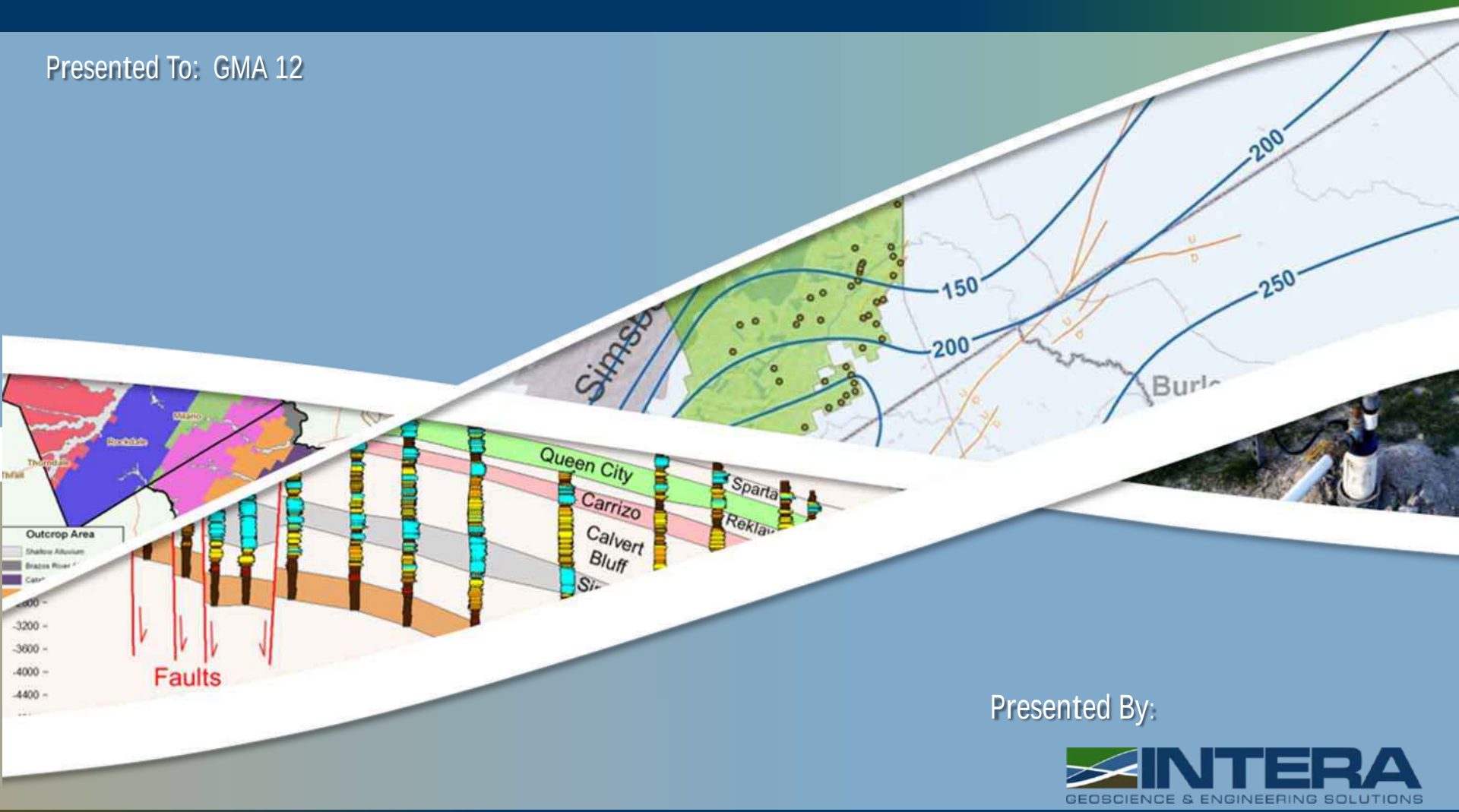
Future Considerations for DFCs

Presented To: GMA 12



Presented By:

