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

Prepared for:

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1 INTRODUCTION

This guidance document outlines how POSGCD uses measured water levels from its groundwater monitoring network to calculate aquifer drawdown over time and to determine Desired Future Conditions (DFCs) and Protective Drawdown Limits (PDLs) compliance.

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 based on the Average Drawdown that occurs between January 2010 and December 2069

County	Average Decrease in Saturated Thickness (ft)
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

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 in order 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 ft
Queen City	20 ft
Carrizo	20 ft
Upper Wilcox (Calvert Bluff Fm)	20 ft
Middle Wilcox (Simsboro Fm)	20 ft
Lower Wilcox (Hooper Fm)	20 ft
Yegua	20 ft
Jackson	20 ft

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”*

The District Management Plan does not provide a schedule for when it will evaluate compliance with its PDLs.

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 modified. The primary reason for the changes in the monitoring network is the addition of wells. At the time this document was prepared, the POSGCD Monitoring Well network consists of the 111 wells shown in **Figure 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 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.

3.2 Aquifer Assignments

POSGCD defines its aquifers based on the elevation surfaces for the model layers in the groundwater availability models. 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 1 and 2 are symbolized according to these 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 a downhole borehole video camera to determine the well screen interval. Aquifer assignments for monitoring wells that are located in either Lost Pines Groundwater Conservation District (LPGCD) or Brazos Valley Groundwater Conservation District (BVGCD) will be jointly decided by POSGCD and the GCD in which the well is located. 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.

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** and **4**.

3.3 Monitoring Frequency

POSGCD plans to manually 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 a eline or steel tape reading at the well. A goal of the monitoring is to obtain a set of water level measurements that are within a time window that is two months or less.

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 and will use transducers to continually measure water levels at several of its monitoring wells. 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.

4 COLLECTING AND RECORDING MONITORING DATA

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

4.1 Collection procedures

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

4.2 Water Level Records

POSGD 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 D**) for each individual well. The handwritten field water level measurements and notes will be scanned and entered into the official POSGCD digital database within 2 weeks of recording.

4.3 Data Availability

POSGCD will post results from monitoring event 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.org/(tbd).

5 METHODOLOGY FOR CALCULATING DRAWDOWN

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 E describes the methodology used by POSGCD to calculate average drawdown values over time from the measured water levels that are used to evaluate compliance with DFCs. The methodology uses GIS to perform most of the mathematical calculations. **Figure 5** illustrates several of the calculation that use GIS. Several key points associated with the methodology are that it:

- Uses 3-year moving averages to determine annual water levels at wells.
- Incorporates wells that have a calculated 3-year moving average water level for both the baseline year (2000) and the evaluation year (ex. 2012).
- Interpolates water level surfaces over the entire District for each Aquifer Management Zone based on monitoring well point data from that aquifer.
- Calculates difference in water level *surfaces*, not the calculated difference at individual monitoring wells.

5.2 Shallow Aquifer Management Zone

Appendices F and **G** describes the methodology used by POSGCD to calculate average drawdown values over time from the measured water levels that are used to evaluate compliance with PDLs. The methodologies are similar to the methodology described in 5.1. **Figure 6** illustrates several of the calculations that use GIS. Several key points associated with the methodology are that it:

- Incorporates 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 3-year moving average water level for both the baseline year (2000) and the evaluation year (ex. 2012).
- Interpolates one shallow water level surface for the entire District based on all shallow monitoring well point data.
- Calculates difference in water level *surfaces*, not the calculated difference at individual monitoring wells.

6 COMPLIANCE WITH MANAGEMENT GOALS

This section describes how POSGCD will track compliance with DFCs and PDLs.

6.1 DFC Compliance - Total Aquifer Management Zones

POSGCD will track DFCs compliance by comparing average drawdowns determined for an aquifer in Section 5 to DFCs. Results from the comparison be appended to **Table 6-1** and **Figure 7**. Table 6-1 and Figure 7 show 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. Results of the comparisons will be compared to action levels identified in POSGCD Groundwater Rule 16.4 “Actions Based on Monitoring Results.”

Table 6-1 Status of DFC compliance by Total Aquifer Management Zone.

Shallow 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	
		Calculated Drawdown	Percent of DFC	Calculated Drawdown	Percent of DFC	Calculated Drawdown	Percent of DFC	Calculated Drawdown	Percent of DFC	Calculated Drawdown	Percent of DFC
Sparta/ Queen City	10[1]	4	40%	4	40%	5	50%	4	40%	3	30%
Carrizo	20	5	25%	6	30%	6	30%	6	30%	4	20%
Calvert Bluff (Upper Wilcox)	20	6	30%	7	35%	7	35%	7	35%	6	30%
Simsboro (Middle Wilcox)	20	6	30%	6	30%	6	30%	6	30%	6	30%
Hooper (Lower Wilcox)	20	6	30%	6	30%	6	30%	6	30%	6	30%
Yegua Jackson	15	6	40%	7	47%	7	47%	8	53%	5	33%

6.2 PDL Compliance - Shallow Aquifer Management Zones

POSGCD will track DFCs compliance by comparing average drawdowns determined for a shallow management zone in Section 5 to PDLs. Results from the comparison be appended to **Table 6-2** and **Figure 8**. Table 6-2 and Figure 8 show 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. Results of the comparisons will be compared 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.

Shallow 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*	
		Calculated Drawdown	Percent of DFC	Calculated Drawdown	Percent of DFC	Calculated Drawdown	Percent of DFC	Calculated Drawdown	Percent of DFC	Calculated Drawdown	Percent of DFC
Sparta/ Queen City	10*	4	40%	4	40%	5	50%	4 *(4)*	40% *(40%)*	3 *(2)*	30% *(20%)*
Carrizo	20	5	25%	6	30%	6	30%	6 *(6)*	30% *(30%)*	4 *(3)*	20% *(15%)*
Calvert Bluff (Upper Wilcox)	20	6	30%	7	35%	7	35%	7 *(7)*	35% *(35%)*	6 *(6)*	30% *(30%)*
Simsboro (Middle Wilcox)	20	6	30%	6	30%	6	30%	6 *(7)*	30% *(35%)*	6 *(6)*	30% *(30%)*
Hooper (Lower Wilcox)	20	6	30%	6	30%	6	30%	6 *(6)*	30% *(30%)*	6 *(6)*	30% *(30%)*
Yegua Jackson	15	6	40%	7	47%	7	47%	8 *(7)*	53% *(47%)*	5 *(4)*	33% *(27%)*

* value in parentheses indicates value calculated using 3D (Volume-weighted) methodology

