Draft: Post Oak Savannah Guidance Document for Evaluating Compliance with Desired Future Conditions and Protective Drawdown Limits

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Draft: Post Oak Savannah Guidance Document for Evaluating Compliance with Desired Future Conditions and Protective Drawdown Limits

1 INTRODUCTION

This guidance document describes POSGCD field protocols to be used for measuring water levels and POSGCD technical analyses to be used for evaluating measured water levels from its groundwater monitoring network to determine compliance with Desired Future Conditions (DFCs) and Protective Drawdown Limits (PDLs). This document is an overview of these protocols and analyses and is not intended to be an instruction manual.

The methodologies provided in this document were discussed and approved through a series of presentations at POSGCD DFC committee meetings and board meetings throughout 2017 and early 2018. Comments from board members and from members of the public have been incorporated into the methodologies provided in this document. This document is intended to be a dynamic document that will be continually updated in response to new information and changes in site conditions. Adjustment to the methodologies are permitted by POSGCD as long as the reason for the adjustment is properly noted in the documentation for the data collection and analysis.

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The purpose of this guidance document is to document the methodologies that POSGCD uses to calculate drawdown from measured water levels.

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1.1 Desired Future Conditions

As described in Section 7 of its Management Plan, the POSGCD DFCs are listed in Tables 1-1 through 1-4. The DFCs in Tables 1-1 through 1-3 were adopted by Groundwater Management Area 12. The DFCs in Table 1-4 were adopted by Groundwater Management Area 8.

Table 1-1 GMA 12 and POSGCD adopted DFCs based on the average drawdown that occurs between January 2000 and December 2069

Aquifer	Drawdown (ft)
Sparta	28
Queen City	30
Carrizo	67
Upper Wilcox (Calvert Bluff Fm)	149
Middle Wilcox (Simsboro Fm)	318
Lower Wilcox (Hooper Fm)	205

Table 1-2 GMA 12 and POSGCD adopted DFCs based on the average drawdown that occurs between January 2010 and December 2069

Aquifer	Drawdown (ft)
Yegua-Jackson	100

Table 1-3 GMA 12 and POSGCD adopted DFCs for Brazos River Alluvium Aquifer based on the average decrease in saturated thickness that occurs between January 2010 and December 2069

Aquifer	County	Average Decrease in Saturated Thickness (ft)
Brazos River Alluvium Aquifer	Milam in GMA 12	5
	Burleson in GMA 12	6

Table 1-4 GMA 8 and POSGCD adopted DFCs based on average drawdown that occurs between January 2010 and December 2070

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Aquifer	Drawdown (ft)
Paluxy	--
Glen Rose	212
Travis Peak	345
Hensell	229
Hosston	345

1.2 Protective Drawdown Limits

As described in Section 7 of its Management Plan, the POSGCD PDLs are listed in Table 1-5. Neither GMA 12 nor GMA 8 has established DFCs for the shallow or unconfined zones of the aquifers. The District developed the PDLs to protect the production capacity of existing wells in the shallow unconfined portions of the aquifer, where the water level above the well screen tends to be less than in the deep confined portions of the aquifer. The District created shallow management zones for each aquifer, except for the Brazos River Alluvium Aquifer. Each of the shallow management zones includes the portion of the aquifer that occurs at a depth of 400 feet or less, as measured from land surface.

Table 1-5 Protective drawdown limits threshold values for average drawdown for the shallow management zones

Aquifer	Average Drawdown (ft) that Occurs between January 2000 and December 2069 in the Shallow Management Zone
Sparta	20
Queen City	20
Carrizo	20
Upper Wilcox (Calvert Bluff Fm)	20
Middle Wilcox (Simsboro Fm)	20
Lower Wilcox (Hooper Fm)	20
Yegua	20
Jackson	20

2 MONITORING PERFORMANCE STANDARDS DEFINED IN POSGCD MANAGEMENT PLAN

The District will use measured water levels in its monitoring wells to determine the District's progress in conforming with its DFCs at least once every three years. This commitment is stated in Section 15.9 of POSGCD's Management Plan and is provided below:

> *"At least once every three years, the general manager will report to the Board the measured water levels obtained from the monitoring wells within each Management Zone, the average measured drawdown for each Management Zone calculated from the measured water levels of the monitoring wells within the Management Zone, a comparison of the average measured drawdowns for each Management Zone with the DFCs for each Management Zone, and the District's progress in conforming with the DFCs. (from Section 15.9 from POSGCD Management Plan"*

While the District Management Plan does not specify a schedule for evaluating compliance with its PDLs, the current POSGCD policy is to evaluate PDL compliance on the same schedule as DFCs.

3 POSGCD GROUNDWATER MONITORING WELL NETWORK

This section describes the monitoring network of groundwater wells that the District uses to measure changes in water levels over time.

3.1 Locations

The POSGCD network of groundwater wells is continually being updated, primarily due to the addition of wells. At the time this document was prepared, the POSGCD Monitoring Well network consists of the 111 wells shown in Figure 3-1. Appendix A provides information for the 111 wells in Figure 1, including their location, well depth, screened interval, and aquifer assignment. In addition to the 111 wells monitored by POSGCD, the District also utilizes additional monitoring data shared by LPGCD (6 wells) and BVGCD (130 wells) from their District monitoring networks. Figure 3-2 shows the monitoring wells that are less than 400 feet deep. This subset of the monitoring network is used for the Shallow Management Zone analyses. The POSGCD Monitoring Well network currently has 20 wells equipped with transducers, which collect continuous water level data. Figure 3-3 shows the locations of POSGCD monitoring wells equipped with transducers.

3.2 Aquifer Assignments

POSGCD defines its aquifers based on the elevation surfaces for the model layers in the groundwater availability models unless there is good cause to use another source of information. Using the information from the groundwater availability models, POSGCD assigns a well to an aquifer (or formation) based on the methodology provided in Appendix B. Monitoring wells that are screened over more than one aquifer (or formation) are assigned to the aquifer (or formation) containing the majority of the screen interval. Wells without well screen information are not included in the monitoring network. The monitoring wells in Figures 3-1 and 3-2 are symbolized according to aquifer assignments.

If well screen information for a well is not available from the Texas Water Development Board (TWDB) groundwater database or cannot be identified from the well's driller log, then POSGCD will use the best available information to assign the well to an aquifer formation until POSGCD can use a downhole borehole video camera to determine the well screen interval. If there is not enough information to determine well screen placement in a well, the water level measurements from the well will not be used as part of the compliance evaluations. When aquifer (or formation) assignments for wells differ from the aquifer (or formation) assignments provided in the TWDB groundwater database, POSGCD will notify TWDB of the differences in the assignments and will coordinate with TWDB to try to agree on the appropriate assignment for the well. If POSGCD and TWDB cannot agree on well assignment, then POSGD will document the discussion process and the reason for the different well assignments.

POSGCD will annually review and verify aquifer assignments according to the latest data available. As part of this annual review process, POSGCD will coordinate with neighboring GCDs to verify aquifer (or formation) assignments for wells. If POSGCD and the neighboring GCDs cannot agree on well assignments, then POSGD will document the discussion process and the reason for the different well assignments.

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Deleted: s part of its well database, POSGCD will create a diagram for each well that shows the Groundwater Availability Model (GAM) surfaces at the well location superimposed on the vertical location of the well screen. Examples of these well diagrams are shown in Figures 3-4 and 3-5.

3.3 Monitoring Frequency

POSGCD will attempt to measure the water level in each monitoring well at least once a year during a four-month period between November 1 and March 1. A manual measurement consists of either an e-line or steel tape reading at the well. A goal of the monitoring is to obtain a set of water level measurements for the entire monitoring network that are all taken within the same time window of two months or less.

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The four-month period between November 1 and March 1 is when seasonal groundwater pumping has historically been the lowest. As a result, the water levels in some of the monitoring wells are recovering during the time period. To capture the seasonal fluctuations in the water levels, POSGCD will manually measure water levels more frequently than once a year in selected monitoring wells that are instrumented with transducers that continually measure water levels. Currently, POSGCD is using transducers to measure water levels hourly. As funding becomes available, POSGCD will expand the seasonal and continual measurements of water levels at its monitoring wells.

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3.4 Data Transparency

POSGCD will provide documentation to support aquifer assignments for every monitoring well. As part of its well database, POSGCD will create a diagram for each well that shows the Groundwater Availability Model (GAM) surfaces at the well location superimposed on the vertical location of the well screen. Examples of these well diagrams are shown in Figures 3-4 and 3-5. Where available, POSGCD will also provide additional aquifer assignment documentation including well logs and downhole videos.

For every monitoring well, POSGCD will produce plots showing water levels through time. For monitoring wells used in DFC compliance, POSGCD will produce plots showing both water levels through time as well as drawdown through time, as compared to the DFC. An example water level and drawdown plot is shown in Figure 3-6. POSGCD will update these plots annually to incorporate new water level measurements.

POSGCD will produce yearly water level surfaces for all aquifer management zones. These will be based on all monitoring wells. An example water level surface map is shown in Figure 3-7 for the Hooper formation. POSGCD will update these plots annually to incorporate new wells and water level measurements.

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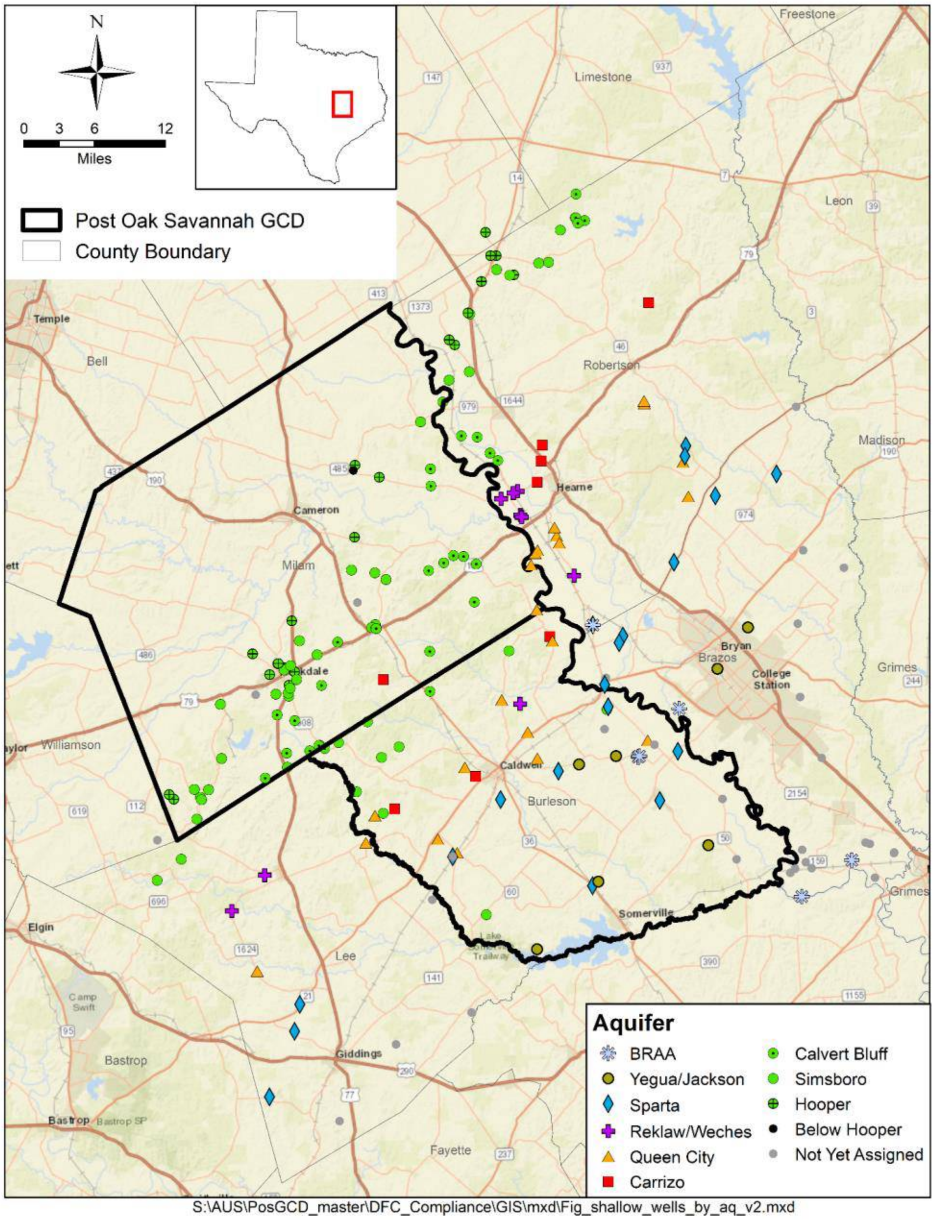

Figure 3-1 Monitoring well locations used in the DFC drawdown calculation.

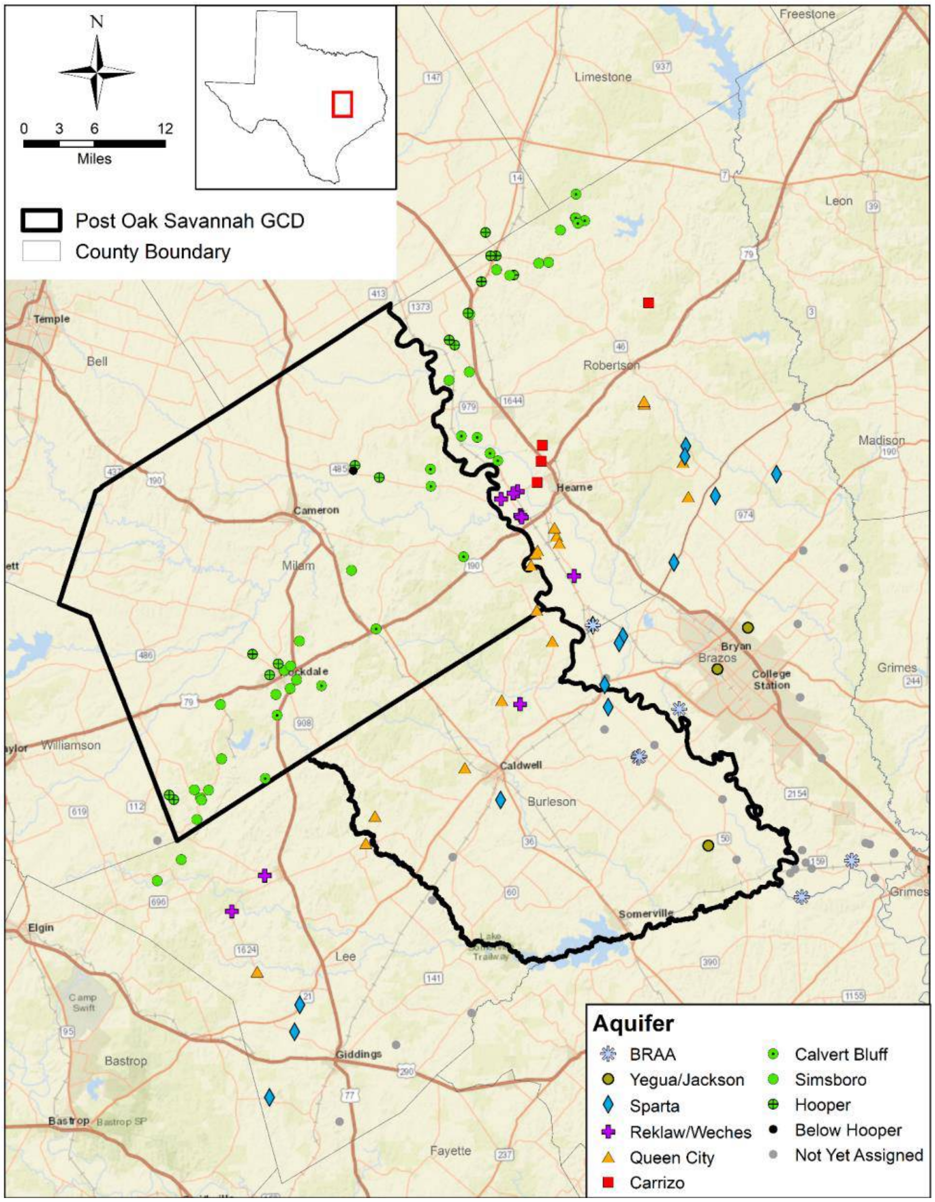

Figure 3-2 Shallow Monitoring well locations used in the PDL drawdown calculation

