Big Creek Research and Extension Team

University of Arkansas System Division of Agriculture

Quarterly Report – April 1 to June 30, 2018

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

Executive Summary

This is the second Quarterly Report of 2018 for the Big Creek Research and Extension Team that details activities and progress made from April 1 through June 30, 2018.

1. Collection of base flow and periodic stormflow water samples from Big Creek above and below the C&H Farm, along with water from a spring (reflecting shallow aquifer flow), ephemeral stream (reflecting landscape drainage from the area of the holding ponds and operation facilities), surface runoff sites on Fields 1, 5a, and 12, two interceptor trenches below the slurry holding ponds (reflecting subsurface flow below the holding ponds), and house well (reflecting deeper ground water) for chemical and bacterial analysis.
2. This Report contains certified analyses of samples collected between April 1 and June 30, 2018.
3. Sample collection and custody logs from the start of BCRET monitoring in September 2013 have been scanned and compiled by quarter and included on the Project's website.
4. The upstream (BC6), downstream (BC7), ephemeral stream (BC4), and trench sites (T1 and T2) needed maintenance over the last several months and actions taken are detailed. In addition, deliberate actions that impaired the accuracy of flow monitoring and ISCO sample collection at the upstream (BC6) and downstream (BC7) sites are noted.
5. Seasonal Kendall's test for trends in nutrient concentrations at sites adjacent to the swine production facility and holding ponds (i.e., well, trenches, and ephemeral stream) were conducted and are reported. There was a statistically significant (probability <0.0001) increase in nitrate-N concentrations in ephemeral stream and well samples over the monitoring period (April 2014 to April 2018).
6. In contrast, chloride, which is a conservative element that can move freely through the soil without chemical, physical, or biological modification, and electrical conductivity did not exhibit any statistically significant change over the monitoring period well (W1) and ephemeral stream (BC4) samples (April 2015 to April 2018).
7. Given the lack of any increasing trend in chloride and electrical conductivity for well (W1) or ephemeral stream (BC4) samples, suggests that elevated nitrate-N concentrations in well and ephemeral stream samples may be influenced by sources other than the holding ponds (i.e., sources that have low chloride and electrical conductivity values).

Big Creek Science Team

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

Andrew Bartlett, Ph.D., Clinical Assistant Professor, Agricultural Statistics Laboratory, Experimental regression, agricultural applications of statistics.

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.

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

Ed Gbur, Ph.D., Professor and Director, Agricultural Statistics Laboratory - Experimental design, linear and generalized linear mixed models, regression, agricultural applications of statistics.

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.

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

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 outstanding and dedicated Program Technicians based in Fayetteville and Little Rock.

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Site 3. Edge-of-field monitoring on Field 12 permitted to receive slurry.

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

Site 5. Spring below Field 1.

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

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

Site 9. Left Fork downstream of the C&H Farm operation.

Site 10. North interceptor trench below the manure holding ponds.

Site 11. South interceptor trench below the manure holding ponds.

Site 12. House well at animal facility.

Table 1. Location of sampling sites on the Big Creek Research and Extension Team project.

Site description	Site	Latitude	Longitude	Elevation, ft
Field 1	BC1	35 55’ 06.42”	93 03’ 38.34”	984
Field 5a	BC2	35 56’03.01”	93 04’ 25.85”	778
Field 12	BC3	35 54’ 13.57”	93 04’ 04.76”	838
Ephemeral stream	BC4	35 55’ 25.89”	93 04’ 14.94”	824
Spring	BC5	35 54’ 57.06”	93 03’ 34.64”	977
Big Creek upstream of farm	BC6	35 53’ 32.28”	93 04’ 06.38”	857
Big Creek downstream of farm	BC7	35 56’ 18.98”	93 04’ 21.81”	769
Left Fork	BC9	35 56’ 48.33”	93 04” 0.92”	760
Trench 1 (south)	T1	35 55’ 19.24”	93 04’ 23.04”	890
Trench 2 (north)	T2	35 55’ 21.39”	93 04’ 19.93”	882
House well	W1	35 55’ 27.02”	93 04’ 22.71”	915
Well water depth		35 55’ 27.02”	93 04’ 22.71”	590
Pond 1 base		35 55’ 20.36”	93 04’ 23.58”	900
Pond 2 base		35 55’ 22.27”	93 04’ 21.61”	892

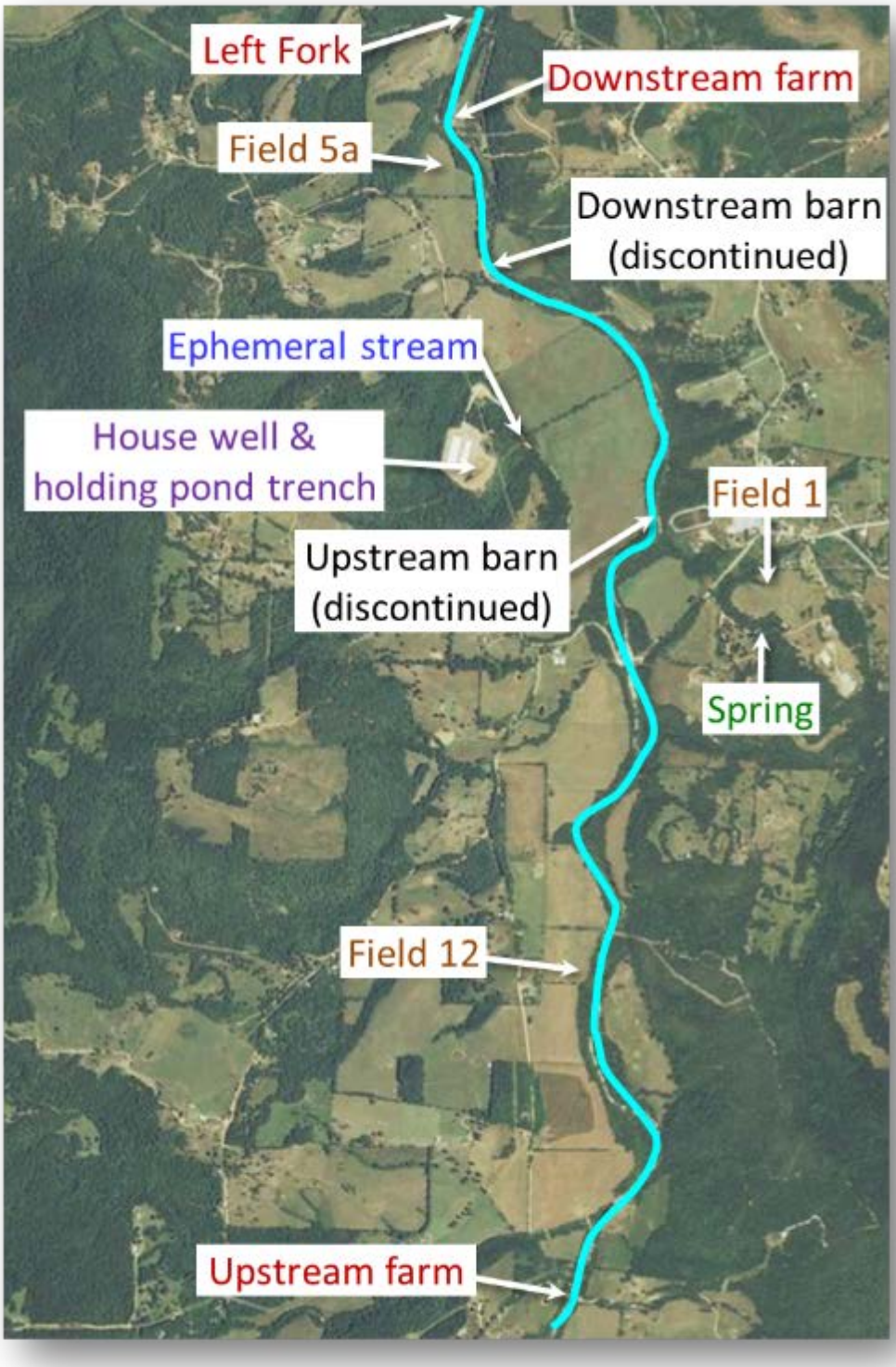

Figure 1. Location of sampling sites for the Big Creek Research and Extension Team project.

Site Repair and Maintenance

Repairs and maintenance was completed at several sites. In September2017, the area above the trenches was reshaped to remove small surface depressions, which had formed with soil settling above trench 1 and 2 lines (Figure 2).

On October 23rd we found that the solar panel had been removed from the upstream site on Big Creek (BC7). The solar panel was replaced with a new one and the site was operation on October 26th (Figure 3)

Two deer carcasses were removed from the ephemeral stream site (BC4), just upstream of our sampling location in mid-October and November 2017, see Figures 4 and 5, respectively. The first carcass likely influenced the October 23, 2017 sampling at this site, when elevated nitrate-N (0.584 mg/L), total N (9.820 mg/L), and dissolved organic carbon concentrations (13.53 mg/L) were observed compared with average values for this site (0.817, 1.28, and 3.72 mg/L, respectively).

Sampling equipment at the upstream site (BC6) was reconfigured after our velocity – flow sensor and ISCO autosampler intake were dislodged and lost in a large storm in February 2018. During the period the ISCO sampler was not working at this site, we missed one storm flow sample that was collected at the downstream site (BC7 on March 29, 2018). The reconfigured site is shown in Figures 6, 7, and 8. However, in late June 2018, a large bolder was apparently placed next to the ISCO velocity module and sample intake, which interrupted accurate flow and sample collection. There were no storm flow events between completion of reconfiguring the upstream site and the appearance of the boulder next to the velocity module and ISCO sample intake.

Figure 2. Reshaped land above trench 1 and 2 at the C&H Farm.

Figure 3. Missing solar panel and cut connecting cable at site BC7, downstream of the C&H Farm on Big Creek.

Figure 4. Deer carcass upstream of ephemeral stream sampling site BC4, October 2017.

Figure 5. Deer carcass upstream of ephemeral stream sampling site BC4, November 2017.

Figure 6. Reconfigured site BC6, upstream of the C&H Farm on Big Creek.

Figure 7. Boulder adjacent to velocity flow module and ISCO sampler intake at site BC6, upstream of the C&H Farm on Big Creek.

Figure 8. Boulder adjacent to velocity flow module and ISCO sampler intake at site BC6, upstream of the C&H Farm on Big Creek.

Sampling Protocols and Analyses

The following protocols were 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.
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, and samples 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.
6. The ISCO autosamplers collect storm flow samples at sites edge-of-field sites on Fields 1, 5a, and 12, and at the ephemeral stream, upstream of the C&H Farm, and downstream of the C&H Farm sites (i.e., BC1, BC2, BC3, BC4, BC 6, and BC 7, respectively). Water-sample collection criteria for each site are detailed in Tables 2 and 3.
7. Analyses included Alkalinity (APHA 2320-B), Ammonia (EPA 351.2), Chloride (EPA 300.0), Dissolved Phosphorus (EPA 365.2), E. coli (APHA 9223-B), Electrical Conductivity (EPA 120.1), Nitrate (EPA 300.0), pH (EPA 150.1), Total Coliforms (APHA 9223-B), Total Dissolved Solids (EPA 160.1), Total Nitrogen (APHA 4500-P J), Total Phosphorus (APHA 4500-P J), and Total Suspended Solids (EPA 160.2). APHA is American Public Health Association from the Wadeable Streams Assessment, Water Chemistry Laboratory Manual http://www.epa.gov/owow/monitoring/wsa/WRS_lab_manual.pdf
8. Prior to collection of a house-well water sample, the well is purged and water temperature, pH, and electrical conductivity measured on-site every 30 seconds until all values stabilize. At that point, a sample of water is collected in a 1-L acid-washed bottle. This method is taken from USGS and EPA well water sampling protocols. See USGS methods for sampling at https://water.usgs.gov/owq/FieldManual/chapter4/pdf/Chap4_v2.pdf. Specific and detailed guidance on the collected of water quality data can be found in the USGS National Field Manual at file:///U:/Words/C&H%20Farm/Publications/Planning/USGS%20National%20Field%20Mannual_complete%202015.pdf

   The U.S. EPA also recommend that selected water quality parameters can be monitored during low-rate purging, with stabilization of these parameters indicating when the discharge water represents aquifer water or source well water. See: http://www.csus.edu/indiv/h/hornert/Geol_210_Summer_2012/Week%202%20readings/Puls%20and%20Barcelona%201996%20Low%20flow%20sampling.pdf and https://in-situ.com/wp-content/uploads/2015/01/Low-Flow-Groundwater-Sampling-Techniques-Improve-Sample-Quality-and-Reduce-Monitoring-Program-Costs-Case-Study.pdf
9. Minimum detection limits (MDLs) for each chemical and biological constituent are listed in Table 4. Some constituent concentrations were reported by the laboratory as less than the MDL but greater

than zero. Those values are given in subsequent tables but have less confidence in their accuracy than concentrations above the MDL.

10. Chemical and biological analyses of samples collected from the beginning of 2017 to the current date are given in Tables 5, 6, 7, and 8.

Table 2. Parameters used to enable ISCO auto-samplers at BCRET edge-of-field sites Field 1, 5a, and 12.

Site	Identifier	ISCO enabled when stage height (inches) above	Volume pacing, 100 mL water collected per gallon of water		
			Rainfall, inches		
			<2.5	2.5 to 4	>4
Field 1	BC1	> 0.75	500	1,000	5,000
Field 5a	BC2	> 0.75	5,000	10,000	50,000
Field 12	BC3	> 0.75	500	1,000	5,000

Table 3. Parameters used to enable ISCO auto-samplers at BCRET stream sites BC4, BC6, and BC7.

Site	Identifier	ISCO enabled when, over a 30-minute period, stage height (inches) increases by	Volume pacing, 100 mL water collected per gallon of water		
			Rainfall, inches		
			<2.5	2.5 to 4	>4
Ephemeral stream	BC4	> 2.0 *	25,000	50,000	100,000
Upstream Big Creek	BC6	1.2	40,000,000	50,000,000	70,000,000
Downstream Big Creek	BC7	1.8	60,000,000	80,000,000	100,000,000

* For ephemeral stream stage height increases >2.0 inches over a 30-min period.

