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Analysis of Hydraulic Fracturing Fluid Data from the FracFocus Chemical Disclosure Registry 1.0

Office of Research and Development

March 2015

Outline

- Research Questions
- General Information
- Anatomy of a Disclosure
- Additive Ingredients
- Base Fluids
- Summary

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Research Questions

- What are the identities of chemicals used in hydraulic fracturing fluids?
- How does chemical composition vary by location?
- How much water is used in hydraulic fracturing operations?
- What are the sources of water used in hydraulic fracturing fluids?

Research Products

- Available at http://www2.epa.gov/hfstudy/published-scientific-papers
  - *Analysis of Hydraulic Fracturing Fluid Data from the FracFocus Chemical Disclosure Registry 1.0* report
  - Access 2013 project database
  - *Data Management and Quality Assessment* report
  - Excel 2013 spreadsheets of summarized data
  - State summaries of FracFocus 1.0 data with user guide

General Information

- More than 38,000 FracFocus 1.0 disclosures analyzed
  - A disclosure covers chemicals and water used at a particular well on a particular date
  - 606 disclosures (1.5%) could not be included in the database
- January 1, 2011 – February 28, 2013 fracture dates
- ~19,700 disclosures for oil wells
- ~18,300 disclosures for gas wells
- From approximately 400 operators in 20 states

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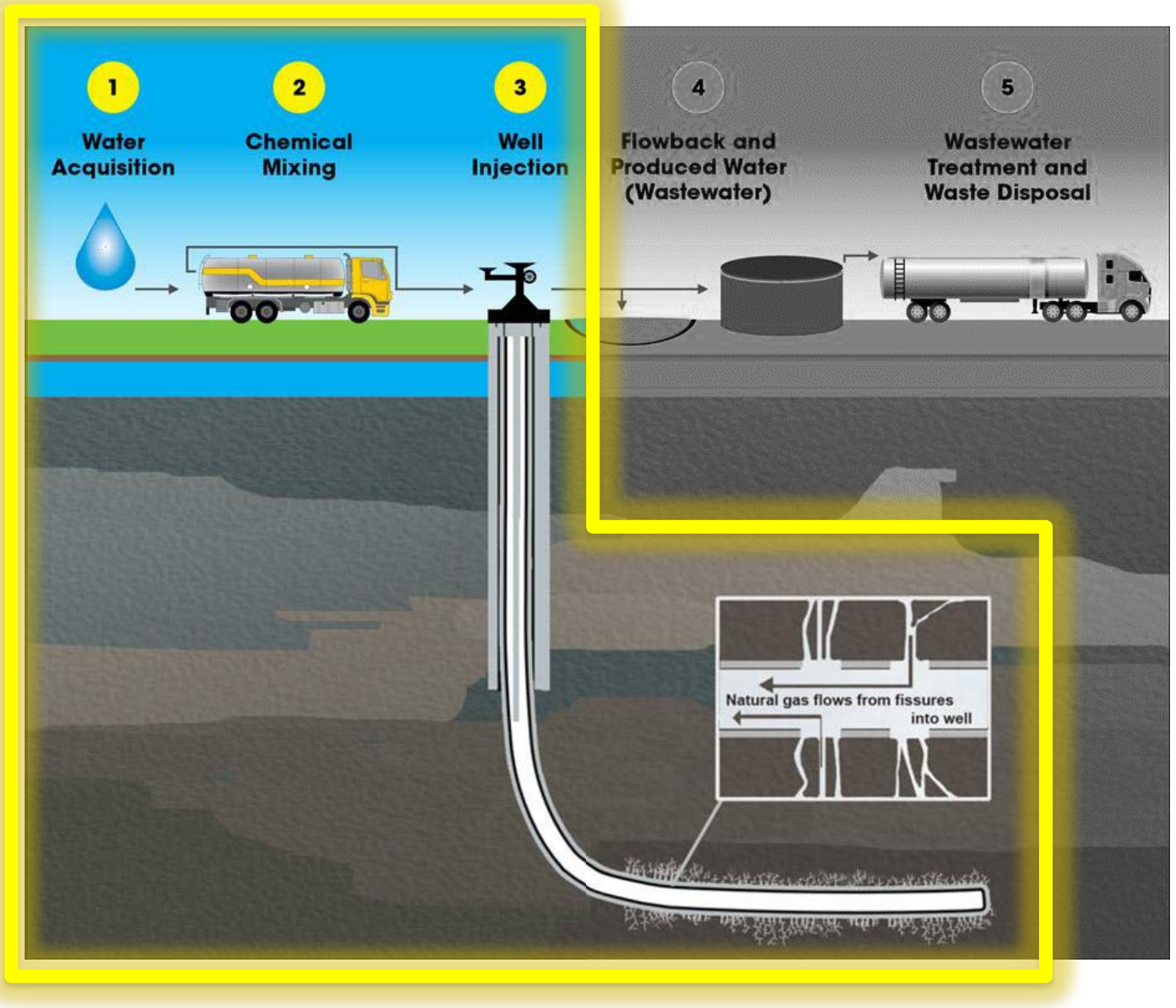
Hydraulic Fracturing Water Cycle



