texas water development board

AGENDA
STAKEHOLDER ADVISORY FORUM
SAF Meeting April 5, 2004

- **Review of previous SAF meeting**
- **Results of model parameter adjustment**
  - **—Steady State (Predevelopment)**
  - **—Transient (1998)**
- **Steps in model parameter adjustment**
  - **—Base of aquifer**
  - **—Recharge**
  - **—Drain and GHB boundary conditions**

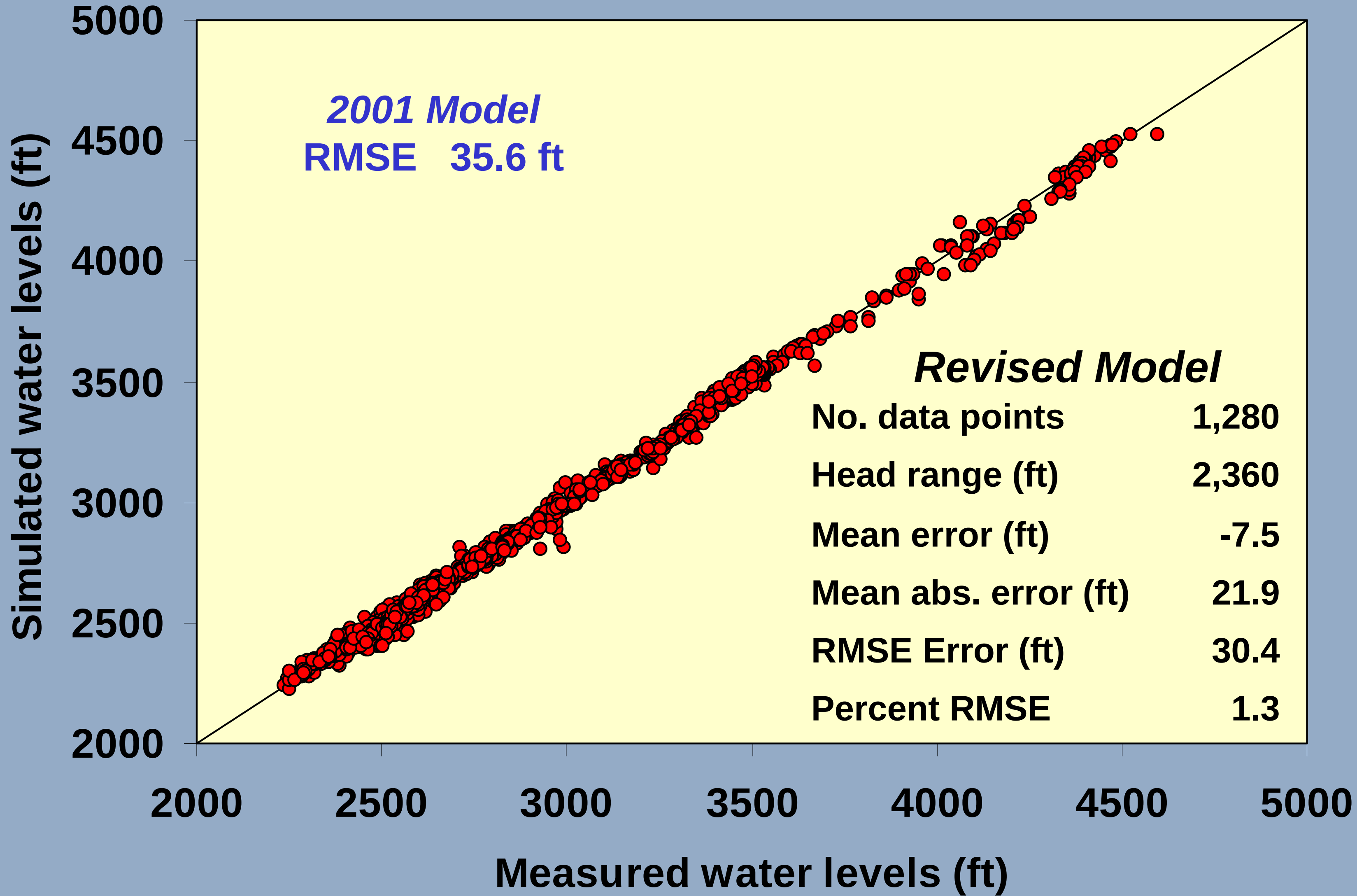
STATUS:
NORTHERN OGALLALA AQUIFER GAM MODEL (Og-n)

- **Developed in December 2000 as part of the process for developing the Panhandle Water Plan for 2000-2050**
- **Revised in December 2001**
  - **Report was revised and additional modeling runs were made to match the style and content of GAM models**
  - **Added more features to improve model calibration**
  - **GAM model for the northern Ogallala aquifer**
- **Additional parameter adjustment during 2004**
  - **Part of process for updating the water plan for 2005-2060**
  - **Goal to improve model calibration in Roberts County area**
  - **Opportunity to revisit calibration regionally**

REVIEW OF PREVIOUS SAF MEETING
(December 18, 2003)

- **Role of GAM models and the SAF**
- **History of the Ogallala aquifer GAM model (Og-n)**
- **Groundwater modeling overview**
- **Method of assigning input for Ogallala aquifer model**
  - **Recharge rate**
  - **Allocation of pumping**
- **Request for supplemental data, for example:**
  - **Base of Ogallala aquifer (records from wells)**
  - **Information on new production wells**
  - **New aquifer test data**
  - **Water-quality analyses**

STEADY STATE CALIBRATION



STEADY STATE RECALIBRATION

			2001 Model		Revised	
COUNTY	No.	Range	RMSE (ft)	RMSE %	RMSE (ft)	RMSE %
Armstrong	37	505	46.0	9.1%	22.4	4.4%
Carson	79	413	50.6	12.2%	20.2	4.9%
Collingsworth	3	66	45.0	68.4%	6.0	9.1%
Dallam	74	1037	47.9	4.6%	49.9	4.8%
Donley	116	727	37.4	5.1%	36.8	5.1%
Gray	117	458	27.2	5.9%	23.4	5.1%
Hansford	89	492	19.7	4.0%	20.1	4.1%
Hartley	58	840	36.0	4.3%	36.2	4.3%
Hemphill	90	385	29.0	7.5%	28.8	7.5%
Hutchinson	57	469	33.5	7.1%	24.3	5.2%
Lipscomb	45	369	24.9	6.7%	24.9	6.7%
Moore	91	404	25.6	6.3%	24.9	6.2%
Ochiltree	49	254	18.3	7.2%	18.4	7.2%
Potter	6	305	50.6	16.6%	26.8	8.8%
Randall	25	189	43.4	23.0%	18.0	9.5%
Roberts	47	480	25.7	5.4%	22.3	4.7%
Sherman	89	365	41.2	11.3%	34.9	9.6%
Wheeler	208	413	39.4	9.5%	35.1	8.5%
Net mean error (ft)			0.1		-7.5	
Net mean absolute error (ft)			27.2		21.9	
Net RMSE		2360	35.6	1.5%	30.4	1.3%

STEADY STATE RECALIBRATION

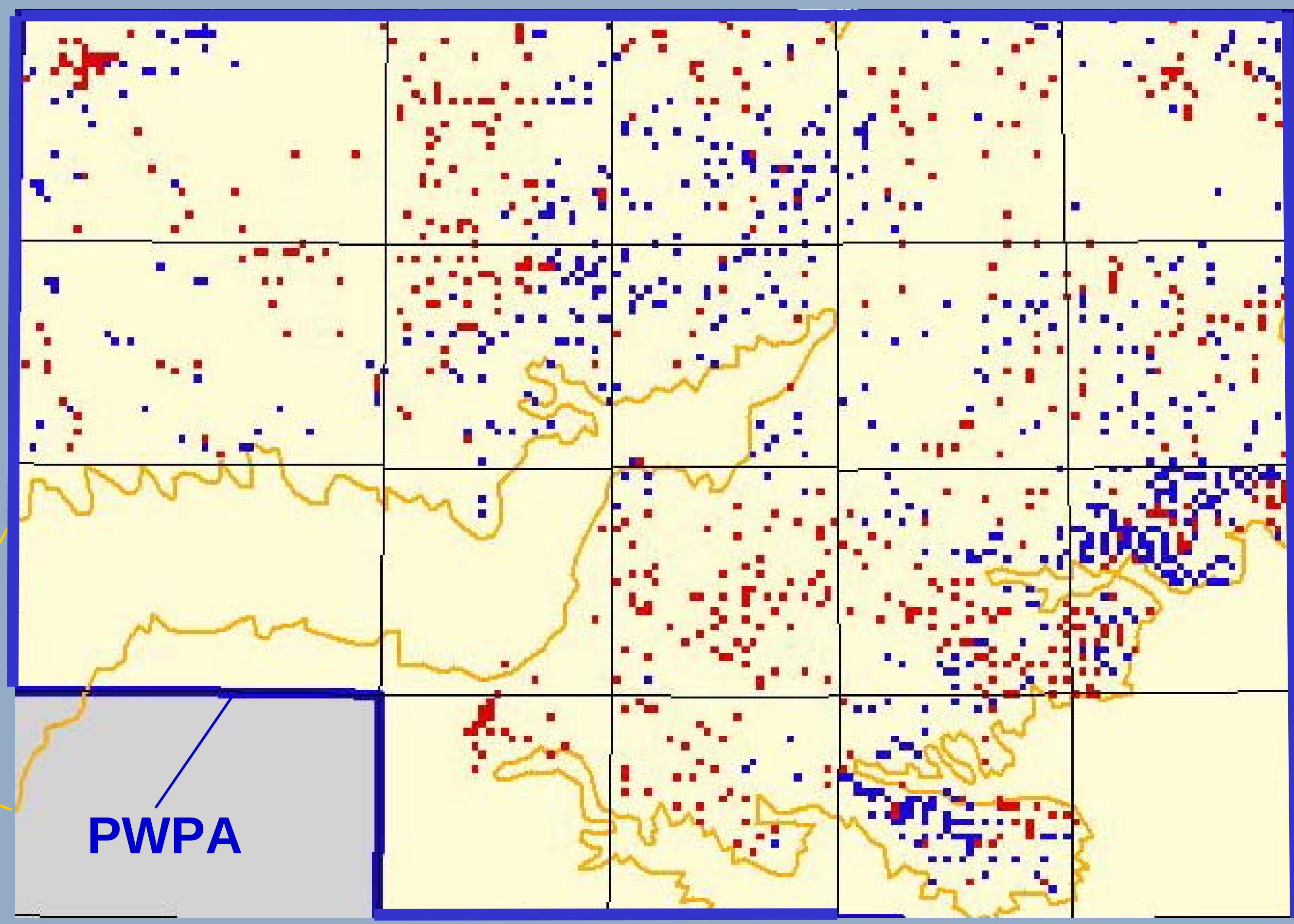
COUNTY	No.	Range	2001 Model RMSE (ft)	2001 Model RMSE %	Revised RMSE (ft)	Revised RMSE %
Armstrong	**37**	**505**	46.0	**9.1%**	22.4	**4.4%**
Carson	**79**	**413**	50.6	**12.2%**	20.2	**4.9%**
Collingsworth	**3**	**66**	45.0	**68.4%**	6.0	**9.1%**
Dallam	**74**	**1037**	47.9	**4.6%**	49.9	**4.8%**
Donley	**116**	**727**	37.4	**5.1%**	36.8	**5.1%**
Gray	**117**	**458**	27.2	**5.9%**	23.4	**5.1%**
Hansford	**89**	**492**	19.7	**4.0%**	20.1	**4.1%**
Hartley	**58**	**840**	36.0	**4.3%**	36.2	**4.3%**
Hemphill	**90**	**385**	29.0	**7.5%**	28.8	**7.5%**
Hutchinson	**57**	**469**	33.5	**7.1%**	24.3	**5.2%**
Lipscomb	**45**	**369**	24.9	**6.7%**	24.9	**6.7%**
Moore	**91**	**404**	25.6	**6.3%**	24.9	**6.2%**
Ochiltree	**49**	**254**	18.3	**7.2%**	18.4	**7.2%**
Potter	**6**	**305**	50.6	**16.6%**	26.8	**8.8%**
Randall	**25**	**189**	43.4	**23.0%**	18.0	**9.5%**
Roberts	**47**	**480**	25.7	**5.4%**	22.3	**4.7%**
Sherman	**89**	**365**	41.2	**11.3%**	34.9	**9.6%**
Wheeler	**208**	**413**	39.4	**9.5%**	35.1	**8.5%**
Net mean error (ft)			**0.1**		**-7.5**	
Net mean absolute error (ft)			**27.2**		**21.9**	
Net RMSE		**2360**	**35.6**	**1.5%**	**30.4**	**1.3%**

