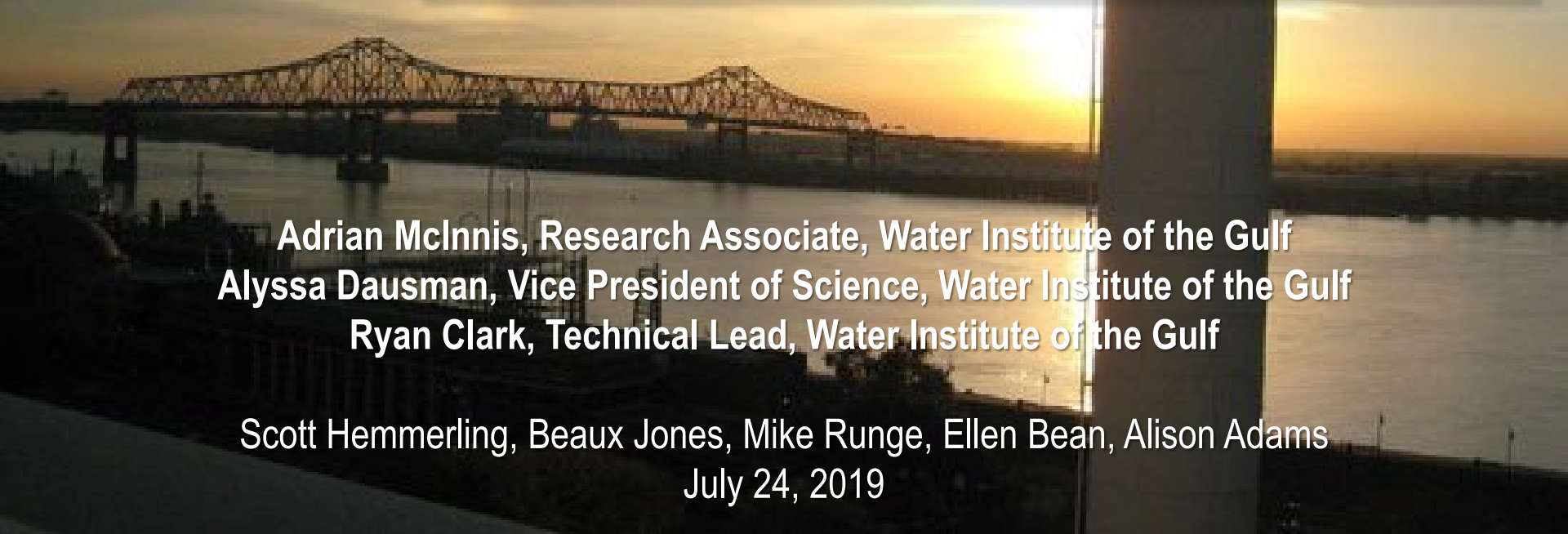


# **WATER RESOURCES IN THE BATON ROUGE AREA AND THE SOUTHERN HILLS AQUIFER: AN OVERVIEW**

## ***PART 4 OF 5: AQUIFER DYNAMICS***



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**July 24, 2019**



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# ACKNOWLEDGEMENTS

- Capital Area Groundwater Conservation Commission
- LA Coastal Protection & Restoration Authority
- LSU
  - Frank Tsai
- USGS
  - Lower Mississippi Gulf Water Science Center
- Technical Team
  - Mike Runge, USGS
  - Ellen Bean
  - Alison Adams, INTERA
  - Alyssa Dausman
  - Adrian McInnis
  - Ryan Clark
  - Beaux Jones
  - Scott Hemmerling



# OVERVIEW

- Legal Framework for Decision Making
- Water Resources Demand in the Capital Area
- ***Aquifer Dynamics & Water Supply***
- ***The Southern Hills Aquifer System***





# **AQUIFER DYNAMICS**



# AQUIFERS: UNCONFINED VS CONFINED

- Unconfined

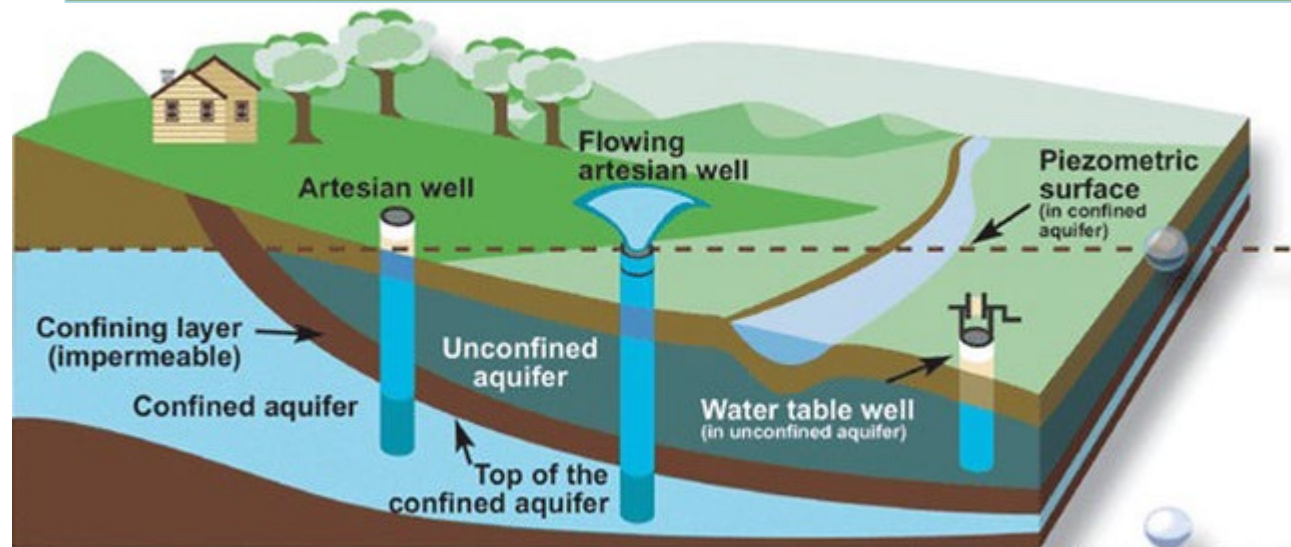
- Upper water surface (water table) is at atmospheric pressure and can rise and fall
- Have recharge areas within the direct vicinity, usually vertically above the water table where present

- Confined

- Saturated with water.
- Layers of impermeable material are both above and below
- Under pressure
- When the aquifer is penetrated by a well, the water will usually rise above the top of the aquifer (i.e. an artesian well)

