4.0 Watershed Analysis, Loading Capacity, and Allocations

The results of the analyses are summarized in tables and graphics in this chapter. The chapter is divided up by the four major sub-watersheds (upper, middle, lower Big Darby Creek and Little Darby Creek). The bedload, habitat, and flood plain capacity and allocation tables are presented at the beginning of each major watershed section. The bedload and habitat allocations are site specific, and all sites with a habitat assessment within the major watershed are presented in the table. The flood plain recommendations table presents flood plain recommendations by stream within each minor sub-watershed. The loading capacity and allocation tables follow and are organized by minor sub-watershed.

The bedload and habitat TMDL tables show the applicable targets per component in the header row of the table. The information presented in the body of the table is grouped by each of the minor sub-watersheds from upstream to downstream, and it is organized by stream and site river mile. The existing scores for each category and the total existing bedload and habit score is defined. The percent deviation the actual bedload score is from the allowable bedload score is shown followed by the main impaired QHEI category of the three used in determining the bedload score (see Section 3.3.5). The existing total habitat score per site can be compared to the allowable habitat score to make the same deviation determination. This table shows what components of the habitat need improvement and to what degree, and it can be used to guide management decisions and implementation activities.

The recommended flood plain widths are summarized in tables per major sub-watershed. Within the table, the information is grouped by minor sub-watershed and is organized by streams within each. All information is presented from upstream to downstream. Note the abbreviation UNT is used to identify an unnamed tributary, and a river mile of the stream the UNT is tributary to is listed for identification purposes. The appropriate flood plain width is specific to each point along a stream and is based on the use designation of the stream and the drainage area upstream of the point of interest as discussed in section 3.2. The use designation of each stream or stream segment is listed in the table as is the drainage area of the lower end site. Because there is a continuum of flood plain widths that gradually widens as you travel downstream, the flood plain table lists the flood plain needed at the upper reaches of the stream segment (this represents the minimum flood plain needed for the stream) and at the lower end. The lower end determination refers to the most downstream point of the stream segment of interest and represents the maximum flood plain needed for that segment. These give the range of flood plain widths needed and should provide some general guidance as to what appropriate flood plain widths are within the segment itself. Equations 3.2 through 3.4 can be used to determine the site specific recommended flood plain widths needed. The widths presented in the table denote the measurement from the centerline of the stream to a side. The total width of the corridor needed to be accessible as flood plain is the setback width multiplied by 2.

An areal estimate of existing active flood plain was done within two pilot areas of the Big Darby Creek watershed. These areas include parts of the upper Big Darby Creek and the Hellbranch sub-watersheds. The amount of existing active flood plain compared with the desired active flood plain for the two pilot areas is shown in Tables 4.1.3 and 4.4.2 respectively. The column labeled '1.5x Actual' should be used as the estimate of existing flood plain as this quantity is the amount needed to assimilate pollutants and is in keeping with the purpose of the TMDL. The '2x Actual' represents a quantity based on the typical flood plain associated with streams in this ecoregion. The percent the current flood plain meets the desired flood plain area is included in these tables. Two types of graphics are included to highlight the differences in existing versus needed flood plain. Areal plots for the Flat Branch and Buck Run areas are shown in Figures 4.1.1 and 4.1.2 respectively. Note the differences between the amount of actual flood plain available to the tributaries and that available to the Big Darby Creek mainstem. The second type of graphic which shows the comparison of actual and needed flood plain widths is a longitudinal plot of specific site measurements shown in a downstream direction for each sub-watershed in the pilot areas. These figures are included with the minor sub-watershed's sub-section of this chapter. The IBI score and use attainment of sites in the sub-watershed are included in these figures for comparison purposes.

The existing and allowable loads for total phosphorus, suspended sediment, and fecal coliform are given in tables organized by minor sub-watershed. The allowable total load (the TMDL number) is stated followed by the allocations of this load to its sources. The total existing load and the existing load by source is included. The overall percent reduction needed and the reductions per source are also listed. The loads are given in kilograms per year which can be converted to pounds per year by multiplying by a conversion factor of 2.2. The nonpoint sources category for total phosphorus and suspended sediment is divided between runoff from managed lands, groundwater from managed lands, and a natural load which includes both the runoff and groundwater load of the sub-watershed if it was still in its natural state (no point or septic sources, no land management for urban or agricultural needs).

The point source allowable load is further distributed amongst the individual NPDES permit holders within the sub-watershed. These waste load allocations are included in a second table. NPDES permit holders in the Darby watershed are generally municipal WWTPs; however, the Hellbranch Run sub-watershed also has Municipal Separate Storm Sewer Systems (MS4s) which require a NPDES permit. The wasteload allocations for these systems are included in the wasteload allocation table for Hellbranch Run.

The individual point source allocation table also includes the permit concentration limits to protect water quality for dissolved oxygen and ammonia. These permit concentrations are included for facilities that were evaluated as a part of the TMDL process. The permit limits are needed to address in-stream dissolved oxygen and ammonia impairments and to protect for the designated uses.

A table is also included which shows the distribution of existing load among the sources. It gives the percent contribution of the existing total phosphorus load per source. The table is organized in descending order of contribution percentage.

Other analyses were done and are presented in this chapter. A statistical comparison of water quality parameters in the upper Darby watershed was done to further our understanding of the unusual chemical signatures and impairment present there. Load duration curves at the three active USGS gage sites are included in the appropriate sub-watershed discussion. The potential for groundwater influence was explored by an examination of specific geology associated with groundwater - surface water interactions. The results are presented in Appendix A.

4.1 Upper Big Darby Creek

The upper Big Darby Creek analysis had a variety of results. A look at the Big Darby Creek mainstem from the headwaters to above Sugar Run shows the mainstem generally has an intact wooded riparian stream buffer (Figure 2.2.2). However the predicted existing active floodplain (Table 4.1.3) indicates the flood plain corridor for the mainstem from the headwaters to Milford Center is generally not sufficient for an EWH stream. The percent difference between the actual active flood plain and the recommended increases in the downstream direction. The active flood plain pilot area ended just downstream of Milford Center; however the attainment of the habitat and bedload TMDL scores (Table 4.1.1) in the section from downstream Milford Center to above Sugar Run would loosely imply the flood plain corridor is sufficient in this reach. The main QHEI categories in the qualitative bedload analysis indicate riparian was not an issue in the mainstem, but that the channel and substrate metrics were. The habitat TMDL was not met at 7 of the 11 sites on the mainstem (64% of the sites did not meet). The 4 sites that did meet the habitat TMDL were all in the stretch from Milford Center to above Sugar Run. Likewise the majority of this reach is fully meeting its designated use.

The tributaries in this sub-watershed generally do not have intact wooded riparian corridors or sufficient connection with the active flood plain to protect for designated uses - either in the tributary itself or for downstream uses. The Flat Branch tributary has a minimal aquatic life designated use which it meets. However, the bedload, habitat, flood plain, and buffer measurements and indices in Flat Branch are very low and contribute to impairment in the Big Darby mainstem downstream of Flat Branch. In addition, unusual chemical signatures in the Flat Branch and Buck Run may be contributing to this impairment as well (Section 4.1.8). Other tributaries have a variety of deficient bedload categories with the channel category being the most commonly impaired. Most of the tributaries do not meet their habitat TMDL with 15 of the 19 tributary QHEI sites measured in the sub watershed not meeting their habitat TMDL. (79% not meeting).

The pollutant loading analysis (Sections 4.1.1 through 4.1.7) corroborates the above. The upper and middle portions of the mainstem within this sub-watershed need higher

reductions in total phosphorus and significantly higher reductions in sediment loading than does the lower portion of the sub-watershed. This reflects the buffering effect the physical properties can have on the load to the system. The loading reductions needed in the tributaries are generally comparable to each other with a 70-80% reduction needed in total phosphorus load and about a 60% reduction needed in sediment load. The Flat Branch WWTP contributes to the phosphorus load and will be asked to reduce its phosphorus output.

The potential for groundwater influence is discussed in Appendix A. The upper Big Darby sub-watershed has geologic indications that groundwater is a buffering factor for some areas of the sub-watershed. Many streams on the western portion of the sub-watershed interact with high-yielding bedrock aquifers making the potential for a strong groundwater contribution likely. A portion of the Big Darby Creek mainstem around Milford Center exhibits this property as well. The tributaries on the eastern side of the sub-watershed do not have geologic properties that indicate groundwater is an unusual buffering influence to the system.

The linkage between multiple factors can be demonstrated by the following situation that has developed in the Big Darby Creek downstream of the Flat Branch tributary. Nutrient sources from the upper Big Darby, Flat Branch and the Flat Branch WWTP enrich the mainstem and supply a rich food source for algae. The hydrologic and hydraulic alterations of the Flat Branch sub-watershed as the watershed has been industrialized by Honda have resulted in increased peak flows to the Big Darby Creek mainstem. This increase in flows and the resultant increased flooding prompted a downstream landowner to levee his land; in addition, he removed the riparian vegetation that had been bordering the stream through his property. The removal of the woody riparian vegetation increased the available sunlight to the stream. The algae now had an unlimited supply of food and energy with which to grow. The bottom algae at this site was the highest recorded at any site within the entire Big Darby Creek watershed leading to dissolved oxygen violations where none had existed before. The levee serves to disconnect this stretch of the mainstem from an effective flood plain which will only exacerbate the flooding, nutrient, and sediment problems downstream.

Actions taken in the watershed have a domino effect. Upstream actions propagate downstream. Proper management of the watershed can allow for development and drainage needs while protecting aquatic life designations. An effective solution to the above situation may have been to start with Flat Branch and to control the export of flow and nutrients from that sub-watershed. This would have likely reduced or removed the flooding problem for the downstream farmer. If the riparian woody corridor had been left intact on the mainstem, the nutrient load in the stream would not necessarily have been reduced significantly; however, the reduced sunlight available to the aquatic vegetation would have controlled their growth. This would have prevented the dissolved oxygen problem that has now arisen.

Table 4.1.1 Bedload and Habitat TMDLs for upper Big Darby Creek (Headwaters to Sugar Run) 05060001-190

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1*	*0 = 1 pt*	*<3 = 1 pt*	QHEI	High Influence	# Modified Attributes	*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	**River Mile**	QHEI Categories: Substrate	Channel	Riparian	Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes				Total Habitat Score
Big Darby Creek: Headwaters to Flat Branch 05060001-190-010														
Big Darby Creek (EWH/CWH) *Impaired*	82.5	16.5	13.5	5	35	-	Channel	68	0	5	0	1	0	1
	80.8	7.5	12.5	5.5	25.5	27%	Substrate	61	1	7	0	0	0	0
	79.2	14	12	5.5	31.5	10%	Channel	64.5	0	4	0	1	0	1
Flat Branch 05060001-190-020														
Flat Branch (MWH)	3.2	4.5	4.5	3.5	12.5	n/a	Substrate	25.5	5	10	-	-	-	n/a
	0.8	3.5	8	4.5	16	n/a	Substrate	36.5	3	9	-	-	-	n/a
UT to Flat Branch (RM 1.50) (MWH)	0.1	5.5	7.5	5.5	18.5	n/a	Substrate	36.5	3	8	-	-	-	n/a

Table 4.1.1 Bedload and Habitat TMDLs for upper Big Darby Creek (Headwaters to Sugar Run) 05060001-190

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1*	*0 = 1 pt*	*<3 = 1 pt*	QHEI	High Influence	# Modified Attributes	*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	**River Mile**	QHEI Categories: Substrate	Channel	Riparian	Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes				Total Habitat Score
Big Darby Creek: Flat Branch to Milford Center 05060001-190-030														
Big Darby Creek (EWH) *Impaired*	78.4	13.5	10	4.5	28	20%	Channel	63.5	1	6	0	0	0	0
	76.6	15	15.5	6.5	37	-	Substrate	73.5	0	3	0	1	1	2
	69.5	16.5	13	5.5	35	-	Channel	70.5	1	5	0	0	0	0
	66	14.5	17.5	7	39	-	Substrate	74.5	0	2	0	1	1	2
Little Darby Creek Logan Co. (EWH/CWH)	3.5	6	4	1	11	69%	All	32	4	7	0	0	0	0
	0.4	15	16	4.5	35.5	-	Riparian	68	0	1	0	1	1	2
UT to Big Darby Creek (RM 74.91) (EWH)	0.2	9.5	15	4.5	29	17%	Substrate	62.5	0	3	0	1	1	2
UT to Big Darby Creek (RM 69.4) (WWH)	0.3	5	7	3.5	15.5	52%	Substrate	33.5	4	9	0	0	0	0
Spain Creek (EWH/WWH[1])	5.7[1]	14	16	5	35	-	Good	66	0	3	1	1	1	3
	3.7	15.5	16.5	4.5	36.5	-	Riparian	72	0	1	0	1	1	2
	0.1	14.5	17	6.5	38	-	Substrate	76	0	2	1	1	1	3

Table 4.1.1 Bedload and Habitat TMDLs for upper Big Darby Creek (Headwaters to Sugar Run) 05060001-190

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1*	*0 = 1 pt*	*<3 = 1 pt*	QHEI	High Influence	# Modified Attributes	*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	**River Mile**	QHEI Categories: Substrate	Channel	Riparian	Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes				Total Habitat Score
Pleasant Run (EWH)	4.6	17	14	4.5	35.5	-	Riparian	72	0	2	0	1	1	2
	0.5	12.5	12.5	4.5	29.5	16%	Substrate	59.5	0	6	0	1	0	1
Hay Run (EWH)	0.3	13.5	10.5	5.5	29.5	16%	Channel	52.5	2	7	0	0	0	0
Big Darby Creek: Milford Center to Sugar Run 05060001-190-040														
Big Darby Creek (EWH) *Impaired*	62.5	17	17	6.5	40.5	-	Good	83.5	0	0	1	1	1	3
	54.2	15	18	6	39	-	Substrate	83.5	0	0	1	1	1	3
	53.9	18	19.5	6	43.5	-	Good	93	0	0	1	1	1	3
	52	18	13	6	37	-	Channel	81	0	1	1	1	1	3
Prairie Run (LRW)	0.3	1	4	3	8	n/a	-	23	5	9	-	-	-	-
Sweeney Run (WWH) *Impaired*	0.1	14	10.5	6	30.5	5%	Channel	58	2	6	0	0	0	0

Table 4.1.1 Bedload and Habitat TMDLs for upper Big Darby Creek (Headwaters to Sugar Run) 05060001-190

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1*	*0 = 1 pt*	*<3 = 1 pt*	QHEI	High Influence	# Modified Attributes	*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	**River Mile**	QHEI Categories: Substrate	Channel	Riparian	Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes				Total Habitat Score
Buck Run 05060001-190-050														
Buck Run (WWH) *Impaired*	10.4	12.5	6.5	4	23	28%	Channel	40	4	10	0	0	0	0
	7.8	12.5	14.5	5.5	32.5	-	Substrate	55.5	1	3	0	1	1	2
	0.1	16	14.5	2.5	33	-	Riparian	70.5	0	3	1	1	1	3
Robinson Run 05060001-190-060														
Robinson Run (WWH) *Impaired*	2.1	17.5	12	5	34.5	-	Channel	64	1	5	1	1	0	2
	0.7	14.5	13.5	7	35	-	Channel	70	1	6	1	1	0	2
Sugar Run 05060001-190-070														
Sugar Run (MWH[2]/WWH) *Impaired*	7.5[2]	7	6.5	2.5	16	n/a	-	31	4	9	-	-	-	n/a
	7.0	6	4	2.5	12.5	61%	Channel	29.5	5	10	0	0	0	0
	5.4	5	4.5	4	13.5	58%	Channel	38.5	4	8	0	0	0	0
	0.5	16	13	5	34	-	Channel	65.5	0	3	1	1	1	3

[1]Denotes a Warm Water Habitat (WWH) Site.
[2]Denotes a Modified Warm Water Habitat (MWH) Site.

Table 4.1.2 Recommended Flood Plain Widths for Upper Big Darby Creek (Headwaters to Sugar Run) 0506001-190

Stream Segment	Use Designation[a]	Drainage Area[b] (sq.mi)	Setback Width[c] (per side, ft)	
			Upper End	Lower End
Big Darby Creek Headwaters to above Flat Branch -010				
Big Darby Creek -- headwaters to RM 78.48	EWH/CWH[d]	5.90	81.1	142.6
-020 Flat Branch				
Flat Branch	MWH/WWH[f]	13.52	54.3	101.8
UNT[e] to Flat Branch at RM 1.5	MWH	0.59	10.0	15.9
Big Darby Creek below Flat Branch to Milford Center -030				
Big Darby Creek -- RM 78.48 to RM 66.0	EWH	83.22	238.1	445.2
Little Darby Creek (Logan Co)	EWH/CWH[d]	7.12	99.4	154.7
UNT to Big Darby Creek at RM 74.91	EWH	3.72	45.5	117.0
Spain Creek -- headwaters to RM 5.0	WWH/CWH[d]	5.99	31.1	71.8
Spain Creek -- RM 5.0 to mouth	EWH/CWH[d]	10.08	143.5	179.6
Pleasant Run	EWH	7.01	121.4	153.6
UNT to Big Darby Creek at RM 69.4	WWH	4.85	48.1	65.6
Hay Run	EWH	6.43	113.4	148.0
Big Darby Creek from Milford Center to above Sugar Run [except Buck & Robinson Run] -040				
Big Darby Creek -- RM 66.0 to RM 50.92	EWH	155.84	445.2	583.0
Prairie Run	LRW[d]	4.23	11.3	12.4
Sweeney Run	WWH	4.33	33.3	62.5
-050 Buck Run				
Buck Run	WWH	29.86	65.8	143.3
-060 Robinson Run				
Robinson Run	WWH	10.62	39.2	91.8
-070 Sugar Run				
Sugar Run -- headwaters to RM 7.4	MWH	3.92	10.6	35.9
Sugar Run -- RM 7.4 to mouth	WWH	20.22	86.1	121.1
UNT to Sugar Run at RM 7.39	MWH	5.23	28.3	40.6

Notes:

(a) Assignments of use designation taken from *Biological and Water Quality Study of the Big Darby Creek Watershed, 2001/2002. Logan, Champaign, Union, Madison, Franklin and Pickaway Counties, Ohio.*

(b) Drainage area applies to lower end of segment; it is derived from digital topographic model and GIS

(c) Width is **one** side (e.g. left bank or right bank and its corresponding floodplain) of stream segment measured from stream centerline.

(d) EWH/CWH and WWH/CWH assume setback width based on EWH and WWH criteria, respectively. LRW assigned setback of half bankfull width.

(e) UNT: un-named tributary

(f) Based on protection of downstream use.

