



Sources of Data for Quantifying Hydraulic Fracturing Water Use in Texas

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**Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin**

**EPA Technical Workshop on
Water Acquisition Modeling**

Arlington, VA – June 5, 2013

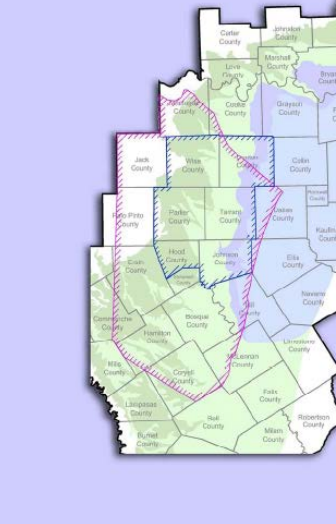
Source of data for publications?

Bureau of Economic Geology

Northern Trinity / Woodbine Aquifer Groundwater Availability Model

Assessment of Groundwater Use in the Northern Due To Urban Growth and Barnett Shale Development

TWDB Contract Number: 0604830613



2007

Prepared for
Texas Water Development Board

Bureau of Economic Geology
Scott W. Tinker, Director
Jackson School of Geosciences
The University of Texas at Austin, Texas 78713-89

2011

June 2011

Current and Projected V Texas Mining and Oil and



September 2012

Oil & Gas Water Use in Texas Update to the 2011 Mining Water U

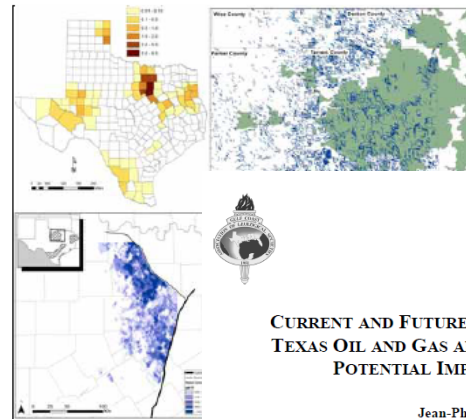
Environmental
Science & Technology

Water Use for Shale-Gas Production in Texas, U.S.

Jean-Philippe Nicot^a and Bridget R. Scanlon

Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas at Austin, 10100 Burnet Road, Building 130, Austin, Texas 78758, United States

Supporting Information



CURRENT AND FUTURE W TEXAS OIL AND GAS AND POTENTIAL IMPAC

Jean-Philippe

Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas at Austin, University State

ABSTRACT

The Texas mining industry, in addition to oil and gas, produces crushed rocks. Operations always involve water, either as an current water use in the various sectors of the mining industry is covered the upstream segment of the oil and gas industry (drilling, hydraulic fracturing, waterfloods), the aggregate industry (washing included but no further processing), the coal industry (pit dewatering and aquifer dewatering), and other substances mined in a fashion similar to that of aggregate (industrial sand, lime, etc.), as well as through solution mining. Overall, in 2008, the industry used ~160 thousand acre-ft (kAft), including 35 kAft for hydraulic fracturing and ~12 kAft for other purposes in the oil and gas industry. The coal and aggregate industries used 20 kAft and 71 kAft, respectively. Mining of industrial sand dominates the remainder. Approximately three-fourths of the water used is consumed, and approximately two-thirds of the water consumed is groundwater. Projection estimates call for a steady increase in water use in coal and aggregate production and a sharp increase, followed by a slow decrease, in the oil and gas industry. Operators favor surface water when it is plentiful, but groundwater is a more drought-proof source. Because the various segments of the energy industry are spread out across the state, they impact many different aquifers. Mining withdrawals represent only ~1% of total withdrawals at the state level but can be much higher locally and compete with other uses, such as municipal usage or irrigation.

INTRODUCTION

Mineral resources in Texas fall into four categories: (1) hydrocarbons (oil and gas), (2) lignite and coal, (3) crushed rock and sand and gravel (collectively known as aggregate), and (4) other substances. Oil and gas make up most of the dollar value and compose a significant fraction in terms of volume with the aggregate category (Table 1). Oil and gas are produced from almost every county in the state (Fig. 1a), whereas lignite mines are located in a narrow band in the middle of the state (Fig. 1b) and parallel to the coast (Kyle, 2008; Kyle and Cliff, 2008). Sand and gravel are exploited mostly along rivers (Fig. 1c). Crushed-stone quarries are present mostly in the footprint of the Edwards Limestone. The objective of a recent study performed

for the Texas Water Development Board (TWDB) was to determine county-level historical and projected mining water use in Texas, focusing on fresh water (total dissolved solid content [TDS] < 1000 mg/L). Disregarding oil and gas wells and other oil- and gas-related facilities, the U.S. Census Bureau (2009) listed a total of 11 lignite mines, 100+ crushed stone, and ~200 sand and gravel operations, many of them small, as well as ~70 facilities of a different type, neither lignite nor aggregate, in Texas in 2000. More details about mine count, as well as a more detailed account of water use, can be found in Nicot et al. (2011).

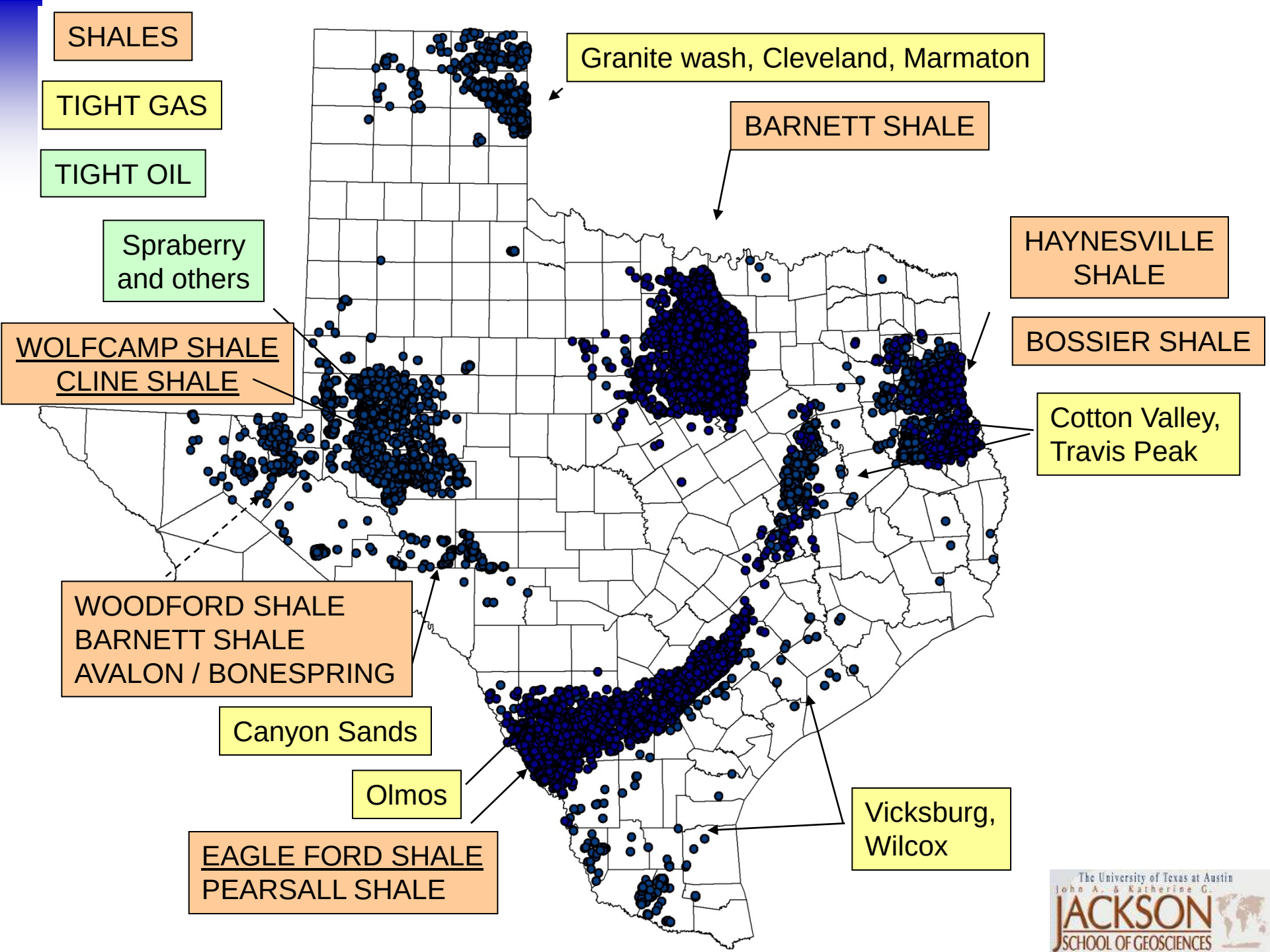
Oil and gas resources are generally sorted into conventional and unconventional categories (Figs. 1a and b). The former represents the archetypal reservoir trap in either sandstone or carbonate and is made up of interconnected pores that allow 'easy' communication with the well bore. The latter is generally characterized by the use of advanced technologies and consists of different types of formations and/or extreme environmental conditions (pressure and temperature). Characteristics of unconventional resources of interest relevant to this study include low permeability and a need to stimulate the reservoir through hydraulic

