Burrton IGUCA Review

October 2016

Kansas Department of Agriculture
Division of Water Resources

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Foreword

This document presents the evidence and analyses relied upon by the Kansas Department of Agriculture, Division of Water Resources (DWR) in its review and evaluation of the performance of the Burrton intensive groundwater use area (IGUCA). This review was performed pursuant to Kansas Administrative Regulation (K.A.R.) 5-20-2 which prescribes in part that the state shall have the burden of proving the need for continuance of the IGUCA designation. The review process involves a hearing before the chief engineer of DWR. In order to preserve the impartiality of the chief engineer in his role as hearing officer, two teams of DWR staff were established: (1) the review team and (2) the chief engineer's team. The review team for this report consists of:

Ginger Pugh	Water Management Services
David Engelhaupt	Water Management Services
Chris Beightel	Program Manager, Water Management Services
Lane Letourneau	Water Appropriations Program Manager
Jeff Lanterman	Water Commissioner, Stafford Field Office
Cameron Conant	Assistant Water Commissioner, Stafford Field Office
Wendee Grady	Attorney, Office of the Secretary of Agriculture
Sumathy Sinnathamby	Basin Management Team*
Tara Lanzrath	Basin Management Team*
Darci Paull	Basin Management Team*
Andrew Lyon	Basin Management Team*
Kenneth Kopp	New Application Unit Supervisor*
Brett Berry	Attorney, Office of the Secretary of Agriculture*

* Left team prior to completion of report.

The review team would like to thank Equus Beds Groundwater Management District No. 2 (GMD #2) staff, particularly Tim Boese and Steve Flaherty, and the GMD #2 Board of Directors for assisting in preparing the review report, providing data, technical reviews and local input, Kansas Geological Survey (KGS) staff, in particular Don Whittemore, for data and technical assistance for the Burrton IGUCA Review.

The review team prepared this report independently from and without counsel or direction by the chief engineer's team.

Executive Summary

In response to the deterioration of groundwater quality caused by chloride contamination in the Burrton area, the board of Equus Beds Groundwater Management District No. 2 (GMD #2) initiated the IGUCA process in June, 1982. Hearings were held in August, 1982 and February, 1984 and the IGUCA order was issued in June, 1984, with a correctional order issued in July, 1984. The order defined a control area, made thirteen recommendations from a task force report and imposed four main corrective controls: (1) the potential effects of each application will be reviewed using a computer groundwater model, (2) the Board of Directors of GMD #2 will annually review all hydrologic data and may request a hearing to amend the IGUCA if deemed necessary, (3) installation of water flowmeters was required, and (4) the chief engineer may amend the IGUCA if deemed to be in the public interest.

This review focuses on answering the question, "Have the Burrton IGUCA corrective controls addressed the issue of groundwater quality in the area?" In order to make this determination the DWR review team, in cooperation with GMD #2, has compiled and analyzed data from the authoritative sources for records of groundwater quality and migration of the saltwater (chloride) plume. The analyses compare plume location over time and review methods utilized by GMD #2 for approving new applications. The analyses do not attempt to simulate what might have happened if the IGUCA had not been established.

The analyses show that corrective controls imposed in the Burrton IGUCA have been effective in establishing a review process that ensures that new wells are constructed at depths with acceptable chloride levels and will not adversely influence plume movement to the detriment of local water quality. In their 2012 report, the Kansas Geological Survey found that the plume had a total migration of about 1.5 to 2 miles east in the period 1982 to 2010. Data collected in 2010 indicate that the plume has advanced just beyond the IGUCA boundary.

Given these observations, the review team concludes that the IGUCA corrective controls are essential for protecting the public interest in water quality in the Burrton area. The review team recommends that the current Burrton IGUCA corrective controls be maintained. The review team also recommends the consideration of further proactive measures to help protect groundwater quality and public health, namely: (1) in light of the movement of the chloride plume, consider extending the boundary of the Burrton IGUCA to the southeast; (2) consider additional corrective controls to help prevent any further groundwater contamination such as additional well grouting requirements; and (3) consider extending model review to existing permits and water rights within the boundaries of the Burrton IGUCA in the path of plume migration in order to better protect the public interest.

I. Introduction

Geographic Location

The Burrton Intensive Groundwater Use Control Area (IGUCA) is located in Harvey and Reno counties within the boundaries of GMD #2 generally in the vicinity of the City of Burrton, Kansas (Figure 1). The Burrton IGUCA encompasses:
Sections 15 through 22 and 27 through 34, Township 23 South, Range 3 West;
Sections 3 through 10, Township 24 South, Range 3 West;
Sections 13, 14, 23, 24, 25, 26, 35, and 36, Township 23 South, Range 4 West;
Sections 1, 2, 11 and 12, Township 24 South, Range 4 West.
The Burrton IGUCA covers approximately 36 square miles (23,040 acres). The City of Burrton provides water for over 900 people within the city and three out-of-city connections (2015 municipal water use report).

Purpose and Objective

The purpose of this report is to guide the formal review of the Burrton IGUCA under K.A.R 5-20-2 which states that a public hearing to review the designation shall be conducted by the chief engineer and the burden of proving the continuance of the IGUCA falls on the state. The public hearing process will determine whether the public interest requires the continuation of the Burrton IGUCA. Upon completion of the review one of several actions shall be taken by the chief engineer as listed as items numbered 1 through 6 under K.A.R. 5-20-2 (see section V) that address the continuation or reduction of the IGUCA. If the chief engineer determines that the boundaries of the Burrton IGUCA may need to be increased, a new IGUCA proceeding shall be initiated by the chief engineer.

II. Genesis of the Burrton IGUCA

Established in 1984, the Burrton IGUCA addresses groundwater quality issues resulting from oil field brine contamination occurring in the 1930s and early 1940s.

Unconsolidated Pleistocene and some Pliocene sands, gravels, silts, and clays make up the geology of the Equus Beds area. Underlying the Equus Beds aquifer is Wellington Shale and a portion of the Wellington aquifer. From 1931 to 1943, the primary method of brine disposal, and hence the main source of groundwater pollution to the Equus Beds aquifer, was discharging the brine initially into surface drainage features and later into brine ponds from which the brine would seep into the groundwater system. The second most prevalent source of pollution was from shallow brine disposal wells in the Wellington Formation. Since many of these disposal wells were used under pressure, this forced saltwater up into the Equus Beds through unplugged or improperly plugged test holes or improperly constructed wells (Task Force, 1984, p. 2). This practice changed and from 1943 to the mid-1950s, 95 percent of the brine was disposed of through deep disposal and enhanced recovery wells, which is the current practice used today.

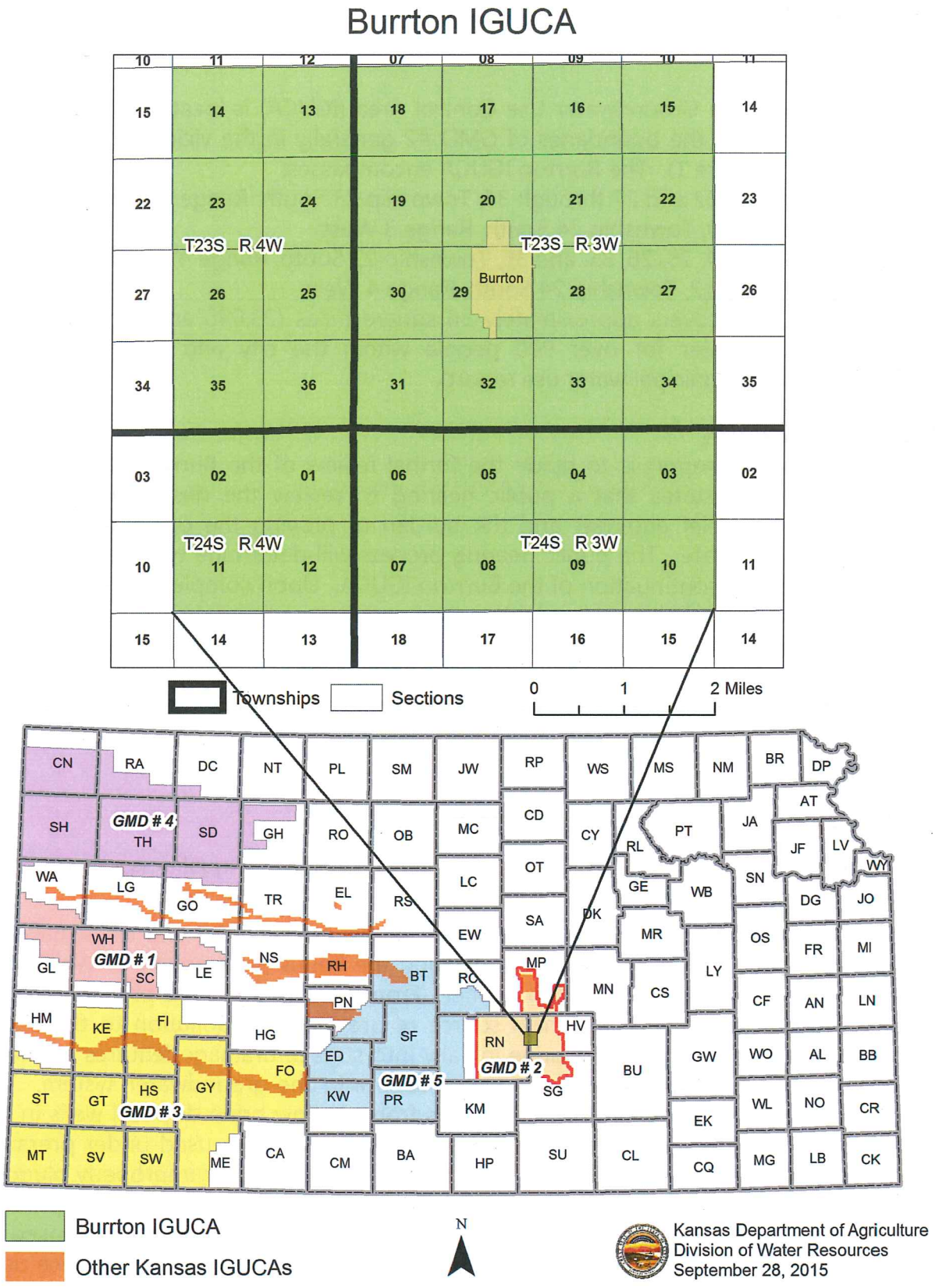

Figure 1: Burrton IGUCA in GMD #2

Thomas C. Bell became manager of GMD #2 in the late 1970s and soon became aware of the saltwater problem in the Burrton Area. On June 11, 1982, Chief Engineer Guy E. Gibson, received a letter from GMD #2 requesting the initiation of proceedings to designate an IGUCA near Burrton, Kansas, on the basis of the deterioration of groundwater quality due to high chloride content. The initial public hearing was held on Wednesday, August 4, 1982, in Burrton, Kansas, at which time a task force was developed since it was determined more time was needed to complete research in the area.

The second half of the public hearing was on February 21, 1984, and occurred with Chief Engineer David Pope. At the second hearing, the task force report was presented. Prior to 1931 and oil field activity, chloride concentrations in the Burrton area ranged from 10 to 100 mg/L. By 1948, chloride concentrations were found in excess of 1,000 mg/L. At the time of the task force report in 1984, the highest chloride concentration was 2,450 mg/l. The U.S. Environmental Protection Agency (EPA) has established a secondary maximum contaminant level (SMCL) for chloride in drinking water of 250 mg/L. Chloride levels are not health threatening at the SMCL and there are only cosmetic and aesthetic effects when ingested. The remedial goal for chloride in water for irrigation use is 350 mg/L, though this may vary with different crop types, as approved by the Kansas Department of Health and Environment (KDHE). Chlorides cause problems for irrigation as they inhibit biological processes in plants such as seed germination and the ability of the plant to take in water and can damage soil structure and permeability (KDHE, 2005). At the second half of the hearing in 1984, Don Whittemore with the Kansas Geological Survey (KGS) presented testimony that the source of pollution in the aquifer is oil-field brine based upon the bromide/chloride ratios.

Members of the Burrton Task Force represented the following entities: GMD #2, Kansas Corporation Commission, Kansas Department of Health and Environment-Division of Environment, Bureau of Oil Field and Environmental Geology, Kansas Geological Survey, Kansas Independent Oil and Gas Association, Kansas Water Authority, and the Kansas Water Office (Task Force, 1984, p. 1). The report included recommendations and conclusions summarized below based on the findings of the task force that were incorporated into the IGUCA order.

III. Task Force Recommendations

The Burrton Task Force made the following recommendations which were incorporated into the Burrton IGUCA order:

1. Move Entire Proposed Intensive Groundwater Use Control Area West One Mile.
2. Check Integrity of Saltwater Lines.
3. Check Competency of Cement-Lined Saltwater Pits.
4. Conduct Detailed Lease Investigation.
5. Investigate Integrity of Plugs of Wells Suspected of Leaking.
6. Conduct Mechanical Integrity Tests on all Injection or Disposal Wells in Area.

7. Sample Soil of Area of Several Abandoned Saltwater Ponds.
8. Establish Deeper Aquifer Monitoring Wells.
9. Utilize Polluted Groundwater for Enhanced Recovery of Oil.
10. Recommend Continuous Monitoring Program in Area.
11. Educate Public in Area about Problem and Future Salinity Trends.
12. Continue Appropriating Water Under Safe Yield Policy by Considering Application on an Individual Basis.
13. Implement Additional Water Well Construction Standards.

