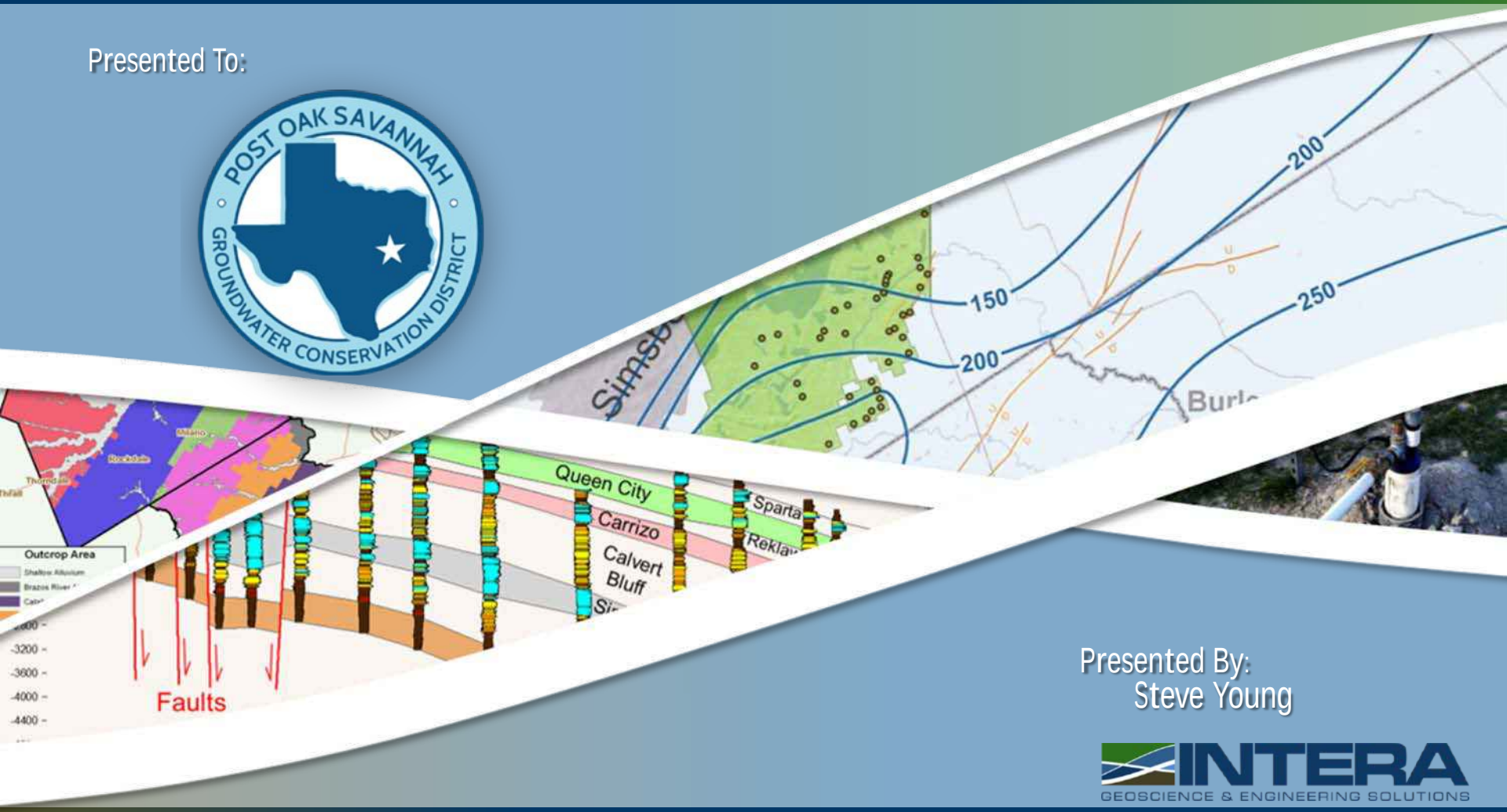
Update on Research Project

Presented To:

POST OAK SAVANNAH GROUNDWATER CONSERVATION DISTRICT



Presented By:
Steve Young

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

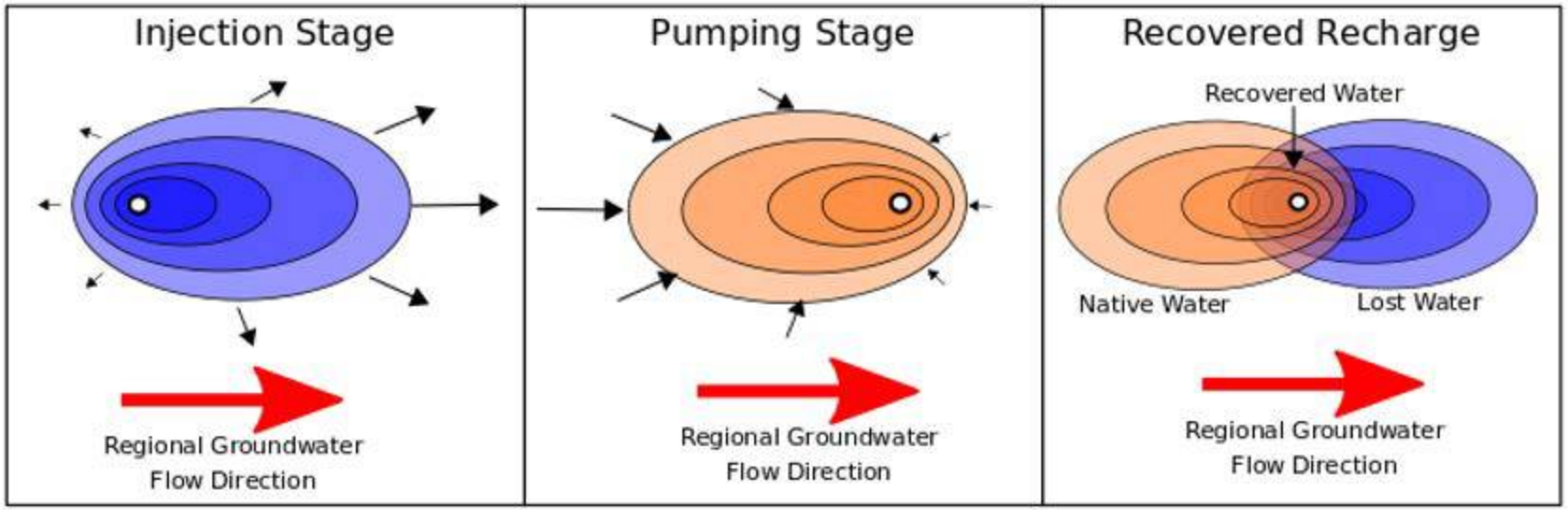
November 6, 2018

Topics

- Aquifer Storage and Recovery
- Surface-water groundwater interaction
- Groundwater Quality

