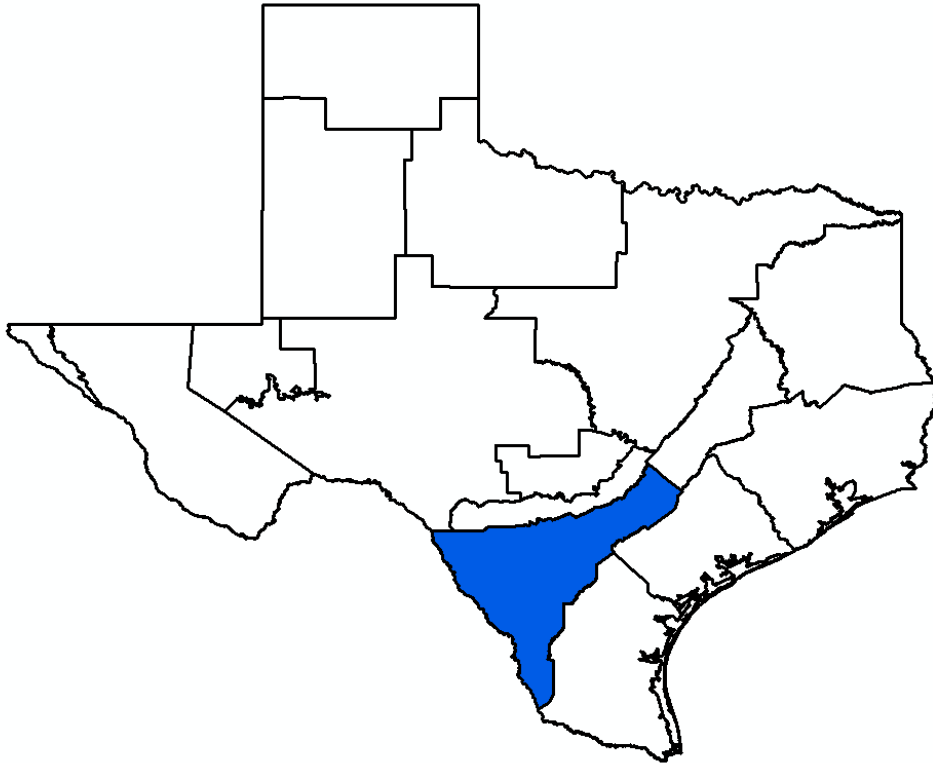


***GMA 13 Technical Memorandum 16-02
Draft 1***

**GAM Predictive Scenarios 9 to 12
Supplemental Analyses in Outcrop Areas of Carrizo and Wilcox
Aquifers**



Prepared for:
Groundwater Management Area 13

Prepared by:
William R. Hutchison, Ph.D., P.E., P.G.
Independent Groundwater Consultant
9305 Jamaica Beach
Jamaica Beach, TX 77554
512-745-0599
billhutch@texasgw.com

February 23, 2016

Table of Contents

1.0	Introduction.....	1
2.0	Tabular Summary of Averages.....	2
2.0	Cross-Plots of Results	4
2.1	2011 Saturated Thickness vs. Drawdown	4
2.2	Saturated Thickness vs. Storage Remaining	6
3.0	Histograms of Drawdown.....	8
4.0	Maps of Saturated Thickness.....	10

List of Tables

Table 1.	Tabular Averages – Carrizo Aquifer	2
Table 2.	Tabular Averages – Wilcox Aquifer	3

List of Figures

Figure 1.	Carrizo Aquifer, 2011 Saturated Thickness vs. Scenario Drawdown.....	4
Figure 2.	Wilcox Aquifer, 2011 Saturated Thickness vs. Scenario Drawdown	5
Figure 3.	2011 Saturated Thickness vs 2070 Saturated Thickness – Carrizo Aquifer	6
Figure 4.	2011 Saturated Thickness vs 2070 Saturated Thickness - Wilcox Aquifer	7
Figure 5.	Histogram of Drawdown - Carrizo Aquifer	8
Figure 6.	Histogram of Drawdown - Wilcox Aquifer	9
Figure 7.	2011 Saturated Thickness of the Outcrop Area of the Carrizo Aquifer.....	10
Figure 8.	Simulated Saturated Thickness of the Outcrop Area of the Carrizo Aquifer in 2070 (Scenario 9).....	11
Figure 9.	2011 Saturated Thickness of the Outcrop Area of the Wilcox Aquifer	12
Figure 10.	Simulated Saturated Thickness of the Outcrop Area of the Wilcox Aquifer in 2070 (Scenario 9).....	13

1.0 Introduction

At the request of Greg Sengelmann, the model output of Scenarios 9 to 12 (covered in Technical Memorandum 16-01) were processed further to obtain more detailed results on impacts to the outcrop areas of the Carrizo and Wilcox aquifers.

Impacts to the outcrop area are important to consider for two reasons: 1) the shallow domestic wells that are completed in the outcrop are more sensitive to drawdown than wells completed in the confined portions of the aquifers, and 2) any impacts to surface water flow would occur in the outcrop areas.

The outcrop areas of the model were identified as those cells where overlying layers were inactive (i.e. if layers 1 to 4 in a particular row and column were inactive, but layer 5 was active, it was assumed that layer 5 outcropped at this location).

In GMA 13, there are 999 cells in the outcrop area of the Carrizo Aquifer (each cell is one square mile). Layer 5 of the model represents the Carrizo Aquifer.

In GMA 13, there are 1,553 cells in the outcrop area of the Wilcox Aquifer (each cell is one square mile). Layers 6, 7, and 8 of the model represent the Wilcox Aquifer.

The analysis considered the 2011 saturated thickness in each model cell (the initial condition of the simulations), the saturated thickness in 2070 of each model cell for each of the four simulations (Scenario 9 to 12), the drawdown in each cell between 2011 and 2070, and the percentage of storage remaining in each cell by dividing the saturated thickness in 2070 by the saturated thickness in 2011 and multiplying the result by 100.

The results are summarized in the form of tables, cross-plots, histograms, and maps in this technical memorandum.

2.0 Tabular Summary of Averages

The average saturated thicknesses, drawdowns, and storage remaining for the Carrizo Aquifer are presented in Table 1. Please note that there are two columns in the table, one for all cells, and one for cells with a 2011 saturated thickness of greater than 50 feet.