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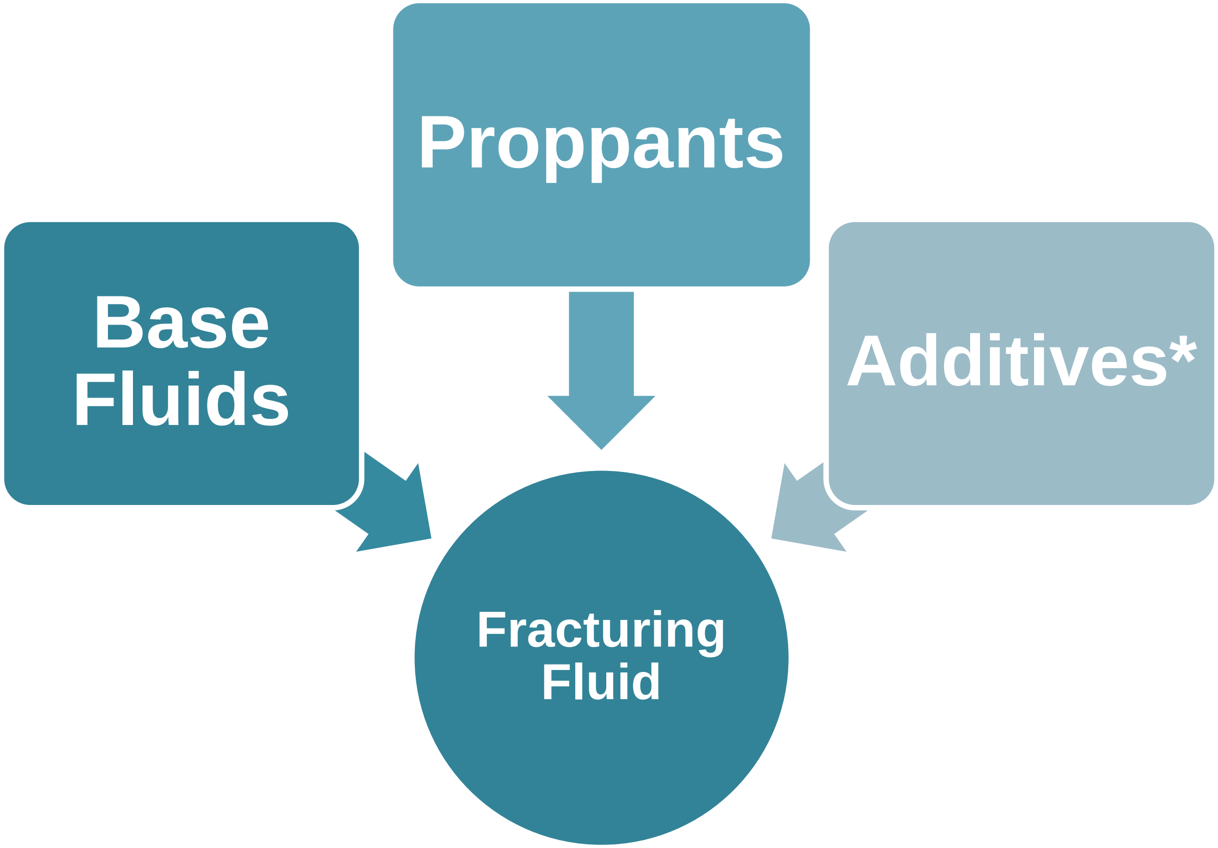