IV. Order Conclusions

The following conclusions were incorporated into the Burrton IGUCA order after the second hearing:

1. That unreasonable deterioration of the quality of water is occurring or may occur within the area in question.
2. That an intensive groundwater use control area should be established and corrective control provisions initiated in order to protect the public interest.
3. That the boundaries of the intensive groundwater use control area should be approximately 36 square miles in the vicinity of Burrton, Kansas, including Sections 15 through 22 and 27 through 34, Township 23 South, Range 3 West; Sections 3 through 10, Township 24 South, Range 3 West;
   Sections 13, 14, 23, 24, 25, 26, 35, and 36, Township 23 South, Range 4 West; Sections 1, 2, 11 and 12, Township 24 South, Range 4 West;
   Sections 1, 2, 11, and 12, Township 24 South, Range 4 West, all located within the boundaries of the Equus Beds Groundwater Management District No. 2.
4. That in order to more accurately monitor the groundwater withdrawals in the area and the effect of those withdrawals on saltwater movement in the area, all groundwater users in the control area should be metered, except for domestic and temporary use.
5. That the public interest required all applications to appropriate water for beneficial use within the proposed intensive groundwater use control area be reviewed on a case by case basis, and which may include analysis on the computer model constructed by the Kansas Geological Survey, if appropriate.
6. That the recommendations of the Task Force should be forwarded to the other entities or agencies having jurisdiction or authority in the area.

In addition, it was ordered that GMD #2 shall annually review all hydrologic data in the intensive groundwater use control area including, but not limited to, static water level information, water use information, water quality information; that annually GMD #2 may, no later than April 1, request a rehearing before the Chief Engineer-Director on the matter of the boundaries of the intensive groundwater use control area, the reconsideration of corrective control provisions or any other matters relative to this intensive groundwater use control area.

V. Data Analysis

The following section presents analyses of groundwater levels, precipitation, groundwater rights, groundwater use and chloride concentration.

A. Groundwater Levels

Though the Burrton IGUCA focuses on water quality, groundwater level changes will increase or decrease the rate of the chloride plume's movement as hydrologic gradients increase or decrease respectively. Of particular importance are groundwater-level declines near the City of Wichita's well field, which lies in the path of the plume (Whittemore, 2012). The Wichita well field began providing water supply in the 1940s and is located in southwest Harvey County and northwest Sedgwick County. The Wichita well field is located to the southeast of the Burrton IGUCA and groundwater level declines from pumping there have been identified as likely to increase the rate of the Burrton chloride plume movement (Hansen, 2007). Groundwater model simulations of the Burrton chloride plume by the USGS (Klager et al, 2014) showed that even without the pumping in the Wichita well field, the Burrton chloride plume would continue to move toward the Wichita well field area.

Figure 2 shows the locations of current monitoring and observation wells within the Burrton IGUCA. Among them, twenty two wells with extended records (Figure 2) were considered for groundwater level analyses. All measurements are available on the KGS Wizard website. Locations of the monitoring wells used in the analyses are presented in the appendix. Figures 3 through 5 present the well measurements. When directly comparing water level measurements over years, every effort was made to compare static or winter (December, January and February) measurements for consistency. Most of the measurements for Harvey County began in early 1939 (Figure 3 and 4). For Reno County, measurements are only available after 1981 (Figure 5). The most recent measurements for both counties were taken in February, 2015.

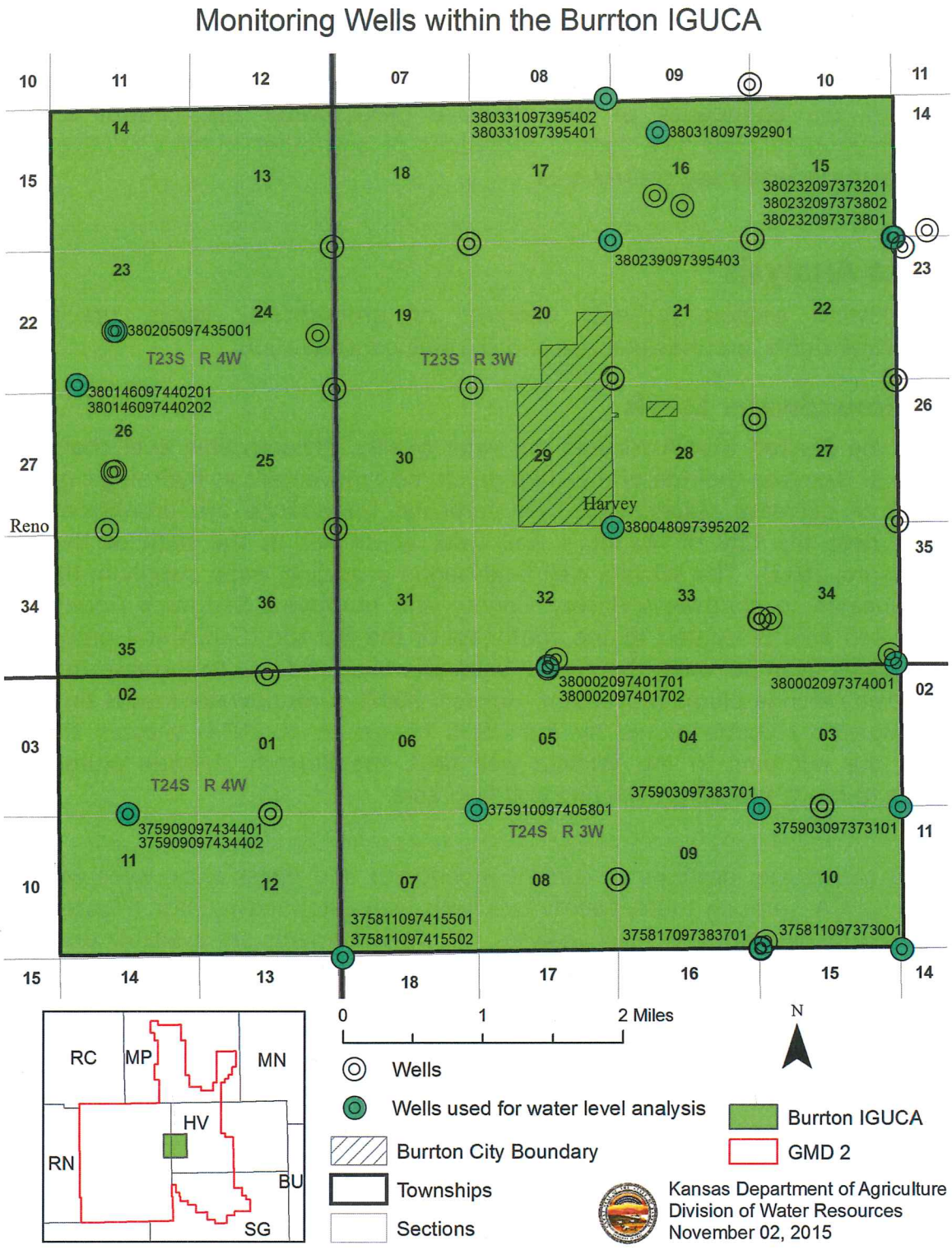

Figure 2: Map of the Monitoring Wells within the Burrton IGUCA

Figures 3, 4 and 5 show water levels prior to, and after the establishment of the IGUCA order. The black vertical line marks 1984, when the Burrton IGUCA Order was enacted. It is noted that groundwater levels are relatively stable in the area and do not vary much before versus after 1984.

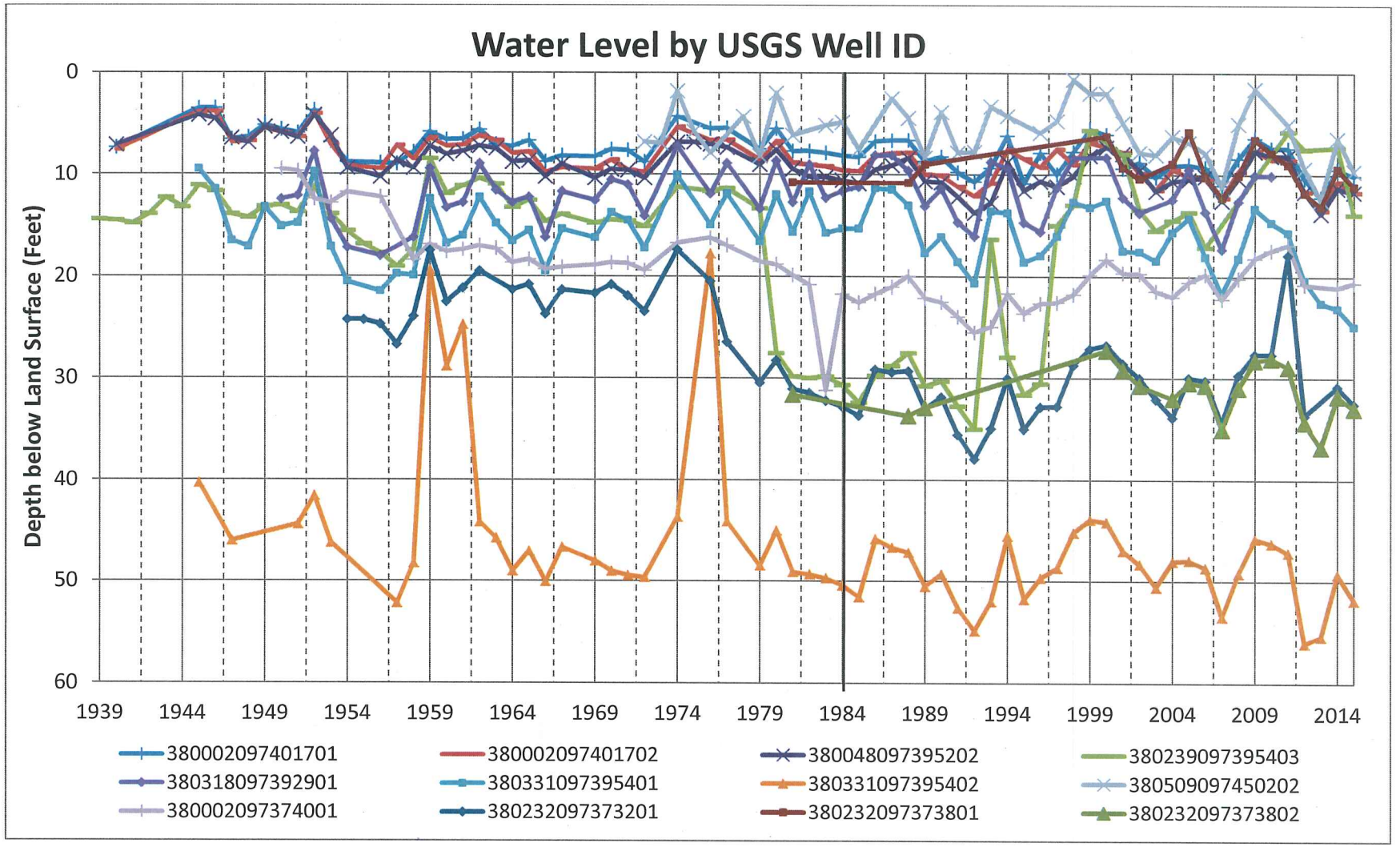

Figure 3: Water Level Measurements for Harvey County Township 23 South Range 03 West Monitoring Wells

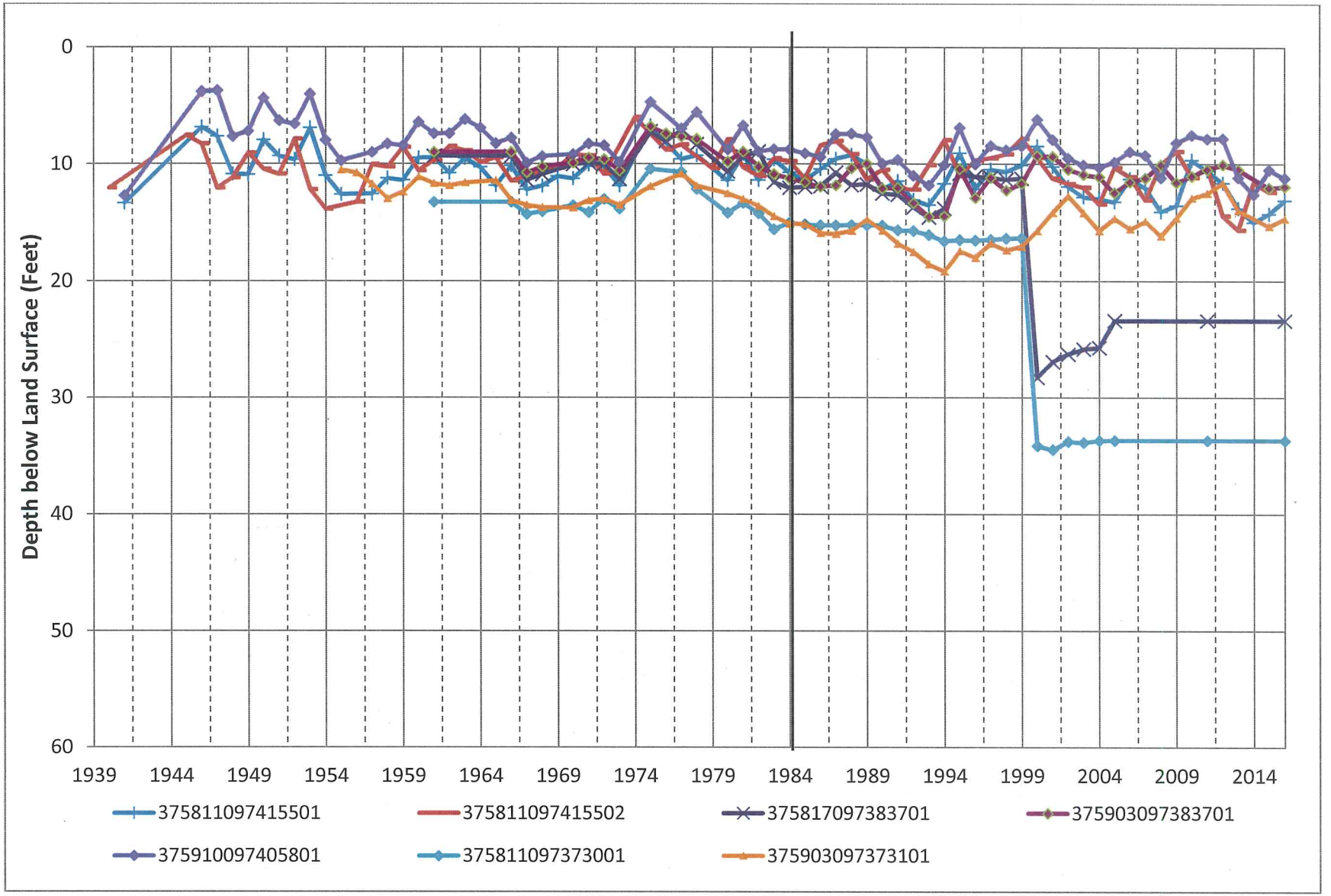

Figure 4: Water Level Measurements for Harvey County Township 24 South Range 03 West Monitoring Wells

