Oil & Natural Gas Technology

DOE Award No.: DE-FE0001466

Quarterly Report 4 (7/1/10 – 9/30/10)

Zero Discharge Water Management for Horizontal Shale Gas Well Development

Submitted by:

West Virginia Water Research Institute
West Virginia University
PO Box 6064
Morgantown, WV 26506

Authors:

Jennifer Hause
Paul Ziemkiewicz, PhD
Doug Patchen, PhD
David Locke
Harry Johnson
Ray Lovett, PhD

Prepared for:

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Disclaimer:

Executive Summary:

Shale gas production depends on the creation of permeability within an otherwise nearly impermeable rock formation. Two technologies have been applied to the shale formations to bring about revolutionary changes in the economic production of natural gas – directional/horizontal drilling and massive hydraulic fracturing, the most common of this latter technique being what is known as “slickwater” fracturing. To produce shale gas, slickwater fracturing uses large volumes of water to create multiple, long fractures in the shale formation. Sand is pumped with the water and left to prop open the fractures, thus providing multiple, permeable flow paths for the natural gas.

The use of the large volumes of water often stresses local fresh water supplies, and the water flowing back from the well after fracturing is a briny mixture, creating a water disposal problem. Previous attempts to mitigate these issues have had only limited success. The West Virginia University (WVU) project team has undertaken to recover and convert the briny waste into a suitable, partial replacement of the fresh water that is currently used as the fracturing fluid of choice. This will include a substantial removal of suspended solids from the frac return water (FRW) as well as the complete or partial removal of certain dissolved solids that could create problems with subsequent hydraulic fracturing treatments and/or natural gas production operations.

Project objectives for Phase I included:

- Determination of water quality requirements for hydraulic fracturing the Marcellus Shale by compiling information on hydraulic fracturing practices, shale gas production practices, and associated problems for the Appalachian Basin shale formations, and

- Development and adaptation of advanced water treatment and filtration technologies that would convert the frac return water into a usable substitute of fresh water for hydraulic fracturing.

The major focus during the 4th quarter of Phase I involved the continued testing of the technologies needed to produce a water quality suitable for the next fracture activity. A 1 gallon per minute (gpm) electro-coagulation (EC) process development unit was installed in the laboratory to pretreat frac return water (FRW) prior to filtration. Raw water samples from various Marcellus wells were subjected to the EC process followed by the FilterSure filtration system. In addition to the significant reductions in concentrations of the divalent ions (e.g., calcium reduced by approximately one-third), total suspended solids (TSS) were reduced by up to 76%, with retention of 100% of particles larger than 3 microns. Excellent cooperation of the Industry Contact Group providing frac water samples allowed the completion of all water treatment tests ahead of schedule, enabling the project to proceed forward to the proto-type design and fabrication phase for field deployment in Spring 2011.

Progress Report 4 - Phase I Review Discussion and Results:

This report summarizes task activities and progress of the Phase I effort from **7/1/10 to 9/30/10,** completing Phase I of the project. The report is organized by task as listed in the Statement of Project Objectives. Phase I objectives have been completed. Discussion, along with highlights of significant activities over the course of Phase I follow. Phase I Budget Review is included as Appendix A.

Task 1.0 Project Management and Planning

Project management and planning is a continuous, ongoing task throughout the project period that includes keeping activities on task and within budget, and coordinating the project team members.

The National Research Center for Coal and Energy (NRCCE) led an internal kick-off meeting at WVU on November 17, 2009, attended by the WVU research team and representatives from subcontractors FilterSure and ShipShaper. Discussions included schedule and milestone updates, specific task assignments, identification of a suitable engineering firm, formation of an Industry Contact Group, and subcontract status. Plans were also made for a FilterSure 2 gallon per minute (gpm) Process Development Unit (PDU) installation including improvements to the electrical and plumbing systems in NRCCE's high bay and preparation for shipment to WVU from the unit's New Jersey location.

A chemical hygiene plan was developed for both the PDU filtration and the bench-scale work. Both were approved by the NRCCE Facilities Manager, the NRCCE Chemical Hygiene Officer, and WVU Environmental Health and Safety.

A Technology Status Report was compiled. This report provided an overview of current industry practices and associated costs to treat and/or dispose of frac return water (FRW). The benefits and inadequacies of current practices and technologies utilized were outlined and showed why further research and development activities are needed to reduce costs and impacts to our water resources. Treatment and reuse of RFW for another drilling operation showed to be a promising area for further research.

Prospective members of an Industry Contact Group were identified and participation was confirmed. To enhance the value of input from the group, a detailed questionnaire was sent to the members of the industry group, yielding valuable information regarding FRW volumes and parameters necessary for recycling. The project team met with representatives from one company in the Industry Contact Group to demonstrate the FilterSure PDU, and discuss plans for obtaining data and FRW samples from wells around the region, as well as possibilities for deployment of the Mobile Treatment Unit in Phase II of the project. The Industry Contact Group consists of seven companies: Covalent Energy, Chesapeake Energy Corporation, Marathon Oil Company, Energy Corporation of America, Range Resources, Gastem USA, Abarta Energy, and Universal Well Services.

The Industry Contact Group provided access to well development sites, water samples for testing by the FilterSure PDU and invaluable advice regarding configuration of our field-deployable technology to match the contingencies of field operations. Some key results from discussions with the Industry Contact Group included:

- slickwater frac was confirmed as the dominant type of stimulation treatment being used;

- frac sizes for most horizontal wells range from about 4 to 6 million gallons, with up to 10 stages, and as much as 250 tons of sand per stage;

- vertical well fracs are similar in size to a single horizontal well stage, 500,000+ gallons, usually in a single stage, with a total of 250 to 500 tons of sand;

- frac return water is approximately 10-20% of the amount injected, measured during the first few days of water flow back and greatly reduced after the first week to 10 days, with flow back rates averaging 3,000 to 5,000 barrels per day (90 to 150 gpm); and

- horizontal and vertical wells are successful upon stimulation, with horizontal wells appearing to provide better economics.

