



Hydrogeology of Class I UIC Injection Wells in the Gulf

Emily Welch, PG

February 26, 2026

Overview of Today's Presentation

- Gulf Coast hydrogeologic setting
- USDWs and regional aquifer systems
- Injection zone characteristics
- Groundwater flow concepts
- Safety and monitoring requirements
- Formation testing and permitting
- Why the Gulf Coast is ideal for Class I wells

What Are Class I UIC Injection Wells?

- Used for **non-hazardous** industrial and municipal liquid waste
- Regulated under EPA's Underground Injection Control Program
 - Louisiana – LDCE
 - Texas – TCEQ
 - Mississippi - MDEQ
- Designed to inject into deep, isolated, saline formations
- Must demonstrate long-term containment



Class I UIC Injection Well Advantages

1. Strong protection of drinking water
2. Environmentally controlled alternative to surface disposal
3. Reliable, long-term capacity
4. Strict regulatory framework
5. Cost effectiveness
6. Smaller surface footprint
7. Supports essential infrastructure
8. Proven track record
9. Compatibility with waste minimization

Why the Gulf Coast Is Ideal

- Thick sedimentary sequences (10,000 – 30,000+ feet)
- Laterally extensive clay confining units
- Deep, high-salinity formations
- Natural hydraulic separation from USDWs
- Predictable depositional environments

STRATIGRAPHIC AND GEOHYDROLOGIC UNITS OF LOUISIANA

SYSTEM	SERIES	STRATIGRAPHIC UNIT	GEOHYDROLOGIC UNIT									
			Northern Louisiana	Central and Southwest Louisiana			Southeast ¹ Louisiana					
			Aquifer or Confining Unit	Aquifer System or Confining Unit	Aquifer or Confining Unit		Aquifer System or Confining Unit	Aquifer				
		Lake Charles Area	Rice Growing Area		Baton Rouge Area	St. Landry, Tangipahoa & Washington Parishes	New Orleans area and lower Mississippi River parishes					
QUATERNARY	HOLOCENE	Undifferentiated alluvial deposits Red River alluvial deposits Mississippi River alluvial deposits	Undifferentiated alluvial aquifers	Alluvial aquifer system	Undifferentiated alluvial aquifers		Alluvial Aquifer System	Undifferentiated alluvial aquifers				
	PLEISTOCENE	Northern Louisiana terrace deposits Unnamed Pleistocene deposits Upland Complex ²	Northern Louisiana terrace aquifer	Chicot aquifer system	"200 foot" aquifer "500 foot" aquifer "700 foot" aquifer	Upper Chicot aquifer Lower Chicot aquifer	Chicot equivalent aquifer system	SOUTHERN HILLS AQUIFER SYSTEM	"400-foot" "600-foot"	Shallow Upper Ponchatoula	Gramercy Norco Gonzales New Orleans "1200-foot"	
TERTIARY	PLIOCENE	FLEMING FORMATION	Blounts Creek Member ²	Equivalent aquifers absent in this area	Evangeline aquifer ²		Evangeline ² equivalent aquifer system		"800-foot" "1000-foot" "1200-foot" "1500-foot" "1700-foot"	Lower Ponchatoula Big Branch Kentwood Abita Covington Shidell	Unnamed saline aquifers	
					MIOCENE	Castor Creek Member			Castor Creek confining unit			Castor Creek equivalent confining unit
						Williamson Creek Member Dough Hills Member Carahan Bayou Member			Jasper aquifer system	Williamson Creek aquifer Dough Hills aquifer unit Carahan Bayou aquifer		Jasper equivalent aquifer system
						Lena Member			Lena confining unit			Lena equivalent confining unit
	OLIGOCENE	Catahoula Formation	Catahoula aquifer	Unnamed saline aquifers		Catahoula equivalent aquifer system						
		Vicksburg Group	Vicksburg confining unit									
	EOCENE	CLABORNE GROUP	Jackson Group	Jackson confining unit								
			Cockfield Formation	Cockfield aquifer								
Cook Mountain Formation			Cook Mountain confining unit									
Sparta Formation			Sparta aquifer									
Cane River Formation			Cane River confining unit									
Wibaux Group			Carrizo Formation	Carrizo-Wilcox aquifer								
Various formations												
PALEOCENE	Midway Group	Midway confining unit										

¹ Clay units separating aquifers in southeastern Louisiana are discontinuous and unnamed.

