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Water Quality and Biological Assessment of the Juniata Subbasin

Publication No. 178 *January 1997*

by Charles A. McGarrell
Biologist

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CONTENTS

APPENDICES

ILLUSTRATIONS

TABLES

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WATER QUALITY AND BIOLOGICAL ASSESSMENT OF THE JUNIATA SUBBASIN

by Charles A. McGarrell

ABSTRACT

Multivariate statistical analyses and the U.S. Environmental Protection Agency's Rapid Bioassessment Protocol III were used to assess the chemical water quality, physical habitat, and biological conditions of 59 sample sites in the Juniata Subbasin in central Pennsylvania. Assessment results indicate that approximately one half (55 percent) of the sites support nonimpaired biological communities. Several stream reaches that were described as having highly depressed water quality and biological conditions in the late 1970s have improved dramatically, while some of these waterways are still moderately degraded. Principal components and cluster analyses were effective techniques for condensing the water quality data into a manageable format and for revealing structure in the water quality data. These multivariate statistical analyses enhanced our ability to identify the environmental factors influencing the biological conditions of impaired waterways and the specific relationships that exist between physical habitat, water quality, and stream biological conditions. These relationships, which vary based on ecoregion designation and drainage area size, are presented as topics to be considered by natural resource managers and policy makers.

INTRODUCTION

The Juniata River drains an area of 3,400 square miles and is the second largest tributary to the Susquehanna River. Land use in the Juniata Subbasin consists primarily of forest and agriculture. The subbasin's population is found largely in numerous villages concentrated in the valleys. The only sizeable urban development in the watershed is the Altoona-Hollidaysburg area. Other developed areas include Tyrone, Huntingdon, Bedford, Lewistown, and Newport.

Although many of the streams in the Juniata Subbasin support healthy, "natural" biological communities, Brezina (1980) and McMorran (1986) reported that the biological communities of several waterways in the subbasin were impacted by nonpoint source pollution, municipal wastewater discharges, and/or industrial effluents. Since the assessments conducted by Brezina and McMorran, a number of research institutions and government agencies have developed bioassessment methods that are generally more robust than those used in the past. For example, the United States Environmental Protection Agency (US EPA) has developed Rapid Bioassessment Protocols (RBPs) for conducting biological assessments of streams and rivers (Plafkin and others, 1989). These protocols include measures that attempt to incorporate the effects of "natural" landscape features such as stream size, geology, and soils into stream assessments to better differentiate "natural" stream ecosystems from those impaired by man's activities.

The US EPA's Rapid Bioassessment Protocol III (RBP III) is designed to provide resource managers with a scientifically valid, cost-effective monitoring procedure for assessing the biological conditions of streams and rivers based primarily on benthic macroinvertebrate community structure and physical habitat conditions. The chemical water quality component of RBP III includes only a limited, number of measured parameters (temperature pH, conductivity, and dissolved oxygen) to characterize stream water quality conditions. Thus, much of the cost-effectiveness of RBP III is realized through the reduction of laboratory and staff requirements associated with detailed, seasonally (or more frequently) conducted assessments of water quality conditions.

Under certain circumstances, sources of impairment to biological communities can be attributed to either degraded physical habitat or water quality conditions, based solely on RBP III data. For example, when a severely impaired biological community occurs in conjunction with good or excellent physical habitat conditions, biological impairment can usually be attributed to poor water quality. However, when a stream exhibits intermediate degrees of both habitat degradation and biological impairment, it becomes more difficult to assess the source of biological impairment based solely on RBP III data.

In this study, Susquehanna River Basin Commission (SRBC) staff used RBP III habitat and biological data, in conjunction with the analysis of 38 physico-chemical water quality parameters, in an extensive bioassessment of the streams and rivers in the Juniata Subbasin. The water quality component of RBP III was expanded to improve our ability to identify the sources of biological impairment in streams that exhibit intermediate degrees of both habitat degradation and biological impairment.

The primary objectives of this report are to: (1) provide information to the Pennsylvania Department of Environmental Protection and the Susquehanna River Basin Commission for their 305(b) Water Quality Inventories; (2) identify the existence, severity, and probable source(s) of impairments to stream biological communities; (3) use standardized methods to build a database that can be used as baseline data for trend monitoring, and (4) identify relationships between landscape features, physical habitat, water quality conditions, and stream biological conditions, and present these findings as management issues to be considered by natural resource managers and policy makers.

METHODS

Field and Laboratory Methods

Field data were collected during a period of little or no precipitation when streamflows were maintained primarily by baseflow. Sixty sites were sampled in the Juniata Subbasin between July 17 and August 9, 1995 (Figure 1). Seven sites were located on the main stem of the Juniata River, and 53 sites were distributed among 31 tributaries to the Juniata River (Table 1). At each sample site, physical habitat and chemical water quality conditions were documented, and benthic macroinvertebrate and chemical water quality samples were collected for analysis in the laboratory.

Chemical water quality

Field water quality measurements included water temperature, dissolved oxygen, conductivity, pH, alkalinity, and acidity. Dissolved oxygen was measured using a YSI dissolved oxygen meter or by the Winkler titration method. Conductivity was measured using a Beckman Solubridge meter. An Orion Model 399A meter was used to measure pH. Alkalinity was measured by titrating a known volume of sample water to pH 4.5 with 0.2N H_2SO_4. Acidity was measured by titrating a known volume of sample water to pH 8.3 with 0.2N NaOH. Approximately 2 liters of water from each site were collected for laboratory analysis. Laboratory samples consisted of two 500 ml bottles for nutrient analysis (one filtered and one unfiltered), and two 500 ml bottles for metal analysis (also one filtered and one unfiltered). Sample water was filtered through a cellulose nitrate filter with a 0.45 um pore size. The samples for metal analyses were acidified to pH 2 or less with nitric acid. All samples were chilled on ice and shipped within 24 hours to the

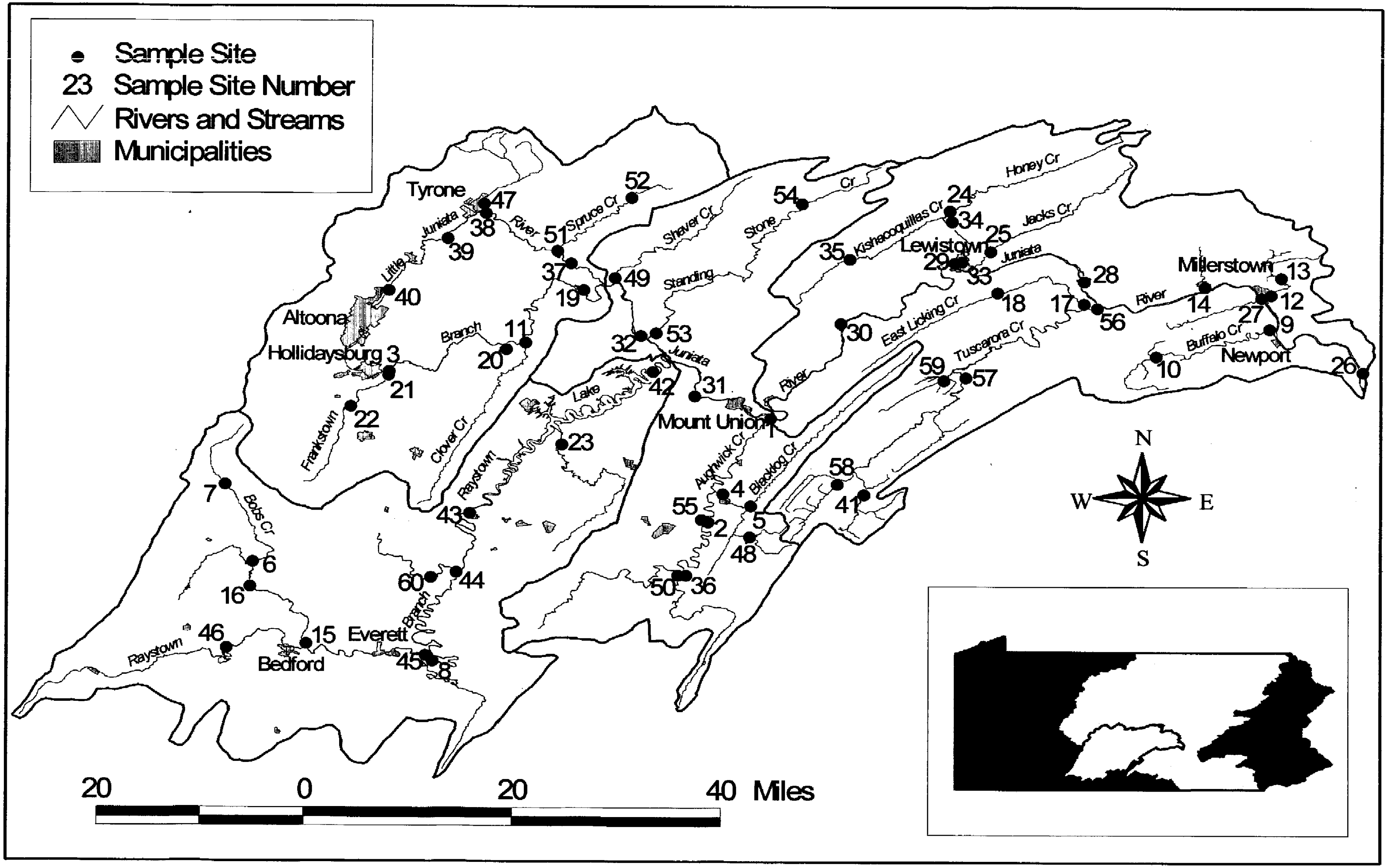


Figure 1. ***Map of the Juniata Subbasin Survey Sample Sites***

Table 1. ***Juniata Subbasin Survey Sample Site Locations***

Sample Site No.	Sample Site	Location
1	AUGH 00.4	Aughwick Creek upstream of Rt 103/1303 Bridge, near Kisler, Pa.
2	AUGH 17.2	Aughwick Creek downstream of Three Springs Creek
3	BEAV 00.1	Beaverdam Branch near Hollidaysburg, Pa.
4	BLLG 00.9	Blacklog Creek upstream of Orbisonia-Rockhill Jt. M.A., Orbisonia, Pa.
5	BLLG 04.6	Blacklog Creek upstream of Peterson Rd. Bridge
6	BOBS 00.9	Bobs Creek at tractor crossing, near Reynoldsdale, Pa.
7	BOBS 11.4	Bobs Creek at ball field, near Pavia, Pa.
8	BRUS 00.1	Brush Creek, near Breezewood, Pa.
9	BUFF 00.4	Buffalo Creek at SR 1007 Bridge, Newport, Pa.
10	BUFF 14.6	Buffalo Creek off of Rte. 849, upstream of Eschol, Pa.
11	CLOV 00.1	Clover Creek at church near mouth, Williamsburg, Pa.
12	COCO 00.2	Cocolamus Creek at old Rte. 22 Bridge, Millerstown, Pa.
13	COCO 09.6	Cocolamus Creek at T 475 Bridge, Greenwood, Twp., Pa.
14	DELA 00.2	Delaware Creek upstream of Thompsontown M.A., Thompsontown, Pa.
15	DUNN 00.1	Dunning Creek at mouth, Bedford, Pa.
16	DUNN 09.9	Dunning Creek upstream of E. St. Clair Twp. M.A. STP discharge, East St. Clair Twp., Pa.
17	ELKC 00.1	East Licking Creek at church on Rte. 333 upstream of of Rte. 333/Rte. 75 intersection
18	ELKC 09.8	E. Licking Cr. Drive (SR 4002) Bridge, above Clearview Reservoir
19	FRNK 01.6	Frankstown Branch Juniata River immediately upstream of Alexandria -Porter Twp. J.A. STP, Porter Twp., Pa.
20	FRNK 18.9	Frankstown Branch Juniata River near Williamsburg, Pa.
21	FRNK 32.5	Frankstown Branch Juniata River near Hollidaysburg, Pa.
22	FRNK 38.1	Frankstown Branch Juniata River immediately upstream of Appleton Papers Inc. wastewater discharge, Brooks Mill, Pa.
23	GTRC 02.9	Great Trough Creek at Trough Creek State Park, upstream of Trough Creek Drive Bridge.
24	HONY 00.2	Honey Creek at Reedsville, Pa.
25	JACK 02.9	Jacks Creek at SR 2004 Bridge, between Lewistown and Maitland, Pa.
26	JUN 02.0	Juniata River at Amity Hall, Pa.
27	JUN 17.3	Juniata River upstream of the confluence of Cocolamus Creek, Millerstown, Pa.
28	JUN 34.0	Juniata River at Mifflintown, Pa.
29	JUN 47.0	Juniata River upstream of the confluence of Kiahacoquillas Creek, Lewistown, Pa.
30	JUN 63.6	Juniata River at McVeytown, Pa.
31	JUN 84.6	Juniata River at Mapleton Depot, Pa.

Table 1. Juniata Subbasin Survey Sample Site Locations —Continued

Sample Site No.	Sample Site	Location
32	JUN 94.0	Juniata River at Huntingdon, Pa.
33	KISH 00.4	Kishacoquillas Creek at Lewistown, Pa.
34	KISH 05.5	Kishacoquillas Creek upstream of Standard Steel, Burnham, Pa.
35	KISH 15.6	Kishacoquillas Creek immediately upstream of Union Twp. M.A. STP, Belleville, Pa.
36	LAUG 00.1	Little Augwick Creek near Brownsville, Pa.
37	LJUN 03.8	Little Juniata River at State Forest Boundry, near Barree, Pa.
38	LJUN 15.0	Little Juniata River immediately upstream of Tyrone Borough STP, Tyrone, Pa.
39	LJUN 19.4	Little Juniata River upstream of PPG Works #27, Antis Twp., Pa.
40	LJUN 29.6	Little Juniata River upstream of Altoona City Authority East STP, Altoona, Pa.
41	NBTC 03.1	Narrows Branch Tuscarora Creek at SR 4007 Bridge, Concord, Pa.
42	RAYS 04.6	Raystown Branch Juniata River downstream of Raystown Dam
43	RAYS 42.8	Raystown Branch Juniata River upstream of Saxton Borough STP, Saxton, Pa.
44	RAYS 54.1	Raystown Branch Juniata River at Hopewell, Pa.
45	RAYS 80.5	Raystown Branch Juniata River immediately downstream of the confluence of Greys Run, West Providence Twp., Pa.
46	RAYS 103	Raystown Branch Juniata River downstream of covered bridge on S.R. 4005 near Manns Choice, Pa.
47	SBEC 01.4	South Bald Eagle Creek at USGS gauging station, Tyrone, Pa.
48	SHAD 04.3	Shade Creek upstream of Shade Gap Area M.A., Shade Gap, Pa.
49	SHAV 01.4	Shaver Creek downstream of S.R. 4011 bridge near Petersburg, Pa.
50	SIDE 00.1	Sideling Hill Creek near Brownsville, Pa.
51	SPRU 01.0	Spruce Creek at Pennsylvania Fish and Boat Commission Special Regulations Area, near Spruce Creek, Pa.
52	SPRU 10.6	Spruce Creek at Rte 45 Bridge, Graysville, Pa.
53	STST 01.0	Standing Stone Creek at Huntingdon, Pa.
54	STST 26.8	Standing Stone Creek at first bridge upstream of SR1023/Black Lick Rd. Jct., Jackson Twp., Pa.
55	TSPC 00.1	Three Spring Creek near Three Springs, Pa.
56	TUSC 00.6	Tuscarora Creek at Mifflintown, Pa.
57	TUSC 22.5	Tuscarora Creek near Reeds Gap, Pa.
58	TUSC 39.3	Tuscarora Creek below confluence of Trough Spring Branch, near Blairs Mills, Pa.
59	WILL 00.4	Willow Creek near Reeds Gap, Pa.
60	YELL 03.5	Yellow Creek at SR 1009 Bridge, Hopewell Twp., Pa.
	6MIL 00.2*	Sixmile Run, at T-864 Bridge, Moshannon State Forest, Centre County, Pa.

* Not in Juniata Subbasin, served as reference site for reference category 69a

Pennsylvania Department of Environmental Protection (Pa. DEP), Bureau of Laboratories in Harrisburg, Pennsylvania.

Physical habitat and biological conditions

Physical habitat conditions at each sample site were assessed using a slightly modified version of the habitat assessment procedure outlined by Plafkin and others (1989). A total of eleven habitat parameters were field evaluated at each site and used to calculate a site-specific Habitat Assessment Score. Habitat parameters were identified as either primary, secondary, or tertiary parameters, based on their contribution to habitat quality. Primary parameters, stream habitat features that have the greatest direct influence on the structure of aquatic communities, were evaluated on a scale of 0-20 and included the characterization of the stream bottom substrate and instream cover, embeddedness, and velocity/depth diversity. Secondary parameters included stream channel morphology characteristics and were scored on a scale of 0-15. Tertiary parameters characterized riparian and bank conditions and were scored on a scale of 0-10. The criteria used to evaluate habitat parameters are summarized in Table 2.

Benthic macroinvertebrate samples were analyzed using field and laboratory methods described by Plafkin and others (1989). Macroinvertebrate communities were sampled using 1 meter square kick nets to collect organisms dislodged from riffle areas by physical agitation of the streambed. Two areas of the streambed, each approximately 1 meter square, were sampled at each site: one area of high velocity and one of lower velocity. The two samples were composited and preserved in a solution of isopropyl alcohol and glycerin for laboratory analysis. In the laboratory, composite samples were sorted into 100-organism subsamples using a gridded pan and a random numbers table. The organisms contained in the subsamples were identified to genus (except for Chironomidae) and enumerated. Each taxon was assigned an organic pollution tolerance value and a functional feeding category as outlined in Appendix A.

Data Analysis Methods

Reference category designation

Sample sites were grouped into reference categories based on: (1) ecoregion designation; (2) drainage area size; and (3) subecoregion designation. Sites with drainage areas less than 100 sq. mi. in Subecoregions 67c (sandstone ridges) and 67d (shale ridges) were combined into a single reference category, due to the relative similarity between these two subecoregions and the limited number of sites located in Subecoregion 67d. For each reference category, one site that represented a combination of the "least disturbed or best attainable" habitat and biological conditions was identified and used as the reference site for the reference category. Reference category delineation criteria are summarized in Table 3.

Chemical water quality

Principal components analysis (PCA) was used to condense the water quality data into a manageable format, to reveal structure in the data, and to efficiently describe the water quality characteristics of the sample sites within a given reference category. PCA results are presented as graphs (ordinations) in which the axes represent subsets of the parameters included in the analysis that account for most of the variation in the data. Parameters that had low axis weightings, and thus accounted for only a small part of the overall variability in the data, were removed from the data set. This process was repeated until the original data set of 38 water quality parameters was condensed to a relatively small number of parameters that produced meaningful ordinations. Next, the condensed data set produced from PCA was used in a hierarchical, agglomerative cluster analysis to produce a dendrogram, a tree-like graph, that shows the relative similarity of sample sites. Separate principal components and cluster analyses were performed for each reference

Table 2. Criteria Used to Evaluate Physical Habitat Parameters

Habitat Parameter	Excellent	Good	Fair	Poor
1. Bottom Substrate	Greater than 50% cobble, gravel, submerged logs, undercut banks, or other stable habitat **(16-20)**	30-50% cobble, gravel, or other stable habitat. Adequate habitat. **(11-15)**	10-30% cobble, gravel, or other stable habitat. Habitat availability is less than desirable. **(6-10)**	Less than 10% cobble, gravel, or other stable habitat. Lack of habitat is obvious. **(0-5)**
2. Embeddedness (a)	Larger substrate particles (e.g., gravel, cobble, boulders) are between 0 and 25% surrounded by fine sediment. **(16-20)**	Larger substrate particles (e.g., gravel, cobble, boulders) are between 25 and 50% surrounded by fine sediment. **(11-15)**	Larger substrate particles (e.g., gravel, cobble, boulders) are between 50 and 75% surrounded by fine sediment. **(6-10)**	Larger substrate particles (e.g., gravel, cobble, boulders) are over 75% surrounded by fine sediment. **(0-5)**
3. Velocity/Depth Diversity	Four habitat categories consisting of slow (<1.0 ft/s), deep (>1.5 ft); slow, shallow (<1.5 ft); fast (> 1.0 ft/s), deep; fast, shallow habitats are all present. **(16-20)**	Only 3 of the 4 habitat categories are present. **(11-15)**	Only 2 of the 4 habitat categories are present. **(6-10)**	Dominated by 1 velocity/depth category (usually pools). **(0-5)**
4. Pool/Riffle Ratio (or Run/Bend)	Distance between riffles divided by mean wetted width equals 5-7. Stream contains a variety of habitats including deep riffles and pools. **(12-15)**	Distance between riffles divided by mean wetted width equals7-15. Adequate depth in pools and riffles. **(8-11)**	Distance between riffles divided by mean wetted width equals 15-25. Stream contains occasional riffles. **(4-7)**	Distance between riffles divided by mean wetted width >25. Stream is essentially straight with all flat water or shallow riffle. Poor habitat. **(0-3)**
5. Pool Quality (b)	Pool habitat contains both deep(>1.5 ft) and shallow areas (<1.5 ft) with complex cover and/or depth greater than 5 ft. **(12-15)**	Pool habitat contains both deep(>1.5 ft) and shallow (<1.5 ft) areas with some cover present. **(8-11)**	Pool habitat consists primarily of shallow (<1.5 ft) areas with little cover. **(4-7)**	Pool habitat rare with maximum depth <0.5 ft, or pool habitat completely absent. **(0-3)**

Table 2. ***Criteria Used to Evaluate Physical Habitat Parameters—Continued***

Habitat Parameter	Excellent	Good	Fair	Poor
6. **Riffle/Run Quality** (c)	Riffle/run depth generally >8 in. and consisting of stable substrate materials and a variety of current velocities. **(12-15)**	Riffle/run depth generally 4-8 in. and with a variety of current velocities. **(8-11)**	Riffle/run depth generally 1-4 in.; primarily a single current velocity. **(4-7)**	Riffle/run depth <1 in.; or riffle/run substrates concreted. **(0-3)**
7. **Channel Alteration** (d)	Little or no enlargement of islands or point bars, and/or no channelization. **(12-15)**	Some new increase in bar formation, mostly from coarse gravel; and/or some channelization present. **(8-11)**	Moderate deposition of new gravel, coarse sand on old and new bars; pools partially filled with silt; and/or embankments on both banks. **(4-7)**	Heavy deposits of fine material, increased bar development; most pools filled with silt; and/or extensive channelization. **(0-3)**
8. **Upper and Lower Streambank Erosion** (e)	Stable. No evidence of erosion or of bank failure. Side slopes generally <30%. Little potential for future problems. **(9-10)**	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. **(6-8)**	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% in some areas. High erosion potential during extreme high flow. **(3-5)**	Unstable. Many eroded areas. Side slopes >60% common. "Raw" areas frequent along straight sections and bends. **(0-2)**
9 **Upper and Lower Streambank Stability** (e)	Over 80% of the streambank surface is covered by vegetation or boulders and cobble. **(9-10)**	50-79% of the streambank surface is covered by vegetation, gravel, or larger material. **(6-8)**	25-49% of the streambank surface is covered by vegetation, gravel, or larger material. **(3-5)**	Less than 25% of the streambank surface is covered by vegetation, gravel, or larger material. **(0-2)**
10. **Streamside Vegetative Cover *(Both Banks)***	Dominant vegetation that provides stream-shading, escape cover, and/or refuge for fish within the bankfull stream channel is shrub. **(9-10)**	Dominant vegetation that provides stream shading, escape cover, and/or refuge for fish within the bankfull stream channel is trees **(6-8)**	Dominant vegetation that provides stream-shading, escape cover, and/or refuge for fish within the bankfull stream channel is forbs and grasses. **(3-5)**	Over 50% of the streambank has no vegetation and dominanat material is soil, rock, bridge materials, culverts, or mine tailings. **(0-2)**

Table 2. ***Criteria Used to Evaluate Physical Habitat Parameters—Continued***

Habitat Parameter	Excellent	Good	Fair	Poor
11. **Forested Riparian Buffer Zone Width (f)** ***(Least Forested Bank)***	Riparian area consists of all three zones of vegetation, Zones 1-3. (see zone descriptions (e)) **(9-10)**	Riparian area consists of Zones 1 and 2. **(6-8)**	Riparian area is limited primarily to Zone 1. Zone 2 may be forested but is subject to disturbance (e.g. grazing, intensive forestry practices, roads). **(3-5)**	Riparian area lacks Zone 1 with or without Zones 2 and/or 3. **(0-2)**

(a) Embeddedness — The degree to which the substrate materials that serve as habitat for benthic macroinvertebrates and for fish spawning and egg incubation (predominantly cobble and/or gravel) are surrounded by fine sediment. Embeddedness is evaluated with respect to the suitability of these substrate materials as habitat for macroinvertebrates and fish by providing shelter from the current and predators, and by providing egg deposition and incubation sites.

(b) Pool Quality — Rated based on the variety and spatial complexity of slow- or still-water habitat within the sample segment. It should be noted that even in high- gradient segments, functionally important slow-water habitat may exist in the form of plunge-pools and/or larger eddies. Within a category, higher scores are assigned to segments which have undercut banks, woody debris, or other types of cover for fish.

(c) Riffle/Run Quality — Rated based on the depth, complexity, and functional importance of riffle/run habitat in the segment, with highest scores assigned to segments dominated by deeper riffle/run areas, stable substrates, and a variety of current velocities.

(d) Channel Alteration — A measure of large-scale changes in the shape of the stream channel. Channel alteration includes: concrete channels, artificial embankments, obvious straightening of the natural channel, rip-rap, or other structures, as well as recent sediment bar development. Sediment bars typically form on the inside of bends, below channel constrictions, and where stream gradient decreases. Bars tend to increase in depth and length with continued watershed disturbance. Ratings for this parameter are based on the presence of artificial structures as well as the existence, extent, and coarseness of sediment bars, which indicate the degree of flow fluctuations and substrate stability.

(e) Upper and Lower Streambank Erosion and Stability — These parameters include the concurrent assessment of both the upper and lower banks. The upper bank is the land area from the break in the general slope of the surrounding land to the top of the bankfull channel. The lower bank is the intermittently submerged portion of the stream cross section from the top of the bankfull channel to the existing water-line.

(f) Forested Riparian Buffer Zone Width —
Zone 1: a 15 ft wide buffer of essentially undisturbed forest located immediately adjacent to the stream.
Zone 2: a 100 ft wide buffer of forest, located adjacent to Zone 1, which may be subject to non-intensive forest management practices.
Zone 3: a 20 ft wide buffer of vegetation, located adjacent to Zone 2, that provides sediment filtering and promotes the formation of sheet flow of runoff into Zone 2. Zone 3 may be composed of trees, shrubs, and/or dense grasses and forbs, which are subject to haying and grazing, as long as vegetation is maintained in vigorous condition.

Source: Modified from Plafkin and others, 1989.

Table 3. Summary of Reference Category Delineation Criteria

Ecoregion Designation (1)	**Ecoregion 67 Central Appalachian Ridges and Valleys**					**Ecoregion 69 Central Appalachians**
Drainage Area Size (2)	**<100 sq. mi.**			**100 - 500 sq. mi**	**> 500 sq. mi.**	**<100 sq. mi.**
Subecoregion Designation (3)	67a Limestone or Dolomite Valleys	67b Shale or Slate Non-Calcareous Valleys	67c + 67d Sandstone Ridges and Shale Ridges	N/A	N/A	69a Forested Hills and Mountains
Reference Category	**67a**	**67b**	**67cd**	**67m**	**67l**	**69a**
Sample Sites	BEAV00.1 CLOV00.1 DELA00.2 FRNK38.1 HONY00.2 KISH15.6 LJUN19.4 LJUN29.6 SHAV01.4 SPRU01.0 SPRU10.6 YEL03.5	BLLG00.9 BOBS00.9 BUFF00.4 COCO09.6 DUNN09.9 JACK02.9 LAUG00.1 NBTC03.1 SIDE00.1 STST26.8 TSPC00.1 TUSC39.3 WILL00.4	BLLG04.6 BOBS11.4 BRUS00.1 BUFF14.6 COCO00.2 ELKC00.1 ELKC09.8 RAYS103 SBEC01.4 SHAD04.3	AUGH00.4 AUGH17.2 DUNN00.1 FRNK01.6 FRNK18.9 FRNK32.5 KISH00.4 KISH05.5 LJUN03.8 LJUN15.0 RAYS80.5 STST01.0 TUSC00.6 TUSC22.5	JUN02.0 JUN17.3 JUN34.0 JUN47.0 JUN63.6 JUN84.6 JUN94.0 RAYS04.6 RAYS42.8 RAYS54.1	GTRC02.9
Reference Site	YEL03.5	LAUG00.1	SBEC01.4	AUGH00.4	JUN34.0	6MIL00.2

(1) Omernik (1987)
(2) Pa. DER (1989)
(3) Pa. DEP (unpublished)

category using software developed by Kovach (1993). Principal components and cluster analyses were conducted using methods discussed in Gauch (1982).

Physical habitat and biological conditions

Habitat assessment scores of sample sites were compared to those of reference sites to classify each sample site into a Habitat Condition Category (Table 4). The biological integrity of each sample site was assessed using a modified version of RBP III, as described by Plafkin and others (1989). This modification included the substitution of several of the indices ("metrics") used to evaluate the overall integrity of the site's benthic macroinvertebrate community. These substitutions included: (1) Shannon Diversity (log base 2) for the Percent Contribution of Dominant Taxa Metric, (2) Percent Taxonomic Similarity for the EPT/Chironomidae Abundances and Community Loss Metrics, and (3) Percent Trophic Similarity for the Scrapers/Filtering Collectors and Shredders/Total Metrics. The metrics used in this survey are summarized in Table 5.

The 100-organism subsample data were used to generate scores for each of the six metrics. Each metric score was then converted to a Biological Condition Score based on the percent similarity of the metric score, relative to the metric score of the appropriate reference site. The sum of the Biological Condition Scores constituted the Total Biological Score for the sample site, and Total Biological Scores were used to assign each site to a Biological Condition Category (Table 6).

RESULTS

Reference Category 67a

Reference category 67a consists of 12 sites located in the limestone/dolomite valleys of the Central Appalachian Ridges and Valleys Ecoregion (Ecoregion 67), and have drainage areas of less than 100 sq. mi. (Figure 2). PCA identified a subset of 20 water quality parameters that account for most of the variation in the data. The results of principal components and cluster analyses are presented in Figures 3 and 4, respectively. Raw water quality data are tabulated in Appendix B.

The biological communities of seven (58 percent) reference category 67a sites are nonimpaired. Of the remaining five sites, two (17 percent) support biological communities that are slightly impaired and three (25 percent) are moderately impaired. RBP III physical habitat and biological data are summarized in Tables 7 and 8 and Figure 5. Raw benthic macro-invertebrate data are tabulated in Appendix C.

Reference Category 67b

Thirteen sample sites are included in reference category 67b, sites with drainage areas of less than 100 sq. mi. located in the shale or slate non-calcareous valleys of Ecoregion 67 (Figure 6). PCA identified a subset of 19 water quality parameters that account for most of the variation in the data. The results of principal components and cluster analyses are presented in Figures 7 and 8, respectively.

The biological communities of 10 (77 percent) reference category 67b sites are nonimpaired, two (15 percent) are slightly impaired and one (8 percent) is moderately impaired. RBP III physical habitat and biological data are summarized in Tables 9 and 10 and Figure 9.

Reference Category 67cd

Reference category 67cd consists of 10 sites located on sandstone or shale ridges in Ecoregion 67 and have drainage areas of less than 100 sq. mi. (Figure 10). PCA identified a subset of 17 water quality parameters that account for most of the variation in the data. The results of principal components and cluster analyses are presented in Figures 11 and 12, respectively.

Table 4. Summary of the Criteria Used to Classify the Habitat Conditions of Sample Sites

DETERMINATION OF HABITAT ASSESSMENT SCORES				
	Habitat Parameter Scoring Criteria			
Parameter	**Excellent**	**Good**	**Fair**	**Poor**
Bottom Substrate	20-16	15-11	10-6	5-0
Embeddedness	20-16	15-11	10-6	5-0
Velocity/Depth Diversity	20-16	15-11	10-6	5-0
Pool-Riffle (Run-Bend) Ratio	15-12	11-8	7-4	3-0
Pool Quality	15-12	11-8	7-4	3-0
Riffle/Run Quality	15-12	11-8	7-4	3-0
Channel Alteration	15-12	11-8	7-4	3-0
Upper and Lower Streambank Erosion	10-9	8-6	5-3	2-0
Upper and Lower Streambank Stability	10-9	8-6	5-3	2-0
Streamside Vegetative Cover	10-9	8-6	5-3	2-0
Forested Riparian Buffer Zone Width	10-9	8-6	5-3	2-0
Habitat Assessment Score (a)				

↓

↓

↓

HABITAT ASSESSMENT	
Percent Comparability of Study and Reference Site Habitat Assessment Scores	**Habitat Condition Category**
>90	Excellent (comparable to reference)
89-75	Supporting
74-60	Partially Supporting
<60	Nonsupporting

(a) Habitat Assessment Score = Sum of Habitat Parameter Scores

Table 5. ***Summary of the Metrics Used to Evaluate the Overall Biological Integrity of Stream and River Benthic Macroinvertebrate Communities***

Metric	Description
1. Taxonomic Richness (1)	The total number of taxa present in the 100 organism subsample.
2. Shannon Diversity Index (2)	A measure of biological community complexity based on the number of equally or nearly equally abundant taxa in the community.
3. Modified Hilsenhoff Biotic Index (1)	A measure of the overall pollution tolerance of a benthic macroinvertebrate community.
4. EPT Index (1)	The total number of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) taxa present in the 100 organism subsample .
5. Percent Taxonomic Similarity (2)	A measure of the similarity between the taxonomic composition of the sample site and its appropriate reference community.
6. Percent Trophic Similarity (2)	A measure of the similarity between the functional feeding group composition of a sample site and its appropriate reference community.

Sources: (1) Plafkin and others (1989); and
(2) calculated using software developed by Kovach (1993).

