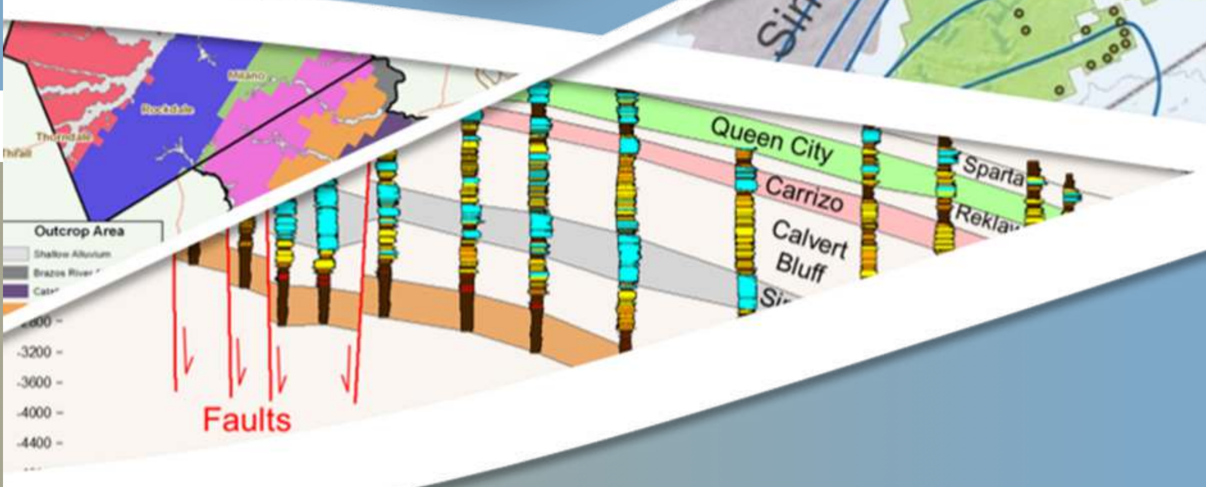
Report on POSGCD DFC Committee Studies

Presented To:

Post Oak Savannah Groundwater Conservation District



Presented By:

Steve Young
Jevon Harding
Ross Kushnereit
Marius Jigmond

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

January 9, 2018

Topics

- Monitoring and DFC/PDL Compliance
  - Approach for Interpolating Measured Water Levels
  - Historical Pumping
  - Proposed Aquifer Study
- Research Projects
  - Aquifer Storage & Recovery/Enhanced Recharge
  - Surface water-Groundwater Interaction
- GMA 12 Topics
  - Update of GAM for Predictive DFC Runs
  - Possible Changes in GMA 12 DFCs
  - Explanation Report
  - Schedule

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

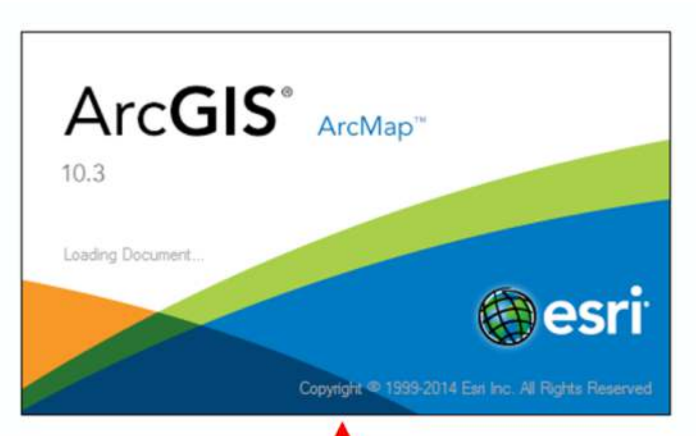
Aquifer	2018					
	POSGCD wells	Interpolated			GAM	
		Kriging	Topo 2 Raster	AI Method	Area	Volume
Yegua-Jackson	215	**215**	**214**	**216**	NA	NA
Sparta	259	**238**	**239**	223	**243**	**244**
Queen City	299	**289**	**270**	**284**	**282**	**262**
Carrizo	267	289	253	264	233	225
Calvert Bluff	284	264	**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

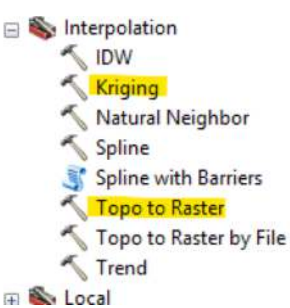
* From November 6 POSCD Presentation

Interpolation Methods

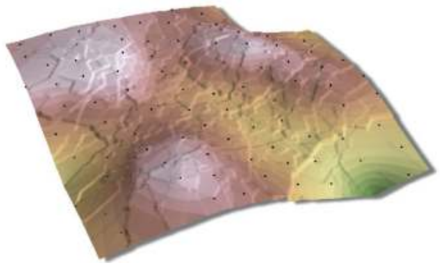
- Methods that are reproducible
- Methods that are transparent and accessible to others



Use Standard industry software (same as POSGCD & TWDB)

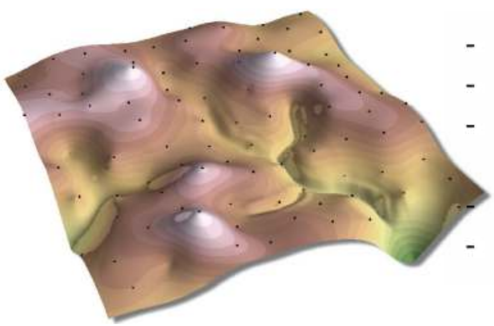


Kriging



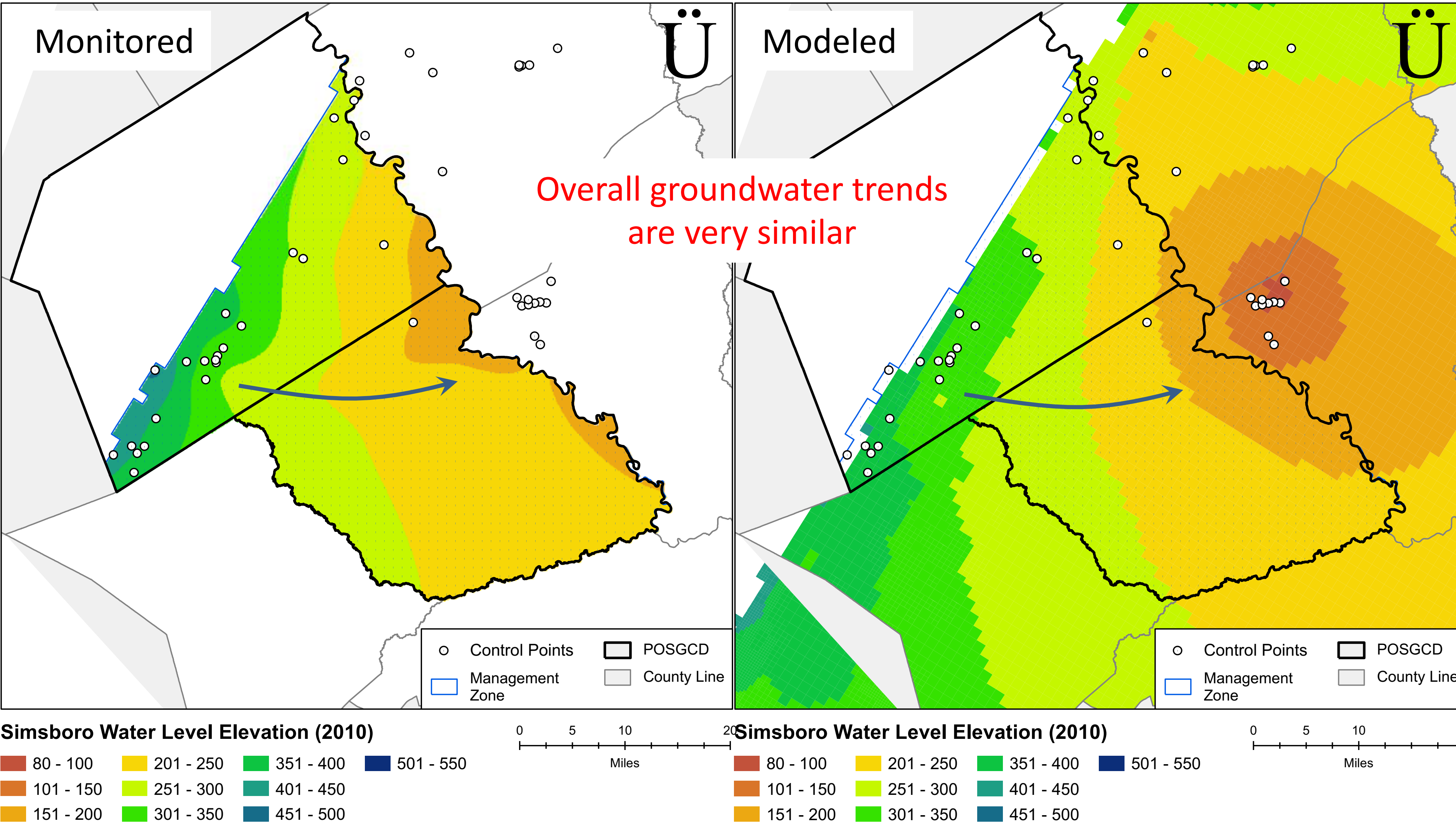
- Built-in ArcGIS tool
- Powerful statistical interpolation method
- Accepted throughout Geosciences field
- Based on Covariance analysis (coorelations)
- Can create “ugly” surfaces

TopoToRaster



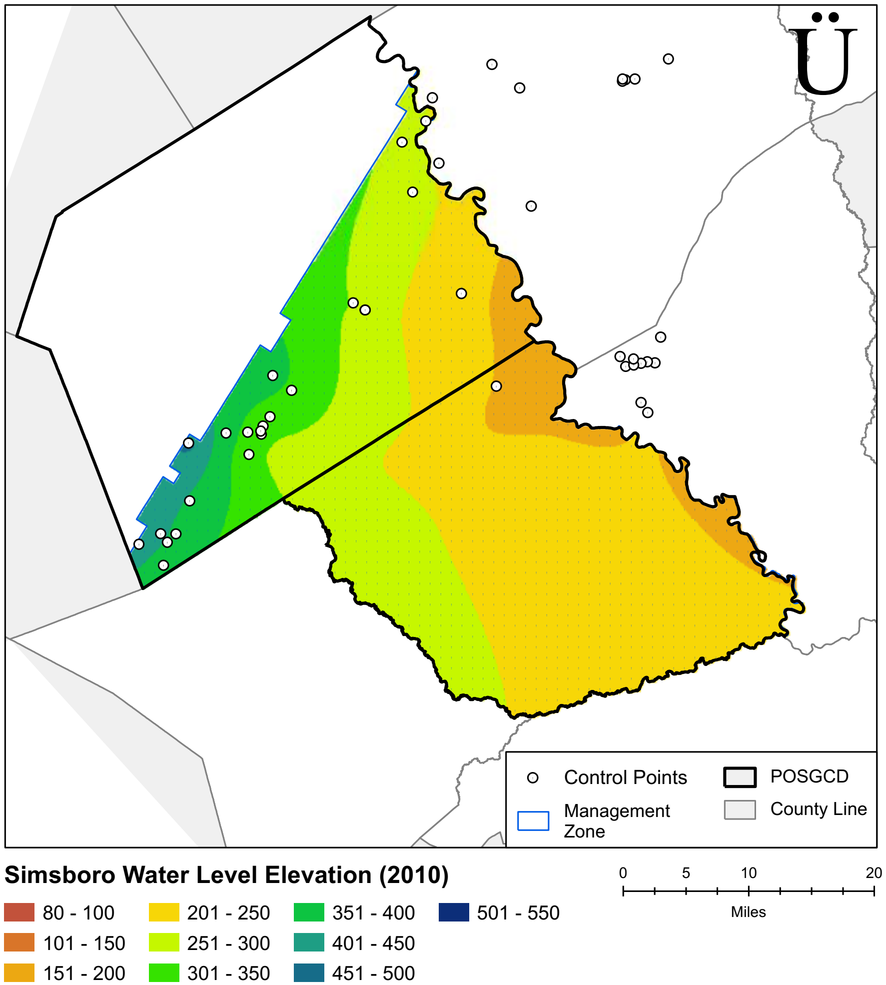
- Built-in ArcGIS tool
- Iterative finite-different interpolation method
- Accepted throughout Geoscience/Hydrology field
- Based on slopes and gradients
- Creates “pretty” hydrologically-correct surface