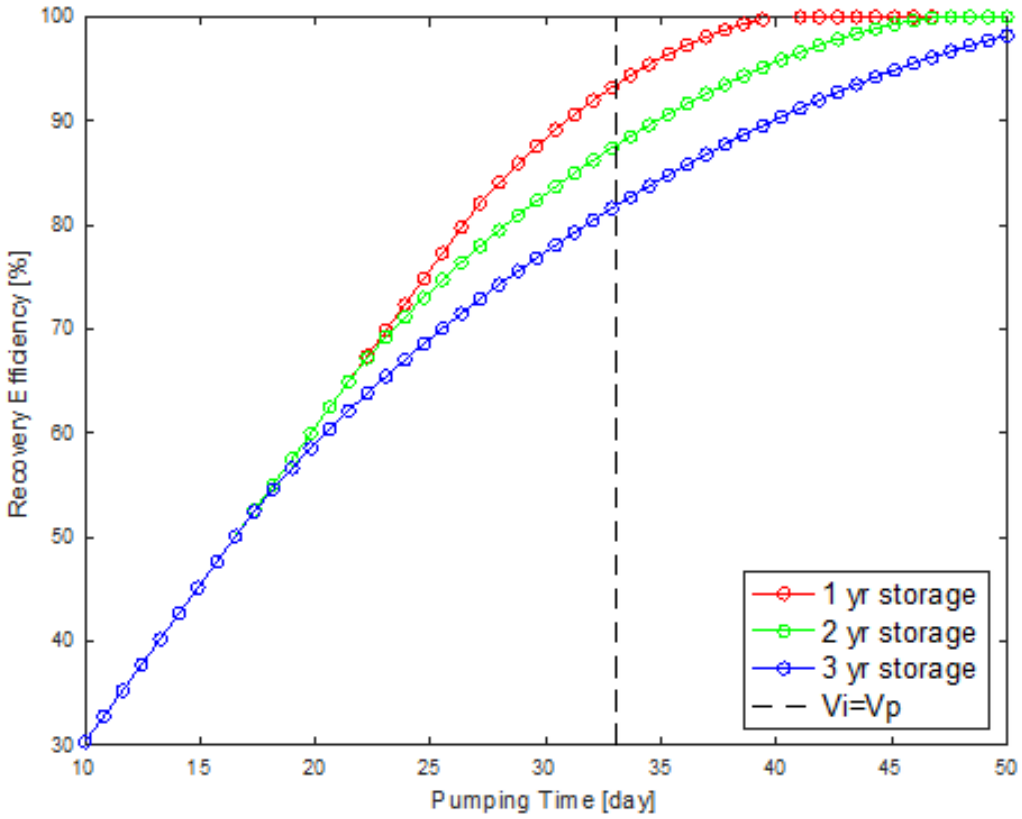
Aquifer Storage and Recovery

- Coordination with University of Texas on their project with TCEQ
  - ground truthing and benchmarking techniques for calculating recoverability



Aquifer Storage and Recovery: UT Development of a Spreadsheet Tool

Parameter	Variable	Units	
Injection Rate	Qi	ft^3/day	200000
Puming Rate	Qp	ft^3/day	200000
Time of Injection	ti	days	33
Time of Storage (delay)	td	yr	1,2,3
Time of Pumping	tp	days	10 to 50
Porosity	n	-	0.3
Hydraulic Conductivity	Kd	ft/day	20
Hydraulic Gradient	dh/dx	ft/ft	0.001
Specific Discharge	q=Kd dh/dx	ft/day	0.02
Thickness of Aquifer	B	ft	100



Initial Round of Model Validation Completed and Presented to TCEQ

TEXAS
The University of Texas at Austin

WHAT STARTS HERE CHANGES THE WORLD

Model comparison/validation with partners from INTERA

Comparison of **Analytical Model** and **MODFLOW Numerical Model**

- Analytical Model
  - Uses equations that have exact solution
  - Solution based on assumptions: Uniform flow, Single well, Cons
    Uniform aquifer thickness, Infinite plane
  - Opportunity for misuse is low risk
- Numerical Model
  - Comprised of equation(s) that provide solutions that inheren
    exact solution. Accuracy of solution is affected by several m
  - Developed to handle the variability of physical aquifer and o
  - Opportunity for misuse is moderate to high risk

Parameter	Variable	Units	TEST 1 Variable Hydraulic Gradient		
Injection Rate	Qi	ft^3/day	20000	20000	20000
Puming Rate	Qp	ft^3/day	220000	220000	220000
Time of Injection	ti	days	330	330	330
Time of Storage (delay)	td	days	0	0	0
Time of Pumping	tp	days	30	30	30
Porosity	n	-	0.3	0.3	0.3
Hydraulic Conductivity	Kd	ft/day	20	20	20
Hydraulic Gradient	dh/dx	ft/ft	0.01	0.0001	0.001
Specific Discharge	q=Kd dh/dx	ft/day	0.2	0.002	0.02
Thickness of Aquifer	B	ft	100	100	100
Injection Volume	Vi	ft^3	6.60E+06	6.60E+06	6.60E+06
Pumping Volume	Vp	ft^3	6.60E+06	6.60E+06	6.60E+06
Analytical Solution Recovery Efficiency	**RE**		**63.62%**	**99.62%**	**96.15%**
MODFLOW ASR Recovery Efficiency	**RE**		**63.6%**	**99.6%**	**96.1%**
Percent Variance			**0.03%**	**0.02%**	**0.05%**

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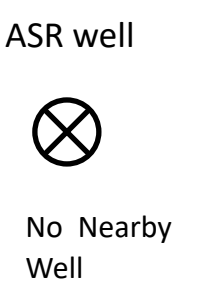
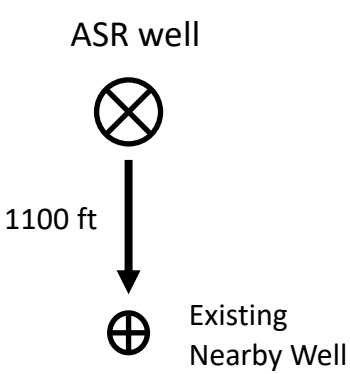
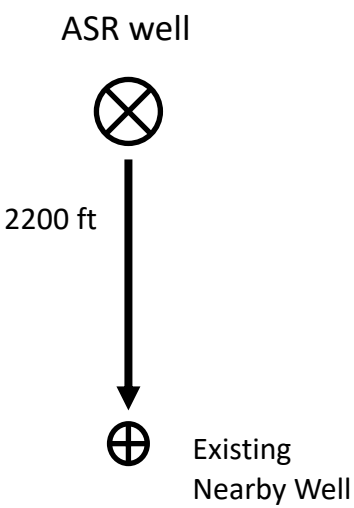
Predicted Efficiency for Single ASR Well – Effect of Nearby Pumping Wells