² May be Pliocene in part; Pliocene not traditionally recognized at the surface in Louisiana.

³ The Southern Hills Aquifer System is a sole surface regulatory aquifer unit. This term is not in general or geologic use.

DEFINITIONS

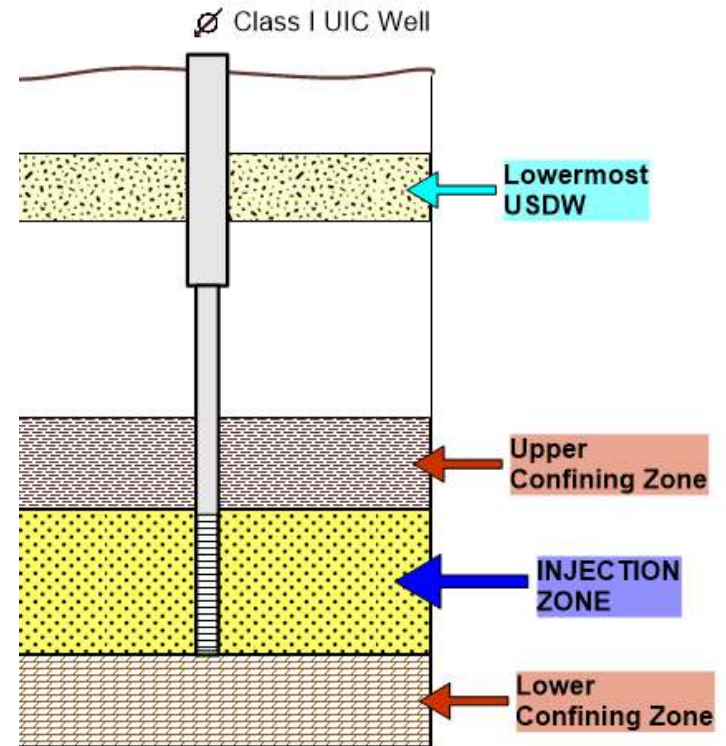
AQUIFER: a formation or group of formations that will yield water to a well or a spring.

AQUIFER SYSTEM: a group of aquifers that function regionally as a water-yielding hydraulic unit.

EQUIVALENTS: Aquifer systems east of the Mississippi River that are stratigraphically correlative but not hydraulically connected to those west of the Mississippi River.

Focus on Southern Louisiana

- Dominated by Mississippi River deltaic deposits
- Highly stratified sands, silts, and clays
- Freshwater aquifers are generally shallow (<2,000 feet)
- Saline formations deepen toward the coast
- Abundant thick confining units