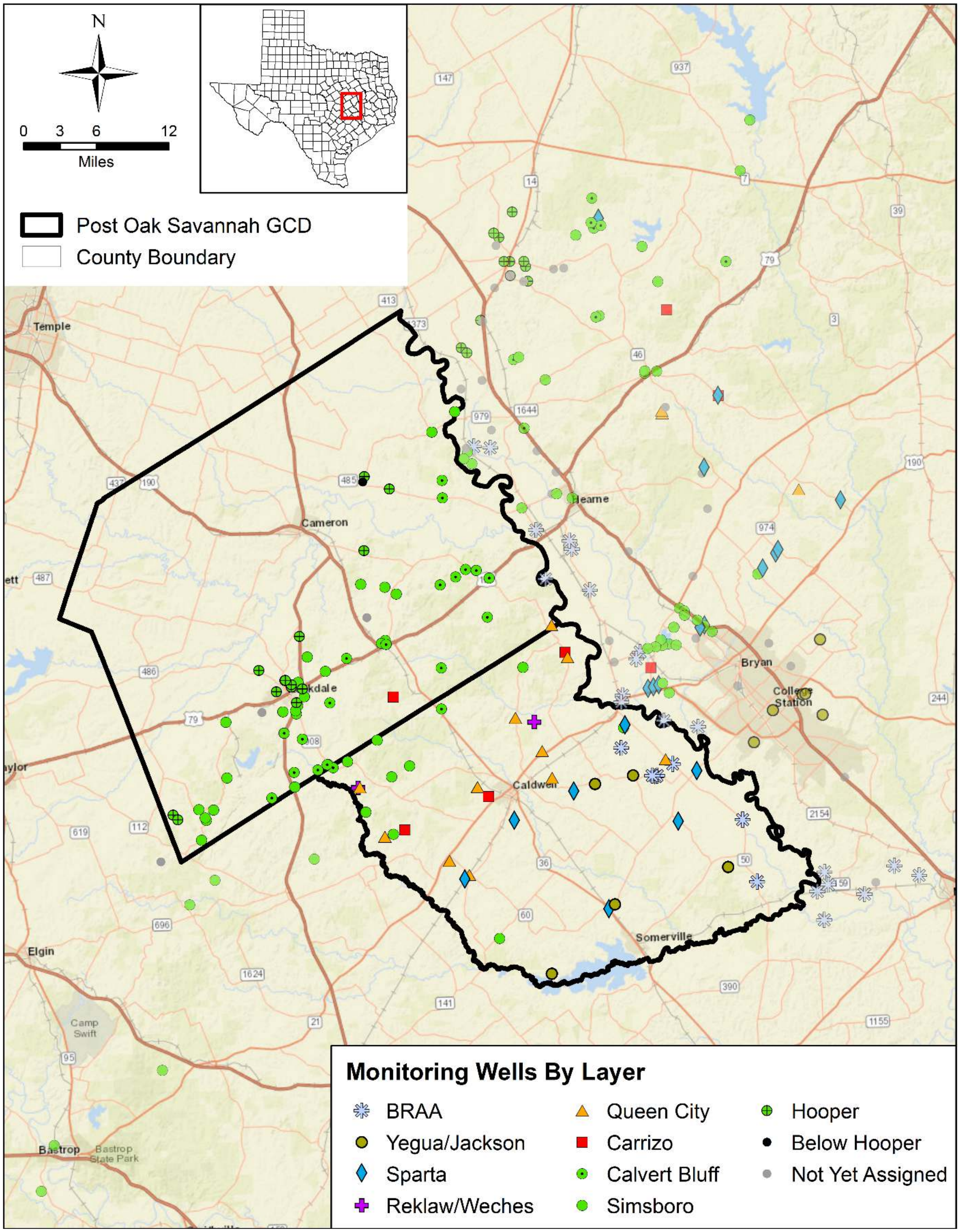


Figure 1 Monitoring well locations used in the DFC drawdown calculation.

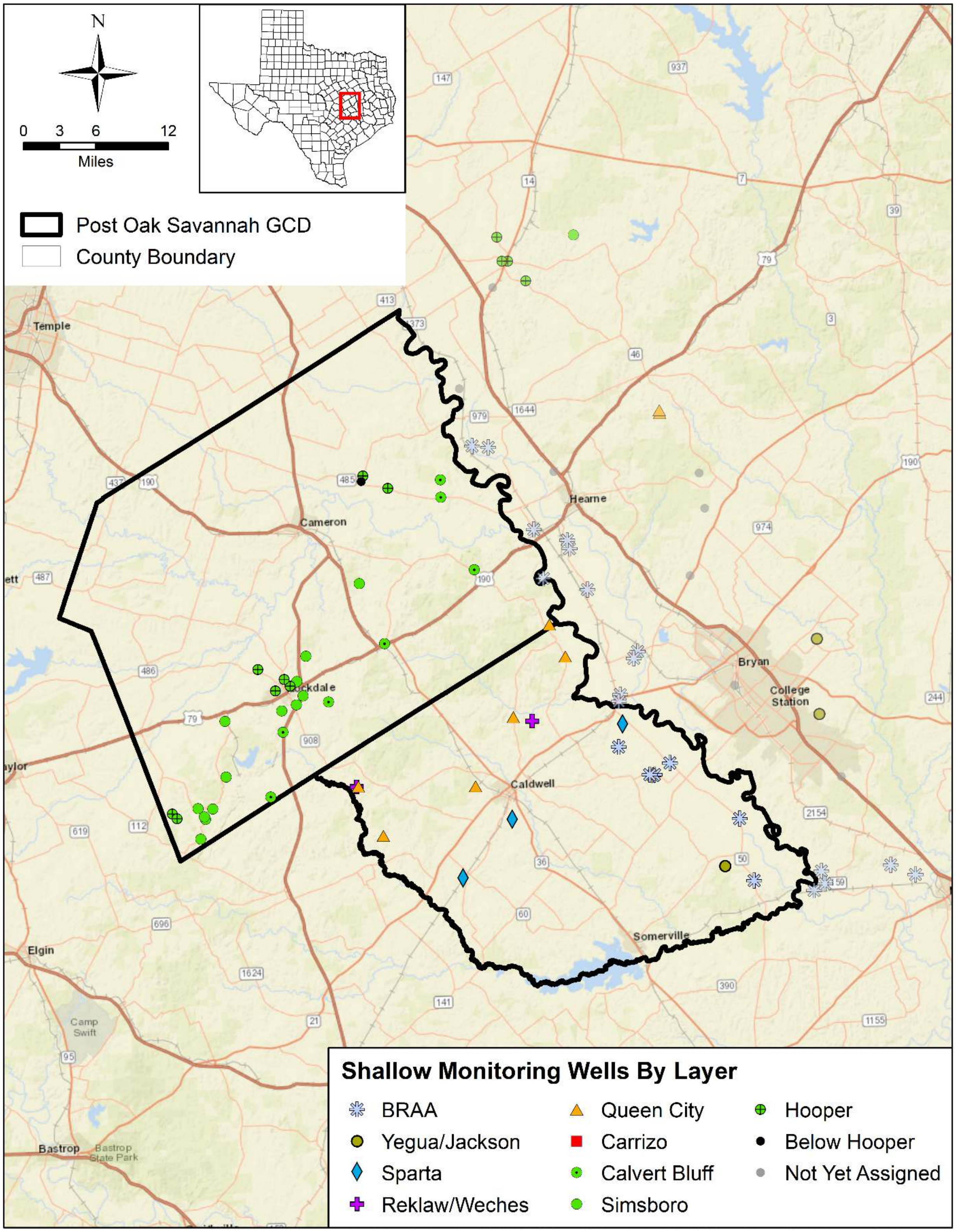


Figure 2 Shallow Monitoring well locations used in the PDL drawdown calculation.

