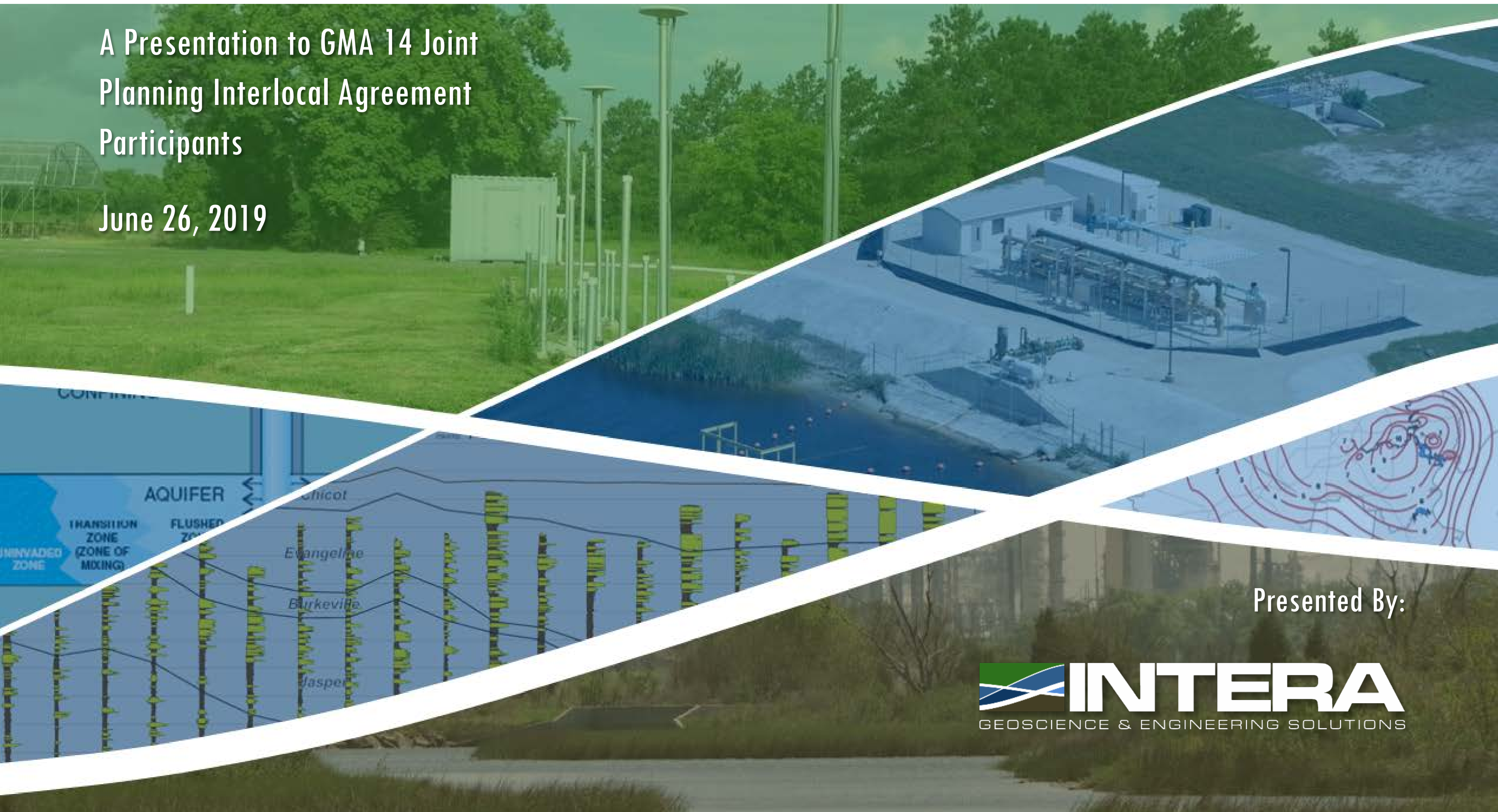
Discussion and Consideration of Hydrologic Conditions

A Presentation to GMA 14 Joint Planning Interlocal Agreement Participants

June 26, 2019



Presented By:

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Objectives

- Review Schedule
- Hydrologic Conditions
- Paths Forward on DFC Delineation

Consideration of Factors

- Aquifer uses or conditions – January 30, 2019
- Water supply needs and management strategies – March 27, 2019
- Hydrological conditions – Today
- Other environmental impacts
- Impact on subsidence
- Socioeconomic impacts
- Impact on private property rights
- Feasibility of achieving the DFC
- Any other relevant information

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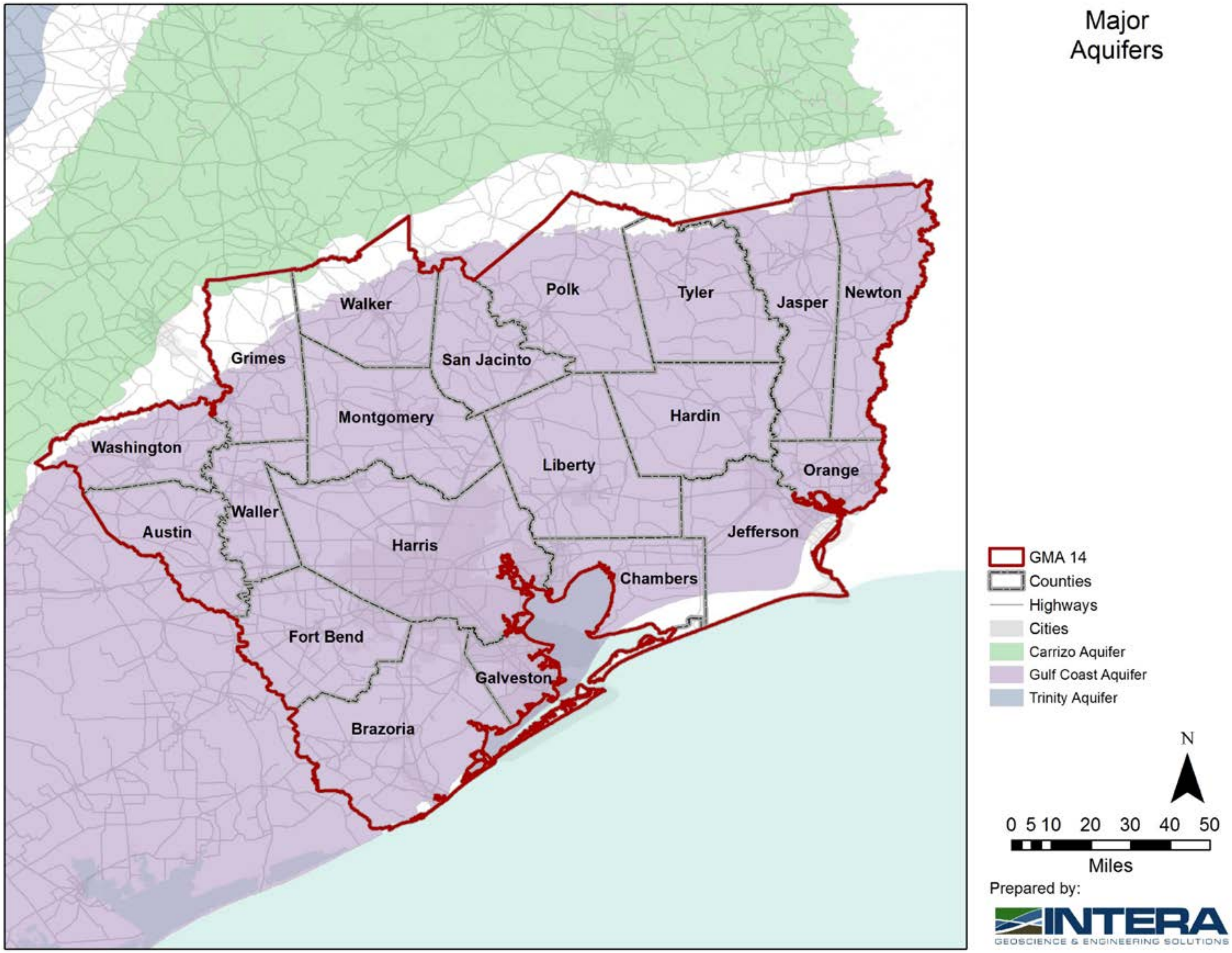
Current Schedule

Main Joint Planning Topics for Meetings	2019												2020												2021				
	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May
Factor 1: Aquifer Uses and Conditions	■																												
Factor 2: Water Supply Needs and Management Strategies		■	■																										
Factor 3: Hydrological Conditions				■	■																								
Factor 4: Environmental Impacts												■	■																
Factor 5: Impact on Subsidence														■	■														
Factor 6: Socioeconomic Impacts																■	■												
Factor 7: Private Property Interests and Rights																		■	■										
Factor 8: Feasibility of Achieving the DFCs																				■	■								
Factor 9: Other Relevant Information																						■	■						
Balancing Test Model Runs						■	■																						
Selection of Model Runs and Metrics for Evaluation								■	■																				
Review of Model Run Results										■	■																		
Draft Explanatory Report Development													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Propose DFC(s) for Adoption (Deadline May 1, 2021)																									■				
Proposed Meeting Dates	*		*		*		*		*		*		*		*		*		*		*		*		*				

Hydrological Conditions

- Requirement in statute
  - –hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator, and the average annual recharge, inflows, and discharge;
  - –This was added with SB 660 in 2011, requiring TWDB to develop estimates of water in storage
- Reading between the lines:
  - –Try to understand how the aquifers work

