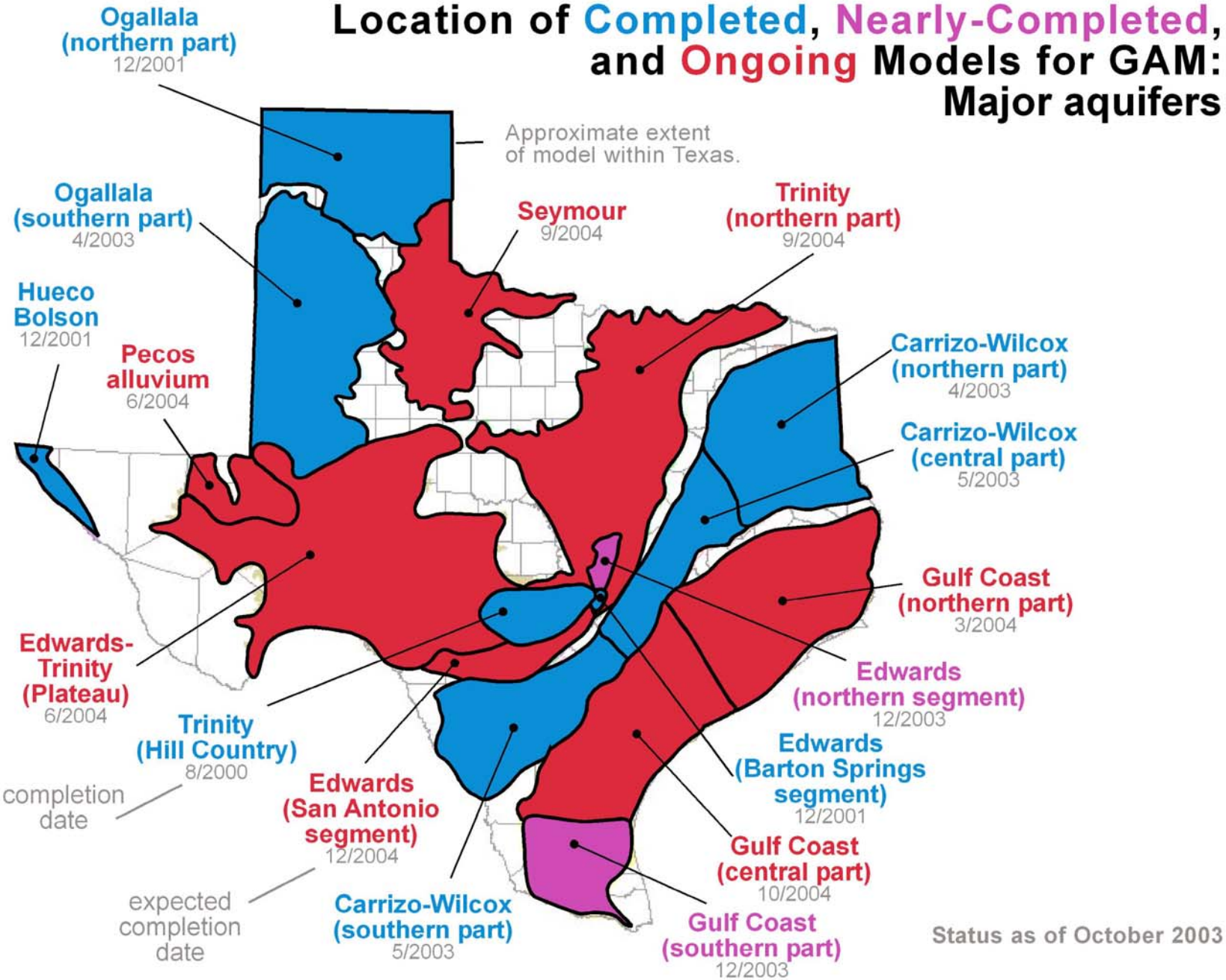
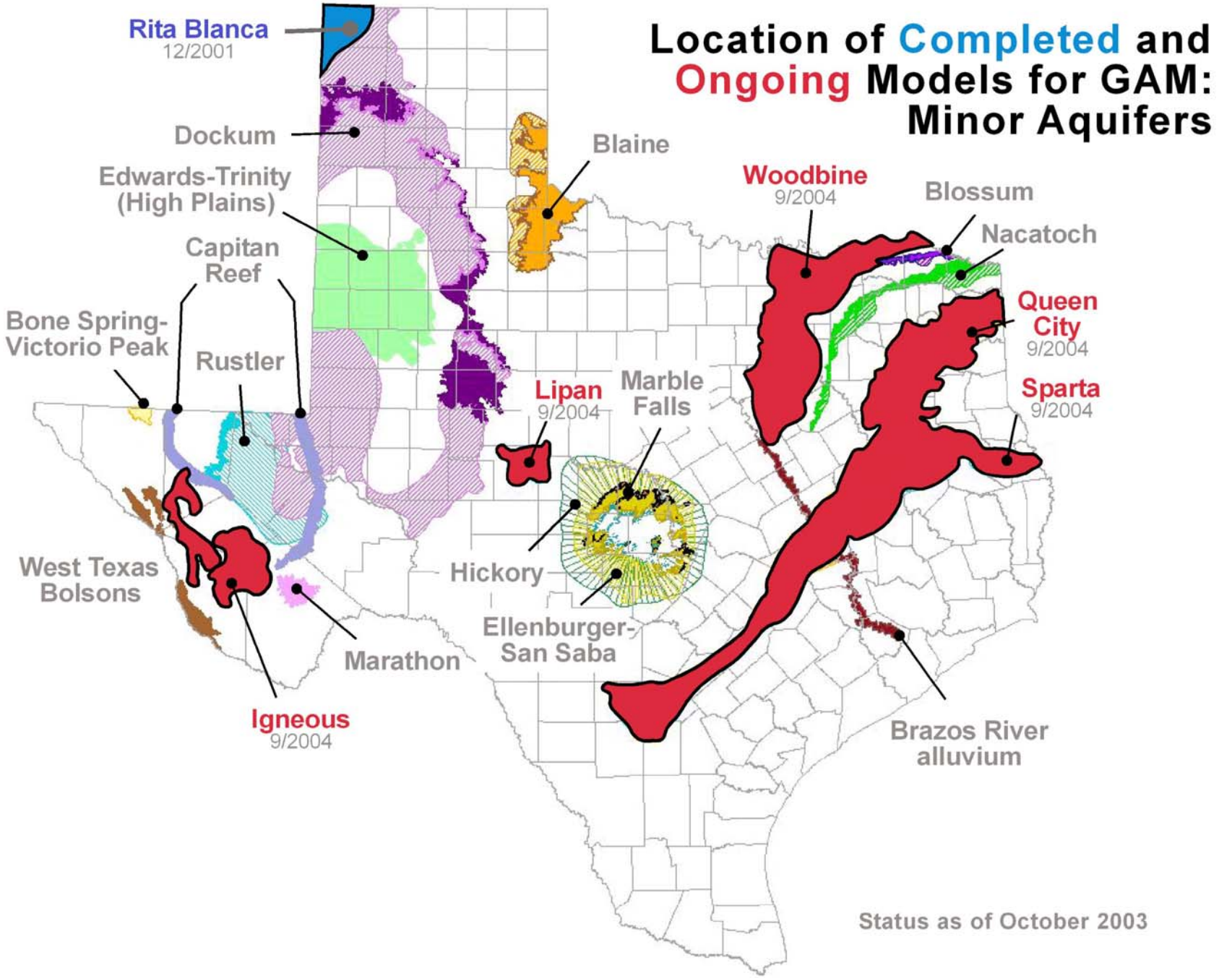
texas water development board

AGENDA
STAKEHOLDER ADVISORY FORUM (SAF) MEETING
December 18, 2003

- Role of GAM models and the SAF
- Status of the Ogallala aquifer model
- Groundwater modeling overview
- The Ogallala aquifer model
- Revisions
  - —Recharge rate
  - —Base of Ogallala aquifer
  - —Allocation of pumping

Location of Completed, Nearly-Completed, and Ongoing Models for GAM: Major aquifers




Location of Completed and Ongoing Models for GAM: Minor Aquifers
Rita Blanca
12/2001
Dockum
Edwards-Trinity (High Plains)
Capitan Reef
Bone Spring-Victorio Peak
Rustler
Blaine
Woodbine
9/2004
Blossum
Nacatoch
Queen City
9/2004
Sparta
9/2004
Lipan
9/2004
Marble Falls
Hickory
West Texas Bolsons
Ellenburger-San Saba
Marathon
Igneous
9/2004
Brazos River alluvium
Status as of October 2003

ROLE OF GAM MODEL

- **Goal of GAM project is to**
  - **develop a realistic and scientifically accurate computer model that represents the aquifer, its water budget, and its groundwater processes such as recharge, discharge, and pumping**
- **Model will be used by groundwater conservation districts (GWCD), regional water planning groups (RWPG), TWDB, and individuals to evaluate availability of groundwater**
  - **2002 State Water Plan**
  - **Panhandle Groundwater Conservation District**
  - **DOE Pantex Plant**
- **Stakeholder participation is important to ensure the model is accepted as a valid representation of the aquifer**

STAKEHOLDER ADVISORY FORUM (SAF)

- **Stakeholder participation is critical to the success of the GAM program!!!**
- **SAF intended to be widely inclusive of interested participants**
- **SAF memo reports and presentation materials will be posted on the TWDB web site (http://www.twdb.state.tx.us)**

STATUS:
NORTHERN OGALLALA AQUIFER GAM MODEL

- 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
  - Model fulfills the role of the GAM model for the northern Ogallala aquifer
- New revisions are in progress as part of the update of the Regional Water Plan for 2005-2060

APPROACH FOR USING THE GAM MODEL OF THE OGALLALA AQUIFER

- **The revised model will be used to predict effects of groundwater use for the *Update* of the State Water Plan:**
  - **2000 to 2060 period**
  - **Projected pumping as given by RWPG water-demand projections under normal and drought-of-record conditions**
- **Initial approach in this contract was for BEG to run the new water demands using the 2001 GAM model**
- **Revised approach is for BEG to make additional model improvements, and to ask TWDB to run the new water demands using this updated GAM model**
- **Model and data to be made available to the public**

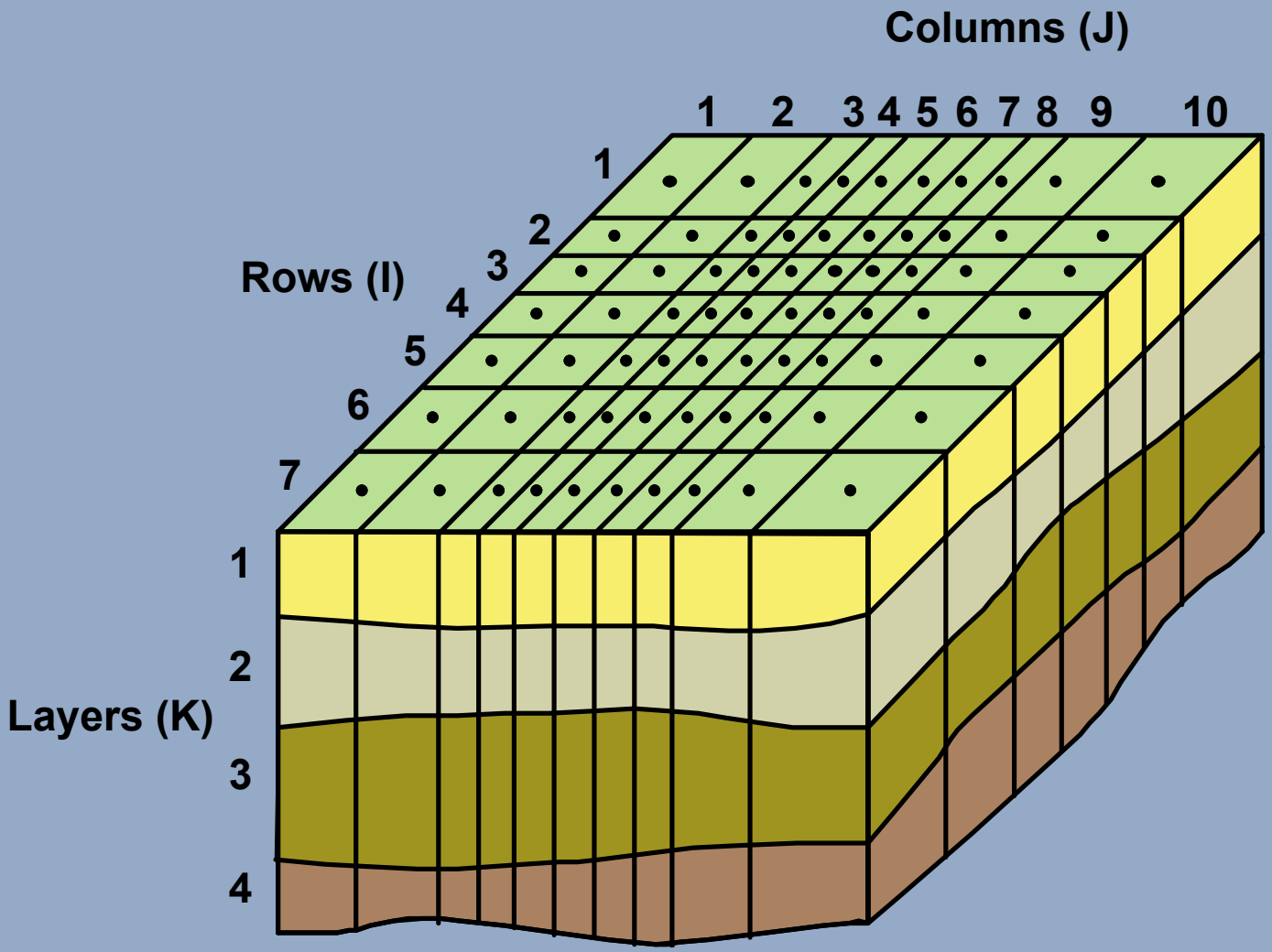
DELIVERABLE

- **Addendum to 2001 GAM model report, documenting changes to the model**
  - **Text summarizing changes**
  - **New maps showing recharge and base of aquifer**
  - **New maps showing saturated thickness**
  - **Revised model input files and metadata**

PROJECT SCHEDULE

First SAF meeting	Dec. 18, 2003
Deadline for receipt of data	Jan. 23, 2004
Revised model done	Feb. 20, 2004
Deliverable submitted	Feb. 27, 2004
Final SAF meeting	Spring 2004

GROUNDWATER FLOW AND GROUNDWATER MODELING



WHAT IS A GROUNDWATER MODEL?

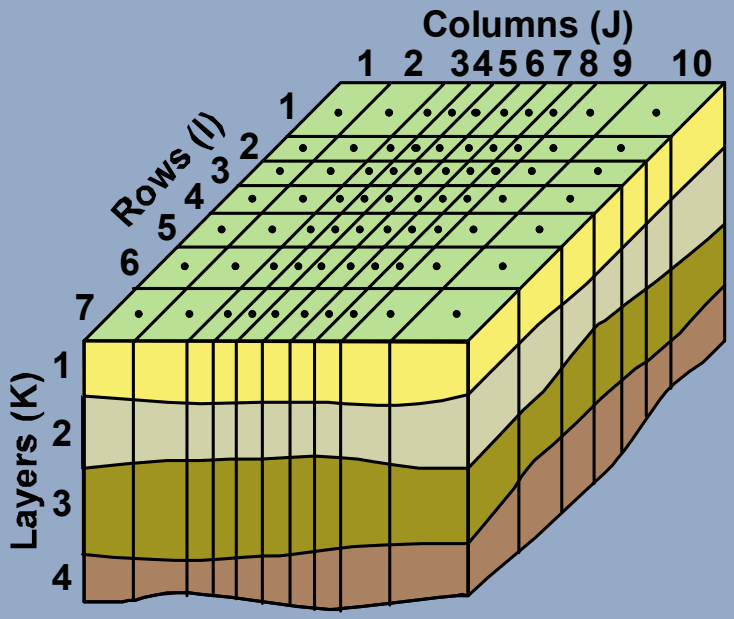
- A groundwater model is "*an aquifer in a computer*" that represents the occurrence and movement of groundwater
- Computer codes calculate the movement of groundwater in an aquifer as a set of mathematical equations
- Models are approximations and require assumptions and simplifications
- Models are useful tools for looking at "*What if*" questions
  - Predictive models require calibration and verification

It's tough to make predictions, especially about the future!

The future ain't what it used to be!

-Yogi Berra

MODFLOW



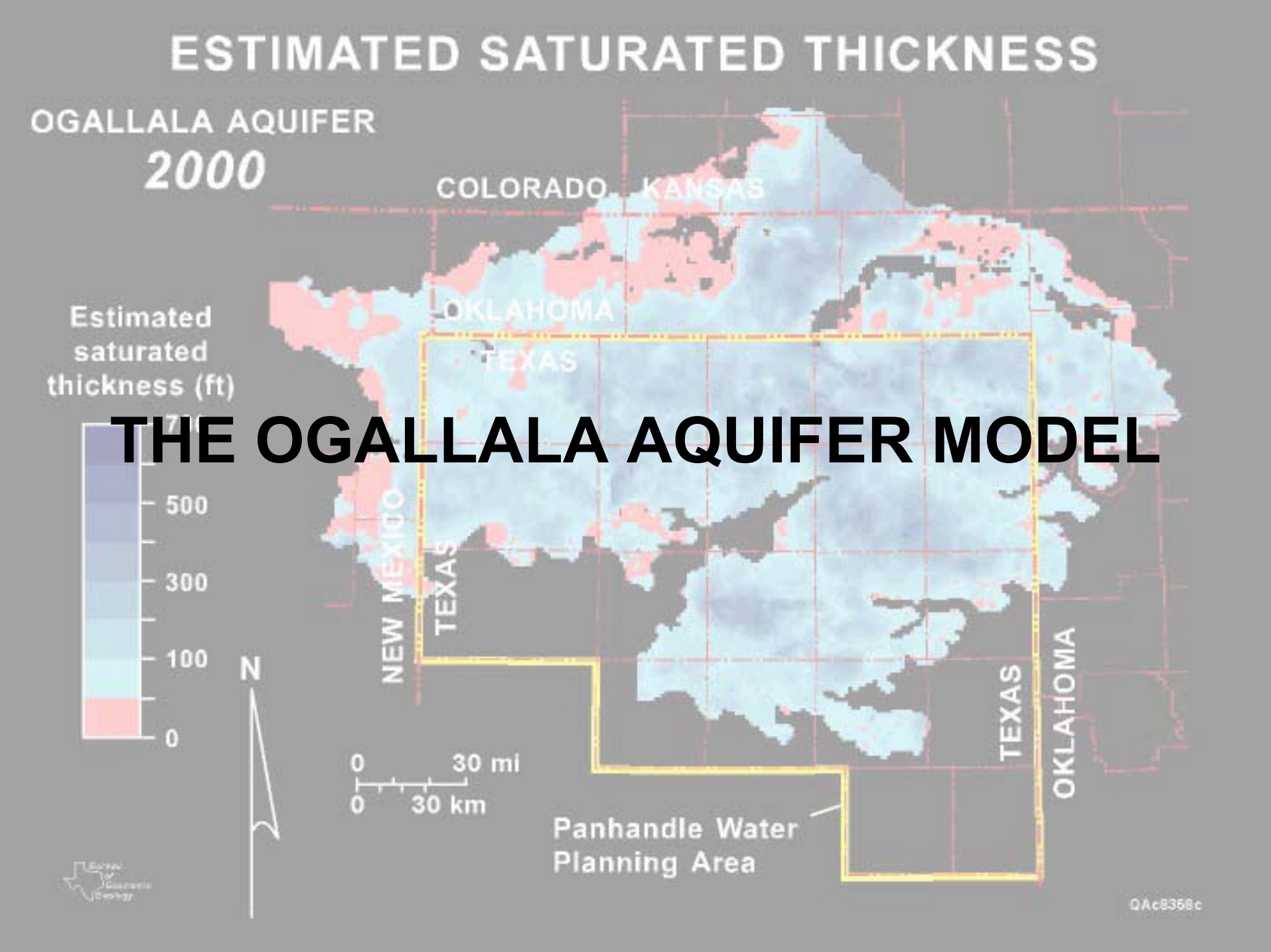
Standard MODFLOW Grid

- USGS public domain software (1984); updated 1988, 1996, 2000
- Modular, finite-difference solution for 3-D groundwater flow
- Extensively used and tested; industry standard for groundwater modeling
- Additional modules developed (e.g., improved solvers, surface-water interaction, deformable media, transport)

- Commercial pre- and post-processing user interfaces
  - Processing MODFLOW for Windows (PMWIN)
  - Visual Groundwater
  - Groundwater Vistas
  - Groundwater Modeling System (GMS)

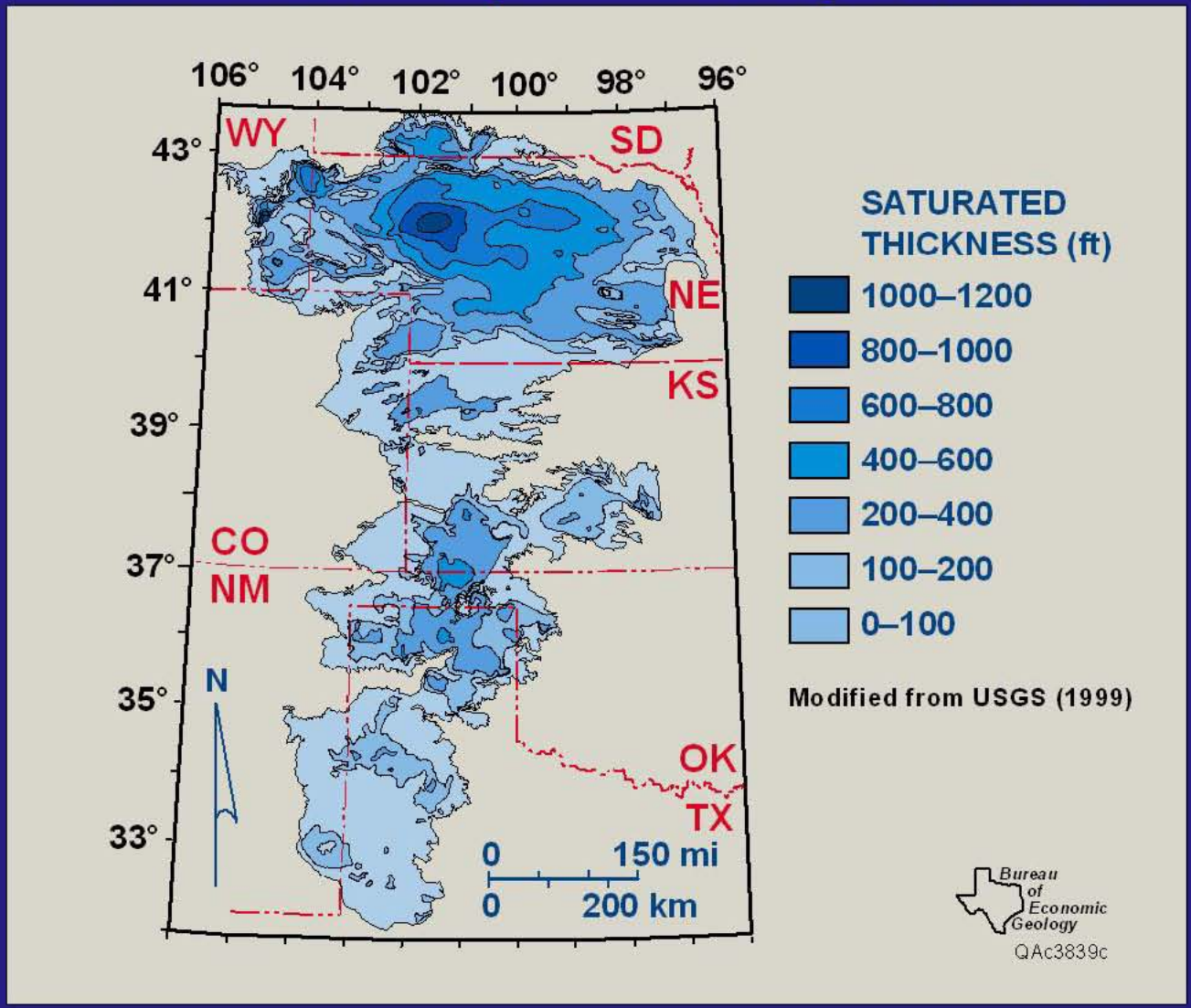
MODEL CAPABILITY AND EXPECTATIONS

- Given RWPG water-demand projections, the water-resource model can predict for 1 square mile areas:
  - Depth to water and water levels
  - Base flow discharge to streams
  - Water budget of inflows and outflows
  - Where areas might be at risk of dewatering if pumping rates were unchanged
  - Where areas might exceed the PWPG 50-50 aquifer planning goal
- Calibration error is to be unbiased and less than 10 percent of change in water levels across model area
- Regional scale model does not fully handle local features or indicate where to drill individual wells
- Model does not estimate soil moisture or other ecosystem attributes