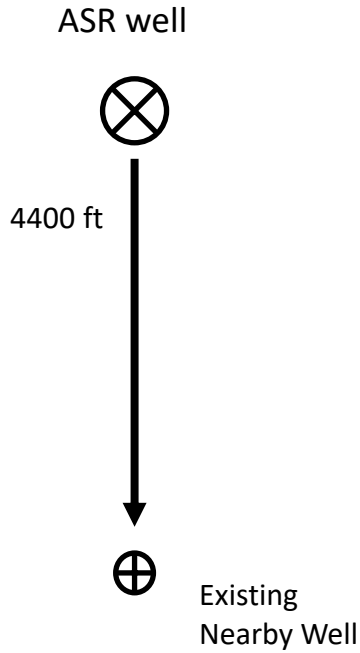
Gradient	Single Well
0.01	85%
0.001	99%
0.0001	100%



Well 1100 ft down gradient		
100 gpm	550 gpm	1100 gpm
76%	43%	26%
90%	52%	29%
91%	53%	29%



Well 2200 ft down gradient		
100 gpm	550 gpm	1100 gpm
81%	64%	47%
95%	76%	57%
96%	77%	58%



Well 4400 ft down gradient		
100 gpm	550 gpm	1100 gpm
83%	74%	64%
97%	87%	76%
98%	89%	77%

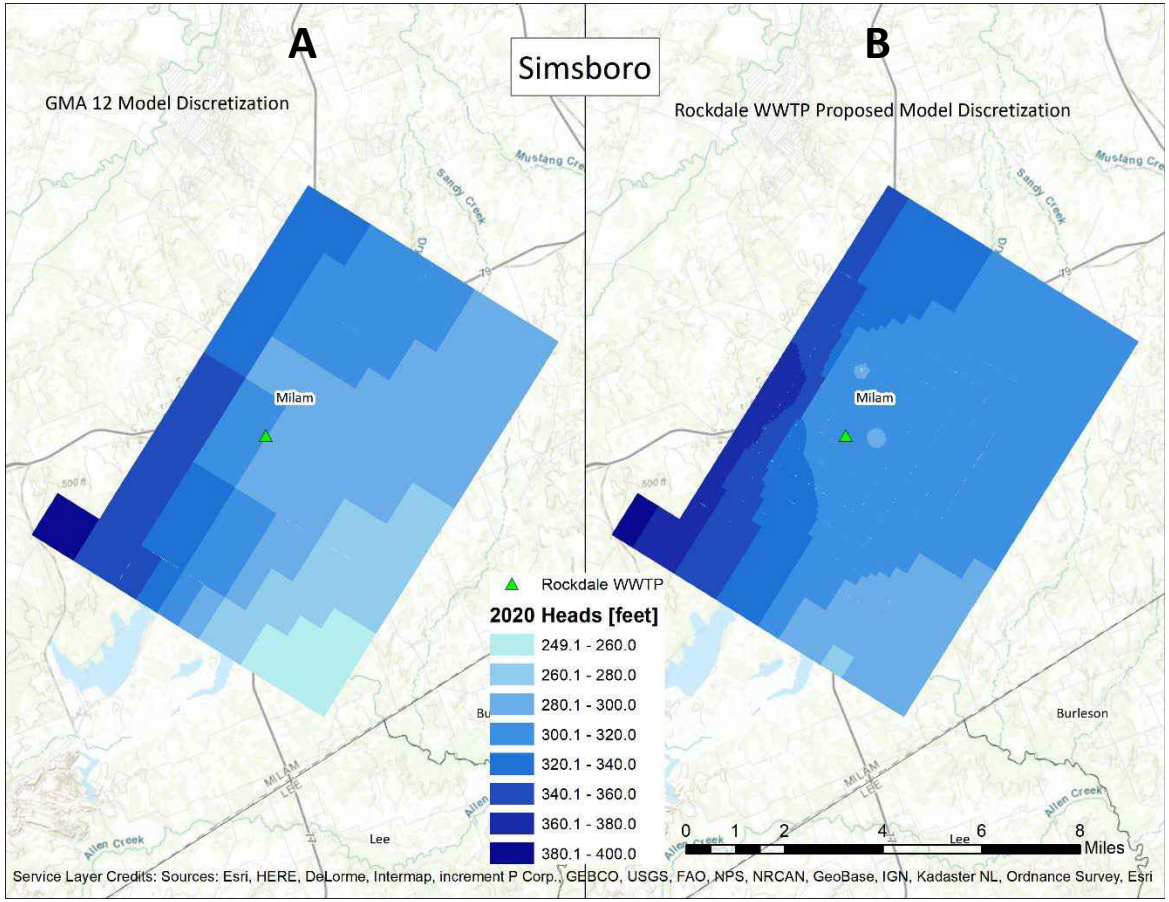
Targeted ASR Aquifer Zone

- **50 feet thick**
- **Hydraulic conductivity = 20 ft/day**

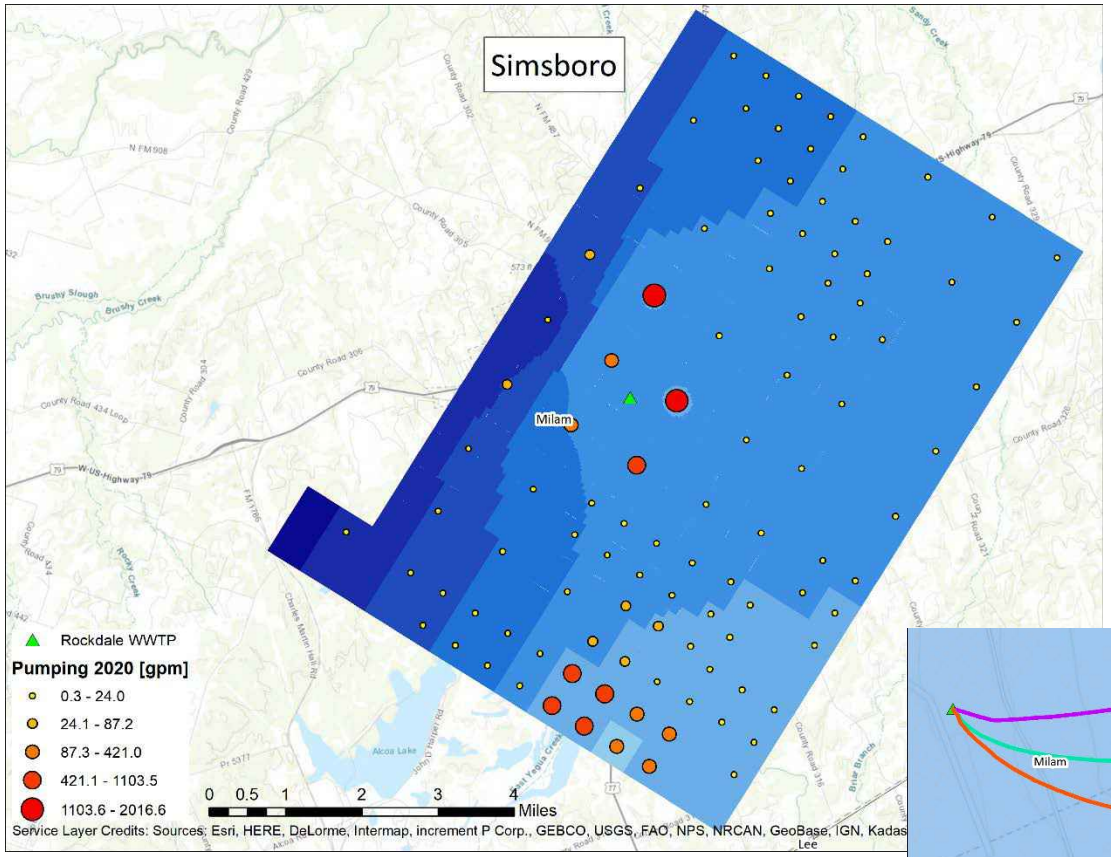
- **Inject water at 100 gpm for 11 months**
- **Extract water at 1100 gpm for 1 month**
- **Calculate Recovery Efficiency after 24 months**

