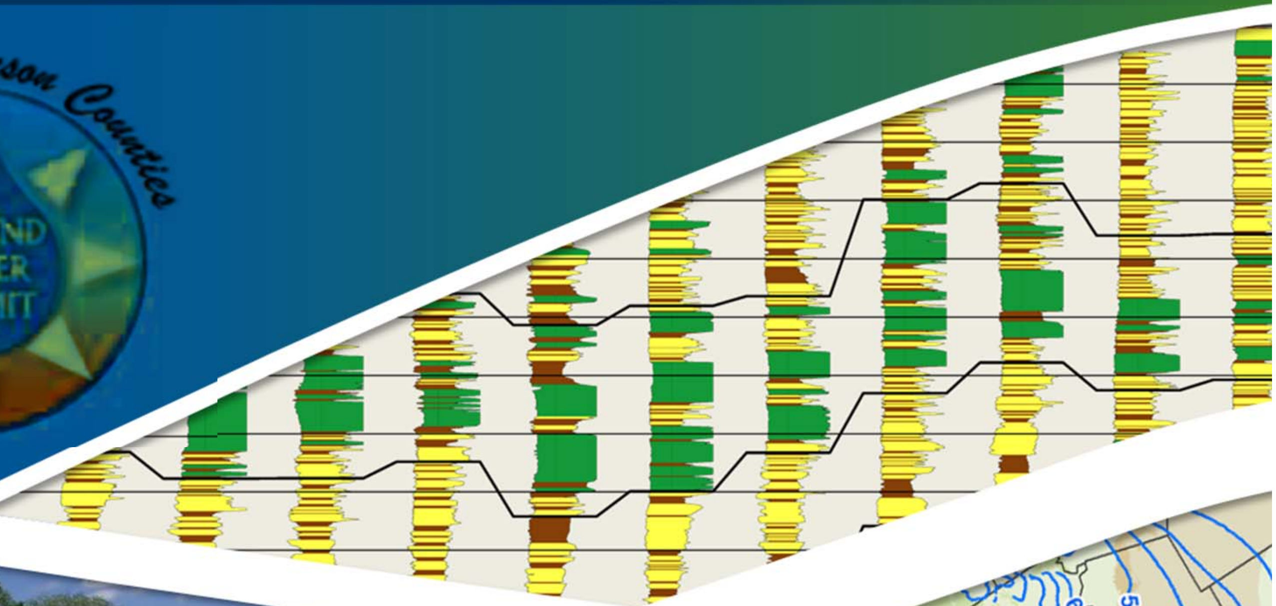
Aquifer Storage Recovery

A Presentation to:

Milam & Burleson Counties Ground Water Summit



Presented by:
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August 12, 2015

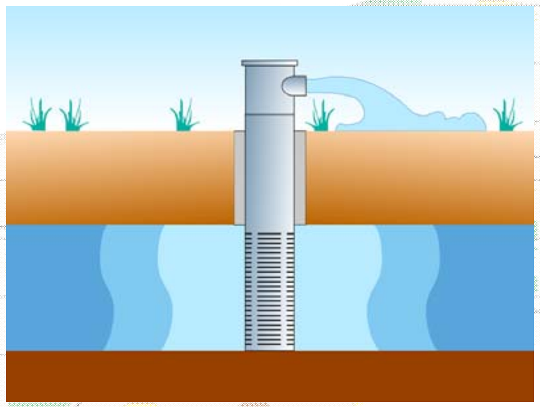
Presentation Outline

- ASR Introduction
  - What is it?
  - How is it used?
  - Where is it currently being used?
  - What are some advantages/disadvantages compared to surface storage?
- Modeling to help answer questions about ASR
- Phase 1 Approach: Case Study for New Braunfels Utility

What is ASR?

"…the storage of water in a suitable aquifer … during times when water is available, and recovery of that water … during times when it is needed."

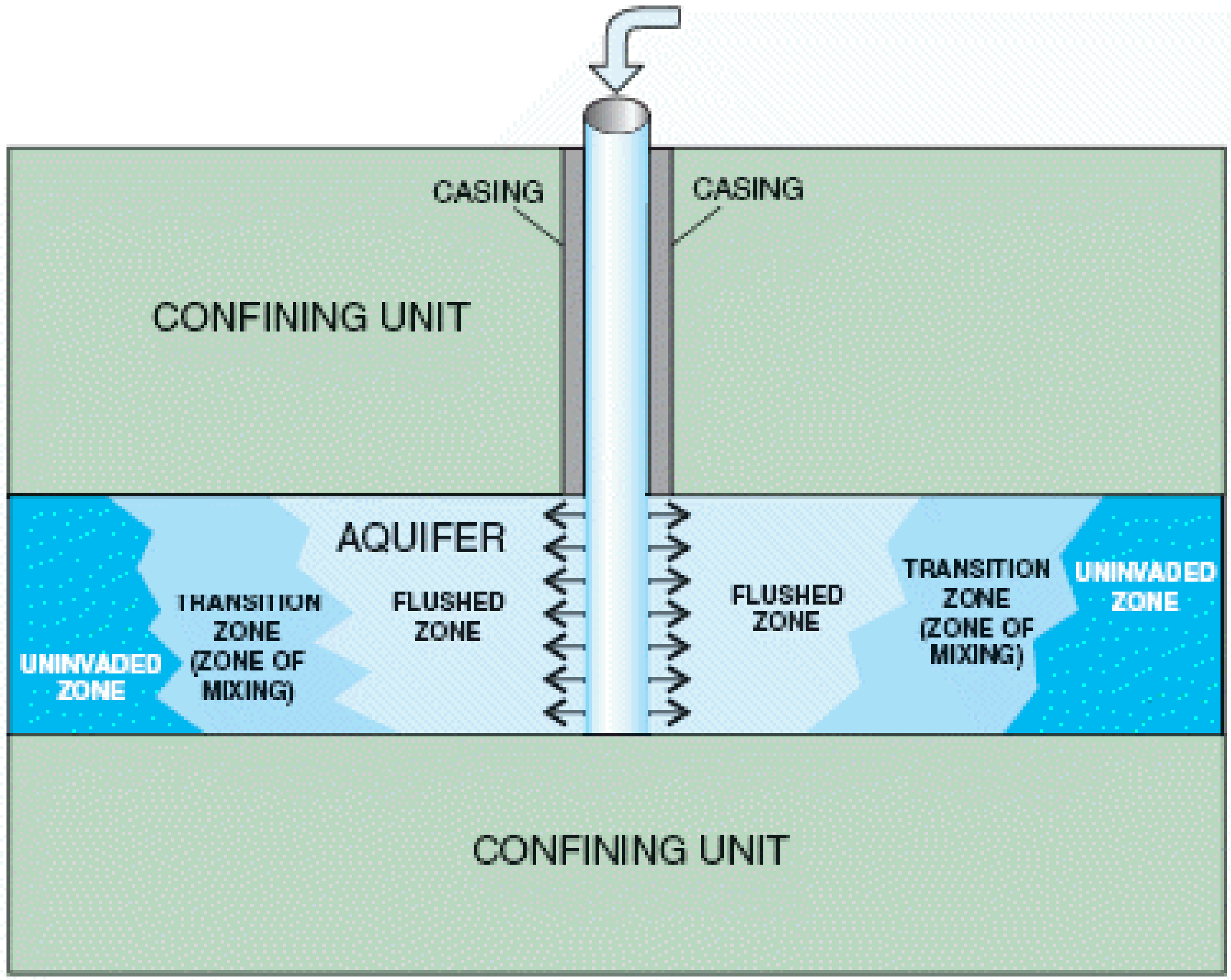
- David G. Pyne, P.E.
ASR Systems, LLC



What is ASR?

Focus of this presentation is ASR using wells in the saturated zone

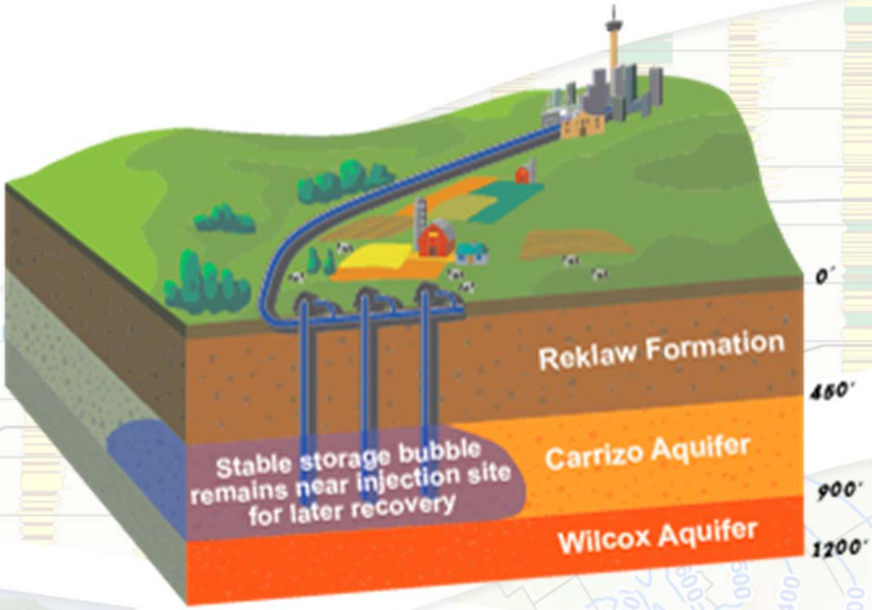
Other types may include recharge basins or vadose zone wells



USGS, 2004

What are the typical objectives?

- Water banking (long term storage)
- Seasonal storage
- Peak or emergency water needs
- Maintain distribution system flows and pressures
- Many other applications….