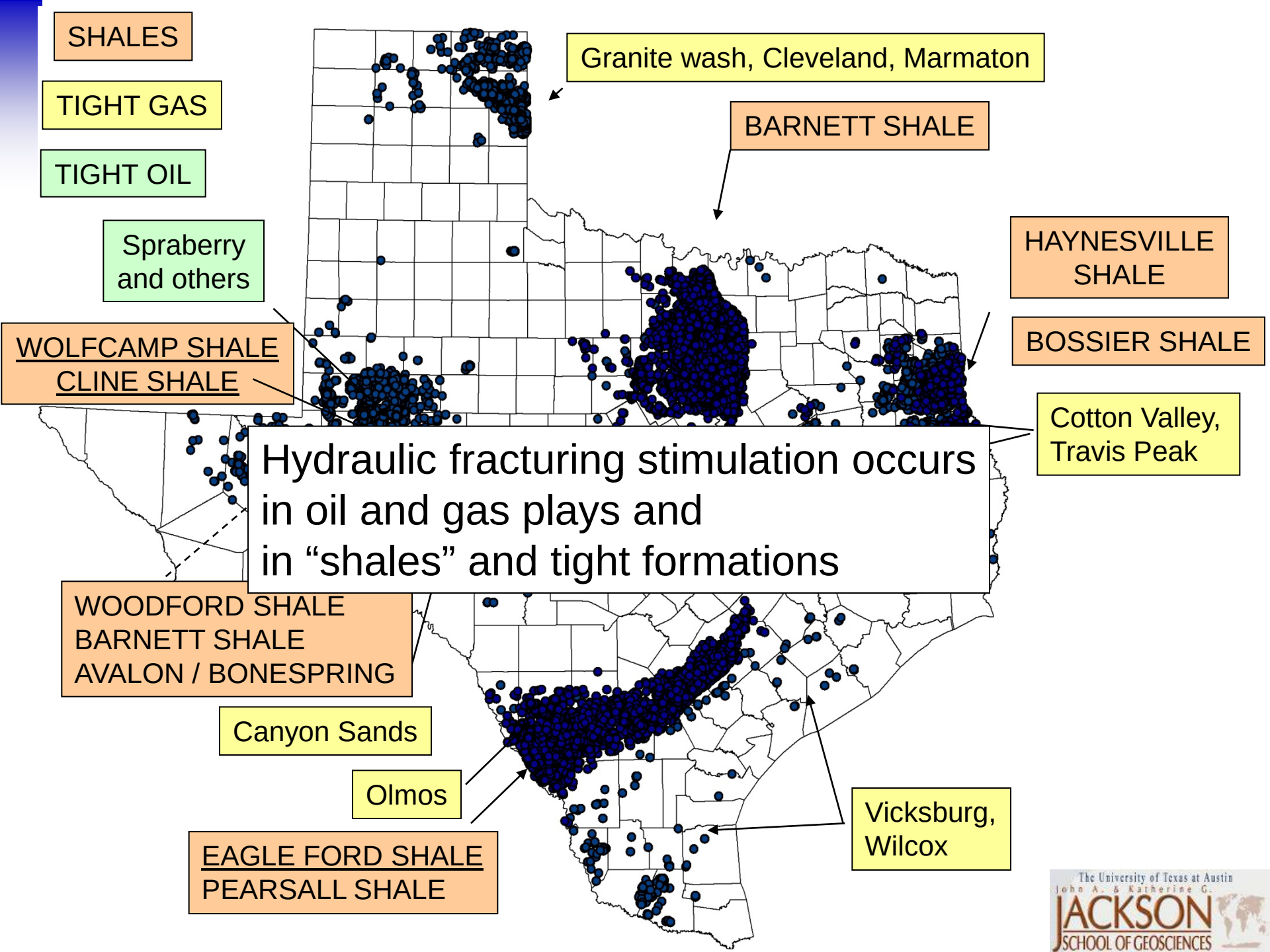
2012

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Manuscript received March 14, 2012; revised manuscript received May 25, 2012; manuscript accepted May 25, 2012.

GCAOS Journal, v. 1 (2012), p. 145–161.



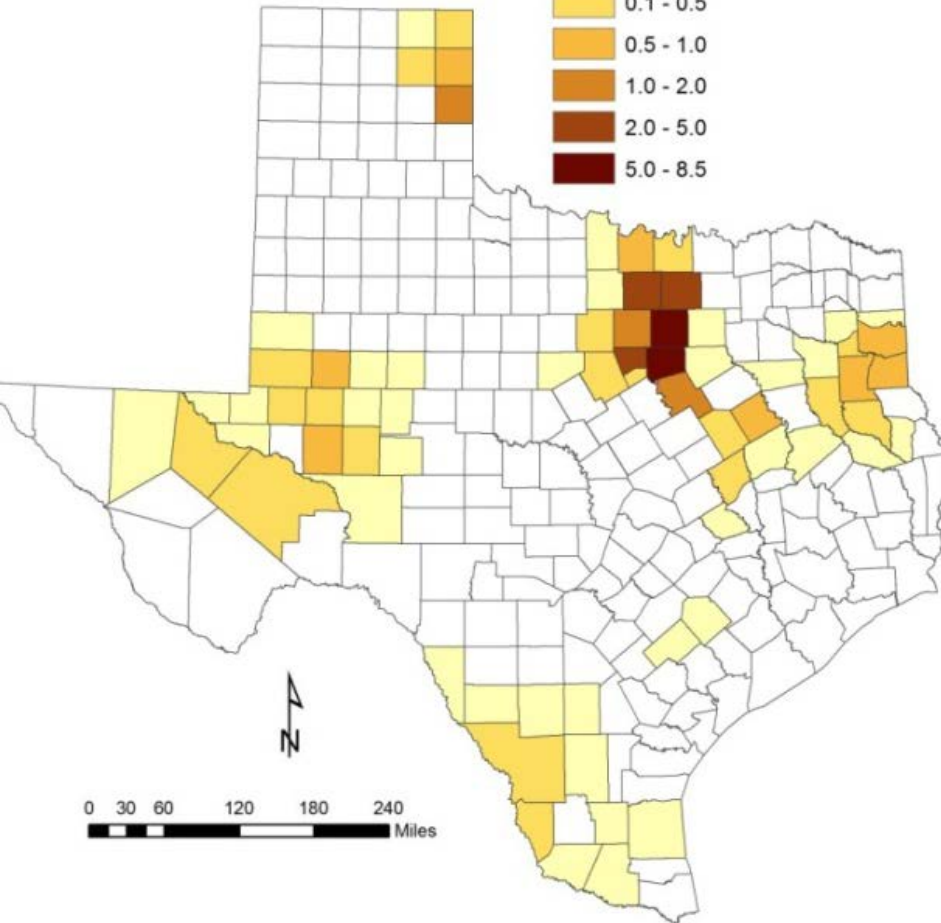
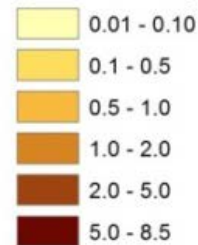


