Big Creek Research and Extension Team

University of Arkansas System Division of Agriculture

Quarterly Report – April 1 to June 30, 2014

MONITORING THE SUSTAINABLE MANAGEMENT OF NUTRIENTS ON C&H FARM IN BIG CREEK WATERSHED

Mission of the University of Arkansas System Division of Agriculture

The mission of the **Division of Agriculture** is to advance the stewardship of natural resources and the environment, cultivate the improvement of agriculture and agribusiness, develop leadership skills and productive citizenship among youth and adults, enhance economic security and financial responsibility among the citizens of the state, ensure a safe, nutritious food supply, improve the quality of life in communities across Arkansas, and strengthen Arkansas families.

Dr. Mark J. Cochran

Vice President for Agriculture

MONITORING THE SUSTAINABLE MANAGEMENT OF NUTRIENTS ON C&H FARM IN BIG CREEK WATERSHED

Executive Summary

This is the third Quarterly Report of the Big Creek Research and Extension Team that details the following progress made from April 1 through June 30, 2014.

1. Two karst hydrogeology specialists, Phil Hays and Tim Kresse, were added to the Team. Phil Hays is a Ground Water Specialist with U.S. Geological Survey, who is an expert on the use of stable isotopes and other geochemical indicators in delineating movement and behavior of contaminants in ground-water systems. Tim Kresse is a Water Quality Specialist, also with U.S. Geological Survey, who is an expert on the natural geochemical evolution of ground water and separating these processes from anthropogenic sources of contamination. Both have extensive field experience in karst hydrogeology in the Ozarks and Boston Mountains region.
2. The Ground Penetrating Radar (GPR) of Field 12 was completed. Results suggest that an argillic layer around 25-cm and a wavy gravel layer (about 35 to 45%) around a depth of 80 to 120 cm, which is typical of the other fields surveyed adjacent to Big Creek. However, the gravel layer appears to be overlain with fine sandy loam (0 to 25 cm depth) and sandy clay loam material (25 to 80 cm depth) that is of valley and alluvial origin.
3. Completed installation of surface runoff monitoring equipment on Fields 1, 5a, and 12 and piezometers on Fields 5a and 12. We are monitoring the ongoing management of these fields and have not requested a change field management by the land owners. Thus, nutrient runoff and leaching is a function of various practices for each field, which includes grazing, mineral fertilizer application, and sine slurry application as determined by the current CNMP.
4. Base flow sampling of Big Creek continued every week above and below the C&H Farm, well adjacent to the production houses, subwatershed draining the production area, surface runoff from Field 1, and from a spring below monitored Field 1. Dissolved P concentration ranged from 0.005 to 0.074 mg/L in Big Creek upstream of C&H, 0.007 to 0.020 mg/L downstream of C&H, and 0.008 to 0.014 mg/L in well water. E. coli ranged from 57 to 921 MPN/100 mL upstream of C&H, 30 to 1553 MPN/100 mL downstream of C&H, and <1 to 11 MPN/100 mL in well water.
5. Installed continuous flow and storm sampling equipment at the up and down stream sites in collaboration with USGS. The downstream site is giving real-time, on-line stream discharge, nitrate concentrations, water temperature, and rainfall data.
6. Contracted with USGS to conduct dye-tracer studies in the Big Creek Watershed, as well as monitoring subsurface movement material from manure holding ponds.

Big Creek Research Team

Faculty

Andrew Sharpley, Ph.D., TEAM LEADER – Distinguished Professor - Soil science, water quality, soil phosphorus chemistry, agricultural management

Kris Brye, Ph.D., Professor - Effects of land application of poultry litter on in-situ nutrient leaching, effects of land use and management practices on soil physical, chemical, and biological properties related to soil quality and sustainability

Rick Cartwright, Ph.D., Professor – Associate Director of Extension for Agriculture and Natural Resources

Mark Cochran, Ph.D., – Vice President, University of Arkansas System Division of Agriculture.

Mike Daniels, Ph.D., Professor – Extension water quality and nutrient management specialist

Brian Haggard, Ph.D., Professor - Ecological engineering, environmental soil and water sciences, water quality chemistry, water quality monitoring and modeling, algal nutrient limitation, pollutant transport in aquatic systems

Phil Hays, Ph.D. Ground Water Specialist, U.S. Geological Survey and Research Professor with Geosciences Dept., University of Arkansas, application of stable isotopes and other geochemical indicators in delineating movement and behavior of contaminants in ground-water systems

Tim Kresse, M.Sc., Water Quality Specialist, U.S. Geological Survey, natural geochemical evolution of groundwater and separating these processes from anthropogenic sources of contamination

Nathan McKinney, Ph.D., – Assistant Director, Agriculture Experiment Station

Mary Savin, Ph.D. - Structure and function of microbial communities in natural and managed ecosystems, microorganisms in nutrient cycling, contaminant degradation

Thad Scott, Ph.D., Associate Professor - Water quality, transport of contaminants to and within water bodies

Karl VanDevender, Ph.D. and P.E., Professor - Extension Engineer, Livestock and poultry manure and mortality management, nutrient management planning

Jun Zhu, PhD., Professor - Biological and agricultural engineering, agricultural sustainability, manure treatment technologies

Adam Willis, M.Sc., Newton County Extension Agent - Agriculture

Field Technicians

The Big Creek Research and Extension Team are ably supported by several excellent Program Technicians based in Little Rock and Fayetteville.

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Introduction

This research project will evaluate the potential impact and sustainable management of the C&H Farm operation (subsequently referred to as C&H, to include animal facilities and permitted land application fields) on the water quality of Big Creek. The study includes the following major tasks:

1. Monitor the fate and transport of nitrogen (N), phosphorus (P), sediment, and bacteria from land-applied swine effluent to pastures.
2. Assess the potential impact of farming operations (effluent holding ponds and land-application of effluent) on the water quality of Big Creek below the C&H Farm as well as emerging springs and ephemeral streams.
3. Determine the effectiveness and sustainability of alternative manure management techniques, including solid separation, which may enhance the export of nutrients out of the watershed.

The project will measure soil fertility levels of all permitted fields annually, to determine the potential impact of current manure management on nutrient balances (i.e., any potential accumulation). This combined with nutrient levels in surface runoff and monitored wells on Fields 1, 5a, and 12, will guide adaptive manure management decisions to address field and environmental sustainability concerns. However, it must be recognized that these fields continue to be managed as they were prior to any manure application and are regularly grazed and hay cut as appropriate. Thus, sources of nutrients in surface runoff and piezometers will be influenced by a number in-field management factors in addition to manure application. The project will assess the feasibility of manure treatment that is regarded as addressing nutrient imbalance concerns on all farms similar to C&H. Manure treatment has the potential to provide the farm with cost-beneficial alternative for the sustainable use and export of treated manures off the farm and/or out of the watershed.

Ground Penetrating Radar for Field 12

Ground Penetrating Radar (GPR) Survey Report

United States Department of Agriculture
Natural Resources Conservation Service

Purpose and Overview:

A series of ground penetrating radar surveys were conducted south of Mount Judea, AR on March 24th, 2014 on a pasture adjacent to Big Creek in Newton County AR. The field is labeled as #12 on University of Arkansas reports. The field was a floodplain/terrace, and the soil at the site was mapped as Spadra loam, occasionally flooded.

Field observations from November 2013 at a similar field a few miles north of this site aided in interpreting and collecting the data.

Participants:

Lawrence Berry	Program Technician, University of Arkansas
Dr. Kris Brye	Professor of Applied Soil Physics and Pedology, University of Arkansas
Dr. Mike Daniels	Professor, Extension Water Quality, University of AR Division of Agriculture
Richard Vaught	Soils Scientist and GPR operator, NRCS
Pearl Webb	University of AR Extension
Dr. Larry West	Retired, NRCS, Lincoln, NE

Activities, Field 12:

1. Five transects were flagged on the field in an east-west direction, roughly perpendicular to Big Creek. The transects were spaced at 50 meters. Each transect was flagged at 10-m intervals, and the approximate location of each flag was recorded with a Garmin 76s GPS. All radar surveys proceeded from east to west.
2. A SIR-3000 Ground-Penetrating Radar (GPR) system (Geophysical Survey Systems Inc.) with 200-Mhz antenna was used.
3. A metal plate was buried at the site at a depth of 50-cm to calibrate the instrument and to ground-truth soil conditions. The plate was buried along transect #4.
4. Three holes were augured on both transect #3 and #4 to ground-truth soil conditions. Ground-truthing along transects #5, #6 and #7 was not possible.

Table 1. Transect information.

Survey/ Transect ID	Length (m)	Flags
3	220	23
4	210	22
5	200	21
6	190	20
7	170	18

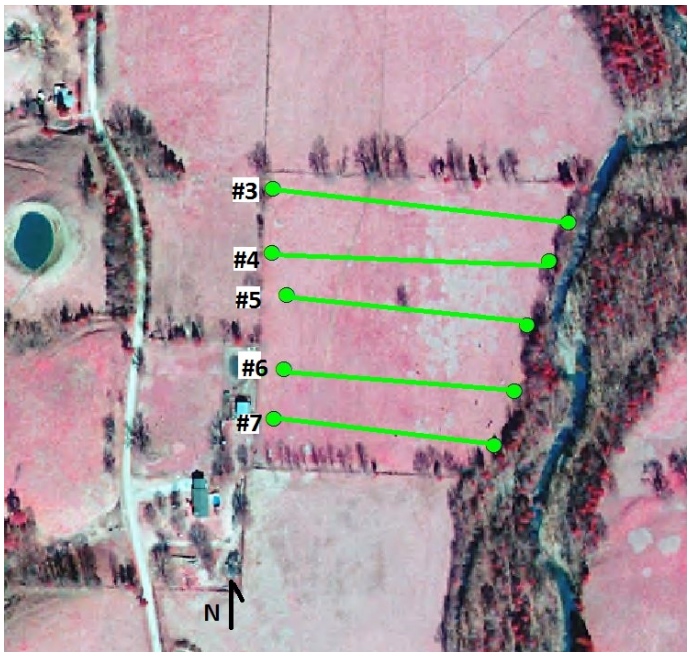


Figure 1. Location of ground penetrating radar surveys at field 12, south of Mount Judea, AR.

Summary, Field 12, Transect 3:

1. Soils observed at the site via test hole mostly agreed with the Newton County soil survey, and resembled the Spadra series, which is an Ultisol. From the county soil survey: "Spadra is a very deep, well-drained soil on stream terraces. This soil formed in loamy alluvial material derived from sandstone, siltstone, and shale. Permeability is moderate and available water capacity is high. This soil is occasionally flooded for brief periods during the winter and spring."
2. Soils observed were well drained; however, conditions were wet due to recent rains. Rafted debris, indicative of overland flow, was observed on the fence row along the north edge of the field.
3. The radar records from this site were of good interpretative quality.
4. Based on the holes augured along the transect, the radar record from this site, and from sites viewed in November 2013 along Big Creek in the same vicinity, the horizonation of the soils seems to be fairly consistent for the first 170-m of the transect.
5. An "A" horizon with a depth of around 0-20 cm seems to be consistent across most of the transect. Field textures observed were silt loam, with fine sandy loam surface texture becoming more common in closer proximity to the creek (after the 150-m mark).
6. The argillic layer along the transect commonly begins at 20-30 cm (figure 2). Field textures observed between 20-80-cm of the argillic horizon were silty clay loam.

7. The radar suggests that the solum along the transect is deeper than 1.5-m. Two test holes were augered to greater than 1-m.
8. Several hyperbola shaped anomalies were evident in the radar record, they were likely tree roots.
9. At around the 170-m mark (figure 3), the soil horizons become more wavy in nature. This change could be related to more recent scouring and deposition from Big Creek.
10. An anomaly at the 170-m mark, at around 1-m deep, could be a pocket of coarse fragments deposited by Big Creek (figure 3).
11. An anomaly was noted on the radar record at the end of survey 3 upon data collection (figure 4). It resembled possible coarse fragment deposits from the previous field visit. A test whole was augered at around the 225-m mark. The upper soil horizons (0-55-cm) were more sandy in nature than observations further from the creek along this transect. Subsurface textures were sandy loam. At 55-cm, augering was not possible due to coarse fragment content. Coarse fragment content was estimated at 35-45%.

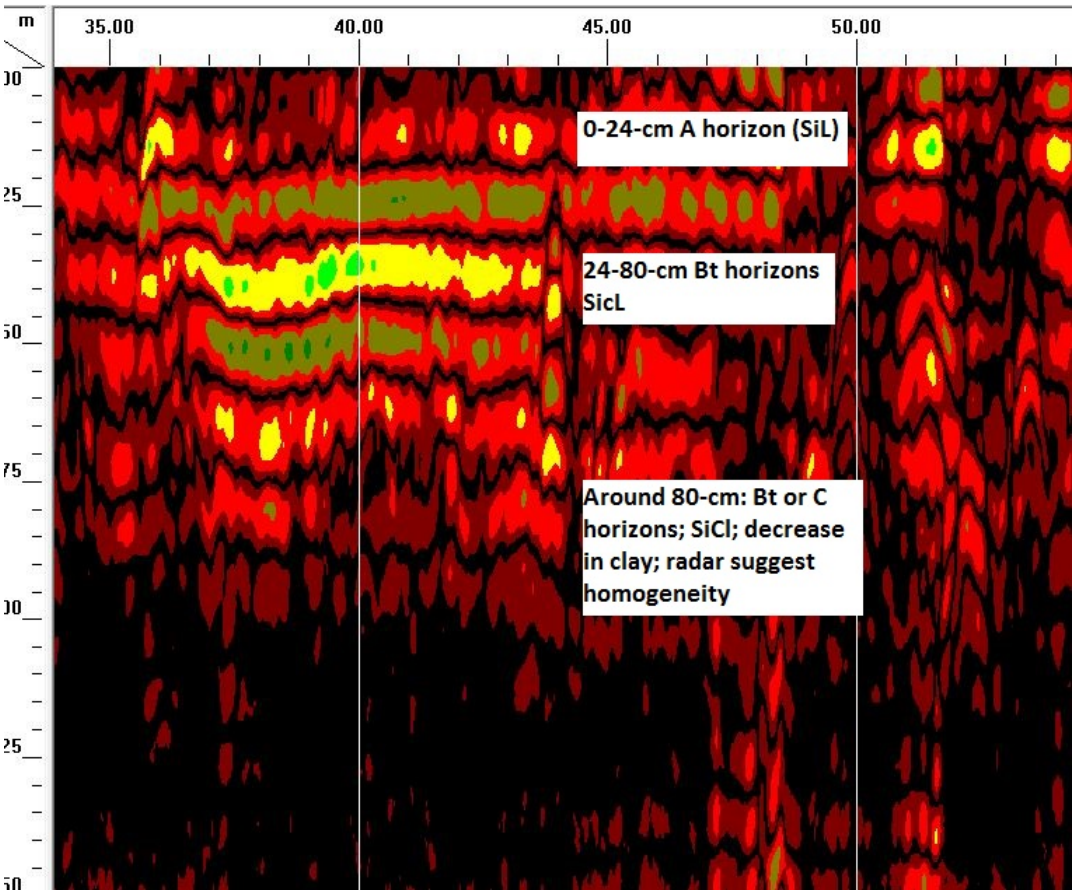


Figure 2. Typical profile from transect #3. A test hole was observed near the 50-m mark.