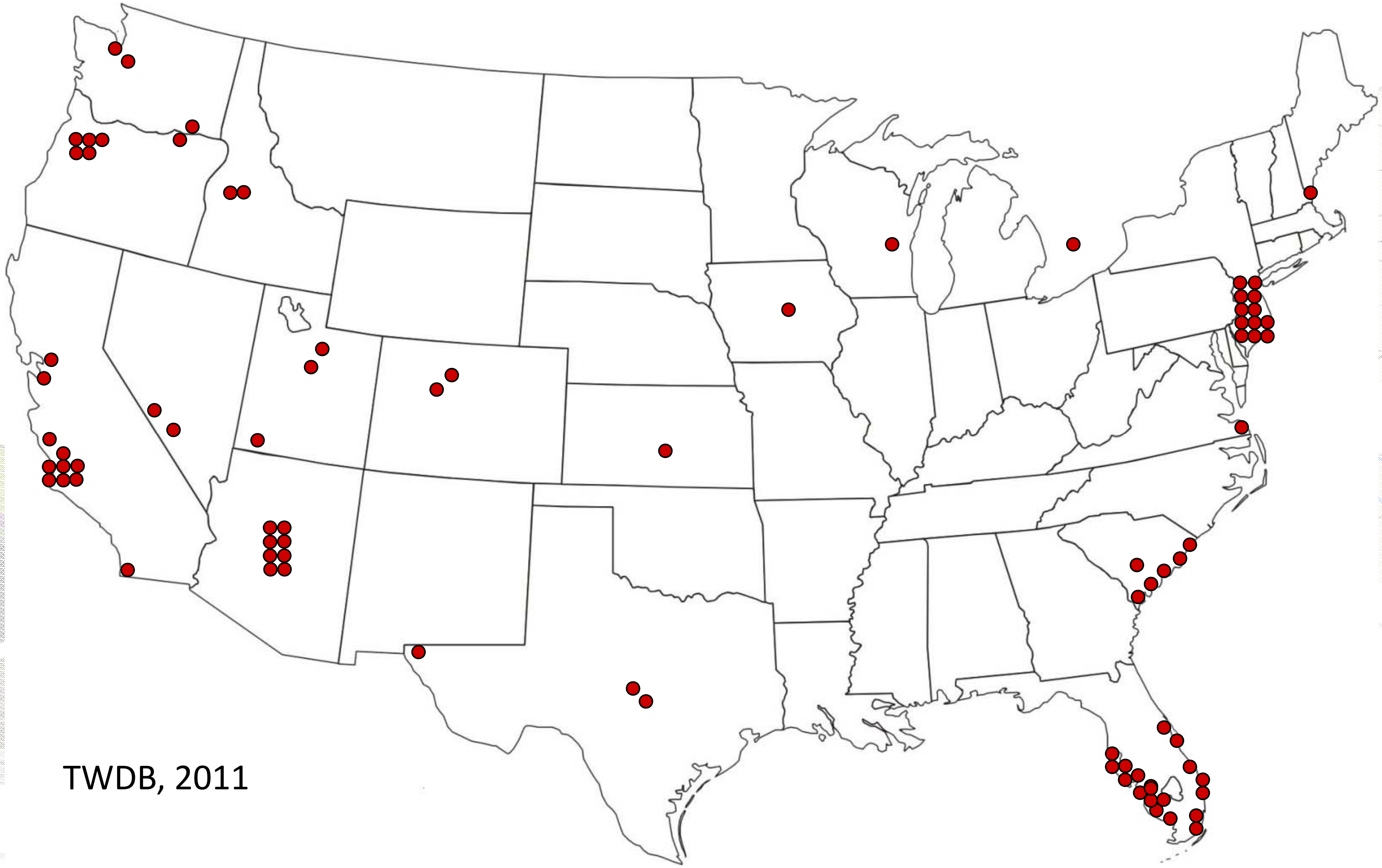


SAWS, 2015

ASR Feasibility considerations

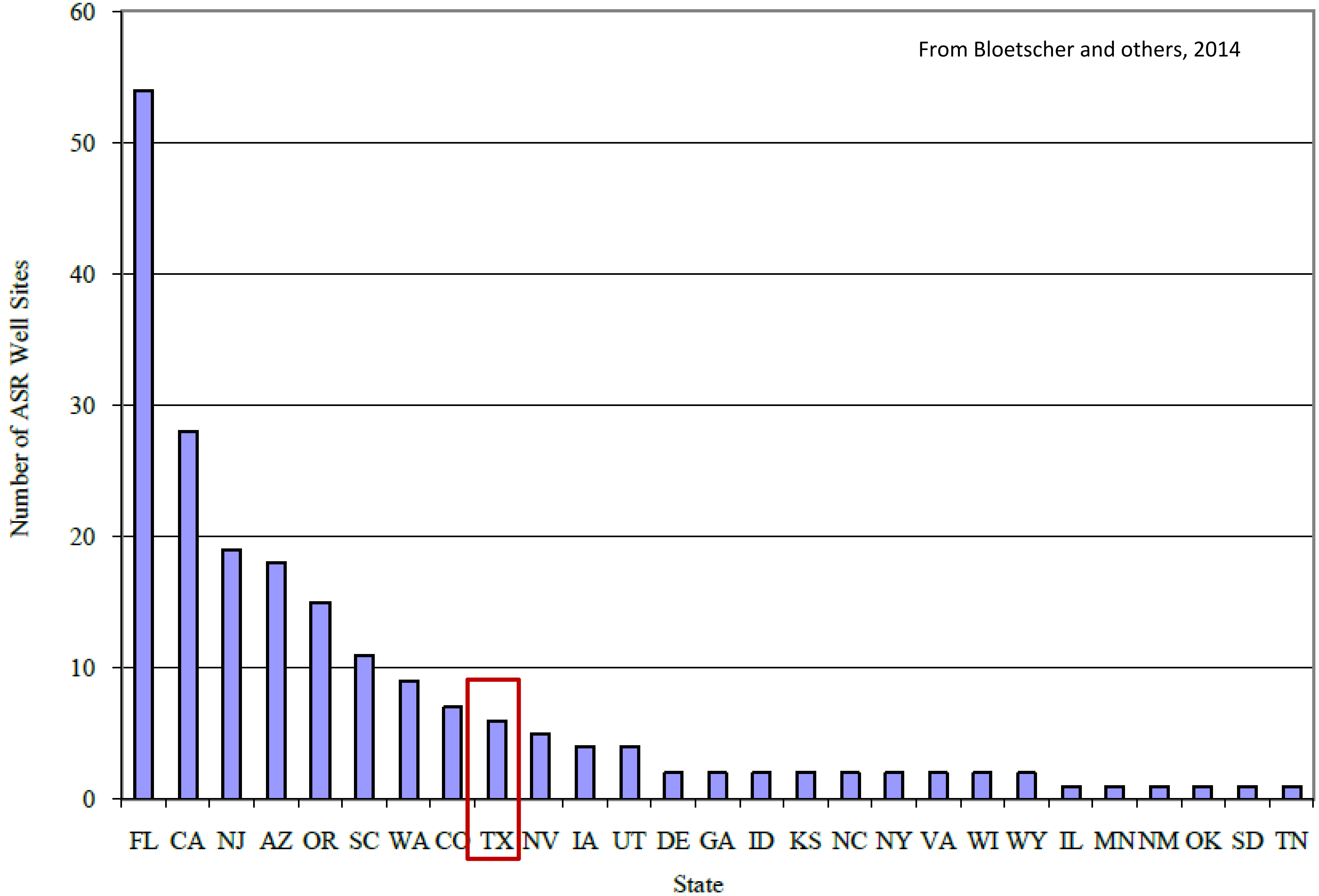
- Need for storage
- Excess water availability
  - Seasonal
  - Long term
  - Reuse
- Sufficient Land Holdings/Water Rights
- Compatible Hydrogeology
- Economic competitiveness with other options

Where is ASR being used?



TWDB, 2011

Where is ASR being used?

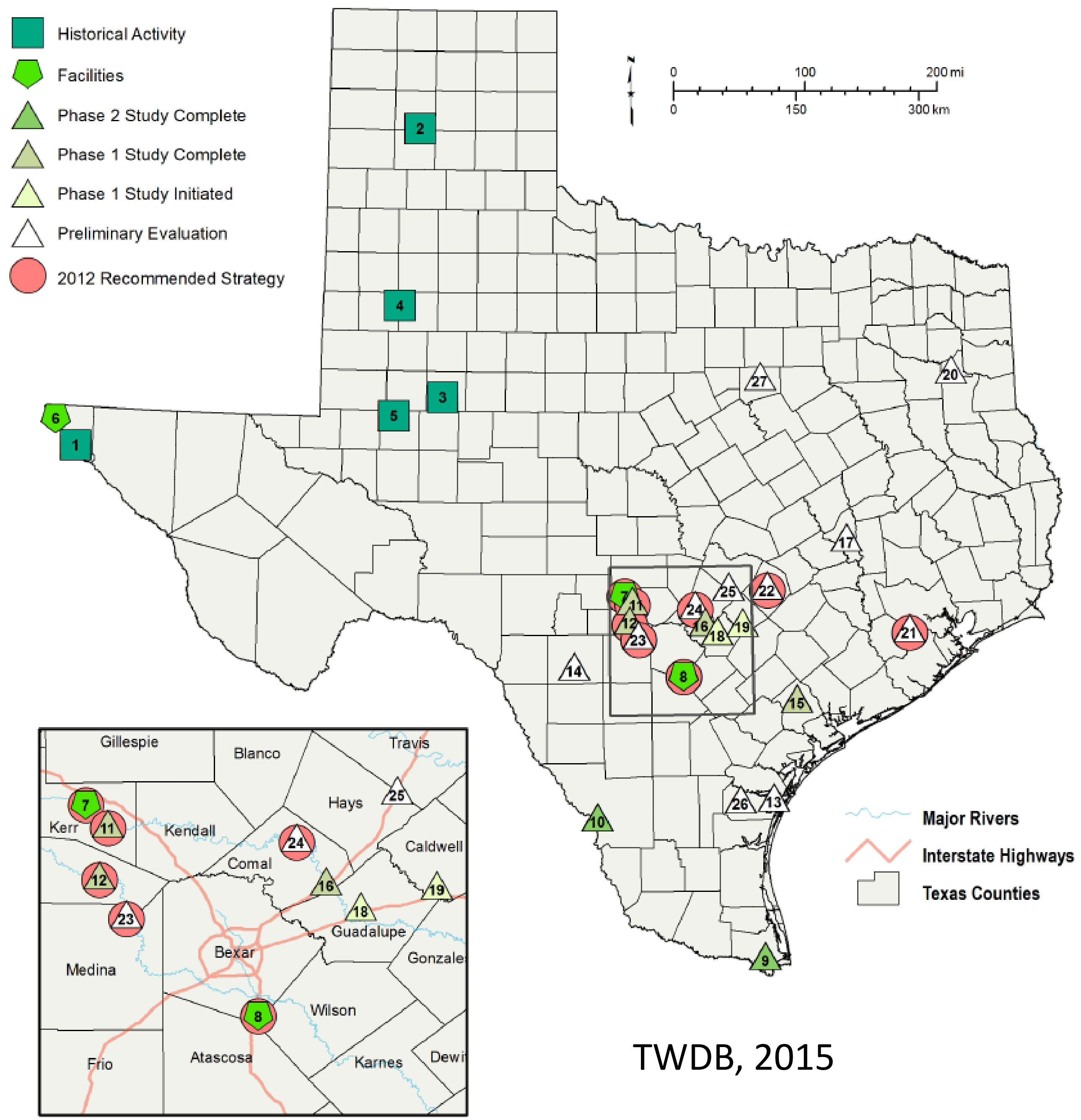


Where is ASR being used?

