The best place in Bell County for ASR and why!

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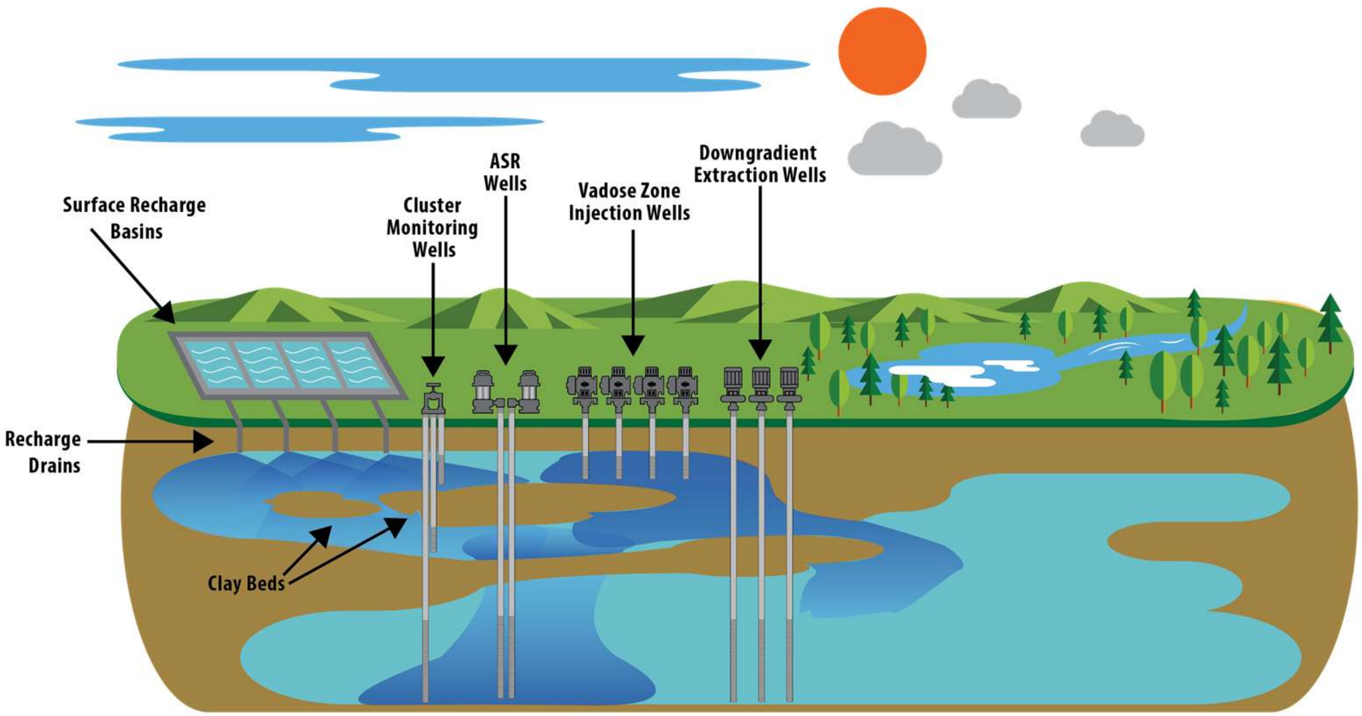
Outline

- Aquifer Storage Recovery (ASR) Defined
- Ongoing ASR Evaluations in Bell County
- ASR Objectives
- The Sweet Spot