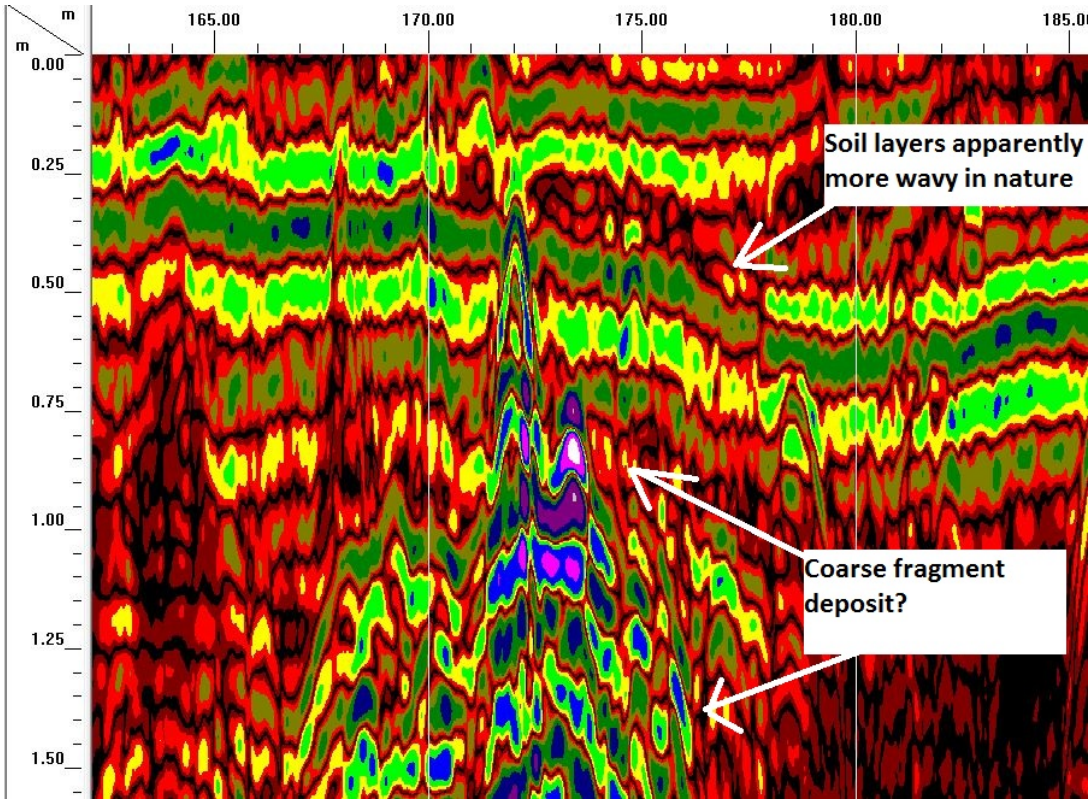


Figure 3. Along Transect 3, possible gravel layers were noted as the survey approaches Big Creek.

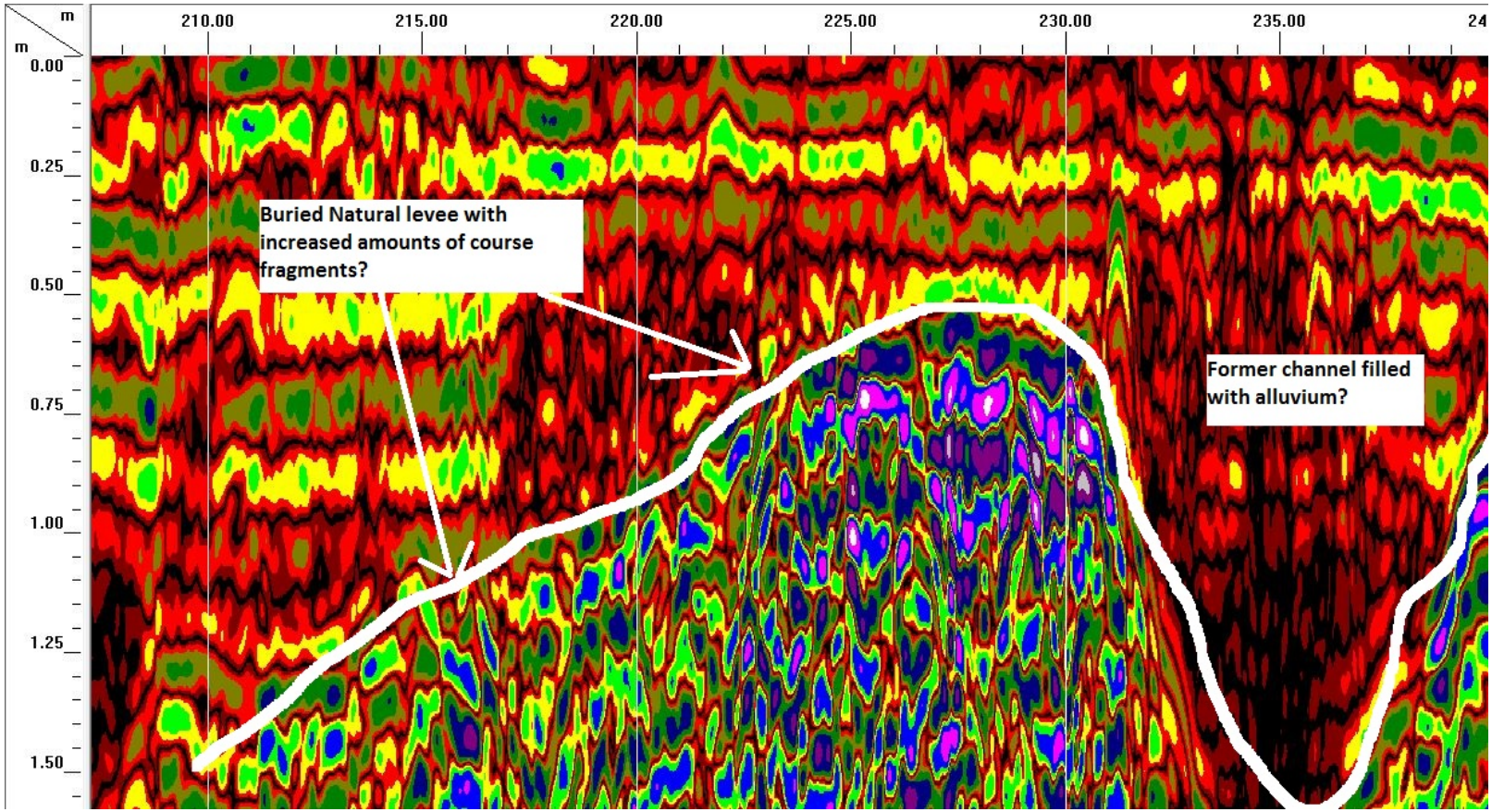


Figure 4. This anomaly at the end of Survey 3 may be a gravel bar deposited by Big Creek.

Summary, field 12, Survey #4

- The soils along this transect appear to be uniformly stratified for about the first 120-m of the survey (Figure 5).

- Test holes observed generally followed the Spadra series concept, except for one where gravels were observed in the subsoil

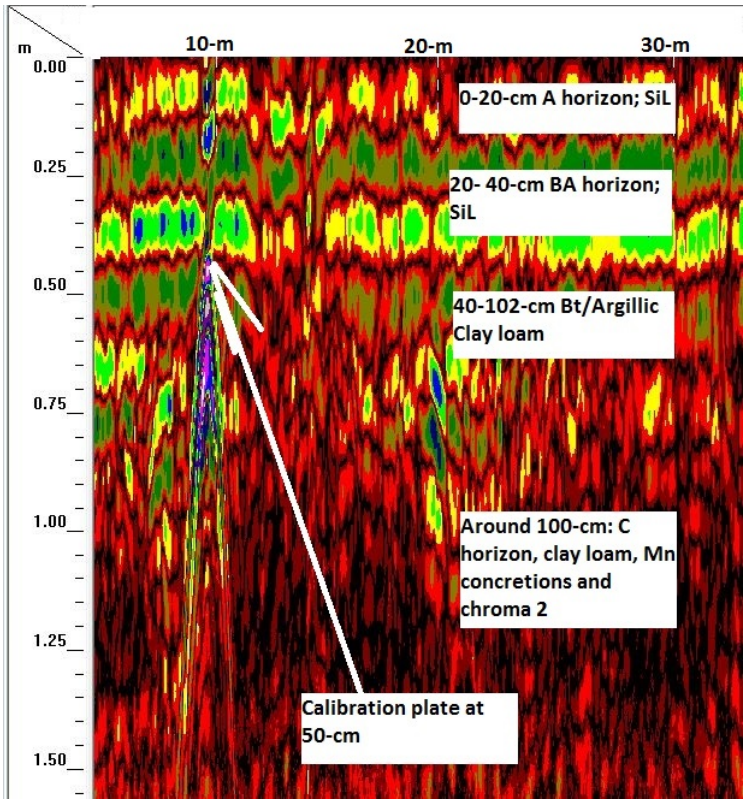


Figure 5. The first 30-m of survey number 4.

- Based on the radar record, soil horizons apparently become more wavy in nature between 120 and 130-m along the transect (Figure 6). This area is also underlain by radar signature that was found to be indicative of gravel deposits in previous test holes.

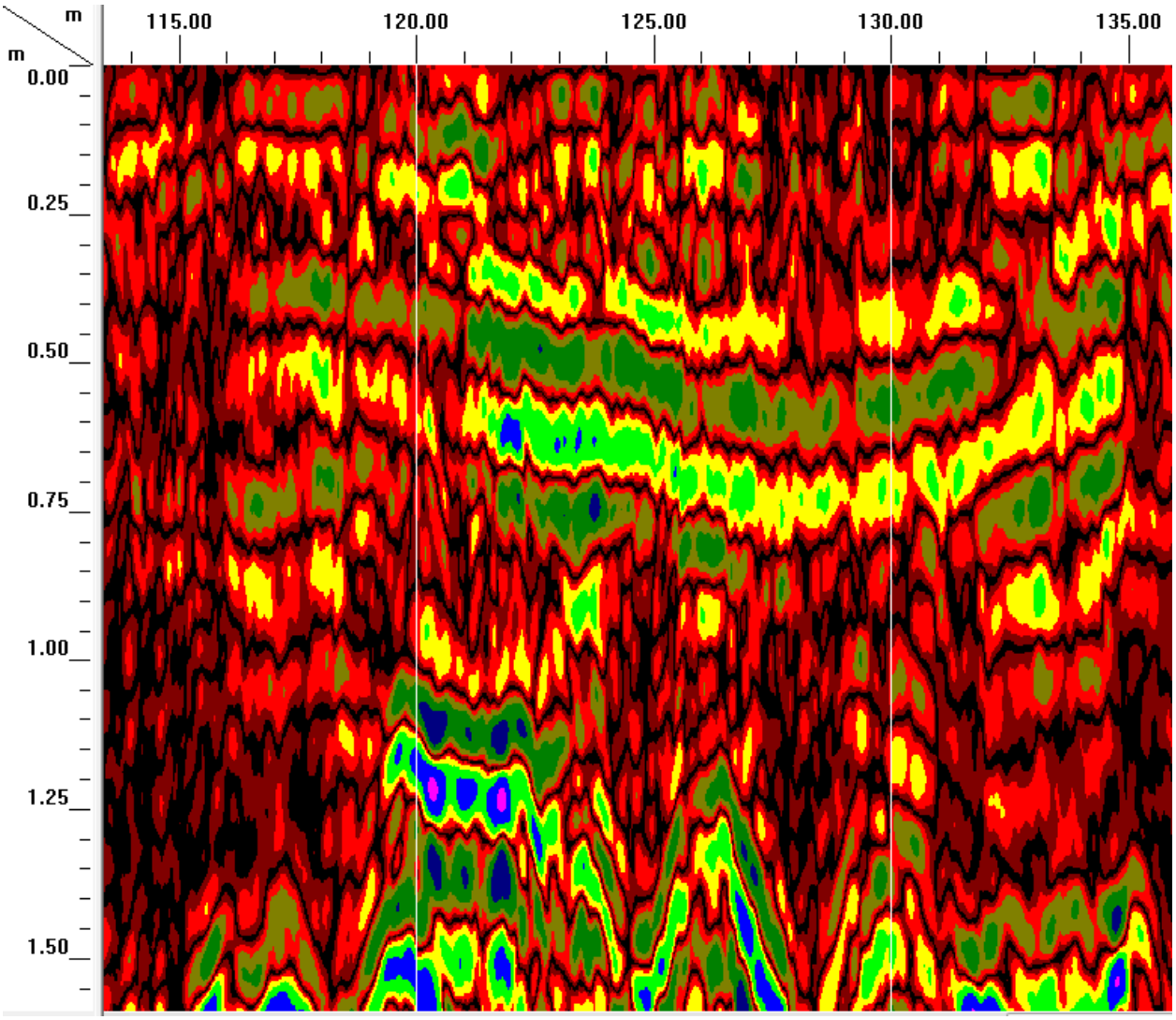


Figure 6. Features at bottom may be gravel deposits along survey number 4.

- A test hole was augured at the 200-m mark on transect 4, as summarized below. A suspected area of gravel deposition was confirmed to be present (Figure 7). The upper 80-cm was covered with loamy alluvium.

