Testimony from Brownie Wilson, Kansas Geological Survey.

Submitted to Hearing Officer Connie Owen, Appointed by David Barfield, Chief Engineer, Division of Water Resources, Kansas Department of Agriculture.

RE: Written Testimony, Proposed GMD4 District-Wide LEMA Hearing, August 23, 2017

My name is Brownie Wilson. I am the Geographic Information Systems (GIS) and Support Services Manager for the Geohydrology Section at the Kansas Geological Survey (KGS). The KGS is a research and service division under the University of Kansas and has been directed by the Kansas Water Plan to provide technical assistance to the three western Groundwater Management Districts (GMD), the Kansas Water Office, and the Kansas Department of Agriculture- Division of Water Resources (KDA-DWR) in the assessment, planning, and management of the groundwater resources of western Kansas.

At the request of GMD4 in May of 2016, the KGS looked at the changes in the saturated thickness of the Ogallala/High Plains aquifer (HPA) from 2004 to 2015 within the District boundaries. The saturated thickness is defined as the thickness of the aquifer in which the pore spaces are saturated with water. For the HPA, this is the difference in elevation between the underlying bedrock and the water table for a given year.

In northwest Kansas, the bedrock surface is typically composed of shale layers underlying the unconsolidated aquifer sediments. Because of its impervious nature to groundwater flow, the bedrock represents the bottom of the aquifer. In 2006, the KGS reviewed the lithologic descriptions from tens of thousands of driller's logs and published updated maps of the Ogallala bedrock surface across western Kansas (Macfarlane and Wilson, 2006).

Each year, the KGS and the KDA-DWR measure the depth-to-water from a network of approximately 1,400 water wells, across the HPA, as part of the state's Cooperative Water Level Program. Customized software developed by the KGS, coupled with Global Positioning System (GPS) data, is used to make sure the same wells are visited each year. The majority of water-level measurements are taken in late December and early January using steel or electric tapes with precisions down to the hundredths of a foot. Measurements are field checked on site at the time of the visit to ensure locational accuracy and that the current measurement is within the historical trend of past measurements. Additional statistical and GIS reviews are conducted later to identify abnormal or anomalous measurements. If deemed necessary, well sites will be re-measured the same day or within a month, depending on the circumstances.

Collected water levels from the Cooperative Water Level Program, along with additional measurements from other local, state, and federal sources, are stored and served online through the KGS' Water Information Storage and Retrieval Database (WIZARD). WIZARD evolved from the U.S. Geological Survey's Ground Water Site Inventory in the mid- 1990s, and today represents the largest repository of depth-to-water measurements in Kansas.

Well site locations in the HPA and their associated water-level measurements were downloaded from WIZARD to estimate the water-table elevations for the 2004, 2009, and 2015 calendar years. The well site locations, based on their listed geographic coordinates, were spatially mapped into the ArcGIS software platform, a GIS mapping software. Within GMD4, all of the measured well locations used in this project have been surveyed with hand-held GPS units, which typically have horizontal accuracy ranges of 12 to 40 feet.

The WIZARD database contains codes indicating the status of the site at the time the water level was measured. Most water level measurements across GMD4 were taken in late December and early January and contain blank or null status codes indicating static or near static water level conditions. Past water level measurements that were coded to be “anomalous” from previous statistical and geostatistical reviews were not included in this project along with measurements taken from locations where the well was obstructed, was pumping at the time of the measurement, had recently been pumped, or had nearby sites that were being pumping at the time of the measurements.

The water-level measurements were used to calculate the 3-year average winter depth to water for each well site, centered on the calendar years 2004, 2009, and 2015. For example, a well’s 3-year average, winter depth to water for 2004 are based on measurements taken in the months of December 2002, January 2003, February 2003, December 2003, January 2004, February 2004, December 2004, January 2005, and February 2005. Given most wells are only measured once a year, most well site’s averages are based on only three measurements, one for each year in the 3-year period, although some could contain over 10 individual measurements depending on the frequency a well was measured. The 3-year average water table elevations for 2004, 2009, and 2015 were then computed by subtracting the averaged depth-to-water values from the land surface elevation listed at each well location.