* Additives may include one or more ingredients

Example FracFocus Disclosure

Hydraulic Fracturing Fluid Product Component Information Disclosure

Fracture Date	7/25/2011
State:	Texas
County:	Gonzales
API Number:	42-177-32123
Operator Name:	EOG Resources, Inc
Well Name and Number:	HFS #2H
Longitude:	-97.461183
Latitude:	29.300589
Long/Lat Projection:	NAD27
Production Type:	Oil
True Vertical Depth (TVD):	11,031
Total Water Volume (gal)*:	2,904,384

Hydraulic Fracturing Fluid Composition:

Trade Name	Supplier	Purpose	Ingredients	Chemical Abstract Service Number (CAS #)	Maximum Ingredient Concentration in Additive (% by mass)**	Maximum Ingredient Concentration in HF Fluid (% by mass)**	Comments
Water	EOG	Carrier/Base Fluid	Water	7732-18-5	100.00%	84.09743%	
Sand		Proppant	Crystalline Silica	14808-60-7	100.00%	12.32189%	
Hydrochloric Acid	Chemplex	Acid	Hydrogen Chloride	7647-01-0	40.00%	1.09518%	
Aceticplex 50	Chemplex	Petrochemical industry: Oil Well Acidizing, Iron Sequesterant	Acetic Acid	64-19-7	50.00%	0.01187%	
Plexgel 907L-EB	Chemplex	Viscosifier for water	Distillate, petroleum, hydrotreated light	64742-47-8	60.00%	0.21713%	
			Propylene Pentamer	15220-87-8	60.00%	0.21713%	
			C-11 to C-14 n-alkanes, mixed	Mixture	60.00%	0.21713%	

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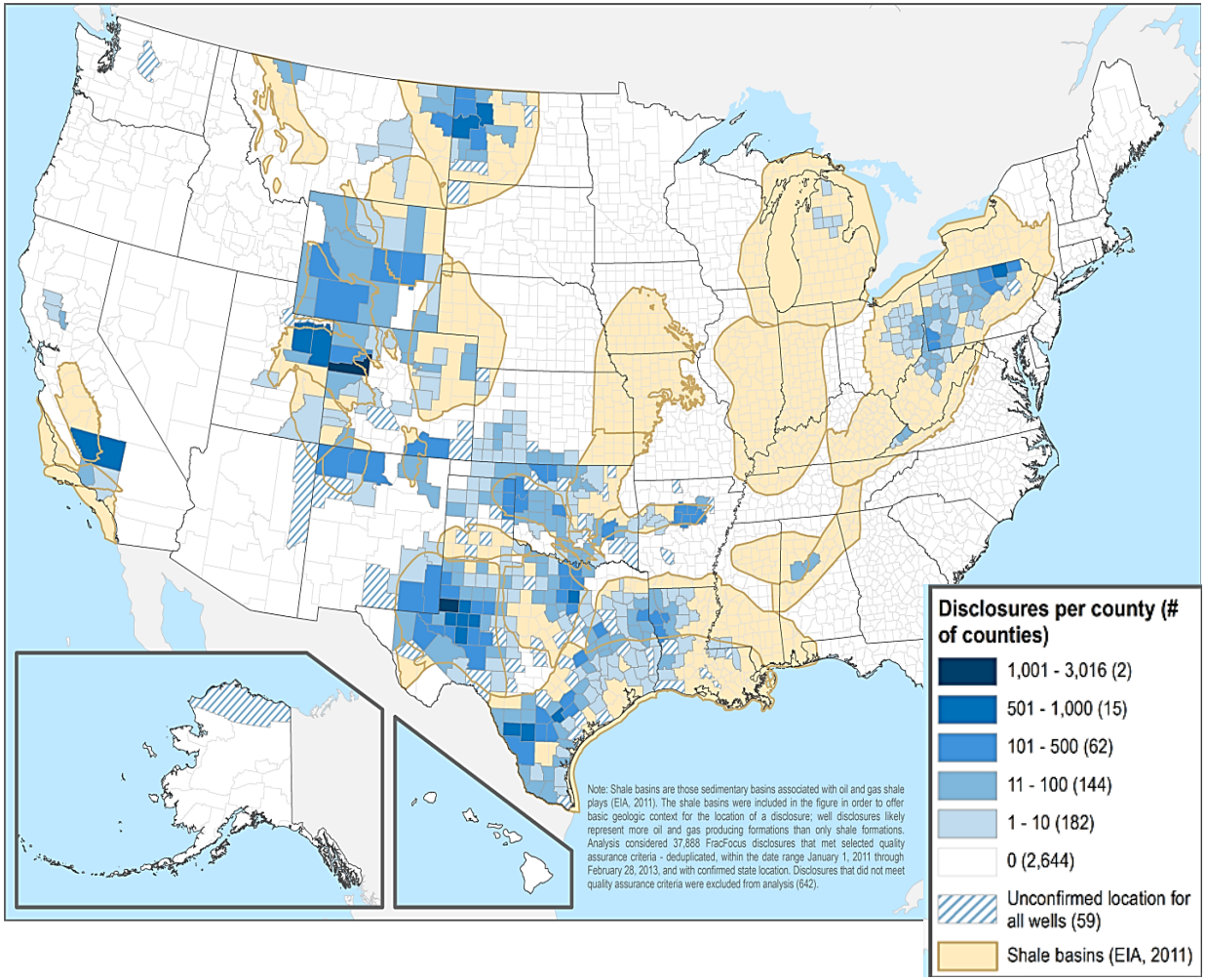
Additives can have single or multiple ingredients