Table 4.1.3 Comparison of Needed and Predicted Active Floodplain for Selected Segments in the Big Darby Creek

Stream Segment	Aquatic Life Use	Active Floodplain Total Area[2] (Acres)			RM	Use Attainment	IBI[3]	ICI[3]	QHEI
		Area Needed[1]	Actual (2x)	Actual (1.5x)					
			% of Needed Area Met	% of Needed Area Met					
Big Darby Creek: Headwaters to Flat Branch 05060001-190-010									
Big Darby Creek -- RM 83.0 to RM 78.5	EWH/ CWH	129.5	111.2 86%	106.3 82%	83.2 82.5 80.8 79.2	(Full) Full (Non) Full	-- 52 42* 48[ns]	42[ns] 46 -- 56	-- 68.0 61.0 64.5
Flat Branch 05060001-190-020									
Flat Branch -- RM 5.2 to RM 0.9	MWH/ WWH[4]	72.5	44.4 61%	26.4 36%	3.2 2.2 0.9	Full (Full) Full	26 -- 28	G MG 50	25.5 -- 36.5
UNT (0.6 mi) to Flat Branch at RM 2.8	WWH (default)	6.8	6.0 89%	3.5 51%	--	--	--	--	--
Big Darby Creek: Flat Branch to Milford Center 05060001-190-030									
Big Darby Creek -- RM 78.5 to RM 66.0	EWH	1124.8	888.5 79%	782.0 70%	78.4 76.6 69.5 67.0	Partial Partial Full Partial	37.3* 43* 52 44*	52 56 52 E	63.5 73.5 70.5 --
UNT (0.26 mi) to Big Darby Creek at RM 74.91	EWH	5.4	4.1 75%	3.7 69%	0.2	Full	50	VG[ns]	62.5
Big Darby Creek: Milford Center to Sugar Run 05060001-190-040									
Big Darby Creek -- RM 66.0 to RM 63.7	EWH	136.4	53.2 39%	33.1 24%	66.0 64.1	Partial Partial	52 49[ns]	40* 50	74.5 80.5
UNT (0.2 mi) to Big Darby Creek at RM 60.6	WWH (default)	0.07	0.06 83%	0.05 66%	--	--	--	--	--
Buck Run 05060001-190-050									
Buck Run -- RM 9.6 to RM 2.1	WWH	211.1	137.0 65%	79.2 38%	10.4 7.8 5.0	Non Partial (Full)	26* 28* --	MG[ns] G MG[ns]	40.0 55.5 --

Table 4.1.3 Comparison of Needed and Predicted Active Floodplain for Selected Segments in the Big Darby Creek

Stream Segment	Aquatic Life Use	Active Floodplain Total Area[2] (Acres)			RM	Use Attainment	IBI[3]	ICI[3]	QHEI
		Area Needed[1]	Actual (2x)	Actual (1.5x)					
			% of Needed Area Met	% of Needed Area Met					
UNT (0.22 mi) to Buck Run at RM 9.45	WWH (default)	2.1	0.8 38%	0.0 0%	--	--	--	--	--
UNT (0.17 mi) to Buck Run at RM 8.16	WWH (default)	1.1	0.04 3%	0.0 0%	--	--	--	--	--
Robinson Run 05060001-190-060									
Robinson Run -- RM 6.7 to RM 2.0	WWH	81.6	51.0 63%	29.9 37%	5.1 2.1	(Non) Non	-- 30	VP* F*	-- 64.0

Notes:

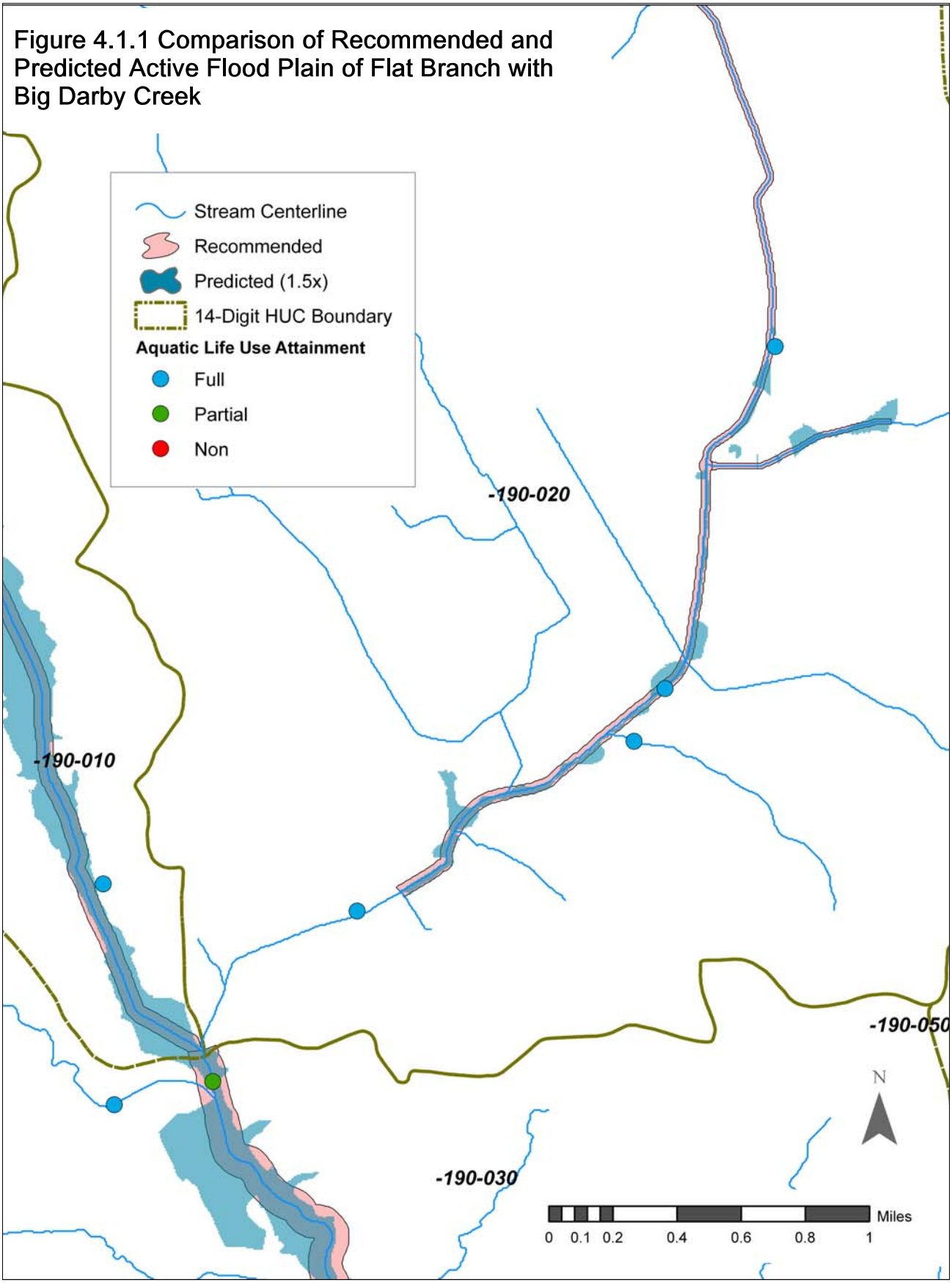
1) Assignments of use designation taken from *Biological and Water Quality Study of the Big Darby Creek Watershed, 2001/2002. Logan, Champaign, Union, Madison, Franklin and Pickaway Counties, Ohio*. EWH/CWH designation assigned EWH width recommendation.

2) Actual floodplain predicted by geographical/analytical model using limited field measurements of active floodplain height; this prediction is considered the actual active floodplain and represents a zone inundated by two (2x) or one-and-a-half times (1.5x) maximum bankfull depth. Area shown is amount overlapping recommended zone only.

3) Use Attainment, IBI, ICI, and QHEI per identified stream segment. Specific notation per IBI, ICI, and QHEI are defined as:
   - * Significant departure from ecoregion biocriteria; poor and very poor results are underlined.
   - ns Non-significant departure from ecoregion biocriteria (4 IBI or ICI units; 0.5 Iwb units).
   - a Narrative evaluation is used in lieu of ICI for qualitative samples (E=Excellent, VG=Very Good, G=Good, MG=Marginally good, F=Fair, P=Poor, VP=Very Poor).
   - c Use attainment status based on one organism group is parenthetically expressed.

4) Based on protection of downstream use.

Figure 4.1.1 Comparison of Recommended and Predicted Active Flood Plain of Flat Branch with Big Darby Creek



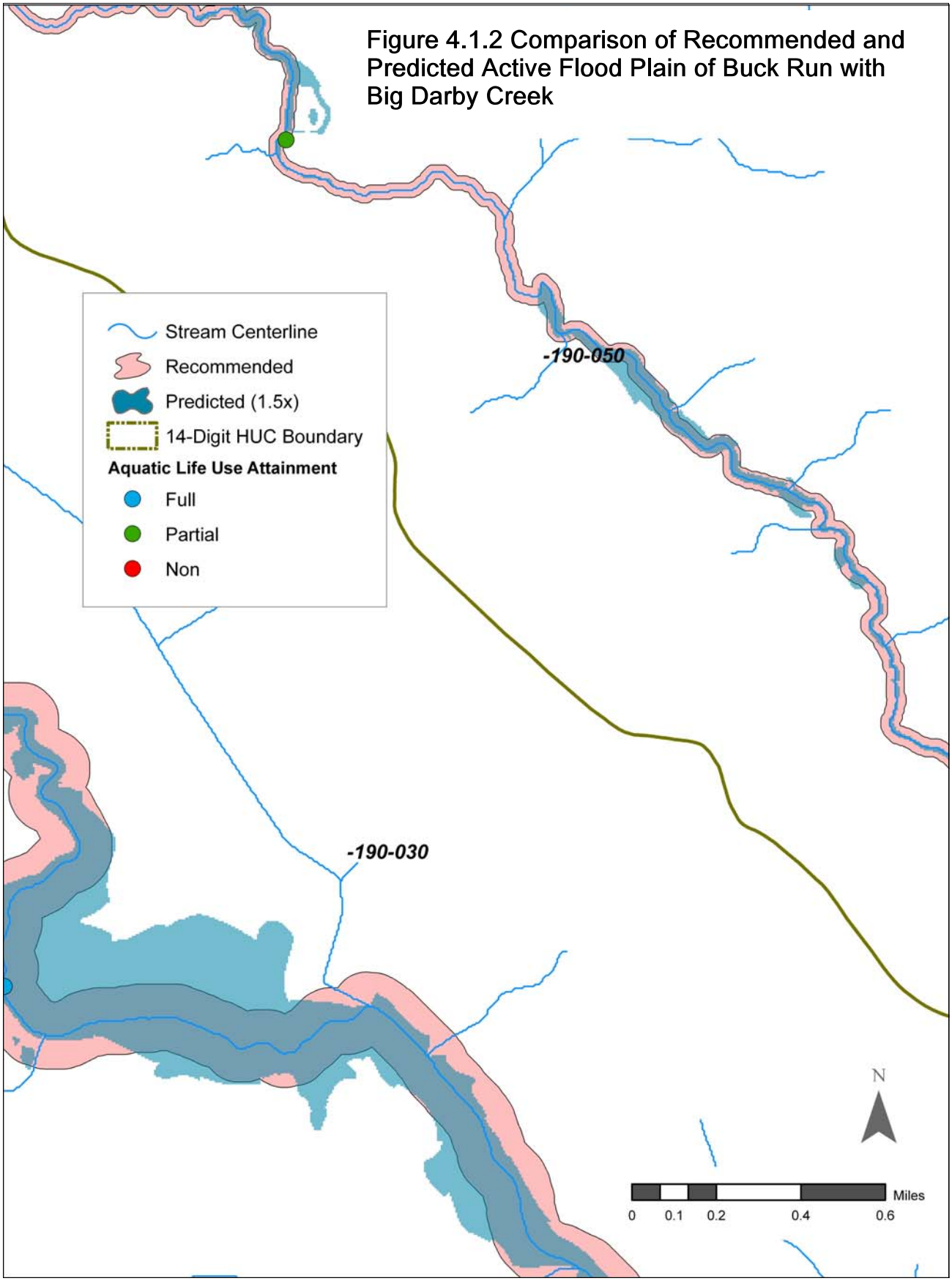


Figure 4.1.2 Comparison of Recommended and Predicted Active Flood Plain of Buck Run with Big Darby Creek

4.1.1 Big Darby Creek: Headwaters to above Flat Branch

Table 4.1.1.1 Allocations for Big Darby Creek Headwaters [2] (190-010)

Total Phosphorus (kg/y)[1]

	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	250	1	138	12	81	6	12	1 lb/acre per year
Existing	2121	11	255	0	1725	118	12	
% Reduction	88%	93%	46%	--	95%	95%	0%	

Suspended Sediment (1000 kg/y)[1]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	50	0.005	0.180	3	47	0.007	387 lb/acre per year
Existing	705	0.067	0.180	0	705	0.007	
% Reduction	93%	93%	0%	--	93%	0%	

Fecal Coliform (number*10^{10}/recreational season)[3]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources	
		Septic	WWTP		Direct Animal Inputs	Washoff
Allowable	1120	0.38	2.65	Implicit	1100	23.1
Existing	1510	5.32	2.65	0	1470	31.1
% Reduction	26%	93%	0%	--	25%	25%

Hydrology Targets

% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
61%	39%	12.7 in/yr	

[1] 1 kg = 2.2 lb
[2] Results are rounded to the nearest whole number based on the percent reduction listed.
[3] Recreational season is from May - October.

Table 4.1.1.2 Point Source Allocations and Other Limits for Big Darby Creek Headwaters

Individual Wasteload Allocations		
WWTP	Flat Branch	Notes
Permit #	1PP00006001	
FC, #/rec.season	2.65E+10	Current permit limit is adequate
Solids, kg/yr	180	Current permit limit is adequate
TP, kg/yr	138	Permit limit of 1 mg/l required
Other permit limits to protect DO and Ammonia Toxicity		
DO, mg/l	6	Current Permit limit is adequate
NH3, mg/l	0.8	Current Permit limit is adequate
$CBOD_5$, mg/l	8	Current Permit limit is adequate

Flat Branch WWTP is contributing to downstream phosphorus enrichment and a permit limit of 1 mg/l is needed. Flat Branch tributary just downstream of the WWTP is having a more deleterious effect on the Big Darby mainstem than the WWTP. A sediment and chemical oxygen demand load from the tributary combined with nutrients from both sources result in depressed DO levels in the downstream pooled area. Further downstream, removal of riparian cover and channelization of the stream adds unlimited sunlight resulting in nuisance algal and eutrophic conditions and violations of DO criteria. The bottom algae was 8 times higher in this reach than ambient conditions - the highest recorded in the watershed.

Table 4.1.1.3 Total Phosphorus Relative Source Contributions in Big Darby Creek Headwaters

Source	% of Existing Load
Row Crops	78.56
Point Source	12.01
Groundwater	5.71
Pasture / Hay	1.82
Commercial	0.83
Septic Systems	0.50

4.1.2 Flat Branch

Table 4.1.2.1 Allocations for Flat Branch [2] (190-020)

Total Phosphorus (kg/y)[1]

	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	658	3	2	33	548	46	26	0.9 lb/acre per year
Existing	4136	20	2	0	3771	317	26	
% Reduction	84%	84%	0%	--	85%	85%	0%	

Suspended Sediment (1000 kg/y)[1]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	132	0.020	0.073	6.6	125	0.002	67 lb/acre per year
Existing	390	0.125	0.073	0	390	0.002	
% Reduction	66%	84%	0%	--	68%	0%	

Fecal Coliform (number*10^{10}/recreational season)[3]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources	
		Septic	WWTP		Direct Animal Inputs	Washoff
Allowable	4141	1	0	Implicit	3700	440
Existing	5936	6	0	0	5310	620
% Reduction	30%	84%	0%	--	30%	30%

Hydrology Targets

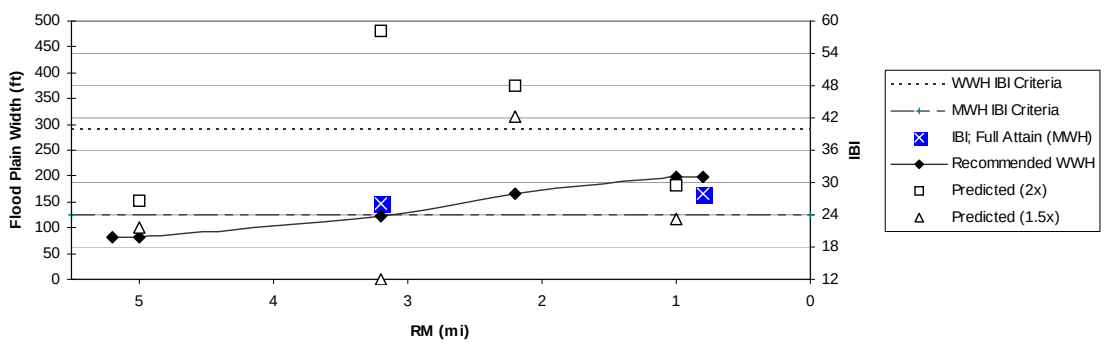
% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
41%	59%	9.9 in/yr	

[1] 1 kg = 2.2 lb
[2] Results are rounded to the nearest whole number based on the percent reduction listed.
[3] Recreational season is from May - October

Table 4.1.2.2 Point Source Allocations for Flat Branch			
Individual Wasteload Allocations			
WWTP	Honda E. Liberty WTP	Honda Benton Rd WTP	Notes
Permit #	1IW00270	4IW00019	
FC, #/rec.season	0	0	No permit limit
Solids, kg/yr	6.73	66.32	Current permit limit is adequate
TP, kg/yr	0.37	1.16	Permit limit probably not needed

Table 4.1.2.3 Total Phosphorus Relative Source Contributions in Flat Branch	
Source	% of Existing Load
Row Crops	76.09%
Commercial	13.31%
Groundwater	7.79%
Pasture / Hay	0.92%
Urban Grasses	0.88%
Residential (new)	0.17%

Figure 4.1.2 Longitudinal distribution of recommended versus predicted flood plain width, IBI, and aquatic life use attainment status for Flat Branch (RM 5.5 to RM 0.5).



4.1.3 Big Darby Creek: below Flat Branch to Milford Center

Table 4.1.3.1 Allocations for Big Darby Creek from below Flat Branch to Milford Center [2] (190-030)

Total Phosphorus (kg/y)[1]

	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	4430	20	350	220	3460	280	100	1 lb/acre per year
Existing	22910	110	660	0	20400	1640	100	
% Reduction	81%	81%	47%	--	83%	83%	0%	

Suspended Sediment (1000 kg/y)[1]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	1441	0.14	1.25	70	1370	0.04	225 lb/acre per year
Existing	5535	0.71	1.25	0	5533	0.04	
% Reduction	74%	81%	0%	--	75%	0%	

Fecal Coliform (number*10^{10}/recreational season)[3]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources	
		Septic	WWTP		Direct Animal Inputs	Washoff
Allowable	11810	14	26	Implicit	4840	6930
Existing	13186	70	26	0	5380	7710
% Reduction	10%	81%	0%	--	10%	10%

Hydrology Targets

% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
51%	49%	11.2 in/yr	

[1] 1 kg = 2.2 lb
[2] Results are rounded to the nearest whole number based on the percent reduction listed.
[3] Recreational season is from May - October

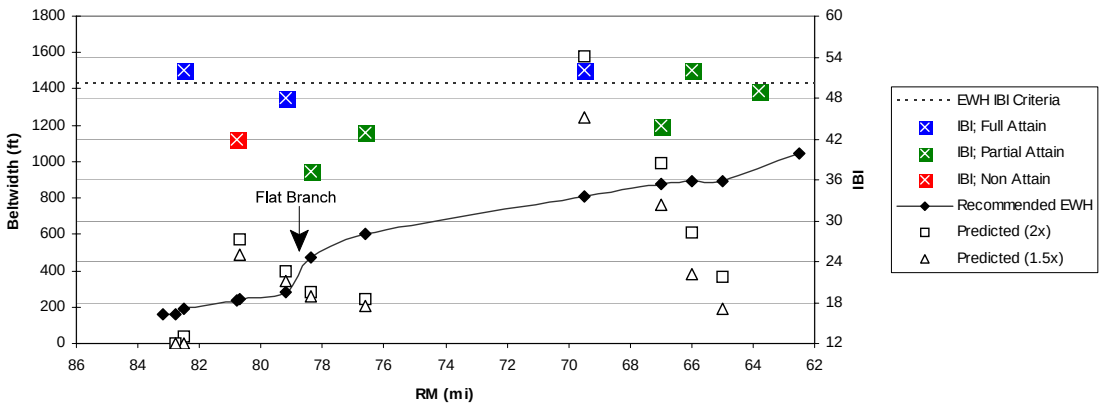
Table 4.1.3.2
Total Phosphorus Load Distribution for Big Darby Creek from below Flat Branch to Milford

Source	% of Existing Load
Row Crops	87.21%
Groundwater	7.31%
Point Source	2.87%
Pasture / Hay	1.38%

Table 4.1.3.3 Point Source Allocations and Other Limits for Big Darby Creek from below Flat Branch to Milford Center

Individual Wasteload Allocations		
WWTP	North Lewisburg	Notes
Permit #	1PB00039	
FC, #/rec.season	2.65E+11	Current permit limit is adequate
Solids, kg/yr	1250	Current permit limit is adequate
TP, kg/yr	347	TP limit is 0.6 mg/l at expanded flow (.42 mgd); 1.5 mg/l at current flow (0.17 mgd)
Other permit limits to protect DO and Ammonia Toxicity:		
CBOD5	10 mg/l	Current permit limit is adequate
DO	6 mg/l	Current permit limit is adequate
TSS	12 mg/l	Current permit limit is adequate
Ammonia	0.4 mg/l	If growth plan is not put in place or if downstream stream corridor degrades
	0.6 mg/l	If growth plan is put into place and downstream corridor is maintained/protected

Figure 4.1.3 Longitudinal distribution of recommended versus predicted flood plain width, IBI, and aquatic life use attainment status for the Big Darby Creek mainstem (RM 84.0 to RM 62.0).