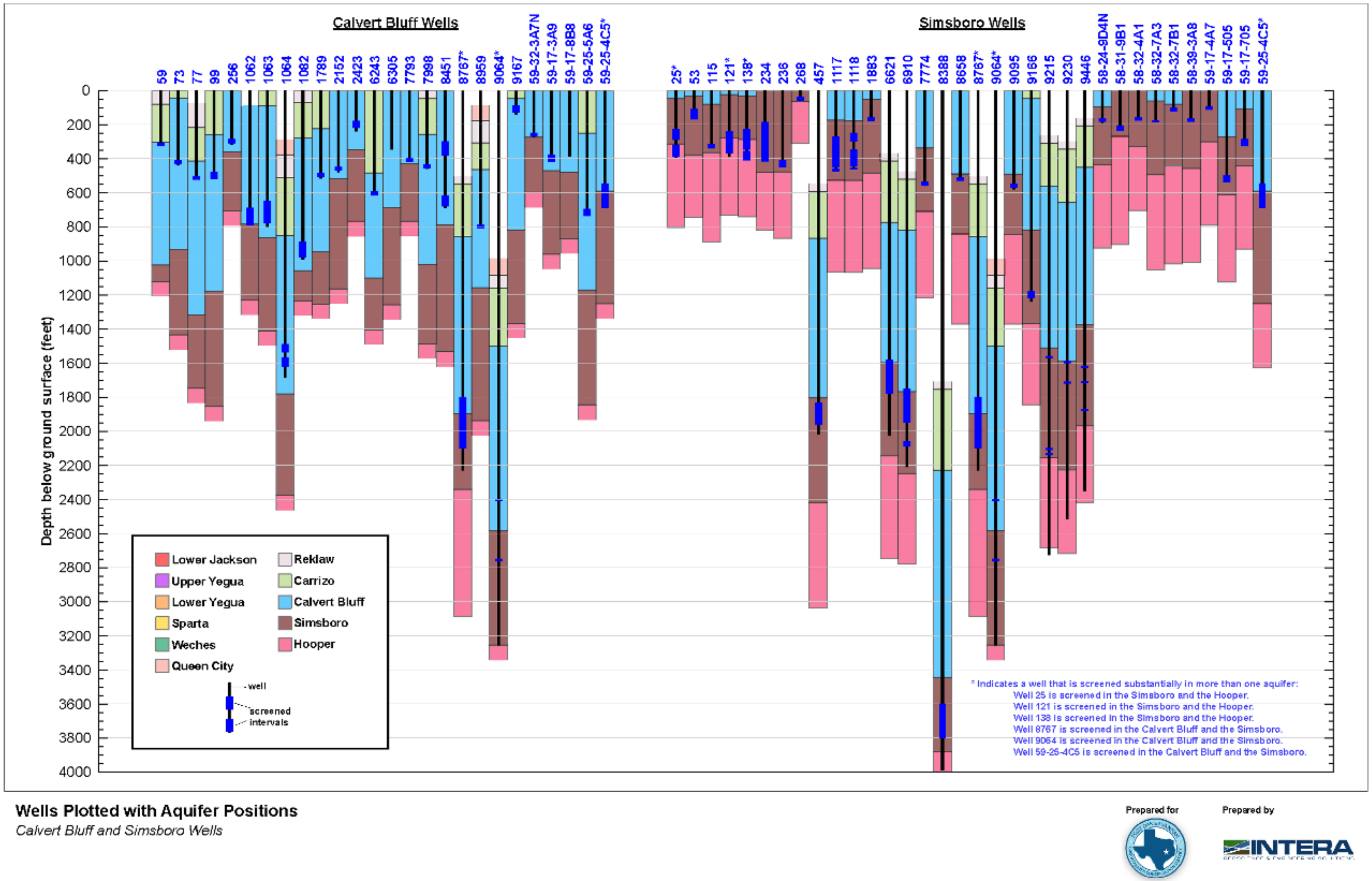


Figure 3. Monitoring wells with aquifer assignments in Calvert Bluff and Simsboro Aquifers.

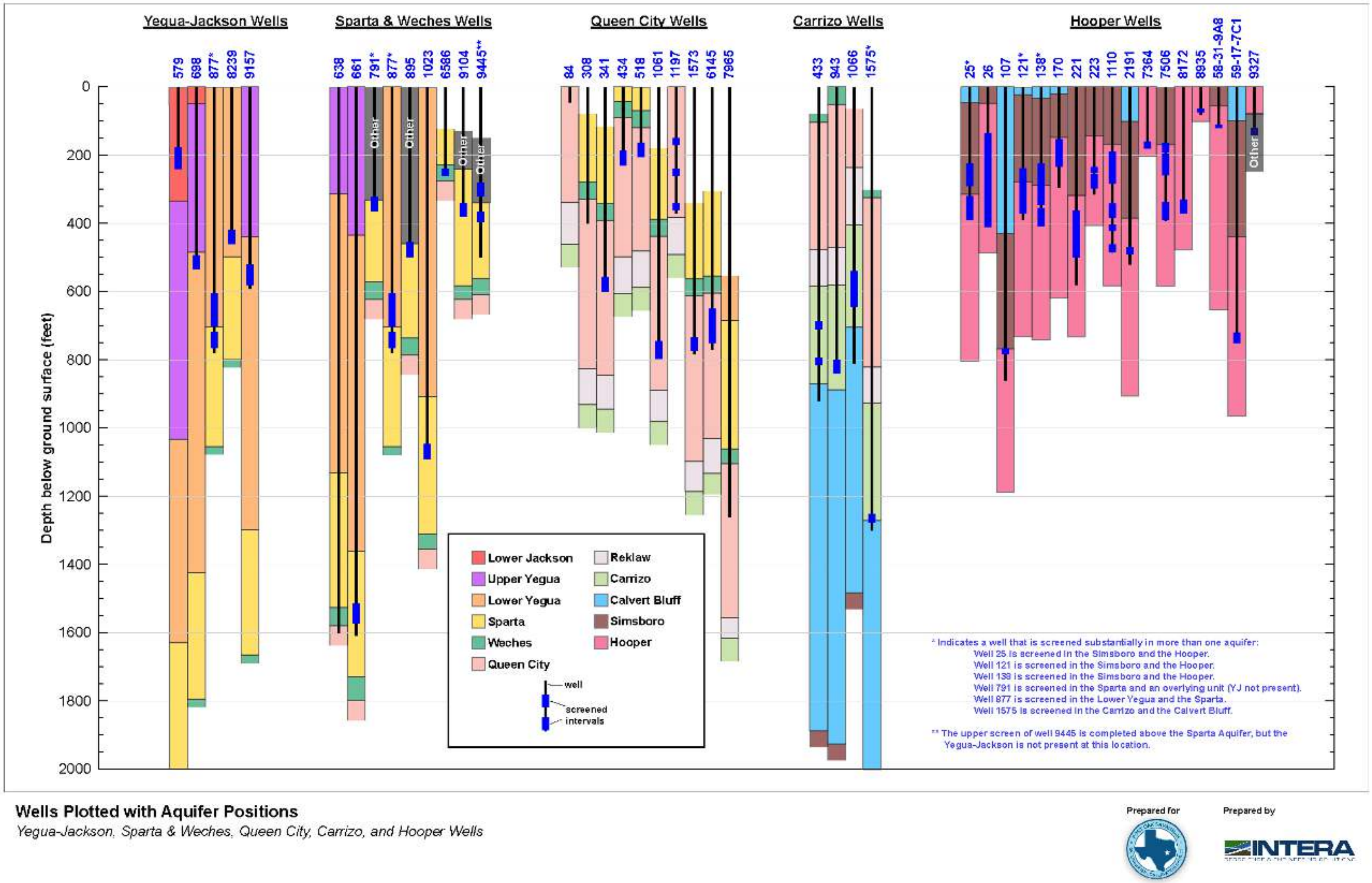


Figure 4 Monitoring wells with aquifer assignments in Yegua-Jackson, Queen City, Sparta, Carrizo and Hooper Aquifer

