Appendix A: Multi-Resolution Land Characteristics (MRLC) Consortium Data Description

Land Cover Classes:

Water
11 Open Water
12 Perennial Ice/Snow

Developed
21 Low-Intensity Residential
22 High-Intensity Residential
23 Commercial/Industrial/Transportation

Barren
31 Bare Rock/Sand/Clay
32 Quarries/Strip Mines/Gravel Pits
33 Transitional

Vegetated Natural Forested Upland
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest

Shrubland
51 Shrubland

Non-natural Woody
61 Orchards/Vineyards/Other

Herbaceous Upland
71 Grasslands/Herbaceous

Herbaceous Planted/Cultivated
81 Pasture/Hay
82 Row Crops
83 Small Grains
84 Fallow
85 Urban/Recreational Grasses

Wetlands
91 Woody Wetlands
92 Emergent Herbaceous Wetlands

Land Cover Classification System and Land Cover Class Definitions:

<u>Water</u> – All areas of open water or permanent ice/snow cover.

11. Open Water – areas of open water, generally with less than 25 percent or greater cover of water (per pixel).

12. Perennial Ice/Snow – all areas characterized by year long cover of ice or snow.

<u>Developed</u> – Areas characterized by high percentage (approximately 30% or greater) of constructed materials (e.g., asphalt, concrete, buildings).

21. Low-Intensity Residential – areas with a mixture of constructed materials and vegetation. Constructed materials account for 30 to 80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high-intensity residential areas.

22. High-Intensity Residential – heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80 to 100 percent of the cover.

23. Commercial/Industrial/Transportation – infrastructure (e.g., roads, railroads) and all highways and all developed areas not classified as High-Intensity Residential.

<u>Barren</u> – Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

31. Bare Rock/Sand/Clay – perennially barren areas of bedrock, desert, pavement, scarps, talus, slides, volcanic material, glacial debris, and other accumulations of earthen material.

32. Quarries/Strip Mines/Gravel Pits – areas of extractive mining activities with significant surface expression.

33. Transitional – areas of sparse vegetative cover (less than 25 percent that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g., fire, flood)

<u>Forested Upland</u> – Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); tree canopy accounts for 25 to 100 percent of the cover.

41. Deciduous Forest – areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest – areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest – areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Shrubland – Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

51. Shrubland – areas dominated by shrubs; shrub canopy accounts for 25 to 100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases where the cover of other life forms (e.g., herbaceous or trees) is less than 25 percent, and shrub cover exceeds the cover of the other life forms.

Non-natural Woody – Areas dominated by non-natural woody vegetation; non-natural woody vegetative canopy accounts for 25 to 100 percent of the cover. The non-natural woody classification is subject to the availability of sufficient ancillary data to differentiate non-natural woody vegetation from natural woody vegetation.

61. Orchards/Vineyards/Other – orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

Herbaceous Upland – Upland areas characterized by natural or semi-natural herbaceous vegetation; herbaceous vegetation accounts for 75-100 percent of the cover.

71. Grasslands/Herbaceous – areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but are often utilized for grazing.

Planted/Cultivated – Areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75 to 100 percent of the cover.

81. Pasture/Hay – areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

82. Row Crops – areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.

83. Small Grains – areas used for the production of graminoid crops such as wheat, barley, oats, and rice.

84. Fallow – areas used for the production of crops that are temporarily barren or with sparse vegetative cover as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.

85. Urban/Recreational Grasses – vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Wetlands - Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

91. Woody Wetlands - areas where forest or shrubland vegetation accounts for 25 to 100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

92. Emergent Herbaceous Wetlands - areas where perennial herbaceous vegetation accounts for 75 to 100 percent of the cover, and the soil or substrate is periodically saturated with or covered with water

Appendix B. Aquatic life attainment status of the existing aquatic life use designations for the Little Beaver Creek study area, 1984 through 1999.

RIVER MILE Fish/Macro.	IBI	Mod. Iwb	ICI[a]	QHEI	Use Attainment Status[a]	Comments
Little Beaver Creek (1999)						
			Western Allegheny Plateau–EWH Use Designation			
15.0(W)/15.0**R**	53	10.0	48	77.5	FULL	At State Park
8.0(B)/8.5**R**	48	10.9	46	76.5	FULL	SR 170
– /4.5**R**	–	–	E	–	(FULL)	Grimms-Bridge Rd.
Little Beaver Creek (1994)						
			Western Allegheny Plateau–EWH Use Designation			
– /4.5**R**	–	–	40*	–	(**NON**)	Grimms-Bridge Rd.
Little Beaver Creek (1987)						
			Western Allegheny Plateau–EWH Use Designation			
8.0(B)/ – **R**	50	10.2	–	–	(FULL)	SR 170
– /4.5**R**	–	–	48	–	(FULL)	Grimms-Bridge Rd.
Little Beaver Creek (1985)						
			Western Allegheny Plateau–EWH Use Designation			
15.0(W)/15.0**R**	52	8.6	50	83.0	FULL	At State Park
– /8.0**R**	–	–	52	82.0	(FULL)	SR 170
4.5(B)/4.5**R**	45[ns]	9.3[ns]	38*	88.0	PARTIAL	Grimms Rd.
Bieler Run (1999)						
			Western Allegheny Plateau–WWH Use Designation (Reccomended)			
0.1(H)/0.2	46	NA	G	67.0	FULL	Near Mouth
Rough Run (1999)						
			Western Allegheny Plateau–WWH Use Designation			
2.3(H)/2.2	42[ns]	NA	44	60.5	FULL	Clarkston Fredricksburg Rd.
Longs Run (1999)						
			Western Allegheny Plateau–WWH Use Designation			
8.1(H)/8.1	42[ns]	NA	E	60.5	FULL	Ust.Cameron Rd.-Natural Conditions
– /8.0	–	–	F*	–	(**NON**)	Dst. Cameron Rd.-Highly modified
5.3(H)/5.1	33*	NA	44	56.0	PARTIAL	SR 267
2.5(H)/2.0	49	NA	48	69.5	FULL	Sprucevale Rd.
North Fork Little Beaver Creek (1999)						
			Erie Ontario Lake Plain- WWH Use Designation			
34.5(H)/34.5	52	NA	MG	79.0	FULL	Unity Rd.
29.1(H)/29.1	37[ns]	NA	38	51.0	FULL	Stateline Rd.
			Western Allegheny Plateau–WWH Use Designation			
7.6(W)/7.6**R**	55	9.6	46	83.0	FULL	Ust. Stateline Creek
7.4(W)/7.4	53	10.1	46	92.0	FULL	Dst Stateline Creek/Ust. Bull Creek
5.6(W)/5.6	50	9.5	36	68.0	FULL	Dst. Bull Cr./Carmel-Anchor Rd.
0.1(W)/0.6	44	9.1	46	75.5	FULL	Near mouth @ Fredericktown

Table 1. continued.

RIVER MILE Fish/Macro.	IBI	Mod. Iwb	ICI[a]	QHEI	Use Attain-ment Status[a]	Comments
North Fork Little Beaver Creek (1985)						
				Western Allegheny Plateau–WWH Use Designation		
7.6$^{(W)}$/7.6$^{\mathbf{R}}$	45	7.3*	40	80.0	PARTIAL	Ust. Stateline Creek
7.3$^{(W)}$/7.4	43^{ns}	7.9^{ns}	38	88.0	FULL	Dst Stateline Creek/Ust. Bull Creek
5.6$^{(W)}$/5.6	42^{ns}	8.3^{ns}	34^{ns}	79.0	FULL	Dst. Bull Cr./Carmel-Anchor Rd.
0.4$^{(W)}$/0.1	37*	6.1*	44	75.5	PARTIAL	Near mouth @ Fredrickstown
Brush Run (1999)						
				Erie Ontario Lake Plain- WWH Use Designation		
0.1$^{(H)}$/0.4	50	NA	38	81.5	FULL	Near Mouth
Bull Creek (1999)						
				Erie Ontario Lake Plain- WWH Use Designation		
9.3$^{(H)}$/9.3	34*	NA	VG	71.5	PARTIAL	Bull Creek Rd.
6.0$^{(H)}$/6.0	52	NA	58	64.5	FULL	Dst. N. Waterford WWTP/SR 558
1.9$^{(W)}$/1.9$^{\mathbf{R}}$	44	8.7	VG	59.5	FULL	Ust. Leslie Run/Pioneer Rd.
0.6$^{(W)}$/0.5	52	9.2	34	63.5	FULL	Dst. Leslie Run/adj. SR 170
Bull Creek (1985)						
				Erie Ontario Lake Plain- WWH Use Designation		
1.9$^{(W)}$/1.9$^{\mathbf{R}}$	38	8.0	E	85.0	FULL	Ust. Leslie Run/Pioneer Rd.
0.6$^{(W)}$/0.6	38	8.4	F*	70.0	PARTIAL	Dst. Leslie Run/adj. SR 170
Leslie Run (1999)						
				Erie Ontario Lake Plain- WWH Use Designation		
4.1$^{(H)}$/4.2	46	NA	VG	41.5	FULL	Kemple Rd.
3.3$^{(H)}$/3.3	29*	NA	F*	44.5	**NON**	Dst. Roshel Trib./Ust. E. Palestine WWTP
1.9$^{(H)}$/1.9	35*	NA	P*	49.5	**NON**	Dst. E. Palestine WWTP
0.2$^{(H)}$/0.1	47	NA	26*	71.5	PARTIAL	Bye Rd.
Leslie Run (1985)						
				Erie Ontario Lake Plain- WWH Use Designation		
4.1$^{(H)}$/4.1	36^{ns}	NA	MG	60.0	FULL	Kemple Rd.
3.3$^{(H)}$/3.3	16*	NA	VP*	60.0	**NON**	Dst. Roshel Trib./Ust. E. Palestine WWTP
1.9$^{(H)}$/1.9	15*	NA	VP*	54.0	**NON**	Dst. E. Palestine WWTP
0.2$^{(H)}$/0.2	33*	NA	P*	56.0	**NON**	Bye Rd.
Roshel Tributary (1999)						
				Erie Ontario Lake Plain- WWH Use Designation		
0.1$^{(H)}$/0.6	28*	NA	VP*	35.0	**NON**	Dst. E. Palestine WWTP Bypass/Main St.
Roshel Tributary (1985)						
				Erie Ontario Lake Plain- WWH Use Designation		
1.0$^{(H)}$/1.0	31*	NA	MG	27.0	PARTIAL	Ust. Roshel
0.9$^{(H)}$/ –	12*	NA	–	–	**(NON)**	Ust. Roshel
– /0.1	–	–	VP*	44.0	**(NON)**	Dst. E. Palestine WWTP Bypass/James St.

