McPherson 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 McPherson 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 original review team for this report consisted 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 on the McPherson 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 declining groundwater levels in the McPherson area, the board of Equus Beds Groundwater Management District #2 (GMD #2) initiated the Intensive Groundwater Use Control Area (IGUCA) process in February, 1979. A hearing was held in September, 1979 and the IGUCA order was issued in March, 1980. The order defined a control area and imposed two main corrective controls: (1) that the IGUCA area shall be closed to new appropriations excepting domestic, temporary and short-term permits and (2) that water flow meters shall be installed on all groundwater wells excepting domestic and temporary wells.

This review focuses on answering the question, "Have the McPherson IGUCA corrective controls addressed the problem of declining groundwater levels 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 level measurements, groundwater rights information, groundwater use, precipitation, and history of compliance and enforcement efforts. The analyses compare groundwater use and groundwater levels before and since the 1980 IGUCA order. The analyses do not attempt to simulate what might have happened if the IGUCA had not been established.

The analyses show that the McPherson IGUCA has been effective in reducing the rate of groundwater declines. In the period 1972-1980, before the IGUCA order, groundwater declines averaged 10.83 inches per year. From 1980-2015 groundwater level decline rates have improved to an average decline of 2.95 inches per year. Yearly precipitation is roughly the same for both pre- and post-IGUCA periods indicating that other factors have affected the stabilization of groundwater levels even as reported groundwater use has increased.

Given these observations, the review team concludes that the IGUCA corrective controls and the compliance and enforcement efforts that implement those controls are at least partly responsible for the improvements in the hydrologic system in the McPherson area. The review team recommends that the current McPherson IGUCA corrective controls be maintained including the efforts by the refinery to mitigate the effects of groundwater pumping on the chloride plume near the City of McPherson well field since 2004 under term permit number 20039082. The review team also recommends that the board of GMD #2 consider further proactive measures to maintain the hydrologic balance of the groundwater system in and adjacent to the McPherson IGUCA area, namely: (1) in light of the increasing trend in groundwater use, consider reducing groundwater use within the McPherson IGUCA; ; and (2) consider extending the borders of the McPherson IGUCA to the south and implementing corrective controls to address declining groundwater levels there.

I. Introduction

Geographic Location

The following report reviews and evaluates the McPherson Intensive Groundwater Use Control Area (IGUCA) within the Equus Beds Groundwater Management District No. 2 (GMD #2) boundaries (Figure 1). The McPherson IGUCA encompasses approximately 56 square miles (35,840 acres). The control area is located in southern McPherson County and includes the City of McPherson. As of Census 2010, the McPherson county population was 29,180 and population density was 32.5 persons per square mile.

Purpose and Objective

K.A.R. 5-20-2 mandates that every IGUCA be periodically reviewed to assess whether the IGUCA is still needed.

This report reviews the McPherson IGUCA order issued on March 28, 1980 and the events leading up to the order. It also provides analyses of the monitoring well water levels before and since the IGUCA order. Other data analyses include total annual precipitation and annual water use for the McPherson IGUCA. This report also includes a section on compliance and enforcement actions within the McPherson IGUCA and a summary of the annual reviews completed by the GMD #2 board and submitted to DWR. Finally this report will address each criterion prescribed by K.A.R. 5-20-2 and document the review team's recommendations for each.

II. Genesis of the McPherson IGUCA

On March 17, 1978, GMD #2 requested that all new applications bounded by the north of Township 19 South, Range 3 West, and Township 19 South, Range 4 West and bounded on the south by a line two miles south of the south line of Township 19 South, Range 3 West, and Township 19 South, Range 4 West and on the east and west by the boundaries of GMD #2 receive an assigned priority date, but not be acted on upon until sufficient data was collected to determine whether groundwater was available for appropriation. GMD #2 subsequently formally requested an IGUCA hearing for the aforementioned area (control area) on February 13, 1979 because it felt that groundwater levels were declining and had declined excessively and also because the rate of withdrawal of groundwater in the control area exceeded the rate of recharge.

The chief engineer acknowledged GMD #2's request for a control area with a letter dated May 24, 1979. On August 15, 1979 a notice was published in the McPherson Daily Sentinel regarding a public hearing on Tuesday, September 18, 1979 in the McPherson County 4-H Building. Notice was mailed to every water right holder in the proposed control area and other interested parties throughout the state. The chief engineer received several letters from concerned constituents between the publication of the notice and the actual hearing. These comments and concerns raised in those letters were addressed in the final order.

The chief engineer held a hearing on Tuesday, September 18, 1979 in the McPherson County 4-H Building. Several expert witnesses testified at the hearing on behalf of GMD #2 including Dr. Don Green, Professor in Chemical and Petroleum Engineering, University of Kansas, Mr. Thomas McClain, Hydrologist for the Kansas Geological Survey and Dr. Carl D. McElwee, Kansas Geological Survey, Groundwater Section. Finally, the GMD #2 Manager, Mr. Thomas Bell also testified on behalf of GMD #2.

Mr. Donald Kostecki, Hydrologist and Meteorologist for the Kansas Water Resources Board, testified on the behalf of Francine Neubauer, Acting Executive Director for the Kansas Water Resources Board. Mr. Lyle Gene Goering testified on his own behalf. Richard G. Luthi, a local implement dealer in McPherson, testified on his own behalf. Finally, Mr. George Moors, an irrigator, testified on his own behalf. All these testimonies were considered regarding the decision of the IGUCA Order.

GMD #2 recommended that the hearing be continued until October 30, 1979 to allow the district to submit final recommendations for corrective control provisions. A letter dated October 15, 1979 from GMD #2 laid out the corrective control provisions that GMD #2 recommended.

That on October 30, 1979, the chief engineer held a hearing. Since no further information had been received the hearing was closed on October 30, 1979.

On March 28, 1980 the chief engineer ordered an Intensive Groundwater Use Control Area (IGUCA) for the area in the vicinity of McPherson, Kansas bounded by the north of Township 19 South, Range 3 West, and Township 19 South, Range 4 West and bounded on the south by a line two miles south of the south line of Township 19 South, Range 3 West, and Township 19 South, Range 4 West and on the east and west by the boundaries of GMD #2 (Figure 1).

That effective March 15, 2012, the McPherson IGUCA was amended to improve water management by allowing multi-year flexibility of water use to better address exceptional drought conditions. Multi-year flex accounts (MYFAs) are term permits that allow for the flexibility of water use within the five-year life of the MYFA.

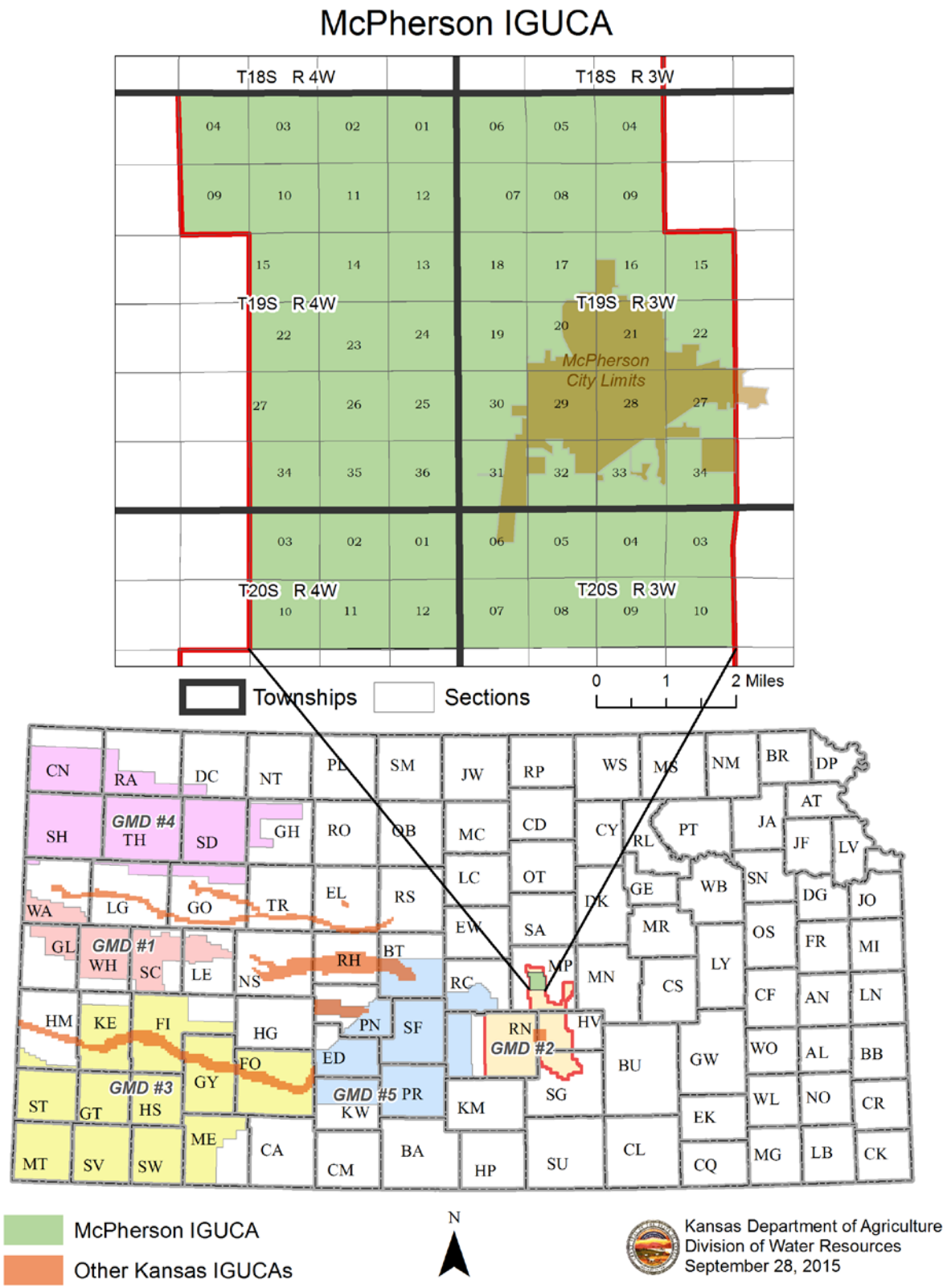

Figure 1: McPherson Intensive Groundwater Use Control Area

III. Conclusions from the 1979 McPherson IGUCA Hearing

Written in the order are four conclusions that the chief engineer and his team arrived at following the hearing:

1. That the groundwater levels in the control area have declined
2. That the rate of withdrawal of groundwater within the control area exceeds the rate of recharge in that area
3. That the area should be closed to further non-domestic, non-temporary, and non-short-term appropriation
4. That the applications to appropriate water for beneficial use within the moratorium area filed after March 20, 1978, which have been held by the chief engineer, but not acted upon, should be dismissed because the rate of withdrawal of groundwater was exceeding the rate of recharge at the time the moratorium was imposed and the rate of withdrawal of groundwater has continued to exceed the rate of recharge in that area since that time, and therefore no water is available for appropriation

Pursuant to these conclusions, the chief engineer closed the McPherson IGUCA to further groundwater appropriations except for domestic and any use authorized by temporary permit granted under the authority of K.S.A. 82a-727 on March 28,1980. Also, the order stated that flow meters shall be installed on all existing water wells except for domestic and temporary wells. Finally, the order prescribed annual review of all water use and static water level information by the GMD #2 board of directors, and if further information or data warrants, GMD #2 may request a rehearing on the McPherson IGUCA. The 1980 order was amended on October 14, 2013 to allow the use of multi-year flex accounts (MYFAs) within the IGUCA with an effective date of March 15, 2012.

IV. Data Analyses

The following section presents analyses of groundwater levels, precipitation, groundwater right development, water use, compliance and enforcement (Blatant and Recurring Overpumping) and annual reviews of the data by GMD #2.

A. **Groundwater Levels**

The Kansas Geological Survey (KGS), GMD #2 and DWR combine efforts to measure 26 monitoring wells within the McPherson IGUCA (Figure 2). Measurements are available on the KGS Wizard website. Locations of the monitoring wells and a graph depicting the measurements are presented in the appendix (Figure 20-30). When directly comparing water level measurements over years, every effort was made to compare winter (December, January and February) measurements for consistency. Measurements began in the early 1970s in some areas. The most recent measurements were in February, 2015.

There are four wells within the McPherson IGUCA – MP28, MP32, MP37 and MP53 – which have complete records of water level measurements from 1972 to 2015. MP 14,

which has complete records of water level measurements from 1972 to 2012, is also included in this analysis.

Figure 3 maps the water level change in average inches per year before the IGUCA (1972-1980) and since the IGUCA (1980-2015). Prior to the IGUCA, the area had steep declines, especially west of McPherson. Since the IGUCA, declines persist, but at a much slower rate that diminishes towards the northern part of the IGUCA. To create the figure the difference in water level measurements was calculated for each monitoring well (i.e. 1972 -1980) and divided by the number of years and then multiplied by 12 to arrive at the average decline in inches per year. The values were then interpolated using the kriging method.

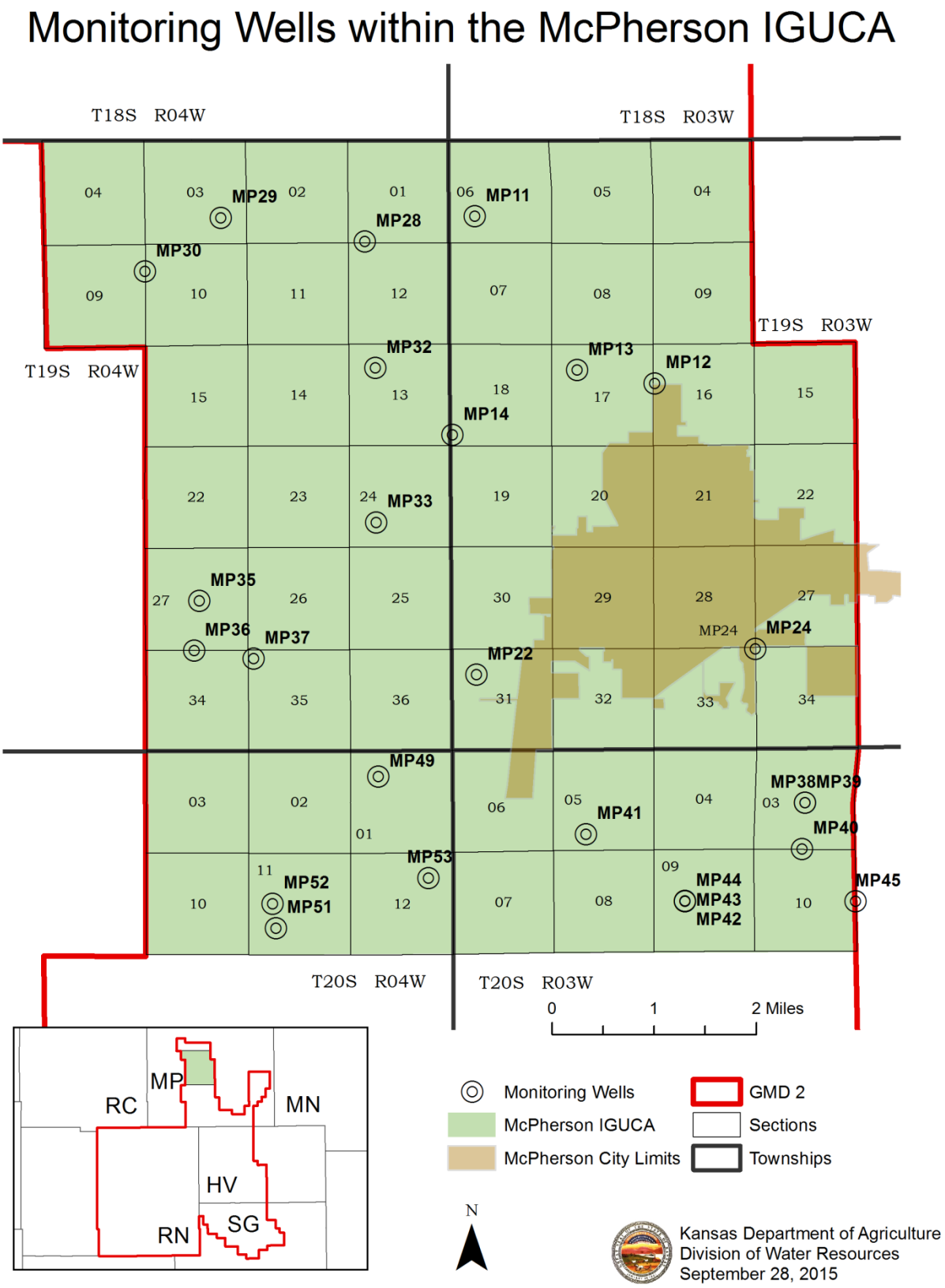

Figure 2: Map of the Monitoring Wells within the McPherson IGUCA

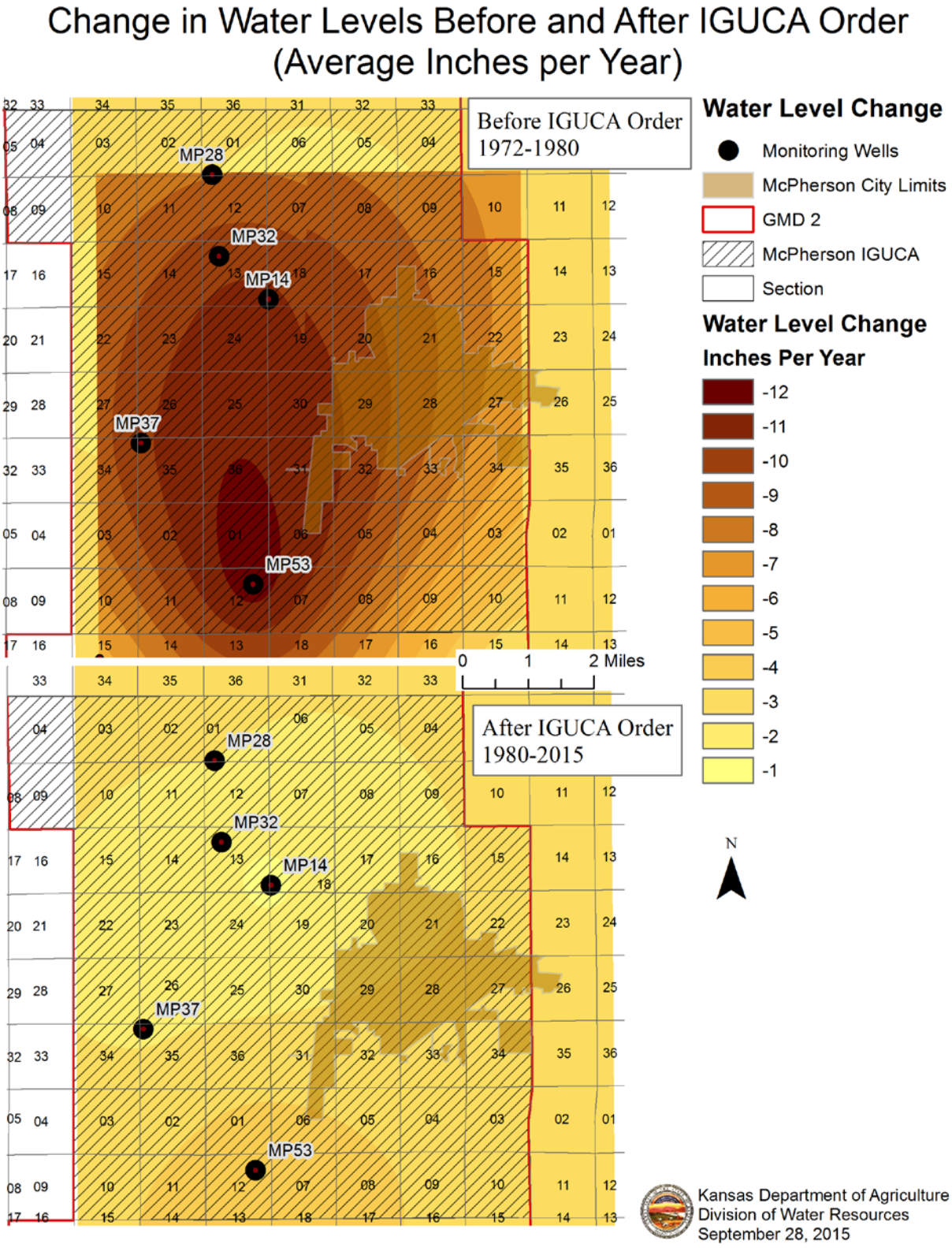

Figure 3: Interpolated Change in Water Levels (inches per year)

B. Precipitation

Precipitation values were obtained from the National Climatic Data Center for the McPherson weather station (COOP 145152) east of the City of McPherson and the IGUCA. The data record for this site begins in 1893. This analysis uses a forty three-year span from 1971 - 2014 (Figure 4). Two years did not have complete data so the best available data is displayed. In 1988, the record lacks February data, and in 2009 no data existed for either January or February. The average precipitation, including only years with a full record, was 32.07 inches. The highest annual total was in 1993 with over 47 inches of precipitation and the lowest annual total was in 2012 at 18.17 inches. There is a difference of 29.50 inches between the maximum and minimum values for a forty three-year span. Based on the graph, precipitation values vary annually, but there does not appear to be a discernible trend in precipitation.