Table 6. Summary of Criteria Used to Classify the Biological Conditions of Sample Sites

SAMPLING AND ANALYSIS

TOTAL BIOLOGICAL SCORE DETERMINATION

Metric	Biological Condition Scoring Criteria (percent)			
	6	4	2	0
1. Taxonomic Richness (a)	>80	79 - 60	59 - 40	<40
2. Shannon Diversity Index (a)	>75	74 - 50	49 - 25	<25
3. Modified Hilsenhoff Biotic Index (b)	>85	84 - 70	69 - 50	<50
4. EPT Index (a)	>90	89 - 80	79 - 70	<70
5. Percent Taxonomic Similarity (c)	>45	44 - 33	32 - 20	<20
6. Percent Trophic Similarity (c,d)	>75	74 - 50	49 - 25	<25
Total Biological Score (e)				

BIOASSESSMENT

Percent Comparability of Study and Reference Site Total Biological Scores	Biological Condition Category
>81	Nonimpaired
81-53	Slightly Impaired
52-20	Moderately Impaired
<20	Severely Impaired

(a) Score is study site value/reference site value X 100.
(b) Score is reference site value/study site value X 100.
(c) Range of values obtained. A comparison to the reference station is incorporated in this index.
(d) Funcional Feeding Group Designations are summarized in Appendix A.
(e) Total Biological Score = the sum of Biological Condition Scores assigned to each metric.

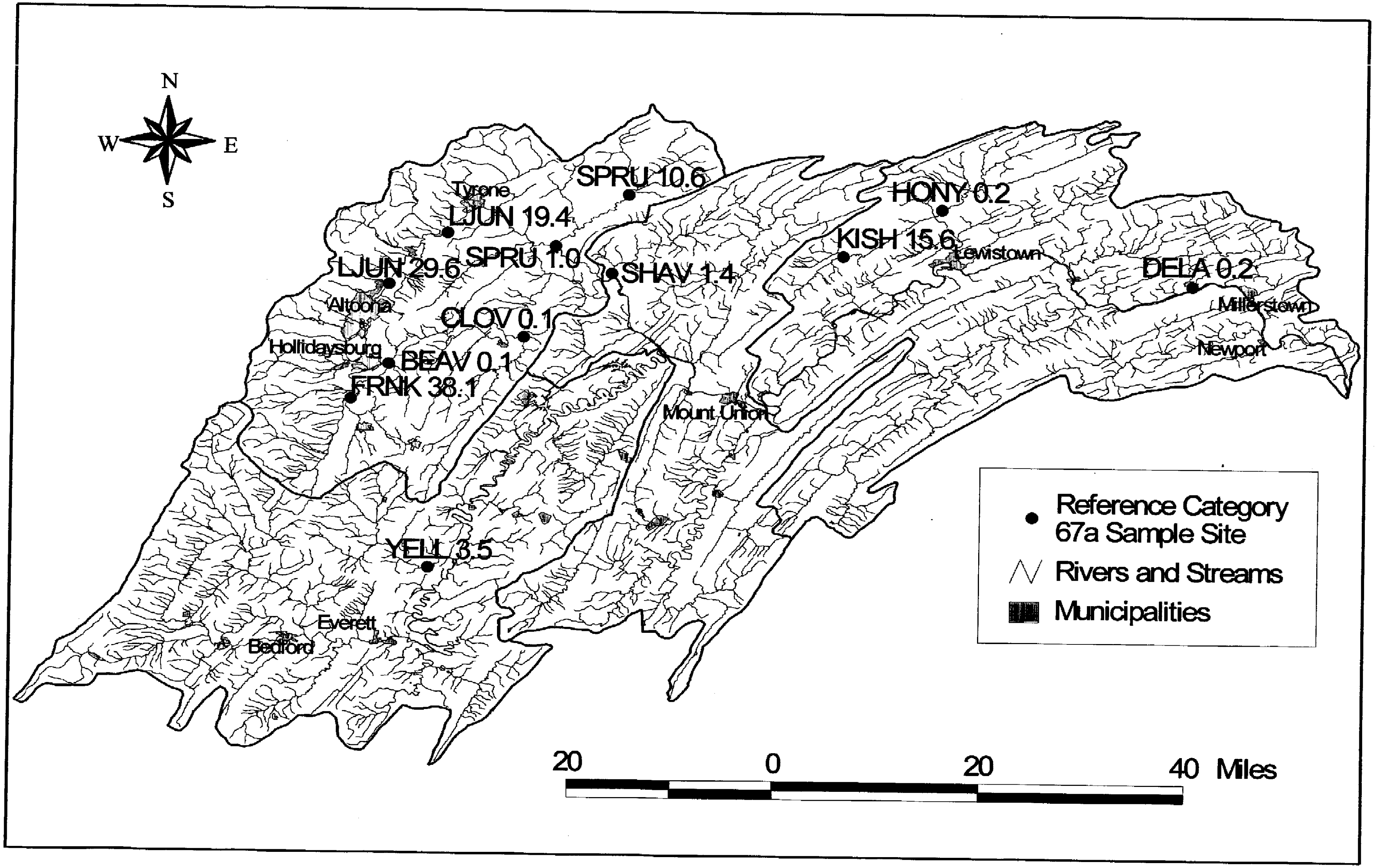


Figure 2. Map of Reference Category 67a Sample Sites, Sites With Drainage Areas Less Than 100 Square Miles Located in Limestone/Dolomite Valleys

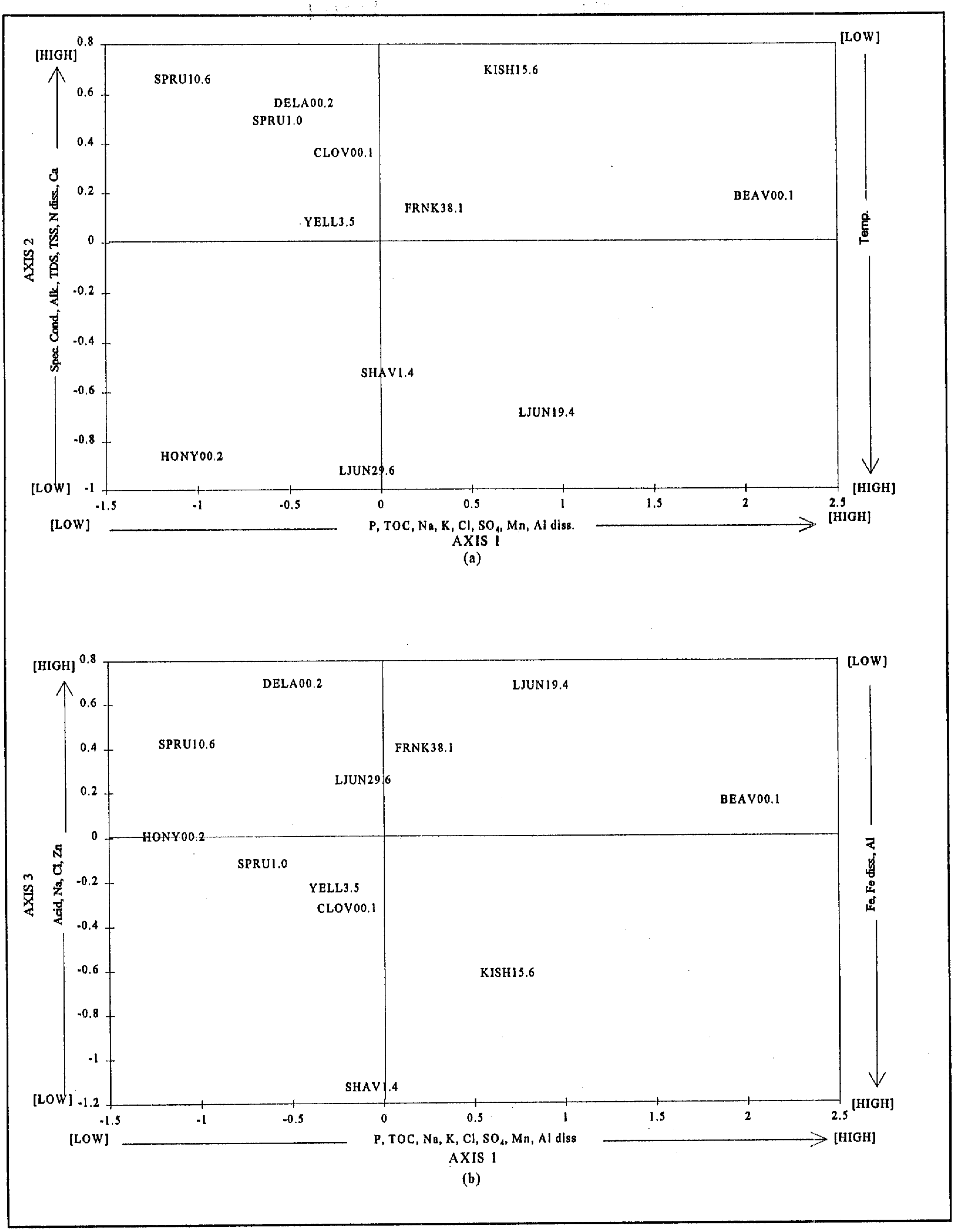
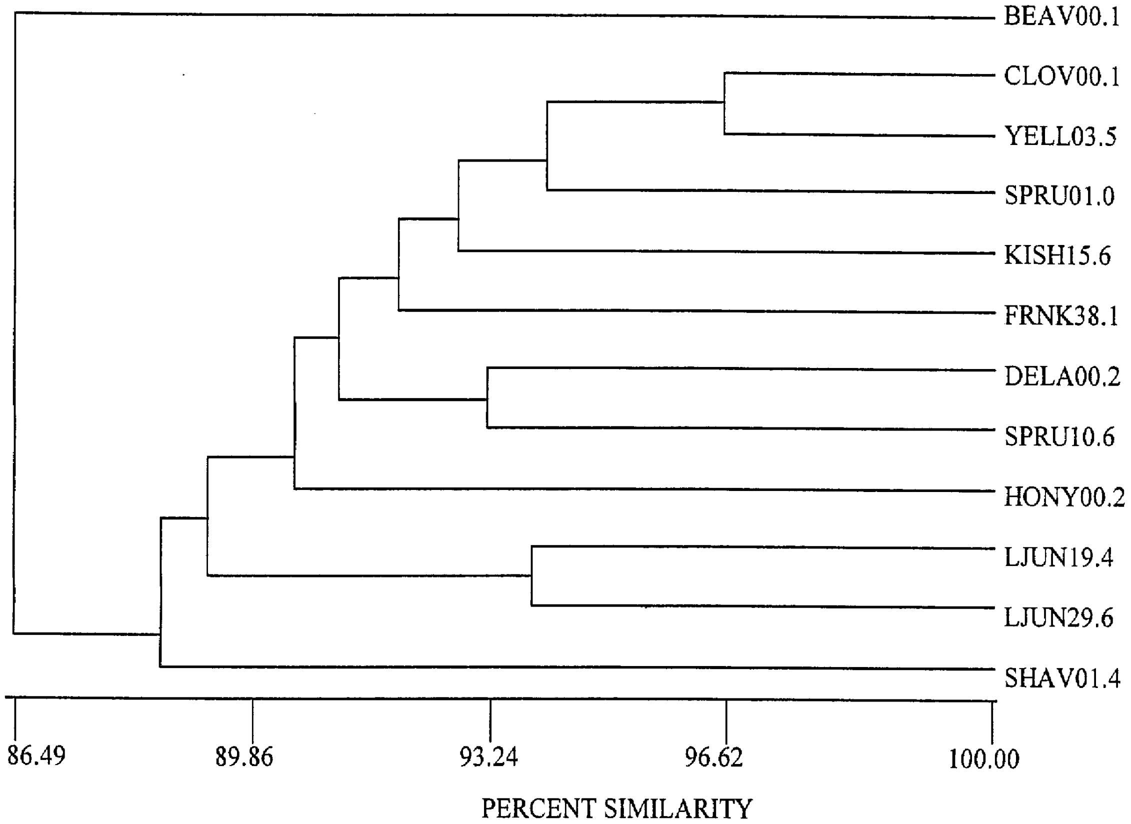


Figure 3. ***Ordinations of Reference Category 67a Sample Sites Based on Principal Components Analysis of Water Quality Data** ((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)*



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Major Ions	Metals
Temp.	N diss.	TOC	Ca	Fe
Spec. Cond.	P		Na	Fe diss.
Alk. (field)			K	Mn
Acid. (field)			Cl	Zn
TDS			SO_4	Al
TSS				Al diss.

Figure 4. Dendrogram of Reference Category 67a Sample Sites Generated by Cluster Analysis of the Water Quality Parameters That Account for Most of the Variability in the 67a Water Quality Data, as Identified by PCA

Table 7. ***Summary of Reference Category 67a RBP III Habitat Data***

	YEL03.5	SPRU00.1	CLOV00.1	FRNK38.1	HONY00.3	KISH15.6	SHAV01.4	LJUN19.4	LJUN29.6	SPRU10.6	BEAV00.1	DELA00.2
Primary Parameters												
Substrate	18	19	19	18	17	6	6	18	18	17	8	17
Embeddedness	14	18	14	15	16	1	7	16	14	12	2	12
Velocity/Depth Diversity	19	18	19	16	19	11	8	19	14	13	12	8
Total	51	55	52	49	52	18	21	53	46	42	22	37
Percent of Reference	100	108	102	96	102	35	41	104	90	82	43	73
Secondary Parameters												
Pool/Riffle Ratio	15	15	15	15	15	1	4	14	14	12	13	11
Pool Quality	13	15	14	10	15	6	4	15	7	14	8	7
Riffle/Run Quality	15	15	14	14	14	4	4	14	7	13	5	8
Channel Alteration	14	15	14	10	10	1	2	10	11	9	0	7
Total	57	60	57	49	54	12	14	53	39	48	26	33
Percent of Reference	100	105	100	86	95	21	25	93	68	84	46	58
Tertiary Parameters												
U/L Strmbnk Erosion	9	10	10	1	6	2	5	9	9	7	0	6
U/L Strmbnk Stability	10	10	10	3	7	4	8	10	10	7	4	8
Vegetative Cover	9	10	10	2	7	7	7	7	8	8	3	9
FRB Zone Width	3	5	5	1	3	1	2	10	3	4	9	5
Total	31	35	35	7	23	14	22	36	30	26	16	28
Percent of Reference	100	113	113	23	74	45	71	116	97	84	52	90
Total Habitat Score												
Total Habitat Score	**139**	**150**	**144**	**105**	**129**	**44**	**57**	**142**	**115**	**116**	**64**	**98**
Habitat % of Reference	**100**	**108**	**104**	**76**	**93**	**32**	**41**	**102**	**83**	**83**	**46**	**71**

Table 8. ***Summary of Reference Category 67a RBP III Biological Data***

	YELL 3.5	SPRU 1.0	KISH 15.6	CLOV 0.1	SHAV 1.4	FRNK 38.1	HONY 0.3	LJUN 29.6	LJUN 19.4	SPRU 10.6	DELA 0.2	BEAV 0.1
Raw Data Summary												
Number of Individuals	102	101	97	102	102	99	101	112	103	100	102	89
Percent Shredders	6.9	2	7.2	7.8	0	1	1	7.1	0	49	67.6	11.2
Percent Collector-Gatherers	48	46.5	36.1	24.5	6.9	55.6	13.9	68.8	38.8	3	8.8	30.3
Percent Filterer-Collectors	21.6	7.9	16.5	14.7	25.5	22.2	50.5	16.1	47.6	20	4.9	55.1
Percent Scrapers	19.6	39.6	39.2	47.1	54.9	17.2	31.7	5.4	10.7	27	17.6	3.4
Percent Predators	3.9	4	1	5.9	12.7	4	3	2.7	2.9	1	1	0
Number of EPT Taxa	10	8	8	7	9	7	10	8	6	4	5	2
Metric Scores												
Taxonomic Richness	20	16	13	16	19	16	16	13	14	10	10	5
Diversity Index	3.47	2.74	2.72	3.32	3.4	2.99	3.28	2.21	2.95	2.22	1.71	1.59
Hilsenhoff Biotic Index	4.36	4.91	5.42	4.48	4.12	5.29	4.36	5.92	5.08	5.44	5.59	5.16
EPT Index	10	8	8	7	9	7	10	8	6	4	5	2
Percent Taxonomic Similarity	100	47	52	54	29	56	31	38	53	8	21	28
Percent Trophic Similarity	100	80	80	70	52	92	59	79	74	51	39	62
Percent of Reference												
Taxonomic Richness	100	80	65	80	95	80	80	65	70	50	50	25
Diversity Index	100	79	78.4	95.7	98	86.2	94.5	63.7	85	64	49.3	45.8
Hilsenhoff Biotic Index	100	88.8	80.5	97.4	106	82.4	100.1	73.7	85.9	80.2	78.1	84.6
EPT Index	100	80	80	70	90	70	100	80	60	40	50	20
Percent Taxonomic Similarity	100	47	52	54	29	56	31	38	53	8	21	28
Percent Trophic Similarity	100	80	80	70	52	92	59	79	74	51	39	62
Biological Condition Scores												
Taxonomic Richness	6	6	4	6	6	6	6	4	4	2	2	0
Diversity Index	6	6	6	6	6	6	6	4	6	4	2	2
Hilsenhoff Biotic Index	6	6	4	6	6	4	6	4	6	4	4	4
EPT Index	6	4	4	2	6	2	6	4	0	0	0	0
Percent Taxonomic Similarity	6	6	6	6	2	6	2	4	6	0	2	2
Percent Trophic Similarity	6	6	6	4	4	6	4	6	4	4	2	4
Total Biological Score												
Total Biological Score	**36**	**34**	**30**	**30**	**30**	**30**	**30**	**26**	**26**	**14**	**12**	**12**
Biological % of Reference	**100**	**94**	**83**	**83**	**83**	**83**	**83**	**72**	**72**	**39**	**33**	**33**

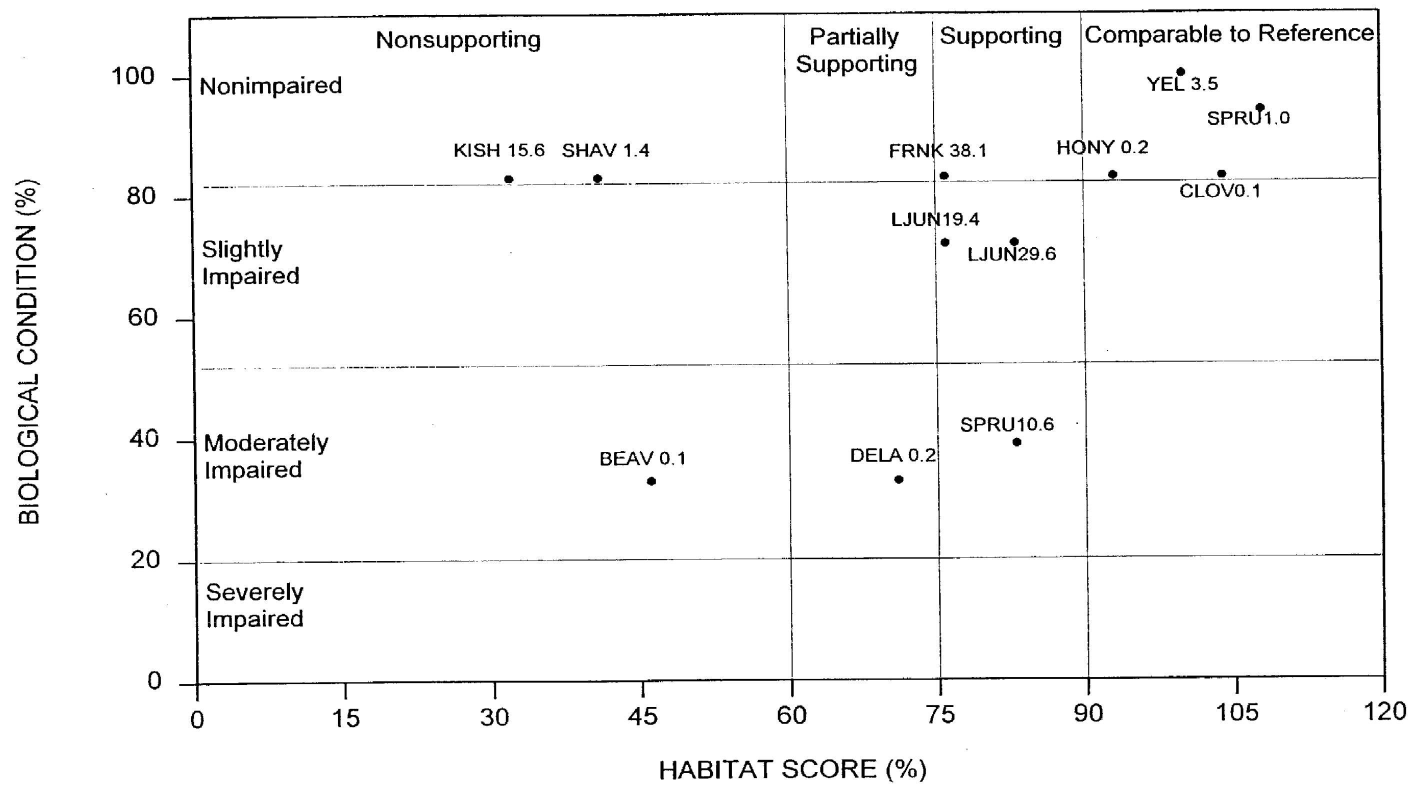


Figure 5. Summary of Reference Category 67a RBP III Habitat and Biological Data

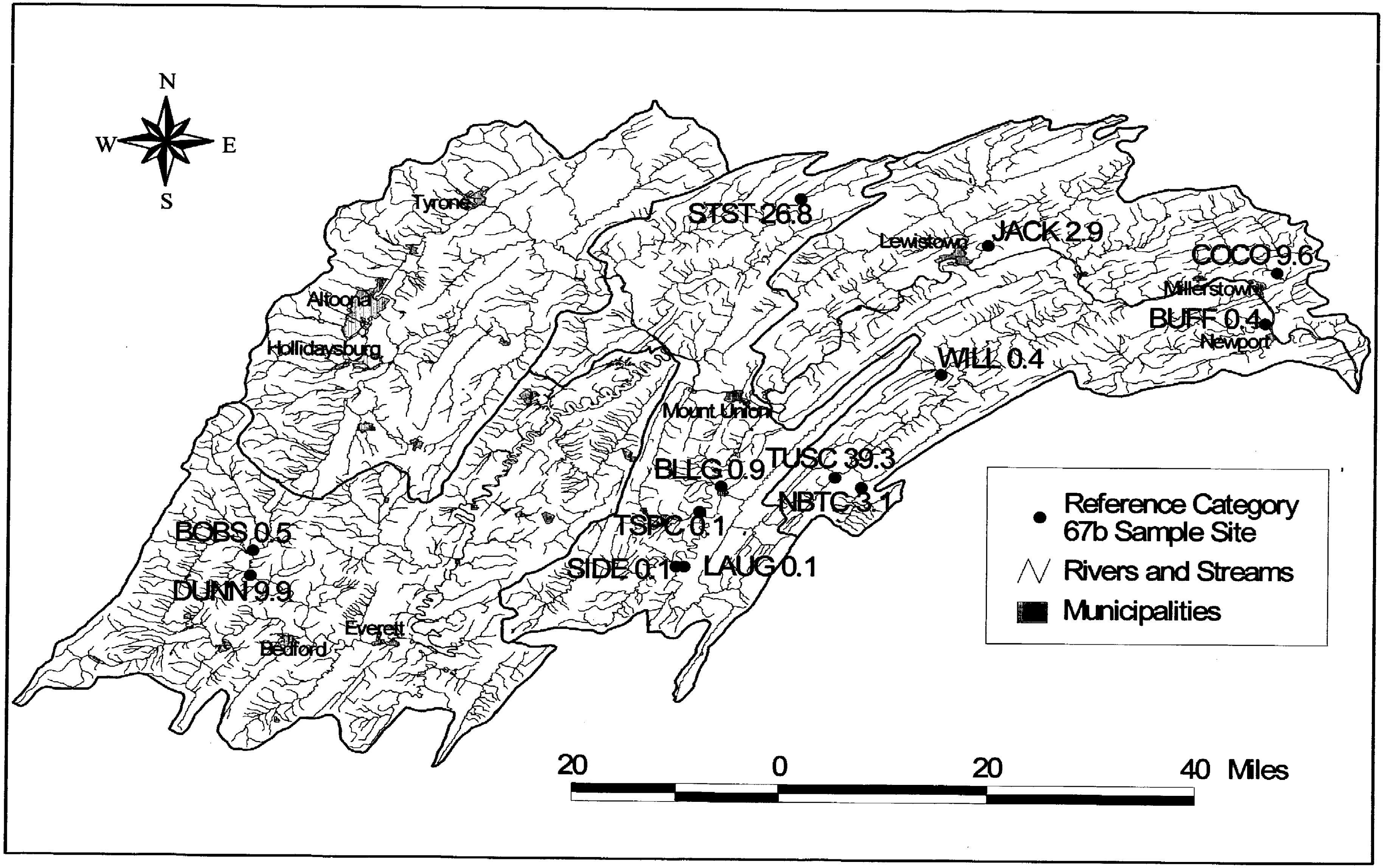


Figure 6. ***Map of Reference Category 67b Sample Sites, Sites With Drainage Areas Less Than 100 Square Miles Located in Non-Calcareous Valleys***

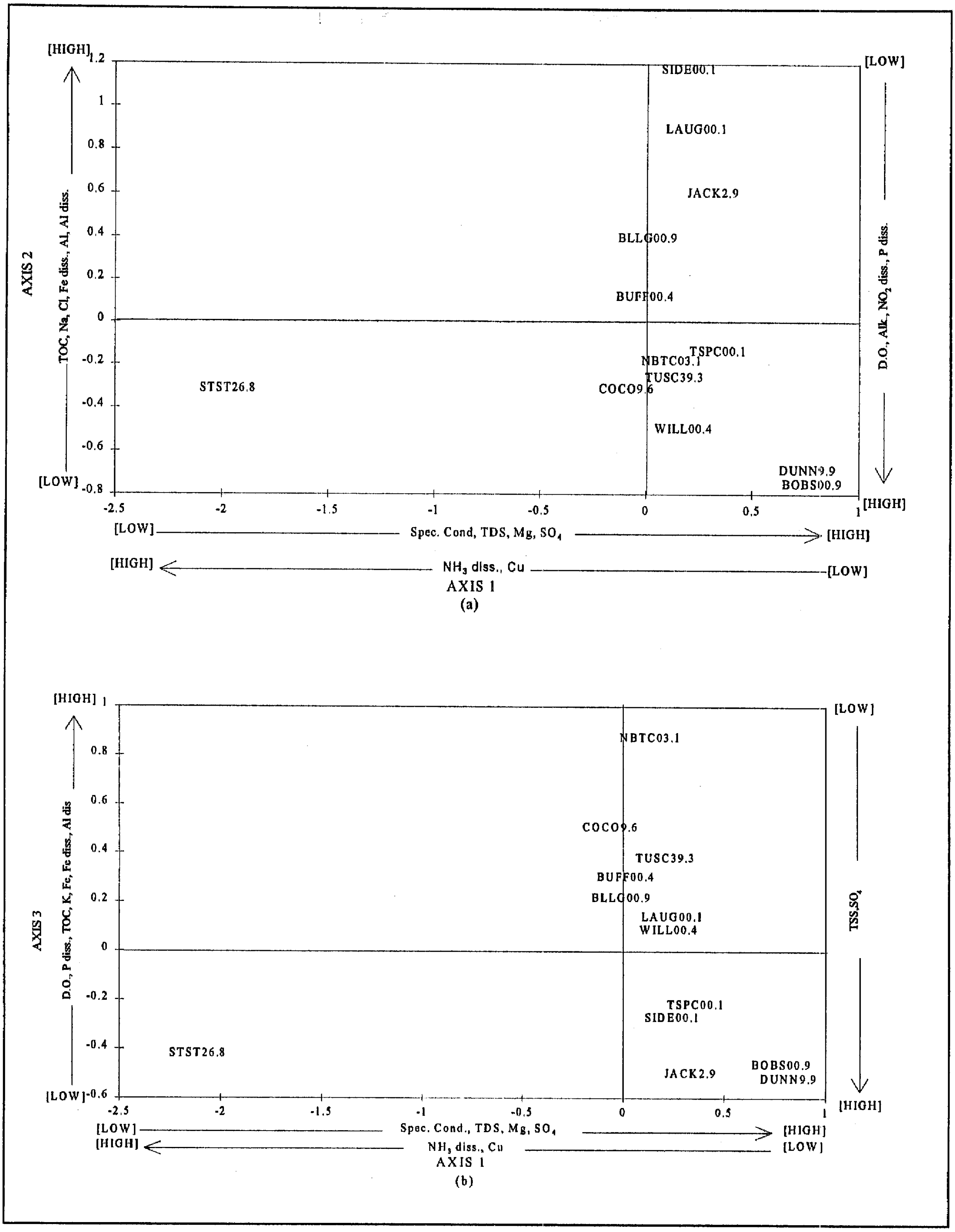
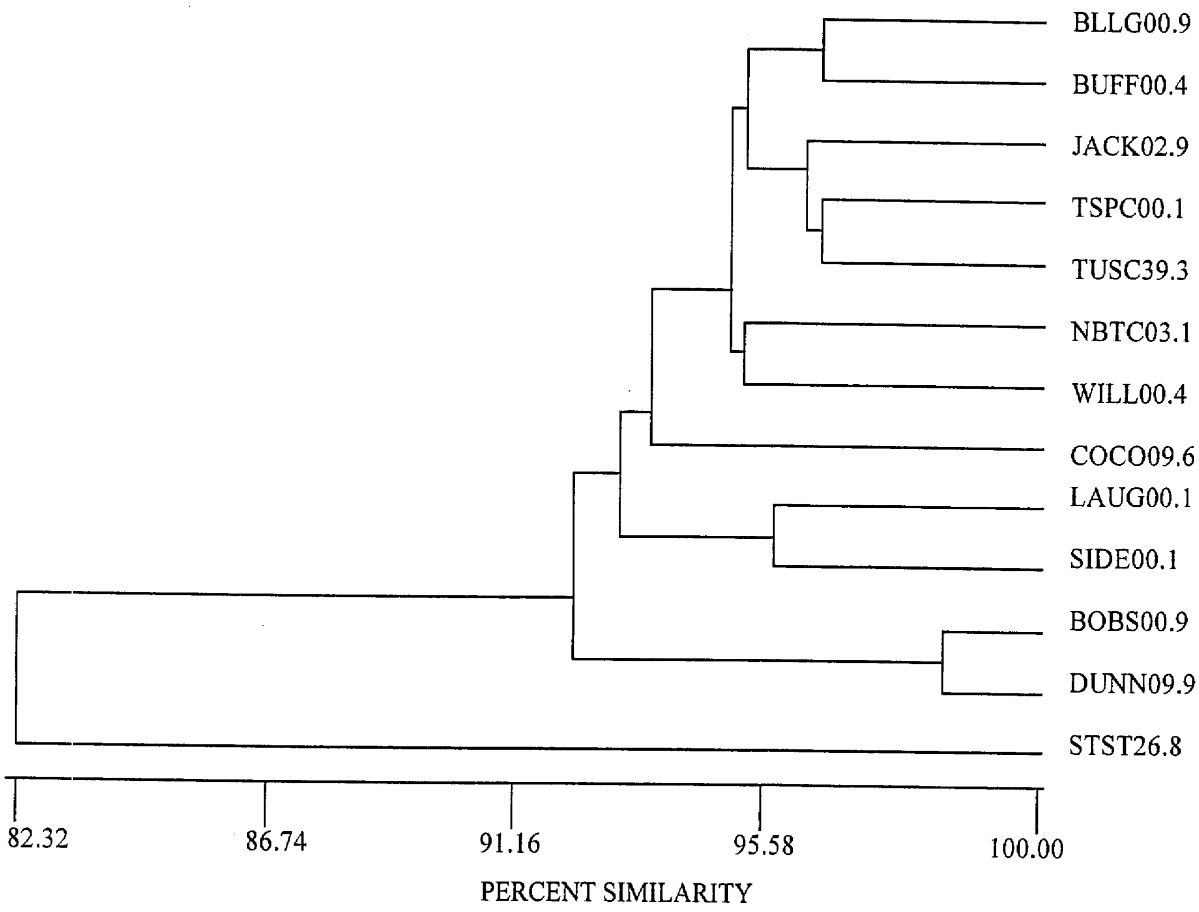


Figure 7. Ordinations of Reference Category 67b Sample Sites Based on Principal Components Analysis of Water Quality Data ((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Major Ions	Metals
D.O.	NH_3 diss.	TOC	Mg	Cu
Spec. Cond.	NO_2 diss.		Na	Fe
Alk. (field)	P diss.		K	Fe diss.
TDS			Cl	Al
TSS			SO_4	Al diss.

