Clermont County Office of Environmental Quality
2011 Water Quality Monitoring Final Report

Hannah Gonzalez

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Introduction

In 1996, Clermont County established a monitoring program to characterize surface water quality within the County. Data collected through this program allows the County to analyze watershed conditions, identify potential water quality problems, support planning and management programs, and track trends and progress over time. Since 2009, the County's data has met level 3 criteria as defined in OAC 3745, which is suitable for regulatory purposes. The 2011 study plan was designed with these goals in mind, and consisted of four project components. Diurnal dissolved oxygen (D.O.) and event-based sampling are addressed in this report. The continuous water quality monitoring station data are stored in a database and available upon request. Ambient sampling is continuing into 2012 and will be addressed in the 2012 Water Quality Report. Details on the objectives and study design for all four study components can be found in the 2011 Project Study Plan.

Diurnal Dissolved Oxygen Profiles

Sampling Design

The County conducted diurnal dissolved oxygen studies to investigate the effect of nutrients and organic loads from point sources and nonpoint sources of pollution on D.O. concentrations in the East Fork of the Little Miami River (EFLMR) and major tributaries to the EFLMR, such as Cloverlick Creek and Stonelick Creek (Table 1). D.O. levels naturally swing from high levels during the day to low levels at night. This is due to aquatic algae photosynthesizing (producing oxygen) during the day and respiring (consuming oxygen) at night. High nutrient loading promotes excessive algal growth (eutrophication), which can lead to greater swings in D.O. levels and cause nighttime levels to dip dangerously low for the aquatic biota. Additionally, effluent from wastewater treatment plants (WWTPs) can contribute organic materials that increase oxygen demand during biodegradation.

Table 1. Sample identifications and descriptions of the point and non-point pollution sources in the watershed of each sample site monitored in the dissolved oxygen study

Sample ID	Location	Point Source Issues	Non-Point Source Issues
DODSN1.4	Dodson Creek RM 1.4 at St. Rt. 134	Quarry, WWTPs	HSTS, agriculture, livestock, wildlife, quarries
EFRM75.3	EFLMR RM 75.3 at Canada Rd	WWTPs, Huhtamaki Plastics, WTP	HSTS, agriculture, wildlife, hog confinement facility
EFRM70.1	EFLMR RM 70.1 at Wise Rd.	WWTPs	HSTS, agriculture, livestock, wildlife, quarries
EFRM60.6	EFLMR RM 60.6 at US 50, Fayetteville Lift Station	WWTPs	agriculture, HSTSs, wildlife
EFRM44.1	EFLMR RM 44.1 at Blue Sky Park Rd.	WWTPs	agriculture, HSTSs, wildlife
EFRM34.8	EFLMR RM 34.8 at Main St.	WWTPs, CECOS	agriculture, HSTSs, wildlife
EFRM15.6	EFLMR RM 15.6 at St. Rt. 222	Harsha Lake	I/I, urban stormwater, agriculture, wildlife
EFRM9.1	EFLMR RM 9.1 at Olivebranch-Stonelick Road	WWTP, Harsha Lake	HSTSs, gravel mining, agriculture, urban stormwater, wildlife
EFRM0.7	EFLMR RM 0.7 at S. Milford Rd.	WWTP, Experimental Stream Facility, Harsha Lake	HSTSs, gravel mining, agriculture, urban stormwater, wildlife
BARNS1.9	Barnes Run RM 1.9 at Bethel-Concord Rd.	N/A	HSTS, agriculture, livestock, wildlife
CLOVE5.1	Clover Creek RM 5.1 at St. Rt. 133	N/A	HSTS, agriculture, livestock, wildlife
POPLR2.1	Poplar Creek RM 2.1 @ Macaedonia Rd.	N/A	I/I, HSTS, urban stormwater, agriculture, wildlife
ST13.4	Stonelick Creek RM 13.4 at 727	package WWTP, Stonelick Lake	HSTS, agriculture, livestock, wildlife
BRUSH0.3	Brushy Fork RM 0.3 at Titus Rd.	package WWTP	HSTS, urban stormwater, agriculture, livestock, wildlife, golf club
ST5.7	Stonelick Creek RM 5.7at Anstaett Rd.	package WWTP, Stonelick Lake	HSTS, agriculture, livestock, wildlife, golf club
STEFLMR	Stonelick Creek RM 0.9 at US 50 monitoring station	package WWTP, Stonelick Lake	HSTS, urban stormwater, agriculture, livestock, wildlife, golf club

Table 1. Weather conditions during diurnal dissolved oxygen profiles. Conditions are reported for each day a data sonde was deployed. Precipitation is reported in inches, discharge in cubic feet/second, and stream stage in feet. Data source refers to rainfall, stage, and discharge data.

Sites Monitored	Date	Prev. 72 hr' rainfall (in)	daily average stage (ft)	*daily average discharge (cfs)	data source
POPLR2.1, BARNS1.9	8/18/2011	0	1.01	6.7	EFRM34.8
POPLR2.1, BARNS1.9	8/19/2011	0	1.07	8.4	EFRM34.8
POPLR2.1, BARNS1.9	8/20/2011	0	1.25	16.9	EFRM34.8
POPLR2.1, BARNS1.9	8/21/2011	0.31	1.08	8.7	EFRM34.8
EFRM70.1, EFRM75.3, DODSN1.4	8/25/2011	0.13	1.59	67.9	GRSSY0.2
EFRM70.1, EFRM75.3, DODSN1.4	8/26/2011	0.13	1.57	63.2	GRSSY0.2
EFRM70.1, EFRM75.3, DODSN1.4	8/27/2011	0.13	1.53	56.5	GRSSY0.2
EFRM70.1, EFRM75.3, DODSN1.4	8/28/2011	0	1.48	46.7	GRSSY0.2
EFRM60.1, EFRM44.1, CLOVE5.1	8/29/2011	0	0.84	3.6	EFRM34.8
EFRM60.1, EFRM44.1, CLOVE5.1	8/30/2011	0	0.83	3.4	EFRM34.8
EFRM60.1, EFRM44.1, CLOVE5.1	8/31/2011	0	0.83	3.4	EFRM34.8
EFRM60.1, EFRM44.1, CLOVE5.1	9/1/2011	0	0.84	3.6	EFRM34.8
EFRM9.1, EFRM15.6, STEFLMR	9/2/2011	0	0.16	38.5	STEFLMR
EFRM9.1, EFRM15.6, STEFLMR	9/3/2011	0	0.16	37.9	STEFLMR
EFRM9.1, EFRM15.6, STEFLMR	9/4/2011	0	0.18	39.8	STEFLMR
EFRM9.1, EFRM15.6, STEFLMR	9/5/2011	0.44	0.20	45.5	STEFLMR
EFRM34.8	9/12/2011	0	1.05	7.8	EFRM34.8
EFRM34.8	9/13/2011	0	1.06	8.1	EFRM34.8
EFRM34.8	9/14/2011	0	1.07	8.4	EFRM34.8
EFRM34.8	9/15/2011	0.16	1.08	8.7	EFRM34.8
ST5.7, BRUSH0.3, ST13.4	9/12/2011	0	0.19	40.3	STEFLMR
ST5.7, BRUSH0.3, ST13.4	9/13/2011	0	0.18	39.3	STEFLMR
ST5.7, BRUSH0.3, ST13.4	9/14/2011	0	0.18	38.2	STEFLMR
ST5.7, BRUSH0.3, ST13.4	9/15/2011	0.38	0.19	46.7	STEFLMR

*If datasource is listed as EFRM34.8 or GRSSY0.2, then rainfall and stream stage data is from those monitoring stations and discharge data is from USGS rating curve for EFRM34.8. Data source of STEFLMR indicates rainfall and stream stage from STEFLMR and discharge from the USGS Perintown gage.

Results

Due to maintenance issues (sonde malfunction) and wet weather, we were unable to deploy a sonde at site EFRM0.7. Conditions at each site where DO monitoring was conducted are shown in Table 2.

D.O. concentrations at many of the monitored sites remained above the minimum DO concentration criteria of 4.0 mg/L for Warm Water Habitat (WWH) streams and 5.0 mg/L for Exceptional Warmwater Habitat (EWH) streams. However, some EWH streams dipped below this criterion: Dodson Creek dropped to 3.3 mg/L, EFLMR at river mile 70.1: 4.9 mg/L, and EFLMR at river mile 44.1: 3.0 mg/L (Fig. 1). Some WWH streams also had DO concentrations dip below the criterion of 4.0 mg/L, the minimum DO concentrations at Barns Run was 0.9 mg/L, Stonelick Creek at river mile 13.4: 2.4 mg/L, and Stonelick Creek at river mile 5.7: 3.4 mg/L (Fig. 2).

Sites in Stonelick Creek and Brushy Fork had wide diel fluctuations in DO saturation with site ST5.7 experiencing an average diel change in DO of 8.9 mg/L, STEFLMR had an average of 5.7 mg/L, and BRUSH0.3 fluctuated an average of 4.8 mg/L DO (Table 3). Generally the mainstem of the EFLMR and tributaries had a moderate diel swing of DO concentrations. EFRM34.8 and EFRM75.3 were exceptions to this and had average DO concentration fluctuations of 4.6 mg/L and 4.5 mg/L, respectively (Table 3).

Table 3. Minimum and maximum dissolved oxygen (D.O.) concentrations and water temperature range during the three-day diurnal D.O. monitoring. Mean D.O. swing is the average of the differences between the minimum and maximum D.O. concentrations. Minimum concentrations below the Ohio EPA minimum instantaneous dissolved oxygen criteria (4.0 mg/L for WWH and 5.0 for EWH) are highlighted in red text.