CAS Numbers can be for single chemicals or mixtures

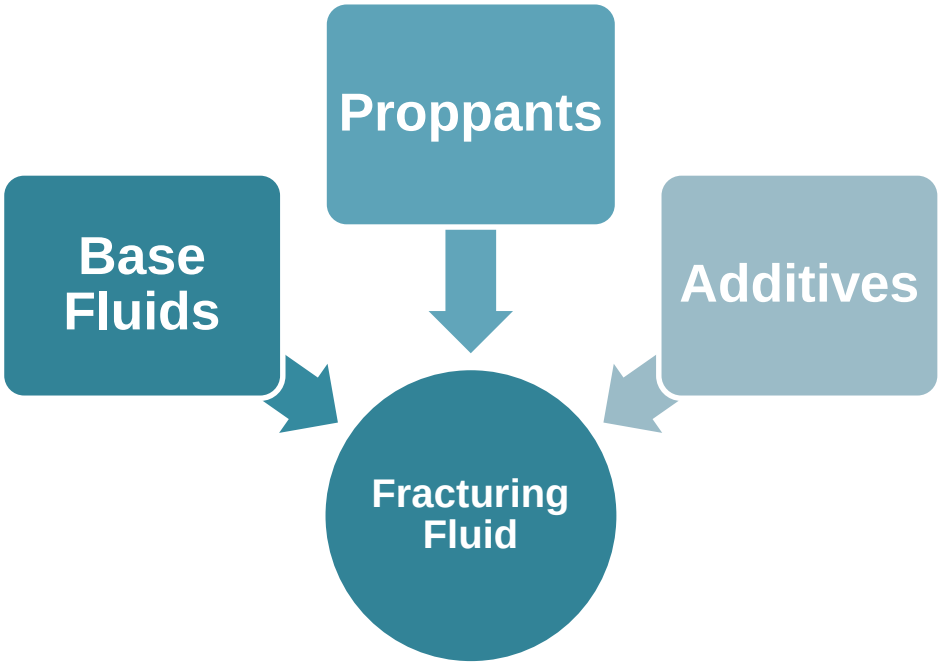
Disclosure Locations

- 48% of disclosures in Texas (18,075)
- 13% in Colorado (4,938)
- 50% of counties with <13 disclosures
- 26% of counties with 1-2 disclosures



Ingredients

- 692 unique ingredients = unique CASRN
- Ingredients associated with base fluids, proppants, or additive purposes (e.g., biocides, friction reducers)



Confidential Business Information (CBI) Ingredients

- CBI ingredients excluded from analysis
  - Where available, chemical family names listed in the appendix
- >70% of disclosures included at least one CBI ingredient record
- 11% of chemical ingredient records identified as CBI

Additive Ingredients

- Hydrochloric acid, methanol, and hydrotreated light petroleum distillates in >65% of all disclosures
- Median of 14 additive ingredients per disclosure with range of 4-28 ingredients (5^{th} – 95^{th} percentile)
- Medians of maximum fluid concentration for individual ingredients are <0.3% by mass
- Median of maximum fluid concentration for all ingredients is 0.43% by mass
- Small fluid concentrations may be 100s or 1000s of pounds brought to, stored, and mixed on the well pad

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Most Frequently Reported Additive Ingredients for Gas Wells

