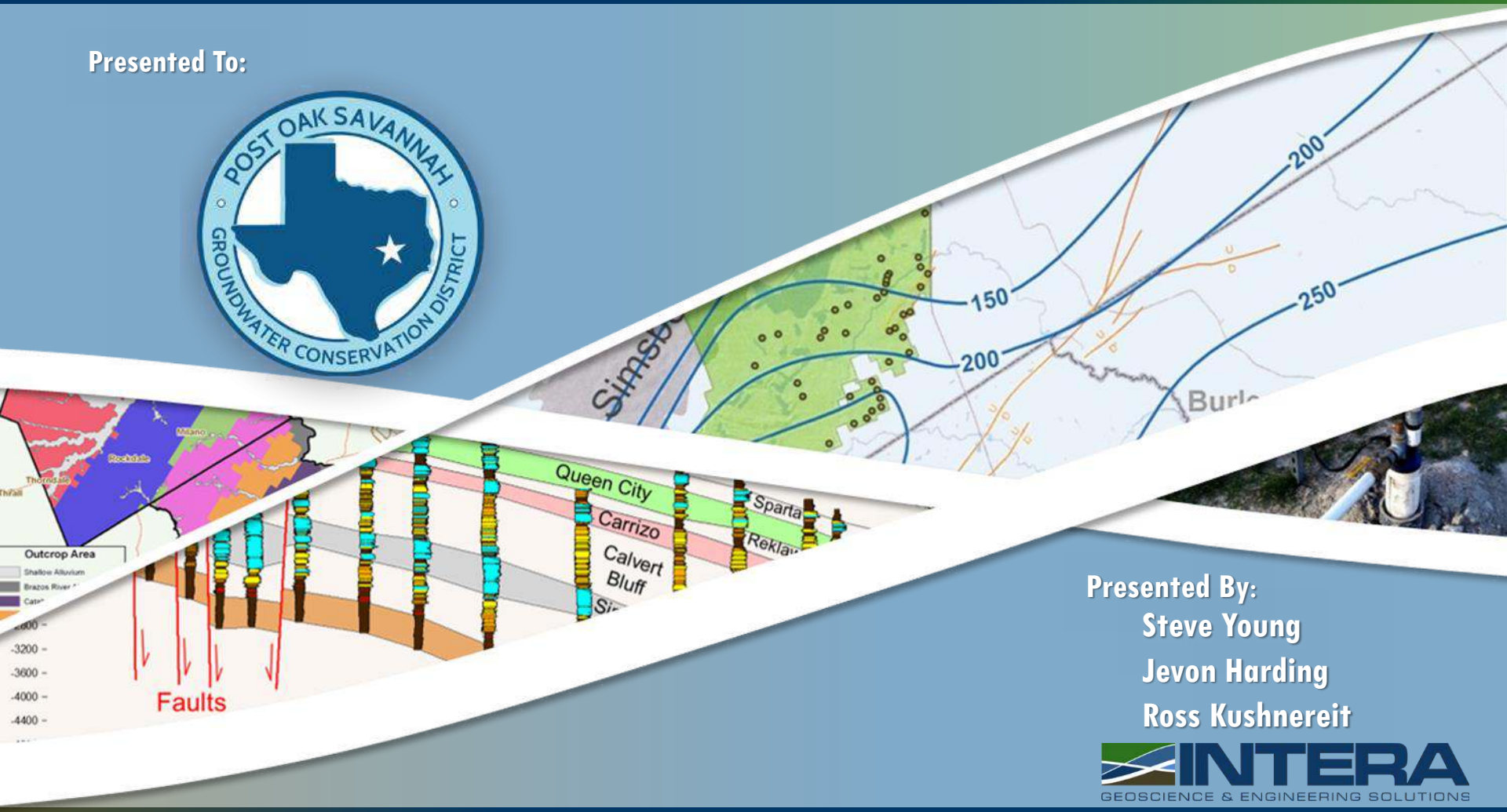
Presentation to DFC Committee: Evaluation of DFCs and PDLs and Demonstration of Compliance

Presented To:

POST OAK SAVANNAH GROUNDWATER CONSERVATION DISTRICT



Presented By:
Steve Young
Jevon Harding
Ross Kushnereit

INTERA
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April 30, 2020

Agenda

- Compliance Assessment: Protective Drawdown Limits
  - Monitored results
  - Modeled Results
- Compliance Assessment: Desired Future Conditions
  - Monitored results
  - Modeled results
- Review of POSGCD Rules
  - 16.4 Actions Based on Monitoring Results
  - 16.6 Adjusting Maximum Production Permitted
  - 16.7 Permit Limitations and Reductions

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Agenda (con't)

- Sensitivity of PDLs for PS-7
  - Depth of Shallow Zone
  - Pumping (Vista Ridge, ALCOA, LPGCD)
- Sensitivity of DFCs for PS-7
  - Pumping (Vista Ridge, ALCOA, LPGCD)
- Sensitivity of PDLs and DFCs for PS-7 under Curtailment

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Agenda (con't)

- Monitoring Well Network
  - Wells used to demonstrate PDL and DFC compliance
  - Evaluation of well coverage
  - Next Steps
- Monitoring Well Program
  - Protocols used to interpolate monitored water levels to check compliance of PDLs and DFCs
  - Evaluation of interpolation techniques
  - Next Steps

Agenda (con't)

- Evaluation of "best science" criteria for application of Groundwater Modeling to simulated DFCs and PDLs
  - Groundwater model
  - Pumping Rates
  - Measured water levels
  - Evaluation of "best science" criteria

- Reports
  - GWAP Annual Needs Assessment
  - Compliance Report (PDLs and DFCs)
  - Proposed Management Strategies

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Protective Drawdown Limits (PDLs)

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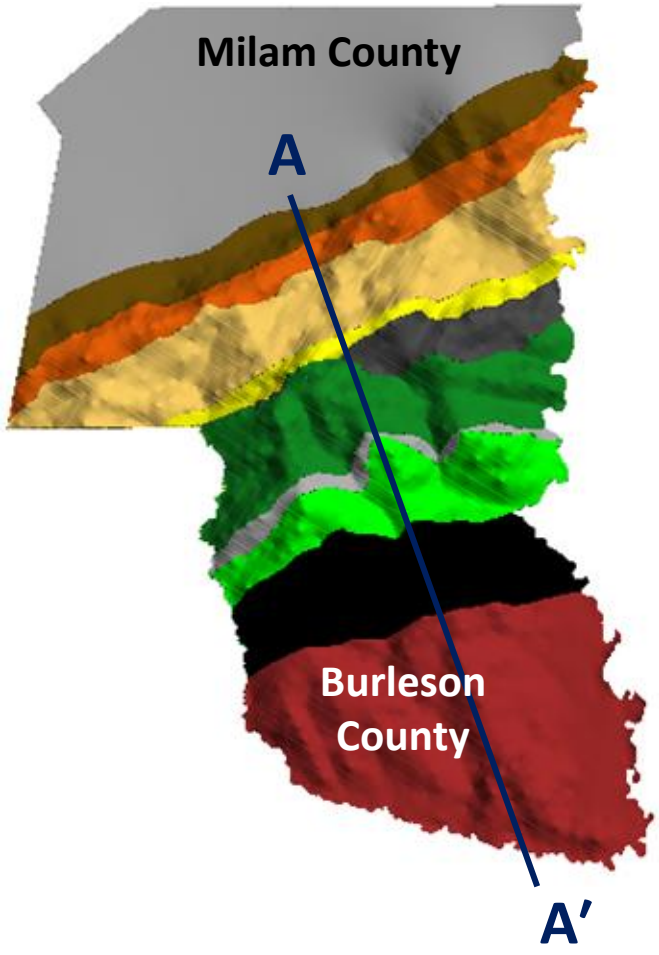
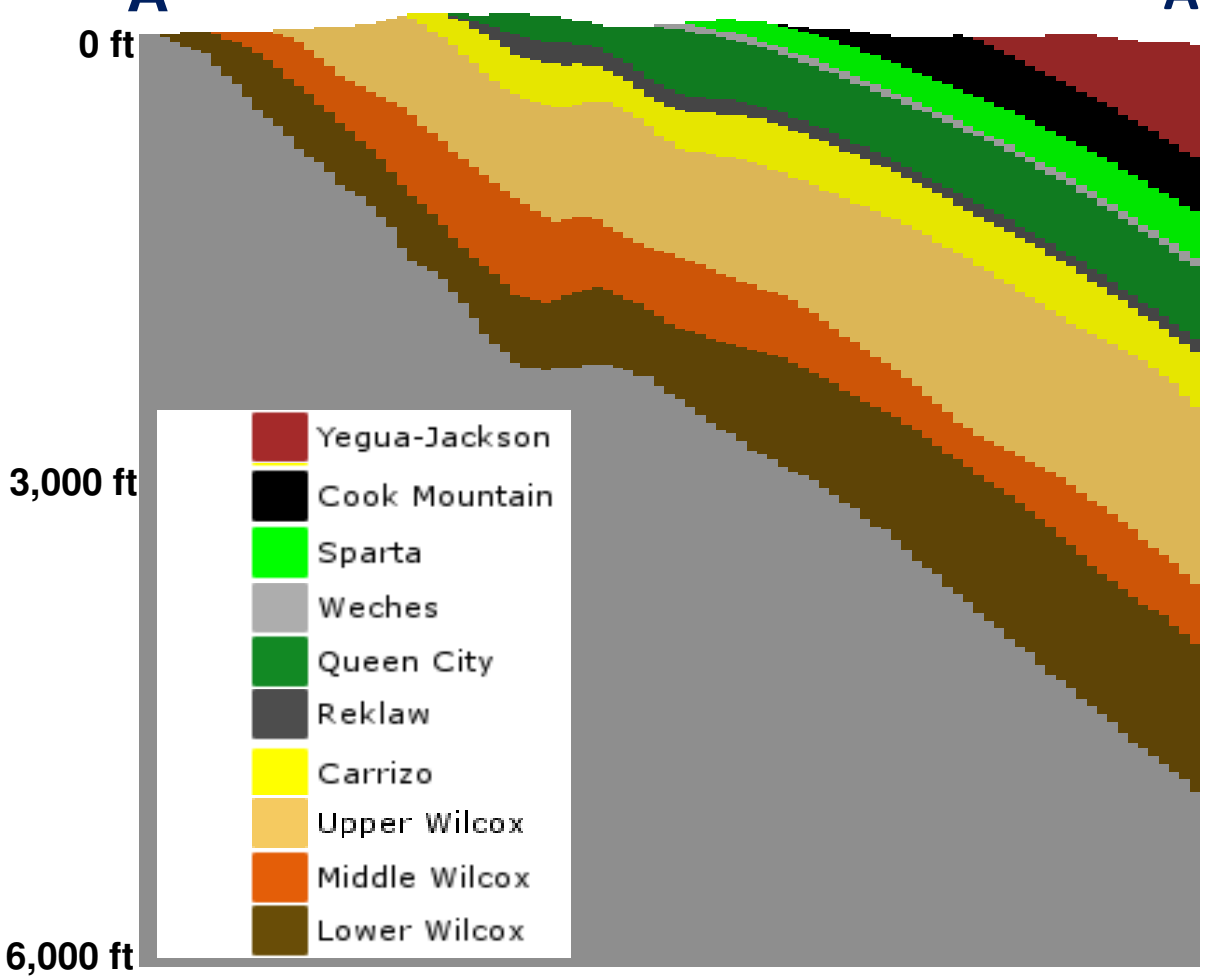
Sparta/Queen City/Carrizo Wilcox/Yegua-Jackson

Aerial View

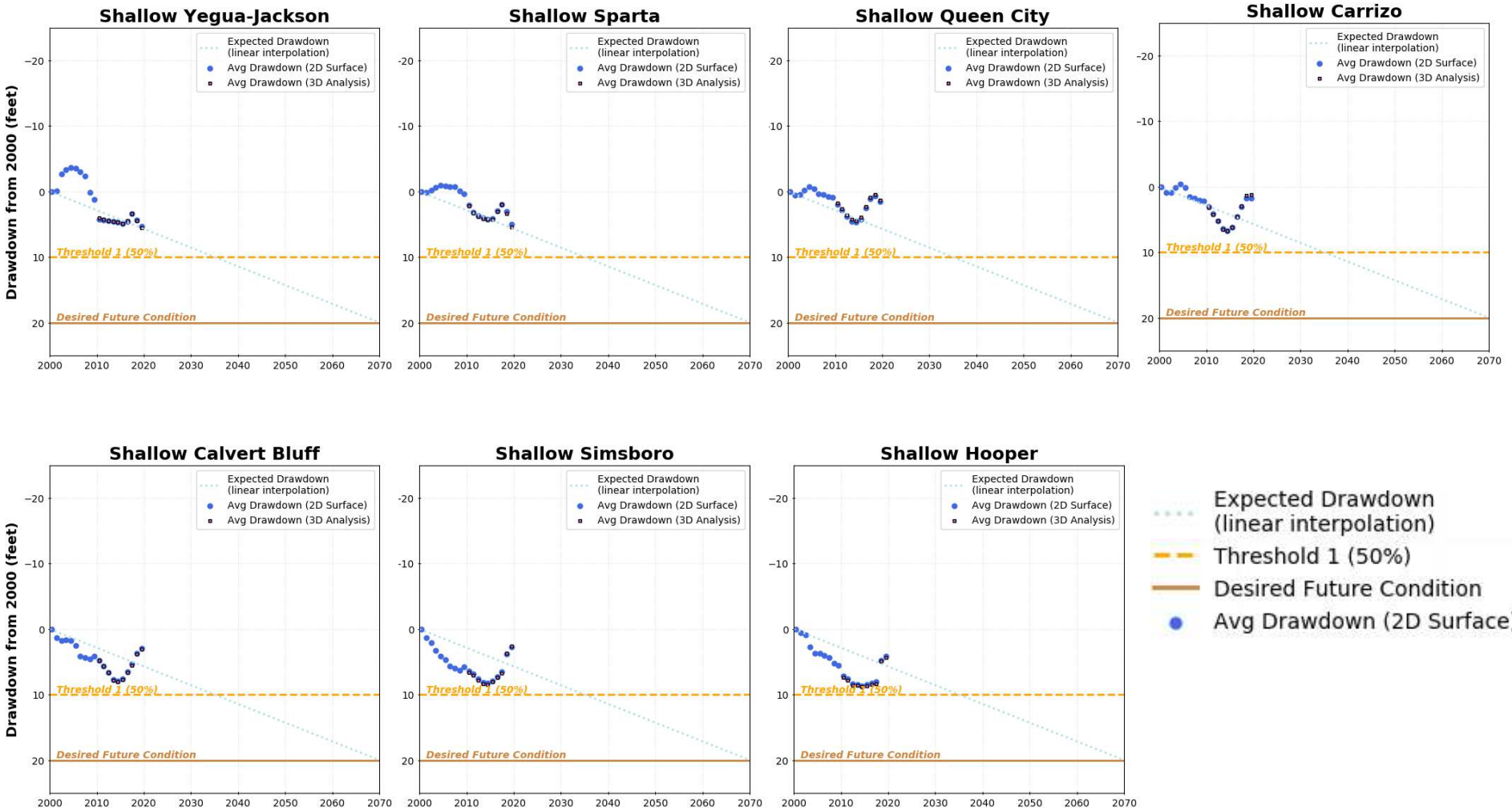


Vertical Cross-Section View Looking From Side

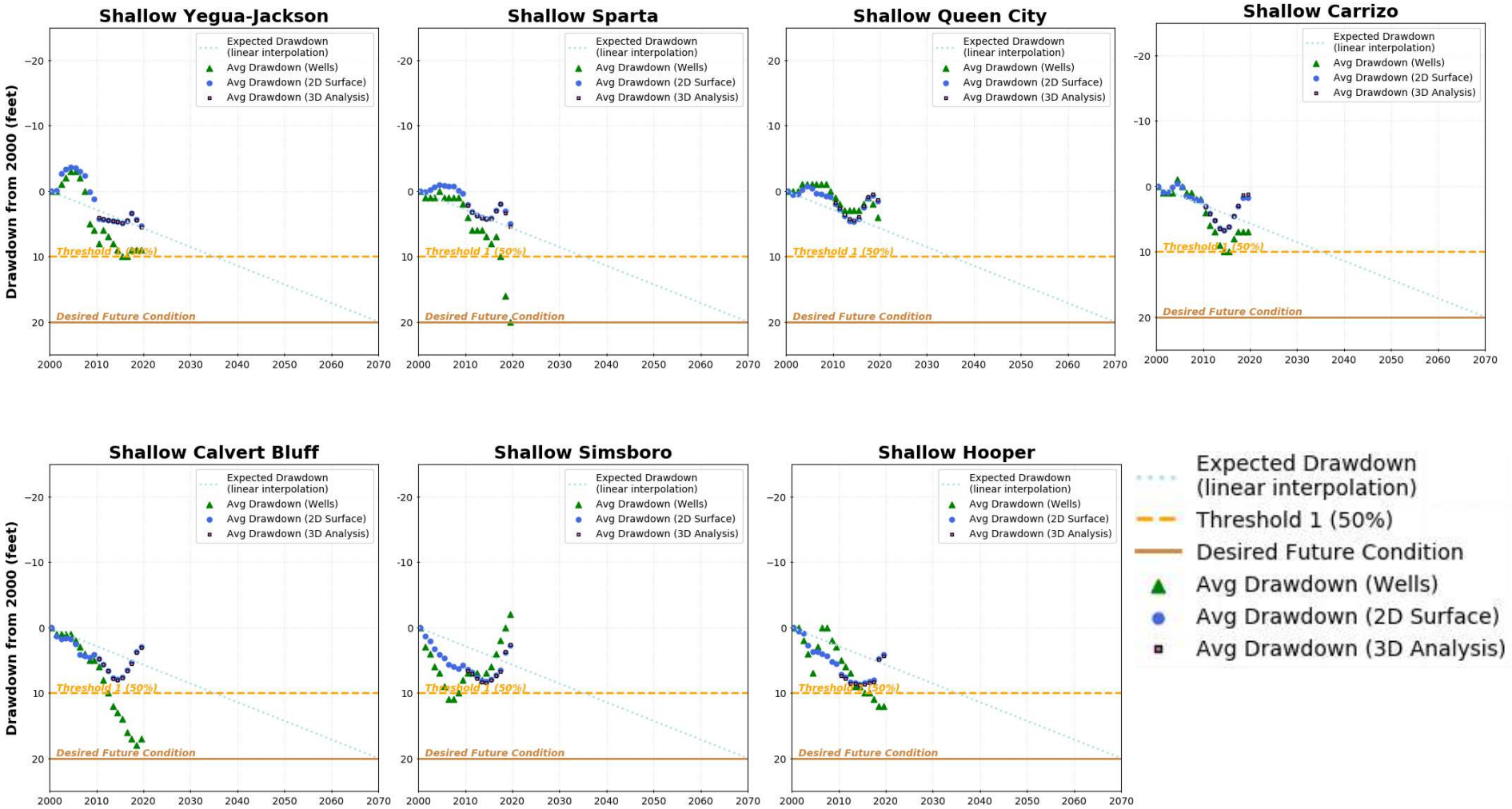


* Provided for general reference

Compliance with POSGCD Shallow PDLs



Compliance with POSGCD Shallow PDLs



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Compliance with POSGCD PDLs Based on Monitored Water Levels

Shallow Management Zone	PDL	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Yegua Jackson	20	0.0	-2.7	-3.3	-3.6	-3.6	-3.0	-2.3	0.1	1.2	4.3	4.3 (4.3)	4.5 (4.4)	4.6 (4.6)	4.7 (4.6)	4.9 (4.9)	4.6 (4.5)	3.4 (3.4)	4.4 (4.4)	5.3 (5.5)
Sparta	20	0.2	-0.2	-0.6	-0.9	-0.9	-0.8	-0.7	0.0	0.4	2.1	3.2 (3.3)	3.7 (3.8)	4.1 (4.1)	4.2 (4.3)	4.1 (4.3)	2.9 (3.1)	1.9 (2)	3.1 (3.4)	5 (5.5)
Queen City	20	0.5	0.4	-0.2	-0.7	-0.4	0.4	0.4	0.8	0.9	2.0	2.9 (2.7)	3.8 (3.6)	4.6 (4.3)	4.7 (4.5)	4.2 (4)	2.5 (2.3)	1.1 (0.9)	0.6 (0.4)	1.6 (1.4)
Carrizo	20	0.9	0.9	0.1	-0.4	0.2	1.6	1.8	2.1	2.1	3.0	4.2 (4.3)	5.2 (5.3)	6.4 (6.5)	6.7 (6.8)	6.2 (6.2)	4.6 (4.5)	3 (2.9)	1.7 (1.4)	1.7 (1.2)
Calvert Bluff (Upper Wilcox)	20	1.4	1.8	1.7	1.8	2.6	4.1	4.4	4.6	4.2	4.8	5.7 (5.7)	6.6 (6.6)	7.7 (7.8)	8 (8)	7.7 (7.7)	6.6 (6.7)	5.4 (5.6)	3.7 (3.8)	3 (3)
Simsboro (Middle Wilcox)	20	1.3	2.1	3.3	4.2	4.7	5.7	5.9	6.3	5.8	6.5	6.9 (7.1)	7.6 (7.8)	8.2 (8.3)	8.3 (8.4)	7.9 (8.1)	7.2 (7.4)	6.5 (6.8)	3.9 (3.8)	2.8 (2.7)
Hooper (Lower Wilcox)	20	0.6	0.9	2.8	3.7	3.7	4.0	4.3	5.3	5.6	7.2	7.6 (7.9)	8.4 (8.6)	8.4 (8.6)	8.7 (8.8)	8.5 (8.7)	8.2 (8.4)	8.1 (8.3)	4.7 (5)	4.1 (4.3)

Rule 16.4 Thresholds

Threshold 1 = 10 ft
Threshold 2 = 12 ft
Threshold 3 = 15 ft

Method

2D calculation
(3D calculation)

Largest Drawdown

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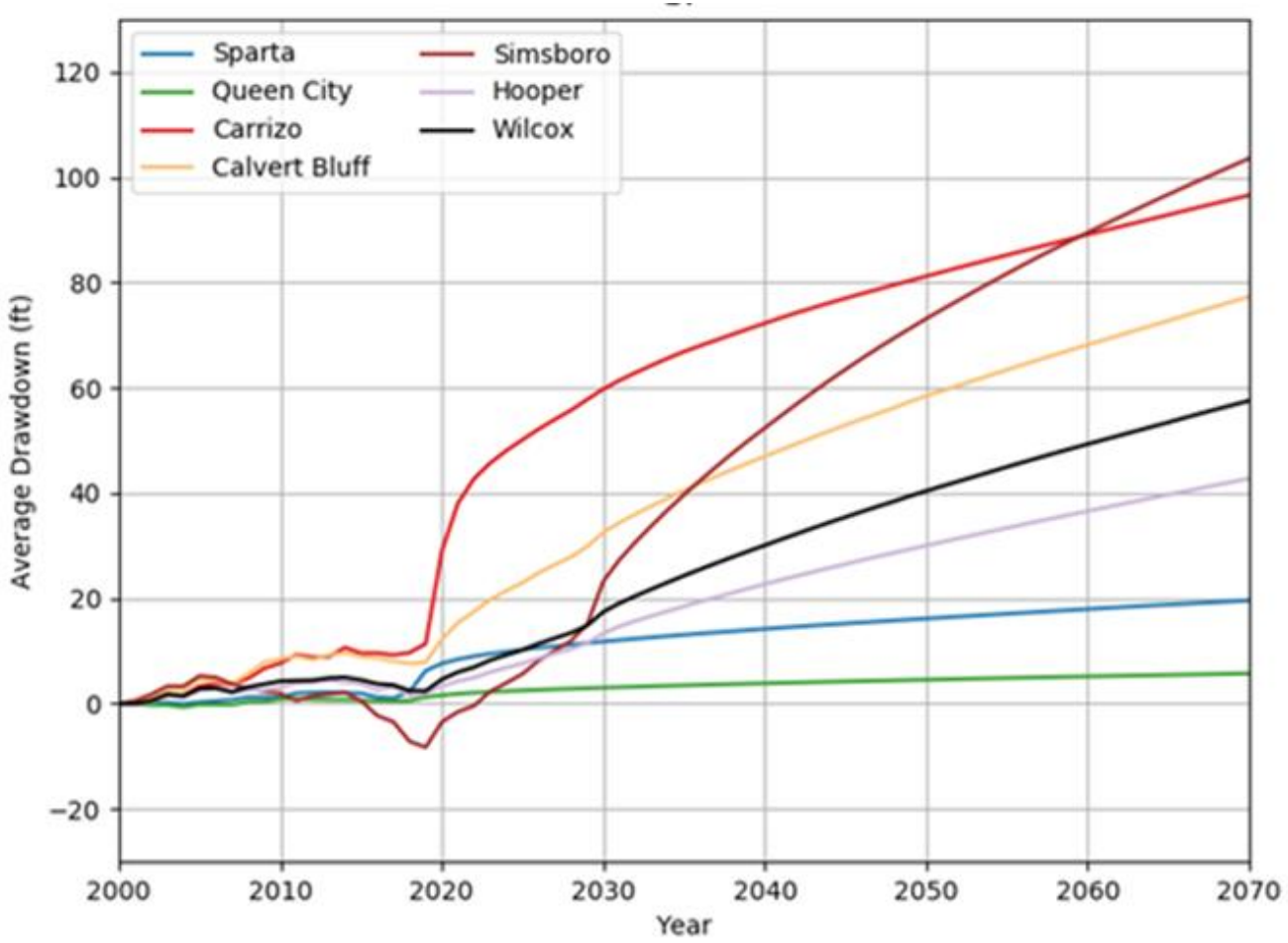
Simulated Average Drawdown for Aquifer Depth of 400 feet (simulated PDL)