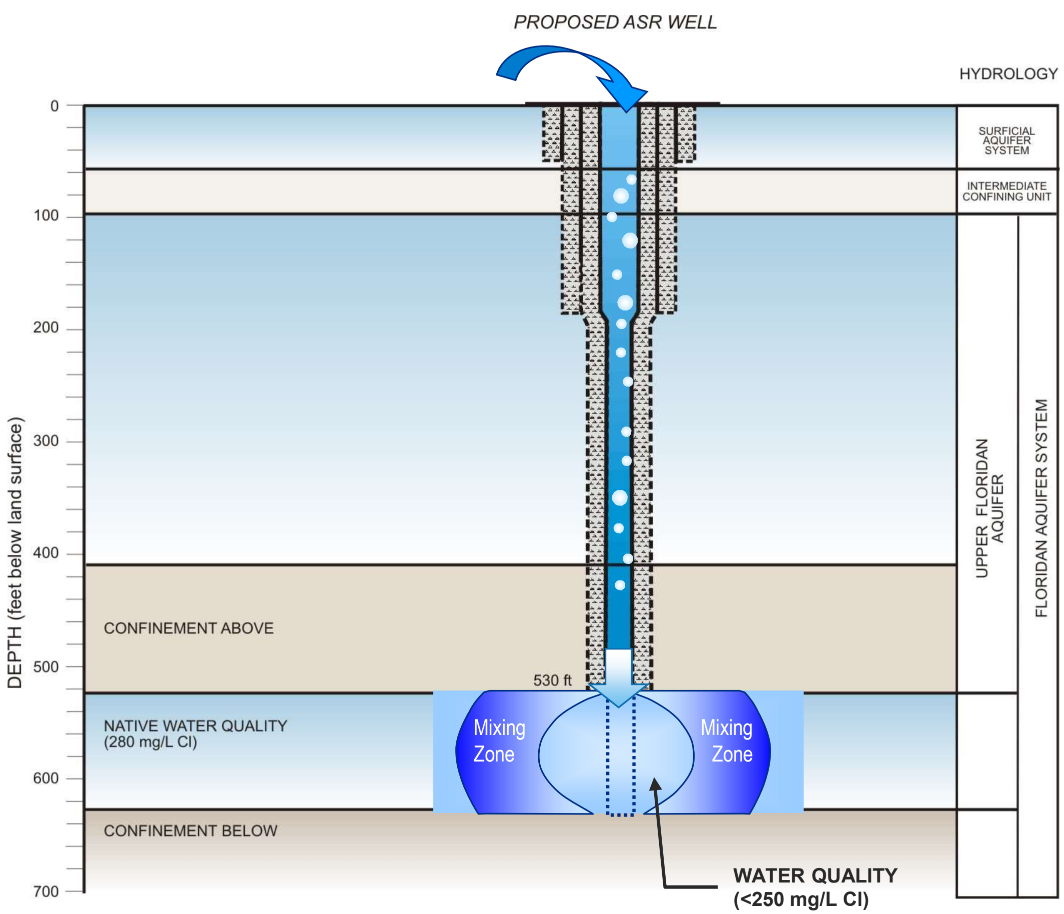
ASR Defined

Aquifer Recharge Technologies

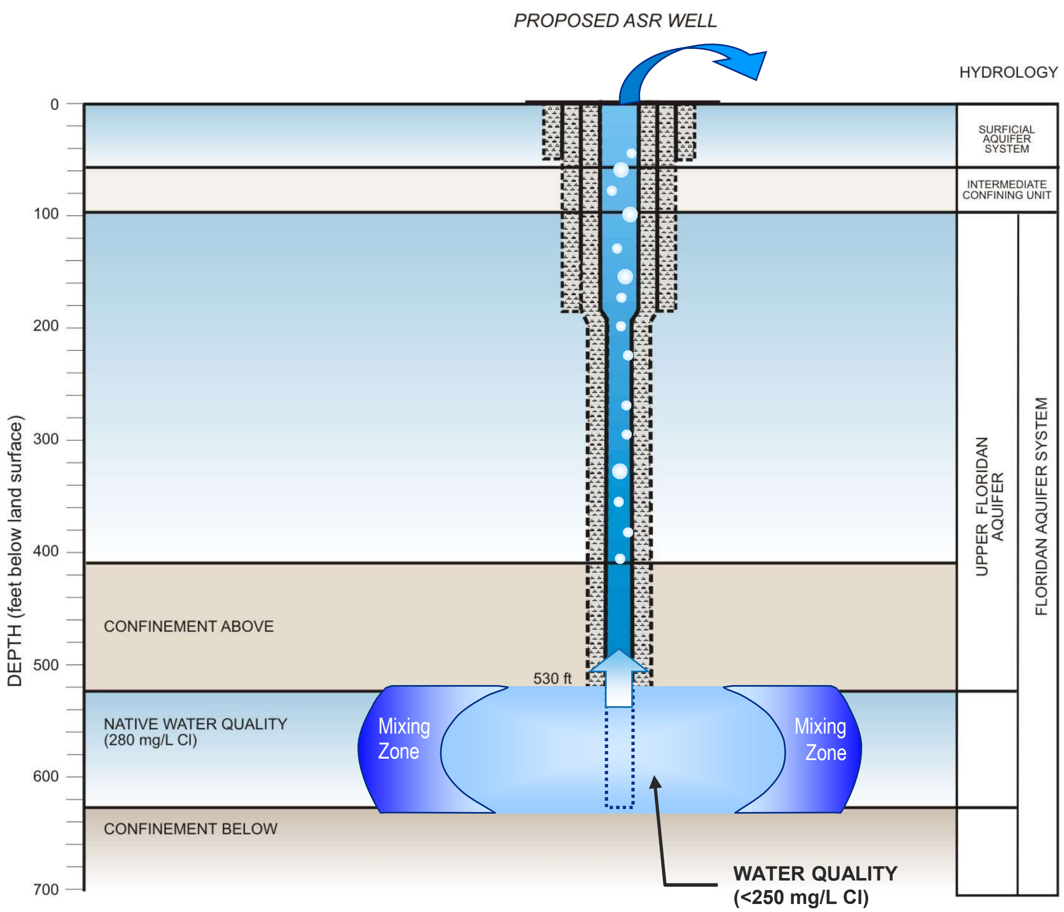


"ASR is one of several aquifer recharge technologies, tailored to the hydrogeologic environment and client needs"

