Produced Water Treatment for Beneficial Reuse

2018 Mastering the Subsurface Through Technology Innovation Partnerships and Collaboration: Carbon Storage and Oil and Natural Gas Technologies Review Meeting

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U.S. DEPARTMENT OF ENERGY

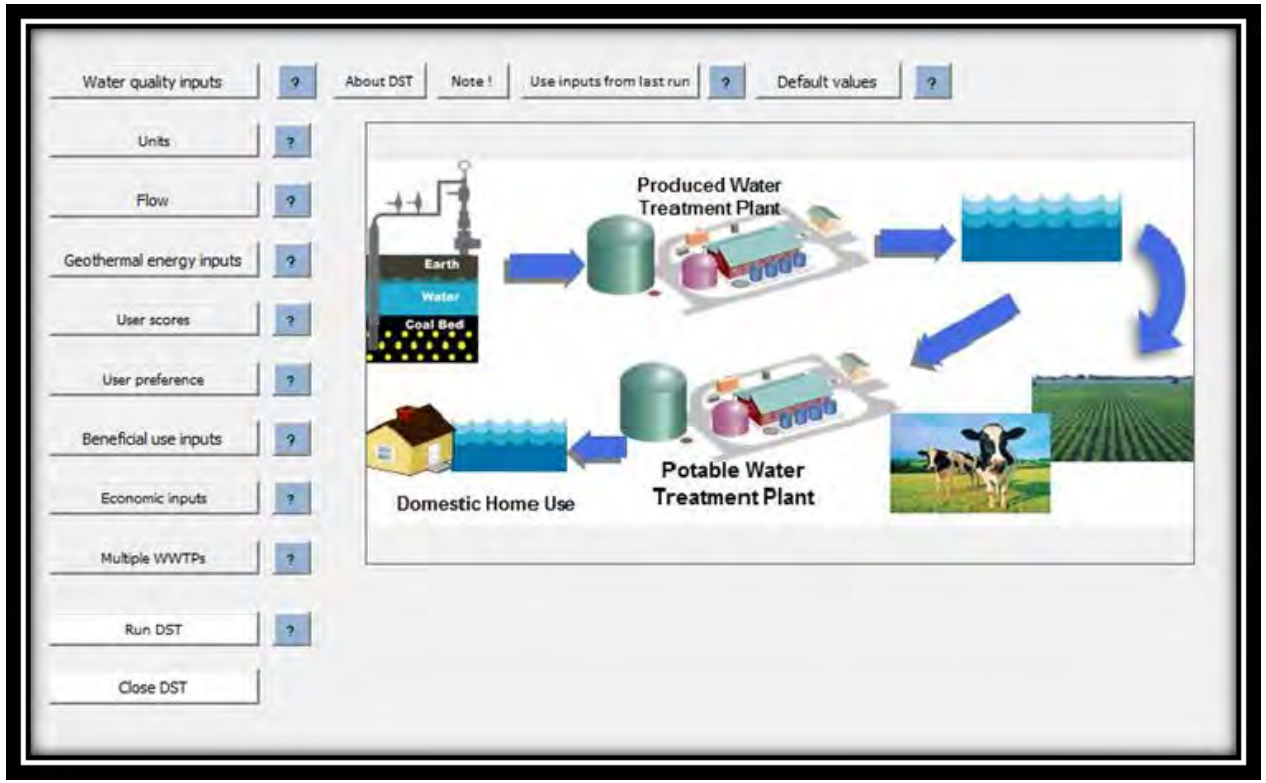
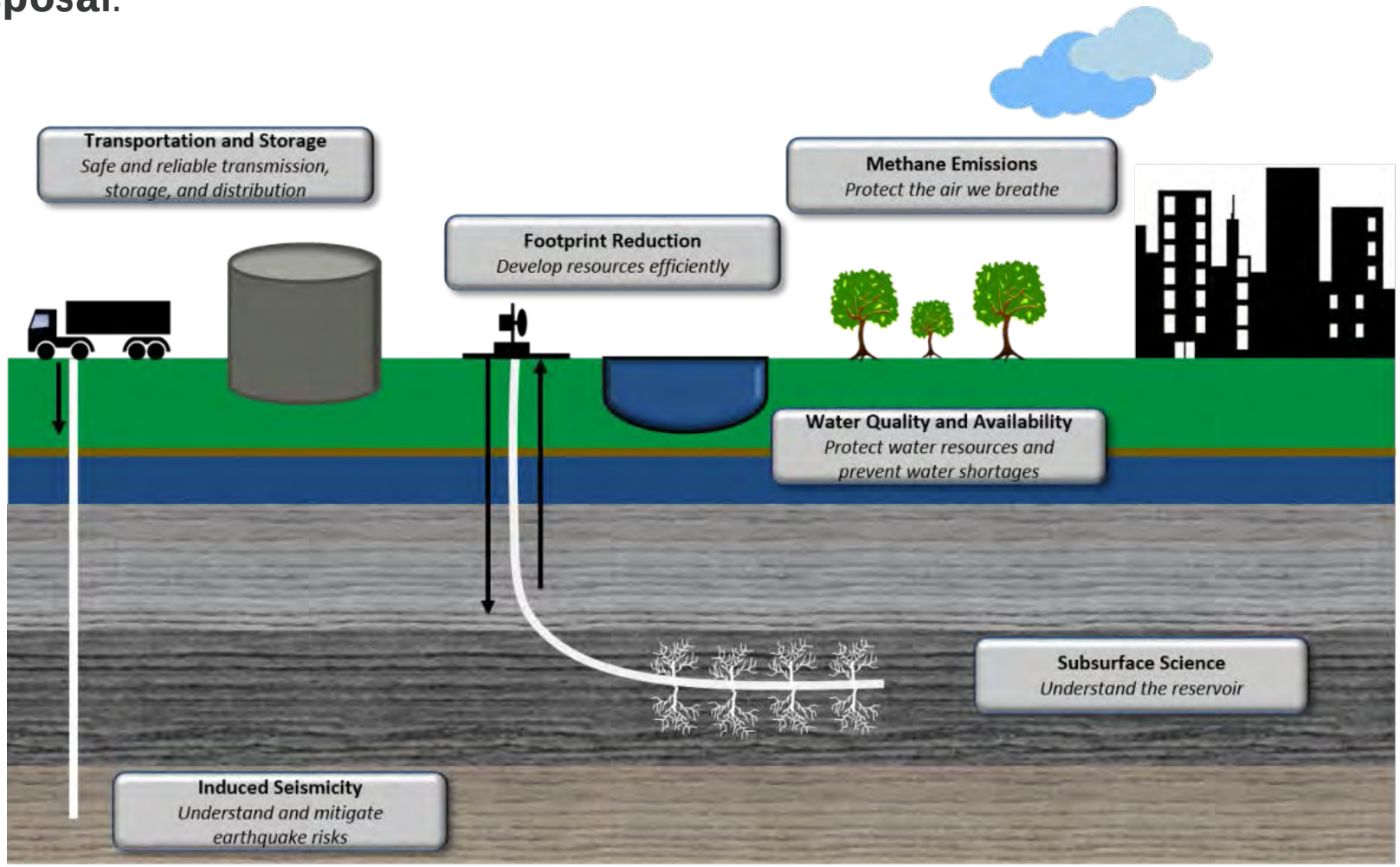


