Have You Met My Water Management Friend ASR?

An Introduction to Aquifer Storage and Recovery

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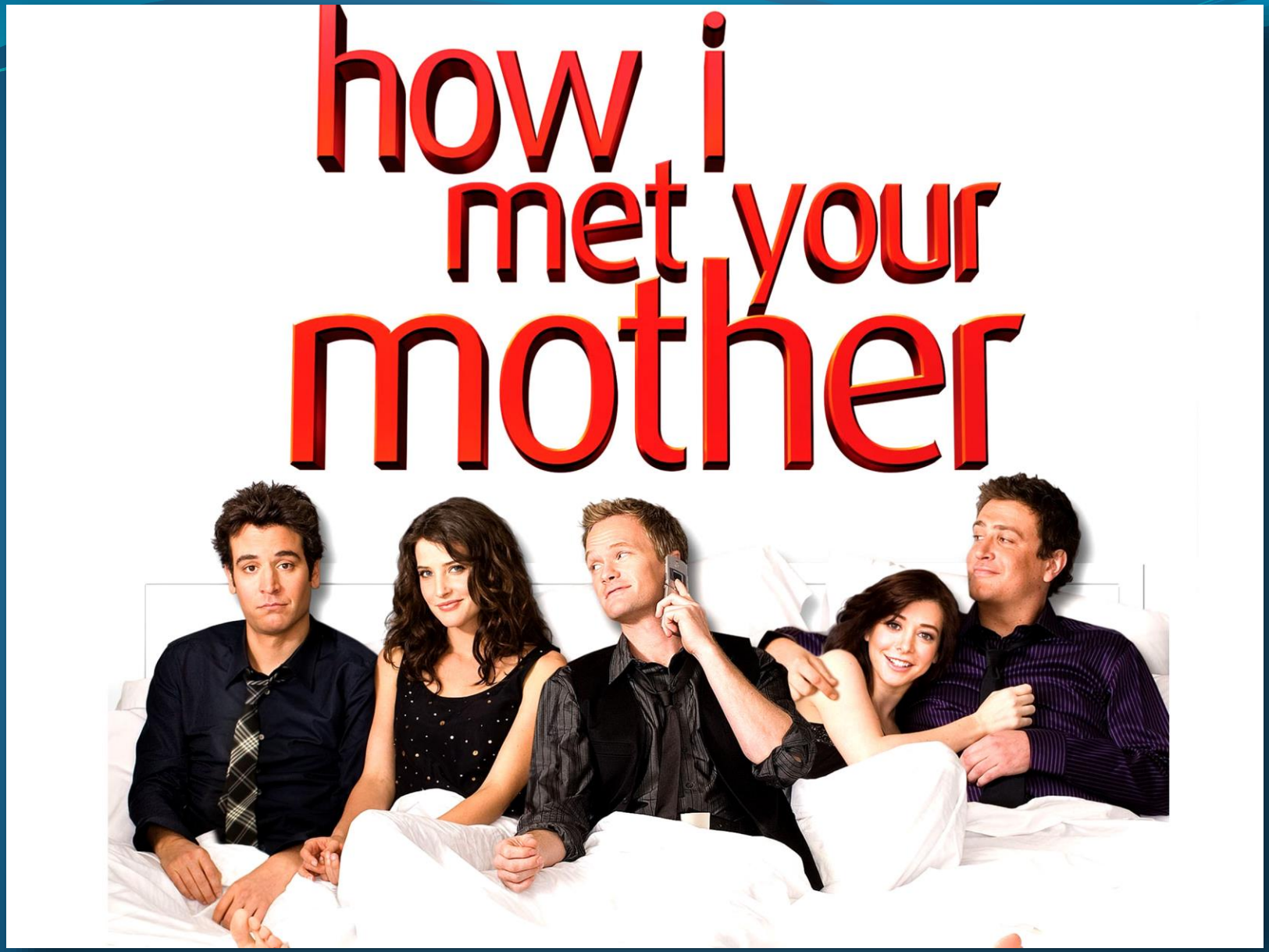

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Outline

Introduction to ASR

Case Study of a Texas ASR Feasibility Study

Examples of ASR Studies in Florida

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Texas Water Supply in a Nutshell

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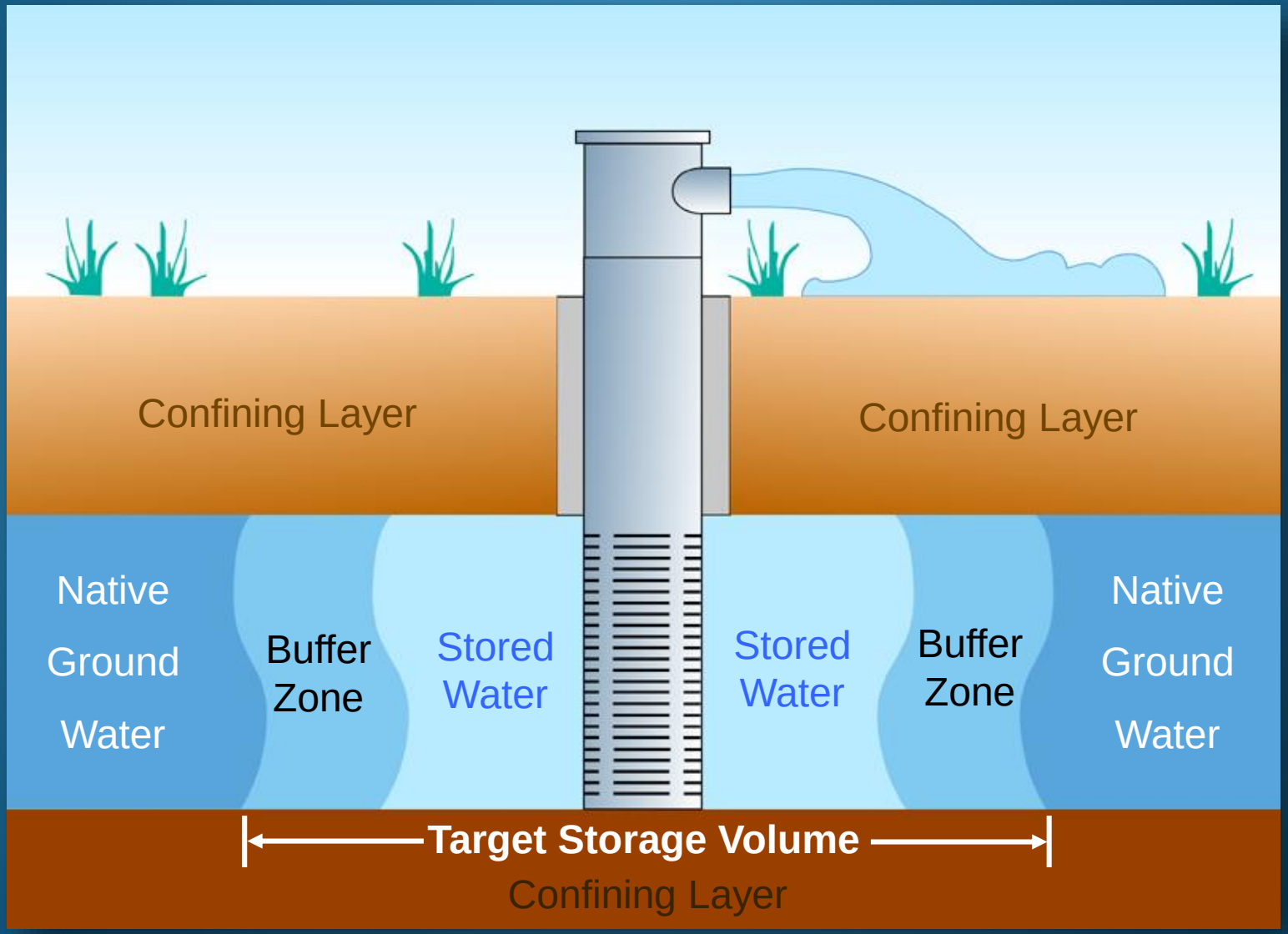
Aquifer Storage Recovery



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Bennett, 2007

Aquifer Storage Recovery

Why ASR?