Figure 8. Dendrogram of Reference Category 67b Sample Sites Generated by Cluster Analysis of the Water Quality Parameters That Account for Most of the Variability in the 67b Water Quality Data, as Identified by PCA

Table 9. ***Summary of Reference Category 67b RBP III Habitat Data***

	LAUG00.1	BUFF00.4	SIDE00.1	WILL00.4	TSPC00.1	COCO09.6	NBTC03.1	JACK02.9	STST26.8	TUSC39.3	BLLG00.9	BOBS00.9	DUNN09.9
Primary Parameters													
Substrate	19	9	18	8	17	17	15	14	18	16	20	16	16
Embeddedness	18	14	18	12	19	16	16	14	18	15	19	14	15
Velocity/Depth Diversity	20	14	19	10	16	15	14	16	15	14	14	19	8
Total	57	37	55	30	52	48	45	44	51	45	53	49	39
Percent of Reference	100	65	96	53	91	84	79	77	89	79	93	86	68
Secondary Parameters													
Pool/Riffle Ratio	15	7	14	9	15	10	10	12	15	7	15	9	2
Pool Quality	14	10	11	6	7	13	5	13	13	10	14	14	13
Riffle/Run Quality	14	11	15	10	15	11	11	11	11	11	14	9	0
Channel Alteration	12	8	15	10	9	11	13	12	10	12	5	13	8
Total	55	36	55	35	46	45	39	48	49	40	48	45	23
Percent of Reference	100	65	100	64	84	82	71	87	89	73	87	82	42
Tertiary Parameters													
U/L Strmbnk Erosion	6	5	10	6	8	8	7	5	9	7	10	5	8
U/L Strmbnk Stabability	10	7	10	5	9	7	9	6	10	9	10	8	8
Vegetative Cover	9	7	5	8	9	7	9	7	7	8	10	9	7
FRB Zone Width	5	5	4	5	4	5	3	5	5	5	3	1	1
Total	30	24	29	24	30	27	28	23	31	29	33	23	24
Percent of Reference	100	80	97	80	100	90	93	77	103	97	110	77	80
Total Habitat Score													
Total Habitat Score	**142**	**97**	**139**	**89**	**128**	**120**	**112**	**115**	**131**	**114**	**134**	**117**	**86**
Habitat % of Reference	**100**	**68**	**98**	**63**	**90**	**85**	**79**	**81**	**92**	**80**	**94**	**82**	**61**

Table 10. Summary of Reference Category 67b RBP III Biological Data

	LAUG00.1	BUFF 0.4	SIDE 0.1	WILL 0.4	TSPC 0.1	COCO 9.6	NBTC 3.1	JACK 2.9	STST 26.8	TUSC 39.3	BLLG 0.9	BOBS00.9	DUNN 9.9
Raw Data Summary													
Number of Individuals	98	101	104	101	104	104	104	100	104	96	99	108	102
Percent Shredders	1	1	1	11.9	3.8	2.9	1	4	20.2	4.2	2	0	0
Percent Collector-Gatherers	12.2	14.9	14.4	12.9	6.7	18.3	7.7	46	12.5	5.2	25.3	58.3	56.9
Percent Filterer-Collectors	51	51.5	58.7	46.5	33.7	22.1	59.6	30	46.2	53.1	21.2	14.8	2.9
Percent Scrapers	26.5	25.7	17.3	16.8	42.3	40.4	22.1	13	3.8	8.3	46.5	20.4	24.5
Percent Predators	9.2	6.9	8.7	11.9	13.5	16.3	9.6	7	17.3	29.2	5.1	6.5	15.7
Number of EPT Taxa	10	9	10	10	8	9	10	13	14	7	8	6	6
Metric Scores													
Taxonomic Richness	21	19	17	20	18	21	17	24	25	18	18	17	13
Diversity Index	3.83	3.33	3.4	3.58	3.49	3.69	3.38	3.71	3.47	3.55	3.19	2.9	2.86
Hilsenhoff Biotic Index	3.7	3.49	3.95	3.06	4.04	4.2	3.19	4.93	1.85	3.26	4.59	5.4	5.49
EPT Index	10	9	10	10	8	9	10	13	14	7	8	6	6
Percent Taxonomic Similarity	100	54.3	68.3	47.2	50.5	44.6	32.7	38.4	24.8	50.5	37.6	28.2	19
Percent Trophic Similarity	100	96.9	90.2	85.7	77.1	71	91.1	63.2	72.4	74.7	66	53.9	48.8
Percent of Reference													
Taxonomic Richness	100	90.5	81	95.2	85.7	100	81	114.3	119	85.7	85.7	81	61.9
Diversity Index	100	86.9	88.8	93.5	91.1	96.3	88.3	96.9	90.6	92.7	83.3	75.7	74.7
Hilsenhoff Biotic Index	100	106.3	93.7	121.1	91.7	88.2	116	75.1	200.6	113.6	80.8	68.6	67.5
EPT Index	100	90	100	100	80	90	100	130	140	70	80	60	60
Percent Taxonomic Similarity	100	54.3	68.3	47.2	50.5	44.6	32.7	38.4	24.8	50.5	37.6	28.2	19
Percent Trophic Similarity	100	96.9	90.2	85.7	77.1	71	91.1	63.2	72.4	74.7	66	53.9	48.8
Biological Condition Scores													
Taxonomic Richness	6	6	6	6	6	6	6	6	6	6	6	6	4
Diversity Index	6	6	6	6	6	6	6	6	6	6	6	6	4
Hilsenhoff Biotic Index	6	6	6	6	6	6	6	4	6	6	4	2	2
EPT Index	6	6	6	6	4	6	6	6	6	2	4	0	0
Percent Taxonomic Similarity	6	6	6	6	6	4	2	4	2	6	4	2	0
Percent Trophic Similarity	6	6	6	6	6	4	6	4	4	4	4	4	2
Total Biological Score													
Total Biological Score	**36**	**36**	**36**	**36**	**34**	**32**	**32**	**30**	**30**	**30**	**28**	**20**	**12**
Biological % of Reference	**100**	**100**	**100**	**100**	**94**	**89**	**89**	**83**	**83**	**83**	**78**	**56**	**33**

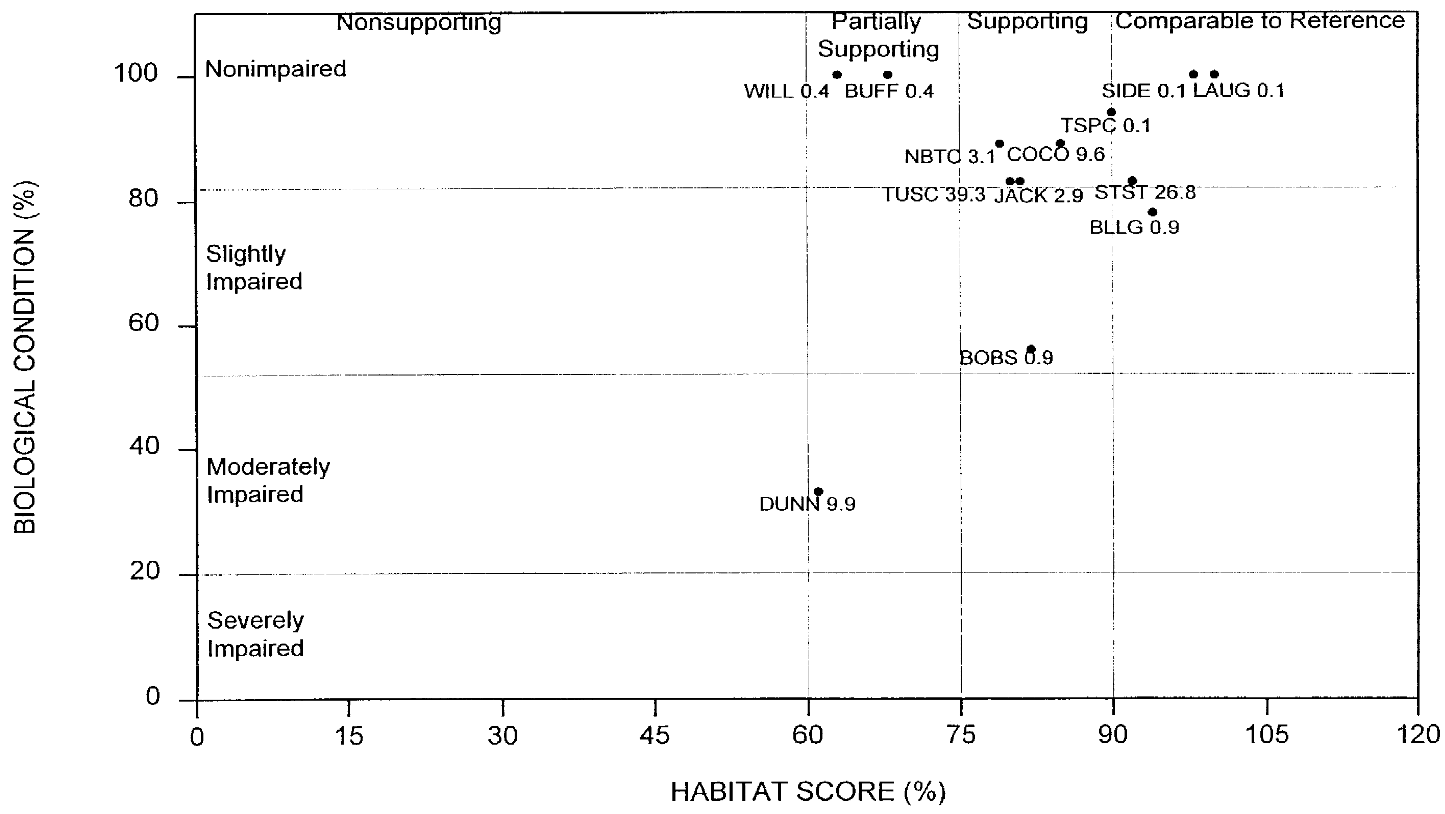


Figure 9. Summary of Reference Category 67b RBP III Habitat and Biological Data

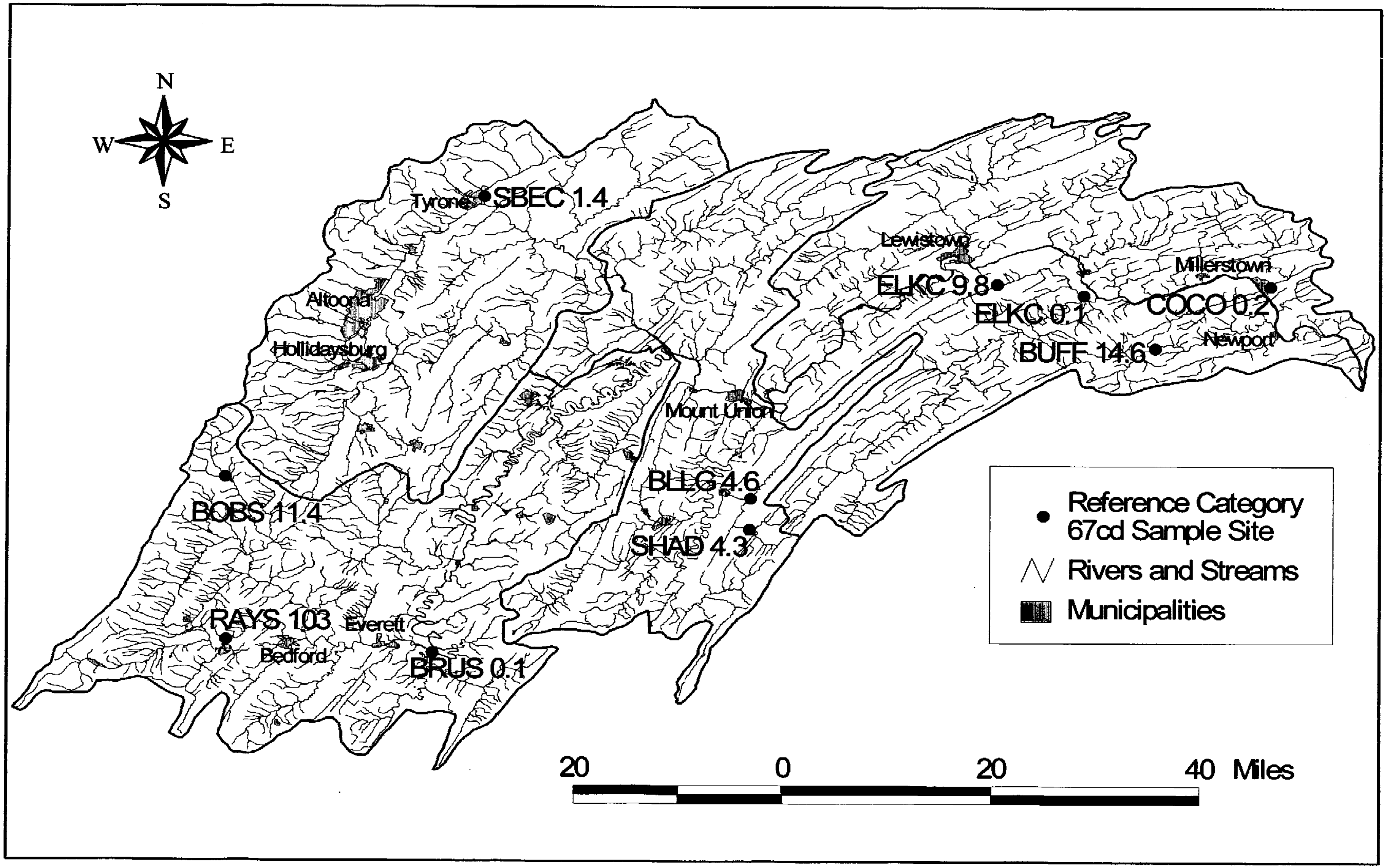


Figure 10. Map of Reference Category 67cd Sample Sites, Sites With Drainage Areas Less Than 100 Square Miles Located on Sandstone or Shale Ridges

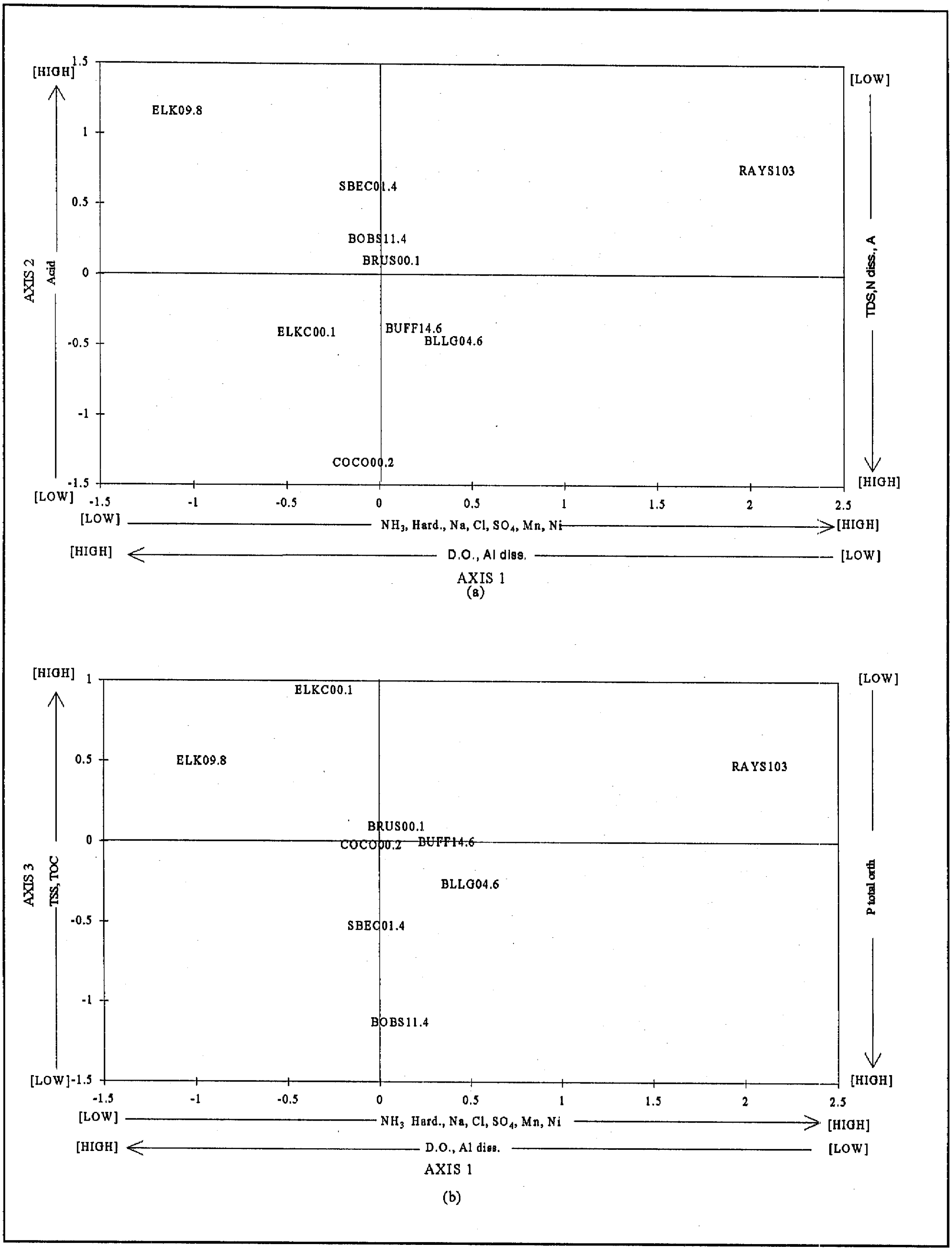
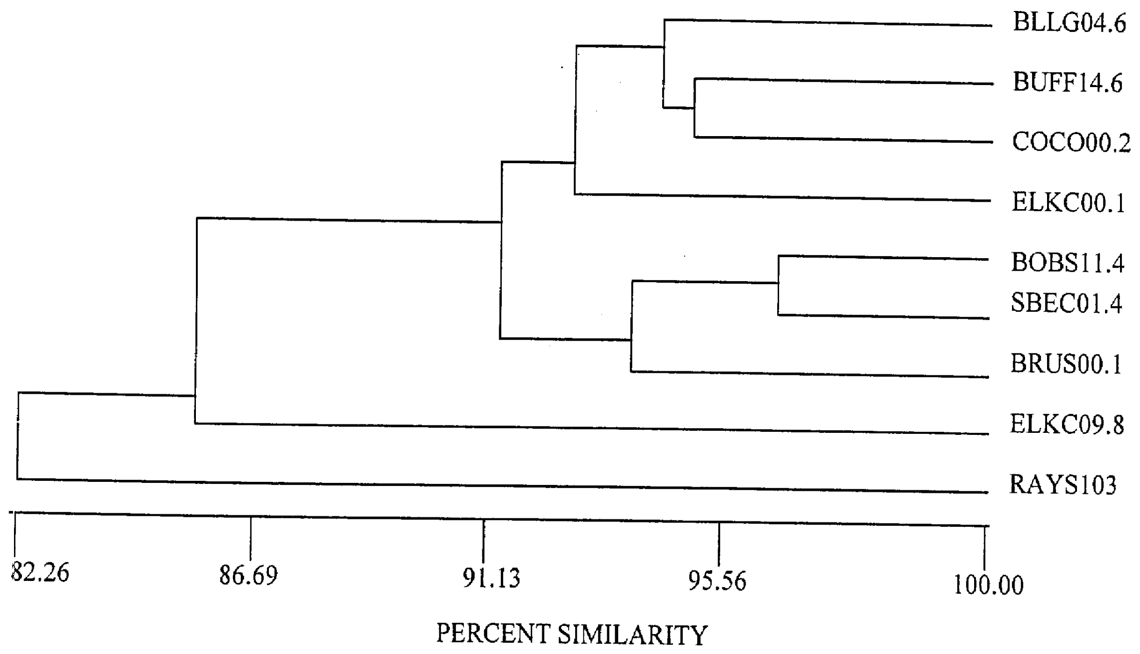


***Figure 11. Ordinations of Reference Category 67cd Sample Sites Based on Principal Components Analysis of Water Quality Data** ((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)*



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Major Ions	Metals
D.O.	N diss.	TOC	Na	Mn
Spec. Cond.	NH_3		Cl	Ni
Acid. (field)	P total ortho		SO_4	Al
TDS				Al diss.
TSS				
Hard.				

Figure 12. Dendrogram of Reference Category 67cd Sample Sites Generated by Cluster Analysis of the Water Quality Parameters That Account for Most of the Variability in the 67cd Water Quality Data, as Identified by PCA

The biological communities of nine (90 percent) of these sites are nonimpaired and one (10 percent) is slightly impaired. RBP III physical habitat and biological data are summarized in Tables 11 and 12 and Figure 13.

Reference Category 67m

Fourteen sample sites are included in reference category 67m, sites located in Ecoregion 67 with drainage areas between 100 and 500 sq. mi. (Figure 14). PCA identified a subset of 14 water quality parameters that account for most of the variation in the data. The results of principal components and cluster analyses are presented in Figures 15 and 16, respectively.

The biological communities of three (21 percent) of these sites are nonimpaired, nine (64 percent) are slightly impaired, and two (14 percent) are moderately impaired. RBP III physical habitat and biological data are summarized in Tables 13 and 14 and Figure 17.

Reference Category 67l

Reference category 67 consists of 10 sites located in Ecoregion 67, with drainage areas greater than 500 sq. mi. (JUN 2.0 water quality only) (Figure 18). PCA identified a subset of 17 water quality parameters that account for most of the variation in the data. The results of principal components and cluster analyses are presented in Figures 19 and 20, respectively.

The biological communities of four (44 percent) of these sites are nonimpaired. Of the remaining sites, three (33 percent) support biological communities that are slightly impaired, and two (22 percent) sites have moderately impaired communities. RBP III physical habitat and biological data are summarized in Tables 15 and 16 and Figure 21.

Reference Category 69a

GTRC 2.9 is the only sample site included in reference category 69a, sites with drainage areas of less than 100 sq. mi., located in the forested hills and mountains section of the Central Appalachians Ecoregion (Ecoregion 69). RBP III data indicate habitat conditions of this site are excellent and the biological community is slightly impaired. RBP III physical habitat and biological data are summarized in Table 17.

Table 11. Summary of Reference Category 67cd RBP III Habitat Data

	SBEC01.4	SHAD04.3	BLLG04.6	BOBS11.4	ELKC00.1	BRUS00.1	BUFF14.6	ELKC09.8	RAYS103	COCO00.2
Primary Parameters										
Substrate	19	16	17	19	13	19	16	16	17	9
Embeddedness	20	18	14	18	17	17	15	16	16	11
Velocity/Depth Diversity	19	14	12	18	17	18	16	14	12	17
Total	58	48	43	55	47	54	47	46	45	37
Percent of Reference	100	83	74	95	81	93	81	79	78	64
Secondary Parameters										
Pool/Riffle Ratio	14	12	15	15	13	15	11	12	11	7
Pool Quality	13	15	12	14	9	9	7	6	9	13
Riffle/Run Quality	15	7	8	14	10	13	12	13	9	13
Channel Alteration	11	8	7	15	10	11	9	12	8	12
Total	53	42	42	58	42	48	39	43	37	45
Percent of Reference	100	79	79	109	79	91	74	81	70	85
Tertiary Parameters										
U/L Strmbnk Erosion	8	3	7	7	7	9	8	9	10	6
U/L Strmbnk Stability	10	9	8	9	9	9	7	9	10	5
Vegetatiave Cover	5	8	7	8	9	9	7	8	7	7
FRB Zone Width	7	2	2	10	2	3	8	9	2	3
Total	30	22	24	34	27	30	30	35	29	21
Percent of Reference	100	73	80	113	90	100	100	117	97	70
Total Habitat Score										
Total Habitat Score	**141**	**112**	**109**	**147**	**116**	**132**	**116**	**124**	**111**	**103**
Habitat% of Reference	**100**	79	77	**104**	**82**	**94**	**82**	**88**	79	73

Table 12. Summary of Reference Category 67cd RBP III Biological Data

	SBEC 1.4	SHAD 4.3	BLLG 4.6	BOBS 11.4	ELKC O.1	BRUS 0.1	BUFF 14.6	ELKC 9.8	RAYS 103	COCO 0.2
Raw Data Summary										
Number of Individuals	104	102	104	101	102	102	102	100	102	102
Percent Shredders	3.8	25.5	1.9	14.9	0	0	3.9	34	1	1
Percent Collector-Gatherers	23.1	14.7	35.6	15.8	17.6	16.7	10.8	24	2.9	60.8
Percent Filterer-Collectors	43.3	39.2	34.6	43.6	48	60.8	30.4	25	65.7	12.7
Percent Scrapers	18.3	11.8	14.4	6.9	29.4	11.8	35.3	5	14.7	17.6
Percent Predators	11.5	8.8	13.5	18.8	4.9	10.8	19.6	12	15.7	7.8
Number of EPT Taxa	10	10	11	12	11	7	10	13	9	11
Metric Scores										
Taxonomic Richness	19	19	20	18	19	20	21	18	19	21
Diversity Index	3.49	3.45	3.81	3.36	3.44	3.55	3.92	3.13	3.38	2.97
Hilsenhoff Biotic Index	3.77	3	3.86	1.97	3.43	4.42	3.65	2.04	4.17	5.42
EPT Index	10	10	11	12	11	7	10	13	9	11
Percent Taxonomic Similarity	100	54.4	34.6	38.1	35.9	47.6	36.9	33.3	32	41.8
Percent Trophic Similarity	100	78.4	85.6	81.4	84.1	82.5	74.8	68.5	73.4	62.3
Percent of Reference										
Taxonomic Richness	100	100	105.3	94.7	100	105.3	110.5	94.7	100	110.5
Diversity Index	100	98.9	109.2	96.3	98.6	101.7	112.3	89.7	96.8	85.1
Hilsenhoff Biotic Index	100	125.6	97.8	191.3	109.8	85.2	103.3	184.8	90.5	69.5
EPT Index	100	100	110	120	110	70	100	130	90	110
Percent Taxonomic Similarity	100	54.4	34.6	38.1	35.9	47.6	36.9	33.3	32	41.8
Percent Trophic Similarity	100	78.4	85.6	81.4	84.1	82.5	74.8	68.5	73.4	62.3
Biological Condition Scores										
Taxonomic Richness	6	6	6	6	6	6	6	6	6	6
Diversity Index	6	6	6	6	6	6	6	6	6	6
Hilsenhoff Biotic Index	6	6	6	6	6	6	6	6	6	2
EPT Index	6	6	6	6	6	2	6	6	6	6
Percent Taxonomic Similarity	6	6	4	4	4	6	4	4	2	4
Percent Trophic Similarity	6	6	6	6	6	6	4	4	4	4
Total Biological Score										
Total Biological Score	**36**	**36**	**34**	**34**	**34**	**32**	**32**	**32**	**30**	**28**
Biological % of Reference	**100**	**100**	**94**	**94**	**94**	**89**	**89**	**89**	**83**	**78**

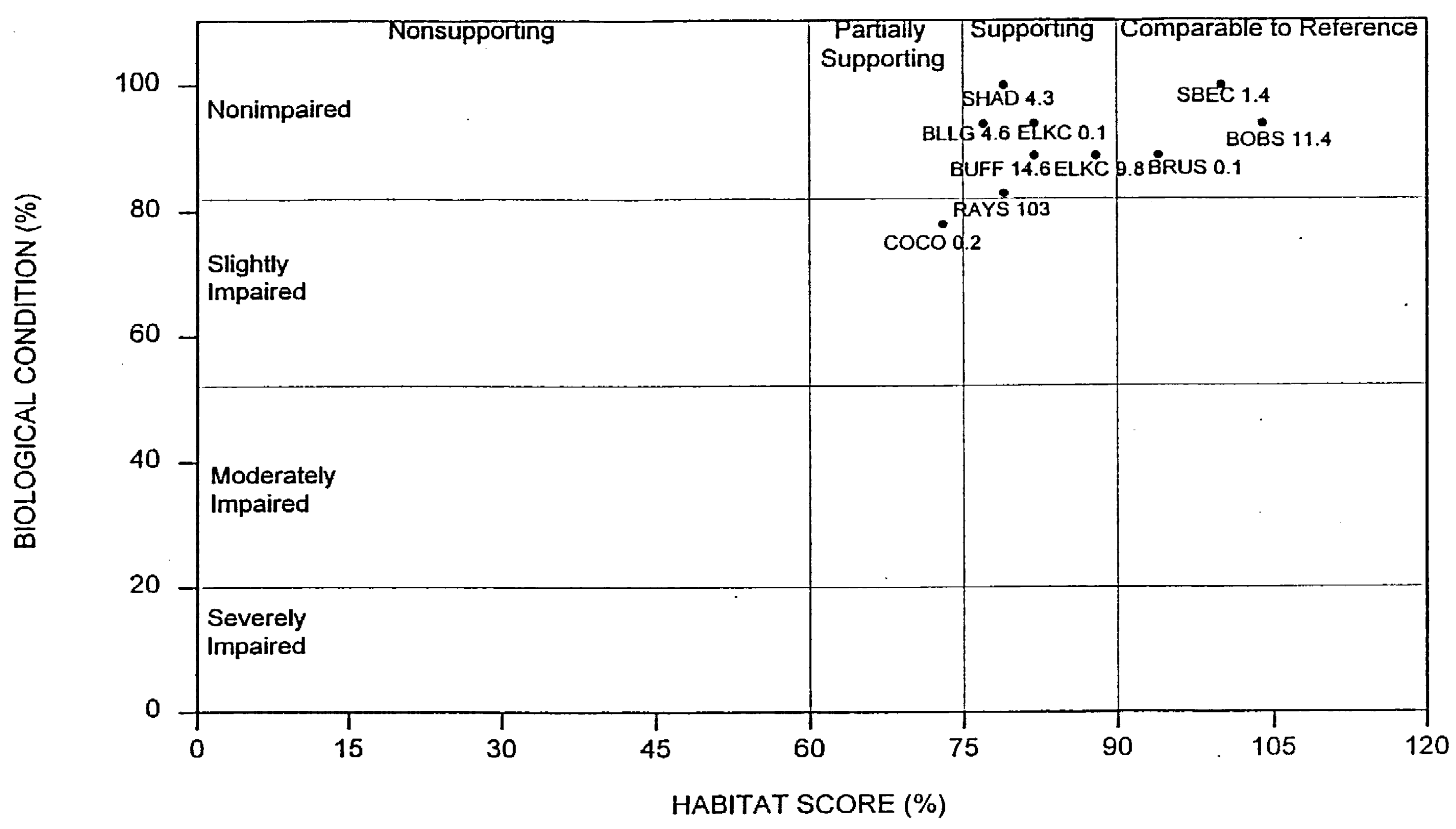


Figure 13. Summary of Reference Category 67cd RBP III Habitat and Biological Data

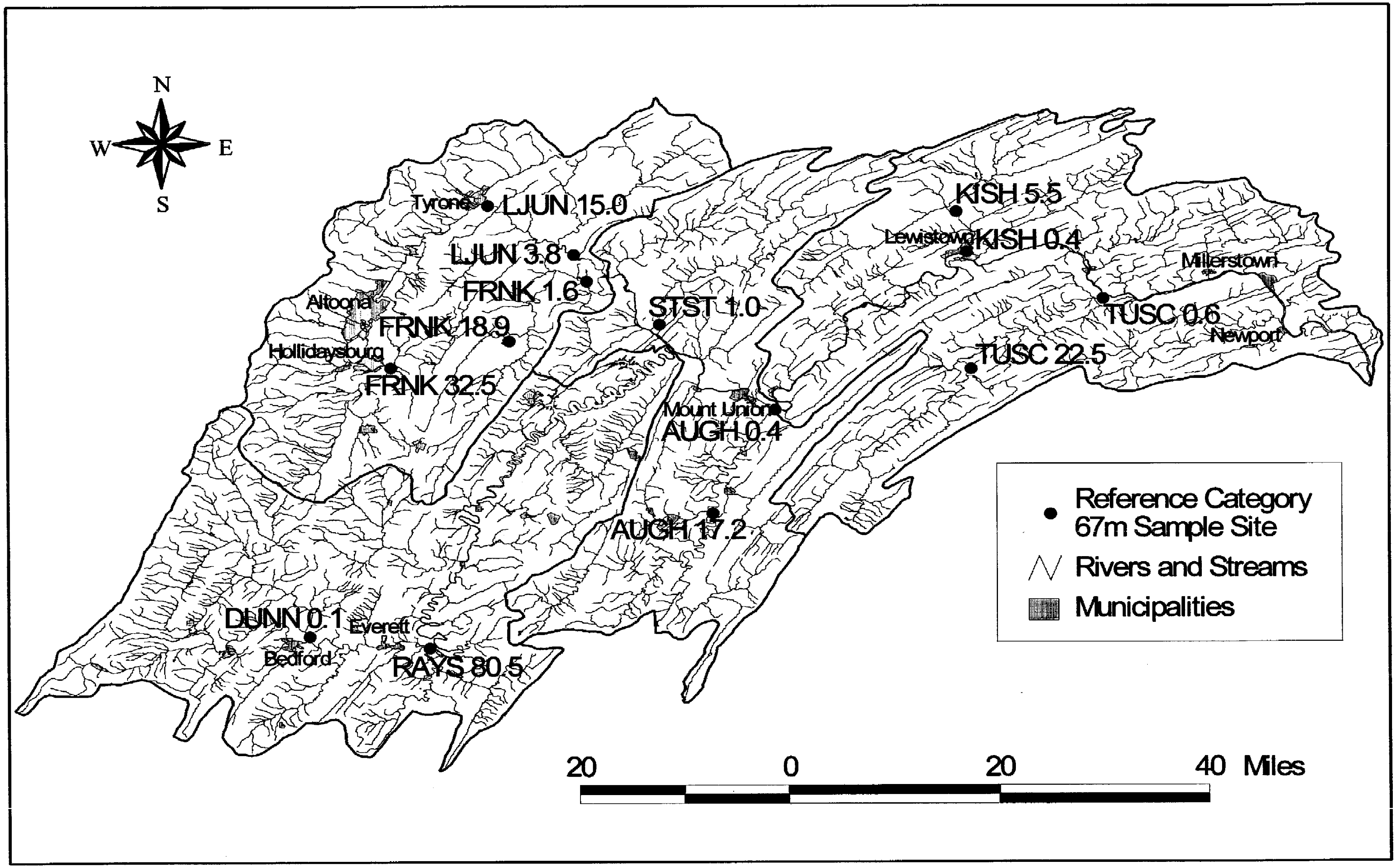


Figure 14. ***Map of Reference Category 67m Sample Sites, Sites Located in the Central Appalachian Ridges and Valleys Ecoregion (Ecoregion 67) With Drainage Areas Between 100 and 500 Square Miles***