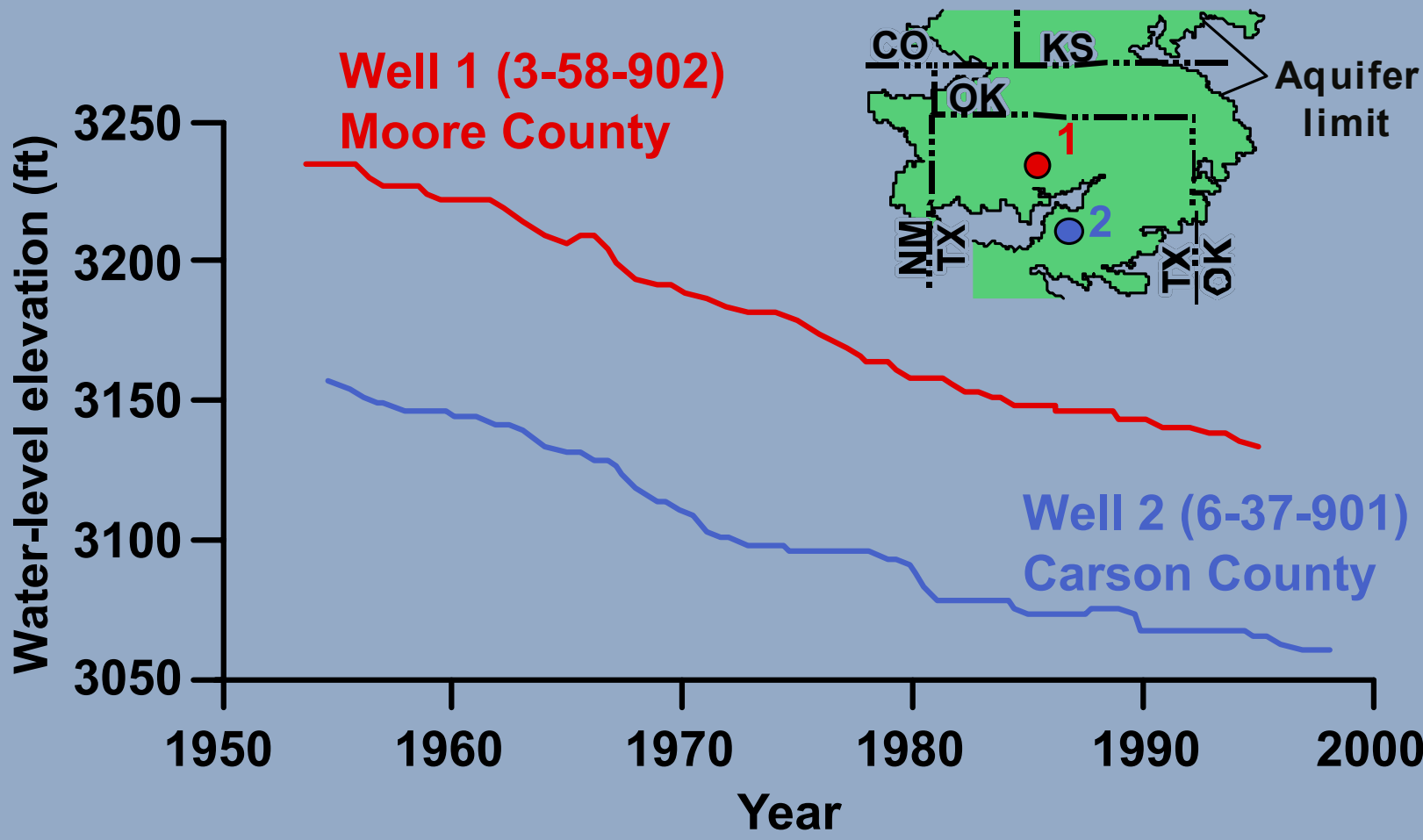


THE OGALLALA AQUIFER MODEL

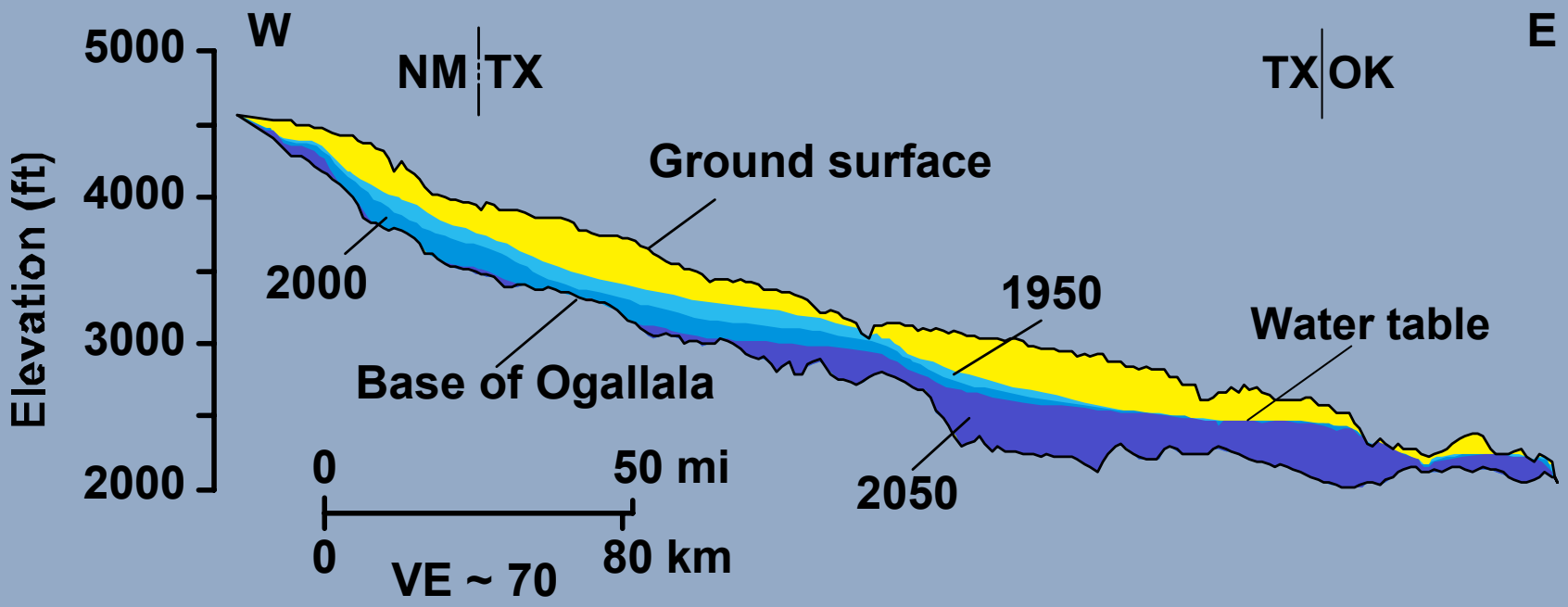
SATURATED THICKNESS
HIGH PLAINS (OGALLALA) AQUIFER



TYPICAL HYDROGRAPHS

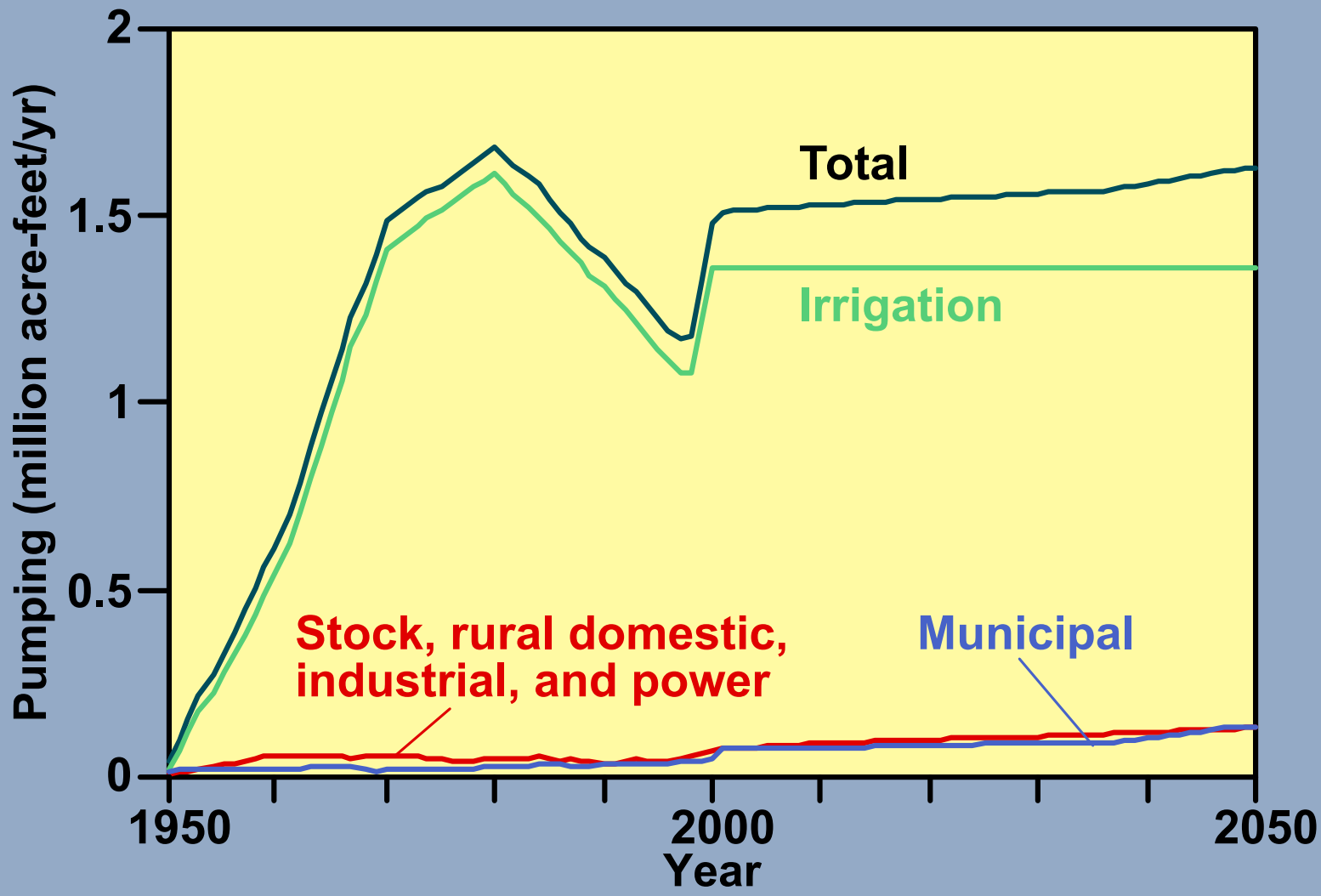


HYDROLOGIC CROSS-SECTION

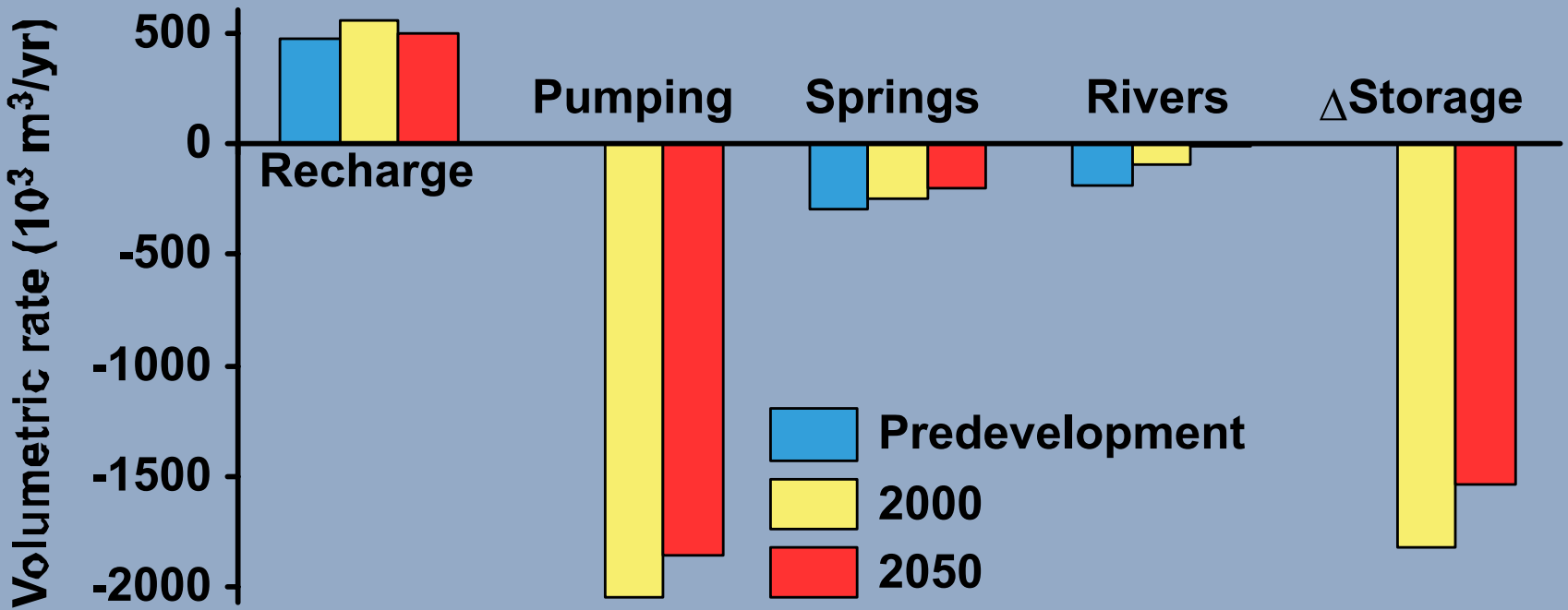


PUMPING RATE

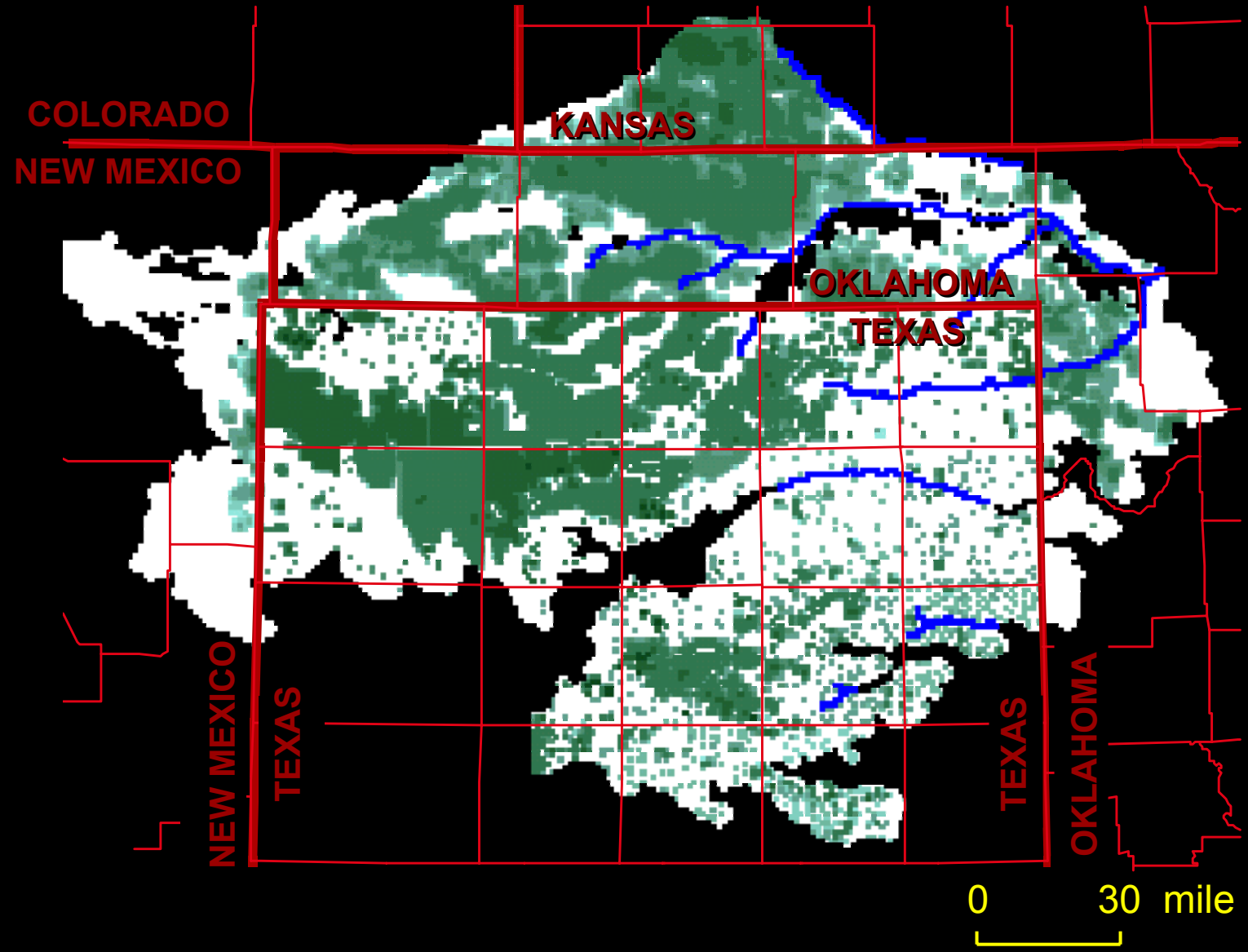
Ogallala aquifer, Central High Plains, Texas



WATER BUDGET



TOTAL PUMPING RATE



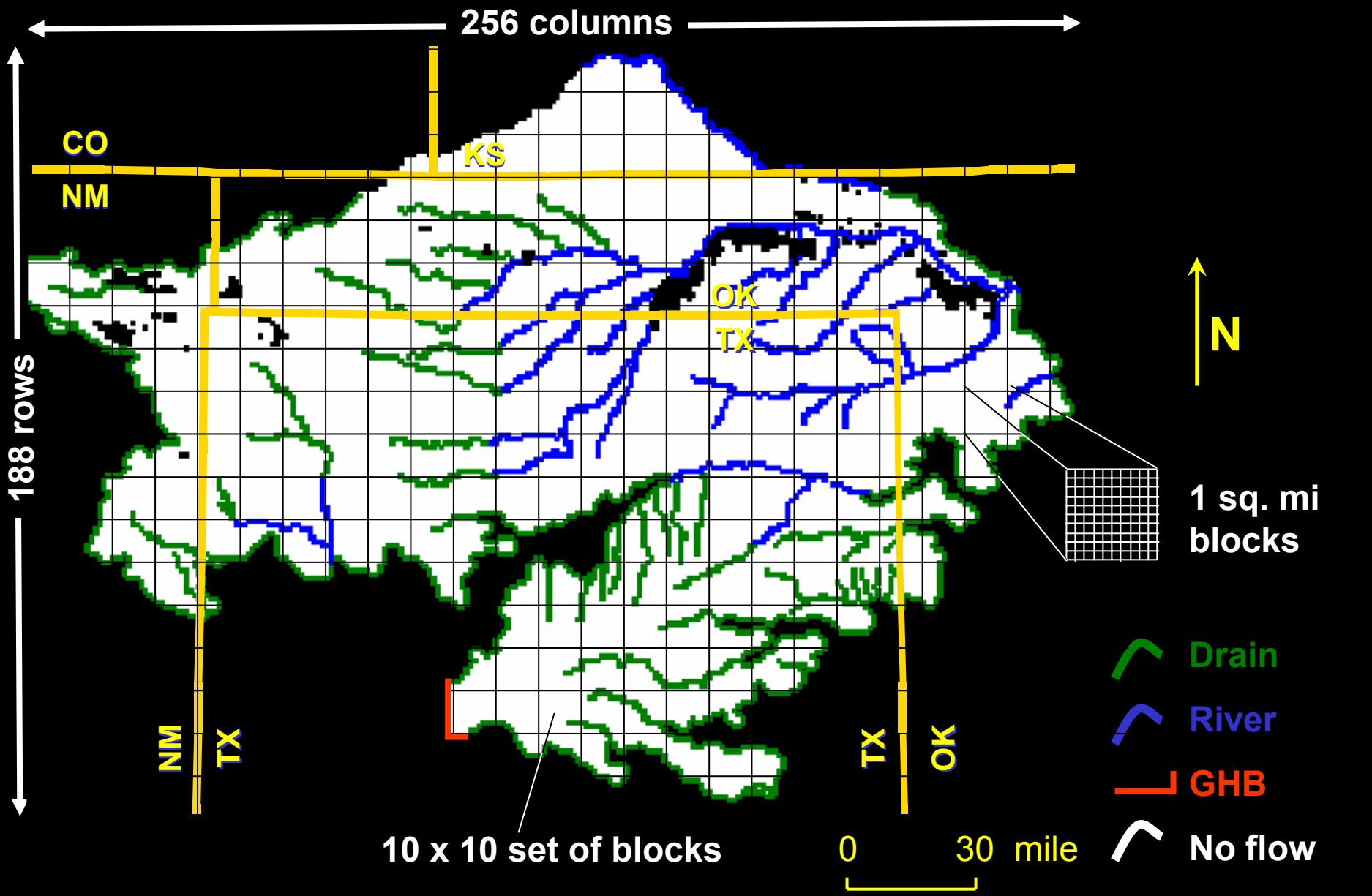
2000

N

Pumping rate (acre-feet/yr)