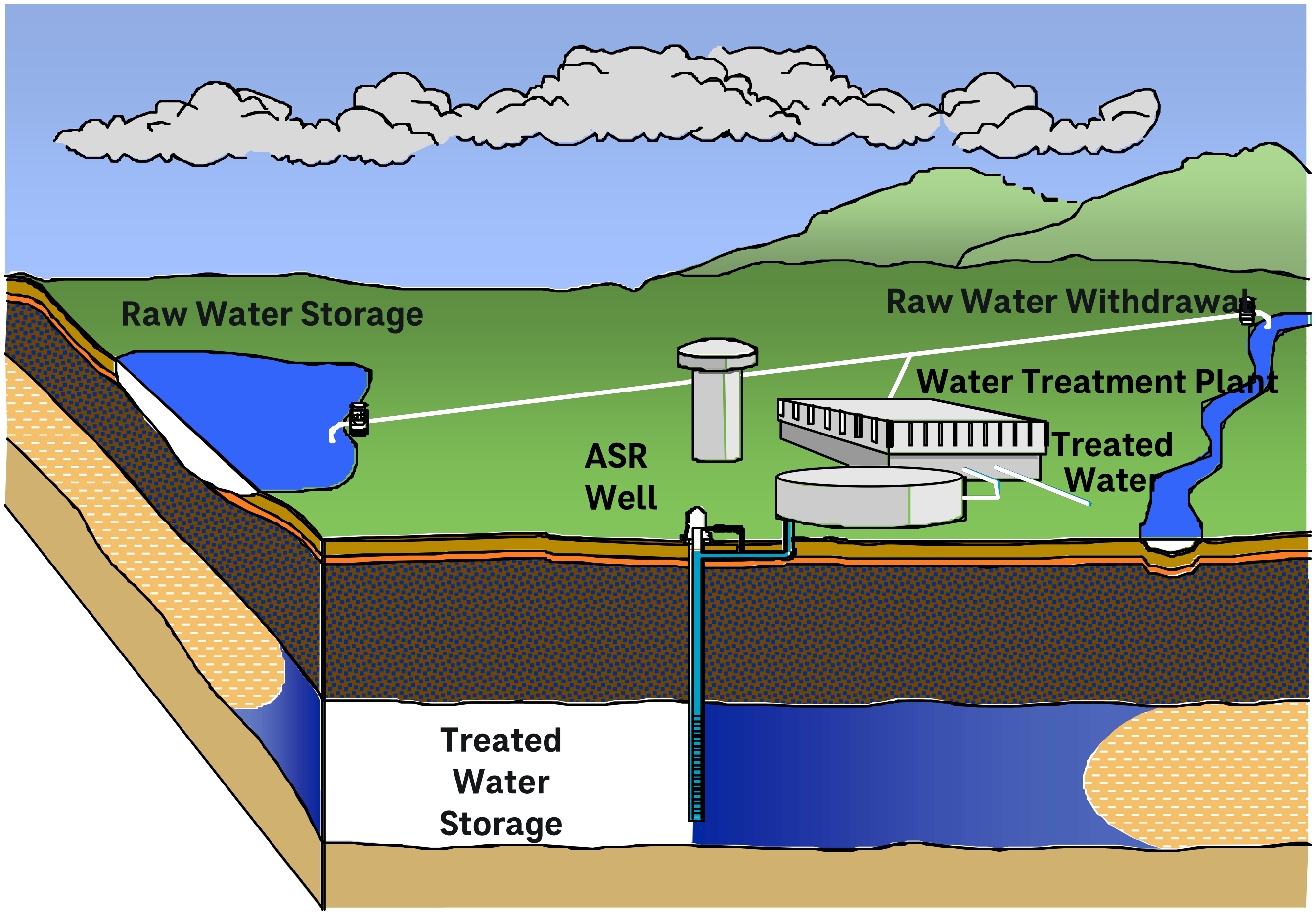
ASR Well Operation – Injection



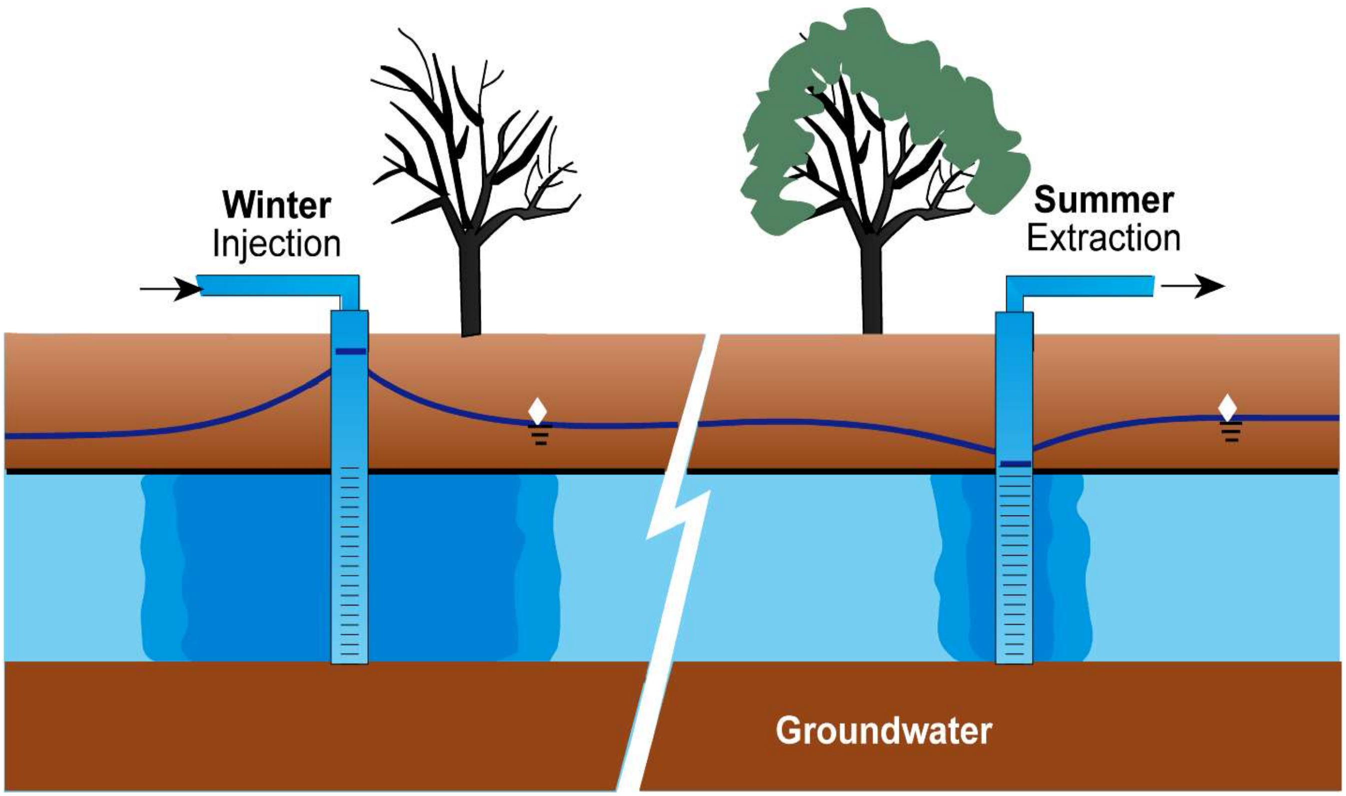
ASR Well Operation – Recovery



Typical Municipal Water ASR



ASR Defined (Seasonal)



