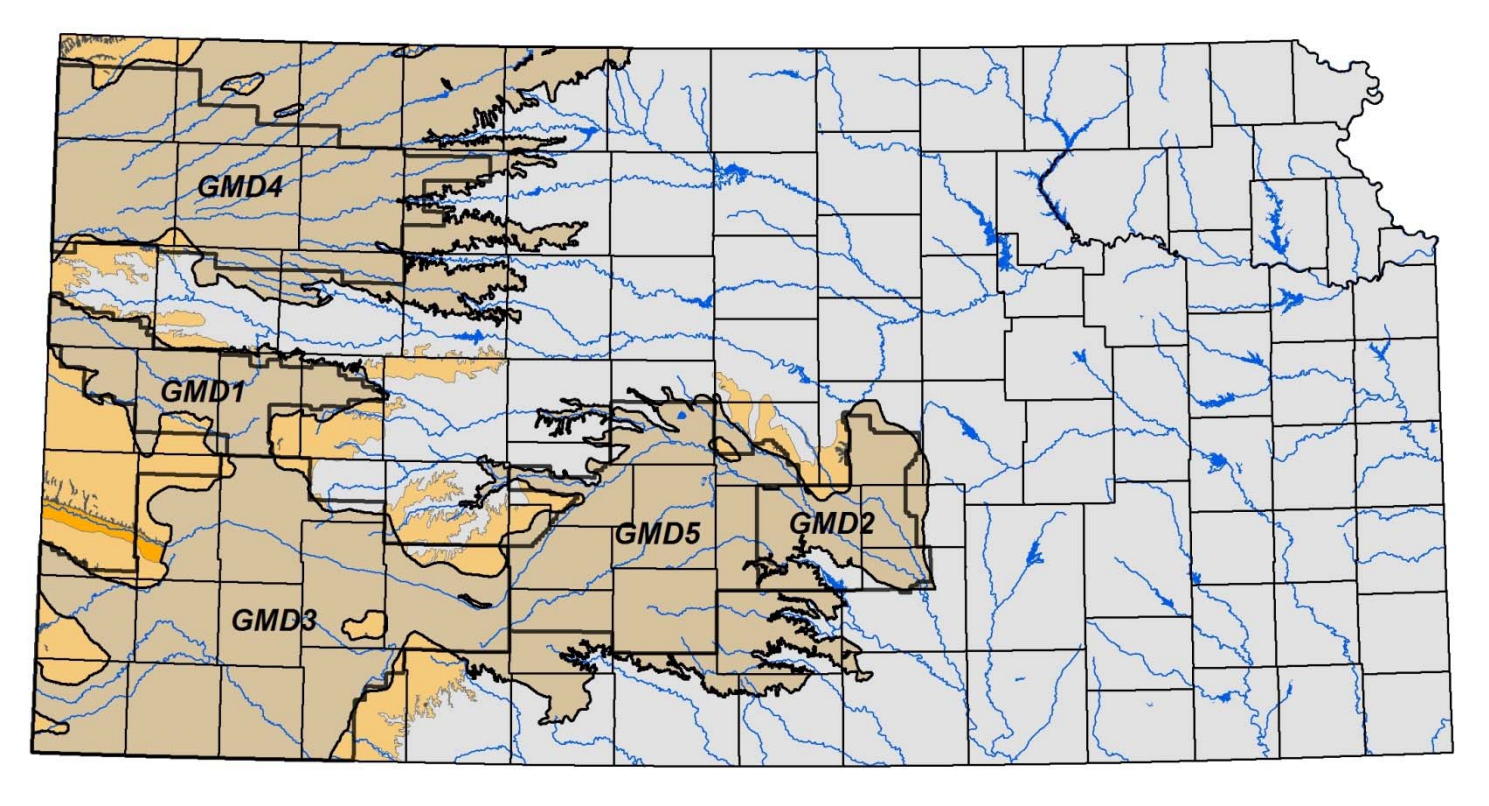
Status of the High Plains Aquifer in Kansas

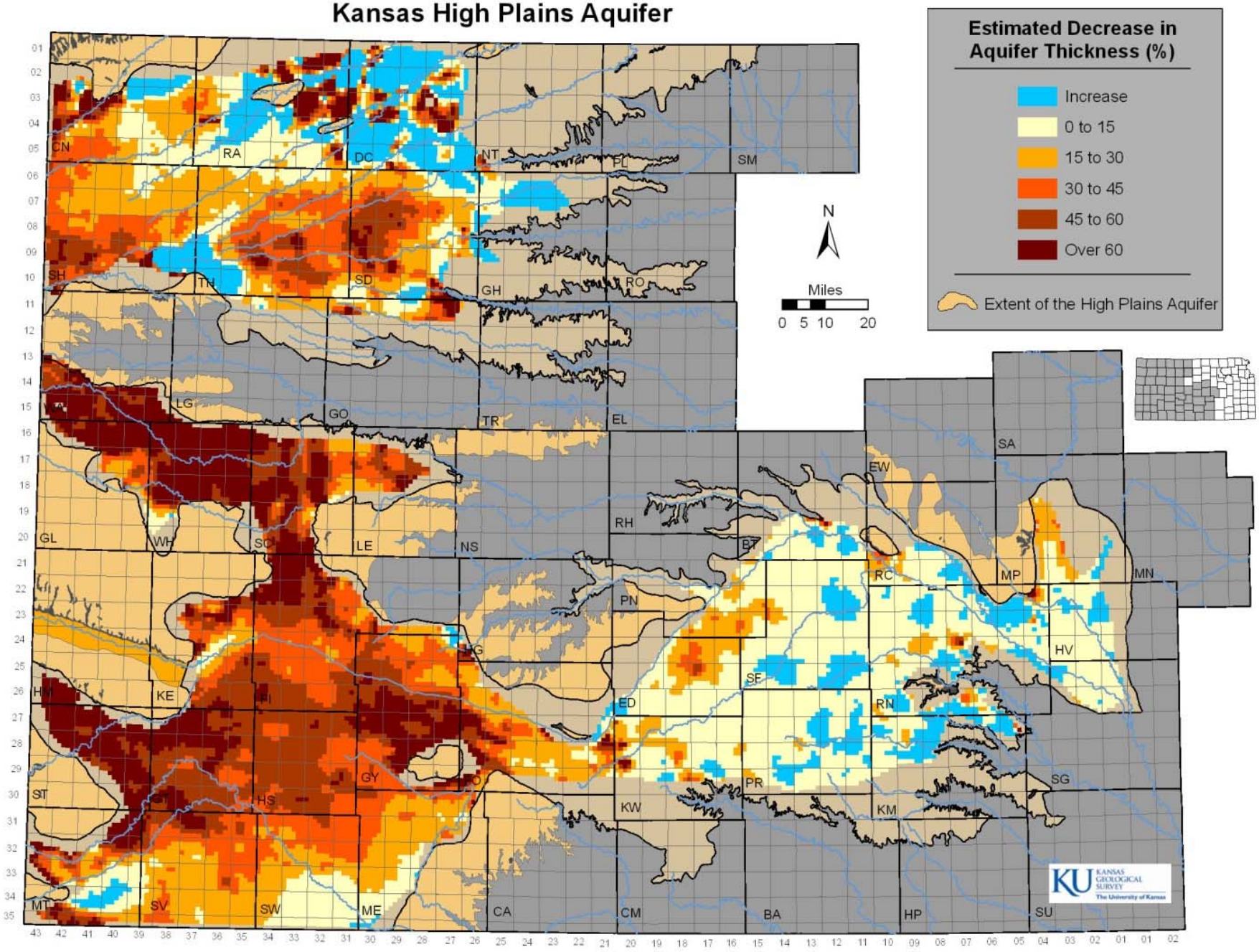
Don Whittemore, Jim Butler, and Brownie Wilson



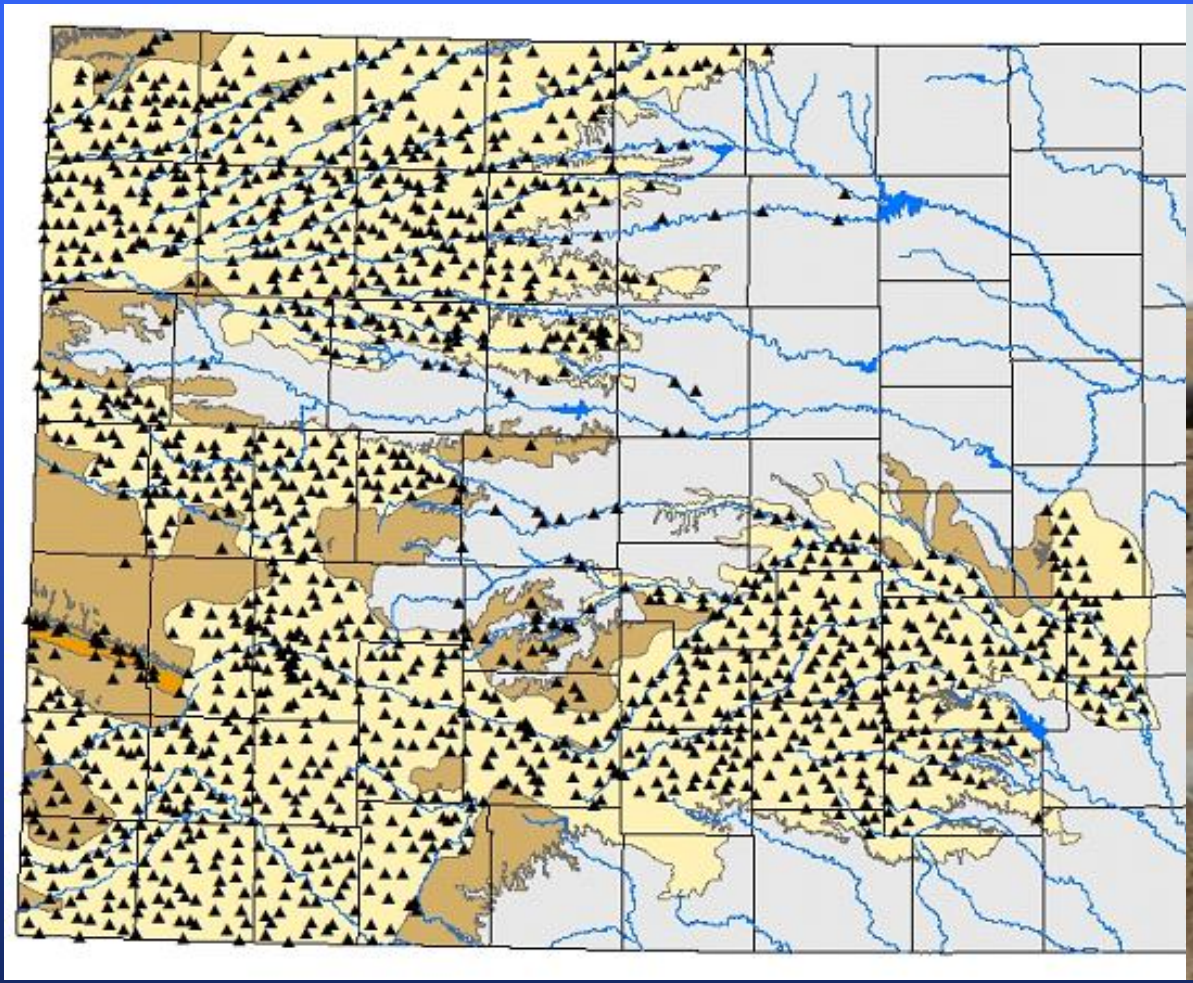
KANSAS GEOLOGICAL SURVEY
The University of Kansas

