GAM run 07-31

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Groundwater Availability Modeling Section
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November 11, 2007

EXECUTIVE SUMMARY:

We ran the groundwater availability models for the northern and southern portions of the Ogallala Aquifer in Texas in order to produce a baseline volume for each grid cell in the models. We extracted average annual recharge for each grid cell. After calculating the total volume in each grid cell and adding the recharge, we calculated the pump rate for each cell that would result in the retention of 50 percent of the volume at the end of fifty years. The results were contoured for each county in Groundwater Management Area 1. Pump rates varied according to saturated thickness, specific yield, and recharge. The range was from less than 25 acre-feet per year to over 600 acre-feet per year per square mile in some isolated areas.

REQUESTOR:

Mr. C.E. Williams with the Panhandle Groundwater Conservation District on behalf of Groundwater Management Area 1.

DESCRIPTION OF REQUEST:

Determine the pump rates in each grid cell (one square mile) in the groundwater availability models for the northern and southern portions of the Ogallala Aquifer which will have the result of achieving fifty percent retention of the year 2000 baseline storage volume in fifty years. Contoured maps of the results for each county in Groundwater Management Area 1 were requested.

METHODS:

To address the request, we did the following steps:

- extracted the average annual recharge rates used in the groundwater availability models for the northern and southern parts of the Ogallala Aquifer within Groundwater Management Area 1. Average recharge is based on a percentage of precipitation for the 1950 through 1990 period of record;
- calculated the groundwater in storage for the baseline year 2000 using unique cell values. To do so, we first calculated saturated thickness by subtracting the bottom of the Ogallala Aquifer, as included in the models, from the simulated and calibrated model water levels in 2000. On a cell-by-cell basis in the models, we multiplied the saturated thickness by the area of the cell and by the model cell's

specific yield to get a volume. See GAM Run 06-25, dated November 2, 2006, for the results;

- annual pump rates were calculated as the percentage change in total storage plus the average recharge for each year from 2000 to 2050 in each grid cell (one square mile) of the two models; and
- the pump rates per grid cell were contoured.

PARAMETERS AND ASSUMPTIONS:

- Used version 2.01 of the groundwater availability model for the northern part of the Ogallala Aquifer (Dutton, 2004) and version 1.01 of the groundwater availability model for the southern part of the Ogallala Aquifer (Blandford and others, 2003),
- See Dutton and others (2001) and Dutton (2004) for assumptions and limitations of the model for the northern part of the Ogallala Aquifer. Root mean squared error for this model is 53 feet. This error has more of an effect on model results where the aquifer is thin.
- See Blandford and others (2003) for assumptions and limitations of the model for the southern part of the Ogallala Aquifer. Root mean squared error for this model is 47 feet. This error will have more of an effect on model results where the aquifer is thin.
- Recharge was reappraised in the updated model of the northern part of the Ogallala Aquifer (Dutton, 2004).
- Average recharge used in both of the models was based on a percentage of precipitation for the 1950 through 1990 period of record. Since this includes the 1950s drought of record, the average recharge used for this analysis is considered a conservative estimate.
- For Randall, Potter, and Armstrong counties, which are partially included in both the northern and southern parts of the Ogallala Aquifer groundwater availability models, we combined the results of the volume calculation from each model to get full county totals. However, we used the volume calculated from each model for that segment of the county covered as the starting point for the annual pump rate calculation, which would result in a fifty percent decline over a fifty year period.
- This approach assumes that little to no groundwater flows between cells.

RESULTS:

Figures 1 and 2 show the locations of pumping within each of the groundwater availability models used in the analysis. Figure 3 shows Armstrong County which contains elements from both groundwater availability models for the northern and southern portions of the Ogallala Aquifer. The results for the northern part give pump rates varying from less than 25 acre-feet per year to over 125 acre-feet per year per square mile. In contrast, the southwest corner of Armstrong County provides pump rates that vary from less than 50 acre-feet per year to a high of over 175 acre-feet per year per square mile.

Figure 4 is the contoured map of Carson County. Calculated pump rates vary from less than 50 acre-feet per year to over 450 acre-feet per year per square mile. This may be an over estimate since it has been indicated that several wells in the area are actually completed in the Dockum Aquifer. However, removal of these data points would result in the necessity for model re-calibration which is beyond the scope of the present analysis.

Figure 5 is the contoured map of Dallam County. A number of grid cells in the county are inactive in the year 2000 baseline volume calculation. The variation in pump rates ranges from less than 40 acre-feet per year to over 300 acre-feet per year. Figure 6, which is the contoured map of Donley County, shows pump rates of less than 50 acre-feet in some areas and highs of over 375 acre-feet near the northern border between Donley and Gray counties. Figure 7 shows the contouring within Gray County, which varies from lows of less than 25 to 50 acre-feet per year to highs of over 325 acre-feet per year. Figure 8 is the contoured map of Hansford County. Pump rates vary between less than 100 acre-feet per year in limited areas to highs of over 500 acre-feet per year. Figure 9 is the contoured map of Hartley County which has calculated pump rates that vary from less than 25 acre-feet per year to over 325 acre-feet per year in isolated areas. Figure 10, which is the contoured map of Hemphill County, varies between less than 75 acre-feet per year to over 325 acre-feet per year. Figure 11 is the contoured map of Hutchinson County. Pump rates vary from less than 75 acre-feet per year to highs of over 525 acre-feet per year in one isolated area near Roberts County. Figure 12 is the contoured map of Lipscomb County. Pump rates vary between less than 25 acre-feet per year in one isolated area to highs in several areas of over 375 acre-feet per year. Figure 13, which is the contoured map of Moore County, shows pump rate variations of less than 25 acre-feet per year to highs of over 300 acre-feet per year. Figure 14 is the contoured map of Ochiltree County. Pump rates vary from lows of less than 25 acre-feet per year to several areas of 400 plus acre-feet per year. Figure 15, which is the contoured map of Potter County, varies from less than 25 to over 100 acre-feet per year. Once again, this may be an over estimate since it has been indicated that numerous wells in the county are actually producing from the Dockum Aquifer. However, removal of these data points would result in the necessity for model re-calibration which is beyond the scope of the present analysis. Figure 16 is the contoured map of Randall County. Elements from both groundwater availability models of the northern and southern portions of the Ogallala Aquifer are present in the analysis of pump rates in Randall County. Pump rates vary from lows of less than 25 to highs of over 250 acre-feet per year. The contoured map in Figure 17 is Roberts County pump rates. The variation ranges from less than 125 acre-feet per year to over 600 acre-feet per year in some areas. Figure 18 is the contoured map of Sherman County. Pump rates calculated for the county vary between 50 acre-feet per year in one area to highs of over 300 acre-feet per year in several areas. The last figure, Figure 19, is the contoured map of Wheeler County. Pump rate variation for this county is from lows of less than 25 acre-feet per year to highs of over 275 acre-feet per year in several isolated areas.

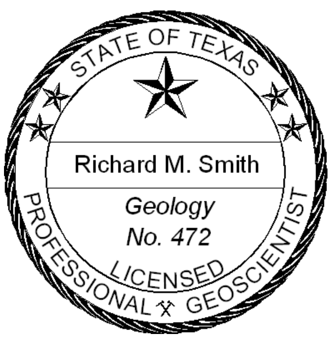
REFERENCES:

Dutton, A., 2004, Adjustments of parameters to improve the calibration of the Og-N model of the Ogallala aquifer, Panhandle Water Planning Area: Bureau of Economic Geology, The University of Texas at Austin, 9 p

Blandford, T.N., Blazer, D.J., Calhoun, K.C., Dutton, A.R., Naing, T., Reedy, R.C., and Scanlon, B.R., 2003, Groundwater availability of the southern Ogallala aquifer in Texas and New Mexico—Numerical Simulations Through 2050: Final Report prepared for the Texas Water Development Board by Daniel B. Stephens & Associates, Inc., 158 p.

Dutton, A., Reedy, R., and Mace, R., 2001, Saturated thickness of the Ogallala aquifer in the Panhandle Water Planning Area—Simulation of 2000 through 2050 Withdrawal Projections: prepared for the Panhandle Water Planning Group by the Bureau of Economic Geology, The University of Texas at Austin, 54 p.

Smith, R, 2006, GAM Run 06-25, Texas Water Development Board, 28 p.



The seal appearing on this document was authorized by Richard M. Smith, P.G. on November 11, 2007

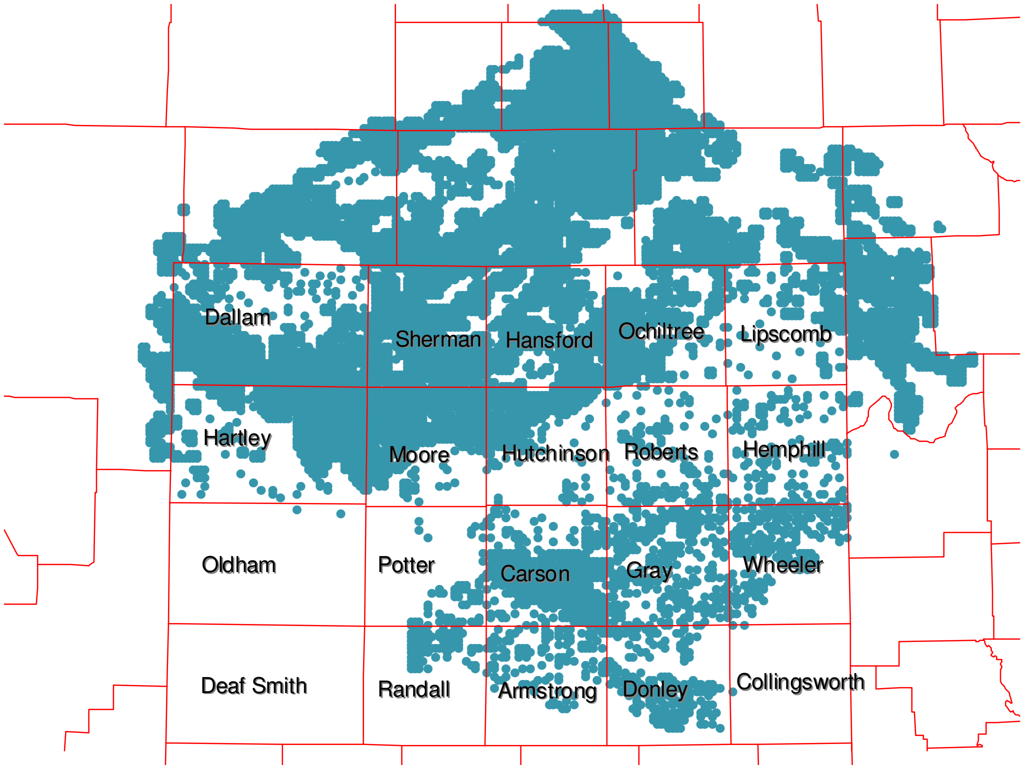


Figure 1: Location of pumping cells in the model of the northern part of the Ogallala Aquifer in 2000.