Historical: El Paso, Amarillo, CRMWD, High Plains, Midland

Today: San Antonio, Kerrville, and El Paso

Studying/studied: Many



TWDB, 2015

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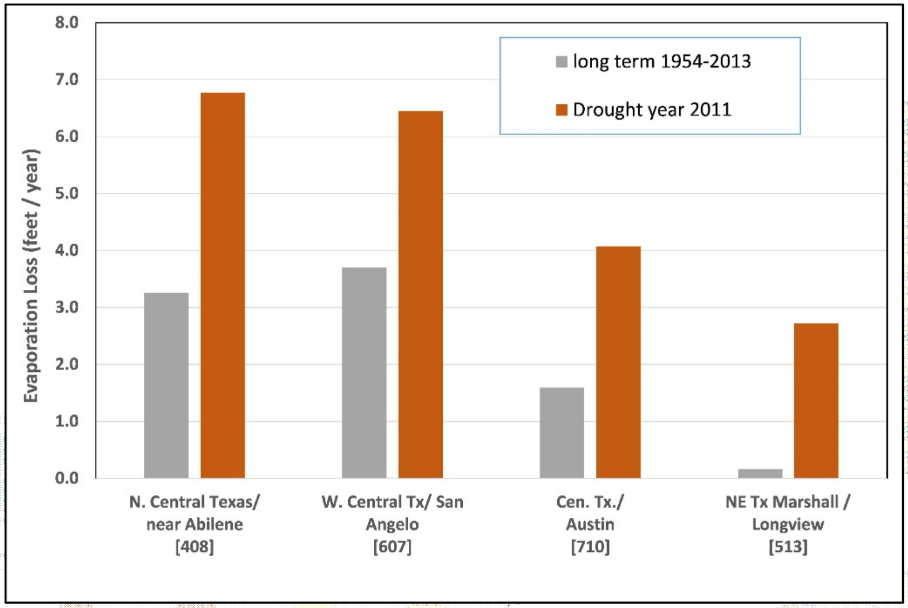
Potential Advantages over Surface Storage

- No evaporation
- No surface inundation
- No sedimentation
- Scalable



The need for surface inundation is typically one of the major obstacles in getting a reservoir built

The 2007 State Water plan indicates a loss of 90,000 AF annually to sedimentation in TX reservoirs

In 2011, the Highland Lakes System lost an estimated 192,000 AF evaporation.

The same year, City of Austin used 168,000 AF from the system.

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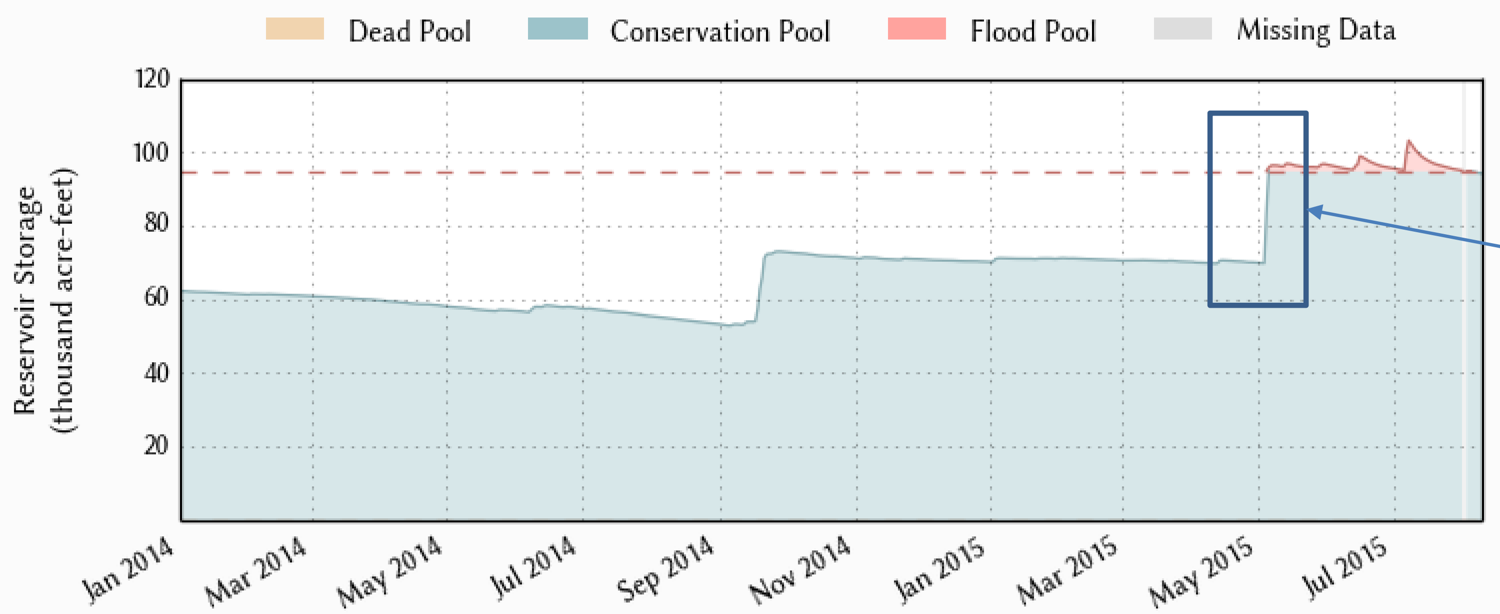
Potential Disadvantages compared to Surface Storage

- No fishing!
- Storage rate comparably limited

25,000 AF/month is comparable to about 185 1,000 gpm recharge wells



Lake Alan Henry gained 25,000 AF of storage in May 2015

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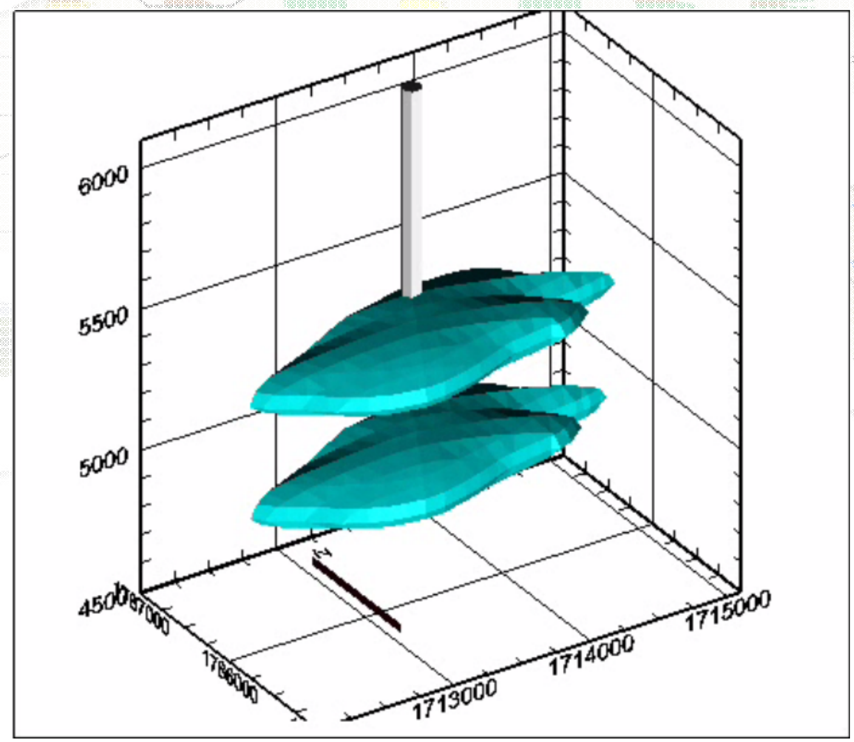
Modeling ASR

- What questions can a model help answer?
  - Recovery efficiency
  - Injectate bubble dimension and distribution
  - Scaling up to multiple wells
  - Geochemical effects
- When should a model be built?
  - Scoping level to help design test well program
  - Detailed level after test well program



Typical Concerns for those Contemplating ASR

- Ability to recover stored water
- Quality of recovered water,
- Cost effectiveness of aquifer storage and recovery, and
- Potential for others to recover the stored water