Table 1. Tabular Averages – Carrizo Aquifer

	Carrizo Aquifer Outcrop (Layer 5)	
	GMA 13 (All Cells)	GMA 13 (Cells where 2011 Saturated Thickness > 50 ft)
Average 2011 Saturated Thickness (ft)	108	194
Average 2070 Saturated Thickness (ft)		
Scenario 9 (All Region L Strategies)	72	126
Scenario 10 (All Carrizo Strategies, 67% of Wilcox Strategies)	73	127
Scenario 11 (All Carrizo Strategies, 33% of Wilcox Strategies)	73	128
Scenario 12 (All Carrizo Strategies, 0% of Wilcox Strategies)	74	129
Average 2012 to 2070 Drawdown (ft)		
Scenario 9 (All Region L Strategies)	35	68
Scenario 10 (All Carrizo Strategies, 67% of Wilcox Strategies)	35	67
Scenario 11 (All Carrizo Strategies, 33% of Wilcox Strategies)	34	66
Scenario 12 (All Carrizo Strategies, 0% of Wilcox Strategies)	34	65
Average 2070 Saturated Thickness as Percentage of 2012 Saturated Thickness (%)		
Scenario 9 (All Region L Strategies)	90	67
Scenario 10 (All Carrizo Strategies, 67% of Wilcox Strategies)	91	67
Scenario 11 (All Carrizo Strategies, 33% of Wilcox Strategies)	91	67
Scenario 12 (All Carrizo Strategies, 0% of Wilcox Strategies)	91	68

The average saturated thicknesses, drawdowns, and storage remaining for the Wilcox Aquifer are presented in Table 2. Please note that there are two columns in the table, one for all cells, and one for cells with a 2011 saturated thickness of greater than 50 feet.

Table 2. Tabular Averages – Wilcox Aquifer

	Wilcox Aquifer Outcrop (Layers 6, 7 and 8)	
	GMA 13 (All Cells)	GMA 13 (Cells where 2011 Saturated Thickness > 50 ft)
Average 2011 Saturated Thickness (ft)	110	231
Average 2070 Saturated Thickness (ft)		
Scenario 9 (All Region L Strategies)	92	193
Scenario 10 (All Carrizo Strategies, 67% of Wilcox Strategies)	94	197
Scenario 11 (All Carrizo Strategies, 33% of Wilcox Strategies)	97	202
Scenario 12 (All Carrizo Strategies, 0% of Wilcox Strategies)	100	209
Average 2012 to 2070 Drawdown (ft)		
Scenario 9 (All Region L Strategies)	18	38
Scenario 10 (All Carrizo Strategies, 67% of Wilcox Strategies)	16	34
Scenario 11 (All Carrizo Strategies, 33% of Wilcox Strategies)	13	29
Scenario 12 (All Carrizo Strategies, 0% of Wilcox Strategies)	10	22
Average 2070 Saturated Thickness as Percentage of 2012 Saturated Thickness (%)		
Scenario 9 (All Region L Strategies)	89	76
Scenario 10 (All Carrizo Strategies, 67% of Wilcox Strategies)	90	78
Scenario 11 (All Carrizo Strategies, 33% of Wilcox Strategies)	92	82
Scenario 12 (All Carrizo Strategies, 0% of Wilcox Strategies)	95	86

2.0 Cross-Plots of Results

2.1 2011 Saturated Thickness vs. Drawdown

Figure 1 presents the cross-plot of 2011 saturated thickness for each cell of the Carrizo Aquifer vs the drawdown in the Carrizo Aquifer for Scenarios 9 to 12. Please note that in many areas, there is no substantial difference between the scenarios, and in other areas, the drawdown is greatest for Scenario 9 and the least for Scenario 12 even though the changes in the scenarios are in the pumping in the Wilcox Aquifer.