4.1.4 Big Darby Creek from Milford Center to above Sugar Run (190-040)

Table 4.1.4.1 Allocations for Big Darby Creek from Milford Center to above Sugar Run [2]

Total Phosphorus (kg/y)[1]								
	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	2487	28	347	124	1758	189	41	0.7 lb/acre per year
Existing	9967	113	949	0	8006	859	41	
% Reduction	75%	75%	63%	--	78%	78%	0%	

Suspended Sediment (1000 kg/y)[1]							
	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	808	0.18	24	40	744	0.007	56 lb/acre per year
Existing	1299	0.72	24	0	1275	0.007	
% Reduction	38%	75%	0%	--	42%	0%	

Hydrology Targets			
% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
51%	49%	11.4 in/yr	

[1] 1 kg = 2.2 lb
[2] Results are rounded to the nearest whole number based on the percent reduction listed.

Table 4.1.4.2 Total Phosphorus Load Distribution in Big Darby Creek

SOURCE CONTRIBUTIONS:	
Source	% of Existing Load
Row Crops	77.07%
Point Source	9.52%
Groundwater	8.77%
Pasture / Hay	1.33%
Commercial	1.17%
Septic Systems	1.14%

Table 4.1.4.3 Point Source Allocations and Other Limits for Big Darby Creek from Milford Center to above Sugar Run

Individual Wasteload Allocations

Discharger:	Darby Ck Golf Course	Fairbanks School	Plain City WWTP	Tuffco Sand & Gravel	Ranco Corp.	Notes
Permit #	4PX00017	4PT00123	4PB00016	4IJ00011002	4IC00008	
FC, #/period	7.68E+09	1.57E+10	7.84E+11	0.00E+00	0.00E+00	Current permit is adequate
Solids, kg/yr	10.47	383	12434	10444	377	Current permit is adequate
TP, kg/yr	10.47	20.72	725.30	149.20	5.39	Permit limits of at least 1 mg/l recommended - monitoring needed

Other permit limits to protect DO and Ammonia Toxicity

Plain City WWTP (mg/l)	**Current** WWTP Q .5 MGD	***Expanded*** WWTP Q .75 MGD
DO	6	6
cBOD5	10	8
NH3	0.9	0.7
TP	1	0.7

4.1.5 Buck Run

Table 4.1.5.1 Allocations for Buck Run[2] (190-050)

Total Phosphorus (kg/y)[1]

	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	2107	34	3	105	1750	150	65	0.75 lb/acre per year
Existing	8620	140	5	0	7760	650	65	
% Reduction	76%	76%	38%	--	77%	77%	0%	

Suspended Sediment (1000 kg/y)[1]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	685	0.21	0.03	34	650	0.01	115 lb/acre per year
Existing	1650	0.87	0.03	0	1649	0.01	
% Reduction	59%	76%	0%	--	61%	0%	

Fecal Coliform (number*10^{10}/recreational season)[3]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources	
		Septic	WWTP		Direct Animal Inputs	Washoff
Allowable	8270	20	0.012	Implicit	7280	970
Existing	13340	90	0.012	0	11700	1550
% Reduction	38%	76%	0%	--	38%	38%

Hydrology Targets

% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
50%	50%	10.8 in/yr	

[1] 1 kg = 2.2 lb
[2] Results are rounded to the nearest whole number based on the percent reduction listed.
[3] Recreational season is from May - October

Table 4.1.5.2 Point Source Allocations for Buck Run (190-050)

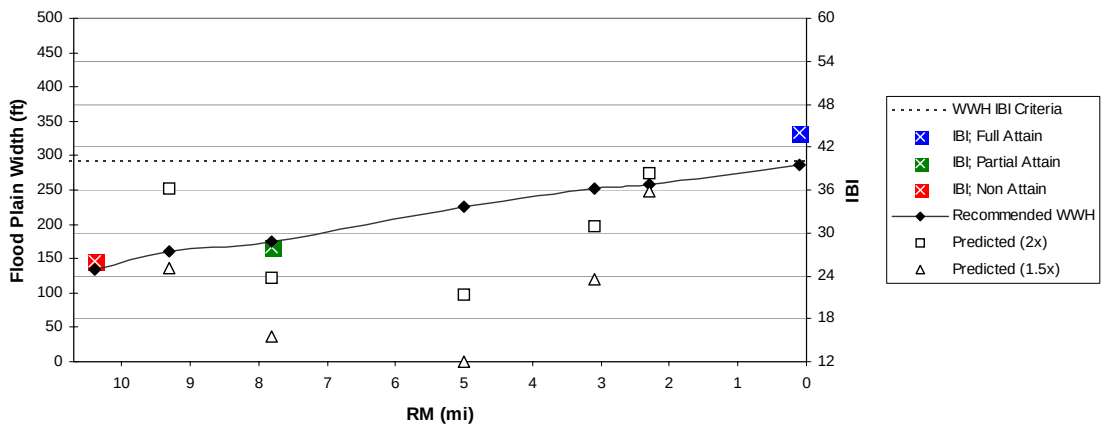
Individual Wasteload Allocations

WWTP	Reflections Subdivision WWTP	Notes
Permit #	4PW00008	
FC, #/period	1.21E+09	Current permit limit is adequate
Solids, kg/yr	29	Current permit limit is adequate
TP, kg/yr	3	TP limit of 1 mg/l is recommended

Table 4.1.5.3 Total Phosphorus Load Distribution in Buck Run

Source	% of Existing Load
Row Crops	84.42%
Groundwater	7.67%
Pasture / Hay	2.78%
Commercial	1.85%
Septic Systems	1.59%
Urban Grasses	0.75%
Residential (new)	0.46%

Figure 4.1.5 Longitudinal distribution of recommended versus predicted flood plain width, IBI, and aquatic life use attainment status for Buck Run (RM 10.5 to confluence).



4.1.6 Robinson Run

Table 4.1.6.1 Allocations for Robinson Run[2] (190-060)

Total Phosphorus (kg/y)[1]

	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	757	18	2	38	610	64	25	0.65 lb/acre per year
Existing	2834	68	2	0	2481	258	25	
% Reduction	73%	73%	0%	--	75%	75%	0%	

Suspended Sediment (1000 kg/y)[1]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	245	0.11	0.15	12	233	0.005	119 lb/acre per year
Existing	611	0.43	0.15	0	611	0.005	
% Reduction	60%	73%	0%	--	62%	0%	

Fecal Coliform (number*10^{10}/recreational season)[3]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources	
		Septic	WWTP		Direct Animal Inputs	Washoff
Allowable	2750	11	7	Implicit	2620	112
Existing	4560	43	55	0	4280	182
% Reduction	40%	73%	87%	--	39%	39%

Hydrology Targets

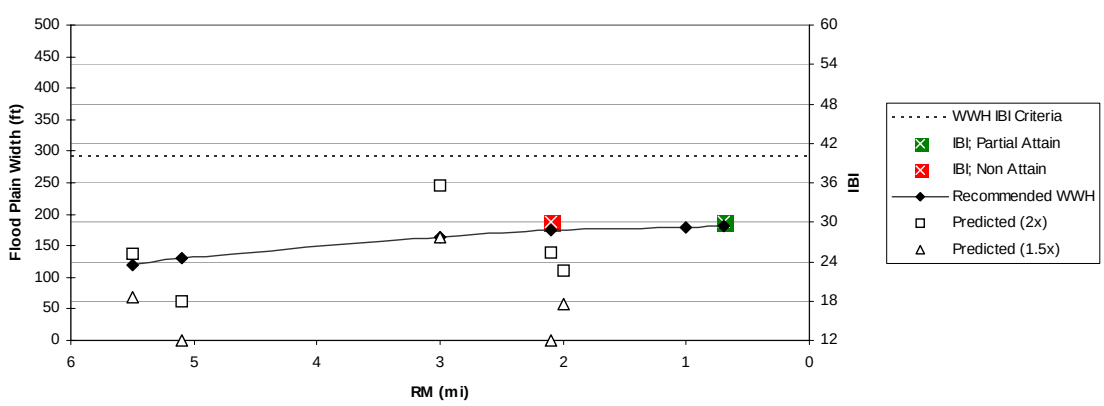
% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
56%	44%	11.5 in/yr	

[1] 1 kg = 2.2 lb
[2] Results are rounded to the nearest whole number based on the percent reduction listed.
[3] Recreational season is from May - October

Table 4.1.6.2 Point Source Allocations in Robinson Run (190-060)			
Individual Wasteload Allocations per Point Source			
WWTP	Darby Meadows WWTP	St. Johns Church	Notes
Permit #	4PG00005	4PT00006	
FC, #/period	6.97E+10	9.69E+08	Darby Meadows needs to comply with permit; otherwise current limits are adequate
Solids, kg/yr	124.34	29.01	Current permit limit is adequate
TP, kg/yr	1.38	0.48	Quarterly monitoring recommended, no permit limit at this time

Table 4.1.6.3 Total Phosphorus Load Distribution in Robinson Run	
Source	% of Existing Load
Row Crops	81.28%
Groundwater	9.28%
Pasture / Hay	4.87%
Septic Systems	2.39%
Residential (new)	1.10%
Commercial	0.35%

Figure 4.1.6 Longitudinal distribution of recommended versus predicted flood plain width, IBI, and aquatic life use attainment status for Robinson Run (RM 6.0 to confluence).



4.1.7 Sugar Run

Table 4.1.7.1 Allocations for Sugar Run[2] (190-070)

Total Phosphorus (kg/y)[1]								
	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	1376	19	1	69	1160	102	25	0.86 lb/acre per year
Existing	6230	86	1	0	5623	495	25	
% Reduction	78%	78%	0%	--	79%	79%	0%	

Suspended Sediment (1000 kg/y)[1]							
	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	447	0.12	0.08	22	425	0.01	149 lb/acre per year
Existing	1265	0.55	0.08	0	1264	0.01	
% Reduction	65%	78%	0%	--	66%	0%	

Hydrology Targets			
% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
48%	52%	10.5 in/yr	

[1] 1 kg = 2.2 lb
[2] Results are rounded to the nearest whole number based on the percent reduction listed.

Table 4.1.7.2 Point Source Allocations in Sugar Run (190-060)

Individual Wasteload Allocations per Point Source		
WWTP	Crottinger Estates WWTP	Notes
Permit #	4PG00003	
Solids, kg/yr	76	Current permit limit is adequate
TP, kg/yr	1	Quarterly monitoring recommended, no permit limit at this time

Table 4.1.7.2 Total Phosphorus Source Contributions in Sugar Run (190-070)

Source	% of Existing Load
Row Crops	84.80%
Groundwater	8.02%
Pasture / Hay	3.48%
Septic Systems	1.39%
Commercial	1.13%
Residential (new)	0.82%

4.1.8 Chemical Associations in the Upper Big Darby Creek Sub-Watershed

The lowest fish community index scores on the Big Darby Creek mainstem were found in the upper Big Darby Creek major sub-watershed in the reach immediately downstream from the confluence with Flat Branch. The results of the water quality and biological survey of 2001 indicated this reach is impacted by a complex mix of causes and sources of pollution. A very visible turbidity plume could be traced in the Big Darby Creek originating in Flat Branch which extended for miles. Elevated nutrients and metals were detected as were depressed dissolved oxygen readings. Several potential sources of these factors were identified in the 2001 study and include road construction activities which had occurred in the headwaters of the BDC, the Flat Branch WWTP, and the Flat Branch tributary.

In June, 2004 a field survey was conducted to provide for development of a water quality model to determine what was occurring in this stretch of Big Darby Creek. Datasonde® continuous data loggers were deployed to gather data on the diel DO pattern in Flat Branch and Big Darby Creek, along with a suite of other data. Results of this sampling effort revealed water quality criteria violations for dissolved oxygen (see Figure 4.1.8.2) in both Flat Branch and Big Darby Creek downstream of Flat Branch. It is clear from the results of the water quality model and data that Flat Branch is the driving force determining water quality in Big Darby Creek downstream of Flat Branch.

The results of the 2001 study and the 2004 model both indicate unusual results for Flat Branch. This lead to further examination of the available water quality data to determine how the totality of the Flat Branch water quality compared with that of other sub-watersheds in the upper basin. Initial review of the data lead to the conclusion that some parameters in Flat Branch greatly exceeded corresponding values in upper Big Darby Creek upstream of Flat Branch. In order to gain definition of the extent of the problem, a detailed statistical analysis of data in the upper Big Darby Creek major sub-watershed was performed, comparing the data from all the minor sub-watersheds to evaluate for differences. The results of this analysis and the chemicals which displayed statistically significant variability are presented in Table 4.1.8 .

Striking similarities exist between water quality of Flat Branch, and of Buck Run, both of which receive discharges from Honda. Flat Branch and Buck Run were grouped together as the highest (or lowest) average concentrations for many of the chemicals examined. In particular, Flat Branch and Buck Run had the highest concentrations and were significantly different from the other sub-watersheds for iron, aluminum, TSS, and potassium. They also had the lowest concentrations and were statistically different from other areas for alkalinity, hardness, and magnesium. In addition, a pervasive turbidity is a shared visual characteristic of these streams. Other than the fact that they both receive discharges from Honda, no immediately apparent cause for this trend has been revealed. A collaborative effort of Ohio EPA and Honda has been initiated to study this situation further.

The U.S. Army Corps of Engineers and the Nature Conservancy contracted with the Ohio State University to study the upper Big Darby Creek sub-watershed and

investigate the water quality of the area and ascertain the suitability of certain areas to supporting wetlands (Mitsch et al., 2002). The study found that the water quality of the Flat Branch tributary was of particular concern due to its high turbidity and high concentrations of iron, aluminum, arsenic, and boron. In addition, the study found that Flat Branch makes up a significant portion of the total flow of the upper Big Darby Creek. Flat Branch contributed 56% of the Big Darby Creek flow during flood events and 88% of the flow during normal flow periods as evaluated at a mainstem site just downstream of Flat Branch (at N. Lewisburg Road). It was further found that 11% of the total Big Darby Creek flow at the USGS Darbyville gage was contributed from Flat Branch during April 2002 flooding periods. The drainage area of the Flat Branch is less than 3% of the drainage area of the USGS Darbyville gage.

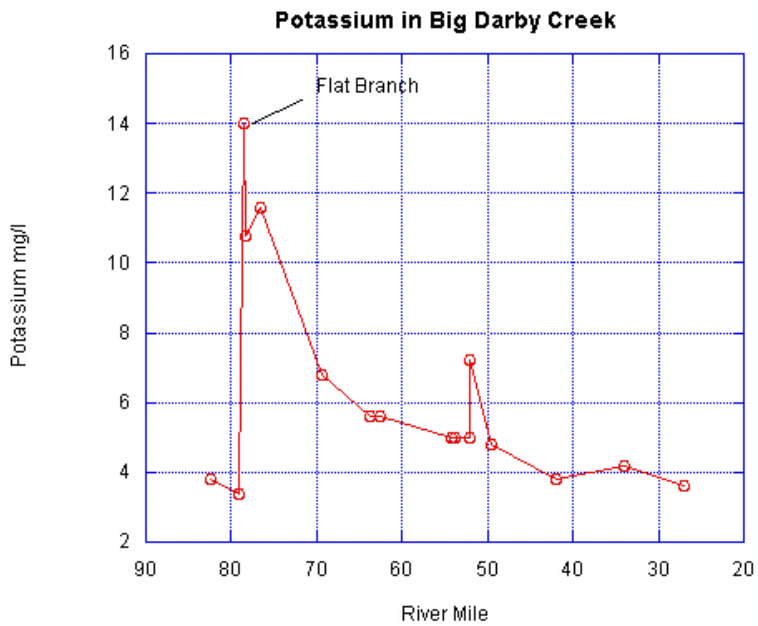


Figure 4.1.8.1 Average potassium levels in the Big Darby Creek Mainstem.

A longitudinal plot of potassium concentrations in the Big Darby Creek mainstem illustrates the degree to which the discharge from Flat Branch effects Big Darby Creek. As a general case, potassium values in the upper Big Darby Creek major sub-watershed are very low. The highest values recorded were in Flat Branch. Graphing mean potassium concentrations from the 2001 water quality survey data in Big Darby Creek, along with the mean concentration from Flat Branch show that the discharge from Flat Branch has a clear influence on water quality in upper Big Darby Creek for miles (see Figure 4.1.8.1)

Based on the results of this analysis, iron, aluminum, zinc, TSS, potassium, and flow contributions are all highly elevated in Flat Branch, and may need to be controlled.