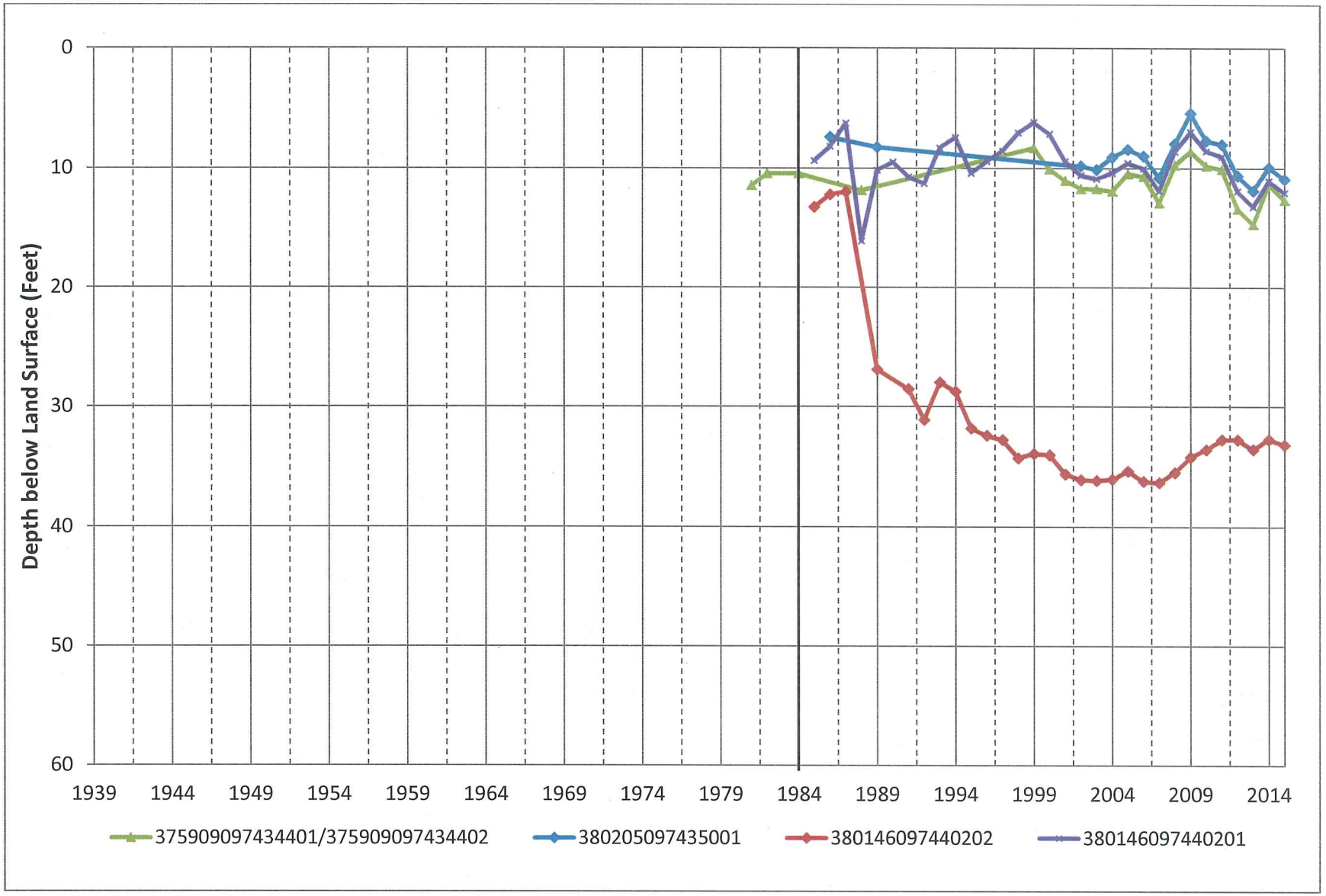

Figure 5: Water Level Measurements for Reno County Monitoring Well

To study the changes in groundwater levels, wells located outside the Burrton IGUCA were also considered in the analysis (Figure 6). The changes in water levels were calculated for three periods; 1960-1984 (Pre IGUCA), 1984-2010 (Chloride plume analysis period, Post IGUCA) and 1984-2015 (Post IGUCA). Almost all of the wells within Harvey County considered for this analysis have complete records of water measurements from 1960-2015. Most of the Reno County monitoring wells only had data from after the implementation of the IGUCA so were not used in the groundwater level interpolations. However, other wells outside of the IGUCA were used to help provide better data coverage (see the inset map on Figure 6).

To create Figure 6, the difference in water level measurements was calculated for each monitoring well (i.e. 1960 – 1984) and divided by the number of years and then converted from feet to inches to get average groundwater level change in inches per year. Groundwater level change values were then interpolated by kriging.

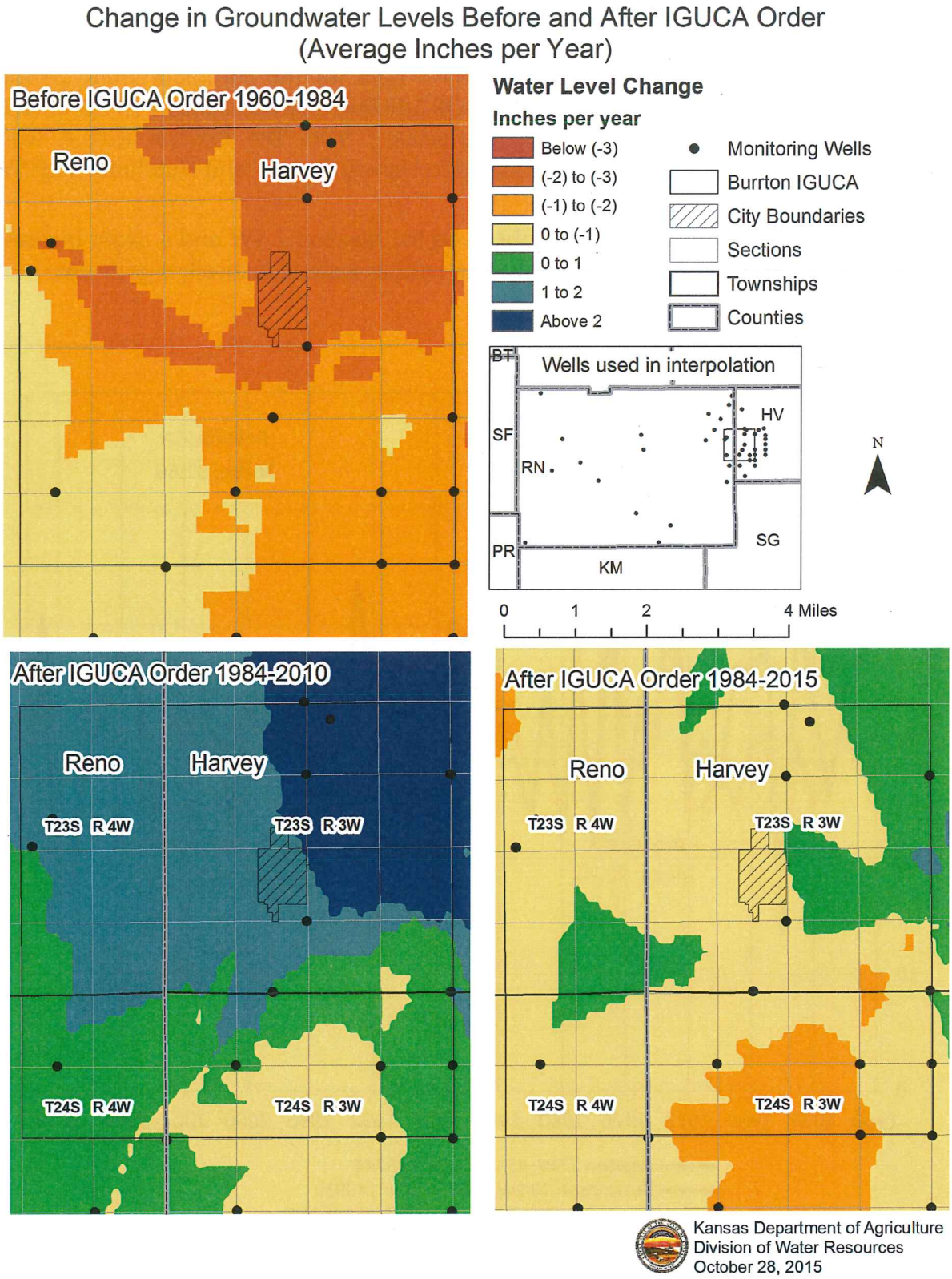

Figure 6: Interpolated Change in Water Levels (inches per year)

B. Precipitation

There is only one National Climatic Data Center (NCDC) weather station, Burrton, KS (COOP 141187), available within the Burrton IGUCA. However, the Burrton station was not considered for analysis since it doesn't have data for the complete study period. Instead two NCDC stations, Newton 2 SW (COOP 145744) and Hutchinson 10 SW (COOP 143930), nearly 16 and 19 miles away respectively from the Burrton IGUCA were considered (Figure 7). Newton 2 SW is located in Harvey County and Hutchinson 10 SW is located at Reno County.

Based on Figure 7, a slight decline was observed for Newton 2 SW and a slight increase was observed for Hutchinson 10 SW. However, neither were statistically significant.

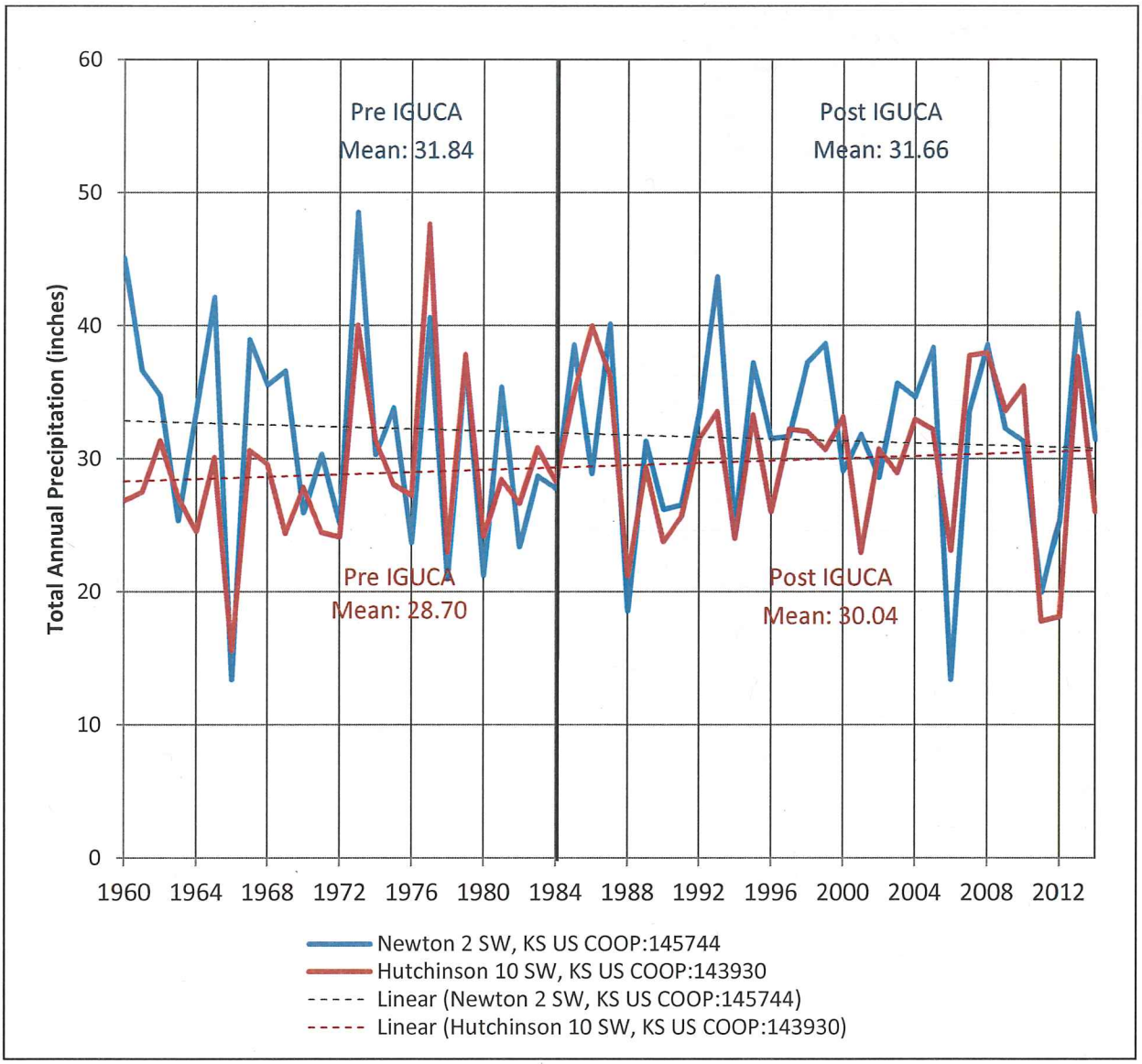

Figure 7: Annual Precipitation for the Newton and Hutchinson Stations

C. Groundwater Rights

As of September 20, 2016 there were 72 active groundwater rights within the Burrton IGUCA; 61 irrigation, 9 recreational, 1 industrial, 1 municipal and 1 hydraulic dredging. Note that one of the rights shares two uses made of water, so the total number of rights is 72 instead of 73 (Table 1). Total authorized quantity for rights within the Burrton IGUCA is 7,754.09 acre-feet per year. The points of diversion associated with the groundwater rights as well as the surrounding region are shown in Figure 9. Approximately 92% of the authorized quantity for groundwater was for irrigation uses. There were no surface water rights in the area at the time of this review.