- Provides larger volume / longer term storage of water resources
- Can use any source of water
- High rates of recovery (can be >90%)
- Allows for full utilization of take and pay contracts and/or water treatment facilities
- Flexibility in well siting / minimal real estate

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Typical ASR Well Head

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ASR Applications

- **Store and Recover**
  - Seasonal storage
  - Long-term storage (water banking)
  - Emergency use
- **Physical Management of the Aquifer**
  - Restore groundwater levels
  - Reduce land subsidence
  - Prevent salt water intrusion
  - Control contaminant plumes
- **Improve Water Quality**

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DWAF, 2009

Operational ASR Well Fields (2009)

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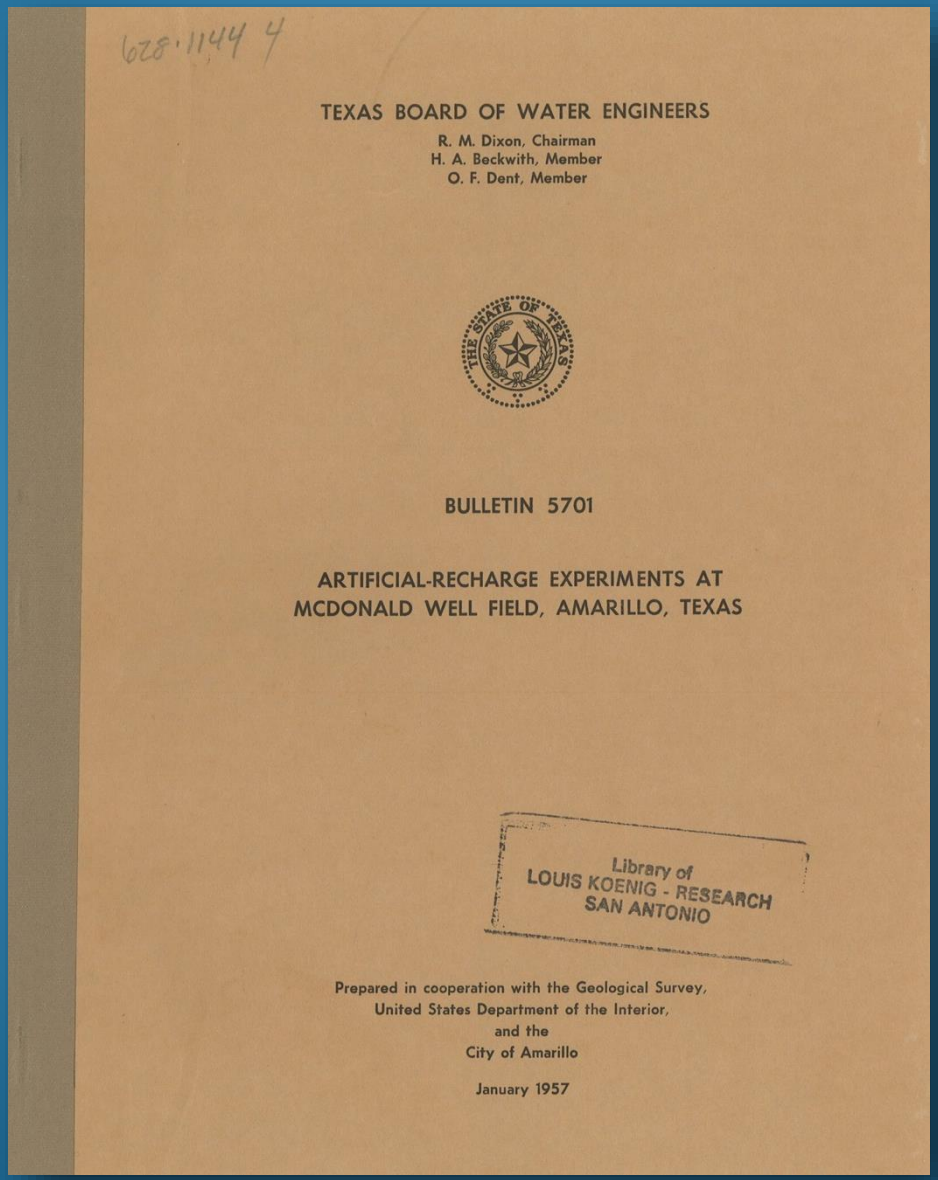
Malcolm Pirnie, et al., 2011

Early ASR in Texas



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TEXAS BOARD OF WATER ENGINEERS

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BULLETIN 5701

ARTIFICIAL-RECHARGE EXPERIMENTS AT
MCDONALD WELL FIELD, AMARILLO, TEXAS

Prepared in cooperation with the Geological Survey,
United States Department of the Interior,
and the
City of Amarillo

January 1957

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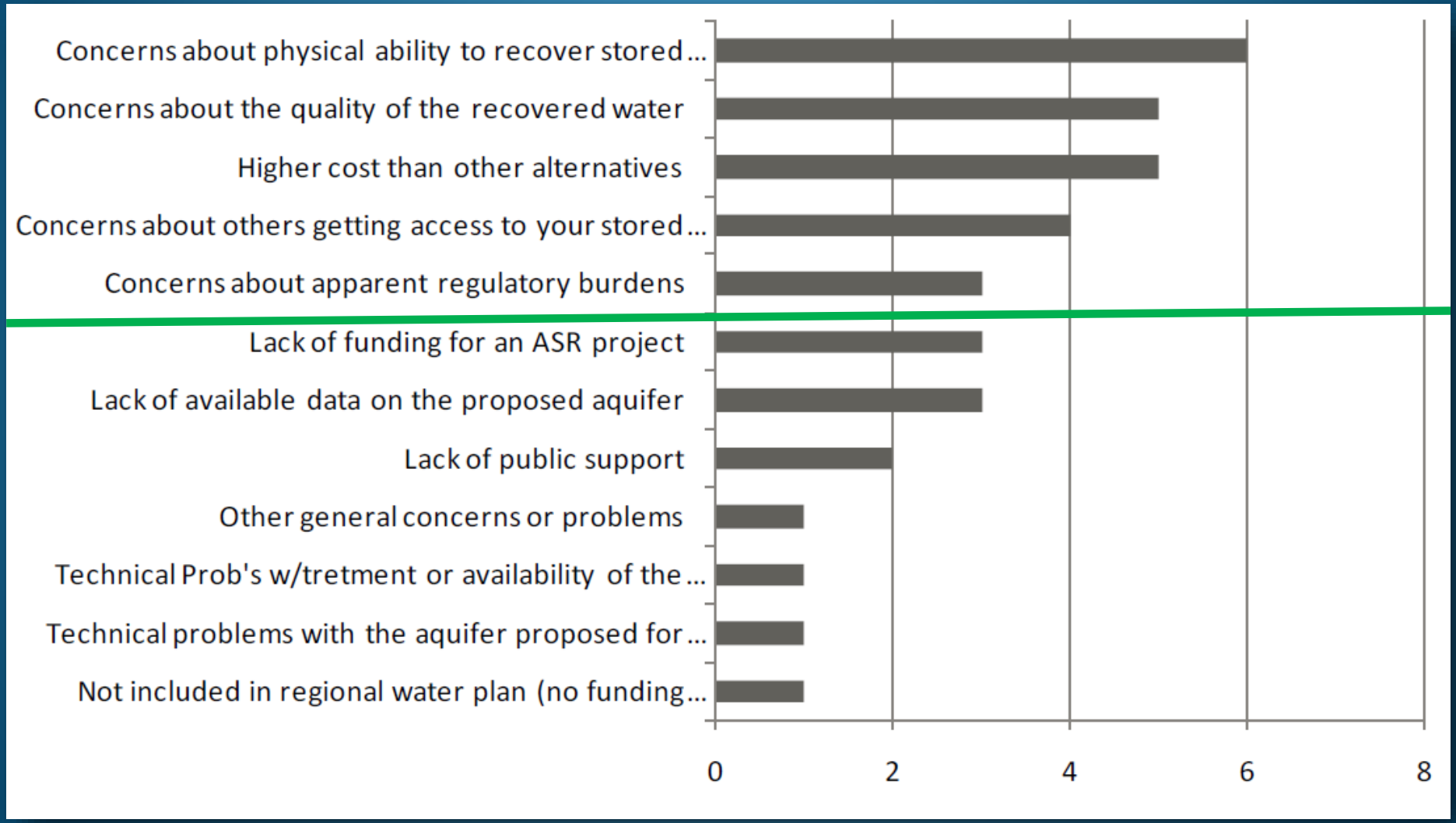
ASR Concerns



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Malcolm Pirnie, et al., 2011

ASR Legislation

- **HB 655**
  - **TCEQ has exclusive jurisdiction (EAA, BSEACD, & Subsidence Districts are exempted)**
  - **If ASR project produces more than authorized by TCEQ, then the well is subject to GCD rules**
  - **Surface water right amendment is not needed to store appropriated surface water**
  - **Eliminates the need for pilot projects**
  - **Requires monthly reporting on injected/recovered volumes and annual water quality testing**

Typical ASR Project Development

Phase 1 – Feasibility and Conceptual Design

Phase 2 – Initial Well and Testing Program

Phase 3 – Facilities Expansion

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ASR Feasibility / Aquifer Selection Criteria