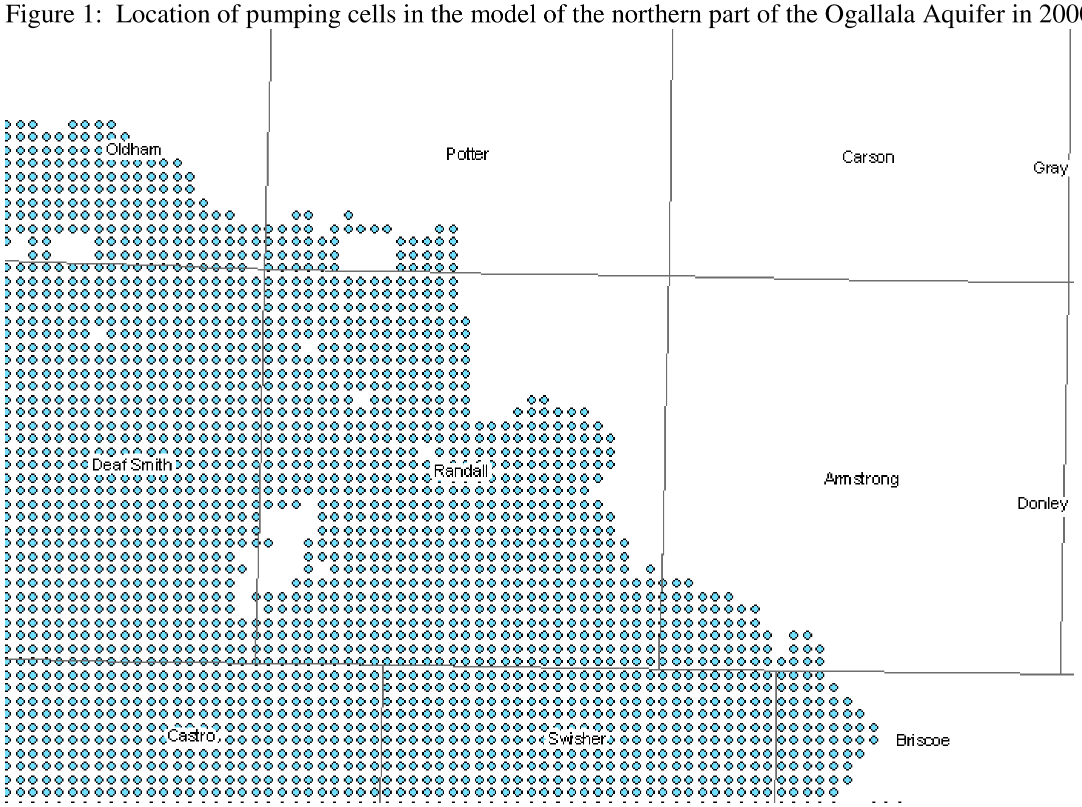


Figure 2: Location of pumping cells in the model of the southern part of the Ogallala Aquifer in 2000.

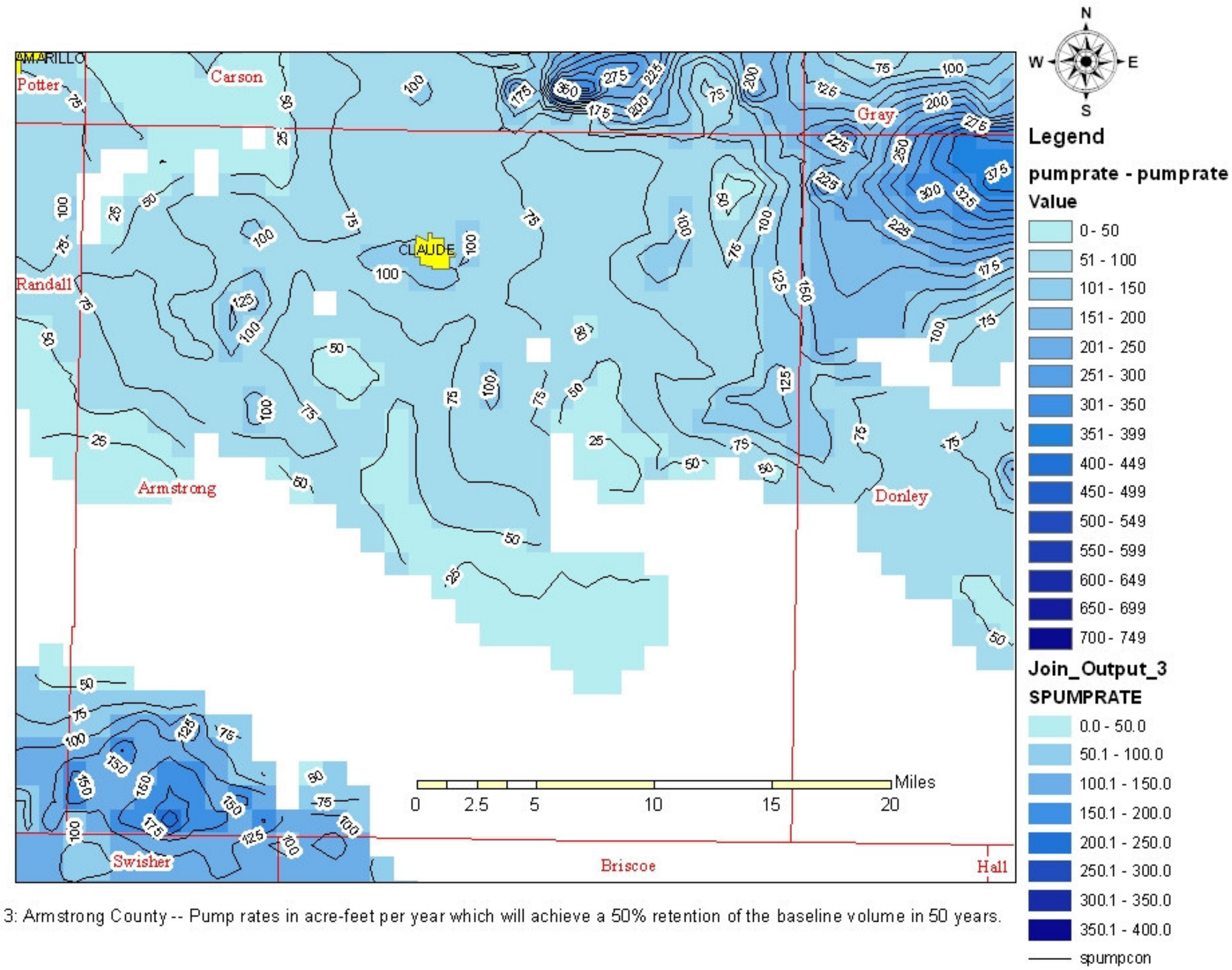


Figure 3: Armstrong County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.