Several members of our Industry Contact Group expressed interest in hosting the field demonstration during Phase II of this project. Continued contact with the Industry Contact Group has been maintained throughout Phase I by providing electronic project update notices as the project progressed. Additionally, a one-half day workshop was planned and conducted during the 2010 West Virginia Water Conference. This workshop titled “Zero Discharge Water Management for Marcellus Shale Play Development,’ was held on October 6, 2010. Although conducted outside the reporting period of this progress report, a synopsis of the workshop can be found in Appendix B.

The 1,600-pound FilterSure PDU was delivered in February 2010 and testing was initiated. Test results were reviewed at a March 2010 project planning meeting held at WVU. These results were sufficiently encouraging (discussed in Task 2.4) to warrant testing Electro Coagulation (EC) as a second component, a pretreatment component, of a commercial process train. A 1 gpm process-development-scale EC unit was installed to pretreat the FRW prior to passage through the FilterSure PDU. Two additional field samples of Marcellus Shale FRW were received from our Industry Contact Group to be tested with and without the use of EC prior to the FilterSure PDU. Results were evaluated and measured against the criteria to proceed to Phase II of the project (discussed in Task 2.4.) It was determined that the technical objectives to proceed to final design and fabrication of a proto-type water treatment unit were met and a high probability existed for the development of an economically viable process.

Task 2.1 Develop Conceptual Process Train

The conceptual process train was developed around the FilterSure equipment. To develop the conceptual process train, acceptable recycle water quality was identified by our Industry Contact Group. Information provided by Group members contained ideal water chemistry requirements for recycling FRW. Members of the Industry Contact Group also supplied FRW samples from shale wells in the region. The samples were processed (discussed in Tasks 2.2 and 2.4) to characterize raw water chemistry, suspended solids characteristics, processing requirements, and processing results.

The conceptual process train includes an EC unit followed by the FilterSure filtration system. The upstream component of the system will pretreat the FRW to enhance the filtration efficiency of the FilterSure system. This component will convert some of the dissolved solids to suspended solids, which can be accomplished either chemically or electrochemically. Early testing demonstrated the capability to remove 99+% suspended solids. The treatment process train has also demonstrated the ability to reduce certain important dissolved solids; therefore, the need for subsequent processing to reduce Total Dissolved Solids (TDS) does not appear to be necessary. FRW samples supplied by Industry were treated by the process train and results supported moving forward with the development and deployment of a mobile unit in the field.

Industry standards for acceptable recycle water quality standards continue to evolve, and now requires only a significant reduction in dissolved divalent ions and suspended solids. Although a downstream (conceptual) option could be to remove dissolved solids to 500 parts per million (ppm) or less (potable or otherwise usable water), the project objective is to only treat the FRW to make it readily acceptable for recycling. If the downstream conceptual component of the process train would become necessary for whatever reason, it would likely be a "polishing process" to remove or reduce a specific chemical or to achieve a specific particle size maximum. Normally, a post-treatment component should not be necessary because the effluent TDS can be readily diluted when the FRW is recycled for the next frac job.

Task 2.2 Develop Process Flow Model

Based on the conceptual process train developed in Task 2.1, the Process Flow Model was developed along two parallel and complimentary lines: (1) a technical model and (2) an economic model.

The technical model assumed an electro-coagulation (EC) pretreatment component of the process train feeding into the FilterSure filtration system. The technical model is relatively straight forward, incorporating variables associated with the FRW chemical make-up, particle size distribution, and suspended solids coupled with additional variables associated with the components of the process train and throughput rates.

The economic model attempted to adapt a previously-developed computer code to the process train to assist in evaluating commercial potential of the evolving process. The model was expanded to include input data from newer and/or somewhat less conventional processes such as electro-coagulation. The method shows promise in being able to help optimize system integration. **Table 1** illustrates the results of a preliminary run of the augmented economic code. The initial run of the code looked at individual processes that might be steps of an integrated system for treating FRW, without regard to their applicability to the actual system contemplated. Some of the processes examined would be applicable only when executed as part of an extensively integrated system.

Table 1: Costs of various treatment methods

Treatment Method	**$/1000 gallons**
Surface disposal	$0.07
Deep injection well - existing	$0.66
Evap/infil pond w/ spray	$0.99
Spray Irrigation	$1.08
Microfiltration	$1.36
Evaporative pond - Lined-Spray	$1.97
Electro-coagulation	$2.00
Shallow injection/aquifer renewal	$2.85
Evaporative pond/infiltration	$2.98
Water hauling	$4.82
Deep injection well - new	$5.64
Nano-filtration	$6.15
Reverse Osmosis	$6.94
Evaporative pond - Lined	$27.56

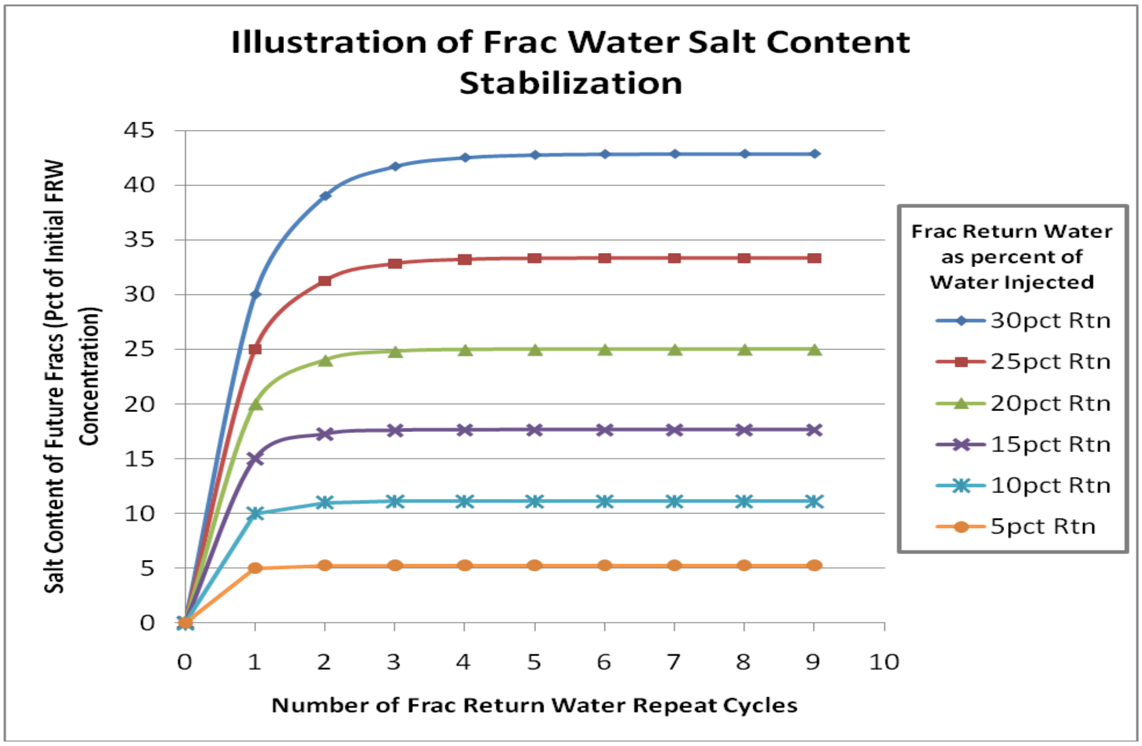
Task 2.3 Identify Recycling Operational Requirements