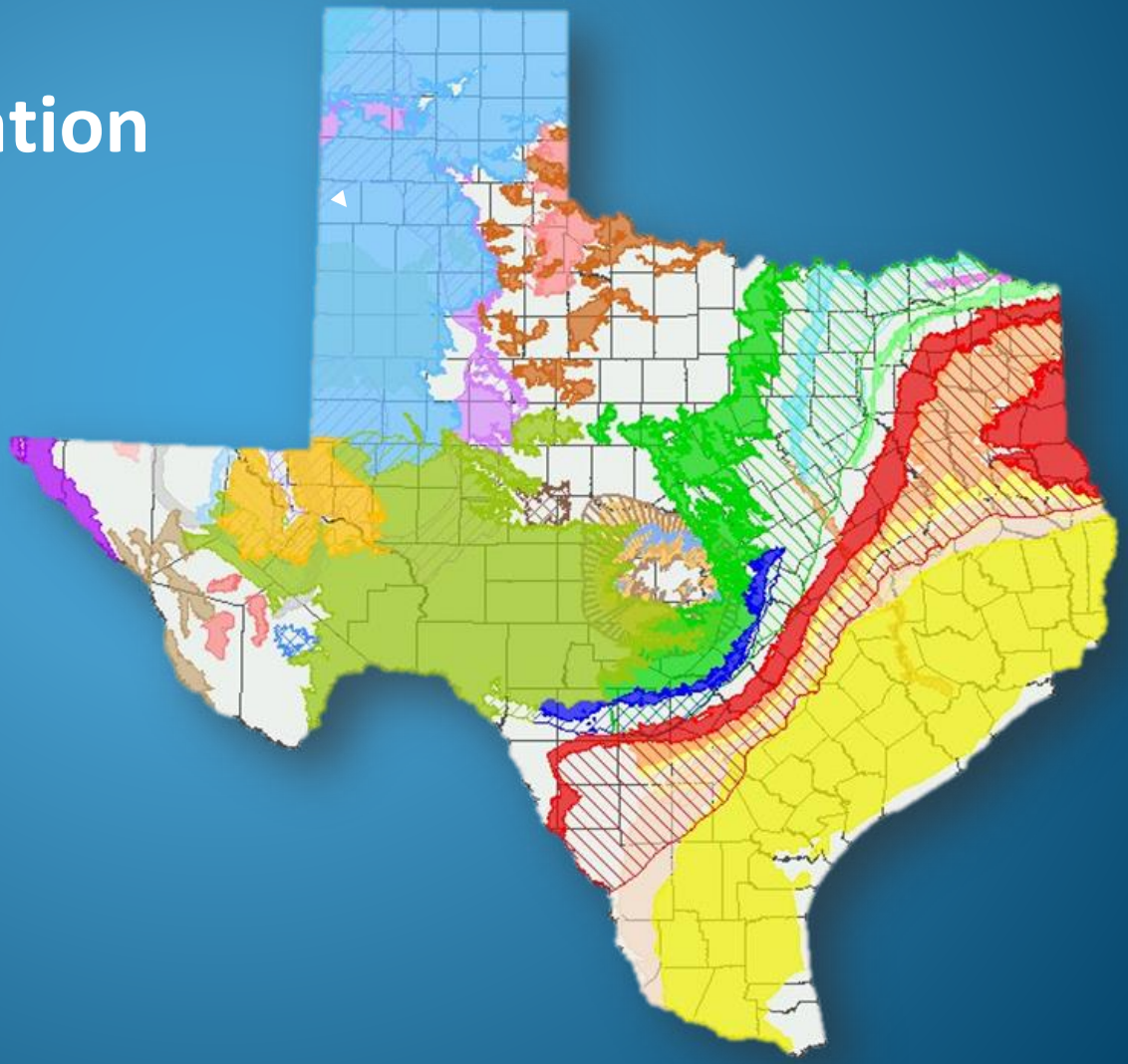
Reasons for Installation

Source(s) of Water

- **Supply Variability**
- **Quality Variability**

Regulations

Hydrogeology



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Phase 1
Feasibility and Conceptual Design

- **Viability Assessment – fatal flaw analysis using existing data**
  - **Availability of source water**
  - **Identify potential injection horizons**
  - **Hydrogeologic assessment of potential injection horizons**
  - **Review current contract(s)**
  - **Review current regulatory environment**
  - **Identify potential well sites**

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Phase 1
Feasibility and Conceptual Design

- Degree of Difficulty Assessment – effort needed to achieve a successful ASR program and environmental and regulatory approvals
  - Geochemical modeling
  - Groundwater modeling
  - Initial cost estimates
  - Identifying any additional pre/post treatment

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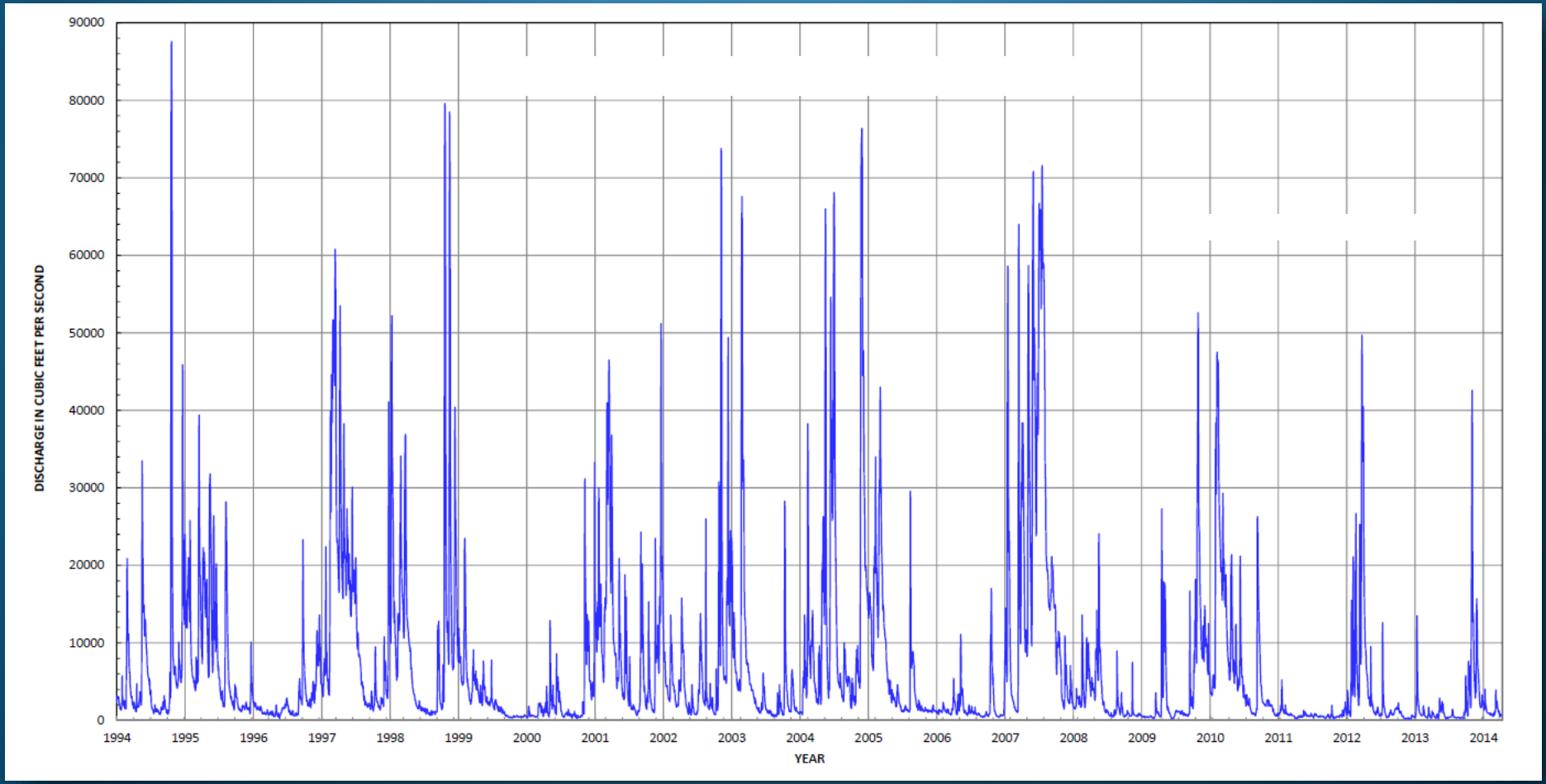
Phase 1 Feasibility: Source Water Variability