Not found in top 20 additive ingredients of oil disclosures

EPA-standardized chemical name	Number (and percent) of disclosures	Maximum ingredient concentration in hydraulic fracturing fluid (% by mass)		
		Median	5th percentile	95th percentile
Hydrochloric acid	12,351 (73%)	0.078	0.0063	0.67
Methanol	12,269 (72%)	0.0020	0.000040	0.053
Distillates, petroleum, hydrotreated light	11,897 (70%)	0.017	0.0021	0.27
Isopropanol	8,008 (47%)	0.0016	0.000010	0.051
Water	7,998 (47%)	0.18	0.000090	91
Ethanol	6,325 (37%)	0.0023	0.00012	0.090
Propargyl alcohol	5,811 (34%)	0.000070	0.000010	0.0016
Glutaraldehyde	5,635 (33%)	0.0084	0.00091	0.023
Ethylene glycol	5,493 (32%)	0.0061	0.000080	0.24
Citric acid	4,832 (28%)	0.0017	0.000050	0.011
Sodium hydroxide	4,656 (27%)	0.0036	0.000020	0.088
Peroxydisulfuric acid, diammonium salt	4,618 (27%)	0.0045	0.000050	0.045
Quartz	3,758 (22%)	0.0024	0.000030	11
2,2-Dibromo-3-nitrilopropionamide	3,668 (22%)	0.0018	0.000070	0.022
Sodium chloride	3,608 (21%)	0.0091	0.000000	0.12
Guar gum	3,586 (21%)	0.10	0.00057	0.38
Acetic acid	3,563 (21%)	0.0025	0.000000	0.028
2-Butoxyethanol	3,325 (20%)	0.0035	0.000010	0.041
Naphthalene	3,294 (19%)	0.0012	0.0000027	0.0050
Solvent naphtha, petroleum, heavy arom.	3,287 (19%)	0.0044	0.000030	0.030

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Most Frequently Reported Additive Ingredients for Oil Wells

Not found in top 20 additive ingredients for gas disclosures

EPA-standardized chemical name	Maximum ingredient concentration in hydraulic fracturing fluid (% by mass)			
	Number (and percent) of disclosures	Median	5th percentile	95th percentile
Methanol	12,484 (72%)	0.022	0.00064	0.16
Distillates, petroleum, hydrotreated light	10,566 (61%)	0.087	0.00073	0.39
Peroxydisulfuric acid, diammonium salt	10,350 (60%)	0.0076	0.00028	0.067
Ethylene glycol	10,307 (59%)	0.023	0.00086	0.098
Hydrochloric acid	10,029 (58%)	0.29	0.013	1.8
Guar gum	9,110 (52%)	0.17	0.027	0.43
Sodium hydroxide	8,609 (50%)	0.010	0.000050	0.075
Quartz	8,577 (49%)	0.0041	0.000040	12
Water	8,538 (49%)	1.0	0.0050	9.1
Isopropanol	8,031 (46%)	0.0063	0.000070	0.22
Potassium hydroxide	7,206 (41%)	0.013	0.000010	0.052
Glutaraldehyde	5,927 (34%)	0.0065	0.00027	0.020
Propargyl alcohol	5,599 (32%)	0.00022	0.000030	0.0030
Acetic acid	4,623 (27%)	0.0047	0.000000	0.047
2-Butoxyethanol	4,022 (23%)	0.0053	0.000000	0.17
Solvent naphtha, petroleum, heavy arom.	3,821 (22%)	0.0060	0.000000	0.038
Sodium chloride	3,692 (21%)	0.0071	0.000000	0.27
Ethanol*	3,536 (20%)	0.026	0.000020	0.16
Citric acid	3,310 (19%)	0.0047	0.00016	0.024
Phenolic resin	3,109 (18%)	0.13	0.019	2.0

Base Fluids

- Largest proportion of a fracturing fluid by mass
- Largest volume of fluid on the well site
- More than 93% of disclosures indicated water as base fluid
  - Median of max fluid concentration by mass is 88% with range of 72-98% (5^{th}-95^{th} percentiles)

Non-Aqueous Fluids in Base Fluid

EPA-standardized chemical name	Number (and percent) of disclosures	Maximum ingredient concentration in hydraulic fracturing fluid (% by mass)		
		Median	5th percentile	95th percentile
Nitrogen, liquid	643 (84%)	16	3.8	30
Carbon dioxide	83 (11%)	32	11	46
Petroleum distillates	18 (2.4%)	46	29	67
Propane	15 (2.0%)	63	1.6	79
Isobutane	12 (1.6%)	29	8.0	52
Butane	10 (1.3%)	2.2	1.5	59
Hexane	4 (0.53%)	14	11	15
Pentane	4 (0.53%)	9.8	5.8	14
Butene	3 (0.39%)	25	8.1	49
1-Propene	2 (0.26%)	3.0	1.2	4.8
2-Methylbutane	2 (0.26%)	16	14	18