Governor's Conference on the Future of Water in Kansas
November 14, 2018

Percent Change in Aquifer Thickness, Predevelopment to Average 2015-2017, Kansas High Plains Aquifer



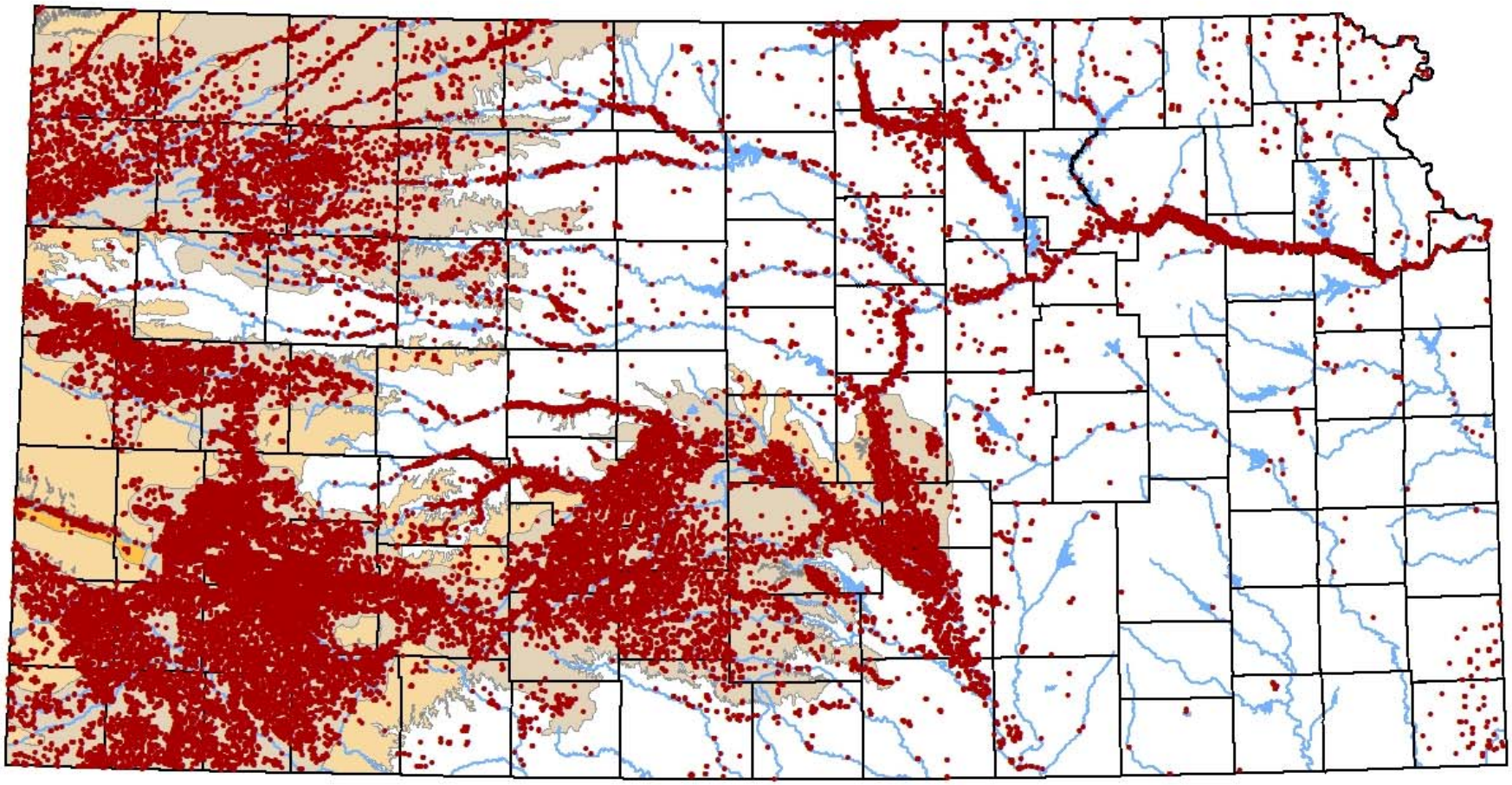
Annual Water-Level Measurement Program



≈1400 wells measured in High Plains aquifer in 2018

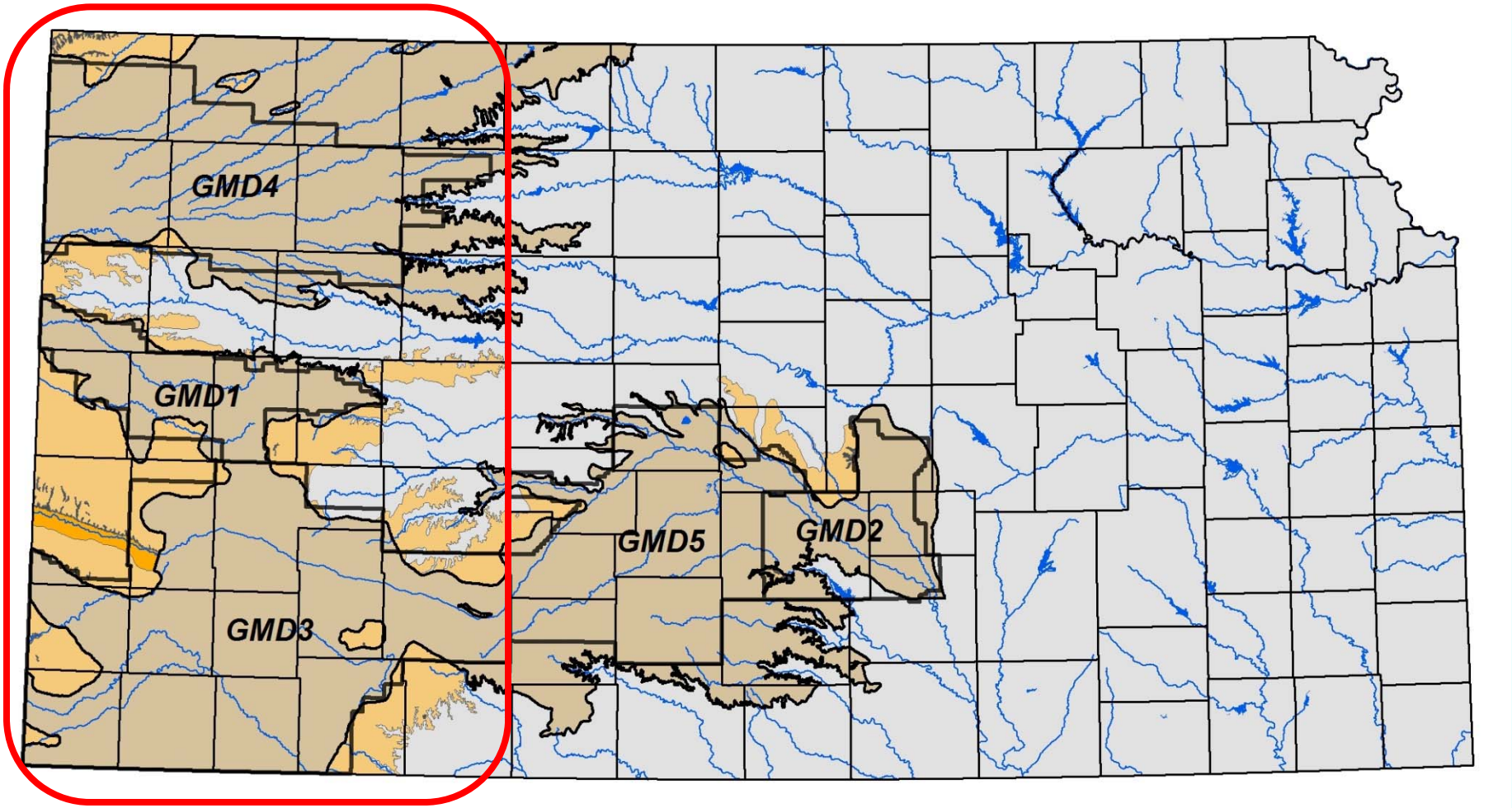
- http://www.kgs.ku.edu/HighPlains/HPA_Atlas/index.html

