B.3 Chemical Water Quality

Upper Big Darby Creek, Including Tributaries
(Headwaters to Plain City ~ RM 82.5 - 52.10)

Chemical water quality sampling in Upper Big Darby Creek extended from the headwaters at RM 82.50 to RM 52.10 just upstream of the Village of Plain City WWTP outfall. Tributaries included in this sampling effort included Flat Branch and tributary, Little Darby Creek (Logan County), two different unnamed tributaries, Spain Creek, Pleasant Run, Hay Run, Buck Run, Robinson Run, and Sweeney Run.

Mainstem
Chemical water quality sampling occurred in upper Big Darby Creek five times during the 2001 survey period. There were no violations of WQS found in upper Big Darby Creek (Table B.3.1).

Some *E. coli* and fecal coliform sample results appear elevated in the upper Big Darby Creek mainstem when compared with WQS benchmarks (Figures B.3.1 and B.3.2).

Dissolved oxygen concentrations in the upper Darby watershed exhibited areas with moderately depressed oxygen concentrations. Mean dissolved oxygen concentrations in the Big Darby Creek decreased downstream of the confluences of both Flat Branch and Buck Run with the site just downstream of Buck Run nearly in non-attainment for mean D.O. (Figure B.3.3). Mean concentrations increased again prior to reaching the Village of Plain City WWTP outfall at RM 52.05 (Figure B.3.3).

Total suspended solids concentrations varied throughout the upper watershed. All values examined in the WWH section of the upper Darby (RMs 82.50 and 79.20), upstream of the confluence with Flat Branch were greater than ECBP background median concentrations with half of these values in excess of the 75th percentile (Table B.3.2). Comparison of these segments with others of similar drainage area showed medians well above the comparison group (Figures B.3.5 and B.3.6).

Table B.3.1. Exceedences of Warmwater Habitat (WWH) and Exceptional Warmwater Habitat (EWH) water quality criteria (OAC 3745-1) for chemical/physical parameters in the Big Darby Creek study area, 2001. Plain text river miles indicate Warmwater Habitat, boldface river miles are designated Exceptional Warmwater Habitat, effluent discharges are in italic print, undesignated streams have a letter U following the river mile, and areas designated Modified Warmwater Habitat are underlined (Units are #/100 ml for bacteria, °C for temperature, µg/l for metals, cyanide and pesticides, mg/l for all other chemical parameters and square miles for drainage area).

River/Stream	NPDES Discharge	IBI/MIWB	QHEI	River Mile	Drainage Area	Parameter	(Value) code
Big Darby Creek		52/NA	68.0	82.50	1.5		
		48/NA	64.5	79.20	5.6		
	Flat Branch WWTP			*78.48*	No effluent samples taken during survey.		
		37.3/NA	63.5	**78.40**	19.4		
		43/NA	73.5	**76.60**	32		
		52/9.24	70.5	**69.40**	70		
	Darby Creek Golf Course WWTP			*64.00*	No effluent samples taken during survey.		
		49/8.18	80.5	**63.80**	89		
	Fairbanks School WWTP			*63.74*	No effluent samples taken during survey.		
		47/7.52	83.5	**62.50**	121		
		53/9.23	83.5	**54.20**	138		
	Ranco, Inc.			*54.00*	No effluent samples taken during survey.		
		52/9.35	93.0	**53.90**	136		
	Tuffco Sand and Gravel			*52.40*	No effluent samples taken during survey.		
		51/9.08		**52.10**	150		
	Plain City WWTP			*52.05*		F. coliform	(22982)✪
		43/8.78	81.0	**52.00**	150		
	Suburbans MHP WWTP			*49.68*	No effluent samples taken during survey.		
		48/8.3	76.0	**49.50**	177		
	Wisslohican Sanitary Sewer Dist. WWTP			*45.00*	No effluent samples taken during survey.		
		55/9.87	81.5	**42.00**	240		
	Battelle Memorial Institute WWTP			*40.55*	No effluent samples taken during survey.		

River/Stream	NPDES Discharge	IBI/MIWB	QHEI	River Mile	Drainage Area	Parameter	(Value) code
	Lake Darby Estates WWTP			*40.00*	No effluent samples taken during survey.		
	Greentree MHP WWTP			*39.00*	No effluent samples taken during survey.		
	Darby Dan Farms WWTP			*36.70*	No effluent samples taken during survey.		
		55/10.14	93.5	**34.10**	253		
	Oak Hills MHP WWTP			*29.29*	No effluent samples taken during survey.		
	Darbydale Elementary WWTP			*29.00*	No effluent samples taken during survey.		
				27.00	453		
		55/10.2	87.5	**23.80**	498		
	Dot-Mar MHP WWTP			*23.77*	No effluent samples taken during survey.		
	Pickaway Correctional Inst. WWTP			*22.92*			
		53/11.36	84.5	**22.80**	505		
		52/10.53	85.0	**19.10**	513		
		52/10.82	85.5	**13.40**	534		
		54/11.02	82.0	**3.10**	552		
-Flat Branch (RM 78.48)	Honda E. Liberty WTP			*4.80*	No effluent samples taken during survey.		
		26/NA	25.5	3.20	3.3	Temp.	(28.1)*
	Honda Benton Road WTP			*2.21*	No effluent samples taken during survey.		
				2.20	9.3	Copper-T	(81)***
		28/NA	36.5	0.80	13.9		
--Unnamed Trib. to Flat Branch (RM 1.50)				0.10 U	3.5		
-Little Darby Creek (RM 78.34, Logan Co.)		55/NA	71.5	3.50 U	2.4	Copper-T	(46)**
		50/NA	68.0	0.40 U	7.0		
-Unnamed Trib. to Big Darby Creek (RM74.91)		50/NA	62.5	0.20 U	3.9		

River/Stream	NPDES Discharge	IBI/MIWB	QHEI	River Mile	Drainage Area	Parameter	(Value) code
-Spain Creek (RM 74.30)		44/NA	66.0	5.70	3.5		
		56/NA	72.0	3.70			
	North Lewisburg WWTP			*1.50*	No effluent samples taken during survey.		
		53/NA	76.0	0.10	9.1		
-Pleasant Run (RM 72.01)		54/NA	72.0	**4.10**	4.9		
		58/NA	59.5	**0.50**	8.5		
-Unnamed Trib. to Big Darby Creek (RM 69.40)		50/NA	64.5	0.40 U	4.6		
-Hay Run (RM 67.60)		54/NA	52.5	0.20	5.8		
-Buck Run (RM 63.74)		26/NA	40.0	10.40	5.1		
		28/NA	55.5	7.80	9.2	D.O.	(3.69)‡‡
				5.00	18.1	D.O.	(3.52)‡‡
		44/7.14	70.5	0.10	29.8		
-Robinson Run (RM 53.69)	St. Johns Church WWTP			*8.04*	No effluent samples taken during survey.		
	Darby Meadows WWTP			*5.23*	No effluent samples taken during survey.		
		30/NA	64.0	2.10	8.4		
		30/NA	70.0	0.70			
-Sweeny Run (RM 52.11)		46/NA	58.0	0.10 U	4.0		
-Sugar Run (RM 50.92)		26/NA	31.0	7.50	4.1		
		26/NA	29.5	7.00		D.O.	(2.88)‡‡
		34/NA	38.5	5.40			
		40/NA	65.5	0.50	19.4		
-Worthington Ditch (RM 50.62)		24/NA		0.20 U	4.4		
-Ballenger-Jones Ditch (RM 49.68)	Jonathan Alder School WWTP			*2.55*	No effluent samples taken during survey.		
		40/NA	69.0	0.20 U	6.0		

River/Stream	NPDES Discharge	IBI/MIWB	QHEI	River Mile	Drainage Area	Parameter	(Value) code
Powell Ditch (RM 48.35)	COJV School District			*2.68*	No effluent samples taken during survey.		
-Yutzy Ditch (RM 47.10)	Canaan Elementary WWTP			*2.25*	No effluent samples taken during survey.		
				0.40 U	4.3		
-Fitzgerald Ditch (RM 44.96)	Canaan Community MHP WWTP			*1.40 U*	No effluent samples taken during survey.		
		32/NA	56.5	0.50 U	5.1		
-Little Darby Creek (RM 34.1)				**41.20**	3.3		
		44/NA		**39.60**	9.4		
	Mechanicsburg WWTP			*39.20*			
		38/NA		**38.80**	13.2		
		46/NA		**34.70**	25.9		
		44/8.40		**29.50**	70		
		54/9.07		**24.50**	83		
		58/9.91		**15.30**	151		
	Fisher Cast Steel			*14.00*	No effluent samples taken during survey.		
	Jefferson Lodge MHP WWTP			*9.00*	No effluent samples taken during survey.		
	Oakwood Acres WWTP			*8.00*	No effluent samples taken during survey.		
	B&B Motel WWTP			*7.00*	No effluent samples taken during survey.		
		58/9.10		**6.50**	163		
	West Jefferson WWTP			*5.35*			
		56/9.62		**4.10**	170		
		49/8.99	77.5	**0.70**	176		
--Clover Run (RM 39.80)		36/NA	60.0	**0.60**	2.0		
--Lake Run (RM 36.90)		42/NA	71.0	**0.90**	6.0		
---Jumping Run (RM 3.90)		30/NA	63.0	**0.30**	2.4		

River/Stream	NPDES Discharge	IBI/MIWB	QHEI	River Mile	Drainage Area	Parameter	(Value) code
--Treacle Creek (RM 31.30)		40/NA	67.5	**11.80**	5.7		
		52/NA		**8.30**	10.3		
		48/NA	66.5	**6.00**	17.0		
				0.80	38.1		
---Howard Run (RM 5.40)		52/NA	55.5	**0.60**	2.6		
---Proctor Run (RM 3.69)	Triad Schools			*7.00*	No effluent samples taken during survey.		
		42/NA	71.5	**4.90**	3.9		
		48/NA	65.0	**3.10**	9.1		
		52/NA	73.0	**1.60**	10.0		
--Barron Creek (RM 24.40)				**0.20**	6.3		
--Spring Fork (RM 17.46)		48/NA	60.5	**15.90**	4.3		
		54/NA	62.5	**13.40**	8.3		
		48/NA	54.5	**7.80**	19.3		
	Green Meadows MHP WWTP			*1.10*	No effluent samples taken during survey.		
				0.80	38.1		
---Bales Ditch (RM 3.64)		50/NA	70.0	0.40 U	5.2		
-Smith Ditch (RM 31.69)		52/NA	77.5	2.10 U	5.9		
-Unnamed Trib. to Big Darby Creek (27.93)	Pleasant Acres MHP			*1.00*	No effluent samples taken during survey.		
	Community Gardens MHP			*1.00*	No effluent samples taken during survey.		
--Unnamed Trib. to Smith Ditch (RM 0.06)		50/NA	67.0	0.10 U	0.9		

River/Stream	NPDES Discharge	IBI/MIWB	QHEI	River Mile	Drainage Area	Parameter	(Value) code
-Hellbranch Run (RM 26.10)		36/6.76	39.5	10.10			
		32/8.17	51.0	7.40			
	Oakhurst Knolls WWTP			*5.81*	No effluent samples taken during survey.		
		35/8.16	65.5	5.80			
		47/9.02	83.5	3.70			
	Pleasantview School WWTP			*1.14*	No effluent samples taken during survey.		
		49/9.18	84.5	0.90			
	Timberlake Subdivision WWTP			*0.51*	No effluent samples taken during survey.		
		41/9.07	83.5	0.50		D.O.	(3.60)‡‡
--Hamilton Ditch (RM 11.19)		16/NA	21.0	3.40	4.3		
	Alton Campground WWTP			0.50	No effluent samples taken during survey.		
		24/NA	36.5	0.50	10.2		
--Clover Groff Ditch (RM 11.19)		18/NA	22.0	4.70	4.5		
	Thorn Apple Country Club WWTP			*2.65*	No effluent samples taken during survey.		
	Cypress Wesleyan School WWTP			*1.30*	No effluent samples taken during survey.		
		28/NA	61.5	0.80	8.2		
-Springwater Run (RM 24.00)		50/NA	48.5	0.20	3.4		
-Unnamed Trib. to Big Darby Creek (aka Clark's Lake Outlet RM 20.20)	Foxlair Farms WWTP			*2.45*	No effluent samples taken during survey.		
	Clark's Lake Subdivision WWTP			*1.54*	No effluent samples taken during survey.		
		44/NA	77.5	0.80 U	4.3		
-Greenbrier Creek (RM 16.75)		40/NA	57.0	2.70	4.4	D.O.	(3.07)‡‡
		46/NA	74.5	1.30			

River/Stream	NPDES Discharge	IBI/MIWB	QHEI	River Mile	Drainage Area	Parameter	(Value) code
-Georges Run (RM 14.40)		46/NA	61.0	0.50	1.2		

❣ Water quality criteria identified for the warmwater habitat use designation apply to water bodies not assigned an aquatic life use designation. Primary Contact Recreation criteria are used for reference only.
✪ exceedence of NPDES permit limitation 30 day average.
* exceedence of numerical criteria for prevention of chronic toxicity [Chronic Aquatic Conc. (CAC)].
** exceedence of numerical criteria for prevention of acute toxicity [Acute Aquatic Conc. (AAC)].
*** exceedence of numerical criteria for prevention of acute toxicity inside the mixing zone [i.e., Final Acute Value (FAV)].
‡‡ exceedence of the minimum exceptional warmwater habitat or warmwater habitat dissolved oxygen criterion (EWH = 5.0 mg/l, WWH = 4.0 mg/l).
◊◊ exceedence of the maximum Primary Contact Recreation (PCR) criterion (E. coli 298/100 ml, Fecal coliform 2000/100mL).
◊◊◊ exceedence of the maximum Secondary Contact Recreation (SCR) criterion (E. coli 576/100 ml, Fecal coliform 5000/100 ml).

Table B.3.2. Comparison of background nutrient and demand parameter concentrations with those found in the Big Darby Creek study area, 2001. Comparisons are made to Eastern Corn Belt Plains (ECBP) ecoregion background 50th percentile (median), 75th, 90th, and 95th percentile values for headwaters, wadeable, and small river sites. Units are mg/l for all parameters. Plain text river miles indicate Warmwater Habitat, boldface river miles are designated Exceptional Warmwater Habitat, effluent discharges are in italic print, undesignated streams have a letter U following the river mile, and areas designated Modified Warmwater Habitat are underlined.

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
Big Darby Creek		68.0	82.50	1.5	TSS Ammonia Nitrite TKN TP	(*39*, *23*, *16*, 11, 7) (*0.077*) (0.074) (1.22, 0.47, 0.41) (**0.476**, 0.051)
		64.5	79.20	5.6	TSS Nitrite TKN TP	(**79**, *16*, 12, 8, 8) (*0.043*) (*0.61*, 0.45) (*0.092*)
	Flat Branch WWTP		*78.48*			
		63.5	**78.40**	19.4	TSS Nitrite TKN TP	(64, 63, *44*, *29*) (0.071, 0.051, 0.027, 0.022) (*0.74*, 0.53, 0.47, 0.42, 0.41) (*0.182*, *0.172*, *0.135*, *0.113*, 0.073)
		73.5	**76.60**	32	TSS Nitrate Nitrite TKN TP	(**105**, 56, 29, 24) (1.04, 1.02) (0.061, *0.024*) (1.00, *0.74*, *0.66*, *0.60*) (0.297, *0.157*)
		70.5	**69.40**	70	TSS Nitrate Nitrite TKN TP	(**89**, *44*, *41*, 19, 15) (*3.03*, 1.24, 0.85) (*0.029*, *0.027*) (0.52) (*0.196*, 0.077, 0.074)
	Darby Creek Golf Course WWTP		*64.00*			
		80.5	**63.80**	89	TSS Nitrate Nitrite TKN TP	(24, 23, 15) (**6.30**, 1.25, 0.98) (*0.044*) (0.56, 0.55, 0.55) (0.078)
	Fairbanks School WWTP		*63.74*			

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
		83.5	**62.50**	121	TSS Ammonia Nitrate Nitrite TKN	(25, 22, 19) (*0.054*) (*4.32*, 1.21, 1.02) (*0.038*, *0.022*) (0.60, 0.59, 0.52, 0.51)
		83.5	**54.20**	136	TSS Nitrate Nitrite TKN TP	(*41*, *34*, *33*, 24) (*4.11*, 1.72, 1.37) (*0.033*, *0.021*) (*0.66*, 0.58) (**1.75**, 0.088, 0.084)
	Ranco, Inc.		*54.00*			
		93.0	**53.90**	136	TSS Ammonia Nitrate Nitrite TKN TP	(40, 29, 27, 20) (*0.052*) (*4.05*, 1.72, 1.46, 1.03) (*0.035*, *0.024*) (*0.67*, 0.52) (0.124, 0.091)
	Tuffco Sand and Gravel		*52.40*			
			52.10	150	TSS Nitrate Nitrite TKN TP	(*42*, *36*, 23, 17, 17) (**6.13**, 1.74, 1.21, 1.10) (0.054, *0.022*) (*0.63*, *0.61*, 0.56, 0.52) (0.166, 0.141, 0.097, 0.092, 0.082)
	Plain City WWTP		*52.05*			
		81.0	**52.00**	150	TSS Ammonia Nitrate Nitrite TKN TP	(*43*, *30*, 29, 26, 15) (**1.54**, **0.329**, **0.314**, **0.227**, 0.131) (**7.6**, *3.61*, *3.32*, 2.45, 1.08) (**0.249**, **0.211**, 0.083, *0.044*, *0.035*) (**2.95**, **1.55**, **1.37**, **1.12**) (**1.65**, 0.226, *0.204*, *0.158*)
	Suburbans MHP WWTP		*49.68*			
		76.0	**49.50**	177	TSS Nitrate Nitrite TKN TP	(29, 23, 17, 16, 15) (*4.01*, 1.52, 1.03) (*0.024*) (0.59, 0.56, 0.55, 0.52) (*0.158*, *0.133*, 0.09, 0.071)
	Wisslohican Sanitary Sewer Dist. WWTP		*45.00*			

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
		81.5	**42.00**		Nitrate Nitrite	(*3.30*) (*0.025*)
	Battelle Memorial Institute WWTP		*40.55*			
	Lake Darby Estates WWTP		*40.00*			
	Greentree MHP WWTP		*39.00*			
	Darby Dan Farms WWTP		*36.70*			
		93.5	**34.10**	253	TSS Nitrate TKN	(29) (2.91, 1.98) (*0.85*, 0.66)
	Oak Hills MHP WWTP		*29.29*			
	Darbydale Elementary WWTP		*29.00*			
			27.00	453	Nitrate TKN	(*3.20*, 1.89) (*0.81*)
		87.5	**23.80**	498	Nitrate TP	(*3.14*, 1.85) (0.218)
	Dot-Mar MHP WWTP		*23.77*			
	Pickaway Correctional Inst. WWTP		*22.92*			
		84.5	**22.80**	505	Nitrite Nitrate TP	(0.021) (3.10, 1.92) (*0.294*, 0.216, 0.215, 0.157)
	Foxlair Farms MHP WWTP		*22.50*			
		85.0	**19.10**	513	Nitrate TP	(2.83, 2.00) (**0.556**, *0.29*, *0.255*, 0.238, 0.222)
		85.5	**13.40**	534	Nitrate Nitrite TP	(2.52, 2.1, 1.75) (0.022) (0.154)
		82.0	**3.10**	552	Nitrate TP	(2.52, 2.07, 1.99) (*0.292*, 0.155)

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
-Flat Branch (RM 78.48)	Honda E. Liberty WTP		*4.80*			
		25.5	3.20	3.3	TSS Nitrite TKN TP	(**111**, *47*, *21*, *26*, *14*) (0.074, *0.037*, *0.030*, 0.022) (*0.91*, *0.79*, 0.56, 0.53, 0.50) (0.274, 0.051)
	Honda Benton Road WTP		*2.21*			
			2.20	9.3	TSS Ammonia Nitrite TKN TP	(**113**, *41*, *24*) (0.116, *0.056*) (**0.104**, *0.041*, *0.031*) (*0.69*, *0.66*, 0.58, 0.52) (0.21, *0.109*, *0.091*, 0.072, 0.07)
		36.5	0.80	13.9	TSS Ammonia Nitrite TKN TP	(**74**, 48, *46*, *42*, *41*) (*0.088*, *0.079*) (**0.106**, 0.053, *0.041*, 0.023) (*0.90*, *0.64*, *0.63*, 0.47, 0.42) (*0.138*, *0.091*, 0.076, 0.075, 0.07)
--Unnamed Trib. to Flat Branch (RM 1.50)			0.10 U	3.5	TSS Nitrite TKN TP	(50, *34*, *29*, *16*, 12) (0.069, 0.023) (1.18, *0.90*, 0.57, 0.55, 0.52) (*0.138*, *0.103*, *0.087*, 0.064)
-Little Darby Creek (RM 78.34, Logan Co.)		71.5	3.50 U	2.4	TSS Nitrate Nitrite TKN TP	(*20*, *20*, 7) (*3.39*, *2.80*, 2.22, 1.61) (0.070, *0.036*) (1.02) (*0.177*, *0.106*)
		68.0	0.40 U	7.0	TSS Nitrate Nitrite TKN TP	(43) (1.83, 1.45, 1.03) (*0.046*, 0.025) (*0.78*) (0.254, 0.223)
-Unnamed Trib. to Big Darby Creek (RM 74.91)		62.5	0.20 U	3.9	TSS Nitrate Nitrite TKN TP	(*18*, 10, 9) (5.47, 4.76, *4.24*, *4.02*, *3.41*) (0.029, 0.023) (*0.81*) (0.313, 0.059)

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
-Spain Creek (RM 74.30)		66.0	5.70	3.5	TSS Nitrate Nitrite TKN TP	(**205**, 10) (*2.42*) (0.07) (*0.75*) (*0.142*)
		72.0	3.70		TSS Ammonia Nitrate Nitrite TKN TP	(**56**, *21*, 7) (**0.208**) (1.92, 1.05) (0.022, 0.022) (0.58) (*0.128*)
	North Lewisburg WWTP		*1.50*			
		76.0	0.10	9.1	TSS Ammonia Nitrate Nitrite TKN TP	(*27*) (**0.269**, 0.123) (1.64, 1.21, 1.18) (**0.104**, 0.082, *0.048*, *0.041*) (*0.80*, *0.70*, *0.68*, 0.51) (0.211, 0.210, *0.151*, *0.140*, *0.085*)
-Pleasant Run (RM 72.01)		72.0	**4.10**	4.9	Nitrate Nitrite	(1.03, 1.00) (*0.038*)
		59.5	**0.50**	8.5	TSS Nitrate Nitrite TKN	(*16*) (*3.55*) (*0.042*) (0.42)
-Unnamed Trib. to Big Darby Creek (RM 69.40)		64.5	0.40 U	4.6	TSS Nitrate Nitrite TKN TP	(9, 9, 7) (**11.0**, 4.53, *2.70*) (*0.039*, *0.038*, 0.025) (*0.72*, 0.53) (0.321, *0.086*)
-Hay Run (RM 67.60)		52.5	0.20	5.8	TSS Nitrate Nitrite TKN TP	(7) (**12.4**, *2.73*, 2.18) (*0.039*, 0.024, 0.022) (0.52, 0.45, 0.41) (0.054)

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
-Buck Run (RM 63.74)		40.0	10.40	5.1	TSS	(**81**, 56, 56, *24*, *22*)
					Ammonia	(*0.091*)
					Nitrite	(0.082, *0.047*, 0.027, 0.025)
					TKN	(*0.96*, *0.86*, *0.68*, *0.65*, *0.65*)
					TP	(*0.148*, *0.11*, 0.056)
		55.5	7.80	9.2	TSS	(50, *32*, *31*, *26*, *18*)
					Ammonia	(**0.31**, 0.123, *0.079*, *0.075*)
					Nitrite	(**0.114**, 0.025)
					TKN	(1.05, *0.97*, *0.92*, *0.89*, *0.86*)
					TP	(0.25, 0.066, 0.065, 0.051)
			5.00	18.1	TSS	(59, 52, 49, *28*, *17*)
					Ammonia	(*0.076*, *0.054*)
					Nitrite	(*0.043*, 0.021)
					TKN	(**1.30**, *0.74*, *0.69*, 0.54, 0.50)
					TP	(0.26, 0.052, 0.051)
		70.5	0.10	29.8	TSS	(*33*, *32*, *27*, *21*, *19*)
					Ammonia	(0.107, *0.084*, *0.072*)
					Nitrate	(1.75)
					Nitrite	(*0.031*, *0.021*)
					TKN	(**1.17**, 1.08, 0.96, *0.71*, *0.63*)
					TP	(0.085, 0.073, 0.072)
-Robinson Run (RM 53.69)	St. Johns Church WWTP		*8.04*			
	Darby Meadows WWTP		*5.23*			
		64.0	2.10	8.4	TSS	(*29*, 12, 7)
					Ammonia	(0.112, *0.083*, *0.063*)
					Nitrate	(**6.01**, 1.15)
					Nitrite	(**0.14**, 0.024)
					TKN	(1.34, 1.20, 1.16, 1.12, 0.90)
					TP	(*0.142*, *0.12*, *0.083*, 0.077, 0.06)
		70.0	0.70	11.5	TSS	(65, 10)
					Ammonia	(*0.064*)
					Nitrate	(1.54, 1.32)
					Nitrite	(0.08, 0.022)
					TKN	(1.11, 1.10, *0.90*, *0.85*, *0.83*)
					TP	(*0.115*, *0.111*, *0.083*, *0.08*, 0.059)
-Sweeney Run (RM 52.11)		58.0	0.10 U	4.0	TSS	(11, 9)
					Ammonia	(**2.55**, *0.053*)
					Nitrate	(**11.2**, 4.66, *2.39*)
					Nitrite	(0.071, *0.039*, 0.029, 0.022)
					TKN	(**3.95**, 1.19, *0.7*, *0.62*, 0.54)
					TP	(**0.76**, 0.222, 0.217, *0.129*, *0.08*)

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
-Sugar Run (RM 50.92)		31.0	7.50	4.1	TSS	(**75**)
					Ammonia	(*0.08*, *0.057*)
					Nitrate	(4.72)
					Nitrite	(*0.036*)
					TKN	(**1.77**, **1.59**, **1.50**, **1.47**, *0.76*)
					TP	(0.313, 0.31, 0.25, *0.139*, *0.093*)
		29.5	7.00	9.5	TSS	(**72**, *34*, *20*, 12, 11)
					Ammonia	(0.111, *0.074*)
					Nitrate	(**8.34**)
					Nitrite	(0.057, *0.036*)
					TKN	(**1.51**, **1.50**, 1.27, *1.01*, *0.98*)
					TP	(0.238, *0.131*, *0.10*, *0.10*, 0.07)
		38.5	5.40	11.0	TSS	(*31*, *27*, *20*, 10, 9)
					Ammonia	(**0.194**, *0.095*, *0.09*, *0.089*, *0.066*)
					Nitrate	(**6.66**)
					Nitrite	(0.074, *0.042*, 0.025, 0.022, 0.021)
					TKN	(**1.42**, 1.33, 1.20, 1.10, *0.66*)
					TP	(*0.188*, *0.136*, *0.134*, *0.123*, *0.11*)
		65.5	0.50	19.4	TSS	(*31*, *21*, *15*, 12, 8)
					Ammonia	(*0.08*, *0.056*)
					Nitrate	(4.81)
					Nitrite	(0.057)
					TKN	(1.15, *0.97*, *0.92*, *0.68*, *0.64*)
					TP	(**0.58**, *0.11*, *0.102*, 0.067, 0.061)
-Worthington Ditch (RM 50.62)			0.20 U	4.4	TSS	(*22*)
					Ammonia	(*0.059*)
					Nitrate	(**10.3**, 1.45, 1.27, 1.16)
					Nitrite	(*0.033*, 0.022)
					TKN	(*0.85*, *0.76*, *0.71*, *0.61*, 0.57)
					TP	(*0.182*, *0.151*, *0.128*, 0.074, 0.059)
-Ballenger-Jones Ditch (RM 49.68)	Jonathan Alder School WWTP		*2.55*			
		69.0	0.20 U	6.0	Nitrate	(**9.17**)
					Nitrite	(*0.036*)
					TKN	(*0.98*, *0.71*, *0.69*, 0.59, 0.57)
					TP	(*0.128*, *0.101*, *0.089*)

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
-Powell Ditch (RM 48.35)	COJV School District WWTP		*2.68*			
-Yutzy Ditch (RM 47.10)	Cannan Elementary WWTP		*2.25*			
			0.40 U	4.3	Nitrate	(**13.0**)
					Nitrite	(*0.03*)
					TKN	(1.28, 1.08, *0.92*, *0.80*, *0.72*)
					TP	(*0.091*, 0.077, 0.064)
-Fitzgerald Ditch (RM 44.96)	Canaan Community MHP WWTP		*1.40*			
		56.5	0.50 U	5.1	TSS	(*15*, 13)
					Ammonia	(**0.215**, 0.10)
					Nitrate	(**11.4**, 4.66, *4.26*, *4.22*, *3.10*)
					Nitrite	(*0.033*, 0.021)
					TKN	(1.3, 1.2, *0.94*, *0.87*, *0.68*)
					TP	(**1.38**, **0.693**, **0.502**, 0.236, *0.111*)
-Little Darby Creek (RM 34.10)			**41.20**	3.3	Nitrate	(*3.81*, *3.74*, *3.69*, *3.67*)
			39.60	9.4	TSS	(*14*)
					Nitrate	(*2.70*, *2.52*, *2.47*, *2.42*, *2.3*)
	Mechanicsburg WWTP		*39.20*			
			38.80	13.2	TSS	(9)
					Ammonia	(*0.09*, *0.08*)
					Nitrate	(*2.48*, *2.27*, 2.17, 2.17, 2.14)
					TKN	(0.49, 0.43)
					TP	(*0.21*, *0.14*, *0.13*, *0.12*)
			34.70	25.9	TSS	(16, 14)
					Ammonia	(*0.08*, *0.07*, *0.07*)
					Nitrate	(2.75, 1.65, 1.28, 1.24, 1.23)
					TP	(0.07)
			29.50	70	TSS	(*30*, 15)
					Ammonia	(*0.08*, *0.06*)
					Nitrate	(5.02, 1.73, 1.41)
					Nitrite	(*0.03*)
					TKN	(0.52)
			24.50	83	TSS	(*37*, 25, 23, 20)
					Ammonia	(0.11, *0.06*)
					Nitrate	(**6.04**, 2.07, 1.55)
					TKN	(0.54, 0.52)
					TP	(*0.14*, 0.07)

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
			15.30	151	TSS Nitrate TKN TP	(14) (**6.07**, 2.48, 1.40) (*0.75*, 0.51) (0.11, 0.07, 0.07)
	Fisher Cast Steel		*14.00*			
	Jefferson Lodge MHP WWTP		*9.00*			
	Oakwood Acres WWTP		*8.00*			
	B&B Motel WWTP		*7.00*			
			6.50	163	TSS Nitrate TKN TP	(14) (5.97, 2.19, 1.53) (*0.65*, 0.53, 0.50) (*0.14*, 0.10, 0.08)
	West Jefferson WWTP		*5.35*			
			4.10	170	Nitrate TKN TP	(5.38, 2.53, 2.1, 1.08, 1.07) (0.57, 0.51) (*0.14*, *0.13*, 0.11, 0.10)
		77.5	**0.70**	176	Nitrate TKN TP	(4.55, 2.44, 2.37, 1.18, 1.08) (0.59, 0.58, 0.54, 0.54) (*0.14*, *0.13*, 0.10, 0.09)
--Clover Run (RM 39.80)		60.0	**0.60**	2.0	TSS Nitrate TKN TP	(7, 7) (1.86, 1.46) (0.42) (*0.08*, 0.07)
--Lake Run (RM 36.90)		71.0	**0.90**	6.0	TSS Ammonia Nitrate TKN	(8) (0.10, *0.08*, *0.07*, *0.07*) (2.12, 1.04) (0.51, 0.43, 0.41, 0.40)
---Jumping Run (RM 3.90)		63.0	**0.30**	2.4	TSS Nitrate TKN	(7) (*3.81*, *2.66*, 1.95) (0.44)