Table 4. Minimum detection limits (MDLs) for each chemical and biological constituent.

Constituent	Minimum detection limit [1]
Alkalinity, mg/L as $CaCO_3$	2
Chloride, mg/L	0.093
Dissolved P, mg/L	0.002
Conductivity, uS/cm	1
Ammonia-N, mg/L	0.03
Dissolved organic carbon, mg/L	0.18
E. coli, MPN/100 mL	1
Nitrate-N, mg/L	0.004
pH	0.1
Total coliform, MPN/100 mL	1
Total dissolved solids, mg/L	15.22
Total N, mg/L	0.006
Total P, mg/L	0.012
Total suspended solids, mg/L	6.58

[1] MDL the Minimum Detection Limit of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero. Further information is available at http://water.usgs.gov/owq/OFR_99-193/detection.html

Big Creek Research and Extension Team Monitoring Data

Nutrients, Sediment, and Bacteria by Date of Sampling

Table 5. Water quality analyses at each sample site since January 2018, with those collected since the last report noted. 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
1/4/2018	**1/4/2018**	**Grab sample**									
12:45	15:20	Upstream farm	0.006	0.006	0.01	0.165	0.270	1.3	2.19	18.3	2880.0
12:05	15:20	Downstream farm	0.009	0.009	0.01	0.300	0.410	0.5	2.22	2.0	613.1
11:52	15:20	Left Fork	0.004	0.005	0.01	0.228	0.310	0.7	1.58	1.0	461.1
12:/22	15:20	House well	0.007	0.007	0.01	0.683	0.840	0.1	3.05	<1.0	1.0
1/18/2018	**1/18/2018**	**Grab sample**									
11:50	14:45	Upstream farm	0.005	0.005	0.02	0.125	0.180	0.5	2.14	24.7	>2419.2
11:01	14:45	Downstream farm	0.007	0.007	0.01	0.214	0.300	0.5	1.97	14.5	547.5
10:45	14:45	Left Fork	0.002	0.002	0.01	0.128	0.180	0.6	1.17	1.0	461.1
11:24	14:45	House well	0.006	0.006	0.03	0.670	0.820	0.3	0.72	<1.0	<1.0
1/30/2018	**1/30/2018**	**Grab sample**									
12:13	14:30	Upstream farm	0.006	0.007	<0.03	0.143	0.210	1.1	2.40	18.9	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
11:36	14:30	Downstream farm	0.005	0.005	<0.03	0.163	0.230	4.6	2.22	4.1	579.4
11:24	14:30	Left Fork	0.005	0.005	<0.03	0.216	0.280	4.0	2.37	9.7	686.7
12:00	14:30	House well	0.009	0.009	<0.03	0.642	0.800	0.4	4.84	<1.0	<1.0
2/14/2018	**2/14/2018**	**Grab sample**									
10:46	13:20	Upstream farm	0.006	0.006	0.01	0.064	0.090	0.7	0.82	53.0	613.1
10:00	13:20	Downstream farm	0.008	0.008	0.01	0.150	0.220	1.4	1.29	35.5	816.1
9:44	13:20	Left Fork	0.004	0.004	0.01	0.143	0.130	1.2	1.29	13.4	866.4
10:31	13:20	House well	0.008	0.008	0.04	0.611	0.820	0.6	1.27	<1.0	<1.0
2/21/2018	**2/21/2018**	**Storm sample**									
11:32	15:32	Field 5a	1.496	2.078	0.14	0.307	2.990	66.9	17.12	ND	ND
2/22/2018	**2/22/2018**	**Grab sample**									
11:16	14:35	Spring	0.010	0.032	0.02	0.560	0.780	1.1	8.28	86.0	>2419.2
12:16	14:35	Upstream farm	0.008	0.043	0.01	0.358	0.460	5.7	2.89	261.3	>2419.2
11:00	14:35	Downstream farm	0.011	0.050	0.03	0.499	0.720	6.5	3.19	387.3	2650.0
12:04	14:35	Ephemeral stream	0.009	0.037	0.01	1.869	2.030	1.4	4.22	90.6	2720.0
10:52	14:35	Left Fork	0.015	0.057	0.02	0.660	0.880	7.4	3.32	238.2	4130.0

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
11:38	14:35	House well	0.007	0.024	0.01	0.697	0.900	0.2	3.19	<1.0	<1.0
11:43	14:35	Trench 1	0.008	0.043	0.06	1.334	1.590	2.1	3.55	8.4	6113.0
Samples collected and analyzed since the last quarterly report											
2/26/2018	**2/26/2018**	**Storm sample**									
11:52	15:40	Ephemeral stream	0.061	0.173	0.04	1.735	2.720	56.5	6.34	ND	ND
12:05	15:40	Field 5a	0.735	1.495	0.12	0.087	2.280	175.5	7.22	ND	ND
3/1/2018	**3/1/2018**	**Grab sample**									
11:43	15:00	Spring	0.014	0.037	<0.03	0.284	0.540	6.9	5.44	74.4	613.1
12:36	15:00	Upstream farm	0.009	0.032	0.01	0.226	0.370	0.0	1.94	325.5	1732.9
11:29	15:00	Downstream farm	0.008	0.035	0.01	0.337	0.460	2.9	2.17	142.1	1413.6
12:24	15:00	Ephemeral stream	0.010	0.029	<0.03	1.078	1.310	0.9	5.62	90.7	>2419.2
11:20	15:00	Left Fork	0.011	0.037	0.01	0.349	0.490	2.6	2.26	137.6	1986.3
11:55	15:00	House well	0.014	0.031	0.02	0.655	0.770	0.5	3.77	8.5	16.0
12:06	15:00	Trench 1	0.007	0.024	0.01	1.668	1.850	0.5	1.89	1.0	235.9
3/7/2018	**3/7/2018**	**Grab sample**									
11:21	15:10	Spring	0.008	0.033	0.01	0.790	1.100	20.2	2.74	34.1	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
12:06	15:10	Upstream farm	0.006	0.009	<0.03	0.177	0.260	1.6	1.02	35.5	344.8
11:03	15:10	Downstream farm	0.008	0.013	<0.03	0.356	0.480	1.3	1.07	29.9	613.1
11:31	15:10	Ephemeral stream	0.008	0.010	0.01	0.764	0.980	1.5	0.72	101.4	5940.0
10:50	15:10	Left Fork	0.009	0.009	<0.03	0.345	0.460	0.8	0.81	63.1	579.4
11:40	15:10	House well	0.012	0.012	0.04	0.679	0.840	0.7	0.81	<1.0	<1.0
3/14/2018	**3/14/2018**	**Grab sample**									
12:20	15:00	Upstream farm	0.006	0.006	<0.03	0.072	0.160	0.6	0.69	118.3	461.1
11:38	15:00	Downstream farm	0.007	0.019	<0.03	0.254	0.410	0.2	0.81	24.3	387.3
11:25	15:00	Left Fork	0.006	0.006	<0.03	0.175	0.270	0.5	1.21	18.3	365.4
3/29/2018	**3/29/2018**	**Grab sample**									
12:13	15:50	Spring	0.007	0.035	<0.03	0.127	0.470	7.3	6.01	1046.2	21430.0
13:30	15:50	Upstream farm	0.037	0.167	0.01	0.149	0.840	99.3	6.10	3840.0	30760.0
12:35	15:50	Ephemeral stream	0.039	0.075	0.02	0.870	1.430	8.6	4.64	5370.0	27550.0
11:45	15:50	Left Fork	0.066	0.275	0.03	0.141	0.950	147.9	7.90	10460.0	54750.0
12:40	15:50	House well	0.013	0.013	0.02	0.648	0.830	0.1	1.28	<1.0	5.2
12:50	15:50	Trench 1	0.003	0.040	0.02	1.014	1.600	3.8	5.22	770.1	32550.0

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
13:05	15:50	Field 5a	2.067	2.247	0.05	0.296	1.750	27.1	12.48	72700.0	>241920
3/29/2018	**3/29/2018**	**Storm sample**									
11:56	15:50	Downstream farm	0.003	0.079	0.01	0.016	0.590	44.1	27.16	ND	ND
4/5/2018	**4/5/2018**	**Grab sample**									
9:39	14:10	Spring	0.008	0.008	<0.03	0.448	0.650	2.7	3.29	21.8	648.8
10:34	14:10	Upstream farm	0.006	0.006	<0.03	0.115	0.190	1.3	1.17	62.0	727.0
9:19	14:10	Downstream farm	0.006	0.006	<0.03	0.268	0.380	1.8	1.31	224.7	1046.2
9:54	14:10	Ephemeral stream	0.005	0.005	<0.03	0.778	0.980	1.1	2.38	40.8	2419.2
9:01	14:10	Left Fork	0.007	0.007	<0.03	0.277	0.410	2.0	1.63	104.6	1046.2
10:07	14:10	House well	0.007	0.007	<0.03	0.524	0.810	0.7	2.38	<1.0	5.2
11:00	14:10	Trench 1	0.002	0.002	0.01	1.291	1.470	0.9	0.88	1.0	275.5
4/12/2018	**4/12/2018**	**Grab sample**									
8:31	13:15	Spring	0.008	0.008	<0.03	0.848	1.050	0.9	12.16	8.4	410.6
9:21	13:15	Upstream farm	0.003	0.003	<0.03	0.051	0.110	0.9	4.09	98.7	1119.9
8:13	13:15	Downstream farm	0.004	0.004	<0.03	0.189	0.280	0.9	3.25	74.9	1119.9
8:46	13:15	Ephemeral stream	0.004	0.004	<0.03	0.717	0.870	0.3	5.75	30.9	>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
7:58	13:15	Left Fork	0.003	0.003	<0.03	0.156	0.250	0.7	3.15	45.7	1203.3
4/16/2018	**4/16/2018**	**Storm sample**									
12:30	15:00	Ephemeral stream	0.009	0.038	0.04	0.920	1.230	7.2	2.20	ND	ND
4/19/2018	**4/19/2018**	**Grab sample**									
10:37	15:30	Spring	0.008	0.008	<0.03	0.772	1.030	0.8	1.94	22.8	410.6
11:17	15:30	Upstream farm	0.006	0.009	<0.03	0.076	0.170	0.9	0.99	88.0	866.4
10:15	15:30	Downstream farm	0.005	0.014	<0.03	0.154	0.250	1.3	0.95	113.7	1553.1
10:51	15:30	Ephemeral stream	0.003	0.004	<0.03	0.654	0.820	0.7	1.09	29.2	1986.3
10:01	15:30	Left Fork	0.004	0.007	<0.03	0.113	0.230	1.3	1.17	127.4	2419.2
11:04	15:30	House well	0.006	0.006	0.01	0.642	0.830	0.1	7.41	<1.0	<1.0
4/23/2018	**4/23/2018**	**Storm sample**									
	15:05	Ephemeral stream	0.002	0.014	0.02	0.680	0.940	10.4	7.70	ND	ND
4/26/2018	**4/26/2018**	**Grab sample**									
11:30	15:10	Spring	0.006	0.032	<0.03	0.131	0.390	2.0	6.56	547.5	2419.2
12:23	15:10	Upstream farm	0.004	0.022	<0.03	0.057	0.150	2.4	1.94	307.6	3500.0
11:15	15:10	Downstream farm	0.004	0.029	<0.03	0.081	0.230	4.5	1.98	686.7	5120.0

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
11:42	15:10	Ephemeral stream	0.005	0.010	<0.03	0.799	1.050	0.3	2.03	60.1	2419.2
11:05	15:10	Left Fork	0.003	0.014	<0.03	0.069	0.210	2.5	1.86	292.4	2010.0
11:53	15:10	House well	0.008	0.009	<0.03	0.628	0.770	0.3	1.60	<1.0	2.0
5/3/2018	**5/3/2018**	**Grab sample**									
10:00	13:44	Spring	0.007	0.058	<0.03	0.115	0.500	4.9	6.06	1046.2	54750.0
11:04	13:44	Upstream farm	0.054	0.305	0.02	0.106	1.080	17.2	3.90	15000.0	173290
9:47	13:44	Downstream farm	0.010	0.065	0.01	0.095	0.400	74.9	5.62	3730.0	23820.0
10:28	13:44	Ephemeral stream	0.017	0.033	<0.03	0.919	1.120	16.2	5.81	248.9	13790.0
9:38	13:44	Left Fork	0.023	0.150	0.01	0.167	0.850	20.9	6.38	7540.0	86640.0
10:38	13:44	House well	0.009	0.026	<0.03	0.661	0.760	0.6	1.62	<1.0	2.0
10:45	13:44	Trench 1	0.004	0.048	<0.03	0.636	0.880	5.9	2.52	135.4	54750.0
10:45	13:44	Trench 2	0.004	0.320	0.02	0.240	1.770	32.1	15.79	290.9	241920
10:15	13:44	Field 1	0.273	0.467	0.06	0.037	1.750	27.5	8.12	41060.0	241920
5/3/2018	**5/3/2018**	**Storm sample**									
10:28	13:44	Ephemeral stream	0.004	0.044	0.01	1.008	1.380	100.8	2.80	ND	ND
5/17/2018	**5/17/2018**	**Grab sample**									

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
8:09	12:30	Spring	0.005	0.023	0.01	0.673	0.870	13.1	3.78	16.0	579.4
8:53	12:30	Upstream farm	0.004	0.010	0.01	0.130	0.240	2.6	1.67	101.7	3500.0
7:48	12:30	Downstream farm	0.007	0.022	0.02	0.275	0.440	1.8	1.47	82.0	8200.0
7:33	12:30	Left Fork	0.006	0.012	0.02	0.268	0.430	2.0	2.12	26.9	2490.0
8:30	12:30	House well	0.005	0.006	0.01	0.814	0.930	0.3	1.13	1.0	2.0
5/24/2018	**5/24/2018**	**Grab sample**									
11:35	14:40	Spring	0.009	0.017	<0.03	0.634	0.780	2.9	1.71	5.1	4260.0
12:25	14:40	Upstream farm	0.006	0.015	<0.03	0.118	0.220	1.1	0.93	517.2	17890.0
11:25	14:40	Downstream farm	0.010	0.017	0.01	0.315	0.460	1.3	0.84	41.1	2419.2
11:15	14:40	Left Fork	0.008	0.015	0.02	0.318	0.510	2.5	1.07	33.7	4020.0
12:05	14:40	House well	0.009	0.012	0.01	0.666	0.770	0.5	0.96	<1.0	<1.0
5/31/2018	**5/31/2018**	**Grab sample**									
11:17	14:45	Spring	0.005	0.012	<0.03	0.473	0.640	2.0	2.35	74.3	8360.0
11:43	14:45	Upstream farm	0.006	0.015	<0.03	0.085	0.200	1.6	1.13	90.6	4080.0
11:05	14:45	Downstream farm	0.008	0.014	0.01	0.198	0.340	1.9	1.13	66.9	4570.0
11:00	14:45	Left Fork	0.006	0.014	0.01	0.146	0.290	3.1	1.22	60.9	3450.0

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
11:30	14:45	House well	0.007	0.010	0.01	0.661	0.780	0.1	0.55	<1.0	<1.0

¶ Values proceeded by '<' were reported by the analytical laboratory as zero and the minimum detection limit is given.
§ ND is No Data, due to coliform not measured on water samples collected automatically by non-sterilized ISCO sampler.
‡ Storm sample collected by hand after a 30-minute storm in the watershed at 7:35 on 11/15/2017.