Active Water-Right Wells in Kansas

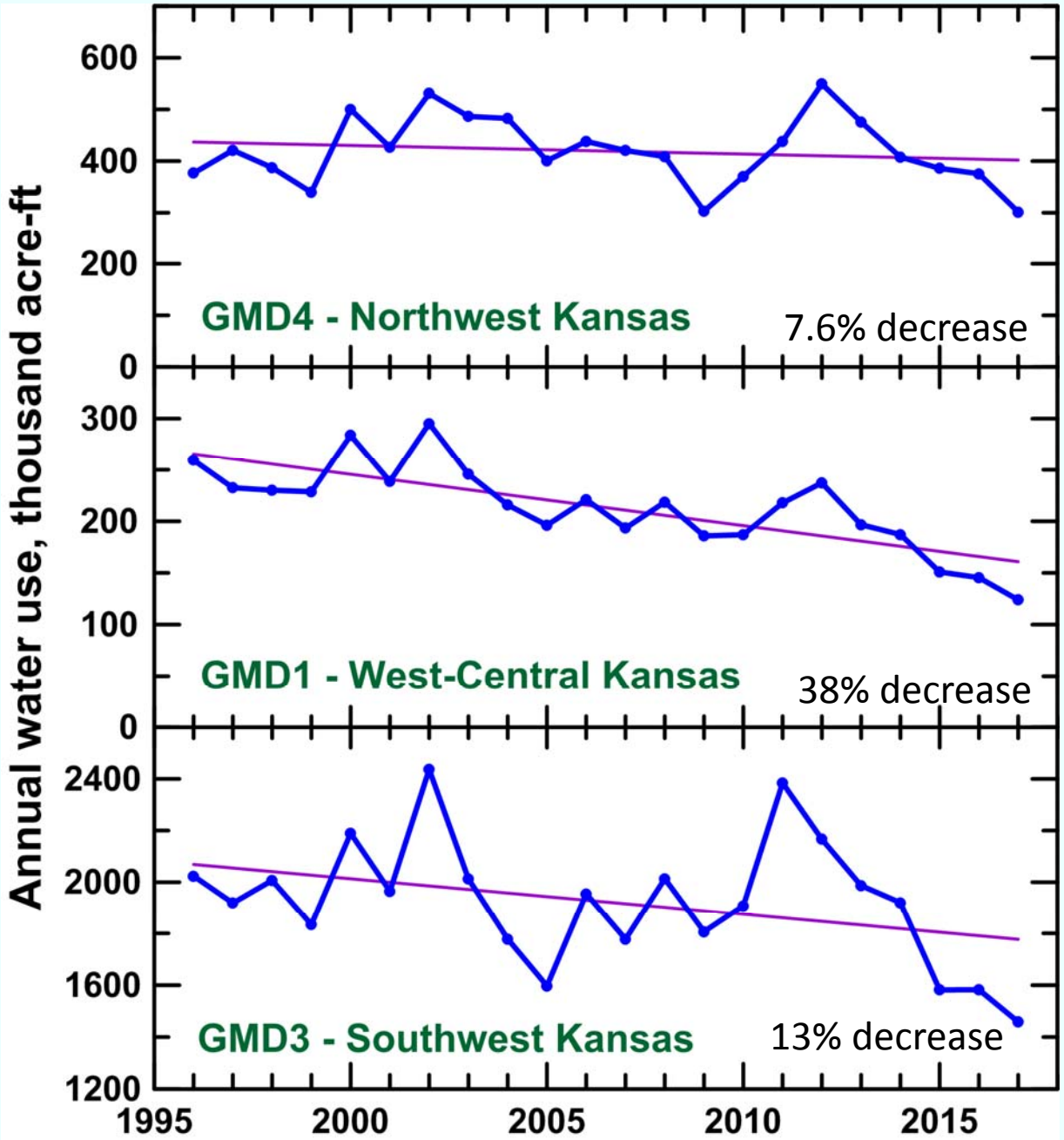


About 27,700 wells with water rights overlie the High Plains aquifer. Nearly all of these now have totalizing flowmeters.

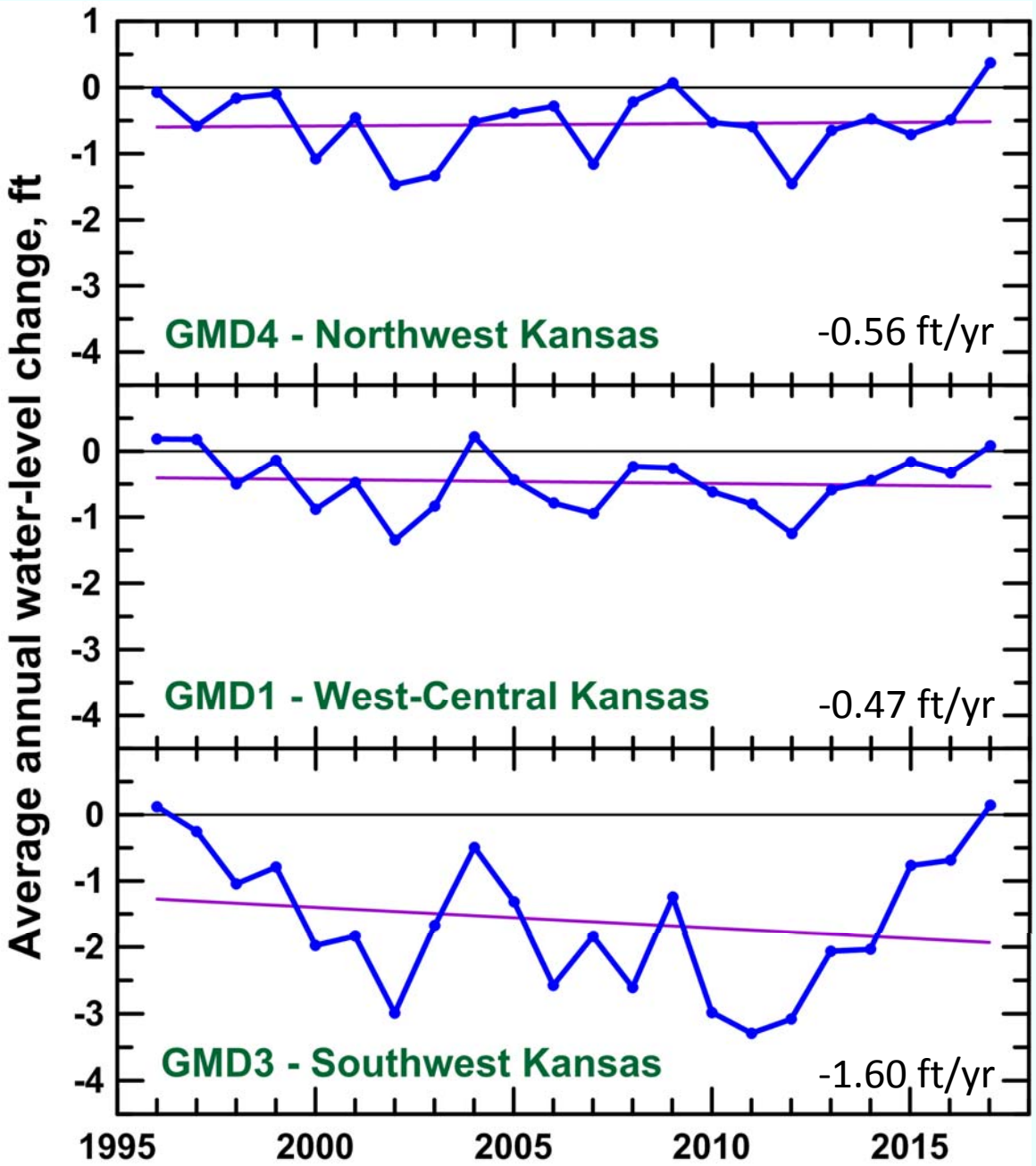
High Plains Aquifer and Groundwater Management Districts (GMDs)



Ogallala region

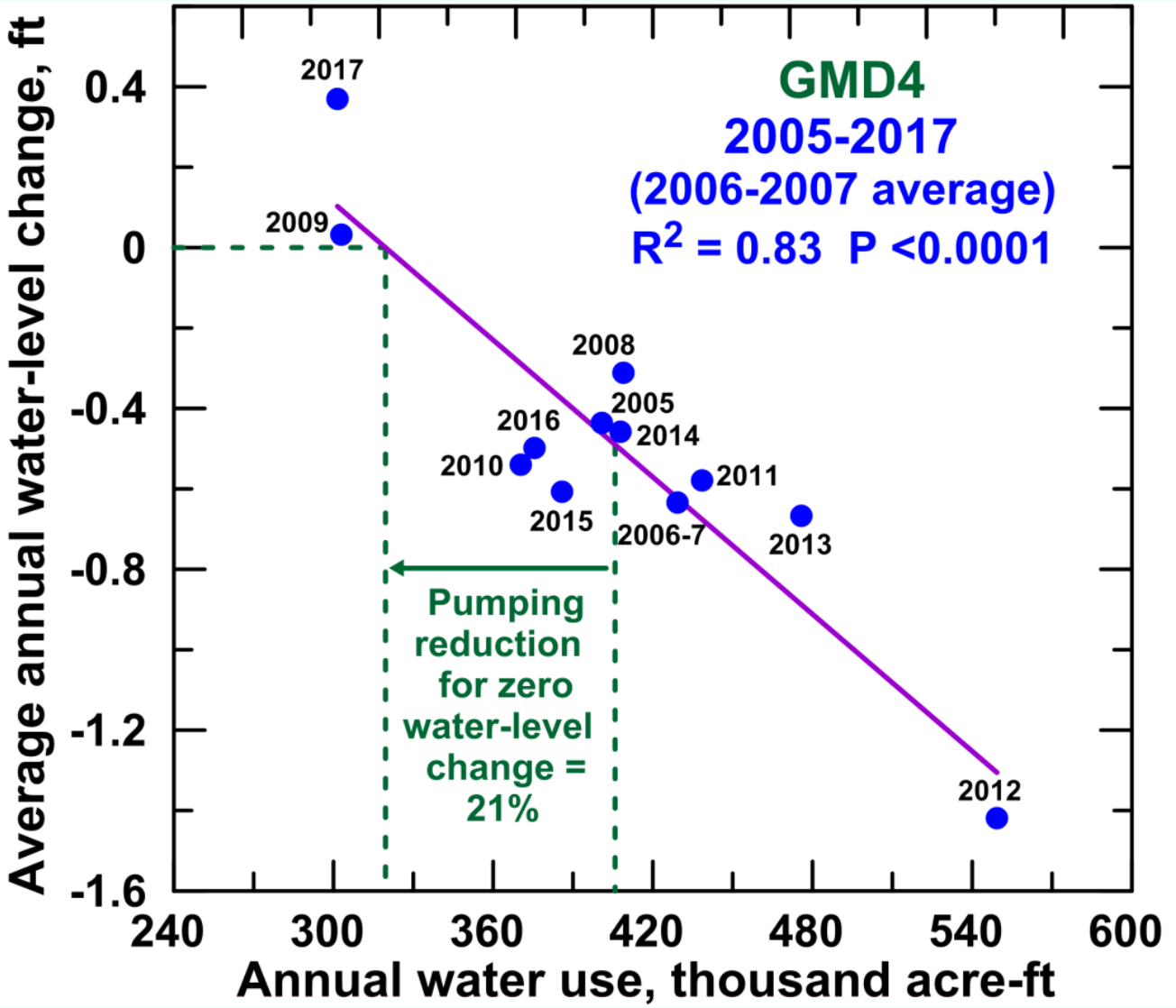


Total annual water use for GMDs in Ogallala region of High Plains aquifer 1996-2017



