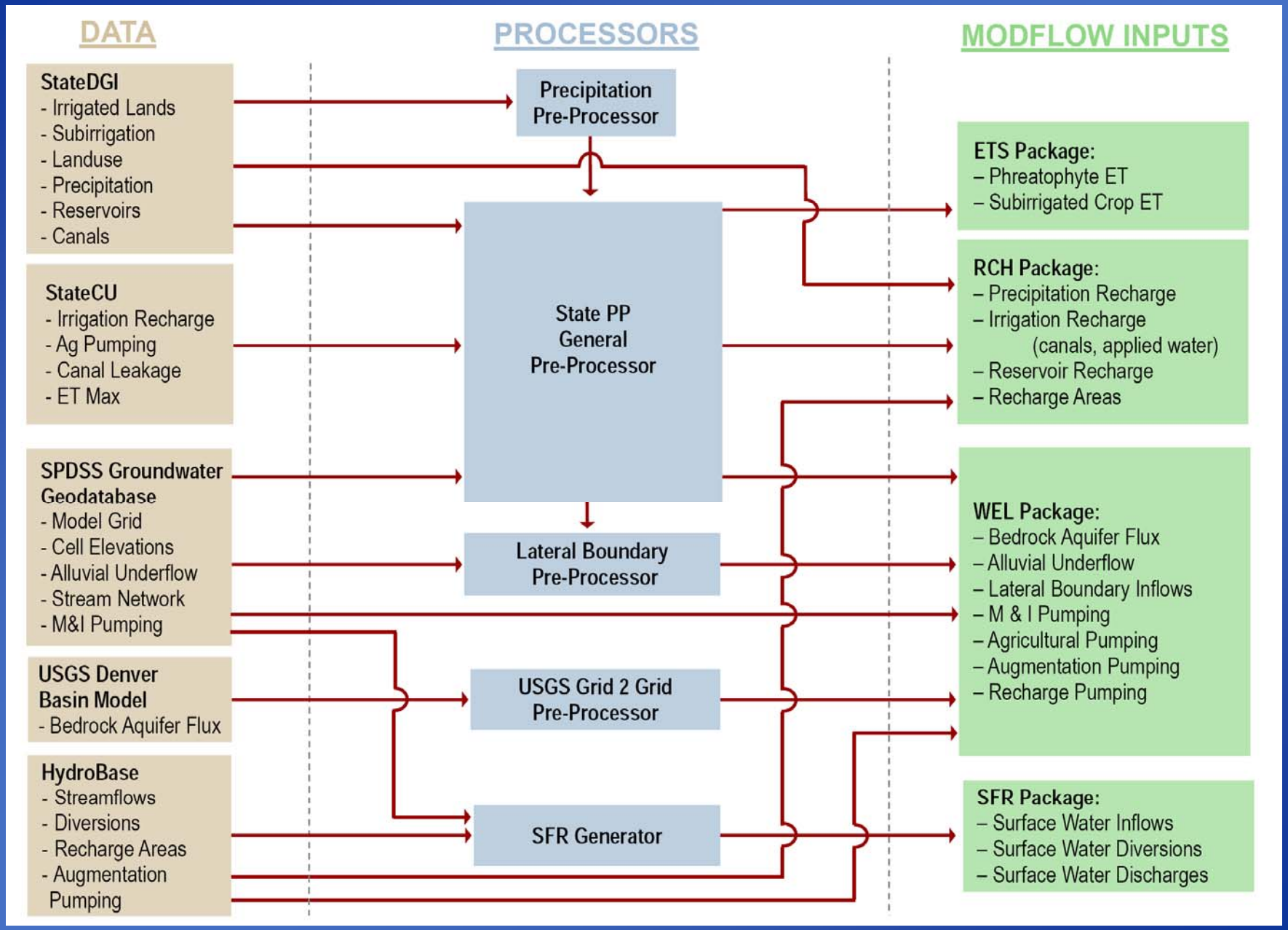
- Stress Inputs from StateCU
  - Irrigation-based recharge
  - Canal seepage
  - Precipitation-based recharge
  - Agricultural pumping
  - Groundwater evapotranspiration
- Other Stress Inputs
  - Recharge areas and wells
  - M&I pumping
  - Lateral boundary inflows
  - Stream flows and diversions
  - Bedrock aquifer flux
  - Reservoir seepage
  - Alluvial groundwater inflow



Model Implementation

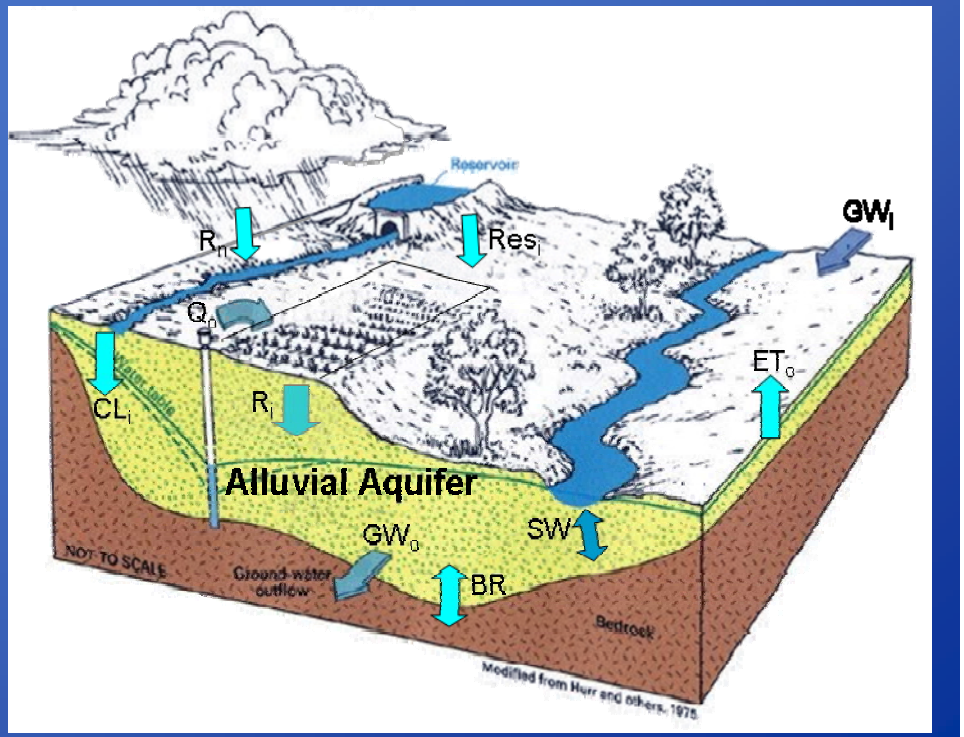
- **MODFLOW Package (& System Components Simulated)**
  - **ETS (GW Evapotranspiration)**
  - **RCH (Precip., Irrigation & Canal-based Recharge, Reservoir Seepage, Recharge Areas)**
  - **WEL (Bedrock Fluxes, Well Production, Alluvial Underflow, Lateral Boundary Inflow)**
  - **SFR (Stream Flow, Stream-Groundwater Interaction)**
- **Using SPDSS data centered tools to develop inputs**
- **Using MODFLOW2000 (V 1.18) with double precision**