Table 1. continued.

RIVER MILE Fish/Macro.	IBI	Mod. Iwb	ICI[a]	QHEI	Use Attainment Status[a]	Comments
Little Bull Creek (1999)						
			Erie Ontario Lake Plain- WWH Use Designation			
5.4$^{(H)}$/5.4	52	NA	VG	70.0	FULL	SR 517
0.5$^{(H)}$/0.5	54	NA	50	68.0	FULL	SR 154
Turkey Run (1999)						
			Erie Ontario Lake Plain- WWH Use Designation			
0.1$^{(H)}$/0.1	38^{ns}	NA	G	60.5	FULL	Adj. Mill Rock Rd.
Honey Creek (1999)						
			Erie Ontario Lake Plain- WWH Use Designation			
10.7$^{(H)}$/10.8	26*	NA	P*	49.0	**NON**	Ust. New Middletown WWTP-Unity Rd.
10.0$^{(H)}$/10.0	24*	NA	P*	59.0	**NON**	Dst. New Middletwon WWTP-S. Range Rd.
7.4$^{(H)}$/7.4	50	NA	50	76.5	FULL	SR 170
East Fork Stateline Creek (1999)						
			Erie Ontario Lake Plain- WWH Use Designation			
0.1$^{(H)}$/0.1$^{\mathbf{R}}$	53	NA	G	52.5	FULL	Cenco-Watts Mill Rd.
East Fork Stateline Creek (1985)						
			Erie Ontario Lake Plain- WWH Use Designation			
0.1$^{(H)}$/0.1$^{\mathbf{R}}$	47	NA	G	67.0	FULL	Cenco-Watts Mill Rd.
Middle Fork Little Beaver Creek (1999)						
			Erie Ontario Lake Plain- WWH Use Designation			
40.3$^{(H)}$/40.3	31*	NA	10*	55.5	**NON**	Georgetown Rd.
38.2$^{(H)}$/38.2	35*	NA	F*	46.0	**NON**	Ust. Salem WWTP-Dst. Buttermilk Creek
37.7$^{(H)}$/37.7	28*	NA	28*	67.5	**NON**	Dst. Salem WWTP-Allen Rd.
36.7$^{(H)}$/36.7	31*	NA	32^{ns}	60.5	PARTIAL	Dst. Nease Chemical-Pine Lake Rd.
33.3$^{(H)}$/33.3	36^{ns}	NA	40	84.0	FULL	Middletown Rd.
32.0$^{(H)}$/32.0	36^{ns}	NA	40	64.0	FULL	New Egypt Swamp
28.8$^{(W)}$/28.8	34^{ns}	5.8*	40	50.0	**NON**	SR 165-New Egypt Swamp
25.8$^{(W)}$/25.8	29*	5.5*	30^{ns}	49.0	**NON**	Rt. 7
23.5$^{(W)}$/23.5	37^{ns}	7.0*	38	59.5	PARTIAL	
21.8$^{(W)}$/21.8	37^{ns}	7.8^{ns}	44	67.5	FULL	Ust. E. Br. Middle Frk.-Lisbon Confield Rd.
20.9$^{(W)}$/20.9	38	7.6^{ns}	26*	48.0	PARTIAL	SR 588-near Franklin Square
15.0$^{(W)}$/15.0	37^{ns}	7.7^{ns}	44	83.5	FULL	Kelch Rd.-Ust. Lisbon
			Erie Ontario Lake Plain- EWH Use Designation			
10.9$^{(W)}$/10.7	49^{ns}	10.0	36*	67.0	PARTIAL	Dst. Lisbon CSOs-US30/SR 45
			Western Allegheny Plateau-EWH Use Designation			
9.9$^{(W)}$/10.0	48^{ns}	10.2	42^{ns}	75.0	FULL	Ust. Perino S&G
9.0$^{(W)}$/9.0$^{\mathbf{R}}$	45*	9.7	40*	71.0	PARTIAL	Ust. Elkton WWTP/dst. Perino S&G-Darner Rd.
8.4$^{(W)}$/8.4	48^{ns}	9.4	50	71.0	FULL	Dst. Elkton WWTP-adj. SR 154
4.4$^{(W)}$/4.4	45*	8.9^{ns}	40*	76.5	PARTIAL	Dst. Pine Run
1.9$^{(W)}$/1.9	50	9.3^{ns}	42^{ns}	77.5	FULL	Bear Hollow Rd.-At Williamsport

Table 1. continued.

RIVER MILE Fish/Macro.	IBI	Mod. Iwb	ICI[a]	QHEI	Use Attainment Status[a]	Comments
Middle Fork Little Beaver Creek (1987)						
			Erie Ontario Lake Plain- WWH Use Designation			
25.1$^{(W)}$/	22*	4.9*	–	–	(**NON**)	adj. Egypt Rd.
15.1$^{(W)}$/	38	8.0	–	–	(FULL)	Kelch Rd.-Ust. Lisbon
Middle Fork Little Beaver Creek (1985)						
			Erie Ontario Lake Plain- WWH Use Designation			
40.3$^{(H)}$/40.3	37^{ns}	NA	18*	60.0	PARTIAL	Georgetown Rd.
38.3$^{(H)}$/38.3	31*	NA	F*	49.0	**NON**	Ust. Salem WWTP-Dst. Buttermilk Creek
37.6$^{(H)}$/37.7	24*	NA	0*	56.0	**NON**	Dst. Salem WWTP-Allen Rd.
36.7$^{(H)}$/36.7	25*	NA	6*	66.0	**NON**	Dst. Nease Chemical-Pine Lake Rd.
35.4$^{(H)}$/35.4	32*	NA	30^{ns}	69.0	PARTIAL	Goshen Rd.
32.7$^{(H)}$/32.6	25*	NA	38	59.0	**NON**	New Egypt Swamp
– /30.1	–	–	MG	–	(FULL)	US 62
28.8$^{(W)}$/28.8	28*	5.6*	24*	37.0	**NON**	SR 165-New Egypt Swamp
26.8$^{(W)}$/26.9	27*	5.1*	40	42.0	**NON**	Adj. Egypt Rd.-New Egypt Swamp
25.1$^{(W)}$/25.1	27*	4.7*	18*	50.0	**NON**	Adj. Egypt Rd., Private Drive
– /24.8	–	–	MG	–	(FULL)	
21.8$^{(W)}$/21.8	37^{ns}	7.1*	28*	58.0	PARTIAL	Ust. E. Br. Middle Frk.-Lisbon Confield Rd.
20.9$^{(W)}$/20.9	24*	6.3*	38	32.0	**NON**	SR 588-near Franklin Square
15.1$^{(W)}$/15.1	35^{ns}	7.7^{ns}	50	89.0	FULL	Kelch Rd.-Ust. Lisbon
			Erie Ontario Lake Plain- EWH Use Designation			
10.9$^{(W)}$/10.9	43*	8.9^{ns}	40*	74.0	PARTIAL	Dst. Lisbon CSOs-US 30/SR 45
			Western Allegheny Plateau-EWH Use Designation			
9.0$^{(W)}$/9.0$^{\mathbf{R}}$	45*	9.2^{ns}	32*	89.0	PARTIAL	Ust. Elkton WWTP-Darner Rd.
1.9$^{(W)}$/1.9$^{\mathbf{R}}$	48^{ns}	8.7*	46	83.0	PARTIAL	Bear Hollow Rd.-At Williamsport
Turkeyfoot Run (1999)						
			Western Allegheny Plateau-WWH Use Designation			
0.1/0.2	54	NA	G	58.0	FULL	Middle Beaver Rd.
Pine Run (1999)						
			Western Allegheny Plateau-WWH Use Designation			
0.1$^{(H)}$/0.1	46	NA	G	70.0	FULL	Middle Beaver Rd.
Elk Run (1999)						
			Western Allegheny Plateau-WWH Use Designation			
2.3$^{(H)}$/2.3	50	NA	58	67.5	FULL	Church Hill Rd.
0.3$^{(H)}$/0.3	52	NA	56	69.5	FULL	SR 154
Middle Run (1999)						
			Erie Ontario Lake Plain-WWH Use Designation			
1.7$^{(H)}$/1.7	38^{ns}	NA	E	62.0	FULL	SR 154

Table 1. continued.