Application In Milam County

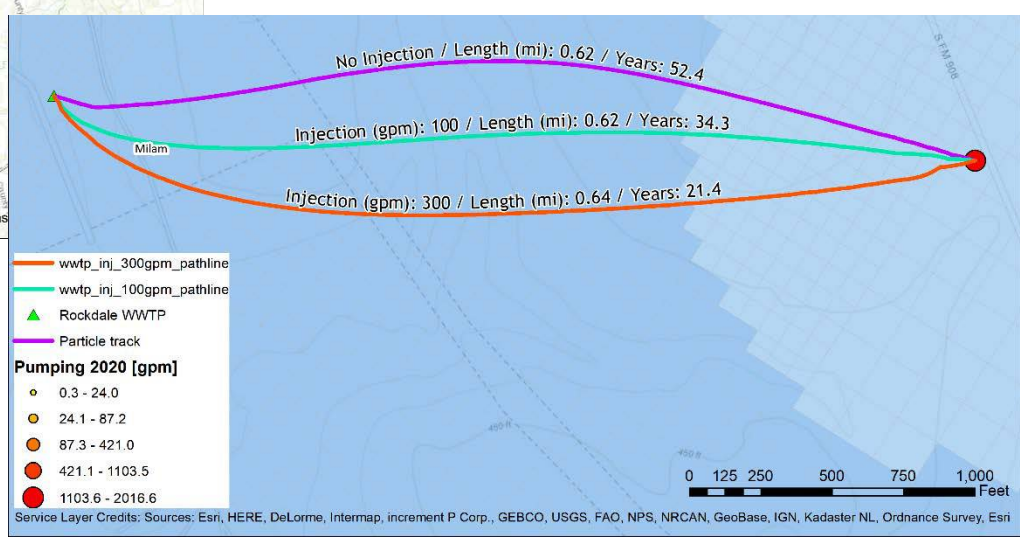
- Injection near Rockdale Wastewater Treatment Plant
- Extract aquifer and groundwater system information from revised GMA 12 GAM (A)
- Develop MODFLOW Model with 50 ft x 50 ft grid instead of 1 mile x 1 mile grid containing WWT Plant (B)
- Generate transient flow field and simulate managed aquifer recharge (MAR) and ASR



Application In Milam County



- Set up smaller MODFLOW model to run 2010 to 2069
- Develop method or tracking injected water
- Develop MAR and ASR Scenarios
- Perform model simulations



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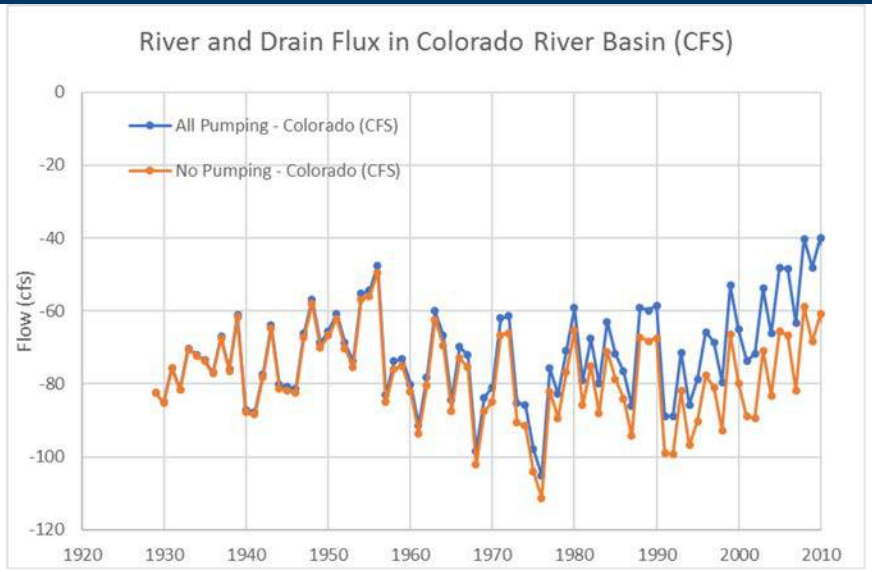
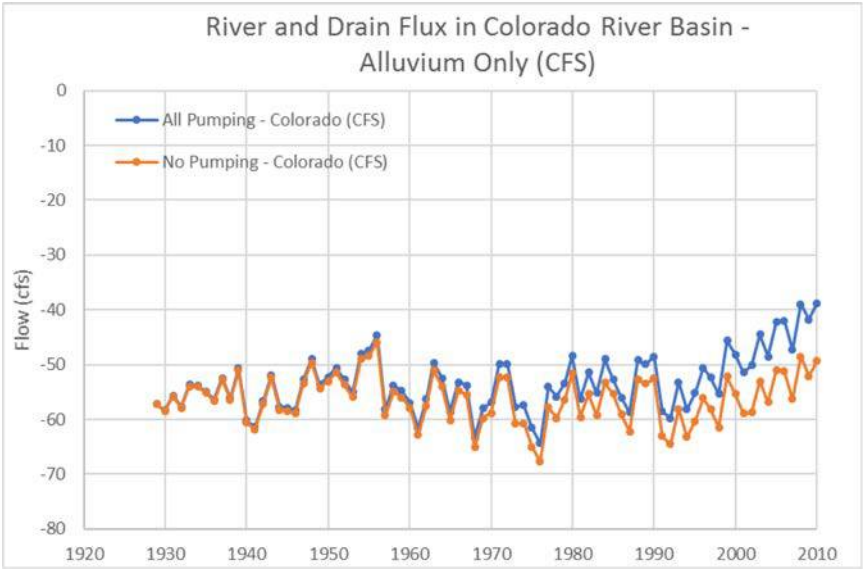
Surface Water – Groundwater Interaction

- Assessment of Pumping Impacts of Flow to and from Streams/Springs/Seeps
- Focus on Colorado River Basin and Brazos River Basin
- Address concerns raised by Environmental Stewardships and others regard environmental flows and water rights
- Evaluate Limitations of Revised GAM for Evaluation GW-SW Interaction and for Establishing DFCs