5000
1000
500
100
50
10
5
1
0

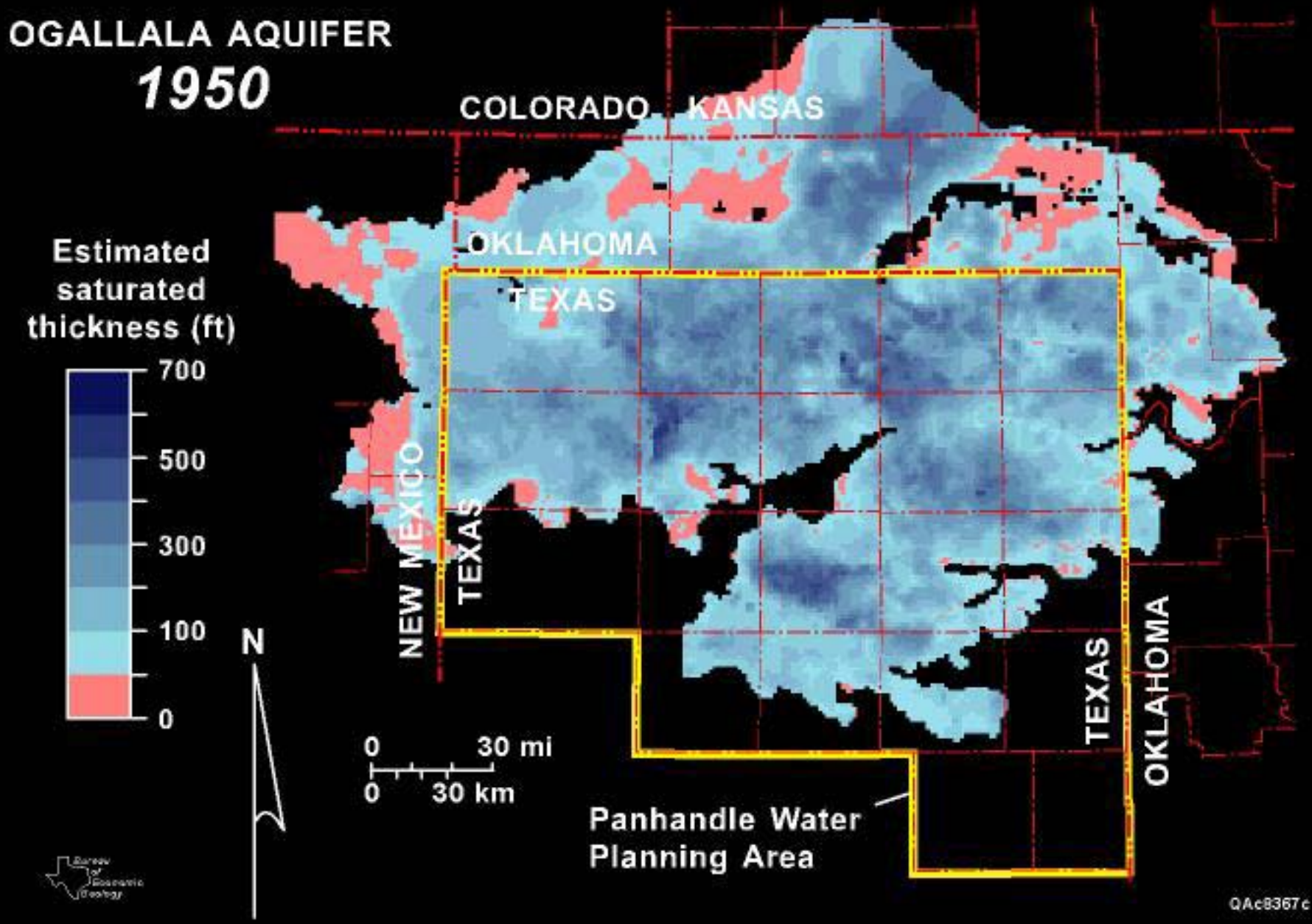
MODEL GRID AND BOUNDARY CONDITIONS



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

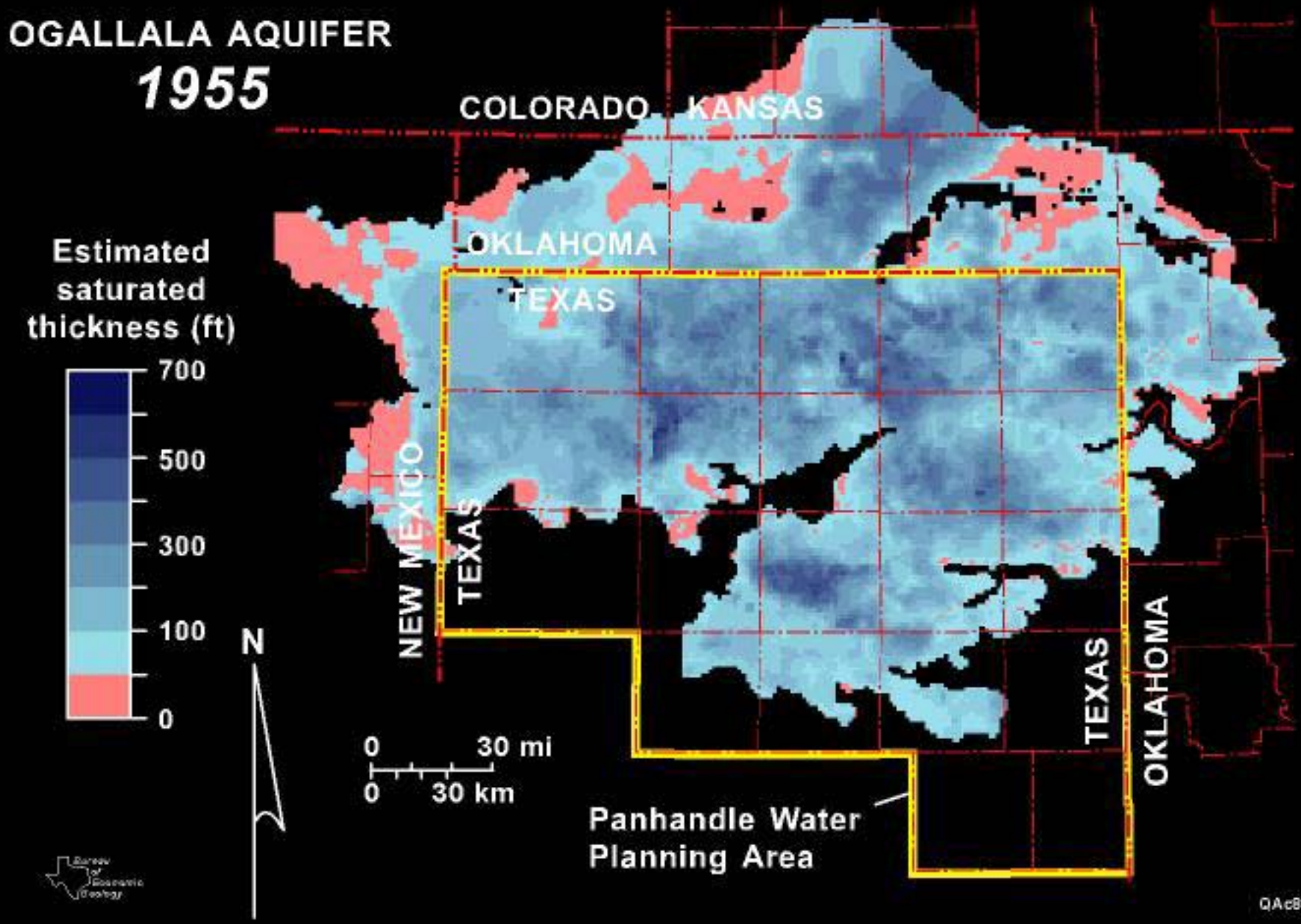
1950



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

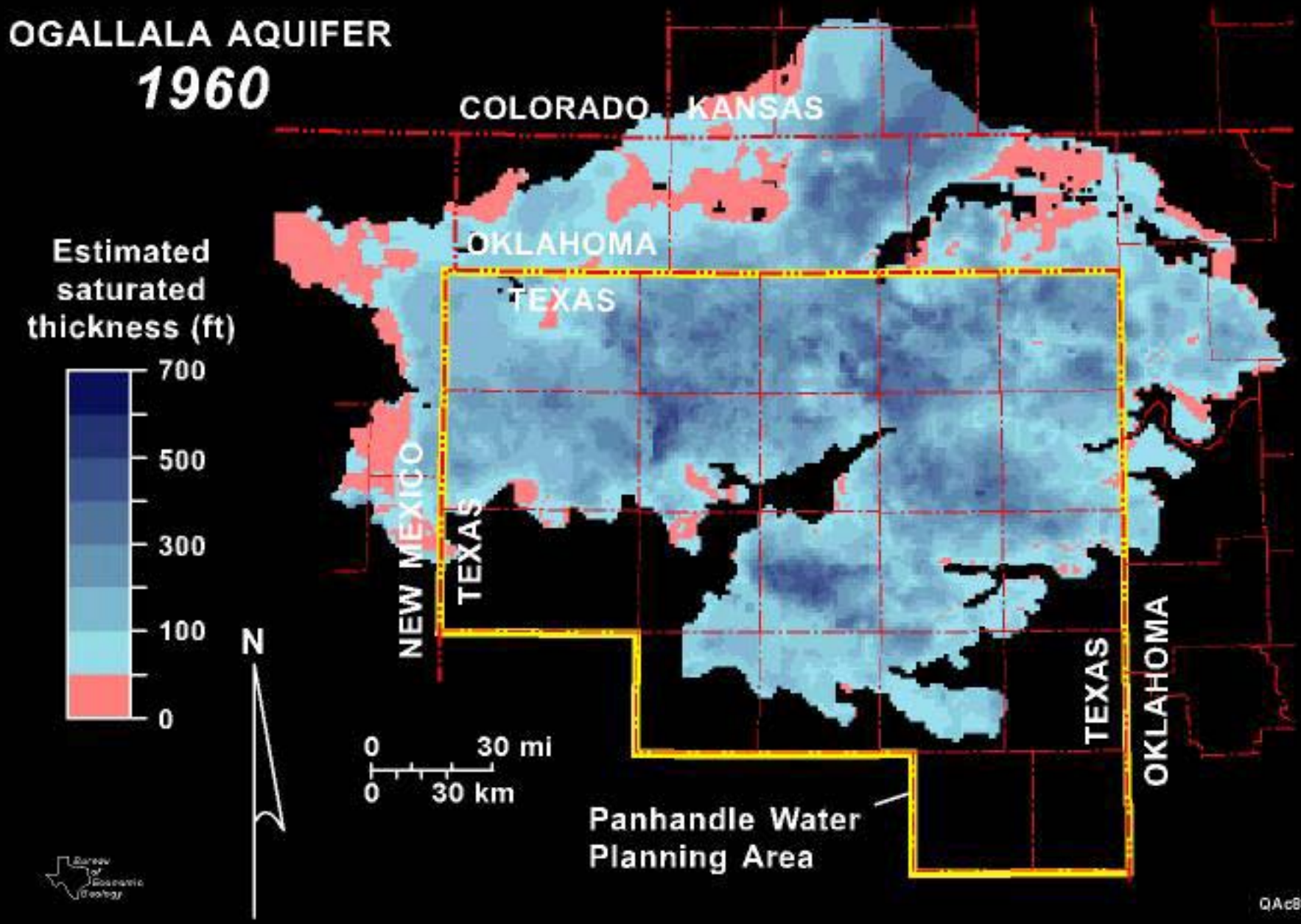
1955



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

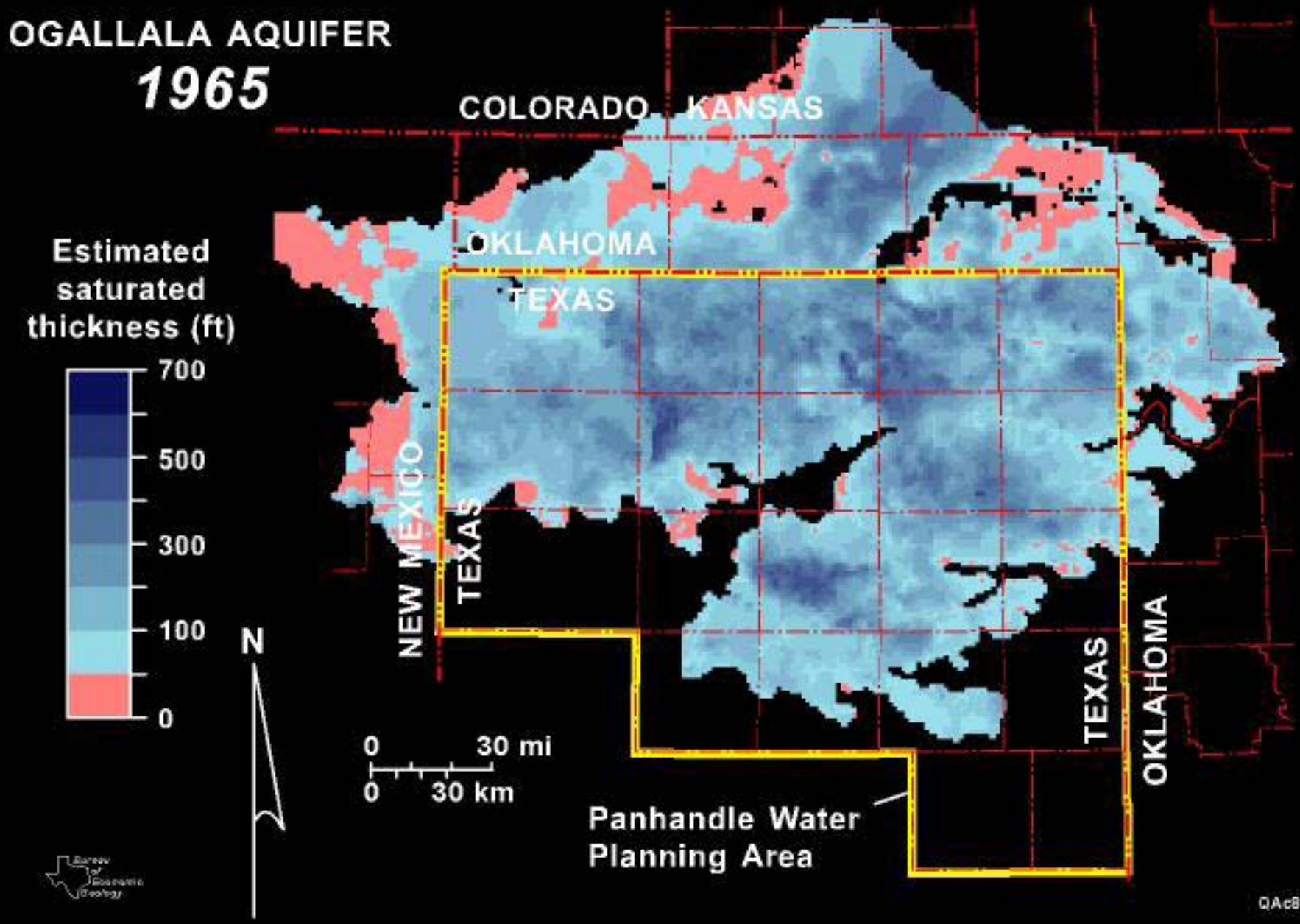
1960



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

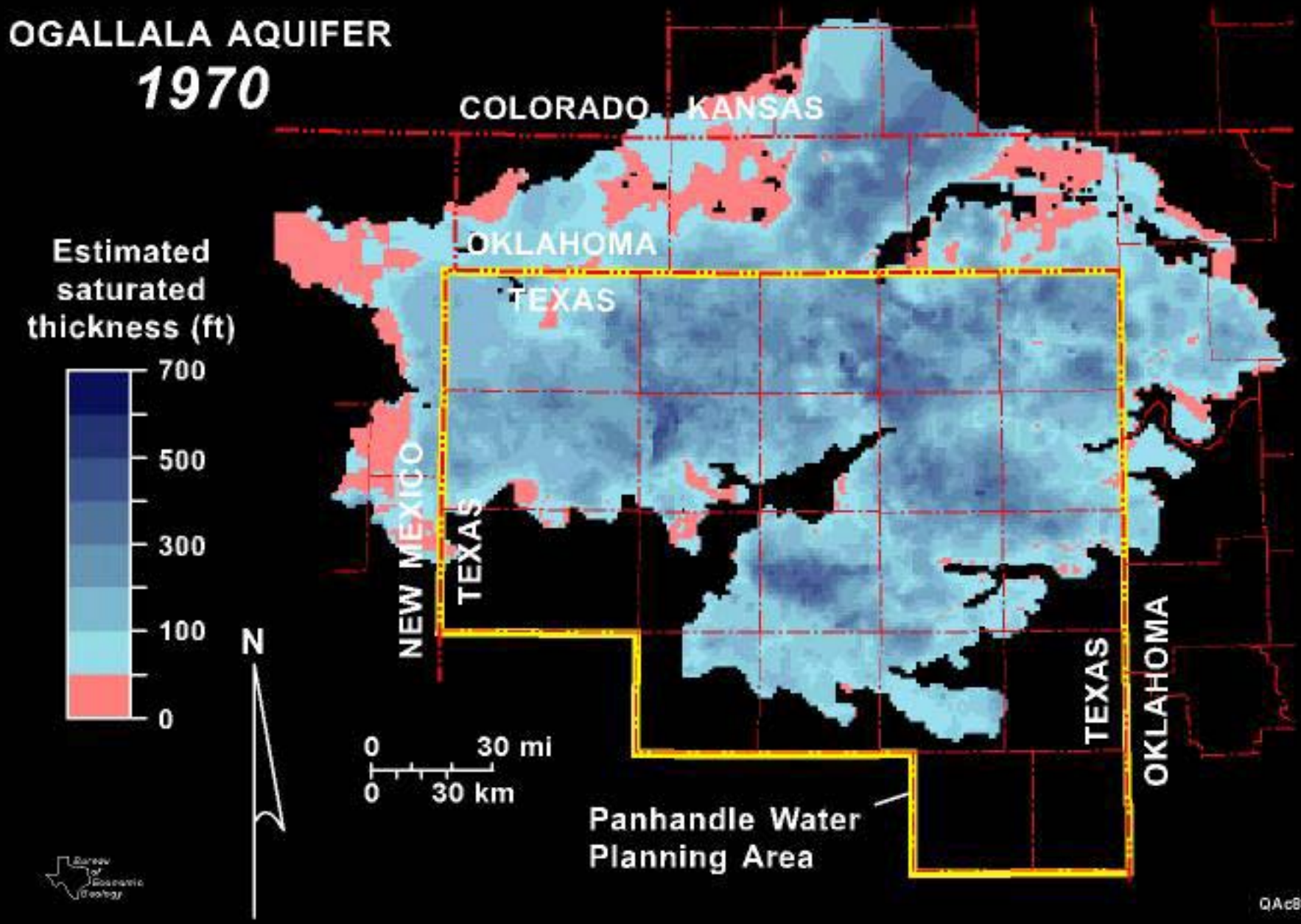
1965



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

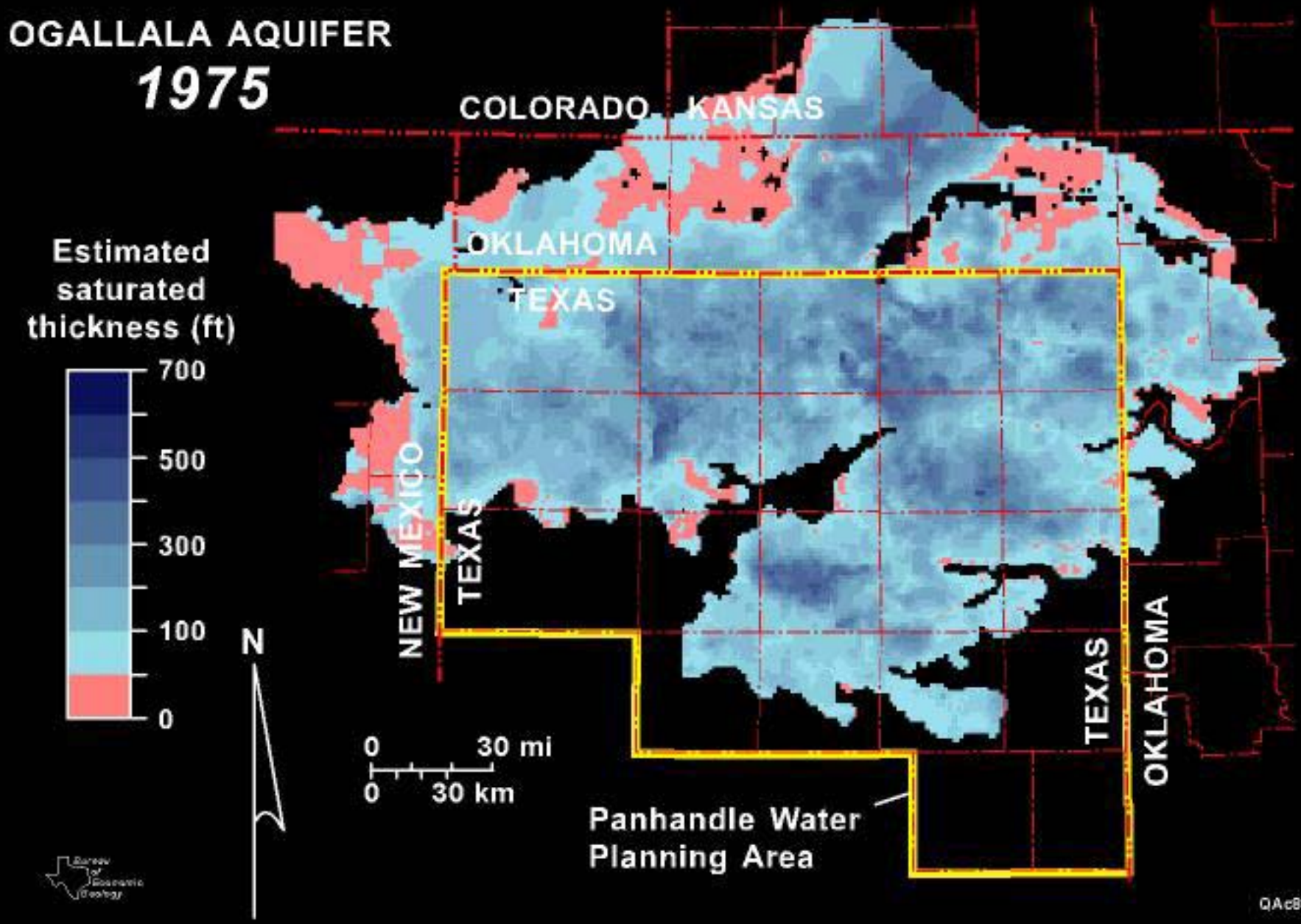
1970



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

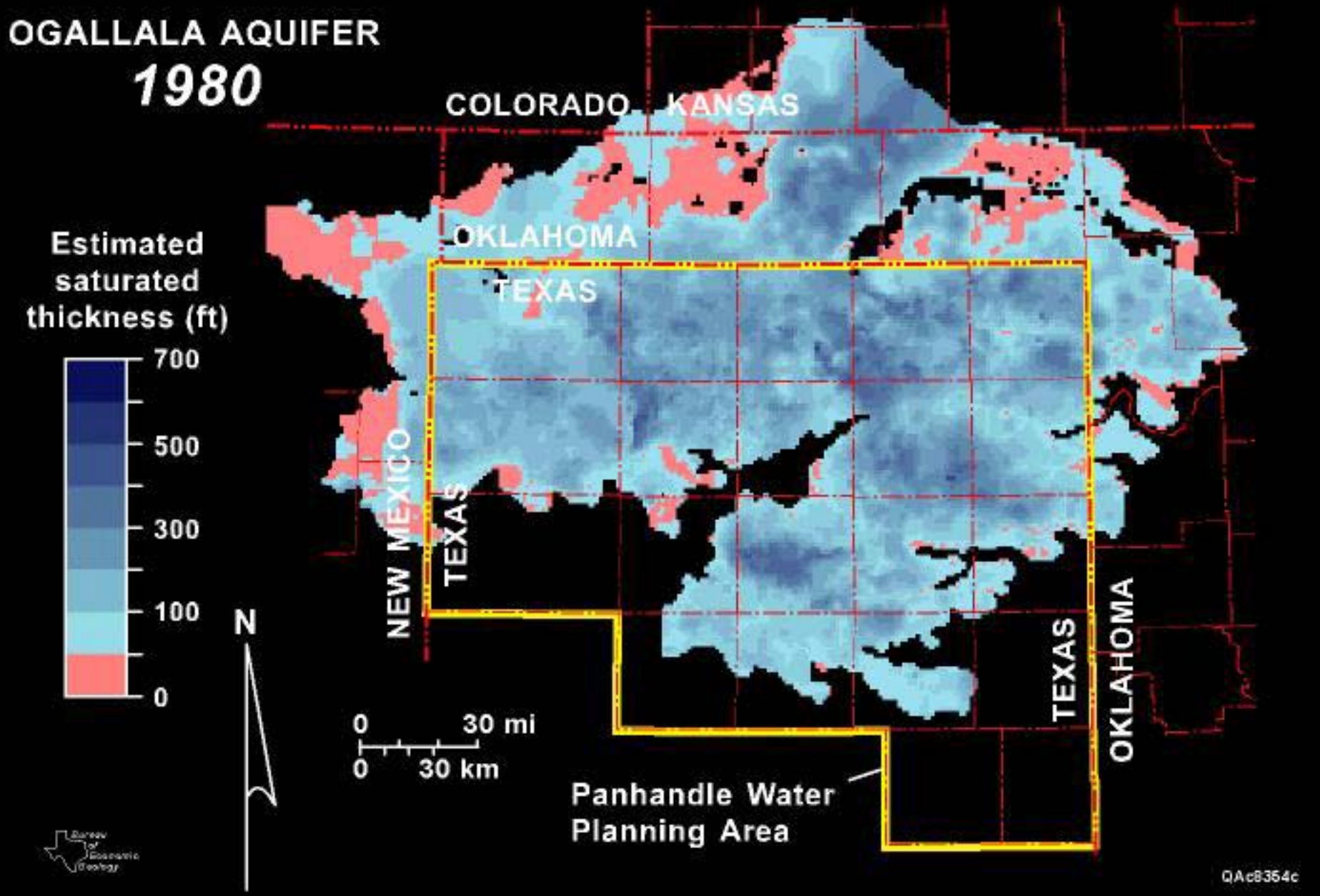
1975

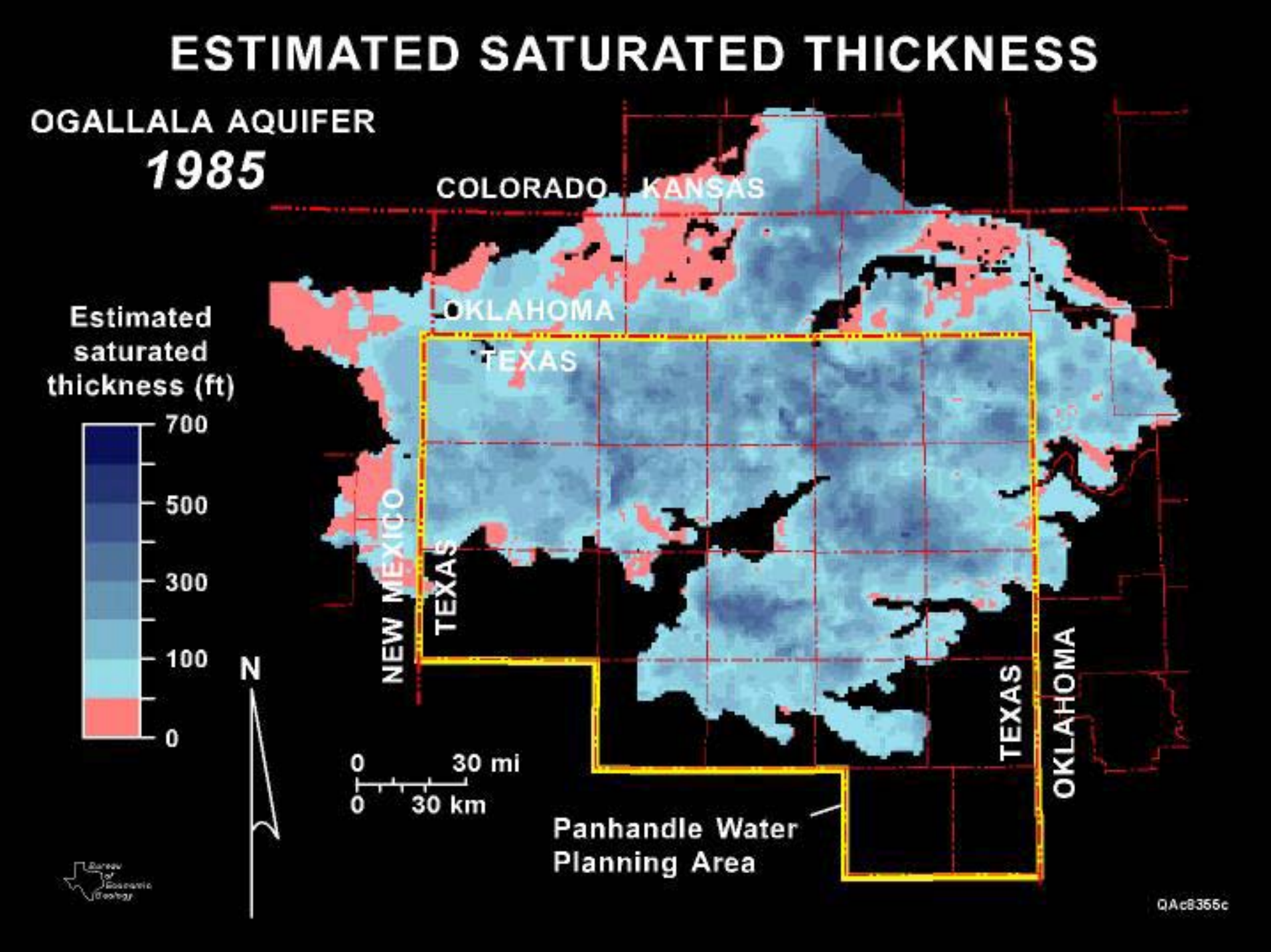


ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

1980

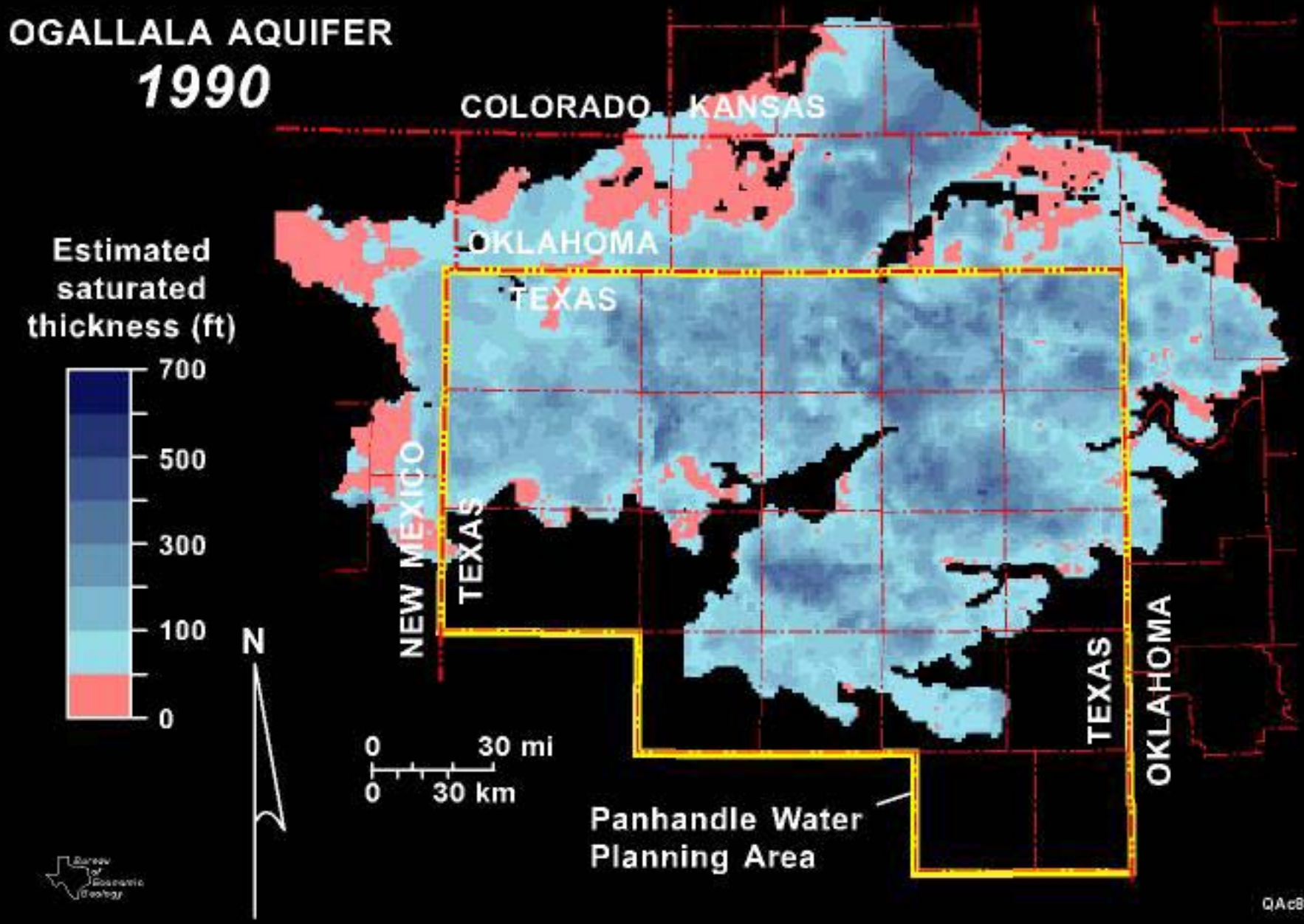



ESTIMATED SATURATED THICKNESS
OGALLALA AQUIFER
1985
COLORADO
KANSAS
OKLAHOMA
TEXAS
NEW MEXICO
TEXAS
TEXAS
OKLAHOMA
Estimated saturated thickness (ft)
700
500
300
100
0
N
0
30 mi
0
30 km
Panhandle Water Planning Area
QAc8355c

ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

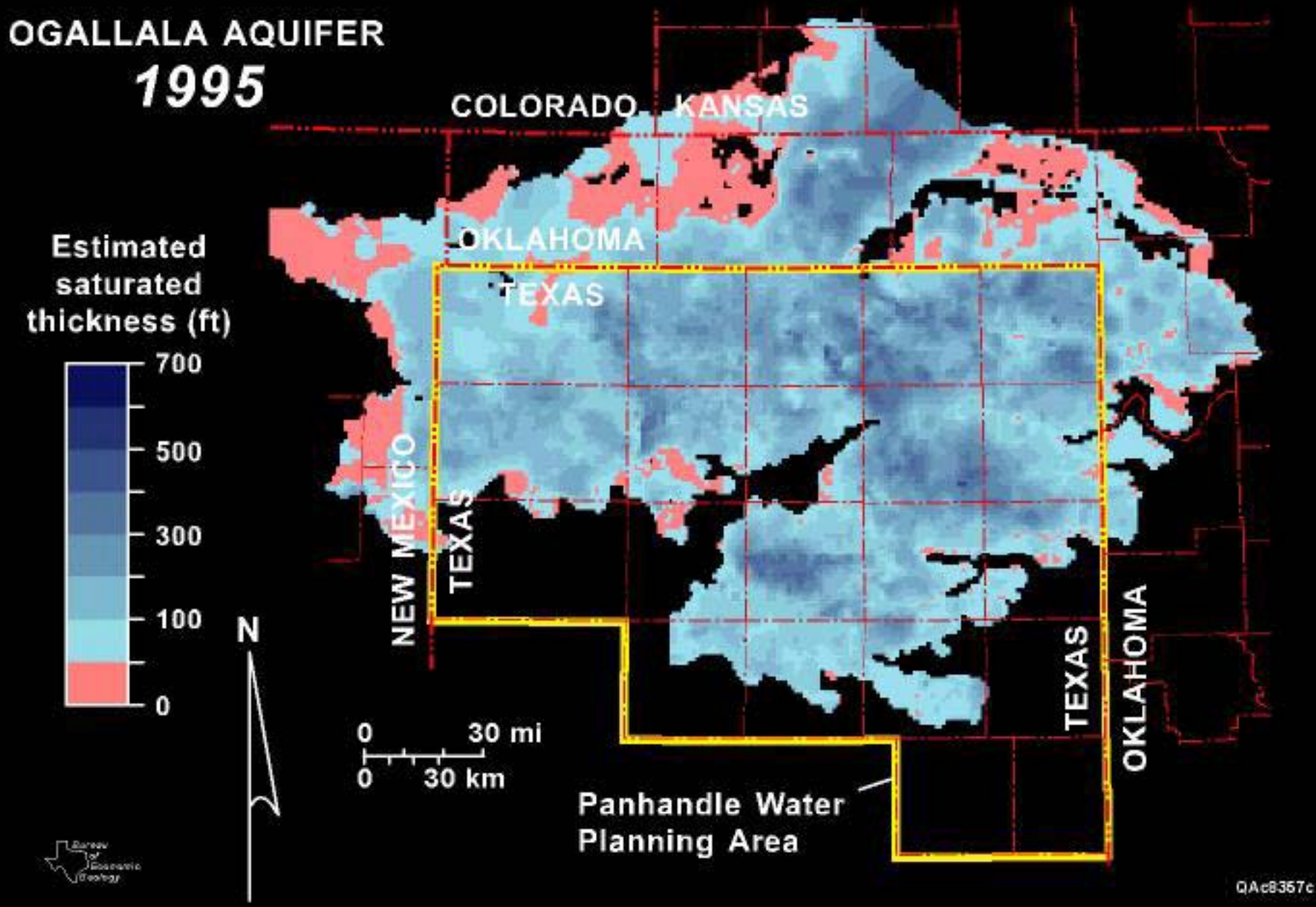
1990



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

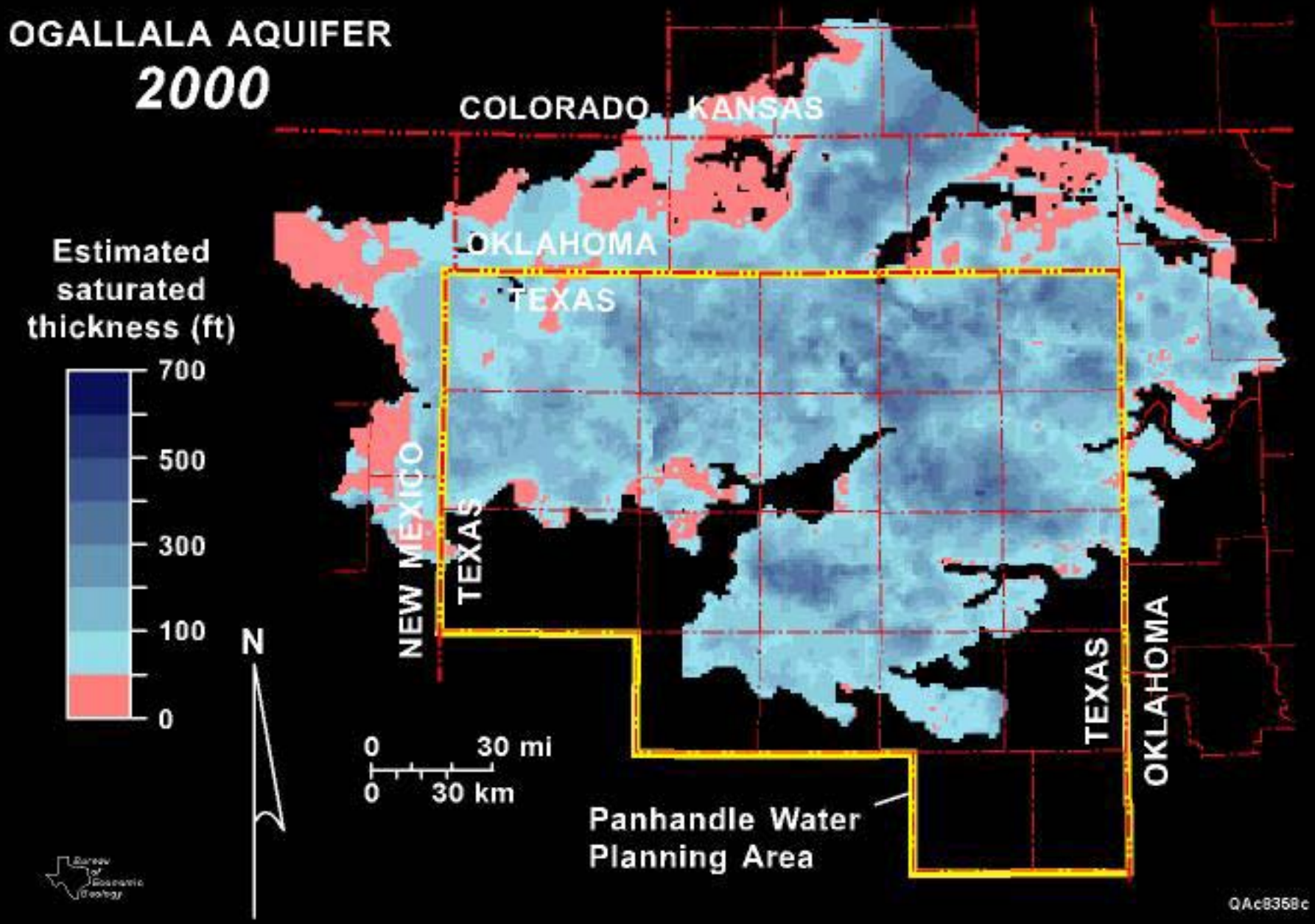
1995



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

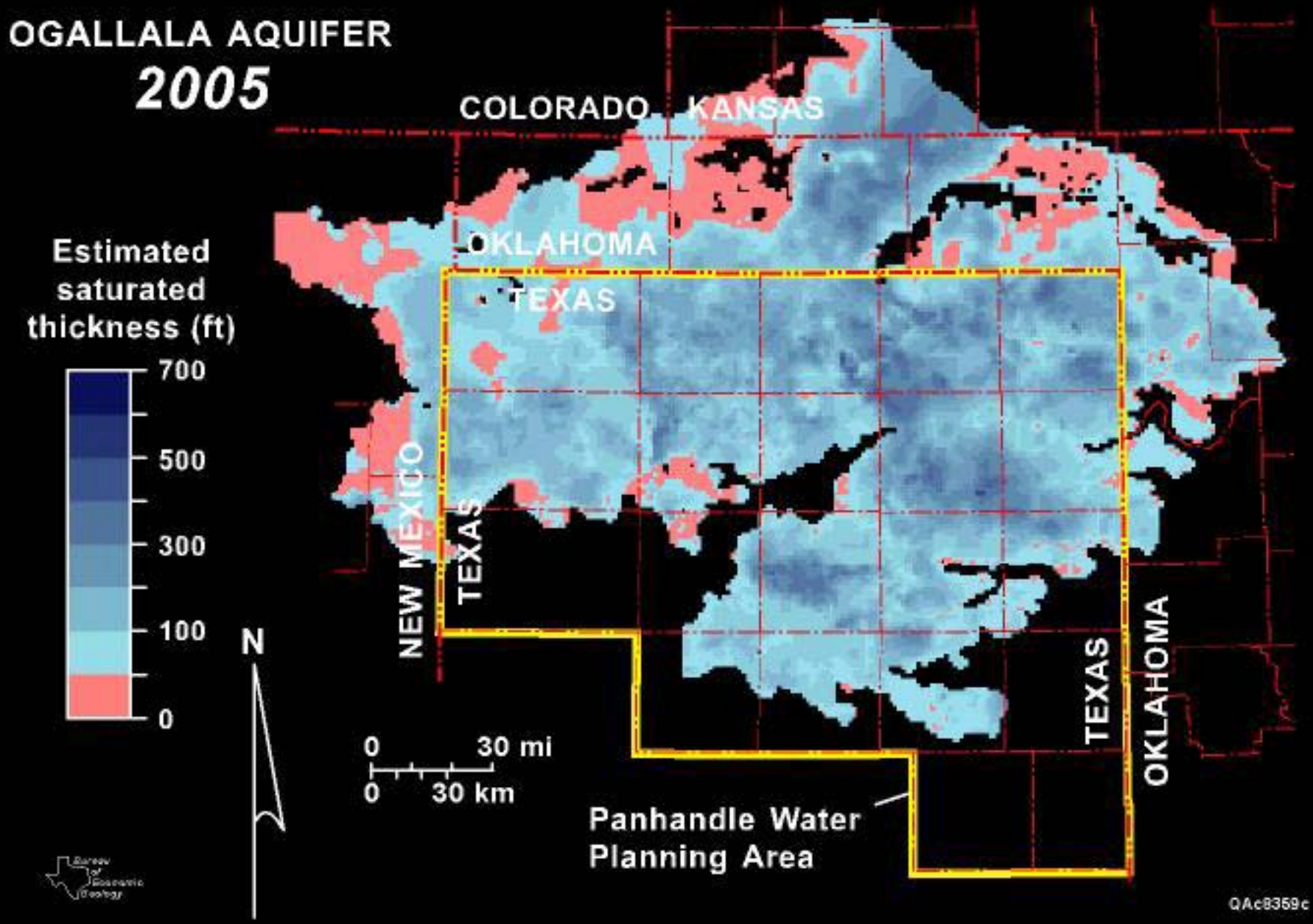
2000



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

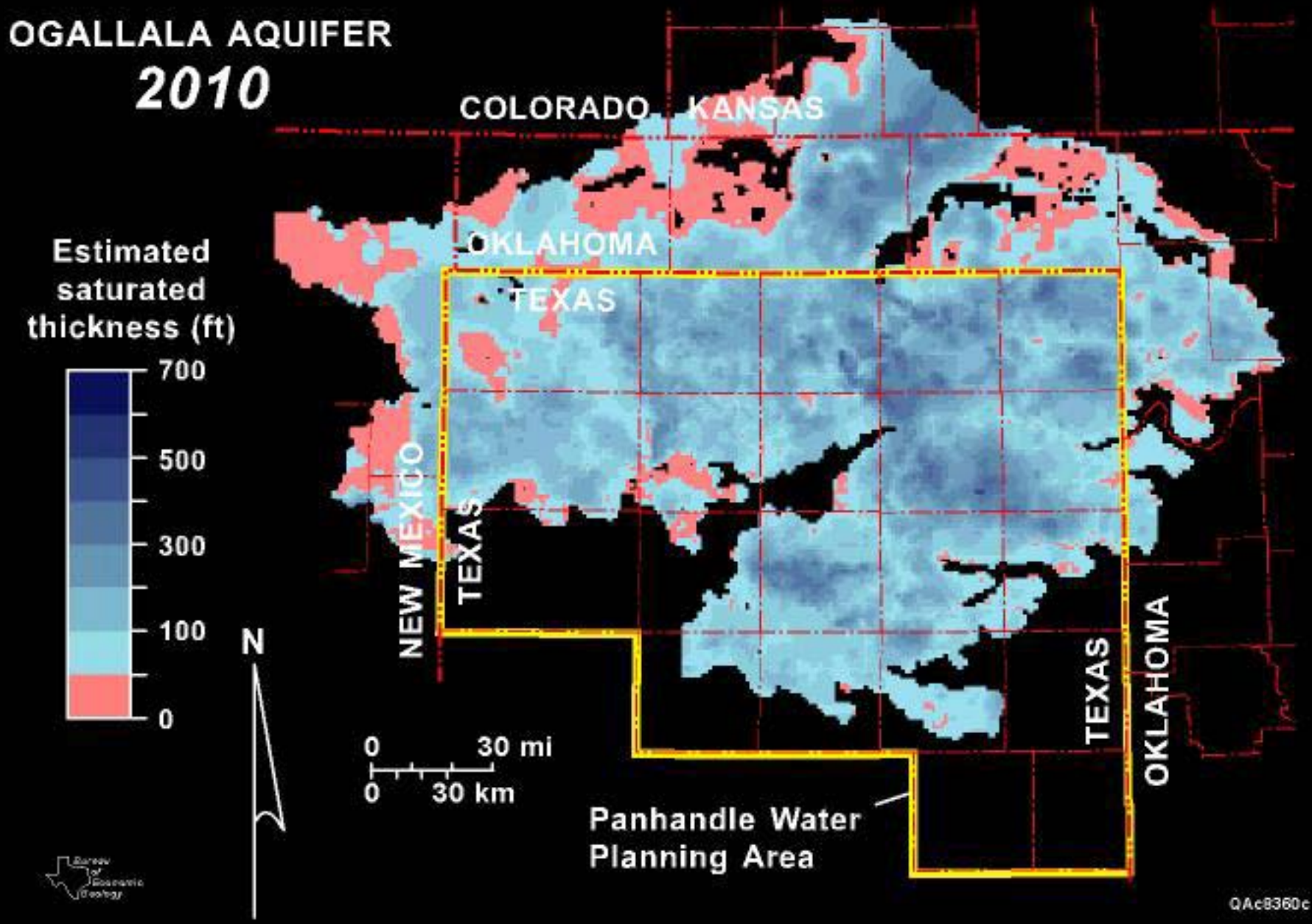
2005



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

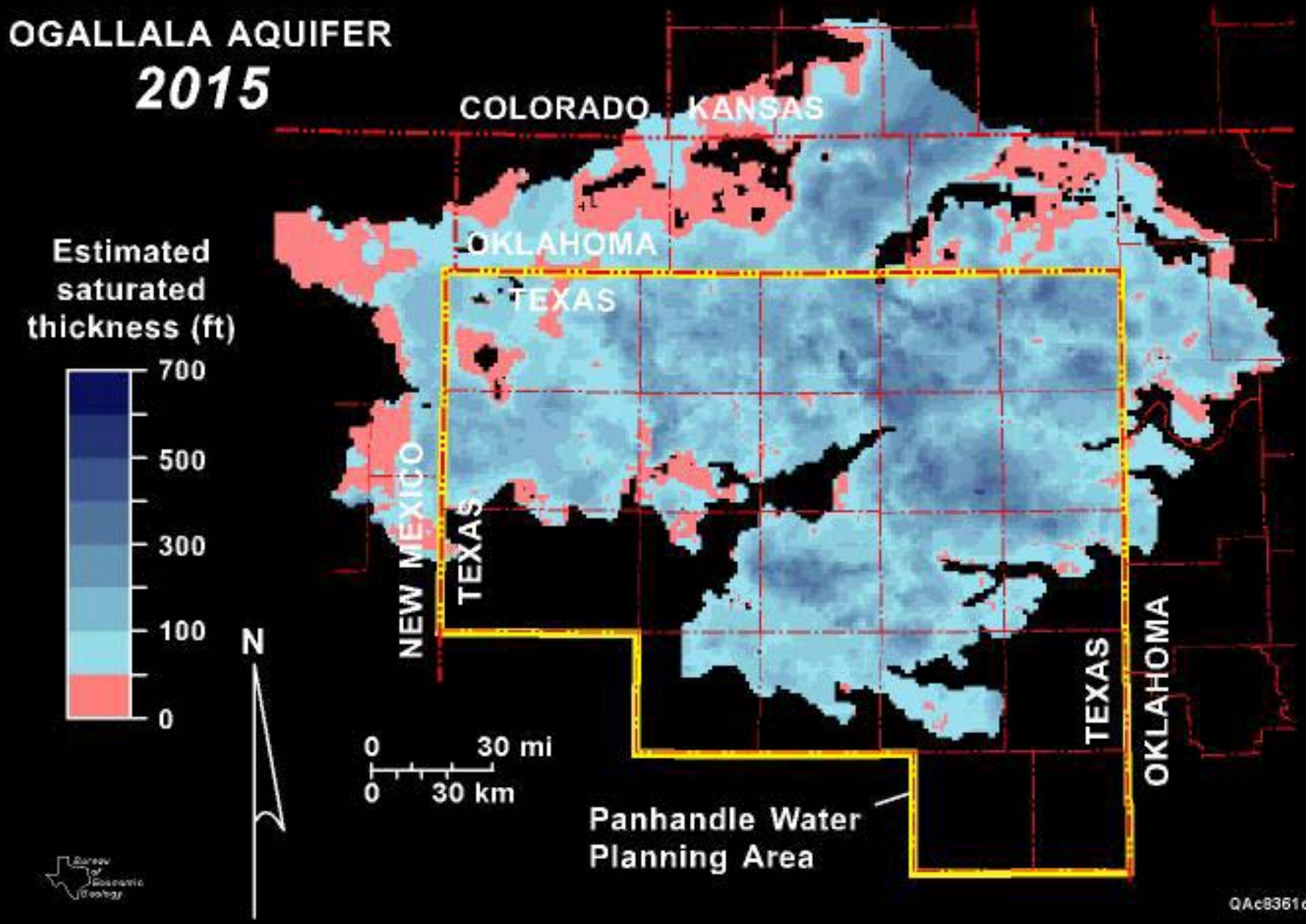
2010



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

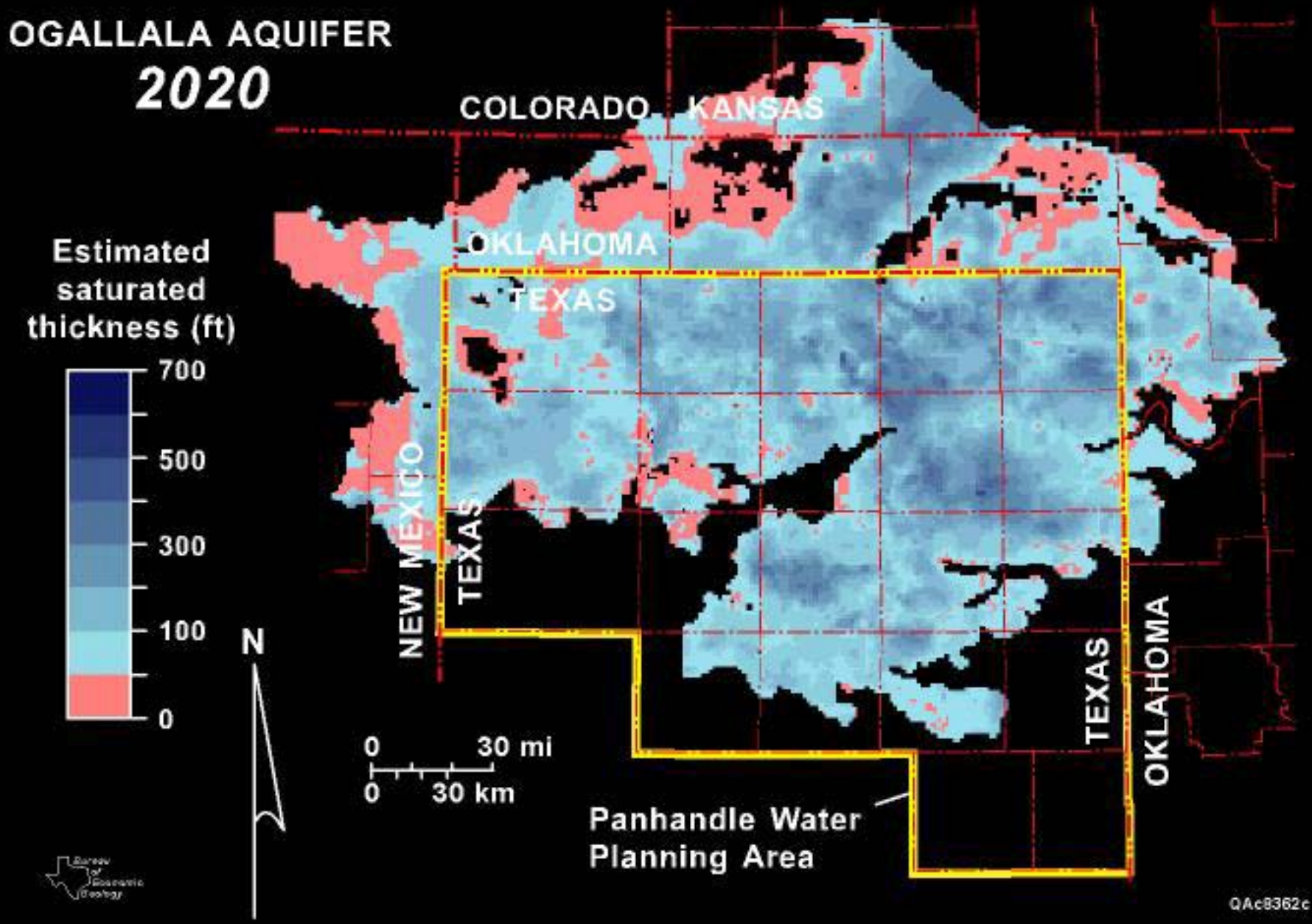
2015



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

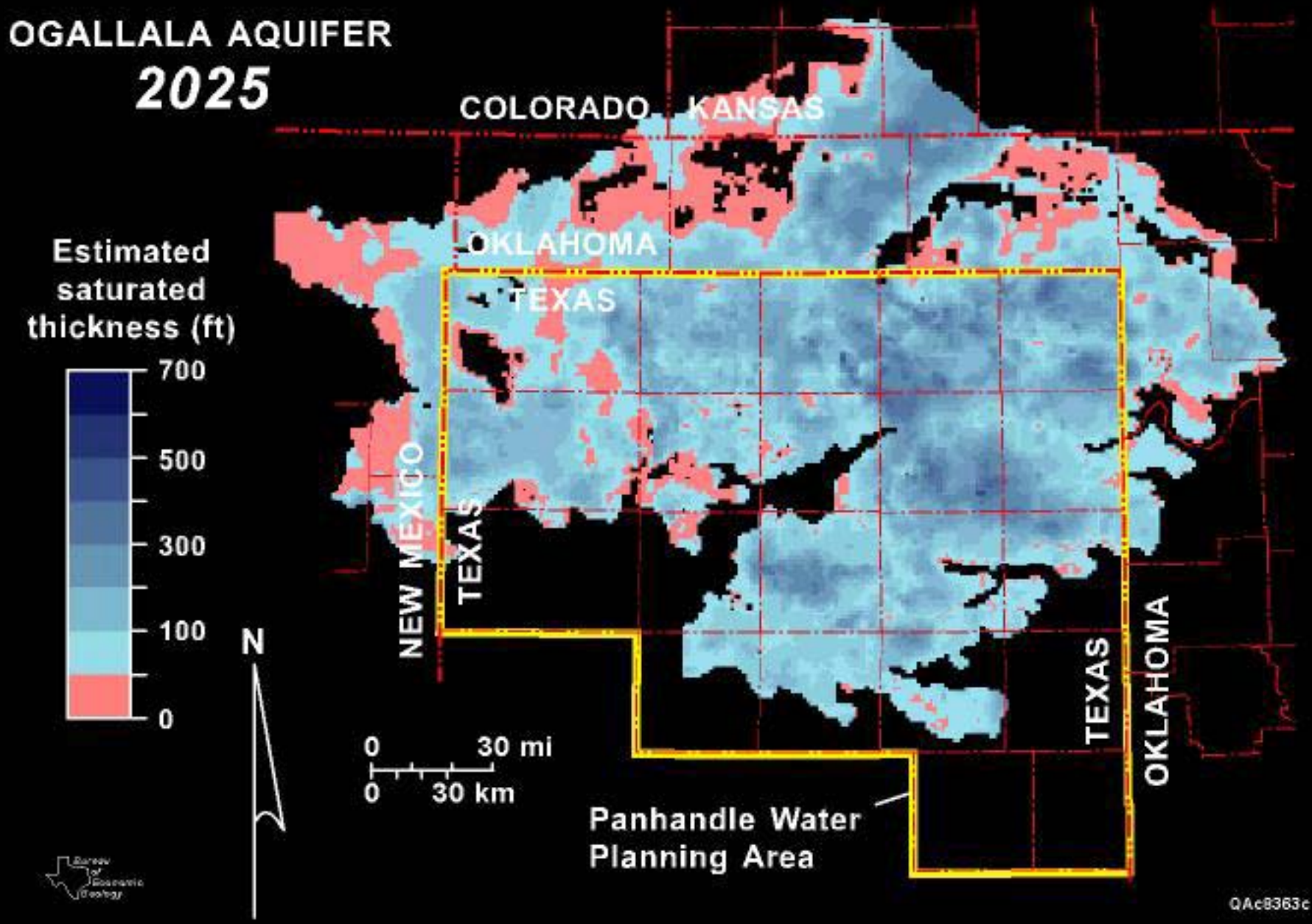
2020



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

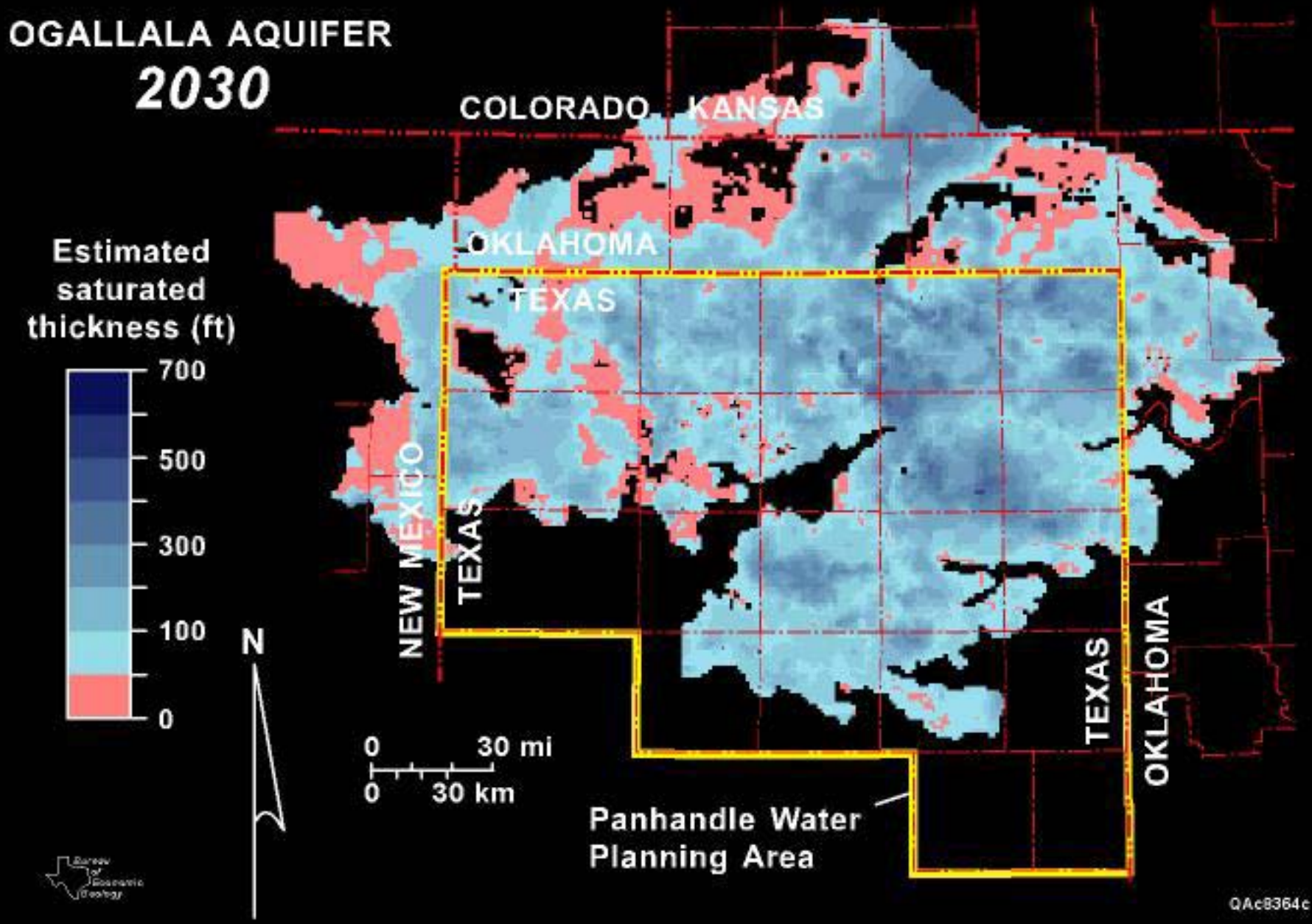