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

January 29, 2019

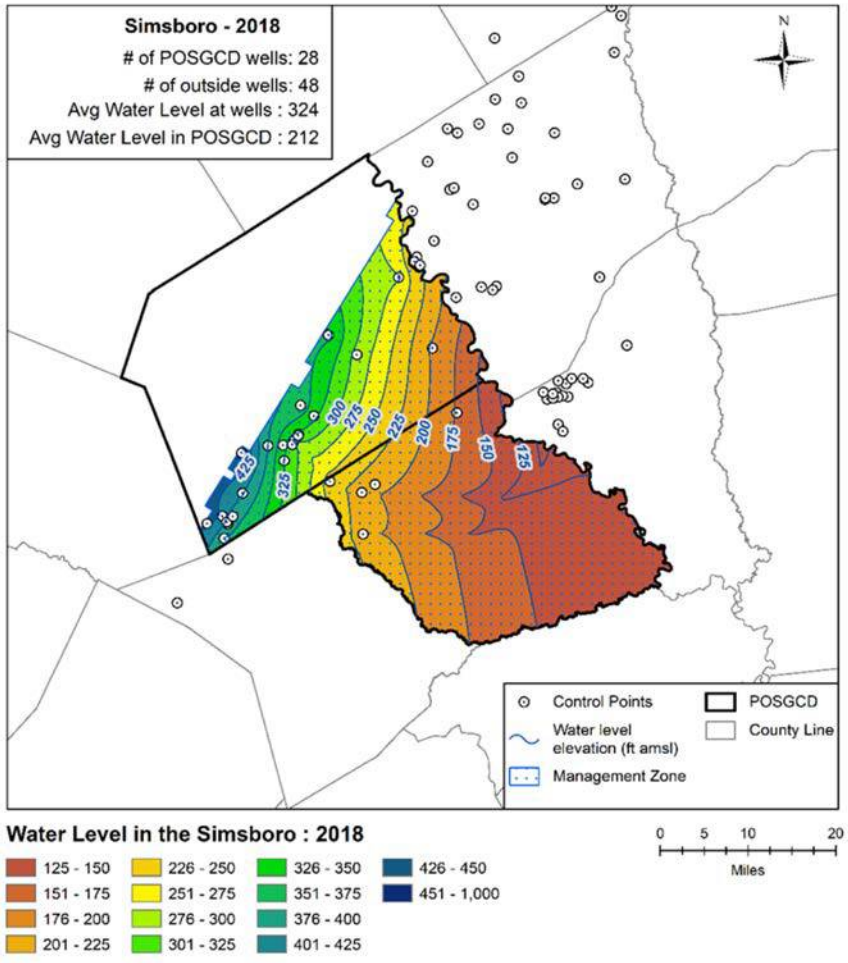
Future Considerations for DFCs

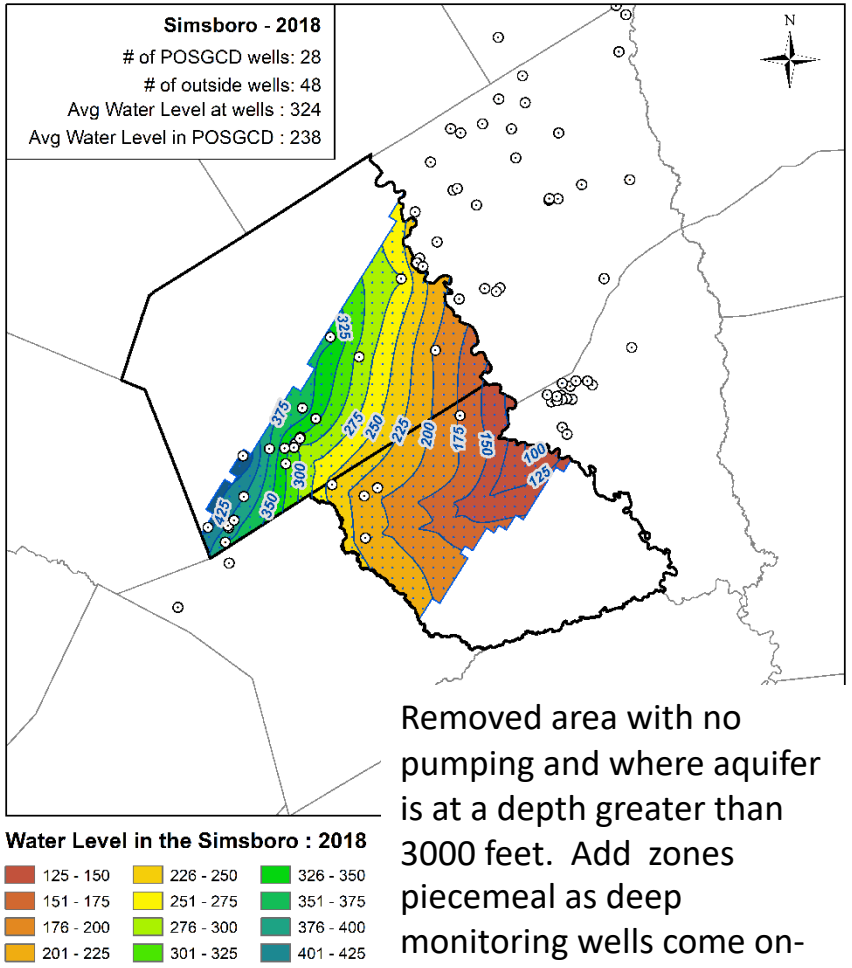
- Restrict Aquifer Area used to calculate DFCs
  - Convert shallow PDLs to DFCs
  - Omit far down-dip regions with no wells
- Water levels instead of Drawdown
- New interpolation methods to better link monitoring to model results

Considerations for Establishing DFCs: Restricting Aquifer Area Used for DFCs

- Monitoring data where aquifers are deep will be non-existent to sparse
- Large areas of down-dip region of aquifers will not be pumped for next 30 years
- Remove portions of the aquifer that are deep and expensive to monitor and that have no pumping
- Focus on area of aquifer where pumping is occurring and there are adequate number of monitoring wells