Image from: Integrated Decision Tool for Produced Water Treatment and Reuse Project (SDSU, CSM, NMSU)

Produced Water Treatment

Goal: Develop water management strategies and technologies for oil and gas produced waters that **result in new revenue streams** and **reduce the need for deep well injection for disposal**.

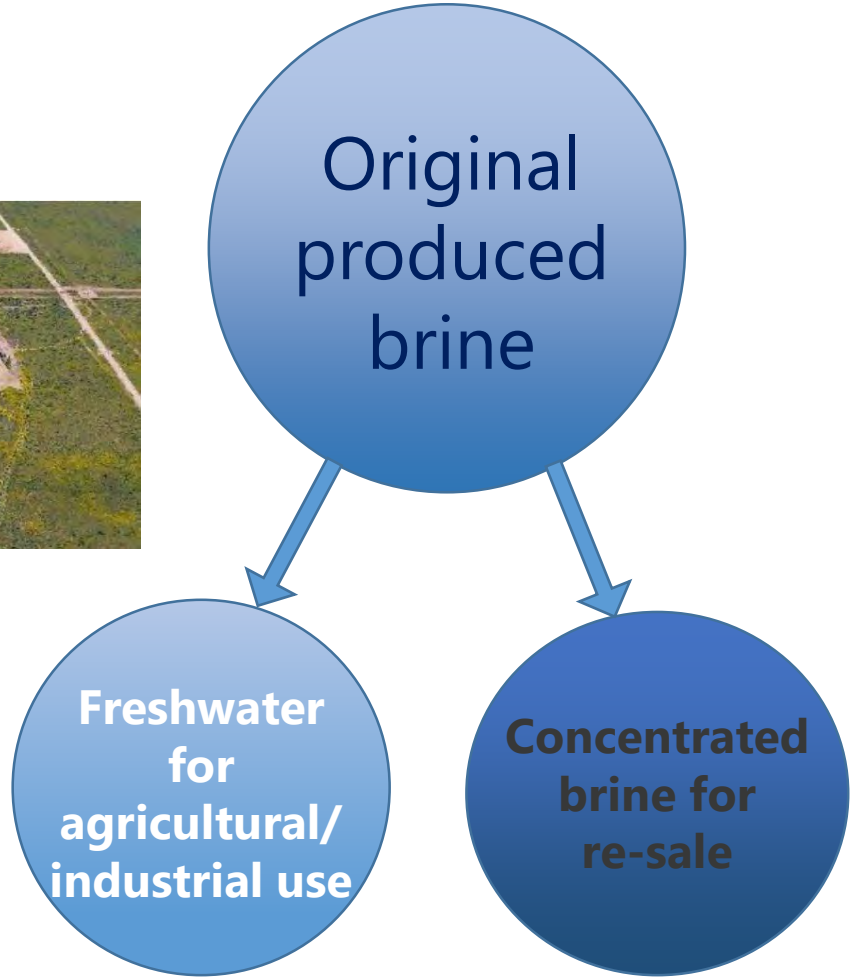


Potential Markets

- **Potential to increase value and create a salable product from the previous waste stream**
  - Fresh water
  - Oilfield use: fracking
  - 10-lb brine for Chemical industry

  ~17 Million metric tonne per year

- **Mediate water stress in arid regions**
- **Reduce fresh water costs through increased recycling**
- **Reduce dependence on salt domes for brine production**
- **Reduce the volume of re-injected brine**
- **Potentially decrease induced seismicity**
  - Comply with rules mandating reduction in volumes



Subtask#1: Produced Water Reuse Gap Analysis

To provide context for current R&D needs

Goal: Complete near-term analysis to identify important research gaps based on topics addressed by prior Oil & Gas R&D

Plan of Action:

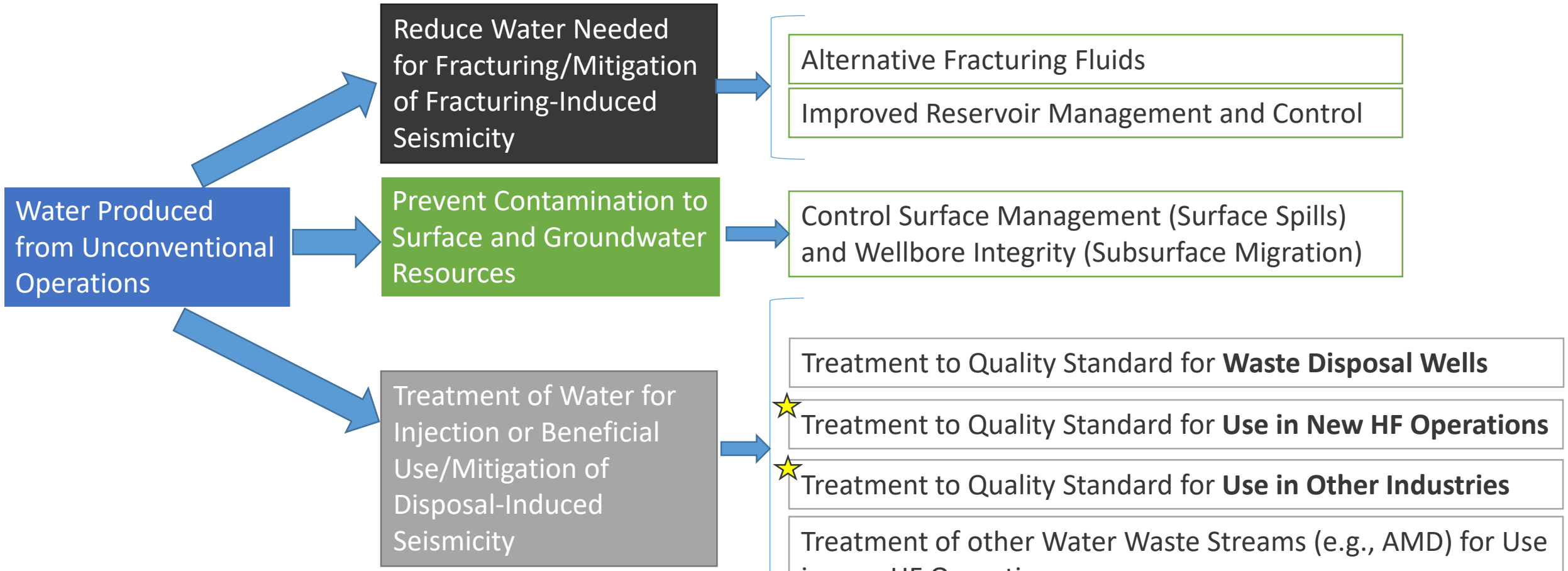
(1) Determine current status of technology developed in each project
(2) Make a preliminary assessment of why the project is/isn't commercially successful
(3) Determine the most promising areas of R&D that would be required to improve the economic viability of produced water management technologies

Associated Steps:

(1) Analyze prior water treatment research funded by Coal R&D
(2) Analyze 2017 DOE/FE/Oil&Gas Request for Information (RFI)

Prior Research on Water Associated with Unconventional Formations

Projects Supported through FE-Oil and Gas



★ *Results from projects focused on these topics may have the most direct applicability for near-term wins in developing approaches/technologies with net revenue streams*

