Upper Brushy Creek Water Quality Monitoring Report

January through June 2010

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Des Moines Water Works

For

Watershed Improvement Review Board

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SITE DESCRIPTION

The Brushy Creek Watershed is located in the Loess Hills and Rolling Prairie Ecoregion (47e) in Southwestern Iowa where a thick mantle of highly erodible loess from the Wisconsin glacial period overlies pre-Illinoisan glacial till. The watershed is a long and narrow and runs parallel to the Middle Raccoon River a couple miles north. The stream begins in the loess mantled Missouri -Mississippi divide (fig 1) and quickly cuts down into the glacial till to form a hilly, highly dissected terrain. Loess soils predominate near the divide and ridge tops, glacial till soils predominate on the steep hillsides. Most farms include a mix of both. Row-crop agriculture is favored on the ridge top and upper slopes. Drainage is enhanced through use of tile. Tile discharge is nearly continuous, even during dry periods.

Steeper slopes are usually protected with terracing or permanent cover. Nearly all farms include livestock operations. Base flow in Upper Brushy Creek transitions from the loess dominated soils to glacial till soils downstream. Steeper slopes downstream are more subject to runoff during rain events.

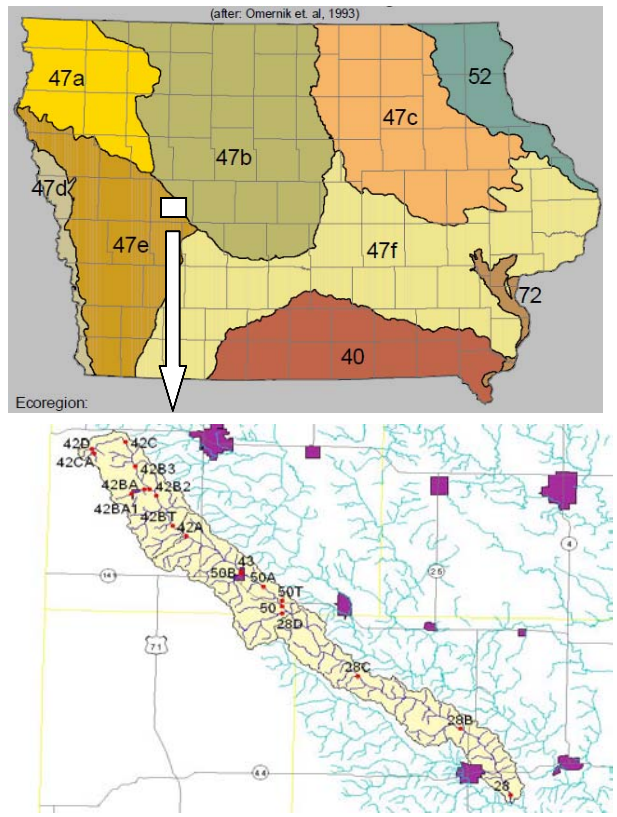


Fig 1. Brushy Creek Watershed sites

Several stream sedimentation basins between sites 42B and 42A alter the flow of contaminants through Brushy Creek and make the determination of contaminant sources more challenging. An analysis of the basin sediments in 2006 suggested a pattern of entrapment of fecal contaminants (1) during moderate runoff events with re-suspension of these contaminants during major rain events with high flow rates. Between major rain events, the basins were nearly filled with highly contaminated sediments. Following a major rain event with high flow, much of the sediment was removed. This suggests deposition of contaminants into the basin during low to moderate runoff events and re-suspension of the sediments contributing to stream loading during larger runoff events.

Monitoring activities of streams in the Raccoon River Watershed beginning in 1999 showed Upper Brushy Creek to be consistently high in both nutrient content and fecal contamination. Several feedlot containment structures were recently constructed to limit fecal runoff and various nutrient management activities such as soil nutrient mapping and corn stalk nitrogen testing were performed to provide guidance to best management practices for this region. Water quality monitoring during this first year of WIRB activities helps establish a baseline from which to measure and demonstrate improvements in water quality as a result of WIRB management practices.