Site ID	Minimum DO conc. (mg/L)	Maximum DO Conc. (mg/L)	Mean 3-day DO Swing (mg/L)	Water Temperature Range (°C)
DODSN1.4	3.3	6.8	2.7	20.4 – 23.9
EFRM75.3	5.0	10.4	**4.5**	19.8 – 33.2
EFRM70.1	4.9	8.5	4.9	21.4 – 25.8
EFRM60.6	5.4	8.9	3.0	18.7 – 24.7
EFRM44.1	3.0	7.1	2.9	21.8 – 27.2
EFRM34.8	5.9	11.1	**4.6**	19.3 – 25.1
EFRM15.6	5.9	8.0	1.7	23.6 – 28.8
EFRM9.1	6.0	9.1	2.3	24.4 – 28.6
BARNS1.9	0.9	4.7	1.7	19.8 – 21.7
CLOVE5.1	4.2	8.3	3.2	17.3 – 25.6
POPLR2.1	5.5	9.7	3.5	20.6 – 23.6
ST13.4	2.4	7.1	**4.3**	17.8 – 23.3
BRUSH0.3	5.9	11.7	**4.8**	15.5 – 22.8
ST5.7	3.4	13.6	**8.9**	17.6 – 26.9
STEFLMR	4.8	12.4	**5.7**	20.9 – 25.7

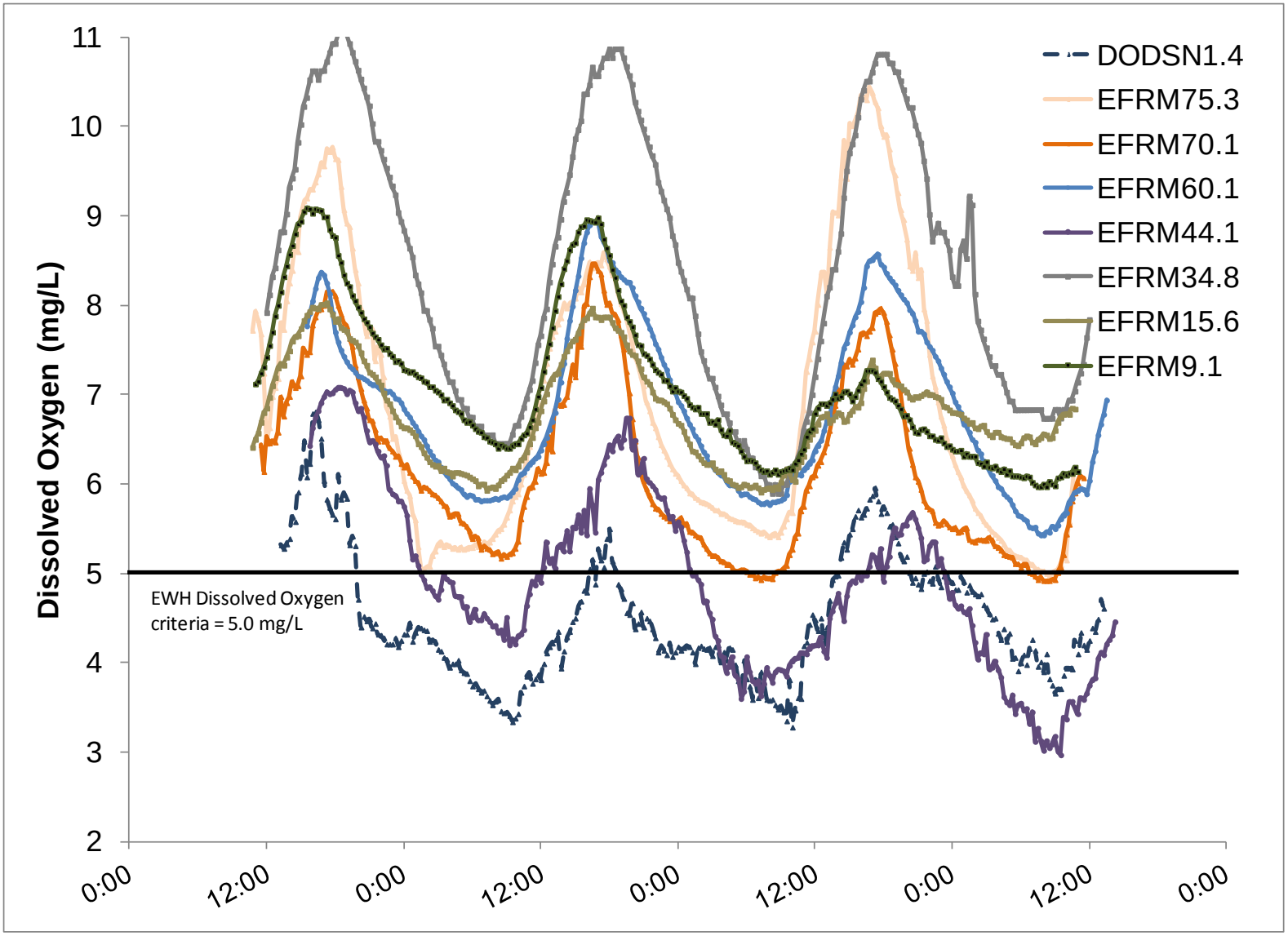

Figure 1. Three-day Diurnal Dissolved Oxygen Concentrations in Streams Designated as Exceptional Warmwater Habitat. Data was not collected in the same three-day period, see Table 2 for deployment dates.

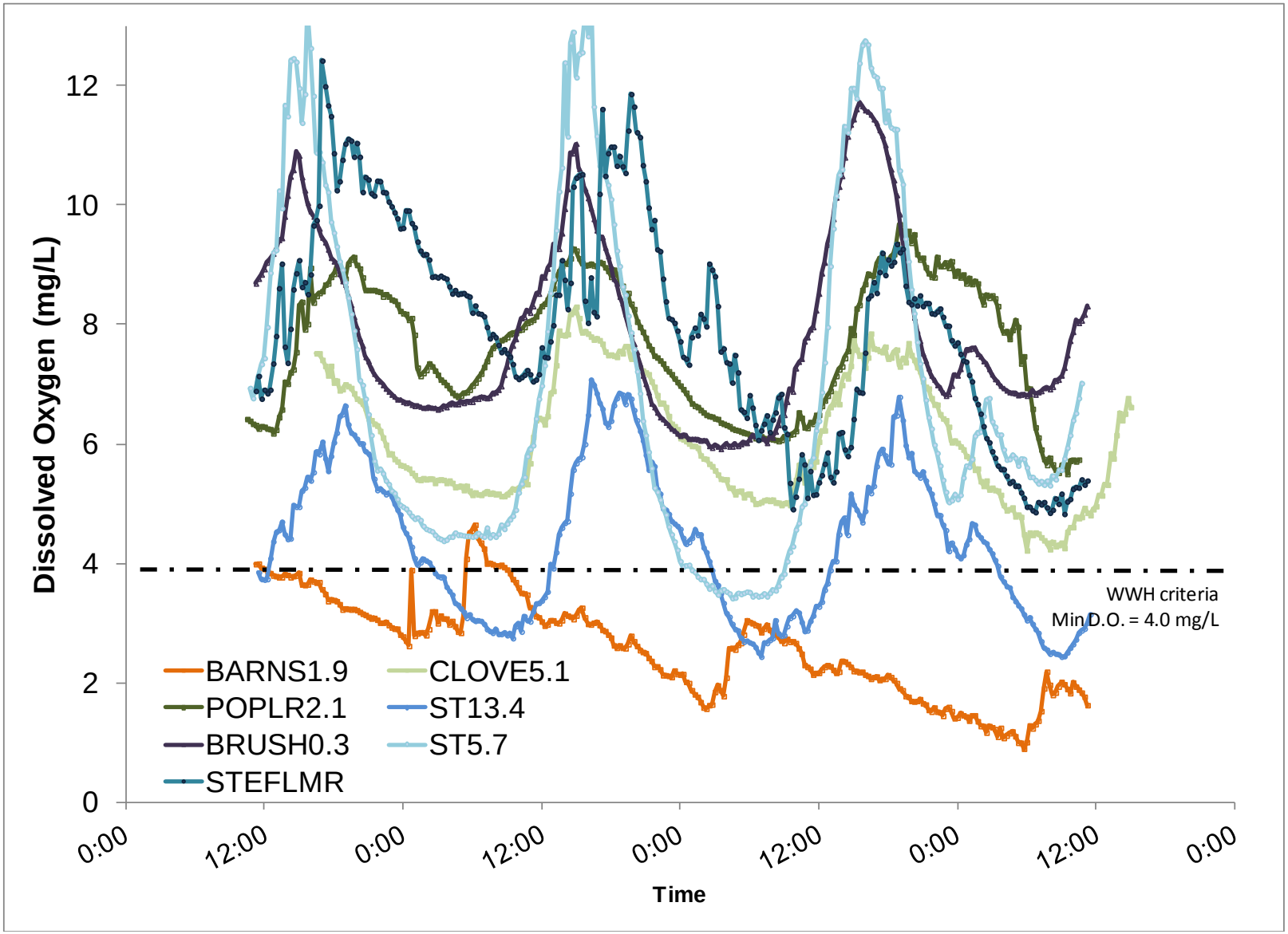

Figure 2. Three-day Diurnal Dissolved Oxygen Concentrations in Streams Designated as Warm Water Habitat. Data was not collected in the same three-day period, see Table 2 for deployment dates.

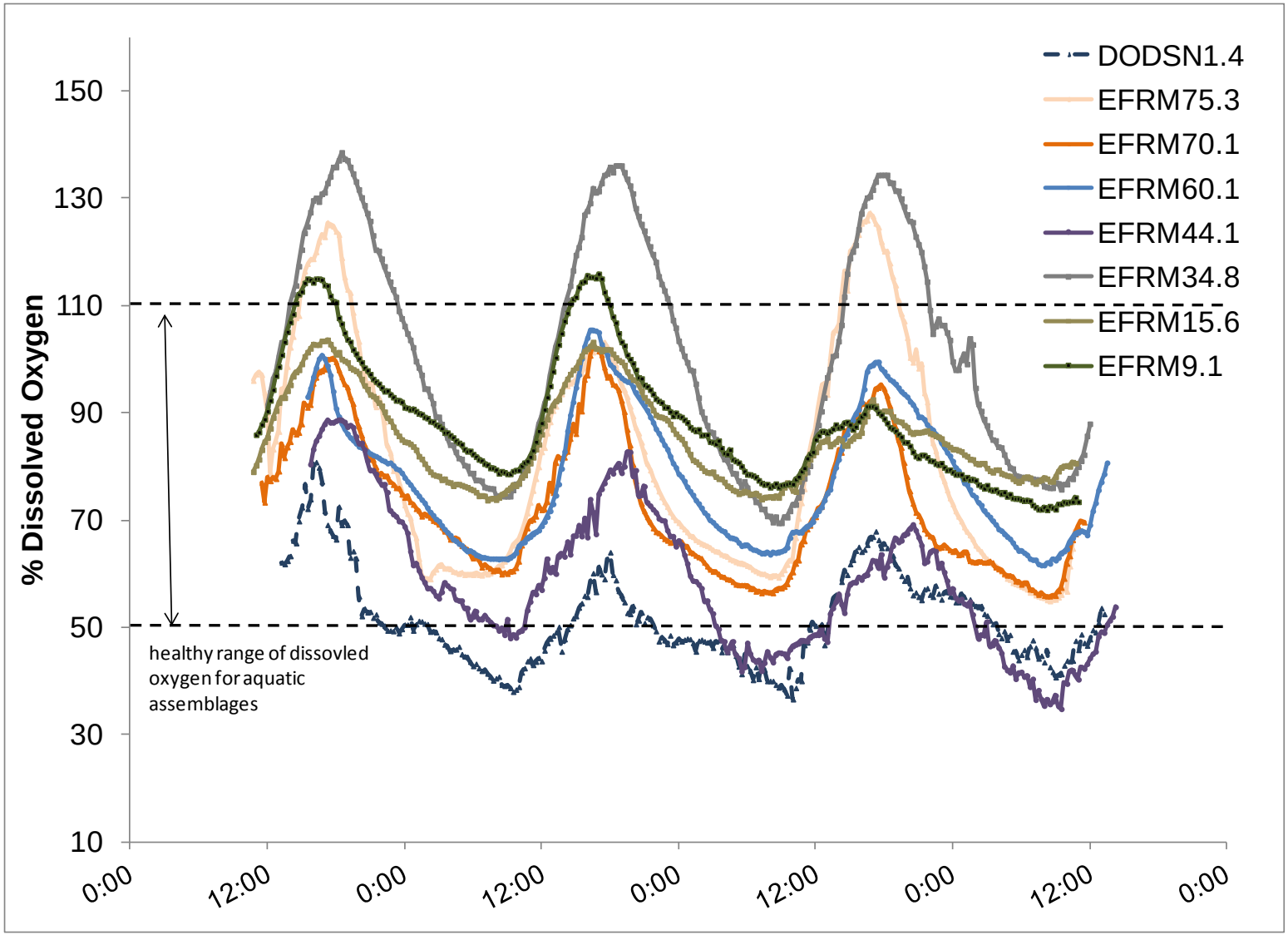

Figure 3. Three-day Diurnal Dissolved Oxygen Percent Saturation Profiles in Streams Designated as Exceptional Warmwater Habitat. Data was not collected in the same three-day period, see Table 2 for deployment dates.