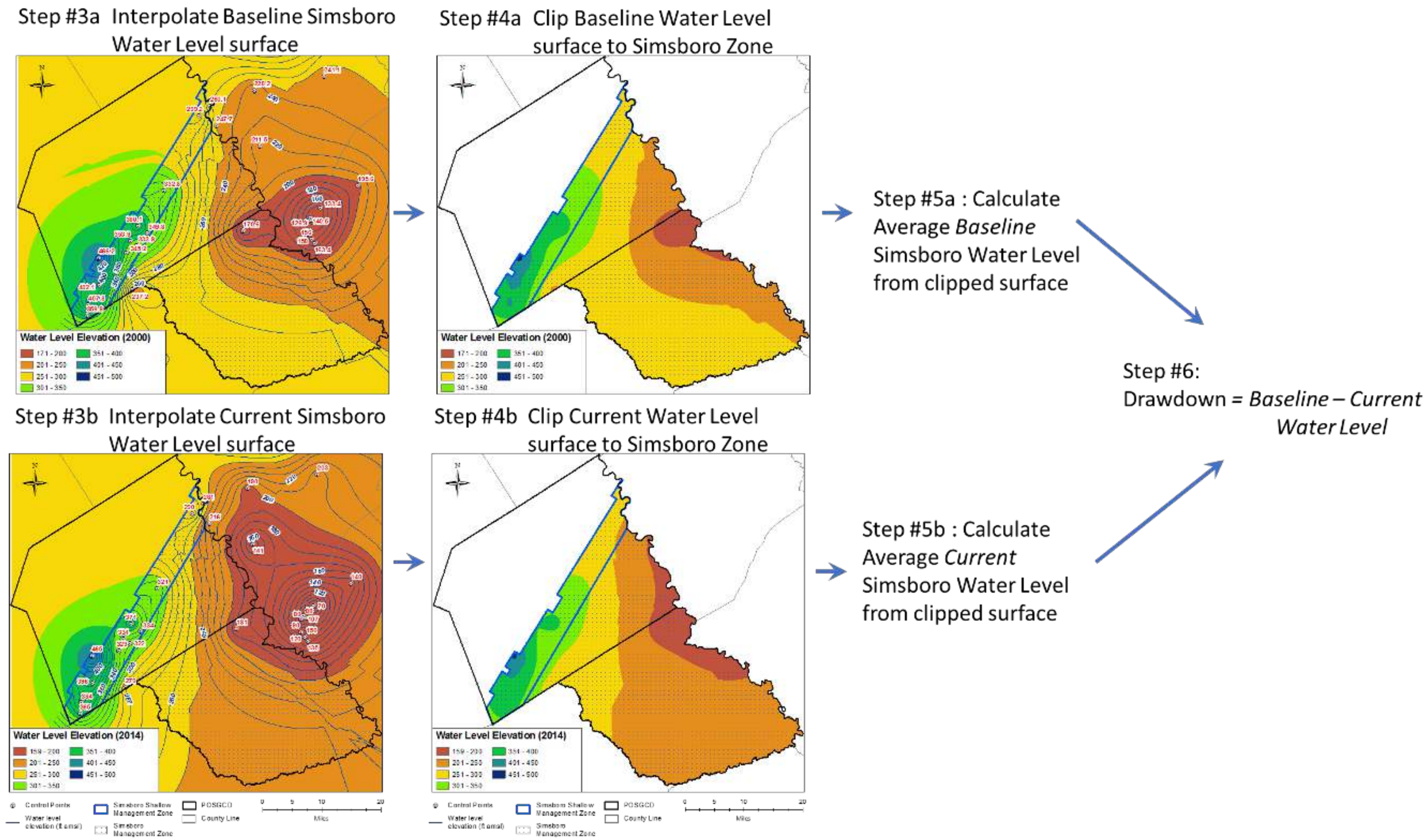


Figure 5 Diagram of Drawdown Calculation Method for Total Aquifer Management Zones , using Simsboro as example.

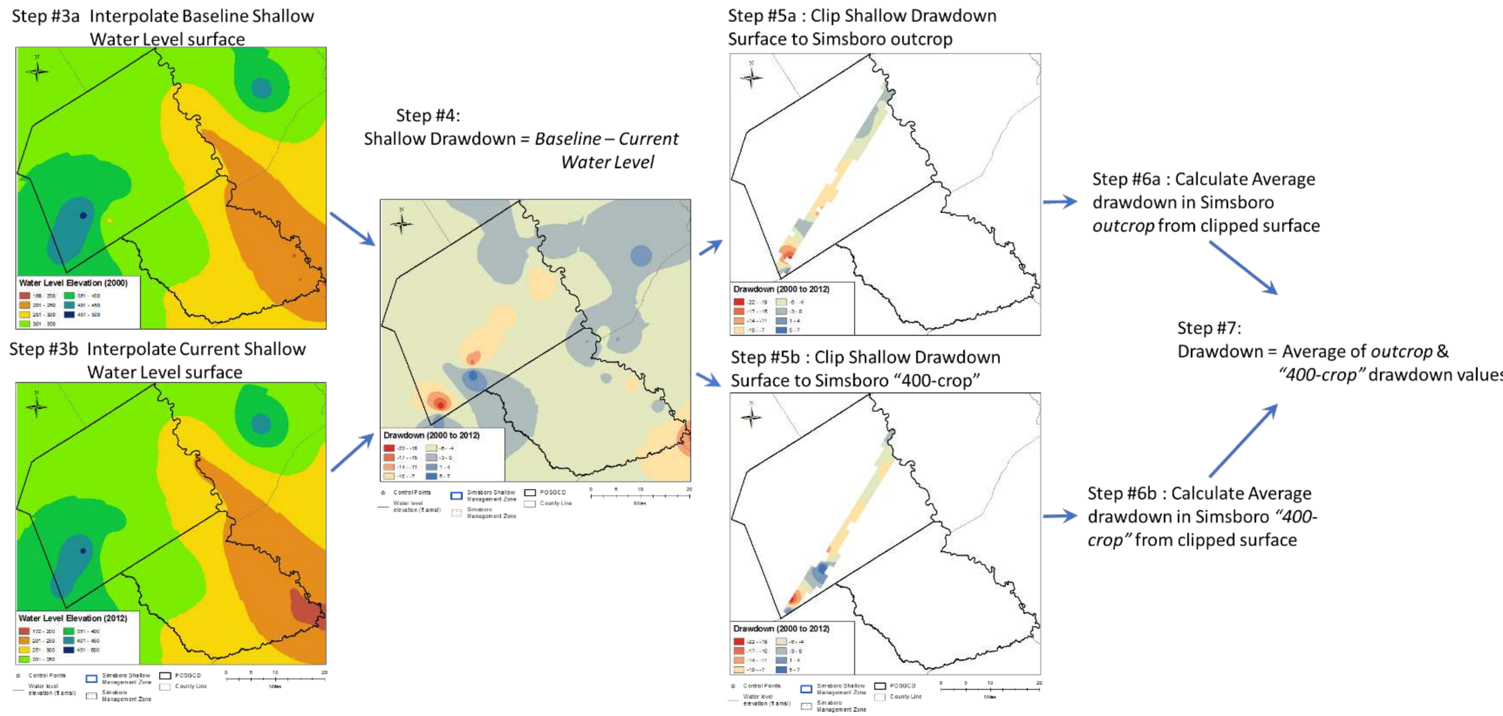


Figure 6 Diagram of Drawdown Calculation Method for Shallow Aquifer Management Zones, using Simsboro as example