WEATHER AND HYDROLOGIC CONDITIONS

Weather conditions and precipitation patterns are primary drivers by which contaminants are transported from the landscape to the rivers and streams. January and February temperatures for SW Iowa were below normal with perpetual snow cover to insulate the ground so that there was little frost in the ground for much of the winter. Some of the snow in contact with the unfrozen ground slowly melted and infiltrated the soil. It is probable that dissolved nutrients from manure application were transported into the soil as well. Total precipitation during the winter months was slightly above normal but nearly exclusively in the form of snow. Spring (March through May) temperatures were slightly above normal while total precipitation was near normal. Snow melt from the extensive snow cover caused considerable runoff and flooding in March. Soil moisture remained quite high through the spring which caused some challenges to spring planting. June was the second wettest month on record with near daily rainfall. High water tables limited infiltration into the soil which contributed to extensive runoff and flooding from the June thunderstorms.

METHODS

Grab samples were routinely collected from eight sites on a weekly basis. This was designed to provide contaminant distribution data across the watershed over a variety of flow and weather conditions. Auto-samplers at sites 42B (upstream of sedimentation basins) and 42A (downstream of sedimentation basins) were programmed to trigger at predetermined stream elevations and pull samples every half hour on the ascending limb of the hydrograph and hourly on the descending limb. The auto-sampler stations also digitally recorded precipitation and stage elevations. This data was used to select subsets of samples according to location on the hydrograph to assure representative sampling across the hydrograph. All analyses presented in this report were performed by the DMWW laboratory.

RESULTS

Table 1. Water quality data from scheduled sampling, January- June 2010.

Sample Date	Site	Turbidity NTU	E. coli counts/100ml	Nitrate -N mg/l	o-Phos as P mg/l	Ammonia-N mg/l
01/13/10	43	16.4	211	11.48	<0.5	
	42A	14	52	11.22	<0.5	
	42B2	23	171	12.85	<0.5	
	42BA	23	354			
01/21/10	43		538	10.48	<0.5	0.13
01/21/10	42A		345	11.97	<0.5	0.15
	42B2		86	12.28	<0.5	0.4
01/27/10	43	27.6	1616	12.1	0.1	0.1
	42A	19.8	2035	12.94	0.13	0.13
	42B2	17.6	1935	12.96	0.12	
	42BA	27.1	294	11.47	0.08	
	42B2.5	27.1	1918	13.93	0.12	
	42B3	21	2014		<0.5	0.07
	42C	22.3	213	13.74	<0.5	
02/04/10	43	18.9	41	11.32	<0.5	
	42A	14	183	12.92	0.05	
	42B2	24.8	135	13.3	0.05	
	42BA	21	86	11.72	<0.5	
	42B3	20	86	13.98	<0.5	
	42B2.5	31.8	52	14.32	<0.5	
	42C	18		14.48	<0.5	
02/10/10	42C	12.5	<10	13.84		0.07
	42B3	17	10	1.52		
	42B2.5	24	63	13.55		
	42BA	15.5	74	10.48		
	42B2	22	86	12.13		0.08
	42A	10.7	131	12.85		
	43	23	52	10.29		0.07
02/18/10	43	14	419	11.68	<0.5	
	42A	13.1	272	13.22	<0.5	
	42B2	18.2	262	13.12	<0.5	
	42BA	11	171	11.33	<0.5	
	42B2.5	22.8	464	13.96	<0.5	
	42B3	17.4	404	13.65	<0.5	
	42C	14.2	20	14.32	<0.5	
02/24/10	43	13	52	12.59	<0.5	
	42A	8.3	253	13.43	<0.5	
	42B2	26	175	14.25	<0.5	