Model Stress Inputs Development Flow Chart

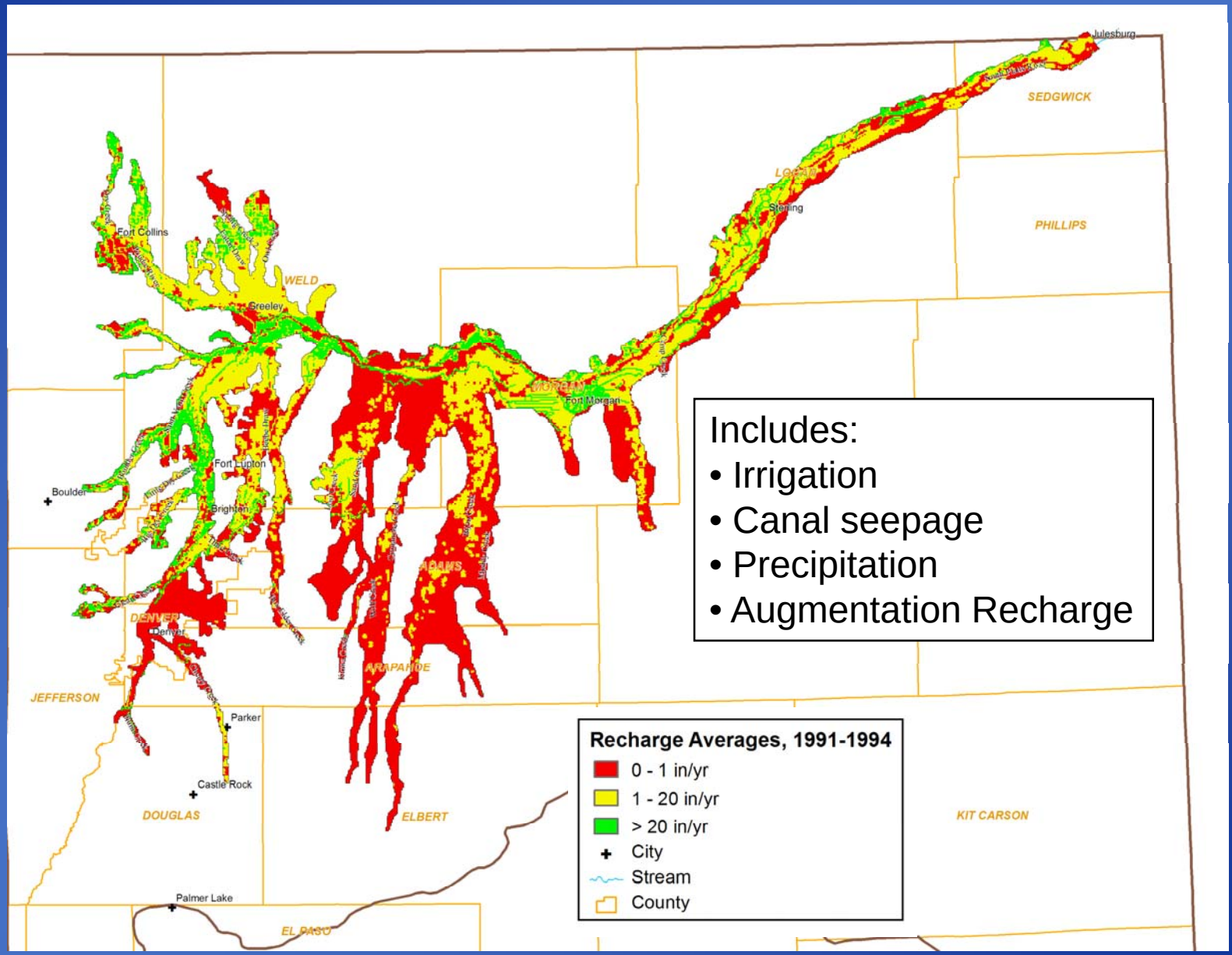


Updated Model Stress Inputs

- **Stress Inputs from StateCU**
  - **Irrigation-based recharge**
  - **Canal seepage**
  - **Precipitation-based recharge**
  - **Agricultural pumping**
  - **Groundwater evapotranspiration**
- **Other Stress Inputs**
  - **Recharge areas and wells**
  - **M&I pumping**
  - **Lateral boundary inflows**
  - **Stream flows and diversions**
  - **Bedrock aquifer flux**
  - **Reservoir seepage**
  - **Alluvial groundwater inflow**