Nutrients, Sediment, and Bacteria by Date Spring, Upstream, and Downstream Sites

Table 6. Water quality analyses in Big Creek upstream and downstream of the C&H Farm boundary of permitted land application since January 2018, with those collected since the last report noted.

Sample location	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 ---	
1/4/2018									
Upstream	0.006	0.006	0.01	0.165	0.270	1.3	2.19	18.3	2880.0
Downstream	0.009	0.009	0.01	0.300	0.410	0.5	2.22	2.0	613.1
1/18/2018									
Upstream	0.007	0.007	0.01	0.214	0.300	0.5	1.97	14.5	547.5
Downstream	0.005	0.005	0.02	0.125	0.180	0.5	2.14	24.7	>2419.2
1/30/2018									
Upstream	0.006	0.007	<0.03	0.143	0.210	1.1	2.40	18.9	613.1
Downstream	0.005	0.005	<0.03	0.163	0.230	4.6	2.22	4.1	579.4
2/14/2018									
Upstream	0.006	0.006	0.01	0.064	0.090	0.7	0.82	53.0	613.1
Downstream	0.008	0.008	0.01	0.150	0.220	1.4	1.29	35.5	816.1
2/22/2018									
Upstream	0.008	0.043	0.01	0.358	0.460	5.7	2.89	261.3	>2419.2
Downstream	0.011	0.050	0.03	0.499	0.720	6.5	3.19	387.3	2650.0

Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
Samples analyzed since the last quarterly report									
3/1/2018									
Upstream	0.009	0.032	0.01	0.226	0.370	0.0	1.94	325.5	1732.9
Downstream	0.008	0.035	0.01	0.337	0.460	2.9	2.17	142.1	1413.6
3/7/2018									
Upstream	0.006	0.009	<0.03	0.177	0.260	1.6	1.02	35.5	344.8
Downstream	0.008	0.013	<0.03	0.356	0.480	1.3	1.07	29.9	613.1
3/14/2018									
Upstream	0.006	0.006	<0.03	0.072	0.160	0.6	0.69	118.3	461.1
Downstream	0.007	0.019	<0.03	0.254	0.410	0.2	0.81	24.3	387.3
4/5/2018									
Upstream	0.006	0.006	<0.03	0.115	0.190	1.3	1.17	62.0	727.0
Downstream	0.006	0.006	<0.03	0.268	0.380	1.8	1.31	224.7	1046.2
4/12/2018									
Upstream	0.003	0.003	<0.03	0.051	0.110	0.9	4.09	98.7	1119.9
Downstream	0.004	0.004	<0.03	0.189	0.280	0.9	3.25	74.9	1119.9
4/19/2018									
Upstream	0.006	0.009	<0.03	0.076	0.170	0.9	0.99	88.0	866.4

Sample location	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
Downstream	0.005	0.014	<0.03	0.154	0.250	1.3	0.95	113.7	1553.1
4/26/2018									
Upstream	0.004	0.022	<0.03	0.057	0.150	2.4	1.94	307.6	3500.0
Downstream	0.004	0.029	<0.03	0.081	0.230	4.5	1.98	686.7	5120.0
5/3/2018									
Upstream	0.054	0.305	0.02	0.106	1.080	17.2	3.90	15000.0	173290
Downstream	0.010	0.065	0.01	0.095	0.400	74.9	5.62	3730.0	23820.0
5/17/2018									
Upstream	0.004	0.010	0.01	0.130	0.240	2.6	1.67	101.7	3500.0
Downstream	0.007	0.022	0.02	0.275	0.440	1.8	1.47	82.0	8200.0
5/24/2018									
Upstream	0.006	0.015	<0.03	0.118	0.220	1.1	0.93	517.2	17890.0
Downstream	0.010	0.017	0.01	0.315	0.460	1.3	0.84	41.1	2419.2
5/31/2018									
Upstream	0.006	0.015	<0.03	0.085	0.200	1.6	1.13	90.6	4080.0
Downstream	0.008	0.014	0.01	0.198	0.340	1.9	1.13	66.9	4570.0

¶ Values proceeded by '<' were reported by the analytical laboratory as zero and the Minimum detection limit is given.

§ ND is No Data, due to coliform not measured on water samples collected automatically by non-sterilized ISCO sampler.

Nutrients, Sediment, and Bacteria by Site for Ephemeral Stream, Trenches, Left Fork and Field Runoff

Table 7. Water quality analyses at the ephemeral stream draining the subwatershed containing the production houses and manure holding ponds, and surface runoff from Fields 1, 5a, and 12 since January, 2018, with those collected since the last report noted.

Date 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 ---	
Ephemeral stream									
2/22/2018	0.009	0.037	0.01	1.869	2.030	1.4	4.22	90.6	2720.0
Samples collected and analyzed since the last quarterly report									
2/26/2018	0.061	0.173	0.04	1.735	2.720	56.5	6.34	ND	ND
3/1/2018	0.010	0.029	<0.03	1.078	1.310	0.9	5.62	90.7	>2419.2
3/7/2018	0.008	0.010	0.01	0.764	0.980	1.5	0.72	101.4	5940.0
3/29/2018	0.039	0.075	0.02	0.870	1.430	8.6	4.64	5370.0	27550.0
4/5/2018	0.005	0.005	<0.03	0.778	0.980	1.1	2.38	40.8	2419.2
4/12/2018	0.004	0.004	<0.03	0.717	0.870	0.3	5.75	30.9	>2419.2
4/16/2018	0.009	0.038	0.04	0.920	1.230	7.2	2.20	ND	ND
4/19/2018	0.003	0.004	<0.03	0.654	0.820	0.7	1.09	29.2	1986.3
4/23/2018	0.002	0.014	0.02	0.680	0.940	10.4	7.70	ND	ND
4/26/2018	0.005	0.010	<0.03	0.799	1.050	0.3	2.03	60.1	2419.2

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
5/3/2018	0.017	0.033	<0.03	0.919	1.120	16.2	5.81	248.9	13790.0
House well									
1/4/2018	0.007	0.007	0.01	0.683	0.840	0.1	3.05	<1.0	1.0
1/18/2018	0.006	0.006	0.03	0.670	0.820	0.3	0.72	<1.0	<1.0
1/30/2018	0.009	0.009	<0.03	0.642	0.800	0.4	4.84	<1.0	<1.0
2/14/2018	0.008	0.008	0.04	0.611	0.820	0.6	1.27	<1.0	<1.0
2/22/2018	0.007	0.024	0.01	0.697	0.900	0.2	3.19	<1.0	<1.0
Samples collected and analyzed since the last quarterly report									
3/1/2018	0.014	0.031	0.02	0.655	0.770	0.5	3.77	8.5	16.0
3/7/2018	0.012	0.012	0.04	0.679	0.840	0.7	0.81	<1.0	<1.0
3/29/2018	0.013	0.013	0.02	0.648	0.830	0.1	1.28	<1.0	5.2
4/5/2018	0.007	0.007	<0.03	0.524	0.810	0.7	2.38	<1.0	5.2
4/19/2018	0.006	0.006	0.01	0.642	0.830	0.1	7.41	<1.0	<1.0
4/26/2018	0.008	0.009	<0.03	0.628	0.770	0.3	1.60	<1.0	2.0
5/3/2018	0.009	0.026	<0.03	0.661	0.760	0.6	1.62	<1.0	2.0
5/17/2018	0.005	0.006	0.01	0.814	0.930	0.3	1.13	1.0	2.0

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
5/24/2018	0.009	0.012	0.01	0.666	0.770	0.5	0.96	<1.0	<1.0
5/31/2018	0.007	0.010	0.01	0.661	0.780	0.1	0.55	<1.0	<1.0
Interceptor Trench 1 (South)									
2/22/2018	0.008	0.043	0.06	1.334	1.590	2.1	3.55	8.4	6113.0
Samples collected and analyzed since the last quarterly report									
3/1/2018	0.007	0.024	0.01	1.668	1.850	0.5	1.89	1.0	235.9
3/29/2018	0.003	0.040	0.02	1.014	1.600	3.8	5.22	770.1	32550.0
4/5/2018	0.002	0.002	0.01	1.291	1.470	0.9	0.88	1.0	275.5
5/3/2018	0.004	0.048	<0.03	0.636	0.880	5.9	2.52	135.4	54750.0
Interceptor Trench 2 (North)									
Samples collected and analyzed since the last quarterly report									
5/3/2018	0.004	0.320	0.02	0.240	1.770	32.1	15.79	290.9	241920
Left Fork									
1/4/2018	0.004	0.005	0.01	0.228	0.310	0.7	1.58	1.0	461.1
1/18/2018	0.002	0.002	0.01	0.128	0.180	0.6	1.17	1.0	461.1
1/30/2018	0.005	0.005	<0.03	0.216	0.280	4.0	2.37	9.7	686.7

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
2/14/2018	0.004	0.004	0.01	0.143	0.143	1.2	1.29	13.4	866.4
2/22/2018	0.015	0.057	0.02	0.660	0.880	7.4	3.32	238.2	4130.0
Samples collected and analyzed since the last quarterly report									
3/1/2018	0.011	0.037	0.01	0.349	0.490	2.6	2.26	137.6	1986.3
3/7/2018	0.009	0.009	<0.03	0.345	0.460	0.8	0.81	63.1	579.4
3/14/2018	0.006	0.006	<0.03	0.175	0.270	0.5	1.21	18.3	365.4
3/29/2018	0.066	0.275	0.03	0.141	0.950	147.9	7.90	10460.0	54750.0
4/5/2018	0.007	0.007	<0.03	0.277	0.410	2.0	1.63	104.6	1046.2
4/12/2018	0.003	0.003	<0.03	0.156	0.250	0.7	3.15	45.7	1203.3
4/19/2018	0.004	0.007	<0.03	0.113	0.230	1.3	1.17	127.4	2419.2
4/26/2018	0.003	0.014	<0.03	0.069	0.210	2.5	1.86	292.4	2010.0
5/3/2018	0.023	0.150	0.01	0.167	0.850	20.9	6.38	7540.0	86640.0
5/17/2018	0.006	0.012	0.02	0.268	0.430	2.0	2.12	26.9	2490.0
5/24/2018	0.008	0.015	0.02	0.318	0.510	2.5	1.07	33.7	4020.0
5/31/2018	0.006	0.014	0.01	0.146	0.290	3.1	1.22	60.9	3450.0

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
Field 1									
Samples collected and analyzed since the last quarterly report									
5/3/2018	0.273	0.467	0.06	0.037	1.750	27.5	8.12	ND	ND
Field 5a									
2/21/2018	1.496	2.078	0.14	0.307	2.990	66.9	17.12	ND	ND
Samples collected and analyzed since the last quarterly report									
2/26/2018	0.735	1.495	0.12	0.087	2.280	175.5	7.22	ND	ND
3/29/2018	2.067	2.247	0.05	0.296	1.750	27.1	12.48	ND	ND
Field 12									
No samples collected since the last quarterly report									

¶ Values proceeded by '<' were reported by the analytical laboratory as zero and the minimum detection limit is given.

§ ND is No Sample. E. coli and total coliform were not measured on surface runoff samples collected by ISCO samplers when sample holding time exceeded the required 8-hour threshold.

Water pH, Alkalinity, Chloride, Electrical Conductivity, and Total Dissolved Solids for Several Big Creek Sites

The pH, alkalinity, chloride concentration, electrical conductivity and total dissolved solids were determined on water samples collected at the upstream and downstream sites, spring, house well, and trenches, to build a database that will enable to eventually source track the major water source pathways at these sites. These values are given below in Table 8.

Table 8. The pH, Chloride concentration, and electrical conducting of water samples collected at upstream, downstream, spring, ephemeral stream, house well and trench sites, initiated at the beginning of 2018, with those collected since the last report noted.