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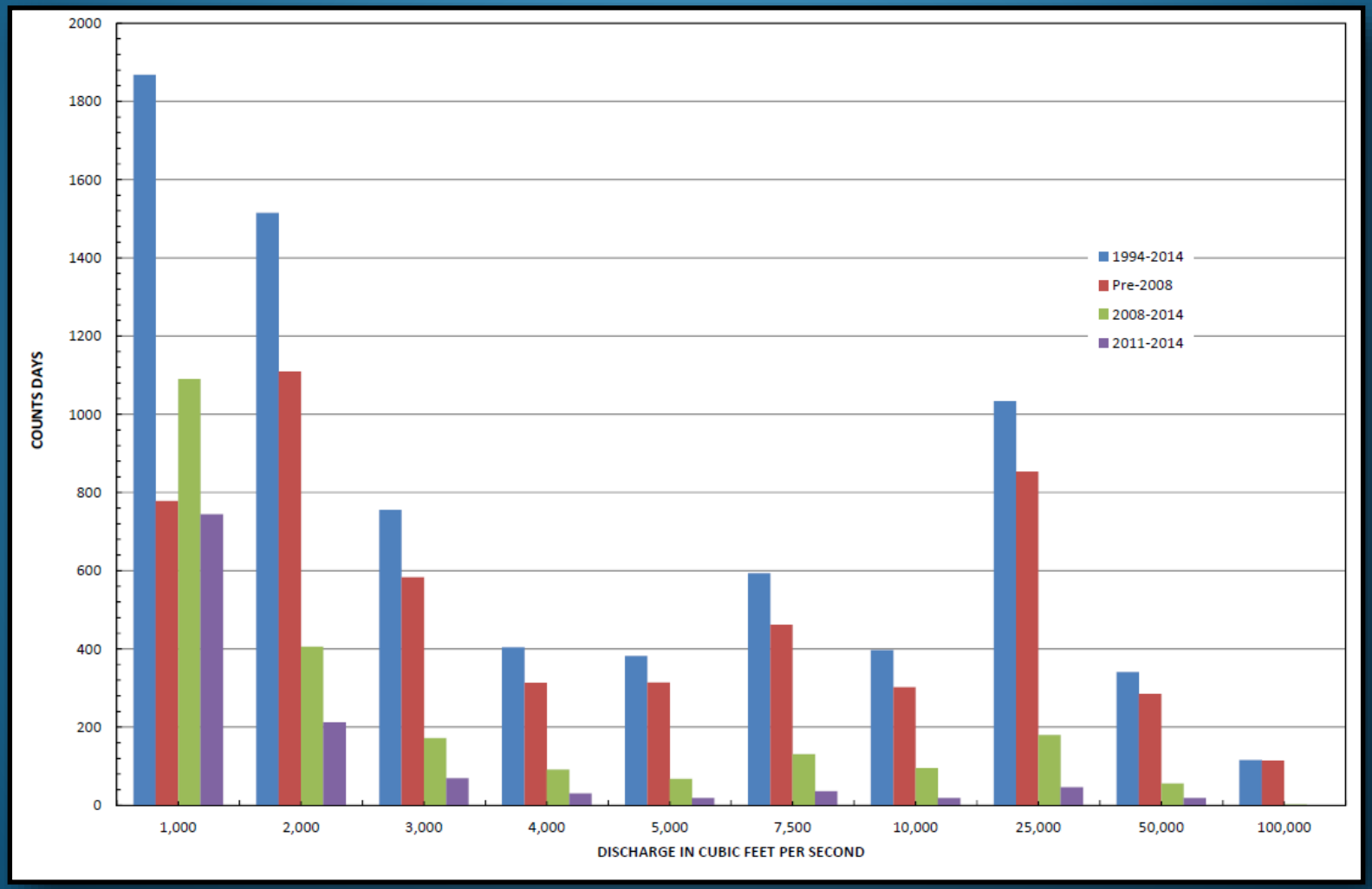
Phase 1 Feasibility: Source Water Variability



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Phase 1 Feasibility: Source Water Variability

	Hypothetical streamflow cutoff for ASR operation (cu.ft./sec.)	Percent of purchased volume of water (28.6 MGD) available for ASR		
	≤ 1,000	10% (2.86 MGD)	15% (4.29 MGD)	20% (5.72 MGD)
	Number of Days > 1,000 cfs	Estimated cumulative volume of excess water available for ASR (gallons)		
2008-2014 (2291 days)	1,225 (53.5%)	3,504,453,333	5,256,680,000	7,008,906,667
2011-2014 (1195 days)	469 (39.2%)	1,340,386,667	2,010,580,000	2,680,773,333

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Phase 1 Feasibility: Hydrogeologic Assessment

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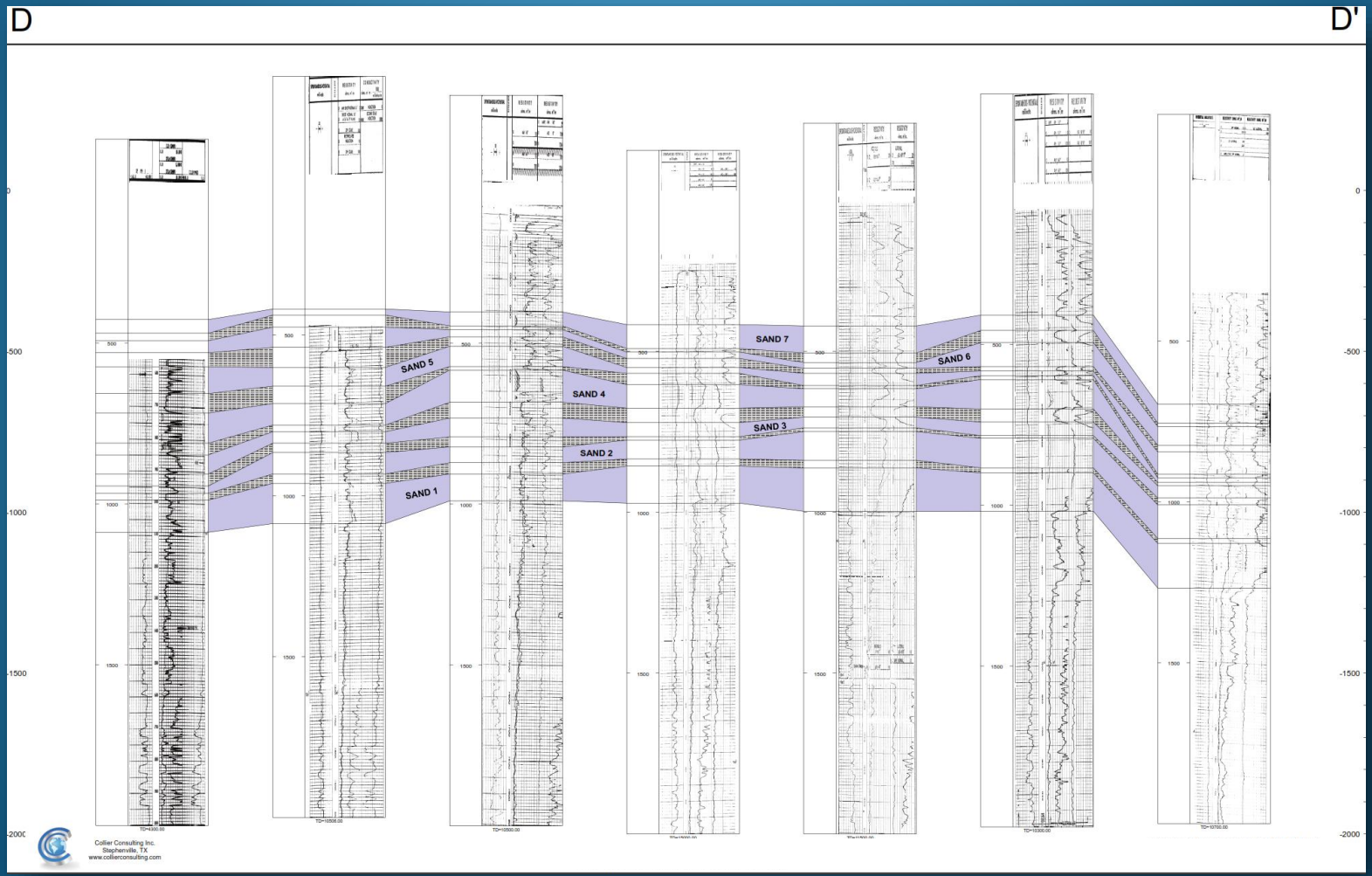
Phase 1 Feasibility: Hydrogeologic Assessment



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Phase 1 Feasibility: Hydrogeologic Assessment

- **Will the recharge water be able to flow into the aquifer?**
  - **Sufficiently permeable**
- **Will the aquifer have sufficient space to accept the water?**
  - **Is the pressure system such that it will accept and store the water**
- **Will the water be recoverable?**
  - **Can you recover it from the point of recharge; can you intercept it down the hydraulic gradient?**
  - **How long can it be stored and still be recoverable?**

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Phase 1 Feasibility: Hydrogeologic Assessment