*Aquifer: A body of permeable rock which can contain or transmit groundwater.*

*The sands of the Southern Hills Aquifer System are confined in the BR area*

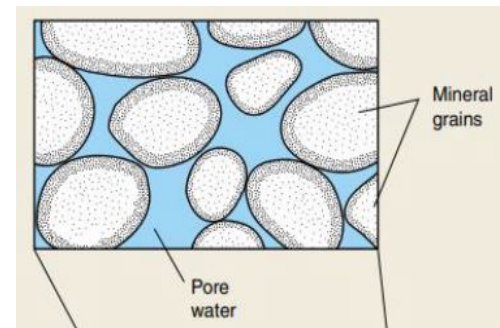


Source: Environment Canada



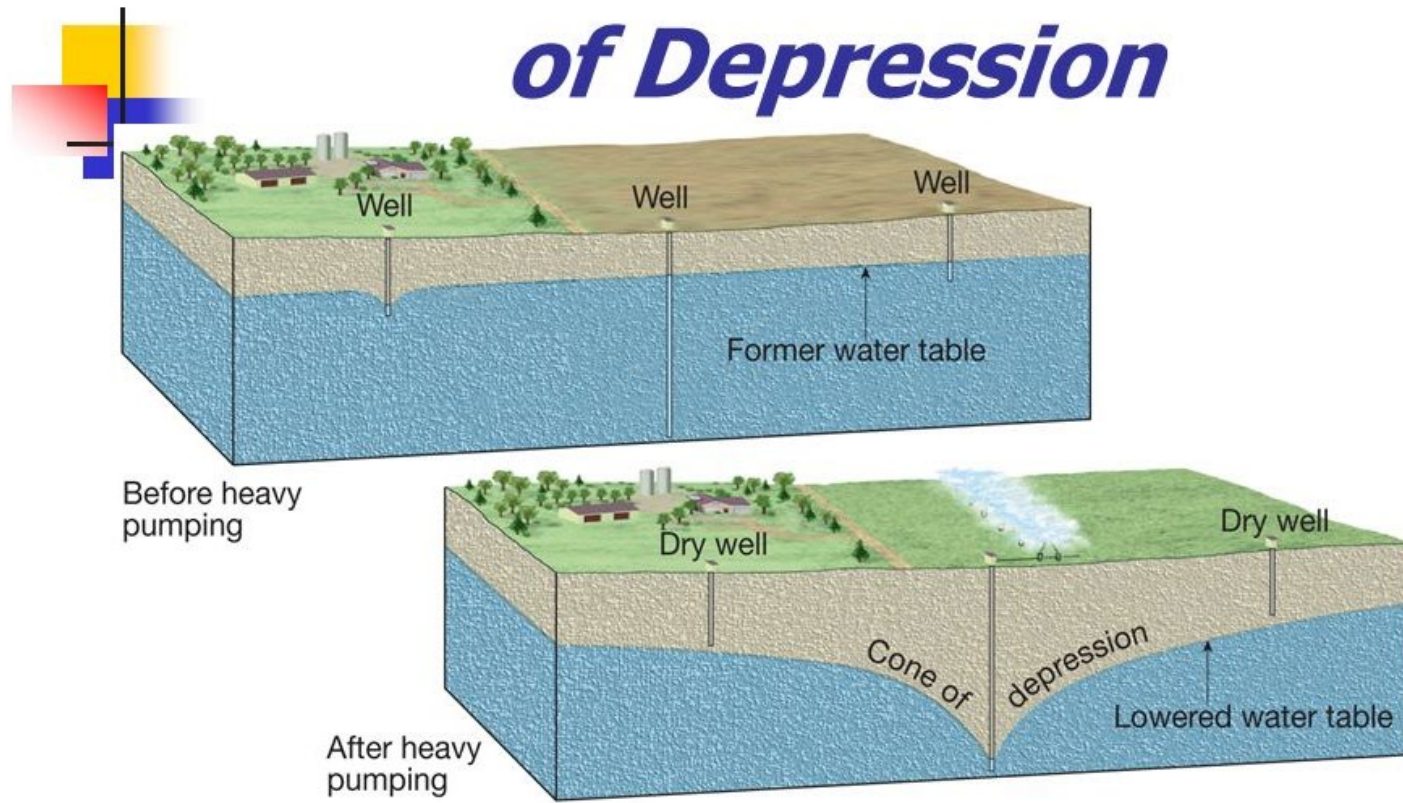
# TERMINOLOGY

- Artesian (Flowing)
  - A well that would flow freely to land surface if tapped
- Potentiometric Surface
  - Theoretical level where water would rise if not confined
- Hydraulic Conductivity
  - How fast a liquid flows through a medium



# PUMPING AND CONES OF DEPRESSION

## *Formation of a Cone of Depression*



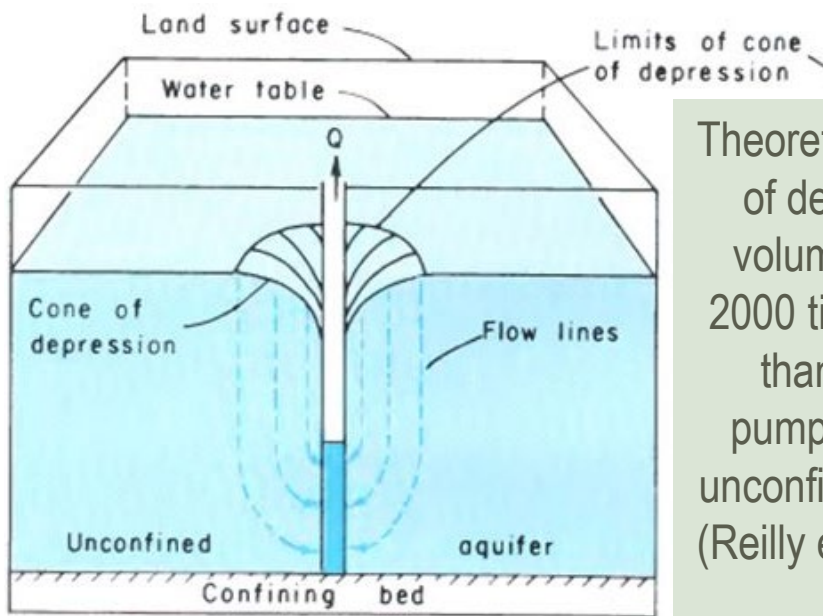
Copyright © 2008 Pearson Prentice Hall, Inc.



# CONES OF DEPRESSION

## Unconfined Aquifer

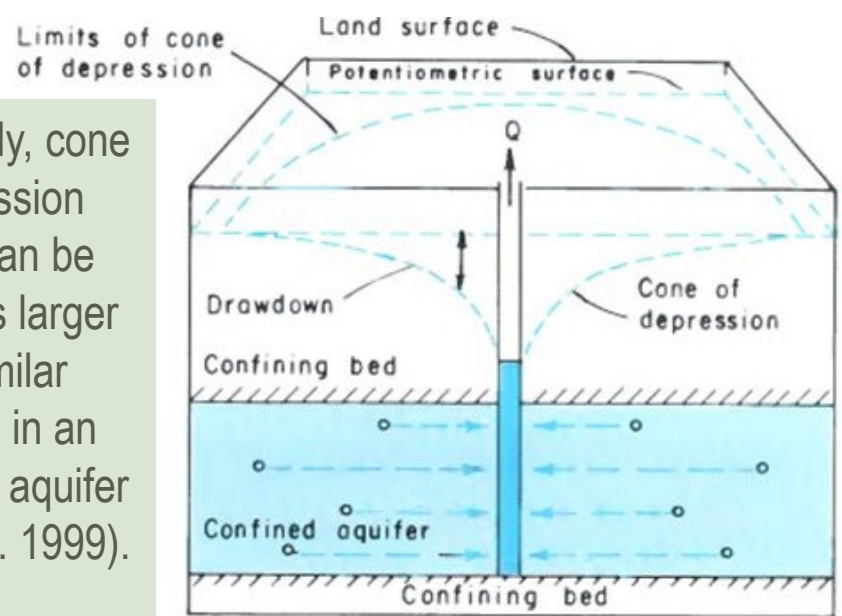
- Cone of depression expands very slowly
- Can lead to dewatering



Theoretically, cone of depression volume can be 2000 times larger than similar pumpage in an unconfined aquifer (Reilly et al. 1999).