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
--Treacle Creek (RM 31.30)		67.5	**11.80**	5.7	TSS	(12, 9, 6)
					Ammonia	(**0.76**, **0.30**, *0.06*)
					Nitrate	(*3.42*, 1.10, 1.04)
					Nitrite	(**0.15**, 0.07, *0.03*, *0.03*)
					TKN	(**1.86**, *0.88*, 0.48, 0.44)
					TP	(*0.08*, *0.08*, 0.06)
			8.30	10.3	TSS	(13)
					Nitrate	(*3.12*, *2.58*, 2.07, 1.29, 1.05)
					TKN	(0.45, 0.45)
					TP	(**0.52**)
		66.5	**6.00**	17.0	TSS	(**134**, *33*, 12)
					Nitrate	(*3.73*, *2.86*, 1.87, 1.25)
					TKN	(*0.60*, 0.43)
			0.80	38.1	TSS	(*43*, *33*, *29*, 20)
					Ammonia	(0.13, 0.10, 0.10)
					Nitrate	(5.64, 1.74, 1.58, 1.11)
					Nitrite	(*0.03*, *0.03*)
					TKN	(*0.68*, 0.58)
					TP	(0.09, 0.07)
---Howard Run (RM 5.40)		55.5	**0.60**	2.6	TSS	(12, 9)
					Nitrate	(4.76, 2.16)
					Nitrite	(*0.03*)
					TKN	(*0.61*, 0.41)
---Proctor Run (RM 3.69)	Triad Schools		*7.00*			
		71.5	**4.90**	3.9	TSS	(*31*, *21*, 13, 9)
					Ammonia	(0.10, *0.07*)
					Nitrate	(1.55)
					TKN	(0.51, 0.44)
					TP	(*0.11*)
		65.0	**3.10**	9.1	TSS	(10)
					Nitrate	(*4.54*, 2.88, 1.03)
					Nitrite	(*0.03*)
					TKN	(*0.62*, 0.49, 0.44)
		73.0	**1.60**	10.0	Nitrate	(*3.94*, 2.11, 1.02)
					TKN	(0.53, 0.46, 0.44, 0.42)
--Barron Creek (RM 24.40)		44.5	**0.20**	6.3	TSS	(58, *20*, 12, 10)
					Ammonia	(*0.08*, *0.06*, *0.06*)
					Nitrate	(*4.56*)
					Nitrite	(*0.04*, *0.03*, *0.03*)
					TKN	(0.91, *0.73*, *0.70*, 0.58, 0.52)
					TP	(*0.16*, *0.11*)

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
--Spring Fork (RM 17.46)		60.5	**15.90**	4.3	TSS Nitrate Nitrite TKN TP	(*21*) (*3.91*, *3.76*, 1.81, 1.77) (*0.04*, *0.03*) (1.06, *0.72*, 0.44, 0.43, 0.42) (*0.15*)
		62.5	**13.40**	8.3	TSS Nitrate Nitrite TKN TP	(*21*) (*2.99*, 1.86) (*0.04*) (1.00, *0.68*) (*0.17*)
		54.5	**7.80**	19.3	TSS Nitrate Nitrite TKN TP	(*32*, 8) (5.06, 2.15, 1.80) (*0.04*) (*0.71*, 0.54, 0.53, 0.51, 0.47) (0.07)
	Green Meadows MHP WWTP		*1.10*			
			0.80	38.1	TSS Ammonia Nitrate Nitrite TKN TP	(24) (*0.09*, *0.07*, *0.06*) (5.34, *2.88*, 2.29, 1.72, 1.10) (0.05, *0.04*, *0.03*, *0.03*) (*0.72*, *0.70*, *0.64*, 0.57) (*0.17*, *0.13*, 0.10, 0.07)
---Bales Ditch (RM 3.64)		70.0	0.40 U	5.2	TSS Nitrate Nitrite TKN TP	(*16*) (**8.28**, *3.04*) (*0.04*, *0.04*) (*0.76*, *0.62*, *0.62*, 0.59, 0.57) (0.08, 0.06)
-Smith Ditch (RM 31.69)		77.5	2.10 U	5.9	TSS Nitrate TKN TP	(10) (2.54, 2.02) (0.41) (0.236, 0.054)
-Unnamed Trib. To Big Darby Creek (RM 27.39)	Pleasant Acres MHP WWTP		*1.00*			
	Community Gardens WWTP		*1.00*			
--Unnamed Trib. to Smith Ditch (RM 0.06)		67.0	0.10 U	0.9	Nitrate TP	(1.93) (0.055)

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
-Hellbranch Run (RM 26.10)		39.5	10.10	23	TSS Ammonia Nitrate Nitrite TKN TP	(*41*, *31*, 19, 16, 16) (*0.084*, *0.084*) (1.75) (*0.024*, *0.023*, *0.021*) (1.02, *0.78*, *0.67*, *0.62*) (0.259, *0.209*, *0.134*, 0.104, 0.092)
		51.0	7.40	27	Nitrite TKN TP	(2.01, 0.89) (*0.77*, *0.75*, *0.66*, 0.56, 0.54) (0.122, 0.114, 0.102, 0.085, 0.081)
	Oakhurst Knolls WWTP		*5.81*			
		65.5	5.80	30	Nitrate Nitrite TKN TP	(2.16, 2.16, 1.53, 1.17) (*0.025*) (*0.86*, *0.80*, *0.78*, *0.76*, *0.67*) (**0.307**, *0.215*, *0.15*, *0.147*, *0.137*)
		83.5	3.70	32	Ammonia Nitrate TKN TP	(*0.06*) (2.12, 1.20, 1.09) (0.95, *0.80*, *0.79*, *0.69*, 0.59) (*0.144*, *0.135*, 0.115, 0.111, 0.103)
	Pleasantville School WWTP		*1.14*			
		84.5	0.90	35	Nitrate TKN TP	(1.83, 1.24) (*0.63*, *0.62*) (0.117, 0.087, 0.078)
	Timberlake Subdivision WWTP		*0.51*			
		83.5	0.50	35	TSS Ammonia Nitrate Nitrite TKN TP	(14) (**0.257**, **0.24**, *0.079*) (1.82, 1.63, 1.36, 1.18) (*0.047*, *0.041*, *0.031*) (0.98, 0.93, *0.80*, 0.58, 0.52) (**0.372**, **0.356**, 0.296, *0.21*, *0.192*)

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
--Hamilton Ditch (RM 11.19)		21.0	3.40	4.3	TSS	(**150**, **96**, *20*, *17*)
					Ammonia	(**0.40**, *0.075*, *0.073*, *0.058*, *0.053*)
					Nitrate	(1.90, 1.21, 0.99)
					Nitrite	(0.059, 0.05, *0.047*, *0.04*, *0.037*)
						(**1.61**, *0.91*, *0.76*, *0.65*, *0.64*)
					TKN	(**0.443**, 0.281, 0.249, 0.227,
					TP	0.226)
	Alton Campground WWTP		*0.50*			
		36.5	0.50	10.2	TSS	(13, 9, 8, 8)
					Ammonia	(0.142, *0.073*, *0.068*, *0.059*)
					Nitrate	(*3.43*, 0.99)
					Nitrite	(*0.043*, *0.037*, *0.03*, 0.028)
					TKN	(1.34, *0.94*, *0.78*, *0.64*, 0.58)
					TP	(0.269, 0.237, 0.226, *0.197*, *0.137*)
--Clover Groff Ditch (RM 11.19)		22.0	4.70	4.5	TSS	(*21*, 11, 9)
					Ammonia	(**0.278**, 0.162, 0.149, 0.10, *0.097*)
					Nitrite	(0.05, *0.031*, 0.029 0.026)
					TKN	(*0.85*, *0.83, 0.75*, 0.54)
					TP	(**0.912**, 0.08, 0.067)
	Thornapple Country Club WWTP		*2.65*			
	Cypress Wesleyan School WWTP		*1.30*			
		61.5	0.80	8.2	TSS	(8, 8)
					Ammonia	(0.105, *0.082*)
					Nitrite	(*0.044*, *0.035*, *0.034*, 0.024)
					TKN	(*0.88*, *0.79*, *0.78*, 0.57, 0.48)
					TP	(0.35, *0.137*, *0.10*, *0.095*, 0.077)
-Springwater Run (RM 24.00)		48.5	0.20	3.4	Nitrate	(*2.94*, *2.62*, 1.50, 1.39, 1.02)
					TKN	(*0.99*, *0.75*, *0.71*, 0.57)
					TP	(0.22, *0.197*, *0.19*, *0.174*, *0.174*)

River/Stream (River Mile of Tributary)	NPDES Discharge	QHEI	River Mile	Drainage Area	Parameter	(Value) code mg/l
-Unnamed Trib. to Big Darby Creek (aka Clark's Lake Outlet, RM 20.20)	Foxlair Farms WWTP		*2.45*			
	Clark's Lake Subdivision WWTP		*1.54*			
		77.5	0.80 U	4.3	TSS Ammonia Nitrate Nitrite TKN TP	(7) (**0.529**) (1.68, 1.65, 1.38, 1.22) (**0.228**, *0.042*, 0.027) (<u>1.16</u>, *0.74*, *0.68*, 0.55, 0.52) (<u>0.208</u>, <u>0.207</u>, *0.197*, *0.157*, *0.115*)
-Greenbrier Creek (RM 16.75)		57.0	2.70	4.4	TSS Ammonia Nitrate TKN TP	(8) (*0.067*) (**7.57**, *4.23*, 1.25) (*0.78*, *0.63*, 0.52, 0.42) (<u>0.216</u>, *0.143*, *0.119*, *0.114*, *0.094*)
		74.5	1.30	7.0	TSS Nitrate TKN TP	(*18*) (*3.75*, *3.67*) (0.40) (*0.125*, *0.095*)
-Georges Run (RM 14.40)		61.0	0.50	1.2	Nitrate TKN TP	(1.25) (0.44) (0.055)

TSS = Total Suspended Solids, TKN = Total Kjeldahl Nitrogen, TP = Total Phosphorus
Normal print values exceed the 50th percentile background
Italic print values exceed the *75th* percentile background
<u>Underlined</u> values exceed the <u>90th</u> percentile background
Boldfaced values exceed the **95th** percentile background

Figure B.3.1 Number of *E. coli* colonies/100 ml. from samples collected in the upper Big Darby Creek mainstem, 2001.

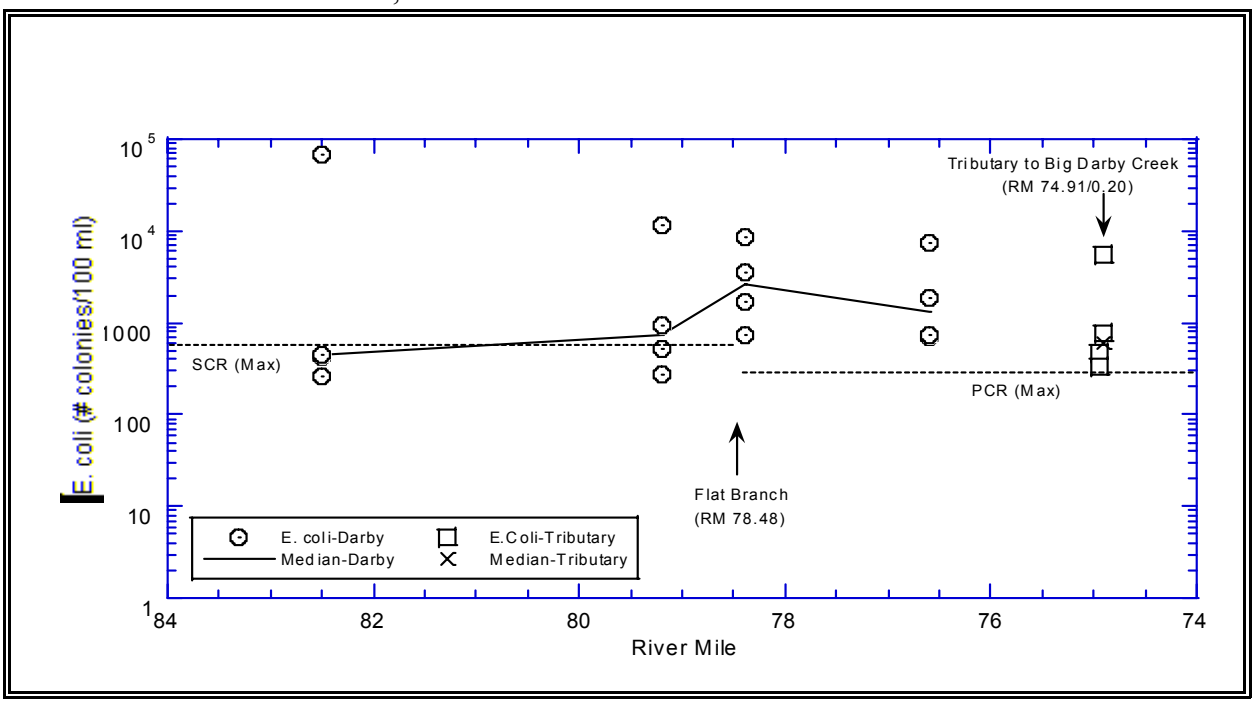


Figure B.3.2. Number of Fecal Coliform colonies/100 ml. from samples collected in the upper Big Darby Creek mainstem, 2001.

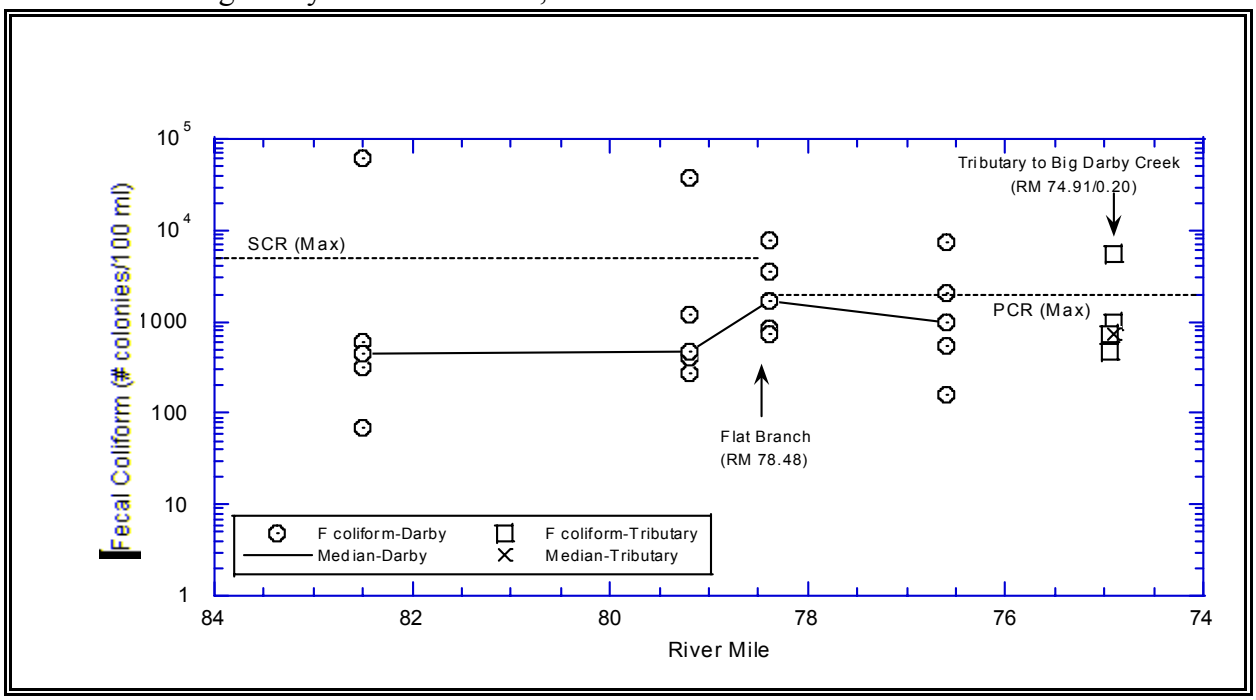
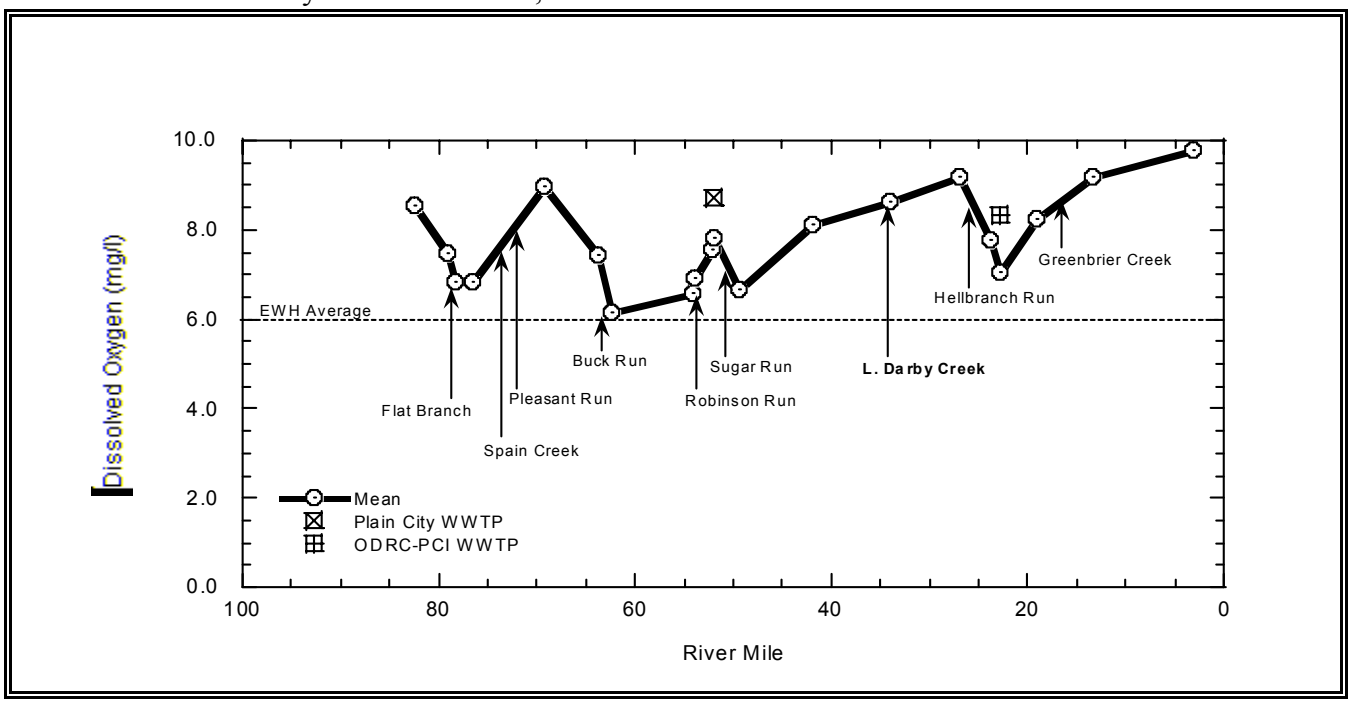


Figure B.3.3. Longitudinal trend in mean Dissolved Oxygen concentrations measured in the Big Darby Creek mainstem, 2002.



Mean total suspended solids in Big Darby Creek increased markedly downstream of the confluence with Flat Branch. Flat Branch was a major source of total suspended solids loading to Big Darby Creek as documented by sample results and photographs (Figure B.3.4). Drainage from the Honda property could be the source, as discussed in the following section on Flat Branch. The pollution influence from Flat Branch extended well downstream and was augmented by suspended solids loadings from the Flat Branch WWTP and Buck Run. Fully 80% of the samples taken at the eight sites between RM 78.40 and 52.10 inclusive were greater than the background median for total suspended solids with 32.5% of the total larger than the 75th percentile (Table B.3.2). Comparison of suspended solids concentrations among stream segments of like drainage areas revealed that most upper Big Darby EWH sites exhibited total suspended solids concentrations significantly above those found in comparable sized streams (Figures B.3.7 and B.3.8).

Figure B.3.4. Confluence of Big Darby Creek (left) and Flat Branch (right) documenting turbidity emanating from Flat Branch, 2002.

Figure B.3.5. Box and whisker plot of Total Suspended Solids concentrations at sites having a drainage area of 0 to 2 square miles in drainage area within the Big Darby Creek watershed, 2001.

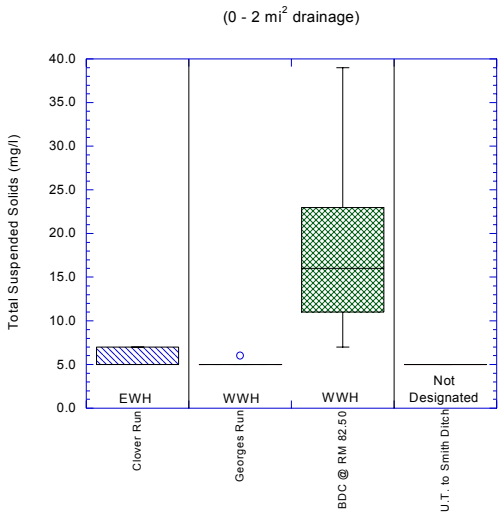


Figure B.3.6. Box and whisker plots of Total Suspended Solids concentrations at sites having a drainage area of 4-8 square miles in drainage area within the Big Darby Creek watershed, 2001.

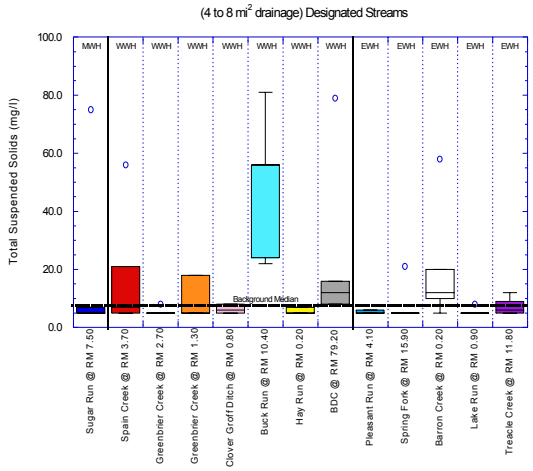


Figure B.3.7. Box and whisker plot of Total Suspended Solids concentrations measured at sampling sites with a drainage area of 16-32 mi² in the Big Darby Creek watershed, 2001.

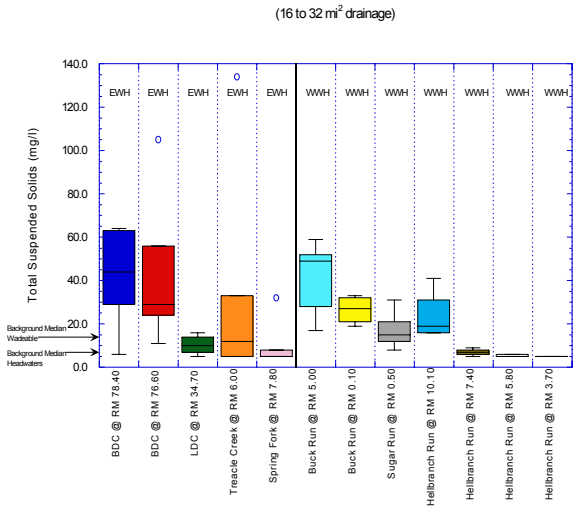
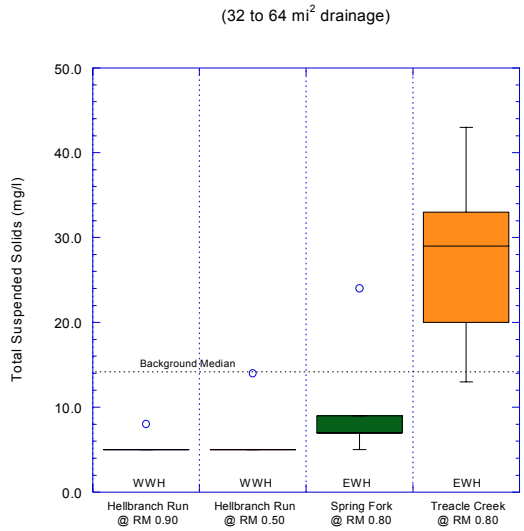


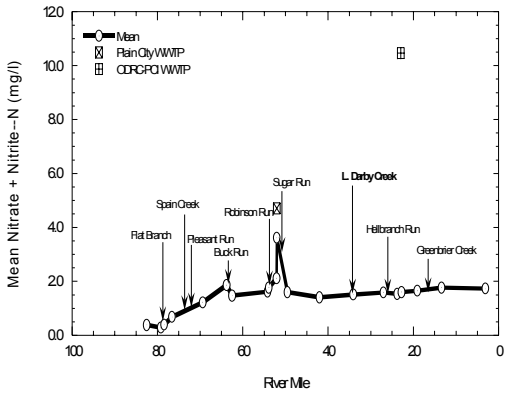
Figure B.3.8. Box and whisker plot of Total Suspended Solids concentrations measured at sampling sites with a drainage area of 64-128 mi² in the Big Darby Creek watershed, 2001.



Nutrient concentrations were also somewhat variable in the upper watershed. Nitrate+nitrite displayed a fairly steady increase over the entire range of the upper Big Darby Creek (Figure B.3.9). Forty four (44) percent of the samples analyzed for nitrate+nitrite in the upper Darby mainstem were found at concentrations greater than the background median (Table B.3.2). Organic nitrogen (TKN) showed a much more stable response with little variation and more consistent readings from site to site. Sixty percent of the samples analyzed for TKN showed concentrations greater than the background median (Table B.3.2). Mean total phosphorus exhibited a more variable response hovering around 0.1 or 0.2 mg/l, peaking and falling again prior to the end of the segment. As with TKN, 60% of the samples exceeded the background median for total phosphorus (Table B.3.2). Flat Branch (stream) and Flat Branch WWTP both contributed significant amounts of phosphorus, nitrite, and organic nitrogen to the Big Darby mainstem as seen at RM 78.40. Although the mean data do not necessarily indicate an increase in nutrients in the mainstem, several tributary streams are contributing significant concentrations of nutrients to Big Darby Creek. Spain Creek (with North Lewisburg WWTP contributing), Buck Run, Robinson Run, and Sweeney Run are all included in this group.

Algal blooms in the upper mainstem, witnessed at various times during the 2001 field effort, were indicative of nutrient enrichment. Partial biological attainment in the mainstem beginning downstream of Flat Branch may be caused by degraded chemical water quality as evidenced by elevated suspended solids and nutrients.

Figure B.3.9. Mean Nitrite + Nitrate concentrations in the Big Darby Creek mainstem, 2001



Flat Branch (02-223) (RM 78.48) (MWH)
Chemical water quality was evaluated at three locations on Flat Branch. Flat Branch is currently designated as MWH, Agricultural Water Supply (AWS), Industrial Water Supply (IWS), and Secondary Contact Recreation (SCR). Water quality criteria were violated in two instances, for temperature at RM 3.20 and copper at RM 2.20 (Table B.3.1). The copper violation may be due to use of an algicide (Cutrine) by Honda of America in ponds directly drained by Flat Branch or its tributaries. Bacterial exceedences were also common at all three sampling locations (Table B.3.1).

Numerous other chemical water quality problems plagued Flat Branch during the survey period. Total suspended solids were found at concentrations that were consistently above the 75th percentile for background and exceeded the 95th percentile at times (Table B.3.2). The problem was traced to runoff from the Honda of America facility. A study was undertaken by the facility, and a plan to ameliorate the water quality problems was developed (Burgess and Niple 2002).

Concentrations of organic nitrogen (TKN), and phosphorus were also excessive (Table B.3.2), but comparable to MWH designated streams of similar drainage area (Figures B.3.11, B.3.12, B.3.16 and B.3.17). Nitrite concentrations in Flat Branch seemed excessive at times with 4 of 15 values greater than the 90th percentile of background. Sources of the nutrients are unknown.

Unnamed Tributary to Flat Branch (02-365) (RM 1.50) (Undesignated/MWH Recommended)
Water quality criteria for WWH apply to this stream even though it is currently undesignated. No chemical water quality criteria violations were noted during the survey period (Table B.3.1). This tributary, however, had some similar water quality problems as its receiving stream, Flat Branch. Suspended solids, organic nitrogen (TKN), and total phosphorus were all found at concentrations much like those found in Flat Branch itself.

Little Darby Creek (02-251) (RM 78.34) (Undesignated/EWH + CWH Recommended)
Chemical water quality sampling was conducted at two sites on Little Darby Creek. Water quality criteria for WWH apply to this stream even though it is currently undesignated. Chemical water quality criteria violations were found at RM 3.50 for copper. Chemical water quality was fairly typical of other streams of the same drainage area (Figures B.3.13, B.3.12, B.3.11, B.3.14, B.3.14', B.3.15 and B.3.18 to B.3.21). Fecal coliform bacterial concentrations also compared favorably with other streams (Figures B.3.22 and B.3.23). *E. coli* concentrations were lower and had a narrow range at the upstream site when compared to similar streams; however, this was not true of the downstream site where values were much wider-ranging with a higher maximum (Figure B.3.24). Comparison of the *E. coli* values with PCR criteria indicated possible bacterial contamination at both sites (Table B.3.1).

Unnamed Tributary to Big Darby Creek (02-361) (RM 74.91) (Undesignated/EWH Recommended)

Chemical water quality sampling was conducted at a single site on this unnamed tributary of Big Darby Creek located southeast of Middleburg. Water quality criteria for WWH apply to this stream even though it is currently undesignated. No chemical water quality criteria violations were noted during the survey period (Table B.3.1).

Nutrient enrichment was apparent with nitrate plus nitrite concentrations exceeding the 75th percentile for background in every sample with 2 of these in excess of the 90th percentile (Table B.3.1). Comparison of this stream with others of the same drainage area also indicated that these concentrations of nitrate plus nitrite were excessive as were *E. coli* bacteria counts (Figures B.3.14 and B.3.24) whereas the presence of other nutrients, suspended solids, and fecal coliform bacteria were at or below the values found in similar streams (Figures B.3.10 to B.3.13 and B.3.22). Dissolved oxygen concentrations varied within a narrow range, suggesting little supersaturation and, therefore, a stable algal community (Figure B.3.15).

Figure B.3.10. Box and whisker plot of Total Suspended Solids concentrations measured at sampling sites with a 2 to 4 mi^2 drainage area in the Big Darby Creek watershed, 2001.

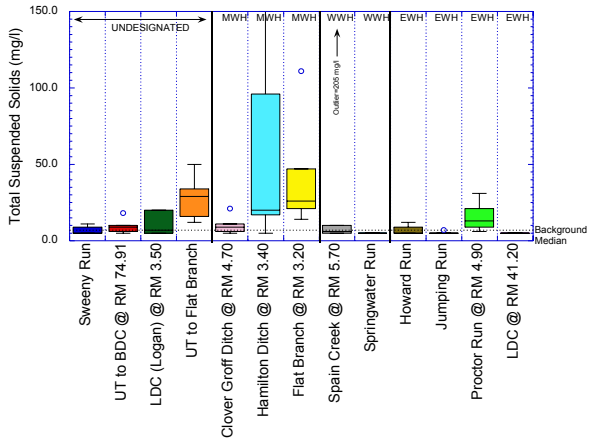


Figure B.3.11. Box and whisker plot for concentrations of Total Kjeldahl Nitrogen in sampling sites having a drainage area of 2-4 mi^2 in the Big Darby Creek watershed, 2001.