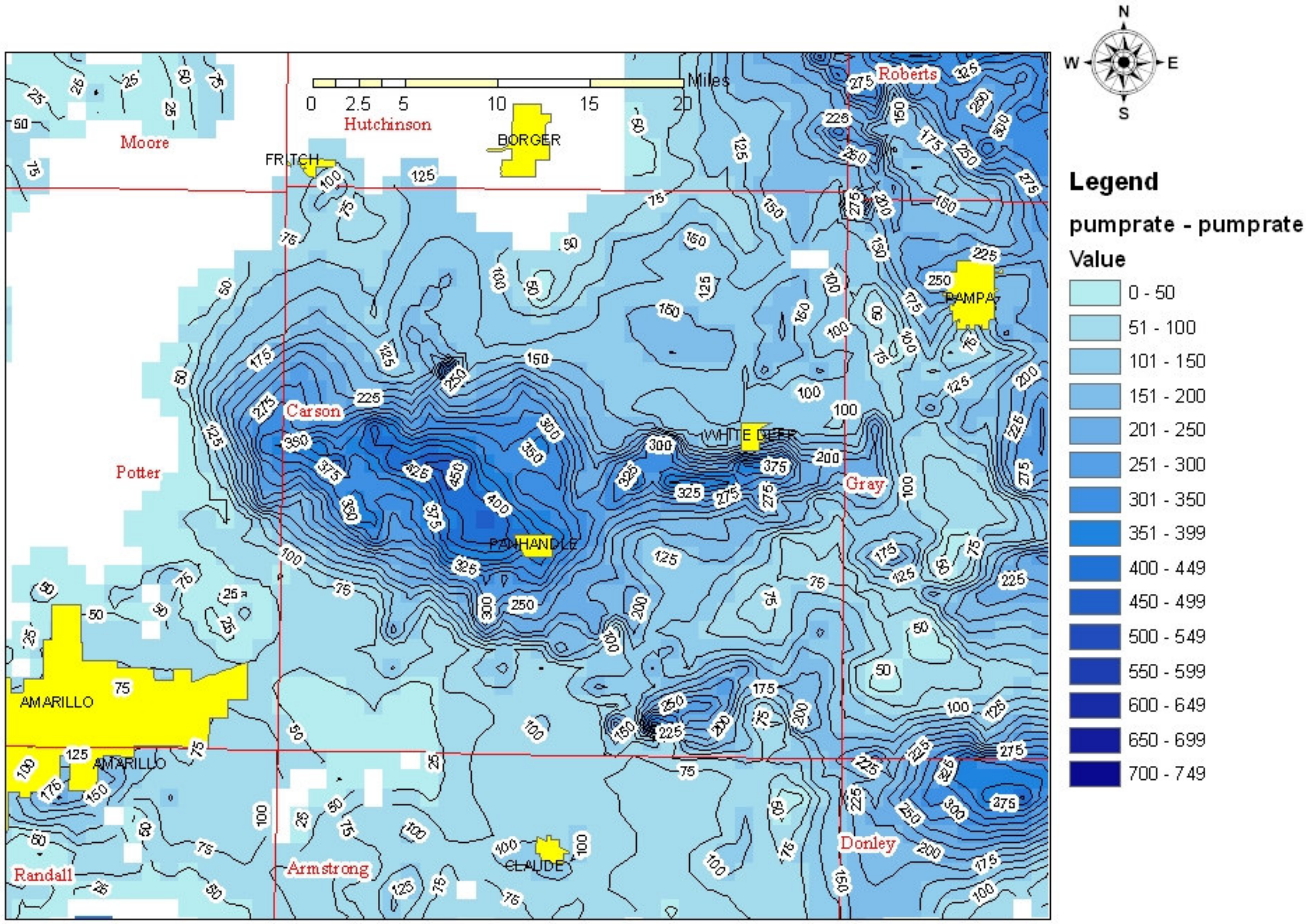


Figure 4: Carson County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years. Contour interval equal 25 acre-feet per year

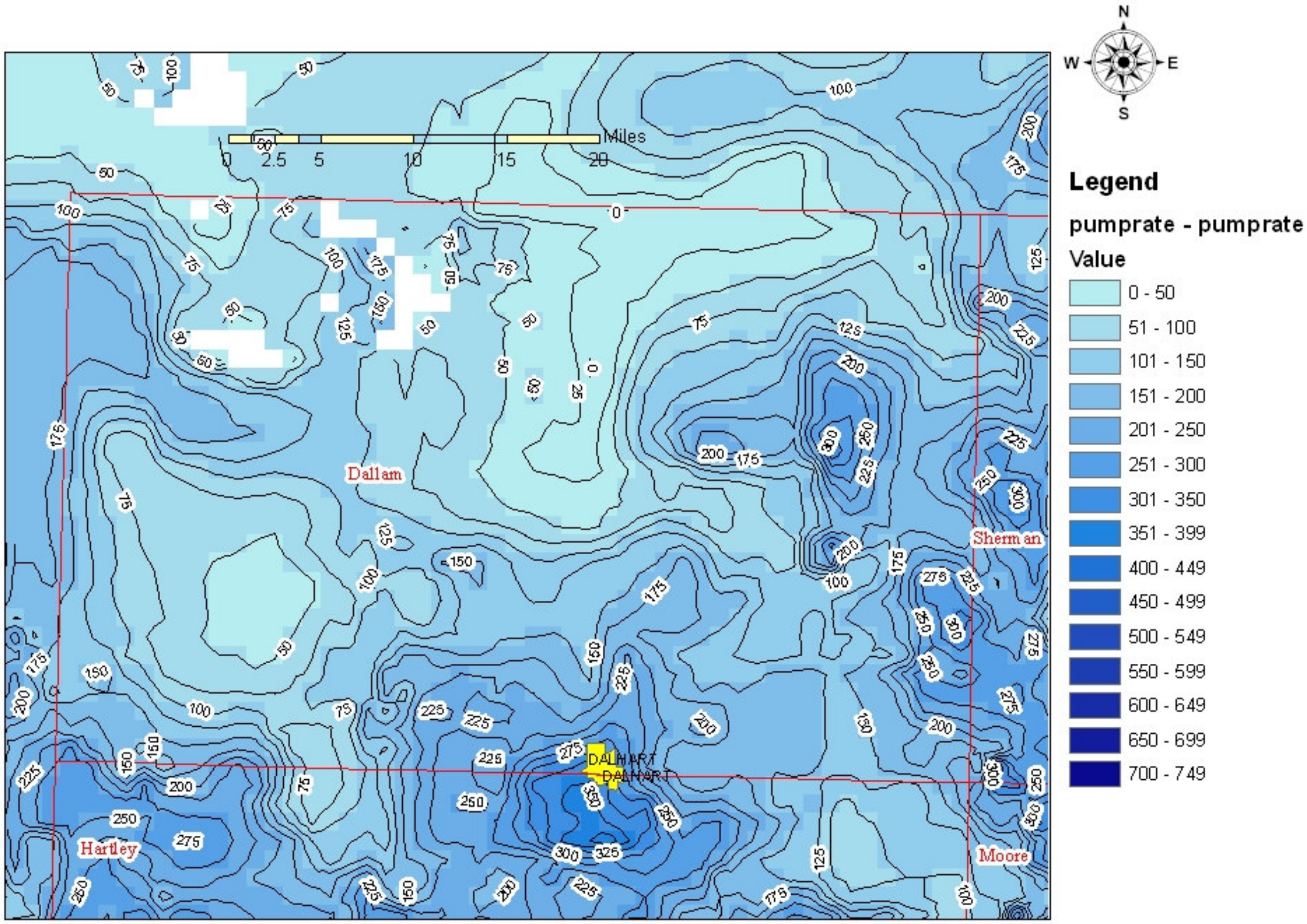


Figure 5: Dallam County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.
Contour interval equal 25 acre-feet per year

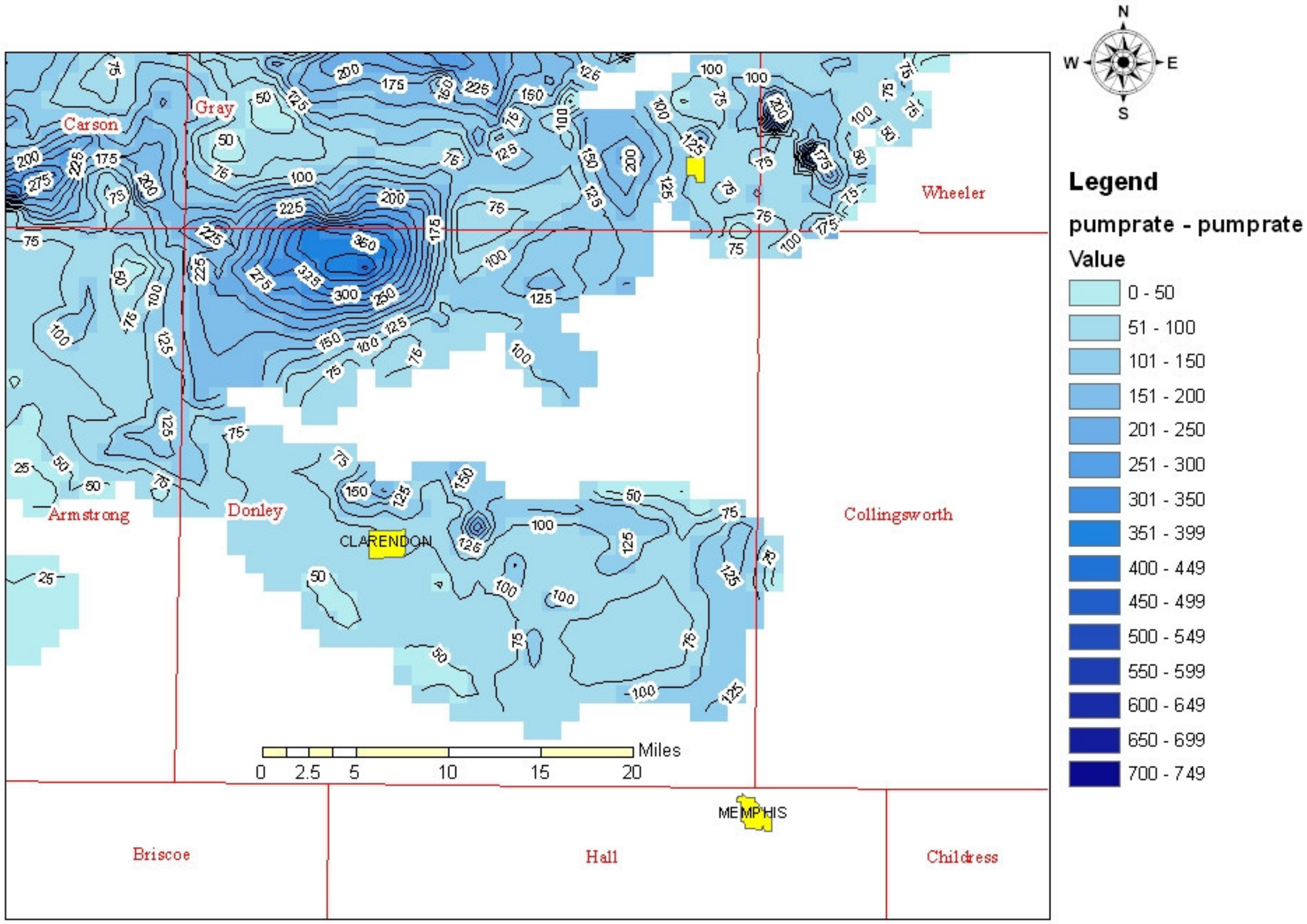


Figure 6: Donley County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years. Contour interval equal 25 acre-feet per year