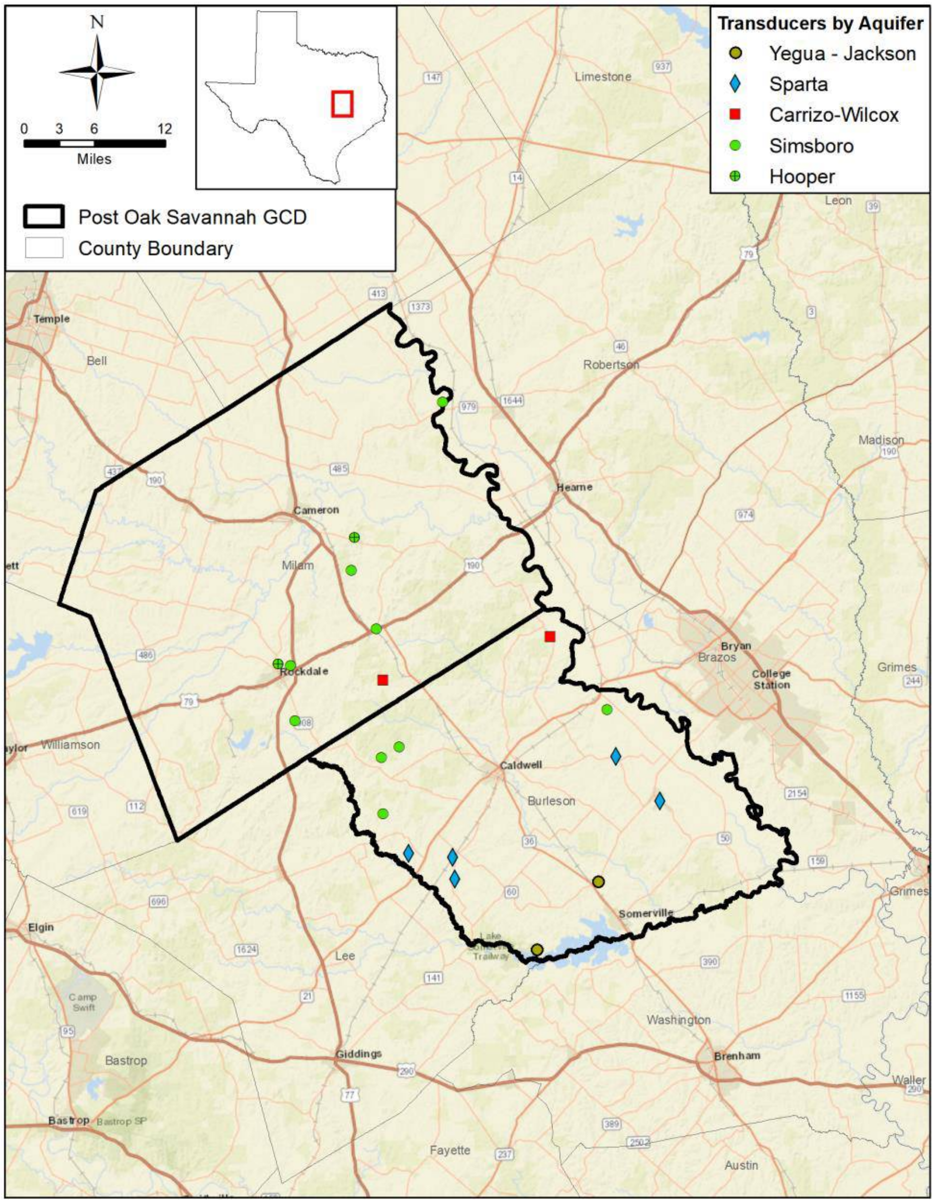

Figure 3-3 Monitoring well locations equipped with transducers in POSGCD

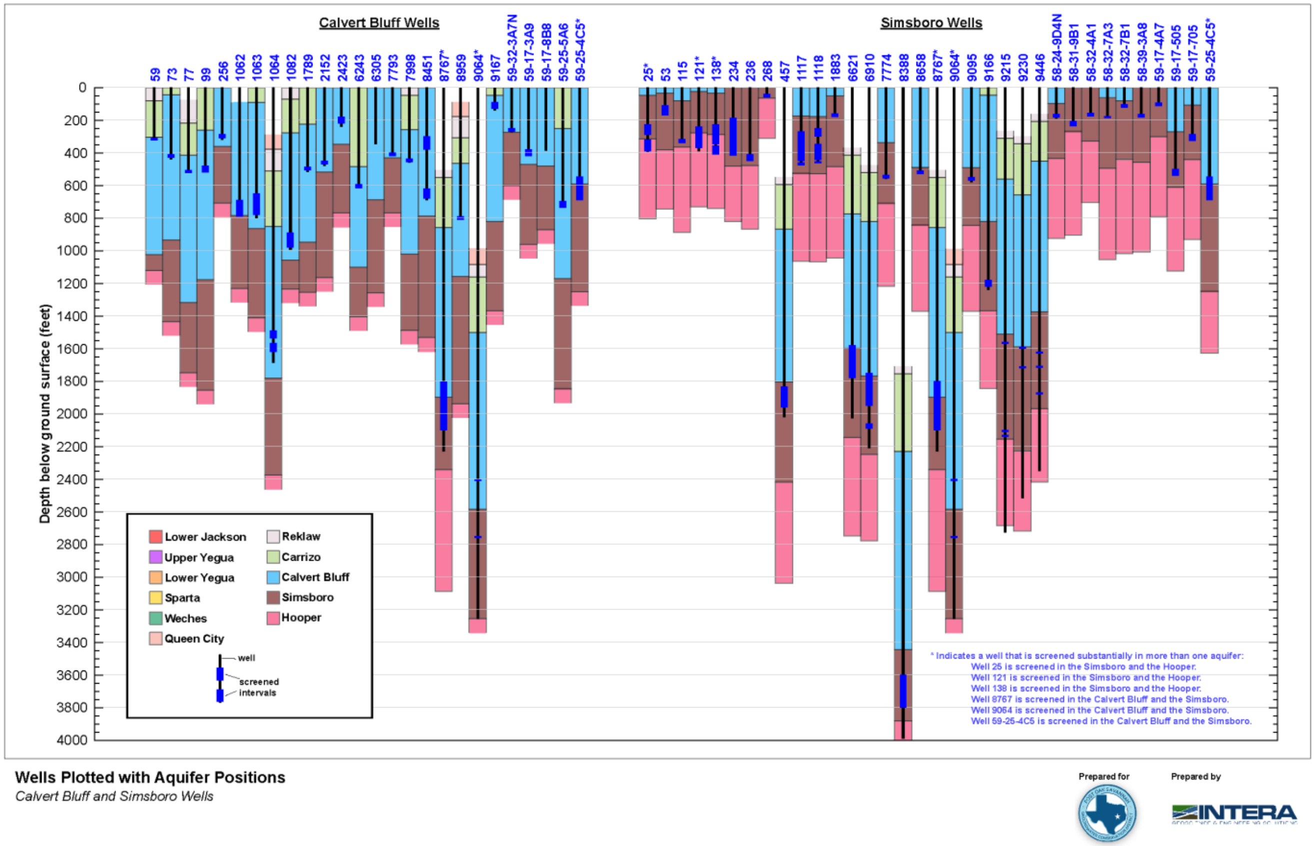

Figure 3-4 Monitoring wells with aquifer assignments in Calvert Bluff and Simsboro aquifers.

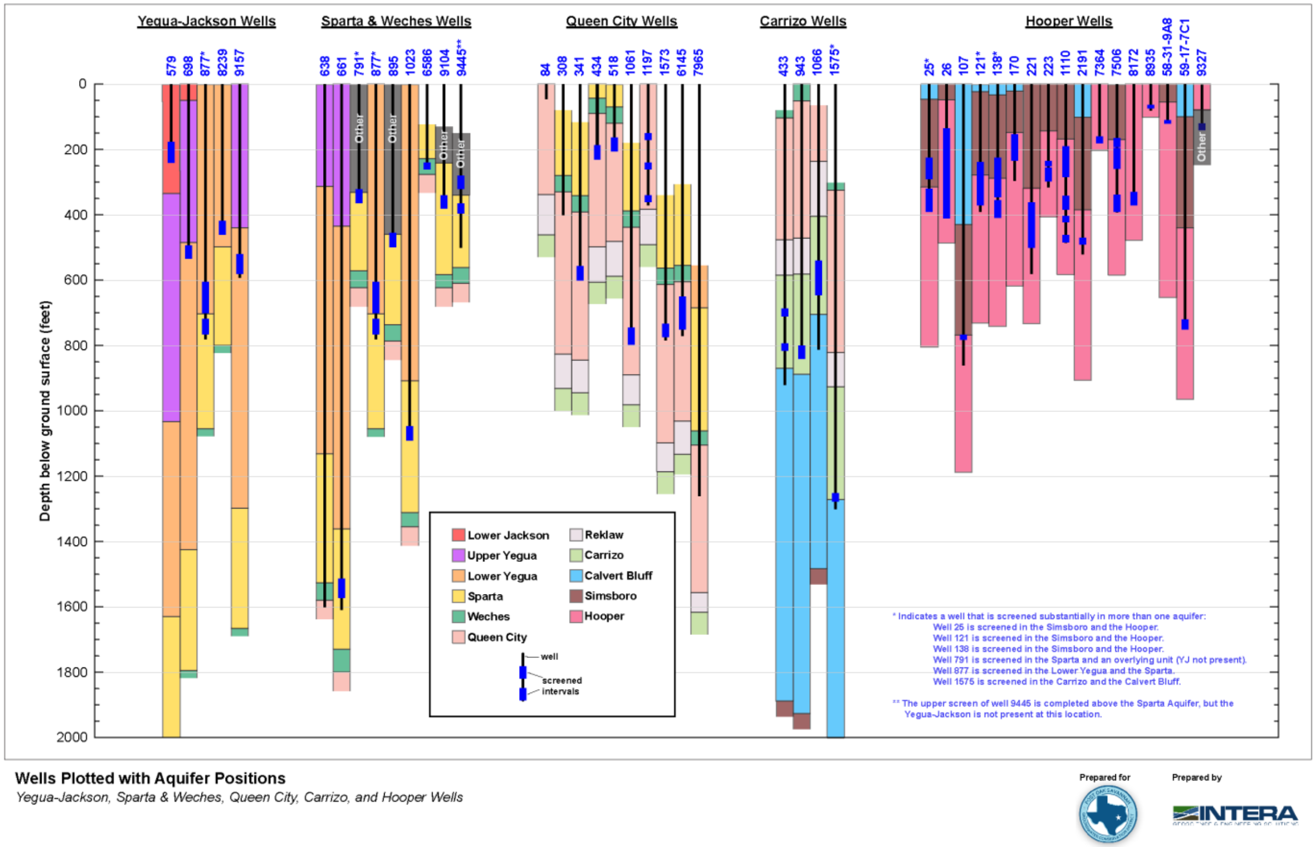

Figure 3-5 Monitoring wells with aquifer assignments in Yegua-Jackson, Queen City, Sparta, Carrizo and Hooper aquifers