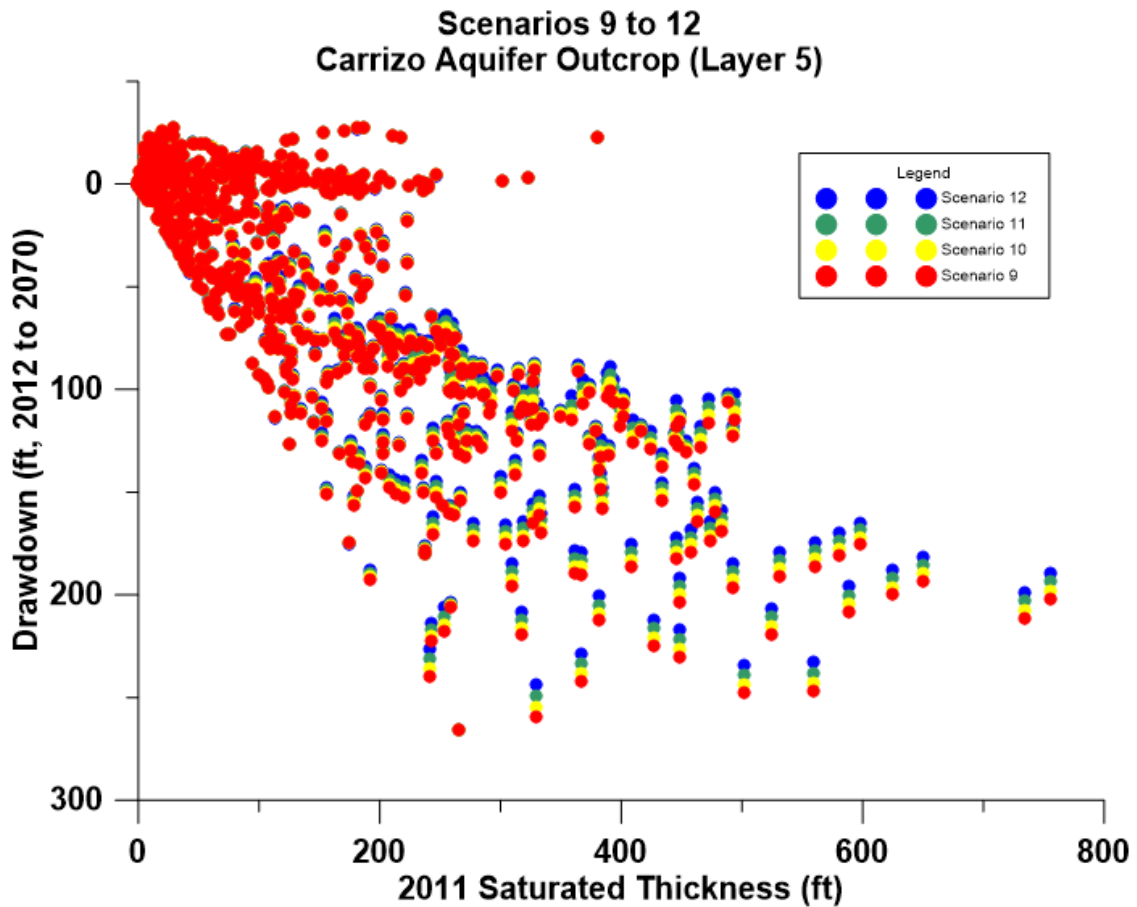


Figure 1. Carrizo Aquifer, 2011 Saturated Thickness vs. Scenario Drawdown

Figure 2 presents the cross-plot of 2011 saturated thickness for each cell of the Wilcox Aquifer vs the drawdown in the Wilcox Aquifer for Scenarios 9 to 12. Note that there are areas where the drawdown is substantially less in Scenario 12 as compared to Scenario 9 due to difference in Wilcox Aquifer pumping. For example, there is a collection of five cells with a 2011 saturated thickness of about 400 feet. Scenario 9 drawdown is about 125 feet, Scenario 10 drawdown is about 100 feet, Scenario 11 drawdown is about 75 feet, and Scenario 12 drawdown is about 50 feet. There are also many areas where the drawdown is substantially the same in all scenarios.

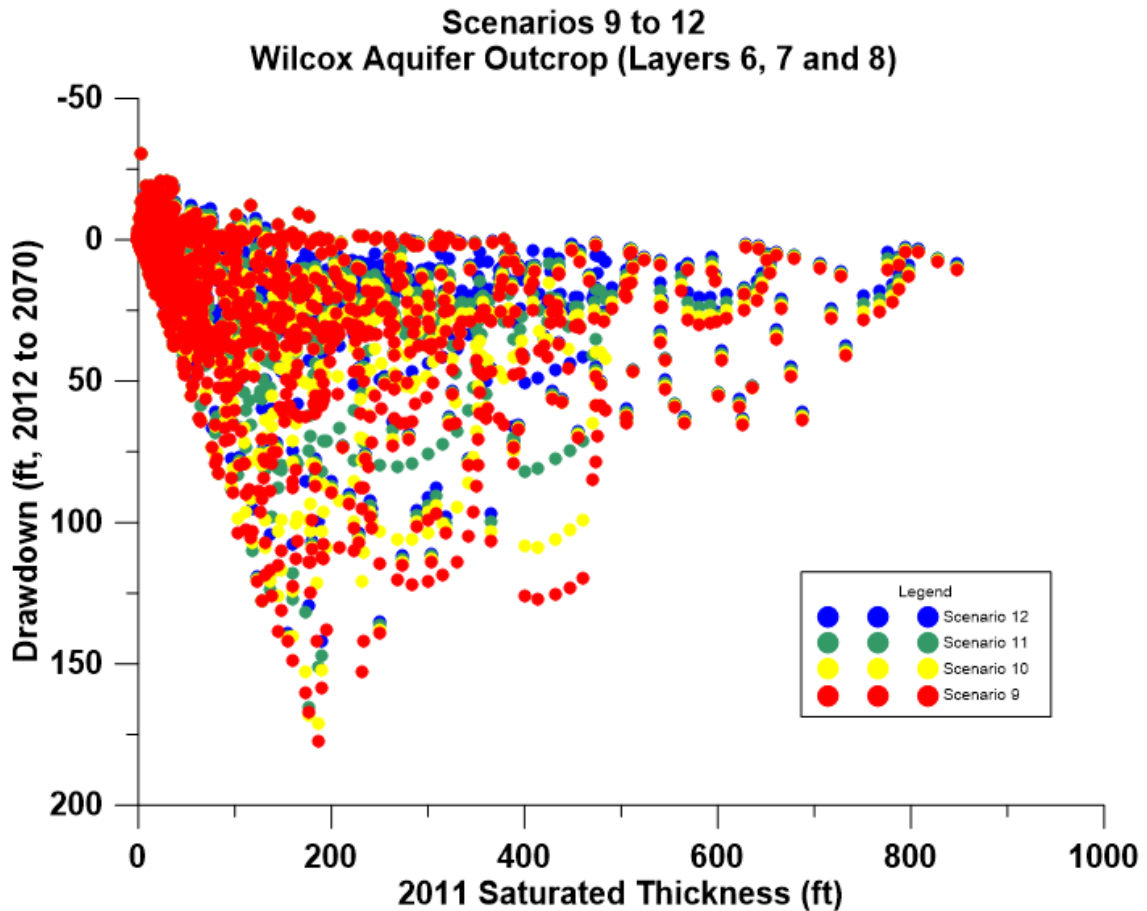


Figure 2. Wilcox Aquifer, 2011 Saturated Thickness vs. Scenario Drawdown

2.2 Saturated Thickness vs. Storage Remaining

Figure 3 presents the cross-plot of 2011 saturated thickness vs the storage remaining in the Carrizo Aquifer in 2070 for Scenarios 9 to 12. Please note that this plot is limited to cells where the 2011 saturated thickness is at least 50 feet. Also, note that the differences between the scenarios is minor.