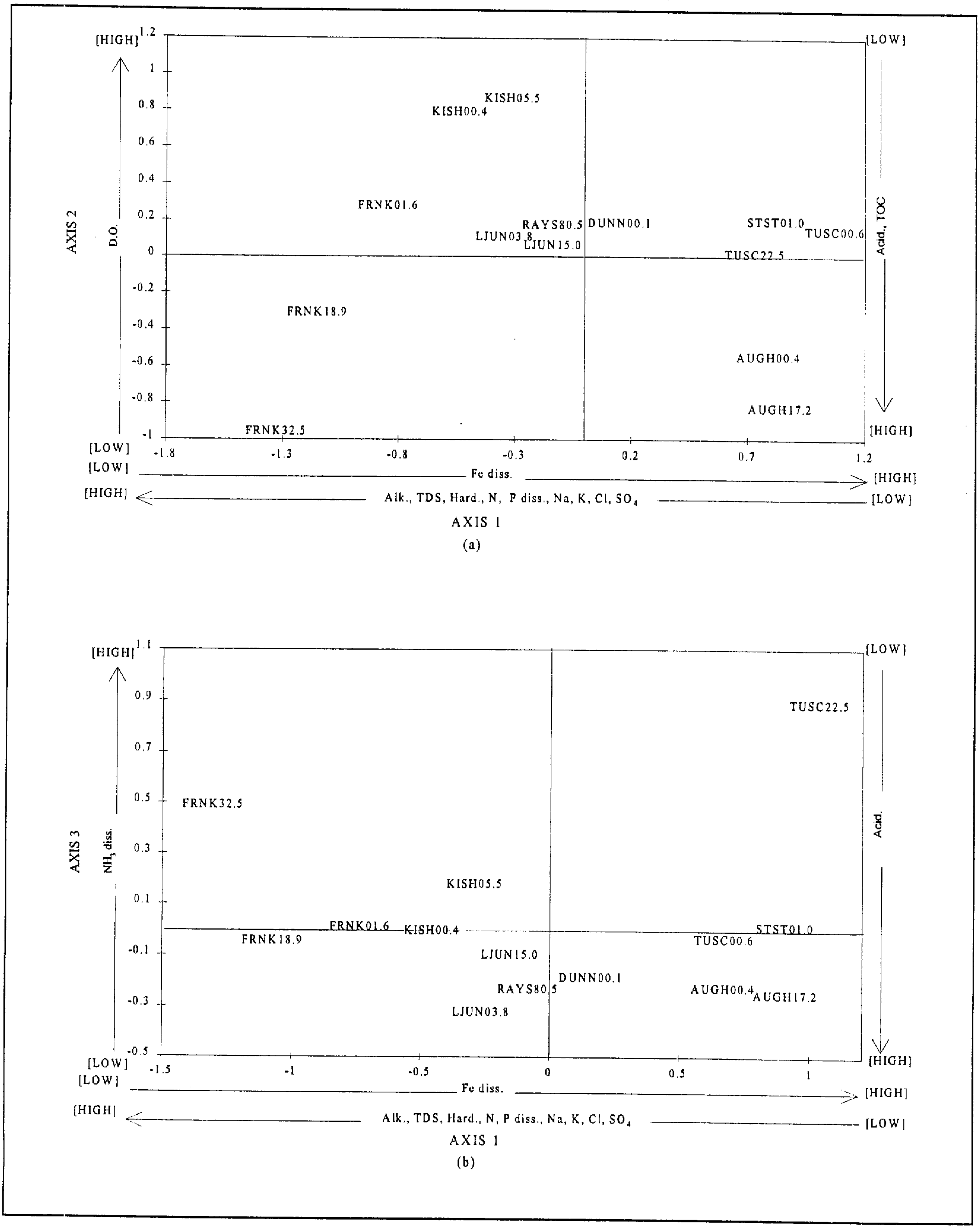
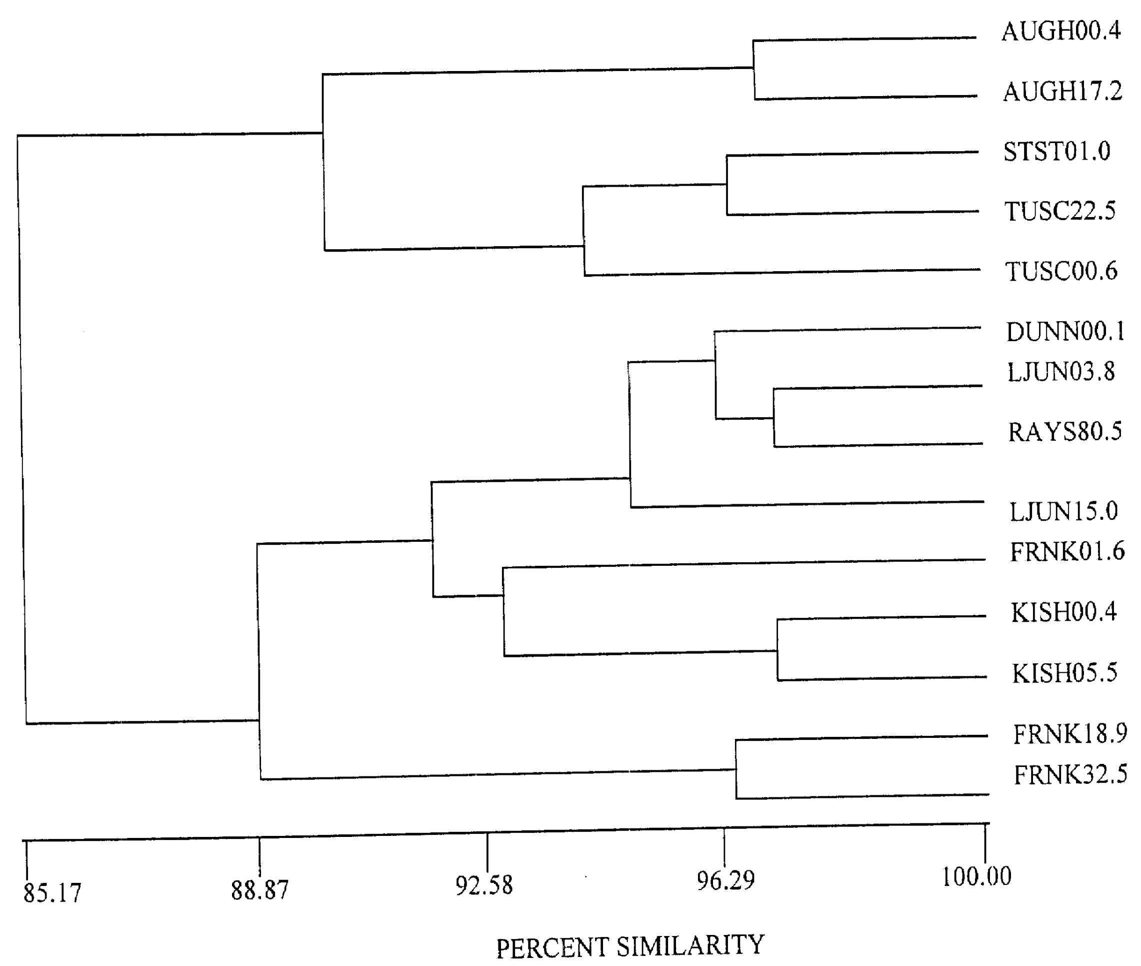


Figure 15. ***Ordinations of Reference Category 67m Sample Sites Based on Principal Components Analysis of Water Quality Data*** *((a) PCA Axis 1 Versus. PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)*



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Major Ions	Metals
D.O.	N	TOC	Na	Fe diss.
Alk. (field)	NH_3 diss.		K	
Acid. (field)	P diss.		Cl	
TDS			SO_4	
Hard.				

Figure 16. Dendrogram of Reference Category 67m Sample Sites Generated by Cluster Analysis of the Water Quality Parameters That Account for Most of the Variability in the 67m Water Quality Data, as Identified by PCA

Table 13. Summary of Reference Category 67m RBP III Habitat Data

	AUGH00.4	TUSC00.6	STST01.0	FRNK01.6	RAYS80.5	AUGH17.2	DUNN00.1	LJUN03.8	LJUN15.0	FRNK18.9	TUSC22.5	KISH 05.5	FRNK32.5	KISH00.4
Primary Parameters														
Substrate	5	13	20	19	16	19	16	18	19	20	15	20	13	14
Embeddedness	20	15	19	11	16	19	3	18	18	15	13	19	7	11
Velocity/Depth Diversity	19	17	18	19	18	18	17	18	14	20	18	20	16	16
Total	44	45	57	49	50	56	36	54	51	55	46	59	36	41
Percent of Reference	100	102	130	111	114	127	82	123	116	125	105	134	82	93
Secondary Parameters														
Pool/Riffle Ratio	14	8	12	14	14	13	6	9	10	15	14	15	12	10
Pool Quality	9	12	14	14	11	12	8	14	13	14	14	15	4	14
Riffle/Run Quality	15	13	15	15	15	15	4	14	9	15	13	15	12	12
Channel Alteration	11	10	14	14	9	13	5	13	13	12	8	14	14	6
Total	49	43	55	57	49	53	23	50	45	56	49	59	42	42
Percent of Reference	100	88	112	116	100	108	47	102	92	114	100	120	86	86
Tertiary Parameters														
U/L Strmbnk Erosion	10	2	6	10	8	10	7	9	10	9	7	10	6	2
U/L Strmbnk Stability	10	5	8	10	10	10	9	10	10	10	8	10	7	2
Vegetative Cover	7	6	9	8	6	8	7	8	8	8	9	8	6	7
FRB Zone Width	4	2	4	9	4	5	1	2	4	8	6	4	4	1
Total	31	15	27	37	28	33	24	29	32	35	30	32	23	12
Percent of Reference	100	48	87	119	90	106	77	94	103	113	97	103	74	39
Total Habitat Score														
Total Habitat Score	**124**	**103**	**139**	**143**	**127**	**142**	**83**	**133**	**128**	**146**	**125**	**150**	**101**	**95**
Habitat % of Reference	**100**	**83**	**112**	**115**	**102**	**115**	**67**	**107**	**103**	**118**	**101**	**121**	**81**	**77**

Table 14. Summary of Reference Category 67m RBP III Biological Data

	AUGH 0.4	TUSC 0.6	STST 1.0	FRNK 1.6	RAYS 80.5	AUGH 17.2	DUNN 0.1	LJUN 3.8	LJUN15.0	FRNK 18.9	TUSC 22.5	KISH 5.5	FRNK 32.5	KISH 0.4
Raw Data Summary														
Number of Individuals	111	101	102	103	103	104	107	101	107	105	103	106	102	100
Percent Shredders	1.8	2	0	9.7	0	1	0	0	0	0	1	24.5	0	22
Percent Collector-Gatherers	14.4	13.9	5.9	18.4	36.9	6.7	11.2	30.7	35.5	20	2.9	34.9	16.7	52
Percent Filterer-Collectors	39.6	51.5	45.1	26.2	31.1	73.1	29.9	40.6	39.3	39	54.4	14.2	21.6	18
Percent Scrapers	35.1	21.8	34.3	39.8	25.2	12.5	56.1	25.7	15	35.2	27.2	20.8	54.9	8
Percent Predators	9	10.9	14.7	5.8	6.8	6.7	2.8	3	10.3	5.7	14.6	5.7	6.9	0
Number of EPT Taxa	15	12	13	9	11	9	10	9	6	6	7	7	3	5
Metric Scores														
Taxonomic Richness	26	22	22	23	20	19	19	15	13	14	14	15	12	12
Diversity Index	4.14	3.97	3.22	4.18	3.56	3.14	3.25	3.19	3.14	2.97	2.81	3.45	2.23	2.71
Hilsenhoff Biotic Index	3.84	3.32	3.08	4.81	4.97	3.27	4.45	4.73	4.45	4.95	3.44	5.08	5.11	5.43
EPT Index	15	12	13	9	11	9	10	9	6	6	7	7	3	5
Percent Taxonomic Similarity	100	56.6	44.1	63.6	46.7	46.5	43.1	47.2	40.4	46.3	43.9	34.1	31.9	25.6
Percent Trophic Similarity	100	86.1	88.8	83.4	77.5	66.5	79	82.7	77.7	94.3	79.7	56.9	78	42.2
Percent of Reference														
Taxonomic Richness	100	84.6	84.6	88.5	76.9	73.1	73.1	57.7	50	53.8	53.8	57.7	46.2	46.2
Diversity Index	100	95.9	77.8	101	86	75.8	78.5	77.1	75.8	71.7	67.9	83.3	53.9	65.5
Hilsenhoff Biotic Index	100	115.7	124.7	79.9	77.2	117.4	86.3	81.1	86.3	77.5	111.7	75.5	75.1	70.7
EPT Index	100	80	86.7	60	73.3	60	66.7	60	40	40	46.7	46.7	20	33.3
Percent Taxonomic Similarity	100	56.6	44.1	63.6	46.7	46.5	43.1	47.2	40.4	46.3	43.9	34.1	31.9	25.6
Percent Trophic Similarity	100	86.1	88.8	83.4	77.5	66.5	79	82.7	77.7	94.3	79.7	56.9	78	42.2
Biological Condition Scores														
Taxonomic Richness	6	6	6	6	4	4	4	2	2	2	2	2	2	2
Diversity Index	6	6	6	6	6	6	6	6	6	4	4	6	4	4
Hilsenhoff Biotic Index	6	6	6	4	4	6	6	4	6	4	6	4	4	4
EPT Index	6	4	4	0	2	0	0	0	0	0	0	0	0	0
Percent Taxonomic Similarity	6	6	4	6	6	6	4	6	4	6	4	4	2	2
Percent Trophic Similarity	6	6	6	6	6	4	6	6	6	6	6	4	6	2
Total Biological Score														
Total Biological Score	**36**	**34**	**32**	**28**	**28**	**26**	**26**	**24**	**24**	**22**	**22**	**20**	**18**	**14**
Biological % of Reference	**100**	**94**	**89**	**78**	**78**	**72**	**72**	**67**	**67**	**61**	**61**	**56**	**50**	**39**

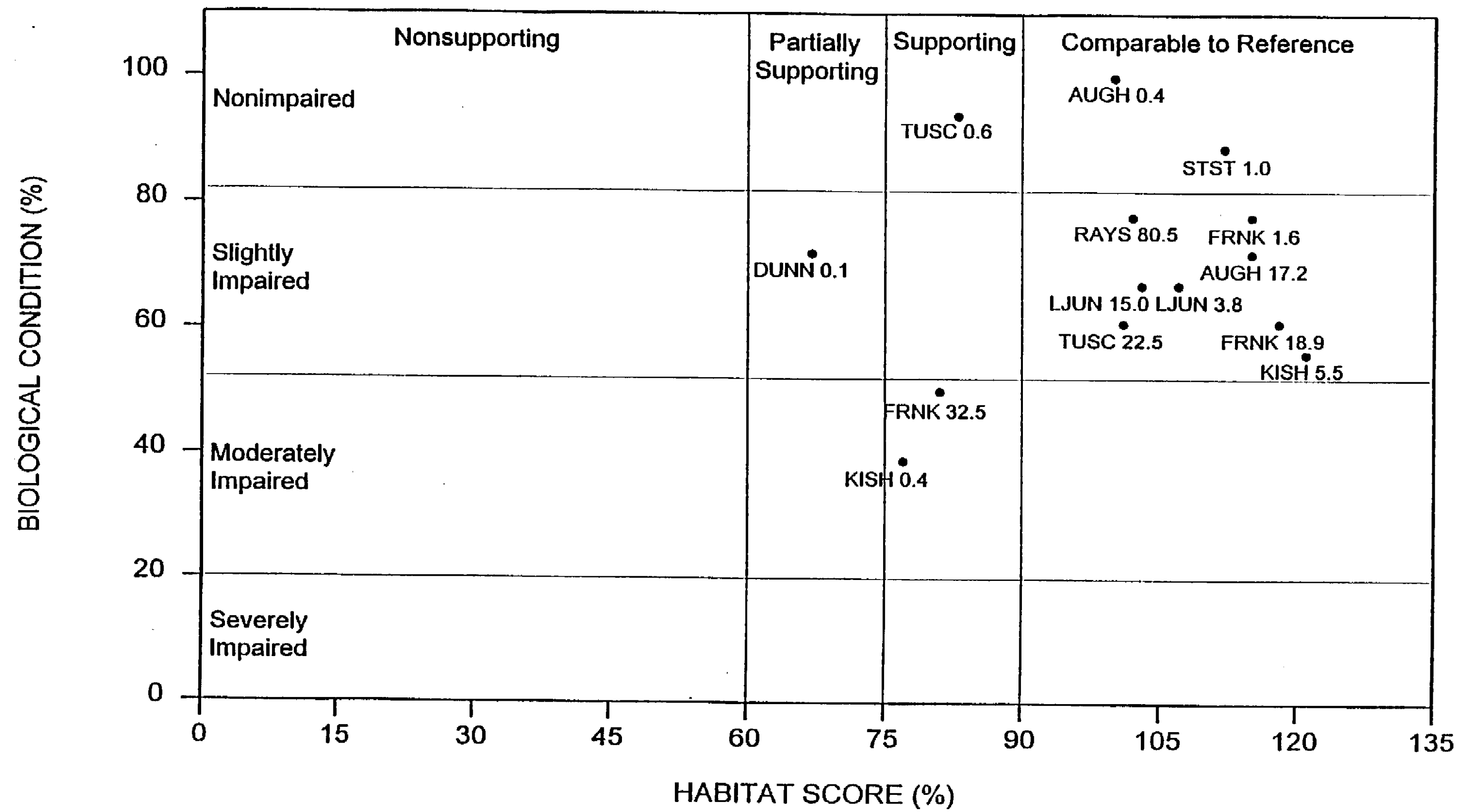


Figure 17. Summary of Reference Category 67m RBP III Habitat and Biological Data

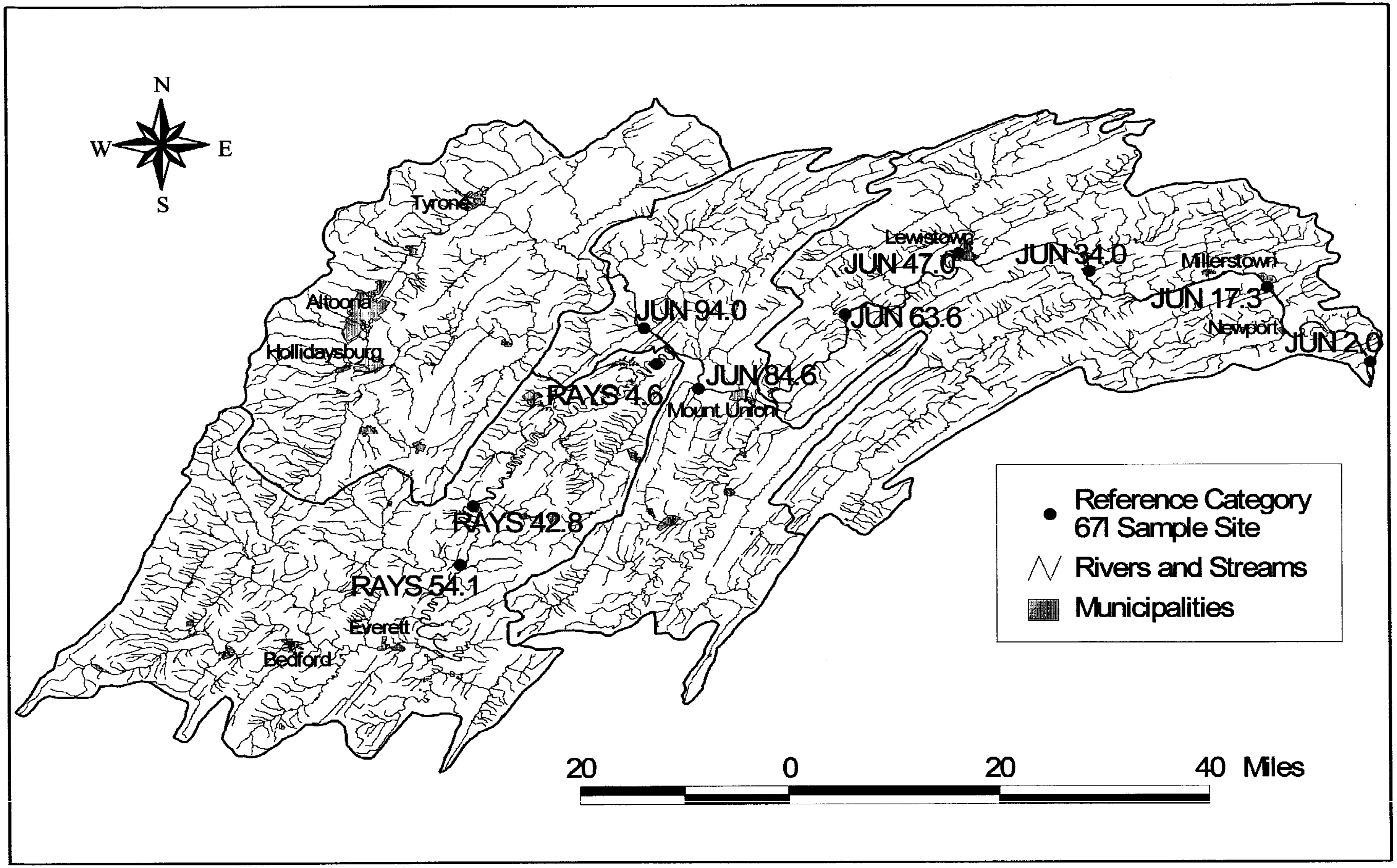


Figure 18. Map of Reference Category 67I Sample Sites, Sites Located in the Central Appalachian Ridges and Valleys Ecoregion (Ecoregion 67) With Drainage Areas Greater Than 500 Square Miles

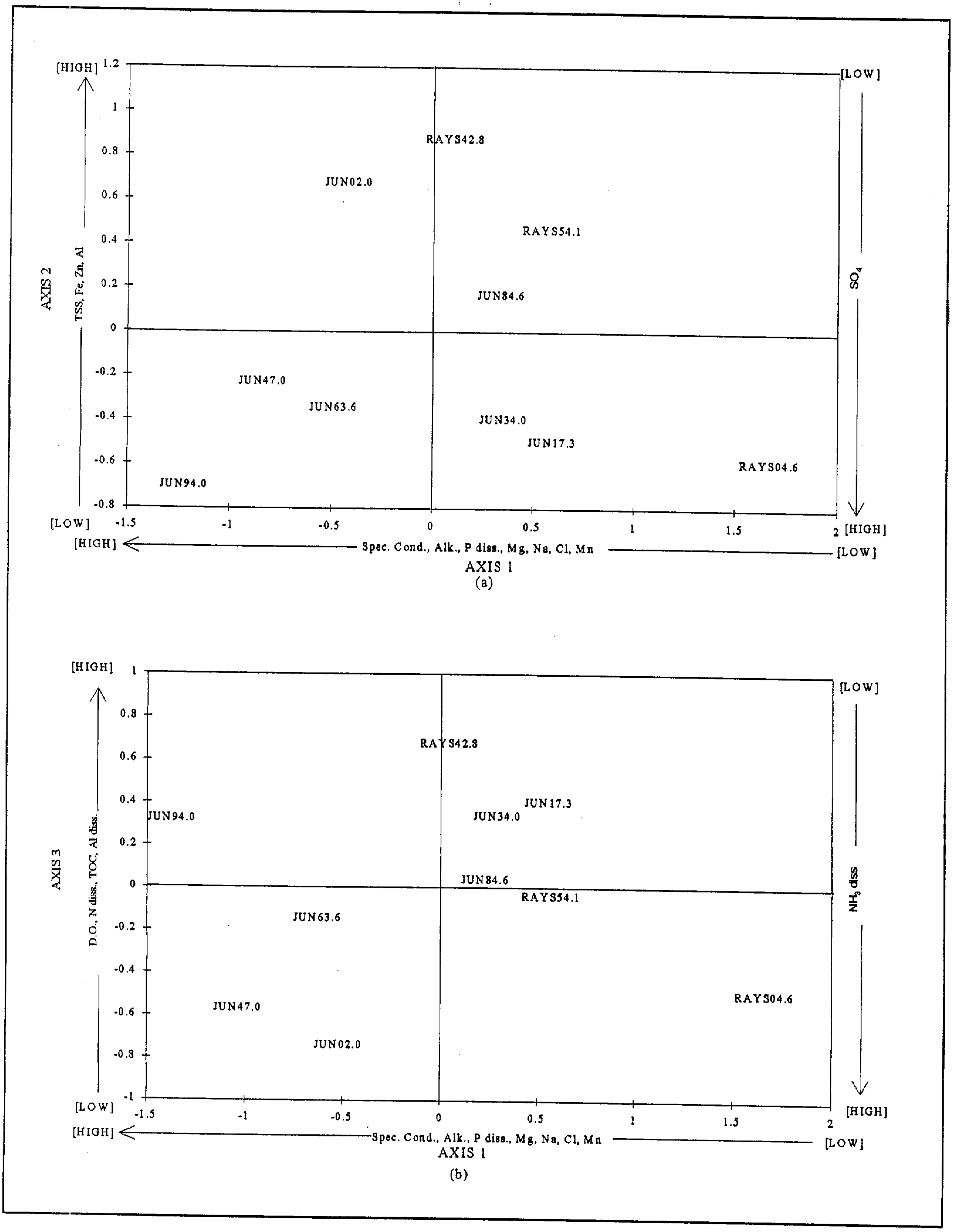
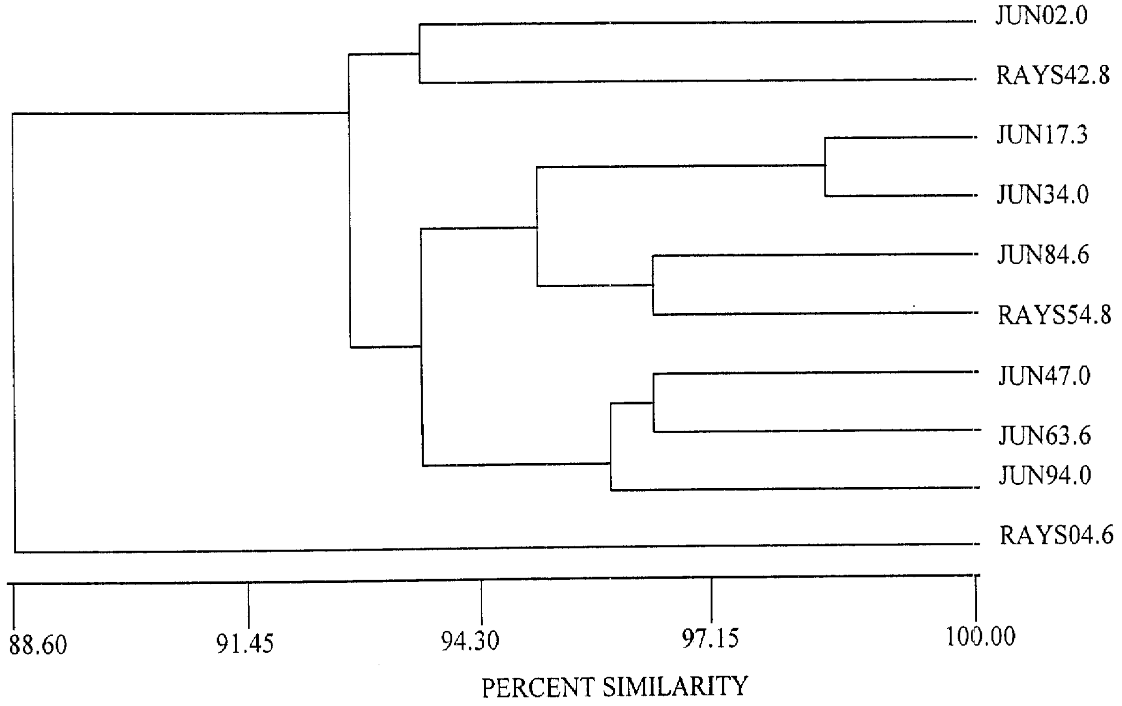


Figure 19. ***Ordinations of Reference Category 67l Sample Sites Based on Principal Components Analysis of Water Quality Data*** *((a) PCA Axis 1 Versus PCA Axis 2, and (b) PCA Axis 1 Versus PCA Axis 3)*



Water Quality Variables Identified by PCA and Used to Generate Dendrogram

General Variables	Nutrients	Organic Matter	Major Ions	Metals
D.O.	NH_3 diss.	TOC	Mg	Fe
Spec Cond	P diss.		Na	Mn
Alk. (field)			Cl	Zn
TSS			SO_4	Al
TDS				Al diss.

Figure 20. Dendrogram of Reference Category 67l Sample Sites Generated by Cluster Analysis of the Water Quality Parameters That Account for Most of the Variability in the 67l Water Quality Data, as Identified by PCA

Table 15. Summary of Reference Category 67l RBP III Habitat Data

	JUN34.0	RAYS54.1	JUN94.0	JUN63.6	JUN17.3	JUN47.0	RAYS42.8	RAYS04.6	JUN84.6
Primary Parameters									
Substrate	15	19	19	17	15	8	19	20	19
Embeddedness	16	19	12	18	16	8	16	20	19
Velocity/Depth Diversity	17	20	18	20	17	6	19	14	7
Total	48	58	49	55	48	22	54	54	45
Percent of Reference	100	121	102	115	100	46	113	113	94
Secondary Parameters									
Pool/Riffle Ratio	12	9	10	13	12	1	1	8	1
Pool Quality	10	14	15	14	11	15	14	8	14
Riffle/Run Quality	13	15	13	12	13	1	14	12	0
Channel Alteration	12	15	0	14	13	3	14	15	15
Total	47	53	38	53	37	20	43	43	30
Percent of Reference	100	113	81	113	79	43	91	91	64
Tertiary Parameters									
U/L Strmbnk Erosion	8	10	8	9	8	8	9	10	10
U/L Strmbnk Stability	8	10	10	9	9	9	10	10	10
Vegetative Cover	3	6	8	8	7	6	9	8	7
FRB Zone Width	2	10	1	5	5	1	9	3	4
Total	21	36	27	31	29	24	37	31	31
Percent of Reference	100	171	129	148	138	114	176	148	148
Total Habitat Score									
Total Habitat Score	**116**	**147**	**114**	**139**	**126**	**66**	**134**	**128**	**106**
Habitat% of Reference	**100**	**127**	**98**	**120**	**109**	**57**	**116**	**110**	**91**

Table 16. Summary of Reference Category 67l RBP III Biological Data

	JUN 34.0	RAYS 54.1	JUN 94.0	JUN 63.6	JUN 17.3	JUN 47.0	RAYS 42.8	RAYS 4.6	JUN 84.6
Raw Data Summary									
Number of Individuals	100	101	112	125	106	105	103	98	102
Percent Shredders	2.0	0.0	1.8	26.4	2.8	31.4	0.0	44.9	70.6
Percent Collector-Gatherers	40.0	14.9	14.3	21.6	27.4	33.3	21.4	34.7	5.9
Percent Filterer-Collectors	24.0	34.7	41.1	11.2	18.9	4.8	6.8	6.1	6.9
Percent Scrapers	30.0	38.6	35.7	34.4	43.4	23.8	70.9	6.1	15.7
Percent Predators	4.0	11.9	7.1	6.4	7.5	6.7	1.0	8.2	1.0
Number of EPT Taxa	16	14	12	12	11	10	9	5	5
Metric Scores									
Taxonomic Richness	24	26	23	24	19	17	14	11	12
Diversity Index	3.87	4.08	3.91	3.52	3.64	3.21	2.15	2.14	1.73
Hilsenhoff Biotic Index	4.62	4.16	4.55	4.90	4.72	4.66	4.77	6.07	5.73
EPT Index	16	14	12	12	11	10	9	5	5
Percent Taxonomic Similarity	100	57.7	57.6	53.3	62.1	21.5	39.4	20.2	21.8
Percent Trophic Similarity	100	72.9	74.1	68.8	82.3	67.9	59.2	52.9	31.5
Percent of Reference									
Taxonomic Richness	100	108.3	95.8	100.0	79.2	70.8	58.3	45.8	50.0
Diversity Index	100	105.4	101.0	91.0	94.1	82.9	55.6	55.3	44.7
Hilsenhoff Biotic Index	100	111.1	101.5	94.2	97.9	99.2	96.9	76.1	80.7
EPT Index	100	87.5	75.0	75.0	68.8	62.5	56.3	31.3	31.3
Percent Taxonomic Similarity	100	57.7	57.6	53.3	62.1	21.5	39.4	20.2	21.8
Percent Trophic Similarity	100	72.9	74.1	68.8	82.3	67.9	59.2	52.9	31.5
Biological Condition Scores									
Taxonomic Richness	6	6	6	6	4	4	2	2	2
Diversity Index	6	6	6	6	6	6	4	4	2
Hilsenhoff Biotic Index	6	6	6	6	6	6	6	4	4
EPT Index	6	4	2	2	0	0	0	0	0
Percent Taxonomic Similarity	6	6	6	6	6	2	4	2	2
Percent Trophic Similarity	6	4	4	4	6	4	4	4	2
Total Biological Score									
Total Biological Score	**36**	**32**	**30**	**30**	**28**	**22**	**20**	**16**	**12**
Biological % of Reference	**100**	**89**	**83**	**83**	**78**	**61**	**56**	**44**	**33**

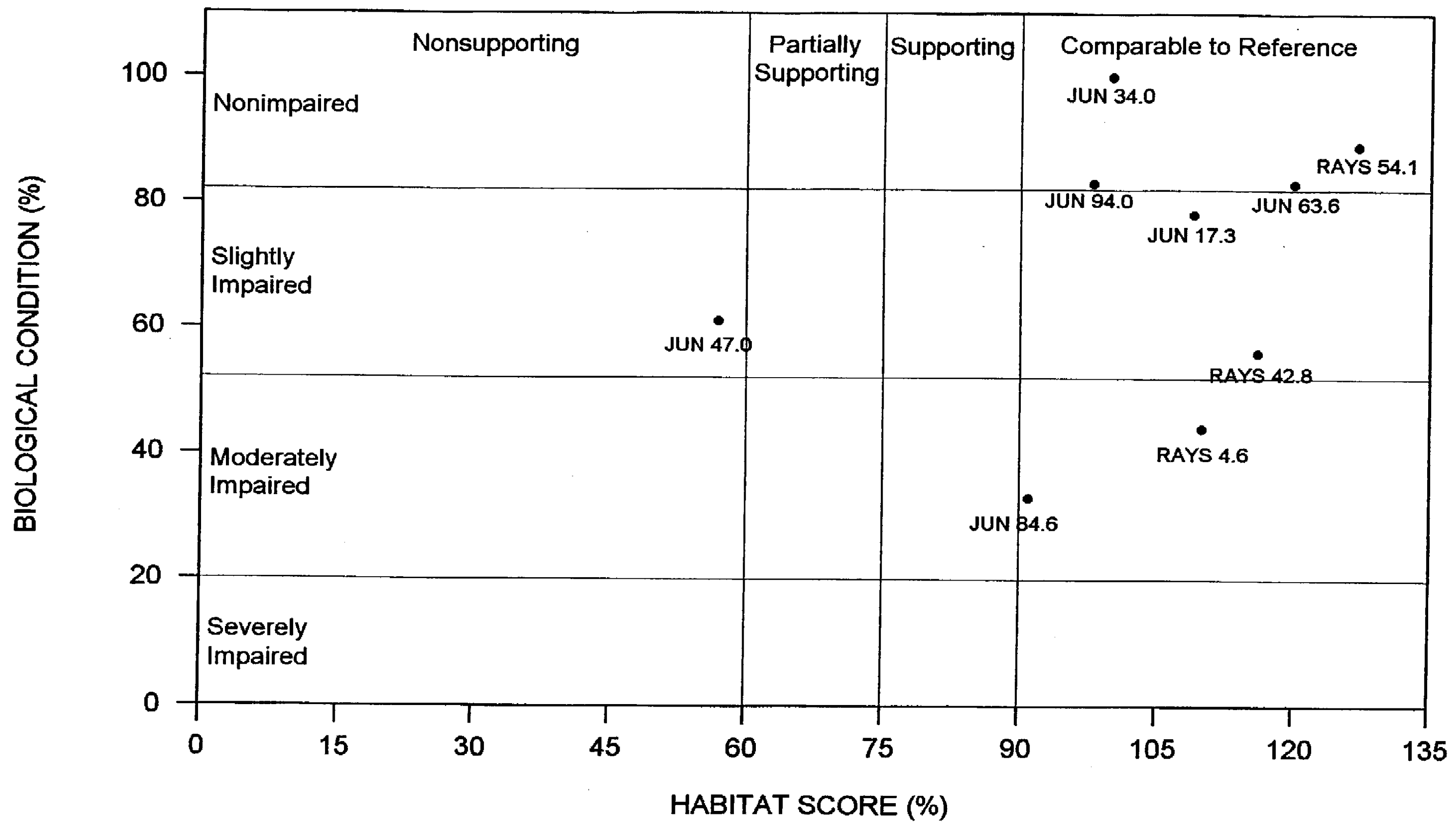


Figure 21. Summary of Reference Category 67l RBP III Habitat and Biological Data

Table 17. Summary of Reference Category 69a RBP III Habitat and Biological Data

Habitat Data	6MIL00.2	GTRC02.9
Primary Parameters		
Substrate	20	19
Embeddedness	19	19
V/D Diversity	15	18
Total	54	56
Percent of Reference	100	104
Secondary Parameters		
Pool/Riffle Ratio	15	15
Pool Quality	14	14
Riffle/Run Quality	15	15
Channel Alteration	15	15
Total	59	59
Percent of Reference	100	100
Tertiary Parameters		
U/L Strmbnk Erosion	8	9
U/L Strmbnk Stability	10	10
Vegetative Cover	8	8
FRB Zone Width	5	10
Total	31	37
Percent of Reference	100	119
Total Habitat Score		
Total Habitat Score	**144**	**152**
Habitat % of Reference	**100**	**106**

Biological Data	6MIL 0.2	GTRC 2.9
Raw Data Summary		
Number of Individuals	108	101
Percent Shredders	4.6	1
Percent Collector-Gatherers	22.2	23.8
Percent Filterer-Collectors	36.1	46.5
Percent Scrapers	5.6	11.9
Percent Predators	31.5	16.8
Number of EPT Taxa	15	12
Metric Scores		
Taxonomic Richness	21	19
Diversity Index	3.87	3.51
Hilsenhoff Biotic Index	2.5	3.73
EPT Index	15	12
Percent Taxonomic Similarity	100	25.8
Percent Trophic Similarity	100	81.7
Percent of Reference		
Taxonomic Richness	100	90.5
Diversity Index	100	90.7
Hilsenhoff Biotic Index	100	67
EPT Index	100	80
Percent Taxonomic Similarity	100	25.8
Percent Trophic Similarity	100	81.7
Biological Condition Scores		
Taxonomic Richness	6	6
Diversity Index	6	6
Hilsenhoff Biotic Index	6	2
EPT Index	6	4
Percent Taxonomic Similarity	6	2
Percent Trophic Similarity	6	6
Total Biological Score		
Total Biological Score	**36**	**26**
Biological % of Reference	**100**	**72**

Ancillary Data

In addition to the data described above, SRBC staff collected field data requested by the Pa. DEP to support several of the department's ongoing water quality management programs. Ancillary data include: (1) physico-chemical water quality, physical habitat, and biological information collected immediately upstream and downstream of 20 randomly selected permitted wastewater discharges; (2) chlorine demand data collected at approximately 70 sample sites; and (3) fish community structure data from numerous transitional (cool water) streams. Ancillary data are summarized in Bollinger and others (1997).