Final Result: Hydraulic Fracturing Water Use

1 AF = 325,851 gallons
1 AF = 2-3 households/yr
1kAF = $1.23 \times 10^6 \text{ m}^3$

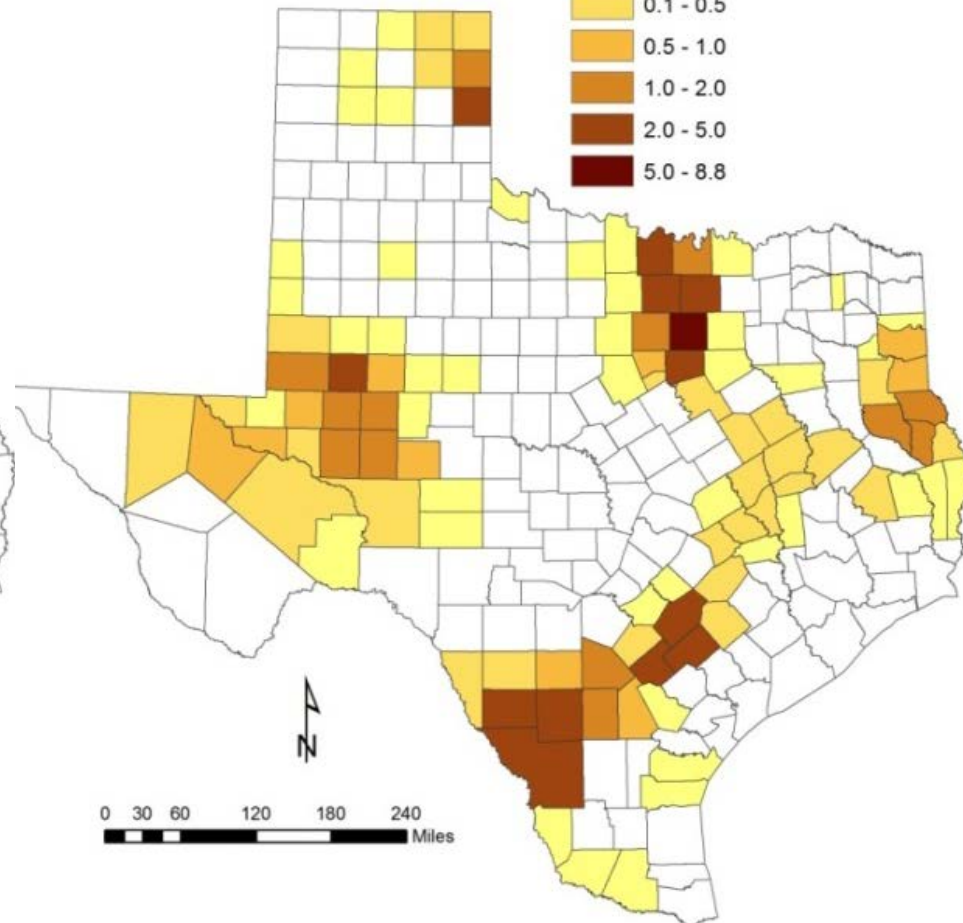
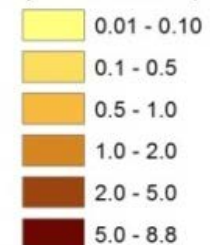
2008: 36 kAF

HF Water Use (year 2008)
(thousand AF)



2011: 81.5 kAF

HF Water Use (year 2011)
(thousand AF)



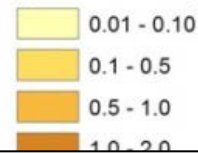
Source of raw data: IHS Enerdeq database; in Nicot et al. 2012 report

Final Result: Hydraulic Fracturing Water Use

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1kAF = $1.23 \times 10^6 \text{ m}^3$

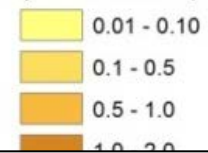
2008: 36 kAF

HF Water Use (year 2008)
(thousand AF)



2011: 81.5 kAF

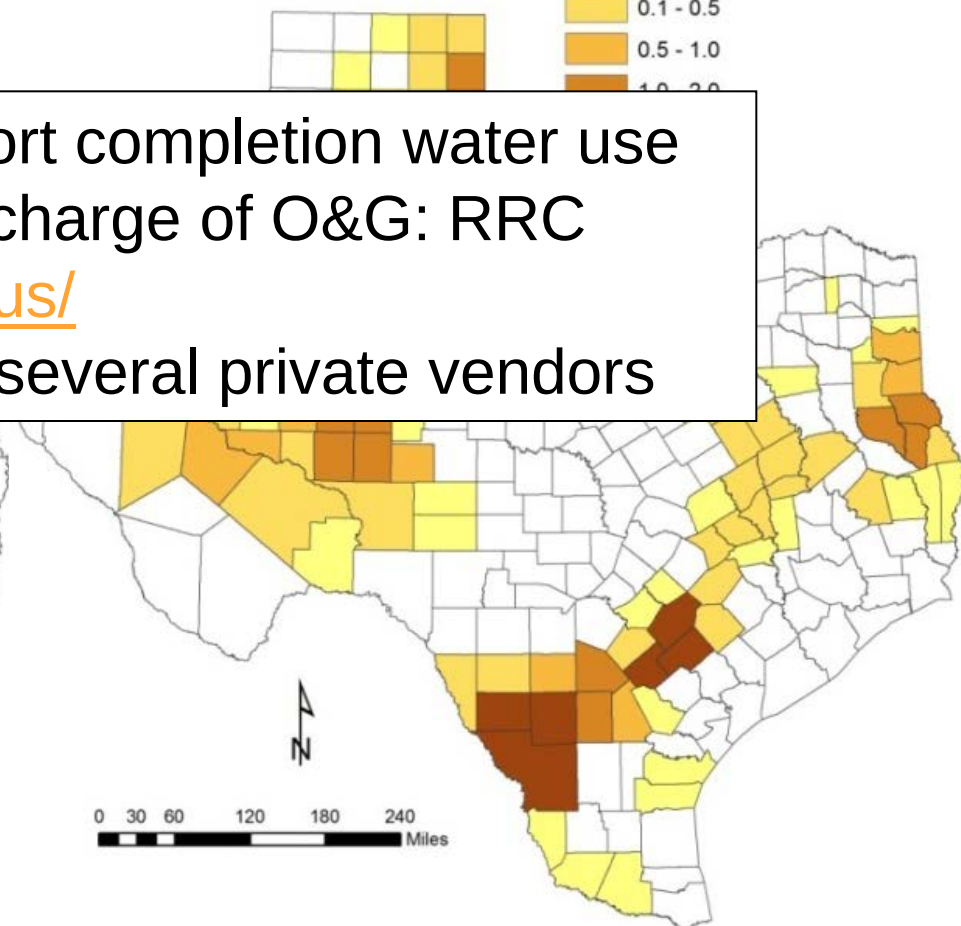
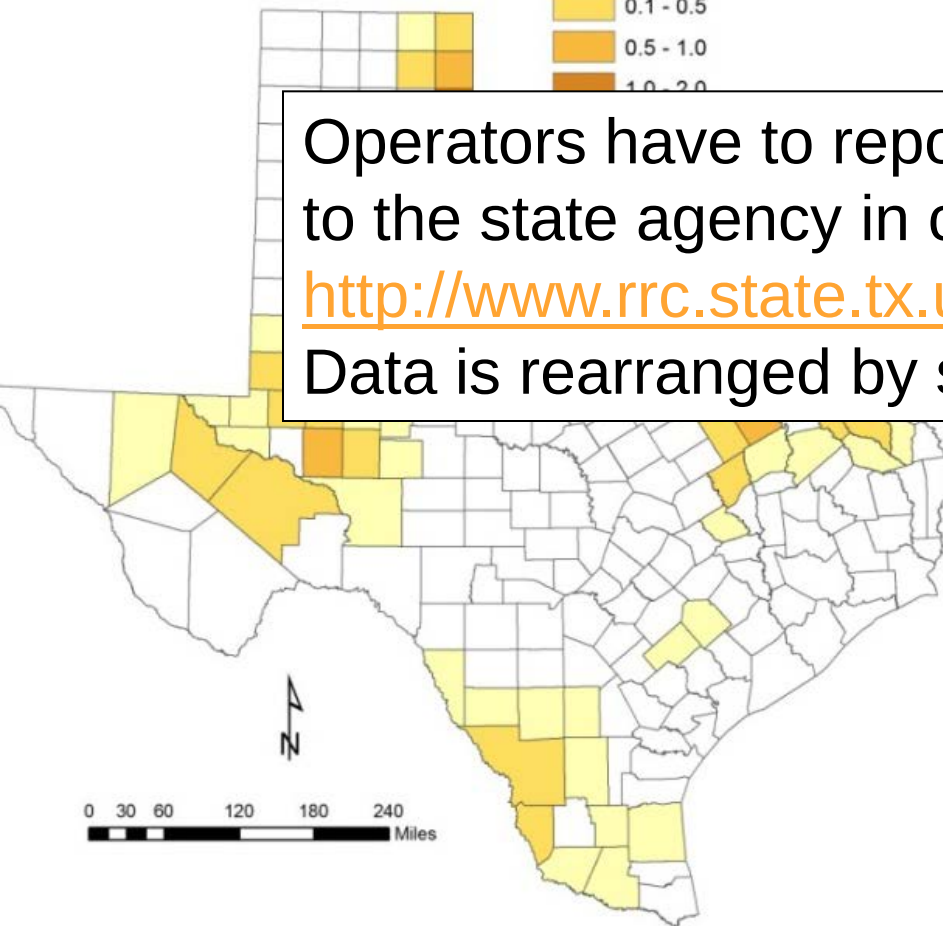
HF Water Use (year 2011)
(thousand AF)