Three-year winter averaging of water levels helps to smooth out single-year variations in the water table caused by late or early season pumping and allows for more well sites to be used for temporal reviews of water levels over decadal periods. For this project, only wells containing a computed 3-year, winter average water levels centered on the calendar years of 2004, 2009, and 2015 were considered. If a well site was missing a 3-year average value for one of these target years, it was removed from the data set. In addition, only wells in and within 20 miles of the District’s boundaries were selected for further analysis. Under these selection criteria, 382 well sites were used with 277 of them located within the boundaries of GMD4.

To estimate the water table elevations across GMD4, the wells sites and their respective 3-year, winter averaged values for 2004, 2009, and 2015 were interpolated into continuous water table surfaces using ArcGIS’ “Topo to Raster” interpolation routine. Topo to Raster is an interpolation method specially designed to create digital elevation models. For this project, the interpolated surfaces are composed of uniform grid cells, 250 x 250 meters in size, each containing estimates of the water table elevation for 2004, 2009, and 2015.

Within ArcGIS, a polygon layer representing public land survey system (PLSS) sections were overlain across the interpolated water table surfaces. The mean interpolated water table elevation, based on the cells occurring within each PLSS section, was computed for 2004, 2009, and 2015. In a similar manner, each PLSS section had the mean bedrock elevation assigned from interpolated surfaces used in published KGS reports (MacFarlane and Wilson, 2006) along with the land surface elevation downloaded from the USGS’ National Elevation Dataset.

GMD4 was provided a Microsoft Excel spreadsheet and GIS files of the PLSS sections within the District, each coded with their average land surface, bedrock, and 2004, 2009, and 2015 water table elevations. Because the water table elevations are based on interpolated surfaces from wells measured during each time period, the change in the water table between those years and the saturated thickness can be readily computed at the PLSS- section level.

After a review of the data, it was mutually decided by GMD4 and the KGS to remove the well in township 11S, range 27 west, section 13. This well shows a significant water level decline from 2004 to 2015, not seen in any other wells in the region over that same period and was felt to be biasing the overall section-based estimates in the south-east portions of the district. The well was removed the dataset and the interpolation process and assignment of mean values for the overlying PLSS sections was repeated.

A second review of the data centered on the possible influence of alluvial wells. Alluvial aquifer systems are associated with stream deposits, are relatively shallow, close to the land surface and have highly connected ground- and surface-water interactions. In past HPA water level mapping exercises, both alluvial and Ogallala wells were used to estimate water levels as the two systems are in hydrologic connection to each other. However, if the hydrologic connection between alluvial deposits and the underlying Ogallala aquifer is small or impeded by a low-permeable formation between the two systems, the interpolated water-table surfaces could be slightly elevated or there could be a more dynamic temporal change in the water table introduced by including shallower depth-to-water measurements associated with alluvial aquifers.

To remove this possible influence, well sites coded as being screened solely in alluvial deposits were deleted from the data set. If the geologic units were unknown or unlisted, wells that are located spatially within the extent of alluvial aquifer deposits or had drill depths less than 80 feet were individually reviewed relative to their surrounding neighboring wells. In these cases, the wells were coded as being alluvial if their drill depths and past water levels measurements reflected alluvial-type conditions. A total of 60 wells were classified as alluvial with 11 being located within GMD4. All of these wells are found along the northern and eastern edges of the district. With these alluvial wells removed from consideration, the interpolation process and assignment of mean values for the overlying PLSS sections was repeated.

Figure 1 displays the 3-year averaged saturated thickness of the aquifer by PLSS section for the 2004 and 2015 calendar years with the alluvial wells excluded. The average saturated thickness for GMD4 was 76 feet in 2004 and 70 feet in 2015. The greatest areas of change in the water table occurred in southwest portions of Sherman County where the average rate of decline from 2004 to 2015 was over 20 feet. Much of Sherman County and portions of Thomas and Sheridan County averaged declines of 12 feet. The major driver for these water level declines is groundwater pumping as illustrated by published reports (Butler et al., 2016 and Whittemore et al., 2016), which show statistically significant correlations exist between annual water-level change and annual groundwater use across GMD4.