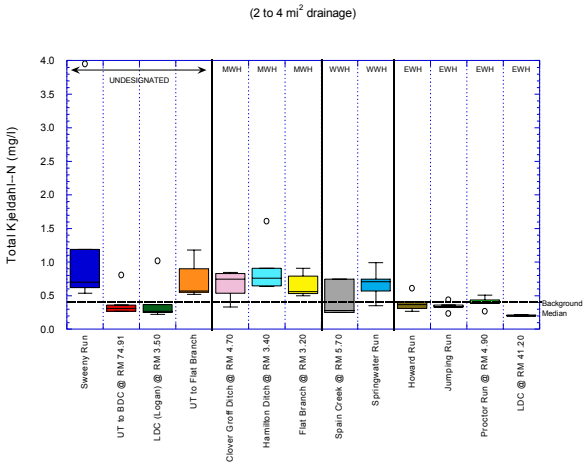


Figure B.3.12. Box and whisker plot for concentrations of Total Phosphorus at sampling sites having a drainage area of 2-4 mi^2 in the Big Darby Creek watershed, 2001.

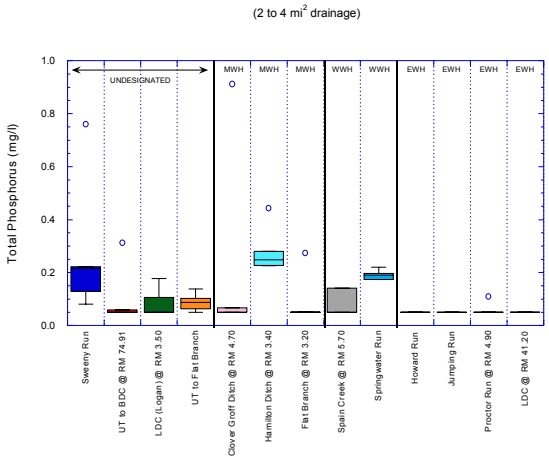


Figure B.3.13. Box and whisker plot of concentrations of Ammonia measured at sampling sites with a drainage area of 2-4 mi^2 in the Big Darby Creek watershed, 2001.

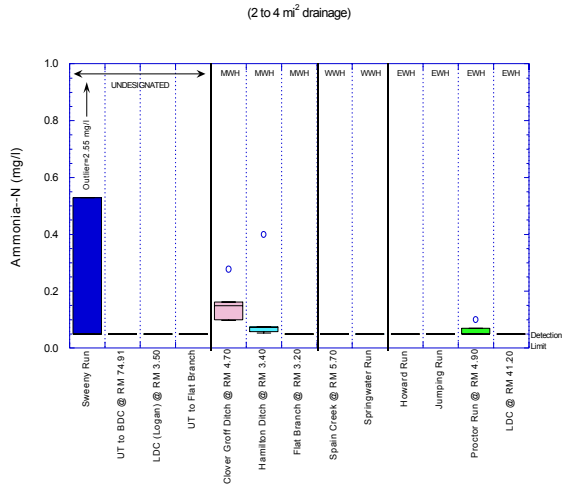


Figure B.3.14. Box and whisker plot of concentrations of Nitrite+Nitrate measured at sampling sites with a drainage area of 2-4 mi^2 in the Big Darby Creek watershed, 2001.

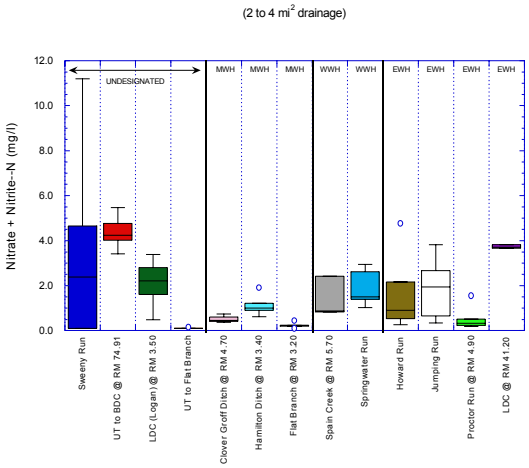


Figure B.3.14'. Box and whisker plot for Total Phosphorus at sites with drainage areas of 2-4 mi^2 in the Big Darby Creek watershed, 2001.

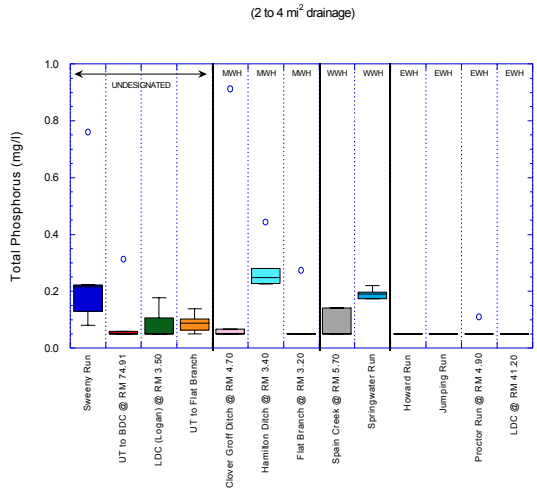


Figure B.3.15. Box and whisker plot for Dissolved Oxygen concentrations at sites with a drainage area of 2-4 mi^2 in the Big Darby Creek watershed, 2001.

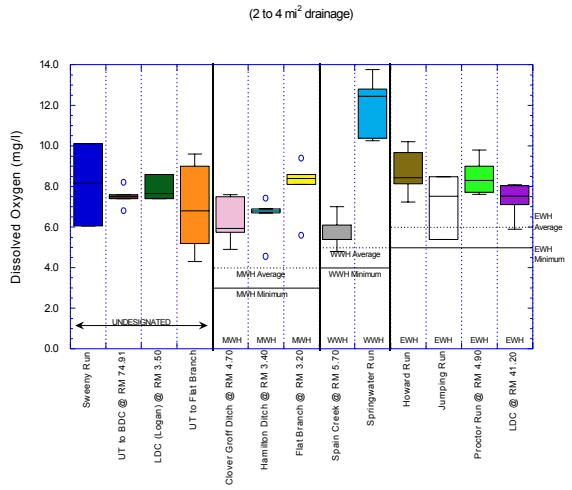


Figure B.3.16. Box and whisker plot for concentrations of Total Kjeldahl Nitrogen at sampling sites having a drainage area of 8-16 mi^2 in the Big Darby Creek watershed, 2001.

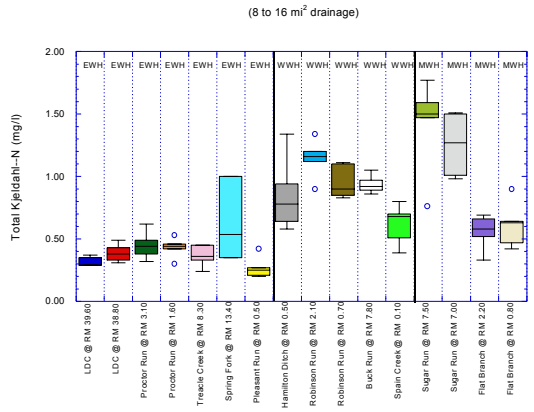


Figure B.3.17. Box and whisker plot for concentrations of Total Phosphorus at sampling sites having a drainage area of 8-16 mi^2 in the Big Darby Creek watershed, 2001.

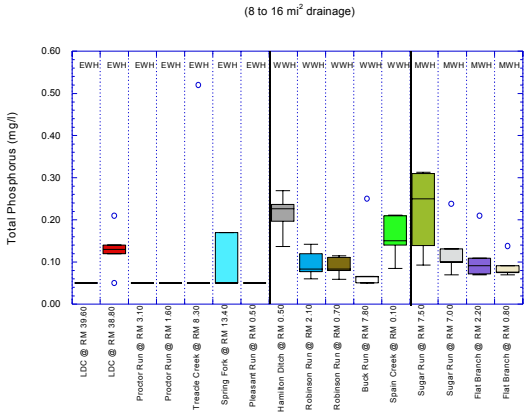


Figure B.3.18. Box and whisker plot for concentrations of Ammonia measured at undesignated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

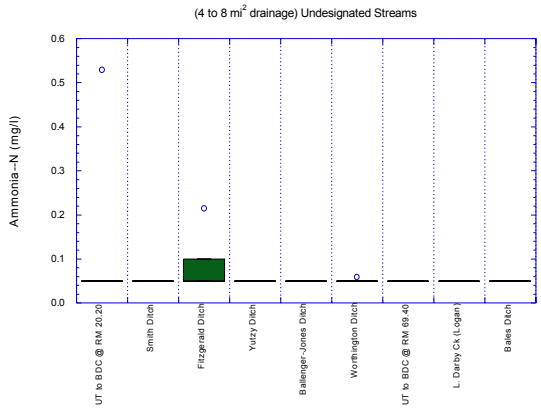


Figure B.3.19. Box and whisker plot for concentrations of Nitrite+Nitrate measured from undesignated sampling sites with a drainage of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

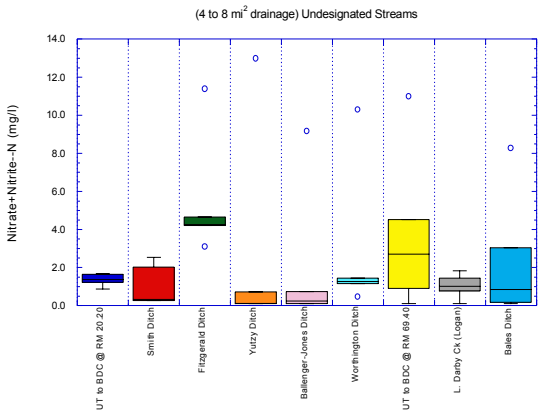


Figure B.3.20. Box and whisker plot of Phosphorus concentrations at undesignated sampling sites with drainage areas of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

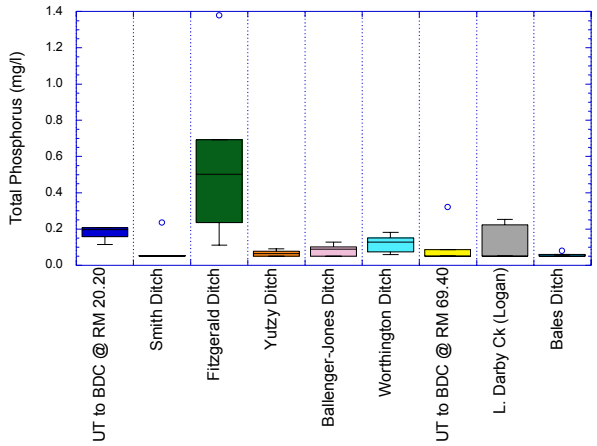


Figure B.3.21. Box and whisker plot of Dissolved Oxygen concentrations at undesignated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

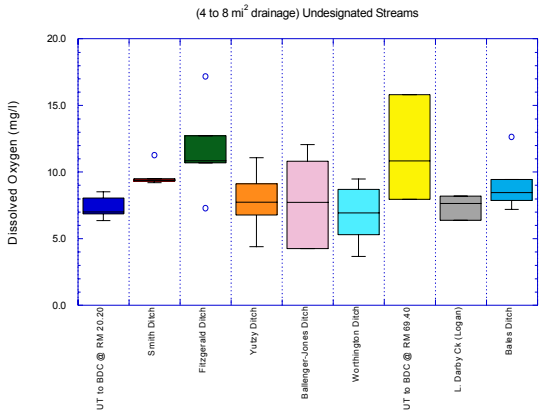


Figure B.3.22. Box and whisker plot for the number Fecal Coliform colonies/100 ml. at sites with a drainage area of 2-4 mi^2 in the Big Darby Creek watershed, 2001.

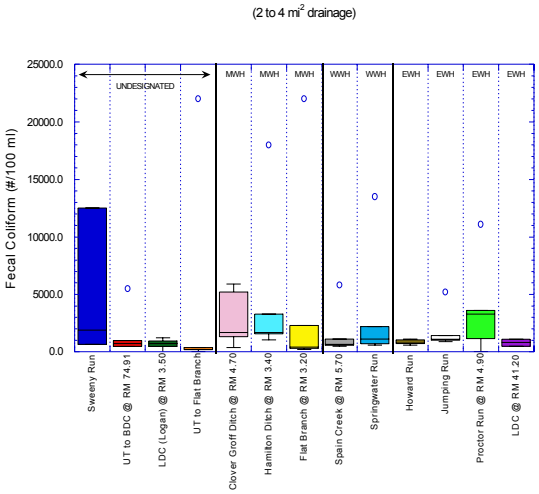


Figure B.3.23. Box and whisker plot for the number Fecal Coliform colonies/100 ml. at undesignated sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

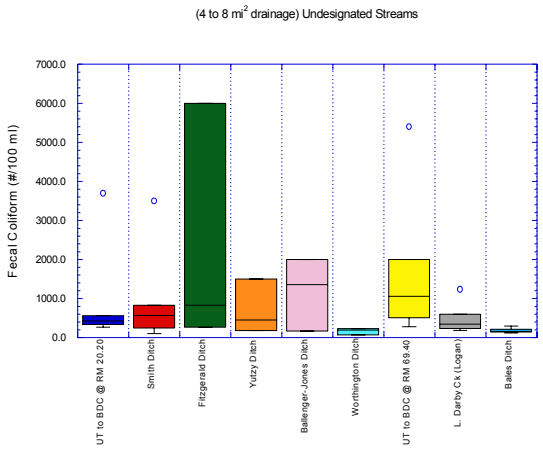
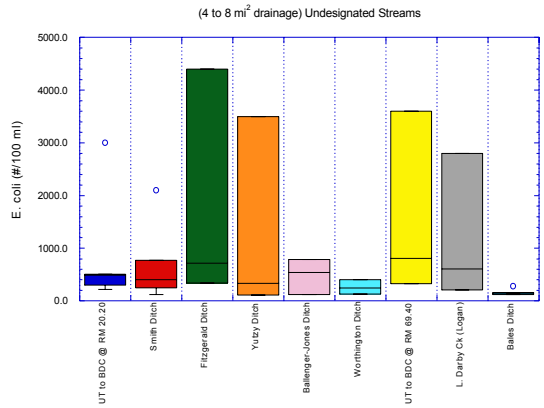


Figure B.3.24. Box and whisker plots of *E. coli* colonies/100 ml. at undesignated sampling sites with drainage areas of 4-8 mi^2 in the Big Darby Creek watershed, 2001.



<u>Spain Creek</u> (02-222) (RM 74.30) (WWH/WWH+CWH Recommended >RM 5.0, EWH+CWH Recommended <RM 5.0)
Chemical water quality was examined at three different sites in the Spain Creek watershed. Spain Creek is currently designated WWH, AWS, IWS, SCR. There were no chemical water quality criteria violations in Spain Creek during the survey period.

Total suspended solids concentrations exceeded the 95th percentile of background at 2 sites on Spain Creek, RM 5.70 and 3.70. The upper watershed seemed to exhibit more of a negative impact from suspended solids than the lower reaches. Median values of suspended solids in Spain Creek were comparable with other streams with similar drainage areas and WWH designations (Figures B.3.10, B.3.25 and B.3.26).

Nutrient concentrations increased incrementally downstream, indicating that the upper part of the Spain Creek watershed was not causing significant nutrient enrichment. Undoubtedly, the North Lewisburg WWTP contributed to the enrichment of the lower section of the creek, downstream of the discharge point, especially for organic nitrogen (TKN), nitrite, total phosphorus and, to some extent, ammonia (Table B.3.2).

<u>Pleasant Run</u> (02-221) (RM 72.01) (EWH)
Pleasant Run was evaluated for chemical water quality at two sites, RM 4.10 and RM 0.50. There were no violations of the chemical water quality criteria for the EWH designation although elevated levels of *E. coli* and fecal coliform bacteria were noted in many of the samples

and were in the middle range of comparably sized streams (Figures B.3.29 to B.3.32). Dissolved oxygen concentrations were in a narrow range at both sites and well in excess of the EWH minimum and average criteria indicating a stable D.O. regime instream and confirming low nutrient values (Figures B.3.27 and B.3.28). Nutrient concentrations were indeed very low with few values exceeding the respective background median (Table B.3.2). In comparison with other streams of similar drainage area, Pleasant Run had some of the lowest ranges of suspended solids and nutrient concentrations and some of the most stable dissolved oxygen readings (Figures B.3.33 to B.3.41) indicating little negative impact from chemical pollutants.

Unnamed Tributary to Big Darby Creek (02-360) (RM 69.40) (Undesignated/WWH Recommended)

This small tributary was evaluated for chemical water quality at one location. Water quality criteria for WWH apply to this stream even though it is currently undesignated. There were no violations of water quality criteria detected in the stream. This tributary showed indications of nutrient enrichment with a median D.O. saturation of approximately 120% (e.g., D.O. concentrations above 15 mg/l) as well as higher median nitrate concentrations than similar-sized streams (Figures B.3.19, B.3.21 and B.3.42).

Figure B.3.25. Box and whisker plot of Total Suspended Solids concentrations at designated sites with a drainage area of 4-8 mi^2 in Big Darby Creek watershed, 2001.

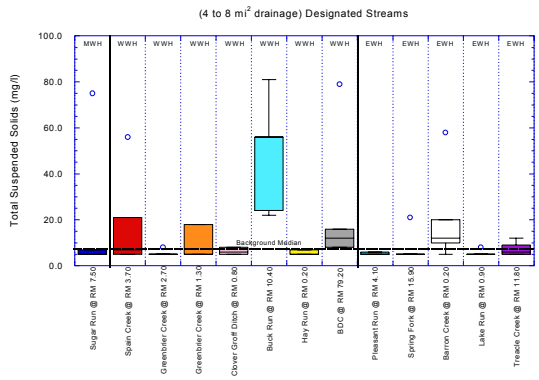


Figure B.3.26. Box and whisker plot of Total Suspended Solids concentrations at designated sites with a drainage area of 8-16 mi^2 in Big Darby Creek watershed, 2001.

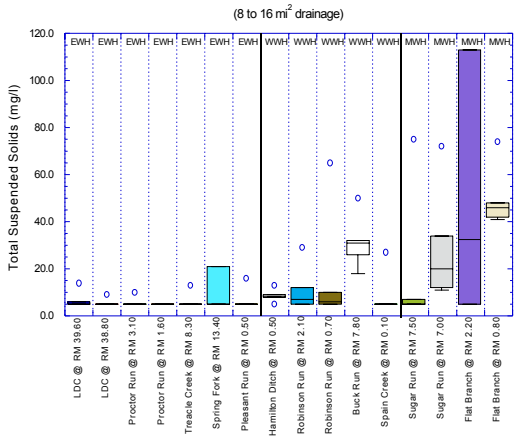


Figure B.3.27. Box and whisker plot of Dissolved Oxygen concentrations at designated sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

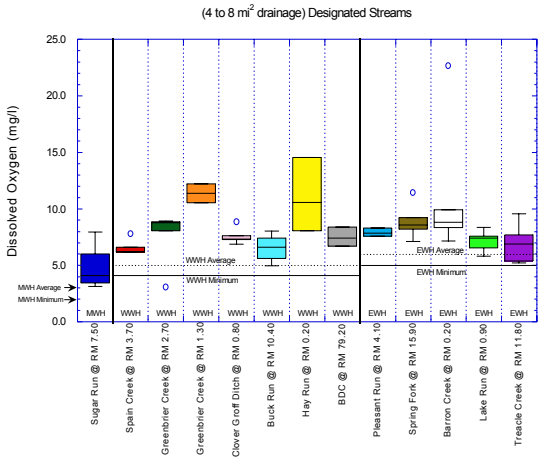


Figure B.3.28. Box and whisker plot of Dissolved Oxygen concentrations at sites with a drainage area of 8-16 mi^2 in the Big Darby Creek watershed, 2001.

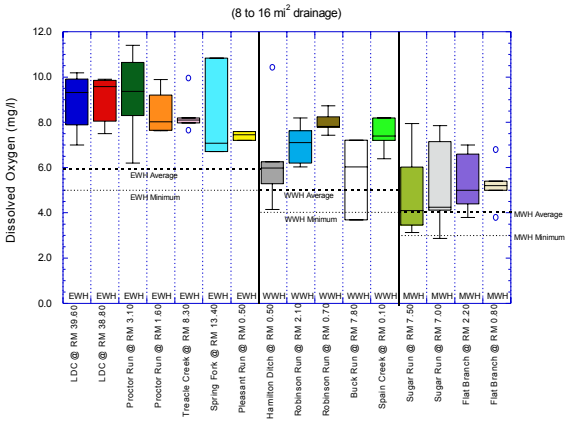


Figure B.3.29. Box and whisker plot of *E. coli* colonies/100 ml. at designated sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

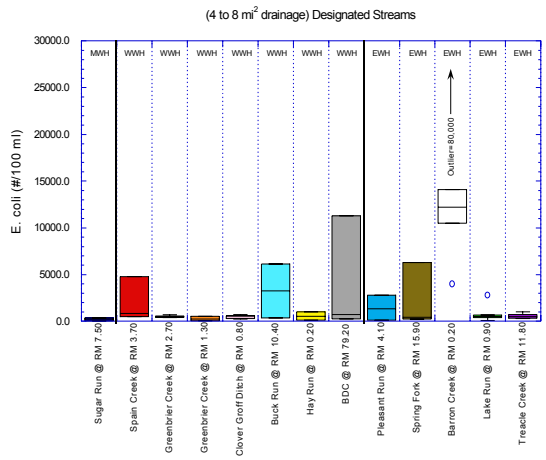


Figure B.3.30. Box and whisker plot of Fecal Coliform colonies/100 ml. at designated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

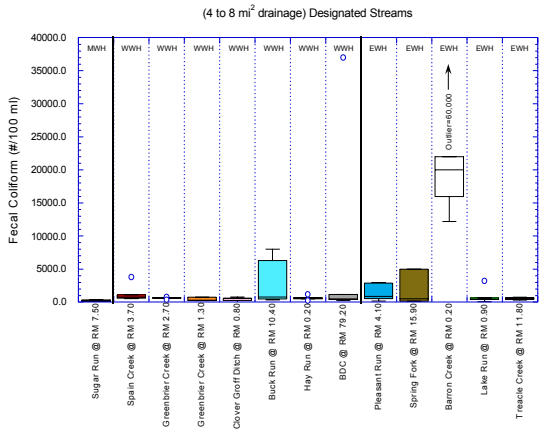


Figure B.3.31. Box and whisker plot of *E. coli* colonies/100 ml. at designated sites with a drainage area of 8-16 mi^2 in the Big Darby Creek watershed, 2001.

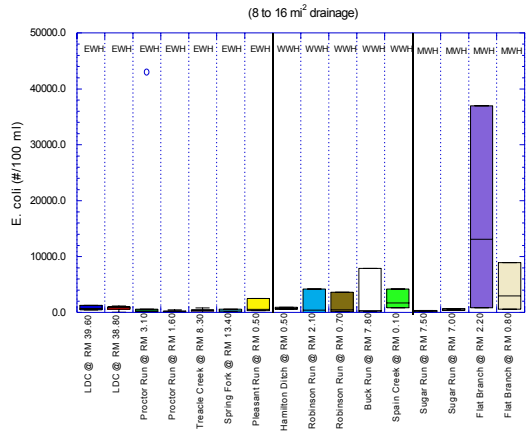


Figure B.3.32. Box and whisker plot of Fecal Coliform colonies/100 ml. at designated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

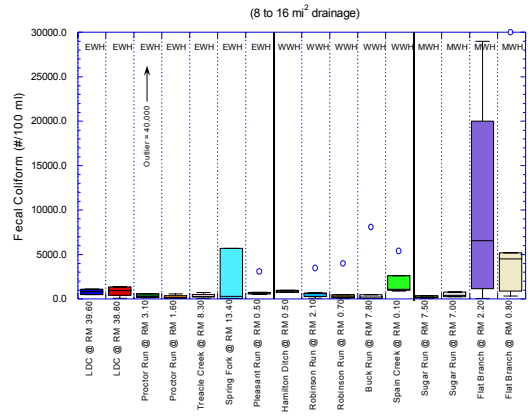


Figure B.3.33. Box and whisker plot for Total Suspended Solid concentrations at designated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

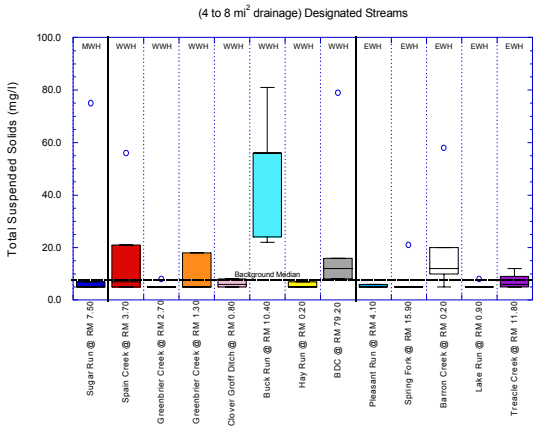


Figure B.3.34. Box and whisker plot for Ammonia concentrations at designated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

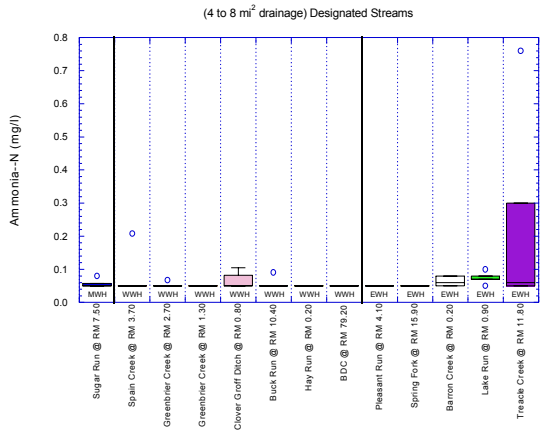


Figure B.3.35. Box and whisker plot for Nitrate+Nitrite concentrations at designated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

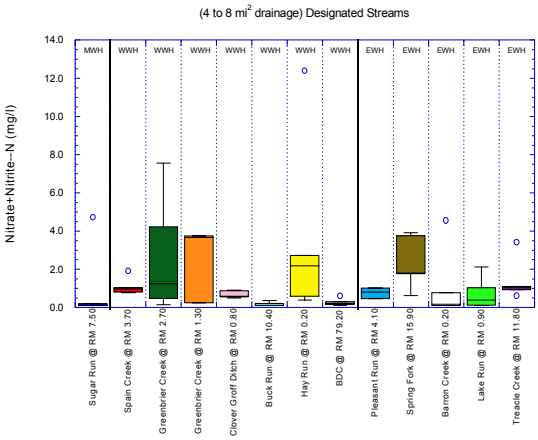


Figure B.3.36. Box and whisker plot for Total Kjeldahl Nitrogen concentrations at designated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

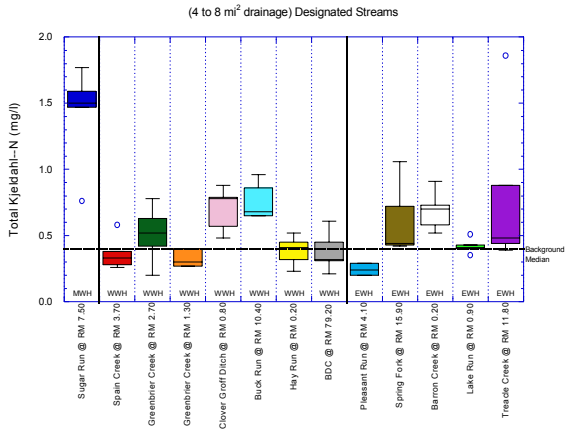


Figure B.3.37. Box and whisker plot for Total Phosphorus concentrations at designated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

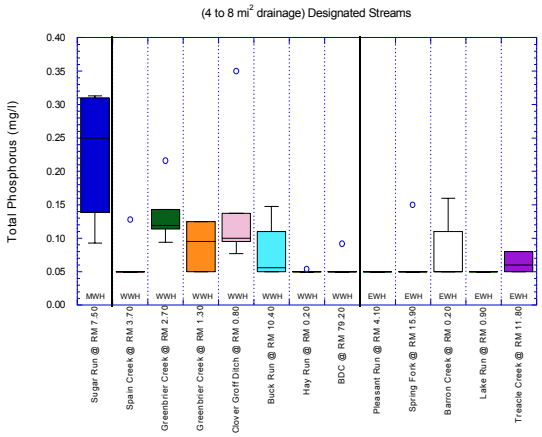


Figure B.3.38. Box and whisker plot for Dissolved Oxygen concentrations at designated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

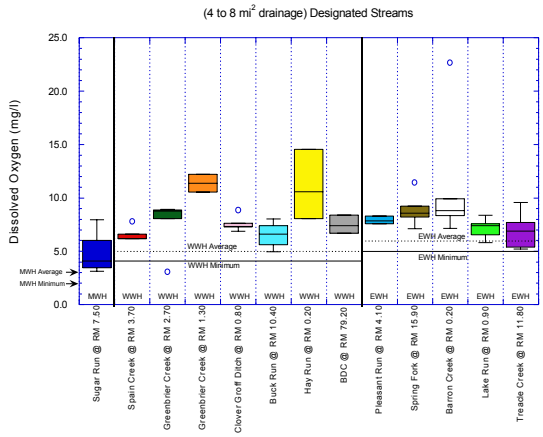


Figure B.3.39. Box and whisker plot for Ammonia concentrations at designated sampling sites with a drainage area of 8-16 mi^2 in the Big Darby Creek watershed, 2001.

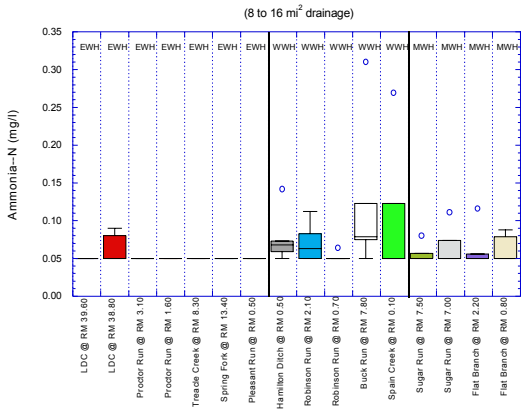


Figure B.3.40. Box and whisker plot for Nitrate+Nitrite concentrations at designated sampling sites with a drainage area of 8-16 mi^2 in the Big Darby Creek watershed, 2001.

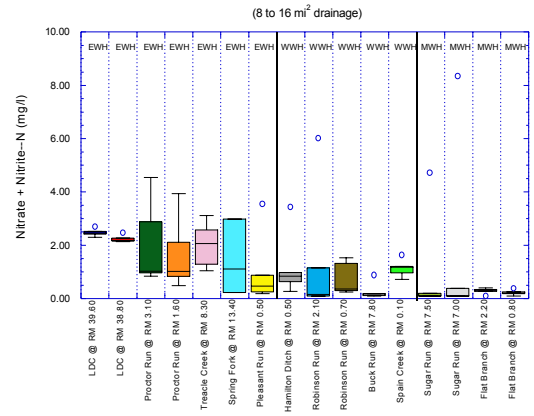


Figure B.3.41. Box and whisker plot of Dissolved Oxygen concentrations at sampling sites with a drainage area of 8-16 mi^2 in the Big Darby Creek watershed, 2001.

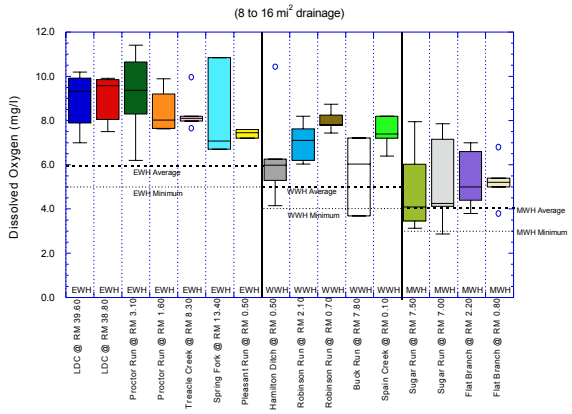
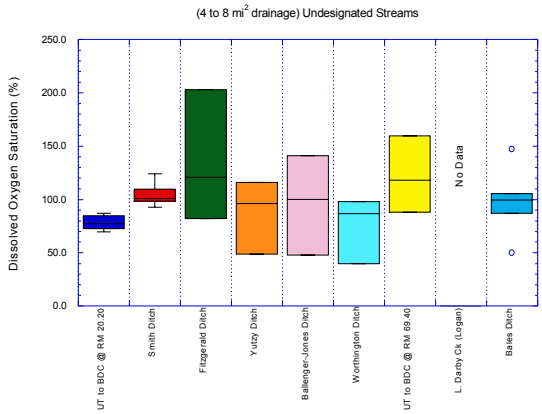


Figure B.3.42. Box and whisker plot of Percent Dissolved Oxygen saturation at designated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.



