AGS
Advanced Groundwater Solutions, LLC
www.advancedgw.com

Technical Memorandum

TO: Mr. Alan Day, General Manager
Brazos Valley Groundwater Conservation District

FROM: Christopher Drabek, P.G., and James Beach, P.G.

SUBJECT: Review of Corpora Farms Simsboro Aquifer Evaluation Report

DATE: July 3, 2023

Introduction

On behalf of the Brazos Valley Groundwater Conservation District (BVGCD, District), Advanced Groundwater Solutions, LLC (AGS) has reviewed the Aquifer Evaluation Report (AER) prepared by Thornhill Group, Inc. (TGI) in support of a permit application for Corpora Farms (Corpora) for 13 proposed new wells to be completed in the Simsboro Aquifer with a withdrawal amount of 21,257 acre-feet per year (ac-ft/yr). The proposed wells are located on six different tracts of land with the furthest north well located just southwest of the Town of Calvert and the furthest south well located about 6.5 miles south of the City of Hearne. The locations of the wells are shown on Figure 1. The first submitted AER dated March 17, 2023 was submitted to BVGCD on May 1, 2023 as part of a Corpora Farms application packet dated April 27, 2023. After preliminary review, AGS and BVGCD provided comments to TGI and requested some clarification on the report on June 2, 2023. Supplemental information from TGI regarding the requested clarification was addressed in a letter dated June 13, 2023. The AER and supplemental information were submitted to address BVGCD Rule 8.4(b)(7)(B) for wells capable of producing 800 or more acre-feet per year and discusses the potential impacts of groundwater production from the Simsboro Aquifer of the proposed new wells in the west part of Robertson County.

AGS has evaluated the hydrogeological conditions, mapping of BVGCD permitted and registered Simsboro wells within one mile of the proposed Corpora wells and the water level drawdown estimates developed using the Texas Water Development Board (TWDB) Groundwater Availability Model (GAM) and analytical tools presented in the submitted aquifer evaluation reports. Discussion of the AER in this memorandum refers to the March 17, 2023 dated AER and supplemental letter dated June 13, 2023.

Proposed Corpora Farms Wells

The AER identifies 13 proposed Corpora wells with maximum pumping rates that range from 550 to 2,750 gallons per minute (gpm) and an annual permit allocation of 21,257 acre-feet. Table 1 below was extracted from the TGI AER and provides the maximum pumping rate in gpm and the annual permitted allocation in acre-feet for each of the proposed Corpora Simsboro Aquifer screened wells.

Well Identification	Maximum Pumping Rate (GPM)	Annual Permit Allocation (AF)
Corpora_1	1,000	1,290
Corpora_2	1,050	1,370
Corpora_3	1,650	2,093
Corpora_4	1,050	1,370
Corpora_5	1,125	1,449
Corpora_6	2,750	3,542
Corpora_7	1,125	1,449
Corpora_8	1,700	2,174
Corpora_9	1,700	2,174
Corpora_10	550	885
Corpora_11	550	885
Corpora_12	800	1,288
Corpora_13	800	1,288

Table 1. Proposed Corpora Farms Well Maximum Pumping Rate and Annual Permit Allocation (From TGI AER)

The proposed locations of the 13 Corpora wells are shown on Figure 1 below.

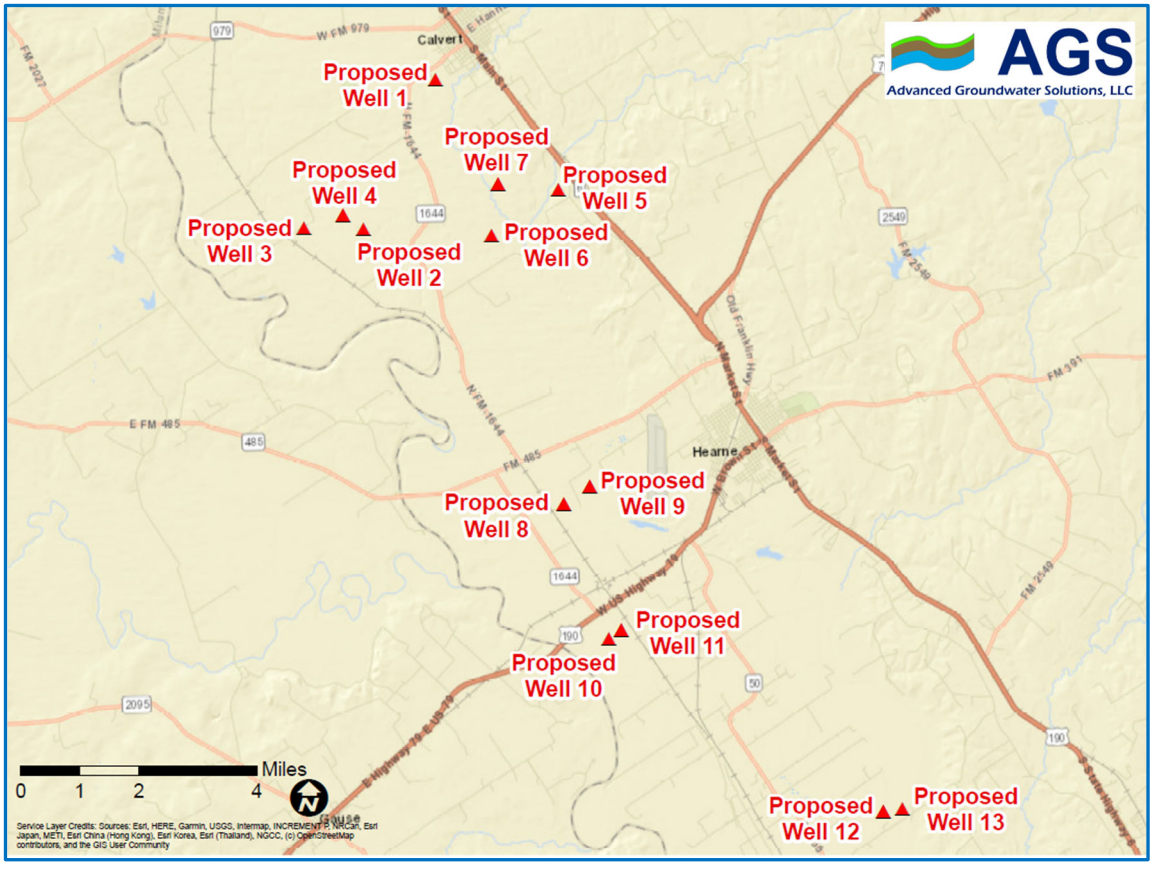


Figure 1. Proposed Corpora Farms Well Location Map

Hydrogeologic Conditions

Rule 8.4(b)(7)(B)(1)

AGS has evaluated the hydrogeological conditions presented in the AER and generally agrees with the information presented in this section.

The AER identifies the top and bottom of the Simsboro Aquifer based on the Layer 9 (Simsboro) information found at each proposed well location from Version 3.02 of the Central Portion of the Sparta, Queen City and Carrizo-Wilcox Aquifers GAM (INTERA Incorporated and others, 2020). The GAM surfaces can often be reasonable approximations of the tops and bottoms of the aquifers, but there can be some uncertainty in the accuracy of the top/bottom of the GAM aquifer layers as the model layers are based on interpolation between a limited number of regional geophysical logs and may not include the detail of a review at the local level.

Figures 4 through 16, attached to this memorandum, show the estimated tops and bottoms of the Simsboro Aquifer based on a localized review of available geophysical logs by Ground Water Consultants and AGS. The local review process also involved interpolation in the estimation of the top and bottom extent of the Simsboro Aquifer. Figures 4 through 16 also show the GAM estimated tops and bottoms of the Simsboro Aquifer. There are differences between the estimated top and bottom of the Simsboro Aquifer between the geophysical log and GAM datasets, with larger differences shown in the updip areas near proposed Corpora Wells 1 through 7. There is a better agreement on the top and bottom of the Simsboro Aquifer between the geophysical log and GAM datasets in downdip areas near proposed Corpora Wells 8 through 13.

Site specific information will be available once the test holes are drilled and logged for each of the proposed Corpora wells.

The top of first screen and total depth for each of the 13 proposed Corpora wells is based on the top and bottom of the GAM Layer 9 (Simsboro) at each proposed well location as shown on Table B of the BVGCD Application for Drilling or Operating Permit included in the Corpora Farms application packet dated April 27th.

Simsboro Aquifer Wells Within 1-mile of the Proposed Wells

Rule 8.4(b)(7)(B)(2)

AGS has confirmed that the BVGCD wells identified in Table 2 of the revised Table 2 in the TGI supplemental letter are the only permitted or registered Simsboro wells within one mile of the proposed Corpora wells at the time of the AER. Revised Table 2 of the TGI supplemental letter includes data on each registered or permitted well screening the Simsboro Aquifer located within one mile of the proposed wells and generally includes most of the required information for the wells. Ideally, the top and bottom of the screen interval would be shown in the Screen Depth column, if available. Maps showing the location of the proposed Corpora wells and the BVGCD registered or permitted wells within one mile of the proposed wells are included as Exhibits 1 -6 in the Corpora Farms application packet dated April 27, 2023.

An additional well has been permitted and registered with BVGCD since the submission of the AER and Corpora Farms application packet. The City of Calvert Well 7 is planned to be located about 2,375 to 2,425 feet to the northeast of proposed Corpora Well 1. The City of Calvert Well 7 (BVDO-0320) is permitted to pump 325 acre-feet per year from the Simsboro Aquifer. Additional information of the City of Calvert Well 7 can be found on the BVGCD Groundwater Management Application Public Web Map (https://brazosvalleygcd.halff.com/default.aspx).

Interference Drawdown Estimates

Rule 8.4(b)(7)(B)(3)

BVGCD Rule 8.4(b)(7)(B)(3) requires an estimate of water level drawdown caused by the well(s) pumping at the permitted rate for 1 year and 10 years at a distance of up to five miles from the well(s) using Version 3.02 of the Central Portion of the Sparta, Queen City and Carrizo-Wilcox Aquifers GAM (INTERA Incorporated and others, 2020). An estimate of the drawdown at locations of existing registered and permitted wells in the BVGCD database that are located within one mile and screen the same aquifer as the well(s) is required to be developed using an analytical tool.