2025



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

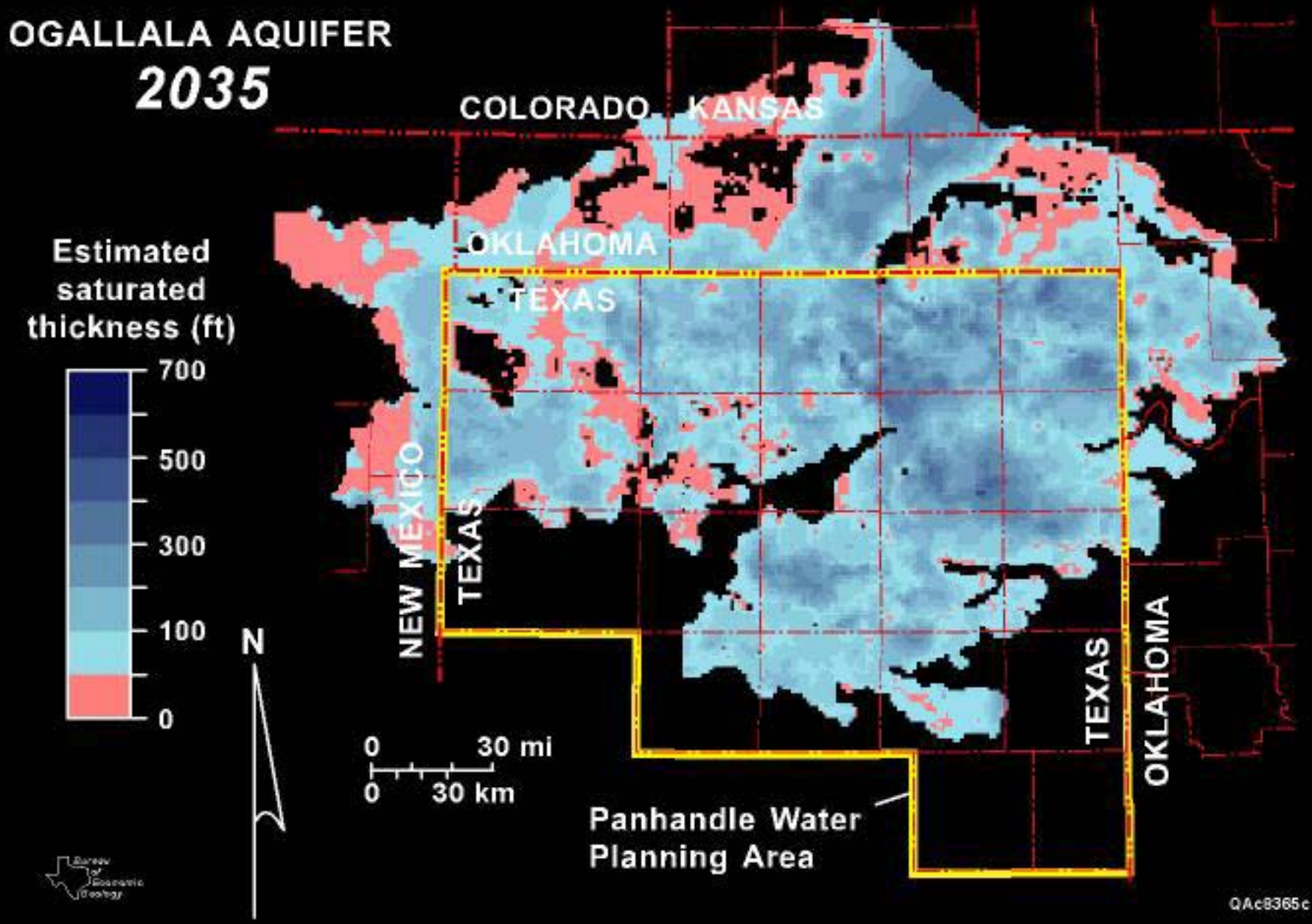
2030



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

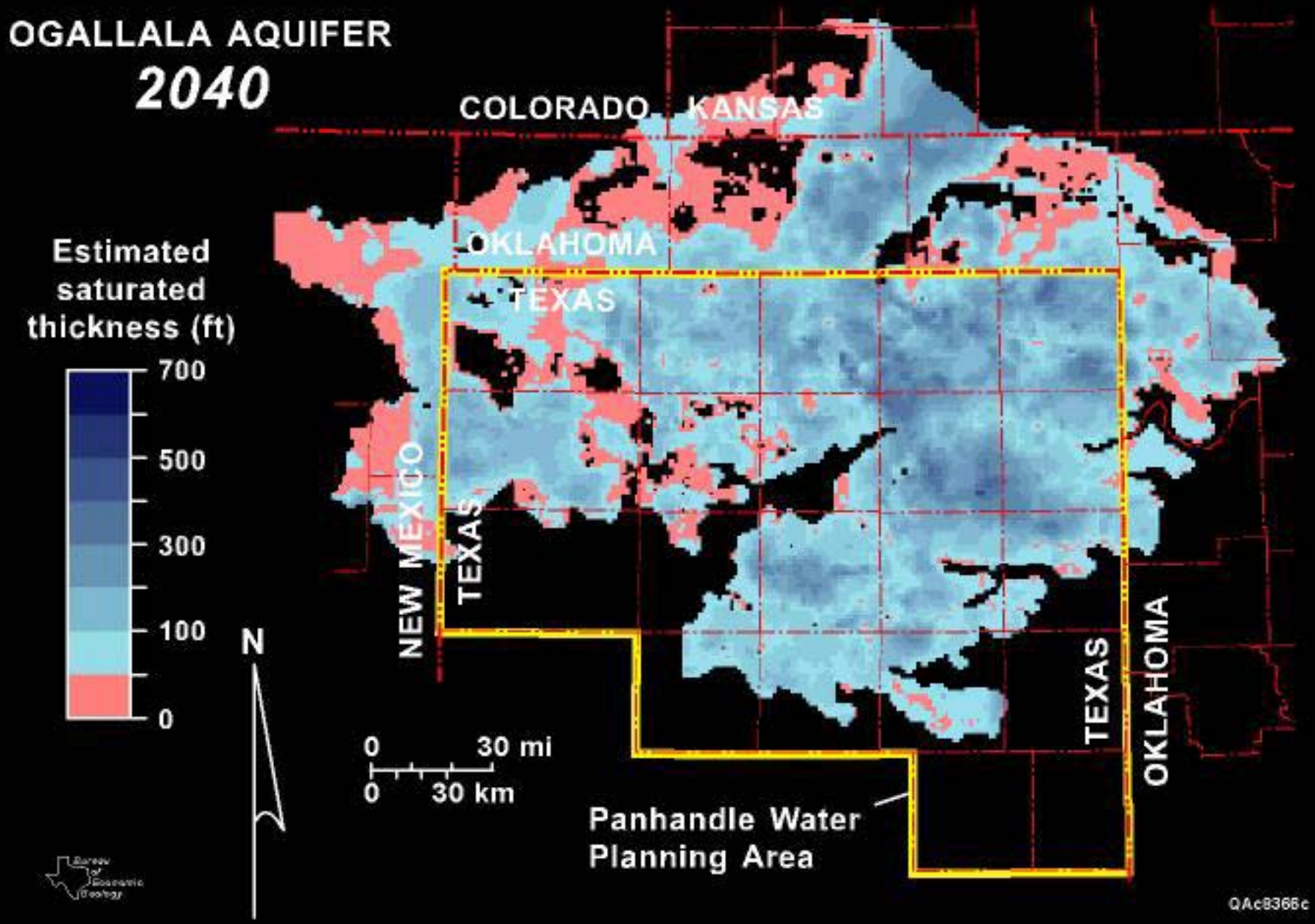
2035



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

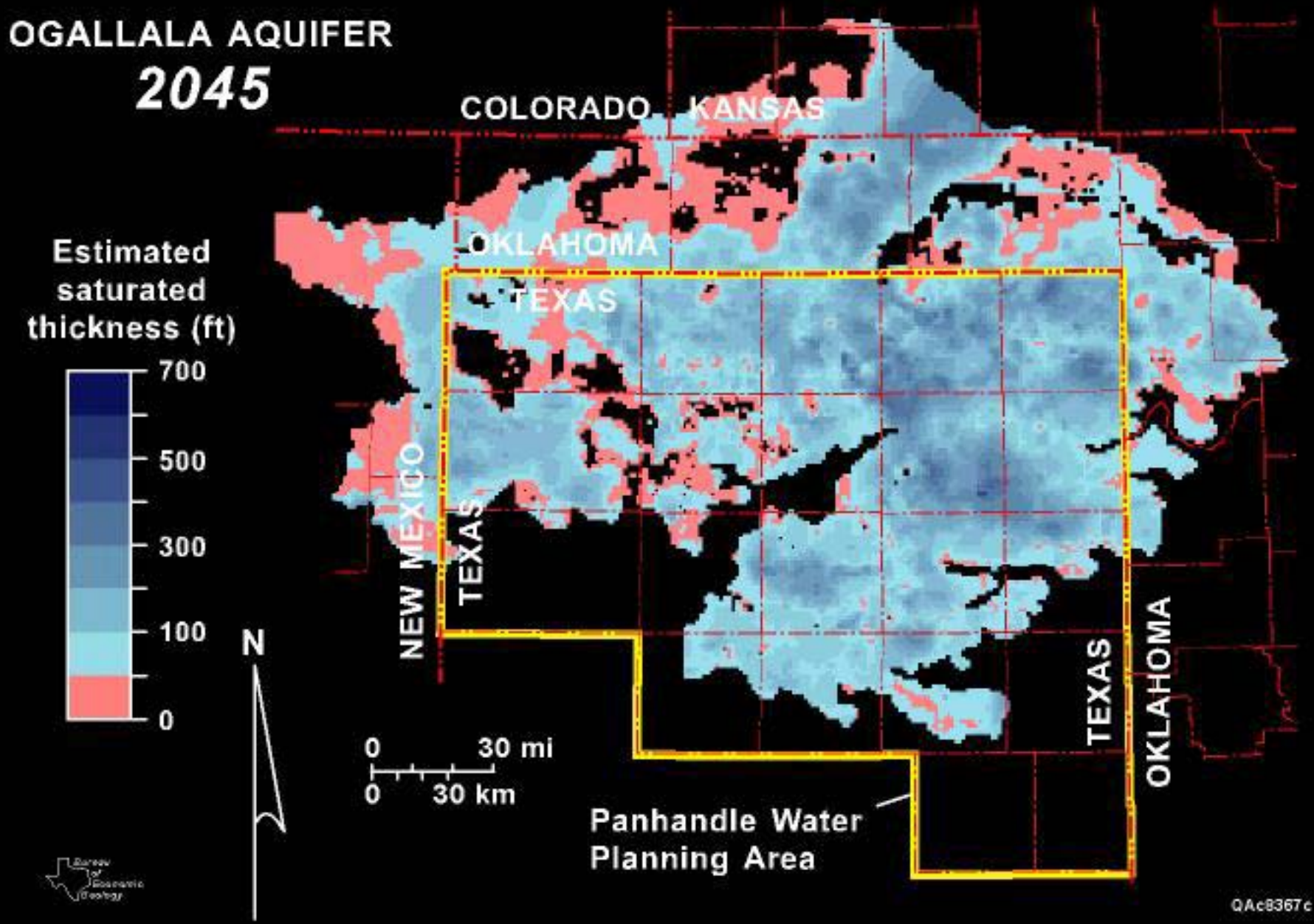
2040



ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

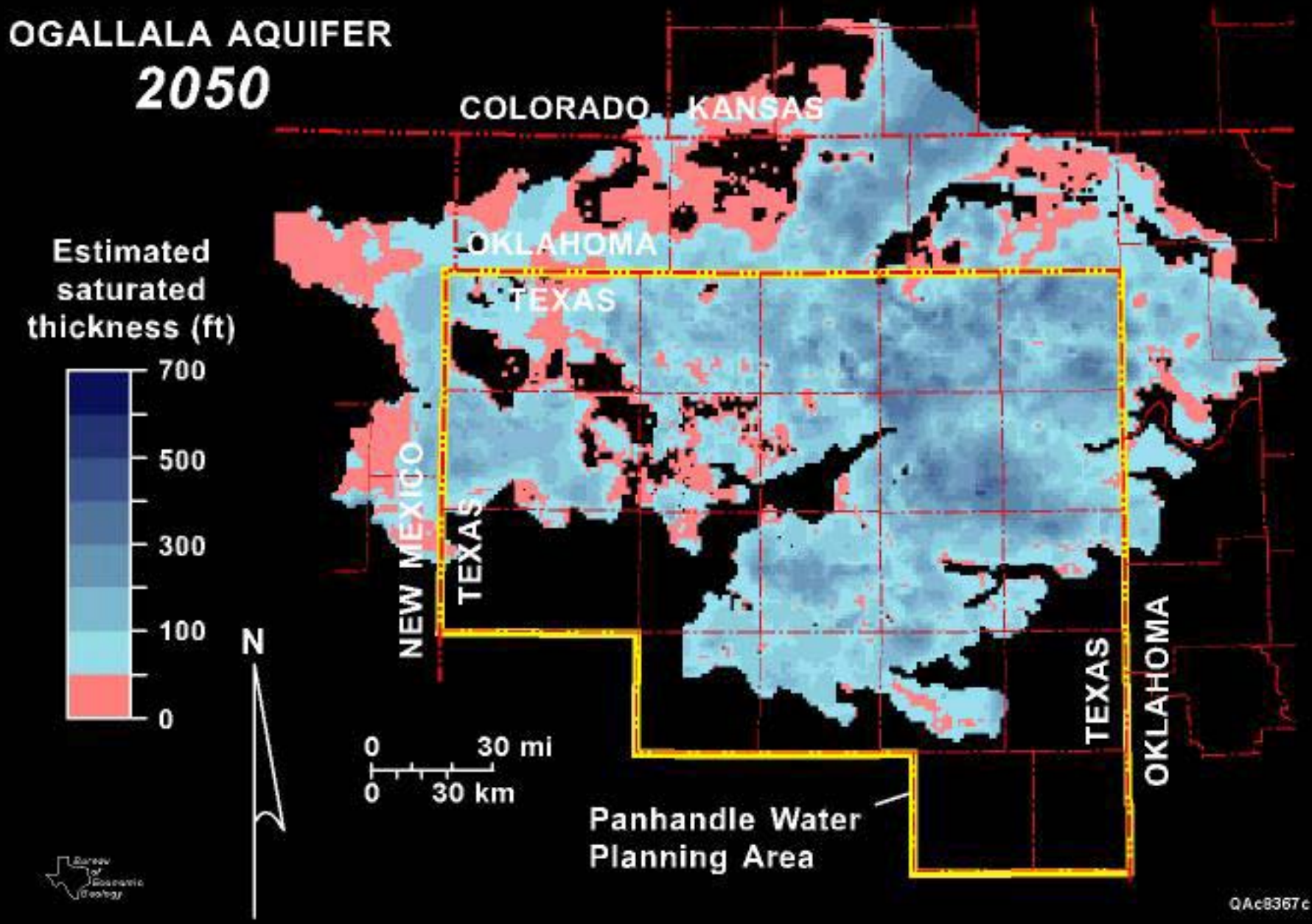
2045

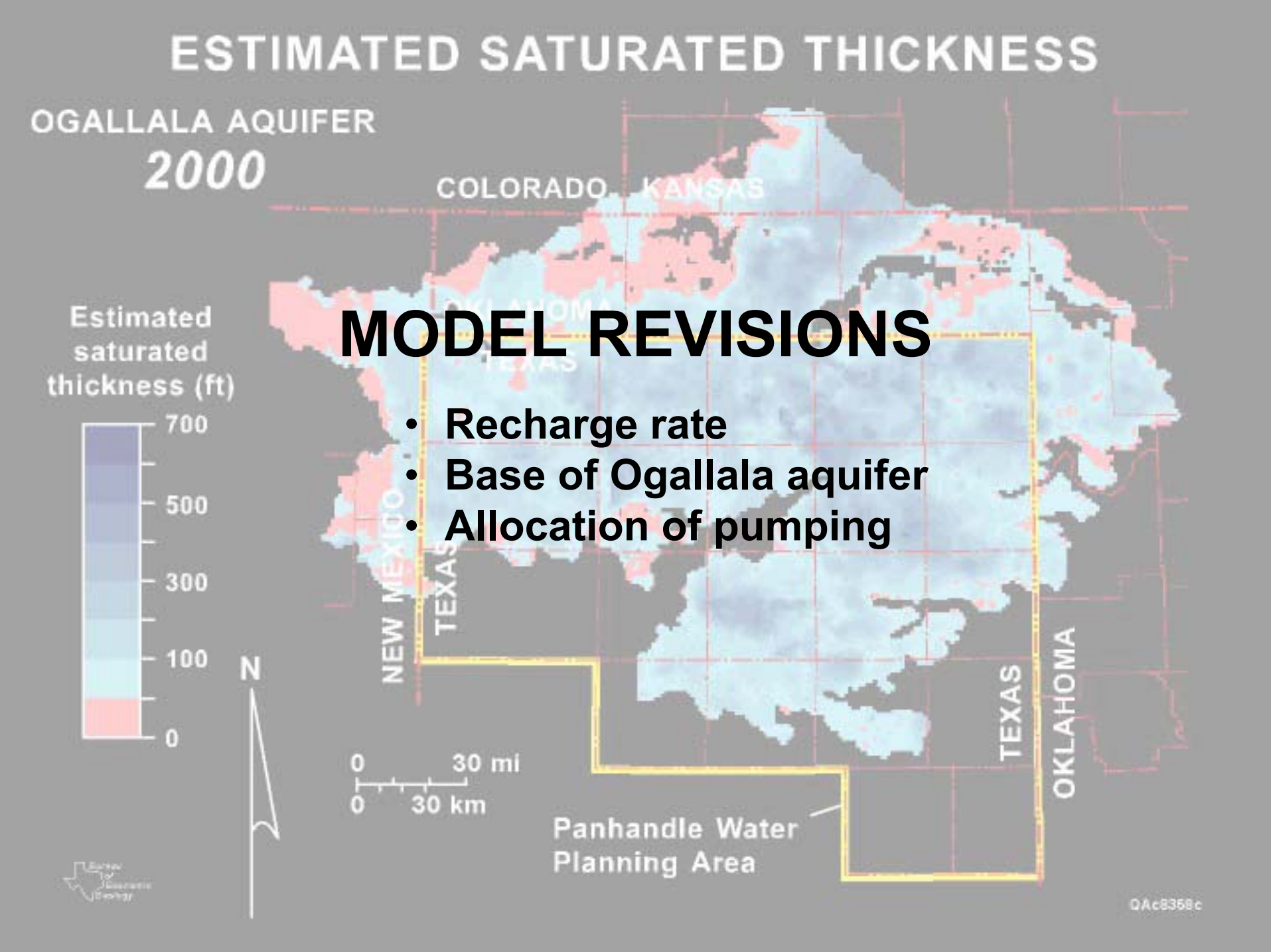


ESTIMATED SATURATED THICKNESS

OGALLALA AQUIFER

2050





MODEL REVISIONS

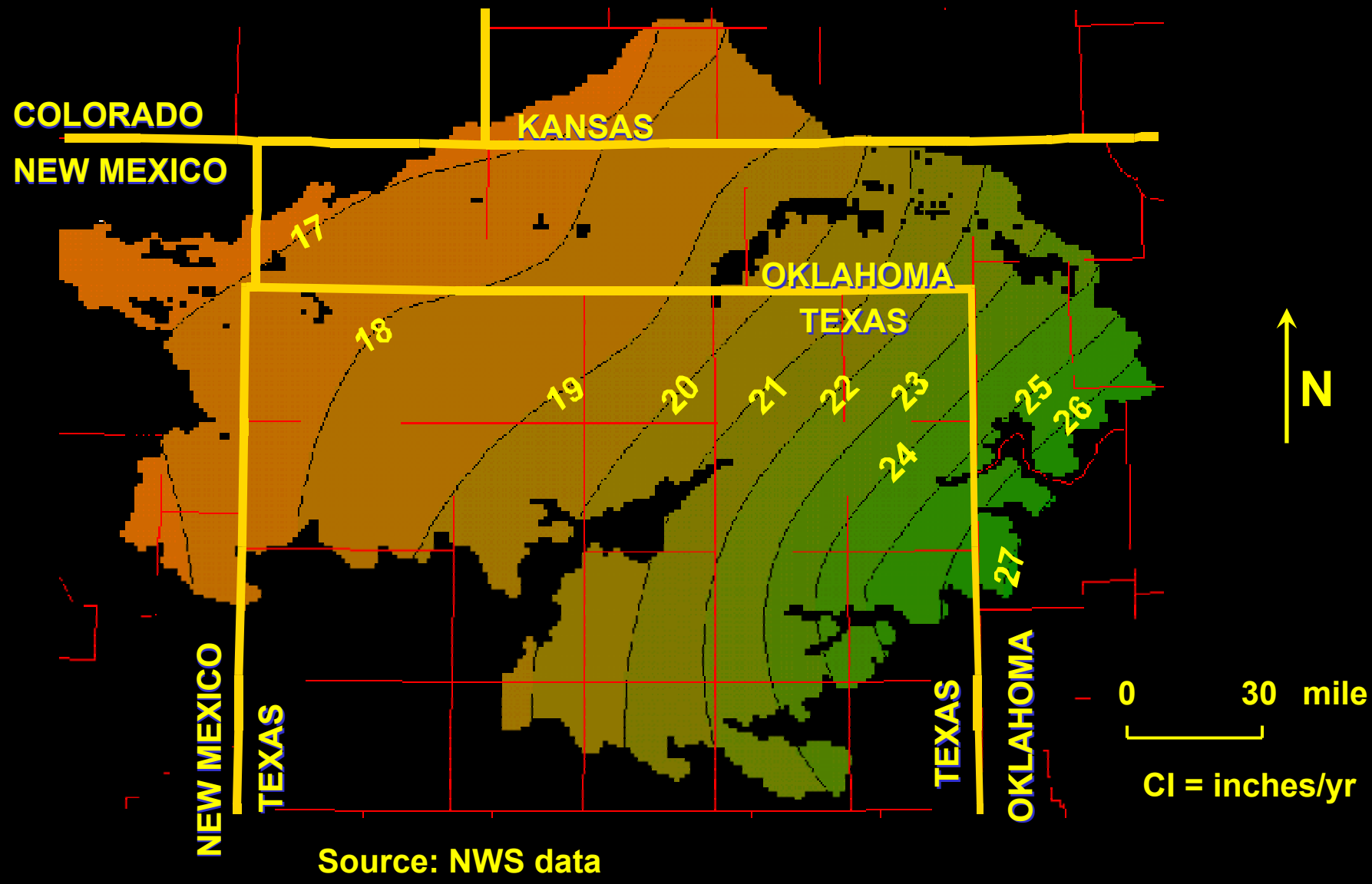
- Recharge rate
- Base of Ogallala aquifer
- Allocation of pumping

RECHARGE

Photo near Washburn, Armstrong County, Texas

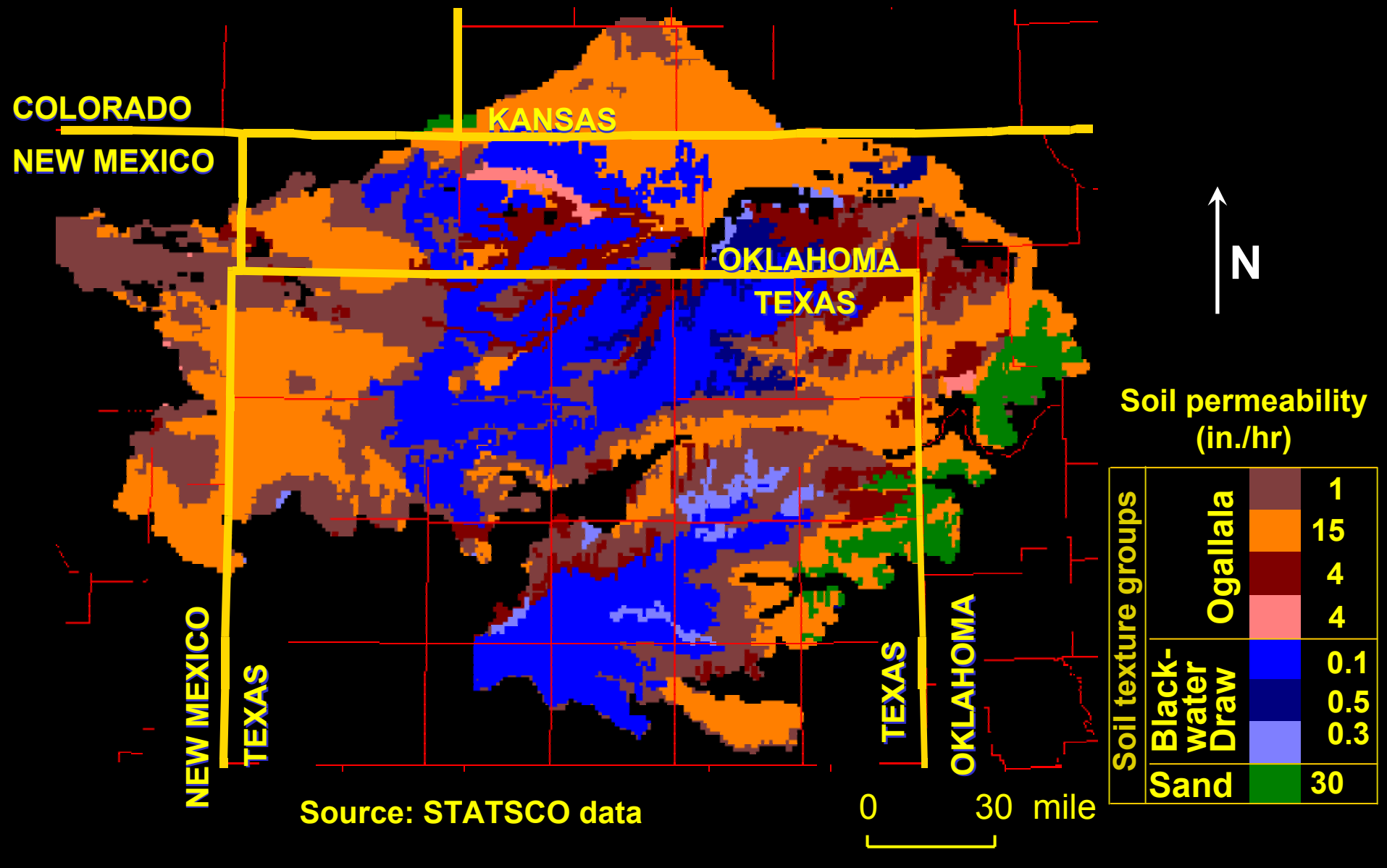
Photo by R. Baumgardner; Digital editing by D. Stephens

ANNUAL PRECIPITATION