Hay Run (02-220) (RM 67.6) (WWH/EWH Recommended)
Chemical water quality was evaluated at one location on Hay Run. There were no violations of water quality criteria detected in the stream. Nitrates were found at concentrations in excess of the median background concentration in 3 of 5 samples (Table B.3.2), with one of these in excess of the 75th percentile and another exceeding the 95th percentile.

Comparisons of Hay Run with similar-sized streams in the watershed showed that Hay Run was comparable to most creeks of the same drainage area except for dissolved oxygen and nitrate. Dissolved oxygen values were wider ranging (into supersaturated conditions), more than other streams of the same drainage area (Figures B.3.42 and B.3.43). Nitrate showed the second highest median concentration and the highest actual concentration of all WWH streams in the 4 to 8 square mile drainage category (Figure B.3.35). These chemical data and visual observations of large algal blooms instream suggest that Hay Run suffers from significant nutrient enrichment.

Prairie Run (02-219) (RM 63.84) (Undesignated/LRW Recommended)
No chemical data taken.

Buck Run (02-209) (RM63.74) (WWH)
Chemical water quality was evaluated at four locations in the Buck Run watershed. Water quality criteria violations of the WWH minimum dissolved oxygen criteria occurred twice during

the survey (Table B.3.1) and the mean values for D.O. in Buck Run were slightly greater than the WWH average D.O. criterion of 5 mg/l at RM 7.80, 5.00, and 0.10.

Total suspended solids concentrations were greater than the 75th percentile of background in every sample taken in Buck Run, even exceeding the 90th percentile 7 times out of 20. Additionally, nutrient concentrations were excessive in many samples. Moderate to elevated concentrations of organic nitrogen (TKN) and total phosphorus were apparent followed by significant appearances of ammonia.

Comparison of Buck Run sampling sites with other sampling stations on streams of similar drainage confirmed that Buck Run was indeed impaired by insufficient dissolved oxygen and elevated concentrations of suspended solids, bacteria, and nutrients (Figures B.3.38, B.3.41, B.3.45 (D.O.), B.3.25, B.3.26, B.3.7 (TSS), B.3.29, B.3.30, B.3.31, B.3.46, B.3.47 (bacteria), B.3.36, B.3.16 (TKN), B.3.37, B.3.44, B.3.48 (P), B.3.34, B.3.39, B.3.49 (ammonia)). Biological community results also confirm this (Table A.15).

Figure B.3.43. Box and whisker plot of Percent Dissolved Oxygen saturation at designated sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

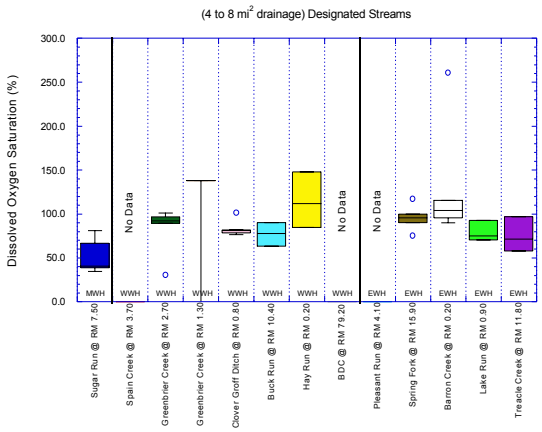


Figure B.3.44. Box and whisker plot of Total Phosphorus concentrations at sampling sites with a drainage area of 8-16 mi^2 in the Big Darby Creek watershed, 2001.

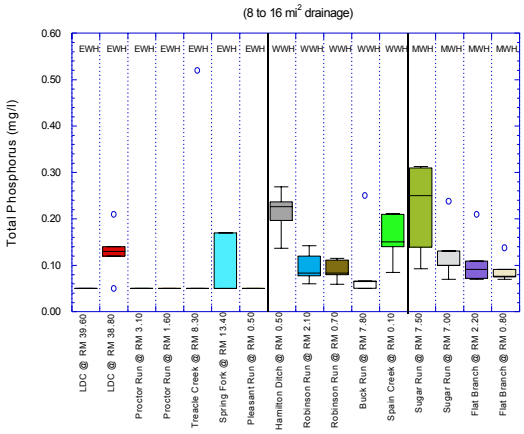


Figure B.3.45. Box and whisker plot of Dissolved Oxygen concentrations at sampling sites with a drainage area of 16-32 mi^2 in the Big Darby Creek watershed, 2001.

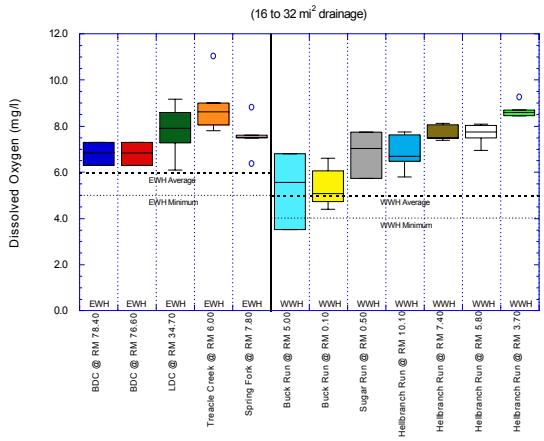


Figure B.3.46. Box and whisker plot of Fecal Coliform colonies/100 ml. at designated sampling sites with a drainage area of 16-32 mi^2 in the Big Darby Creek watershed, 2001.

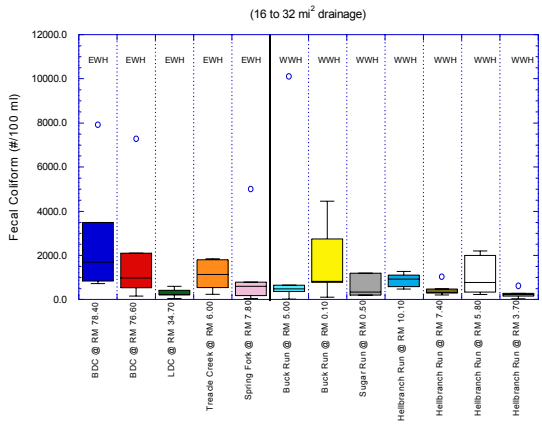


Figure B.3.47. Box and whisker plot of *E. coli* colonies/100 ml. at designated sampling sites with a drainage area of 16-32 mi^2 in the Big Darby Creek watershed, 2001.

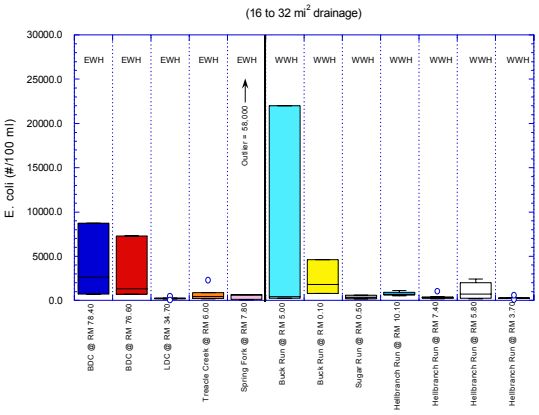


Figure B.3.48. Box and whisker plot of Total Phosphorus concentrations at designated sampling sites with a drainage area of 16-32 mi^2 in the Big Darby Creek watershed, 2001.

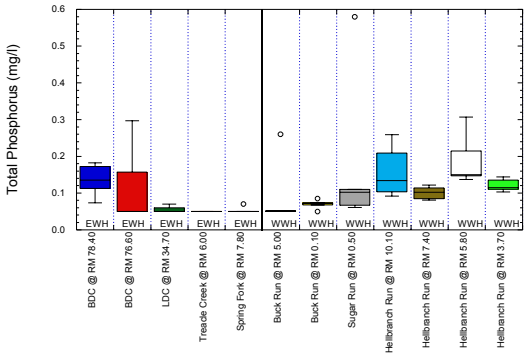
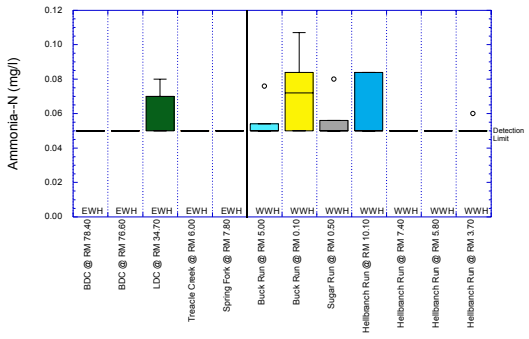


Figure B.3.49. Box and whisker plot of Ammonia concentrations at designated sampling sites with a drainage area of 16-32 mi^2 in the Big Darby Creek watershed, 2001.



Robinson Run (02-207) (RM 53.69) (WWH)

Robinson Run is designated WWH, AWS, IWS, and PCR. There were no violations of chemical water quality criteria in Robinson Run during the survey. Dissolved oxygen concentrations were well above WWH criteria (Figure B.3.28). Nitrogen (TKN) concentrations were well above the background 75th percentile in all cases with many values exceeding the 90th percentile (Table B.3.2). Total phosphorus was also greater than the background 75th percentile in 70% of the samples taken in Robinson Run (Table B.3.2). Concentrations of suspended solids, nitrate, nitrite, and ammonia were also noticeable.

Comparison of Robinson Run with streams of similar drainage area yielded little difference for nutrients. All of the WWH streams in this drainage range seemed impaired by nutrients (Figures B.3.16, B.3.44 and B.3.39). The WWTPs in the upper portion of the watershed did not appear to be causing this nutrient enrichment.

Sweeney Run (02-357) (RM 52.11) (Undesignated/WWH Recommended)

Chemical water quality sampling in Sweeny Run included a single sampling location within the Village of Plain City. Water quality criteria for WWH apply to this stream even though it is currently undesignated. Nutrient enrichment was apparent via the observation of large algal blooms instream coupled with excessive concentrations of ammonia, nitrate, organic nitrogen, and total phosphorus (Table B.3.2).

Comparison of Sweeney Run with other streams of similar drainage area showed a narrow range of values for TSS clustered very close to the background median (Figure B.3.10); widely variable results for nitrates, including some values elevated above the 90th percentile of background; and wide-ranging concentrations of fecal coliform bacteria (Table B.3.2, Figures B.3.14 and B.3.22). Organic nitrogen, ammonia and total phosphorus were also present in significantly higher concentrations when compared with similar streams (Figures B.3.11 to B.3.13)

Middle Big Darby Creek, Including Tributaries

(Plain City to confluence with Little Darby Creek)

Chemical water quality sampling in Middle Big Darby Creek extended from just downstream of the Village of Plain City WWTP outfall (RM 52.00) to the confluence with Little Darby Creek at RM 34.10 (4 sampling stations). Tributaries included in this sampling effort included Sugar Run (4 sampling stations), Worthington Ditch (1 sampling station), Ballenger-Jones Ditch (1 sampling station), Yutzy Ditch (1 sampling station), and Fitzgerald Ditch (1 sampling station).

Mainstem

Chemical water quality sampling occurred in middle Big Darby Creek five times during the 2001 survey period. There were no violations of water quality criteria found in the middle Big Darby Creek mainstem (Table B.3.1). Effluent sampling at the Village of Plain City WWTP outfall revealed a single violation of the fecal coliform limit in the NPDES permit issued to the village (Table B.3.1). Biosolids deposits were witnessed immediately downstream of the outfall, in violation of the "free froms" in the WQS. Significant increases in bacterial and nutrient concentrations in Big Darby Creek immediately downstream of the Plain City WWTP outfall were observed. The NPDES permit limits have been adjusted to eliminate these violations (see discussion of Plain City WWTP in Section B.1).

The Village of Plain City WWTP was the main cause of degradation and partial biological attainment in this segment of stream. Nutrient concentrations immediately downstream of the outfall were always greater than the background median and often greater than the 95th percentile of background (Table B.3.2). Concentrations of suspended solids, nitrate+nitrite, TKN, and total phosphorus remained elevated downstream to RM 49.50 and were likely due to the residual effects of the Plain City WWTP discharge (Table B.3.2). Chemical water quality and biological attainment were not compromised at RM 42.00 and RM 34.10. The numerous small WWTPs scattered along this stretch of river did not appear to impair chemical water quality or the biota.

Sugar Run (02-206) (RM 50.92) (WWH/MWH Recommended > RM7.0, WWH<RM 7.0)

Sugar Run was sampled for chemical water quality at four different sites along its length. Chemical water quality criteria in Sugar Run were violated by a few instances of low dissolved oxygen (Table B.3.1). Mean dissolved oxygen concentrations were less than 1.0 mg/l above the standard of 4.0 mg/l for modified streams (Figure B.3.50). Dissolved oxygen concentrations in Sugar Run were similar to those found in streams of the same drainage area (Figures B.3.41 and

B.3.45). *E. coli* bacteria concentrations were excessive on only a few occasions and were mild in comparison with area streams of similar drainage and designation (Figures B.3.31 and B.3.47).

Mean total suspended solids were consistently at or above 18 mg/l in Sugar Run. Total suspended solids concentrations were found in excess of at least the background median concentration on every sampling occasion at the three lowermost sampling sites (Table B.3.2). The uppermost site at RM 7.50 showed only one instance of this during a rain event, when the sample exceeded the 95th percentile for background (Table B.3.2). Comparison of Sugar Run sampling locations with similarly-sized drainage areas indicated that the upper site at RM 7.50 was much like other sites as was the site at RM 7.0. Sugar Run at RM 5.4 and RM 0.5 exhibited modestly elevated suspended solids concentrations when compared with reaches of similar drainage.

Organic forms of nitrogen as measured by TKN and total phosphorus were well above the 75th percentile of background at all four sites (Table B.3.2). Mean concentrations of TKN were above 1 mg/l at all sites but the mouth (Figure B.3.51). Comparisons with stream reaches of similar drainage area and designation (MWH, WWH) showed that Sugar Run was suffering from gross nutrient enrichment in the modified section and moderate nutrient enrichment in the WWH portion (Figures B.3.36, B.3.16, B.3.60, B.3.37, B.3.44 and B.3.48). Ammonia concentrations were also found to be regularly above background conditions and certainly contribute to nutrient pollution along with nitrate+nitrite (Figure B.3.51).

Figure B.3.50. Mean concentrations of Dissolved Oxygen at sampling sites in Sugar Run, 2001.

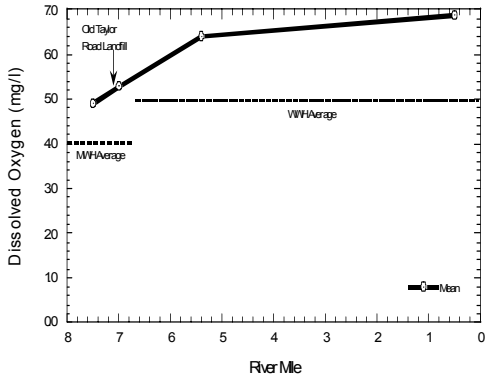
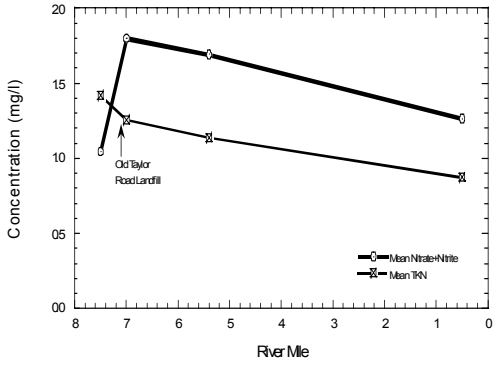


Figure B.3.51. Mean concentrations of Total Kjeldahl Nitrogen and Nitrate+Nitrite at sampling sites in Sugar Run, 2001.



These chemical water quality problems are caused by several conditions. First, the majority of the Sugar Run watershed is dominated by poor habitat including modified (channelized) sections and missing riparian corridor as evidenced by the poor QHEI scores. This modified habitat allows for more erosion with accompanying increases in suspended materials and siltation. Poor habitat also short-circuits proper nutrient cycling. Add to this the additional nutrient inputs from a golf course in the upper watershed, and widespread agricultural practices and the result is impaired chemical water quality. Since the majority of the watershed has degraded habitat, even the section at the mouth (which had better habitat and exhibited biological attainment) was nutrient enriched and negatively impacted by suspended solids, threatening biological attainment.

Worthington Ditch (02-02-356) (RM 50.62) (Undesignated/WWH Recommended)
This small headwater stream drains approximately 4.4 square miles. Water quality criteria for WWH apply to this stream even though it is currently undesignated. No violations of chemical water quality criteria were in evidence following testing (Table B.3.1). Nutrient concentrations in Worthington Ditch were significantly greater than median background conditions as shown by the concentrations of nitrates, TKN, and total phosphorus (Table B.3.2). Water chemistry in this stream compares favorably with others of the same drainage area exhibiting lower ammonia, suspended solids and bacterial concentrations as well as moderate to good oxygen saturation (Figures B.3.6, B.3.23, B.3.24 and B.3.42). However, TKN values were all found to be above the background median and well above those of some other small streams (Figure B.3.36).

Ballenger-Jones Ditch (02-355) (RM 49.68) (Undesignated/WWH Recommended)
This small headwater stream drains approximately 6.0 square miles. Water quality criteria for WWH apply to this stream even though it is currently undesignated. No violations of chemical water quality criteria were in evidence following testing (Table B.3.1). Elevated concentrations of TKN and phosphorus were also noted in this waterbody (Table B.3.2). These instances of bacterial contamination and nutrient enrichment are due in part to the discharge from the Jonathan Alder High School WWTP. Comparison with other streams of the same drainage area shows similar concentrations of ammonia, total suspended solids, phosphorus, and bacteria with moderately elevated concentrations of TKN (Figures B.3.18, B.3.6, B.3.20, B.3.23, B.3.24 and B.3.36).

Yutzy Ditch (02-364) (RM 47.10) (Undesignated/WWH Recommended)
This small headwater stream drains approximately 4.3 square miles. Water quality criteria for WWH apply to this stream even though it is currently undesignated. No violations of chemical water quality criteria were in evidence following testing (Table B.3.1). Elevated concentrations of nutrients were also noted and similar to those found in Ballenger-Jones Ditch (Table B.3.2). The Canaan Elementary School WWTP is found on this stream; however, no discharge was occurring during the summer sampling season because school was not in session.

Chemical water quality in Yutzy Ditch was comparable to other streams of similar drainage area for ammonia, phosphorus, total suspended solids and dissolved oxygen (Figures B.3.18, B.3.6

and B.3.20). Concentrations of both *E. coli* and TKN were wider in scope and higher than most other streams of the same size evaluated in the study (Figures B.3.24 and B.3.36).

Fitzgerald Ditch (02-272) (RM 44.96) (Undesignated/WWH Recommended)

This small headwater stream drains approximately 5.1 square miles. Water quality criteria for WWH apply to this stream even though it is currently undesignated. No violations of chemical water quality criteria were in evidence following testing (Table B.3.1). Nutrient concentrations were excessive in Fitzgerald Ditch with values for ammonia, nitrates, and total phosphorus all greater than the 75th percentile of background with some exceeding the 95th percentile (Table B.3.2). These instances of bacterial contamination and nutrient enrichment are due in part to the discharge from the poorly operated and maintained Canaan Community MHP WWTP, approximately a mile upstream.

Chemical water quality in Fitzgerald Ditch tended to be the most degraded when compared with other streams of similar drainage area. Elevated concentrations of bacteria as well as suspended solids, TKN, phosphorus, and ammonia were the norm as was dissolved oxygen supersaturation (Figures B.3.18, B.3.6, B.3.20, B.3.23, B.3.24, B.3.36 and B.3.42).

Little Darby Creek

Chemical water quality sampling in Little Darby Creek extended from the headwaters at RM 41.20 to RM 0.70 at the mouth (10 sampling stations). Tributaries included in this sampling effort included Clover Run (1 sampling station), Lake Run (1 sampling station), Jumping Run (1 sampling station), Treacle Creek (4 sampling stations), Howard Run (1 sampling station), Proctor Run (3 sampling stations), Barron Creek (1 sampling station), Spring Fork (4 sampling stations) and Bales Ditch (1 sampling station).

Mainstem

Chemical water quality sampling was conducted five times in Little Darby Creek during the 2001 survey. No violations of water quality criteria were discovered. Mean bacterial concentrations were high up and downstream of the Mechanicsburg WWTP apparently resulting from on-site waste treatment systems and the WWTP respectively (Figures B.3.52 and B.3.53). Bacterial concentrations dropped precipitously at the next downstream site (RM 34.70) and then increased again downstream of the confluence of Little Darby and Treacle Creek (RM 29.50). Following the spike at the Treacle Creek confluence, bacterial numbers decreased to insignificant levels moving toward the mouth (Figures B.3.52 and B.3.53). Dry weather flow from the West Jefferson WWTP did not appear to contribute to any bacterial degradation.

Mean dissolved oxygen concentrations in Little Darby Creek were all greater than the EWH average of 6 mg/l. The Mechanicsburg WWTP discharge appeared to promote a slight sag in dissolved oxygen downstream at RM 34.70, but nothing that violated water quality criteria. Dissolved oxygen concentrations became excessive at the mouth with mean saturation values over 150%. This was indicative of nutrient enrichment and poor riparian coverage as well a

Figure B.3.52. Mean number of colonies/100 ml. of Fecal Coliform bacteria at sampling sites on Little Darby Creek, 2001.

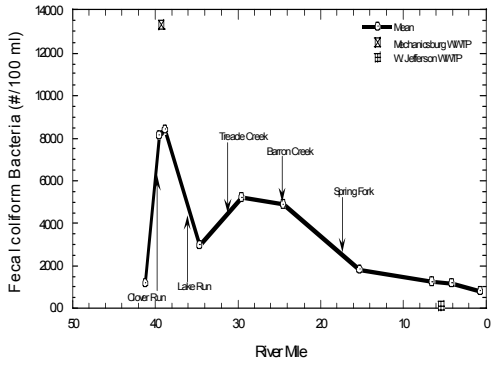
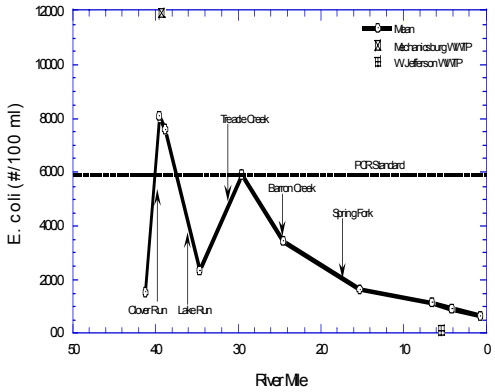


Figure B.3.53. Mean number of colonies/100 ml. of *E. coli* bacteria at sampling sites in Little Darby Creek, 2001.



modified stream channel with poor pool development.

Mean values of total suspended solids showed a marked increase downstream of Mechanicsburg (RM 34.70) to RM 24.50 (Figure B.3.54). Some of this increase was directly attributable to Treacle Creek and Barron Creek, both of which contributed large amounts of suspended solids to Little Darby Creek (see discussion of these creeks in the sections below) so that average values were well in excess of background median concentrations. Suspended solids mean concentrations decreased downstream of Spring Fork and remained below background median values down to the mouth (Figure B.3.54). Comparison of sites on Little Darby Creek with other EWH streams of similar drainage area revealed that the Little Darby Creek had relatively low suspended solids concentrations in most cases (Figures B.3.10, B.3.26, B.3.55 and B.3.56).

Mean concentrations of nitrate+nitrite exhibited a downward trend beginning at around 4 mg/l and leveling off around 2 mg/l just downstream of Lake Run and remaining relatively consistent down to the mouth (Figure B.3.57). Neither Mechanicsburg WWTP nor the West Jefferson WWTP seemed to create a significant increase in nitrate+nitrite concentrations instream. However, comparison of sites on Little Darby Creek with similar EWH sites of similar drainage area showed differences. Median nitrate+nitrite concentrations at most sites were among the highest detected for comparably-sized stream segments (Figures B.3.14, B.3.40, B.3.58 and B.3.59). Fully 74% of the samples analyzed for nitrate+nitrite in the Little Darby Creek were greater than the background median with 32% greater than the 75th percentile (Table B.3.2).

Other nutrients, including organic nitrogen (measured by TKN), ammonia, and total phosphorus were generally more consistent with their comparison stream segments. TKN concentrations were all comparable or lower than their counterparts (Figures B3.11, B.3.16, B.3.60, B.3.61 and B.3.62). Ammonia was typically undetected except in a few instances downstream of the Mechanicsburg WWTP and downstream of Treacle Creek at RM 29.50 and RM 24.50 (Figures B.3.13, B.3.39 and B.3.49). Mean total phosphorus showed notable peaks downstream of Mechanicsburg WWTP and West Jefferson WWTP as well as a gradual increase moving downstream (Figure B.3.63).

Storm water monitoring was performed at various times over a year's period for Little Darby Creek at Middle Pike (RM 7.35). This sampling station houses a USGS gauge which provided flow data for the calculation of different pollutant loadings. Total suspended solids and 3 nutrients were evaluated. Loadings of suspended solids, ammonia, nitrate+nitrite, and total phosphorus all increased with increasing flow volume, though not proportionally (Figures B.3.64 to B.3.67). For example, a storm event sampled on March 28, 2002 exhibited a flow of 25,734 liters/second (909 ft^3/s) with loadings of 115,617 kg/d of suspended solids, 25,792 kg/d of nitrate+nitrite, 145 kg/d of ammonia, and 238 kg/d of phosphorus whereas a storm event monitored on April 15, 2002 showed a flow of 46,428 liters/second (1640 ft^3/s) with loadings of 437,247 kg/d of suspended solids, 26,395 kg/d of nitrate+nitrite, 237 kg/d of ammonia, and 911 kg/d of phosphorus. Comparisons of the flows and loadings between these events shows increased flow (1.8 fold) with a 3.8 fold increase in suspended solids, a slightly increased loading of nitrate+nitrite, a 1.6 fold increase in ammonia loadings, and a 3.8 fold increase in phosphorus loadings.

Figure B.3.54. Mean Total Suspended Solids concentrations at sampling sites in Little Darby Creek, 2001.

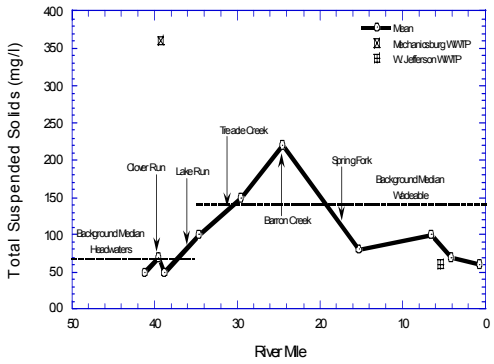


Figure B.3.55. Box and whisker plot of Total Suspended Solid concentrations at sampling sites with a drainage area of 64-128 mi^2 in the Big Darby Creek watershed, 2001.

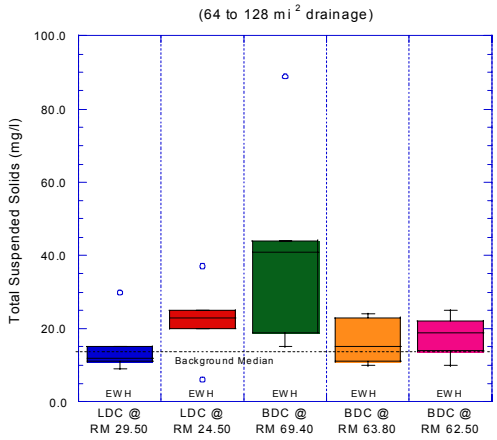


Figure B.3.56. Box and whisker plot of Total Suspended Solid concentrations at sampling sites with a drainage area of 128-256 mi^2 on the Big Darby Creek mainstem, 2001.

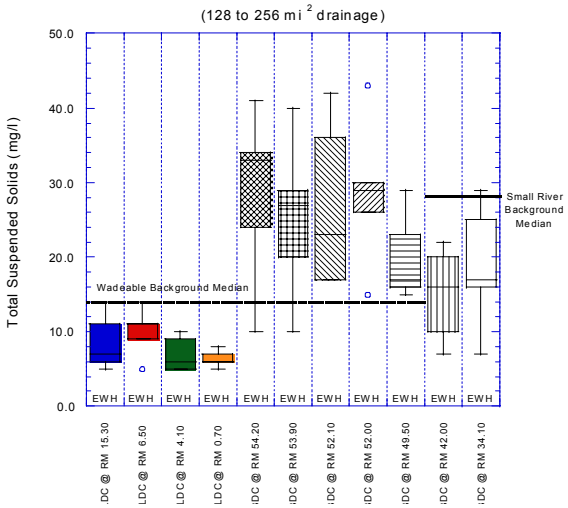


Figure B.3.57. Mean Nitrite+Nitrate concentrations at sampling sites in Little Darby Creek, 2001.

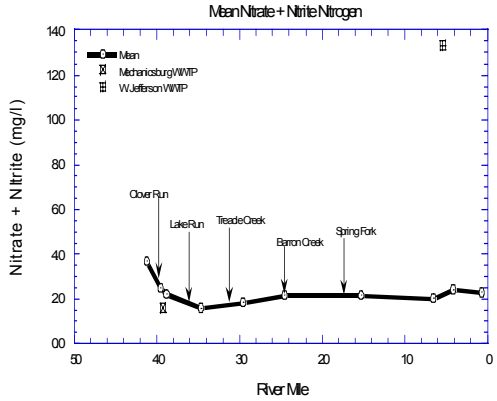


Figure B.3.58. Box and whisker plots of Nitrate+Nitrite concentrations at sampling sites with a drainage area of 64-128 mi^2 in the Big Darby Creek, 2001.

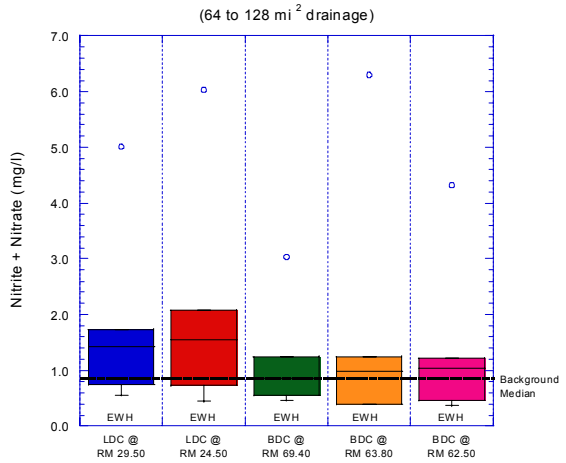


Figure B.3.59. Box and whisker plots of Nitrate+Nitrite concentrations at sampling sites with a drainage area of 128 -256 mi^2 in the Big Darby Creek, 2001.

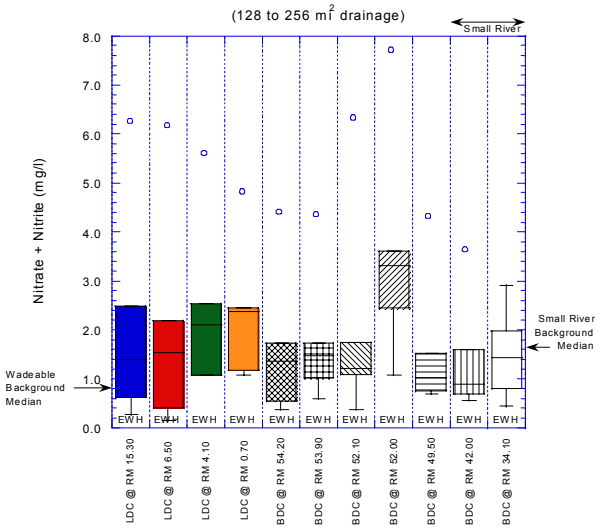


Figure B.3.60. Box and whisker plot of Total Kjeldahl Nitrogen concentrations at sampling sites with a drainage area of 16-32 mi^2 in the Big Darby Creek watershed, 2001.