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Desired Future Conditions

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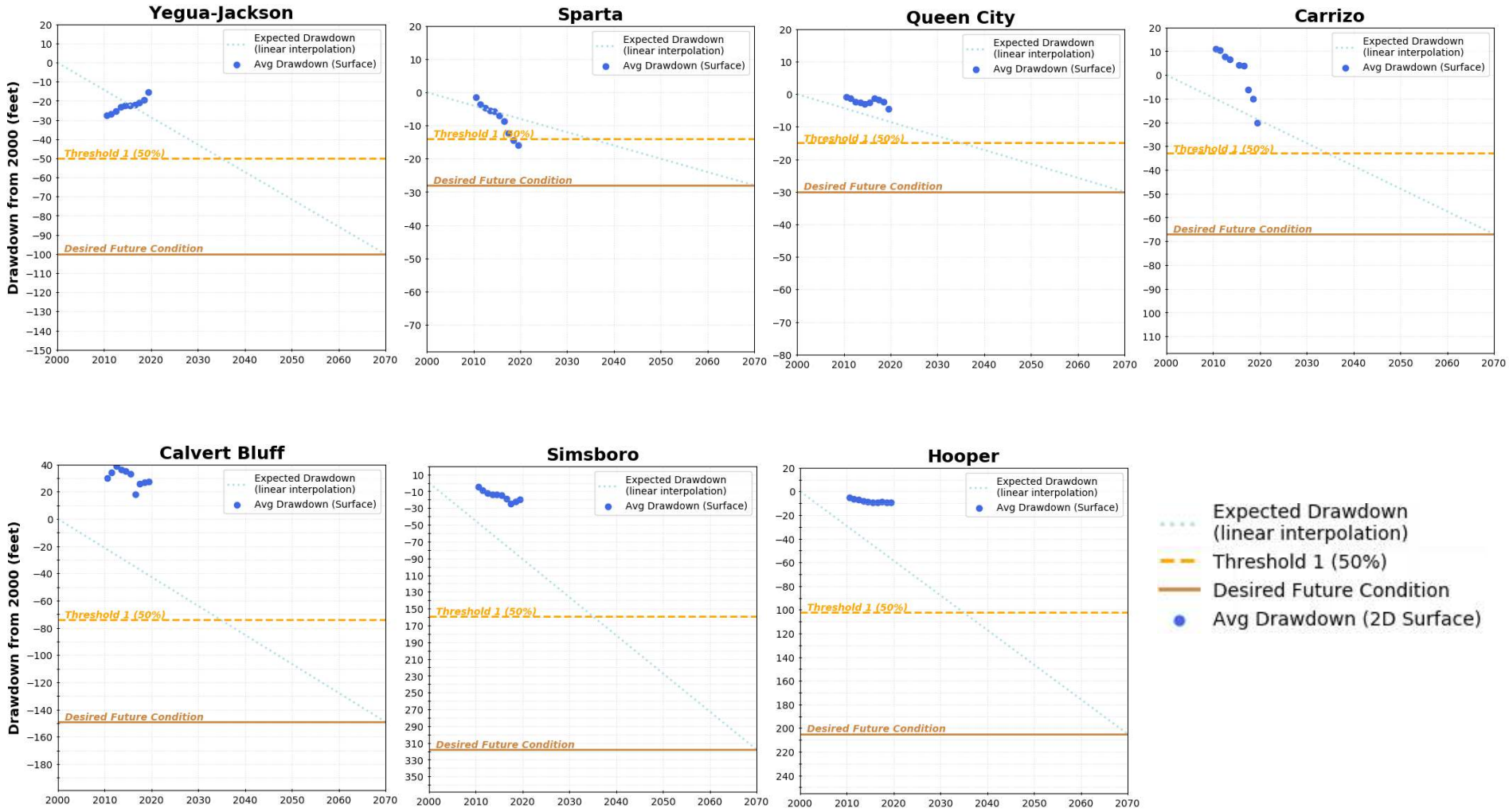
Compliance with POSGCD DFCs



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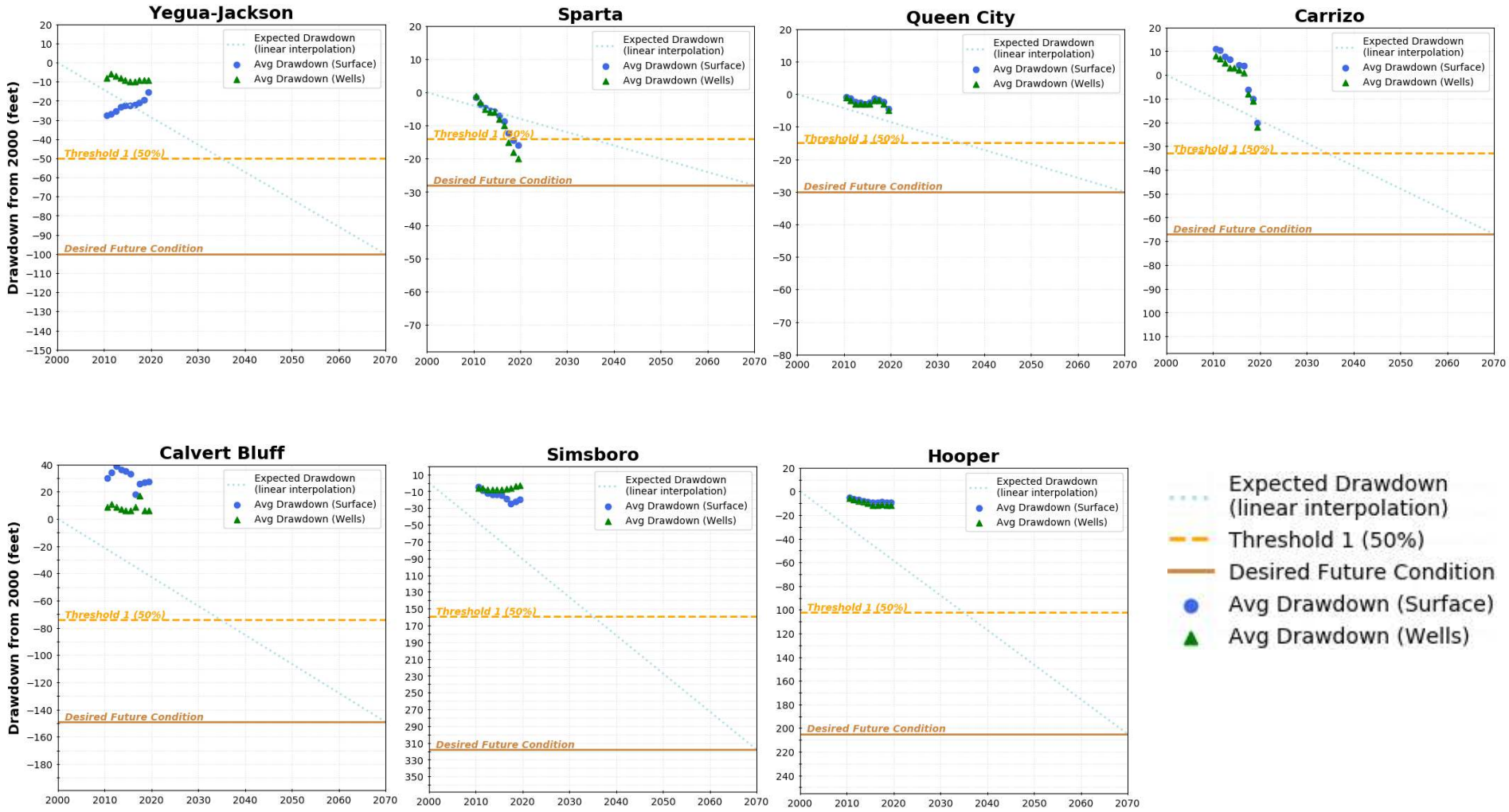
Compliance with POSGCD DFCs



Compliance with POSGCD DFCs based on Monitored Water Levels

Management Zone	DFC	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Yegua Jackson	100	27.5	26.8	25.4	23.0	22.3	22.3	22.2	21.0	19.6	15.6
Sparta	28	1.4	3.6	4.6	5.4	5.6	7.0	8.6	12.3	14.5	15.9
Queen City	30	0.9	1.4	2.4	2.7	2.9	2.6	1.3	1.6	2.4	4.6
Carrizo	67	-11.1	-10.4	-7.9	-6.6	--	-4.3	-3.8	6.1	9.9	20.0
Calvert Bluff (Upper Wilcox)	149	-29.9	-34.2	-39.0	-36.4	-35.4	-33.3	-18.0	-25.8	-27.0	-27.2
Simsboro (Middle Wilcox)	318	5.0	8.9	12.2	13.7	13.8	14.9	19.0	24.7	22.5	19.5
Hooper (Lower Wilcox)	205	5.4	6.2	6.9	7.9	8.7	9.5	9.5	8.9	9.2	9.2

Threshold 1 = 50% of DFC
Threshold 2 = 60% of DFC
Threshold 3 = 75% of DFC

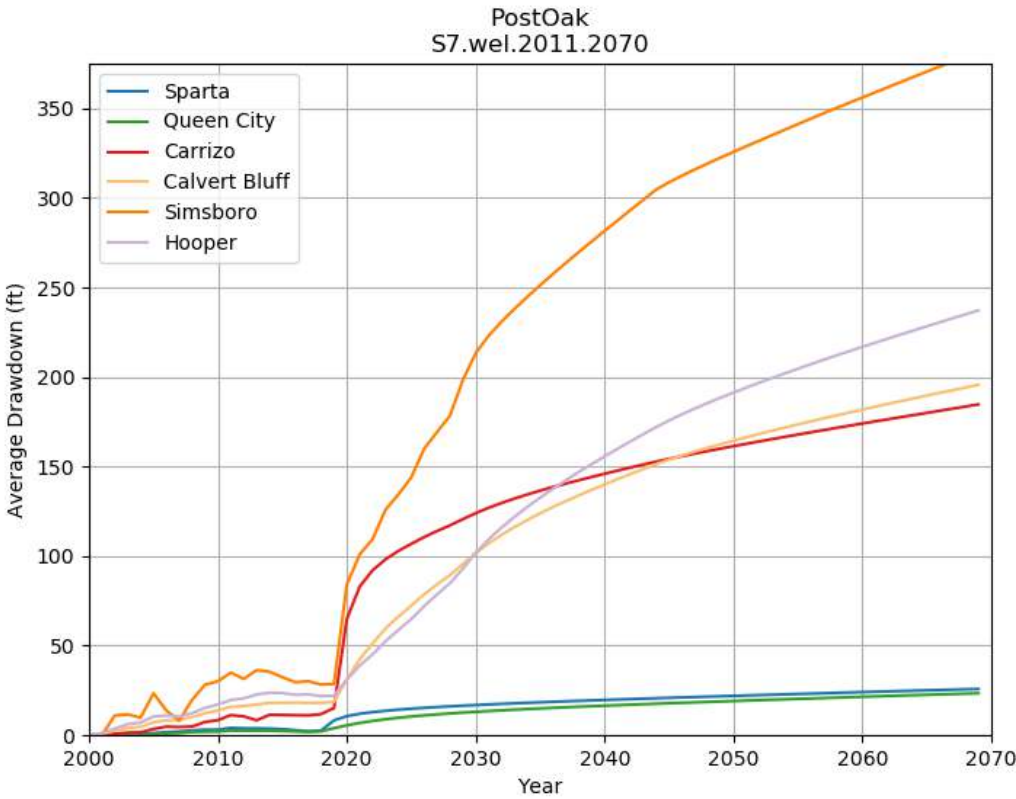
Simulated DFC for PS-7

Comparison of PS-7 Simulated DFCs and POSGCD DFCs*

	Current DFC (feet)	Current MAG in 2070	S-7 Drawdown from 2010 to 2070 (feet)	S-7 Pumpage in 2070 (acre-feet)
Sparta	28	6,735	17	1,983
Queen City	30	504	19	1,045
Carrizo	67	7,058	177	18,205
Calvert Bluff	149	1,036	183	4,761
Simsboro	318	48,503	355	85,855
Hooper	205	4,422	222	3,126

* From GMA 12 Sept 2019 presentation (note: different time periods for PS-7 and POSGCD DFCs)

PS-7 Simulation



By 2070, DFCs are exceeded for Carrizo, Calvert Bluff, Simsboro, and Hooper Aquifers

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Rule 16.4 Actions Based on Monitoring Results

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POSGCD Rules: Section 16 Thresholds

Criteria	Threshold Level		
	1	2	3
Total annual production	> 60% of MAG in Management Plan	>70% of MAG in Management Plan	NA
Average drawdown in Section 7 of Management Plan	> 50% of PDLs		> 75% of PDLs
	> 50% of DFCs	> 60% of DFCs	> 75% of DFCs
Average drawdown in Shallow Management Zone	> 50% of PDLs	>60% of PDLs	NA
Projected Average drawdowns calculated with a District	> PDLs in 15 years	NA	NA
	> DFC in 15 years	NA	NA

Threshold 1	Perform studies to improve quantification of pumping effects, characterization of aquifer, and prediction of changes in future water levels
Threshold 2	Re-evaluate the Management Plan and rules regarding management zones, collection and analysis of monitoring data, and DFCs.
Threshold 3	1. Conduct public hearing to discuss aquifer conditions. Develop a Response Action Work Plan to achieve DFCs and PDLs. 2. If drawdowns are exceeded, the maximum water production permitted per acre for the Management Zone and the water authorized to be produced under any permit issued by the District for that zone will be reduced.

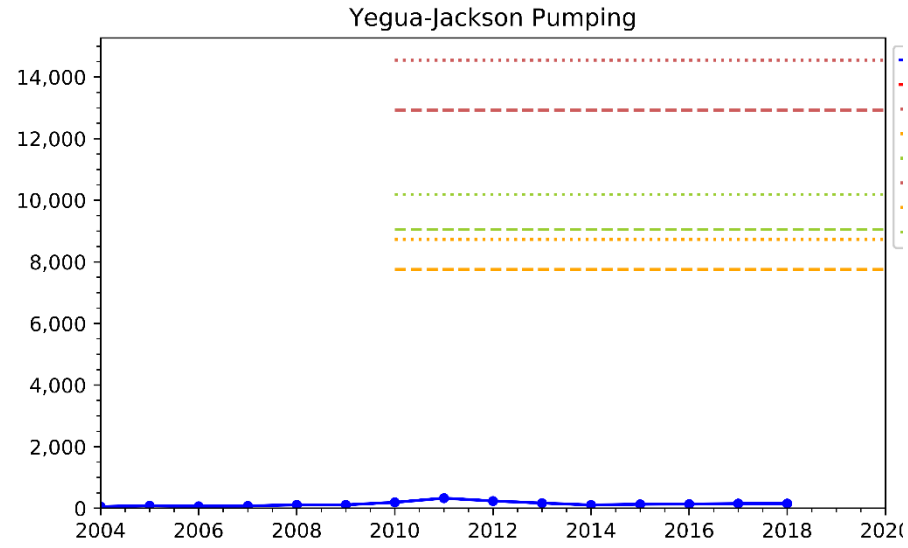
POSGCD Rules: Section 16 Thresholds

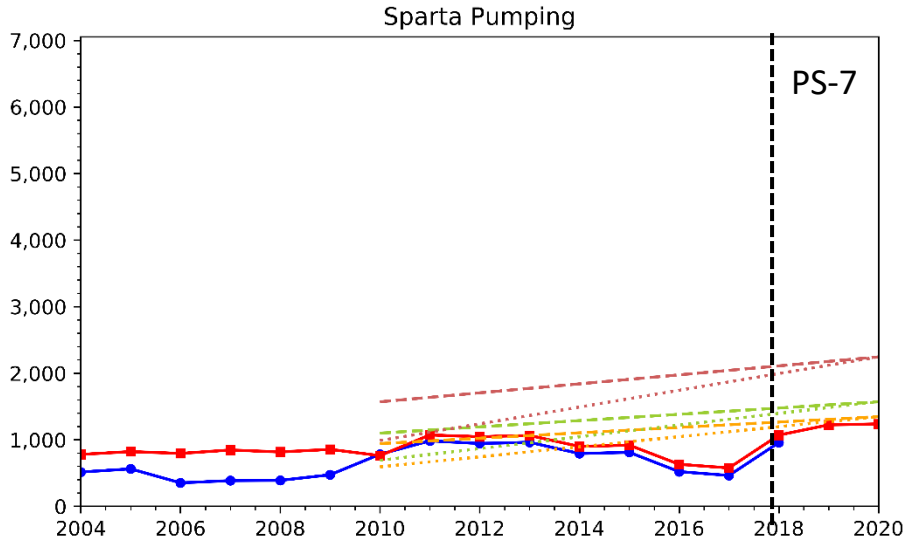
Threshold	Description	Aquifer
Level 1	> 60% of MAG in Management Plan	Queen City
Level 1	> 50% of DFCs	Sparta
Level 1	> PDLs in 15 years	Carrizo
Level 1	> PDLs in 15 years	Calvert Bluff
Level 1	> PDLs in 15 years	Simboro
Level 2*	> 70% of MAG in Management Plan	Queen City

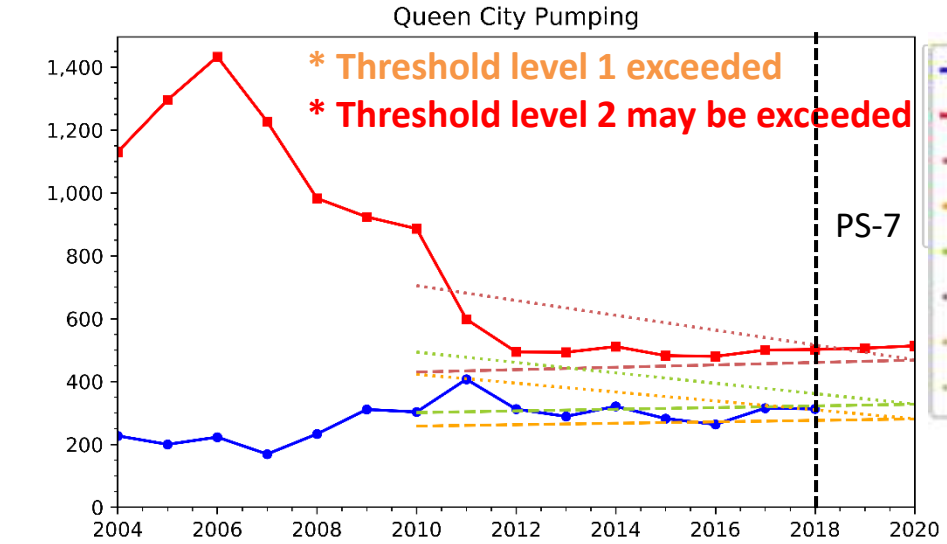
* based on anticipated 2020 pumping

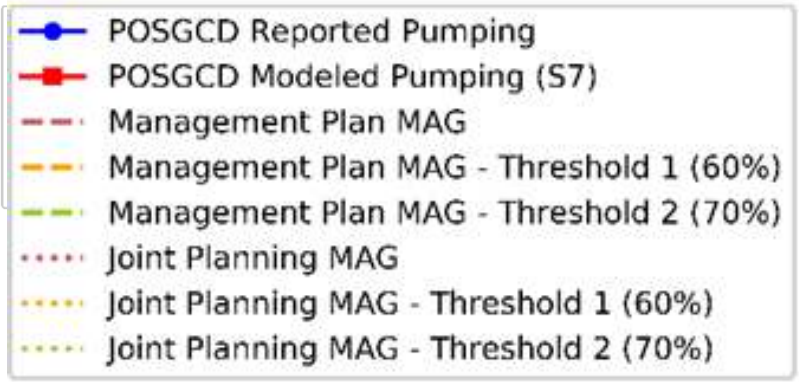
Threshold 1	Perform studies to improve quantification of pumping effects, characterization of aquifer, and prediction of changes in future water levels
Threshold 2	Re-evaluate the Management Plan and rules regarding management zones, collection and analysis of monitoring data, and DFCs.
Threshold 3	1. Conduct public hearing to discuss aquifer conditions. Develop a Response Action Work Plan to achieve DFCs and PDLs. 2. If drawdowns are exceeded, the maximum water production permitted per acre for the Management Zone and the water authorized to be produced under any permit issued by the District for that zone will be reduced.

Compliance with POSGCD DFCs









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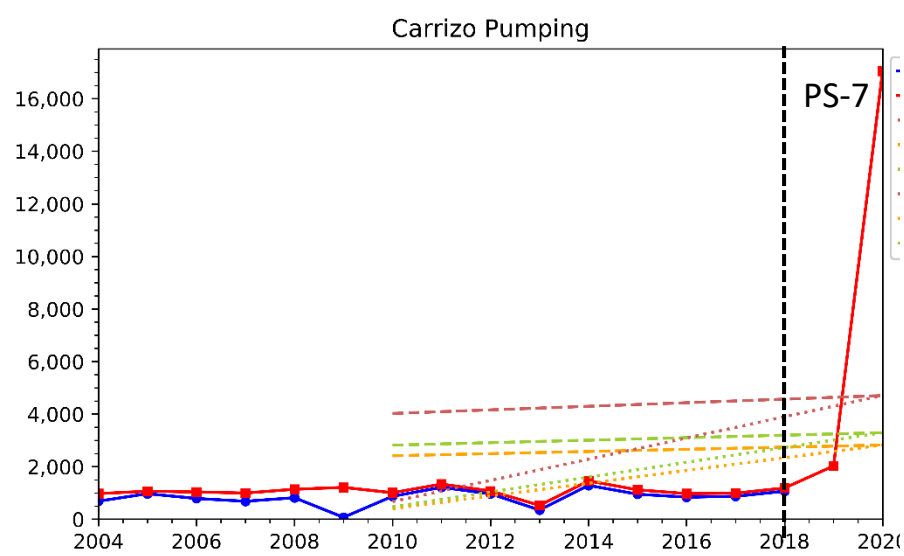
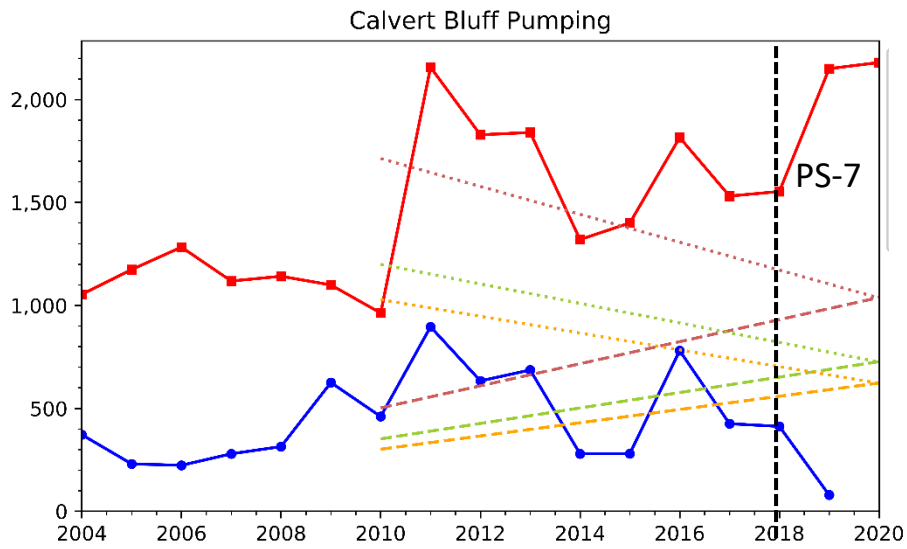
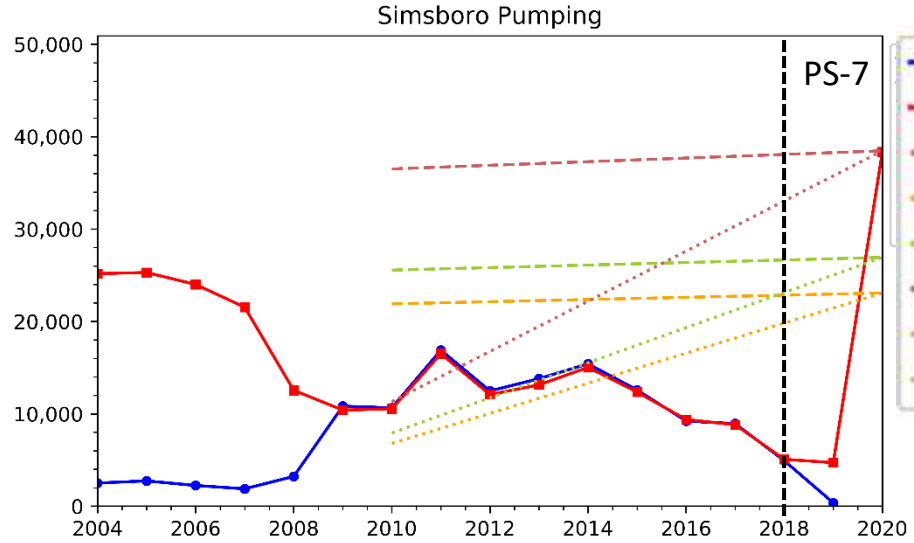
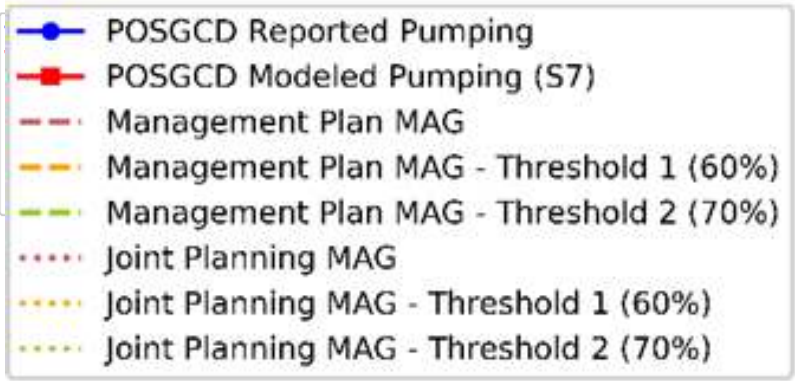
Compliance with POSGCD DFCs









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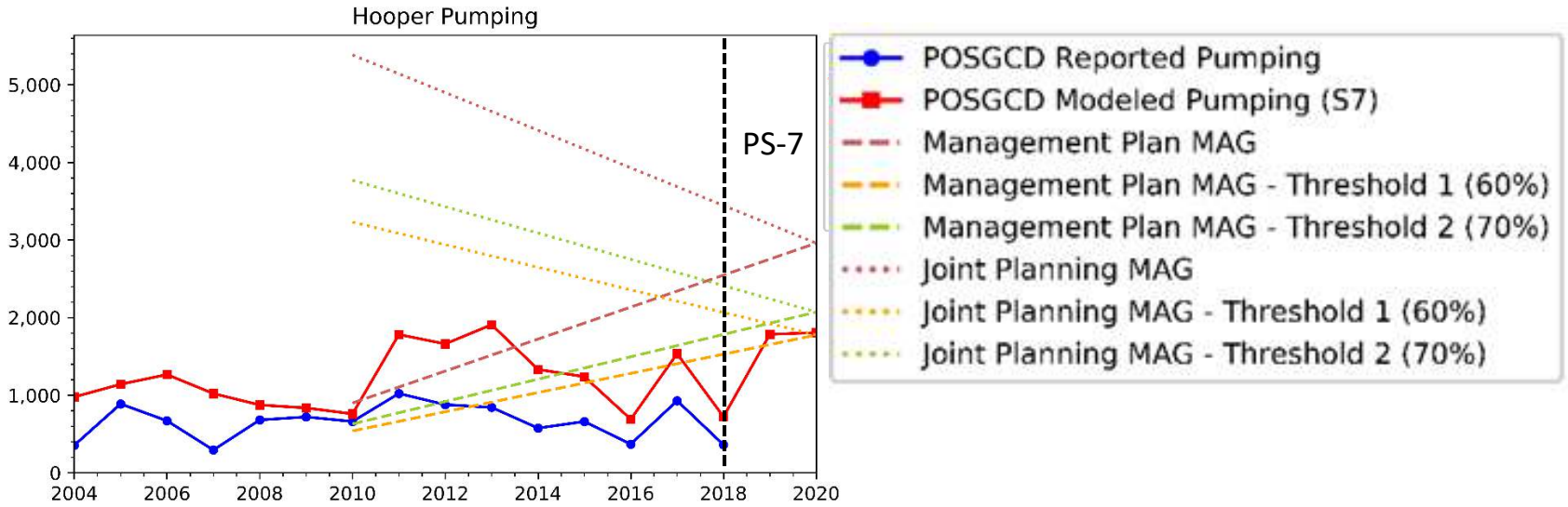
Compliance with POSGCD DFCs



Compliance with POSGCD DFCs Based on Monitoring Results

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Threshold 1 = 50% of DFC
Threshold 2 = 60% of DFC
Threshold 3 = 75% of DFC

Summary

- 2020 Monitoring Event
  - Data collection will be completed by April 30th
  - Data analysis will be completed by May 15th

- Rule 16. 4
  - Level 1 Action : Perform studies to improve quantification of pumping effects, characterization of aquifer, and prediction of changes in future water levels
  - Level 2 Action : Re-evaluate the Management Plan and rules regarding management zones, collection and analysis of monitoring data, and DFCs.