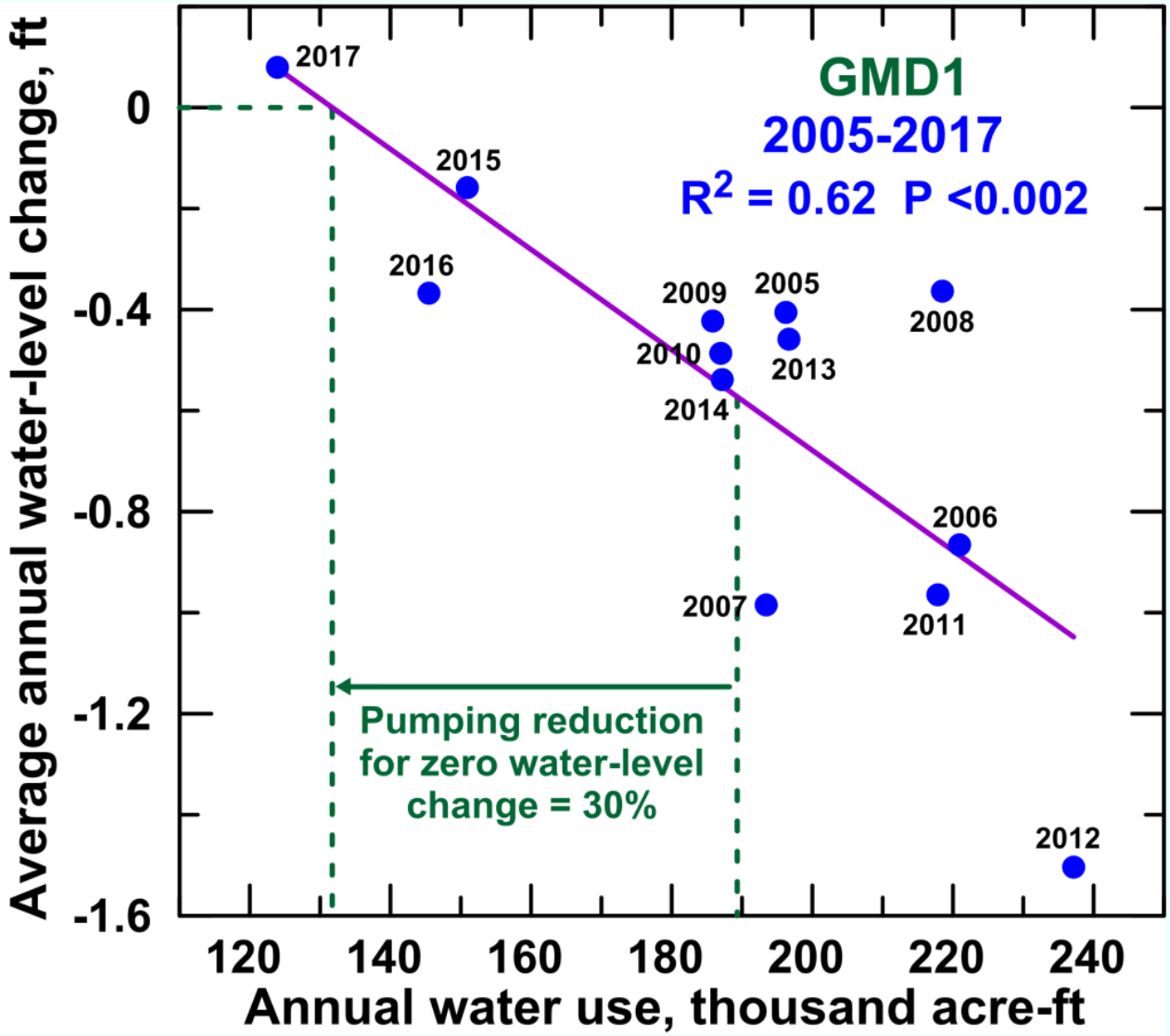
Average annual water-level change for GMDs for network wells measured every year in Ogallala region of High Plains aquifer 1996-2017

Short-term sustainability for GMD4 requires pumping reduction of 21% based on 2005-2017 data



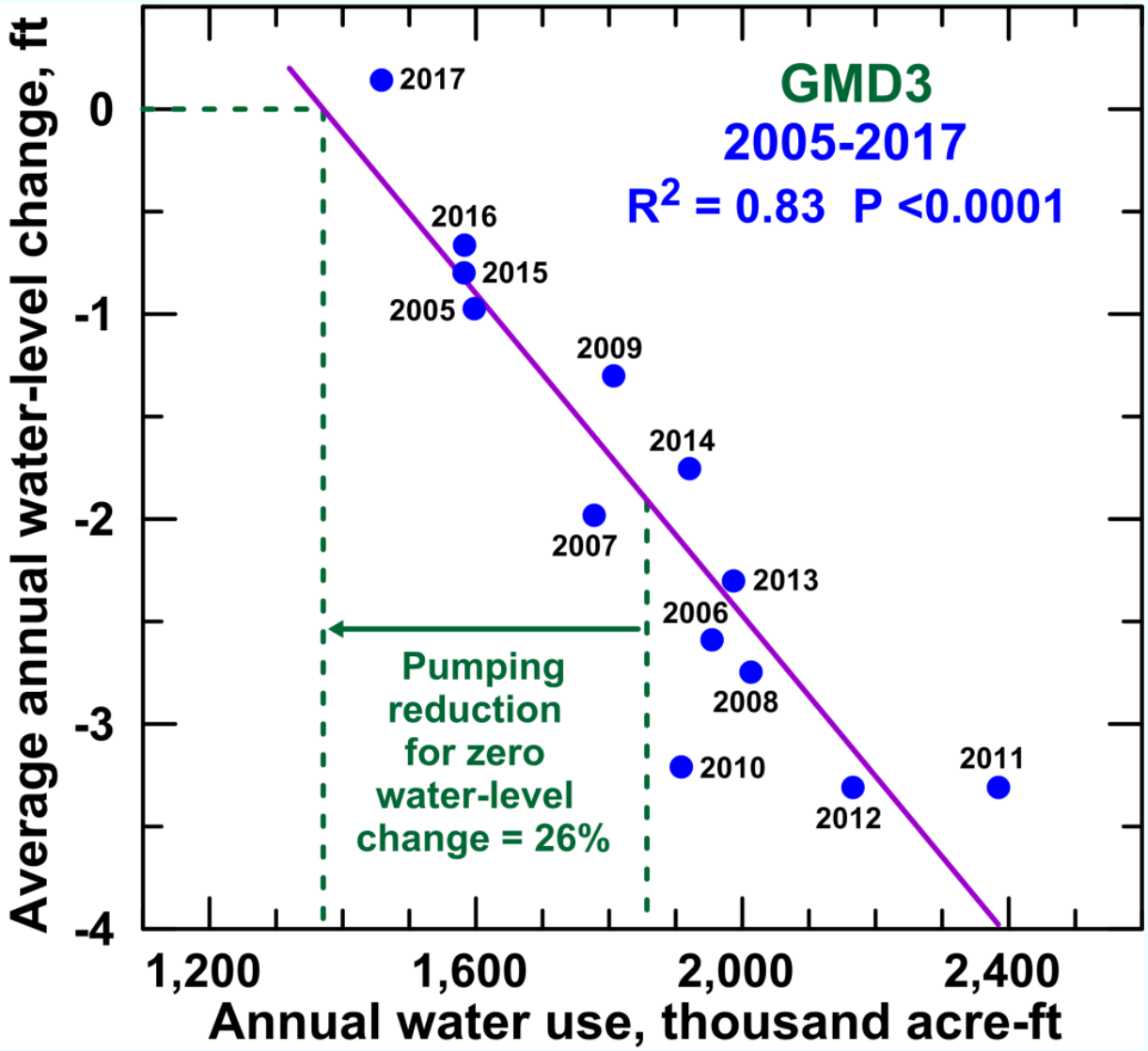
Adjustment to normal climate: 24% pumping reduction

Short-term sustainability for GMD1 requires pumping reduction of 30% based on 2005-2017 data



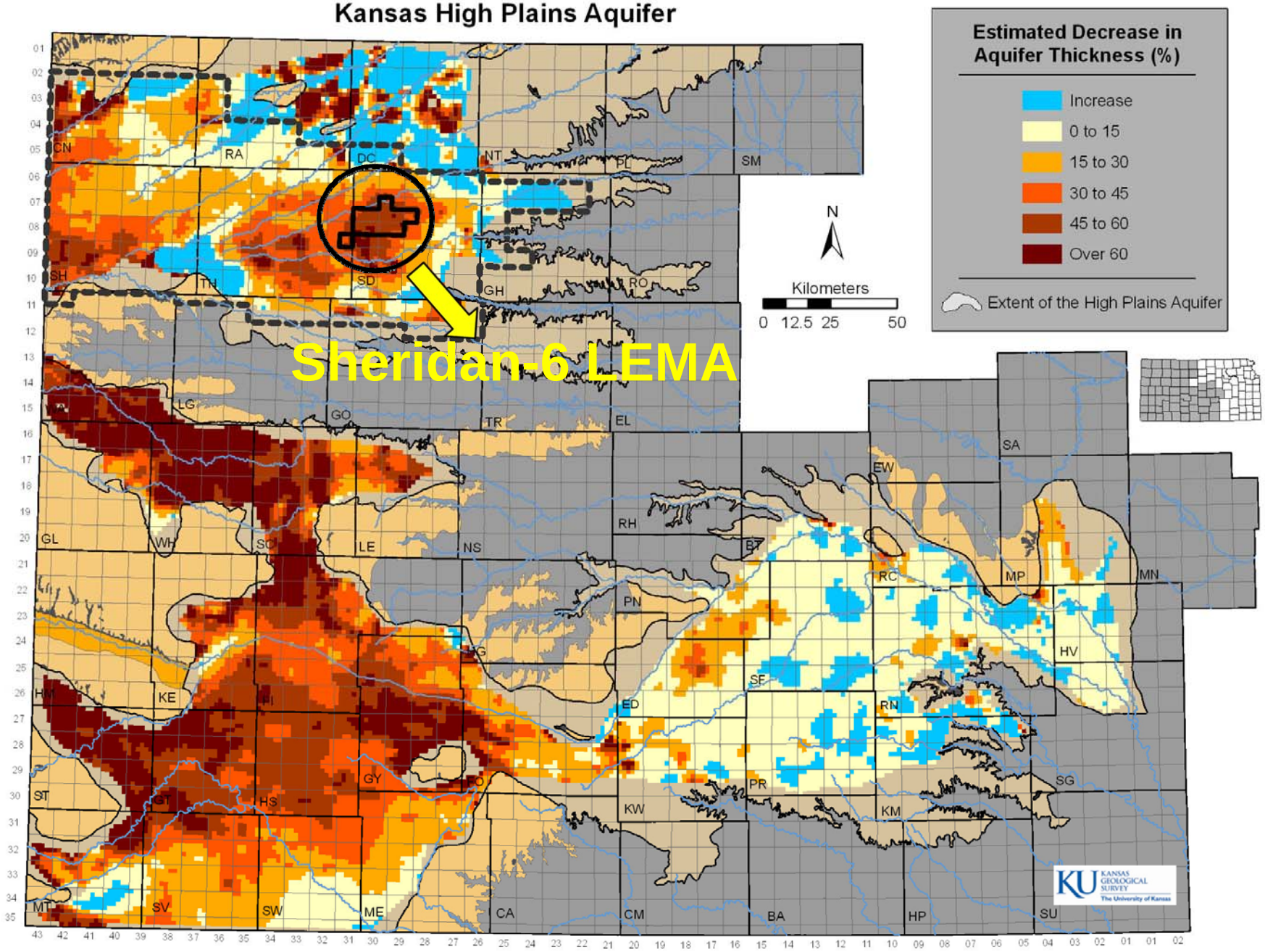
Adjustment to normal climate: 32% pumping reduction