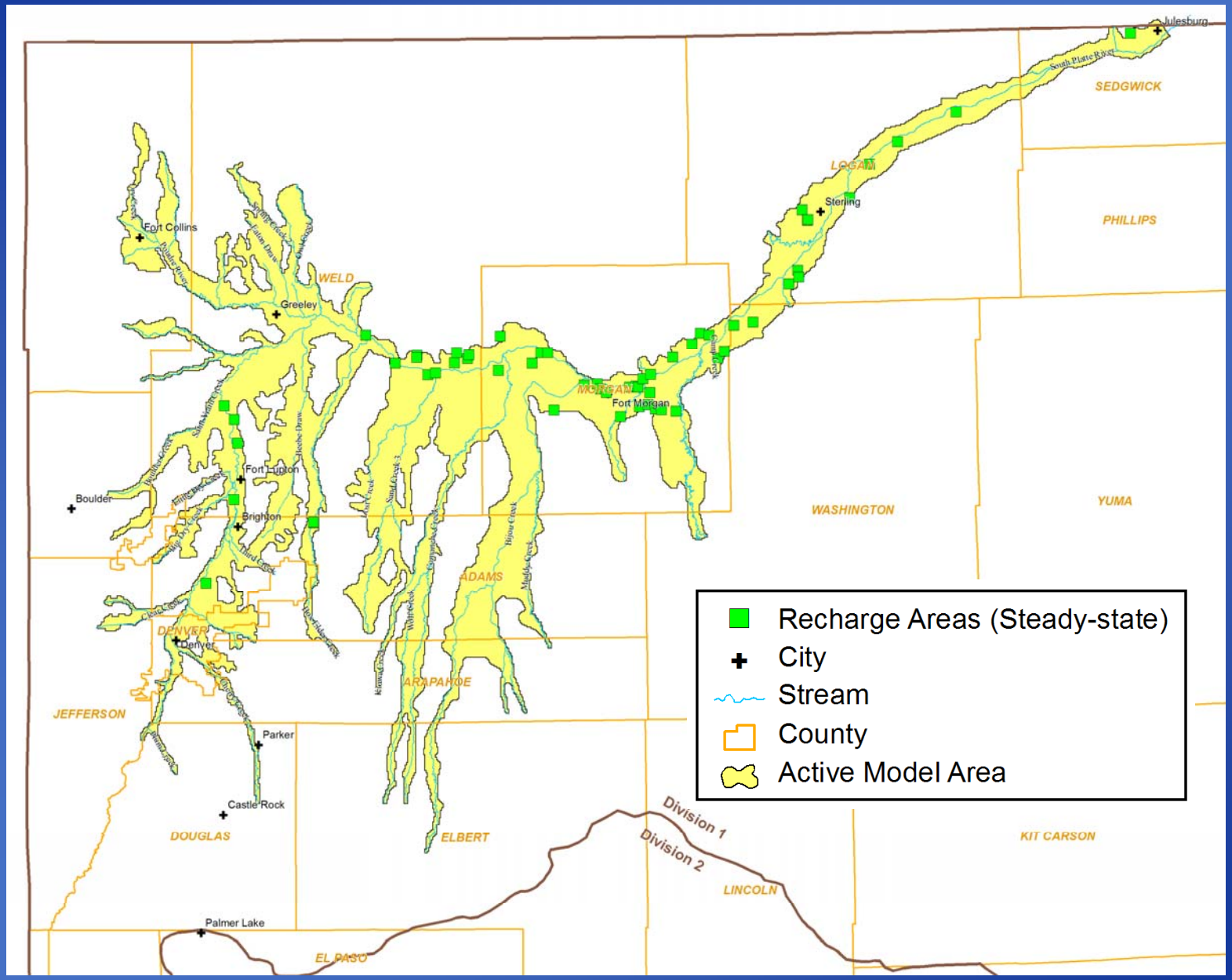
Updated Recharge



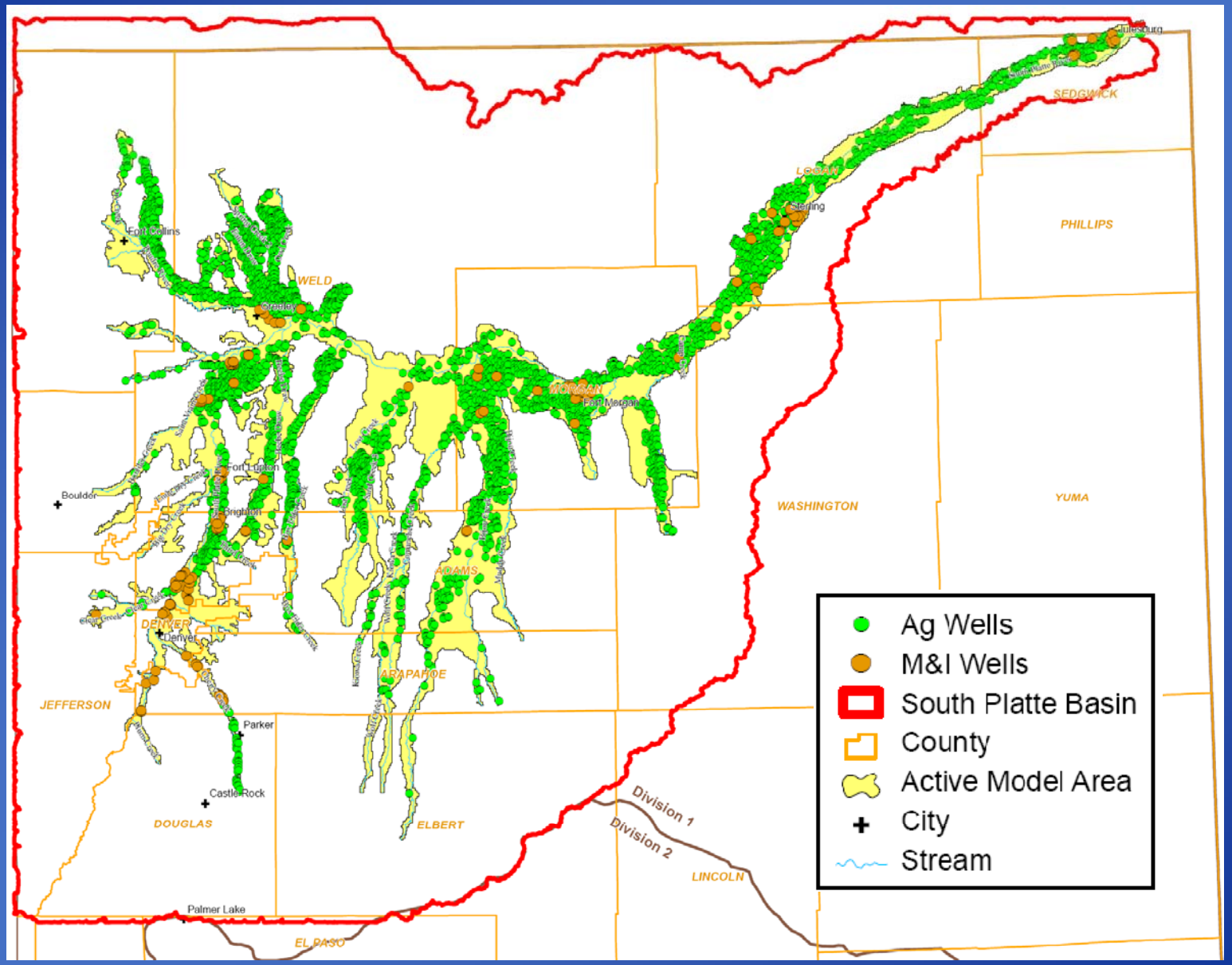
Augmentation Recharge

- Includes:
  - Augmentation wells
  - Augmentation recharge ponds
- Data Sources:
  - DWR Division 1 files
  - HydroBase
- Input Development Process:
  - Structure locations, recharge and pumping rates provided by DWR
- Model Stress Input:
  - MODFLOW Well (WEL) Package
  - MODFLOW Recharge (RCH) Package