Summarized from TWDB, 2011
Based on a survey of 22 utilities

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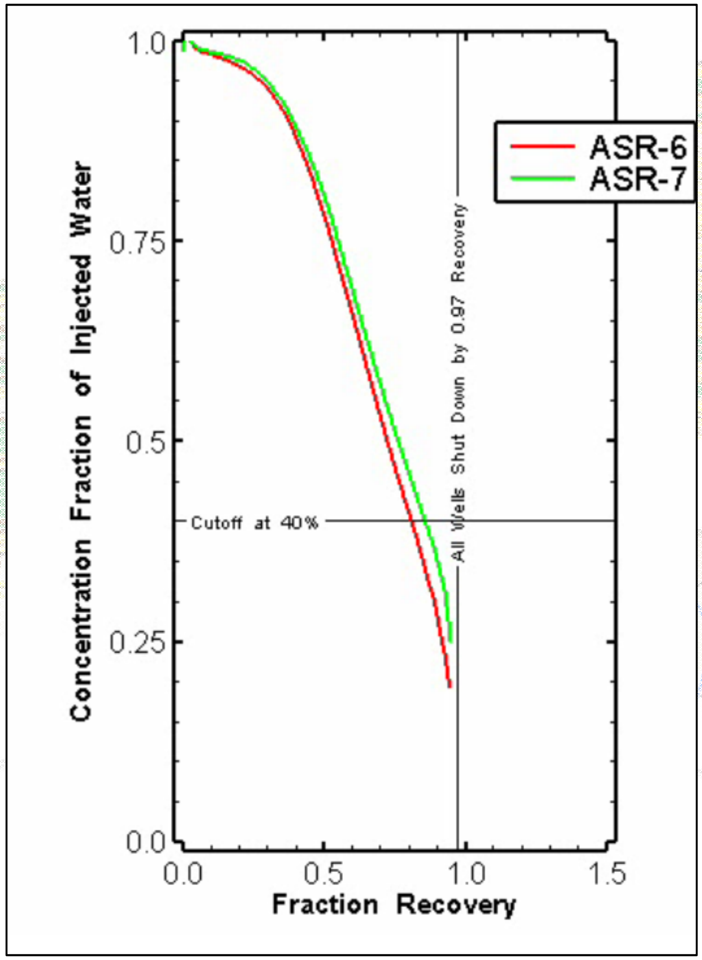
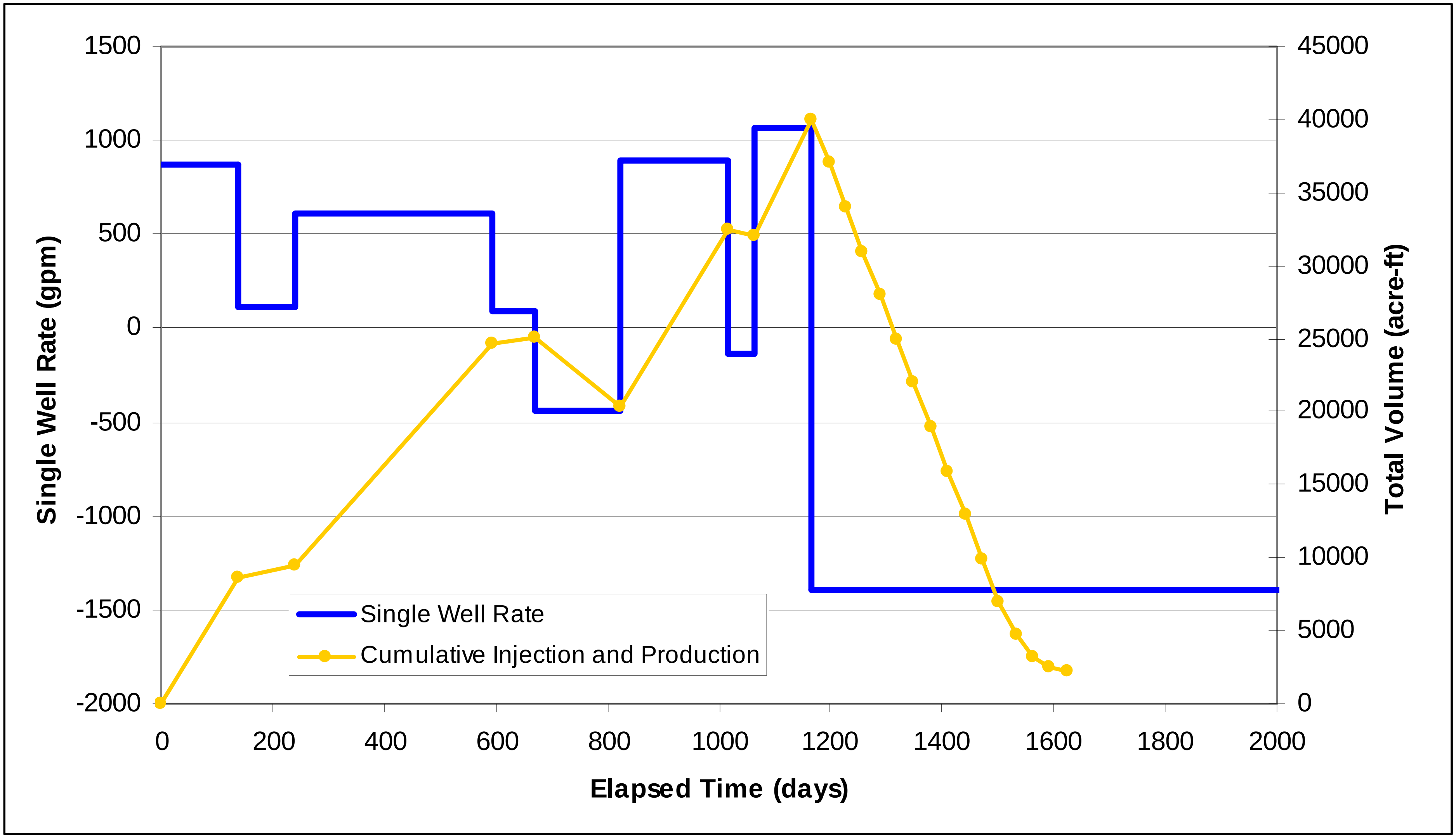
Ability to Recover Stored Water

- Recovery efficiency: the fraction of recharge water that is recovered compared to native groundwater
- Dependent on many factors specific to a given site, including operational factors
- Primary drivers:
  - Aquifer containment
  - Natural gradient
  - Extent of "bubble"
  - Density effects

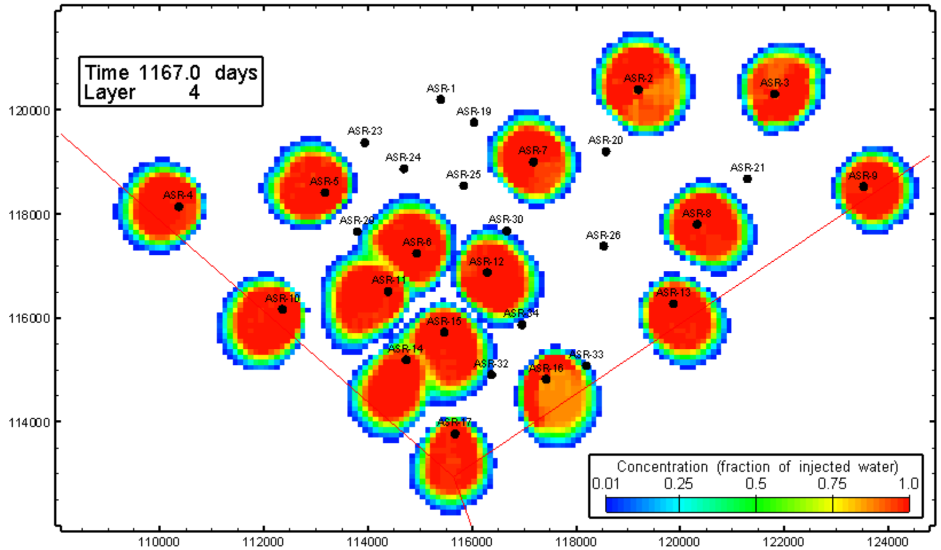


Modeling ASR: Large Well Field (Twin Oaks)



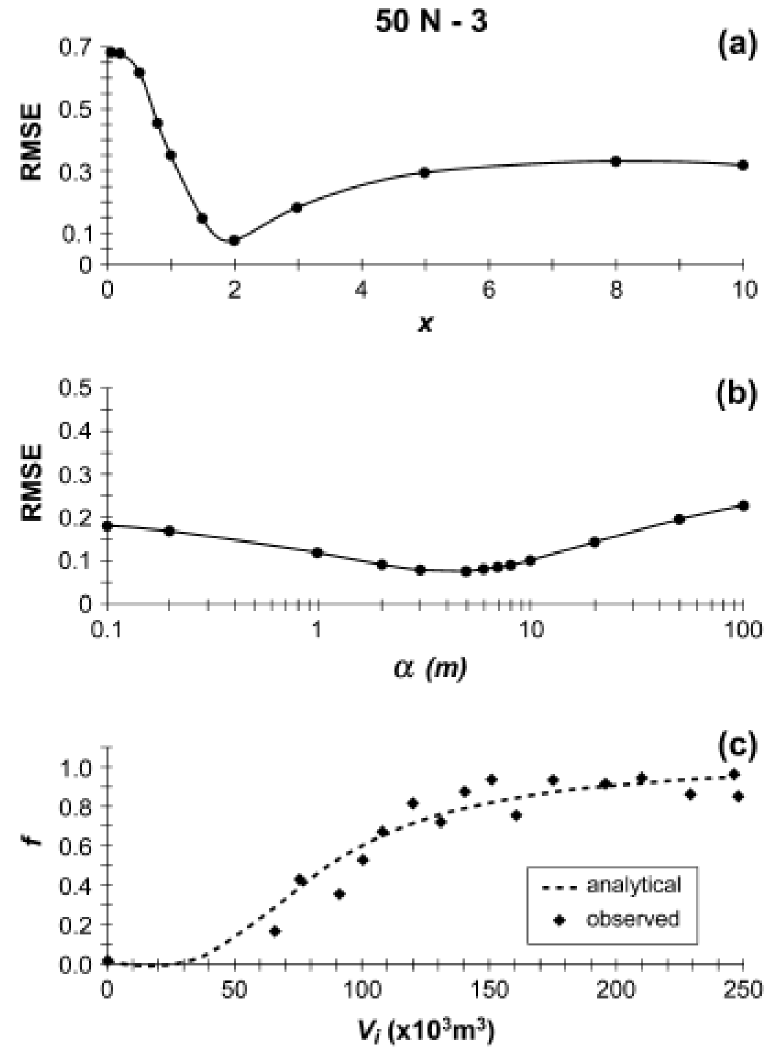
Modeling ASR

- Flow parameters
  - Formation thickness
  - Hydraulic conductivity (horizontal/vertical)
  - Storativity/Specific Yield
- Transport parameters
  - Dispersivity
  - Porosity
- Geochemistry



Modeling ASR

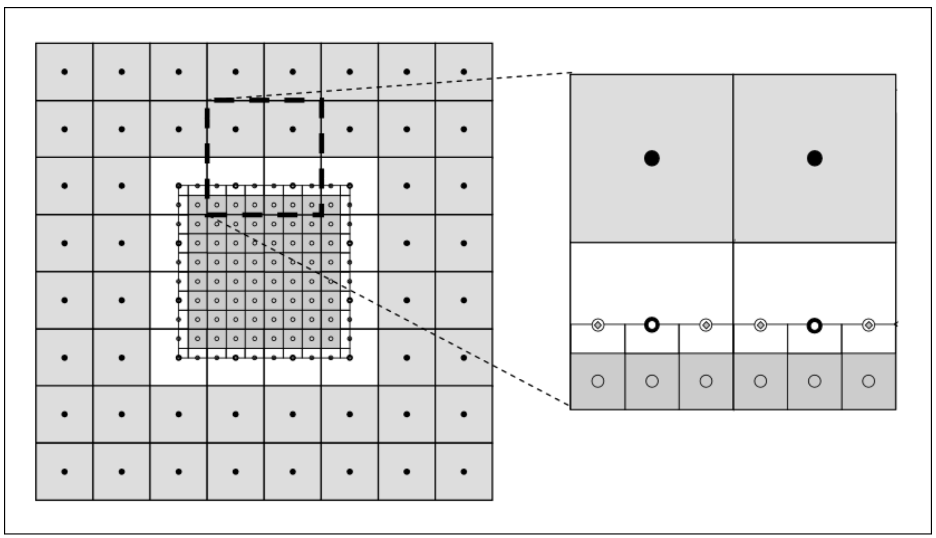
- Flow parameters typically derived from well tests
- Dispersivity estimated from cycle testing (native water breakthrough)
- Gelhar (1971) analytic solution provides simple approach