Major Aquifers



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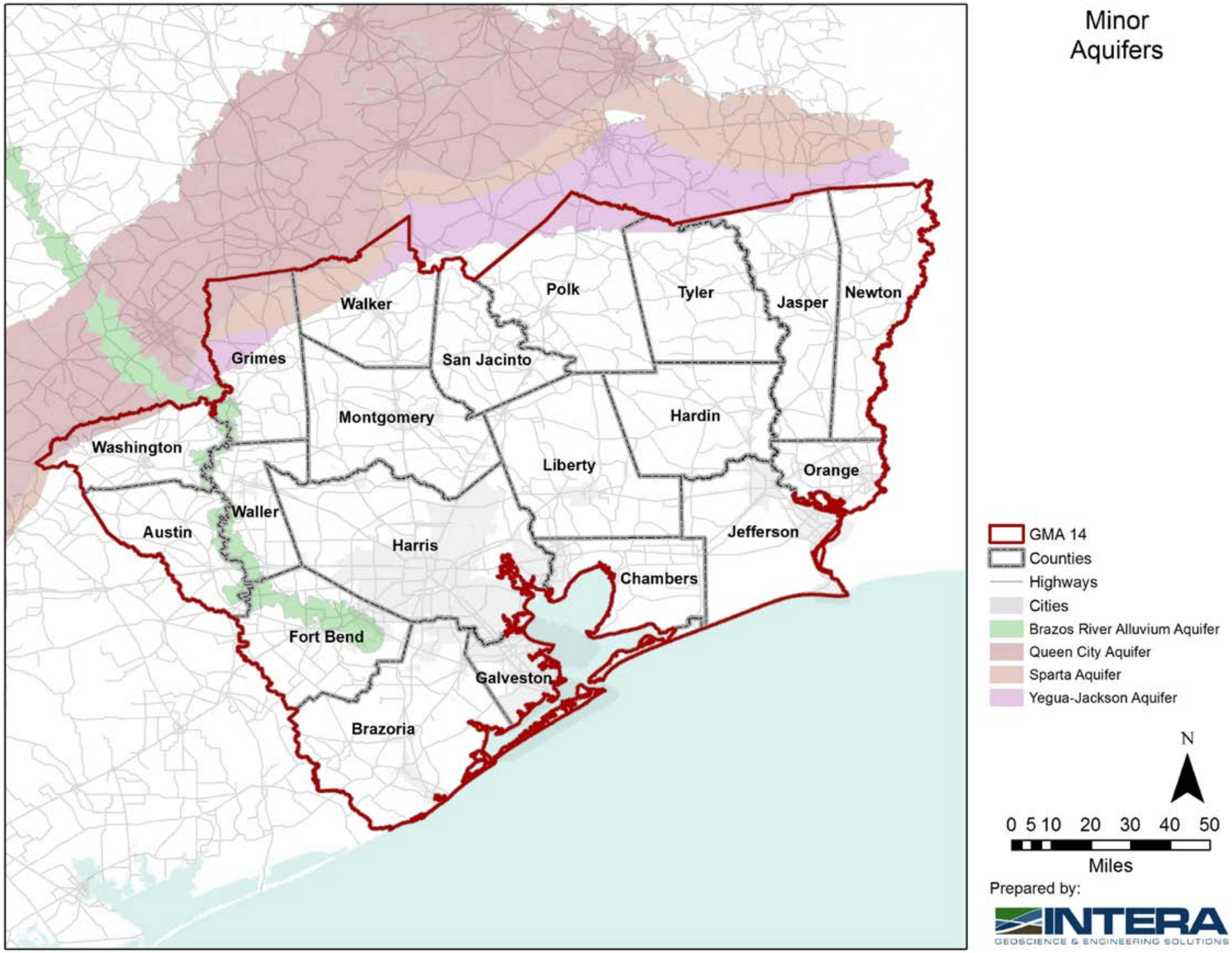
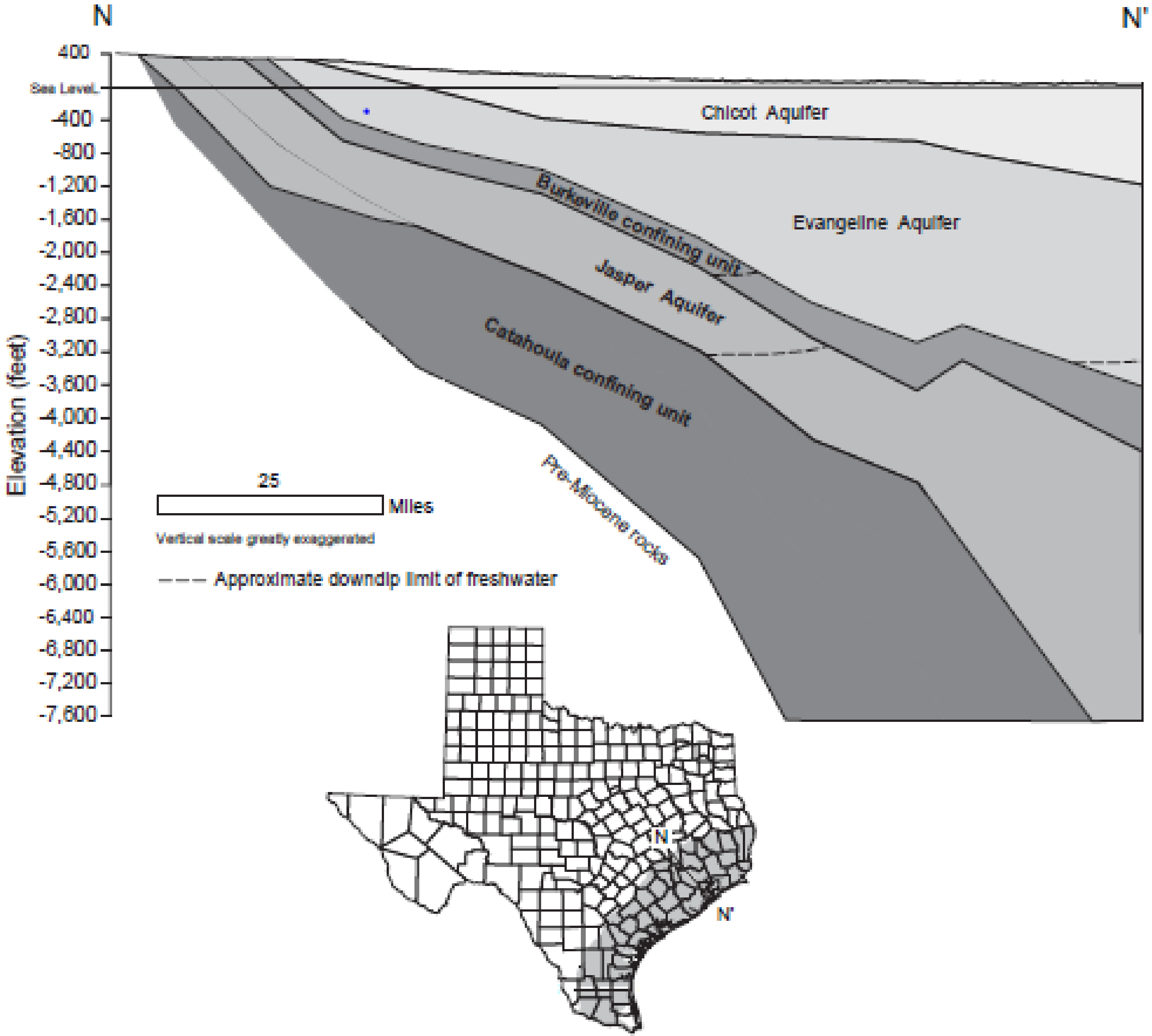
Minor Aquifers



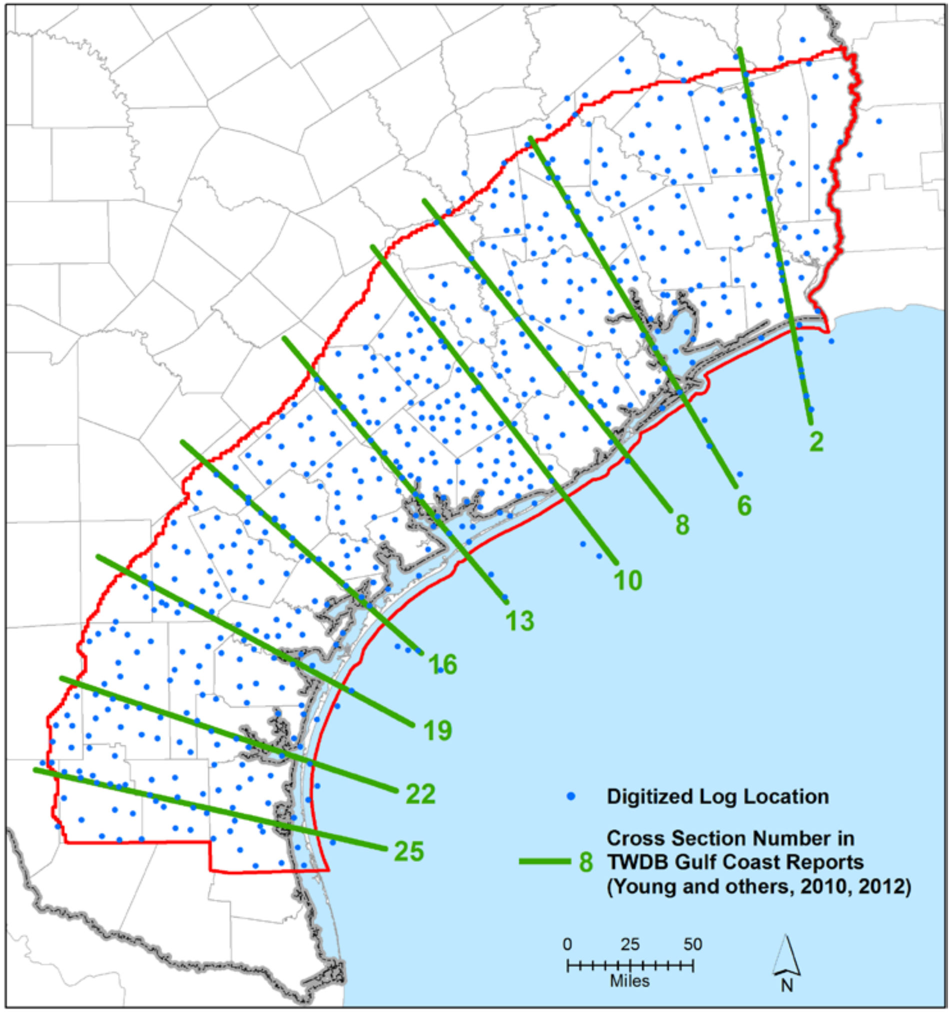
Gulf Coast Aquifer Conceptual Cross-Section



Gulf Coast Aquifer Stratigraphic Section

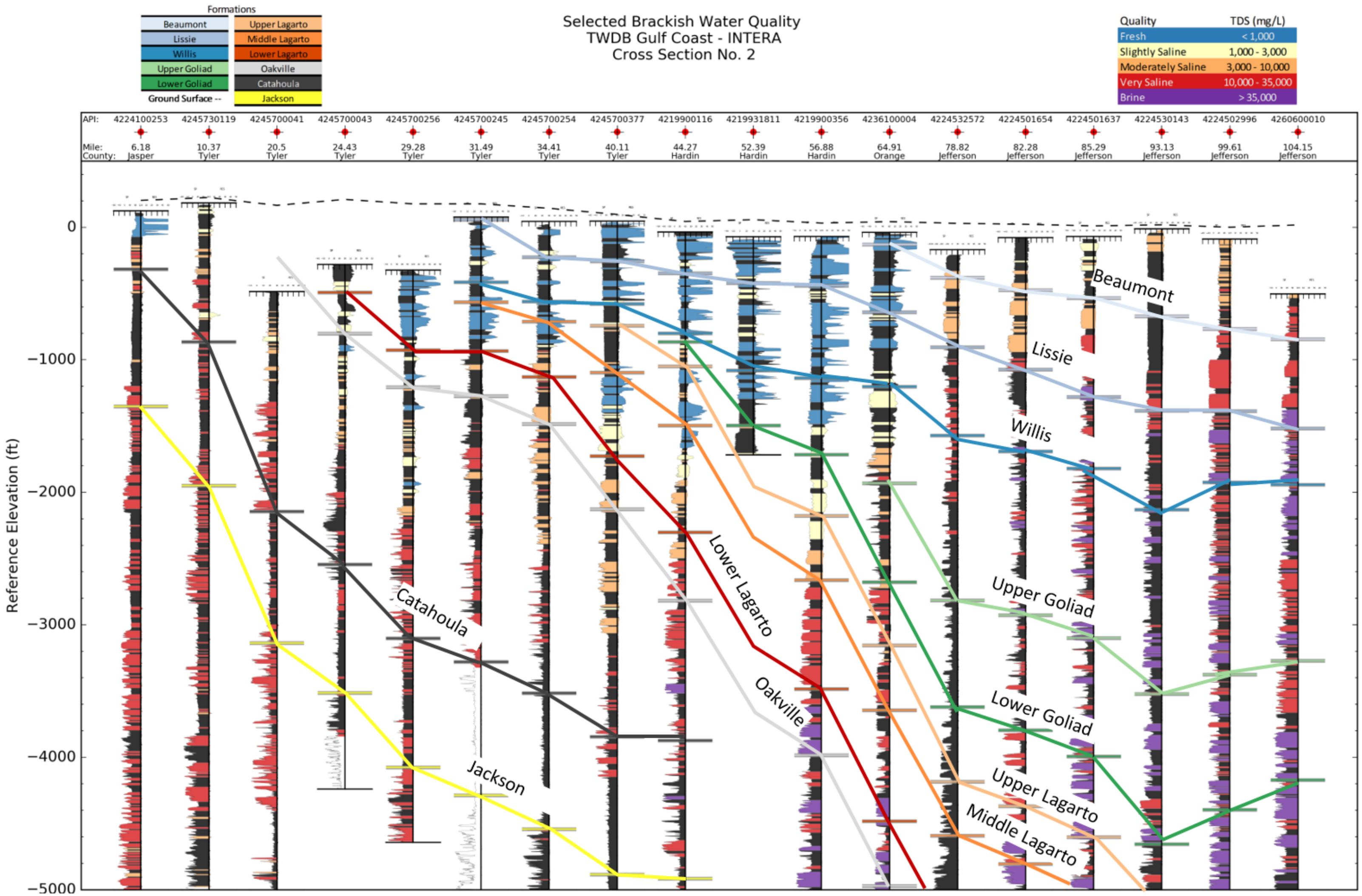
ERA	Epoch		Est. Age (M.Y)	Geologic Unit	Hydrogeologic Unit
Cenozoic	Pleistocene		0.7	Beaumont	CHICOT AQUIFER
			1.6	Lissie	
	Pliocene		3.8	Willis	
	Miocene	Late	11.2	Upper Goliad	EVANGELINE AQUIFER
			14.5	Lower Goliad	
		Middle	17.8	Upper Lagarto	
				Middle Lagarto	BURKEVILLE
		Early		Lower Lagarto	JASPER AQUIFER
			24.2	Oakville	
	Oligocene		32	Frio	CATAHOULA
			34	Vicksburg	

Gulf Coast Aquifer Cross-Section Locations



Young and others (2016)