Appreciable reduction (green-highlighted rows)

CALIBRATION RESIDUALS

2001 Model -- Steady State

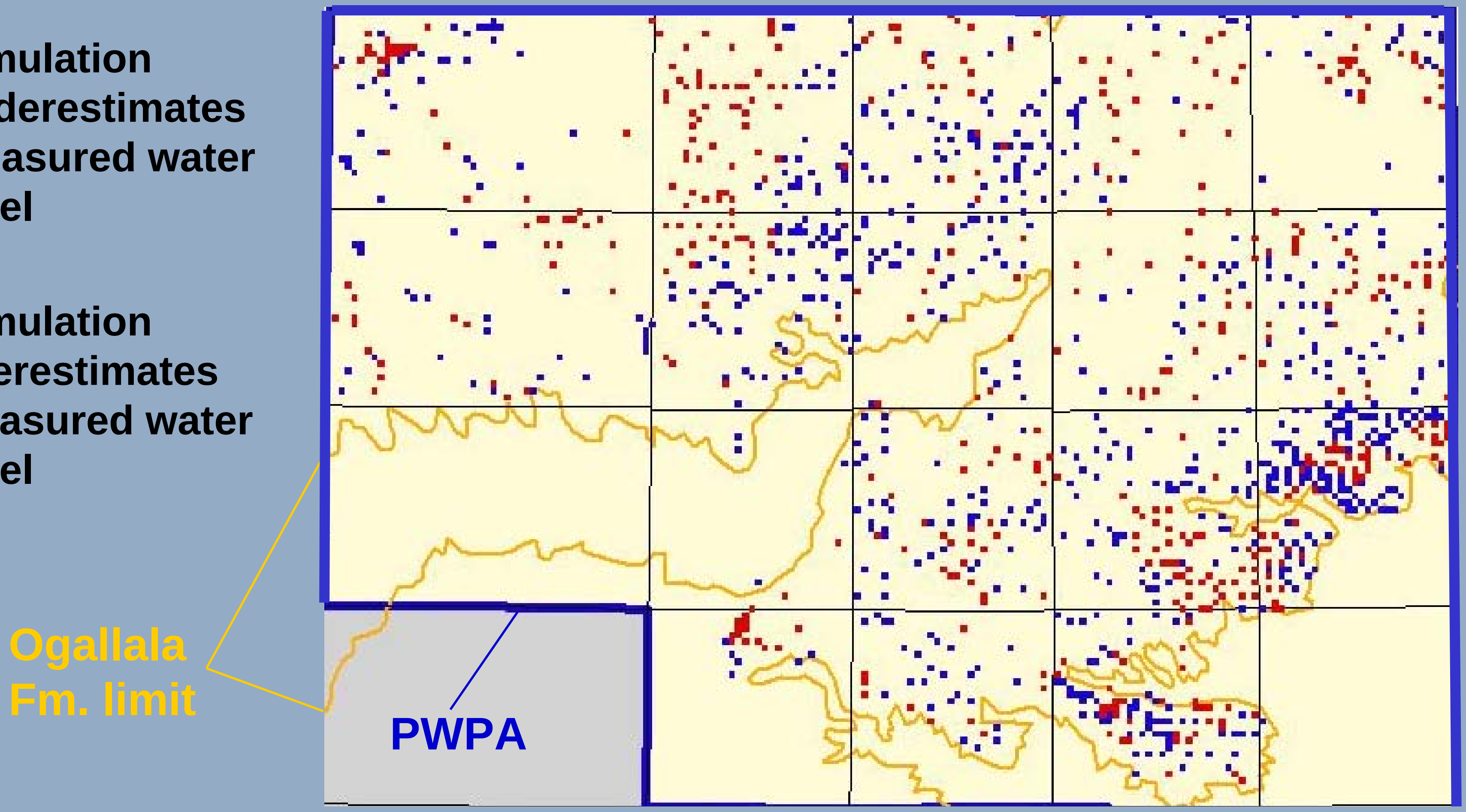
- **Simulation underestimates measured water level** (blue)
- **Simulation overestimates measured water level** (red)



Ogallala Fm. limit

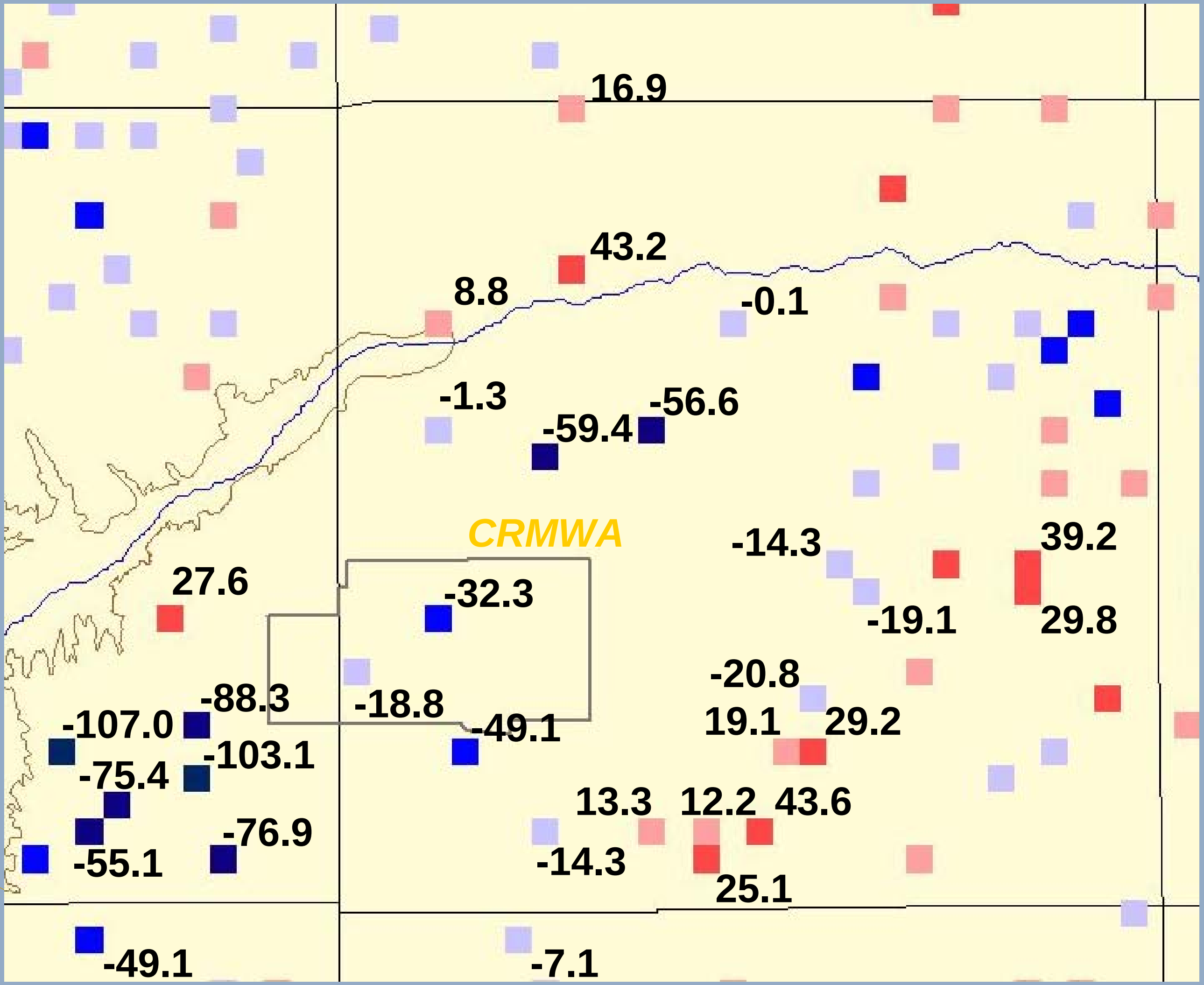
CALIBRATION RESIDUALS
Revised Model -- Steady State

- **Simulation underestimates measured water level**
- **Simulation overestimates Measured water level**



CALIBRATION RESIDUALS
2001 Model -- Steady State

- **Simulation underestimates measured water level (25 ft intervals)**
- **Simulation overestimates Measured water level (25 ft intervals)**