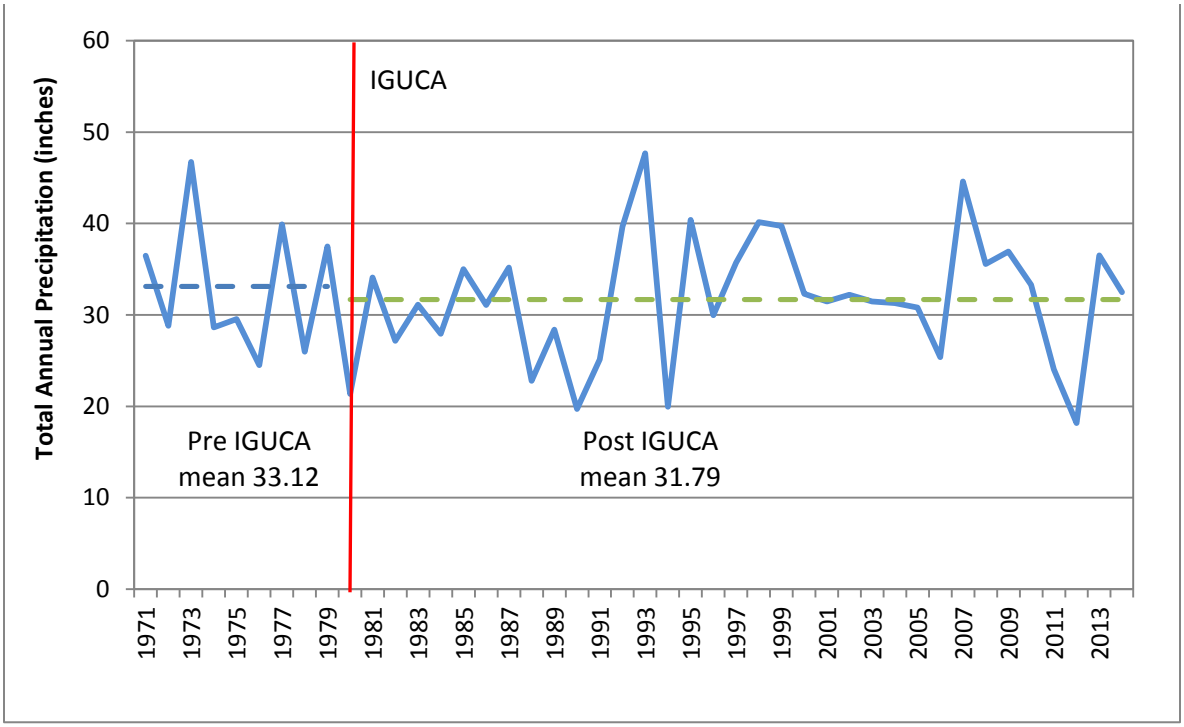

Figure 4: Annual Precipitation for the McPherson Weather Station

C. Groundwater Rights

The McPherson IGUCA had 75 active groundwater rights as of March 9, 2016. Table 1 separates the active water rights by type of use and includes all right types. There is more development on the western half of the IGUCA than in the eastern half of the IGUCA. The distribution of appropriated and certified rights in the area is shown in Figure 5.

Table 1: Active Groundwater Rights within McPherson IGUCA Boundaries

Water Right Type	Count	Authorized Quantity (AF)
Irrigation	58	8020
Industrial	8	7564.85
Municipal	4	4603.33
Domestic	1	0.92
Stock	1	12.28
Recreation	2	116
Contamination Remediation	1	2420
Total	**75**	22737.38

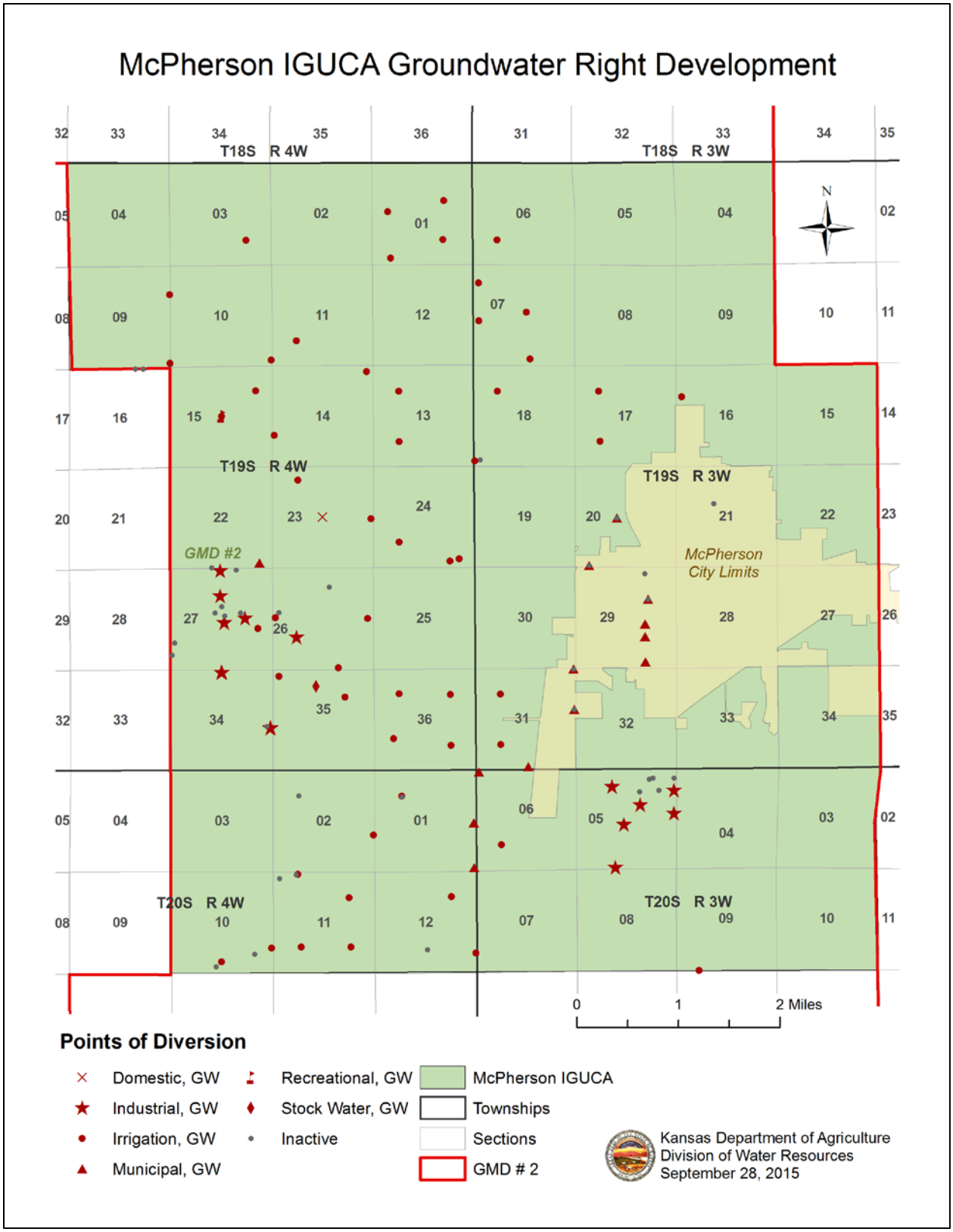

Figure 5: Groundwater Right Development in McPherson IGUCA

D. Groundwater Use

The groundwater use analysis is based on information stored in DWR's water rights information system (WRIS) database. The data was queried on September 11, 2015.

DWR is aware of three different sources of groundwater use records: (1) DWR's WRIS database, (2) the 1979 KGS Model Report (McElwee, 1979) and (3) GMD #2 annual reports. Both the KGS report and GMD #2 annual reports show significantly more groundwater use than what was reported to DWR in most years. Some of the difference may be attributed to voluntary water use reporting and the minimal metering prior to the late 1980s. Water use reporting was made mandatory in 1988 under K.S.A. 82a-732. Upon review it appears that the GMD #2 annual report data may be a reasonable estimate of groundwater use in the earlier years before 1990. Both WRIS and GMD #2 annual report data show an increasing trend in groundwater use, but the trend is much less in the GMD #2 annual report data. The KGS Model Report and GMD #2's annual report data are included in the appendix.

The McPherson IGUCA order required water flow meters on all points of diversion excepting domestic and temporary wells. As a result, the water use values are more accurate after the 1980 order and even more accurate after water use reporting was made mandatory in 1988. Since industrial, irrigation and municipal uses account for more than 99% of the water use within the IGUCA boundary, only those uses are included in Figure 6. Water use included in the analysis was for all rights reporting use within the McPherson area. The highest water use reported was 15,340 acre-feet in 2011. That total being nearly 5,000 acre-feet less than the total amount of groundwater appropriated in the area.

Figure 6: Groundwater Use for All Points of Diversion in the McPherson IGUCAFigure 6 shows an increase in groundwater use in the McPherson IGUCA. The chart depicts groundwater use from 1974-2014 (Note: total 1974-1980 water use data is from GMD #2 Annual Reviews while all other water use data is from WRIS). The figure also shows annual fluctuations in water use, but an overall increasing trend. The years 2006, 2011 and 2012 have the highest water use with over 14,900 acre-feet reported. Because early water use data was not required to be reported, the review team has relatively little confidence in its accuracy. Because water flowmeters and mandatory water use were both required by 1988, the review team has confidence in the accuracy of the data available after about 1990. Water use in the 1970s averaged 11,090 acre-feet per year, in the 1980s averaged 10,359 acre-feet per year, in the 1990s averaged 10,988 acre-feet per year, in the 2000s averaged 12,3610 acre-feet per year and as of 2014 water use data, the 2010s average use is at 12,926 acre-feet per year.

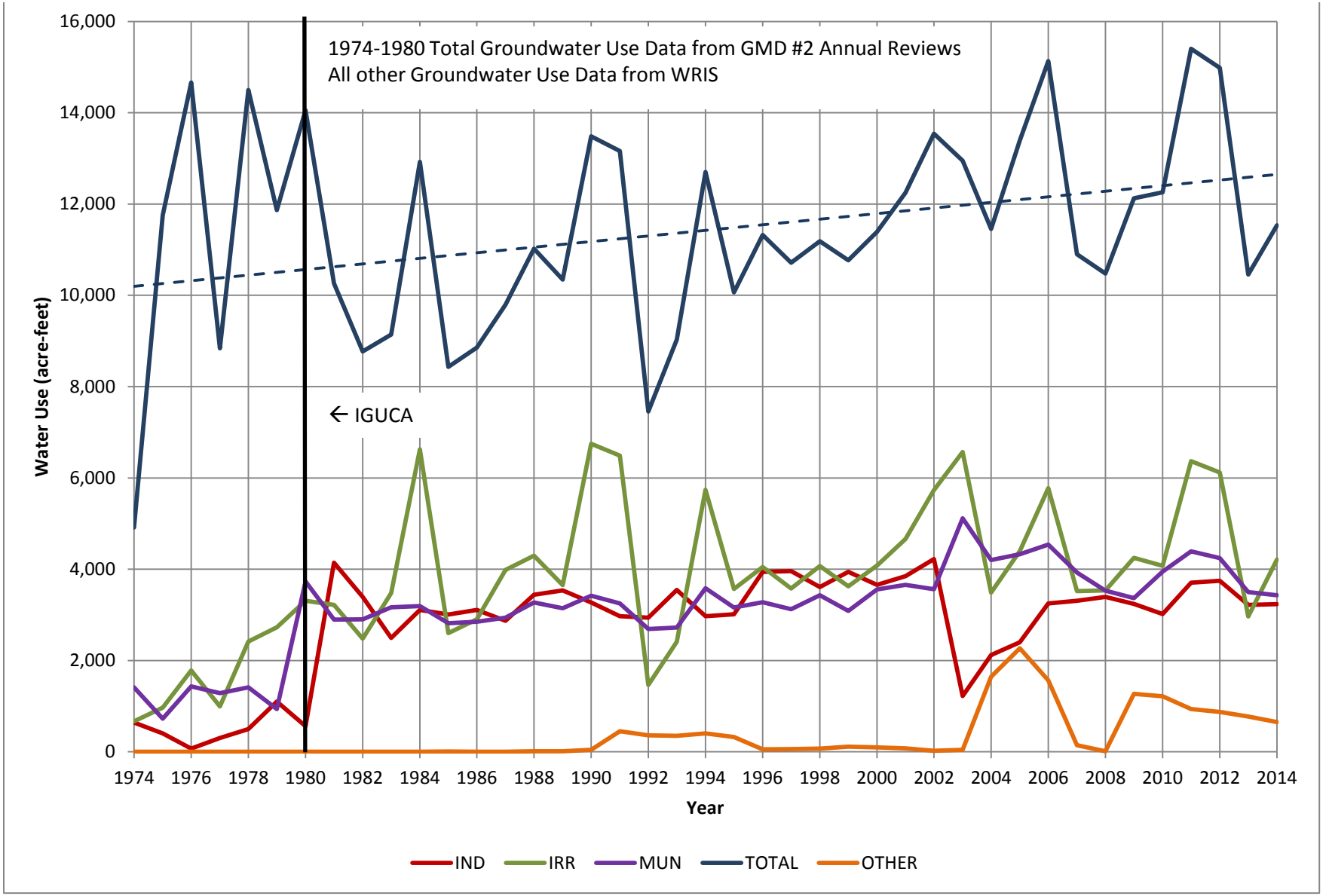

Figure 6: Groundwater Use for All Points of Diversion in the McPherson IGUCA

E. Compliance and Enforcement

The Stafford field office started to focus on compliance and enforcement outside of defined Basin Management Team subbasins in 2005. Within the McPherson IGUCA, there have been 6 over pumping non-compliances, 1 over pumping penalty, 3 drought term over pump penalties, and 3 additional non-compliances for poor water use reporting and water use report falsification levied since 2005.

F. GMD #2 Annual Review of IGUCA Data

Pursuant to the IGUCA order, GMD #2 submitted annual reports to the chief engineer until 2002 when budget constraints required them to stop. The reports included water level measurements, water use and later reports included precipitation. Attached to the reports were letters stating that the board approved the report and the current management status of the McPherson IGUCA and did not recommend any changes in the management of the control area.

All the annual reviews submitted to the chief engineer are included in the appendix.

V. IGUCA Review Criteria Pursuant to K.A.R. 5-20-2

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

While the rate of decline is not as great as prior to the IGUCA order, the water levels still show a decline (Figure 3). Five monitoring wells, MP28, MP32, MP14, MP37 and MP53, had measurements in 1970* and 1980. There was an average net decline of 8.56 feet during those years or 0.856 feet per year. The largest decline was recorded by MP53 at 9.7 feet. The smallest decline was at MP28 with 6.3 feet. (*Note: The 1970 measurements were taken April 1, 1970 instead of in the winter. This is the only data available.) The same five wells averaged a net decline of 8.59 feet or 0.25 feet per year from 1980 to 2015. The smallest decline was MP14 of 5.33 feet, but the largest decline was monitored at MP53 at 14.06 feet. Even though the rate of decline in water levels has slowed since the IGUCA order, declines persist.

Also, the Equus Beds Groundwater Management District No. 2 Water Flowmeter Requirement Regulation K.A.R. 5-22-4a required all nondomestic, non-temporary wells in the District to be equipped with flowmeters by the end of 2015; therefore, the review team recommends that the water flowmeters requirements remain in place.

The review team finds that the provisions are essential for protecting the public interest by reducing groundwater level decline.

(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 review team does not recommend a reduction in the restrictions imposed by one or more corrective control provisions within the scope and goals specified in the original order. The McPherson IGUCA order closed the area to new appropriations and required installation of flow meters. The review team recommends the area remain closed because of the decline in water levels (Figure 3) and the rise in groundwater use (Figure 6). Table 2 displays the authorized quantity and decadal averages for groundwater use in the 1990s, 2000s and 5-year averages in the 2010s. During the last five years, water use has increased. The IGUCA restrictions prevent further groundwater development and more severe declines.

Table 2: Average Decadal Groundwater Use in McPherson IGUCA (active water rights only)

Use Made of Water	Authorized Quantity (AF)	1970s Average Use (AF)	1980s Average Use (AF)	1990s Average Use (AF)	2000s Average Use (AF)	2010s Average Use (AF)
Total	22,737.38	11,089.67	10,359.48	10,988.36	12,361.36	12,926.34
Industrial	7,564.85	502.11	2,965.97	3,416.10	3,066.74	3,386.09
Irrigation	8,020.00	1,592.86	3,653.83	4,173.95	4,600.89	4,748.16
Municipal	4,603.33	1,201.18	3,091.01	3,175.63	3,978.73	3,901.79
Other	2,549.20	0.00	3.33	222.67	715.01	890.29

(3) Reduce the IGUCA boundaries.

Recommendation: **No**

The review team does not recommend reducing the boundaries of the McPherson IGUCA. In comparing all active wells within the McPherson IGUCA boundary, all have a decline in water level from their first to last measurement. The average net change for all 26 monitoring wells from 1980 to 2015 was a decline of 7.27 feet. Any reductions in the IGUCA boundaries could lead to further groundwater development, exacerbating the decline in water levels.

(4) Increase any allocations within the IGUCA.

Recommendation: **No**

The McPherson IGUCA did not have any allocations written into the original order. If the desire is for the McPherson IGUCA to reach safe yield, reductions will be needed. Groundwater use is greater than annual recharge within the IGUCA boundaries.

Recharge is lower in the northern part of GMD #2 including the McPherson IGUCA compared to the rest of GMD #2 (Figure 35). United States Geological Survey estimated an annual recharge of 2.77 inches over the McPherson IGUCA from 1951-1980. That equates to a total annual recharge of 8,355.12 acre-feet. The McPherson IGUCA has 20,611 acre-feet appropriated to groundwater use. The decadal average of water use in the 2000s was 11,039 acre-feet (Table 2). The last 5-year average groundwater use was 12,074 acre-feet. These values are higher than the annual recharge. In order to reach safe yield in the McPherson IGUCA and further stabilize water levels, groundwater use must decrease.

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

Recommendations: **None**

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

Recommendation: **No**

The review team does not recommend revoking the McPherson IGUCA order. At present, the IGUCA order has limited further development within the IGUCA and also allows for better reporting of water use due to the flowmeter requirement.

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

Recommendation: **Yes**

As mentioned previously in criteria (4), if the goal is safe yield, reductions will need to be implemented since the groundwater use is higher than recharge. The McPherson Board of Public Utilities (BPU), which supplies municipal water from a well field in the McPherson IGUCA to the City of McPherson and surrounding area, is actively seeking an additional water source from outside the McPherson IGUCA. The McPherson BPU has

filed three water permit applications for a south well field to be located approximately 16 miles south of the southern edge of the McPherson IGUCA. If the water permit applications are approved and developed, the McPherson BPU could reduce water use from the McPherson IGUCA by up to 2,909 acre-feet per year by utilizing the new south well field. The refinery has also implemented actions to reduce groundwater use, including using treated wastewater effluent from the McPherson BPU and treating and using oil production brine (chloride) contaminated groundwater. The plume is located south of the city in Sec. 5 T.20 S., R. 3 W. and Sec 32, T. 19S., R. 3 W (Whittemore, 2004). The primary source of this saline groundwater has been identified as oil-production brine. Chloride concentrations in the groundwater were found to be substantially greater near the bottom of the High Plains Aquifer. The plume has migrated west following the sloping bedrock surface, but water level declines from pumping have increased the flow rate (Whittemore, 2007). These water use reduction actions could significantly assist in achieving safe yield water use in and near the current McPherson BPU and refinery well fields in the IGUCA.

