

**Kansas Water Resources Research Institute
Annual Technical Report
FY 2016**

Introduction

The Kansas Water Resources Institute (KWRI) is part of a national network of water resources research institutes in every state and territory of the U.S. established by law in the Water Resources Research Act of 1964. The network is funded by a combination of federal funds through the U.S. Department of the Interior/Geological Survey (USGS) and non-federal funds from state and other sources.

KWRI is administered by the Kansas Center for Agricultural Resources and the Environment (KCARE) at Kansas State University. An Administrative Council comprised of representatives from participating higher education or research institutions, state agencies, and federal agencies assists in policy making.

The mission of KWRI is to: 1) develop and support research on high priority water resource problems and objectives, as identified through the state water planning process; 2) facilitate effective communications among water resource professionals; and 3) foster the dissemination and application of research results.

We work towards this mission by: 1) providing and facilitating a communications network among professionals working on water resources research and education, through electronic means, newsletters, and conferences; and 2) supporting research and dissemination of results on high priority topics, as identified by the Kansas State Water Plan, through a competitive grants program.

Research Program Introduction

Our mission is partially accomplished through our competitive research program. We encourage the following through the research that we support: interdisciplinary approaches; interagency collaboration; scientific innovation; support of students and new young scientists; cost-effectiveness; relevance to present and future water resource issues/problems as identified by the State Water Plan; and dissemination and interpretation of results to appropriate audiences.

In implementing our research program, KWRI desires to: 1) be proactive rather than reactive in addressing water resource problems of the state; 2) involve the many water resources stakeholders in identifying and prioritizing the water resource research needs of the state; 3) foster collaboration among state agencies, federal agencies, and institutions of higher education in the state on water resource issues; 4) leverage additional financial support from state, private, and other federal sources; and 5) be recognized in Kansas as a major institution to go to for water resources research.

Water Research for the Fort Riley Net Zero Initiative

Basic Information

Title:	Water Research for the Fort Riley Net Zero Initiative
Project Number:	2014KS180S
USGS Grant Number:	
Sponsoring Agency:	EPA
Start Date:	11/25/2015
End Date:	7/31/2016
Funding Source:	104S
Congressional District:	
Research Category:	Not Applicable
Focus Category:	Water Quality, Water Quantity, None
Descriptors:	None
Principal Investigators:	Stacy Lewis Hutchinson, Gerad Middendorf, Natalie Mladenov

Publications

1. Hutchinson, Stacy L, 2016. Final Report. Disinfection of biological agents in the field using a mobile advanced oxidation process. Kansas State University, Manhattan, Kansas.
2. Hutchinson, Stacy L, 2016. Final Report. Disinfection of biological agents in the field using a mobile advanced oxidation process. Kansas State University, Manhattan, Kansas.
3. Scott, Jeffrey D. 2017. Fluorescence spectroscopy as a monitoring technique for membrane bioreactor water reclamation systems. "M.S. Dissertation," Department of Biological & Agricultural Engineering, College of Engineering, Kansas State University, Manhattan, KS, 429 pages.

Summary of work to date:

Kansas State University is working with Fort Riley personnel, EPA ORD, and EPA Region 7 to develop strategies for meeting the Department of Defense Net Zero Water goals. Specific project objectives for the Fort Riley demonstrations are:

1. Investigation of methods for safe reuse of waste water through the decentralized treatment of water from sewer lines (Titled: Decentralized Waste Water Treatment Technology Demonstration);
2. Containment, control and disposal of large volumes of wastewater following an event involving biological agents (Titled: Wastewater Security Investigation);
3. Use of engagement, education, motivation, and empowerment to reduce water demand at Ft. Riley, with a measurement of the effectiveness of each (Titled: Demand Side Outreach and Intervention Study).

Research was initiated in January 2014 and work is ongoing for the wastewater reuse and water security project. The Demand Side Outreach and Intervention Study was completed in December 2014 and the water security project final report was submitted in January 2016 (see attached).

Specific Project work:

1. Decentralized Waste Water Treatment Technology Demonstration – supporting one MS student on this project. Continued to participate in monthly project meetings via telephone and attended several on-site meetings with EPA, Fort Riley, and contractors to discuss system function, operation and monitoring. Continued issues with the MBR function have resulted in the collection of very little viable research.
2. Wastewater Security Investigation – Supporting one MS student on this project. Continued to assess AOP trailer function and determine the impact of total suspended solids on the performance of the system. While there is solid performance of the system about 50% of the time, problems with the UV light source continue to plague tests and require maintenance. Additional maintenance was performed and more test to determine what was causing the inconsistency of performance. Residual chloramines were determined to impact system performance and studies are being re-worked to dechlorinate and/or use natural waters for testing.
3. Demand Side Outreach and Intervention – no work this year.

Final Report

Disinfection of biological agents in the field using a mobile advanced oxidation process

by

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Final Report
January 2016

Table of Contents

1.0	PROJECT OBJECTIVES	2
1.1	Project Objective.....	2
2.0	Methods & Procedures.....	4
2.1	AOP System Design	4
2.2	Treatment Process.....	5
2.3	Experimental Design.....	7
2.4	Evaluation objectives	8
3.0	SAMPLING AND MEASUREMENT APPROACH AND PROCEDURES.....	10
3.1	Sampling Procedures	10
3.2	Preservation Procedure for Microbial Samples	10
3.3	Analytical Laboratories.....	11
3.4	Sampling and Analytical Procedures	11
4.0	Results and Discussion	17
4.1	Resultant Data.....	17
4.2	Data Analysis	22
4.2.1	Relation of Suspended Solids	24
4.3	Statistical Analysis.....	25
5.0	Conclusions and Observations.....	26

List of Tables

- Table 2-1. Experimental Design Parameters
- Table 2-2. Critical Parameter Measurement Summary
- Table 2-3. Non-critical Experimental Measurements
- Table 2-4. Water Quality Measurements
- Table 3-1. Sample Containers, Preservation Method, and Holding Times for Grab Sample Parameters
- Table 3-2. Analytical Methods for Grab Sample Parameters
- Table 3-3. Test Run Summary
- Table 4-1. General Statistical Analysis
- Table 4-2. Flow Rate: Single Factor ANOVA
- Table 4-3. Total Suspended Solids: Single Factor ANOVA

List of Figures

- Figure 2-1 Schematic Diagram of Pilot-Scale AOP System
- Figure 2-2. Medium-Pressure UV Lamp System
- Figure 2-3. Cone Diffuser for Ozone Concentration
- Figure 2-2. Treatment example of sourced Pond Water with added bacteria
- Figure 3-1. Log Inactivation of Bacteria relative to TSS concentration in mg/L.
- Figure 3-2. Log Inactivation of Bacteria relative to Flow rate in gpm.

Acronyms and Abbreviations

AOP	advanced oxidation process	ORD	Office of Research and
EPA	Environmental Protection Agency	PI	Principal Investigator
H ₂ O ₂	hydrogen peroxide	QA	Quality assurance
HO ₂ ⁻	hydroperoxide ion	QAM	Quality Assurance Manager
MP	medium pressure	QAPP	Quality Assurance Project Plan
mg/L	milligrams per liter	QC	Quality control
mL	milliliters	scfh	standard cubic feet per hour
O ₂	oxygen	SOP	standard operating procedures
O ₃	ozone	SS	stainless steel
•OH	hydroxyl radical	TiO ₂	titanium dioxide
	Development	UV	ultraviolet
		WAM	Work Assignment Manager

PROJECT OBJECTIVES

Project Objective

The Army's Net Zero initiative seeks to reduce water consumption and improve reuse on military installations throughout, both locally and globally. In response to the necessity of water security to protect against contamination, promote control, and the handling of large volumes of wastewater following an event involving biological agents the following research to optimize a mobile Advanced Oxidation Process was developed. The research seeks to evaluate the limitations, applicability, and advantages of such a process and how well it performs under varying water quality conditions.

The use of a mobile system is key for situations in theatre where local treatment and fresh water is not readily available. Such water could be hazardous due to elevated levels of TSS, nutrients, harmful microorganisms, or chemical contamination. In dire situations water reuse may be necessary and precautions must be exercised to ensure contamination does not occur from wash water that might be recycled. In the field immediate access to chemicals such as chlorine may not be available and while effective, the transport of such chemicals could prove hazardous in the event of an attack. The design of the AOP eliminates the need for additive chemicals, concerns for residual chemicals, undesired reactions with the chemical and possible contaminants, and is transportable from one station to the next.

Convoys are vulnerable targets in desert regions with extensive open space and routinely followed trails making for easy targets. These convoys carry vital supplies including sustenance, medical equipment, and fresh water between operations. When convoys are not available or become delayed soldiers must rely on local sources for provisions. Advanced filtration, chemical treatment options, and fresh sources are frequently scarce. Soldiers who have access to a local system or well water may be fortunate, but the water cannot be guaranteed for safe consumption or secondary utilization without additional treatment.

The Army and ORD are currently partnering to promote and demonstrate innovative technologies on Army installations in support of the Army's Net Zero initiative. Through ORD's research program, EPA scientists and engineers are working with the Army and other partners to identify specific installation technology needs. One challenge of interest is containment, control and disposal of large volumes of wastewater following an event involving biological or agents. Wash racks, or areas where military vehicles are washed after exercise, provide researchers access to water contaminated with oil, grease, some metals and mixtures of suspended solids (dirt and mud). Access to the wash rack water provides a unique opportunity to evaluate disinfection of biological agents in the field with water that could hinder the disinfection process.

The proposed AOP consists of ozone and ultraviolet radiation in combination to produce three treatment measures including direct and indirect ozonation and UV irradiation. Produced ozone is injected into the water stream, which is then exposed to UV radiation to induce the formation of H₂O₂ and indirect oxidation. The limitations of an AOP are not fully understood while limitations of the individual processes have been examined in previous studies. The combined

effects of UV and Ozone together potentially overcome these limitations by advancing the rate of oxidation and speeding inactivation of microorganisms.

The potential of this process as designed has not been extensively studied in the combination proposed nor with respect to contact time and water quality interference. This investigation has been designed to evaluate the operation of the AOP system as it performs relative to elevated TSS and flowrates for optimal performance as designed. All components are designed within parameters suggested by existing literature including the intensity of the medium pressure UV lamp at 254 nm and the high concentration of ozone at 5.8 mg/L.

This project will examine the inactivation and/or removal of biological agents in wash water using portable unit treatment processes. Wash water will come from the wash racks at Ft. Riley. The water in these basins is representative of water washed from cars or structures after an outdoor contamination event so it is uniquely suited for use as a “real world” surrogate. Biological agents will be spiked into streams of clean tap water and dirty water. The effect of dirt and grime on biological agent removal efficiency will be determined and compared with results from clean tap water.

The objectives of this investigation aim to evaluate the limitations of an Advanced Oxidation Process treatment with set values of UV irradiation and Ozone concentration, and optimize the performance of the system according to those limitations. Experimentation was proposed to analyze the influence of total suspended solids and flowrate on the ability of the system to inactivate high levels of inoculum in the form of *Escherichia coli*. Based on the proposed source water from military field vehicle wash operations other possible parameters that might cause differences of inactivation include temperature, bio-solids, nutrient load, and pH.

Methods & Procedures

AOP System Design

The AOP trailer system consists of a 1-inch stainless steel (SS) pipe loop system, a variable speed recirculation pump, a MP UV lamp and a LP UV lamp, an oxygen (O₂) concentrator, an O₃ generator, an ozone injection system, and an O₃ destructor (Figure 2-1). Influent samples were removed from the blend tank used to feed the AOP unit, and just after initial entrance to the unit to establish fluctuations during loading. Effluent samples were removed from the sampling port immediately before the treated water was discharged. Water with biological agents was exposed to the ozone and UV light as it passed through the AOP unit.

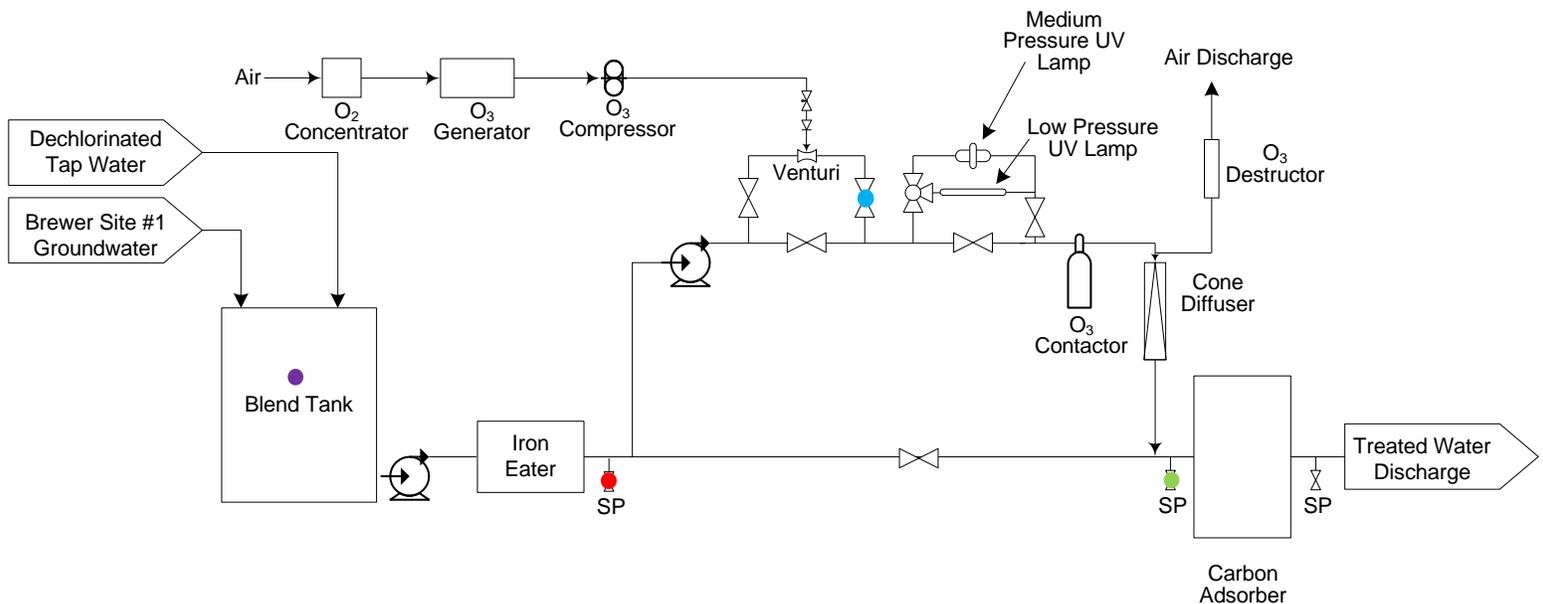


Figure 2-1 Schematic Diagram of Pilot-Scale AOP System

● Supply tank sample port ● Cart influent sample port ● Ozone sample port ● Effluent sample port

UV radiation was provided by a medium pressure (MP) UV reactor (Aquionics InLine 20 UV System, Aquionics, Inc., Erlanger, KY) in Figure 2-2. O₃ was generated using an O₂ concentrator and an O₃ generator. The O₂ concentrator separates O₂ from compressed air through a pressure swing adsorption (PSA) process. The PSA process uses a molecular sieve (a synthetic zeolite), which adsorbs nitrogen and other impurities from the air at high pressure and desorbs them at low pressure. The O₂ concentrator is designed for a maximum airflow rate of 6.6 standard cubic feet per hour (scfh). The O₂ is then fed into the O₃ generator. In the reaction chamber of the O₃ generator, the feed gas is exposed to multiple high-voltage electrical discharges, producing O₃. The O₃ is injected into the system through a venturi-type, differential pressure injector (Mazzei 3/4-inch MNPT Model 684) located on the discharge side of the system

recirculation pump ($\frac{3}{4}$ -horsepower G&L Pump NPE/NPE-F). When the contaminated water enters the injector inlet, it is constricted towards the injection chamber and emerges as a high-velocity jet stream. The increase in velocity through the injection chamber results in a decrease in pressure, thereby enabling O_3 to be drawn through the suction port and entrained into the motive stream. The venturi is assisted by an ozone compressor (Air Dimensions, Inc. DiaVac pump) to allow the system to operate at lower differential pressures while maintaining a high ozone concentration in the system. The ozone concentrations are further increased by the use of an ozone cone diffuser shown in Figure 2-3. Excess O_3 is converted back to O_2 using an O_3 destruct unit before it is vented into the atmosphere. The recirculation pump is connected to a variable-speed controller (1AB2 AquaBoost II Controller), which enables the flow rate in the loop to be set to any desired value.

Treatment Process

The AOP disinfection technology is UV irradiation combined with O_3 . Due to the high molar extinction coefficient of ozone, UV radiation can be applied to ozonated water to form highly reactive $\bullet OH$. Because photolysis of O_3 generates H_2O_2 , the UV/ O_3 process involves the disinfection mechanisms present in O_3/H_2O_2 and UV/ H_2O_2 AOPs. For instance, H_2O_2 in conjunction with O_3 can enhance the formation of $\bullet OH$. H_2O_2 is a weak acid that partially dissociates into hydro-peroxide ion (HO_2^-) in water. The HO_2^- ion can rapidly react with O_3 to form $\bullet OH$. Meanwhile, hydroxyl radicals are produced from the photolytic dissociation of H_2O_2 in water by UV radiation. Disinfection can occur either by direct photolysis or by reactions with $\bullet OH$.

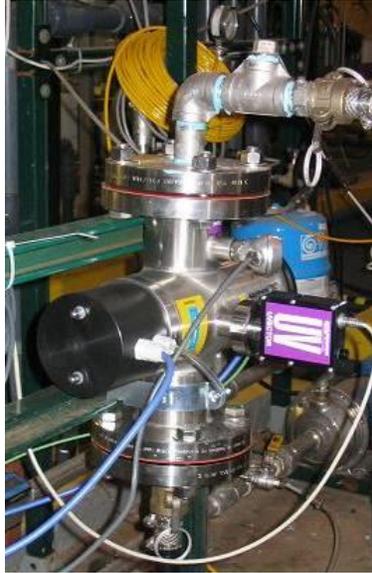


Figure 2-2. Medium-Pressure UV Lamp System

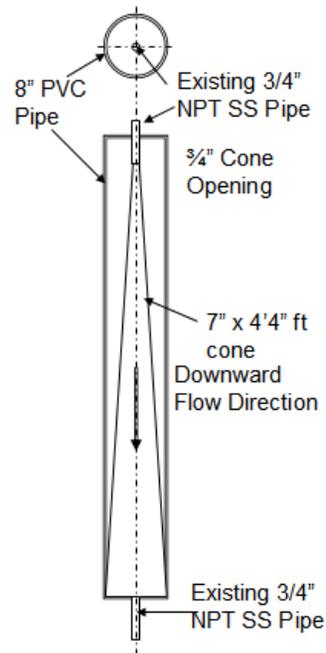


Figure 2-3. Cone Diffuser for Ozone Concentration

Experimental Design

The investigation consisted of the treatment of *Escherichia coli* in clean tap water, dirty water from Fort Riley wash racks, and naturally sourced water from a local runoff collection pond using the mobile AOP trailer.

All tests were conducted on the Kansas State University campus in the Biological and Agricultural Engineering workshop. Water from the wash racks was used directly without dilution to establish whether an interference of turbidity existed. Carboys of water from the wash racks at Ft. Riley were collected as needed along with water from a local runoff pond. Additional treatment analysis consisted of the influence of flowrate, bacteria interaction with suspended particles, and water quality.

The MP-UV lamp installed in the AOP system provided UV radiation at an emission spectrum between 200 nm and 300 nm with a power requirement of 0.9 kW and a UV dose >10 mg/cm². The UV unit had one setting, so UV conditions were constant for all experiments in the study. Preliminary tests were performed by running carbon-filtered tap water and ozone through the AOP system to test the capacity of the ozone generator and to determine the ozone concentration in the AOP system. The setting of the ozone generator was adjusted during the preliminary tests to achieve the target ozone concentration of approximately 5.8 mg/L or greater in the AOP system. The levels of ozone were never definitively established due to the high reactivity of O₃. Settings for the ozone generator were left at the highest values possible, but could not be recorded conclusively. The presence of ozone was observed throughout testing, but a true value of concentration was never determined. Unable to establish; consistent presence confirmed.

Experiments were conducted by filling the feed tank with *E. coli* at an initial microbial density of 1x10⁶ cfu/ml or mpn/ml. Water was fed to the AOP unit at two different rates, 6 gpm or <4gpm. One sample was removed from the feed tank to determine the initial concentration (T_i). Water exiting the AOP unit (effluent samples) were sampled at the last sampling point before the water left the AOP unit (C_e). Samples were removed at 1, 5, 10, 15, and 20 minutes after the contaminated water feed to the AOP unit started. Disinfection was assessed by examining the log reduction (LR) of samples taken at 1, 5, 10, 15, and 20 minutes compared to the initial microbial density in the feed tank using the following equation:

$$LR = -\log \frac{C_e}{T_i}$$

Table 2-1a lists the primary experimental design parameters for AOP disinfection of *E. coli*. Table 2-1b shows a summary of the test runs for the experimental program. Clean tap water was pumped through the AOP trailer for 20 minutes prior to each experiment to clear the disinfection

unit of particulates and residual bacteria. During this same time bacteria inoculum was allowed to circulate in the mixing tank for consistent distribution.

Table 2-1. Experimental Design Parameters

Parameters	Designed Values
Source Water	Pond/Lagoon water, Dechlorinated tap water
dilution water	Pond/Lagoon water, Dechlorinated tap water
target contamination	<i>Escherichia coli</i>
Concentration of contaminant	10 ³ -10 ⁵ mpn/mL
AOP method	UV irradiation/O3
Type of UV lamp	Medium-pressure UV lamp
UV Intensity	preset level kept constant
Ozone concentration	approx. 5.8 mg/L (indeterminate)
Temperature Range	20-23°C
Flow rates	less than 4 gpm and 6 gpm
Recirculation ratio	once-through flow
Collection Points	T, C0, C5, C10, C15, C20, E5, E10, E15, E20
Test Duration	20 minutes

Evaluation objectives

Measurement analyte, location, reporting units, and sampling frequency for critical measurements are summarized in Table 2-2. Table 2-3 summarized the measurement analyte, reporting units, sampling type, sample location, and frequencies for non-critical measurements.

Table 2-2. Critical Parameter Measurement Summary

Measurement	Reporting Unit ^a	Sampling Location	Measurement Purpose
<i>E. coli</i>	mpn/ml	Supply tank, and Influent to Cart and Effluent from Outlet of AOP System at 0, 1, 5, 10, 15, and 20 minutes after the start of a test run.	Primary microbial contaminant for study
<i>Ozone</i>	mg/L	Outlet sampling port, 2 grab sampling events per test run (at the beginning and end of the test run)	Disinfectant concentration

a: cfu = colony forming units, mpn = most probably number, mg/L = milligrams per liter

The information in Table 2-2 highlights critical parameters for treatment. The initial bacteria concentration was required to evaluate inactivation rates. The presence of ozone, while difficult to measure precisely was identified in treatment grab samples to verify effectiveness of the system. A total of 10 samples were collected per run: 5 initial samples were drawn from the AOP cart at the intake, 1 sample directly from the mixing tank, and 4 treated samples were drawn from the effluent. Ozone sampling was tested prior to treatment and following. Neither sample provided consistent results suitable for reporting. Due to the rapid reactivity of ozone

the ability to accurately sample was diminished and at time resulted in complete absence.

Table 2-3. Non-critical Experimental Measurements

Measurement	Reporting Unit ^a	Sample Type	Sampling Location	Sampling Frequency
Total Suspended Solids	mg/L	Each sample per run	Supply tank and outlet sample ports	10 sampling events per test run (T, C0, C5, C10, C15, C20, E5, E10, E15, E20)
Temperature*	°C	Analog gauge reading	On-line gauge	2 readings per test run (at the beginning and end of the test run)
Flow rate*	gpm	Digital flow meter reading	On-line meter	2 readings per test run (at the beginning and end of the test run)
Water pressure*	psi	Analog gauge reading	On-line gauge	2 readings per test run (at the beginning and end of the test run)
Air flow into the ozone generator*	scfh	Flow meter	On-line meter	2 readings per test run involving ozone (at the beginning and end of the test run)

A: mg/L = milligrams per liter; gpm = gallons per minute; psi = pounds per square inch; scfh = standard cubic feet per hour, * = Process data

The experimental measurements indicated in Table 2-3 are indications of quantifiable characteristics monitored for each test run. Total suspended solids were observed for each sampling event drawn during a treatment run. This provided 10 incidences of TSS observation to evaluate how sediment behaved in the system. Temperatures were controlled by the ambient conditions of the day and did not fluctuate drastically. Flowrate, water pressure, and air flow were determined by inline sensors on the AOP cart. Maintaining consistent measurements provided uniformity by which to compare results.

Table 2-4. Water Quality Measurements

Measurement	Reporting Unit ^a	Sample Type	Sampling Location	Sampling Frequency
*TDS	mg/L	Sample from supply tank	Mixing Tank	1 sampling every test run
*Conductivity	m S/cm	Sample from supply tank	Mixing Tank	1 sampling every test run
*Total N	ppm	Sample from supply tank	Mixing Tank	1 sampling every test run
*Total P	ppm	Sample from supply tank	Mixing Tank	1 sampling every test run
COD	mg/L	Sample from supply tank	Mixing Tank	1 sampling every test run
pH	Standard unit	Sample from supply tank	Mixing Tank	1 sampling every test run
TSS	mg/L	Sample from supply tank	Mixing Tank	10 samplings every test run

mg/L = milligrams per liter; ppm = parts per million; m S/cm = micro Siemens per centimeter

*Conducted by Kansas State Soil Testing Lab

The measurements in Table 2-4 are indicative of the water quality between test batches. Depending on source, settling time, and the discrete sampling these values fluctuated throughout testing. Correlations of these measurements with inactivity were used to compare water quality as it affects AOP treatment.

SAMPLING AND MEASUREMENT APPROACH AND PROCEDURES

Sampling Procedures

The sampling points were located in the supply tank and two outlets of the AOP system as shown in Figure 2-1. Samples for critical parameters (microbial contaminants) as well as non-critical parameters were collected at the frequency presented in Table 2-2 and Table 2-3. Sampling containers, preservation techniques, and holding times for grab sample measurements are presented in Table 3-1. As soon as practical, each sample was aliquoted into the proper containers and the appropriate preservation technique were applied in accordance with the guidelines in Table 3-1. Each container was labeled with the date and time sampled, sample location (inlet or outlet), and the parameters for analysis.

Table 3-1. Sample Containers, Preservation Method, and Holding Times for Grab Sample Parameters

Parameter	Sample Container	Preservation Method	Holding Time
<i>E. coli</i>	Sterile 200 ml glass sample bottle	Cool to 4 ± 2 °C	24 hours from collection
Ozone	200-ml glass bottle	None	Samples analyzed immediately in the field
pH	200-mL glass bottle	Cool to 4 ± 2 °C	Samples analyzed immediately, or held for no more than 4 hours
TSS	200 ml glass sampling bottle	Cool to 4 ± 2 °C	Samples analyzed immediately, or held for no more than 48 hours

Preservation Procedure for Microbial Samples

Microbial samples from the supply tank and AOP unit influent/effluent were collected in 200 ml glass sampling bottles. Once the bottles were full the samples were immediately analyzed or placed in a refrigerator at 4 ± 2 °C until analysis.