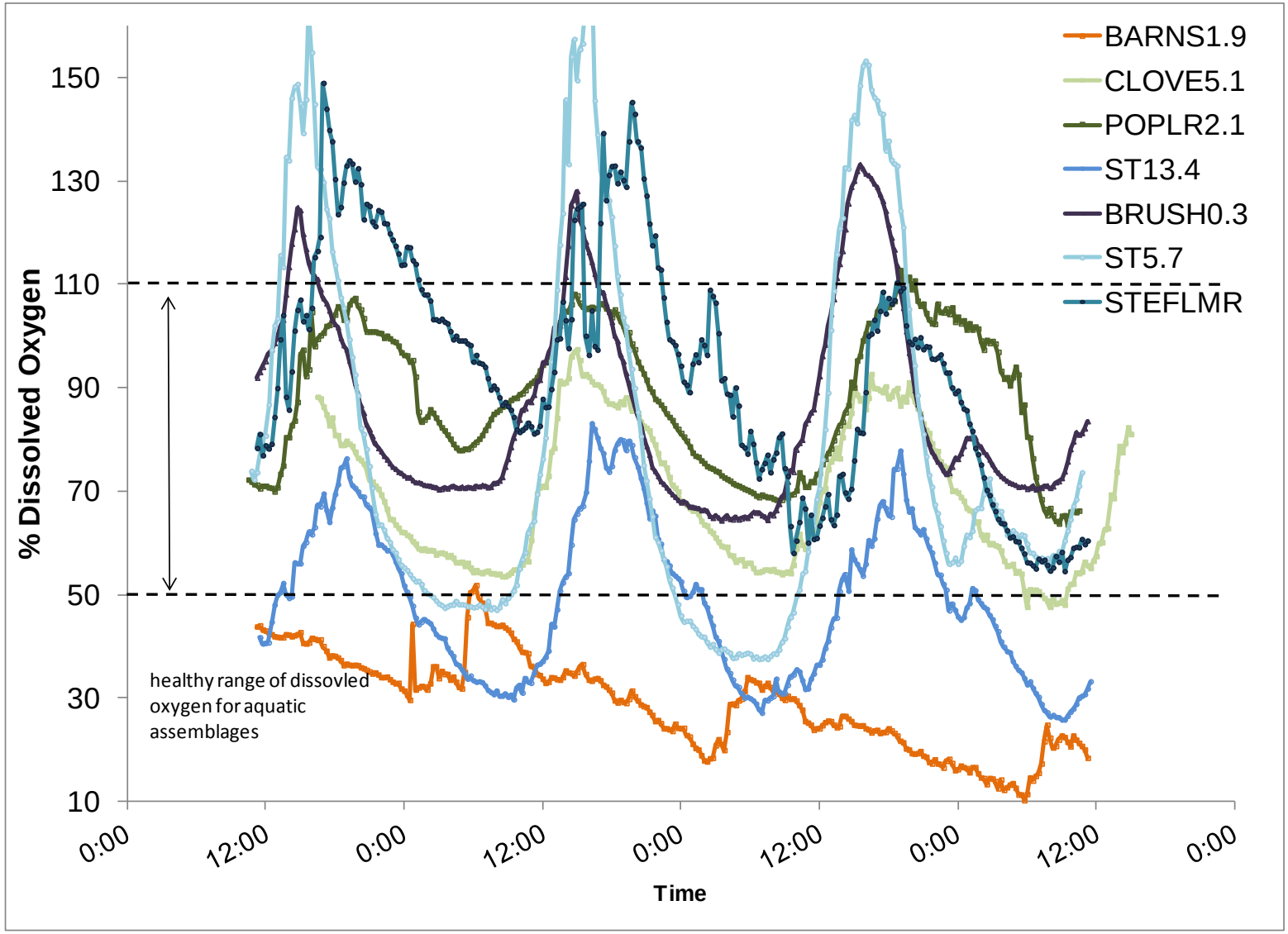

Figure 4. Three-day Diurnal Dissolved Oxygen Percent Saturation Profiles in Streams Designated as Warm Water Habitat. Data was not collected in the same three-day period, see Table 2 for deployment dates.

Conclusions/Recommendations

It appears organic enrichment from failing septic systems and nutrient loading from agricultural areas may be causing issues in some of the WWH and EWH streams. Of greatest concern is the site in Stonelick Creek (ST5.7) downstream of the entry of a tributary draining the village of Newtonsville. This small community has many failing septic systems which leach into open drainage ditches. Ohio EPA and Clermont County Office of Environmental Quality and Health District have documented the pollution in the immediate vicinity of the Village and failing systems, yet this is the first set of data that seems to indicate the pollution is causing impacts further downstream. High DO swings at STEFLMR, downstream of ST5.7, may also be due to organic and nutrient loads from Newtonsville. To protect aquatic life, alternative waste treatment options need to be explored and implemented in the Village of Newtonsville.

Oxygen concentrations were not super saturated during the daytime at ST13.4, but DO concentrations dropped below fairly low at night (2.4 mg/L). This indicates a high oxygen demand without a supersaturated environment. Excess organic material from Stonelick Lake may accumulate here and increase the oxygen demand. The absence of supersaturation and high photosynthesis could be due to low light availability at this site.

Dodson Creek and the EFLMR at RM 44.1 both have immediate habitat features which may be leading to low DO concentrations in these locations. The channel immediately upstream of EFRM44.1 was at one time modified into a straight channel and is now slow moving with limited oxygenating features in the channel. DODSN1.4 is also slow moving with limited riffle features to enable diffusion. Nutrient assimilation in these reaches may improve with instream restoration. Agricultural Best Management Practices (BMPs) may reduce sediment loads which could be depositing in and filling riffles in these sections of river.

EFMR34.8 experienced high DO swings, and supersaturated DO levels. Nutrient loads from agriculture and WWTP effluent may be causing eutrophic conditions at this site. EFRM75.3 also experienced high DO swings and supersaturation over the 3-day, low flow period. This is a highly agricultural watershed, with WWTPs in the headwaters

and a hog confinement facility; all possible contributors of nutrient and organic matter loads which may result in hypereutrophic systems with high oxygen demand. The increased use of BMPs in the watershed will help reduce nutrient and organic loads to the stream.

Wet Weather Sampling

Sampling design

Wet weather sampling is intended to quantify the cumulative impacts of major rain events, which serve to flush contaminants such as chemicals from agricultural applications, oil and gas from parking lot run-offs and other contaminants that cannot be identified as coming from any specific point (hence the term non-point source pollution). These types of stressors primarily enter streams during and immediately after rainstorms, and this component of the sampling program is intended to capture these events. In this way, the County can determine the magnitude of these non-point source loadings, and monitor the effectiveness of programs designed to eliminate or reduce them. Specifically, the monitoring in Grassy Fork is being used to monitor the effectiveness of BMPs being installed in the headwaters of Grassy Fork as part of a Natural Resources Conservation Service Conservation Innovation Grant.

During 2011, the County collected wet weather samples at four of the long-term monitoring stations; The East Fork LMR at Williamsburg, (EFRM34.8), Grassy Fork (GRSSY0.2) , Shayler Creek (SHYLR1.7), and Stonelick Creek (STEFLMR) using an ISCO 6700 series refrigerated autosampler which collects separate time paced samples (Table 4). Two other locations (GRSSY3.0 & GRSSY3.2) were monitored alongside GRSSY0.2 via a time-paced composite autosampler, ISCO 3710, during the spring and via grab samples during the autumn (full details are outlined in the 2011 Project Study Plan). The County attempted to collect these samples during at least three different storm events (wet weather sampling). Samples collected by the autosampler were analyzed for nitrate (NO_3), total kjeldahl nitrogen (TKN: organic nitrogen + ammonia),

total phosphorus (TP), and suspended solids (SS). Ortho-phosphorus (ortho-P), dissolved organic carbon (DOC) and *E. coli* were not analyzed on samples collected via autosampler due to hold time and filtering requirements.

Table 4. Monitoring locations for wet weather sampling

Location	Sample ID	Autosampler Monitoring Parameters	Grab Sample Parameters
EFLMR RM 34.8 at Main St., 15 minutes continuous sensing* & time paced discrete wet weather	EFRM34.8	TP, NH_3, NO_2, NO_3, TKN, SS	N/A
Stonelick Creek RM 0.9 at US 50., 15 minute continous sensing* & time paced discrete wet weather	STEFLMR	TP, NH_3, NO_2, NO_3, TKN, SS	N/A
Shayler Creek RM 1.7 at Baldwin Rd., 15 minute continous sensing* & time paced discrete wet weather	SHYLR1.7	TP, NH_3, NO_2, NO_3, TKN, SS	N/A
Grassy Fork RM 0.2 at Glancy Corner-Marathon Rd., 15 minute continuous sensing* & time paced discrete wet weather	GRSSY0.2	TP, NH_3, NO_2, NO_3, TKN, SS	ortho-P, TP, NH_3, NO_2, NO_3, TKN, SS, DOC, TOC, *E.coli*
Grassy Fork RM 3.0 at Marathon-Edenton Rd., time paced composite samples	GRSSY3.0	TP, NH_3, NO_2, NO_3, TKN, SS	ortho-P, TP, NH_3, NO_2, NO_3, TKN, SS, DOC, TOC, *E.coli*
Grassy Fork RM 3.2 at St. Rt. 131, time paced composite samples	GRSSY3.2	TP, NH_3, NO_2, NO_3, TKN, SS	ortho-P, TP, NH_3, NO_2, NO_3, TKN, SS, DOC, TOC, *E.coli*

*continuous sensing of stage and precipitation

Results

Three wet weather events were collected at EFRM34.8 (East Fork of the Little Miami River RM 34.8). The first event on April 4th occurred after an antecedent dry period of three days and 0.93” of rain fell within four hours. This was a fairly erosive event as observed in the highest SS reading of 734 mg/L during peak flow (Figure 5). Total phosphorus reached over 20 times the recommended criterion for maintaining biological use attainment for EWH (0.05 mg/L) with a maximum concentration of 1.35 mg/L during peak flow. TKN reached a maximum of 5.09 mg/L during peak flow, while nitrate was only slightly over the recommended criterion of 0.5 mg/L for EWH.

SS were much lower, though still elevated during the next two wet weather events sampled at EFRM34.8 on April 11th and April 27th (Figures 6 & 7). The April 11th event followed a less intense storm of 1.96” of rain which fell over 24 hours. This event only had an antecedent dry period of two days. The April 27th event was collected after 0.47” of rain and the days preceding this event received small amounts of rainfall daily.