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Sensitivity of PDLs for PS-7 Pumping

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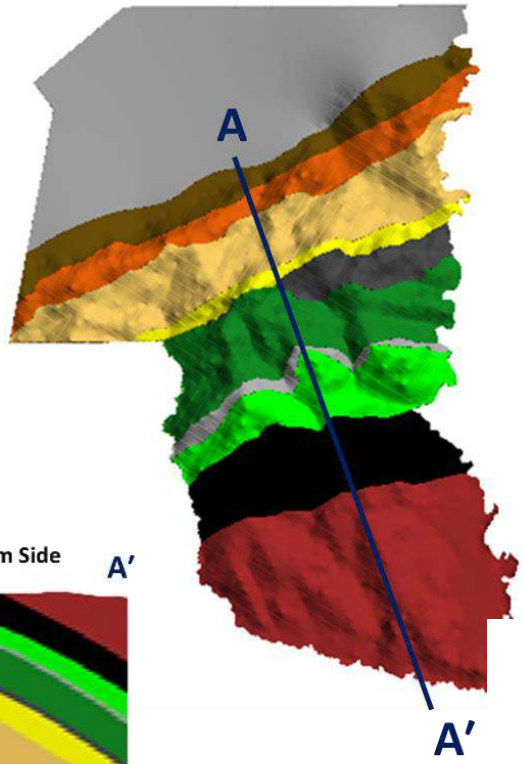
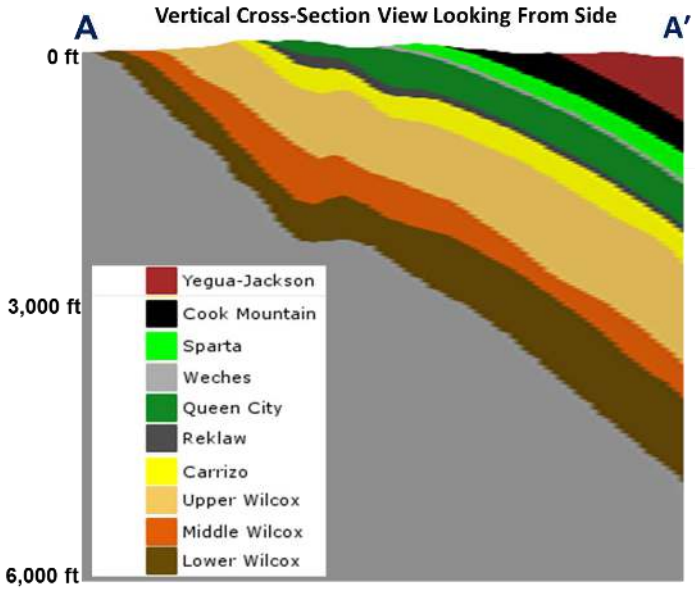
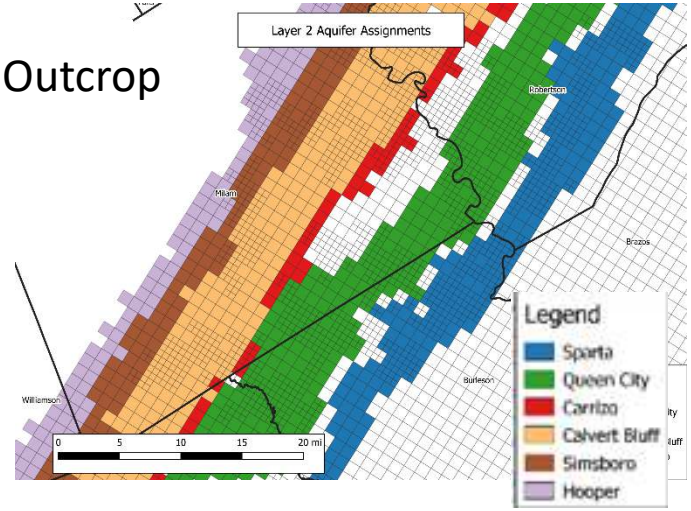
3D Analysis For PDLs

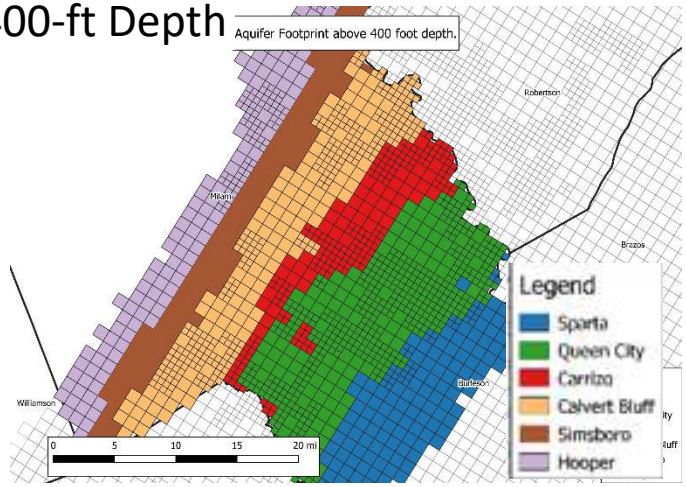




Outcrop



400-ft Depth



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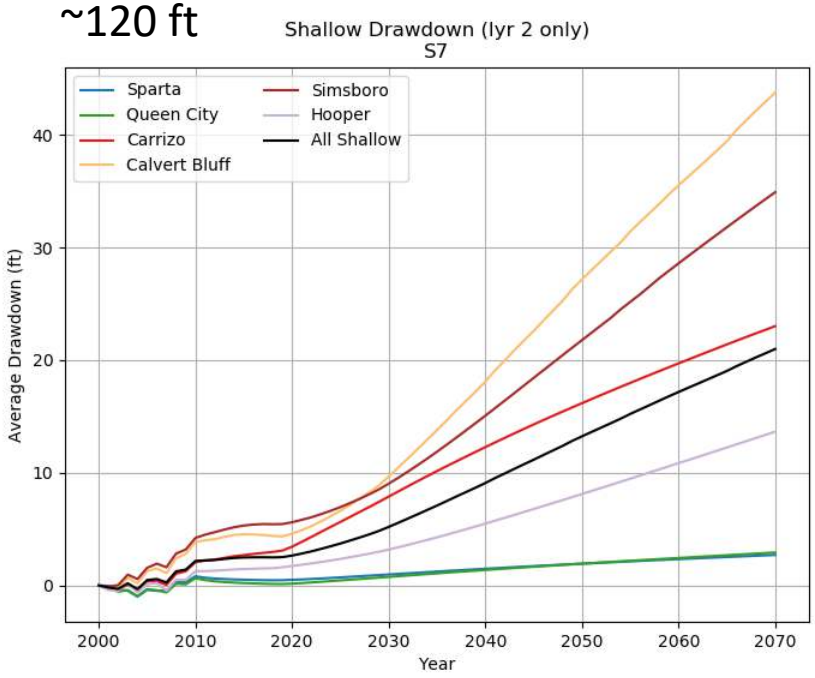
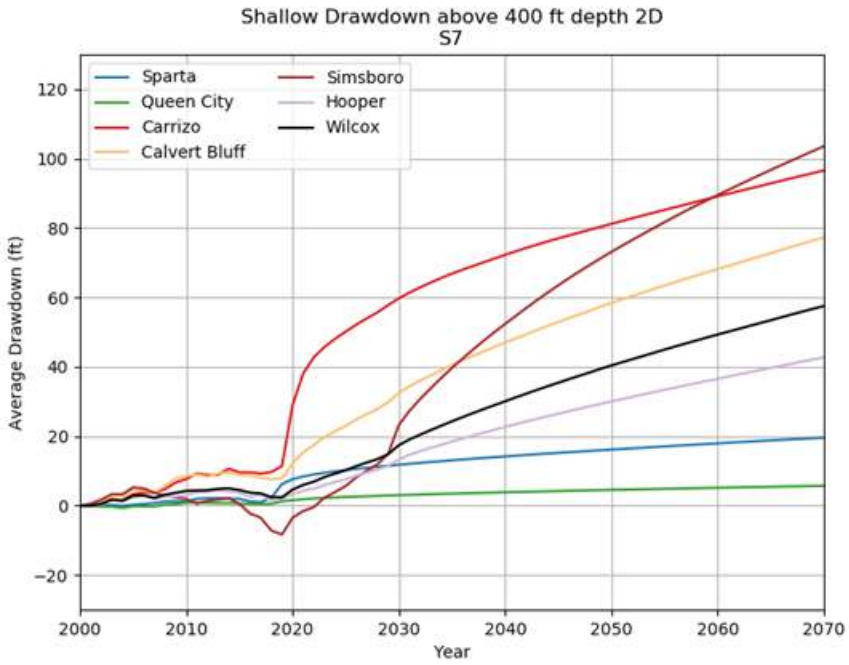
Sensitivity of Calculated PDF to Depth using Results From Groundwater Model

~120 ft



A PDL (for Calvert Bluff) is not exceeded until after 2040



A PDL (Carrizo) is exceeded after 2020

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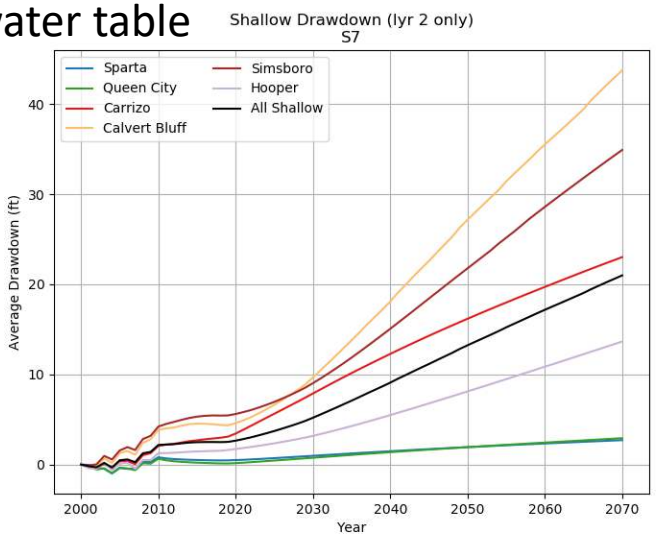
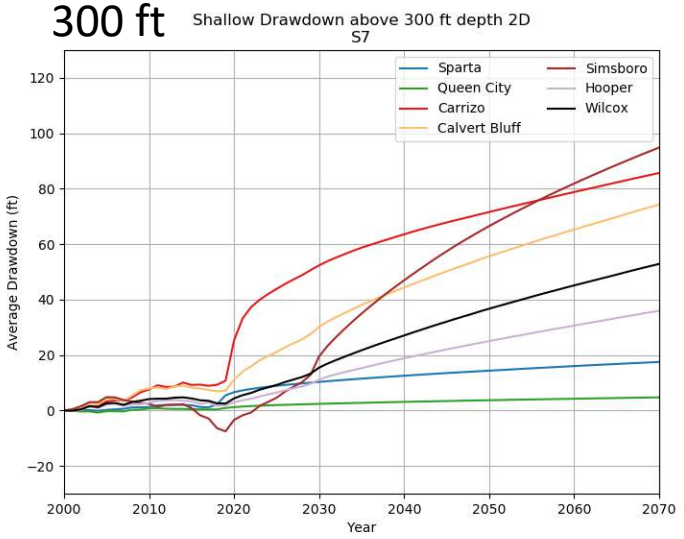
Sensitivity to Depth of Shallow Zone

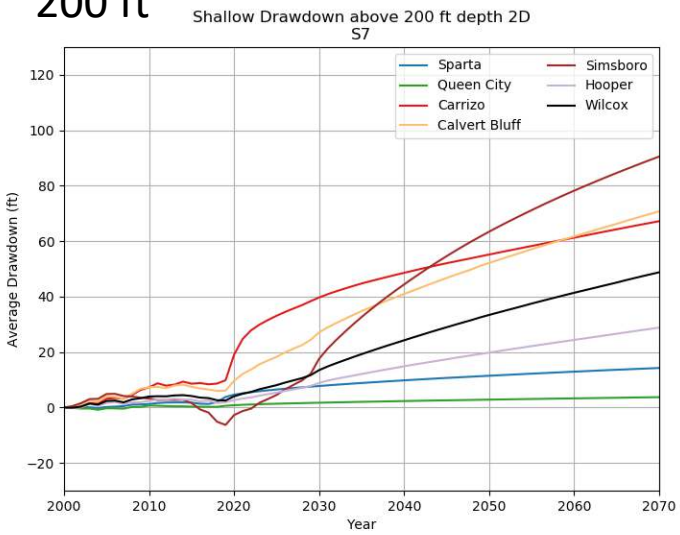
~water table



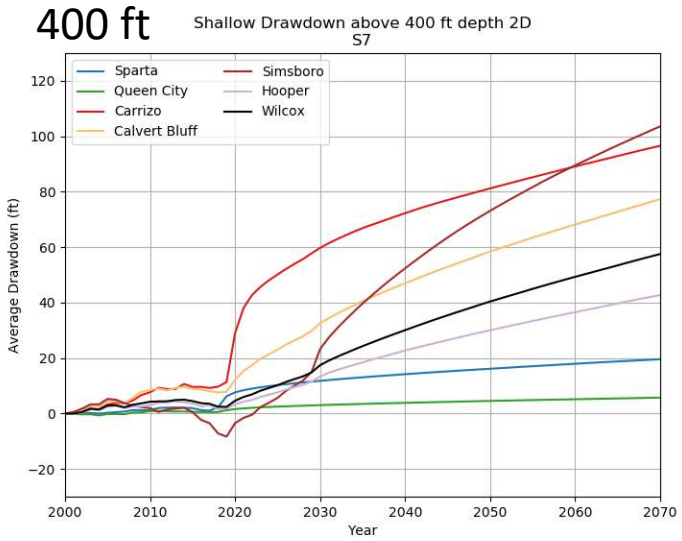
300 ft



200 ft



400 ft



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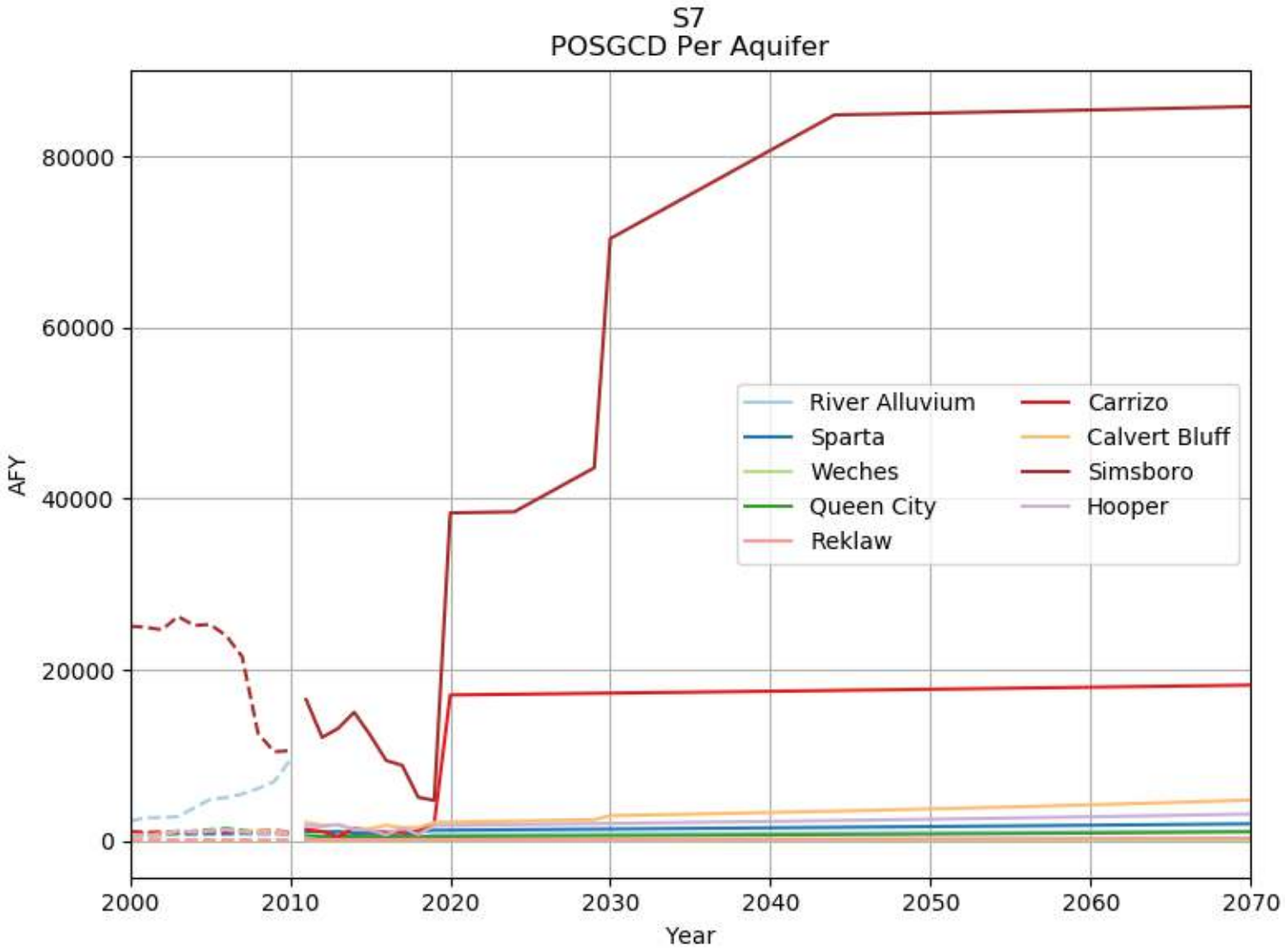
POSGCD Pumping for PS-7



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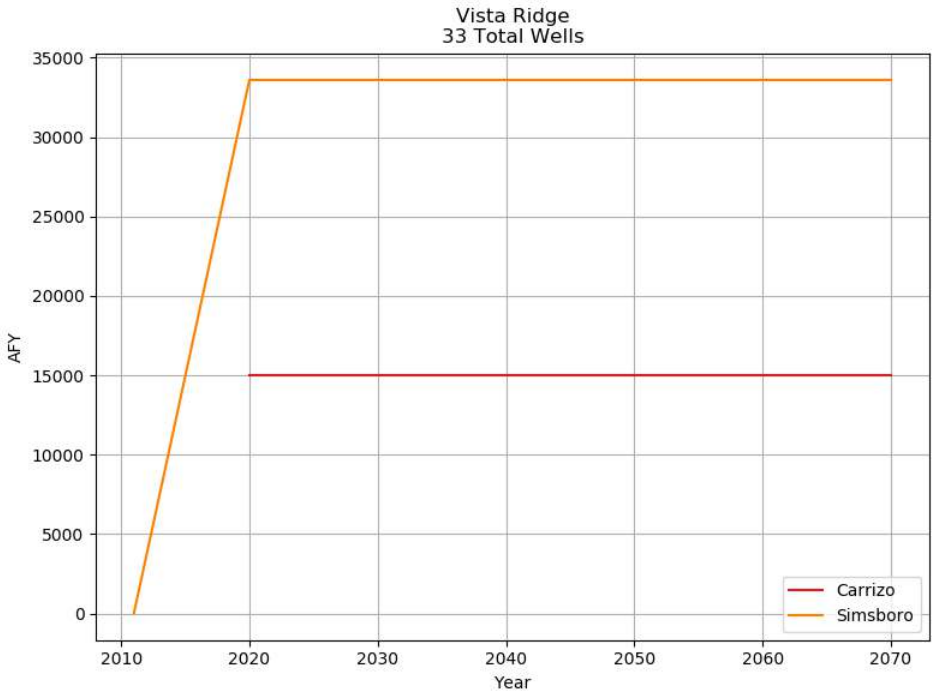
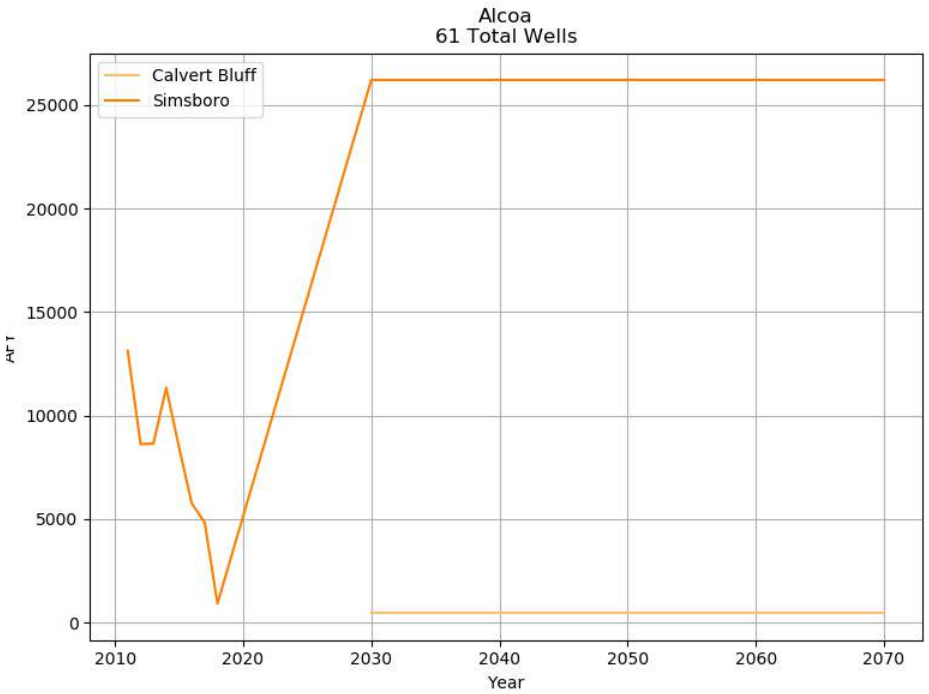
PS – 7 Pumping for Simsboro & Carrizo*





* Carrizo pumping is too high in 2020

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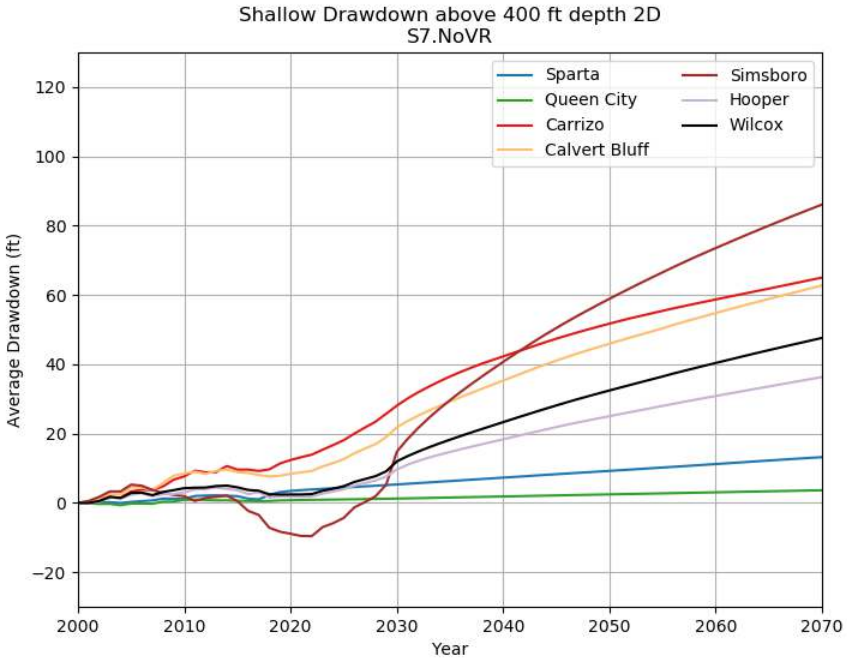
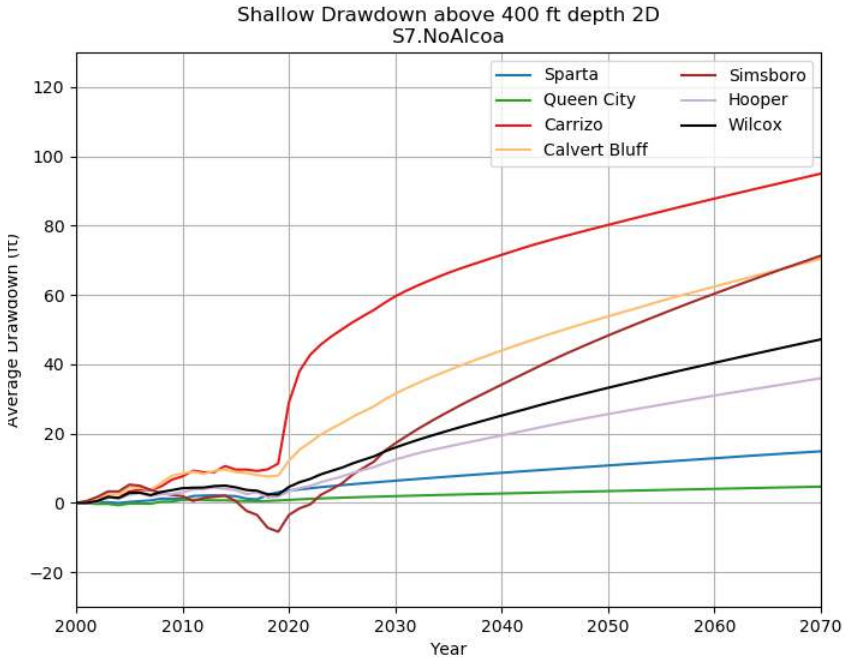
Simulated PDLs for a Depth of 400 feet for Shallow Zone