Analytical Laboratories

All analyses and measurements listed in tables 2-2 and 2-3 were conducted at Kansas State University with the Kansas State University Soil Testing Lab performing additional analysis to characterize the water samples.

Sampling and Analytical Procedures

Analytical procedures are summarized in Table 3-2. The AOP system is outfitted with inlet and outlet sample taps. When collecting a grab sample, the sample tap was opened and water allowed to flow for approximately 10 seconds to flush the sampling port.

Table 3-2. Analytical Methods for Grab Sample Parameters

Parameter	Units^a	Method	Citation	Method Summary
<i>E. coli</i>	mpn/ml	9221 B, C	Standard Methods for Examination of Water and Wastewater, 22nd Edition	Colilert reagent and quanti-tray 2000
Ozone	mg/L	4500-O ₃ -B	Standard Methods for Examination of Water and Wastewater, 22nd Edition	Colorimetric, Indigo dye method
pH	pH units	150.1	EPA/600/4-79-020, Methods for the Chemical Analysis of Water and Waste, March 1983	Litmus paper strips
TSS	mg/L	SM 2540 D	Standard Methods for Examination of Water and Wastewater, 22nd Edition	
*TDS	mg/L	SM 2540C	Standard Methods for Examination of Water and Wastewater, 22nd Edition	
COD	mg/L	SM 5200D/Hach 8000	Standard Methods for Examination of Water and Wastewater, 22nd Edition	
*Conductivity	μS/cm	SM 2510	Standard Methods for Examination of Water and Wastewater, 22nd Edition	
*Total N		USGS WRIR 03-4174	USGS WRIR 03-4174	
*Total P		USGS WRIR 03-4174/EPA 365.2	USGS WRIR 03-4174	

^a; mg/L = milligrams per liter., mpn=most probable number, cfu=colony forming units

* Conducted at the Kansas State University Soil Testing Lab (<http://www.agronomy.k-state.edu/services/soiltesting/>)

Samples were labeled in accordance with the following identification scheme: date, sample location, sample time, and experiment number. Temperature, flow and pressure readings were recorded 2 times per test run (at the beginning and the end of the test run). The number of tests completed is delineated in Table 3.3.

Table 3-3. Test Run Summary

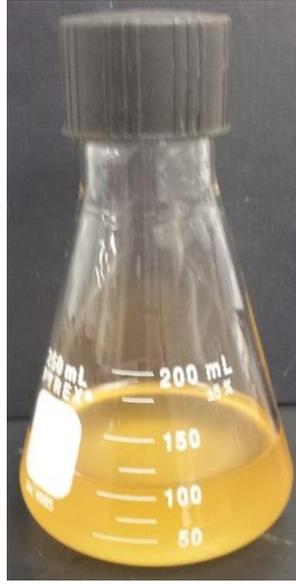
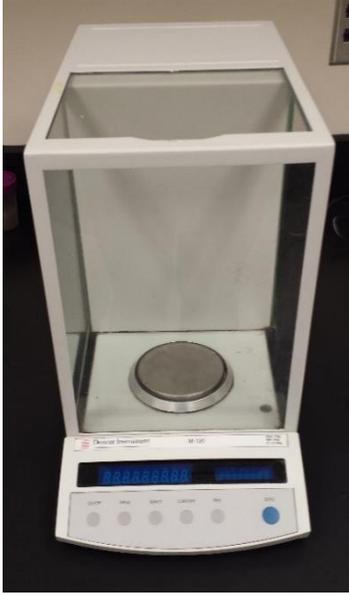
Test Run	Source Water	Flowrate (gpm)	TSS (mg/L)	Source Volume	Run Time
BL	Tap	6	0	100	10
LW1	Lagoon	4	197	100	20
LW2	Lagoon	4	121	100	20
LW3	Lagoon	3.5	70	100	20
PW10	Pond	6	52	150	20
PW11	Pond	6	110	150	20
PW12	Pond	6	70	150	20
PW2	Pond	6	49	100	10
PW3	Pond	5.5	65	150	20
PW5	Pond	6	682	150	20
PW6	Pond	3	155	150	20
PW7	Pond	6	50	150	20
PW8	Pond	3	278	100	20
PW9	Pond	3	176	100	20
TW1	Tap	4	67	100	20
TW3	Tap	4	210	100	20

The information in Table 3-3 lists the source for each test batch of water, its characteristic properties, and flowrate maintained during treatment. Tests were labeled according to the sequence of the batch and the associated source of water. The extended runtime of 20 minutes was applied to all, but two tests to provide additional sampling times as the 1 minute sampling time was omitted after verification that tap water chloramines were interfering with AOP inactivation.

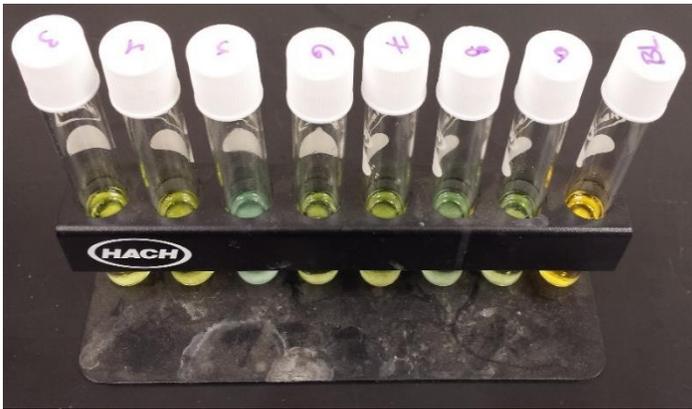
Preparing and running the AOP trailer for an individual test required approximately 2 hours per run with 24 hours of preparation between tests for bacteria propagation and final enumeration. Pretreatment maintenance of the AOP trailer entailed flushing of the system for 20 minutes with tap water, loading of source water to supply tank from storage tank at 15-23 minutes, mixing of inoculum bacteria and source water was 20 minutes and 30 minutes for 100 and 150 gallons respectively, and configuration of outlet and inlet hoses to appropriate locations. Setup and decommissioning of equipment for each test run was labor intensive as the area utilized was a common space for multiple projects.

The supply pump from mixing tank to AOP trailer provided a flowrate of ~11 gpm while the small mixing pump circulated water or transferred from the source tank to the mix tank at ~7 gpm.

Bacteria Propagation



**Water Quality Evaluation:
BOD Testing**

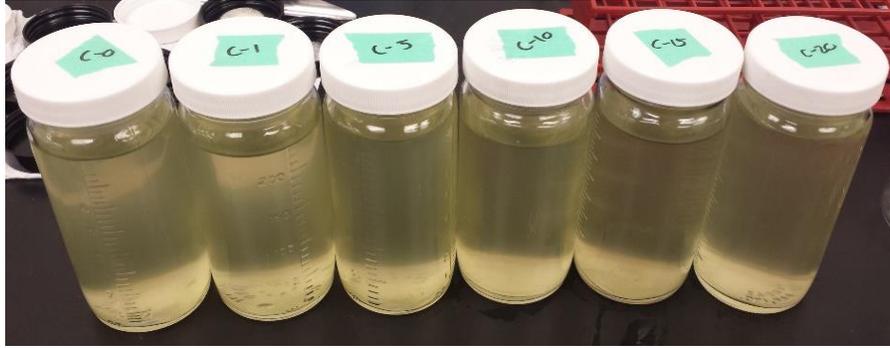


Total Suspended Solids Testing

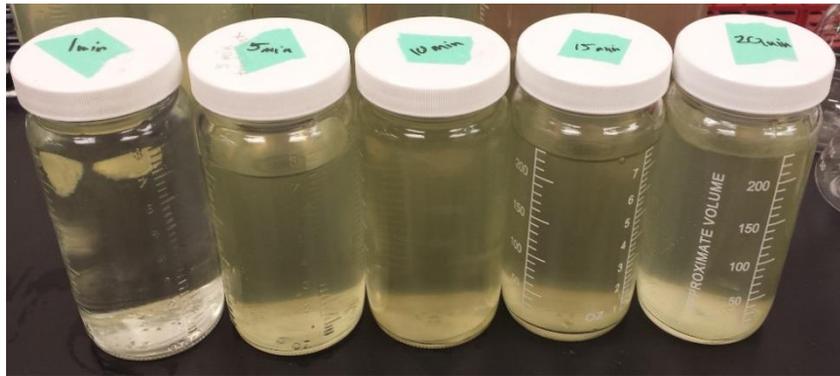


Sampling glass containers with treated water and high TSS

Storage and Labeling



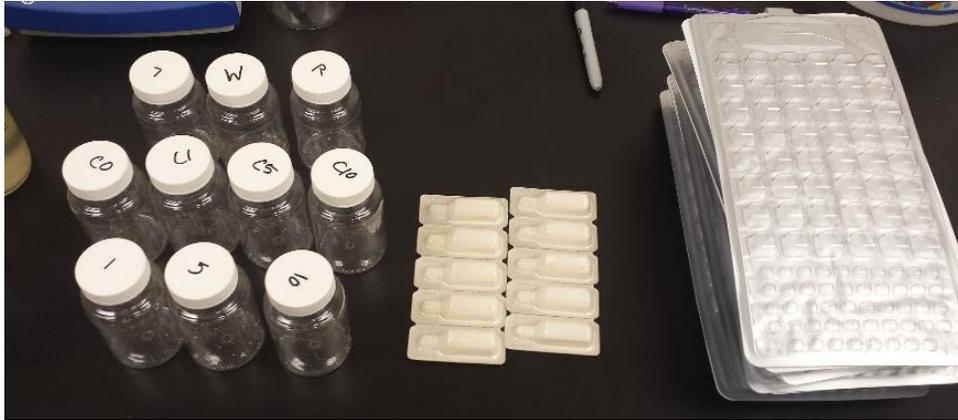
Sampling containers for withdrawing



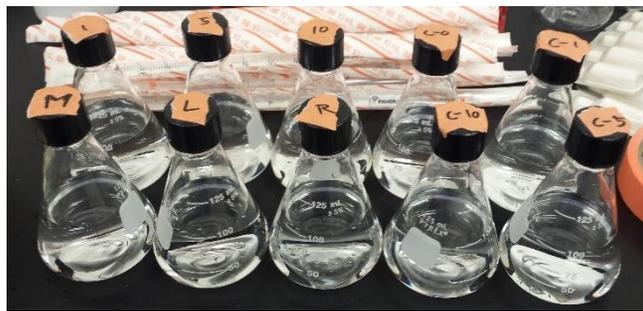
Bacteria Enumeration



Colilert-18 120 mL vessels with Sodium Thiosulfate labeled for enumeration.



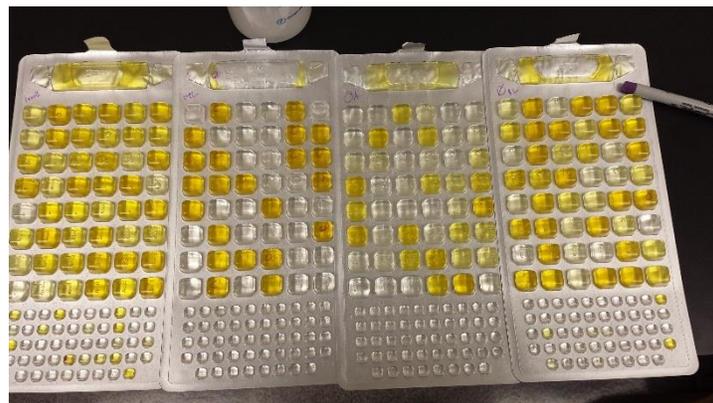
Colilert-18 sodium thiosulfate vessels, reagent snap packets, and Quanti-trays



Treatment sample dilution flasks



Colilert-18 method Quanti-Tray Sealer and





Results and Discussion

The overall results for the AOP treatment do not indicate a connection between inactivation and suspended solids, but there does exist a significant relationship to contact time as indicated by changes in the flow rate. The experimental data showed a correlation to increased inactivation with lower flow rates. Although inactivation was not complete, the once through flow system could be adjusted to recirculate water for additional treatment. Due to time constraints additional testing was not possible, but the benefit could be examined in future research. The relationship of TSS to inactivation was not evident as inactivation occurred in similar distributions whether suspended solids were elevated or reduced.

Resultant Data

Decreased flow rates resulted in a longer period of exposure to the AOP treatment including time for higher levels of $\cdot\text{OH}$ ions to form, and H_2O_2 molecules the opportunity to react prior to O_3 destruction. The difference in flow rates from 6 gpm to 4 gpm is not a large gap, but the results demonstrate a significant rate change of inactivation. Increases in flow rate were not tested, but data suggests the recirculation would be necessary for flow rates above 6 gpm.

The information in Table 4-1 expresses the water quality data provided by results from the Kanas State University soil Testing Lab. Tests with incomplete data were not submitted for evaluation, but whose values were determined by standardized lab protocol mentioned in the methods section. Complete water quality evaluations were not conducted for TW1 and TW3.

Table 4-1. Water Quality Measurements

Test	TSS (mg/L)	TDS (mg/L)	Conductivity (m S/cm)	Total N (ppm)	Total P (ppm)	COD (mg/L)	pH
BL	0	0	-	-	-	-	7
PW2	38	-	-	-	-	-	-
PW3	65	648	0.93	11.03	0.9	123	8
PW5	682	569	0.813	15.91	1.66	150	8
PW6	155	616	0.88	13.48	1.22	142	8
PW7	52	571	0.816	15.68	1.17	143	8
PW8	278	591	0.844	17.42	1.36	150	7
PW9	176	601	0.858	15.95	1.23	150	8
LW1	197	356	0.509	4.17	0.33	47	8
LW2	121	368	0.525	4.41	0.34	60	8
LW3	70	365	0.521	3.99	0.29	37	8
PW10	52	573	0.819	10	1.01	145	8
PW11	110	591	0.844	12.71	1.46	150	8
PW12	70	604	0.863	12.18	1.31	155	8
TW1	67	-	-	-	-	-	-
TW3	120	-	-	-	-	-	-
<i>Statistical Variation</i>							
Average	141	496	0.77	11	1.02	121	8
Minimum	0	0	0.509	3.99	0.29	37	7
Maximum	682	648	0.93	17.42	1.66	155	8
Median	90	573	0.8315	12.445	1.195	144	8
Std Deviation	155	174	0.15	4.66	0.45	43	0.36

Inconsistent inactivation for E1 compared to remaining time intervals was prevalent among all flow rate samplings (Table 4-2). This observation led to the disregard of E1 sampling times based on the conclusion that chloramine rich tap water was still present in the system at the 1 minute effluent sample time leading to incomparable inactivation. Due to the uncertainty of chloramine level fluctuations prior to the 1 minute sampling times were considered outliers.

Table 4-2. Sequential order of testing and log reductions based on sampling time

Test	1 min	5 min	10 min	15 min	20 min	Std Deviation
BL	0.4	1.4	1.1	-	-	0.4
PW 2	10.3	2.8	1.5	-	-	3.9
PW 3	9.9	1.9	1.5	1.2	1.9	3.3
PW 5	9.9	0.6	1.6	2.0	2.6	3.4
PW 6	9.7	9.7	9.7	9.7	9.7	0.0
PW 7	9.4	9.4	9.4	9.4	9.4	0.0
PW 8	4.8	5.1	5.1	5.3	5.0	0.1
PW 9	6.1	5.8	6.3	5.1	5.0	0.5
LW 1	9.6	5.8	6.3	6.2	6.3	1.4
LW 2	4.2	4.2	6.0	5.5	5.2	0.7
LW 3	7.0	5.8	5.6	5.7	5.5	0.5
PW 10	-	0.7	0.7	0.8	0.7	0.0
PW 11	-	1.0	0.8	0.8	0.8	0.1
PW 12	-	1.1	1.0	0.8	0.8	0.1
TW 1	-	2.7	3.8	3.4	2.7	0.5
TW 3	-	3.2	2.8	3.2	2.8	0.2
Average	<i>7.4</i>	4.8	4.9	5.6	5.6	

Because inactivation outliers for E1 samples were most common among higher flowrate tests, the data was broken down into two sets for observation. The information in Figure 4-1 demonstrates the performance of the AOP for flow rates exceeding 5 gpm. The reduction observed at 1 minute sampling times expresses the effect of chloramines remaining in the system prior to complete circulation of the batch influent. The system at 1 minute had not yet been purged of tap water used to flush the system before testing.

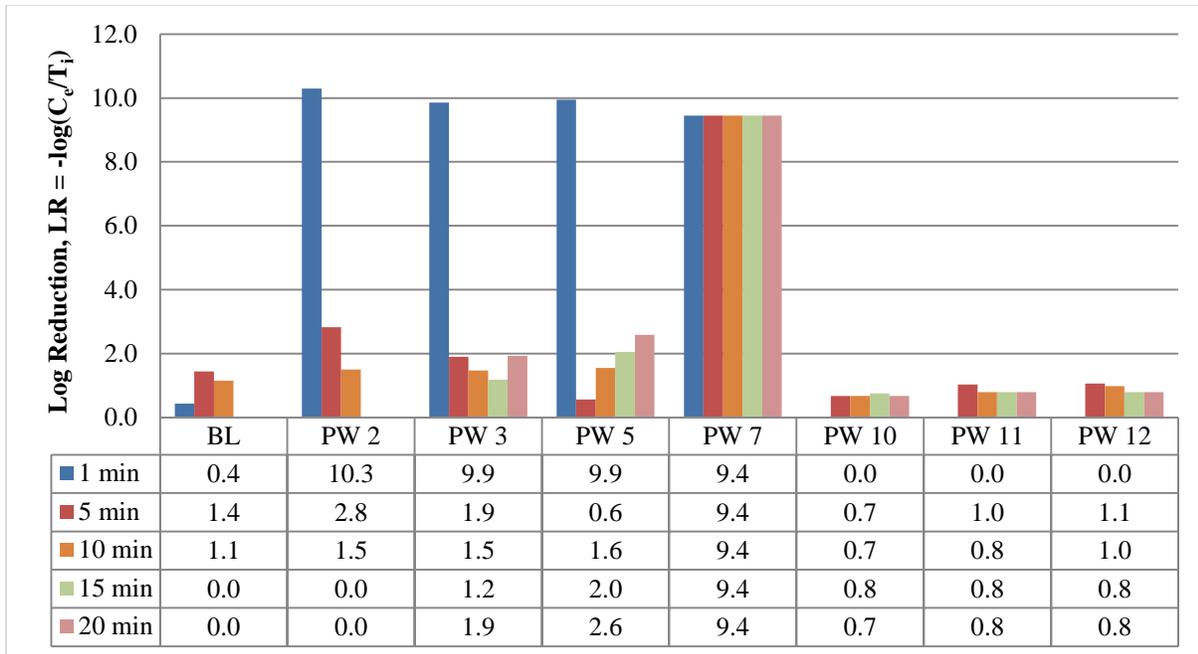


Figure 4-1. Log Inactivation based on sampling time for High Flowrate

The information presented in Figure 4-2 expresses a similar trend to that of Figure 4-1 with inconsistent reduction for the 1 minute effluent sampling. The trend is not as common for all tests as it is with higher flowrates. The lower rate of reduction could be attributed to the difference between the recirculating pump pressure and the influent pressure. Influent pressure was regulated to determine a high or low flowrate while the circulating pump moved water at a continuous rate. The pump required a minimum pressure of 1 psi in order to continue operation throughout the entire run. Dropping below 3 gpm would in effect lower the pressure to below this threshold.

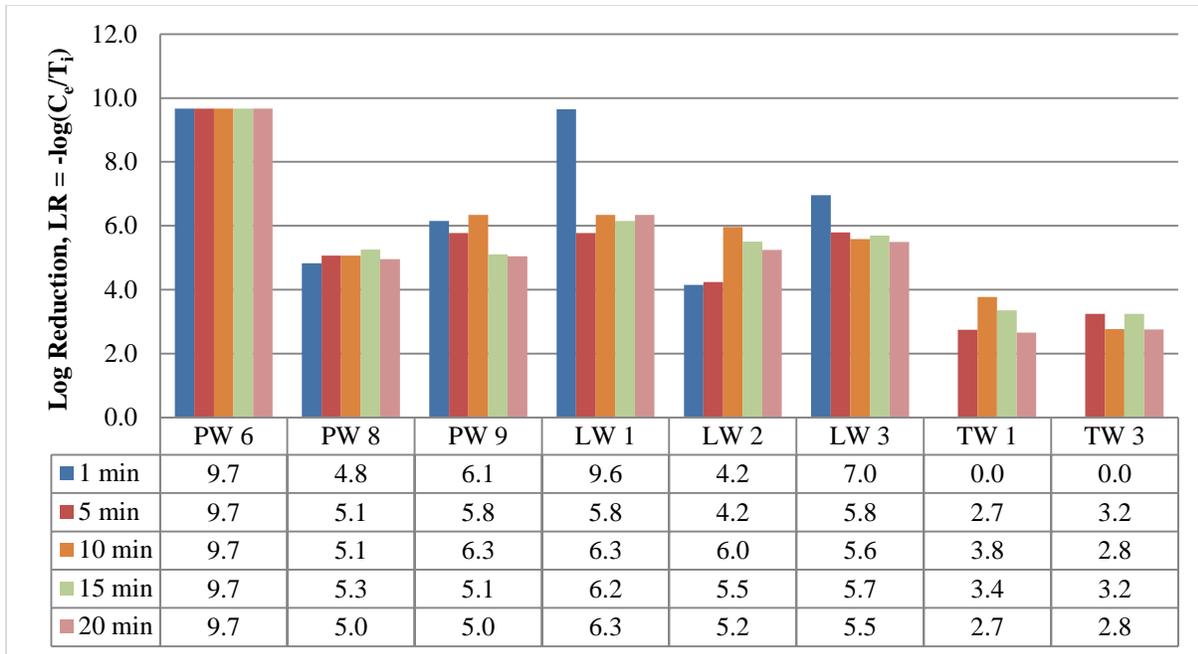


Figure 4-2. Log Inactivation based on sampling time for Low Flowrate

Uniformity of inactivation indicates the chloramines would have to be evenly distributed throughout the system. The lower flow rate may have permitted slower introduction of bacteria to treatment and thus to chloramine presence. While the in-flow rate was lowered the recirculation pump on the cart was not altered. Flowrate to the system was adjusted by increasing or decreasing inlet pressure. The rate at which the circulation pump moves the water would not be changed. Chloramine would have had adequate time to be flushed from the system without mixing of the two streams. The inactivation of 1 minute sampling times were disregarded by this reasoning.

Table 4-3. Influent and Average Effluent rates for individual test

Test	Influent (mpn/mL)	Effluent (mpn/mL)	Percent Reduction (%)	Log Reduction
BL	1.99E+05	1.06E+04	94.67	1.27
PW2	1.99E+05	3.31E+03	98.33	1.78
PW3	7.22E+04	2.24E+03	96.90	1.51
PW5	8.88E+04	6.93E+03	92.20	1.11

PW6	4.62E+04	1.00E+00	100.00	4.66
PW7	2.81E+04	1.00E+00	100.00	4.45
PW8	1.71E+04	1.45E-01	100.00	5.07
PW9	4.37E+04	2.07E-01	100.00	5.33
LW1	4.43E+04	3.65E-02	100.00	6.08
LW2	3.45E+05	5.82E+00	100.00	4.77
LW3	9.10E+04	2.15E-01	100.00	5.63
PW10	1.14E+05	2.31E+04	79.67	0.69
PW11	1.52E+05	2.17E+04	85.69	0.84
PW12	1.50E+05	1.92E+04	87.18	0.89
TW1	3.65E+05	4.21E+02	99.88	2.94
TW3	1.75E+04	2.03E+01	99.88	2.94

Effluent averages omitted the E1 sampling time due to incongruity throughout testing to the remaining sampling times. The pervasiveness of chloramine disinfection from the tap water used to prime the AOP cart contributed inconclusive results. The value for effluent (E_A) was determined from the average of E5, E10, E15, and E20 treated samples. The percent reduction was based on the difference of the initial (T) and effluent average reduction (E_A). Log Reduction values utilized the initial (T) and effluent average reduction (E_A).

Data Analysis

The value of total suspended solids ranged from 0 mg/L to 682 mg/L between 16 treatment samples. Values for TSS were collected from water quality testing by the Kansas State University Soil Testing lab. The rate of reduction indicates the elimination of bacteria based on percentage of inactivation from original values. The standard error for log reduction within each grouping of TSS levels reinforced the evidence that particulates were not a significant hindrance to a UV/O3 AOP. Figure 4-2 illustrates groupings of TSS ranges and the relative inactivation rates. For 0-60 mg/L the reduction averaged 93.17% with similar rates for 60-100 mg/L and 100-160 mg/L at 95.99% and 95.23%. The highest TSS levels or <160 mg/L experienced the highest rate of inactivation with 98.42%. The various groups represent 3-5 tests without distinguishing flowrate. The error bars represent standard deviation within the data groups. Reduction values were based on the average of inactivation for all associated effluent sampling times.

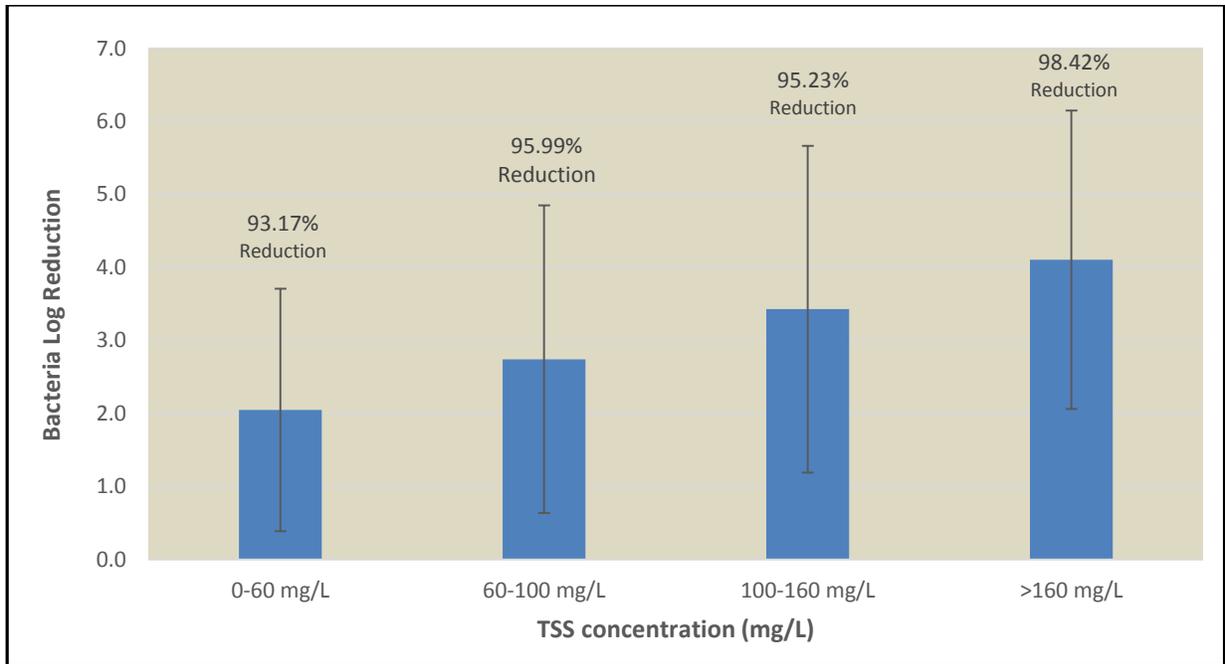


Figure 4-2. Log Inactivation of Bacteria relative to TSS concentration in mg/L.