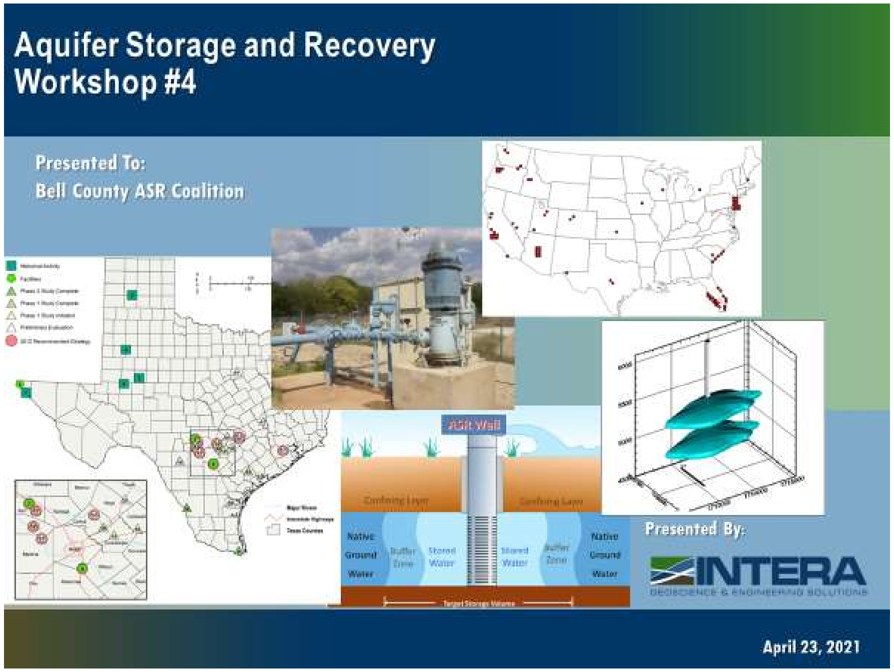
ASR Benefits Already Proven

- Storage
  - Seasonal storage
  - Long term storage (banking)
  - Emergency storage / supply
  - Reclaimed water storage for reuse
- Operation/Infrastructure
  - Defer expansion of water facilities
  - Peak demand management
  - Maintain distribution pressures
- Impacts
  - Evaporation management
  - Environmental river flows / ecosystem maintenance
  - Restoration of groundwater levels
  - Control subsidence

Ongoing Evaluations in Bell County

ASR Feasibility

- INTERA, with the help of others have performed desktop evaluations of ASR feasibility for Clearwater GCD and member participants, with emphasis on groundwater modelling tools.
- Multiple public ASR workshops held
- Independent feasibility assessments underway



All Candidate Sites

Hosston Properties

Thickness (ft): 80 - 1000
Transmissivity(ft^2/day): 680 - 23,500
Water Level (ft, msl) : 418 – 582
Hydraulic Gradient(ft/ft): 0.0001 –0.0003

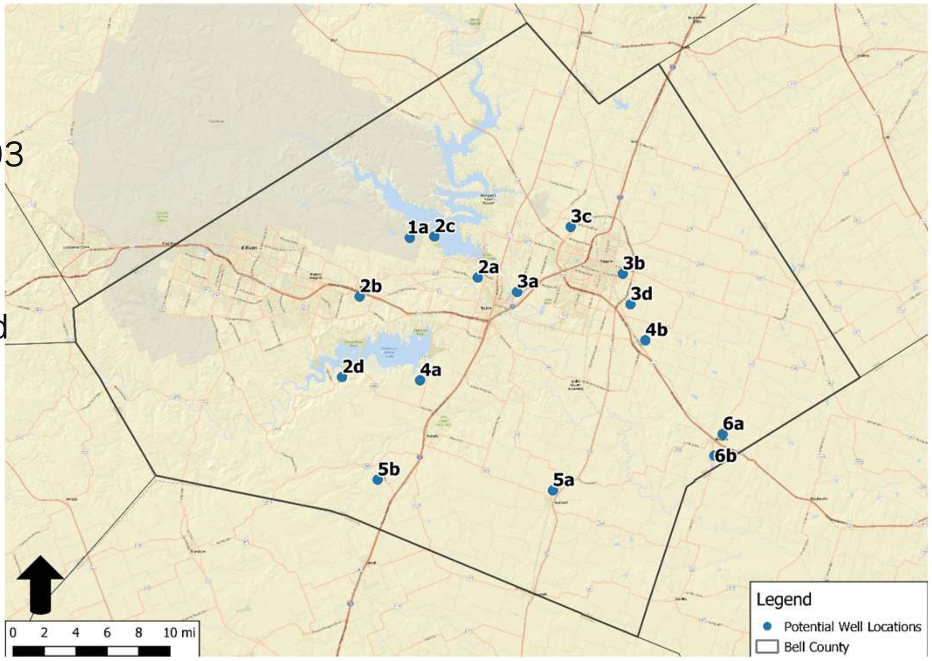
Phase 3 Evaluations

2a, 2b, 2c, 2d (WCID #1) - not evaluated
3a (City of Temple) - not evaluated

Phase 3 ASR Operations

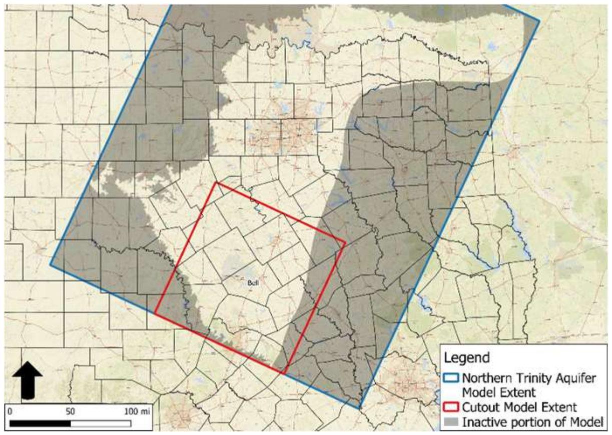
Recovery Rate (MGD): 0.6 – 6.5
Duration (months): 0.5 - 12
Storage Volume (MG) : 82 – 2,196