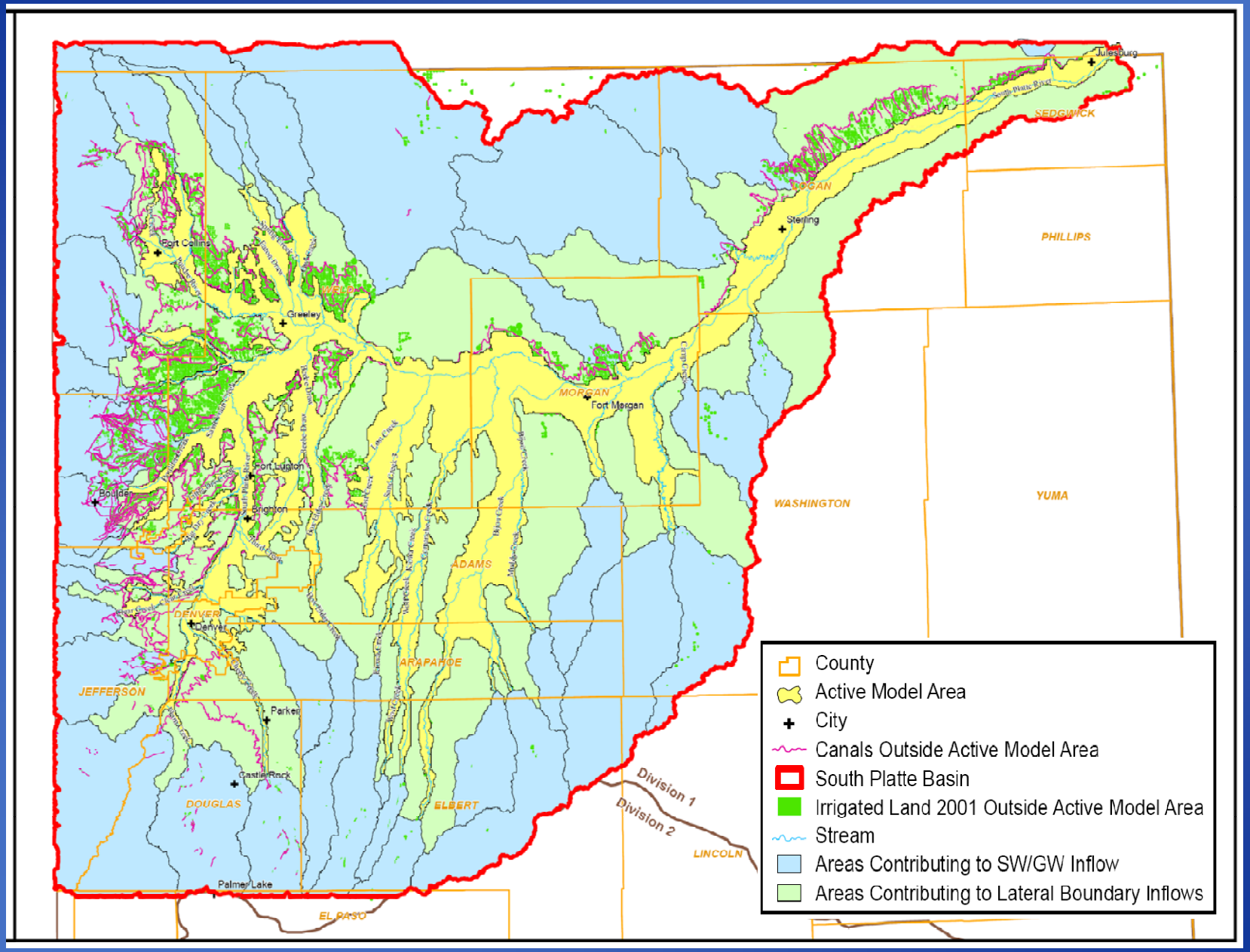
Augmentation Recharge Locations



Updated Pumping



Updated Lateral Boundary Inflows



Updated Streamflows and Diversions

- Switched from using 8-point cross-section to power function approach for stream stage-discharge relationships

To be consistent with StateCU updates:

- Updated surface water inflows based on disaggregation of diversions near inflow locations
- Updated diversions based on disaggregation of minor structures

Other PRC comments

- Re-evaluate changes in phreatophyte areas over time
- Re-evaluate use of an extinction depth larger than 15 ft for groundwater ET
- Look into use of diurnal fluctuations and examine USGS data from NE for ET estimates
- Include lined gravel pits and drains in model
- Include reservoir stage-area variations over time

Discussion on Model Process and Stress Inputs

Break

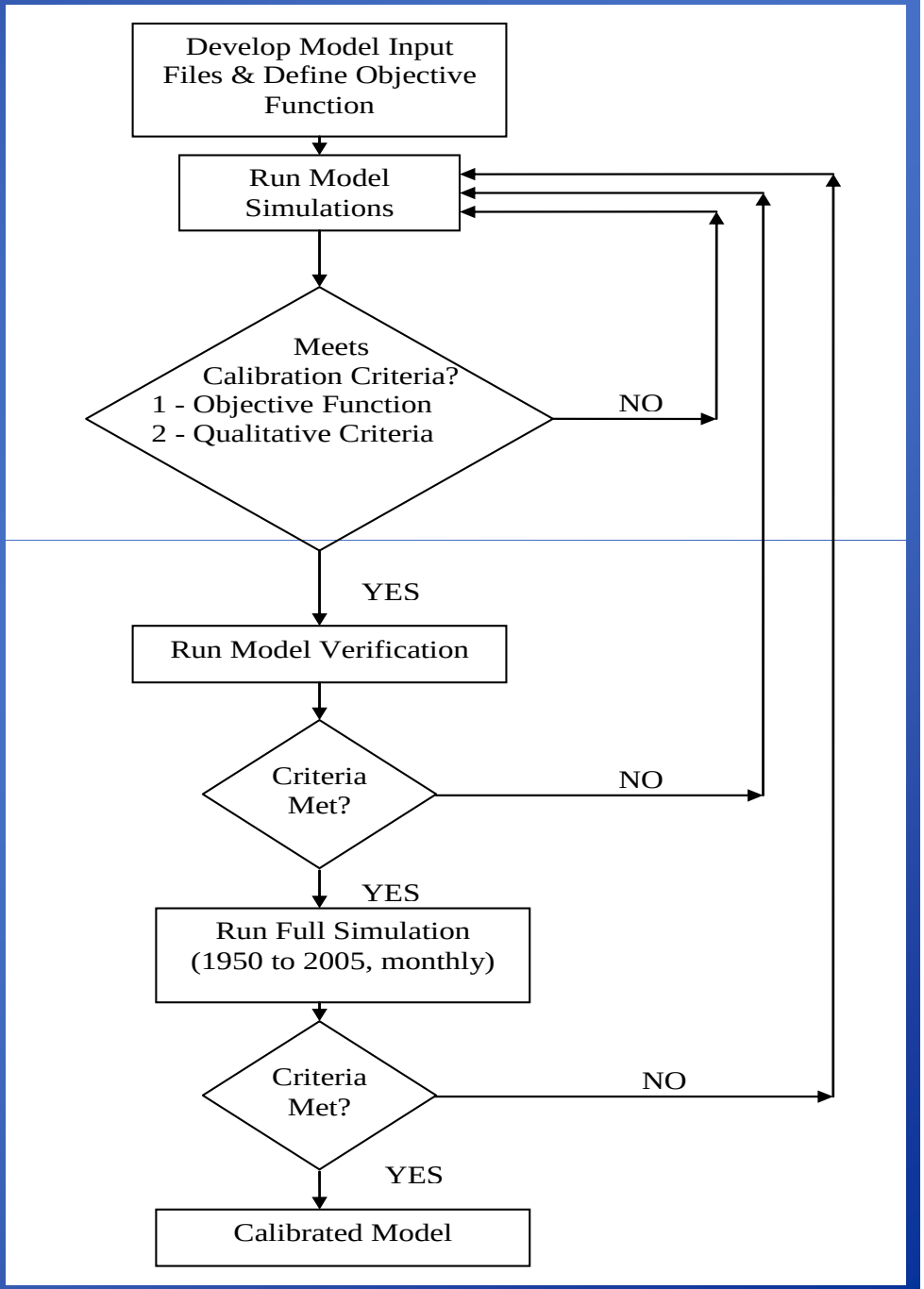
(10 Minutes)

