Ephemeroptera; (4) percent contribution of dominant taxon; (5) number of Ephemeroptera/Plecoptera/Trichoptera (EPT) taxa; (6) percent Chironomidae; and (7) Shannon-Wiener Diversity Index. Reference sites were determined for each reference category, primarily based on the results of the macroinvertebrate metrics and secondarily based on habitat and water quality scores, to represent the best combination of conditions. The metric scores were compared to the reference scores, and a biological condition category was assigned based on RBP III methods (Plafkin and others, 1989; Barbour and others, 1999). The same reference sites were used in the analysis for the habitat scores. The ratings for each habitat condition were totaled, and a percentage of the reference site was calculated. The percentages were used to assign a habitat condition category to each site (Plafkin and others, 1989; Barbour and others, 1999).

Taxonomic Richness: Total number of taxa in the sample. Number decreases with increasing stress.

Hilsenhoff Biotic Index: A measure of organic pollution tolerance. Index value increases with increasing stress.

Percent Ephemeroptera: Percentage of number of Ephemeroptera in the sample divided by the total number of macroinvertebrates in the sample. Percentage decreases with increasing stress.

Percent Contribution of Dominant Taxa: Percentage of the taxon with the largest number of individuals out of the total number of macroinvertebrates in the sample. Percentage increases with increasing stress.

EPT Index: Total number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa present in a sample. Number decreases with increasing stress.

Percent Chironomidae: Percentage of number of Chironomidae individuals out of total number of macroinvertebrates in the sample. Percentage increases with increasing stress.

Shannon-Wiener Diversity Index: A measure of the taxonomic diversity of the community. Index value decreases with increasing stress.

Results/Discussion

Water quality, macroinvertebrate, and habitat site conditions for each sampling site in the Juniata Subbasin in 2004 are depicted in Figures 4 - 6. Twelve sites demonstrated the best overall conditions in each category with nonimpaired macroinvertebrates, "higher" water quality, and excellent habitat. Twenty-three sites did not exceed water quality levels of concern and received a "higher" water quality designation. Sixty-four sites slightly exceeded levels of concern and received a "middle" quality designation, and 14 sites were considered "lower" quality. Nonimpaired biological conditions were found at 44 sites (54 percent), slightly impaired conditions were found at 26 sites (32 percent), moderately impaired conditions were found at eight sites (10 percent), and severely impaired conditions were found at three sites (four percent). Habitat conditions throughout the subbasin were rated highly. Habitat conditions were excellent at 66 sites (81.5 percent), supporting at 13 sites (16 percent), and partially supporting at two sites (2.5 percent).

Seventy-eight sites had at least one parameter that exceeded a level of concern (Table 4). The highest number of parameters exceeding levels of concern occurred at BURG 0.5 and HALT 0.6. Total nitrogen exceeded the level of concern at 66 sites while total nitrate-n exceeded the level of concern at 61 sites. The values set for nitrogen and nitrate-n (1.0 mg/l) are based on natural background concentrations; therefore, values higher than 1.0 mg/l indicate the potential presence of nitrogen sources such as agriculture in the watershed. This level is not based on aquatic life tolerances or levels of concern, as standards have not yet been developed for nutrients in Pennsylvania.

The third highest parameter to exceed levels of concern was total aluminum, which was exceeded 16 times. At seven of those 16 sites, abandoned mine drainage (AMD) conditions were the likely cause of the higher aluminum values, and atmospheric deposition was most likely the cause for at least one other site. The cause for high aluminum at the other eight sites needs further research. Since the sample is a one-time sample, duplication of these results at different times, flows, and seasons would be necessary. The land use in many of these watersheds contains agricultural activity, some of which includes farmland applications of biosolids from municipal wastewater treatment plants. In fact, farms that apply or in the past have applied biosolids are located in the area of at least six of those eight sites with higher aluminum values (PADEP, 2005). Some wastewater treatment plants use alum as a flocculent to settle out solids. Research suggests that chemicals, such as alum, added to waste during the treatment process can affect the chemical composition of the biosolids (USEPA, 1999).