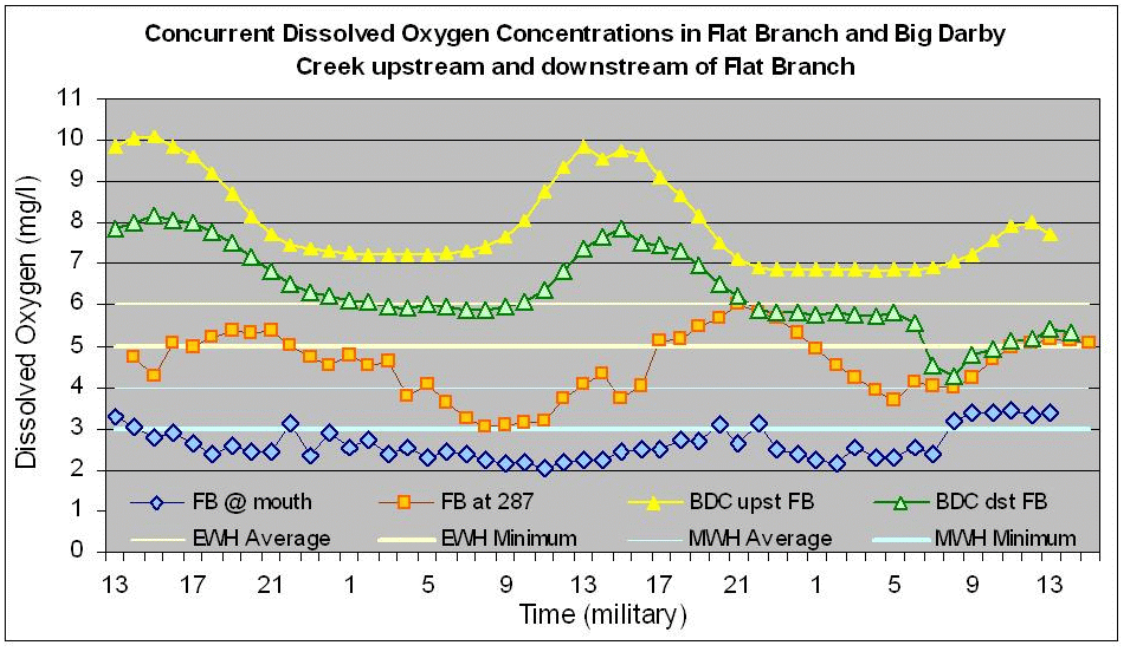


Figure 4.1.8.2 Dissolved Oxygen Concentrations in Flat Branch and Big Darby Creek

Table 4.1.8 Comparisons of the Statistical Significance of Water Chemistry by Sub-watershed in the Upper Big Darby Ck

Parameter	Unit	Sub-watersheds listed in descending order based on mean concentration (in parentheses). Those that are not significantly different are grouped by the colored band underneath the listing.						
Iron	µg/l	**020** (3312.1)	**050** (2128.8)	**010** (1060.3)	**030** (1051.2)	**060** (1031.8)	**070** (978.0)	**040** (757.1)
Aluminum	µg/l	**020** (2068.4)	**050** (1549.1)	**070** (904.7)	**030** (872.1)	**060** (708.9)	**010** (655.0)	**040** (555.8)
Zinc	µg/l	**020** (28.2)	**030** (13.8)	**050** (12.9)	**010** (11.5)	**070** (11.5)	**040** (11.3)	**060** (11.3)
TSS	mg/l	**020** (39.4)	**050** (36.7)	**030** (21.5)	**070** (21.5)	**040** (20.0)	**010** (17.7)	**060** (14.9)
Potassium	mg/l	**020** (12.7)	**050** (9.2)	**070** (8.4)	**060** (7.1)	**040** (5.0)	**030** (4.1)	**010** (3.2)
Alkalinity	mg/l	**010** (257.6)	**030** (254.6)	**040** (238.1)	**060** (191.0)	**070** (181.7)	**050** (169.1)	**020** (102.1)
Hardness	mg/l	**010** (372.1)	**060** (360.1)	**070** (348.8)	**030** (332.1)	**040** (330.5)	**050** (280.3)	**020** (157.1)
Magnesium	mg/l	**060** (38.5)	**010** (38.3)	**030** (33.9)	**040** (33.5)	**070** (33.5)	**050** (26.7)	**020** (13.9)
Nitrate	mg/l	**040** (2.57)	**030** (2.09)	**070** (1.66)	**060** (1.13)	**010** (0.47)	**050** (0.38)	**020** (0.21)
Ammonia	mg/l	**040** (0.170)	**050** (0.079)	**070** (0.072)	**020** (0.065)	**060** (0.062)	**030** (0.057)	**010** (0.052)
Phosphorus	mg/l	**040** (0.186)	**070** (0.168)	**030** (0.115)	**010** (0.114)	**020** (0.093)	**060** (0.093)	**050** (0.085)
Manganese	µg/l	**050** (227.4)	**070** (138.6)	**020** (102.6)	**060** (75.8)	**010** (49.2)	**040** (44.6)	**030** (43.8)

Table 4.1.8 Comparisons of the Statistical Significance of Water Chemistry by Sub-watershed in the Upper Big Darby Ck

Parameter	Unit	Sub-watersheds listed in descending order based on mean concentration (in parentheses). Those that are not significantly different are grouped by the colored band underneath the listing.						
COD	mg/l	**060** (24.4)	**070** (22.7)	**020** (21.3)	**050** (20.8)	**040** (15.1)	**010** (12.7)	**030** (11.8)
TKN	mg/l	**070** (1.172)	**060** (1.051)	**050** (0.841)	**040** (0.720)	**020** (0.665)	**030** (0.423)	**010** (0.419)

Key:

HUC14 Code	Sub-Watershed
010	Big Darby Creek to Flat Branch
020	Flat Branch
030	Big Darby Creek from Flat Branch to Milford Center, Spain Creek, Little Darby Creek (Logan County), UT's
040	Big Darby Creek, Milford Center to just below Plain City WWTP, Sweeny Run
050	Buck Run
060	Robinson Run
070	Sugar Run

4.2 Middle Big Darby Creek

The middle Big Darby Creek mainstem is impaired from Plain City to Lucas Rd. A look at the physical properties of this section of the Big Darby Creek mainstem shows the mainstem generally has an intact wooded riparian stream buffer (Figure 2.3.2). The habitat and bedload targets are generally met, but are stressed by the presence of modified habitat attributes particularly low sinuosity and substrate embeddedness. No estimation of existing active flood plain was done for this area due to resource limitations; however, the substrate embeddedness may be an early sign the flood plain in the area is being threatened. The embeddedness could also be a carry over from the lack of sufficient flood plain in the upper Big Darby sub-watershed. The existing sediment loading in the middle Big Darby Creek sub-watershed is just shy of the allowable sediment loading indicating the existing flood plain is sufficient, but should be protected to prevent future sediment problems.

The fairly good physical condition of the upper middle Big Darby Creek mainstem indicates chemical stressors are the main cause of impairment in this segment. An in-stream water quality model was developed from upstream of the Plain City WWTP to Lucas Road to evaluate this situation. The Plain City WWTP is located in the upper Big Darby Creek sub-watershed but at the very downstream end of it. The effects of the WWTP materialize in the mainstem of the middle Big Darby Creek; hence, it will be discussed in this section. Note that the Plain City WWTP loads are included in section 4.1.4

The model shows there are two critical chemical points in this segment of the mainstem. Both of these areas are large pooled sections of river where the velocity and turbulence of the stream decreases which promotes settling of particulate matter to the streambed sediments. The first area is just downstream of the Plain City WWTP discharge. The extremely high in-stream concentrations of nutrients in the pooled section indicate a cycle of nutrient particles settling to the sediments followed by a release of dissolved nutrients from the sediments when the dissolved oxygen at the sediment/water interface gets low. The Plain City WWTP has a history of problems with release of solids from their plant. These solids have collected in the pooled section downstream of the effluent and are a main contributor to the nutrient sediment-water interactions. The high nutrient concentrations spark the growth of algae in the river which exerts an influence along this entire stretch of river. Both the suspended algae and bottom algae increase in quantity as you progress downstream. The turbidity in the pooled section and the mostly intact riparian corridor protects this segment from gross algal blooms. However, if sunlight has access to the river a serious algal and dissolved oxygen problem would emerge. One other potential source discharges to the pooled section. A small stormwater pipe from a nearby housing development discharges here as well. The pipe had a very small discharge at the time of the field survey (which was during dry weather) indicating it has a connection to groundwater or other flow source other than stormwater. The quality of this effluent was much better than the WWTP, and the flow substantially less; however, the concentrations were twice background. It may be an additional source of nutrients. Plain City is upgrading its WWTP currently; therefore, if the plant is operated well, the solids and nutrient loading from the WWTP should

decrease. However, as the nutrients are in the sediments it will take some time before the legacy nutrients are flushed from the system.

The second critical spot is the mainstem from Fitzgerald Ditch to Lucas Rd. This pooled section shows an extremely large nutrient problem. The contributions from the upstream pooled area combine with a legacy of spills from agricultural sources in Fitzgerald Ditch. The settling of organic nutrients to the sediments and the release of their dissolved form from the sediments back into the water column result in a eutrophic situation where dissolved oxygen concentrations are violating the criteria.

Figure 4.2 Plain City WWTP Discharge to the Big Darby Creek

Table 4.2.1 Bedload and Habitat TMDLs for middle Big Darby Creek (Sugar Run to Little Darby Creek) (05060001-200)

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1 pt*	*0 = 1 pt*	*<3 = 1 pt*	QHEI	High Influence	# Modified Attributes	*3 pts*
	WW	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1 pt*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	River Mile	QHEI Categories			Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes				Total Habitat Score
		Substrate	Channel	Riparian										
Big Darby Creek below Sugar Run to High Free Pike 05060001-200-010														
Big Darby Creek (EWH) (Impaired)	49.5	14	15	6.5	35.5	-	Substrate	76	1	4	1	0	0	1
	42	15	16	8.5	39.5	-	Substrate	81.5	0	2	1	1	1	3
Worthington Ditch (WWH) (Impaired)	0.2	14	8	3	25	24%	Channel	46.5	3	8	0	0	0	0
Ballenger-Jones Ditch (WWH)	0.5	16	16.5	4	36.5	-	Riparian	69	0	2	1	1	1	3
Fitzgerald Ditch (WWH) (Impaired)	0.5	13	11.5	7.5	32	-	Channel	56.5	2	7	0	0	0	0
Big Darby Creek from High Free Pike to above Little Darby Creek 05060001-200-020														
Big Darby Creek (EWH)	38.9	15	16	9.5	40.5	-	Good	82.5	0	2	1	1	1	3
	34.1	19	18	8.5	45.5	-	Good	93.5	0	0	1	1	1	3

Table 4.2.2 Recommended Flood Plain Widths for Middle Big Darby Creek (Sugar Run to Little Darby Creek) 0506001-200

Stream Segment	Use Designation[a]	Drainage Area[b] (sq.mi)	Setback Width[c] (per side, ft)	
			Upper End	Lower End
Big Darby Creek below Sugar Run to High Free Pike 05060001-200-010				
Big Darby Creek -- RM 50.92 to RM 41.75	EWH	234.73	614.4	695.3
Worthington Ditch	WWH	6.59	52.7	74.8
Ballenger-Jones Ditch	WWH	6.27	41.6	73.2
Yutzy Ditch	WWH	3.19	35.6	54.8
Fitzgerald Ditch	WWH	5.45	25.7	68.9
Big Darby Creek from High Free Pike to above Little Darby Creek 05060001-200-020				
Big Darby Creek -- RM 41.75 to RM 34.1	EWH	250.84	695.3	715.4

Notes:
(a) Assignments of use designation taken from *Biological and Water Quality Study of the Big Darby Creek Watershed, 2001/2002. Logan, Champaign, Union, Madison, Franklin and Pickaway Counties, Ohio.*
(b) Drainage area (sq.mi) applies to lower end of segment and is derived from digital topographic model and GIS (geographic information system).
(c) Width is **one** side (e.g. left bank or right bank and its corresponding floodplain) of stream segment measured from stream centerline.

4.2.1 Big Darby Creek from Sugar Run to High Free Pike

Table 4.2.1.1 Allocations for Big Darby Creek from below Sugar Run to High Free Pike (200-010)[1,3]

Total Phosphorus (kg/y)[2]								
	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	9853	118	318	493	8119	688	119	0.54 lb/acre per year
Existing	19359	231	318	0	17232	1460	119	
% Reduction	49%	49%	0%	--	53%	53%	0%	

Hydrology Targets			
% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
43%	57%	10.2 in/yr	

[1] Existing suspended sediment and fecal coliform loads below allowable; no TMDL needed.
[2] 1 kg = 2.2 lbs
[3] Results are rounded to the nearest whole number based on the percent reduction listed.

Table 4.2.1.2 Point Source Allocations of Big Darby Creek (200-010)

Individual Wasteload Allocations per Point Source				
WWTP	Wisslohican	Suburbans MHP WWTP	Canaan MHP WWTP	Dutch Kitchen
Permit #	4PG00024	4PR00031001	4PR00032001	4PR00077001
FC, #/period	1.07E+10	1.19E+11	3.68E+10	5.22E+08
Solids, kg/yr	41.464	165.783	145.051	6.205
TP, kg/yr	25.84	130.71	145.90	4.56
WWTP	COJV School District	Canaan School	Jonathon-Alder High School	
Permit #	4PT00104001	4PT00118001	4PT00119001	
FC, #/period	5.10E+09	3.71E+03	1.87E+09	
Solids, kg/yr	15.47	3.80E-05	23.83	
TP, kg/yr	6.81	7.60E-06	3.83	

The current permit limits are adequate at this time.
Quarterly monitoring for total phosphorus is recommended.

Table 4.2.1.3 Total Phosphorus Load Distribution for Big Darby Creek (200-010)

Source	% of Existing Load
Row Crops	87.08%
Groundwater	7.68%
Point Source	1.64%
Pasture / Hay	1.49%
Septic Systems	1.19%
Commercial	0.39%
Residential (new)	0.24%

4.2.2 Big Darby Creek from High Free Pike to above Little Darby Creek (200-020)

Table 4.2.2.1 Allocations for Big Darby Creek (200-020)[1,3]

Total Phosphorus (kg/y)[2]								
	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	2353	59	897	118	1096	147	35	0.43 lb/acre per year
Existing	5393	136	2189	0	2674	360	35	
% Reduction	56%	56%	59%	--	59%	59%	0%	

Hydrology Targets			
% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
57%	43%	12.4 in/yr	

[1] Existing suspended sediment and fecal coliform loads below allowable; no TMDL needed.
[2] 1 kg = 2.2 lbs
[3] Results are rounded to the nearest whole number based on the percent reduction listed.

Table 4.2.2.2 Point Source Allocations of Big Darby Creek (200-020)

Individual Wasteload Allocations per Point Source					
WWTP	BMI	Darby Dan Farms	Lake Darby Estates	Greentree MHP WWTP	Notes
Permit #	4IN00004	4PR00031	4PU00001	4PY00001	
FC, #/period	8.81E+09	5.36E+10	9.05E+10	7.23E+09	Current permit limit is adequate
Solids, kg/yr	552.67	60.79	690.84	66.32	Current permit limit is adequate
TP, kg/yr	249.25	4.99	623.13	19.94	A 1 mg/l TP limit needed and at least quarterly monitoring.

Table 4.2.2.3 Total Phosphorus Load Distribution in Big Darby Creek (200-020)	
Source	% of Existing Load
Row Crops	44.45%
Point Source	40.58%
Groundwater	6.78%
Septic Systems	2.52%
Pasture / Hay	2.18%
Residential (new)	1.76%
Commercial	0.91%
High Intensity Residential	0.19%
Low Intensity Residential	0.18%

4.3 Little Darby Creek

Much of the Little Darby Creek upstream of the town of Chuckery is impaired including the majority of Treacle Creek. The upper portion of Spring Fork is also impaired, but the rest of the Little Darby sub-watershed is mainly in attainment of designated uses.

The quality and width of the riparian buffer zones roughly follows the impairment pattern. A review of Figure 2.4.2 shows that the areas with impairment generally have much spottier and less thick woody riparian zones, and a higher proportion of grassed riparian corridors. Table 4.6 summarizes the bedload and habitat scores. The headwaters of the Little Darby are in attainment and 24% of the total available habitat score is not met. In comparison, the Treacle Creek sub-watershed (including upper and lower Treacle Ck and Proctor Run) is mostly impaired and had 75% of the total available habitat score not met. The bedload scores reflect similar results with 29% of the upper Little Darby sites not meeting the bedload target and 50% of the Treacle Creek sub-watershed sites do not meet. The middle Little Darby Creek had 100% of the QHEI sites not attain either the bedload or the habitat TMDLs. The Spring Fork sub-watershed had 86% of the habitat measured sites not attaining the TMDL and 57% not meeting the bedload TMDL. The lower Little Darby in contrast is in full attainment and all sites meet the bedload TMDL and 75% meet the habitat TMDL.

These results indicate the physical properties of the stream channel and corridor need improvement. An analysis of the existing available flood plain in this area was not done due to project resource constraints; however, the buffer and QHEI analyses imply the existing flood plain available to the streams is not sufficient to maintain the use.

A load duration curve analysis of the the available in-stream suspended sediment load is presented in figure 4.3.7. This site is in the attaining area of the lower Little Darby Creek watershed. The graph indicates that the sediment load at this point in the Little Darby exceeds the target under high flow conditions. The available data is sparse at this site, so strong conclusions cannot be made from it; however, it does serve to groundtruth the GWLF model predictions which state that this portion of the Darby should reduce its total sediment load by 59% (to prevent export downstream). The LDC analysis indicates a 46% reduction is needed. The GWLF model reflects all conditions over many years. The LDC data only represent isolated points. Given these differences, they are in relative agreement as to the predictions. Some of the difference could be due to the activity of the available flood plain in the lower Little Darby allowing the load off the land to settle out and reducing bank erosion; these factors are not accounted for in the GWLF model. However, GWLF predicts a much higher sediment reduction is needed in the upper and middle portions of the Little Darby Creek. These predictions are supported by the bedload analysis which also indicates a sediment-rich stream environment. The predicted model loadings indicate a reduction in land disturbing activities and re-introduction of accessible flood plain is needed to bring the watershed into attainment.

A visual examination of the Little Darby Creek between Mechanicsburg and Van Ness Rd. showed the Little Darby Creek becoming increasingly entrenched with little access

to the adjacent riparian land (steep banks, eroding banks) as it travels downstream. In addition, the land use patterns in the impaired areas of Little Darby Creek also indicate a large portion of these sub-watersheds are under land-disturbing activities. Agricultural land use makes up 93% of the lower Treacle Creek and 87% of the middle Little Darby Creek. There is little natural or unmanaged land left in these basins to help to buffer the effects of land disturbing activities. The large proportion of managed land use in these areas makes the need for a riparian corridor and flood plain all the more critical. Recommended set backs are included in table 4.3.2.

Total phosphorus load in streams is often associated with sediment as phosphorus has a tendency to attach to soil particles. This holds true in the Little Darby Creek sub-watershed as well. However, the total phosphorus load duration curve (LDC) in Figure 4.3.7 shows some difference from the suspended sediment curve at the same site. The target load is exceeded more often than the sediment load is, and over a broader range of flows. This difference could indicate the presence of a higher proportion of dissolved phosphorus in the system from field tiles as the site the LDCs were done are upstream of most of the major point sources. Four field tiles were sampled in the Little Darby Ck watershed. Two of these tiles had low total phosphorus concentrations (0.025-0.04 mg/l TP) and two had high concentrations (0.35 - 0.5 mg/l). While this is not a rigorous dataset, it does serve to indicate field tile discharge can be significant sources of total phosphorus to the system (and that they can also function without being significant sources).

A water quality model was developed for the Little Darby Creek from Mechanicsburg to Chuckery. The purpose of the model was to evaluate the Mechanicsburg WWTP and to evaluate the system for protection of the endangered mussel species located in the Little Darby Creek downstream of Chuckery. The Mechanicsburg WWTP bypass has been eliminated and a discharge from a mill upstream of the plant has also been eliminated. The effects of these discharges appear to have been assimilated by the system. The Mechanicsburg WWTP has had a historical compliance issue with its permits. Mechanicsburg is working with Ohio EPA to improve the plant performance. Compliance with its current effluent permit limitations with the addition of a new phosphorus limit should be sufficient to protect water quality as a result of the WWTP discharge. Downstream of the discharge the Little Darby becomes channelized and entrenched as discussed above, and the riparian corridor changes from wooded to grassed as it travels downstream. Masses of algae occur where there is unobstructed sunlight, with concentrated algal growths occurring downstream of many of the tile drainage outlets indicating that nutrients are being lost from the bordering agricultural fields. The recommended management options for this stretch of the Little Darby would be to reserve a riparian corridor around the stream, allow trees to re-vegetate this setback, and to allow the stream to regain some flood plain. The stream downstream from Wing Rd has a forested riparian corridor which is not entrenched despite the farming activities that occur on adjacent land.