RIVER MILE Fish/Macro.	IBI	Mod. Iwb	ICI[a]	QHEI	Use Attainment Status[a]	Comments
Stone Mill Run (1999)						
			Erie Ontario Lake Plain- WWH Use Designation			
4.2$^{(H)}$/ –	28*	NA	–	49.5	(**NON**)	Adj. SR 444
2.0$^{(H)}$/2.0^{R}	44	NA	20*	69.5	PARTIAL	Cunningham Rd.
– /0.1	–	–	F*	–	(**NON**)	
East Branch Middle Fork Little Beaver Creek (1999)						
			Erie Ontario Lake Plain- WWH Use Designation			
9.3$^{(H)}$/9.3	26*	NA	VP*	56.5	**NON**	Renkenberger Rd.
5.9$^{(H)}$/5.9	12*	NA	0*	26.0	**NON**	Ust.Cherry Fork Rd-Channelized
– /5.3	–	–	36	–	(FULL)	SR 344
3.0$^{(H)}$/3.0^{R}	39^{ns}	NA	30^{ns}	64.0	FULL	Lisbon Rd.-Ust. Leetonia WWTP & Washingtonville WWTP (via Cherry Valley Run)
0.1$^{(W)}$/0.1	34*	6.5*	38	34.0	PARTIAL	Dst. Leetonia &Washingtonville WWTPs-Lisbon Canfield Rd.
East Branch Middle Fork Little Beaver Creek (1985)						
			Erie Ontario Lake Plain- WWH Use Designation			
3.0$^{(H)}$/3.0^{R}	43^{ns}	NA	G	67.0	FULL	Lisbon Rd.-Ust. Cherry Valley Run
2.0$^{(W)}$/2.0	31*	NA	F*	45.0	**NON**	Ust. Leetonia WWTP
0.1$^{(W)}$/0.1	29*	NA	F*	39.0	**NON**	Dst. Leetonia WWTP-Lisbon Canfield Rd.
Cherry Valley Run (1999)						
			Erie Ontario Lake Plain- WWH Use Designation			
3.9$^{(H)}$/3.6	40	NA	MG	57.0	FULL	Ust. Washingtonville WWTP-Garfield Rd.
2.2$^{(H)}$/2.2	40	NA	46	59.0	FULL	Dst. Washingtonville WWTP
Cherry Valley Run (1985)						
			Erie Ontario Lake Plain- WWH Use Designation			
2.0$^{(H)}$/2.4	32*	NA	F*	38.0	**NON**	Dst. Washingtonville WWTP
West Fork Little Beaver Creek (1999)						
			Western Allegheny Plateau-WWH Use Designation			
24.2$^{(H)}$/24.2	30*	NA	12*	51.0	**NON**	Ust Guilford WWTP, Dst. Guilford Lake-SR 172
22.8$^{(H)}$/22.8	32*	NA	P*	69.0	**NON**	Gas Tax Rd.
18.2$^{(W)}$/18.7	48	9.4	42	71.0	FULL	Dst. Guilford WWTP-Church Rd.
			Western Allegheny Plateau-EWH Use Designation			
12.9$^{(W)}$/13.0^{R}	50	8.9^{ns}	52	60.0	FULL	Ust. Chemline Tributary
9.2$^{(W)}$/9.2	54	10.4	40*	86.0	PARTIAL	McCormick Rd.
0.8$^{(W)}$/0.8^{R}	50	9.9	44^{ns}	81.5	FULL	Lones Rd.
West Fork Little Beaver Creek (1990)						
			Western Allegheny Plateau-EWH Use Designation			
12.9$^{(W)}$/ – ^{R}	49^{ns}	9.3^{ns}	–	–	(FULL)	Ust. Chemline Tributary
12.7$^{(W)}$/ –	47^{ns}	9.0^{ns}	–	–	(FULL)	Dst. Chemline Tributary-Adj. SR 518
11.4$^{(W)}$/ –	53	9.0ns	–	–	(FULL)	Steubenville Rd.

Table 1. continued.

RIVER MILE Fish/Macro.	IBI	Mod. Iwb	ICI[a]	QHEI	Use Attain-ment Status[a]	Comments
West Fork Little Beaver Creek (1990)						
9.2[(W)]/ –	51	9.4	–	–	(FULL)	McCormic Rd.
West Fork Little Beaver Creek (1989)						
				Western Allegheny Plateau-EWH Use Designation		
12.9[(W)]/ – [R]	42*	10.0	–	–	(PARTIAL)	Ust. Chemline Tributary
12.7[(W)]/ –	58	10.1	–	–	(FULL)	Dst. Chemline Tributary-Adj. SR 518
11.4[(W)]/ –	56	9.5	–	–	(FULL)	Steubenville Rd.
9.2[(W)]/ –	54	9.9	–	–	(FULL)	McCormick Rd.
0.8[(W)]/ – [R]	48[ns]	9.9	–	–	(FULL)	Lones Rd.
West Fork Little Beaver Creek (1987)						
				Western Allegheny Plateau-EWH Use Designation		
12.9[(W)]/12.9[R]	52	9.9	44[ns]	–	FULL	Ust. Chemline Tributary
12.7[(W)]/12.7	56	9.7	46	–	FULL	Dst. Chemline Tributary-Adj. SR 518
11.4[(W)]/11.4	50	9.4	46	–	FULL	Steubenville Rd.
9.2[(W)]/9.2	52	9.8	48	–	FULL	McCormick Rd.
– /0.8[R]	–	–	44[ns]	–	(FULL)	Lones Rd.
West Fork Little Beaver Creek (1985)						
				Western Allegheny Plateau-WWH Use Designation		
16.4[(W)]/ –	50	8.2[ns]	–	–	(FULL)	
13.7[(W)]/ –	54	9.4	–	–	(FULL)	
				Western Allegheny Plateau-EWH Use Designation		
12.9[(W)]/12.9[R]	57	9.9	48	86.0	FULL	Ust. Chemline Tributary
12.7[(W)]/12.7	54	9.9	52	91.0	FULL	Dst. Chemline Tributary-Adj. SR 518
11.4[(W)]/11.4	55	9.6	46	83.0	FULL	Steubenville Rd.
9.2[(W)]/9.2	56	10.0	32*	90.0	PARTIAL	McCormick Rd.
4.1[(W)]/4.1	53	10.2	44[ns]	95.0	FULL	Pine Ridge Camp Rd.
0.8[(W)]/0.8[R]	55	10.2	46	91.0	FULL	Lones Rd.
West Fork Little Beaver Creek (1984)						
				Western Allegheny Plateau-EWH Use Designation		
– /12.9[R]	–	–	E	–	(FULL)	Ust. Chemline Tributary
– /12.7	–	–	E	–	(FULL)	Dst. Chemline Tributary-Adj. SR 518
– /11.4	–	–	E	–	(FULL)	Steubenville Rd.
– /9.2	–	–	E	–	(FULL)	McCormic Rd.
Patterson Run (1999)						
				Western Allegheny Plateau-WWH Use Designation		
1.6[(H)]/1.6	30*	NA	F*	48.5	**NON**	Applegate Rd.
Peters Run (1999)						
				Western Allegheny Plateau-WWH Use Designation		
0.1[(H)]/0.1	44	NA	G	64.0	FULL	Near Mouth

Table 1. continued.

RIVER MILE Fish/Macro.	IBI	Mod. Iwb	ICI[a]	QHEI	Use Attain-ment Status[a]	Comments
Brush Run (1999)						
				Western Allegheny Plateau-WWH Use Designation		
0.2(H)/0.2	48	NA	G	54.0	FULL	SR 518
McCormick Run (1999)						
				Western Allegheny Plateau-WWH Use Designation		
0.1(H)/0.1	48	NA	G	60.5	FULL	Near Mouth
Brush Creek (1999)						
				Western Allegheny Plateau-WWH Use Designation		
4.9(H)/4.8	30*	NA	P*	41.0	**NON**	TR 844
2.6(W)/2.4	42[ns]	7.5*	42	45.5	PARTIAL	Foundry Rd.
Brush Creek (1985)						
				Western Allegheny Plateau-WWH Use Designation		
4.9(H)/ –	52	NA	–	–	(FULL)	TR 844
3.0(H)/ –	36*	NA	–	–	(**NON**)	Foundry Rd.
Willard Run (1999)						
				Western Allegheny Plateau-WWH Use Designation		
0.7(H)/0.7	44	NA	G	58.0	FULL	SR 518
Cold Run (1999)						
				Western Allegheny Plateau-WWH Use Designation		
0.4(H)/0.5	50	NA	50	57.0	FULL	Dunningham Rd.
Cold Run (1985)						
				Western Allegheny Plateau-WWH Use Designation		
0.3(H)/ –	48	NA	–	–	(FULL)	Dunningham Rd.

* -Significant departure from ecoregion biocriterion; poor and very poor results are underlined.

ns -Nonsignificant departure from biocriterion (≤4 IBI or ICI units; ≤0.5 Iwb units).

a -Narrative evaluations based upon qualitative samples (VP-very poor, P-poor, F-fair, G-good, VG-very good, and E-exceptional).

Sample Type: H-Headwater station, W-Wading station, or B-Boat station.

R - Ecoregional reference station.

Ecoregion Biocriteria:

Erie Ontario Lake Plain (ELOP)

INDEX - Site Type	WWH	EWH	MWH
IBI - wading/headwater	40/38	50	24
MIwb - wading	7.9	9.4	6.2
ICI	34	46	22

Western Allegheny Plateau (WAP)

INDEX - Site Type	WWH	EWH	MWH
IBI - wading/headwater	44/44	50	24
MIwb - wading	8.4	9.4	6.2
IBI - boat	40	48	24
MIwb - boat	8.6	9.6	5.8
ICI	36	46	22

Appendix C   Development of Watershed Loading Model

Loading of water, sediment, and nutrients in the Little Beaver Creek watershed was simulated using the Generalized Watershed Loading Function or GWLF model (Haith et al., 1992). The complexity of the loading function model falls between that of detailed, process-based simulation models and simple export coefficient models which do not represent temporal variability. GWLF provides a mechanistic, but simplified simulation of precipitation-driven runoff and sediment delivery, yet is intended to be applicable without calibration. Solids load, runoff, and ground water seepage can then be used to estimate particulate and dissolved-phase pollutant delivery to a stream, based on pollutant concentrations in soil, runoff, and ground water.