Sample Date	Site	Turbidity NTU	E. coli counts/100ml	Nitrate -N mg/l	o-Phos as P mg/l	Ammonia-N mg/l
	42BA	17	161	12.13	<0.5	
	42B2.5	32	134	14.68	<0.5	
	42B3	19	63	13.73	<0.5	
	42C	9.3	30	14.68	<0.5	
03/04/10	43	18	171	10.77	<0.5	0.43
	42A	17.3	1022	12.16	0.18	0.86
	42B2	15.8	327	12.84	<0.5	0.145
	42BA	9.1	20	11.47	<0.5	0.07
	42B2.5	12.5	187	13.86	0.08	0.11
03/04/10	42B3	10	160	13.72	<0.5	0.065
	42C	8.1	1723	14.45	<0.5	<0.01
03/10/10	43	420	5630	7.08	0.4	0.935
	42A	380	8550	7.64	0.51	1.1
	42B2	408	7800	8.09	0.52	0.705
	42BA	170	1730	7.5	0.49	1.03
	42B2.5	430	12590	8.31	0.5	0.7
	42B3	244	10100	7.96	0.54	0.8
	42C	396	200	8.5	0.14	0.36
	42CT	156	>241920	4.66	5.02	5.75
03/18/10	43	135	740	11.19	0.17	0.18
	42A	104	740	12.76	0.15	0.2
	42B2	69.1	410	12.97	0.14	0.17
	42BA	52.9	410	11.75	0.15	0.19
	42B2.5	82.5	410	13.54	0.15	0.16
	42B3	58.5	630	13.53	0.14	0.13
	42C	51.7	<100	14.36	0.09	0.09
03/24/10	43	62.7	100	11.76	<0.5	<0.01
	42A	38.4	310	13.45	<0.5	0.01
	42B2	26.8	200	13.77	<0.5	<0.01
	42BA	20.8	100	12.05	0.1	0.01
	42B2.5	32.9	<100	14.58	<0.5	0.02
	42B3	24.9	310	14.52	<0.5	<0.01
	42C	20.4	<100	15.34	<0.5	0.01
04/02/10	43	38.9	100	11.95	<0.5	
	42A	22.9	100	13.85	<0.5	
	42B2	21.1	100	12.2	<0.5	
	42BA	16.7	100	12.21	<0.5	
	42B2.5	20.6	100	15.08	<0.5	
	42B3	16	<100	13.66	<0.5	
	42C	15.4	<100			
04/07/10	43	32	860	12.37	<0.5	0.02
	42A	16.3	630	13.79	<0.5	0.02

Sample Date	Site	Turbidity NTU	E. coli counts/100ml	Nitrate -N mg/l	o-Phos as P mg/l	Ammonia-N mg/l
	42B2	12.8	410	13.99	<0.5	<0.01
	42BA	8	520	12.41	<0.5	0.03
	42B2.5	13.6	300	15.04	<0.5	<0.01
	42B3	11.4	410	15.07	<0.5	<0.01
	42C	10	200	16.01	<0.5	<0.01
04/15/10	43	10.6	300	11.19	<0.5	
	42A	6.64	410	12.9	<0.5	
	42B2	8.93	200	13.5	<0.5	
	42BA	5.49	100	11.67	<0.5	
04/15/10	42B2.5	7.98	300	14.5	<0.5	
	42B3	5.54	<100	14.45	<0.5	
	42C	6.23	<100	15.4	<0.5	
04/21/10	43	2.46	<100	11.95	<0.5	0.01
	42A	3.07	410	13.73	<0.5	<0.01
	42B2	2.82	<100	14.36	<0.5	<0.01
	42BA	2.45	<100	12.29	<0.5	0.01
	42B2.5	2.35	<100	15.46	<0.5	0.02
	42B3	2.27	310	15.56	<0.5	0.01
	42C			16.71	<0.5	
04/29/10	43	12.7	410	11.58	<0.5	0.02
	42A	3.71	410	13.44	<0.5	0.01
	42B2	3.18	100	14.01	<0.5	<0.01
	42BA	1.77	<100	12.33	<0.5	0.03
	42B2.5	2.63	100	15.01	<0.5	<0.01
	42B3	3.03	100	15.11	<0.5	0.01
	42C	2.15	100	16.21	<0.5	<0.01
05/05/10	43	5.14	310	11.05	<0.5	
	42A	12.1	310	12.64	<0.5	
	42B2	4.73	100	13.22	<0.5	
	42BA	3.87	100	11.65	<0.5	
	42B2.5	5.98	<100	14.1	<0.5	
	42B3	5.11	<100	14.15	<0.5	
	42C	3.12	<100	15.21	<0.5	
05/13/10	43	417	173290	10.97	0.17	0.53
	42A	158	>241920	11.65	1.34	0.8
	42B2	134	173290	14.57	0.35	0.45
	42BA	91	72700	13.1	0.41	0.29
	42B2.5	136	111990	15.44	0.29	0.44
	42B3	91	68670	15.18	0.22	0.3
	42C	47	3270	16.57	<0.5	0.03
05/19/10	43	21	1350	11.92	<0.5	0.06
	42BA	14	950	12.27	<0.5	0.05