The Little Darby Creek from just above Treacle Creek to Chuckery indicated that nutrient export from Treacle Creek is affecting the water quality of the Little Darby as the

dissolved oxygen is significantly decreased immediately downstream of Treacle Creek. Further, this study revealed that while groundwater is a factor in much of the rest of the upper Little Darby areas (based on the groundwater and hydrologic analysis), this stretch did not indicate groundwater inflow. Strongly elevated nutrients at two sites indicate that either nutrients are entrained in the sediments due to episodic runoff events or that there is an unidentified source that was not measured in the study. Since the flow did not increase downstream, the likelihood of an additional external source is small. Washoff from row crops and animal operations are the probable sources to the high spikes of nutrients detected given proximity of these sources to the elevated sites. The model predicts increasing suspended and attached algae populations and increasing temperature as the Little Darby flows downstream. The ammonia load exported from Treacle Creek appears to be assimilated by the time it reaches Chuckery. However, the study area did not extend downstream of Chuckery, and nutrient cycling could be occurring resulting in additional nutrient spikes downstream.

The potential for groundwater influence is discussed in Appendix A. The upper Little Darby sub-watershed has geologic indications that groundwater is a buffering factor for some areas of the sub-watershed. The headwaters of Little Darby Creek, Lake Run, and the lower portion of Little Darby Creek interact with high-yielding bedrock aquifers making the potential for a strong groundwater contribution likely. Other areas in the Little Darby sub-watershed do not have geologic properties that indicate groundwater is an unusual buffering influence to the system.

Table 4.3.1 Bedload and Habitat TMDLs for Little Darby Creek (05060001 210)

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1 pt*	*0 = 1 pt*	*<3 = 1 pt*				*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1 pt*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	River Mile	QHEI Categories			Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
		Substrate	Channel	Riparian										
Little Darby Creek headwaters to above Treacle Creek 05060001-210-010														
Little Darby Creek (CWH[1]/EWH) (Impaired)	41.2[1]	17.5	17	7.5	42	-	Good	80.5	0	0	1	1	1	3
	39.6[1]	14.5	12.5	3.5	30.5	13%	Riparian	69.5	1	6	0	0	0	0
	38.8[1]	16.5	16	7	39.5	-	Good	82	0	3	1	1	1	3
	34.7	17.5	17	6.5	41	-	Good	82.5	0	0	1	1	1	3
Clover Run (WWH)	0.6	14	17	6	37	-	Substrate	60	1	3	1	1	1	3
Jumping Run (WWH) (Impaired)	0.3	6.5	15.5	6	28	13%	Substrate	63	1	6	1	1	0	2
Lake Run (EWH) (Impaired)	0.9	16.5	14.5	7.5	38.5	-	Good	71	0	4	1	1	0	2

Table 4.3.1 Bedload and Habitat TMDLs for Little Darby Creek (05060001 210)

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1 pt*	*0 = 1 pt*	*<3 = 1 pt*				*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1 pt*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	River Mile	QHEI Categories			Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
		Substrate	Channel	Riparian										
Treacle Creek headwaters to above Proctor Run 05060001-210-020														
Treacle Creek (EWH) (Impaired)	11.8	16	13.5	6	35.5	-	Channel	67.5	1	5	0	0	0	0
	8.3	16	16.5	6	38.5	-	Good	67.5	0	2	0	1	1	2
	6.0	13.5	15	5	33.5	-	Substrate	66.5	0	3	0	1	0	1
Howard Run (EWH)	0.5	9.5	7	3.5	20	43%	Channel	56	3	6	0	0	0	0
Proctor Run 05060001-210-030														
Proctor Run (EWH) (Impaired)	4.9	16.5	16	5.5	38	-	Good	71.5	0	3	0	1	0	1
	3.1	15	12	3	30	14%	Riparian	65	0	5	0	1	0	1
	1.6	13.5	14	4	31.5	10%	Riparian	73	0	5	0	1	0	1
Treacle Creek from below Proctor Run to mouth 05060001-210-040														
Treacle Creek (EWH) (Impaired)	0.8	1	7	1.5	9.5	73%	Substrate	29.5	3	8	0	0	0	0

Table 4.3.1 Bedload and Habitat TMDLs for Little Darby Creek (05060001 210)

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1 pt*	*0 = 1 pt*	*<3 = 1 pt*				*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1 pt*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	River Mile	QHEI Categories			Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
		Substrate	Channel	Riparian										
Little Darby Creek from below Treacle Creek to above Spring Fork 05060001-210-050														
Little Darby Creek (EWH) (Impaired)	29.5	16	12.5	3	31.5	10%	Riparian	66.5	1	3	0	0	0	0
	26.6	11.5	15.5	4.5	31.5	10%	Substrate	58	0	2	0	1	1	2
	24.5	13.5	9.5	6	29	17%	Channel	62.5	1	6	0	0	0	0
	23.1	8	9	5.5	22.5	36%	Substrate	55.5	2	7	0	0	0	0
	20.5	13	11	5	29	17%	Channel	64.5	1	5	0	0	0	0
Wamp Ditch (WWH)(Impaired)	0.1	14.5	7.5	3	25	22%	Channel	45.5	4	9	0	0	0	0
Barron Creek (WWH)	2.1	14.5	8.5	2.5	25.5	23%	Riparian	44.5	2	7	0	0	0	0
Spring Fork 05060001-210-060														
Spring Fork (EWH) (Impaired)	15.8	14	10.5	5.5	30	14%	Channel	60.5	1	4	0	0	0	0
	13.7	13	11.5	4	28.5	19%	Channel	62.5	1	6	0	0	0	0

Table 4.3.1 Bedload and Habitat TMDLs for Little Darby Creek (05060001 210)

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1 pt*	*0 = 1 pt*	*<3 = 1 pt*				*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1 pt*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	River Mile	QHEI Categories			Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
		Substrate	Channel	Riparian										
	13.4	16	9	3	28	20%	Channel	53	2	4	0	0	0	0
	10.1	12	18	4	34	-	Substrate	69	0	2	0	1	1	2
	7.8	12	10.5	3.5	26	26%	Channel	54.5	2	7	0	0	0	0
	3.3	16	12	4.5	32.5	-	Channel	67.5	0	5	0	1	0	1
Bales Ditch (WWH)	0.4	14.5	16	7	37.5	-	Good	70	0	2	1	1	1	3
05060001-210-070														
Little Darby Creek (EWH)	15.3	19	19.5	9.5	48	-	Good	95.5	0	0	1	1	1	3
	6.5	20.5	19.5	7	47	-	Good	95.5	0	0	1	1	1	3
	4.1	21	20	9.5	50.5	-	Good	99	0	0	1	1	1	3
	0.7	17	11	9.5	37.5	-	Channel	63.5	2	5	0	0	0	0

[1]Denotes a Warm Water Habitat (WWH) Site.
[2]Denotes a Modified Warm Water Habitat (MWH) Site.

Table 4.3.2 Recommended Flood Plain Widths for Little Darby Creek 05060001-210

Stream Segment	Use Designation[a]	Drainage Area[b] (sq. mi)	Setback Width[c] (per side, ft)	
			Upper End	Lower End
Little Darby Creek headwaters to Treacle Creek -010				
Little Darby Creek -- headwaters to RM 31.30	EWH/CWH[d]	29.41	101.1	284.6
Clover Run	WWH	1.89	35.1	43.7
Lake Run	EWH	6.65	64.1	150.2
Jumping Run	WWH	2.74	39.7	51.3
Treacle Creek headwaters above Proctor Run -020				
Treacle Creek -- headwaters to RM 3.68	EWH	14.52	130.0	210.1
Howard Run	EWH	3.40	73.1	112.5
Proctor Run -030				
Proctor Run	EWH	11.02	99.0	186.6
Treacle Creek below Proctor Run to Little Darby Creek -040				
Treacle Creek -- RM 3.68 to mouth	EWH	38.19	230.0	318.5
Little Darby Creek below Treacle Creek to above Spring Fork -050				
Little Darby Creek -- RM 31.30 to RM 17.46	EWH	106.16	407.1	494.3
Barron Creek	WWH	6.89	39.9	76.3
Wamp Ditch	WWH	8.64	56.5	84.0
Spring Fork -060				
Spring Fork	EWH	39.20	101.5	322.0
Bales Fork	WWH	6.40	31.2	73.9
Little Darby Creek below Spring Fork to Big Darby Creek -070				
Little Darby Creek -- RM 17.46 to mouth	EWH	178.77	565.8	618.5

Notes:
(a) Assignments of use designation taken from *Biological and Water Quality Study of the Big Darby Creek Watershed, 2001/2002. Logan, Champaign, Union, Madison, Franklin and Pickaway Counties, Ohio.*
(b) Drainage area (sq.mi) applies to lower end of segment and is derived from digital topographic model and GIS (geographic information system).
(c) Width is **one** side (e.g. left bank or right bank and its corresponding floodplain) of stream segment measured from stream centerline.
(d) EWH/CWH and WWH/CWH assume setback width based on EWH and WWH criteria, respectively. LRW assigned setback of half bankfull width.

4.3.1 Upper Little Darby Creek headwaters to Treacle Creek[2] (210-010)

Table 4.3.1.1 Allocations for upper Little Darby Creek (Headwaters to Treacle Creek) (210-010)

Total Phosphorus (kg/y)[1]								
	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	2086	6	690	104	1143	88	55	0.93 lb/acre per year
Existing	10542	33	876	0	8896	683	55	
% Reduction	80%	80%	21%	--	87%	87%	0%	

Suspended Sediment (1000 kg/y)[1]							
	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	678	0.04	8.3	33.9	636	0.03	239 lb/acre per year
Existing	2704	0.21	8.3	0	2695	0.03	
% Reduction	75%	80%	0%	--	76%	0%	

Hydrology Targets			
% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
55%	45%	11.8 in/yr	

[1] 1 kg = 2.2 lbs.
[2] Results are rounded to the nearest whole number based on the percent reduction listed.

Table 4.3.1.2 Point Source Allocations and Other Limits for upper Little Darby Creek (Headwaters to Treacle Creek) (210-010)		
Individual Wasteload Allocations per Point Source		
Facility	Mechanicsburg WWTP	Notes
Permit #	1PB00037	
Solids, kg/yr	3813	Current Permit limit is adequate
TP, kg/yr	318	Limit of 1 mg/l needed
Other permit limits to protect DO and Ammonia Toxicity:		
DO, mg/l	6.0	Current Permit limit is adequate
NH3, mg/l	1.5, summer	Current Permit limit is adequate
$CBOD_5$, mg/l	10	Current Permit limit is adequate
Mechanicsburg WWTP compliance with these limits have been problematic; Mechanicsburg is currently working on a plan to improve the performance of their plant with financial and technical assistance provided by Ohio EPA.		

Table 4.3.1.3 Total Phosphorus Load Distribution for upper Little Darby Creek	
Source	% of Existing Load
Row Crops	81.68%
Point Source	8.31%
Groundwater	6.61%
Pasture / Hay	1.63%
Urban Grasses	0.50%
Septic Systems	0.31%
Commercial	0.30%
Residential (new)	0.17%
Low Intensity Residential	0.12%

4.3.2 Upper Treacle Creek (210-020)

Table 4.3.2.1 Allocations for upper Treacle Creek (Headwaters to Proctor Run)[2] (210-020)

Total Phosphorus (kg/y)[1]								
	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	846	2	0	42	711	60	30	1 lb/acre per year
Existing	6682	19	0	0	6117	517	30	
% Reduction	87%	87%	0%	--	88%	88%	0%	

Suspended Sediment (1000 kg/y)[1]							
	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	169	0.02	0	8.5	161	0.01	263 lb/acre per year
Existing	1666	0.12	0	0	1666	0.01	
% Reduction	90%	87%	0%	--	90%	0%	

Hydrology Targets			
% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
52%	48%	11.3 in/yr	

[1] 1 kg = 2.2 lbs.
[2] Results are rounded to the nearest whole number based on the percent reduction listed.

Table 4.3.2.2 Total Phosphorus Load Distribution for upper Treacle Creek

Source	% of Existing Load
Row Crops	90.09%
Groundwater	7.86%
Pasture / Hay	1.51%
Septic Systems	0.28%

4.3.3 Proctor Run (210-030)

Table 4.3.3.1 Allocations for Proctor Run [2] (210-030)

Total Phosphorus (kg/y)[1]

	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	722	2	20	36	603	46	16	1 lb/acre per year
Existing	3852	10	20	0	3536	271	16	
% Reduction	81%	81%	0%	--	83%	83%	0%	

Suspended Sediment (1000 kg/y)[1]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	235	0.01	0.02	12	223	0.01	279 lb/acre per year
Existing	1067	0.06	0.02	0	1067	0.01	
% Reduction	78%	81%	0%	--	79%	0%	

Fecal Coliform (number*10^{10}/recreational season)[3]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources	
		Septic	WWTP		Direct Animal Inputs	Washoff
Allowable	3670	1.2	0.09	Implicit	3390	278
Existing	14300	6.2	0.09	0	13200	1080
% Reduction	74%	81%	0%	--	74%	74%

Hydrology Targets

% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
51%	49%	11.3 in/yr	

[1] 1 kg = 2.2 lbs.
[2] Results are rounded to the nearest whole number based on the percent reduction listed.
[3] Recreational season is from May - October

Table 4.3.3.2 Point Source Allocations for Proctor Run		
Individual Wasteload Allocations per Point Source		
Facility	Triad Local Schools WWTP	Notes
Permit #	1PT00099	
Solids, kg/yr	19	Current permit limit is adequate
TP, kg/yr	20	Monitoring recommended
FC, #/period	8.75E+08	Current permit limit is adequate

Table 4.3.3.3 Total Phosphorus Load Distribution for Proctor Run	
Source	% of Existing Load
Row Crops	89.87%
Groundwater	7.16%
Pasture / Hay	1.15%
Commercial	0.56%
Point Source	0.51%
Septic Systems	0.26%
Residential (new)	0.20%

4.3.4 Lower Treacle Creek (210-040)

Table 4.3.4.1 Allocations for Lower Treacle Creek (Proctor Run to Little Darby Creek)[2] (210-040)

Total Phosphorus (kg/y)[1]

	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	503	2	0	25	432	35	8	1 lb/acre per year
Existing	2488	12	0	0	2281	186	8	
% Reduction	80%	80%	0%	--	81%	81%	0%	

Suspended Sediment (1000 kg/y)[1]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	164	0.02	0	8.2	155	0.001	112 lb/acre per year
Existing	386	0.07	0	0	386	0.001	
% Reduction	58%	80%	0%	--	60%	0%	

Fecal Coliform (number*10^{10}/recreational season)[3]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources	
		Septic	WWTP		Direct Animal Inputs	Washoff
Allowable	2570	1.5	0	Implicit	1990	586
Existing	5430	7.3	0	0	4190	1240
% Reduction	53%	80%	0%	--	53%	53%

Hydrology Targets

% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
43%	57%	10.2 in/yr	

[1] 1 kg = 2.2 lbs.
[2] Results are rounded to the nearest whole number based on the percent reduction listed.
[3] Recreational season is from May - October

Table 4.3.4.2 Total Phosphorus Load Distribution for lower Treacle Ck

Source	% of Existing Load
Row Crops	91.15%
Groundwater	7.62%
Pasture / Hay	0.53%

4.3.5 Little Darby Creek from below Treacle Creek to above Spring Fork [2]

Table 4.3.5.1 Allocations for middle Little Darby Creek (Treacle Creek to Spring Fork) (210-050)

Total Phosphorus (kg/y)[1]

	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	2574	10	15	129	2184	188	48	0.8 lb/acre per year
Existing	11180	43	15	0	10198	876	48	
% Reduction	77%	77%	0%	--	79%	79%	0%	

Suspended Sediment (1000 kg/y)[1]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	836	0.06	0.02	41.8	795	0.01	64 lb/acre per year
Existing	1481	0.27	0.02	0	1481	0.01	
% Reduction	44%	77%	0%	--	46%	0%	

Fecal Coliform (number*10^{10}/recreational season)[3]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources	
		Septic	WWTP		Direct Animal Inputs	Washoff
Allowable	1.13E+14	6.24E+10	7.07E+09	Implicit	8.47E+13	2.81E+13
Existing	1.92E+14	2.71E+11	7.07E+09	0	1.44E+14	4.78E+13
% Reduction	41%	77%	0%	--	41%	41%

Hydrology Targets

% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
46%	54%	10.6 in/yr	

[1] 1 kg = 2.2 lbs.
[2] Results are rounded to the nearest whole number based on the percent reduction listed.
[3] Recreational season is from May - October

Table 4.3.5.2 Point Source Allocations for middle Little Darby Creek		
Individual Wasteload Allocations per Point Source		
Facility	Rosedale Bible School	Notes
Permit #	4PT00102	
Solids, kg/yr	17	Current Permit limit is adequate
TP, kg/yr	15	Monitoring recommended
FC, #/period	7.07E+09	Current Permit limit is adequate

Table 4.3.5.3 Total Phosphorus Load Distribution for middle Little Darby Creek	
Source	% of Existing Load
Row Crops	90.41%
Groundwater	7.98%
Pasture / Hay	0.90%
Septic Systems	0.39%
Point Source	0.14%

4.3.6 Spring Fork (210 - 060)

Table 4.3.6.1 Allocations for Spring Fork[2] (210-060)

Total Phosphorus (kg/y)[1]

	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	2641	5	115	132	2155	175	59	0.93 lb/acre per year
Existing	12940	24	249	0	11661	947	59	
% Reduction	80%	80%	55%	--	81%	81%	0%	

Suspended Sediment (1000 kg/y)[1]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	858	0.03	0.44	43	815	0.02	168 lb/acre per year
Existing	2666	0.15	0.44	0	2665	0.02	
% Reduction	68%	80%	0%	--	69%	0%	

Fecal Coliform (number*10^{10}/recreational season)[3]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources	
		Septic	WWTP		Direct Animal Inputs	Washoff
Allowable	13100	3.10	3.56	Implicit	10400	2740
Existing	29100	15.2	3.56	0	23000	6080
% Reduction	55%	80%	0%	--	55%	55%

Hydrology Targets

% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
49%	51%	11 in/yr	

[1] 1 kg = 2.2 lbs.
[2] Results are rounded to the nearest whole number based on the percent reduction listed.
[3] Recreational season is from May - October

Table 4.3.6.2 Point Source Allocations for Spring Fork			
Individual Wasteload Allocations per Point Source			
Facility	Monroe Elem	Green Meadows MHP	Notes
Permit #	4PT00122	4PV00000	
Solids, kg/yr	160	282	Current permit limit is adequate
TP, kg/yr	3	112	A limit of 1 mg/l TP is recommended for Green Meadows
FC, #/period	7.68E+08	3.48E+10	Current permit limit is adequate

Table 4.3.6.3 Total Phosphorus Load Distribution for Spring Fork	
Source	% of Existing Load
Row Crops	88.76%
Groundwater	7.45%
Point Source	1.90%
Pasture / Hay	1.14%
Septic Systems	0.39%
Residential (new)	0.35%

4.3.7 Lower Little Darby Creek (210-070)

Table 4.3.7.1 Allocations for Lower Little Darby Creek (Spring Fork to Big Darby Creek)[2] (210-070)

Total Phosphorus (kg/y)[1]								
	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	2694	36	1523	135	848	92	61	0.9 lb/acre per year
Existing	12219	165	1523	0	9441	1030	61	
% Reduction	78%	78%	0%	--	91%	91%	0%	