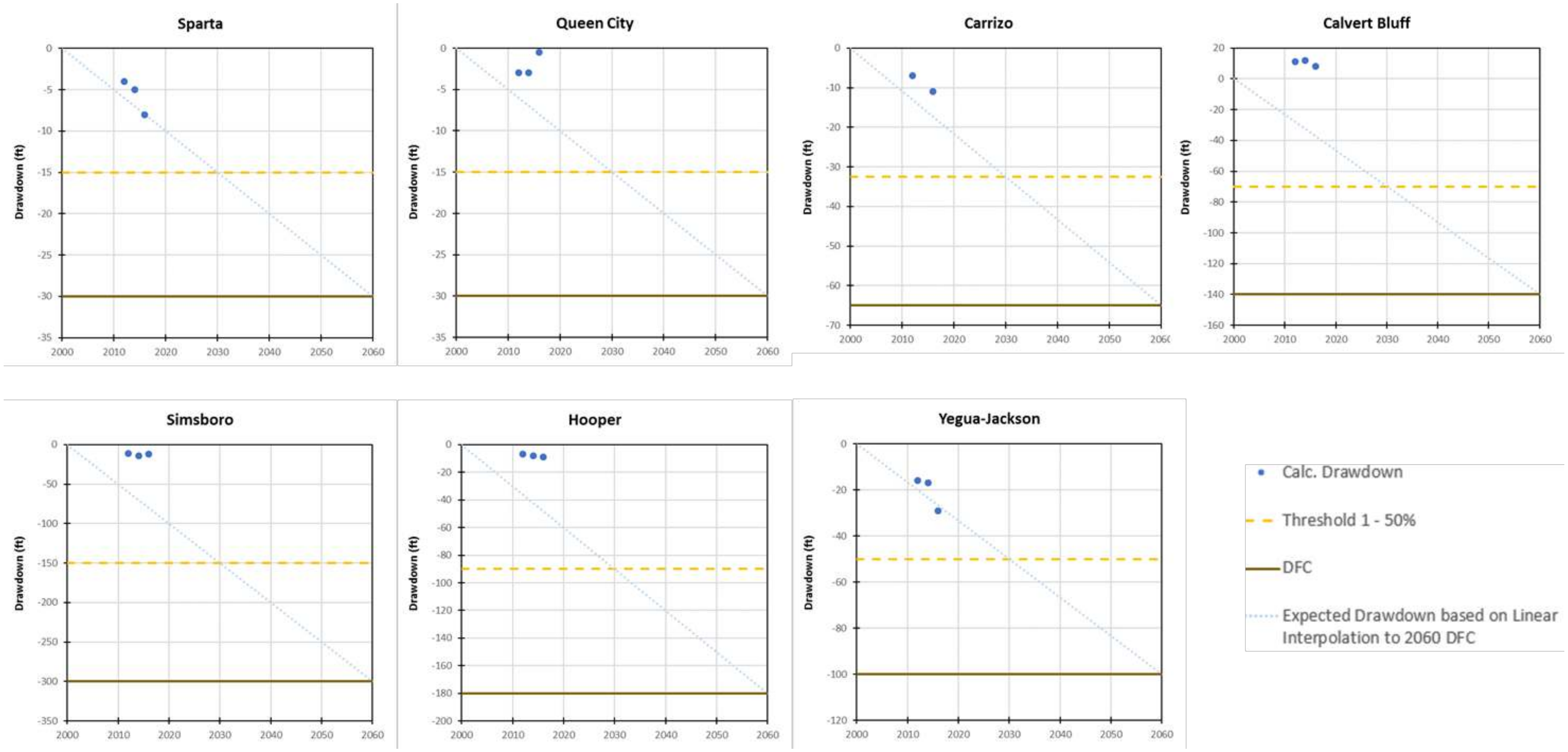


Figure 7 Status of DFC compliance by Total Aquifer Management Zone

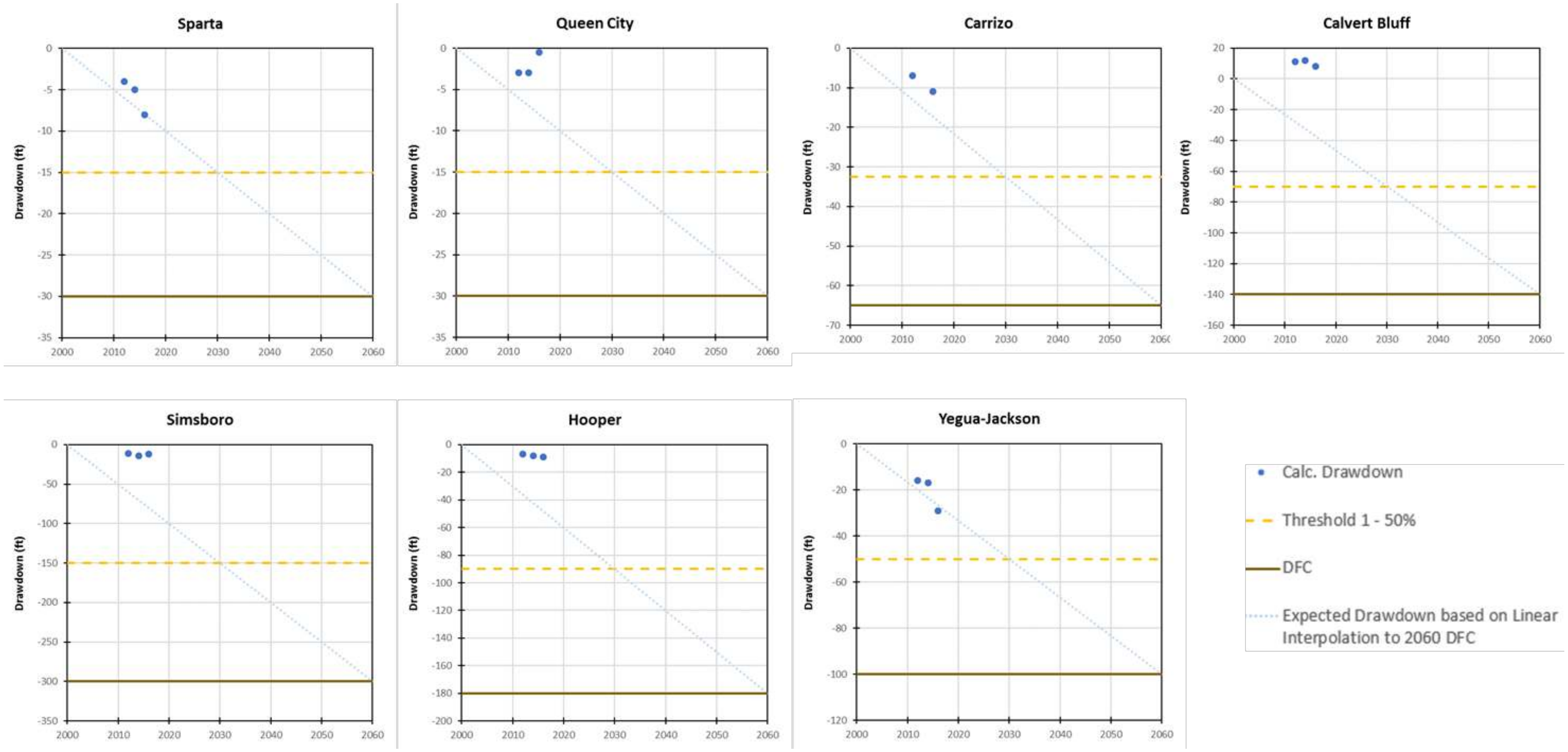


Figure 8 Status of PDL compliance by Shallow Aquifer Management Zone

APPENDIX A

POSGCD Groundwater Monitoring Well Network

25	5917409	City of Rockdale (Belton)	30.668888	-96.986388	505	391	226-290, 320-390	124HOOP - Ho
26	5917103	Ralph Summers- Mary Jane Boyd	30.723888	-96.982777	457	410	136-410	124HOOP - Ho
53	5909901	Richard Frock	30.784166	-96.895555	434	169	109-169	124SMBR - Sin
59	5911402	Harold Lange	30.796944	-96.734444	426	323	307-323	124CABF - Calv
73	5910907	Willard Kornegay	30.780832	-96.784999	383	440	410-430	124CABF - Calv
77	5919103	Charles Hoppe	30.740555	-96.720832	433	522	507-522	124CABF - Calv
84	5919302	James Ayers	30.728610	-96.632221	340	45	--	124QNCT - Qu
99	5925508	Larry Sexton	30.569443	-96.947777	410	520	480-520	124CABF - Calv
107	5925102	Noack Family Partnership, Ltd.	30.600833	-96.982499	412	860	767-782	124SMBR - Sin
115	5917715	L.B. Kubiak	30.640833	-96.987777	443	337	316-337	124SMBR - Sin
121	5917714	City of Rockdale (Texas)	30.663611	-96.995833	475	390	238-370	124SMBR - Sin
138	5917713	City of Rockdale (Tracy)	30.666388	-96.995833	485	408	226-346, 356-408	124SMBR - Sin
170	5824914	Rockdale ISD	30.658333	-97.016666	495	295	153-233	124SMBR - Sin
221	5909605	Marlow WSC	30.824443	-96.889721	424	503	340-500	124HOOP - Ho
223	5902706	North Milam WSC	30.897499	-96.851944	359	315	235-250, 256-298	124WLCX - Wi
234	5902309	Wendy Breck	30.987777	-96.757777	299	417	185-417	124SMBR - Sin
236	5902307	Jared & Heather Campbell	30.964166	-96.790555	416	450	410-450	124WLCX - Wi
256	5902901	North Milam WSC	30.884999	-96.778332	371	318	284-308	124WLCX - Wi
268	5832101	Wayne Diver	30.623332	-97.088055	474	60	40-60	124HOOP - Ho
308	5927716	R. B. Wilkens	30.537221	-96.741666	452	400	--	124QNCT - Qu
341	5927606	Rudy Steck	30.578054	-96.650555	394	600	558-600	124QNCT - Qu
433	5920410	Milano WSC- Rita Test	30.695555	-96.614444	299	920	688-710, 794-815	124SMBR - Sin
434	5920409	L. C. Hall, Sr.	30.689721	-96.611388	299	230	188-230	124QNCT - Qu
457	5919502	Milano WSC - Well 4	30.679166	-96.673610	462	2018	1832-1958	124CZSB - Carr
518	5927204	Dale Hill	30.618888	-96.686388	315	205	163-205	124QNCT - Qu
579	5937611	Camilla J. Godfrey	30.432221	-96.397777	233	240	177-240	124JCKSL - Lov
596	5937329	Finley Company	30.488610	-96.375554	215	58	--	111ABZR - Allu
638	5937101	Snook well #1	30.489166	-96.465000	240	1600	--	124QNCT - Qu
661	5936802	Lyons Water Supply	30.386944	-96.564722	342	1609	1513-1573	124SPRT - Spa
698	5943608	Birch Creek Recreation	30.310833	-96.646388	270	533	494-533	124YEGUL - Lo
787	5938701	Burnside Services, Inc.	30.413611	-96.358333	205	56	--	111ABZR - Allu
791	5935208	Juanita Amidon	30.496354	-96.691918	379	364	322-364	124SPRT - Spa
859	5929456	Marion Malazzo	30.543633	-96.493766	231	60	--	111ABZR - Allu
860	5929457	Marion Malazzo	30.544533	-96.492043	231	60	--	111ABZR - Allu
877	5928619	Tunis Water Supply	30.545555	-96.525554	267	780	605-700, 719-765	124SPRT - Spa
894	5928601	P. G. Haines	30.579166	-96.540555	240	58	--	111ABZR - Allu