Concept for using Co-kriging to Generate Water Level Surfaces

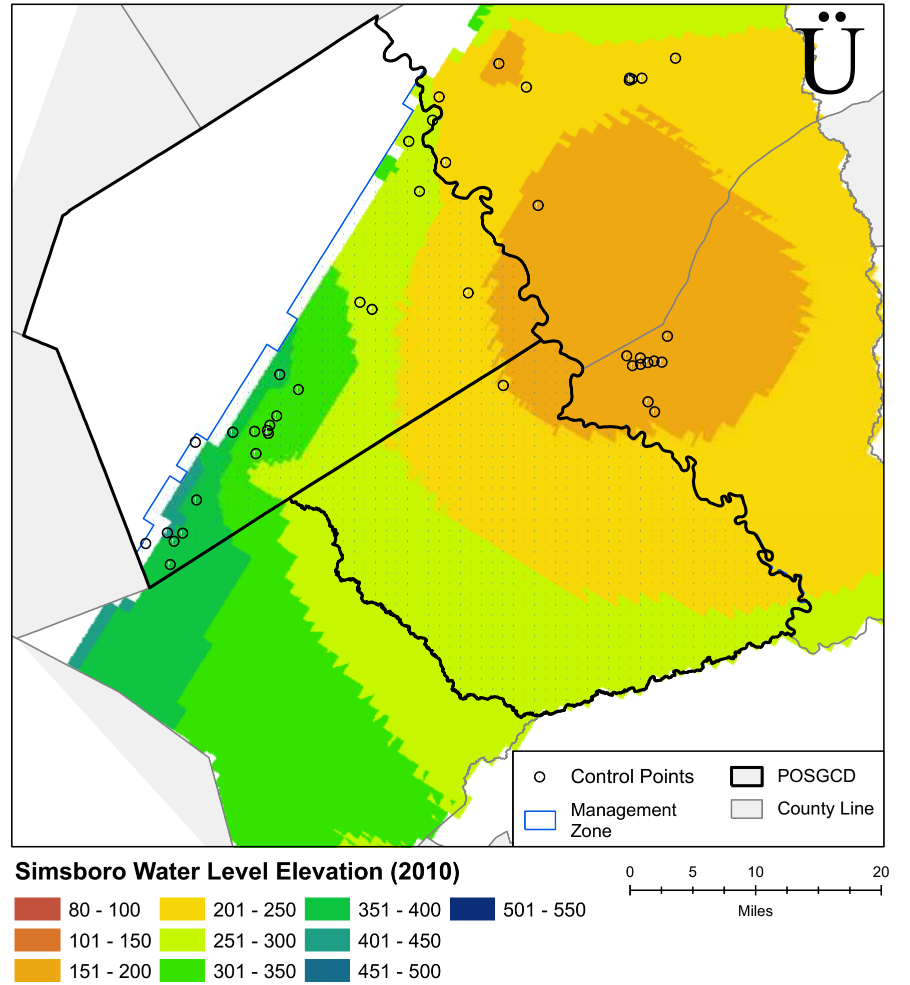


Comparison of Kriged and Co-Kriged Surfaces

Kriged 2010 Simsboro Water Level

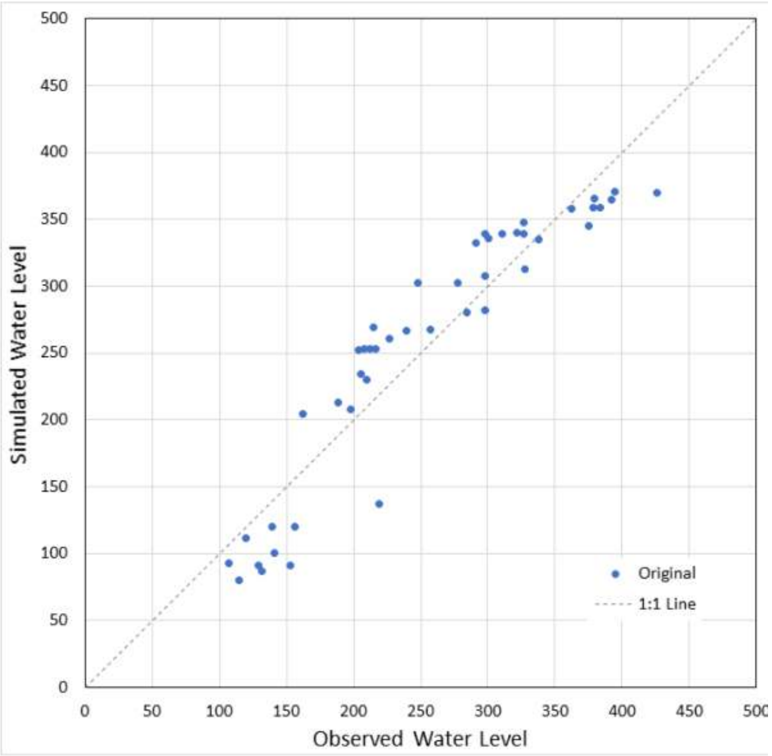


Co-Kriged 2010 Simsboro Water Level

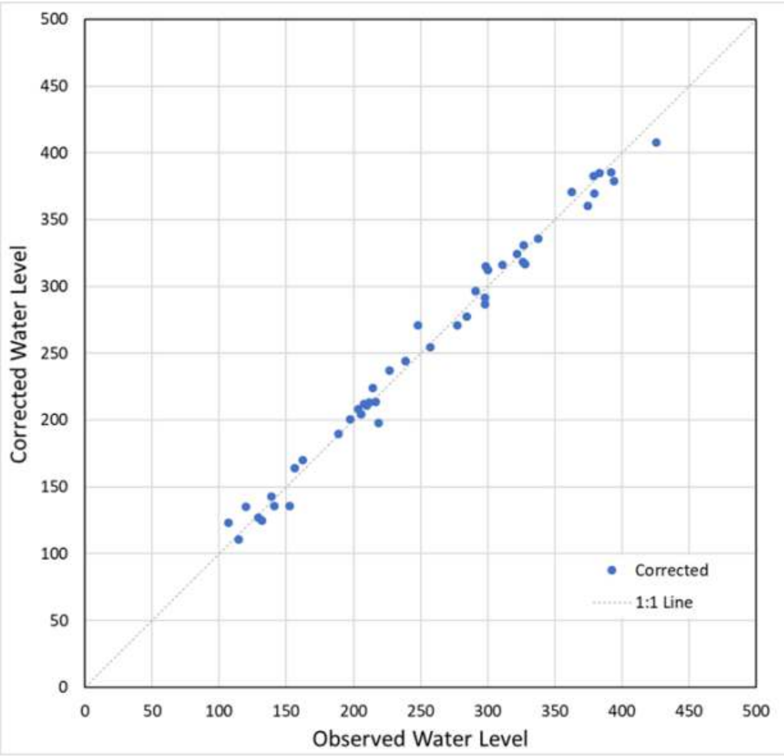


Comparison of Measured and Modeled Water Levels

Kriging (original)



Co-Kriging (corrected)



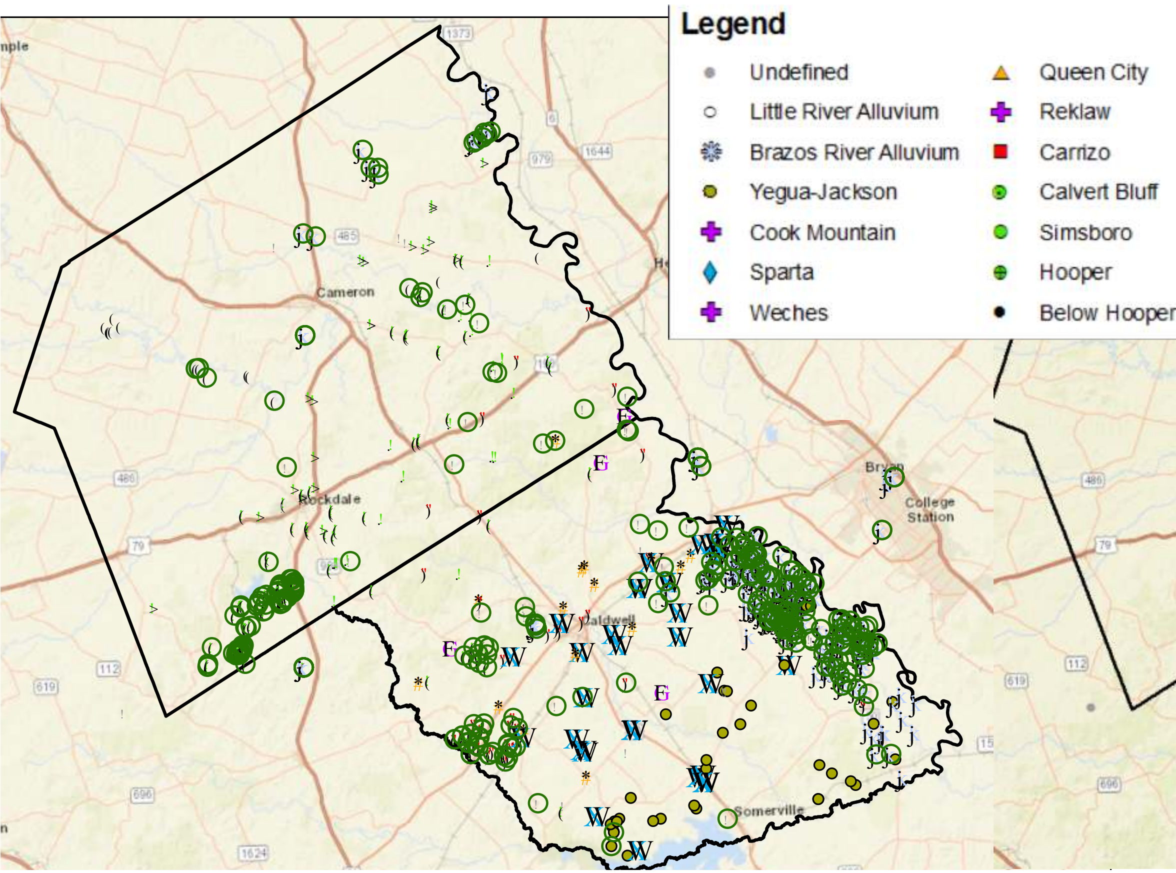
	Original	Corrected
Mean error	-2.10	0.12
Abs mean error	29.42	7.86
RMSE	33.91	9.69