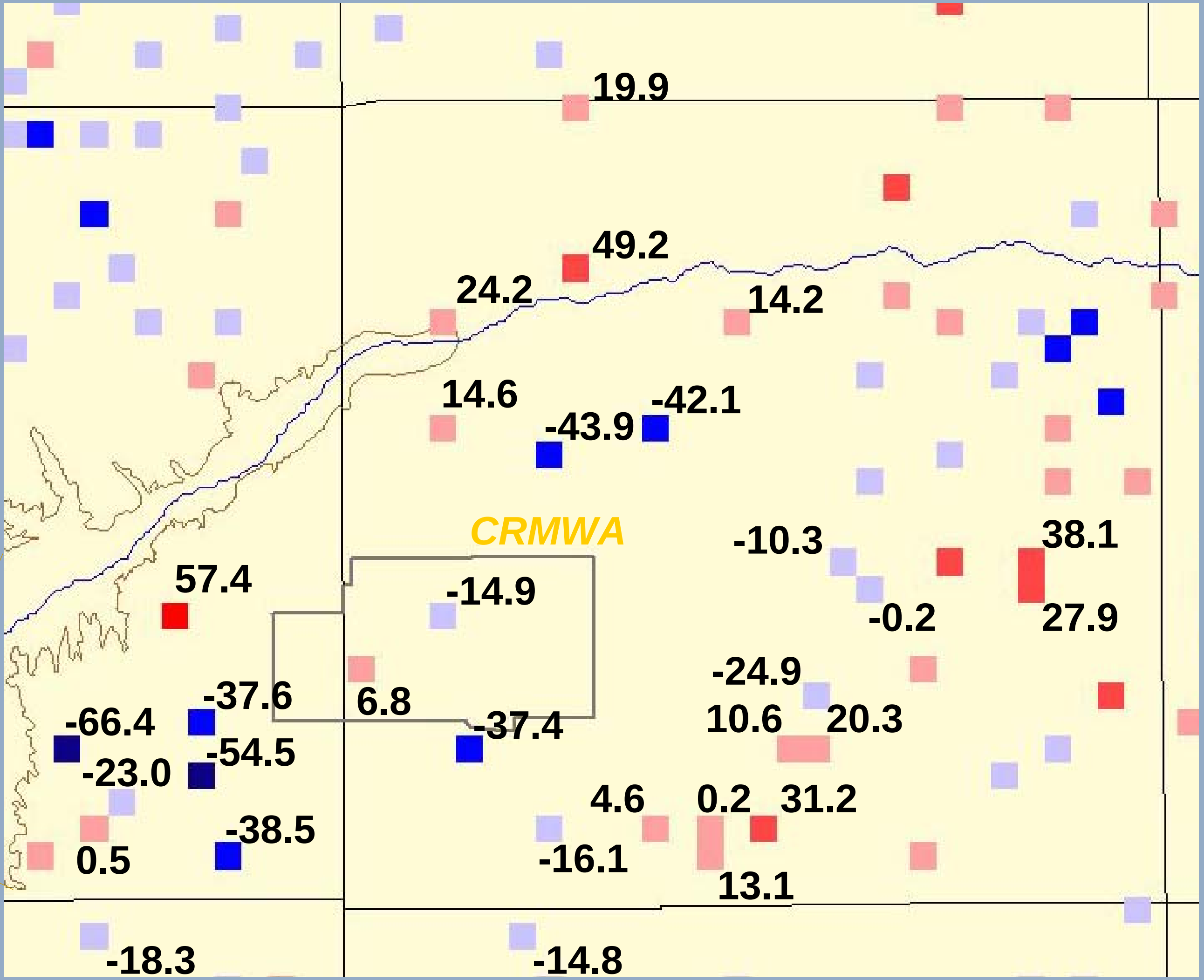


Ogallala Fm. limit

Residual (ft) = Simulated minus observed

CALIBRATION RESIDUALS
Revised Model -- Steady State

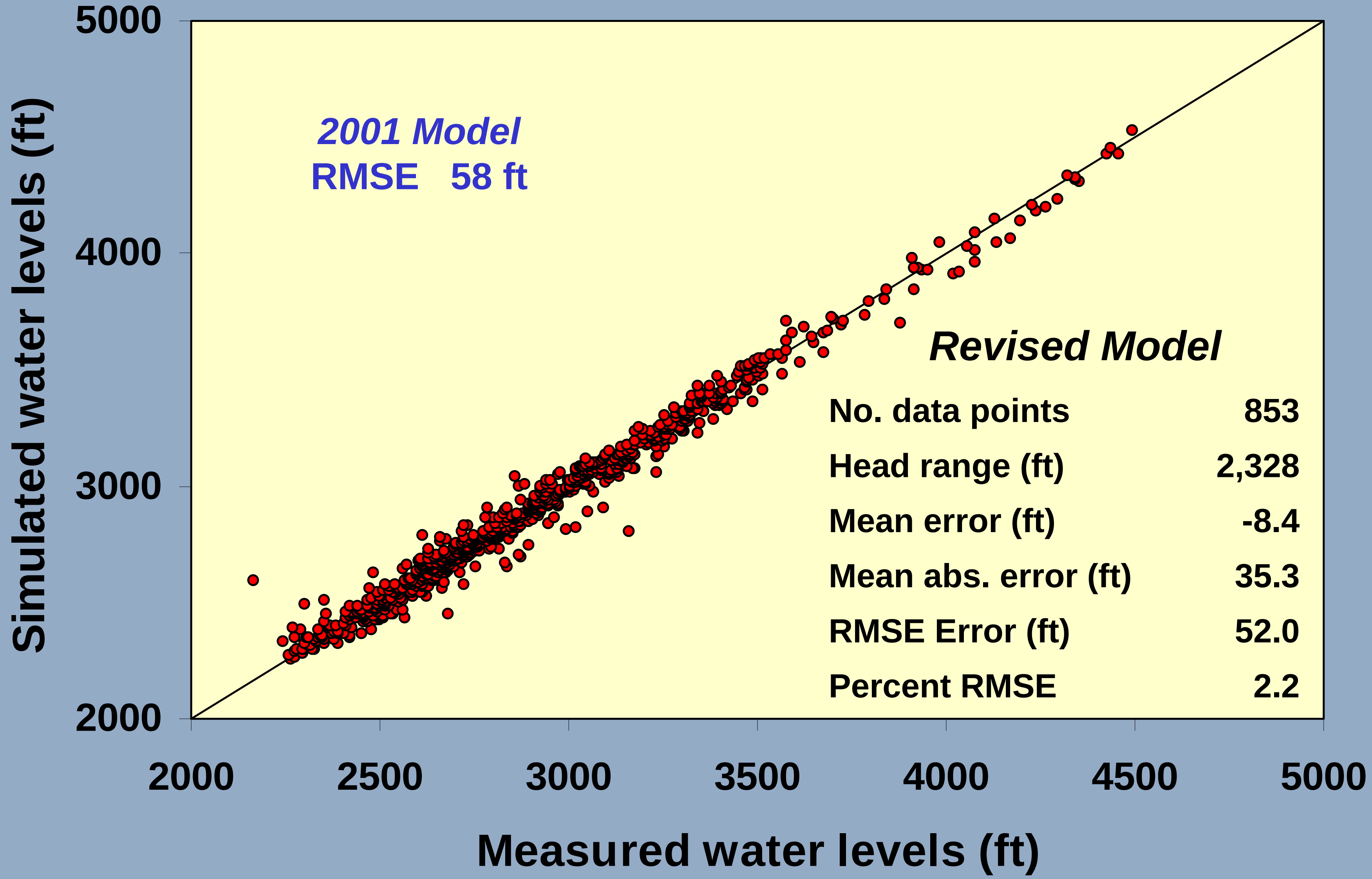
- Simulation underestimates measured water level (25 ft intervals)
- Simulation overestimates Measured water level (25 ft intervals)



Ogallala Fm. limit

Residual (ft) = Simulated minus observed

TRANSIENT CALIBRATION



TRANSIENT RECALIBRATION

COUNTY	2001 Model Range	2001 Model RMSE (ft)	2001 Model RMSE %	Revised Range	Revised RMSE (ft)	Revised RMSE %
Armstrong	558	61.5	11.0%	492	26.1	5.3%
Carson	629	63.5	10.1%	421	28.4	6.7%
Dallam	962	47.3	4.9%	998	61.7	6.2%
Donley	585	63.7	10.9%	701	54.8	7.8%
Gray	468	49.3	10.5%	467	30.8	6.6%
Hansford	465	62.0	13.3%	622	67.7	10.9%
Hartley	676	44.1	6.5%	669	36.6	5.5%
Hemphill	298	39.1	13.1%	420	50.1	11.9%
Hutchinson	437	40.2	9.2%	496	48	9.7%
Lipscomb	382	54.7	14.3%	423	68.1	16.1%
Moore	484	52.7	10.9%	461	61.3	13.3%
Ochiltree	966	87.2	9.0%	671	88.5	13.2%
Potter	254	51.2	20.1%	378	19.4	5.1%
Randall	228	76.6	33.6%	179	30.9	17.3%
Roberts	425	50.8	12.0%	752	45.1	6.0%
Sherman	415	65.7	15.8%	367	39.7	10.8%
Wheeler	292	39.0	13.3%	425	39.1	9.2%
Net mean error (ft)		16.3			-8.4	
Net mean absolute error (ft)		50.12			35.3	
Net RMSE	2191	58.8	2.7%	2328	52.0	2.2%

RMSE% <10% (highlighted in green)

MODEL PARAMETER ADJUSTMENT

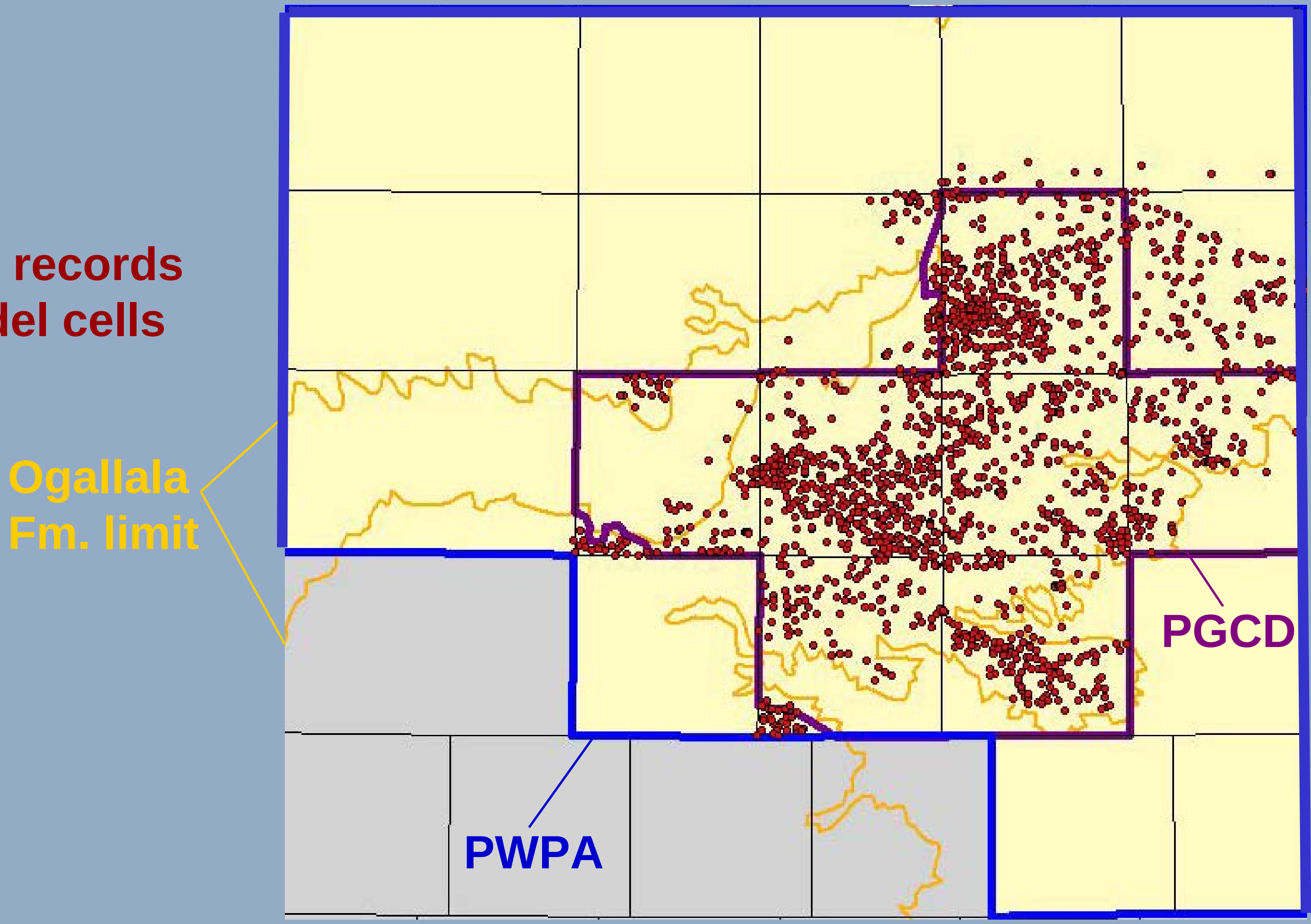
Summary

- **Base of Ogallala aquifer (top of “Red Beds”)**
  - **Merge new estimates of top of “Red Beds” with Dec. 2001 model “base of aquifer”**
- **Recharge rate**
  - **Adjust recharge regionally on the basis of soil permeability maps**
- **Model boundary**
  - **Adjust parameters used to control discharge of groundwater around edge of High Plains**