Experimentation involved direct evaluation of highly turbid water from a runoff collection pond. Test sampling was expanded to 20 minutes with 150 gallons of water and 10 vials of 100 mL E. coli. To establish a baseline for comparison a dechlorinated tap water test was run with the 100 gallons of water and 8 vials of 100 mL E. coli with Tank samples reduced to a singular sample drawn from the middle. Bacteria concentrations and TSS levels were determined as consistent through several split samplings using Left, Right, and Middle collection points. One of the most important notes of the literature review dictates that contact time with ozone disinfection is vital. By reducing the flowrate to just above 3 gpm the level of inactivation was increased by 2-3 logs. Figure 4-3 illustrates the data as separated by difference of flowrate relative to percent inactivation. The two groupings, 6 gpm and 4 gpm, each consist of 8 individual tests and their average reduction. The error bars represent the standard deviation of inactivation within the two groups. Average reduction at a flowrate less than 4 gpm was significantly different than of flowrates of 6 gpm.

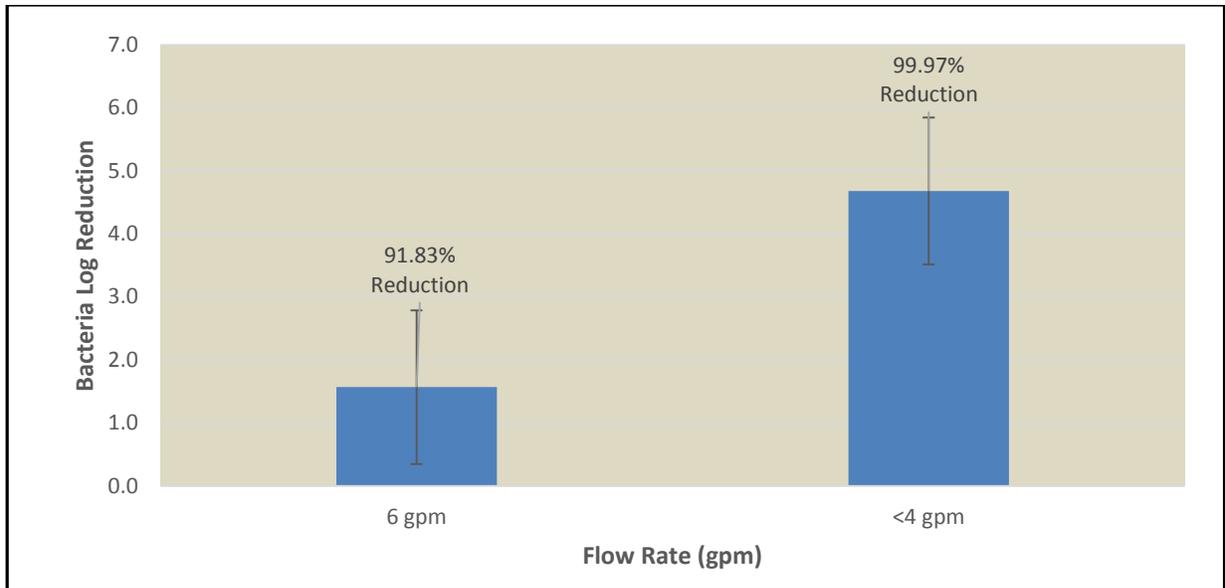


Figure 4-3. Log Inactivation of Bacteria relative to Flow rate in gpm.

Relation of Suspended Solids

The question of whether TSS was influential to the treatment process required closer observation of TSS levels and distribution. Analysis of TSS values, from 100 mg/L to 600 mg/L, resulting in similar reduction. Despite the increase of TSS the reduction ability of the AOP trailer remained uninhibited. In addition, higher TSS correlated with lower flowrates expressing the possibility of settling within the equipment, which would be expected to further hinder inactivation. At higher flowrates the relative TSS levels averaged 135 mg/L while at lower flowrates 160 mg/L.

Statistical Analysis

Is bacteria inactivation dependent on flow rate? The independent variable of flowrate was compared against the response variable, level of inactivation (Table 4-5). The high F value indicates a greater variation between the two scenarios rather than within the samples groups indicating flowrate is a significant contributor to inactivation. Flowrate can be observed as a relation to contact time, or the time of exposure to the treatment process. The connection between contact time and inactivation has been well established in the literature in reference to oxidation reactions and the advanced oxidation reactions occurring in the UV/O3 system. By reducing the flowrate, even marginally by 2 gpm, the rate of inactivation increased substantially. In a system requiring additional contact time the alternative to reducing flowrate would be repeated treatment or recirculation through the treatment system. This holds potential for future research on the matter.

Table 4-5. Single Factor ANOVA: Flow Rate

SUMMARY						
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>		
Low	8	37.42194	4.677743	1.360293		
High	8	12.54557	1.568197	1.484671		

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	38.67711	1	38.67711	27.18988	0.000131	4.60011
Within Groups	19.91475	14	1.422482			
Total	58.59186	15				

Variation between groups is lower than variation within groups of high and low TSS (Table 4-6). The low F statistic illustrates this relationship indicating that TSS does not have a significant influence on inactivation. The variation within the data shows that whether or not TSS is elevated does not influence effectiveness of the UV/O3 AOP to inactivate E. coli. The same principle is established in the literature in reference to ozonation, but not for UV irradiation. Because an AOP works in combination of the effects of UV and ozone the deficiency of ultraviolet irradiation as it is interfered with by particulate matter is overcome by the presence of ozonation and oxidation products

Table 4-6. Single Factor ANOVA: Total Suspended Solids

SUMMARY						
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>		
Low	8	19.15929	2.394912	3.220706		
High	8	30.80822	3.851028	3.937974		

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	8.481098	1	8.481098	2.369459	0.146022	4.60011
Within Groups	50.11076	14	3.57934			
Total	58.59186	15				

Conclusions and Observations

From the results of the AOP treatment, the most imperative parameter can be isolated as the contact time, which is limited by flow rate. The ability of the AOP system to overcome interference of particulates from a variety of water sources demonstrates the potential of the system and its applicability across a broad spectrum.

Many studies have been conducted to reinforce the ability of an AOP to degrade chemicals, particularly organics, but the verification of its multiplicity as it applies to pretreated sources has not been examined as here in.

In addition to the work performed in this study further testing could be used to evaluate the definitive capacity of the system to inactivate bacteria by recirculation, and therefore longer treatment contact. The ability to rule out interference from sediment and particulate matter is a valuable time saving tool. Filtration of water usually precludes treatment to eliminate reactivity consumption by particulates, but within the UV/O₃ system this may not be necessary initially. Depending on use of the water source the need to filtrate may be secondary to disinfection.

Quantifying Ephemeral Gully Erosion and Evaluating Mitigation Strategies with Field Monitoring and Computer Modeling

Basic Information

Title:	Quantifying Ephemeral Gully Erosion and Evaluating Mitigation Strategies with Field Monitoring and Computer Modeling
Project Number:	2016KS185B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	KS-001
Research Category:	Water Quality
Focus Category:	Sediments, Models, Water Quality
Descriptors:	None
Principal Investigators:	Aleksey Sheshukov

Publications

1. Bandara, C., A. Sheshukov, W. Boyer, 2016. Evaluating Soil Loss from Ephemeral Gullies with Photogrammetry and Computer Modeling. Governor's Conference on the Future of Water in Kansas. Nov. 2016. Manhattan, KS.
2. Karimov, V., A.Y. Sheshukov. 2016. Reservoirs sedimentation in Central Kansas: Aspect of soil erodibility due to subsurface and surface flows. Poster presentation at the Governor's Conference on the Future of Water in Kansas. Nov. 2016. Manhattan, KS

KWRRRI Annual Progress Report

- Title:** Quantifying Ephemeral Gully Erosion and Evaluating Mitigation Strategies with Field Monitoring and Computer Modeling
- Research category:** Water Quality
- Focus Category:** Sediments, Models, Water Quality
- Primary PI:** Aleksey Y. Sheshukov, Biological & Agricultural Engineering, Kansas State University, 129 Seaton Hall, Manhattan, KS 66506, ashesh@ksu.edu, (785) 532-5418
- Co-PI:** Ronald W. Graber, Kansas Center for Agricultural Research and Environment, Kansas State University, 3402 S. Haven Rd., Hutchinson, KS 67501, rgraber@ksu.edu, 620-727-5665
- Co-PI:** Will Boyer, Kansas Center for Agricultural Research and Environment, Kansas State University, 2014 Throckmorton Hall, Manhattan, KS, 66506, wboyer@ksu.edu, (785) 587-7828
- Reporting Period:** 3/1/2016 – 2/28/2017

Rationale and objectives:

Soil erosion causes severe soil degradation and significantly contributes to total soil loss in agricultural fields. Sheet, rill and ephemeral gully (EG) erosion are the main mechanisms that highly contribute to total soil loss in agricultural fields. This project focuses on understanding mechanisms related to EG formation, location, geomorphological properties related to storm characteristics, and quantifying the amounts of soil losses from EG erosion in Kansas. The objectives of the project are:

1. To assess EG-driven soil erosion by monitoring soil loss from EGs on several no-till fields in Kansas.
2. To evaluate factors that majorly contribute to soil loss along concentrated flow paths with a physically-based predictive model, and
3. To analyze a set of agricultural BMPs for effective mitigation of EG erosion.

Field measurements and data analysis

During first year of the project, we primarily focused on data collection from field measurements and preparation for computer modeling. We researched aerial imagery, land use/land cover, and digital elevation datasets in Riley and McPherson counties to select crop fields for our project that contained ephemeral gullies and were in no-till. With assistance of PIs, NRCS office in Manhattan, county extension agents, and after communicating with individual farmers, one no-

till field at Pillsbury crossing near School creek in Riley County was selected for field measurements (Figure 1). The field had several ephemeral gullies that were visible during in-person visits. Three gullies were selected for detailed soil loss monitoring (Table 1). All gullies had contributing catchment embedded within the field, which eliminated external inflows into the catchment with unknown runoff characteristics. A tipping bucket type rain gauge and flow meter were installed in the field to continuously measure rainfall and runoff rates.

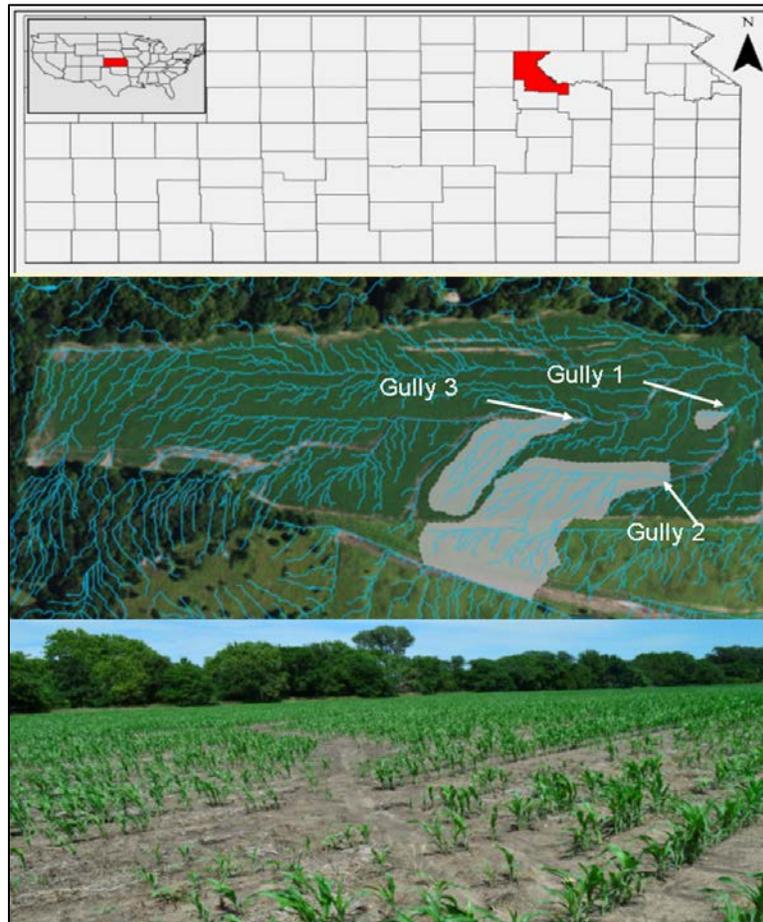


Figure 1. Map of the field, three studied gullies and their contributing areas.

Table 1. Catchment characteristics of three gullies.

	Gully 1	Gully 2	Gully 3
Drainage area (m ²)	390	12,700	4,270
Length of longest flow path (m)	33	242	140
Average slope of the longest flow path (degrees)	0.5	0.7	0.5

We used photogrammetry technique to detect soil elevation and calculate the changes between field visits and elevation measurements. Photogrammetry is based on the analysis of multiple photographs taken of the same area and creating a 3-D elevation model. To geospatially reference

the 3-D model and assure the accurate scale, several reference points within the observation area were established. We drove 10 cm long plastic survey stakes into the soil around a gully for X, Y, and Z reference. Each stake was surveyed by the total station prior to the use in photogrammetry software. We placed on average 2 stakes per square meter of an area. We purchased a full frame camera, Sony Alpha a7, with 50 mm prime lens, and designed and self-manufactured a backpack frame to mount the camera during field surveys. The camera was mounted on the frame at the height of 3 meters above the ground with 5 degree tilt away from the operator. The frame was attached to a backpack that was worn by the operator. The images were captured wirelessly through Wi-Fi technology invoked the shot from a tablet while walking along the gully. The imaging required six overlapping photographs to cover one square meter of ground surface and two consecutive photographs with at least 30% overlap.

The photogrammetry processing software, Photomodeler Scanner by Eos Systems Inc. (Vancouver, British Columbia, Canada) was purchased for image processing and building of 3-D elevation point clouds. The created point cloud datasets were geospatially referenced and scaled using the reference points. Final elevation data points were exported into ArcGIS software (<http://desktop.arcgis.com/en/arcmap/>) and desktop environment, where they were converted into digital elevation models (DEM).

Each gully was surveyed from headcut to end of channel areas during every field visit and point clouds were created. Variations in soil elevation between surveys were calculated as differences in point values. The total soil loss was obtained as an elevation difference multiplied by the pixel size for each point.

Due to field selection during spring and early summer of 2016, data collection started on July 13th of 2016. The field was frequently visited and surveyed six times in 2016: from July 13th to December 8th.

Results

All gullies showed total soil loss including gully deepening and widening over the entire observation period in 2016. Each gully showed average loss of soil depth from 35 mm to 45 mm (Figure 2) in 2016. Only few rainfall events were responsible for gully development. This contrasts with sheet and rill erosion, which has soil movement detected for each event.

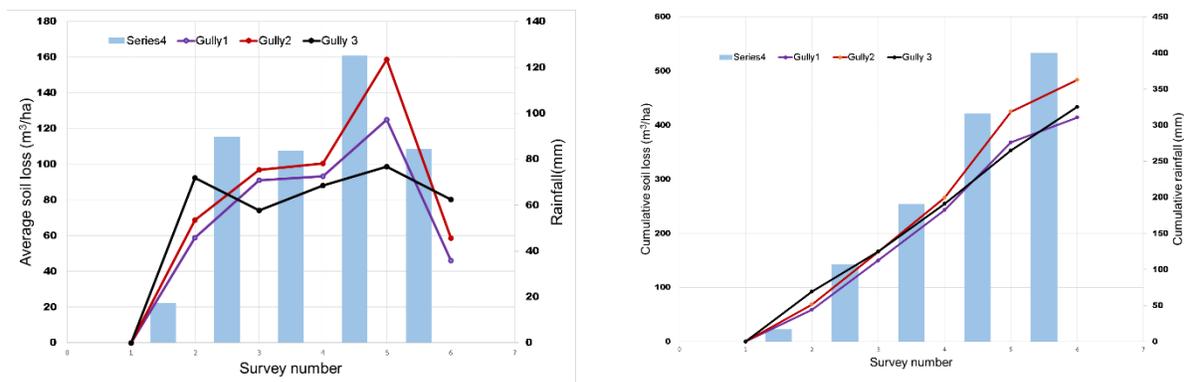


Figure 2. Event average (left) and season cumulative (right) soil loss (m³/ha) and rainfall (m)

The progression of gully 1 at a representative cross-section (Figure 3) and along thalweg (Figure 4) show clear headcut movement over time. According to cross sectional profiles the gully cross section had rectangular shape at the end of the growing season, which was consistent with observations in Gully 2 and 3. The headcut area had soil loss from 10 to 16 cm during one storm event in October. Map of the changes in soil elevation from the beginning to the end of 2016 is shown in the figure 5 for Gully 1. Positive values indicate soil loss and negative values indicate sediment deposition.

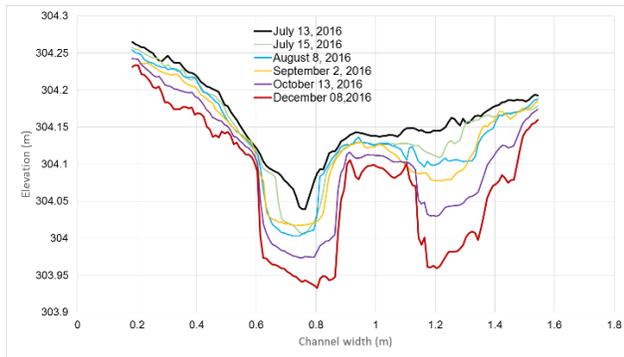


Figure 3. Elevation at a cross section of gully 1 at 6 surveys in 2016.

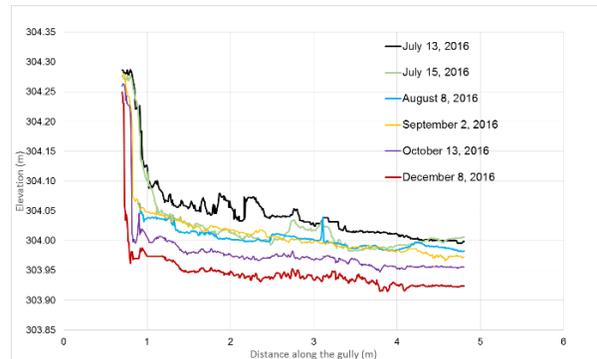


Figure 4. Elevation along thalweg of gully 1 at 6 surveys in 2016.

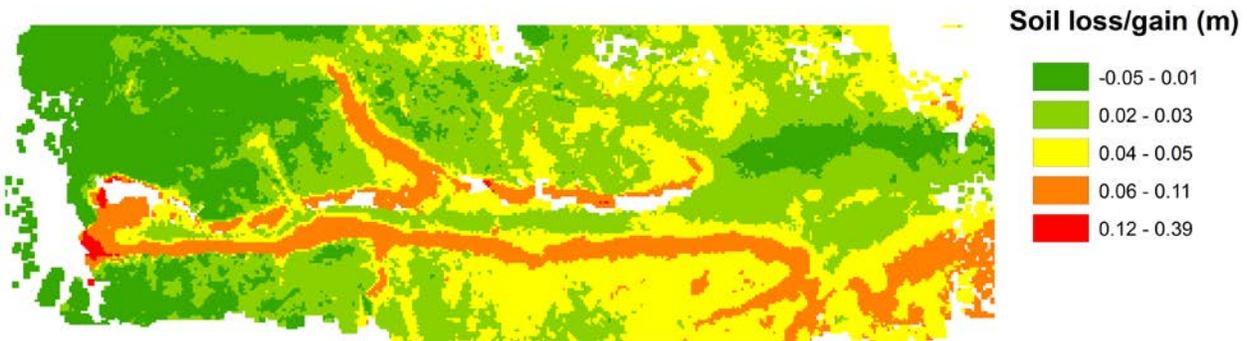


Figure 5: Map of soil elevation changes for gully 1 between July 13 and October 13, 2016. Positive values indicate soil loss due to erosion, while negative values show soil gain due to sediment deposition.

Future work in Year 2

In year 1, we established field measurements and collected continuous and survey data for three gullies. In year 2, we will continue data collection until the end of the year 2017. The elevation, runoff, and elevation datasets will allow us to restore the dynamics of runoff events for computer model calibration.

In year 1, we collected most of the required input data for tRIBS model. We also began a process of computer model development by preparing DEM, land use/land cover maps, soil, and other data for three gully catchments. A specific ephemeral gully model has been in development since

2016. The model is designed to work with tRIBS output datasets on the event basis. In year 2, the computer models will be developed for each gully and calibrated on field data.

Graduate training

We recruited one MS graduate student, Mr. Chinthaka Bandara, in Biological and Agricultural Engineering department who was fully engaged in field data collection and computer modeling. His expected graduation date is spring 2018. Another graduate student, Vladimir Karimov, PhD candidate in Biological and Agricultural Engineering department was involved in computer model development, especially, the gully model.

Mr. Vladimir Karimov was awarded first place at the student research poster competition at the Governor's Conference on the Future of Water in Kansas in Manhattan, KS. November 2016.

Monitoring the Effectiveness of Streambank Stabilization Projects in Northeast Kansas

Basic Information

Title:	Monitoring the Effectiveness of Streambank Stabilization Projects in Northeast Kansas
Project Number:	2016KS186B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	KS-001
Research Category:	Water Quality
Focus Category:	Sediments, Water Quantity, None
Descriptors:	None
Principal Investigators:	Charles J Barden

Publications

There are no publications.

KWRRI Annual Progress Report

- Title:** Monitoring the Effectiveness of Streambank Stabilization Projects in Northeast Kansas
- Research category:** Water Quality
- Focus Category:** Sediments, Water Quality
- Primary PI:** Charles J. Barden, Horticulture and Natural Resources, Kansas State University, 1712 Claflin Road, Throckmorton 2021, Manhattan, KS 66506, cbarden@ksu.edu, (785) 532-1444
- Reporting Period:** 3/1/2016 – 2/28/2017

Project Goals and Objectives

The project goal is to quantify the environmental benefits of government-sponsored streambank stabilization and restoration projects in northeastern Kansas, with a focus on sites within the Kickapoo Tribe in Kansas and Prairie Band Potawatomi Nation Indian Reservations. Specific objectives are to:

- 1) Document the erosion and deposition rates of existing streambank stabilization sites;
- 2) Compare the performance of cedar revetment and rock vein and weir projects;
- 3) Conduct bio-assessment surveys to document aquatic organism presence at the stabilized sites compared to nearby unstabilized reaches.

Field Data Collection

Stream bioassessments with macro invertebrates sampling was conducted twice on two sites on the Delaware River and Craig Creek, both on the Kickapoo reservation. The sampling was conducted in May and June 2016. Sample areas on the Delaware River were sites with rock weir and riparian buffer plantings. Control sites were unstabilized reaches immediately downstream. The Craig Creek site had a redcedar revetment installed in 2013, and the control site was immediately downstream.

Site Selection for New Cedar Revetments

Several sites were examined on the Kickapoo reservation for installing new revetments as part of this project. Also, several sites were nominated by the Delaware River Wraps coordinator, and Kansas Forest Service staff. Two sites were selected for installation in the spring of 2017, on Little Grasshopper Creek in Atchison county and Wolfley Creek in Nemaha county, both within the Delaware WRAPS area.

Outreach and Technology Transfer

Two new watershed foresters were hired by the Kansas Forest Service, and the PI spent several days teaching the new staff about streambank stabilization techniques, and visiting previously treated and potential project sites.

Graduate training

One MS graduate student, Denisse Benitez Nassar, was recruited, and began her program in January 2017 in the Horticulture and Natural Resources department. She had served as an intern on the project from January – April 2016, while an additional intern Paola Carolina Negrete served in that capacity from January – April 2017. Both interns came from Zamorano University in Honduras.

Future Work in Year 2

Research

In March and April 2017 the new cedar revetments will be installed, and a set of bank pins will be inserted above stabilized and unstabilized reaches at both sites.

We will repeat the macroinvertebrate sampling on the Kickapoo sites in May and June 2017.

During the summer and fall, we will revisit the long-term streambank monitoring sites for measurements on exposed bank pins on a site near Axtel in Nemaha county (installed March 2007), and on Little Soldier Creek on the Prairie Band Potawatomi Nation (installed March 2000).

Outreach and Technology Transfer

In May 2017, the study sites will be included on a field tour for the North Central Extension Water Summit "Building Collaboration Between State Land Grant Universities and Tribal Colleges". Also the PI will be presenting about the current study at the summit.

The Kickapoo tribe no longer organizes the conservation day camp, so instead, the project will help organize an Earth Day celebration and lessons at the Kickapoo Nation School.

Assessing the impact of constructed wetlands on nitrogen transformation and release from tile outlet terraces (TOTs) in Kansas

Basic Information

Title:	Assessing the impact of constructed wetlands on nitrogen transformation and release from tile outlet terraces (TOTs) in Kansas
Project Number:	2016KS187B
Start Date:	3/1/2016
End Date:	2/28/2017
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Publications

There are no publications.

Title: Assessing the impact of constructed wetlands on nitrogen transformation and release from tile outlet terraces (TOTs) in Kansas.

Research Category: Nutrient Transport and Transformation

Focus Category: Nitrogen

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Abstract

The goal of this work was to determine the influence of tile outlet terrace (TOT) croplands that are connected to constructed wetlands on fluxes of nitrogen and sediment. Work on this research commenced in June 2016 and is ongoing through 2018. Here we provide the 2016 preliminary results from two TOT fields where tiles are drained to constructed wetlands. During this period we measured water fluxes and water chemistry into and out of the wetlands. Rainfall, water velocity and water levels were measured continuously, while automated samplers facilitated the collection of water chemistry during storm events and grab samples were collected weekly/biweekly from within the wetlands to understand wetland water chemistry variability. Over the next year we will continue with water sampling collection, collecting soil water in fields using lysimeters and finish bulk chemical analysis of soil. We will use these data together to separate storm hydrographs to event and pre-event water, determine the sources and interactions of pre-event water and develop a conceptual model of N transformation and flux for TOT systems.

Introduction

Nitrogen (N) contamination of water bodies pose serious risks to human health and ecological services. Enhanced applications of N fertilizer over the past ~60 years have also been concomitant with increases in bicarbonate (HCO_3^-), metals and metalloid concentrations in some of our largest river systems (Raymond and Cole, 2003; Stets et al., 2014). The transformation of N is sensitive to the availability of oxygen (O_2): NH_4^+ produces NO_3^- and protons (H^+) through nitrification by autotrophic bacteria in the presence of O_2 , while NO_3^- can be reduced by denitrification in the absence of O_2 , consuming protons. These processes can take place at roughly the same time depending on the soils O_2 availability (Reddy et al., 1976), but the overall production of H^+ drives soil acidification and chemical weathering, which releases metal and metalloids into solution (Semhi et al., 2000).