Agricultural land use appeared to influence many of the Juniata Subbasin Survey sampling sites. Total nitrogen values were very high at some sites, with the highest value being 11.64 mg/l (Table 4). Total phosphorus and orthophosphate values were exceeded four and 11 times, respectively. Orthophosphate and phosphorus can be indicators of wastewater and septic systems,

detergents, chemical fertilizers, animal waste, some industrial discharges, and soil erosion. The highest value for total phosphorus was 0.471 mg/l, and the highest value for total orthophosphate was 0.463 mg/l (Table 4). Many areas in the subbasin are conducive to farming due to the limestone and dolomite geology in the valleys between the ridges (Figure 2).

AML are not as prevalent in this subbasin (Figure 3), since the geology that is conducive to mining (Ecoregion 69) is not as prevalent (Figure 2). Parameters indicative of AMD conditions such as iron, manganese, aluminum, pH, alkalinity, and acidity were not exceeded as often as the parameters indicative of agricultural conditions, such as total nitrogen. The AMD conditions of the sites sampled were not very severe, with the lowest pH being 4.0. The highest concentrations of metals consisted of iron at 5,570 µg/l, manganese at 3,670 µg/l, and aluminum at 3,080 µg/l. Approximately seven sites indicate at least some impact from AMD pollution.

Section 303(d) of the Clean Water Act requires a Total Maximum Daily Load (TMDL) to be developed for any waterbody designated as impaired, or not meeting the state water quality standards or its designated use. Streams in Pennsylvania are being assessed as part of the State Surface Waters Assessment Program, and, if they are found to be impaired, a TMDL is calculated for the watershed. Some of the watersheds in the Juniata Subbasin have been rated impaired, and subsequently, will require a TMDL. Table 5 identifies those watersheds that have been found to be impaired, their impairment causes and the date they were sampled, the proposed date for TMDL completion, and Juniata Subbasin Survey stations located in impaired sections. More information on the TMDL program is available at: http://www.dep.state.pa.us/watermanagement_apps/tmdl/default.asp.

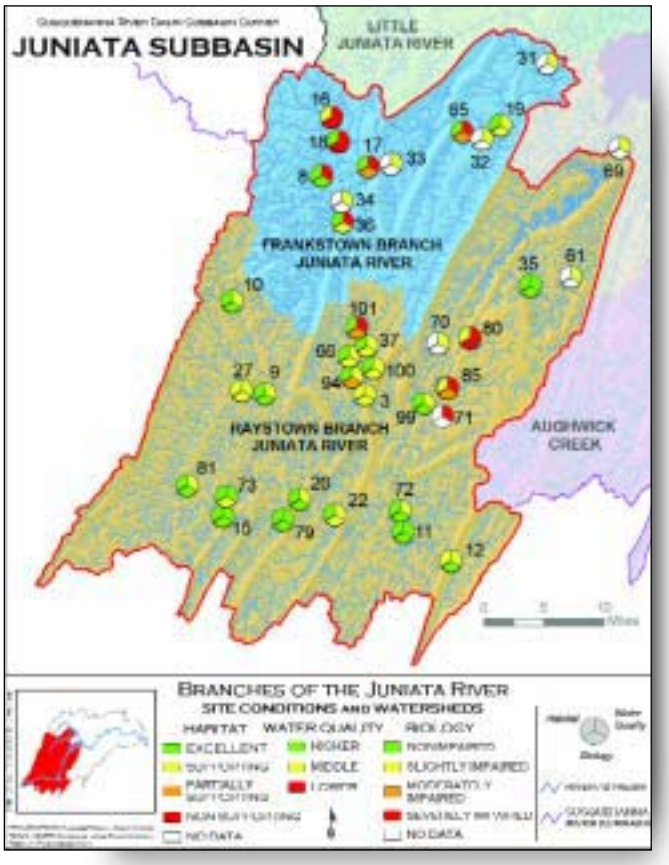

Figure 4. Water Quality, Biological, and Habitat Conditions in the Frankstown and Raystown Branches