TKN ranged from 1.37 to 1.95 mg/L during the April 11th event and 1.91 to 2.54 mg/L during the April 27th event. Nitrate ranged from 0.09 to 0.37 during the April 11th event and 0.17 to 0.40 mg/L during the April 27th event. Nitrate was not elevated as much as would be expected during wet weather events, but this could be due to the large amount of rainfall received throughout the spring of 2011, which continuously flushed the watershed. Phosphorus remained above the recommended criteria for biological use attainment, but was not nearly as elevated as in the erosive event on April 4th.

Three wet weather events were collected at STEFLMR (Stonelick Creek, RM 0.9). The April 9th event followed a moderately intense storm with a moderate rainfall total of 0.64" and an antecedent dry period of three days (Figure 8). The April 27th event was collected after a less intense storm of only 0.41" of rain with wet days preceding the sampling event (Figure 9). TKN ranged from 0.83 to 1.39 mg/L during the April 9th event and 1.32 to 2.06 mg/L during the April 27th event. The difference in organic nitrogen in the watershed between April 9th and April 27th could be due to fertilizer applications in that watershed between those dates. Nitrate ranged from 0.31 to 0.40 mg/L during the April 9th event and 0.23 to 0.27 mg/L during the April 27th event. SS were elevated during these two storms but the maximum concentration was only 216 mg/L, which was measured during the peak flow of the storm on April 27th. Phosphorus was above the recommended criterion for biological use attainment in WWH (0.1 mg/L), ranging from 0.83 to 1.39 mg/L April 9th and 0.48 to 0.65 mg/L April 27th.

The event at STEFLMR on July 24th occurred after an antecedent dry period of five days and following 1.35" of rain which fell within one hour (Figure 10). This was an erosive event as observed in the highest suspended solids reading of 500 mg/L during peak flow (Figure 10). Total phosphorus reached over 15 times the recommended criterion for maintaining biological use attainment for WWH (0.08 mg/L) with a maximum concentration of 1.22 mg/L during the falling limb. TKN reached a maximum of 2.81 during peak flow, while nitrate remained below the recommended criterion of 1.0 mg/L for WWH throughout the entire event.

Only two wet weather events were collected at the SHYLR1.7 (Shayler Creek, RM 1.7). The April 9th event followed a moderately intense storm with a rainfall total of

only 0.50” and an antecedent dry period of five days (Figure 11). TKN ranged from 0.98 to 1.50 mg/L and nitrate ranged from 0.33 to 0.73 mg/L, below the recommended criterion of 1.0 mg/L for WWH streams. Suspended solids were elevated during these two storms but the maximum concentration was only 214 mg/L, which was measured during peak flow. Phosphorus was above the recommended criterion for biological use attainment in WWH (0.08 mg/L), ranging from 0.18 to 0.44 mg/L.

The event at SHYLR1.7 on July 24th occurred after an antecedent dry period of greater than five days and 1.50” of rain fell within one hour (Figure 12). This was a very erosive event as observed in the highest SS reading of 1106 mg/L during peak flow (Figure 12). Total phosphorus reached over 21 times the recommended criterion for maintaining biological use attainment for WWH (0.08 mg/L) with a maximum concentration of 1.71 mg/L during peak flow. TKN reached a maximum of 3.32 during peak flow, while nitrate remained below the recommended criterion of 1.0 mg/L for WWH throughout the entire event.

Four wet weather events were sampled using autosamplers at GRSSY0.2 (Grassy Fork RM 0.2) during the spring of 2011. The first event on April 5th occurred after an antecedent dry period of greater than five days and 1.26” of rain fell within four hours. This was a fairly erosive event as observed in the highest SS reading of 696 mg/L during the rising limb (Figure 13). Total phosphorus reached over 13 times the recommended criterion for maintaining biological use attainment for WWH (0.08 mg/L) with a maximum concentration of 1.08 mg/L during peak flow. TKN reached a maximum of 4.33 during peak flow, while nitrate was below the recommended criterion of 1.0 mg/L for WWH.

The second event at GRSSY0.2 on April 11th occurred after an antecedent dry period of only two days and 1.36” of rain fell over 24 hours. This was still a fairly erosive event as observed in the highest SS reading of 580 mg/L during peak flow (Figure 14). Total phosphorus reached over 14 times the recommended criterion for maintaining biological use attainment for WWH (0.08 mg/L) with a maximum concentration of 1.17 mg/L during peak flow. TKN reached a maximum of 4.21 during peak flow, while nitrate was below the recommended criterion of 1.0 mg/L for WWH.

The hydrograph for the April 11th event at GRSSY0.2 is unusual because of the less intense storm during this event. Because the monitoring station is near the mouth of the watershed and the area is very flat, backwater from the East Fork of the Little Miami River typically reaches this sampling location shortly after peak flow from the Grassy Fork watershed is measured. So during wet weather, the hydrograph from this station will typically show one peak in stage which represents the majority flow coming from the Grassy Fork watershed, followed shortly by backwater from the East Fork LMR (Figures 13 & 16). The distance between the two peaks in stage on the hydrograph depends on the intensity and location of the storm (some storms may be localized over a small area). Figure 14 is showing only peak flow stage from the Grassy Fork watershed, followed by the slowly rising limb of the backwater from the EFLMR.

GRSSY3.0 (Grassy Fork RM 3.0) and GRSSY3.2 (Grassy Fork RM 3.2) were sampled (time paced, composite sample) along with the autosampler at GRSSY0.2 on April 16th (Figure 15). Power was lost during the peak flow of this event, so the reported rainfall total for this event of 0.74" is from the Stonelick Creek monitoring station. The antecedent dry period for this event was three days. TKN was elevated at all sites, ranging from the highest concentration at GRSSY0.2 of 3.31 mg/L to the lowest concentration observed at GRSSY3.0 of 1.69 mg/L (Figure 15). Total phosphorus was below the recommended criterion for WWH streams of 1.0 mg/L at all sites and samples except for the sample collected during the rising limb at GRSSY0.2, which read 1.02 mg/L. Nitrate was below the recommended criterion for WWH streams of 1.0 mg/L at all sites (Figure 15). SS were elevated during this event, ranging from 104 to 334 mg/L (Figure 13). No large differences in pollutant concentrations were observed between the three sites in Grassy Fork.

The fourth event on April 27th occurred after an antecedent dry period of only two days and only 0.54" of rain fell over six hours (Figure 16). This was still a fairly erosive event as observed in the highest SS reading of 434 mg/L during the rising limb (Figure 16). Total phosphorus reached over 11 times the recommended criterion for maintaining biological use attainment for WWH (0.08 mg/L) with a maximum concentration of 0.91 mg/L during the rising limb. TKN reached a maximum of 3.29

during peak flow, while nitrate was below the recommended criterion of 1.0 mg/L for WWH.

During October and November, grab samples were collected during three wet weather events in the Grassy Fork watershed at GRSSY0.2, GRSSY3.0 & GRSSY3.2 (Table 5). The rainfall totals for these events ranged from 0.7 to 1.25". The average nitrate concentration was below the recommended criterion of 1.0 mg/L for WWH (range 0.21 to 0.69 mg/L; Table 5). Total phosphorus was above the recommended criterion of 0.08 mg/L for WWH (range 0.23 to 1.40 mg/L). Ortho phosphorus ranged from 0.16 to 1.04 mg/L and was over 1.0 mg/L at GRSSY3.0 & GRSSY3.2 during the November 15th event, pointing to a possible fall application of fertilizer. TKN was slightly lower during the fall than during spring wet weather events, with a range of 0.44 to 2.30 mg/L TKN. Total organic carbon ranged from 27.4 to 32.30 mg/L, which is within the range of typical concentrations during wet weather events. SS were not as high during the autumn as during spring wet weather events, with a range of concentrations of 1.4 to 82 mg/L. This could be due to more well established root zones in agricultural fields during this the autumn as opposed to barren fields during April. Bacteria levels were high during these events, ranging from 900 to 4400 #/100 mL *E. coli*. These samples exceeded instream criterion for class B primary contact streams of a single sample maximum of 523 #/100 mL *E. coli.*

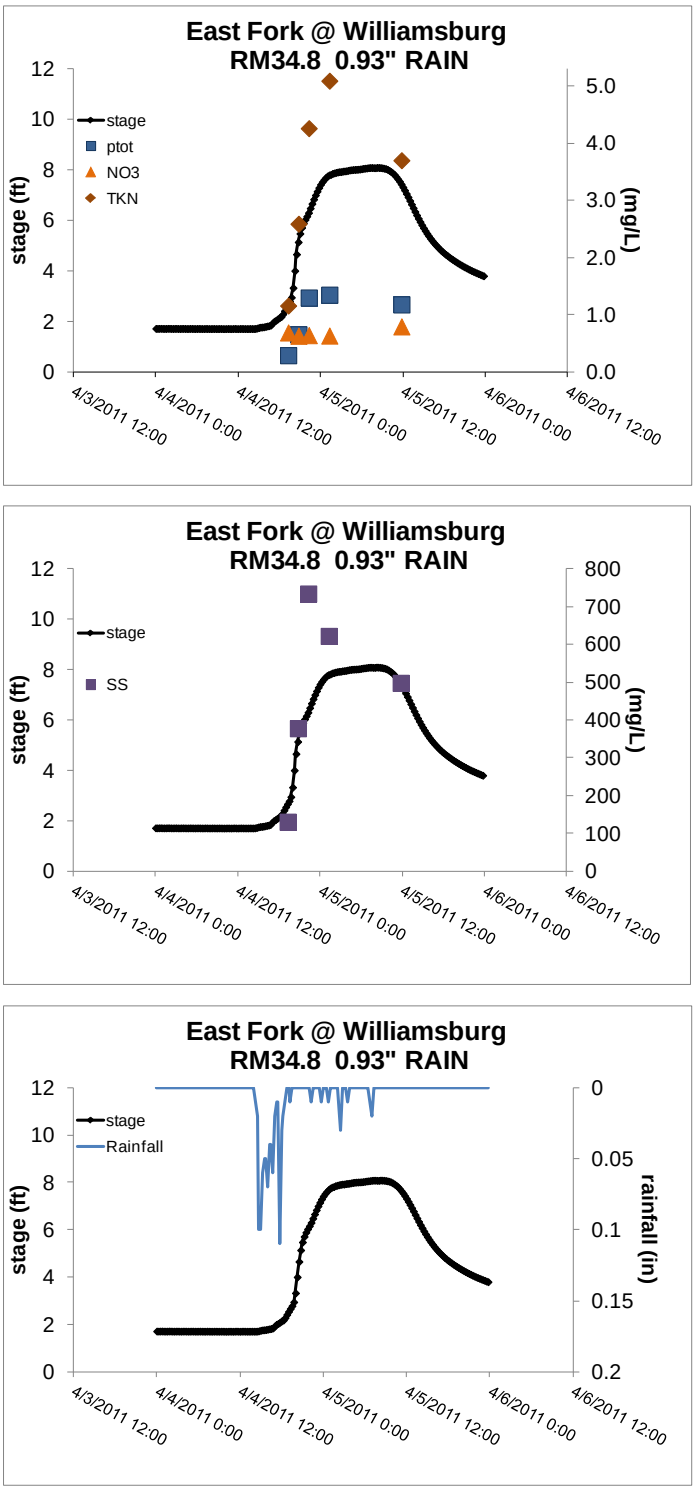

Figure 5.
Wet weather sampling on 4/4/2011 at the East Fork of the Little Miami River, river mile 34.8 at St. Rt. 133, Williamsburg. There was 0.93" of rain received and an antecedent dry period of 3 days.