Gulf Coast Aquifer Cross-Sections



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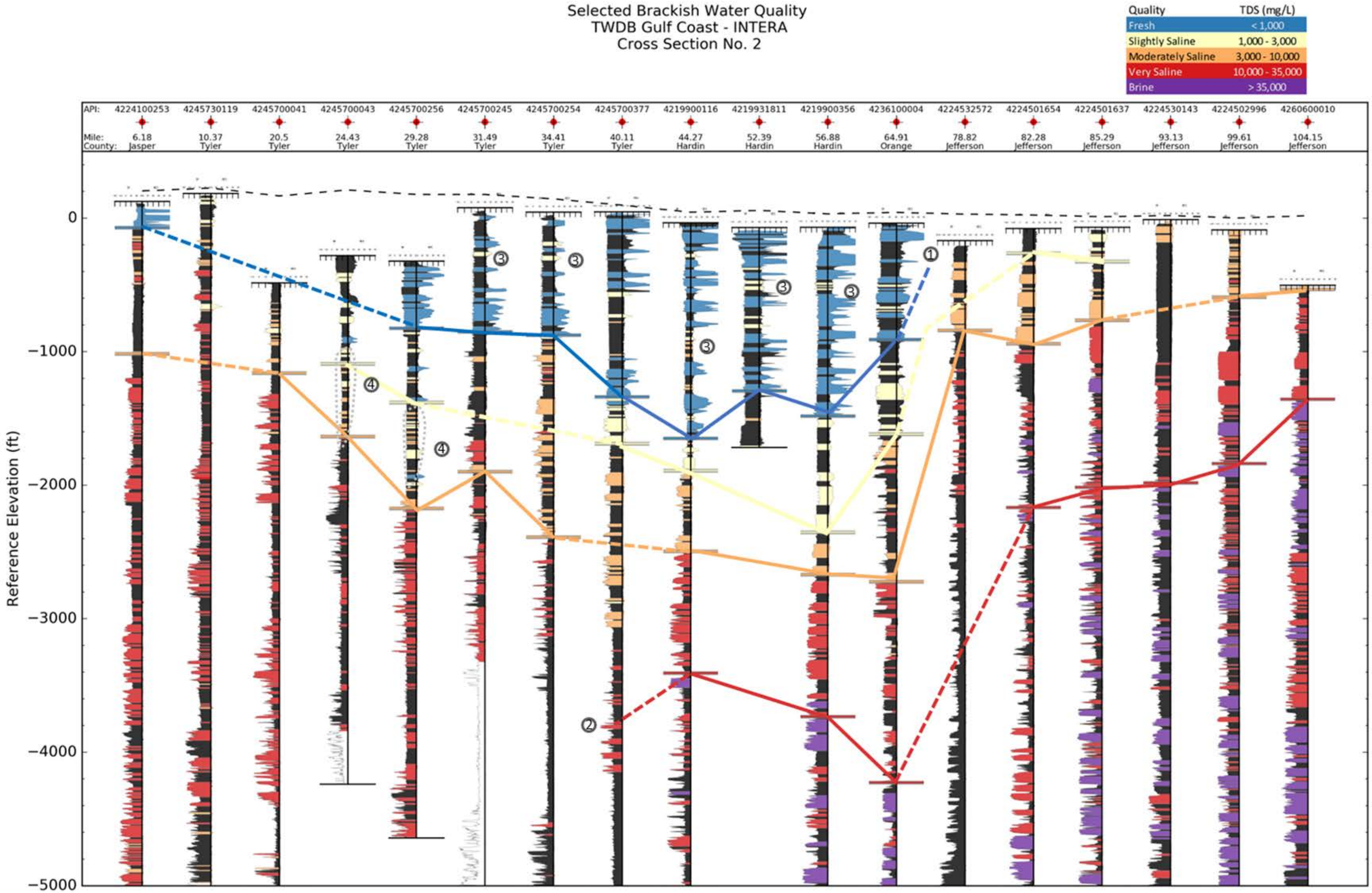
Gulf Coast Aquifer Cross-Sections



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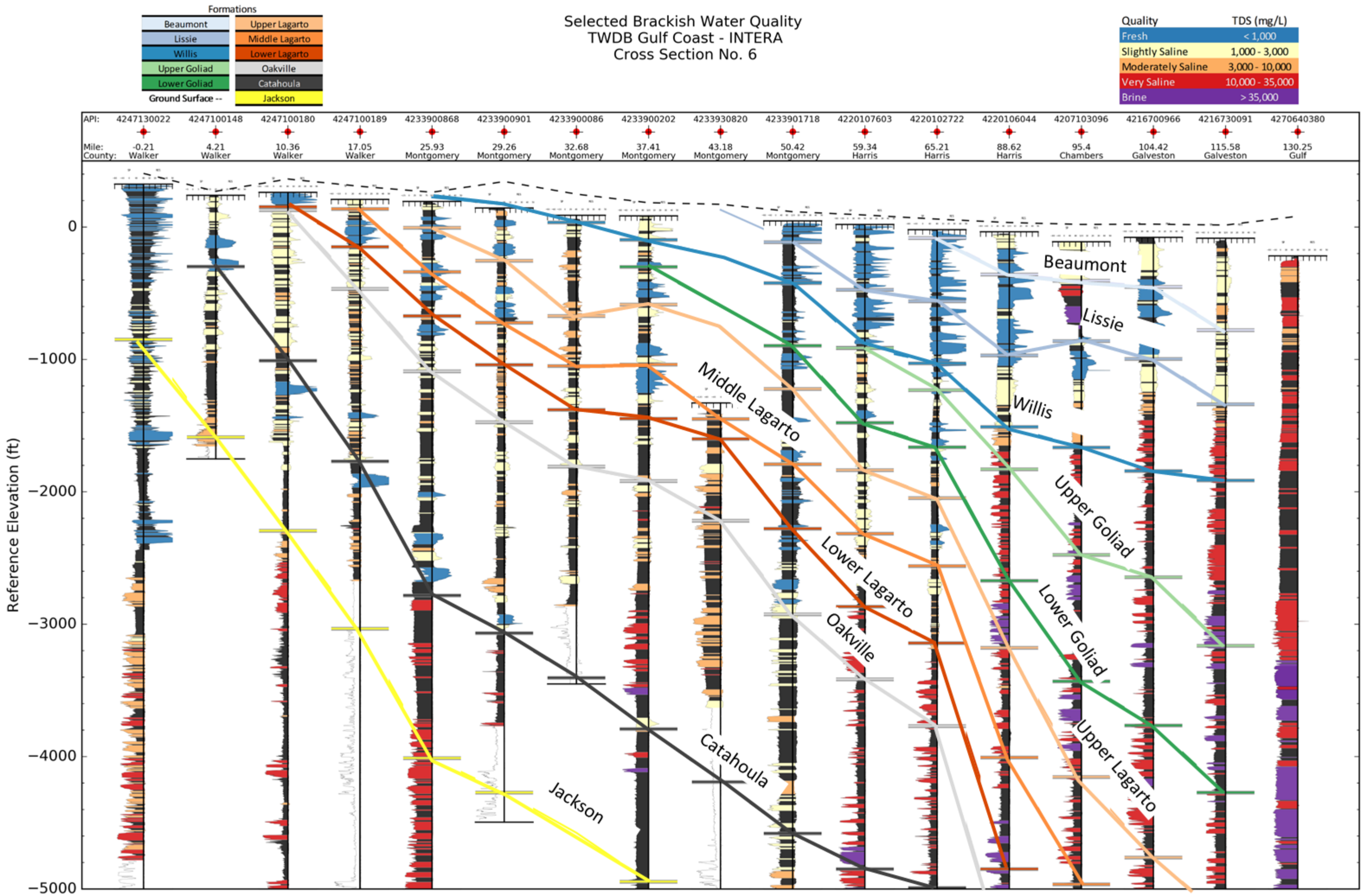

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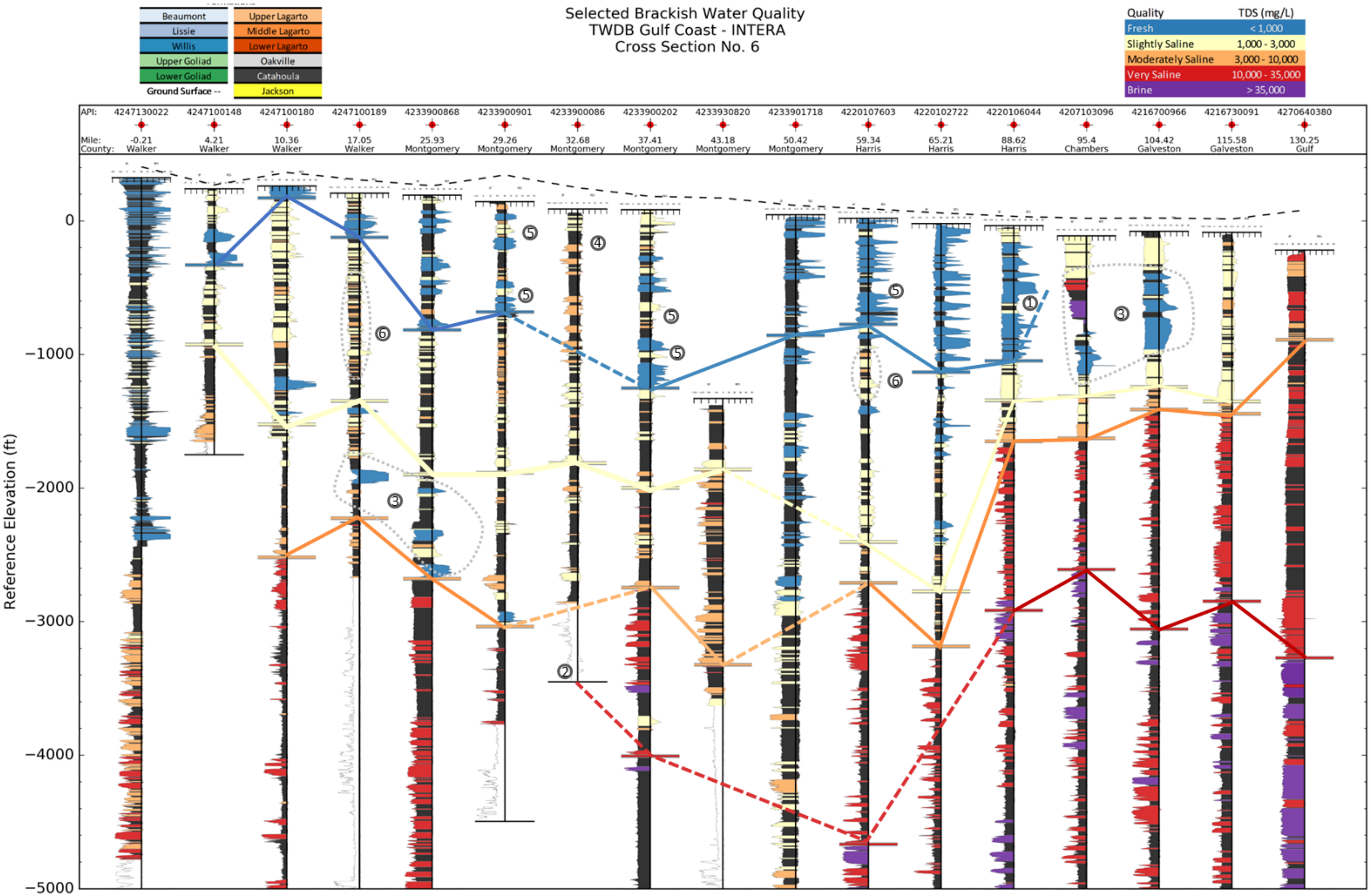