No Vista Ridge Pumping in Simsboro & Carrizo after 2020



PDL exceeded by 2025 and 2030 for Carrizo and Simsboro, respectively

Alcoa no increase in Simsboro pumping after 2020

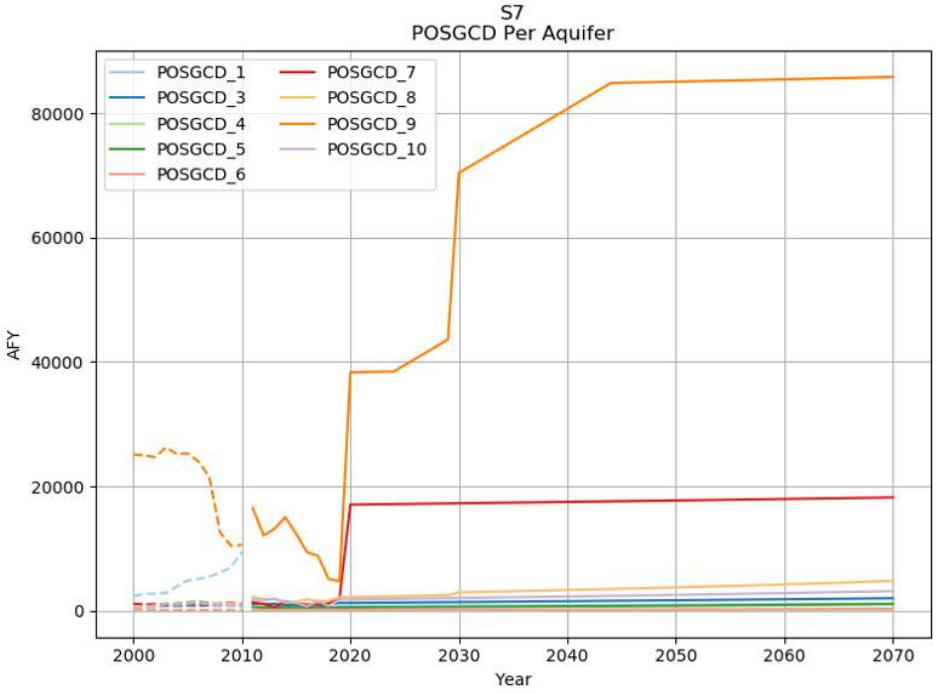


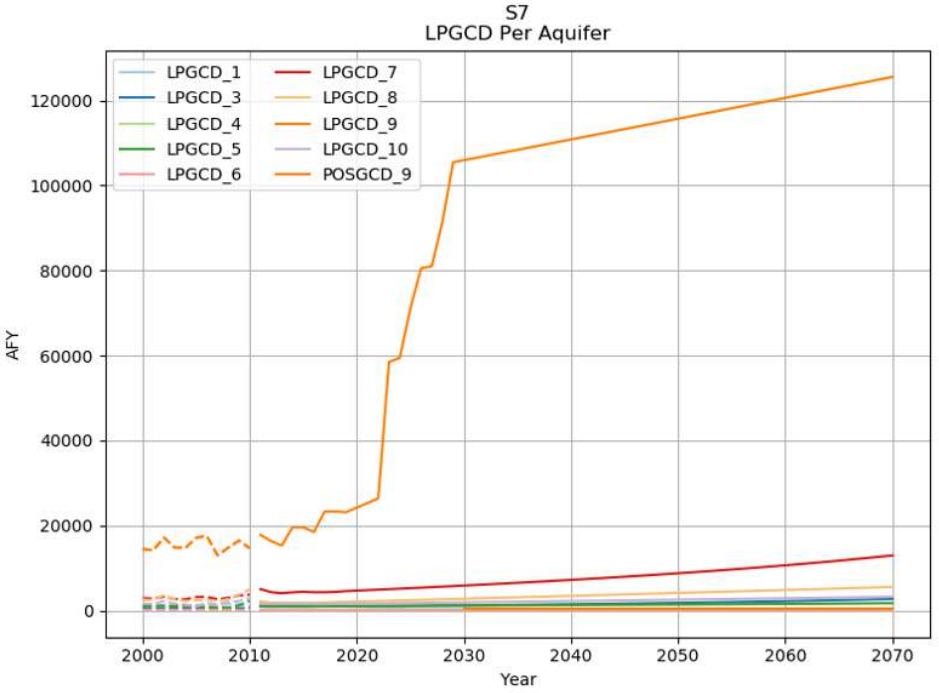
PDL exceeded by 2021 and 2025 for Carrizo and Simsboro, respectively

* 400-ft depth

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

PS – 7 Pumping



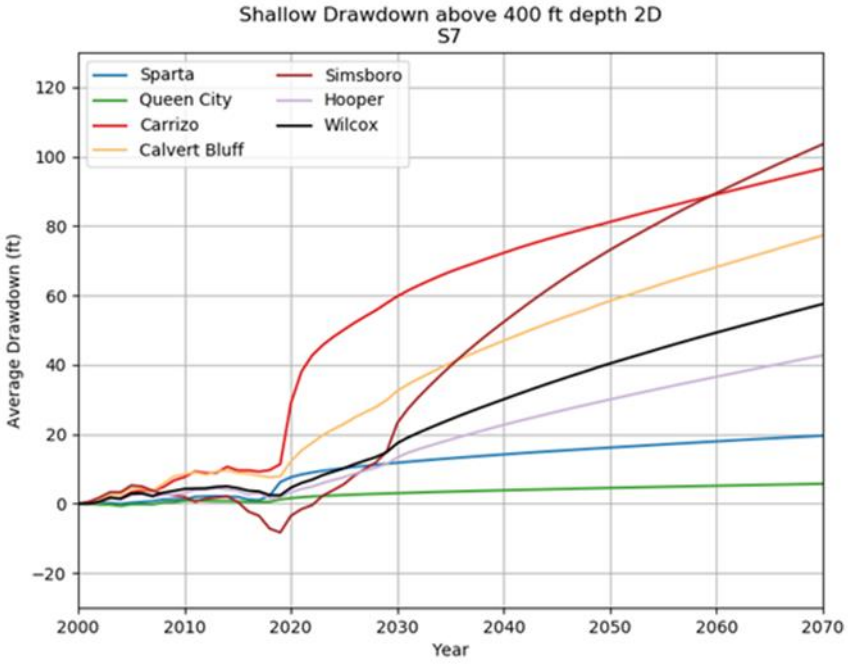


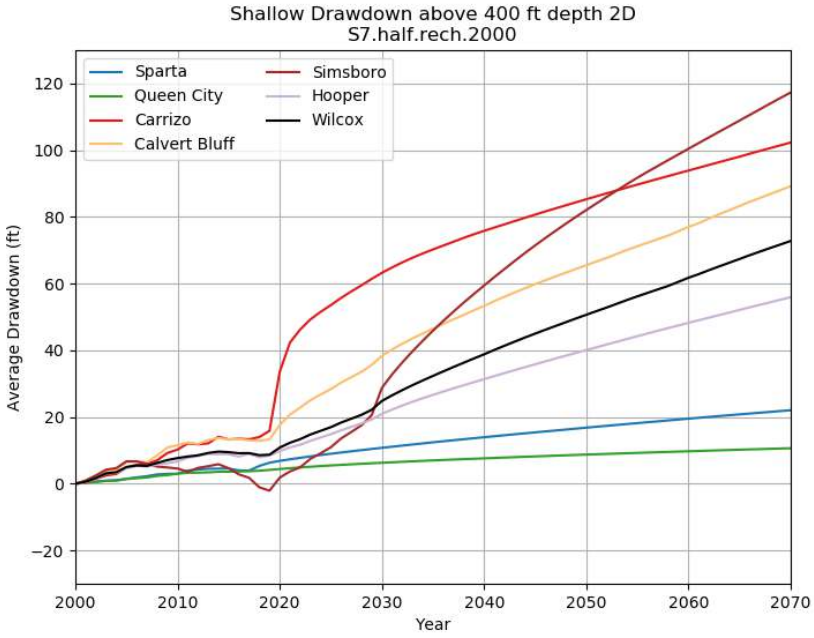
INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Sensitivity of Simulated PDLs* to changes 50% Reduction in Recharge

PS-7

50% Reduction in Recharge Across all Aquifers in GMA 12 from 2000 to 2070 for PS-7



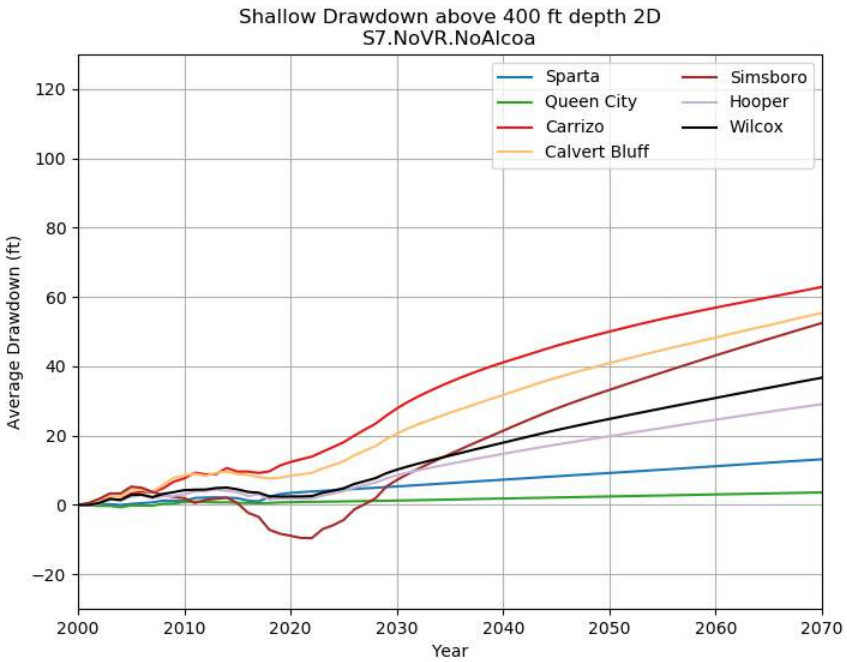


* 400-ft depth

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

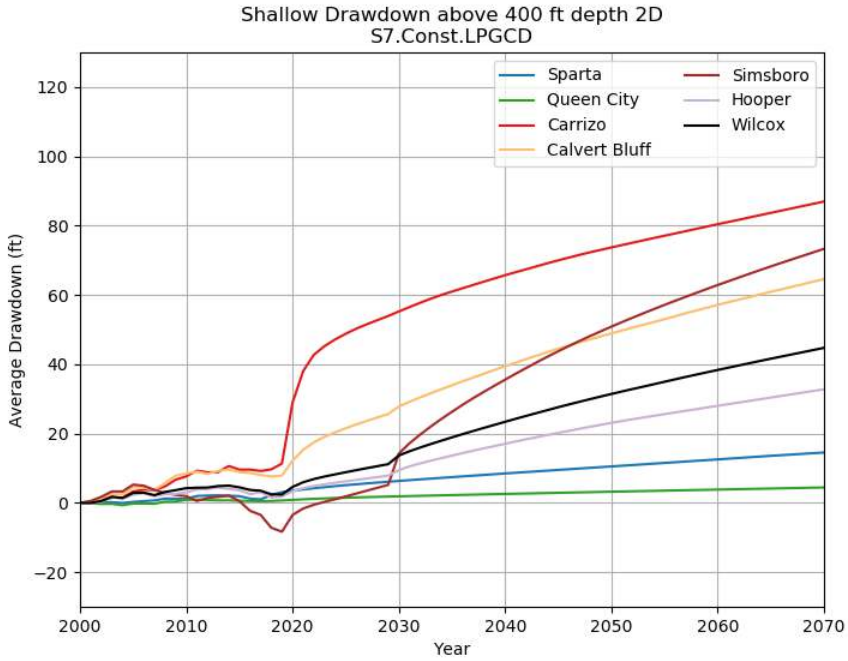
Sensitivity of Simulated PDLs* to changes in POSGCD and LPGCD Pumping

No Vista Ridge Pumping After 2020 & Alcoa Pumping is constant after 2020



PDL exceeded by 2025 and 2030 for Carrizo and Simsboro, respectively

LPGCD pumping is constant (~22,000 AFY) after 2020



PDL exceeded by 2021 and 2025 for Carrizo and Simsboro, respectively

* 400-ft depth

INTERA
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Sensitivity of DFCs for PS-7 Pumping

INTERA
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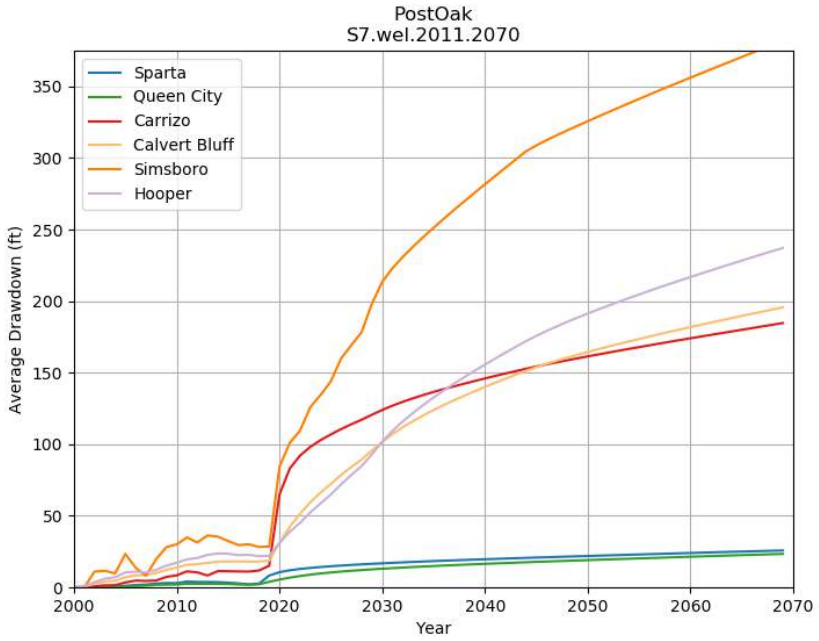
Simulated DFC for PS-7

Comparison of PS-7 Simulated DFCs and POSGCD DFCs*

	Current DFC (feet)	Current MAG in 2070	S-7 Drawdown from 2010 to 2070 (feet)	S-7 Pumpage in 2070 (acre-feet)
Sparta	28	6,735	17	1,983
Queen City	30	504	19	1,045
Carrizo	67	7,058	177	18,205
Calvert Bluff	149	1,036	183	4,761
Simsboro	318	48,503	355	85,855
Hooper	205	4,422	222	3,126

PS-7 Simulation

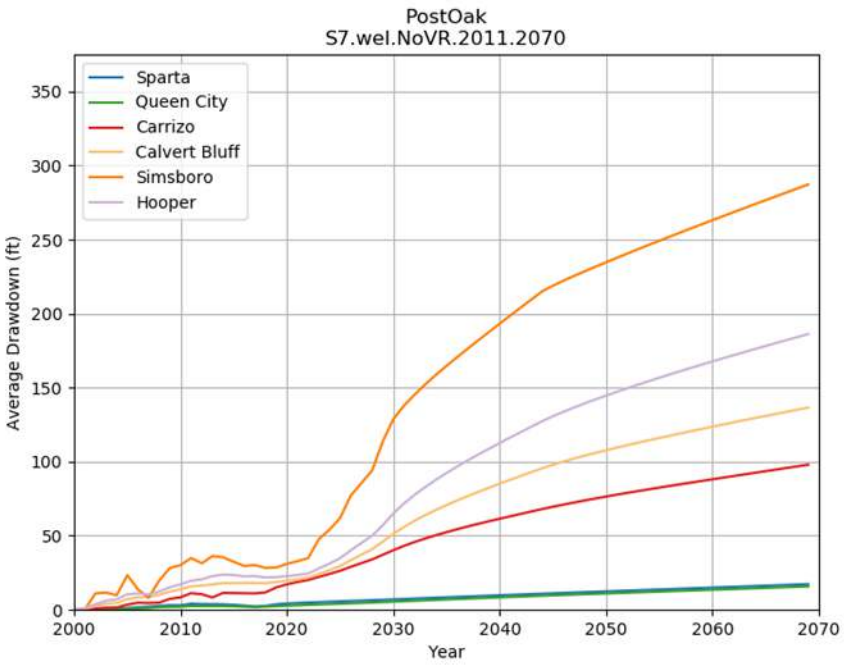


* From GMA 12 Sept 2019 presentation (note: different time periods for PS-7 and POSGCD DFCs)

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

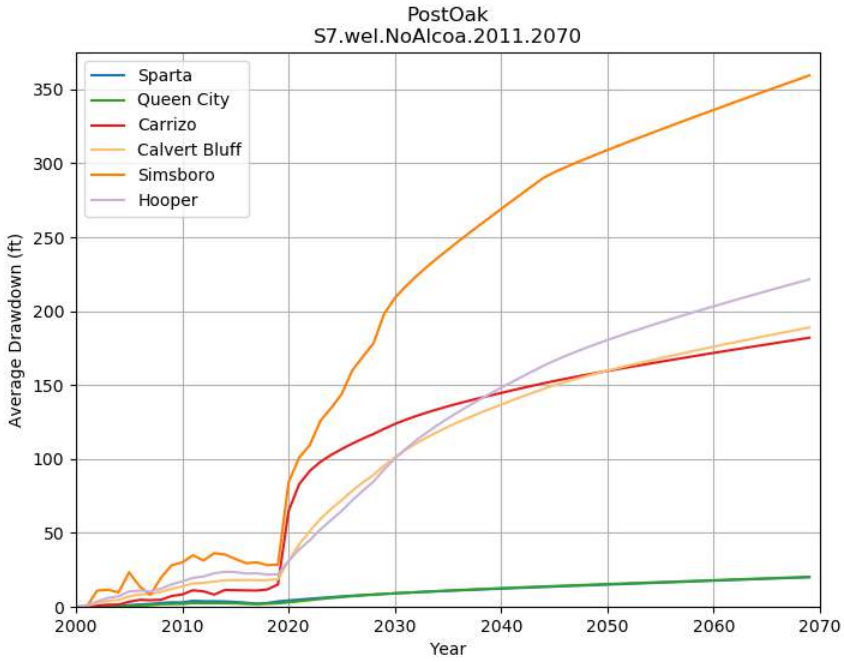
Sensitivity of Simulated DFCs to Changes in Pumping

No Vista Ridge Pumping After 2020 & Alcoa Pumping is constant after 2020



DFCs are exceeded in 2070 for Carrizo (67 ft)

Alcoa Simsboro Pumping is constant after 2020

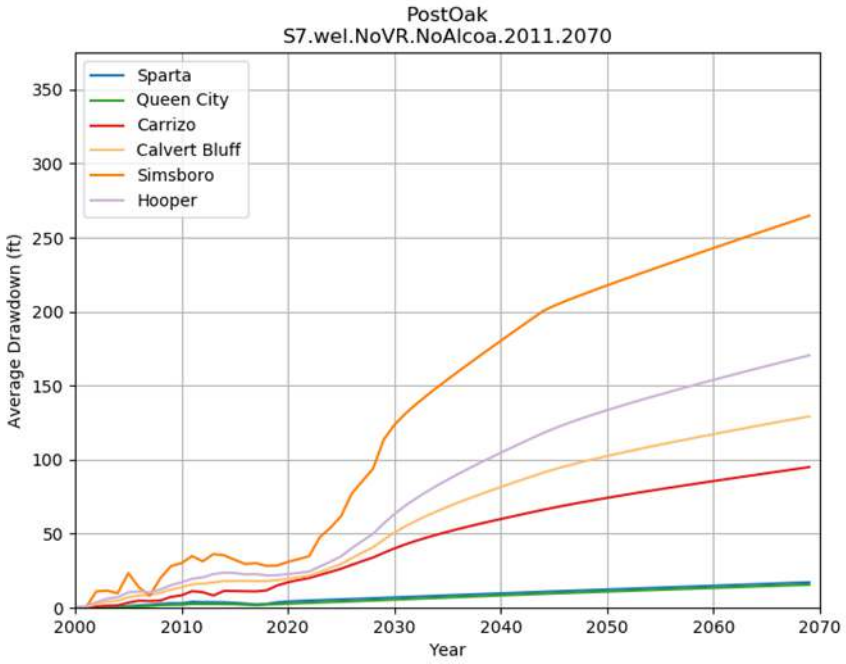


DFCs are exceeded in 2070 for Carrizo (67 ft), Simsboro (318), Hooper (205), and Calvert Bluff (183)

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

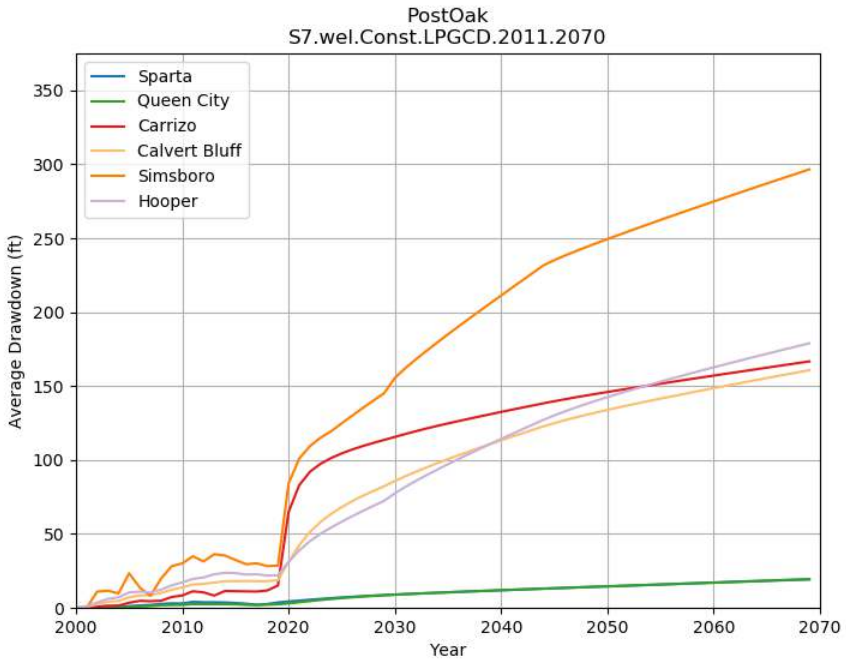
Sensitivity of Simulated DFCs to Changes in Pumping

No Vista Ridge Pumping After 2020 & ALCOA Simsboro Pumping is constant after 2020



DFCs are exceeded in 2070 for Carrizo (67 ft)

LPGCD Pumping is Held Constant after 2020



DFCs are exceeded in 2070 for Carrizo (67 ft)

INTERA
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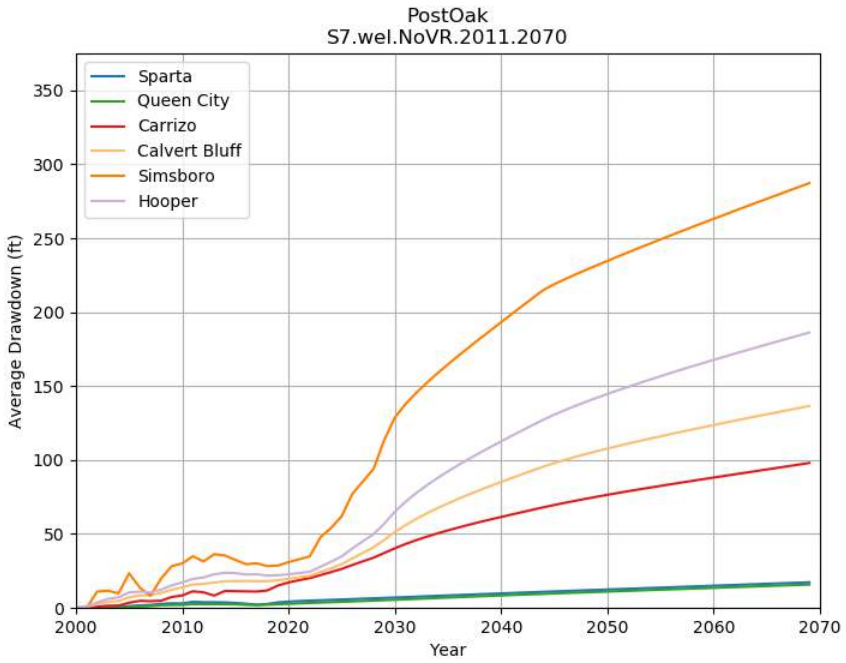
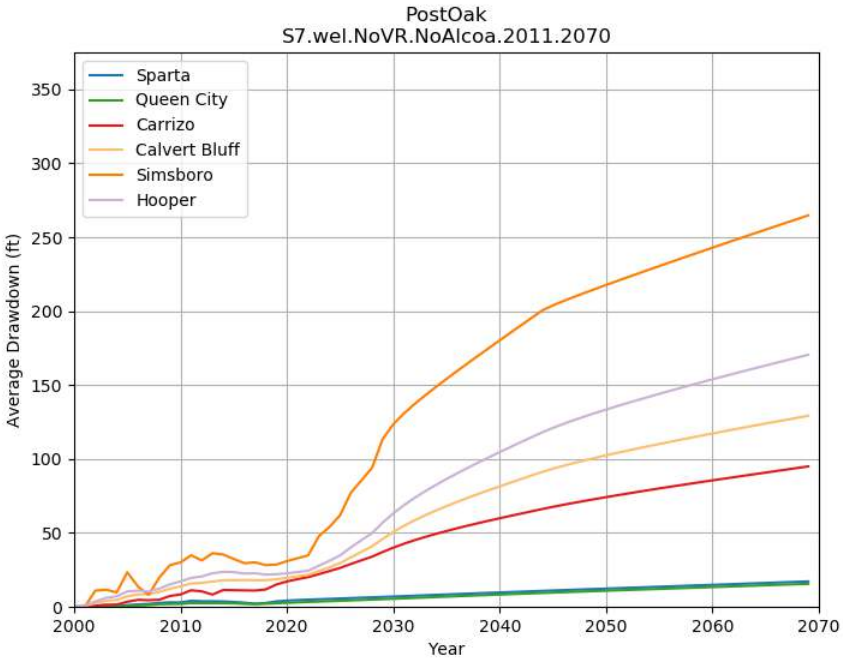
Sensitivity of Simulated DFCs to Changes in Pumping

No Vista Ridge Pumping After 2020



DFCs are exceeded before 2070 for Carrizo (67 ft)

No Vista Ridge Pumping After 2020 & Alcoa Pumping is constant after 2020



DFCs are exceeded before 2070 for Carrizo (67 ft)

* 400-ft depth

INTERA
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Sensitivity of PDLs and DFCs for PS-7 Pumping to Curtailment

INTERA
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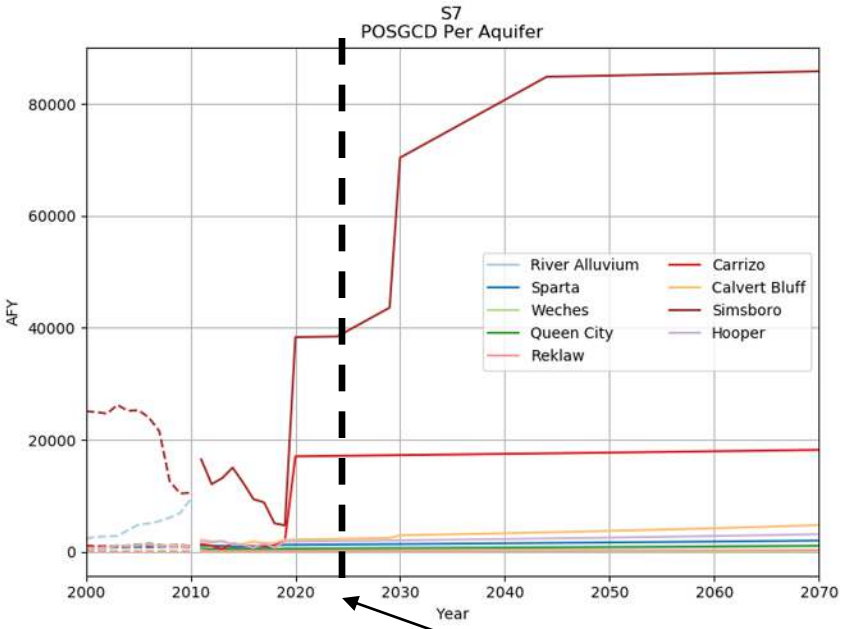
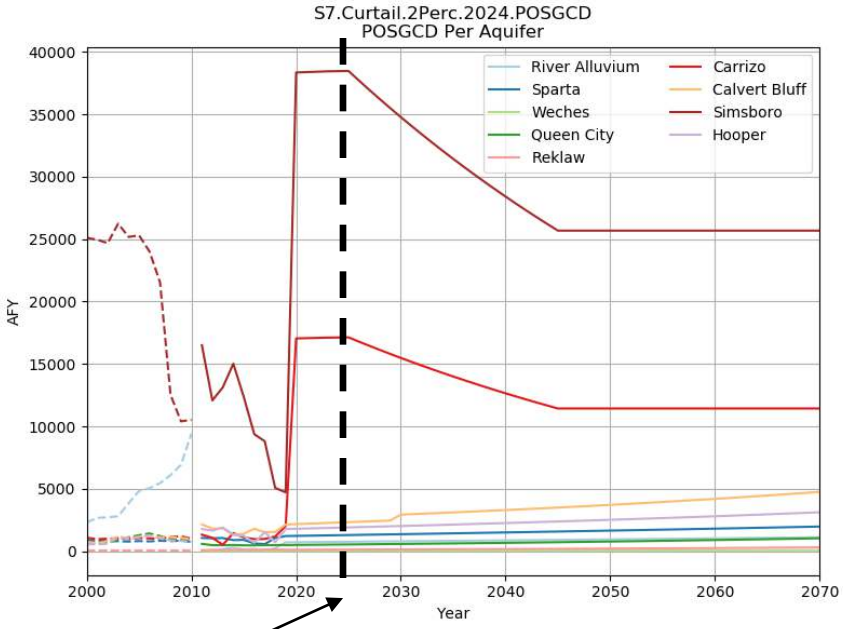
POSGCD Rule 16.7 (pending)

- The **volume of water authorized by permit to be produced in one or more Management Zones may be reduced by the Board, if it determines a reduction is necessary, based on studies and evaluations performed by the Board or as determined by the Board to have scientific merit**. This reduction shall begin as soon after a decision by the Board that such reduction is reasonably required for the conservation and preservation of groundwater, or the protection of the aquifer or groundwater users, within such Management Zone(s).