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

Recommendation: **Yes**

Jeff Lanterman, DWR Water Commissioner, Stafford Field Office, and Tim Boese, GMD #2 Manager, noted concerns about declining water levels south of the IGUCA. Because of this concern, the review team prepared monitoring well data for the area south of the IGUCA. Figure 7 shows the location of all 29 monitoring wells. All the monitoring wells fall within or near the GMD #2 boundaries. Two graphs were constructed to compare water levels.

In order to help illustrate wells on the Southern edge of the IGUCA, two tiers were defined based on proximity to the McPherson IGUCA (Figure 7). Tier 1 displays monitoring wells directly south of the IGUCA that fall within Township 20 South, Range 3 West, sections 15 through 22 and 27 through 35 or Township 20 South Range 4 West, sections 13 through 16, 21 through 28, and 33 through 36 (Figure 7). Tier 2 displays monitoring wells south of Tier 1 that fall within Township 21 South Range 3 West sections 2 through 11 and 13 through 36 or Township 22 South Range 3 West Sections 1 through 30 or Township 21 South Range 4 West sections 1 through 3, 10 through 15, 22 through 27 and 34 through 36 or Township 22 South Range 4 West Sections 1 through 3, 10 through 15 and 22 through27. Tier 1 and 2 included wells that had five or move feet of groundwater decline from 1972 - 2015.

Thirteen wells are measured within Tier 1 and values of static water levels, winter levels November through March and sometimes April if no earlier data available, were used in this analysis. A black vertical line in Figure 13 delineates the periods before and after the IGUCA order. Four wells, MP56, MP58, MP61 and MP62, have records since 1970 and show a historical decline. MP58 was abandoned and MP59 took its place. The average decline over the period of record for the four historical wells approximately 19 feet (0.4 feet per year or about 5 inches decline per year). Only MP27, which is not located within Tier 1 but was included in the analysis due it its close proximity to the IGUCA, shows a relatively stable water level. MP27 is located in T19S R3W, east rather than south of the IGUCA.

To better illustrate water level trends prior to the IGUCA and post-IGUCA, four of the long-term monitoring wells were analyzed individually (Figure 9-12). Each graph is the same scale as Figure 9 and has two graphed trend lines. The blue trend line corresponds with water levels prior to the McPherson IGUCA and the red trend line is for the measurements after the IGUCA is implemented. MP56 (Figure 9) and MP61 (Figure 11) declines increased since the IGUCA was implemented. MP58/59 (Figure 10) and MP62 (Figure 12) water levels stabilized since the IGUCA. While Tier 1 and Tier 2 are not in the current McPherson IGUCA Figure 9 through Figure 12 and Figure 14 through Figure 18 compare to similar charts of monitoring wells in the McPherson IGUCA located in the appendix.

Tier 2 does not display the same trends as Tier 1 (Figure 13). For example, MP75 and MP76 (MP76 replaced MP75) fluctuate seasonally, but the overall trend is neutral. Other wells, MP65, MP66 and MP67, in the southern part of Tier 2 have similar trends. Tier 2 has six monitoring wells, MP65, MP70, MP73, MP75/76, MP77 and MP78, with historical water level measurements. Their average decline over the period of record (1970-2015) is about 17 feet, but the decline varies geographically. USGS well 38083809740051 has the smallest declines at -10.75. Following that, MP65 and MP73 have the small declines at 15.21 and 15.76 feet, respectively. The other four wells located further north all have declines over 17 feet with the largest belonging to MP78 at 20.65 feet. Water levels fluctuate throughout the year, but the overall trend appears to have leveled off since the IGUCA's implementation. Five of the monitoring wells are graphed individually below. MP65 (Figure 14), MP75/76 (Figure 15) and USGS 380838097400501 (Figure 16) are located in the southern portion of Tier 2. As their graphs and trend lines show, post-IGUCA Tier 2 water level declines have stabilized or decreased since pre-IGUCA conditions. MP73 (Figure 17) and MP70 (Figure 18) are located further north and continue to see similar water level trends pre- and post-IGUCA.

Figure 19 depicts the water right development in Tier 1 and Tier 2. Tier 1 has 63 active groundwater rights, of which one is for domestic use, one for industrial use, one for recreational use and 61 for irrigation use –one of the rights has both irrigation and recreational uses. Twenty four of the 63 water rights have priority dates after the McPherson IGUCA order. Tier 2 has 242 active groundwater rights of which three are recreational, six are municipal, two are industrial and 231 are irrigation water rights. 126 of the water rights within Tier 2 have a priority date after the McPherson IGUCA order.

Figure 20 shows an increasing trend in groundwater use for both Tier 1 and Tier 2.

Table 3 shows the decadal averages for all groundwater use in both Tier 1 and Tier 2. Each decade has an increase of groundwater use in both tiers. Note that early data summaries are low due to poor reporting up to the 1980s.

Table 3: Tier 1 and Tier 2 Decadal Averages for All Points of Diversion

	Average Water Use				
	1970	1980	1990	2000	2010
Tier 1	1,239.25	3,682.09	4,733.44	5,223.61	5,617.78
Tier 2	1,505.37	65,503.80	71,934.21	86,042.29	51,047.42