Table 1: Active Groundwater Rights within Burrton IGUCA Boundaries

Active Groundwater Rights within the Burrton IGUCA		
Use Made of Water	**Number of Rights**	**Authorized Quantity (AF)**
Irrigation	60	7,124.60
Recreational	8	325.00
Industrial	1	84.33
Municipal	1	0.16
Hydraulic Dredging	1	220.00

D. Groundwater Use

Average annual groundwater use[1] within the Burrton IGUCA was 4,818 acre-feet per year from 2005 - 2014. From 2000 - 2010 average annual use was 3,150 acre-feet per year. The time period 2000 - 2010 was considered here for comparisons with the chloride plume analyses time period. The highest year of groundwater use (5,300 acre-feet) was observed in 2012 with nearly all of this water being for irrigation purposes (Figure 8). Since the boundaries of the originally recommended IGUCA were moved pursuant to a recommendation from the task force, a direct historical comparison of groundwater use is not available.

The ten-year average of 2005-2014 is shown in Figure 9 below to display spatial trends of groundwater use. This analysis summed water use by section and showed that the majority of water use within the IGUCA boundaries is located in the southern and eastern portions of the IGUCA, while very little to no use was often reported for the northern and western portions.

The Burrton IGUCA order requires the monitoring of groundwater withdrawals and the effects of those withdrawals on saltwater movement in the area. All groundwater appropriations within the Burrton IGUCA also required to be metered by the IGUCA

[1] Average annual groundwater use based on an October 29, 2015, query of DWR's Water Rights Information System database and includes use reported from active rights.

order, except for domestic and temporary uses, which improved groundwater use data quality.

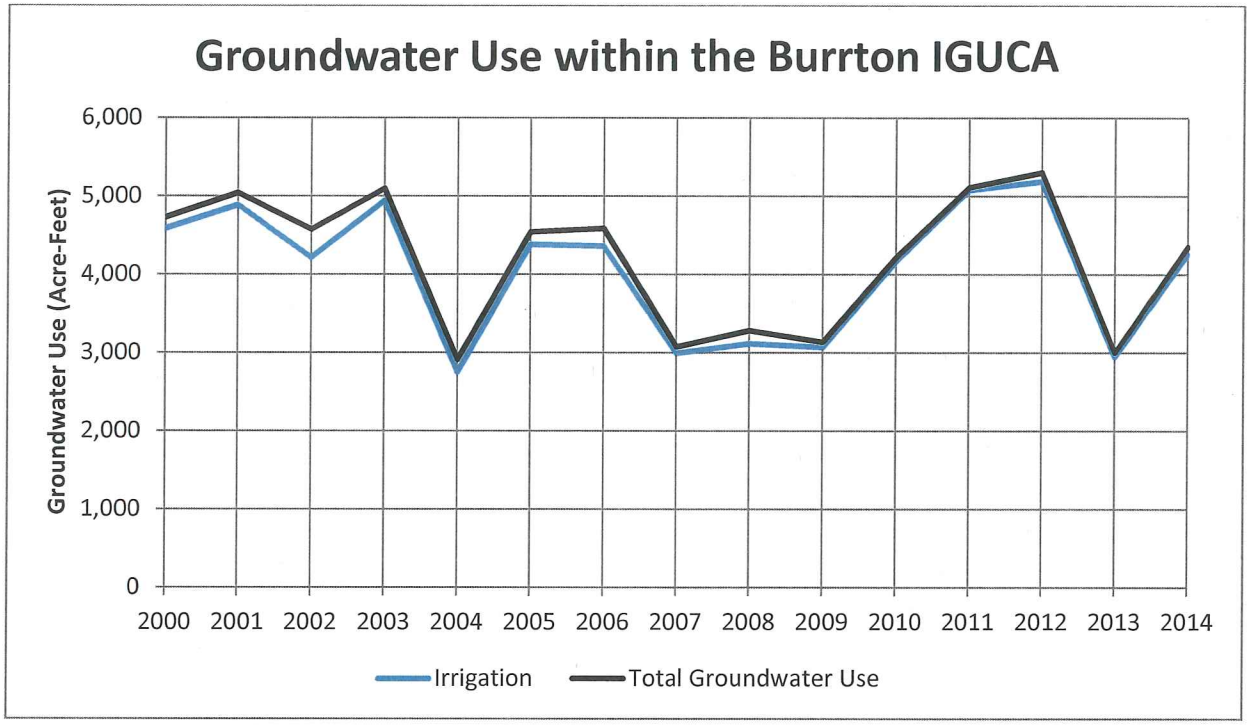

Figure 8: Annual Reported Groundwater Use

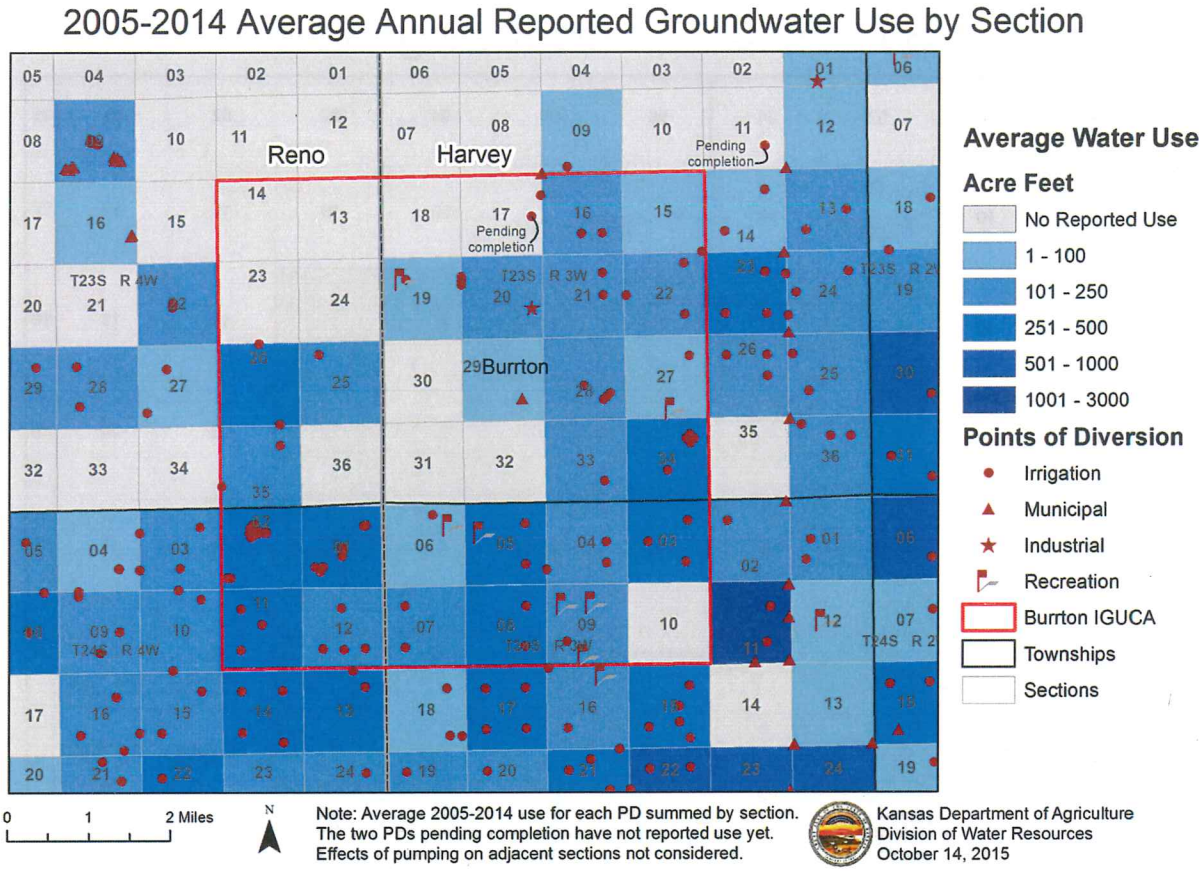

Figure 9: Average Annual Groundwater Use and Point of Diversion Distribution

E. Chloride Concentration

Most of the chloride data analyses and results in this section were extracted from the report Whittemore (2012) of KGS produced for DWR. GMD #2 and the USGS monitor many wells for chlorides in and around the Burrton IGUCA and the most recent chloride data was included from analysis and graphics prepared by GMD #2. Of particular interest is the Wichita well field to the southeast of the Burrton IGUCA. The City of Wichita provides water for over 393,000 persons within their city, to more than 6,000 connections outside of their city and to eleven other water suppliers in the area (2015 municipal water use report).

Monitoring Network

Whittemore (2012) used the GMD #2 groundwater monitoring network to monitor salinity changes in the Burrton IGUCA area (Figure 10). With the establishment of GMD #2 in 1975, a groundwater monitoring network was developed to monitor water levels and quality. In the Burrton oil field area, the first wells were installed and sampled in 1979 to improve knowledge about the saltwater contamination (Whittemore, 2012 p. 2).

Figure 10 includes wells constructed by:

1. GMD #2 (denoted EB),
2. City of Wichita before GMD #2 was formed (denoted P and also considered part of the GMD #2 network),
3. U.S. Geological Survey (USGS)/City of Wichita (denoted IW).
4. Other wells (domestic, municipal, etc.)

Monitoring wells designated as EB in their site identification labels were constructed as part of a GMD #2 monitoring program. Other wells, which are designated as P wells, were installed in the Burrton area by the City of Wichita before GMD #2 was formed. EB monitoring wells are variously screened at four different zones generally in order from shallowest to deepest (AA, A, B, and C). However, letters do not always indicate depth. In P wells, the well with the A designation is generally deeper than wells without the A designation. Within his report, Whittemore (2012) defines the upper aquifer as extending down to 65 feet below land surface. The division between the middle and lower aquifers is variable depending on the depth to bedrock. It can be defined as the greater depth between either 60 feet above the bedrock, or a depth halfway between 65 feet and the underlying bedrock (2012, p. 7). At this time no consistent standards apply in well nomenclature and zone depth delineation. Not all well sites have wells screened at each depth. A more detailed look at the chloride concentration at the wells is given in the following section.

GMD #2, in cooperation with the Kansas Corporation Commission, annually samples all of the EB and P monitoring wells in the Burrton IGUCA. The samples are analyzed for chloride, sodium and electrical conductivity by a state of Kansas certified laboratory. Additionally, all water appropriation applications approved after the IGUCA was established were required to be sampled twice annually and the samples analyzed for chloride and electrical conductivity by a state of Kansas certified laboratory.