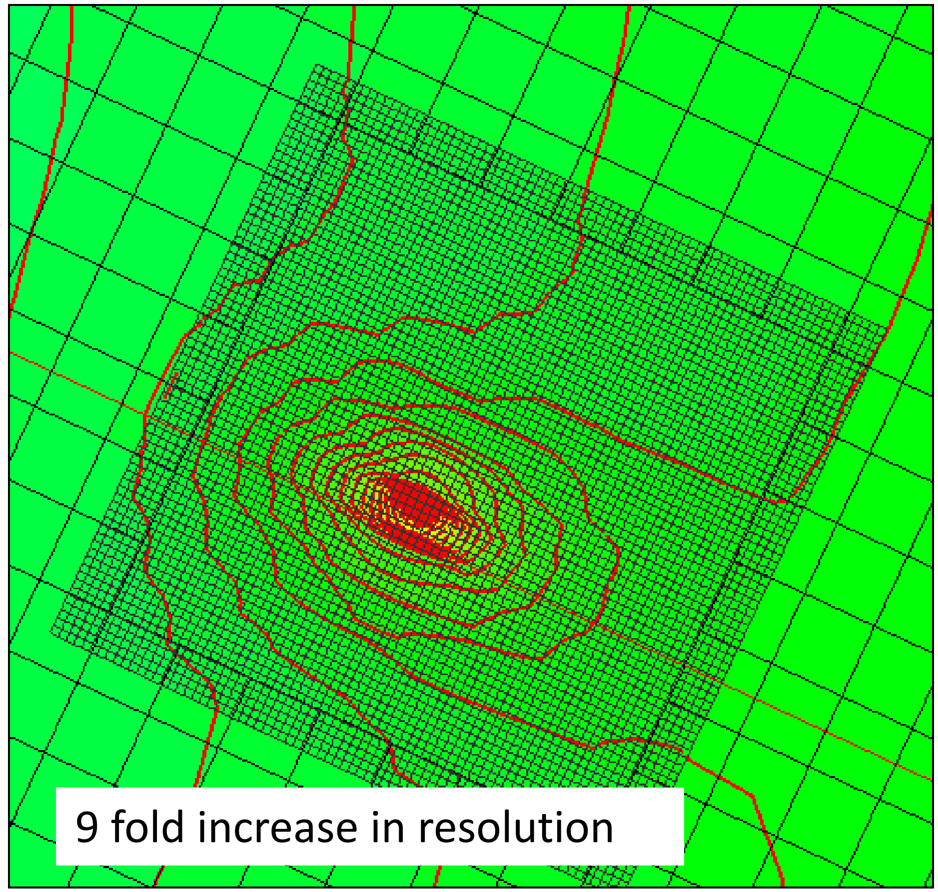


P. Pavelic et al. GROUND WATER 44, no. 2: 155–164

Modeling ASR

- When starting with a regional model, the grid must typically be locally refined
- MODFLOW-LGR works fairly well for this application

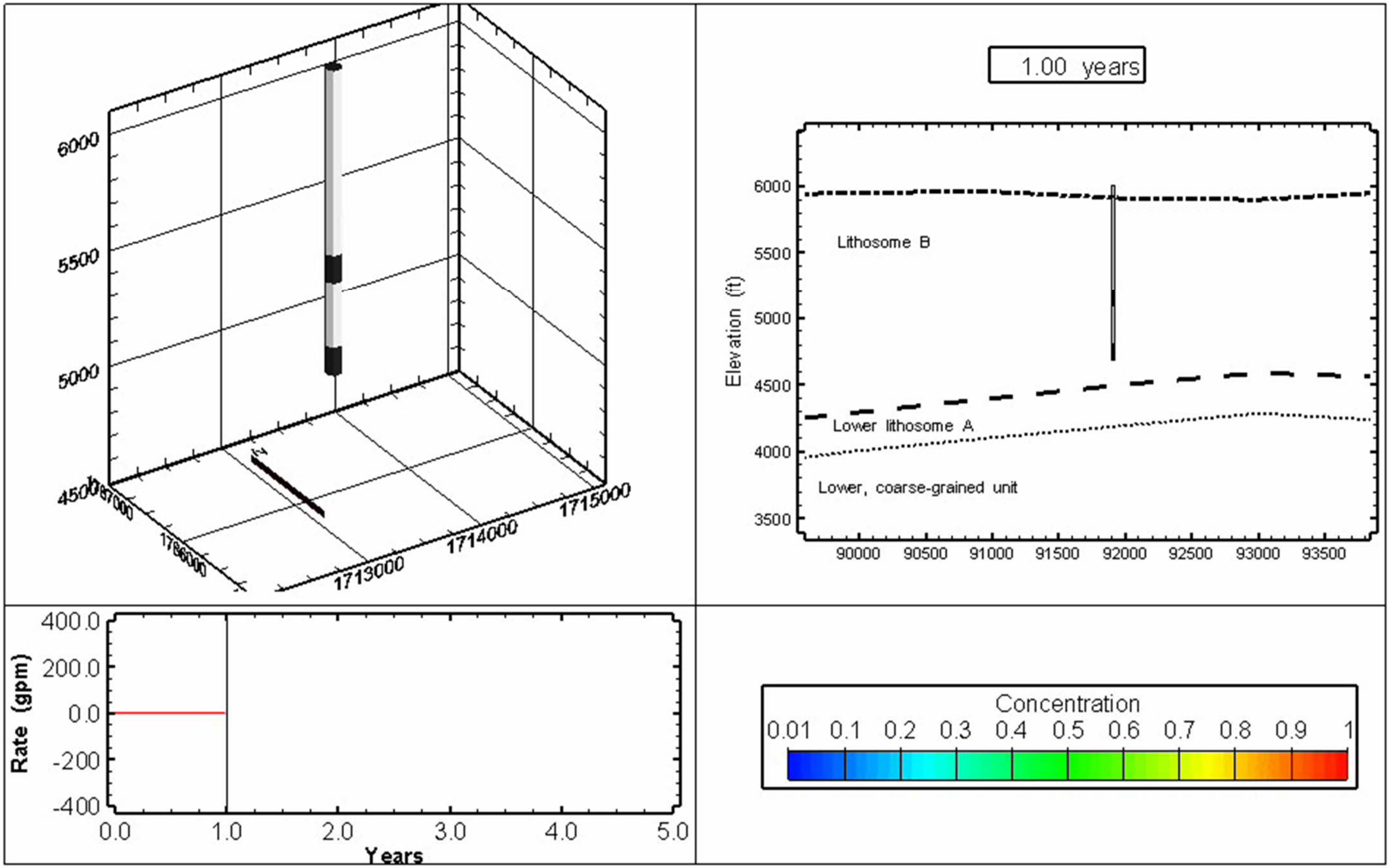




Ability to Recover Stored Water

- Primary drivers for recovery efficiency:
  - Aquifer containment
  - Natural gradient
  - Extent of "bubble"
  - Density effects
- Related to concern about "others recovering stored water"

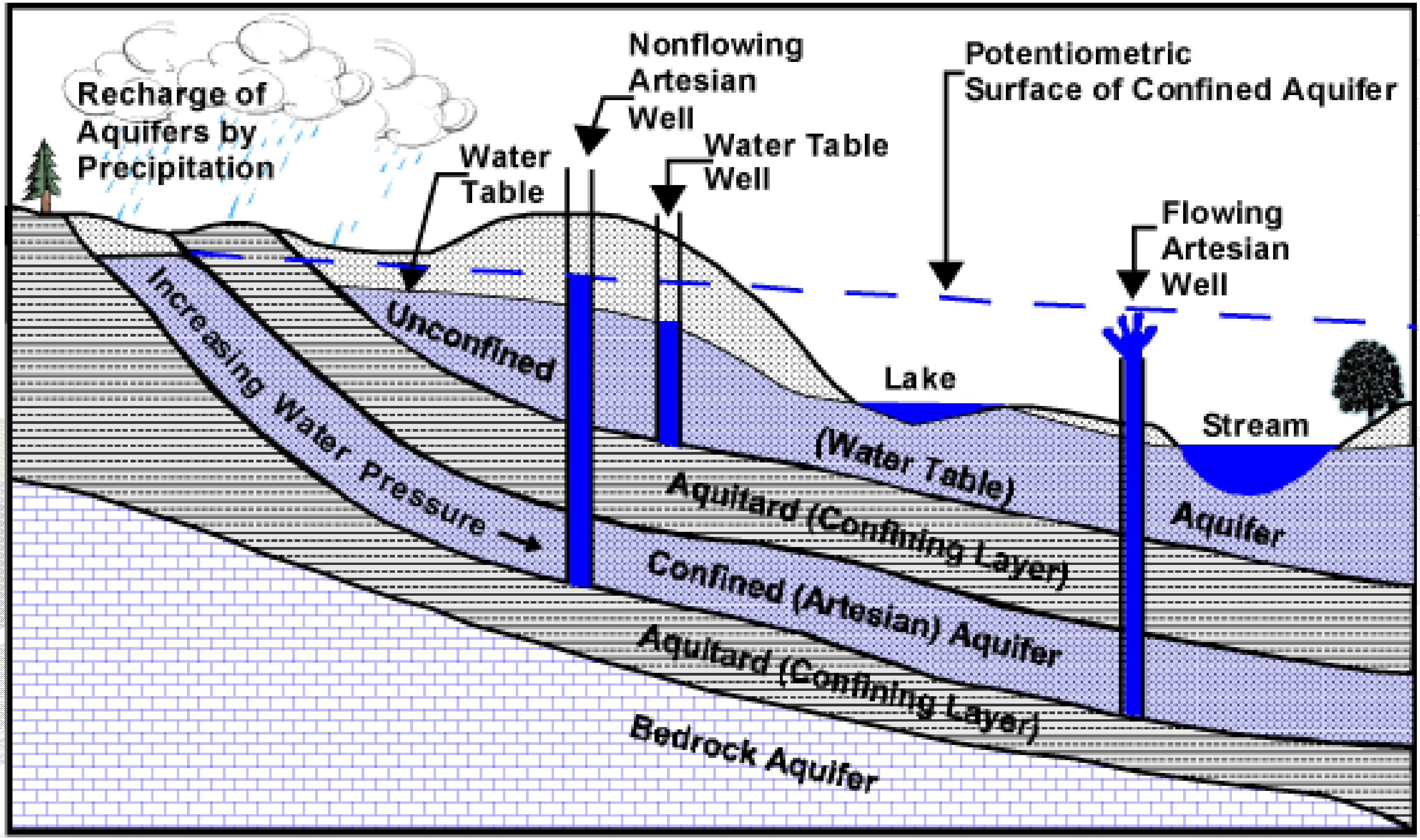
Modeling ASR: Single Well Confined Aquifer