- If the Board, based on studies and evaluations performed or determined by the Board to have scientific merit, determines **it is necessary to reduce the maximum allowable production per acre, or the permitted production for any Management Zone or Zones,** to accomplish the desired future conditions, the protective drawdown limits, to preserve and conserve groundwater, to protect groundwater users within a Management Zone or Zones, or to implement reductions required under Rule 16.5, the Board shall establish a schedule for a reduction in the maximum allowable production or permitted production for the Management Zone or Zones.

Curtailment in Vista Ridge Pumping from 2024 to 2044 at 2% Reduction per year





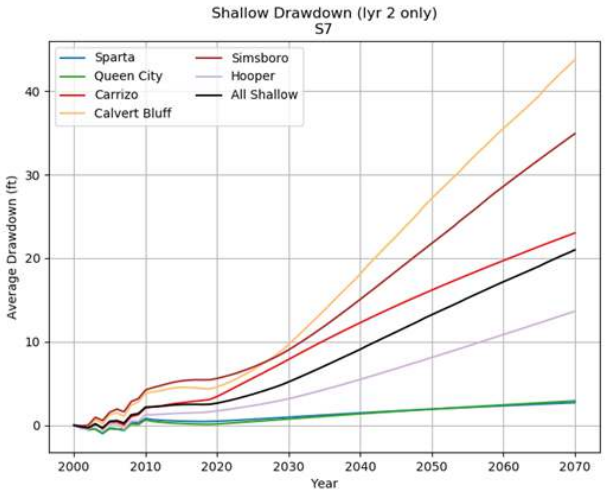
Curtailment begins in 2024 – note that total production increases set to occur after 2024 do not occur

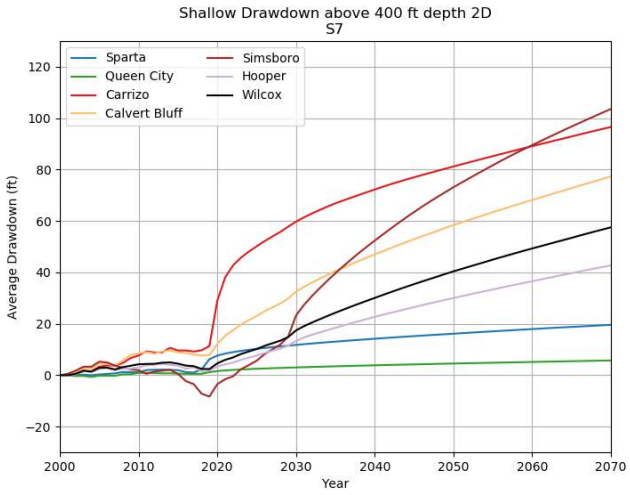
* 400-ft depth

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

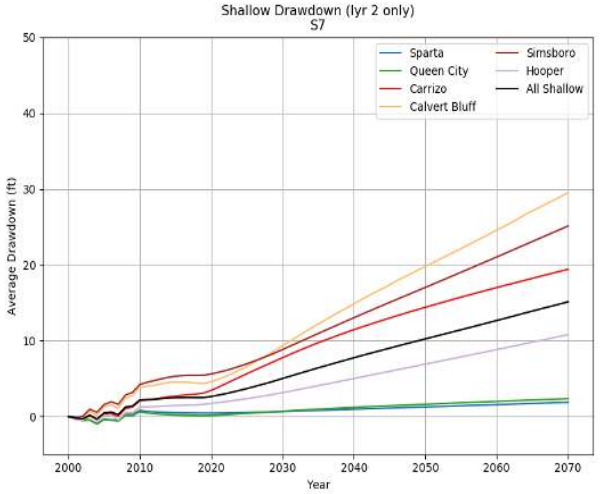
Curtailment in Vista Ridge Pumping from 2024 to 2044 at 2% Reduction per year : Impacts on PDLs

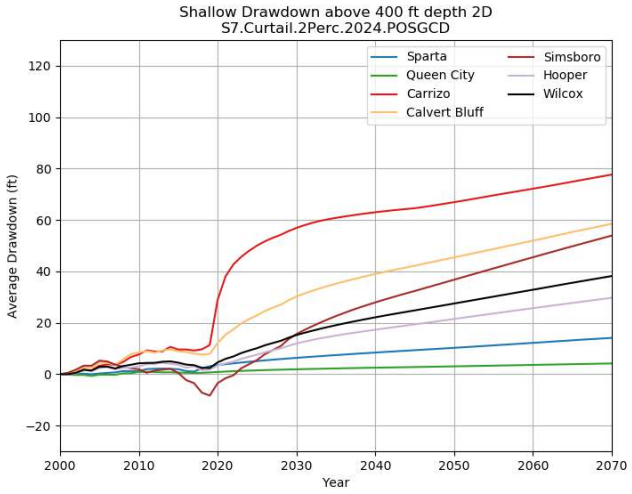
PS-7





PS-7 with POSGCD curtailment

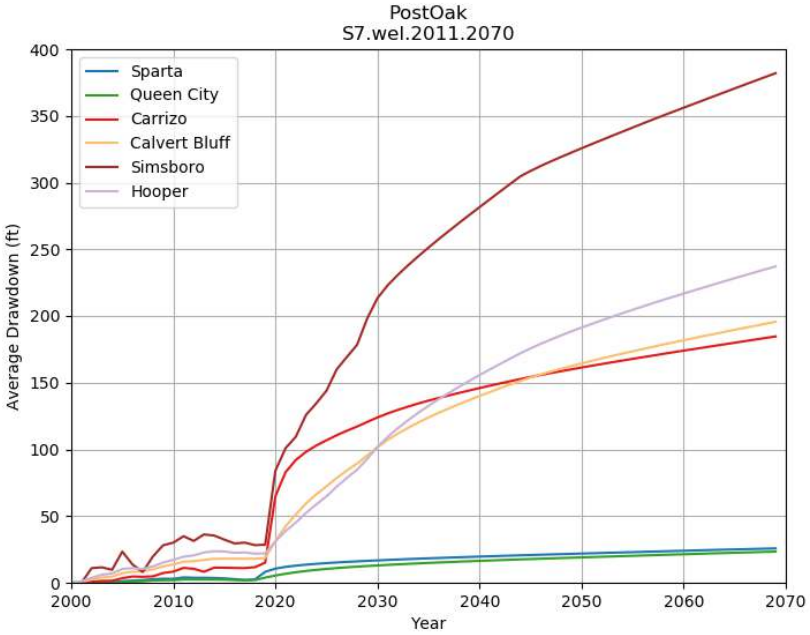




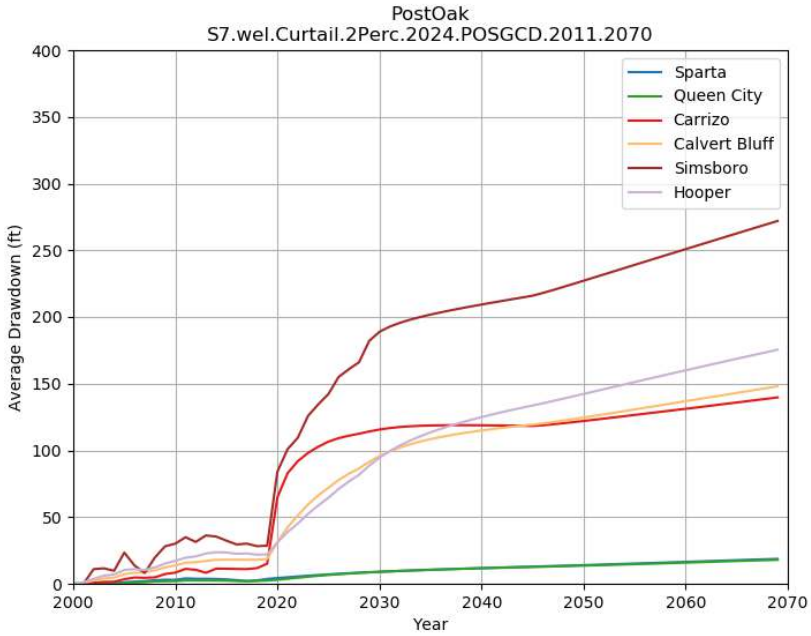
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Curtailment in Vista Ridge Pumping from 2024 to 2044 at 2% Reduction per year: Impacts on DFCs

PS-7



PS-7 with POSGCD curtailment



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Monitoring Well Network

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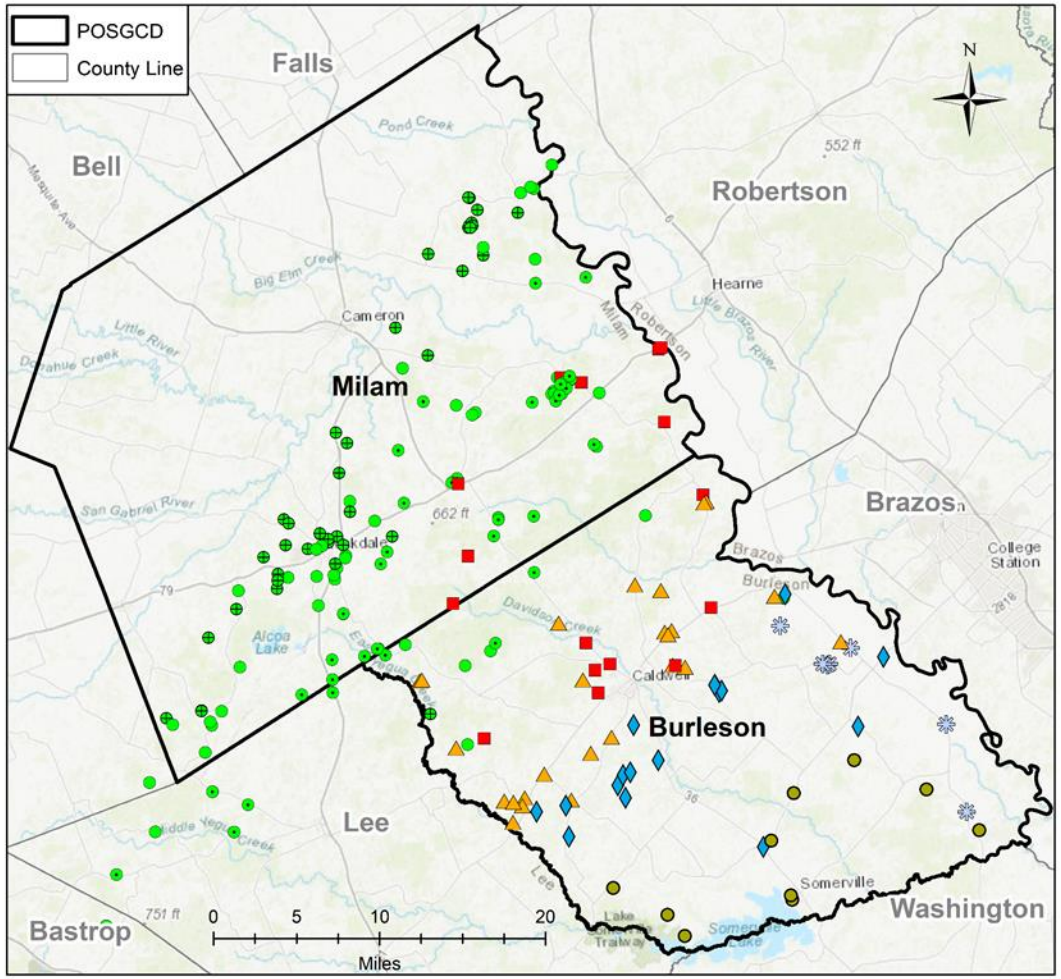
Current Monitoring Network

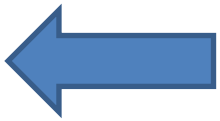
Monitoring Well Network (243 wells)



- BRAA
- Yegua/Jackson
- Sparta
- Reklaw/Weches
- Queen City
- Carrizo
- Calvert Bluff
- Simsboro
- Hooper
- Below Hooper
- Not Yet Assigned

Current Well Database: Spreadsheet

- Well Name
- Location
- Depth
- Top Screen/Bottom Screen (if available)
- Aquifer Assignment
- Aquifer(s) Intersected
- Year First Water Level
- Owner
- Multiple Hyperlinks

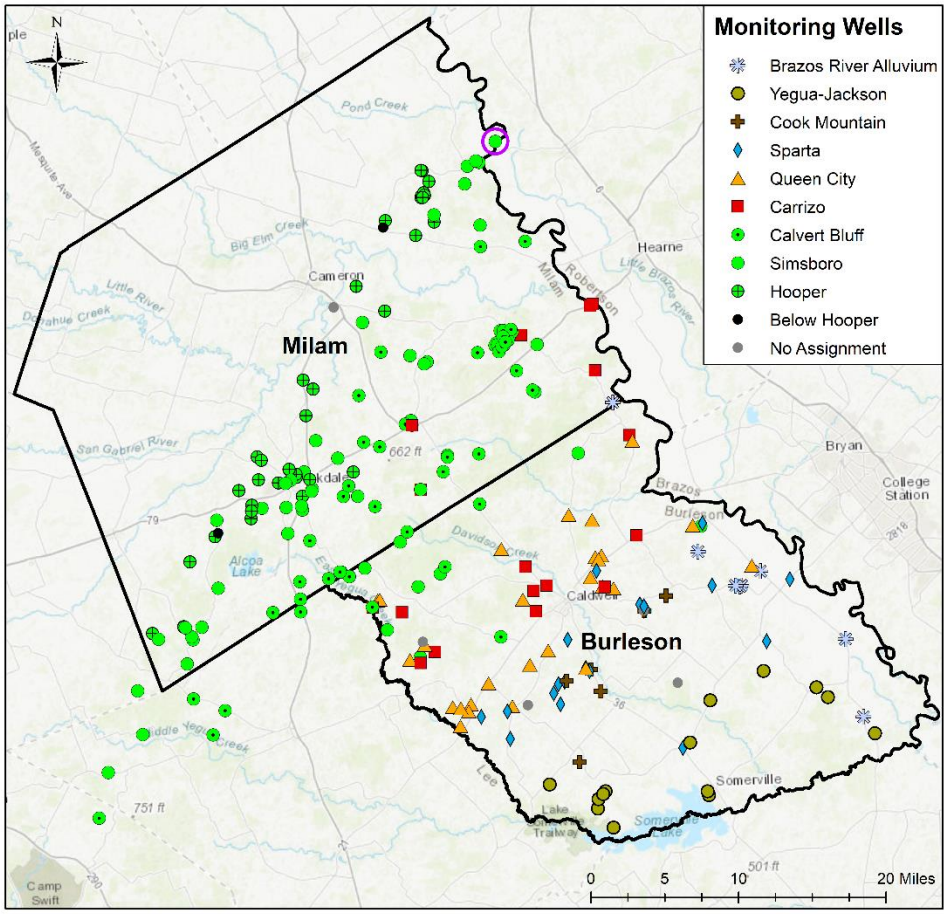


Click and image appears

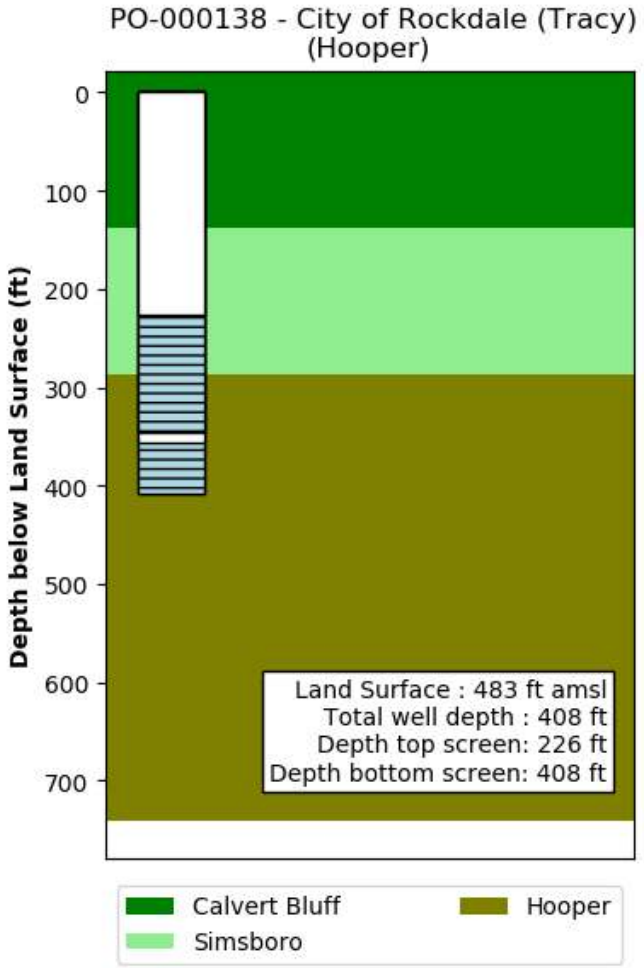
purpose is to facilitate checking

Current Well Database: Hyperlinks

Well Location



Well Construction



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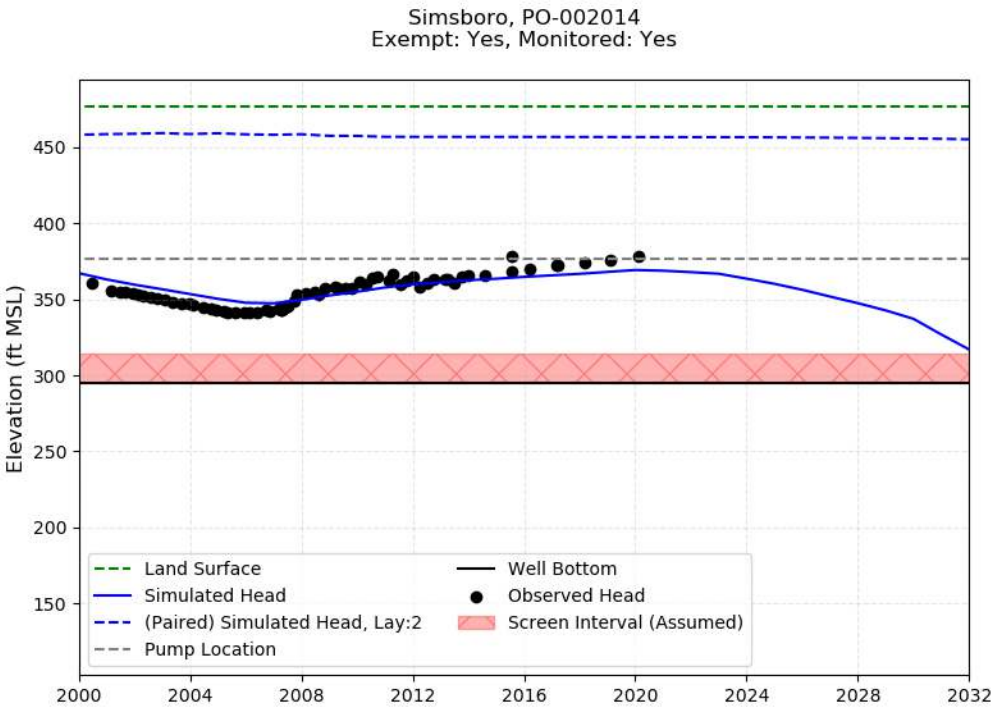
Current Well Database: Hyperlinks

Modeled and Measured Water Levels



Driller Log

STATE OF TEXAS WELL REPORT for Tracking #386114

Owner:	Post Oak Savannah GCD	Owner Well #:	Burleson Pct. 1
Address:	PO Box 92 Milano, TX 76556	Grid #:	59-34-6
Well Location:	CR 144 & FM 11 Deanville, TX 77852	Latitude:	30° 25' 40" N
		Longitude:	096° 45' 47" W
Well County:	Burleson	Elevation:	320 ft. above sea level
Type of Work:	New Well	Proposed Use:	Monitor

Drilling Start Date: 1/12/2015 Drilling End Date: 1/20/2015

Borehole:

Diameter (in.)	Top Depth (ft.)	Bottom Depth (ft.)
8.75	0	400
7.5	400	500

Drilling Method: Mud (Hydraulic) Rotary

Borehole Completion: Filter Packed

Filter Pack Intervals:

Top Depth (ft.)	Bottom Depth (ft.)	Filter Material	Size
155	500	Gravel	12 - 20

Annular Seal Data:

Top Depth (ft.)	Bottom Depth (ft.)	Description (number of sacks & material)
0	10	25 Sakrete
125	155	10 Portland

Seal Method: Grout and Tremie
Sealed By: Driller
Distance to Property Line (ft.): 50
Distance to Septic Field or other concentrated contamination (ft.): 100
Distance to Septic Tank (ft.): No Data
Method of Verification: Measured

Surface Completion: Surface Sleeve Installed

Water Level: 60 ft. below land surface on 2015-01-19 Measurement Method: Unknown
Packers: No Data
Type of Pump: No Pump Set
Well Tests: Jetted Yield: 80+ GPM with 38 ft. drawdown after 4 hours

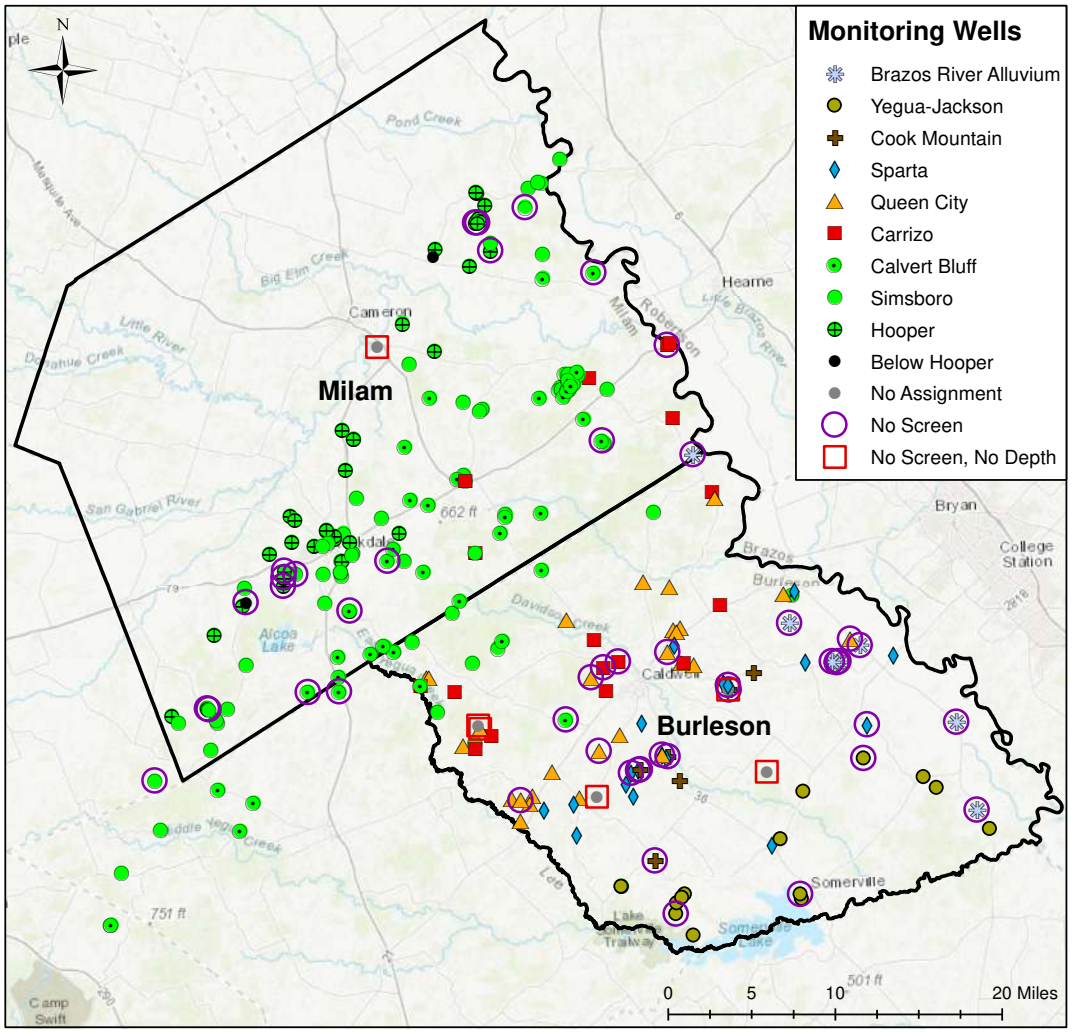
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Aquifer Assignment: Lack of Well Construction Info