Date	pH	Chloride	Electrical conductivity
		mg/L	µS/cm
Upstream			
1/4/2018	8.1	1.771	153.0
1/18/2018	8.3	2.198	143.0
1/30/2018	7.8	2.148	111.0
2/14/2018	8.5	4.213	129.0
2/22/2018	7.5	1.430	66.0
Samples analyzed since the last quarterly report			
3/1/2018	8.1	1.378	63.0
3/7/2018	8.1	1.535	89.0
3/14/2018	8.2	1.692	103.0
3/29/2018	8.2	0.932	100.0
4/5/2018	8.2	1.354	102.0
4/12/2018	8.0	1.546	107.0
4/19/2018	8.1	1.338	88.0
4/26/2018	8.0	1.113	93.0
5/3/2018	7.7	1.095	95.0

Date	pH	Chloride	Electrical conductivity
5/17/2018	7.9	1.444	156.0
5/24/2018	8.3	1.600	162.0
5/31/2018	8.3	1.373	139.0
Downstream			
1/4/2018	8.3	2.288	210.0
1/18/2018	8.1	2.516	224.0
1/30/2018	8.0	2.330	160.0
2/14/2018	7.9	2.598	178.0
2/22/2018	7.4	1.559	96.0
Samples analyzed since the last quarterly report			
3/1/2018	7.8	1.548	99.0
3/7/2018	7.7	1.864	136.0
3/14/2018	8.0	2.176	164.0
3/29/2018	8.1	1.392	112.0
4/5/2018	7.7	1.655	149.0
4/12/2018	7.6	2.000	166.0
4/19/2018	7.6	1.619	132.0
4/26/2018	7.9	1.246	131.0
5/3/2018	7.7	1.586	148.0
5/17/2018	7.6	1.981	225.0
5/24/2018	8.0	2.319	226.0
5/31/2018	8.0	1.795	189.0
Left Fork			
1/4/2018	8.6	2.735	217.0
1/18/2018	8.0	3.029	203.0
1/30/2018	8.3	2.829	201.0

Date	pH	Chloride	Electrical conductivity
2/14/2018	7.9	5.810	192.0
2/22/2018	7.4	2.251	95.0
Samples analyzed since the last quarterly report			
3/1/2018	7.9	2.202	137.0
3/7/2018	7.7	2.652	177.0
3/14/2018	8.2	2.841	192.0
3/29/2018	8.0	1.121	181.0
4/5/2018	7.6	2.244	179.0
4/12/2018	7.9	2.731	205.0
4/19/2018	7.9	2.363	187.0
4/26/2018	8.3	1.907	146.0
5/3/2018	7.8	1.843	178.0
5/17/2018	7.9	2.745	267.0
5/24/2018	8.0	3.191	265.0
5/31/2018	8.0	2.029	211.0
Spring			
2/22/2018	7.2	2.067	371.0
Samples analyzed since the last quarterly report			
3/1/2018	8.3	1.794	362.0
3/7/2018	7.2	2.808	493.0
3/29/2018	7.4	0.903	489.0
4/5/2018	7.3	1.933	481.0
4/12/2018	7.1	2.974	533.0
4/19/2018	7.1	2.810	489.0
4/26/2018	7.3	1.057	387.0
5/3/2018	7.1	1.236	413.0
5/17/2018	7.1	2.812	593.0

Date	pH	Chloride	Electrical conductivity
5/24/2018	7.3	2.852	564.0
5/31/2018	7.3	2.539	557.0
Ephemeral Stream			
2/22/2018	7.1	2.460	236.0
Samples analyzed since the last quarterly report			
3/1/2018	8.2	2.945	269.0
3/7/2018	7.7	3.517	370.0
3/29/2018	7.5	2.077	369.0
4/5/2018	7.5	2.700	361.0
4/12/2018	7.6	3.235	400.0
4/16/2018	7.8	2.779	261.0
4/19/2018	7.6	2.831	337.0
4/23/2018	8.1	3.285	334.0
4/26/2018	7.5	2.810	381.0
5/3/2018	7.4	3.157	412.0
House Well			
1/4/2018	7.8	5.025	321.0
1/18/2018	8.3	5.282	450.0
1/30/2018	7.7	5.334	436.0
2/14/2018	7.5	5.684	405.0
2/22/2018	7.3	5.088	317.0
Samples analyzed since the last quarterly report			
3/1/2018	8.4	5.576	413.0
3/7/2018	7.4	5.197	446.0
3/29/2018	7.4	5.315	422.0
4/5/2018	7.5	1.647	460.0
4/19/2018	7.4	4.955	440.0

Date	pH	Chloride	Electrical conductivity
4/26/2018	7.6	5.106	450.0
5/3/2018	7.4	5.160	468.0
5/17/2018	7.4	4.861	464.0
5/24/2018	7.4	4.960	442.0
5/31/2018	7.7	4.840	283.0
Trench 1			
2/22/2018	7.2	1.094	134.0
Samples analyzed since the last quarterly report			
3/1/2018	8.2	1.224	152.0
3/29/2018	7.8	0.966	179.0
4/5/2018	7.7	1.365	192.0
5/3/2018	7.3	1.208	335.0
Trench 2			
Samples analyzed since the last quarterly report			
5/3/2018	7.0	0.456	111.0

Discharge at USGS 07055790 Site Downstream of C&H Operation

Discharge downstream of the C&H Farm (USGS station 07055790 Big Creek near Mt. Judea, AR) is available at https://nwis.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

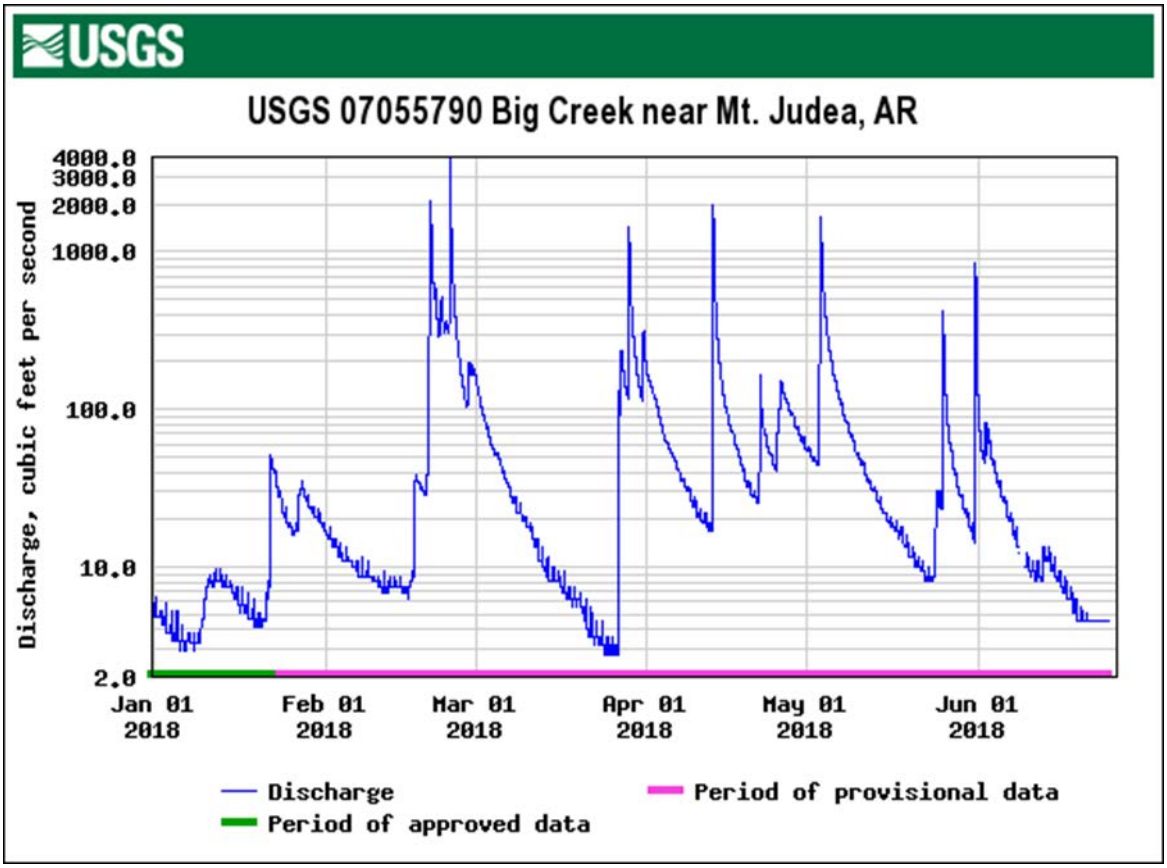

Figure 9. Discharge in Big Creek downstream of the C&H Farm for the period of monitoring; January 1 to June 30, 2018.

Temporal Trends in Phosphorus, Nitrogen, Bacteria, and Chloride in Big Creek above and below the C&H Farm

The concentration of dissolved P, total P, nitrate-N, total N, bacteria and chloride in Big Creek above and below the C&H Farm are presented in subsequent figures to show the season / temporal trends in measured concentrations (Figures 3, 4, 5, 6, 7, 8, and 9).

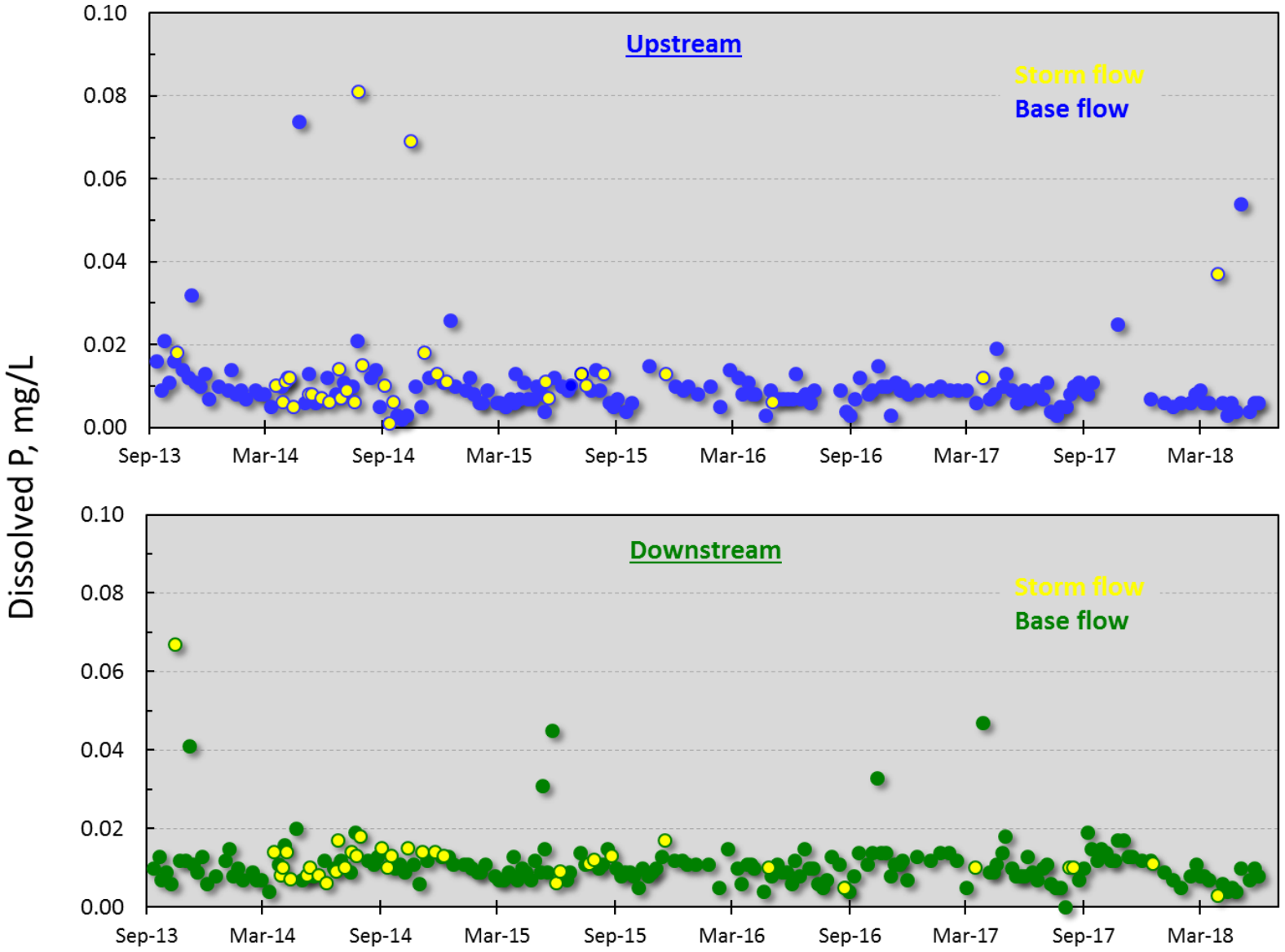

Figure 10. Dissolved P concentration at the Big Creek monitoring site up- and downstream of the C&H Farm, Newton County, AR.

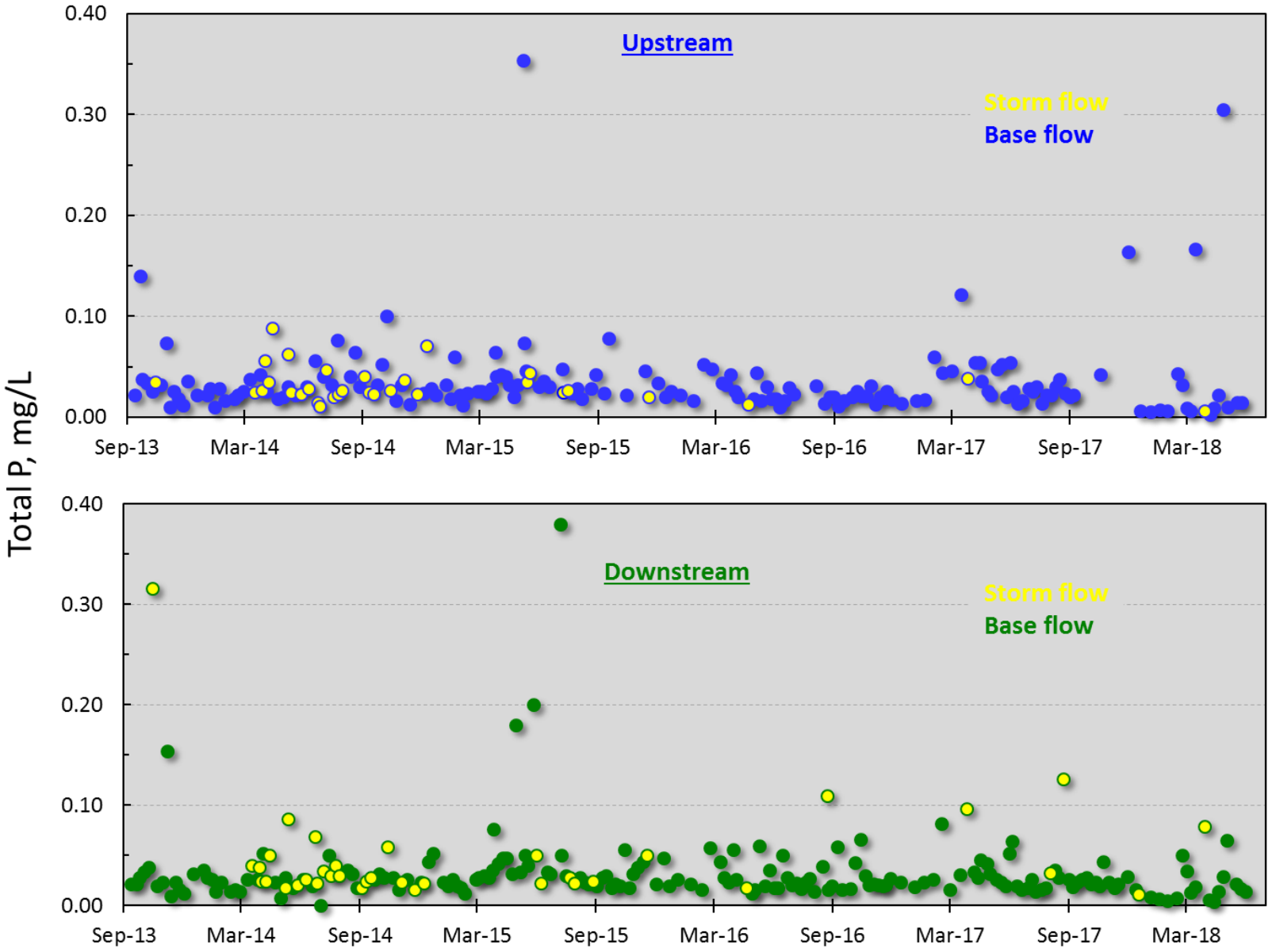

Figure 11. Total P concentration at the Big Creek monitoring site up- and downstream of the C&H Farm, Newton County, AR.