Breakdown of Prior Projects and Thematic Areas

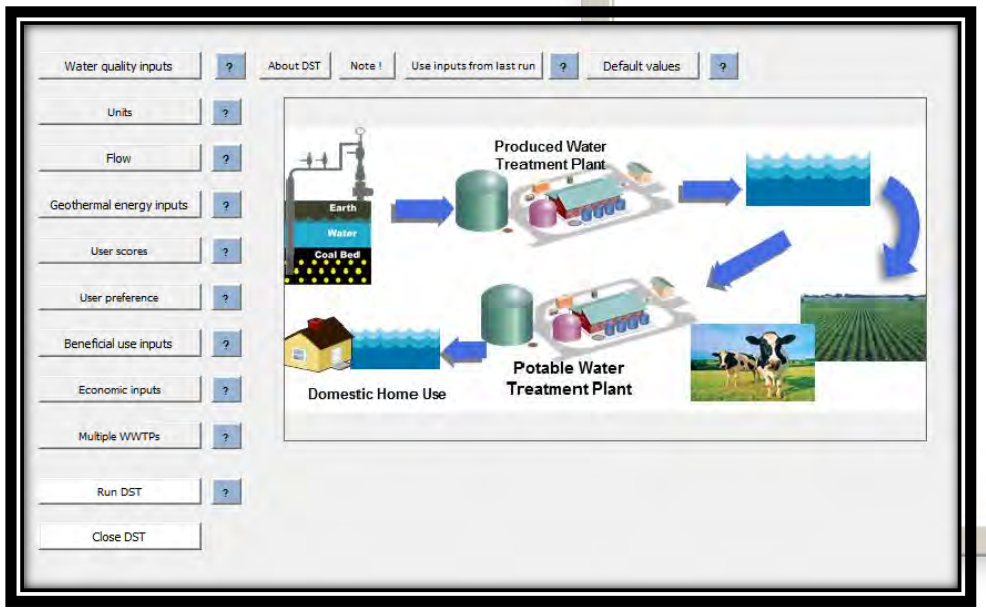
Thematic Area	Number of Prior Projects	Regions/Basins
1. Reduce Water Needed for Fracturing/Mitigation of Fracturing-Induced Seismicity	**16**	
1A. Alternative Fracturing Fluids	5	Primarily lab-based studies; will need to review results in detail for basin-specific information
1B.Improved Reservoir Management and Control	11	Haynesville, Marcellus, Utica, Barnett, Multiple Basins
2. Prevent Contamination to Surface and Groundwater Resources	**10**	Marcellus, Multiple Basins
3. Treatment of Water for Injection or Beneficial Use/Mitigation of Disposal-Induced Seismicity	**31** (17*)	