Sample Date	Site	Turbidity NTU	E. coli counts/100ml	Nitrate -N mg/l	o-Phos as P mg/l	Ammonia-N mg/l
	42B2.5	11.8	410	14.85	<0.5	0.03
	42B3	14.3	310	14.66	<0.5	0.04
	42C	3.3	100	15.39	<0.5	0.03
	42B2	10.8	410	13.93	<0.5	0.03
	42A	11.5	100	13.44	<0.5	0.07
05/27/10	42A	8.7	630	13.26	<0.5	
	42B2	17.9	1750	13.84	<0.5	
	42BA	17.3	1870	12.25	<0.5	
	42B2.5	16.1	630	14.74	<0.5	
05/27/10	42B3	17.5	310	14.64	<0.5	
	42C	9.6	310	15.6	<0.5	
	42CT					
	43	25.4	620	11.7	<0.5	
06/02/10	42B2	11.9	1890	13.57	<0.5	0.065
	42BA	26.8	4080	12	<0.5	0.09
	42C	8.81	630	15.34	<0.5	0.05
	42B2.5	9.94	2230	14.48	<0.5	0.055
	42A	8.44	1870	12.78	<0.5	0.08
	43	20.8	1480	11.3	<0.5	0.045
	42B3	10.9	520	14.4	<0.5	0.065
06/10/09	42B2.5	7.13		15.07	<0.5	
	42C	11.3		16	<0.5	
	42BA	22.7		12.22	<0.5	
	42B2	12.6		14.01	<0.5	
	42A	5.15		13.51	<0.5	
	43	22.4		11.9	<0.5	
	42B3	14.8		14.58	<0.5	
06/16/10	42A		3840	16.14	<0.5	
	42B2		1600	16.51	<0.5	
	42BA		1950	14.43	<0.5	
	42C		100	17.82	<0.5	
	43		3410	14.47	<0.5	
	42B2.5		1970	17.41	<0.5	
	42B3		980	17.08	<0.5	
06/24/10	42B2.5	19.6	1080	17.59	<0.5	0.04
	42C	18.8	<100	18.08	<0.5	0.04
	42BA	31.4	2950	14.96	<0.5	0.06
	42B2	30.8	1100	16.73	<0.5	0.05
	42A	25	2310	16.04	0.08	0.05
	43	49.3	2280	14.38	0.08	0.06
	42B3	14.4	310			0.04
06/30/10	42A	30.3	860	16.58	<0.5	

Sample Date	Site	Turbidity NTU	E. coli counts/100ml	Nitrate -N mg/l	o-Phos as P mg/l	Ammonia-N mg/l
06/30/10	42BA	18.4	1210	15.28	<0.5	
	42C	10.8	200	18.12	<0.5	
	42B2.5	23	310	18.19	<0.5	
	42B2	29.8	520	17.18	<0.5	
	43	70.6	980	14.77	<0.5	

All sites in the upper Brushy Creek basin showed a similar distribution of *E. coli* counts and nutrients during this monitoring period. Winter counts were generally low except for January 27 when daytime temperatures exceeded 32°Fahrenheit from January 21 through January 27. This caused minor melting and transport of fecal material and associated nutrients into Brushy Creek. The spring thaw produced much higher counts and concentrations of phosphorus and ammonia at all sites on March 10. These counts and nutrient concentrations, however, were well below spring snowmelt concentrations in 2009. It is probable that some of this difference is due to infiltration of these nutrients into unfrozen ground prior to the spring runoff.

Counts during relatively dry weather in April were often below the detection limit of 100 counts/100 ml. Counts during the May and June rain events were high as may be expected. Summary statistics (Table 2) show a similar distribution of counts between sites in upper Brushy Creek with the exception of the 3rd quartile. Counts closest to the headwaters (42C and 42B3) were less than those further downstream. Higher 3rd quartile counts are more closely associated with runoff events and higher flows. The highest counts occurred in Halbur Creek (42BA) though counts further downstream at site 43 were similar even though the flow was much greater than at site 42B2.

Table 2. *E. coli* Counts in Upper Brushy Creek, January –June 2010

Site	42C	42B3	42B2.5	42BA	42B2	42A	43
1st quartile	100	100	100	100	126	267	153
2nd quartile	100	310	305	294	295	410	479
3rd quartile	203	520	968	1470	1225	1234	1383

This does not necessarily mean uniform contributions from the watershed. Numerous sedimentation basins are present in upper Brushy Creek which trap fecal material below a critical velocity which can be re-suspended during elevated flows. Counts at all sites however were much lower than what was reported for the July-December 2009 monitoring period (Table 3) even though wet conditions prevailed in 2010. Ammonia and o-phosphorus concentrations were also much lower suggesting overall less runoff of fecal contaminants relative to stream flow during this monitoring period.

Table 3. *E.coli* counts in Upper Brushy Creek, July-December 2009

quartile	42C	42B3	42B2.5	42BA	42B2	42A	43
1st	200	658	913	1508	710	308	823
2nd	575	1265	1285	2815	1860	1290	1340
3rd	1140	3730	6796	8390	8658	6248	5990

Nitrate concentrations remained well above the water quality standard of 10 mg/l for most sites through this entire period (Table 4).