895	5928702	Sarah Engleman	30.529166	-96.608333	346	498	456-498	124SPRT - Spa

1061	5934607	Deanville Water Supply Corporation 2	30.450000	-96.783333	404	797	745-797	124QNCT - Qu
1062	5918101	Milano WSC - Well # 1	30.716233	-96.863433	565	790	689-790	124CABF - Calv
1063	5918104	Milano WSC - Well # 2	30.712780	-96.868890	549	800	650-780	124CABF - Calv
1064	5918908	Milano WSC - Well # 3	30.632283	-96.788067	520	1687	1490-1534, 1564-1620	124CZSB - Carr
1066	5918705	Milano WSC - Buer Well	30.648217	-96.854650	581	813	540-645	124SMBR - Sin
1082	5911703	Gause Water Supply # 1	30.787222	-96.716667	367	992	889-980	124SMBR - Sin
1110	5824611	Southwest Milam Water Supply Corp.	30.671417	-97.004500	490	485	190-283, 343-383, 403-423, 463-483	124HOOP - Ho
1117	5917712	City of Rockdale (runway)	30.631200	-96.990100	460	475	270-450, 460-475	124SMBR - Sin
1118	5917711	City of Rockdale (airport)	30.634917	-96.991033	462	463	250-300, 345-443, 453-463	124SMBR - Sin
1166	5929410	Holland Porter	30.557917	-96.470083	225	71	--	111ABZR - Allu
1197	5934107	Nathan C. Ausley	30.481100	-96.872100	440	370	150-170, 240-260, 340-360	124QNCT - Qu
1573	5934601	Deanville Water Supply Corporation 1	30.432499	-96.756388	383	784	734-774	124QNCT - Qu
1575	5927718	Deanville Water Supply Corporation 4	30.525554	-96.726660	447	1300	1252-1277	124CZCB - Car
1789	--	Terry & Sheryl Hall	30.798454	-96.748917	436	515	487-507	--
1883	5832704	Martin Hobbs	30.506500	-97.118558	482	180	160-180	124SMBR - Sin
2152	5925409	Glynn Phillips	30.560960	-96.995140	467	480	450-470	124CABF - Calv
2191	5917716	L.B. Kubiak	30.644744	-96.989442	464	520	470-490	124HOOP - Ho
2423	5902904	Gary & Deryl Emola	30.905951	-96.778042	401	240	180-220	124SMBR - Sin
6145	5927611	Alvin J. Kutach	30.545711	-96.637995	397	770	650-750	ND
6243	5925502	Birdie Kristoff	30.565500	-96.941000	427	614	593-614	124CZCB - Car
6305	5832908	Charles Lee McDaniel	30.531240	-97.026850	438	344	--	124CABF - Calv
6586	5927309	Francis Joseph Landry, Jr.	30.613416	-96.660202	381	260	240-260	ND
6621	5926402	Frederick A. Jackson	30.552496	-96.860040	489	2020	1580-1780	124SMBR - Sin
6910	5926403	Charles & Jacqulin Stone Revocable Living Trust	30.564870	-96.834660	496	2200	1750-1950, 2060-2090	124SMBR - Sin
7364	5824612	Richard H. Griffith	30.684551	-97.040073	432	180	160-180	124HOOP - Ho
7506	5824610	Southwest Milam Water Supply Corp.	30.671633	-97.003883	492	392	165-193, 196-259, 339-390	124HOOP - Ho
7774	5910705	Jay Wise	30.780000	-96.862300	442	560	535-555	124CABF - Calv
7793	5925103	Noack Family Partnership, Ltd.	30.600880	-96.982490	412	420	400-420	124WLCX - Wi
7965	--	Heirs of Mary Anne oliver	30.563800	-96.479600	231	1260	--	--
7998	--	Walter D. Fischer	30.789912	-96.763097	490	460	435-455	--
8172	--	Norbert B. Zeschke	30.513820	-97.164501	579	370	330-370	--
8239	5928804	Providence Baptist Church	30.536717	-96.578450	304	460	418-460	124SPRT - Spa
8388	5943104	Wayne Edwards	30.355200	-96.717300	326	3988	3600-3800	124SMBR - Sin
8415	5929433	Portee FLP	30.544721	-96.498610	233	59	--	111ABZR - Allu
8451	5925408	Antonio E. Cantu	30.563228	-96.962233	382	690	300-380, 620-680	124CABF - Calv