GWLF simulates runoff and streamflow by a water-balance method, based on measurements of daily precipitation and average temperature. Precipitation is partitioned into direct runoff and infiltration using a form of the Natural Resources Conservation Service’s (NRCS) Curve Number method (SCS, 1986). The Curve Number determines the amount of precipitation that runs off directly, adjusted for antecedent soil moisture based on total precipitation in the preceding 5 days. A separate Curve Number is specified for each land use by hydrologic soil grouping. Infiltrated water is first assigned to unsaturated zone storage where it may be lost through evapotranspiration. When storage in the unsaturated zone exceeds soil water capacity, the excess percolates to the shallow saturated zone. This zone is treated as a linear reservoir that discharges to the stream or loses moisture to deep seepage, at a rate described by the product of the zone's moisture storage and a constant rate coefficient.

Flow in streams may derive from surface runoff during precipitation events or from ground water pathways. The amount of water available to the shallow ground water zone is strongly affected by evapotranspiration, which GWLF estimates from available moisture in the unsaturated zone, potential evapotranspiration, and a cover coefficient. Potential evapotranspiration is estimated from a relationship to mean daily temperature and the number of daylight hours.

The user of the GWLF model must divide land uses into “rural” and “urban” categories, which determines how the model calculates loading of sediment and nutrients. For the purposes of modeling, “rural” land uses are those with predominantly pervious surfaces, while “urban” land uses are those with predominantly impervious surfaces. It is often appropriate to divide certain land uses into pervious (“rural”) and impervious (“urban”) fractions for simulation. Monthly sediment delivery from each “rural” land use is computed from erosion and the transport capacity of runoff, whereas total erosion is based on the universal soil loss equation (USLE) (Wischmeier and Smith 1978), with a modified rainfall erosivity coefficient that accounts for the precipitation energy available to detach soil particles (Haith and Merrill, 1987). Thus, erosion can occur when there is precipitation, but no surface runoff to the stream; delivery of sediment, however, depends on surface runoff volume. Sediment available for delivery is accumulated over a year, although excess sediment supply is not assumed to carry over from one year to the next. Nutrient loads from rural land uses may be dissolved (in runoff) or solid-phase (attached to sediment loading as calculated by the USLE).

For “urban” land uses, soil erosion is not calculated, and delivery of nutrients to the water bodies is based on an exponential accumulation and washoff formulation. All nutrients loaded from urban land uses are assumed to move in association with solids.

GWLF Model Inputs

GWLF application requires information on land use, land cover, soil, and parameters that govern runoff, erosion, and nutrient load generation.

Land Use/Land Cover

Digital land use/land cover (LULC) data for the Little Beaver Creek watershed were obtained from the National Land Cover Dataset (NLCD). The NLCD is a consistent representation of land cover for the conterminous United States generated from classified 30-meter resolution Landsat thematic mapper (TM) satellite imagery data. The NLCD is classified into urban, agricultural, forested, water, and transitional land cover subclasses. The imagery was acquired by the Multi-Resoultion Land Characterization (MRLC) Consortium, a partnership of federal agencies that produce or use land cover data. The imagery was acquired between 1991-1993. Table 1 summarizes the acreage in each land use category in the Little Beaver Creek watershed.

Table 1. Land Use and Land Cover in Little Beaver Creek Watershed, 1991-1993.

Land Use Code	Land Use	Acres	% of Total
11	Open Water	3,795	1.2
21	Low Intensity Residential	9,732	3.0
22	High Intensity Residential	599	0.2
23	Commercial/industrial/transportation	2,496	0.8
32	Quarries/strip Mines/gravel Pits	1,508	0.5
33	Transitional	263	0.1
41	Deciduous Forest	137,189	42.5
42	Evergreen Forest	7,077	2.2
43	Mixed Forest	7,271	2.3
81	Pasture/hay	108,768	33.7
82	Row Crops	42,792	13.2
85	Urban/recreational Grasses	110	0.0
91	Woody Wetlands	806	0.3
92	Herbaceous Wetlands	754	0.2
	Total	**323,160**	**100**

Soisl data for the Little Beaver Creek watershed were obtained from the NRCS State Soil and Geographic (STATSGO) database (http://www.ftw.nrcs.usda.gov/stat_data.html). Attribute data associated with soil map units were used to assign soil hydrologic groups and to estimate values for some of the USLE parameters, as described in sections below.

The entire surface of the Little Beaver Creek watershed was divided into subwatersheds corresponding to the segments appearing on the 303(d) list as impaired for nutrients. The subwatersheds, land uses, and the soils coverages were overlain in a Geographic Information System (GIS) environment. For the purposes of the GWLF modeling of runoff and erosion, the land use categories were grouped as summarized in Table 2. Runoff and erosion potential are expected to be affected both by land use and by the soil hydrologic group, so each land use group was divided into sub-categories based on the hydrologic group (A, B, C or D) of the underlying soil type. Finally, the high density residential land uses, which mixes substantial amounts of pervious and impervious areas, was further subdivided into pervious and impervious areas based on an assumed percent imperviousness (80%).

Table 2. Land Use Groupings for GWLF Modeling

MRLC Land Use	Group Code	Pollutant Simulation
Open Water	Water	Rural
Low Intensity Residential	Low Intensity Res	Urban
High Intensity Residential	High Intensity Res	Urban
Commercial/industrial/transportation	Commercial/industrial/transportation	Urban
Quarries/strip Mines/gravel Pits	Barren	Urban
Transitional		
Deciduous Forest	Forest	Rural
Evergreen Forest		
Mixed Forest		
Pasture/hay	Pasture/hay	Rural
Row Crops	Row Crops	Rural
Urban/recreational Grasses	Urban/rec Grasses	Urban
Woody Wetlands	Woody Wetlands	Rural
Herbaceous Wetlands	Herbaceous Wetlands	Rural

Rainfall and Runoff Input Data and Parameters

<u>Meteorology:</u>
Hydrology in GWLF is simulated by a water-balance calculation, based on daily observations of precipitation and temperature. A search was made of available Midwestern Regional Climate Center reporting stations. Based on this review, the most appropriate available meteorological data appears to be that from the station at Youngstown (Station ID: 9406), located at 41.25° N, 80.67° W, in Trumbull County. This station supplies daily data on precipitation and minimum and maximum temperature. Daily mean temperature was estimated as the mean of the minimum and maximum values.

<u>Runoff Curve Numbers:</u>
The direct runoff fraction of precipitation in GWLF is calculated using the curve number method from the SCS TR55 method literature based on land-use and soil hydrologic group (SCS 1986). Curve numbers vary from 25 for undisturbed woodland with good soils, to, in theory, 100, for impervious surfaces. The hydrologic soil group was determined from available soils data and curve numbers were calculated for each land use category/soil hydrologic group. Curve numbers assigned for the Little Beaver Creek watershed are summarized in Table 3. For each land use, the table also indicates whether GWLF simulates nutrient loading via the USLE equation ("rural" areas) or a buildup-washoff formulation ("urban" areas).

Table 3. Runoff Curve Numbers for the Little Beaver Creek Watershed.

GWLF Land Use Group	GWLF Loading Methodology	SCS Curve Number by Soil Hydrologic Group			
		A	B	C	D
Water	Usle Equation	100	100	100	100
Low Intensity Res	Build-up Washoff Formulation	NA	72	81	NA
High Intensity Res	Build-up Washoff Formulation	NA	72	81	NA
Commercial/industrial/trans portation	Build-up Washoff Formulation	NA	72	81	NA
Barren	Build-up Washoff Formulation	NA	86	91	NA
Forest	Usle Equation	NA	55	70	77
Pasture/hay	Usle Equation	NA	61	74	80
Row Crops	Usle Equation	NA	78	85	89
Urban/rec Grasses	Build-up Washoff Formulation	NA	NA	74	NA
Woody Wetlands	Usle Equation	NA	95	95	95
Herbaceous Wetlands	Usle Equation	NA	95	95	95

Evapotranspiration Cover Coefficients:

The portion of rainfall returned to the atmosphere is determined by GWLF based on temperature and the amount of vegetative cover. For all land uses the cover coefficent was determined based on season. The April through June cover coefficient was 0.7, July was 0.77, August through December was 0.8, and January through March was 0.67. These cover coefficients were chosen based on several calibration runs of the model.

Soil Water Capacity:

Water stored in soil may evaporate, be transpired by plants, or percolate to ground water below the rooting zone. The amount of water that can be stored in soil (the soil water capacity) varies by soil type and rooting depth. Based on soil water capacities reported in the STATSGO database, soil types present in the watershed, and GWLF user's manual recommendations, a GWLF soil water capacity of 8 cm was used.

Recession and Seepage Coefficients:

The GWLF model has three subsurface zones: a shallow unsaturated zone, a shallow saturated zone, and a deep aquifer zone. Behavior of the second two stores is controlled by a ground water recession and a deep seepage coefficient. The recession coefficient was set to 0.08 per day and the deep seepage coefficient to 0.055, based on several calibration runs of the model.

Erosion Parameters

GWLF simulates rural soil erosion using the Universal Soil Loss Equation (USLE). [Note: For land uses indicated as "Buildup-Washoff" in Table 4, solids loads are generated separately, as described below in the section entitled Parameters Governing Nutrient Load Generation.] This method has been applied extensively, so parameter values are well established. This computes soil loss per unit area (sheet and rill erosion) at the field scale by

$$A = R * K * LS * C * P$$

where,

A = rate of soil loss per unit area,
R = rainfall erosivity index,
K = soil erodibility factor,
LS = length-slope factor,
C = cover and management factor, and
P = support practice factor.