BASE OF AQUIFER

ADDITIONAL DATA ON ELEVATION OF TOP OF "RED BEDS"

- 1529 well records
- 1263 model cells

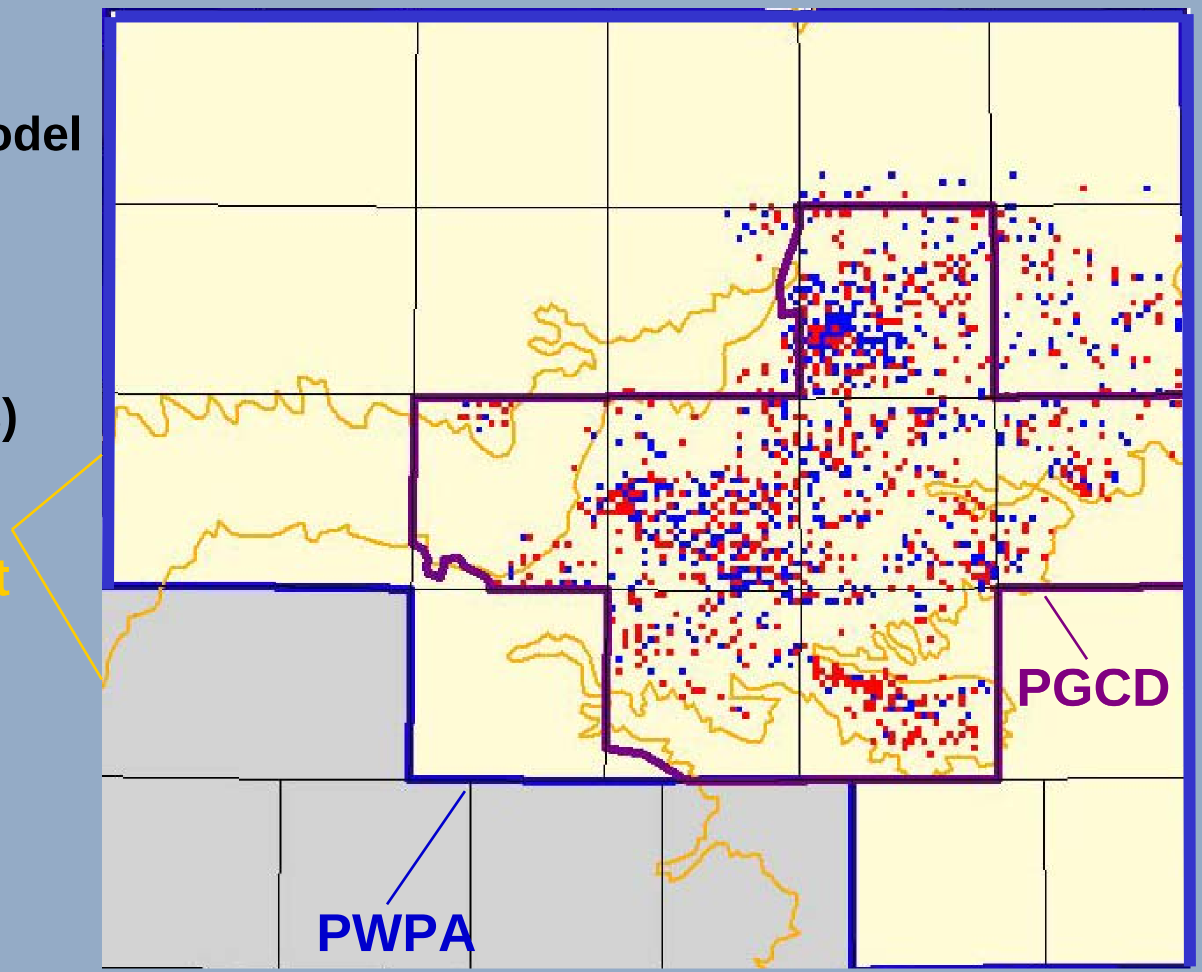


Data courtesy of R. Brady

BASE OF AQUIFER COMPARISON

New Data vs. Old Model

- New estimates lower than in model (549 cells)
- New estimates higher than in model (714 cells)