Historical Pumping

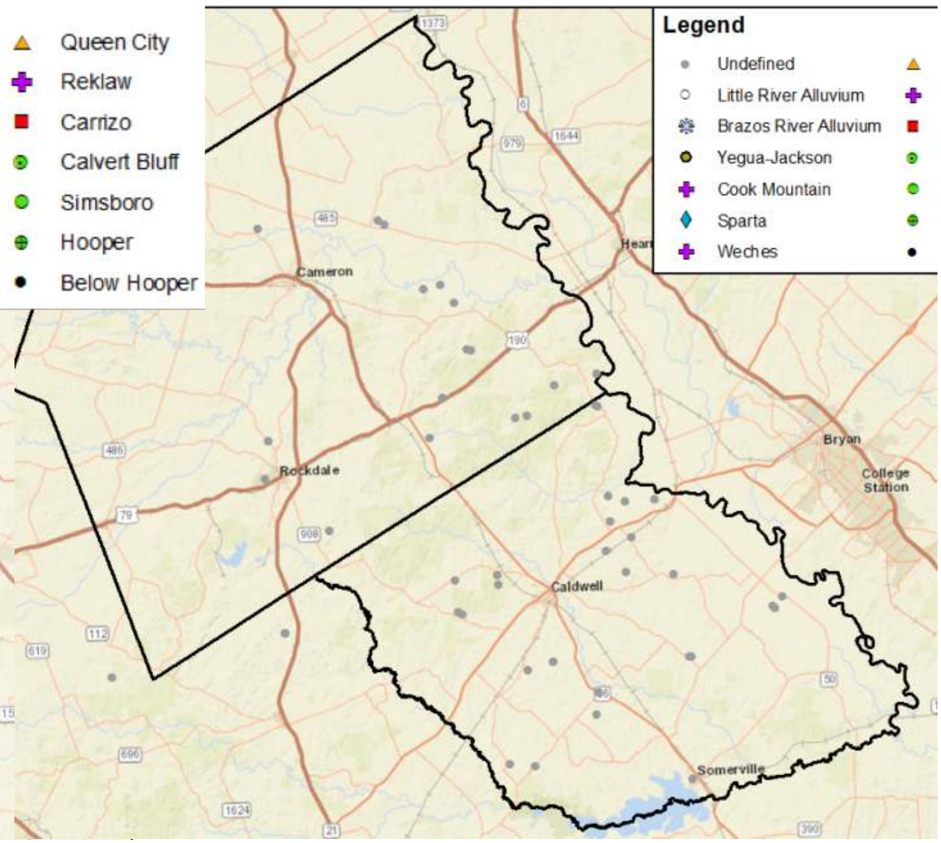
- Potential Uses
  - Update GAMs beyond 2010 to support interpolation approaches and groundwater
  - Update GAMs beyond 2010 to provide improve predictions for DFC runs
  - Develop relationships between pumping and drawdown for different management zones
  - Track production versus permitted pumping
- Required Tasks for Update
  - Update productions for 2016 & 2017 and later (spring) 2018
  - Check well information in HALFF database
  - Complete well assignments

Incomplete Well Specifications

Permitted wells with no depth or screen info

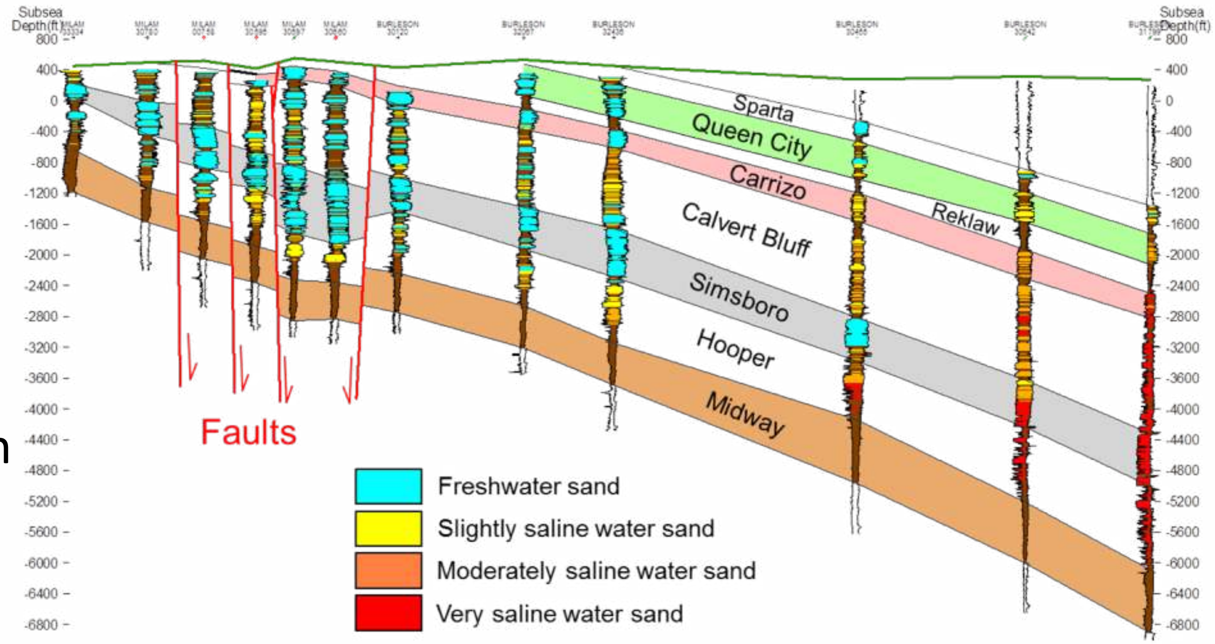


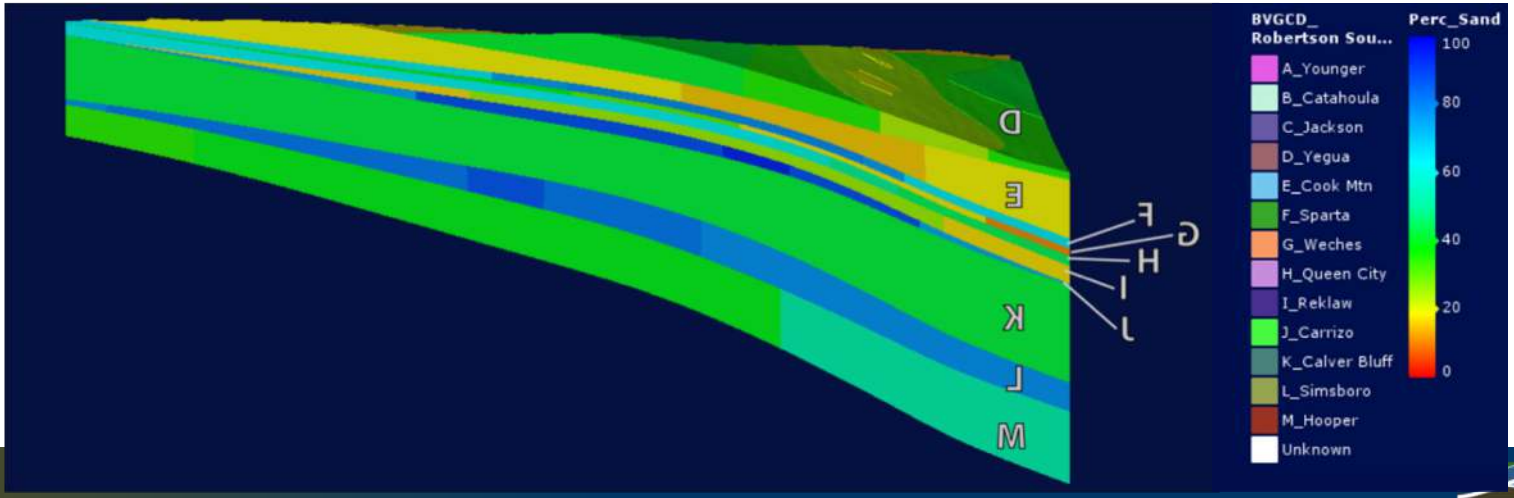
Wells with no aquifer assignment



Proposed Aquifer Study

- Objective
  - Assemble and analyze geophysical logs to identify tops/bottoms and sand/clay layers in selected aquifers
  - coordinate the work with Brazos Valley GCD, Lost Pines GCD, GMA 12, and the TWDB.

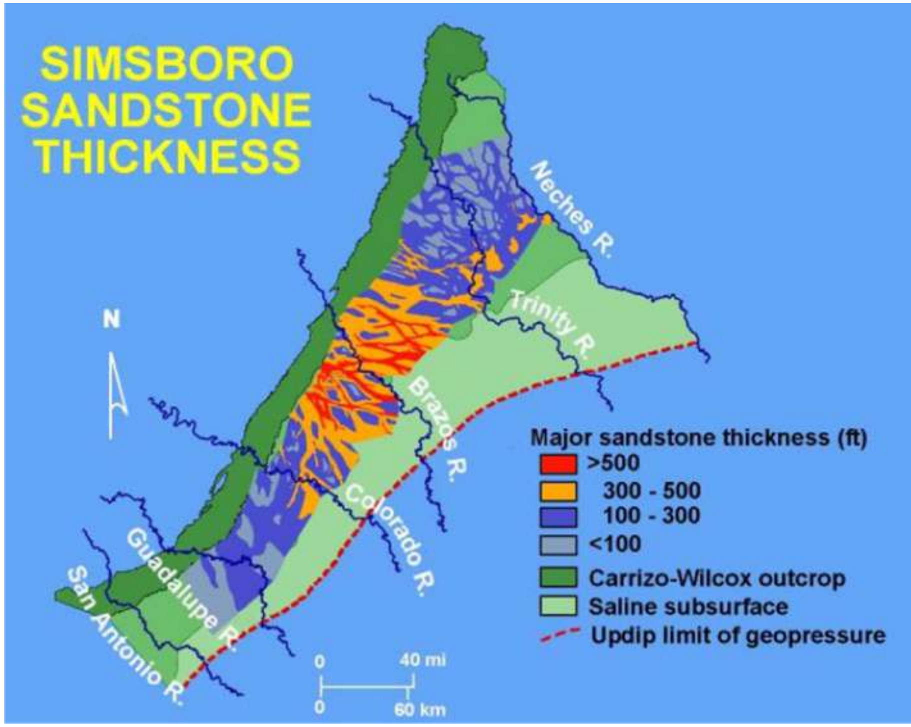




INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Proposed Aquifer Study

- **Background**
  - Tops and bottom of Carrizo-Wilcox, Queen City, and Sparta aquifers used in GAM lack a defensible set of picks from geophysical logs
  - Current surfaces are based on conceptualization that large sand channels controlled the transmissivity of aquifers – this concept has been disproven
  - Known problems exists in previous GAMs – examples are Gause well in Milam County and Vista Ridge well field in Burleson County

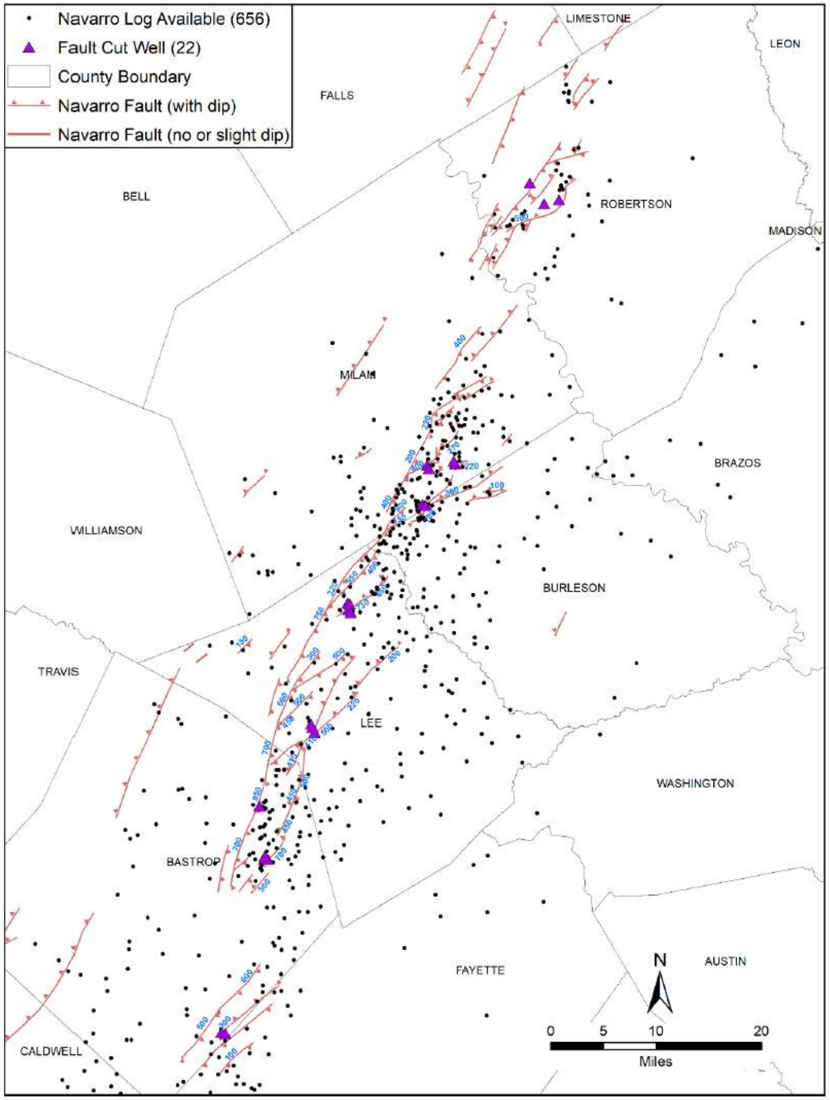


- **Rationale**
  - Information required to improve monitoring program, permitting, process, and modeling
  - TWDB has not plans for work
  - Complements work performed by BVGCD