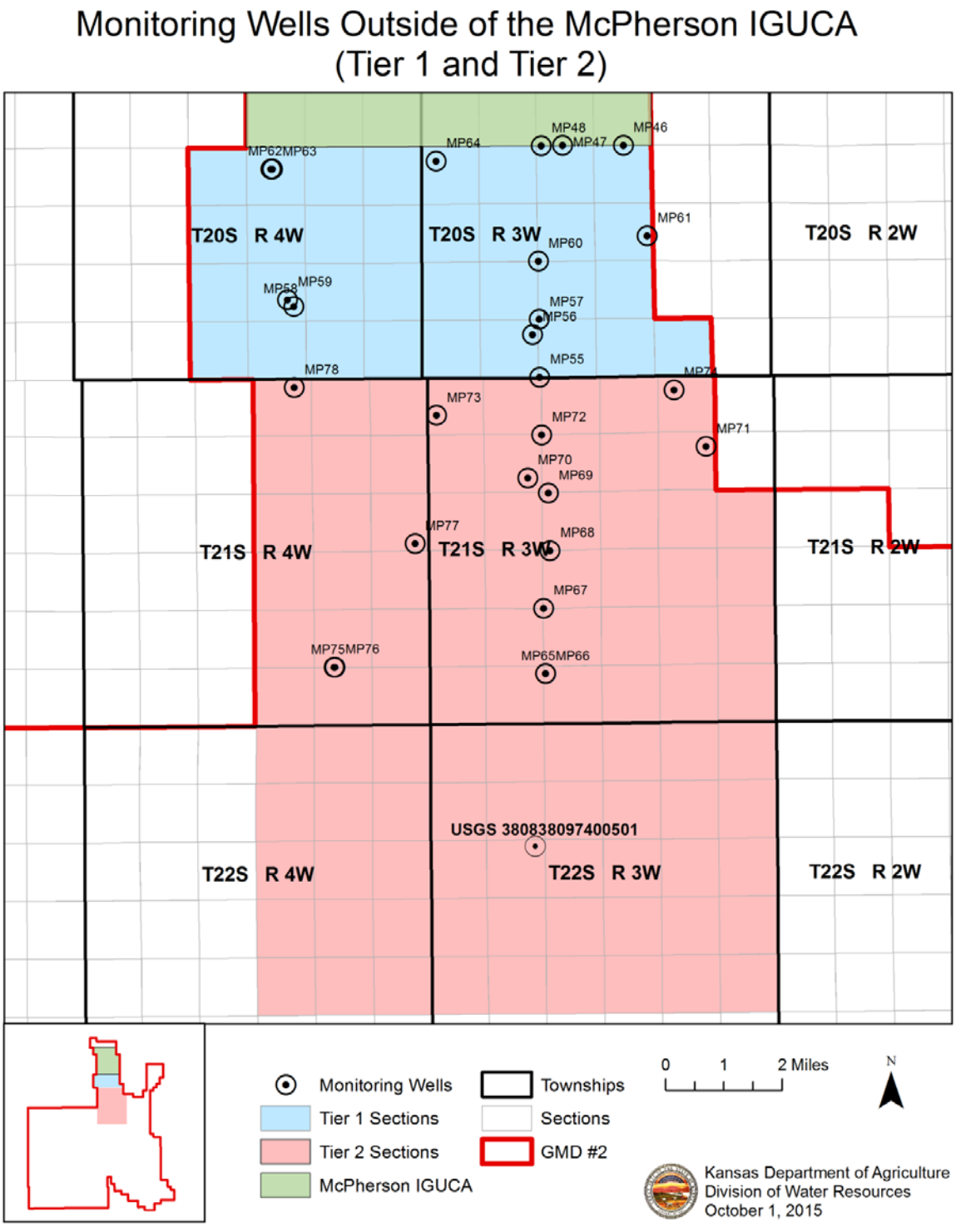

Figure 7: Monitoring Wells outside the McPherson IGUCA

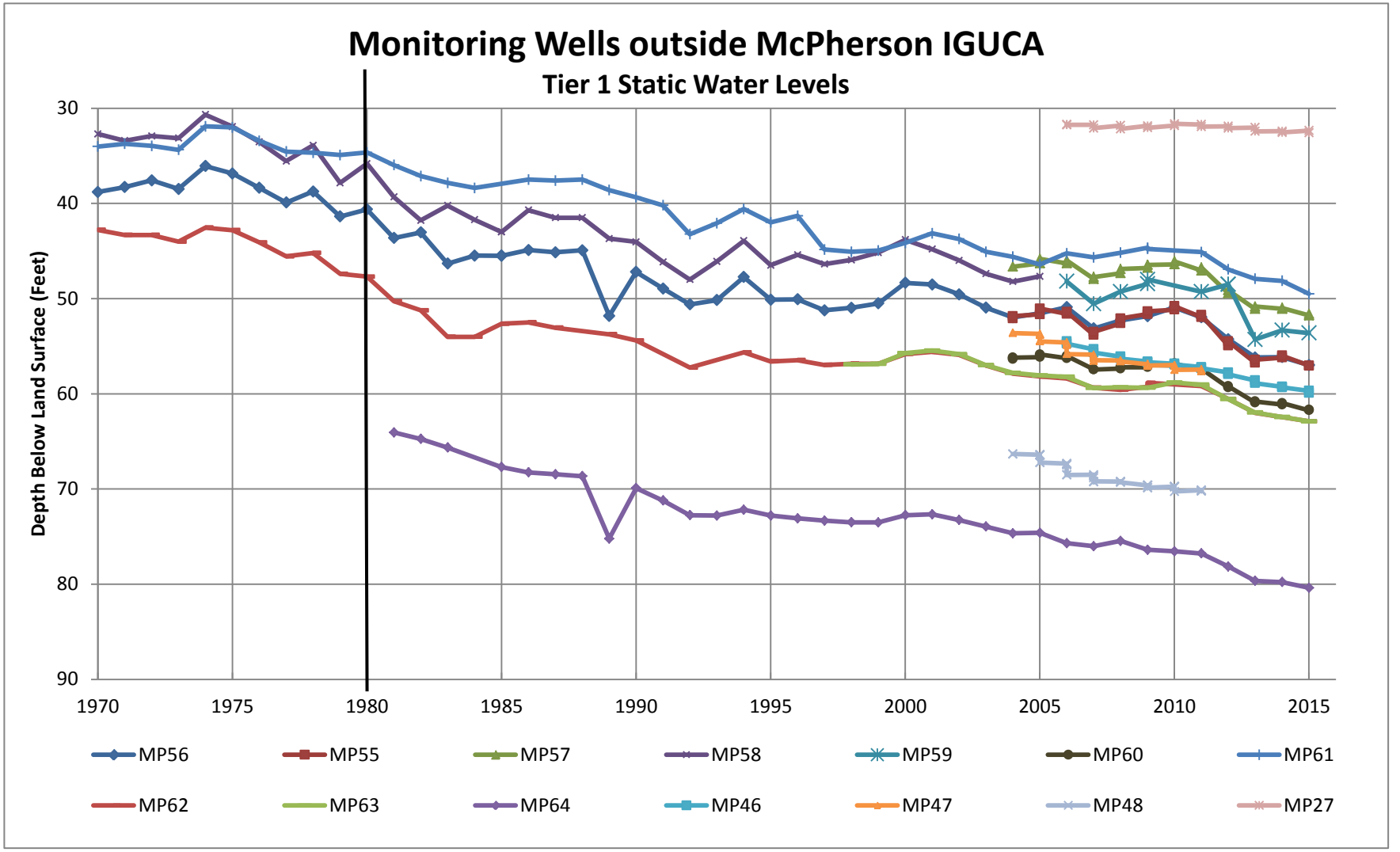

Figure 8: Measurements for Monitoring Wells outside the McPherson IGUCA, Tier

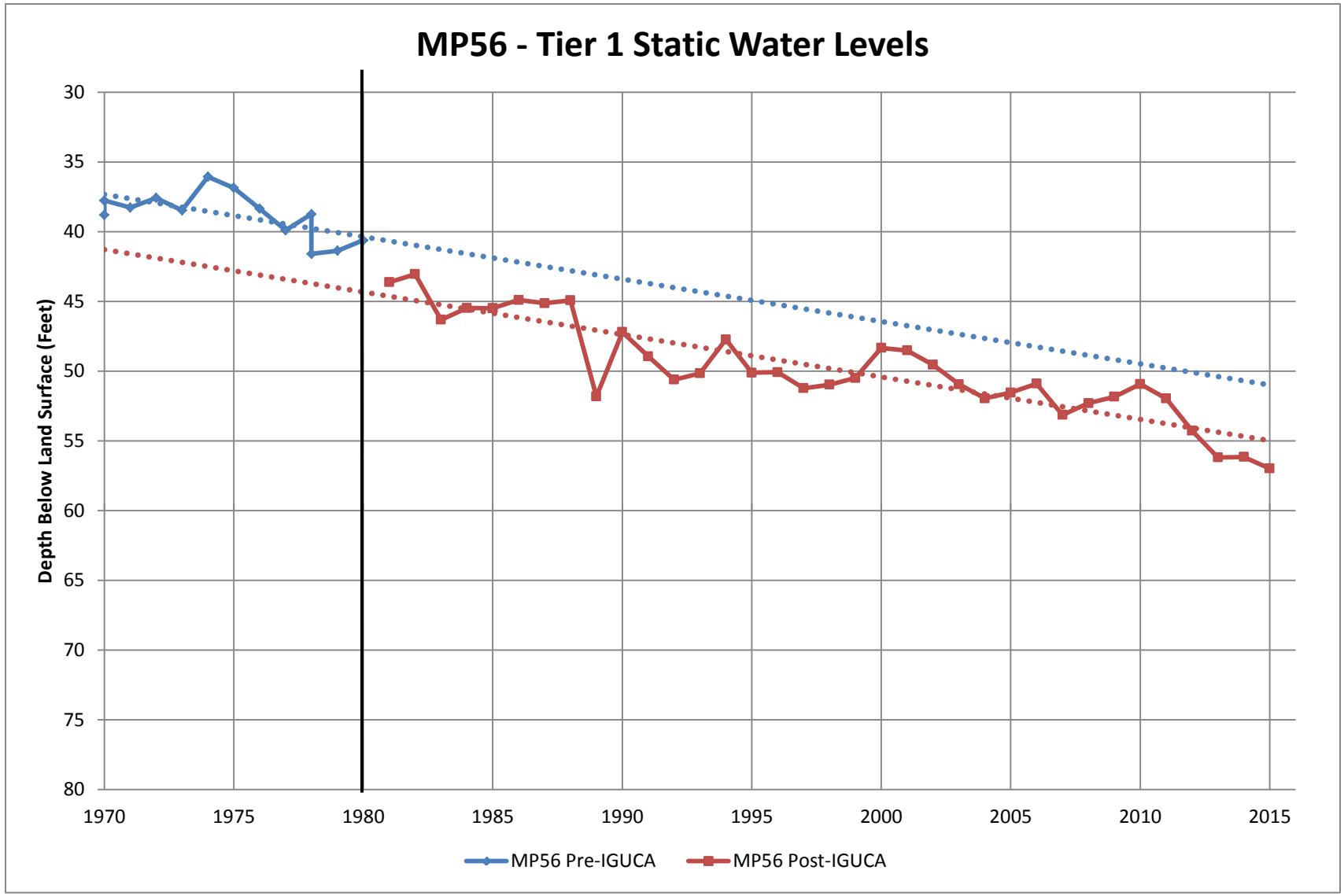

Figure 9: MP56 - Tier 1

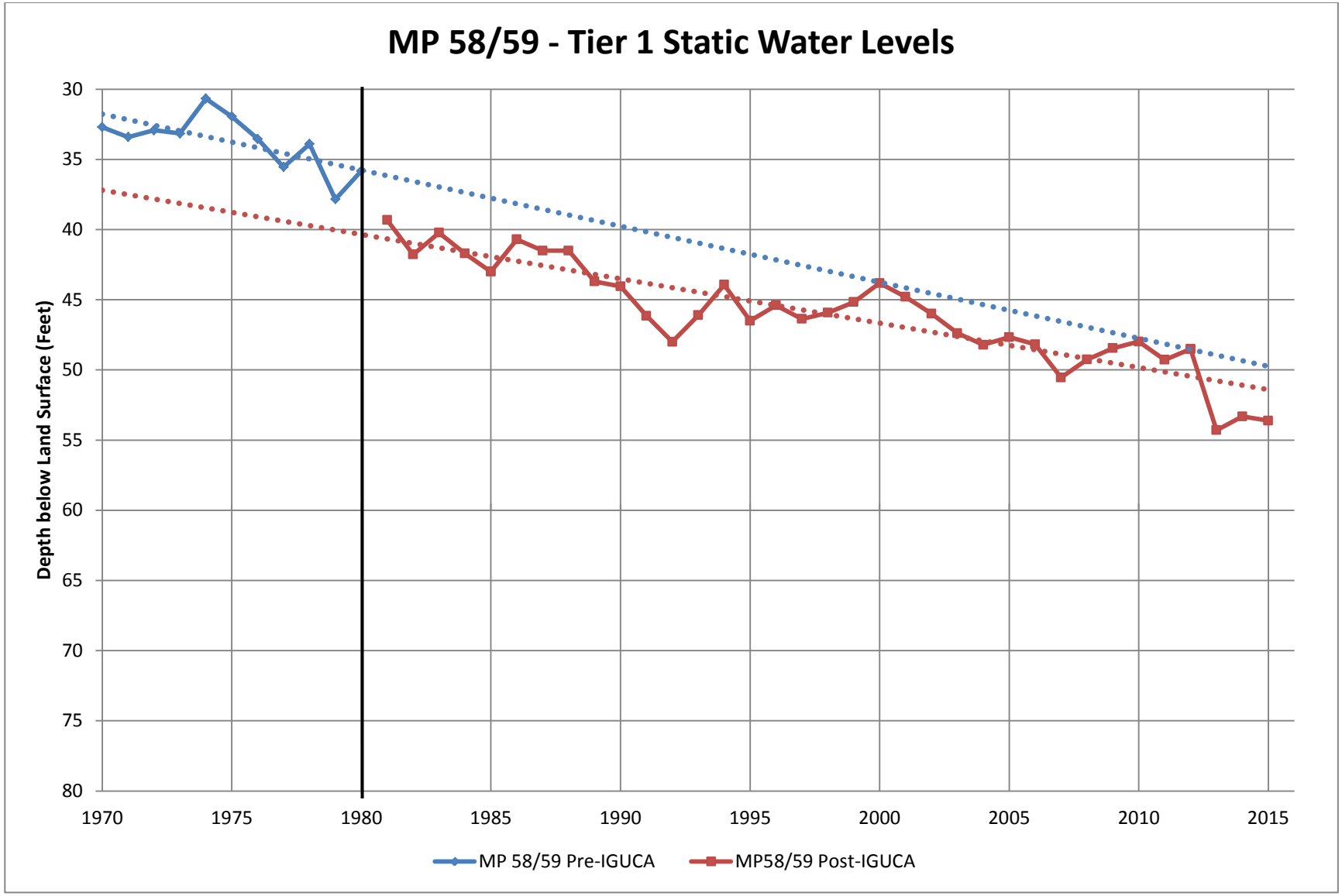

Figure 10: MP58/59 - Tier 1

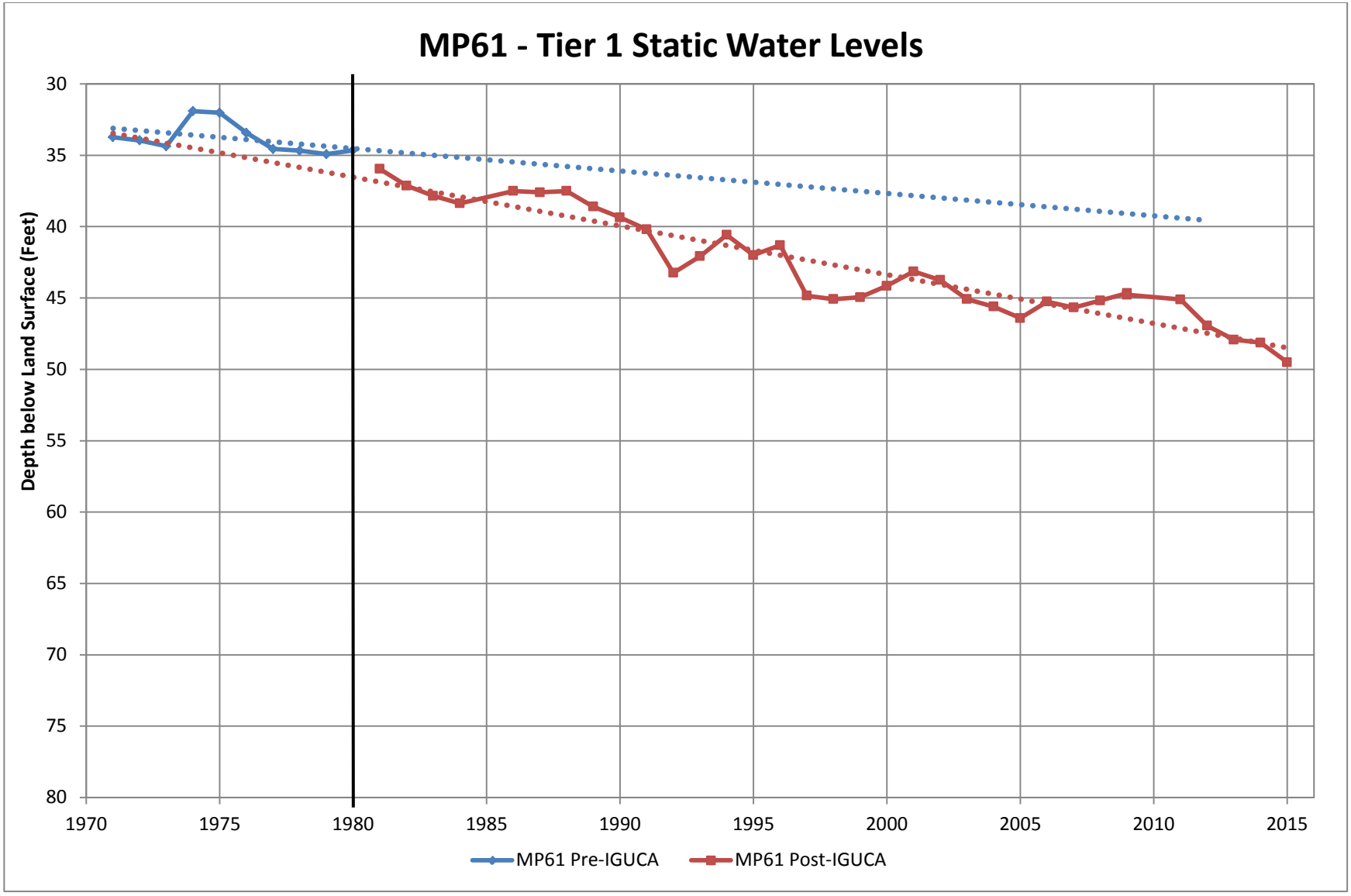

Figure 11: MP61 - Tier 1

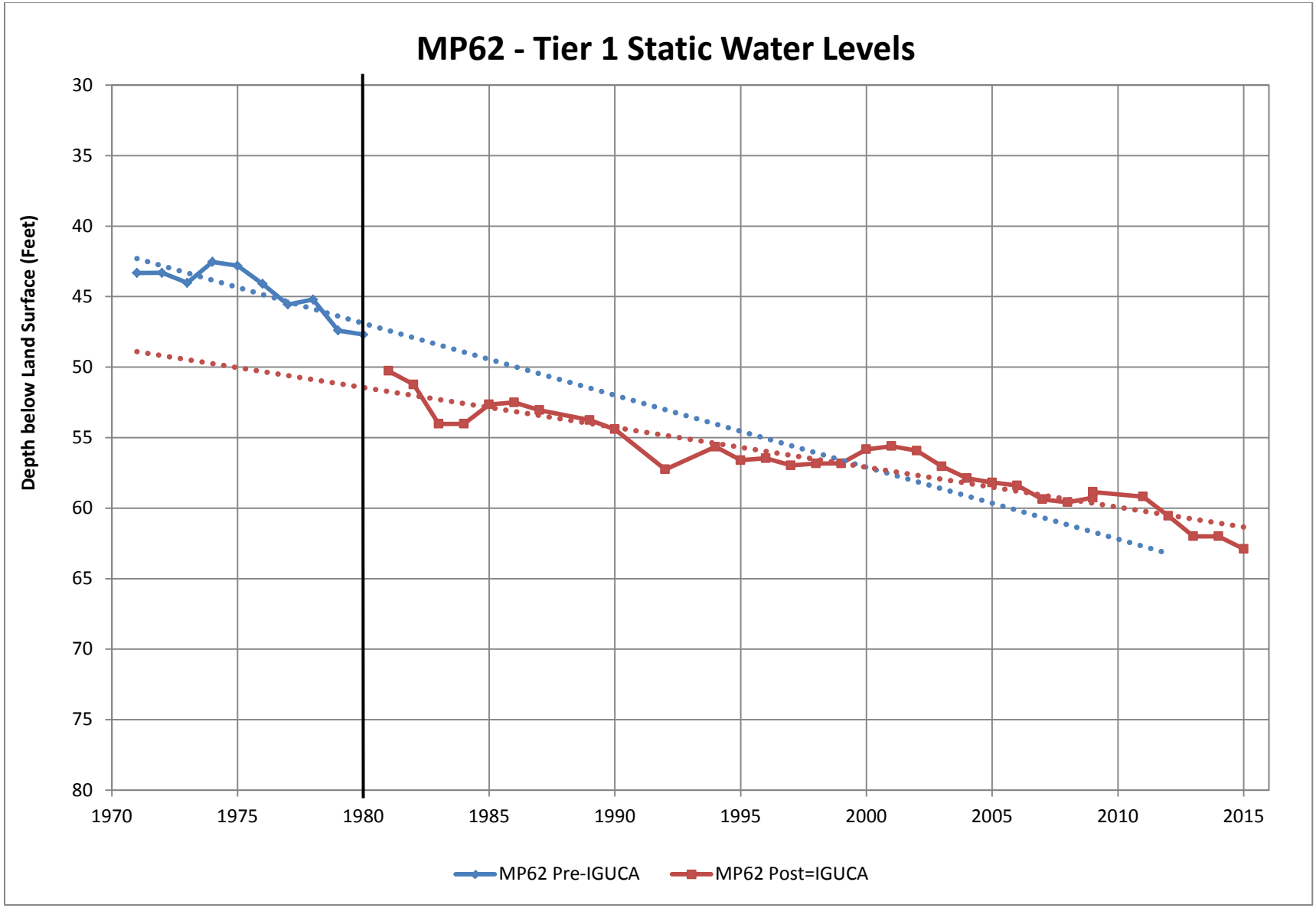

Figure 12: MP62 - Tier

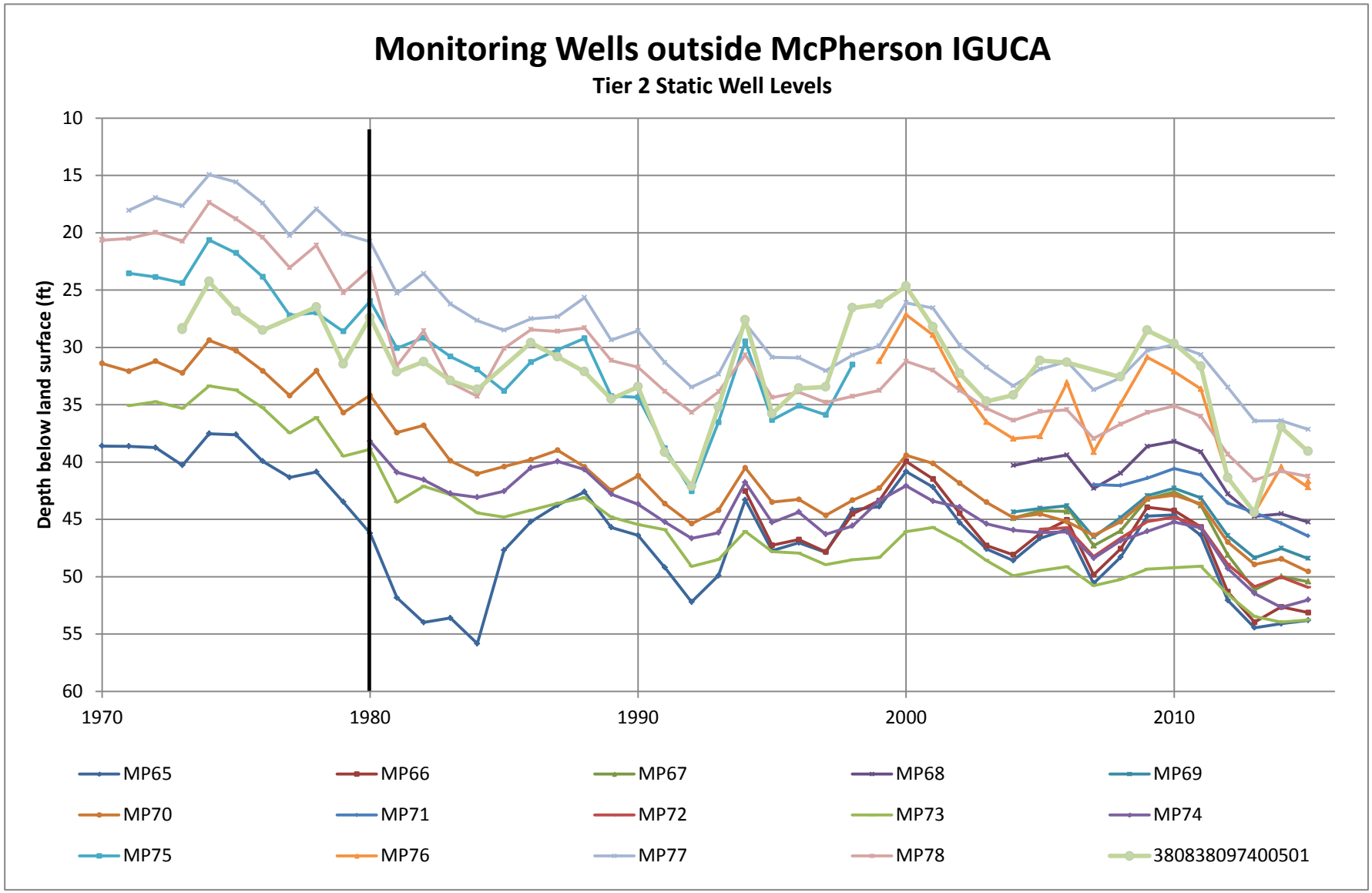

Figure 13: Measurements for Monitoring Wells outside McPherson IGUCA, Tier 2

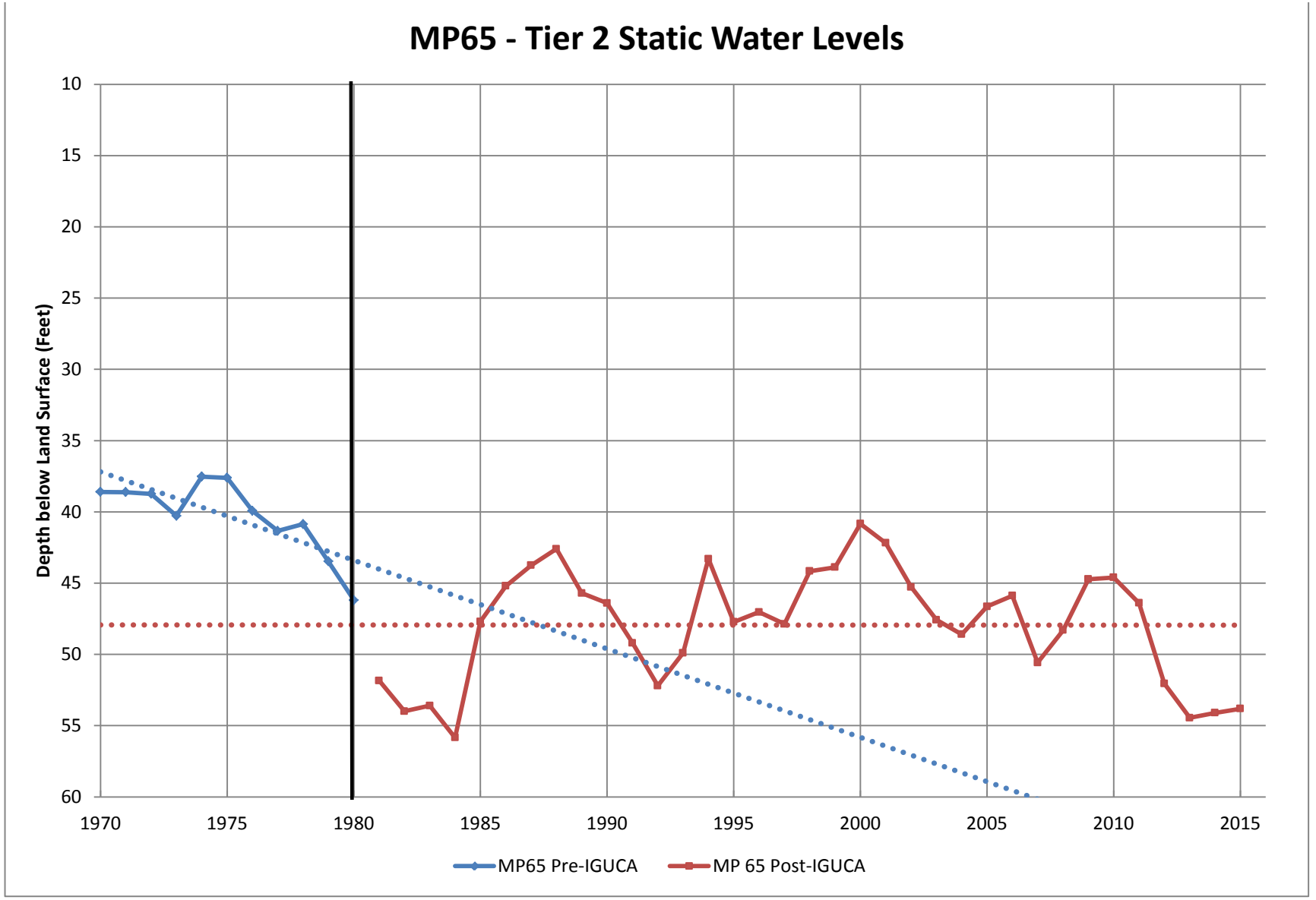

Figure 14: MP65 - Tier 2

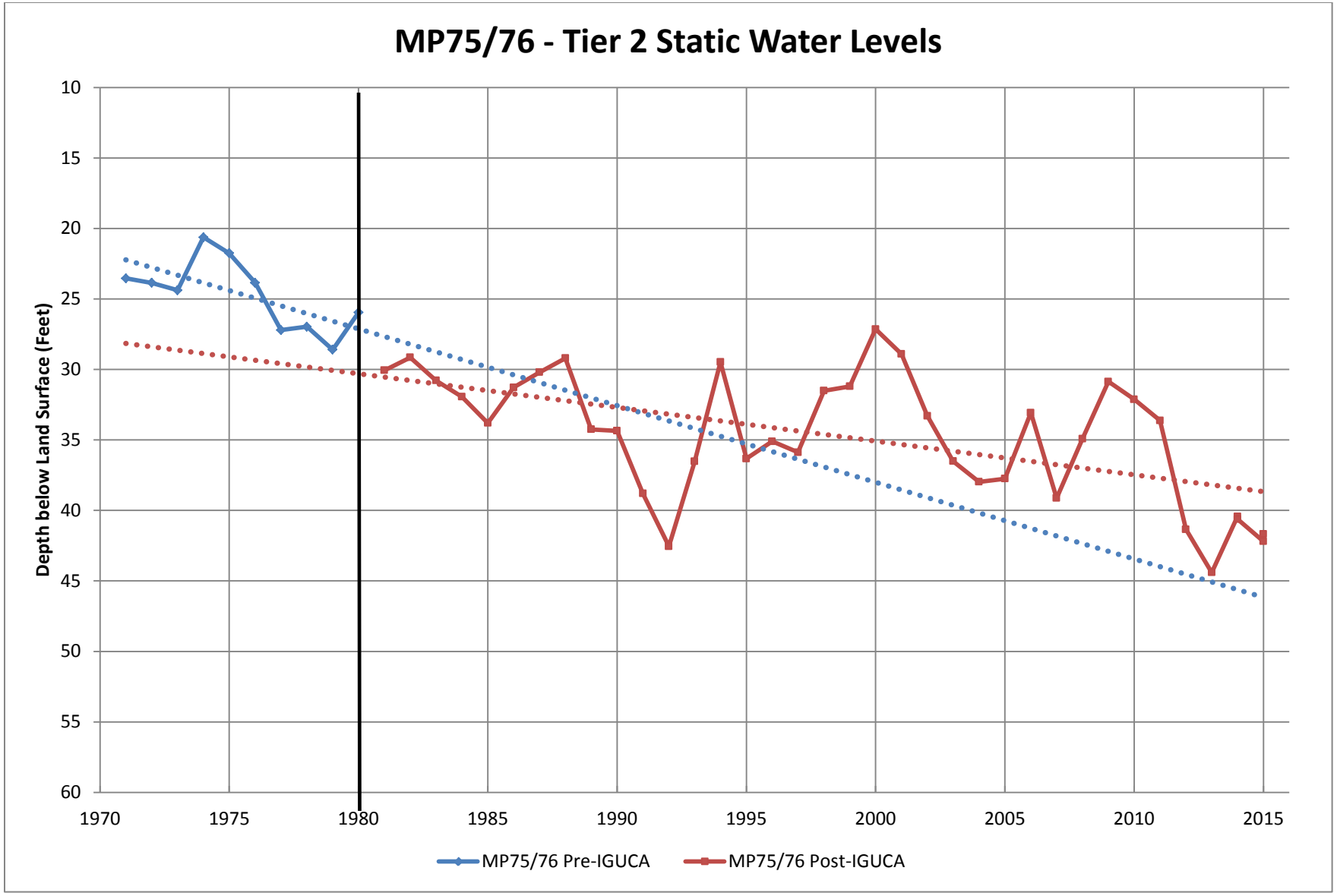

Figure 15: MP75/76 - Tier 2

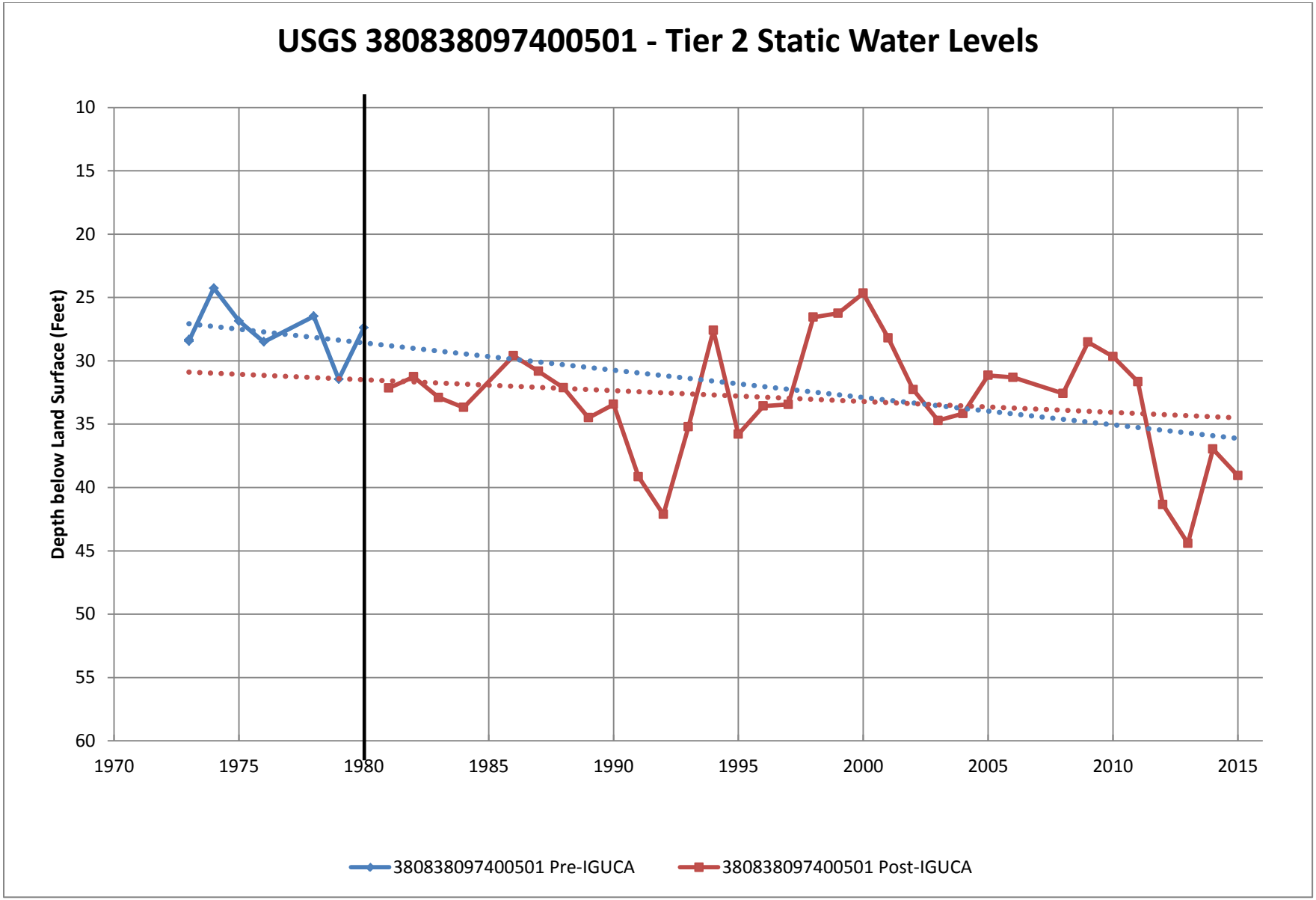

Figure 16: USGS 380838097400501 - Tier 2

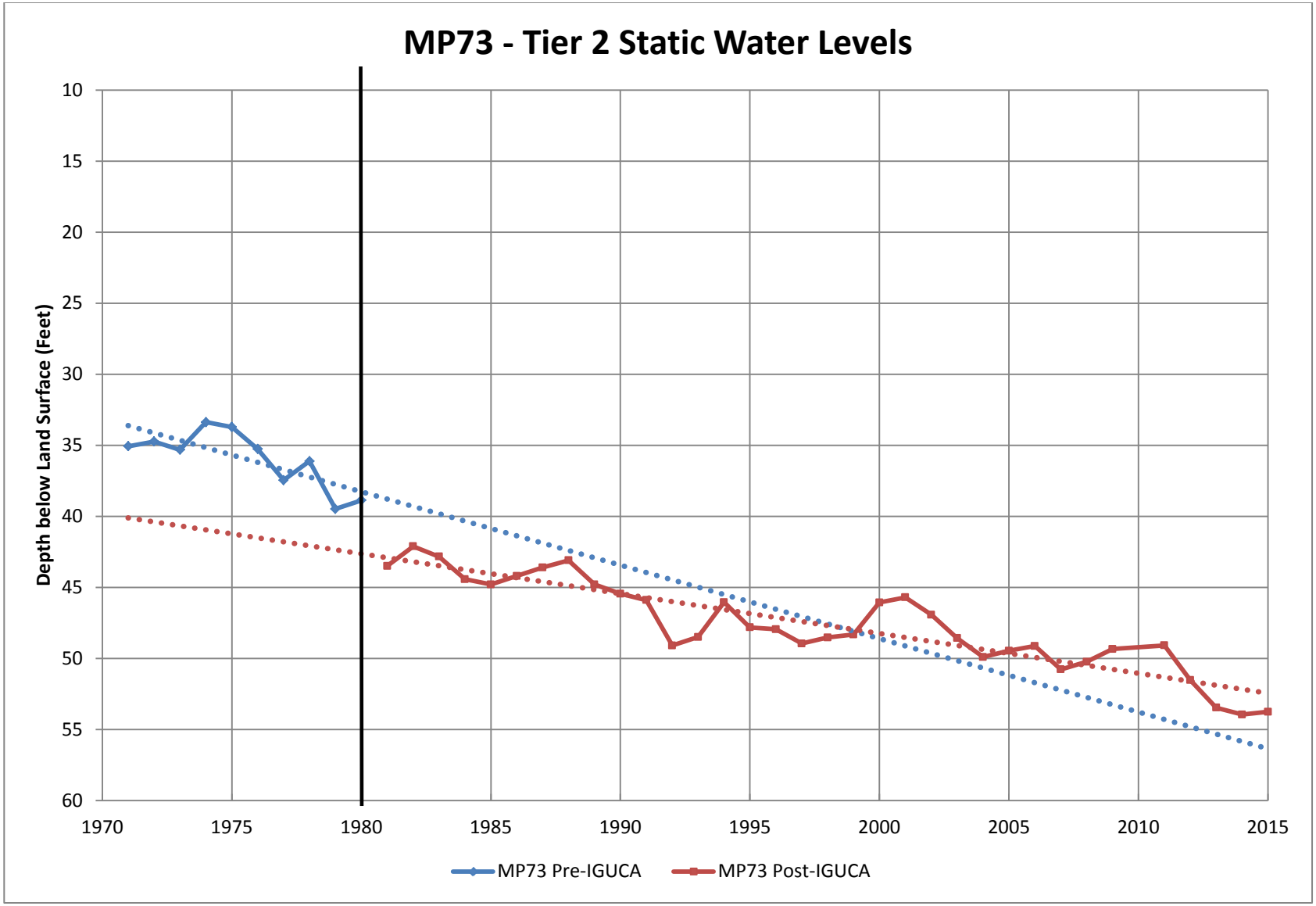

Figure 17: MP73 - Tier 2

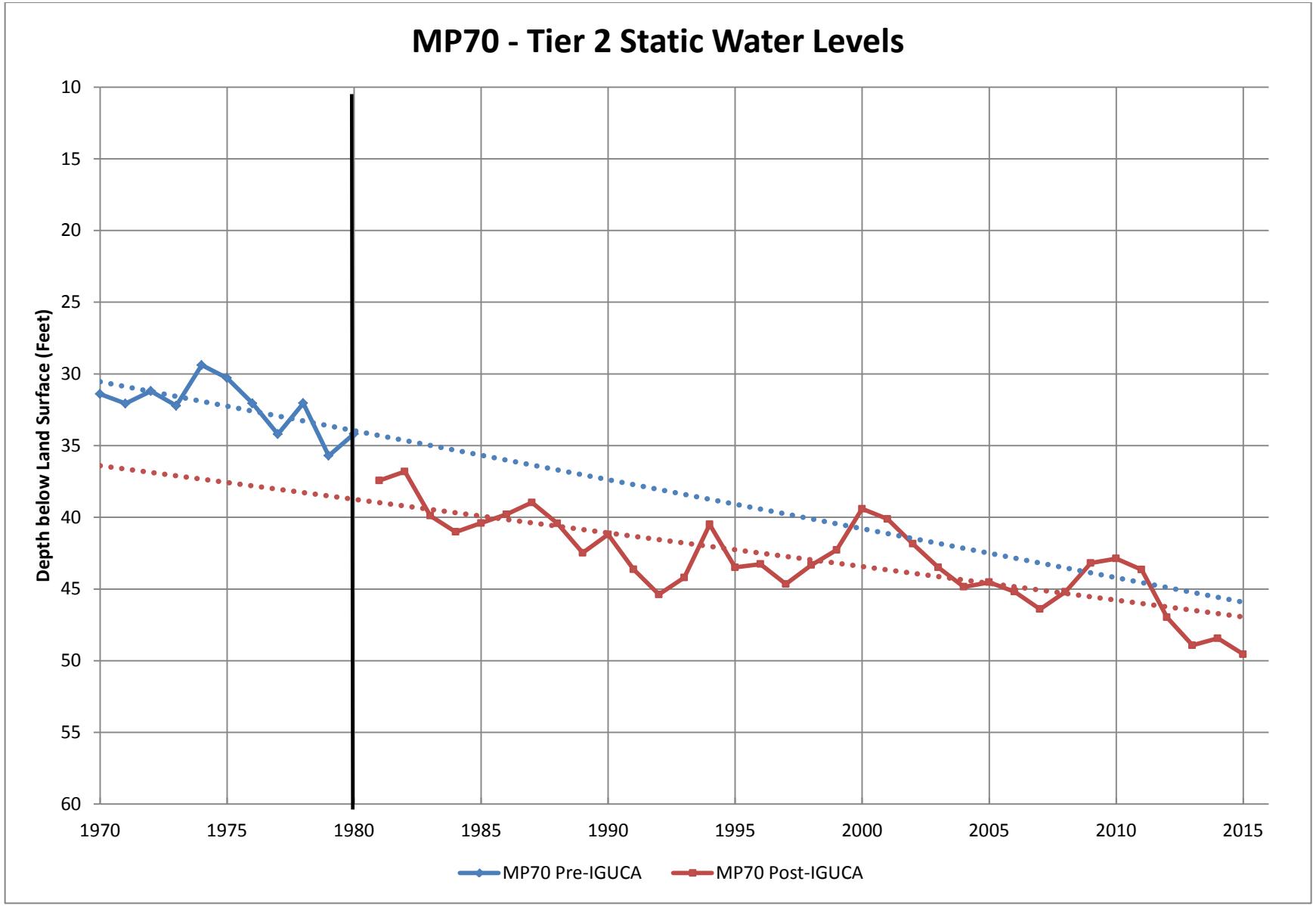

Figure 18: MP70 - Tier 2

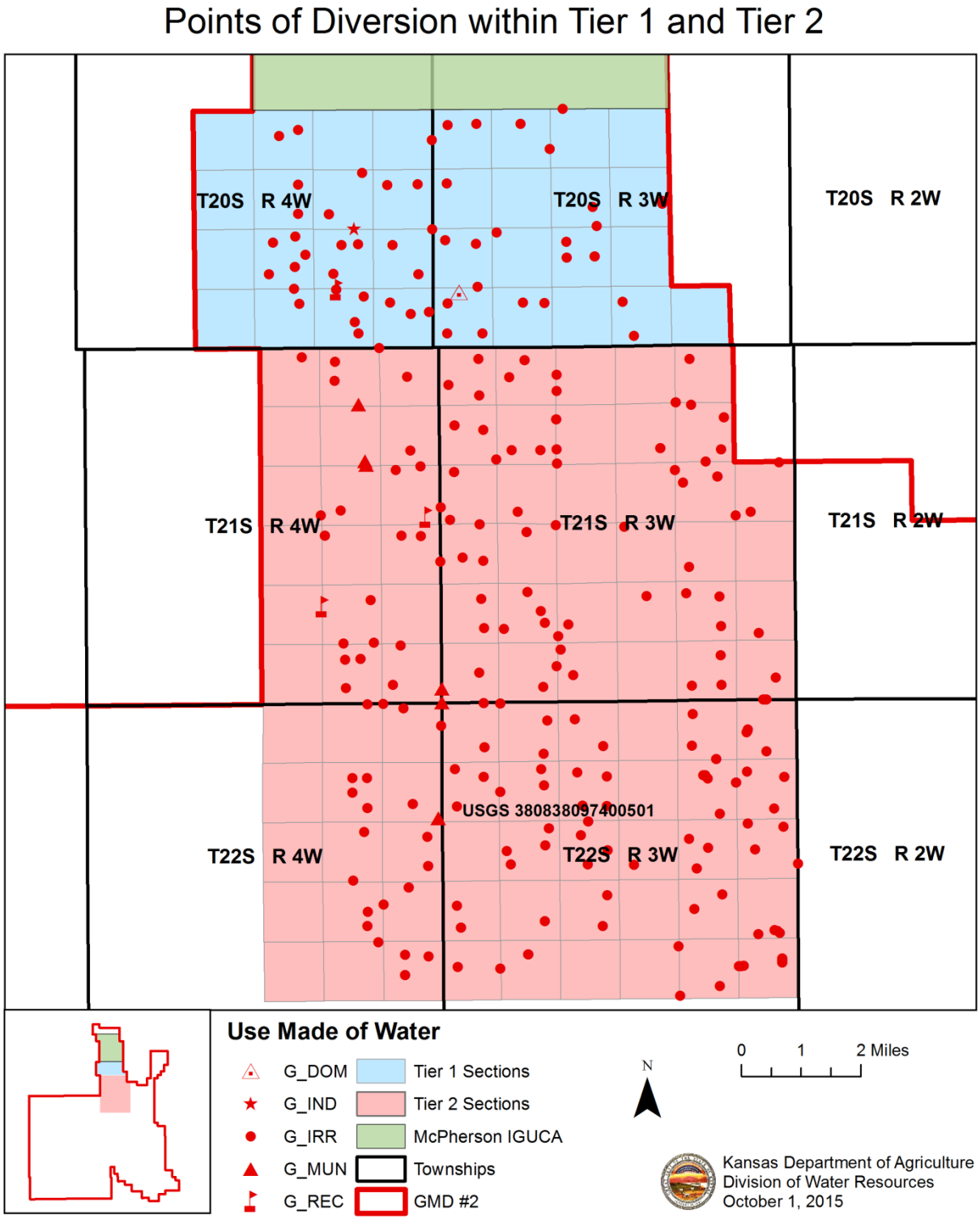