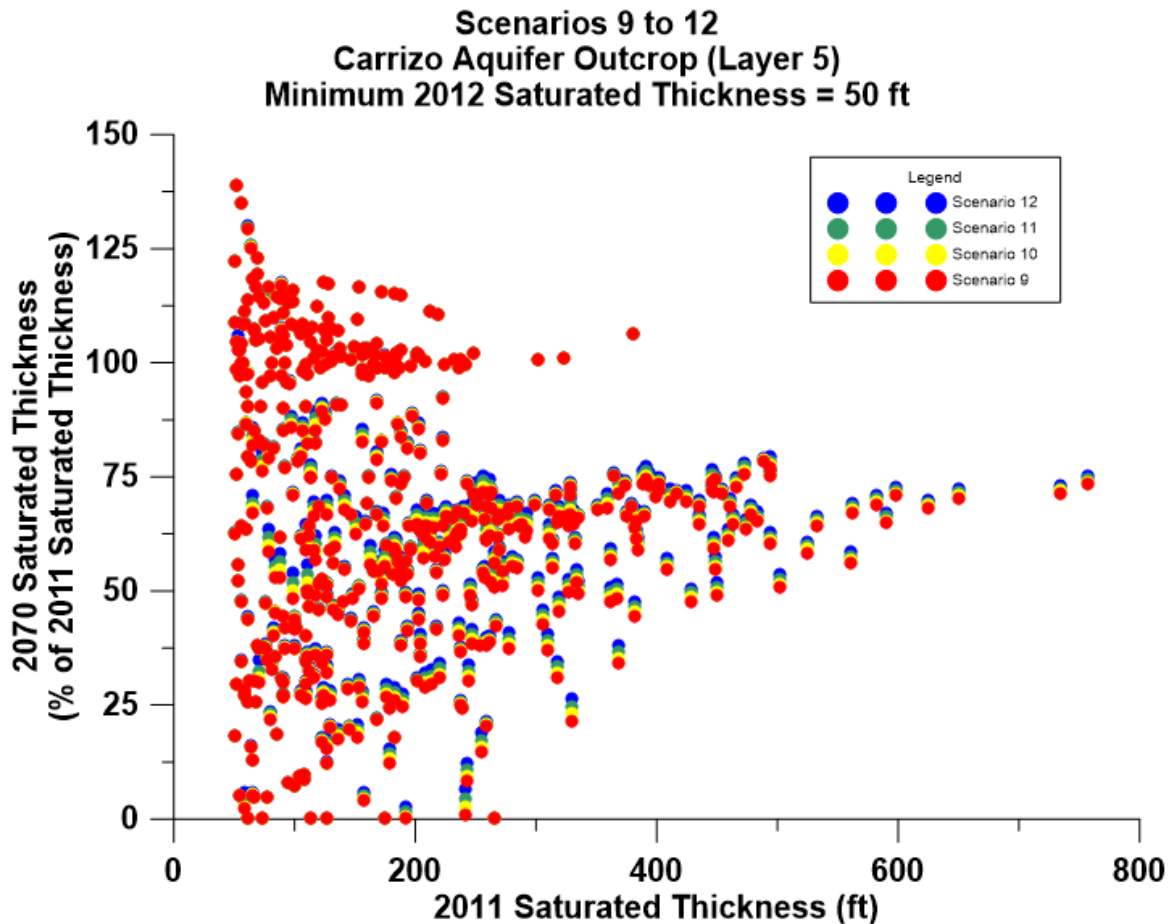


Figure 3. 2011 Saturated Thickness vs 2070 Saturated Thickness – Carrizo Aquifer

Figure 4 presents the cross-plot of 2011 saturated thickness vs the storage remaining in the Wilcox Aquifer in 2070 for Scenarios 9 to 12. Please note that this plot is limited to cells where the 2011 saturated thickness is at least 50 feet. Note that the five cells that were discussed from Figure 2 also show up in Figure 4. There are five cells with 2011 saturated thickness of about 400 feet. In 2070, Scenario 9 results show that 2070 saturated would be about 70 percent of 2011 saturated thickness, but in Scenario 12, 2070 saturated thickness would be nearly 90 percent of 2011 saturated thickness. This is the result of differences in Wilcox pumping.