Appropriate analytical models are generally used to provide estimates of pumping effects at or near the well(s) over shorter time horizons. Regional numerical models like the TWDB GAMs are generally used to account for regional variability in the aquifer such as changes in transmissivity and faulting as well as recharge, leakage between aquifers, stream-aquifer interaction, other pumping, and other factors impacting water levels. Appropriate numerical models can provide more reliable estimates of pumping effects on a more regional scale and over longer time horizons.

Groundwater Availability Model Simulation

TGI used the TWDB Central Portion of the Sparta, Queen City and Carrizo-Wilcox Aquifer GAM to estimate drawdown that results from continuously pumping the proposed Corpora wells at a combined rate of 21,257 ac-ft/yr for 1 year and 10 years. A copy of the TGI 1-year and 10-year GAM simulated interference drawdown illustrations from the AER (TGI Figures 5 and 6) are attached to this memorandum. Table 1 from the AER shows GAM simulated 1-year and 10-year drawdown estimates at BVGCD permitted and registered Simsboro wells within a five-mile radius of the proposed wells. The TGI report did not discuss the GAM simulation methodology, but the GAM model results appear generally reasonable based on AGS simulation verification runs.

In the AGS verification runs, two GAM simulations were completed with the first simulation (the baseline run) using the unmodified Groundwater Management Area (GMA) 12 "S-19" Desired Future Conditions (DFC) run and with the second simulation (the modified run) being identical to the baseline except that the requested 21,257 ac-ft/yr of pumping was included in the MODFLOW WEL file. The simulated water levels from each simulation were compared by subtracting the simulated water level elevations of the baseline run from the modified run. This comparison isolates the pumping effects of the requested pumping. GMA 12 "S-19" includes additional

regional pumping, which gradually increases through time. GMA 12 "S-19" was approved in 2021 and does not include all of the pumping from the Simsboro Aquifer that has been permitted by BVGCD in the area in the past year.

The AGS GAM simulation results after 1 and 10 years of pumping 21,257 ac-ft/yr generally show drawdown estimates to be slightly less than the TGI drawdown estimates at proposed Corpora Wells 1 through 7, approximately the same amount of drawdown as TGI at proposed Corpora Wells 8 and 9 and slightly higher drawdown estimates than TGI at proposed Corpora Wells 10 through 13. The slight drawdown differences between the AGS and TGI runs could potentially be attributed to background pumping in the TGI simulations if TGI did not use the approach described above to isolate drawdown.

The AGS GAM simulation results after 1 and 10 years of pumping 21,257 ac-ft/yr from the proposed Corpora wells show about 51 and 62 feet and feet of drawdown, respectively, at the recently permitted City of Calvert Well 7 (Simsboro Aquifer) location.

The GAM estimated drawdown contours to the northwest appear to be influenced by a fault included in the GAM, which is in the same general area as a fault that has been mapped recently by Groundwater Consultants, LLC and AGS using local geophysical logs and other hydrogeologic data.

AGS has reviewed this AER based on the hydrogeologic information available today, the information provided by the applicant, and the models and tools available at this time. New scientific or hydrogeologic information or updated models may change the findings of this review.

Analytical Model Simulation

TGI used an analytical model based on the Theis non-equilibrium equation to estimate theoretical potentiometric head declines at and surrounding the proposed wells. TGI used transmissivity values ranging from 45,000 to 90,000 gallons per day per foot (gpd/ft) and storativity value of 0.0005 for the 1-year simulation and 0.003 for the 10-year simulation. A copy of the updated TGI 1-year and 10-year analytical simulated interference drawdown illustrations from the June 13th supplemental letter (TGI Revised Figures 7 and 8) are attached to this memorandum. Table 1 provided in the AER was not updated by TGI in conjunction with the updated proposed Corpora Well analytical drawdown estimates developed by TGI as part of the June 13th supplemental response. TGI personnel indicated that they used the same method in the analytical approach that has been used in BVGCD in the past. That approach has historically included estimating analytical drawdown values at the proposed well locations by averaging the estimated drawdown at the well over the grid cell within the analytical tool.

AGS estimated the drawdown at the pumping wells using the Theis analytical model and calculating the drawdown at one foot from the well. Table 1 below provides a summary of the AGS simulated drawdown estimates at each of the proposed Corpora wells. TGI used different storage values in the analytical simulations (0.0005 for the 1-year simulation and 0.003 for the 10-year simulation). AGS performed additional 1-year and 10-year simulations assuming that the

storage value approximates the storage value found in the GAM to show the difference between the TGI simulations and the simulations using a storage value of 0.0001. If the actual storage coefficient is 0.0001 the drawdown is estimated to be as shown in the table below.

Proposed Corpora Well	AGS Simulated Drawdown After 1-Year of Pumping	AGS Simulated Drawdown After 10-Years of Pumping	AGS Simulated Drawdown After 1-Year of Pumping with Storage Vaule of 0.0001	AGS Simulated Drawdown After 10-Years of Pumping with Storage Vaule of 0.0001
Well 1	124	137	164	223
Well 2	141	154	181	240
Well 3	149	161	189	247
Well 4	140	153	180	239
Well 5	135	148	175	234
Well 6	186	199	227	285
Well 7	140	153	181	239
Well 8	126	138	166	224
Well 9	126	139	166	225
Well 10	85	97	125	183
Well 11	86	98	125	184
Well 12	68	79	105	163
Well 13	67	78	104	162

Table 1. AGS Theis Analytical Simulated Drawdown at the Proposed Corpora Wells After 1-Year and 10-Years of Pumping 21,257 ac-ft/yr Using TGI Hydraulic Properties and Also Using a Storage Coefficient of 0.0001 for the 1-year and 10-year Simulations

AGS was able to verify the TGI analytical estimated drawdown at all other locations shown in Table 1 of the TGI AER report. The AGS analytical simulation results after 1 and 10 years of pumping 21,257 ac-ft/yr from the proposed Corpora wells using TGI hydraulic properties shows about 90 and 102 feet and feet of simulated drawdown, respectively, at the recently permitted City of Calvert Well 7 location.

There is an increased density of contours near the proposed Corpora wells using the AGS approach and we think these are more appropriate estimates of “near well” drawdown. However, there are

many factors that will determine the actual drawdown near the well during pumping, and therefore, these differences are assumed to be minor for the purposes of the AER. Figures 2 and 3 below show the estimated AGS analytical modeling drawdown contours that result from pumping 21,257 ac-ft/yr for 1-year and 10-years, respectively. Simulated drawdown contours developed with TGI hydraulic properties at distance are similar for both methodologies.

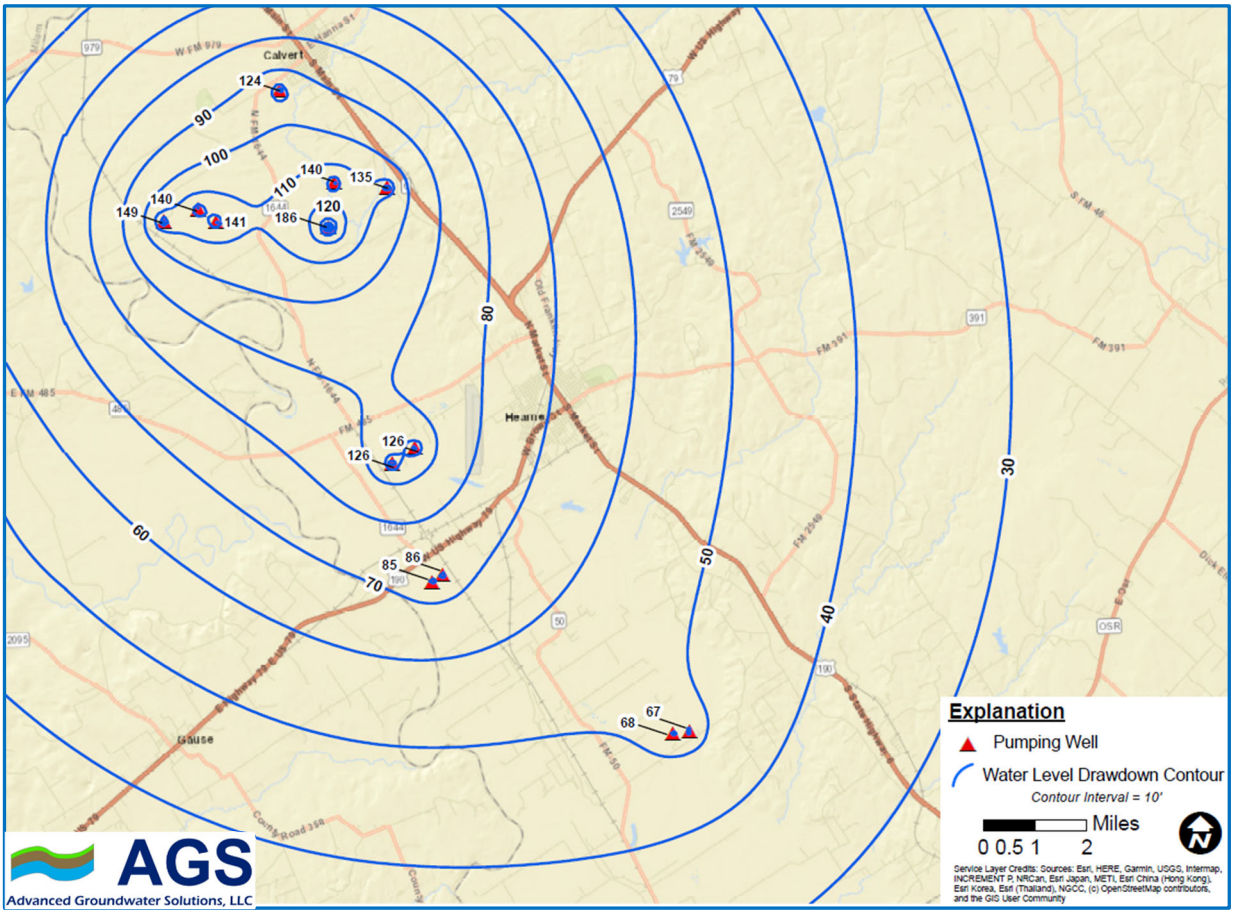


Figure 2. AGS Theis Analytical Simulated Drawdown After Proposed Corpora Pumping of 21,257 ac-ft/yr for 1-Year (TGI Hydraulic Properties)