## Confined Aquifer

- Cone of depression expands very rapidly
- No dewatering



**Mutual interference of expanding cones around adjacent wells occurs more rapidly in confined aquifers**

Eckstein, 2003

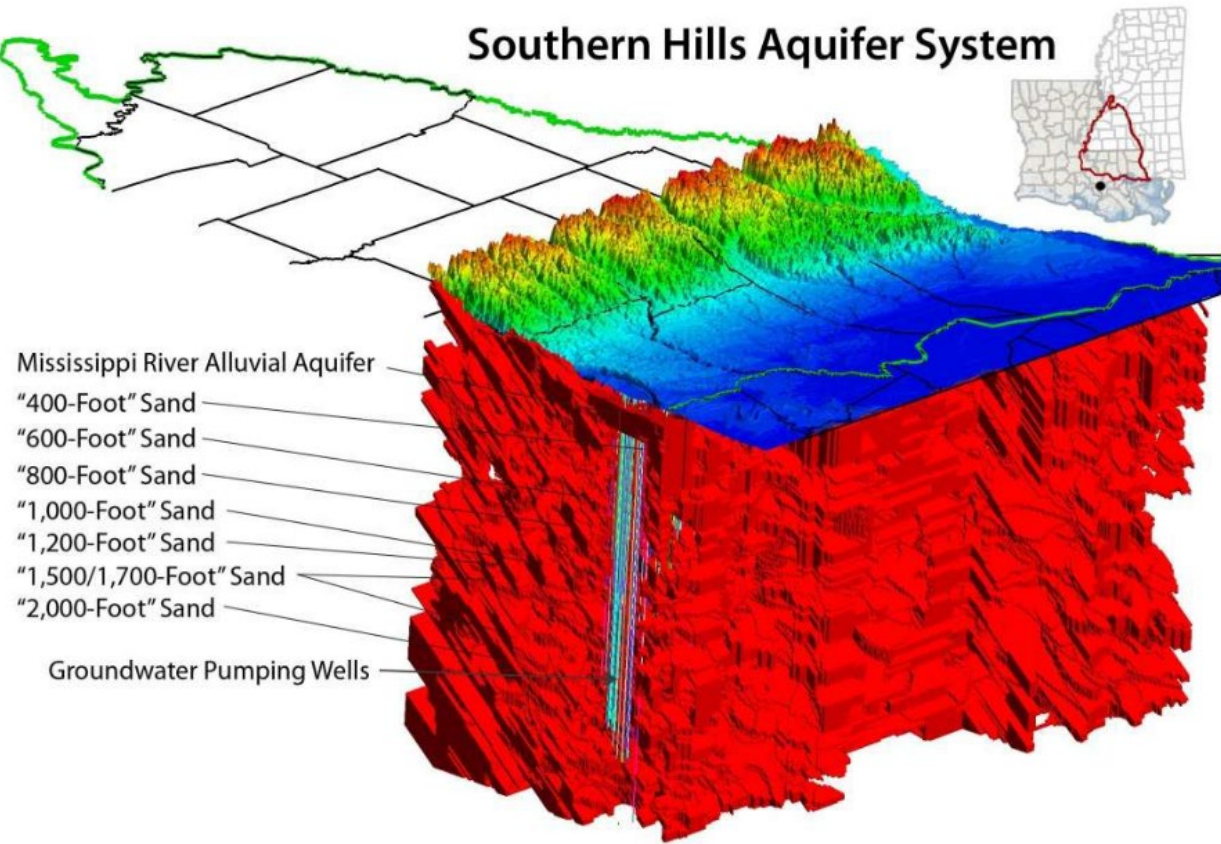




# **THE SOUTHERN HILLS AQUIFER SYSTEM**



# SOUTHERN HILLS AQUIFER SYSTEM



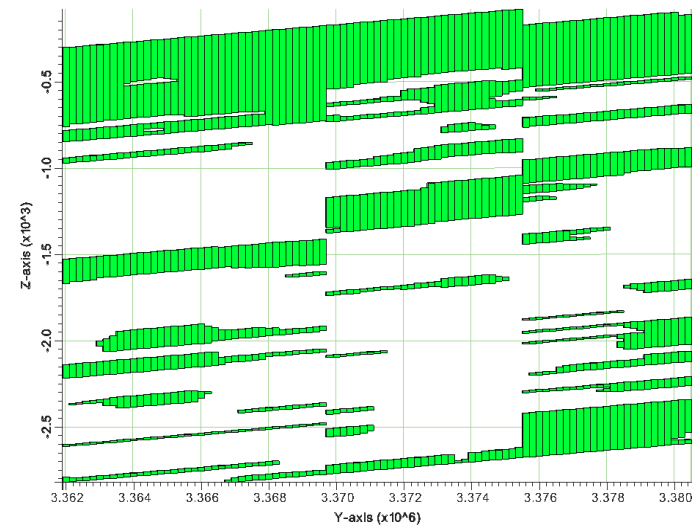
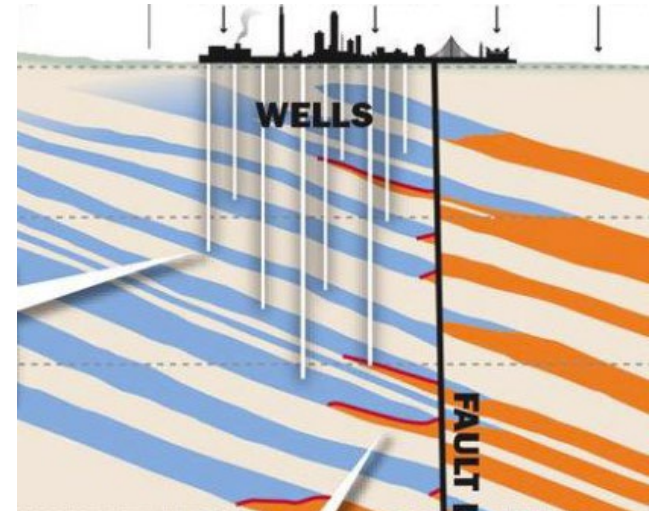
- Sole source aquifer (EPA), for public and domestic use in 10 parishes
- Sediments dip and thicken toward the Gulf of Mexico
- Mississippi River to Pearl River, West to East.
- Extends from the northern limit of the recharge area in the vicinity of Vicksburg, Mississippi, southward approximately to the Baton Rouge fault

Data source: Frank Tsai



# GEOLOGICAL UNCERTAINTY

- Limited data
- Must infer structure and water bearing properties between data points
- Faults - structure and hydrogeologic character
- Uncertainty in how aquifer functions:
  - How does that contribute to management?
  - How does it contribute to predictions?



Data Source: Top: Baton Rouge Advocate

Bottom: <https://sites.google.com/site/franktctsai/home/data>

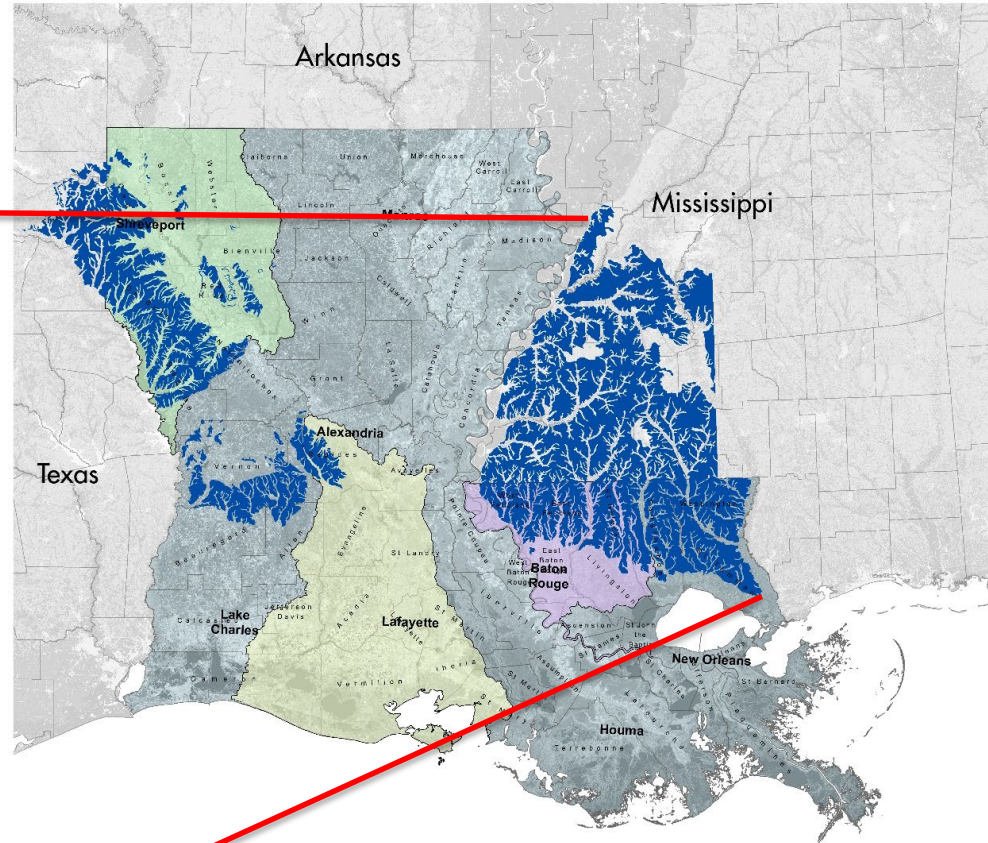
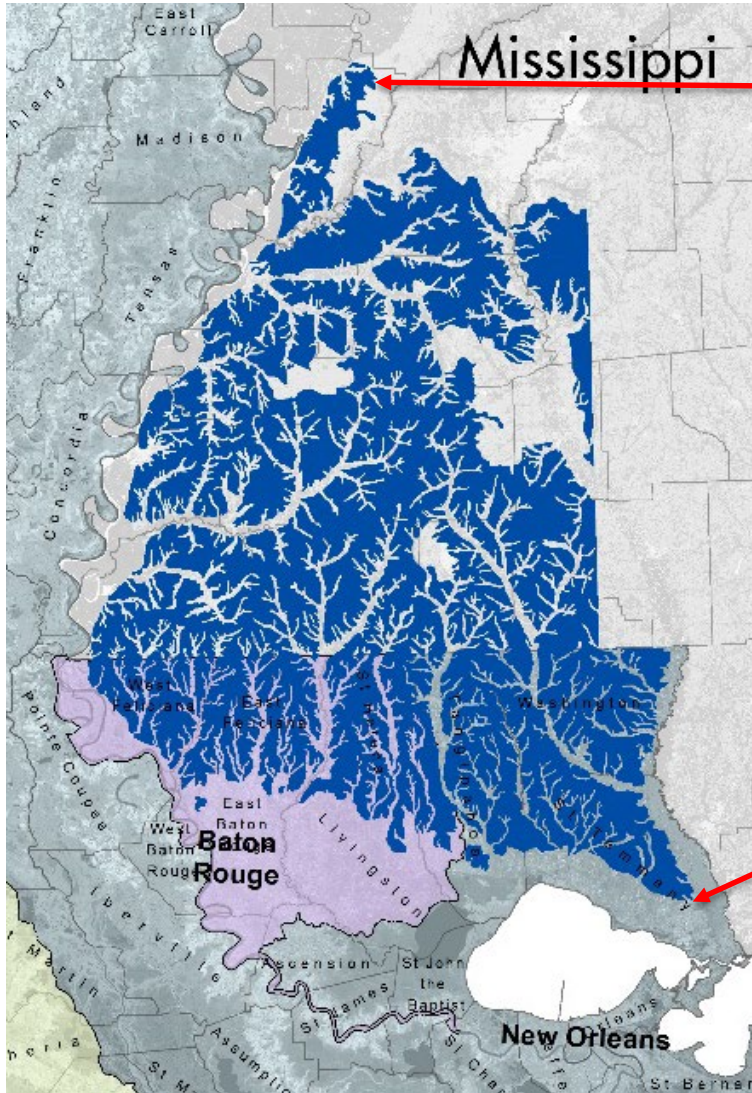