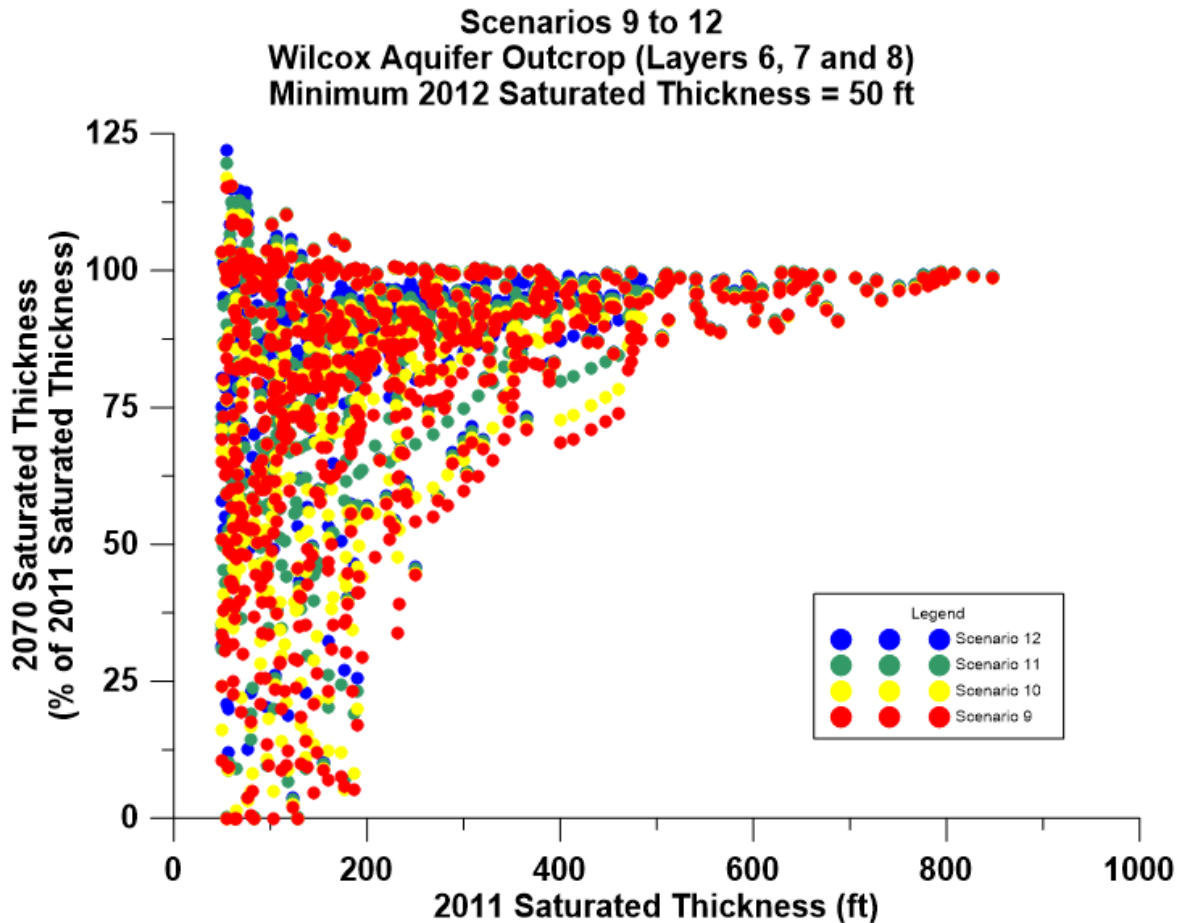


Figure 4. 2011 Saturated Thickness vs 2070 Saturated Thickness - Wilcox Aquifer

3.0 Histograms of Drawdown

Figure 5 presents a histogram of cell-by-cell drawdown in the Carrizo Aquifer between 2011 and 2070 for all Scenarios. Please note the large number of cells for which there was a recovery of groundwater levels from 2011 to 2070 (negative drawdown). This is due to the relatively dry conditions of 2011 and the use of average recharge from 2012 to 2012 for the predictive simulations. In areas with no increase in pumping, a slight increase in groundwater level would be expected as a result of the recharge conditions simulated.

Note that there are only minor differences in the scenarios since the only pumping changes between the scenarios is in the underlying Wilcox Aquifer.

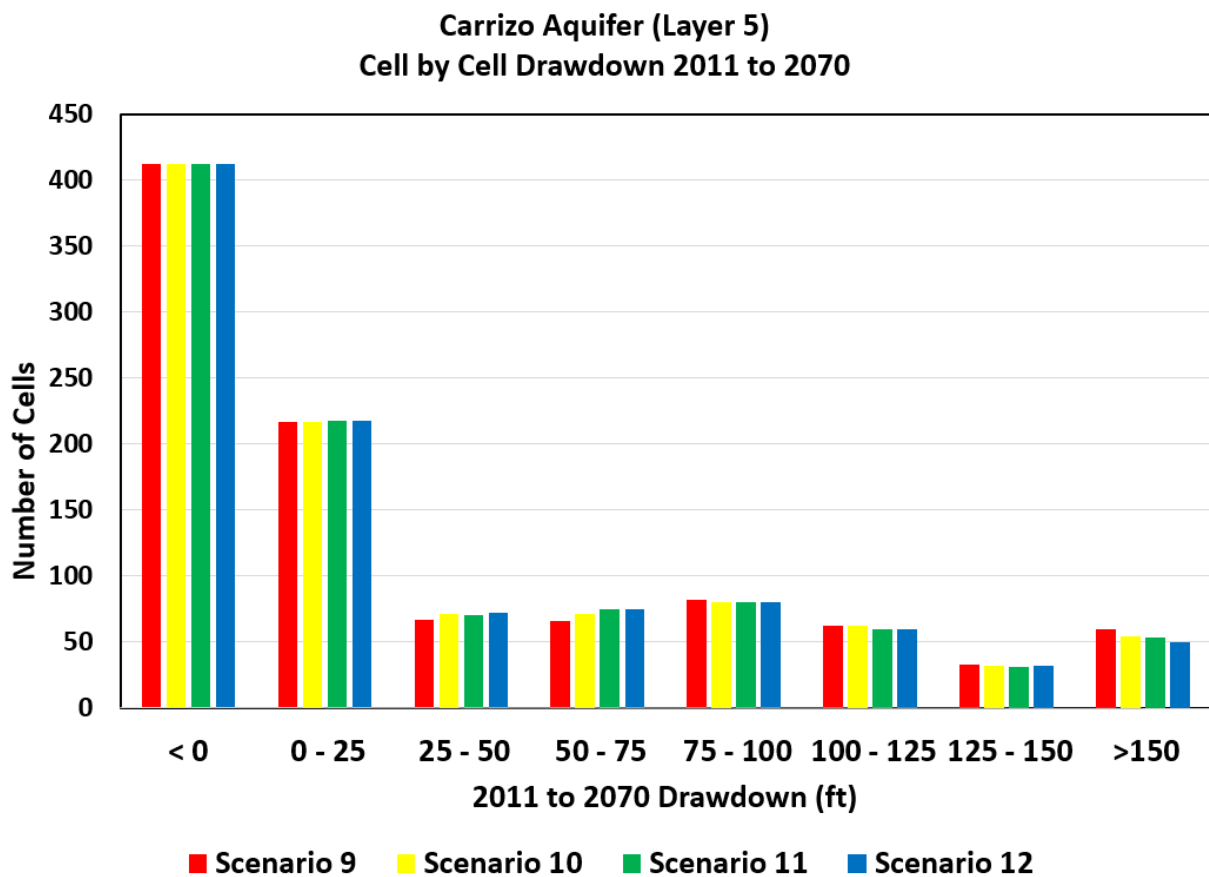


Figure 5. Histogram of Drawdown - Carrizo Aquifer

Figure 6 presents a histogram of cell-by-cell drawdown in the Wilcox Aquifer between 2011 and 2070 for all Scenarios. Please note the large number of cells for which there was a recovery of groundwater levels from 2011 to 2070 (negative drawdown). This is due to the relatively dry conditions of 2011 and the use of average recharge from 2012 to 2012 for the predictive simulations. In areas with no increase in pumping, a slight increase in groundwater level would be expected as a result of the recharge conditions simulated.

Note that there are differences in drawdown between the simulations since these scenarios were based on different pumping in the Wilcox Aquifer. There are more cells with high drawdown (greater than 50 feet) in Scenario 9 (the highest pumping scenario). However, there are more cells with 0 to 25 feet of drawdown in Scenario 12 (the lowest pumping scenario).