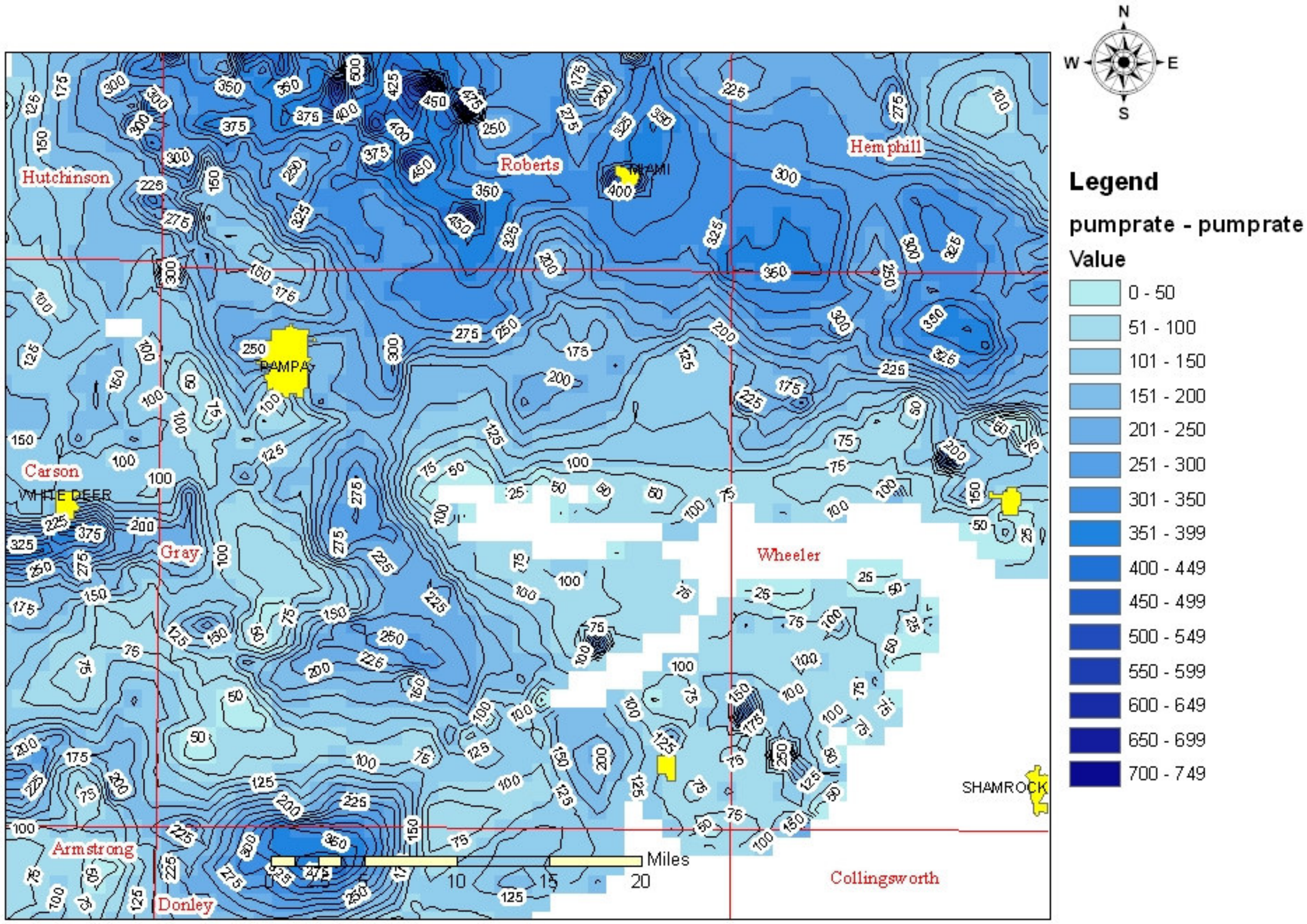


Figure 7: Gray County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.
Contour interval equal 25 acre-feet per year

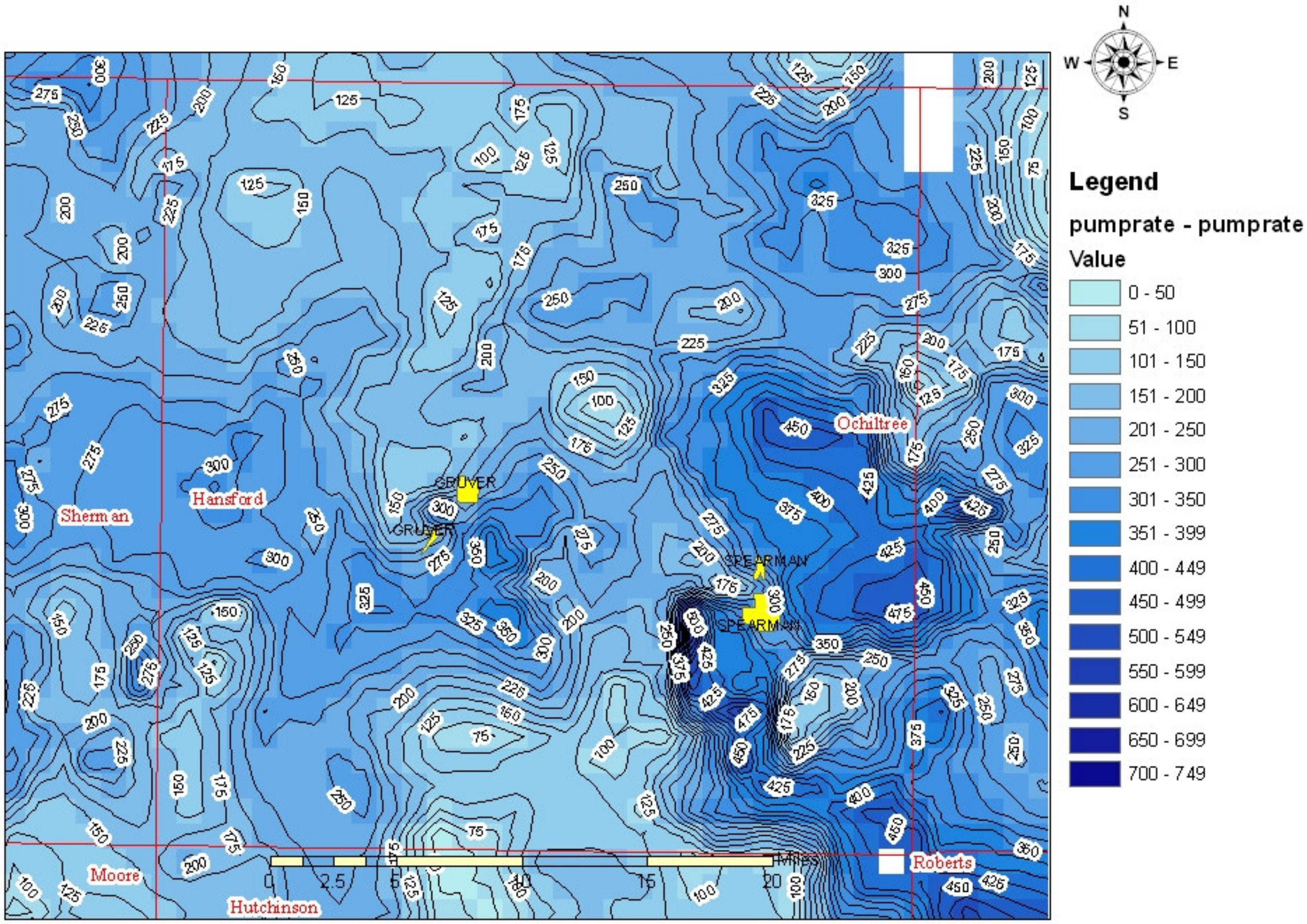


Figure 8: Hansford County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.
Contour interval equal 25 acre-feet per year

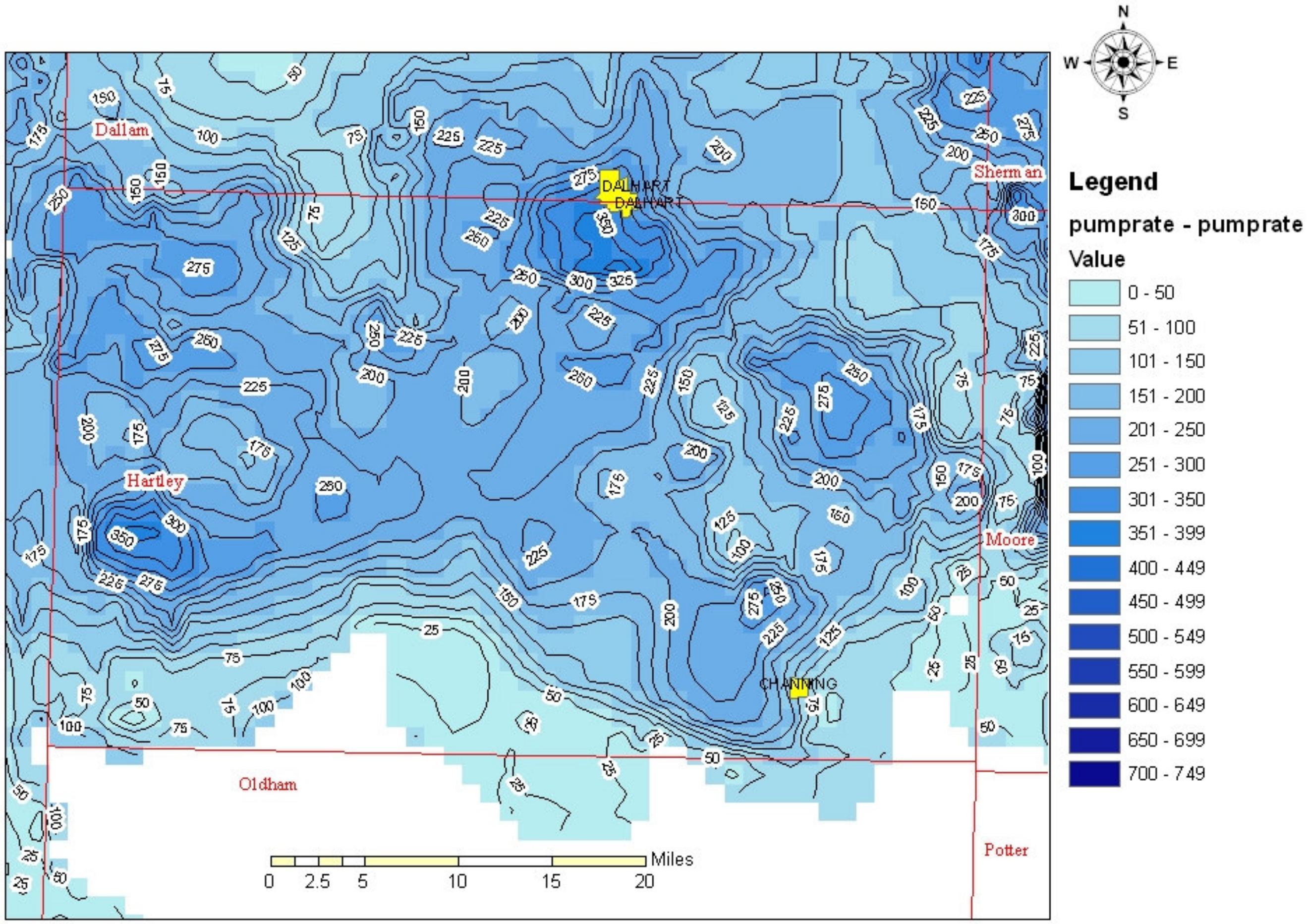


Figure 9: Hartley County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years. Contour interval equal 25 acre-feet per year