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Proposed Aquifer Study Tasks

- Scope of Work
  - <u>Define Aquifer Tops and Bottoms ($35K)</u>
    - Use 100 logs.
    - Build on GAM 12 GAM fault study.
    - Assign wells to aquifers
  - <u>Define Clays and Sands (additional $30K)</u>
    - Use 100 logs
    - Pick layers at 1-foot resolution
    - Develop sand and clay maps
    - Estimate water quality (TDS concentrations) of sands
    - Estimate hydraulic properties for evaluation of permits and well spacing calculations
- Coordination
  - BVGCD and LPGCD
  - TWDB



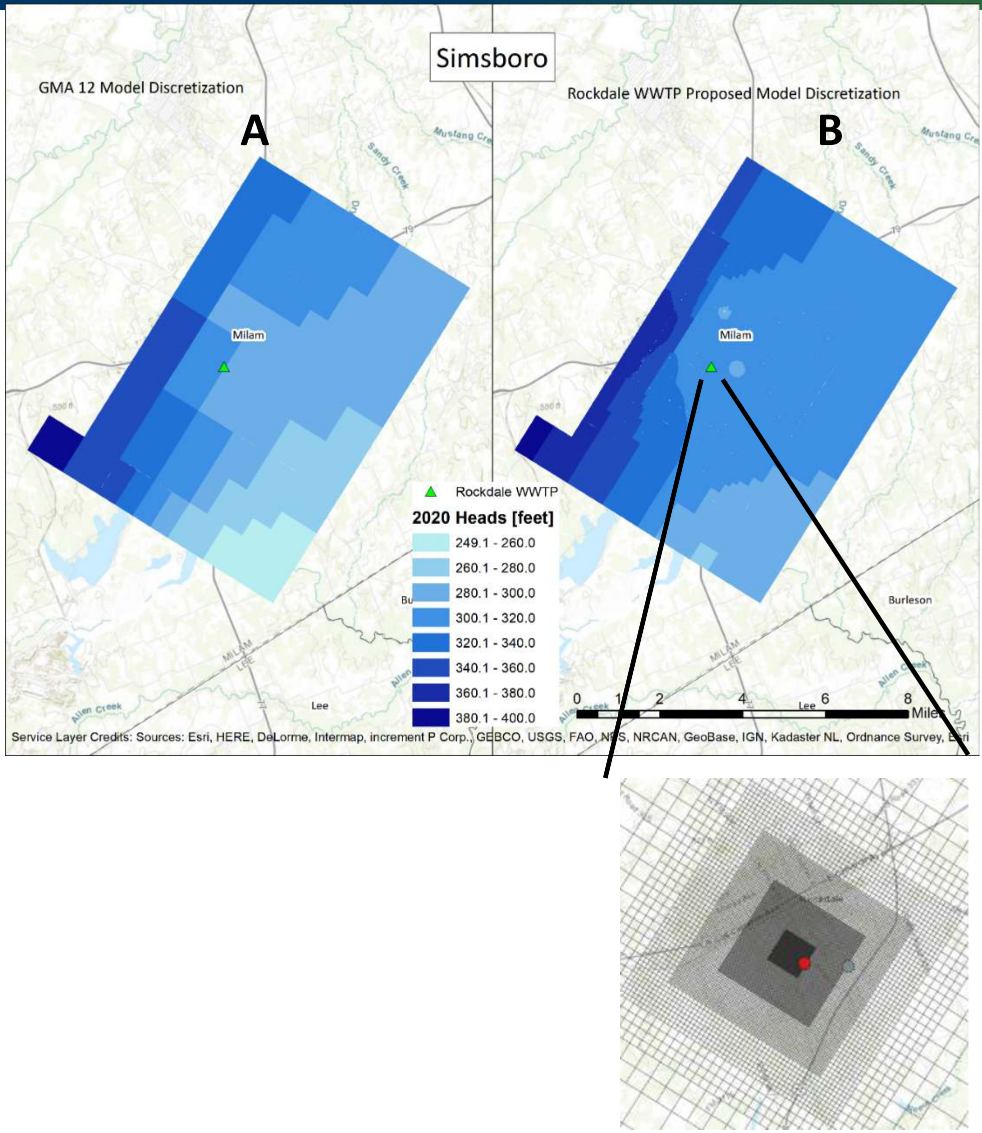
Aquifer Storage and Recovery and Enhanced Recharge

- Enhanced Recharge
  - Objective is to replenish water in the aquifer
  - Options
    - Injection wells
    - Surface spreading
    - Infilitration pits and basins
- Aquifer Storage and Recovery
  - Objective is to store water in the ground and to recover the water when needed
  - Options:
    - Wells that Inject and recovery
    - Wells fields with designated injection and recovery wells

Application In Milam County

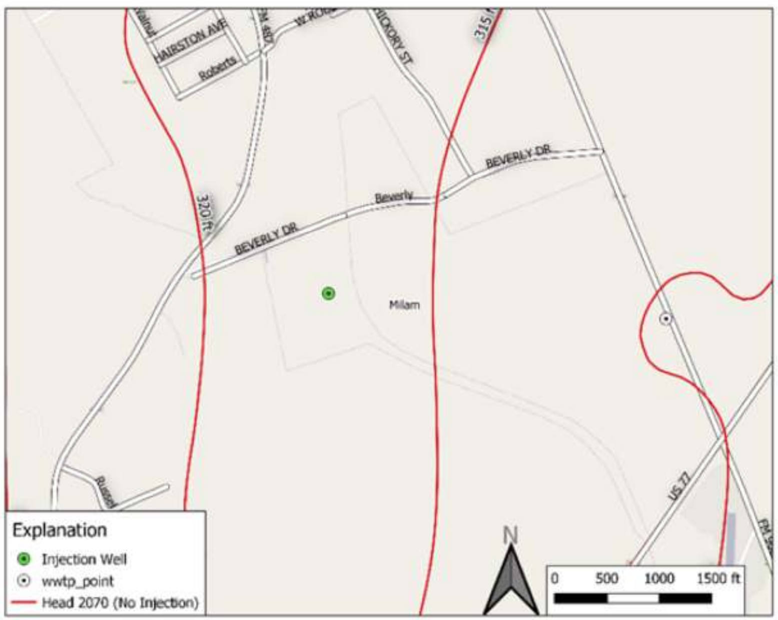
- Water source is Rockdale Wastewater Treatment Plant
- Develop flow model from GMA 12 GAM

Month	Monthly Average	
	MGD	GPM
Jan	0.404	281
Feb	0.429	298
Mar	0.440	306
Apr	0.415	288
May	0.388	269
Jun	0.396	275
Jul	0.359	249
Aug	0.366	254
Sep	0.433	301
Average	0.403	280



Groundwater Flow Conditions in Desired Future Condition (DFC) Simulation

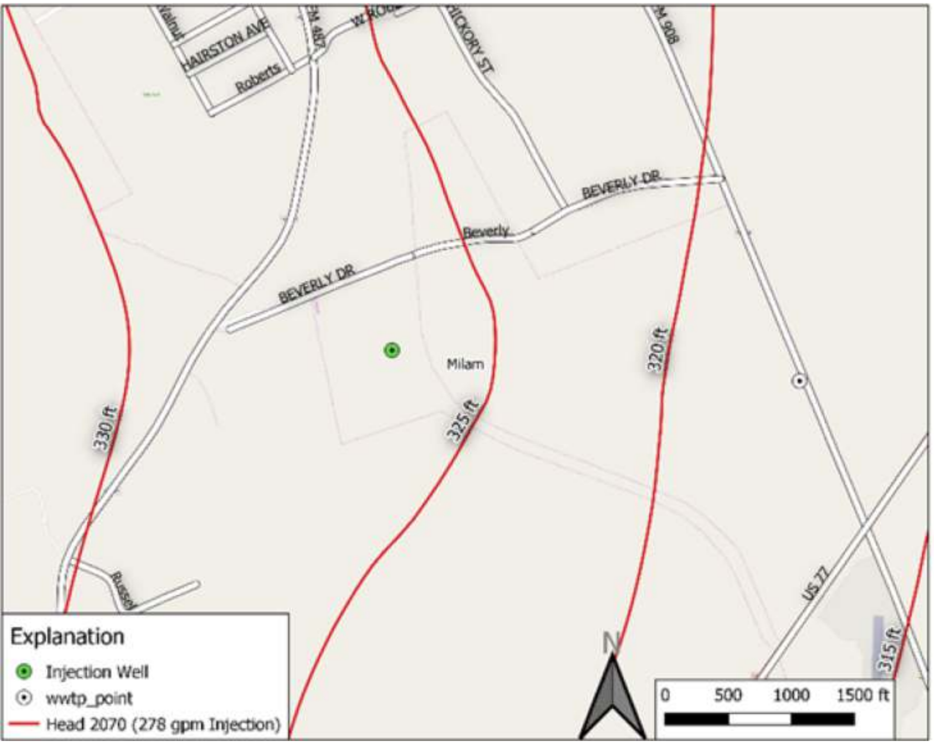
Hydraulic head contours for groundwater flow field



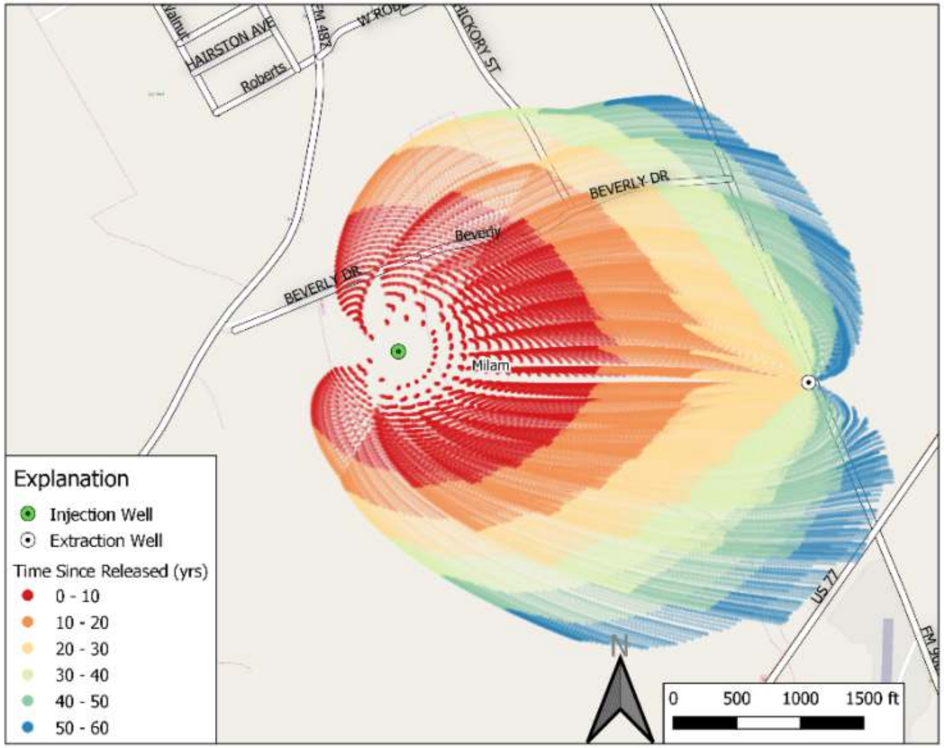
Travel time between WTTP and a nearby Pumping Well is about 50 years

Groundwater Flow Conditions in DFC Simulation with Enhanced Recharge at Injection at 277 gpm