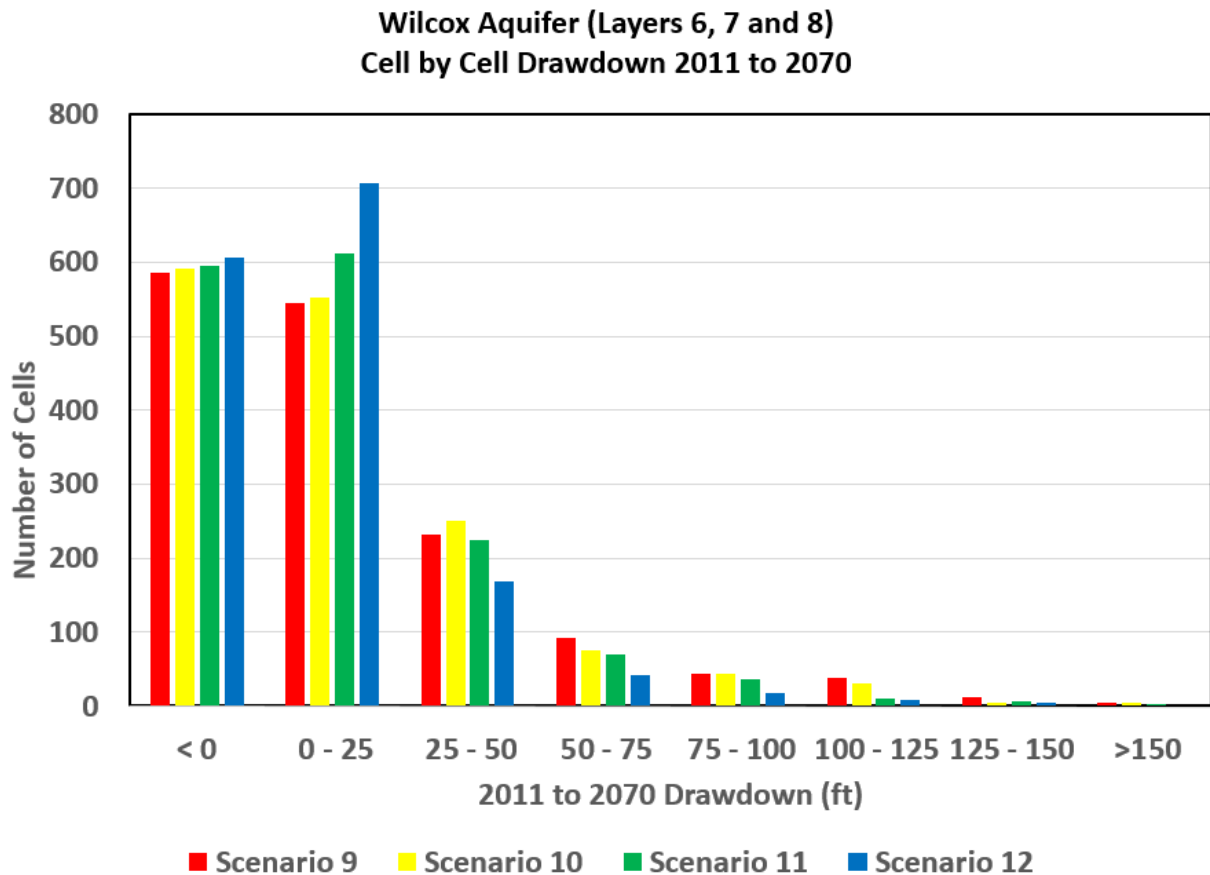


Figure 6. Histogram of Drawdown - Wilcox Aquifer

4.0 Maps of Saturated Thickness

Figure 7 presents the saturated thickness in 2011 of the outcrop area of the Carrizo Aquifer in 2011. Figure 8 presents the simulated saturated thickness of 2070 of the outcrop area of the Carrizo Aquifer in 2070 under Scenario 9 (the highest pumping scenario). Maps of Scenarios 10 to 12 are not presented since there are only minor differences with Scenario 9.