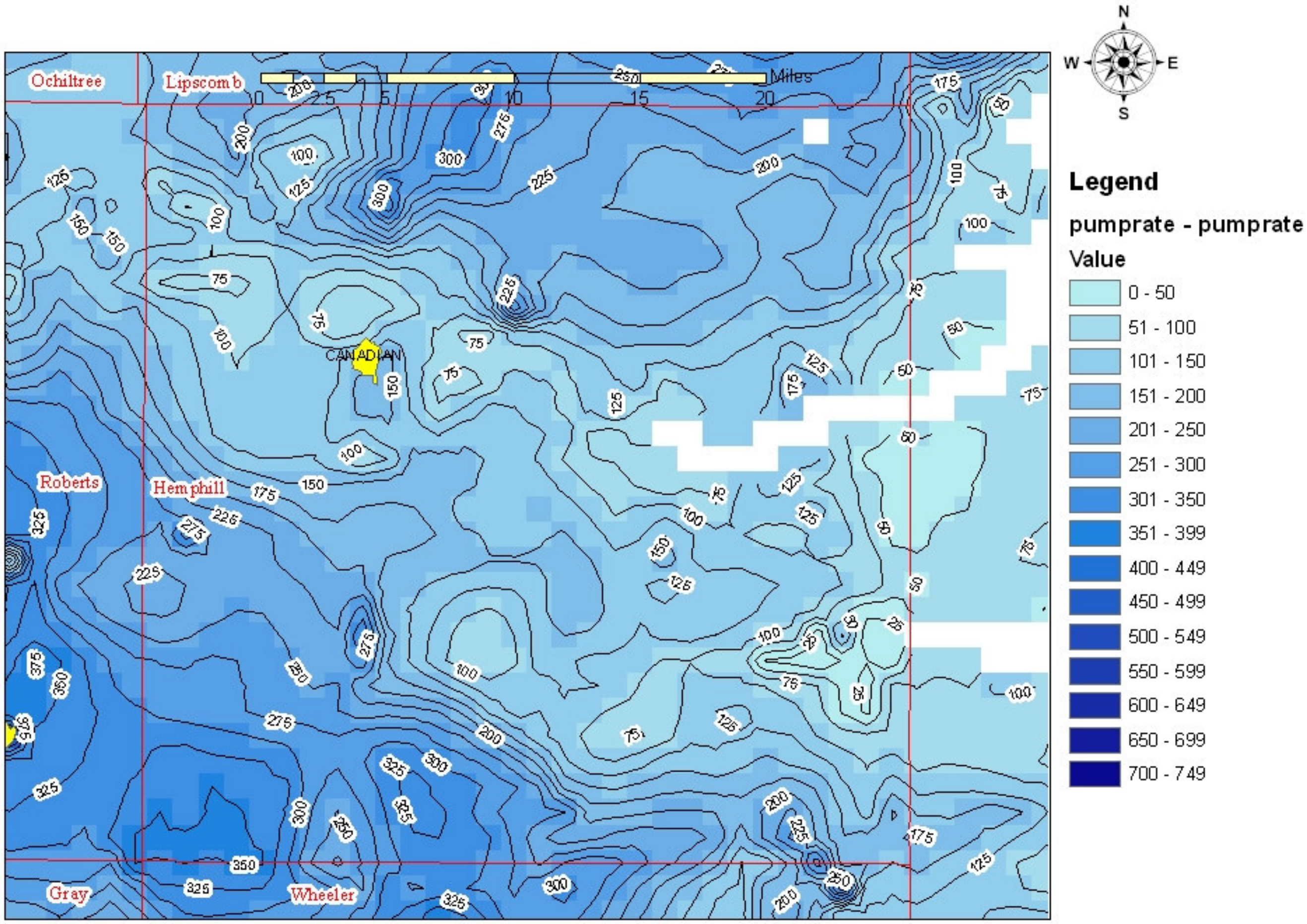


Figure 10: Hemphill County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.
Contour interval equal 25 acre-feet per year

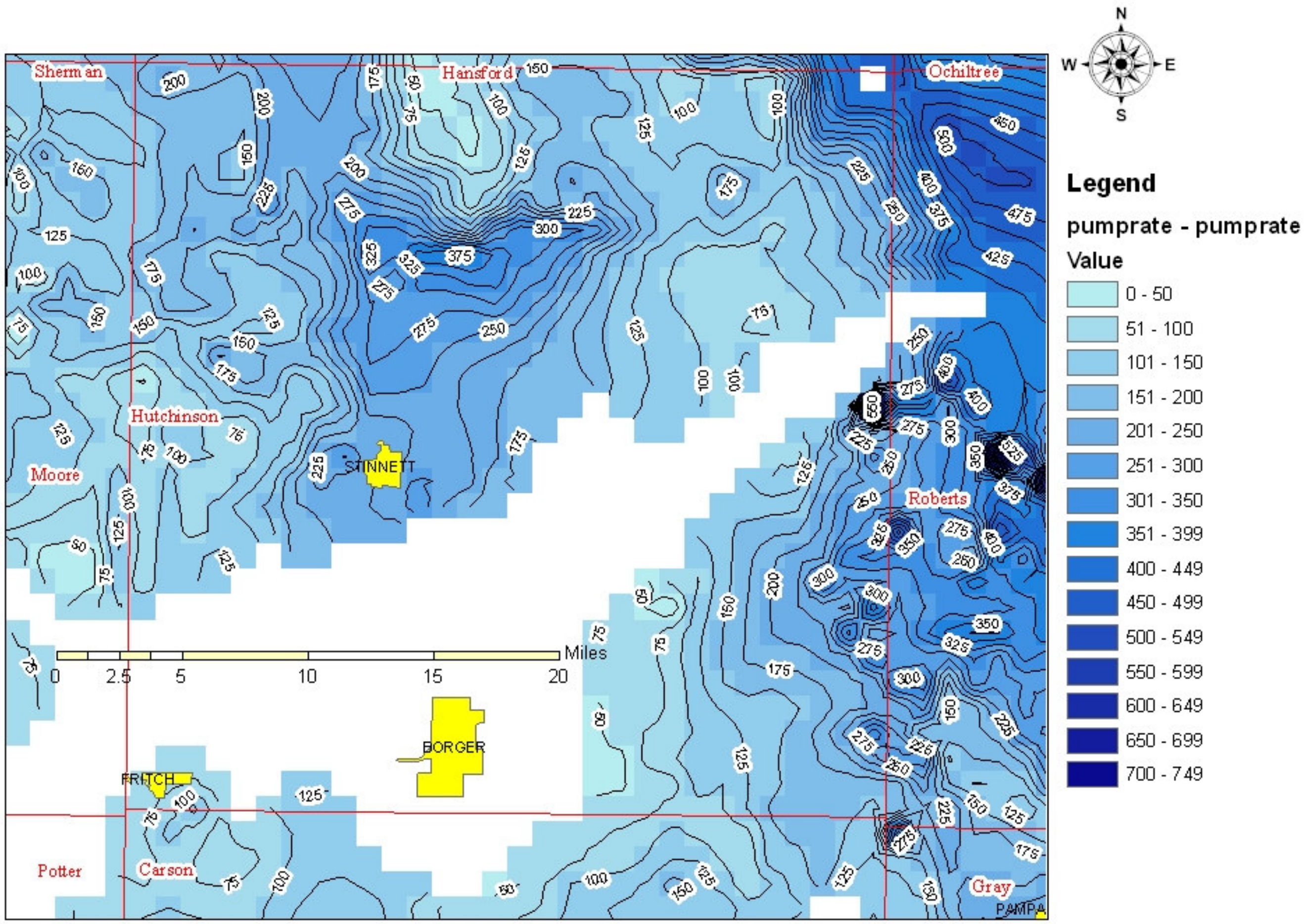


Figure 11: Hutchinson County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years. Contour interval equal 25 acre-feet per year