15 Candidates Sites Established in Phase 1

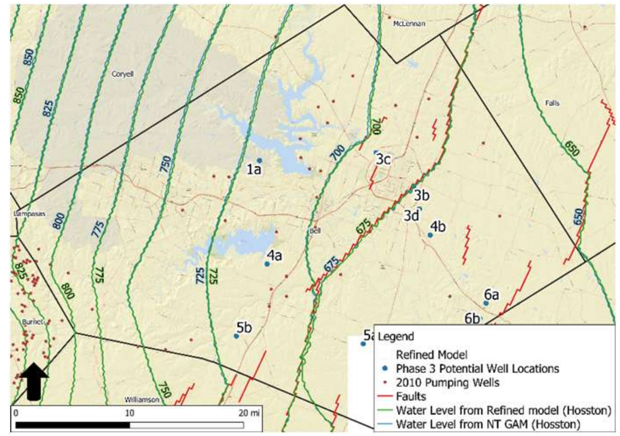


Modeling Approach for Workshop #4

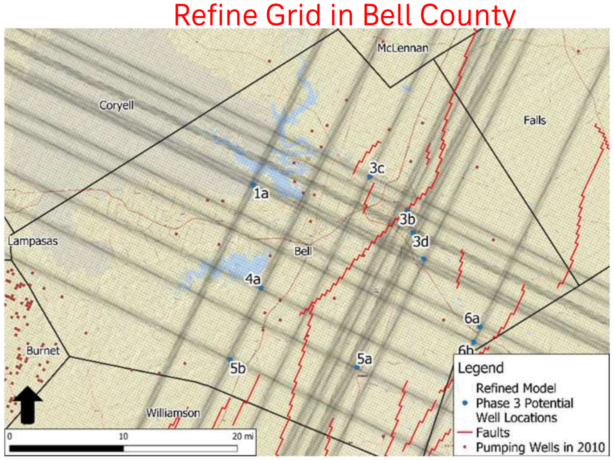
Construct Bell County Model from NTGAM



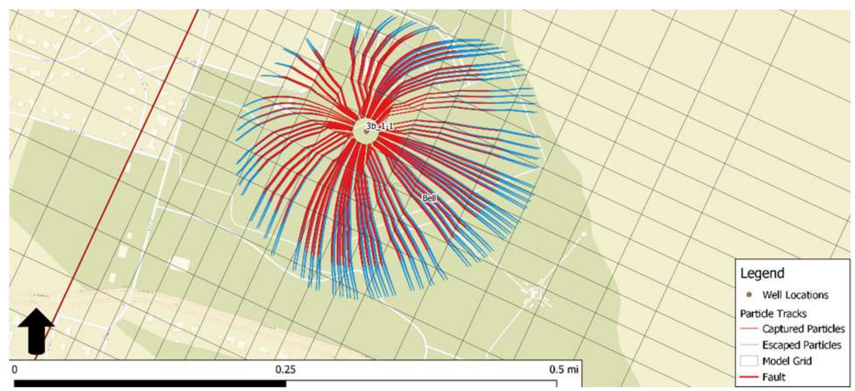
Validate Bell County Model Simulation with NTGAM



Refine Grid in Bell County



Perform Particle Tracking



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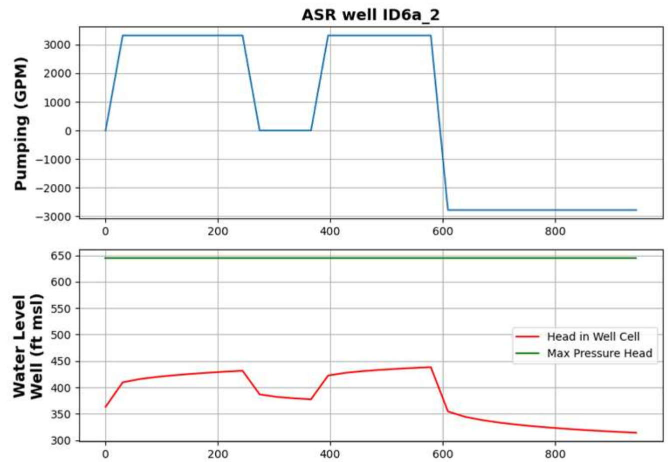
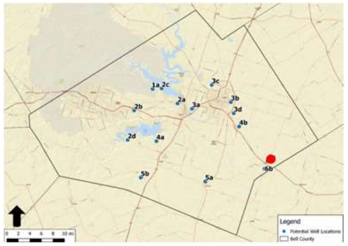
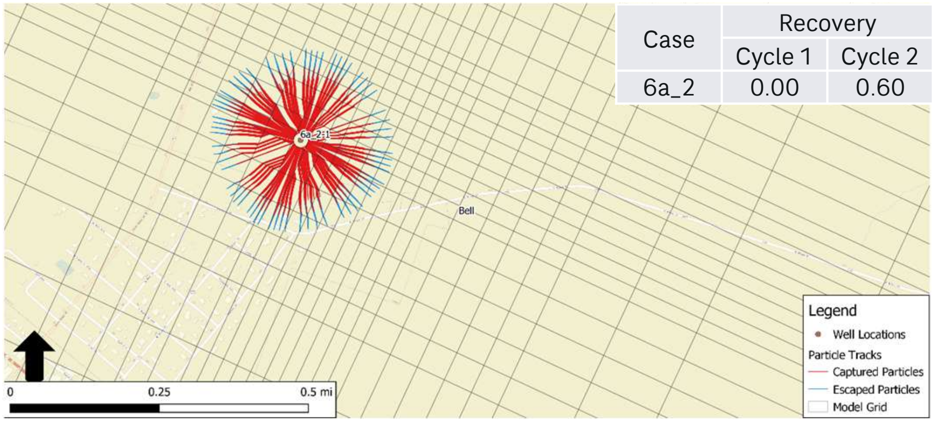
City of Rogers: Site 6a