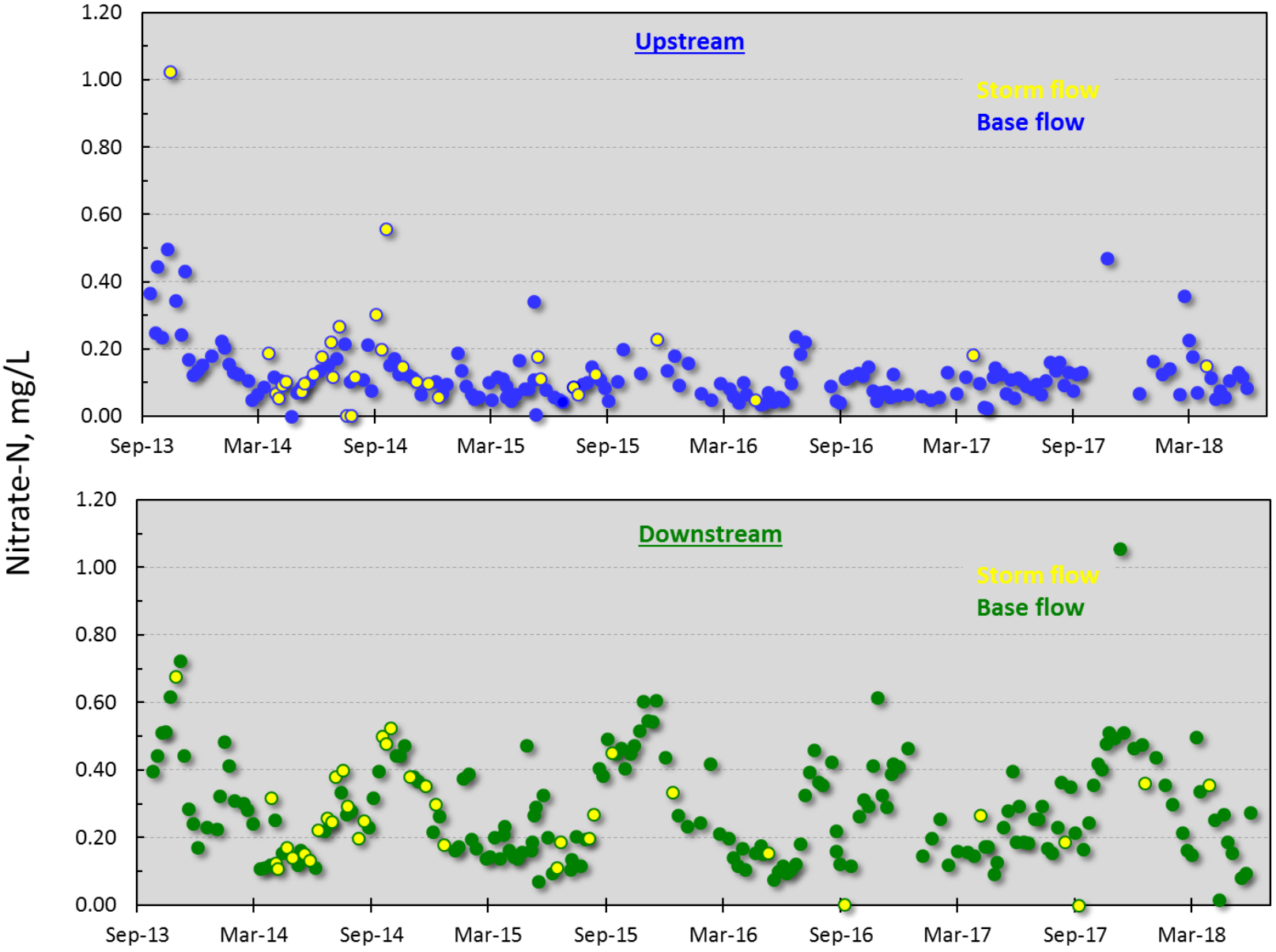

Figure 12. Nitrate-N concentration at the Big Creek monitoring site up- and downstream of the C&H Farm, Newton County, AR.

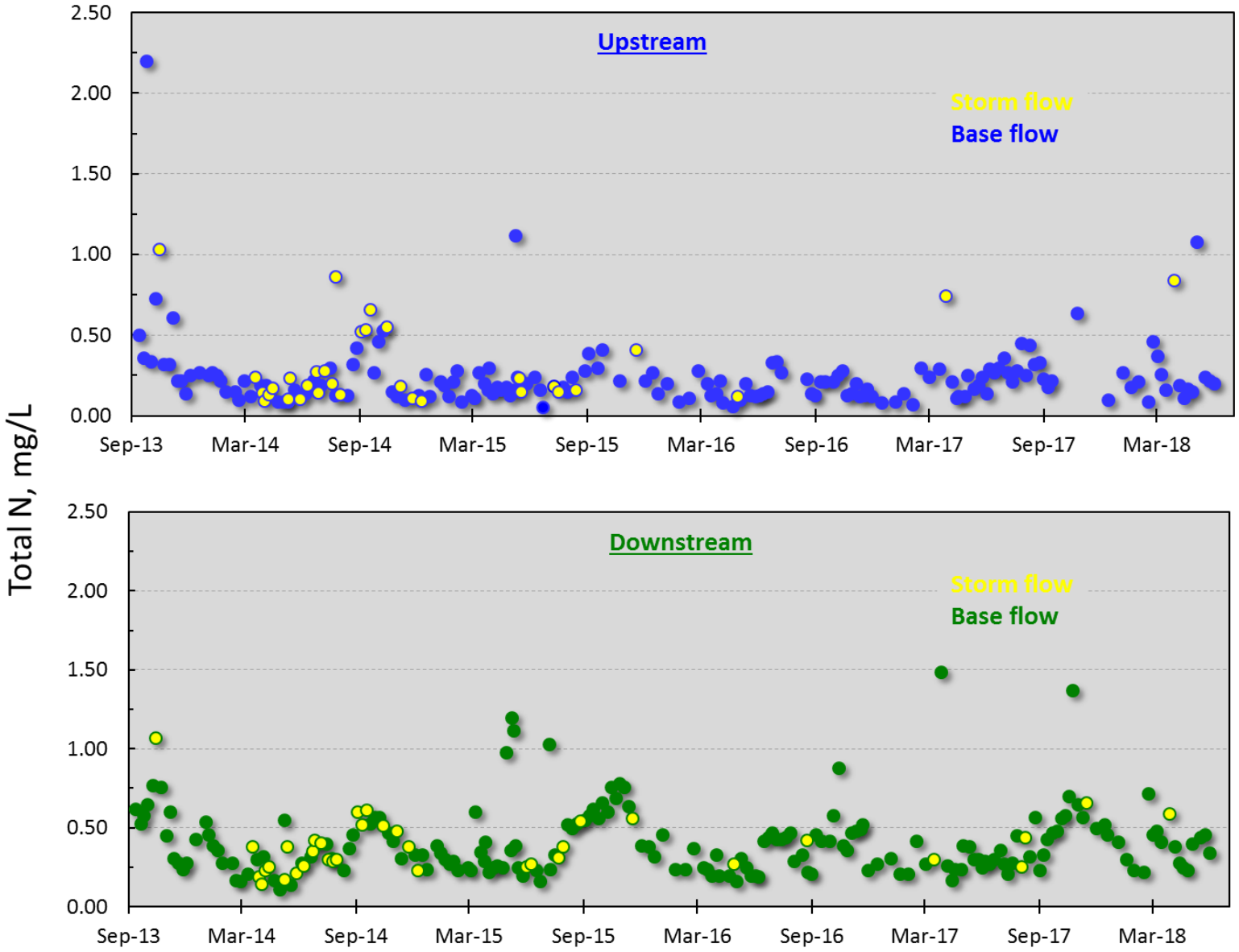

Figure 13. Total N concentration at **the Big Creek monitoring site up- and downstream of the C&H Farm, Newton County, AR.**

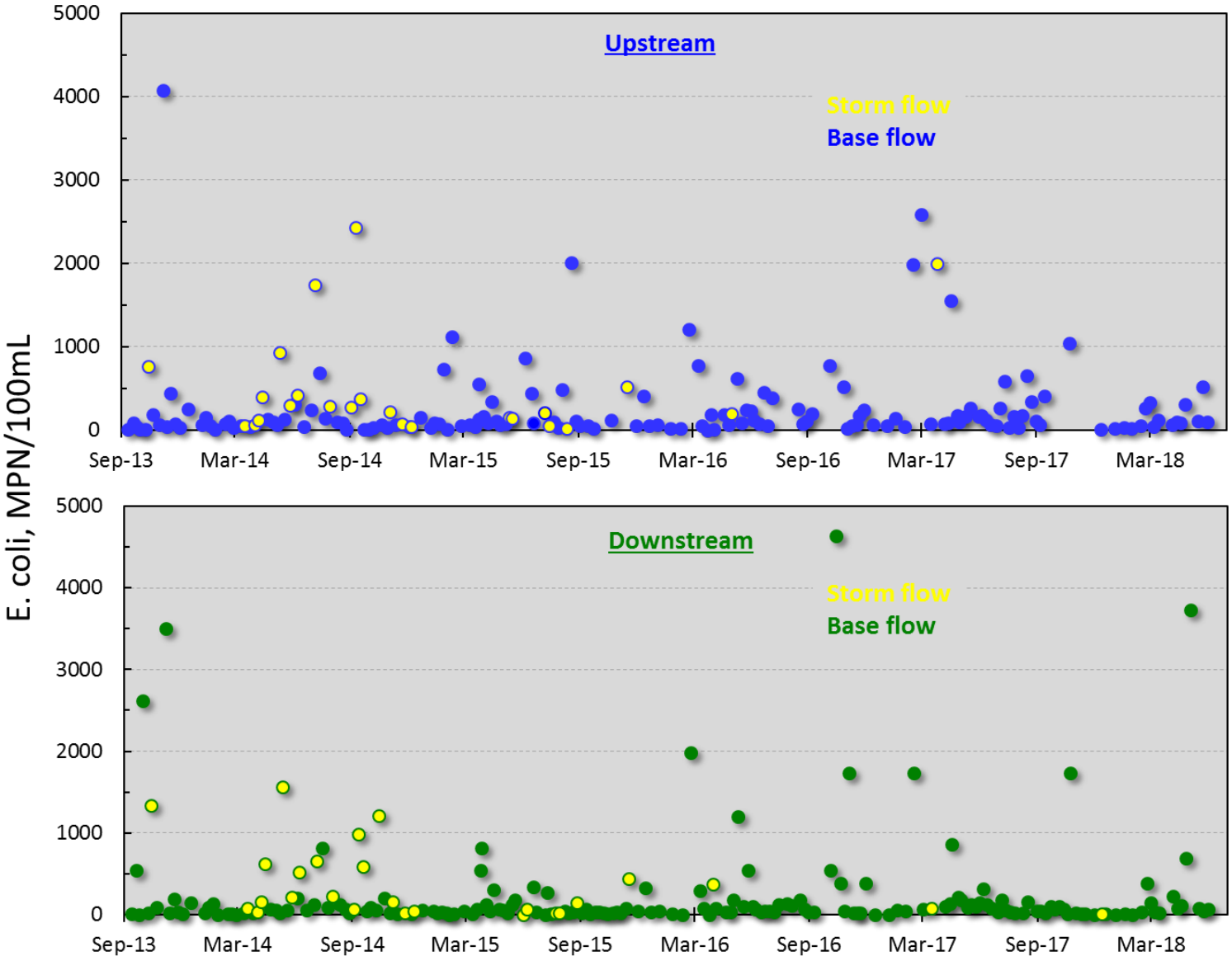

Figure 14. E. coli numbers at the Big Creek monitoring site up- and downstream of the C&H Farm, Newton County, AR.