Examples of Trimming Aquifer Area for DFC: Simsboro



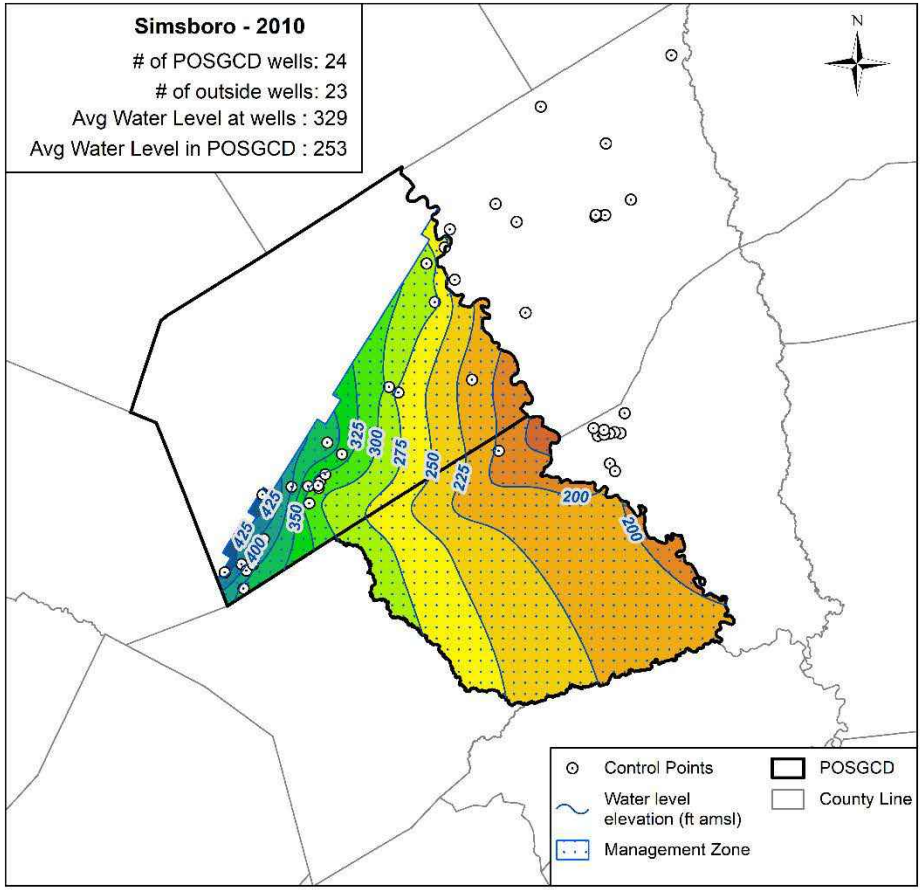


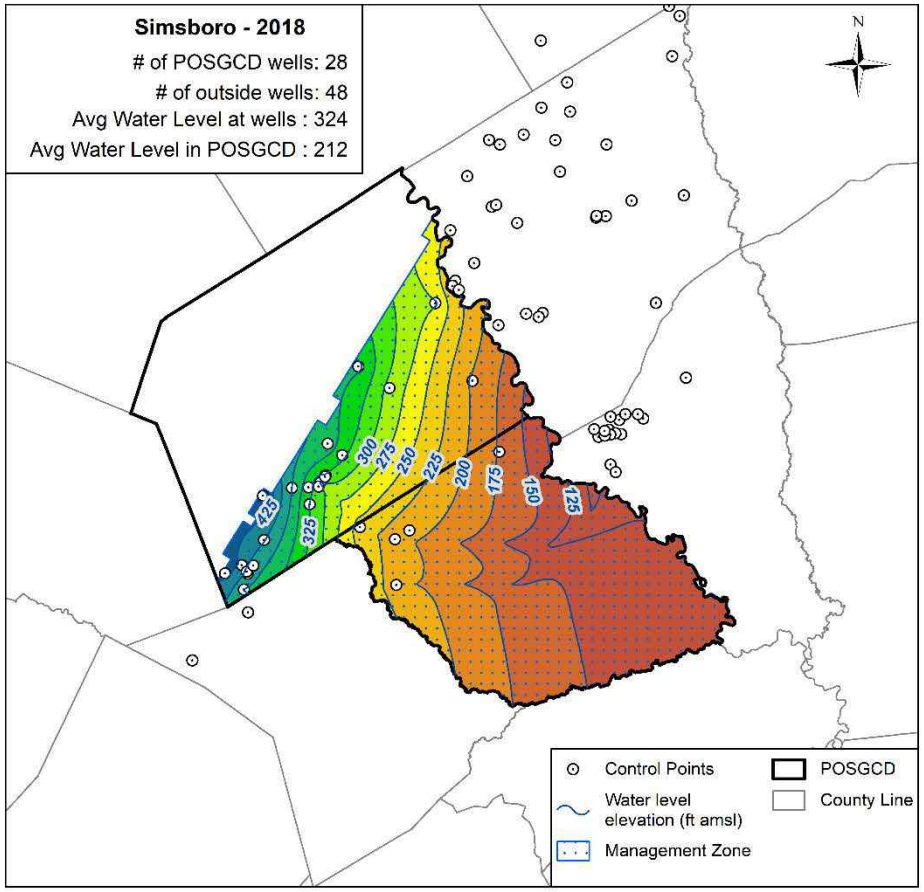
Removed area with no pumping and where aquifer is at a depth greater than 3000 feet. Add zones piecemeal as deep monitoring wells come on-line

Considerations for Establishing DFCs and PDLs: Water Level Instead of Drawdown

- Options for Evaluation of Water Levels
  - at POSGCD wells
  - areas selected to be representative of aquifer
  - entire aquifer
- Routine for Interpolating Monitoring Data Is Important Component of Method
  - Interpolation is difficult because of sparseness of data and impacts of pumping, faults, and differences in aquifer properties
  - Need an interpolation method that can extract a pattern from simulated GAM water levels and used that pattern to interpolate between the measured water levels
  - One such routine is co-kriging. INTERA has successfully used co-kriging water levels with topographic data to help map elevation surfaces of water tables

Simsboro Water Levels (ft msl)





Water Level in the Simsboro : 2010

125 - 150	226 - 250	326 - 350	426 - 450
151 - 175	251 - 275	351 - 375	451 - 1,000
176 - 200	276 - 300	376 - 400	
201 - 225	301 - 325	401 - 425	

0 5 10 20
Miles

Water Level in the Simsboro : 2018

125 - 150	226 - 250	326 - 350	426 - 450
151 - 175	251 - 275	351 - 375	451 - 1,000
176 - 200	276 - 300	376 - 400	
201 - 225	301 - 325	401 - 425	