Figure 19: Groundwater Right Development in Tier 1 and Tier 2

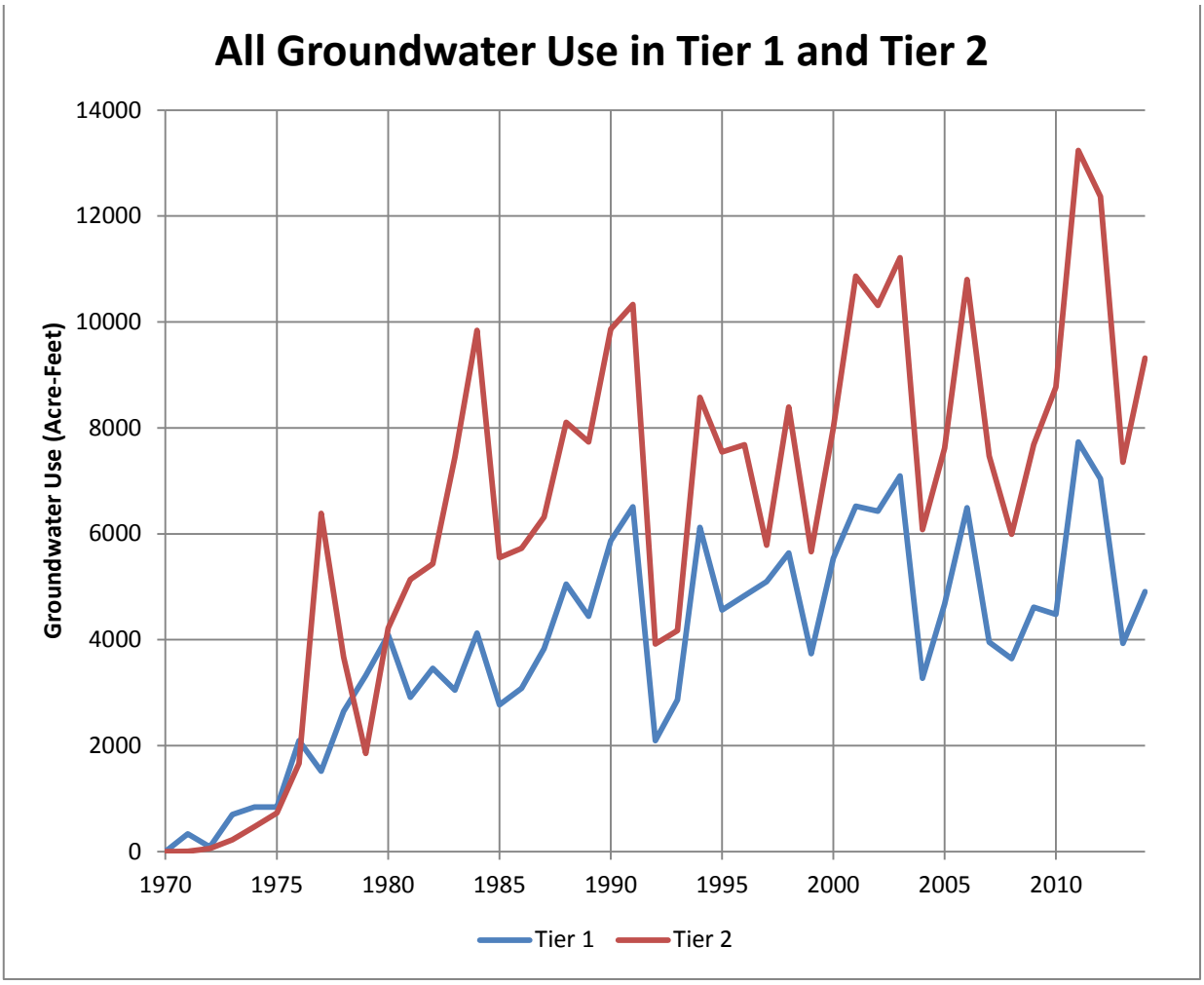

Figure 20: Groundwater Use Tier 1 and Tier 2 for All Points of Diversion

Based on the declining water levels in Tier 1 and Tier 2 and the continued increase in water use (Figure 32 and 33) the review team suggests expanding the McPherson IGUCA to include all or parts of Tier 1 and Tier 2.

VI. References

McElwee, C.D., McClain, T., and Butt, M. (1979). "A Model Study of the McPherson Moratorium Area in Groundwater Management District #2." Kansas Geological Survey.

Whittemore, D.O. (2004). "Geochemical Identification of Sources of Salinity in Ground Waters of the High Plains Aquifer South of McPherson, Kansas." Kansas Geological Survey Open-Field Report 2004-62.

Whittemore, D.O. (2007). "Fate and identification of oil-brine contamination in different hydrogeologic settings." Applied Geochemistry 22, 2099-2114.

VII. Appendix

A. Groundwater Levels

Location of monitoring wells within the McPherson IGUCA (NAD 1983).