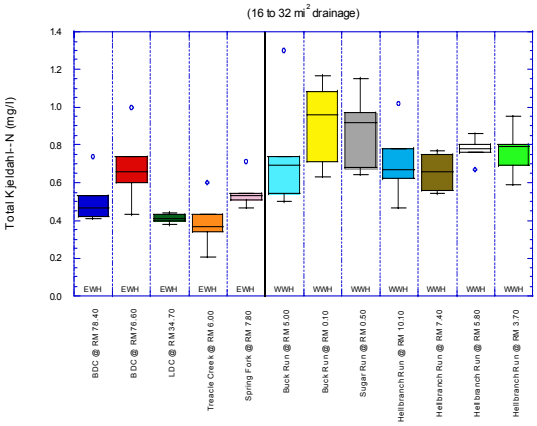


Figure B.3.61. Box and whisker plot of Total Kjeldahl Nitrogen concentrations at sampling sites with a drainage area of 64-128 mi^2 in the Big Darby Creek watershed, 2001.

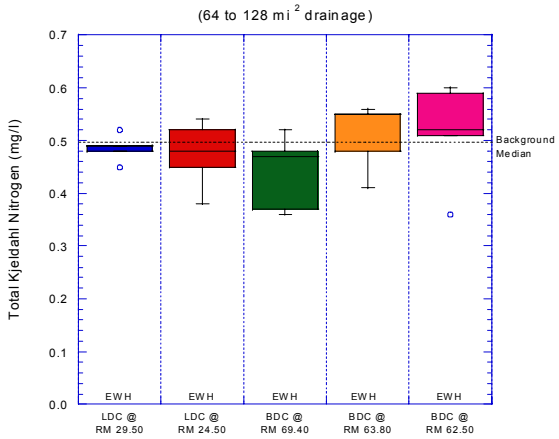


Figure B.3.62. Box and whisker plot of Total Kjeldahl Nitrogen concentrations at sampling sites with a drainage area of 128-256 mi^2 in the Big Darby Creek watershed, 2001.

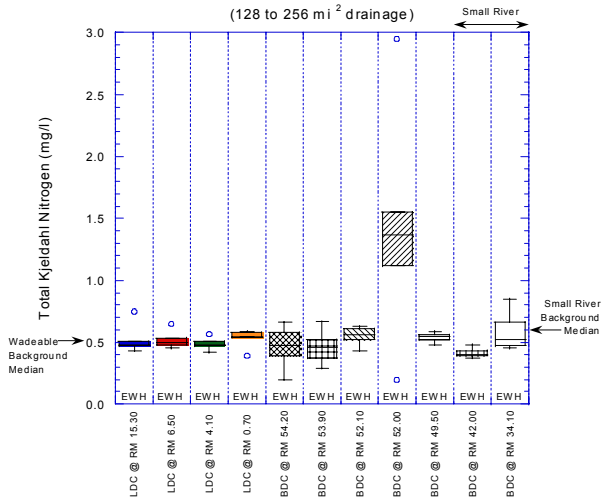


Figure B.3.63. Mean concentrations of Total Phosphorus at sampling sites in the mainstem of Little Darby Creek, 2001.

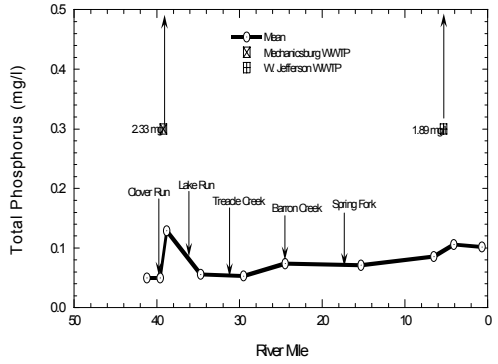


Figure B.3.64. Little Darby Creek storm event sampling - Mean Daily Flow vs. Total Suspended Solids Loadings based on sampling at the USGS Gaging Station at Middle Pike (RM 7.35) in Little Darby Creek, 2001.

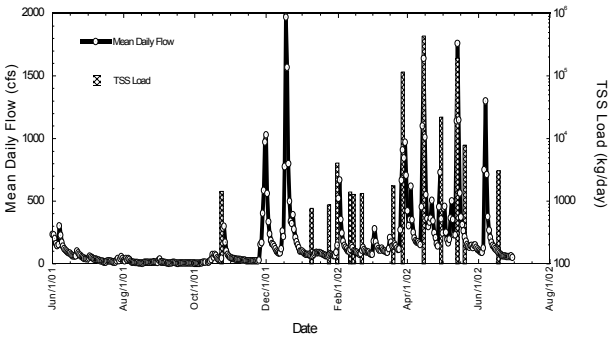


Figure B.3.65. Little Darby Creek storm event sampling - Mean Daily Flow vs. Nitrate+Nitrite Loadings based on sampling at the USGS Gaging Station at Middle Pike (RM 7.35) in Little Darby Creek, 2001.

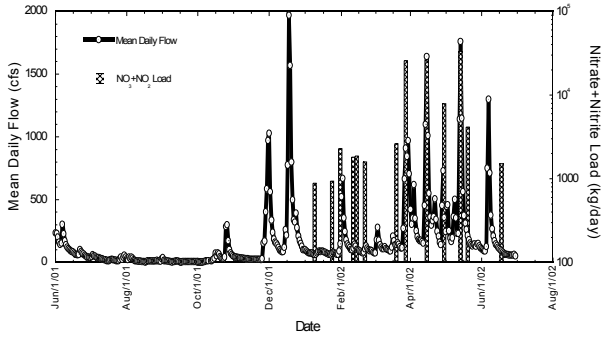


Figure B.3.66. Little Darby Creek storm event sampling - Mean Daily Flow vs. Ammonia Loadings based on sampling at the USGS Gaging Station at Middle Pike (RM 7.35) in Little Darby Creek, 2001.

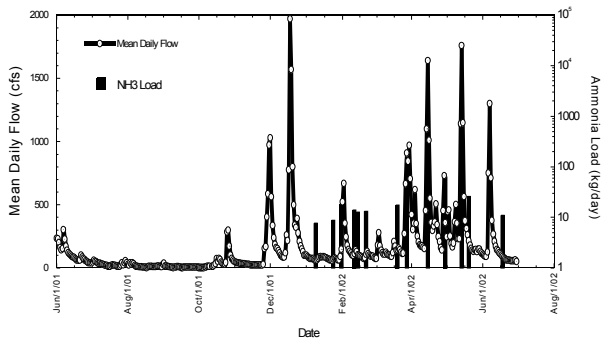
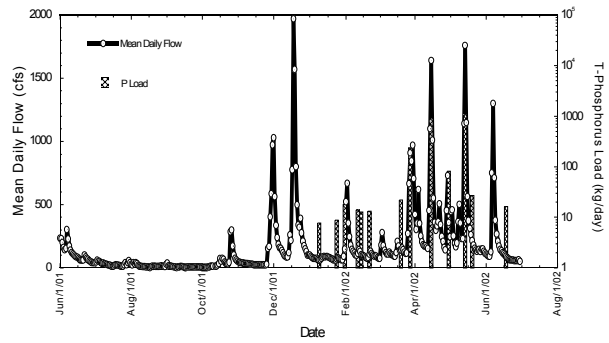


Figure B.3.67. Little Darby Creek storm event sampling - Mean Daily Flow vs. Total Phosphorus Loadings based on sampling at the USGS Gaging Station at Middle Pike (RM 7.35) in Little Darby Creek, 2001.



Clover Run (02-218) (RM 39.80) (EWH/WWH Recommended)

Water chemistry in Clover Run showed no violations of water quality criteria although bacterial contamination from *E. coli* was apparent in every sample taken in 2001 (Table B.3.1). Dissolved oxygen was found at acceptable concentrations with a median well above the average standard and no supersaturated conditions (Figures B.3.68 and B.3.69). Nutrient concentrations were not elevated with respect to background, nor were they found at median concentrations much different than other streams of similar size (comparison of Clover Run, an EWH stream was made to other WWH streams as there were no small EWH streams for comparison).

Lake Run (02-216) (RM 36.90) (EWH/EWH Deferred)

Chemical water quality in Lake Run exhibited no violations of water quality criteria (Table B.3.1). Dissolved oxygen concentrations compared well with stream segments of similar drainage area and were adequate and narrow-ranged showing nearly saturated conditions in most cases (Figures B.3.70 and B.3.71). Concentrations of nutrients, including ammonia and TKN were slightly elevated whereas phosphorus concentrations were below detection (Table B.3.1, Section C.1). Comparison of these values with EWH stream segments of similar drainage showed that ammonia values were indeed abnormal (Figure B.3.34) while organic nitrogen (TKN) was comparable with similar-sized locations (Figure B.3.36) even though most TKN values were in excess of the median for headwater streams. Nitrate+nitrite concentrations were similar to other stream segments (Figure B.3.35).

Figure B.3.68. Box and whisker plot of Dissolved Oxygen concentrations for sampling sites with a drainage area of 0-2 mi^2 in the Big Darby Creek watershed, 2001.

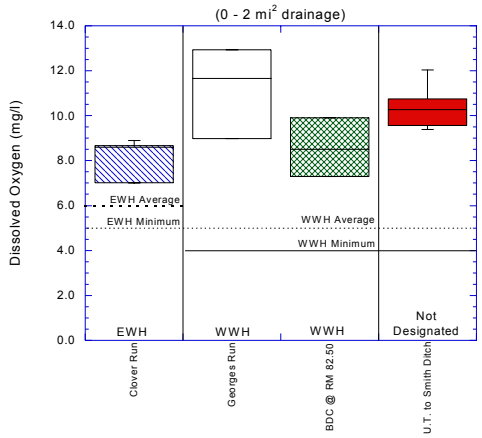


Figure B.3.69. Box and whisker plot of percent Dissolved Oxygen Saturation for sampling sites with a drainage area of 0-2 mi^2 in the Big Darby Creek watershed, 2001.

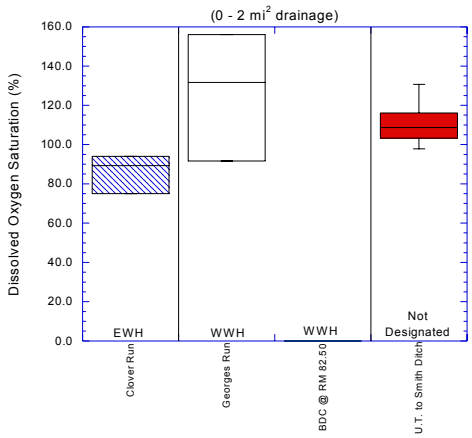


Figure B.3.70. Box and whisker plot of Dissolved Oxygen concentrations for sampling sites with a drainage area of 4-8 mi^2 in the Big Darby Creek watershed, 2001.

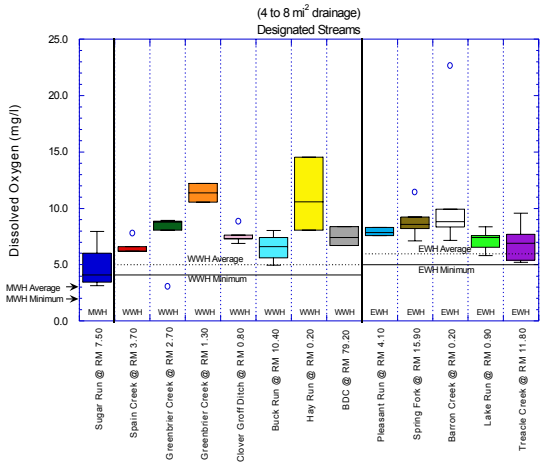
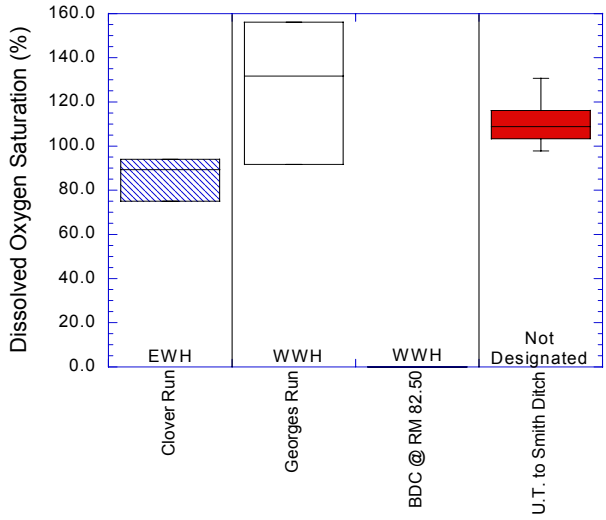


Figure B.3.71. Box and whisker plot of percent Dissolved Oxygen Saturation for sampling sites with a drainage area of 0-2 mi^2 in the Big Darby Creek watershed, 2001.



Jumping Run (02-217) (RM 3.90) (EWH/WWH Recommended)
Water quality sampling in Jumping Run in 2001 showed no violations of water quality criteria. Bacterial contamination from *E. coli* was evident in the majority of the samples, however (Table B.3.1). Dissolved oxygen concentrations did show some wider variability than other streams segments of similar drainage area, with the lower end of the range nearly at the EWH minimum of 5 mg/l (Figure B.3.15). This may be a sign of the beginning of chemical water quality problems. Nutrient concentrations in Jumping Run were comparable with other stream segments of similar drainage area (Figures B.3.11 to B.3.14) and suspended solids were some of the lowest in this category (Figure B.3.10).

Treacle Creek (02-213) (RM 31.30) (EWH)
Water quality sampling in Treacle Creek revealed no violations of water quality criteria. *E. coli* bacteria were found in the majority of the samples at elevated mean concentrations (Figure B.3.72).

Mean dissolved oxygen concentrations were well above the 6.0 mg/l standard for EWH streams (Figure B.3.73). However, dissolved oxygen ranges exhibited some disturbingly low values that were very near the minimum criteria of 5 mg/l at RM 11.80 and RM 0.80 (Section C.1). Generally, dissolved oxygen concentrations in Treacle Creek were comparable to other stream segments of similar drainage area (Figures B.3.27, B.3.28 and B.3.45).

Total suspended solids concentrations in Treacle Creek increased with distance downstream. Mean values increased more than 3-fold from RM 8.30 to RM 6.00 (Figure B.3.74) with half of the concentrations in excess of the 75th percentile of background at the lower 2 sites (Table B.3.2). Comparison of suspended solids concentrations at the lower site showed a large disparity between similarly-sized sites on Hellbranch Run (even though Hellbranch Run is only a WWH stream) and Spring Fork with Treacle Creek showing much greater values and a median concentration much higher than background.

Upper Treacle Creek (RM 11.80) exhibited some of the highest ammonia concentrations when compared with similarly sized stream segments; with two values topping the 95th percentile for background (Figure B.3.34, Table B.3.2). Organic nitrogen (TKN) and total phosphorus concentrations were also elevated in comparison with similar streams (Figures B.3.36 and B.3.37) and nitrate values that were analogous (Figure B.3.35).

The middle section of Treacle Creek (RM 8.30 and RM 6.00) showed no evidence of ammonia contamination or abnormal concentrations of TKN (Section C.1, Figures B.3.16 and B.3.60); however, mean nitrate+nitrite concentrations increased by about 33% compared with the upstream site (Figure B.3.75). Median nitrate+nitrite concentrations in middle Treacle Creek were among the highest of comparably-sized streams (Figure B.3.40).

Lower Treacle Creek exhibited slight increases in the mean concentrations of ammonia, nitrate+nitrite, and TKN compared with the middle section (Figure B.3.75). Sixty percent of the ammonia values were greater than the 75th percentile of background and 80 percent of the

Figure B.3.72. Mean number of colonies/100 ml. of *E. coli* bacteria at sampling sites in Treacle Creek, 2001.

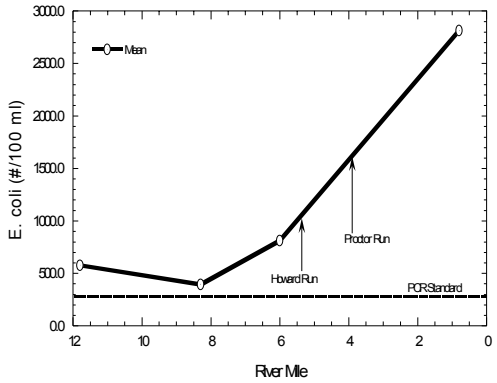


Figure B.3.73. Mean Dissolved Oxygen concentrations at sampling sites in Treacle Creek, 2001.

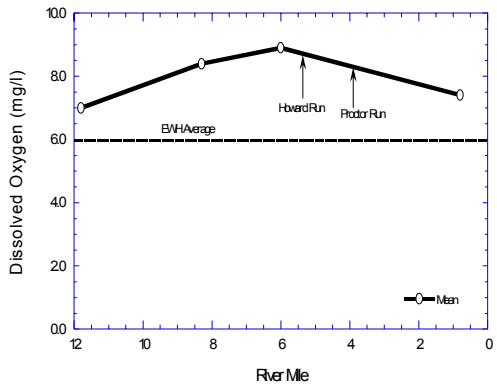


Figure B.3.74. Mean Total Suspended Solids concentrations at sampling sites in Treacle Creek, 2001.

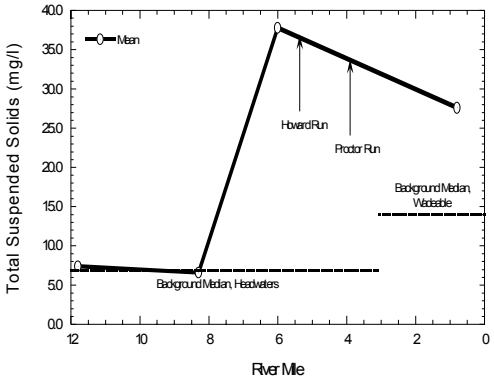
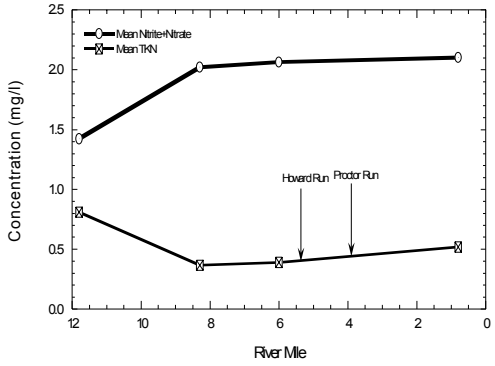


Figure B.3.75. Mean Nitrate+Nitrite and Total Kjeldahl Nitrogen concentrations at sampling sites in Treacle Creek, 2001.



nitrate+nitrite values were greater than the 50th percentile for background with one exceeding the 90th percentile (Table B.3.2).

Treacle Creek appears threatened by excessive numbers of *E. coli* bacteria over the entire stream channel along with high concentrations of suspended solids and immoderate nutrient concentrations in the upper and lower watersheds. This is likely due to contributions from multiple agricultural sources.

Howard Run (02-215) (RM 5.40) (EWH)

A single sampling location on Howard Run revealed no violations of water quality criteria during the 2001 survey. *E. coli* concentrations were, however, elevated in all samples (Table B.3.1). Dissolved oxygen concentrations and saturation were well within criteria and norms respectively and compared favorably to similarly sized streams (Figures B.3.68 and B.3.69). Phosphorus and ammonia were at or near detection levels in all samples with median TKN concentrations below background median. Nitrate+nitrite concentrations were more variable, but still comparable with similarly-sized stream segments (Figure B.3.14). Elevated concentrations of *E. coli* bacteria from Howard Run may contribute to bacterial contamination in Treacle Creek.

Proctor Run (02-214) (RM 3.69) (EWH)

Chemical water quality evaluation of Proctor Run revealed no violations of water quality criteria at any sampling site during the survey. However, numerous water quality problems were identified throughout this subwatershed.

Upper Proctor Run (RM 4.90) exhibited good dissolved oxygen concentrations with little to no supersaturation noted during instantaneous sampling (Figure B.3.15). Bacterial concentrations were noticeably higher than comparable stream segments (Figure B.3.22). Additionally, suspended solids concentrations were nearly all above the background median and generally greater than comparable EWH waterways (Figure B.3.10). Other nutrient concentrations were commensurate or minutely higher than comparison streams (total phosphorus, ammonia, TKN) or significantly lower (nitrate+nitrite).

Lower Proctor Run (RM 3.10 and RM 1.60) exhibited D.O. values similar to the upper reach although the site at RM 3.10 showed much wider variability. Comparison with stream reaches of similar size and drainage showed little difference, however (Figure B.3.41). Bacterial concentrations were lower possibly indicating attenuation from a source upstream. Mean values for suspended solids decreased from upstream values as did mean ammonia and phosphorus (Figures B.3.76 and B.3.77). Mean nitrate+nitrite increased by a factor of 4 before dropping slightly (Figure B.3.78) and mean TKN values remained steady. All nutrient concentrations in lower Proctor Run were commensurate with stream reaches of similar drainage area (Figures B.3.16, B.3.17, B.3.39 and B.3.40).

Figure B.3.76. Mean concentrations of Total Suspended Solids at sampling sites in Proctor Run, 2001.

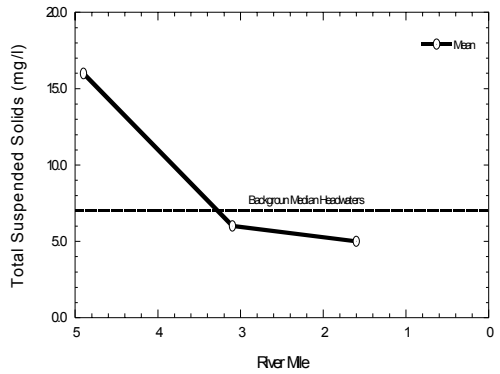


Figure B.3.77. Mean concentrations of Ammonia and Total Phosphorus at sampling sites in Proctor Run, 2001.

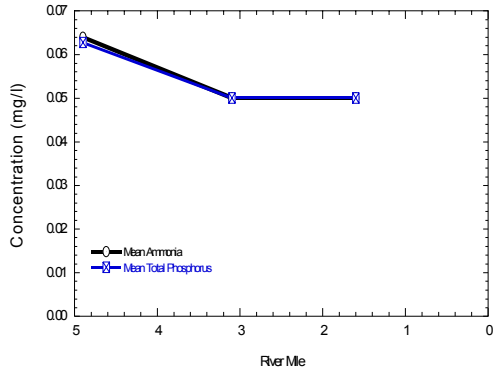
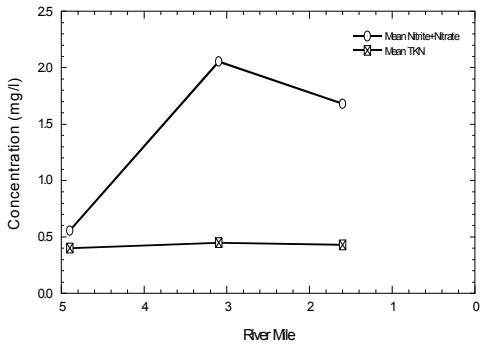


Figure B.3.78. Mean concentrations of Nitrate+Nitrite and Total Kjeldahl Nitrogen at sampling sites in Proctor Run, 2001.



Barron Creek (02-212) (RM 24.40) (EWH/WWH Recommended)
Chemical water quality monitoring in Barron Creek took place near the mouth at RM 0.20. There were no instances of water quality criteria violations noted during the sampling although serious chemical water quality problems were verified. Dissolved oxygen concentrations were generally within norms; however, one sample exhibited an extraordinary concentration of dissolved oxygen, greater than 20 mg/l with a saturation greater than 250% (extreme supersaturation). This could be indicative of a periodic pollution event.

Bacterial testing revealed contamination in every sample and with concentrations well above similar EWH streams (Figures B.3.30 and B.3.32) and indicative of a chronic contaminant source, perhaps poor manure management practices or another agricultural source.

Total suspended solids concentrations were all greater than the background median and higher than similarly sized streams (Figure B.3.25). Ammonia, organic nitrogen (TKN), and phosphorus were all present in concentrations that were in excess of other EWH streams of the same drainage area (Figures B.3.34, B.3.36 and B.3.37)). Concentrations of nitrate+nitrite were in the same range as comparison stream reaches (Figure B.3.35).

Spring Fork (02-211) (RM 17.46) (EWH)
Chemical water quality monitoring for Spring Fork occurred at four locations ranging from the headwaters to near the mouth. No water quality criteria violations were observed during the survey; however, some chemical water quality impairments were noted.

Dissolved oxygen mean concentrations were well over the EWH average found in the Ohio WQS. Dissolved oxygen saturation levels were between 80% and 100%. The site at RM 15.90 exhibited excellent oxygen concentrations and nearly saturated conditions during most of the survey (Section C.1). These values were comparable to other EWH stream segments of similar drainage (Figure B.3.27). The sampling location at RM 13.40 exhibited somewhat more variable dissolved oxygen concentrations and a wider range of saturation than similar EWH reaches, although median values for each were comparable to other sites (Figure B.3.41). Spring Fork at RM 7.80 also showed excellent dissolved oxygen concentrations (Figure B.3.45). Spring Fork at RM 0.80 displayed a more variable result for dissolved oxygen concentration and saturation. Saturation values were particularly disturbing with low and high values of around 62% and 130% respectively. This large variability in the data may be indicative of pollution caused by nutrient enrichment. Sources of nutrients to the stream in this area include the Green Meadows MHP WWTP and unrestricted access of livestock (many cattle were seen in the stream several times during the survey).

Both *E. coli* and fecal coliform bacteria results exhibited median values corresponding to EWH stream segments of similar size but the maximum values found were well in excess of these same locations in most cases (Figures B.3.30, B.3.32, B.3.79 and B.3.80).

Figure B.3.79. Mean number of colonies/100 ml. of *E. coli* bacteria from sampling sites in Spring Fork, 2001.

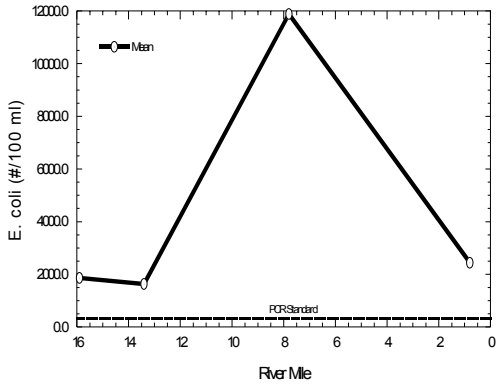
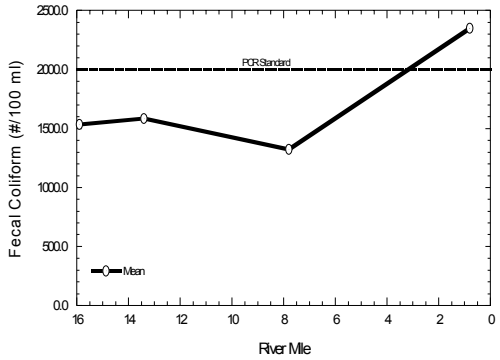


Figure B.3.80. Mean number of colonies/100 ml. of Fecal Coliform bacteria from sampling sites in Spring Fork, 2001.



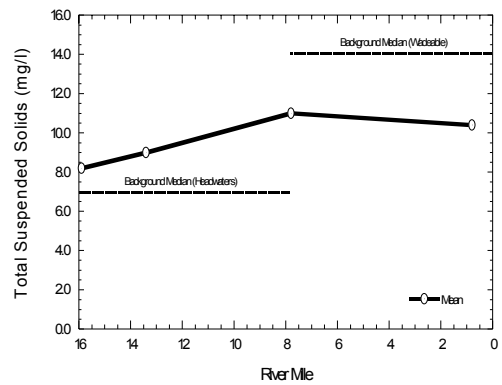
Spring Fork at RM 13.40 and RM 7.80 exhibited similar bacterial results compared to RM 15.40 (Figures B.3.31, B.3.46 and B.3.47). Sampling which occurred during a precipitation event produced the highest values while dry weather flow accounted for the rest. The problem is not completely precipitation-related, however. The site at RM 0.80 was atypical with median values much higher than comparably-sized stream reaches. Precipitation events did not seem to change the concentrations of bacteria noted at this site indicating a regular source of contamination (likely Green Meadows MHP WWTP and cattle in the creek).

Mean total suspended solids concentrations tended to rise slightly from RM 15.90 to RM 7.80 followed by a slight decrease at RM 0.80 (Figure B.3.81). Median values and ranges for suspended solids were much like those found in stream segments of similar EWH use designation and drainage area (Figures B.3.6, B.3.7 and B.3.26) although infrequently, elevated suspended solids concentrations were found in Spring Fork (Section C.1, Table B.3.2).

Nutrient concentrations were mixed with insignificant concentrations of ammonia and total phosphorus found in the upper part of the basin (RM 15.90 to RM 7.80). However, both ammonia and total phosphorus were detected with much more frequency and in higher concentrations at RM 0.80. Four out of 5 phosphorus concentrations were greater than the background median with 2 of these greater than the 75th percentile of background (Table B.3.2). Nitrate and TKN were present in the majority of samples taken at each site. At the upper site (RM 15.90) four out of 5 of the nitrate concentrations were greater than the background median with 2 of these greater than the 75th percentile of background (Table B.3.2). All samples

collected for organic nitrogen (TKN) were greater than the background median with one sample exceeding the 75th percentile and another exceeding the 90th percentile (Table B.3.2). The range of nitrate+nitrite concentrations at RM 15.90 was well above comparison stream segments (Figure B.3.35). Total Kjeldahl Nitrogen samples were comparable to most EWH segments in the 4 to 8 square mile drainage category but much higher than Pleasant Run (one of the higher quality streams noted in the survey, and an appropriate reference stream, see discussion on Pleasant Run above). Detections of nitrate+nitrite at RM 13.40 were fewer with an upper value of nearly 3 mg/l (Table B.3.2). The range and median of nitrate+nitrite values was commensurate with other EWH sites of similar drainage area, basically in the middle of the group (Figure B.3.40). The range of values measured for TKN was much wider than similar stream segments exhibiting the highest median value in the group (Figure B.3.16). Spring Fork at RM 7.80 exhibited results similar to the headwater location at RM 15.90. Most nitrate+nitrite values were greater than the background median as were concentrations of TKN (Table B.3.2). Comparison of this site with other EWH stream segments between 16 and 32 square miles revealed that median values were among the highest for both nitrate+nitrite and TKN (Figure B.3.60). Sampling performed at RM 0.80 exhibited concentrations of nitrate+nitrite that were all above median background concentrations and the highest median of all of the comparison stream reaches. Three of five TKN values exceeded the 75th percentile for background and comparison of these values to other stream reaches revealed that Spring Fork was second only to Hellbranch Run near the mouth.

Figure B.3.81. Mean concentration of Total Suspended Solids at sampling sites in Spring Fork, 2001.



Bales Fork (02-362) (RM 3.64) (Undesignated/WWH)

Chemical water quality monitoring in Bales Fork took place near the mouth at RM 0.40. There were no instances of water quality criteria violations noted during the sampling. Bacterial contamination was non-existent, which was an uncommon phenomenon for this study. Dissolved oxygen concentrations were certainly within the realm of an EWH stream (Figure B.3.21); however, a single instance of supersaturated conditions (nearly 150%) indicated sporadic nutrient enrichment (Section C.1). The regular presence of organic nitrogen (TKN) above the background median and the presence of nitrate+nitrite at concentrations above the 95th percentile of background is further proof of nutrient enrichment (Table B.3.2). Comparison of this reach with undesignated streams of similar drainage area revealed that Bales Ditch is about average in most categories except bacterial concentrations (Figures B.3.21, B.3.42, B.3.19 and B.3.20).