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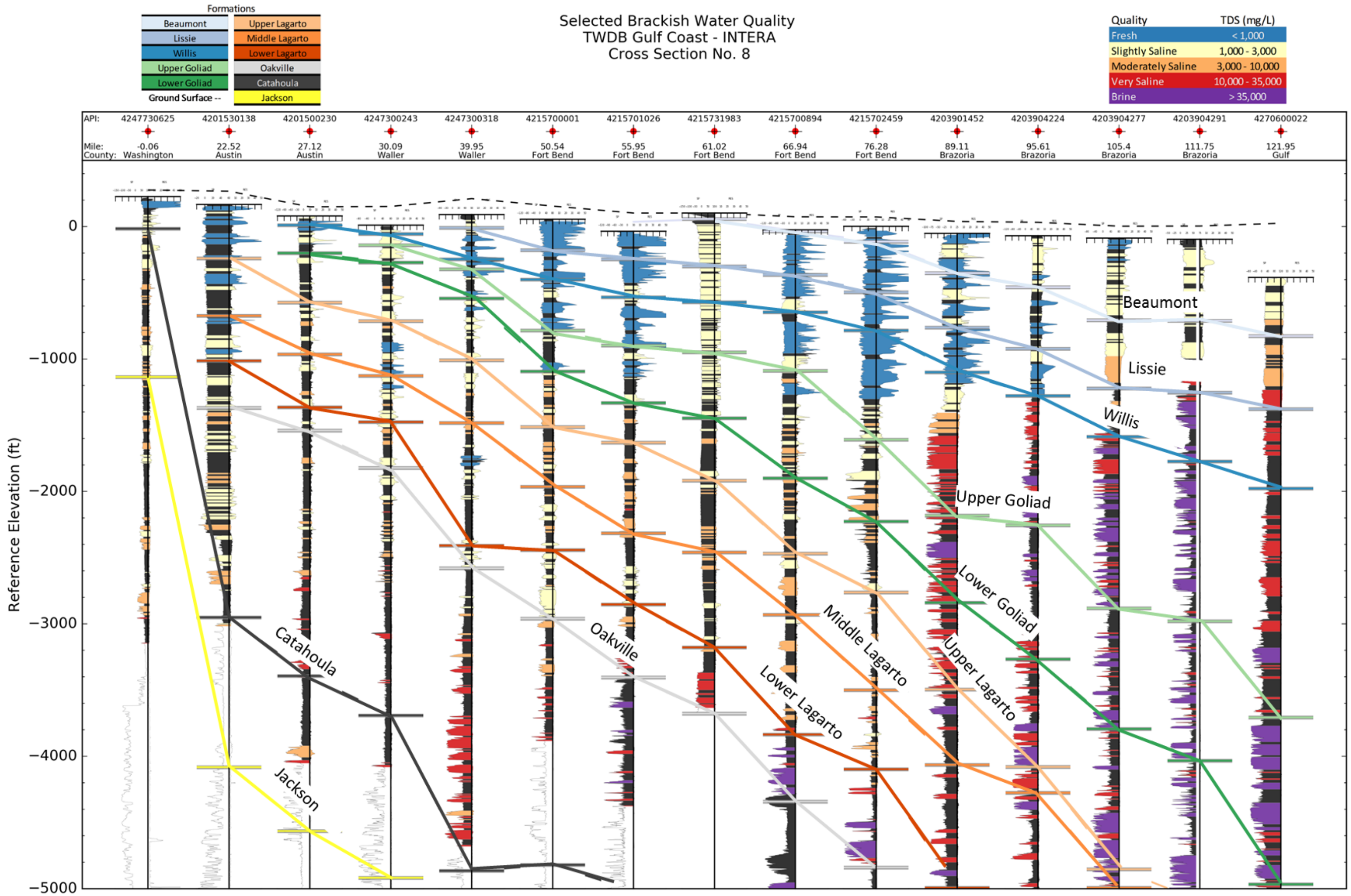
Gulf Coast Aquifer Cross-Sections



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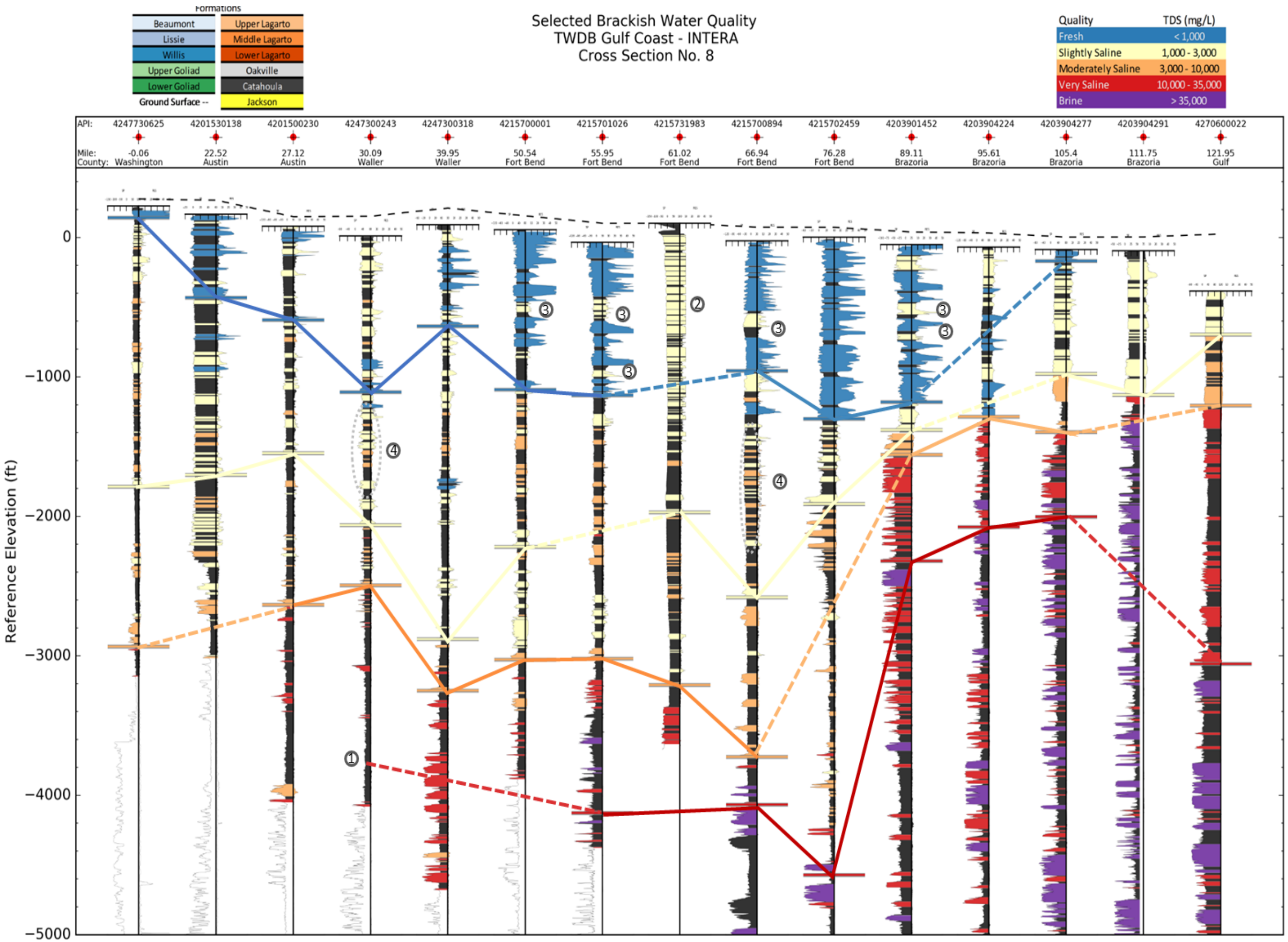
Gulf Coast Aquifer Cross-Sections