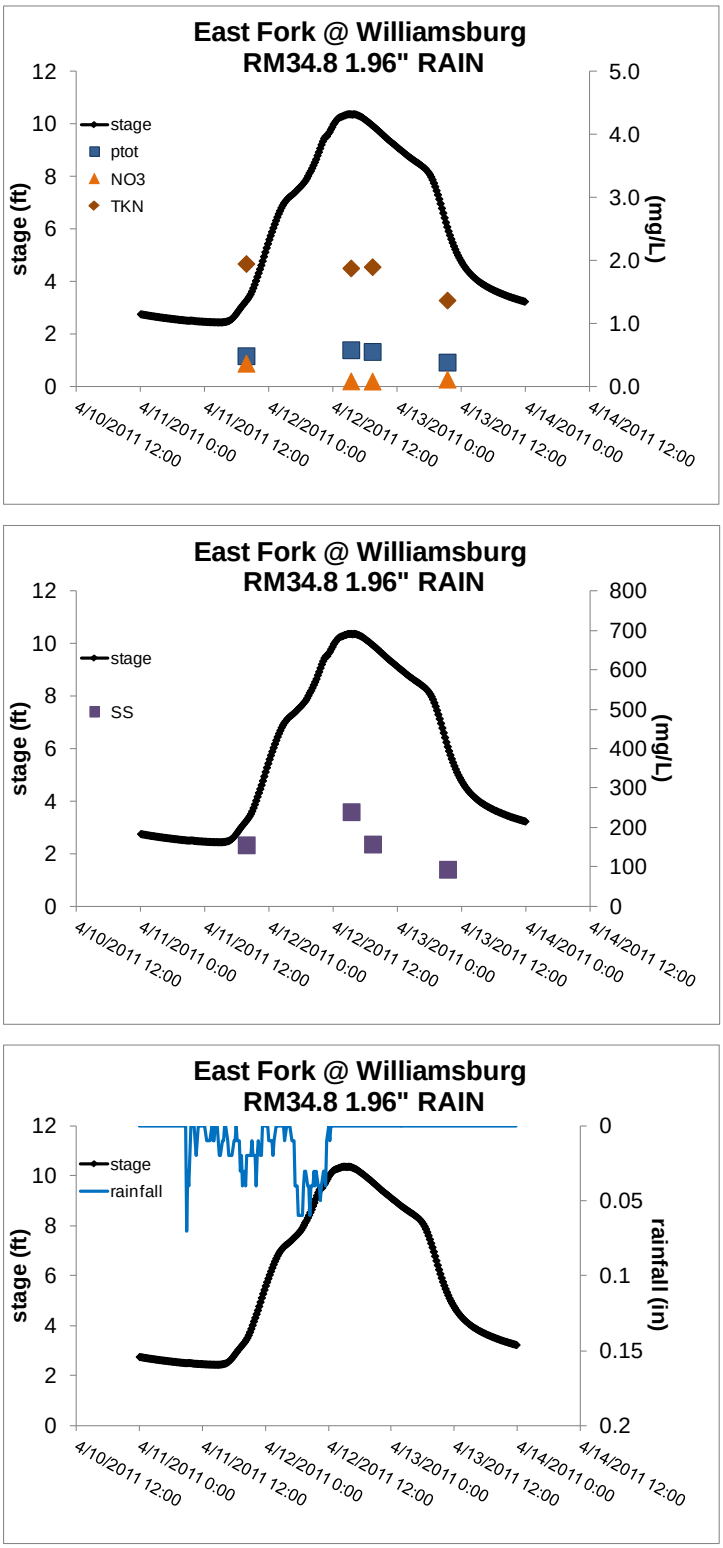

Figure 6.

Wet weather sampling on 4/11/2011 at the East Fork of the Little Miami River, river mile 34.8 at St. Rt. 133, Williamsburg. There was 1.96" of rain received and an antecedent dry period of 2 days.

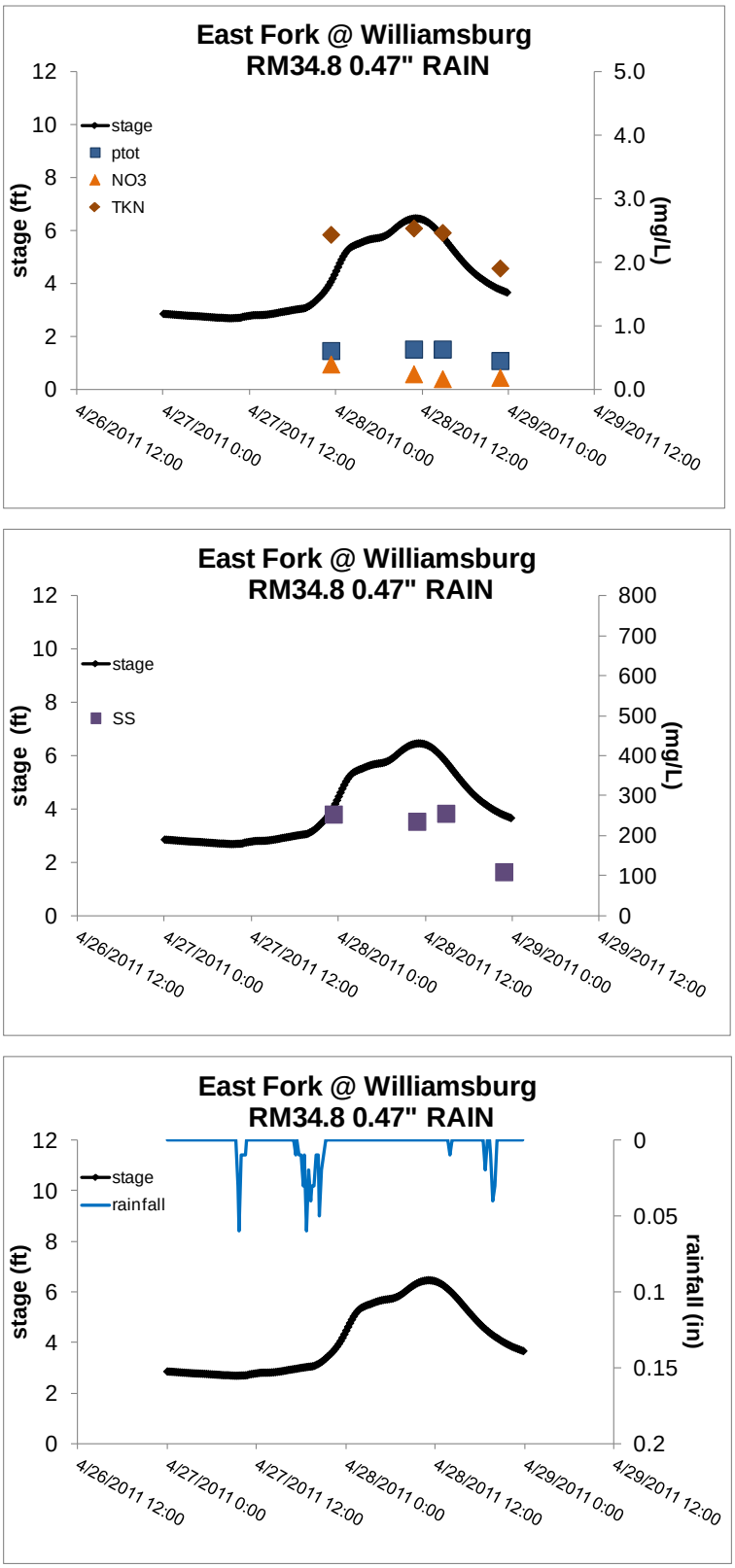

Figure 7

Wet weather sampling on 4/27/2011 at the East Fork of the Little Miami River, river mile 34.8 at St. Rt. 133, Williamsburg. There was 0.47" of rain received and an antecedent dry period of 0 days.

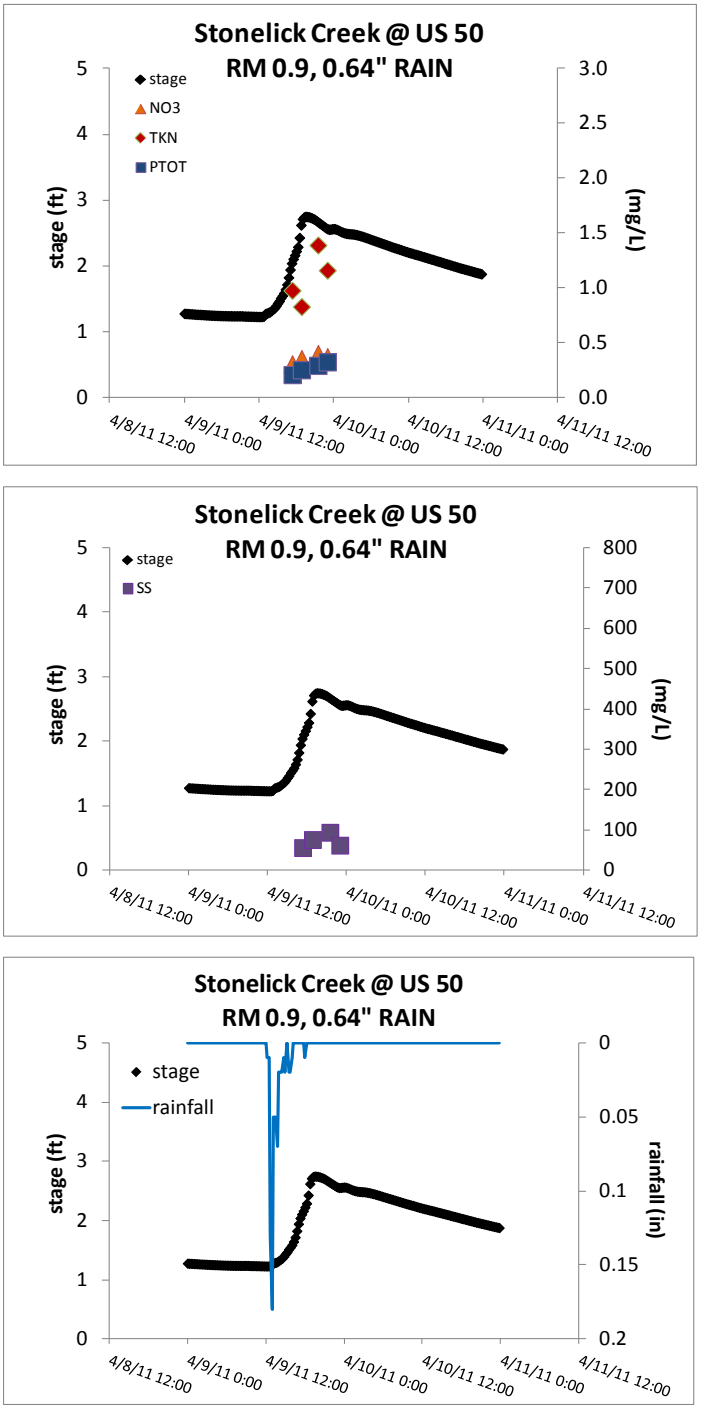

Figure 8

Wet weather sampling on 4/9/2011 at Stonelick Creek, river mile 0.9 at US 50. There was 0.64" of rain received and an antecedent dry period of 3 days.