Model Calibration – Overview

- Calibration Approach
- Selection of Calibration Periods
- Calibration Targets and Parameters
- Calibration Status

Calibration Approach

- Develop model input files
- Develop a stable model
- Develop Objective Function and Weighting Factors for PEST
- Run Steady-state & Transient models
- Evaluate Model Calibration



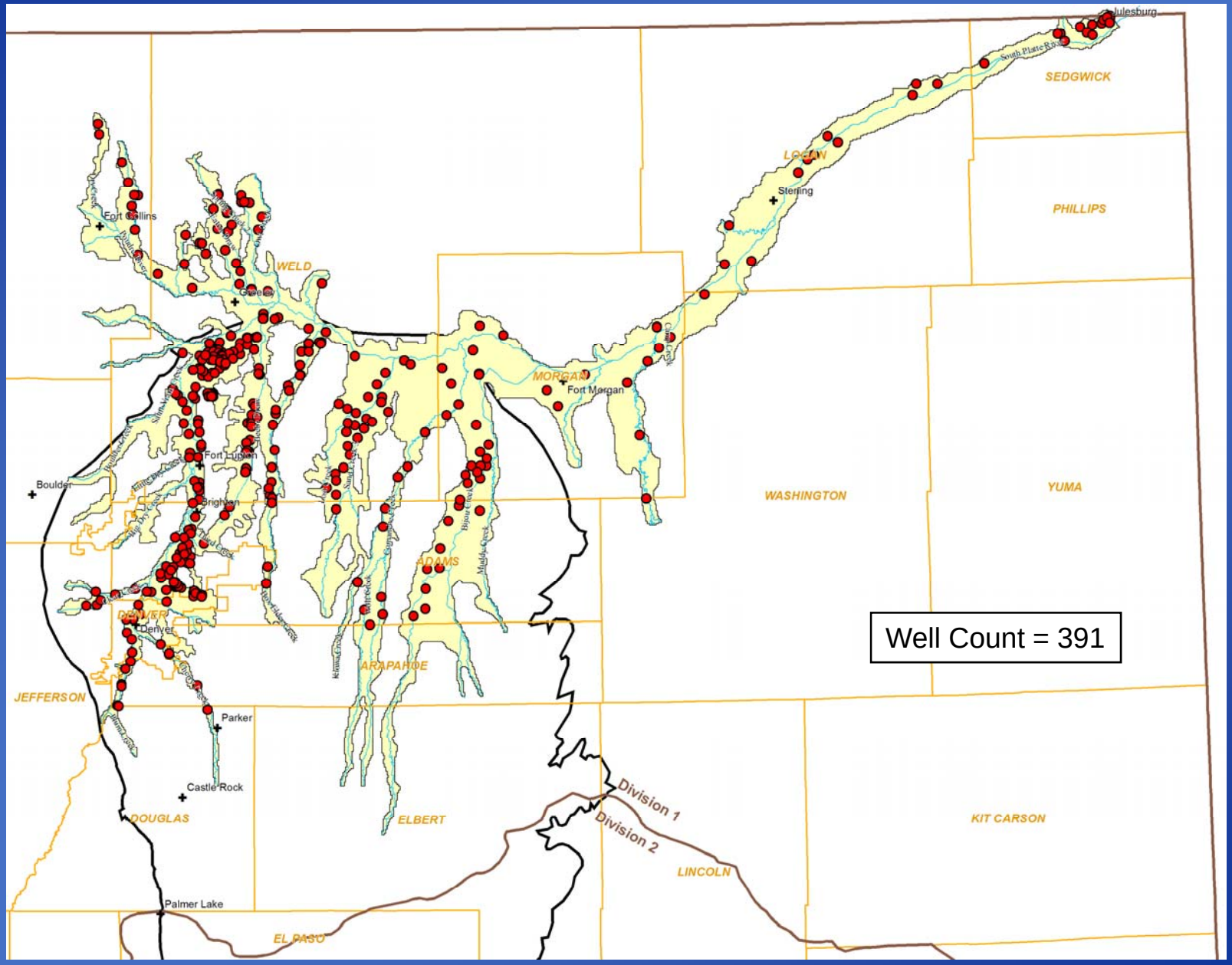
Model Calibration Periods

- Steady-state period (1991 - 1994)
  - Steady alluvial water table (min. change in storage)
  - Minimal change in number of wells (Q >50 gpm)
  - Total number of water level measurements
- Transient Calibration (1999 - 2005)
  - Climate variability
  - Total number of water level measurements
  - Seasonal water level data
- Validation Period (1950 - 2006)