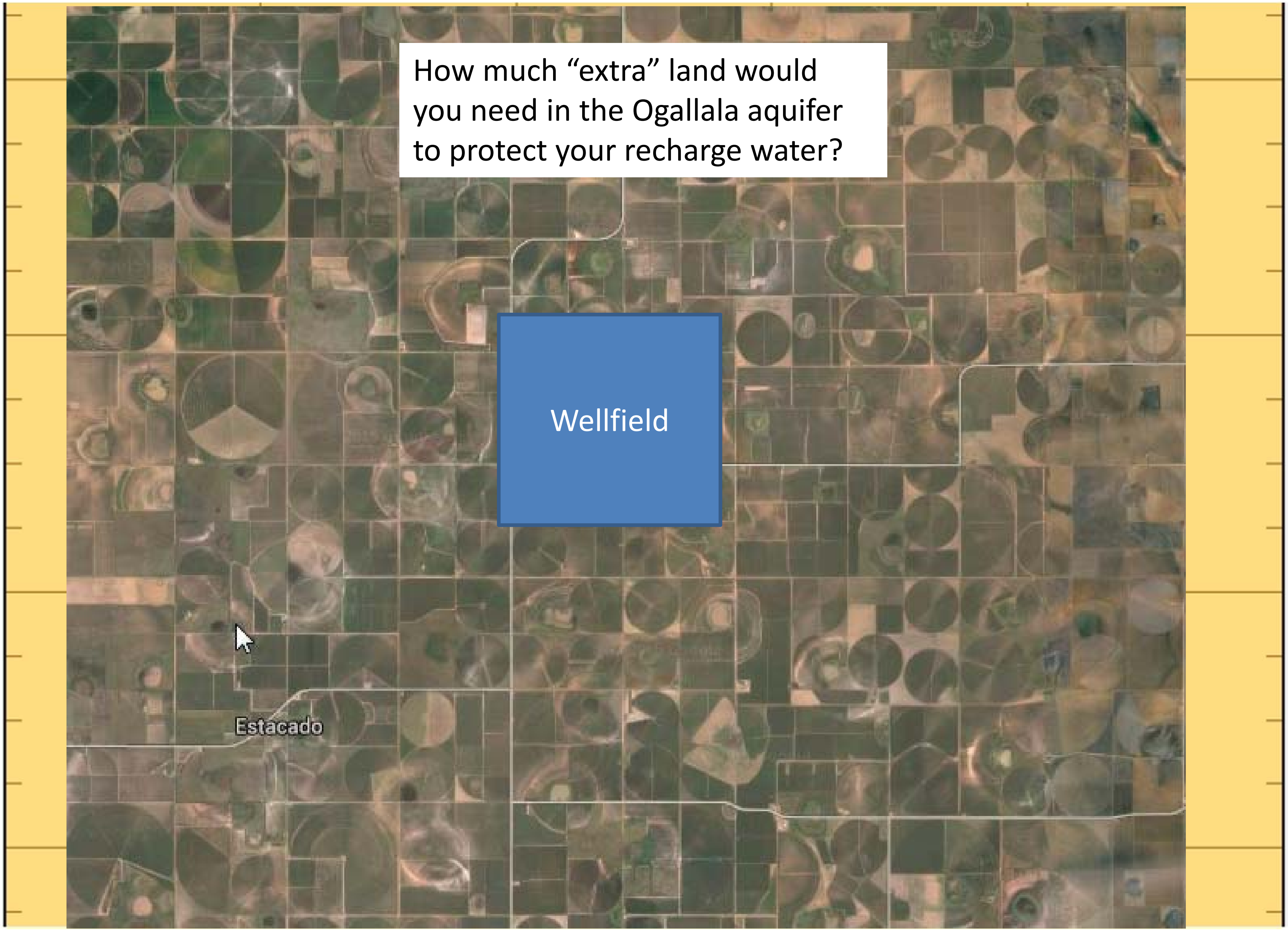
Ability to Recover Stored Water

- Primary drivers for recovery efficiency:
  - Aquifer containment
  - Natural gradient
  - Extent of "bubble"
  - Density effects
- Related to concern about "others recovering stored water"

Confined versus Unconfined Aquifers



From in.gov

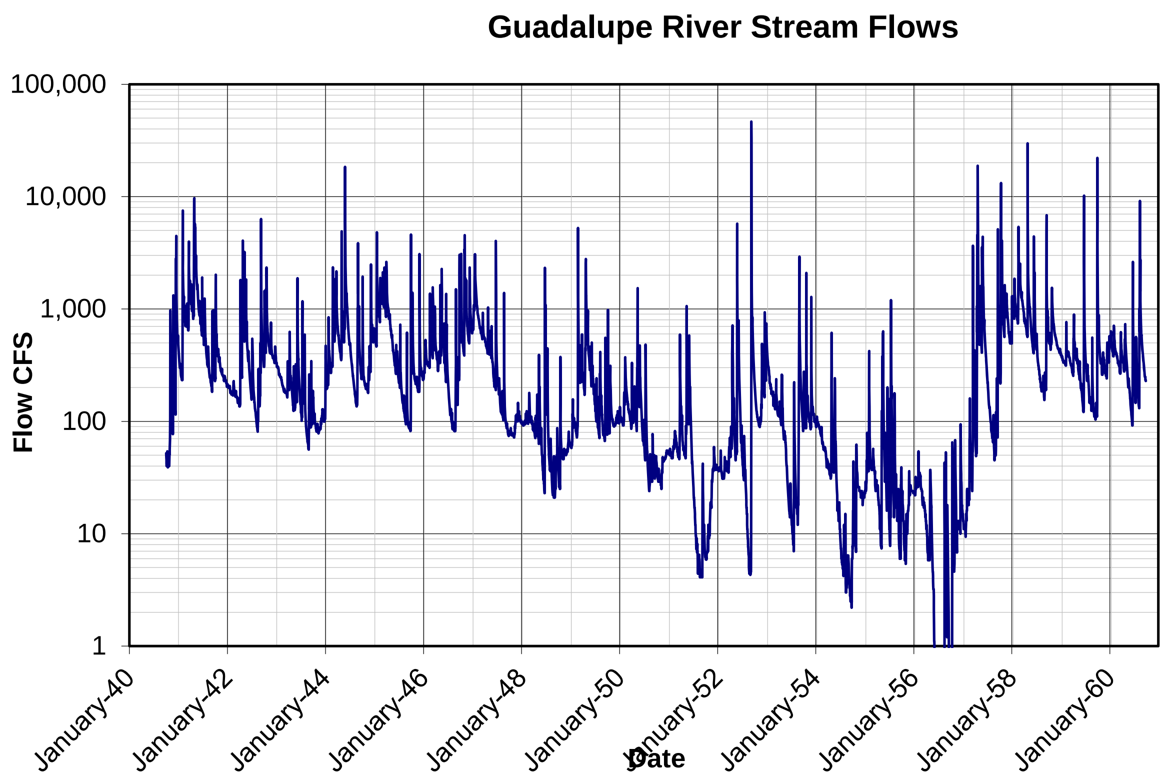

How much "extra" land would you need in the Ogallala aquifer to protect your recharge water?
Wellfield
Estacado

Phase 1 Feasibility: NBU

- Current Demand: Averages 11,000 – 12,000 AFY
- Growth in Demand: Averages 4.5%/year
- Demand/Supply: During Drought of Record (DOR)
  - Demand increases (14,000 AFY in 2010/2011)
  - Run of River supply is zero or nearly zero
  - Canyon Lake supply is steady at 9,720 ac-ft/yr
  - Edwards Aquifer supply may be reduced to as low as 5,562 ac-ft/yr with Stage IV restrictions
- Increase in demand due to growth reduces system reliability

Water Demand, Supply and Variability

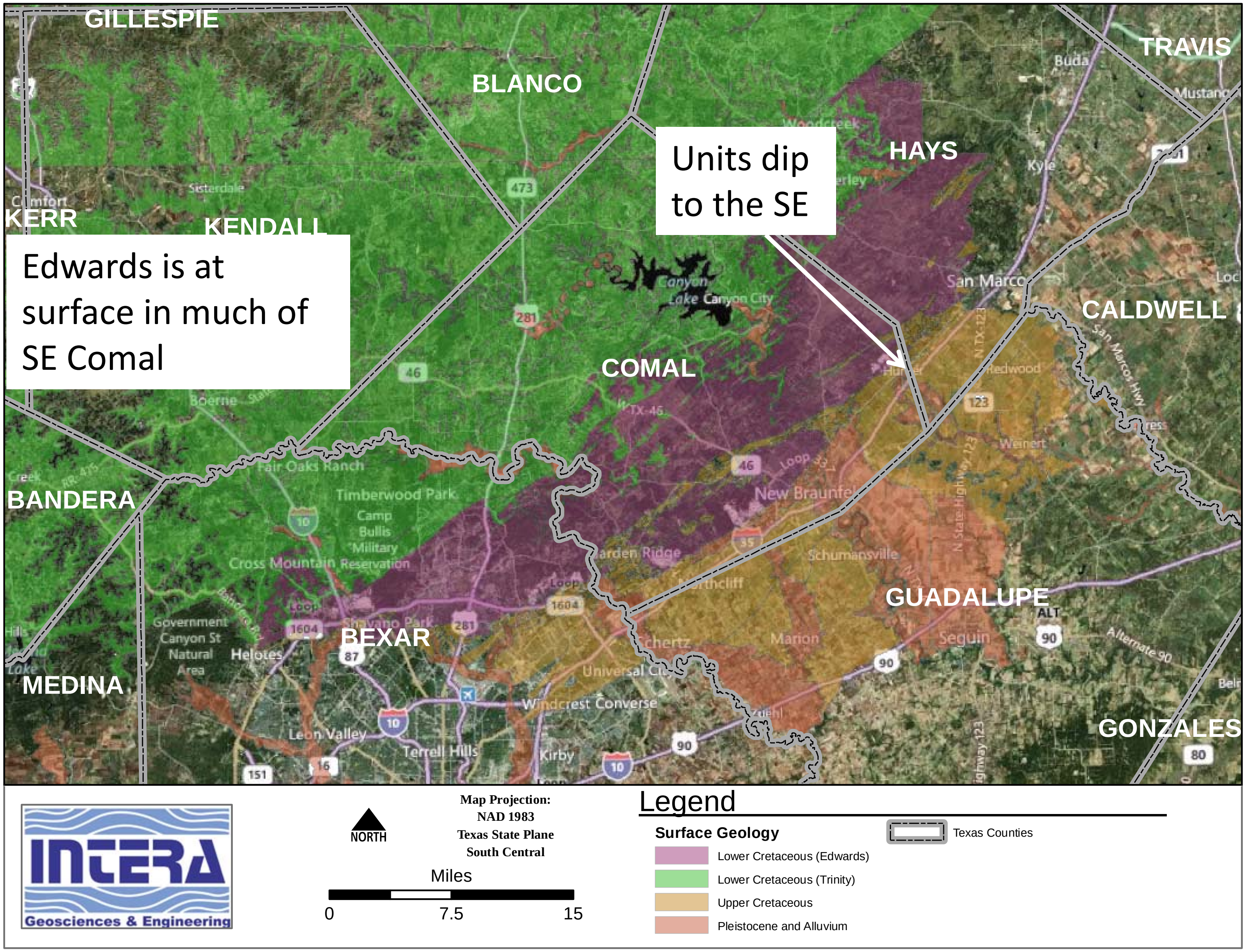
- Potential for supply exists even during DOR