Unfortunately, while research efforts have focused on developing BMPs for fertilizer application, N contamination to surface water and more recently shallow and deep groundwater remains a real threat (Burow et al. 2010; Gurdak and Qi, 2012). For example, groundwater in the Central Plains has been highlighted to have some of the highest groundwater NO_3^- concentrations. In Kansas, roughly 0.03 to 0.12 t ha^{-1} of N fertilizer is applied annually for agriculture, and long term studies of N fertilizer purchase suggests the rate of consumption has increased at ~8% over the last decade (EPA, 2015). Thus, questions still remain as to the transformation, transport and fate of N under varying agricultural practices and its influence of metal and metalloid transport.

One runoff control practice that has been employed for the last century is tile outlet terraces. Here, the goal is to reduce surface runoff (and associated erosion) by effectively creating a sewer drainage system within an agriculture landscape. As such, the hydrology of the landscape is transformed, water is allowed to pool in depressions on the landscape before entering surface pipes where it is transmitted in the subsurface to the outlet drainage system (ditch or stream). While a larger proportion of water is lost through the tile drains this re-routing of water alters natural subsurface flow paths to increase infiltration, lateral vadose zone water flow and soil-water interaction, and thus enhances adsorption/desorption

processes and colloid mobility. Until recently these systems emptied directly into adjacent streams, enhancing the transport of dissolved nutrients between the agricultural fields and streams. New BMPs that create wetland intermediaries to capture nutrients from the outflow are now being tested. The development of these tile outlet terrace systems and constructed wetland systems begs the questions: *how have these modification altered water flow across the system and the transformation and fate of N?* and *what is the effect of wetland design on nutrient capture effectiveness?*

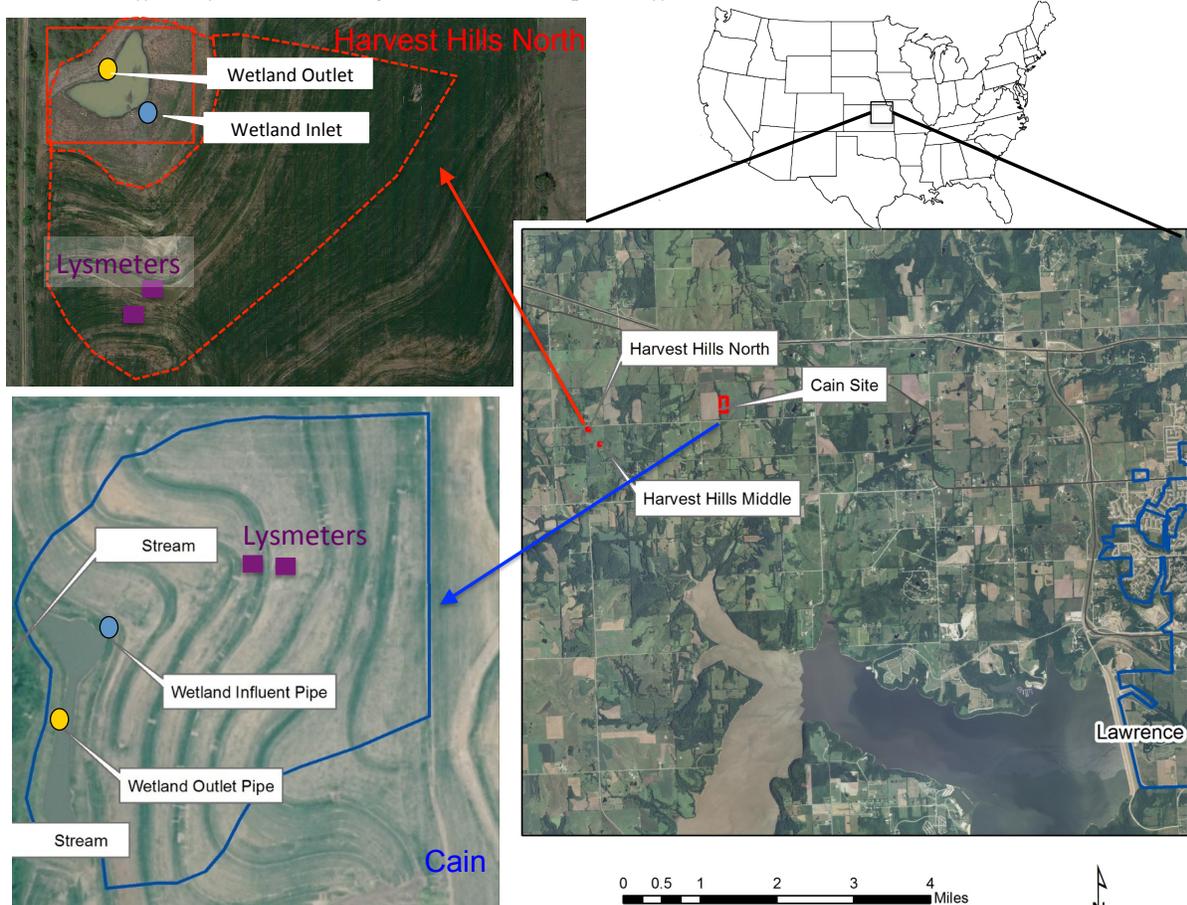


Fig. 1 Two tile outlet terraces (TOTs) with constructed wetlands at the outlet were monitored in 2016. These fields are located in the Wakarusa Watershed and drain to Clinton Lake, main drinking water supply for the city of Lawrence. Water from the inlet and outlet pipes as well as soil water was collected and measured over this period.

Study Area: Two tile terraced cropland systems located within the Wakarusa Watershed in Douglas County, KS, and drain to Clinton Lake were examined for this project in 2016 (Fig. 1): Harvest Hills North (HHN) (38°59'05.5"N, 95°27'19.0"W) and Cain (38°59'21.9"N, 95°25'19.9"W). A third site Harvest Hills Middle (HHM) will be included in 2017. All sites are (Fig. 2): 1) terraced and consist of slight ridges and depressions across the landscape, 2) have perforated standpipes, located in the depressions, connect to the tiles helping to drain depressions, and 3) have tiles that discharge to constructed wetland ponds (built between 2008-2011), which eventually discharge to nearby intermittent streams through a weir box. The streams drain into the Clinton Lake, a main drinking water supply to the city of Lawrence (KS).

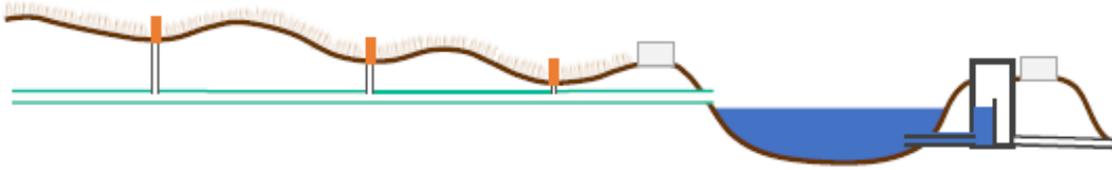


Fig. 2 Diagram of tile outlet terraces and associated wetlands for the Harvest Hills North and Cain fields. The orange boxes represent the perforated standpipes, located in depressions, that connect to the tiles below the surface.

Harvest Hills North drains ~ 7.6 ha and consists of four terraces, while Cain drains ~ 16.6 ha and consists of six terraces. In 2016, Harvest Hills North was planted with corn followed by wheat, while Cain was planted with corn on the four upland terraces and soy on the lower two terraces.

The agricultural research sites are located about 20 km west of Lawrence, and are separated by ~3.2 km. The general lithology of Douglas county (which encompasses the research sites), consists of limestone, shale, and sandstone. The local climate of Lawrence and extending areas are continental and the growing season spans ~196 days. The average annual temperature according to NOAA (1981-2010 Normals; <https://www.ncdc.noaa.gov>) is 12.4 °C and ranges from 30.3 °C in the summer to -6.3 °C in the winter. The average annual precipitation is 1013 mm with ~70% of the total precipitation falling in the spring and summer months.

Methods

Water Flux Measurements and Water Sample Collect From Tile Outlet and Wetland

The water flux and sample collection methods were configured the same for the HHN and Cain outlets. Here, the tile outlet, the pipe that connects to the drainage tiles from field to the wetland, was equipped with a velocity area meter (Model 750, ISCO) to determine water flux (discharge, m³/s) from the pipe into the wetland and automated water sampler (ISCO Model 6712 Full-Size Portable Samplers) to collect samples. The velocity area meter records both velocity and depth of water. Discharge (m³/s) is the product of the velocity (m/s) and the filled water area (m²) in the pipe. The area (A) is solved using the following equation

$$A = \frac{R^2}{2} (\theta - \sin\theta)$$

where R is the radius of the circle and θ is the central angle in radians.

At the wetland outlet two configurations were used: at HHN, the outlet pipe that drained the wetland went to a weir box that was outfitted with a pressure transducer (Model 720, ISCO) and automated water sampler (ISCO Model 6712 Full-Size Portable Samplers) to collect samples, while at Cain, a culvert directly drained the wetland and water levels were determined at the mouth of the culvert using a pressure transducer (Model 720, ISCO) and water samples were collected from inside the culvert using an automated water sampler (ISCO Model 6712 Full-Size Portable Samplers). The outlet discharge (Q, ft³) from the HHN sites was calculated using a stage-discharge relationship:

$$Q = 3.33 \times L \times H^{1.5}$$

where L is the width across the weir and H is the height of water above the weir crest. For the Cain outlet a rating curve was employed

$$Q = 1.511 \times S^2 - 3116.195 \times S + 1606117.046$$

where Q, discharge (ft³) is related to S, stage (ft, elevation). Discharge values were then converted from

ft³ to m³.

All data collected from the tile outlet is referred to as *Inlet* data (e.g., HHN_Inlet and Cain_Inlet), while data collected from the wetland outlets is referred to as *Outlet* data (e.g., HHN_Outlet and Cain_Outlet). At all automated sensors (velocity meters and pressure transducers) collected data at a 1-minute frequency, while water samples were collected every 30 minutes per storm event once flow was detected at the velocity meters at the inlet sites or once a specific water height surpassed for the outlets sites. Water then was collected for the 12 hours following the rain event given velocity and water levels were large enough to produce flow into or out of the wetland. Within one day of the rain event, water samples were collected from ISCOs. In addition, to tile outlet velocity, precipitation was also measured at the inlets using a standard rain gauge tipping bucket (674 Tipping Rain, ISCO). Rain measurements were also collected at a 1-minute interval. In 2016, inlet and outlet sites were outfitted with equipment at the HHN on 5/27/16 and at Cain on 6/8/16 and removed on 10/27/16, before the first frost. In 2017, inlet and outlet sites were outfitted with equipment at the HHN on 5/15/17 and at Cain on 5/8/17 and are expected to be removed at the end of October 2017. Grab water samples were also collected weekly to bi-weekly from the wetlands to quantify changes in the wetland water chemistry between rain and flow events.

Soil Water Sampling from Suction-Cup Lysimeters

In March 2017, nested suction-cup lysimeters (SK20, Decagon) were installed at 30, 60, and 90 cm in to the soil using an auger specific to the diameter of the suction-cups. Soil samples were collected from the auger every 10 cm for bulk geochemical analysis. Nested lysimeters were installed at a ridgetop and depression couplet of one terrace at each of the field sites to quantify nutrient transformation with depth under more (ridgetop) and less (depression) drained conditions. A hand held pump was used to apply suction to the lysimeters, lysimeters were vacuumed to ~100 PSI. Water samples were collected weekly from lysimeters given water availability.

Water Chemistry Measurements

All water samples were immediately brought back to the lab, aliquoted for appropriate chemical analysis (unfiltered, filtered with 0.8 μm filter, and filtered with 0.45 μm filter) and then stored in a refrigerator at 4°C. Unfiltered samples were analyzed for total nitrogen (TN) and phosphorus (TP). Water was then filtered through a 0.8 μm filter for total dissolved nitrogen (TDN) and phosphorus (TDP) analyses. TN and TDN were prepared for analysis using alkaline-persulfate digestion that oxidizes inorganic and organic nitrogenous compounds to nitrate (Reschke et al., 2014). TP and TDP were prepared for analysis acidic persulfate digestion that oxidizes organo-phosphates to inorganic ortho-phosphate (v). A Shimadzu 1650-PC UV/Visible light spectrophotometer was then used to determine the concentrations of TN, TDN, TP and TDP. Suspended load in the water samples was determined by weight change on the 0.8 μm filters, filters were dried and weighed prior to filtration and then dried and weight post filtration, given ample water was collected 250 ml of sample was filtered. Finally, the water underwent a second filtration using 0.45 μm nylon filters, this water was analyzed for major anions and cations (preserved with HCL) using an Dionex IC-1600. Anion analysis included measurements of chloride (Cl⁻), nitrate (NO₃⁻), and sulfate (SO₄⁻) while cation analysis included measurements of sodium (Na⁺), potassium (K⁺), magnesium (Mg²⁺), ammonium (NH₄⁺) and calcium (Ca²⁺).

Bulk Geochemical Analysis

Soils were ground to 150 μm in spring of 2016 and are awaiting digestion by the lithium metaborate fusion technique (Feldman, 1983). Digestions will be analyzed for bulk cation concentrations on an Inductively Coupled Plasma with Optical Emission Spectrometry (ICP-OES) in the summer of 2017.

Preliminary Results and Future Analysis

Hydrology

During the 2016 monitoring period (157 days), there were 37 and 58 rain events recorded at the HHN and Cain sites, respectively. Rainfall events averaged 0.19 and 0.10 cm for HHN and Cain, respectively (Fig. 3a). A minimum threshold of flow, 0.1 m/s, was necessary for water sampling collection to take place, given this restriction, there were 6 and 11 flow events that produced enough flow for sample collection at the inlets of HHN and Cain, respectively (Fig. 3b,c). At the outlet of both sites flow was produced for the same number of events as inlet flows (Fig 3d), with slightly fewer events at the HHN than observed at Cain. Overall the magnitude for velocity and water level responses at Cain inlet and outlet was greater than that of HHN, which is not surprising given the Cain field is nearly triple the size of the HHN field.

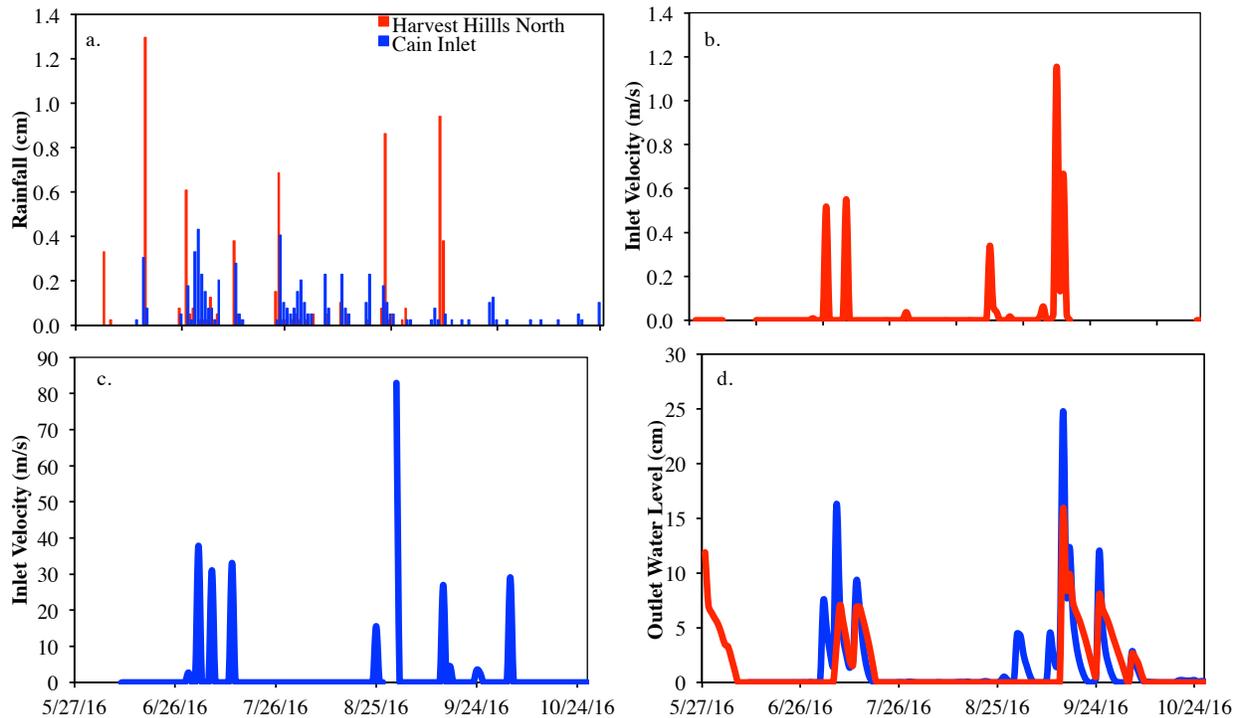


Fig 3. (a) Rainfall at the HHN and Cain sites over 2016 compared to velocity at the inlets of (b) HHN and (c) Cain sites and (d) water levels at the outlets of HHN (red) and Cain (blue).

For each flow event, we are currently in the process of evaluating the hydrograph response. Here our goal is to take a statistical approach to examining the change in slope of the falling limb. Preliminary analysis suggests a steep change in the hydrograph (indicated in dashed black line, Fig 4). One inference is that upper part of the hydrograph is considered event water that has undergone little interaction with subsurface while the lower part of the hydrograph is pre-event water that was stored in the soils prior to the rain event. Over the next several months we will use water chemistry data to help us decipher the waters contributing to the title outlet runoff. The same analysis will also be performed on the Cain sites.

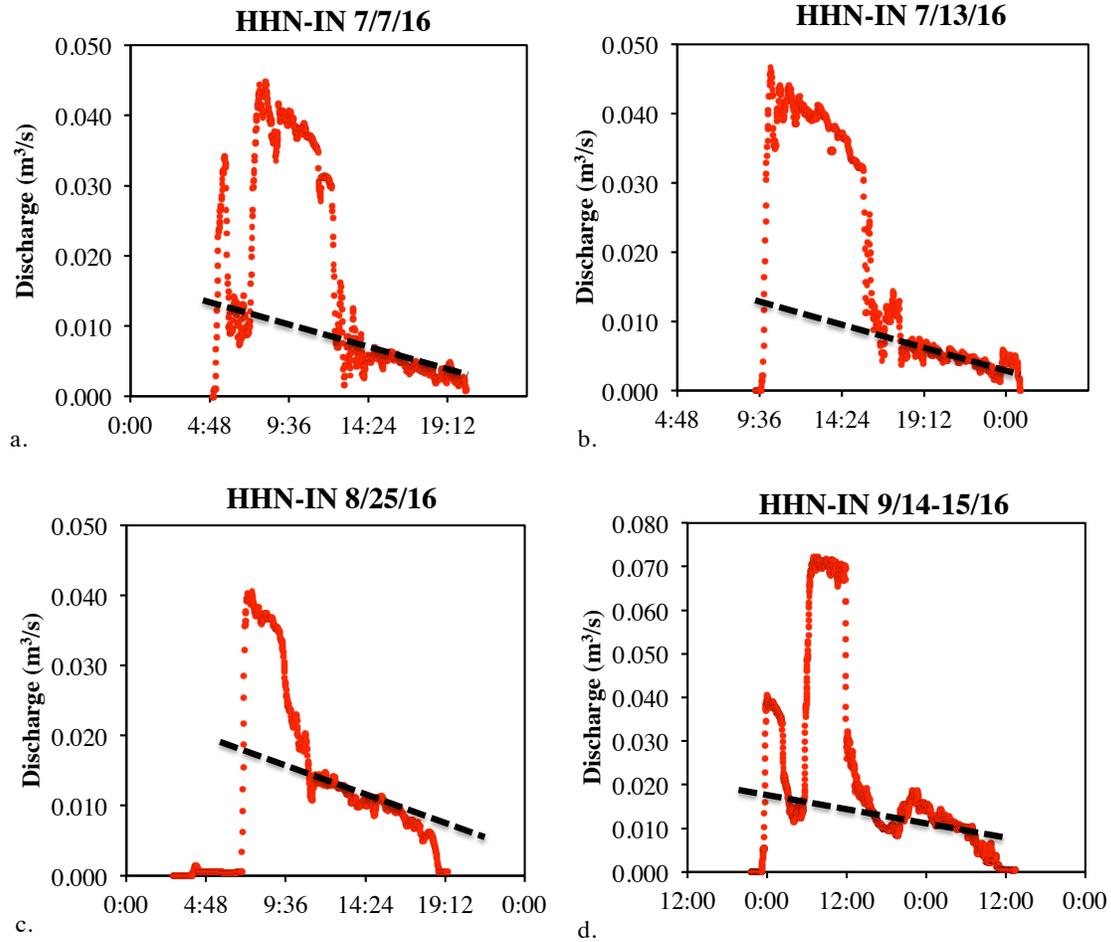


Fig 4. Hydrographs for four different storm events at the HHN site. Black line indicates meaningful change in slope.

Water Chemistry

Multiple approaches were used to monitor water chemistry at the inlet, within the wetland and from the outlet over the study period. Cation analysis is still on going for many of the samples and will be presented with the final report. Here, we report back on concentration of total nitrogen (TN), total phosphorus (TP), total dissolved N (TDN), total dissolved P (TDP), total suspended solids (TSS), nitrate (NO₃⁻), chloride (Cl⁻) and sulfate (SO₄²⁻).

WETLAND CHEMISTRY

For the wetlands themselves, grab samples were collected weekly to biweekly to monitor variability over the growing season and early fall. At HHN wetland total nutrient concentrations (Fig. 5 a.TP, b.TN, c. TDP) declined over the growing season in the wetlands while NO_3^- and SO_4^{2-} increased (Fig. 5f and h). Concentrations of Cl⁻ appeared to show more of a seasonal signal increase in the early summer and decline into the fall (Fig. 5g).

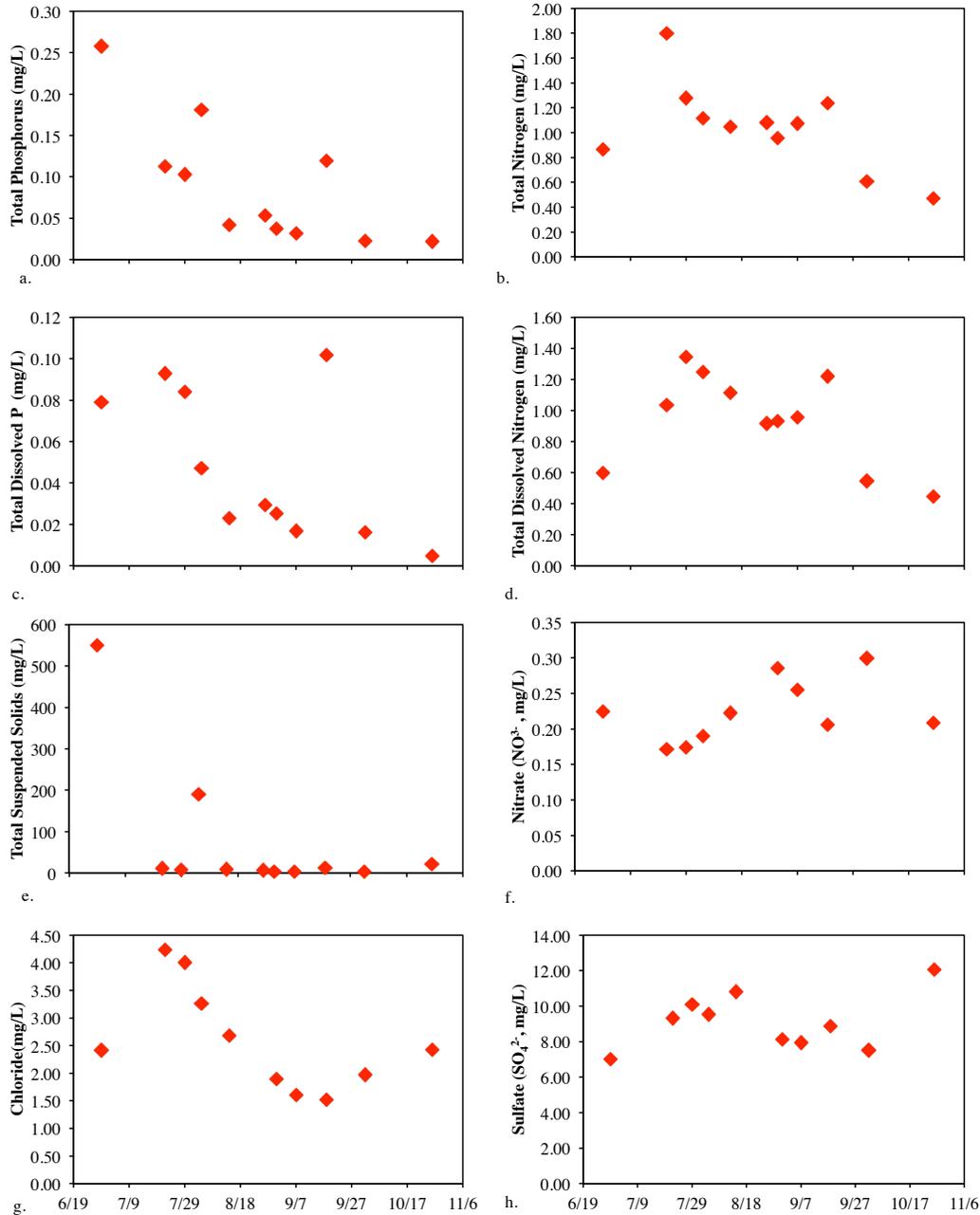


Fig. 5 Harvest Hills Wetland concentrations of (a) total phosphorus, (b) total nitrogen, (c) total dissolved phosphorus, (d) total dissolved nitrogen, (e) total suspended solids, (f) nitrate as nitrate, (g) chloride and (h) sulfate as sulfate for the 2016 monitoring period.

The trends in wetland water chemistry at Cain were less apparent over time. Concentrations of many constituents were high following the spring rains and then declined abruptly and remained fairly stable (Fig 6). Interestingly, concentrations of TDN, NO_3^- , Cl^- and SO_4^{2-} were all elevated in HHN wetland compared to the Cain wetland.