Using the data from the Industry Contact Group questionnaire, recycling operational requirements have been evaluated. Although this Task is considered to be 100% complete, the actual recycling requirements have been fluid in nature and have changed during the course of the project; therefore, we will continue to monitor the operational requirements and modify them as appropriate. The Industry Contact Group has kept the WVU project team informed throughout this project period. Any further changes in the operational requirements will **not** have a significant effect on the project. Recycling operational requirements were evaluated based on data from Industry:

- TDS should be < 50,000 mg/liter (may be subject to frequent revisions),
- calcium should be < 250 mg/liter,
- total water hardness should be < 2,500 mg/liter Ca CO3 equivalent,
- segregated water storage will be required for separating treated and untreated FRW, and
- for multiple horizontal wells on a single location (rapidly becoming the typical case in most of the region), it will be beneficial to clean up all of the FRW within a well's initial flowback period providing a larger portion of FRW that can be reused in the next frac on location.

The process of combining mostly fresh water with a lesser amount of salty water will result in a relatively constant mix after a few reuses. For a given development region, the maximum salt concentration of the water mixtures used for subsequent frac jobs should stabilize by the 3rd repeat cycle as shown in **Figure 1**. The salt concentration would be the same for the 4th frac cycle and remain constant for subsequent frac cycles at that site.

Figure 1: Frac Water Salt Content Stabilization



Task 2.4 Develop and Test Treatment Methods

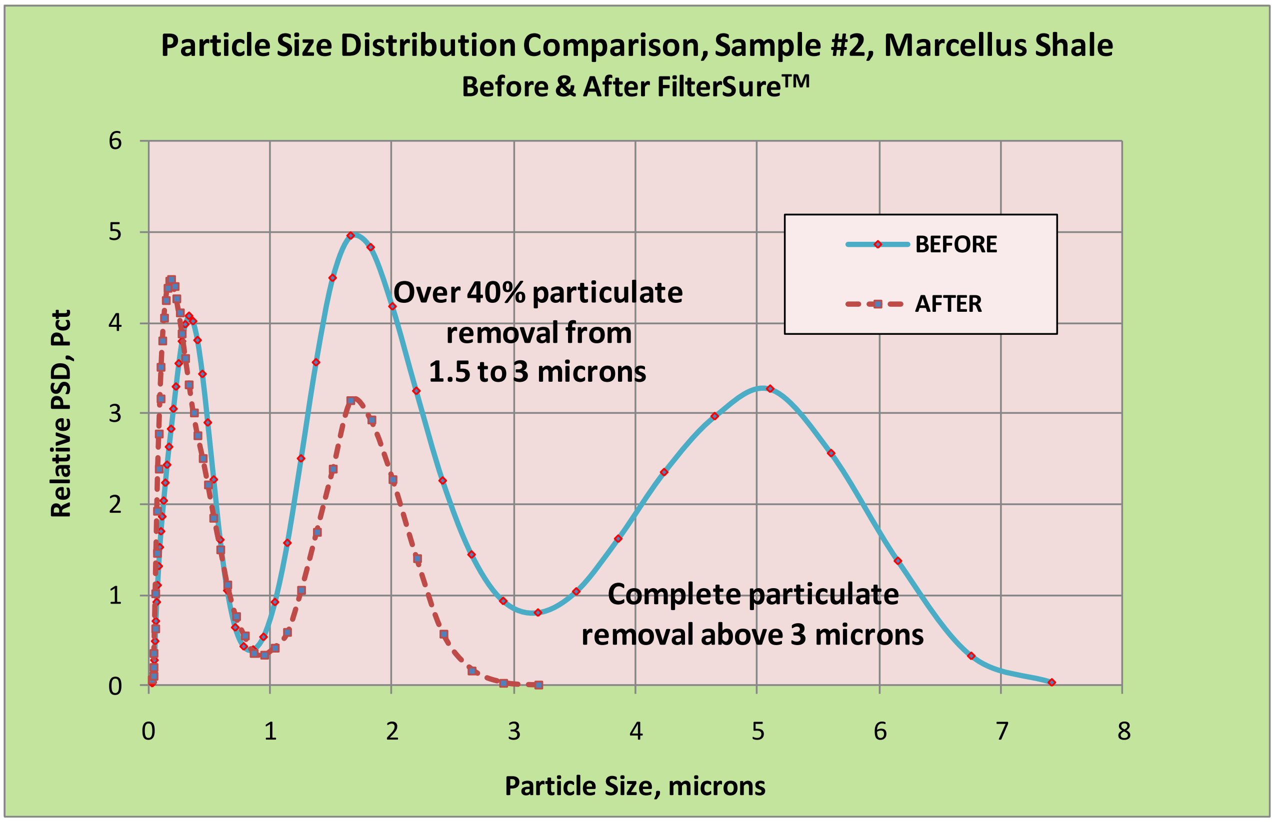
The FilterSure filtration system has proven itself under a number of different water treatment situations; however, performance on FRW and its unique water chemistry was unknown. Media reports indicated FRW presented a major problem to the natural gas industry, presenting a challenge with cost-effective disposal or utilization. Three main problems were identified: 1) an abundance of scale-forming chemicals in the FRW, 2) the presence of heavy metals such as barium and possibly NORMS, and 3) high-salinity with TDS levels of greater than 200 mg/liter. Many enterprises offering services to the gas producers are conventional water treatment companies, well-qualified to turn the FRW into fresh water and to dispose of the solids or concentrated brines that resulted, at a cost that is arguably competitive with treating and hauling the FRW to a disposal well, which are both very expensive. FilterSure and WVU developed a mobile treatment system with a small footprint to address water quality concerns of recycling FRW for additional frac jobs at a lesser cost compared to current practices.