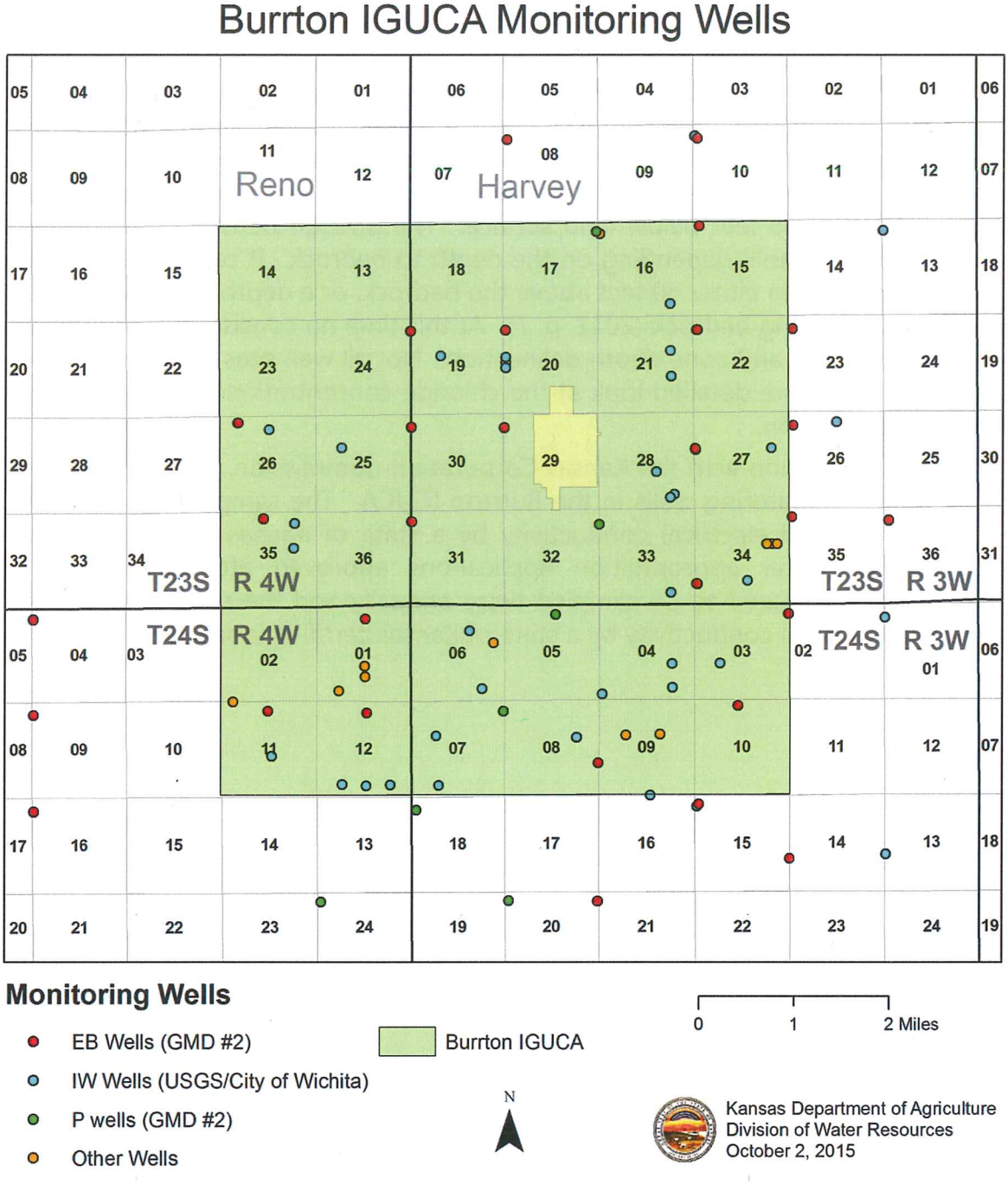

Figure 10: Overview of Burrton Monitoring Wells

Burrton Plume Movement 1982 to 2010

From 1982-2010 the Burrton chloride plume migrated some 1.5 to 2 miles to the east; equivalent to about 0.8 to 1.0 foot per day (Whittemore, 2012, p. 21). The nearest municipal supply well of the City of Wichita well field was within about a mile of the 500 mg/L plume front during the reporting period (Whittemore, 2012) and directly in the current path of migration (Whittemore, 2012, p. 31). Because saline water is denser than fresh water, the plume has also migrated to greater depths over time (Whittemore, 2012, p. 22). Migration of the saline water has also been affected by the distribution of clay layers within the Equus Beds aquifer. When the brine water came into contact with a clay layer it moved in the direction of groundwater flow along the top of the clay until it reached the edge of the clay and downward migration could continue (Whittemore, 2012, p. 24).

As the plume moves eastward and deeper into the ground, areas to the west should continue to show a decrease in chloride concentration. Whittemore suggests that areas containing water once unusable for irrigation, stock and drinking, will increasingly meet standards on the western edge of the IGUCA boundary (Whittemore, 2012, p. 29). Figures 11, 12 and 13 show a comparison of the approximate chloride concentrations at different depths (upper, middle, and lower) for different historical time frames. The density distribution for average reported groundwater use 2000-2010 is displayed in the background. The chloride contours in the figures below were obtained from Don Whittemore with the KGS. A 3D representation of the Burrton plume over time is located within the 2012 KGS report for DWR focused on the Burrton IGUCA area (Whittemore, 2012, p. 25).

Since the 2010 report by Whittemore, GMD #2 has continued to sample and monitor wells within the Burrton IGUCA (Figure 14). 2015 chloride plume estimates for upper, middle and lower portions of the aquifer were created by GMD #2 and are shown in Figures 15 through 17.