- 2% of disclosures (761)
  - Water with gas or hydrocarbon
  - Hydrocarbon mix (no water)
- >96% indicate a combination of non-aqueous fluid with water

Cumulative Water Volume, by State

- Ranged from 2 million – 44 billion gallons
- Larger cumulative volumes typically in states with larger number of disclosures
- WV, OH, MS have relatively lower numbers of disclosures and large cumulative water volume

State	Number of disclosures with valid volumes	Cumulative water volume (gallons)
Texas	17,934	44,600,000,000
Pennsylvania	2,467	10,600,000,000
Arkansas	1,444	7,500,000,000
Oklahoma	1,898	6,670,000,000
Colorado	4,924	6,650,000,000
Louisiana	1,031	5,410,000,000
North Dakota	2,235	4,790,000,000
West Virginia	277	1,390,000,000
Wyoming	1,449	1,110,000,000
New Mexico	1,159	788,000,000
Ohio	146	614,000,000
Utah	1,421	534,000,000
Montana	213	338,000,000
Kansas	134	145,000,000
California	718	94,400,000
Michigan	15	55,100,000
Mississippi	4	35,100,000
Alaska	37	13,200,000
Virginia	77	3,020,000
Alabama	55	2,070,000
State Uncertain*	158	488,000,000
Entire Dataset	37,796	91,800,000,000

Per-Disclosure Water Volume, by State

- Ranged from ~30,000 – 7.2 million gallons
- Median of 2.9 million gallons for gas wells
- Median of 1.2 million gallons for oil wells

State	Number of disclosures with valid volumes	Water volume per disclosure (gallons)		
		Median	5th percentile	95th percentile
Mississippi	4	9,170,000	4,320,000	12,700,000
Arkansas	1,444	5,280,000	2,680,000	7,480,000
Louisiana	1,031	5,150,000	278,000	8,940,000
West Virginia	277	5,010,000	2,500,000	7,890,000
Pennsylvania	2,467	4,180,000	1,090,000	7,480,000
Ohio	146	3,890,000	2,530,000	7,440,000
State Uncertain*	158	2,770,000	80,100	6,950,000
Oklahoma	1,898	2,580,000	115,000	8,290,000
North Dakota	2,235	2,020,000	558,000	3,690,000
Montana	213	1,470,000	217,000	3,200,000
Kansas	134	1,420,000	9,870	2,450,000
Texas	17,934	1,410,000	26,000	7,410,000
Colorado	4,924	464,000	104,000	4,330,000
Wyoming	1,449	306,000	5,500	3,110,000
Utah	1,421	303,000	35,100	1,060,000
New Mexico	1,159	172,000	22,100	2,850,000
Alaska	37	88,400	36,400	436,000
California	718	77,200	18,700	356,000
Alabama	55	37,700	23,600	51,700
Virginia	77	33,500	13,300	96,700
Michigan	15	33,300	15,700	15,100,000
Entire Dataset	37,796	1,510,000	29,500	7,200,000

Water Sources

- 29% (10,301) of disclosures included a description of the water source
- Interpretation difficult due to undefined terms and voluntary disclosure
- “Fresh” was most often identified as only source -- 68% (of the 29%, 7005) of disclosures

Analysis Summary

- 692 unique ingredients (CAS number)
- Hydrochloric acid, methanol, and hydrotreated light petroleum distillates in >65% of disclosures
- Median of maximum fluid concentration is <0.3% by mass for individual additive ingredients
- Small fluid concentrations may be 100s or 1000s of pounds brought to, stored, and mixed on the well pad
- Median of 1.5 million gallons of water per disclosure with range of 30,000 – 7.2 million gallons of water