BIOASSESSMENT OF STREAMS AND RIVERS IN THE JUNIATA SUBBASIN

Frankstown Branch/Little Juniata River Section

The 13 sample sites in the Frankstown Branch/Little Juniata River section are distributed among the following reference categories:

67a	67cd	67m
LJUN 29.6	SBEC 01.4	LJUN 15.0
LJUN 19.4		LJUN 03.8
SPRU 10.6		FRNK 32.5
SPRU 01.0		FRNK 18.9
FRNK 38.1		FRNK 01.6
BEAV 00.1		
CLOV 00.1		

The biological conditions of these sites are summarized in Figure 22.

<u>Frankstown Branch Juniata River Watershed</u>

Biological conditions of the Frankstown Branch Juniata River (FRNK 38.1) at McKee, Pa., immediately upstream of Appleton Papers Inc. wastewater discharge, are nonimpaired. Biological and water quality conditions at FRNK 38.1 have improved dramatically since the late 1970s. Brezina (1980) reported that this section of the Frankstown Branch and the lower end of Halter Creek were highly depressed due to Appleton Papers' wastewater that was discharged into Halter Creek. Currently, Appleton's wastewaters bypass Halter Creek and are discharged directly into the Frankstown Branch Juniata River, approximately 0.25 miles below the confluence of Halter Creek. The nonimpaired biological community at FRNK 38.1, located between Halter Creek and Appleton's discharge, indicates the biological integrity of this section of the Frankstown Branch has been completely restored.

Approximately 6 miles downstream of Appleton's discharge, immediately upstream of the confluence of Beaverdam Branch, the biological community of the Frankstown Branch Juniata River (FRNK 32.5) is moderately impaired, and water quality is poor (Figure 15). Several of the water quality parameters that are elevated at FRNK 32.5 are associated with Appleton's discharge. These parameters include: specific conductance; alkalinity; acidity; totally dissolved solids (TDS); total organic carbon (TOC); total, dissolved, and total ortho-phosphorus; hardness; major ions except magnesium; and dissolved and total manganese, iron, and aluminum. Dissolved oxygen and pH at FRNK 32.5 are relatively low, compared to FRNK 38.1.

Immediately downstream of FRNK 32.5, Beaverdam Branch flows into the Frankstown Branch. The biological community of Beaverdam Branch (BEAV 00.1) near Hollidaysburg, Pa., is moderately impaired and is affected by both degraded water quality and nonsupporting habitat conditions (Figures 3 and 5). BEAV 0.1 has the most degraded biological community included in this survey, with taxonomic richness limited to five taxa, a diversity index of 1.59, a Hilsenhoff score of 5.16, and an EPT index score of 2. Brezina (1980) reported that Beaverdam Branch was impacted by acid mine drainage and inadequately treated sewage. Other pollution sources include numerous municipal and industrial wastewater discharges and stormwater runoff from the Altoona/Hollidaysburg area. Water quality at BEAV 0.1 is characterized by very high concentrations of nutrients (including nitrite and ammonia), sodium, chloride, sulfate, total iron, manganese, aluminum, nickel, and zinc, and low dissolved oxygen.

At Williamsburg, Pa., approximately 18 miles downstream of Appleton's wastewater discharge and 13 miles downstream of the confluence of Beaverdam Branch, the biological conditions of Frankstown Branch (FRNK 18.9) improve from moderately impaired, at FRNK 32.5, to slightly impaired. Improved biological conditions are indicated by slightly higher taxonomic richness and diversity and lower Hilsenhoff index scores and

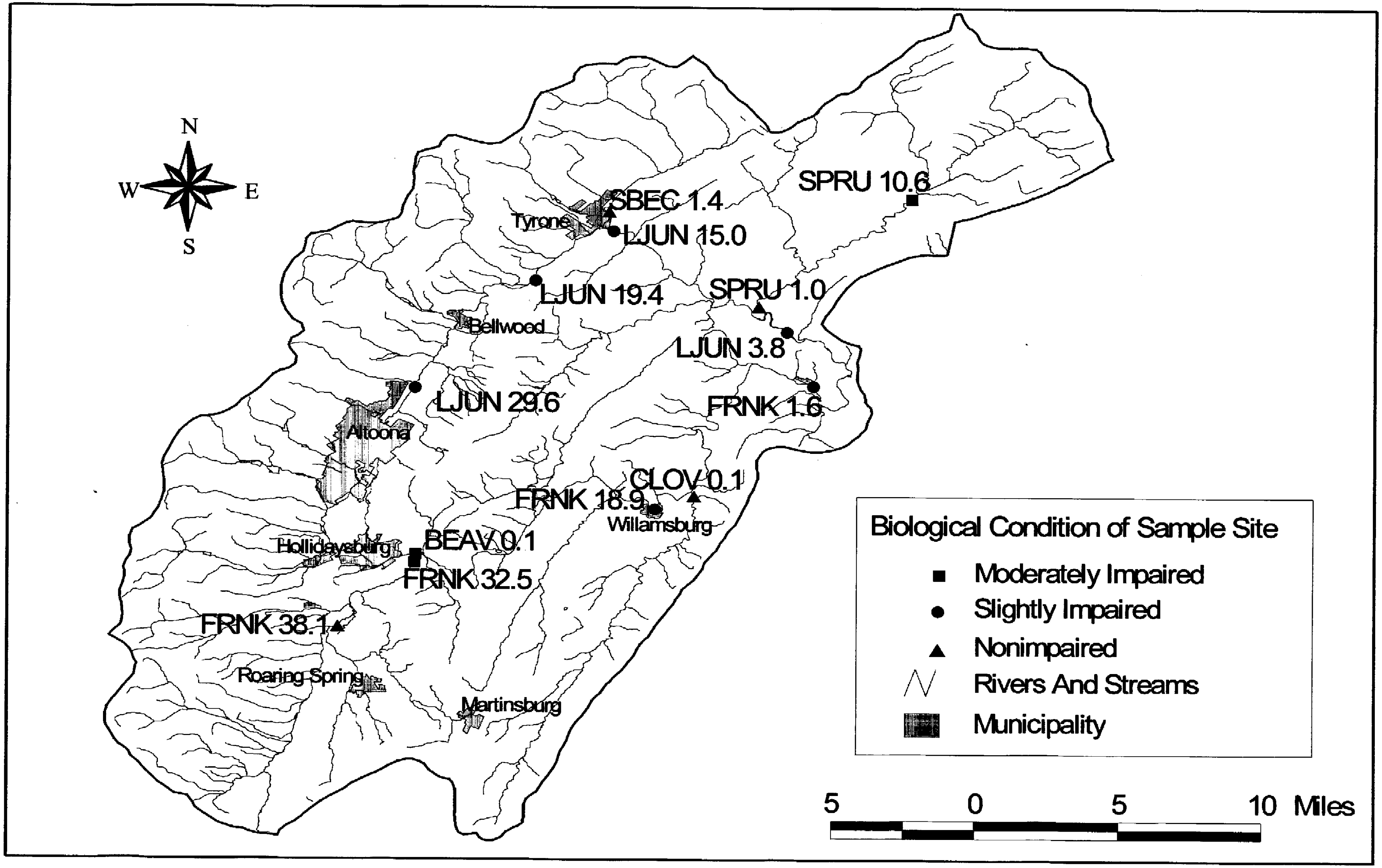


Figure 22. Biological Conditions of Sample Sites in the Frankstown Branch/Little Juniata River Section

by the presence of the pollution-intolerant mayflies *Leucrocuta* (Ephemeroptera: Heptageniidae) and *Isonychia* (Ephemeroptera: Oligoneuriidae) at FRNK 18.9. However, water quality conditions remain somewhat degraded, and the concentrations of many of the parameters that are very high at Hollidaysburg, including specific conductance, TDS, and several major ions, remain elevated (Figure 15). Concentrations of total, dissolved, and total orthophosphorus; total and dissolved manganese; total and dissolved aluminum; and zinc at FRNK 18.9 exceed those observed at FRNK 32.5 and represent some of the impact of Beaverdam Branch on the Frankstown Branch Juniata River.

Between Williamsburg and the river's mouth, the water quality and biological conditions of the Frankstown Branch Juniata River continue to improve. However, RBP III results indicate the biological community of the Frankstown Branch (FRNK 1.6) at Alexandria, Pa., is slightly impaired. Taxonomic richness and diversity and EPT metric scores indicate a substantial improvement in biological conditions between FRNK 18.9 and FRNK 1.6, yet both of these sites fall into the slightly impaired biological condition category (Figure 17). Between FRNK 18.9 and FRNK 1.6, Clover Creek enters the Frankstown Branch. Clover Creek (CLOV 0.1) supports a nonimpaired biological community, and water quality conditions are very good. Thus, Clover Creek is a source of high quality water and contributes to the restoration of water quality conditions in the lower section of the Frankstown Branch Juniata River.

Little Juniata River Watershed

Near Altoona, Pa., upstream of the Altoona East sewage treatment plant (LJUN 29.6), the biological community of the Little Juniata River is slightly impaired. Acidity, total phosphorus, TOC, major ions, total manganese, and dissolved aluminum concen-trations are somewhat elevated. Possible sources of these pollutants include stormwater runoff from the Altoona area and industrial discharges on Spring Run and Kettle Creek.

Immediately upstream of PPG Industries Inc. near Tipton, Pa., habitat conditions of the Little Juniata River (LJUN 19.4) are excellent. However, the level of water quality degradation is more severe than that observed near Altoona, and the river's biological community remains slightly impaired (Figure 3). Although acidity is lower near Tilpton, zinc and most of the parameters that are elevated near Altoona increase in concentration between Altoona and Tipton. Permitted industrial and sewage wastewater discharges between Altoona and Tipton include several drinking water treatment facilities and the Altoona East, Central Blair County, and Bellwood Borough sewage treatment plants (STPs). Although the macroinvertebrate communities of LJUN 29.6 and LJUN 19.4 are composed primarily of pollution tolerant midges (Diptera: Chironomidae), both of these sites support sparse populations of pollution-intolerant *Isonychia* and *Nigronia* (Megaloptera: Corydalidae).

Downstream of Tipton, water quality and biological conditions of the Little Juniata River begin to improve. At LJUN 15.0, immediately upstream of the Tyrone Borough STP, most water quality parameters have concentrations lower than those at LJUN 19.4, with the exception of iron and manganese. The biological community at LJUN 19.4, although still slightly impaired, shows some improvement based on the relative abundance of midges and *Isonychia*, which decrease and increase, respectively, between LJUN 19.4 and LJUN 15.0.

Approximately 0.5 miles upstream of LJUN 15.0, South Bald Eagle Creek flows into the Little Juniata River. The biological community of South Bald Eagle Creek (SBEC 1.4), upstream of Westvaco Corp., is nonimpaired and supports populations of numerous pollution-intolerant taxa, including *Macronychus* (Coleoptera: Elmidae), *Epeorus* (Ephemeroptera: Heptageniidae), *Isonychia*, *Nigronia*, *Leuctra* (Plecoptera:

Leuctridae), *Acroneuria* ((Plecoptera: Perlidae), *Paragnetina* (Plecoptera: Perlidae), and *Rhyacophila* (Trichoptera: Rhyacophilidae). Although the iron and manganese concentrations of South Bald Eagle Creek at SBEC 1.4 are relatively high compared to those of LJUN 19.4, they are not high enough to account for the concentrations that exist at LJUN 15.0. Permitted industrial discharges between LJUN 19.4 and LJUN 15.0 include PPG Industries Inc. and Westvaco Corp.

Between Tyrone, Pa., and Barree, Pa., Spruce Creek enters the Little Juniata River. Near its mouth, Spruce Creek (SPRU 1.0) supports a nonimpaired biological community and has excellent physical habitat and water quality conditions. However, water quality and biological conditions of Spruce Creek are somewhat degraded at SPRU 10.6 near Graysville, Pa. (Figure 3). The biological community at SPRU 10.6 is moderately impaired and acidity and total suspended solids (TSS) are high (20 mg/l) and very high (112 mg/l), respectively.

Approximately 11 miles downstream of Tyrone near Barree (LJUN 3.8), iron and manganese concentrations are lower and alkalinity, acidity, hardness, nitrogen, and sulfate concentrations are slightly higher than those of LJUN 15.0. At LJUN 3.8, habitat conditions are excellent, and the biological community is slightly impaired (Figure 17). However, this section of the Little Juniata River shows signs of biological recovery in that it supports sparse populations of the pollution-intolerant genera *Paragnetina*, *Brachycentrus* (Trichoptera: Brachycentridae), and *Rhyacophila*, none of which were observed at the other three mainstem sample stations. The Tyrone STP is the only permitted industrial or municipal wastewater discharge between LJUN 15.0 and LJUN 3.8.

Raystown Branch Juniata River Section

The 12 sample sites in the Raystown Branch Juniata River section are distributed among the following reference categories:

67a	67b	67cd
YELL 03.5	DUNN 09.9 BOBS 00.9	RAYS 103 BOBS 11.4 BRUS 00.1
67m	**67l**	**69a**
DUNN 00.1 RAYS 80.5	RAYS 54.1 RAYS 42.8 RAYS 04.6	GTRC 02.9

The biological conditions of these sites are summarized in Figure 23.

Raystown Branch upstream of Bedford, Pa.

Near Manns Choice, Pa., the Raystown Branch (RAYS 103) supports a nonimpaired biological community. However, ammonia, hardness, sodium, chloride, sulfate, manganese, and nickel concentrations are elevated and dissolved oxygen concentration is low. Upstream of RAYS 103, land use consists primarily of forest and agriculture and the Manns Choice-Harrison Township STP is the only permitted municipal or industrial discharge.

Dunning Creek Watershed

At Bedford, Pa., Dunning Creek flows into the Raystown Branch Juniata River. Four sample sites are located in the Dunning Creek Watershed; two on Dunning Creek, and two on Bobs Creek. Bobs Creek (BOBS 11.4) at Pavia, Pa., supports a nonimpaired biological community, and water quality and habitat conditions are excellent. However, near the mouth of Bobs Creek (BOBS 0.9) at Reynoldsdale, Pa., TSS, total ammonia, and total and dissolved nitrite concentrations are somewhat elevated, and the biological community of Bobs Creek is slightly impaired. There are no permitted industrial or municipal wastewater discharges in the Bobs Creek watershed, and land use is primarily forest and agriculture. Agricultural runoff and malfunctioning on-lot treatment systems are the most probable sources of pollutants at BOBS 0.9.

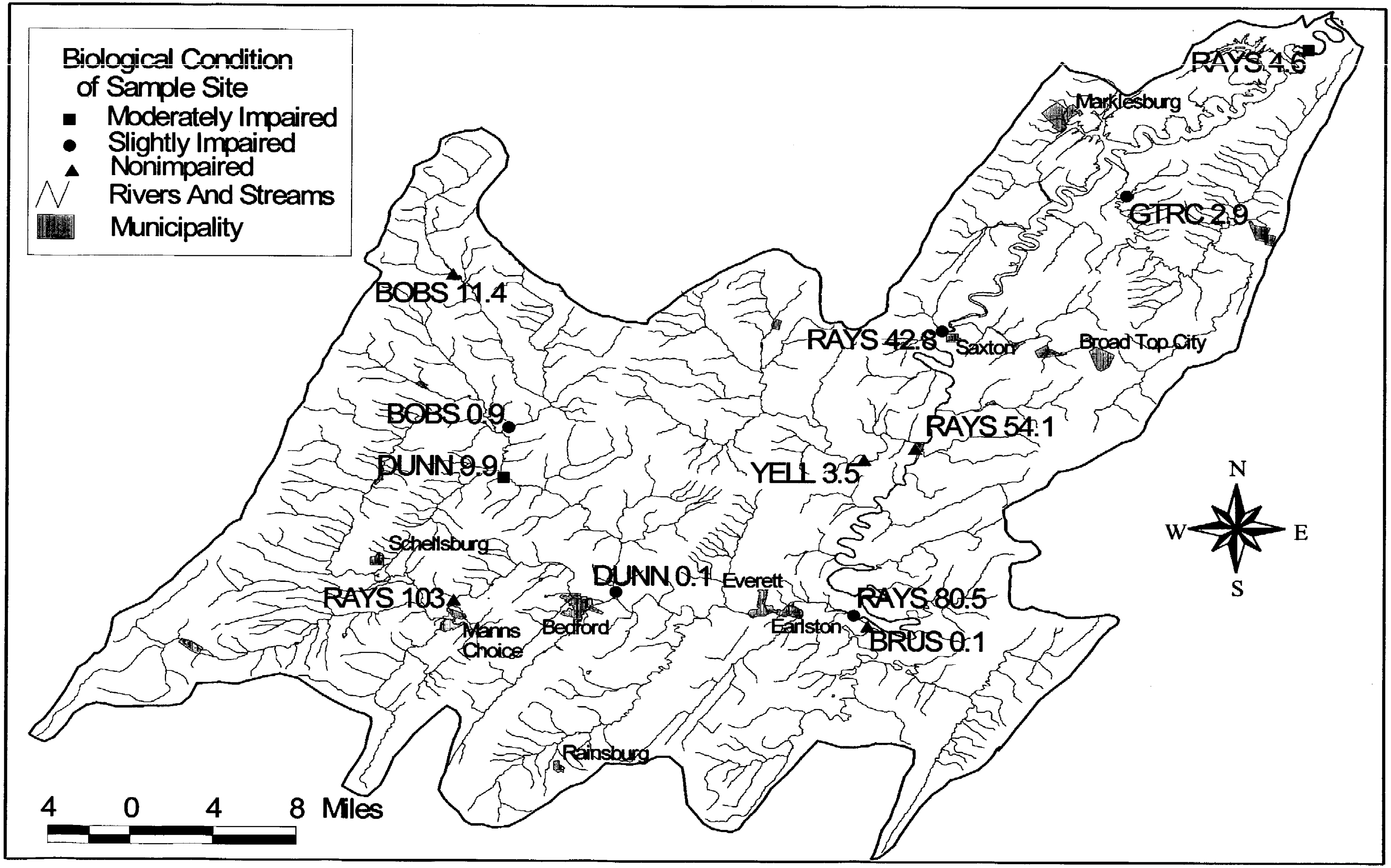


Figure 23. ***Biological Conditions of Sample Sites in the Raystown Branch Juniata River Section***

Approximately 3 miles below the confluence of Bobs and Dunning Creeks, the biological community of Dunning Creek (DUNN 9.9) is moderately impaired (Figure 9). Biological impairment at this site is due to a combination of degraded habitat and water quality conditions. Water quality conditions at DUNN 9.9 are very similar to those at BOBS 0.9, with the exception of slightly higher acidity and lower pH at DUNN 9.9 (Figures 7 and 8). Degraded stream channel morphology and riparian conditions appear to be the primary factors influencing the biological community at DUNN 9.9. Similarly, Brezina (1980) reported stream substrate conditions as a major limiting factor for the invertebrate and fish communities of Dunning Creek near Reynoldsdale.

The biological conditions of Dunning Creek improve between DUNN 9.9 and its confluence with the Raystown Branch Juniata River (DUNN 0.1). However, the biological community at DUNN 0.1 is slightly impaired, suggesting that complete biological recovery does not occur. Although acidity, TSS, total ammonia, and dissolved and total nitrite concentrations are substantially lower than those at DUNN 9.9, degraded habitat conditions throughout the lower section of Dunning Creek continue to impair the biological integrity of the creek.

Raystown Branch between Bedford and Saxton, Pa.

The biological community at RAYS 80.5 is slightly impaired due to degraded water quality conditions. Water quality conditions at RAYS 80.5, characterized by moderately elevated concentrations of alkalinity, TDS, hardness, nutrients, and major ions, are similar to those of LJUN 3.8, DUNN 0.1, and LJUN 15.0 (Figures 15 and 16). Potential sources of pollutants between RAYS 103 and RAYS 80.5 include numerous municipal and industrial wastewater discharges, agricultural runoff, urban runoff from the Bedford and Everett, Pa., areas, and malfunctioning on-lot treatment systems. Immediately downstream of RAYS 80.5, Brush Creek flows into the Raystown Branch Juniata River. Brush Creek (BRUS 0.1) supports a nonimpaired biological community and contributes high quality water to the Raystown Branch.

The next downstream sample site on the Raystown Branch Juniata River (RAYS 54.1) is at Hopewell, Pa. The water quality and biological conditions of the river show much improvement between RAYS 80.5 and RAYS 54.1. Although iron and aluminum concentrations increase, the concentrations of most nutrients and major ions decrease downstream of RAYS 80.5 and result in a nonimpaired biological community at Hopewell. The taxonomic richness and diversity scores of RAYS 54.1, 26 and 4.08, respectively, are the highest in reference category 671. This site was considered for reference site designation, but was not selected due to its relatively small drainage area, in comparison to the other category 671 sites. The biological community of the Raystown Branch at Hopewell consists of numerous pollution-intolerant taxa, including *Heterocloeon* (Ephemeroptera: Baetidae), *Serratella* (Ephemeroptera: Ephemerellidae), *Isonychia*, *Ephoron* (Ephemeroptera: Polymitarcidae), *Nigronia* and *Phasganophora* (Plecoptera: Perlidae).

Immediately downstream of RAYS 54.1, Yellow Creek flows into the Raystown Branch Juniata River. Approximately 3.5 miles upstream of its mouth, nitrogen and nitrate concentrations are high, but overall water quality and habitat conditions of Yellow Creek (YELL 3.5) are good and the stream supports a nonimpaired biological community. YELL 3.5 is the reference category 67a reference site.

The biological community of Raystown Branch (RAYS 42.8) at Saxton, Pa., is slightly impaired due to degraded water quality conditions. Water quality degradation is primarily in the form of elevated concentrations of total and dissolved nitrogen and nitrate, calcium, magnesium, zinc, dissolved iron, and total and dissolved aluminum. Only two of the six pollution-intolerant taxa identified at RAYS 54.1 are found at RAYS 42.8, *Ephoron* and *Phasganophora*. Taxonomic richness, diversity, and EPT metric scores at Saxton are substantially lower than those at Hopewell. Furthermore, the trophic structure of the biological communities at Hopewell and Saxton are quite different. Filtering-collectors and scrapers occur in approximately equal abundance at Hopewell. However, filtering-collectors constitute only a small percentage of the scraper-dominated community at Saxton. One possible explanation for the reduced abundance of filtering-collectors at Saxton is that these organisms may be subject to toxicological stress associated with the ingestion of metals-contaminated, fine particulate organic matter. Probable sources of metals at RAYS 42.8 include mine drainage from Six Mile Run (Brezina, 1980) and urban stormwater runoff from the Stonerstown/Saxton area.

Raystown Branch downstream of Saxton, Pa.

Great Trough Creek flows directly into Raystown Lake. Biological conditions at Great Trough Creek State Park (GTRC 2.9) are slightly impaired, and water quality conditions are good. GTRC 2.9 is the only sample site in this survey of the Juniata Subbasin located in the Central Appalachians Ecoregion (Ecoregion 69).

Downstream of Raystown Dam (RAYS 4.6), the nutrient and metal concentrations of the Raystown Branch are substantially lower than those observed upstream of the dam at Saxton (Figure 19). However, the low concentrations of biologically important substances such as nutrients, calcium, and magnesium, and modified water temperature and stream flow regimes result in a moderately impaired biological community that consists primarily of midges and the freshwater shrimp *Gammarus* (Amphipoda: Gammaridae).

Upper Juniata River Section

The 13 sample sites in the Upper Juniata River section are distributed among the following reference categories:

67a	67b	67cd
SHAV 01.4	STST 26.8	BLLG 04.6
	SIDE 00.1	SHAD 04.3
	LAUG 00.1	
	TSPC 00.1	
	BLLG 00.9	
67m	**67l**	
STST 01.0	JUN 94.0	
AUGH 17.2	JUN 84.6	
AUGH 00.4		

The biological conditions of these sites are summarized in Figure 24.

Shaver Creek

Shaver Creek flows into the main stem Juniata River approximately 2 miles below the confluence of the Frankstown Branch and the Little Juniata River. Habitat conditions at Shaver Creek (SHAV 1.4) near Petersburg, Pa., are nonsupporting due to severely degraded stream channel morphology conditions and excessive embeddedness. With the exception of nitrite, dissolved aluminum, and total and dissolved iron, the concentrations of most water quality parameters are low, compared to other reference category 67a sites (Figure 3). In spite of poor habitat conditions, the biological community at SHAV 1.4 is nonimpaired.

Standing Stone Creek

The biological community at STST 26.8, approximately 1 mile downstream of the Rothrock State Forest boundary is nonimpaired, and habitat conditions are excellent. Water quality conditions are somewhat degraded due to elevated ammonia, copper, and zinc concentrations (Figure 7). However, the biological community at STST 26.8 is exceptionally healthy, and water quality conditions do not appear to be adversely affecting the biological community. Land use upstream of STST 26.8 is forest, and several vacation homes are located immediately upstream. Failing on-lot septic systems may possibly be the source of ammonia, copper, and zinc at this site. Standing Stone Creek (STST 1.0) near Huntingdon, Pa.,

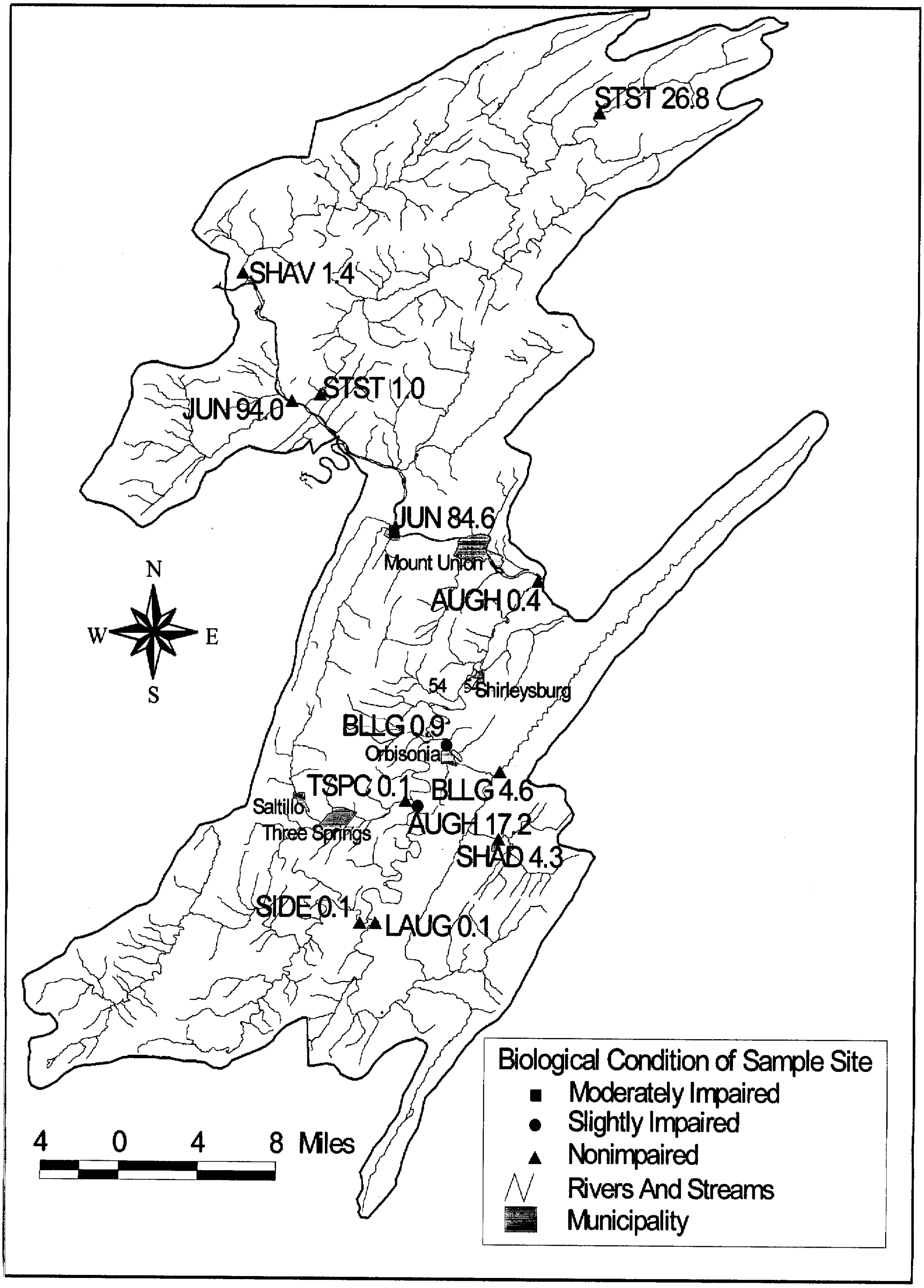


Figure 24. Biological Conditions of Sample Sites in the Upper Juniata River Section

supports a nonimpaired biological community and water quality conditions are similar to those of other reference category 67m sites with nonimpaired biological communities (Figures 15 and 16).

Aughwick Creek Watershed

Aughwick Creek begins at the confluence of Sideling Hill and Little Aughwick Creeks near Maddensville, Pa., in southern Huntingdon County. Both Sideling Hill Creek (SIDE 0.1) and Little Aughwick Creek (LAUG 0.1) support nonimpaired biological communities, and the habitat conditions of both streams are excellent. Water quality conditions are good at both sites. However, sodium and chloride concentrations are slightly elevated at SIDE 0.1. Land use upstream of both SIDE 0.1 and LAUG 0.1 consists primarily of agriculture and forest.

Near Pogue, Pa., the biological community of Aughwick Creek (AUGH 17.2) is slightly impaired, and habitat conditions are excellent. Water quality is good except for slightly elevated nitrite and TOC concentrations. All other nutrient concentrations are low. However, filter-feeding organisms constitute 73 percent of the 100-organism subsample, indicating an abundance of fine particulate organic matter and organic enrichment upstream of AUGH 17.2. Land use upstream of AUGH 17.2 is predominantly forest and agriculture.

Immediately downstream of AUGH 17.2, Three Springs Creek flows into Aughwick Creek. Three Springs Creek (TSPC 0.1) near Pogue supports a nonimpaired biological community, has excellent habitat conditions, and good water quality.

Approximately 5 miles downstream of the confluence of Three Springs Creek, Blacklog Creek joins Aughwick Creek. Sample sites in the Blacklog Creek Watershed include: BLLG 4.6 (Blacklog Creek approximately 1.5 miles upstream of the confluence of Shade Creek); SHAD 4.3 (Shade Creek upstream of Shade Gap Area STP); and BLLG 0.9 (Blacklog Creek upstream of Orbisonia-Rockhill Jt. STP). Both BLLG 4.6 and SHAD 4.3 have slightly degraded habitat conditions due to poor riffle/run quality, channel alteration, and poor riparian buffer conditions. However, the biological communities of both sites are nonimpaired.

The biological community at BLLG 0.9 is slightly impaired. However, water quality is good, and habitat conditions are excellent. The assessed water quality and habitat parameters provide little information regarding the source of biological impairment at BLLG 0.9. Land use upstream of BLLG 0.9 is predominantly forest, with some agriculture. The Shade Gap Area STP is the only permitted industrial or municipal wastewater discharge upstream of BLLG 0.9.

The water quality, physical habitat, and biological conditions of Aughwick Creek at its mouth (AUGH 0.4) are excellent. AUGH 0.4, the reference category 67m reference site, supports a nonimpaired biological community that is characterized by very high taxonomic richness and diversity and EPT metric scores. Aughwick Creek supports populations of numerous pollution-intolerant taxa, and contributes high quality water to the Juniata River.

Lower Juniata River Section

The 22 sample sites in the Lower Juniata River section are distributed among the following reference categories:

67a	67b	67cd
KISH 15.6	JACK 02.9	ELKC 09.8
HONY 00.2	TUSC 39.3	ELKC 00.1
DELA 00.2	NBTC 03.1	COCO 00.2
	WILL 00.4	BUFF 14.6
	COCO 09.6	
	BUFF 00.4	
67m	**67l**	
KISH 05.5	JUN 63.6	
KISH 00.4	JUN 47.0	
TUSC 22.5	JUN 34.0	
TUSC 00.6	JUN 17.3	
	JUN 02.0	

The biological conditions of these sites are summarized in Figure 25.