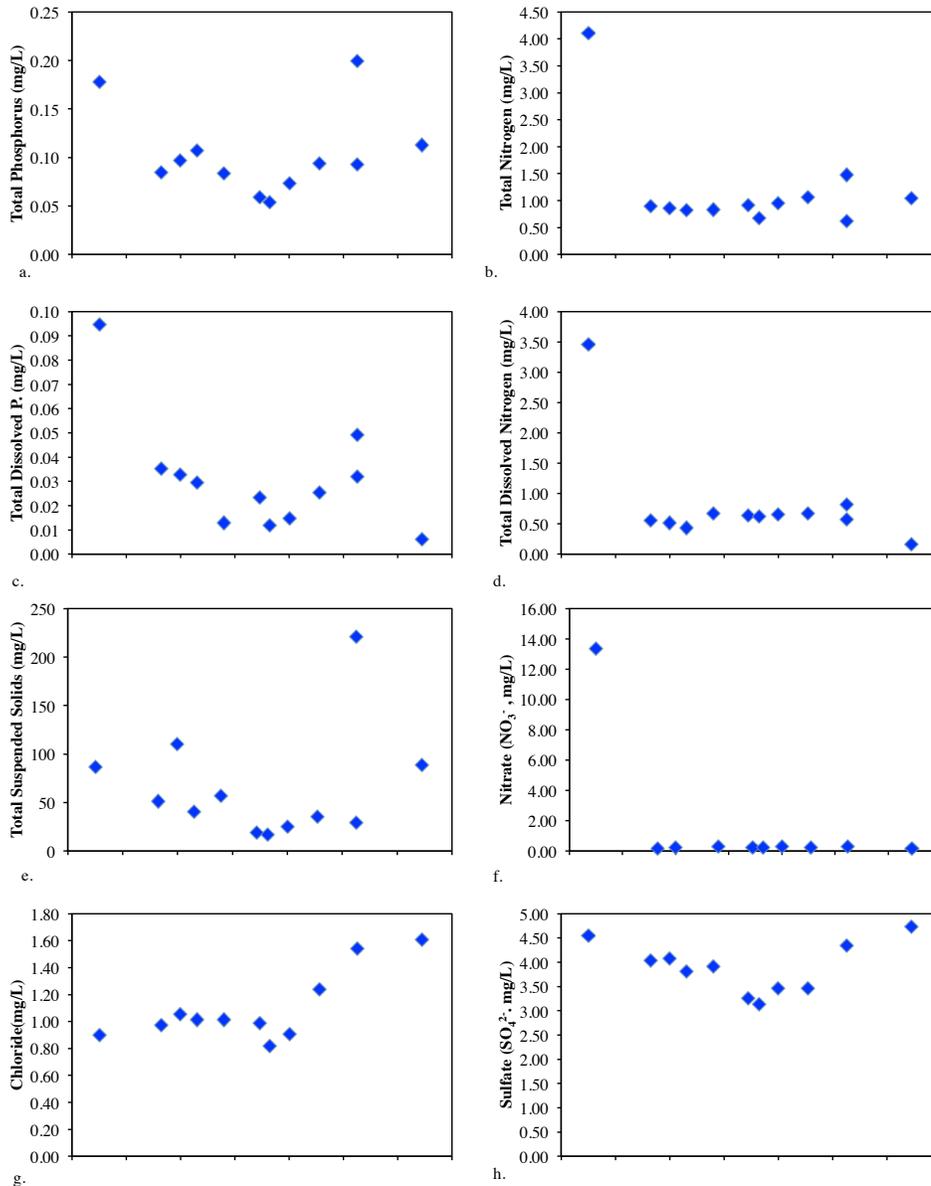


Fig. 6 Cain wetland concentrations of (a) total phosphorus, (b) total nitrogen, (c) total dissolved phosphorus, (d) total dissolved nitrogen, (e) total suspended solids, (f) nitrate as nitrate, (g) chloride and (h) sulfate as sulfate for the 2016 monitoring period.

STORM EVENT WATER CHEMISTRY

Currently we are in the process of examining the storm event water chemistry from the site. For rain events that produced ample flow, inlet and outlet water were collected on a 30 min interval using automatic samplers. During 2016 a number of malfunctions occurred with the samplers, where samples

were either skipped or not collect. We have worked this winter on the automatic samplers to insure this will not be a problem in 2017. We were able to capture the greatest number of storm events from the Cain Site. Fig. 7 demonstrates one event on 7/7/16 (discharge hydrograph shown in Fig.4a). Over this storm event, the wetland appears to have sequestered TP, TDP, and TSS, evinced by the higher concentrations coming into the wetland than leaving the wetland. Conversely, the wetland had little impact on sequestering TN with greater concentrations of TDN leaving from the wetland than entering, and primarily in the form of NO_3^- . In addition, concentrations of SO_4^{2-} leaving the wetland were greater than that entering, suggesting an addition of SO_4^{2-} to the system. These concentrations will be paired with discharge data so that we can quantify this specific flux.

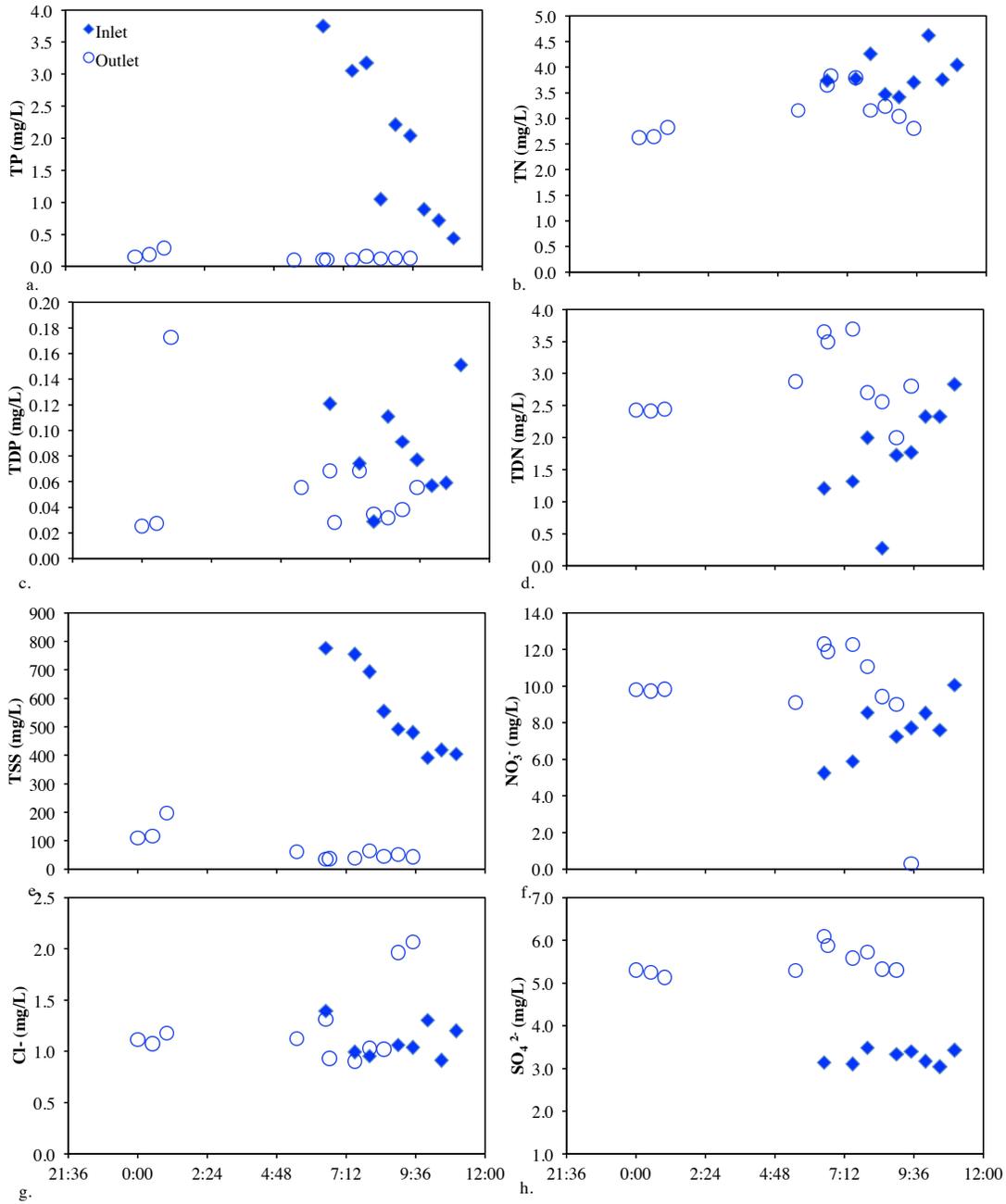


Fig. 7 Inlet (closed) and outlet (open) water chemistry collect from a storm event on 7/7/16 at Cain. Concentrations include: (a) total phosphorus, (b) total nitrogen, (c) total dissolved phosphorus, (d) total dissolved nitrogen, (e) total suspended solids, (f) nitrate as nitrate, (g) chloride and (h) sulfate.

LYSIMETER WATER CHEMISTRY

Preliminary soil water chemistry data collected using lysimeters demonstrates that anion (Cl^- , NO_3^- , and SO_4^{2-}) concentrations are generally greater at HHN than Cain at all depths. At the HHN site the ridgetops tend to have higher concentrations of Cl^- and NO_3^- , while the depressions are extremely elevated in SO_4^{2-} . At Cain the concentrations of Cl^- and NO_3^- are elevated at 30 cm deep in the ridgetops but greatly reduced at 60 and 90 cm, where the concentration are similar to that of the depression. At Cain, soil water concentrations of SO_4^{2-} were most elevated at the ridgetop 30 cm depth and in the depressions at 60 and 90 cm deep.

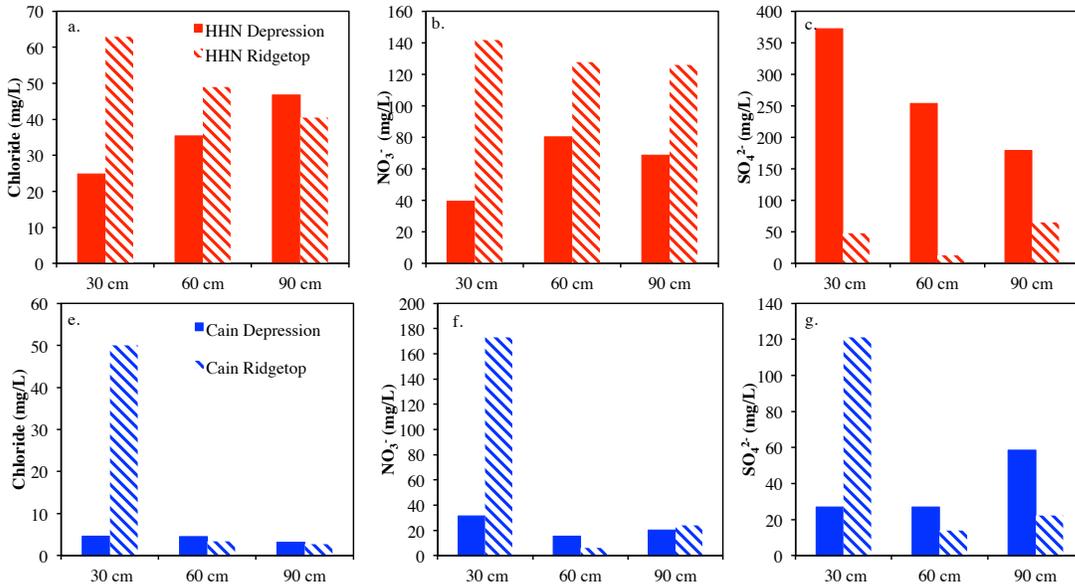


Fig. 8 Soil water chemistry at 30, 60, and 90 cm deep collected on the ridgetops (hashed) and depressions (closed) at HHN (top) and Cain (bottom) site.

Sampling and Analysis in 2017

All water measurements will continue in 2017. In addition, wetland soil samples will be collected in May 2017 and October 2017. Hydrograph analysis will continue and mixing models will be developed to elucidate chemical fluxes through the inlet. Finally, overall effectiveness of the wetlands will be established by comparing inlet and outlet chemical fluxes.

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Contaminant Barriers or Pathways? Hydraulic and chemical methods to improve characterization of shallow aquitards.

Basic Information

Title:	Contaminant Barriers or Pathways? Hydraulic and chemical methods to improve characterization of shallow aquitards.
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End Date:	2/28/2017
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Focus Category:	Groundwater, Water Quality, None
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Principal Investigators:	Jordi Batlle-Aguilar, James J Butler

Publications

There are no publications.

Project number: 2016KS188B –progress report year 1.

Project Title: **Contaminant barriers or pathways? Hydraulic and chemical methods to improve characterization of shallow aquitards**

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1 Introduction and project goals

Shallow aquifers are heavily exploited for drinking-water and irrigation supplies. These aquifers are often part of multi-layered systems where confining layers (aquitards) play a paramount role in “isolating” an aquifer from overlying or underlying units with poorer quality waters. The “isolating” capability of an aquitard —i.e. its ability to serve as a protective barrier to point (e.g., accidental spillage) or diffuse (e.g., agricultural fertilizer, manure, and pesticides) contamination— is commonly characterized using the vertical component of hydraulic conductivity (K_z). This parameter, which in a simplistic fashion is often assumed to be 0.1 of its horizontal component (K_H), requires more confident estimates when it comes to protect groundwater used, directly or indirectly, for human supply. The vertical hydraulic conductivity of an aquitard can be estimated using hydraulic or chemical methods; each method represents specific spatial and temporal scales and is based on a certain set of assumptions. The key questions are what method is most appropriate for a particular application and how much uncertainty is introduced by each one.

The main goal of this research project is to explore the variability of K_z estimates on shallow aquitards using different methods at two sites in Kansas with shallow aquitards but contrasted hydrogeological settings: the Geohydrologic Experimental and Monitoring Site 2 (GEMS2) and the Larned Research Site (LRS). This progress report covers the first year of the project and focuses on the GEMS2 field site only.

2 Field site location and hydrogeology

The Geohydrologic Experimental and Monitoring Site 2 (GEMS2), a Kansas Geological Survey (KGS) research site, was selected as a representative shallow clay aquitard with a confined alluvial aquifer underneath. The site is located northeast of Lawrence, Kansas, in the alluvial plain of the Kansas River, at 30 meters distance from Mud Creek (Figure 1). Previous Electrical Conductivity (EC) direct push logging performed on the site suggested that overlying the confined aquifer are 7 m of clay and 2 m of silt at the

surface. The sandy-gravel confined aquifer, approximately 11 m thick, is bounded underneath by low permeability bedrock (Liu et al., 2012).



Figure 1. Location of the study site GEMS2 (Geohydrologic Experimental and Monitoring Site 2) (source: Google Earth).

3 Materials and methods

3.1 *Drilling, coring and instrumentation*

The aquitard at GEMS2 was equipped with four aquitard piezometers and two vibrating wire piezometers (VWP). Screen depths for the aquitard piezometers and VWPs were selected based on a direct-push EC profile performed at the study site in August 2016 (Figure 2). Drilling and equipment installation were performed between August 2016 and April 2017. Four aquitard piezometers were drilled with a maximum intake zone of 1 m, at increasing depths (in meters below ground): G2J1 (3.8–4.0 m), G2J2 (5.0–6.0 m), G2J3 (6.0–7.0 m), and G2J4 (7.0–8.0 m). Two vibrating wire piezometers, VWP1 and VWP2, were installed at 5.5 m and 7.5 m depths, respectively, with their pressure-sensitive diaphragm located at 5.7 m and 7.7 m.

Each of the four aquitard piezometers was drilled using a dual-rod system (8.25 cm outer diameter [OD] with a shoe 8.78 cm OD) using the KGS Geoprobe® 7822DT. Both inner and outer rods were simultaneously driven to the depth where the top of the screen would be located. There, the inner rods and attached drive point were removed from inside the outer rods. A thin-walled sample barrel (5.3 cm OD × 4.6 cm inner diameter [ID]) with attached cutting shoe (5.4 cm OD) and a plastic liner with core catcher inside was then lowered back inside the cased hole and advanced for half a meter. A core (4.2 cm diameter)

was retrieved, and this process was repeated once more, obtaining a total of two cores for each intake zone. Given the plasticity of the clay, each of the two extracted cores expanded by approximately 30%. To diminish the impact of soil compaction, the sidewall of the screen length was scraped several times with an 8.6 cm diameter brush. The 1 m screen length of piezometers G2J2–G2J4 was filled with clean industrial quartz sand, and the outer steel rods above the screen length were left on site until the sand was completely saturated with porewater. In piezometer G2J1, only the lower 30 cm were filled with sand. Without waiting for the sand to saturate, the same day of drilling a 3.175 cm outer diameter PVC pipe was pushed 2.5 cm into the sand. With the top of the PVC sealed with a cap to avoid contamination inside the piezometer, the area between the aquitard and the PVC was filled with clean industrial quartz sand for 70 cm, followed by 10 cm of granular bentonite (Enviroplug® #16). Finally, the outer steel rod was pulled up at the same time that the empty space between the PVC and the aquitard was grouted to the land surface (Enviroplug® grout; K approximately $1 \times 10^{-11} \text{ m s}^{-1}$). For piezometers G2J2–G2J4, the completion procedure was the same once the 1 m sand intake zone was saturated. Details on each aquitard piezometer can be found in Table 1.

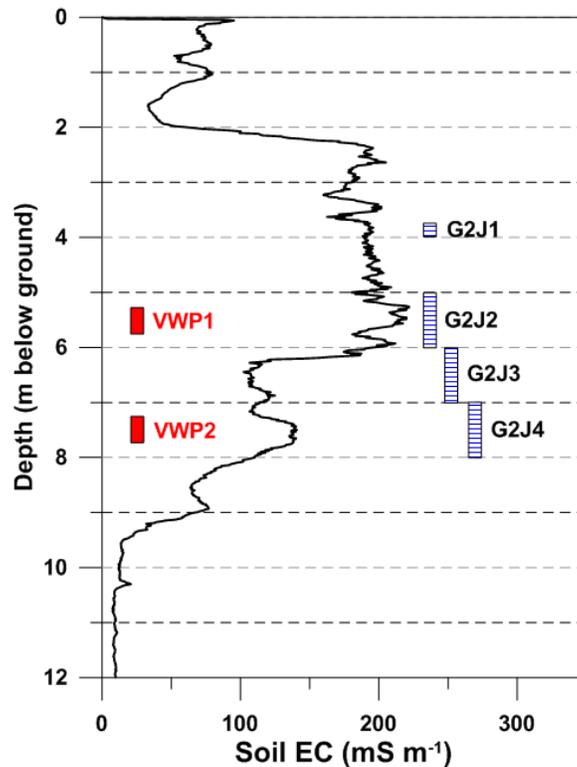


Figure 2. GEMS2 vertical profile showing the location of vibrating wire piezometers (VWP1 and VWP2) and screens of aquitard piezometers (G2J1–G2J4). Location of VWPs and aquitard piezometers screen were decided on the basis of the Direct Push (DP) Electrical Conductivity (EC) profile performed on the site. Low EC values represent sand and gravels, while high EC values represent clays. The top of the confined aquifer is located between 9 and 10 m below ground.

Boreholes for VWP1 and VWP2 were drilled following the same procedures as for the piezometers. After adding 30 cm of clean sand at the bottom of the borehole, we lowered the VWP into each borehole and added 70 cm of sand, making the entire collection zone of the VWP 1 m long. The steel rods were left on site until the whole collection zone was saturated. Then, we added 10 cm of granular bentonite (Enviroplug® #16) followed by bentonite grout (Enviroplug® grout NSF/ANSI/60) to the land surface as the steel rods were pulled up. Two cores were collected in the 1 m collection zone of VWP1, and the whole vertical profile of VWP2 was cored every 0.5 m.

VWPs (Geokon 4500AL-170 kPa unvented) were connected to a solar-powered CR6 Campbell Scientific® datalogger, recording VWP readings every 5 min (Figure 3). VWP readings are converted to porewater pressure and corrected for temperature and barometric changes using a formula dictated by the instrument used.

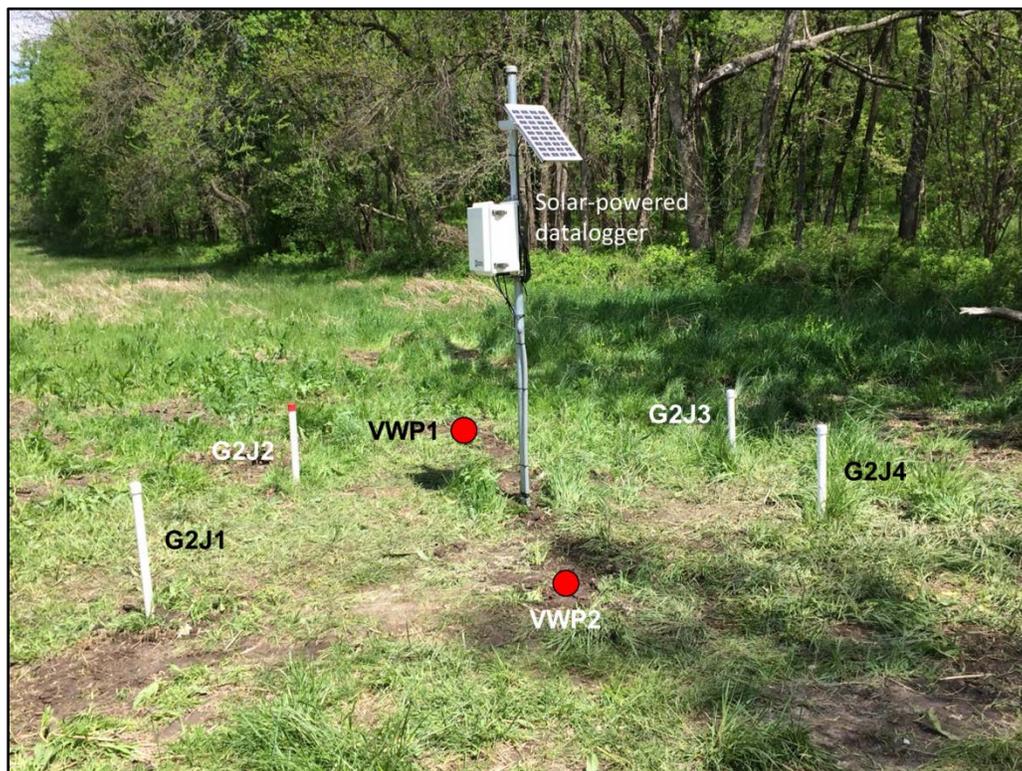


Figure 3. Geohydrologic Experimental and Monitoring Site 2 (GEMS2) setup and instrumentation. VWP1 and VWP2 are vibrating wire piezometers deployed at depths of 5.5 m and 7.5 m below ground, respectively. G2J1–G2J4 are piezometers screened in the aquifer at depths of 3.8–4.0 m, 5.0–6.0 m, 6.0–7.0 m, and 7.0–8.0 m, respectively. VWPs are wired to a solar-powered CR6 Campbell Scientific® datalogger with 5 min interval measurement and recording.

An existing well (C2; approximately 20 m from the aquitard piezometers) screened in the confined aquifer was equipped with a pressure transducer INW (Instrumentation Northwest Inc.) PT2X 0–30 psi at the center of the screen length. Effects of barometric fluctuations on piezometric heads are corrected using barometric pressures obtained from a barometer (INW PT2X 0–20 psi) installed inside at the top of C2. Pressure head and barometric fluctuations were monitored at 5 min intervals. The same monitored barometric fluctuations were used to correct porewater changes.

Table 1. Details of drilling and instrumentation at GEMS2 (mbg: meters below ground)

Aquitard piezometers						
ID	Total depth (m)	Screen depth (mbg)	Drilling date	Completion date	Time for sand to saturate (days)	Sampling date
G2J1	4	3.8 – 4.0	4/19/2017	4/19/2017	Not yet	Not yet
G2J2	6	5.0 – 6.0	11/16/2016	4/19/2017	127	Not yet
G2J3	7	6.0 – 7.0	9/1/2016	9/27/2016	7	12/5/2016
G2J4	8	7.0 – 8.0	9/29/2016	10/19/2016	16	12/5/2016
Vibrating Wire Piezometers						
ID	Total depth (m)	Diaphragm depth (mbg)	Drilling date	Grouting date	Time for sand to saturate (days)	Monitoring interval (mins)
VWP1	6	5.7	8/30/2016	11/11/2016	57	5
VWP2	8	7.7	11/10/2016	4/19/2017	18	5
Confined aquifer						
ID	Total depth (m)	Screen depth (mbg)	Pressure transducer	Barometer	Monitoring interval (mins)	Sampling date
C2	21	10.3 – 21.0	yes	yes	5	12/5/2016

3.2 Soil laboratory analyses

To obtain a vertical profile of gravimetric water content (θ_g , mass of water per mass of dry soil) from the clay aquitard, a small portion of each core was weighed, dried in an oven at 105°C for at least 24h (or until no additional loss in weight was observed) to remove the water, and weighed again dry. Subsequently Eq. (1) was used:

$$\theta_g = \frac{M_w - M_d}{M_d} \quad (1)$$

where M_w and M_d are mass of wet and dry soil.

Aquitard porosity n was calculated using Eq. 2:

$$n = 1 - \frac{\rho_{bulk}}{\rho_{particle}} \quad (2)$$

where $\rho_{particle}$ is the density of solid particles ($M L^{-3}$) and assumed by default as 2.65 g cm^{-3} , and ρ_{bulk} is the soil bulk density ($M L^{-3}$), calculated as follows:

$$\rho_{bulk} = \frac{M_d}{V_{sample}} \quad (3)$$

where V_{sample} is the volume of the aquitard sample [L^3].

3.3 Porewater sampling, extraction, and analyses

One of the main reasons that make aquitards challenging formations to study is their low to extremely low fluid velocity and low capacity to yield a significant amount of water (Batlle-Aguilar et al., 2016). After a waiting period from weeks to months, porewater was sampled from each aquitard piezometer using a low flow rate peristaltic pump. Samples were collected for analysis of major cations (Ca, Na, K, Mg) and anions (Cl, HCO_3 , SO_4 , NO_3) as well as water stable isotopes (2H , ^{18}O). A multiparameter probe (Thermo Scientific Orion Star A321) was used to measure pH, specific electrical conductivity (SEC), and temperature in the field. Porewater samples for analyses of major ions were collected in 50 mL polyethylene bottles, filtered ($0.45 \mu m$) and, for cations, acidified with concentrated HNO_3 (the same day in the laboratory). Porewater samples for water stable isotope ratios ($^2H/^1H$, $^{18}O/^{16}O$) were collected in 20 mL polyethylene vials and filtered ($0.45 \mu m$) in the field.

Groundwater at well C2 was also sampled for major cations and anions and stable isotope ratios using a peristaltic pump, but these samples were collected once pH, SEC, and temperature stabilized or did not change by more than 5% within a half-hour period to ensure representativeness of samples. Surface water from Mud Creek was also sampled for major cations, anions, and stable isotope ratios using a submersible pump and following the same procedure for sample representativeness.

Extraction of porewater from cores was performed using a centrifuge at the Kansas Geological Survey. A portion of each core was centrifuged for at least 8h at 2,300 rpm.

Anions were analyzed by ion chromatography (Dionex-120) at the department of Geography & Atmospheric Sciences at the University of Kansas, and cations will be analyzed by inductively coupled plasma optical emission spectrometry (Horiba Ultima 2) at the Kansas Geological Survey. Samples for water stable isotope ratios were analyzed at the University of Kansas Keck Paleoenvironmental Stable Isotope Laboratory on a Picarro L2120-i Cavity Ring Down Spectrometer (CRDS) water isotope analyzer with an A0211 High Precision Vaporizer. The spectrometer was calibrated with two external standards that

have been calibrated through inter-laboratory comparisons. Results are reported as a deviation from the Vienna Standard Mean Ocean Water (SMOW) in per mil (‰) difference using delta (δ) notation.