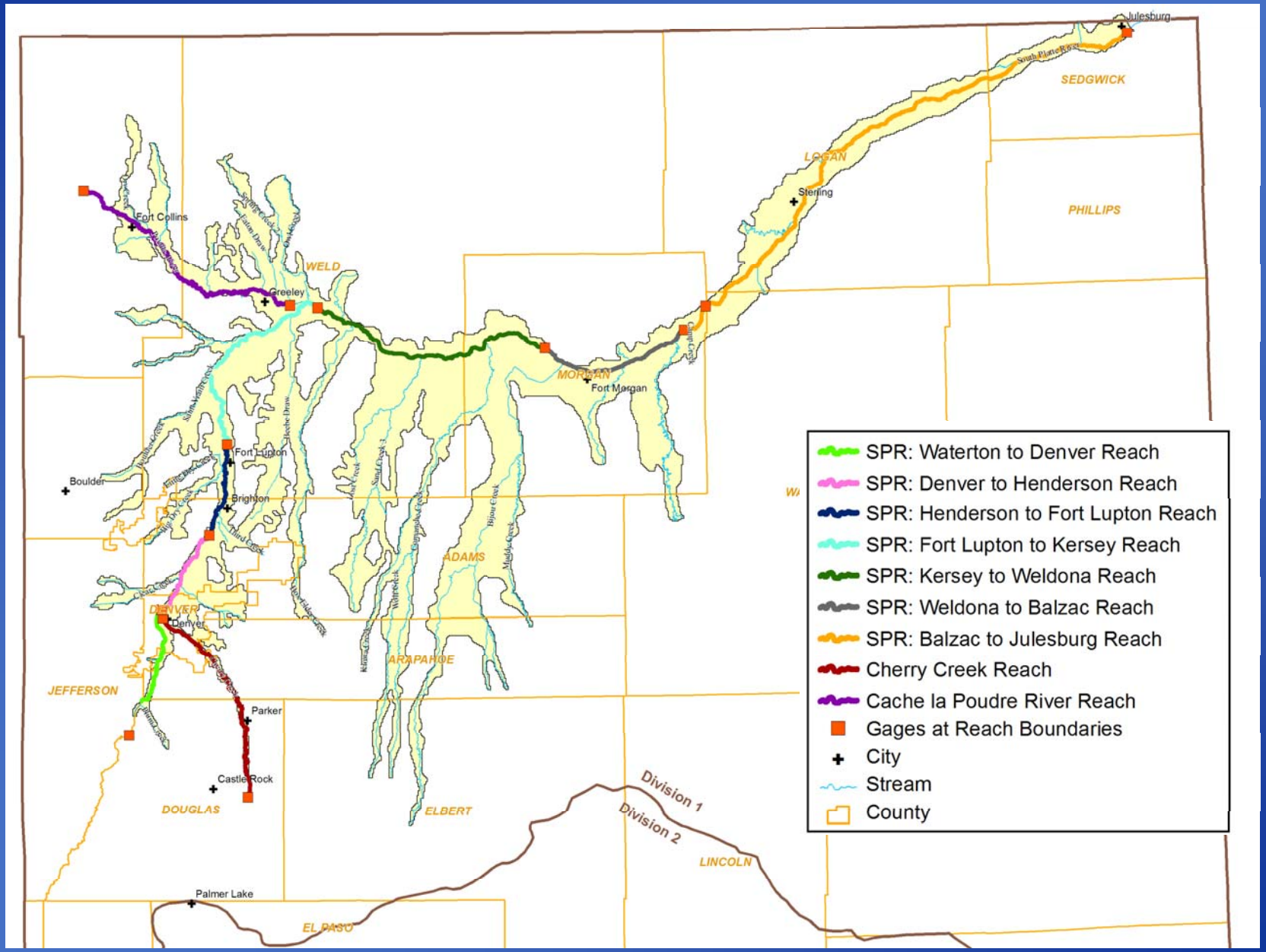
Calibration Targets

- Quantitative Targets (used in PEST)
  - Head (groundwater levels)
  - Streamflow
  - Stream gain/loss
- Other Targets
  - Diversion amounts
  - ET extent
  - Wet/dry cells
  - Water balance
  - General shape of water table surface

Steady-state Head Targets (1991-1994)



Streamflow Locations & Gain/Loss Reaches



Calibration Parameters

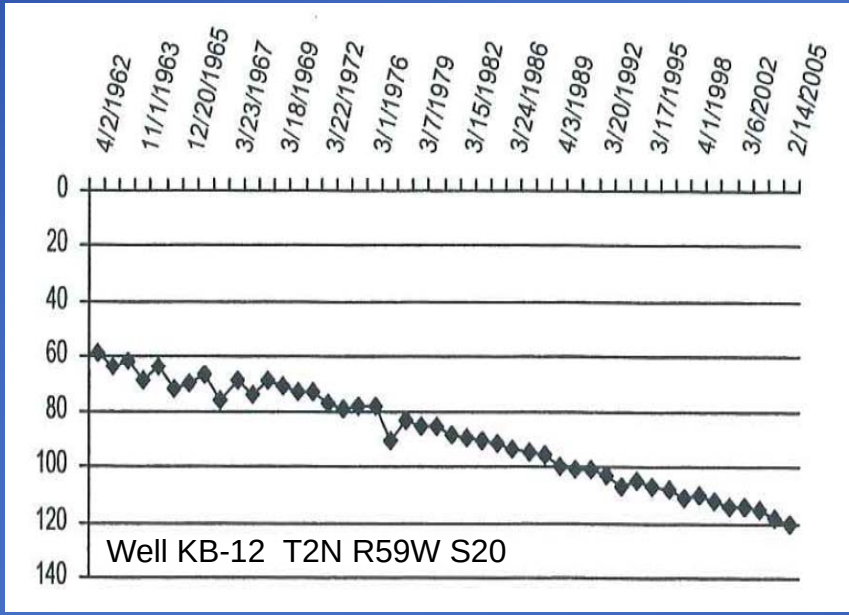
- Aquifer Hydraulic conductivity (K)
- Streambed conductance
- Recharge
- Well pumping
- Lateral boundary inflows
- Specific yield (Sy)

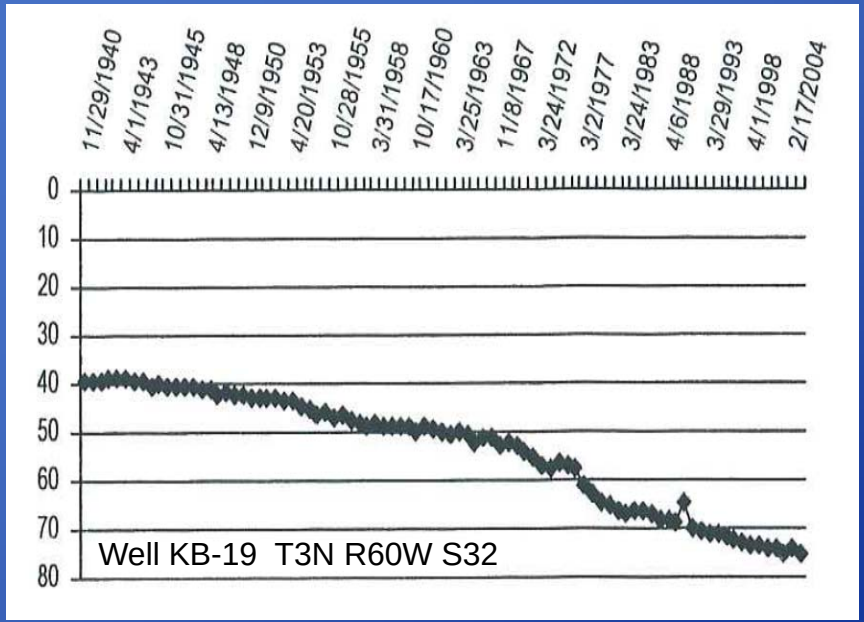
Steady-State Model Calibration Status

- Steady-state model goals:
  - Used to develop starting water levels for transient model
  - Conduct initial sensitivity analysis on calibration parameters
- Steady-state model status:
  - Steady-state model has run successfully
  - Includes areas with flooded and dry cells