Lower Big Darby Creek, Including Tributaries

(Downstream of confluence with Little Darby Creek to the mouth)

Chemical water quality sampling in Lower Big Darby Creek extended from RM 27.00 downstream of the confluence with Little Darby Creek to RM 3.10 near the mouth (6 sampling stations). Tributaries included in this sampling effort included Smith Ditch (2 sampling stations), Hellbranch Run (6 sampling stations), Hamilton Ditch (2 sampling stations), Clover Groff Ditch (2 sampling stations), Springwater Run (1 sampling station), an unnamed tributary (1 sampling station), Greenbrier Creek (2 sampling stations), and Georges Run (1 sampling station).

Mainstem

Chemical water quality was evaluated in lower Big Darby Creek a total of five times during the 2001 field survey. No violations of water quality criteria were in evidence. Chemical water quality contributions from Little Darby Creek provided a positive influence on Big Darby Creek (e.g., increased dissolved oxygen concentrations and decreased total phosphorus concentrations were evident downstream of the confluence, Figures B.3.82 and B.3.83). Hellbranch Run seemed to negatively influence Big Darby Creek through increased concentrations of bacteria (Figures B.3.84 and B.3.85) and decreases in dissolved oxygen (Figure B.3.82). Mean bacterial concentrations continued a downward trend which began downstream of Sugar Run, until reaching Hellbranch Run and PCI-OCRC WWTP where there was an upward spike (Figures B.3.84 and B.3.85). Mean total suspended solids concentrations decreased downstream of Little Darby Creek and moderated at their lowest level in the entire mainstem, well below background median concentration (Figure B.3.86).

Nutrient concentrations in this section of Big Darby Creek were mixed in comparison to other parts of the basin. Nitrate+nitrite and TKN values were very consistent from the confluence with Little Darby Creek to the mouth (Figures B.3.87 and B.3.88). Mean total phosphorus concentrations rose throughout the same segment, increasing significantly downstream of Hellbranch Run and PCI-ODRC WWTP (Figure B.3.83). Elevated nutrient concentrations in the lower Big Darby Creek revealed nutrient enrichment threatens lower section of the mainstem. Nitrate+nitrite concentrations were found above the background median in nearly 47% of the samples whereas total phosphorus values exceeded the background median in over 43% of the samples (over a third of the total phosphorus values exceeded the 75th percentile for background, (Table B.3.2).

Figure B.3.82. Mean Dissolved Oxygen concentrations at sampling sites in the mainstem of Big Darby Creek, 2001.

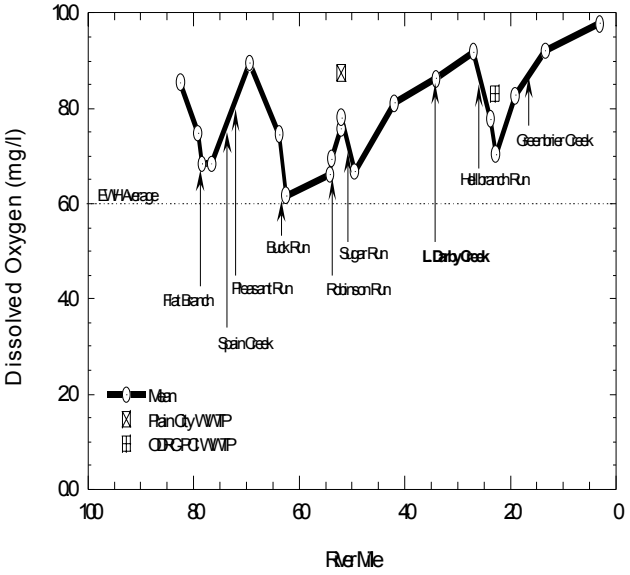


Figure B.3.83. Mean Total Phosphorus concentrations at sampling sites in the mainstem of Big Darby Creek, 2001.

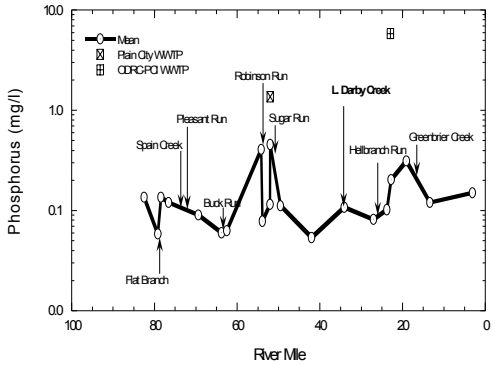


Figure B.3.84. Mean number of colonies of Fecal Coliform bacteria in the Big Darby Creek mainstem, 2001.

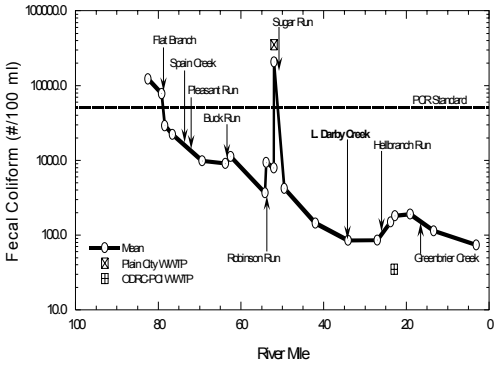


Figure B.3.85. Mean number of colonies of E. coli bacteria in the Big Darby Creek mainstem, 2001.

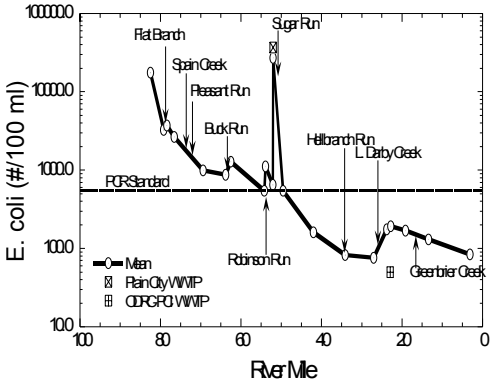


Figure B.3.86. Mean concentration of TSS at sampling sites in the Big Darby Creek mainstem, 2001.

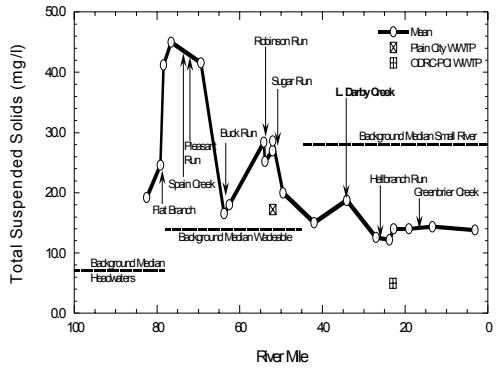


Figure B.3.87. Mean concentration of Nitrate+Nitrite at sampling sites in the Big Darby Creek mainstem, 2001.

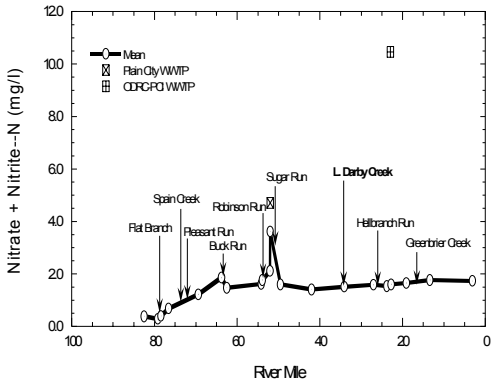
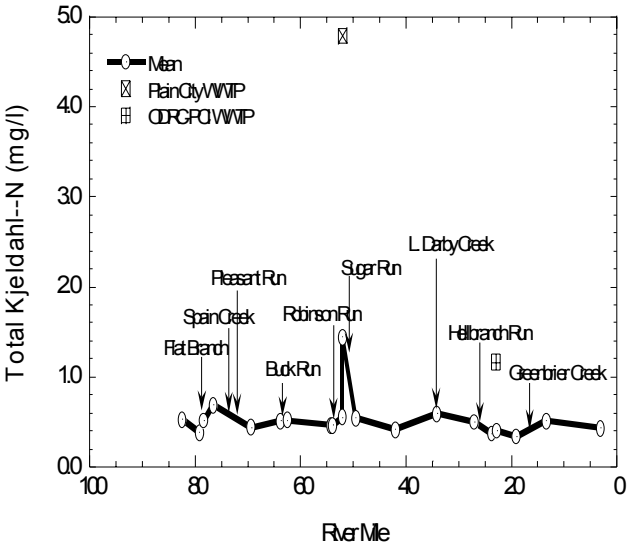


Figure B.3.88. Mean concentration of Total Kjeldahl Nitrogen at sampling sites in the Big Darby Creek mainstem, 2001.



Storm water monitoring was performed at various times over a year's period for Big Darby Creek at S.R. 316 near Darbyville (RM 13.40). This sampling station houses a USGS gauge which provided flow data which allowed for the calculation of different pollutant loadings. Total suspended solids and three nutrients were evaluated. Results similar to those found in Little Darby Creek were noted, that is, loadings increased with flow (Figures B.3.89 to B.3.92). For example, a storm event sampled on April 30, 2002 showed a flow of 32,557 liters/second (1150 ft^3/s) with loadings of 140,645 kg/d of suspended solids, 17,946 kg/d of nitrate+nitrite, 239 kg/d of ammonia, and 456 kg/d of phosphorus, whereas a storm event monitored on March 28, 2002 exhibited a flow of 66,528 liters/second (2,350 ft^3/s) with loadings of 482,840 kg/d of suspended solids, 49,836 kg/d of nitrate+nitrite, 420 kg/d of ammonia, and 770 kg/d of phosphorus. Comparisons of the flows and loadings between these events shows increased flow (2 fold) with a 3.4 fold increase in suspended solids, a 2.8 fold increase in loadings of nitrate+nitrite, a 1.8 fold increase in ammonia loadings, and a 1.7 fold increase in phosphorus loadings.

Generally, concentrations of pollutants tended to increase with flow. Graphs of flow versus concentration for ammonia, nitrate+nitrite, and total suspended solids show that concentrations increased with flow with good correlation (Figures B.3.89 to B.3.91). The relationship with total phosphorus did not show increased concentrations with flow (Figure B.3.92).

Smith Ditch (02-353) (RM 31.69) (Undesignated/EWH Recommended)
Smith Ditch was evaluated for chemical water quality at a single location at RM 2.10. Water quality criteria for WWH apply to this stream even though it is currently undesignated. Violations of water quality criteria were not found. Comparisons of bacterial values with similar undesignated stream segments revealed that Smith Ditch was average. Suspended solids and nutrient concentrations tended to be average (nitrate+nitrite, TSS) or lower (TKN, total phosphorus) than most comparison stream segments (Figures B.3.6, B.3.20 and B.3.19).

Unnamed Tributary to Smith Ditch (02-354) (RM0.06) (Undesignated/EWH Recommended)
This small tributary of Smith Ditch (0.9 square mile drainage area) contained consistent flow during the summer, likely due to groundwater input. Chemical water quality was evaluated just upstream of the confluence with Smith Ditch. Water quality criteria for WWH apply to this stream even though it is currently undesignated. No violations of water quality criteria were found for this stream. Dissolved oxygen concentrations were more than adequate to support an exceptional fauna, although moderately supersaturated conditions were noted (Figures B.3.68 and B.3.69). Suspended solids and nutrients were not a concern in this tributary and compared favorably with other streams of small drainage.

Gay Run (02-298) (RM 26.48) (Undesignated/WWH Recommended)
No chemical data taken.

Figure B.3.89. Big Darby Creek Storm Event Sampling: Mean Daily Flow vs. Total Suspended Solids Loadings based on USGS Gaging Station sampling at SR 316 near Darbyville (RM 13.4), 2001.

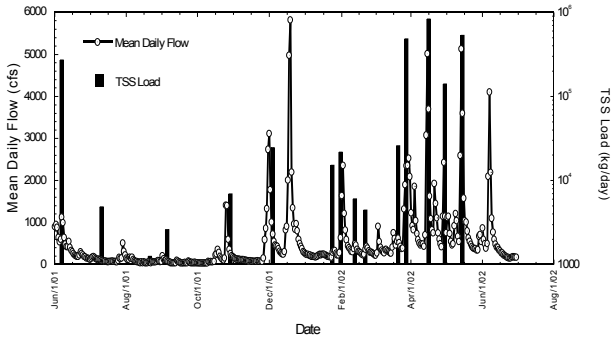


Figure B.3.90. Big Darby Creek Storm Event Sampling: Mean Daily Flow vs. Nitrate+Nitrite Loadings based on USGS Gaging Station sampling at SR 316 near Darbyville (RM 13.4), 2001.

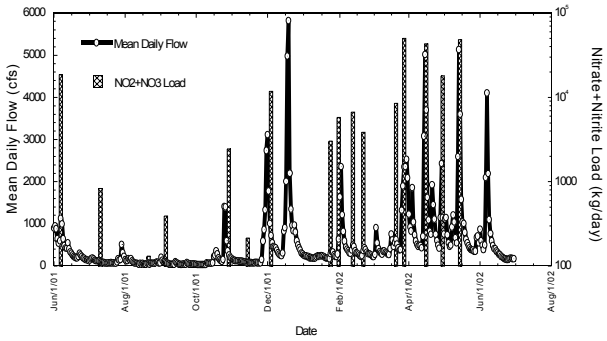


Figure B.3.91. Big Darby Creek Storm Event Sampling: Mean Daily Flow vs. Ammonia Loadings based on USGS Gaging Station sampling at SR 316 near Darbyville (RM 13.4), 2001.

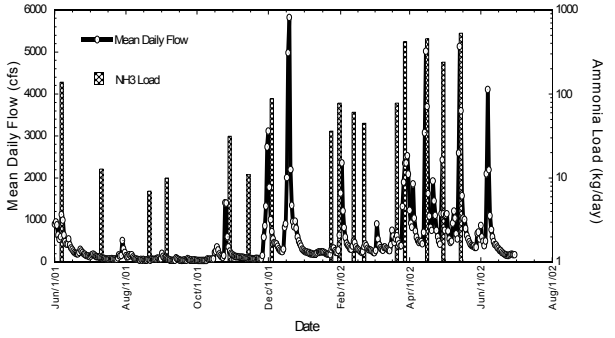
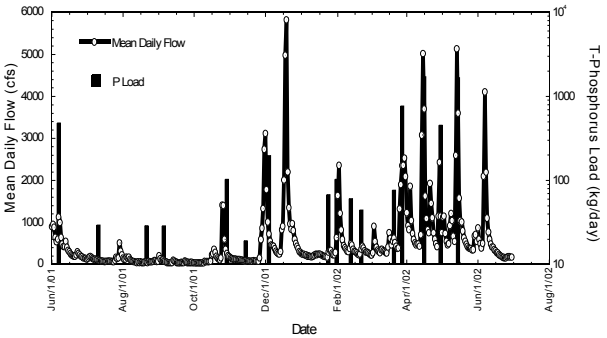


Figure B.3.92. Big Darby Creek Storm Event Sampling: Mean Daily Flow vs. Total Phosphorus Loadings based on USGS Gaging Station sampling at SR 316 near Darbyville (RM 13.4), 2001.



Hellbranch Run (02-204) (RM 26.1) (WWH)

Chemical water quality was evaluated in Hellbranch Run five times at six locations. There was only 1 water quality criteria violation during the sampling period. At RM 0.50, the dissolved oxygen minimum standard was violated (Table B.3.1). Mean concentrations of dissolved oxygen showed an upward trend in the subbasin which was well above the WWH average standard (Figure B.3.93). Mean oxygen concentrations then fell downstream of the Timberlake WWTP.

Total suspended solids values found in Hellbranch Run were highest at RM 10.10, just downstream of the confluence of Clover Groff and Hamilton Ditches. All suspended solids measurements at RM 10.10 were greater than the background median (Table B.3.2). These concentrations diminished downstream and stabilized at an average concentration of about 6 mg/l before increasing slightly downstream of the Timberlake WWTP (Figure B.3.94).

Hellbranch Run also experienced problems with nutrient enrichment. Seventy percent of the samples analyzed for organic nitrogen (TKN) showed values in excess of the 75th percentile for background with over 13 percent of the samples exceeding the 90th percentile (Table B.3.2). Samples analyzed for total phosphorus showed even larger values. Over 93 percent of the samples analyzed for total phosphorus transcended the background median with over 10 percent exceeding the 95th percentile (Table B.3.2). Both the Oakhurst Knolls WWTP and the Timberlake WWTP were responsible for some of the nutrient enrichment in the stream. Increases in TKN, total phosphorus, and nitrate+nitrite were all noted downstream of each WWTP (Figures B.3.95 to B.3.97).

Storm water monitoring was performed at various times over a year's period for Hellbranch Run at Lambert Road (RM 0.50). This sampling station is just downstream of a USGS gauge which provided flow data which allowed for the calculation of different pollutant loadings. Total suspended solids and 3 nutrients were evaluated. Again, increased flows generally corresponded to increased loadings of pollutants (Figures B.3.98 to B.3.102). For example, a storm event sampled on March 28, 2002 exhibited a flow of 4,303 liters/second (152 ft^3/s) with loadings of 12,269 kg/d of suspended solids, 1,985 kg/d of nitrate+nitrite, 25 kg/d of ammonia, and 54 kg/d of phosphorus whereas a storm event monitored on April 15, 2002 showed a flow of 11,352 liters/second (401 ft^3/s) with loadings of 96,123 kg/d of suspended solids, 3276 kg/d of nitrate+nitrite, 61 kg/d of ammonia, and 200 kg/d of phosphorus. Comparisons of the flows and loadings between these events showed increased flow (2.6 fold) with a 7.8 fold increase in suspended solids, (well above that found in Little and Big Darby Creeks and perhaps indicative of the high rate of development (i.e., disturbed landscape) in this watershed), a 1.7 fold increased loading of nitrate+nitrite, a 2.3 fold increase in ammonia loadings, and a 3.7 fold increase in phosphorus loadings.

Hamilton Ditch (02-259) (RM 11.19) (MWH, WWH)

Hamilton Ditch was evaluated for chemical water quality at two locations, RM 3.40 which is designated MWH (due to channel modification) and RM 0.50 which is designated WWH. There were no violations of chemical water quality criteria.

Figure B.3.93. Mean concentrations of Dissolved Oxygen at sampling sites in Hellbranch Run, 2001.

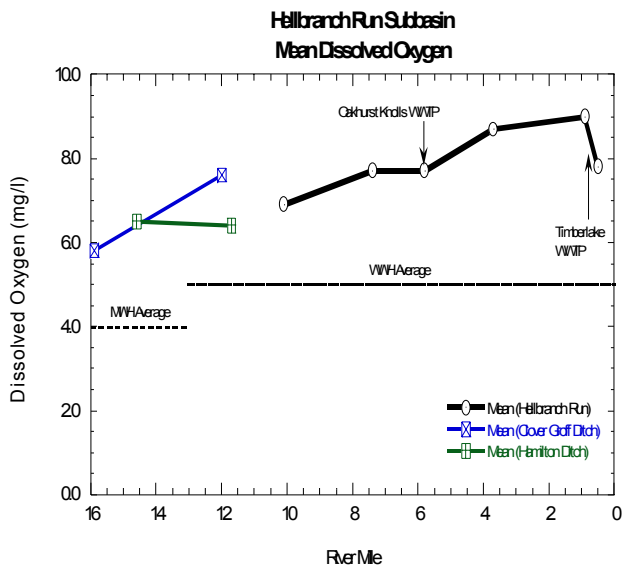


Figure B.3.94. Mean concentrations of Total Suspended Solids at sampling sites in Hellbranch Run, 2001.

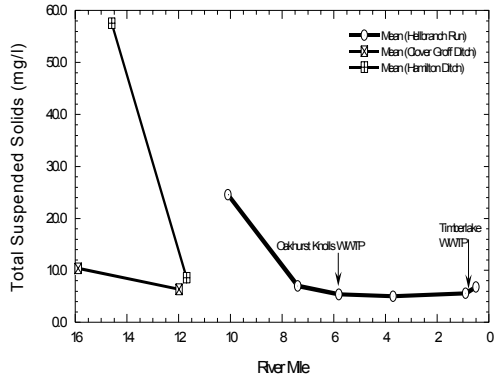


Figure B.3.95. Mean concentrations of Total Kjeldahl Nitrogen at sampling sites in Hellbranch Run, 2001.

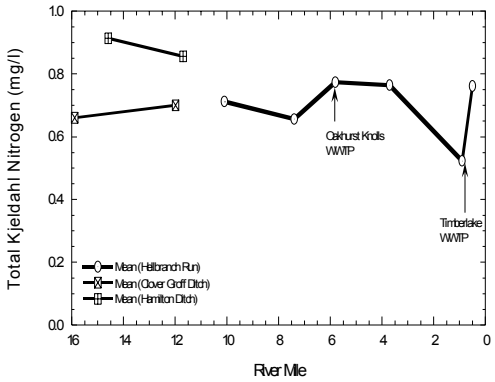


Figure B.3.96. Mean concentrations of Total Phosphorus at sampling sites in Hellbranch Run, 2001.

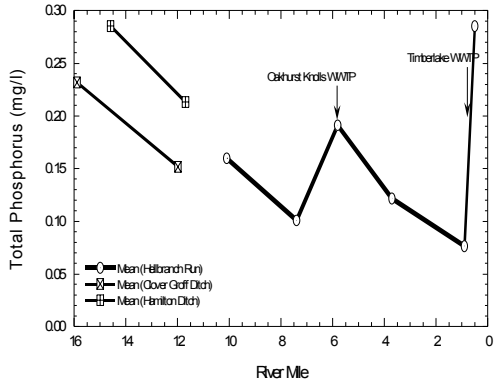


Figure B.3.97. Mean concentration of Nitrate+Nitrite at sampling sites in the Hellbranch Run subwatershed, 2001.

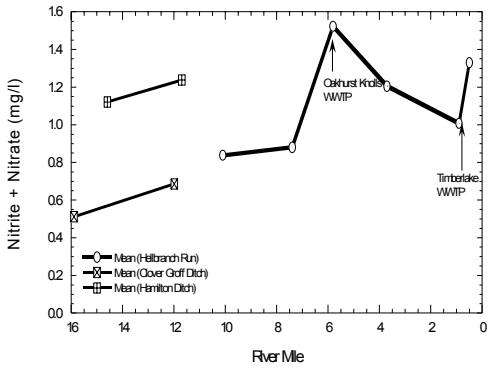


Figure B.3.98. Hellbranch Run Storm Event Sampling: Mean Daily Flow vs. Total Suspended Solids Loadings based on USGS Gaging Station sampling at Lambert Rd. (RM 0.5), 2001.

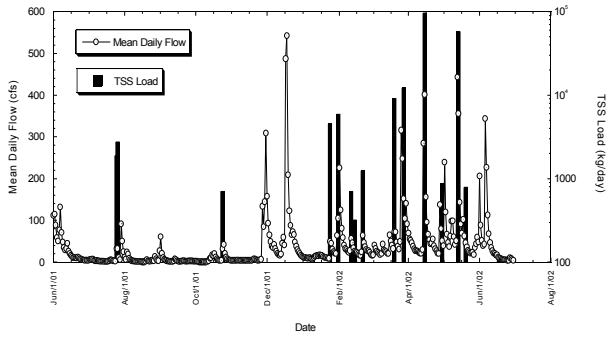


Figure B.3.99. Hellbranch Run Storm Event Sampling: Mean Daily Flow vs. Total Suspended Solids Loadings based on USGS Gaging Station sampling at Lambert Rd. (RM 0.5), 2001.

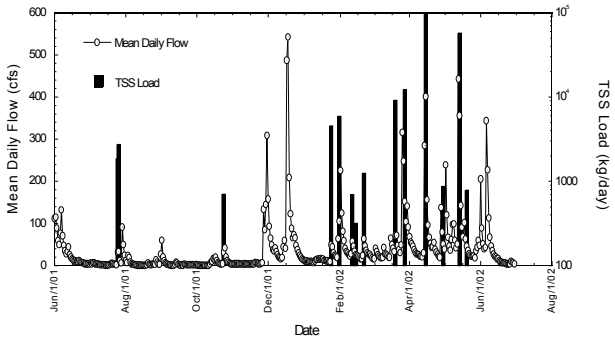


Figure B.3.100. Hellbranch Run Storm Event Sampling: Mean Daily Flow vs. Nitrate+Nitrite Loadings based on USGS Gaging Station sampling at Lambert Rd. (RM 0.5), 2001.

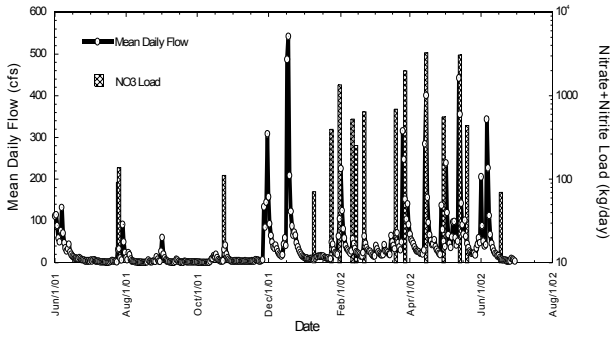


Figure B.3.101. Hellbranch Run Storm Event Sampling: Mean Daily Flow vs. Ammonia Loadings based on USGS Gaging Station sampling at Lambert Rd. (RM 0.5), 2001.

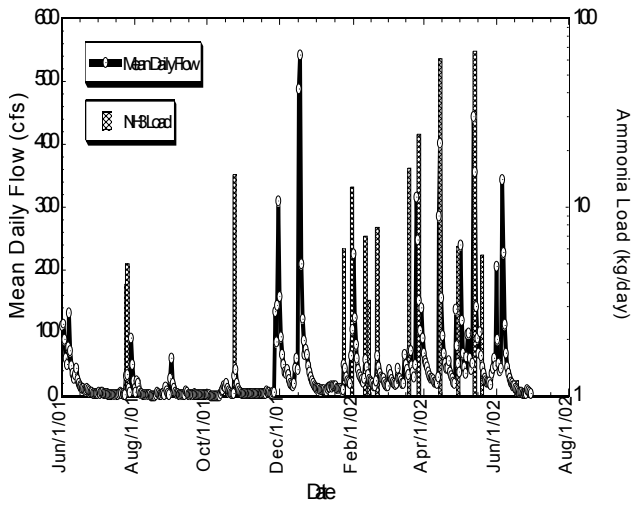
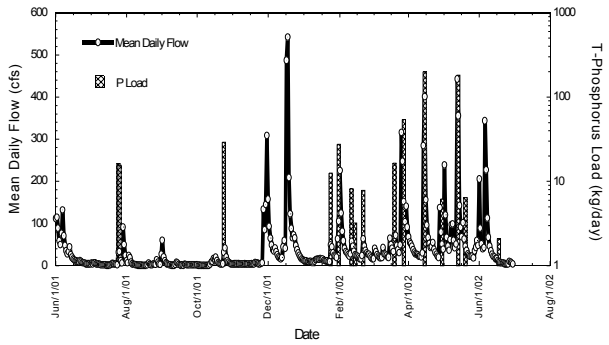


Figure B.3.102. Hellbranch Run Storm Event Sampling: Mean Daily Flow vs. Total Phosphorus Loadings based on USGS Gaging Station sampling at Lambert Rd. (RM 0.5), 2001.



Dissolved oxygen concentrations were more than adequate at the upstream site with small variation in the data; however, the WWH site exhibited highly variable dissolved oxygen concentrations, even though water quality criteria were not violated (Section C.1). The range of dissolved oxygen concentration and saturation was large (Figure B.3.41) indicative of environmental stress.

Total suspended solids concentrations at the upstream site were also highly variable with values exceeding the 95th percentile of background down to the detection level (Table B.3.2). Median values were typical for MWH sites (Figure B.3.10). Eighty percent of the TSS results taken from the downstream site were above the background median; however, none of the large variability found upstream, was encountered here. Total suspended solids concentrations at RM 0.50 were similar to other WWH sites of the same drainage area (Figure B.3.26).

Nutrient concentrations for RM 3.40 and RM 0.50 Hamilton Ditch were commensurate with those found at sites with similar drainage areas for nitrate+nitrite, TKN, and ammonia (Figures B.3.11, B.3.13, B.3.14, B.3.16, B.3.39 and B.3.40). Even though these were "typical" of modified sites, nutrient values were still much above background median concentrations, often above the 75th percentile values (Table B.3.2). Total phosphorus concentrations were noticeably higher than most other comparison locations for both sites (Figures B.3.12 and B.3.17) mostly exceeding the 90th percentile of background (Table B.3.2).

Clover Groff Ditch (02-245) (RM 11.19) (MWH, WWH)

Clover Groff Ditch was evaluated for chemical water quality at 2 locations, RM 4.70 which is

designated MWH (due to channel modification) and RM 0.80 which is designated WWH. There were no violations of chemical water quality criteria.

Both sites on Clover Groff Ditch exhibited adequate dissolved oxygen concentrations for their respective use designations (Figures B.3.15 and B.3.27). Dissolved oxygen saturation values were also adequate, although somewhat depressed.

Median total suspended solids concentrations were slightly above and below the background median value at RM 4.70 and RM 0.80 respectively. The wide ranges in values were absent here, compared with Hamilton Ditch and similar stream segments and were more representative of "normal" levels of suspended solids concentration (Figures B.3.10 and B.3.25).

Nitrate+nitrite was not detected above background median values in Clover Groff Ditch (Table B.3.2). Other nutrients were discovered at high concentrations at times during the survey. Most ammonia values found at RM 4.70 were in excess of the 90th percentile for background. Ammonia concentrations diminished at RM 0.80. TKN concentrations almost all exceeded the median background concentration for each site indicating the presence of excess organic nitrogen compounds. Comparison with similar stream segments showed that Clover Groff Ditch had "normal" concentrations of TKN at RM 4.70 and above average concentrations of TKN at RM 0.80 (Figures B.3.11 and B.3.36). Median total phosphorus concentrations at RM 4.70 were comparable to some of the EWH and WWH streams of similar drainage area although there was one value which spiked high (Figure B.3.12). However, total phosphorus was elevated at RM 0.80 in comparison with similar stream reaches, with most of the values above the 75th percentile of background.

The Thornapple Country Club WWTP and the Cypress Wesleyan School WWTP may be contributing to some of the nutrient enrichment noted at RM 0.80.

Springwater Run (02-203) (RM 24.0) (WWH)
Chemical water quality was evaluated in Springwater Run at one location near the mouth at RM 0.20. No violations of water quality criteria were noted in Springwater Run.

Dissolved oxygen concentrations and saturation were excessive with all samples exhibiting supersaturated conditions (Figure B.3.15). Supersaturated oxygen concentrations are often due to algal overpopulation exacerbated by nutrient enrichment and poor riparian cover. Nutrient concentrations found in Springwater Run do indeed confirm that the stream is nutrient enriched with all nitrate+nitrite values exceeding the background median, 60% of the TKN values above the 75th percentile for background, and all results for total phosphorus in excess of the 75th percentile for background. Suspended solids were not problematic in this stream. The unsewered community of Harrisburg could be contributing to the nutrient enrichment..

Unnamed Tributary to Big Darby Creek (02-352) (RM 23.77) (Undesignated/WWH Recommended)
No chemical data taken.

Unnamed Tributary to Big Darby Creek (02-270) (RM 20.2) (Undesignated/WWH Recommended)

Chemical water quality was evaluated on this unnamed tributary at RM 0.80. Water quality criteria for WWH apply to this stream even though it is currently undesignated. No violations of water quality criteria were noted in "Clark's Lake Outlet".

Dissolved oxygen concentrations and saturation levels were adequate for a warmwater stream and similar to many of the undesignated streams of the same drainage area (Figures B.3.21 and B.3.42). Total suspended solids concentrations were also low, similar to most comparison stream reaches.

Nutrient concentrations were variable for certain parameters and fairly consistent for others. Ammonia concentrations varied widely as did nitrite (Section C.1). Total phosphorus, nitrate+nitrite, and TKN concentrations were more consistent, but elevated, especially total phosphorus with all values exceeding the 75th percentile for background (Table B.3.2). Comparisons with similarly-sized, undesignated streams shows elevated TKN and "normal" concentrations of total phosphorus and nitrate+nitrite (Figures B.3.19 and B.3.20). Organic nitrogen concentrations may result from the Clark's Lake subdivision discharge.