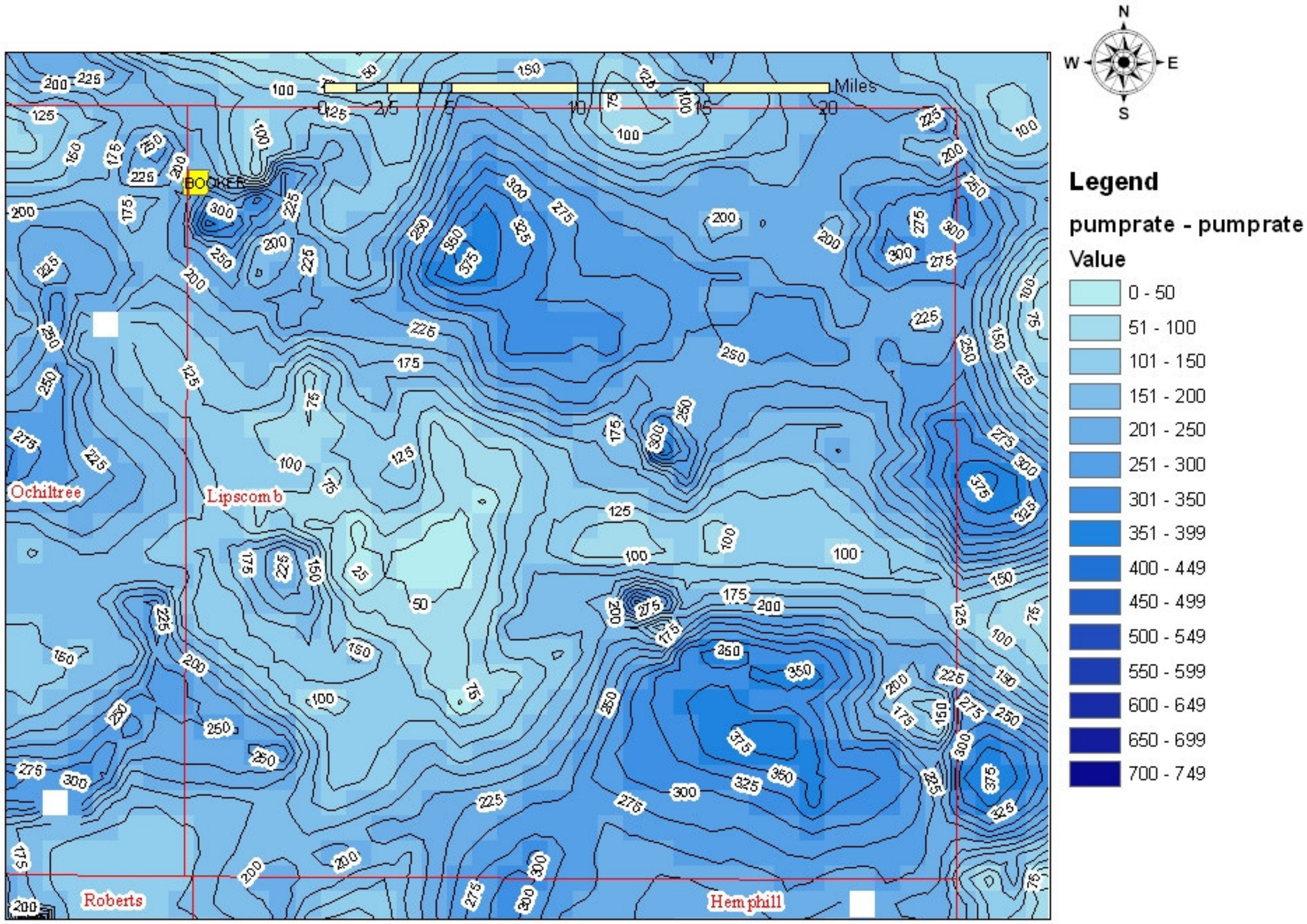


Figure 12: Lipscomb County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.
Contour interval equal 25 acre-feet per year

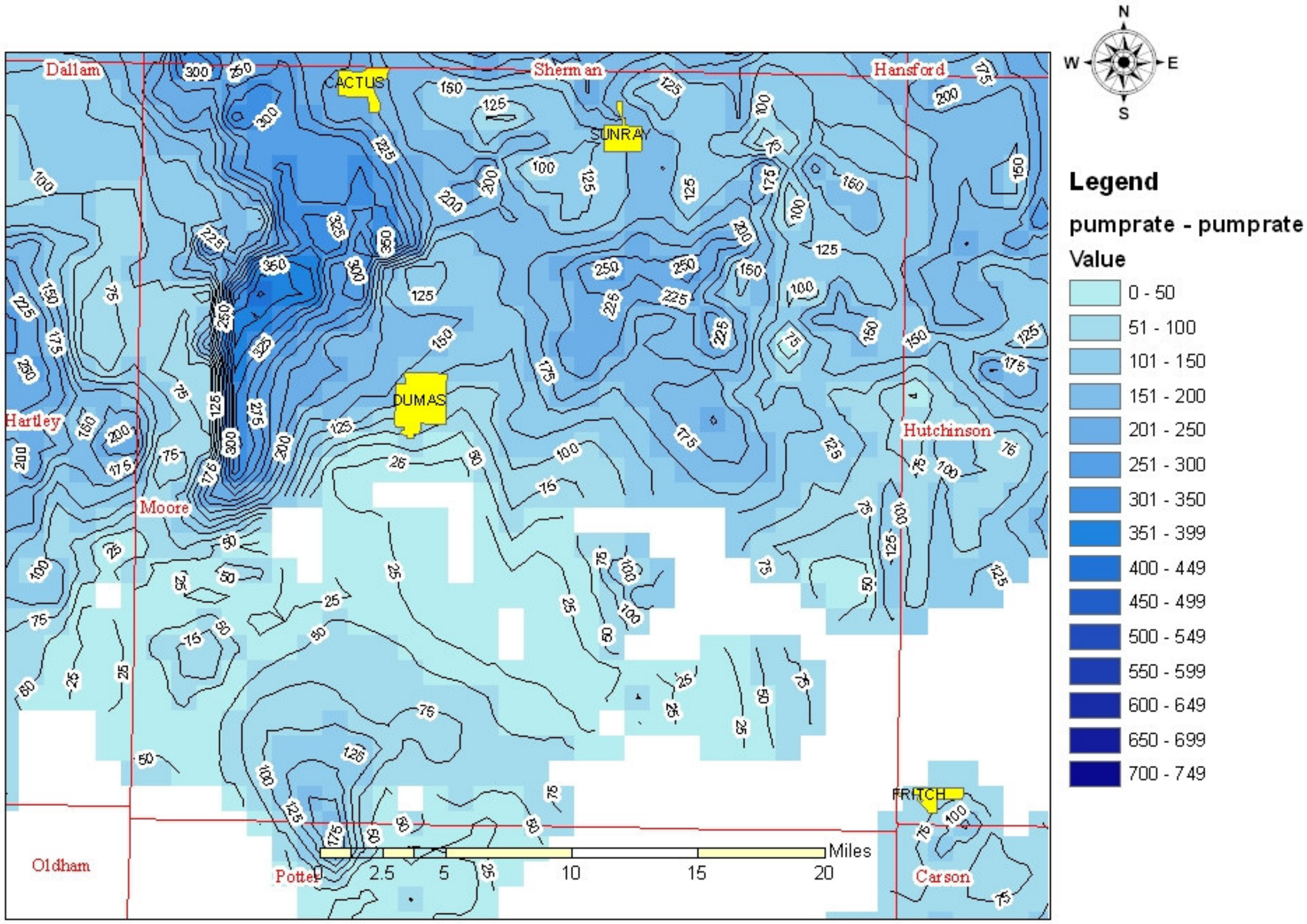


Figure 13: Moore County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.
Contour interval equal 25 acre-feet per year

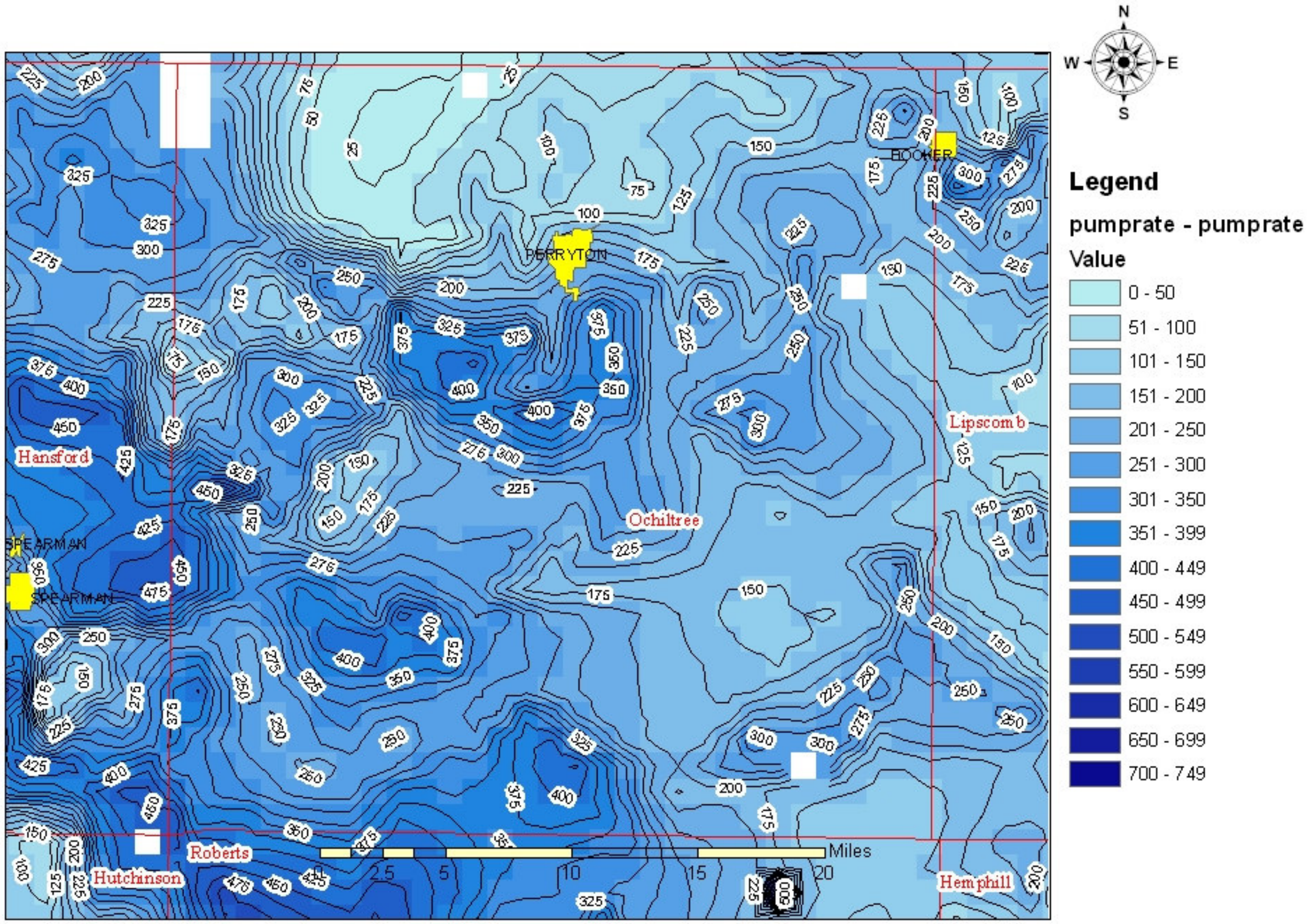


Figure 14: Ochiltree County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.
Contour interval equal 25 acre-feet per year