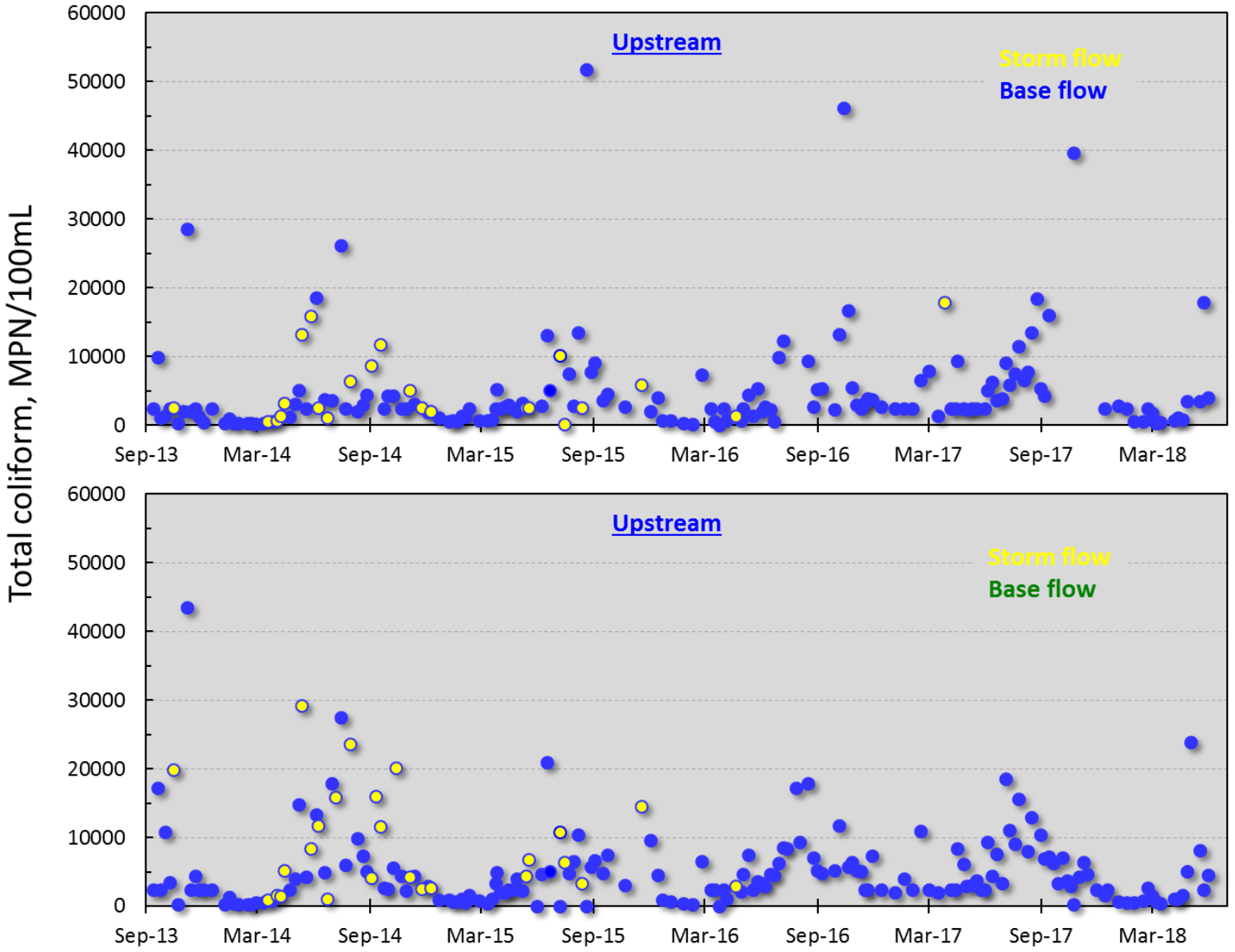

Figure 15. Total coliform numbers at the Big Creek monitoring site up- and downstream of the C&H Farm, Newton County, AR.

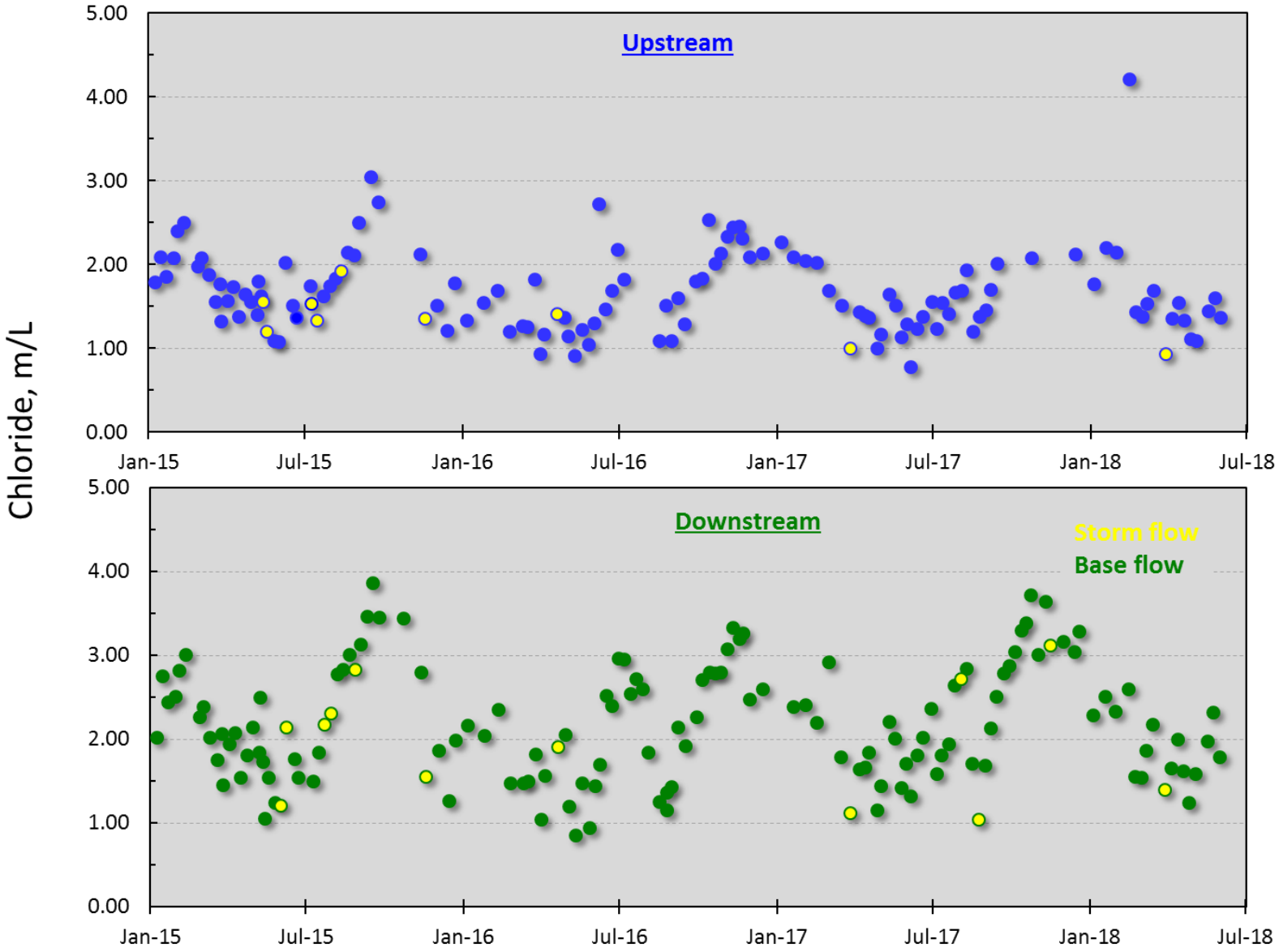

Figure 16. Chloride concentration at the Big Creek monitoring site up- and downstream of the C&H Farm, Newton County, AR.

Nutrient Concentrations in Well, Spring, Ephemeral Stream, and Trenches

The concentration of dissolved, total P, nitrate-N, ammonia-N, total N, , E. coli, chloride, and, electrical conductivity from well, ephemeral stream, and trench sites with time since sampling began are presented in Figures 17 to 23, respectively.

Seasonal Kendall's test for monotonic trends in dissolved P, nitrate-N, and chloride, were determined for the ephemeral stream (site BC4) and house well (site W1) and trend data included on Figures 17 through 23. The purpose of the Seasonal Kendall Tau test (described in Helsel and Hirsch, 2002) is to test for a monotonic increasing or decreasing trend of a variable, in this case nutrient concentration, when the data was collected over time. The Seasonal Kendall test results in two values, the tau value, and a probability value. The tau value has a possible range from -1.0 (perfect inverse correlation), 0.0 (no correlation), to +1.0 (perfect positive correlation). Probability values below the threshold value (typically 0.05) indicate that any observed trend is statistically unlikely to occur by chance and therefore the observed trend is statistically significant.

The following assumptions are made in the Seasonal Kendall's test:

1. Water samples collected over time are representative of the true conditions at the time of sampling.
2. Sample collection, handling, and measurement methods provide unbiased and representative observations of concentrations over time.
3. Any monotonic trends present are all in the same direction (increase or decrease). If there is an increasing trend in some seasons and a decreasing trend in other seasons, the Seasonal Kendall's test may be misleading.

This analysis indicates a statistically significant increase in nitrate-N concentrations in ephemeral stream and well samples over the monitoring period (Figure 19). Additionally, there has been a gradual increase in geomean nitrate concentrations of well samples each water year of site monitoring (i.e., April 1 to March 31; Figure 24). In contrast, concentrations of chloride, a conservative element that can move freely through the soil without chemical, physical, or biological modification, did not exhibit any statistically significant change over the monitoring period in ephemeral stream and well samples (i.e., April 2015 to April 2018; Figure 22).

Further, we do not see any change (increase or decrease) in nitrate-N, chloride, or electrical conductivity in trench 1, or trench 2 water (Figures 19, 22, and 23, respectively). As there are fewer observations due to a lack of flow at the trench sites, Seasonal Kendall's test was not conducted on trench samples.

The chloride concentration and electrical conductivity of slurry in holding ponds 1 and 2 is appreciably greater than that measured upstream of the C&H Farm in Big Creek (i.e., BC6), which represents background concentrations not impacted by farm operations (see Table 9). Given chloride and electrical conductivity can be considered as conservative tracers of water flow, the lack of any increasing trend in these analytes for well (W1), trench (T1 and T2), or ephemeral stream (BC4) samples,

suggests that elevated nitrate-N concentrations in well and ephemeral stream samples may be influenced by sources other than the holding ponds (i.e., sources that have low chloride and electrical conductivity values).

Final trends in sample concentrations and loads will be statistically evaluated when a 5-year period of record has been obtained. Analysis of seasonal or annual trends over a shorter period can lead to incorrect interpretations.

Reference

Helsel, D.R., and R.M. Hirsch. 2002. Statistical methods in water resources. Chapter A3. *In* Techniques of Water-Resources Investigations of the United States Geological Survey. Book 4, Hydrologic Analysis and Interpretation. U.S. Geological Survey. Available at https://pubs.usgs.gov/twri/twri4a3/pdf/twri4a3-new.pdf. 524 pages.

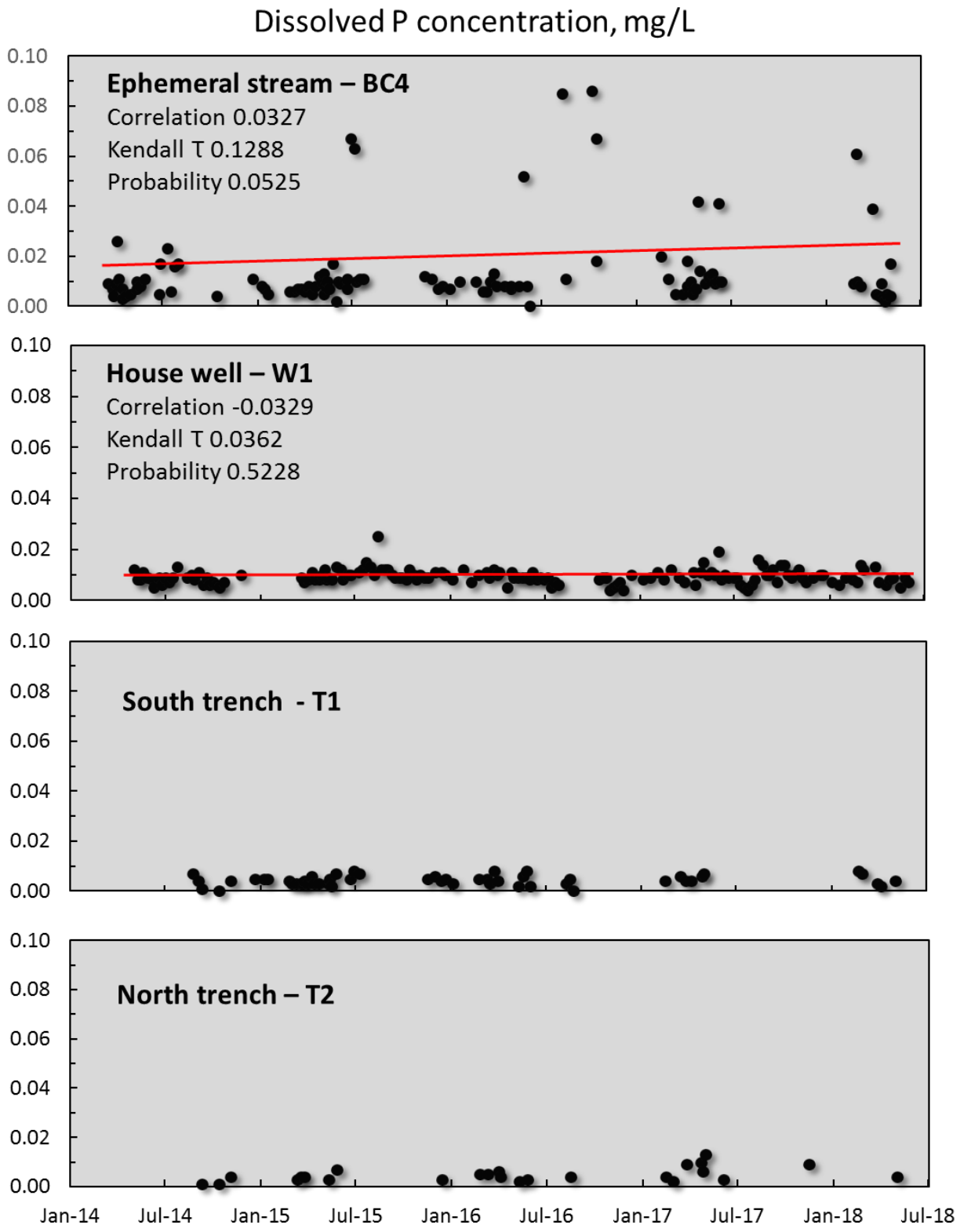

Figure 17. Dissolved P concentrations around the production area (ephemeral stream, spring, well, and trenches 1 and 2) over the period of monitoring, including Seasonal Kendall's statistical trends for the ephemeral stream and well sites.