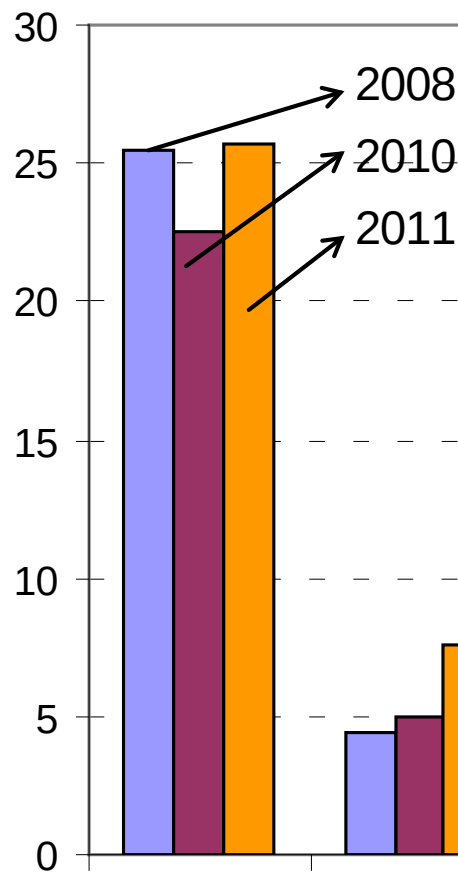
Operators have to report completion water use
to the state agency in charge of O&G: RRC

<http://www.rrc.state.tx.us/>

Data is rearranged by several private vendors



2008, '10, '11 Water Use (thousand AF)



Jump in completion water use in oil/liquid plays (EF, PB), mostly steady or decreasing in gas plays (Barnett, Haynesville)

Barnett Sh.
Haynesville Sh. / East Texas TG
Eagle Ford Sh.
Woodford / Barnett PB / Pearsall Sh.
Anadarko TG
Permian Basin TO
South Texas / Gulf Coast TG

Example 2 of RRC data

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40.	ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.	
	Depth Interval	Amount and Kind of Material Used
	7120' – 9128'	60,391 bbl. Slickwater and 8000 sx sand

41.	FORMATION RECORD (LIST DEPTHS OF PRINCIPAL GEOLOGICAL MARKERS AND FORMATION TOPS)			
	Formations	Depth	Formations	Depth
	Upper Barnett	6552'		
	Lower Barnett	6611'		
	Ellenburger	6720'		

REMARKS

Well shut in waiting on pipeline connection.

VALID PERMIT
JUL 29 2008
60762701

- Year 2006
- 60,391bbl = ~2.5 Mgal for ~2000ft; 1250gal/ft OK
- 8000sx = ~2,900,000#; loading of 1.15lb/gal OK

Example 2 of RRC data

Bureau of Economic Geology

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38. TUBING RECORD			39. Producing Interval (this completion) Indicate depth of perforation or open hole	
Size	Depth Set	Packer Set	From	To
2 3/8"	5188'		5781' <i>md</i>	7217' <i>md</i>
			From	To
			From	To
			From	To

40. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.	
Depth Interval	Amount and Kind of Material Used
5781' - 6043'	12643 bbls SW w/110006#'s 30/70 + 24772#'s 20/40 WSD
6335' - 6615'	13842 bbls SW w/119050#'s 30/70 + 30404#'s 20/40 WSD
6924' - 7217'	13992 bbls SW w/119050#'s 30/70 + 30404#'s 20/40 WSD

41. FORMATION RECORD (LIST DEPTHS OF PRINCIPAL GEOLOGICAL MARKERS AND FORMATION TOPS)			
Formations	Depth	Formations	Depth
Lower Atoka	4999'		
Marble Falls	5469'		
Lower Barnett	5884'		

REMARKS Amended Test Information

- Year 2006
- 40,477bbl = ~1.7 Mgal for 835 (1436) ft; 2000 (1200) gal/ft
- 433,689#; loading of 0.26 lb/gal



Oil & Gas Well Data Data Sets

The following data sets are available either on CD or by FTP. Pricing does not include the cost of CDs and postage. Please note that some data is provided in the original EBCDIC format. Conversion of data and choice of conversion tools is the responsibility of the user. Refer to the [General Ordering](#) page for further details.

[2-Year Inactive Wells](#)[3-Year Inactive Wells](#)[Final Oil and Gas Annuals](#)[Gas Allowable by Gatherer](#)[Gas Allowable by Operator](#)[Gas Master](#)[Gas Proration Schedule](#)[Gas Purchaser Stripout](#)[Gas Well Status \(Monthly G-10\)](#)[Historical Ledger](#)[Oil Allowable by Gatherer](#)[Oil Allowable by Operator](#)[Oil Detail Well](#)[Oil Master](#)[Oil Proration Schedule](#)[Oil Well Status \(Monthly W-10\)](#)

RRC Data Sets Information

- General Ordering
- Computer Generated Listings
- Digital Map Data
- Drilling Permit Data
- Oil & Gas Field Data
- Oil & Gas Production Data
- Oil & Gas Regulatory Data
- Oil & Gas Well Data
- Pipeline Data



RAILROAD COMMISSION OF TEXAS

[» County/District List](#) » [Oil & Gas Directory](#)

KEY FIELD SEARCH

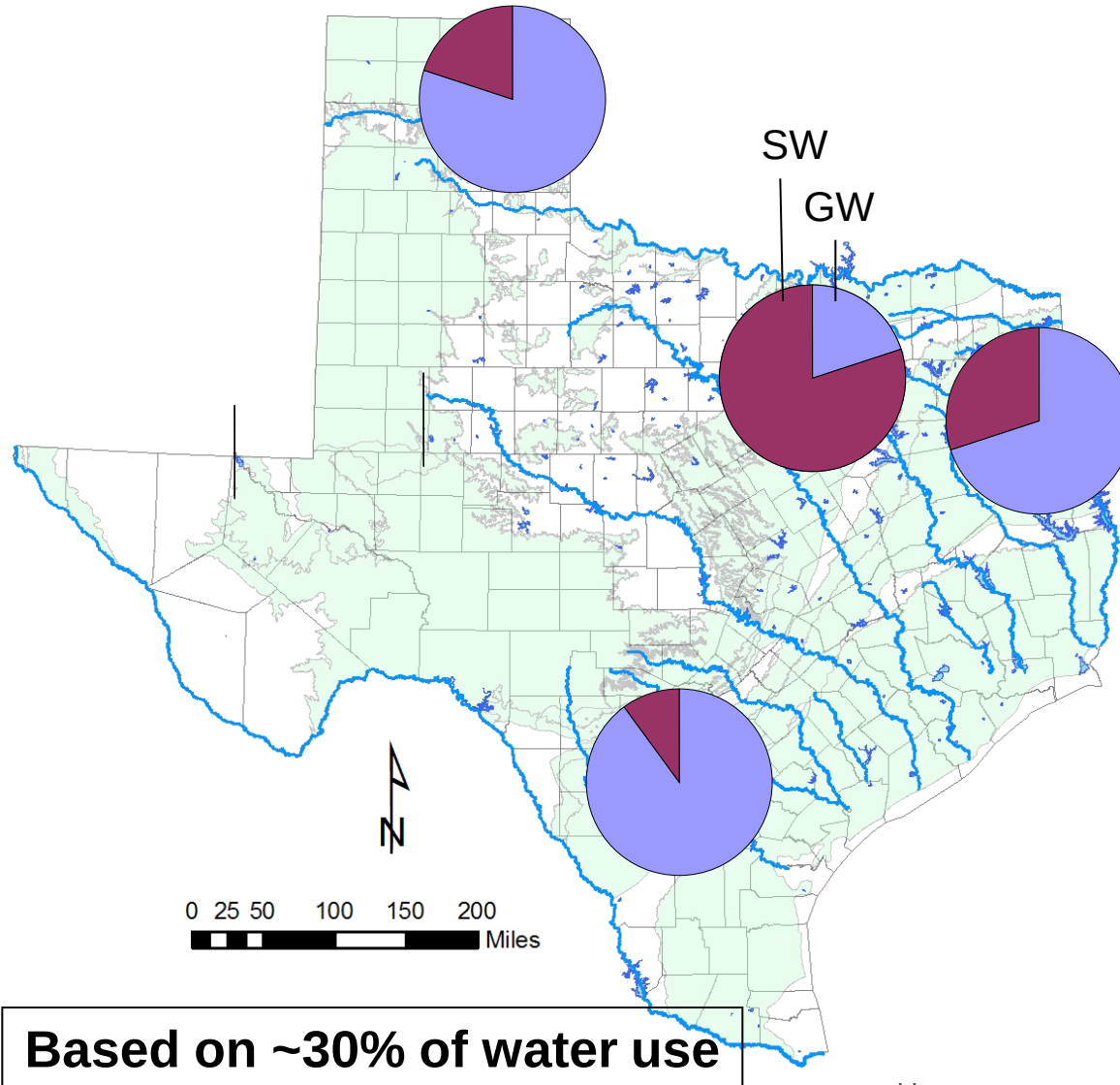
[KEY FIELD](#) [FULL TEXT](#) [HELP](#)Profile Selected: Oil and Gas Well Records