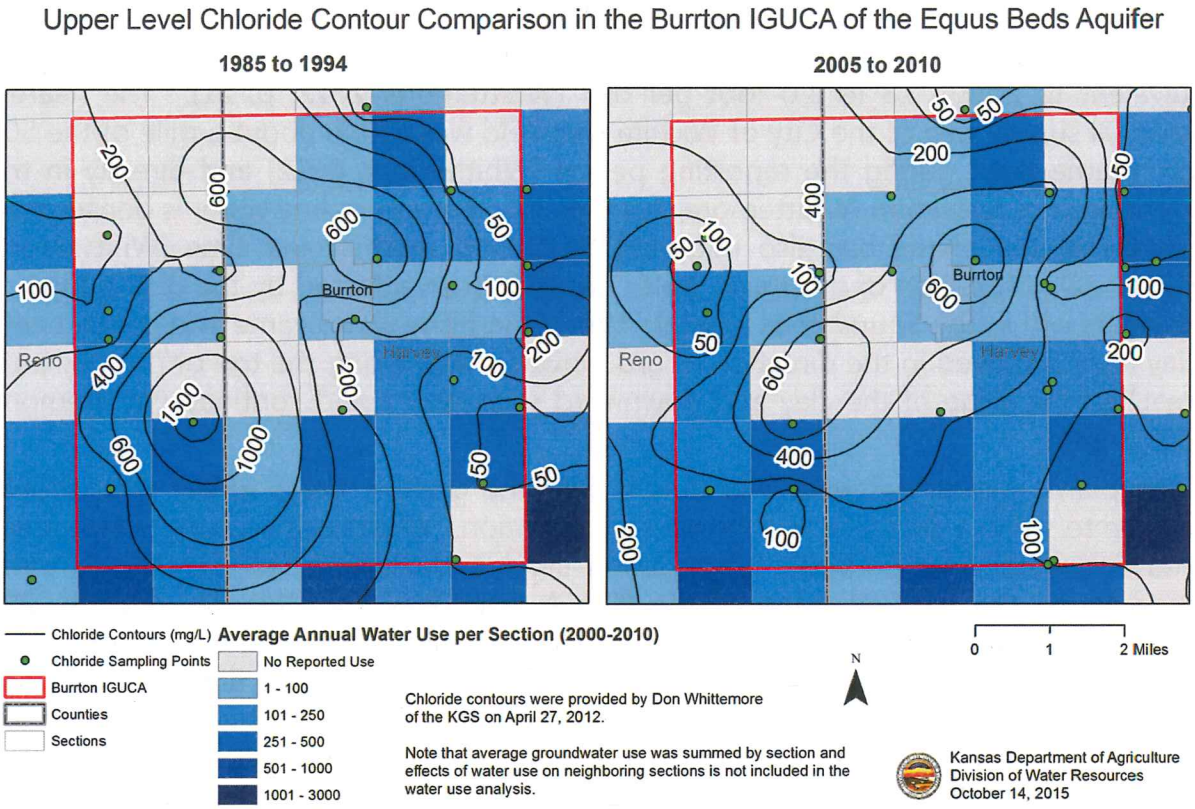

Figure 11: Upper Level Aquifer Chloride Comparisons for the Burrton IGUCA

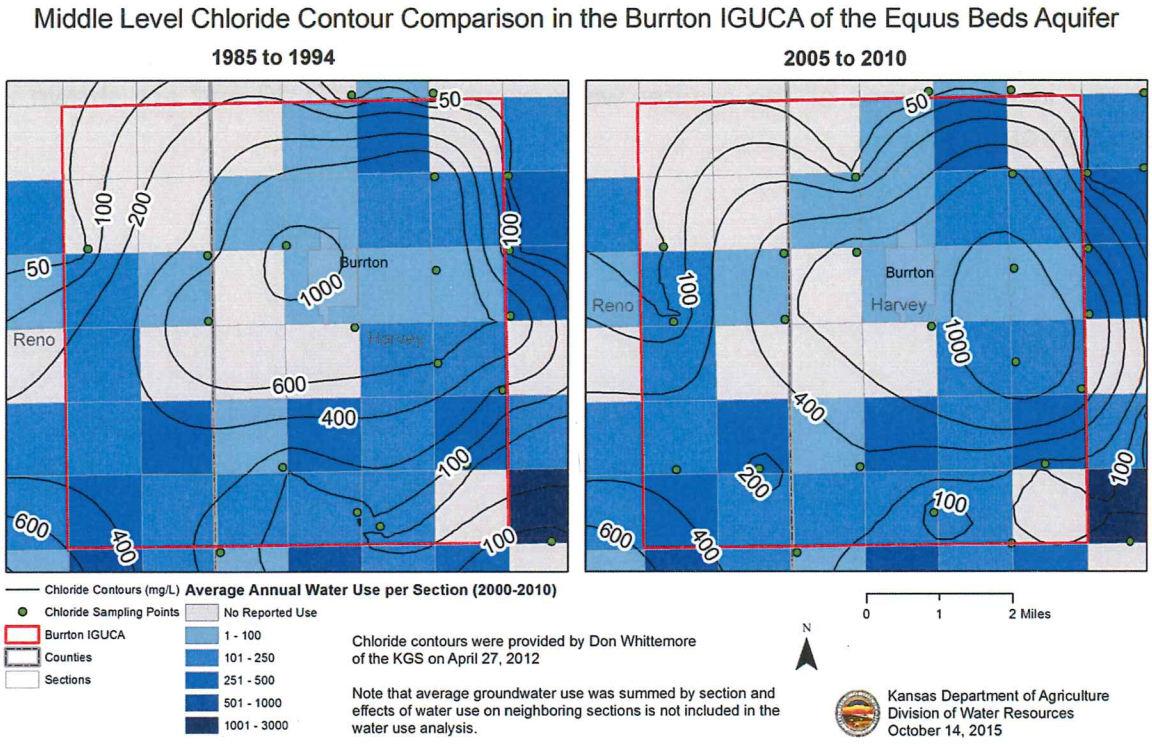

Figure 12: Middle Level Aquifer Chloride Comparisons for the Burrton IGUCA

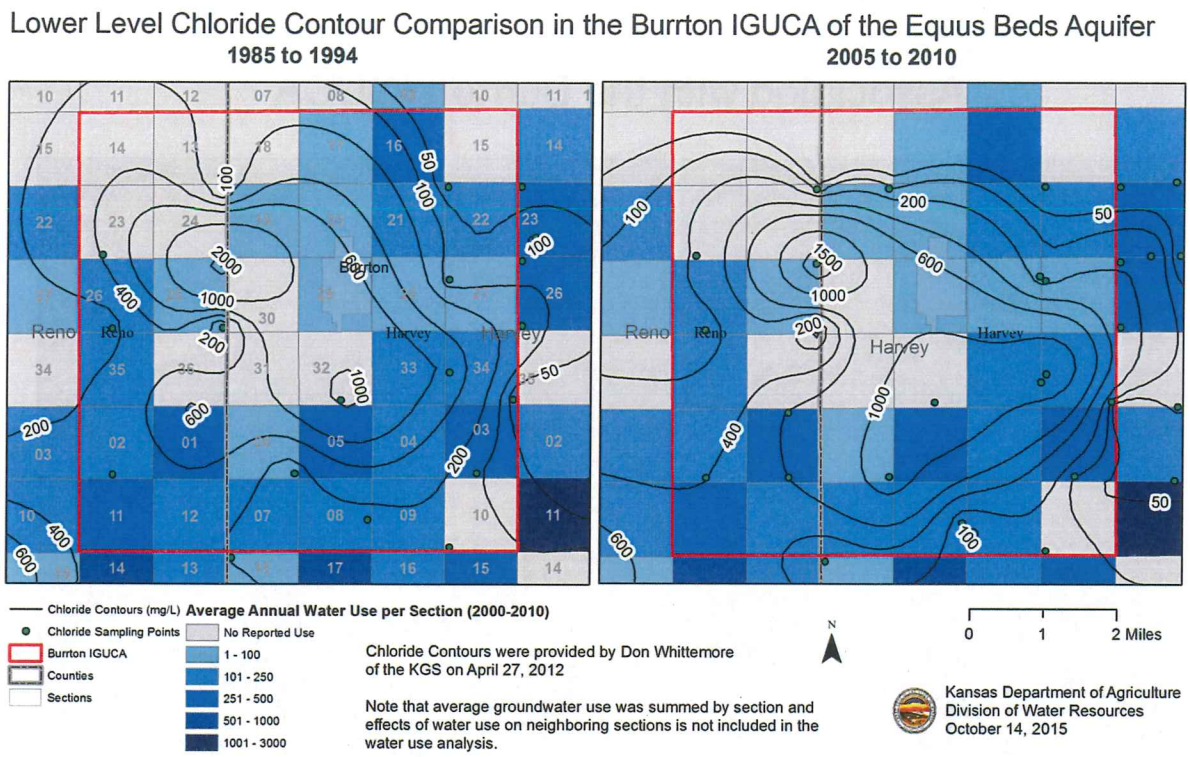

Figure 13: Lower Level Aquifer Chloride Comparison for the Burrton IGUCA

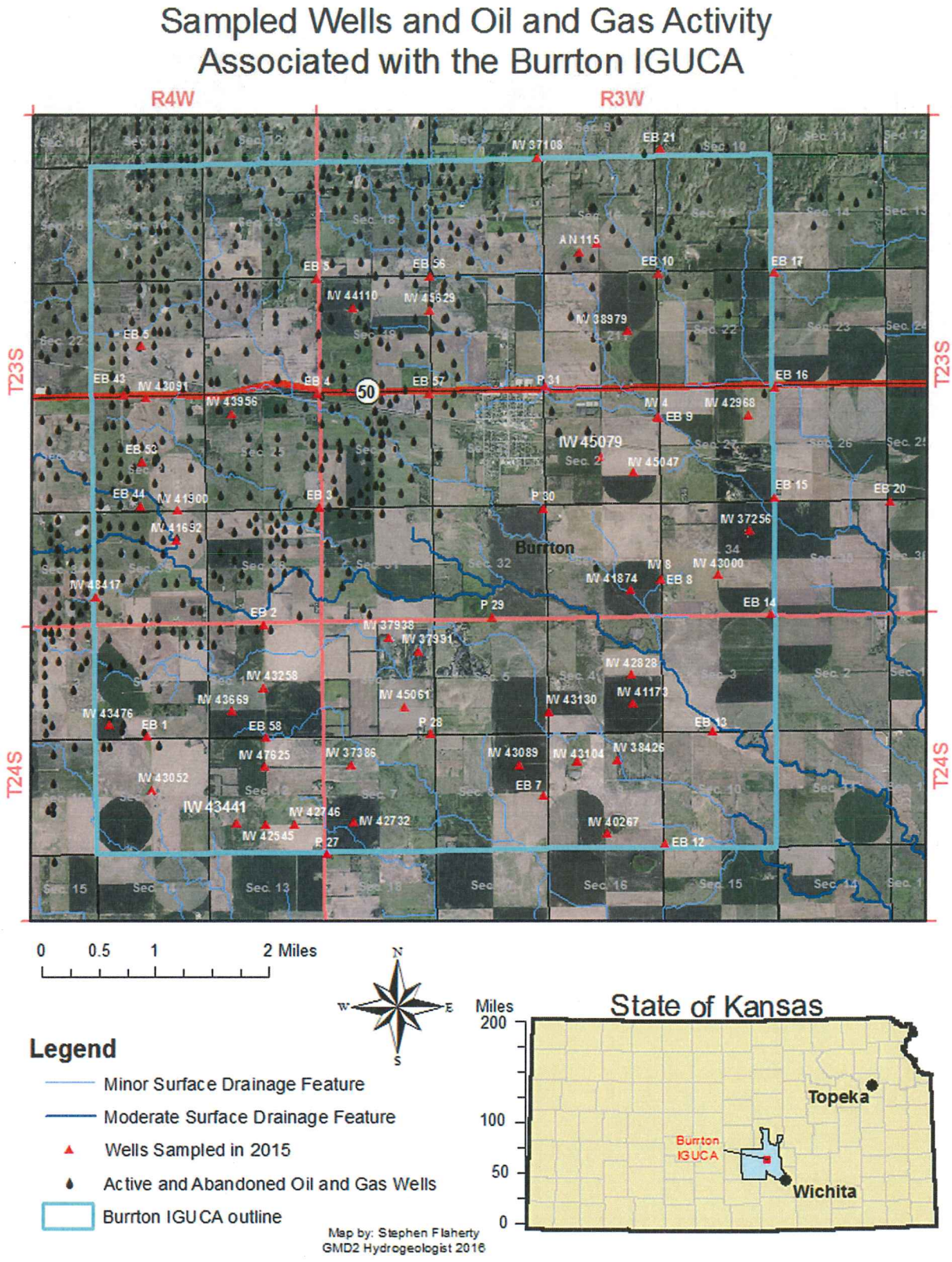

Figure 14: GMD #2 Sampling Sites (GMD #2, 2016)

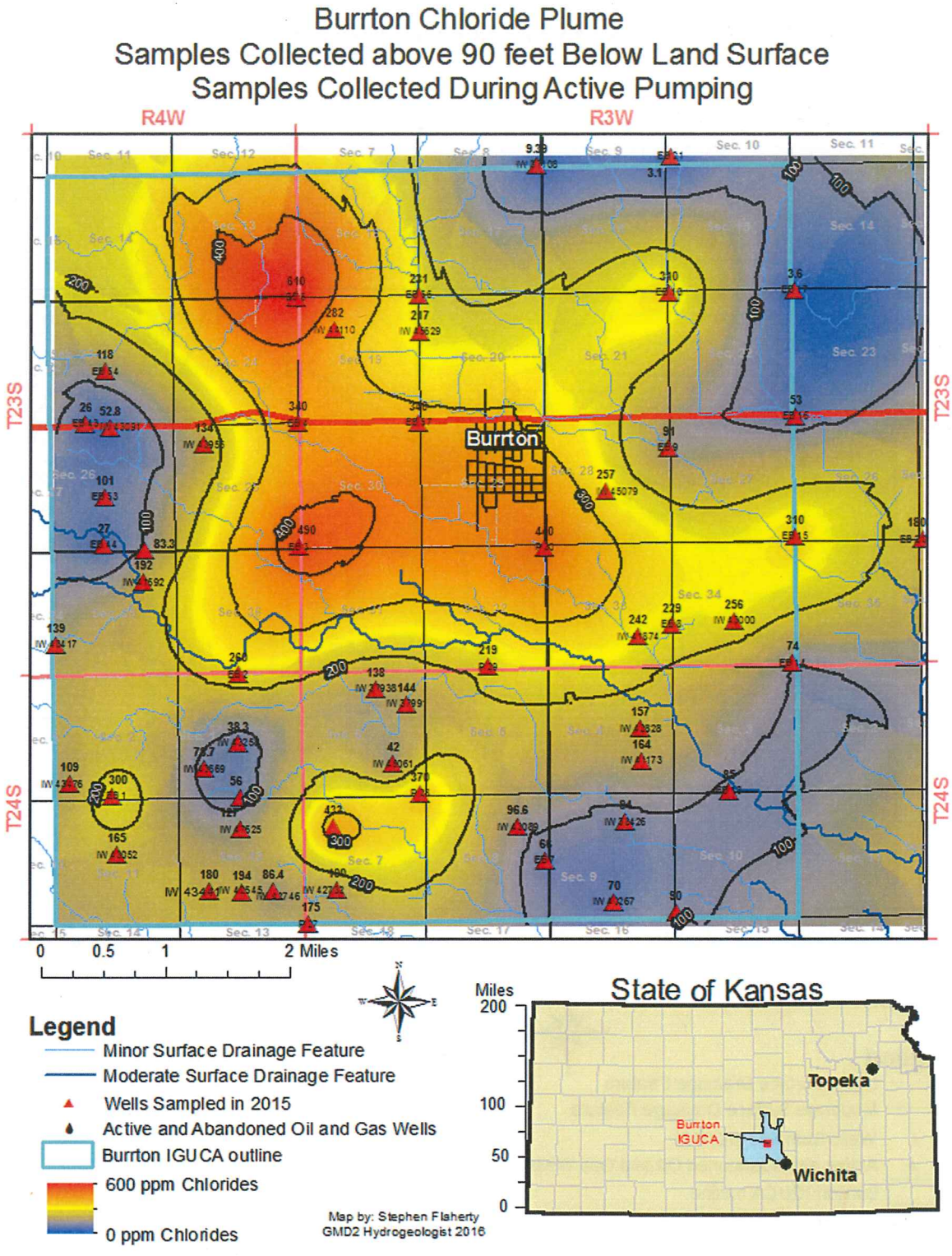

Figure 15: 2015 Upper Aquifer Chloride Concentrations (GMD #2, 2016)

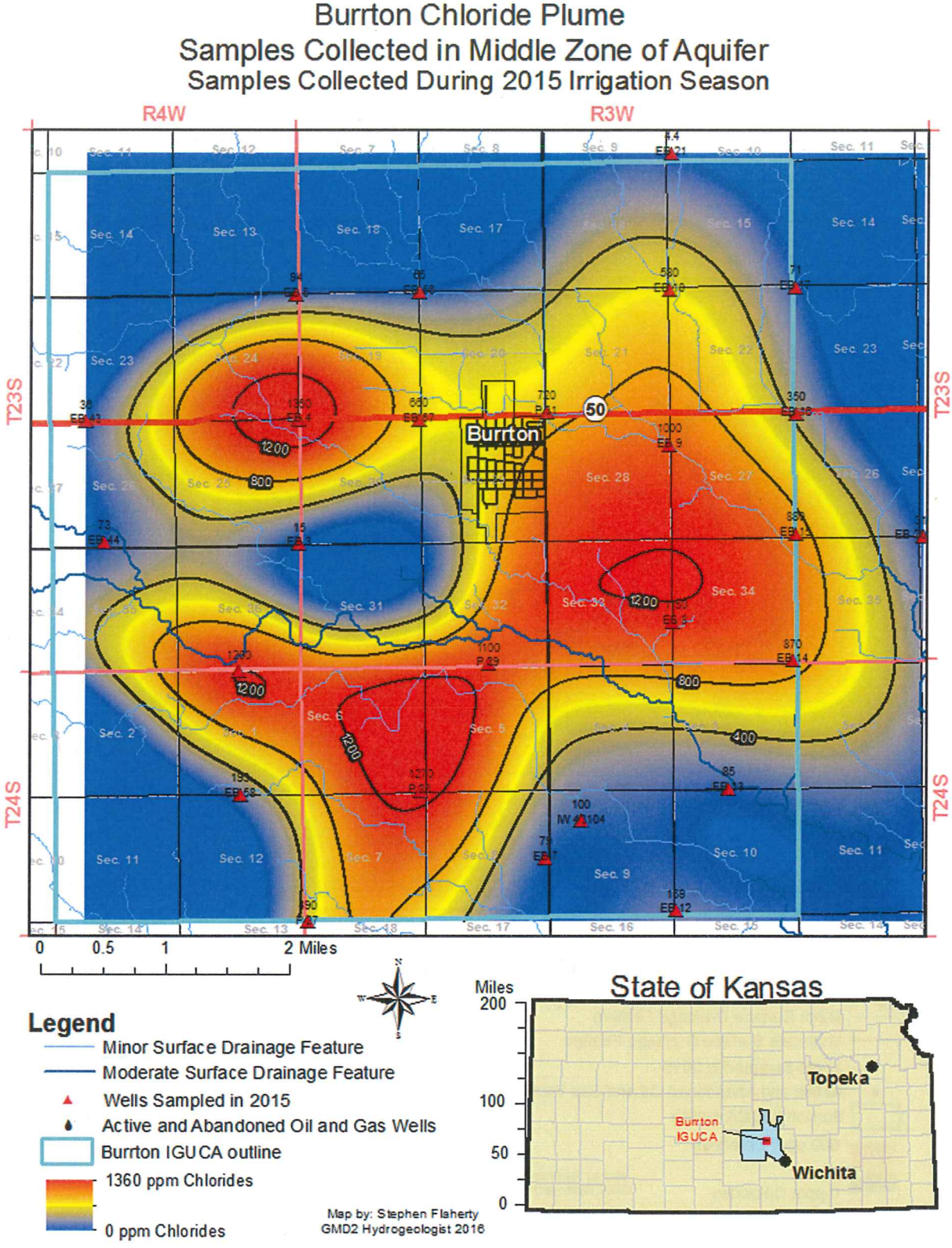

Figure 16: 2015 Middle Aquifer Chloride Concentrations (GMD #2, 2016)

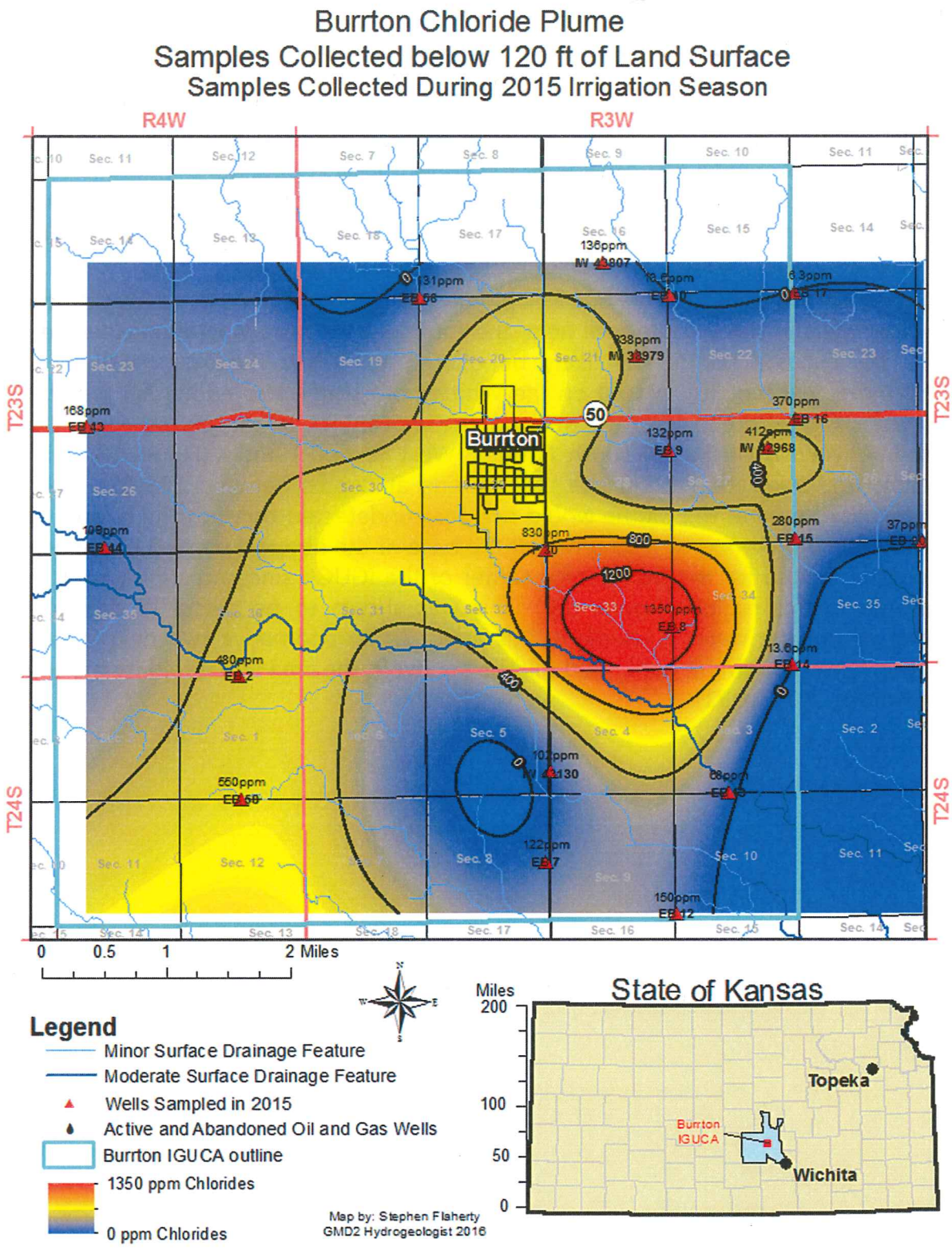

Figure 17: Lower Aquifer Chloride Concentrations (GMD #2, 2016)

Future Movement of the Chloride Plume

Figure 18 shows the 2010 zonal chloride concentrations at different depths for wells in the GMD #2 network. The highest concentration observed at that time in these wells was 1,900 mg/L in the deep zone of well EB8C. Towards the eastern edge at wells EB15B and EB14B, the chloride concentrations have reached 860 and 940 mg/L respectively. These levels have moved just outside of the current IGUCA boundary. Migration of the chloride plume to the east will eventually degrade the quality of groundwater along the southeastern part of Township 23 South, Range 3 West, and the northeast corner of Township 24 South, Range 3 West (Whittemore, 2012, p. 29).