Analysis Summary *(continued)*

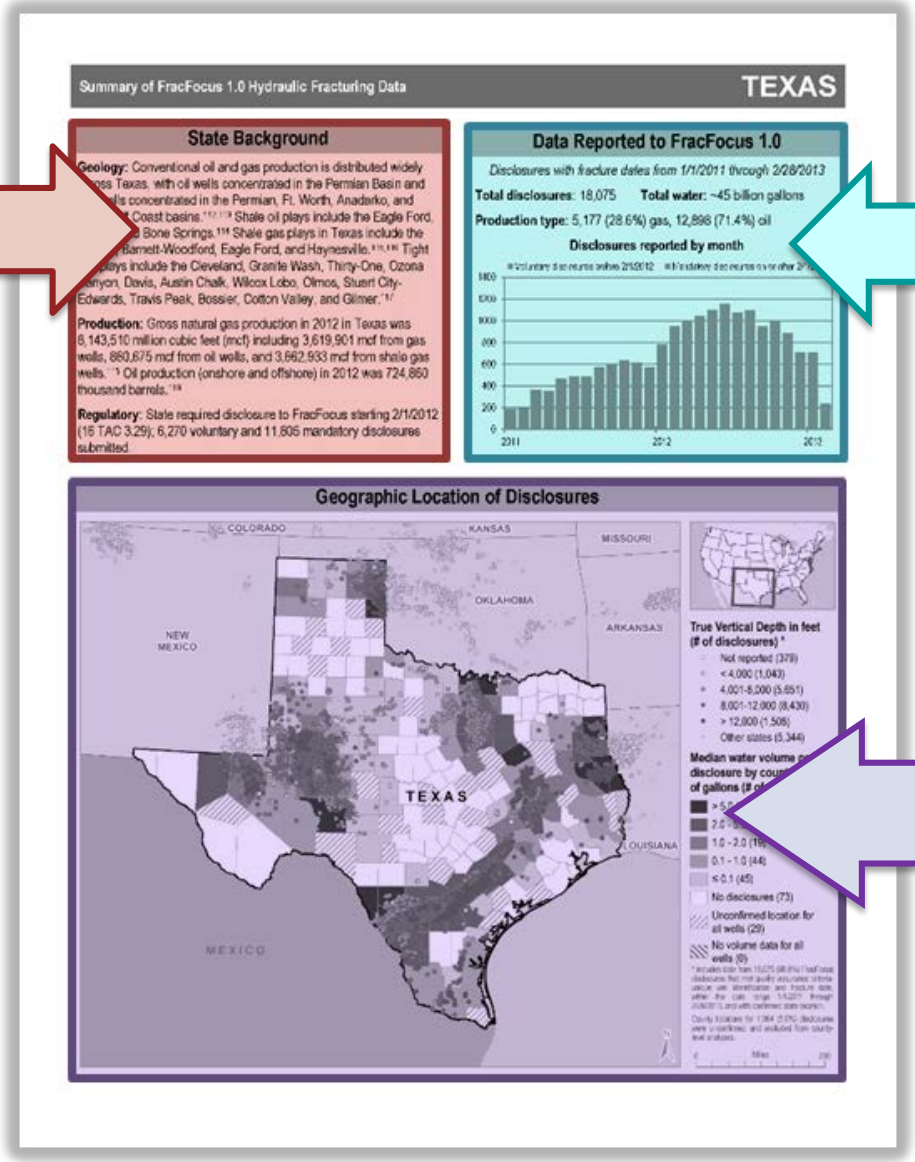
- Additive ingredients and water volumes vary considerably across the United States
- >70% of FracFocus 1.0 disclosures had at least 1 confidential business information (CBI) ingredient
- 11% of chemical ingredient records identified as CBI
- Additive ingredients, proppants, cumulative water volumes are underestimated in EPA analysis due to:
  - Not all states require reporting of chemicals
  - States with mandatory reporting of chemicals do not all require reporting to FracFocus
  - Ingredients reported as CBI

State Summaries

- User guide
  - Brief project background
  - Description of information included in summaries
  - Note that information in summaries was not verified by state or GWPC and may be different than information available to states
- One page summary for 20 states
- References

State Summaries *(continued)*

- Geology
- Production
- Regulations



Number of disclosures (3 ways)

- Well locations
- Median per-disclosure water volumes, by county
- True vertical depth

State Summaries *(continued)*

Frequently reported chemicals

Summary of FracFocus 1.0 Hydraulic Fracturing Data — **TEXAS**

Additive Ingredients in Fracturing Fluid Most Frequently Reported to FracFocus 1.0