Kishacoquillas Creek Watershed

The physical habitat conditions of Kishocoquillas Creek, immediately upstream of the Union Twp. STP (KISH 15.6), are nonsupporting due to severely degraded stream channel morphology, excessive embeddedness, and poor riparian conditions. In addition to poor habitat conditions, KISH 15.6 has the highest concentrations of total and dissolved nitrogen, nitrite, and nitrate recorded in this survey of the Juniata Subbasin. However, RBP III bioassessment results indicate the biological community of this site is nonimpaired. This nonimpaired designation may be somewhat misleading in that the biological condition scores of the more robust metrics (taxonomic richness, Hilsenhoff index, and EPT index) are quite low. None the less, both KISH 15.6 and SHAV 1.4 demonstrate the ability of reference category 67a streams with degraded habitat conditions to support surprisingly healthy macroinvertebrate communities when water quality degradation is limited primarily to nutrient enrichment (Figure 5). The predominant land use upstream of KISH 15.6 is agriculture.

Approximately 9 miles downstream of KISH 15.6, Honey Creek flows into Kishacoquillas Creek. The water quality and physical habitat conditions of Honey Creek (HONY 0.2) at Reedsville, Pa., are excellent, and the biological community is nonimpaired. Honey Creek contributes high quality water to Kishacoquillas Creek.

The water quality and physical habitat conditions of Kishacoquillas Creek improve downstream of KISH 15.6 and the confluence of Honey Creek. Immediately upstream of Standard Steel (KISH 5.5) at Burnham, Pa., the concentrations of most water quality parameters are substantially lower than those recorded at KISH 15.6. However, total and dissolved nitrogen and nitrate concentrations are still very high. Total and dissolved phosphorus and total orthophosphorus concentrations are elevated above those at KISH 15.6. Although habitat conditions are excellent, the biological community of KISH 5.5 is slightly impaired (Figure 17). Permitted discharges between KISH 15.6 and KISH 5.5 include the Union Township and Brown Township STPs. Land use upstream of KISH 5.5 is mostly agriculture with some forest.

Downstream of KISH 5.5, Kishacoquillas Creek flows through Burnham, Highland Park, and Mt. Rock, Pa., to its confluence with the Juniata River at Lewistown, Pa. Although the Kishacoquillas Creek watershed changes from predominantly agricultural at KISH 5.5 to urban/suburban throughout its lower 5 miles, summer baseflow water quality conditions of the creek show little change between these two sites (Figure 15). The most noticeable changes in water quality include slight increases in specific conductance, TDS, total ammonia, hardness, sulfate, and dissolved aluminum concentrations at KISH 0.4. However, the physical habitat and biological conditions of the creek undergo substantial change between KISH 5.5 and KISH 0.4 (Figure 17).

Although the habitat condition score of KISH 0.4 (77 percent) is considerably lower than that of KISH 5.5 (121 percent), habitat conditions at KISH 0.4 are still suitable for supporting a healthy macroinvertebrate community. However, the biological community of Kishacoquillas Creek at KISH 0.4 is moderately impaired; water quality and habitat data do not explain the source(s) of impairment. Possible explanations for the level of impairment observed at KISH 0.4 include: (1) the physical habitat conditions of the site are adversely affecting the biological community to a greater extent than the habitat assessment results suggest; (2) the site may be impacted by episodic pollution sources such as urban stormwater runoff or point source discharges that were not substantially influencing water quality conditions at the time of sampling; and (3) substances such as aryl phosphates or other compounds that were not included in the analysis of water quality samples may be impacting the biological community at KISH 0.4 (Brezina, 1980).

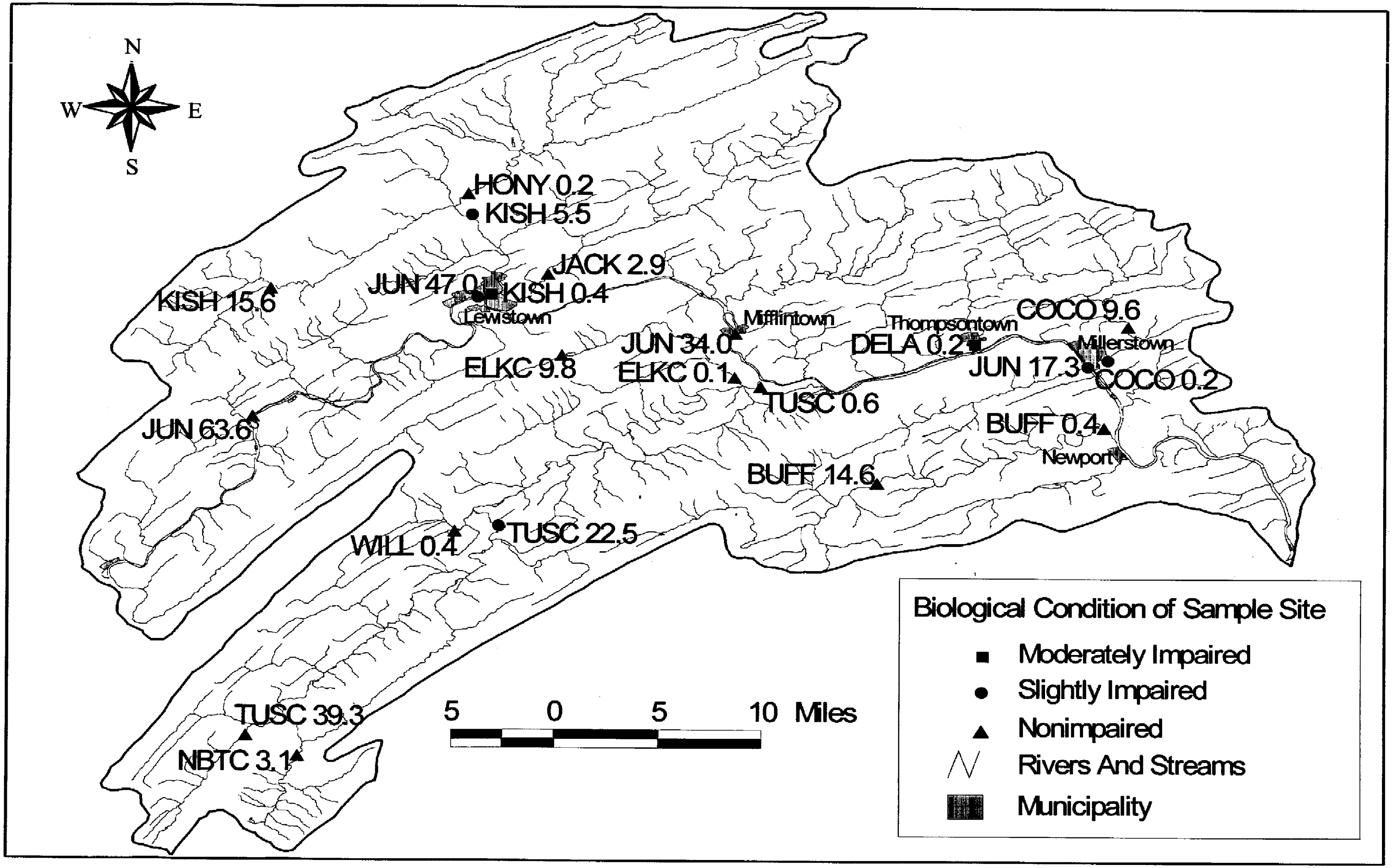


Figure 25. ***Biological Conditions of Sample Sites in the Lower Juniata River Section***

Jacks Creek

Approximately 1.5 miles downstream of the confluence of Kishacoquillas Creek, Jacks Creek flows into the Juniata River. The biological community of Jacks Creek (JACK 2.9) downstream of Maitland, Pa., is nonimpaired, and supports populations of several pollution-intolerant genera, including *Centroptilum* (Ephemeroptera: Baetidae), *Isonychia*, *Nigronia*, and *Leuctra*. Water quality and physical habitat conditions are good. However, TSS and aluminum concentrations are slightly high. The biological conditions in Jacks Creek have improved substantially since the late 1970s. Brezina (1980) described the biota of Jacks Creek as being highly depressed throughout most of its length.

Tuscarora Creek Watershed

Tuscarora Creek flows into the Juniata River at Port Royal, Pa. Seven sample sites are located in the Tuscarora Creek Watershed, and all but one of these sites support nonimpaired biological communities. The biological community of Tuscarora Creek (TUSC 22.5) near McCullochs Mills, Pa., is slightly impaired, as evidenced by reduced taxonomic richness and diversity and EPT metric scores. However, in spite of a very high total ammonia concentration, a Hilsenhoff score of 3.44 and an abundance of *Isonychia* and *Nigronia* at TUSC 22.5 indicate the biological community is not severely stressed by organic pollution. There are no permitted industrial or municipal wastewater discharges upstream of TUSC 22.5, and land use is mostly forest, with some agriculture.

Downstream of TUSC 22.5, Willow and East Licking Creeks support nonimpaired biological communities and contribute good quality water to Tuscarora Creek. Near its mouth, the biological community of Tuscarora Creek (TUSC 0.6) is nonimpaired and supports numerous pollution-intolerant genera, including *Heterocloeon*, *Isonychia*, *Ephoron*, *Nigronia*, *Leuctra*, *Acroneuria*, and *Dolophilodes* (Trichoptera: Philopotamidae). Tuscarora Creek contributes high quality water to the Juniata River.

Delaware Creek

Nine miles downstream of Tuscarora Creek, Delaware Creek flows into the Juniata River. The biological community of Delaware Creek (DELA 0.2) is moderately impaired due to degraded physical habitat and water quality conditions. Water quality conditions at DELA 0.2 are similar to those of SPRU 10.6, and are characterized by elevated acidity and TSS concentrations (Figures 3 and 4). There are no permitted industrial or municipal wastewater discharges upstream of DELA 0.2, and land use is predominantly agriculture and forest.

Cocolamus Creek

Cocolamus Creek (COCO 9.6), between Maze and Dimmsville, Pa., has the highest total iron concentration (2.06 mg/l) of all the sites included in this survey of the Juniata Subbasin. However, concentrations of all other water quality parameters are relatively low, and the biological community at COCO 9.6 is nonimpaired.

The biological community of Cocolamus Creek (COCO 0.2) at Millerstown, Pa., is slightly impaired. The designation of slightly impaired is largely the result of a high Hilsenhoff index score (5.42) due to an abundance of chironomids (pollution tolerance value = 7). However, COCO 0.2, in addition to supporting an abundance of chironomids, supports a number of pollution-intolerant genera, including *Heterocloeon*, *Isonychia*, *Ephoron*, *Nigronia*, *Leuctra*, and *Acroneuria*, indicating that the degree of biological impairment at the site is minimal. Although nitrogen and TDS concentrations are slightly elevated, the water quality conditions at COCO 0.2 are quite similar to those of BLLG 4.6 and BUFF 14.6, both of which support nonimpaired biological communities (Figures 11 and 12). Biological impairment at COCO 0.2 is attributed to degraded physical habitat conditions.

Buffalo Creek

Both sample sites on Buffalo Creek, BUFF14.6 at Eshcol, Pa., and BUFF 0.4 near its mouth, support nonimpaired biological communities. However, habitat conditions are slightly degraded at BUFF 0.4. Buffalo Creek contributes good quality water to the Juniata River.

Main Stem Juniata River

The main stem Juniata River begins at the confluence of the Frankstown Branch and Little Juniata Rivers near Alexandria, Pa. Approximately 9 miles downstream of its origin the river flows through Huntingdon, Pa. Thirty-two of the 38 water quality parameters assessed on the main stem Juniata River (JUN 94.0) at Huntingdon have values intermediate to, or lower than, those recorded at FRNK 1.6 and LJUN 3.8. Parameters that are elevated at JUN 94.0 include temperature, dissolved oxygen, total and dissolved nitrite, TOC, and total manganese. However, the biological community at JUN 94.0 is nonimpaired and supports populations of the pollution-intolerant mayflies *Serratella* (Ephemeroptera: Ephemerellidae), *Isonychia*, and *Ephoron*.

Approximately 3 miles downstream of Huntingdon, the Raystown Branch flows into the Juniata River. The waters of the Raystown Branch have a substantial impact on the water quality characteristics of the main stem Juniata River. At Mapleton Depot, Pa., approximately 6.5 miles downstream of the confluence of the Raystown Branch, the water quality conditions of the Juniata River (JUN 84.6) are similar to those of the Raystown Branch (RAYS 54.1) at Hopewell, Pa. (Figures 19 and 20). However, the biological community at RAYS 54.1 is nonimpaired, and that of JUN 84.6 is moderately impaired (Figure 21). Furthermore, in spite of the fact that both sites have habitat conditions comparable to the reference site, high quality riffle habitat, which is abundant at RAYS 54.1, is virtually nonexistent at JUN 84.6. Therefore, although the waters of the Raystown Branch substantially influence water quality conditions at JUN 47.8, impairment at this site is most likely due to habitat conditions and/or inadequacies in the methods used in this survey for assessing the habitat and biological conditions of large rivers.

At McVeytown, Pa., nutrient and major ion concentrations of the Juniata River (JUN 63.6) are substantially higher than those immediately downstream of the confluence of the Raystown Branch Juniata River. The concentrations of most of the water quality parameters at JUN 63.6 are lower than those recorded upstream of the confluence of the Raystown Branch at JUN 94.0 (Figure 19). However, the concentration of total ammonia at JUN 63.6 exceeds that of JUN 94.0, and total and dissolved nitrite concentrations approach those of JUN 94.0. Habitat conditions at McVeytown are excellent, and the biological community is nonimpaired. Pollution-intolerant genera at JUN 63.6 include *Ancyronyx* (Coleoptera: Elmidae), *Heterocloeon*, *Isonychia*, *Ephoron*, and *Pteronarcys* (Plecoptera: Pteronarcidae).

Approximately 14 miles downstream of McVeytown, the Juniata River flows through Lewistown, Pa. Water quality conditions of the river at Lewistown (JUN 47.0), upstream of the confluence of Kishacoquillas Creek, are similar to those of JUN 63.6 at McVeytown and JUN 94.0 at Huntingdon (Figures 19 and 20). However, total and dissolved ammonia concentrations at Lewistown are higher than those of both the upstream sites. Habitat conditions at JUN 63.6 are poor, and this section of the river consists of one large, slow-flowing pool. Since riffle habitat is absent at this site, macroinvertebrates were collected from rocky areas along the water's edge that provided marginal sampling habitat.

Bioassessment results indicate the biological community at JUN 47.0 is slightly impaired (Figure 21). Furthermore, none of the five pollution-intolerant genera observed at JUN 63.6 are present at JUN 47.0. However, JUN 47.0 supports several pollution-intolerant genera that were not present at JUN 63.6, including *Macronychus*, *Centroptilum*, and *Ephemera* (Ephemeroptera: Ephemeridae). The presence of pollution-intolerant taxa at JUN 47.0 indicates biological impairment at this site is most likely due to poor habitat conditions, rather than degraded water quality.

Between Lewistown (JUN 47.0) and Millerstown (JUN 17.3), the concentrations of most water quality parameters tend to decrease (Figure 19). However, temperature and dissolved oxygen, TOC, and hardness concentrations increase through this section of the river. TSS and dissolved and total nitrite are elevated at Mifflintown (JUN 34.0). The physical habitat and biological conditions of the river improve dramatically between Lewistown and Mifflintown (Figure 21). The biological community at Mifflintown (JUN 34.0) is nonimpaired and supports populations of *Macronychus*, *Heterocloeon*, *Serratella*, *Isonychia*, *Ephoron*, *Nigronia*, and *Dolophilodes*.

Bioassessment results indicate taxonomic richness and EPT index scores are relatively low, and the biological community of the Juniata River at Millerstown (JUN 17.3) is slightly impaired. However, water quality and physical habitat conditions are very good, and JUN 17.3 supports populations of the pollution-intolerant mayflies *Heterocloeon*, *Isonychia*, and *Ephoron*, indicating that the degree of biological impairment at Millerstown is minimal (Figures 19 and 21).

The water quality conditions of the Juniata River (JUN 2.0) are somewhat degraded at Amity Hall, Pa.. The concentrations of most water quality parameters increase between Millerstown and Amity Hall, especially concentrations of TSS, acidity, total and dissolved ammonia, and the metals iron, zinc, and aluminum. The water quality conditions at Amity Hall are somewhat similar to those of RAYS 42.8, the Raystown Branch Juniata River at Saxton, Pa. (Figure 20). The biological community at RAYS 42.8 is slightly impaired due to degraded water quality conditions. Channel depth precluded macroinvertebrate data collection and an assessment of the biological conditions of the Juniata River at JUN 2.0.

Summary of the Biological Conditions in the Juniata Subbasin

Approximately one half (55 percent) of the 59 sites assessed in the Juniata Subbasin support nonimpaired biological communities. Biological conditions are slightly impaired and moderately impaired at 31percent and 14 percent of the sites, respectively (Figure 26 and Table 18). In general, the biological conditions of most of the streams and rivers in the subbasin appear to be similar to those documented by Brezina (1980) and McMorran (1986). However, in most cases, only general conclusions can be made regarding changes in the biological conditions of the streams and rivers discussed in these reports, because different data collection and analysis methods were used in these surveys.

The biological communities of several of the waterways that were described by Brezina as being highly depressed in the late 1970s are still moderately impaired. These waterways include the Frankstown Branch Juniata River, downstream of the Appleton Papers wastewater discharge; the lower section of Beaverdam Branch; and Kishacoquillas Creek at Lewistown. However, the biological integrity of the Frankstown Branch, between the confluence of Halter Creek and the Appleton Papers wastewater discharge, has been completely restored in response to the diversion of Appleton's wastewater from Halter Creek to the Frankstown Branch. Although Halter Creek was not included in this assessment of the Juniata Subbasin, the diversion of Appleton's wastewater has most likely also resulted in dramatic improvements in the biological and water quality conditions of Halter Creek. The biological conditions of the lower section of Jacks Creek have improved from highly depressed in the late 1970s to nonimpaired.

Two of the sample sites identified during this survey as having moderately impaired biological communities were not included in the assessments conducted by Brezina (1980) and McMorran (1986). These sites are Spruce Creek (SPRU 10.6) at Graysville, Pa., and Delaware Creek (DELA 0.2) at Thompsontown, Pa.

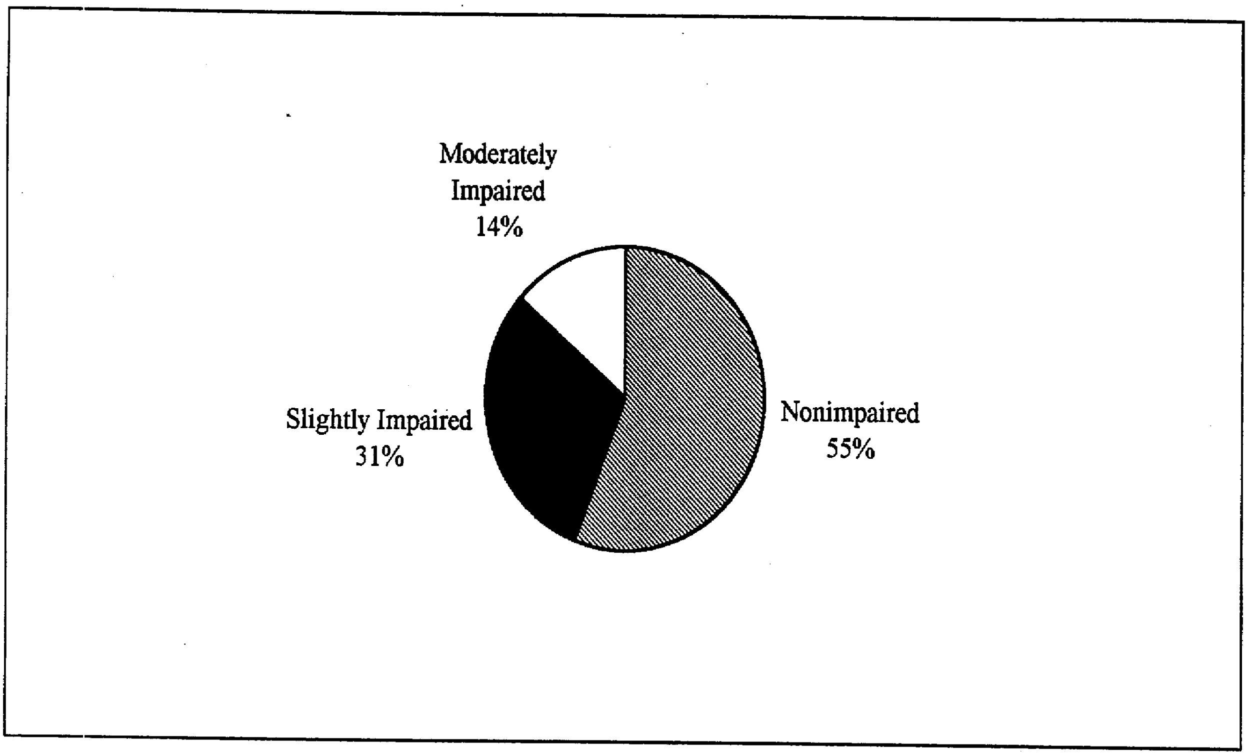


Figure 26. Summary of the Biological Conditions of the Streams and Rivers in the Juniata Subbasin

Table 18. Summary of the physical Habitat and Biological Conditions of Sample Sites in the Juniata Subbasin

Sample Site	Reference Category	Habitat Percent of Reference	Habitat Condition	Biological Percent of Reference	Biological Condition
YELL03.5	67a	100	Excellent	100	Nonimpaired
SPRU01.0	67a	108	Excellent	94	Nonimpaired
CLOV00.1	67a	104	Excellent	83	Nonimpaired
HONY00.2	67a	93	Excellent	83	Nonimpaired
FRNK38.1	67a	76	Supporting	83	Nonimpaired
SHAV01.4	67a	41	Nonsupporting	83	Nonimpaired
KISH15.6	67a	32	Nonsupporting	83	Nonimpaired
LJUN19.4	67a	102	Excellent	72	Slightly Impaired
LJUN29.6	67a	83	Supporting	72	Slightly Impaired
SPRU10.6	67a	83	Supporting	39	Moderately Impaired
DELA00.2	67a	71	Partially Supporting	33	Moderately Impaired
BEAV00.1	67a	46	Nonsupporting	33	Moderately Impaired
LAUG00.1	67b	100	Excellent	100	Nonimpaired
SIDE00.1	67b	98	Excellent	100	Nonimpaired
BUFF00.4	67b	68	Partially Supporting	100	Nonimpaired
WILL00.4	67b	63	Partially Supporting	100	Nonimpaired
TSPC00.1	67b	90	Excellent	94	Nonimpaired
COCO09.6	67b	85	Supporting	89	Nonimpaired
NBTC03.1	67b	79	Supporting	89	Nonimpaired
STST26.8	67b	92	Excellent	83	Nonimpaired
JACK02.9	67b	81	Supporting	83	Nonimpaired
TUSC39.3	67b	80	Supporting	83	Nonimpaired
BLLG00.9	67b	94	Excellent	78	Slightly Impaired
BOBS00.9	67b	82	Supporting	56	Slightly Impaired
DUNN09.9	67b	61	Partially Supporting	33	Moderately Impaired
SBEC01.4	67cd	100	Excellent	100	Nonimpaired
SHAD 4.3	67cd	79	Supporting	100	Nonimpaired
BOBS11.4	67cd	104	Excellent	94	Nonimpaired
ELKC00.1	67cd	82	Supporting	94	Nonimpaired
BLLG04.6	67cd	77	Supporting	94	Nonimpaired
BRUS00.1	67cd	94	Excellent	89	Nonimpaired
ELKC09.8	67cd	88	Supporting	89	Nonimpaired
BUFF14.6	67cd	82	Supporting	89	Nonimpaired
RAYS103	67cd	79	Supporting	83	Nonimpaired
COCO00.2	67cd	73	Partially Supporting	78	Slightly Impaired
AUGH00.4	67m	100	Excellent	100	Nonimpaired
TUSC00.6	67m	83	Supporting	94	Nonimpaired
STST01.0	67m	112	Excellent	89	Nonimpaired
FRNK01.6	67m	115	Excellent	78	Slightly Impaired
RAYS80.5	67m	102	Excellent	78	Slightly Impaired
AUGH17.2	67m	115	Excellent	72	Slightly Impaired
DUNN00.1	67m	67	Partially Supporting	72	Slightly Impaired
LJUN03.8	67m	107	Excellent	67	Slightly Impaired
LJUN15.0	67m	103	Excellent	67	Slightly Impaired
FRNK18.9	67m	118	Excellent	61	Slightly Impaired
TUSC22.5	67m	101	Excellent	61	Slightly Impaired
KISH05.5	67m	121	Excellent	56	Slightly Impaired
FRNK32.5	67m	81	Supporting	50	Moderately Impaired
KISH00.4	67m	77	Supporting	39	Moderately Impaired

Table 18. Summary of the physical Habitat and Biological Conditions of Sample Sites in the Juniata Subbasin—Continued

Sample Site	Reference Category	Habitat Percent of Reference	Habitat Condition	Biological Percent of Reference	Biological Condition
JUN34.0	671	100	Excellent	100	Nonimpaired
RAYS54.1	671	127	Excellent	89	Nonimpaired
JUN63.6	671	120	Excellent	83	Nonimpaired
JUN94.0	671	98	Excellent	83	Nonimpaired
JUN17.3	671	109	Excellent	78	Slightly Impaired
JUN47.0	671	57	Nonsupporting	61	Slightly Impaired
RAYS42.8	671	116	Excellent	56	Slightly Impaired
RAYS04.6	671	110	Excellent	44	Moderately Impaired
JUN84.6	671	91	Excellent	33	Moderately Impaired
GTRC02.9	69a	106	Excellent	72	Slightly Impaired

MANAGEMENT IMPLICATIONS

The physical habitat and water quality characteristics of a stream form the foundation upon which its biological community develops. Furthermore, the natural landscape features within a stream's watershed influence these abiotic (non-living) characteristics of the stream, and in turn, the biological community that it supports. Therefore, the biological community of a particular stream or river, in the absence of man's influence, represents the sum of the relationships between the natural landscape features and the physical habitat and water quality conditions of that waterway.

The water quality, physical habitat, and biological data generated in this survey of the streams and rivers in the Juniata Subbasin indicate the relationships between the abiotic and biotic conditions of these waterways vary based on ecoregion designation and drainage area size. Statistically significant relationships ($P < 0.05$) observed between the abiotic characteristics and the biological communities of the streams and rivers in the Juniata Subbasin are described below. These findings, although based on a relatively small number of observations, are presented as possible subject areas for future research and as management issues to be considered by natural resource managers and policy makers.

Reference Category 67a, Small Limestone/Dolomite Valley Streams

Reference category 67a sites show a high degree of variability in their water quality, physical habitat, and biological conditions. A relatively large percentage of these sites have nonsupporting habitat conditions (Figure 27). However, none of the habitat parameters assessed are significantly correlated with the biological condition scores of these sites. Many of the biologically impaired category 67a sites are located in the Frankstown Branch Juniata River and the Little Juniata River Watersheds. Many of these sites are adversely impacted by a combination of industrial and municipal discharges and urban runoff. Acidity is the only water quality parameter significantly correlated with biological condition scores of category 67a sites. As acidity concentrations increase, biological communities tend to be more degraded.

An interesting characteristic of reference category 67a streams is that when water quality degradation is limited primarily to nutrient enrichment, riffle areas in these waterways appear to have the ability to support surprisingly healthy macroinvertebrate communities. How-ever, the morphological characteristics of many of the small limestone/dolomite valley streams throughout the Commonwealth have been degraded to the point where riffle habitat is of poor quality, rare, or even nonexistent. Thus, many of the nutrient enriched, lime-stone/dolomite valley streams with degraded habitat conditions such as those impacted by intensive agriculture and/or mill dam construction may have good to excellent biological recovery potential and may be prime candidates for habitat restoration projects.

Reference Category 67b, Small Shale or Slate Non-Calcareous Valley Streams

The biological scores of reference category 67b sites are significantly correlated to the concentrations of sulfate, dissolved nitrite, TDS, and magnesium and the habitat parameters forested riparian buffer (FRB) zone width, riffle/run quality, and pool/riffle ratio. Furthermore, these water quality and habitat parameters also are closely related to each other. Sulfate, dissolved nitrite, and TDS concentrations are all negatively correlated with FRB zone width, riffle/run quality, and pool/riffle ratio scores. Magnesium concentrations are negatively correlated with FRB zone width scores.

The biological communities of small shale and slate valley streams are substantially influenced by both water quality and physical habitat conditions. Furthermore, the reference category

67b streams in the Juniata Subbasin appear to be somewhat susceptible to habitat degradation (Figure 27). Thus, natural resource management activities in the watersheds of these streams should focus on the restoration and protection of instream habitat and riparian vegetative conditions, as well as water quality conditions.

Reference Category 67cd, Small Sandstone or Shale Ridge Streams

Most of the reference category 67cd sites support nonimpaired biological communities (Figure 27). However, the biological condition scores of these waterways are positively correlated with the habitat parameters, pool/riffle ratio, and embeddedness. Furthermore, the pool/riffle ratio and embeddedness scores of these sites are significantly correlated with each other, and both are positively correlated with upper and lower streambank stability scores. Thus, management activities in the watersheds of small sandstone and shale ridge streams should be directed toward streambank stabilization and/or stream channel morphology projects that minimize sediment deposition and embedded-ness and restore or maintain riffle/pool equilibrium.

Reference Category 67m, Medium-Sized Streams and Rivers in Ecoregion 67

In spite of good habitat conditions, the biological communities of a relatively large percentage of reference category 67m sites are slightly impaired (Figure 27). The biological condition scores of category 67m sites are negatively correlated with dissolved phosphorus, total nitrogen, hardness, TDS, and alkalinity and are positively correlated with dissolved iron concentrations. No statistically significant relationships exist between any of the habitat parameter scores and the biological scores of these sites. Thus, the biological communities of these streams appear to be predominantly influenced by physico-chemical water quality conditions.

Reference Category 67l, Large Rivers in Ecoregion 67

Correlation analysis of the water quality, physical habitat, and biological data from reference category 67l sites provides little insight into the relationships that exist between these components of large river ecosystems. However, the pool/riffle ratio and biological condition scores of reference category 67l sites are significantly correlated, suggesting the biological communities of large rivers in the Juniata Subbasin are predominantly influenced by physical habitat conditions.

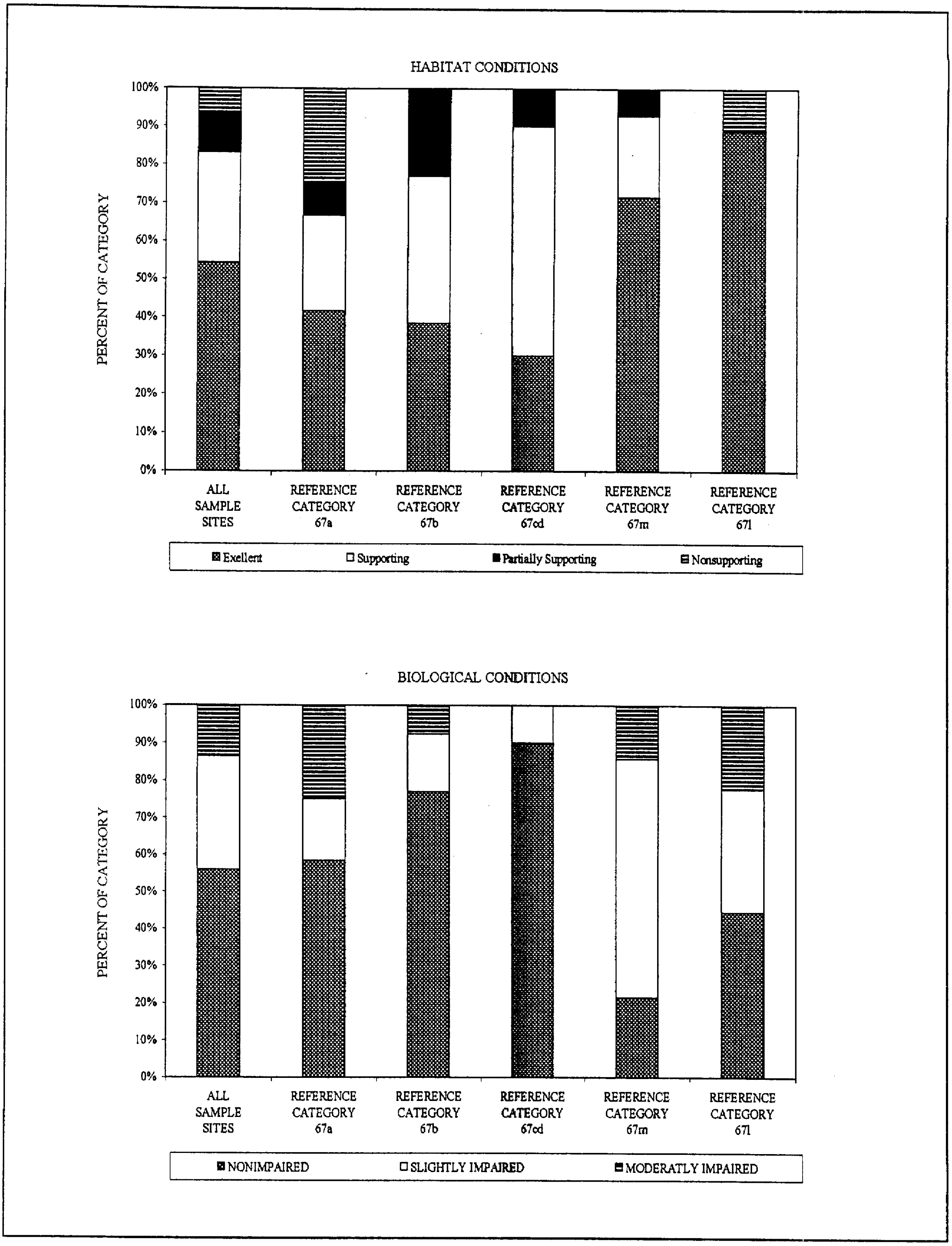


Figure 27. ***Summary of the Physical Habitat and Biological Conditions of the Streams in the Juniata Subbasin***

CONCLUSIONS

Approximately one half (55 percent) of the 59 sites assessed in the Juniata Subbasin support nonimpaired biological communities. Biological conditions are slightly impaired and moderately impaired at 31 percent and 14 percent of the sites, respectively. In general, the biological conditions of most of the streams and rivers in the subbasin appear to be similar to, or better than, those documented by Brezina (1980) and McMorran (1986). However, the biological communities of several of the waterways highly depressed in the late 1970s are still moderately impaired. These waterways include the Frankstown Branch Juniata River, downstream of the Appleton Papers wastewater discharge; the lower section of Beaverdam Branch; and Kishacoquillas Creek at Lewistown, Pa.