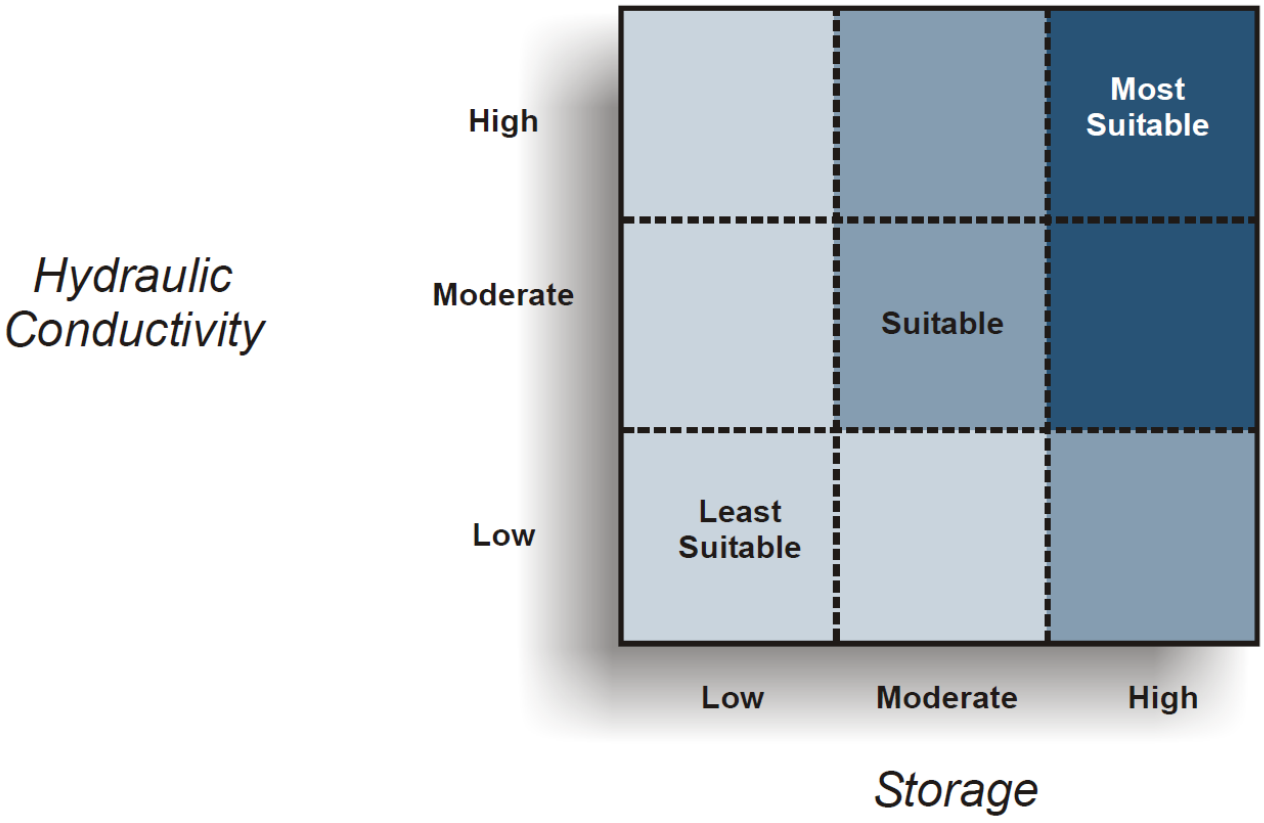

Figure 19: Suitability of an aquifer to receive artificially recharged water (Murray and Tredoux, 1998)

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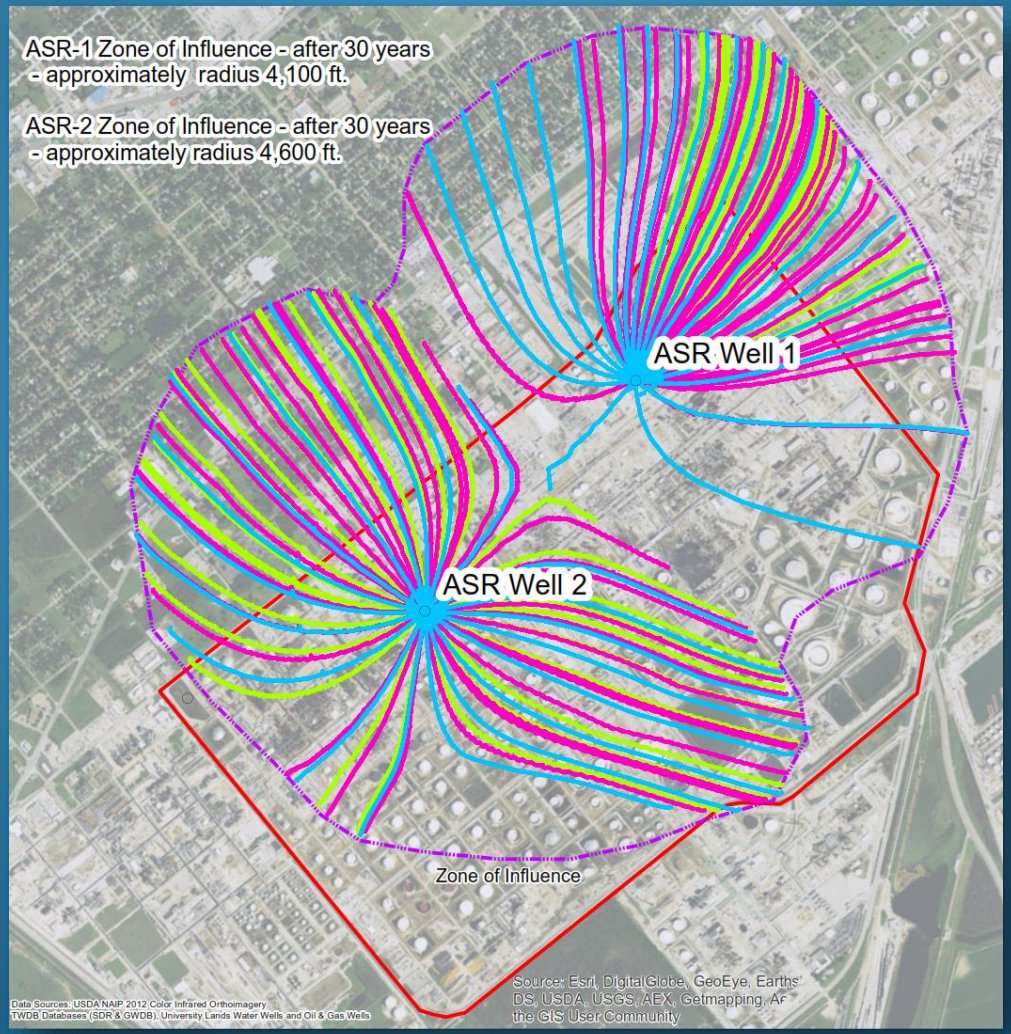
R. Murray, 2009

Phase 1 Feasibility: Groundwater Modeling



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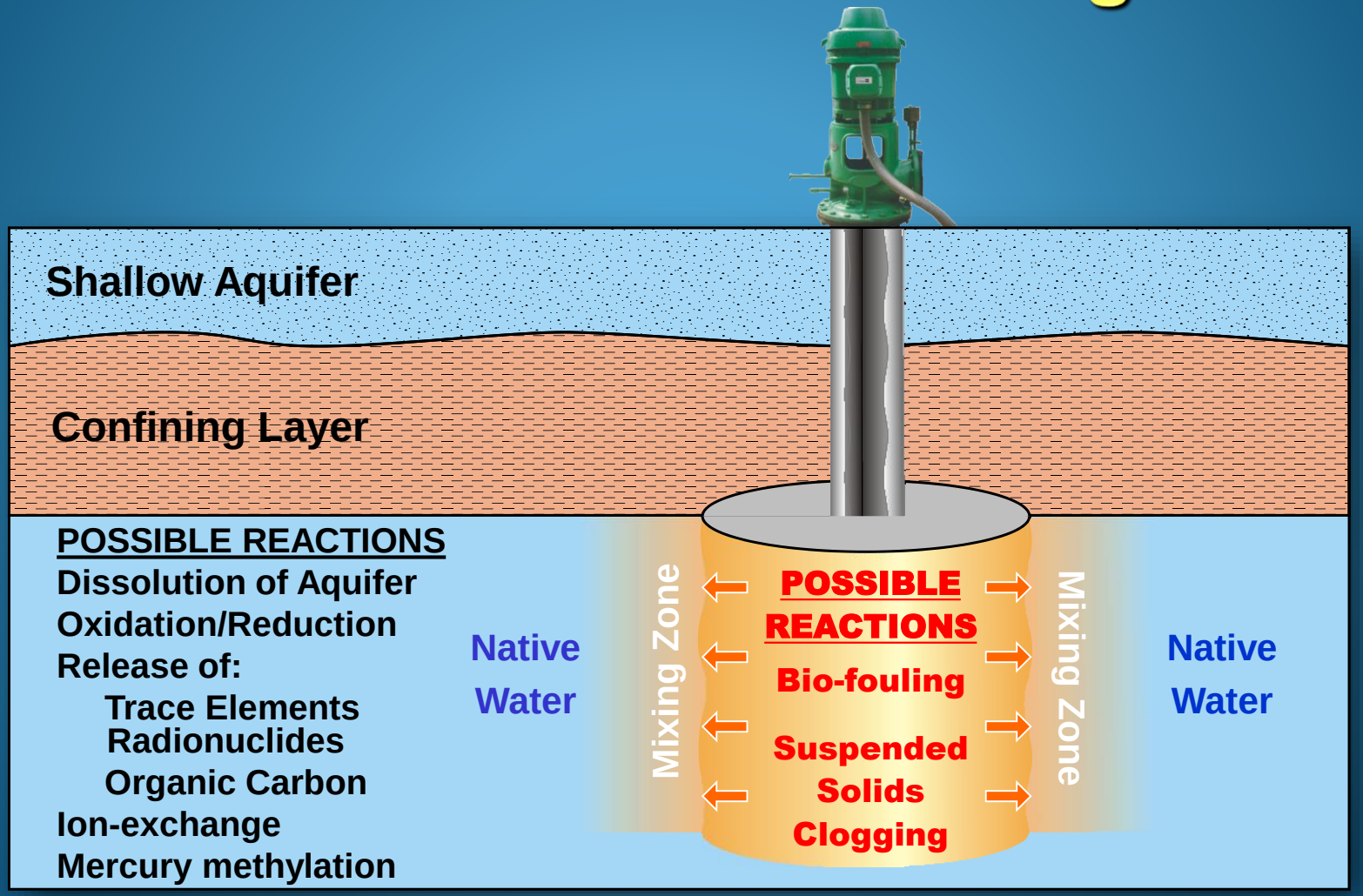
Phase 1 Feasibility: Geochemical Modeling



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Bennett, 2007

Phase 2
Initial Well and Testing Program

- Preliminary design of the ASR system – well and surface facilities
- State and local permitting
- Drilling test wells and sample formations (cutting and/or cores)
- Obtain site specific hydraulic characteristics of the proposed ASR horizon and overlying and underlying confining units (seals) via pumping tests and geophysical techniques
- Laboratory analysis of source water and groundwater
- Cycle testing