Table 4. Nitrate-N Concentrations at Scheduled Sites 2010

Sample Date	42C	42B3	42B2.5	42B2	42A	43	42BA
1/13/2010				12.85	11.22	11.48	
1/21/2010				12.28	11.97	10.48	
1/27/2010	13.74		13.93	12.96	12.94	12.1	11.47
2/4/2010	14.48	13.98	14.32	13.3	12.92	11.32	11.72
2/10/2010	13.84		13.55	12.13	12.85	10.29	10.48
2/18/2010	14.32	13.65	13.96	13.12	13.22	11.68	11.33
2/24/2010	14.68	13.73	14.68	14.25	13.43	12.59	12.13
3/4/2010	14.45	13.72	13.86	12.84	12.16	10.77	11.47
3/10/2010	8.5	7.96	8.31	8.09	7.64	7.08	7.50
3/18/2010	14.36	13.53	13.54	12.97	12.76	11.19	11.75
3/24/2010	15.34	14.52	14.58	13.77	13.45	11.76	12.05
4/2/2010		13.66	15.08	12.2	13.85	11.95	12.21
4/7/2010	16.01	15.07	15.04	13.99	13.79	12.37	12.41
4/15/2010	15.4	14.45	14.5	13.5	12.9	11.19	11.67
4/21/2010	16.71	15.56	15.46	14.36	13.73	11.95	12.29
4/29/2010	16.21	15.11	15.01	14.01	13.44	11.58	12.33
5/5/2010	15.21	14.15	14.1	13.22	12.64	11.05	11.65
5/13/2010	16.57	15.18	15.44	14.57	11.65	10.97	13.10
5/19/2010	15.39	14.66	14.85	13.93	13.44	11.92	12.27
5/27/2010	15.60	14.64	14.74	13.84	13.26	11.70	12.25
6/2/2010	15.34	14.40	14.48	13.57	12.78	11.30	12.00
6/16/2010	17.82	17.08	17.41	16.51	16.14	14.47	14.43
6/24/2010	18.08		17.59	16.73	16.04	14.38	14.96
6/30/2010	18.12		18.19	17.18	16.58	14.77	15.28
Average	15.2	14.2	14.7	13.6	13.1	11.7	12.1

Concentrations were highest near the headwaters (42C) and slowly decreased downstream (43). Halbur Creek (42BA) which is also near the headwaters had lower nitrate concentrations than Brushy Creek. Where it discharged into Brushy Creek (between sites 42B2.5 and 42B2) nitrate concentrations decreased approximately 1 mg/l. The progressive decline in nitrate concentrations indicates lower nitrate concentrations in the groundwater further downstream.

RAIN EVENT SAMPLING RESULTS

Though numerous rain events occurred during this period, only two events produced good sampling across the hydrograph that also met logistical and laboratory method requirements. A third event was collected shortly after the second event but was not analyzed for bacteria as hold times were exceeded (fig 1). The distribution of rainfall and runoff with high stream flows often precluded an opportunity to reset event samplers. Tile and groundwater discharge from elevated water tables caused elevated base flow and several adjustments to stage height were needed to trigger the event samplers. The May 12 event sampling closely followed a previous rain event as did the June 12 sampling. The hydrograph of the second June event (June 12) rides on the hydrograph of the previous event (June 8). The sampling events therefore are evaluated in the context of previous rainfall and runoff events.