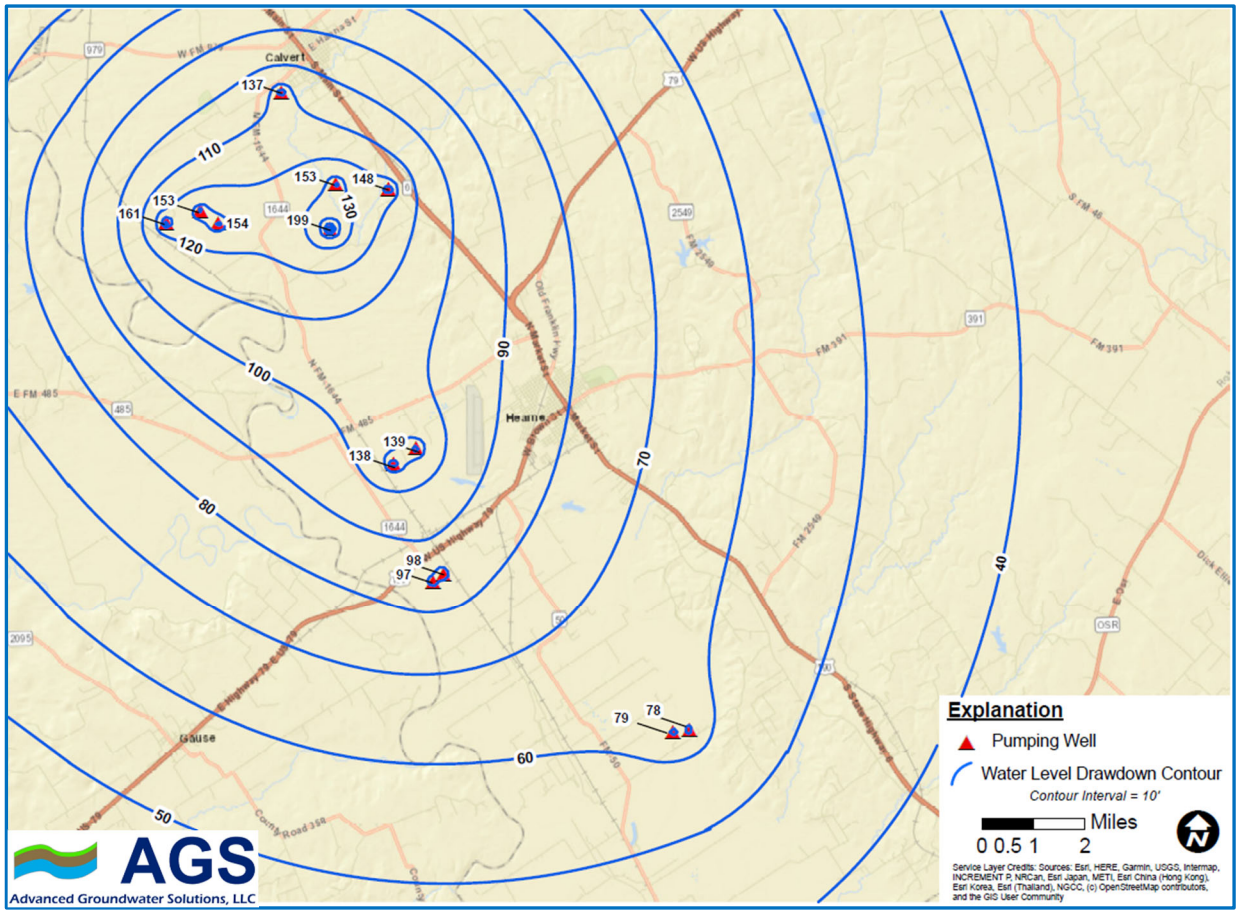


Figure 3. AGS Theis Analytical Simulated Drawdown After Proposed Corpora Pumping of 21,257 ac-ft/yr for 10-Years (TGI Hydraulic Properties)

Estimated Long-term impacts at the Proposed Corpora Farm Wells based on the GMA 12 2021 DFC Run

As a way of evaluating potential long-term estimated water level decline at the proposed Corpora wells, AGS plotted the simulated water level decline at each well location based on the 2021 GMA 12 DFC/Modeled Available Groundwater (MAG) projections for the Simsboro Aquifer as shown on the attached Figures 4 through 16. The water level projections shown in the attached figures are from the TWDB approved DFC/MAG run known as GMA 12 "S-19", but do not include the local impacts from the proposed Corpora wells included in the AER, nor do they include all of the pumping from the Simsboro Aquifer that has been permitted in the area in the past year. The DFC run includes pumping estimates from the Groundwater Conservation Districts in GMA 12 as of about December 2021 that yield DFCs so that the TWDB can estimate the MAG. The detailed assumptions for the DFC simulation can be found in the GMA 12 Explanatory Report (Daniel B. Stephens & Associates and others, 2022) and documentation of the TWDB MAG run can be found

in GAM Run 21-017 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 12 (Shi and Harding, 2022).

The graphs illustrate the relationship between the land surface, estimated static water level through time, the GAM estimated top and bottom of the Simsboro Aquifer (GAM Layer 9) and the estimated top and bottom of the Simsboro Aquifer based on review of available local electric logs near the locations of the proposed Corpora wells.

Available historical static water level measurements from wells located near the proposed Corpora wells are also shown on the attached Figures 4, 6, 8 and 9. The City of Calvert Well 6 (BVGCD Permit BVOP-0012) is shown on Figure 4 and is located about 0.8 miles to the northeast of proposed Corpora Well 1. Well 6 screens sands of the Simsboro Aquifer in the depth interval of about 404 to 658 feet below land surface. A private irrigation well (BVGCD Permit BVDO-0092) is shown on Figure 6 and is located about 1 mile to the southwest of the proposed Corpora Well 3. Well 3 screens sands of the Simsboro Aquifer in the depth interval of about 367 to 517 feet below land surface. A private domestic well (BVGCD Permit BVR-1506) is shown on Figures 11 and 12 and is located about 1.3 miles to the northwest of proposed Corpora Well 8 and about 1.7 miles to the west-northwest of proposed Corpora Well 9. BVGCD well BVR-1506 screen sands of the Simsboro Aquifer and has a total depth of about 1,250 feet below land surface.

Available drawdown in wells in the Simsboro Aquifer will decline over time based on the DFC simulation. Although not evaluated or discussed in detail herein, these levels of water level decline in wells and artesian head decline in the aquifer will have some impact on vertical leakage, intercepted discharge, reduction in confined and unconfined storage, and potential flow directions in the aquifer. Pumping by the proposed wells will have some of the same type effects on the aquifer.

TGI's report makes note of the testing observed by BVGCD representatives on March 18, 2009. For clarification, BVGCD representatives (John Seifert, LBG-Guyton Associates) observed short term pumping (15-20 minutes) of the irrigation wells with flow meter readings of about 3,000 gpm on March 18, 2009.

Conclusions

The submitted AER generally addresses the requirements defined by BVGCD Rule 8.4(b)(7)(B) for wells capable of producing 800 or more acre-feet per year.

There are some differences in the estimates of the depth of the top and bottom of the Simsboro Aquifer near proposed Corpora Well 1. The estimates of the top / bottom of the Simsboro Aquifer based on Layer 9 of the GAM are deeper than estimates developed by review of available area geophysical log data. Hydrogeologic characteristics of the Simsboro Aquifer at the proposed location of Corpora Well 1 will influence the depth of the well screen settings, which could potentially affect the available drawdown at or near the proposed well. Site specific information will be available once the test holes are drilled and logged for each of the proposed Corpora wells.

Overall, the TGI GAM simulations look reasonable and AGS was able to generally recreate the TGI simulation results. There are minor differences in the simulated drawdown estimated by TGI and AGS near the proposed Corpora well locations, but these can most likely be attributed to differences in the approach to the GAM simulation(s).

The TGI analytical modeling results show less drawdown as a result of pumping the requested permitted amount of 21,257 ac-ft/yr at the proposed Corpora well locations than calculated by AGS. This may be due to the difference in application of the Theis analytical approach. To provide a drawdown at the well, AGS calculates the drawdown at the pumping wells at one foot from the well.

AGS is documenting the differences but does not consider them to be major for the purposes of this report.

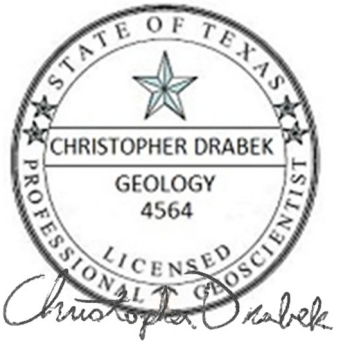
References

Daniel B. Stephens & Associates, INTERA Incorporated, and Ground Water Consultants, LLC, 2022, Desired Future Condition Explanatory Report for Groundwater Management Area 12, 859 p.

INTERA Incorporated, D.B. Stephens & Associates, and Ground Water Consultants, LLC, 2020, GMA 12 Update to the Groundwater Availability Model for the Central Portion of the Sparta, Queen City, Carrizo-Wilcox Aquifers: Update to Improve Representation of the Transmissive Properties of the Simsboro Aquifer in the Vicinity of the Vista Ridge Well Field, 30 p.