Samples of FRW were acquired from four natural gas producers in four different areas of production, with TDS ranging from 10,000 mg/liter to 185,000 mg/liter. WVU analyzed the chemical characteristics of these FRW samples, determining that radioactivity was at or below background levels. Total water hardness (a key parameter with a target value < 2,500 mg/liter) ranged from 4,000 to 50,000 mg/liter.

WVU analyzed particle size distributions (PSD) for the FRW samples, raw and filtered samples, and all samples subjected to electro-coagulation before and after filtration. **Figure 2** shows an example of the results of filtering a Pennsylvania Marcellus Shale FRW sample. Results indicated the removal of all particles larger than 3 microns and approximately 40% of particles larger than 1.5 microns. There is no industry standard regarding acceptable particle size limits; but, some members of the Industry Contact Group have indicated that they are using 5-micron or 10-micron absolute filters.

Other members have indicated that they are using conventional sand filters only. At the 3-micron level, the FilterSure filtration system easily met or exceeded industry requirements.

Figure 2: Particle size distribution before and after FilterSure filtration



WVU submitted a sample of Marcellus Shale FRW to an electro-coagulation (EC) company for treatment. The sample was then processed through the FilterSure filtration system. As shown in **Figure 3**, this non-optimized EC test verified that EC was effective in coagulating many small particles to create much larger particles that could be readily removed by filtration. A visual indication of the filtration results is presented in **Figure 4**. It is expected that commercially-available electro-chemical treatment will be the most cost-effective pretreatment method and post-filtration treatment will not be necessary in most cases.

To further verify this expectation, two additional Marcellus samples were processed through the treatment scheme of EC followed by the FilterSure filtration system. **Table 2** summarizes the results of the tests ran on the three samples. Results indicate significant reductions with respect to the divalent ion concentration, one of the primary objectives of this project. In addition to the reductions in divalent ions concentrations, total suspended solids (TSS) were reduced by up to 76%, with retention of 100% of particles larger than three microns.

The treatment system design proposed by WVU project team and verified through analyses has the capability to achieve the technical goals of low water hardness; minimal, environmentally-safe concentrations of heavy metals; and lower TDS for the water to be readily-used by frac service companies for the next frac job.

Figure 3: Particle size distribution before and after EC

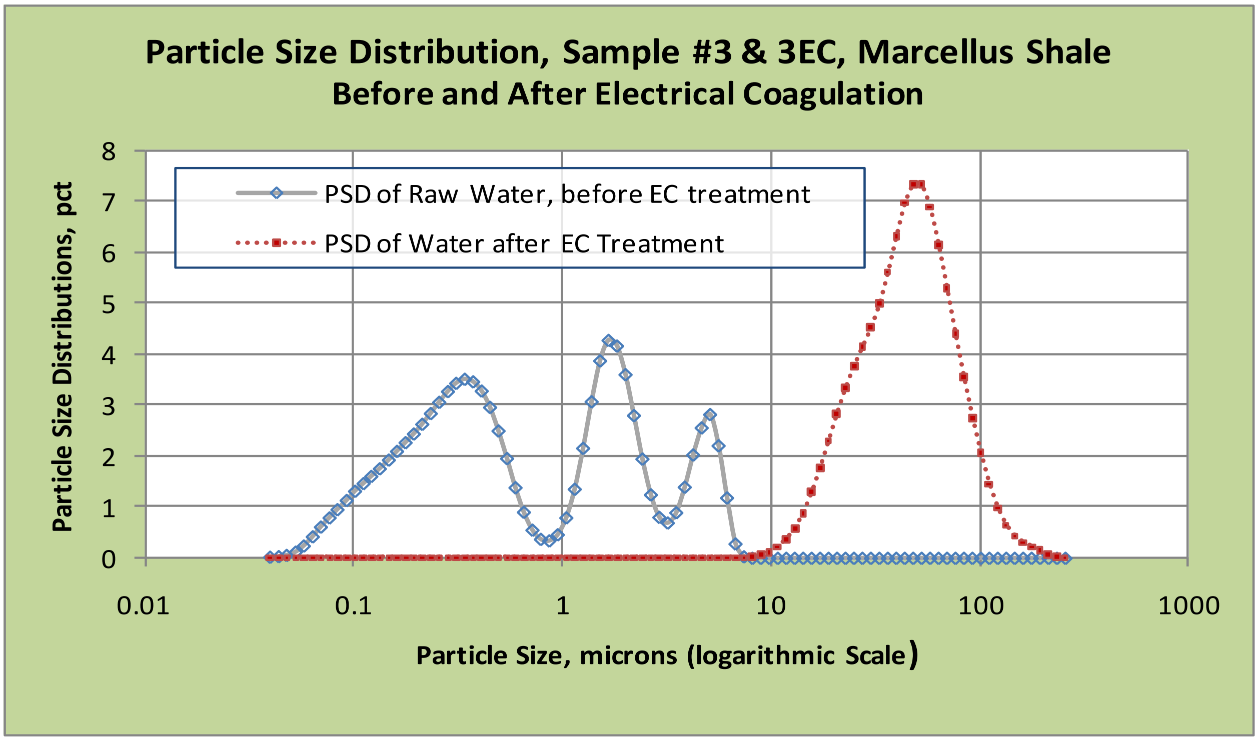


Figure 4: Effluent (left) following EC treatment and FilterSure filtration of Marcellus Shale FRW (right)