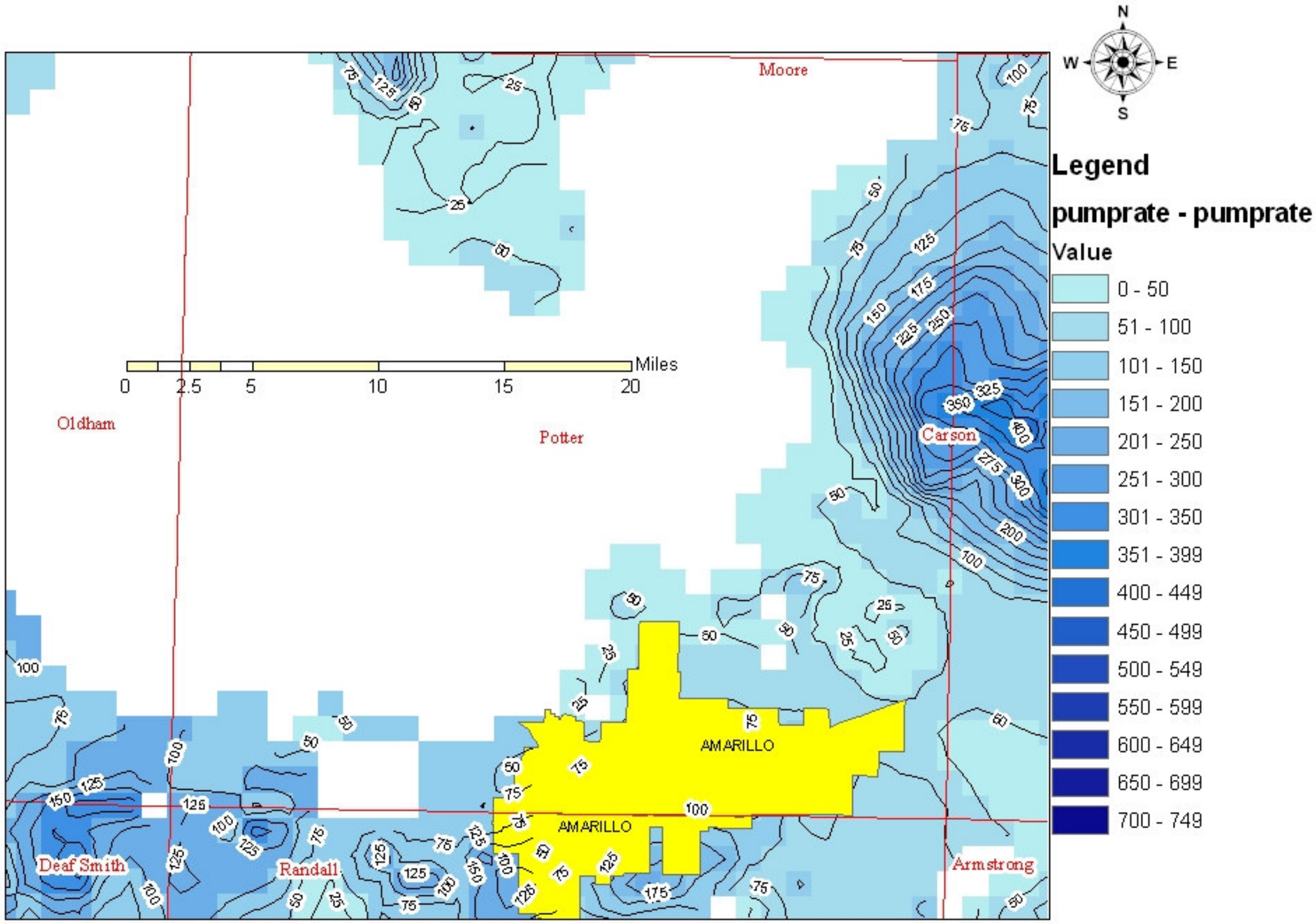


Figure 15: Potter County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.
Contour interval equal 25 acre-feet per year

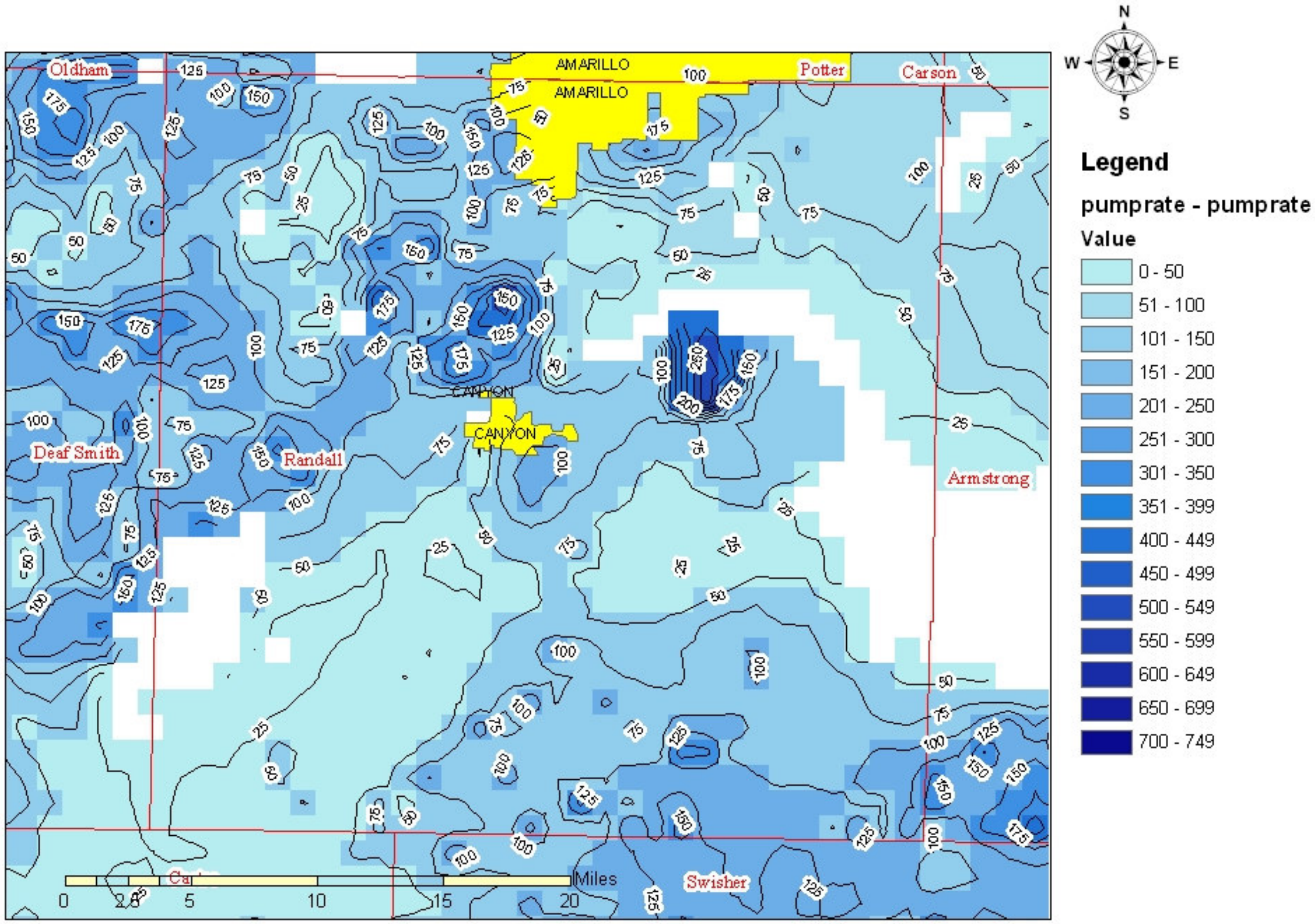


Figure 16: Randall County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.
Contour interval equal 25 acre-feet per year