The water quality and biological conditions of several streams have improved dramatically since the late 1970s. The biological integrity of the Frankstown Branch, between the confluence of Halter Creek and the Appleton Papers wastewater discharge, has been completely restored in response to the diversion of Appleton's wastewater from Halter Creek to the Frankstown Branch. Although Halter Creek was not included in this assessment of the Juniata Subbasin, the diversion of Appleton's wastewater has most likely also resulted in the restoration of the biological and water quality conditions of Halter Creek. The biological conditions of the lower section of Jacks Creek have improved substantially since the late 1970s.

The specific relationships that exist between the physical habitat, water quality, and biological conditions of the streams and rivers in the Juniata Subbasin vary, based on ecoregion designation and drainage area size. Some of the water quality and physical habitat parameters that are significantly ($P<0.05$) correlated with the biological condition scores of sample sites in the Juniata Subbasin include: (1) acidity concentrations in small limestone/dolomite valley (Ecoregion 67a) streams; (2) sulfate, dissolved nitrite, TDS, and magnesium concentrations and forested riparian buffer zone width, riffle/run quality, and riffle/pool ratio scores in small shale or slate non-calcareous valley (Ecoregion 67b) streams; (3) pool/riffle ratio and embeddedness scores in small sandstone or shale ridge (Ecoregion 67c and 67d) streams; (4) dissolved phosphorus, total nitrogen, hardness, TDS, and alkalinity concentrations in medium-sized streams and rivers (drainage areas between 100 and 500 sq. mi.) in Ecoregion 67; and (5) pool/riffle ratio scores in large rivers (rivers with drainage areas greater than 500 sq. mi.) in Ecoregion 67. These relationships are presented as subject areas possibly warranting additional research and as management issues to be considered by natural resource managers and policy makers.

Principal components and cluster analyses were effective techniques for condensing the water quality data into a manageable format and for revealing structure in the water quality data. Furthermore, these multivariate statistical analyses enhanced our ability to identify the environmental factors influencing the biological conditions of impaired streams and rivers in the Juniata Subbasin.

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Appendix A
Organic Pollution Tolerance Values and Functional Feeding Group Designations of Benthic Macroinvertebrate Taxa

Order	Family	Genus	Organic Pollution Tolerance Value	Functional Feeding Group Designation
Coleoptera	Elmidae	*Ancyronyx*	2	CG
		Gonielmis	5	SC
		Macronychus	2	SC
		Optioservus	4	SC
		Stenelmis	5	SC
	Gyrinidae	*Dineutis*	4	P
	Hydrophilidae	*Hydrobius*	5	P
	Psephenidae	*Psephenus*	4	SC
		Ectopria	5	SC
Diptera	Athericidae	*Atherix*	2	P
	Chironomidae		7	CG
	Empididae	*Hemerodromia*	6	P
	Simulidae	*Simulium*	6	FC
	Tipulidae	*Antocha*	3	CG
		Hexatoma	2	P
		Tipula	4	SH
Ephemeroptera	Baetidae	*Baetis*	6	CG
		Centroptilum	2	CG
		Heterocloeon	2	SC
		Neocloeon	6	CG
		Pseudocloeon	4	CG
	Caenidae	*Brachycercus*	3	CG
		Caenis	7	CG
	Ephemerellidae	*Drunella*	1	SC
		Ephemerella	1	SC
		Eurylophella	4	SC
		Serratella	2	SC
	Ephemeridae	*Ephemera*	2	CG
		Hexagenia	6	CG
	Heptageniidae	*Epeorus*	0	CG
		Heptagenia	4	SC
		Leucrocuta	1	SC
		Stenacron	4	SC
		Stenonema	3	SC
	Leptophlebidae	*Leptophlebia*	4	CG
		Paraleptophlebia	1	CG
	Oligoneuriidae	*Isonychia*	2	FC
	Polymitarcidae	*Ephoron*	2	CG
	Potamanthidae	*Potamanthus*	4	CG
	Siphlonuridae	*Ameletus*	0	CG
		Parameletus	7	CG
	Tricorythidae	*Tricorythodes*	4	CG
Megaloptera	Corydalidae	*Corydalus*	4	P
		Nigronia	2	P
	Sialidae	*Sialis*	4	P

Order	Family	Genus	Organic Pollution Tolerance Value	Functional Feeding Group Designation
Odonata	Aeshnidae	*Boyeria*	2	P
	Coenagrionidae	*Argia*	6	P
		Nehalennia	7	P
	Gomphidae	*Erpentogomphus*	5	P
		Gomphus	5	P
		Ophiogomphus	1	P
		Stylogomphus	4	P
Plecoptera	Capniidae	*Paracapnia*	1	SH
	Chloroperlidae	*Alloperla*	0	CG
	Leuctridae	*Leuctra*	0	SH
	Peltoperlidae	*Peltoperla*	0	SH
	Perlidae	*Acroneuria*	0	P
		Neoperla	3	P
		Paragnetina	1	P
		Phasganophora	2	P
	Pteronarcidae	*Pteronarcys*	0	SH
Trichoptera	Brachycentridae	*Brachycentrus*	1	FC
	Hydropsychidae	*Cheumatopsyche*	5	FC
		Hydropsyche	4	FC
		Macronema	3	FC
		Potamyia	5	FC
		Sympitopsyche	4	FC
	Philopotamidae	*Chimarra*	4	FC
		Dolophilodes	0	FC
	Polycentropodidae	*Neureclipsis*	7	FC
		Polycentropus	6	FC
	Psychomyiidae	*Lype*	2	CG
	Rhyacophilidae	*Rhyacophila*	1	P
Amphipoda	Gammaridae	*Gammarus*	6	SH
Decapoda	Cambaridae	*Cambarus*	6	CG
		Procambarus	6	SH
Gastropoda	Lymnaeidae	*Lymnaea*	7	SC
	Physidae	*Physa*	8	SC
Isopoda	Asellidae	*Asellus*	8	SH
Pelecypoda	Corbiculidae	*Corbicula*	4	FC
	Sphaeridae	*Pisidium*	8	FC

Source: US EPA (1990)

APPENDIX B
RAW WATER QUALITY DATA FROM SAMPLE SITES IN THE JUNIATA SUBBASIN

Parameter Symbol	Parameter Name	Pa. DEP Test No.	Units	AUGH00.4	AUGH17.2	BEAV00.1	BLLG00.9	BLLG04.6	BOBS00.9	BOBS11.4	BRUS00.1
Date	Date		yymmdd	95/07/20	95/07/18	95/08/01	95/07/20	95/07/19	95/07/25	95/07/27	95/07/26
Time	Time		hhmm	1230	1830	1330	900	1000	1630	1200	930
Temp.	Water Temperature	10	C	25.0	26.5	23.0	19.0	20.0	24.0	19.5	22.0
pH	pH (field)	400	S.U.	7.70	7.30	7.50	8.25	8.25	8.60	7.25	7.80
D.O.	Dissolved Oxygen (field)	300	mg/l	8.00	7.20	6.40	8.40	8.00	9.00	8.00	8.00
Spec. Cond.	Specific Conductancd (field)	94		165	150	525	130	80		80	90
Alk.	Alkalinity (field as CaCO3)	410	mg/l	44	28	92	42	22	94	26	24
Acid.	Acidity (field as CaCO3)	435	mg/l	4	4	4	<2	<2	0	4	4
T. RES	Total Residue	500	mg/l	114	89	404	128	145	198	148	103
TDS	Total Dissolved Solids	515	mg/l	106	88	392	122	144	180	146	102
TSS	Total Suspended Solids	530	mg/l	8	<2	12	6	<2	18	2	<2
N	Total Nitrogen	600	mg/l	0.53	0.67	5.45	0.53	1.14	1.73	0.91	0.88
N. diss.	Dissolved Nitrogen	602	mg/l	0.47	0.67	5.45	0.56	1.14	1.64	0.91	0.85
NH3 diss.	Dissolved Ammonia Nitrogen	608	mg/l	<0.02	<0.02	0.08	<0.02	<0.02	<0.02	<0.02	<0.02
NH3	Total Ammonia Nitrogen	610	mg/l	<0.02	<0.02	0.08	<0.02	<0.02	<0.02	<0.02	<0.02
NO2 diss.	Dissolved Nitrite Nitrogen	613	mg/l	0.004	0.018	0.020	0.004	0.004	0.022	0.004	0.008
NO2	Total Nitrite Nitrogen	615	mg/l	0.004	0.012	0.020	0.006	0.004	0.022	0.006	0.008
NO3 diss.	Dissolved Nitrate Nitrogen	618	mg/l	0.24	0.35	3.81	0.31	0.88	1.52	0.78	0.63
NO3	Total Nitrate Nitrogen	620	mg/l	0.24	0.36	3.81	0.31	0.88	1.52	0.78	0.63
P	Total Phosphorus	665	mg/l	0.04	0.03	0.31	0.03	0.03	0.05	0.04	0.05
P diss.	Dissolved Phosphorus (wet meth.)	666	mg/l	0.019	0.013	0.228	0.027	0.009	0.032	0.035	0.033
TOC	Total Organic Carbon	680	mg/l	4.2	4.9	3.1	3.2	2.9	2.4	1.2	3.5
Hard.	Total Hardness (CaCO3)	900	mg/l	62	40	195	65	98	111	22	28
Ca	Total Calcium	916	mg/l	15.80	11.50	50.70	21.30	34.20	36.20	6.18	9.44
Mg	Total Magnesium	927	mg/l	3.82	3.19	13.60	4.67	6.72	9.19	2.50	2.71
Na	Total Sodium	929	mg/l	8.22	9.99	24.70	2.98	3.70	5.24	2.79	5.06
K	Total Potassium	937	mg/l	1.97	2.39	3.57	1.49	1.94	1.70	1.53	2.47
Cl	Total Chloride	940	mg/l	13	16	46	3	6	8	4	7
SO4	Total Sulfate	945	mg/l	12.7	12.4	94.8	11.4	15.2	30.7	10.7	8.5
Cu	Total Copper	1042	µg/l	<4	<4	<4	<4	<4	<4	<4	5.6
Fe	Total Iron	1045	µg/l	201	271	397	368	310	200	83	466
Fe diss.	Dissolved Iron	1046	µg/l	66	84	11	99	missed	33	18	176
Pb	Total Lead	1051	µg/l	<1	<1	<1	<1	<1	<1	<1	<1
Mn	Total Manganese	1055	µg/l	20.1	25.2	286.0	23.3	23.9	13.0	26.9	29.4
Mn diss.	Dissolved Manganese	1056	µg/l	16	16	230	24	missed	17	<10	24
Ni	Total Nickel	1067	µg/l	<4	<4	<20	<4	<4	<4	<4	<4
Zn	Total Zinc	1092	µg/l	<5	<5	13.2	<5	<5	<5	<5	<5
Al	Total Aluminum	1105	µg/l	76.9	149.0	204.5	136.6	122.0	94.2	47.2	145.0
Al diss.	Dissolved Aluminum	1106	µg/l	<10	21.4	21.1	13.5	<10	<10	<10	16.7
TOP	Total Ortho Phosphorus	70507	mg/l	0.004	0.002	0.234	0.002	0.008	0.011	0.018	0.009

Parameter Symbol	Parameter Name	Pa. DEP Test No.	Units	BUFF00.4	BUFF14.6	CLOV00.1	COCO00.2	COCO09.6	DELA00.2	DUNN00.1	DUNN09.9
Date	Date		yymmdd	95/07/19	95/07/19	95/08/01	95/07/19	95/07/19	95/08/08	95/07/25	95/07/27
Time	Time		hhmm	1205	945	930	1625	1415	940	1430	1430
Temp.	Water Temperature	10	C	24.2	21.1	22.0	25.7	22.9	15.5	23.0	25.0
pH	pH (field)	400	S.U.	7.95	7.60	8.20	8.60	8.20	6.80	8.10	7.80
D.O.	Dissolved Oxygen (field)	300	mg/l	9.48	8.12	7.20	9.99	10.13	8.80	7.60	8.40
Spec. Cond.	Specific Conductancd (field)	94		153	184	350	202	157	375	285	250
Alk.	Alkalinity (field as CaCO3)	410	mg/l	52	64	164	68	56	124	96	96
Acid.	Acidity (field as CaCO3)	435	mg/l	2	4	<2	0	1	36	<2	4
T. RES	Total Residue	500	mg/l	78	117	270	145	96	270	218	210
TDS	Total Dissolved Solids	515	mg/l	76	116	258	144	94	256	210	194
TSS	Total Suspended Solids	530	mg/l	2	<2	12	<2	2	14	8	16
N	Total Nitrogen	600	mg/l	1.20	1.58	5.14	2.02	1.52	3.70	1.29	1.50
N. diss.	Dissolved Nitrogen	602	mg/l	1.14	1.52	4.57	1.96	1.44	3.70	1.23	1.44
NH3 diss.	Dissolved Ammonia Nitrogen	608	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
NH3	Total Ammonia Nitrogen	610	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02
NO2 diss.	Dissolved Nitrite Nitrogen	613	mg/l	0.008	0.014	0.014	0.010	0.006	0.006	0.008	0.020
NO2	Total Nitrite Nitrogen	615	mg/l	0.008	0.014	0.016	0.010	0.006	0.006	0.008	0.020
NO3 diss.	Dissolved Nitrate Nitrogen	618	mg/l	0.96	1.38	3.64	1.71	1.27	2.81	1.09	1.23
NO3	Total Nitrate Nitrogen	620	mg/l	0.96	1.38	3.81	1.71	1.27	3.03	1.11	1.23
P	Total Phosphorus	665	mg/l	<0.02	0.04	0.07	0.04	0.03	0.04	0.05	0.05
P diss.	Dissolved Phosphorus (wet meth.)	666	mg/l	0.020	0.013	0.046	0.029	0.031	0.032	0.032	0.028
TOC	Total Organic Carbon	680	mg/l	3.0	2.5	2.1	2.8	2.3	1.1	2.4	2.3
Hard.	Total Hardness (CaCO3)	900	mg/l	57	76	208	79	62	168	122	100
Ca	Total Calcium	916	mg/l	16.80	22.60	44.40	19.30	19.30	52.60	41.10	33.00
Mg	Total Magnesium	927	mg/l	4.31	4.92	19.60	3.91	3.88	9.18	9.26	7.82
Na	Total Sodium	929	mg/l	2.99	2.53	3.04	2.02	2.04	4.99	4.65	4.58
K	Total Potassium	937	mg/l	1.87	1.57	2.27	1.70	1.27	1.77	2.01	1.59
Cl	Total Chloride	940	mg/l	5	4	8	5	4	11	8	7
SO4	Total Sulfate	945	mg/l	10.6	11.8	14.6	14.0	9.4	31.1	30.5	37.5
Cu	Total Copper	1042	µg/l	<4	<4	<4	<4	<4	<4	<4	<4
Fe	Total Iron	1045	µg/l	267	418	240	72	2060	74	284	263
Fe diss.	Dissolved Iron	1046	µg/l	79	101	<10	58	69	<10	35	47
Pb	Total Lead	1051	µg/l	<1	<1	<1	<1	<1	<1	<1	<1
Mn	Total Manganese	1055	µg/l	27.1	31.7	22.0	16.4	13.3	17.0	16.4	22.9
Mn diss.	Dissolved Manganese	1056	µg/l	13	20	22	<10	<10	<10	12	<10
Ni	Total Nickel	1067	µg/l	<4	<4	<4	<4	<4	<4	<4	<4
Zn	Total Zinc	1092	µg/l	<5	<5	<5	<5	<5	5.0	<5	<5
Al	Total Aluminum	1105	µg/l	122.0	169.0	63.0	128.0	96.5	39.6	139.0	92.3
Al diss.	Dissolved Aluminum	1106	µg/l	10.9	10.5	<10	13.6	11.8	<10	<10	<10
TOP	Total Ortho Phosphorus	70507	mg/l	0.006	0.015	0.031	0.017	0.017	0.012	0.013	0.013

Parameter Symboi	Parameter Name	Pa. DEP Test No.	Units	ELKC00.1	ELKC09.8	FRNK01.6	FRNK18.9	FRNK32.5	FRNK38.1	GTRC02.9	HONY00.2
Date	Date		yymmdd	95/07/18	95/07/18	95/07/24	95/08/01	95/08/01	95/07/31	95/07/25	95/08/08
Time	Time		hhmm	1615	1220	1830	1100	1230	1645	930	1220
Temp.	Water Temperature	10	C	24.0	19.4	23.0	25.0	24.5	25.0	21.0	18.5
pH	pH (field)	400	S.U.	8.25	7.20	8.30	8.00	7.90	8.25	7.50	7.35
D.O.	Dissolved Oxygen (field)	300	mg/l	9.26	8.76	8.20	6.80	6.20	8.20	7.80	9.20
Spec. Cond.	Specific Conductancd (field)	94		162	52	460	550	650	405	95	190
Alk.	Alkalinity (field as CaCO3)	410	mg/l	60	20	124	120	142	122	24	80
Acid.	Acidity (field as CaCO3)	435	mg/l	1	6	0	<2	4	<2	4	8
T. RES	Total Residue	500	mg/l	106	42	358	362	434	280	74	176
TDS	Total Dissolved Solids	515	mg/l	90	30	342	356	418	266	68	168
TSS	Total Suspended Solids	530	mg/l	16	12	16	6	16	14	6	8
N	Total Nitrogen	600	mg/l	1.29	0.43	2.61	2.40	2.38	2.79	0.59	0.94
N. diss.	Dissolved Nitrogen	602	mg/l	1.23	0.38	2.58	2.40	2.38	2.14	0.56	0.85
NH3 diss.	Dissolved Ammonia Nitrogen	608	mg/l	<0.02	<0.02	<0.02	<0.02	0.02	0.03	<0.02	<0.02
NH3	Total Ammonia Nitrogen	610	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02
NO2 diss.	Dissolved Nitrite Nitrogen	613	mg/l	0.004	0.004	0.008	0.010	0.024	0.024	<0.004	0.006
NO2	Total Nitrite Nitrogen	615	mg/l	0.006	0.004	0.008	0.018	0.024	0.024	0.004	0.006
NO3 diss.	Dissolved Nitrate Nitrogen	618	mg/l	1.08	0.29	2.15	1.75	1.63	1.67	0.42	0.69
NO3	Total Nitrate Nitrogen	620	mg/l	1.08	0.29	2.45	1.78	1.65	1.61	0.44	0.72
P	Total Phosphorus	665	mg/l	0.03	0.02	0.11	0.19	0.15	0.10	0.03	0.04
P diss.	Dissolved Phosphorus (wet meth.)	666	mg/l	0.008	0.005	0.091	0.160	0.134	0.094	0.027	0.028
TOC	Total Organic Carbon	680	mg/l	3.1	2.2	3.1	4.8	7.1	2.6	3.0	2.1
Hard.	Total Hardness (CaCO3)	900	mg/l	70	15	157	195	197	175	39	87
Ca	Total Calcium	916	mg/l	21.20	5.95	53.30	48.00	48.90	44.60	11.10	30.00
Mg	Total Magnesium	927	mg/l	5.89	1.57	16.40	12.70	13.80	14.40	2.55	3.63
Na	Total Sodium	929	mg/l	1.64	0.65	22.00	35.70	52.90	12.60	2.38	1.81
K	Total Potassium	937	mg/l	1.30	1.05	3.15	4.88	6.68	2.53	1.61	1.37
Cl	Total Chloride	940	mg/l	3	1	33	54	82	19	4	3
SO4	Total Sulfate	945	mg/l	9.5	6.0	44.5	64.5	53.8	34.8	13.3	11.7
Cu	Total Copper	1042	μg/l	<4	<4	<4	<4	<4	<4	<4	<4
Fe	Total Iron	1045	μg/l	307	256	178	115	174	70	280	125
Fe diss.	Dissolved Iron	1046	μg/l	101	89	<10	24	26	<10	67	18
Pb	Total Lead	1051	μg/l	<1	<1	<1	<1	<1	<1	<1	<1
Mn	Total Manganese	1055	μg/l	17.3	19.5	29.1	76.0	51.0	15.0	19.1	17.0
Mn diss.	Dissolved Manganese	1056	μg/l	10	<10	15	53	38	11	24	17
Ni	Total Nickel	1067	μg/l	<4	<4	<4	<4	<4	<4	<4	<4
Zn	Total Zinc	1092	μg/l	<5	<5	11.5	5.1	<5	<5	<5	<5
Al	Total Aluminum	1105	μg/l	158.0	71.2	82.3	127.7	92.9	41.6	127.0	99.8
Al diss.	Dissolved Aluminum	1106	μg/l	15.6	19.3	29.1	69.5	40.6	13.1	27.1	<10
TOP	Total Ortho Phosphorus	70507	mg/l	0.003	0.002	0.080	0.146	0.120	0.075	0.004	0.011

Parameter Symbol	Parameter Name	Pa. DEP Test No.	Units	JACK02.9	JUN02.0	JUN17.3	JUN34.0	JUN47.0	JUN63.6	JUN84.6	JUN94.0
Date	Date		yymmdd	95/0718	95/07/20	95/07/31	95/07/31	95/08/09	95/09/95	95/07/20	95/08/03
Time	Time		hhmm	1000	905	1335	1200	1400	1135	1515	1430
Temp.	Water Temperature	10	C	20.3	25.4	29.7	28.1	25.0	22.5	25.0	26.5
pH	pH (field)	400	S.U.	7.85	8.10	8.50	8.60	8.15	8.30	8.20	8.15
D.O.	Dissolved Oxygen (field)	300	mg/l	5.74	7.28	10.92	9.94	7.60	6.40	8.40	8.80
Spec. Cond.	Specific Conductancd (field)	94		214	284	262	282	300	310	220	380
Alk.	Alkalinity (field as CaCO3)	410	mg/l	76	76	92	96	100	96	70	124
Acid.	Acidity (field as CaCO3)	435	mg/l	2	2	0	0	2	0	<2	2
T. RES	Total Residue	500	mg/l	146	280	198	232	230	228	192	256
TDS	Total Dissolved Solids	515	mg/l	122	258	190	216	220	222	176	254
TSS	Total Suspended Solids	530	mg/l	24	22	8	16	10	6	16	2
N	Total Nitrogen	600	mg/l	1.00	1.11	1.00	1.14	1.52	1.61	1.41	2.02
N. diss.	Dissolved Nitrogen	602	mg/l	0.94	1.06	1.00	1.11	1.41	1.55	1.32	1.88
NH3 diss.	Dissolved Ammonia Nitrogen	608	mg/l	<0.02	0.04	<0.02	<0.02	0.06	<0.02	<0.02	<0.02
NH3	Total Ammonia Nitrogen	610	mg/l	<0.02	0.04	<0.02	<0.02	0.06	0.03	<0.02	<0.02
NO2 diss.	Dissolved Nitrite Nitrogen	613	mg/l	0.004	0.012	0.012	0.016	0.014	0.012	0.010	0.014
NO2	Total Nitrite Nitrogen	615	mg/l	0.006	0.012	0.012	0.016	0.014	0.012	0.010	0.016
NO3 diss.	Dissolved Nitrate Nitrogen	618	mg/l	0.81	0.80	0.56	0.75	0.98	1.22	1.05	1.46
NO3	Total Nitrate Nitrogen	620	mg/l	0.98	0.80	0.56	0.77	0.98	1.24	1.05	1.48
P	Total Phosphorus	665	mg/l	0.02	0.08	0.05	0.05	0.09	0.09	0.07	0.12
P diss.	Dissolved Phosphorus (wet meth.)	666	mg/l	0.010	0.048	0.044	0.045	0.072	0.075	0.047	0.087
TOC	Total Organic Carbon	680	mg/l	2.3	3.0	3.6	3.6	3.2	3.0	3.5	3.2
Hard.	Total Hardness (CaCO3)	900	mg/l	87	102	95	99	48	48	96	148
Ca	Total Calcium	916	mg/l	27.40	31.00	27.80	28.90	31.90	31.30	30.90	38.70
Mg	Total Magnesium	927	mg/l	5.21	9.06	8.40	8.75	10.30	10.00	8.86	13.40
Na	Total Sodium	929	mg/l	3.67	12.10	8.30	8.87	12.10	11.40	9.16	14.70
K	Total Potassium	937	mg/l	1.70	2.10	1.88	2.01	2.62	2.55	2.60	2.98
Cl	Total Chloride	940	mg/l	5	17	11	13	17	15	12	19
SO4	Total Sulfate	945	mg/l	15.5	26.9	27.3	28.4	32.5	30.5	27.8	37.2
Cu	Total Copper	1042	µg/l	<4	<4	<4	<4	<4	<4	<4	<4
Fe	Total Iron	1045	µg/l	316	472	88	102	228	119	217	172
Fe diss.	Dissolved Iron	1046	µg/l	87	71	29	33	34	24	19	<10
Pb	Total Lead	1051	µg/l	1.2	<1	<1	<1	<1	<1	<1	<1
Mn	Total Manganese	1055	µg/l	16.6	45.8	14.3	15.4	73.0	56.0	22.0	67.0
Mn diss.	Dissolved Manganese	1056	µg/l	<10	33	<10	<10	73	52	11	53
Ni	Total Nickel	1067	µg/l	<4	<4	<4	<4	<4	<4	<4	<4
Zn	Total Zinc	1092	µg/l	12.7	11.2	<5	<5	<5	<5	5.9	<5
Al	Total Aluminum	1105	µg/l	145.0	219.0	46.1	46.6	94.9	61.1	85.6	79.3
Al diss.	Dissolved Aluminum	1106	µg/l	13.4	13.3	21.4	24.3	10.2	27.9	23.2	28.0
TOP	Total Ortho Phosphorus	70507	mg/l	0.007	0.028	0.019	0.025	0.055	0.055	0.031	no data

Parameter Symbol	Parameter Name	Pa. DEP Test No.	Units	KISH00.4	KISH05.5	KISH15.6	LAUG00.1	LJUN03.8	LJUN15.0	LJUN19.4	LJUN29.6
Date	Date		yymmdd	95/08/08	95/08/08	95/08/07	95/07/17	95/08/03	95/08/07	95/08/02	95/08/02
Time	Time		hhmm	1715	1340	1640	1345	900	1030	1345	1500
Temp.	Water Temperature	10	C	20.5	19.5	21.0	25.5	21.5	25.0	26.0	23.0
pH	pH (field)	400	S.U.	8.60	8.30	8.15	8.25	7.90	8.10	7.15	6.70
D.O.	Dissolved Oxygen (field)	300	mg/l	8.60	10.20	7.60	8.40	7.20	8.20	8.00	9.20
Spec. Cond.	Specific Conductancd (field)	94		370	230	480	170	335	68	310	250
Alk.	Alkalinity (field as CaCO3)	410	mg/l	122	142	192	50	120	68	72	78
Acid.	Acidity (field as CaCO3)	435	mg/l	0	0	<2	<2	3	<2	10	20
T. RES	Total Residue	500	mg/l	291	282	362	104	217	214	224	197
TDS	Total Dissolved Solids	515	mg/l	290	278	354	86	216	202	222	196
TSS	Total Suspended Solids	530	mg/l	<2	4	8	18	<2	12	2	<2
N	Total Nitrogen	600	mg/l	3.23	3.58	6.31	0.62	2.26	1.85	2.29	0.38
N. diss.	Dissolved Nitrogen	602	mg/l	3.11	3.58	6.16	0.56	2.23	1.82	2.23	0.35
NH3 diss.	Dissolved Ammonia Nitrogen	608	mg/l	<0.02	<0.02	0.06	<0.02	<0.02	<0.02	<0.02	<0.02
NH3	Total Ammonia Nitrogen	610	mg/l	0.02	<0.02	0.07	0.02	<0.02	<0.02	<0.02	<0.02
NO2 diss.	Dissolved Nitrite Nitrogen	613	mg/l	0.010	0.010	0.134	0.004	0.008	0.008	0.008	0.004
NO2	Total Nitrite Nitrogen	615	mg/l	0.010	0.010	0.136	0.004	0.008	0.008	0.008	0.004
NO3 diss.	Dissolved Nitrate Nitrogen	618	mg/l	2.50	2.89	6.20	0.31	1.77	1.46	1.86	0.09
NO3	Total Nitrate Nitrogen	620	mg/l	2.50	2.89	6.20	0.33	1.79	1.46	1.88	0.09
P	Total Phosphorus	665	mg/l	0.16	0.17	0.14	0.02	0.14	0.18	0.29	0.05
P diss.	Dissolved Phosphorus (wet meth.)	666	mg/l	0.153	0.157	0.112	0.007	0.119	0.157	0.275	0.042
TOC	Total Organic Carbon	680	mg/l	2.1	2.1	3.0	4.2	2.4	2.6	2.9	2.1
Hard.	Total Hardness (CaCO3)	900	mg/l	175	156	254	59	129	88	89	95
Ca	Total Calcium	916	mg/l	52.30	46.90	59.00	20.10	33.60	34.70	39.30	39.70
Mg	Total Magnesium	927	mg/l	12.70	11.90	18.20	3.83	12.80	8.17	8.27	6.75
Na	Total Sodium	929	mg/l	5.22	5.00	4.78	5.42	11.30	13.40	17.10	9.60
K	Total Potassium	937	mg/l	2.26	2.48	4.31	1.99	2.10	2.71	3.00	2.30
Cl	Total Chloride	940	mg/l	10	9	14	8	10	20	26	16
SO4	Total Sulfate	945	mg/l	26.4	17.8	21.1	9.7	30.3	28.8	35.0	28.8
Cu	Total Copper	1042	µg/l	<4	<4	<4	<4	<4	<4	<4	<4
Fe	Total Iron	1045	µg/l	80	118	196	325	105	300	142	205
Fe diss.	Dissolved Iron	1046	µg/l	<10	12	24	102	34	22	<10	21
Pb	Total Lead	1051	µg/l	<1	<1	<1	<1	<1	<1	<1	<1
Mn	Total Manganese	1055	µg/l	51.0	45.0	38.0	22.7	28.0	113.0	34.0	29.0
Mn diss.	Dissolved Manganese	1056	µg/l	51	46	36	<10	55	104	77	22
Ni	Total Nickel	1067	µg/l	<4	<4	<4	<4	<4	<4	<4	<4
Zn	Total Zinc	1092	µg/l	<5	<5	<5	<5	<5	5.6	7.0	<5
Al	Total Aluminum	1105	µg/l	39.8	70.3	115.0	128.0	43.0	74.4	56.3	50.5
Al diss.	Dissolved Aluminum	1106	µg/l	17.1	11.2	14.5	20.8	<10	18.4	23.6	10.5
TOP	Total Ortho Phosphorus	70507	mg/l	0.139	0.144	0.086	<0.002	no data	0.145	0.266	0.021

Parameter Symbol	Parameter Name	Pa. DEP Test No.	Units	NBTC03.1	RAYS04.6	RAYS42.8	RAYS54.1	RAYS80.5	RAYS103	SBEC01.4	SHAD04.3
Date	Date		yymmdd	95/07/17	95/07/19	95/07/25	95/07/25	95/07/25	95/07/31	95/08/02	95/07/19
Time	Time		hhmm	945	1815	1300	1500	1130	1100	915	1230
Temp.	Water Temperature	10	C	22.0	18.0	26.0	28.0	23.5	24.5	20.0	20.0
pH	pH (field)	400	S.U.	7.80	7.50	8.30	8.25	8.05	7.40	8.00	7.90
D.O.	Dissolved Oxygen (field)	300	mg/l	8.74	7.40	8.60	8.00	7.80	6.80	8.00	8.40
Spec. Cond.	Specific Conductancd (field)	94		225	210	285	255	320	215	85	249
Alk.	Alkalinity (field as CaCO3)	410	mg/l	82	42	84	68	122	56	36	50
Acid.	Acidity (field as CaCO3)	435	mg/l	2	4	0	<2	2	4	4	4
T. RES	Total Residue	500	mg/l	135	168	234	200	254	68	65	
TDS	Total Dissolved Solids	515	mg/l	134	166	222	188	244	62	64	
TSS	Total Suspended Solids	530	mg/l	<2	2	12	12	10	6	<2	
N	Total Nitrogen	600	mg/l	1.82	1.00	2.11	1.58	1.79	0.59	0.41	
N. diss.	Dissolved Nitrogen	602	mg/l	1.73	0.94	2.08	1.55	1.73	0.67	0.41	
NH3 diss.	Dissolved Ammonia Nitrogen	608	mg/l	0.02	<0.02	<0.02	<0.02	<0.02	0.11	<0.02	
NH3	Total Ammonia Nitrogen	610	mg/l	0.04	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	
NO2 diss.	Dissolved Nitrite Nitrogen	613	mg/l	0.016	0.008	0.006	0.008	0.006	0.018	0.004	
NO2	Total Nitrite Nitrogen	615	mg/l	0.016	0.008	0.008	0.010	0.008	0.012	0.004	
NO3 diss.	Dissolved Nitrate Nitrogen	618	mg/l	1.63	0.74	1.62	1.22	1.60	0.24	0.20	
NO3	Total Nitrate Nitrogen	620	mg/l	1.63	0.74	1.64	1.24	1.60	0.25	0.22	
P	Total Phosphorus	665	mg/l	0.08	0.03	0.05	0.05	0.05	0.04	0.03	
P diss.	Dissolved Phosphorus (wet meth.)	666	mg/l	0.046	0.018	0.033	0.029	0.027	0.044	0.023	
TOC	Total Organic Carbon	680	mg/l	3.3	2.9	3.0	3.1	2.6	4.0	1.6	
Hard.	Total Hardness (CaCO3)	900	mg/l	91	67	109	94	128	156	30	
Ca	Total Calcium	916	mg/l	26.90	18.90	35.70	31.80	37.90	16.70	10.00	
Mg	Total Magnesium	927	mg/l	6.14	5.75	11.00	8.85	11.10	4.53	2.52	
Na	Total Sodium	929	mg/l	2.99	6.37	5.83	6.49	7.71	13.50	2.52	
K	Total Potassium	937	mg/l	2.77	2.03	2.69	2.03	1.99	1.85	1.46	
Cl	Total Chloride	940	mg/l	6	10	10	11	12	22	4	
SO4	Total Sulfate	945	mg/l	9.0	25.2	25.9	20.7	25.7	15.6	8.9	
Cu	Total Copper	1042	µg/l	4.2	<4	<4	<4	<4	<4	<4	
Fe	Total Iron	1045	µg/l	278	32	223	317	172	257	218	
Fe diss.	Dissolved Iron	1046	µg/l	62	<10	60	20	18	98	60	
Pb	Total Lead	1051	µg/l	<1	<1	<1	<1	<1	<1	<1	
Mn	Total Manganese	1055	µg/l	25.9	8.4	30.9	22.1	16.9	68.0	33.0	
Mn diss.	Dissolved Manganese	1056	µg/l	24	12	22	18	11	52	44	
Ni	Total Nickel	1067	µg/l	<4	<4	<4	<4	<4	218	<4	
Zn	Total Zinc	1092	µg/l	7.3	<5	7.7	<5	<5	<5	<5	
Al	Total Aluminum	1105	µg/l	115.0	23.8	198.0	149.0	109.0	56.8	79.3	
Al diss.	Dissolved Aluminum	1106	µg/l	34.2	11.5	124.0	14.1	<10	<10	<10	
TOP	Total Ortho Phosphorus	70507	mg/l	0.035	<0.002	0.012	0.013	0.003	0.006	0.008	