0 5 10 20
Miles

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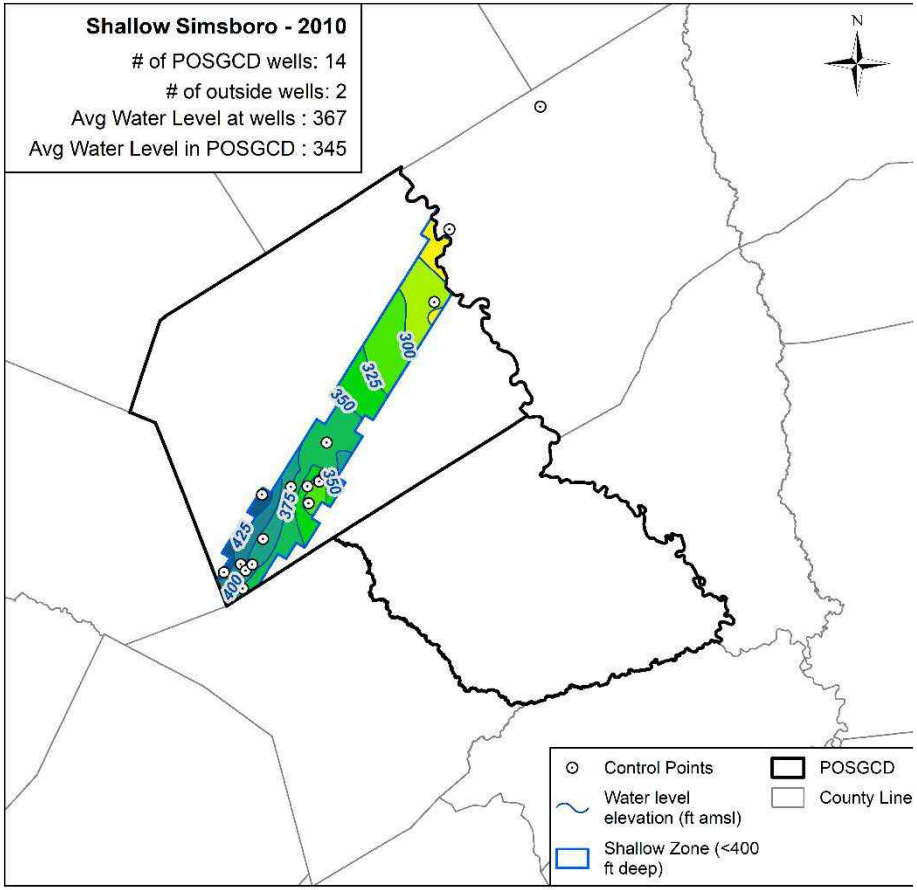
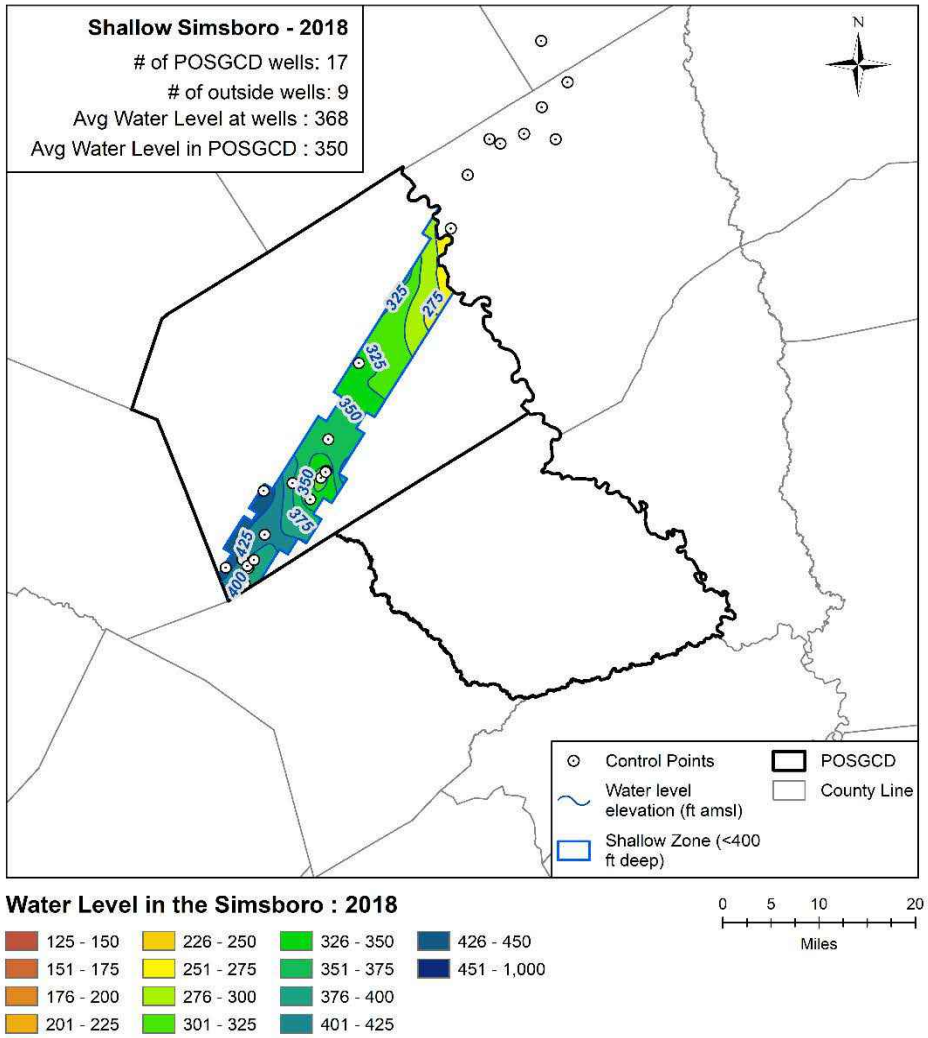
Shallow Simsboro Water Levels (ft msl)





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Comparison of Interpolation Methods for Determining an Average Water Level (ft, msl)

- POSGCD wells –average all wells in POSGCD
- Three methods used to interpolate points in between POSGCD and then average all of the points
  - Kriging – often used by geologists
  - Topo2raster – often used by geographers
  - Artificial Intelligence – new type of program that looks for patterns
- GAM
  - Area – thickness of model cell is ignored
  - Volume – thickness of model cell is considered

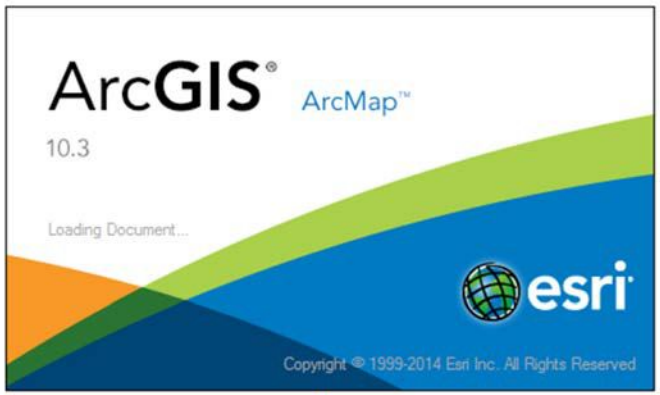
Aquifer	2010					
	POSGCD wells	Interpolated			GAM	
		Kriging	Topo 2 Raster	AI Method	Area	Volume
Yegua-Jackson	214	215	207	210	NA	NA
Sparta	263	**264**	**260**	**252**	**259**	**241**
Queen City	304	312	**295**	**312**	**293**	276
Carrizo	308	318	**295**	325	**296**	**292**
Calvert Bluff	298	**290**	273	282	300	**290**
Simsboro	329	264	**253**	**255**	**256**	242
Hooper	336	311	**292**	319	**303**	293