Colorado River Basin*

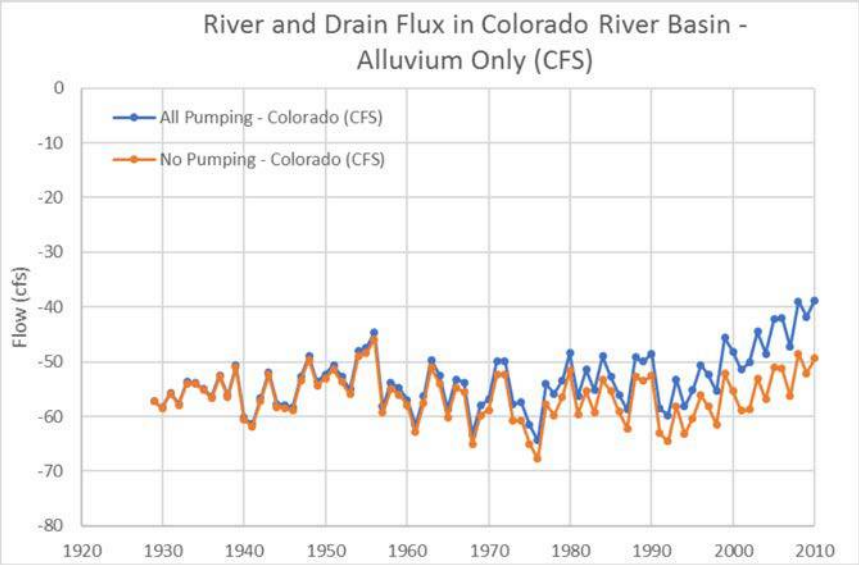


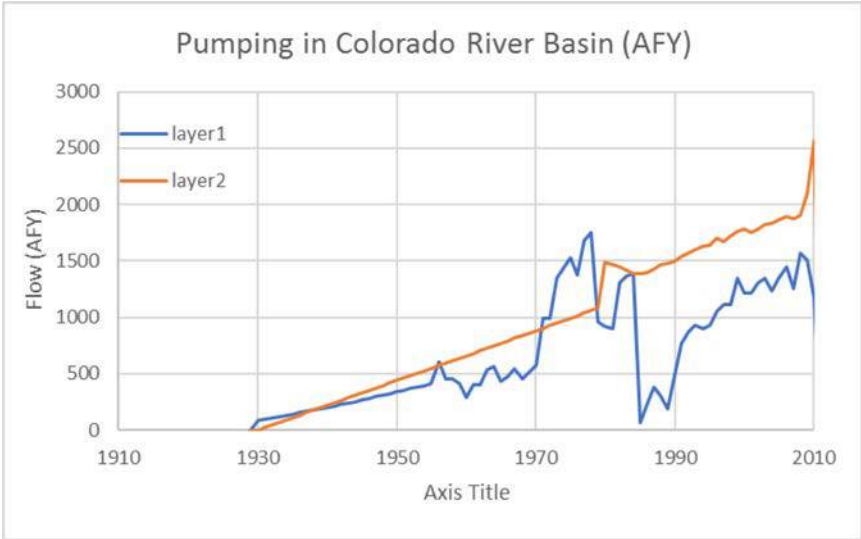


- About 80 cfs of groundwater flows into Colorado River/seeps/springs
- Variation in groundwater flow caused by changes in precipitation and pumping
- Saunders gain-loss studies estimate about 30 cfs to 60 cfs of groundwater flow to Colorado River in Bastrop in 2000's
- Difference between lines is the amount of groundwater intercepted by pumping before it can reach springs/seeps/Colorado River
- In 2010, impacts of pumping of SW-GW interaction is about 10 cfs (~7300 AFY)