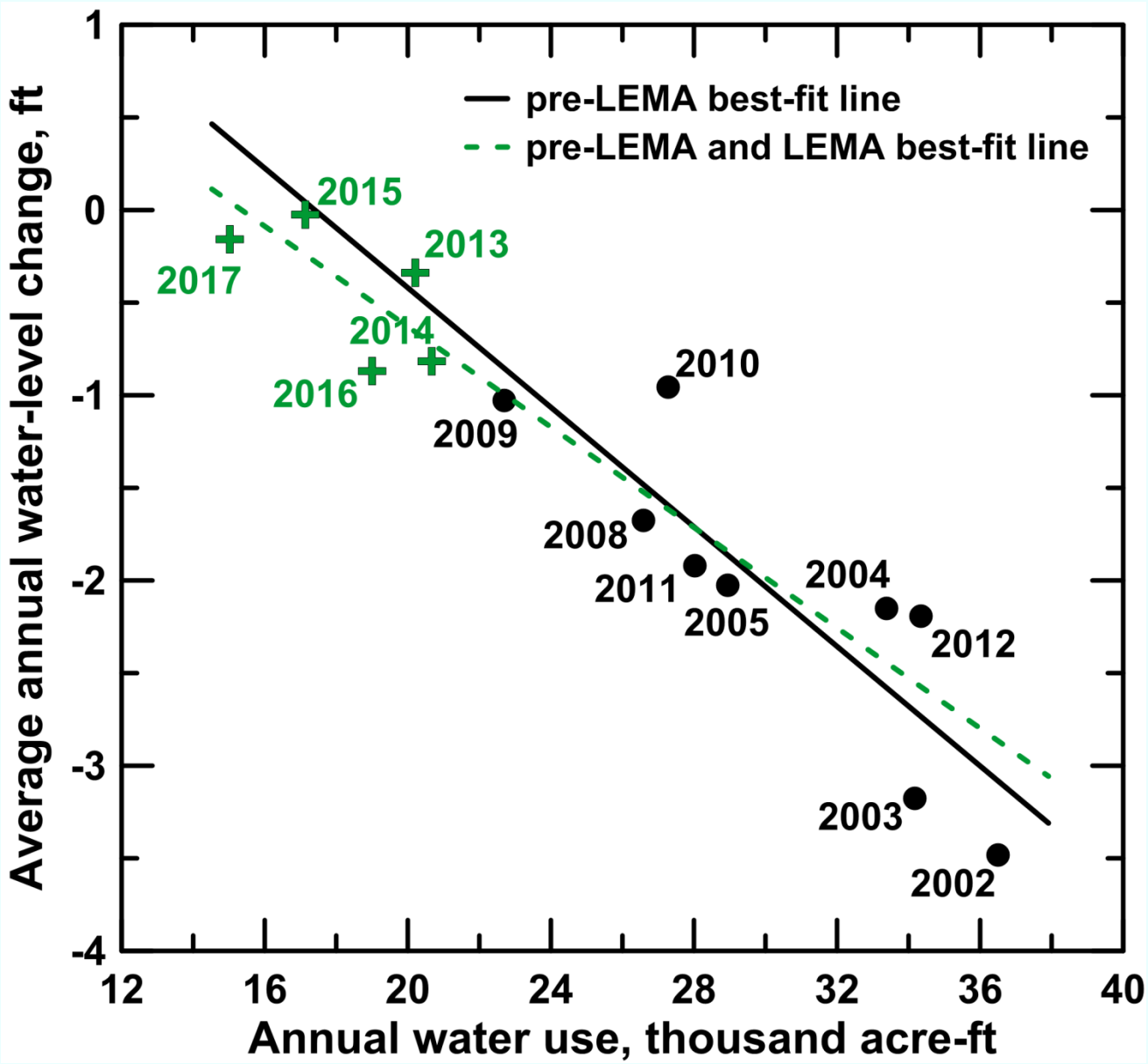
Short-term sustainability for GMD3 requires pumping reduction of 26% based on 2005-2017 data



Adjustment to normal climate: 27% pumping reduction

Percent Change in Aquifer Thickness, Predevelopment to Average 2015-2017, Kansas High Plains Aquifer



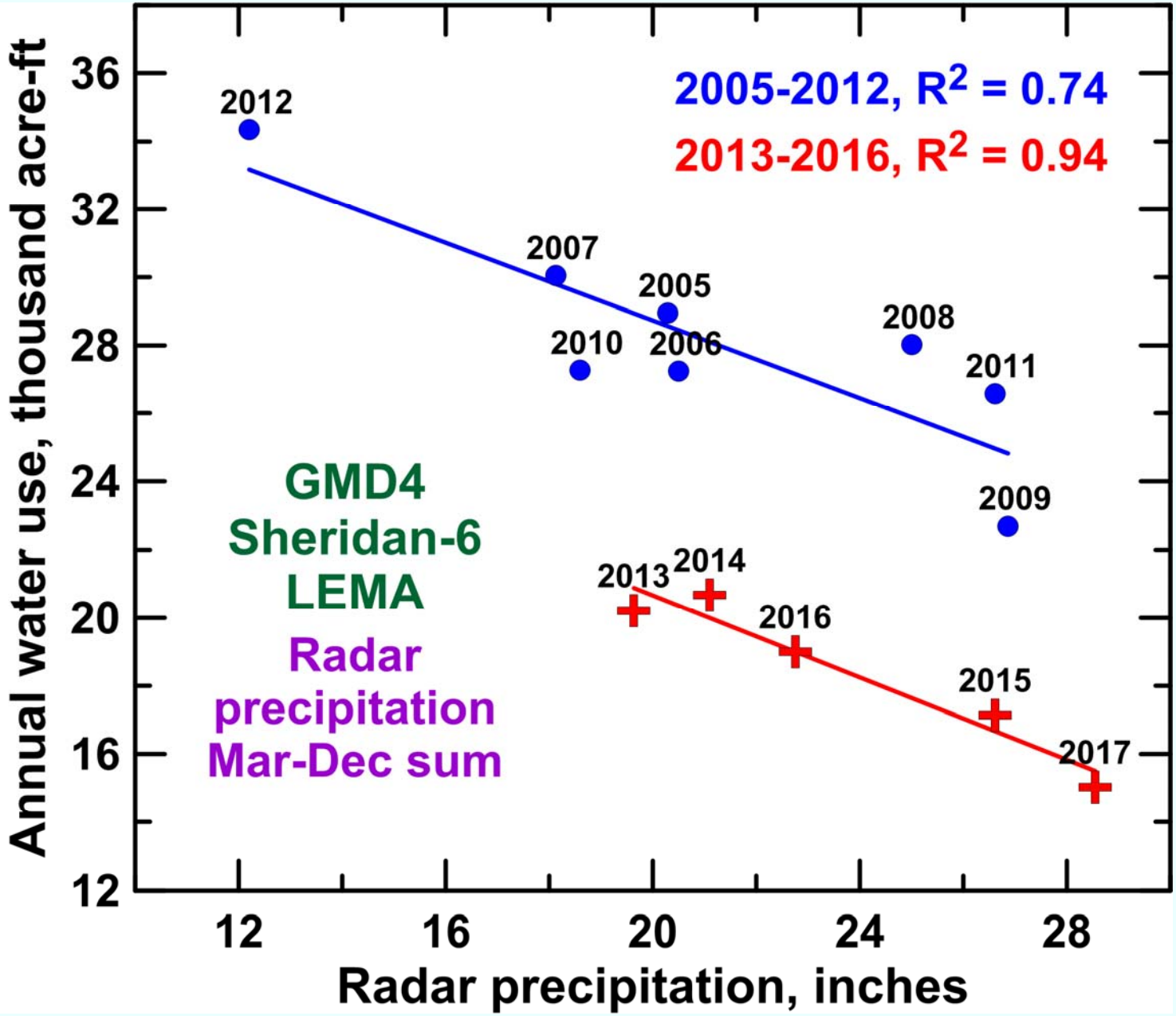


GMD4 Sheridan-6 LEMA

2002-2005, 2008-2012
R^2 = 0.76

2002-2005, 2008-2017
R^2 = 0.88

2006 and 2007 not included due to snow delaying 2007 winter water-level measurements.


2005-2012, R^2 = 0.74
2013-2016, R^2 = 0.94
GMD4
Sheridan-6
LEMA
Radar
precipitation
Mar-Dec sum
2012
2007
2005
2010
2006
2008
2011
2009
2013
2014
2016
2015
2017
Annual water use, thousand acre-ft
Radar precipitation, inches
12
16
20
24
28
32
36

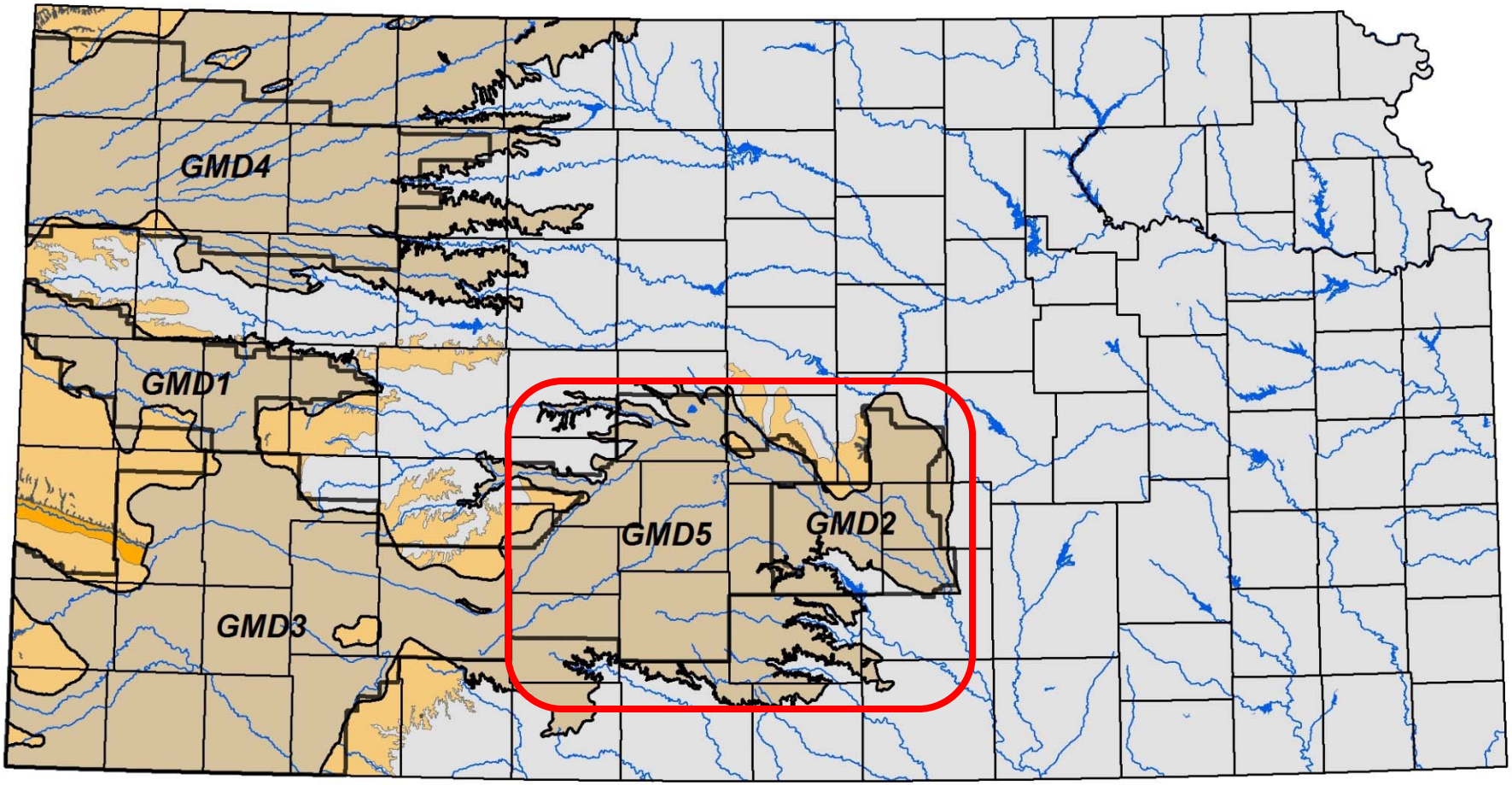
Change in Water Levels and Water Use in Sheridan-6 LEMA