Aquifer	2018					
	POSGCD wells	Interpolated			GAM	
		Kriging	Topo 2 Raster	AI Method	Area	Volume
Yegua-Jackson	215	**215**	**214**	**216**	NA	NA
Sparta	259	**238**	**239**	223	**243**	**244**
Queen City	299	**289**	**270**	**284**	**282**	**262**
Carrizo	267	289	253	264	233	225
Calvert Bluff	284	264	**235**	263	**244**	**226**
Simsboro	324	230	**212**	**215**	173	152
Hooper	345	308	277	310	234	212

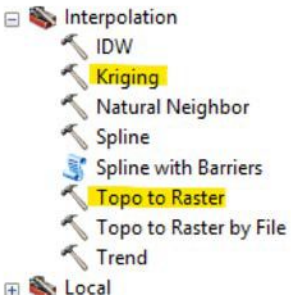
The differences among the values for an aquifer reflects the amount of uncertainty there exists – solution is better interpolation approach

Interpolation Methods

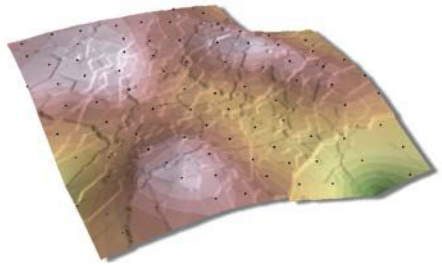
- Methods that are reproducible
- Methods that are transparent and accessible to others



Use Standard industry software
(same as POSGCD & TWDB)

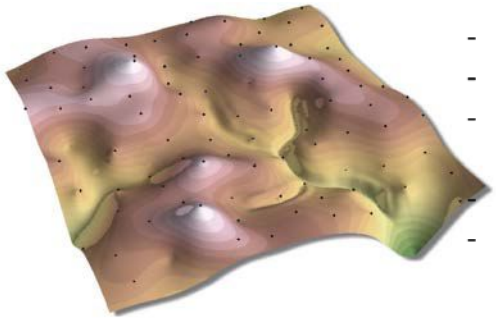


Kriging



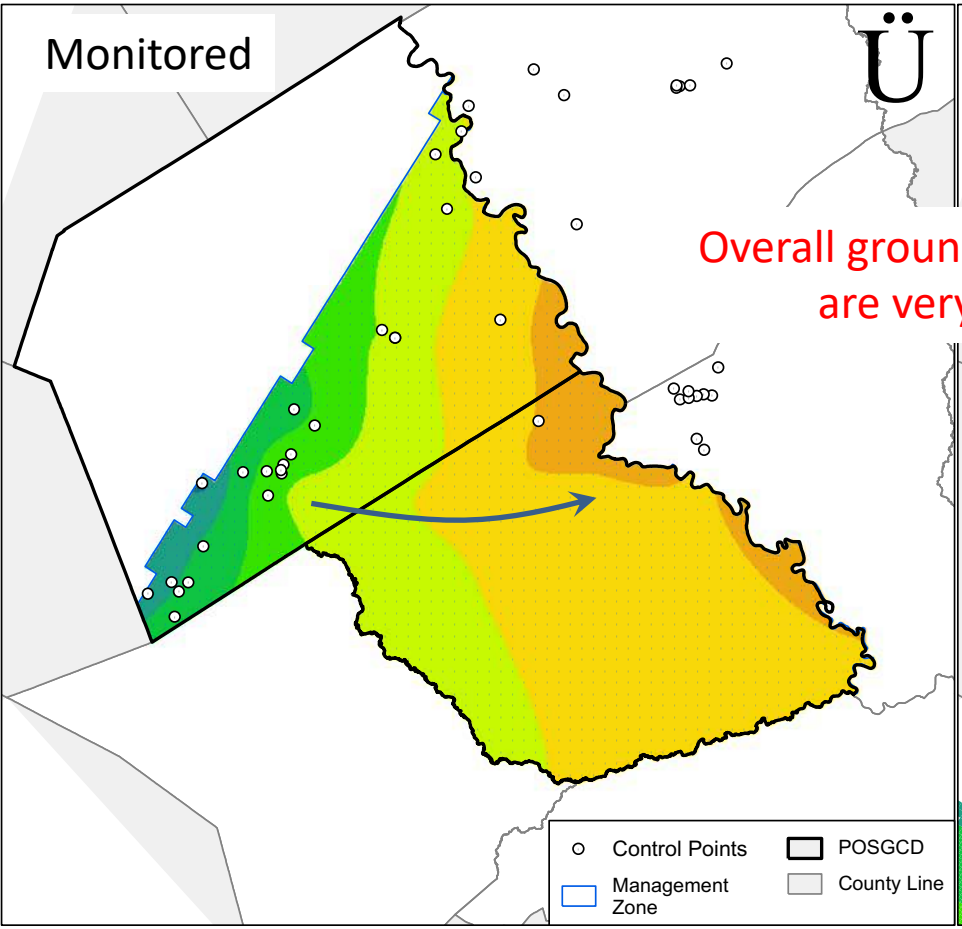
- Built-in ArcGIS tool
- Powerful statistical interpolation method
- Accepted throughout Geosciences field
- Based on Covariance analysis (coorelations)
- Can create “ugly” surfaces