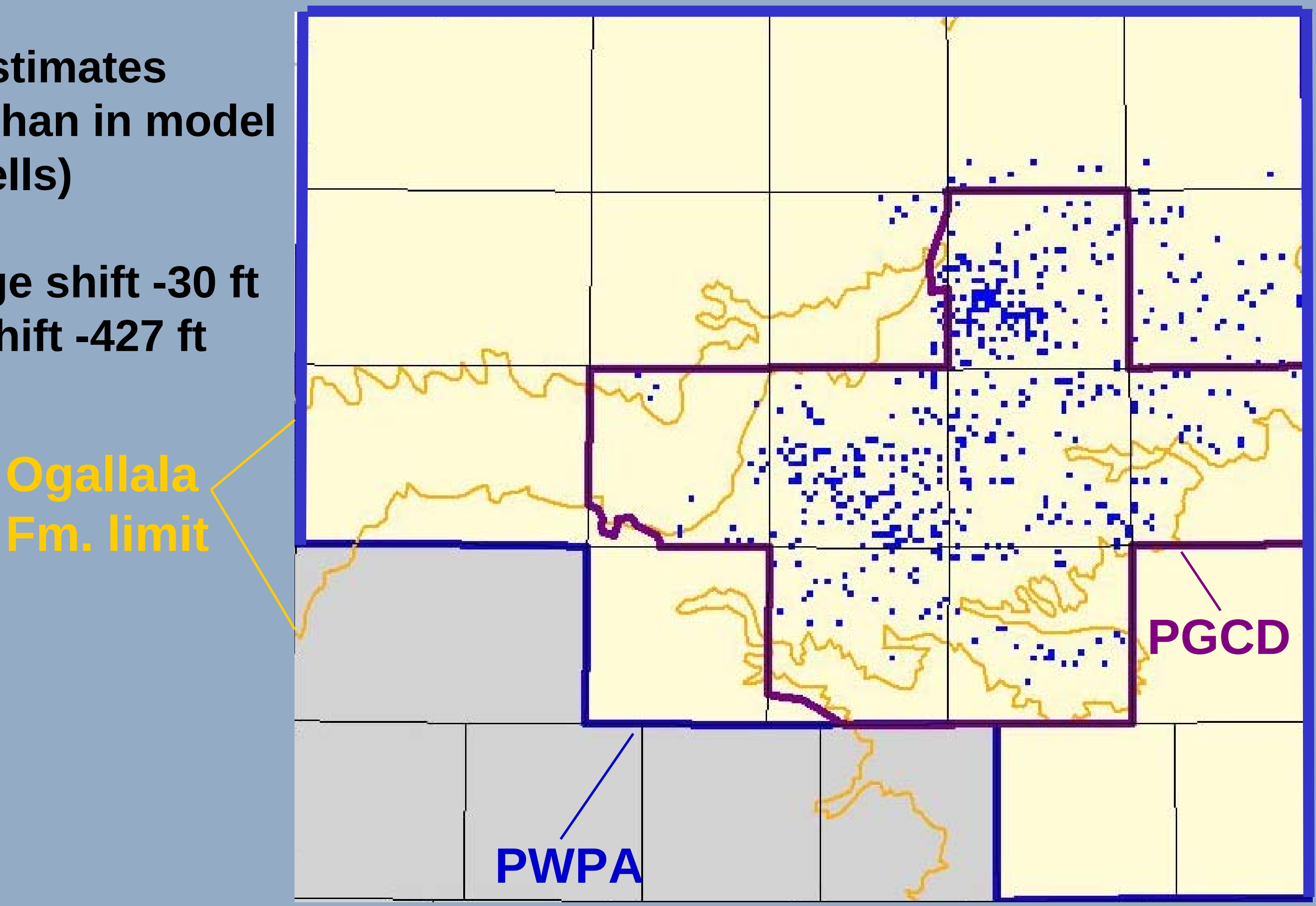
Data courtesy of R. Brady

BASE OF AQUIFER COMPARISON

New Data vs. Old Model

■ **New estimates lower than in model (549 cells)**

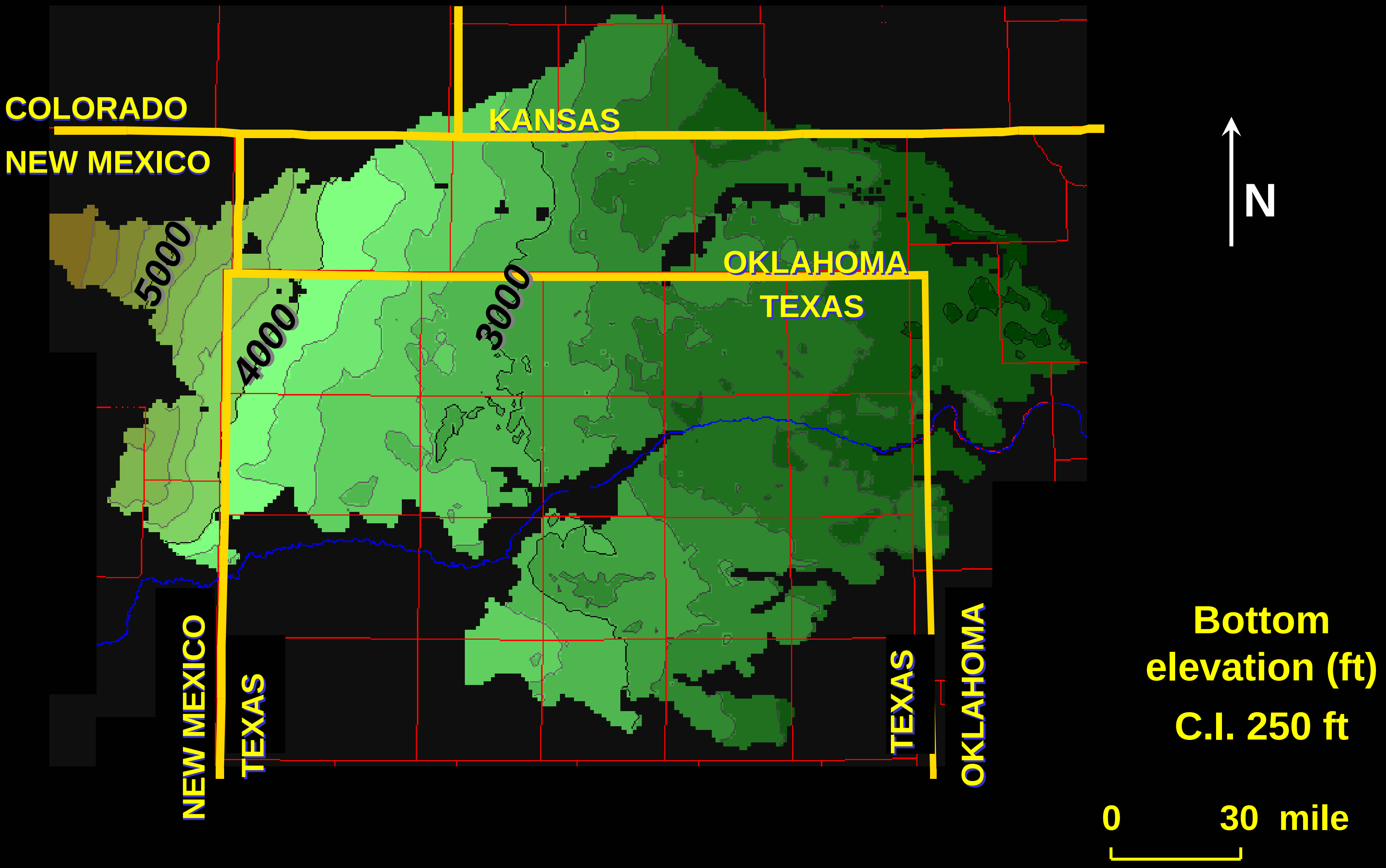
Average shift -30 ft
Max. shift -427 ft



Data courtesy of R. Brady

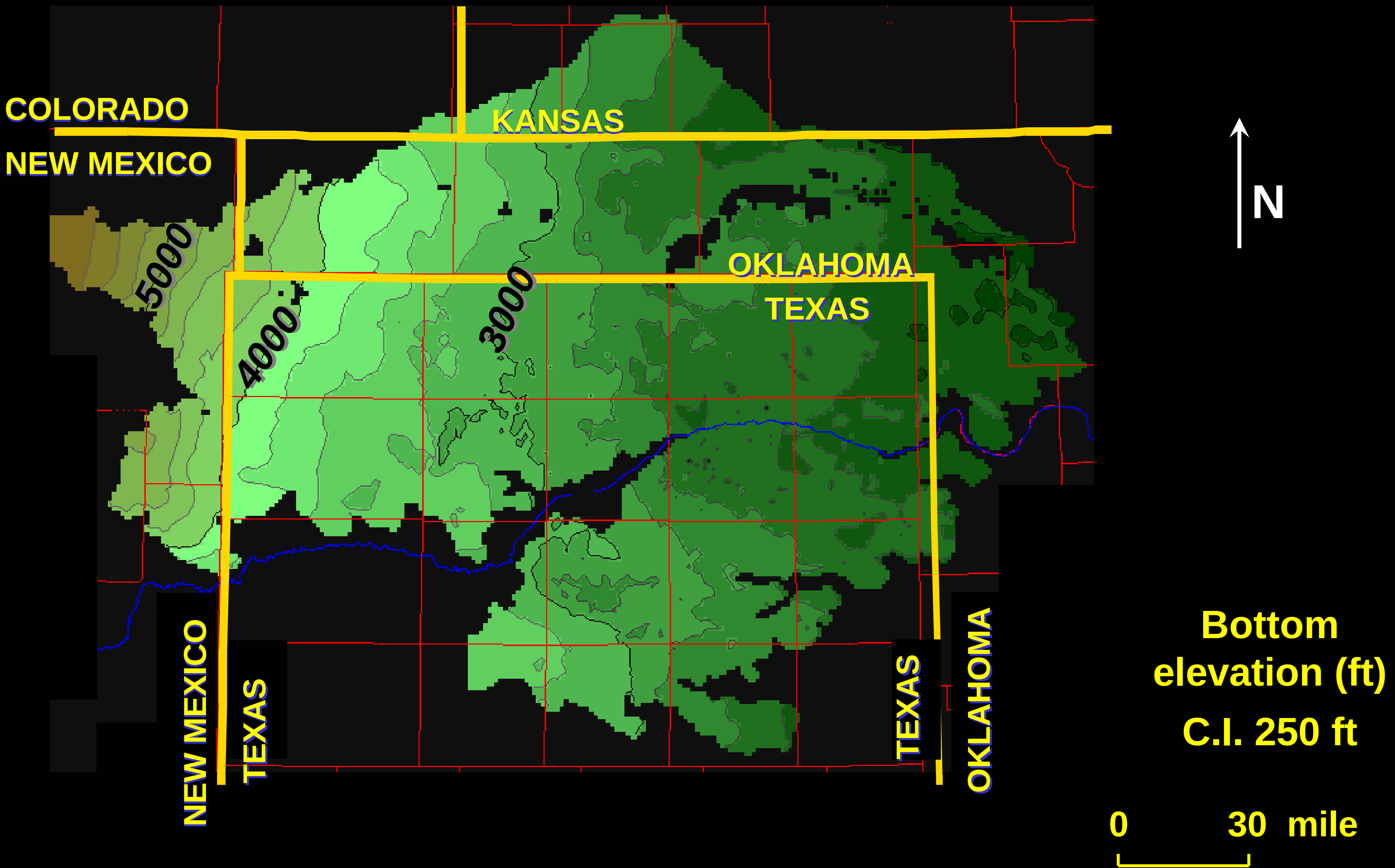
ELEVATION OF AQUIFER BASE

2001 Model



ELEVATION OF AQUIFER BASE

Merged 2001 Model and New Data



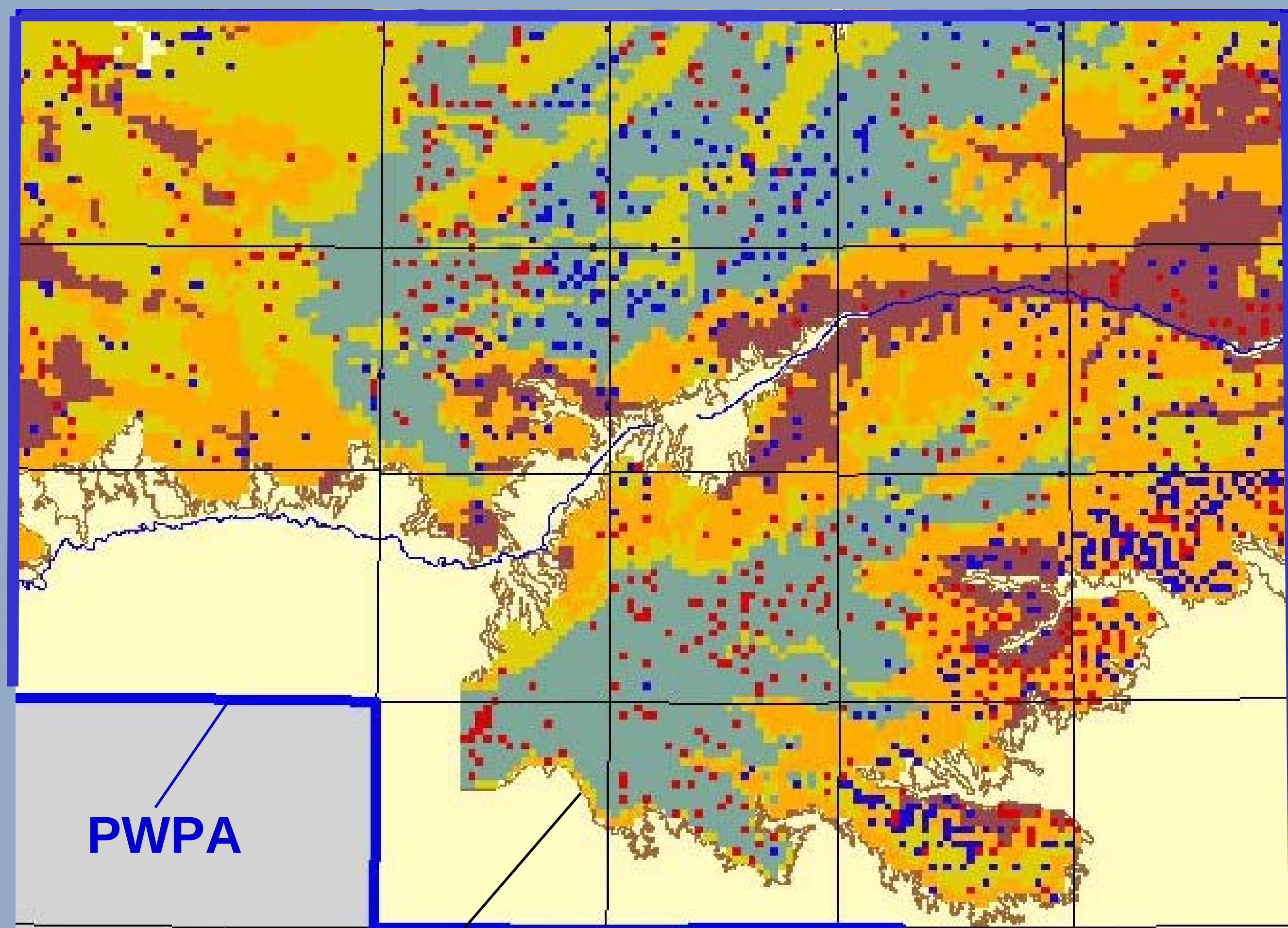
RECHARGE RATES

SOILS
Comparison with 2001 Model Residual

- Simulation underestimates measured water level
- Simulation overestimates measured water level

Soil permeability (inches/hour)