- **Pumping reduction required for zero water-level change for pre-LEMA period (2002-2012): 42%**
- **Average annual water-level decline**

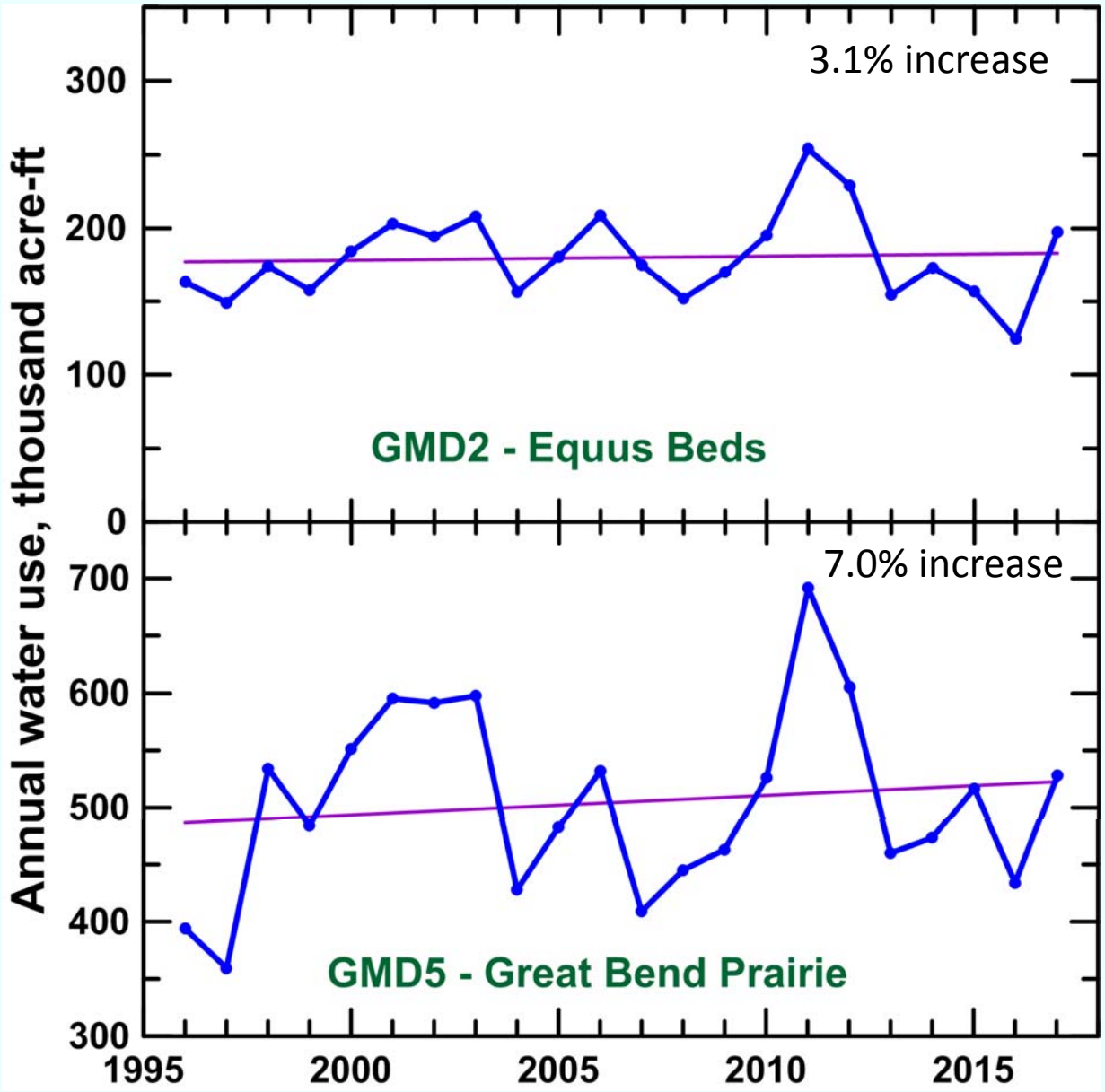
  Pre-LEMA (2002-2012): -2.1 ft

  Post-LEMA (2013-2017): -0.44 ft
- **Average annual water use decrease from pre-LEMA to post-LEMA periods for similar climatic conditions: ~30%**

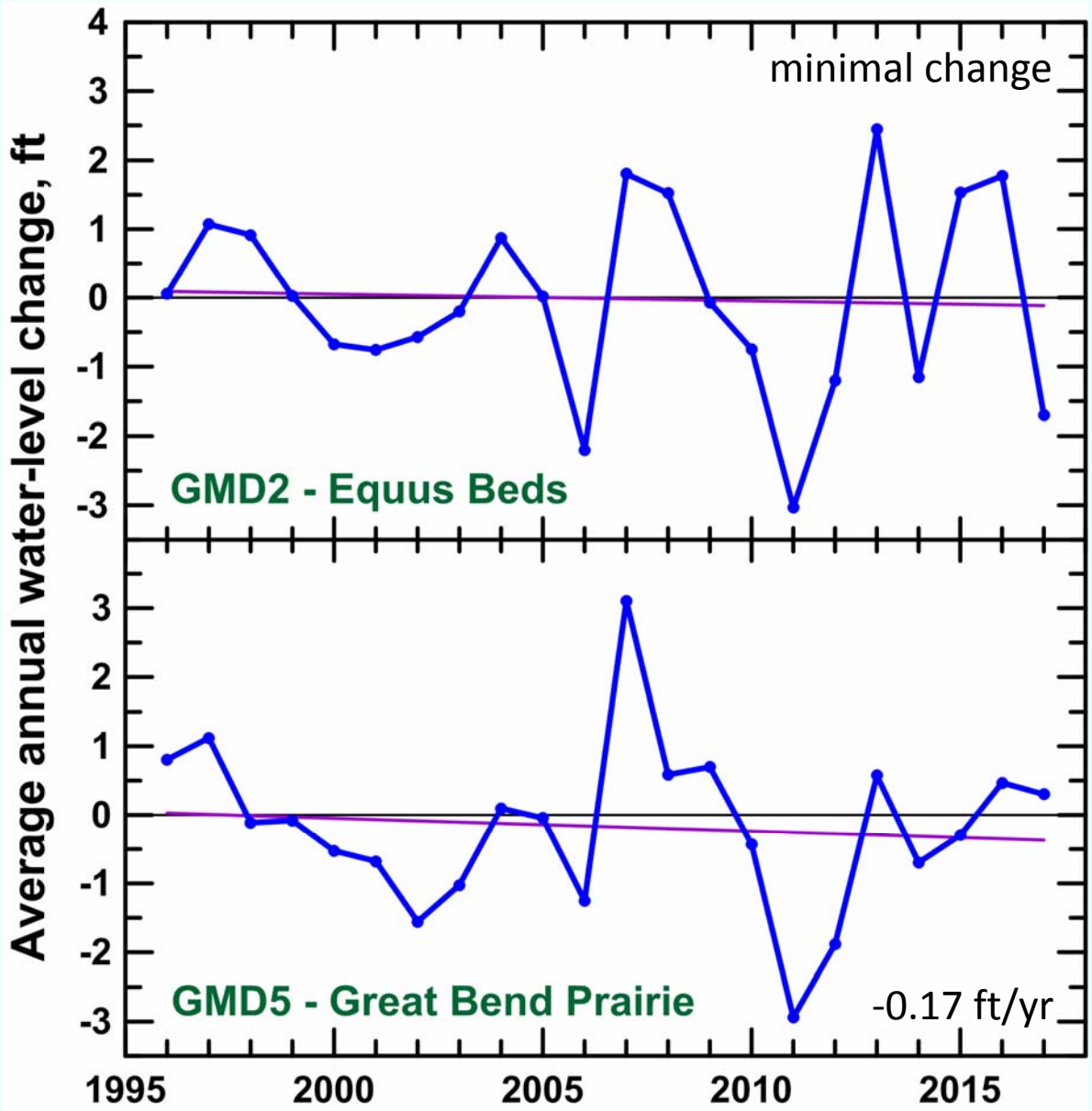
High Plains Aquifer and Groundwater Management Districts (GMDs)