Greenbrier Creek (02-202) (RM 16.75) (WWH)

Chemical water quality was evaluated on Greenbrier Creek at 2 locations, RM 2.70 and RM 1.30. A single water quality criteria violation was noted for dissolved oxygen at RM 2.70 (Table B.3.1).

Median concentrations of total suspended solids were less than the background median at both sites. Nutrient enrichment was a concern at RM 2.70. Nitrate+nitrite, TKN and total phosphorus concentrations were obviously elevated compared to other WWH streams of similar drainage area (Figures B.3.11, B.3.12 and B.3.14). All phosphorus concentrations measured at RM 2.70 were greater than the 75th percentile of background Table B.3.2. Total phosphorus and nitrate+nitrite also appeared elevated at RM 1.30 (Figures B.3.12 and B.3.14).

Georges Run (02-201) (RM 14.4) (WWH)

Water chemistry was examined in Georges Run at a single point (RM 1.20) during the 2001 survey. No violations of water quality criteria were discovered. Dissolved oxygen concentrations were variable but largely supersaturated, with a median value that was the highest of any 0-2 mile drainage stream (Figures B.3.68 and B.3.69). Supersaturated conditions generally result from nutrient enrichment and lack of riparian shading which promote algal overpopulation. Median nutrient concentrations were found to be comparable or less than streams with similar drainage areas. Few nutrient values exceeded the background median (Table B.3.2).

Diurnal Dissolved Oxygen Study-Big Darby Creek Watershed

Upper Watershed

Mainstem sites on Big Darby Creek in the upper watershed (headwaters to Plain City WWTP outfall) generally exhibited normal daily fluctuations in dissolved oxygen, although some sites showed supersaturated conditions of around 120% (Figures B.3.103 and B.3.104) which indicated nutrient enrichment and an open canopy. The only site which deviated from this pattern was found at RM 78.40, just downstream from the confluence with Flat Branch where dissolved oxygen concentrations fell below minimum criteria for EWH streams (Figure B.3.105). This area is influenced by the discharge from Flat Branch (Figures B.3.106 and B.3.107).

Tributary streams in this part of the watershed proved to be influenced in a variety of ways. Flat Branch showed wide fluctuations in dissolved oxygen concentrations/saturation in the upper and middle parts of the subbasin. Supersaturated conditions during the daylight hours result from nutrient enrichment and an open canopy (Figures B.3.108 to B.3.111). Poorly saturated conditions existed at the mouth at RM 0.80 during midsummer (Figures B.3.114 and B.3.115), likely influencing Big Darby Creek itself. Autumn conditions showed improvement in dissolved oxygen levels near the mouth (Figure B.3.112 and B.3.113). Little Darby Creek (Logan County), Robinson Run, and Buck Run all exhibited normal diurnal fluctuations for sites at the mouth and adequate to good concentrations and saturations (Figures B.3.114 to B.3.119). Robinson Run in the upper part of the stream showed similar diurnal variability, but without the smooth curves (Figures B.3.120 and B.3.121).

Figure B.3.103. Diel percent Dissolved Oxygen Saturation at RM 78.5 on the mainstem of Big Darby Creek, 2001.

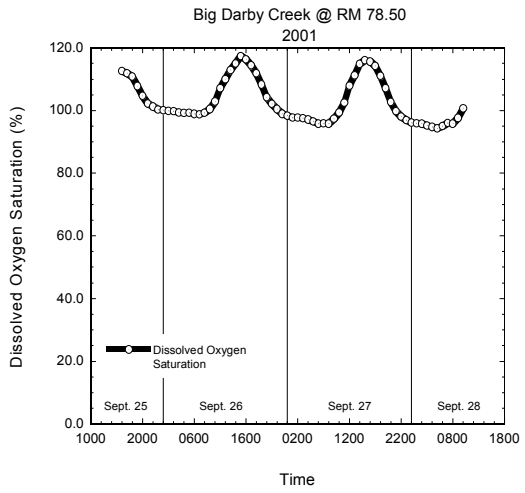


Figure B.3.104. Diel percent Dissolved Oxygen Saturation at RM 76.6 on the mainstem of Big Darby Creek, 2001.

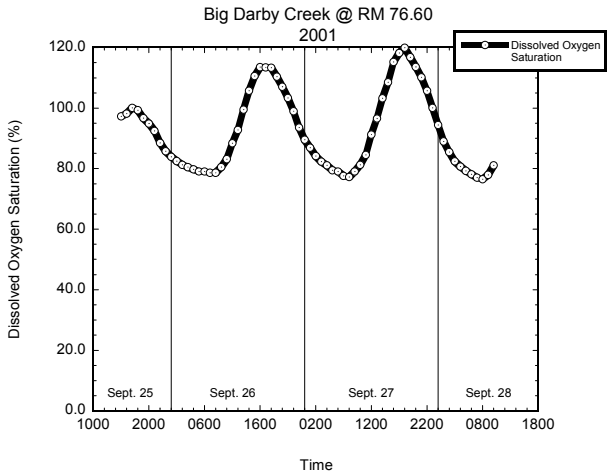


Figure B.3.105. Diel Dissolved Oxygen concentrations at RM 78.4 on the mainstem of Big Darby Creek, 2001.

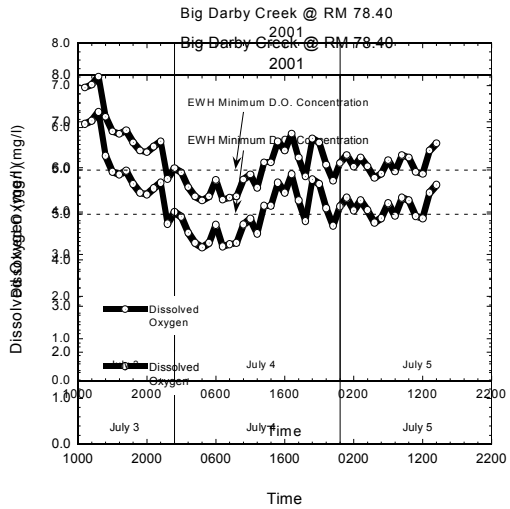


Figure B.3.106. Diel Dissolved Oxygen concentrations at RM 0.8 on Flat Branch, 2001.

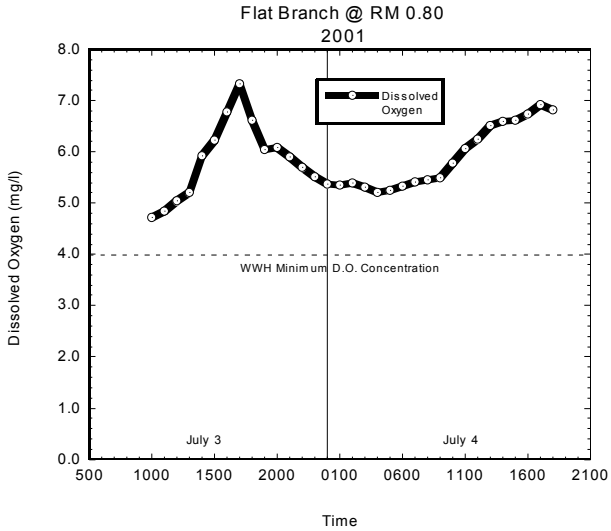


Figure B.3.107. Diel percent Dissolved Oxygen Saturation at RM 0.8 in Flat Branch, 2001.

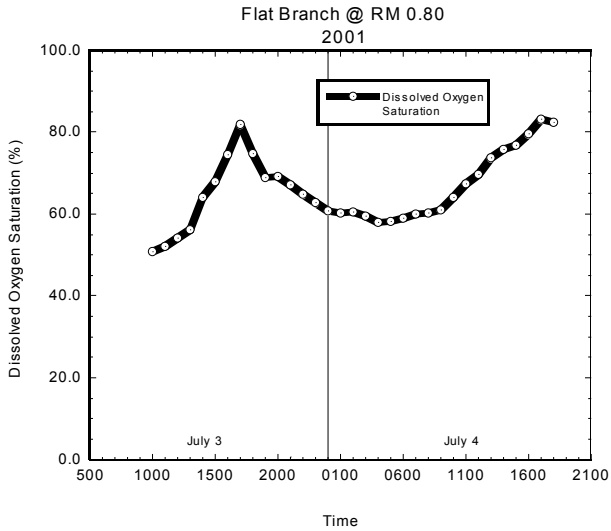


Figure B.3.108. Diel Dissolved Oxygen concentrations at RM 5.3 on Flat Branch, 2001.

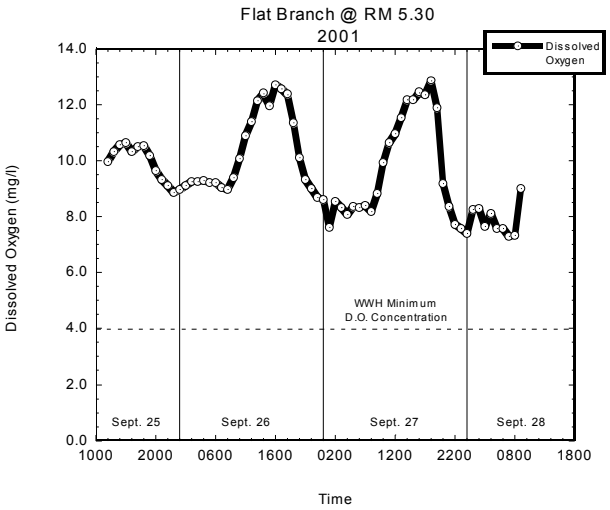


Figure B.3.109. Diel percent Dissolved Oxygen Saturation at RM 5.3 in Flat Branch, 2001.

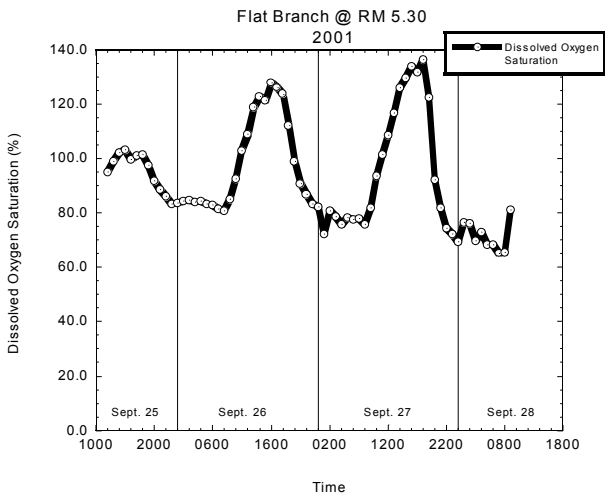


Figure B.3.110. Diel Dissolved Oxygen concentrations at RM 2.2 in Flat Branch, 2001.

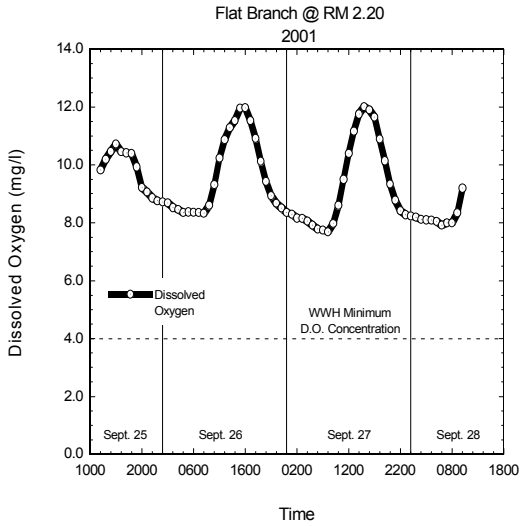


Figure B.3.111. Diel percent Dissolved Oxygen Saturation at RM 2.2 in Flat Branch, 2001.

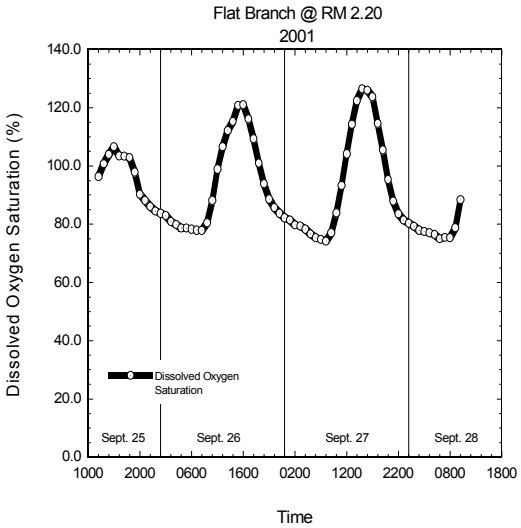


Figure B.3.112. Diel Dissolved Oxygen concentrations at RM 0.05 in Flat Branch, 2001.

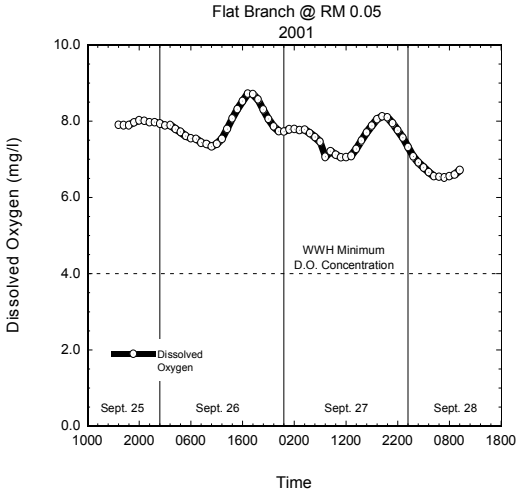


Figure B.3.113. Diel percent Dissolved Oxygen Saturation at RM 0.05 in Flat Branch, 2001.

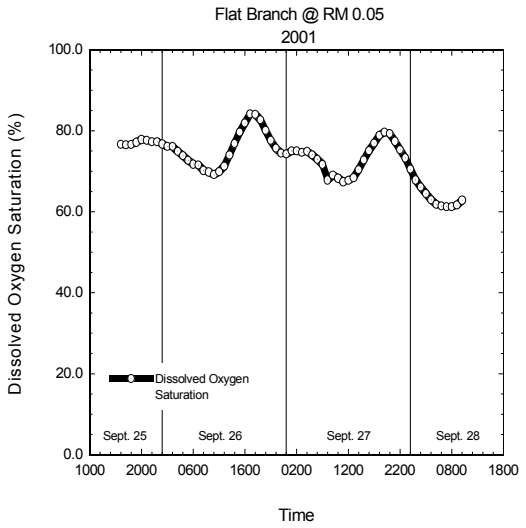


Figure B.3.114. Diel Dissolved Oxygen concentration at RM 0.4 in Little Darby Creek (Logan County), 2001.

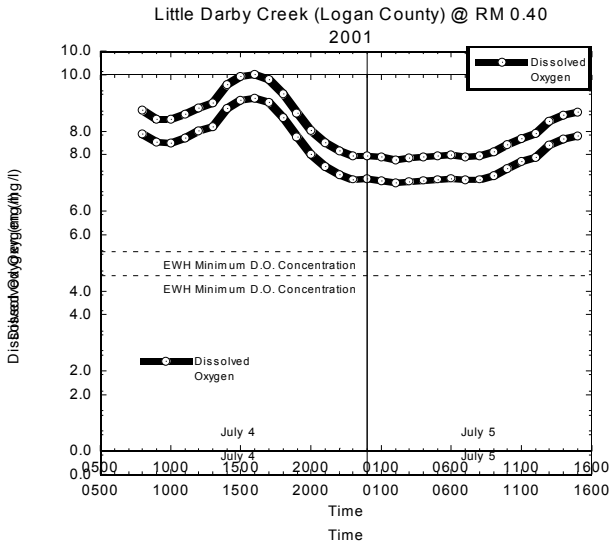


Figure B.3.115. Diel percent Dissolved Oxygen Saturation at RM 0.4 in Little Darby Creek (Logan County), 2001.

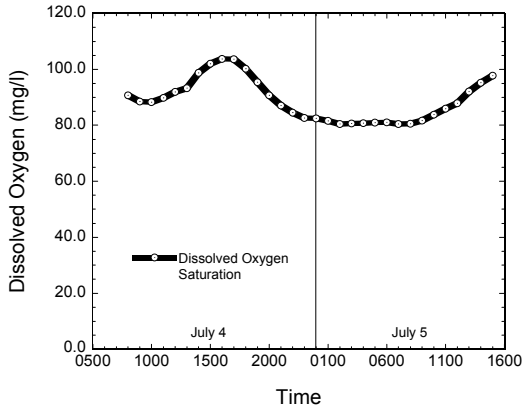


Figure B.3.116. Diel Dissolved Oxygen concentrations at RM 0.7 in Robinson Run, 2001.

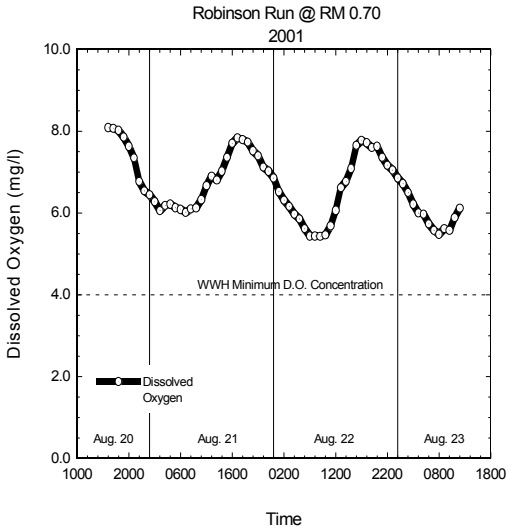


Figure B.3.117. Diel percent Dissolved Oxygen Saturation at RM 0.7 in Robinson Run, 2001.

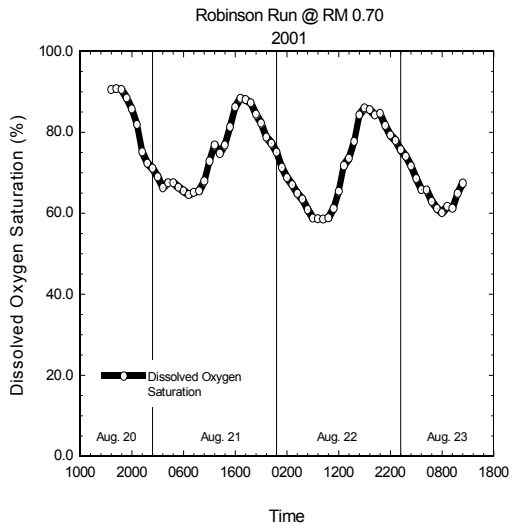


Figure B.3.118. Diel Dissolved Oxygen concentrations at RM 0.1 in Buck Run, 2001.

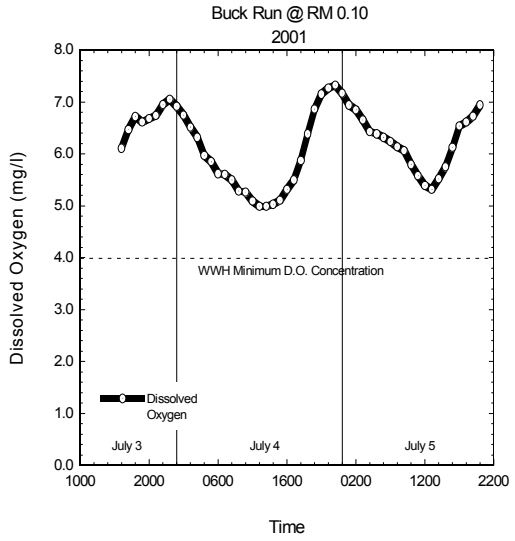


Figure B.3.119. Diel percent Dissolved Oxygen Saturation at RM 0.1 in Buck Run, 2001.

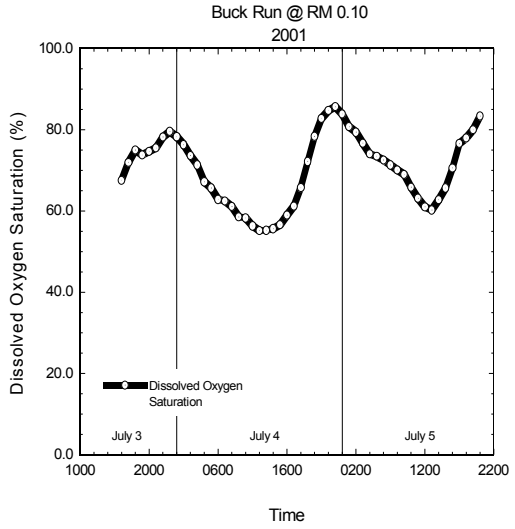


Figure B.3.120. Diel Dissolved Oxygen concentrations at RM 2.1 in Robinson Run, 2001.

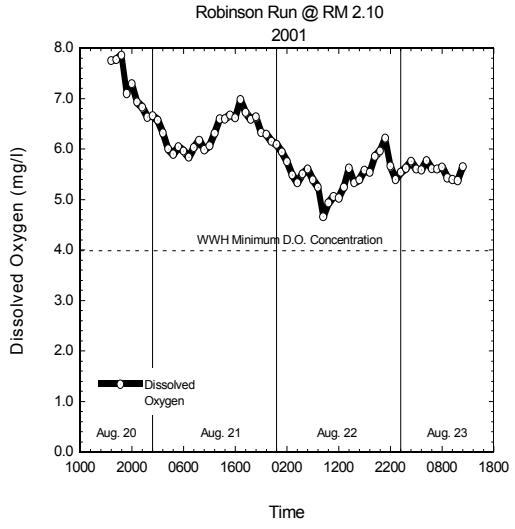
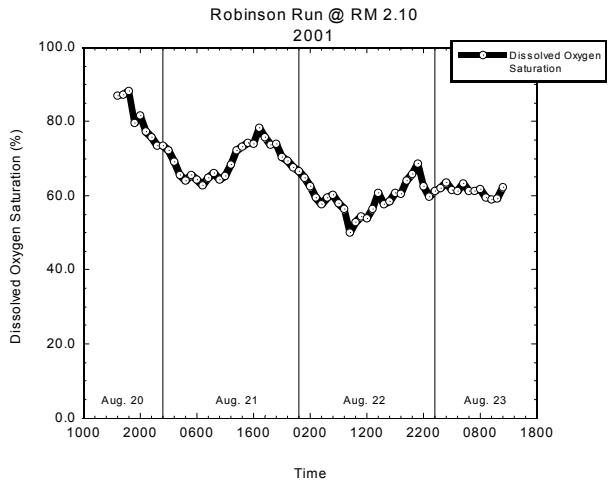


Figure B.3.121. Diel percent Dissolved Oxygen Saturation at RM 2.1 in Robinson Run, 2001.



Middle Watershed

Dissolved oxygen concentrations in this section of the Big Darby mainstem exhibited a variety of conditions. Directly downstream of the Plain City WWTP outfall, dissolved oxygen concentrations were adequate and exhibited a normal diurnal fluctuation (Figure B.3.122). However, further downstream, dissolved oxygen values were consistently below EWH minimum dissolved oxygen criteria with little or no normal diurnal fluctuation (Figure B.3.123). This site is likely located in the "oxygen sag" downstream of the Plain City WWTP. The site at the confluence with Little Darby Creek showed some supersaturated conditions early but moderated later (Figures B.3.124 and B.3.125). Sugar Run exhibited excellent concentrations of dissolved oxygen at the mouth, well above WWH criteria without harmful levels of supersaturation (Figures B.3.126 and B.3.127).

Little Darby Creek Watershed

Diel dissolved oxygen values found in the Little Darby Creek mainstem were all in normal ranges for concentration and saturation. The only area of concern was found downstream of the confluence with Treacle Creek at RM 29.50 (Figure B.3.128). Dissolved oxygen concentrations were found near the EWH minimum standard. Samples taken from the mouth of Treacle Creek (RM 0.80) confirmed that dissolved oxygen concentrations are not meeting EWH minimum criteria during early morning hours (Figure B.3.129). This has negatively influenced the dissolved oxygen values in Little Darby Creek and is likely due to organic enrichment arising from Treacle Creek. A tributary to Treacle Creek called Proctor Run exhibited a normal diel fluctuation for dissolved oxygen and oxygen saturation.

Lower Watershed

Diurnal dissolved oxygen concentrations in the lower Big Darby Creek watershed showed some variability. Normal diel fluctuations in concentration and saturation were noted at RM 28.00, just upstream of the Darbydale area. At RM 27.70, just downstream of the influence of Darbydale, dissolved oxygen concentrations were more irregular and dipped below the EWH minimum criteria. The Darbydale unsewered area likely contributes to organic enrichment here. Samples taken at locations throughout this section downstream of Darbydale exhibited some wide variability. Supersaturated conditions were common, often reaching and exceeding 120% (Figures B.3.130 and B.3.131). Concentrations often ranged widely during a 24 hour period, nearly 7 mg/l in some cases (Figure B.3.132). This wide variability seen in diurnal dissolved oxygen values provided evidence of nutrient enrichment and algal overproduction. Hellbranch Run exhibited excellent concentrations of dissolved oxygen at the mouth, well above WWH criteria without harmful levels of supersaturation (Figure B.3.133).

Figure B.3.122. Diel Dissolved Oxygen concentrations at RM 52.0 in Big Darby Creek, 2001.

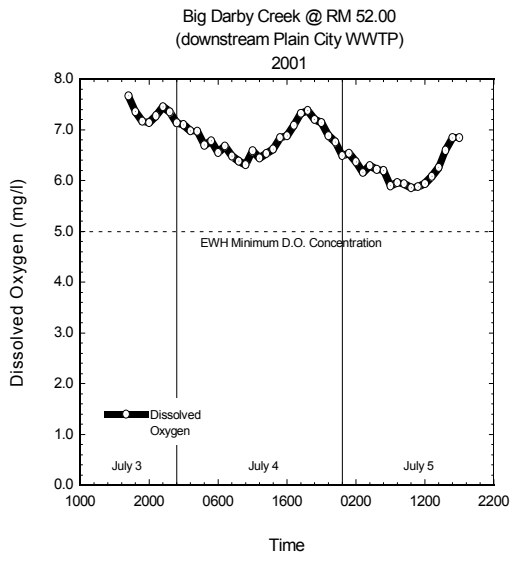


Figure B.3.123. Diel Dissolved Oxygen concentrations at RM 49.5 in Big Darby Creek, 2001.

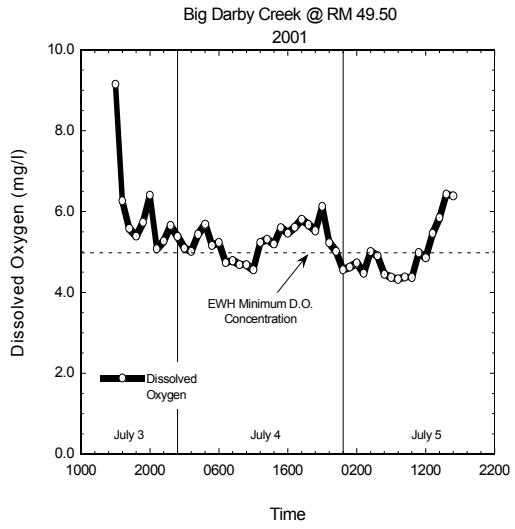


Figure B.3.124. Diel Dissolved Oxygen concentrations at RM 34.1 in Big Darby Creek, 2001.

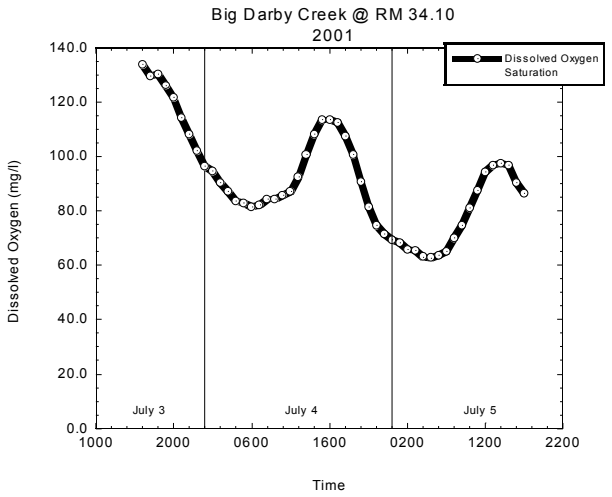


Figure B.3.125. Diel percent Dissolved Oxygen Saturation at RM 34.1 in Big Darby Creek, 2001.

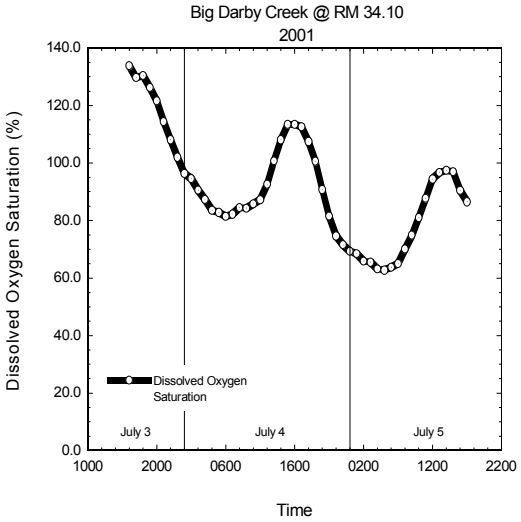


Figure B.3.126. Diel Dissolved Oxygen concentrations at RM 0.5 in Sugar Run, 2001.

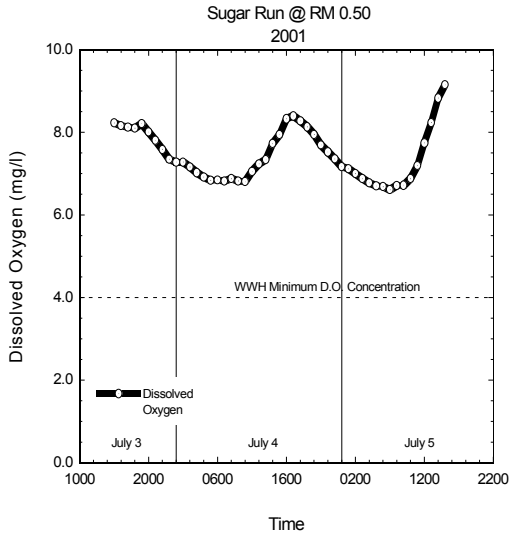


Figure B.3.127. Diel Dissolved Oxygen Saturation at RM 0.5 in Sugar Run, 2001.

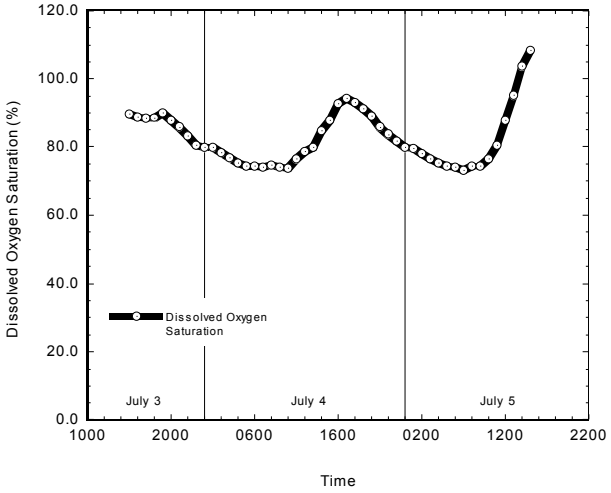


Figure B.3.128. Diel Dissolved Oxygen concentrations in Little Darby Creek at RM 29.5, 2001.