TopoToRaster

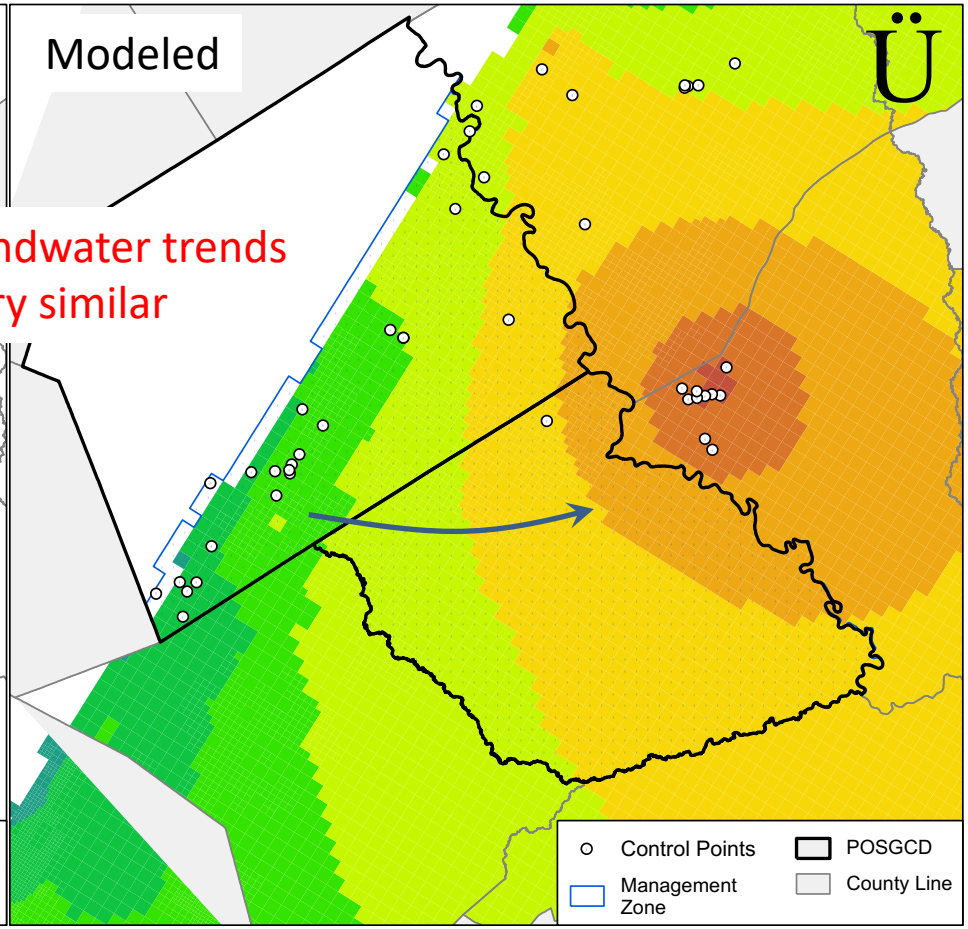


- Built-in ArcGIS tool
- Iterative finite-different interpolation method
- Accepted throughout Geoscience/Hydrology field
- Based on slopes and gradients
- Creates “pretty” hydrologically-correct surface

Concept for using Co-kriging to Generate Water Level Surfaces



Overall groundwater trends are very similar



Simsboro Water Level Elevation (2010)

80 - 100 | 101 - 150 | 151 - 200 | 201 - 250 | 251 - 300 | 301 - 350 | 351 - 400 | 401 - 450 | 451 - 500 | 501 - 550

0 5 10 20 Miles

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80 - 100 | 101 - 150 | 151 - 200 | 201 - 250 | 251 - 300 | 301 - 350 | 351 - 400 | 401 - 450 | 451 - 500 | 501 - 550