Quaternary region

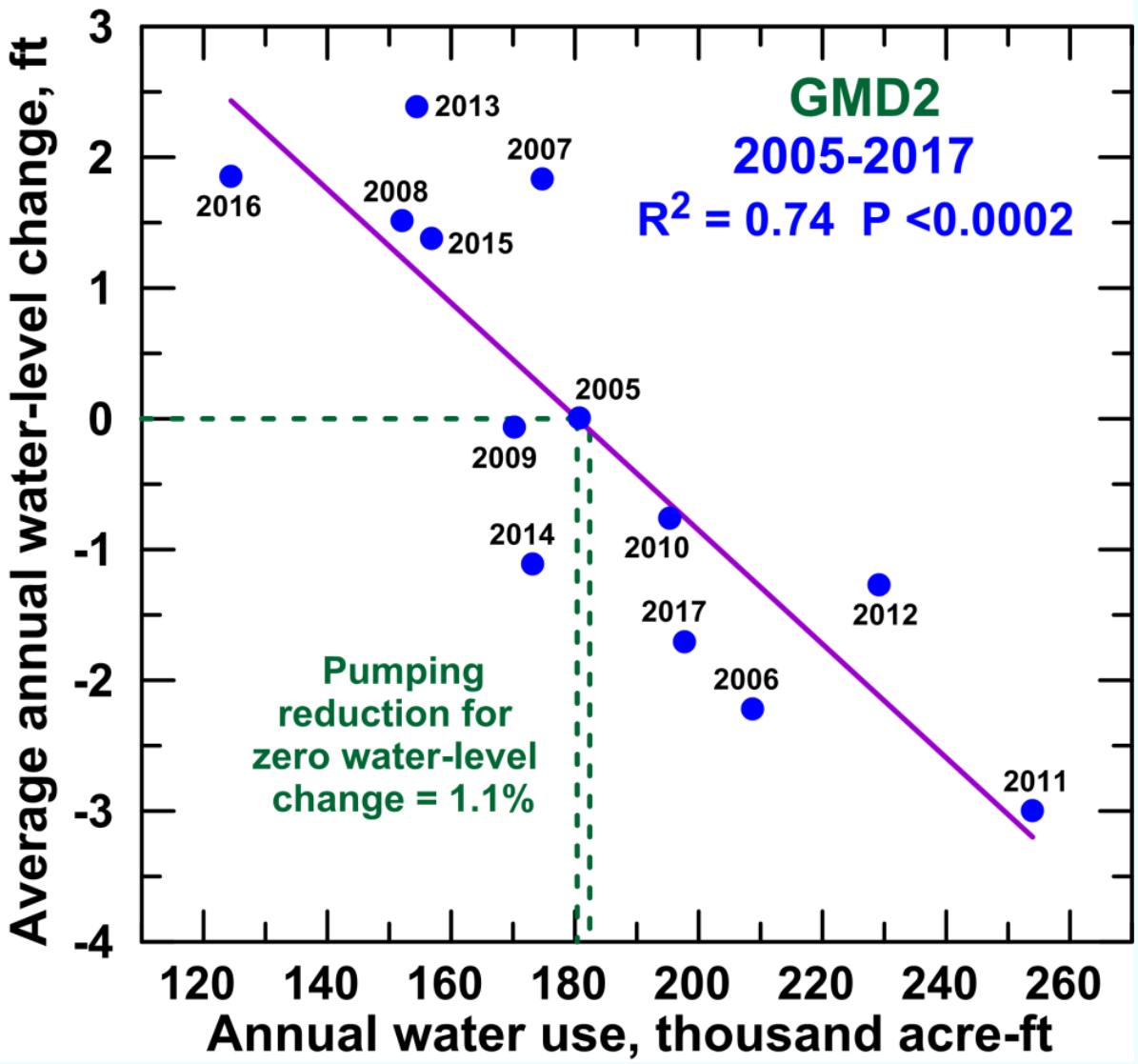


Total annual water use for GMDs in south-central region of High Plains aquifer 1996-2007



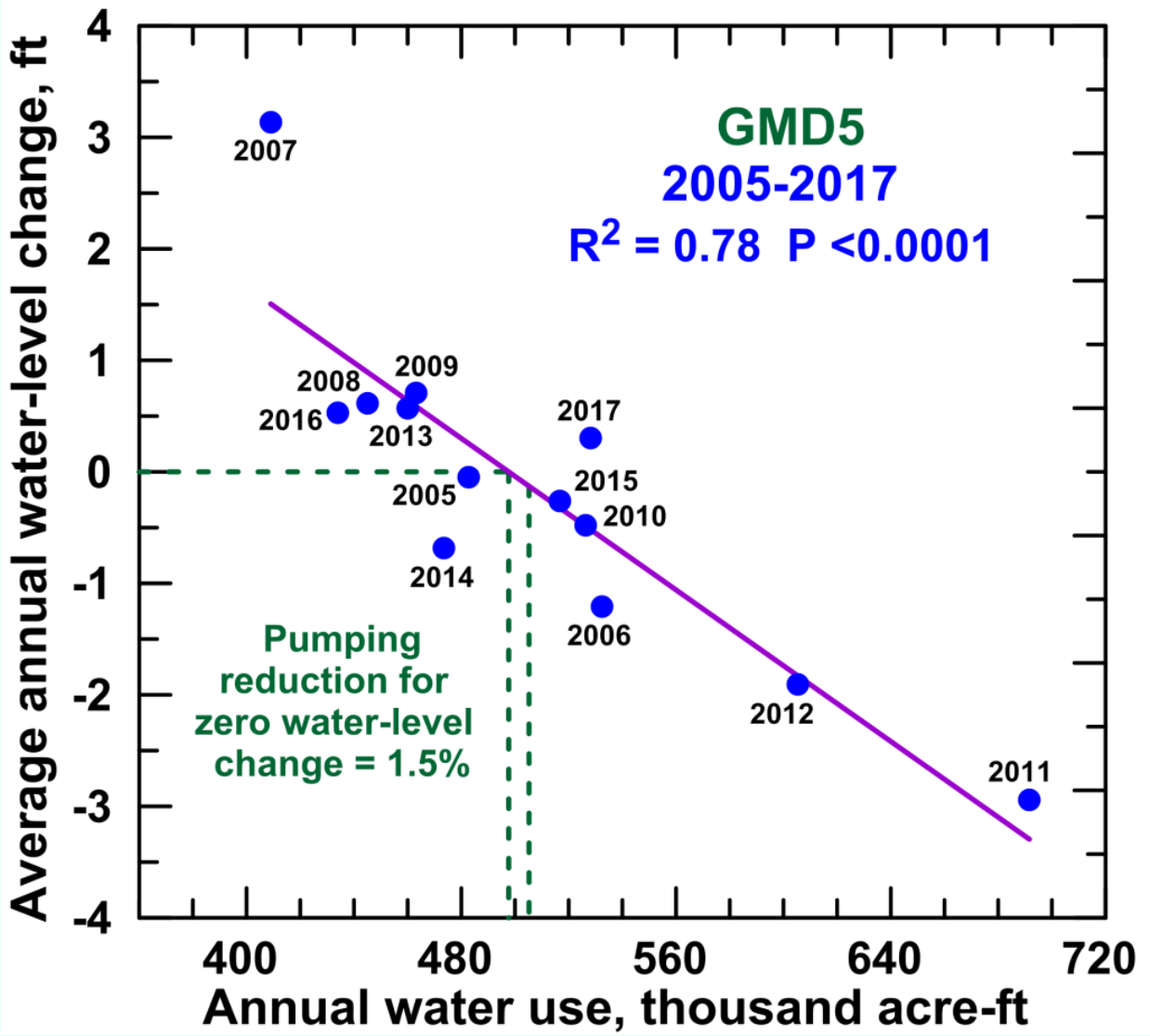
Average annual water-level change for GMDs for network wells measured every year in south-central region of High Plains aquifer 1996-2017

Pumping is nearly sustainable for the short-term for GMD2 based on 2005-2017 data



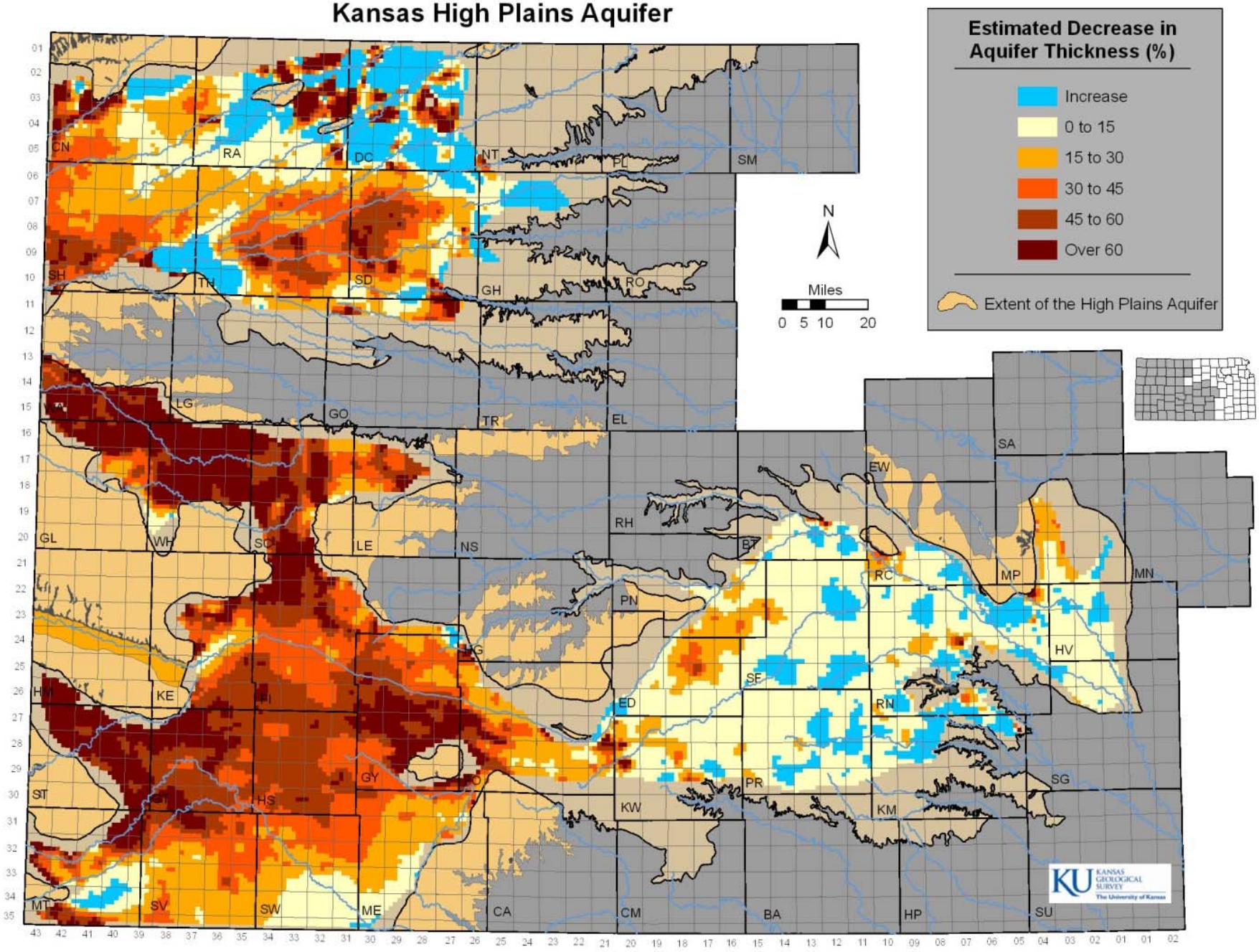
Adjustment to normal climate: 6.2% pumping reduction

Short-term sustainability for GMD5 requires pumping reduction of 1.9% based on 2005-2017 data