Some monitoring wells do not have depth or screen information →

6 wells - no depths

47 wells - no screen info



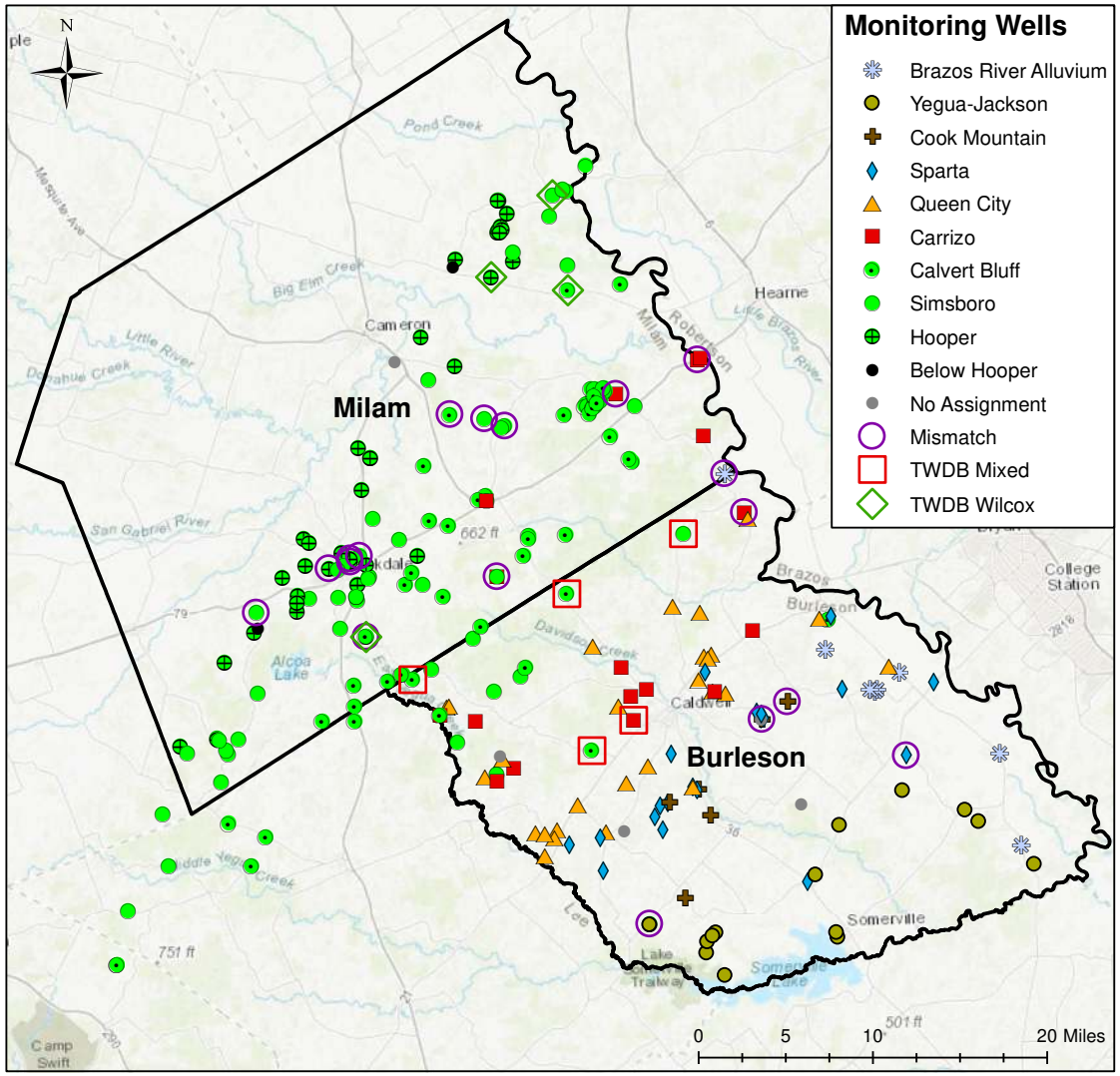
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Aquifer Assignment: TWDB Assignments Differ from INTERA Assignments*

TWDB dB does not match INTERA assignment

18 wells – difference between TWDB and INTERA assignments

Note: Also INTERA locations will differ from TWDB because INTERA uses locations from Trimble (35 wells lack Trimble measurements)



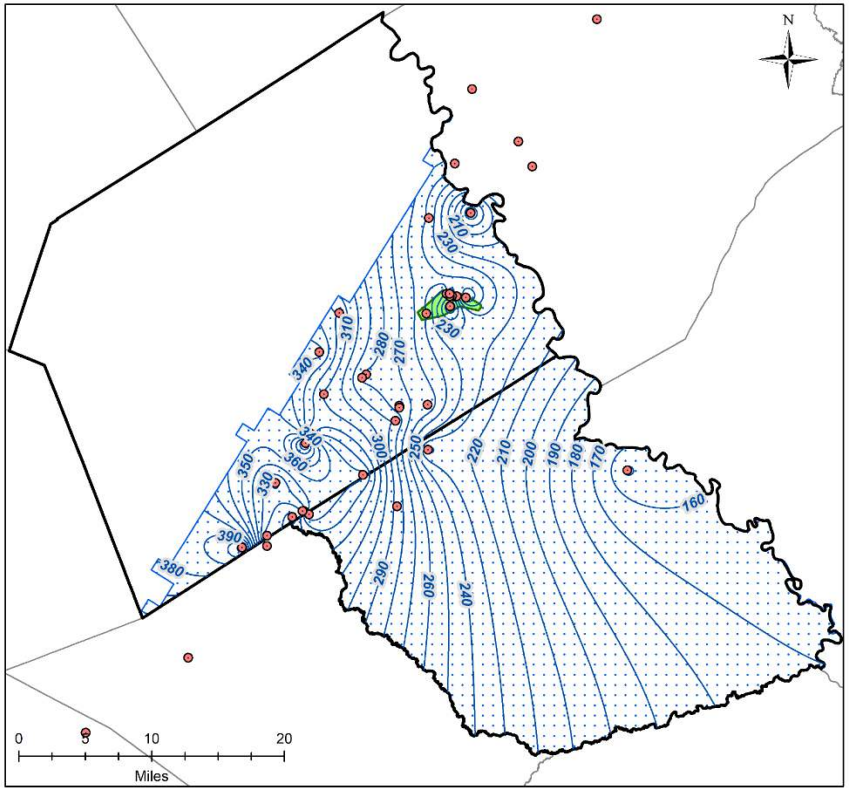
* There are Differences

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

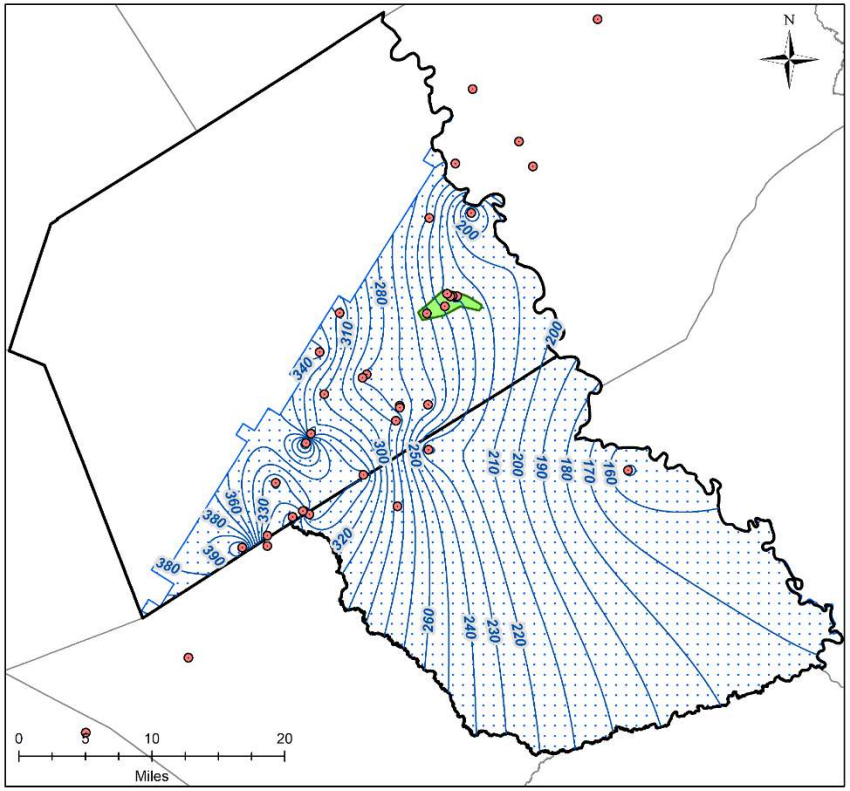
Aquifer Assignment: Inconsistent Water Level Information

- Some monitoring wells appear to be completed in one aquifer but water table does not match aquifer

Original 2018 Water Level

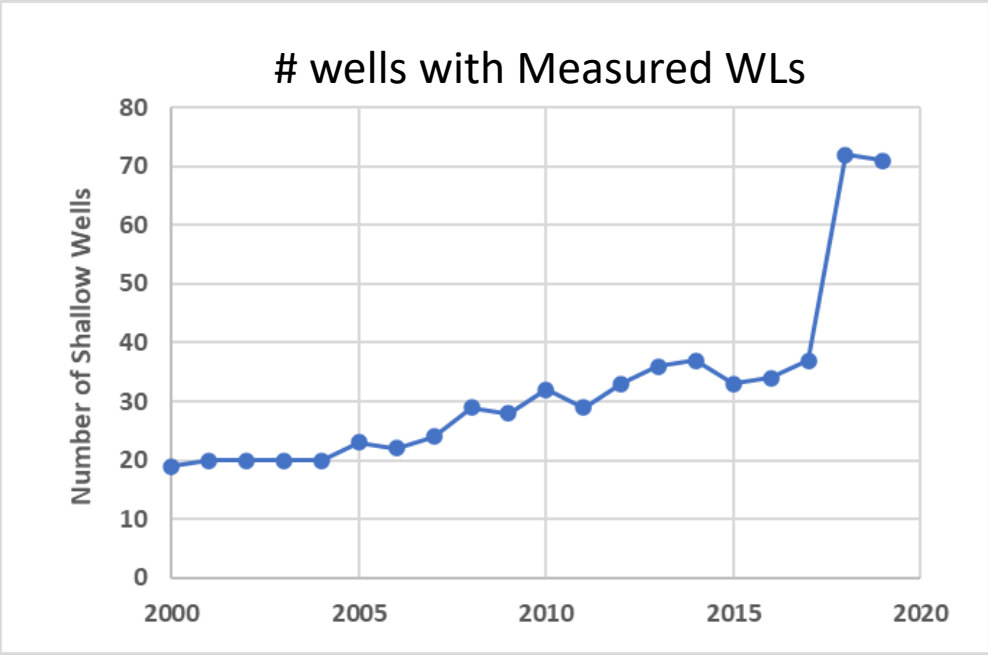


Moved 2 wells in 22 Hills area from Calvert Bluff to Carrizo



Well Coverage for PDL Compliance

	# of Shallow Monitoring Wells with Measured WLs																			
Aquifer	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Brazos River Alluvium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yegua-Jackson	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	6	5
Sparta	1	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	4	4
Queen City	3	3	3	3	3	3	3	3	3	4	4	4	4	5	7	3	5	3	8	8
Carrizo	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	4
Calvert Bluff	2	2	2	2	2	3	3	3	4	3	3	3	4	4	4	4	3	3	7	7
Simsboro	9	10	9	9	10	12	12	13	14	14	15	15	15	15	15	14	14	15	22	22
Hooper	2	3	3	3	1	2	1	2	4	4	7	4	5	7	6	7	7	11	22	21
Total	19	20	20	20	20	23	22	24	29	28	32	29	33	36	37	33	34	37	72	71



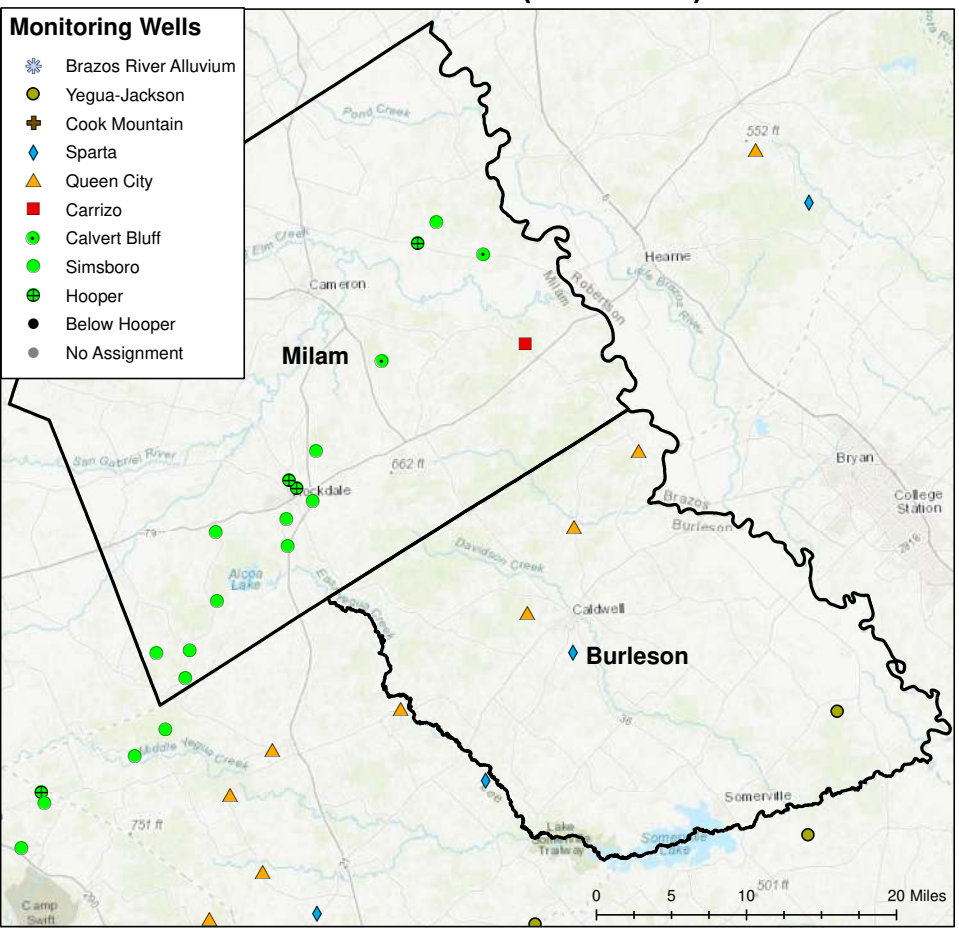
* Note: BRAA wells are excluded from PDL calculation

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

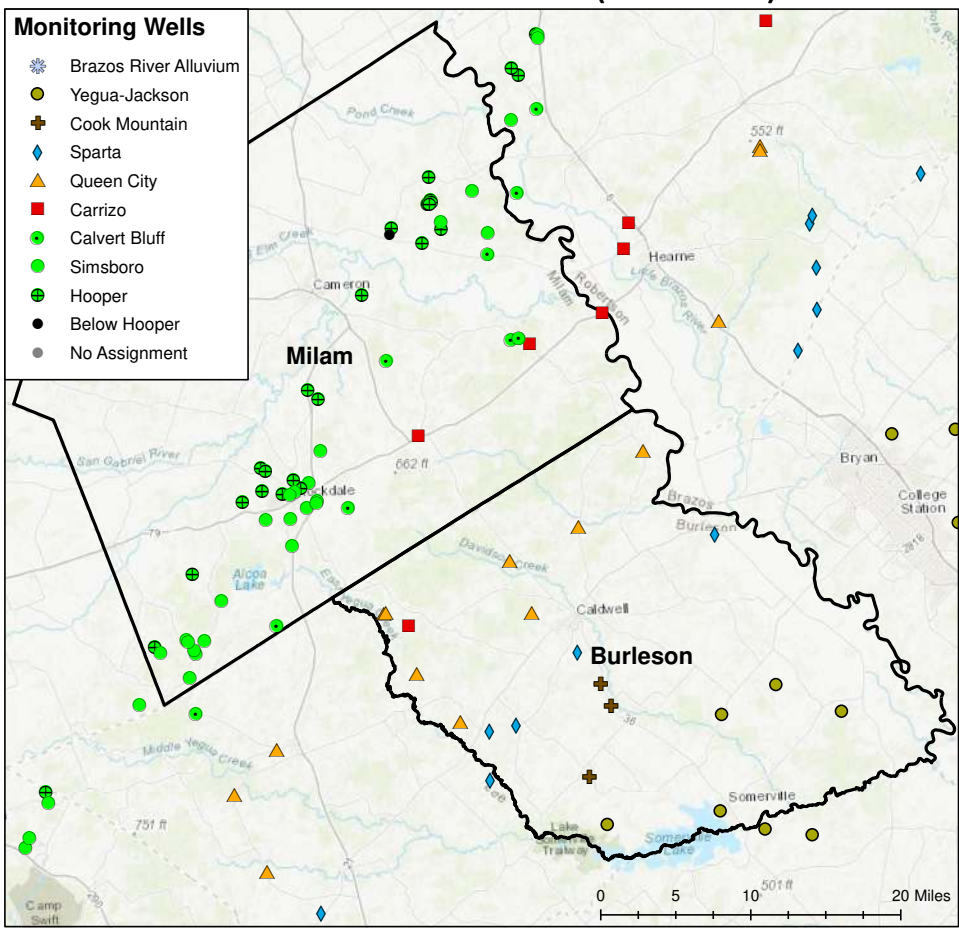
Well Coverage for PDL Compliance

Wells available if DFC Drawdown is measured from other years (instead of from 2000)

2000 (19 wells)



2019 (71 wells)

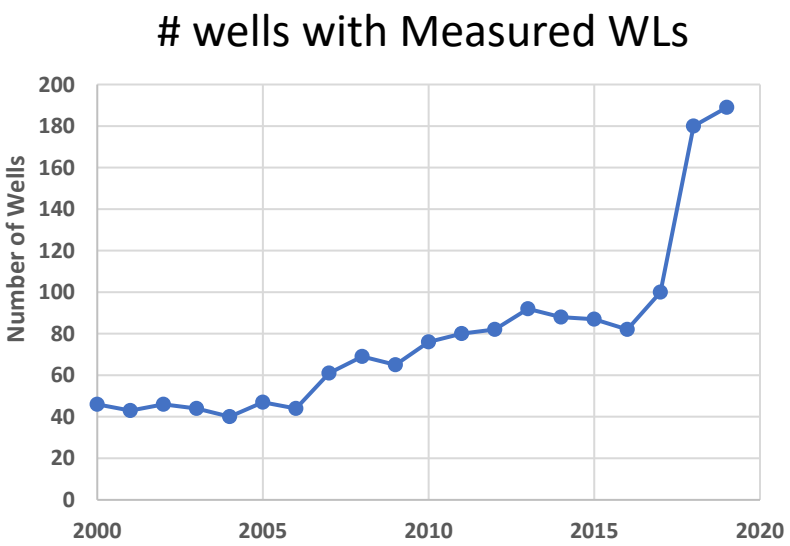


INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Well Coverage for DFC Compliance

Wells available if DFC Drawdown is measured from other years (instead of from 2000)

	# of Monitoring Wells with Measured WLs																			
Aquifer	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Brazos River Alluvium	5	5	5	5	5	5	5	7	7	7	7	7	7	7	5	4	4	5	5	6
Yegua-Jackson	1	1	1	1	2	1	1	2	3	2	2	2	3	3	3	1	3	4	8	11
Sparta	3	2	3	3	3	3	3	3	3	3	3	4	5	6	8	5	6	7	17	19
Queen City	4	4	5	4	4	4	4	4	4	5	7	8	5	10	11	8	7	10	23	21
Carrizo	4	2	3	2	2	2	2	2	4	4	5	5	5	6	5	6	5	6	11	14
Calvert Bluff	11	11	10	12	8	12	10	15	16	14	14	17	18	18	18	22	19	25	44	45
Simsboro	14	13	13	12	13	16	16	20	21	20	24	26	28	27	25	28	26	26	38	39
Hooper	4	5	6	5	3	4	3	8	11	10	14	11	11	15	13	13	12	17	34	34
Total	46	43	46	44	40	47	44	61	69	65	76	80	82	92	88	87	82	100	180	189



INTERA
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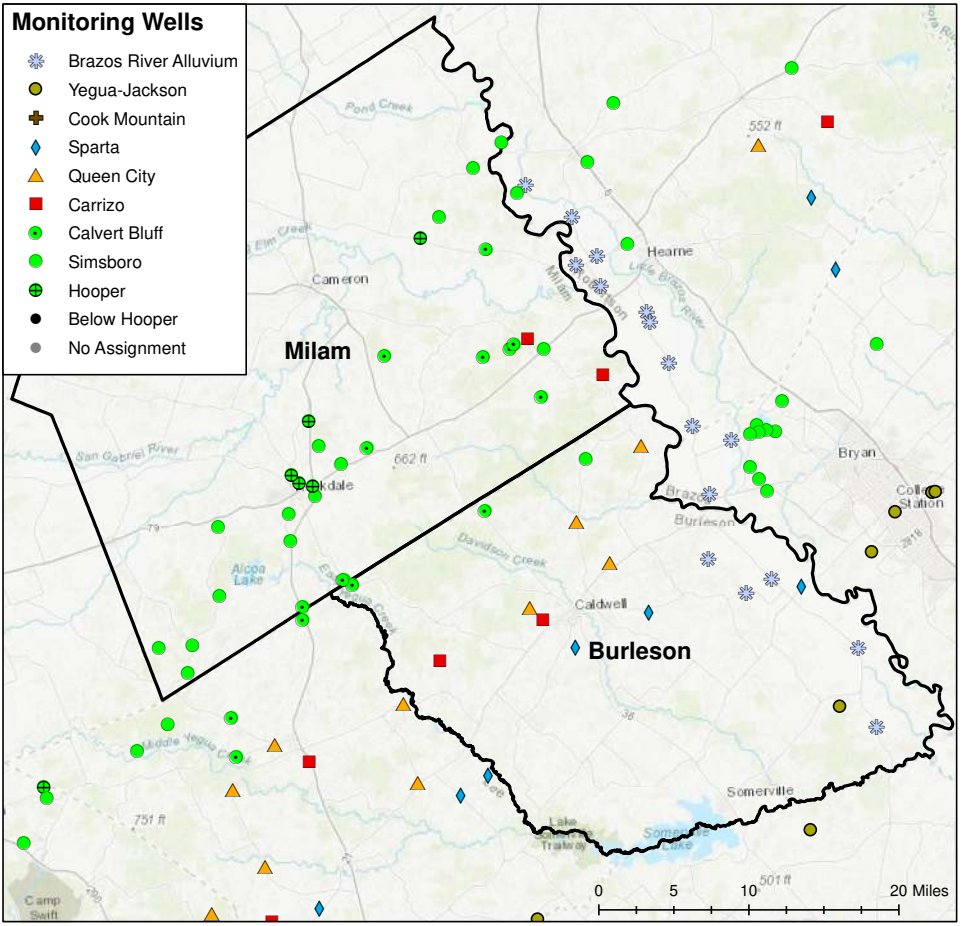
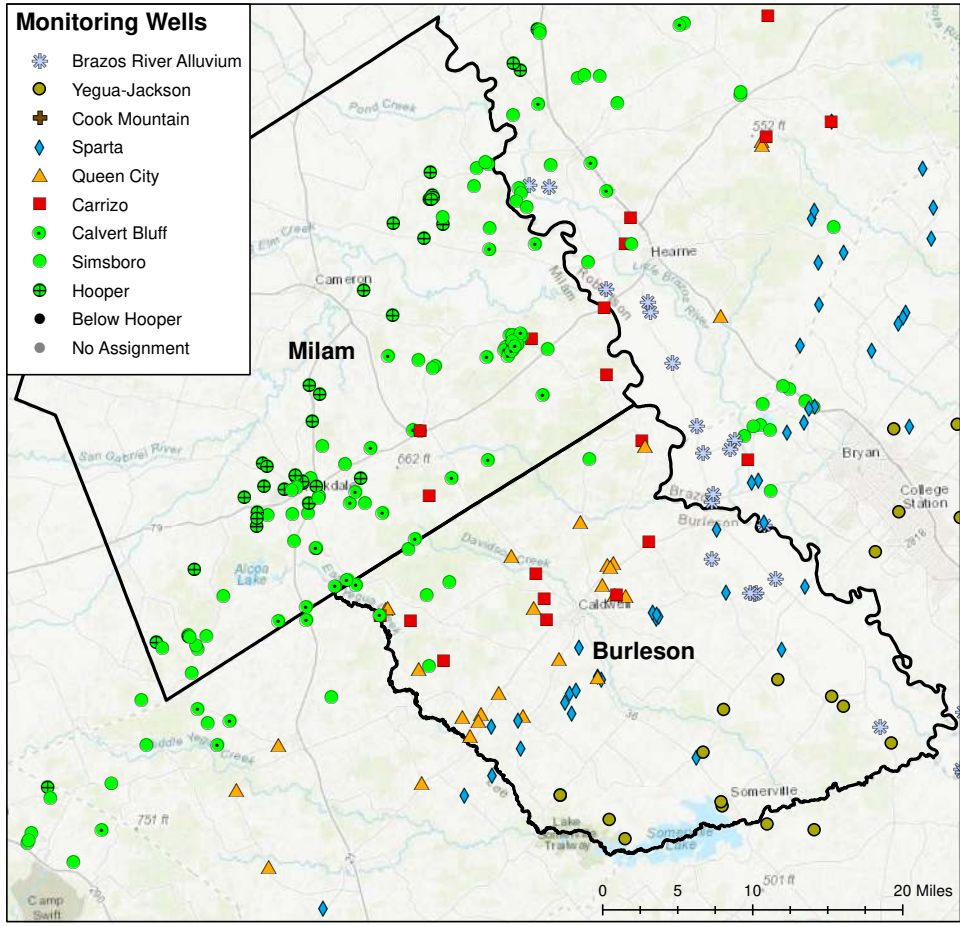
Well Coverage for DFC Compliance

Wells available if DFC Drawdown is measured from other years (instead of from 2000)