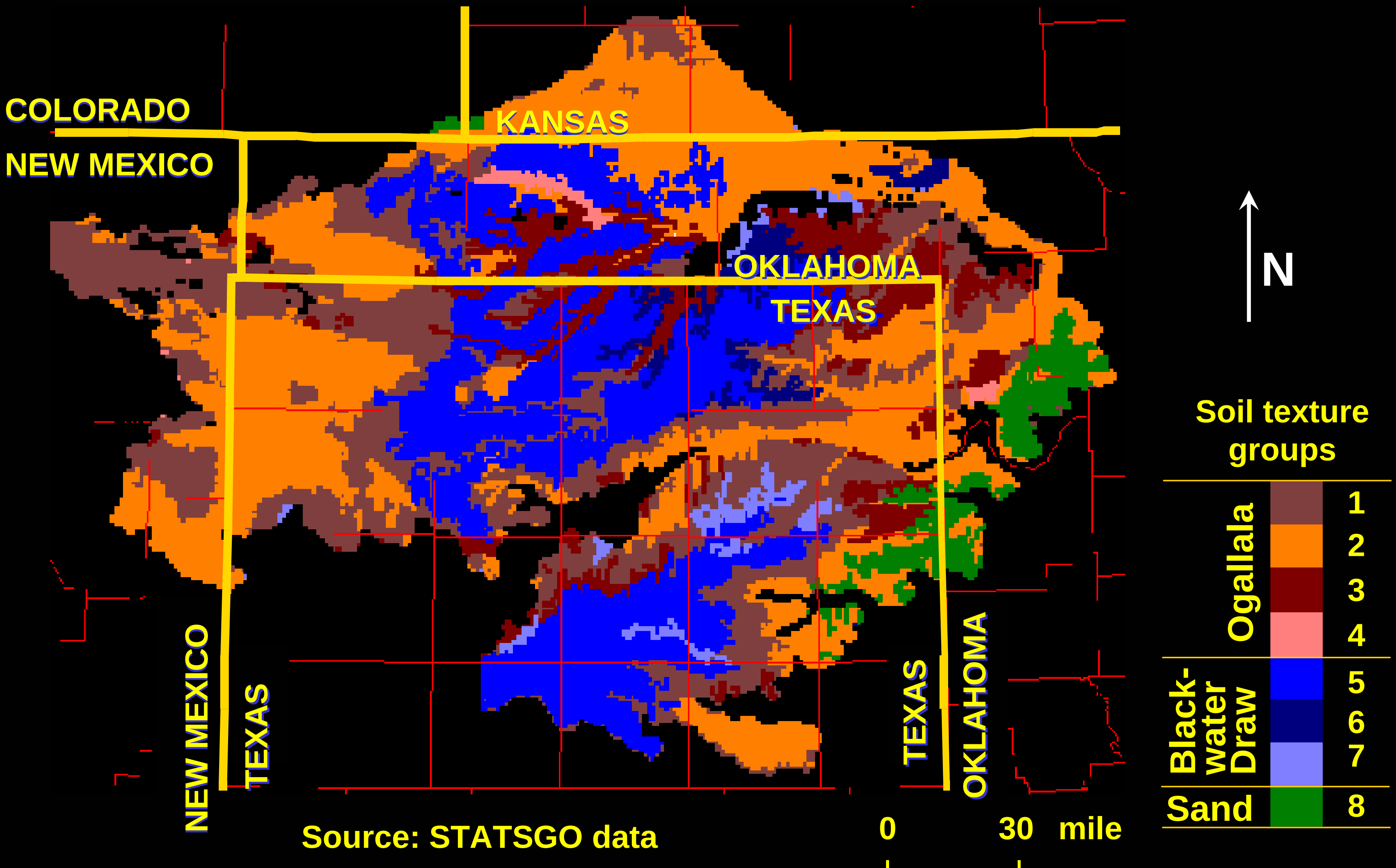
- >4
- 2 to 4
- 1 to 2
- 0.1 to 1



Ogallala Fm. limit

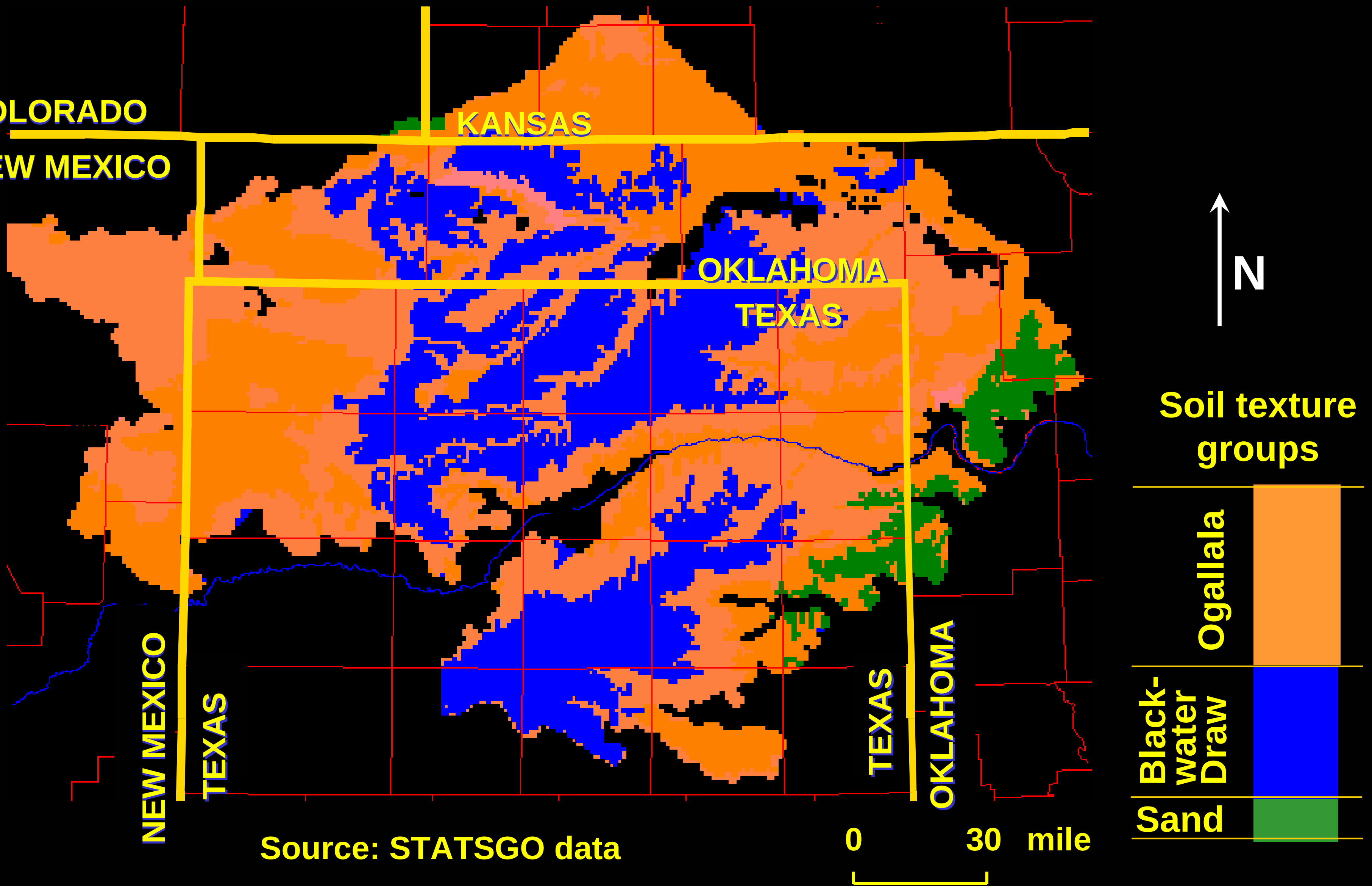
Soil data source: STATSGO data

SOIL TEXTURE GROUPS



Source: STATSGO data

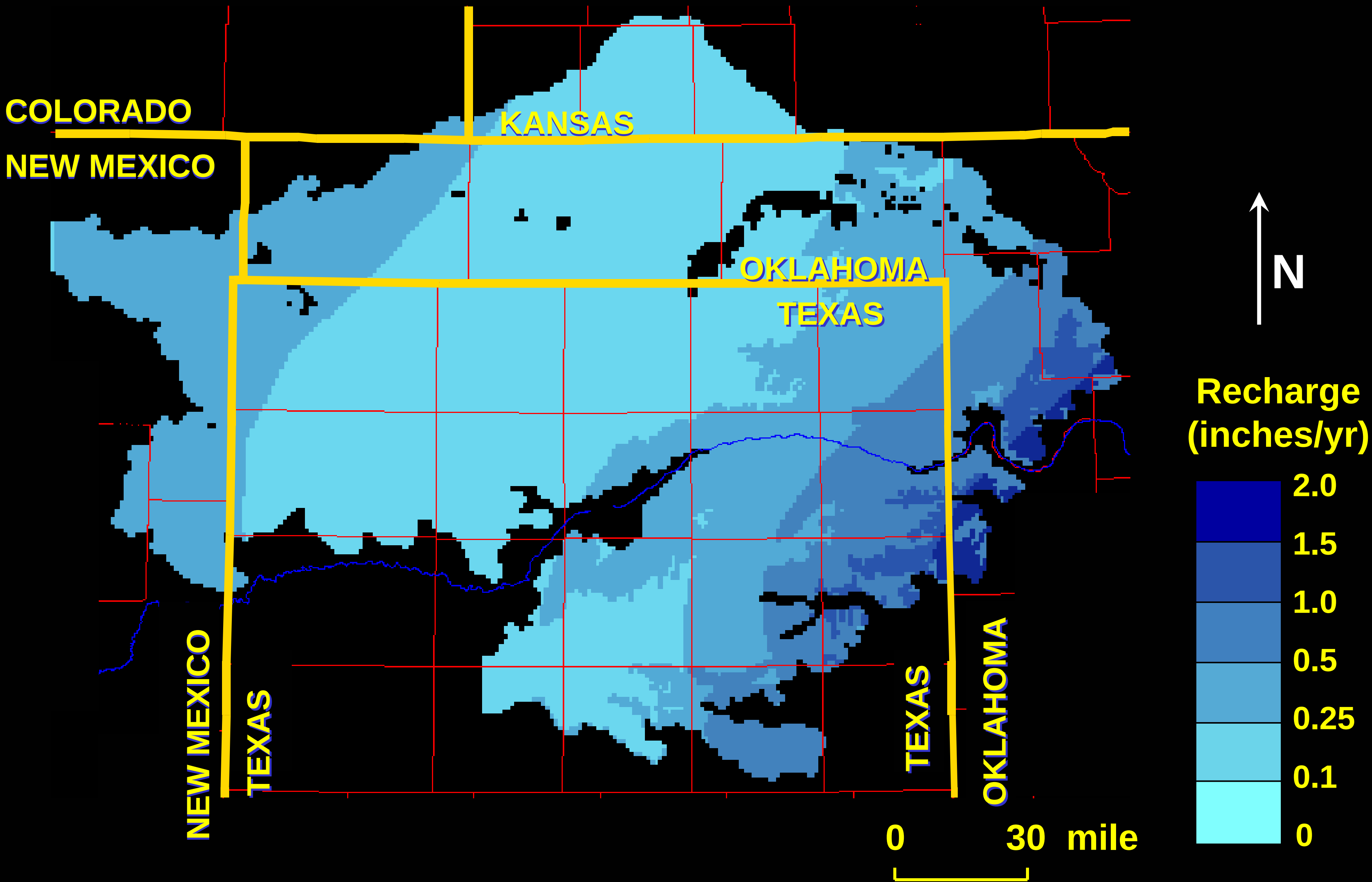
SOIL UNITS IN 2001 MODEL
Generalized for Assigning Recharge