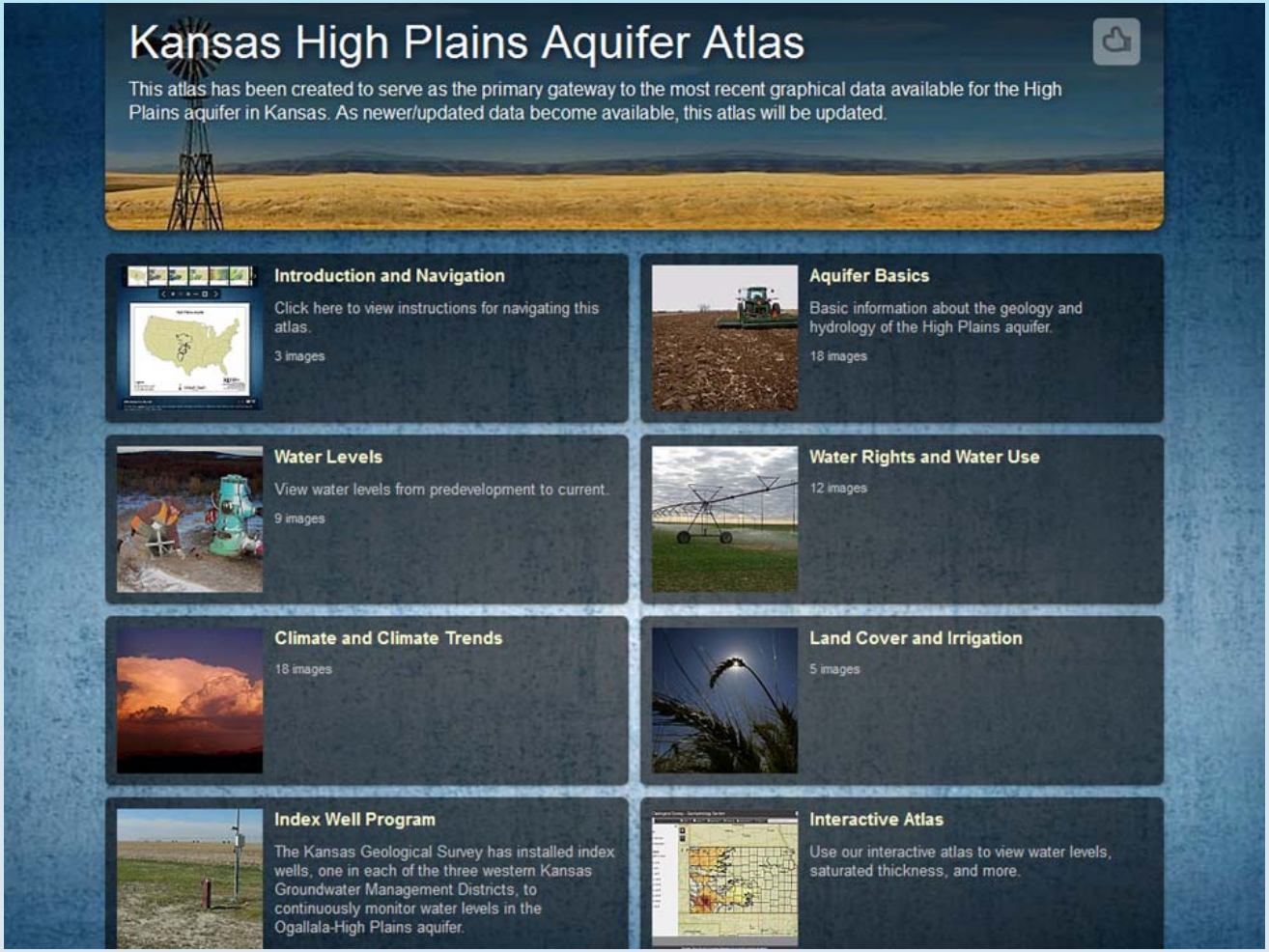
Adjustment to normal climate: 5.7% pumping reduction

Percent Change in Aquifer Thickness, Predevelopment to Average 2015-2017, Kansas High Plains Aquifer



ACKNOWLEDGMENT

This work was supported, in part, by funding from the Kansas Water Office, the Kansas Water Plan, the National Science Foundation, and the U.S. Department of Agriculture.



www.kgs.ku.edu/HighPlains/HPA_Atlas/index.html

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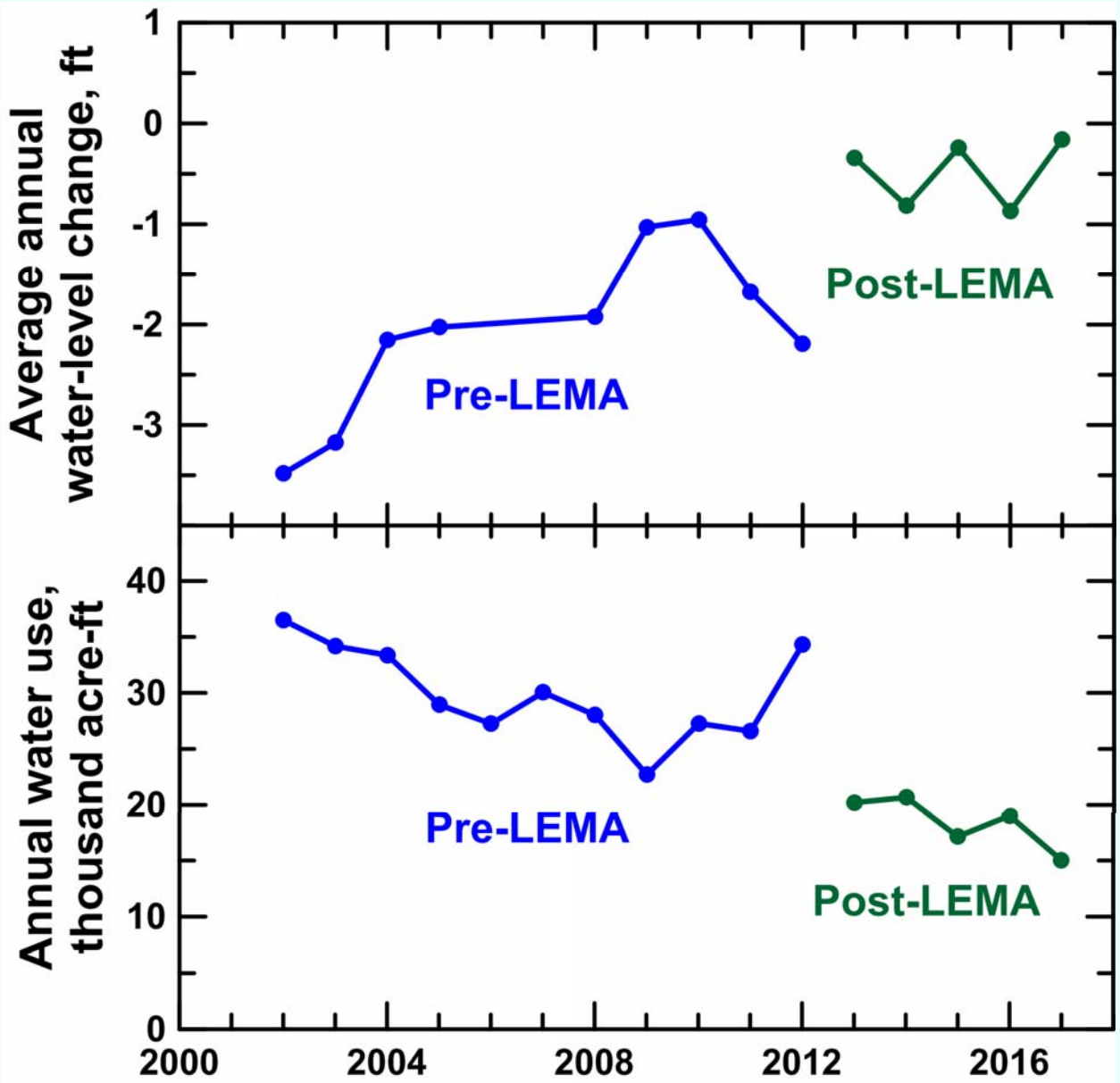
Butler, J.J., Jr., D.O. Whittemore, B.B. Wilson, and G.C. Bohling, Sustainability of aquifers supporting irrigated agriculture: a case study of the High Plains aquifer in Kansas, *Water International*, v. 43, no. 6, pp. 815-828, doi: 10.1080/02508060.2018.1515566, 2018.

Butler, J.J., Jr., D.O. Whittemore, B.B. Wilson, and G.C. Bohling, A new approach for assessing the future of aquifers supporting irrigated agriculture, *Geophysical Research Letters*, v. 43, no. 5, pp. 2004-2010, doi: 10.1002/2016GL067879, 2016.

Whittemore, D.O, J.J. Butler, Jr., and B.B. Wilson, Assessing the major drivers of water-level declines: New insights into the future of heavily stressed aquifers, *Hydrological Sciences Journal*, v. 61, no. 1, pp. 134-145, doi: 10.1080/02626667.2014.959958, 2016.



Sheridan-6 LEMA Water-level change and water use for 2002-2012 and 2013-2017 periods

2006 and 2007 not included due to snow delaying 2007 winter water-level measurements.

Conclusions

Ogallala Part of High Plains Aquifer

- **Water levels have declined ~0.5-0.6 ft/yr in GMDs 1 and 4 and 1.6 ft/yr in GMD3 during the last 22 years.**
- **Pumping reductions needed to achieve stable water levels in the Ogallala are 32%, 27%, and 24% for GMDs 1, 3, and 4, respectively, adjusted for normal climatic conditions.**
- **Water-use reductions of ~30% (adjusted for climatic conditions) in the Sheridan-6 LEMA have significantly decreased water-level declines.**

Short-Term Sustainability of Ogallala Region

(based on average annual water-level change and water-use relationships)

- **Reduction in water use needed for no water-level change over one or two decades:**

  GMD4: 21% (for normal climate 24%)

  GMD1: 30% (for normal climate 32%)

  GMD3: 26% (for normal climate 27%)

- **Reduction in water use of even half these values would decrease water-level declines in half.**
- **Reduction percentages are dependent on climate (whether wetter or drier conditions prevail).**

Conclusions

South-Central Kansas Part of High Plains Aquifer

- **Water levels have not changed significantly in GMD2 and have declined ~0.2 ft/yr in GMD5 during the last 22 years.**
- **Pumping would need to be reduced by ~6% for stable water levels in GMDs 2 and 5 based on 2005-2017 data and adjusted for normal climatic conditions. Sustainability is highly dependent on recharge during very wet years.**

Last 22 Years for South-Central Kansas

- **Average annual water-level change (trend in regression line) during 1996-2017**

  GMD2: Insignificant trend

  GMD5: Slight decline; average -0.17 ft/yr

- **Annual water use (regression line trend 1996-2017)**

  GMD2: 3.1% increase

  GMD5: 7.0% increase

- **Greater water-level fluctuation than in Ogallala**
- **High correlation between water-level change and water use**
- **High correlation between precipitation and water use**

Changes Over Last 22 Years for Ogallala Region

- **Average annual water-level change (regression line trend from 1996 to 2017)**

  GMD4: Steady decline rate; average -0.56 ft/yr

  GMD1: Steady decline rate; average -0.47 ft/yr

  GMD3: Increasing rate of decline; average -1.60 ft/yr

- **Annual water use (regression line trend 1996 to 2017)**

  GMD4: 7.6% decline

  GMD1: 38% decline

  GMD3: 13% decline

- **High correlation between water-level change and water use**

- **High correlation between precipitation and water use**