Soil loss or erosion at the field scale is not equivalent to sediment yield, as substantial trapping may occur, particularly during overland flow or in first-order tributaries or impoundments. GWLF accounts for sediment yield by (1) computing transport capacity of overland flow, and (2) employing a sediment delivery ratio (DR) which accounts for losses to sediment redeposition.

Rainfall Erosivity (RE):
Rainfall erosivity accounts for the impact of rainfall on the ground surface, which can make soil more susceptible to erosion and subsequent transport. Precipitation-induced erosion varies with rainfall intensity, which shows different average characteristics according to geographic region. The factor is used in the Universal Soil Loss Equation and is determined in the model as follows:

$$RE_t = 64.6 * a_t * R_t 1.81$$

where

RE_t = Rainfall erosivity (in megajoules mm/ha-h),
a_t = Location- and season-specific factor, and
R_t = Rainfall on day t (in cm).

The erosivity coefficient (a_t) was assigned a value of 0.3 for the growing season and 0.12 for the dormant season, based on erosivity coefficients provided in the GWLF User's Manual.

Soil Erodibility (K) Factor:
The soil erodibility factor indicates the inherent erodibility of a given soil type, and is a function of soil physical properties and slope. Soil erodibility factors were extracted from the STATSGO soil coverage. For each land use category, the K factors of the soil types underlying all land of this category were area-averaged to result in an overall K factor for the land use category.

Length-Slope (LS) Factor:
Erosion potential varies by slope as well as soil type. The LS factor is calculated following Wischmeier and Smith (1978):

$$LS = (0.138 * x_k)b * (65.41 * \sin^2\phi_k + 4.56 * \sin\phi_k + 0.065)$$

where

ϕ_k = tan - 1(ps_k/100), where ps_k is percent slope
x_k = slope length (ft)
b = a factor of percent slope, as follows:

Percent Slope	b
0-1	0.2
1 - 3.5	0.3
3.5 - 5	0.4
5 +	0.5

Slopes were extracted from the STATSGO soils database. For each soil type, slope was assumed to be the mid-point of the minimum and maximum slope given by STATSGO. As with the K factor, slope for each land use was calculated as an area-weighted average of the slopes of underlying soil types. The slope length was assumed to be 500 feet based on a visual analysis of the land use/soils coverage.

Cover and Management (C) and Practice (P) Factors:
The mechanism by which soil is eroded from a land area and the amount of soil eroded depends on soil treatment resulting from a combination of land uses (e.g., forestry versus row-cropped agriculture) and the specific manner in which land uses are carried out (e.g., no-till agriculture versus non-contoured row cropping). Land use and management variations are represented by cover and management factors in the universal soil loss equation and in the erosion model of GWLF. Cover and management factors were drawn from several sources (Wischmeier and Smith, 1978; Haith et al., 1992; Novotny and Olem, 1994), and are summarized in Table 4. Practice (P) factors were generally set to 1, consistent with recommendations for non-agricultural land.

Table 4. Cover and Management Factors for Little Beaver Creek Watershed Land Uses*

GWLF Land Use Group	C	P
Water	0	1
Low Intensity Res	0.01	1
High Intensity Res	0.01	1
Commercial/industrial/transportation	0.01	1
Barren	0.05	1
Forest	0.001	1
Pasture/hay	0.1	1
Row Crops	0.1	1
Urban/rec Grasses	0.1	1
Woody Wetlands	0.005	1
Herbaceous Wetlands	0.005	1

* C and P factors are not required for the "urban" land uses which are modeled in GWLF via a buildup-washoff formulation rather than USLE.

Sediment Delivery Ratio:
The sediment delivery ratio (DR) converts erosion to sediment yield, and indicates the portion of eroded soil that is carried to the watershed mouth from land draining to the watershed. The BasinSim program (a Windows version of GWLF) includes a built-in utility which calculates the sediment delivery ratio based an empirical relationship of DR to watershed area (SCS, 1973). The sediment delivery ratio for the entire Little Beaver Creek watershed was calculated at 0.0533.

Parameters Governing Nutrient Load Generation

Groundwater Nutrient Concentrations:

The GWLF model requires input of groundwater nutrient concentrations excluding loads due to septic systems, which are accounted for separately. Even in the absence of septic system loads, groundwater concentrations are expected to increase with a shift from forest to either agriculture or development, due to the input of fertilizer on crops, lawns, and gardens. The effect is greatest for nitrate, which is highly soluble, but some elevation of groundwater concentrations of phosphorus is also expected with increased development.

Groundwater nutrient concentrations were estimated using recommendations from the GWLF Manual. The resulting groundwater concentrations for the watershed were 0.008 mg/L phosphorus and 0.71 mg/L nitrogen.

Dissolved and Solid Phase Nutrient Concentrations for Rural Land Uses:

GWLF requires a dissolved phase concentration for surface runoff from rural land uses. Particulate concentrations are taken as a general characteristic of area soils, determined by bulk soil concentration and an enrichment ratio indicating preferential association of nutrients with the more erodible soil fraction, and not varied by land use. The estimates of dissolved phase and solid phase nutrient concentrations were selected from the GWLF User's Manual and are shown in Table 5.

Table 5. Dissolved and Solids Phase Nutrient Concentrations for Rural Land Uses.

GWLF Land Use Group	Nitrogen		Phosphorus	
	Dissolved Phase (mg/L)	Solids Phase (mg/kg)	Dissolved Phase (mg/L)	Solids Phase (mg/kg)
Forest	0.066	3800	0.008	440
Pasture/hay	3.19	3800	0.17	440
Row Crops	3.19	3800	0.17	440
Woody Wetlands	0.066	3800	0.008	440
Herbaceous Wetlands	0.066	3800	0.008	440

Buildup/Washoff Parameters for Urban Land Uses:

Nutrients and solids generated from urban land uses are described by a buildup/washoff formulation. Pollutant accumulation is summarized by an exponential buildup rate, and GWLF assumes that 95 percent of the limiting pollutant storage is reached in a 20-day period without washoff. The resulting buildup parameters are summarized in Table 6.

Table 6. Pollutant Buildup Rates for Urban Land Uses.

Land use	Nitrogen build up (kg/ha-d)	Phosphorus build up (kg/ha-d)
Urban/rec Grasses	0.013	0.0014
Low Intensity Res	0.05	0.0041
High Intensity Res	0.1	0.01008
Commercial/industrial/transportation	0.111	0.01008
Barren	0.1	0

Septic Systems:
GWLF contains routines for the simulation of nutrient loading from both normal and failing septic systems. The number of septic systems in the Little Beaver Creek Watershed was estimated based on 1990 census data. Several assumptions had to be made to categorize the systems according to their performance. These assumptions were based on the data provided by the public health departments, where available, and best professional judgement otherwise. Table 7 summarizes the results of these assumptions.

Table 7. Estimated Number of People Served by Septic Systems in Little Beaver Creek Watershed.

Estimated Number of People Served by Septic Systems	Estimated Number of People Served by Category			
	Normal	Ponded	Short-circuited	Direct Discharge
38,050	37,150	300	300	300

Normal: Septic systems conform to EPA standards and operating effectively.
Ponded: System failure results in surfacing of effluent.
Short-circuited: Systems are close enough to surface water (< 15 meters) that negligible absorption of phosphorus takes place.
Direct Discharge: Illegal systems discharge effluent directly into surface waters.

Parameters affecting nutrient loading from septic systems were specified at GWLF default values. Effluent phosphorus from failing septic systems was set to 1.5 g/day (default for areas with non-phosphate detergents), while effluent nitrogen was set to 12.0 g/day. Plant uptake rates were assumed to be 1.6 g/day nitrogen and 0.4 g/day phosphorus.

Point Sources:
Nutrient loads from point sources are calculated outside of the GWLF model and then added to the model as direct loads. Monthly loads from the active facilities in the watershed were estimated based on the average nutrient discharge concentrations and flows provided by Ohio EPA. Effluent nutrient concentrations were not available for several of the smaller plants so average values from similar plants were used instead.

Calibration Results

The results of calibrating the GWLF model for the Little Beaver Creek watershed are summarized in the following table and figures. The results indicate that the simulated flow modeling period agrees well with observed stream flow data. The greatest errors occur in simulated fall storm volumes and these are the only errors that are outside the recommended calibration parameters (Lumb et al., 1994). In general, the hydrologic calibration appears adequate in that it reflects the total water yield, annual variability, and magnitude of individual storm events in the basin.

The results of the water quality calibration results are presented in Figures 3, 4, and 5 below and indicate good agreement between simulated and observed sediment, nitrogen, and phosphorus loads. The loads for some months are significantly under- or over-predicted but most are within the 95 percent confidence interval range.

Table 8. Little Beaver Creek Watershed Calibration Results for the Simulation Period April 1997 to March 2002. Units shown are cm/yr.