Site Info
Run ID: 6a_2
Entity: City of Rogers
Location: North of Town
ASR Operation
Purpose:Drought Supply
Recovery Rate (MGD): 4.0
Recovery Duration(months): 12
Hosston Info
Total Thickness (ft): 960
Transmissivity(ft2/day): 20,155
Depth (ft): 2,800
Water Level Info
Static Level (ft, msl): 363
Hydraulic Gradient(ft/ft): .0002
Max Draw Up(ft): 96
Max Drawdown(ft): 66
Well Info
Number: 1
Spacing(ft): na
Screened Interval (ft): 200
Max Injection(gpm): 3,319
Max Pumping (gpm):2,778







Case	Recovery	
	Cycle 1	Cycle 2
6a_2	0.00	0.60

INTERA GEOSCIENCE & ENGINEERING SOLUTIONS

ASR Objectives

Recharge Objectives

- The rates and volumes of water that need to be recovered impact hydrogeologic suitability
  - Thicker more porous aquifers can store significantly larger volumes
  - More permeable formations allow higher injection and recovery rates
  - Less permeable and/or thinner aquifers still potentially viable, but for smaller ASR systems
- Often the ideal hydrogeological situation does not coincide with locations with excess water or demand centers

Recharge Source Waters

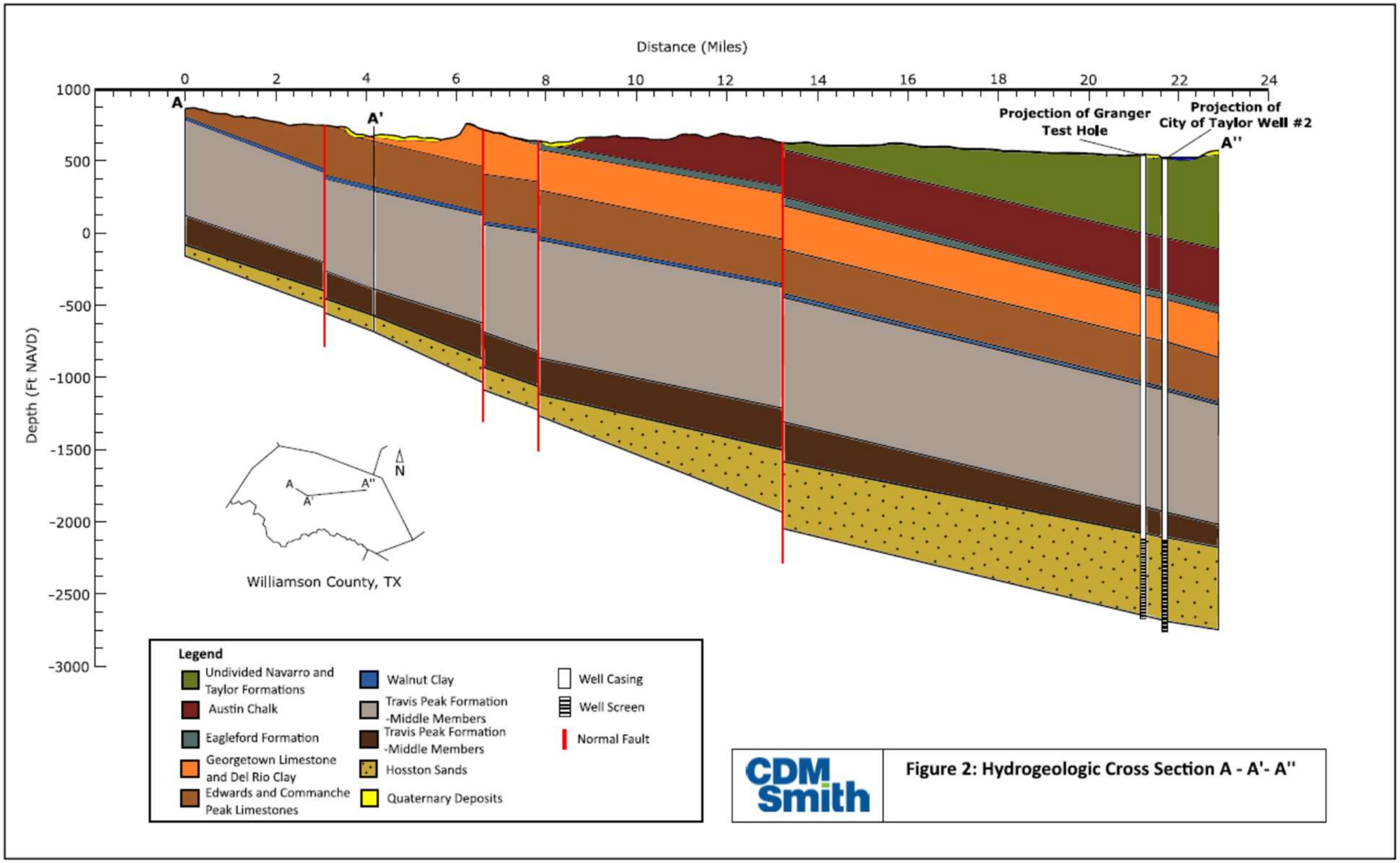
- Multiple source waters possible
  - Surface water
  - Treated stormwater or reservoir flood pool
  - Groundwater from other aquifers
  - High quality reclaim water
- TCEQ UIC sole permitting agency provided water recovered does not exceed the volume recharged
- Water quality standards for recharge in Texas under review

The Sweet Spot!