Well ID	USGS ID	Latitude	Longitude	Legal Description
MP11	382526097415501	38.42402	-97.699	19S03W06C01
MP12	382406097395501	38.39998	-97.6665	19S03W16BCB01
MP13	382407097404901	38.40195	-97.6806	19S03W17B01
MP14	382333097420701	38.39281	-97.7033	19S03W18CCC01
MP22	382142097415902	38.35855	-97.6992	19S03W31BDB02
MP24	382143097385501	38.36199	-97.6486	19S03W33AAA01
MP28	382518097430501	38.42049	-97.719	19S04W01CCD01
MP29	382526097444101	38.424	-97.7451	19S04W03D01
MP30	382456097453401	38.4164	-97.7589	19S04W09ADA01
MP32	382413097443601	38.40243	-97.7172	19S04W15AAC01
MP33	382259097432201	38.38038	-97.7172	19S04W24CCA01
MP35	382209097445302	38.36929	-97.7494	19S04W27DBB02
MP36	382140097450201	38.36221	-97.7504	19S04W34BAA01
MP37	382143097442002	38.36102	-97.7396	19S04W35BBB02
MP38	382024097382301	38.33996	-97.6397	20S03W03CAA01
MP39	382024097382302	38.33996	-97.6397	20S03W03CAA02
MP40	382000097382501	38.33338	-97.6403	20S03W03CDD01
MP41	382010097404601	38.33567	-97.6795	20S03W05CDB01
MP42	381934097394201	38.32601	-97.6616	20S03W09CAB01
MP43	381934097394202	38.32604	-97.6616	20S03W09CAB02
MP44	381934097394203	38.32602	-97.6616	20S03W09CAB03
MP45	381933097375101	38.32581	-97.6307	20S03W10ADD01
MP49	382038097430101	38.3441	-97.7171	20S04W01B01
MP51	381920097440801	38.32252	-97.7358	20S04W11C01
MP52	381930097441301	38.326	-97.7364	20S04W11CBA01
MP53	381951097422301	38.32956	-97.7081	20S04W12A01

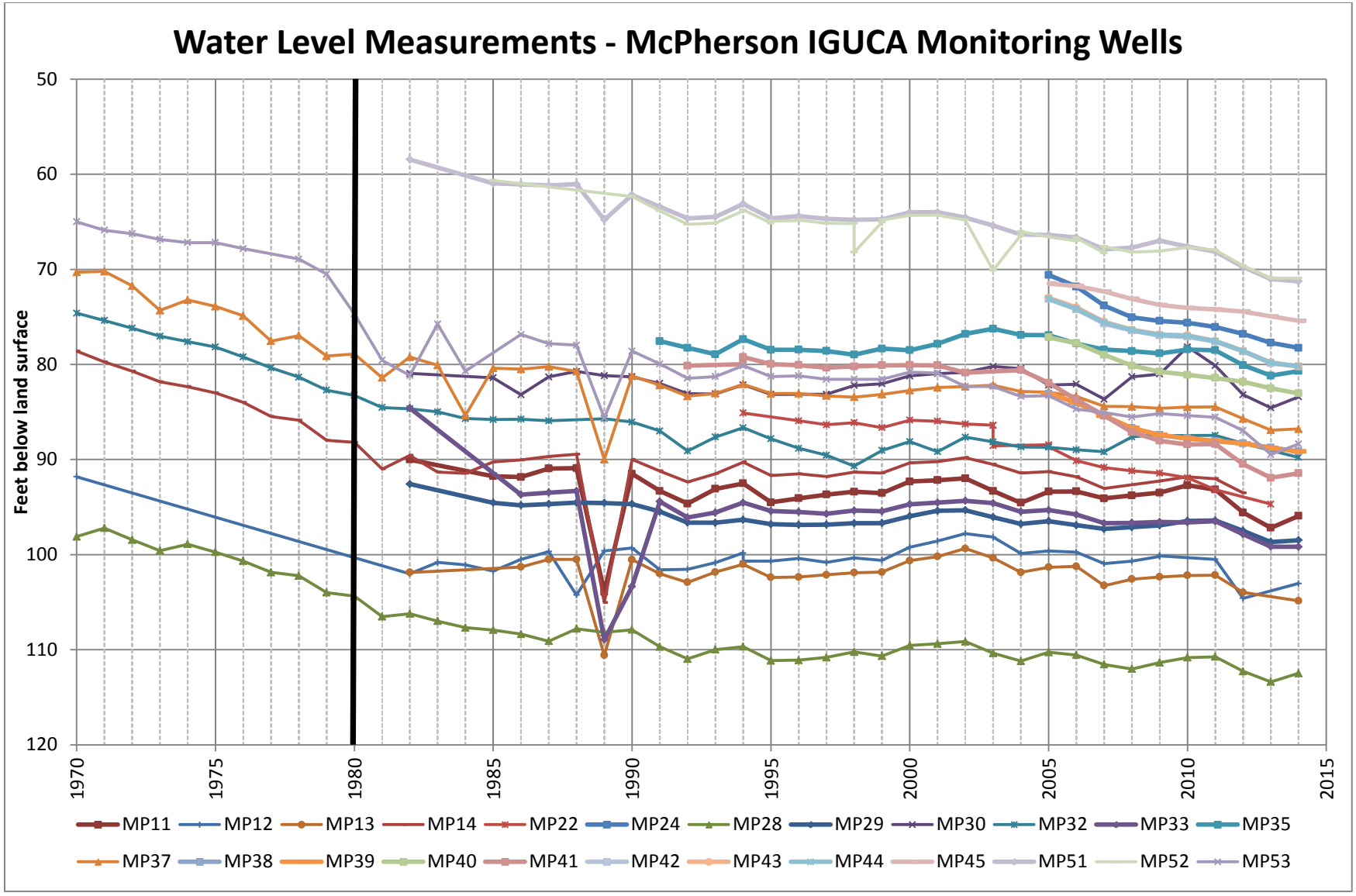

Figure 21: Water Level Measurements for McPherson IGUCA Monitoring Wells

Figure 21 shows that water levels were declining prior to the IGUCA order. The vertical line marks March, 1980, when the McPherson IGUCA Order was enacted. Following the order, water levels continued to decline but for the most part the rate of decline decreased.

The water levels in the northern part of the IGUCA appear to have stabilized more than in the southern half. The southern-most well, MP53 had the largest water level decline since 1980 of the five historical wells. Monitoring wells; MP12, MP13, MP29 and MP33 all lie in the northern half of the IGUCA and while all four wells see fluctuations in their water levels, there is not a defined decline as observed in southern wells, MP22, MP44 and MP51.

Within the IGUCA, five monitoring wells have measurements dating back to at least 1972. The five wells are charted in the following 10 figures and are similar to the Tier 1 and Tier 2 graphs earlier in this report. The first chart maintains the same scale as Figure 21 and the second chart zooms in the scale to better view the measured values and associated trendlines.

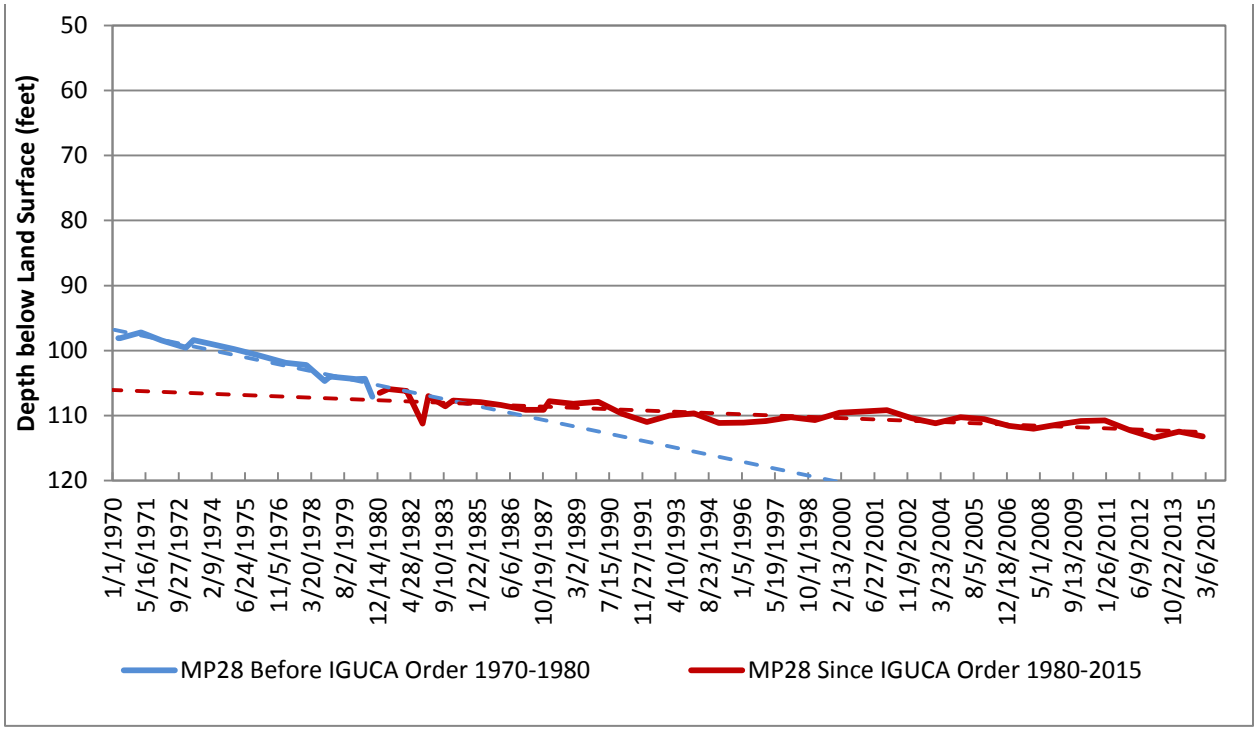

Figure 22: MP28 - IGUCA

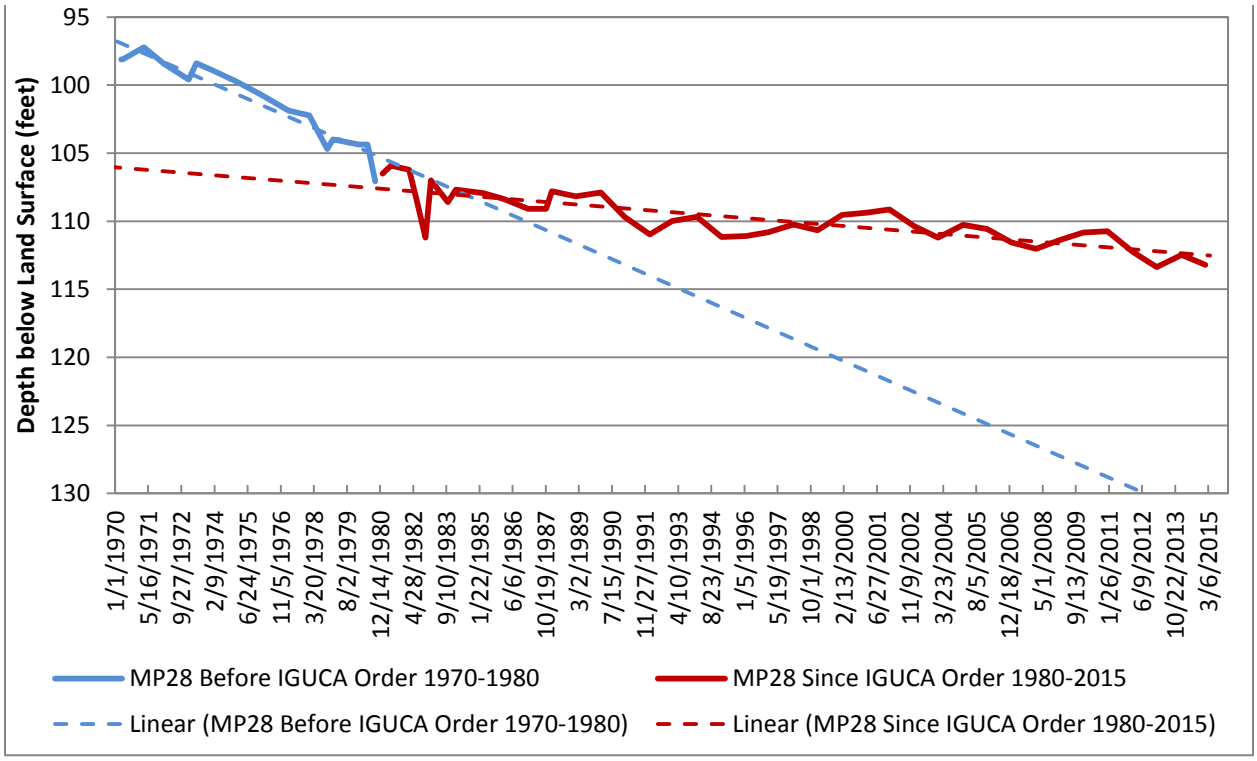

Figure 23: MP28 - IGUCA, Enhanced Scale

MP28 is located in the northern part of the IGUCA. Figure 22 and Figure 23 show that the monitoring well measurements prior to the IGUCA had a much steeper decline than post-IGUCA.

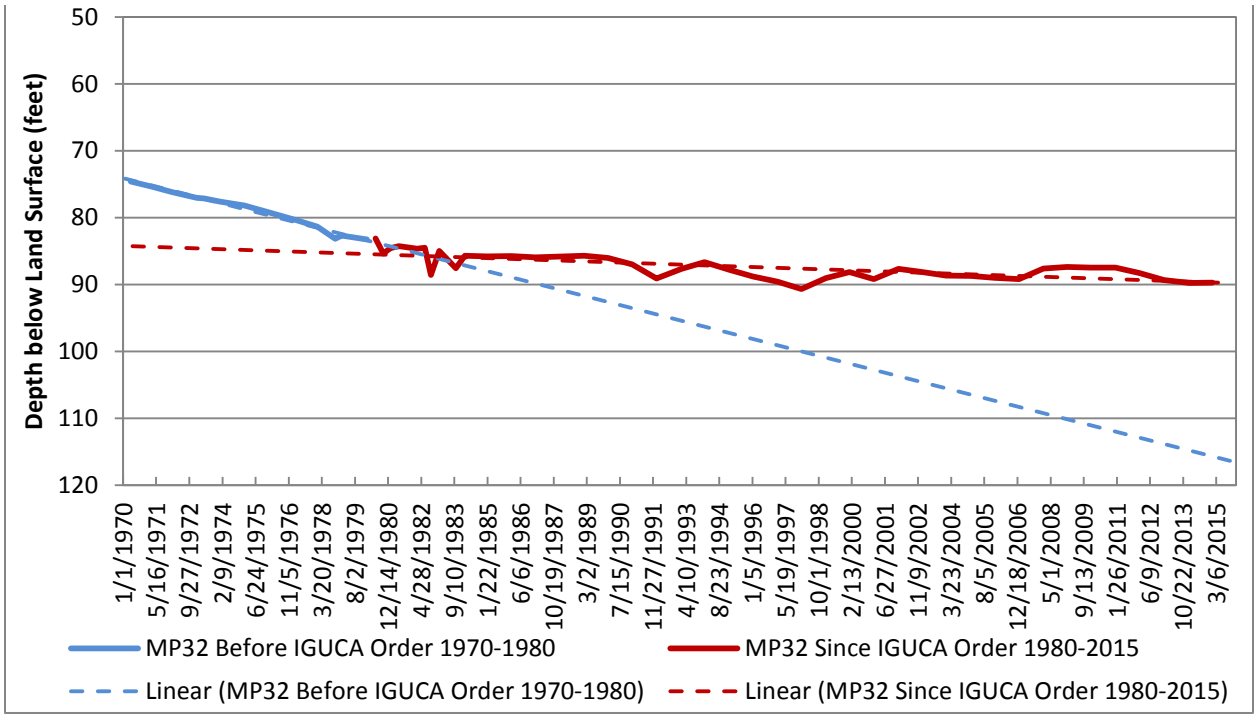

Figure 24: MP32 - IGUCA

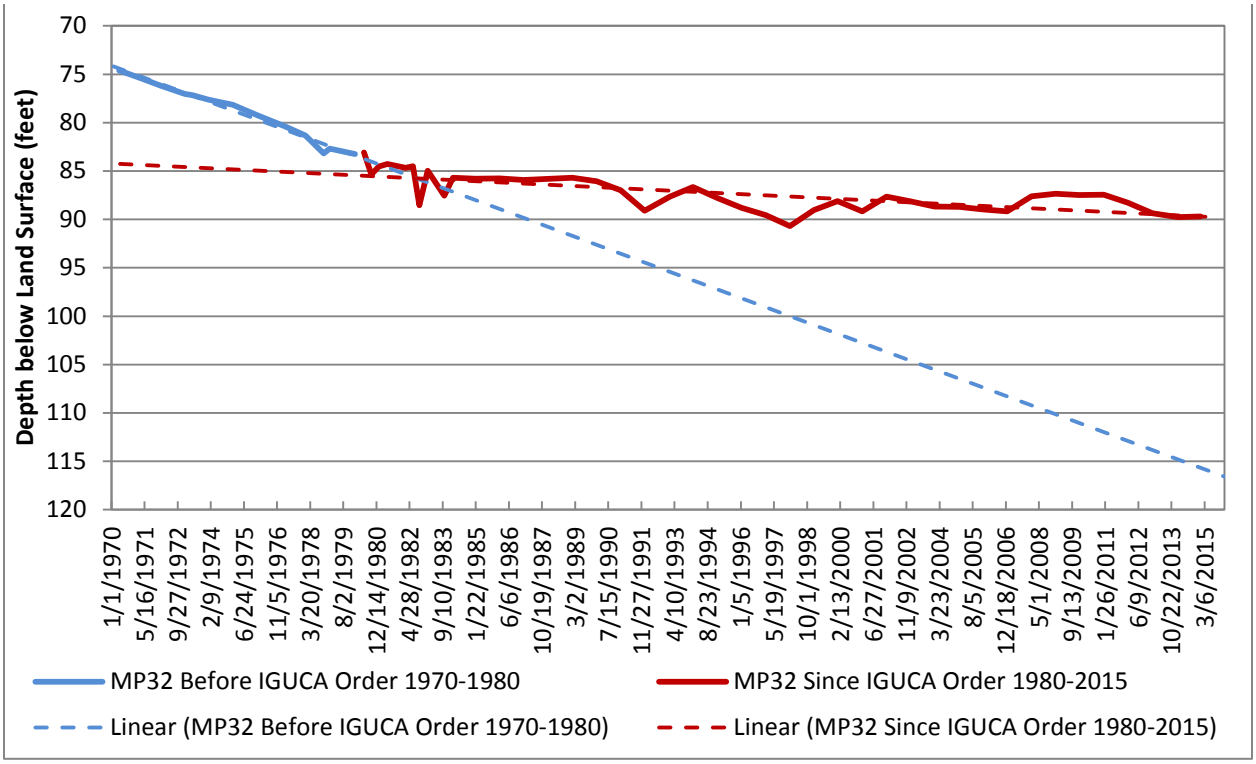

Figure 25: MP32 - IGUCA, Enhanced Scale

MP32 is straight south of MP28 approximately a mile. Figure 24 and Figure 25 show a similar trend for MP32 compared to MP28. MP32 has a smaller rate of decline than MP28 after the IGUCA.