Total Simulated In-stream Flow:	28.67	Total Observed In-stream Flow:	30.1
Total of highest 10% flows:	8.29	Total of Observed highest 10% flows:	8.51
Total of lowest 50% flows:	5.38	Total of Observed Lowest 50% flows:	5.73
Simulated Summer Flow Volume:	2.32	Observed Summer Flow Volume:	2.14
Simulated Fall Flow Volume:	4.18	Observed Fall Flow Volume:	5.71
Simulated Winter Flow Volume:	11.13	Observed Winter Flow Volume:	11.14
Simulated Spring Flow Volume:	11.03	Observed Spring Flow Volume:	11.12
Errors (Simulated-Observed)	%	*Recommended Criteria*[1]	
Error in total volume:	4.99	10	
Error in 50% lowest flows:	2.64	10	
Error in 10% highest flows:	6.64	15	
Seasonal volume error - Summer:	-7.93	30	
Seasonal volume error - Fall:	36.45	30	
Seasonal volume error - Winter:	0.05	30	
Seasonal volume error - Spring:	0.75	30	

[1] Recommended criteria are form Lumb et al., 1994

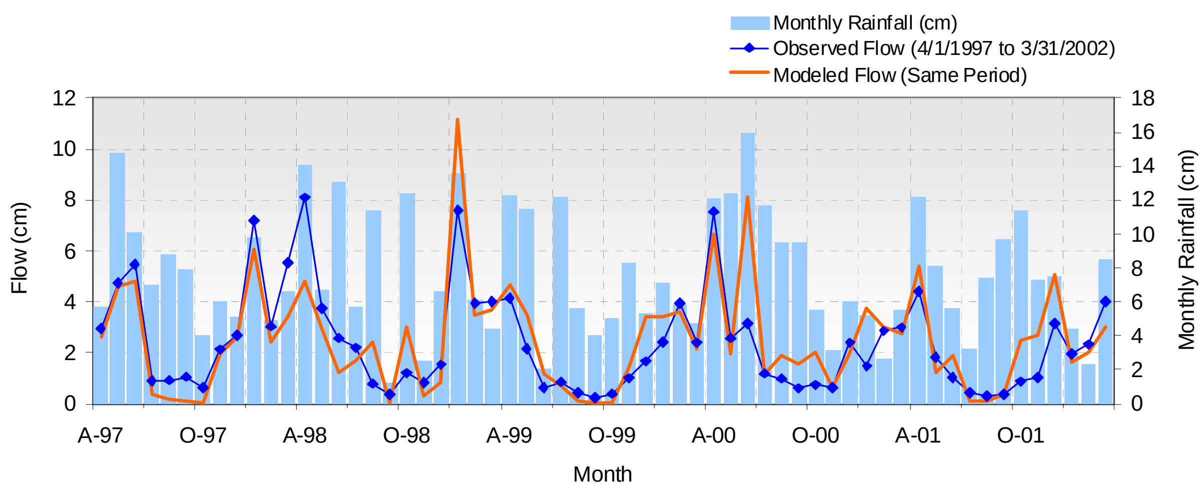

Figure 1. Little Beaver Creek observed versus simulated monthly streamflows (April 1, 1997 to March 31, 2002). R2 = 0.66.

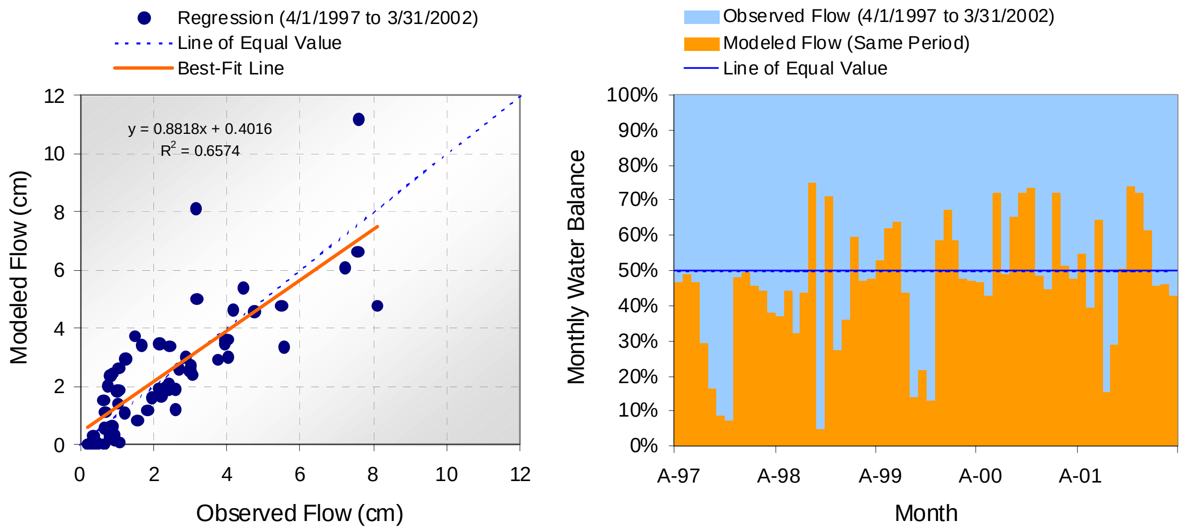

Figure 2. Time series hydrologic calibration results for Little Beaver Creek (April 1, 1997 to March 31, 2002).

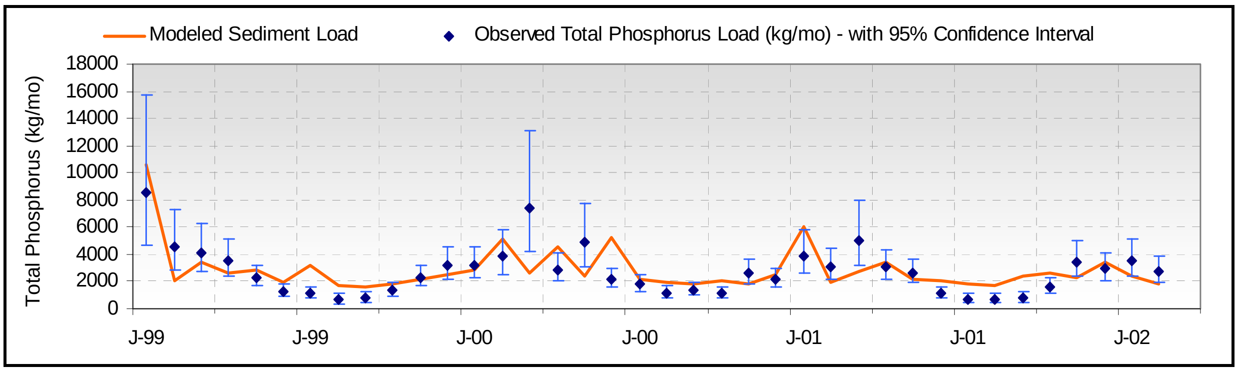

Figure 3. Comparison of predicted and observed total phosphorus data for Little Beaver Creek at station 03109500. R2 = 0.13.

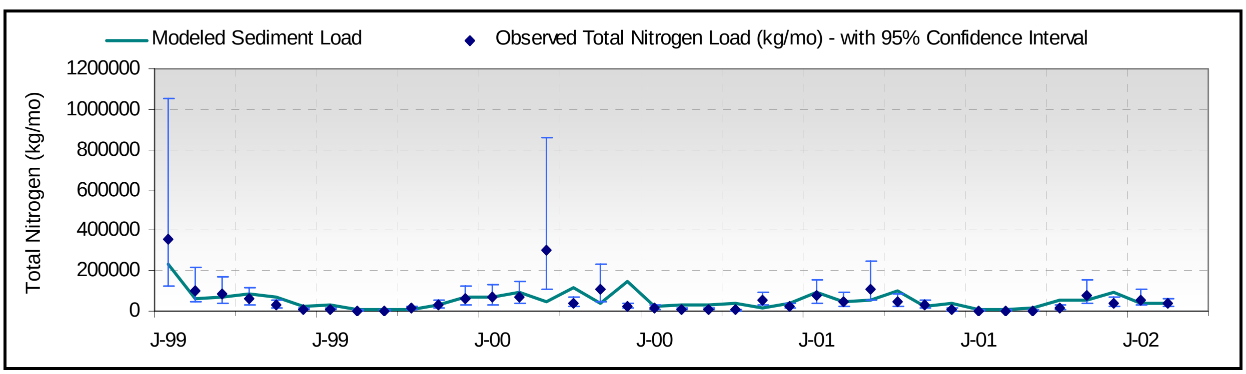

Figure 4. Comparison of predicted and observed total nitrogen data for Little Beaver Creek at station 03109500. R2 = 0.35.

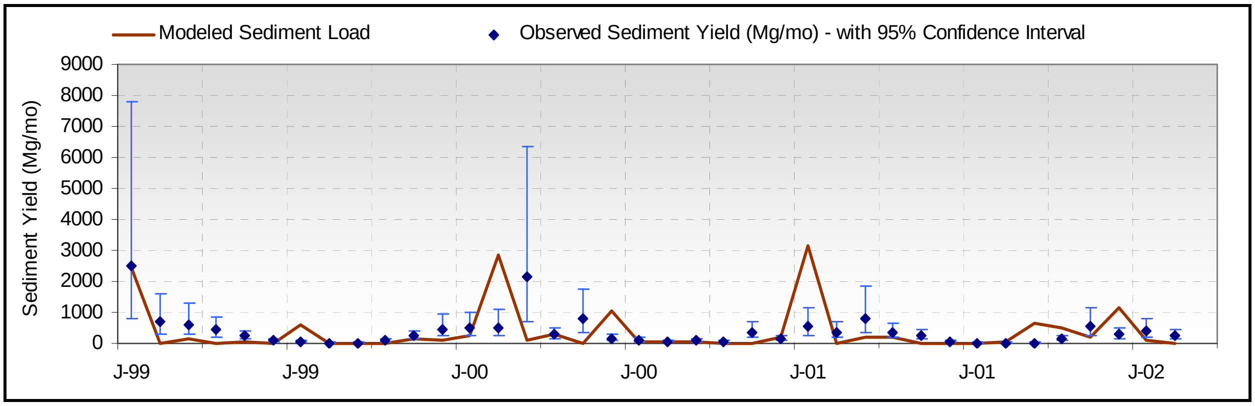

Figure 5. Comparison of predicted and observed total solids data for Little Beaver Creek at station 03109500. R2 = 0.36.

REFERENCES

Haith, D.A., R. Mandel, and R.S. Wu. 1992. GWLF, Generalized Watershed Loading Functions, Version 2.0, User's Manual. Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.

Haith, D.A. and D.E. Merrill. 1987. Evaluation of a daily rainfall erosivity model. *Transactions of the American Society of Agricultural Engineers*, 30(1): 90-93.