**Barnett, Appalachian, Marcellus, Uintah, Multiple Basins; States: NY, PA, WV, CO, MT, NM, UT, WY**
3A. Treatment to Quality Standard for Waste Disposal Wells	1	Northern Appalachian Basin
3B. Treatment to Quality Standard for Use in New HF Operations	**3**	**Upstate NY, Fayetteville**
3C. Treatment to Quality Standard for Use in Other Industries	**5**	**Marcellus, Multiple Basins; NM**
3D. Treatment of other Water Waste Streams (e.g., AMD) for Use in New HF Operations	**5**	**Appalachian, Multiple Basins**

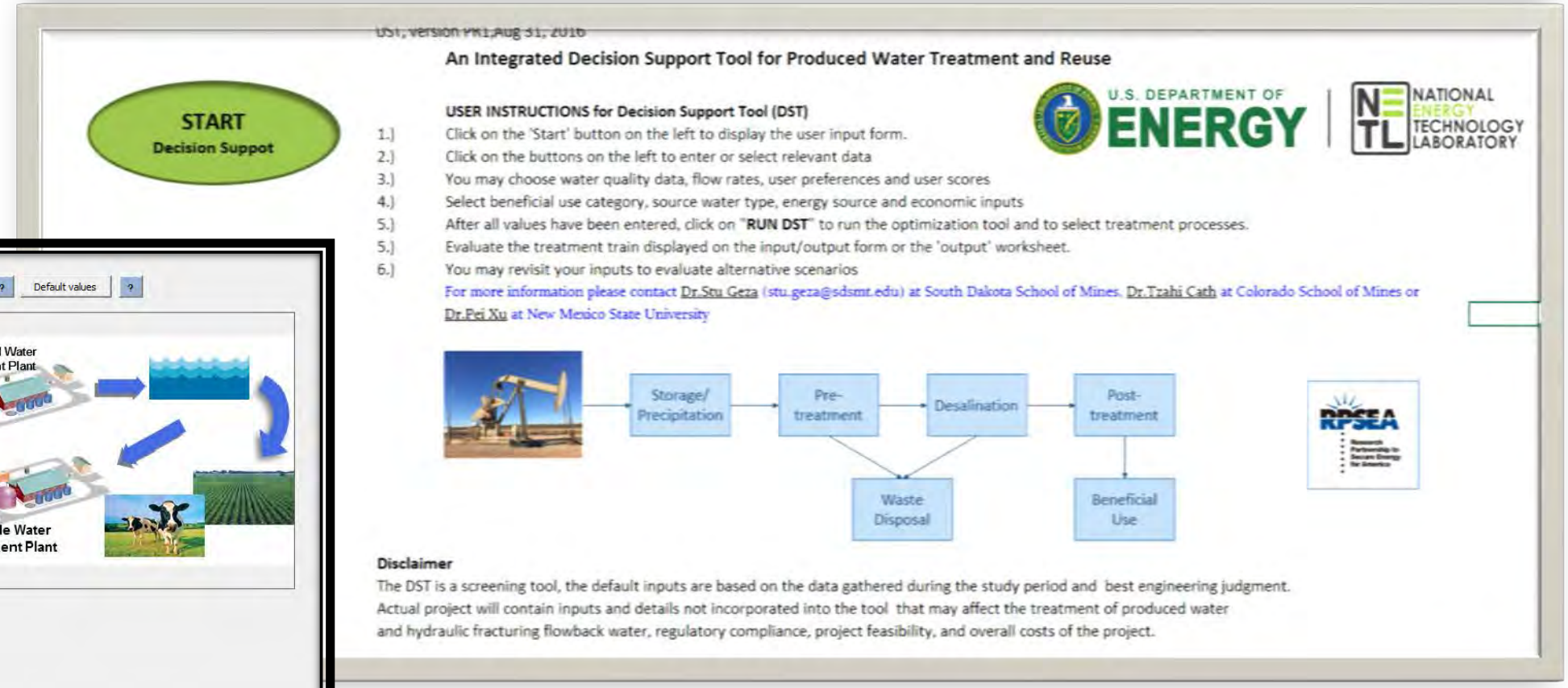
Other: Coalbed Methane (2 projects), Constructed Wetland (1 project), Transportation in Arctic (3 projects)