3.4 Porewater stable isotopes analyses by liquid-vapor equilibration

Vertical profiles of $\delta^{18}\text{O}$ and $\delta^2\text{H}$ have been extensively used in aquitards to determine the origin and movement of water, vertical hydraulic conductivity, and paleoclimate, among others (Desaulniers et al., 1981; Hendry et al., 2013; Hendry and Wassenaar, 1999; Remenda et al., 1996; Sanford et al., 2013). Although installing aquitard piezometers can be a successful method to obtain porewater for analysis, it can take a long time for porewater to flow into the piezometer (Neuzil and Provost, 2014). Recently, Wassenaar et al. (2008) proposed a new technique based on $\text{H}_2\text{O}_{(\text{liquid})} - \text{H}_2\text{O}_{(\text{vapor})}$ equilibration. The basis of the method is to store aquitard samples in Ziploc[®] freezing bags with double zipper seal, inflate the bag with dry air and allow isotopic equilibration between porewater and air at room temperature for 24h. To avoid failure of proper sealing, a double bagging system is used.

Equilibrated vapor samples were analyzed for water stable isotope ratios at the University of Kansas Keck Paleoenvironmental Stable Isotope Laboratory on a Picarro L2120-i Cavity Ring Down Spectrometer (CRDS) water isotope analyzer with an A0211 High Precision Vaporizer. The same protocol for standards applies as for water analysis as previously described.

4 Preliminary results

4.1 Confined aquifer

At GEMS2, the boundary between the clay aquitard and the confined aquifer is between 9 and 10 m deep (Figure 2). The potentiometric head of the confined aquifer varies between 4.5 m and 5.5 m below ground (Figure 4). The potentiometric head of the confined aquifer strongly fluctuates on a daily basis as a result of groundwater pumping in a nearby pumping station (approximately 600 m from the study site) for the rural community living in the area. Simultaneously, the confined aquifer is very responsive to rainfall, as can be seen for precipitation events during September 2016 and the beginning of April 2017 (Figure 4).

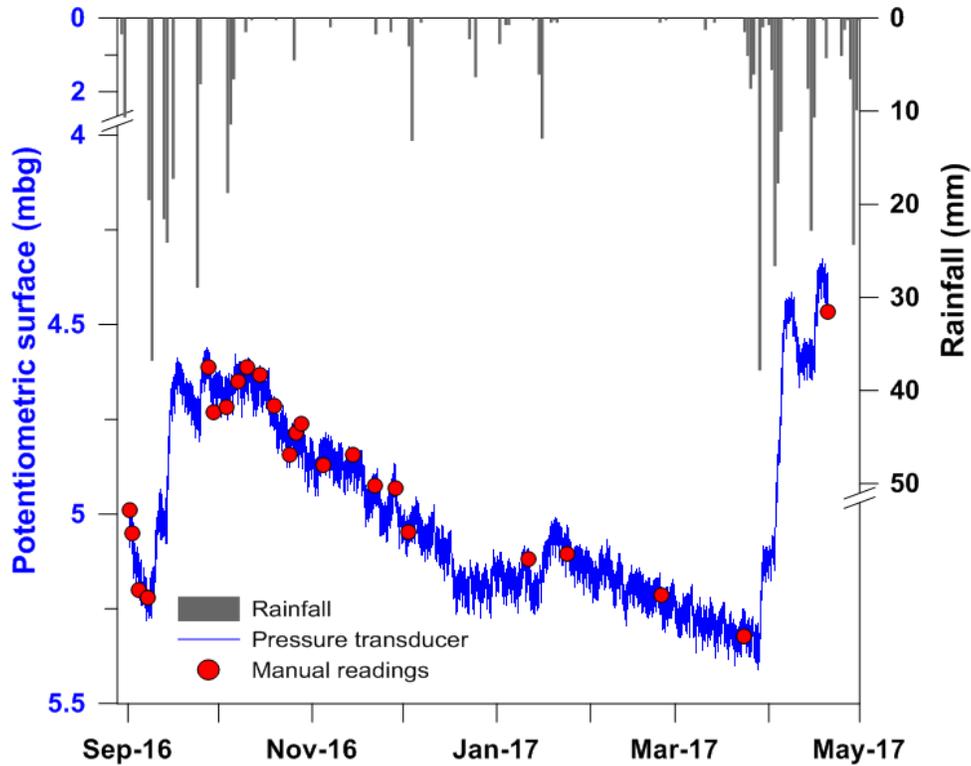


Figure 4. Potentiometric surface at well C2 (pressure transducer and manual readings) and rainfall as measured at the Lawrence airport weather station, ~1 km from GEMS2 (source: NOAA).

4.2 Vibrating wire piezometers

During the period before the VWP's were not grouted, we were able to follow the evolution of saturation of the collection zone for each VWP through pore pressure measurements. The uncorrected pore pressure fluctuated with barometric pressure changes, providing confidence that the VWP's were functioning properly (red line in Figure 5). Once the pore pressure was corrected for barometric fluctuations, the barometric effect was removed and we were able to follow the saturation of the sand in the collection zone of the VWP (blue line in Figure 5). We could conclude that the sand was saturated when we saw a sharp change in slope in the corrected pore pressure. Once the sand in the collection zone was saturated, we grouted each VWP as described in Section 3.1.

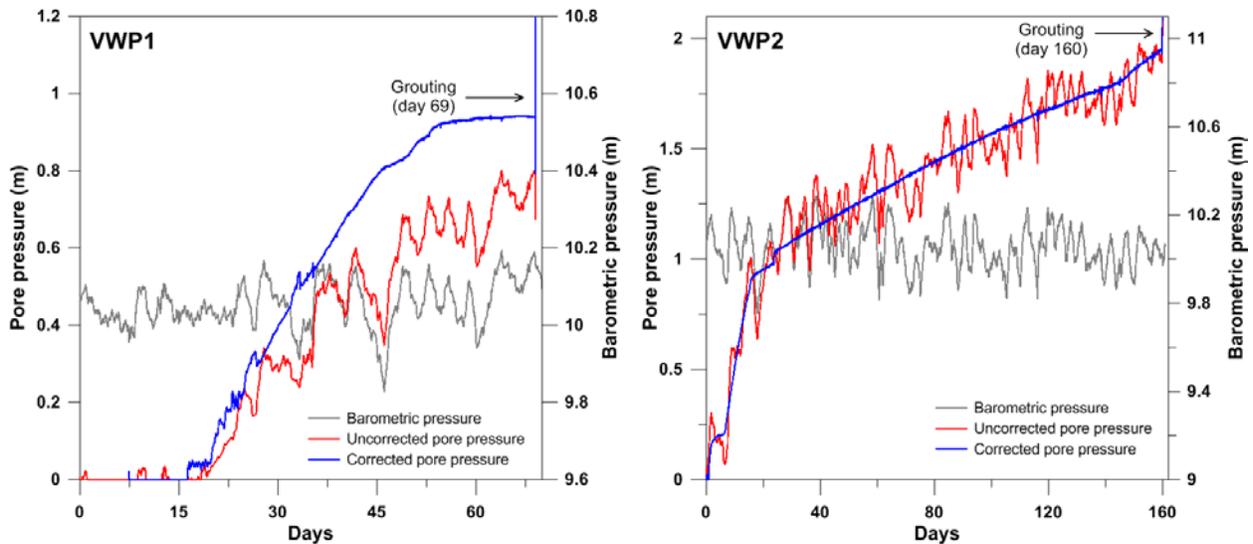


Figure 5. Pore pressure in VWP1 (left) and VWP2 (right) before grouting. These graphs provide confidence that the VWPs are functioning properly because uncorrected pore pressure fluctuates with barometric pressure changes. The change of slope in the corrected pore pressure line marks the moment when the sand in the collection zone is fully saturated. Day 0 corresponds to the day when the VWP was placed into the borehole in the sand collection zone but not grouted. Grout was pumped down on days 69 and 160, respectively.

After a sharp increase in pressure during grouting, the pressure decreased when we stopped grouting and remained unstable for a relatively long period (3 months and counting; Figure 6). During this time, uncorrected pore pressure have shown limited influence of barometric pressure fluctuations, although some periods of more stable pore pressure show small but damped influence of barometric fluctuations (see inset in Figure 6). In principle, one would expect a more direct influence of barometric fluctuations in the uncorrected pore pressure than what we observe, but we anticipate that other processes may be involved in GEMS2. For instance, a close look at Figure 7 shows that the pore pressure is directly correlated to increases in potentiometric head in the confined aquifer. The pressure of the confined aquifer into the aquitard is upward, whereas the atmospheric pressure is downward. With the limited data available at this stage, it is difficult to postulate a definite explanation, but it could potentially indicate that VWPs are measuring the result of two different pressures acting in opposite directions.

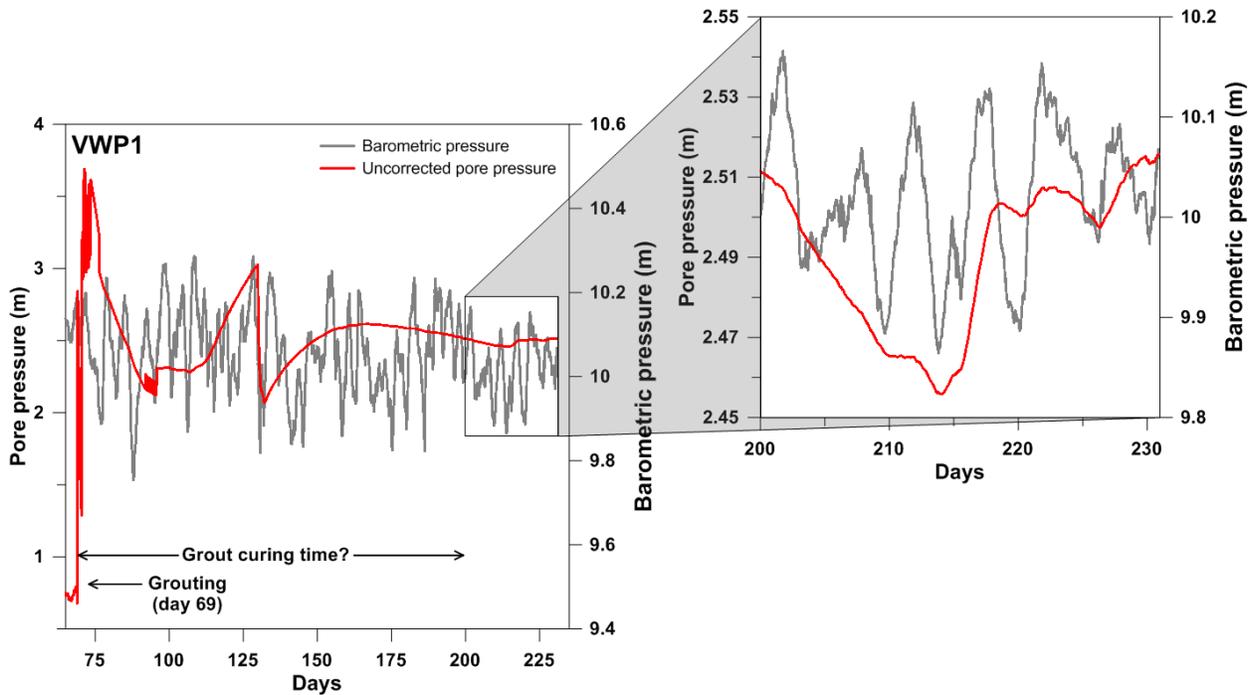


Figure 6. Uncorrected pore pressure in VWP1 after grouting. Barometric fluctuations seem to disappear during a period after grouting (grout curing time?) and reappear at approximately day 200 (~130 days after grouting).

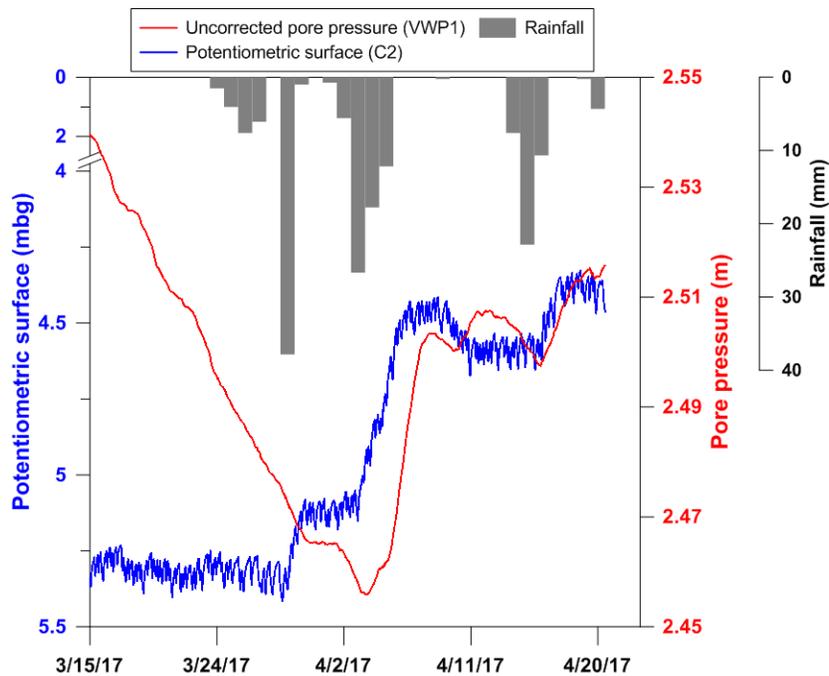


Figure 7. Relationship between rainfall (as measured at the Lawrence airport NOAA weather station), potentiometric surface in well C2, and uncorrected pore pressure in VWP1.

4.3 Aquitard profile

The gravimetric water content of the clay aquitard at GEMS2, as collected from the VWP2 borehole, ranges between 0.25 and 0.46 (profile VWP2_o in Figure 8a). The water content increases from 0.27 at the soil surface to up to 0.46 at a depth of 4.5 m. From there, the water content of the clay aquitard decreases in a relatively steady fashion to about 0.28 at a depth of about 8.5 m. The gravimetric water content was also analyzed on cores from intake zones of other aquitard piezometers and collection zone of vibrating wire piezometers (different colors in Figure 8a). Generally speaking, the water content from other cores closely reproduced the vertical trend of water content as estimated from the VWP2_o profile. Also the vertical water content profile reproduces in general terms the aquitard EC profile.

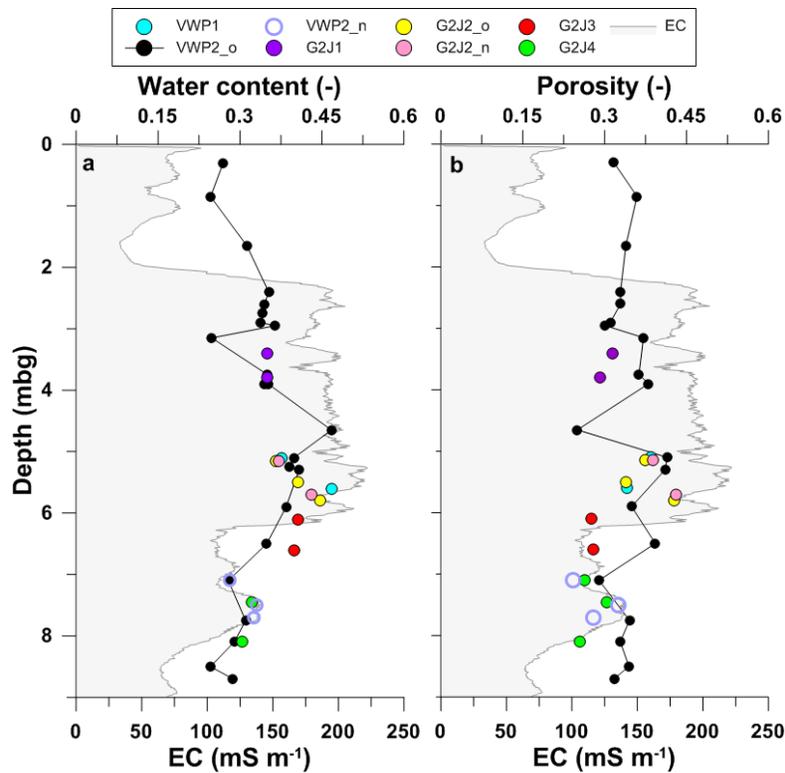


Figure 8. Vertical profiles of (a) gravimetric water content, and (b) porosity. Black solid dots are from a single borehole that was cored from top to bottom. For comparison, cores from different screen depths in other boreholes were analyzed (multiple colors). Aquitard EC is shown in the background for reference.

The porosity of the clay aquitard ranges between 0.25 and 0.41 (profile VWP2_o in Figure 8b). There seems to be a decrease of porosity with depth, although data are not conclusive. Two main characteristics are worth highlighting: 1) peaks of lower and higher porosity are inversely correlated to peaks of gravimetric water content. This is expected and thus provides a certain degree of confidence on both gravimetric water content and porosity estimates. It also shows that the clay aquitard is not homogeneous in the vertical

direction, with the possible presence of interbedded layers or lenses richer in silt. 2) Porosity from intake zones of various aquitard piezometers and collection zone of vibrating wire piezometers (different colors in Figure 8b) do not reproduce the main porosity profile as well as the water content did. This may be caused by using the same value of $\rho_{particle}$ (density of solid particles; 2.65 g cm^{-3}) throughout the field site; but it also indicates that clay heterogeneity does not only occur vertically but also horizontally at different locations.

4.4 Porewater chemistry and water stable isotope ratios

Only chemistry results for anions were available at the time of writing this report (Table 2). Nonetheless, some lines of evidence can be noted. Porewater chemistry appears to strongly differ from groundwater, with higher conductivity (EC) and bicarbonate (HCO_3) and sulfate (SO_4) concentrations. Porewater chloride (Cl) as measured in G2J3 (intake zone 6–7 m deep) is very close to that measured in the aquifer (12.89 and 12.26 mg L^{-1} , respectively), whereas porewater Cl as measured in G2J4 (intake zone 7–8 m deep) is much lower (4.42 mg L^{-1}). Once results for cations are available and aquitard piezometers G2J2 and G2J1 have enough standing water to be sampled, chemical results will be fully interpreted. It is interesting to note that nitrate (NO_3) concentration, with 17.13 mg L^{-1} , is quite high for a confined aquifer. This is particularly relevant because NO_3 is very low in Mud Creek and below the detection limit in the porewater.

Gravimetric water contents between 0.25 and 0.46 confirmed that the liquid-vapor equilibration method to analyze water stable isotope ratios is appropriate (the method is considered not accurate if gravimetric water content is less than 5%; Orłowski et al., 2016; Wassenaar et al., 2008). Preliminary results of porewater stable isotopes are shown in Figure 9. Oxygen-18 and deuterium (^2H) ratios still need to be corrected upon laboratory internal standards used, but some interesting patterns can already be seen. The vertical profile of stable isotope ratios quite closely reproduces the aquitard EC: depleted or lighter porewater (ratio values shifted toward more negative values) is directly correlated with clay areas; enriched or heavier porewater (ratio values shifted toward more positive values) is found in those depths where more silt and possibly fine sand exist. Nevertheless this is not the case for the two upper meters of the profile, where low clay contents coexist with depleted (lighter) porewater. Also some cores collected in intake and collected zones other than the general profile VWP2_o present heavier (shifted toward more positive values) porewater ratios than those from the main VWP2_o profile. This could possibly indicate fractionation effects due to evaporation processes during handling of the cores. We also anticipate that porewater in some cores will have to be re-analyzed to confirm their data. Isotopic ratios for the G2J1 core, for example, appear inconsistent (see opposite vertical trends between ^{18}O and ^2H in Figure 9).

Table 2. Chemistry and stable isotope ratios for surface water, groundwater, and porewater directly obtained from the aquitard piezometers and extracted using a centrifuge (n.d.: not detected; r.n.a.y.: results not available yet; D: deuterium ^2H).

	Extraction method	Field measured			mg L ⁻¹									‰	
		T (°C)	EC (μS cm ⁻¹)	pH	HCO ₃	NO ₃	Cl	SO ₄	Ca	Mg	Na	K	δ ¹⁸ O	δD	
Surface water															
Mud Creek	-	6.7	566	8.25	215.25	0.71	7.17	26.81	r.n.a.y.						
Groundwater															
Well C2	-	13.9	467	6.71	133.10	17.13	12.26	18.38	r.n.a.y.						
Porewater															
G2J3	Direct	14.4	1,211	6.82	299.35	n.d.	12.89	278.74	r.n.a.y.						
G2J4	Direct	14.8	888	6.86	273.75	n.d.	4.42	127.55	r.n.a.y.						
G2J3_6.5-7m	Centrifuge	Insufficient volume of water										r.n.a.y.			
VWP2_o_8.5m	Centrifuge	Insufficient volume of water										r.n.a.y.			

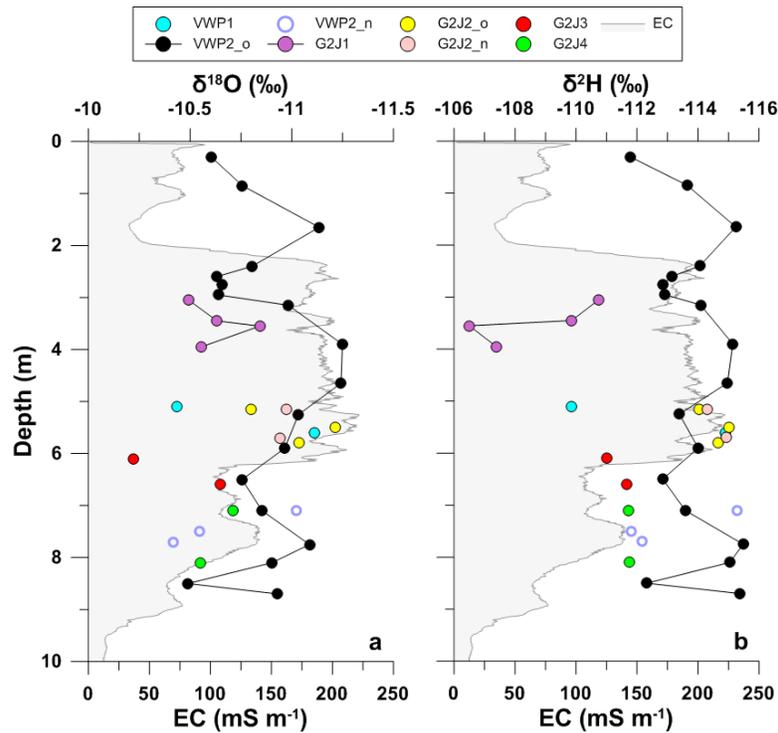


Figure 9. Vertical profile of (a) ^{18}O and (b) ^2H ratios at GEMS2. Aquitard EC is shown in the background for reference.

5 Continuing and forthcoming work

At the time of this report, drilling and equipment installation have been finished at the GEMS2 field site. The following are tasks under way and planned to start in the following weeks/months:

- VWP1 and VWP2 in GEMS2 are currently in their cure time. Once the cure is complete, we expect to obtain reliable pore pressure data from their records.
- Once enough porewater has been collected in the aquitard piezometers G2J2 and G2J1, they will be sampled and analyzed for major anions and stable isotopes. Additionally, aquitard piezometers G2J3 and G2J4, well C2, and Mud Creek will be resampled to confirm sampling results from the first effort in December 2016.
- Pending cations analyses will be finalized, and preliminary isotopic results shown in this report will be corrected as required.
- We will drill and instrument at the Larned Research Site (LRS) in the floodplain of the Arkansas River (Pawnee County). The clay aquitard at the LRS sits between an unconfined and a confined aquifer and thus will provide insights on a new hydrogeological setup.

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Examining Sedimentation and water quality of small impoundments: Sediment capturing opportunity upstream of federal reservoirs

Basic Information

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End Date:	2/28/2017
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Research Category:	Water Quality
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Descriptors:	None
Principal Investigators:	Vahid Rahmani

Publications

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Examining sedimentation and water quality of small impoundments: Sediment capturing opportunity upstream of federal reservoirs

Report Date: 18 May, 2017

Report Period: March 1, 2016 – February 28, 2017

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Submitted by: Vahid Rahmani, Kansas State University

Project goals and objectives

The objectives of this project were to study two main properties of the farm ponds in Delaware River Basin: 1) sediment quantity, quality, and infill; and 2) water quality. We planned to study 6 (\pm 3) ponds (two small-, two mid-, and two large-size), with the final number depending upon existing and possibly limiting sediment sampling, as well as field and weather conditions. We were successful in sampling 9 ponds. With this study we expect to begin to quantify the nature of sedimentation and water holding capacity in upland ponds and better define their water quality, both of which are important factors for understanding the nature and function of the complex impoundment networks that drain into our major reservoirs in Kansas. This effort is necessary to better understand and potentially model (or quantify) the transportation and storage mechanisms that, in part, control and contribute to downstream sedimentation. In this project, we seek to improve the state's understanding of watershed-wide sedimentation processes in order to facilitate the development and optimization of sediment control strategies that will help prolong the life and services of our small impoundments and large reservoirs.

Completed tasks

Hydrology, Remote Sensing, and GIS. Nine study sites were selected from the candidate population developed from an earlier project using GIS and LiDAR analysis. Catchments for the study site impoundments were determined and characterized using LiDAR and available land use/land cover data. Pond boundaries to use for field sample location determination were refined using LiDAR, existing GIS layers from the USGS National Hydrography Dataset, and available aerial imagery. These boundaries were analyzed to determine approximate locations for field sampling of water, sediment, pond depth, and sediment thickness.

Water Quality. Water quality samples were drawn from a single composite sample of water collected from the upper 0.25 meters of the water column at five locations within each pond.

Three equally-spaced 500 ml samples were collected along a longitudinal transect following the mid-line of the study reach from the uppermost boat accessible site to the dam. In addition, at the center longitudinal sampling point two samples were collected midway between the center sample and right and left shorelines to create a perpendicular sample transect line (Fig. 1). These five 500 ml samples were composited into a one-gallon sample container, placed on ice, and returned to the Kansas State University (KSU) labs. The samples were tested for total suspended solids (TSS) and volatile suspended solids (VSS) in the PIs and Civil engineering labs, and for nutrient analysis in the KSU soils lab. Samples were sent to the University of Iowa state hygienic lab for chlorophyll analysis. A Horiba® Model U-52 sonde was used to measure *in situ* water parameters including: air temperature, water temperature, pH, dissolved oxygen, turbidity, conductivity, total dissolved solids, salinity, and oxygen reduction potential.