Source: STATSGO data

MODELED RECHARGE

2001 Model (Steady state-No return flow)

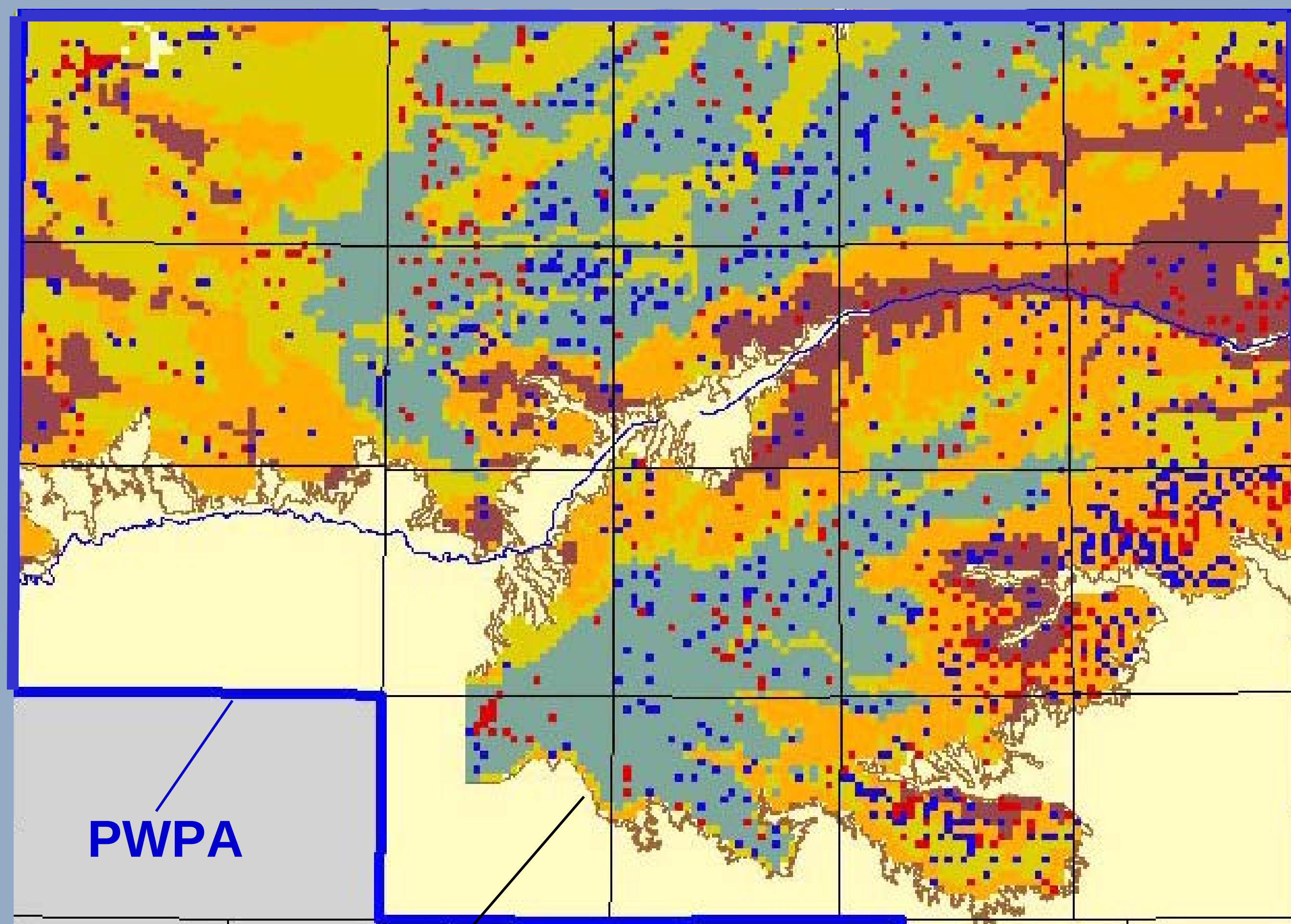


SOILS IN REVISED MODEL
Match with Revised Model Residual

- **Simulation underestimates measured water level**
- **Simulation overestimates measured water level**

Soil permeability (inches/hour)

- **>4**
- **2 to 4**
- **1 to 2**
- **0.1 to 1**

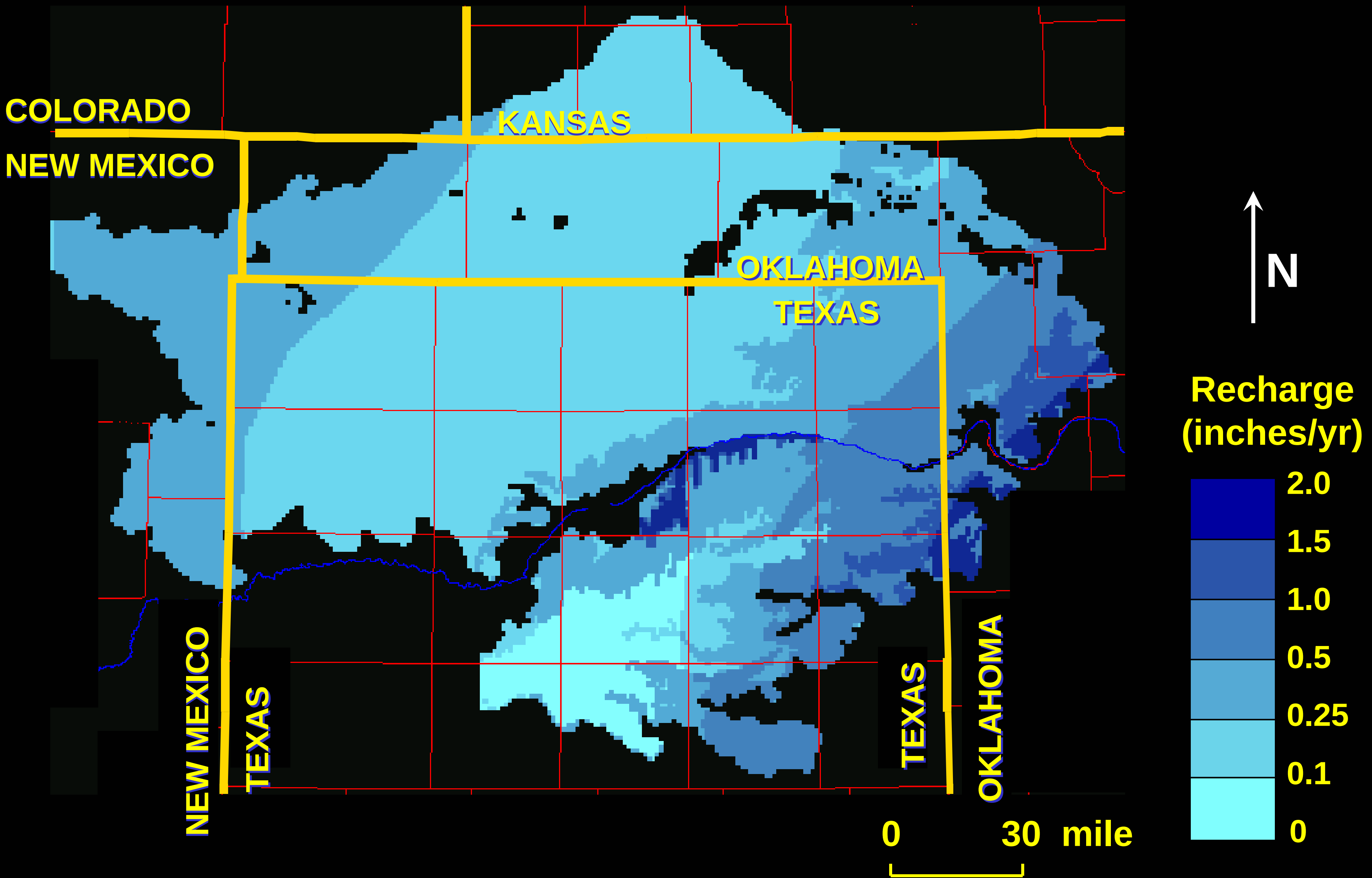


Ogallala Fm. limit

Soil data source: STATSGO data

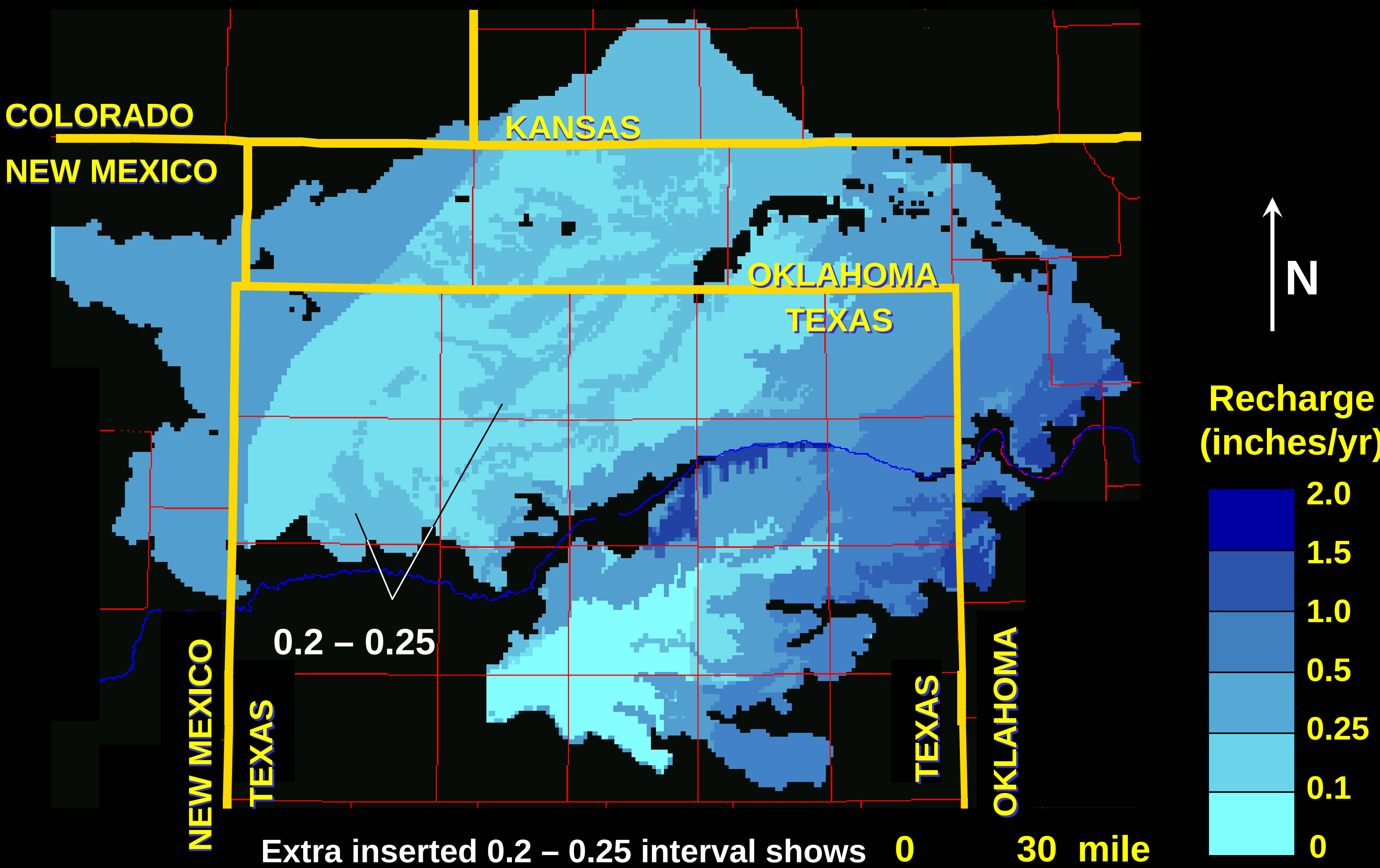
MODELED RECHARGE

Revised Model (Steady state-No return flow)



MODELED RECHARGE

Revised Model (Steady state-No return flow)