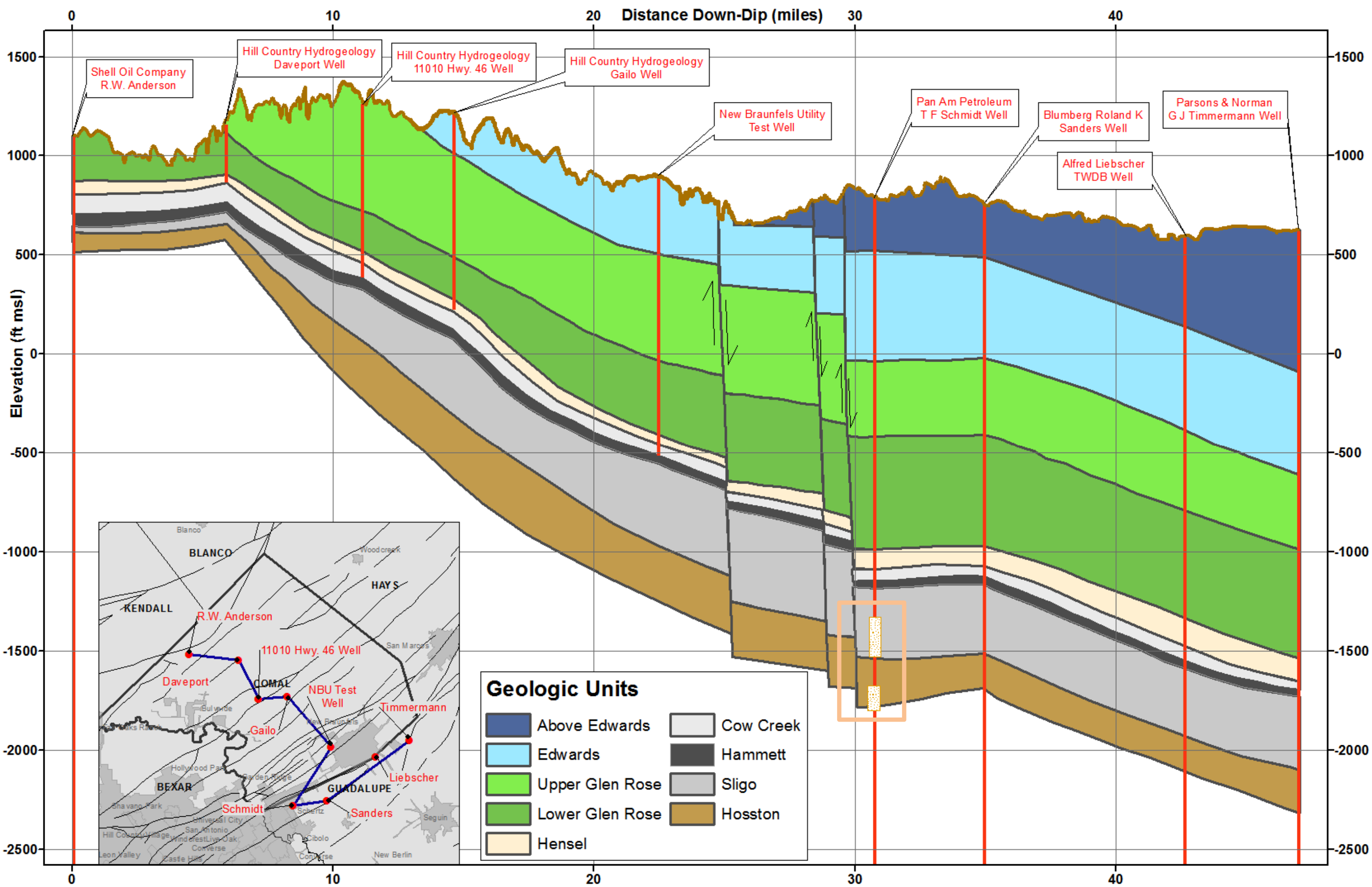
Basic Stratigraphy in New Braunfels Area

System	Stratigraphic Unit	Hydrogeologic Unit
Upper Cretaceous	Austin Chalk	Upper Confining Unit
	Eagle Ford Group	
	Buda Limestone	
	Del Rio Clay	
Lower Cretaceous	Georgetown Formation	Edwards Aquifer
	Person Formation	
	Kainer Formation	
	Upper Glen Rose Formation	Upper Trinity Aquifer
	Lower Glen Rose Formation	Middle Trinity Aquifer
	Hensel Sand	
	Cow Creek Limestone	
	Hammett Shale	
	Sligo Formation	Lower Trinity Aquifer
	Hosston Formation	

Surface Geology



Dip Section



Distance Down-Dip (miles)
0
10
20
30
40
Elevation (ft msl)
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
Shell Oil Company
R.W. Anderson
Hill Country Hydrogeology
Daveport Well
Hill Country Hydrogeology
11010 Hwy. 46 Well
Hill Country Hydrogeology
Gailo Well
New Braunfels Utility
Test Well
Pan Am Petroleum
T F Schmidt Well
Blumberg Roland K
Sanders Well
Alfred Liebscher
TWDB Well
Parsons & Norman
G J Timmermann Well
BLANCO
KENDALL
HAYS
COMAL
BEXAR
GUADALUPE
R.W. Anderson
11010 Hwy. 46 Well
Daveport
NBU Test
Well
Timmermann
Gailo
Liebscher
Schmidt
Sanders
Geologic Units
Above Edwards
Edwards
Upper Glen Rose
Lower Glen Rose
Hensel
Cow Creek
Hammett
Sligo
Hosston

Important Hydrogeologic Characteristics for ASR

- **Depth**: Typically both construction and operational costs increase with depth
- **Formation confinement**: Well-confined zones improve containment of injected water
- **Transmissivity**: Higher transmissivity allows higher injection and recovery rates
- **Water Quality**:
  - Fresh water means that native groundwater recovery is of less concern
  - Storage in brackish aquifers is typically possible if TDS < 5,000 mg/L

Lower Trinity

- Successful formation for Kerrville ASR (@500-600 ft bgs)
- Lack of data in this area (not used for water supply)
- Lower portion of the Sligo reported to contain the highest porosity (Bebout and Loucks, 1977)
- Water quality unknown (brackish?)
- Test well would be required for sufficient characterization