Steady-State Model Issues

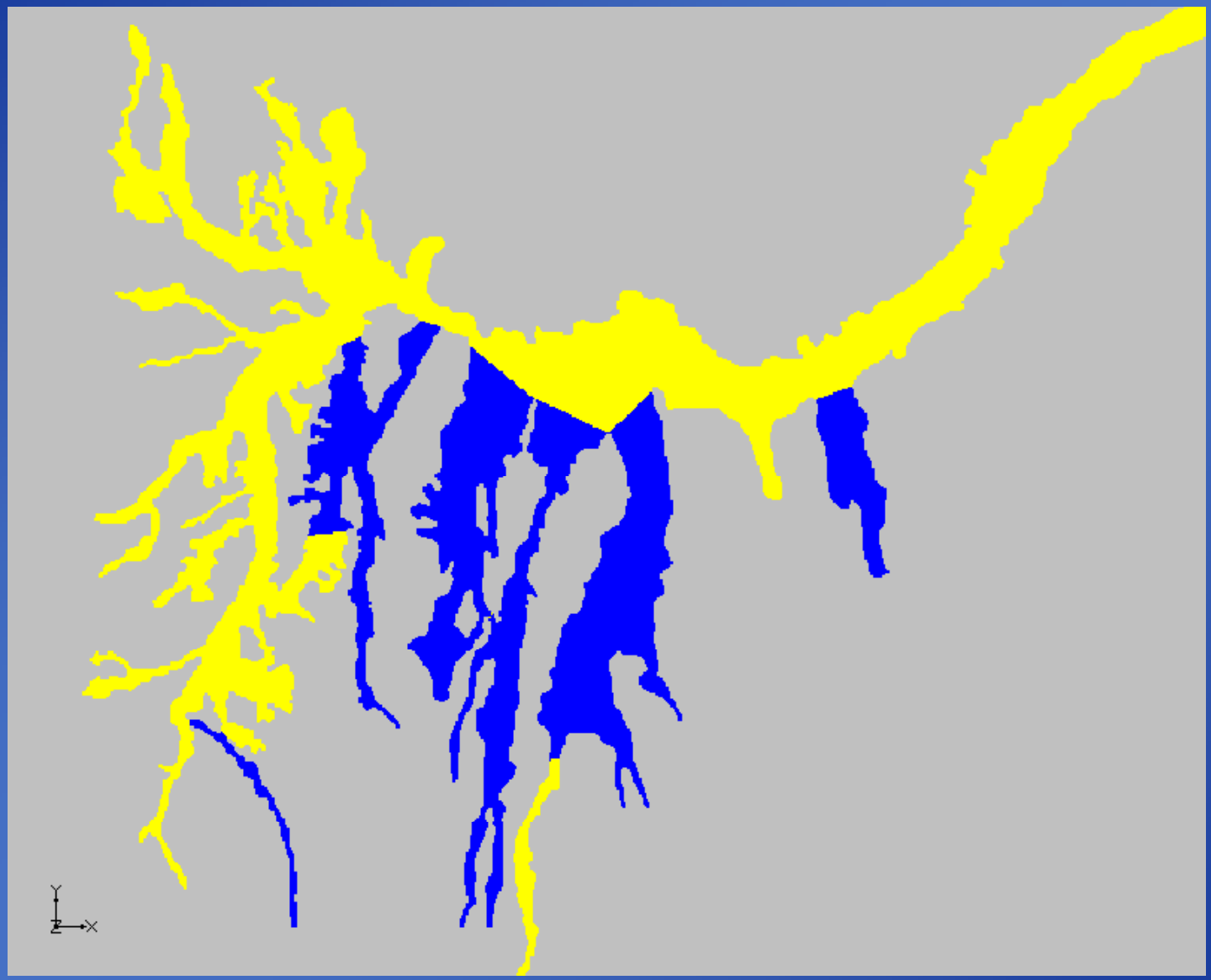
- Certain model areas appear to be in overdraft conditions
- Additional flux needed to offset observed water declines
- Is not an issue for transient modeling





Example hydrographs showing overdraft issue; in Kiowa-Bijou Basin

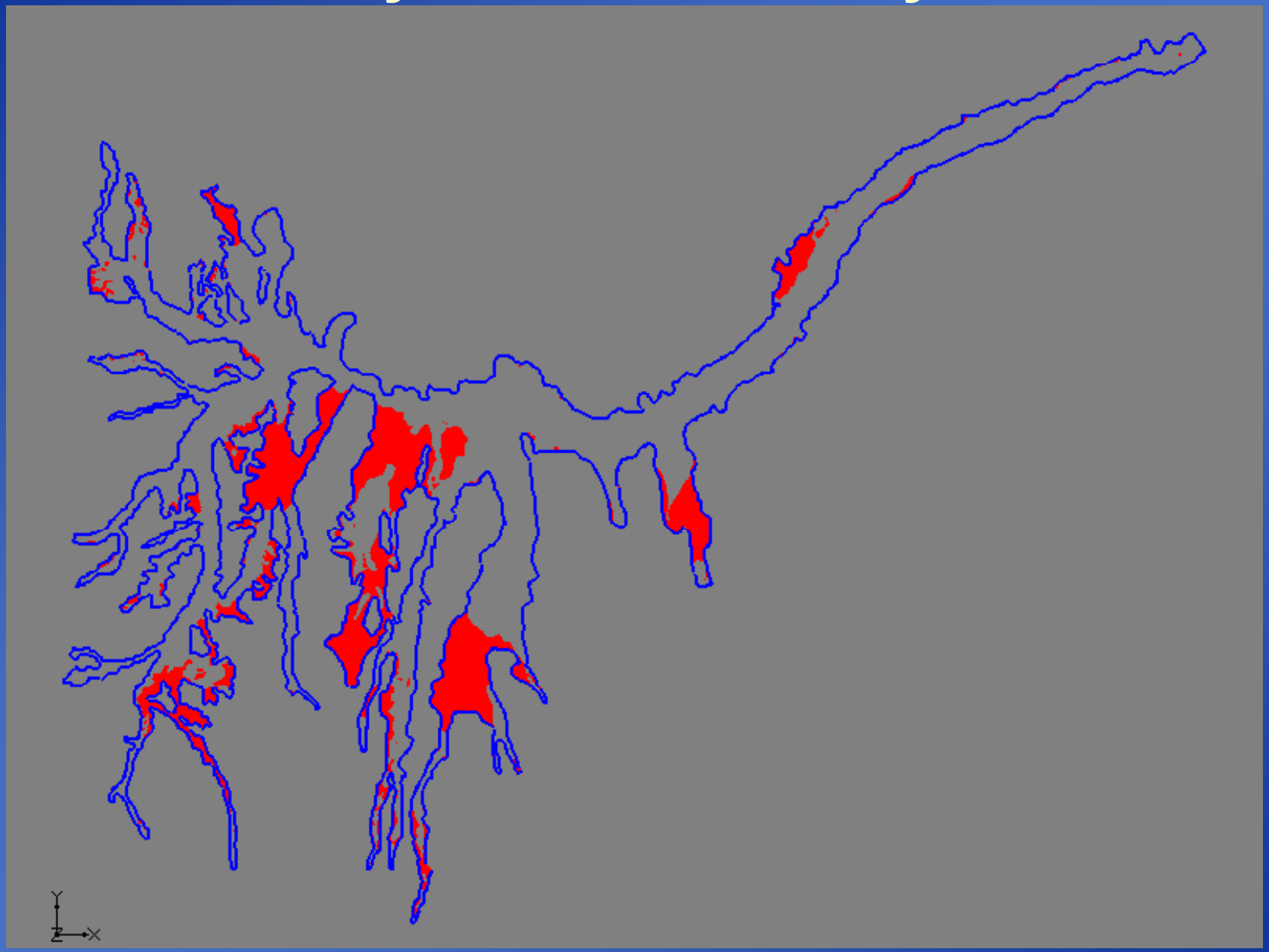
Model Areas Currently with Overdraft Issues