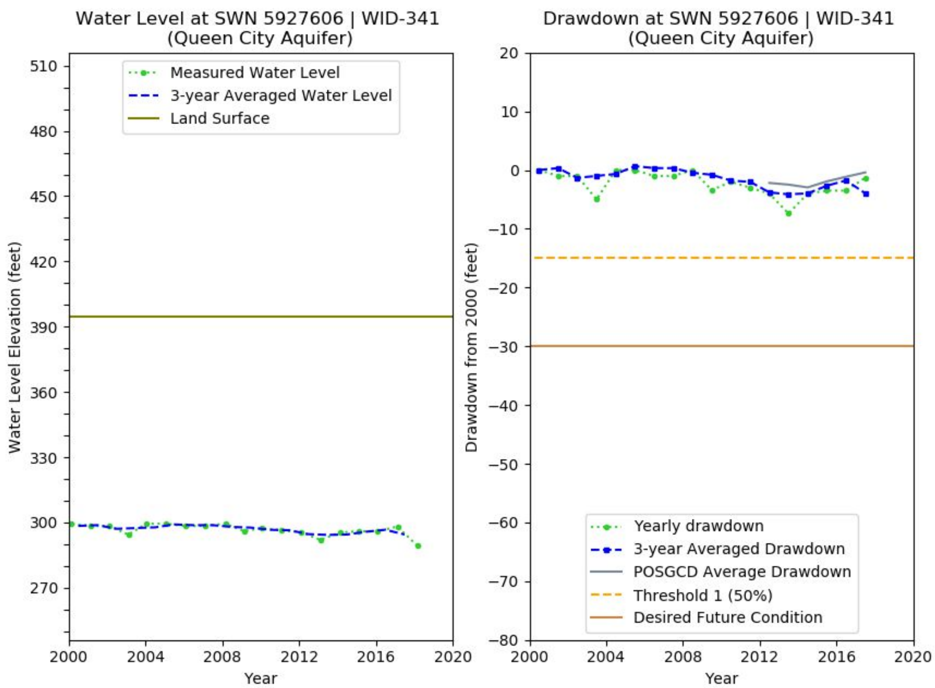

Figure 3-6 Example plot of water levels and drawdown at a monitoring well

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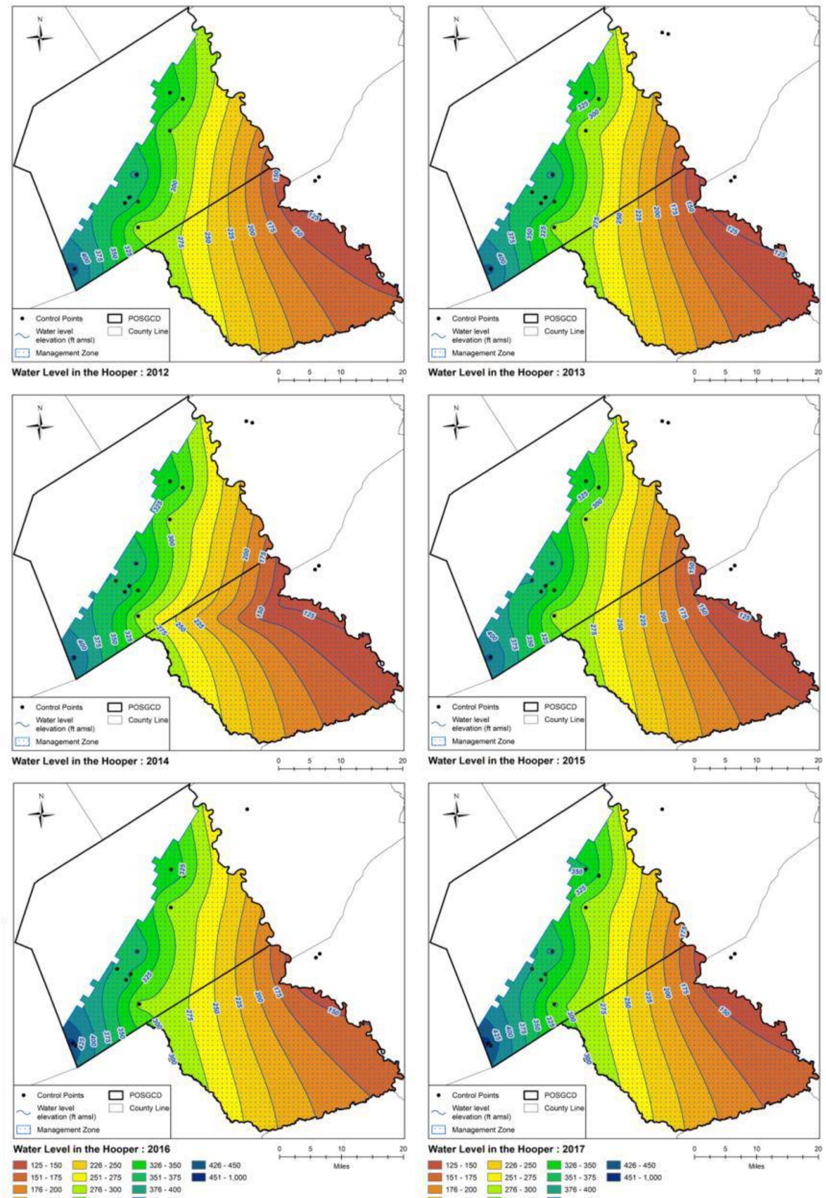

Figure 3-7 Example maps showing water level surfaces through time.

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4 COLLECTING AND MANAGING MONITORING DATA

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This section describes the collection and management of water level measurements.

4.1 Collection procedures

POSGCD staff is responsible for measuring water levels from monitoring wells in Milam and Burleson counties. POSGCD staff will be trained prior to collecting monitoring data. Training requirements will include reading the most current set of POSGCD field data collection protocols and participating in a measurement survey. Appendix C contains the protocols that have been adopted by POSGCD at the time this document was finalized.

4.2 Health and Safety Plan

POSGCD monitoring activities will be conducted in accordance with the POSGCD Health and Safety Plan (Appendix D). POSGCD staff will be required to review the Health and Safety Plan prior to monitoring events and to have access to the Health and Safety Plan during a monitoring event.

4.3 Water Level Records

POSGCD will use field notebooks to record field notes associated with each measurement event. During or immediately after a measurement event, the level measurements will be recorded on the POSGCD water level form (Appendix E) for each individual well. The handwritten field water level measurements and notes will be scanned and entered into the POSGCD digital database within 2 weeks of recording.

4.4 Data Availability

POSGCD will post results from monitoring events on their web site in a timely fashion after the information has been properly reviewed and checked. Well location, well construction and water level hydrographs for the monitoring wells will be available on POSGCD's online mapping portal at www.posgcd.halff.com.

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5 METHODOLOGY FOR CALCULATING DRAWDOWN FROM MEASURED GROUNDWATER LEVELS

This section describes the methodology that will be used to calculate an average drawdown over time that will be used to evaluate compliance to DFCs and PDLs.

5.1 Total Aquifer Management Zone

Appendix F describes the methodology used by POSGCD to calculate average drawdown values over time from the measured water levels. These drawdowns are used to evaluate compliance with DFCs. Figure 5-1 shows the management zones over which average drawdown is calculated. The methodology uses GIS to perform most of the mathematical calculations. Figure 5-2 illustrates several of the calculations that use GIS. Several key points associated with the methodology are that it:

- Uses a two-dimensional averaging process that ignores the different thicknesses of the grid cells within an aquifer.
- Uses 3-year moving averages to assign water levels at wells.
- Incorporates only those wells that have a calculated annual water level for both the baseline year (2000) and the evaluation year (ex. 2012).
- Interpolates water level surfaces for the baseline year and the evaluation year over the entire District for each Aquifer Management Zone based on monitoring well point data from that aquifer.
- Distributes interpolated water levels to a grid with a uniform spacing of 500 feet by 500 feet.
- Calculates drawdown in an aquifer by averaging the baseline water level value of all grid cells in the Aquifer Management Zone and subtracting that from the average evaluation water level value of all grid cells in the Aquifer Management Zone.

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5.2 Shallow Aquifer Management Zone

Appendix G describes the methodology used by POSGCD to calculate average drawdown values in the shallow aquifer (<400 feet deep) over time from the measured water levels. These drawdowns are used to evaluate compliance with PDLs. Figure 5-3 shows the shallow zones (<400 feet deep) of each aquifer in the district. Several key points associated with the methodology are that it:

- Uses a three-dimensional averaging process that takes into account the different thicknesses of grid cells within an aquifer.
- Incorporates only those wells that are shallower than 400 feet deep.
- Uses 3-year moving averages to determine annual water levels at wells.
- Incorporates wells that have a calculated annual water level for both the baseline year (2000) and the evaluation year (ex. 2012).
- Interpolates shallow water level surfaces for the baseline year and the evaluation year over the entire District based on all shallow monitoring well point data.
- Distributes interpolated water levels to a grid with a uniform spacing of 500 feet by 500 feet.
- Calculates a drawdown for each grid cell as the difference in the baseline and evaluation year water elevations in that grid cell.

- Subdivides the 400-foot-thick shallow zone into 50-foot-thick layers to create a grid of 500 ft x 500 ft x 50 ft grid blocks that are each assigned to an aquifer
- Calculates drawdown in an aquifer by averaging the drawdown values of all blocks assigned to that aquifer.

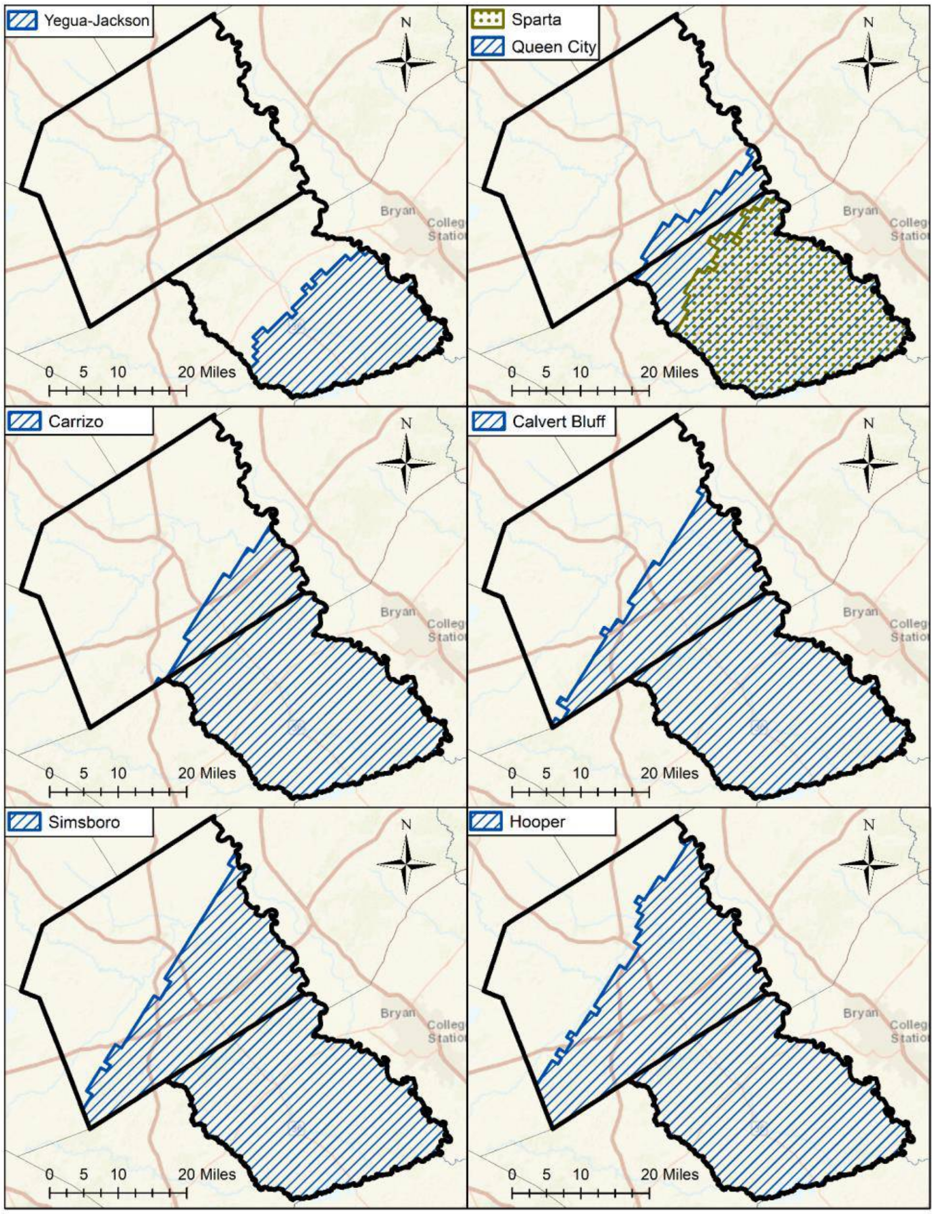

Figure 5-1 POSGCD total aquifer management zones for evaluating GMA 12 DFCs

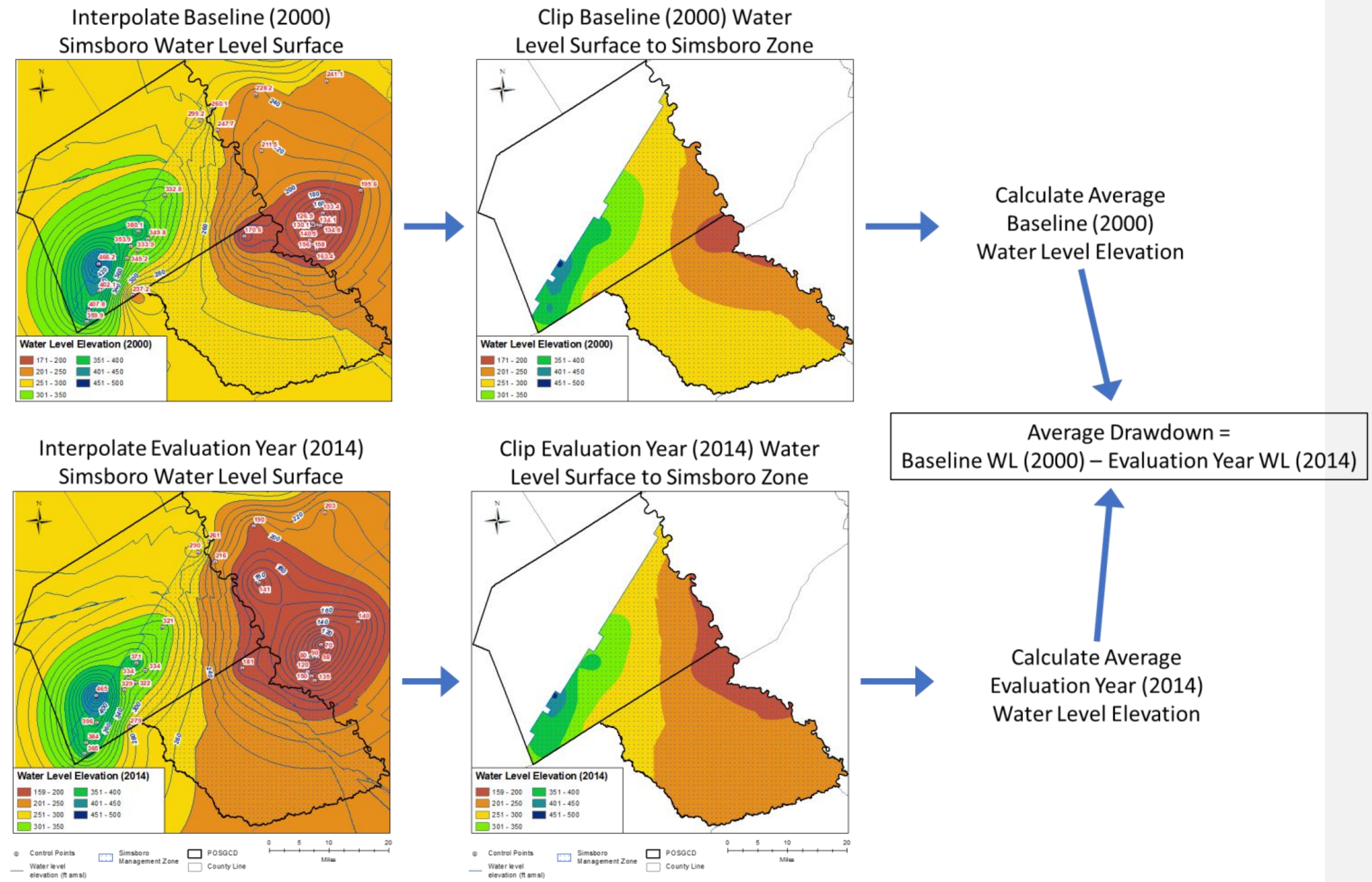

Figure 5-2 Diagram of drawdown calculation method for total aquifer management zones, using Simsboro as example.