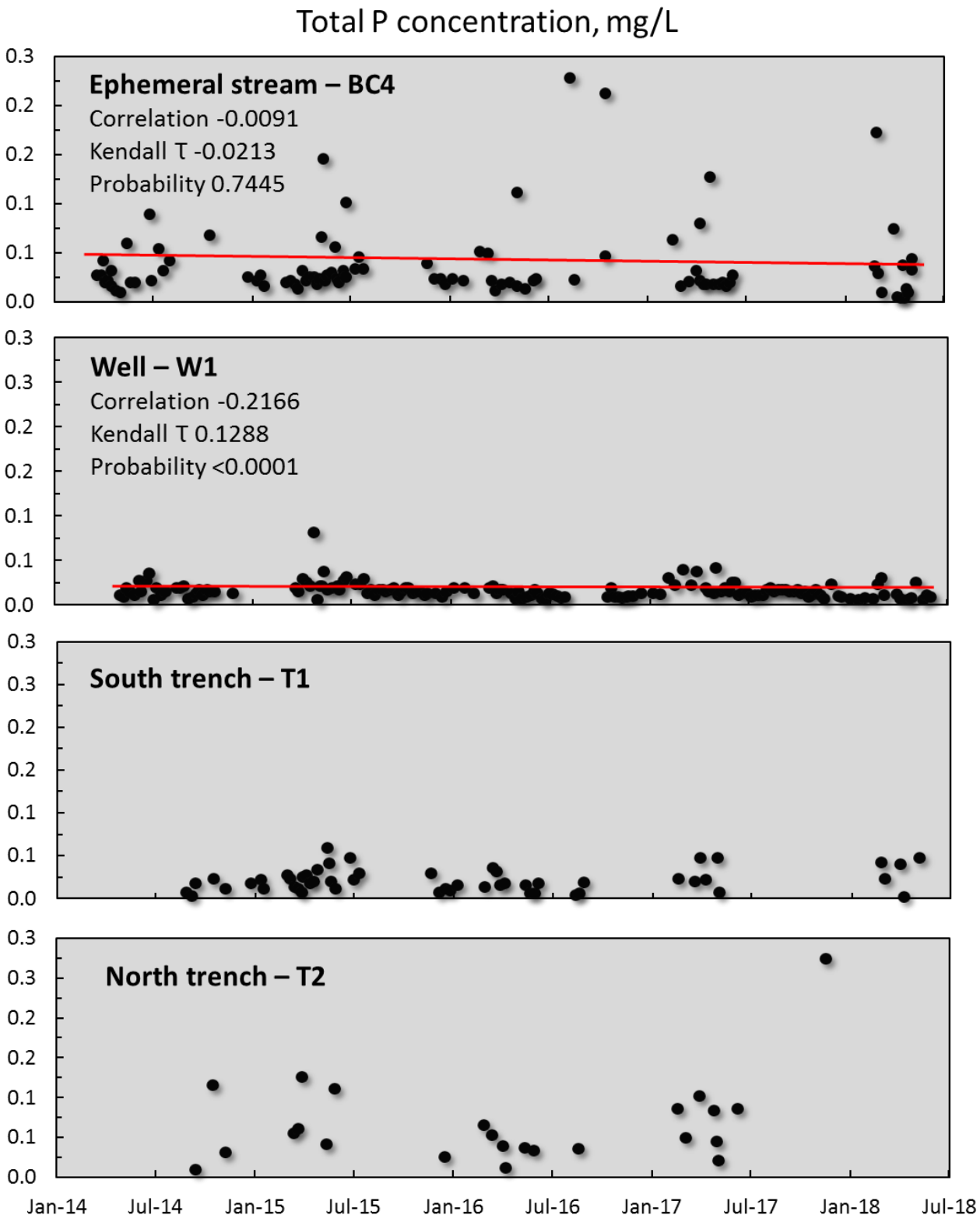

Figure 18. Total P concentrations around the production area (ephemeral stream, spring, well, and trenches 1 and 2) over the period of monitoring, including Seasonal Kendall's statistical trends for the ephemeral stream and well sites.

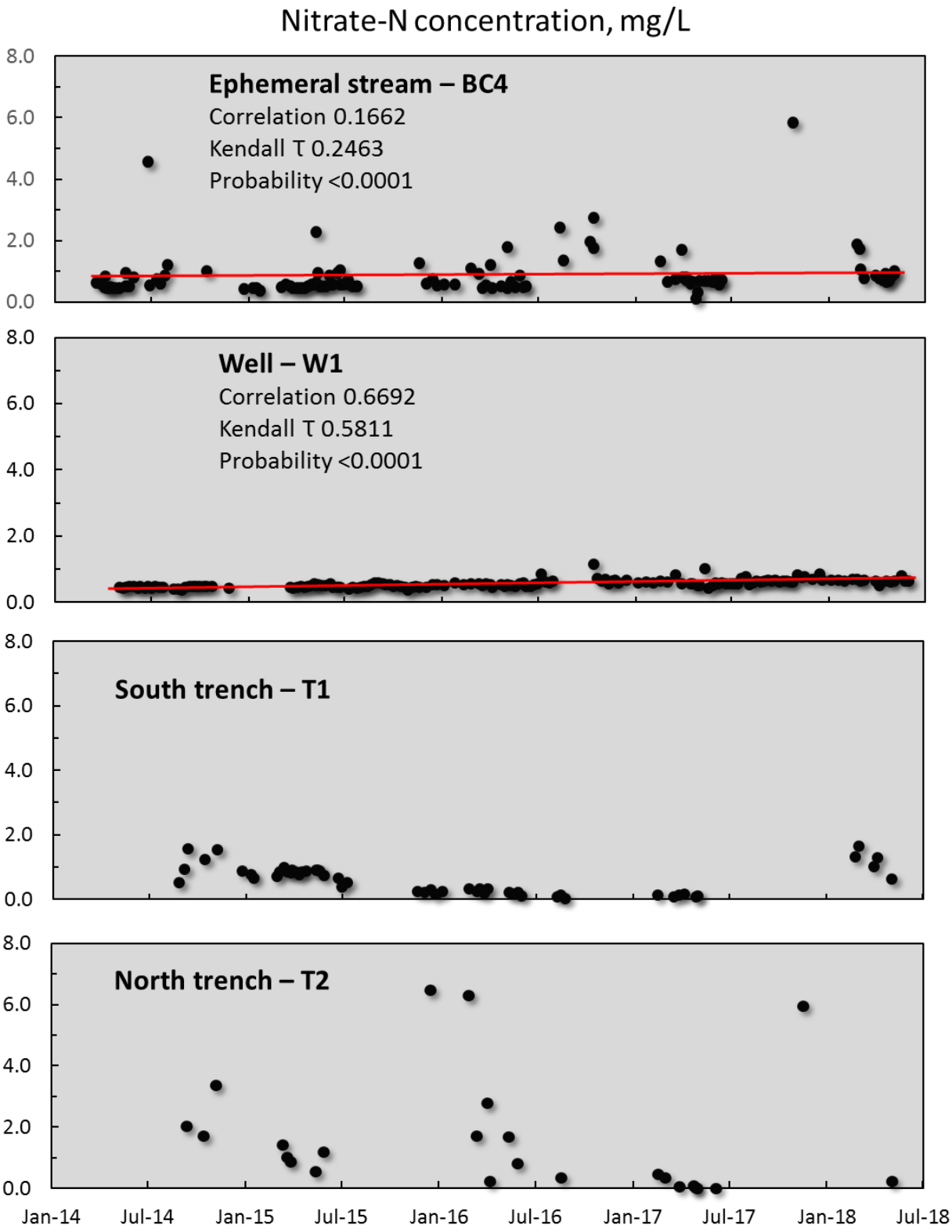

Figure 19. Nitrate-N concentrations around the production area (ephemeral stream, spring, well, and trenches 1 and 2) over the period of monitoring, including Seasonal Kendall's statistical trends for the ephemeral stream and well sites.

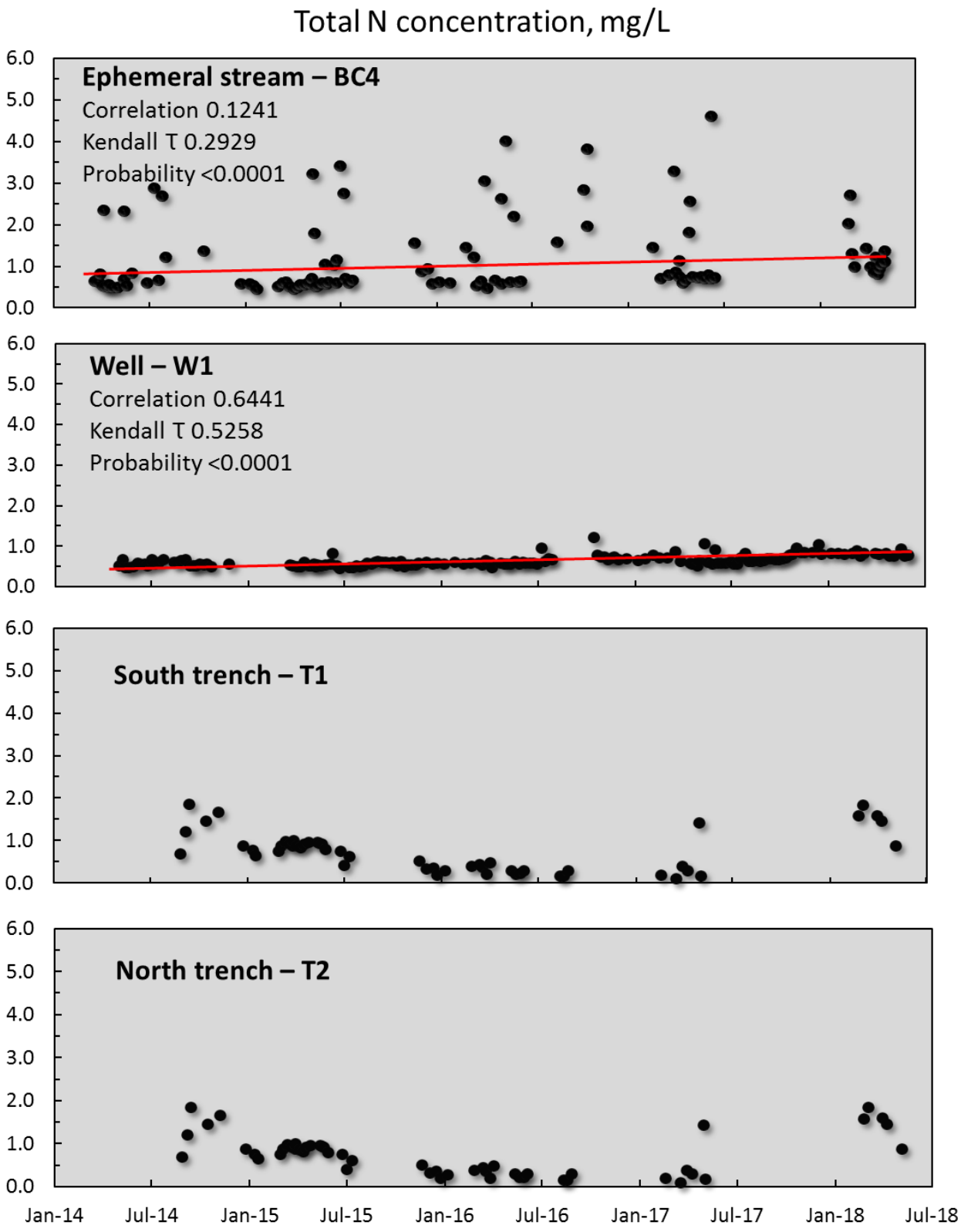

Figure 20. Total N concentrations around the production area (ephemeral stream, spring, well, and trenches 1 and 2) over the period of monitoring, including Seasonal Kendall's statistical trends for the ephemeral stream and well sites.