*Projects that addressed 2 or more sub-themes

Example of Prior FE Oil&Gas Research:

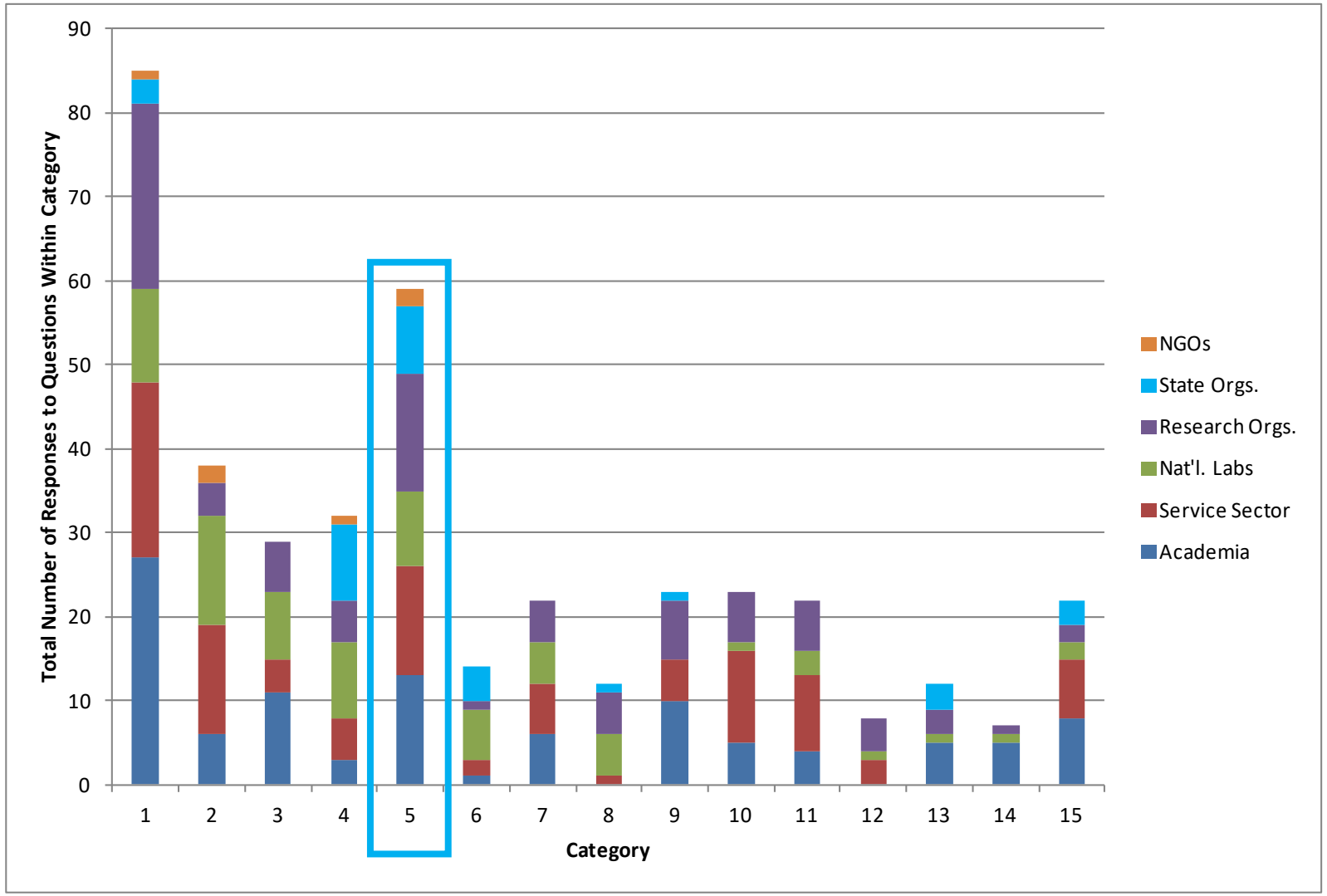
Integrated Decision Tool for Produced Water Treatment and Reuse (SDSU, CSM, NMSU)