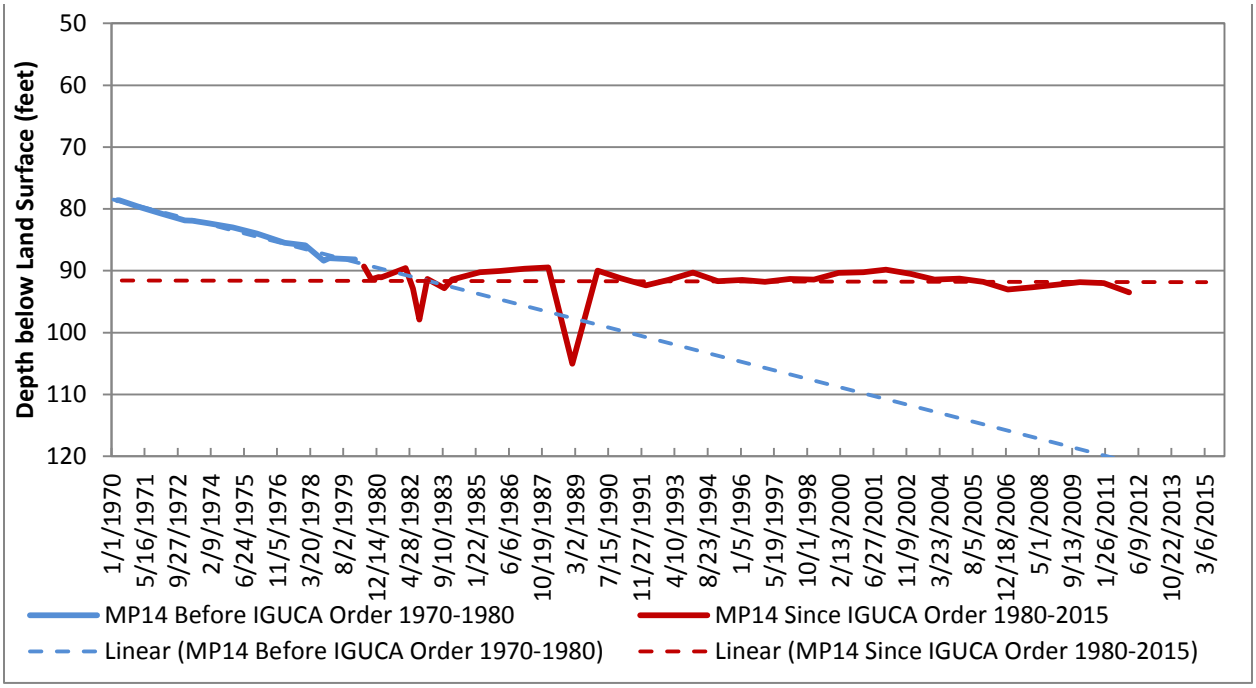

Figure 26: MP14 - IGUCA

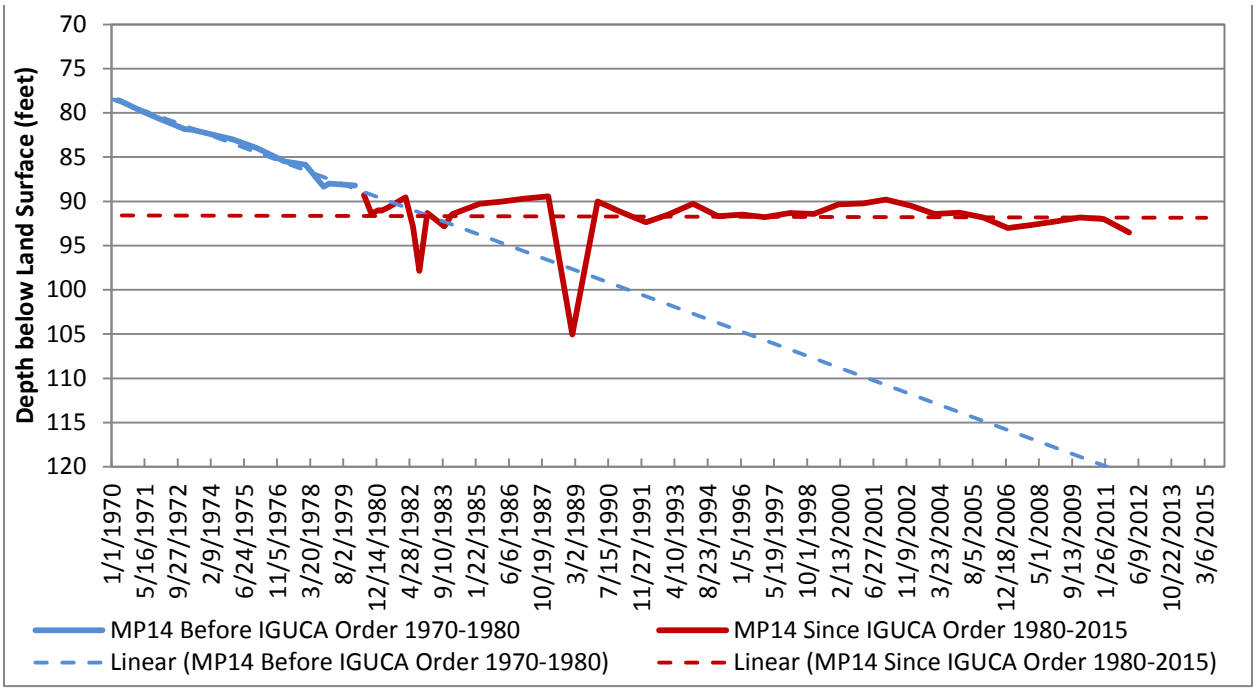

Figure 27: MP14 - IGUCA, Enhanced Scale

MP14 is located just south and east of MP32. Figure 26 and Figure 27 chart the water levels and trendlines for pre and post-IGUCA. The pre-IGUCA trendline has a significant decline, but the post-IGUCA trendline and water levels appear stable.

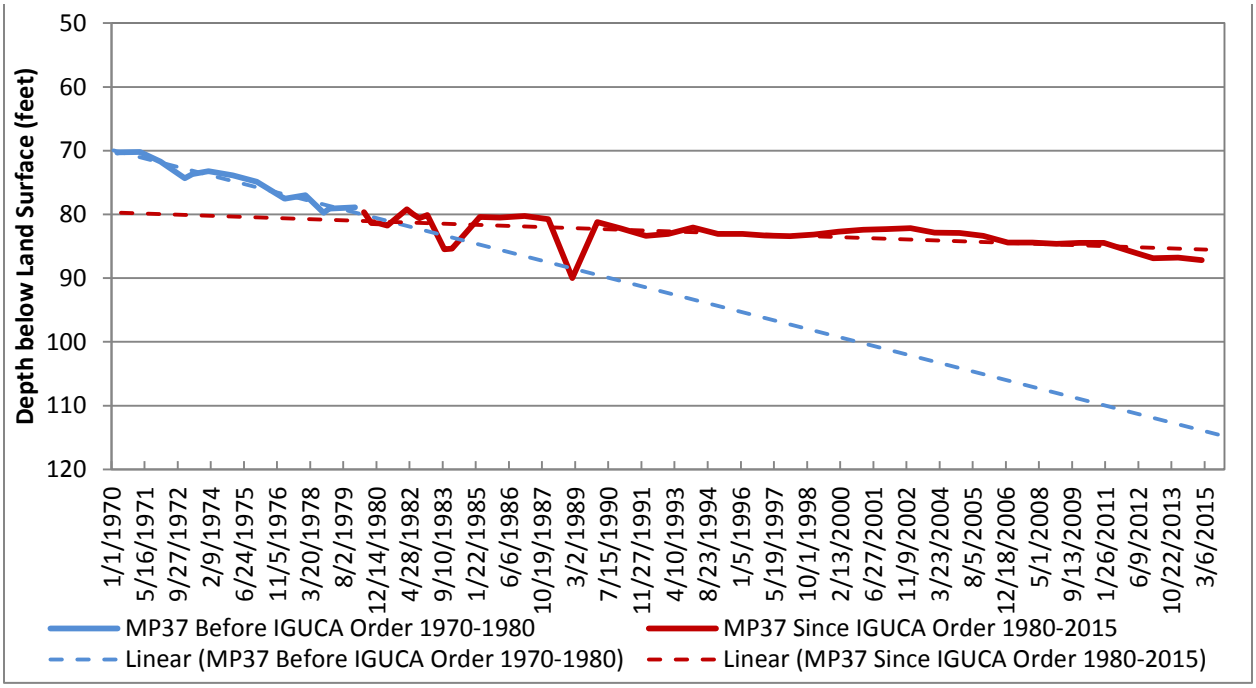

Figure 28: MP37 - IGUCA

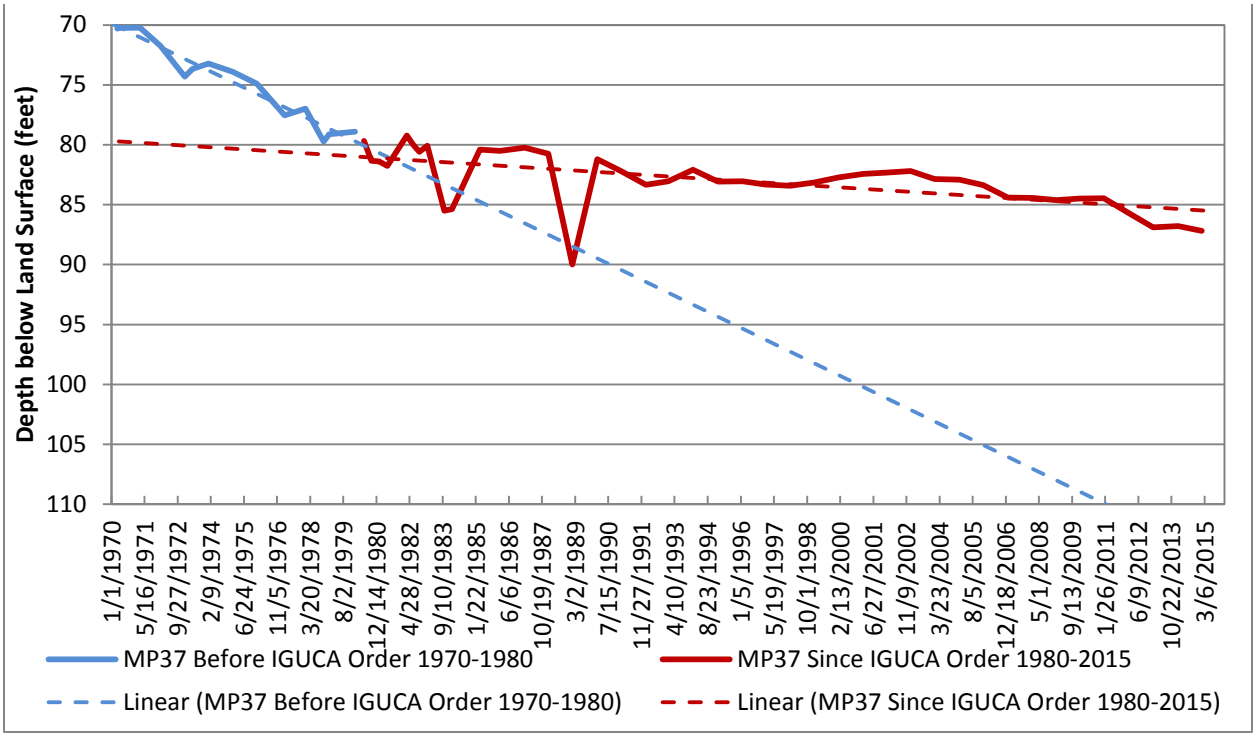

Figure 29: MP37 - IGUCA, Enhanced Scale

MP37 is located in the western half of the IGUCA. Figure 28 and Figure 29 show that the pre-IGUCA and post-IGUCA trendlines have a smaller rate of decline compared to some of the other monitoring wells.

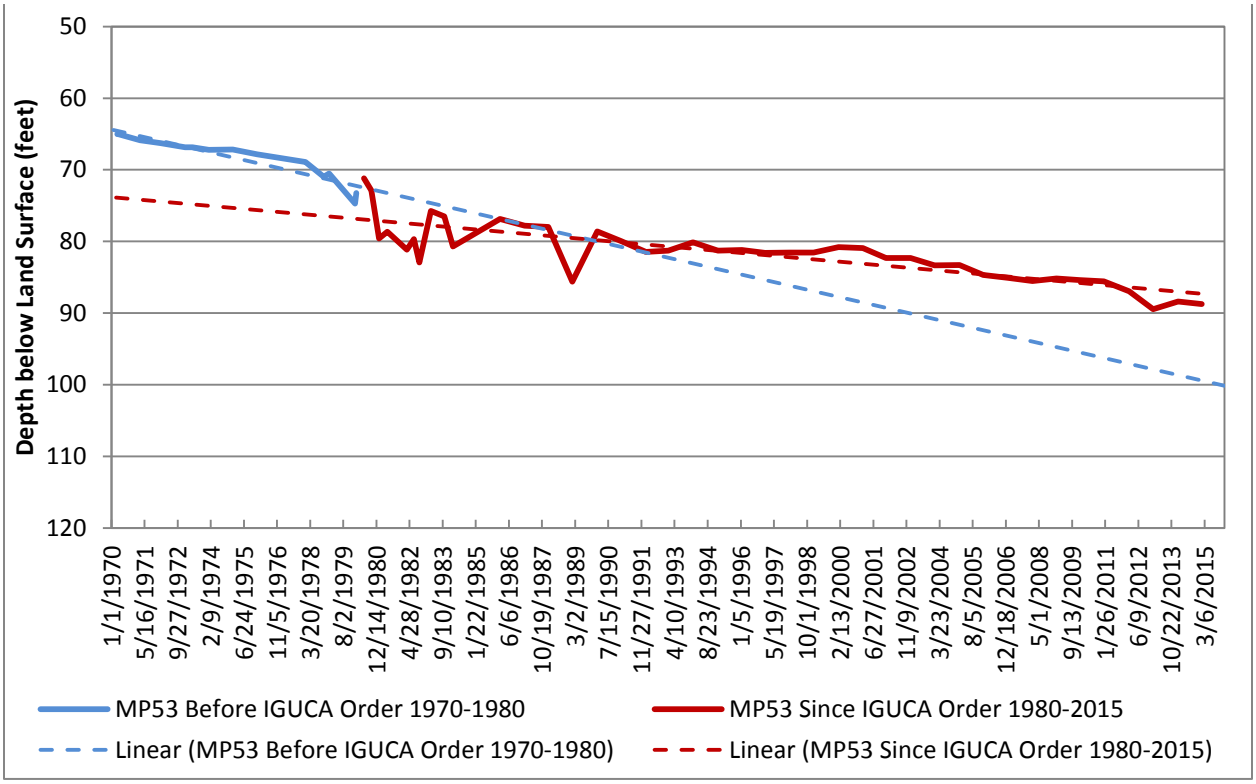

Figure 30: MP53 - IGUCA

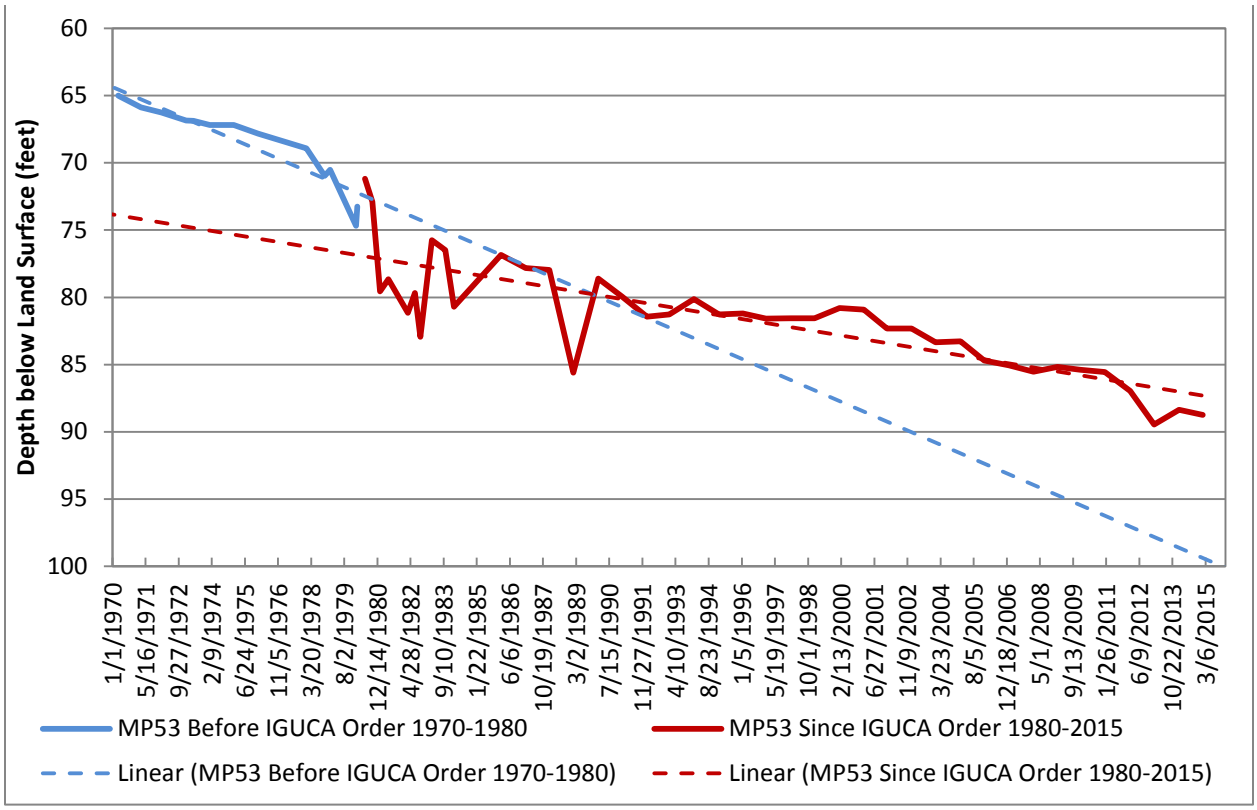

Figure 31: MP53 - IGUCA, Enhanced Scale

Finally, Figure 30 and Figure 311 chart MP53 water levels and trendlines. The two trendlines are the most similar of the five monitoring wells. MP53 is located in the southern portion of the IGUCA close to the boundary.

Location of monitoring wells outside the McPherson IGUCA

Well ID	USGS ID	Latitude	Longitude	Legal Description	Tier
MP27	382053097374701	38.348022	-97.62983	19S03W35CCC01	Outside
MP46	381907097382201	38.318704	-97.63954	20S03W15ABB01	Tier 1
MP47	381908097393201	38.31877	-97.65877	20S03W16BAA01	Tier 1
MP48	381908097395601	38.318771	-97.66555	20S03W16BBA01	Tier 1
MP55	381539097395901	38.260756	-97.66657	20S03W33CCC01	Tier 1
MP56	381609097400301	38.271456	-97.6688	20S03W32ADD01	Tier 1
MP57	381631097395901	38.275285	-97.66658	20S03W28CCC01	Tier 1
MP58	381649097443601	38.278792	-97.74452	20S04W27DAC01	Tier 1
MP59	381649097443602	38.28057	-97.74648	20S04W27DBD01	Tier 1
MP60	381724097400001	38.28987	-97.66676	20S03W21CCC01	Tier 1
MP61	381747097375101	38.296026	-97.6321	20S03W22DAA01	Tier 1
MP62	381847097450101	38.313326	-97.75157	20S04W15BDD01	Tier 1
MP63	381850097450601	38.313277	-97.75109	20S04W15BD 01	Tier 1
MP64	381859097420701	38.315079	-97.69905	20S03W18B 01	Tier 1
MP65	381109097395001	38.186493	-97.66537	21S03W33BBC01	Tier 2
MP66	381114097395101	38.186473	-97.66535	21S03W33BBB02	Tier 2
MP67	381210097395701	38.202899	-97.66584	21S03W21CCC01	Tier 2
MP68	381302097394901	38.217336	-97.66365	21S03W16CCD01	Tier 2
MP69	381354097395101	38.231704	-97.66405	21S03W16BBB02	Tier 2
MP70	381405097400801	38.235542	-97.6706	21S03W08D 01	Tier 2
MP71	381435097365301	38.243136	-97.61389	21S03W11AAC01	Tier 2
MP72	381447097395801	38.246297	-97.66608	21S03W08AAA01	Tier 2
MP73	381504097415701	38.251392	-97.69942	21S03W06CBD01	Tier 2
MP74	381537097373101	38.257311	-97.624	21S03W02BA01	Tier 2
MP75	381122097435901	38.188408	-97.73236	21S04W26CDC02	Tier 2
MP76	381122097435903	38.188432	-97.7321	21S04W26CDC03	Tier 2
MP77	381306097422101	38.219275	-97.70649	21S04W13DDC01	Tier 2
MP78	381530097443401	38.258543	-97.74452	21S04W03AAC01	Tier 2