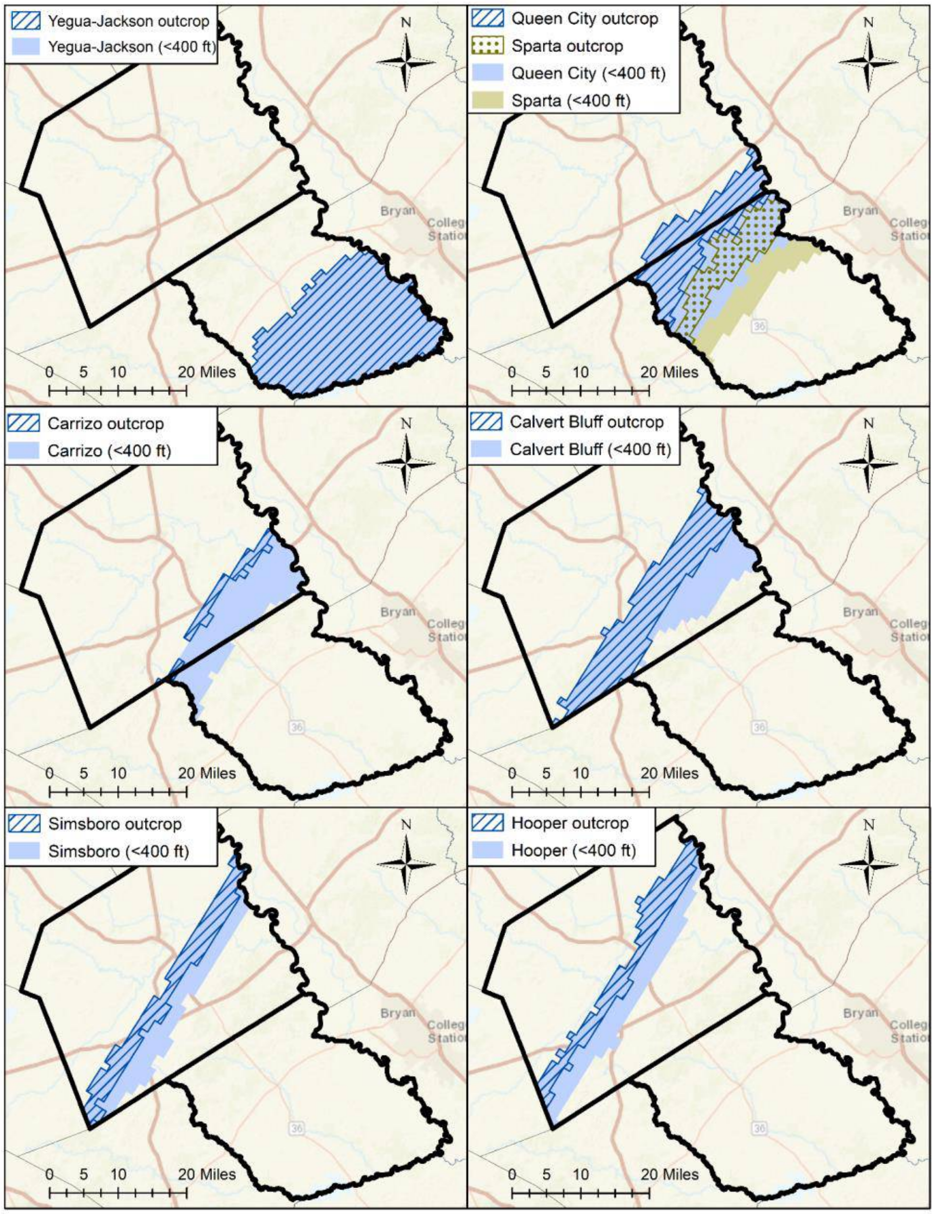

Figure 5-3 POSGCD shallow aquifer management zones for evaluating District PDLs.

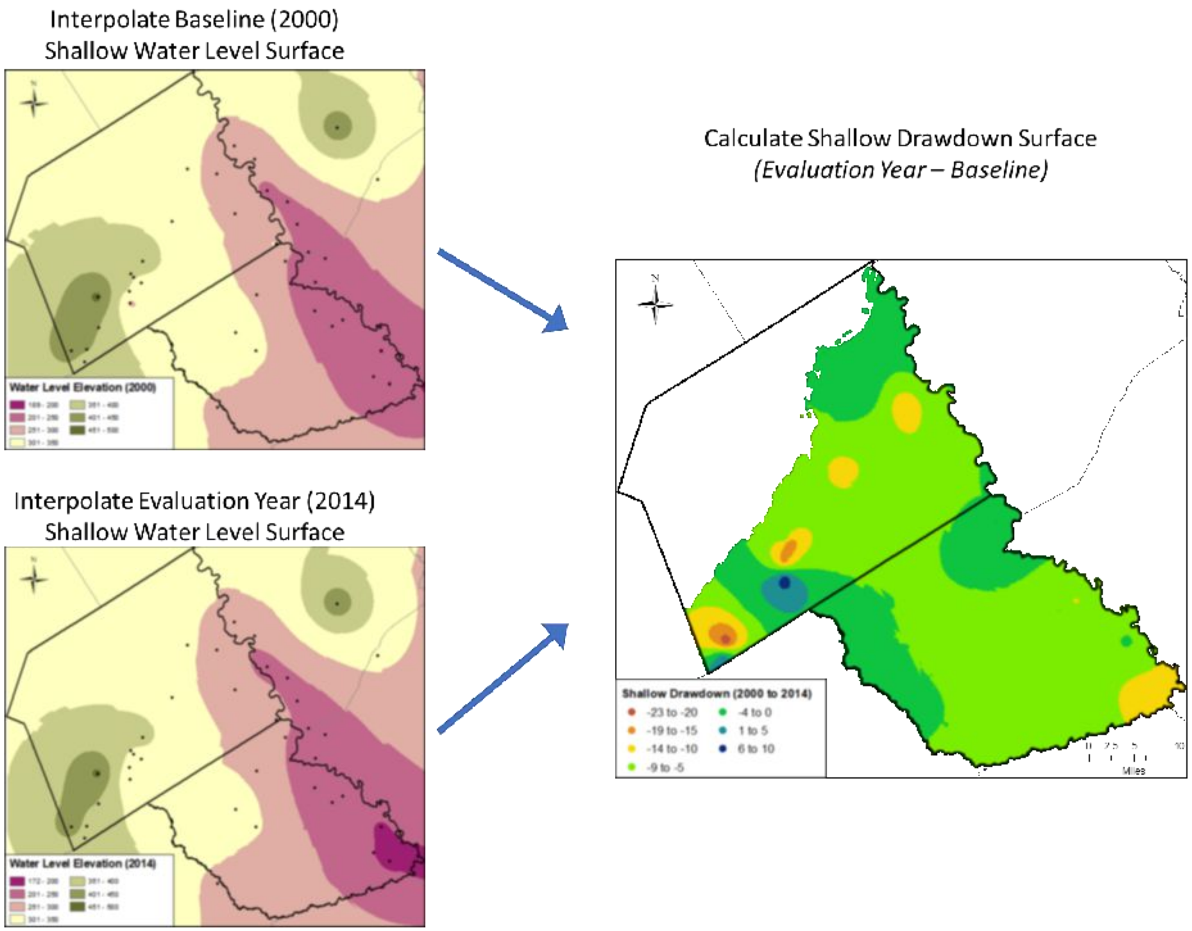

Figure 5-4 Diagram of drawdown calculation method for shallow aquifer zone, using all wells <400 feet deep.

6 EVALUATING COMPLIANCE WITH DFCS AND PDLS

This section describes how POSGCD tracks compliance with DFCs and PDLs.

6.1 DFC Compliance - Total Aquifer Management Zones

POSGCD tracks compliance with DFCs by comparing average drawdowns determined for an aquifer in Section 5 to DFCs. Table 6-1 provides the results from five previous evaluations that include the time periods 2000 to 2012, 2000 to 2013, 2000 to 2014, 2000 to 2014, 2000 to 2015, and 2000 to 2016. Figure 6-1 compares the results from these evaluations to action levels identified in POSGCD Groundwater Rule 16.4 "Actions Based on Monitoring Results." POSGCD does not currently evaluate compliance with the Brazos River Alluvium Aquifer DFC defined as change in saturated thickness.

POSGCD does not currently evaluate compliance with GMA 8 DFCs (Table 1-4) since there is not currently any permitted pumping from these aquifers. POSGCD will re-visit GMA 8 DFCs if and when pumping is permitted in these aquifers in the future.

Table 6-1 Status of DFC compliance by total aquifer management zone (green text indicates compliance, orange text indicates at or above Threshold 1).

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Management Zone	DFC	Drawdown from 2000 to 2012	Drawdown from 2000 to 2013	Drawdown from 2000 to 2014	Drawdown from 2000 to 2015	Drawdown from 2000 to 2016	Drawdown from 2000 to 2017
		Calculated Drawdown (% of DFC)	Calculated Drawdown (% of DFC)	Calculated Drawdown (% of DFC)	Calculated Drawdown (% of DFC)	Calculated Drawdown (% of DFC)	Calculated Drawdown (% of DFC)
Yegua Jackson	100	31.8 (32%)	34.5 (34%)	35.7 (36%)	40.0 (40%)	47.0 (47%)	46.9 (47%)
Sparta	28	3.8 (14%)	3.9 (14%)	4.5 (16%)	6.0 (21%)	10.4 (37%)	14.9 (53%)
Queen City	30	2.2 (7%)	2.5 (8%)	3.0 (10%)	1.9 (6%)	1.1 (4%)	0.4 (1%)
Carrizo	67	6.7 (10%)	9.3 (14%)	--	10.2 (15%)	10.6 (16%)	11.4 (17%)
Calvert Bluff (Upper Wilcox)	149	-13.2 (-9%)	-11.2 (-8%)	-10.5 (-7%)	-9.4 (-6%)	-9.7 (-6%)	-10.7 (-7%)
Simsboro (Middle Wilcox)	318	9.4 (3%)	12.1 (4%)	11.8 (4%)	11.0 (3%)	9.5 (3%)	8.8 (3%)
Hooper (Lower Wilcox)	205	7.1 (3%)	7.3 (4%)	8.0 (4%)	9.1 (4%)	8.6 (4%)	6.0 (3%)

6.2 PDL Compliance - Shallow Aquifer Management Zones

POSGCD will track compliance with PDLs by comparing average drawdowns determined for a shallow management zone in Section 5 to PDLs. Table 6-2 shows the results from five previous evaluations that include the time periods 2000 to 2012, 2000 to 2013, 2000 to 2014, 2000 to 2014, 2000 to 2015, and 2000 to 2016. Figure 6-2 compares the results from these evaluations for the shallow aquifer to action levels identified in POSGCD Groundwater Rule 16.4 "Actions Based on Monitoring Results."

Table 6-2 Status of PDL compliance by shallow aquifer management zone (green text indicates compliance).

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Management Zone	PDL	Drawdown from 2000 to 2012	Drawdown from 2000 to 2013	Drawdown from 2000 to 2014	Drawdown from 2000 to 2015	Drawdown from 2000 to 2016	Drawdown from 2000 to 2017
		Calculated Drawdown (% of DFC)	Calculated Drawdown (% of DFC)	Calculated Drawdown (% of DFC)	Calculated Drawdown (% of DFC)	Calculated Drawdown (% of DFC)	Calculated Drawdown (% of DFC)
Yegua Jackson	20	5.7 (29%)	6.4 (32%)	6.8 (34%)	7.3 (36%)	4.1 (21%)	3.1 (15%)
Sparta	20	4 (20%)	4.5 (22%)	4.9 (25%)	4.5 (22%)	3.1 (15%)	2.4 (12%)
Queen City	20	3.4 (17%)	4.1 (20%)	4.6 (23%)	4.1 (20%)	2.2 (11%)	1.2 (6%)
Carrizo	20	4.7 (23%)	5.8 (29%)	6.2 (31%)	5.6 (28%)	3.5 (18%)	2.2 (11%)
Calvert Bluff (Upper Wilcox)	20	5.9 (29%)	7 (35%)	7.2 (36%)	6.7 (34%)	5.5 (27%)	4.5 (22%)
Simsboro (Middle Wilcox)	20	6 (30%)	6.6 (33%)	6.7 (33%)	6.1 (31%)	5 (25%)	4 (20%)
Hooper (Lower Wilcox)	20	6 (30%)	6.2 (31%)	6.3 (32%)	6.2 (31%)	5.1 (26%)	4.3 (22%)

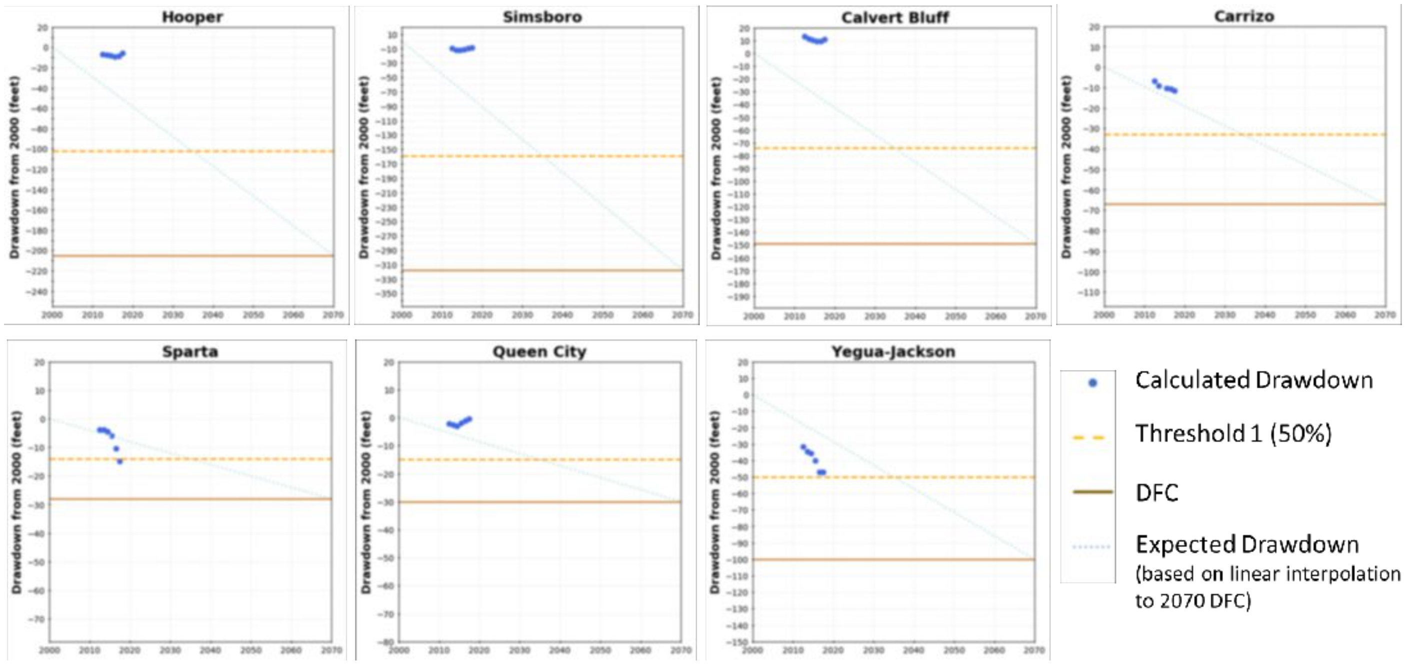

Figure 6-1 Status of DFC compliance by aquifer management zone

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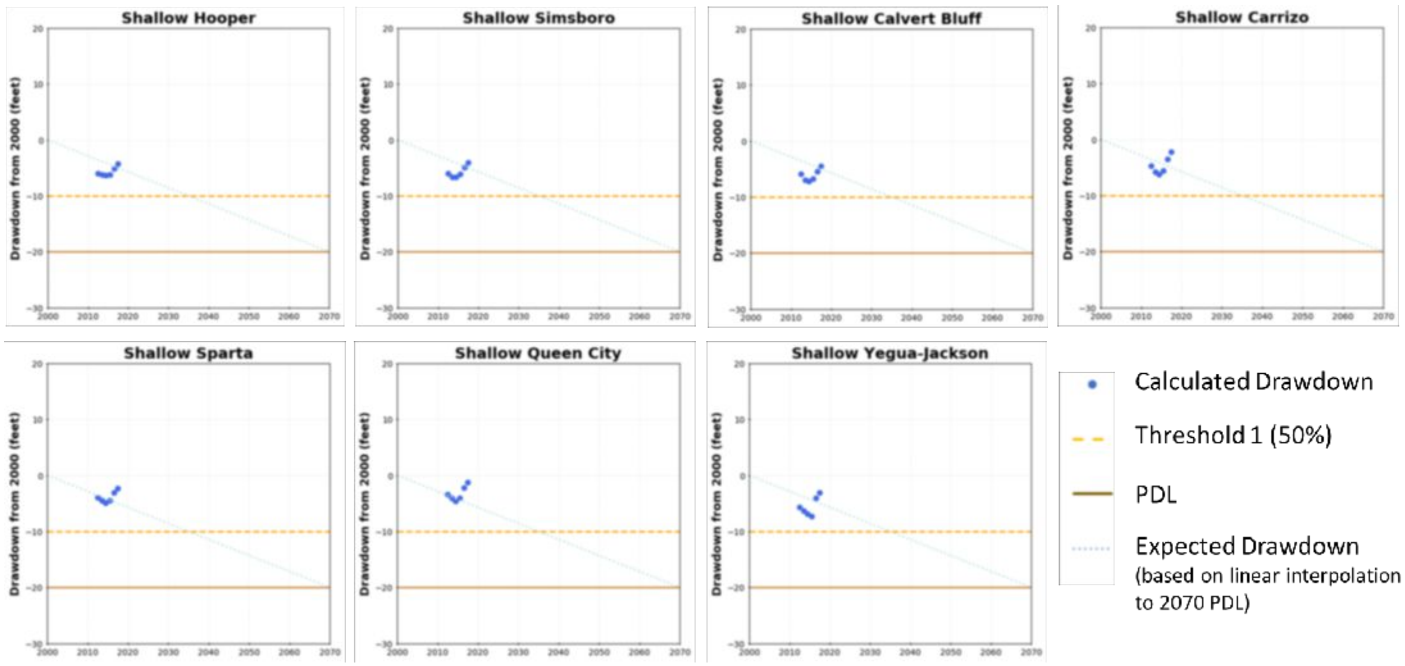