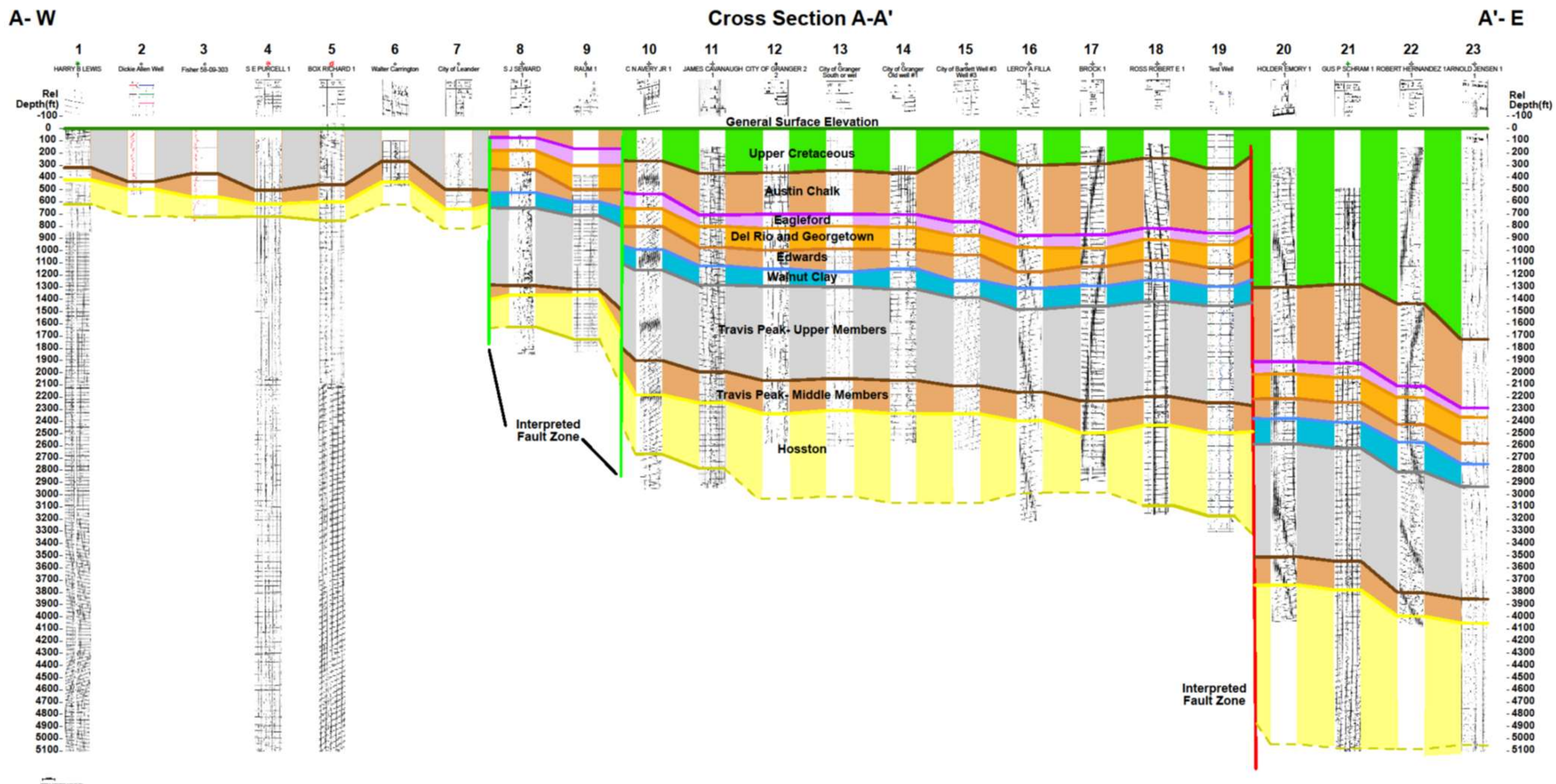
Geologic Units Potentially Suitable for ASR

Age	Stratigraphic Group	Stratigraphic Unit	Hydrogeologic Unit	Lithologic Description	Hydrogeologic Description	Range of Thickness (ft)	Potential Suitability for ASR
Cretaceous	Navarro		Navarro and Taylor Groups	Massive beds of shale and marl with clayey chalk, clay, sand and some nodular phosphatic zones	Yields very small quantities of freshwater	820	Likely unsuitable
	Taylor						
	Austin		Austin Chalk	Massive beds of chalk and marl with bentonite seams, glauconite and pyrite nodules	Yields small to very small quantities of freshwater	425	Unlikely to store sufficient water, and unconfined throughout much of the GUS area
	Eagle Ford			Massive calcareous shale with thin interbeds of silty and sandy flaggy limestone	Not known to yield water	30	Unsuitable
	Washita	Buda Limestone		Massive, fine grained, burrowed, shell-fragment limestone	Not known to yield water	50	Likely unsuitable
		Del Rio Clay		Clay and marl with gypsum, pyrite and a few thin siltsone and sandstone beds	Not known to yield water	60	Confining Layer
		Georgetown Formation	Edwards and associated limestones	Thin interbeds of richly fossiliferous, nodule, massive, finegrained limestone and marl	Yields small to very large quantities of freshwater, especially from cavernous zones	90	Unconfined aquifer over large parts of GUA area, already heavily used for local agricultural and domestic supply. Possible use in confined down-dip areas, but well yields unproven
	Fredricksburg	Kamichi Formation		Marl, thin limestone seams and shell aggregates	Not known to yield water	15	
		Edwards Limestone		Massive, brittle, vugular limestone and dolomiet with nodular chert, gypsum, anhydrite and solution collapse features	Yields small to very large quantities of freshwater, especially from cavernous zones in the Edwards limestone	185	
		Comanche Peak Limestone		Fine-grained, fairly hard, nodular fossiliferous marly, extensively burrowed limestone	Yields little or no water	50	
		Walnut Formation		Hard and soft limestones, marls, clays and shell beds	Yields little or no water	110	
	Trinity	Paluxy Formation	Upper Trinity	Fine-grained quartz sand, in part undurated by calcium carbonate cement. Locally contains thin beds of limestone and marl	Yields very small to moderate quantities of fresh to moderately saline water	10	Formation thickness not suitable
		Glen Rose Upper member		Alternating beds of limestone, dolomite, shale and marl with some anhydrite and gypsum		430	Worth investigating, but alternating lithologies may be problematic
		Glen Rose Lower member	Middle Trinity	Massive, fossiliferous limestone and dolomite in the basal part grading upward into thin beds of limestone, shale, marl and gypsum	Yields very small to moderate quantities of fresh to moderately saline water	430	
		Hensell Sand Member		Sand, gravel, conglomerate,sandstone, siltstone and shale. Grades into sandy limestone and dolomite eastwards		75	
		Cow Creek Limestone Member		Massive, often sandy, dolomitic limestone, contains gypsum and anhydrite beds		80	Potential water quality issues due to anhydrites
		Hammett Shale Member		Shale and Clay	Not known to yield water in this area	30	Confining Layer
		Hosston Member	Lower Trinity	Basal sand and conglomerate grading upward into a mixture of sand, siltstone and shale with some limestone beds	Yields small to moderate, and with acidizing large quantities of fresh to moderrately saline water	100 - 815	Potential for ASR. Suitable isolation with overlying Hammett Shale and underlying Lower Pensylvanian Shales. Potential high yields to the east with increased sand thickness