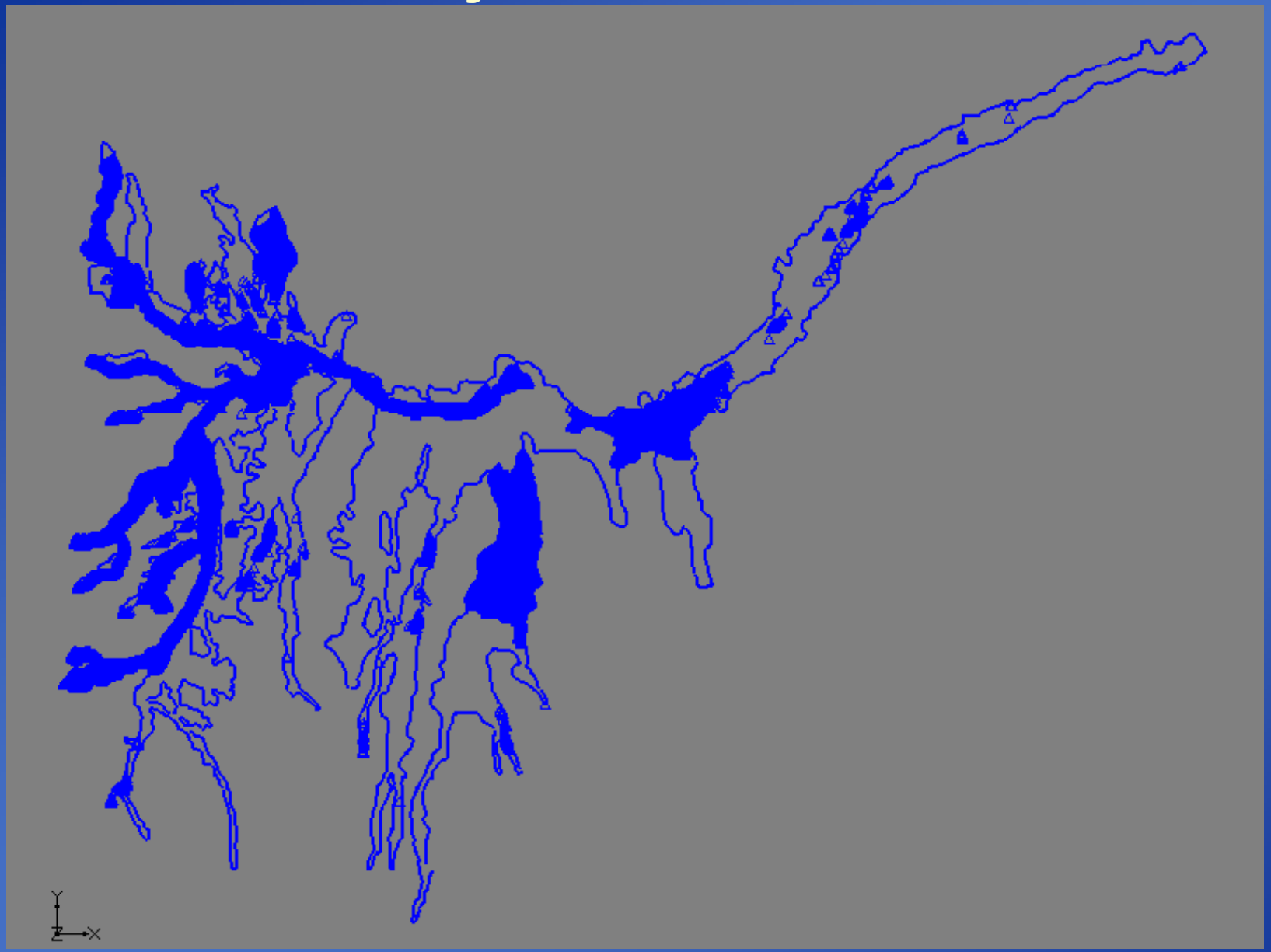
Preliminary Steady-State Water Budget

Steady-State GroundWater Balance (1991-1994) All values in af/yr				
Inflows		MODFLOW package used to simulate flux	Simulated Flux** (af/yr)	Percent of Total
	Precipitation - based Recharge	RCH	69,800	5.1%
	Irrigation/Canal Recharge	RCH	1,038,000	76.4%
	Bedrock Aquifer Flux	WEL	19,400	1.4%
	Lateral Boundary Inflow	WEL	18,800	1.4%
	Alluvial Underflow	WEL	27,700	2.0%
	Reservoir Leakage	RCH	31,300	2.3%
	Change in Storage - Additional Recharge	RCH	66,900	4.9%
	Leakage to Streams	SFR2	86,400	6.4%
	Total		***1,358,300***	
Outflow				
	Ag Pumping	WEL	462,200	33.7%
	M&I Pumping	WEL	54,200	4.0%
	Recharge and Augmentation Pumping	WEL	4,400	0.3%
	Bedrock Aquifer Flux	WEL	5,500	0.4%
	Alluvial Underflow	GHB	9,200	0.7%
	Evapotranspiration & Subirrigation	ETS	246,300	18.0%
	Discharge to Streams	SFR2	588,500	42.9%
	Total		***1,370,300***	
	Net			
Note: Head-dependant simulated fluxes (GHB, ETS, SFR2) are not reliable until model is calibrated				

Preliminary SS Results - Dry Cells



Preliminary SS Results - Flooded Cells



Preliminary SS Results - Water Table

Discussion of Steady-State Model

- Feedback on Task 48.2 Model Calibration TM
- Feedback on preliminary steady-state modeling

Upcoming Modeling Activities

- Complete Steady-State Calibration
- Undertake Transient Calibration
- Perform Model Validation Simulation
- Run Model Simulations
- Develop Modeling Report (Task 48)

Addition Documentation

- Technical Memoranda
  - Municipal & Industrial Pumping (Task 41.3)
  - Aquifer Configuration (Task 42.3)
  - Aquifer Properties (Task 43.3)
  - Water Levels (Task 44.3)
  - Stream Gain/Loss (Task 46.2)
  - Calibration Targets & Approach (Task 48.2)
  - Historic Consumptive Use (LRE, 2008)
- Available via CDSS website
  - cdss.state.co.us

Meeting Summary

- Model Stress Input Updates
  - Updated Recharge and Ag Pumping from StateCU
  - Added Augmentation Wells and Recharge Areas
  - Updated Lateral Boundary Inflows
  - Updated M&I Pumping and Stream Inflows
- Discussion of Calibration Approach
- Steady-State Calibration Status

Closing Remarks/Action Items

For Further Information and Comment:

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