* Preliminary results – should not be cited

Colorado River Basin: Comparison of SW-GW Exchange and Shallow Pumping *

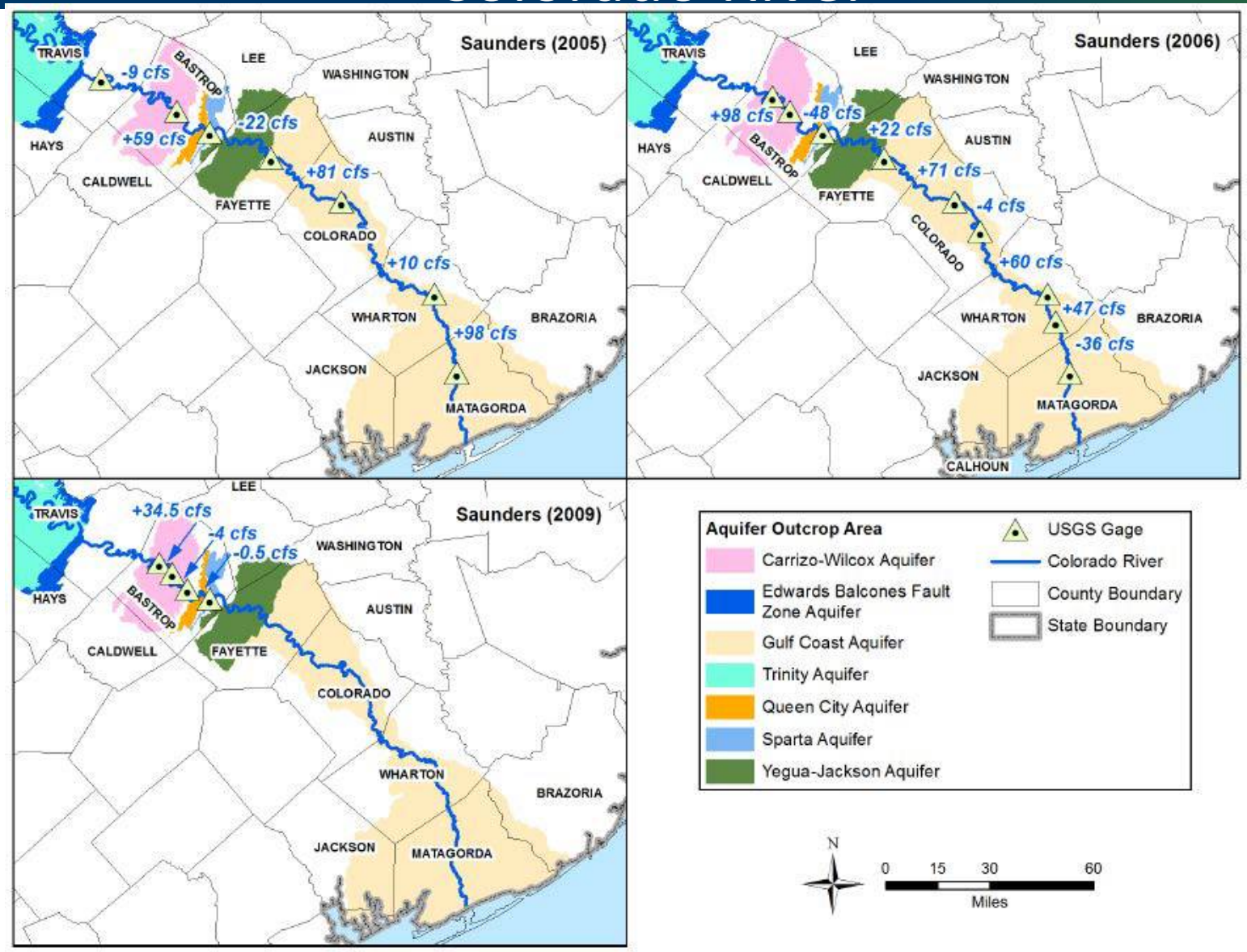




1 cfs = 720 AFY

* Preliminary results – should not be cited

Estimates of Gains and Losses Along Lower Colorado River



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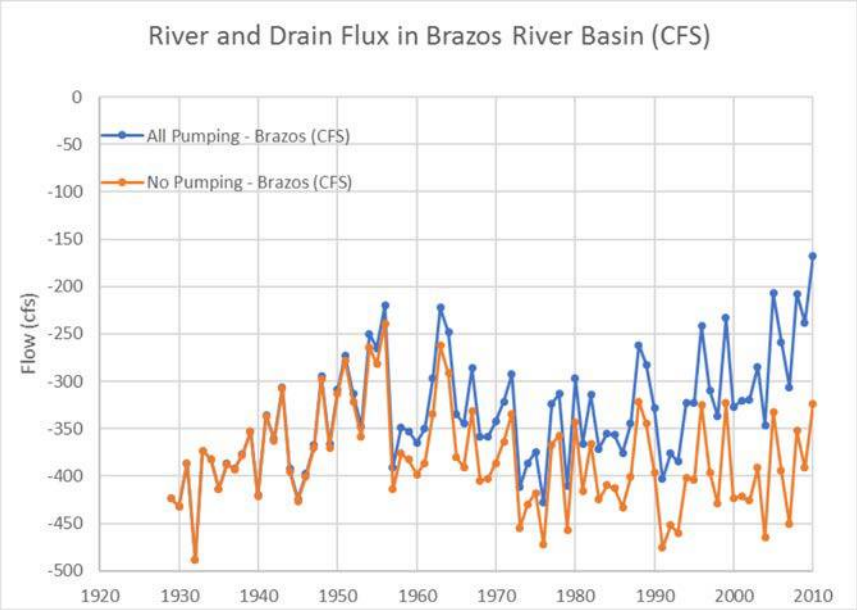
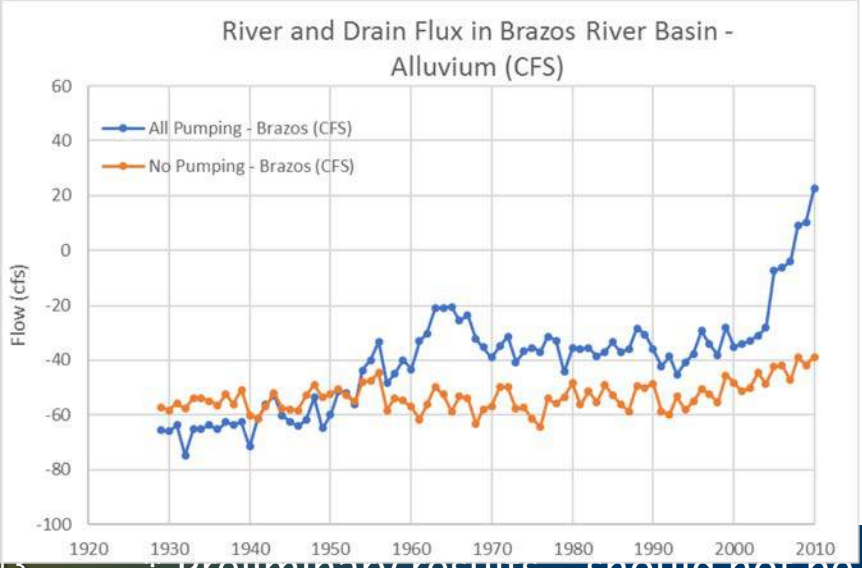
Brazos River Basin*

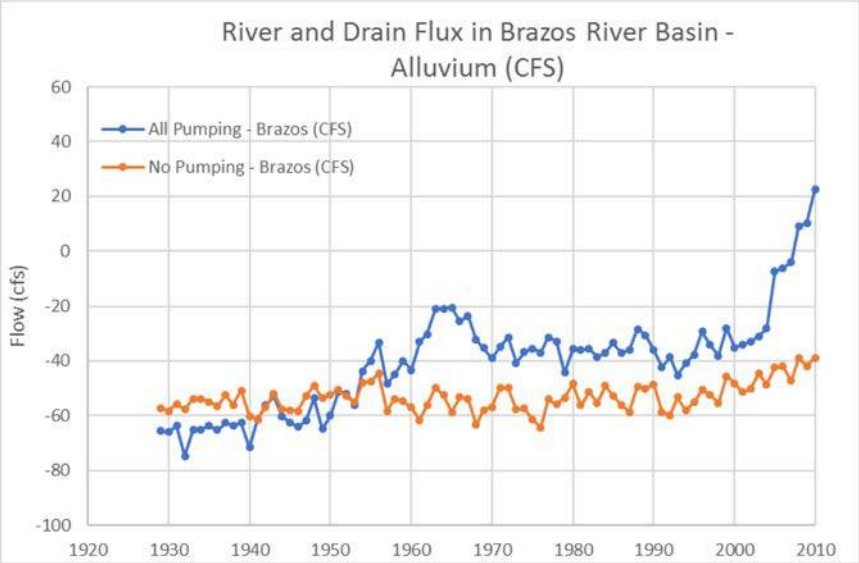


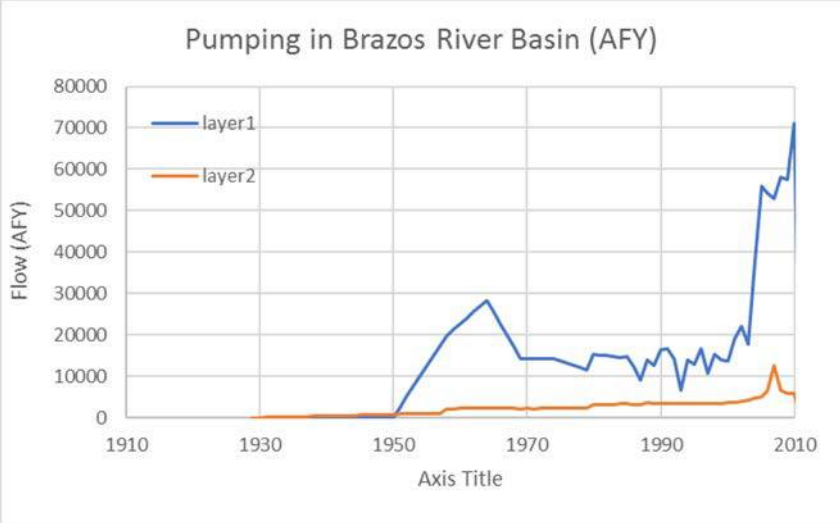


- About 400 cfs of groundwater flows into Brazos River/seeps/springs
- Variation in groundwater flow caused by changes in precipitation and pumping
- USGS gain-loss study provides unreliable estimates of groundwater flow to Brazos River
- Difference between lines is the amount of groundwater intercepted by pumping before it can reach springs/seeps/Colorado River
- In 2010, impacts of pumping of SW-GW interaction is about 10 cfs (~7300 AFY)