Shi, J. and Harding, J., 2022, GAM RUN 21-017 MAG: Modeled Available Groundwater for the Aquifers in Groundwater Management Area 12, 36 p.

Geoscientist's Seal:



The seal appearing on this document was authorized by Christopher Drabek, P.G. 4564 on 7/3/2023.
Advanced Groundwater Solutions, LLC (TBPG Firm Registration No. 50639)

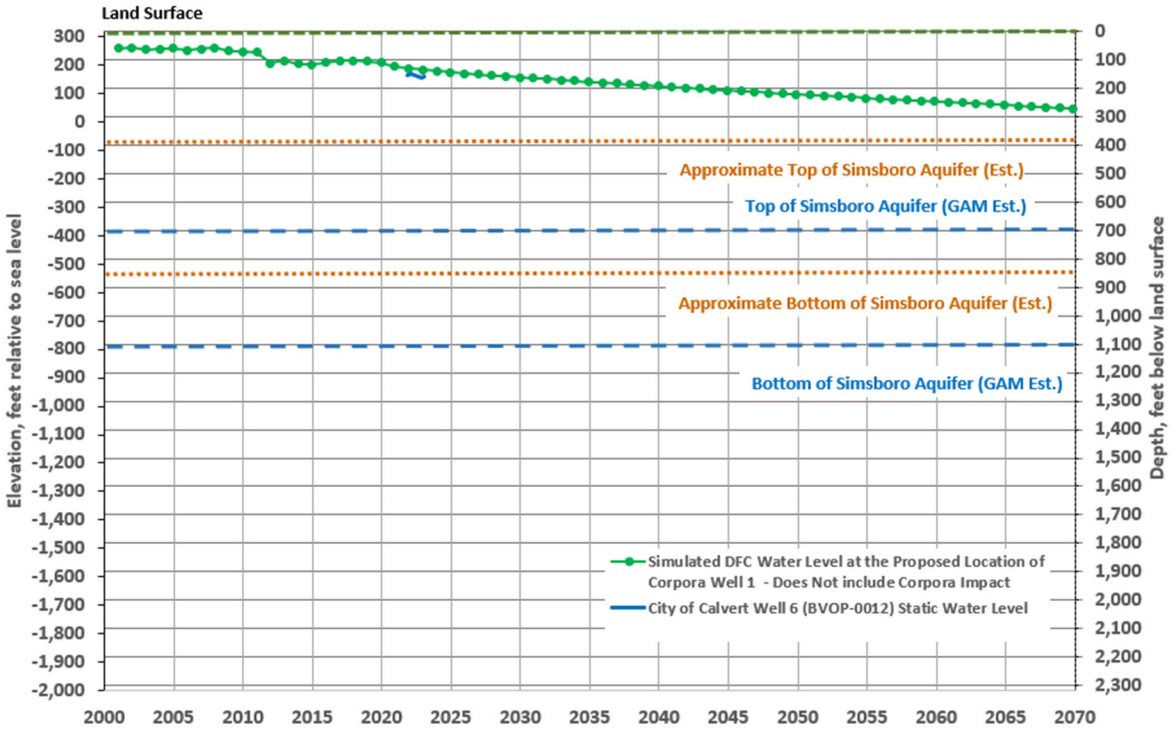


Figure 4. Projected DFC Water Level Change at Proposed Corpora Farms Well 1

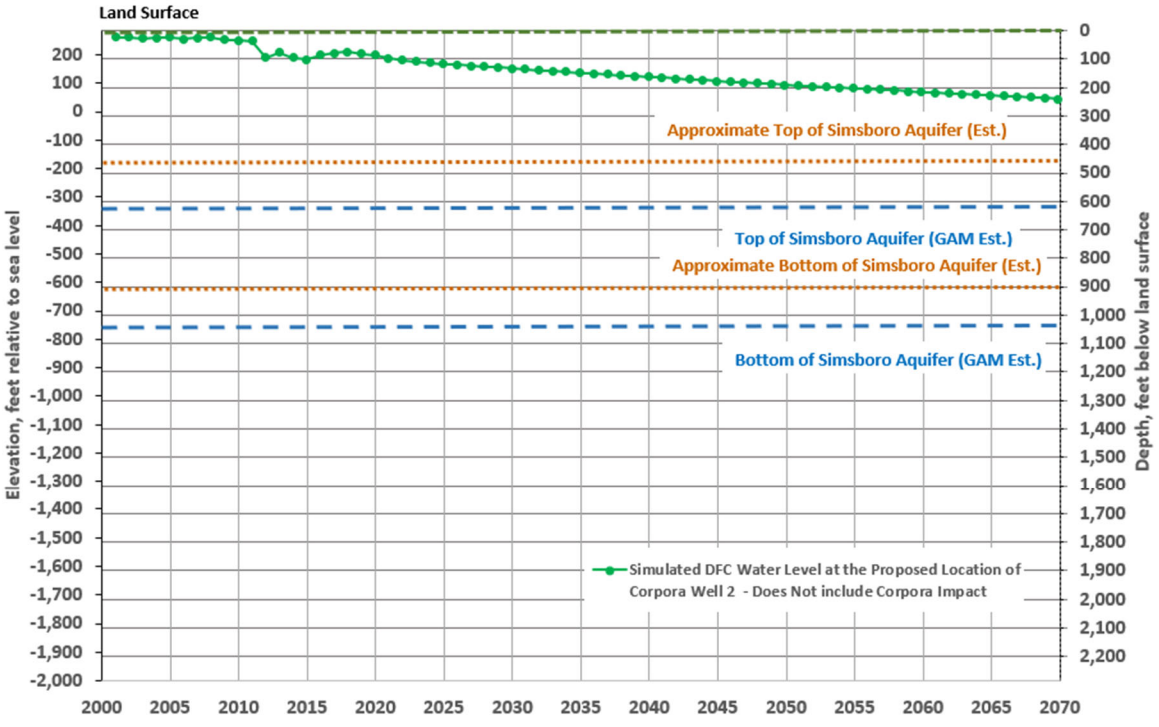