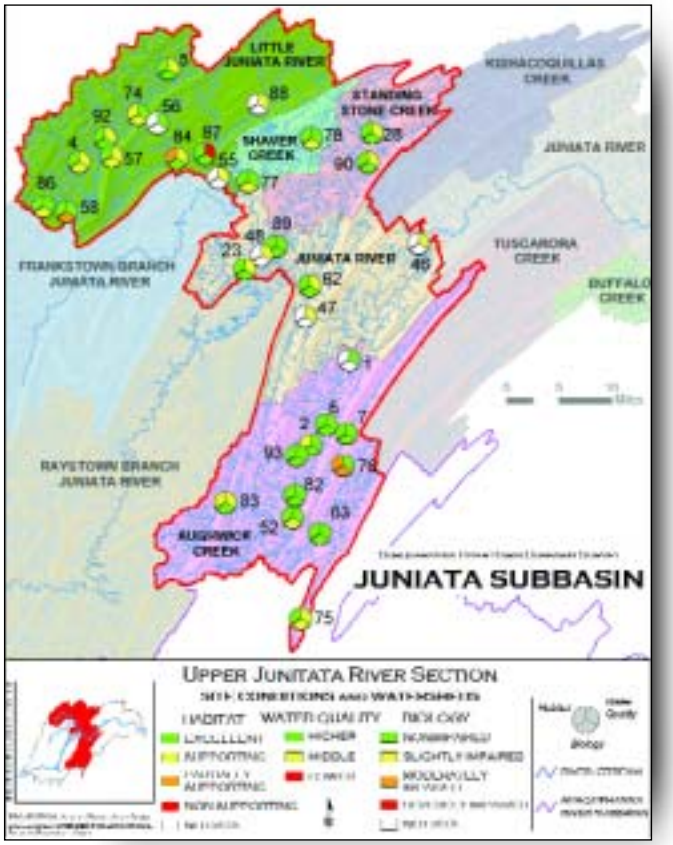

Figure 5. Water Quality, Biological, and Habitat Conditions in the Upper Juniata River Section

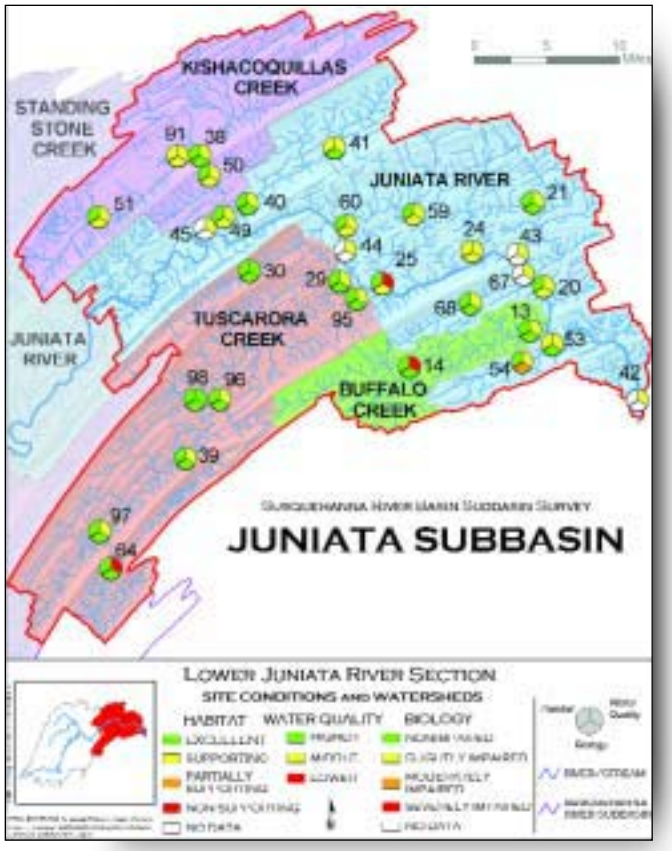

Figure 6. Water Quality, Biological, and Habitat Conditions in the Lower Juniata River Section

Table 4. *Juniata Subbasin Sites with Water Quality Values Exceeding Levels of Concern*

