

***US EPA Technical Workshop on Analytical Chemical Methods
For Hydraulic Fracturing***

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Beneficial Reuse of Produced and Flowback Water



Introduction

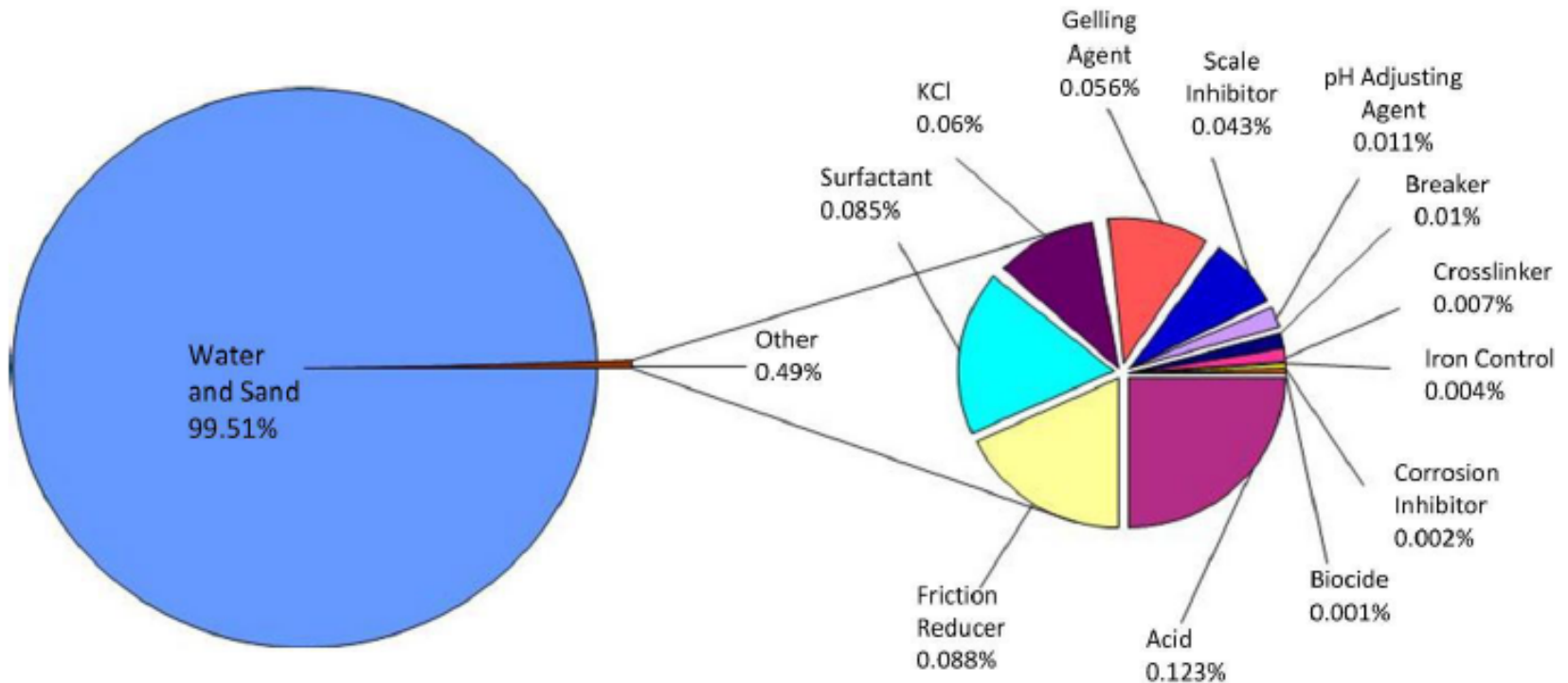
- 💧 Water reuse and recycling is a significant issue in the development of oil and gas shale plays in the United States
- 💧 Drilling operations – 60,000 to 650,000 gallons per well
- 💧 Hydraulic fracturing operations – 3 million to 5 million gallons per well
- 💧 Definition of produced water and flowback water
- 💧 Interactions of water quality constituents as they relate to water reuse and recycling
- 💧 Testing criteria in the laboratory and field operations

Water Quality Criteria for Reuse

- 💧 Constituents of concern for water reuse:
 - 💧 Total Dissolved Solids
 - 💧 Oil and Grease
 - 💧 Suspended solids
 - 💧 Dispersed oil
 - 💧 Dissolved and volatile organic compounds
 - 💧 Heavy metals
 - 💧 Radionuclides
 - 💧 Dissolved Gases and Bacteria
 - 💧 Chemical additives such as biocides, scale and corrosion inhibitors, guar gum and emulsion/ reverse-emulsion breakers

Wastewater Characteristics and treatment concerns

- Fracturing solution consists of sand and water
- Additives include biocides, corrosion inhibitors, O₂ scavengers, friction reducers, surfactants, etc.