Figure 6-2 Status of PDL compliance by shallow aquifer management zone

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APPENDIX A

POSGCD Groundwater Monitoring Well Network

POSGCD Well Number	State Well Number	Latitude *(decimal degrees)*	Longitude *(decimal degrees)*	Surface Elevation *(ft amsl)*	Depth *(ft)*	Screened Intervals	TWDB Aquifer	POSGCD Aquifer (First Unit)	POSGCD Aquifer (Second Unit)	County	Shallow?	Transducer
25	5917409	30.668888	-96.986388	505	391	226-290, 320-390	124HOOP - Hooper	Simsboro	Hooper	Milam	Yes	Yes
26	5917103	30.723888	-96.982777	457	410	136-410	124HOOP - Hooper	Hooper	--	Milam	No	
53	5909901	30.784166	-96.895555	434	169	109-169	124SMBR - Simsboro	Simsboro	--	Milam	Yes	Yes
59	5911402	30.796944	-96.734444	426	323	307-323	124CABF - Calvert Bluff	Calvert Bluff	--	Milam	Yes	
73	5910907	30.780832	-96.784999	383	440	410-430	124CABF - Calvert Bluff	Calvert Bluff	--	Milam	No	
77	5919103	30.740555	-96.720832	433	522	507-522	124CABF - Calvert Bluff	Calvert Bluff	--	Milam	No	
84	5919302	30.728610	-96.632221	340	45	--	124QNCT - Queen City	Queen City	--	Milam	Yes	
99	5925508	30.569443	-96.947777	410	520	480-520	124CABF - Calvert Bluff	Calvert Bluff	--	Milam	No	
107	5925102	30.600833	-96.982499	412	860	767-782	124SMBR - Simsboro	Hooper	--	Milam	No	Yes
115	5917715	30.640833	-96.987777	443	337	316-337	124SMBR - Simsboro	Simsboro	--	Milam	Yes	
121	5917714	30.663611	-96.995833	475	390	238-370	124SMBR - Simsboro	Hooper	Simsboro	Milam	Yes	
138	5917713	30.666388	-96.995833	485	408	226-346, 356-408	124SMBR - Simsboro	Hooper	Simsboro	Milam	No	
170	5824914	30.658333	-97.016666	495	295	153-233	124SMBR - Simsboro	Hooper	--	Milam	Yes	
221	5909605	30.824443	-96.889721	424	503	340-500	124HOOP - Hooper	Hooper	--	Milam	No	Yes
223	5902706	30.897499	-96.851944	359	315	235-250, 256-298	124WLCX - Wilcox	Hooper	--	Milam	Yes	
234	5902309	30.987777	-96.757777	299	417	185-417	124SMBR - Simsboro	Simsboro	--	Milam	No	Yes
236	5902307	30.964166	-96.790555	416	450	410-450	124WLCX - Wilcox	Simsboro	--	Milam	No	
256	5902901	30.884999	-96.778332	371	318	284-308	124WLCX - Wilcox	Calvert Bluff	--	Milam	Yes	
268	5832101	30.623332	-97.088055	474	60	40-60	124HOOP - Hooper	Simsboro	--	Milam	Yes	
308	5927716	30.537221	-96.741666	452	400	--	124QNCT - Queen City	Queen City	--	Burleson	Yes	
341	5927606	30.578054	-96.650555	394	600	558-600	124QNCT - Queen City	Queen City	--	Burleson	No	
433	5920410	30.695555	-96.614444	299	920	688-710, 794-815	124SMBR - Simsboro	Carrizo	--	Burleson	No	Yes
434	5920409	30.689721	-96.611388	299	230	188-230	124QNCT - Queen City	Queen City	--	Burleson	Yes	
457	5919502	30.679166	-96.673610	462	2018	1832-1958	124CZSB - Carrizo and Simsboro	Simsboro	--	Burleson	No	
518	5927204	30.618888	-96.686388	315	205	163-205	124QNCT - Queen City	Queen City	--	Burleson	Yes	
579	5937611	30.432221	-96.397777	233	240	177-240	124JCKSL - Lower Jackson	Lower Jackson	--	Burleson	Yes	
596	5937329	30.488610	-96.375554	215	58	--	111ABZR - Alluvium, Brazos River	BRAA	--	Burleson	Yes	
638	5937101	30.489166	-96.465000	240	1600	--	124QNCT - Queen City	Sparta	Weches/QC	Burleson	No	Yes
661	5936802	30.386944	-96.564722	342	1609	1513-1573	124SPRT - Sparta	Sparta	--	Burleson	No	
698	5943608	30.310833	-96.646388	270	533	494-533	124YEGUL - Lower Yegua	Lower Yegua	--	Burleson	No	Yes
787	5938701	30.413611	-96.358333	205	56	--	111ABZR - Alluvium, Brazos River	BRAA	--	Burleson	Yes	
791	5935208	30.496354	-96.691918	379	364	322-364	124SPRT - Sparta	Sparta	Above Sparta	Burleson	Yes	
859	5929456	30.543633	-96.493766	231	60	--	111ABZR - Alluvium, Brazos River	BRAA	--	Burleson	Yes	
860	5929457	30.544533	-96.492043	231	60	--	111ABZR - Alluvium, Brazos River	BRAA	--	Burleson	Yes	
877	5928619	30.545555	-96.525554	267	780	605-700, 719-765	124SPRT - Sparta	Lower Yegua	Sparta	Burleson	No	Yes
894	5928601	30.579166	-96.540555	240	58	--	111ABZR - Alluvium, Brazos River	BRAA	--	Burleson	Yes	
895	5928702	30.529166	-96.608333	346	498	456-498	124SPRT - Sparta	Sparta	--	Burleson	No	
943	5934106	30.488610	-96.843610	441	840	800-840	124CRRZ - Carrizo	Carrizo	--	Burleson	No	
1023	5929537	30.549166	-96.436944	225	1090	1048-1090	124SPRT - Sparta	Sparta	--	Burleson	No	

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POSGCD Well Number	State Well Number	Latitude *(decimal degrees)*	Longitude *(decimal degrees)*	Surface Elevation *(ft amsl)*	Depth *(ft)*	Screened Intervals	TWDB Aquifer	POSGCD Aquifer (First Unit)	POSGCD Aquifer (Second Unit)	County	Shallow?	Transducer
1061	5934607	30.450000	-96.783333	404	797	745-797	124QNCT - Queen City	Queen City	--	Burleson	No	
1062	5918101	30.716233	-96.863433	565	790	689-790	124CABF - Calvert Bluff	Calvert Bluff	--	Milam	No	
1063	5918104	30.712780	-96.868890	549	800	650-780	124CABF - Calvert Bluff	Calvert Bluff	--	Milam	No	
1064	5918908	30.632283	-96.788067	520	1687	1490-1534, 1564-1620	124CZSB - Carrizo and Simsboro	Calvert Bluff	--	Burleson	No	
1066	5918705	30.648217	-96.854650	581	813	540-645	124SMBR - Simsboro	Carrizo	--	Milam	No	Yes
1082	5911703	30.787222	-96.716667	367	992	889-980	124SMBR - Simsboro	Calvert Bluff	--	Milam	No	
1110	5824611	30.671417	-97.004500	490	485	190-283, 343-383, 403-423, 463-483	124HOOP - Hooper	Hooper	--	Milam	No	
1117	5917712	30.631200	-96.990100	460	475	270-450, 460-475	124SMBR - Simsboro	Simsboro	--	Milam	No	
1118	5917711	30.634917	-96.991033	462	463	250-300, 345-443, 453-463	124SMBR - Simsboro	Simsboro	--	Milam	No	
1166	5929410	30.557917	-96.470083	225	71	--	111ABZR - Alluvium, Brazos River	BRAA	--	Burleson	Yes	
1197	5934107	30.481100	-96.872100	440	370	150-170, 240-260, 340-360	124QNCT - Queen City	Queen City	--	Burleson	Yes	
1573	5934601	30.432499	-96.756388	383	784	734-774	124QNCT - Queen City	Queen City	--	Burleson	No	
1575	5927718	30.525554	-96.726660	447	1300	1252-1277	124CZCB - Carrizo and Calvert Bluff	Carrizo	Calvert Bluff	Burleson	No	
1789	--	30.798454	-96.748917	436	515	487-507	--	Calvert Bluff	--	Milam	No	
1883	5832704	30.506500	-97.118558	482	180	160-180	124SMBR - Simsboro	Simsboro	--	Milam	Yes	
2152	5925409	30.560960	-96.995140	467	480	450-470	124CABF - Calvert Bluff	Calvert Bluff	--	Milam	No	
2191	5917716	30.644744	-96.989442	464	520	470-490	124HOOP - Hooper	Hooper	--	Milam	No	
2423	5902904	30.905951	-96.778042	401	240	180-220	124SMBR - Simsboro	Calvert Bluff	--	Milam	Yes	
6145	5927611	30.545711	-96.637995	397	770	650-750	ND	Queen City	--	Burleson	No	
6243	5925502	30.565500	-96.941000	427	614	593-614	124CZCB - Carrizo and Calvert Bluff	Calvert Bluff	--	Burleson	No	
6305	5832908	30.531240	-97.026850	438	344	--	124CABF - Calvert Bluff	Calvert Bluff	--	Milam	Yes	
6586	5927309	30.613416	-96.660202	381	260	240-260	ND	Weches	--	Burleson	Yes	
6621	5926402	30.552496	-96.860040	489	2020	1580-1780	124SMBR - Simsboro	Simsboro	--	Burleson	No	Yes
6910	5926403	30.564870	-96.834660	496	2200	1750-1950, 2060-2090	124SMBR - Simsboro	Simsboro	--	Burleson	No	Yes
7364	5824612	30.684551	-97.040073	432	180	160-180	124HOOP - Hooper	Hooper	--	Milam	Yes	
7506	5824610	30.671633	-97.003883	492	392	165-193, 196-259, 339-390	124HOOP - Hooper	Hooper	--	Milam	Yes	Yes
7774	5910705	30.780000	-96.862300	442	560	535-555	124CABF - Calvert Bluff	Simsboro	--	Milam	No	
7793	5925103	30.600880	-96.982490	412	420	400-420	124WLCX - Wilcox	Calvert Bluff	--	Milam	No	
7965	--	30.563800	-96.479600	231	1260	--	--	Queen City	--	Burleson	No	
7998	--	30.789912	-96.763097	490	460	435-455	--	Calvert Bluff	--	Milam	No	
8172	--	30.513820	-97.164501	579	370	330-370	--	Hooper	--	Milam	Yes	
8239	5928804	30.536717	-96.578450	304	460	418-460	124SPRT - Sparta	Lower Yegua	--	Burleson	No	
8388	5943104	30.355200	-96.717300	326	3988	3600-3800	124SMBR - Simsboro	Simsboro	--	Burleson	No	
8415	5929433	30.544721	-96.498610	233	59	--	111ABZR - Alluvium, Brazos River	BRAA	--	Burleson	Yes	
8451	5925408	30.563228	-96.962233	382	690	300-380, 620-680	124CABF - Calvert Bluff	Calvert Bluff	--	Milam	No	
8658	5910706	30.771300	-96.846400	420	528	508-528	124SMBR - Simsboro	Simsboro	--	Milam	No	
8767	5934108	30.483595	-96.860039	411	2230	1800-2100	124SMBR - Simsboro	Simsboro	Calvert Bluff	Burleson	No	Yes