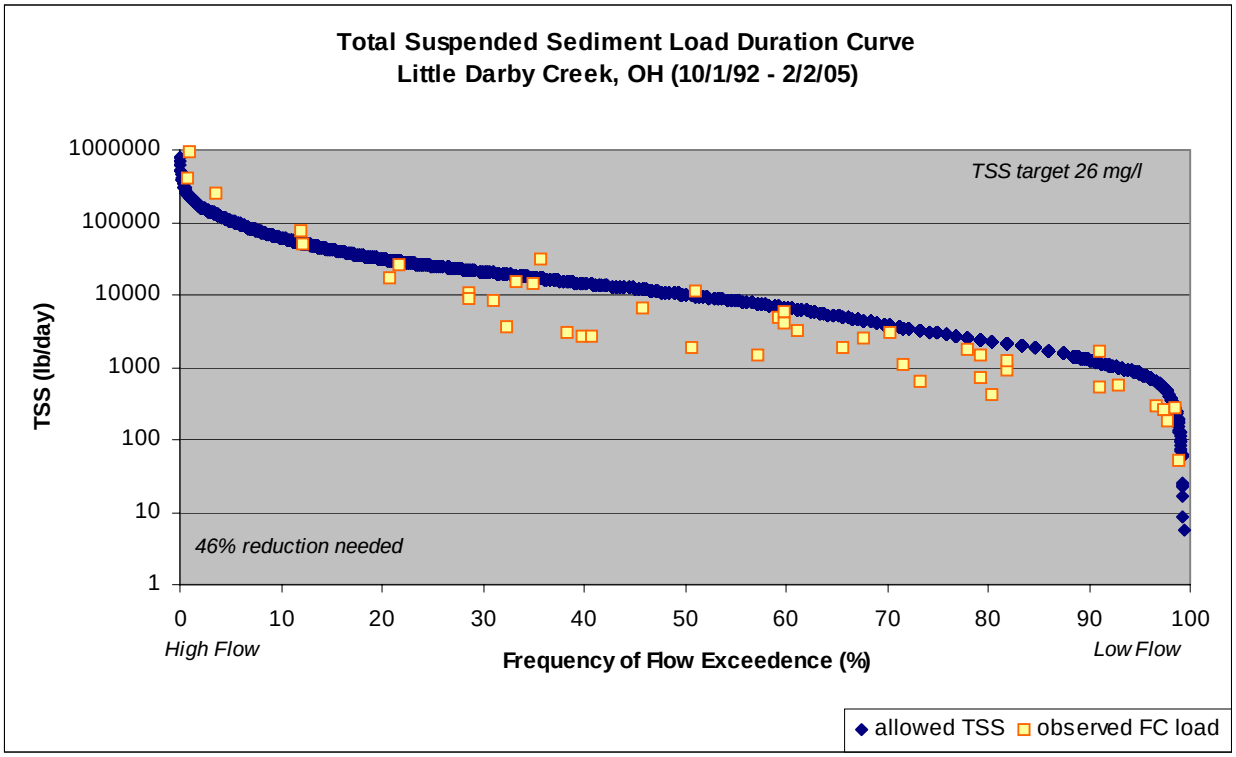
Suspended Sediment (1000 kg/y)[1]							
	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	876	0.23	5.04	43.8	827	0.02	124 lb/acre per year
Existing	2156	1.04	5.04	0	2150	0.02	
% Reduction	59%	78%	0%	--	62%	0%	

Hydrology Targets			
% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
54%	46%	11.9 in/yr	

[1] 1 kg = 2.2 lbs.
[2] Results are rounded to the nearest whole number based on the percent reduction listed.

Table 4.3.7.2 Point Source Allocations for lower Little Darby Creek						
Individual Wasteload Allocations per Point Source						
WWTP	Fisher Steel	West Jefferson WWTP	Jefferson Lodge MHP WWTP	Oakwood Acres MHP WWTP	B&B Motel WWTP	Notes
Permit #	4ID00001	4PB00024	4PV00004	4PV00097	4PV00107	
Solids, kg/yr	0	4960	50	17	13	Current permit limit is adequate
TP, kg/yr	3	1361	122	30	7	Quarterly monitoring recommended, West Jefferson WWTP permit limit of 1 mg/l

Table 4.3.7.3 Total Phosphorus Load Distribution in lower Little Darby Creek	
Source	% of Existing Load
Row Crops	72.54%
Point Source	12.46%
Groundwater	8.57%
Residential (new)	1.75%
Pasture / Hay	1.52%
Septic Systems	1.35%
Commercial	1.08%
High Intensity Residential	0.30%
Low Intensity Residential	0.17%



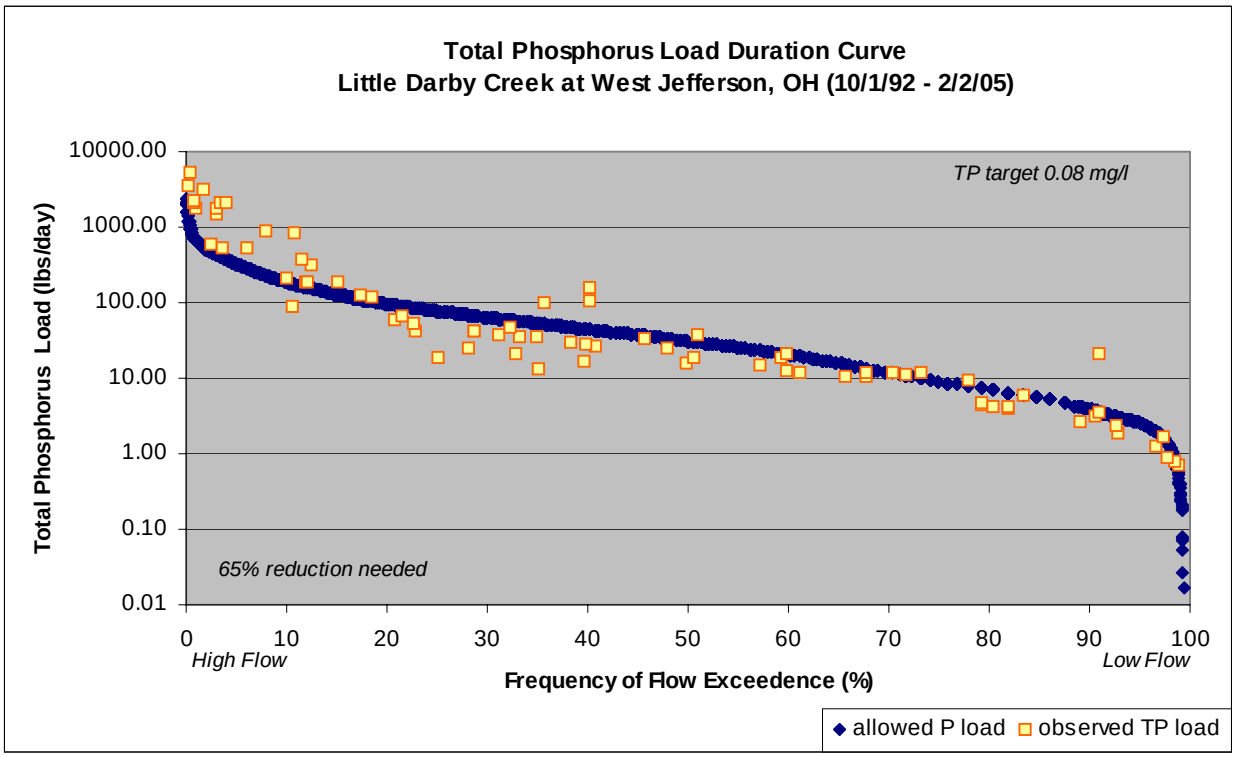


Figure 4.3.7 TSS and Total Phosphorus Load Duration Curves for the Lower Little Darby

4.4 Lower Big Darby Creek

The physical habitat and intact riparian corridor is generally good in the lower Big Darby sub-watershed with the exception of the upper reaches of the Hellbranch Run. Likewise, the lower Big Darby Creek sub-watershed is mainly in attainment with the exception of the Hellbranch watershed. However, there are indications that impacts from upstream loads, loads from within this sub-watershed, and the development of the Hellbranch sub-watershed are starting to be seen in the downstream reaches. Keeping the riparian corridor and existing flood plain intact is of vital importance to protect the lower Big Darby Creek into the future as these strong characteristics of the mainstem help to buffer such stresses. The Big Darby Creek downstream of Darbyville to the mouth (sub-watershed 220-040) is in full attainment of its designated uses and does not contribute to a downstream impairment within the Big Darby Creek watershed; therefore, load calculations for this section were not included in this report. However, habitat and floodplain set back recommendations are included to buffer and protect this section of river into the future.

The load duration curves and GWLF results indicate that the Hellbranch sub-watershed is mainly impacted by stream bank erosion and construction activities. The sediment load duration curve in Figure 4.4.1.2 shows the TSS target is conservatively achieved under all flow conditions except high flows where tremendous suspended sediment loads are observed. GWLF does not predict runoff is the source of this sediment indicating bank erosion and construction activities are the sources. The lack of sufficient existing flood plain in Hamilton Ditch can be extrapolated to similiar conditions in Clover Groff Ditch which gives further evidence that bank erosion and construction activities are the major sediment sources in this watershed. Likewise, incorporation of sufficient flood plain and stormwater control are the needed fixes to this problem. The embedded substrates found in the Darby downstream of the Hellbranch are an early indication of the effects of the Hellbranch sediment load on the Darby.

The hydrologic model for the Hellbranch sub-watershed was run for land use based on a 2000/2001 data set and an updated 2003 dataset; each run using the same weather data and the only differences being land use changes. The development changes in the 3 years resulted in a 3% reduction in annual groundwater recharge and a 13% increase in runoff. Hydrologic targets based on the earlier land use are suggested to be maintained in order to protect the integrity of the Hellbranch and the Big Darby Creek.

The total phosphorus load duration curves for the Hellbranch at Lambert Rd. and the Big Darby Creek at Darbysville indicate excessive total phosphorus loading at most flows is occurring as well. The physical habitat of the lower Big Darby Creek is currently shielding the system from most of the effects of this load. Aeration systems for home septic treatment are pervasive in the Hellbranch watershed. Many unsewered areas or small package treatment plants have historically served the lower Big Darby Creek sub-watershed. However, a new regional WWTP is being constructed in Darbydale and the Pickaway County Correctional WWTP is expanding to accept these poorly serviced areas. The phosphorus and bacteria loads should improve as a result of these actions.

Table 4.4.1 Bedload and Habitat TMDLs for lower Big Darby Creek (05060001 220)

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1 pt*	*0 = 1 pt*	*<3 = 1 pt*				*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1 pt*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	River Mile	QHEI Categories: Substrate	Channel	Riparian	Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Hellbranch Run 05060001-220-010														
Hellbranch Run (WWH[1]/EWH) (Impaired)	10.3[1]	5	8	5.5	18.5	42%	Substrate	39.5	3	8	0	0	0	0
	7.4[1]	13	8	6	27	16%	Channel	51	2	6	0	0	0	0
	5.8[1]	13	13	8	34	-	Substrate	65.5	2	3	0	0	1	1
	3.7	18	16	7.5	41.5	-	Good	83.5	0	0	1	1	1	3
	1.0	18	16.5	8	42.5	-	Good	84.5	1	0	1	1	1	3
	0.5	18	17	8.5	43.5	-	Good	83.5	0	0	1	1	1	3
Hamilton Ditch (MWH/WWH[1]) (Impaired)	3.4	1	4	3	8	n/a	-	21	5	9	-	-	-	n/a
	0.5[1]	4	7	3	14	58%	Substrate	36.5	5	10	0	0	0	0
Clover Groff Ditch (MWH/WWH[1]) (Impaired)	4.7	1	4	4	9	-	-	22	5	9	-	-	-	n/a
	0.8[1]	15.5	12	5	32.5	-	Channel	61.5	1	5	1	1	0	2

Table 4.4.1 Bedload and Habitat TMDLs for lower Big Darby Creek (05060001 220)

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1 pt*	*0 = 1 pt*	*<3 = 1 pt*				*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1 pt*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	River Mile	QHEI Categories: Substrate	Channel	Riparian	Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Big Darby Creek from below Little Darby Creek to above Hellbranch Run 05060001-220-020														
Big Darby Creek (EWH)	29.1	18	18	5.5	41.5	-	Good	86	0	0	1	1	1	3
Smith Ditch (EWH) (Impaired)	2.1	18	20	6.5	44.5	-	Good	77.5	0	3	1	1	0	2
	0.3	19	16.5	9.5	45	-	Good	73	0	1	0	1	1	2
UT to Smith Ditch (EWH)	0.2	18	16.5	7	41.5	-	Good	67	1	3	0	0	0	0
Big Darby Creek from below Hellbranch Run to Darbyville 05060001-220-030														
Big Darby Creek (EWH)	26.1	18	19	9.5	46.5	-	Good	94.5	0	0	1	1	1	3
	23.8	18	16.5	7	41.5	-	Good	87.5	0	1	1	1	1	3
	22.8	18	16.5	5	39.5	-	Riparian	84.5	0	1	1	1	1	3
	18.7	18	16.5	5.5	40	-	Good	85	0	1	1	1	1	3
	15.7	18	18.5	6	42.5	-	Good	88.5	0	0	1	1	1	3
	13.4	18	17	5	40	-	Riparian	85.5	0	1	1	1	1	3

Table 4.4.1 Bedload and Habitat TMDLs for lower Big Darby Creek (05060001 220)

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1 pt*	*0 = 1 pt*	*<3 = 1 pt*				*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1 pt*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	River Mile	QHEI Categories: Substrate	Channel	Riparian	Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Springwater Run (WWH) (Impaired)	0.8	13.5	11.5	4	29	12%	Riparian	48.5	3	8	0	0	0	0
UT to Big Darby Ck (RM 23.77)(WWH) (Impaired)	0.1	18.5	15.5	9.5	43.5	-	Good	61.5	2	5	1	0	0	1
UT to Big Darby Ck (RM 20.20) (WWH)	0.8	15	16.5	9.5	41	-	Good	77.5	0	2	1	1	1	3
UT to Big Darby Ck (RM 18.41)(WWH) (Impaired)	0.1	11	10	9.5	30.5	-	Channel	52.5	3	8	0	0	0	0
Greenbrier Creek (WWH)	2.7	13	15	6	34	-	Substrate	57	0	5	0	1	0	1
	1.3	16	15.5	7	38.5	-	Good	74.5	0	4	1	1	1	3
Georges Run (WWH)	0.9	12.5	16	3	31.5	-	Riparian	61	0	3	1	1	1	3

Table 4.4.1 Bedload and Habitat TMDLs for lower Big Darby Creek (05060001 220)

		Bedload TMDL						Habitat TMDL						
	Use	Allocations			TMDL			Allocations			Subscore			TMDL
TMDL Targets →	*EWH*	*≥15*	*≥15*	*≥5*	*35*			*≥75 = 1 pt*	*0 = 1 pt*	*<3 = 1 pt*				*3 pts*
	WWH	*≥13*	*≥14*	*≥5*	*32*			*≥60 = 1 pt*	*<2 = 1 pt*	*<5 = 1 pt*				*3 pts*
Existing Scores Stream/River (Use) *Impaired indicates use is not met*	River Mile	QHEI Categories: Substrate	Channel	Riparian	Total Bedload Score	% Deviation from Target	Main Impaired Category if any	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Big Darby Creek from Darbyville to Scioto River 05060001-220-040														
Big Darby Creek (EWH)	10.4	16.5	16	6	38.5	-	Good	85	0	2	1	1	1	3
	8.4	15	14	5.5	34.5	1%	Channel	69.5	0	3	0	1	0	1
	3.1	16.5	16.5	5	38	-	Riparian	82	0	2	1	1	1	3
	0.3	14	16	4	34	3%	Riparian	71.5	0	2	0	1	1	2

[1]Denotes a Warm Water Habitat (WWH) Site.
[2]Denotes a Modified Warm Water Habitat (MWH) Site.

Table 4.4.2 Comparison of Needed and Predicted Active Floodplain for Selected Segments in the Big Darby Creek

Stream Segment	Aquatic Life Use	Active Floodplain Total Area[2] (Acres)			RM	Use Attainment	IBI[3]	ICI[3]	QHEI
		Area Needed[1]	Actual (2x)	Actual (1.5x)					
			% of Needed Area Met	% of Needed Area Met					
Hellbranch Run 05060001-220-010									
Hamilton Ditch -- RM 5.4 to RM 2.1	MWH	37.2	32.41 87%	25.8 69%	3.4	Non	16*	NA	21.0
Hamilton Ditch -- RM 2.1 to confluence	WWH	26.6	25.94 98%	24.7 93%	0.5	Non	24*	NA	36.5
Hellbranch Run -- RM 11.7 to RM 10.8	WWH	9.7	7.50 77%	6.2 64%	10.3	Partial	36[ns]	46	39.5

Notes:

1) Assignments of use designation taken from *Biological and Water Quality Study of the Big Darby Creek Watershed, 2001/2002. Logan, Champaign, Union, Madison, Franklin and Pickaway Counties, Ohio*. EWH/CWH designation assigned EWH width recommendation.

2) Actual flood plain predicted by geographical/analytical model using limited field measurements of active flood plain height; this prediction is considered the actual active flood plain and represents a zone inundated by two (2x) or one-and-a-half times (1.5x) maximum bankfull depth. Area shown is amount overlapping recommended zone only.

3) Use Attainment, IBI, ICI, and QHEI per identified stream segment. Specific notation per IBI, ICI, and QHEI are defined as:
   - * Significant departure from ecoregion biocriteria; poor and very poor results are underlined.
   - ns Non-significant departure from ecoregion biocriteria (4 IBI or ICI units; 0.5 Iwb units).
   - a Narrative evaluation is used in lieu of ICI for qualitative samples (E=Excellent, VG=Very Good, G=Good, MG=Marginally good, F=Fair, P=Poor, VP=Very Poor).
   - c Use attainment status based on one organism group is parenthetically expressed.