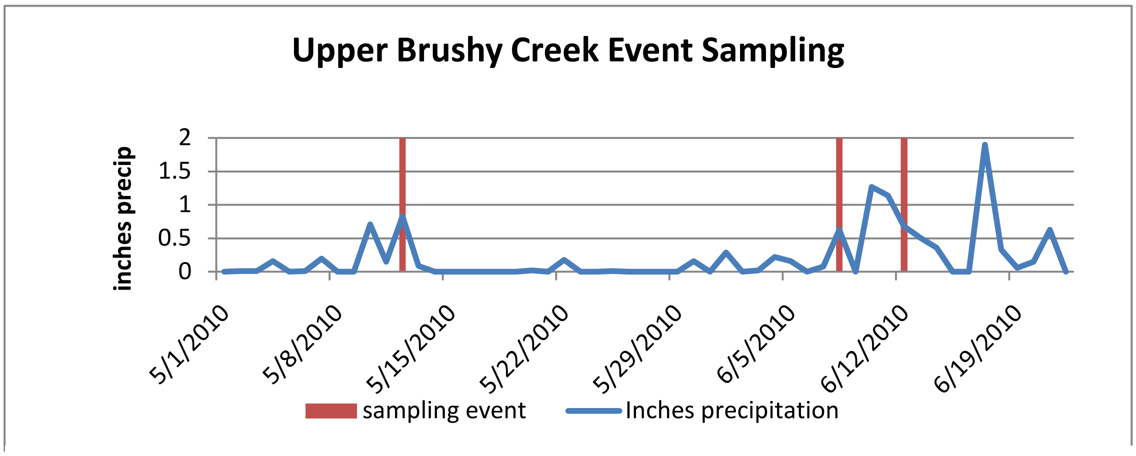


Fig 2. Event sampling and precipitation

There was little rainfall in April and May prior to the 0.7 inch rain that fell on May 10. Most of the rain infiltrated the soil so that there was little rise in stream elevation. The rain on May 12 came from two showers just hours apart and produced a total of 0.8 inches of precipitation. This event produced a split hydrograph at 42B2 and a somewhat complex pattern of contaminant runoff. The relationship of contaminant runoff to stream flow, however, is consistent to that observed last fall where *E. coli* counts and ammonia concentration were higher on the descending limb of the hydrograph. The count distribution lags behind turbidity and the dip in nitrate-N concentration suggesting a delay in fecal transport relative to surface runoff (fig 3). The change in water quality across the 42A hydrograph downstream shows the influence of the previous May 10 rain event Fig 4.