	FIELD	VALUE
☒	District	* Two character district required.
☒	Field #	* Numeric only; leading zeroes will be automatically added.
☒	Field Name	* No punctuation; wildcards permitted.
☒	Lease/Gas ID	* Exact match/numeric only.
☒	Lease Name	* No punctuation; wildcards permitted.
☒	API Number	* No punctuation; Exact match only.
	Display	10 Records Per Page

[Submit](#)[Clear](#)ESD - Release 1.0rrc - CVS Version 1.5 - Powered by **neubus, inc.** - Need Help? Contact us at: records@rrc.state.tx.us

GW/SW split: little known

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2006 survey in Barnett:
~60% groundwater

2012 Barnett:
~20% groundwater

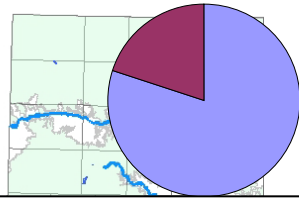
2012 Haynesville-ETx:
~70% groundwater

2012 Eagle Ford:
~90% groundwater

2012 Permian B.:
~100% groundwater

GW/SW split: little known

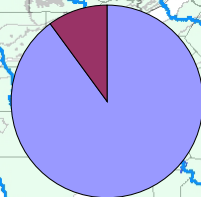
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SW

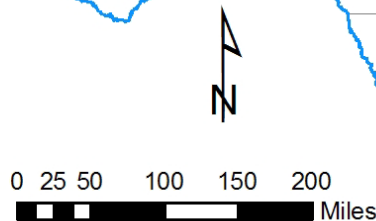
2006 survey in Barnett:
~60% groundwater

Information on GW/SW split, amount of reuse (no treatment) and recycling (treatment), and of brackish water use not captured in state database, partly available from operators, water providers, GCD's, ETX:



2012 Eagle Ford:
~90% groundwater

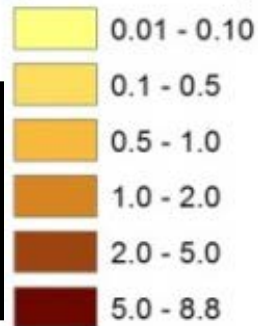
2012 Permian B.:
~100% groundwater



Based on ~30% of water use

Based on ~30% of water use

HF Water Use (year 2011)
(thousand AF)



Fraction from recycling / reuse and Brackish

Large Operators:
From 0% to 100% BK
Depending on play and operator

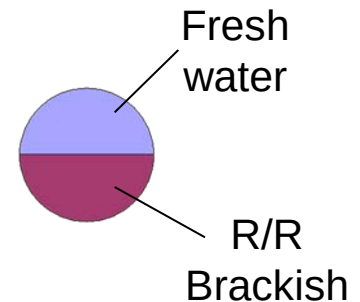
Barnett:
R/R: 5%
BK: 3%

Midland:
R/R: 2%
BK: 30%

East Texas:
R/R: 5%
BK: ~0%

Delaware:
R/R: 0%
BK: 80%

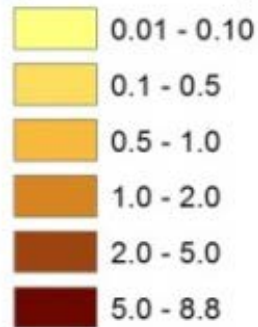
Eagle Ford:
R/R: ~0%
BK: 20%



0 30 60 120 180 240 Miles

Based on ~30% of water use

HF Water Use (year 2011)
(thousand AF)



Flowback at end of Year1

Anadarko:
~100%

Midland:
~75%

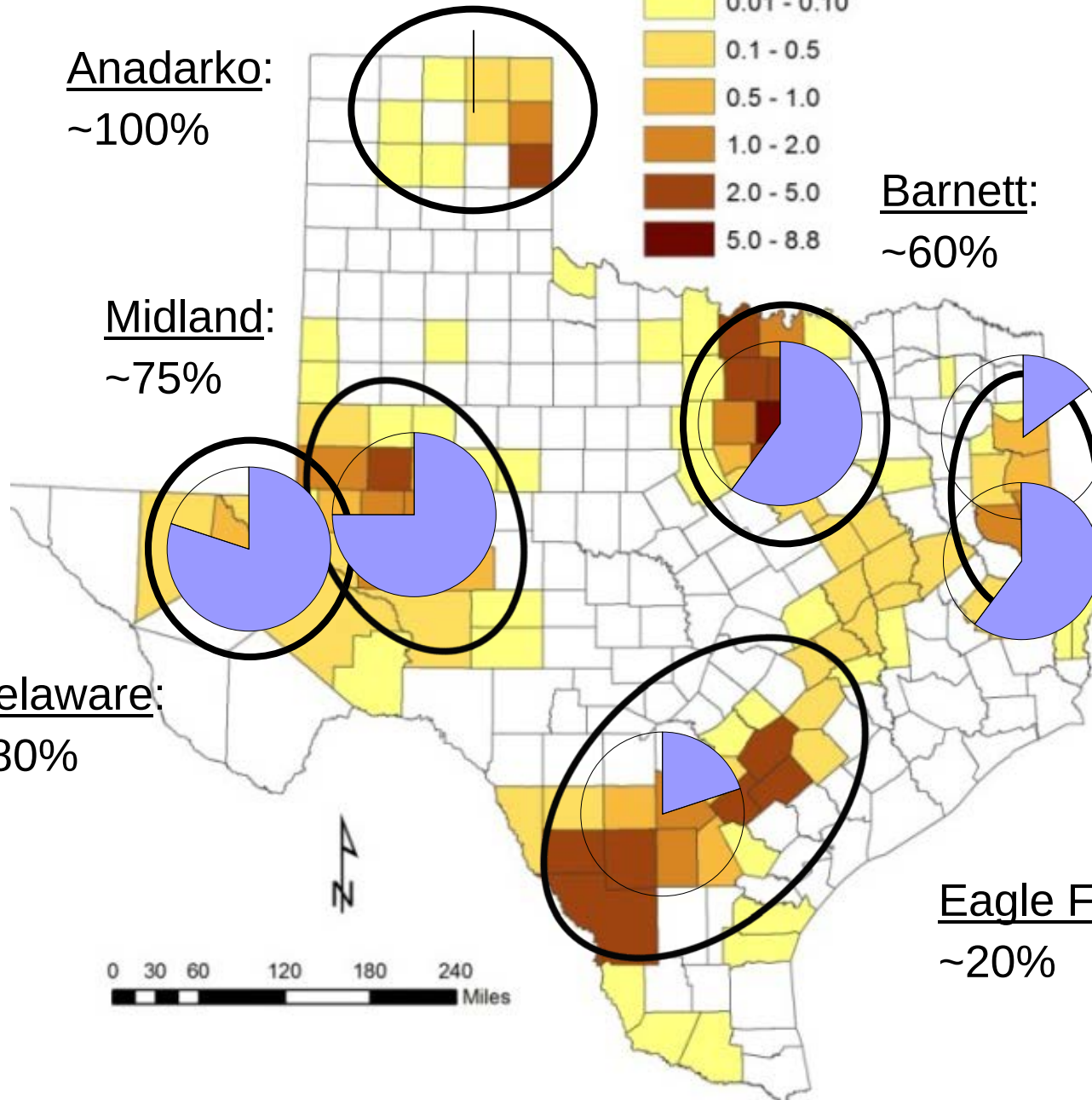
Barnett:
~60%

Haynesville:
~15%

Cotton Valley:
~60%

Delaware:
~80%

Eagle Ford:
~20%



Groundwater Conservation Districts (GCD's)