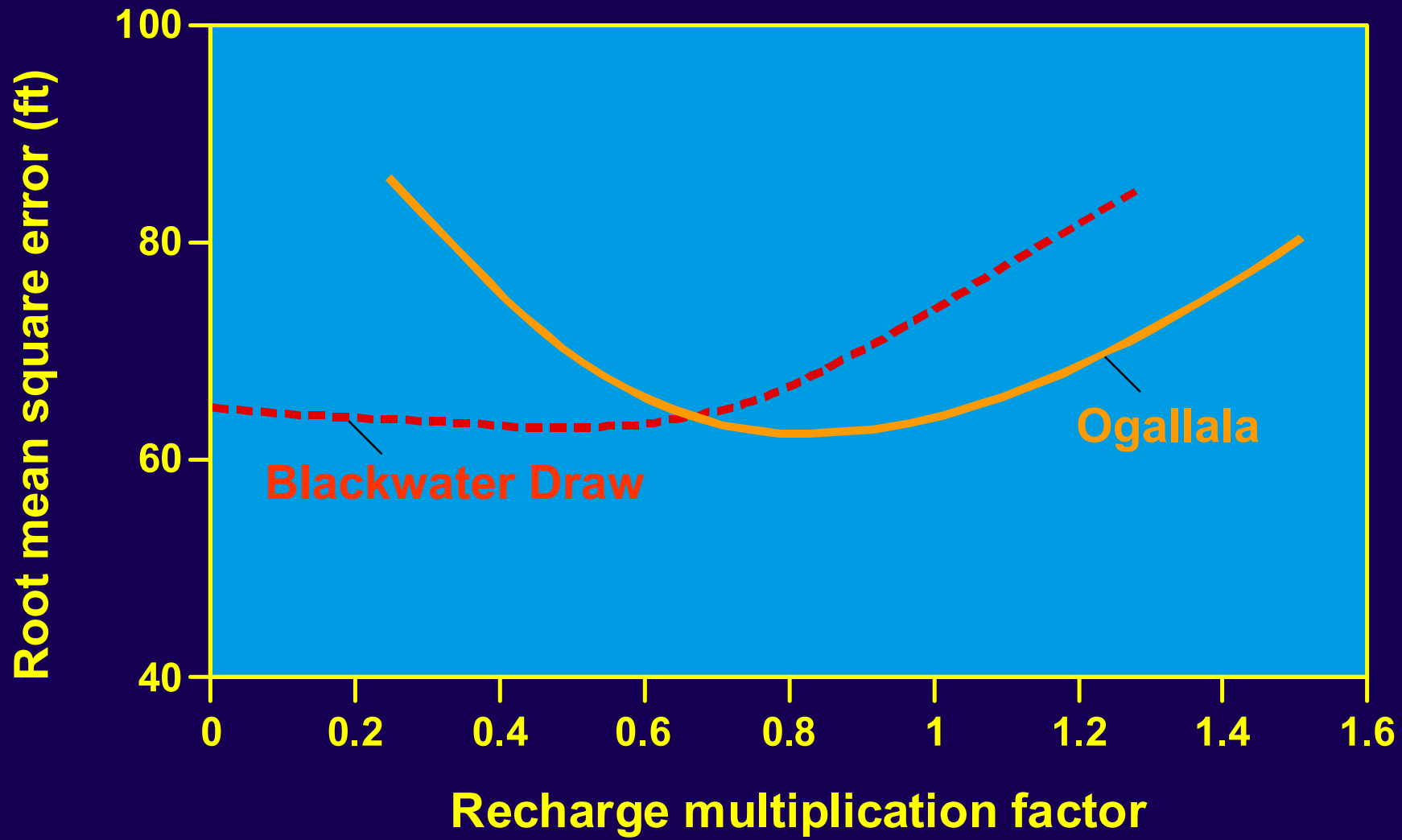


Source: NWS data

SOILS

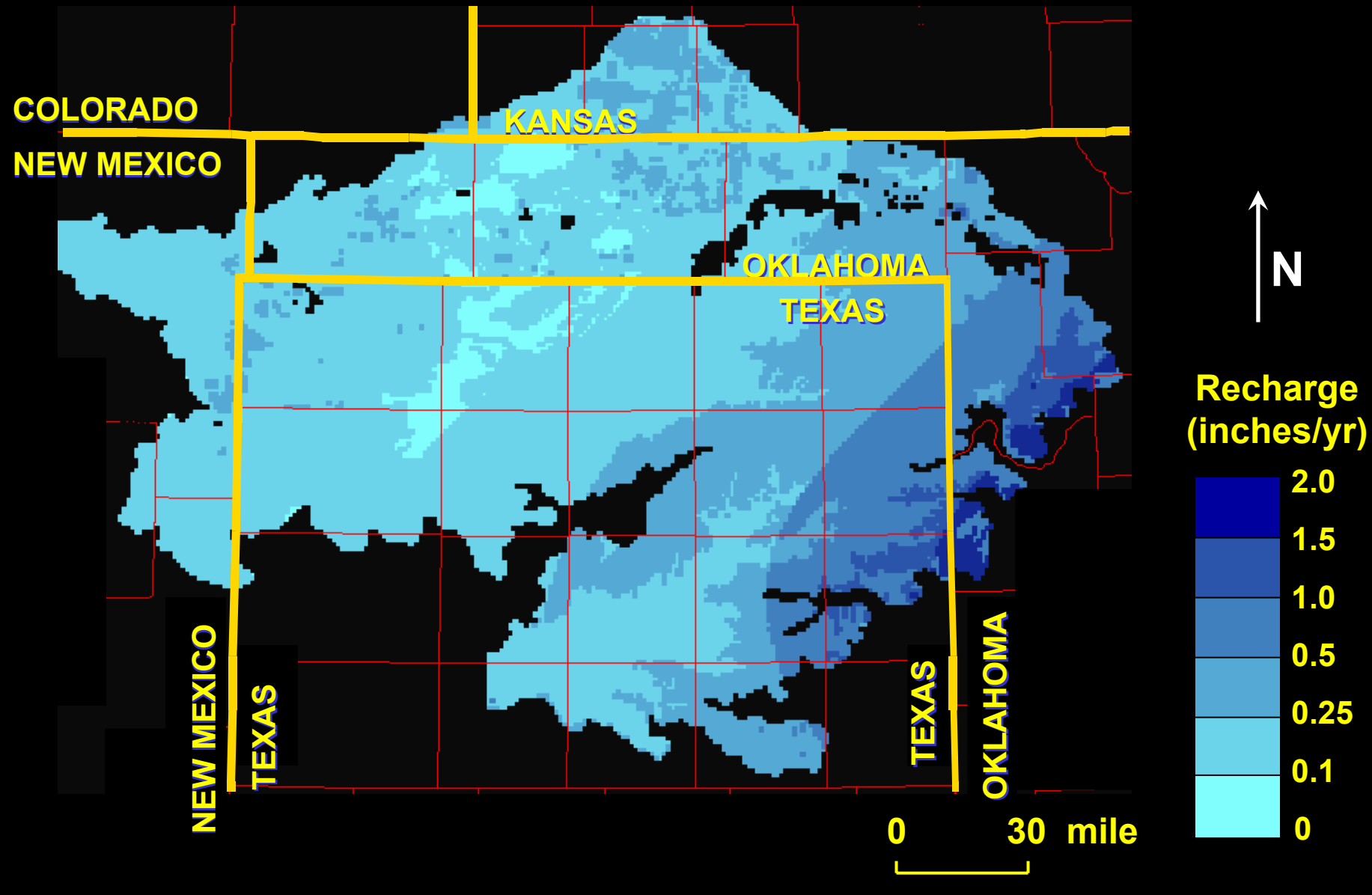

COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
NEW MEXICO
TEXAS
TEXAS
OKLAHOMA
N
Soil permeability (in./hr)
Soil texture groups
Ogallala
1
15
4
4
Black-water Draw
0.1
0.5
0.3
Sand
30
Source: STATSCO data
0
30 mile

SENSITIVITY TO SOIL-BASED RECHARGE FACTOR



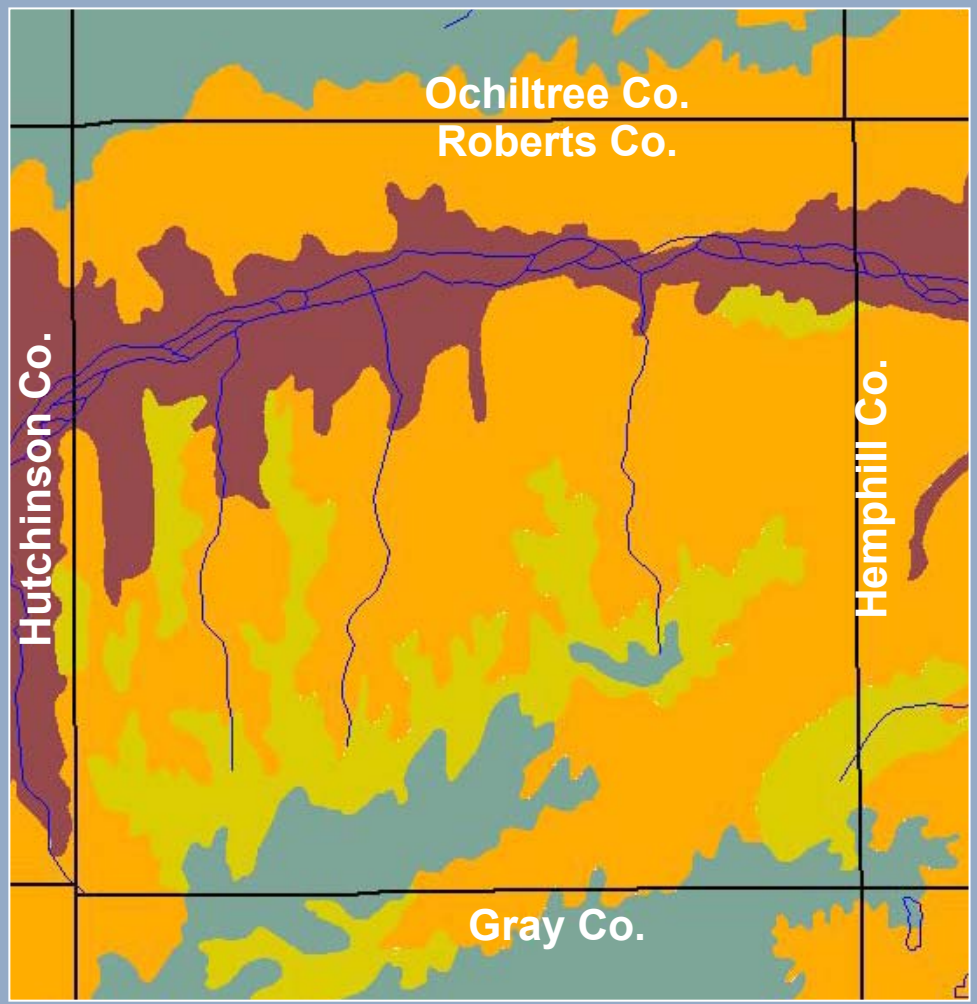
MODELED RECHARGE

"Predevelopment"



NEW SOILS MAPPING

A New Look at STATSGO Data as a Basis for Mapping Recharge



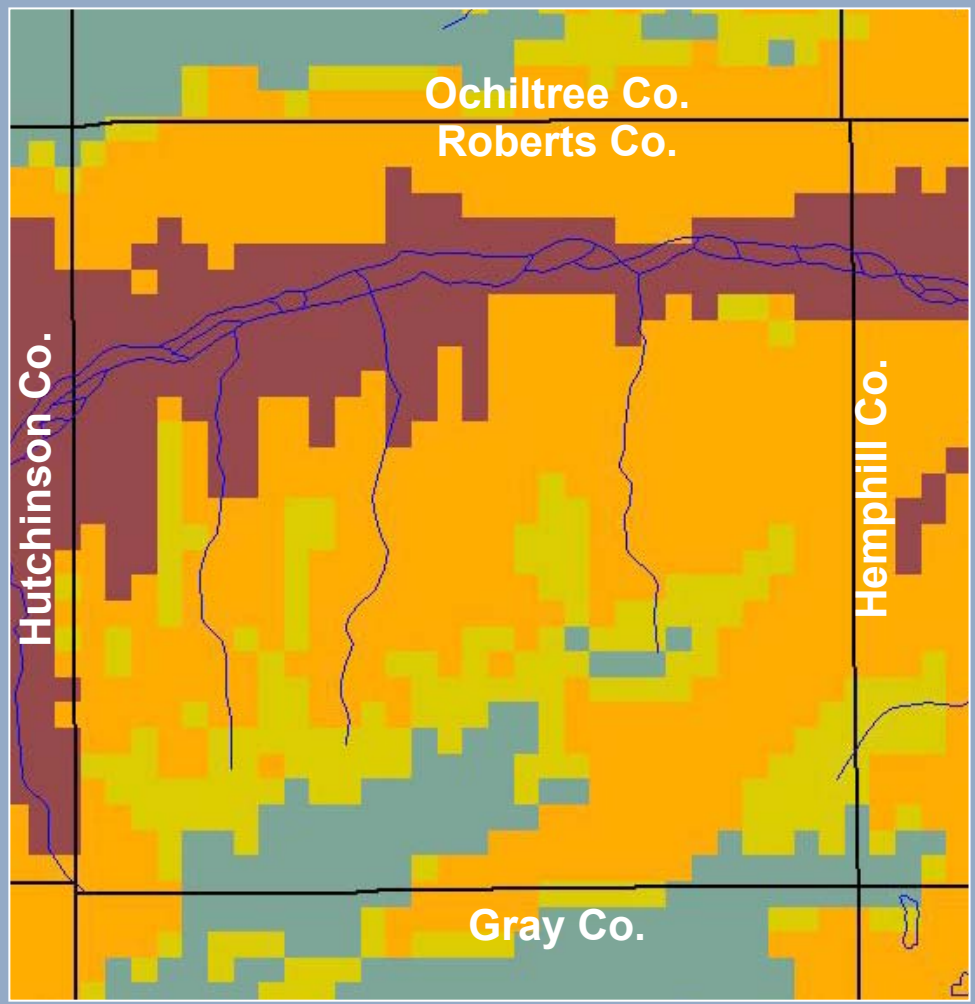
STATSGO Polygons

Soil permeability (inches/hour)

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

NEW SOILS MAPPING

A New Look at STATSGO Data as a Basis for Mapping Recharge



Model Grid Cells

Soil permeability (inches/hour)