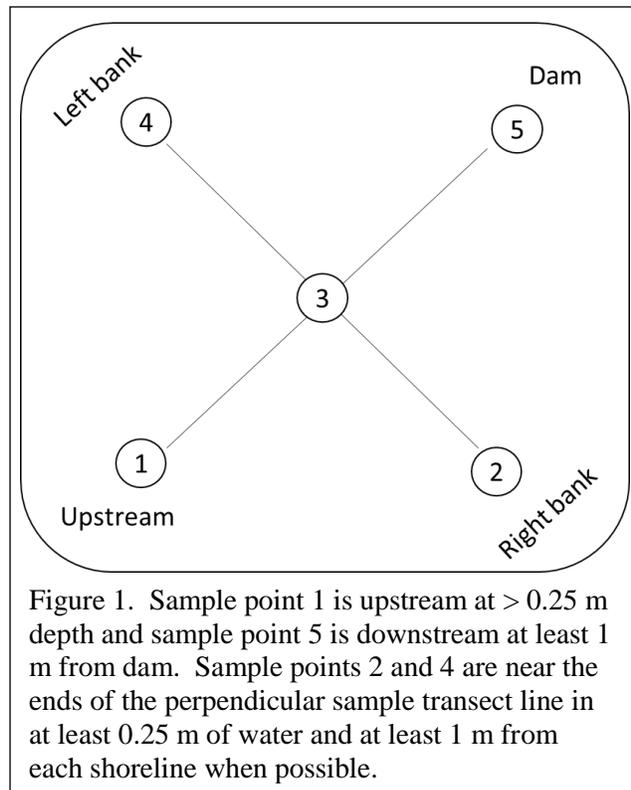


Figure 1. Sample point 1 is upstream at > 0.25 m depth and sample point 5 is downstream at least 1 m from dam. Sample points 2 and 4 are near the ends of the perpendicular sample transect line in at least 0.25 m of water and at least 1 m from each shoreline when possible.

Sediment. Sediment cores were collected and analyzed to determine sediment physicochemical conditions in the study ponds. The same sampling regime was used to generate a composite sample from five samples obtained from the upper 5 – 10 cm of sediment using a small hand corer (Wildco® liner-type Hand Corer). The composite samples were returned to the University of Kansas (KU) Pedology Laboratory for analyses of three soil particle size classes, bulk density, total phosphorus and nitrogen, and percent organic matter.

One of the primary challenges in sediment thickness and quality characterization in small impoundments is the sampling technique. These small ponds usually do not have boat access ramps and typically are shallow, making sampling with a large boat prohibitive. A large number of devices and methods have been designed and developed to collect bottom sediment cores in waterbodies. These include gravity corers, multiple gravity corers, hydraulically damped corers, box corers, piston corers, freeze corers, vibracoring corers, and drilling. All of these have specific advantages and disadvantages. Our perceived need was to somehow obtain a small but minimally disturbed bottom core that could take a complete sample of the new sediment that had been deposited in small, artificial ponds of various ages. The small size of the waterbodies precluded the use of large, bulky and had to operate corers but yet the corer must facilitate it being driven into the full depth of the softer sediments until the corer contacted the original and more consolidated (i.e. harder and denser compacted substrates) pond bottom. With some trial and error we determined that a clear PVC corer of about 1-1/4 inch could be manual driven into the pond sediments from a small flat-bottom boat that could accommodate two researchers. Sections of the PVC coring pipe were linked as each segment was lowered into the water and then driven into the sediment. This linking of shore corer sections allow the researchers to both

eliminate the handling of long cumbersome sections and to reduce the protruding end section height to a level that could be driven with a commercial posthole driver purchase from a farm and home store. In addition, we used a stainless steel penetrometer which penetrated into the bottom layer and provided an estimate of the thickness. The full-design and procedure will be made a part of the final report.

Preliminary results and discussion

Our analyses show a strong agreement between the measurements from the PVC tubes and the rod penetrometer (Fig. 2). Using the PVC tube method is time consuming and more expensive in materials. We propose to use the penetrometer for future analysis to save time and cost.

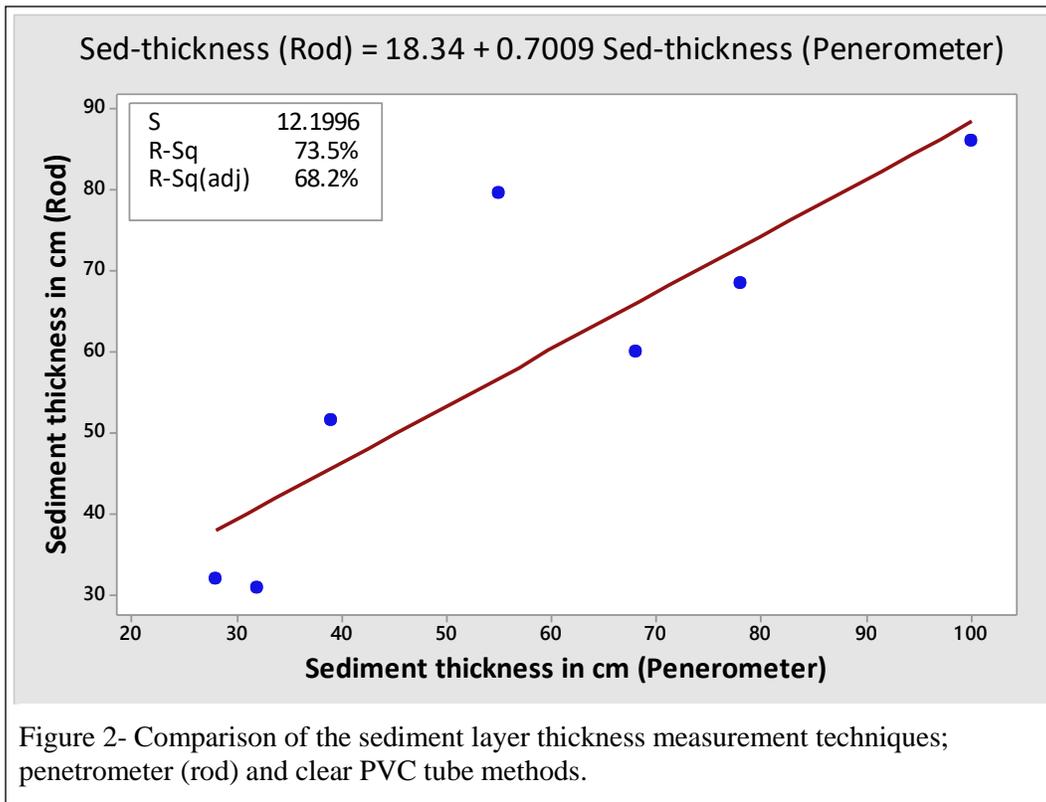


Figure 2- Comparison of the sediment layer thickness measurement techniques; penetrometer (rod) and clear PVC tube methods.

Ongoing activities and next steps

All the hydrology, remotely sensed, and GIS data has been collected for the pond basins. The lab results for water quality and sediment has been received. At this stage, watershed characteristics of each pond is being analyzed. Preliminary analysis of the watershed and ponds have been conducted. The next step will be to study the impacts of various watershed characteristics on water quality and sediment conditions for individual ponds. A summary of the collected and lab results is shown in Table 1.

Table 1- Summary of the lab results for sediment and water quality

Pond Number	Sediment		Water				
	Total N (ppm)	Total P (ppm)	Total N (mg/L)	Total P (mg/L)	TSS (g/L)	VSS (g/L)	Chlorophyll a (micrograms/L)
28	1,165	361	5.87	0.80	0.1211	0.1000	170
50	786	348	0.55	0.04	0.0870	0.0830	12
62	2,548	645	0.98	0.08	0.0230	0.0170	32
67	2,152	430	1.47	0.04	0.0050	0.0020	22
105	2,883	644	1.11	0.09	0.0090	0.0030	55
200	1,796	457	1.08	0.16	0.0490	0.0460	27
230	906	246	3.65	0.34	0.2029	0.0778	45
231	973	251	0.54	0.03	0.0250	0.0210	6
279	1,478	370	2.34	0.15	0.0070	0.0030	59

Training

The PI of the project, Dr. Vahid Rahmani, is a young investigator in his early career stage. Leading this project has supported his activities and leadership skills. Dr. Rahmani supervises a PhD student, an undergraduate student, and a research technician who work on this project. All trainees are in the Department of Biological and Agricultural Engineering at the Kansas State University. Figure 3 shows the undergraduate student and the research technician sampling water and sediment samples.



Figure 3a- Sampling for sediment layer thickness using PVC tube.



Figure 3b- Sampling for sediment surface layer using a Wildco® liner-type Hand Corer.

Conclusions

Challenges were faced during the sampling in the field. A few of ponds were deeper than our measurement apparatus length at a few sample points (out of five sampled points). Data for those lakes might not show agreement with other parts of the pond particularly in estimating sediment volume, sediment rate, pond water depth and volume. Further analysis will be conducted to improve the results.

Despite the challenges, all the proposed data were collected. Because of unpredictability nature of weather and other field conditions, all studied ponds were sampled during the first year. We will focus our second year activities to analyze all the collected data in the lab.

Presentations/publications

1. V. Rahmani (2016), Climate Change and Finite Water Resources in Kansas, *Natural Resources and Environmental Science (NRES) Course*, Manhattan, KS. Oct. 13, 2016
2. V. Rahmani (2016), Impacts of Climate Change on Kansas Water Resources, *Water Resources Engineering Course*, Manhattan, KS. Oct. 26, 2016
3. Rahmani, Vahid, Donald Huggins, Jude Kastens, and Ameneh Tavakol (2016), Sediment Capturing Opportunity by Small Impoundments Upstream of Federal Reservoirs, *Annual Governor's Conference on the Future of Water in Kansas*, Manhattan, KS. Nov. 15, 2016
4. V. Rahmani (2016), Extreme Weather Events and Finite Water Resources in Kansas, *Annual Governor's Conference on the Future of Water in Kansas*, Manhattan, KS. Nov. 15, 2016
5. V. Rahmani (2017), Extreme Events and Streamflow Quantity and Quality, *Kansas Department of Health and Environment*, Topeka, KS. Apr. 18, 2017
6. Tavakol, Ameneh, and Vahid Rahmani (2017), Analyzing the Impacts of Watershed Characteristics on Sedimentation Quality and Quantity in Small Ponds, *American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting*, Spokane, WA. July 17, 2017

Information Transfer Program Introduction

The KWRI is committed to transferring knowledge generated by its researchers to clientele. The KWRI uses a variety of methods. These include:

1. The fourth statewide Kansas "Governor's Conference on the Future of Water in Kansas Conference" was held on November 14-15, 2016 in Manhattan, Kansas. The conference was highly successful with 570 people attending on Day One and 539 attending on Day Two of the conference. Attending the conference was the Governor of Kansas, Sam Brownback, and several state and national senators and representatives. The Governor fully supports this conference and has expressed his concern about the issue of preserving and protecting the future viability of water in Kansas. Fifty-five volunteer scientific and ten invited presentations were presented in plenary and concurrent sessions. A showing of the films *When the Wells Run Dry* and *Feast and Famine: Securing Kansas Water Needs* were presented at the Flint Hills Discovery Center. Thirteen Faculty/Staff/Professional scientific posters were presented in the poster session. Nineteen student posters were presented during the poster session. An undergraduate/graduate student poster award program was conducted to encourage student participation. The program agenda is included with this report. The conference will be held again on November 8-9, 2017. The conference website is located at: <http://www.kwo.org/Projects/Governors-Conference.html>
2. The KWRI website, <http://www.kcare.k-state.edu/>, is used to transfer project results and inform the public on issues and scientists on grant opportunities.

Governor's Conference on the Future of Water in Kansas

Basic Information

Title:	Governor's Conference on the Future of Water in Kansas
Project Number:	2016KS184B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	KS-001
Research Category:	Not Applicable
Focus Category:	Conservation, Water Quantity, Education
Descriptors:	None
Principal Investigators:	Dan Devlin

Publications

1. Rivard, Cary and Cathie Lavis. 2016. Drip Irrigation Basics . Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF3125, 8 pg.
2. Soil Testing Laboratory. 2016. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF734, 2 pg.
3. Owensby, Clenton and Walter Fick. 2016. Summer Grazing Strategies for Stocker Cattle in the Kansas Flint Hills. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF3232, 8 pg.
4. Scanavez, A.; Rocha, L.; Voelz, B. E.; Hulbert, L.; and Mendonca, L. (2016) "Evaluation of Weather Information from On-Farm and Meteorological Stations to Assess Heat Stress in Dairy Cows in Southwest Kansas," Kansas Agricultural Experiment Station Research Reports: Vol. 2: Iss. 9.
5. Bond, H. D. and Mai, R. (2016) "Weather Information for Tribune," Kansas Agricultural Experiment Station Research Reports: Vol. 2:Iss. 7.
6. Elliott, J. (2016) "Weather Information for Garden City, 2015," Kansas Agricultural Experiment Station Research Reports: Vol. 2: Iss. 7.
7. Schlegel, A. (2016) "Alternative Cropping Systems with Limited Irrigation," Kansas Agricultural Experiment Station Research Reports:Vol. 2: Iss. 7.
8. Schlegel, A.; Haag, L.; and O'Brien, D. (2016) " Large-Scale Dryland Cropping Systems," Kansas Agricultural Experiment StationResearch Reports: Vol. 2: Iss. 7.
9. Kisekka, I.; Oker, T.; Nguyen, G.; Aguilar, J.; and Rogers, D. (2016) " Mobile Drip Irrigation Evaluation in Corn," Kansas AgriculturalExperiment Station Research Reports: Vol. 2: Iss. 7.
10. Kisekka, I.; Lamm, F.; and Schlegel, A. (2016) " Sorghum Yield Response to Water Supply and Irrigation Management," Kansas Agricultural Experiment Station Research Reports: Vol. 2: Iss. 7.
11. Kisekka, I.; Holman, J. D.; Waggoner, J. W.; Aguilar, J.; and Currie, R. (2016) "Forage Sorghum and Corn Silage Response to Full and Deficit Irrigation," Kansas Agricultural Experiment Station Research Reports: Vol. 2: Iss. 7.
12. Holman, J. D.; Roberts, T.; and Maxwell, S. (2016) "Integrated Grain and Forage Rotations," Kansas Agricultural Experiment StationResearch Reports: Vol. 2: Iss. 7.
13. Knapp, M. (2016) "Precipitation Data," Kansas Agricultural Experiment Station Research Reports: Vol. 2: Iss. 6.
14. Newell, T.; Roozeboom, K.; Ciampitti, I. A.; Adey, Eric; Cramer, G.; Holman, J. D.; and Schlegel, A. (2016) "Response of Drought-Tolerant Hybrids to Environmental Yield Potential," Kansas

Governor's Conference on the Future of Water in Kansas

- Agricultural Experiment Station Research Reports: Vol. 2: Iss. 5.
15. Aubert, A.; Roozeboom, K.; Ruiz Diaz, D.; Gipps, A.; and Wolf, T. (2016) "Subsurface Drip Nitrogen Fertigation of Corn," Kansas Agricultural Experiment Station Research Reports: Vol. 2: Iss. 5.
 16. Broeckelman, J.; Kluitenberg, G. J.; Roozeboom, K.; Cramer, G.; Adey, Eric; Schlegel, A.; Holman, J. D.; and Ciampitti, I. A. (2016) "Grain Sorghum Response to Water Supply and Environment," Kansas Agricultural Experiment Station Research Reports: Vol. 2: Iss. 5.

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Governor's Conference on the Future of Water in Kansas

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November 14-15, 2016



Held at the Hilton Garden Inn & Conference Center, Manhattan, Kansas

Hosted By



K-State Research & Extension/Kansas Water Resource Institute

Kansas Geological Survey/KU

Kansas Department of Agriculture

Kansas Department of Health & Environment

Kansas Department of Wildlife, Parks & Tourism

Sunday, Nov. 13 Evening Kickoff!

Early Registration 6:30-7:30 pm

Game Show Road Show 7:30-8:30 pm with snacks & drinks

AGENDA - Day 1

Monday, November 14, 2016

Breakfast Available at 7:30 am

- 7:30 - Registration/Tour Exhibits (*Foyer*)
- 8:30 - Opening Session/Welcome
Tracy Streeter, Kansas Water Office
- 8:40 - Presentation of Colors
Gary Harshberger, Chairman, Kansas Water Authority
- 8:45 - Vision for the Future of Water in Kansas
Second Year of Implementation - Governor's Vision Team
- 9:20 - Governor Sam Brownback - Moving Forward
Water Legacy Award Presentation
- 10:00 - Break/Tour Exhibits
- 10:15 - Blue Ribbon Funding Task Force for Water Resource Management
- 10:40 - Education & Public Outreach Working Group - *Jackie McClaskey*
- 11:05 - Denise Hickey, North Texas Municipal Water District
- 11:30 - Break/Tour Exhibits
- 12:15 - Lunch
- 12:45 - Be the Vision - *Susan Metzger*
- 1:15 - Michael J. Teague, Oklahoma Secretary of Energy and Environment
- 2:05 - David B. LaFrance, CEO, American Water Works Association
- 2:50 - Break/Tour Exhibits
- 3:05 - Ogallala Economic Panel
 - *Eli Fenichel, Assistant Professor, Yale School of Forestry & Environmental Studies*
 - *Bill Golden, Research Assistant Professor, K-State University, Department of Agricultural Economics*
 - *Tim James, Senior Sustainability Scientist, Arizona State University, Julie Ann Wrigley Global Institute of Sustainability*
- 4:30 - Final Wrap Up
Questions, Discussion & Final Comments
- 5:00 - Evening Social at Flint Hills Discovery Center - (5:00 pm - 6:30 pm)

Concurrent Sessions - Day 2

Tuesday, November 15, 2016

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11:20 - Concurrent Session 3



A. Interstate Water Conflicts in the U.S.: State & Federal Roles

(Flint Hills, Kings & Konza)

Moderator: Earl Lewis, Kansas Water Office

PANEL:

- *Lewis Jones, King & Spalding's Tort & Environmental Litigation Practice Group, Atlanta, GA, Eastern US Water Law*
- *Burke Griggs, Washburn University; Western US Water Law*

B. New Research on Water Communication & Conservation (*McDowell*)

Moderator: Matt Sanderson, Kansas State University

- *Water is in Their Blood - B.J. Gray, KU*
- *What is Common: How Team Leaders Spoke Before the Kansas Water Authority - Colene Lind, KSU*
- *A Food-Water-Energy Calculator - Mary Hill, KU*

C. Groundwater - Surface Water Interactions (*Ft. Riley*)

Moderator: Lane Letourneau, Kansas Department of Agriculture

- *An Investigation into the Playa Basins as a Point Source for Recharge of the High Plains Aquifer - William Johnson, KU*
- *Recharge Rates & Groundwater Age in the High Plains Aquifer - Randy Stotler, KU*
- *The Importance of Capture in Stream Valleys to Water Resources in the High Plains Aquifer - Don Whittemore, KGS*

D. Film (*Discovery Center, 2nd Floor*)

Moderator: Kirk Heger, Stanton County Producer

- *Feast and Famine: Securing Kansas Water Needs - Discussion afterwards - Chris Wilson, Kansas Aqueduct Coalition, Trevor Hands, Co-Producer*

12:30 - Lunch (*Kaw Nation & Big Basin*)

1:15 - Dan Devlin, KSU

Presentation of Graduate/Undergraduate Student Poster Awards

1:30 - Rob Manes, Director of The Nature Conservancy, Kansas

2:15 - Closing Words - Tracy Streeter, Director, Kansas Water Office

2:30 - Adjournment

The Kansas Water Authority's Regional Advisory Committees have been working since 2015 to develop regional goals and associated Regional Goal Action Plans for each goal. These Regional Goal Action Plans were approved by the Kansas Water Authority at their August and October 2016 meetings and are now available for public input. The Action Plans are located in the Foyer with the Regional Advisory Committee displays. Please stop by and give us your input.



Concurrent Sessions - Day 2

Tuesday, November 15, 2016

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9:40 Concurrent Session 2 (Continued)



C. Reservoir Restoration (Big Basin)

Moderator: Ed Martinko, Kansas Biological Survey

- Effects of May through July 2015 Storm Events on Suspended Sediment Loads, Sediment Trapping on John Redmond, East-Central Kansas - Guy Foster, USGS

PANEL: John Redmond Reservoir Dredging Project

- Bryan Taylor, U.S. Army Corps of Engineers
- Stan Ekren, Great Lakes Dredge & Dock
- Matt Unruh, Kansas Water Office

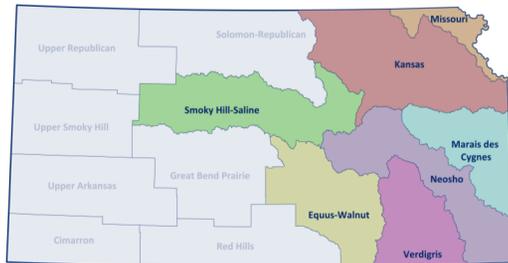


D. Kansas Water Authority Regional Advisory Committees (McDowell)

Moderator: Bobbi Lutjohann, Kansas Water Office



- Reservoirs - Earl Lewis, Kansas Water Office



PANEL: Sarah Hill-Nelson (Kansas), Angela Anderson (Neosho), Martha Tasker (Smoky Hill-Saline) and Steven Hieger (Equus-Walnut)

E. Urban Water & Watershed Issues (Ft. Riley)

Moderator: Ed Peltier, KU

- Kansans Access to Quality Clean Water - Brandon Johnson, Sunflower Community Action
- Hot Topic: Lead in Drinking Water - Monica Wurtz, KFWA
- Urban Green Infrastructure & Water Conservation - Lee Skabelund, KSU
- WRAPS Update - Amanda Reed, KDHE



F. Film (Discovery Center, 2nd Floor)

Moderator: Ernie Minton, KSU

- Thirsty Land – Film followed by discussion - Jim Whitt, Assoc. Producer

11:00 - Break/View Posters



AGENDA - Day 2

Tuesday, November 15, 2016

Breakfast Available at 7:15 am

7:15 - Registration/View Posters

8:00 - Concurrent Session 1

- A. Kansas Water Data (Flint Hills, Kings & Konza Prairie)
- B. Sedimentation and Water Quality (Kaw Nation)
- C. Water Reuse and Health (Big Basin)
- D. KWA Regional Advisory Committees (McDowell)
- E. Water Quality/Water Storage (Ft. Riley)
- F. Agricultural Water Use (Discovery Center, 2nd Floor)

9:20 - Break/View Posters

9:40 - Concurrent Session 2

- A. High Plains Aquifer Conservation Update (Flint Hills, Kings & Konza)
- B. Tribal Nations in Kansas Strategies for Sustainable Water in a Changing Climate (Kaw Nation)
- C. Reservoir Restoration (Big Basin)
- D. KWA Regional Advisory Committees (McDowell)
- E. Urban Water and Watershed Issues (Ft. Riley)
- F. Film: Thirsty Land (Discovery Center, 2nd Floor)

11:00 - Break/View Posters

11:20 - Concurrent Session 3

- A. Interstate Water Conflicts in the U.S.: State and Federal Roles (Flint Hills, Kings & Konza)
- B. New Research on Water Communication and Conservation (McDowell)
- C. Groundwater - Surface Water Interaction (Ft. Riley)
- D. Feast and Famine: Securing Kansas Water Needs (Film) (Discovery Center, 2nd Floor)

12:20 - Break/View Posters

12:30 - Lunch - Tracy Streeter, Kansas Water Office

1:15 - Student Poster Awards - Dan Devlin, Kansas State University

1:35 - Rob Manes, Director of The Nature Conservancy, Kansas

2:15 - Closing Words - Tracy Streeter, Kansas Water Office

2:30 - Adjourn

The Kansas Water Authority's Regional Advisory Committees have been working since 2015 to develop regional goals and associated Regional Goal Action Plans for each goal. These Regional Goal Action Plans were approved by the Kansas Water Authority at their August and October 2016 meetings and are now available for public input. The Action Plans are located in the Foyer with the Regional Advisory Committee displays. Please stop by and give us your input.