Hydraulic head contours for groundwater flow field

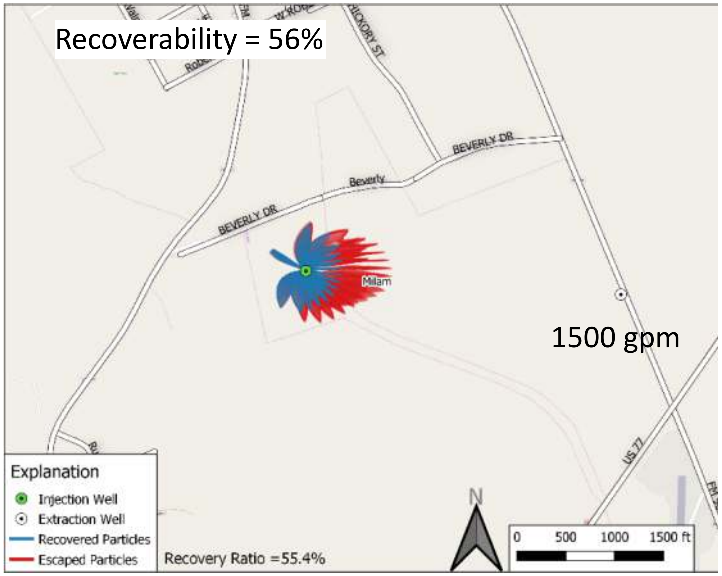


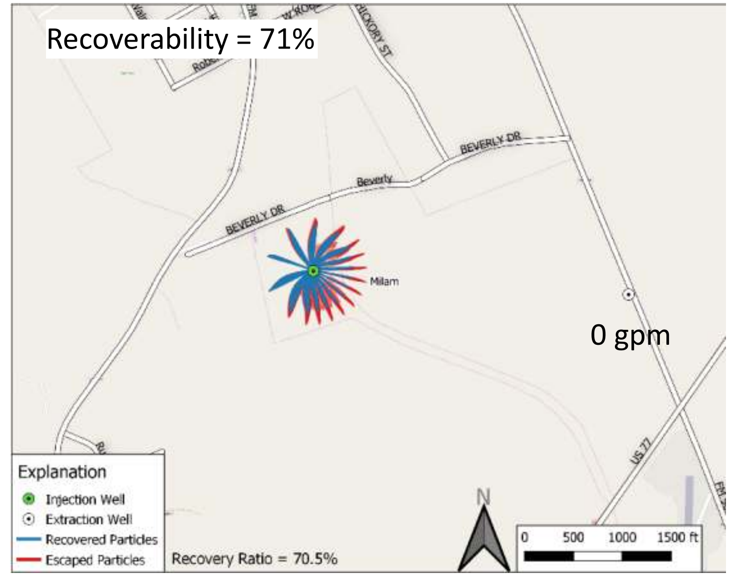
Travel time between WTTP and a nearby pumping Well is 25 to 50 years

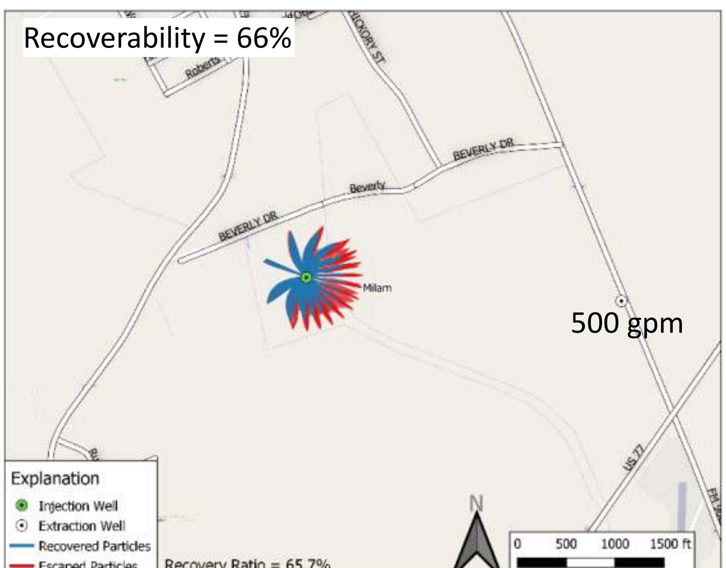


INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

ASR on a Two-year Cycle







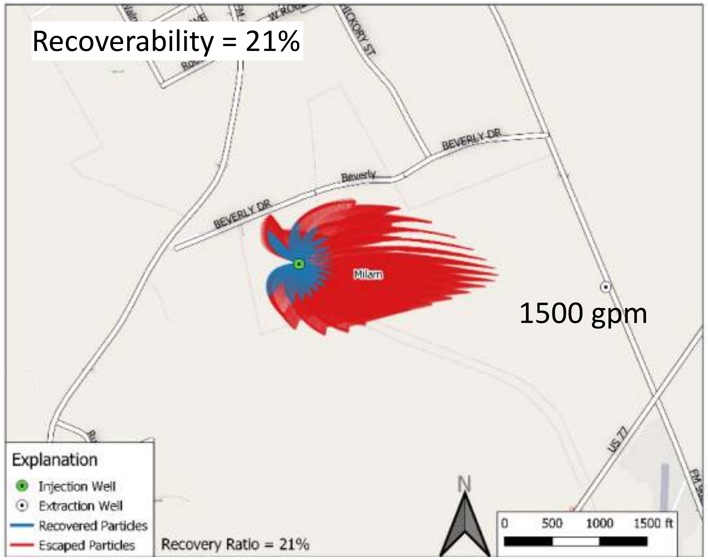
ASR Injection/Pumping Schedule

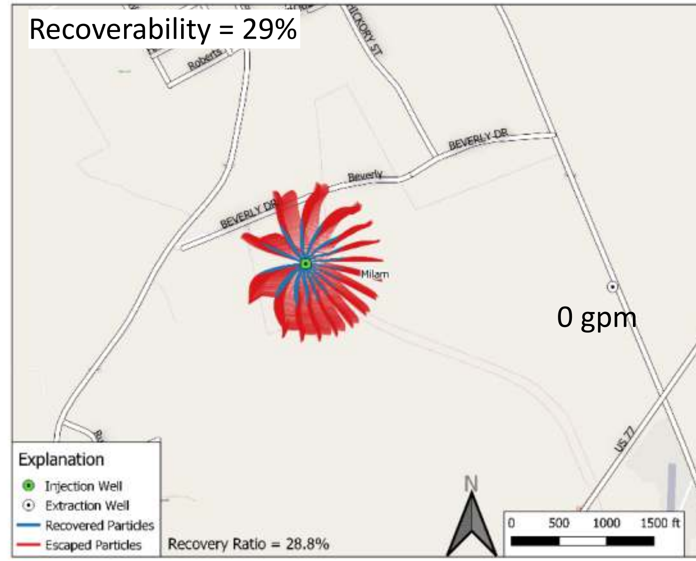
- Inject at 280 gpm for 29 months
- Extract at 2,030 gpm For 4 months
- Inject at 280 gpm for 32 months
- Extract at 2,240 gpm for 4 month

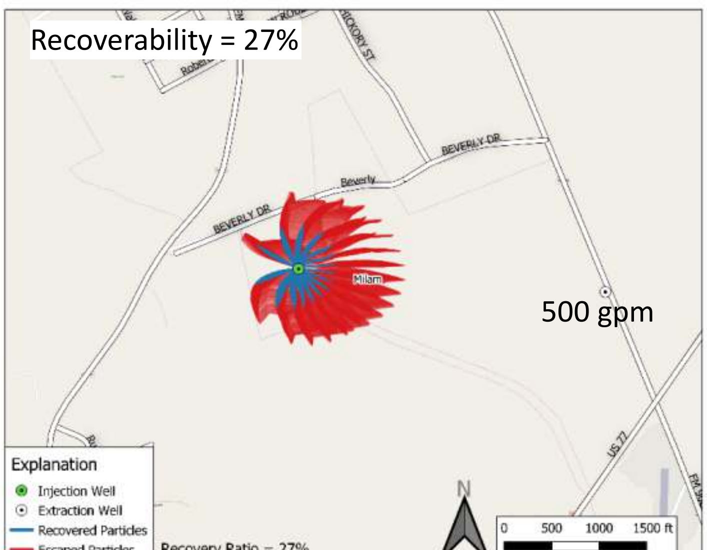
Nearest Pumping Well

- Vary from 1500, 500, and 0 gpm

ASR on a Six-year Cycle







<u>ASR Injection/Pumping Schedule</u>

- Inject at 280 gpm for 65 months
- Extract at 4,550 gpm For 4 months
- Inject at 280 gpm for 68 months
- Extract at 4,760 gpm for 4 month

<u>Nearest Pumping Well</u>

- Vary from 1500, 500, and 0 gpm

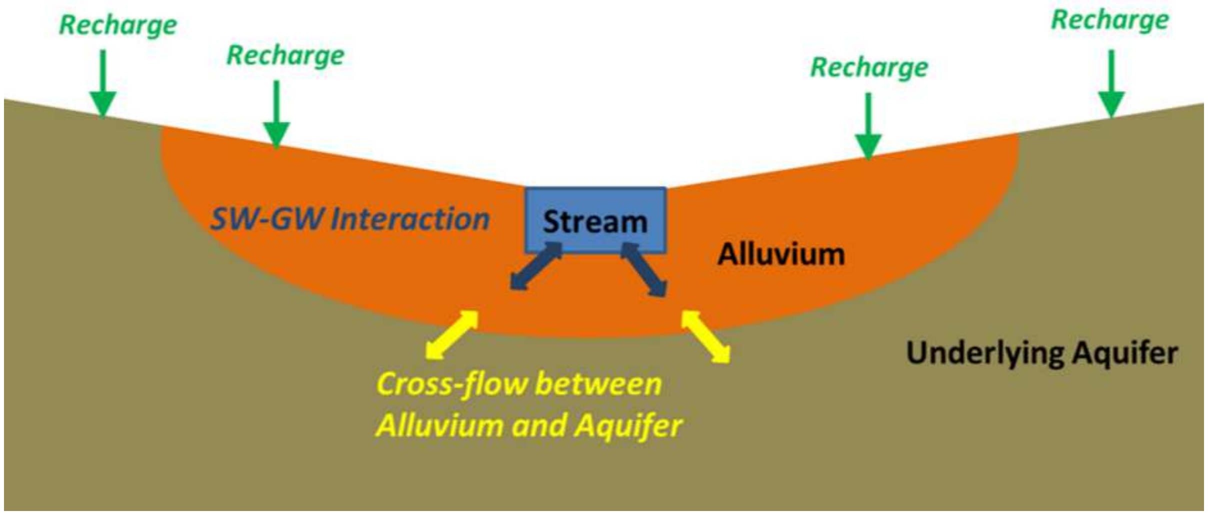
Issues of Potential Interest to District

- Enhanced Recharge (ER)
  - Potential benefits for aquifer protection and DFC/PDL compliance
  - geochemical reactions in aquifer
  - Incentives to promote ER