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

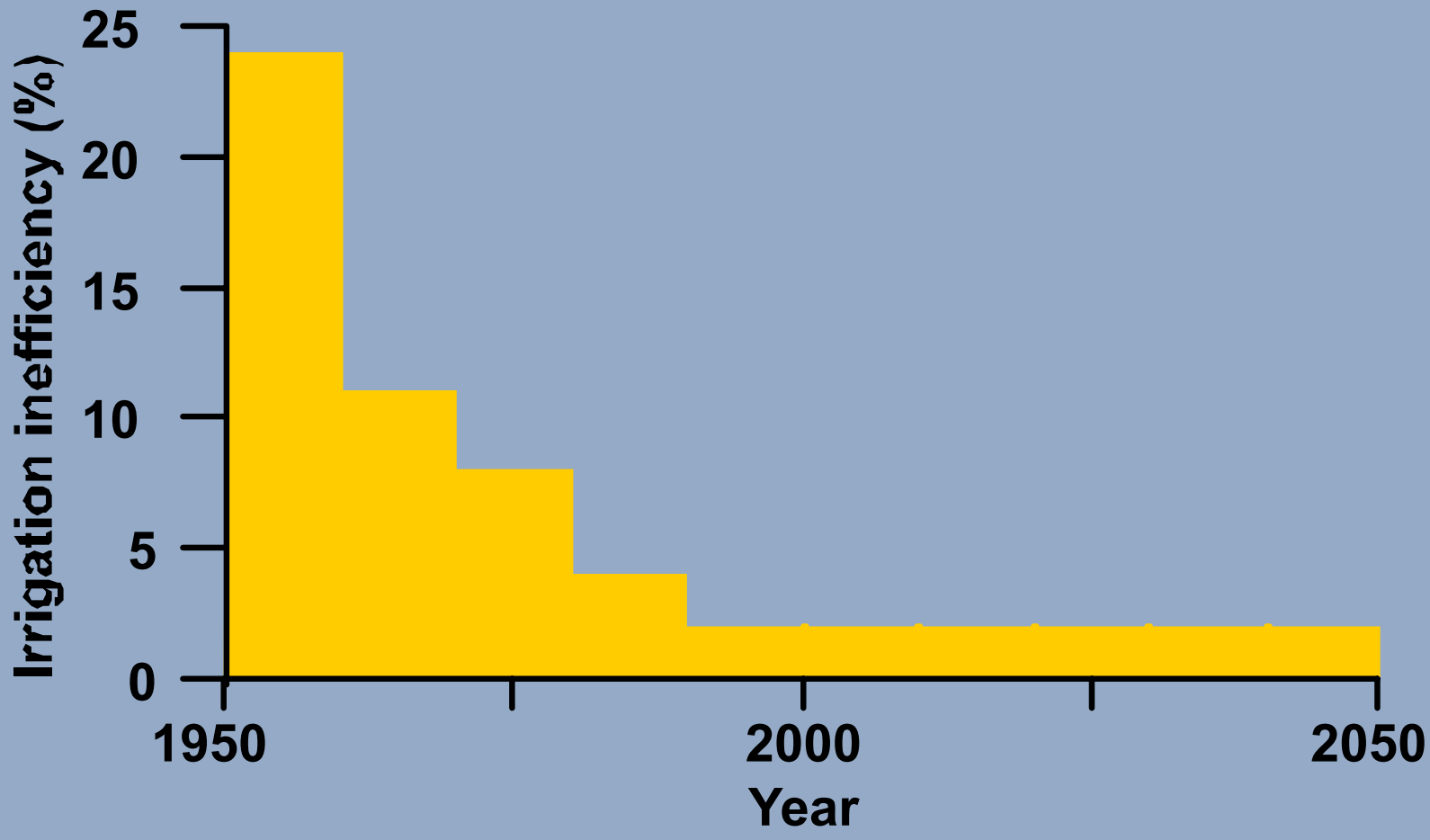
RETURN FLOW FROM IRRIGATION

Variables

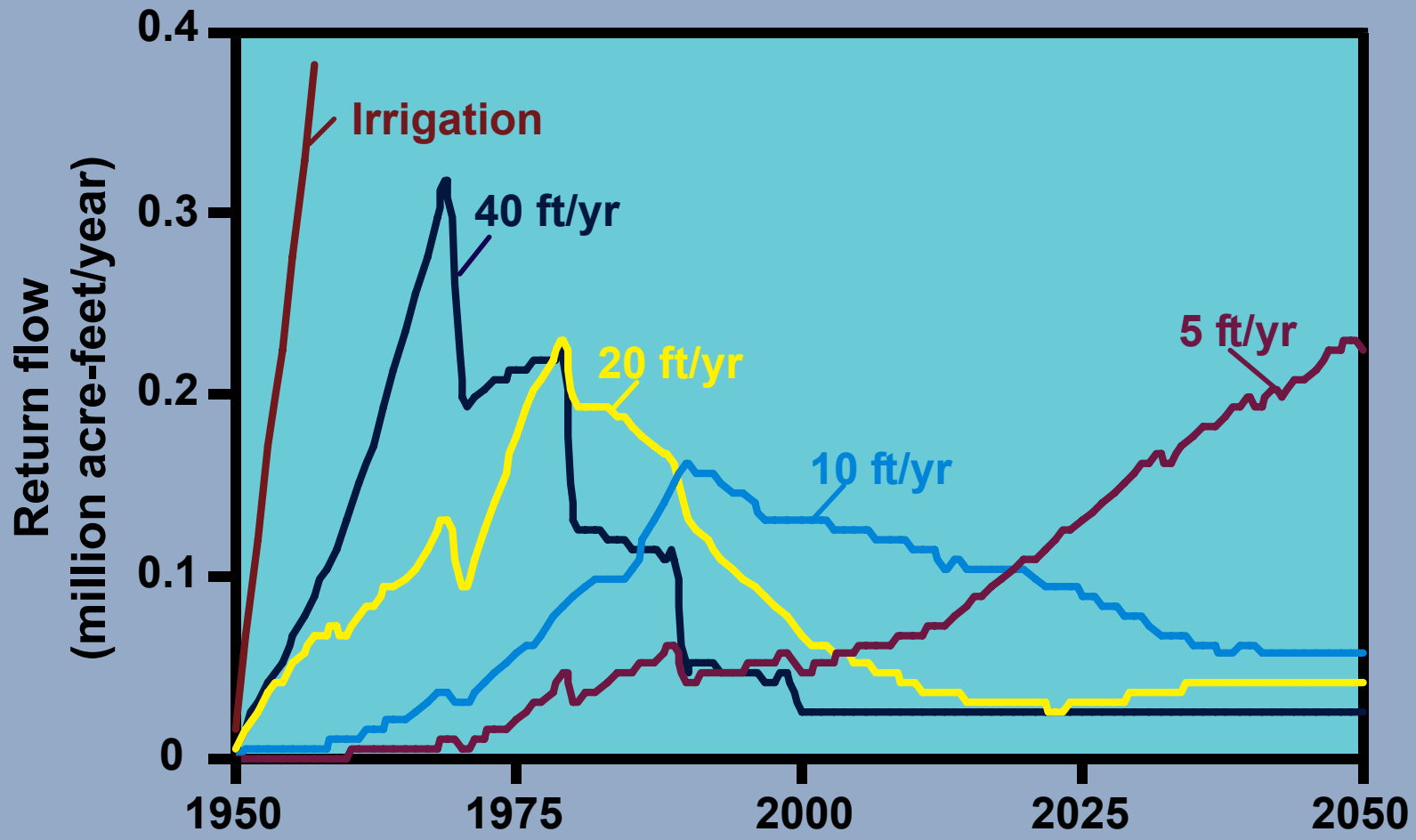
- Irrigation rate
- Irrigation efficiency
- Soil permeability
- Depth to water
- Velocity through unsaturated zone

IRRIGATION INEFFICIENCY MODEL

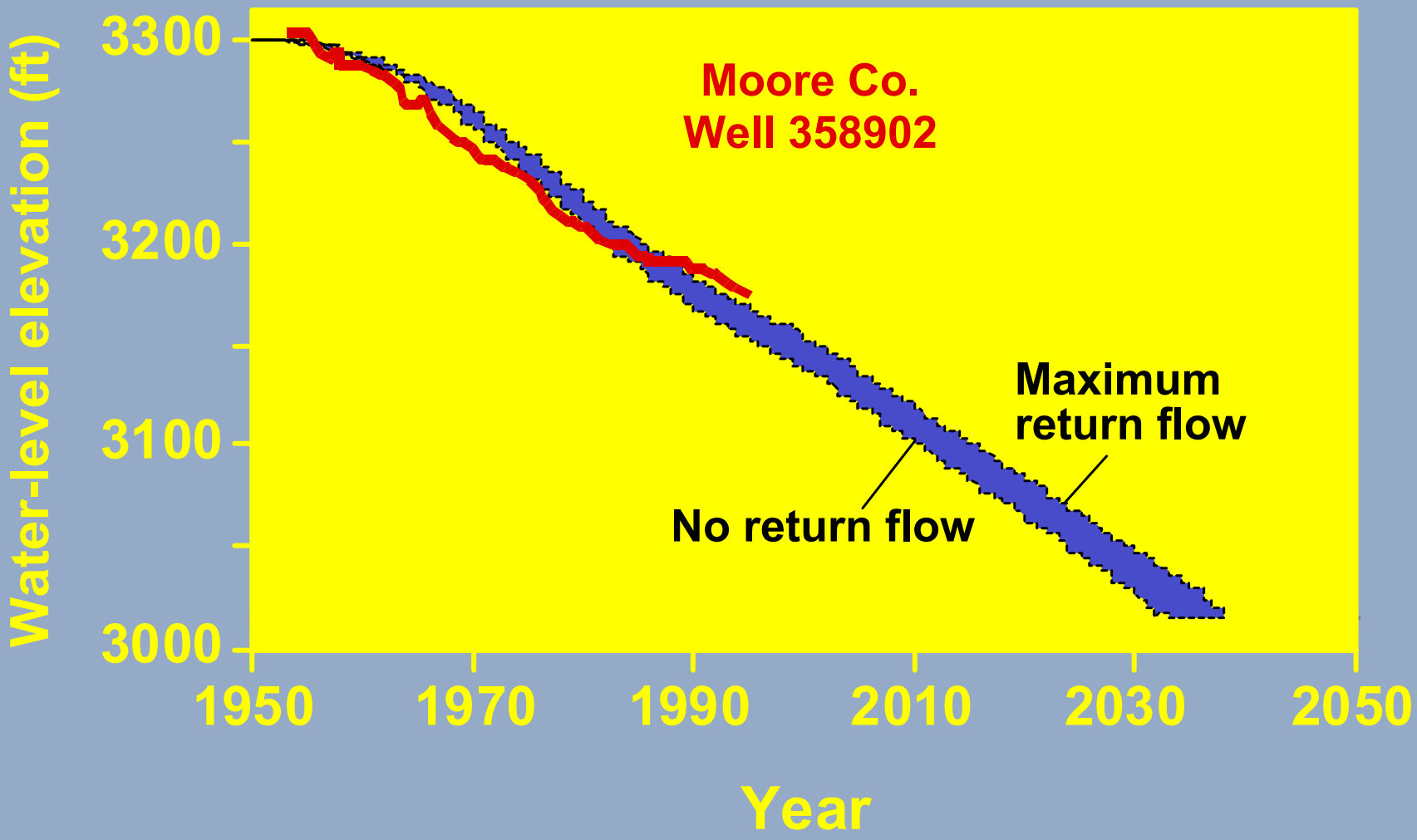
(Luckey and Becker, 1999)



RETURN FLOW VELOCITY MODEL

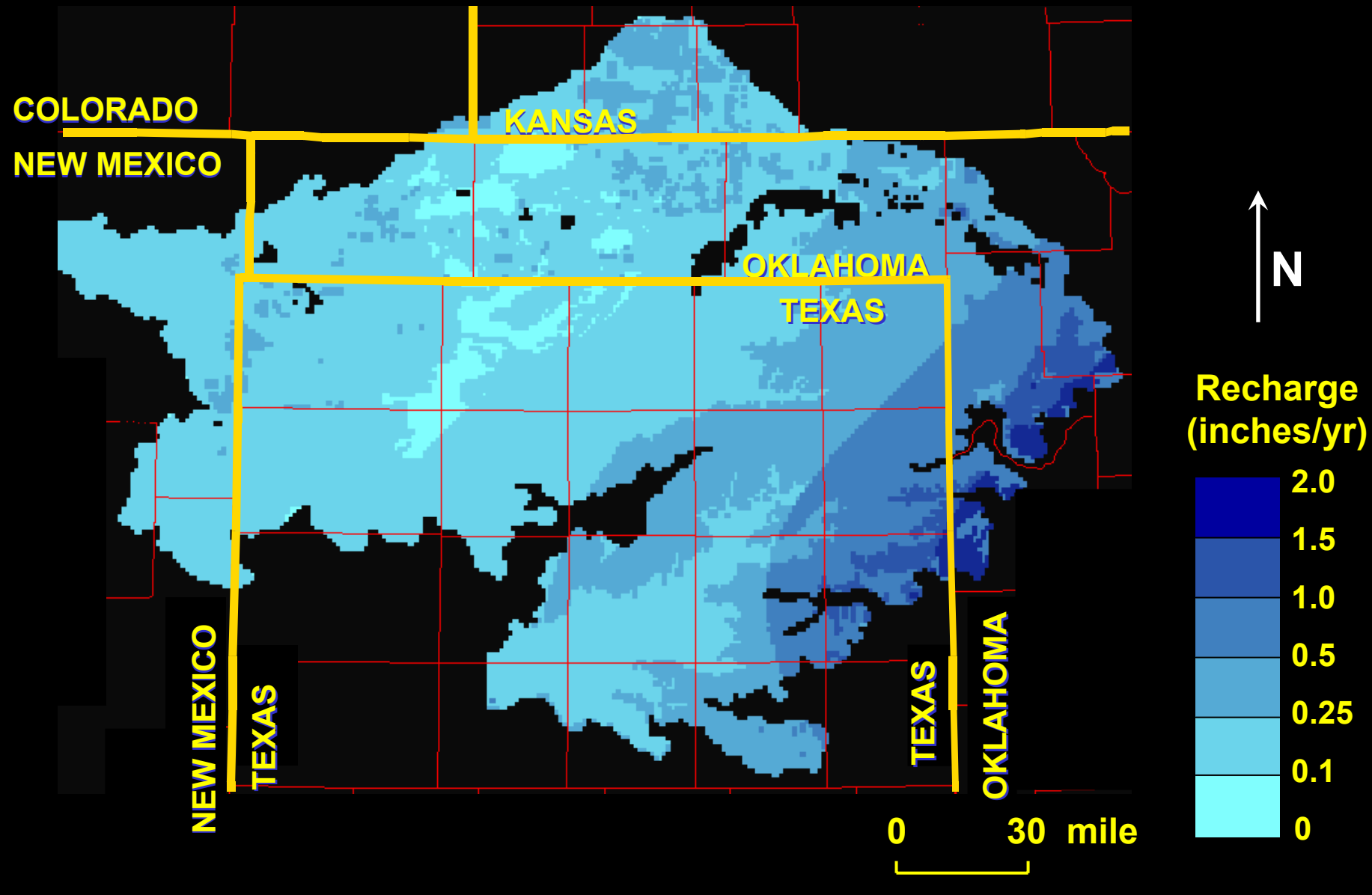


HYDROGRAPH SHOWING RETURN FLOW ESTIMATES



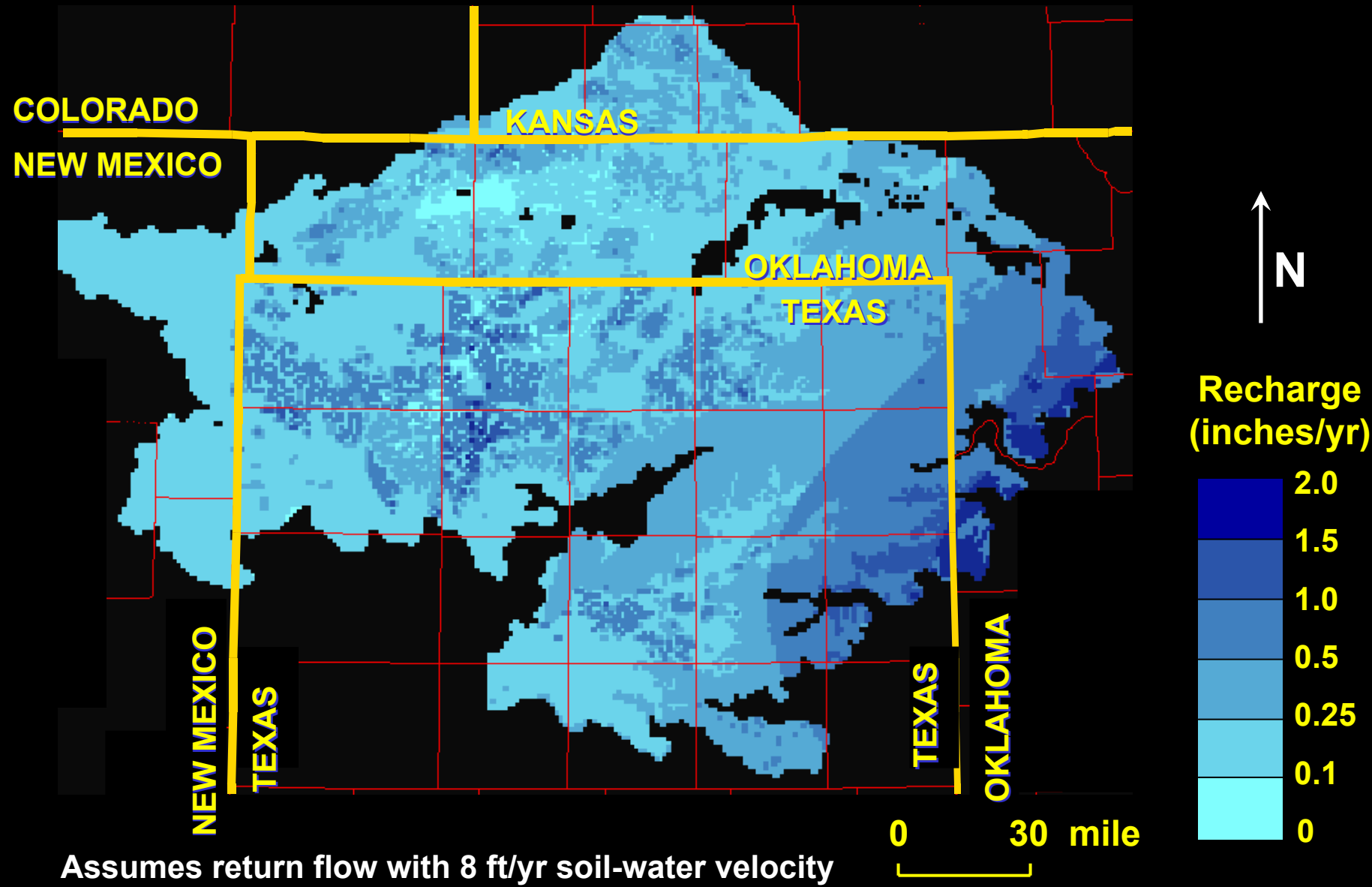
MODELED RECHARGE

"Predevelopment"