* Preliminary results – should not be cited

Brazos River Basin: Comparison of SW-GW Exchange and Shallow Pumping *

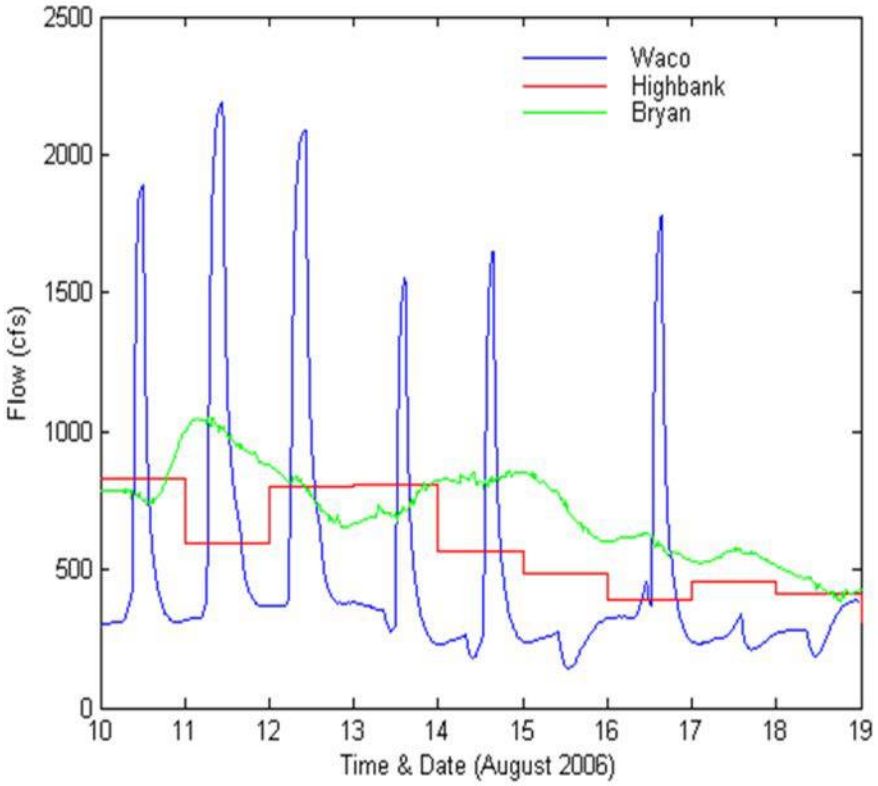


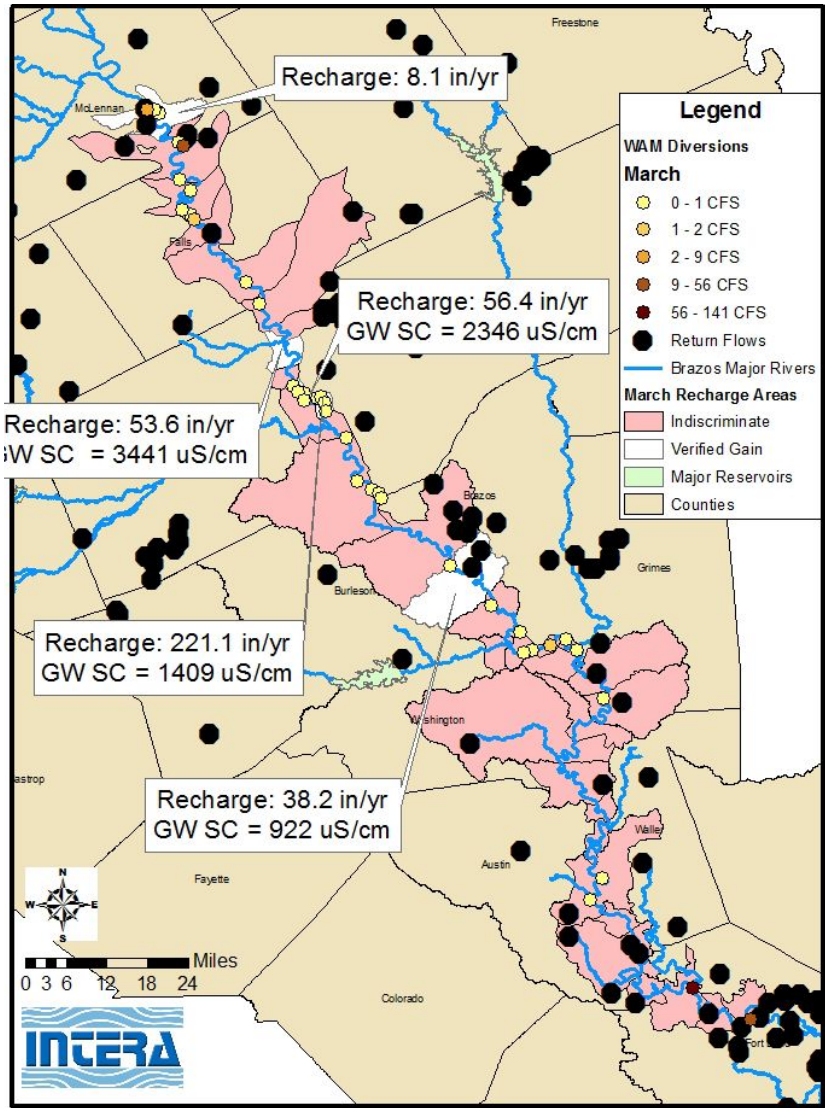


1 cfs = 720 AFY
60000 AFY = 83 cfs

* Preliminary results – should not be cited

Results from Brazos River Gain-Loss Study in 2010 and 2011





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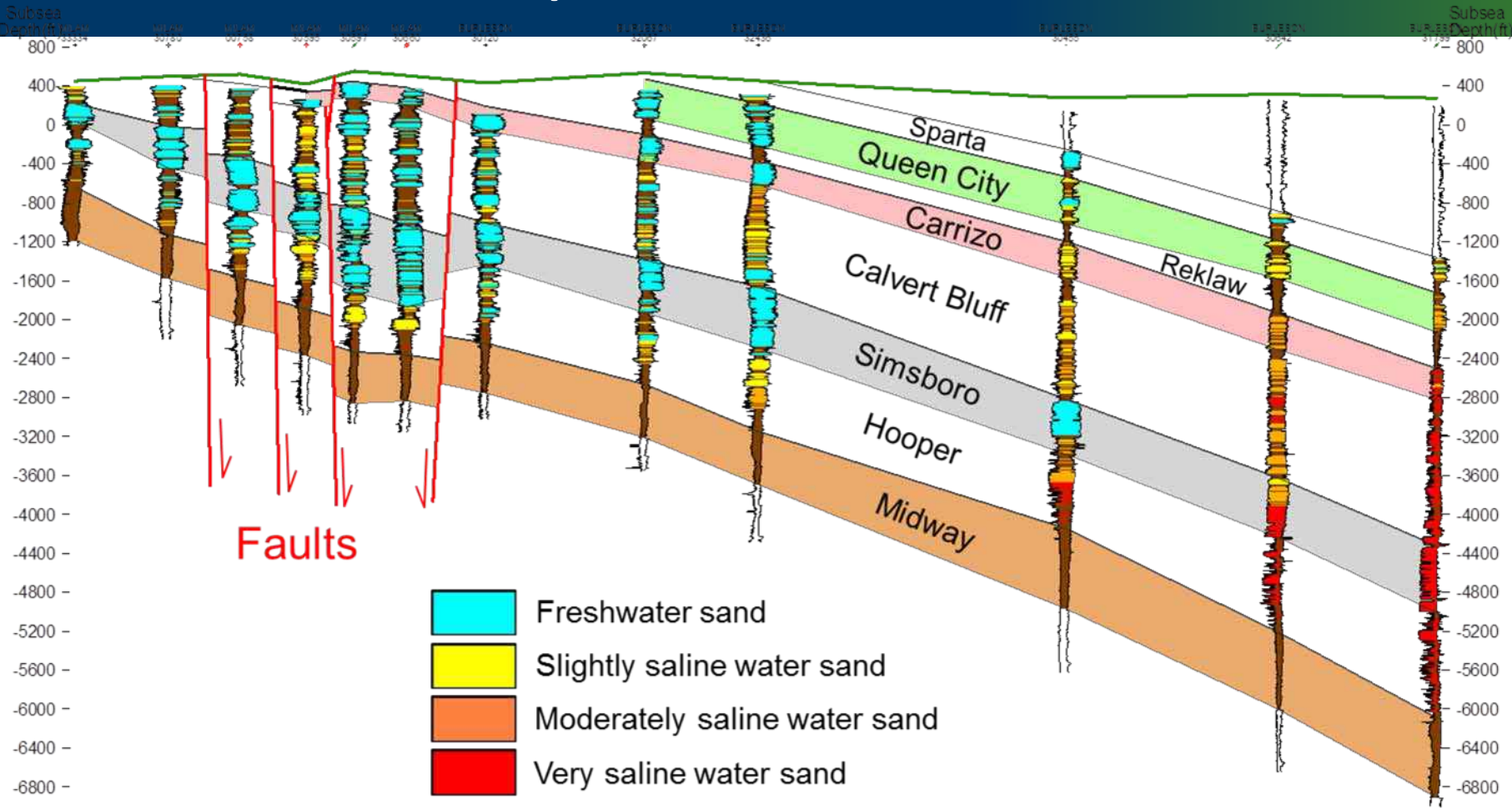