  A: 0-25-cm; Fine sandy loam
  Bt1: 25-50-cm; Sandy clay loam
  Bt2: 50-80-cm Sandy clay loam (marked clay increase)
  BC: 80-120-cm Very gravelly Sandy loam 35% fragments
  C: 120-cm plus; Very gravelly (or cobbly) Sandy loam >40% fragments

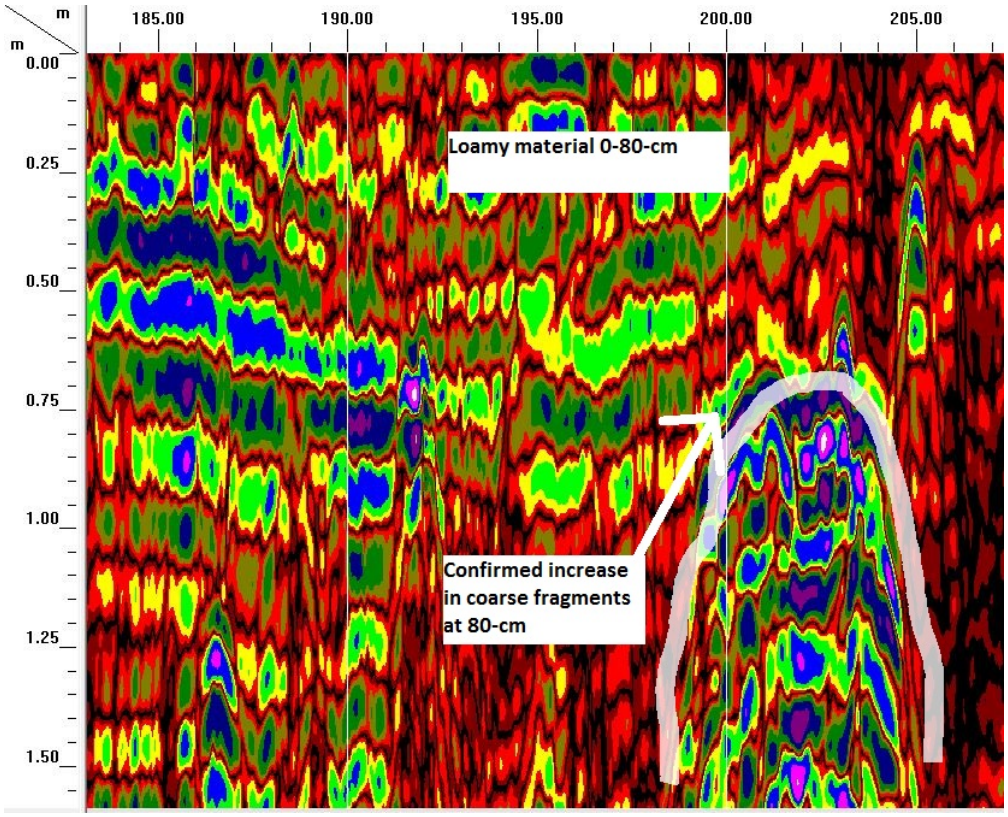


Figure 7. A subsurface horizon with increased fragment content was suspected and confirmed in the field along survey # 4.

Summary: Field 12, Survey # 5

- No points were ground-truthed along this radar survey
- The data indicates that most of this soil is uniformly layered, with a radar record resembling surveys # 3 and # 4. The survey indicates that the argillic layer usually starts around 25-cm.
- There were no anomalies associated with gravel at the end of this radar survey.
- There were highly contrasting materials noted at a depth of >1-m over the first 30-m of this transect (figure 8). This could be layers that greatly increase in clay content, or layers that increase in coarse fragments that are alluvial in nature. Less likely at this position would be “valley fill” material from nearby uplands that is overlain by alluvium.

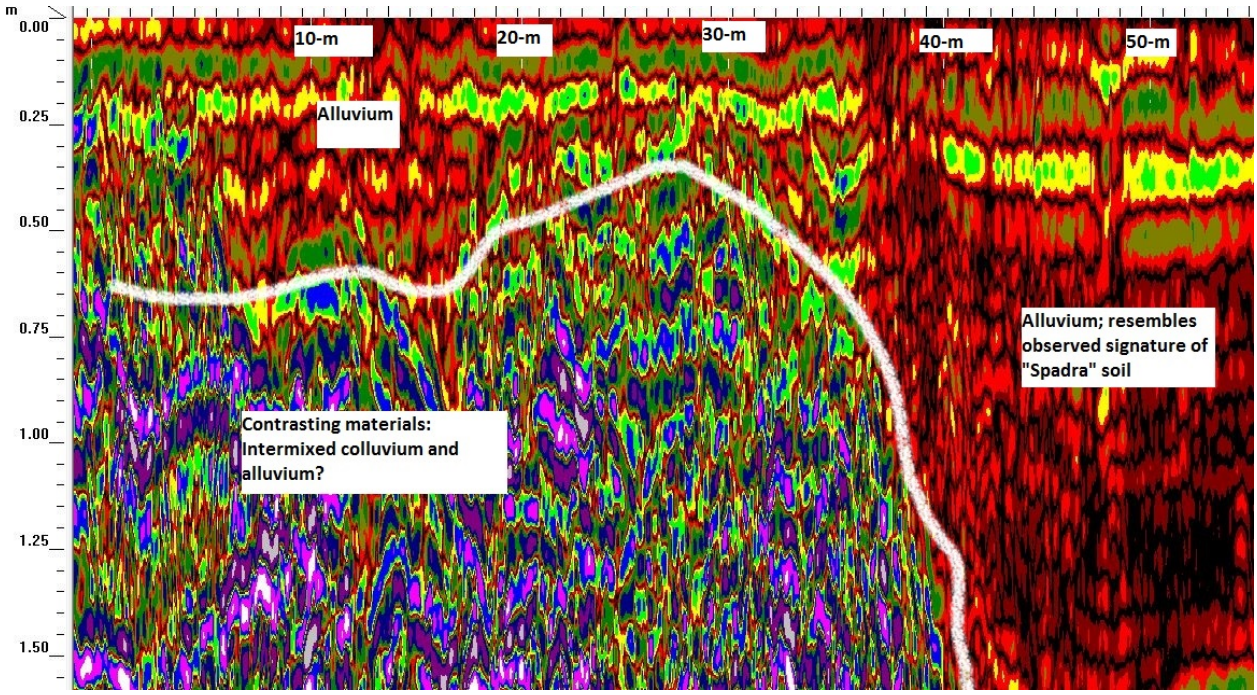


Figure 8. Contrasting, high amplitude features noted at the beginning of transect #5.

Summary: Field 12, Survey # 6

- No points were ground-truthed along this radar survey
- The data indicates that most of this soil is uniformly layered, with a radar record resembling surveys # 3 and # 4. The survey indicates that the argillic layer usually starts around 25-cm.
- There were highly contrasting materials noted at a depth of 60-cm from around the 40-m mark of this transect until around the 90-m mark (figure 9). Speculatively, this could be layers that greatly increase in clay content, or an increase in coarse fragments that are alluvial in nature.

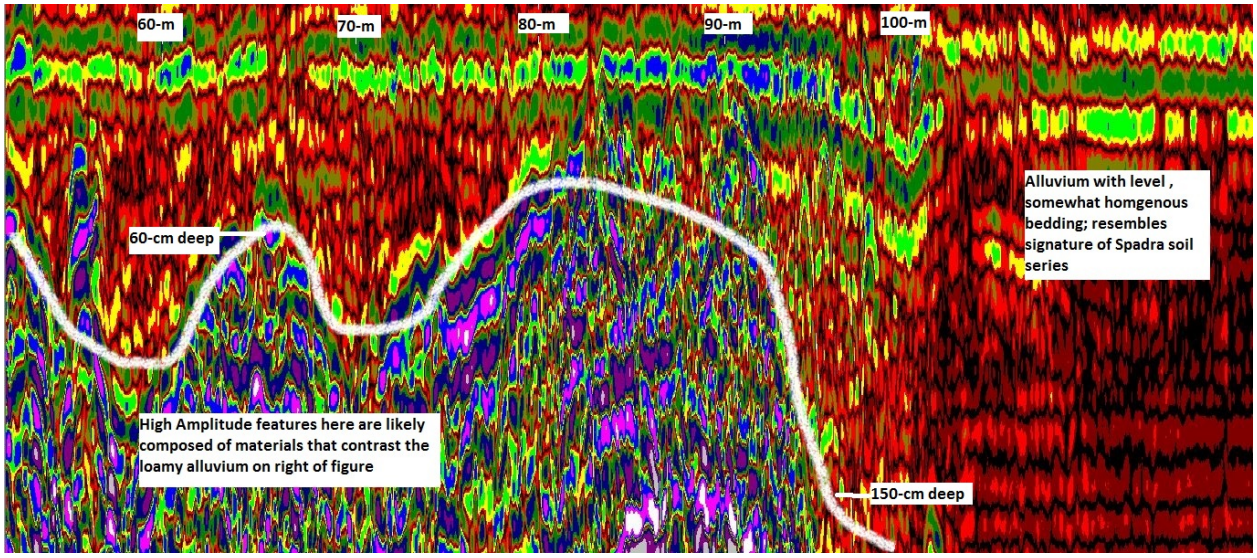


Figure 9. Contrasting materials below loamy alluvium disappear at the 100-m mark on transect #6.

Summary: Field 12, Survey # 7

a. From the 0-m to 80-m mark on this survey, the radar record suggests that most of the soil is level bedded and relatively homogenous. There are areas on this first portion of the transect that exhibit high amplitude and likely contrasting features (figure 10) that could contain higher amounts of coarse fragments or clay.

b. From the about the 80-m mark through the 130-m mark on the survey, there are subsurface deposits at depths deeper than 100-cm that contrast with what is likely loamy alluvium in the upper portion of the soil profile (Figure 11). Again, speculatively, these contrasting materials could be an increase in coarse fragments, or an increase in clay content.

c. There were no anomalies noted on the radar record from the 130-m mark to the end of the survey at 170-m (Figure 11). The radar record suggests that most of the soil is level bedded and relatively homogenous in this portion of the surey. The radar record mimics the loamy alluvium that resembled the Spadra series in surveys #3 and #4.

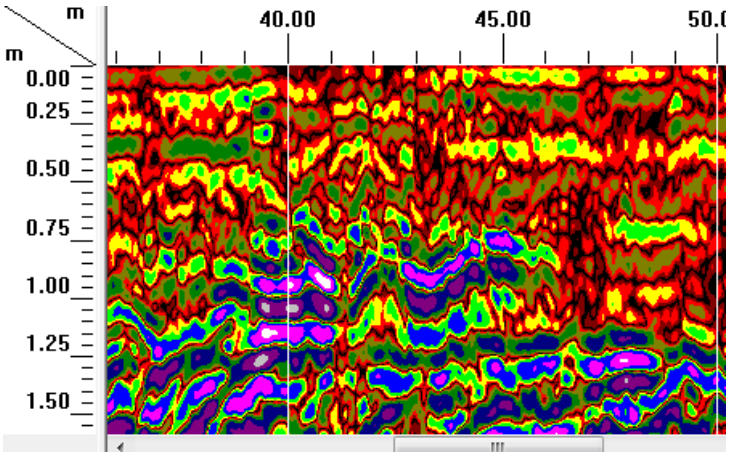


Figure 10. Purple features above could possibly be pockets of increased fragment deposition.

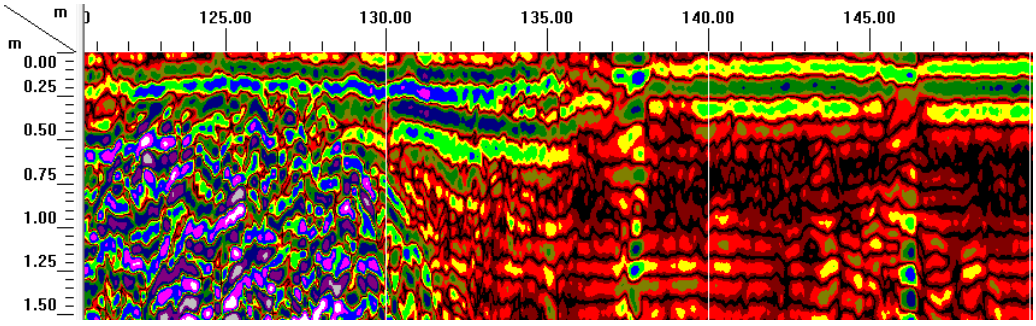


Figure 11. Highly contrasting features (left) were suggested by the radar record from the 80-m to 130-m marks along survey 7. The eastern most portion of the survey appears to be more evenly stratified and mimics similar radar signatures where fine-loamy Ultisols where observed in test holes on previous transects.

Water Sampling and Analyses

Sampling Locations

Topographic surveys of permitted Fields 1 and 12 were conducted to determine the appropriate location for edge-of-field surface runoff collection flumes. Figure 10 shows the low point on Field 1 where the flume was sited. The location for a similar flume on Field 12 is shown on Figure 11 and construction will begin as soon as the Field dries to allow construction without damaging or rutting any of the farmed field.

Water quality sampling was initiated on September 24, 2013, prior to the formal start of the project (Figure 12). Since January 1 and reported in the 1st Quarterly Report, installation of edge-of-field surface runoff monitoring equipment was completed and became operational April 2, 2014, as shown in Figure 13. Additionally runoff volume and auto-sampling equipment was also installed on an ephemeral stream draining a sub-watershed in which the C&H Farm operations and swine slurry storage lagoons are located, as shown in Figure 12. These sites are;

Site 1. Edge-of field monitoring on Field 1 permitted to receive slurry – Figure 13.

Site 2. Edge-of field monitoring on Field 5a – still to be determined

Site 3. Edge-of field monitoring on Field 12 permitted to receive slurry – still to be completed

Site 4. Ephemeral stream flow draining a subwatershed containing the production facilities – Figure 14.

Site 5. Spring below Field 1 – Figure 15.

Site 6. Big Creek upstream of the C&H Farm operation – Figure 16.

Site 7. Big Creak downstream of the C&H Farm operation – Figure 17.

USGS Stations

Big Creek Continuous Flow

Collaborating with USGS, Big Creek at the downstream site of prior water sample collection was instrumented with continuous flow gaging equipment, along with a nitrate sensor, which provided real-time flow, water temperature, water nitrate and precipitation. These data are available on-line at the following sites.