Table 2: Results of Marcellus Shale FRW samples with EC pretreatment followed by FilterSure filtration

Results of experimental treatments on three Marcellus frac return water samples

3.5.4	Sample A, 40,000 ppm TDS			Sample B, 110,000 ppm TDS			Sample C, 190,000 ppm TDS		
Solute	Raw	Treated	Change	Raw	Treated	Change	Raw	Treated	Change
Concentration	milligrams/liter			milligrams/liter			milligrams/liter		
Cl	17100	12600	-26%	65000	62400	-4%	107000	89600	-16%
Na	8530	4960	-42%	32800	22600	-31%	41900	31100	-26%
Ca	1610	1040	-35%	12800	10600	-17%	21200	14600	-31%
Sr	280	214	-24%	1340	1250	-7%	2850	3090	8%
K	243	207	-15%	398	357	-10%	668	595	-11%
Mg	188	121	-36%	1200	933	-22%	1930	1120	-42%
Ba	172	71	-59%	201	120	-40%	1280	741	-42%
Fe	32	0	-99%	6	na	na	41	na	na
SO4	28	13	-52%	414	88	-79%	49	na	na
TDS	38700	26800	-31%	114200	98400	-14%	189000	166000	-12%
TSS	40	34	-15%	570	138	-76%	882	302	-66%
Hardness	4890	3960	-19%	38000	25200	-34%	63,400	42,200	-33%
pH	7.4	7.9	7%	5.3	6.0	11%	5.5	5.5	1%

Removal of salts through the use of solvents

Research on methods for removal of salts using solvents has been initiated and includes the use of mixed solvent systems. The solubility for KCl was determined to be 34.5 gm/100 gm of water. Investigations of mixed solids beginning with the use of 2-propanol followed to evaluate solubilities and conductivities. The solubility of KCl in 2-propanol/water mixtures showed that the initial 26% KCl by weight dropped to nearly 1% when the solvent was 80% 2-propanol by weight. The concentration, referenced to the original water, decreased from 345,000 mg/liter to approximately 40,000 mg/liter. Removal of the precipitated salt followed by removal of the 2-propanol resulted in an 88% reduction of salt.

Experiments with K_2SO_4 showed 90% less solubility with 20% (w/w) 2-propanol than pure water. Solubility of K_2SO_4 is shown in **Figure 5**. Determinations below 1 gm/100 gm are difficult to perform; thus, higher amounts of 2-propanol were not used. The data conform to other experimental data as seen in **Figure 6**.

Figure 5: Solubility of K_2SO_4 in water and water-2-propanol mixtures

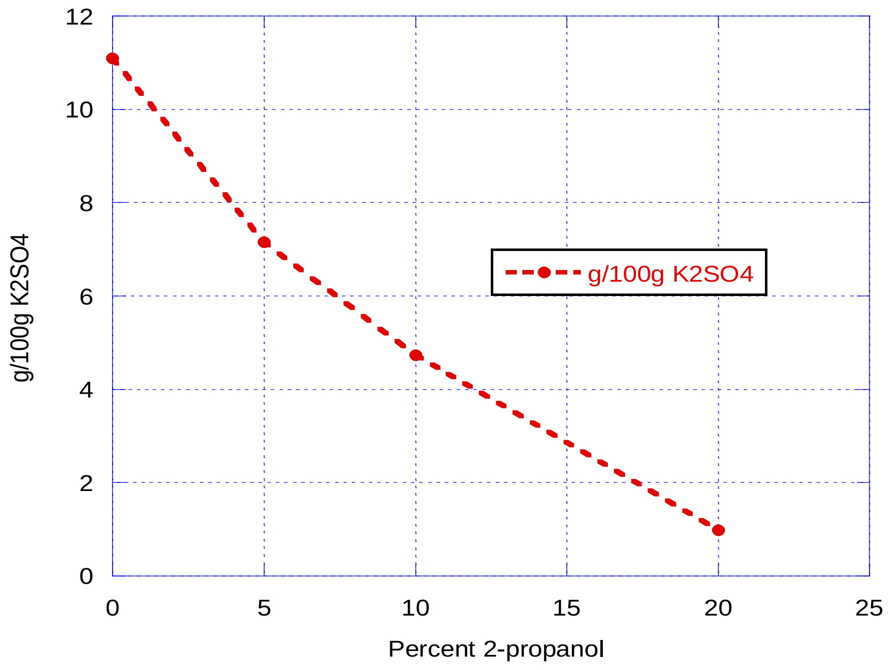
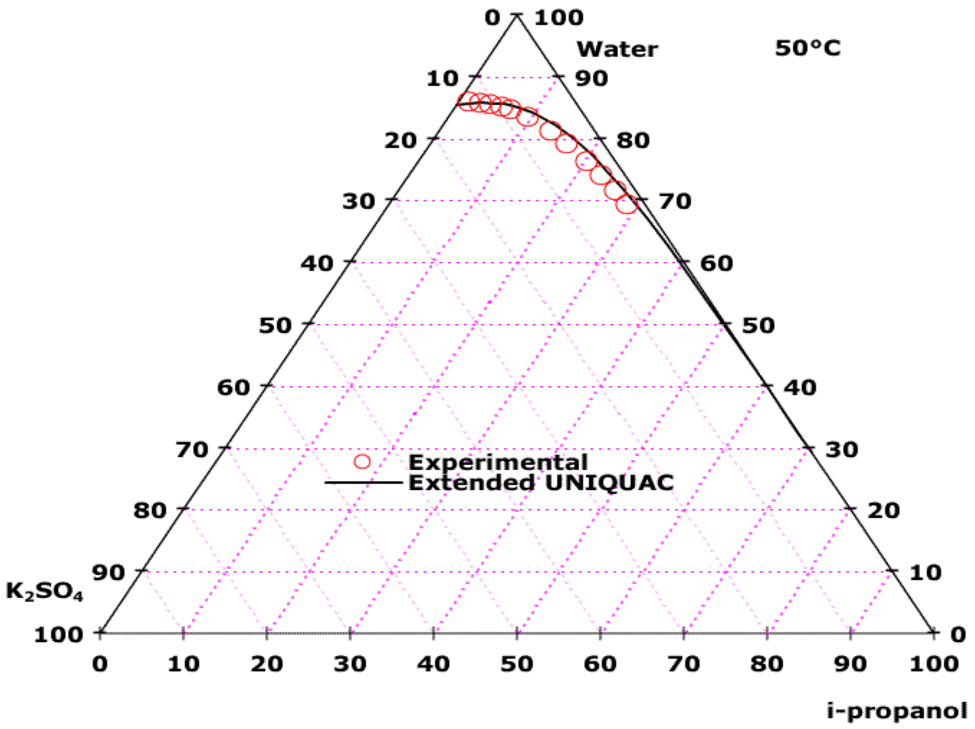