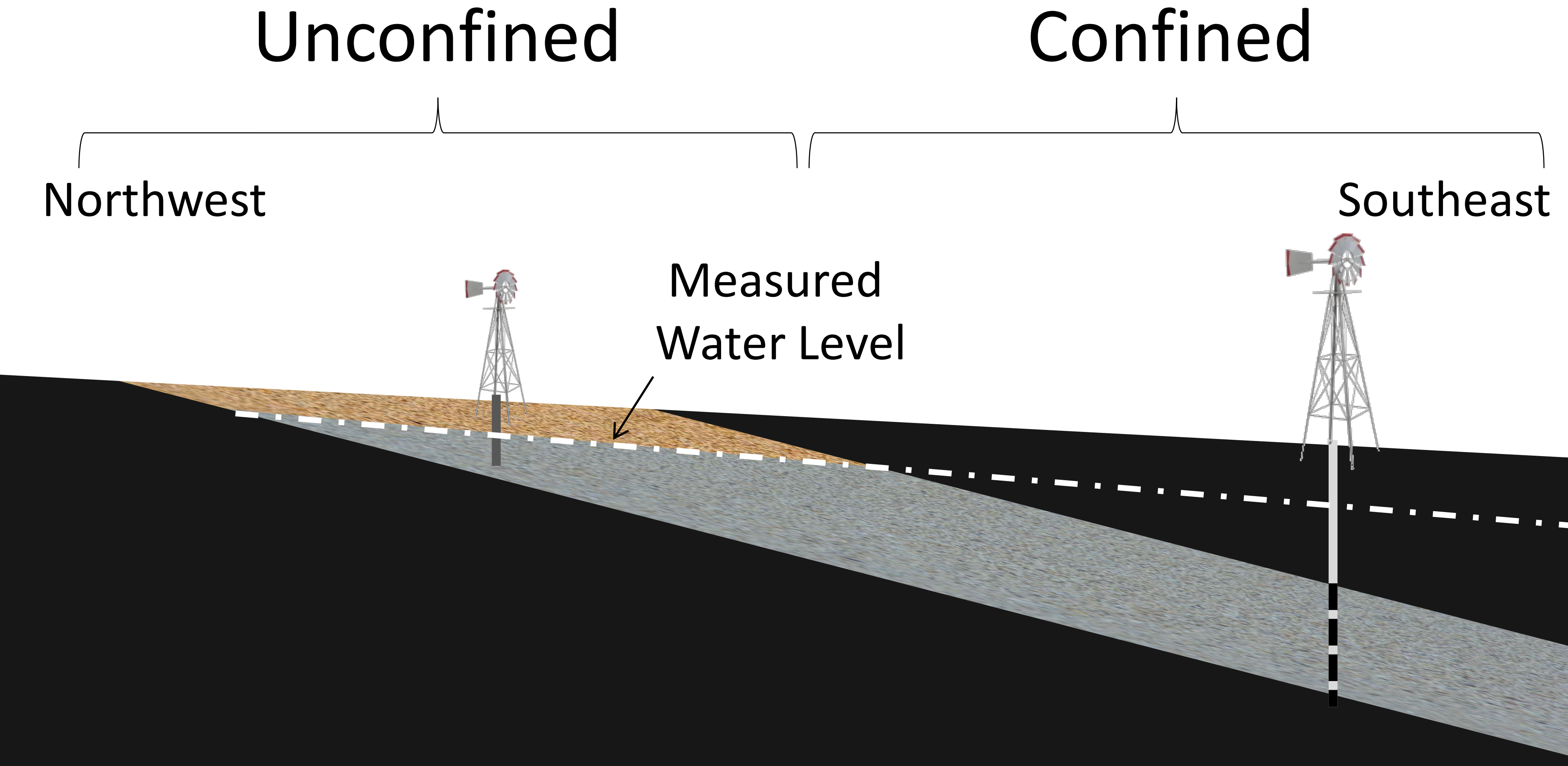


Total Estimated Recoverable Storage Definition

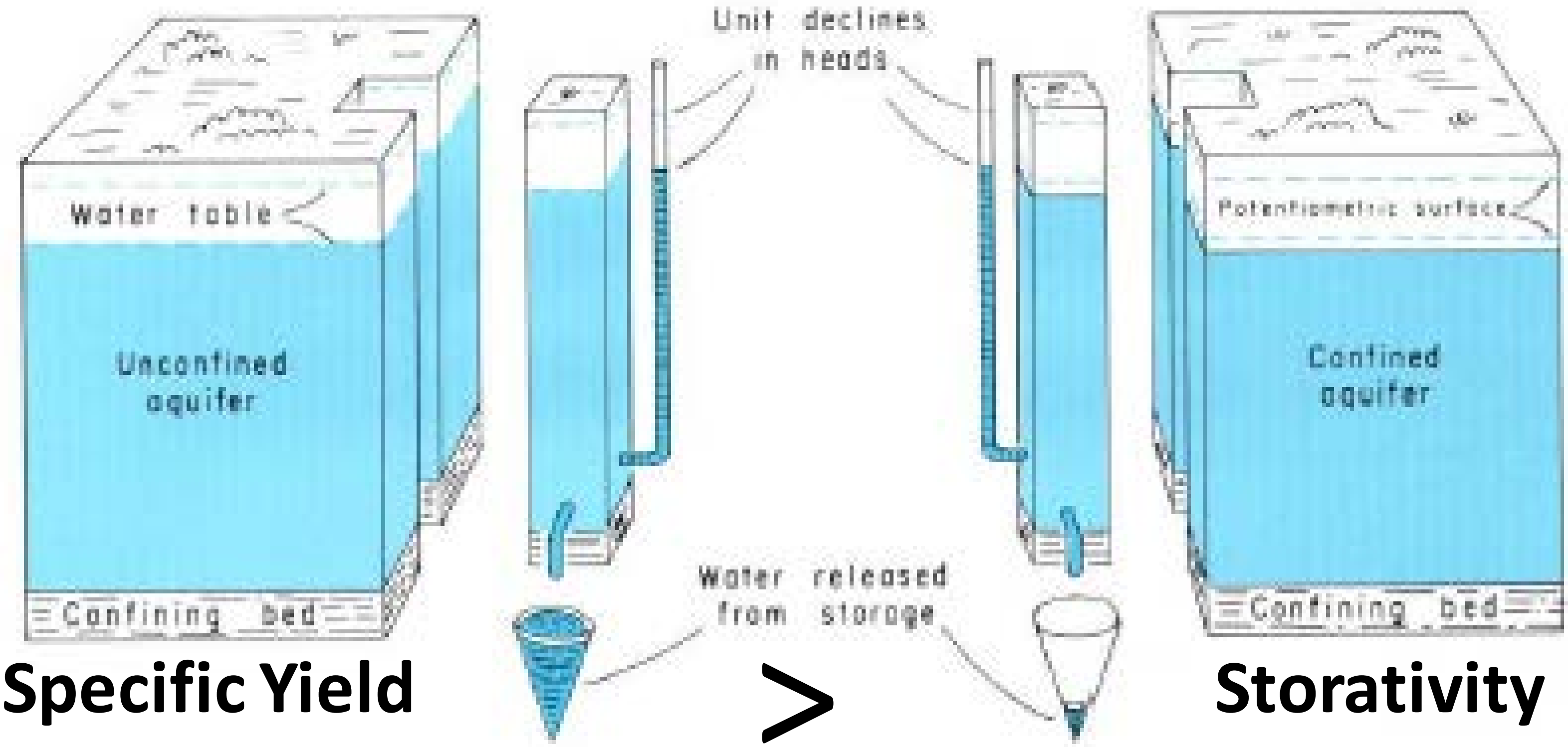
Total Estimated Recoverable Storage – The estimated amount of groundwater within an aquifer that accounts for recovery scenarios that range between 25% and 75% of the porosity-adjusted aquifer volume

Texas Administrative Code Sec. 356.10

Types of Aquifers



Unconfined vs. Confined Storage

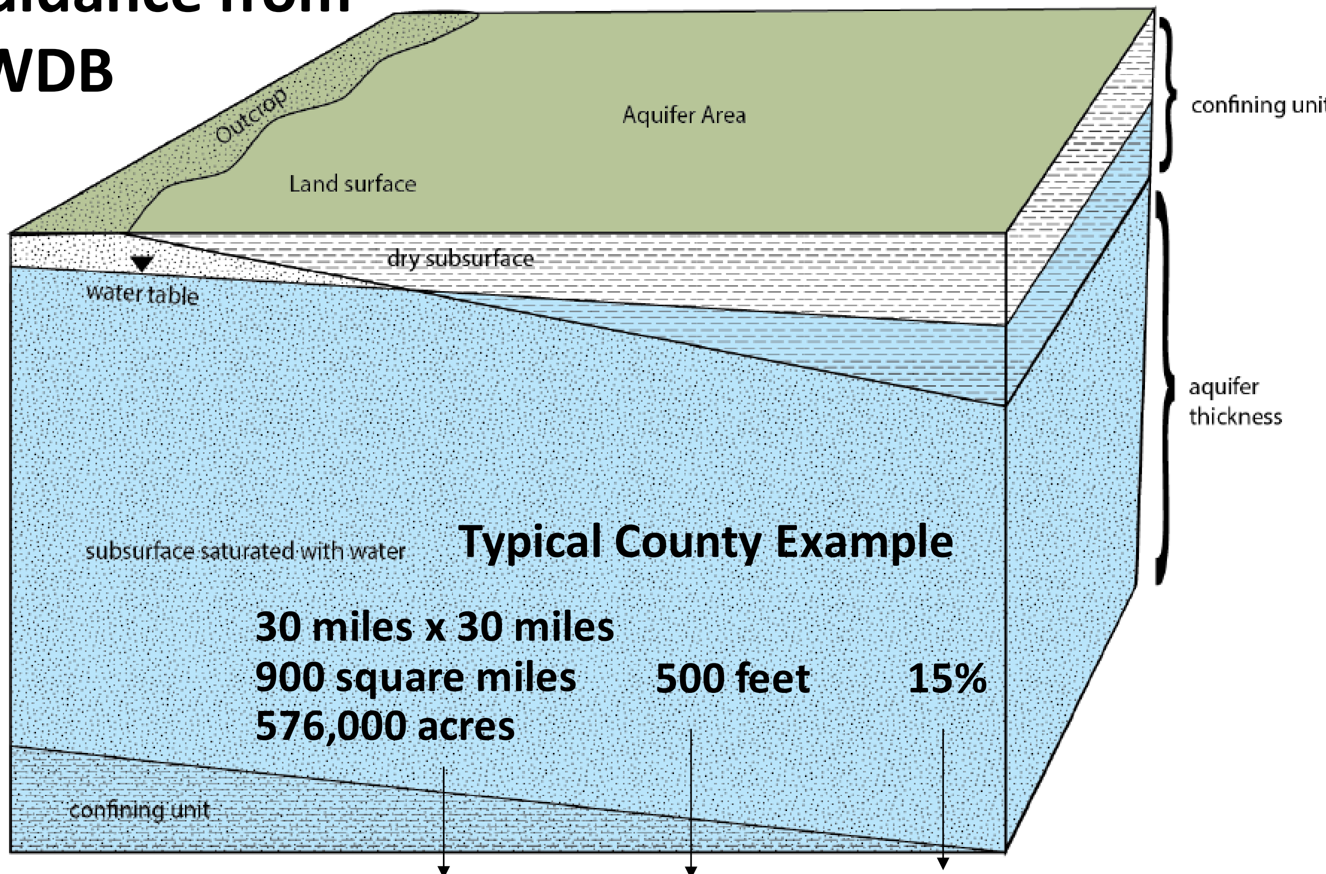


Specific Yield **>** **Storativity**

Takeaway: In theory, each foot of drawdown yields much more water when an aquifer is unconfined than when it is confined.

From Heath (1983)

Guidance from TWDB

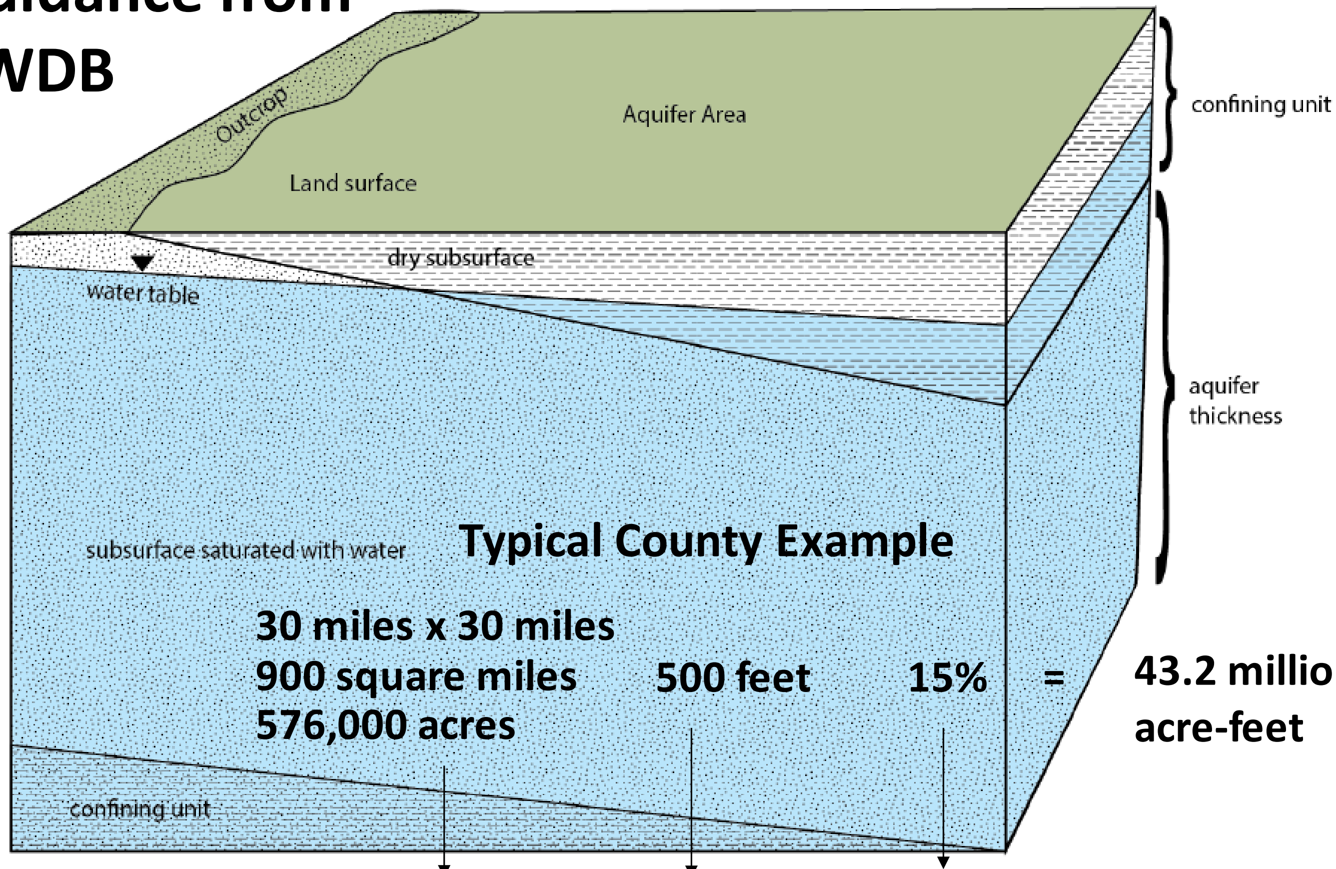


Storage volume = area x thickness x specific yield

(Plus some for the confined storage)

TERS – How it's calculated

Guidance from TWDB



Typical County Example

30 miles x 30 miles
900 square miles
576,000 acres

500 feet

15%

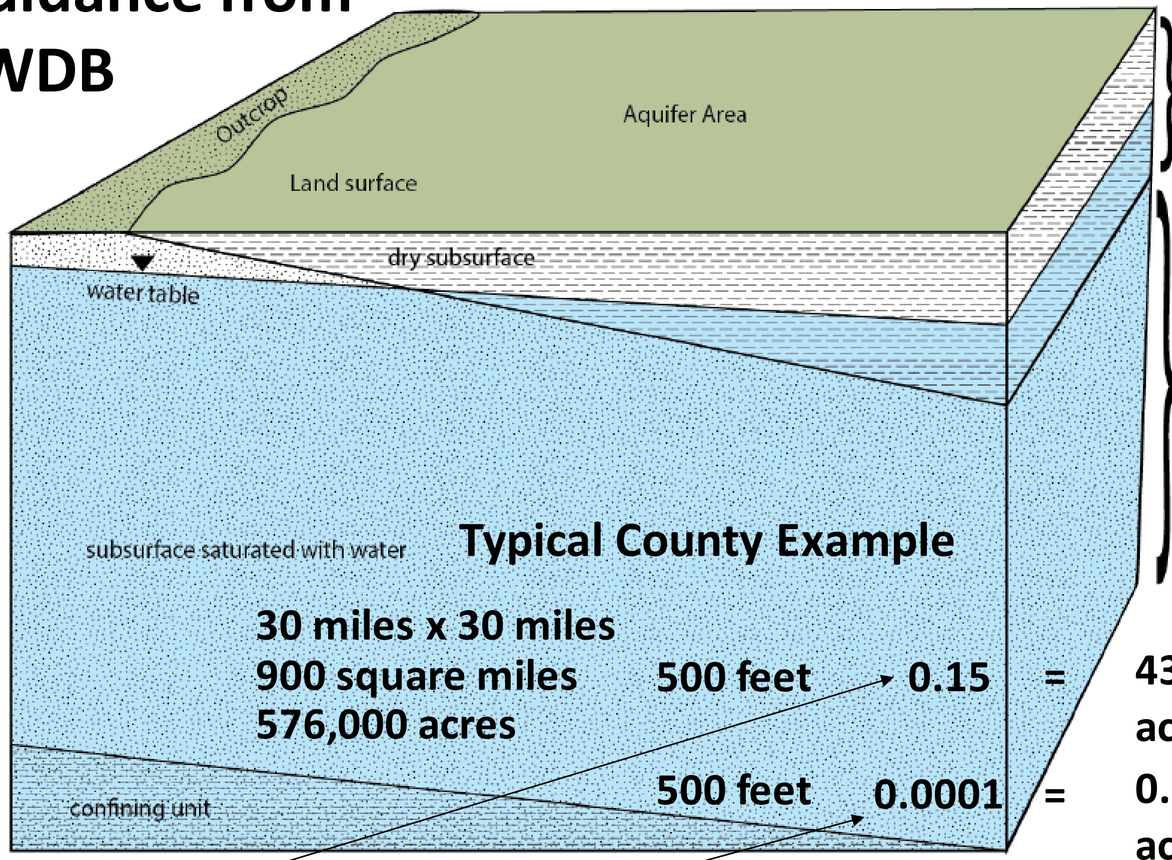
=

43.2 million acre-feet

Storage volume = area x thickness x specific yield
(Plus some for the confined storage)