- **Value tool for both brine composition and treatment costs**
  - But limited data for Eagle Ford and Frio as well as limited ability to chose outlet salinity

High External Interest in Beneficial Reuse



The largest number of responses to the 2017 RFI were in the following two categories:

- Category#1: Mitigate Environmental Impacts of Unconventional Oil & Gas Development via Dedicated Unconventional Oil and Gas Field Labs
- **Category#5: Beneficial Reuse of Water Produced from Unconventional Oil and Natural Gas Wells**

Water Management for the Top Ten Producing States

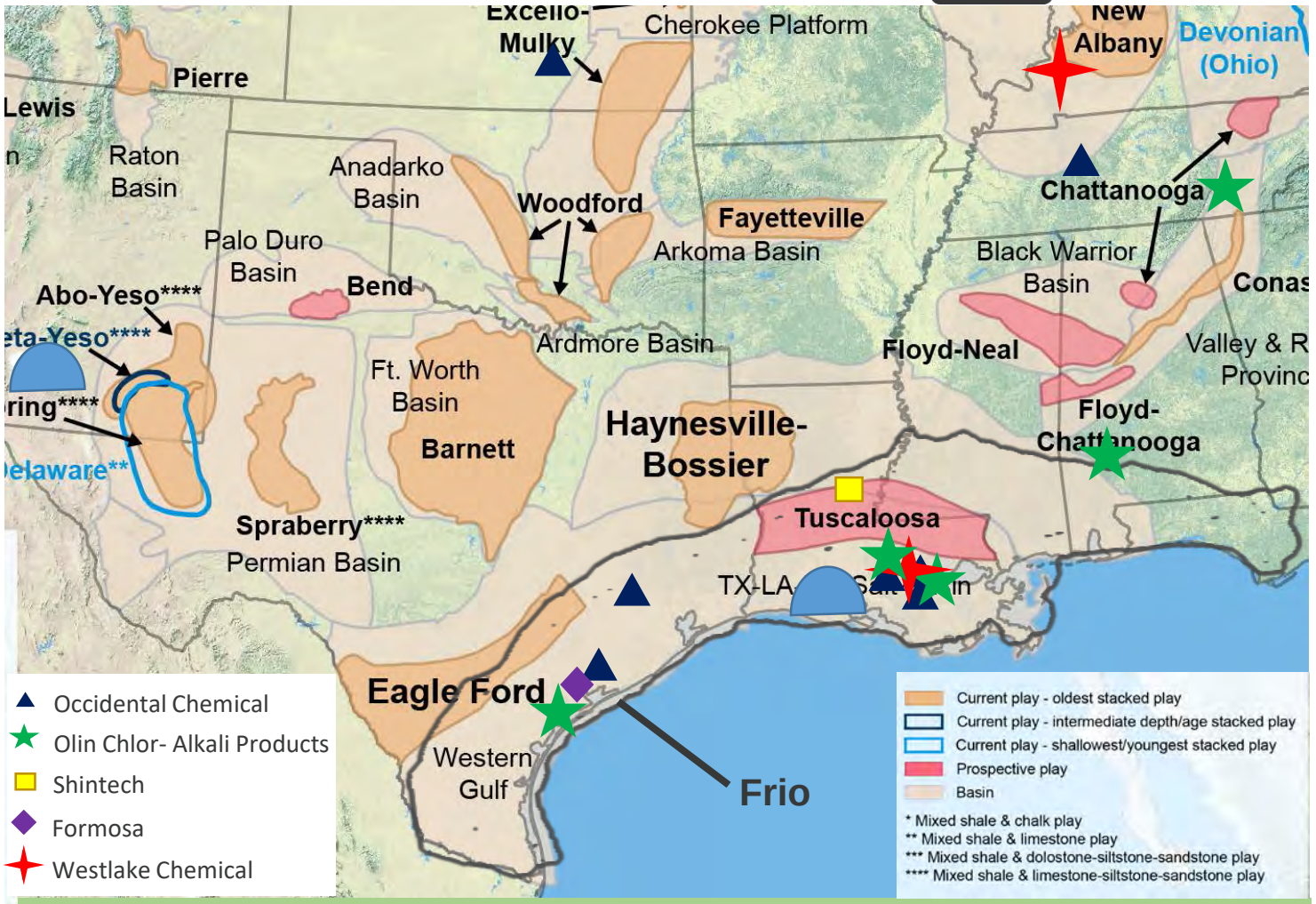
	Injection for EOR		Injection for Disposal		Surface Discharge		Evaporation		Offsite Commercial Disposal		Beneficial Reuse		Total Produced Water Managed	
	MMbbl/ year	*% total*	*MMbbl/ year*	*% total*	*MMbbl/ year*	*% total*	*MMbbl/ year*	*% total*	*MMbbl/ year*	*% total*	*MMbbl/ year*	*% total*	*MMbbl/ year*	*% total generated*
Texas	3,718	48%	2,923	37%	371	5%	-	-	795	10%	NR	NR	7,807	105%
California	1,412	46%	623	20%	60	2%	649	21%	284	9%	46	2%	3,075	100%
Oklahoma	1,098	47%	1,087	47%	-	-	-	-	140	6%	-	-	2,325	100%
Wyoming	856	73%	313	27%	NR	NR	NR	NR	NR	NR	NR	NR	1,169	54%
Kansas	276	26%	785	74%	-	-	-	-	-	-	NR	NR	1,061	100%
Louisiana	31	3%	857	92%	-	-	-	-	39	4%	-	-	928	100%
Alaska	652	85%	85	11%	33	4%	-	-	-	-	-	-	769	100%
New Mexico	381	50%	381	50%	-	-	-	-	-	-	-	-	762	98%
Colorado	124	32%	124	32%	40	10%	35	9%	22	6%	48	12%	393	110%
North Dakota	52	18%	162	56%	-	-	-	-	77	26%	-	-	291	100%

NR = Not reported in full

Veil, Groundwater Protection Council, 2015.

Example: Win-Win Beneficial Water Reuse

- Unconventional resources:
  - Eagle Ford
  - Haynesville-Bossier
  - Tuscaloosa
- Frio – aging oil wells generate high ratios of water to oil
- Close proximity to chemical industries that need brine
- Areas with clean water needs



Locations of Basins & Chemical Plants

Conclusions

- Gap Analysis will be completed this Fall to determine key areas where R&D focus could create the best value for converting produced water into net revenue positive products

Water Technology Dec. 17, 2015. Link to image