2000



2019

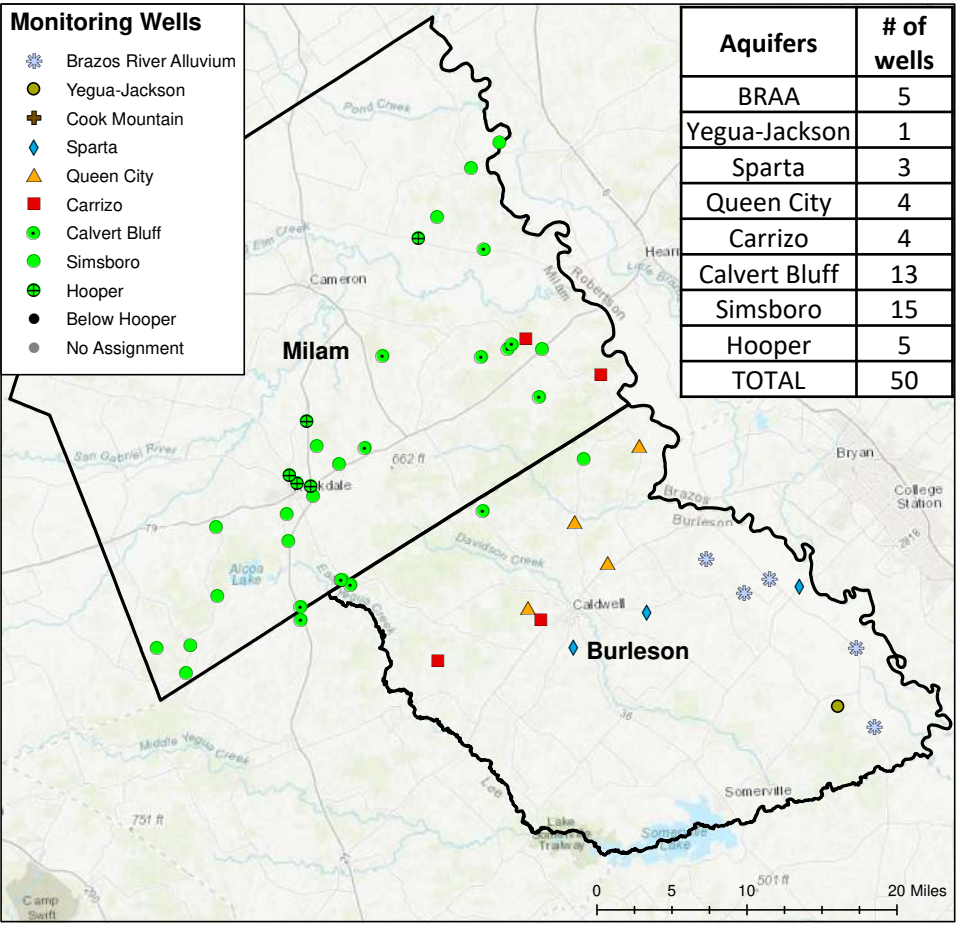


INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Adequacy of Coverage

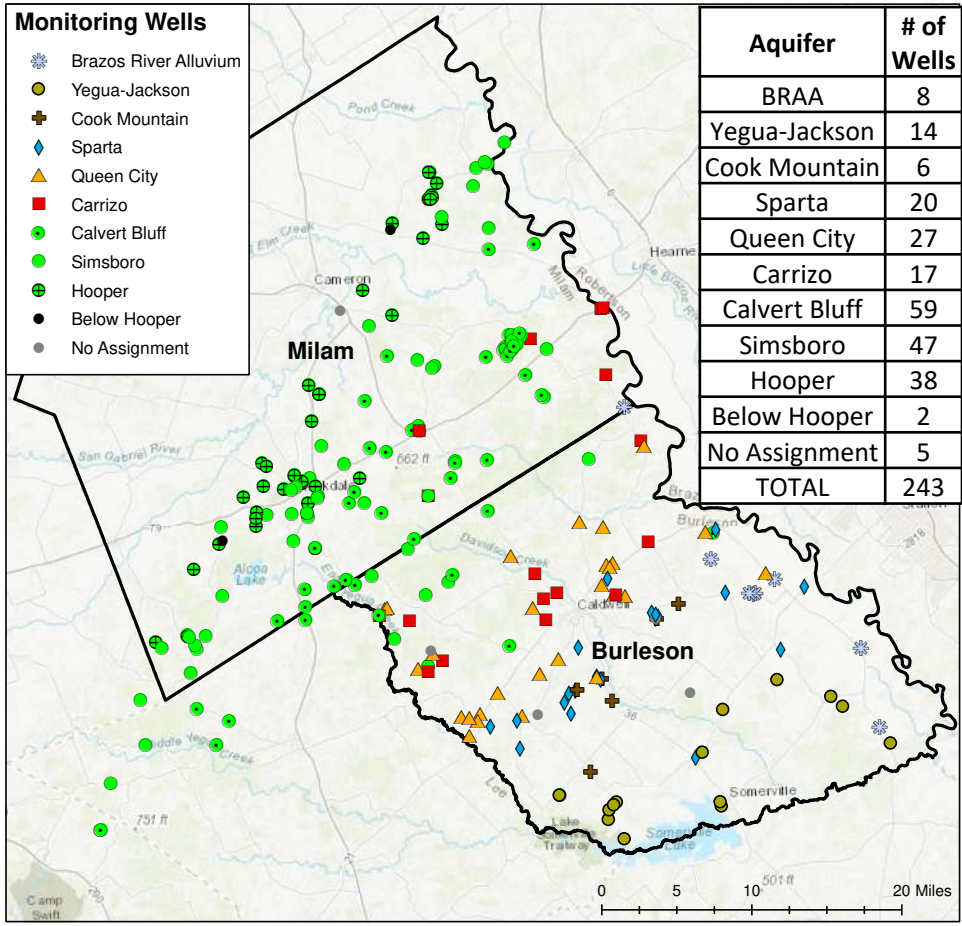
Total Monitoring Wells

2000



Aquifers	# of wells
BRAA	5
Yegua-Jackson	1
Sparta	3
Queen City	4
Carrizo	4
Calvert Bluff	13
Simsboro	15
Hooper	5
TOTAL	50

2020



Aquifer	# of Wells
BRAA	8
Yegua-Jackson	14
Cook Mountain	6
Sparta	20
Queen City	27
Carrizo	17
Calvert Bluff	59
Simsboro	47
Hooper	38
Below Hooper	2
No Assignment	5
TOTAL	243

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Next Steps

- Confirm depths (and screen intervals, where possible) for every monitoring well
- Establish protocols for well aquifer assignments
  - GAM model layers
  - INTERA analysis of stratigraphy
  - Water levels
- Develop consistency between aquifer assignments used by POSGCD, TWDB, and adjacent GCDs
- Determine if there are spatial gaps in coverage
- If gaps exist, develop plan to fill data gaps (note: 2020 data should be augmented with Vista Ridge wells)

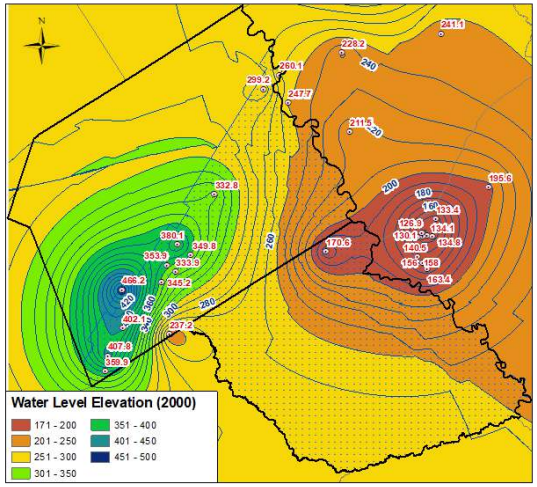
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Monitoring Well Program

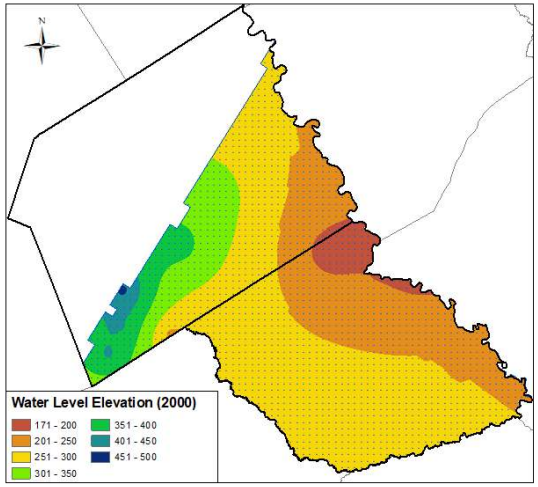
INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Review of Drawdown Calculation

Interpolate Baseline (2000) Simsboro Water Level Surface

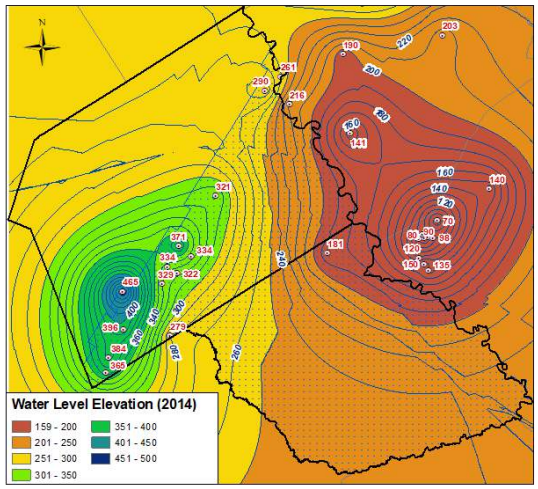


Clip Baseline (2000) Water Level Surface to Simsboro Zone

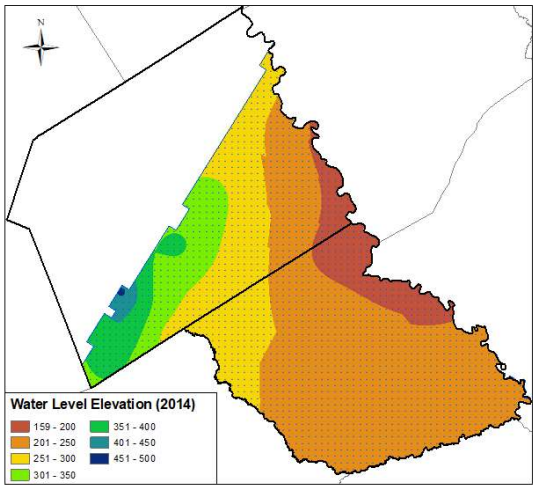


Calculate Average Baseline (2000) Water Level Elevation

Interpolate Evaluation Year (2014) Simsboro Water Level Surface



Clip Evaluation Year (2014) Water Level Surface to Simsboro Zone



Calculate Average Evaluation Year (2014) Water Level Elevation

Average Drawdown = Baseline WL (2000) – Evaluation Year WL (2014)

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Current Interpolation Routine: Benefits

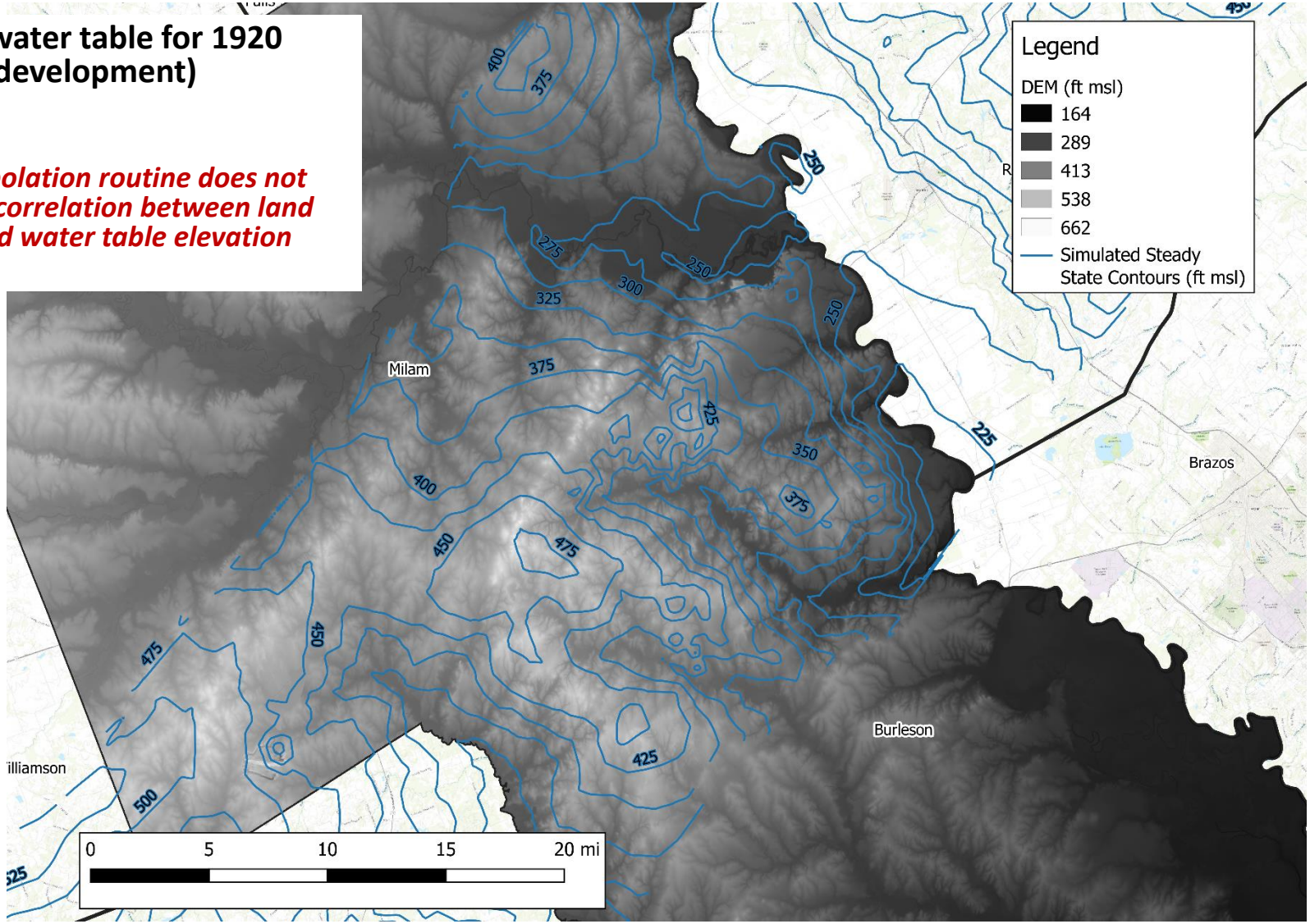
- Benefits Compared to Averaging Measured Water Levels at Individual Wells
  - Provides coverage across entire area of interest
  - Allows integration of monitoring data from adjacent GCDs
  - Prevents bias associated with clustered data points
  - Minimizes subjectivity associated with how to weight individual measurements
  - Well documented methodology that is publicly available

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Reasons for Improving Current Interpolation Routine

Modeled water table for 1920 (predevelopment)

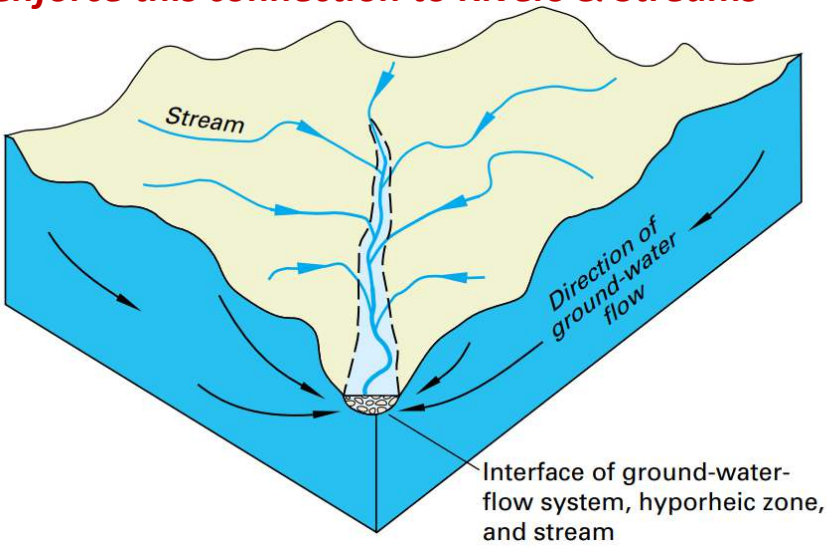
Current interpolation routine does not recognize the correlation between land elevation and water table elevation



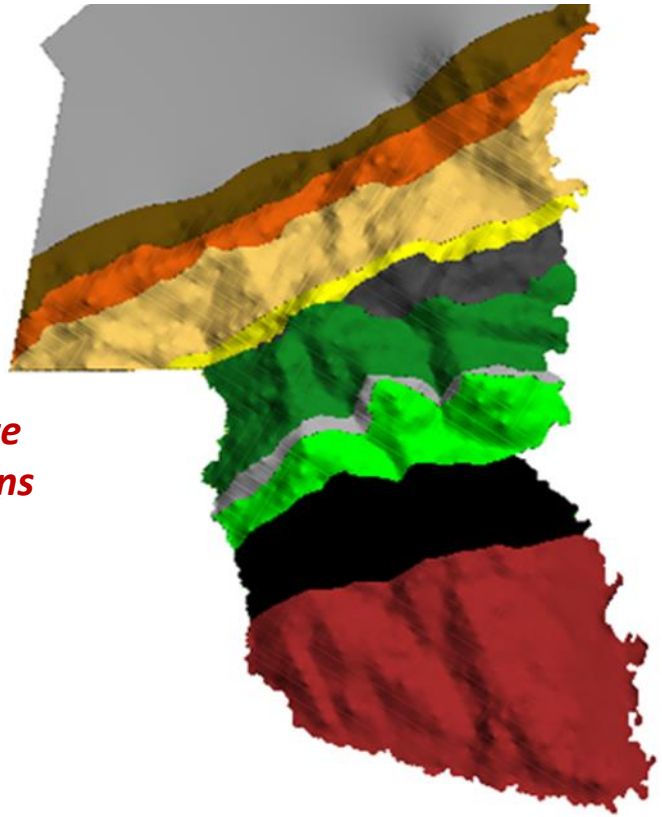
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Reasons for Improving Current Interpolation Routine (con't)

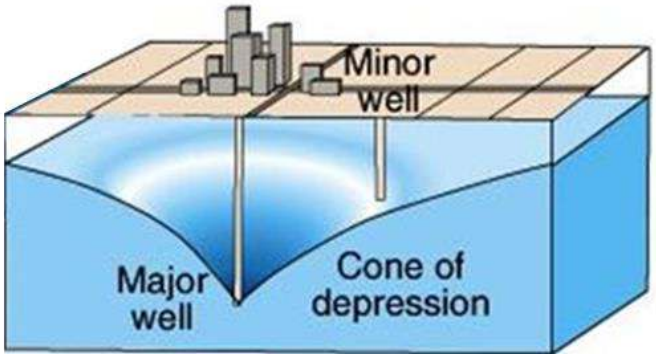
Current interpolation routine does not enforce this connection to Rivers & Streams



Current interpolation routine does not recognize that water levels and groundwater flow are affected by aquifer properties



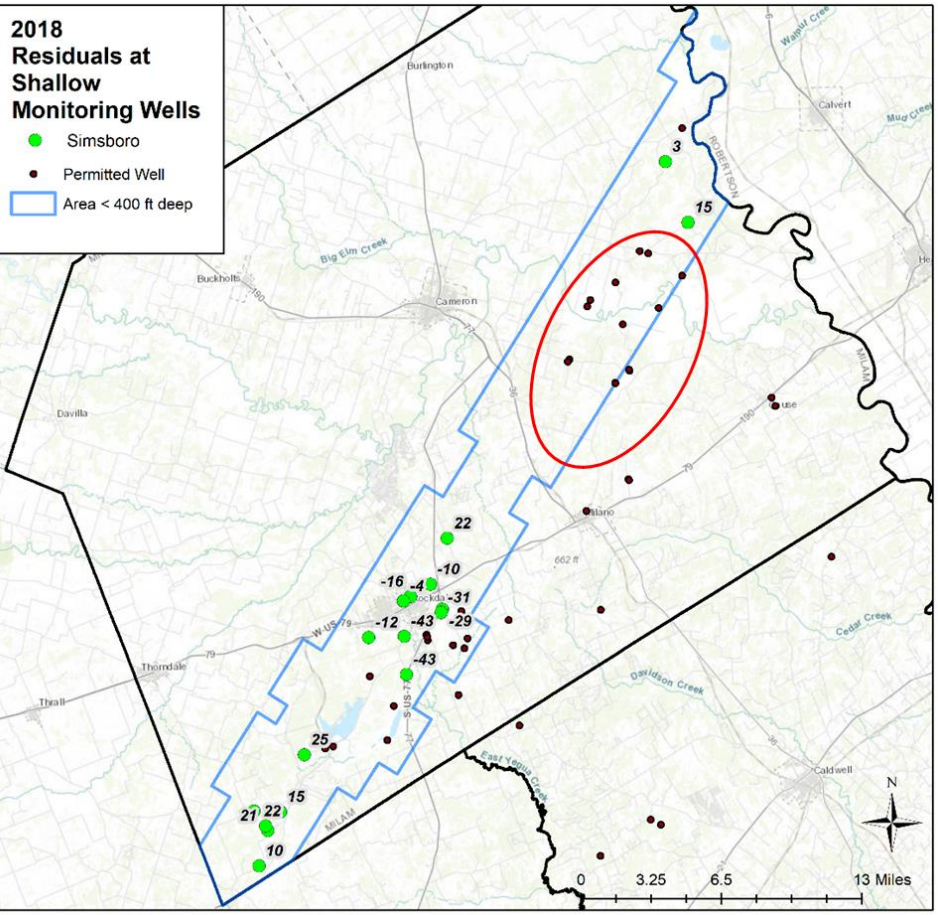
Current interpolation routine does not recognize that pumping wells produce cones of depressions

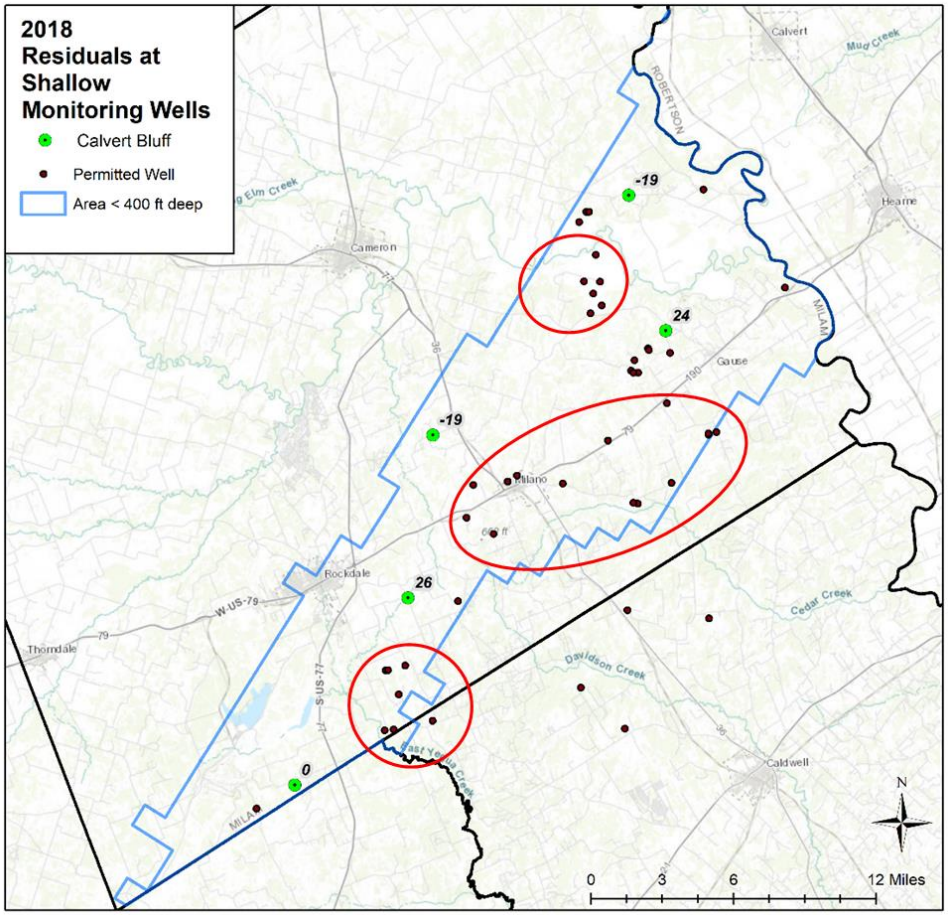


INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Reasons for Improving Current Interpolation Routine (con't)

Gaps where there are Permitted Wells but no nearby Monitoring Wells





INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Consideration for Adjusting Shallow Management Zone

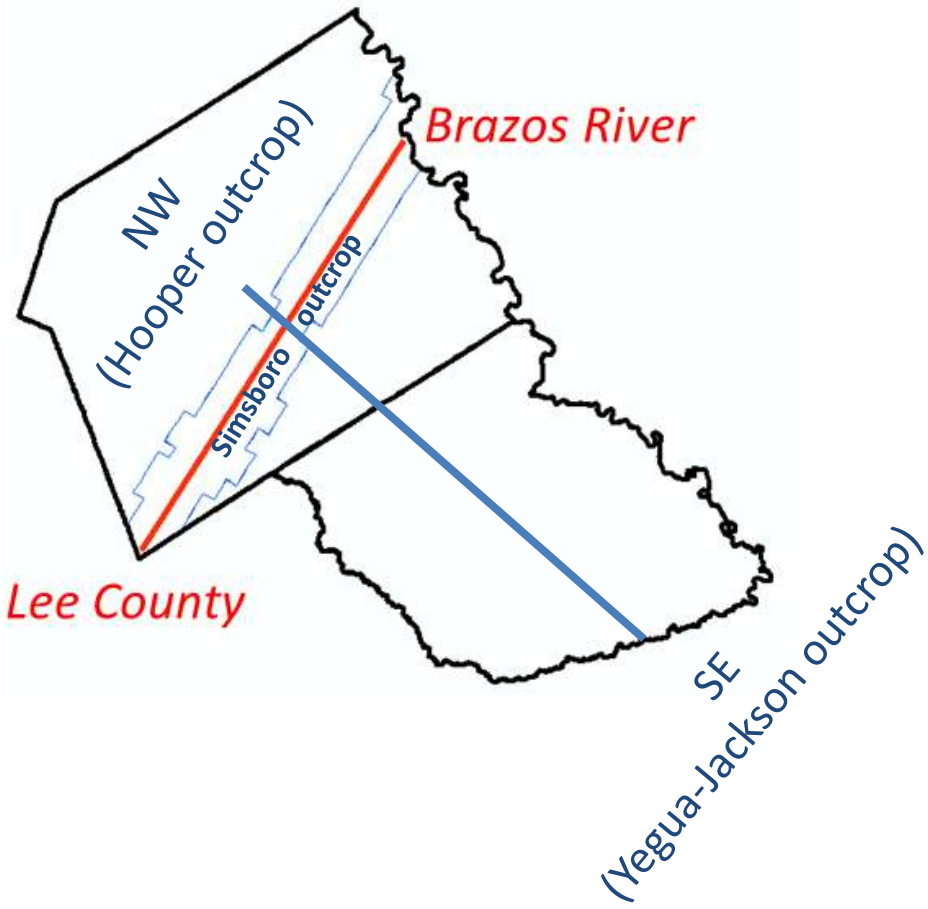
Net drawdown Simulated by the GAM from 1920 to 2010