TERS – How it's calculated

Guidance from TWDB



Typical County Example

30 miles x 30 miles
900 square miles
576,000 acres

500 feet 0.15 = 43.2 million acre-feet

500 feet 0.0001 = 0.03 million acre-feet

Unconfined Portion: Specific Yield

Confined Portion: Storativity

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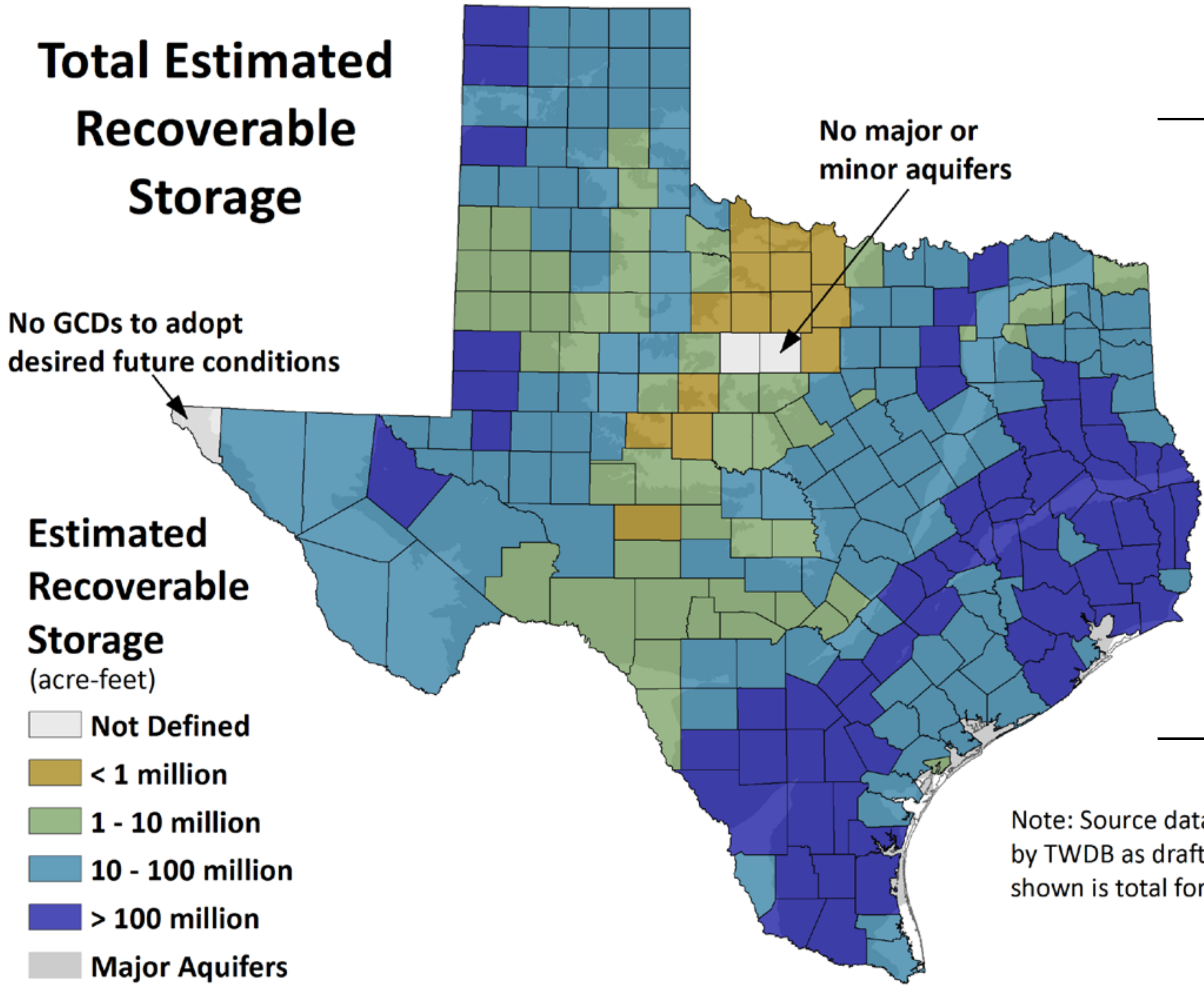
TERS Across Texas



GMA	Total Estimated Storage (million acre-feet)
1	588
2	968
3	476
4	160
5	*NA*
6	180
7	447
8	1,628
9	33
10	46
11	2,488
12	1,380
13	2,756
14	3,085
15	443
16	2,205
Total	**16,883**

Note: Source data provided by TWDB as draft. TERS shown is total for all aquifers.

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Gulf Coast Aquifer – Total Estimated Recoverable Storage

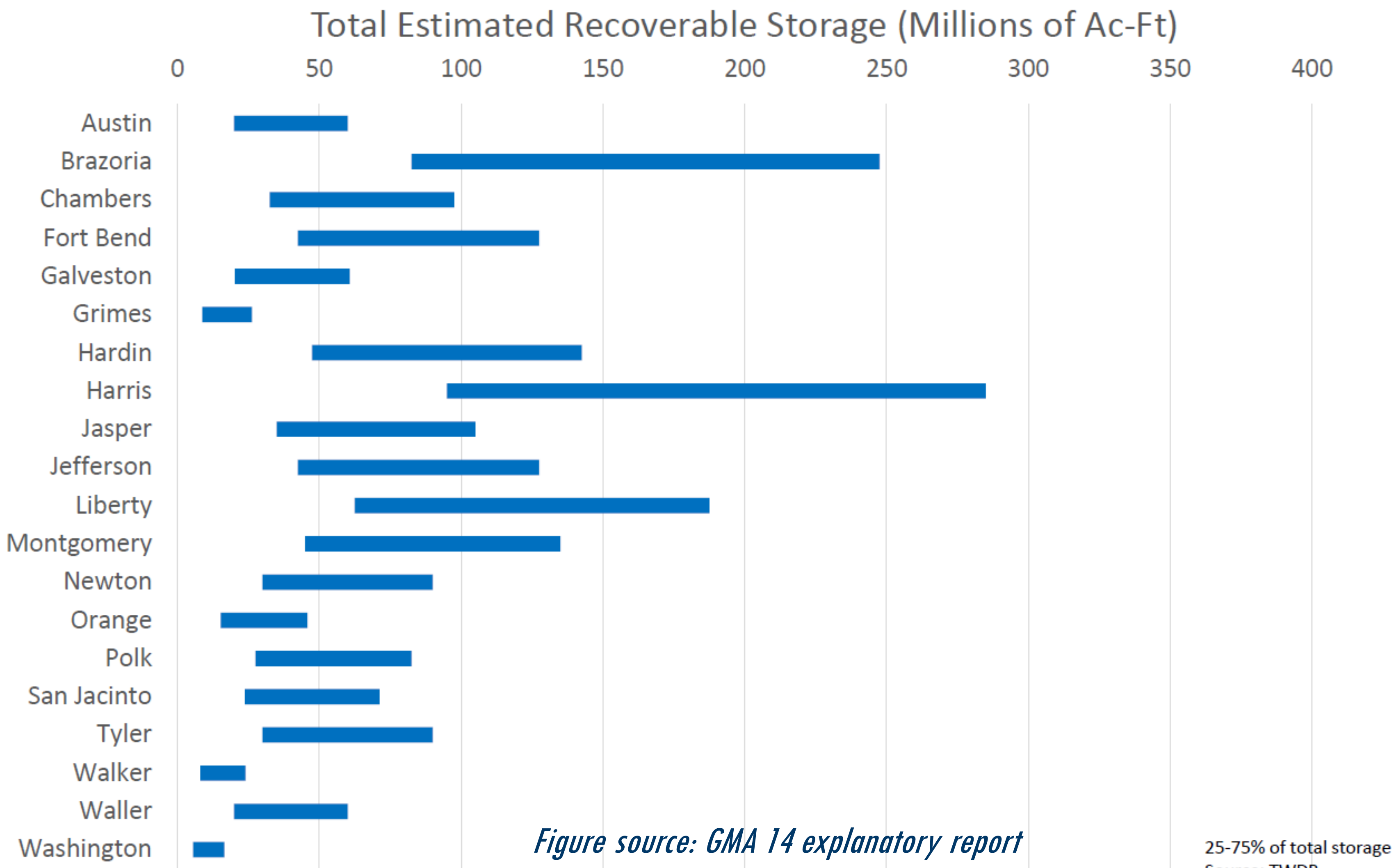

Figure source: GMA 14 explanatory report prepared by Freese and Nichols. Values from TWDB unchanged from 2nd round of joint planning.

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Carrizo-Wilcox Aquifer – Total Estimated Recoverable Storage

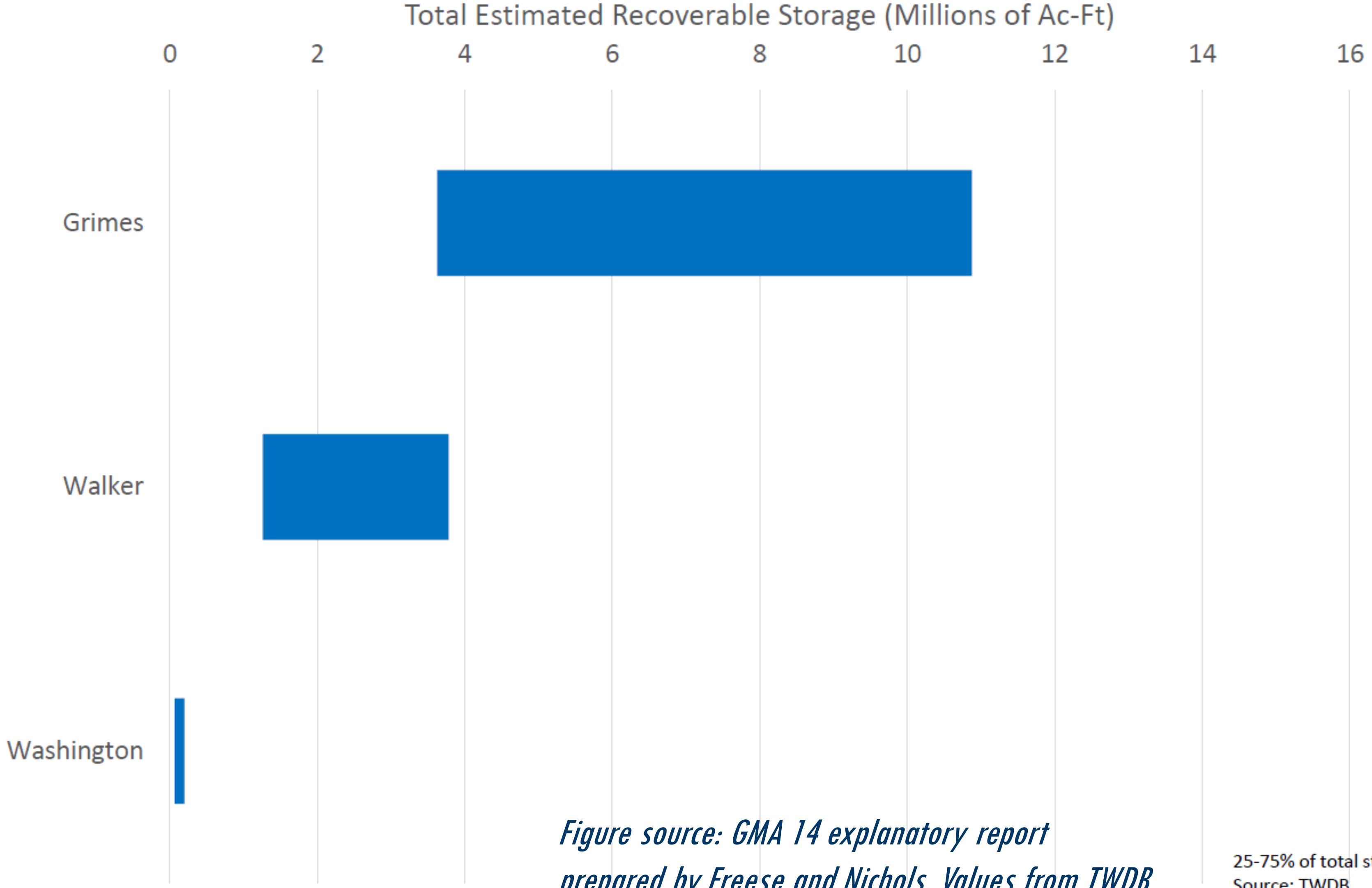

Figure source: GMA 14 explanatory report prepared by Freese and Nichols. Values from TWDB unchanged from 2nd round of joint planning.