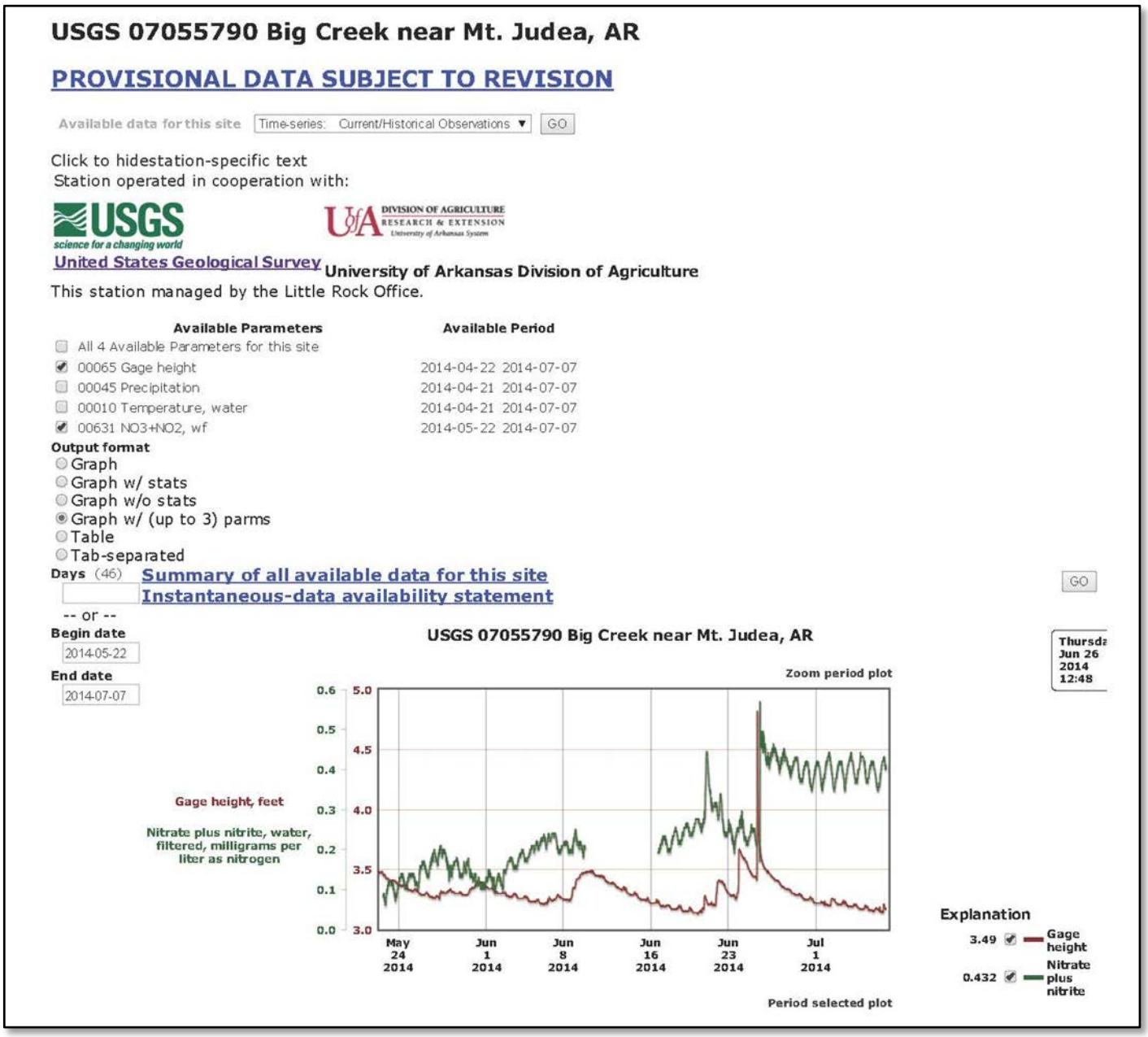
USGS 07055790 Big Creek near Mt. Judea, AR

http://waterdata.usgs.gov/ar/nwis/uv?cb_00065=on&cb_00045=on&cb_00010=on&format=gif_default&period=&begin_date=2014-04-16&end_date=2014-04-23&site_no=07055790

Big Creek Nitrate Sensor

http://waterdata.usgs.gov/ar/nwis/uv/?site_no=07055790&PARAmeter_cd=00010,00300,00095,00400,63680,00631,70301,00090,00940

Figure 12. Display of USGS gaging site on Big Creek, downstream of the C&H Farm showing continuous flow and nitrate plus nitrite concentrations since the equipment became active in May, 2014.



USGS 07055814 Big Creek at Carver, AR

http://waterdata.usgs.gov/ar/nwis/uv?cb_all_00065_00045_00010_00095_00400_63680_00300_00631=on&cb_00065=on&cb_00045=on&cb_00010=on&cb_00095=on&cb_00400=on&cb_63680=on&cb_00300=on&cb_00631=on&format=gif_default&site_no=07055814&period=&begin_date=2014-05-30&end_date=2014-06-06

Current conditions for Arkansas sites including Big Creek at Carver

http://waterdata.usgs.gov/ar/nwis/current?index_pmcode_STATION_NM=1&index_pmcode_DATETIME=2&index_pmcode_99409=3&index_pmcode_63680=4&group_key=NONE&sitefile_output_format=html_table&column_name=agency_cd&column_name=site_no&column_name=station_nm&format=html_table&sort_key_2=site_no&html_table_group_key=NONE&rdb_compression=file&list_of_search_criteria=realtime_parameter_selection

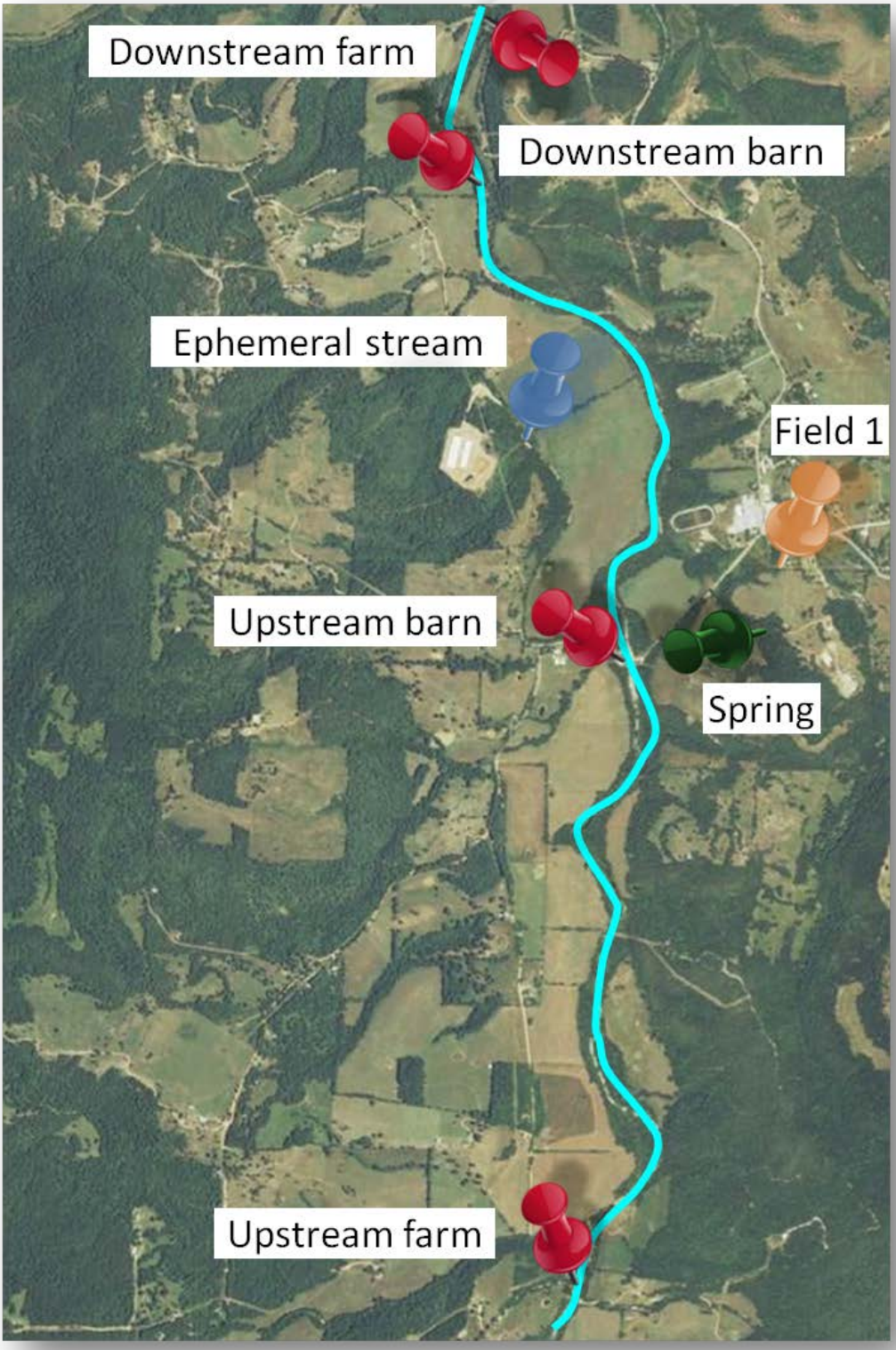


Figure 13. Location of water quality sampling sites on Big Creek and the C&H Farm.

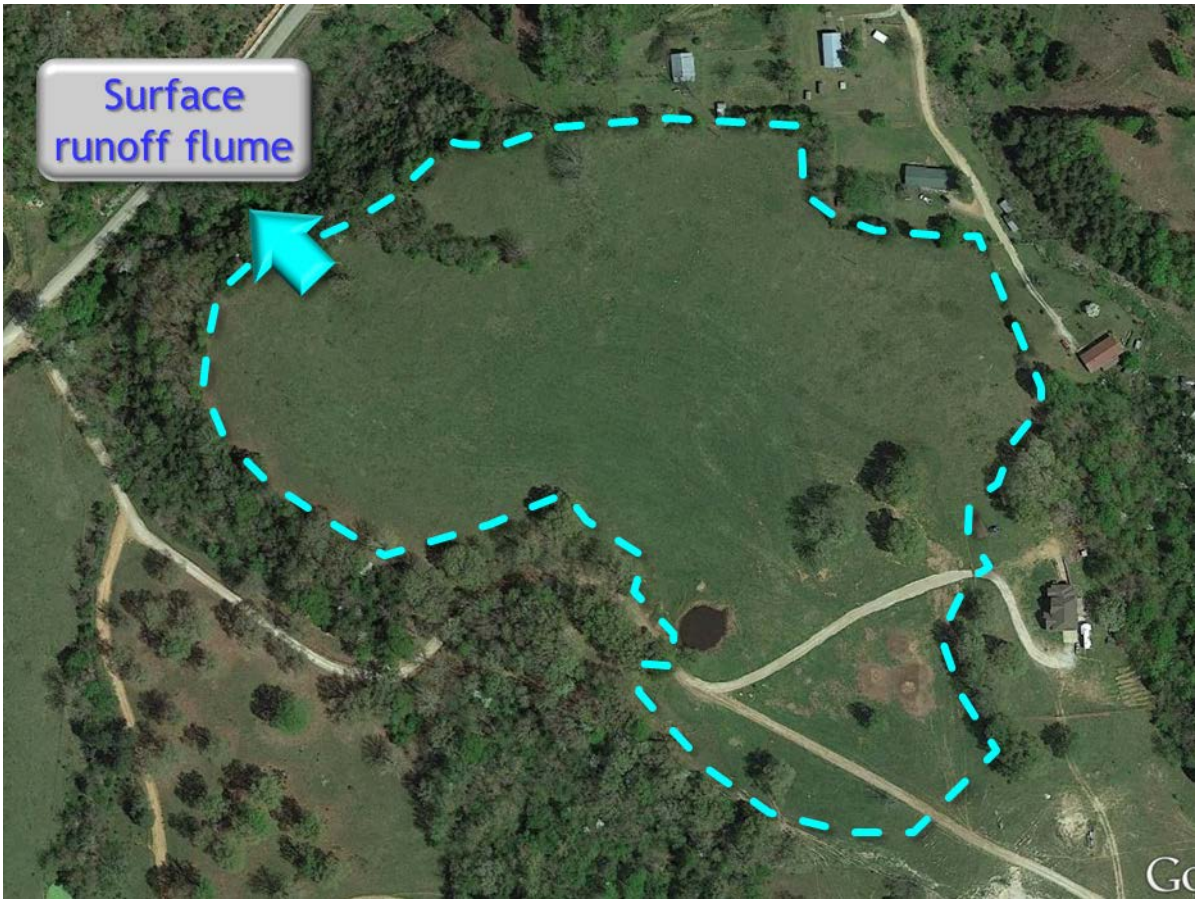


Figure 14. Surface and subsurface flow monitoring on Field 1 on the C&H Farm.

Figure 15. Edge-of-field surface runoff flume on Field 1 on the C&H Farm.

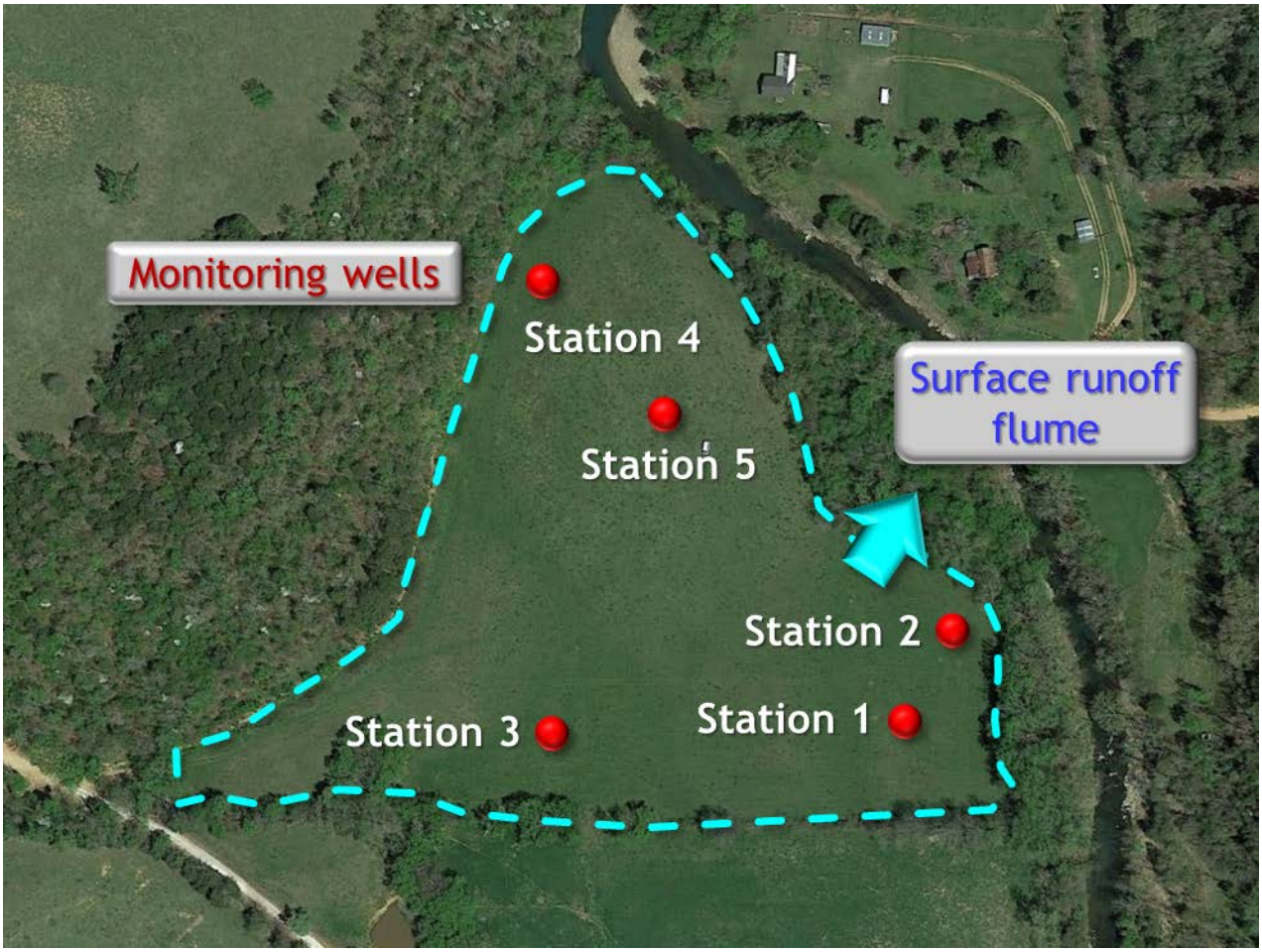


Figure 16. Surface and subsurface flow monitoring on Field 5a on the C&H Farm.