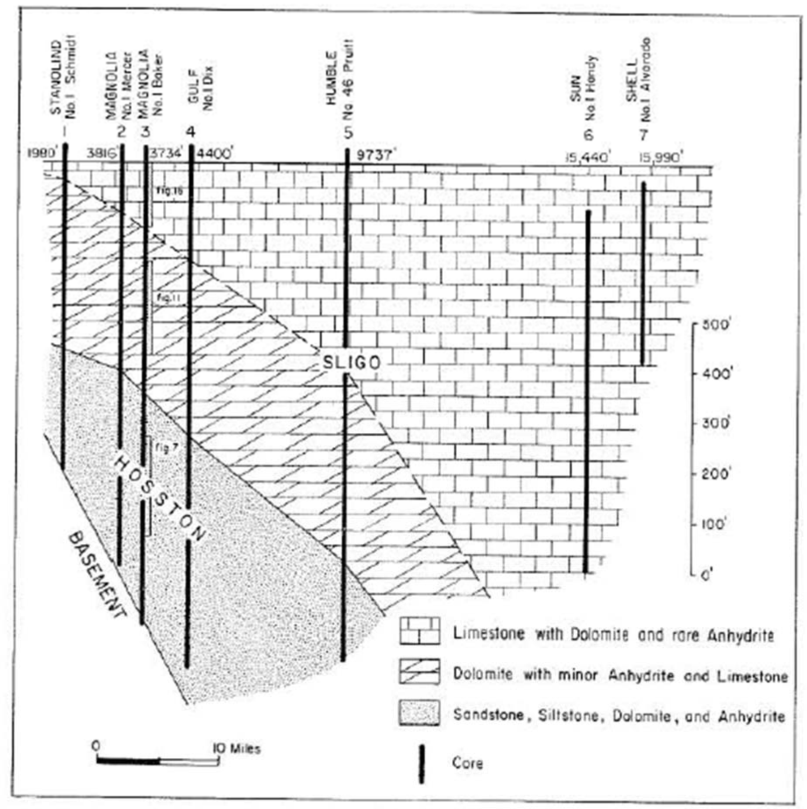


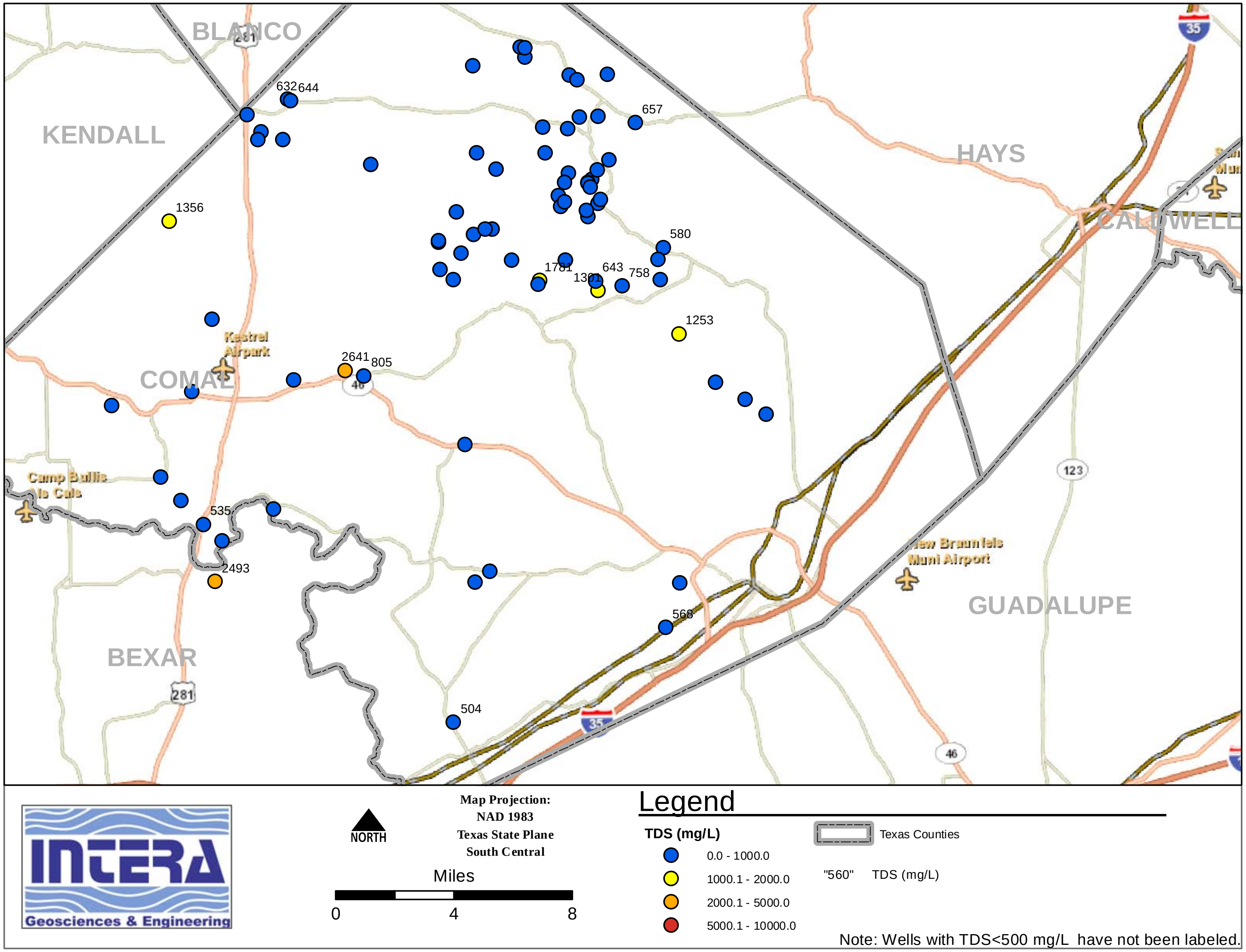
Figure 5

Middle Trinity

- Lower Glen Rose typically most productive formation
- Nearby production rates range from 200-500 gpm
- Water quality is typically good (<1,000 mg/L) northwest of the BFZ

Middle Trinity

Water Quality

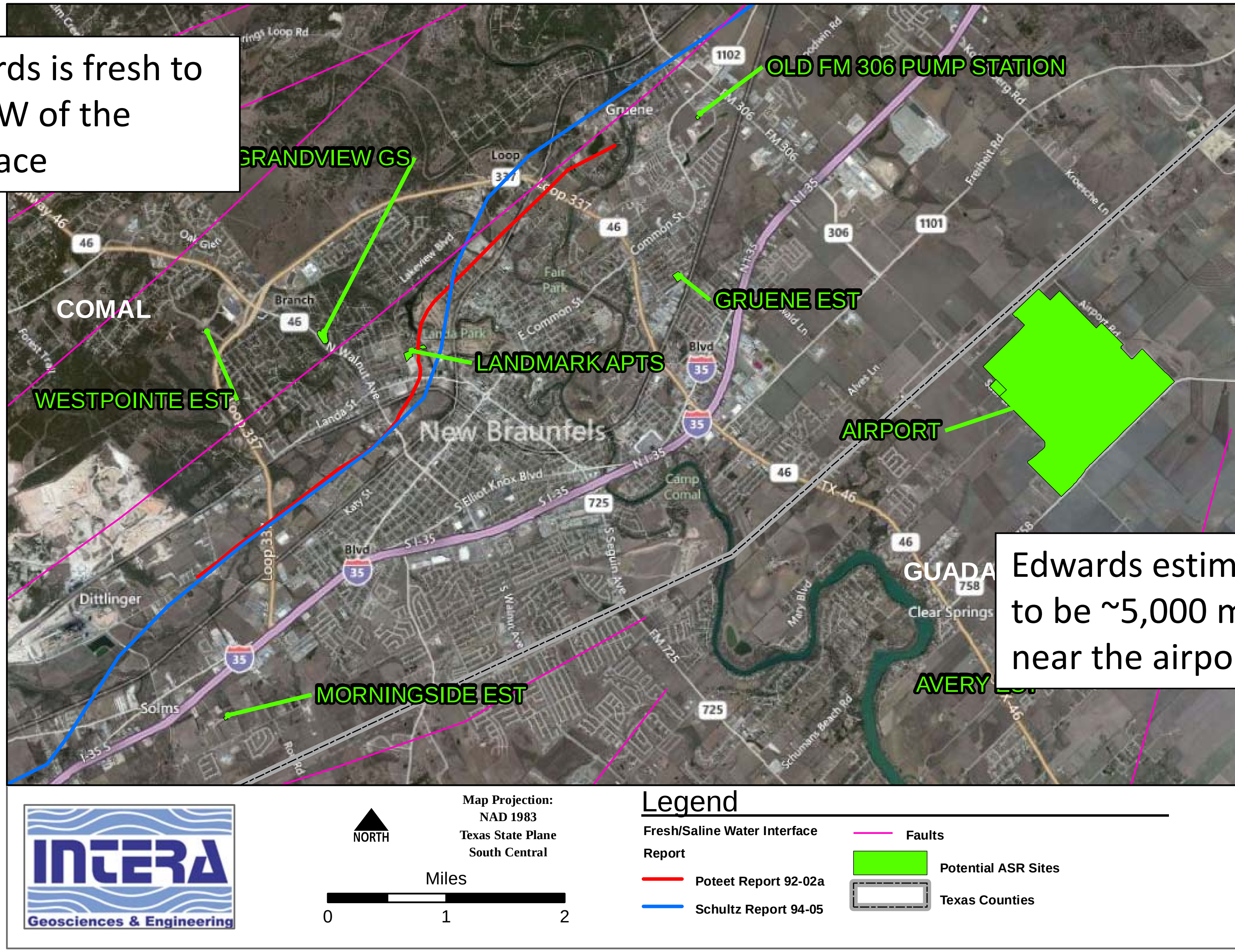


Brackish Edwards

- Brackish targeted for regulatory reasons
- No measurements of hydraulic properties in the brackish portion of the Edwards near NB
- Estimated transmissivity of 11,600 ft2/d over 500 ft of open hole at City of San Antonio test well

Brackish Edwards

Edwards is fresh to the NW of the interface



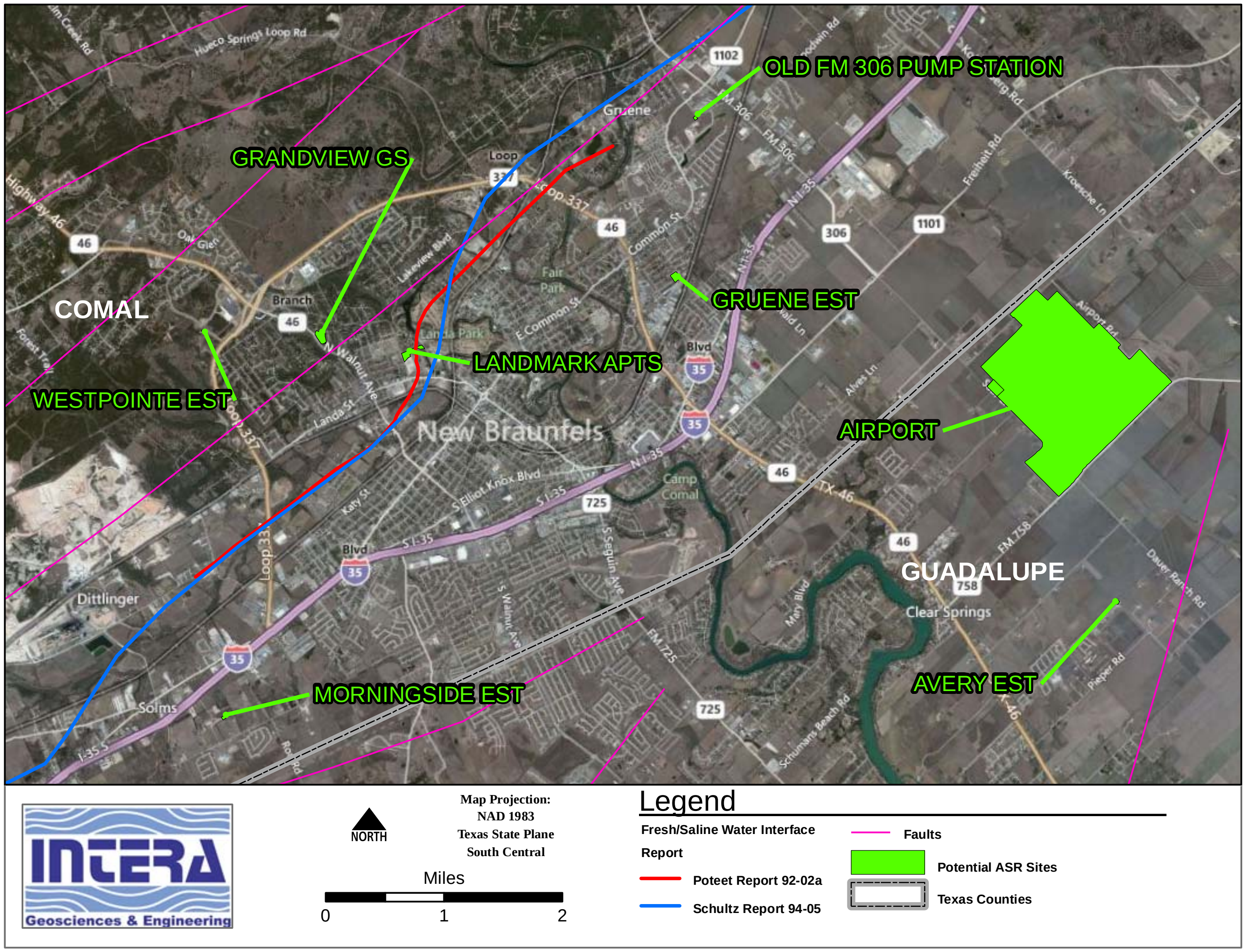
Edwards estimat to be ~5,000 mg near the airport

Summary of Formation Characteristics in NB Area

Formation	Approximate Well Depth (ft)	Confinement	Transmissivity	Water Quality
Brackish Edwards	1000	Moderate	Uncertain, likely high	Brackish, ~4,000-5,000 mg/L
Middle Trinity (Lower Glen Rose)	1500	Moderate	Moderate	Typically Fresh, < 1,000 mg/L
Lower Trinity (Lower Sligo)	2000	High	Uncertain, likely low to moderate	Uncertain, likely brackish

Considerations for Site Selection

- Accessible city land
- Near existing transmission
- Favorable hydrogeology



Preliminary Recommendation

- ASR demonstration program, starting with test well in brackish Edwards on airport site
- Based on agreement with EAA, testing can proceed using Edwards water during off-peak periods

Summary

- Aquifer Storage Recovery can be an important tool in a water resources portfolio
- ASR currently has momentum in TX, both from the legislature and from municipalities/water providers
- Modeling ASR can help inform system performance, both at the feasibility level or potentially at the design level
- Phase 1 type feasibility studies are fairly standardized way to examine the potential for ASR

Questions?

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