# SOUTHERN HILLS AQUIFER SYSTEM

Series	Hydrogeologic Unit		Aquifer Unit	Mean Thickness (ft)	Hydraulic Conductivity (ft/day)
	aquifer system or confining unit <sup>1</sup>	Baton Rouge area			
Pleistocene	Chicot equivalent aquifer system or surficial confining unit	Mississippi River alluvial aquifer or surficial confining unit Shallow sand "400-foot" sand "600-foot" sand	"800-foot" sand	100	36
			"1,000-foot" sand	65	n/a
			"1,200-foot" sand	95	119
			"1,500-foot" sand	80	142
Pliocene	Evangeline equivalent aquifer system or surficial confining unit	"800-foot" sand "1,000-foot" sand "1,200-foot" sand "1,500-foot" sand "1,700-foot" sand	"1,700-foot" sand	130	33
			"2,000-foot" sand	200	175
Miocene	unnamed confining unit	"2,000-foot" sand "2,400-foot" sand "2,800-foot" sand	"2,400-foot" sand	150	79
	Jasper equivalent aquifer or surficial confining unit		"2,800-foot" sand	200	n/a
	unnamed confining unit				

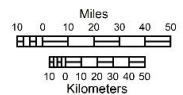


# RECHARGE AREA



## Legend

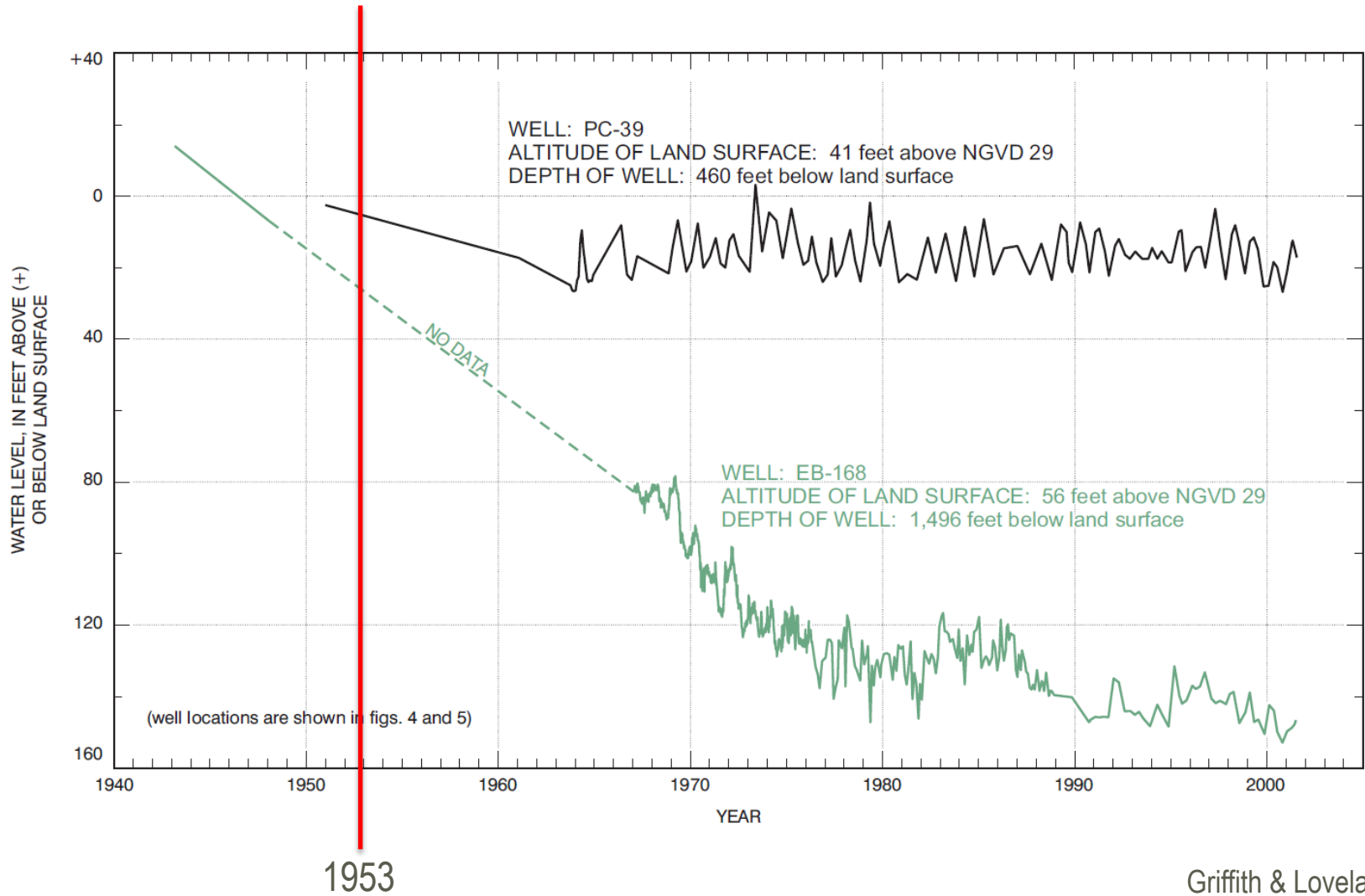
- Southeast Study Area
- Northwest Study Area
- Southwest Study Area
- Groundwater Recharge Areas