Stations	Hardness T >300 mg/l	Magnesium T >35 mg/l	Nitrate-N T >1.0 mg/l	Nitrogen T >1.0 mg/l	Orthophosphate T >0.05 mg/l	Phosphorus T >0.1 mg/l	Sodium T >20 mg/l	T Susp Solid >25 mg/l	Acidity >20 mg/l	pH < 5.0	Alkalinity <20 mg/l	Aluminum T >200 µg/l	Iron T >1,500 µg/l	Manganese T >1,000 µg/l	TOTAL
BEAV0.1			5.6	5.65											2
BELG2.4											13.6				1
BIGF1.0											17.6	213			2
BLRG2.5												281			1
BOBS0.9			1.65	1.8											2
BOBS11.4											15				1
BRUS14.1											17.4				1
BUFF0.4			1.78	2.2											2
BUFF14.6			1.72	1.92	0.194	0.207						227			5
BURG0.5				1.05					23	**4**	**0**	**3080**	**5570**	**3670**	7
BVDB0.1			1.39	1.66								275			3
BVDB5.0				1.27				**44**			18.6	2080	2060	1800	6
CLOV0.1			5.65	6.04											2
COCO0.2			3.08	3.04											2
COCO9.6			2.26	2.32	**0.463**	**0.471**									4
COVE7.7			5	5.09											2
CRKD0.3			1.28	1.47											2
DELA0.2			5.07	5.06											2
DOER0.3			4.98	5.01								359			3
DUNN0.1			1.14	1.3											2
DUNN9.9				1.2											1
EBSS0.5			1.26	1.29											2
ELKC0.1			1.26	1.46											2
FRNK1.6			3.06	3.6	0.054										3
FRNK18.9			2.59	3.13	0.064										3
FRNK32.5			2.17	2.66	0.073		21.3								4
FRNK38.1			3.09	3.67	0.056										3
HALT0.6	**382**	35.3	5.79	6.2	0.103	0.115	**21.8**								7
HKBC0.1			5	5.2											2
HONY0.2			1.07	1.15											2
HSVR0.5				1.06											1
JACK2.9			1.72	1.88											2
JACK11.7			2.55	2.84											2
JUNR2.0			1.75	2.5											2
JUNR17.3			1.68	2.32											2
JUNR34.0			1.89	2.08											2
JUNR47.0			1.61	2.18											2
JUNR63.6			1.58	2.07											2
JUNR84.6			1.61	2.14											2
JUNR94.0			2.55	3.06											2
KISH0.4			3.39	3.54											2
KISH5.5			3.54	3.66	0.059										3
KISH15.6			7.2	7.07											2
LBUF0.1			1.03	1.32											2
LBUF2.1			1.15	1.46	0.05										3
LJUN3.8			2.27	2.64											2
LJUN19.4			1.27	1.55	0.11	0.117									4
LLOS0.5			6.38	5.97	0.072										3
LOSC0.2			1.8	1.9											2
LTRO0.8												205			1
MILL0.3			1.59	1.98											2
NBTC3.1			2.96	3.32								245			3
PINY0.6			7.81	7.74								469			3
PTRC0.1			6.4	6.42											2
RACC0.2			1.86	2.1											2
RACC5.0			1.5	1.79											2
RAYS4.6			1.09	1.57											2
RAYS42.8			2.16	2.46											2
RAYS54.1			1.19	1.42								803			3
RAYS80.5			1.96	2.18											2
SBLA8.3											3.6				1
SHUP0.1											3.4	1460		1080	3
SHWN4.2			1.98	2.13											2
SIDE13.9											17.4				1
SINK0.3			1.75	1.88								203			3
SIXM0.3									**28**		2.2	1940	1550		4
SPRU1.0			3.32	3.67								370			3
SPRU10.6			3.5	3.51											2
STST26.8											19.6				1
TEAC0.1			3.59	3.65								209			3
TIPT1.3											15.2				1
TSPR0.1			9.25	9.26											2
TUSC0.6			1.13	1.48											2
TUSC22.5				1.33											1
TUSC39.3			1.26	1.56											2
YELL3.5			5.55	5.72											2
YELL9.1			7.98	8.07											2
YELL12.0	342	**39.6**	**11.7**	**11.64**											4
TOTAL	2	2	61	66	11	4	2	1	2	1	12	16	3	3	

**Highest or lowest values are in bold print.*

Table 5. *Juniata Subbasin Survey Streams Identified as Impaired Streams Requiring a TMDL on PADEP's 2004 Integrated List of All Waters*