Table 4.4.3 Recommended Flood Plain Widths for Lower Big Darby Creek (Little Darby Creek to Mouth) 0506001-220

Stream Segment	Use Designation[a]	Drainage Area[b] (sq.mi)	Setback Width[c] (per side, ft)	
			Upper End	Lower End
Hellbranch Run -010				
Hellbranch Run -- headwaters to RM 5.0	WWH	29.88	85.6	143.3
Hellbranch Run -- RM 5.0 to mouth	EWH	34.13	286.6	303.5
Hamilton Ditch -- headwaters to RM 2.1	MWH	4.65	33.5	38.6
Hamilton Ditch -- RM 2.1 to mouth	WWH	5.91	64.4	71.4
Clover Groff Ditch -- headwaters to RM 2.5	MWH	5.94	29.1	42.9
Clover Groff Ditch -- RM 2.5 to mouth	WWH	8.11	71.5	81.8
Big Darby Creek below Little Darby Creek to above Hellbranch Run -020				
Big Darby Creek -- RM 34.1 to RM 26.23	EWH	454.56	901.7	923.8
Smith Ditch	EWH	7.54	137.0	158.5
UNT to Smith Ditch at RM 0.06	EWH	0.87	44.1	62.7
Gay Run	WWH	3.20	25.4	54.8
Big Darby Creek below Hellbranch Run to Darbyville -030				
Big Darby Creek -- RM 26.23 to RM 13.35	EWH	526.78	953.0	984.3
Springwater Run	WWH	3.53	26.1	57.2
UNT to Big Darby Creek at RM 23.77	WWH	0.43	16.2	23.2
UNT to Big Darby Creek at RM 20.2	WWH	5.15	34.0	67.3
UNT to Big Darby Creek at RM 18.41	WWH	2.49	33.9	49.2
Greenbriar Creek	WWH	8.80	40.6	84.7
Georges Run	WWH	1.24	32.4	36.4
Big Darby Creek from Darbyville to Scioto River -040				
Big Darby Creek -- RM 13.35 to mouth	EWH	548.81	984.7	1001.8
Lizard Run	LRW[d]	1.15	4.1	7.1

Notes:
(a) Assignments of use designation taken from *Biological and Water Quality Study of the Big Darby Creek Watershed, 2001/2002. Logan, Champaign, Union, Madison, Franklin and Pickaway Counties, Ohio.*
(b) Drainage area (sq.mi) applies to lower end of segment and is derived from digital topographic model

and GIS (geographic information system).
(c) Width is **one** side (e.g. left bank or right bank and its corresponding flood plain) of stream segment measured from stream centerline.
(d) LRW assigned setback of half bankfull width.
(e) UNT: un-named tributary

4.4.1 Hellbranch Run (220-010)

Table 4.4.1.1 Allocations for Hellbranch Run[2] (220-010)

Total Phosphorus (kg/y)[1]

	Total Load	Major Source Allocations							
		Point Sources			Margin of Safety	Nonpoint Sources			
		Septic	WWTP	MS4[4]		Runoff	Ground-water	Natural	Reduction Needed
Allowable	3175	163	193	179	159	2175	161	145	1.1 lb/acre per year
Existing	16359	844	394	1064	0	12955	957	145	
% Reduction	81%	81%	51%	83%	--	83%	83%	0%	

Suspended Sediment (1000 kg/y)[1]

	Total Load	Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Overland Runoff	Bank Erosion/ Construction	Natural	Reduction Needed
Allowable	1086	1.03	1.71	51.6	153	879	0.05	264 lb/acre per year
Existing	20645	5.34	1.71	0	3051	17587	0.05	
% Reduction	95%	81%	0%	--	95%	95%	0%	

Fecal Coliform (number*10^{10}/recreational season)[3]

	Total Load	Point Sources			Margin of Safety	Nonpoint Sources	
		Septic	WWTP	MS4[4]		Direct Animal Inputs	Washoff
Allowable	11200	100	16.2	22.6	Implicit	10200	851
Existing	16600	527	17.6	32.8	0	14800	1230
% Reduction	33%	81%	8%	31%	--	31%	31%

Hydrology Targets

% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 39 inches
Baseflow	Runoff		
41%	59%	8.6 in/yr	

[1] 1 kg = 2.2 lbs.
[2] Results are rounded to the nearest whole number based on the percent reduction listed.
[3] Recreational season is from May - October
[4] MS4 = municipal separate storm sewer system; this denotes the portion of stormwater that is discharged from MS4s.

Table 4.4.1.2 Total Phosphorus Load Distribution in Hellbranch Run	
Source	% of Existing Load
Row Crops	76.09%
Groundwater	5.94%
Septic Systems	5.16%
Residential	4.9%
Pasture / Hay	3.13%
Point Source	2.41%
Commercial	1.07%
Urban Grasses	0.53%

Table 4.4.1.3 Municipal Separate Storm Sewer System (MS4) Allocations in Hellbranch Run			
Breakdown of MS4 Jurisdictions and % of Area		Allocated Load to MS4 Area	
MS4 Area (mi^2)	5.83	TP (kg/yr)	FC (#/period)
Columbus	55%	98.5	1.24E+11
Hilliard	10%	17.9	2.26E+10
Norwich township	7%	12.5	1.58E+10
Brown township	1%	1.8	2.26E+09
Prairie township	27%	48.3	6.10E+10
TOTAL	100%	179	2.26E+11

Table 4.4.1.4 WWTP Allocations for Hellbranch Run (220-010)							
Individual Wasteload Allocations							
WWTP	Alton Camp	Cypress Wesleyan	Thorn-apple	Oakhurst Knolls	Pleasant-view	Timber-lake	NOTES
Permit #	4PX00041	4PT00115	4PX00029	4PH00000	4PT00106	4PU00003	
FC, #/period	1.14E+10	1.99E+08	2.94E+08	2.76E+10	2.56E+10	9.72E+10	Alton Needs to Comply with Permit
Solids, kg/yr	20	26	6	601	564	490	No changes needed
TP, kg/yr	2.3	2.9	1	67.7	63.5	55.3	All WWTPs go to 1 mg/l concentration

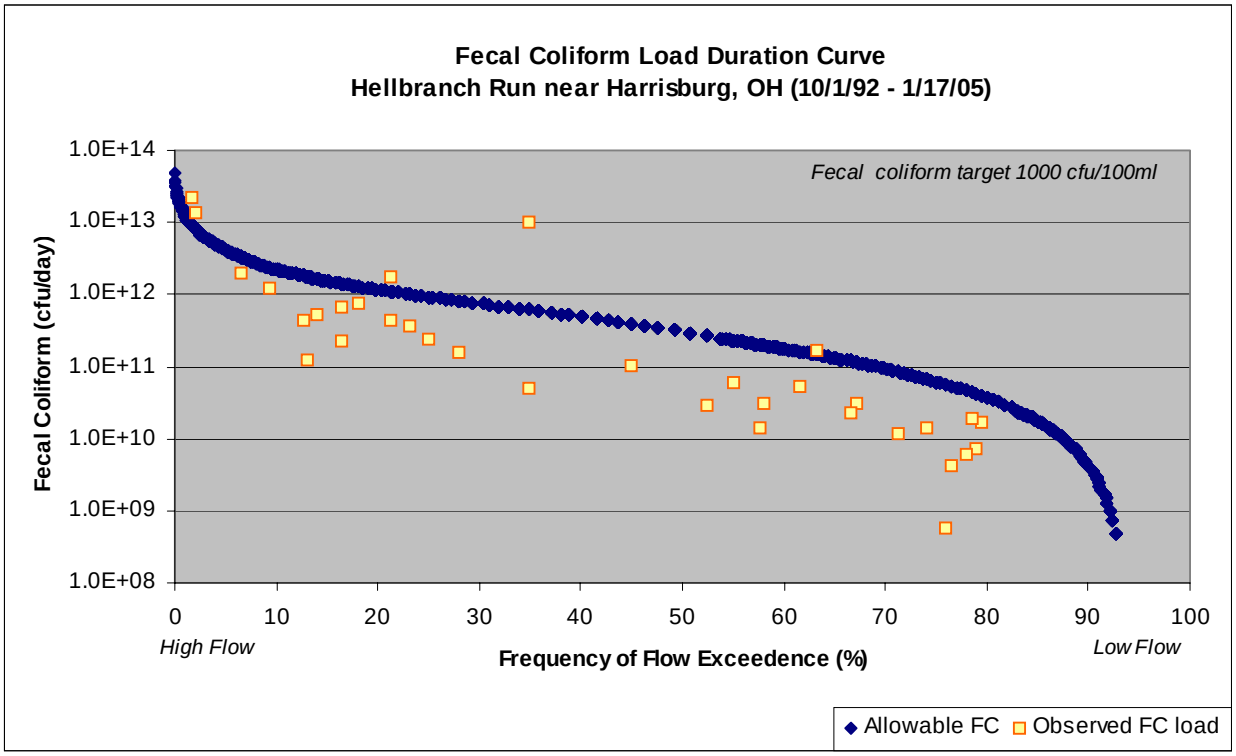
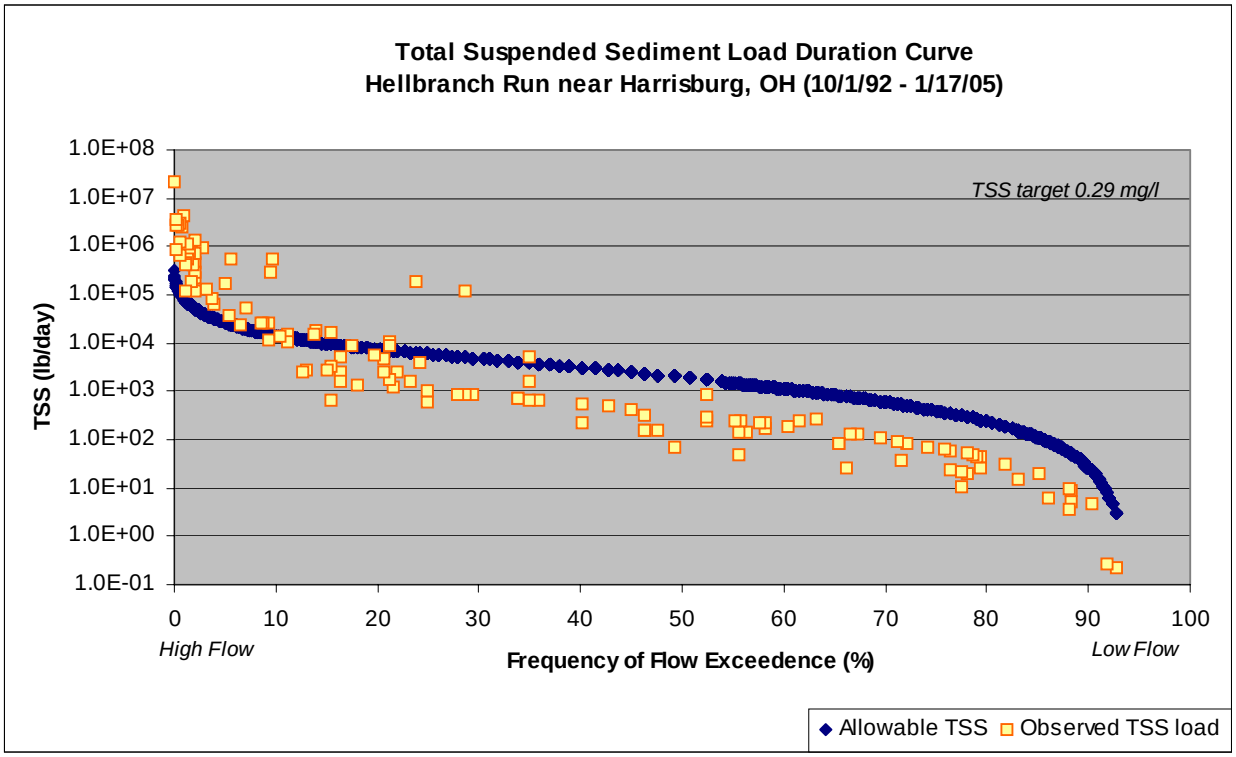


Figure 4.4.1.1 Fecal Coliform Load Duration Curve for Hellbranch Run at Lambert Rd.



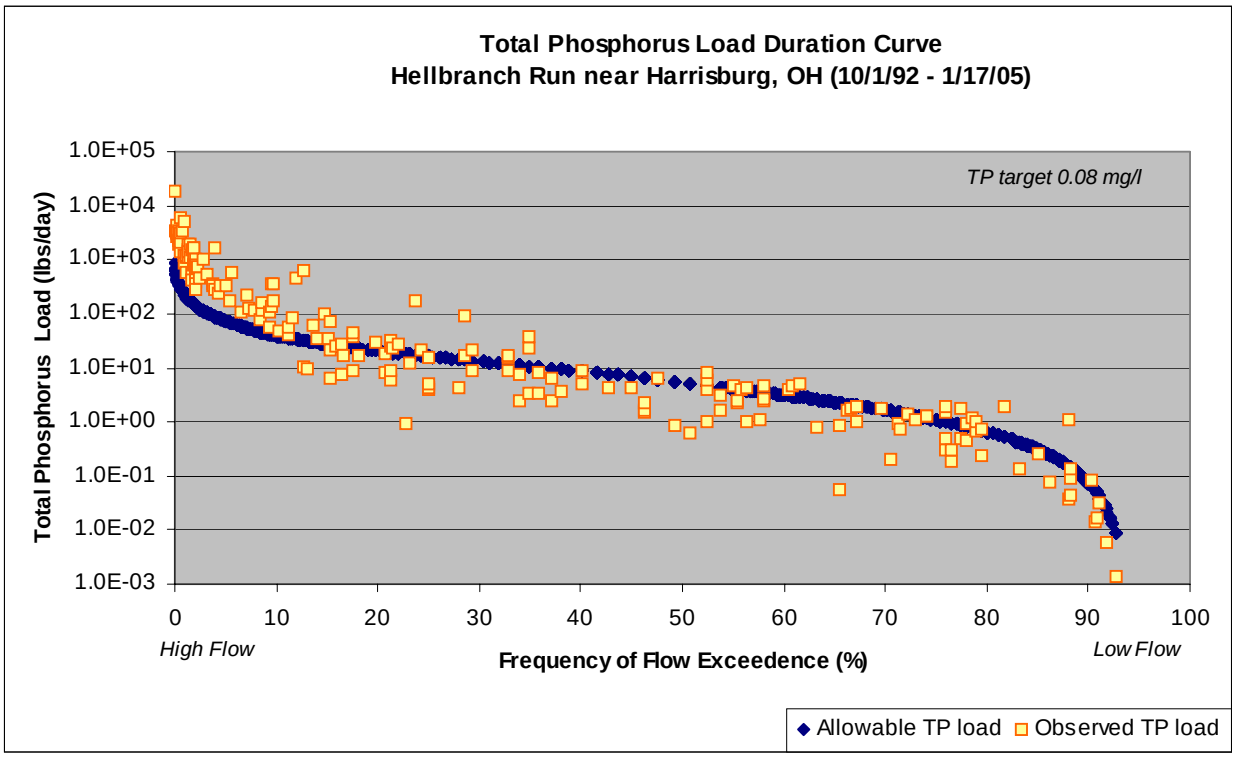


Figure 4.4.1.2 TSS and Total Phosphorus Load Duration Curves for Hellbranch Run

Figure 4.4.1.3 Longitudinal distribution of recommended versus predicted flood plain width, IBI, and aquatic life use attainment status for Hellbranch Run (RM 12.0 to RM 5.5).

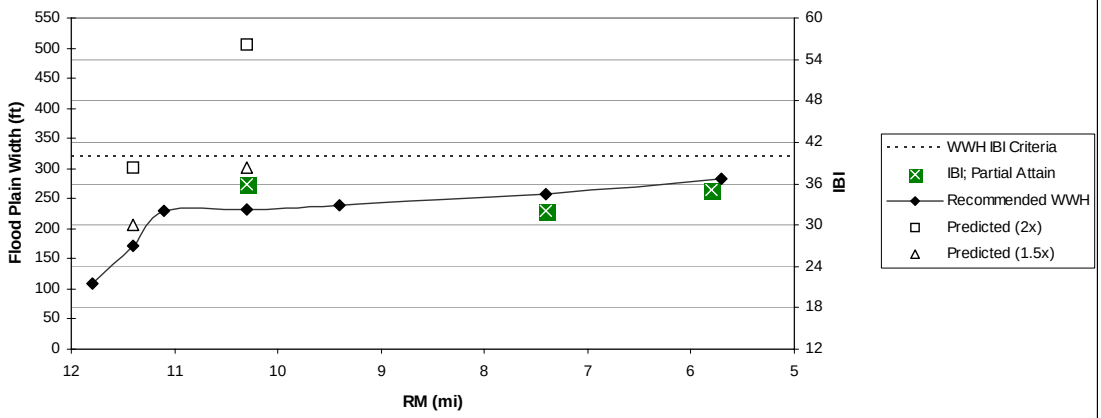
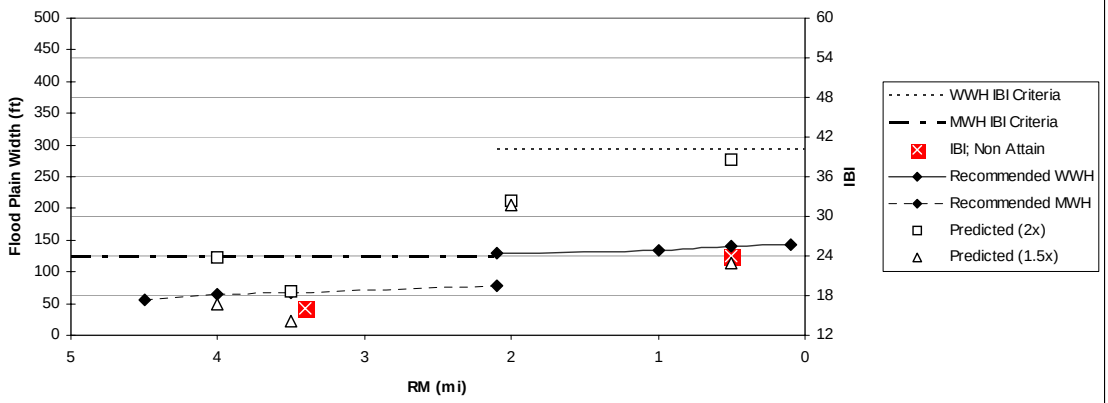


Figure 4.4.1.4 Longitudinal distribution of recommended versus predicted flood plain width, IBI, and aquatic life use attainment status for Hamilton Ditch (RM 5.0 to confluence).



4.4.2 Big Darby Creek from below Little Darby Creek to above Hellbranch Run (220-020)

Table 4.4.2.1 Allocations for upper lower Big Darby Creek (Little Darby Creek to Hellbranch Run)[2] (220-020)

Total Phosphorus (kg/y)[1]								
	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	3871	55	415	194	2839	307	62	0.3 lb/acre per year
Existing	5905	274	442	0	4627	500	62	
% Reduction	34%	80%	6%	--	39%	39%	0%	

Hydrology Targets			
% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
58%	42%	12.4 in/yr	

[1] 1 kg = 2.2 lbs.
[2] Results are rounded to the nearest whole number based on the percent reduction listed.