Data Source: Louisiana Department of Natural Resources; U.S. Geological Survey



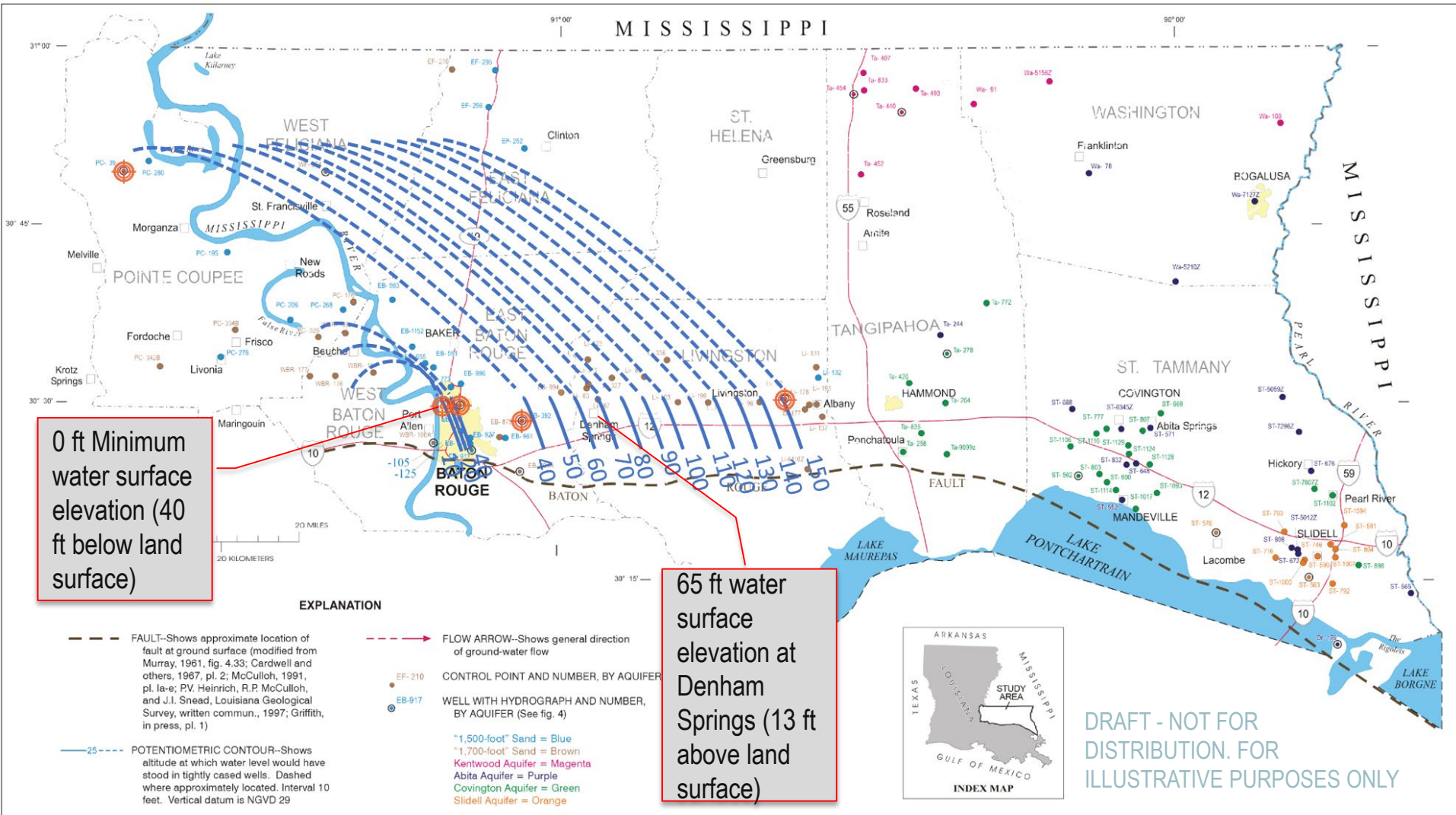
# PUMPAGE & DRAWDOWN



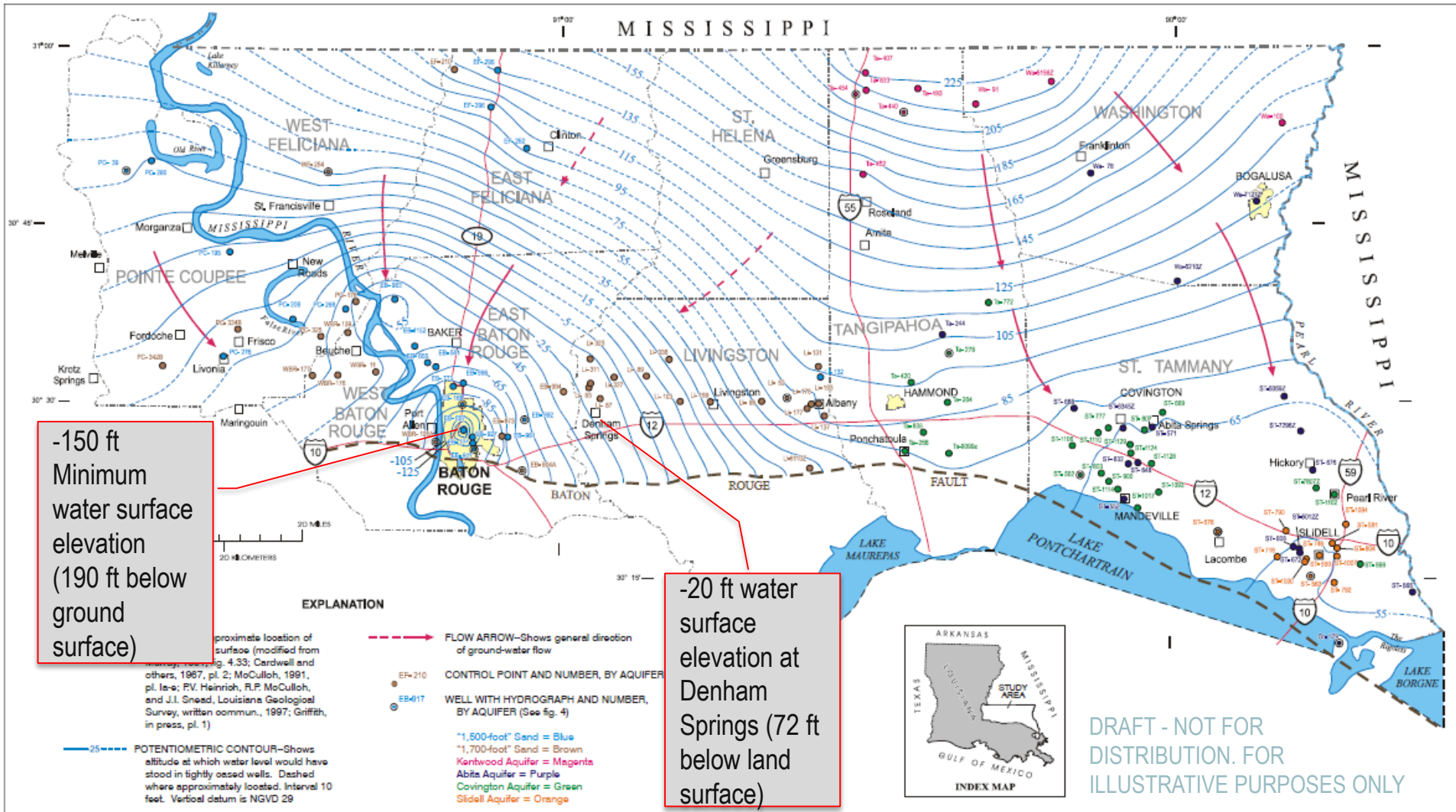