According to Whittemore, the Burrton plume will eventually move to the cluster of municipal wells in the Wichita well field, the four southeastern-most municipal wells in Figure 18, but the plume will likely be diluted to a few hundred mg/L by then (Whittemore, 2012, p. 30). Based on the Whittemore study, two additional monitoring wells were suggested to improve tracking the movement of the plume. Site IW-09, located between Township 24 South, Range 3 West Section 1 and 2 (Figure 18) only has a shallow and deep monitoring site. Monitoring at depths between 118-128 feet was recommended so that the plume would not pass undetected through the middle zone. In addition, a monitoring well screened at the base of the deepest portion of the aquifer was recommended for the geographic center of the IGUCA since no supply wells were monitored in this region (Figure 19). This was shown to be useful in determining whether or not the water is usable in this area. As an alternative two deep domestic wells grouted through the upper and middle aquifer in the area that could be monitored (Whittemore, 2012, p. 31).

Burrton IGUCA Monitoring Wells with 2010 Zonal Chloride Concentrations (mg/L)

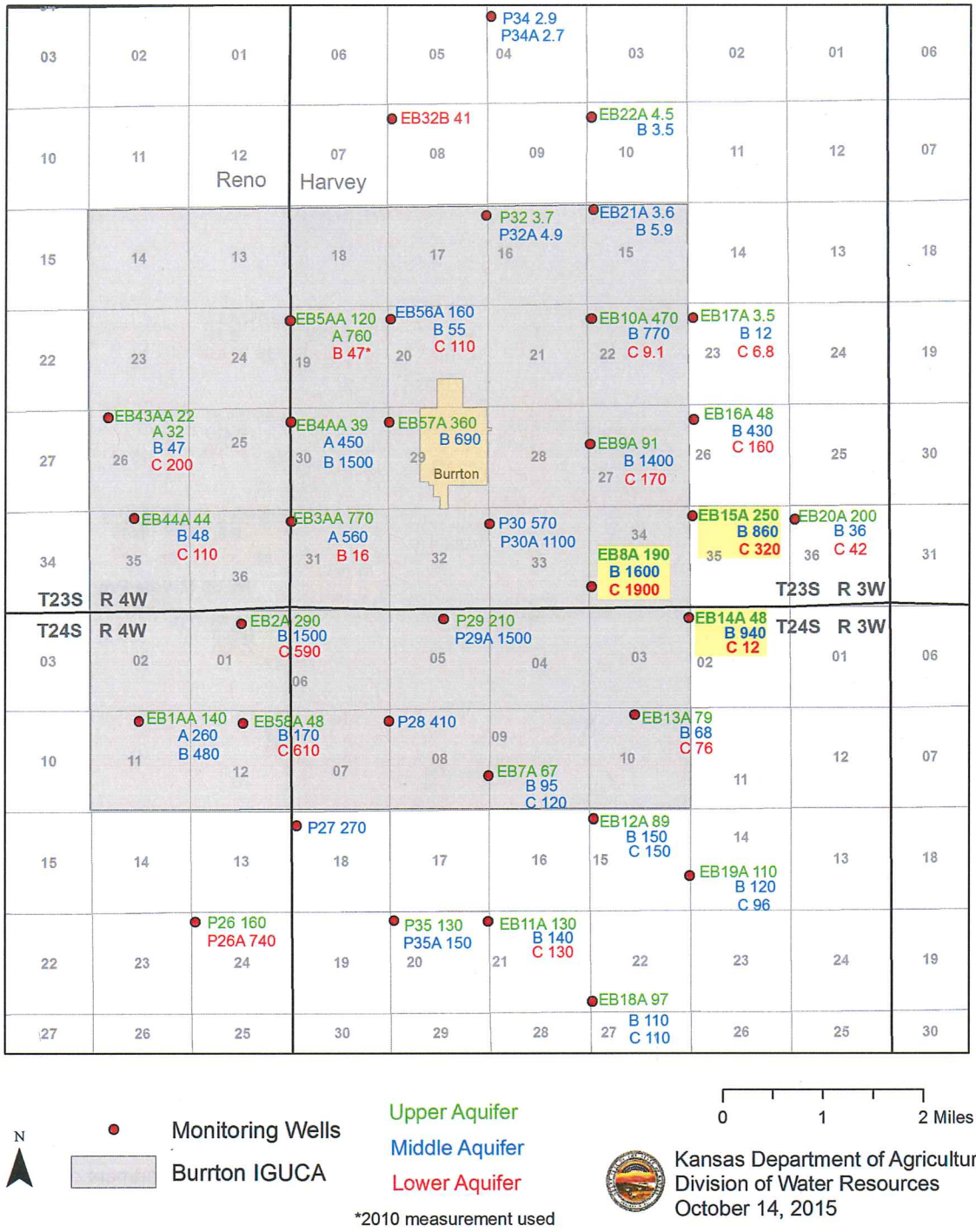

Figure 18: Burrton IGUCA Monitoring Wells 2010 Chloride Concentrations

Burrton IGUCA Monitoring Wells with 2010 Zonal Chloride Concentrations (mg/L) and KGS Proposed Additional Monitoring

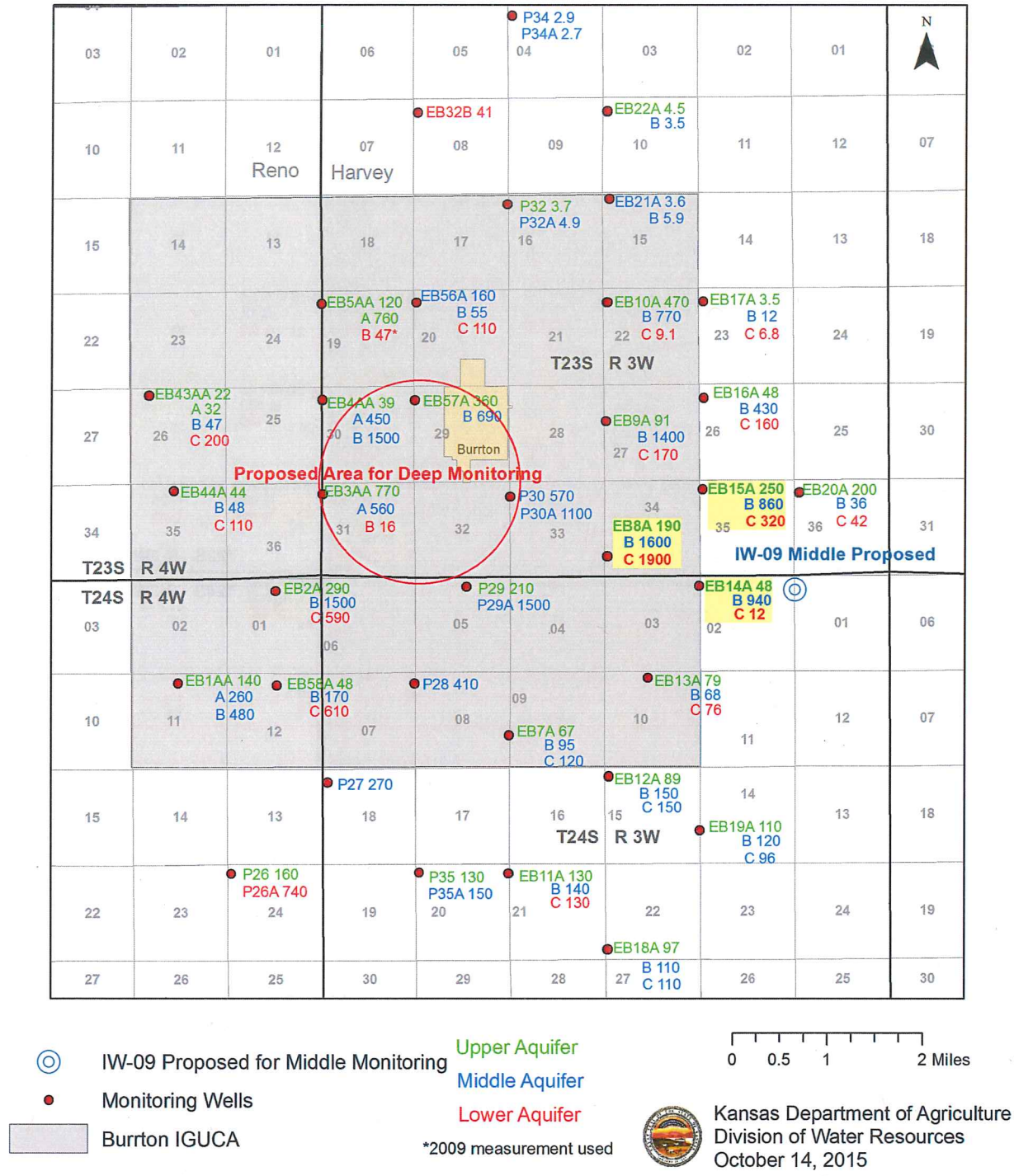

Figure 19: Proposed Location of KGS Recommended Additional Monitoring

VI. GMD #2 Procedures for New Application Review

GMD #2 staff evaluates all new applications to appropriate water that are filed within the GMD #2 boundaries to determine if the application complies with the district's rules and regulations and Revised Management Program.

On April 13, 2004, GMD #2 set the following criteria for applications filed in the Burrton IGUCA:

1. Applications filed for proposed points of diversion located down gradient of the maximum contamination areas of the saltwater plumes shall not be recommended for approval; and
2. Applications filed for proposed points of diversion located up gradient of the maximum contamination areas of the saltwater plumes shall be reviewed on a case-by-case basis by the District board of directors to determine site specific effects on the aquifer and prior appropriations.

In the Burrton IGUCA, in addition to reviewing each new application using the District's rules and regulation and revised Management Program, each application is evaluated by GMD #2 to determine whether the proposed groundwater withdrawal would adversely affect water quality or senior water rights. A computational groundwater model is used to determine if the proposed groundwater withdrawal would alter natural plume migration and what impact this would have on senior water rights.

An analysis is performed and documented for each new application within the IGUCA. If a new application is recommended for approval based on the results of the analysis, the new permit may include restrictions such as a drilled depth, water quality monitoring, or other criteria on the well in order to protect water quality. Well construction in the Burrton IGUCA is also subject to well grouting requirements set by KDHE. Grouting involves placing a sealing material such as bentonite or neat cement into the space between a well casing and the borehole created during well construction in order to physically isolate different aquifer formations from one another.

VII. IGUCA Review Criteria

As stated in K.A.R. 5-20-2 (f), (g), and (h) below, the chief engineer must make certain determinations regarding the Burrton IGUCA.

(f) Based on the review specified in subsection (e), one of the following actions shall be taken by the chief engineer:

(1) Continue the IGUCA with its original or current corrective control provisions;

(2) reduce the restrictions imposed by one or more corrective control provisions within the scope and goals specified in the original IGUCA order;

(3) reduce the IGUCA boundaries;
(4) increase any allocations within the IGUCA;
(5) address any other issues that have been identified in the review; or
(6) revoke the IGUCA order and implement alternative measures, if necessary, to address the water issues in the affected areas.

(g) If, as a result of the review specified in subsection (e), the chief engineer determines that the restrictions imposed by current corrective control provisions may need to be increased or additional corrective control provisions may be needed, a hearing shall be conducted by the chief engineer according to K.A.R. 5-14-3a.

(h) If, as a result of the review specified in subsection (e), the chief engineer determines that the boundaries of the IGUCA may need to be increased, a new IGUCA proceeding shall be initiated by the chief engineer pursuant to K.A.R. 5-20-1. (Authorized by K.S.A. 82a-706a; implementing K.S.A. 82a-706 and K.S.A. 82a-1036; effective Sept. 18, 2009.)

This section will focus on each criterion individually and the review team's recommendation.

(1) Continue the IGUCA with its original or current corrective control provisions.

Recommendation: **Yes**

The review team finds that the IGUCA corrective controls are essential for protecting the public interest in water quality in the Burrton area and recommends that the current Burrton IGUCA corrective controls be maintained, subject to the implementation of recommended additional corrective controls.

(2) Reduce the restrictions imposed by one or more corrective control provisions within the scope and goals specified in the original IGUCA order.

Recommendation: **No**

The corrective controls are essential for protecting the public health and environment. Stronger or more specific measures may need to be considered and possibly written into the order.

(3) Reduce the IGUCA boundaries.

Recommendation: **No**

Even though salinity levels in the western part of the IGUCA may be decreasing, the review team recommends that these areas should still be monitored to determine if continued or increased pumping induces saline water to flow back into those areas.

(4) Increase any allocations within the IGUCA.

Recommendation: **No**

This IGUCA did not close the area to new appropriations or consider allocations and only addresses water quality.

(5) Address any other issues that have been identified in the review.