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POSGCD Well Number	State Well Number	Latitude *(decimal degrees)*	Longitude *(decimal degrees)*	Surface Elevation *(ft amsl)*	Depth *(ft)*	Screened Intervals	TWDB Aquifer	POSGCD Aquifer (First Unit)	POSGCD Aquifer (Second Unit)	County	Shallow?	Transducer
8935	5901904	30.913160	-96.886300	390	80	64-74	124HOOP - Hooper	Hooper	--	Milam	Yes	
8959	--	30.681466	-96.786821	442	810	790-810	--	Calvert Bluff	--	Milam	No	
9064	--	30.603240	-96.536250	241	3255	2400-2410, 2750-2760	--	Calvert Bluff	Simsboro	Burleson	No	Yes
9095	5910707	30.771301	-96.846388	420	580	550-570	124SMBR - Simsboro	Simsboro	--	Milam	No	
9104	5928342	30.606600	-96.534440	243	380	340-380	124SPRT - Sparta	Sparta	--	Burleson	Yes	
9157	5936809	30.391670	-96.556110	294	592	520-580	124JKYG - Jackson and Yegua	Lower Yegua	--	Burleson	No	Yes
9166	5918108	30.711389	-96.862500	505	1240	1178-1220	124SMBR - Simsboro	Simsboro	--	Milam	No	Yes
9167	5918109	30.711389	-96.862500	505	140	90-130	124CRRZ - Carrizo	Calvert Bluff	--	Milam	Yes	
9215	--	30.511139	-96.897167	386	2724	1560-1570, 2100-2110, 2130-2140	--	Simsboro	--	Burleson	No	
9230	--	30.596886	-96.878937	526	1720	1590-1600, 1710-1720	--	Simsboro	--	Burleson	No	
9327	--	30.906660	-96.888880	368	140	120-140	--	Below Hooper	--	Milam	Yes	
9346	--	30.540583	-96.907083	0	80	--	--	Reklaw	--	Burleson	Yes	
9372	--	30.541111	-96.904850	0	120	--	--	Queen City	--	Burleson	Yes	
9445	--	30.427742	-96.762821	0	400	--	--	Sparta	--	Burleson	Yes	Yes
9446	--	30.572378	-96.920656	0	2350	--	--	Simsboro	--	Burleson	No	
58-24-9D4N	--	30.634119	-97.008415	464	188	163-183	--	Simsboro	--	Milam	Yes	
58-24-9V7	--	30.633943	-97.037523	500	--	--	--	--	--	Milam	--	
58-31-9A8	--	30.507962	-97.158012	544	120	110-120	--	Hooper	--	Milam	Yes	
58-31-9B1	--	30.519604	-97.128551	552	235	205-235	--	Simsboro	--	Milam	Yes	
58-32-3A7N	--	30.608502	-97.007428	435	271	250-270	--	Calvert Bluff	--	Milam	Yes	
58-32-4A1	--	30.556658	-97.088541	495	174	154-174	--	Simsboro	--	Milam	Yes	
58-32-7A3	--	30.509591	-97.120047	493	185	175-185	--	Simsboro	--	Milam	Yes	
58-32-7B1	--	30.518687	-97.108176	477	123	103-123	--	Simsboro	--	Milam	Yes	
58-39-3A8	--	30.482943	-97.126022	476	182	162-182	--	Simsboro	--	Milam	Yes	
59-17-3A9	--	30.696090	-96.918013	450	418	378-418	--	Calvert Bluff	--	Milam	No	
59-17-3B8	--	30.743985	-96.888371	433	--	--	--	--	--	Milam	--	
59-17-4A7	--	30.698952	-96.972804	430	113	93-113	--	Simsboro	--	Milam	Yes	
59-17-505	--	30.681059	-96.948042	432	540	498-540	--	Simsboro	--	Milam	No	
59-17-705	--	30.651470	-96.978145	490	326	286-326	--	Simsboro	--	Milam	Yes	
59-17-7C1	--	30.660943	-96.980573	491	750	720-750	--	Hooper	--	Milam	No	
59-17-8B8	--	30.643409	-96.942916	478	385	--	--	Calvert Bluff	--	Milam	Yes	
59-25-4C5	--	30.543583	-96.994972	443	690	545-690	--	Simsboro	Calvert Bluff	Milam	No	
59-25-5A6	--	30.569386	-96.949069	401	734	694-734	--	Calvert Bluff	--	Milam	No	
UNK_01	--	30.427742	-96.762821	361	500	280-320, 365-395	--	Sparta	Above Sparta	Burleson	No	
UNK_02	--	30.572378	-96.920656	423	2350	1620-1630, 1706-1716, 1870-1880	--	Simsboro	--	Burleson	No	

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APPENDIX B

POSGCD Aquifer Assignment Methodology

The following section outlines the methodology used by POSGCD to assign monitoring wells to aquifers. This methodology focuses on comparing the aquifer tops and bottoms (based on groundwater availability model surfaces) to screened intervals at a well location. The aquifer surfaces for the Queen City, Sparta, Carrizo, Calvert Bluff, Simsboro, and Hooper aquifers are taken from the Groundwater Availability Model (GAM) for the Queen City and Sparta Aquifers (Kelley and others, 2004). The aquifer surfaces for the Yegua-Jackson Aquifer are taken from the Yegua-Jackson Aquifer GAM (Deeds and others, 2010).

Step 1:
Extract the top and bottom of aquifer surfaces from groundwater available models (GAMs) at the center of the GAM grid cells.

Step 2:
Develop rasters for the tops and bottoms of aquifers of interest using the information from Step 1.

Step 3:
At each well location (designated by a latitude and longitude), extract the elevation of the tops and bottom of aquifers of interest. Convert the aquifer elevations to depths below ground surface elevation.

Step 4:
Using information from driller logs, the TWDB groundwater well database, field-measured values, or data tables in state reports, record the depth of the well and depth to each of the well's screened intervals into the POSGCD well database.

Step 5:
Using information from Steps 1 through 4, determine in which aquifer or formation the well terminates and in which aquifer or formation the screened intervals of a well are partitioned. Determine whether the well screen intervals reside in a single aquifer or multiple aquifers. If the well screens span multiple aquifers, then determine the portion of the well screens that intersect the different aquifers.

Step 6:
Construct figures that show the bottom of the well and the vertical location of the well screens relative to the tops and bottoms of the aquifers that exist at the well location.

Step 7:
Construct a table that lists the aquifers that the well screens intersect and the thickness of each intersected aquifer.

Step 8:
For wells with screens that intersect only one aquifer, assign the well to the aquifer intersected by the well screen.

Step 9:
For wells with screens that intersect more than one aquifer, assign the well to all aquifers intersected with priority given to the aquifer that contains the largest screened interval.

APPENDIX C

POSGCD Monitoring Protocols

Draft: Post Oak Savannah Groundwater Conservation District Monitoring Protocols

Post Oak Savannah Groundwater Conservation District
310 E Ave C
Milano, TX 76556

January 2018

Version 1.0

I. WATER LEVEL MEASUREMENT PROTOCOLS

A. Steel Tape (wetted-tape) method

Appropriate Wells for this method:

- ✓ water levels < 500 ft (< 200 ft for best results)
- ✓ an estimated water level is available

- X does NOT have angled casing
- X is NOT pumping
- X is NOT flowing
- X does NOT have water dripping into well or condensing on well casing

Required Materials:

- Graduated steel tape.
- Non-lead break-away weight (to attach to the end of the tape, if necessary)
- Non-toxic blue carpenter's chalk
- Clean rag.
- Pencil or pen.
- Water-level measurement field form.
- Two wrenches with adjustable jaws or other tools for removing well cap.
- Cleaning supplies for water-level tapes.

Steps:

1. If well is equipped with a submersible pump, confirm and record that the pump is not in operation. If the pump is operating, no water-level measurement should be taken or recorded. Obtain permission to collect measurement at a later time.
2. Record how long the pump has been off prior to taking the measurement. If the well has been pumped less than 24 hours prior to taking the water-level measurement, try to reschedule the measurement for another time when the pump can be shut down for the recommended 24 hours. If rescheduling is not possible, mark the *Less than 24 hrs* box on the field form. Estimate how long the well has been off and enter the time since pumping.
3. Identify a port or opening that provides access for the steel tape.
4. Measure and record the height of this opening above ground level. Record this as the measuring point correction value (*MP correction*). Describe the measuring point in the official record for the well, and use the same measuring point each time when measuring the water level. If not possible, record the height of the measuring point above land surface each time the static water level is measured.

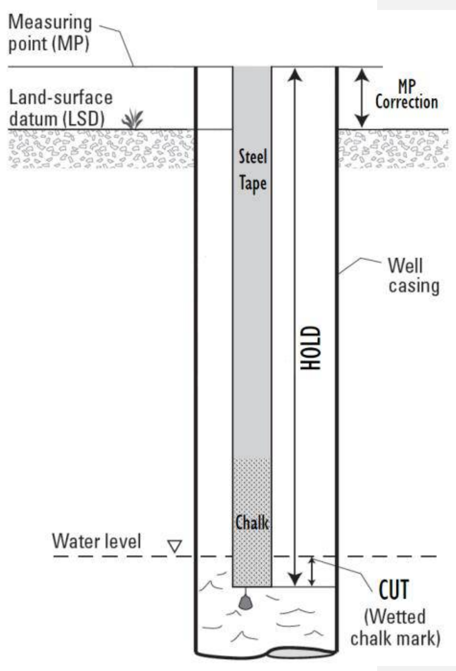


Figure 6-3 Steel tape diagram (modified from USGS, 2011)

5. Chalk the lowest 20 feet of the tape using a piece of blue carpenter's chalk.
6. Review recent measurements from the well and calculate a depth that is 10 feet lower than the last recorded static water level. Record this as the HOLD value.
7. Pinch the thumb and index finger on the tape at the HOLD value. Lower the weight and tape into the well the thumb and index finger meet the MP. The weight and tape should be lowered into the water slowly to prevent splashing.
8. Bring the tape to the surface. Record the length of the wetted chalk as the CUT value.
9. Subtract the CUT from the HOLD and record this number as the *Depth to water from MP*.
10. Remove the wet chalk, wait 5 minutes and then make a check measurement by repeating steps 5 through 9 using a different HOLD value (1-2 feet lower or deeper) than that used for the original measurement.
11. If the check measurement does not agree with the original measurement within 0.02 foot, continue to make measurements until the measurements agree. If measurements continue to be unreliable, note in field log and reschedule the water-level measurement for a future date.
12. Subtract the *MP correction* from the *Depth to water from MP* value to get the depth to water below land-surface datum (LSD). Record the water level as the *Depth to Water from Land Surface*. Note: If the water level is above LSD, record the depth to water in feet below land surface as a negative number.
13. Record date and time of measurement.
14. After completing the water-level measurement, remove the chalk and clean the lowest 30 feet with bleach wipes (0.525% sodium hypochlorite) or a chlorine bleach solution (minimum 0.5% sodium hypochlorite [NaOCl] and water). This will reduce the possibility of contamination of other wells from the tape.
15. Replace cap on any port in discharge head or casing. Leave the well and pump in the same condition as you found it prior to measurement.

Data Recording

- Scan and enter handwritten field water level measurements and notes into the official POSGCD digital database within 2 weeks of the measurement.

Other considerations

- Periodically check the tape for rust, breaks, kinks, and stretching.
- Calibrate the tape annually by comparing to an unused (unstretched) tape.

B. Electric Tape (E-Line) method

Appropriate Wells for this method:

- ✓ water levels < 500 ft (< 200 ft for best results)
- ✓ dripping or condensation on inside casing is OK
- X does NOT have very low specific conductance
- X does NOT have angled casing

Required Materials:

- Electric tape and supply reel.
- Clean rag.
- Pencil or pen.
- Water-level measurement field form.
- Two wrenches with adjustable jaws or other tools for removing well cap.
- Cleaning supplies for water-level tapes.
- Replacement batteries

Steps:

1. If well is equipped with a submersible pump, confirm and record that the pump is not in operation. If the pump is operating, no water-level measurement should be taken or recorded. Obtain permission to collect measurement at a later time.
2. Record how long the pump has been off prior to taking the measurement. If the well has been pumped less than 24 hours prior to taking the water-level measurement, try to reschedule the measurement for another time when the pump can be shut down for the recommended 24 hours. If rescheduling is not possible, mark the *Less than 24 hrs* box on the field form. Estimate how long the well has been off and enter the time since pumping.
3. Identify a port or opening that provides access for the steel tape.
4. Measure and record the height of this opening above ground level. Record this as the measuring point correction value (*MP correction*). Describe the measuring point in the official record for the well, and use the same measuring point each time when measuring the water level. If not possible,

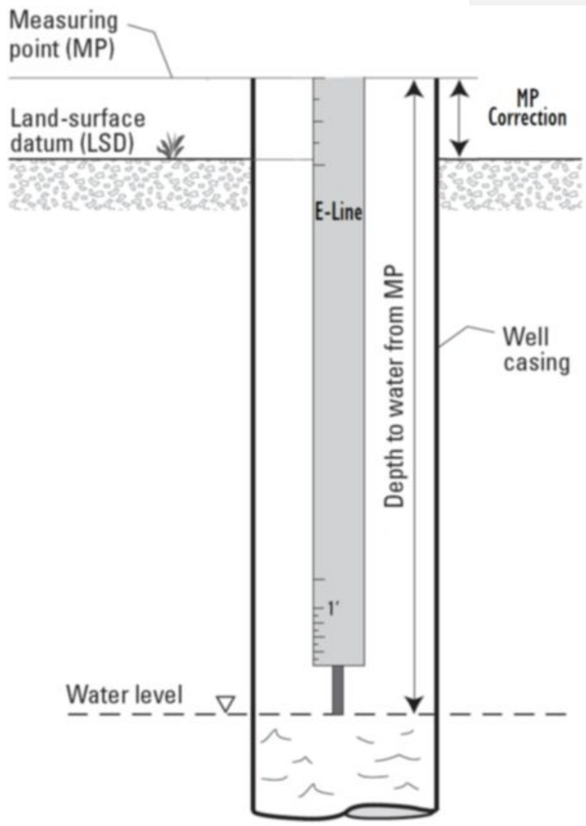


Figure 6-4 Electric tape diagram (modified from USGS, 2011)

record the height of the measuring point above land surface each time the static water level is measured.

5. Prior to lowering the tape down the well, dip the probe into tap water to check whether the electric tape is working properly.
6. Lower the tape slowly into the well until the indicator shows that the probe has made contact with the water surface.
7. Retract the e-line about one foot above the water surface and slowly lower again until the probe makes contact with the water surface.
8. Hold the electric line with a fingertip at the measuring point. Based on the 0.01 feet markings on the electric line, determine depth to water to the nearest 0.01 of a foot and record this value as the *Depth to water from MP*.
9. Retract the e-line about 5 feet, wait five minutes and then repeat the measurement.
10. If the check measurement does not agree with the original measurement within 0.05 foot, continue to make measurements until the measurements agree. If measurements continue to be unreliable, note in field log and reschedule the water-level measurement for a future date.
11. Subtract the *MP correction* from the *Depth to water from MP* value to get the depth to water below land-surface datum (LSD). Record the water level as the *Depth to Water from Land Surface*. Note: If the water level is above LSD, record the depth to water in feet below land surface as a negative number.
12. Record date and time of measurement.
13. After completing the water-level measurement, remove the chalk and clean the lowest 30 feet with bleach wipes (0.525% sodium hypochlorite) or a chlorine bleach solution (minimum 0.5% sodium hypochlorite [NaOCl] and water). This will reduce the possibility of contamination of other wells from the tape.
14. Replace cap on any port in discharge head or casing. Leave the well and pump in the same condition as you found it prior to measurement.

Data Recording

- Scan and enter handwritten field water level measurements and notes into the official POSGCD digital database within 2 weeks of the measurement.

Other considerations

- Periodically check the tape for rust, breaks, kinks, and stretching.
- Calibrate the tape annually by comparing to an unused (unstretched) steel tape and/or checking measurements against measurements from a calibrated steel tape.
- Check battery strength regularly.

C. Air Line method

Appropriate Wells for this method:

- ✓ Air line is already installed or can be installed
- ✓ Depth of air line is known

Required Materials:

- 1/8 or 1/4-inch diameter air line (seamless copper tubing, brass tubing, galvanized pipe or flexible plastic tubing)
- suitable pipe tee for connecting an altitude or pressure gauge to air line.
- Calibrated altitude gauge (readings in feet) or pressure gauge (readings in psi), and spare gauges.
- Compressed air source (ex. tire pump) and corresponding valve stem (ex. Schrader valve)
- Small open-end wrench
- Wire or electrician's tape
- Graduated steel tape
- Blue carpenter's chalk
- Clean rag
- Field notebook
- Pencil or pen
- Water-level measurement field form

Steps:

1. If well is equipped with a submersible pump, confirm and record that the pump is not in operation. If the pump is operating, no water-level measurement should be taken or recorded. Obtain permission to collect measurement at a later time.
2. Record how long the pump has been off prior to taking the measurement. If the well has been pumped less than 24 hours prior to taking the water-level measurement, try to reschedule the measurement for another time when the pump can be shut down for the recommended 24 hours. If rescheduling is not possible, mark the *Less than 24 hrs* box on the field form. Estimate how long the well has been off and enter the time since pumping.