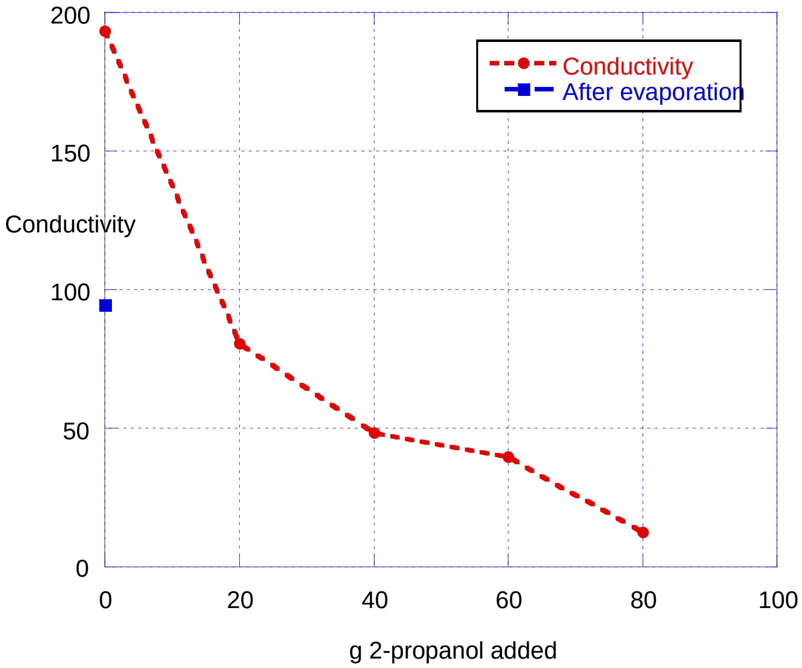
Figure 6: Ternary diagram of the solubility of K_2SO_4 in the water/2-propanol system



Although the analyses displayed in Figure 5 were conducted at 22°C, not 50°C as in Figure 6, K_2SO_4 was more soluble at the higher temperature. Figure 6 also indicated that less salt was dissolved at higher 2-propanol contents. The water solubility, 11.2 gm salt/100 gm water, is roughly 112,000 mg/liter as TDS. The solubility at 20% 2-propanol is 1.06 gm salt/100 gm water, a TDS of 10,600 mg/liter.

Samples of frac water were treated with 2-propanol. The method is the obverse of the solubility experiments where 2-propanol was added to an existing solution. The behavior was tracked using conductivity as seen in **Figure 7**. Lower conductivity is a complex function of solution dielectric changes and salt loss. The solution was recovered through filtering after addition of 80 gm of 2-propanol. The 2-propanol was evaporated, regenerating an aqueous solution that had a conductivity of 97 mS/cm, 50.5% of the original 92 mS/cm. Comparison of salt content of the original and final solutions showed 24% of the original sodium (55,000 mg/liter) and 37% of the original chloride (100,000 mg/liter) were removed, yielding 41,800 mg/liter sodium and 63,000 mg/liter chloride. The final added 2-propanol, 80 gm, corresponds to a solution that is 44% 2-propanol. When converted to molar concentration, 0.57M of sodium is removed and 1M of chloride. Other ions must be involved in chloride removal, 1:1 Molar removal is expected for NaCl. Other analyses are in progress and will continue through the first quarter of Phase II.