Thank you for your time today and I would be glad to answer questions or provide additional information.

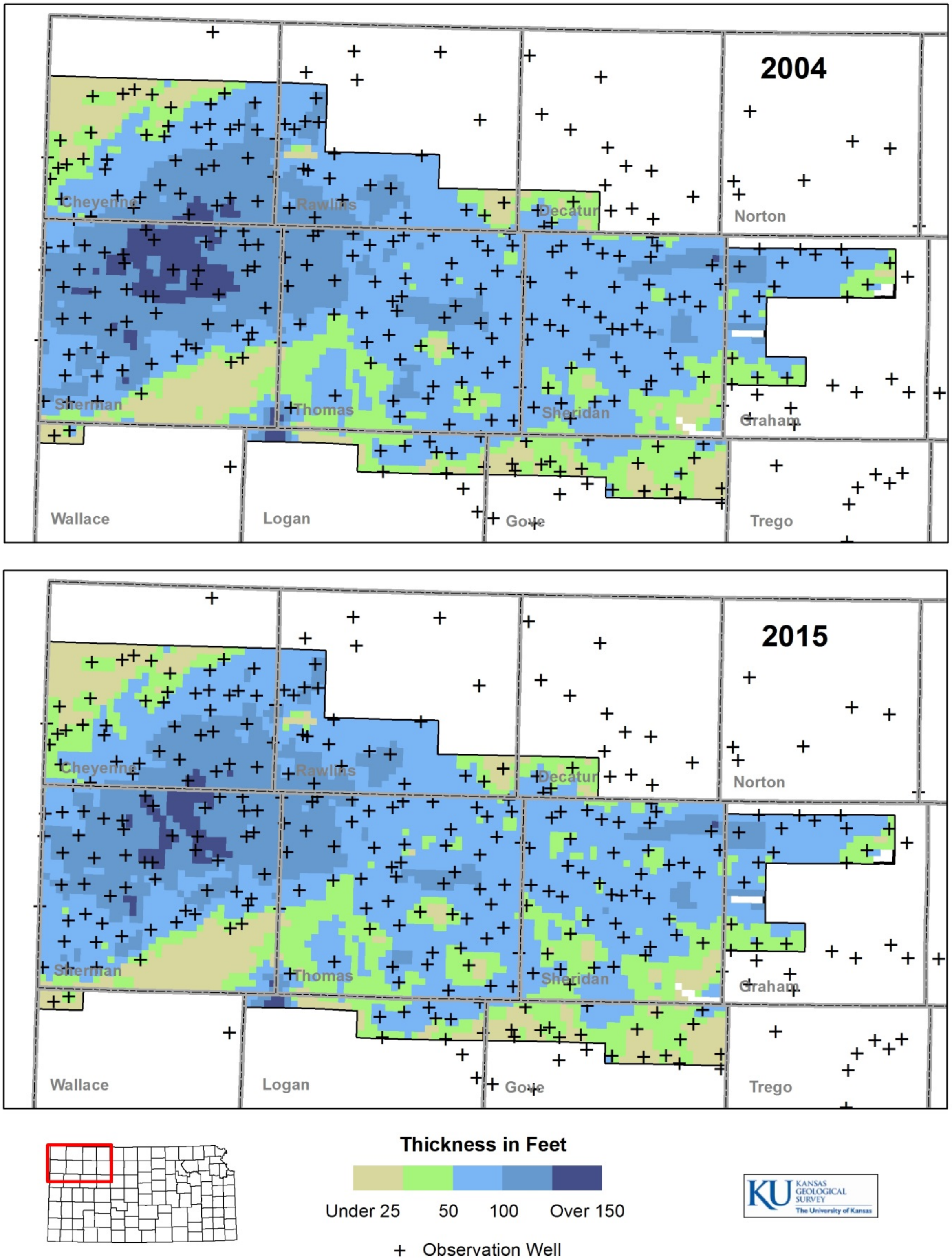

Figure 1. Interpolated 2004 and 2015 three-year averaged saturated thickness of the High Plains Aquifer, by PLSS sections, Northwest Kansas Groundwater Management District no. 4.

References:

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