Figure 5. Projected DFC Water Level Change at Proposed Corpora Farms Well 2

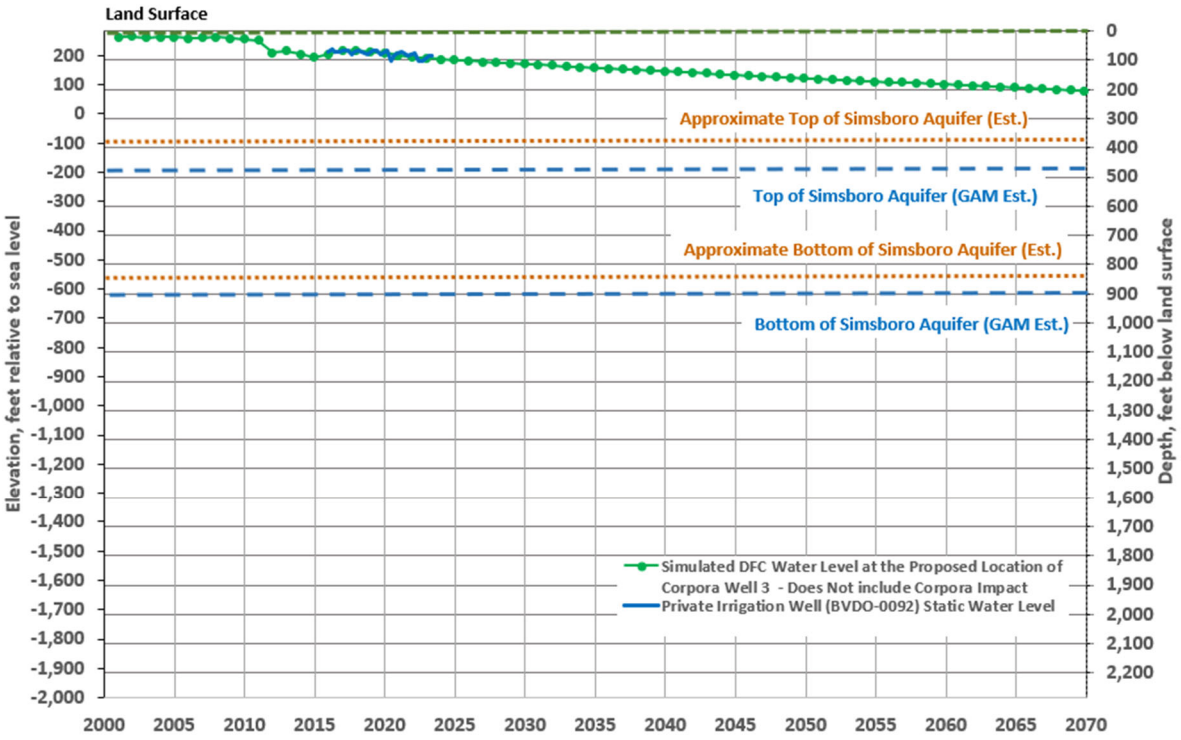


Figure 6. Projected DFC Water Level Change at Proposed Corpora Farms Well 3

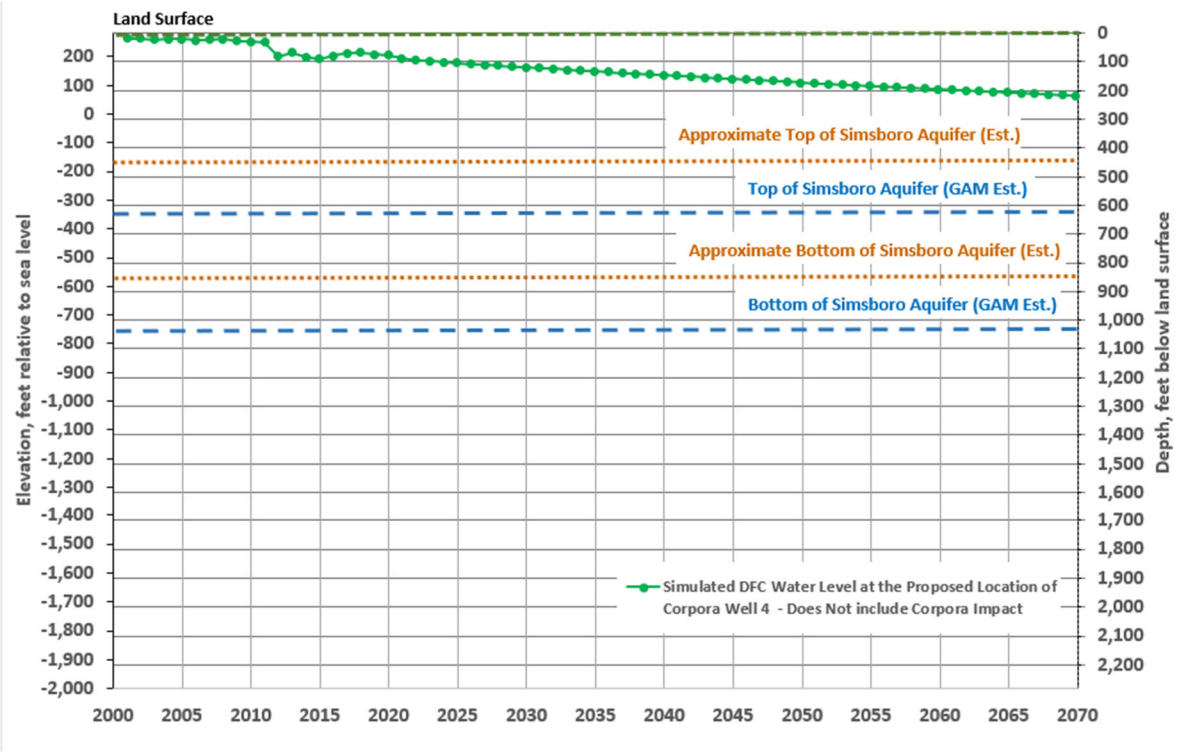


Figure 7. Projected DFC Water Level Change at Proposed Corpora Farms Well 4

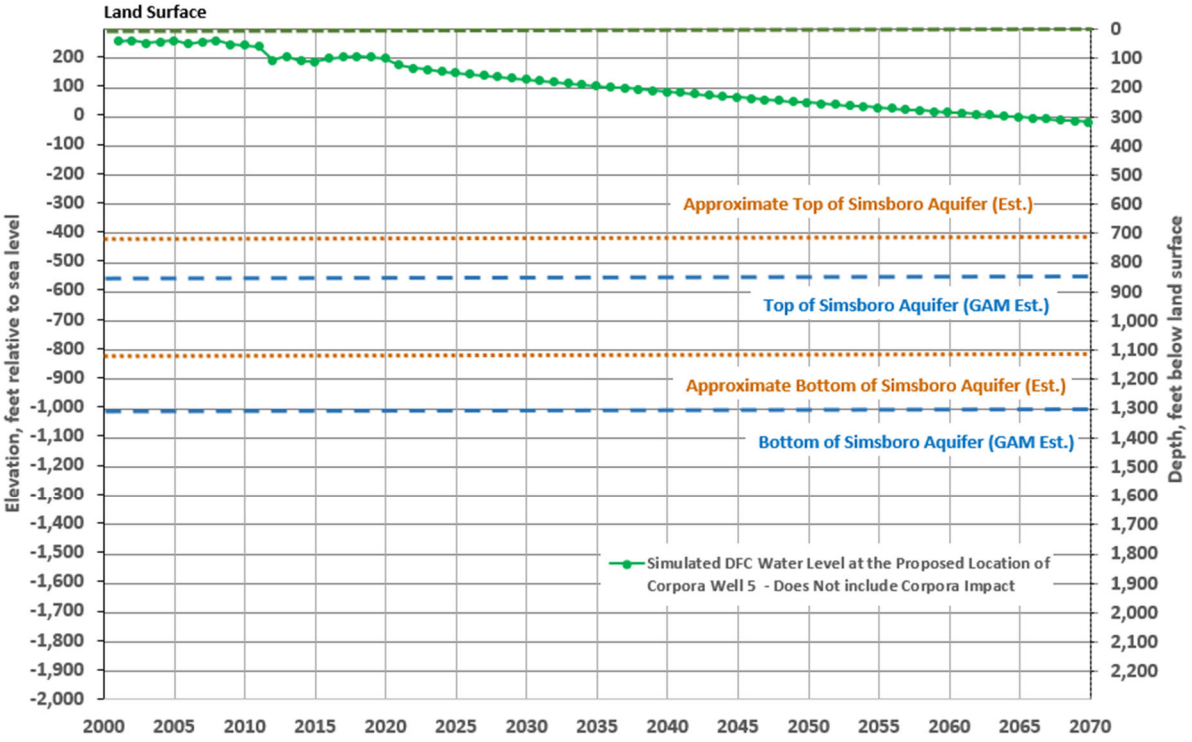


Figure 8. Projected DFC Water Level Change at Proposed Corpora Farms Well 5

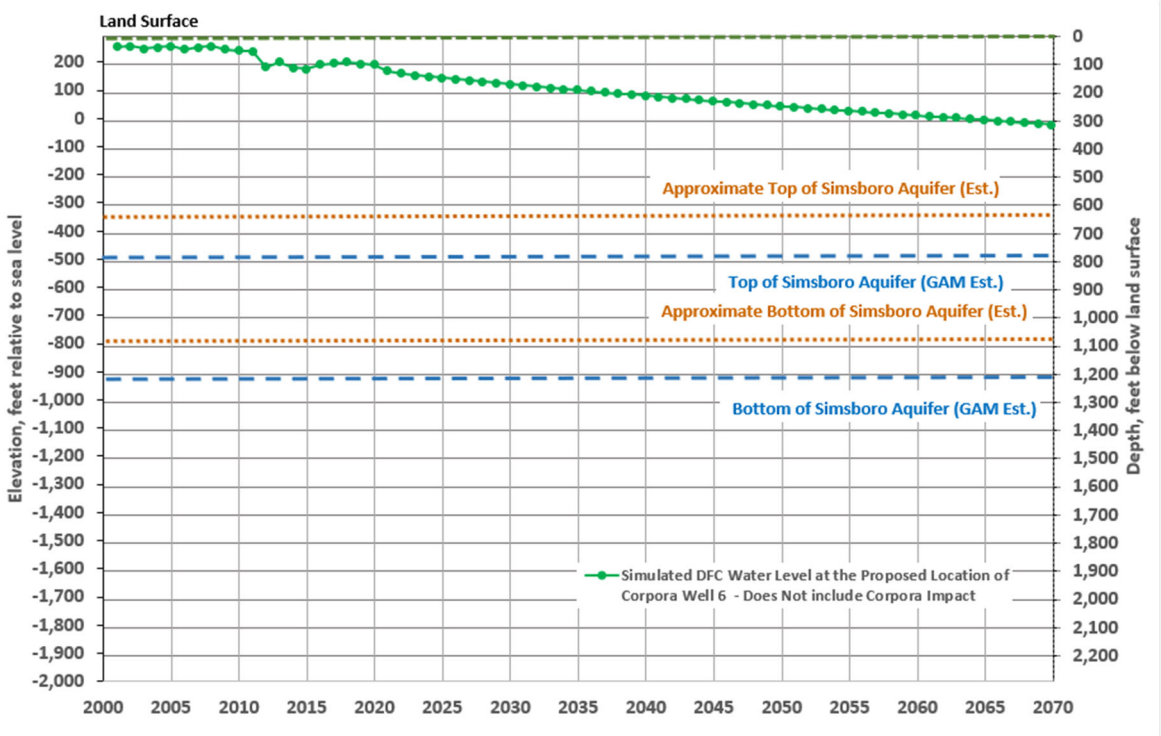


Figure 9. Projected DFC Water Level Change at Proposed Corpora Farms Well 6