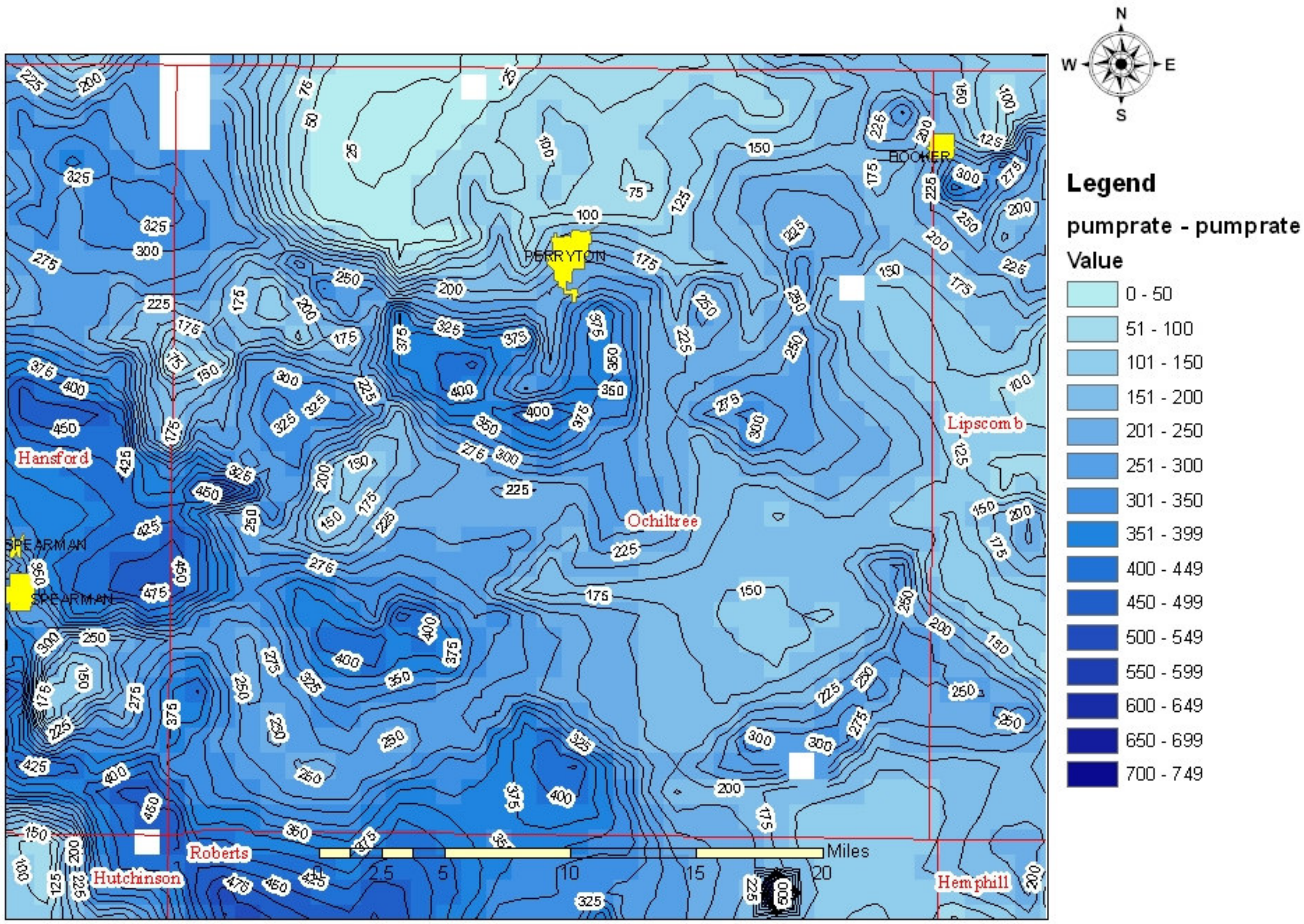


Figure 17: Roberts County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.
Contour interval equal 25 acre-feet per year

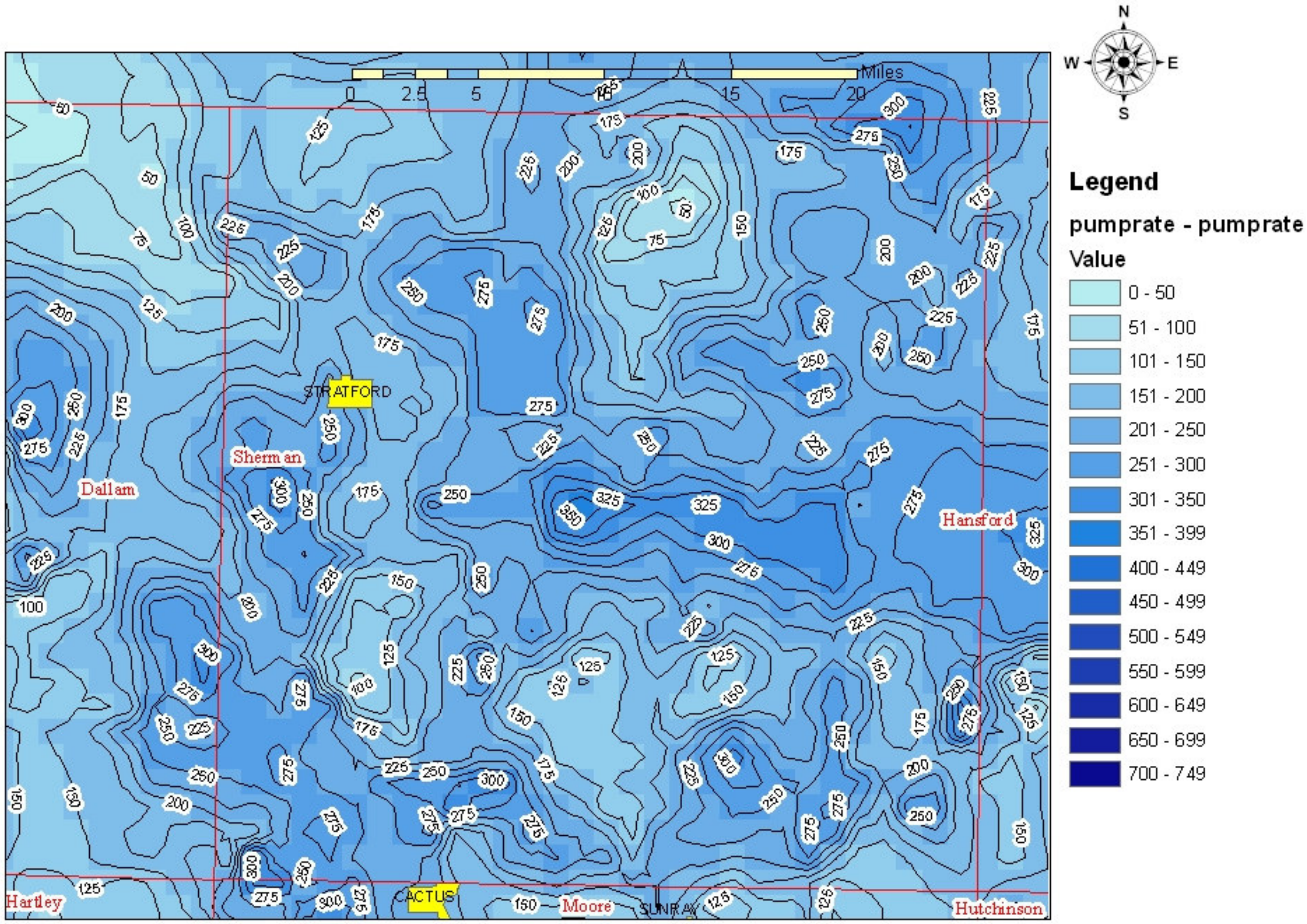


Figure 18: Sherman County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years.
Contour interval equal 25 acre-feet per year

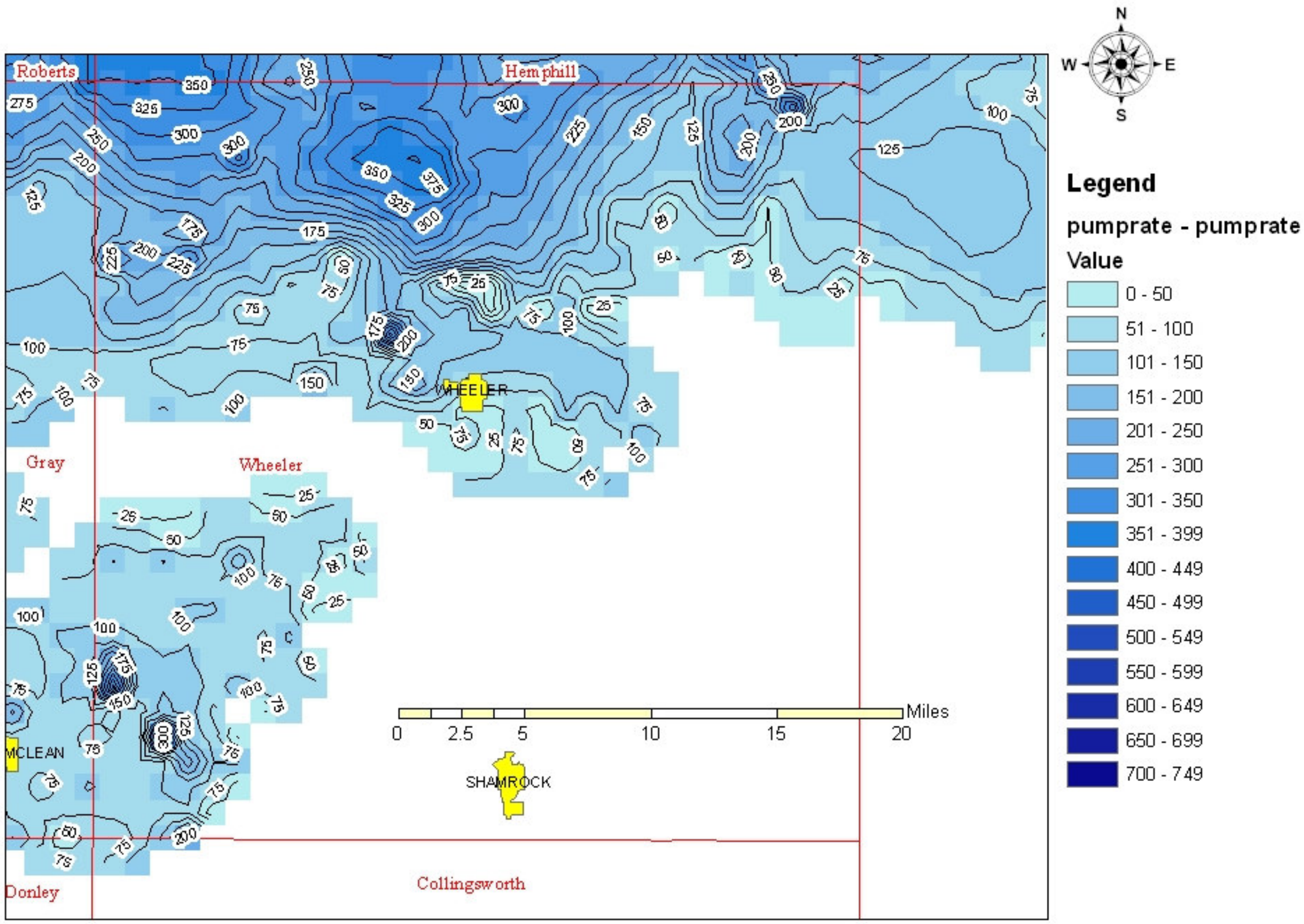


Figure 19: Wheeler County -- Pump rates in acre-feet per year which will achieve a 50% retention of the baseline volume in 50 years. Contour interval equal 25 acre-feet per year