Griffith & Lovelace, 2003



# CONE OF DEPRESSION 1953

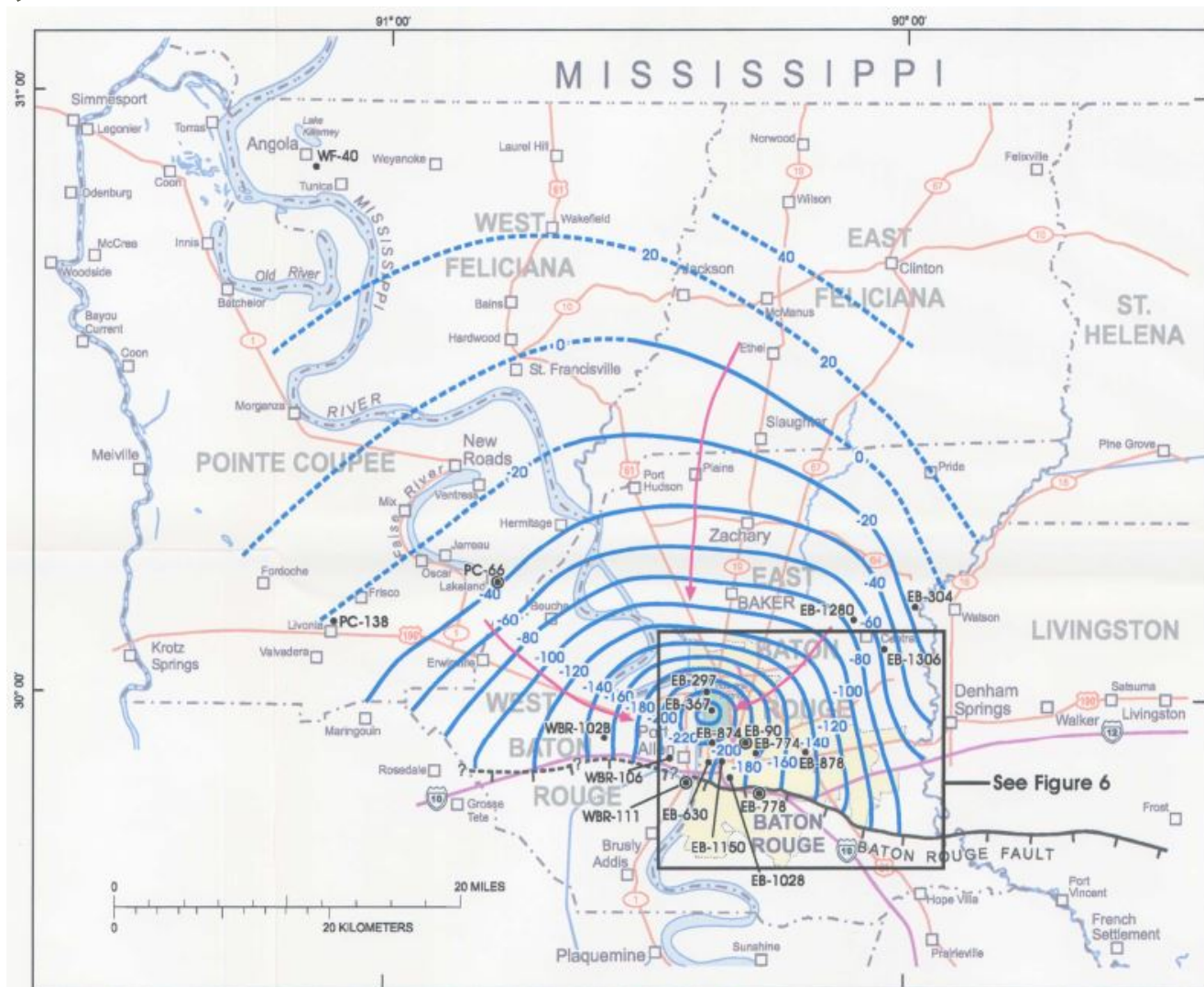


# CONE OF DEPRESSION 2003



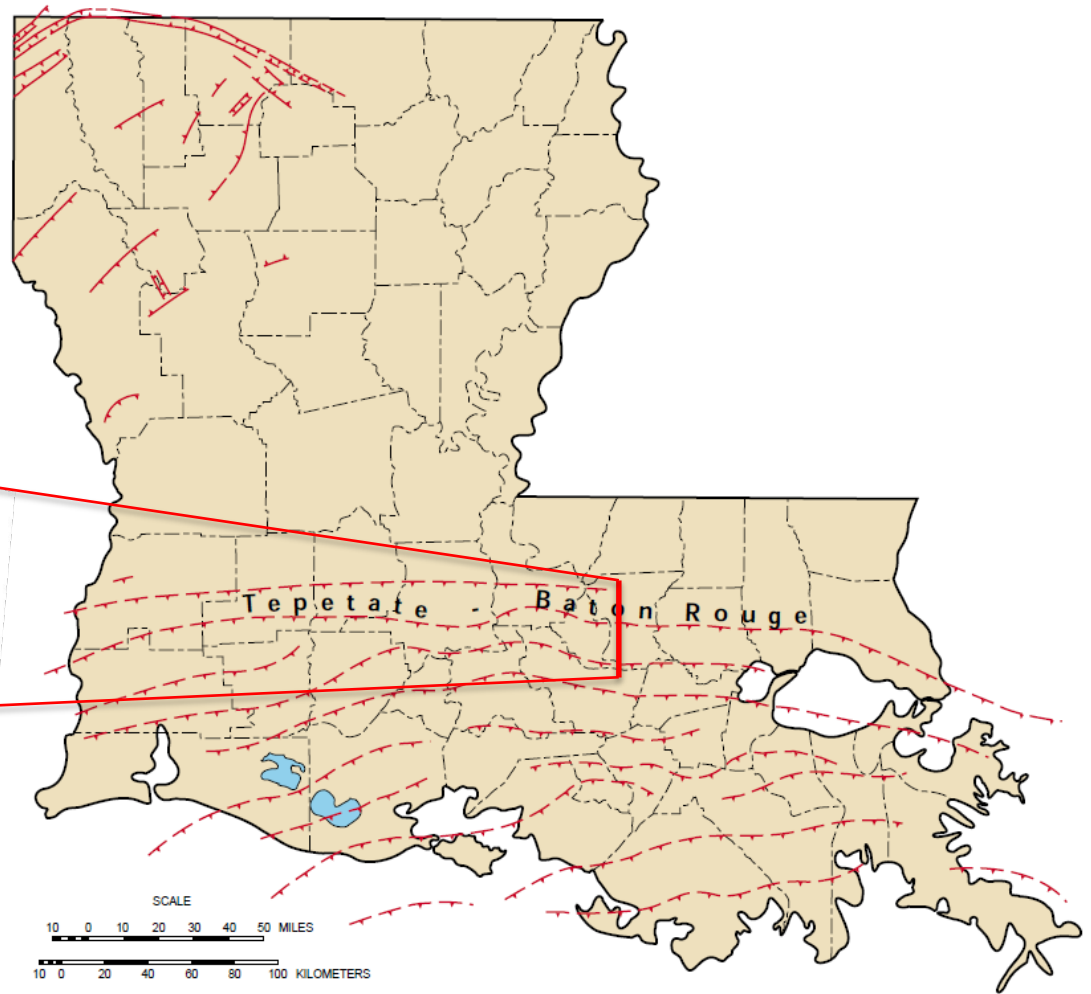
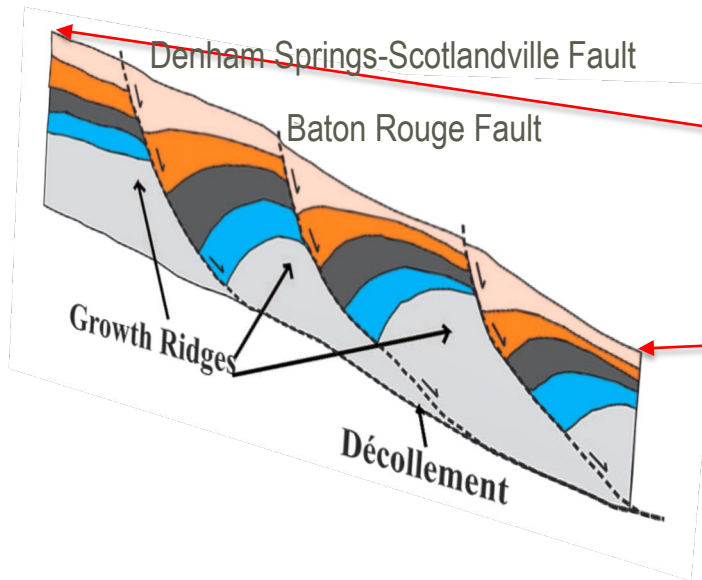