Parameter Symbol	Parameter Name	Pa. DEP Test No.	Units	SHAV01.4	SIDE00.1	SPRU01.0	SPRU10.6	STST01.0	STST26.8	TSPC00.1	TUSC00.6
Date	Date		yymmdd	95/08/03	95/07/18	95/07/24	95/07/24	95/07/19	95/08/07	95/07/18	95/07/18
Time	Time		hhmm	1130	900	1150	1400	1530	1400	1430	1445
Temp.	Water Temperature	10	C	24.5	23.5	18.0	15.0	29.0	19.0	25.0	25.8
pH	pH (field)	400	S.U.	7.80	7.65	8.40	7.25	8.55	7.00	8.20	8.15
D.O.	Dissolved Oxygen (field)	300	mg/l	7.60	7.20	9.20	9.20	8.80	7.80		9.12
Spec. Cond.	Specific Conductancd (field)	94		350	150	360	350	175	38	190	203
Alk.	Alkalinity (field as CaCO3)	410	mg/l	148	18	148	140	60	18	68	72
Acid.	Acidity (field as CaCO3)	435	mg/l	6	4	0	20	0	4	<2	2
T. RES	Total Residue	500	mg/l	210	100	264	388	126	31	134	150
TDS	Total Dissolved Solids	515	mg/l	208	88	254	276	124	30	122	140
TSS	Total Suspended Solids	530	mg/l	2	12	10	112	2	<2	12	10
N	Total Nitrogen	600	mg/l	1.44	0.73	3.11	3.17	0.70	0.17	0.88	1.17
N. diss.	Dissolved Nitrogen	602	mg/l	1.34	0.67	3.11	3.17	0.64	0.29	0.91	1.14
NH3 diss.	Dissolved Ammonia Nitrogen	608	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02	<0.02
NH3	Total Ammonia Nitrogen	610	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02	<0.02
NO2 diss.	Dissolved Nitrite Nitrogen	613	mg/l	0.022	0.004	0.006	0.008	0.008	<0.004	0.004	0.010
NO2	Total Nitrite Nitrogen	615	mg/l	0.022	0.004	0.006	0.008	0.010	<0.004	0.004	0.010
NO3 diss.	Dissolved Nitrate Nitrogen	618	mg/l	0.99	0.44	2.85	2.98	0.30	0.07	0.81	0.89
NO3	Total Nitrate Nitrogen	620	mg/l	1.04	0.44	2.89	2.98	0.30	0.07	0.84	0.89
P	Total Phosphorus	665	mg/l	0.06	0.04	0.04	0.03	0.03	0.03	0.05	0.03
P diss.	Dissolved Phosphorus (wet meth.)	666	mg/l	0.042	0.008	0.030	0.024	0.023	0.023	0.031	0.009
TOC	Total Organic Carbon	680	mg/l	2.9	3.7	1.5	1.0	3.4	1.6	3.0	3.2
Hard.	Total Hardness (CaCO3)	900	mg/l	154	29	157	146	69	12	79	88
Ca	Total Calcium	916	mg/l	45.30	8.51	48.70	39.20	23.50	3.66	26.00	26.90
Mg	Total Magnesium	927	mg/l	12.70	2.87	19.00	17.40	5.91	1.07	5.82	6.31
Na	Total Sodium	929	mg/l	2.70	13.50	3.00	2.99	2.36	0.47	3.81	2.36
K	Total Potassium	937	mg/l	2.44	2.04	1.42	1.41	1.50	0.62	2.28	2.17
Cl	Total Chloride	940	mg/l	6	23	7	7	3	1	6	4
SO4	Total Sulfate	945	mg/l	20.4	11.8	12.0	10.4	18.4	5.2	17.7	13.5
Cu	Total Copper	1042	µg/l	<4	<4	<4	<4	<4	6.6	<4	<4
Fe	Total Iron	1045	µg/l	338	309	161	106	419	67	175	302
Fe diss.	Dissolved Iron	1046	µg/l	317	74	26	15	68	35	39	98
Pb	Total Lead	1051	µg/l	<1	<1	<1	<1	<1	<1	<1	<1
Mn	Total Manganese	1055	µg/l	61.0	27.4	9.6	11.5	34.3	35.0	16.1	21.6
Mn diss.	Dissolved Manganese	1056	µg/l	53	17	<10	<10	17	33	12	13
Ni	Total Nickel	1067	µg/l	<4	<4	<4	<4	<4	<4	<4	<4
Zn	Total Zinc	1092	µg/l	<5	6.2	5.3	<5	<5	5.8	<5	<5
Al	Total Aluminum	1105	µg/l	181.0	126.0	35.0	30.7	189.0	85.9	94.7	169.0
Al diss.	Dissolved Aluminum	1106	µg/l	<10	19.8	<10	<10	24.0	22.6	11.5	12.6
TOP	Total Ortho Phosphorus	70507	mg/l	no data	0.007	0.011	0.006	<0.002	<0.002	0.024	0.024

Parameter Symbol	Parameter Name	Pa. DEP Test No.	Units	TUSC22.5	TUSC39.3	WILL00.4	YELL03.5	6MIL00.2
Date	Date		yymmdd	95/07/17	95/07/17	95/07/17	95/07/23	95/08/07
Time	Time		hhmm	1545	1205	1345	1700	1020
Temp.	Water Temperature	10	C	25.7	22.6	21.4	22.0	17.0
pH	pH (field)	400	S.U.	8.55	7.80	8.05	8.00	7.20
D.O.	Dissolved Oxygen (field)	300	mg/l	11.38	9.13	10.47	7.20	7.60
Spec. Cond.	Specific Conductancd (field)	94		147	212	223	350	58
Alk.	Alkalinity (field as CaCO3)	410	mg/l	54	88	86	100	16
Acid.	Acidity (field as CaCO3)	435	mg/l	0	2	2	4	4
T. RES	Total Residue	500	mg/l	93	126	143	274	38
TDS	Total Dissolved Solids	515	mg/l	92	118	142	258	30
TSS	Total Suspended Solids	530	mg/l	<2	8	<2	16	8
N	Total Nitrogen	600	mg/l	0.76	1.26	1.03	4.28	0.26
N. diss.	Dissolved Nitrogen	602	mg/l	0.70	1.14	0.97	4.28	0.23
NH3 diss.	Dissolved Ammonia Nitrogen	608	mg/l	0.02	0.03	0.02	<0.02	0.02
NH3	Total Ammonia Nitrogen	610	mg/l	0.08	0.04	0.03	<0.02	0.03
NO2 diss.	Dissolved Nitrite Nitrogen	613	mg/l	0.006	0.014	0.006	0.010	<0.004
NO2	Total Nitrite Nitrogen	615	mg/l	0.006	0.018	0.010	0.010	<0.004
NO3 diss.	Dissolved Nitrate Nitrogen	618	mg/l	0.50	0.98	0.83	3.99	0.13
NO3	Total Nitrate Nitrogen	620	mg/l	0.50	0.97	0.85	4.08	0.13
P	Total Phosphorus	665	mg/l	0.02	0.06	0.03	0.05	0.02
P diss.	Dissolved Phosphorus (wet meth.)	666	mg/l	0.013	0.029	0.015	0.040	0.022
TOC	Total Organic Carbon	680	mg/l	2.9	3.0	2.5	2.3	1.0
Hard.	Total Hardness (CaCO3)	900	mg/l	54	80	91	144	15
Ca	Total Calcium	916	mg/l	17.30	25.70	28.50	41.40	5.03
Mg	Total Magnesium	927	mg/l	3.98	5.37	5.87	16.60	1.06
Na	Total Sodium	929	mg/l	1.97	2.68	2.17	3.20	2.09
K	Total Potassium	937	mg/l	2.64	2.40	1.81	2.00	1.22
Cl	Total Chloride	940	mg/l	3	5	4	7	5
SO4	Total Sulfate	945	mg/l	10.4	10.4	15.0	14.9	6.7
Cu	Total Copper	1042	µg/l	<4	<4	<4	<4	<4
Fe	Total Iron	1045	µg/l	225	307	256	156	80
Fe diss.	Dissolved Iron	1046	µg/l	69	71	75	16	44
Pb	Total Lead	1051	µg/l	<1	<1	<1	<1	<1
Mn	Total Manganese	1055	µg/l	18.9	28.0	15.3	21.5	<10
Mn diss.	Dissolved Manganese	1056	µg/l	11	17	13	16	<10
Ni	Total Nickel	1067	µg/l	<4	<4	<4	<4	<4
Zn	Total Zinc	1092	µg/l	<5	<5	6.7	<5	5.2
Al	Total Aluminum	1105	µg/l	89.8	97.3	94.2	98.6	15.0
Al diss.	Dissolved Aluminum	1106	µg/l	12.0	17.5	<10	<10	<10
TOP	Total Ortho Phosphorus	70507	mg/l	0.003	0.017	0.007	0.023	<0.002

Appendix C
Raw Benthic Macroinvertebrate Data From Sample Sites in the Juniata Subbasin

Order	Family	Genus	AUGH 0.4	AUGH 17.2	BEAV 0.1	BLLG 0.9	BLLG 4.6	BOBS 0.9	BOBS 11.4	BRUS 0.1	BUFF 0.4	BUFF 14.6	CLOV 0.1
Coleoptera	Elmidae	*Ancyronyx*											
		Gonielmis											
		Macronychus											
		Optioservus	2			3	1	1	2	1	2	11	7
		Stenelmis	16	2	3	10		10		3	9	12	30
	Gyrinidae	*Dineutis*	1					1			1		
	Hydrophilidae	*Hydrobius*											
	Psephenidae	*Psephenus*	3	1		31	5	9	1	8	5	10	11
		Ectopria											
Diptera	Athericidae	*Atherix*		1			1	1	1	1		6	1
	Chironomidae	Chironomidae	5	3	27	18	9	47	9	3		5	5
	Empididae	*Hemerodromia*						1		1			2
	Simulidae	*Simulium*						1		2			1
	Tipulidae	*Antocha*				6	12	10		3	2	1	11
		Hexatoma						2	7		1		
		Tipula											
Ephemeroptera	Baetidae	*Baetis*	2				14		4	10	10	4	7
		Centroptilum											
		Heterocloeon	1										
		Neocloeon											
		Pseudocloeon											
	Caenidae	*Brachycercus*											
		Caenis						5					
	Ephemerellidae	*Drunella*							4				
		Ephemerella											
		Eurylophella											
		Serratella	2								1		
	Ephemeridae	*Ephemera*	3			1	2	1					
		Hexagenia											
	Heptageniidae	*Epeorus*		2					2				2
		Heptagenia	4			1	4				9		
		Leucrocuta											
		Stenacron	1										
		Stenonema	9	7		1	5	2				3	
	Leptophlebidae	*Leptophlebia*											
		Paraleptophlebia							1			1	
	Oligoneuriidae	*Isonychia*	14	41		6	12	1		6	32	17	
	Polymitarcidae	*Ephoron*	6	2						1	3		
	Potamanthidae	*Potamanthus*											

Order	Family	Genus	AUGH 0.4	AUGH 17.2	BEAV 0.1	BLLG 0.9	BLLG 4.6	BOBS 0.9	BOBS 11.4	BRUS 0.1	BUFF 0.4	BUFF 14.6	CLOV 0.1
	Siphlonuridae	*Ameletus*											
		Parameletus											
	Tricorythidae	*Tricorythodes*											
Megaloptera	Corydalidae	*Corydalus*	2	2		3	1			3	1		
		Nigronia	1	1			6		5	2	1	5	
	Sialidae	*Sialis*	3	1		1	1	2		1	1	2	
Odonata	Aeshnidae	*Boyeria*											
	Coenagrionidae	*Argia*		1		1	1						
		Nehalennia											
	Gomphidae	*Erpentogomphus*											
		Gomphus										4	
		Ophiogomphus											
		Stylogomphus											
Plecoptera	Capniidae	*Paracapnia*											
	Chloroperlidae	*Alloperla*											
	Leuctridae	*Leuctra*				1	2		15		1	4	
	Peltoperlidae	*Peltoperla*											
	Perlidae	*Acroneuria*	3	1			2		3	3			
		Neoperla					2						
		Paragnetina							2			2	2
		Phasganophora							1				1
	Pteronarcidae	*Pteronarcys*	1										
Trichoptera	Brachycentridae	*Brachycentrus*					3						1
	Hydropsychidae	*Cheumatopsyche*	4	14		10	14	3	1	24	13	4	
		Hydropsyche			48				1				
		Macronema		5	1								
		Potamyia				1							
		Sympitopsyche	14	7		3	7	11	14	21	6	6	10
	Philopotamidae	*Chimarra*	4	9						4		1	3
		Dolophilodes	2						28		1		
	Polycentropodidae	*Neureclipsis*											
		Polycentropus										1	
	Psychomyiidae	*Lype*											
	Rhyacophilidae	*Rhyacophila*											
Amphipoda	Gammaridae	*Gammarus*	1	1	10								8
Decapoda	Cambaridae	*Cambarus*											
		Procambarus				1							
Gastropoda	Lymnaeidae	*Lymnaea*		3									
	Physidae	*Physa*	1										
Isopoda	Asellidae	*Asellus*											
Pelecypoda	Corbiculidae	*Corbicula*								1			
	Sphaeridae	*Pisidium*	6			1				4		2	

Order	Family	Genus	COCO 0.2	COCO 9.6	DELA 0.2	DUNN 0.1	DUNN 9.9	ELKC O.1	ELKC 9.8	FRNK 1.6	FRNK 18.9	FRNK 32.5	FRNK 38.1
Coleoptera	Elmidae	*Ancyronyx*											
		Gonielmis											
		Macronychus											
		Optioservus		18	13	10	2	13	1	4	1		3
		Stenelmis	4	17		35	14	1		11	35	54	6
	Gyrinidae	*Dineutis*					1						
	Hydrophilidae	*Hydrobius*											
	Psephenidae	*Psephenus*	10	7	4	14	4	11		8		2	5
		Ectopria											
Diptera	Athericidae	*Atherix*		3	1	1		1		1	1	1	1
	Chironomidae	Chironomidae	47	11	8	6	34	6	16	6	18	17	39
	Empididae	*Hemerodromia*	1	1						1	2	1	1
	Simulidae	*Simulium*	1			1							
	Tipulidae	*Antocha*	2	3		2		8	1	1			13
		Hexatoma		2								1	
		Tipula		1									
Ephemeroptera	Baetidae	*Baetis*	10	3	1	1		3		6			1
		Centroptilum											
		Heterocloeon	2					1		6			2
		Neocloeon											
		Pseudocloeon											
	Caenidae	*Brachycercus*											
		Caenis				1	21				3		2
	Ephemerellidae	*Drunella*							1				
		Ephemerella											
		Eurylophella											
		Serratella											
	Ephemeridae	*Ephemera*		1		1	3						
		Hexagenia											
	Heptageniidae	*Epeorus*						1	6				
		Heptagenia						2	1				
		Leucrocuta									1		
		Stenacron	1							2			
		Stenonema	1		1	1	5	2	2	8			1
	Leptophlebidae	*Leptophlebia*											
		Paraleptophlebia											
	Oligoneuriidae	*Isonychia*	1				1	31	13	4	6		
	Polymitarcidae	*Ephoron*	2	1						6			
	Potamanthidae	*Potamanthus*											

Order	Family	Genus	COCO 0.2	COCO 9.6	DELA 0.2	DUNN 0.1	DUNN 9.9	ELKC O.1	ELKC 9.8	FRNK 1.6	FRNK 18.9	FRNK 32.5	FRNK 38.1
	Siphlonuridae	*Ameletus*				1							
		Parameletus											
	Tricorythidae	*Tricorythodes*											
Megaloptera	Corydalidae	*Corydalus*				1		1		1	3	1	2
		Nigronia	1	4			7	2	9				
	Sialidae	*Sialis*	4	1		1	8			2		3	
Odonata	Aeshnidae	*Boyeria*											
	Coenagrionidae	*Argia*								1			
		Nehalennia											
	Gomphidae	*Erpentogomphus*											
		Gomphus		2					1				
		Ophiogomphus											
		Stylogomphus											
Plecoptera	Capniidae	*Paracapnia*											
	Chloroperlidae	*Alloperla*											
	Leuctridae	*Leuctra*	1	1					33				
	Peltoperlidae	*Peltoperla*											
	Perlidae	*Acroneuria*	1	4				1	1				
		Neoperla											
		Paragnetina							1				
		Phasganophora											
	Pteronarcidae	*Pteronarcys*		1					1				
Trichoptera	Brachycentridae	*Brachycentrus*											
	Hydropsychidae	*Cheumatopsyche*	1	10	1	8		5	2	5	7	6	13
		Hydropsyche				2	1	3			8	13	3
		Macronema				9							
		Potamyia											
		Sympitopsyche	1	12	3	10	1	5	3	8	16	2	6
	Philopotamidae	*Chimarra*	9	1	1	2		5		2			
		Dolophilodes							7				
	Polycentropodidae	*Neureclipsis*											
		Polycentropus											
	Psychomyiidae	*Lype*							1				
	Rhyacophilidae	*Rhyacophila*											
Amphipoda	Gammaridae	*Gammarus*			69					2			1
Decapoda	Cambaridae	*Cambarus*	1										
		Procambarus											
Gastropoda	Lymnaeidae	*Lymnaea*											
	Physidae	*Physa*								2			
Isopoda	Asellidae	*Asellus*								8			
Pelecypoda	Corbiculidae	*Corbicula*									2		
	Sphaeridae	*Pisidium*								8	2	1	

Order	Family	Genus	GTRC 2.9	HONY 0.2	JACK 2.9	JUN 17.3	JUN34.0	JUN 47.0	JUN 63.6	JUN 84.6	JUN 94.0	KISH 0.4	KISH 5.5
Coleoptera	Elmidae	*Ancyronyx*							1			1	
		Gonielmis											
		Macronychus					1	2					
		Optioservus		20	1	1					3	1	6
		Stenelmis		3	7	26	15		29	11	21	5	5
	Gyrinidae	*Dineutis*							2				
	Hydrophilidae	*Hydrobius*											
	Psephenidae	*Psephenus*	7	7	2	2	1		1	1	5	1	6
		Ectopria											
Diptera	Athericidae	*Atherix*	3	1	1								
	Chironomidae	Chironomidae	7	9	28	4	10	8	4		7	34	11
	Empididae	*Hemerodromia*		1					1				1
	Simulidae	*Simulium*			1								
	Tipulidae	*Antocha*	3		2						1	13	9
		Hexatoma											
		Tipula											
Ephemeroptera	Baetidae	*Baetis*	7	2	5	19	19	3	14		2	3	13
		Centroptilum			1			14					
		Heterocloeon	3	2		2	3		3			1	
		Neocloeon					1						
		Pseudocloeon			1								
	Caenidae	*Brachycercus*											
		Caenis		2	4	1		1		2	2	1	4
	Ephemerellidae	*Drunella*											
		Ephemerella											
		Eurylophella											
		Serratella					4				2		
	Ephemeridae	*Ephemera*						1					
		Hexagenia						1					
	Heptageniidae	*Epeorus*		1									
		Heptagenia	2		1	5	1						5
		Leucrocuta											
		Stenacron			2			13	2	2	3		
		Stenonema				6	5	10	7	1	5		
	Leptophlebidae	*Leptophlebia*			5								
		Paraleptophlebia											
	Oligoneuriidae	*Isonychia*		4	10	4	3		3		5		
	Polymitarcidae	*Ephoron*	7			4	1		4		4		
	Potamanthidae	*Potamanthus*					7		4	4			

Order	Family	Genus	GTRC 2.9	HONY 0.2	JACK 2.9	JUN 17.3	JUN34.0	JUN 47.0	JUN 63.6	JUN 84.6	JUN 94.0	KISH 0.4	KISH 5.5
	Siphlonuridae	*Ameletus*											
		Parameletus					2						
	Tricorythidae	*Tricorythodes*				1		7					
Megaloptera	Corydalidae	*Corydalus*			2	8	3		4	1	3		
		Nigronia			1		1						
	Sialidae	*Sialis*			3			5			5		1
Odonata	Aeshnidae	*Boyeria*											
	Coenagrionidae	*Argia*						1	1				
		Nehalennia						1					
	Gomphidae	*Erpentogomphus*											
		Gomphus											
		Ophiogomphus	1										
		Stylogomphus											
Plecoptera	Capniidae	*Paracapnia*	1										
	Chloroperlidae	*Alloperla*											
	Leuctridae	*Leuctra*		1	1								
	Peltoperlidae	*Peltoperla*											
	Perlidae	*Acroneuria*	6	1									1
		Neoperla											
		Paragnetina	4										
		Phasganophora											
	Pteronarcidae	*Pteronarcys*							1				
Trichoptera	Brachycentridae	*Brachycentrus*											
	Hydropsychidae	*Cheumatopsyche*	4	20	2	5	3		1		3		6
		Hydropsyche			1	3	1				1	7	
		Macronema					1		1		1		
		Potamyia			2				2				
		Sympitopsyche	34	14	14		3	3		1	5	11	9
	Philopotamidae	*Chimarra*	5	13		3	11		2		22		
		Dolophilodes					1						
	Polycentropodidae	*Neureclipsis*	1					1					
		Polycentropus											
	Psychomyiidae	*Lype*											
	Rhyacophilidae	*Rhyacophila*	2										3
Amphipoda	Gammaridae	*Gammarus*			3	3	2	33	32	72	2	22	26
Decapoda	Cambaridae	*Cambarus*											
		Procambarus											
Gastropoda	Lymnaeidae	*Lymnaea*				4			1				
	Physidae	*Physa*								1	1		
Isopoda	Asellidae	*Asellus*											
Pelecypoda	Corbiculidae	*Corbicula*				5	1		4	3	2		
	Sphaeridae	*Pisidium*	3					1	1	3	7		

Order	Family	Genus	KISH 15.6	LAUG00.1	LJUN 3.8	LJUN15.0	LJUN 19.4	LJUN 29.6	NBTC 3.1	RAYS 4.6	RAYS 42.8	RAYS 54.1	RAYS 80.5
Coleoptera	Elmidae	*Ancyronyx*											
		Gonielmis											
		Macronychus									1		
		Optioservus		4	2				9				
		Stenelmis	34		16	2	9				64	19	10
	Gyrinidae	*Dineutis*											1
	Hydrophilidae	*Hydrobius*											
	Psephenidae	*Psephenus*	1	4	7	1	1	2	10		5	4	2
		Ectopria		1									
Diptera	Athericidae	*Atherix*				1	1		8			1	
	Chironomidae	Chironomidae	27	3	18	25	33	67	6	33	9	8	26
	Empididae	*Hemerodromia*	1		1	1						1	
	Simulidae	*Simulium*		1			2						
	Tipulidae	*Antocha*		3	9	9	6	9	1				
		Hexatoma											1
		Tipula											
Ephemeroptera	Baetidae	*Baetis*	5	3	4		1	1	1	1	4	1	10
		Centroptilum	3										
		Heterocloeon	2	2		4						1	3
		Neocloeon											
		Pseudocloeon											
	Caenidae	*Brachycercus*											
		Caenis				4							2
	Ephemerellidae	*Drunella*											
		Ephemerella											
		Eurylophella											
		Serratella										1	
	Ephemeridae	*Ephemera*											
		Hexagenia											
	Heptageniidae	*Epeorus*											
		Heptagenia									1	3	
		Leucrocuta											
		Stenacron						2	1				
		Stenonema	1	11	1	9	1	2	3	2	2	11	11
	Leptophlebidae	*Leptophlebia*											
		Paraleptophlebia											
	Oligoneuriidae	*Isonychia*		19	3	17	5	1				5	4
	Polymitarcidae	*Ephoron*		3							9	5	
	Potamanthidae	*Potamanthus*										1	

Order	Family	Genus	KISH 15.6	LAUG00.1	LJUN 3.8	LJUN15.0	LJUN 19.4	LJUN 29.6	NBTC 3.1	RAYS 4.6	RAYS 42.8	RAYS 54.1	RAYS 80.5
	Siphlonuridae	*Ameletus*											
		Parameletus											
	Tricorythidae	*Tricorythodes*											
Megaloptera	Corydalidae	*Corydalus*		5		9	1					2	1
		Nigronia		3			1	1	1	6		3	
	Sialidae	*Sialis*										1	3
Odonata	Aeshnidae	*Boyeria*											
	Coenagrionidae	*Argia*							1	2		2	
		Nehalennia											
	Gomphidae	*Erpentogomphus*											
		Gomphus											1
		Ophiogomphus											
		Stylogomphus											
Plecoptera	Capniidae	*Paracapnia*											
	Chloroperlidae	*Alloperla*											
	Leuctridae	*Leuctra*							1				
	Peltoperlidae	*Peltoperla*											
	Perlidae	*Acroneuria*		1				2					
		Neoperla											
		Paragnetina			1								
		Phasganophora									1	1	
	Pteronarcidae	*Pteronarcys*		1									
Trichoptera	Brachycentridae	*Brachycentrus*			2				29				
	Hydropsychidae	*Cheumatopsyche*	8	13	22	19	18	3	3	2	1	7	14
		Hydropsyche	4				11	11	6			5	4
		Macronema									1	1	2
		Potamyia							4				
		Sympitopsyche	3	11	13	6	13	3	15	1	3	6	4
	Philopotamidae	*Chimarra*	1	2	1				5		1	8	2
		Dolophilodes											1
	Polycentropodidae	*Neureclipsis*								2			
		Polycentropus											
	Psychomyiidae	*Lype*											
	Rhyacophilidae	*Rhyacophila*			1								
Amphipoda	Gammaridae	*Gammarus*	7							44			
Decapoda	Cambaridae	*Cambarus*											
		Procambarus											
Gastropoda	Lymnaeidae	*Lymnaea*		4									
	Physidae	*Physa*								4			
Isopoda	Asellidae	*Asellus*						8					
Pelecypoda	Corbiculidae	*Corbicula*		3						1		1	
	Sphaeridae	*Pisidium*		1							1	2	1

Order	Family	Genus	RAYS 103	SBEC 1.4	SHAD 4.3	SHAV 1.4	SIDE 0.1	SPRU 1.0	SPRU 10.6	STST 1.0	STST 26.8	TSPC 0.1	TUSC 0.6
Coleoptera	Elmidae	*Ancyronyx*											
		Gonielmis							10				
		Macronychus		9									
		Optioservus	2	3		13		34	12	2	3	5	3
		Stenelmis	2	1	1	33	1	2		9		24	6
	Gyrinidae	*Dineutis*	2										
	Hydrophilidae	*Hydrobius*								2			
	Psephenidae	*Psephenus*	4	6	10	7	4	4				13	8
		Ectopria											
Diptera	Athericidae	*Atherix*	12	2	5	2				1			2
	Chironomidae	Chironomidae		18	8	4	11	33	2	1	8	7	8
	Empididae	*Hemerodromia*						1			1		1
	Simulidae	*Simulium*	7						19		2		
	Tipulidae	*Antocha*		3	6			7			1		2
		Hexatoma			3	2					4	6	
		Tipula			1								
Ephemeroptera	Baetidae	*Baetis*					2	3		1	2		2
		Centroptilum				3				1			
		Heterocloeon			1					2		1	3
		Neocloeon											
		Pseudocloeon											
	Caenidae	*Brachycercus*											
		Caenis	1	1	1			2	1				
	Ephemerellidae	*Drunella*							4				
		Ephemerella											
		Eurylophella							1				
		Serratella											
	Ephemeridae	*Ephemera*	2				2	1					
		Hexagenia											
	Heptageniidae	*Epeorus*		2						2			
		Heptagenia				1				20			
		Leucrocuta											
		Stenacron								1	1		
		Stenonema	7			2	13			1		1	2
	Leptophlebidae	*Leptophlebia*											
		Paraleptophlebia						1		1			
	Oligoneuriidae	*Isonychia*	3	4	5	8	21			37		12	10
	Polymitarcidae	*Ephoron*											2
	Potamanthidae	*Potamanthus*											

Order	Family	Genus	RAYS 103	SBEC 1.4	SHAD 4.3	SHAV 1.4	SIDE 0.1	SPRU 1.0	SPRU 10.6	STST 1.0	STST 26.8	TSPC 0.1	TUSC 0.6
	Siphlonuridae	*Ameletus*											
		Parameletus											
	Tricorythidae	*Tricorythodes*											
Megaloptera	Corydalidae	*Corydalus*	1			3	3			1			1
		Nigronia		1		2	1	1		4	5	2	5
	Sialidae	*Sialis*		2		1	2			2		3	1
Odonata	Aeshnidae	*Boyeria*									2		
	Coenagrionidae	*Argia*					2					1	
		Nehalennia											
	Gomphidae	*Erpentogomphus*			1								
		Gomphus								1		1	
		Ophiogomphus											
		Stylogomphus									1		
Plecoptera	Capniidae	*Paracapnia*									2		
	Chloroperlidae	*Alloperla*									1		
	Leuctridae	*Leuctra*		4	24		1				17	3	2
	Peltoperlidae	*Peltoperla*									1		
	Perlidae	*Acroneuria*		3				1			1	1	1
		Neoperla				2							
		Paragnetina		3						3	1		
		Phasganophora	1				1			1			
	Pteronarcidae	*Pteronarcys*									1		
Trichoptera	Brachycentridae	*Brachycentrus*			1			2			1		
	Hydropsychidae	*Cheumatopsyche*	31		4	9	16			2	9	13	9
		Hydropsyche	3		2	1							
		Macronema											
		Potamyia		1			4						2
		Sympitopsyche	16	24	21	1	16	6		7	1	8	14
	Philopotamidae	*Chimarra*	4	16	6	7	4					2	3
		Dolophilodes			1						35		14
	Polycentropodidae	*Neureclipsis*											
		Polycentropus											
	Psychomyiidae	*Lype*											
	Rhyacophilidae	*Rhyacophila*		1				1	1		2		
Amphipoda	Gammaridae	*Gammarus*			1			2	49			1	
Decapoda	Cambaridae	*Cambarus*									1		
		Procambarus	1										
Gastropoda	Lymnaeidae	*Lymnaea*											
	Physidae	*Physa*											
Isopoda	Asellidae	*Asellus*											
Pelecypoda	Corbiculidae	*Corbicula*	1										
	Sphaeridae	*Pisidium*	2						1				

Order	Family	Genus	TUSC 22.5	TUSC 39.3	WILL 0.4	YELL 3.5	6MIL 0.2
Coleoptera	Elmidae	*Ancyronyx*					
		Gonielmis				1	
		Macronychus			1		
		Optioservus	7			1	
		Stenelmis	3			14	
	Gyrinidae	*Dineutis*					
	Hydrophilidae	*Hydrobius*					
	Psephenidae	*Psephenus*	13	4	13	2	
		Ectopria					1
Diptera	Athericidae	*Atherix*		7	1		
	Chironomidae	Chironomidae		3	6	21	9
	Empididae	*Hemerodromia*					
	Simulidae	*Simulium*			6		4
	Tipulidae	*Antocha*	1		4	19	
		Hexatoma					4
		Tipula		1			
Ephemeroptera	Baetidae	*Baetis*	2		1	8	5
		Centroptilum					
		Heterocloeon			1		2
		Neocloeon					
		Pseudocloeon					8
	Caenidae	*Brachycercus*			1		
		Caenis			1		
	Ephemerellidae	*Drunella*					3
		Ephemerella				1	
		Eurylophella					
		Serratella					
	Ephemeridae	*Ephemera*					
		Hexagenia					
	Heptageniidae	*Epeorus*					1
		Heptagenia	3				
		Leucrocuta					
		Stenacron					
		Stenonema	2	1		1	
	Leptophlebidae	*Leptophlebia*					
		Paraleptophlebia					
	Oligoneuriidae	*Isonychia*	16	13	25		1
	Polymitarcidae	*Ephoron*				1	1
	Potamanthidae	*Potamanthus*					

Order	Family	Genus	TUSC 22.5	TUSC 39.3	WILL 0.4	YELL 3.5	6MIL 0.2
	Siphlonuridae	*Ameletus*					
		Parameletus					
	Tricorythidae	*Tricorythodes*					
Megaloptera	Corydalidae	*Corydalus*	1	1		1	
		Nigronia	13	18	7	1	4
	Sialidae	*Sialis*	1		2	1	
Odonata	Aeshnidae	*Boyeria*					
	Coenagrionidae	*Argia*					
		Nehalennia					
	Gomphidae	*Erpentogomphus*		1			
		Gomphus		1			
		Ophiogomphus			2		
		Stylogomphus					4
Plecoptera	Capniidae	*Paracapnia*				4	
	Chloroperlidae	*Alloperla*					
	Leuctridae	*Leuctra*	1	3	12		3
	Peltoperlidae	*Peltoperla*					
	Perlidae	*Acroneuria*					10
		Neoperla					
		Paragnetina					4
		Phasganophora					
	Pteronarcidae	*Pteronarcys*					2
Trichoptera	Brachycentridae	*Brachycentrus*		7	1	8	
	Hydropsychidae	*Cheumatopsyche*		7		3	
		Hydropsyche					
		Macronema					
		Potamyia					11
		Sympitopsyche	39	18	8	10	
	Philopotamidae	*Chimarra*	1	4	6	1	
		Dolophilodes			1		22
	Polycentropodidae	*Neureclipsis*					
		Polycentropus					1
	Psychomyiidae	*Lype*					
	Rhyacophilidae	*Rhyacophila*				1	8
Amphipoda	Gammaridae	*Gammarus*				3	
Decapoda	Cambaridae	*Cambarus*		2			
		Procambarus					
Gastropoda	Lymnaeidae	*Lymnaea*		3	2		
	Physidae	*Physa*					
Isopoda	Asellidae	*Asellus*					
Pelecypoda	Corbiculidae	*Corbicula*					
	Sphaeridae	*Pisidium*		2			