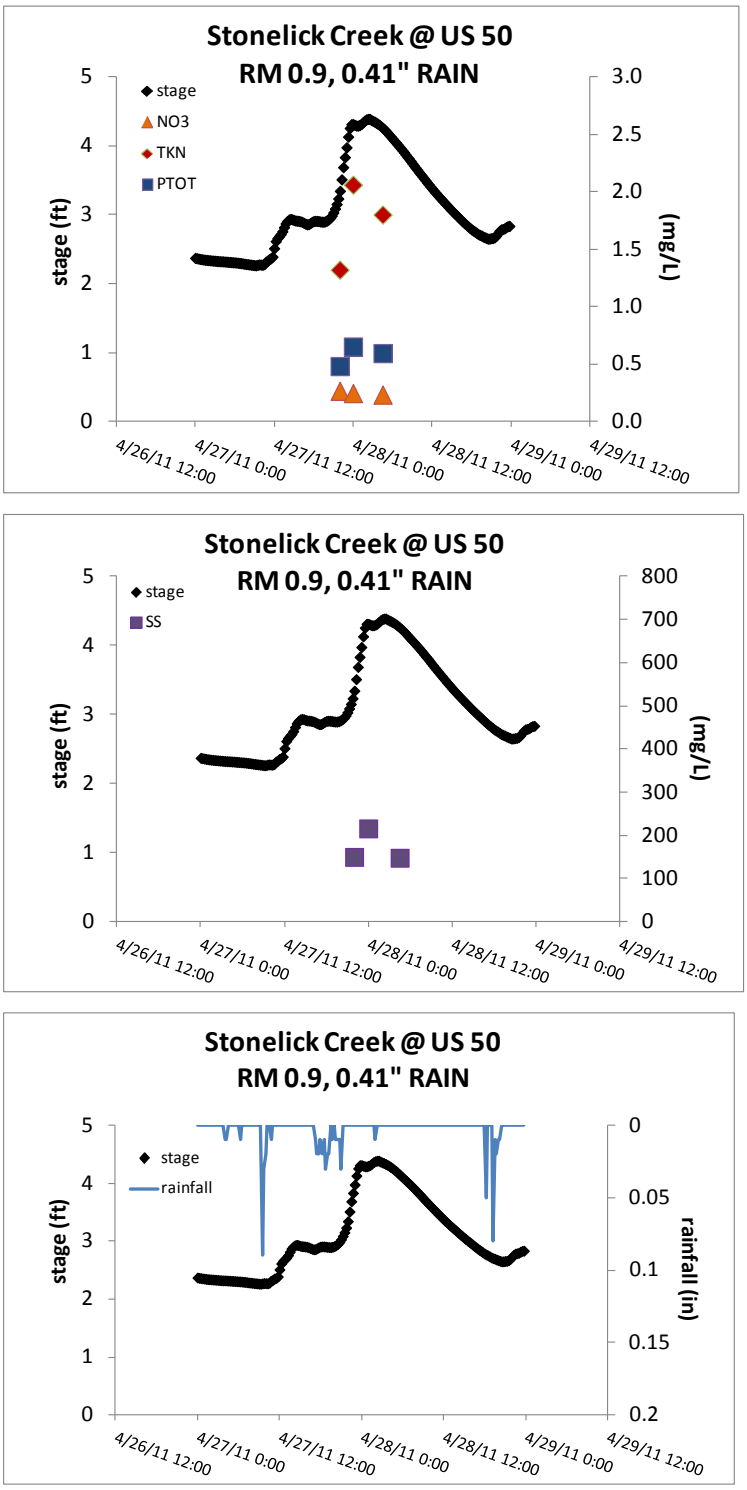

Figure 9

Wet weather sampling on 4/27/2011 at Stonelick Creek, river mile 0.9 at US 50. There was 0.41" of rain received and an antecedent dry period of 0 days.

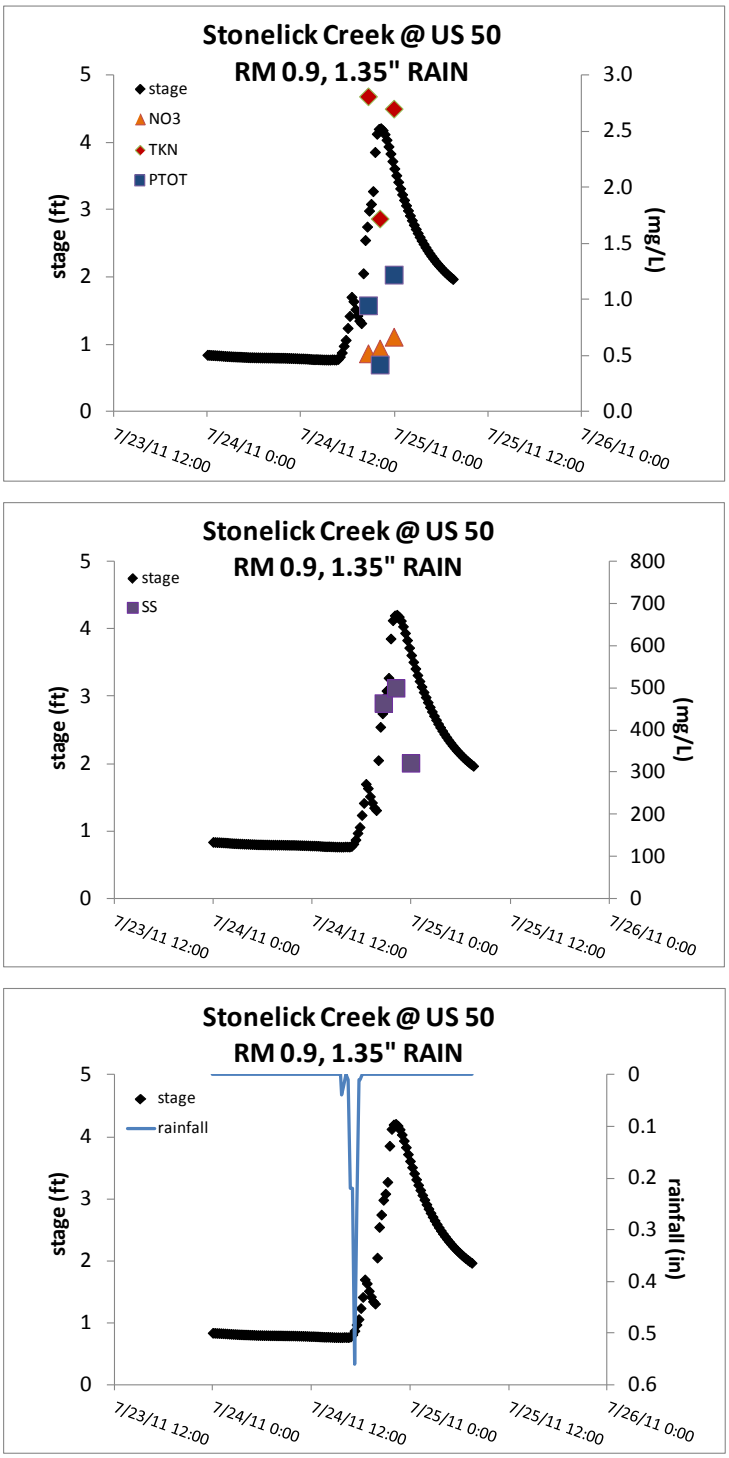

Figure 10

Wet weather sampling on 7/24/2011 at Stonelick Creek, river mile 0.9 at US 50. There was 1.35" of rain received and an antecedent dry period of 5 days.

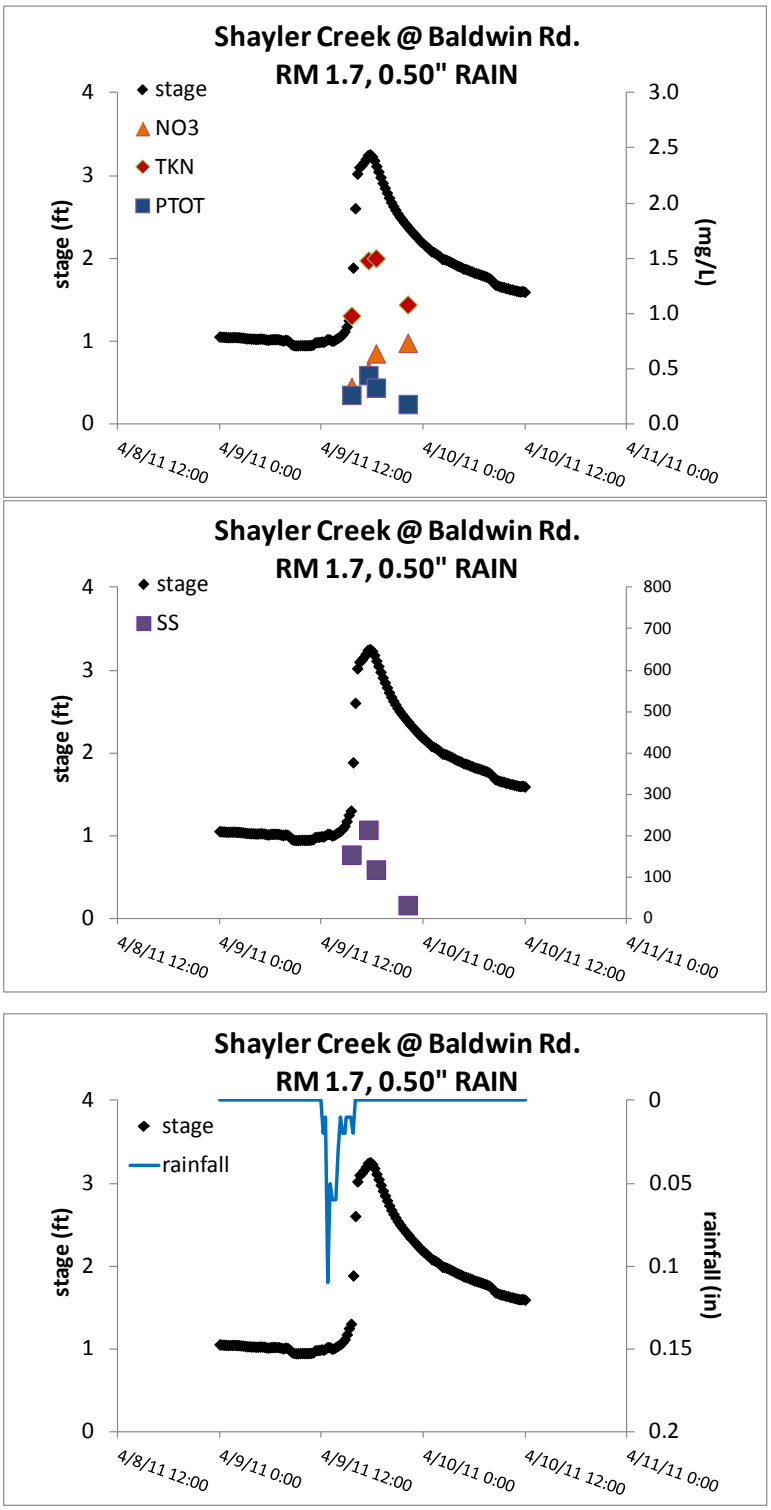

Figure 11

Wet weather sampling on 4/9/2011 at Shayler Creek, river mile 1.7 at Baldwin Rd.. There was 0.50” of rain received and an antecedent dry period of 5 days.