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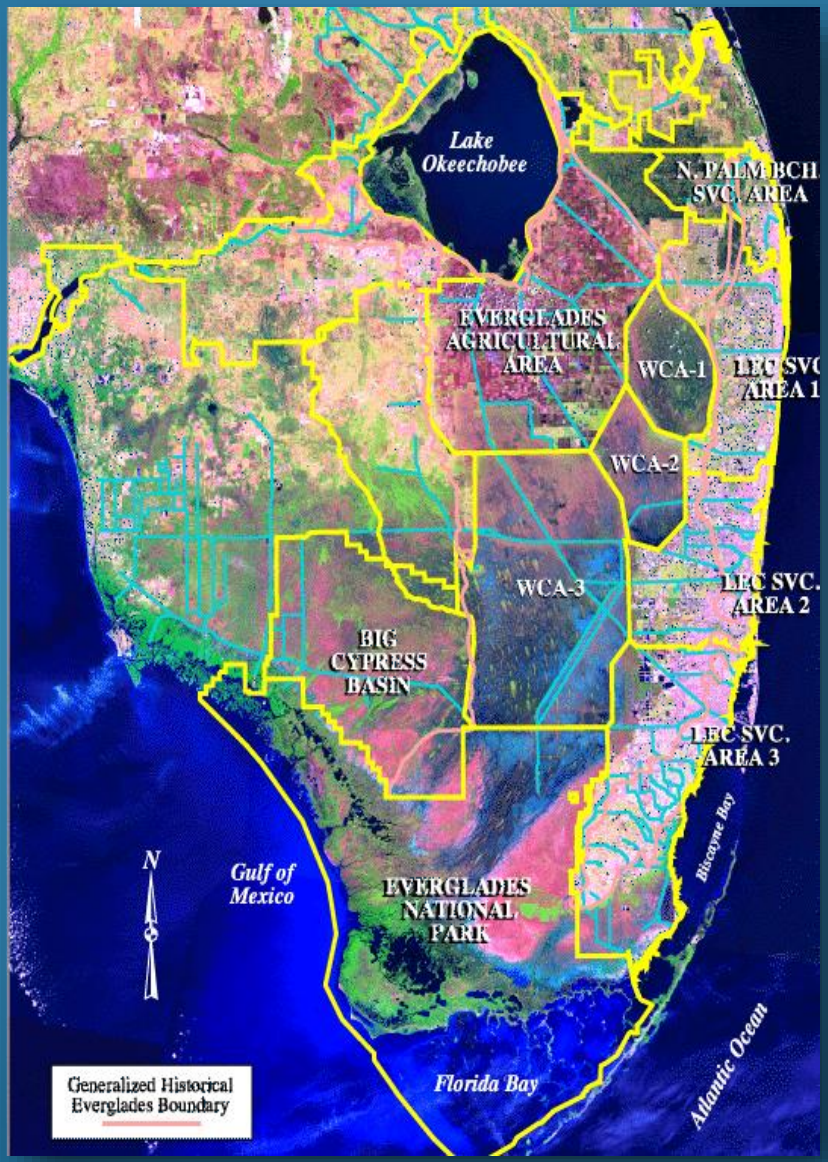
Phase 2 Case Study: ASR In Support Of The Comprehensive Everglades Restoration Project

Case Study Location: SFWMD



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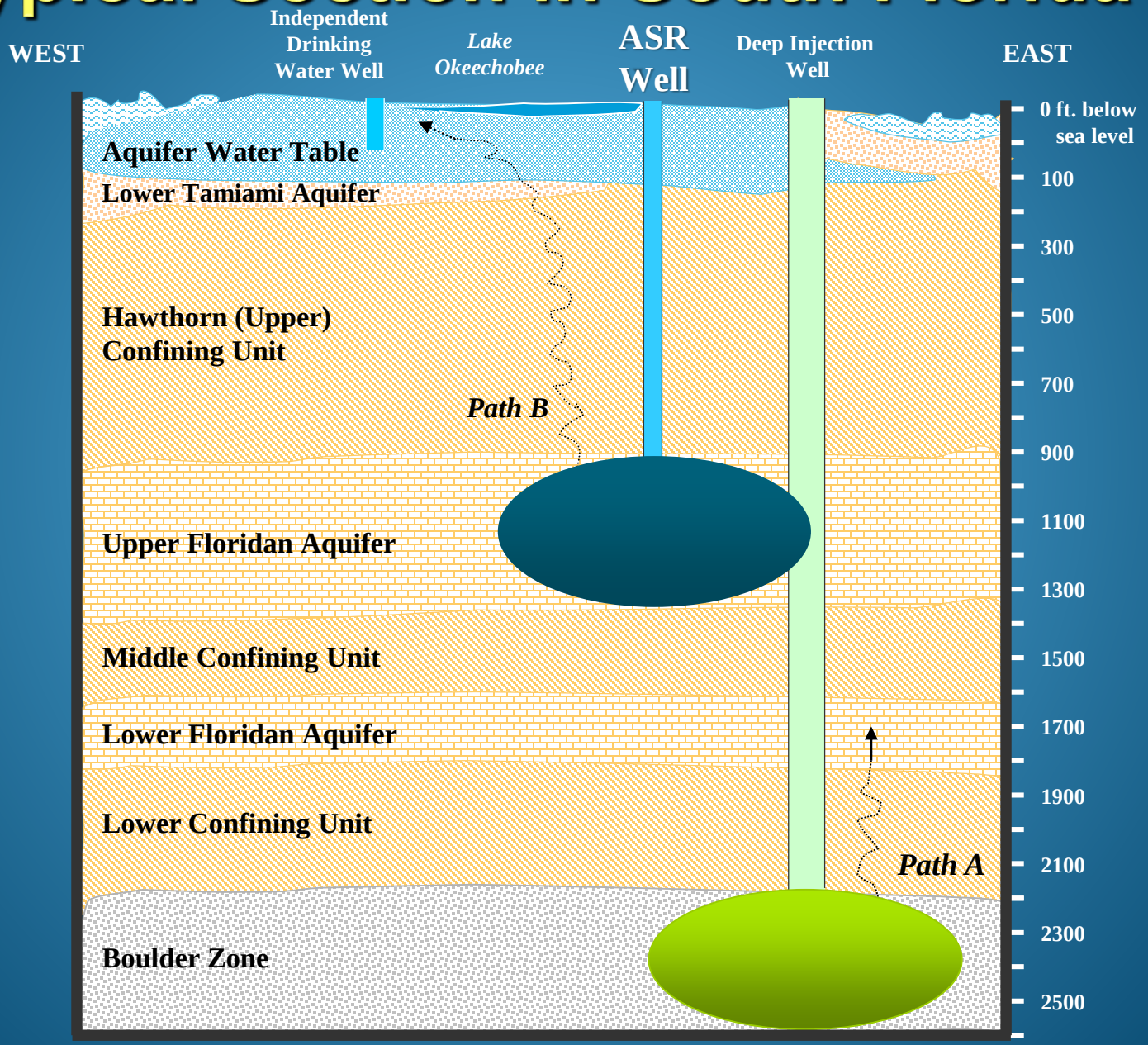
Typical Section in South Florida



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Exploratory Drill / Test Sites

Moore Haven ASR Test Monitor Well GLF-6

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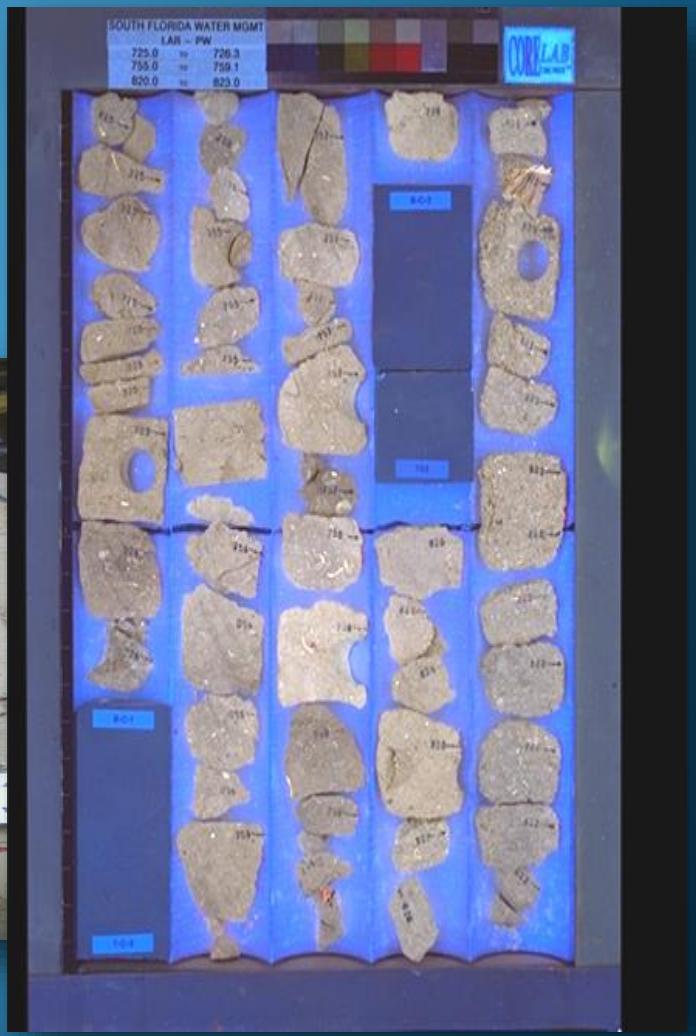
Full Diameter Coring