WATERSHEDS	MAJOR SOURCES OF IMPAIRMENT	TMDL STATUS	STATIONS IN IMPAIRED SECTIONS
Aughwick Creek	Source Unknown/Mercury:2002	Proposed 2011	
Beaver Creek	Agriculture/Siltation:2004, Agriculture/Nutrients:2004	Proposed 2017	BEAV 0.1
Beaver Dam Branch	Abandoned Mine Drainage/Metals:1996, Combined Sewer Overflow/Organic Enrichment/Low D.O.:1996, Urban Runoff/Storm Sewers/Cause Unknown:1996	Proposed 2005	BVDB 0.1/ BVDB 5.0
Bells Gap Run	AMD/Siltation:2002, AMD/pH:2002, AMD/Metals:2002	Proposed 2017	
Brush Creek	Crop Related Agriculture/Siltation:2002, Crop Related Agriculture/ Nutrients:2002, Small Residential Runoff/Nutrients:2002	Proposed 2017	
Buffalo Creek	Crop Related Agriculture/Siltation:2002	Proposed 2015	
Burgoon Run	AMD/Metals:1996, AMD/Siltation:2002, AMD/pH:2002	Proposed 2005	BURG 0.5
Cocolamus Creek	Grazing Related Agriculture/Siltation:2002, Agriculture/ Siltation:2002, Animal Feeding Agriculture/Nutrients:2002	Proposed 2015	
Doe Run (Cedar Spring Run)	Agriculture/Siltation:2002	Proposed 2015	
Frankstown Branch	Industrial Point Source/Nonpriority Organics:1996, Industrial Point Source/ Priority Organics:1996, Industrial Point Source/Suspended Solids: 1998 and 2002, Road Runoff/Siltation:2002	Proposed 2005/2015	FRNK 32.5
Halter Creek	Urban Runoff/Storm Sewers/Suspended Solids:1998, Source Unknown/Cause Unknown:1998	Proposed 2005	HALT 0.6
Hickory Bottom Creek	Agriculture/Siltation:2004	Proposed 2015	HKBC 0.1
Honey Creek	Agriculture/Nutrients:2002, Agriculture/Siltation:2002, Crop Related Agriculture/Siltation:2002	Proposed 2015	
Jacks Creek	Source Unknown/PCB:1998	Proposed 2009	
Juniata River	Crop Related Agriculture/Siltation:2002	Proposed 2015	
Kishacoquillas Creek	Agriculture/Siltation:2002, Agriculture/Nutrients:2002, Hydromodifications/Siltation:2002, Construction/Siltation:2002	Proposed 2015/2017	KISH 15.6
Little Juniata River	Municipal Point Source/Organic Enrichment/Low D.O.:1996, Urban Runoff/Storm Sewers/Cause Unknown:1996	Proposed 2005	LJUN 29.6
Little Lost Creek	Crop Related Agriculture/Siltation:2002, Crop Related Agriculture/Nutrients:2002	Proposed 2015/2017	LLOS 0.5
Lost Creek	Crop Related Agriculture/Nutrients:2002, Crop Related Agriculture/Siltation:2002	Proposed 2015	
Narrows Branch Tuscarora Creek	Agriculture/Siltation:2002	Proposed 2015	
North Branch Little Aughwick Creek	Crop Related Agriculture/Nutrients:2002, Crop Related Agriculture/Siltation:2002	Proposed 2015/2017	
Piney Creek	Agriculture/Siltation:2002	Proposed 2017	
Potter Creek	Agriculture/Siltation:2004	Proposed 2017	PTRC 0.1
Raystown Branch Juniata	Agriculture/Siltation:2004, Small Residential Runoff/Siltation:2004, Industrial Point Source/Nutrients:2004	Proposed 2017	
Raystown Branch Juniata	Source Unknown/Mercury:2002	Proposed 2011	
Shoups Run	Abandoned Mine Drainage/pH:1996, Abandoned Mine Drainage/metals:1996	Completed TMDL 2001	SHUP 0.1
Sixmile Run	Abandoned Mine Drainage/pH:1996, Abandoned Mine Drainage/metals:1996	Proposed 2009	SIXM 0.3
South Bald Eagle Creek	Industrial Point Source/Thermal Modifications:1996	Proposed 2009	SBEC 1.4
Spruce Creek	Agriculture/Siltation:2002, Grazing Related Agriculture/Siltation:1998, 2002, Grazing Related Agriculture/Nutrients:2002, Agriculture/Suspended Solids:1998	Proposed 2017	
Three Springs Run	Agriculture/Siltation:2004	Proposed 2017	TSPR 0.1
Tuscarora Creek	Agriculture/Siltation:2002, Grazing Related Agriculture/Siltation:2002, Grazing Related Agriculture/Nutrients:2002	Proposed 2015	
Yellow Creek	Agriculture/Siltation:2004	Proposed 2017	YELL 9.1/YELL 12.0