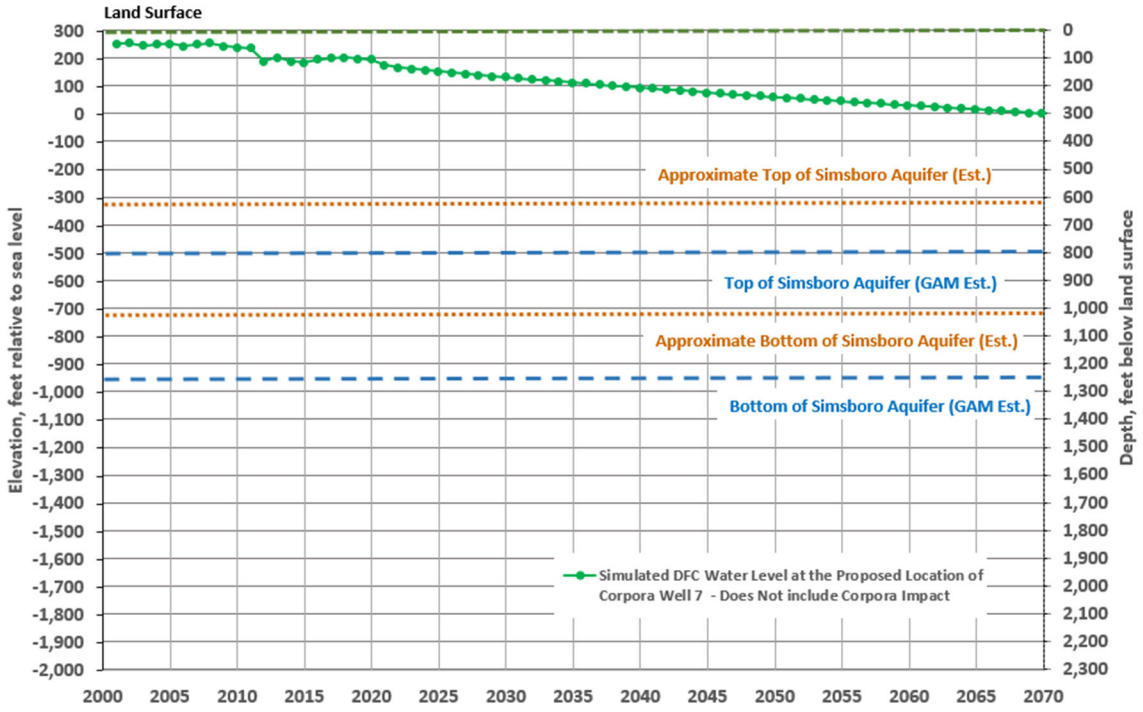


Figure 10. Projected DFC Water Level Change at Proposed Corpora Farms Well 7

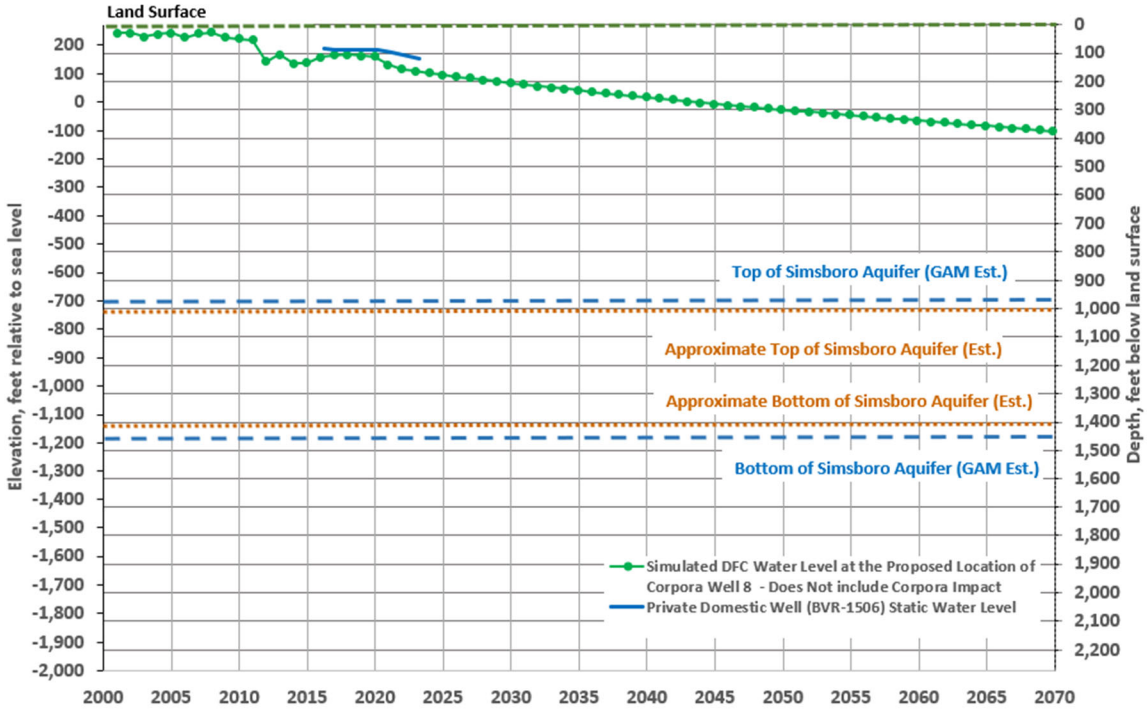


Figure 11. Projected DFC Water Level Change at Proposed Corpora Farms Well 8

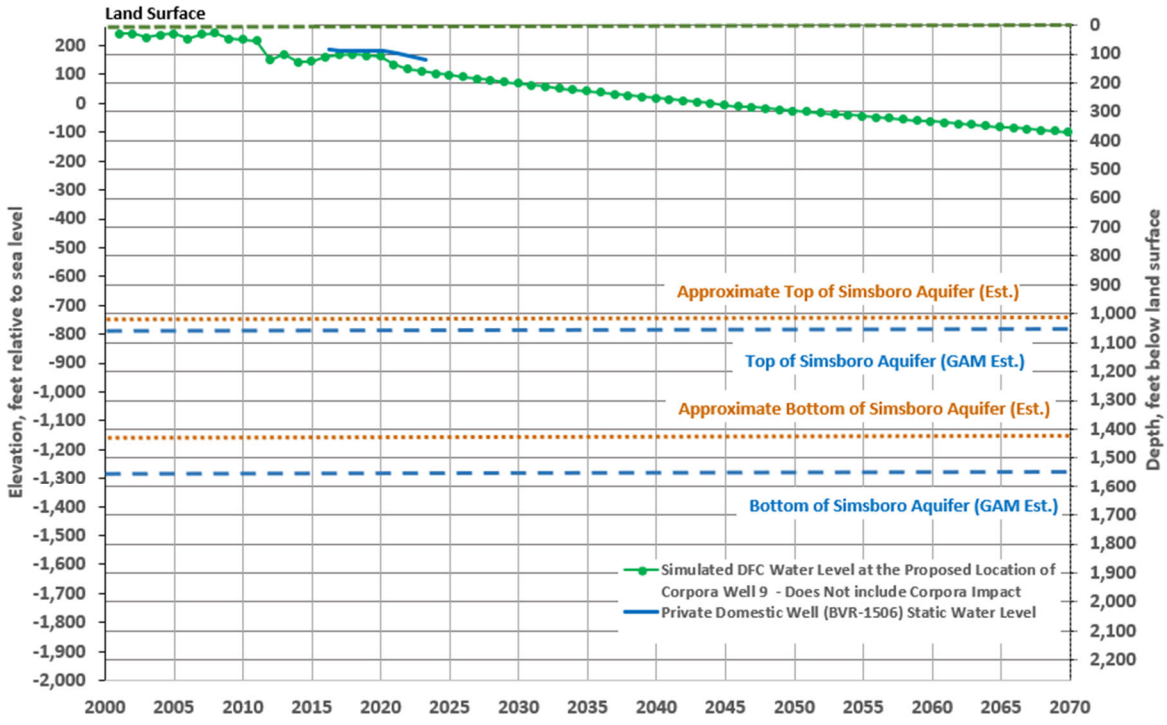


Figure 12. Projected DFC Water Level Change at Proposed Corpora Farms Well 9

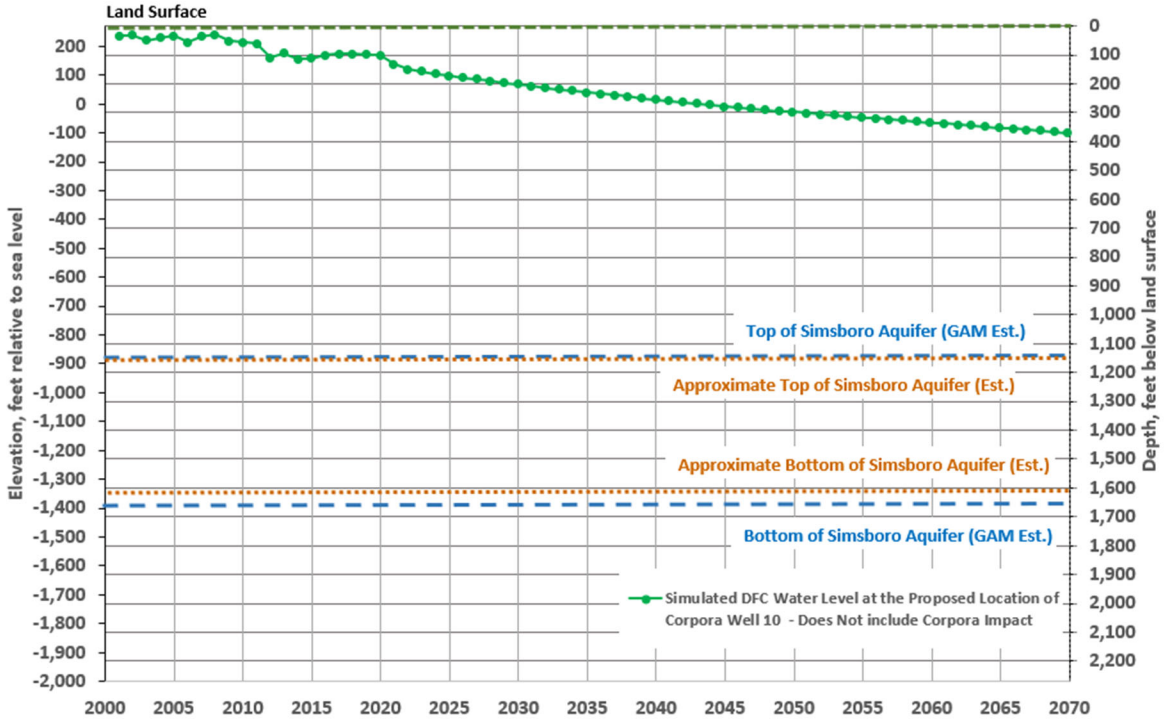


Figure 13. Projected DFC Water Level Change at Proposed Corpora Farms Well 10

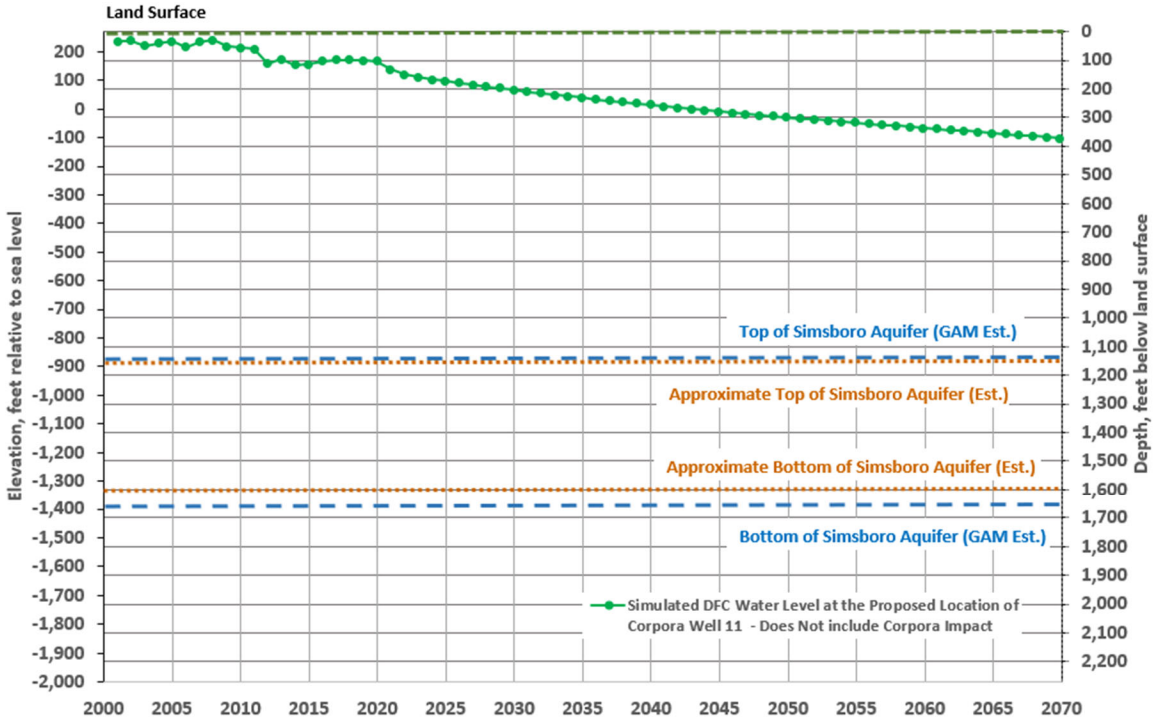