# 2,000FT REGIONAL VIEW



# GROWTH FAULTS IN LOUISIANA

## Example (Typical) Cross-Section

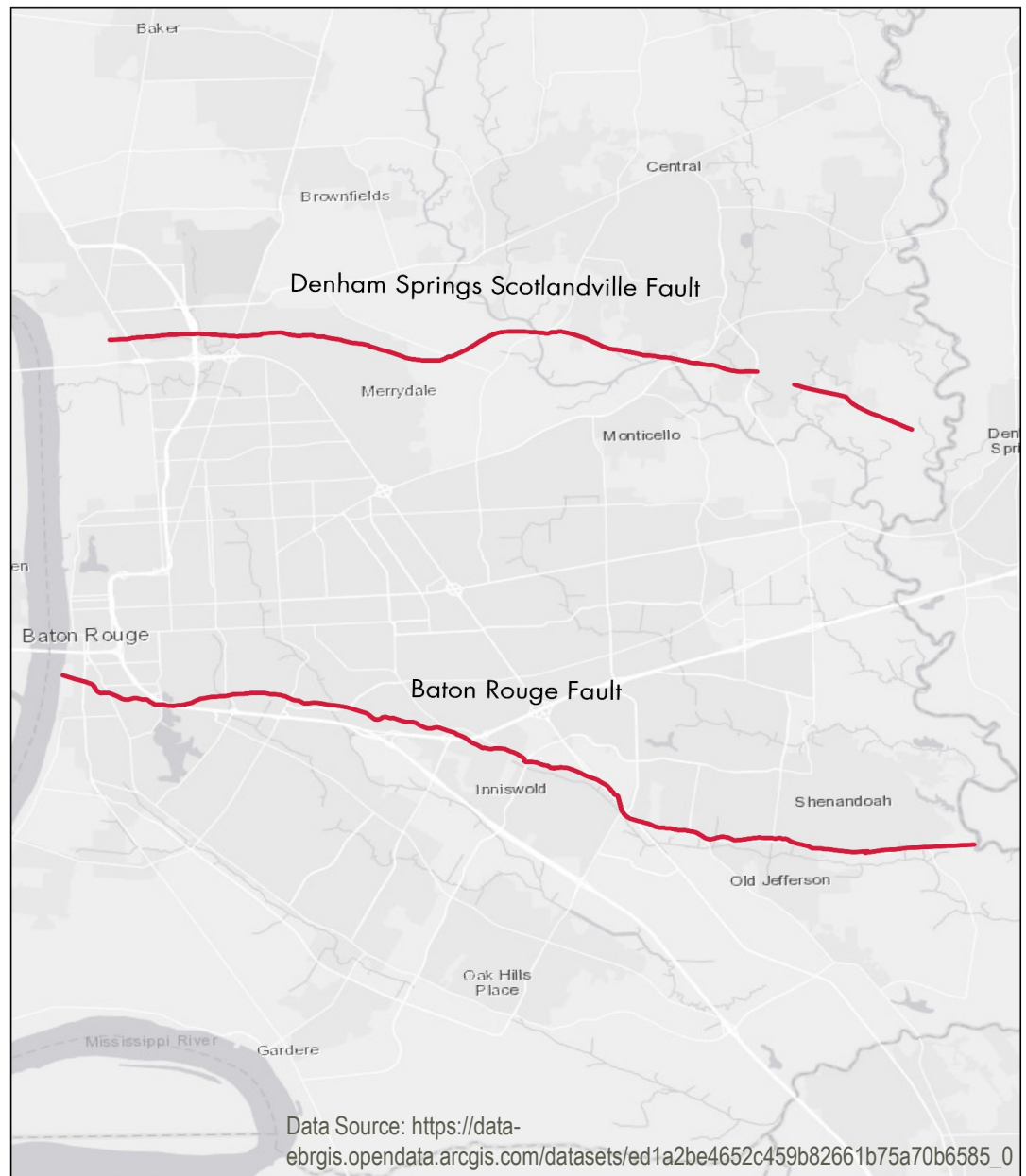


Left: Wikipedia. Right: McCulloh, 2001



# FAULTS IN BATON ROUGE AREA

- Denham Springs Scotlandville Fault
  - Relatively permeable fault
- Baton Rouge Fault
  - Leaky impermeable fault
  - 70° dip to the south
  - Topographic change seen at these faults. Minor, only a couple feet.



# SALTWATER INTRUSION

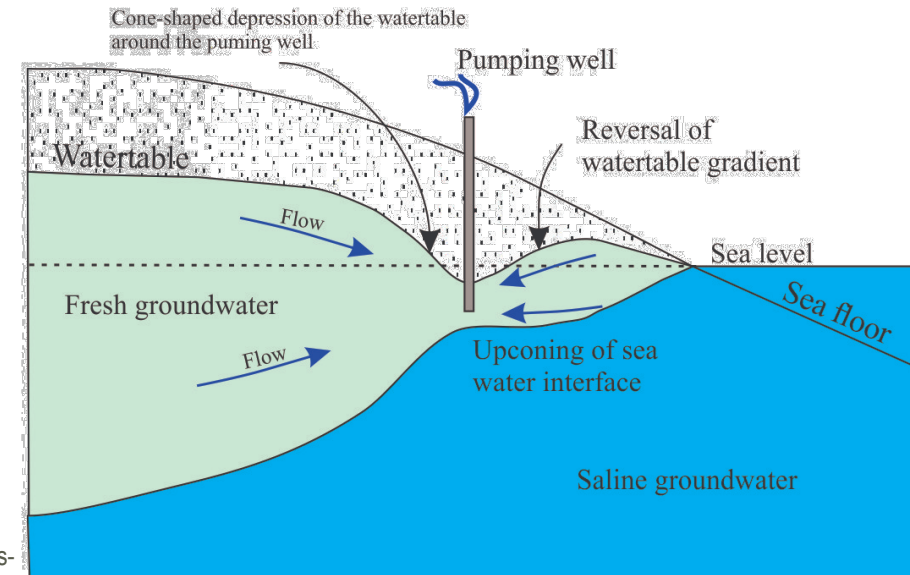
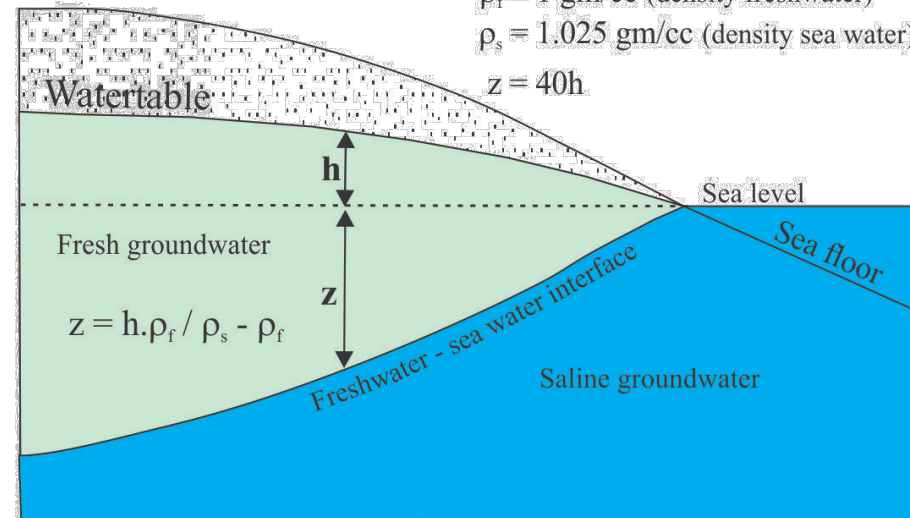
- The depression of the water tables, under the removal wells, causes an imbalance between the hydrological pressures on the north (fresh water) side of the fault and the pressures on the south (salt water) side of the Fault.
- Leaky Baton Rouge Fault



# SALTWATER INTRUSION

## The Ghyben-Herzberg Principle

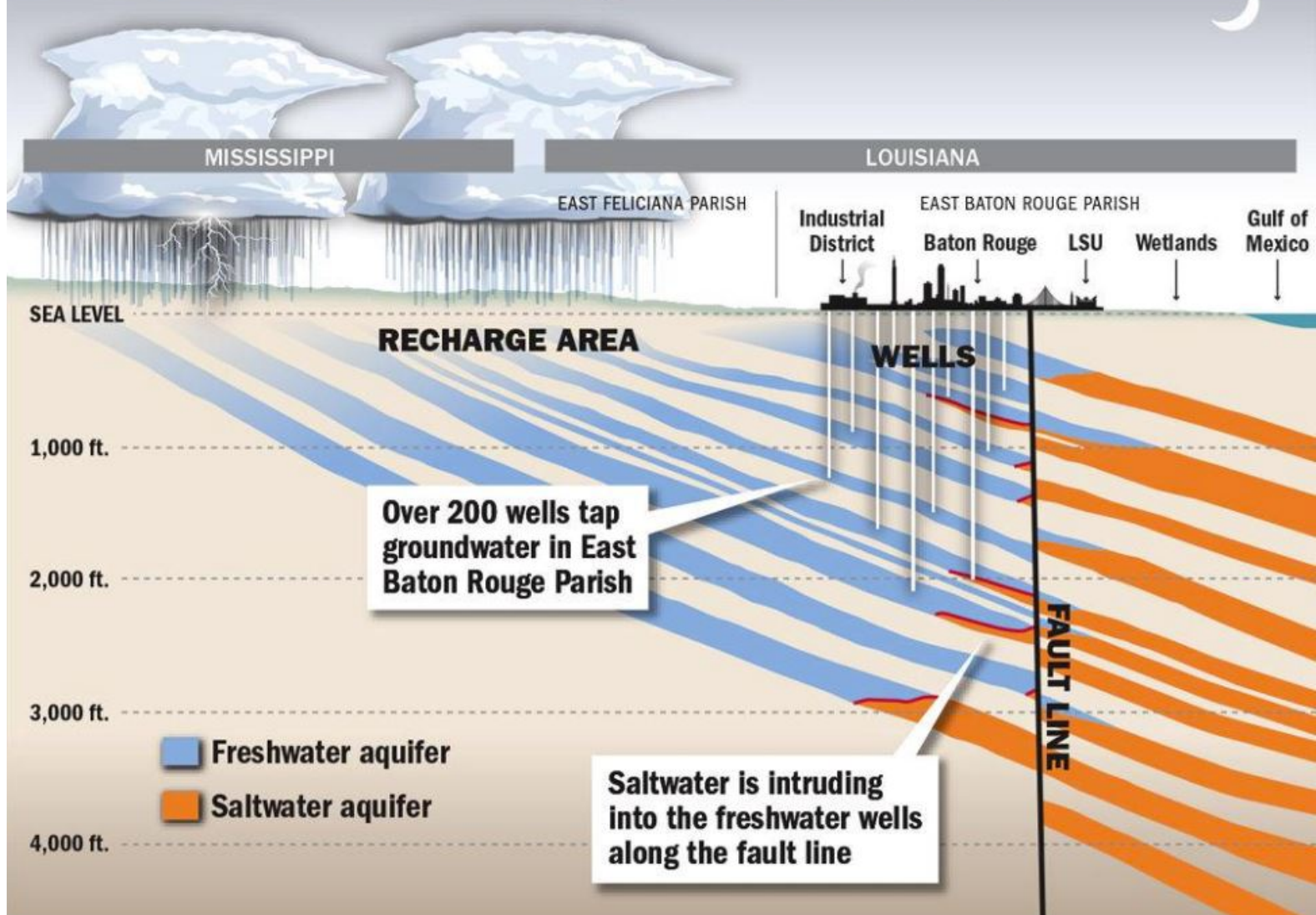
$\rho_f \equiv 1 \text{ gm/cc}$  (density freshwater)  
 $\rho_s \equiv 1.025 \text{ gm/cc}$  (density sea water)  
 $z = 40h$