Figure 17. Edge-of-field surface runoff flume on Field 5a on the C&H Farm.

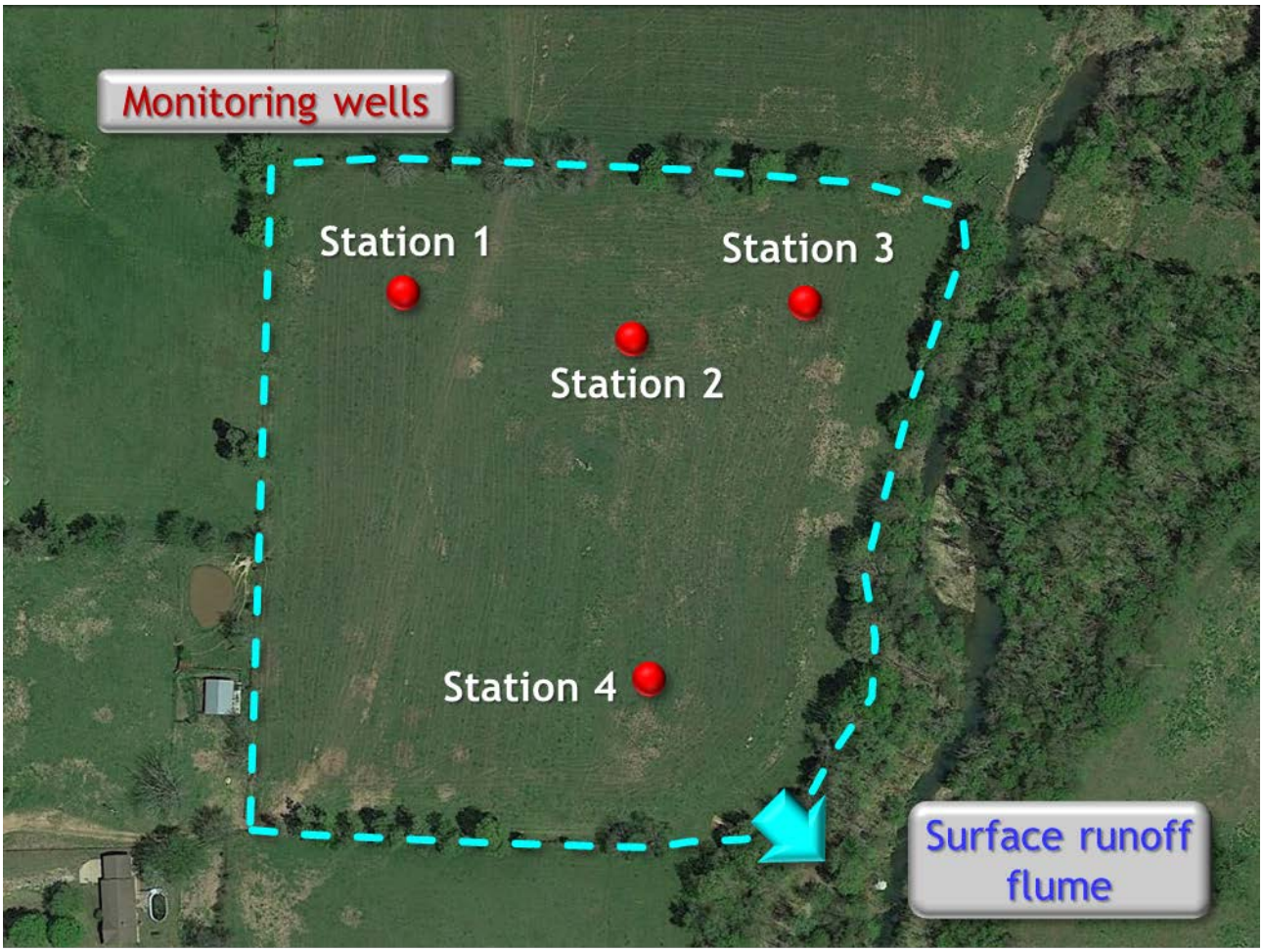


Figure 18. Surface and subsurface flow monitoring on Field 12 on the C&H Farm.

Figure 19. Edge-of-field surface runoff flume on Field 12 on the C&H Farm.

Figure 20. Installed piezometer that measures water table depth and can collect water samples from 15 and 48 inch depths.

Figure 21. The culvert sampling an ephemeral stream draining a subwatershed containing the C&H Farm operation facilities.

Figure 22. The spring sampled adjacent to Big Creek on the C&H Farm.

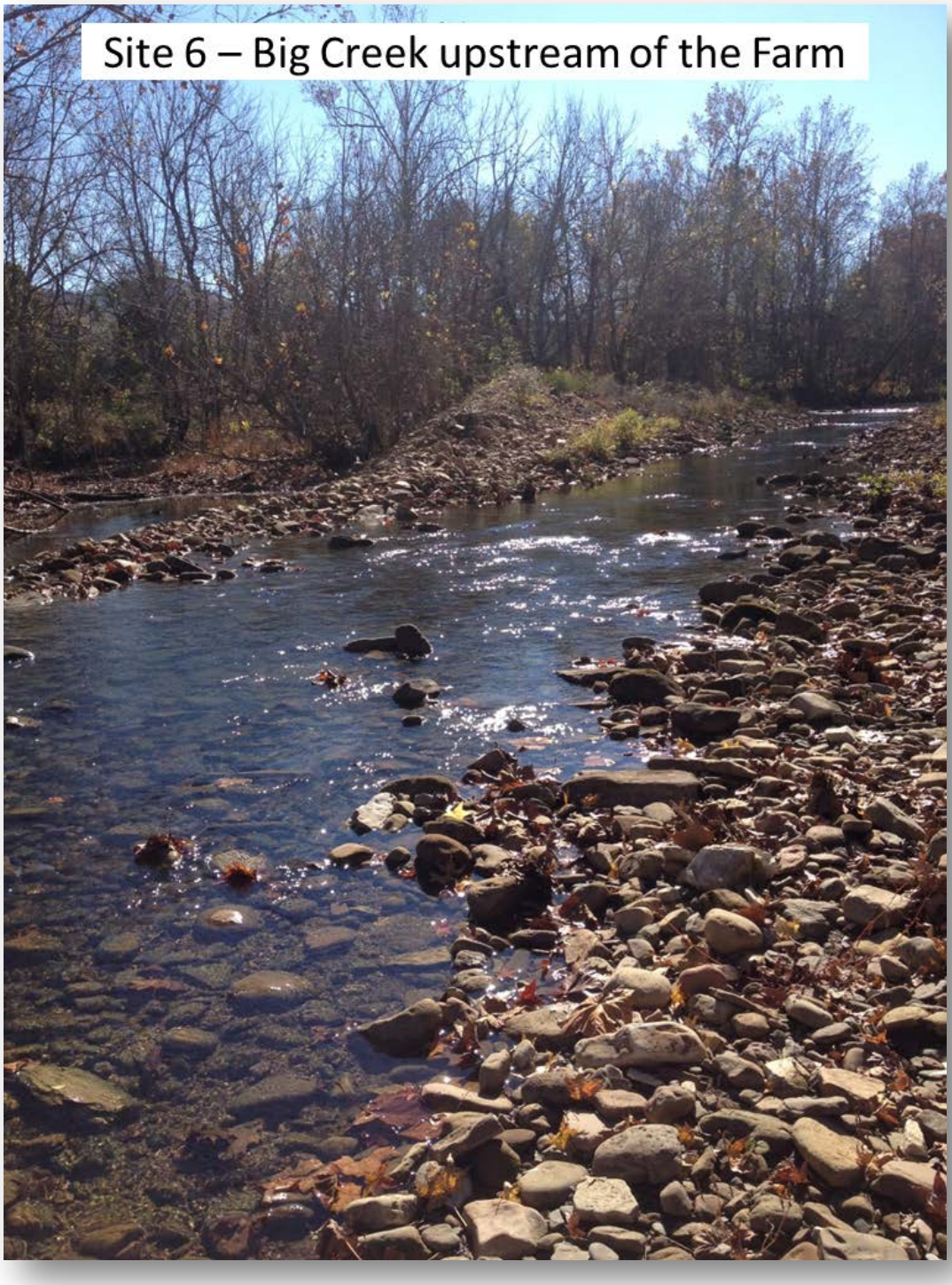


Figure 23. The Big Creek sampling site upstream of the C&H Farm during baseflow.

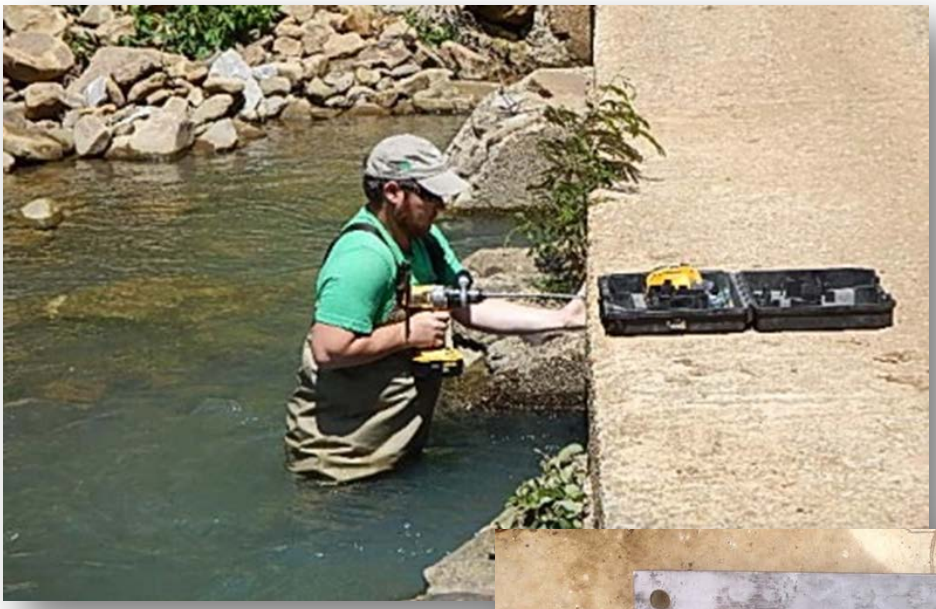


Figure 24. The Big Creek sampling station at the site upstream of the C&H Farm.

Figure 25. The Big Creek sampling site downstream of the C&H Farm during baseflow.

Figure 26. The Big Creek sampling station at the site downstream of the C&H Farm.

Figure 27. The Big Creek sampling station at the site downstream of the C&H Farm.

Sampling Protocols and Analyses

The chemical composition of water samples collected prior to June 30, 2014 is given in Tables 2, 3, and 4. The following procedure was used to collect, prepare and analyze all water samples;

1. One-liter acid-washed bottles were used to collect the stream samples for nutrient analyses.
2. Water was collected from just beneath the surface where the stream was actively moving and well-mixed. After March 31st, 2014, samples noted as storm flow in Tables 2, 3, and 4 were collected by automatic, flow initiated ISCO[1] water samplers.
3. The bottle was rinsed with stream water before collecting the sample.
4. Sterilized specimen cups were used to collect samples for bacterial evaluation.
5. Time of collection was noted.
6. Samples were placed in a cooler on ice to preserve them until processed and were submitted to the Arkansas Water Resources Center Water Quality Lab on the day of collection for analyses.
7. Analyses included Dissolved Phosphorus (EPA 365.2), Total Phosphorus (APHA 4500-P), Ammonia (EPA 351.2), Nitrate (EPA 300.0), Total Nitrogen (APHA 4500-P), Total Suspended Solids (EPA 160.2), E. Coli (APHA 9223, B) and Total Coliforms (APHA 9223, B).

[1] Mention of ISCO water samplers does not imply endorsement by the Division of Agriculture, University of Arkansas System.

Table 2. Water quality analyses at each sample site. Coliform units are Most Probable Number (MPN) per 100 mL of water.