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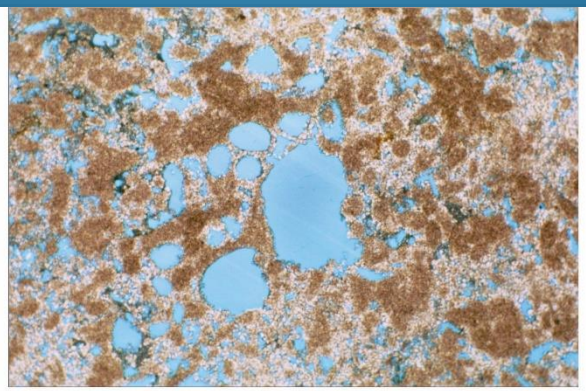
Petrophysical & Mineralogical Properties



WELL: MF-37
DEPTH: 1945.9
MAGNIFICATION: 40X

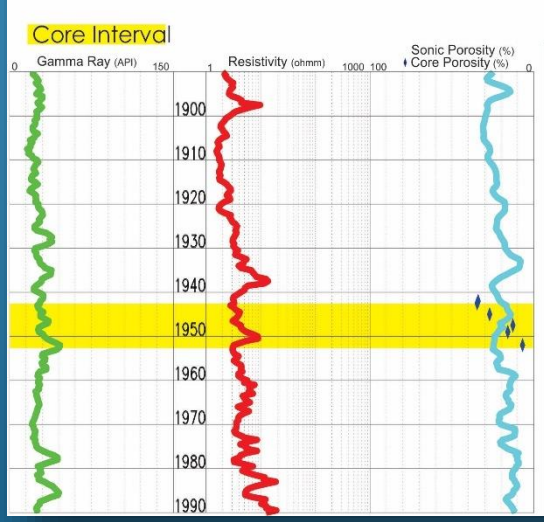
Lithofacies: Peloid-Pellet-Dolopackstone

Depositional Environment: Restrictive Shallow Lagoon

Porosity Amount: Good

Dominant Porosity Type: Vuggy-Moldic

Other Constituents:



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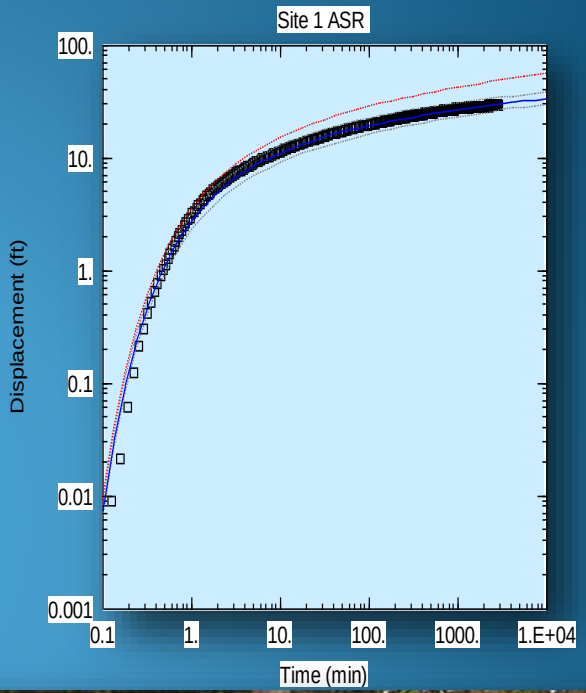
Aquifer Performance Testing



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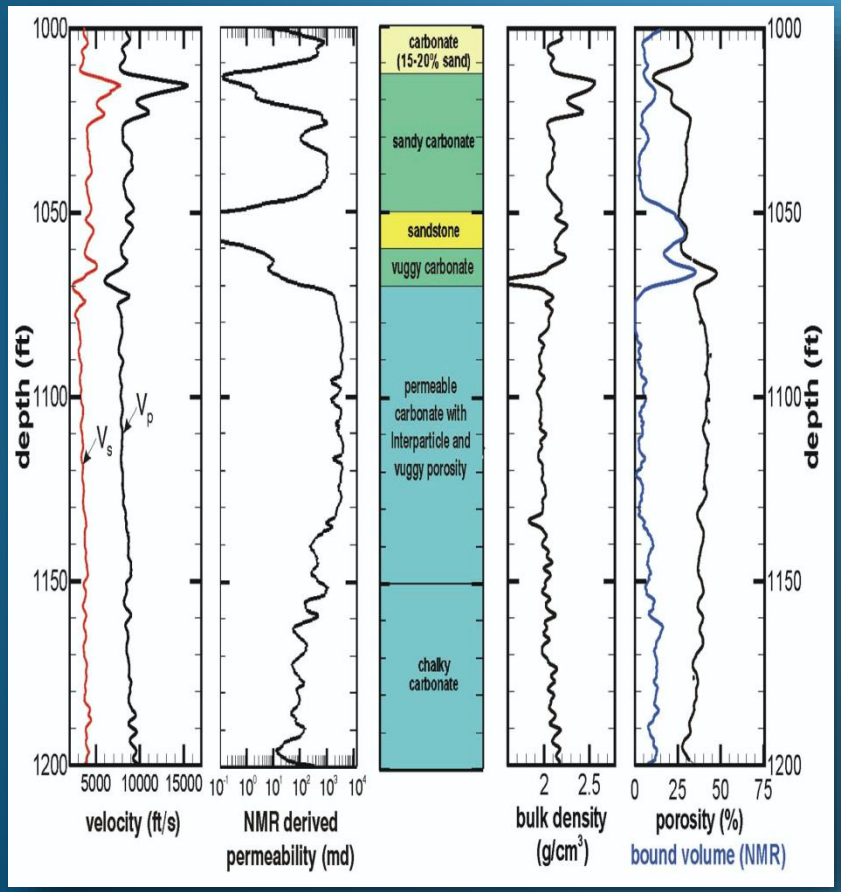
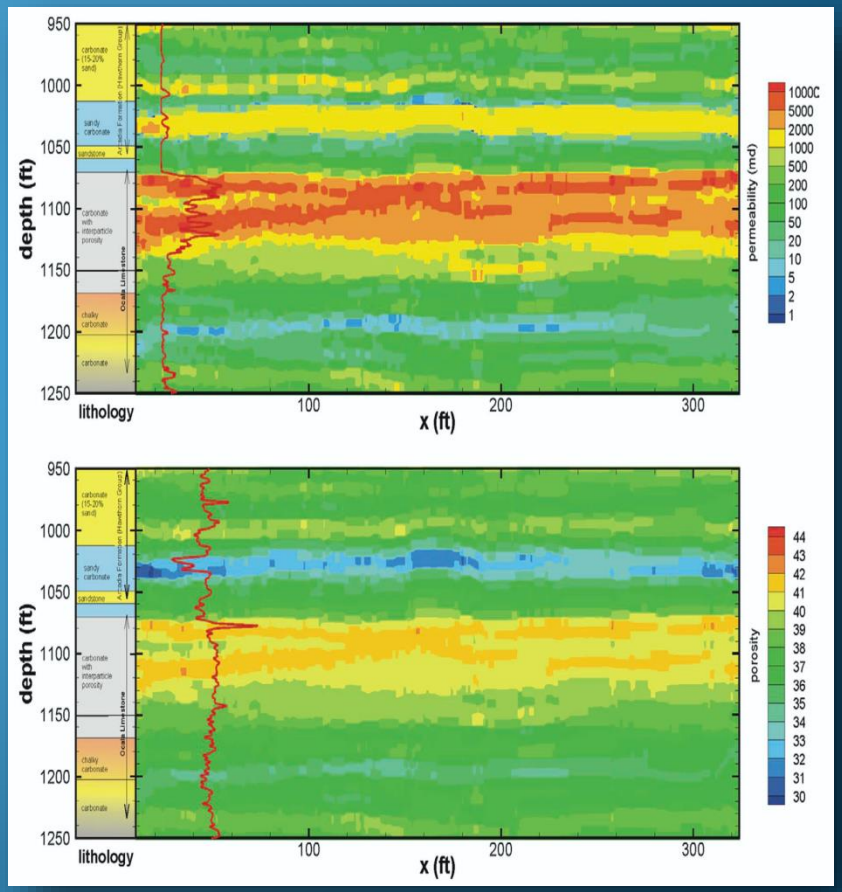
Integration of Geophysical & Petrophysical Data to Define ASR Horizon & Lateral Continuity