0 5 10 20 Miles

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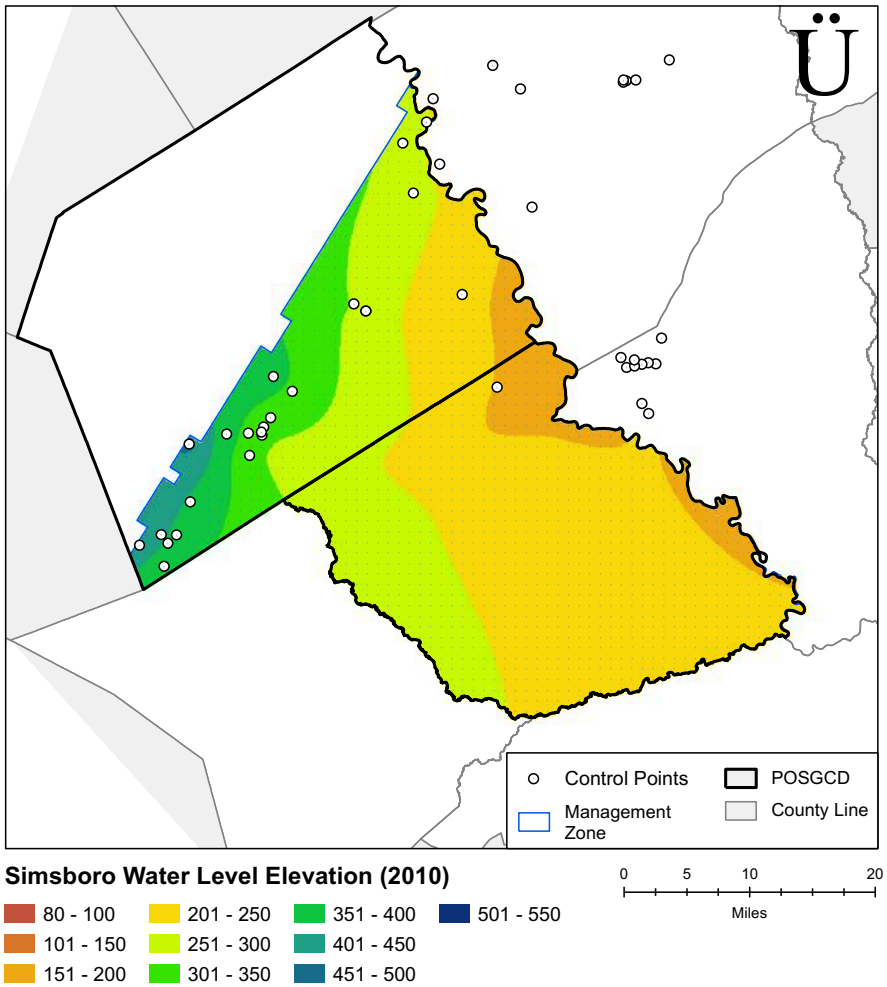
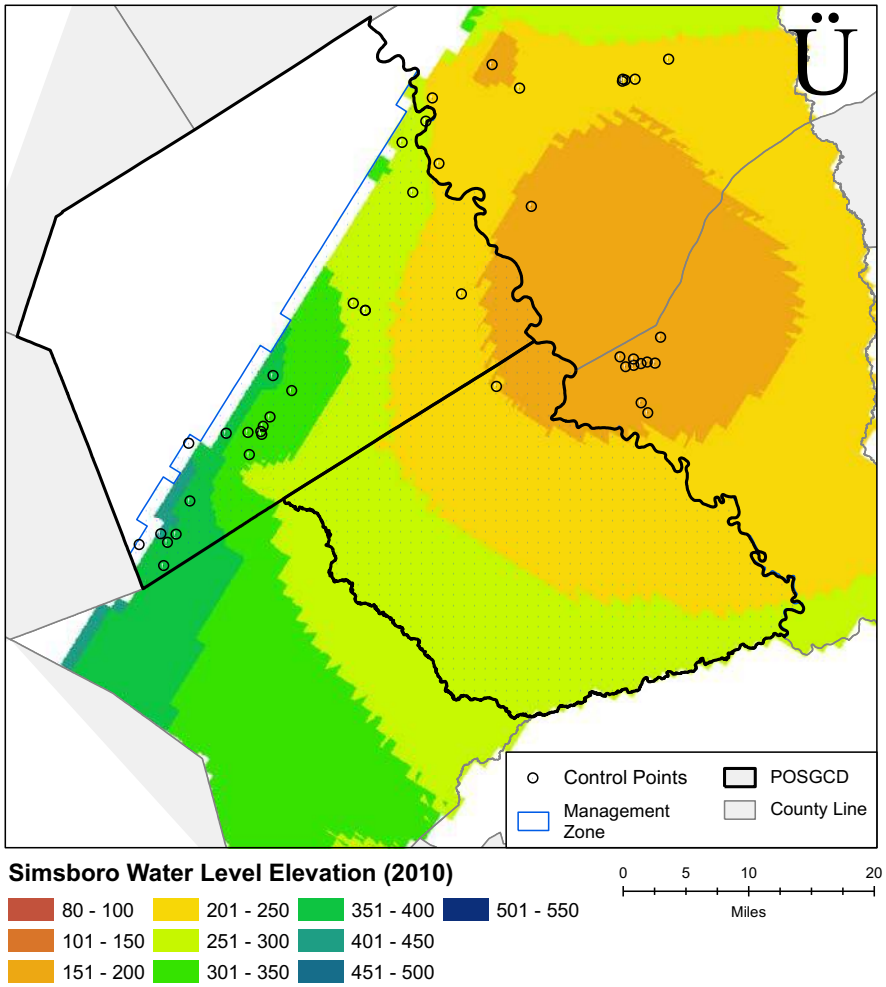
Comparison of Kriged and Co-Kriged Surfaces

Kriged 2010 Simsboro Water Level



Co-Kriged 2010 Simsboro Water Level



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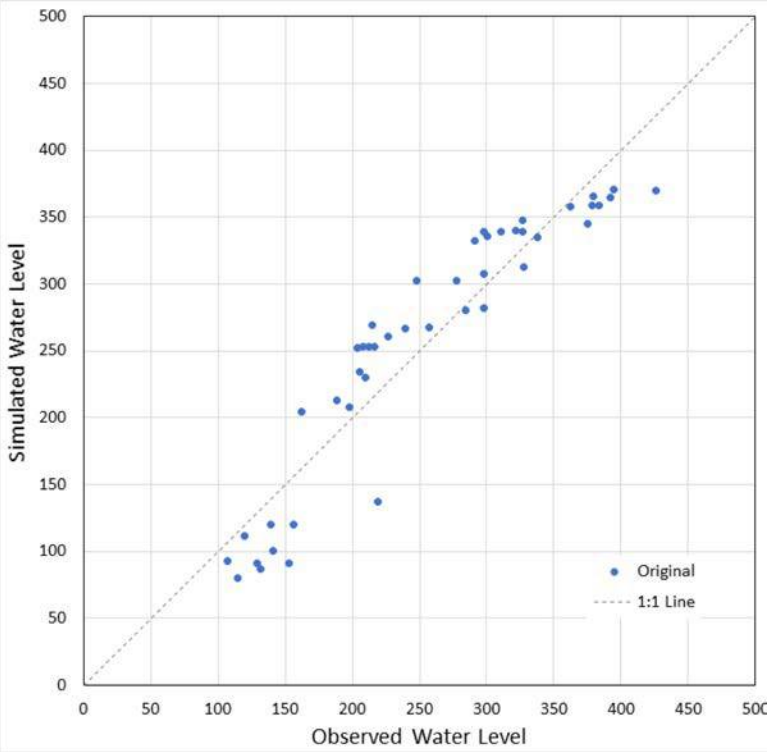
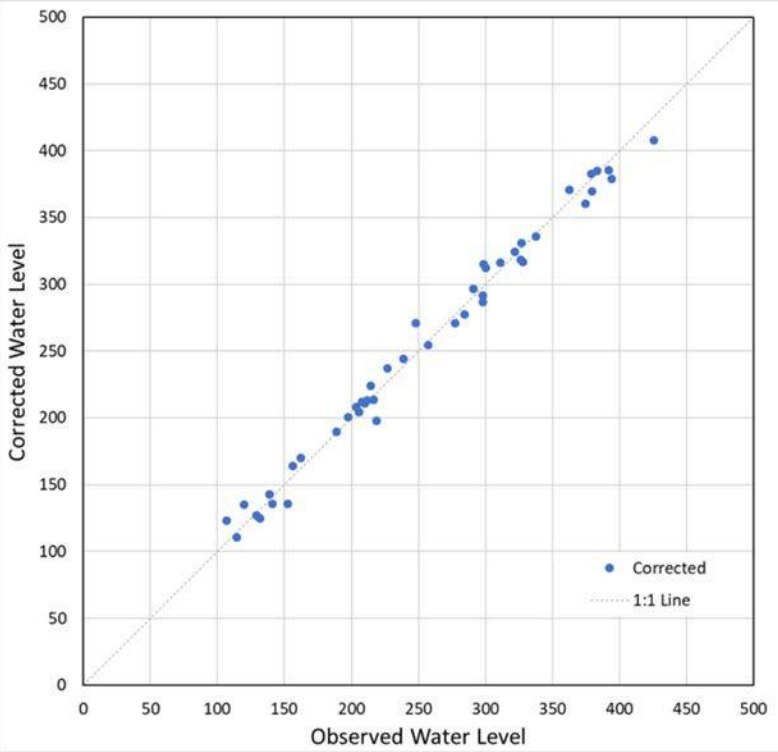
Comparison of Measured and Modeled Water Levels