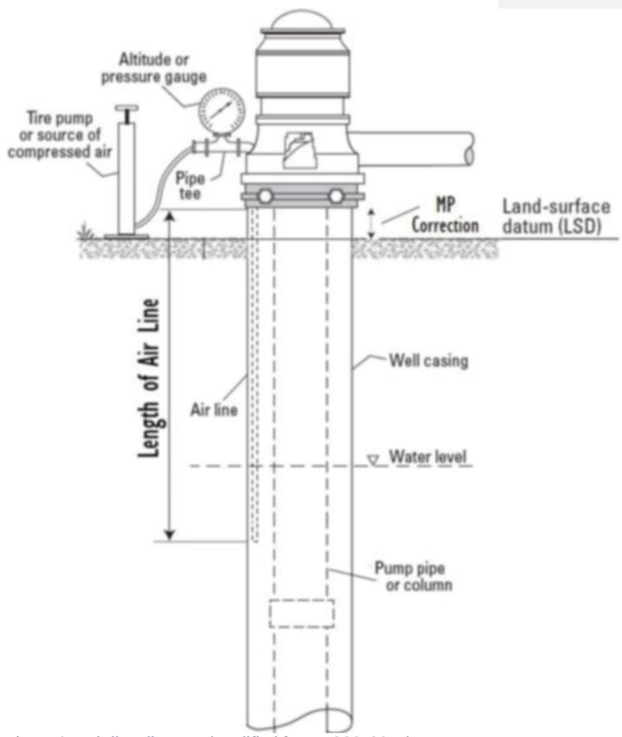


Figure 6-5 Air line diagram (modified from USGS, 2011)

3. Attach a pipe tee to the top end of the air line. On the opposite end of the pipe tee, attach a Schrader valve stem.
4. Use a wrench to connect an altitude gauge (readings in feet) or a pressure gauge (readings in psi) to the fitting on top of the pipe tee.
5. Connect a compressed air source to the valve stem fitting on the pipe tee.
6. Add compressed air to the air line and make sure that the gauge shows pressure is increasing. If the gauge does not move, this means there is a leak. Check connections and retry until problem is fixed. If problem cannot be fixed, retry with a different pressure gauge. If problem still cannot be fixed, measurement by air line is not possible.
7. Continue adding compressed air to the air line until gauge pressure stops increasing. This means all the water has been purged from the air line. Record this maximum pressure as the pressure at the bottom of the air line.
8. Remove the compressed air and make sure that the gauge shows pressure slowly decreasing. If the pressure instead decreases sharply to zero, this means there is a leak in the air line (ex. the tubing is cut or severed). If the pressure does not change, this means there is a blockage in the air line (ex. the tubing is plugged or crushed). In these cases, retry with a different pressure gauge. If problem cannot be fixed, measurement by air line is not possible until air line is replaced.
9. If air line and pressure gauge are working correctly, then after removing the compressed air, the gauge should slowly decrease and eventually stop at a constant pressure. Once the gauge holds constant for 5 minutes, record the gauge reading as the pressure of the water above the bottom of the air line.
10. Repeat steps 7 through 9 until gauge readings are consistent.
11. a) If using an altitude gauge (reads in feet), subtract the gauge reading from the total length of air line. Record this value as *Depth to water from MP*.
    b) If using a pressure gauge (reads in psi), multiply the gauge reading by 2.31 to convert pressure to feet. Subtract this value from the total length of air line. Record this value as *Depth to water from MP*.
12. Subtract the *MP correction* from the *Depth to water from MP* value to get the depth to water below land-surface datum (LSD). Record the water level as the *Depth to Water from Land Surface*. Note: If the water level is above LSD, record the depth to water in feet below land surface as a negative number.
13. Record date and time of measurement.
14. Replace cap on any port in discharge head or casing. Leave the well and pump in the same condition as you found it prior to measurement.

Data Recording

- Scan and enter handwritten field water level measurements and notes into the official POSGCD digital database within 2 weeks of the measurement.

Other considerations

- If possible, air line length and measurement accuracy should be verified using an independent method (ex. steel tape measurement).
- The altitude/pressure gauge should be periodically calibrated.

D. Transducer method

Appropriate Wells for this method:

✓ Transducer is already installed or can be installed
✓ Has reliable power supply

X Water levels do NOT fluctuate beyond range of transducer

Required Materials:

- Vented submersible pressure transducer (most installations) or non-vented submersible pressure transducer (for telemetry installations)
- Perforated PVC pipe to provide protective housing for transducer (necessary in pumping wells)
- Transducer Cables
- Suspension system for the transducer and cables (ex. wire ties)
- Power supply
- Computer with appropriate adapters and transducer software
- Graduated steel tape
- Blue carpenter's chalk
- Clean rag
- Field notebook
- Pencil or pen
- Contact-burnishing tool (ex. artist's eraser)
- Multi-meter
- Spare desiccant
- Replacement batteries
- Water-level measurement field form

Steps (Initial Installation):

1. Based on known well characteristics, choose the appropriate type of transducer for the well. For wells with little or no pumping, a 30 psi transducer (which allows 69 feet of submergence) is sufficient. In high-volume pumping wells, a 100 psi transducer (which allows for up to 197 feet of submergence) may be necessary.
2. For pumping wells, determine the depth to the pump and manufacture a protective sleeve that is long enough to extend well head down to just above the pump. This will be used to isolate the transducer from any frequency or electrical noise that may be generated by the pump.

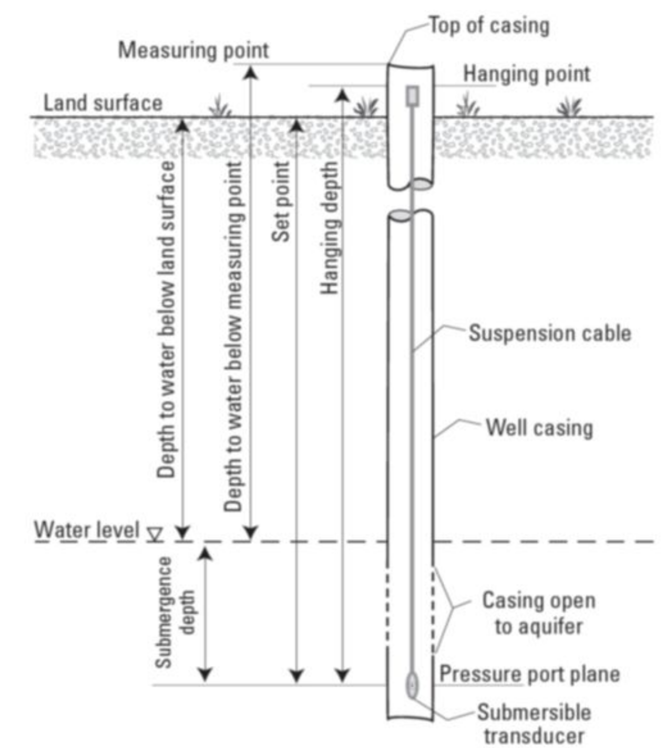


Figure 6-6 Transducer diagram (modified from USGS, 2011)

3. Prior to going to field, install manufacturer supplied software to computer(s) that will be used to interface with the transducers and make sure software is working correctly.
4. Follow manufacturer's instructions to install transducer onto cable and connect transducer cable to computer, allowing software to establish signal to transducer.
5. In the software, input settings for data recording task. Start with a data collection frequency of one measurement per hour. After signal established and transducer programmed, disconnect transducer from computer.
6. Measure the water level in the well with a steel tape following the steel tape measuring protocol.
7. Install transducer in well by lowering it (with its protective pipe, if used) into the well slowly until it is submerged below the water level measured with the steel tape. **Do NOT allow the transducer to free fall into the well.**
8. Continue lowering the transducer until it is deep enough that it will not go dry under anticipated water levels. For wells with little to no pumping (30 psi transducer), lower the transducer to approximately 50 feet below depth to water. For wells with high-volume pumping (100 psi transducer), lower the transducer to either the depth to the pump or 150 feet below depth to water, whichever is shallower.
9. Secure transducer and cable following manufacturer's recommendations to keep unit stable.
10. Mark the cable at the hanging point so that any future slippage can be determined.
11. Reconnect transducer to computer and ensure that the channel, scan intervals, and other functions selected are correct. Activate the data logger and set the correct time. Check that the water level measured is consistent with the water level measured with the steel tape. Make sure the data logger is operating prior to disconnecting from computer.
12. Record well and measuring point (MP) configuration, including the MP correction length above the land surface, the hanging point, and the hanging depth.

13. If necessary, install an instrument shelter that will protect the transducer and data logger from vandalism and weather.

Steps (Existing Installation):

1. Every 3-4 months (or life expectancy of desiccant), retrieve groundwater data by connecting transducer cable to computer and using data logger software.
2. Record the current water level displayed by the sensor.
3. Measure the water level in the well with a steel tape following the steel tape measuring protocol and record this value.
4. If the water-level measurement and transducer reading differ by more than 1 foot:
    a. Check that the transducer is working by raising the transducer in the well slightly and taking a reading. Return transducer exactly to its original position after this check.
    b. Check for other causes of measurement inconsistency such as cable kinks or slippage.
    c. Recalibrate or replace the transducer if necessary and reset the instrumentation to reflect the proper depth to water.
    d. Note ALL changes in the record.
5. If the water-level measurements retrieved from the transducer over the past months show any periods of flat-lining, this means the transducer went dry and indicates that the water level fluctuation exceeded the range of the transducer. If a 30 psi transducer is being used, replace the transducer with a 100 psi transducer and lower it to a deeper depth. If a 100 psi transducer is being used, lower the transducer to a deeper depth. If problem persists, continuous water level monitoring may not be possible at that well.
6. Perform basic maintenance checks:
    a. Check the charge on the battery and the charging current supply to the battery using a multimeter and replace batteries as necessary
    b. Check connections to the data logger and tighten as necessary.
    c. If corrosion is occurring, burnish contacts.
    d. Check desiccant and replace if necessary.
7. Verify the logger channel and scan intervals, document any changes to the data logger program, and reactivate the data logger to resume data collection. Make sure the data logger is operating prior to disconnecting cable from computer.
8. Repeat Steps 1 through 6.

Data Recording

- Scan and enter handwritten field water level measurements and notes into the official POSGCD digital database within 2 weeks of the measurement.
- Process downloaded transducer data and enter into the official POSGCD digital database within 2 weeks of collection.
- If data is collected remotely via telemetry, upload to the official POSGCD digital database weekly every Sunday at midnight.

Other considerations

- Transducers should be checked against other water level measurement methods regularly.
- Transducers may need to be periodically recalibrated and/or replaced.

II. Water Quality Measurement Protocols

A. Specific conductance meter (TDS)

Appropriate Wells for this method:

- ✓ Direct water sample retrievable
- ✓ Approx. TDS range known

- X Does NOT have high TDS values (that exceed range of meter)

Required Materials:

- Specific conductance meter
- Standard solution for instrument calibration
- Deionized water
- Plastic wash bottle
- Kimwipes
- Pencil or pen
- Water-level measurement field form
- Lab collection container & lab-specific instructions [if sending sample to outside testing facility]

Steps:

1. The meter should be calibrated on-site with two conductivity standards that bracket the expected conductivity of the sample. Pick these two standards and verify that they are not expired.
2. Bring standard solutions to the temperature of well water by suspending the standards in a bucket into which well water is flowing. Allow at least 15 minutes for temperature equilibration.
3. Rinse the probe with deionized water and blot dry.
4. Connect the probe to the meter and place the probe in one of the standardizing solutions.
5. Set the selector knob to conductivity and allow the reading to stabilize. Adjust the reading using the knob on the back of the instrument until the reading matches that of the standard.
6. Remove the conductivity probe from the standard solution, rinse with deionized water, and blot dry.
7. Repeat steps 4 through 6 with the second standardizing solution.
8. Submerge multimeter into well water and wait for temperature, pH and conductivity values to stabilize. Record temperature, pH and conductivity once readings have stabilized.
9. If taking a grab sample for further laboratory testing, acquire clean water sample from well after multimeter readings have stabilized. Follow the lab-specific instructions for collection and packaging of grab sample.
10. Remove probe, rinse with deionized water, and blot dry.
11. Turn meter off, disconnect probe, and pack both in their case.

Data Recording

- Scan and enter handwritten field water level measurements and notes into the official POSGCD digital database within 2 weeks of the measurement.
- Process downloaded transducer data and enter into the official POSGCD digital database within 2 weeks of collection.

Other considerations

- Meters need to be calibrated before each measurement.
- Calibration standard solutions need to be replaced regularly.
- Meters need regular maintenance and should be checked and calibrated periodically.

APPENDIX D

POSGCD Health and Safety Plan

APPENDIX E

POSGCD Water Level Measurement Form

Commented [JH9]: Updated

Aquifer(s) ____________________ **State Well No.** ____________

Owner **Address:** ____________________

Land Surface Elevation : ______________ **County:** ____________________

Well Location: Lat: ____________________ **Phone:** __________________
Long: ____________________

Pump: Type: __________ **Depth:** ft.
Setting: __________ft.
M.P. ____________ ft. above land surface

Remarks:

Date of current measurement mm/dd/yyyy	Time since last pumped	Less than 24 hrs	Measuring Method	Measuring Point (MP) correction	Steel Tape Only		Depth to water from MP	Depth to water from Land Surface	Change in level since last static measurement	Field Observations	User I.D.
					HOLD	CUT					

APPENDIX F

Determining Average Drawdown in POSGCD Aquifer Management Zones for GMA 12 DFCs

The following section summarizes the methodology used by POSGCD to calculate average drawdown in the Aquifer Management Zones in order to determine DFC compliance:

Step 1:

For each monitoring well in the aquifer, determine the average *baseline* water level by averaging all water levels recorded at that well during a 3-year window around 2000 (1999 to 2001), including available monitoring data from neighboring Brazos Valley GCD and Lost Pines GCD.

Step 2:

For each monitoring well in the aquifer, determine the average *end* water level by averaging all water levels recorded at that well during a 3-year window around the *end* year, including available monitoring data from neighboring Brazos Valley GCD and Lost Pines GCD.

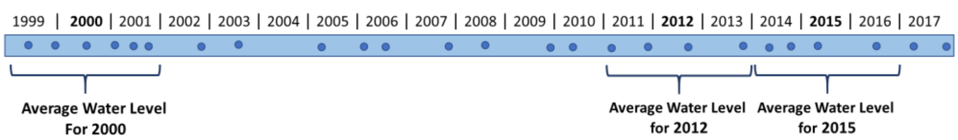


Figure E-1 Diagram of 3-year moving average calculation. Dots represent water level measurements.