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
			---------- mg/L ----------							-- MPN/100 mL --	
9/12/2013	**9/12/2013**	**Base flow**									
10:45	15:30	Upstream farm	0.016	0.030	0.06	0.37	0.50	3.0	N.D.	6.3	>2420
11:15	15:30	Upstream barn	0.010	0.032	0.05	0.36	0.54	5.8	N.D.	4.1	4040.0
11:50	15:30	Downstream barn	0.019	0.026	0.05	0.63	0.78	1.2	N.D.	1.0	488.4
13:00	15:30	Downstream farm	0.010	0.022	0.04	0.40	0.62	1.7	N.D.	16.0	>2420
9/20/2013	**9/20/2013**	**Base flow**									
10:50	16:08	Spring	0.006	0.020	0.03	0.38	0.50	4.7	N.D.	72.7	5040
11:15	16:08	Upstream farm	0.009	0.022	0.03	0.25	0.36	1.1	N.D.	80.9	9870
11:40	16:08	Upstream barn	0.015	0.024	0.04	0.36	0.42	1.2	N.D.	1203	26130
12:20	16:08	Downstream barn	0.024	0.032	0.06	0.76	0.85	1.3	N.D.	218.7	2430
12:50	16:08	Downstream farm	0.013	0.022	0.05	0.44	0.53	1.1	N.D.	548	17230

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9/24/2013	**9/24/2013**	**Base flow**									
10:30	16:15	Spring	0.004	0.024	0.00	0.12	0.35	50.0	N.D.	8.5	>2420
10:45	16:15	Upstream farm	0.011	0.014	0.03	0.44	0.20	17.9	N.D.	39	1120
11:00	16:15	Upstream barn	0.007	0.024	0.00	0.33	0.41	1.6	N.D.	42	>2419
12:20	16:15	Downstream barn	0.017	0.032	0.01	0.79	0.82	0.7	N.D.	42	816
12:40	16:15	Downstream farm	0.007	0.028	0.01	0.51	0.58	1.5	N.D.	5	>2420
10/1/2013	**10/1/2013**	**Base flow**								N.D.	
9:45	14:42	Spring	0.001	0.162	0.00	0.11	0.41	89.2	N.D.	4	920
10:00	14:42	Upstream farm	0.011	0.038	0.02	0.24	0.34	2.2	N.D.	8	1300
10:15	14:42	Upstream barn	0.006	0.032	0.03	0.24	0.40	6.7	N.D.	82	5200
10:35	14:42	Downstream barn	0.018	0.032	0.00	0.8	0.92	1.1	N.D.	19	649
10:55	14:42	Downstream farm	0.009	0.034	0.02	0.51	0.65	3.6	N.D.	2620	10810
10/9/2013	**10/9/2013**	**Base flow**									
9:00	13:52	Spring	0.011	0.054	0.00	0.09	0.28	29.1	N.D.	3	1413
9:30	13:52	Upstream	0.016	0.034	0.00	0.50	0.73	7.1	N.D.	11	2419

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
		farm									
9:45	13:52	Upstream barn	0.016	0.030	0.00	0.39	0.53	6.2	N.D.	194	4730
10:00	13:52	Downstream barn	0.017	0.02	0.00	0.87	0.89	0.4	N.D.	29	1986
10:20	13:52	Downstream farm	0.006	0.038	0.00	0.62	0.77	13.6	N.D.	28	3450
10/15/2013	**10/15/2013**	**Storm flow**									
11:13	15:47	Spring	0.010	0.250	0.15	0.09	0.58	66.9	N.D.	1401	19863
12:24	15:47	Upstream farm	0.018	0.026	0.00	1.02	1.03	1.1	N.D.	759	>2419
12:47	15:47	Upstream barn	0.019	0.036	0.06	0.84	0.99	2.1	N.D.	472	8664
13:13	15:47	Downstream barn	0.033	0.244	0.12	1.28	1.44	89.2	N.D.	959	12997
13:34	15:47	Downstream farm	0.067	0.316	0.20	0.68	1.07	101.1	N.D.	1334	19863
10/22/2013	**10/22/2013**	**Base flow**									
10:10	15:31	Spring	0.005	0.086	0.10	0.31	0.53	36.4	N.D.	1733	>2419
10:30	15:31	Upstream farm	0.014	0.034	0.00	0.35	0.32	0.3	N.D.	186	299
10:45	15:31	Upstream barn	0.016	0.024	0.03	0.58	0.60	1.2	N.D.	411	11190

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:00	15:31	Downstream barn	0.016	0.022	0.00	0.79	0.77	0.1	N.D.	150	2419
11:20	15:31	Downstream farm	0.012	0.020	0.04	0.72	0.76	0.7	N.D.	87	292
10/31/2013	**10/31/2013**	**Base flow**									
11:00	15:15	Spring	0.003	0.404	0.14	0.32	1.02	400.9	N.D.	91	32550
10:45	15:15	Upstream farm	0.012	0.032	0.00	0.24	0.32	1.1	N.D.	66	1986
10:15	15:15	Upstream barn	0.007	0.044	0.04	0.25	0.38	2.3	N.D.	261	6310
10:00	15:15	Downstream barn	0.018	0.022	0.11	0.52	0.66	0.9	N.D.	14	218
10:30	15:15	Downstream farm	0.012	0.024	0.03	0.44	0.45	1.4	N.D.	Leaked	Leaked
11/6/2013	**11/6/2013**	**Base flow**									
8:35	14:35	Spring	0.013	0.130	0.10	0.06	0.72	21.2	N.D.	8570	34480
9:00	14:35	Upstream farm	0.032	0.074	0.03	0.43	0.61	4.7	N.D.	4080	28510
9:10	14:35	Upstream barn	0.020	0.038	0.00	0.18	0.27	2.5	N.D.	579	13330
9:45	14:35	Downstream barn	0.040	0.164	0.12	0.41	0.67	32.9	N.D.	3180	36090
10:00	14:35	Downstream farm	0.041	0.154	0.12	0.29	0.60	28.4	N.D.	3500	43520

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11/12/2013	**11/12/2013**	**Base flow**									
10:56	16:28	Spring	0.006	0.022	0.05	2.45	2.61	8.9	N.D.	48	2750
11:35	16:28	Upstream farm	0.011	0.010	0.00	0.17	0.22	1.0	N.D.	45	1986
12:15	16:28	Upstream barn	0.012	0.014	0.09	0.22	0.33	1.4	N.D.	36	1733
13:03	16:28	Downstream barn	0.012	0.012	0.00	0.30	0.34	0.5	N.D.	21	1046
13:35	16:28	Downstream farm	0.011	0.010	0.00	0.24	0.31	0.0	N.D.	24	>2419
11/19/2013	**11/19/2013**	**Base flow**									
9:20	14:35	Spring	0.007	0.022	0.02	3.06	3.06	4.4	N.D.	579	9880
9:45	14:35	Upstream farm	0.010	0.026	0.00	0.12	0.22	0.7	N.D.	435	2400
10:05	14:35	Upstream barn	0.011	0.028	0.00	0.18	0.32	0.3	N.D.	172	>2419
10:35	14:35	Downstream barn	0.011	0.028	0.00	0.23	0.34	0.5	N.D.	238	2419
10:55	14:35	Downstream farm	0.009	0.024	0.02	0.17	0.28	1.0	N.D.	194	4410
11/26/2013	**11/26/2013**	**Base flow**									
10:35	14:40	Spring	0.007	0.018	0.00	1.69	1.70	4.5	N.D.	86	1553
10:45	14:40	Upstream farm	0.013	0.018	0.00	0.14	0.14	0.4	N.D.	77	1203

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:06	14:40	Upstream barn	0.014	0.016	0.00	0.19	0.20	0.7	N.D.	249	1986
11:30	14:40	Downstream barn	0.014	0.018	0.03	0.30	0.33	1.3	N.D.	40	613
11:45	14:40	Downstream farm	0.013	0.016	0.00	0.23	0.24	1.2	N.D.	36	2419
12/3/2013	**12/3/2013**	**Base flow**									
8:30	13:23	Spring	0.007	0.046	0.04	1.05	1.37	26.9	N.D.	25	1986
8:45	13:23	Upstream farm	0.007	0.012	0.00	0.15	0.25	0.5	N.D.	27	435
9:00	13:23	Upstream barn	0.009	0.012	0.00	0.21	0.28	0.3	N.D.	29	548
9:15	13:23	Downstream barn	0.010	0.018	0.00	0.30	0.35	0.6	N.D.	248	687
9:35	13:23	Downstream farm	0.006	0.012	0.00	0.23	0.28	0.5	N.D.	12	>2419
12/17/2013	**12/17/2013**	**After snow melt**									
9:35	14:03	Spring	0.007	0.042	0.05	0.37	0.65	2.0	N.D.	248.1	2419.2
10:00	14:03	Upstream farm	0.010	0.036	0.06	0.18	0.27	1.2	N.D.	248.1	2419.2
10:10	14:03	Upstream barn	0.011	0.032	0.02	0.38	0.48	0.7	N.D.	157.6	>2419.2
10:30	14:03	Downstream barn	0.008	0.032	0.03	0.39	0.50	1.6	N.D.	127.4	2419.2

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:50	14:03	Downstream farm	0.008	0.032	0.00	0.33	0.43	2.1	N.D.	148.3	>2419.2
PROCEEDING SAMPLES COLLECTED DURING SECOND QUARTER											
1/2/2014	**1/2/2014**	**Base flow**									
10:45	14:19	Spring	0.006	0.024	0.05	3.35	3.24	0.5	N.D.	ND	ND
10:55	14:19	Upstream farm	0.009	0.022	0.01	0.22	0.25	0.7	N.D.	ND	ND
11:10	14:19	Upstream barn	0.012	0.024	0.00	0.44	0.47	0.3	N.D.	ND	ND
11:25	14:19	Downstream barn	0.012	0.024	0.00	0.54	0.58	0.8	N.D.	ND	ND
11:50	14:19	Downstream farm	0.012	0.036	0.00	0.49	0.54	0.8	N.D.	ND	ND
1/7/2014	**1/7/2014**	**Base flow**									
10:10	13:43	Spring	0.008	0.024	0.00	2.36	2.32	1.3	N.D.	20.9	1413.6
10:20	13:43	Upstream farm	0.014	0.022	0.02	0.20	0.27	0.8	N.D.	66.3	307.6
10:30	13:43	Upstream barn	0.017	0.022	0.00	0.36	0.43	0.3	N.D.	24.3	344.8
10:50	13:43	Downstream barn	0.015	0.022	0.00	0.50	0.54	1.1	N.D.	21.1	290.9
11:10	13:43	Downstream farm	0.015	0.028	0.00	0.41	0.46	0.2	N.D.	18.3	325.5

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
1/14/2014	**1/14/2014**	**Base flow**									
11:35	15:35	Spring	0.010	0.042	0.00	1.97	2.09	2.3	N.D.	24.3	1732.9
12:15	15:35	Upstream farm	0.008	0.028	0.01	0.16	0.25	0.3	N.D.	151.5	980.4
11:50	15:35	Upstream barn	0.008	0.030	0.03	0.21	0.73	0.9	N.D.	238.2	920.8
12:50	15:35	Downstream barn	0.008	0.028	0.02	0.33	0.43	0.5	N.D.	156.5	1119.9
13:15	15:35	Downstream farm	0.008	0.026	0.05	0.31	0.39	0.5	N.D.	95.9	1299.7
1/21/2014	**1/21/2014**	**Base flow**									
8:10	15:00	Spring	0.008	0.006	0.02	2.11	2.10	0.9	N.D.	5.2	613.1
8:30	15:00	Upstream farm	0.009	0.010	0.00	0.13	0.22	0.0	N.D.	55.7	290.9
8:20	15:00	Upstream barn	0.010	0.010	0.01	0.21	0.28	0.3	N.D.	51.2	488.4
8:45	15:00	Downstream barn	0.011	0.012	0.01	0.34	0.45	1.0	N.D.	49.6	249.9
9:05	15:00	Downstream farm	0.010	0.014	0.01	0.30	0.36	0.5	N.D.	131.3	410.6
1/29/2014	**1/29/2014**	**Base flow**									
10:20	14:15	Spring	0.009	0.024	0.00	0.85	0.86	1.4	N.D.	3.1	325.5
10:40	14:15	Upstream	0.007	0.028	0.00	0.13	0.15	0.6	N.D.	10.9	248.1

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
		farm									
10:30	14:15	Upstream barn	0.007	0.024	0.01	0.20	0.24	0.0	N.D.	28.2	290.9
11:00	14:15	Downstream farm	0.007	0.024	0.00	0.28	0.28	0.0	N.D.	<1	275.0
2/13/2014	**2/13/2014**	**Base flow**									
8:30	13:22	Spring	0.009	0.024	0.00	0.65	0.73	5.1	N.D.	<1	461.1
8:50	13:22	Upstream farm	0.009	0.016	0.00	0.11	0.15	0.9	N.D.	68.9	238.2
8:40	13:22	Upstream barn	0.011	0.014	0.00	0.14	0.23	0.9	N.D.	31.4	260.2
9:10	13:22	Downstream farm	0.009	0.014	0.00	0.24	0.28	0.4	N.D.	9.8	290.9
2/19/2014	**2/19/2014**	**Base flow**									
9:15	14:36	Spring	0.006	0.020	0.02	0.57	0.62	0.8	N.D.	1.0	365.4
10:17	14:36	Upstream farm	0.008	0.018	0.00	0.05	0.10	0.4	N.D.	111.9	325.5
9:30	14:36	Upstream barn	0.009	0.018	0.00	0.07	0.15	0.5	N.D.	45.5	235.9
11:30	14:36	Downstream farm	0.007	0.016	0.00	0.11	0.17	0.3	N.D.	8.5	272.3
2/27/14	**2/27/14**	**Base flow**									
10:40	15:10	Spring	0.007	0.106	0.06	0.59	0.82	70	N.D.	<1	307.6

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
11:03	15:10	Upstream farm	0.008	0.022	0.02	0.07	0.22	2.1	N.D.	29.5	209.8
11:40	15:10	Upstream barn	0.008	0.016	0.00	0.08	0.11	0.3	N.D.	14.8	235.9
12:22	15:10	Downstream farm	0.007	0.014	0.00	0.11	0.16	0.6	N.D.	2.00	547.5
3/10/2014	**3/10/2014**	**Base flow/Snow melt**									
10:30	15:08	Spring	0.006	0.048	0.02	0.37	0.53	19.9	3.8	6.3	517.2
10:55	15:08	Upstream farm	0.005	0.026	0.06	0.09	0.12	0.9	1.4	52.1	275.5
11:40	15:08	Upstream barn	0.007	0.020	0.04	0.10	0.13	1.3	1.3	59.4	547.5
12:15	15:08	Downstream farm	0.004	0.026	0.04	0.12	0.21	6.1	1.2	27.8	579.4
3/18/2014	**3/18/2014**	**Storm flow**									
12:08	15:24	Spring	0.011	0.026	0.00	0.90	0.99	1.7	2.5	21.1	>2419.2
12:48	15:24	Upstream farm	0.010	0.038	0.08	0.19	0.24	2.1	1.2	50.4	435.2
12:20	15:24	Upstream barn	0.012	0.040	0.04	0.24	0.76	3.1	1.2	63.7	648.8
13:03	15:24	Downstream farm	0.014	0.040	0.06	0.31	0.38	3.4	1.7	78.8	866.4
12:36	15:24	Culvert	0.009	0.028	0.05	0.64	0.63	1.0	0.7	19.3	365.4

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
3/26/2014	**3/26/2014**	**Base flow**									
10:40	14:06	Spring	0.010	0.026	0.01	1.00	1.13	3.0	1.4	8.4	980.4
10:22	14:06	Upstream farm	0.010	0.024	0.00	0.12	0.19	0.6	0.8	43.5	517.2
10:32	14:06	Upstream barn	0.011	0.024	0.00	0.17	0.22	0.5	0.5	48.7	579.4
11:31	14:06	Downstream farm	0.011	0.026	0.00	0.25	0.30	1.2	0.7	21.8	866.4
9:55	14:06	Culvert	0.007	0.028	0.00	0.61	0.62	11.0	1.2	260.2	>2419.2
3/29/2014	**3/31/2014**	**Storm flow**									
9:40	8:42	Spring	0.006	0.044	0.00	0.29	0.51	3.3	8.1	ND	ND
10:00	8:42	Upstream farm	0.006	0.042	0.06	0.07	0.14	2.1	2.1	ND	ND
9:50	8:42	Upstream barn	0.007	0.036	0.00	0.09	0.16	1.5	2.3	ND	ND
10:35	8:42	Downstream farm	0.008	0.038	0.00	0.13	0.19	2.5	2.2	ND	ND
10:24	8:42	Culvert	0.004	0.042	0.00	0.69	0.81	3.3	4.9	ND	ND
PROCEEDING SAMPLES COLLECTED DURING THIRD QUARTER											
4/2/2014	**4/2/2014**	**Base flow**									
11:15	14:30	Spring	0.011	0.020	0.00	0.60	0.67	0.6	2.1	3.1	307.6
10:14	14:30	Upstream	0.011	0.026	0.00	0.05	0.09	1.0	0.5	60.5	613.1