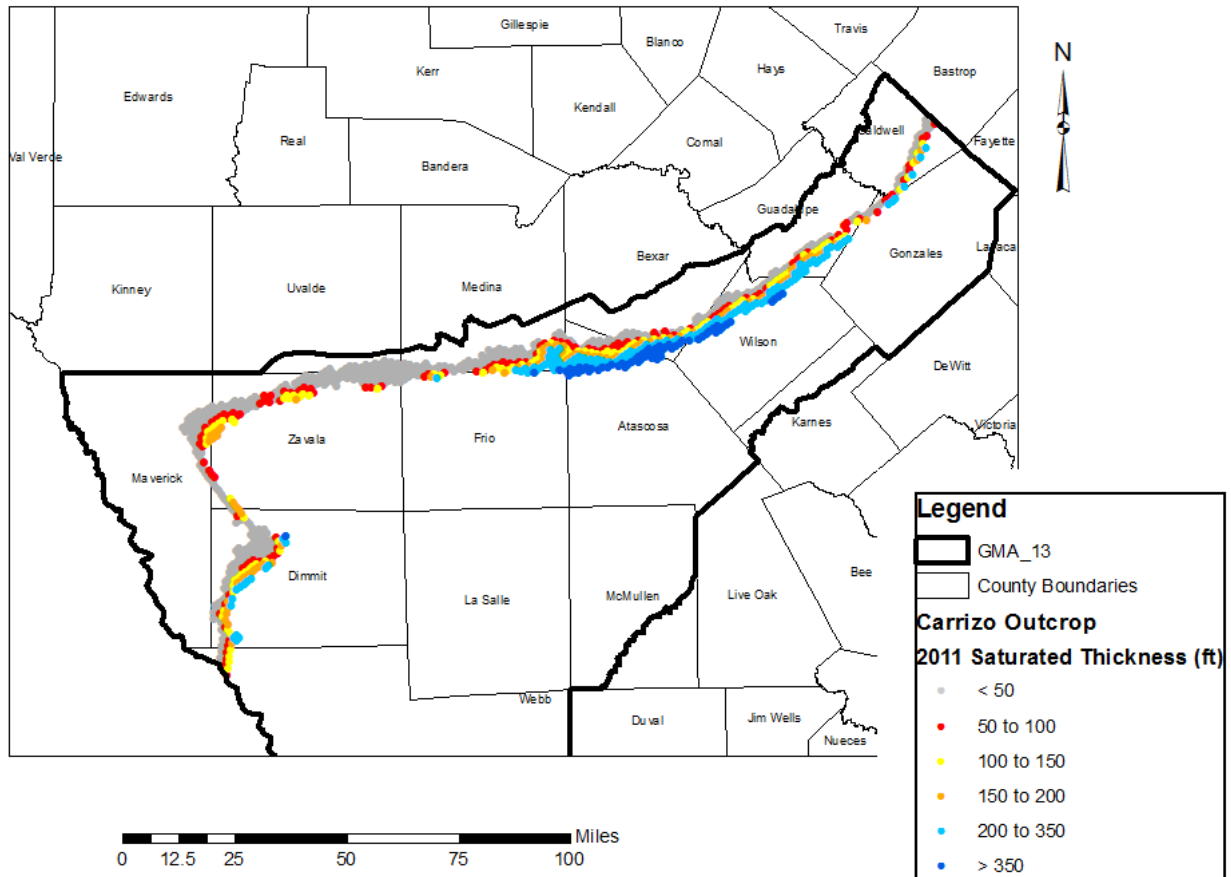


Figure 7. 2011 Saturated Thickness of the Outcrop Area of the Carrizo Aquifer

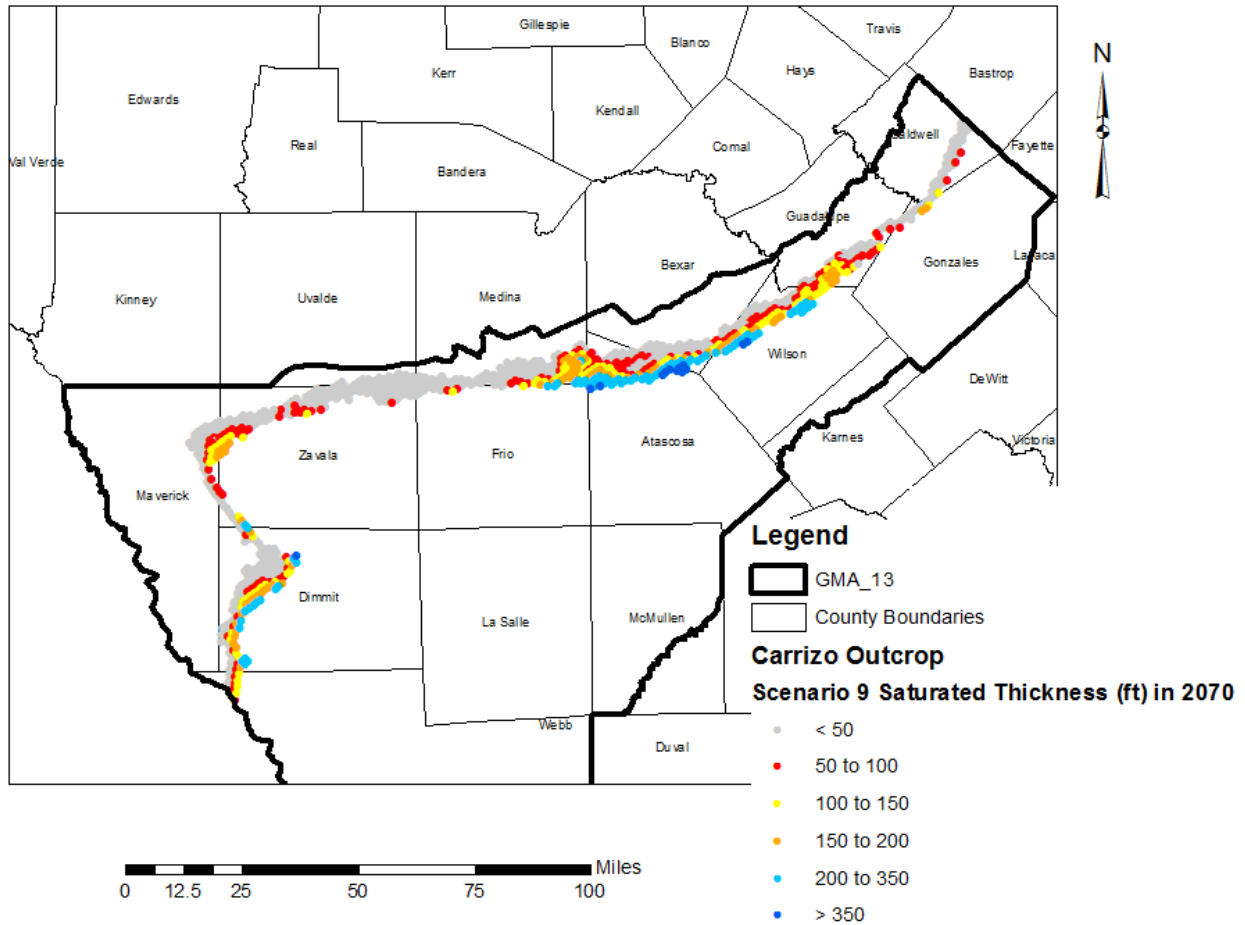


Figure 8. Simulated Saturated Thickness of the Outcrop Area of the Carrizo Aquifer in 2070 (Scenario 9)

Figure 9 presents the saturated thickness in 2011 of the outcrop area of the Wilcox Aquifer in 2011. Figure 10 presents the simulated saturated thickness of 2070 of the outcrop area of the Wilcox Aquifer in 2070 under Scenario 9 (the highest pumping scenario). Maps of Scenarios 10 to 12 are not presented since there are only minor differences with Scenario 9.