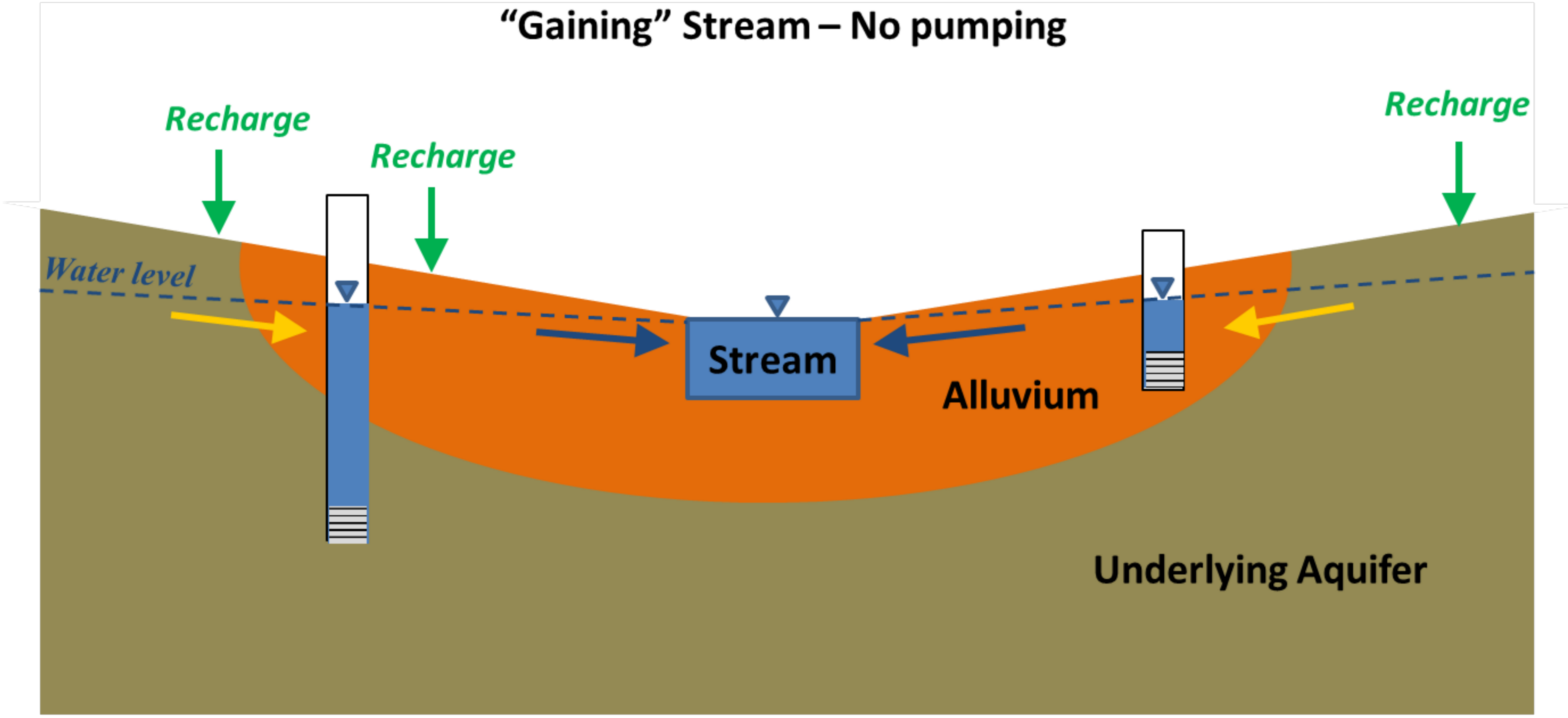
- Aquifer Storage and Recovery (ASR)
  - Potential benefits for reducing demands on groundwater resources
  - Recovery amount is greater than Injected water
  - Method for Estimating recoverability rates
  - How to monitor and check the recoverability rates
  - Well Spacing

SW-GW Interaction

- Under natural conditions, groundwater should be recharging major streams in GMA 12
- Two important interactions: Stream and alluvium; alluvium and underlying aquifer
- For well in alluvium what is the source of the water?
- For well in underlying aquifer, what is the source of water that is pumped?



SW-GW Interaction– No Pumping

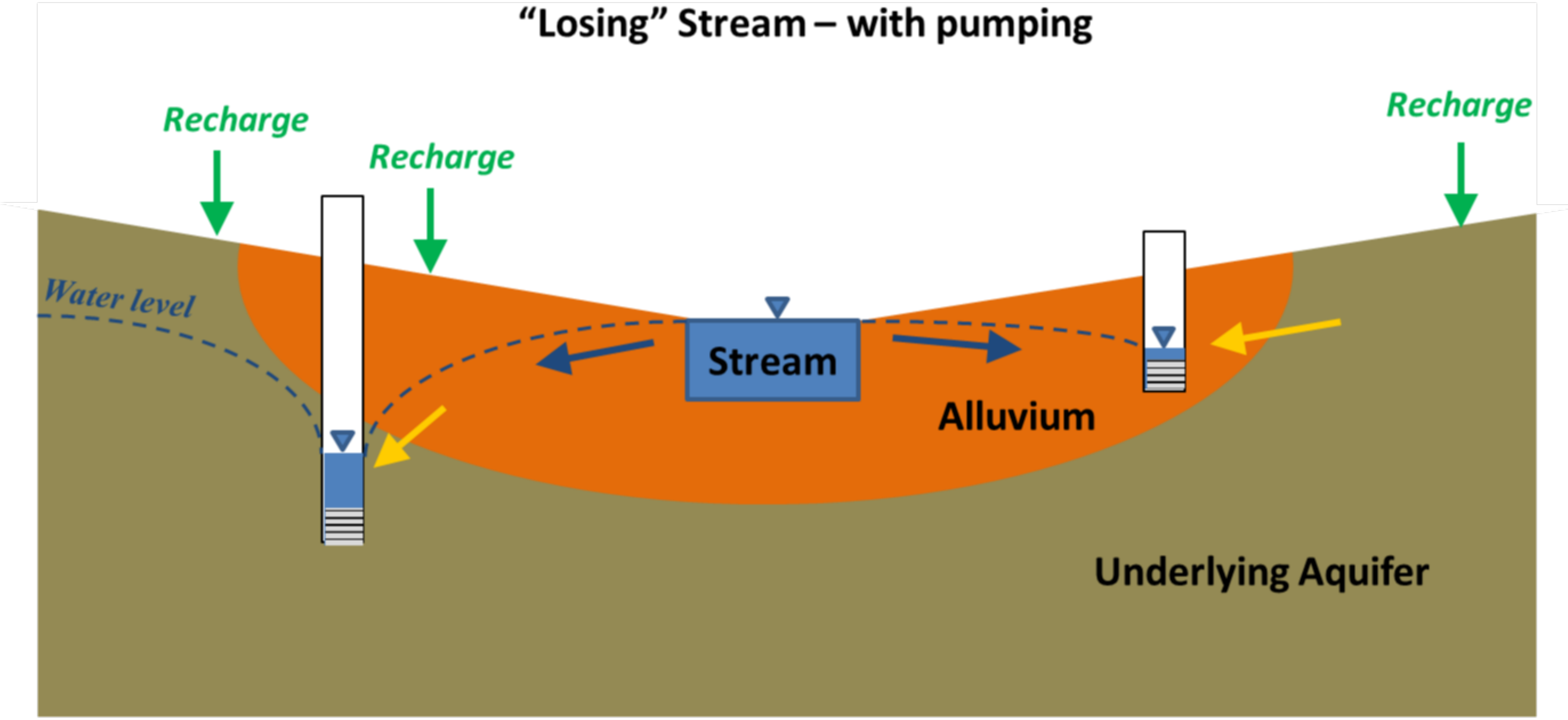


Surface-Groundwater interaction (between Stream & Alluvium)

Crossflow between Alluvium & Aquifer

Water Level

SW-GW Interaction– Pumping



Surface-Groundwater interaction (between Stream & Alluvium)

Crossflow between Alluvium & Aquifer

Water Level

SW-GW Interaction

- TWDB GAM RUN 17-030 MAG Report (December 2017)
- MAG for Brazos River Alluvium Based on Decreased in Thickness of Saturated Deposits
  - Milam County is 5 feet decrease from 2010 to 2070
  - Burleson County is 6 feet decrease from 2010 to 2070

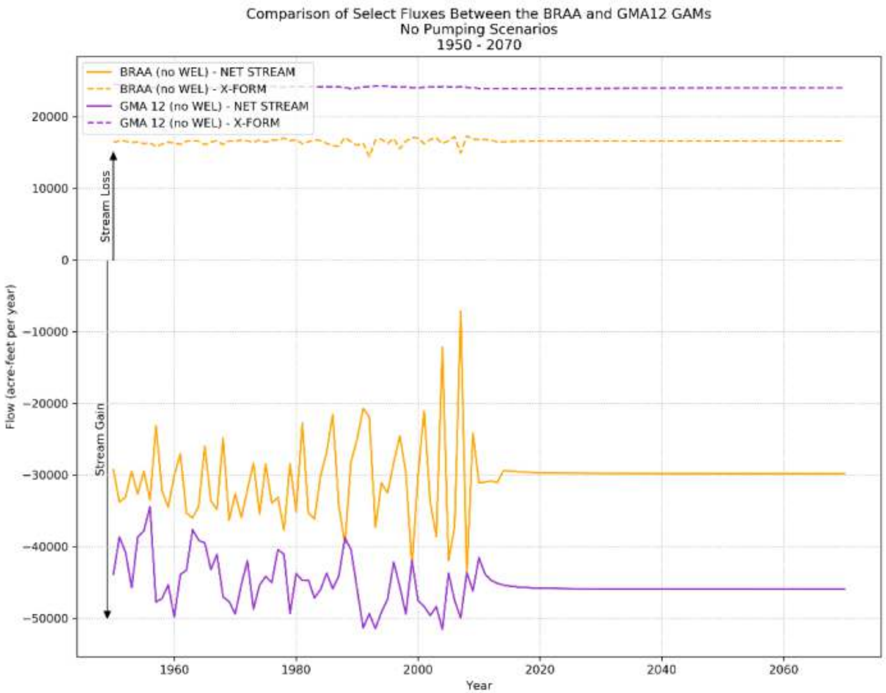
TABLE 19 MODELED AVAILABLE GROUNDWATER BY DECADE FOR THE BRAZOS RIVER ALLUVIUM AQUIFER IN GROUNDWATER MANAGEMENT AREA 12. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE SUMMARIZED BY COUNTY, REGIONAL WATER PLANNING AREA (RWPA), RIVER BASIN, AND AQUIFER.

County	RWPA	River Basin	Aquifer	2020	2030	2040	2050	2060	2070
Brazos	G	Brazos	Brazos River Alluvium	81,581	80,311	80,081	79,976	79,913	79,872
Burleson	G	Brazos	Brazos River Alluvium	28,472	28,418	28,414	28,414	28,414	28,413
Falls	G	Brazos	Brazos River Alluvium	NR	NR	NR	NR	NR	NR
Milam	G	Brazos	Brazos River Alluvium	47,818	47,785	47,779	47,775	47,773	47,771
Robertson	G	Brazos	Brazos River Alluvium	61,161	57,959	57,633	57,544	57,503	57,480
GMA 12 Total			**Brazos River Alluvium**	**219,032**	**214,473**	**213,907**	**213,709**	**213,602**	**213,536**

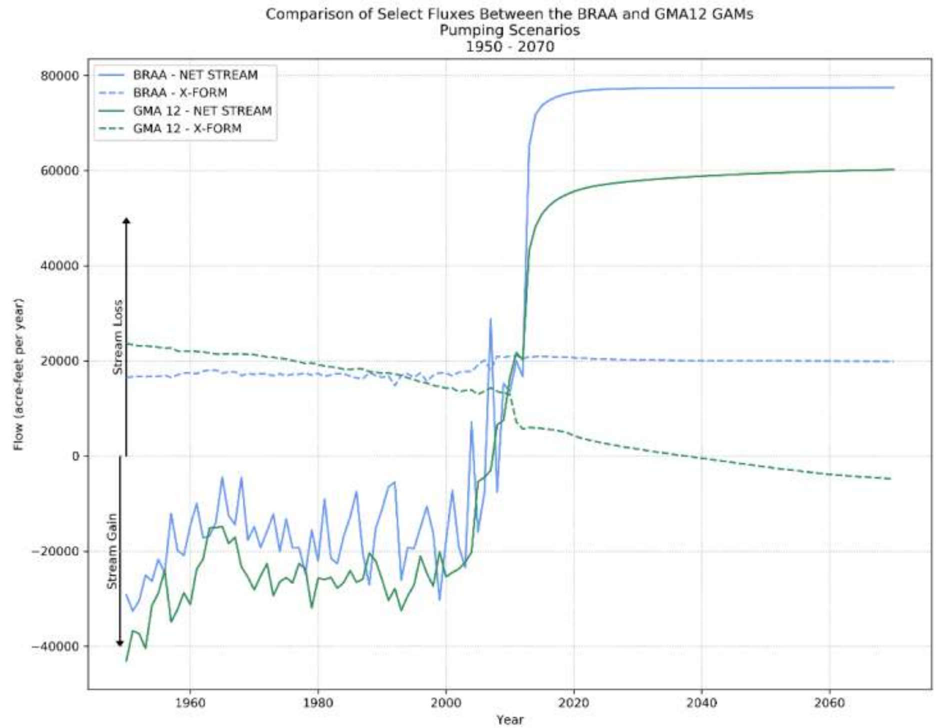
NR: Groundwater Management Area 12 declared the Brazos River Alluvium Aquifer not relevant in these areas.