Extra inserted 0.2 – 0.25 interval shows detail within area of low recharge

DRAIN AND GHB BOUNDARIES

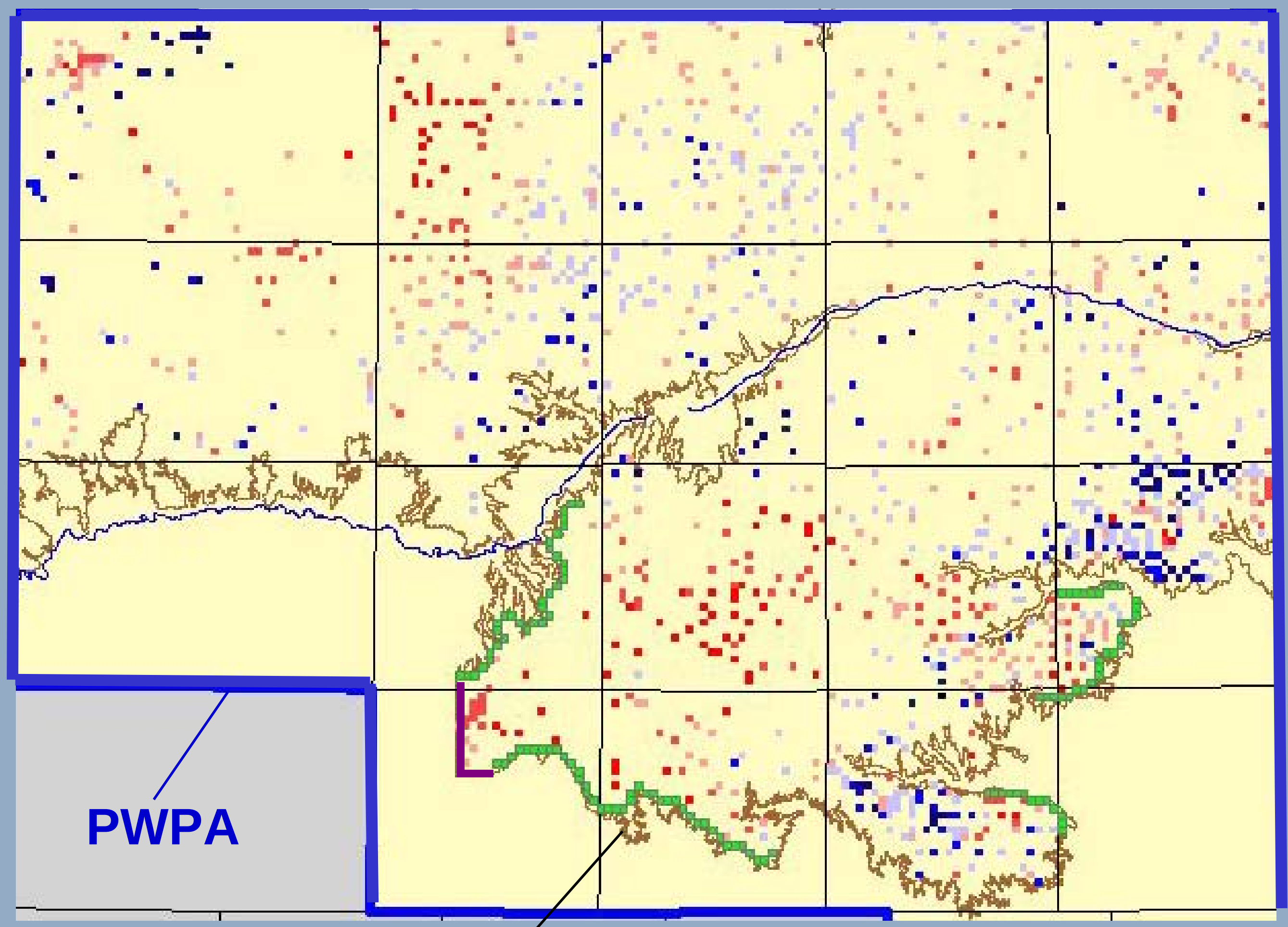
ADJUSTED “DRAIN” AND GHB BOUNDARIES

“Drain” boundary (lowered head on boundary)

GHB boundary (lowered head and increased conductance on boundary)

2001 model residuals

- Underestimates
- Overestimates



Ogallala Fm. limit

OGALLALA AQUIFER
(OG-N) MODEL ADJUSTMENT

- **Steady-state model RMSE error reduced by >5 ft to 30.4 ft at 1.3 % of head range. RMSE error in all counties <10%.**
- **Transient model RMSE error reduced by ~6 ft to 52.0 ft at 2.2 % of head range. Some county errors >10%.**
- **Distribution of error is more evenly distributed.**
- **Parameter adjustment primarily based on continued geological refinement.**

ADDITIONAL INFORMATION NEEDS

- **Data on recharge rates and the hydrogeological controls on recharge rates**
- **Data on layering of hydraulic conductivity between the aquifers in the Ogallala Fm. And Rita Blanca Fm.**
- **Data on contribution of groundwater from the Ogallala aquifer to base flow in the Canadian River**
- **Merging of Og-s and Og-n models (southern and northern Ogallala GAM models) to make overlap for Randall and Potter Counties area**

List of Attendees
April 5, 2004 Final Stakeholder Advisory Forum
Revisions to Northern Ogallala GAM
Panhandle Regional Planning Commission, Amarillo

Name	**Affiliation**
Alan Dutton	UT Bureau of Economic Geology
Stefan Schuster	Freese and Nichols, Inc.
Temple McKinnon	TWDB
Richard Smith	TWDB
Janet Tregellas	Agriculture, Panhandle RWPG
Bob Harden	Harden and Associates
Jarrett Atkinson	PRPC
C.E. Williams	Panhandle GCD, Panhandle RWPG
Ray Brady	Panhandle GCD
John Williams	Panhandle RWPG
Gale Henslee	Xcel Energy, Panhandle RWPG

Final Stakeholder Advisory Forum (SAF) for updates to Northern Ogallala Groundwater Availability Model (GAM)
April 5, 2004

Panhandle Regional Planning Commission, Amarillo Texas.

John Williams gave an introduction of those present and to the meeting in general. Stefan Schuster of Freese and Nichols reviewed stakeholder process thus far for revisions to the GAM and introduced Alan Dutton of the Bureau of Economic Geology (UTBEG). Dr. Dutton presented the results of the revisions to the Northern Ogallala GAM. Recharge values were updated across the model where soil information was available. New geophysical data from Ray Brady at the Panhandle Groundwater Conservation District was incorporated to refine red bed elevations. The previous model used the TWDB data set of total well depths rather than the log geophysical data from the district. Results indicate that lowering the aquifer base to match the geophysical data changes the saturated thickness, but doesn't significantly change the calibration.

The root mean square error (RMSE) of the revised model is less than the TWDB-required 10%. This was the case in the previous model, but RMSE for several counties decreased substantially. Error is now more uniformly distributed as well. Changes in the recharge rates in the model account for much of the improvement in the calibration results. No real improvements were gained in the northwest portion of the model (Dallam, Hartley, Sherman, and Moore Counties). This is due to a lack of hydraulic conductivity data in this area of the model.

Drain points on the perimeter of the model were checked in relation to water levels. Elevation changes didn't significantly effect the model's calibration. The model still uses the specific yield from the 1984 TWDB model - geologic controls were not considered.

Questions from attendees and answers included:

Q: When calibrations are from the revised and previous model, is the same calibration data being compared?
A: No, the 2000 model contains data from calendar years 1997 and 1998. The revised model also contains data from December 31, 1998 to March 1999 and a tighter data calibration results.

Q: What about streams?
A: It was reviewed whether the underestimate in the Canadian Breaks is from discharge. In the 2001 model, cell elevations in the river package were at ground surface. The conductance in those cells brings water to the ground surface. Since the conductivity of the Ogallala is so high, the water level climbs gradually as you move south. If you decrease the conductance, water loss occurs more slowly, but you flood the Canadian River valley. So the boundary has been made more complicated by adding more model cells to represent seepage.

Q: What about tributary streams in the model?
A: Tributaries handle the steady state excesses and no revisions were made at this time. There really isn't much water removed and these tributaries aren't responsible for underestimated values.

Q: Have there been no runs yet for the 2005 - 2060 demands?
A: No, UTBEG is not under contract to do that work. This work has been submitted for supplemental funding to the TWDB and timing should work well if funded.

Q: For predictive runs, have decisions been made on run types, pumpage to be included, and other factors?
A: Two scenarios will be run: full allocation with full demands and 1.25% reduction each year.

Q: With the City of Amarillo, have decisions been made regarding Carson, Potter, and Roberts Counties and the distribution of demands as relates to the model?
A: No decisions have been made yet.

Q: Have you modeled CRMWA assumptions of use in Roberts County?
A: The Planning Group is making the request for funding from the TWDB to contract out those runs. Hope to contract in early June for this effort. In that request was included the task of evaluating the firm yield of Lake Meredith and Palo Duro Reservoir to identify the necessary groundwater demand distributions. Region A won't reduce by 1.25% each year but rather will be reducing demand over time. The Planning Group has established changing the rate of irrigation demand based upon reduced yields and cropping patterns. These demand reductions will be compared to the 1.25% goal to identify where unmet needs exist. These runs would be compared on a year to year basis to see the saturated thickness changes each year.

Q: Is there any test information that could be developed to help quantify yield figures for the formation?
A: If it was affordable, more data would be available. Two things could be done to help with this. Mapping hydraulic conductivity in the model could provide some correlation between specific yield and hydraulic conductivity. You could see if the distribution of specific yield reflected hydraulic conductivity values due to the tie to depositional environments. This would make the model more geologically based. You could also develop local models of CRMWA or the City of Amarillo and stage measurement during well recovery to see if other values are reasonable.

Q: Would that effort involve measurement on all wells to be meaningful?
A: Probably for a short time.

Q: How long would the recovery period be?
A: You could use the model to see the feasibility of such a test. You could use the study by John Ashworth at the TWDB. Or you could determine specific yields on new wells drilled.

Q: What about oil and gas well data?
A: That data is generally not so good.

Q: Was the revision effort worthwhile? Are we approaching the point of the model being as good as it can get?
A: South of the Canadian River, the model is about as good as it can get without additional data. The model should incorporate new data as it is available. In the northwestern counties, hydraulic conductivity data is a constraint as is the conceptual model for how to represent the Rita Blanca and Ogallala together correctly. With additional small adjustment of recharge and boundary conditions, you could make small incremental improvements once new data is available.

Q: Do you give credit to changes in the red bed values for cells going dry when the depth to the red beds has been shortened? Cells are going dry when pumping but there is still water in adjacent cells - isn't this a misrepresentation of aquifer behavior?
Comment: Wouldn't that average out over cell depths decreasing and increasing? Is averaging out a realistic picture?
A: The next generation model may use a wet/dry package that would allow dry cells to rewet from adjacent cells. This might be appropriate where useful.

Q: Do we not know which well logs went through the Ogallala and reached the bottom?
A: Ray Brady tried to catch that.

Q: There are high spots (underestimations of thickness).
A: Need to consider that of approximately 700 wells, a lot of wells may be 5 to 10 feet into red bed and stop. Many wells may be multiple aquifer completions.

Comment: The Dockum has historically been grouped into the Ogallala. Need to look at the return flow in the eastern part of the model. Model reflects dry cells, but that isn't the case.