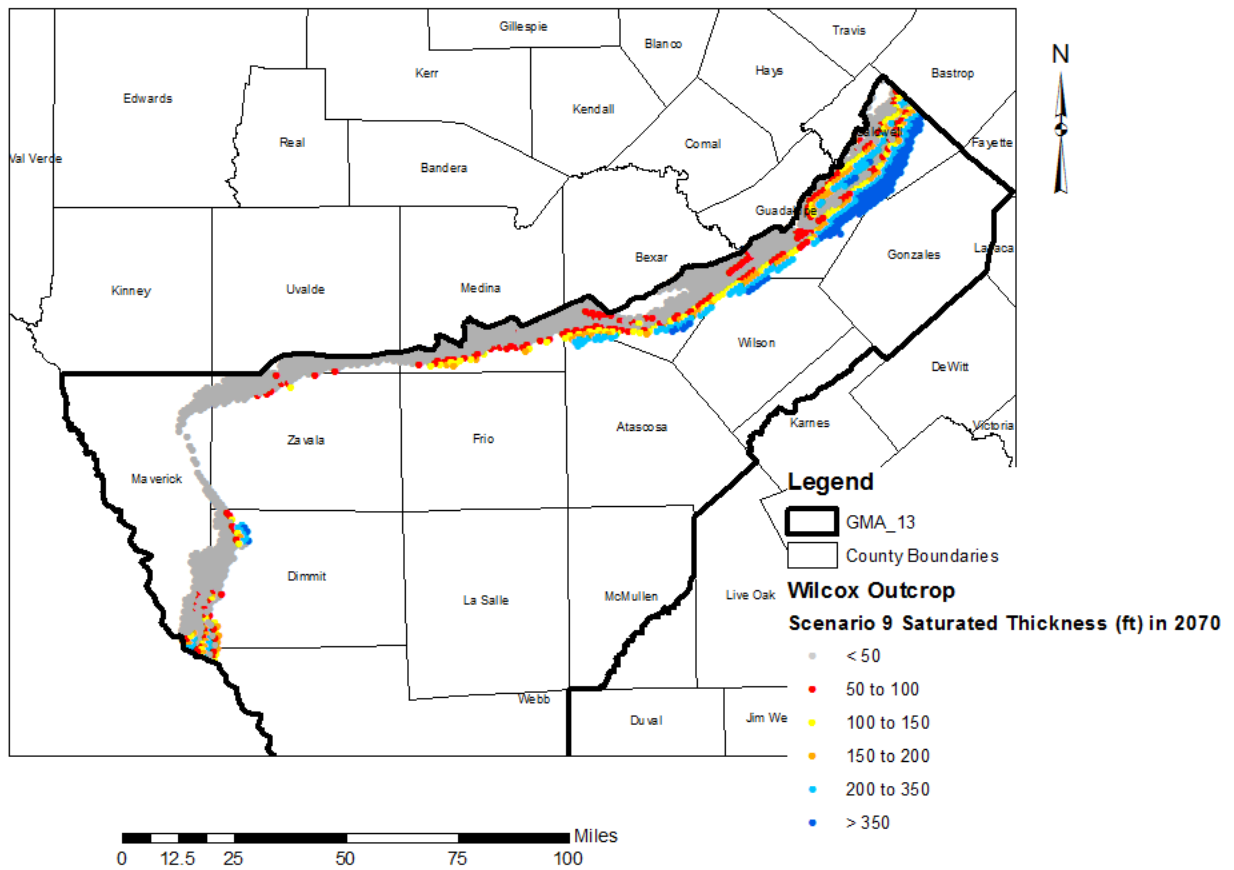


Figure 9. 2011 Saturated Thickness of the Outcrop Area of the Wilcox Aquifer

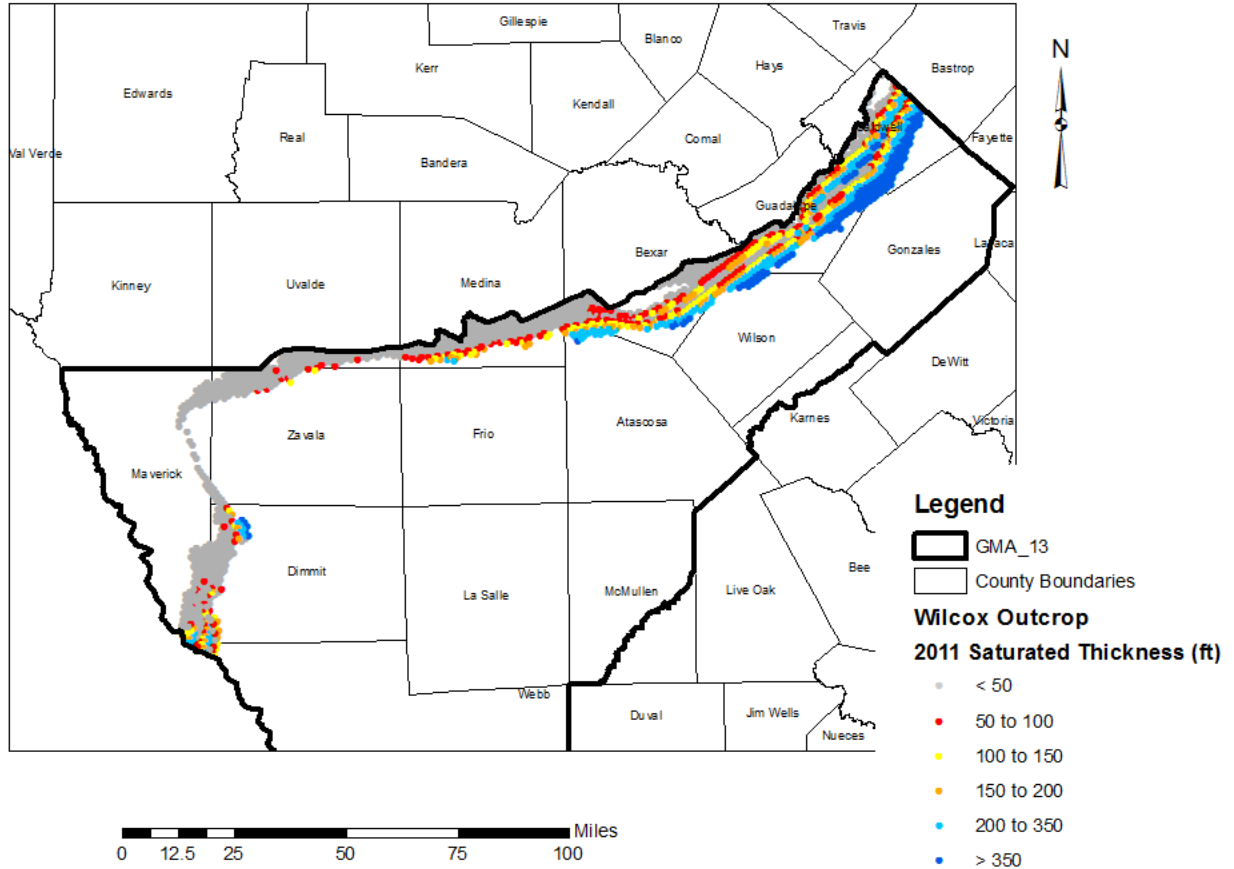


Figure 10. Simulated Saturated Thickness of the Outcrop Area of the Wilcox Aquifer in 2070 (Scenario 9)