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
		farm									
10:21	14:30	Upstream barn	0.012	0.028	0.00	0.08	0.11	0.7	1.4	12.1	1732.1
12:11	14:30	Downstream farm	0.010	0.024	0.00	0.11	0.14	0.8	0.6	29.5	1553.1
9:30	14:30	House well	0.014	0.024	0.00	0.50	0.50	0.1	0.8	7.5	117.2
9:30	14:30	House well, duplicate	0.014	0.020	0.04	0.50	0.49	0.3	0.7	ND	ND
9:47	14:30	Culvert	0.009	0.020	0.00	0.48	0.54	2.1	1.1	44.3	517.2
4/4/2014	**4/4/2014**	**Storm flow**									
9:07	12:19	Spring	0.014	0.052	0.02	0.39	0.59	3.9	4.9	N.D.	**N.D.**
9:40	12:19	Upstream farm	0.012	0.056	0.05	0.11	0.19	3.3	2.3	N.D.	**N.D.**
9:30	12:19	Upstream barn	0.013	0.044	0.04	0.08	0.21	5.2	2.6	N.D.	**N.D.**
10:08	12:19	Downstream farm	0.016	0.052	0.05	0.16	0.32	6.3	2.7	N.D.	**N.D.**
9:50	12:19	Culvert	0.026	0.262	0.46	0.85	2.36	908.8	6.5	N.D.	**N.D.**
4/3/2014, 4:04	12:19	Field 1	0.181	0.638	0.25	0.11	2.08	207.0	14.7	N.D.	**N.D.**
4/8/2014	**4/8/2014**	**Storm flow**									
9:15	15:24	Spring	0.016	0.018	0.00	0.53	0.59	0.7	4.7	74.9	488.4

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
10:25	15:24	Upstream farm	0.012	0.026	0.02	0.09	0.13	0.8	1.4	110.6	1299.7
9:58	15:24	Upstream barn	0.012	0.024	0.02	0.10	0.16	2.1	1.2	179.3	1299.7
9:05	15:24	Downstream farm	0.014	0.024	0.03	0.17	0.23	2.2	1.5	155.3	1413.6
10:15	15:24	Culvert	0.011	0.022	0.04	0.47	0.53	2.5	2.7	70.8	770.1
4/14/2014	**4/14/2014**	**Storm flow**									
9:47	13:57	Spring	0.006	0.038	0.01	0.43	0.54	0.9	4.4	172.2	>2419.2
11:17	13:57	Upstream farm	0.005	0.034	0.04	0.10	0.17	3.7	2.1	387.3	3090.0
10:38	13:57	Upstream barn	0.009	0.040	0.06	0.11	0.19	5.0	3.1	517.2	2980.0
9:35	13:57	Downstream farm	0.007	0.050	0.08	0.14	0.25	8.7	3.1	613.1	5210.0
4/13/2014, 9:57	13:57	Culvert, ISCO	0.003	0.016	0.00	0.46	0.49	4.7	1.8	8.5	195.6
10:50	13:57	Culvert	0.007	0.032	0.03	0.48	0.56	1.9	2.0	547.5	4320.0
4/22/2014	**4/22/2014**	**Base flow**									
9:40	13:57	Spring	0.013	0.020	0.00	0.59	0.66	1.7	0.9	11.0	>2419.2
10:21	13:57	Upstream farm	0.074	0.888	0.00	0.00	0.09	1.2	0.5	126.6	1203.3
10:10	13:57	Upstream barn	0.009	0.022	0.01	0.09	0.10	0.8	0.5	95.9	>2419.2

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
9:25	13:57	Downstream farm	0.020	0.024	0.01	0.13	0.17	1.6	0.6	66.3	>2419.2
11:00	13:57	House well	0.008	0.022	0.00	0.49	0.55	0.3	0.0	9.8	770.1
10:47	13:57	Culvert	0.004	0.012	0.00	0.45	0.50	1.0	0.0	47.9	>2419.2
5/1/2014	**5/1/2014**	**Base flow**									
10:09	13:05	Spring	0.007	0.012	0.00	0.51	0.57	1.4	1.0	52.1	1986.3
10:29	13:05	Upstream farm	0.006	0.018	0.00	0.07	0.09	1.9	1.0	96.0	3050.0
10:19	13:05	Upstream barn	0.007	0.014	0.04	0.10	0.10	2.2	0.4	73.8	4310.0
9:58	13:05	Downstream farm	0.007	0.008	0.05	0.12	0.11	1.5	0.9	62.4	3990.0
10:49	13:05	House well	0.012	0.012	0.08	0.47	0.52	0.7	0.5	<1	116.9
10:44	13:05	Culvert	0.005	0.010	0.00	0.45	0.50	1.5	0.6	90.5	4790.0
5/8/2014	**5/8/2014**	**Base flow**									
13:00	15:32	Spring	0.009	0.020	0.00	0.39	0.48	11.1	1.0	8.6	5560.0
12:45	15:32	Upstream farm	0.013	0.020	0.06	0.09	0.09	1.2	0.9	57.3	5120.0
12:53	15:32	Upstream barn	0.008	0.016	0.01	0.12	0.14	1.4	0.9	34.1	5760.0
13:13	15:32	Downstream farm	0.008	0.028	0.03	0.16	0.55	4.7	1.0	19.9	14760.0

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
12:34	15:32	House well	0.008	0.010	0.18	0.44	0.68	0.3	1.4	<1	<1
5/9/2014	**5/9/2014**	**Storm flow**									
10:05	13:54	Spring	0.009	0.030	0.02	0.16	0.36	5.8	4.0	ND	ND
10:42	13:54	Upstream farm	0.008	0.030	0.00	0.07	0.10	1.5	0.7	ND	ND
11:22	13:54	Upstream barn	0.008	0.020	0.06	0.10	0.10	2.0	0.7	ND	ND
9:52	13:54	Downstream farm	0.008	0.018	0.00	0.15	0.17	2.1	0.6	ND	ND
5/8/2014, 13:54	13:54	Field 1	0.079	0.312	0.17	0.21	1.63	125.9	9.6	ND	ND
5/13/2014	**5/13/2014**	**Storm flow**									
9:33	13:15	Spring	0.008	0.062	0.06	0.25	0.45	3.8	4.3	435.2	7280.0
10:38	13:15	Upstream farm	0.008	0.062	0.00	0.10	0.23	10.1	2.9	920.8	13130.0
10:05	13:15	Upstream barn	0.008	0.074	0.06	0.11	0.30	11.8	5.7	1046.2	15290.0
9:22	13:15	Downstream farm	0.010	0.086	0.07	0.13	0.38	19.4	5.6	1553.1	29090.0
10:13	13:15	House well	0.008	0.020	0.06	0.46	0.49	0.5	0.5	<1	18.9
10:20	13:15	Culvert	0.007	0.060	0.12	0.51	0.70	5.1	2.6	307.6	10760.0
5/12/2014, 16:26	13:15	Field 1	0.190	0.366	0.10	0.13	1.33	42.1	10.2	ND	ND

Time sample collected	Time received @ laboratory	Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
5/19/2014	**5/19/2014**	**Base flow**									
13:17	15:38	Spring	0.007	0.018	0.00	0.64	0.70	3.7	0.8	27.5	>2419.2
12:11	15:38	Upstream farm	0.006	0.024	0.05	0.10	0.16	1.9	0.5	133.3	2419.2
13:10	15:38	Upstream barn	0.008	0.020	0.00	0.00	0.10	1.5	0.5	95.9	4710.0
13:30	15:38	Downstream farm	0.008	0.018	0.00	0.11	0.14	2.0	0.3	53.7	4220.0
12:46	15:38	House well	0.011	0.016	0.03	0.49	0.49	0.2	0.4	11.0	123.6
12:41	15:38	Culvert	0.008	0.020	0.08	0.52	0.55	0.8	0.3	204.6	5940

N.D. is No Data. On March 10, 2014 Dissolved Organic Carbon measurement was initiated in all collected water samples.

The water quality data in Table 2 for the monitored spring and Big Creek above and below the boundary of the permitted fields of the C&H Farm only is given in Table 3.

Table 3. Water quality analyses at the spring and in Big Creek upstream and downstream of the C&H Farm boundary of permitted land application fields (see Figure 13).

Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
	---------- mg/L ----------							-- MPN/100 mL --	
9/12/2013 Base flow									
Upstream	0.016	0.030	0.06	0.37	0.50	3.0	N.D.	6	>2420
Downstream	0.010	0.022	0.04	0.40	0.62	1.7	N.D.	16	>2420
9/20/2013 Base flow								N.D.	
Spring	0.006	0.020	0.03	0.38	0.50	4.7	N.D.	73	5040
Upstream	0.009	0.022	0.03	0.25	0.36	1.1	N.D.	81	9870
Downstream	0.013	0.022	0.05	0.44	0.53	1.1	N.D.	548	17230
9/24/2013 Base flow									
Spring	0.004	0.024	0.00	0.12	0.35	50.0	N.D.	9	>2420
Upstream	0.021	0.140	0.03	0.44	2.20	17.9	N.D.	39	1120
Downstream	0.007	0.028	0.01	0.51	0.58	1.5	N.D.	5	>2420
10/1/2013 Base flow									
Spring	0.001	0.162	0.00	0.11	0.41	89.2	N.D.	4	920.8
Upstream	0.011	0.038	0.02	0.24	0.34	2.2	N.D.	8	1300

Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
Downstream	0.009	0.034	0.02	0.51	0.65	3.6	N.D.	2620	10810
10/9/2013 Base flow									
Spring	0.011	0.054	0.00	0.09	0.28	29.1	N.D.	3	1413.6
Upstream	0.016	0.034	0.00	0.50	0.73	7.1	N.D.	11	2419.6
Downstream	0.006	0.038	0.00	0.62	0.77	13.6	N.D.	28	3450.0
10/15/2013 Storm flow									
Spring	0.010	0.250	0.15	0.09	0.58	66.9	N.D.	1401	19863.0
Upstream	0.018	0.026	0.00	1.02	1.03	1.1	N.D.	759	>2419.6
Downstream	0.067	0.316	0.20	0.68	1.07	101.1	N.D.	1334	19863.0
10/22/2013 Base flow									
Spring	0.005	0.086	0.10	0.31	0.53	36.4	N.D.	1733	>2419.6
Upstream	0.014	0.034	0.00	0.35	0.32	0.3	N.D.	186	299.0
Downstream	0.012	0.020	0.04	0.72	0.76	0.7	N.D.	87	292.0
10/31/2013 Base flow									
Spring	0.003	0.404	0.14	0.32	1.02	400.9	N.D.	91	32550.0
Upstream	0.012	0.032	0.00	0.24	0.32	1.1	N.D.	66	1986.3
Downstream	0.012	0.024	0.03	0.44	0.45	1.4	N.D.	Leaked	Leaked
11/6/2013 Base flow									

Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
Spring	0.013	0.130	0.10	0.06	0.72	21.2	N.D.	8570	34480.0
Upstream	0.032	0.074	0.03	0.43	0.61	4.7	N.D.	4080	28510.0
Downstream	0.041	0.154	0.12	0.29	0.60	28.4	N.D.	3500	43520.0
11/12/2013 Base flow									
Spring	0.006	0.022	0.05	2.45	2.61	8.90	N.D.	48	2750.0
Upstream	0.011	0.010	0.00	0.16	0.22	1.00	N.D.	45	1986.3
Downstream	0.011	0.010	0.00	0.24	0.31	0.0	N.D.	24	>2419.2
11/19/2013 Base flow									
Spring	0.007	0.022	0.02	3.06	3.06	4.4	N.D.	579	9880.0
Upstream	0.010	0.026	0.00	0.12	0.22	0.7	N.D.	435	2400.0
Downstream	0.009	0.024	0.02	0.17	0.28	1.0	N.D.	194	4410.0
11/26/2013 Base flow									
Spring	0.007	0.018	0.00	1.69	1.70	4.5	N.D.	86	1553.1
Upstream	0.013	0.018	0.00	0.14	0.14	0.4	N.D.	77	1203.3
Downstream	0.013	0.016	0.00	0.23	0.24	1.2	N.D.	36	2419.2
12/3/2013 Base flow									
Spring	0.007	0.046	0.04	1.05	1.37	26.9	N.D.	25	1986.3
Upstream	0.007	0.012	0.00	0.15	0.25	0.5	N.D.	27	435.2

Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
Downstream	0.006	0.012	0.00	0.23	0.28	0.5	N.D.	12	>2419.2
12/17/2013 After snow melt									
Spring	0.007	0.042	0.05	0.37	0.65	2.0	N.D.	248.1	2419.2
Upstream	0.010	0.036	0.06	0.18	0.27	1.2	N.D.	248.1	2419.2
Downstream	0.008	0.032	0.00	0.33	0.43	2.1	N.D.	148.3	>2419.2
PROCEEDING SAMPLES COLLECTED DURING SECOND QUARTER									
1/2/2014 Base flow									
Spring	0.006	0.024	0.05	3.35	3.24	0.5	N.D.	ND	ND
Upstream	0.009	0.022	0.01	0.22	0.25	0.7	N.D.	ND	ND
Downstream	0.012	0.036	0.00	0.49	0.54	0.8	N.D.	ND	ND
1/7/2014 Base flow									
Spring	0.008	0.024	0.00	2.36	2.32	1.3	N.D.	20.9	1413.6
Upstream	0.014	0.022	0.02	0.20	0.27	0.8	N.D.	66.3	307.6
Downstream	0.015	0.028	0.00	0.41	0.46	0.2	N.D.	18.3	325.5
1/14/2014 Base flow									
Spring	0.010	0.042	0.00	1.97	2.09	2.3	N.D.	24.3	1732.9
Upstream	0.008	0.028	0.01	0.16	0.25	0.3	N.D.	151.5	980.4
Downstream	0.008	0.026	0.05	0.31	0.39	0.5	N.D.	95.9	1299.7

Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
1/21/2014 Base flow									
Spring	0.008	0.006	0.02	2.11	2.10	0.9	N.D.	5.2	613.1
Upstream	0.009	0.010	0.00	0.13	0.22	0.0	N.D.	55.7	290.9
Downstream	0.010	0.014	0.01	0.30	0.36	0.5	N.D.	131.3	410.6
1/29/2014 Base flow									
Spring	0.009	0.024	0.00	0.85	0.86	1.4	N.D.	3.1	325.5
Upstream	0.007	0.028	0.00	0.13	0.15	0.6	N.D.	10.9	248.1
Downstream	0.007	0.024	0.00	0.28	0.28	0.0	N.D.	<1	275.0
2/13/2014 Base flow									
Spring	0.009	0.024	0.00	0.65	0.73	5.1	N.D.	<1	461.1
Upstream	0.009	0.016	0.00	0.11	0.15	0.9	N.D.	68.9	238.2
Downstream	0.009	0.014	0.00	0.24	0.28	0.4	N.D.	9.8	290.9
2/19/2014 Base flow									
Spring	0.006	0.020	0.02	0.57	0.62	0.8	N.D.	1.0	365.4
Upstream	0.008	0.018	0.00	0.05	0.10	0.4	N.D.	111.9	325.5
Downstream	0.007	0.016	0.00	0.11	0.17	0.3	N.D.	8.5	272.3
2/27/14 Base flow									
Spring	0.007	0.106	0.06	0.59	0.82	70	N.D.	<1	307.6

Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
Upstream	0.008	0.022	0.02	0.07	0.22	2.1	N.D.	29.5	209.8
Downstream	0.007	0.014	0.00	0.11	0.16	0.6	N.D.	2.00	547.5
3/10/2014 Base flow/After snow melt									
Spring	0.006	0.048	0.02	0.37	0.53	19.9	3.8	6.3	517.2
Upstream	0.005	0.026	0.06	0.09	0.12	0.9	1.4	52.1	275.5
Downstream	0.004	0.026	0.04	0.12	0.21	6.1	1.2	27.8	579.4
3/18/2014 Storm flow									
Spring	0.011	0.026	0.00	0.90	0.99	1.7	2.5	21.1	>2419.2
Upstream	0.010	0.038	0.08	0.19	0.24	2.1	1.2	50.4	435.2
Downstream	0.014	0.040	0.06	0.32	0.38	3.4	1.7	78.8	866.4
3/26/2014 Base flow									
Spring	0.010	0.026	0.01	1.00	1.13	3.0	1.4	8.4	980.4
Upstream	0.010	0.024	0.00	0.12	0.19	0.6	0.8	43.5	517.2
Downstream	0.011	0.026	0.00	0.25	0.30	1.2	0.7	21.8	866.4
3/29/2014 Storm flow									
Spring	0.006	0.044	0.00	0.29	0.51	3.3	8.1	ND	ND
Upstream	0.006	0.042	0.06	0.07	0.14	2.1	2.1	ND	ND
Downstream	0.008	0.038	0.00	0.13	0.19	2.5	2.2	ND	ND

Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
PROCEEDING SAMPLES COLLECTED DURING THIRD QUARTER									
4/2/2014 Base flow									
Spring	0.011	0.020	0.00	0.60	0.67	0.6	2.1	3.10	307.6
Upstream	0.011	0.026	0.00	0.05	0.09	1.0	0.5	60.5	613.1
Downstream	0.010	0.024	0.00	0.11	0.14	0.8	0.6	29.5	1553.1
4/4/2014 Storm flow									
Spring	0.014	0.052	0.02	0.39	0.59	3.9	4.9	ND	ND
Upstream	0.012	0.056	0.05	0.11	0.19	3.3	2.3	ND	ND
Downstream	0.016	0.052	0.05	0.16	0.32	6.3	2.7	ND	ND
4/8/2014 Storm flow									
Spring	0.016	0.018	0.00	0.53	0.59	0.7	4.7	74.9	488.4
Upstream	0.012	0.026	0.02	0.09	0.13	0.8	1.4	110.6	1299.7
Downstream	0.014	0.024	0.03	0.17	0.23	2.2	1.5	155.3	1413.6
4/14/2014 Storm flow									
Spring	0.006	0.038	0.01	0.43	0.54	0.9	4.4	172.2	>2419.2
Upstream	0.005	0.034	0.04	0.10	0.17	3.7	2.1	387.3	3090.0
Downstream	0.007	0.050	0.08	0.14	0.25	8.7	3.1	613.1	5210.0

Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
4/22/2014 Base flow									
Spring	0.013	0.020	0.00	0.59	0.66	1.7	0.9	11.0	>2419.2
Upstream	0.074	0.888	0.00	0.00	0.09	1.2	0.5	126.6	1203.3
Downstream	0.020	0.024	0.01	0.13	0.17	1.6	0.6	66.3	>2419.2
5/1/2014 Base flow									
Spring	0.007	0.012	0.00	0.51	0.57	1.4	1.0	52.1	1986.3
Upstream	0.006	0.018	0.00	0.07	0.09	1.9	1.0	96.0	3050.0
Downstream	0.007	0.008	0.05	0.12	0.11	1.5	0.9	62.4	3990.0
5/8/2014 Base flow									
Spring	0.009	0.020	0.00	0.39	0.48	11.1	1.0	8.6	5560.0
Upstream	0.013	0.020	0.06	0.09	0.09	1.2	0.9	57.3	5120.0
Downstream	0.008	0.028	0.03	0.16	0.55	4.7	1.0	19.9	14760.0
5/9/2014 Storm flow									
Spring	0.009	0.030	0.02	0.16	0.36	5.8	4.0	ND	ND
Upstream	0.008	0.030	0.00	0.07	0.10	1.5	0.7	ND	ND
Downstream	0.008	0.018	0.00	0.15	0.17	2.1	0.6	ND	ND

Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic Carbon	E. coli	Total coliform
5/13/2014 Storm flow									
Spring	0.008	0.062	0.06	0.25	0.45	3.8	4.3	435.2	7280.0
Upstream	0.008	0.062	0.00	0.10	0.23	10.1	2.9	920.8	13130.0
Downstream	0.010	0.086	0.07	0.13	0.38	19.4	5.6	1553.1	29090.0
5/19/2014 Base flow									
Spring	0.007	0.018	0.00	0.64	0.70	3.7	0.8	27.5	>2419.2
Upstream	0.006	0.024	0.05	0.10	0.16	1.9	0.5	133.3	2419.2
Downstream	0.008	0.018	0.00	0.11	0.14	2.0	0.3	53.7	4220.0

N.D. is No Data. On March 10, 2014 Dissolved Organic Carbon measurement was initiated in all collected water samples.

Table 4. Water quality analyses at the culvert draining the subwatershed containing the production houses and manure holding ponds, the well adjacent to the ponds, and surface runoff from Field 1 (see Figure 13).

Date & time sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E_ coli	Total coliform
	---------- mg/L ----------							--- MPN/100 mL ---	
Culvert									
3/18/2014	0.009	0.028	0.05	0.64	0.63	1.0	0.7	19.3	365.4
3/26/2014	0.007	0.028	0.00	0.61	0.62	11.0	1.2	260.2	>2419.2
3/29/2014	0.004	0.042	0.00	0.69	0.81	3.3	4.9	ND	ND
4/2/2014	0.009	0.020	0.00	0.48	0.54	2.1	1.1	44.3	517.2
4/4/2014	0.026	0.262	0.46	0.85	2.36	908.8	6.5	ND	ND
4/8/2014	0.011	0.022	0.04	0.47	0.53	2.5	2.7	70.8	770.1
4/13/2014	0.003	0.016	0.00	0.46	0.49	4.7	1.8	8.5	195.6
4/13/2014	0.007	0.032	0.03	0.48	0.56	1.9	2.0	547.5	4320.0
4/22/2014	0.004	0.012	0.00	0.45	0.50	1.0	0.0	47.9	>2419.2
5/1/2014	0.005	0.010	0.00	0.45	0.50	1.5	0.6	90.5	4790.0
5/12/2014	0.010	0.290	0.61	0.94	2.33	847.6	4.7	ND	ND
5/13/2014	0.007	0.060	0.12	0.51	0.70	5.1	2.6	307.6	10760.0
5/19/2014	0.008	0.020	0.08	0.52	0.55	0.8	0.3	204.6	5940

Date & time sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E_ coli	Total coliform
House well									
4/2/2014	0.014	0.024	0.00	0.50	0.50	0.1	0.8	7.5	117.2
4/2/2014	0.014	0.020	0.04	0.50	0.49	0.3	0.7	ND	ND
4/22/2014	0.008	0.022	0.00	0.49	0.55	0.3	0.0	9.8	770.1
5/1/2014	0.012	0.012	0.08	0.47	0.52	0.7	0.5	<1	116.9
5/8/2014	0.008	0.010	0.18	0.44	0.68	0.3	1.4	<1	<1
5/13/2014	0.008	0.020	0.06	0.46	0.49	0.5	0.5	<1	18.9
5/19/2014	0.011	0.016	0.03	0.49	0.49	0.2	0.4	11.0	123.6
Field 1									
4/3/2014	0.181	0.638	0.25	0.11	2.08	207.0	14.7	ND	ND
5/8/2014	0.079	0.312	0.17	0.21	1.63	125.9	9.6	ND	ND
5/12/2014	0.190	0.366	0.10	0.13	1.33	42.1	10.2	ND	ND

N.D. is No Data. On March 10, 2014 Dissolved Organic Carbon measurement was initiated in all collected water samples.

Future Plan of Work

1. Complete installation of automatic water sampling equipment on Big Creek upstream of the C&H Farm. This is being done in partnership with USGS, who have installed a downstream real-time flow and nitrate monitoring, which is available on the web.
2. Conduct electrical resistivity analysis on application fields to determine the potential for subsurface areas of preferential flow pathways.
3. Continue to collect runoff, spring, and stream samples after each rainfall event from the autosamplers and manually collect baseflow samples every two weeks from the well, spring, and streams, for analysis of N, P, sediment, and bacteria (E. coli and total coliform from baseflow grab samples).
4. Collect water samples from the piezometers installed in Fields 5a and 12.
5. Install a subsurface flow collector trench immediately downslope of the manure holding ponds, which will routinely samples for analysis of N, P, sediment, and bacteria (E. coli and total coliform). In addition, an inventory of karst seeps or springs immediately down slope of the storage ponds will be conducted. These karst features represent natural emergence points where integration of flow occurs and will offer additional sampling points for detecting potential leakage.
6. Conduct dye-tracer tests on the C&H Farm in cooperation with USGS Geologists with experience and training in conducting dye-tracer tests.
7. Monitor flow, nutrients and sediment in Dry Creek entering Big Creek. See Figure 28 for location of Dry Creek.
8. Periodically determine plant uptake by collecting plant and hay samples for tissue analysis and determine yield (dry-matter mass for a pre-determined area).
9. Determine nutrient application rate by determining nutrient content of swine effluent before land application via manure application and determine volume of effluent being applied to known monitoring area.

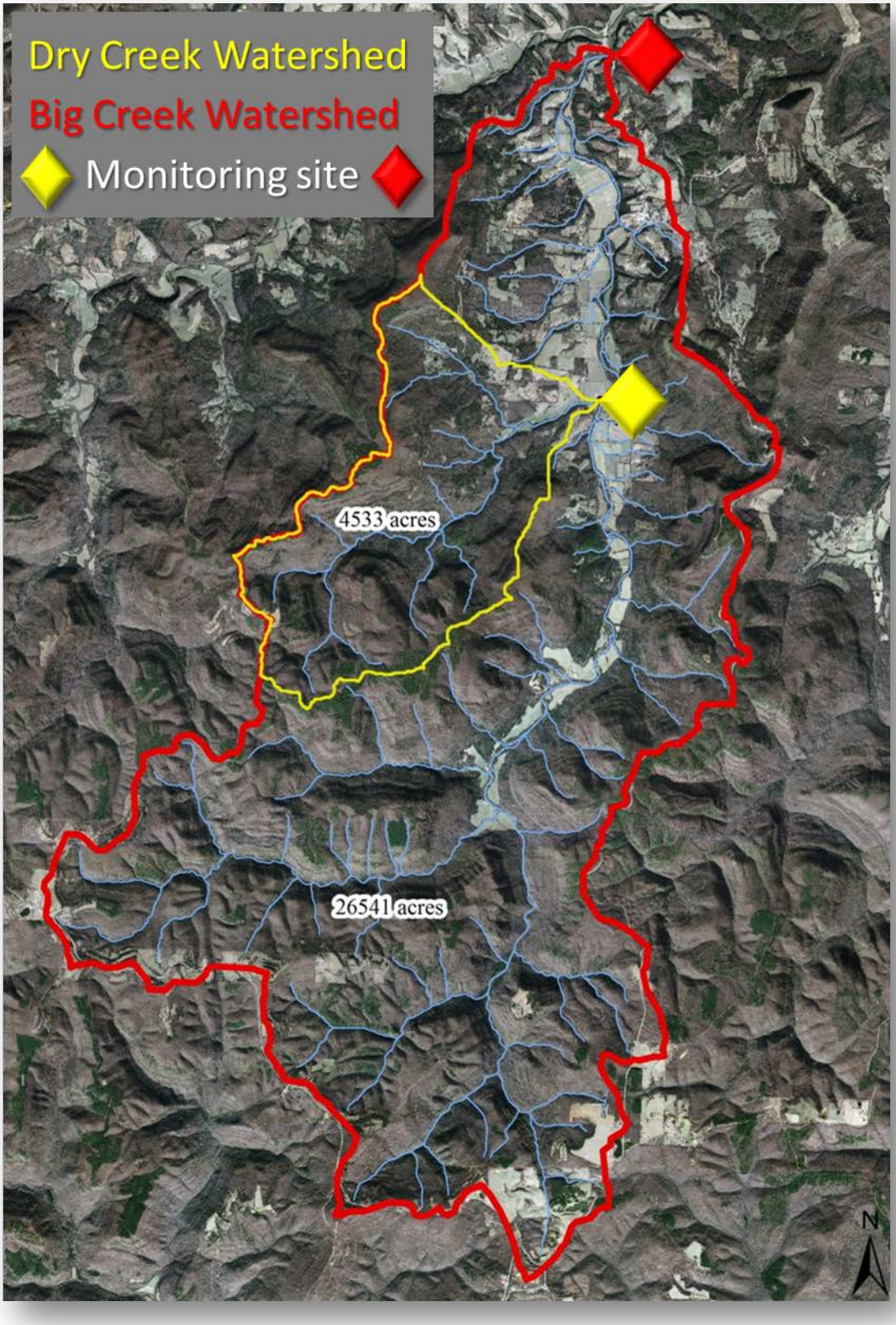


Figure 28. Location of Dry creek Watershed with the Big Creek Watershed.

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