Geology

Confirmed Groundwater Conservation Districts

1. Anderson County UWCD - 10/17/1987
2. Bandera County River Authority & Ground Water District - 11/7/1988
3. Barton Springs/Edwards Aquifer CD - 8/13/1987
4. Bee GCD - 1/20/2001
5. Blanco-Pedernales GCD - 1/23/2001
6. Blanton GCD - 11/6/2002
7. Brazoria County GCD - 11/8/2006
8. Brazos Valley GCD - 11/6/2002
9. Brewster County GCD - 11/8/2001
10. Brush County GCD - 11/3/2008
11. Central Texas GCD - 8/24/2006
12. Clear Fork GCD - 11/6/2002
13. Clearwater UWCD - 8/21/1999
14. Coastal Bend GCD - 11/8/2001
15. Coastal Plains GCD - 11/8/2001
16. Coke County UWCD - 11/4/1998
17. Colorado County GCD - 11/8/2007
18. Corpus Christi ASRCD - 8/17/2006
19. Cow Creek GCD - 11/6/2002
20. Crockett County GCD - 1/28/1981
21. Culberson County GCD - 6/2/1988
22. Duval County GCD - 7/26/2009
23. Edwards Aquifer Authority - 7/28/1998
24. Evergreen UWCD - 8/30/1986
25. Fayette County GCD - 11/8/2001
26. Fox Crossing Water District - 4/4/1988
27. Garza County UWCD - 11/5/1988
28. Gateway GCD - 6/3/2003
29. Glasscock GCD - 8/22/1981
30. Goliad County GCD - 11/8/2001
31. Gonzales County UWCD - 11/2/1984
32. Guadalupe County GCD - 11/14/1999
33. Hays Trinity GCD - 6/3/2003
34. Headwaters GCD - 11/6/1991
35. Hemphill County UWCD - 11/4/1987
36. Hickory UWCD No. 1 - 8/4/1982
37. High Plains UWCD No. 1 - 8/28/1981
38. Hill Country UWCD - 8/8/1987
39. Huddell County UWCD No. 1 - 10/6/1967
40. Irion County WCD - 8/2/1986
41. Jeff Davis County UWCD - 11/2/1983
42. Kenedy County GCD - 11/2/2004
43. Kimble County GCD - 6/3/2002
44. Kinney County GCD - 11/2/2002
45. Lipan-Kilgus GCD - 11/3/1987
46. Live Oak UWCD - 11/7/1988
47. Llano Estacado UWCD - 11/3/1988
48. Lone Star GCD - 11/8/2001
49. Lone Wolf GCD - 2/2/2002
50. Lost Pines GCD - 11/6/2002
51. Lower Trinity GCD - 11/7/2008
52. McLennan GCD - 11/8/2001
53. Medina County GCD - 8/28/1991
54. Menard County UWCD - 8/14/1999
55. Meca UWCD - 1/20/1980
56. Mesquite GCD - 11/4/1988
57. Mid-South Texas GCD - 11/6/2002
58. Middle Pease GCD - 11/6/2002
59. Middle Trinity GCD - 6/4/2002
60. Neches & Trinity Valleys GCD - 11/8/2001
61. North Plains GCD - 1/2/1986
62. North Texas GCD - 12/1/2008
63. Northern Trinity GCD - 6/16/2007
64. Panhandle GCD - 1/21/1988
65. Panois County GCD - 11/8/2007
66. Pecos Valley GCD - 11/8/2001
67. Permian Basin UWCD - 8/21/1986
68. Pineywoods GCD - 11/8/2001
69. Plateau Water Supply District - 3/4/1974
70. Plum Creek GCD - 6/1/1989
71. Port Oak Savannah GCD - 11/6/2002
72. Prairielands GCD - 8/1/2008
73. Presidio County UWCD - 8/31/1988
74. Reel-Edwards C and R District - 6/30/1989
75. Red River GCD - 8/1/2009
76. Red Sands GCD - 11/6/2002
77. Refugio GCD - 11/8/2001
78. Rolling Plains GCD - 1/8/1989
79. Rusk County GCD - 8/6/2004
80. San Patricio County GCD - 6/12/2007
81. Sandy Land UWCD - 11/7/1988
82. Santa Rita UWCD - 8/18/1989
83. Saratoga UWCD - 11/7/1988
84. South Plains UWCD - 2/8/1992
85. Southeast Texas GCD - 11/2/2004
86. Southern Trinity GCD - 8/18/2006
87. Starr County GCD - 1/8/2007
88. Sterling County UWCD - 11/3/1987
89. Sutton County UWCD - 4/6/1988
90. Tarrant County GCD - 11/8/2012
91. Texoma GCD - 11/8/2002
92. Trinity Glen Rose GCD - 11/6/2002
93. Upper Trinity GCD - 11/8/2007
94. Uvalde County UWCD - 8/1/1983
95. Victoria County GCD - 8/2/2006
96. Waco GCD - 11/6/2002
97. Winter Garden GCD - 1/17/1988

Unconfirmed Groundwater Conservation Districts

- 98. W. Llanos County GCD - #
- 99. W. Llanos County GCD - #

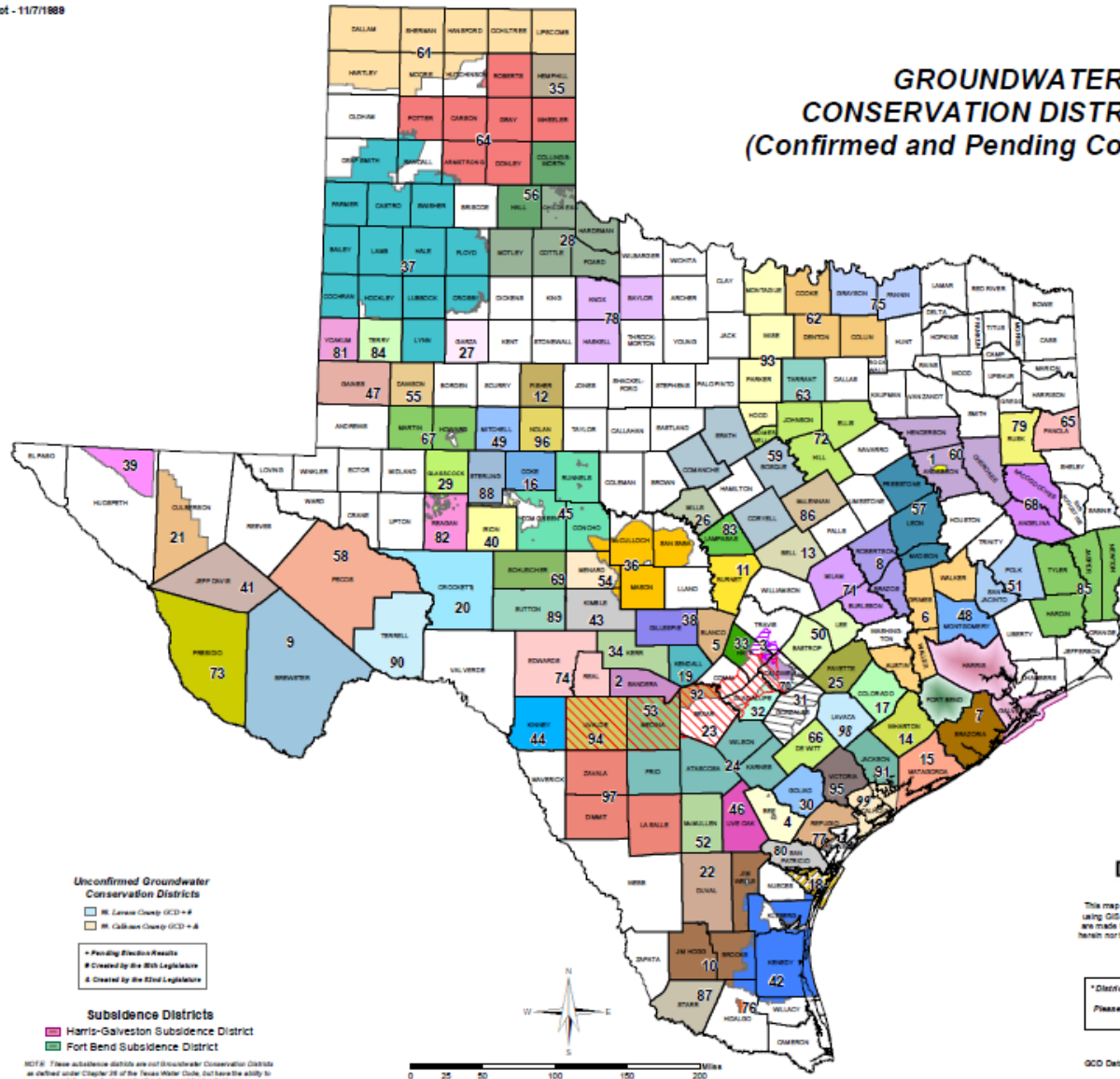
- * Pending Election Results
- # Created by the 8th Legislature
- & Created by the 82nd Legislature