Understanding USDWs

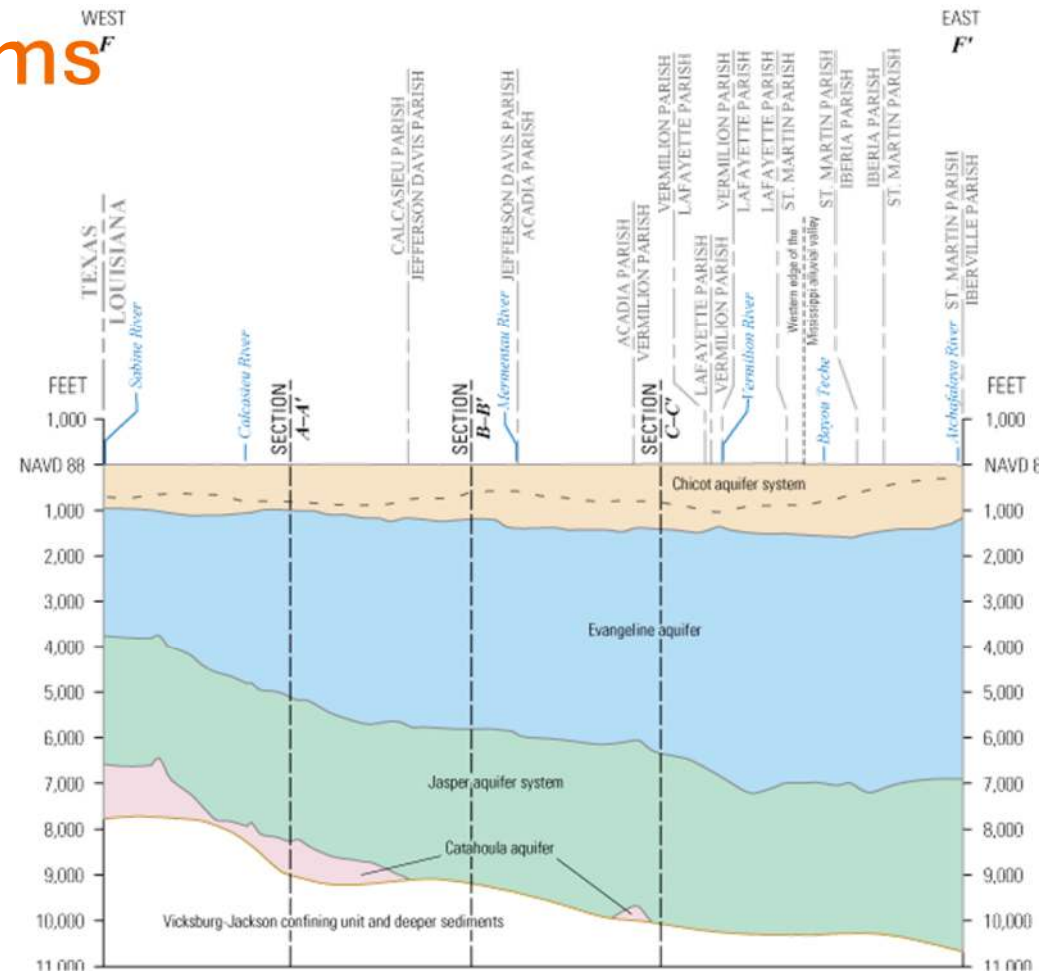
Underground Sources of Drinking Water

- Defined by the EPA as:
 - <10,000 mg/L TDS
 - Sufficient quantity to supply a public water system
- Typically shallow in the Gulf Coast
- Must be protected from vertical and lateral migration

Type of Water	Total Dissolved Solids Levels (mg/L)
Fresh	<1,000
Brackish	>4,000
Saline	>10,000

Regional Aquifer Systems ^{WEST}_F

- Chicot
- Evangeline
- Jasper
- Southern Louisiana equivalents



Zone Requirements

Injection Zone:

- High Porosity (20-30% typical for Gulf Coast sands)
- Adequate Permeability for Sustained Injection
- Sufficient Thickness (often >50-100 feet)
- High Formation Water Salinity
- Lateral Continuity

Confining Zone:

- Very Low Permeability
- Thick, Laterally Continuous Clay or Shale
- Faults and Seismicity - No Faults or Fractures That Could Transmit Fluids
- Must Withstand Injection Pressures

Injection Zone Reservoir Properties

- Porosity and Permeability – Injection capacity limited by the permeability thickness of the formation, as well as surface injection pressure limitations
- Lithology of the Injection Formation
- Bottomhole Temperature and Pressure
- Formation Fracture Pressure

Reservoir Testing

- Step-Rate Tests – identifies fracture pressure
- Injectivity Tests – how easily the formation accepts fluid
- Pressure Falloff Tests – helps estimate permeability and reservoir boundaries