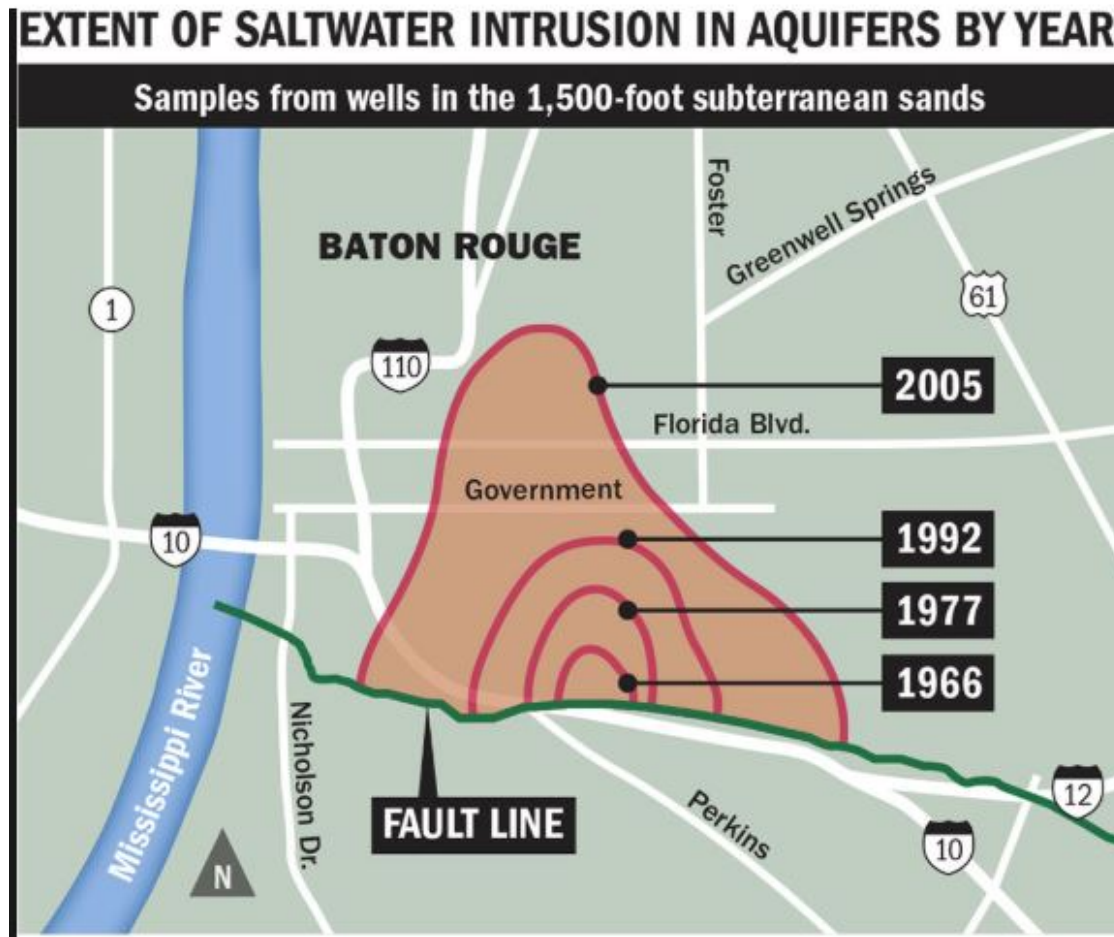
Data source: Brian Ricketts.  
<https://www.geological-digressions.com/coastal-aquifers-groundwater-at-sea/>



# Freshwater wells threatened by saltwater intrusion

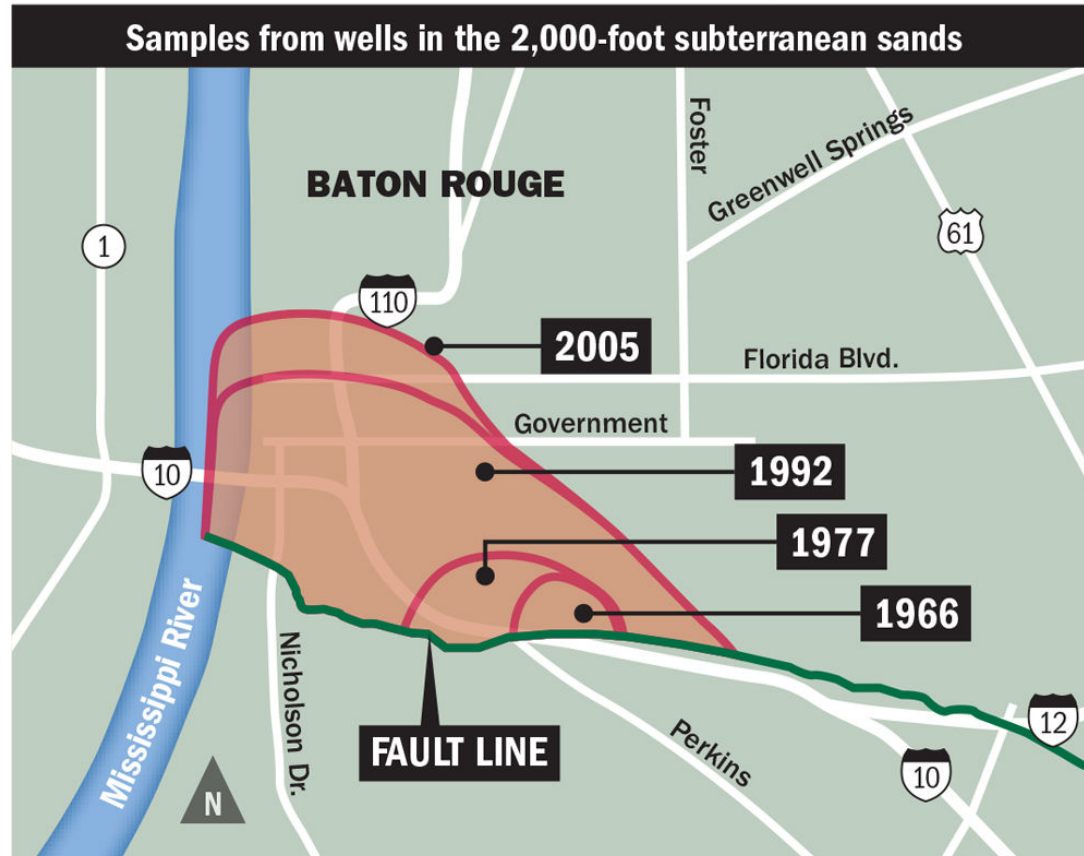


# SALTWATER ENCROACHMENT 1,500FT SAND



# SALTWATER ENCROACHMENT 2,000FT SAND

## EXTENT OF SALTWATER INTRUSION IN AQUIFERS BY YEAR



Source: U.S. Geological Survey

Advocate map

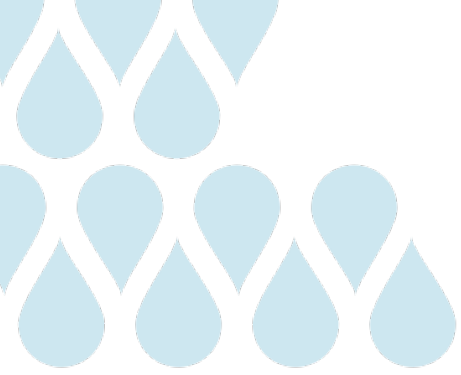




# TAKE HOME MESSAGE

- Greater Baton Rouge area-continued economic and population growth
- Greater water needs into the future
- If the goal is sustainability:
  - How do you define sustainability?
  - How does that tie back to current aquifer characteristics?
    - For example, what would a sustainable potentiometric surface look like?





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**THANK YOU**

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