Figure 14. Projected DFC Water Level Change at Proposed Corpora Farms Well 11

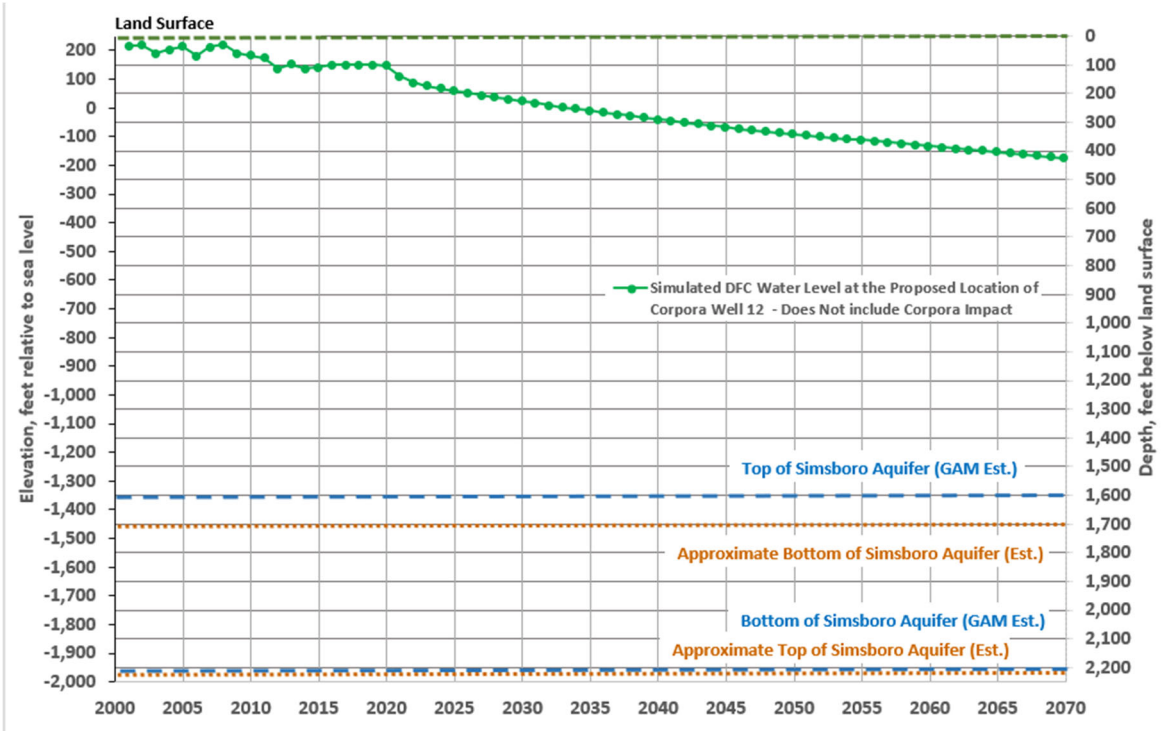


Figure 15. Projected DFC Water Level Change at Proposed Corpora Farms Well 12

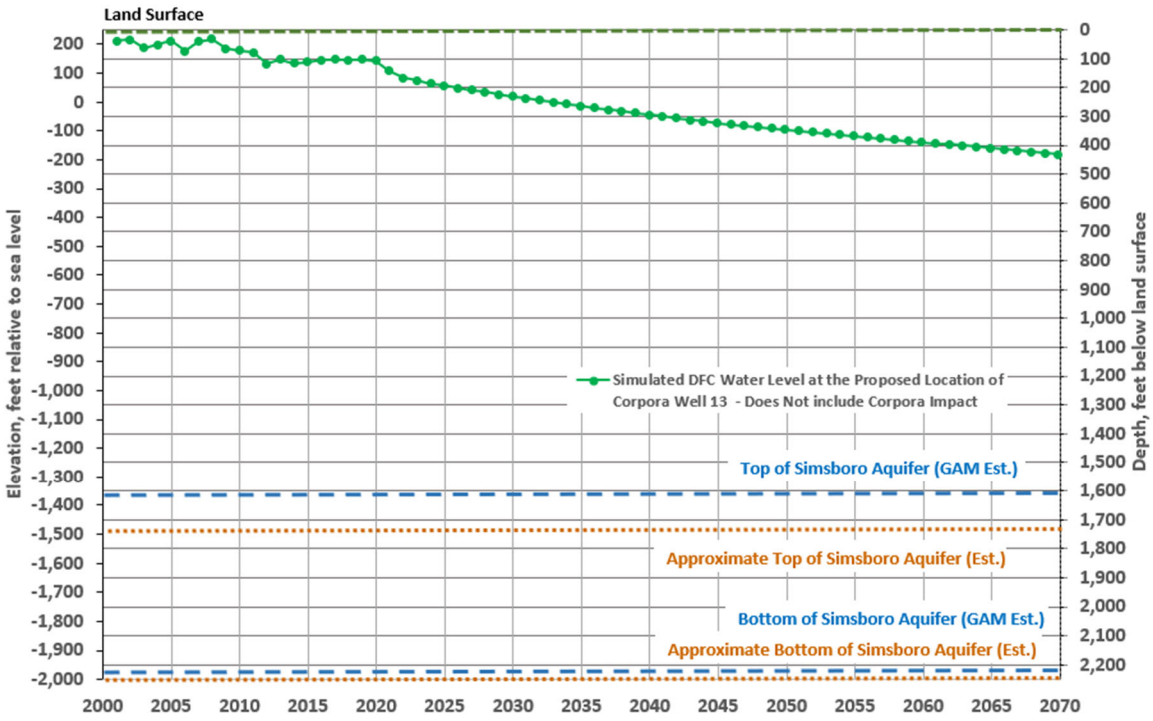


Figure 16. Projected DFC Water Level Change at Proposed Corpora Farms Well 13

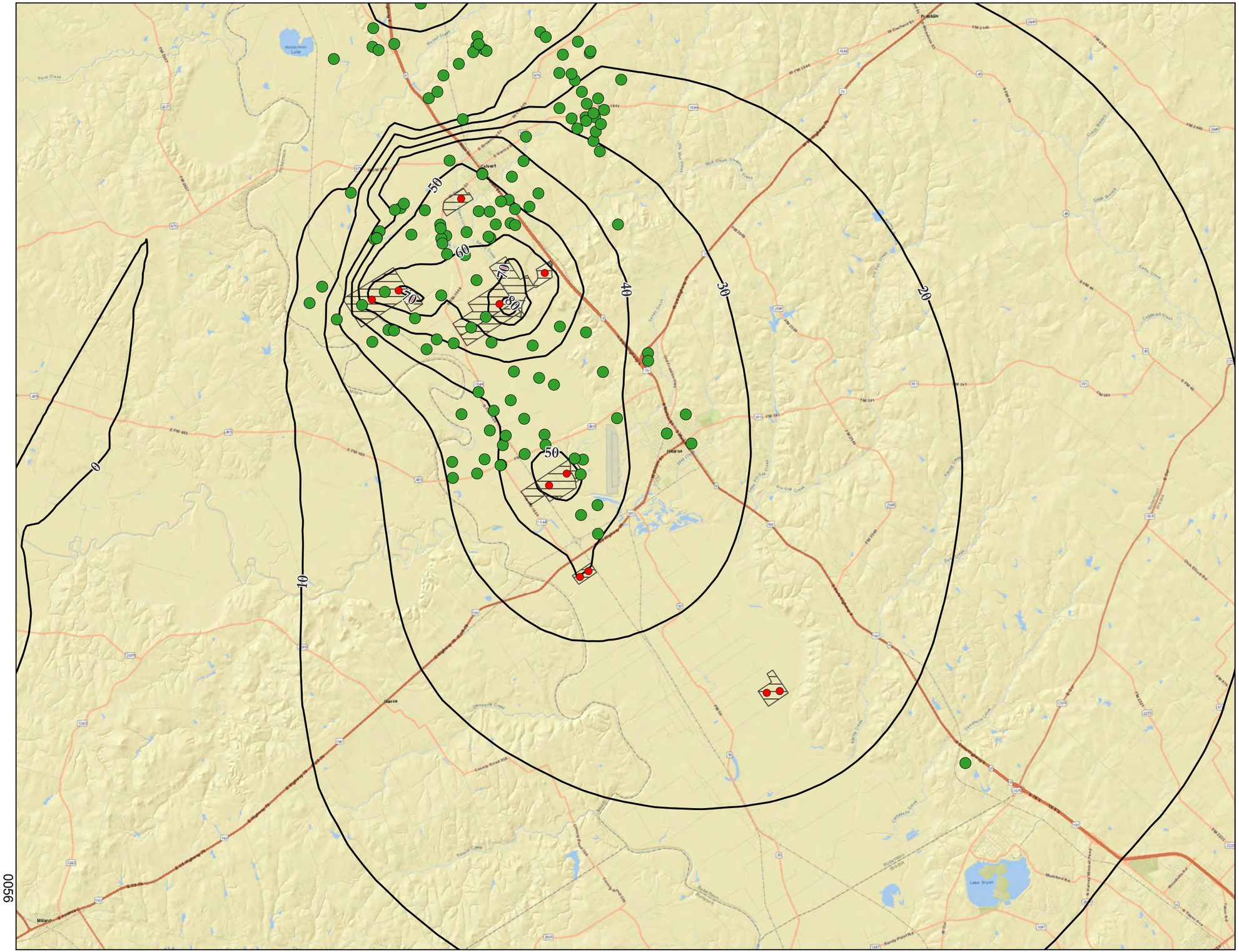


Figure 5: 1-Year QCSP GAM Drawdown Contours

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Corpora Proposed Well

BVGCD Registered Simsboro Well

10-Year Drawdown (feet)