Reference: All Consulting 2009

Note – fracking fluid is less than 0.5% of the overall fluid but has some issues with treatment

Flowback Chemistry

- 💧 Note the following
 - 💧 Barium levels
 - 💧 Iron levels
 - 💧 TOC
 - 💧 TSS
- 💧 These will be issues in treatment resulting in issues for reuse or recycling

Parameter	Feed Water	Flowback
pH	8.5	4.5 to 6.5
Calcium	22	22,200
Magnesium	6	1,940
Sodium	57	32,300
Iron	4	539
Barium	0.22	228
Strontium	0.45	4,030
Manganese	1	4
Sulfate	5	32
Chloride	20	121,000
Methanol	Neglible	2,280
TOC	Neglible	5,690
TSS	Neglible	1,211

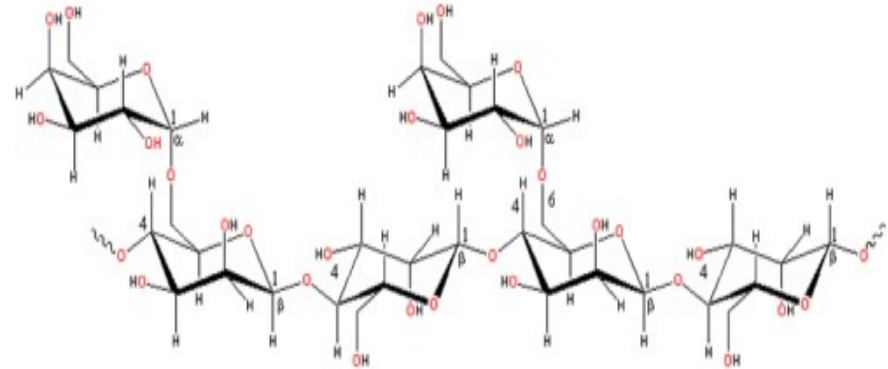
Flowback Chemistry Variability

Parameter	Frac 1	Frac 2	Frac 3	Frac 4
Barium	7.75	2,300	3,310	4,300
Calcium	683	5,140	14,100	31,300
Iron	211	11.2	52.5	134.1
Magnesium	31.2	438	938	1,630
Manganese	16.2	1.9	5.17	7.0
Strontium	4.96	1,390	6,830	2,000
TDS	6,220	69,640	175,268	248,428
TSS	490	48	416	330
COD	1,814	567	600	2,272

Ref: ProChemTech International, Inc.

Guar Gum Issue

- 💧 Note the following
 - 💧 Long chain polymer
 - 💧 Reactive sites will need to be neutralized for effective filtration
 - 💧 Enzyme treatment
 - 💧 Cation reactions
 - 💧 Oxidation demand
 - 💧 Low ORP readings in the field



Scale Formation & Chemical Interference Issues for Water Reuse

- ❄️ Constituents of concern:
 - ❄️ Barium sulfate formation
 - ❄️ Hardness (Calcium and Magnesium) interactions
 - ❄️ Silicate formations
 - ❄️ Boron issues
 - ❄️ Salt removal
 - ❄️ Radionuclides

Table 3 – An Example of Water Quality Goals for Hydraulic Fracturing Fluids

Bacteria	100,000 per 100 ml
Barium (mg/l)	< 2
Bicarbonates (mg/l)	250 to 100,000
Calcium (mg/l)	300
Chlorides (mg/l)	2,000 to 40,000
Iron (mg/l)	10
Hydrogen Sulfide (mg/l)	ND
Magnesium (mg/l)	100
pH	6.5 to 8.0
Phosphates (mg/l)	10
Radionuclides (pCi/l)	<15
Reducing agents (mg/l)	ND
Silica (mg/l)	<20
Strontium (mg/l)	<10
Sulfate (mg/l)	400 to 1,000
Total Dissolved Solids (mg/l)	500 to 5,000