25-75% of total storage
Source: TWDB

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Queen City Aquifer – Total Estimated Recoverable Storage

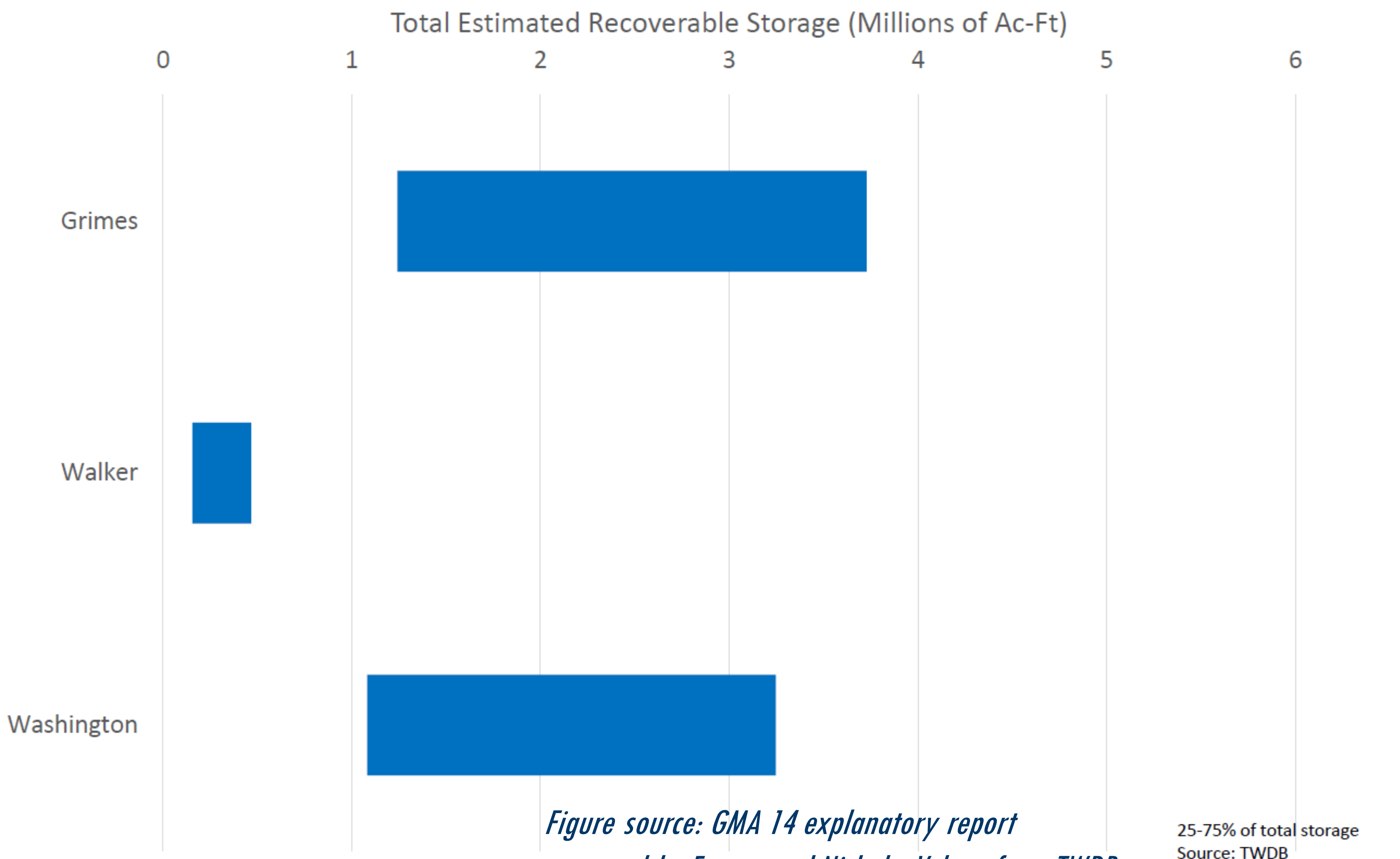

Figure source: GMA 14 explanatory report prepared by Freese and Nichols. Values from TWDB unchanged from 2nd round of joint planning.

25-75% of total storage
Source: TWDB

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Sparta Aquifer – Total Estimated Recoverable Storage

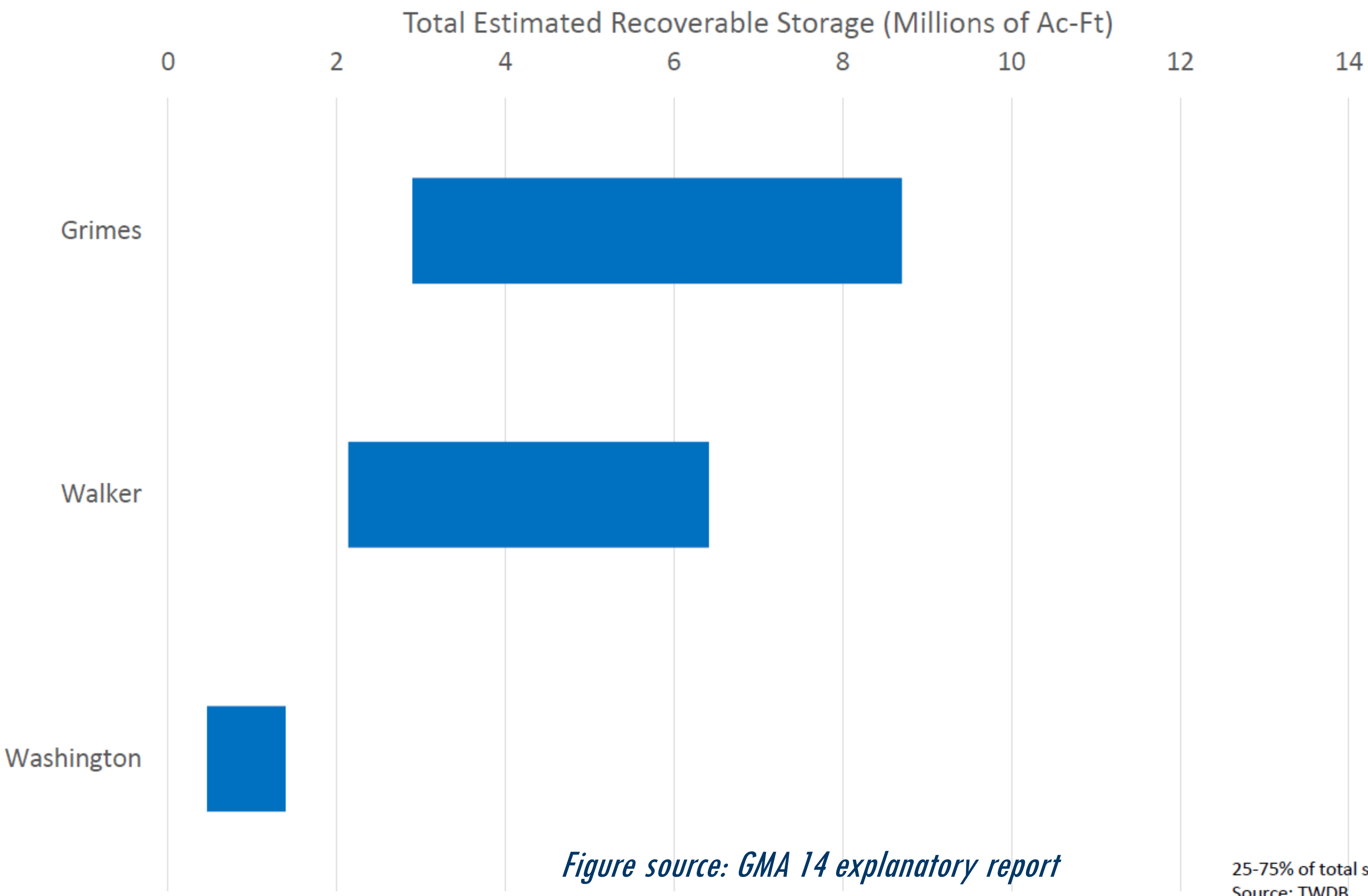

Figure source: GMA 14 explanatory report prepared by Freese and Nichols. Values from TWDB unchanged from 2nd round of joint planning.

25-75% of total storage
Source: TWDB

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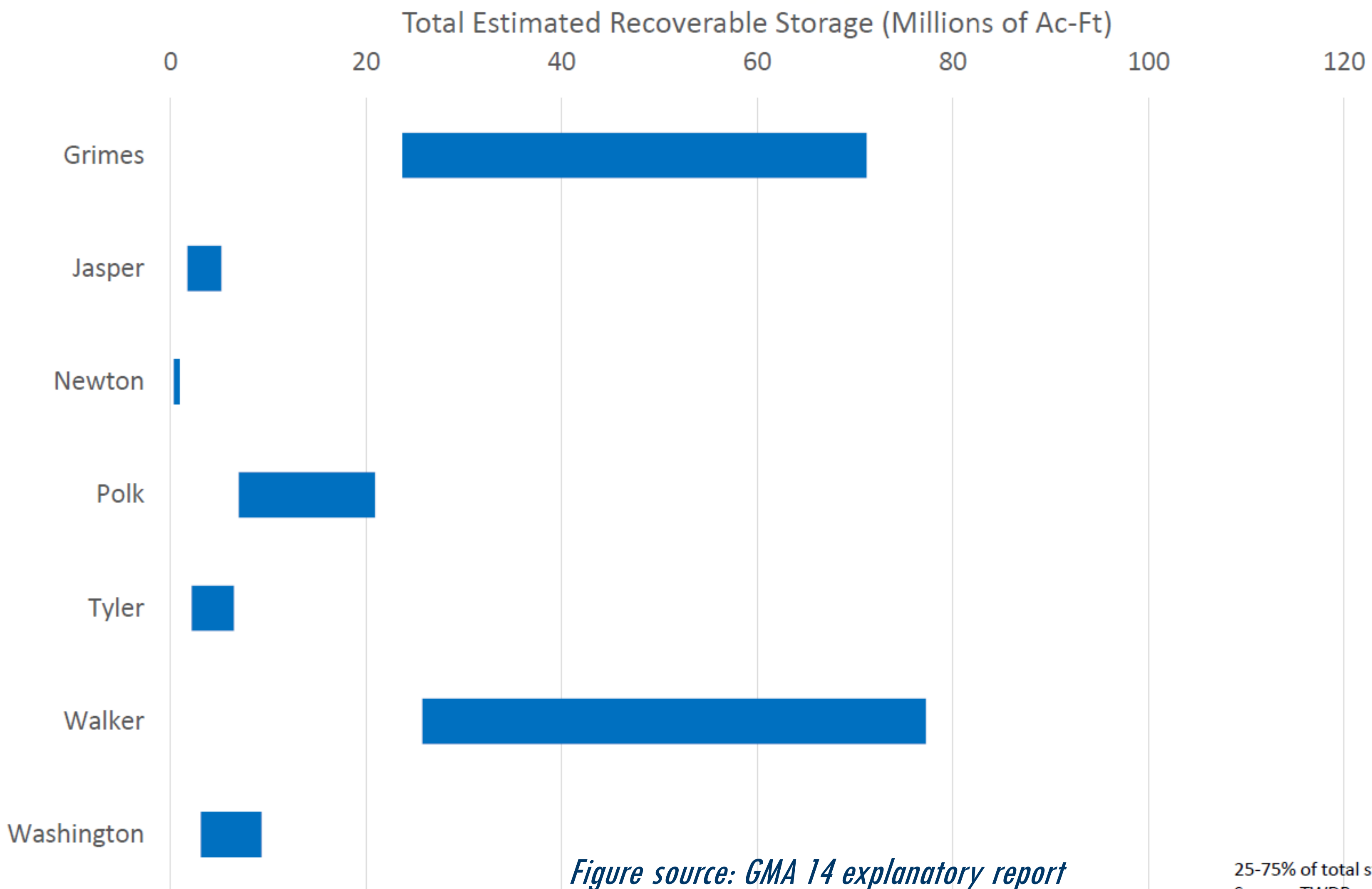
Yegua Jackson – Total Estimated Recoverable Storage



25-75% of total storage
Source: TWDB

Figure source: GMA 14 explanatory report prepared by Freese and Nichols. Values from TWDB unchanged from 2nd round of joint planning.