Lumb, A.M., R.B. McCammon, and J.L. Kittle, Jr. 1994. Users Manual for an Expert System (HSPEXP) for Calibration of the Hydrological Simulation Program-Fortran. U.S. Geologic Survey. Water-Resources Investigations Report 94-4168, Reston, VA, 1994.

Novotny, V. and H. Olem. 1994. Water Quality: Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, New York.

Omernik, J.M. 1977. Nonpoint Source–Stream Nutrient Level Relationships: A Nationwide Study. EPA-600/3-77-105. U.S. Environmental Protection Agency, Corvallis, OR

Parker, C.A. *et al*. 1946. Fertilizers and Lime in the United States. Miscellaneous Publication No. 586. U.S. Department of Agriculture, Washington, DC.

SCS, 1973. *National Engineering Handbook*. Section 3, Chapter 6. Soil Conservation Service, U.S. Department of Agriculture, Washington, DC.

SCS. 1986. *Urban Hydrology for Small Watersheds*. Technical Release No. 55 (second edition). Soil Conservation Service, U.S. Department of Agriculture, Washington, DC.

Wischmeier, W.H. and D.D. Smith. 1978. *Predicting Rainfall Erosion Losses, A Guide to Conservation Planning*. Agricultural Handbook 537, U.S. Department of Agriculture, Washington, DC.

Appendix D. Regression Analysis

Regression analysis was used to estimate parameters which are not directly modeled by the GWLF model. This appendix presents the results of regression analyses performed at the USGS monitoring station (03109500) near the mouth of the Little Beaver Creek watershed.

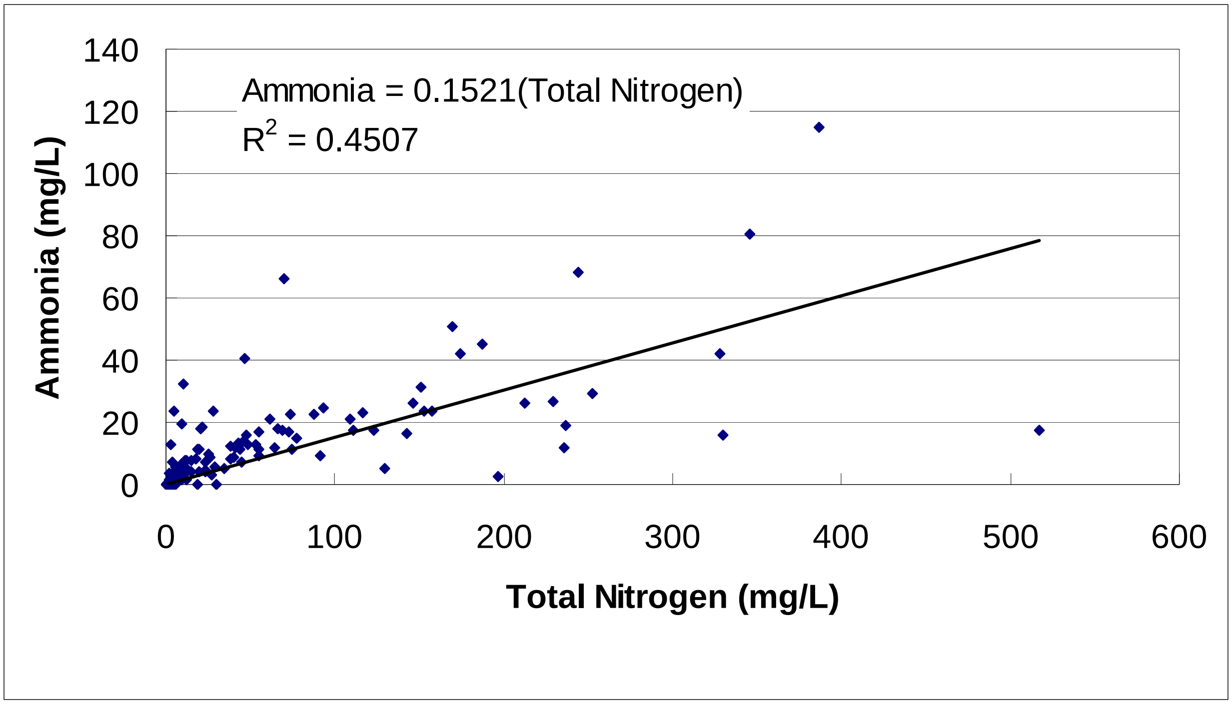

Figure D-1. Correlation between ammonia and total nitrogen concentrations observed at monitoring station 03109500 near the mouth of the Little Beaver Creek watershed.

Because ammonia is a nonconservative substance the relationship above between ammonia and total nitrogen is most relevant only at the USGS monitoring station. Ammonia is nonconservative primarily due to uptake and oxidation except at high concentrations when volatilization can also be important. Low concentrations are likely to be controlled by biological activity and much of the ammonia instream is likely due to decay of organic matter. Ammonia from source areas (e.g., point sources) is likely lost moving downstream but more ammonia is probably generated from the sediment downstream.

Ammonia:TN fractions were calculated for the four streams with ammonia listings to verify the above relationship. The results are shown in the table below and indicate a reasonable level of agreement. As explained in the TMDL report, the GWLF analysis of ammonia is primarily to assess the potential significance of nonpoint sources. Permit limits for point sources should be derived using OEPA’s standard wasteload allocation procedures.

Table D-1. Ammonia:TN relationships at ammonia listed streams in the Little Beaver Creek watershed.

Segment	# Paired Samples	Minimum Ammonia:TN	Median Ammonia:TN	Maximum Ammonia:TN
Brush Creek	3	0.06	0.08	0.22
Honey Creek	17	0.01	0.13	0.81
Leslie Run	84	0.00	0.17	0.96

Appendix E. Fecal coliform data used during load duration curve analysis.

Station ID	STATION_NA	Date	Segment	Value (#/100 mL)
LBC 10	Brush Creek @TR 844	7/8/1999	Brush Creek	8700
LBC 10	Brush Creek @TR 844	7/8/1999	Brush Creek	11000
LBC 10	Brush Creek @TR 844	8/24/1999	Brush Creek	160000
390370-901	Leetonia STP (3PB00017)	8/31/1998	East Branch	280
390370-901	Leetonia STP (3PB00017)	8/31/1998	East Branch	283
390370-901	Leetonia STP (3PB00017)	6/18/1999	East Branch	400
390370-901	Leetonia STP (3PB00017)	6/18/1999	East Branch	415
LBC 59	E Branch M Fork Little Beaver Creek @ Renkenberger Rd.	8/5/1999	East Branch	3200
390370-901	Leetonia STP (3PB00017)	8/19/1999	East Branch	30
390370-901	Leetonia STP (3PB00017)	8/20/1999	East Branch	21
LBC 59	E Branch M Fork Little Beaver Creek @ Renkenberger Rd.	9/8/1999	East Branch	72000
390370-901	Leetonia STP (3PB00017)	6/8/2000	East Branch	450
390370-901	Leetonia STP (3PB00017)	6/8/2000	East Branch	480
390370-901	Leetonia STP (3PB00017)	8/29/2000	East Branch	145
390370-901	Leetonia STP (3PB00017)	8/29/2000	East Branch	170
390370-901	Leetonia STP (3PB00017)	6/1/2001	East Branch	8
390370-901	Leetonia STP (3PB00017)	6/7/2001	East Branch	26
390370-901	Leetonia STP (3PB00017)	8/20/2001	East Branch	12
390370-901	Leetonia STP (3PB00017)	8/20/2001	East Branch	20
390370-901	Leetonia STP (3PB00017)	6/19/2002	East Branch	300
390370-901	Leetonia STP (3PB00017)	6/19/2002	East Branch	604
390370-901	Leetonia STP (3PB00017)	8/19/2002	East Branch	358
390370-901	Leetonia STP (3PB00017)	8/19/2002	East Branch	392
LBC-56	Honey Creek at S Range Rd dst New Middletown WWTP	8/5/1999	Honey Creek/New Middleton Area	1700
LBC-56	Honey Creek at S Range Rd dst New Middletown WWTP	8/5/1999	Honey Creek/New Middleton Area	1000
L01S41	HONEY CREEK SW OF NEW MIDDLETOWN - UNITY RD.	8/5/1999	Honey Creek/New Middleton Area	240
LBC-57	Honey Creek at SR 170	8/5/1999	Honey Creek/New Middleton Area	770
L01S41	HONEY CREEK SW OF NEW MIDDLETOWN - UNITY RD.	9/8/1999	Honey Creek/New Middleton Area	500
LBC-56	Honey Creek at S Range Rd dst New Middletown WWTP	9/8/1999	Honey Creek/New Middleton Area	730
LBC-57	Honey Creek at SR 170	9/8/1999	Honey Creek/New Middleton Area	800
390362-901	Leslie Run - East Palestine STP (3PD00042)	5/27/1998	Leslie Run/East Palenstine Area	417
390362-901	Leslie Run - East Palestine STP (3PD00042)	5/27/1998	Leslie Run/East Palenstine Area	721
390362-901	Leslie Run - East Palestine STP	6/23/1998	Leslie Run/East	575