Step 3a:

Using only those wells with a water level value in both the *baseline* year (2000) and the *end* year, interpolate a *baseline* (2000) water level surface with 500-foot grid cell size for the aquifer using the Kriging toolbox in ArcGIS.

Step 3b:

Using only those wells with a water level value in both the *baseline* year (2000) and the *end* year, interpolate a *current* water level surface with 500-foot grid cell size for the aquifer using the Kriging toolbox in ArcGIS.

Step 4a:

Clip the *baseline* water level surface (Step 3a) to the Management Zone extent using the Clip Raster toolbox in ArcGIS

Step 4b:

Clip the *end* water level surface (Step 3b) to the Management Zone extent using the Clip Raster toolbox in ArcGIS.

Step 5a:

Determine the average *baseline* water level value from the Raster Properties of the clipped *baseline* water level surface (Step 4a). This represents the average value of all grid cells falling within that Management Zone.

Step 5b:

Determine the average *end* water level value from the Raster Properties of the clipped *end* water level surface (Step 4b). This represents the average value of all grid cells falling within that Management Zone.

Step 6:

Calculate drawdown by subtracting the *end* water level value (Step 5b) from the *baseline* water level value (Step 5a).

APPENDIX G

Determining Average Drawdown in Shallow Aquifer Management Zones for POSGCD PDLs

The following section outlines the 2D (area-weighted) methodology that POSGCD used to calculate average drawdown in the Shallow Aquifer Management Zones. This value was used to determine PDL compliance.

Step 1:
For each monitoring well < 400 feet deep in the District, determine the average *baseline* water level by averaging all water levels recorded at that well during a 3-year window around 2000 (1999 to 2001).
Step 2:
For each monitoring well < 400 feet deep in the District, determine the average *evaluation* water level by averaging all water levels recorded at that well during a 3-year window around the *evaluation* year.

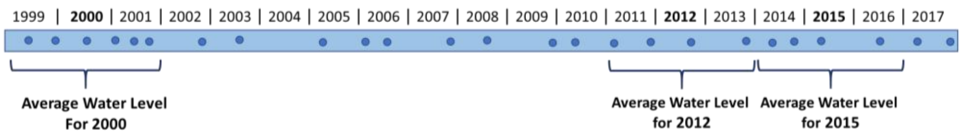


Figure G-1 Diagram of 3-year moving average calculation. Dots represent water level measurements.

Step 3a:
Using only those wells with a water level value in both the *baseline* year (2000) and the *evaluation* year, interpolate a *baseline* (2000) Shallow water level surface with 500-foot grid cell size using the Kriging toolbox in ArcGIS.
Step 3b:
Using only those wells with a water level value in both the *baseline* year (2000) and the *evaluation* year, interpolate an *evaluation* Shallow water level surface with 500-foot grid cell size for the aquifer using the Kriging toolbox in ArcGIS.
Step 4:
Calculate drawdown by subtracting the *baseline* water level surface (Step 3a) from the *evaluation* water level surface (Step 3b) using the Map Algebra toolbox in ArcGIS.
Step 5:
Create grid made of cells that are 500 ft L x 500 ft W x 50 ft H, as illustrated in Figure G.2, orthogonal to the rasters created in Steps #3a and 3b. The maximum elevation for this grid is 500 feet amsl and the minimum elevation is -200 feet amsl.
Step 6:
Assign each grid cell a drawdown value, using the drawdown raster created in Step #4. Each cell within a column of the grid (same easting and northing coordinates) will thus have the same drawdown value as the other cells within that column.
Step 7:
Assign each grid cell to an aquifer based on the centroid (middle point) of the grid cell. Figure G-3 shows the aquifer assignments of grid cells at elevations of 400 ft amsl, 200 ft amsl, 50 ft amsl and -100 ft amsl. Table G-1 shows the number of grid cells assigned to each aquifer by grid layer.
Step 8:
Calculate average drawdown for each aquifer according to the following equation, using Simsboro as an example. Figure G-4 shows an illustration of this calculation, using Simsboro as an example.

$$Average\ Simsboro\ Drawdown = \frac{\sum Simsboro\ cell\ drawdown\ values}{number\ of\ Simsboro\ cells}$$

Table G-1 Number of grid cells assigned to each aquifer by 50-foot grid block layer

Elevation	Hooper	Simsboro	Calvert Bluff	Carrizo	Queen City	Sparta	Yegua-Jackson
500	677	3,047	1,292	1,337	1,432	198	165
450	3,058	5,096	7,058	2,243	5,404	1,384	556
400	6,806	7,562	12,587	2,681	8,687	3,200	2,294
350	11,825	9,415	14,455	4,355	13,708	4,691	9,199
300	13,354	10,637	15,784	4,615	15,852	5,977	20,746
250	11,799	11,728	18,386	5,627	16,429	7,065	31,681
200	11,264	11,331	18,455	6,876	16,296	6,908	47,254
150	10,373	10,869	18,620	8,736	16,481	6,384	47,264
100	7,902	10,203	17,508	8,600	15,775	6,150	45,930
50	4,856	7,410	13,408	7,017	13,894	6,226	44,544
0	3,103	4,024	8,783	4,848	9,600	6,114	43,108
-50	1,491	1,909	5,872	2,189	4,918	4,171	38,857
-100	647	874	3,255	656	1,951	2,091	29,043
-150	0	5	114	87	319	1,308	17,354
-200	0	0	0	0	0	0	1,403
TOTAL	*87,155*	*94,110*	*155,577*	*59,867*	*140,746*	*61,867*	*379,398*

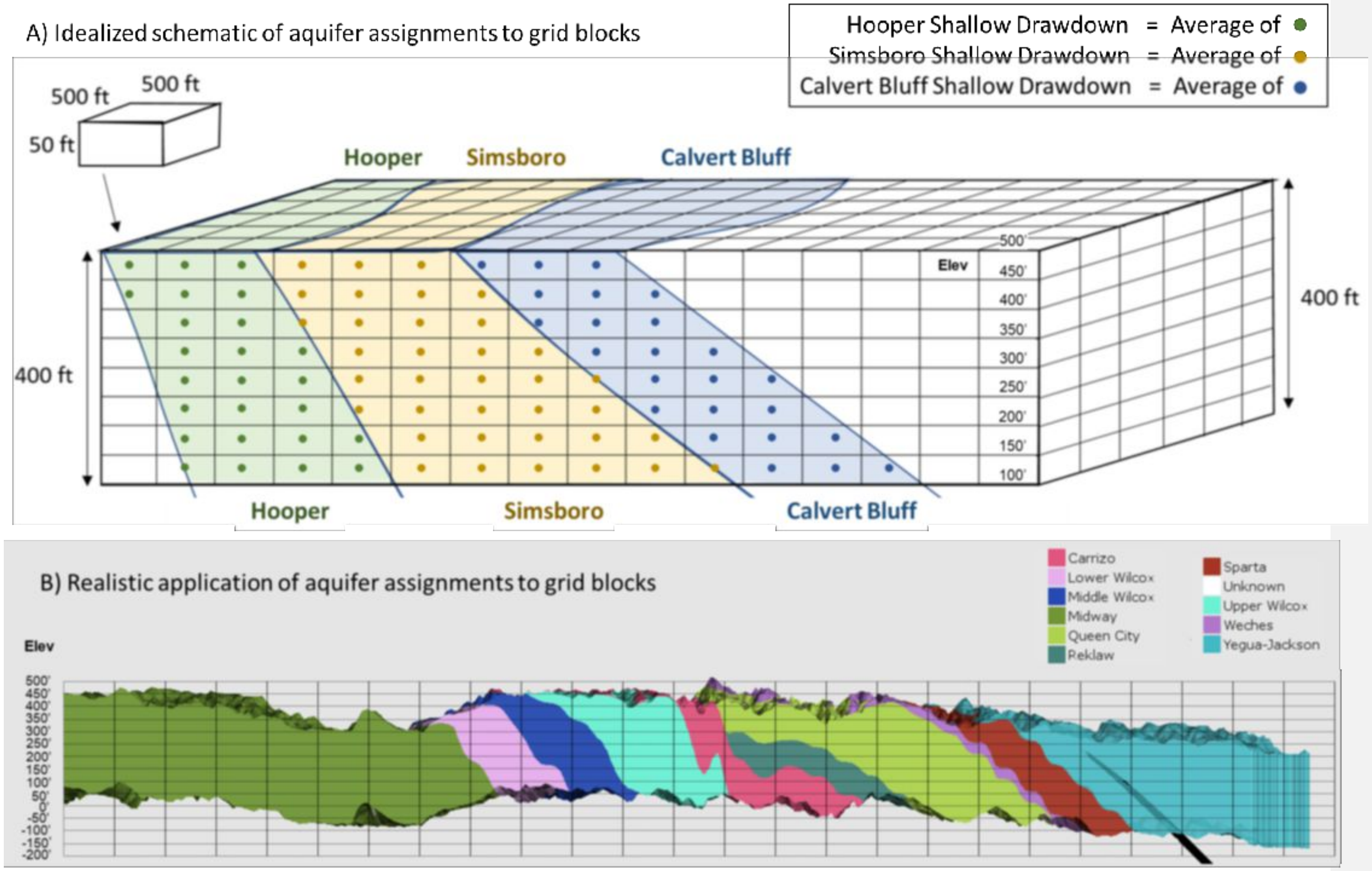


Figure G-2 Schematic diagram of A) idealized schematic of the aquifer assignments to grid blocks and B) a realistic application of aquifer assignments to grid blocks.

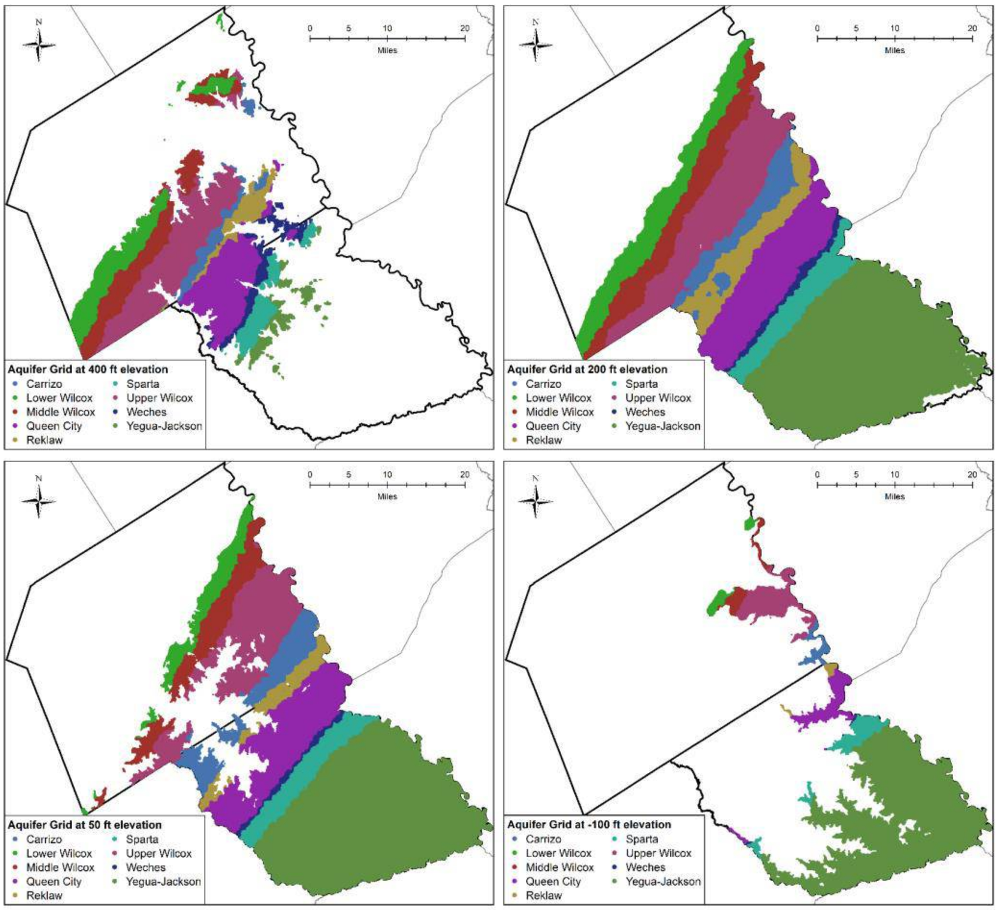
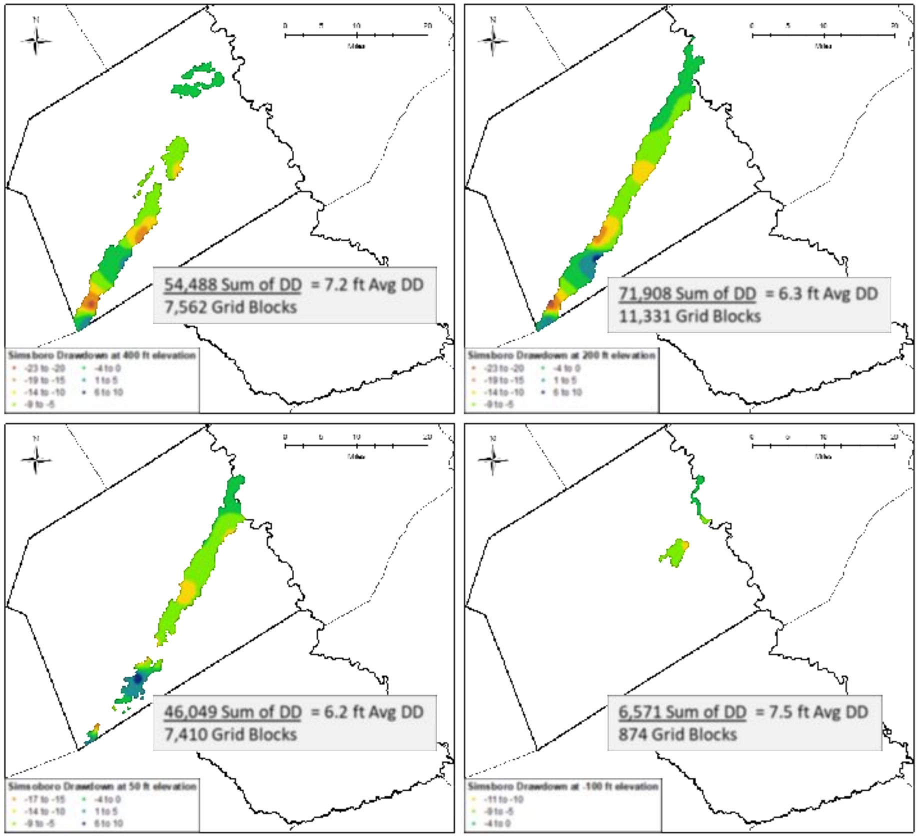


Figure G-3 Aquifer assignments of grid cells at elevations of 400, 200, 50 and -100 ft amsl



$$\frac{\text{Total Sum of Simsboro DD}}{\text{Total \# Simsboro Grid Blocks}} =$$

$$\frac{\mathbf{630{,}462}}{\mathbf{94{,}110}} = \textbf{6.7 ft Avg DD}$$

Figure G-4 Illustrated example of the 3D drawdown calculation, using Simsboro as an example.