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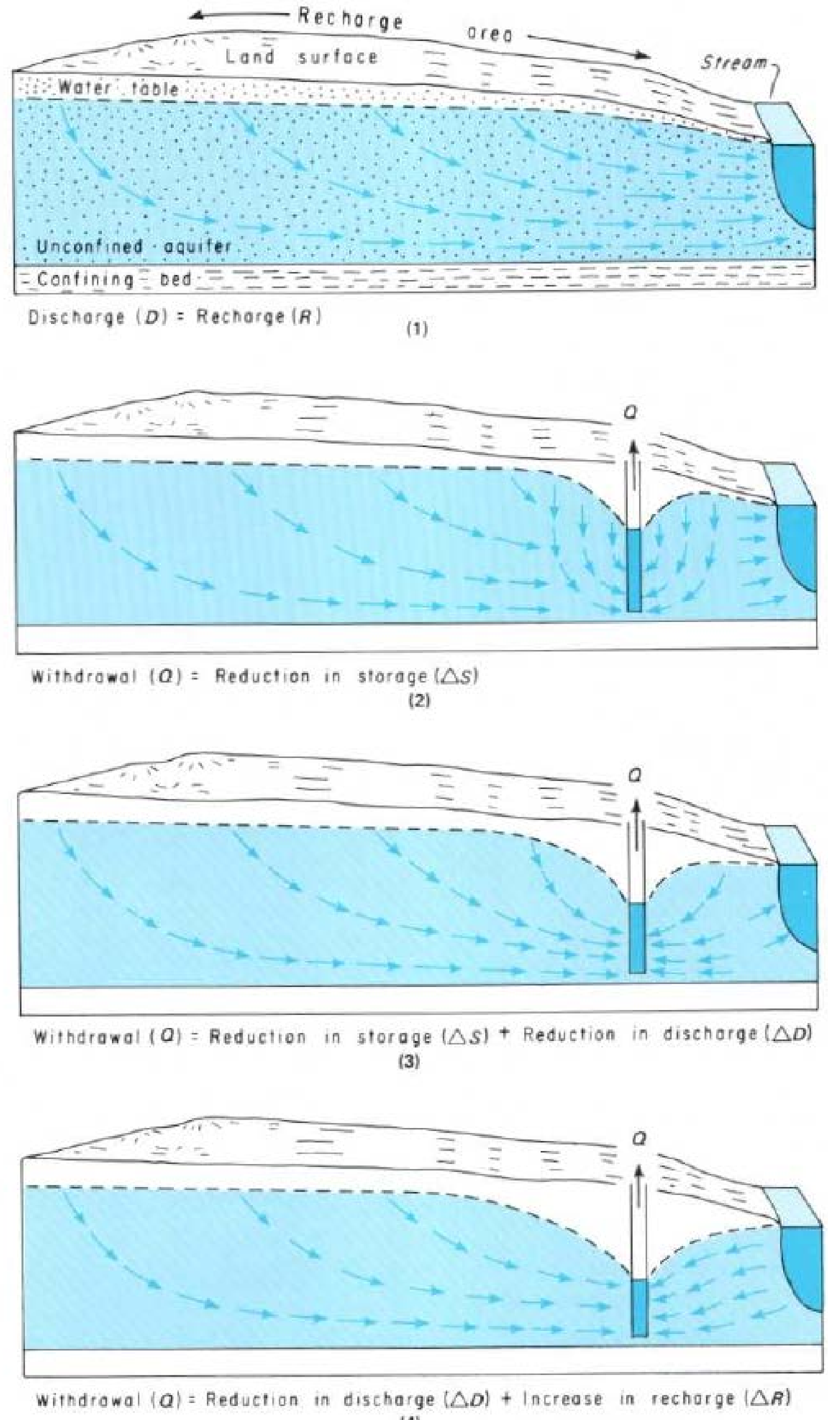
TERS - Limitations

- No consideration given to:
  - Aquifer water quality
  - Water levels dropping below pumps
  - Land surface subsidence
  - Degradation of water quality
  - Changes to surface water-groundwater interaction
  - Recharge
  - Practicality/economics of development
- As calculated, the 25% to 75% TERS range represents the approximate fraction of total storage in the aquifer that is in the water-producing zones (e.g. sands), not what is “recoverable” from those zones.
- TERS is a simple volumetric calculation that does not account for many important factors that limit groundwater production

Water Budgets

- Budgets posted for each aquifer and county
- Aquifers work as systems
- Consideration of average conditions is required
- Most useful part of water budgets – changes due to stress



Water Budgets

Waller County				
Inflow	**Chicot**	**Evangeline**	**Burkeville**	**Jasper**
Recharge/Stream Loss (GHB)	24,327	775	—	—
Storage	13,993	1,525	82	928
Leakage From Upper Unit	—	24,350	88	35
Leakage From Lower Unit	1	—	—	—
Lateral Flow From Austin	1,573	3,271	3	422
Lateral Flow From Fort Bend	847	428	0	42
Lateral Flow From Grimes	74	1,593	2	852
Lateral Flow From Harris	193	892	1	364
Lateral Flow From Montgomery	76	190	0	—
Lateral Flow From Washington	—	942	5	245
Total Inflow	41,084	33,965	182	2,888
Outflow	**Chicot**	**Evangeline**	**Burkeville**	**Jasper**
Wells	803	24,992	—	169
Evapotranspiration/Stream Gain (GHB)	13	960	—	—
Storage	328	306	74	2
Leakage To Upper Unit	—	1	142	76
Leakage To Lower Unit	24,350	88	35	—
Lateral Flow To Austin	437	527	0	71
Lateral Flow To Fort Bend	7,311	1,686	1	70
Lateral Flow To Grimes	2	287	1	203
Lateral Flow To Harris	6,854	4,044	3	1,113
Lateral Flow To Montgomery	987	1,027	1	1,166
Lateral Flow To Washington	—	188	1	18
Total Outflow	41,084	34,107	258	2,889
Inflow - Outflow	0	-142	-76	0
Storage Increase (+)/Decrease(-)	-13,666	-1,218	-8	-926

All values are average acre-feet per year from 2000 through 2009.

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Water Budgets – Recharge and Pumping

Waller County

Inflow	Chicot	Evangeline	Burkeville	Jasper
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Water Budgets – Net Storage Change

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Water Budgets – Vertical Flows

Waller County

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Water Budgets – Lateral Flows

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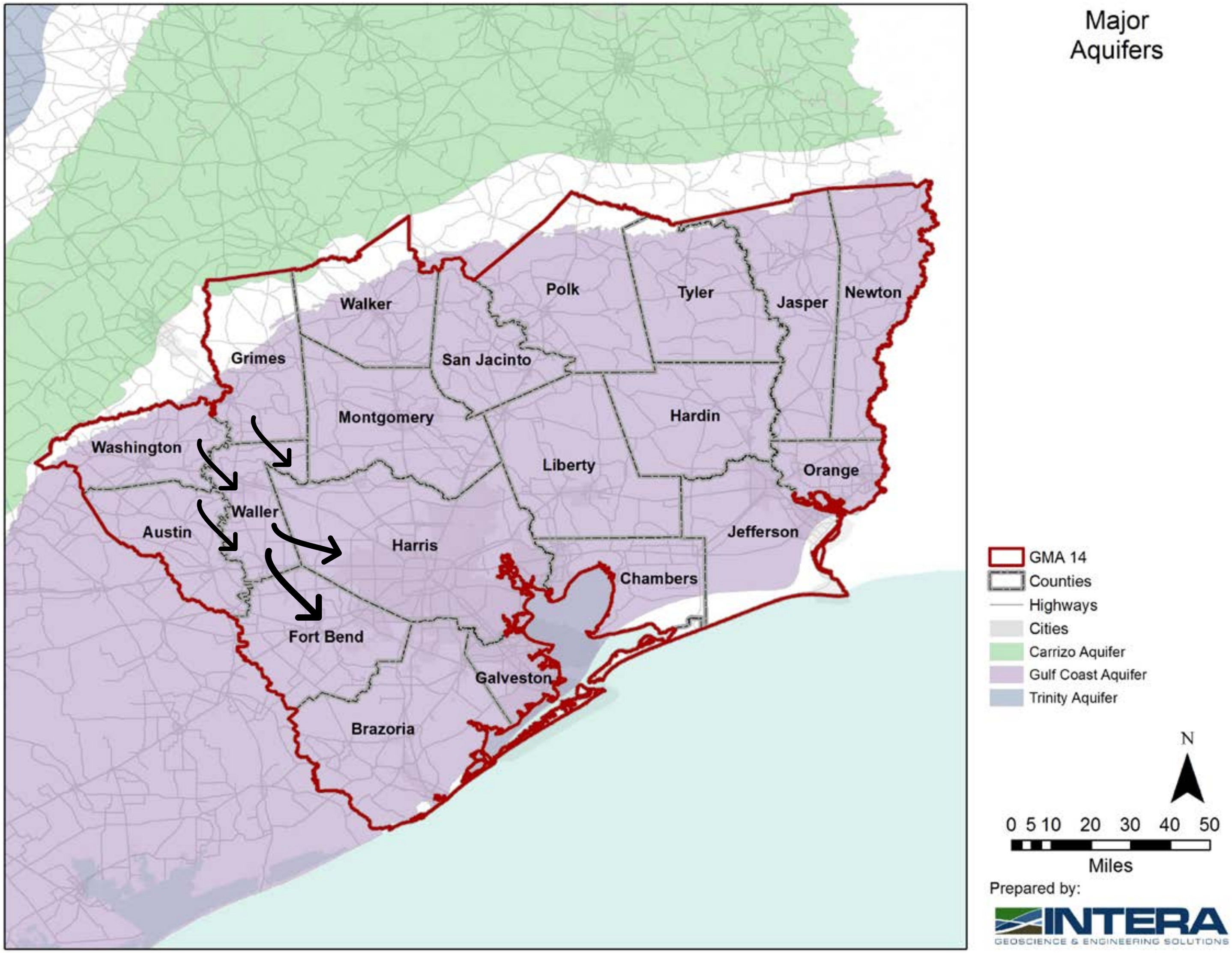
Lateral Flows



Useful References

The Water Budget Myth Revisited: Why Hydrogeologists Model

Bredehoeft (2005)

https://ngwa.onlinelibrary.wiley.com/doi/10.1111/j.1745-6584.2002.tb02511.x

Another Water Budget Myth: The Significance of Recoverable Ground Water in Storage

Alley (2007)

https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1601&context=usgsstaffpub

Identification of Potential Brackish Groundwater Production Areas – Gulf Coast Aquifer System

Young and others (2016)

http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/1600011947_InteraGulf_Coast_Brackish.pdf

GAM Task 13-037: Total Estimated Recoverable Storage for Aquifers in GMA 14

Wade and others (2014)

http://www.twdb.texas.gov/groundwater/docs/GAMruns/Task13-037.pdf

Basic Groundwater Hydrology

Heath (1983)

https://pubs.usgs.gov/wsp/2220/report.pdf

Reviewed LSGCD Presentation on Approach to Management

- Focused on delineation of "common reservoir" for DFCs
- Lays out process for developing information to use in the delineation including consideration of current use, water level changes, storage, subsidence, projected future uses
- "Common reservoir" approach for delineation may result in areas within the aquifer without DFCs

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Approaches for Delineating DFCs

- **Option 1**: Proceed without changes to scope and approach
  - –No additional cost or time
- **Option 2**: Move DFC delineation discussion to end of process after evaluation of factors
  - –No additional cost, rearrange schedule
- **Option 3**: Follow process for delineating common reservoir prior to evaluation of factors
  - –Estimated additional $24k, push back or compress schedule

Current Schedule

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Balancing Test Model Runs						■	■																						
Selection of Model Runs and Metrics for Evaluation								■	■																				
Review of Model Run Results										■	■																		
Draft Explanatory Report Development													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Propose DFC(s) for Adoption (Deadline May 1, 2021)																									■				
Proposed Meeting Dates	*		*		*		*		*		*		*		*		*		*		*		*		*				

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