Kriging (original)



Co-Kriging (corrected)



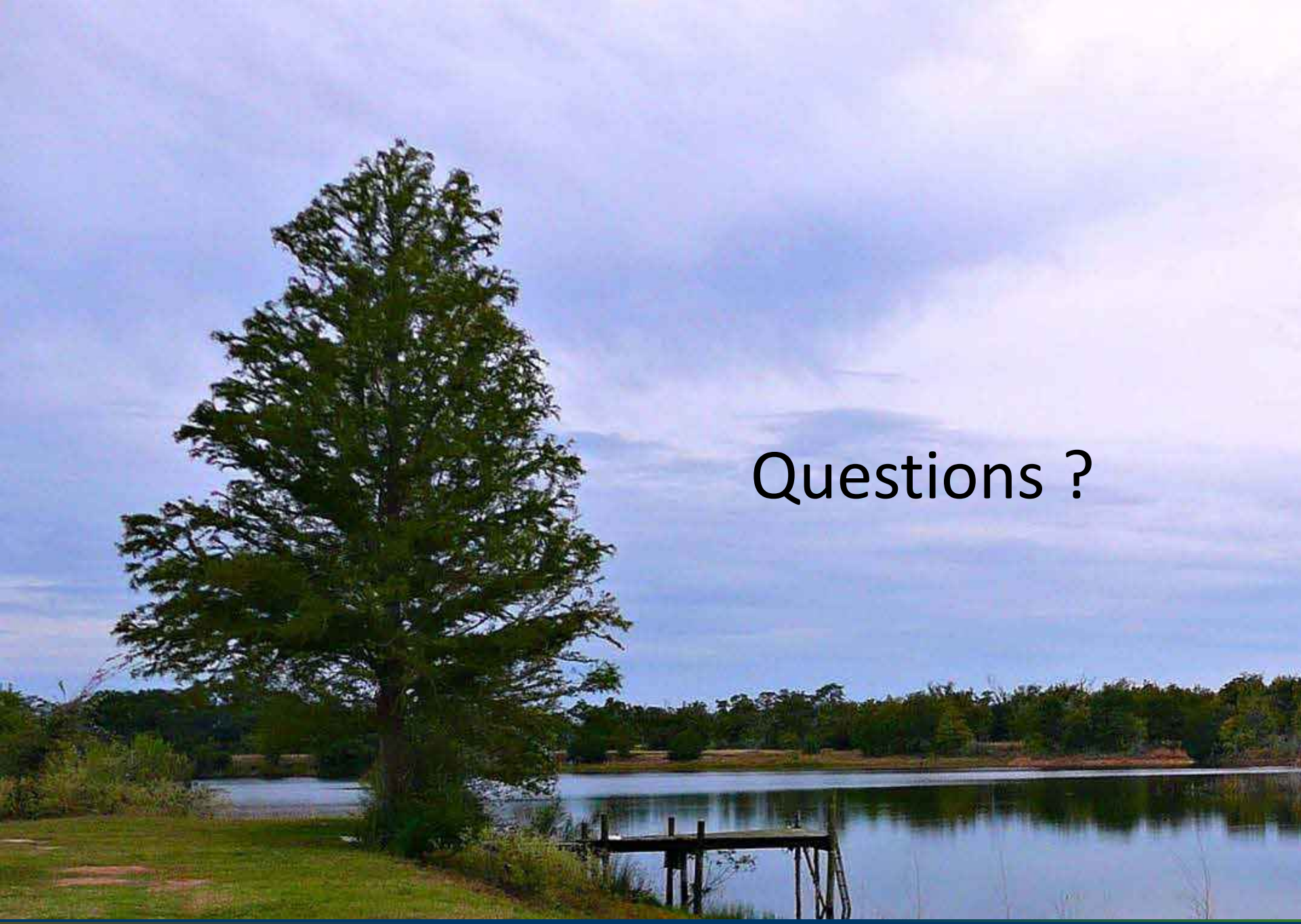
	Original	Corrected
Mean error	-2.10	0.12
Abs mean error	29.42	7.86
RMSE	33.91	9.69

Historical Pumping

- Potential Uses
  - Update GAMs beyond 2010 to support interpolation approaches and groundwater
  - Update GAMs beyond 2010 to provide improve predictions for DFC runs
  - Develop relationships between pumping and drawdown for different management zones
  - Track production versus permitted pumping

GMA 12 Discussion Topics

- Sharing Monitoring Protocols and Data among Districts
- Approaches for Evaluating DFC Compliance
- Future Consideration for DFCs
- Schedule for Updating Historical Pumping


Questions ?