Corpora Property Boundaries

N

0 1 2 3 4 5 6 mi

Scale 1:150,000

Figure 6:
10-Year QCSP GAM Drawdown Contours

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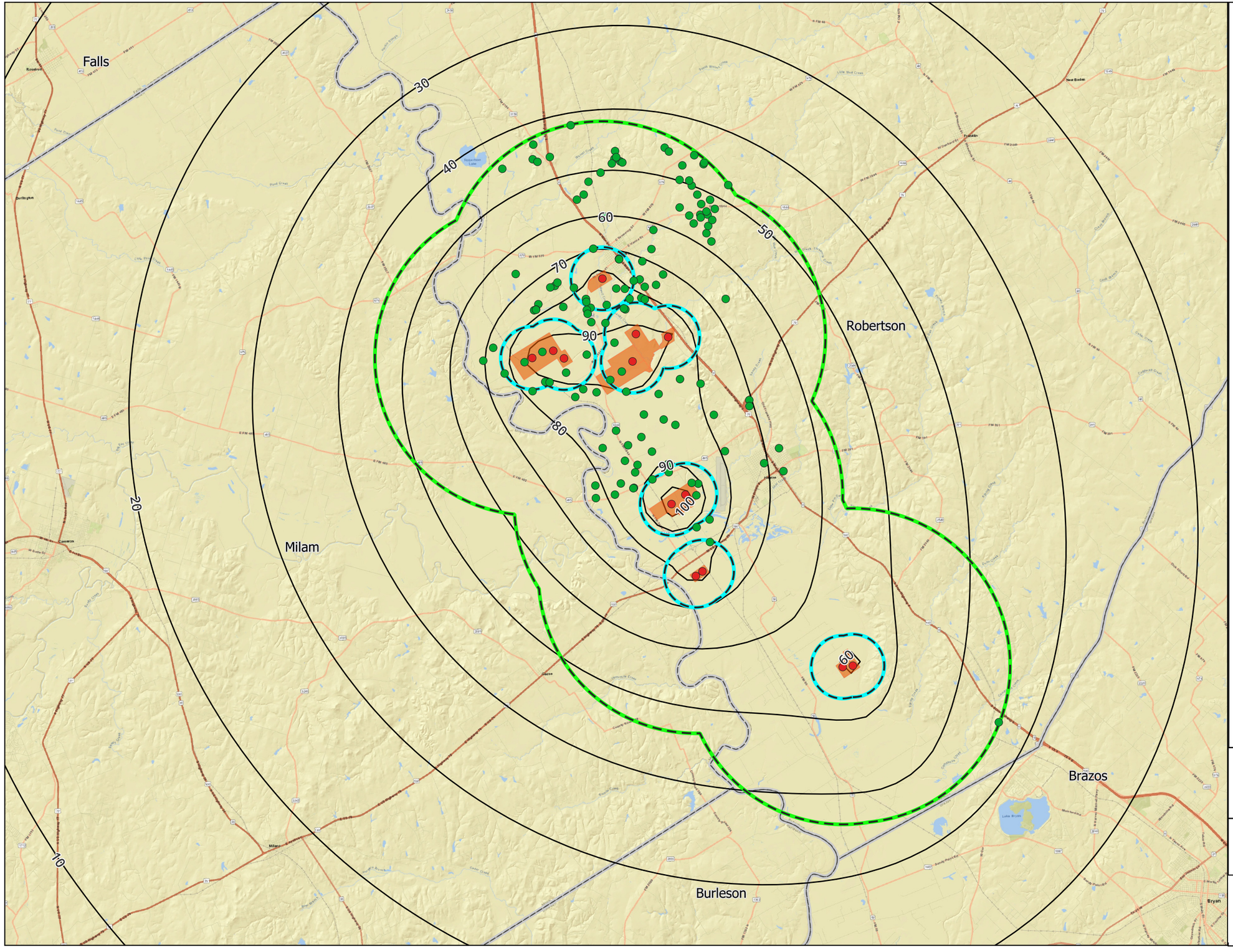

Explanation

- BVGCD Reported Well Completed in the Simsboro and W/in 5 Miles
- Proposed Corpora Well
- 1-Yr Modeled Drawdown Contour Interval = 10 feet
- 1 Mile Radius from Well Locations
- 5 Mile Radius from Well Locations
- Corpora Property Boundary
- Counties

0 3 6 mi

Corpora Farms

Revised Figure 7:
1-Year Analytical Drawdown

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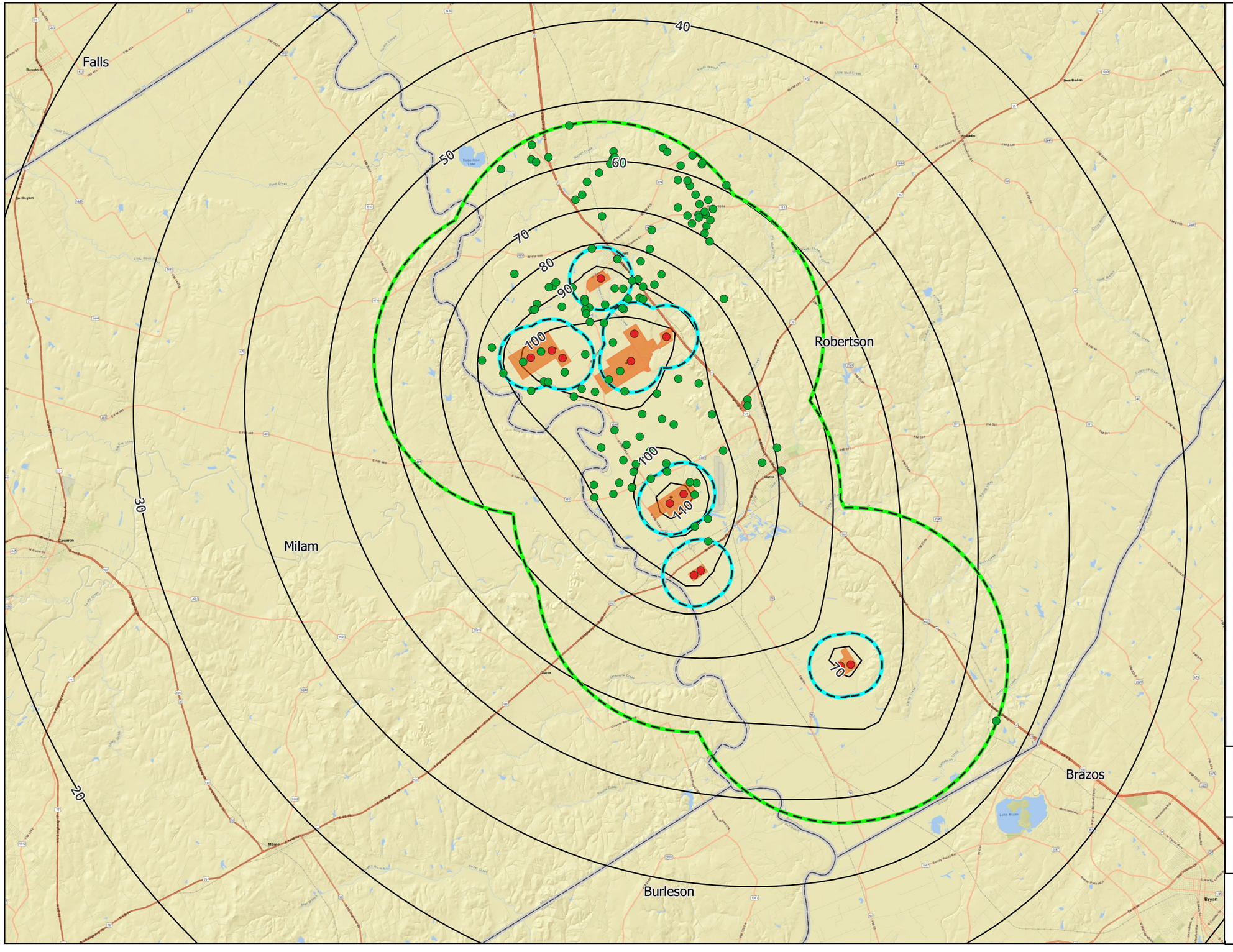

Explanation

- BVGCD Reported Well Completed in the Simsboro and W/in 5 Miles
- Proposed Corpora Well
- 10-Yr Modeled Drawdown Contour Interval = 10 feet
- 1 Mile Radius from Well Locations
- 5 Mile Radius from Well Locations
- Corpora Property Boundary
- Counties

0 3 6 mi

Corpora Farms

Revised Figure 8:
10-Year Analytical Drawdown

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