Table 4.4.2.4 Point Source Allocations for upper lower Big Darby Creek

Individual Wasteload Allocations per Point Source		
Facility	Darbydale WWTP	Notes
Permit #	4PH00012	
Solids, kg/yr	4974.02	Current Permit limit is adequate
TP, kg/yr	414.50	Limit of 1 mg/l needed

Table 4.4.2.3 Total Phosphorus Load Distribution for upper lower Big Darby Creek

Source	% of Existing Load
Row Crops	71.96%
Groundwater	8.65%
Point Source	7.49%
Septic Systems	4.65%
Pasture / Hay	2.66%
Urban Grasses	1.32%
Residential	1.74%
Commercial	0.74%

4.4.3 Middle Lower Big Darby Creek from below Hellbranch Run to Darbyville (220-030)

Table 4.4.3.1 Total Phosphorus Allocations for middle lower Big Darby Creek (Hellbranch Run to Darbyville) [2] (220-030)

Total Phosphorus (kg/y)[1]								
	Total Load	Major Source Allocations						
		Point Sources		Margin of Safety	Nonpoint Sources			
		Septic	WWTP		Runoff	Ground-water	Natural	Reduction Needed
Allowable	6337	33	2079	317	3462	347	100	0.6 lb/acre per year
Existing	12655	166	2547	0	8948	896	100	
% Reduction	50%	80%	18%	--	61%	61%	0%	

Suspended Sediment (1000 kg/y)[1]							
	Total Load	Point Sources		Margin of Safety	Nonpoint Sources		
		Septic	WWTP		Overland Runoff	Natural	Reduction Needed
Allowable	1528	0.21	16.2	76.4	1435	0.04	18 lb/acre per year
Existing	1697	1.05	19.9	0	1676	0.04	
% Reduction	10%	80%	16%	--	14%	0%	

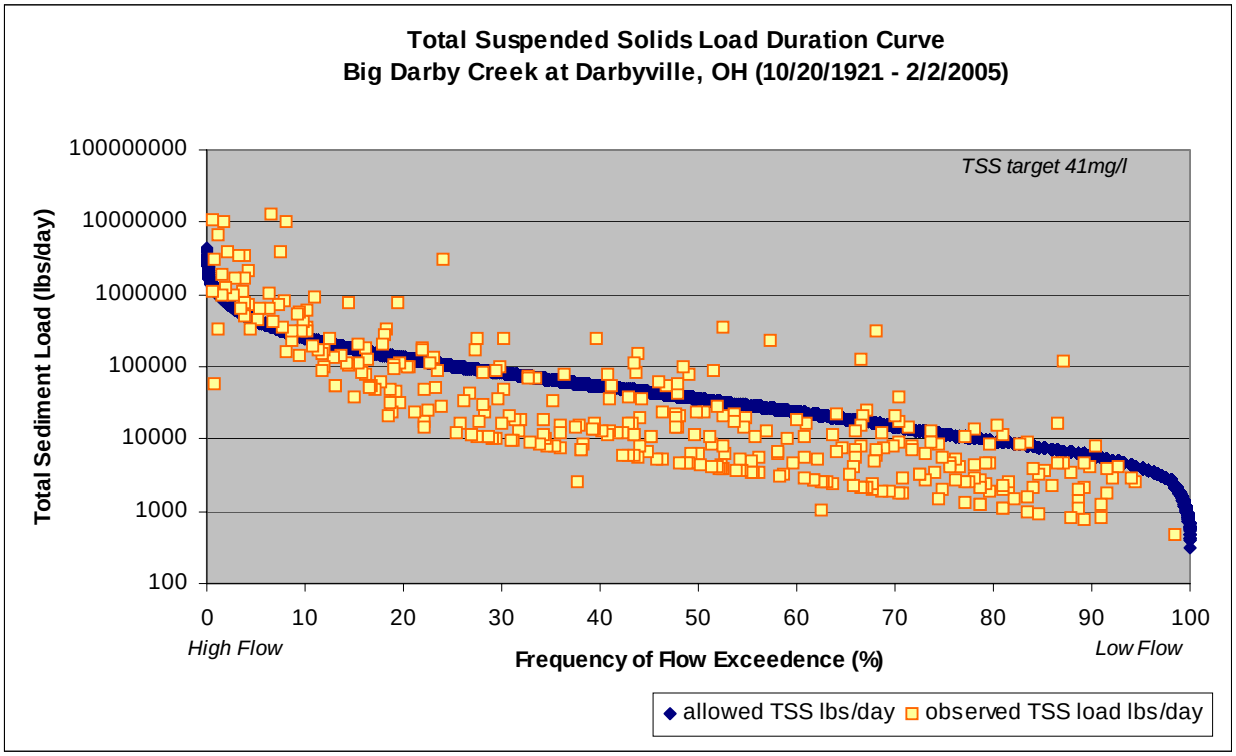
Hydrology Targets			
% of Stream Flow		Average Annual Groundwater Recharge	Targets are based on average annual precipitation of 36.2 inches
Baseflow	Runoff		
52%	48%	11.6 in/yr	

[1] 1 kg = 2.2 lbs.
[2] Results are rounded to the nearest whole number based on the percent reduction listed.

Table 4.4.3.2 Point Source Allocations for Big Darby Creek (220-030)

Individual Wasteload Allocations per Point Source			
Facility	Dot-Mar MHP	PCI WWTP	Notes
Permit #	4PV00100	4PP00003	
Solids, kg/yr	138	16580	Current Permit limit is adequate
TP, kg/yr	6	2073	Limit of 1 mg/l needed for PCI WWTP

Table 4.4.3.3 Total Phosphorus Load Distribution for middle lower Big Darby Ck	
Source	% of Existing Load
Row Crops	66.54%
Point Source	20.08%
Groundwater	7.21%
Pasture / Hay	2.32%
Septic Systems	1.31%
Commercial	0.99%
Urban Grasses	0.57%
Residential	0.50%



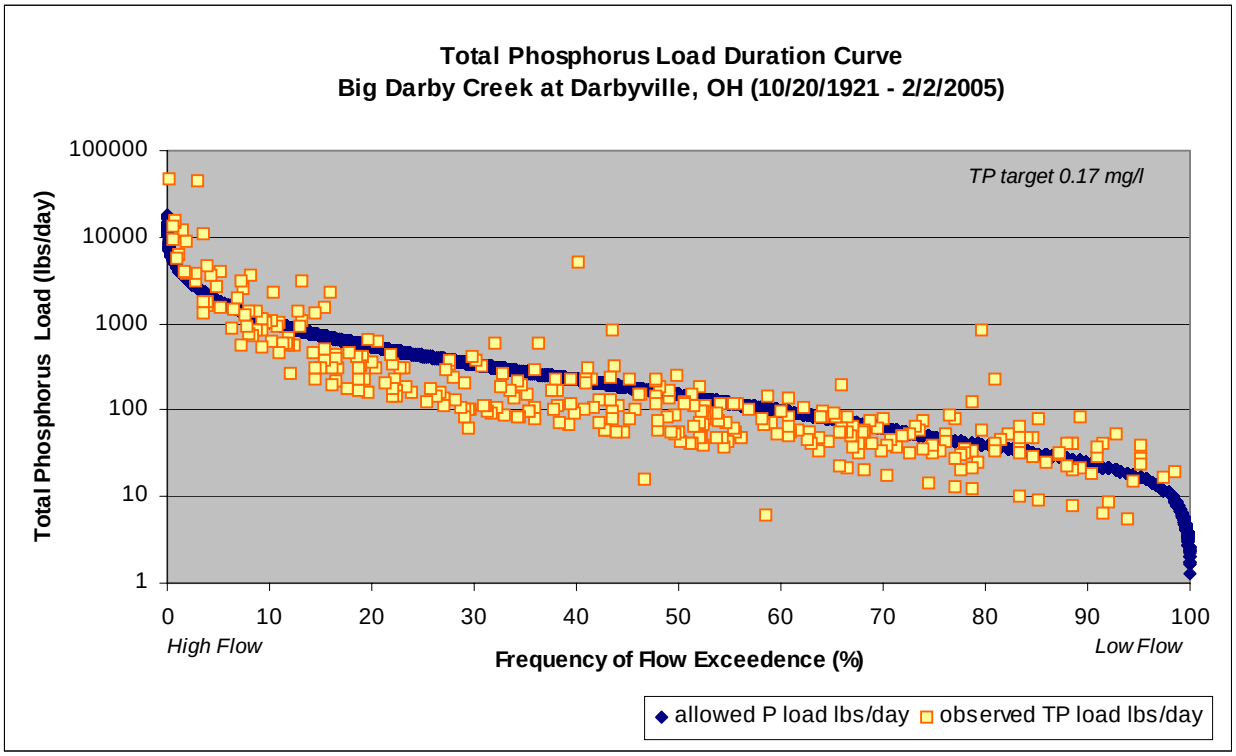


Figure 4.4.3 TSS and Total Phosphorus Load Duration Curves for the Lower Big Darby

4.5 Floodplains of the Big Darby Creek Watershed

This section includes three figures representing different ways of expressing areas that may be subject to inundation in the Big Darby Creek watershed. Figure 4.5.1 depicts the active floodplain as described previously in this report. This floodplain is based on the equations in Chapter 3, and it is a guideline representing the critical floodplain area which the stream needs access to in order to maintain a good, stable stream equilibrium. Activities in this active floodplain area need to be compatible with frequent flooding, and the stream should be able to easily flood into these areas. Figure 4.5.2 represents the 100 year floodplain. No development or inclusion of manmade structures and paved surfaces should be considered within the either of these 2 floodplain areas, or a 100 foot minimum, whichever is greater. Chapter 5 discusses activities that are compatible with inundation in a flood plain in more detail. Figure 4.5.3 shows the frequently flooded soils as determined by county soil scientists. This figure serves as a complement to the 2 floodplain representation, and it can serve to adjust the active floodplain to site specific considerations. The frequently flooded zones based on soils are similar to the active floodplain, and activities in these zones should also be compatible with frequent flooding.

The resolution of these watershed maps is not sufficient to view the small scale of the floodplains. The zoom function can serve to highlight specific areas of interest, and the overall maps give a graphical view of how the floodplains increase with increasing drainage area and stream size.

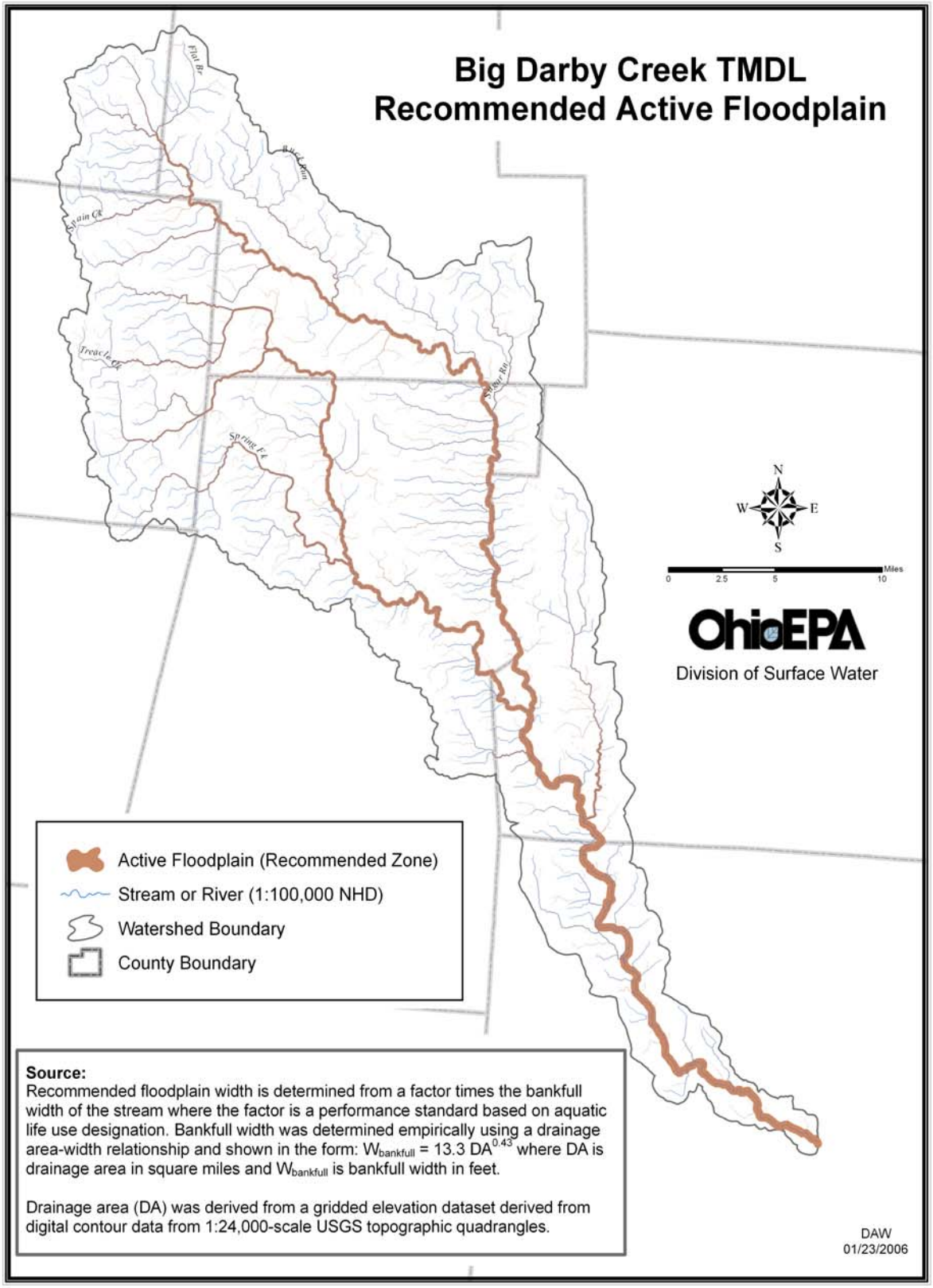


Figure 4.5.1 Big Darby Creek active floodplain

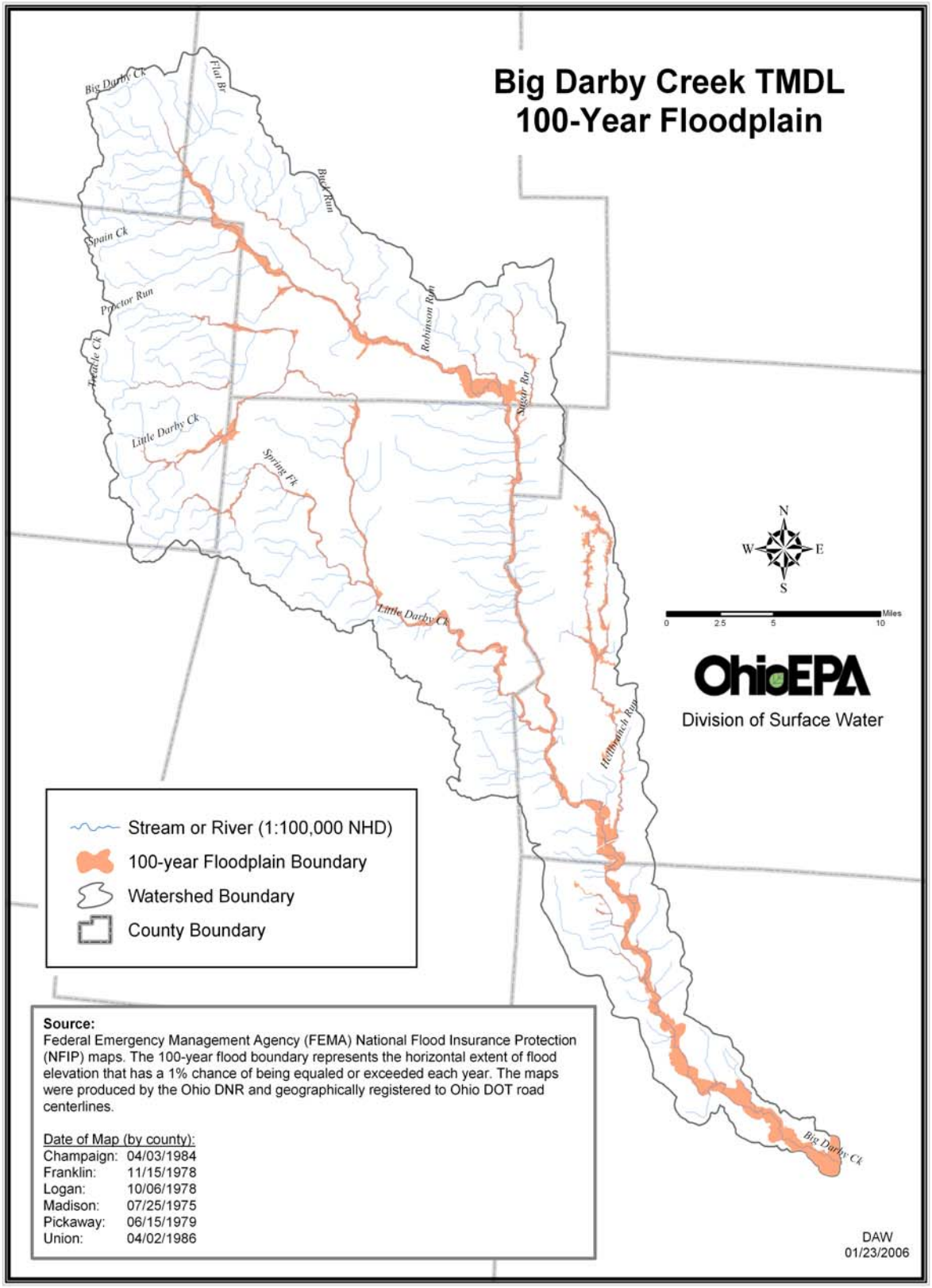


Figure 4.5.2 100-year floodplain of the Big Darby Creek

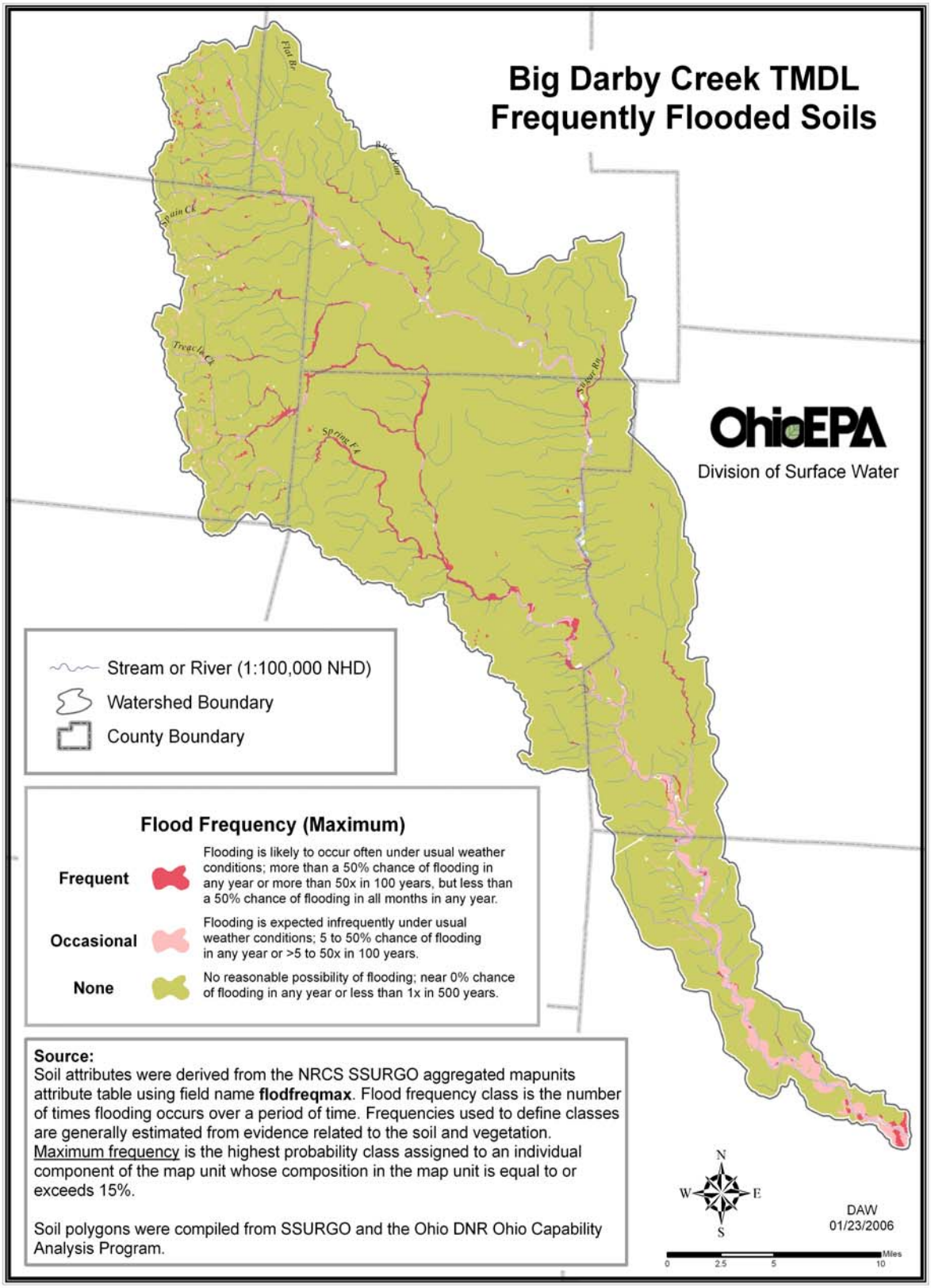


Figure 4.5.3 Frequently flooded soils in the Big Darby Creek watershed