Water Quality

- Evaluation of methods for estimating Total Dissolved Solids (TDS) concentration in groundwater based on geophysical log
- Developing stratigraphic cross-sections showing sands, clays and water quality
- Compiling and Evaluating Brackish Rules used by other GCDs

Example Cross Section



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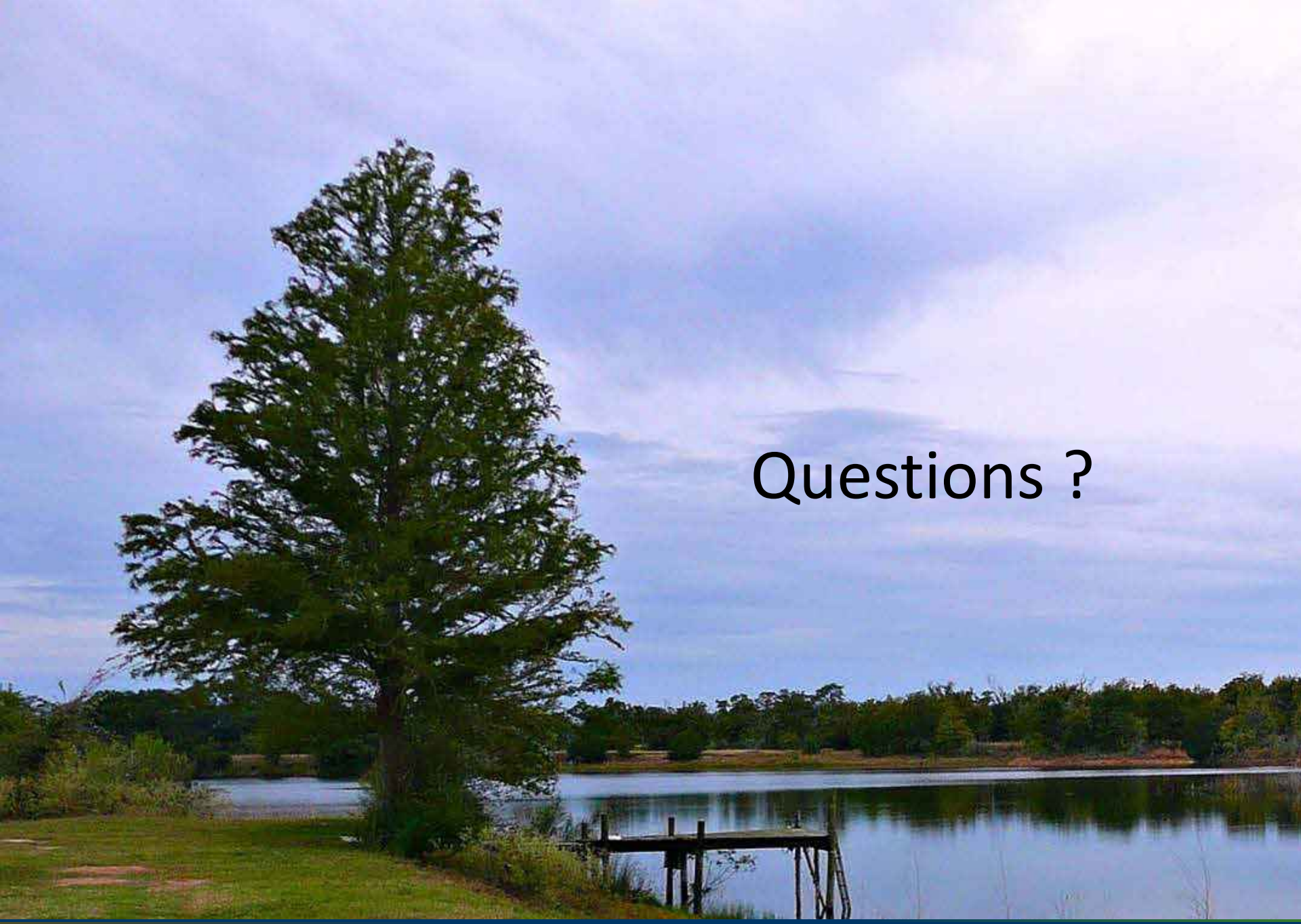
Questions ?