Station ID	STATION_NA	Date	Segment	Value (#/100 mL)
	(3PD00042)		Palenstine Area	
390362-901	Leslie Run - East Palestine STP (3PD00042)	6/23/1998	Leslie Run/East Palenstine Area	850
390362-901	Leslie Run - East Palestine STP (3PD00042)	7/31/1998	Leslie Run/East Palenstine Area	144
390362-901	Leslie Run - East Palestine STP (3PD00042)	7/31/1998	Leslie Run/East Palenstine Area	188
390362-901	Leslie Run - East Palestine STP (3PD00042)	8/31/1998	Leslie Run/East Palenstine Area	68
390362-901	Leslie Run - East Palestine STP (3PD00042)	8/31/1998	Leslie Run/East Palenstine Area	86
390362-901	Leslie Run - East Palestine STP (3PD00042)	9/23/1998	Leslie Run/East Palenstine Area	42
390362-901	Leslie Run - East Palestine STP (3PD00042)	9/23/1998	Leslie Run/East Palenstine Area	97
390362-901	Leslie Run - East Palestine STP (3PD00042)	10/23/1998	Leslie Run/East Palenstine Area	35
390362-901	Leslie Run - East Palestine STP (3PD00042)	10/23/1998	Leslie Run/East Palenstine Area	42
390362-901	Leslie Run - East Palestine STP (3PD00042)	5/11/1999	Leslie Run/East Palenstine Area	154
390362-901	Leslie Run - East Palestine STP (3PD00042)	5/11/1999	Leslie Run/East Palenstine Area	172
390362-901	Leslie Run - East Palestine STP (3PD00042)	6/2/1999	Leslie Run/East Palenstine Area	1132
390362-901	Leslie Run - East Palestine STP (3PD00042)	6/2/1999	Leslie Run/East Palenstine Area	2240
390362-901	Leslie Run - East Palestine STP (3PD00042)	7/21/1999	Leslie Run/East Palenstine Area	380
390362-901	Leslie Run - East Palestine STP (3PD00042)	7/21/1999	Leslie Run/East Palenstine Area	425
L01S09	LESLIE RUN DST E PALESTINE- UNNAMED RD (RM 1.93)	8/5/1999	Leslie Run/East Palenstine Area	740
TTC5	LESLIE RUN @ BROOKDALE RD	8/5/1999	Leslie Run/East Palenstine Area	340
TTC6	LESLIE RUN @ DST ROSHEL TRIB	8/5/1999	Leslie Run/East Palenstine Area	16000
390362-901	Leslie Run - East Palestine STP (3PD00042)	8/23/1999	Leslie Run/East Palenstine Area	40
390362-901	Leslie Run - East Palestine STP (3PD00042)	8/23/1999	Leslie Run/East Palenstine Area	179
L01S09	LESLIE RUN DST E PALESTINE- UNNAMED RD (RM 1.93)	9/8/1999	Leslie Run/East Palenstine Area	2500
TTC5	LESLIE RUN @ BROOKDALE RD	9/8/1999	Leslie Run/East Palenstine Area	800
TTC6	LESLIE RUN @ DST ROSHEL TRIB	9/8/1999	Leslie Run/East Palenstine Area	120
390362-901	Leslie Run - East Palestine STP	9/27/1999	Leslie Run/East	26

Station ID	STATION_NA	Date	Segment	Value (#/100 mL)
	(3PD00042)		Palenstine Area	
390362-901	Leslie Run - East Palestine STP (3PD00042)	9/27/1999	Leslie Run/East Palenstine Area	1794
390362-901	Leslie Run - East Palestine STP (3PD00042)	10/22/1999	Leslie Run/East Palenstine Area	57
390362-901	Leslie Run - East Palestine STP (3PD00042)	10/22/1999	Leslie Run/East Palenstine Area	68
390362-901	Leslie Run - East Palestine STP (3PD00042)	5/2/2000	Leslie Run/East Palenstine Area	481
390362-901	Leslie Run - East Palestine STP (3PD00042)	5/2/2000	Leslie Run/East Palenstine Area	549
390362-901	Leslie Run - East Palestine STP (3PD00042)	6/9/2000	Leslie Run/East Palenstine Area	90
390362-901	Leslie Run - East Palestine STP (3PD00042)	6/9/2000	Leslie Run/East Palenstine Area	160
390362-901	Leslie Run - East Palestine STP (3PD00042)	7/10/2000	Leslie Run/East Palenstine Area	168
390362-901	Leslie Run - East Palestine STP (3PD00042)	7/10/2000	Leslie Run/East Palenstine Area	175
390362-901	Leslie Run - East Palestine STP (3PD00042)	8/9/2000	Leslie Run/East Palenstine Area	150
390362-901	Leslie Run - East Palestine STP (3PD00042)	8/9/2000	Leslie Run/East Palenstine Area	165
390362-901	Leslie Run - East Palestine STP (3PD00042)	9/18/2000	Leslie Run/East Palenstine Area	209
390362-901	Leslie Run - East Palestine STP (3PD00042)	9/18/2000	Leslie Run/East Palenstine Area	239
390362-901	Leslie Run - East Palestine STP (3PD00042)	10/20/2000	Leslie Run/East Palenstine Area	217
390362-901	Leslie Run - East Palestine STP (3PD00042)	10/20/2000	Leslie Run/East Palenstine Area	402
390362-901	Leslie Run - East Palestine STP (3PD00042)	5/2/2001	Leslie Run/East Palenstine Area	55
390362-901	Leslie Run - East Palestine STP (3PD00042)	5/2/2001	Leslie Run/East Palenstine Area	130
390362-901	Leslie Run - East Palestine STP (3PD00042)	6/11/2001	Leslie Run/East Palenstine Area	182
390362-901	Leslie Run - East Palestine STP (3PD00042)	8/22/2001	Leslie Run/East Palenstine Area	212
390362-901	Leslie Run - East Palestine STP (3PD00042)	9/28/2001	Leslie Run/East Palenstine Area	147
390362-901	Leslie Run - East Palestine STP (3PD00042)	9/29/2001	Leslie Run/East Palenstine Area	192
390362-901	Leslie Run - East Palestine STP (3PD00042)	10/22/2001	Leslie Run/East Palenstine Area	305
390362-901	Leslie Run - East Palestine STP (3PD00042)	6/6/2002	Leslie Run/East Palenstine Area	683
390362-901	Leslie Run - East Palestine STP (3PD00042)	6/6/2002	Leslie Run/East Palenstine Area	818
390362-901	Leslie Run - East Palestine STP	7/3/2002	Leslie Run/East	75

Station ID	STATION_NA	Date	Segment	Value (#/100 mL)
	(3PD00042)		Palenstine Area	
390362-901	Leslie Run - East Palestine STP (3PD00042)	8/8/2002	Leslie Run/East Palenstine Area	65
390362-901	Leslie Run - East Palestine STP (3PD00042)	8/8/2002	Leslie Run/East Palenstine Area	140
390362-901	Leslie Run - East Palestine STP (3PD00042)	9/5/2002	Leslie Run/East Palenstine Area	652
390362-901	Leslie Run - East Palestine STP (3PD00042)	9/5/2002	Leslie Run/East Palenstine Area	697
390362-901	Leslie Run - East Palestine STP (3PD00042)	10/3/2002	Leslie Run/East Palenstine Area	140

Appendix F: Public Comment Responsiveness Summary

Comments on the June 1, 2005 draft Little Beaver Creek Watershed TMDL report were received from one citizen, as presented below.

Comment: Jacquelyn Yates, East Liverpool, OH

Thank you for the interesting and informative report on Ohio's Little Beaver Creek TMDL.

Some of the problems that were identified appear to be quite solvable, as they are point source problems with local sewage treatment plants that can benefit from the application of public resources and will probably be agreeable to doing so.

I just wanted to call your attention to special conditions and problems in the LBC watershed that probably deserve the support of public policy as well. I'm a resident of the southern portion of the watershed, and so I speak to my direct experience.

1. In the unglaciated section of the watershed, the walls of the river valley are typically very steep. I believe that an effective riparian corridor in this area should include some land at the top of the valley wall, to slow runoff before it reaches the steep slopes that end near the water's edge. This means a riparian corridor wider than the traditional 100'. To me, it seems like this should be written into criteria for acquiring desirable properties and easements.

2. The Calcutta area is suffering from a peculiar blight of development, where new commercial properties are developed even when older facilities stand vacant. And every new commercial property has a parking lot that increases runoff to the stream, adding petroleum distillates and speeding erosion in the watershed. There should be more emphasis and incentives for refitting existing properties. Or more justification required to develop new properties.

3. The use of trees, green strips and dry wells in and around parking lots is virtually nonexistent, in the Calcutta area in particular, but throughout the watershed in Ohio. These low-cost remedies could greatly reduce erosion and pollution of the stream.

4. There are upland wetlands in the unglaciated portion of the watershed that function well to buffer runoff. Public policy should encourage the preservation of these areas.

5. As you stated in the report, runoff from mining operations is a serious problem. In rainstorms, I have traced sediment-filled runoff into Little Beaver Creek back to its origins, and it is very often a mine for gravel, stone or coal. Some of the mines are on the valley walls or even right at the water. Only public policy (and fines or threat of prosecution) will effectively prevent the careless discharge of runoff, which benefits only the mine operators, while the public pays the cost in polluted waters, backed up dams, and dredging the channels in navigable waterways.

6. At present, there are just a few "semi-public" septic systems in the Little Beaver Creek watershed. I foresee that these will proliferate, increasing discharge and cost of enforcement. In

my view, these should simply not be permitted. Such institutions should be developing within the reach of municipal sewage treatment, where a systematic solution can be applied, keeping the cost of enforcement low.

Response:
The comment writer points out a number of areas needing attention in the Little Beaver Creek watershed. The most effective venue for consideration of these issues is during local planning activities and during local discussion on individual issues before zoning officials and other local decision-makers. One formal planning activity currently underway is the preparation of a watershed action plan; these comments are being forwarded to the local watershed coordinator for consideration in that plan. The wastewater issues (#6) in particular would be best dealt with through Clean Water Act Section 208 planning.

Ohio EPA will follow up on NPDES permit recommendations made in the report, but voluntary actions in the local communities will be crucial to improving the condition of the Little Beaver Creek watershed. Funding for preservation and restoration may be available from Ohio EPA and other sources, as described in Chapter 9 of the report.