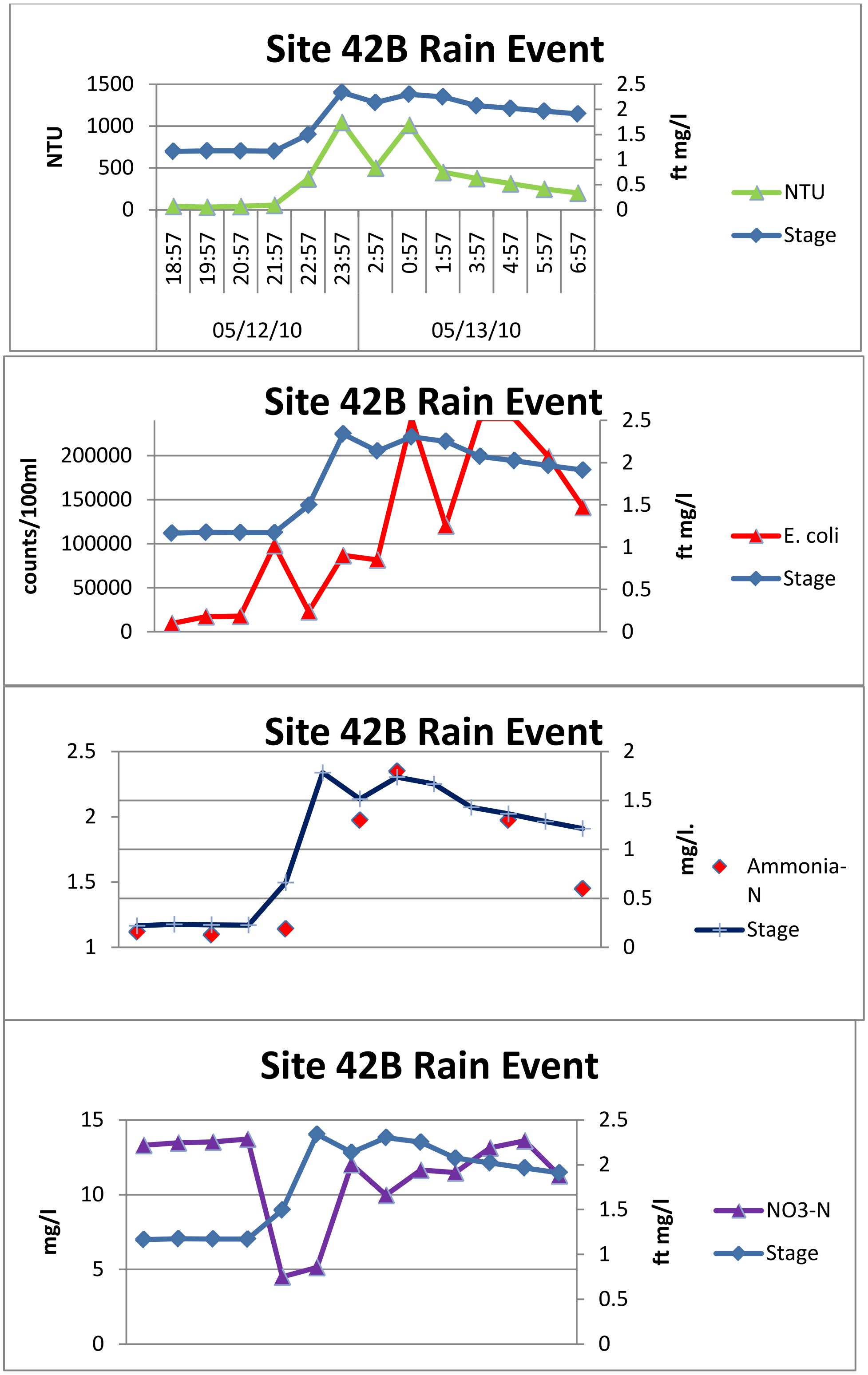


Fig 3. Change in water quality across 42B hydrograph May 12, 2010

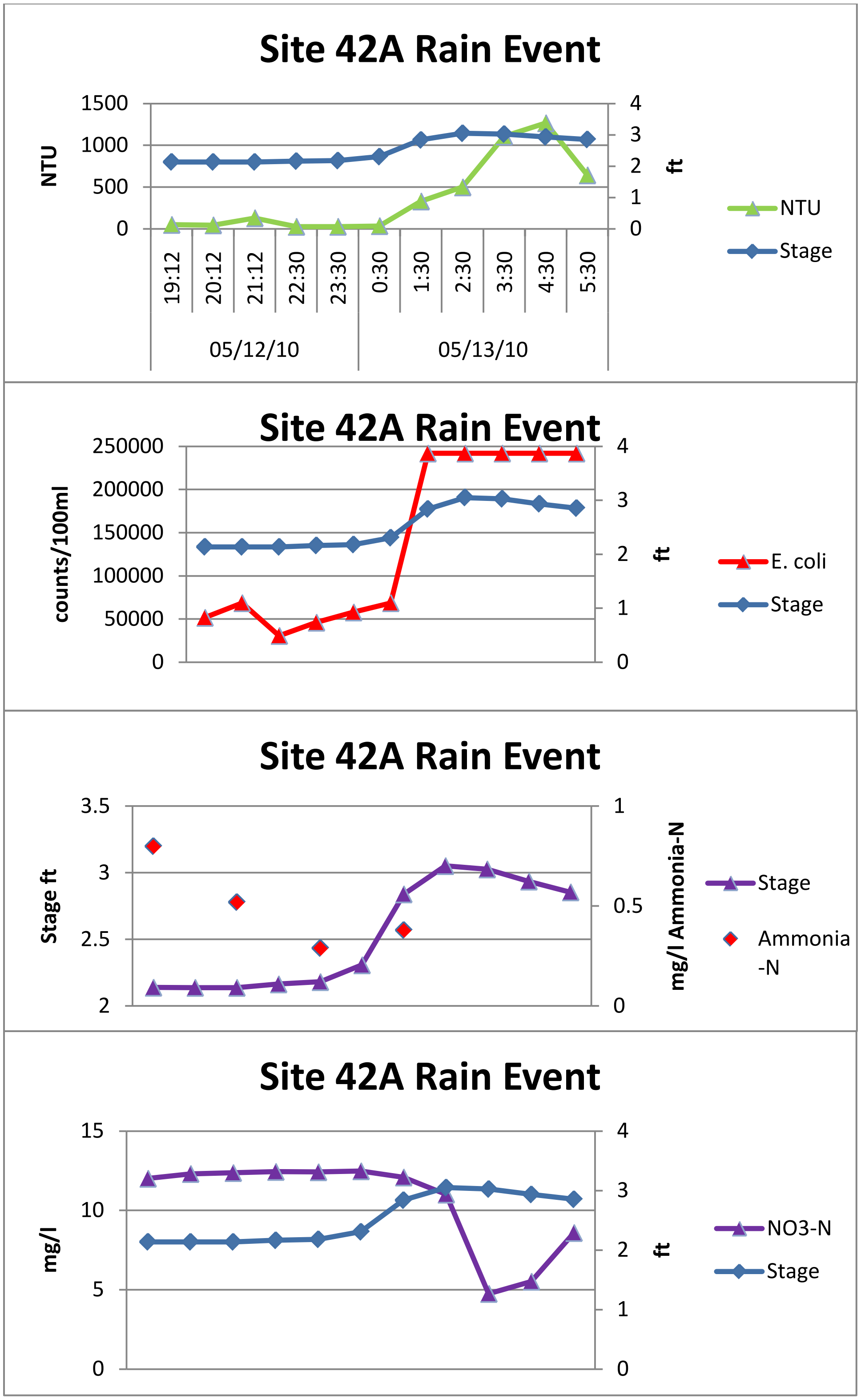


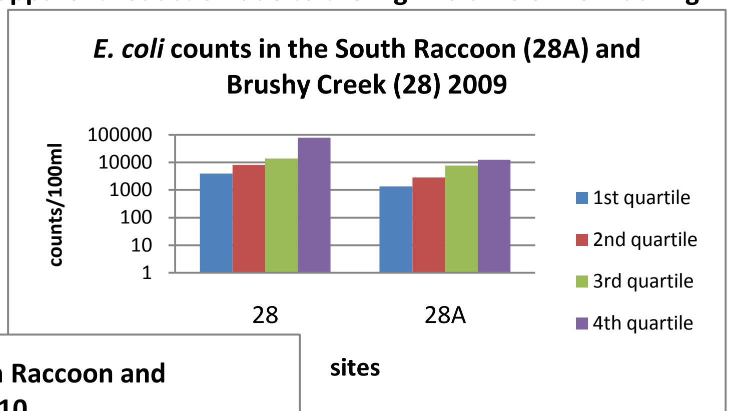
Fig 4. Change in water quality across 42A hydrograph May 12, 2010

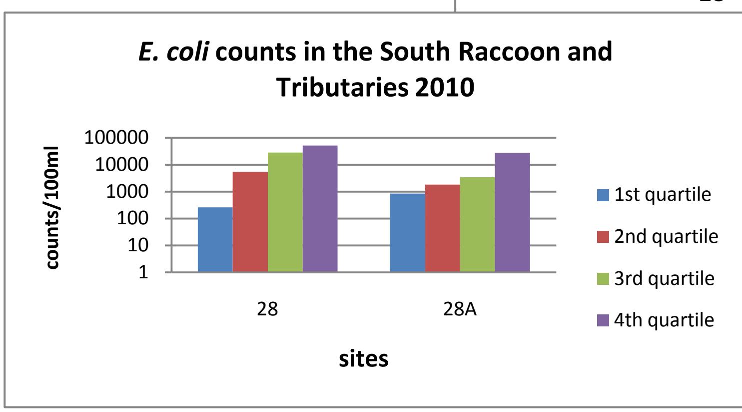
The declining ammonia concentration at 42A before the rise in stage height is likely the result of elevated ammonia coming from the previous May 10 rain event. Assuming deposition of *E. coli* from this earlier event, a rise in flow would re-suspend the recently deposited bacteria. This is supported by the observation that the counts increased immediately with increase in flow and before indicators of surface runoff (elevated turbidity and inverted spikes in nitrate concentration).

The June rain events were nearly continuous which resulted in complex hydrographs and water quality changes. These are still under review and not shown in this report.

DISCUSSION AND SUMMARY

Monitoring activities during this period shows lower *E. coli* counts than during the July-December 2009 monitoring period. It is uncertain whether this represents a reduction in load i.e. amount of fecal transport or an apparent reduction due to the high volume of flow during this monitoring period. Samples collected this year by the Agriculture Clean Water Alliance shows slight improvement in Brushy Creek relative to the South Raccoon at their confluence. This suggests that the lower counts this year in upper Brushy Creek may have produced some improvement in the counts in the discharge from Brushy Creek during this monitoring period. It is likely that the benefits in the changes in management will take time to be more definitive. As seen with the event sampling, weather conditions and time of sampling can skew the data. No two monitoring periods have the same weather and hydrologic conditions for comparison.





The headwaters area near the divide continued to have nitrate concentration well above the water quality standard of 10 mg/l. High concentrations remained through the winter, even when the Raccoon River fell well below the water quality standard. This suggests export to the stream from nutrient enriched soils. There will be a lag time between implementation of nutrient management practices to a reduction in losses to the stream. How long this will take for loess mantled soils is uncertain. This purpose of this report is to provide WIRB with an

update on water quality, identify improvements in water quality related to management practices, and determine continuing and potential losses from the landscape so that producers can more knowledgably target and apply best management practices for profitable farming practices that also improve stream and water quality.