Recommendation: **Yes**

The current IGUCA corrective controls do not address chloride levels in existing authorized wells. The review team recommends that as the plume moves to the southeast, the wells in its path should be increasingly monitored and may have their permits modified through a subsequent hearing process if their pumping exacerbates the plume migration. The team further recommends that well operators in the path of the plume should consider well grouting practices even beyond those requirements set by KDHE.

(6) Revoke the IGUCA order and implement alternative measures, if necessary, to address the water issues in the affected areas.

Recommendation: **No**

This IGUCA is unique in that it addresses water quality. The review team recommends that the IGUCA remain in place to continue to protect the public interest.

(7) The restrictions imposed by current corrective control provisions may need to be increased or additional corrective control provisions may be needed.

Recommendation: **Yes**

Additional corrective controls such as more stringent well grouting requirements and modifications to the permits that authorize pumping in the path of the plume should be considered to further protect the public interest. Given the movement of the chloride plume, an expansion of the IGUCA boundaries to the southeast is recommended for consideration.

(8) The boundaries of the IGUCA may need to be increased.

Recommendation: **Yes**

The review team recommends extending the boundary due to plume movement to the East and South to include Township 23 South, Range 3 West, Sections 23, 26, and 35 and Township 24 South, Range 3 West, Sections 2, 11 and 14 through 17 as illustrated in Figure 21. A figure of groundwater elevation was provided by GMD #2 which helps to illustrate the general direction of groundwater flow to the east-southeast (Figure 22). Rate of plume movement is considered while proposing area for expansion. Whittemore (2012) reported rate of plume movement as 0.8 to 1.0 foot per day. Based

on that, it can be expected that chloride contours presented in Figure 11 to 13 may have already moved approximately a quarter of a mile as of the date of this report. It is expected it will move about another half of a mile in 10 years. According to Whittemore, the Burrton plume will eventually move to the cluster of municipal wells in the Wichita well field, but it is expected that the plume's chloride concentration will be diluted to a few hundred mg/L by then (2012, p. 30). To continue to protect the public interest, the review team recommends expanding the current IGUCA boundary by about 1 mile (or one section width) along the eastern and southern edges of the IGUCA, which would add nine sections to the IGUCA in the path of the plume. Although the areas may be largely closed to new applications by GMD #2's safe yield rules, there are still exemptions for small use, domestic and temporary permits. It is recommended that more specific criteria such as additional well grouting requirements be considered. The review team also recommends that GMD #2's method of analyzing new applications be applied to existing water rights within the path of the plume.

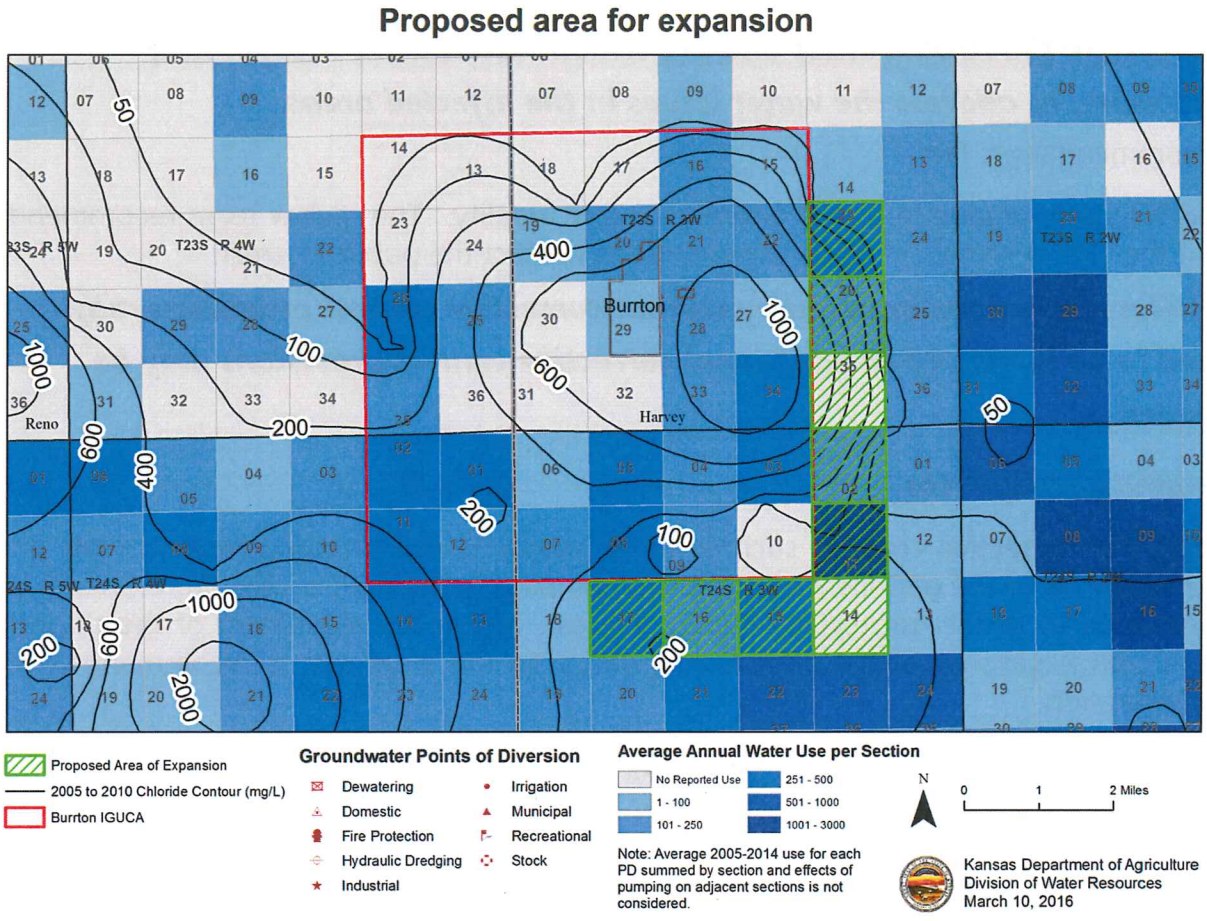

Figure 20: Proposed IGUCA Area Expansion

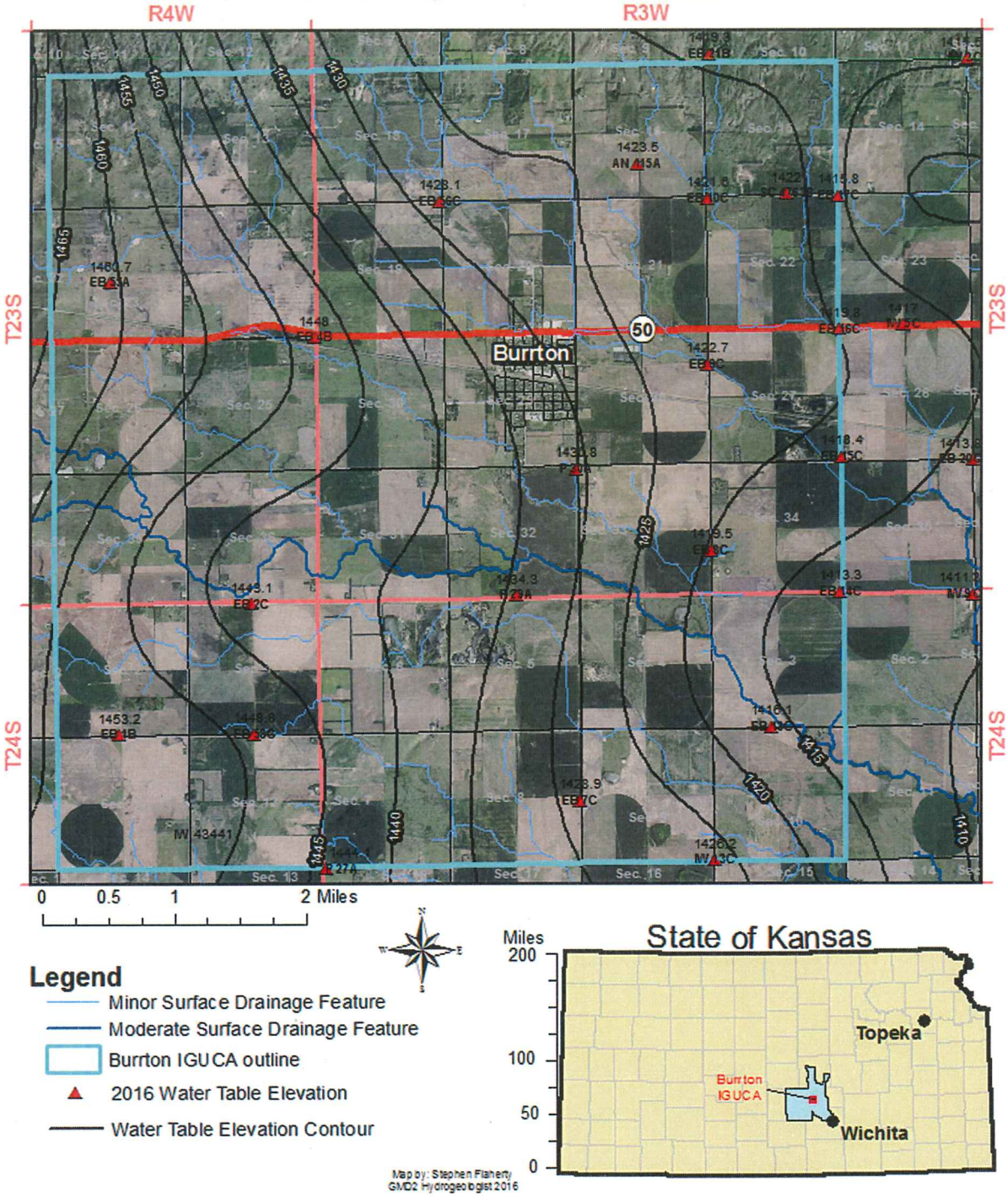

Figure 21: 2016 Groundwater Elevation (GMD #2, 2016)

VIII. Conclusions

The Burrton IGUCA corrective controls have been effective in protecting the public interest by establishing comprehensive water-quality based processes and criteria for processing new applications to appropriate water. Additional corrective controls such as more stringent well grouting requirements and modifications to the permits that authorize pumping in the path of the plume should be considered to further protect the public interest. Part of the IGUCA review regulations, K.A.R. 5-20-2 (g), indicates that if the chief engineer determines that the restrictions imposed by current corrective control provisions may need to be increased or additional corrective control provisions may be needed, that a new hearing shall be initiated by the chief engineer pursuant to K.A.R. 5-14-3a. Given the movement of the chloride plume, an expansion of the IGUCA boundaries to the southeast is recommended for consideration. K.A.R. 5-20-2 (h) indicates that if the chief engineer determines the boundaries of the IGUCA may need to be increased, a new IGUCA proceeding shall be initiated by the chief engineer pursuant to K.A.R. 5-20-1.

IX. References

Burrton Task Force. (1984). "Proposed Burrton Intensive Groundwater Use Control Area: prepared for the Kansas State Board of Agriculture, Division of Water Resources". 103 p.

Kansas Department of Health and Environment (KDHE). 2005. Bureau of Environmental Remediation/Remedial Section Guidance. Investigation and Remediation of Salt (Chloride)-Impacted Soil and Ground Water.
http://www.kdheks.gov/ber/policies/BER_RS_013A.pdf

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U.S. Environmental Protection Agency (EPA). 2013. "Secondary Drinking Water Regulations: Guidance for Nuisance Chemicals".
http://water.epa.gov/drink/contaminants/secondarystandards.cfm

Whittemore, Donald O. (2012). Distribution and Change in Salinity in the Equus Beds Aquifer in the Burrton Intensive Groundwater Use Control Area. Kansas Geological Survey, Open-file Report 2012-1, Lawrence, KS, 31 p.

X. Appendix

A. Groundwater Levels

Location of monitoring wells within the Burrton IGUCA (NAD 1983)

USGS ID	Latitude	Longitude	County	PLSS
375811097415501	37.97042	-97.7018	Harvey	24S 03W 18BBB 01
375811097415502	37.97042	-97.7018	Harvey	24S 03W 18BBB 02
375817097383701	37.97069	-97.6471	Harvey	24S 03W 10CCC 01
375903097383701	37.985	-97.6471	Harvey	24S 03W 10BBB 01
375910097405801	37.98528	-97.684	Harvey	24S 03W 06DDD 01
375811097373001	37.97042	-97.6286	Harvey	24S 03W 14BBB 01
375903097373101	37.985	-97.6286	Harvey	24S 03W 11BBB 01
380002097401701	37.99987	-97.6745	Harvey	23S 03W 32DCC 01
380002097401702	37.99984	-97.6745	Harvey	23S 03W 32DCC 02
380048097395202	38.01399	-97.6658	Harvey	23S 03W 32AAA 02
380239097395403	38.04333	-97.6657	Harvey	23S 03W 17DDD 03
380318097392901	38.05431	-97.6594	Harvey	23S 03W 16BAC 01
380331097395401	38.0578	-97.6661	Harvey	23S 03W 08DDD 01
380331097395402	38.05779	-97.6661	Harvey	23S 03W 08DDD 02
380509097450202	38.08587	-97.751	Harvey	23S 04W 03BAB 02
380002097374001	37.99968	-97.629	Harvey	23S 03W 34DDD 01
380232097373201	38.04319	-97.6286	Harvey	23S 03W 23BBB 01
380232097373801	38.0432	-97.6288	Harvey	23S 03W 23BBB 01
380232097373802	38.04318	-97.6288	Harvey	23S 03W 23BBB 02
375909097434401/375909097434402	37.98539	-97.7296	Reno	24S 04W 02CDD 01
380205097435001	38.03481	-97.7305	Reno	23S 04W 23CAA 01
380146097440202	38.02931	-97.7356	Reno	23S 04W 23CCD 04
380146097440201	38.02931	-97.7357	Reno	23S 04W 23CCD 02