Regulatory Issues

- 💧 Safe Drinking Water Act – Class II Injection wells
- 💧 Clean Water Act
 - 💧 NPDES Permits
 - 💧 Water Rights
 - 💧 Special cases
 - 💧 Colorado River
 - 💧 Colorado Statewide Permits
- 💧 Colorado Rule 609

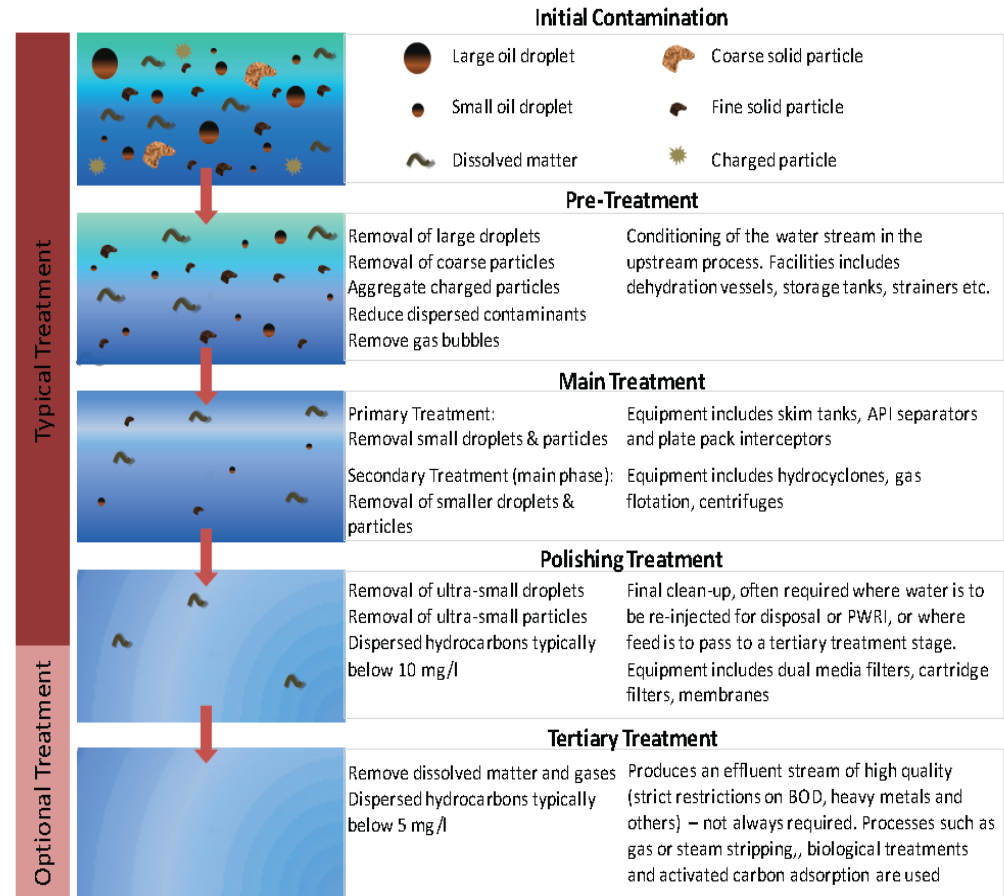
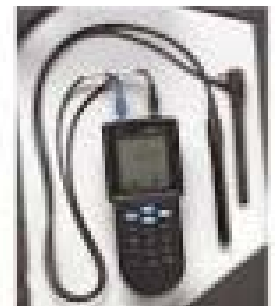


Fig. 2 - Typical water treatment process in the oil and gas industry (modified from Shell 2009).

Testing Requirements

- 💧 Testing requirements based on level of treatment
- 💧 Class II Injection well vs. surface water discharge
- 💧 Field testing for evaluation of operations



Conclusions

- 💧 Recycling and Reuse of produced water and flowback water will become a significant issue for the development of oil and gas shale plays in the United States
- 💧 Development of criteria for reuse and recycling needs to be developed
- 💧 Treatment technologies that fit the final reuse and recycling criteria will need to be developed
- 💧 Analytical techniques will need to be developed both in the field and in the laboratory to assist in the development of reuse and recycling