Subsidence Districts

- Harris-Galveston Subsidence District
- Fort Bend Subsidence District

NOTE: These subsidence districts are not Groundwater Conservation Districts as defined under Chapter 36 of the Texas Water Code, but have the ability to regulate groundwater production to prevent land subsidence. (Refer to Senate Bill 1307 from the 79th Legislature Session)

GROUNDWATER CONSERVATION DISTRICTS*, (Confirmed and Pending Confirmation)



Texas Water Development Board

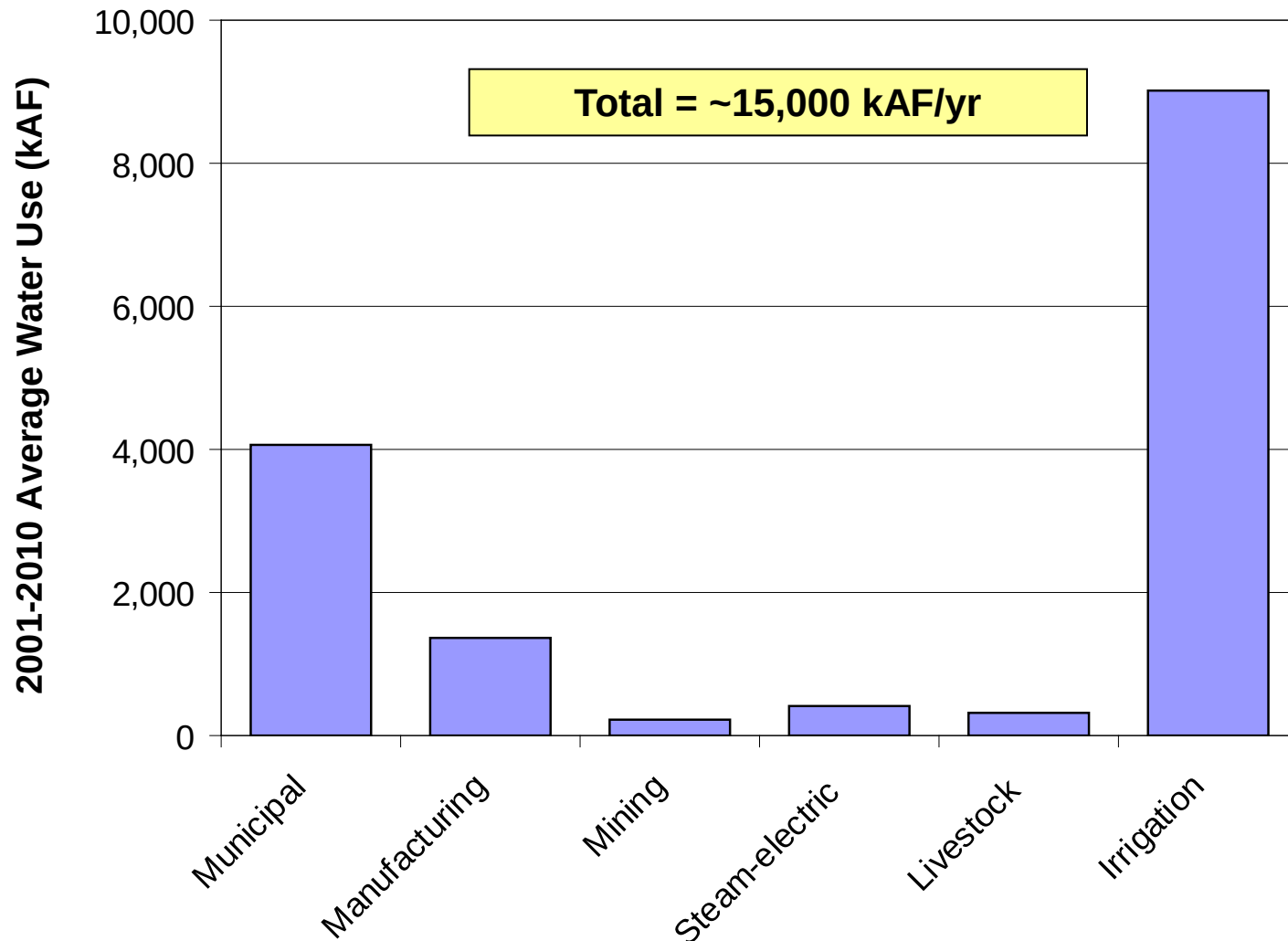
DISCLAIMER
This map was generated by the Texas Water Development Board using GIS (Geographical Information System) software. No claim is made to the accuracy or completeness of the information shown herein nor to its suitability for a particular use. The scale and location of all mapped data are approximate.

* Districts that have, in whole or part, authority as assigned by Chapter 36 of the Texas Water Code.
Please refer questions pertaining to individual districts to the district themselves.

GCD Data Source: Texas Commission on Environmental Quality (TCEQ) 512-358-1000
Map updated: January 2013

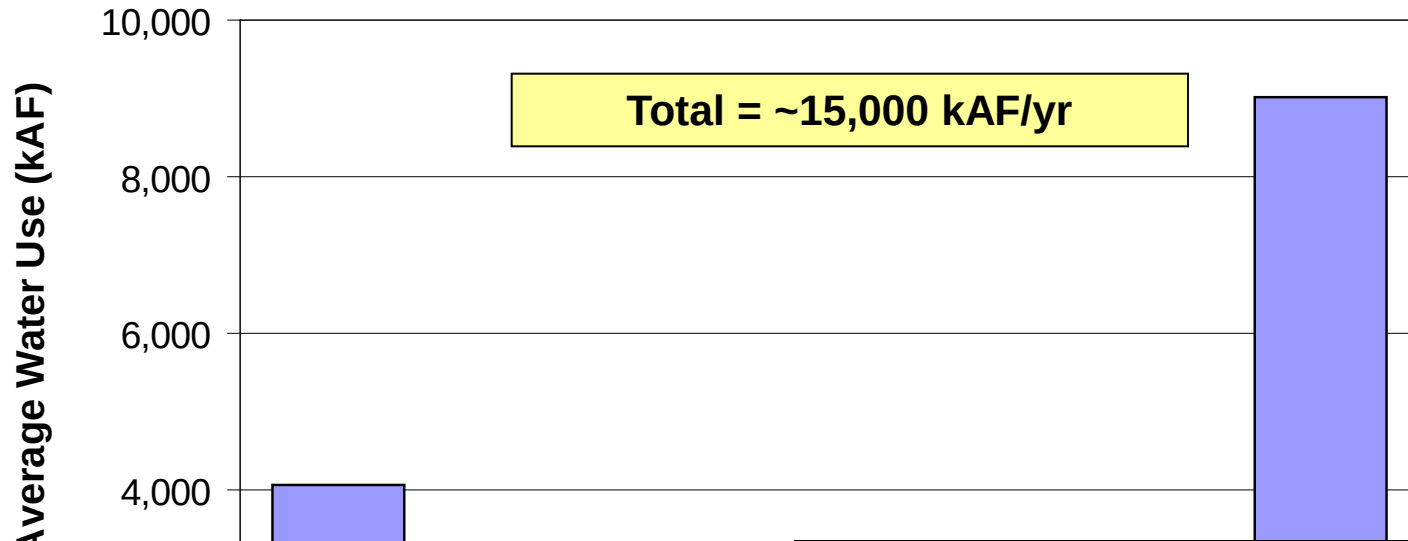
Texas water use

Bureau of Economic Geology



Texas water use

Bureau of Economic Geology



2008 Mining consumption:

Oil and Gas = ~60 kAF (~36 kAF HF)
(HF, drilling, waterflooding)

Coal/Lignite = ~20 kAF

Aggregates = ~70 kAF

Others = ~10 kAF

Total = ~160 kAF

2011 Mining consumption:

Oil and Gas = ~120 kAF water use
(HF, drilling, waterflooding)