8935	5901904	Donald R. Schuerman	30.913160	-96.886300	390	80	64-74	124HOOP - Ho
8959	--	John Pruett	30.681466	-96.786821	442	810	790-810	--
9064	--	Royalty Pecan Farms	30.603240	-96.536250	241	3255	2400-2410, 2750-2760	--
9095	5910707	Randal C. Leo	30.771301	-96.846388	420	580	550-570	124SMBR - Sin
9104	5928342	David L. Hodges	30.606600	-96.534440	243	380	340-380	124SPRT - Spa
9157	5936809	Burleson County Pct. 4	30.391670	-96.556110	294	592	520-580	124JKYG - Jack
9166	5918108	Post Oak Savannah	30.711389	-96.862500	505	1240	1178-1220	124SMBR - Sin
9167	5918109	Post Oak Savannah	30.711389	-96.862500	505	140	90-130	124CRRZ - Car
9215	--	Linda Garrison	30.511139	-96.897167	386	2724	1560-1570, 2100-2110, 2130-2140	--
9230	--	David Pawlowski	30.596886	-96.878937	526	1720	1590-1600, 1710-1720	--
9327	--	Naomi White	30.906660	-96.888880	368	140	120-140	--
9346	--	David L. Hancock	30.540583	-96.907083	0	80	--	--
9372	--	David Hancock	30.541111	-96.904850	0	120	--	--
9445	--	Burleson County Pct 1	30.427742	-96.762821	0	400	--	--
9446	--	Walter Wentzel	30.572378	-96.920656	0	2350	--	--
58-24-9D4N	--	Rodgers	30.634119	-97.008415	464	188	163-183	--
58-24-9V7	--	Bocenegra (Simmons)	30.633943	-97.037523	500	--	--	--
58-31-9A8	--	Ansley	30.507962	-97.158012	544	120	110-120	--
58-31-9B1	--	Hirt	30.519604	-97.128551	552	235	205-235	--
58-32-3A7N	--	Young	30.608502	-97.007428	435	271	250-270	--
58-32-4A1	--	R. Crump	30.556658	-97.088541	495	174	154-174	--
58-32-7A3	--	K. Biehle	30.509591	-97.120047	493	185	175-185	--
58-32-7B1	--	Smith	30.518687	-97.108176	477	123	103-123	--
58-39-3A8	--	Jordan	30.482943	-97.126022	476	182	162-182	--
59-17-3A9	--	L. Warren	30.696090	-96.918013	450	418	378-418	--
59-17-3B8	--	J. Denio	30.743985	-96.888371	433	--	--	--
59-17-4A7	--	Caywood	30.698952	-96.972804	430	113	93-113	--
59-17-505	--	Ed Garner	30.681059	-96.948042	432	540	498-540	--
59-17-705	--	Keys	30.651470	-96.978145	490	326	286-326	--
59-17-7C1	--	Brahm	30.660943	-96.980573	491	750	720-750	--
59-17-8B8	--	Wigginton	30.643409	-96.942916	478	385	--	--
59-25-4C5	--	David Cork	30.543583	-96.994972	443	690	545-690	--
59-25-5A6	--	E. Crump	30.569386	-96.949069	401	734	694-734	--
UNK_01	--	Burleson County Pct. 1	30.427742	-96.762821	361	500	280-320, 365-395	--
UNK_02	--	Walter Wentzel	30.572378	-96.920656	423	2350	1620-1630, 1706-1716, 1870-1880	--

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

APPENDIX D

POSGCD Water Level Measurement Form

APPENDIX E

Methodology for determining Average Drawdown in an Aquifer Management Zone

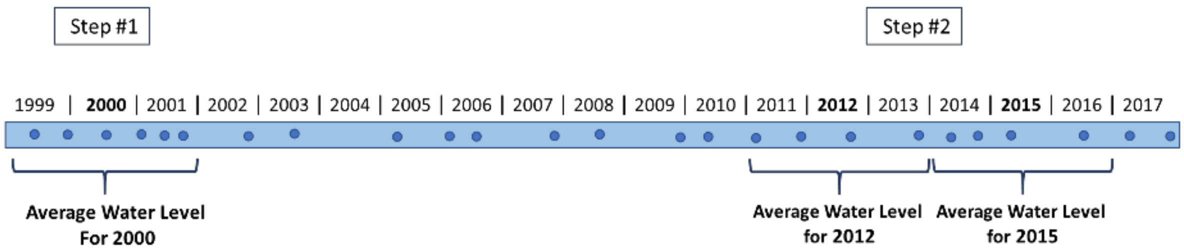
The following section summarizes the methodology used by POSGCD to calculate average drawdown in the Aquifer Management Zones in order to determine DFC compliance:

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



Step 3a:

Using only those wells with a water level value in both the *baseline* year (2000) and the *current* 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 *current* 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 *current* 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 *current* water level value from the Raster Properties of the clipped *current* 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 *current* water level value (Step 5b) from the *baseline* water level value (Step 5a).

APPENDIX F

Methodology for determining Average Drawdown in a Shallow Aquifer Management Zone (2D Area-Weighted Methodology)

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 *current* water level by averaging all water levels recorded at that well during a 3-year window around the *current* year.

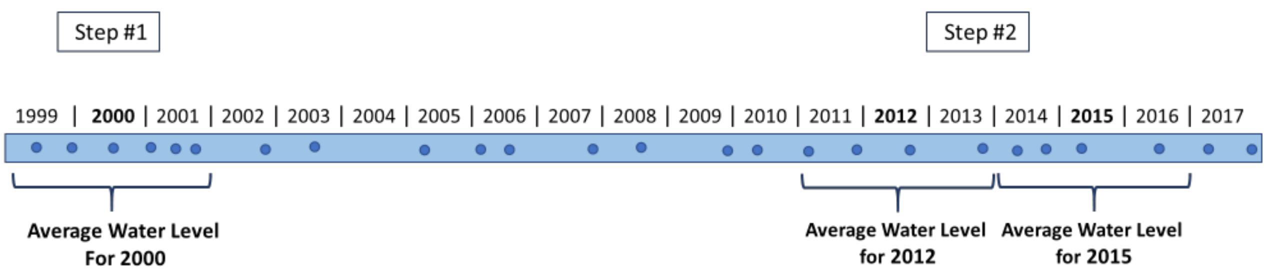


Figure 2. Diagram of 3-year moving average calculation. Dots represent water level measurements.

Step 3a:

Using only those wells with a water level value in both the *baseline* year (2000) and the *current* year, interpolate a *baseline* (2000) Shallow water level surface using Kriging toolbox in ArcGIS.

Step 3b:

Using only those wells with a water level value in both the *baseline* year (2000) and the *current* year, interpolate a *current* Shallow water level surface for the aquifer using Kriging toolbox in ArcGIS.

Step 4:

Calculate drawdown by subtracting the *baseline* water level surface (Step 3a) from the *current* water level surface (Step 3b) using the Map Algebra toolbox in ArcGIS.

Step 5a:

Clip the drawdown water level surface (Step 4) to the *outcrop* extent using the Clip Raster toolbox in ArcGIS.

Step 5b:

Clip the drawdown water level surface (Step 3b) to the *"400-crop"* extent (see **Figure G.1** for "400-crop" definition) using the Clip Raster toolbox in ArcGIS.

Step 6a:

Determine the average *outcrop* drawdown value from the Raster Properties of the clipped drawdown surface for the *outcrop* (Step 5a).