Figure 7: Frac water treatment with 2-propanol



Task 2.5 Preliminary Cost Estimate and Development of Decision Criteria

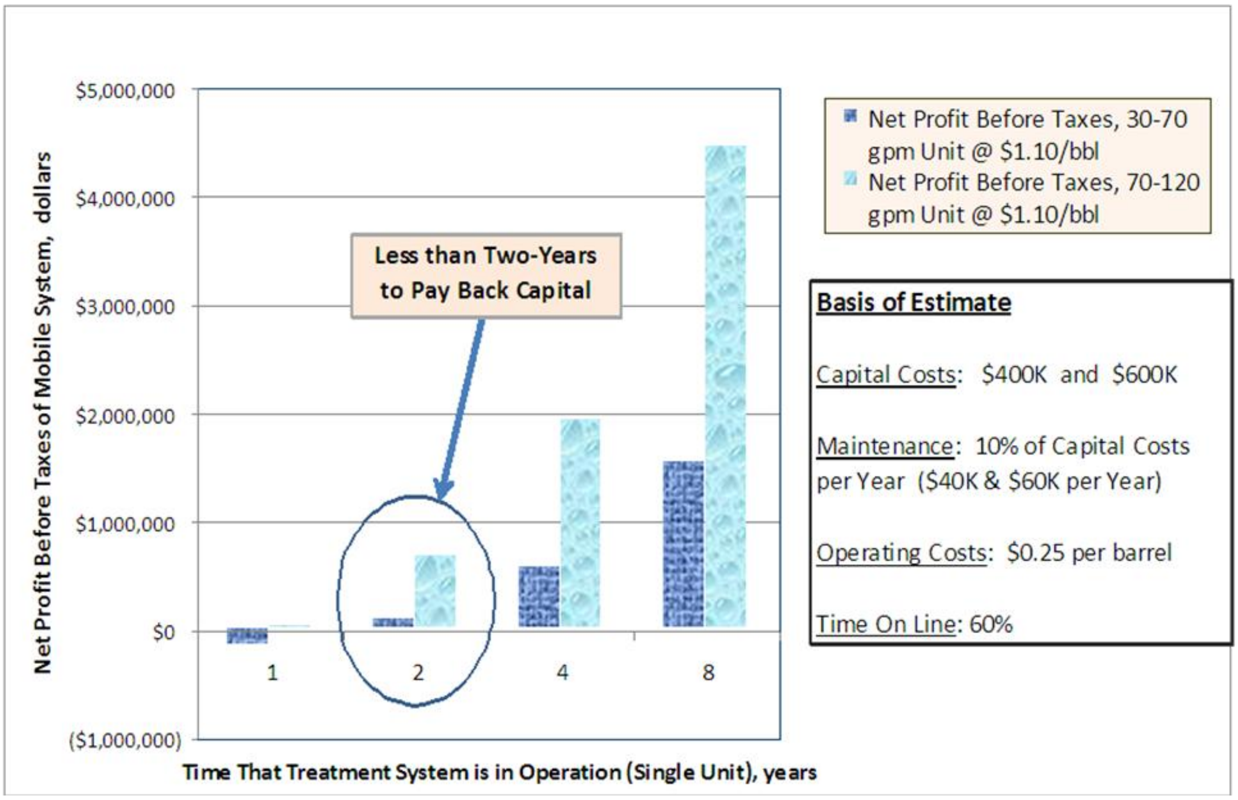
Three separate laboratory tests using a 1 gpm EC unit preceding the FilterSure filtration unit confirmed the ability of the combined system to remove suspended and dissolved solids from FRW.

Preliminary cost estimates were completed and presented to DOE in September 2010. **Figure 8** shows the mobile treatment system to be potentially profitable at the 30 gpm prototype size. However, net profits before taxes are increased using a 70 gpm system. Both units will pay back the investment in less than two years.

The mobile unit is expected to be highly-competitive with any other system that can be developed, and well below the cost of the current common method of trucking and disposal of the FRW at $2.00 to $8.00 per barrel ($47 to $190 per 1000 gallons). Because this system can be placed on-site and can treat the FRW without the need for long settling times, the FRW can be reused immediately, on-location, eliminating trucking from site to site.

Research results to date confirm the system will meet the technical goals stated throughout this discussion. Specifically, the system will remove water hardness chemicals to less than 2,500 mg/liter, calcium to less than 250 mg/liter, and heavy metals to near-zero presence when blended with fresh water. Both the economic and technical criteria were shown to be favorable and the decision to proceed to Phase II was made.

Figure 8: Potential profitability of 30 gpm mobile treatment unit



Task 2.6 Go-No-Go Decision to Proceed to Phase II

Based on results obtained through project tests of Marcellus FRW samples, including the separate tests applying electro-chemical technology in concert with FilterSure technology on FRW samples of 40,000, 110,000, and 190,000 mg/liter, the final composite system met both technical and economic criteria, fully justifying the forward movement into Phase II. Phase II will consist of the design and fabrication of a commercial-scale prototype system that will be taken into the field for verification and validation that it will treat FRW to a level that the water can be recycled and reused again during the drilling process.

Issues & Challenges:

The excellent cooperation of our Industry Contact Group in providing frac water samples has resulted in the completion of all treatment and analyses ahead of schedule. The project is proceeding to the design and fabrication stage of the prototype unit for field deployment in spring 2011.

Milestone Report:

All milestones for Phase I were completed. **Table 3** provides a log of all milestones for Phase I and II, including actual start and completion dates for Phase I milestones and anticipated start and completion dates for Phase II milestones.

Cost Status Report:

Project costs associated with Phase I are detailed in Appendix A.

Summary of Accomplishments:

The project remained within budget and schedule. Significant accomplishments this quarter included:

- A 1 gpm EC process development unit was installed in the laboratory to test its use in pretreating FRW prior to filtration. The testing proved successful.

- Industry Contact Group members provided additional flowback frac water samples that were subsequently processed through the EC unit and the FilterSure filtration system. The WVU Radiation Safety Department tested these samples for radioactivity and again found them to be at or below background values. A faculty member in the WVU Department of Civil and Environmental Engineering determined particle size distribution measurements for each sample received and tested. A commercial lab was used for the chemical analyses of the samples.

- Tests of the combined EC and filtration system verified previous results showing significant reductions in concentrations of the divalent ions and TSS. Divalent calcium was reduced by approximately 30% and TSS was reduced by up to 76% while retaining 100% of the particles larger than 3 microns.

- All task objectives and milestones, both economic and technical, for Phase I were completed and within budget.

- The decision to proceed to Phase II of the project was made based on the tests yielding positive technical and economical results.

Table 3: Project task and milestone log for Phases I and II

Task/ Subtask #	Project Milestone Description	Planned Start Date	Planned End Date	Actual/ Projected Start Date	Actual/ Projected End Date
2.1/2.2	Complete Conceptual Process Train and Flow Model	2/1/10	5/31/10	2/1/10	7/31/2010
2.3	Recycling Requirement Identification	2/1/10	4/30/10	2/1/10	4/30/10
2.4	Treatment Method Development Preliminary Findings	2/1/10	7/31/10	2/1/10	7/31/10
2.4/2.5	Treatment Method Development Final Recommendations including Preliminary Cost Estimate	2/1/10	8/31/10	2/1/10	9/30/10
2.6	Go/No Go decision to proceed to Phase II	9/1/10	9/30/10	9/1/10	9/30/10
3.1/3.2	Mobile Treatment Unit (MTU) Design and Fabrication	10/1/10	3/31/11	10/13/10	3/31/11
3.4	MTU Installation & Startup	4/1/11	4/30/11	4/1/11	4/30/11
3.5	MTU Field Test	5/1/11	7/31/11	5/1/11	7/31/11
3.6	MTU Decommissioning	8/1/11	8/31/11	8/1/11	8/31/11
3.7	MTU Demonstration Report	9/1/11	9/30/11	9/1/11	9/30/11