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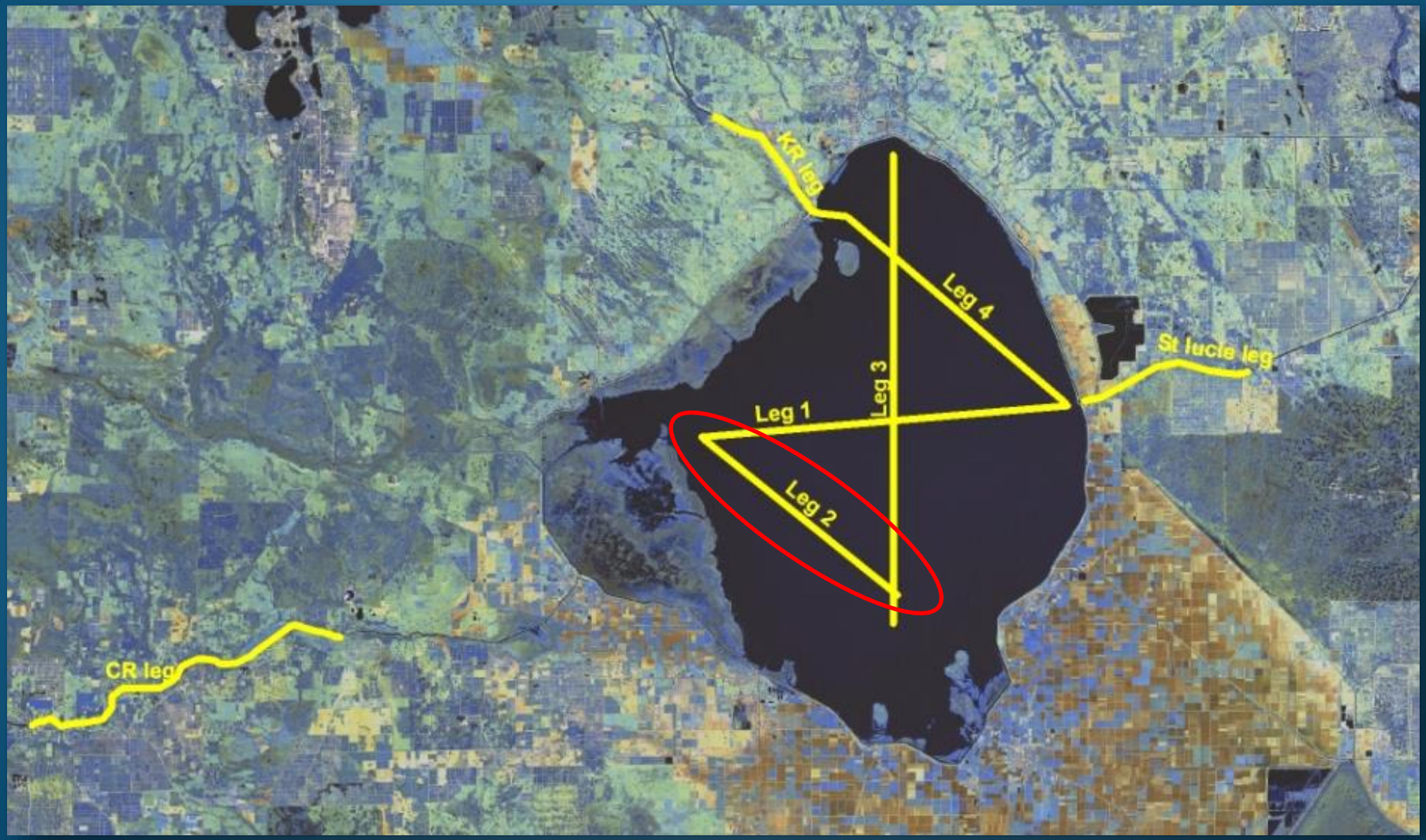
Marine Seismic Reflection Survey



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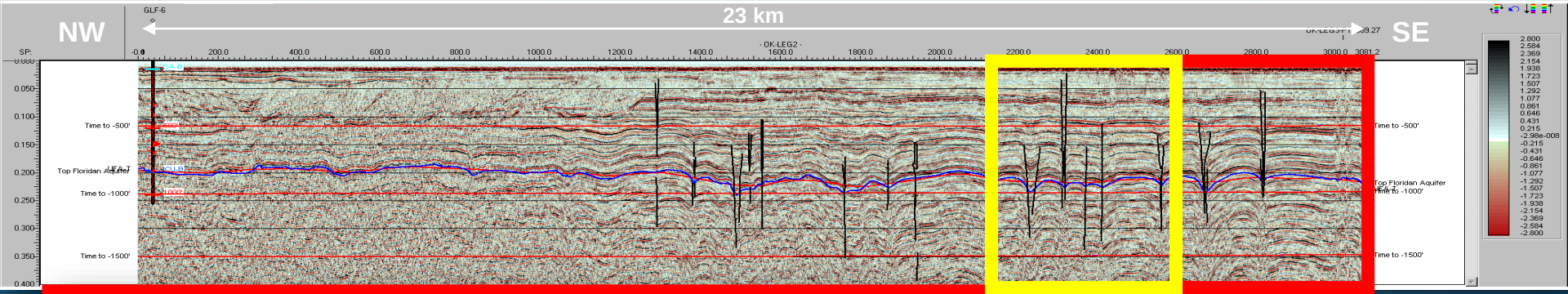
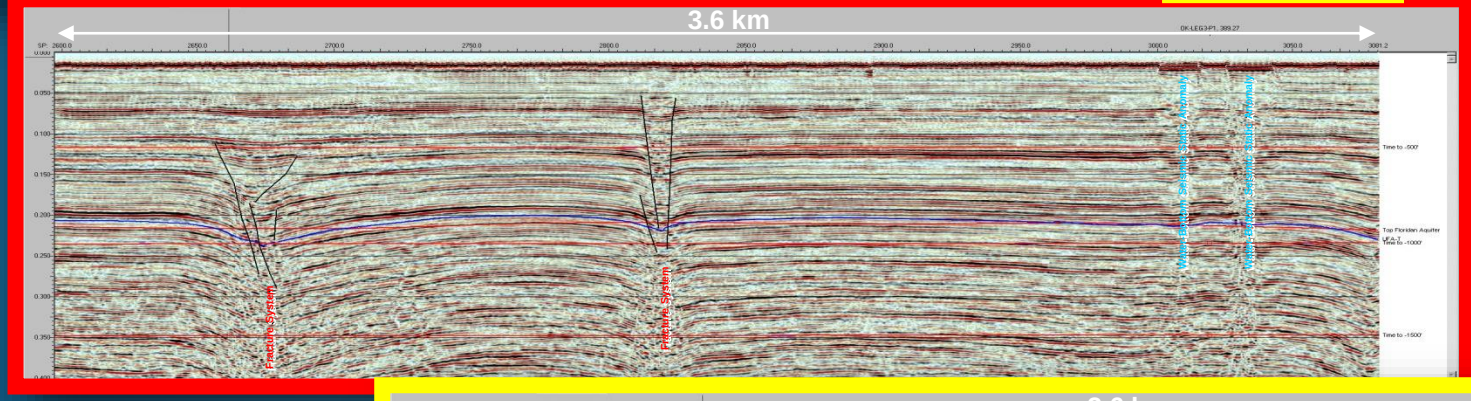
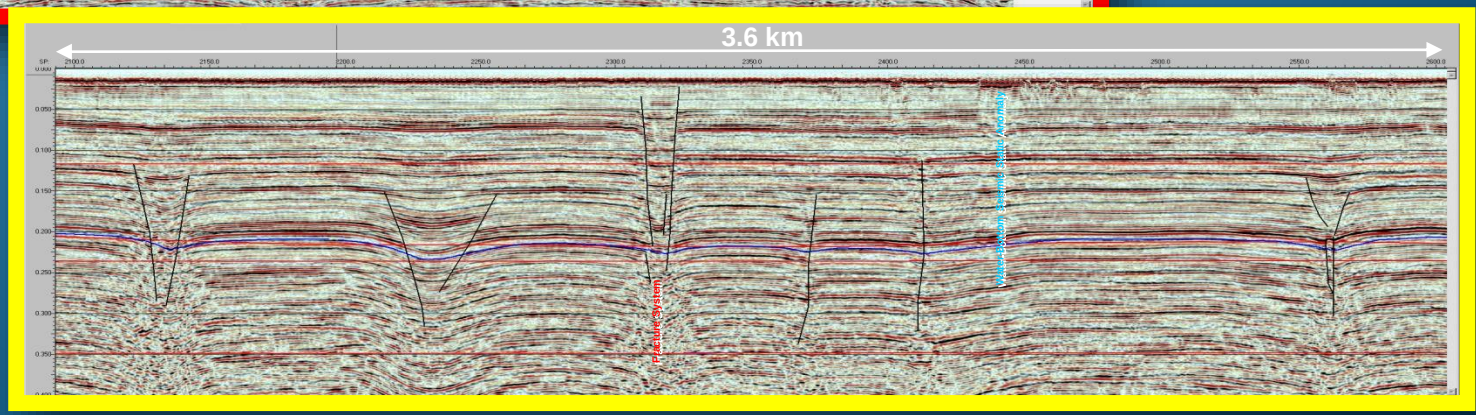
Lake Okeechobee Seismic Line – Leg 2







Fractures penetrating the Upper Confining Unit from the Floridan Aquifer

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A Successful ASR Project Provides:

- Larger volume / longer term storage of water resources
- High rates of recovery (can be >90%)
- Full utilization of take and pay contracts and/or water treatment facilities
- Flexibility in well siting / minimal real estate

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Steps for a Successful ASR Project

Phase 1 – Feasibility and Conceptual Design

Phase 2 – Initial Well and Testing Program

Phase 3 – Facilities Expansion

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QUESTIONS

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