Water Budget for Brazos River for Pumping and No Pumping Conditions

No Pumping

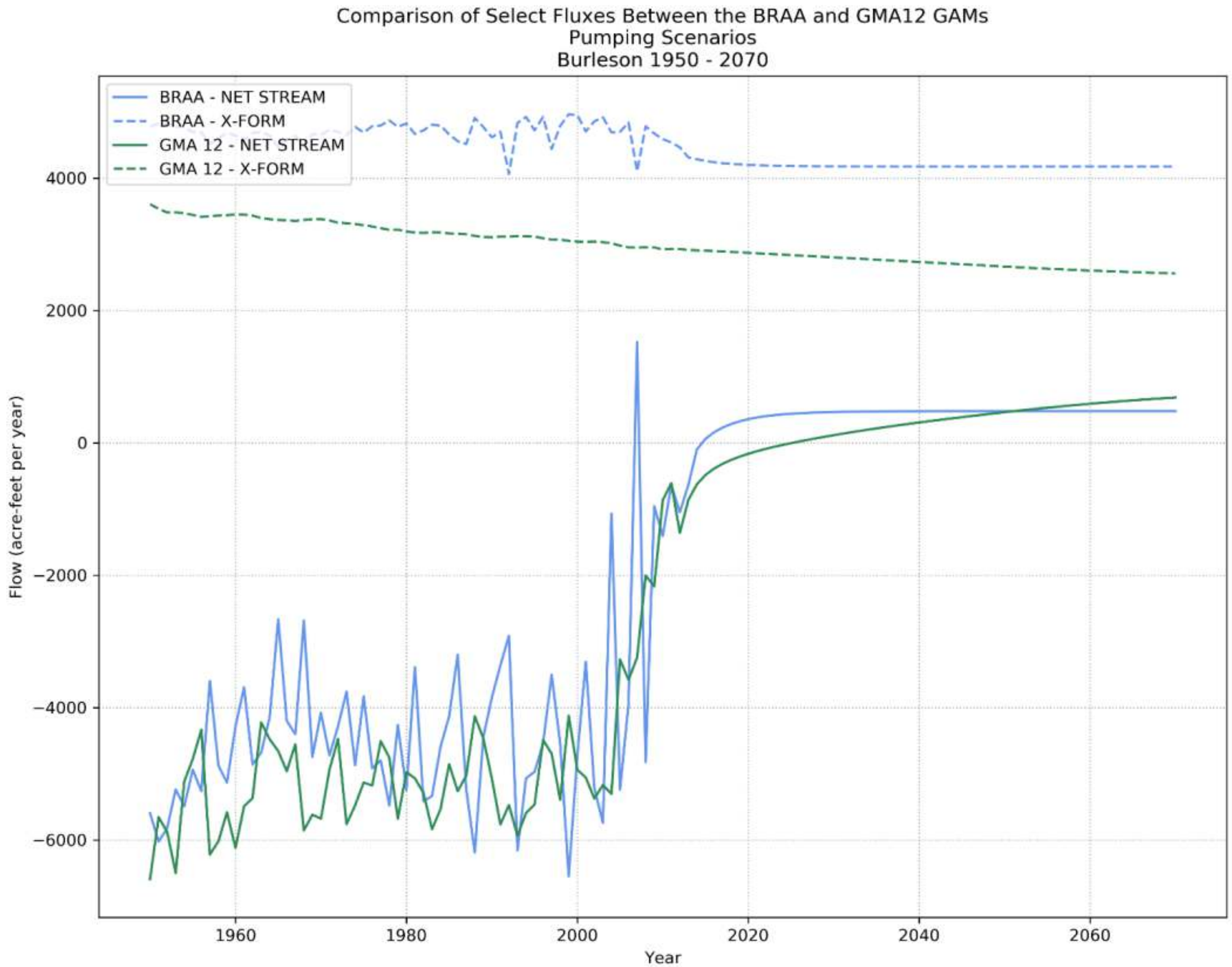


Pumping

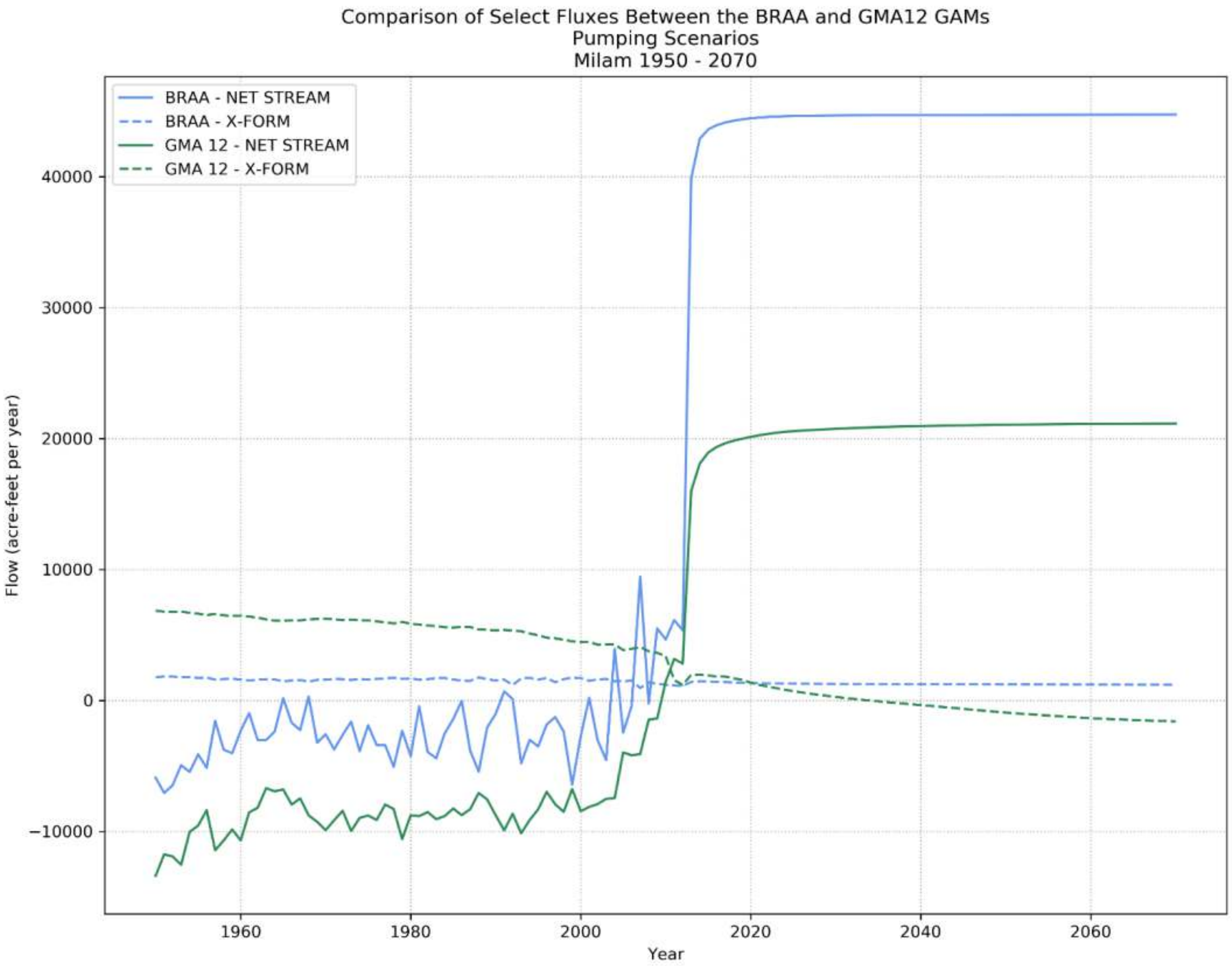


- Under No pumping conditions, Brazos River gains about 40,000 AFY consistently
- Under pumping conditions, Brazos River gains about 20,000 AFY until year 2000
- At about 2010, Brazos becomes a losing stream. DFC runs cause stream to lose 65,000 AFY