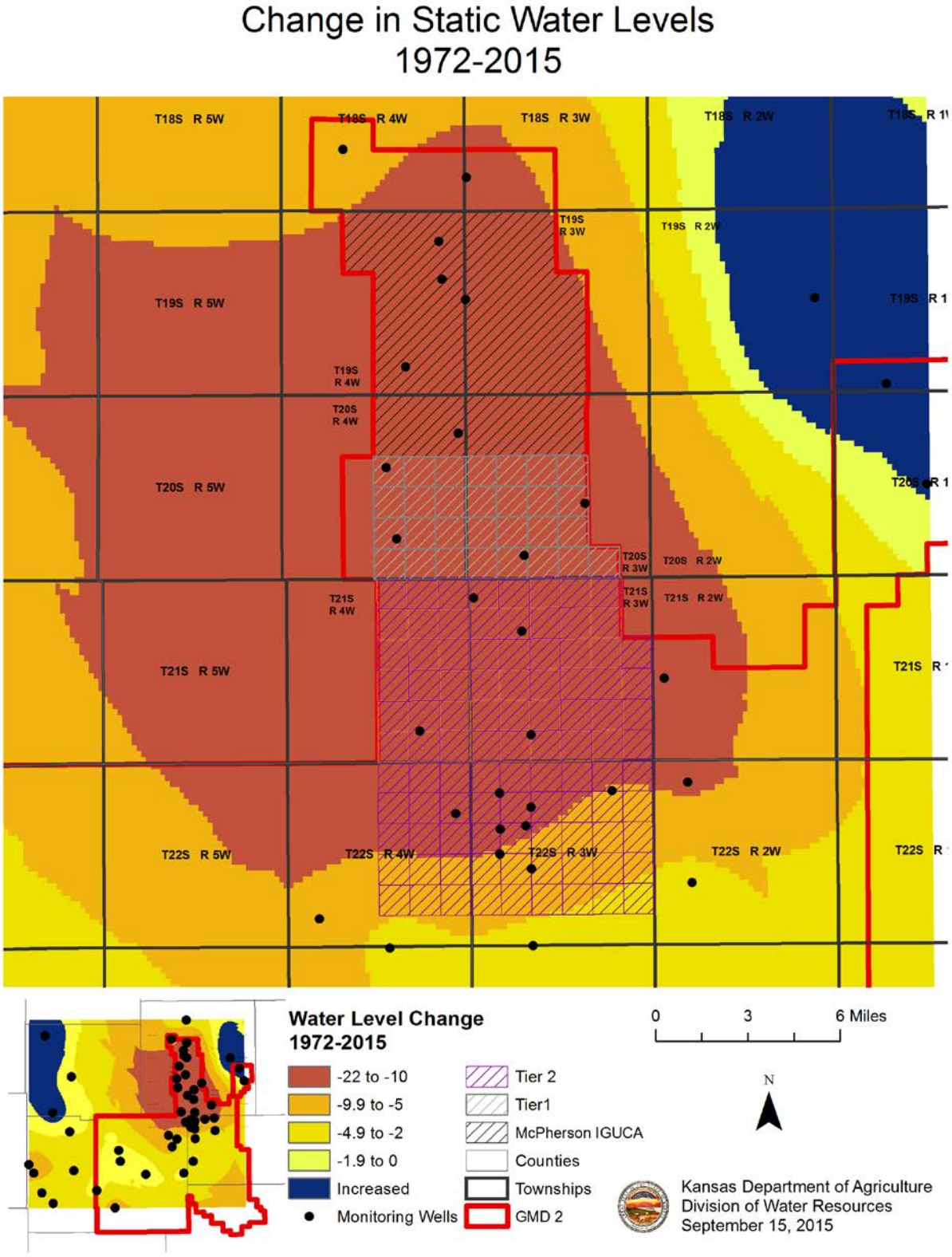

Figure 32: Change in Water Levels 1972-2015

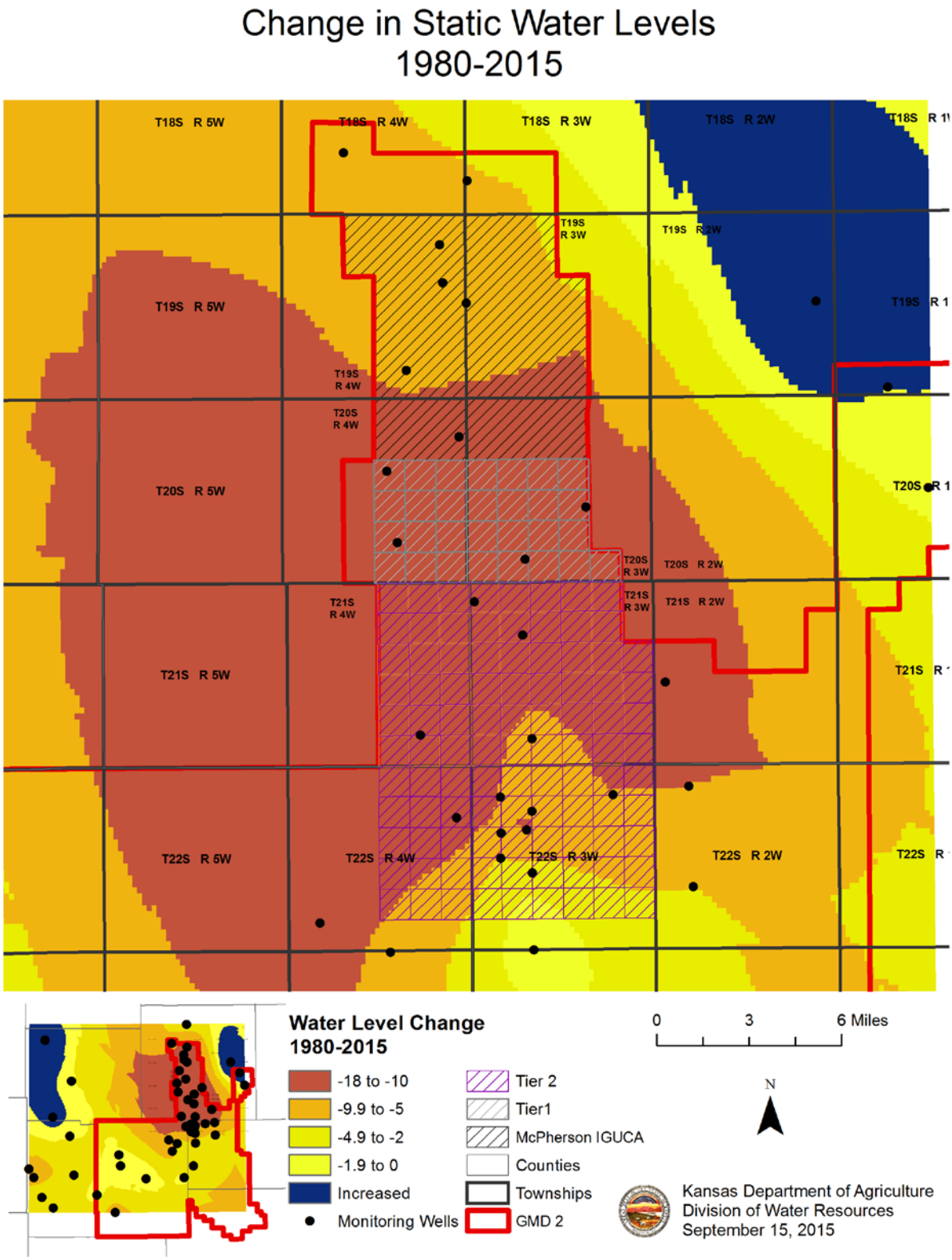

Figure 33: Change in Water Levels 1980-2015

B. Groundwater Use

All groundwater points of diversion annual water use

*Water Use from the GMD #2 Annual Reviews

Year	Contamination Remediation	Domestic	Industrial	Irrigation	Municipal	Recreational	Stock	Total
1974								4,916.00*
1975								11,757.00*
1976								14,661.00*
1977								8,839.00*
1978								14,497.00*
1979								11,868.00*
1980								14,054.00*
1981			4,143.79	3,219.92	2,898.67		0.00	10,262.38
1982			3,391.48	2,477.33	2,900.84		0.00	8,769.65
1983			2,496.65	3,476.47	3,164.91		0.00	9,138.02
1984			3,105.84	6,624.42	3,191.03		0.00	12,921.30
1985			3,008.84	2,601.38	2,815.98		5.00	8,431.20
1986			3,108.22	2,901.15	2,848.52		0.00	8,857.89
1987		0.88	2,869.85	3,983.74	2,939.71		0.00	9,794.18
1988		1.10	3,438.91	4,295.61	3,270.81		12.28	11,018.69
1989		0.82	3,536.25	3,650.70	3,146.47		13.25	10,347.49
1990		1.14	3,270.76	6,746.46	3,421.00		41.89	13,481.25
1991	404.00	1.19	2,971.29	6,487.85	3,251.06		43.70	13,159.09
1992	338.00	1.24	2,937.39	1,466.45	2,690.90		19.78	7,453.76
1993	340.00	0.98	3,547.15	2,409.14	2,723.05		10.00	9,030.32
1994	347.00	1.26	2,971.72	5,737.78	3,585.88		56.00	12,699.64
1995	301.00	1.39	3,011.08	3,566.89	3,162.22		23.00	10,065.59
1996	0.00	1.24	3,940.52	4,050.35	3,278.26		53.00	11,323.37
1997	0.00	0.62	3,960.69	3,575.60	3,123.32	31.00	26.00	10,717.23
1998	40.00	0.84	3,607.81	4,071.66	3,432.13	5.00	26.00	11,183.43
1999	53.00	0.48	3,942.59	3,627.28	3,088.53	43.00	15.00	10,769.87
2000	36.00	0.32	3,658.49	4,081.17	3,554.72	49.00	11.00	11,390.70
2001	0.00	0.76	3,849.96	4,663.11	3,659.53	73.00	0.00	12,246.36
2002	0.00	0.42	4,223.46	5,732.16	3,563.94	21.00	2.00	13,542.98
2003	0.00	0.19	1,219.74	6,569.57	5,113.02	43.00	3.00	12,948.52
2004	1,534.00	0.00	2,119.50	3,486.62	4,200.53	113.00	0.00	11,453.65
2005	2,244.00	0.00	2,401.98	4,397.97	4,329.24	22.38	0.00	13,395.58
2006	1,567.00	0.28	3,251.35	5,773.21	4,541.43	0.00	0.00	15,133.27
2007	136.00	0.06	3,307.58	3,519.88	3,927.19	9.10	0.00	10,899.82
2008	0.00	0.00	3,393.92	3,537.99	3,530.81	13.03	0.05	10,475.80
2009	1,222.00	0.00	3,241.38	4,247.22	3,366.84	49.50	0.00	12,126.94
2010	1,182.00	0.00	3,018.65	4,073.07	3,950.03	33.00	0.00	12,256.75
2011	837.00	0.00	3,706.29	6,368.31	4,389.22	98.97	0.00	15,399.80
2012	798.00	0.00	3,747.31	6,121.32	4,242.22	74.90	0.00	14,983.75
2013	722.00	0.00	3,221.40	2,964.72	3,497.34	53.00	0.00	10,458.46
2014	627.00	0.00	3,236.81	4,213.39	3,430.12	21.00	4.60	11,532.93

Tier 1 and Tier 2 groundwater use

Year	Tier 1	Tier 2
1959	427.04	102.16
1960	0.00	41.10
1961	146.42	48.76
1962	74.39	1.47
1963	0.00	33.83
1964	269.57	37.06
1965	45.67	148.25
1966	518.64	68.87
1967	52.46	27.34
1968	0.00	49.50
1969	410.00	0.00
1970	0.00	0.00
1971	334.18	2.58
1972	90.23	59.42
1973	702.43	221.70
1974	840.70	468.21
1975	839.08	727.20
1976	2,094.56	1,665.15
1977	1,516.95	6,384.87
1978	2,651.13	3,672.12
1979	3,323.20	1,852.45
1980	4,091.39	4,218.73
1981	2,911.78	5,135.66
1982	3,460.02	5,434.89
1983	3,050.83	7,444.90
1984	4,123.54	9,839.88
1985	2,770.67	5,549.98
1986	3,081.88	5,724.63

Year	Tier 1	Tier 2
1987	3,834.24	6,315.94
1988	5,052.48	8,104.21
1989	4,444.06	7,734.97
1990	5,870.20	9,867.72
1991	6,507.88	10,331.33
1992	2,097.20	3,918.42
1993	2,867.47	4,172.13
1994	6,119.94	8,576.32
1995	4,559.93	7,544.50
1996	4,834.49	7,684.26
1997	5,099.47	5,784.70
1998	5,639.64	8,392.26
1999	3,738.19	5,662.57
2000	5,540.78	8,001.82
2001	6,522.01	10,866.17
2002	6,427.28	10,313.67
2003	7,090.39	11,211.86
2004	3,272.26	6,081.58
2005	4,673.17	7,615.52
2006	6,490.73	10,799.61
2007	3,957.91	7,468.33
2008	3,644.68	5,993.49
2009	4,616.85	7,690.23
2010	4,477.86	8,769.47
2011	7,732.77	13,240.23
2012	7,039.79	12,370.10
2013	3,932.30	7,351.95
2014	4,906.18	9,315.67

C. Current Monitoring Wells Site

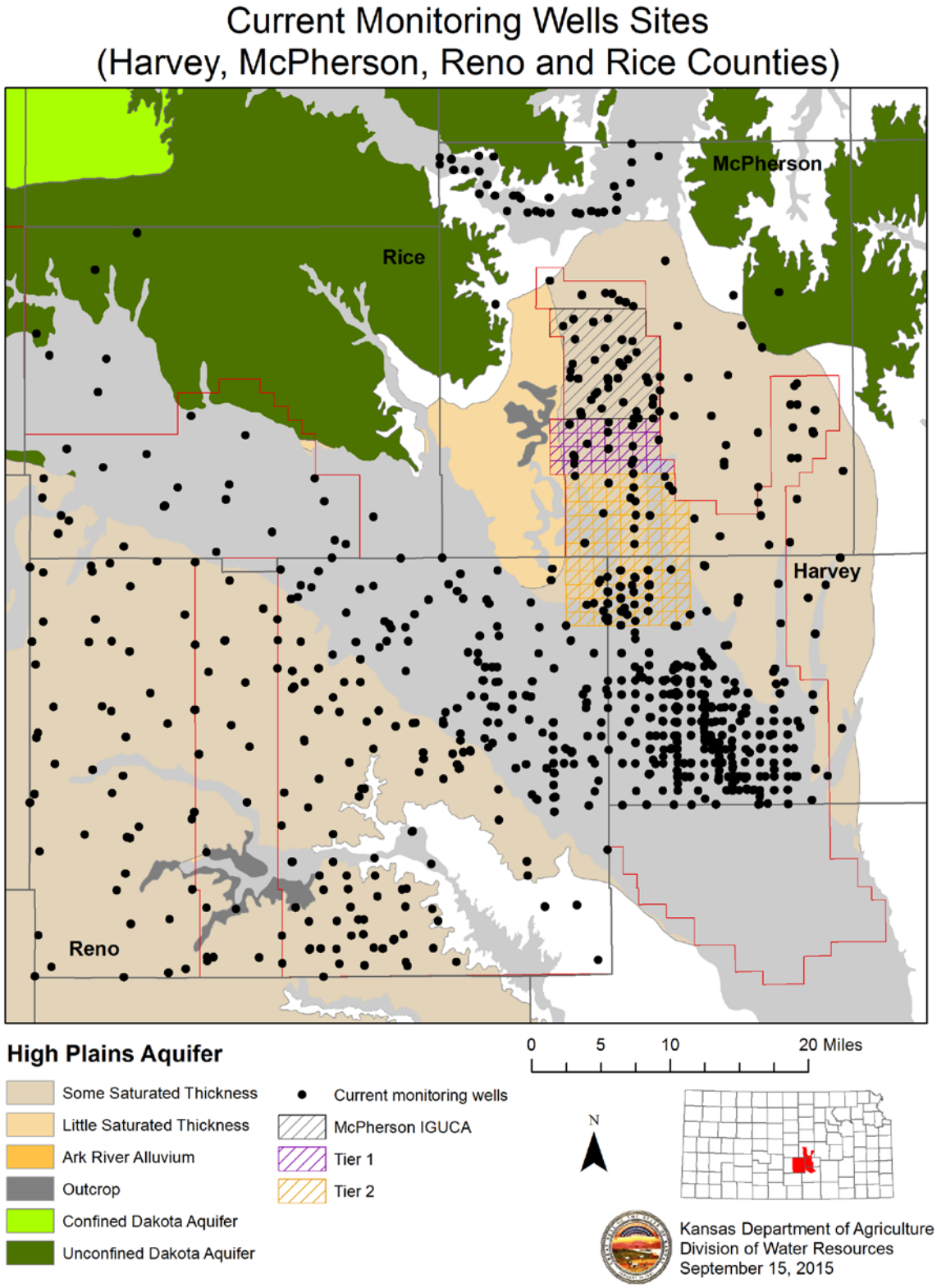

Figure 34: Location of current monitoring wells in Harvey, McPherson, Reno and Rice Counties

D. Recharge

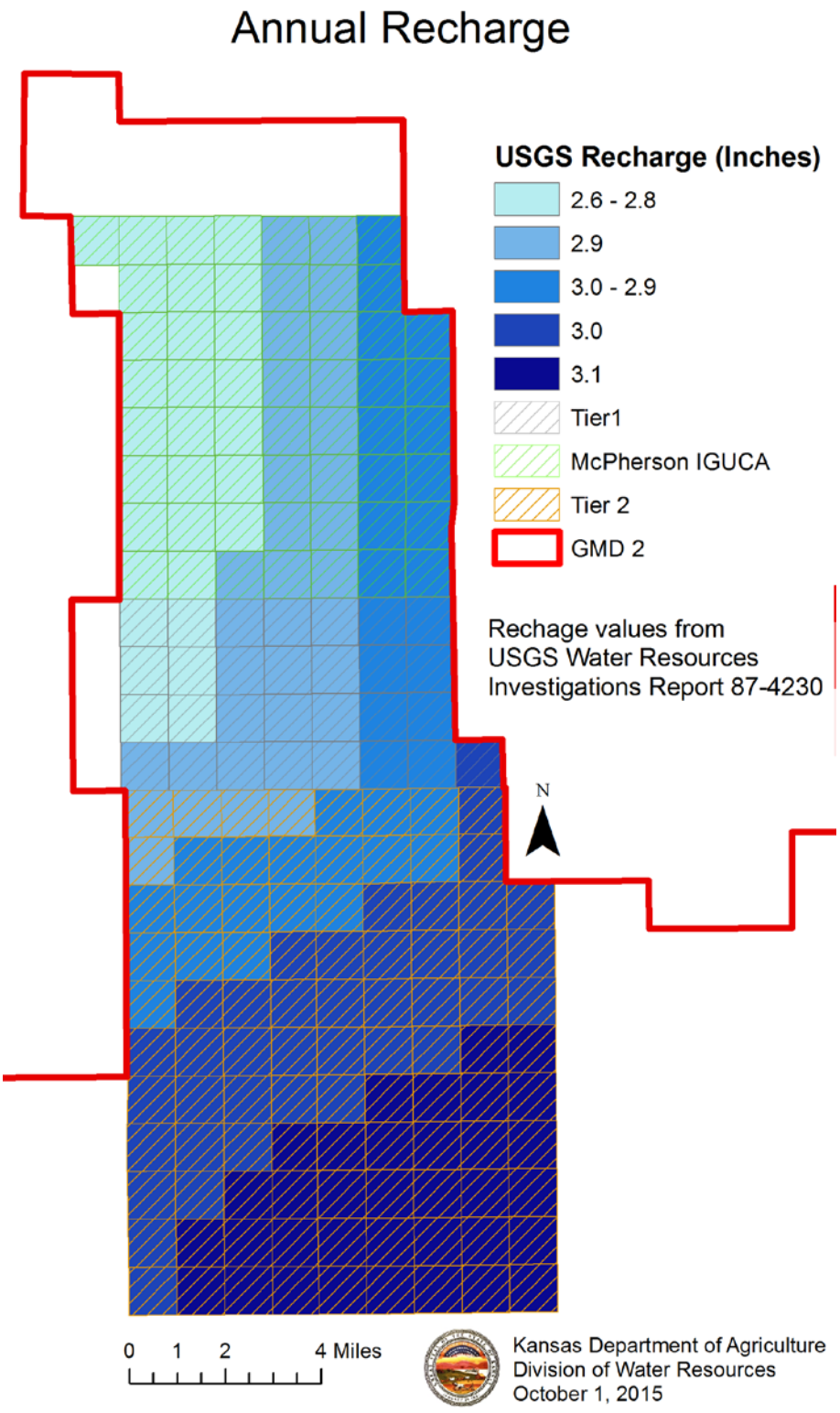

Figure 35: USGS Recharge Values