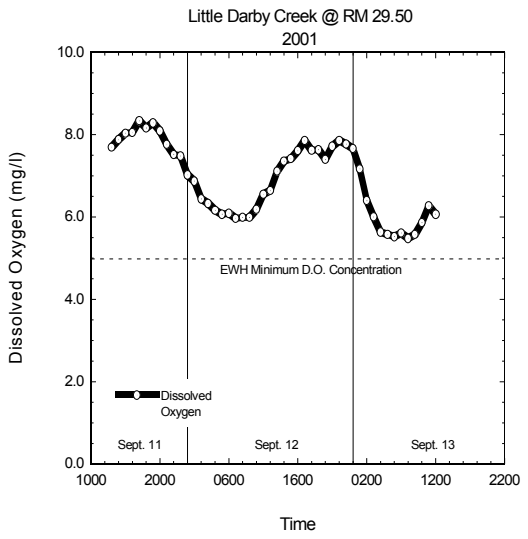


Figure B.3.129. Diel Dissolved Oxygen concentrations in Treacle Creek at RM 0.8, 2001.

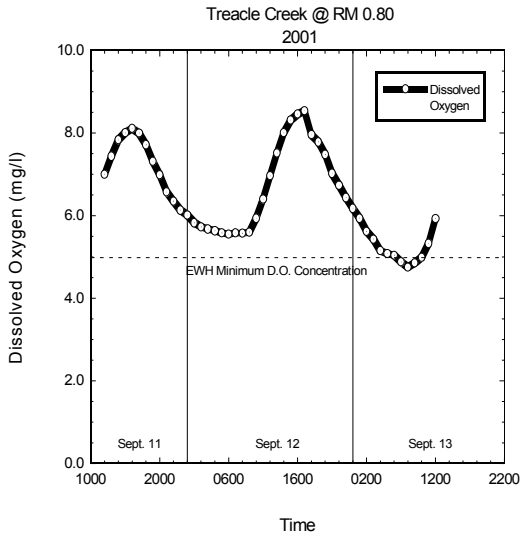


Figure B.3.130. Diel percent Dissolved Oxygen Saturation in Big Darby Creek at RM 23.8, 2001.

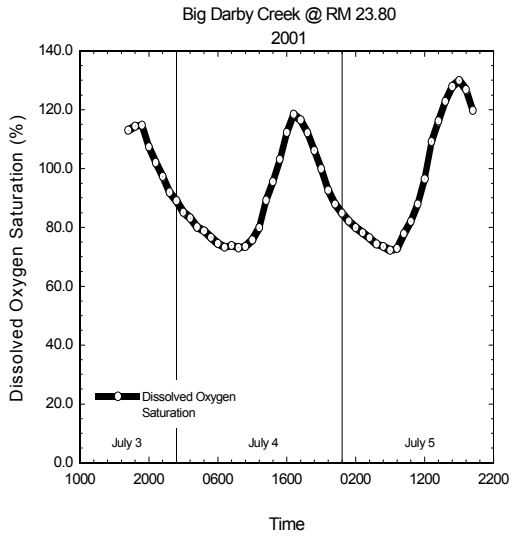


Figure B.3.131. Diel percent Dissolved Oxygen Saturation in Big Darby Creek at RM 12.9, 2002.

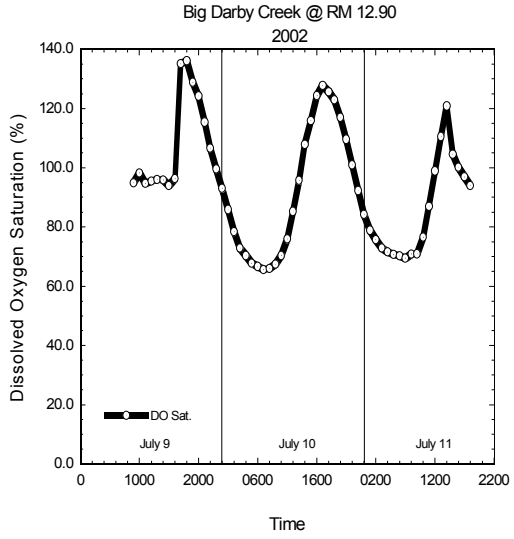


Figure B.3.132. Diel Dissolved Oxygen concentration in Big Darby Creek at RM 13.4, 2002.

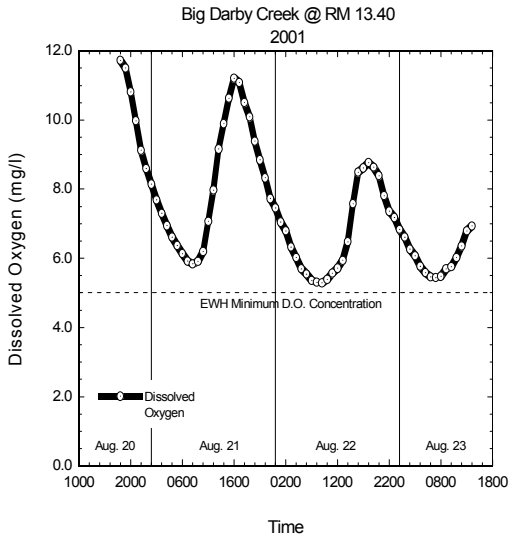
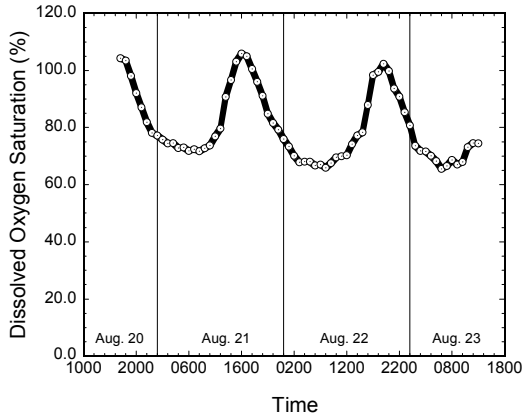


Figure B.3.133. Diel percent Dissolved Oxygen Saturation in Hellbranch Run at RM 0.9, 2001.



Water Column Organics: Big Darby Creek and Tributaries

Water samples were obtained for organic chemical analysis once during the survey period. Several different varieties of organic chemicals were sought, including volatile organic compounds (VOCs), base neutral and acid extractable compounds (BNAs), polychlorinated biphenyls (PCBs) and pesticides. Five sites on Big Darby Creek and 7 tributary sites (3 on Little Darby Creek plus the Mechanicsburg WWTP effluent) were evaluated.

VOCs were detected only in the Mechanicsburg WWTP effluent or in the area immediately downstream of the Timberlake WWTP outfall on Hellbranch Run (Table B.3.3). These VOCs were in the form of halogenated methanes. Halogenated methanes are often detected in the samples of WWTP effluent and are a result of reaction of chlorine disinfectant with organic material in the effluent. The presence of toluene (a component of gasolene) in the Mechanicsburg WWTP effluent is likely due to leakage of fuel into the collection system from a spill or leaking tank.

The plasticizer, bis (2-ethylhexyl) phthalate was also noted in several of the tributary streams as well as the Mechanicsburg WWTP effluent. This is a common organic contaminant and generally associated with towns, industrial areas, and/or disposal facilities (e.g., landfills).

Pesticides and their residues were the only organic chemicals detected in water samples taken from the Big Darby Creek mainstem. The majority of organic compounds detected in the tributaries were pesticides also. Lindane (γ-BHC) and/or its isomers (α-BHC, β-BHC, δ-BHC)

were detected in all samples in Big Darby Creek (Table B.3.4) and in numerous tributary streams (Table B.3.3) as well as the Mechanicsburg WWTP effluent. The presence of Lindane and its isomers in the effluent and in Little Darby Creek adjacent and downstream of Mechanicsburg (but not upstream) may be an artifact of runoff from the grain elevator/farm cooperative business in the center of town. Lindane is presently used as a seed and soil insect treatment for many grain crops; this use may explain why this chemical and its residues are so widespread.

Aldrin was detected at two upstream sites on Big Darby Creek (Table B.3.4) and at the mouth of Hellbranch Run (Table B.3.3). Aldrin is an organochlorine insecticide primarily used to control soil insects on farms and was used by professional pest control companies to treat building foundations for termites. Use of this pesticide in the United States has been prohibited for some time. The presence of this material in the water column may indicate a nearby source or use since it was not found in the sediments at this locale or any other in the survey area.

Atrazine was detected at all sites on Big Darby Creek downstream of RM 34.10 inclusive (Table B.3.4). Atrazine is currently used to control weeds year round for corn and other crops. Atrazine use instructions stipulate a buffer area between application sites and surface waters.

Metolachlor was also detected at the most upstream site on Big Darby Creek (Table B.3.4). Metolachlor is used as a preemergence and preplant weed control for corn, soybeans, potatoes, and pod crops (e.g., peas, beans).

Endosulfan is an insecticide and acaricide currently used on a wide variety of crops including grains, nuts, oil crops, fruits, and vegetables. It was detected in Robinson Run at RM 0.70.

Table B.3.3. Results of water quality organics sampling conducted in the Big Darby Creek study area during October, 2001. **HR** = Hellbranch Run at mouth (RM 0.50), **RR** = Robinson Run at U.S. 42 (RM 0.70), **LD1** = Little Darby Creek at Allison Road (RM 41.20), **LD2** = Little Darby Creek S.R.29 (RM 39.60). **LD3** = Little Darby Creek at Wing Road (RM 38.80), **M** = Mechanicsburg WWTP effluent, **SR** = Sugar Run at Taylor Road (RM 7.00). A blank cell means the compound was not detected in the sample.

Big Darby Creek Tributaries Water Column Organic Analysis									
Type	Analyte	Units	**HR**	**RR**	**LD1**	**LD2**	**LD3**	**M**	**SR**
Pesticides	Aldrin	mg/l	0.014						
	a-BHC	mg/l		0.021		0.012			
	b-BHC	mg/l		0.008					
	d-BHC	mg/l		0.014					0.011
	g-BHC (aka Lindane)	mg/l					0.010	0.087	
	Dieldrin	mg/l				0.008			
	Endosulfan I	mg/l		0.019					
	Heptachlor	mg/l							0.004
	Hexachlorobenzene	mg/l				0.005			
	Propachlor	mg/l	0.33						
Plasticizers	bis(2-Ethylhexyl) phthalate	mg/l		0.55		0.65		0.52	0.55
Volatiles	Bromodichloromethane	mg/l	5.31					3.38	
	Chloroform	mg/l	7.00					9.71	
	Dibromochloromethane	mg/l	1.59						
	Toluene	mg/l						32.5j	
j = estimated									

Table B.3.4. Results of chemical/physical water quality sampling conducted in the Big Darby Creek study area during October 2001. Blank spaces indicate that the compound was not detected in the sample. NA means the compound was not analyzed.

Big Darby Creek Mainstem Water Column Organic Analysis						
		River Mile				
Analyte	Units	54.20	53.90	34.10	23.80	22.80
Aldrin	mg/l	0.011	0.011			
Atrazine	mg/l		NA	0.25	0.24	0.25
a-BHC	mg/l	0.009	0.009	0.008	0.008	0.007
d-BHC	mg/l	0.010	0.010	0.006	0.007	0.006
4-4' DDE	mg/l			0.004		
Metolachlor	mg/l	0.50	NA			

Heptachlor is an organochlorine insecticide (a derivative of technical grade chlordane) that was used to treat seed and seed furrows to protect corn and other grains from pests. It was also used to control ants, cutworms, maggots, termites, and other pests in agriculture and in the home. Heptachlor is no longer sold and has extremely limited legal usage which does include uses to control termites around homes, although use is limited to stocks on hand since it has not been manufactured since the late 1980s. Heptachlor was detected in Sugar Run at RM 7.00. Sources of this contamination may include the old Taylor Road landfill.

Hexachlorobenzene was detected in Little Darby Creek at RM 39.60. This substance is a byproduct of the manufacture of many organic chemicals, including solvents and pesticides. It was used as a pesticide up until 1965. Currently, there are no allowable commercial uses for hexachlorobenzene. The presence of this material in the water column may indicate a nearby source (the agribusiness located in Mechanicsburg) or use since it was not found in the sediments at this locale or any other in the survey area.

Dieldrin was discovered in Little Darby Creek at RM 39.60. This organochlorine insecticide has been banned from manufacture and use in the United States for many years. Dieldrin is persistent and breaks down only slowly. The presence of this material in the water column may indicate a nearby source (perhaps the agribusiness located in Mechanicsburg) or use since it was not found in the sediments at this locale or any other in the survey area.

The pesticide residue 4-4' DDE was detected at RM 34.10 in Big Darby Creek. This residue is a direct breakdown product of the insecticide DDT which has been banned from use for many

years. The presence of this breakdown product in the water column may indicate a nearby source or use of the parent chemical since it was not found in the sediments at this locale or any other in the survey area.

The herbicide propachlor was detected in Hellbranch Run at the mouth (RM 0.50). Propachlor is used as a pre-emergence control for grasses and certain broadleaf weeds for field and seed corn and soybeans and is supposed to degrade rapidly in soils over several weeks. Application is limited to once per year. The presence of this material in the water column indicated a recent use since it degrades rather rapidly.

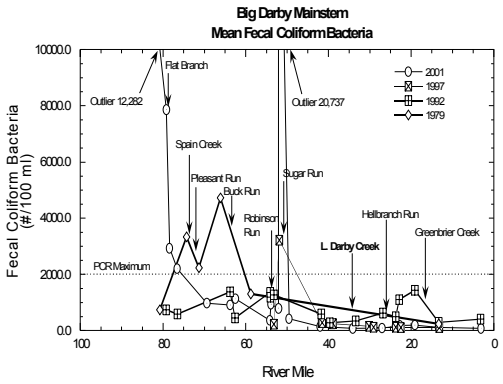
Row crop agriculture is the largest single land use in the Big Darby Creek watershed. Agribusinesses which provide support to this industry include sales of seed, fertilizers, and pesticides as well as equipment sales/rental and maintenance. Water pollution from these pesticides and/or their breakdown products most likely arose from wide-ranging uses revolving around application of these materials by agricultural interests either in the past or present, and subsequent migration into waterways from runoff events (application of pesticides also includes equipment preparation and cleaning before and after use as well as transport and mixing of chemicals). All of the pesticide compounds detected in the water column are/were listed for agricultural use as either seed/soil treatments or topical application for insect or weed control and about half are in current usage. Most of them do not have a water quality standard, not because they are nontoxic (many are toxic to fish and/or invertebrates like bees), but because no one has performed an assessment. Even so, these pesticides were found in low concentrations and do not appear to be the major cause of impairment. However, their presence is evidence that runoff does indeed carry chemicals of various types and concentrations to surrounding streams and rivers.

B.3.1 Chemical, Physical Water Quality Changes 1979-2001

Big Darby Creek Mainstem

Chemical water quality trends were evaluated on the Big Darby Creek mainstem using data from the years 1979, 1992, 1997, and 2001. Recent trends in fecal coliform bacteria indicated increased presence with higher mean concentrations in headwater areas falling to "normal" downstream of Spain Creek. A definite spike was also noted downstream of the Plain City WWTP, indicative of problems at the plant that were first noticed during the 1997 survey, but not before that (Figure B.3.1.1).

Figure B 3.1.1. Longitudinal and Temporal Trends in Mean number of colonies/100 ml. Fecal Coliform in the mainstem of Big Darby Creek, 1979, 1992, 1997 and 2001.



Dissolved oxygen values in 2001 seemed noticeably lower in certain areas of the mainstem although none of the values dropped below the WWH or EWH average. In particular, the areas downstream from Flat Branch and Buck Run exhibited lower mean concentrations than in previous years as did the areas downstream of Sugar Run, Little Darby Creek and Hellbranch Run. Even though these decreases seemed minor this may constitute a threat to the stream segments affected and to the watershed as a whole.

Mean total suspended solids concentrations generally exhibited decreases from those observed in previous surveys except in the upper watershed and downstream of Flat Branch and Spain Creek (Figure B.3.1.2). In this area, suspended solids concentrations showed increases over 1992 values and most 1979 values. This could be part of the cause for fish community impairment.

Trends in mean nutrient concentrations to the mainstem of Big Darby Creek showed decreases in mean nitrate+nitrite from previous surveys (Figure B.3.1.3). Organic nitrogen (measured via TKN) showed similar concentrations in the upper and lower watershed compared with survey results from 1992 and 1997 (Figure B.3.1.4). A pronounced peak was evident downstream of the Plain City WWTP in both 1997 and 2001 indicating worsening nutrient enrichment downstream of the plant. Survey results obtained in 1979 exhibited much higher concentrations of TKN than other survey years indicating improved chemical water quality conditions for this parameter except downstream of the Plain City WWTP. Mean total phosphorus concentrations showed very mixed trend results (Figure B.3.1.5). The upper watershed showed some slight increases compared with previous surveys especially downstream of Flat Branch. These concentrations

Figure B 3.1.2. Longitudinal and Temporal Trends in Mean Total Suspended Solids in the mainstem of Big Darby Creek, 1979, 1992, 1997 and 2001.

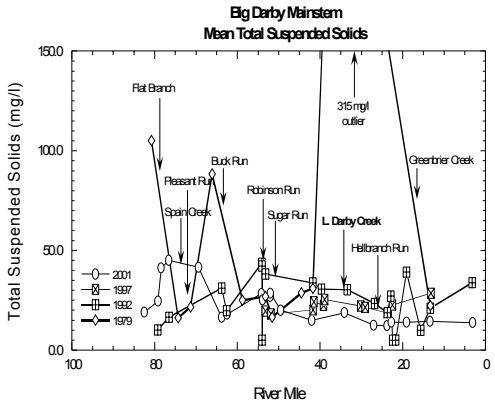


Figure B 3.1.3. Longitudinal and Temporal Trends in Mean Nitrate+Nitrite in the mainstem of Big Darby Creek, 1979, 1992, 1997 and 2001.

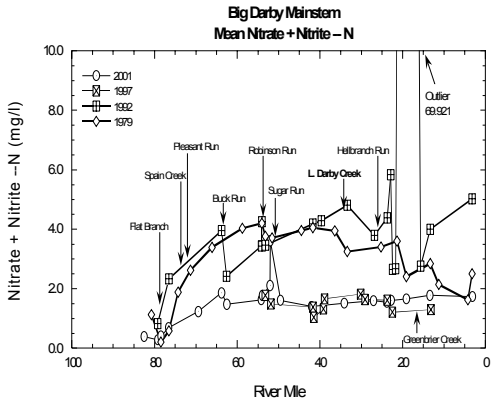


Figure B 3.1.4. Longitudinal and Temporal Trends in Total Kjeldahl Nitrogen in the mainstem of Big Darby Creek, 1979, 1992, 1997 and 2001.

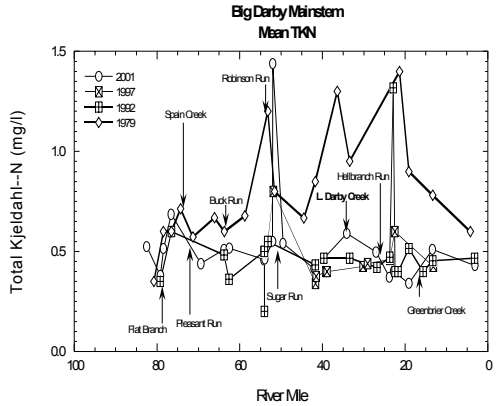
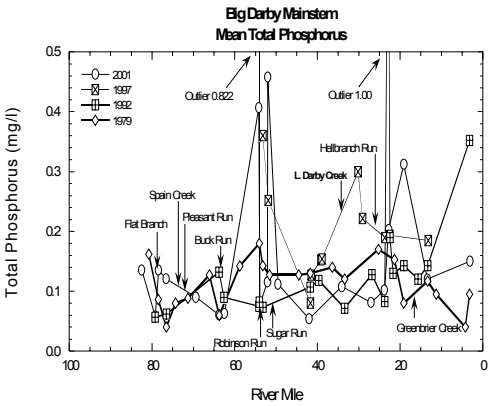


Figure B 3.1.5. Longitudinal and Temporal Trends in Total Phosphorus in the mainstem of Big Darby Creek, 1979, 1992, 1997 and 2001.



remained this way until downstream of Pleasant Run where they dipped below previous results. Phosphorus concentrations peaked in three other places on the mainstem, just upstream of Robinson Run, downstream of the Plain City WWTP, and downstream of the complex of wastewater treatment facilities including PCI-ODRC WWTP (RM 22.92), Clark's Lake Tributary (RM 20.20) and Foxlair Farms WWTP (RM 22.50).

Hellbranch Run (02-204) (RM 26.1) (WWH, EWH Recommended)
Chemical water quality trends were evaluated on the Hellbranch Run mainstem using data from the years 1992, 1997, and 2001. In most instances, average summer conditions on Hellbranch Run remained static and unchanging. Both mean ammonia and mean dissolved oxygen trends were similar until reaching the site downstream of the Timberlake WWTP outfall. There, ammonia spiked higher and dissolved oxygen drifted lower than noted in previous years (Figures B.3.1.6 and B.3.1.7). Mean total phosphorus concentrations were somewhat similar and just as variable as in previous years. Wastewater treatment plant influences seemed to provide the majority of nutrient spikes as in the past (Figure B.3.1.8). Mean nitrate+nitrite concentrations trended lower than in both 1992 and 1997 (Figure B.3.1.9). Mean bacterial values were found to be generally the same or lower than in the past except downstream of the Oakhurst Knolls WWTP. Mean total suspended solids concentrations were generally lower than historical values except in the headwaters. The negative influence from both Clover Groff and Hamilton ditches and the accelerating development in the upper watershed are contributing to these problems.

Little Darby Creek (02-210) (RM 34.1) (EWH)
Chemical water quality trends were evaluated on the Little Darby Creek mainstem using data from the years 1979, 1992, 1997, and 2001. Trends for both mean total suspended solids and mean fecal coliform bacteria were down from past evaluations as were concentrations of total phosphorus. Mean dissolved oxygen trends showed little change except for a slight drop at the headwaters and an increase around RM 15.30. Mean organic nitrogen concentrations trended higher downstream of Barron Creek to the mouth. Mean nitrate+nitrite concentrations were highest of any year at the headwaters falling to levels between those found in 1992 and 1997 (Figure B.3.1.10).

Treacle Creek (02-213) (RM 31.3) (EWH)
Chemical water quality trends were evaluated on Treacle Creek for the years 1992-95, 1997, and 2001. Trends evaluation could only be performed for the site at the mouth of the creek as there was no data for comparison at upstream sites. For total phosphorus and total suspended solids the 2001 data showed the lowest mean concentrations of any year (Figures B.3.1.11 and B.3.12). Mean dissolved oxygen concentrations were among the highest of any year (Figure B.3.1.13). Fecal coliform bacteria mean concentrations were midway between other years as were concentrations of nitrate+nitrite (Figures B.3.1.14 and B.3.1.15).

Figure B.3.1.6. Longitudinal and Temporal Trends in Ammonia in Hellbranch Run, 1992, 1997 and 2001.

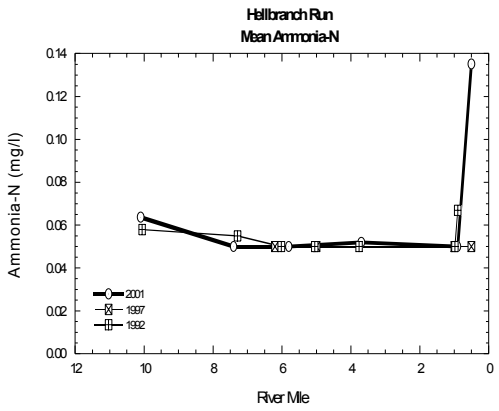


Figure B.3.1.7. Longitudinal and Temporal Trends in Dissolved Oxygen in Hellbranch Run, 1992, 1997 and 2001.

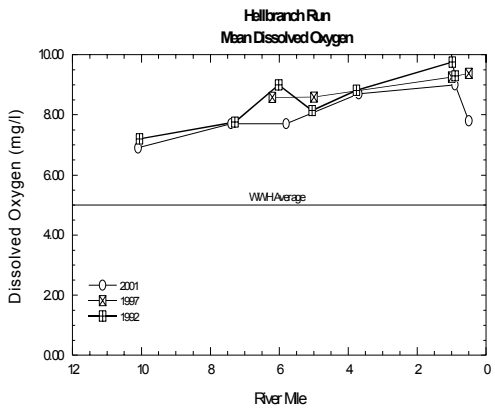


Figure B.3.1.8. Longitudinal and Temporal Trends in Total Phosphorus in Hellbranch Run, 1992, 1997 and 2001.

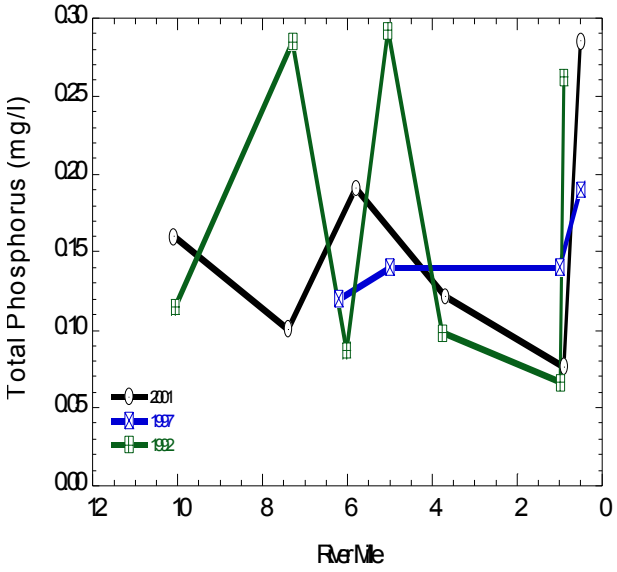


Figure B.3.1.9. Longitudinal and Temporal Trends in Nitrate - Nitrite in Hellbranch Run, 1992, 1997 and 2001.

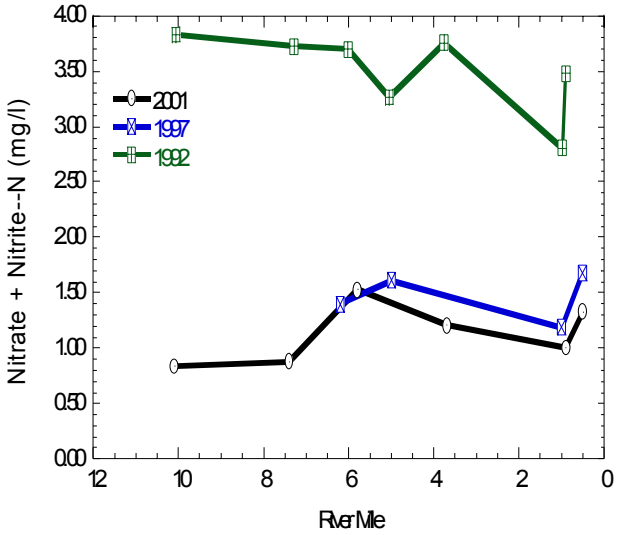


Figure B.3.1.10. Longitudinal and Temporal Trends in Nitrate+Nitrite in Little Darby Creek, 1979 1992, 1997 and 2001.

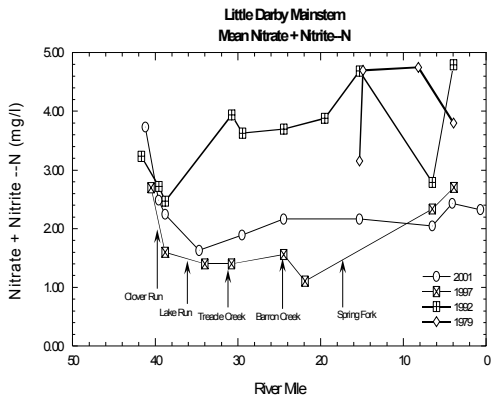


Figure B.3.1.11. Longitudinal and Temporal Trends in Total Phosphorus in Treacle Creek, 1992, 1993, 1994, 1995, 1997 and 2001.

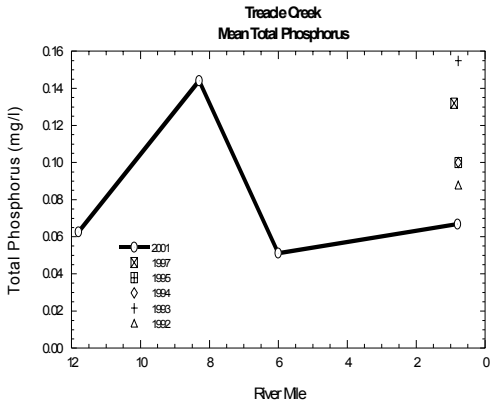


Figure B.3.1.12. Longitudinal and Temporal Trends in Total Suspended Solids in Treacle Creek, 1992, 1993, 1994, 1995, 1997 and 2001.

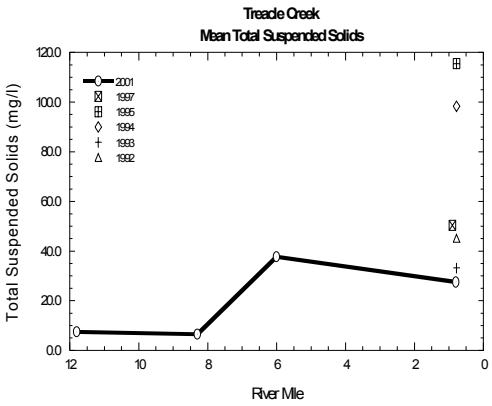


Figure B.3.1.13. Longitudinal and Temporal Trends in Dissolved Oxygen in Treacle Creek, 1992, 1993, 1994, 1995, 1997 and 2001.

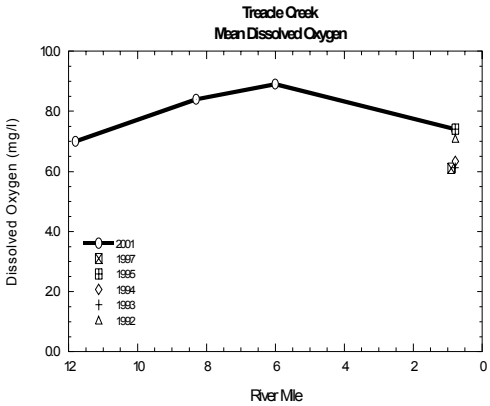


Figure B.3.1.14. Longitudinal and Temporal Trends in colonies/100 ml. of Fecal coliform bacteria in Treacle Creek, 1992, 1993, 1994, 1995, 1997 and 2001.

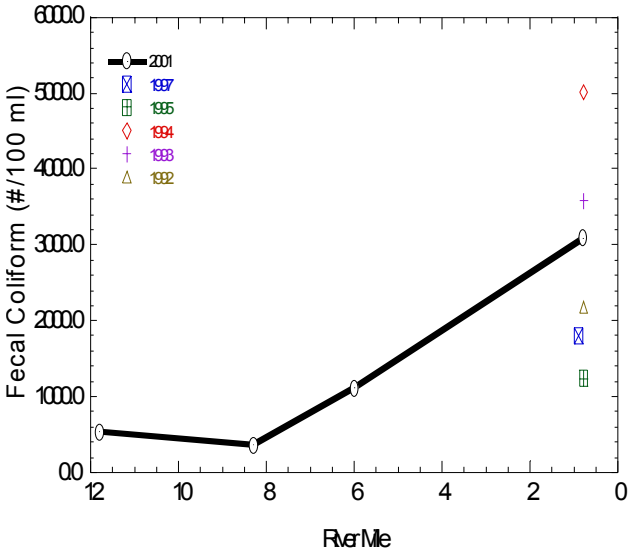
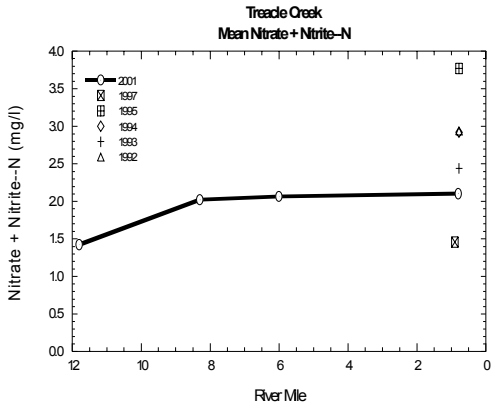



Figure B.3.1.15. Longitudinal and Temporal Trends in Mean Nitrate+Nitrite in Treacle Creek, 1992, 1993, 1994, 1995, 1997 and 2001.