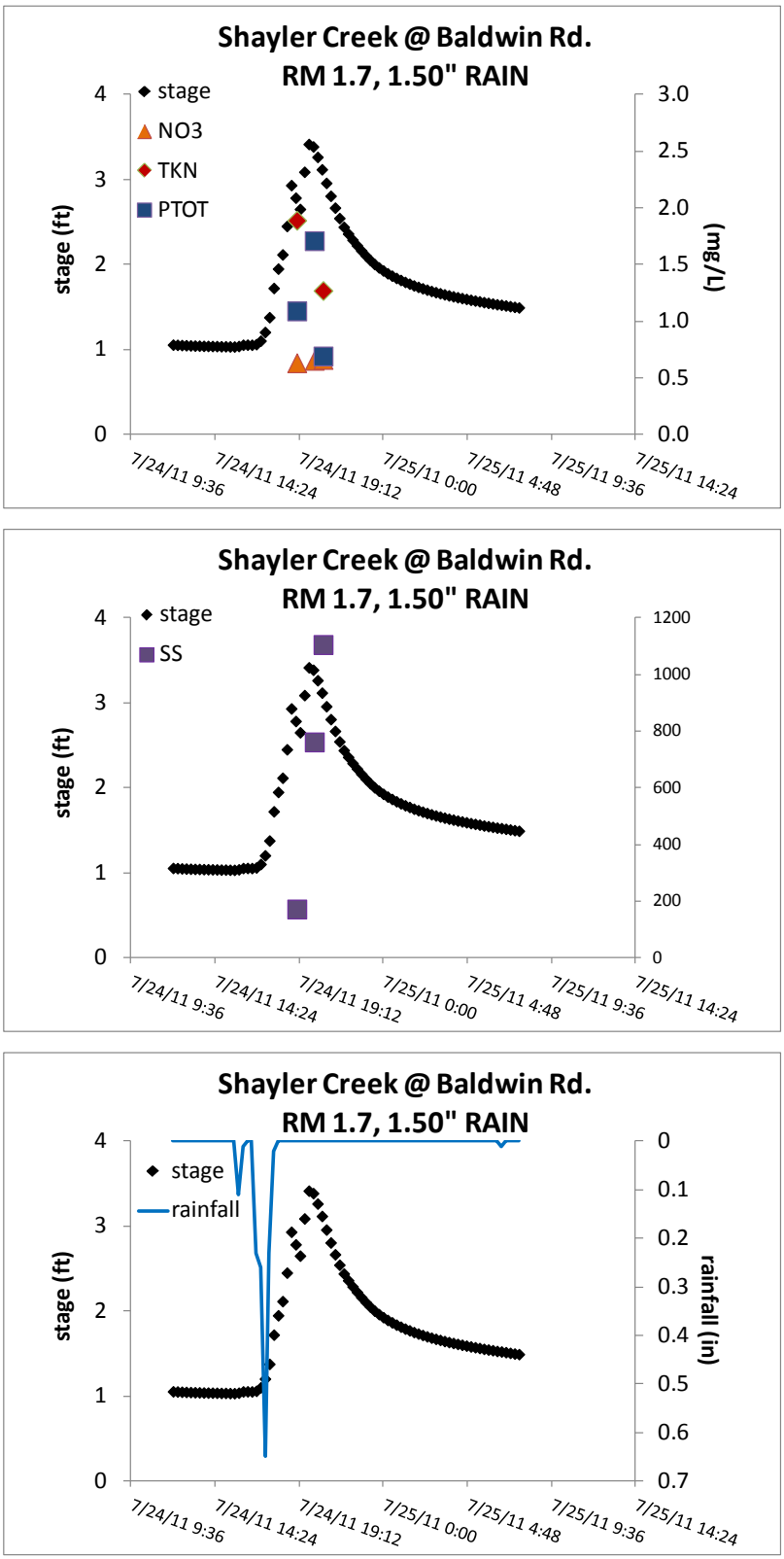

Figure 12

Wet weather sampling on 7/24/2011 at Shayler Creek, river mile 1.7 at Baldwin Rd.. There was 1.50” of rain received and an antecedent dry period of greater than 5 days.

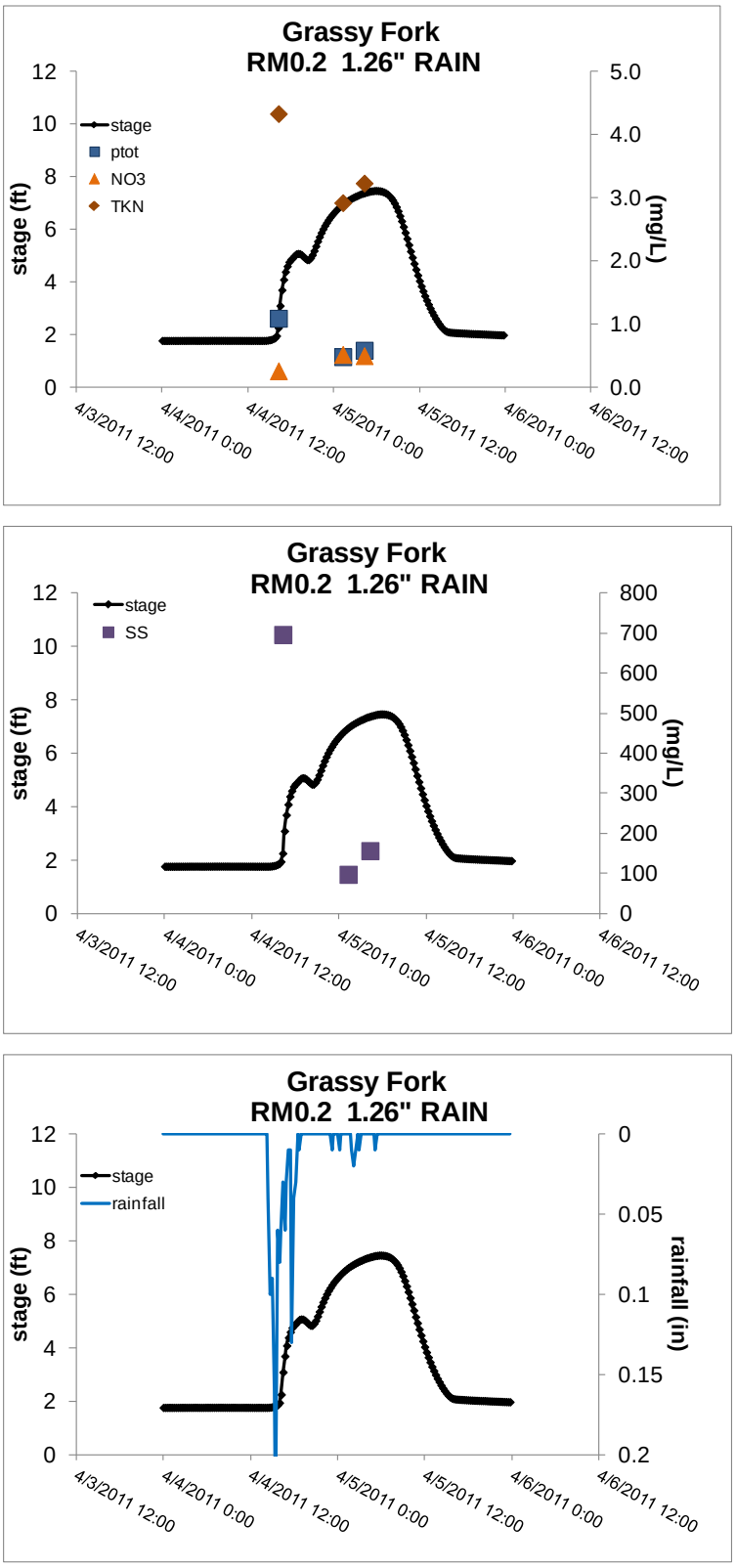

Figure 13

Wet weather sampling on 4/5/2011 at Grassy Fork, river mile 0.2 at Glancy Corner-Marathon Rd. There was 1.26" of rain received and an antecedent dry period of greater than 5 days.

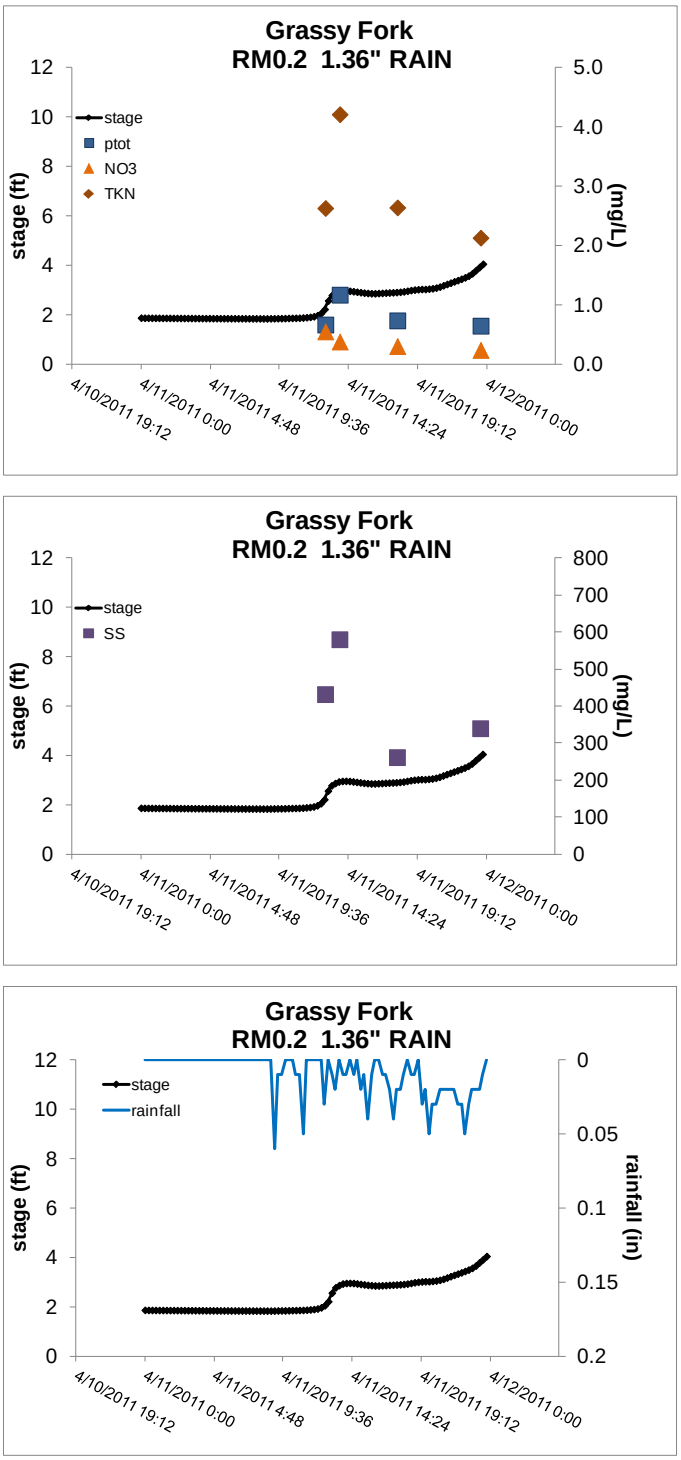

Figure 14

Wet weather sampling on 4/11/2011 at Grassy Fork, river mile 0.2 at Glancy Corner-Marathon Rd. There was 1.36” of rain received and an antecedent dry period of 2 days.