MODELED RECHARGE

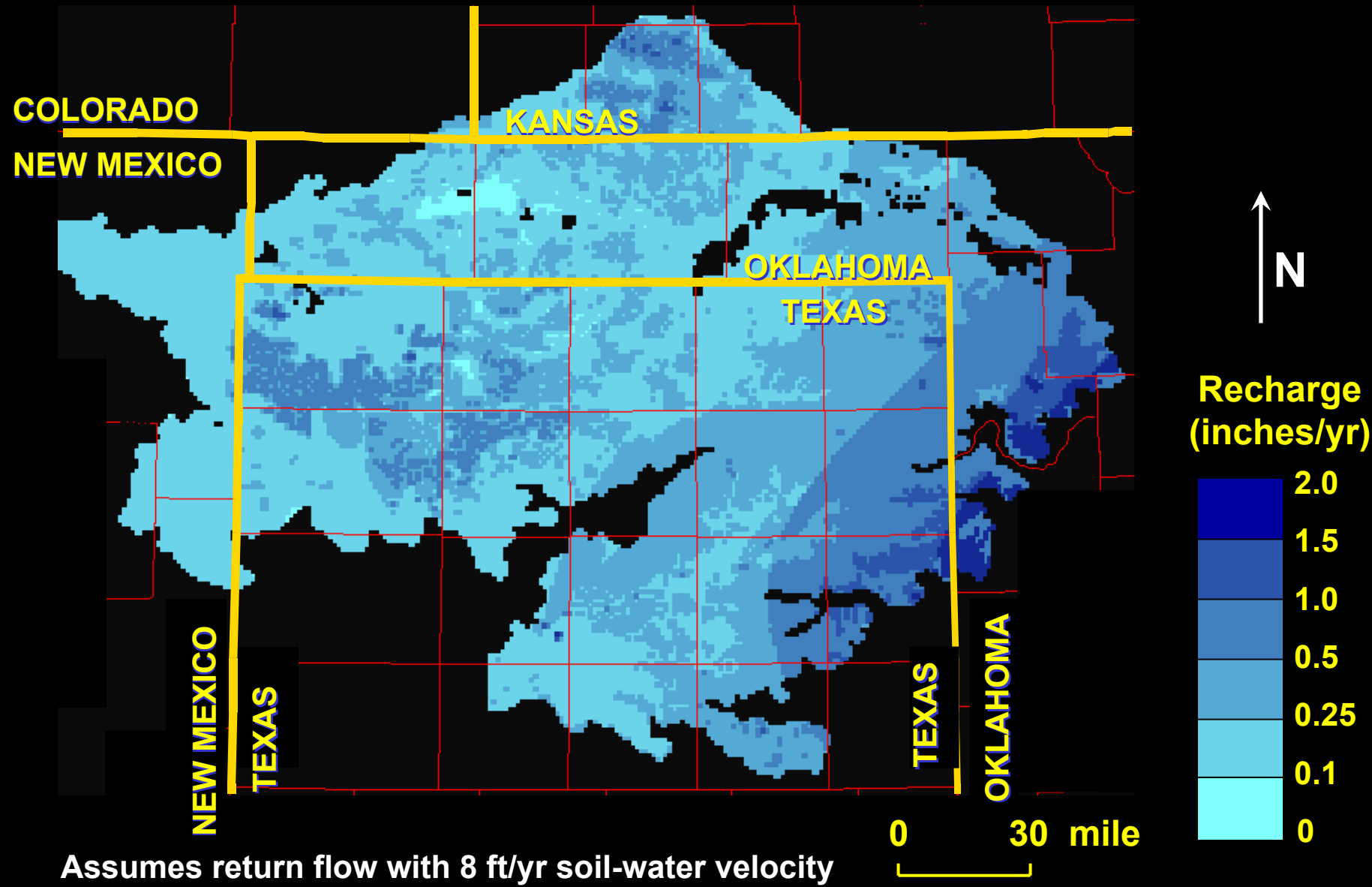
2000



Assumes return flow with 8 ft/yr soil-water velocity

MODELED RECHARGE

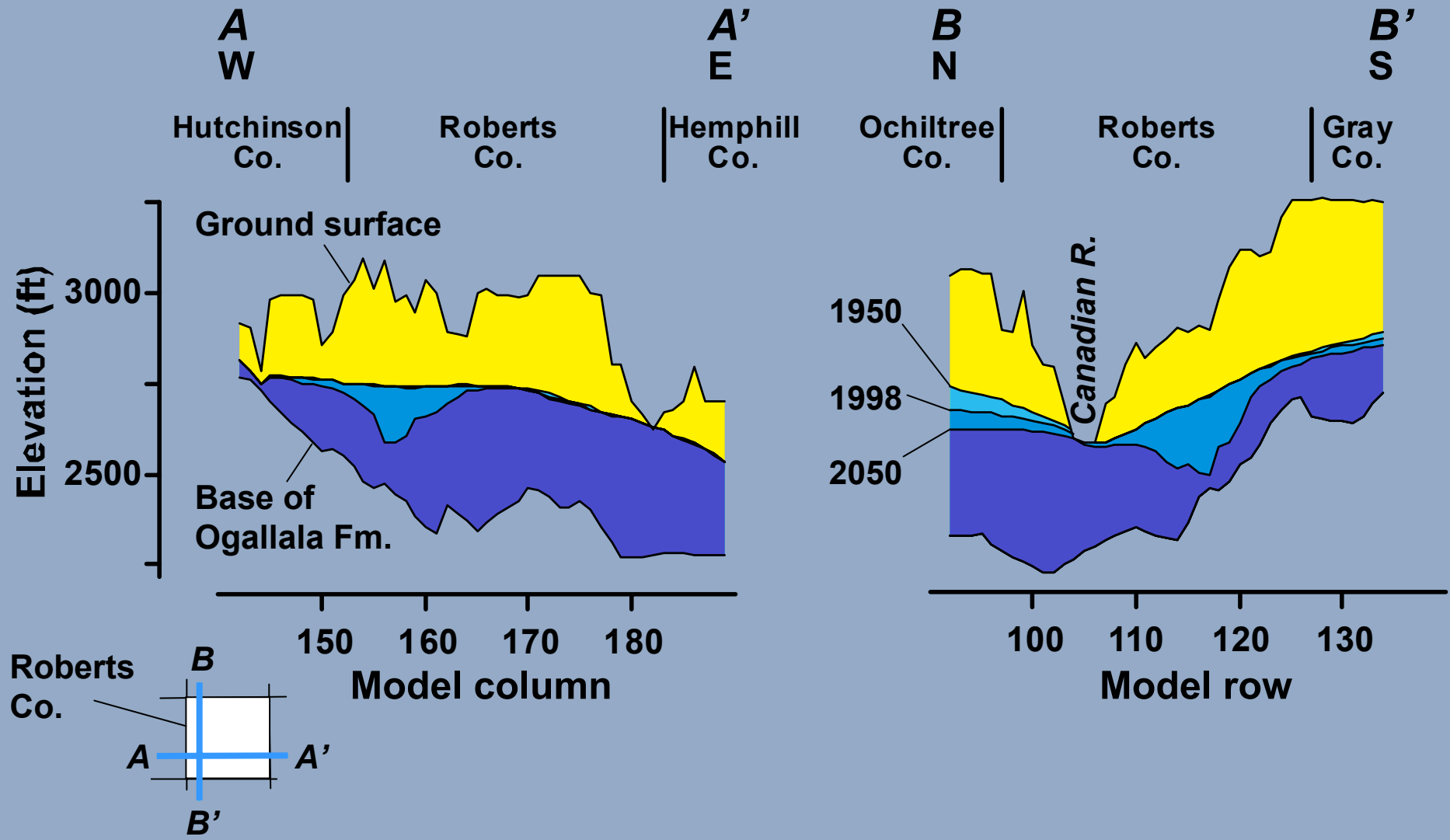
2050



Assumes return flow with 8 ft/yr soil-water velocity

STRUCTURE

Base of Ogallala Formation in 2001 Model

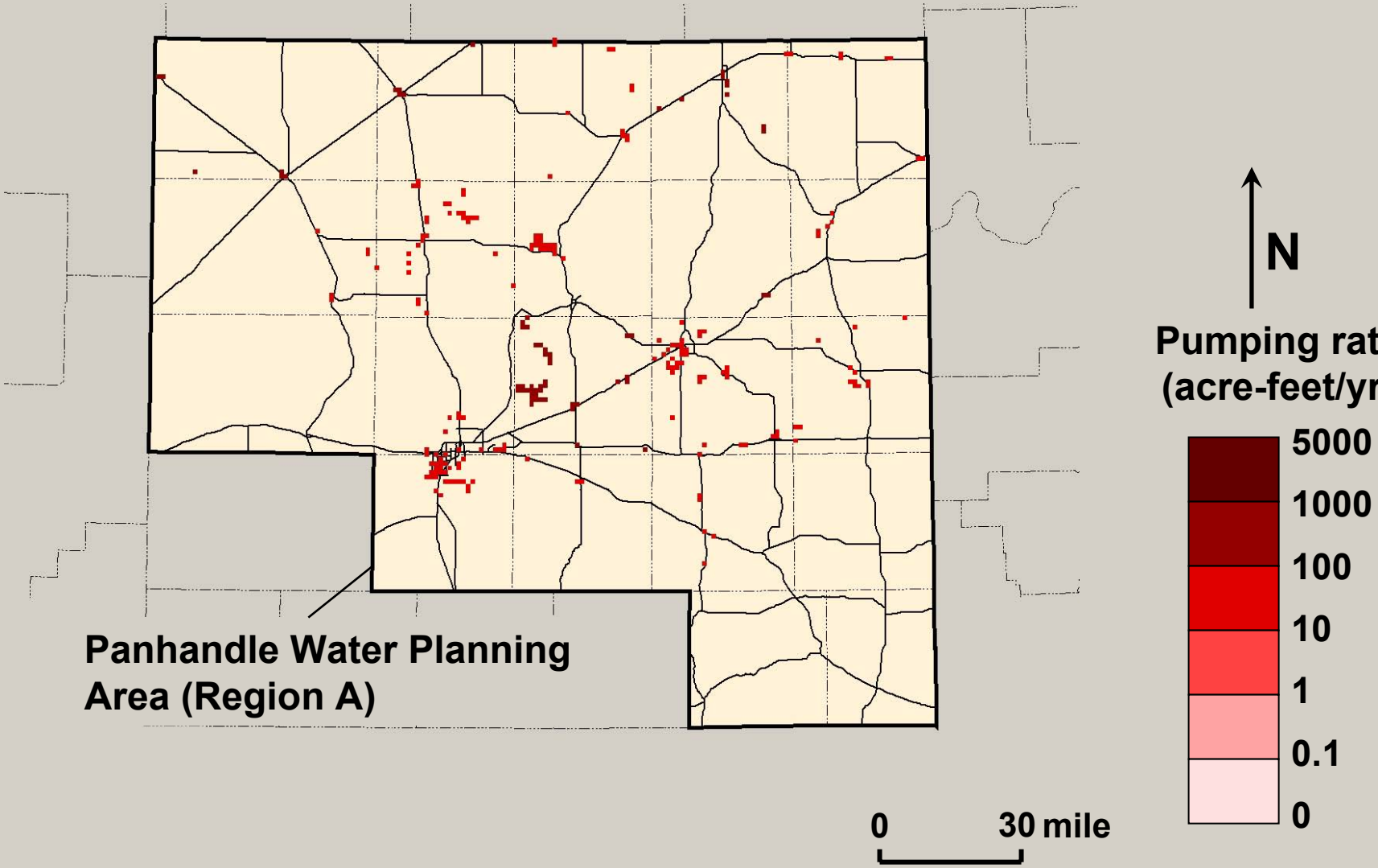


ALLOCATION OF PUMPING

PUMPING ALLOCATION 2001 GAM MODEL

1998 Municipal

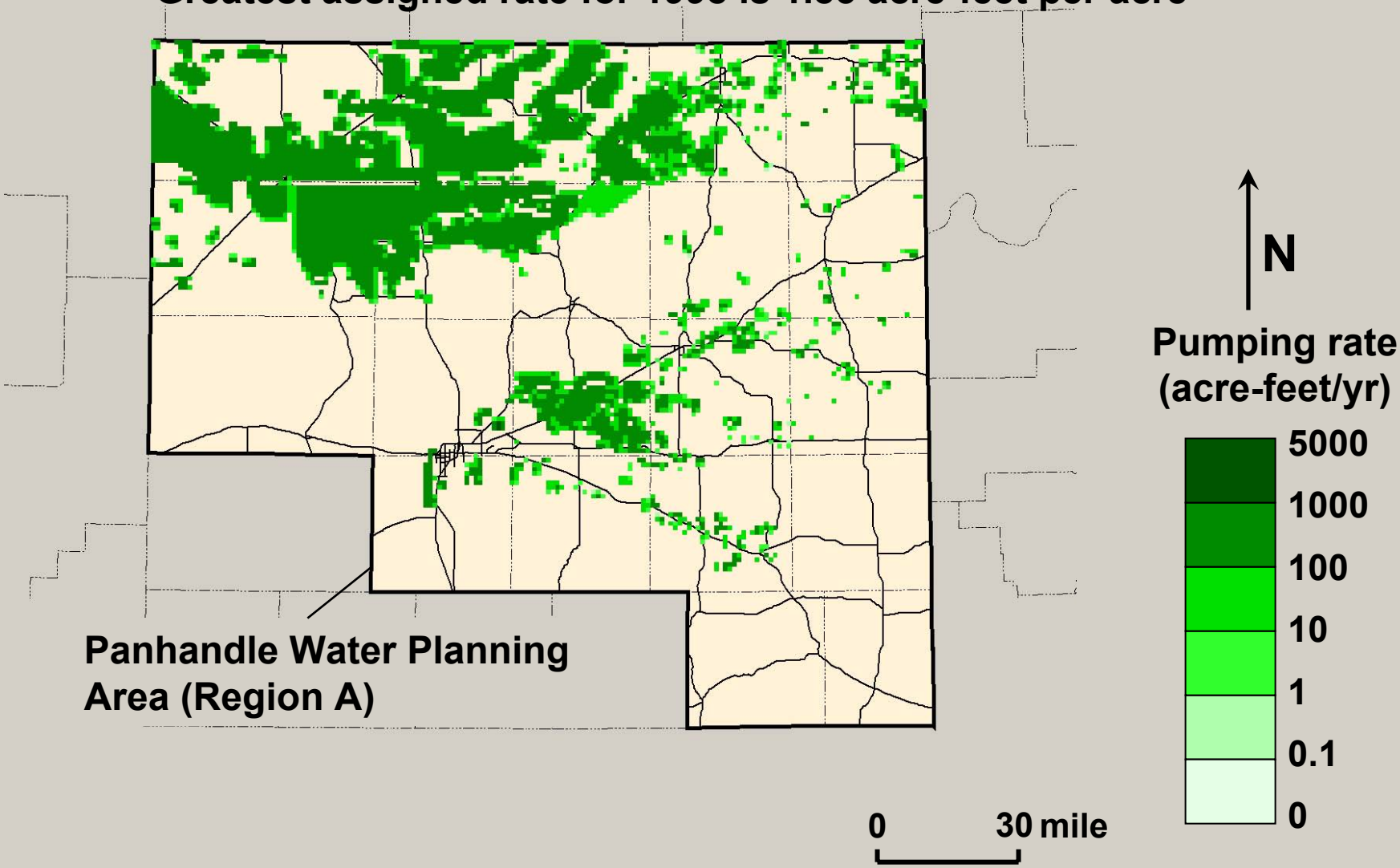
1 square mile model cells to which pumping is assigned



PUMPING ALLOCATION 2001 GAM MODEL

1998 Irrigation

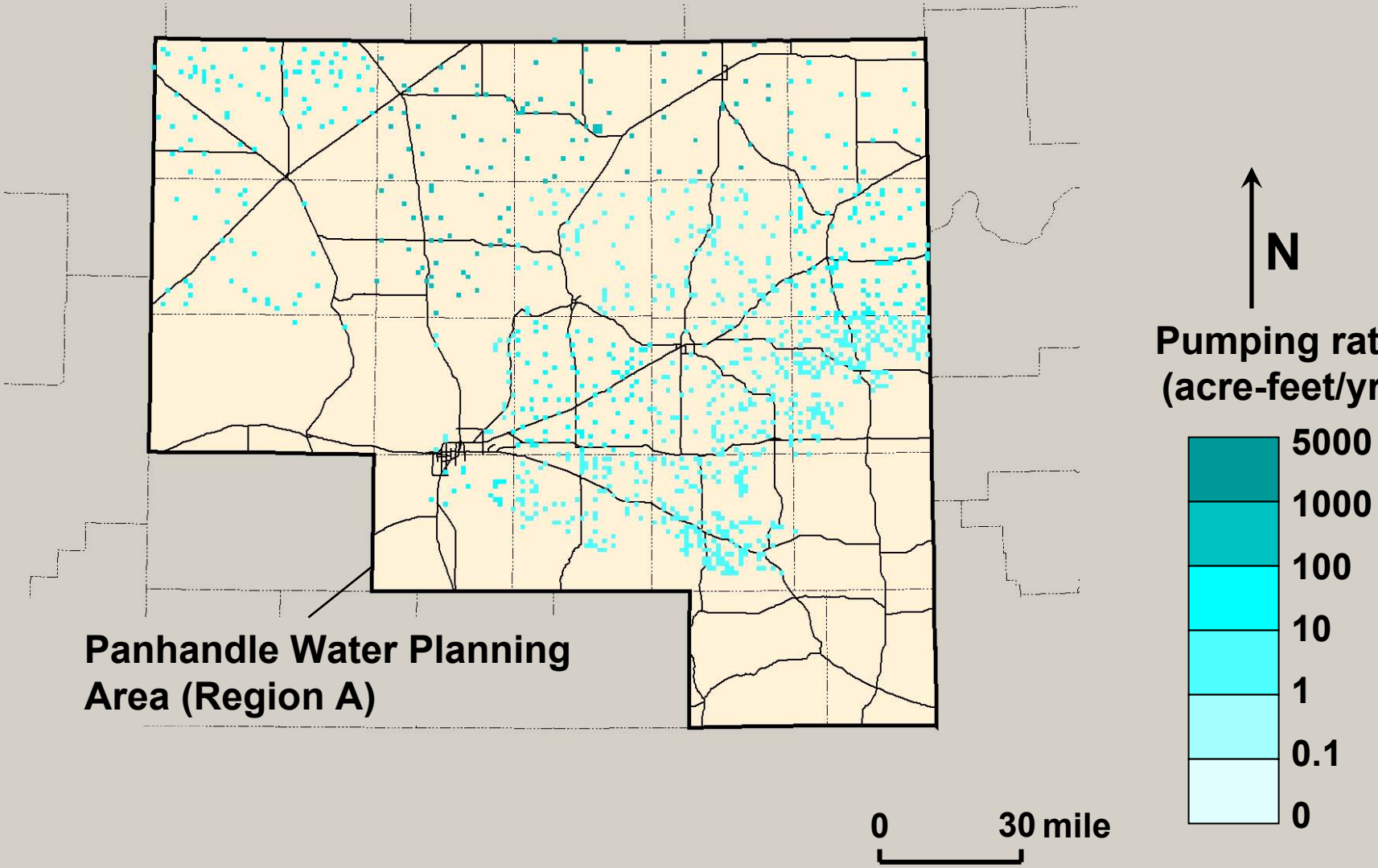
1 square mile model cells to which municipal pumping is assigned;
Greatest assigned rate for 1998 is 1.85 acre-feet per acre



PUMPING ALLOCATION 2001 GAM MODEL

1998 Domestic and Stock

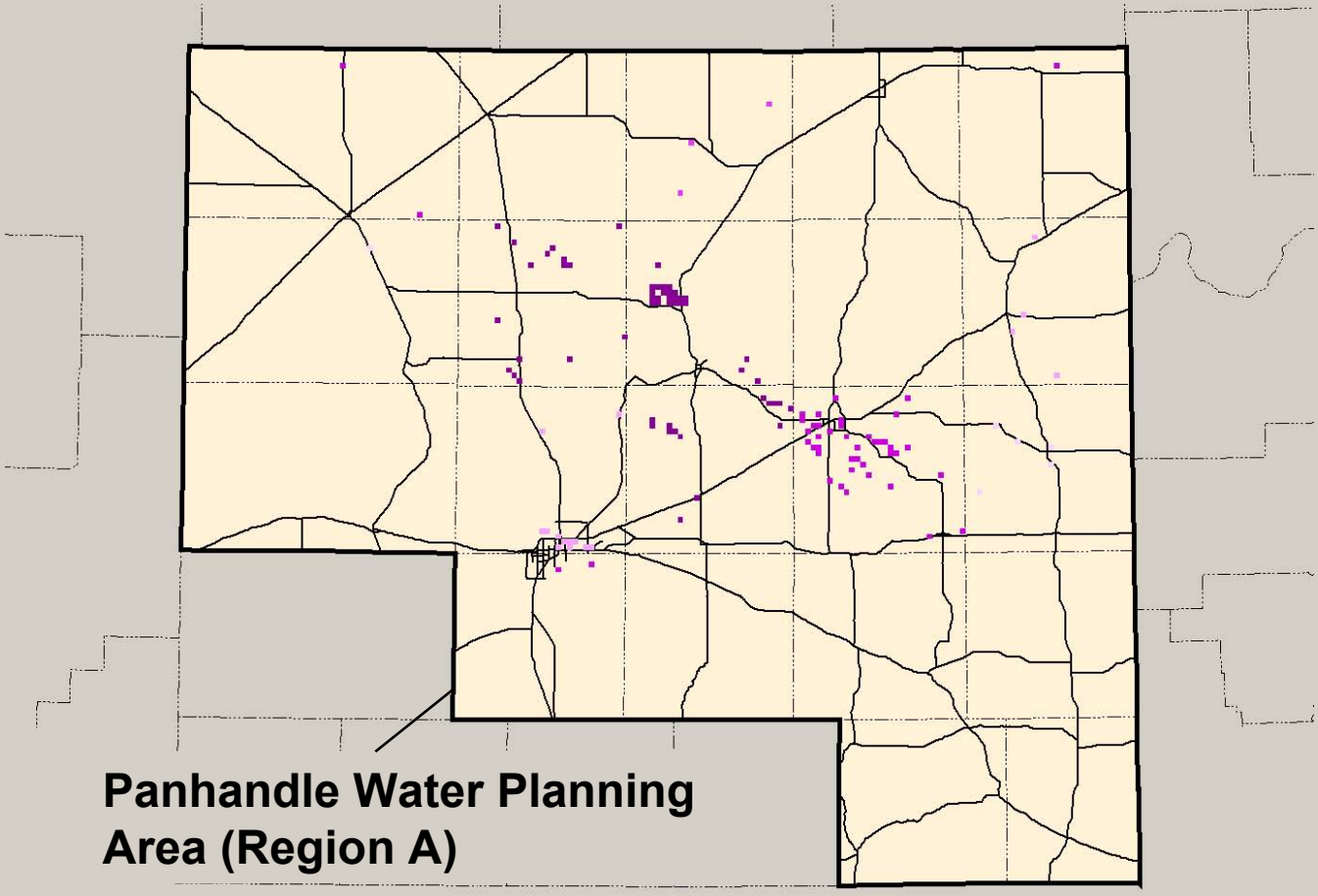
1 square mile model cells to which pumping is assigned



PUMPING ALLOCATION 2001 GAM MODEL

1998 Industrial

1 square mile model cells to which pumping is assigned



Additional Discussion

Ogallala North GAM
December 18, 2003
Revision to GAM Stakeholder Meeting Attendees

Name	Entity
Temple McKinnon	TWDB
Shirley Wade	TWDB
Janet Tregellas	PWPG
Alan Dutton	UT/BEG
Kevin Spencer	RW Harden and Associates
Gale Henslee	XCEL Energy
Dean Looper	PWPG
Bill Hallerberg	PWPG
Judy Reeves	High Plains UWCD
C. E. Williams	Panhandle GCD
John C. Williams	CRMWA
Jarrett Atkinson	PWPG
Stefan Schuster	Freese and Nichols
Michael Peters	PRPC

First Stakeholder Advisory Forum (SAF) for updates to
Northern Ogallala Groundwater Availability Model (GAM)
December 18, 2003

Panhandle Regional Planning Commission, Amarillo Texas.

John Williams gave an introduction and handed the floor to Stefan Schuster of Freese and Nichols. Mr. Schuster provided background to the initial development of the Northern Ogallala model and the Texas Water Development Board's (TWDB's) GAM process. Mr. Schuster introduced Alan Dutton of the Bureau of Economic Geology (UTBEG) who provided a presentation including an overview of the GAM process and the role of Stakeholder advisory forums in that process. He gave a brief background of groundwater modeling, then described what updates would be included in the revised Northern Ogallala GAM. Recharge will be updated and additional structure data will be incorporated, particularly in Roberts County. Also, any new information about recent historic pumpage will be included and the model will be recalibrated if necessary. He also explained that the deliverable will be an addendum to the original 2001 report. After the model is complete, the Panhandle Regional Water Planning Group (PWPG) will turn the model over to the TWDB. Staff at the TWDB will run the model with updated pumpage files based on an analysis of TWDB Board approved demands for predictive modeling runs.

Proposed schedule for model update:

1st SAF	12/18/03
Deadline for receipt of data	1/23/04
Revised model completed by UTBEG	2/20/04
Addendum report submitted to PWPG	2/27/04
Final SAF	Spring 2004

Following this process, the model will be submitted to the TWDB for technical assistance with groundwater availability estimates.

Questions from attendees and answers included:

Q: (In reference to a slide in the presentation reflecting a vertical cross section) Is the topographic "notch" the Canadian River?
A: No, it is the Wolf or Beaver River in Ochiltree County.

Q: (Follow up to previous question) Does the aquifer leak into the river at that point?
A: It is a perennial stream and some of its base flow is contributed by the aquifer. These are the same conditions for Sweetwater Creek in Wheeler County.

Q: (In reference to slide in presentation reflecting pumping distribution in region) What do the pixels represent?
A: Each pixel is a one square mile model cell and the units represented would be one-acre foot per year per square mile.

Q: As part of a discussion about the model design and boundaries being tied to hydrologic conditions, Modeling Committee Chairman John Williams asked Alan Dutton to discuss the model's coverage of Oldham County.
A: The Canadian River was used as a boundary in this area of the model so the northern part of Oldham County is in the model, but the southern part of Oldham County is in the Southern Ogallala GAM. When the revised model is submitted to the TWDB, the PWPG should request that both the Northern and Southern Ogallala GAMs be run to reflect the most recent demands to determine availability. This would apply for Randall County as well.

Q: Is the model on the other side of the general head boundary (S. Ogallala GAM) compatible with the N. Ogallala GAM?
A: Yes, to the best extent possible.

Q: (In reference to discussion of developing recharge multiplication factors based upon soil permeability) You are correlating recharge rate to precipitation and then multiplying by recharge factors for soil types. Does alluvium correspond to the Ogallala Formation?
A: Currently in the model, a more generalized approach was used that related soil textures to the underlying geologic formations. In this model update, recharge values will be based upon USDA soil permeability values irrespective of whether that soil overlies riverbed alluvium or the Ogallala Formation or other geologic formations.

Q: (Follow up to previous question) So how would multiplication factors assist with this?
A: You have to have a way to translate precipitation into recharge. To factor soil variability you use multiplication factors in a linear equation.

Q: Are the soil types mapped in the PowerPoint presentation?
A: No, but following the presentation the information is in ArcView and can be presented.

Q: (In reference to discussion on reviewing base of Ogallala and viewing drawdown data) Is the pumping you are showing here related to the CRMWA project?
A: The slide reflects total pumping of CRMWA and everyone else as included in the regional water plan.

Q: (Follow up to previous question) Does this slide reflect use north of the river and include irrigation use?
A: Irrigation is the predominant use. There is no Amarillo well field north of the river and Mesa pumping scenarios are not included in the regional water plan. Maximum use scenarios will be covered later in the presentation.

Q: Are you improving the base of the Ogallala only in Roberts County or in the whole model?
A: Only in Roberts County due to resource limitations.

Q: A similar uncertainty of the base of the Ogallala exists in the Southern Ogallala GAM. There is local information available, but how do you best improve upon the values for the base of the Ogallala?
A: I can't answer for the Southern High Plains aquifer, but Ray Brady with the Panhandle Groundwater Conservation District is determining if there is a need to reinterpret the red bed data in the well logs. The District is reevaluating historic reports on a well-by-well basis. New wells deeper than the assumed depth of the red bed have coarse-grained material similar to the Ogallala so there is the question of a false red bed higher in the stratigraphic section. The base of the Ogallala may be revised for the entire district and, if so, that information will be used in the model revision rather than just Roberts County as stated in the previous question.

Q: Maybe the districts and TWDB can collaborate on new available data for revisions to the GAMs?
A: Yes, that would be very useful because the TWDB intends to update the models every 5 years and new data could be incorporated at that time.

Comment: There is a lot of new data in Roberts County from the geophysical logs generated from CRMWA's new wells.

Q: Is the Ogallala base in the GAM right now too low or too high?
A: It is the general public consensus that the base is too high so revisions would likely lower the base and increase the saturated thickness.

Comment: This downward revision would pair with the calibration results.

Q: What would be the magnitude of the revision, tens of feet?
A: We don't really know. It would probably be variable. The area is geologically complex because the Ogallala was deposited on topographic relief coupled with dissolved salt deposits and karstic features that don't appear as frequently in the Southern High Plains GAM.

Q: (In reference to the Arc View portion of the presentation) What is the stripe on the pumping distribution map?
A: That is an artifact from the original GIS data and how it intersects with the county boundaries. It needs to be smoothed.

Comment: Part of Oldham County is in the Southern High Plains GAM so the Planning Group may want to request that the TWDB run both GAMs for their availability determinations.
Comment: The Planning Group included this in their request.
Comment: A portion of Randall County is also in the Southern High Plains model.

Q: There is an "island" of Ogallala in Randall County. What model is that in?
A: May not be in either model because it is too thin and isolated. There is not much water being pumped in that area.

Q: (In reference to map of soil classifications for determining recharge rate) Are these the recharge rates?
A: Now mapping soil permeability and creating conversion factors to go from precipitation to recharge and that is what is shown here.

Q: So higher recharge rates will exist in the revised model.
A: It will be a more continually varying feature rather than a stepwise feature.

Q: Have you determined if recharge currently in the model is similar but just distributed differently?
A: We hope to maintain the model structure and calibration and just refine the resolution.

Q: Is part of your scope of work to recalibrate the model?
A: It essentially has to be because you can't degrade the calibration of the model with refinements.

Q: Weren't there calibration problems in Dallam County too originally?
A: There isn't much hydrologic information in the northeast portion of New Mexico. Need additional geologic information to significantly improve the model.

Q: Will the base adjustments in Roberts County affect the calibration?
A: We hope it will improve the model calibration. Trying to get the residuals to less than 50 feet.

Q: For the base in Roberts County, are you including Ogallala and all of the units hydrologically connected to it?
A: Not much of an issue in Roberts County. In the region, only the Rita Blanca in Dallam and Hartley are connected to the Ogallala.

Q: Is the false red bed mentioned hydrologically connected?
A: There are some geology questions that need answering. Is the false red bed reworked material? Or Permian sections that are water bearing? Fundamentally, trying to find the base of the flow unit.

Q: Model should include units that are in hydrologic continuity with the Ogallala?
A: Yes. Even if the units are not in hydrologic continuity and there is a significant development of wells tapping the unit beneath the Ogallala, the model should pick it up.

Q: Is the Ogallala the deepest of the aquifers in the region?
A: The Rita Blanca underlies the Ogallala.

Q: If you expect greater recharge in the northwest corner of the region, will there be a general flow to the southwest?
A: Gradient is east to southeast.

Q: Does the model have any water quality parameters in it?

A: Not at this time?

Q: Will the model include water quality parameters?
A: We are in the process of building a vertical cross-sectional model using SUTRA and building upon previous work by the University of Kentucky.

Q: Can you describe the SUTRA model?
A: MODFLOW assumes the same density of water (fresh water). Erosional topography may force Ogallala water into the Permian section to pick up dissolved solids and then the higher salinity water would move laterally (cross-formation) into the Ogallala. SUTRA would simulate this based upon density variations. The model can be used in 3-D but it is costly so a vertical cross-section is being developed instead to get an improved understanding more than to statistically quantify water quality variations (i.e. more qualitative exercise).

Comment: This will go directly towards assessing water availability - something that the last regional water plan did not address clearly.

Q: Is the water quality assessment done through the GAM process or through Region A?
A: It is not a part of the GAM process. It is a task in the contract with the Planning Group.

Q: Is there any reason that this revision to the GAM isn't in the 5-year update cycle?
A: This wasn't an official GAM.

Q: Is this process making it an official GAM?
A: Yes. This is an approved GAM but hasn't been in the GAM process even though it met the criteria. The region has preempted the revision cycle.

Q: Is the presentation available?
A: It will be available on the TWDB website.

Q: Will the ArcView images be available as well?
A: Meeting notes will reflect the discussion represented in the ArcView images and information can be posted if determined necessary.

Q: Does Harden and Assoc. have any projections of Mesa pumping that would provide some insight during the model revision?
A: Bob Harden has several scenarios and he can talk to you.

Comment: The only information that the group has now on Mesa pumping projections is what was from the settlement of the permit matter.

Comment (Kevin Spencer): Nothing has changed to my knowledge but Bob Harden will check. Does the group have Harden's red bed information?

Q: When the Planning Group requests runs of the GAM, it will be useful to have Mesa predictions. Is the GAM available for anyone to run hypothetical scenarios?
A: The models are on the TWDB website for public access and the groundwater conservation districts can assist with such an effort.

Q: How well calibrated will this model become because it effects the volume of groundwater that is being determined and that becomes a bigger issue with time. It also effects the use of the model.
A: The model is calibrated over a range of conditions that are observed. We want to use the model to predict the drying up of the aquifer, which is not desired and is outside of the calibration window. The model doesn't account for vertical change in the effective permeability of the aquifer.

Comment: We also need to better define the volume of water that is used. That may be the most important task.

Comment: We need to collectively improve the calibration of these models.

Comment: We have seen that a little variation in the calibration of other areas of the model makes a big difference in future availabilities. We may never be able to predict specifics with this type of model.