Groundwater Flow Basics

- Groundwater properties determine:
 - How much fluid the formation can accept
 - Sustainable injection pressure
 - Risk of fracturing the formation
- Injectate follows:
 - Paths of highest permeability
 - Regional downgradient direction
 - Bedding planes within the sandstone
- Darcy's Law governs movement

$$Q = K \times A \times \frac{\Delta h}{L}$$

- Injection increases formation pressure, influencing plume movement

Injection Flow = Natural Flow + Induced Flow

Practical Examples

High Perm, Good Natural Flow:

Low Injection Pressure

Large Radius of Influence

Stable Long-Term Operation

Tight Formation, Minimal Flow:

Rapid Pressure Buildup

Limited Capacity

Need For:
-Multiple Wells
-Lower Rates

Strong Regional Gradient:

Plume Migrates Preferentially One Direction

Monitoring Must Be Downgradient

AOR Becomes Asymmetric

Groundwater Characterization Evaluation

- Define USDW
- Baseline Water Quality Sampling – Major ions, TDS, pH, alkalinity, trace metals, organics of concern, and background parameters tied to the waste stream
- Compatibility between formation water and proposed injectate (precipitation, scaling, mobilization of metals)
- Presence of hydrocarbons, H₂S, or other constituents that could react
- Geochemical stability (clay mineralogy, potential for dissolution)

Pressure Management

- Groundwater flow analysis used to:
 - Set maximum allowable injection pressure
 - Predict radius of pressure influence
 - Prevent
 - Fracturing
 - Upward migration
 - Interference with other wells
- Injection pressure must stay below fracture pressure
- Formation pressure increases over time
- Pressure buildup helps distribute fluids laterally
- Modeling predicts long-term plume extent

Safety Measures

- Mechanical Integrity Tests
- Annulus Pressure Monitoring
- Radioactive Tracer Surveys
- Cement Bond Logs
- Periodic Well Workovers
- Monitoring Wells