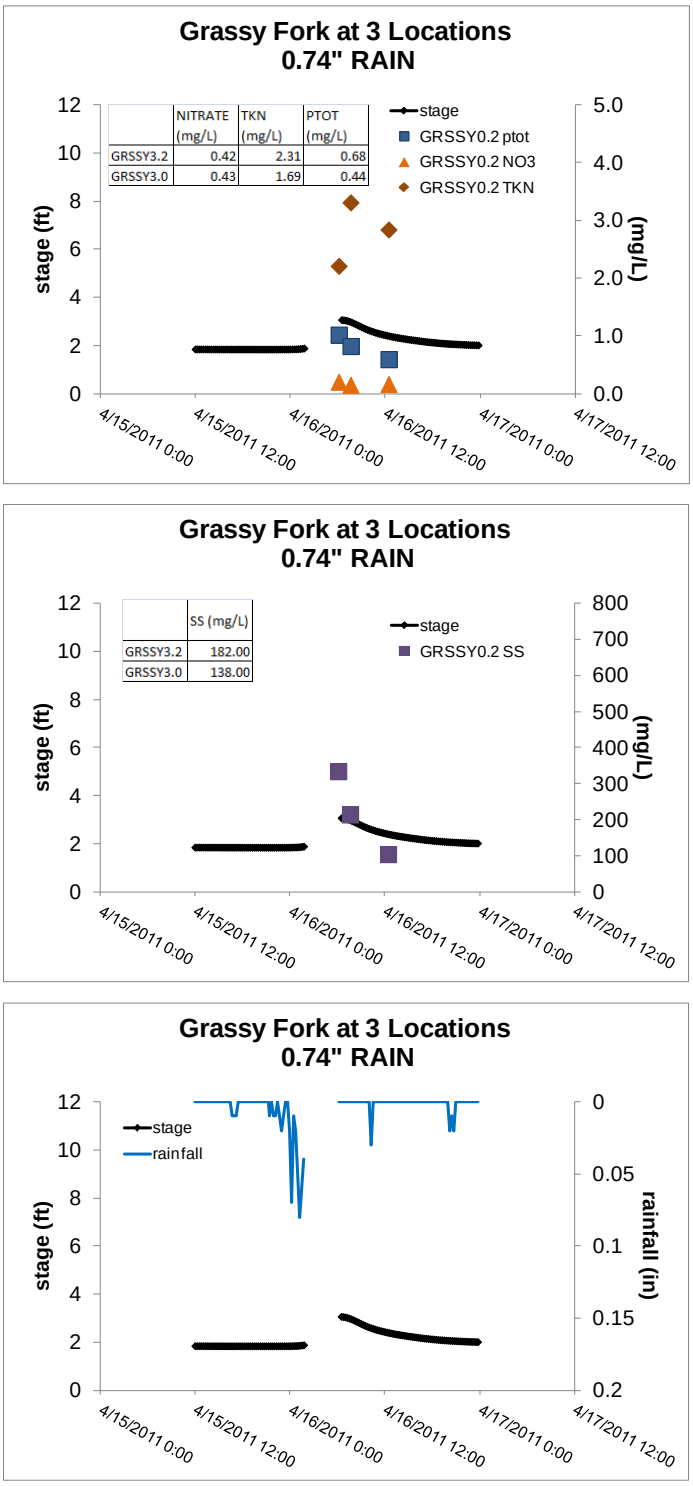

Figure 15

Wet weather sampling on 4/16/2011 at 3 locations in Grassy Fork. Composite samples and hydrograph data were collected at river mile 0.2 at Glancy Corner-Marathon Rd. Precipitation total is from the Stonelick Creek monitoring stations due to the loss of data from a power outage at the Grassy Fork station from 1:00 a.m. to 6:00 a.m. Grab samples were taken at river mile 3.0 and 3.2 and are shown in the table inset. There was 0.74" of rain received and an antecedent dry period of 3 days.

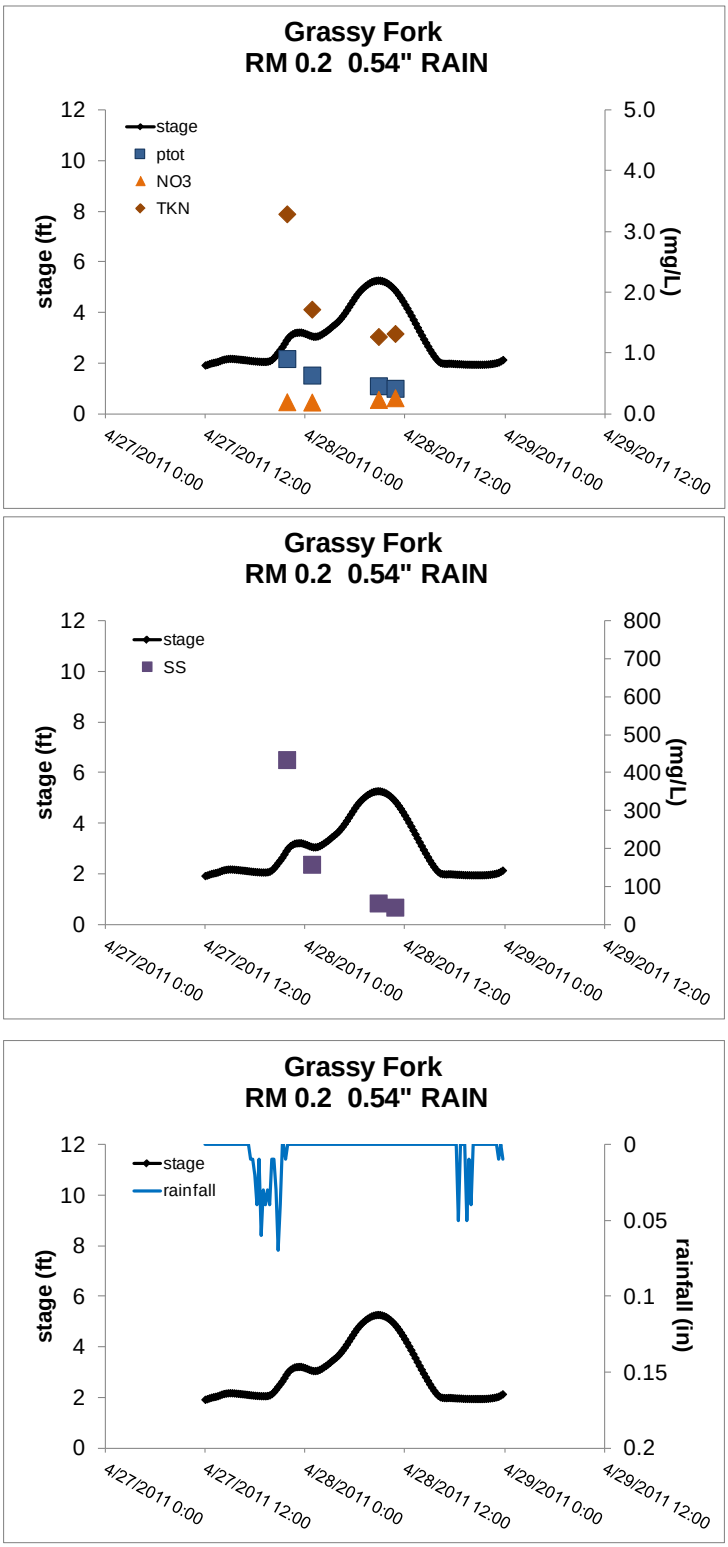

Figure 16.
Wet weather sampling on 4/27/2011 at Grassy Fork, river mile 0.2 at Glancy Corner-Marathon Rd. There was 0.54" of rain received and an antecedent dry period of 2 days.

Table 5. Mean concentrations from wet weather grab samples taken in October and November, 2011. N= 3, with the exception of TKN and TOC, which were only analyzed for one event and *E. coli* which was only analyzed for two events. Rainfall totals ranged from 0.7 to 1.25" during the three different events.

StationID	GRSSY0.2	GRSSY3.0	GRSSY3.2
Nitrate (mg/L)	0.42	0.38	0.41
Total Kjeldahl Nitrogen (mg/L)	0.59	1.32	1.52
Total Phosphorus (mg/L)	0.72	0.74	0.78
Suspended Solids (mg/L)	39.1	27.2	29.7
Total Organic Carbon (mg/L)	27.4	31.2	32.3
E.coli (#/100 mL)	3382	3447	1697

Conclusions

Generally, the largest pollutant loads were observed during wet weather events with large amounts of intense rainfall and/or an antecedent dry period of greater than three days. Unless a very large intense rainfall event is occurring, the County should limit wet weather sampling to those events which follow at least three dry days.

Surprisingly, nitrate was below Ohio EPA's recommended nutrient criterion for the protection of biological life of 0.5 (EWH) to 1.0 mg/L (WWH). This could be due to the large amount of rainfall observed during the spring of 2011, which ensured nitrate was continuously flushed from drainages, resulting in no one event having a very large concentration of nitrate. Organic materials which tie up organic nitrogen (TKN-also includes ammonia) were likely flushed from the watersheds only during strong rain events since it is not as water soluble as NO_3. Total phosphorus was above the recommended criteria for EWH, 0.05 and WWH 0.08 to 0.1 mg/L in all of the samples collected during wet weather and was exceptionally high during intense, erosive rainfall events since phosphorus binds to soil particles.

Grassy Fork had very high phosphorus, TKN, and SS during all events in the spring, regardless of rainfall intensity and antecedent dry period. Very high TKN and SS concentrations were seen more frequently at EFRM34.8 than at Shayler Creek, with a suburban watershed and Stonelick Creek with a mixed forested/agricultural

watershed. This is likely because there are many agricultural fields in the EFRM34.8 and Grassy Fork watershed which are fertilized and are highly erodible during rain events, contributing high volumes of sediment and nutrients to these streams.

During the intense storm on July 24th, very high suspended sediment was observed at Shayler Creek, 1106 mg/L. There are several unstable banks in Shayler Creek that were likely eroded during this storm. The urbanized watershed of this stream yields very flashy flows during storm events that exacerbate the unstable stream banks in Shayler Creek. Urban stormwater BMPs in this watershed might help reduce the flashy hydrograph in Shayler Creek and reduce sediment loading to receiving streams.