EPA standardized chemical name	CAS Registry Number	Number of disclosures	Median of max concentration by mass in HF fluid	Median of max concentration by mass in additive
Methanol	67-56-1	12,664	0.013%	35%
Hydrochloric acid	7647-01-0	11,424	0.21%	15%
Distillates, petroleum, hydrotreated light	64742-47-8	10,677	0.070%	50%
Ethylene glycol	107-21-1	9,591	0.018%	30%
[illegible]ydisulfuric acid, diammonium salt	7727-54-0	8,666	0.0060%	100%
[illegible]	7732-18-5	8,280	0.93%	69%
[illegible]	67-63-0	7,731	0.0031%	15%
[illegible]ydroxide	1310-73-2	7,371	0.0065%	10%
[illegible]	14808-60-7	6,869	0.0037%	2.0%
[illegible]ar gum	9000-30-0	6,863	0.16%	50%
Glutaraldehyde	111-30-8	6,470	0.0063%	15%
Potassium hydroxide	1310-58-3	6,369	0.015%	20%
Propargyl alcohol	107-19-7	6,269	0.00024%	8.0%
Acetic acid	64-19-7	4,936	0.0037%	38%
2-Butoxyethanol	111-76-2	3,898	0.0012%	10%
Citric acid	77-92-9	3,820	0.0031%	56%
Sodium chloride	7647-14-5	3,462	0.0044%	25%
Ethanol	64-17-5	3,439	0.0012%	5.0%
Phenolic resin	9003-35-4	2,903	0.12%	5.0%
Solvent naphtha, petroleum, heavy arom.	64742-94-5	2,751	0.0034%	5.0%
Methenamine	100-97-0	2,490	0.0073%	1.0%
Ethoxylated propoxylated C12-14 alcohols	68439-51-0	2,368	0.0059%	2.0%
Formic acid	64-18-6	2,327	0.0055%	60%
Nonyl phenol ethoxylate	9016-45-9	2,261	0.0087%	20%
Boric acid	10043-35-3	2,182	0.016%	25%
Naphthalene	91-20-3	2,132	0.00084%	5.0%
Quaternary ammonium compounds, benzyl-C12-16-alkyldimethyl, chlorides	68424-85-1	1,870	0.0014%	7.0%

Ingredients from 1,934 (10.7%) disclosures were excluded from this summary due to invalid CAS Registry Numbers.
Water and quartz were reported as ingredients in some fracturing fluid additives as well as base fluids and proppants.

Reported Water Volume by County

County	Number of disclosures with valid volumes	Number of oil disclosures	Number of gas disclosures	Cumulative water volume (gallons)	Water volume per disclosure (gallons)		
					Median	5th percentile	95th percentile
Andrews	1,171	1,146	25	519,000,000	91,697	29,631	1,429,964
Glasscock	935	935	0	1,242,000,000	951,372	569,677	2,662
Martin	823	785	38	937,500,000	1,099,924	494,534	1,[illegible]
Ector	822	808	14	497,400,000	209,209	40,444	1,[illegible]
Upton	777	775	2	974,800,000	1,216,885	30,060	1,924,[illegible]
Tarrant	747	0	747	2,968,000,000	3,678,696	1,324,407	7,575,66[illegible]
Dimmit	715	326	389	3,939,000,000	5,322,954	3,076,202	8,769,221
Karnes	595	475	120	2,255,000,000	3,514,377	2,148,427	6,484,902
La Salle	568	452	116	2,683,000,000	4,488,267	2,684,300	7,498,348
Midland	530	530	0	654,000,000	1,254,809	455,722	1,892,368

Ingredient names in this summary were standardized and may be different than those reported by operators in the original FracFocus disclosures.
The data in the summary sheet were derived from FracFocus disclosures in PDF format, not machine-readable files.

Water volumes by county

Project Database

- Database contains
  - All original data as it was extracted from PDF disclosures
  - Standardized data
  - Whether data met quality assurance criteria
- *Guide to Reproducing Tables and Figures* with statistical codes
- *Data Management and Quality Assessment* report

What Did We Learn?

- We have advanced our understanding of
  - Where hydraulically fractured wells are located and where potential impacts may occur
  - The chemicals used in fracturing fluids nationally
  - The amount of water used for fracturing wells
- FracFocus data, combined with literature, other EPA research, and input collected through outreach, provides a new lens to help states and communities understand the potential impacts to drinking water resources

United States Environmental Protection Agency

Questions?

For any questions after this webinar, please contact Dayna Gibbons at

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