Step 6b:

Determine the average *"400-crop"* drawdown water level value from the Raster Properties of the clipped drawdown water level surface for *"400-crop"* (Step 5b).

Step 7:

Calculate average drawdown for Shallow Management Zone by averaging *outcrop* drawdown (Step 6a) and *"400-crop"* drawdown (Step 6b)

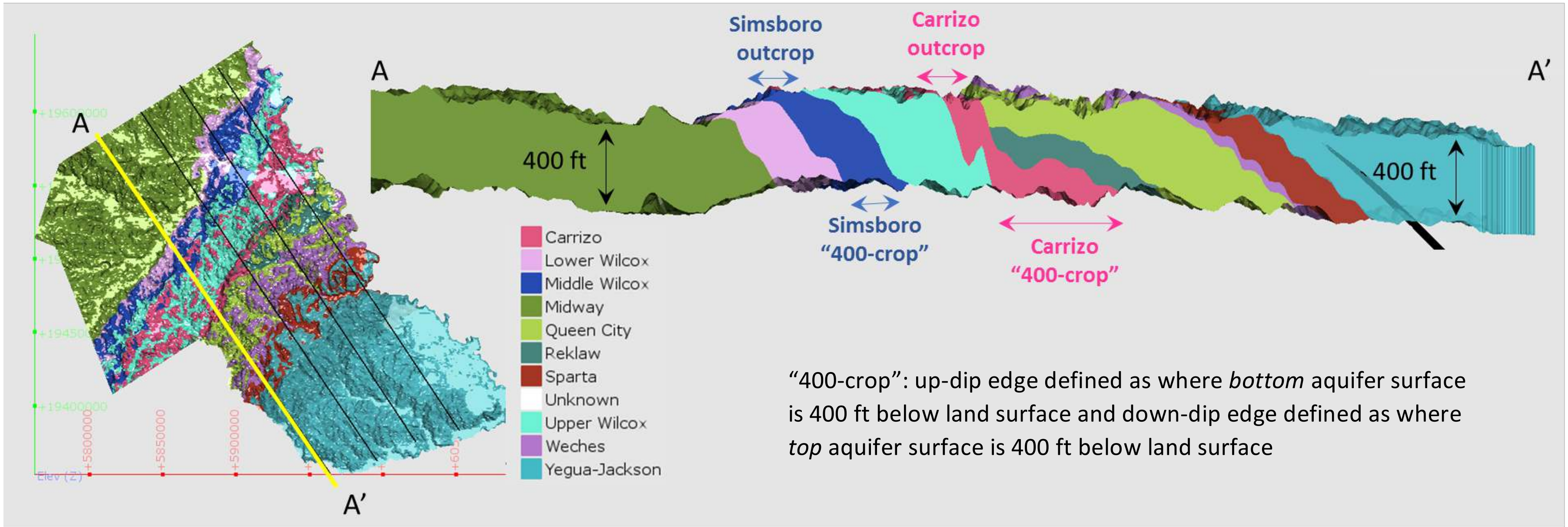


Figure G-1 Schematic of Outcrop vs "400-Crop"

APPENDIX G

Methodology for determining Average Drawdown in a Shallow Aquifer Management Zone (3D Volume-Weighted Methodology)

The following section outlines the 3D (volume-weighted) methodology that POSGCD used to calculate drawdown in the Shallow Aquifer Management Zones. This methodology was used to verify the values calculated using the 2D (area-weighted) methodology described in **Appendix G.**

Step 1:
Create grid of aquifer structures made of cells that are 500 ft L x 500 ft W x 50 ft H, as illustrated in **Figure H.1**

Step 2:
Assign each grid cell a drawdown value, using the drawdown raster created in Step #4 of the 2D methodology. This raster also has cells that are 500 ft L x 500 ft W. Each cell within a column of the grid will thus have the same drawdown value as the other cells within that column.

Step 3:
Calculate a volume-weighted drawdown by aquifer for each grid cell, according to the following equation, using Simsboro as an example:

$$\begin{aligned} &Simsboro\ volume\ weighted\ cell\ drawdown \\ &\qquad = \%\ of\ cell\ volume\ in\ Simsboro \times cell\ drawdown\ value \end{aligned}$$

Step 4:
Calculate a volume by aquifer for each grid cell, according to the following equation, using Simsboro as an example:

$$Simsboro\ cell\ volume\ = \%\ of\ cell\ volume\ in\ Simsboro \times total\ cell\ volume$$

Step 5:
Calculate average drawdown for each aquifer according to the following equation, using Simsboro as an example.

$$Average\ Simsboro\ Drawdown = \frac{\sum Simsboro\ volume\ weighted\ cell\ drawdowns}{\sum Simsboro\ cell\ volumes}$$

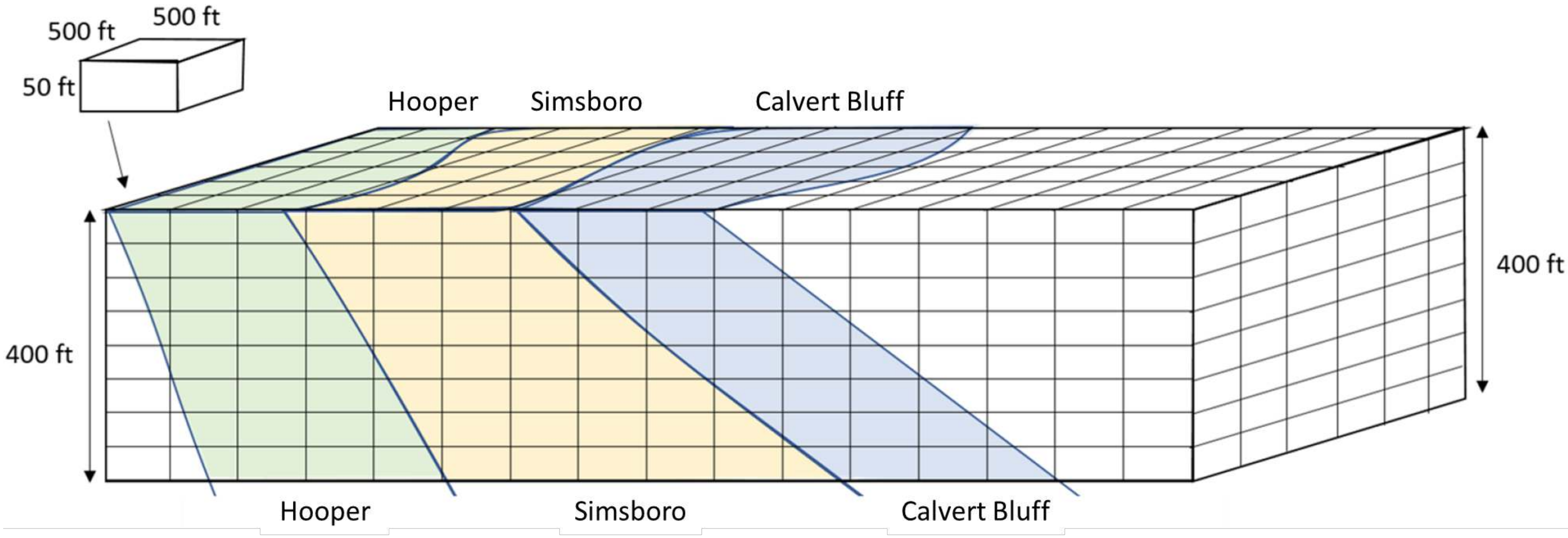


Figure H-1 Schematic diagram of Wilcox sub-aquifers assigned to a 3D model grid.