Generalized Regional Hydro-geologic Cross Section

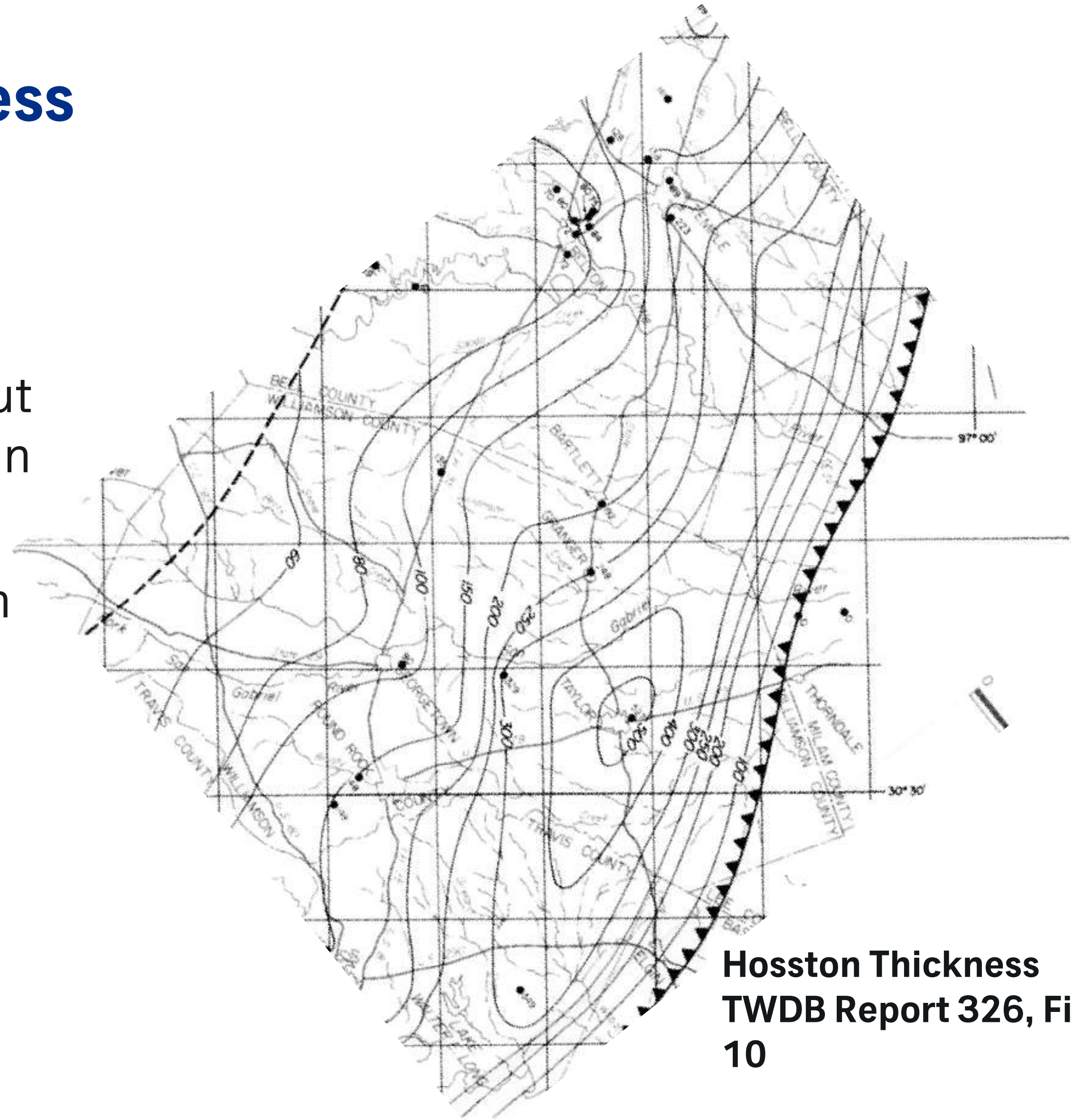


Hydrogeologic Cross Section – Geophysical Log Interpretation



Hosston Aquifer Thickness (limited data)

- In western Bell and Williamson County Hosston geometry reasonably well understood, but generally poor understanding in the east of both counties
- Increasing thickness and depth eastwards
- Not shown, complex fault geometry



Hosston Thickness TWDB Report 326, Figure 10

Think Strategic!

- Potential ability to store large volumes of water equivalent to a surface reservoir
- Key constraints:
  - Limited hydrogeologic knowledge and test well drilling needed
  - Conveyance costs potentially high
  - Alternate recharge sources to be considered
  - Increasing depths to the Hosston aquifer eastwards

listen. think. deliver.

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