Appendix A: Cost Status Report (as of 10/25/10)

	Current Budget	Encumbrances	Expended to Date	Unobligated Balance
Salaries	40,771.94	0.00	57,549.98	-16,778.04
Fringe	9,142.55	0.00	10,859.71	-1,717.16
General Expenses	19,821.00	62.00	24,640.95	-4,881.95
Subcontracts/Pro Services	169,237.00	17,212.34	125,457.88	26,566.78
Travel	1,000.00	0.00	172.47	827.53
F & A	65,618.51	443.60	66,598.82	-1,423.91
Totals	305,591.00	17,717.94	285,279.81	2,593.25

Cost Share	Current Budget	Expended to Date	Unobligated Balance
WRI/NRCCE/WVU Direct	7,088.12	8,264.93	-1176.81
F & A	3,295.88	3,843.19	-547.31
External	29,600.00	32,762.50	-3162.5
Totals	39,984.00	44,870.62	(4,579.50)

Appendix B: PTTC Workshop Summary Report
Eastern Region – Appalachian Basin

Title/Topic: Zero Discharge Water Management for Marcellus Shale Play Development
Date: October 6, 2010
Location: Morgantown, WV
Co-Sponsor: West Virginia Water Research Institute
Speaker(s): Kristin Carter, Carbon Sequestration Section, Pennsylvania Geological Survey
Paul Ziemkiewicz, Director, West Virginia Water Research Institute
Ronald McIlwain, President, FilterSure, Inc.
C. David Locke, Principle Petroleum Engineer, Marcellus Shale Fracwater Cleanup Project
Attendees: Industry: 25
Others: 22
Total: 47

Synopsis/Overall Assessment:
This half-day workshop was designed to alert the oil and gas industry and those concerned with water management issues in the northeast with the results of a DOE-funded research project to treat flowback water from large frac jobs in Marcellus Shale wells. The goal of the project is to treat and reuse 100% of the flow back water (i.e., zero discharge to surface streams) in the next frac job.

At the beginning of the project, industry advised the research team that they were achieving 60-80% water returns from frac jobs in vertical wells and short lateral horizontal wells. Therefore, the team began to design an integrated approach to remove all suspended solids (TSS) and reduce dissolved solids (TDS) to an acceptable level. However, after the research began, industry advised the team, through responses to a questionnaire sent out by the team, that total frac water returns were as low as 20% in longer laterals. This essentially eliminated the need for expensive treatments to reduce TDS; simple mixing of filtered frac water with four parts of fresh water would produce enough water of sufficient quality for the next frac job.

Successful filtering of the flow-back water has been achieved by modifying filters provided by FilterSure, a member of the research team. This process involves customizing a series of five filters to meet the specific needs of the water sample, based on a pre-treatment size distribution analysis. Simple filtration alone can remove 99% of the TSS.

Filtering combined with electrocoagulation (EC) has proven to be effective in removing a significant percent of TDS as well. The EC process produces larger flocs of what were smaller TDS, and these flocs are then removed by the filtering process. The end product is a clear liquid with TDS reduced to levels that are acceptable for makeup water in the next frac job.

Kristin Carter, Section Chief of the Pittsburgh office of the Pennsylvania Geological Survey, set the stage for the research talks that followed by presenting an excellent summary of the regional geology and production history of the Marcellus Shale play, with an emphasis on the water needs and resulting water-associated problems inherent in the play. Paul Ziemkiewicz, Director of the West Virginia Water Research Institute, followed with a summary of project goals and the results of Phase 1, the lab phase that incorporated EC technology with FilterSure technology.

Ronald McIlwain, President of FilterSure, Inc., presented a more detailed examination of the technology developed by his company, including a case study of using this technology for twenty years on the Potomac River near Baltimore.

C. David Locke, the Principle Petroleum Engineer on the Marcellus Shale Fracwater Cleanup Project, concluded the session with a presentation of the Zero Discharge Project team's plan for Phase II, a field demonstration phase. During Phase II, a mobile unit will be designed and constructed, consisting on an EC unit and a FilterSure filtration system, designed to treat flowback water on-site.

The workshop ended following a 30 minute period in which attendees could ask questions of any speaker. Interaction between speakers and registrants was dynamic throughout the workshop, as several of those present seemed truly interested in applying this technology to their wells.

Participant Feedback:

Because the workshop topic involved treatment of flow-back water, and the theme of the WV Water Conference was "West Virginia's Water Resources: Threats and Opportunities," we decided that incorporating our PTTC workshop into their meeting would bring gas operators and water experts together to discuss the results of this research. This proved to be a successful approach, as the audience was essentially split fifty-fifty between gas producers and those professionals who worked in water-related fields.

However, this did cause a few problems for us. Because the workshop was one of three concurrent sessions, we could not charge a separate registration fee, and we had no control over who attended the workshop, or if they attended the entire session or just one or two talks. Because of this, we circulated a sign-in sheet before each talk in an attempt to capture the names of those who attended at least part of the workshop. The final list may not have included everyone who was in the room at one time or another, but it was close.

It also was difficult to distribute an evaluation sheet and get it back at the end of the day, so we gave up on this endeavor. We can only report that for a workshop that competed with two other sessions, we had more than 40 of the 100 total registrants in the room at all times, and those in the room followed up each talk with multiple questions, and stayed at the end to speak individually with the key speakers.

National Energy Technology Laboratory

626 Cochrans Mill Road
P.O. Box 10940 Pittsburgh, PA 15236-0940 3610 Collins Ferry Road
P.O. Box 880 Morgantown, WV 26507-0880

One West Third Street, Suite 1400 Tulsa, OK 74103-3519
1450 Queen Avenue SW Albany, OR 97321-2198
2175 University Ave. South Suite 201 Fairbanks, AK 99709
Visit the NETL website at: www.netl.doe.gov
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