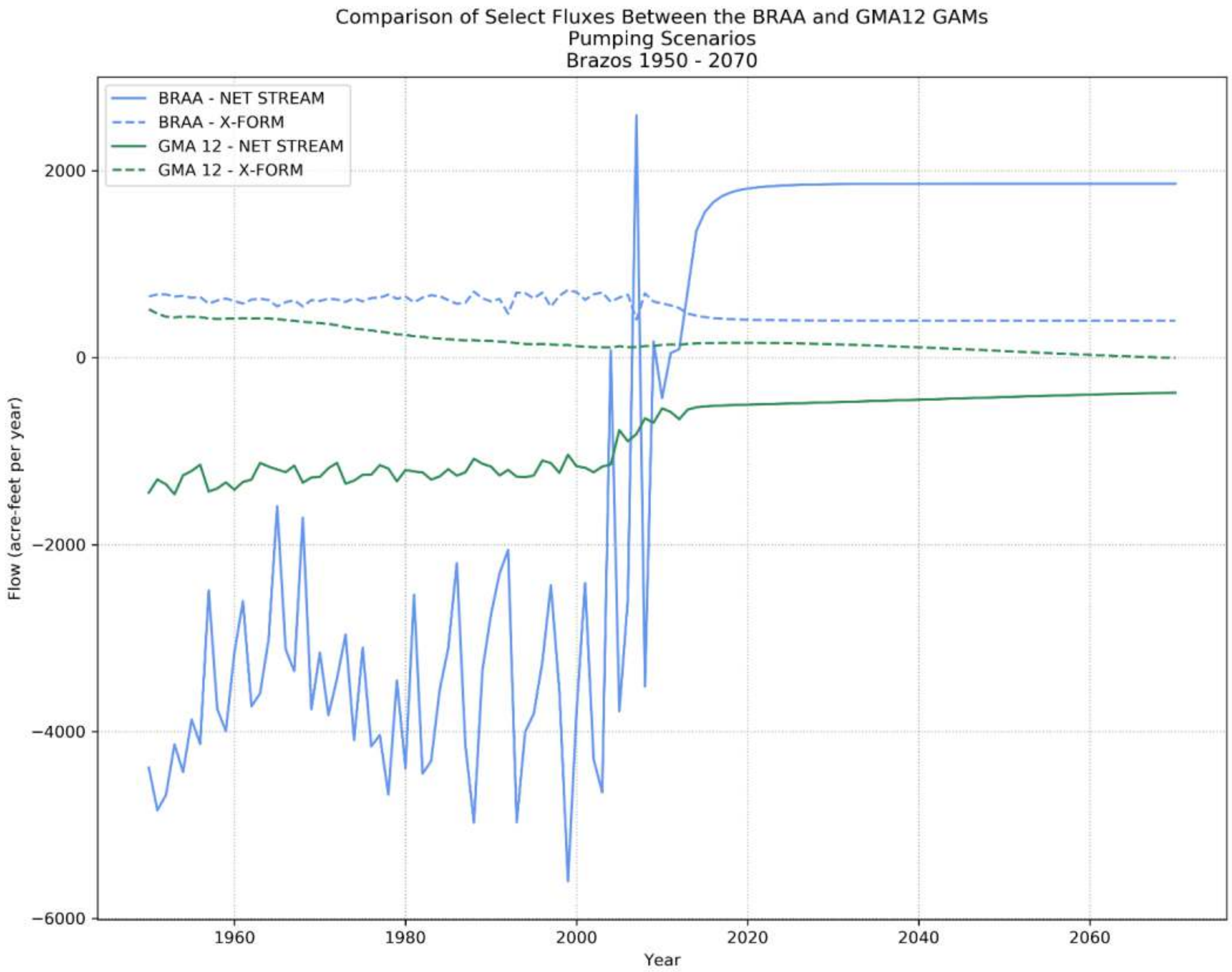
Brazos Alluvium: Burleson County



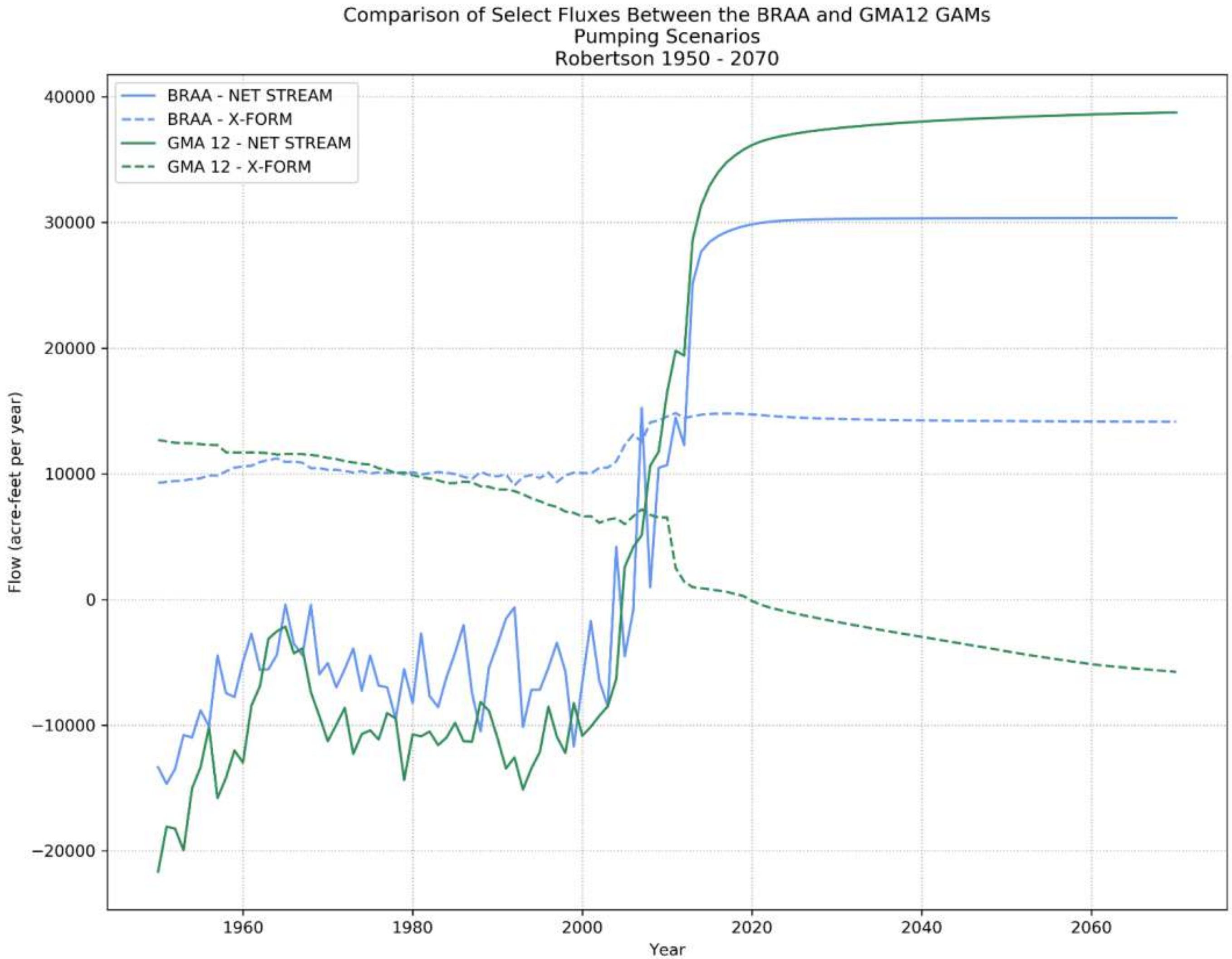
Brazos Alluvium: Milam County



Brazos Alluvium: Brazos County



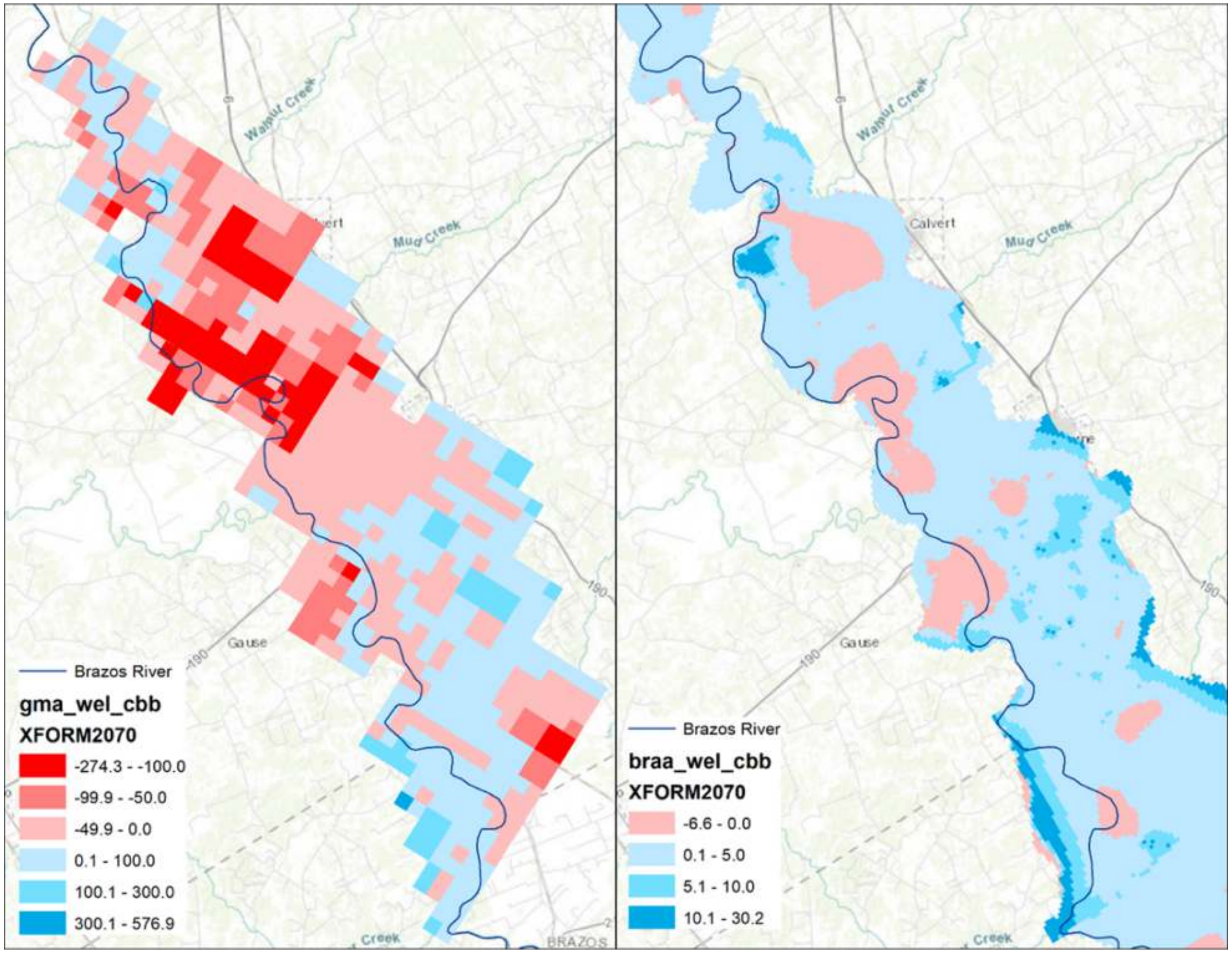
Brazos Alluvium: Robertson County



INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

BRAA GAM and Central SP/QC/CW GAM Differ with Cross-Flow Between Alluvium and Underlying Aquifer

Cross-flow (AFY) between Brazos Alluvium and Underlying Aquifer



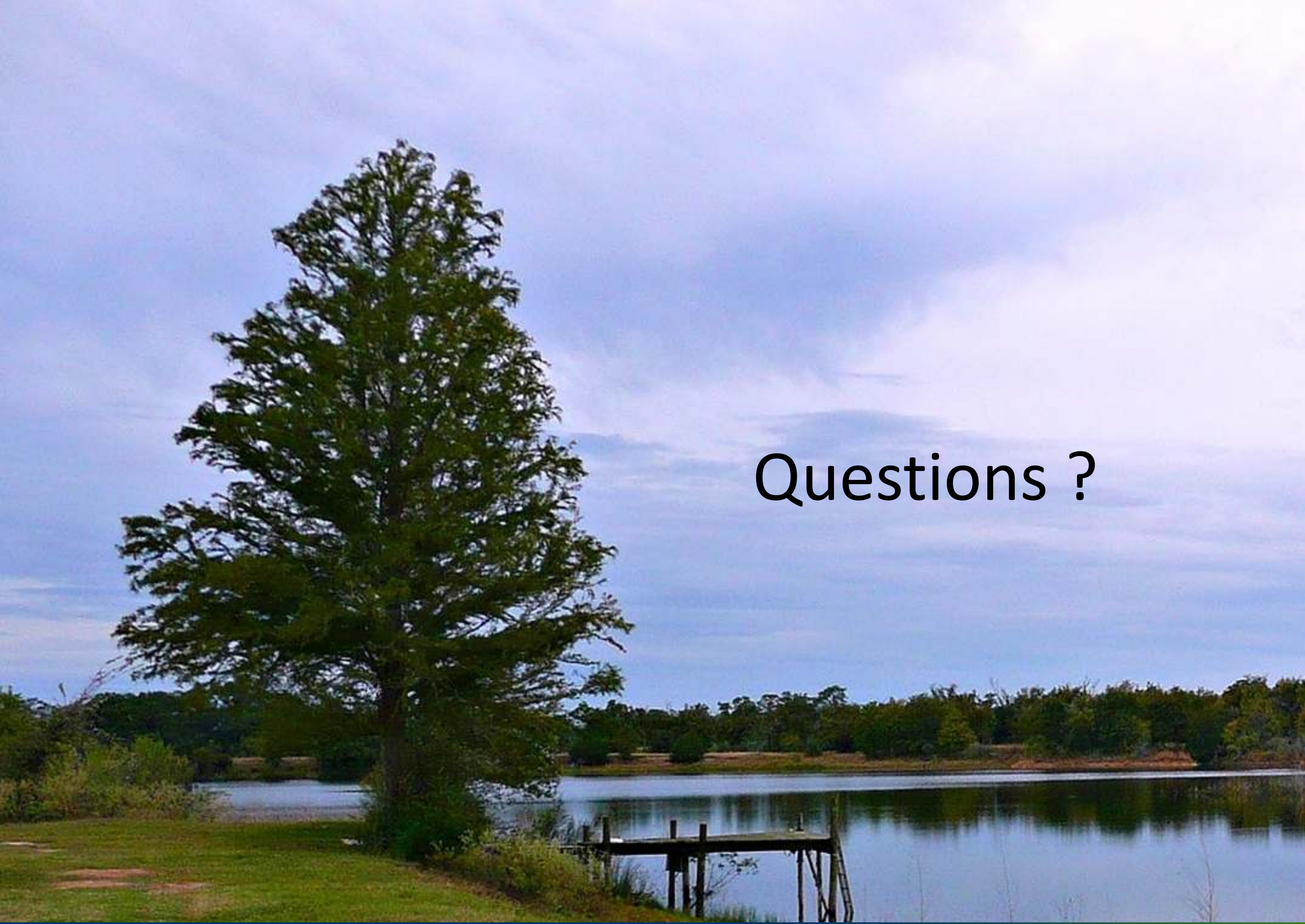
INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

Issues of Potential Interest to District

- DFC other than percent saturation?
- Additional monitoring?
- Which GAM to used for DFC calculations?
- Discussions
  - Texas Water Development Board
  - Brazos County GCD
  - Brazos River Authority
  - GMA 12

GMA 12 Discussion Topics

- Consultants
  - INTERA (Mid East Texas & POSGCD)
  - Committed Funds to GMA 12
- Update of GAM(s) for Predictive DFC Runs
  - Assignment of wells to model grids
  - Production rates from 2010 to 2017 based on historical use
  - Production rates after 2017
- Possible Changes in GMA 12 DFCs
  - Drawdown values
  - Shallow zone or partial county for an aquifer
  - Surface water – Groundwater interaction
  - Dates besides 2070
- Schedule
  - Explanatory Report
  - Adoption of DFC



Questions ?