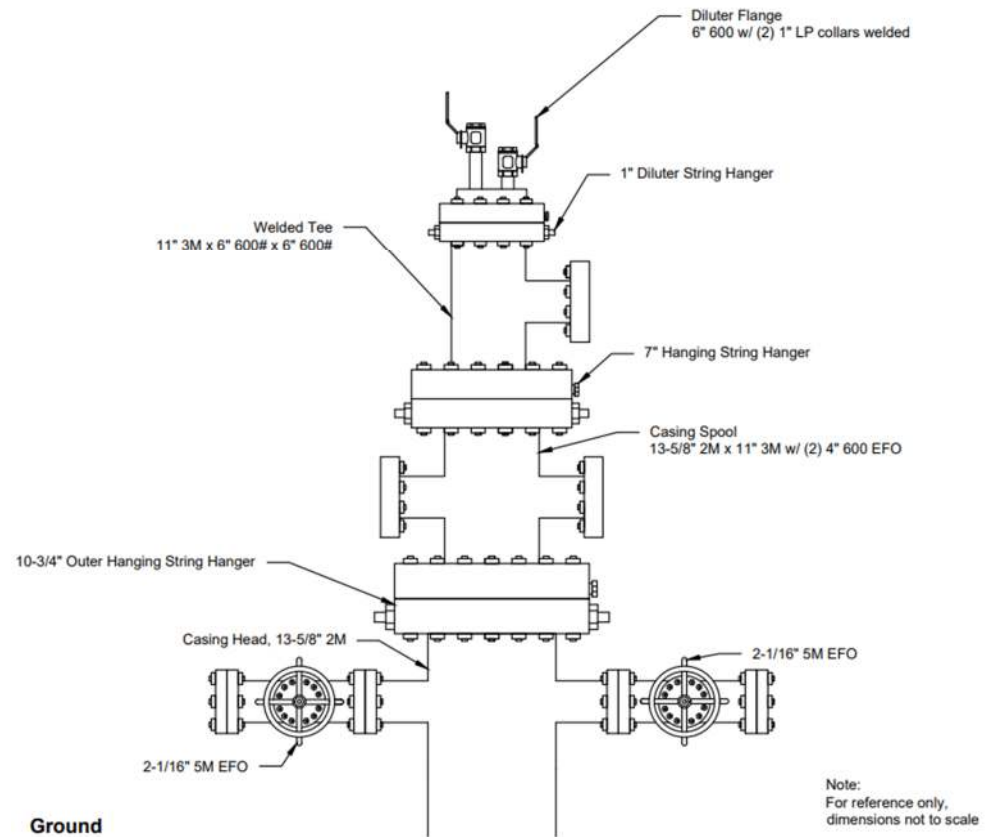
Permitting Requirements

- Geologic and hydrogeologic characterization
- Well construction design
- Area of Review (AOR) modeling
- Monitoring, Testing, and Reporting
- Waste stream characterization
- Contingency Plans
- Closure and Post-Closure Plans
- Financial Responsibility
- IT Questions



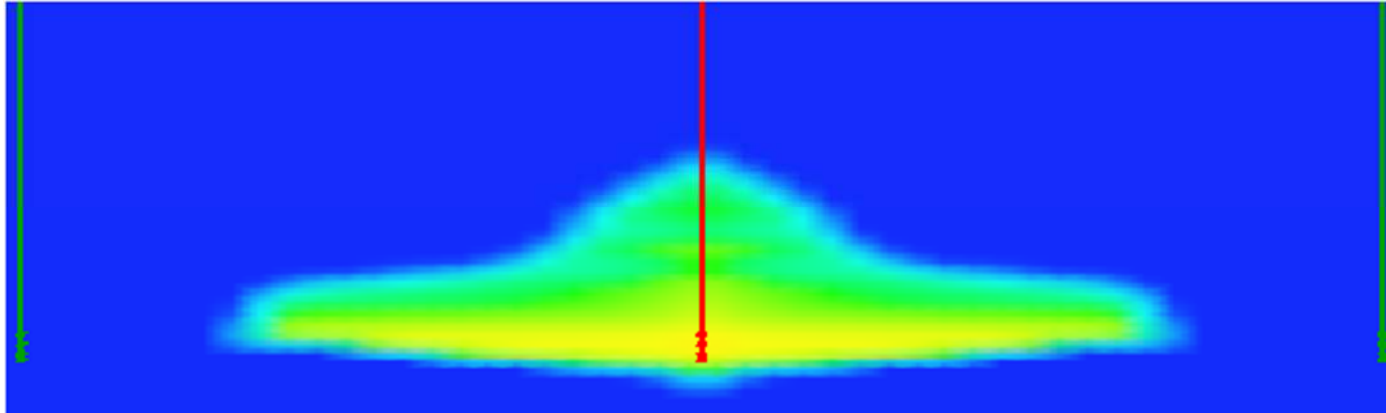
Well Construction Overview

- Multiple casing strings
- Cemented to surface
- Steel + cement barriers
- Tubing and packer isolate injection fluids



Long-Term Containment

- Modeled plume extent
- Pressure dissipation over time
- Confining unit integrity
- Monitoring ensures continued isolation



Why Class I Wells Are A Safe Disposal Alternative

- Deep, isolated formations
- Multiple engineered barriers
- Multiple geologic barriers
- Continuous monitoring
- Strict regulatory oversight

Summary

- Gulf Coast's geology is ideal for injection
- USDWs are shallow and well-protected
- Injection zones are deep, saline, and isolated
- Safety systems ensure long-term containment
- Class I wells provide reliable waste management

Citations

- EPA UIC Program
- Louisiana Department of Conservation & Energy
- USGS Gulf Coast Aquifer System studies
- LSU, Louisiana Geological Survey
- Freeze & Cherry, Groundwater
- Domenico & Schwartz, *Physical and Chemical Hydrogeology*
- EPA Class I Well Guidance
- USGS Water Resources of Louisiana



THANK YOU! Any Questions?

Emily Welch, PG

ewelch@gecinc.com

225-612-4146