HF = ~81.5 kAF water use

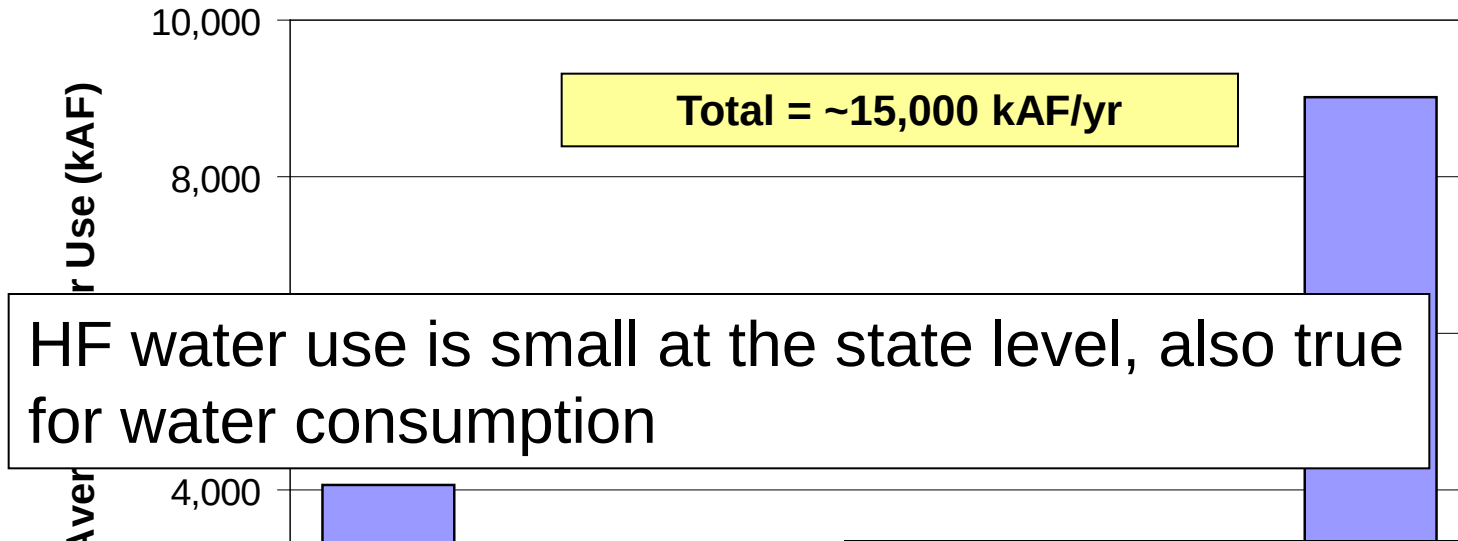
HF = ~65 kAF water consumption

All others = ~100 kAF

Total consumption = ~190 kAF

Texas water use

Bureau of Economic Geology



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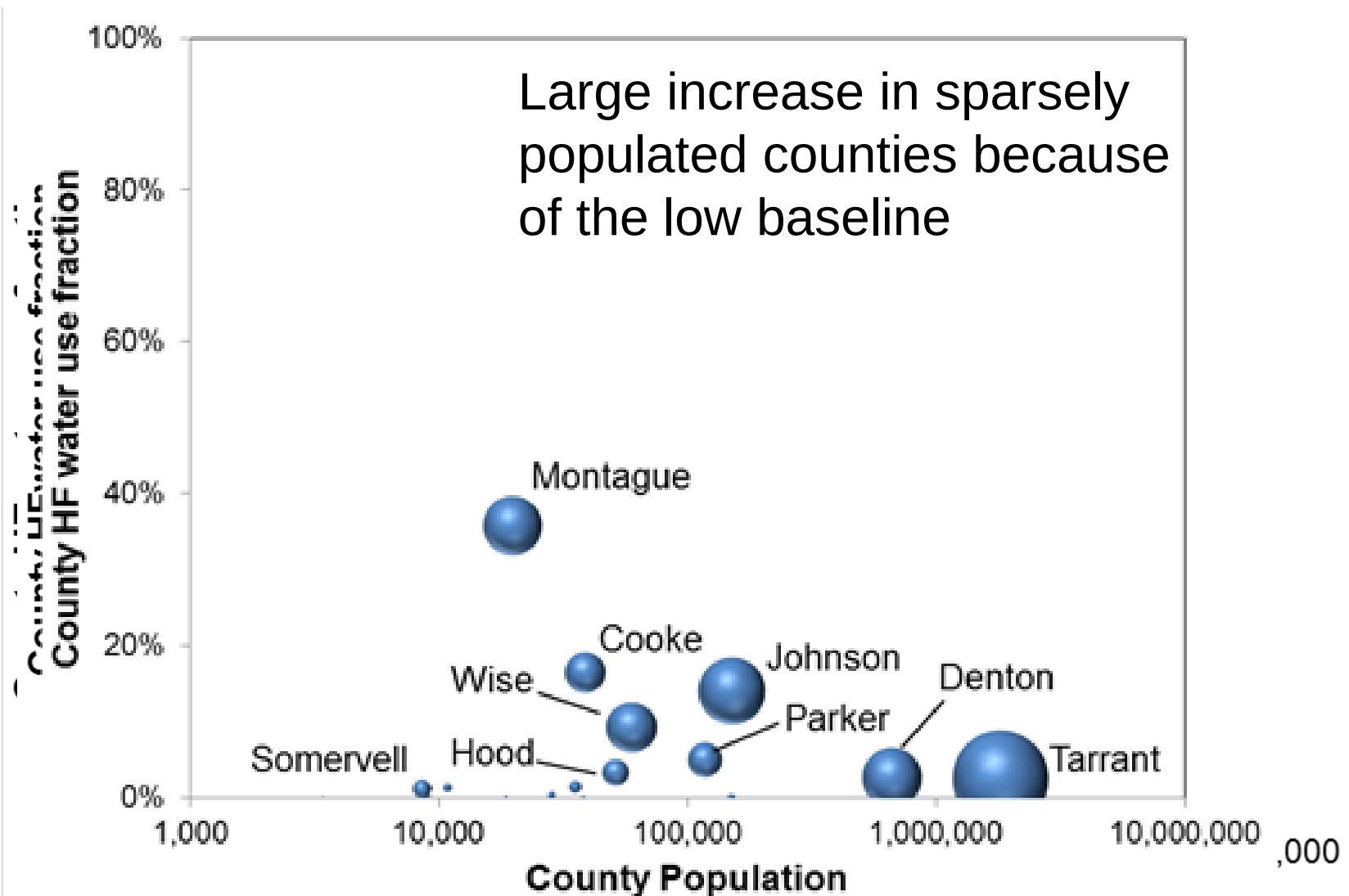
HF = ~65 kAF water consumption

All others = ~100 kAF

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Baseline water use

Bureau of Economic Geology



Historical Water Use Estimates



Each year the Texas Water Development Board conducts an annual survey of ground and surface water use by municipal and industrial entities within the state of Texas. The information obtained is then utilized by the Texas Water Development Board for Water Resources Planning. The historical water use estimates are subject to revision as additional data and corrections are made available to the TWDB.

Please read [Frequently Asked Questions](#) for more information on water use survey estimates and GPCDs and how they are derived.

For more information, please contact [Water Use Survey Team](#).

Water Use Summary Estimates

- [2010 Water Use Summary Estimates](#)
- [2009 Water Use Summary Estimates](#)
- [2008 Water Use Summary Estimates](#)
- [2007 Water Use Summary Estimates](#)
- [2006 Water Use Summary Estimates](#)
- [2005 Water Use Summary Estimates](#)
- [Historical Water Use Summary Information Database](#)

Water Planning >

- ★ [State Water Plan](#)
- ★ [Regional Water Planning](#)
- ★ [Planning Data](#)
- ★ [Water Use Survey](#)
 - [Online Water Use Survey](#)
 - [Printable Water Use Survey](#)
 - [Historical Water Use Estimates](#)
 - [Historical Groundwater Pumpage](#)
 - [Frequently Asked Questions](#)

- ★ [Water Bank and Trust](#)
- ★ [Maps & GIS Data](#)
- ★ [Useful links and Resources](#)
- ★ [Water Planning Staff](#)

Flood Mitigation Planning >>

TNRIS >>

QUESTIONS?

San Antonio

Eagle Pass+

Houston

C.C.

Laredo+

The Valley

Credit: **NASA - NOAA**