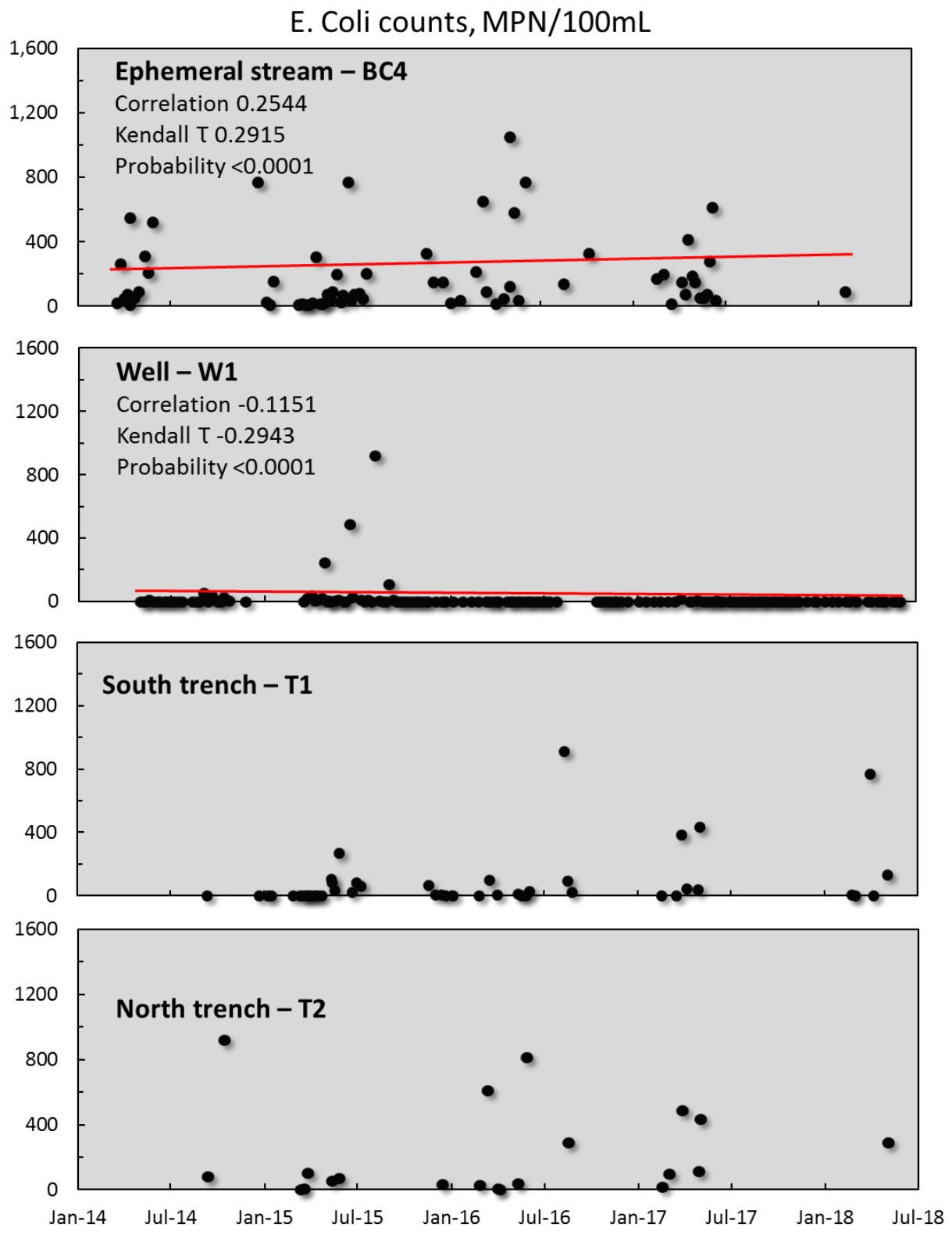

Figure 21. E. coli, concentrations around the production area (ephemeral stream, spring, well, and trenches 1 and 2) over the period of monitoring, including Seasonal Kendall's statistical trends for the ephemeral stream and well sites.

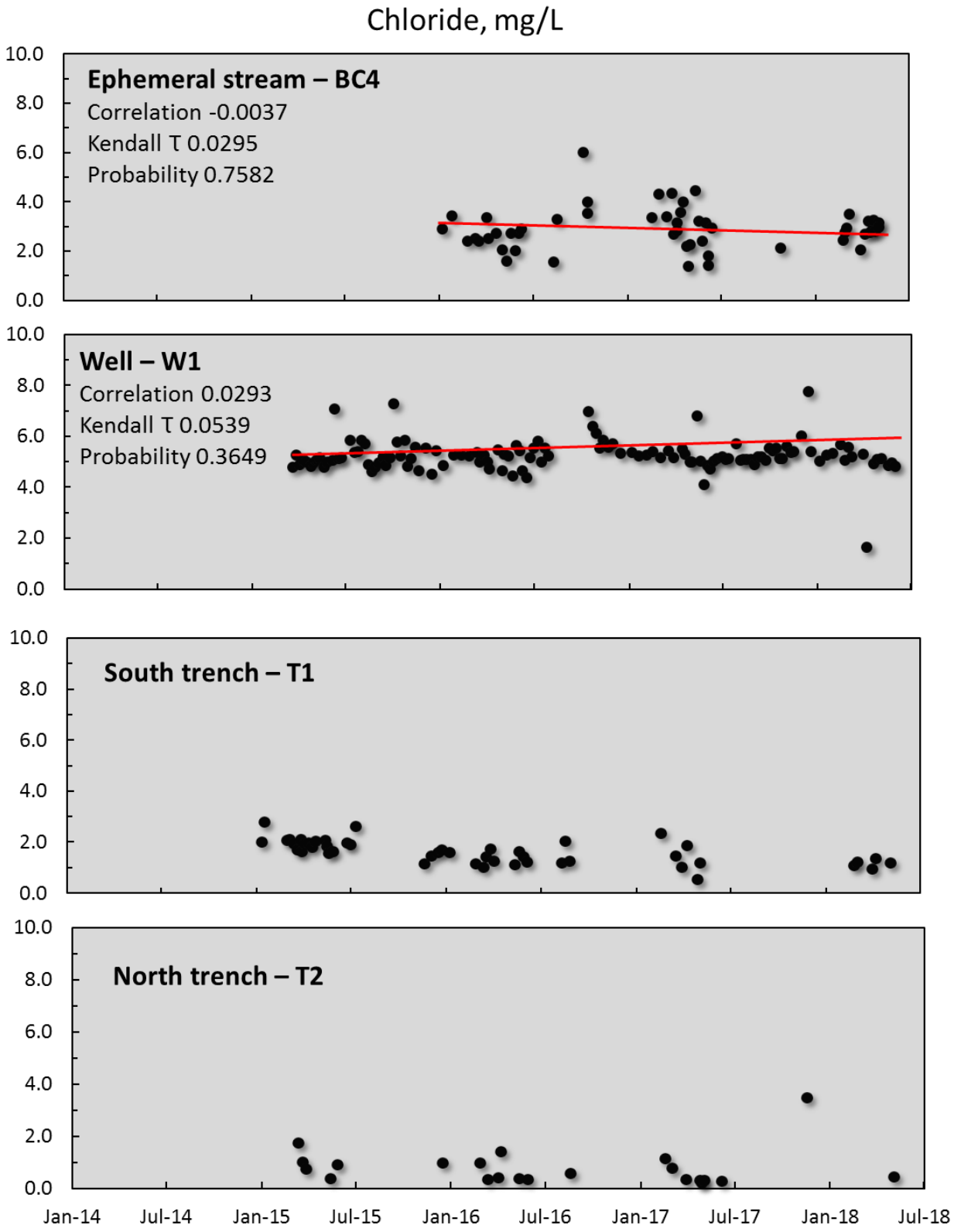

Figure 22. Chloride concentrations around the production area (ephemeral stream, spring, well, and trenches 1 and 2) over the period of monitoring, including Seasonal Kendall's statistical trends for the ephemeral stream and well sites.

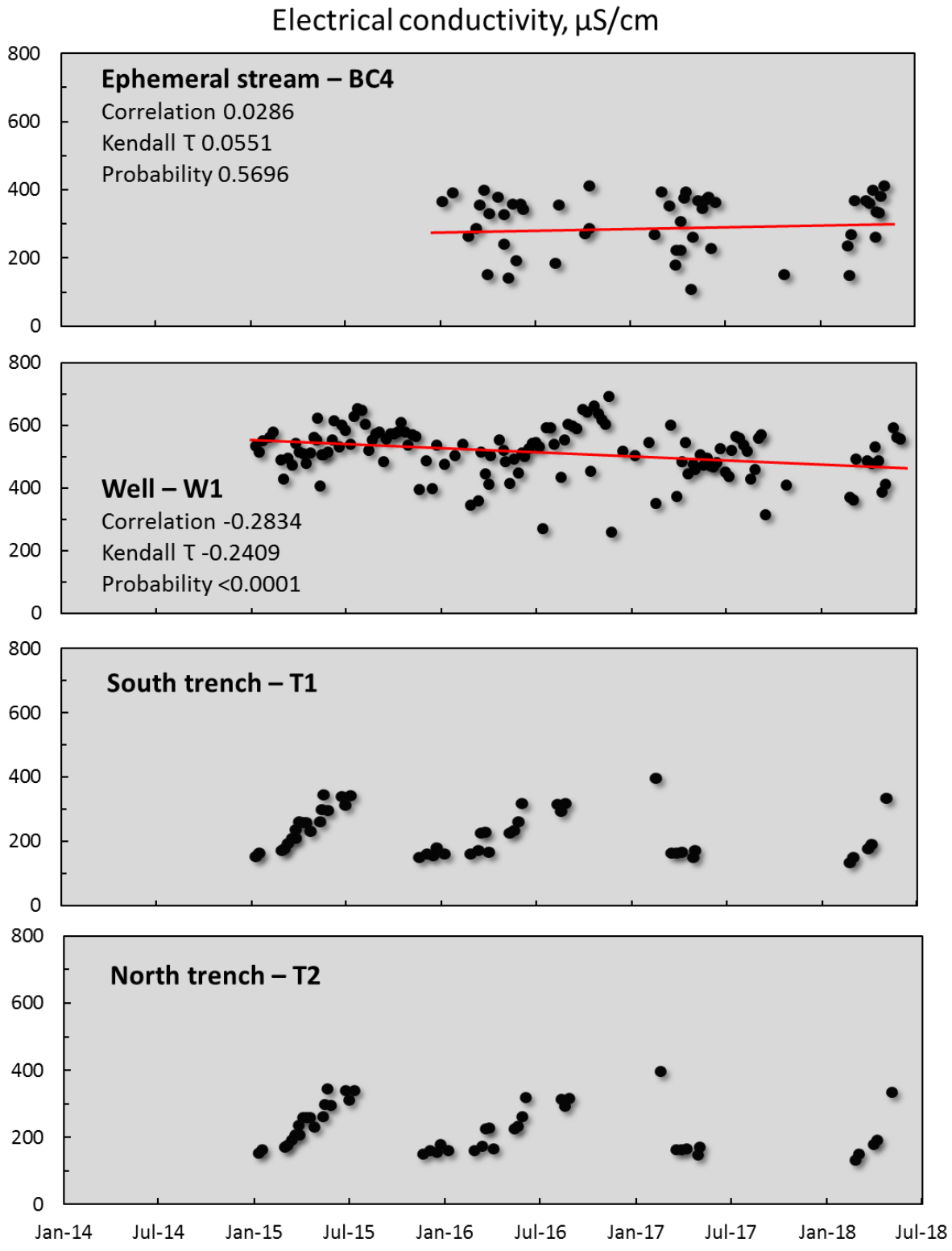

Figure 23. Electrical conductivity around the production area (ephemeral stream, spring, well, and trenches 1 and 2) over the period of monitoring, including Seasonal Kendall's statistical trends for the ephemeral stream and well sites.

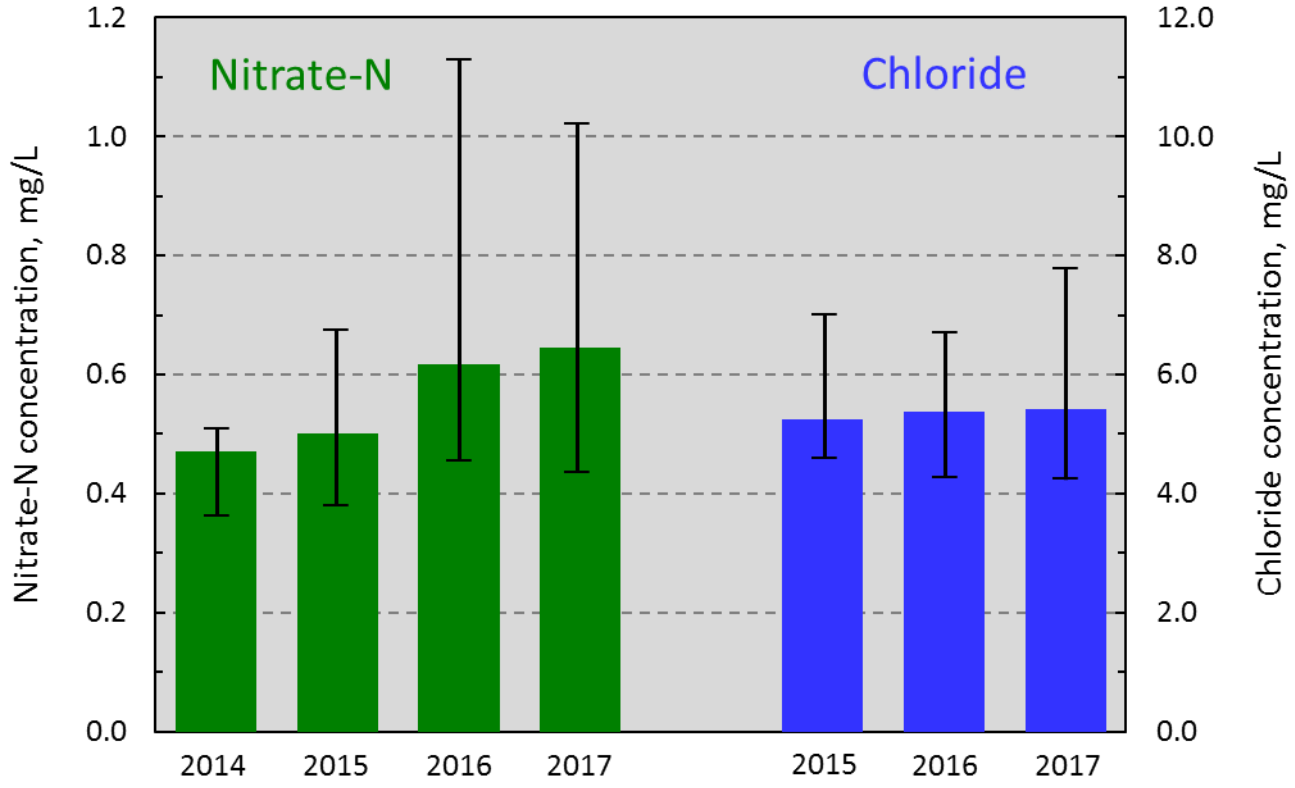

Figure 24. Geomean annual nitrate-N and chloride concentrations in the house well, based on water sampling year, which is April 2014 to April 2018 for nitrate-N and April 2015 to April 2018 for chloride. Vertical bars represent concentration range from minimum and maximum values. There were 30, 45, 32, and 43 samples collected in 2014, 2015, 2016, and 2017 water years, respectively.

Table 9. Mean chemical constituent concentration in Ponds 1 and 2 between 2014 and 2018.

Constituent	Pond 1	Pond 2	Big Creek upstream of C&H, BC6
Ammonia-N, mg/L	1,147	589	0.028
Nitrate-N, mg/L	0.058	0.090	0.101
Dissolved P, mg/L	177	99	0.009
Chloride, mg/L	468	483	1.60
Electrical conductivity, µS/cm	12,413	8,159	126