Concurrent Sessions - Day 2

Tuesday, November 15, 2016

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8:00 - Concurrent Session 1

A. Kansas Water Data (Flint Hills, Kings & Konza)

Moderator: Marcia Schulmeister, Emporia State University

- Surface Water Conditions in KS, Water Year 2016 - *Madison May, USGS*
- Lessons Learned from a Statewide Survey of Brine Disposal & Seismicity in Kansas - *Tandis Bidgoli, Kansas Geological Survey*
- Estimate of Aquifer Hydraulic Properties Using Geophysical Measurements - *Chi Zhang, University of Kansas*
- Interpreting Satellite-Based Data from GRACE Mission Using *in situ* Measurements from the High Plains Aquifer in KS - *Andrea Brookfield, KGS*



B. Sedimentation and Water Quality (Kaw Nation)

Moderator: Andy Ziegler, U.S. Geological Survey

- Constructed Wetlands for Sediment, Nutrient & Runoff Volume Reduction in NE Kansas - *Edward Peltier, University of Kansas*
- Erodibility Testing in Tuttle Creek Lake & Novel Approaches for Sediment Management - *John Shelley, USACE*
- A Stratigraphic Approach to Assessing Variability in Streambank Erosion in NE Kansas - *Tony Layzell, Kansas Geological Survey*
- Healthy Soils - Healthy Water: The Role of Soil Health in Securing Water Resources - *Gretchen Sassenrath, Kansas State University*



C. Water Reuse and Health (Big Basin)

Moderator: Jack Brown, KU School of Medicine

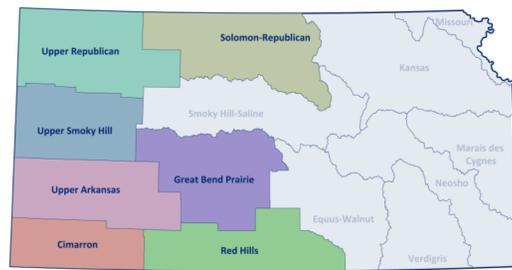
- Domestic Water Well Practices & Policies in Kansas - *Elizabeth Ablah, KU*
- **Panel:** Water Reuse Health Impact Assessment - *Sara Hartsig, KHI*; Goals & Steps to Expand Water Reuse in a Municipality - *Fred Jones, Garden City*; Historical Trends in Water Reuse - *Steve Randtke, KU*



D. Kansas Water Authority Regional Advisory Committees (McDowell)

Moderator: Margaret Fast, Kansas Water Office

- **High Plains Aquifer** - *Susan Metzger, Kansas Department of Agriculture*



PANEL: Nick Hatcher (Cimarron); Frank Mercurio (Upper Smoky Hill); Kyle Nelson (Upper Arkansas); Ken McCarty (Upper Republican)



Concurrent Sessions - Day 2

Tuesday, November 15, 2016

#kswaterfuture16

8:00 - Concurrent Session 1 - (Continued)

E. Water Quality, Water Storage (Ft. Riley)

Moderator: Jaime Gaggero, Kansas Dept. of Health & Environment

- Cyanobacteria & Associated Toxins & Taste & Odor Compounds in the Kansas River - *Guy Foster, USGS*
- Effects of Aquifer Storage & Recovery Activities on Water Quality in the Little Arkansas River - *Mandy Stone, USGS*
- Restoring Oklahoma's Waurika Lake to a Resilient Regional Water Supply - *James Umdenstock, Keithline Engineering Group*
- Centennial Water & Sanitation District; Lessons Learned from the Chatfield Reservoir Reallocation Project - *John Kaufmann, Centennial Water*



F. Agriculture Water Use (Discovery Center, 2nd Floor)

Moderator: Danny Rogers, Kansas State University

- Update on Water CAP Project; & Characterization of Irrigation Systems & Management Challenges for KS - *Danny Rogers & Vahid Rahmani, KSU*
- Water Technology Demonstration Farms: Goals & Results - *Jonathan Aguilar, KSU*
- Mobile Drip Irrigation Systems for Corn Production - *Isaya Kisekka, KSU*
- Drought, Water & Weather Variability: Factors Effecting the Adoption of Best Management Practices in Grazing Systems - *Audrey King, KSU*



9:20 - Break/View Posters

9:40 - Concurrent Session 2

A. High Plains Aquifer Conservation Update (Flint Hills, Kings & Konza)

Moderator: Susan Stover, Kansas Geological Survey

- Sustainability Assessment for SW Kansas - *Jim Butler, KGS*
- The Economics of Modeled Water Use Reductions in SW Kansas - *Bill Golden, KSU*



PANEL: Update on LEMA in Northwest Kansas

- *Jim Butler, Kansas Geological Survey*
- *Ray Luhman, NW Kansas GMD No. 4*
- *Bill Golden, Kansas State University*
- *Jeff Torluemke, Farmer, Banker & LEMA Participant*



B. Tribal Nations in Kansas Strategies for Sustainable Water in a Changing Climate (Kaw Nation)

Moderator: Doug Kluck, NOAA

- Changes in Precipitation & Drought in KS Over 100 Years - *Xiaomao Lin KU*
- Tribal Water Sovereignty 101 - *Eric Sheets, Kickapoo Tribe in Kansas*



PANEL:

- *Lisa Montgomery, Sac & Fox Nation*
- *Ma'Ko'Quah Jones, Prairie Band Potawatomi Nation*
- *Eric Sheets, Kickapoo Tribe in Kansas*

Governor's Conference on the Future of Water in Kansas

Poster Presenters

Faculty/Staff/Professional

- 1. Water Workforce Challenges – Young Professional Solutions**
Michaela Rempkowski, Burns & McDonnell
- 2. Status of Groundwater Levels and Storage Volume in the Equus Beds Aquifer near Wichita, Kansas, January 2016**
Brian Klager, Kansas Water Science Center, U.S. Geological Survey
Mandy Stone, Kansas Water Science Center, U.S. Geological Survey
- 3. Sediment oxygen demand in eastern Kansas streams, 2014 and 2015**
Lindsey King, Kansas Water Science Center, U.S. Geological Survey
Guy Foster, Kansas Water Science Center, U.S. Geological Survey
Jennifer Graham, Kansas Water Science Center, U.S. Geological Survey
Thomas Williams, Kansas Water Science Center, U.S. Geological Survey
- 4. Spatial Variability of Harmful Algal Blooms in Milford Reservoir**
Lindsey King, Kansas Water Science Center, U.S. Geological Survey
Guy Foster, Kansas Water Science Center, U.S. Geological Survey
Jennifer Graham, Kansas Water Science Center, U.S. Geological Survey
Thomas Williams, Kansas Water Science Center, U.S. Geological Survey
- 5. Twenty Years of Water-Quality Studies in the Cheney Reservoir Basin, Kansas, 1996–2016**
Ariele Kramer, Kansas Water Science Center, U.S. Geological Survey
Jennifer Graham, Kansas Water Science Center, U.S. Geological Survey
Guy Foster, Kansas Water Science Center, U.S. Geological Survey
- 6. Cyanobacterial Harmful Algal Blooms and U.S. Geological Survey Science Capabilities**
Jennifer Graham, Kansas Water Science Center, U.S. Geological Survey
Neil Dubrovsky, California Water Science Center, U.S. Geological Survey
Sandra Eberts, Ohio Water Science Center, U.S. Geological Survey
- 7. Occurrence of Cyanobacteria, Microcystin, and Taste-and-Odor Compounds in Cheney Reservoir, Kansas, 2001 through 2016**
Thomas Williams, Kansas Water Science Center, U.S. Geological Survey
Ariele Kramer, Kansas Water Science Center, U.S. Geological Survey
Jennifer Graham, Kansas Water Science Center, U.S. Geological Survey
Guy Foster, Kansas Water Science Center, U.S. Geological Survey
- 8. Spatiotemporal Variability of Inorganic Nutrients during Wastewater Effluent Dominated Streamflow Conditions in Indian Creek, Johnson County, Kansas, 2012–2015**
Thomas Williams, Kansas Water Science Center, U.S. Geological Survey
Jennifer Graham, Kansas Water Science Center, U.S. Geological Survey
Guy Foster, Kansas Water Science Center, U.S. Geological Survey
Lindsey King, Kansas Water Science Center, U.S. Geological Survey
- 9. Satellite Data as a Tool in the Monitoring of Water Fluxes in Native Prairie Grasses in Kansas**
Gabriel de Oliveira, Geography and Atmospheric Science, University of Kansas
Nathaniel Brunsell, Geography and Atmospheric Science, University of Kansas
- 10. Sediment Capturing Opportunity by Small Impoundments Upstream of Federal Reservoirs**
Vahid Rahmani, Biological and Agricultural Engineering, Kansas State University
Donald Huggins, Kansas Biological Survey, University of Kansas
Ameneh Tavako, Biological and Agricultural Engineering, Kansas State University

11. 2015 Water Use in Kansas

Jennifer Lanning-Rush, Kansas Water Science Center, U.S. Geological Survey
Andy Terhune, Division of Water Resources, Kansas Department of Agriculture
Ginger Pugh, Division of Water Resources, Kansas Department of Agriculture

12. Analysis of Minimum Desirable Streamflow Restrictions in the Lower Republican River Basin

Dietrich Earnhart, Economics, University of Kansas
Blaine Bengtson, School of Law, University of Denver
Babak Mardan Doost, School of Engineering, University of Kansas
Belinda Sturm, School of Engineering, University of Kansas

13. Water is Life: The Significance of Water and its Relationship to Health and Well-being on a Kansas American Indian Reservation

Felicia Mitchell, School of Social Work, Arizona State University

Student Posters

1. Trends in Snow Cover Frequency

Jim Coll, Geography and Atmospheric Science, University of Kansas

2. Temporal visualization of water resource evolution with application to over-pumping the High Plains aquifer in western Kansas

Misty Porter, Geology, University of Kansas
Mary C. Hill, Geology, University of Kansas
Xingong Li, Geography, University of Kansas

3. Development and Testing of an In-well Point Velocity Probe for Rapid Site Characterization

Trevor Osorno, Geology, University of Kansas
J. F. Devlin, Geology, University of Kansas

4. Monitoring green roof soil moisture dynamics on two large-scale prairie green roofs in the Flint Hills Eco-region with the aim of conserving potable water and promoting native plant coverage

Allyssa Decker, Environmental Design and Planning, Kansas State University
Priyasha Shrestha, Landscape Architecture, Kansas State University
Lee R. Skabelund, Landscape Architecture/Regional and Community Planning, Kansas State University
Mary Knapp, Agronomy, Kansas State University
Trisha Moore, Biological and Agricultural Engineering, Kansas State University
Ajay Sharda, Biological and Agricultural Engineering, Kansas State University
Deon van der Merwe, Diagnostic Medicine and Pathobiology, Kansas State University
Jeffrey L. Bruce, Jeffrey L. Bruce & Company, LLC
Devon Baddad, Biological Systems Engineering, Kansas State University

5. Space-Time Variability of Historical and Projected Drought in the Central United States

Zachary Zambreski, Agronomy, Kansas State University
Xiaomao Lin, Agronomy, Kansas State University

6. Identifying Potential Wetland Areas within Aging Reservoirs using Historical Hydrological Data

Kaitlyn Loeffler, Civil, Environmental and Architectural Engineering, University of Kansas
Vahid Rahmani, Kansas Biological Survey, University of Kansas
Jude Kastens, Kansas Biological Survey, University of Kansas
Don Huggins, Kansas Biological Survey, University of Kansas

7. Using marginal waters to produce Salicornia as an alternative biofuel source

Erica Schmitz, Biological and Agricultural Engineering, Kansas State University
Stacy L. Hutchinson, Biological and Agricultural Engineering, Kansas State University
Ganga Hettiarachchi, Agronomy, Kansas State University

8. Evaluating Hydrologic Processes along the Arkansas River through Applied Hydrogeophysics and Remote Sensing

Weston Koehn, Civil Engineering, Kansas State University
Sarah Auvenshine, Civil Engineering, Kansas State University
Vilem Ernest, Civil Engineering, Kansas State University
David Steward, Civil Engineering, Kansas State University

- 9. Evaluating Soil Loss from Ephemeral Gullies with Photogrammetry and Computer Modeling**
Chinthaka Weerasekara, Biological and Agricultural Engineering, Kansas State University
Aleksey Shesukov, Biological and Agricultural Engineering, Kansas State University
Will Boyer, Kansas Center for Agricultural Research and the Environment, Kansas State University
- 10. A Novel Approach to Measure Site-Specific Erodibility in Claypan Soils**
Tri Tran, Civil Engineering, Kansas State University
Stacey Tucker Kulesza, Civil Engineering, Kansas State University
Gretchen Sassenrath, Agronomy, Kansas State University
Weston Koehn, Civil Engineering, Kansas State University
Lauren Erickson, Civil Engineering, Kansas State University
- 11. Reservoirs sedimentation in Central Kansas: Aspect of soil erodibility due to subsurface and surface flows**
Vladimir Karimov, Biological and Agricultural Engineering, Kansas State University
Aleksey Sheshukov, Biological and Agricultural Engineering, Kansas State University
- 12. Are school districts the solution we have been looking for? Analyzing the potential of school districts to overcome political fragmentation and improve water quality within the urban corridor**
Kelsey McDonough, Biological and Agricultural Engineering, Kansas State University
Stacy Hutchinson, Biological and Agricultural Engineering, Kansas State University
Trisha Moore, Biological and Agricultural Engineering, Kansas State University
Shawn Hutchinson, Geography, Kansas State University
- 13. Soil Microbial Properties with Depth in Claypan Soils of Southeast Kansas**
Che-Jen Hsiao, Agronomy, Kansas State University
Gretchen F. Sassenrath, Agronomy, Kansas State University
Charles W. Rice, Agronomy, Kansas State University
Lydia H. Zeglin, Biology, Kansas State University
Ganga M. Hettiarachchi, Agronomy, Kansas State University
- 14. Application of a New Point Measurement Device to Measure Groundwater-Surface Water Interactions at a Contaminated Site**
Mackenzie Cremeans, Geology, University of Kansas
J. F. Devlin, Geology, University of Kansas
- 15. Analysis of Big Creek Aquifer Alluvial Facies, Hays, Kansas**
Kris Neuhauser, Geosciences, Fort Hays State University
- 16. “Groundwater Citizenship” and Water Literacy: A Survey of the Kansas Aqueduct, Water Supply Infrastructure, and Well Ownership in Kansas**
Brock Ternes, Sociology, University of Kansas
- 17. Fluorescence Spectroscopy as a Monitoring Technique for Membrane Bioreactor Water Reclamation Systems**
Jeffrey Scott, Biological and Agricultural Engineering, Kansas State University
- 18. Seasonal streamflow predictions for Kansas that utilize a simple large-scale routing scheme that includes reservoir characteristics**
Faith Johnson, Civil, Environmental, and Architectural Engineering, University of Kansas
J. K. Roundy, Civil, Environmental, and Architectural Engineering, University of Kansas
- 19. Seasonal Weather Prediction from NMME Models**
Grace Roth, Civil, Environmental, and Architectural Engineering, University of Kansas
J. K. Roundy, Civil, Environmental, and Architectural Engineering, University of Kansas

Special thanks to the Governor’s Award judges:

Amber Campbell, KCARE, Kansas State University; Leena Divakar, Kansas Department of Health and Environment; Diane Knowles, Kansas Water Office; Gaisheng Liu, Kansas Geological Survey; Heidi Mehl, The Nature Conservancy; Ginger Pugh, Kansas Department of Health and Environment; Vahid Rahmani, Kansas State University; Stan Roth, Kansas Biological Survey; Anna Smith, Burns & McDonnell; Andrew Swindle, Wichita State University; Nathan Westrup, Kansas Water Office

A Long-Term Vision for the Future of Water Supply in Kansas

EDUCATION AND PUBLIC OUTREACH SUPPLEMENT

Many Phase I Action Items in the *Vision for the Future of Water Supply in Kansas* relate to education and outreach — critical aspects to creating a long-term commitment to the future of our state’s water resources. Education action items range from K-12 and outside the classroom youth activities to university research and technical programs to prepare the future workforce in water resource career fields. The action items also call for enhanced educational programming for policy makers, community leaders and broadly to all Kansas citizens.

To develop strategies and receive additional stakeholder input on the education and outreach action items, an interagency and interorganizational coordinating team was formed in the fall of 2015. Throughout 2016 the coordinating team hosted a series of outreach meetings to solicit input into the development of statewide education and public outreach materials, and to develop tangible action plans aimed at strengthening Kansans’ knowledge and awareness of water and water-related issues. The following multipart educational strategic framework for target audiences of youth, municipalities, K-12, business entities, community leaders, media and the general public was developed to evaluate the education, communication and outreach action items from the Vision.

KANSAS WATER

PRESERVING TODAY. ENSURING TOMORROW.

Water Vision Education and Outreach Working Groups

In response to Phase 1 action items of the *Vision for the Future of Water Supply in Kansas*, the purpose of the working groups will be to identify needs, develop statewide education and outreach materials, and implement tangible action steps to help all Kansans understand the importance of water and water issues in the state.

2016 WORKING GROUP MEETING SCHEDULE

January 7 • March 10 • May 12 • September 8 • October 6

All working group meetings will be held at the
Kansas Farm Bureau Building,
2627 KFB Plaza, Manhattan, Kansas 66503.
 All sessions are on a Thursday and will run from 12:30-3:30 p.m.



For more information, contact Dana Ladner at (785) 564-6660 or e-mail Dana.Ladner@ks.gov

Nov. 7, 2016

VISION EDUCATION-RELATED ACTION ITEMS

This document is designed to be a supplement to the statewide *Vision for the Future of Water Supply in Kansas* and provides a strategic framework for addressing the following education-related action items contained in the Vision.

1. Appoint a task force to develop a multi-phased educational proposal for target audiences of K-12, community leaders and media to promote local conservation decisions. Existing educational efforts, programs and activities should be incorporated as appropriate. Ideas to be considered by the task force include:
 - *Implement community facilitation programs, with partners like K-State Research and Extension (KSRE), to develop ownership for local conservation districts.*
 - *Design and implement a statewide curriculum for K-12 on water conservation, building on current resources and knowledge such as Project WET and integrate water conservation into science curriculum, by working with partners such as the Kansas Association of Conservation and Environmental Education (KACEE) and the Kansas Department of Education.*
 - *Develop additional activities within youth and adult organizations such as 4-H and the K-State Research and Extension (KSRE) system to educate others and promote youth activities related to water conservation.*
2. Create a long-term commitment to water conservation education by designating responsibility for water conservation public information and outreach within agencies of the Water Resources Sub-Cabinet.
 - *Develop continual media plans and message maps related to water conservation and the importance of local engagement to be implemented by multiple partners through all aspects of traditional paid, earned and social media.*
3. Enhance educational programming specifically for state legislators as well as other state officials, the Congressional delegation and local policy makers.
4. Utilize agricultural education and 4-H to encourage young people to develop agricultural programs using water efficient technologies and less water intensive crops or crop varieties through recognition and incentive programs.
5. Develop models for the inclusion of water conservation into the agricultural education curriculum, including classroom, supervised agricultural experience and FFA activities.
6. Encourage the development of community college, technical programs and university programs to prepare the future workforce to work in irrigation efficiency technologies and with necessary expertise in less water intensive crops and crop varieties.

GUIDING PRINCIPLES

Following are guiding principles which directed the development of this supplement. These guiding principles will continue to serve as precepts for the implementation of the action items.

1. Nothing in this supplement is intended to displace current water education programs. Instead, the initiatives are designed to promote such programs and to encourage the development of complementary programs.
2. The initiatives and concepts described in this supplement are strategic in nature and, as such, do not describe the details of the implementation of the initiatives. The initiative implementation plans will be developed following the approval of the initiatives. Any local, regional or state agency, educational institution, non-government organization, private company or individual

stakeholders interested in water education programs are invited and encouraged to provide input and feedback regarding the implementation plans and to participate in these initiatives.

3. All of the initiatives will be unified through a social marketing campaign and a central web-based platform.
4. All strategies and action items within this supplement exist under the larger umbrella of the Vision, and will support its mission to provide Kansans with the framework, policy and tools to manage, secure and protect a reliable, long-term statewide water supply. A reliable water supply is dependent upon both sufficient quantity and quality.

BUILDING ON SUCCESS

As described in the guiding principles, this supplement is not intended to displace any of the current water education programs. This strategic plan represents an opportunity to build upon and maximize the many successful education organizations and activities currently in place in Kansas. Just a few of these successes include the youth conservation poster and essay contests hosted through the County Conservation Districts, local community water festivals, the KACEE's Project WET, and the Awesome Aqua magazine and natural resource educator's guides developed through Kansas Foundation for Agriculture in the Classroom.

While we have many successes to celebrate related to water resource education in Kansas, gaps still exist and opportunities remain to strengthen Kansans' knowledge and awareness of water and water-related issues. Filling these gaps will require cooperation and collaboration between many entities and agencies, and will begin with an open commitment by all partners to seek mutual support and improvement. Success in the end will require everyone on all levels working together with a common goal of conserving and protecting our water resources for the next generation.

THEMES AND STRATEGIES

This section includes the themes and strategies identified during the education supplement development process.

During each working group meeting attendees focused discussion on the following themes:

- Community Facilitation and Learning
- K-12 Curriculum and Career Education
- Out-of-Classroom Youth Education
- Media and Public Outreach Campaigns
- Career Development

STRATEGY OVERVIEW

- Develop and enhance a statewide marketing campaign to include brand recognition within our state's residential households.
- Establish a brand recognizable centralized website.
- Increase awareness and knowledge of Kansas youth on water-related issues through K-12 education and beyond-the-classroom opportunities.
- Provide opportunities for Kansans of all ages to increase their awareness of local water issues.
- Develop partnerships between industry, community, and educational institutions that will promote and train for water-related careers.

Similar to the overall *Vision for the Future of Water Supply in Kansas*, strategies are identified and categorized in Phases according to the priority for implementation.

- Phase I action items are the highest priority and will be initiated, but not necessarily completed, during the first year of this draft of the Vision supplement.
- Phase II action items will be initiated within five years.
- Phase III action items are longer-term and may require additional research, development and stakeholder coordination before the action item can be initiated.

COORDINATING TEAM SUBGROUP CHAIRS

Dana Ladner, Kansas Dept. of Agriculture
Chair, Coordinating Team

Ginger Harper, Kansas Water Office
Community Facilitation & Learning Subgroup

Gregg Hadley, K-State Research & Extension
Community Facilitation & Learning Subgroup

Kurt Dillon, Kansas State Dept. of Education
K-12 Curriculum & Career Education Subgroup

Bobbi Luttjohann, Kansas Water Office
Out-of-Classroom Youth Education

Heather Lansdowne, Kansas Dept. of Agriculture
Media & Public Outreach Campaigns Subgroup

Katie Patterson-Ingels, Kansas Water Office
Media & Public Outreach Campaigns Subgroup

Russell Plaschka, Kansas Dept. of Agriculture
Career Development Subgroup

DEVELOP AND ENHANCE A STATEWIDE MARKETING CAMPAIGN TO INCLUDE BRAND RECOGNITION WITHIN OUR STATE'S RESIDENTIAL HOUSEHOLDS.

STATEWIDE ACTION ITEMS

PHASE I

Assess Kansans' knowledge and awareness of water resources through a statewide assessment. Improve Kansans', as well as federal, state and other public officials, knowledge and awareness of water resources through a unified statewide message.

1. Work with the marketing firm under current state contract, assuming capabilities match the needs of the campaign.
2. Develop and conduct statewide awareness assessment through the marketing firm to establish baseline knowledge of Kansans' understanding and comprehension of water issues.
3. Analyze and share findings.

PHASE II

Utilizing the marketing firm, develop a media plan and campaign message maps to improve knowledge and awareness of water resources and promote local citizen knowledge and engagement in water conservation.

1. Create a unified and recognizable brand for the media plan.
2. Develop a portfolio of water resource education messages.
3. Debut campaign through a concerted outreach launch event including social media, print coverage and television broadcasting.
4. Make modifications and improvements to media plan and message maps as necessary.
5. Conduct a mid-campaign survey to assess effectiveness of media plan, comparing results with initial findings of baseline survey.
6. Assess the success of the campaign through a post-campaign survey and adapt accordingly annually.
7. Continue to develop and incorporate digital strategies for end user interaction as identified by the marketing firm.

ESTABLISH A BRAND RECOGNIZABLE CENTRALIZED WEBSITE.

STATEWIDE ACTION ITEMS

PHASE I

Create an online “one-stop shop” of statewide water-related resources and information for all Kansans including federal, state and other public officials.

1. Work with a marketing firm, under current state contract, to develop the website resource.
2. Hire, or designate internally, a website administrator responsible for working with the firm on the website design, development and content management.
3. Collect and incorporate general information about the state’s water resources in the one stop shop site.
4. Collect current and relevant materials through contributions by water agencies and designated subgroups.
5. Initiate development and promotion of the centralized website.
6. Create a clearinghouse for resource libraries on the website. Information to be included, but not limited to the following: curriculum resources, vetted resources for K-12 for utilization in classrooms, scientific research based resources, economic indicator models, and water-related workshop resources as well as a list of experts and researchers who can provide information on water-related issues.

PHASE II

Launch and continue adding to centralized website, utilizing materials and resources collected in Phase I, and promote website throughout the state.

1. Enhance centralized website by adding interactive user engagement opportunities such as online information requests and downloadable curriculum.
2. Maintain and add to resource library, keeping materials current and relevant.
3. Continue to assess the usefulness of the “one-stop shop” website.

INCREASE AWARENESS AND KNOWLEDGE OF KANSAS YOUTH ON WATER-RELATED ISSUES.

STATEWIDE ACTION ITEMS

PHASE I

1. Establish baseline knowledge of youth in Kansas on water-related issues through a review of marketing research data on youth education.
2. Create opportunities to encourage collaboration between organizations currently involved in water education for youth:
 - a. Hold Governor's roundtable including the Kansas Commissioner of Education, the President and CEO of the Kansas Board of Regents, and leadership from organizations involved in water-related education for youth and which establishes a commitment for integrating efforts in water education.
 - b. Hold a statewide Summit on Water Education for educators and educational organizations to share best practices, resources, curriculum and services.
 - c. Develop a collaborative plan for sharing water educational resources on an ongoing basis, to include organizing them on the website and sharing them through professional development programs.
3. Develop a grant program for new and existing water education organizations to provide professional development, curriculum and resources which build on statewide messaging efforts.
4. Collaborate with youth-related organization leadership on water-related educational opportunities and establish sessions and experiences focused on water.

PHASE II

1. Launch and promote statewide grant program and award grants for water education.
2. Provide information to K-12 educators about available resources that correlate with educational standards.
3. Provide information to beyond the classroom education organizations on water education curriculum, tools and resources.
4. Provide recognition and awards to youth on water-related projects, offered through schools, clubs and organizations.
5. Increase opportunities for professional development for educators on water-related curriculum to strategically emphasize information and education regarding the importance of water and water conservation practices. Some opportunities may be made possible through the grant program established in Phase I.
6. Conduct surveys to assess changes in youth awareness and knowledge in water-related conditions and issues.

PHASE III

1. Continue grant program from Phases I and II.
2. Continue to assess changes in youth awareness and knowledge in water-related conditions and issues.

PROVIDE OPPORTUNITIES FOR KANSANS OF ALL AGES TO INCREASE THEIR AWARENESS OF LOCAL WATER ISSUES.

STATEWIDE ACTION ITEMS

PHASE I

1. Establish and hire Community Outreach Specialist position(s). The ideal candidate(s) will possess a water conservation background coupled with strong community discussion, education and facilitation skills.
2. Expand current collaboration efforts between university water researchers and water agencies to include higher education institutions in Kansas. Discussions would include state and regional water priorities, current and potential water research projects, and additional opportunities to collaborate.
3. Work with developers of centralized website to create links to existing economic indicator resources. Site should provide continual evaluation of the economic impacts of reduced water use based on decision support resources.
4. Establish the "Top 3" water conservation measures for each Regional Planning Area for household, agriculture and industrial/municipal water use. These should be developed by the Regional Advisory Committees using existing data and displayed on the central website.

PHASE II

1. Utilize the statewide media plan and message maps to promote local engagement in water resource management.
2. Enhance working relationships between local and state entities for collaboration on water strategies. This should consist of a unified message disseminated throughout the state by local entities.
3. Coordinate workshops for local decision makers on water initiatives held throughout the state.
4. Develop a grant program to support Regional Advisory Committees and other organizations that are working with communities to raise awareness about water issues, recognize successes and engage citizens in water conservation initiatives.
5. Establish region-specific, targeted improvements for household, agricultural and industrial/municipal water conservation. These measures will be shared through the Community Outreach Specialist(s) and workshops and educational events.

DEVELOP PARTNERSHIPS BETWEEN INDUSTRY, COMMUNITY, AND EDUCATIONAL INSTITUTIONS THAT WILL PROMOTE AND TRAIN FOR WATER-RELATED CAREERS.

STATEWIDE ACTION ITEMS

PHASE I

1. Begin evaluation of higher education institutions current academic offerings and identify water-related courses and curricula.
2. Coordinate regional/topical workshops to facilitate development of partnerships between higher education and business and industry. Partnerships will analyze existing academic degree programs leading to water-related careers.
3. Develop workshops and professional developments based on information found in KDA Agriculture Workforce Needs Assessment and state meetings.
4. Develop a grant-sponsored internship/mentorship program in water-related careers, sponsored across water agencies.

PHASE II

1. Host professional development opportunities to prepare individuals in multiple related career paths to understand water resources.
2. Seek opportunities to promote existing water-related degree programs at Regents institutions, based on evaluations of all academic offerings, apply for United States Department of Agriculture, National Institute of Food and Agriculture funding through programs such as Higher Education Challenge Grants and Secondary Education, Two-Year Postsecondary Education, and Agriculture in the K-12 Classroom (SPECA) Challenge Grants.
3. Collaborate with higher education institutions to fill any gaps in the water-related academic career tracks that were identified during Phase I.
4. Initiate and evaluate internship/mentorship grant program.

PHASE III

1. Evaluate and increase enrollment and business participation in the internship/mentorship program.
2. Complete and evaluate U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA) funded grant projects.

USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	2	0	0	0	2
Masters	3	0	0	0	3
Ph.D.	2	0	0	0	2
Post-Doc.	0	0	0	0	0
Total	7	0	0	0	7

Notable Awards and Achievements