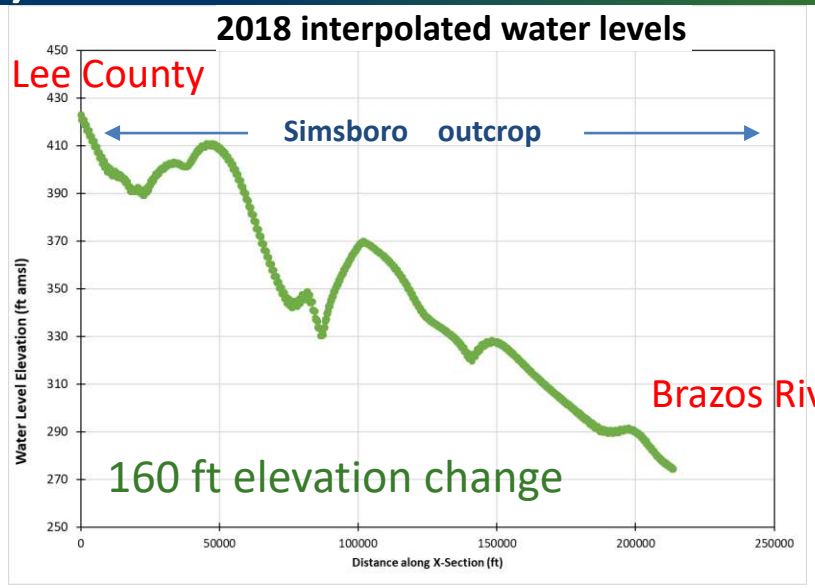
Carrizo-Wilcox Outcrop

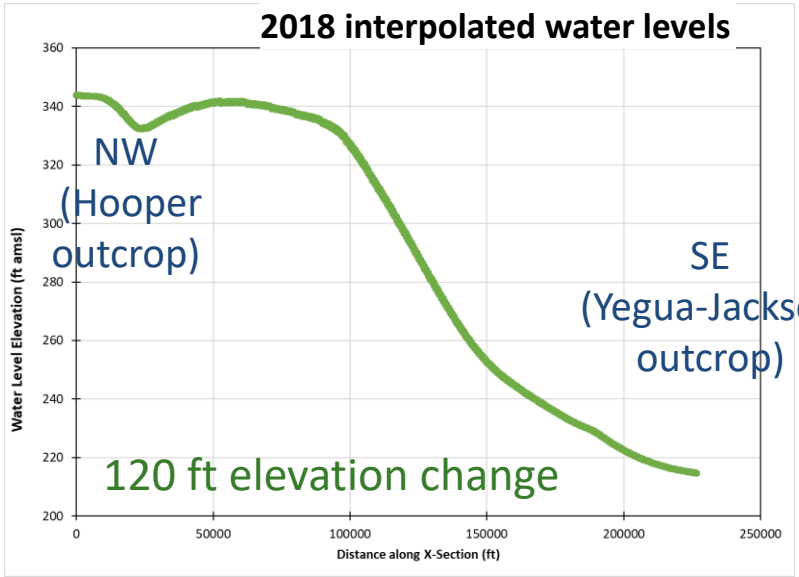
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Reasons for Improving Current Interpolation Routine (con't)

Interpolation between large changes in water level elevations occurs with no consideration to factors that affect water levels







INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Reasons to Improve Interpolation Routine: Regulatory

- District has responsibility to apply Best-Science
- Significant consequences associated with decisions
  - Rule 16.4 : reduce permitted production rate and/ormax production per acre
  - Rule 16.6 : if new permit will exceed PDLs or DFCs, then production associated with permit and permits in the Management zone is reduced
  - Rule 16.7 : cut production rates by 2% or more in a production zones

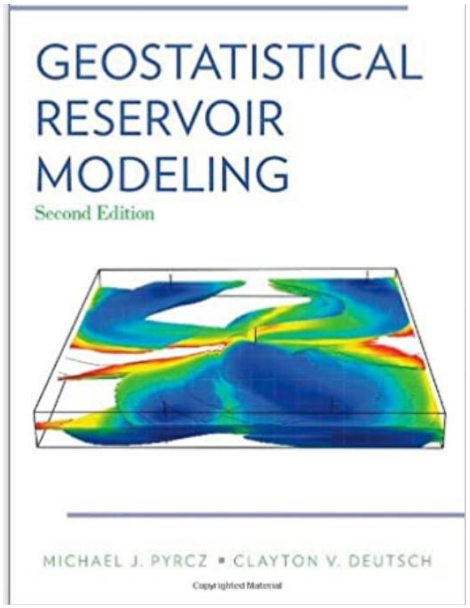
Planned Improvements for Interpolation Routine

- Use a geostatistical-based interpolation technique that will use information in the groundwater model to help condition and constrain the interpolation of the measured water levels

- Improve protocols for filtering measured water levels before they are used in interpolation

Next Steps

- QA/QC water level measurements for 2019 and 2020
- Work with Dr. Michael Pyrcz at UT Austin on developing and applying geostatistical methods
  - Dr. Pyrcz has developed software that is publicly available
  - Tenured Professor with distinguished publication record and 14 years with industry
- Apply Co-kriging Interpolation Routines
  - Routine that can incorporate info on topography and hydraulic boundaries
  - Routine that can incorporate simulated water levels from groundwater models

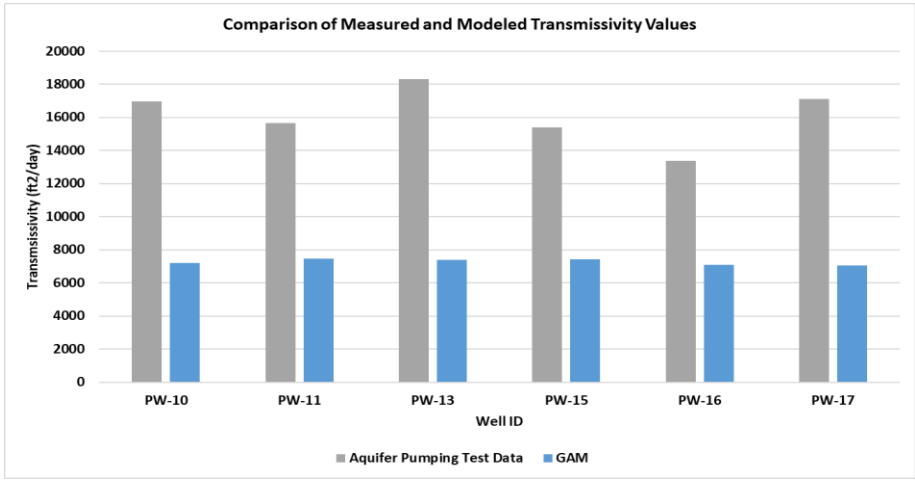


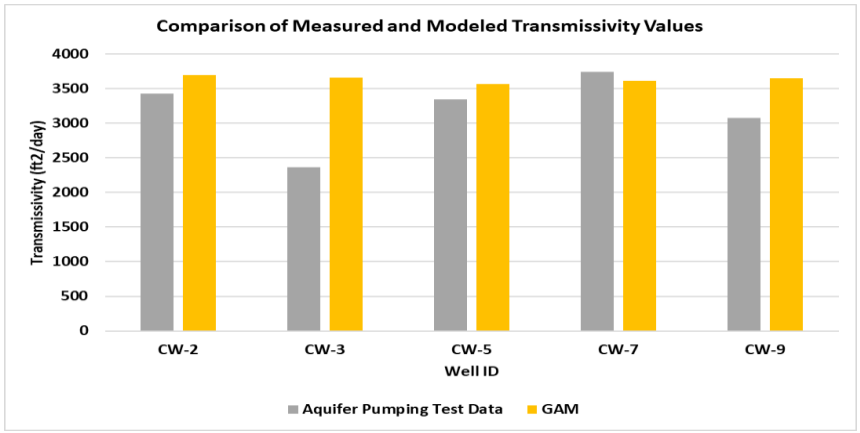
Improvements to Groundwater Model(s)

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

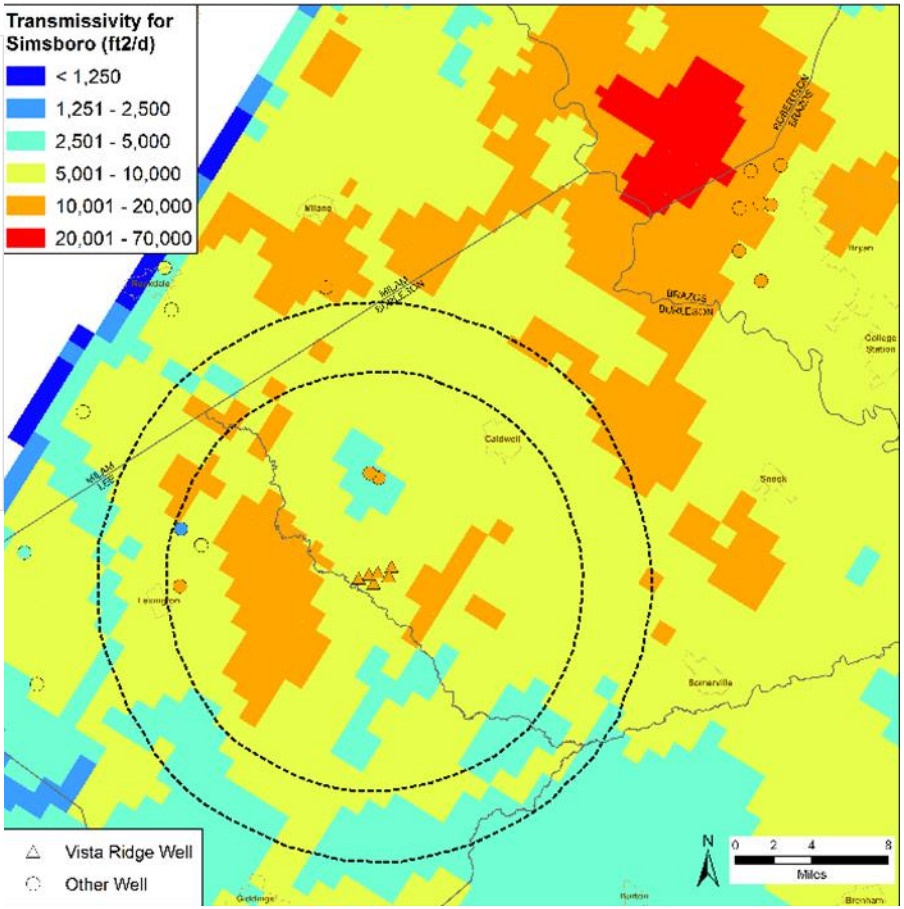
Reasons to Improve Sparta/Queen City/Carrizo-Wilcox GAM: Technical

- Simsboro Transmissivity in the Vicinity of Vista Ridge Wells is Low



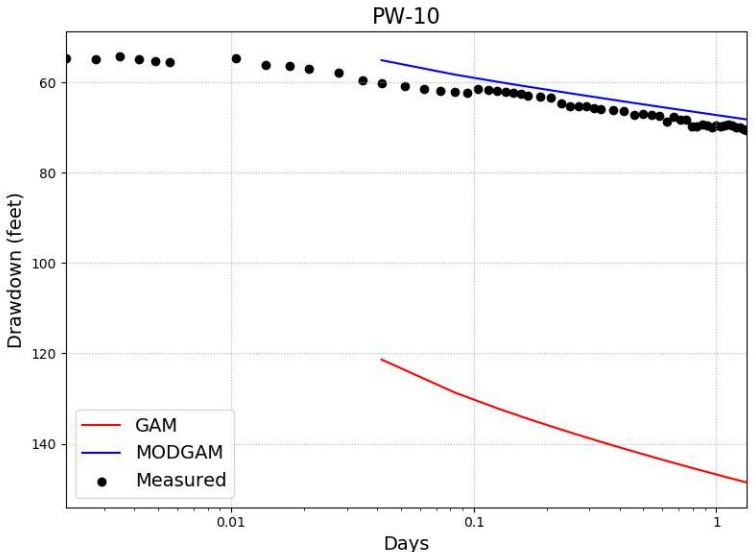


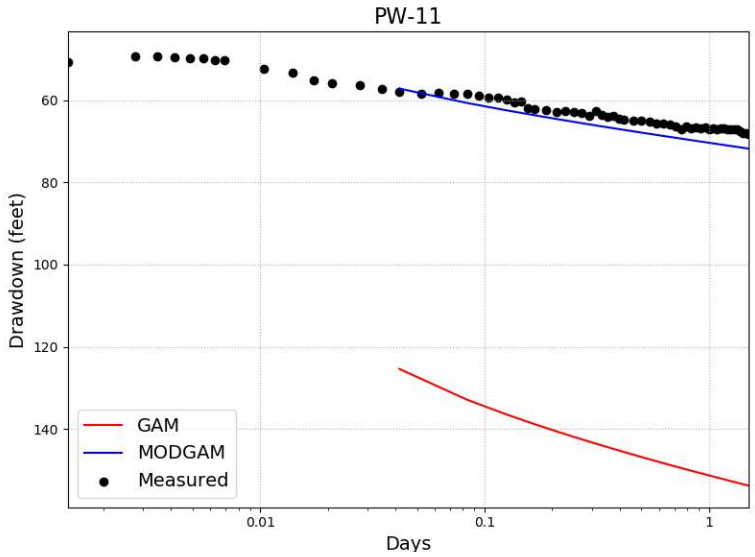
GAM
Simsboro Transmissivity

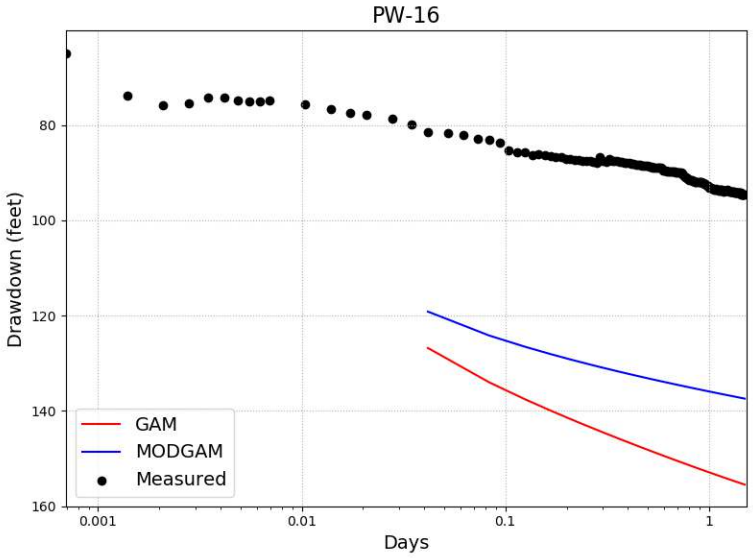


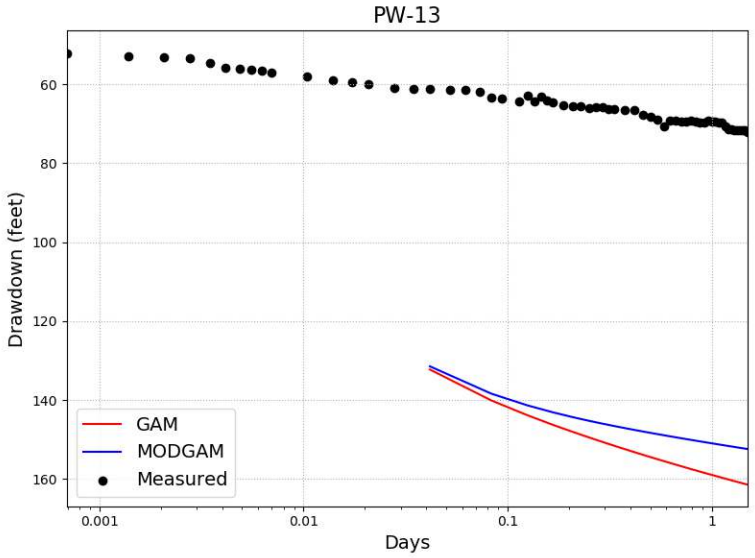
INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Evaluation of GAM and MODGAM*: Simulation of Simsboro Aquifer Pumping Tests









* MODGAM Developed to Support Vista Ridge Permit

Options for Improving GAM

- Phase 1: Modify GAM Simsboro transmissivity values to be consistent with results from Vista Ridge's Simsboro pumping tests
  - Time Frame: 2 months
  - Coordination: TWDB and other GMA 12 consultants
  - Use: 1) GMA 12 joint planning
    2) Compliance Evaluation for PDLs and DFCs
    3) GWAP Annual Needs Assessment Report

- Phase 2: Adjust GAM to provide simulations consistent with monitoring data
  - Time Frame: On-going as needed
  - Use: 1) Evaluation of Compliance
    2) Regulation and Enforcement

Reports

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Reports

GANA Report
Groundwater Assistance Program Annual Needs Assessment

Objective: Evaluate the potential of *water wells* going "dry" based on *simulated water levels* from GMA 12 DFC simulations

CR Report
Evaluation of Compliance Goals Based on Monitored Water Levels

Objective: Evaluate compliance to *DFC's and PDL's* based on interpretation of *measured water levels*

MS Report
Assessment of Management Strategies for Water Availability and Production

Objective: Using best science to:

1) predict year that Rule 16 thresholds may occur
2) evaluate timing for production cutbacks to achieve management goals
3) assess the need for adjusting maximum allowable production of 2 ac-ft/ac
4) assess effectiveness of current management strategies for achieving management goals
5) identify possible changes in management strategies to help achieve management goals

GANA = Groundwater Assistance Program Annual Needs Assessment
CR = Compliance Report
MS = Management Strategies

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

Possible Considerations for Accessing Maximum Production Rate per Acre

Possible Considerations

- Production Capacity
- Storage Capacity
- Depth/outcrop
- Water Quality

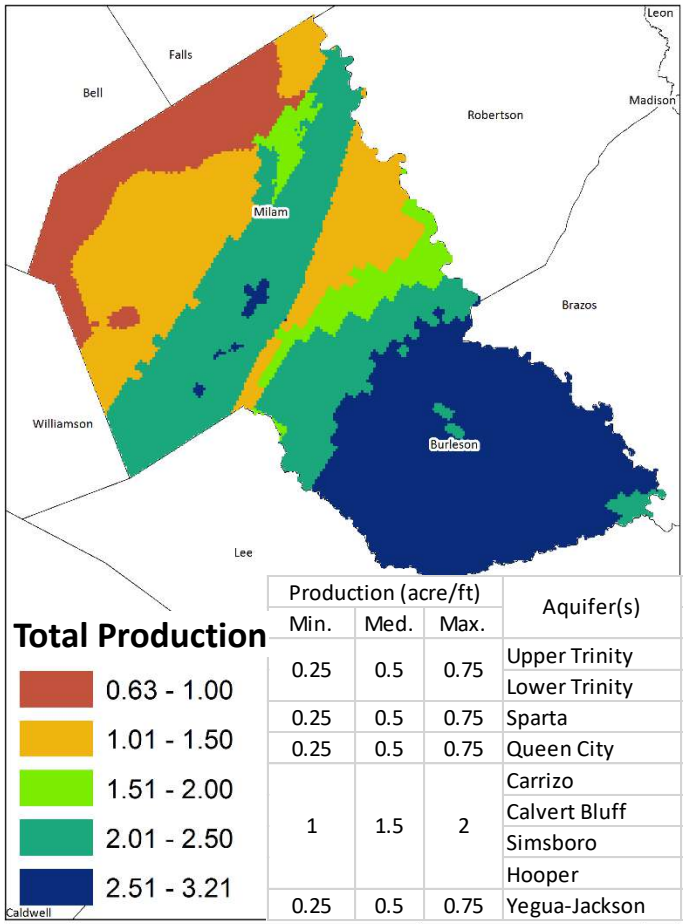
Differences Among Aquifers

Storage

Aquifer(s)	Volume in Storage (10^6 AF)	Area (sq miles)	% Total Storage
Upper Trinity	86	807	19.0%
Lower Trinity*	78	807	17.3%
Sparta	16	576	3.5%
Queen City	30	753	6.6%
Carrizo	29	835	6.4%
Calvert Bluff	63	1024	13.9%
Simsboro	53	1132	11.7%
Hooper	55	1237	12.2%
subtotal	200	4229	44.2%
Yegua-Jackson	42	291	9.3%
total	452**		100.0%
*Hensell, Pearsall, & Hossten			
** equivalent of 415 feet of water above the district			

Transmissivity

Aquifer(s)	% Production Capacity	Area (sq miles)	Average Trans. (ft^2/day)
Upper Trinity	0.8%	807	211
Lower Trinity*	6.6%	807	591
Sparta	1.4%	576	532
Queen City	2.1%	753	608
Carrizo	12.7%	835	3,311
Calvert Bluff	10.9%	1024	2,322
Simsboro	46.1%	1132	8,874
Hooper	18.2%	1237	3,207
subtotal	88.0%	4229	4,530
Yegua-Jackson	1.1%	291	847
total	100.0%	7464	
*Hensell, Pearsall			



Production (acre/ft)			Aquifer(s)
Min.	Med.	Max.	
0.25	0.5	0.75	Upper Trinity
			Lower Trinity
0.25	0.5	0.75	Sparta
0.25	0.5	0.75	Queen City
1	1.5	2	Carrizo
			Calvert Bluff
			Simsboro
			Hooper
0.25	0.5	0.75	Yegua-Jackson

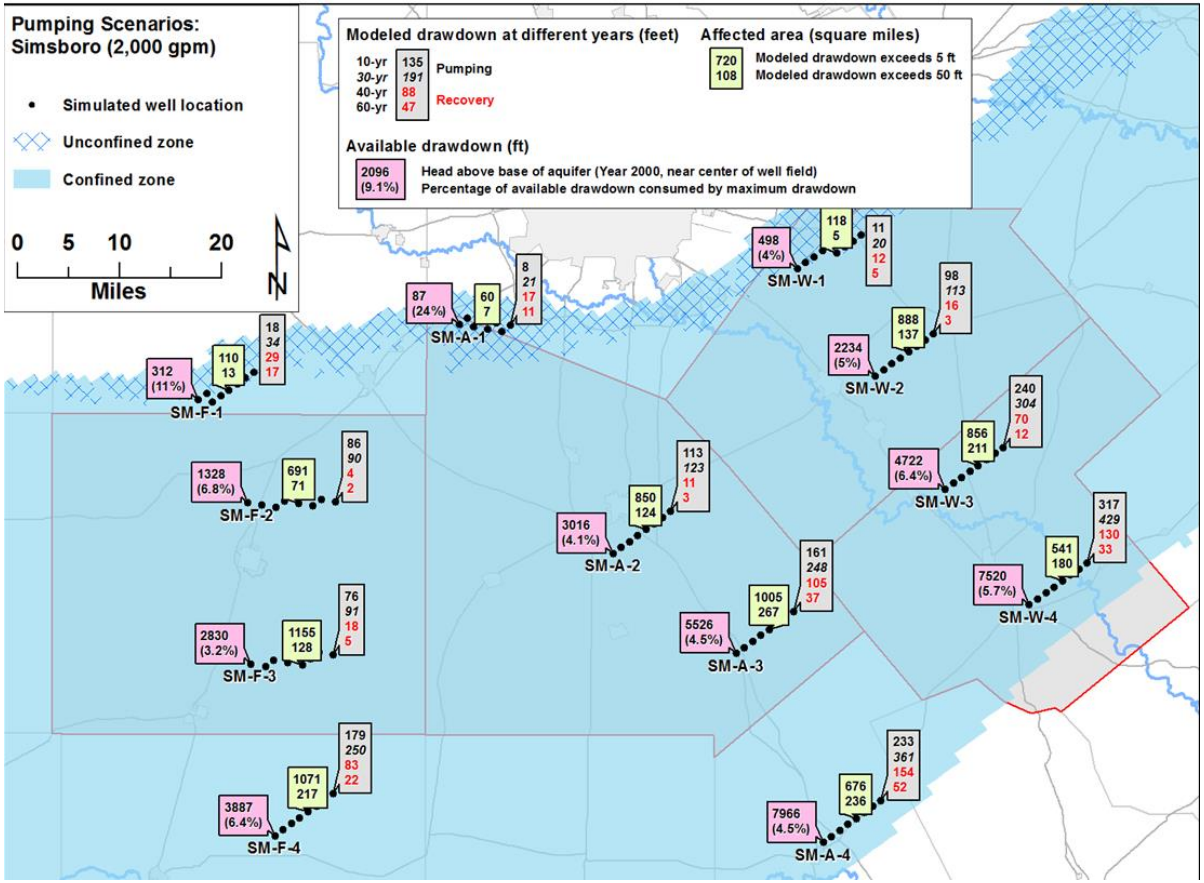
* Tabular data presented to DFC committee on March 9, 2017

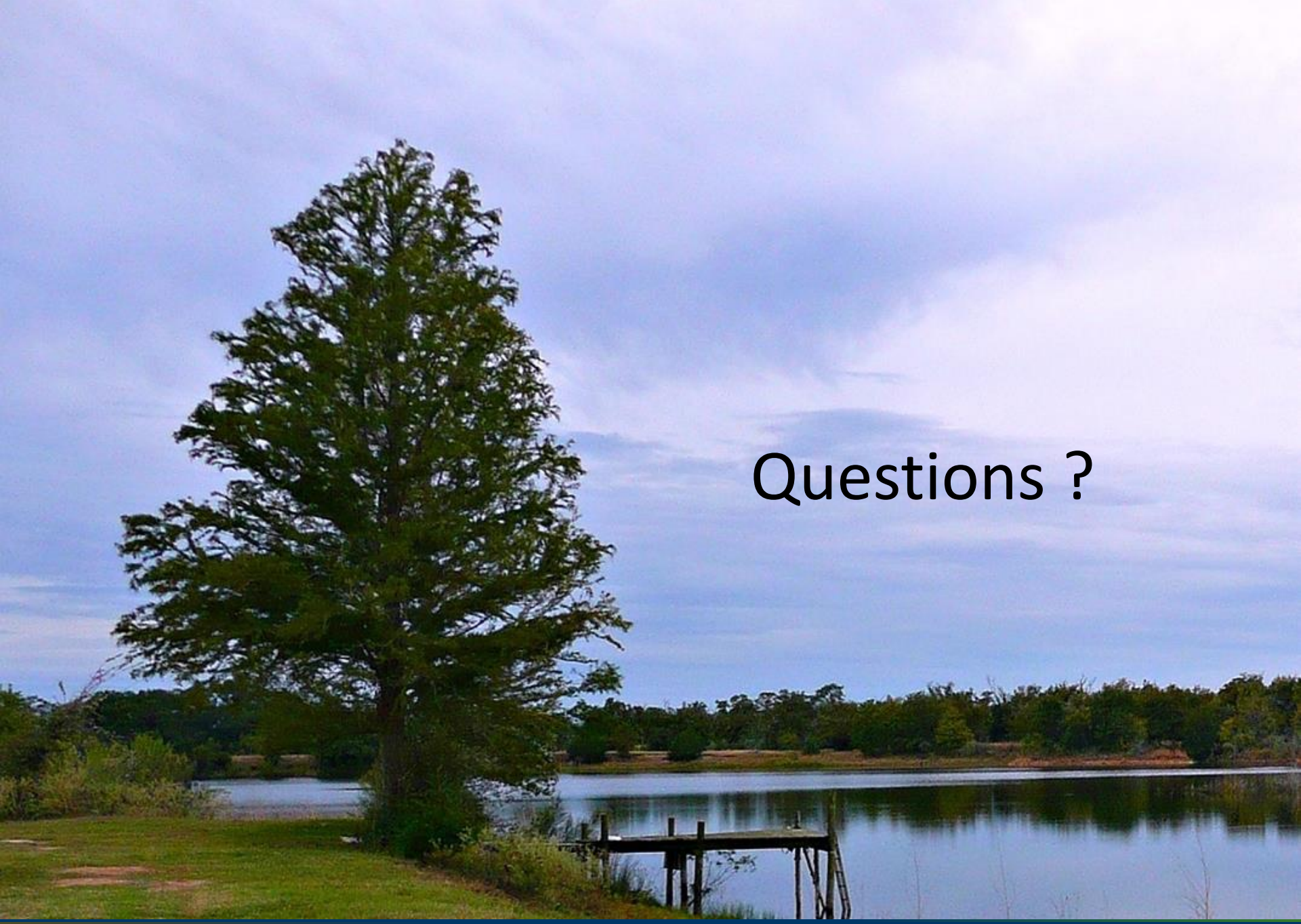
Possible Considerations for Accessing Maximum Production Rate per Acre

Possible Considerations

Perform similar well field simulations in different aquifers and compare aquifer response

- Drawdown
- Size of Cone of Depression
- Available Drawdown




Questions ?