

**Biological Criteria for the Protection of Aquatic Life:
Volume III: Standardized Biological Field Sampling and
Laboratory Methods for Assessing Fish and
Macroinvertebrate Communities**

First Update September 30, 1989)



Volume III, pp. V-1-7 to V-1-9. Replaces Tables V-1-1 and V-1-2 with Table V-1.

Table V-1. Current taxonomic keys and the level of taxonomy routinely used by the Ohio EPA for various macroinvertebrate taxonomic classifications.

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- Porifera: Species (Pennak 1989)
Coelenterata: Genus (Pennak 1989)
Platyhelminthes: Class (Pennak 1989)
Nemertea: Phylum (Pennak 1989)
Nematomorpha: Phylum/genus (Pennak 1989)
Ectoprocta: Genus/species (Thorp and Covich 1991)
Entoprocta: Species (Thorp and Covich 1991)
Annelida
 Oligochaeta: Class (Pennak 1989)
 Hirudinea: Species (Klemm 1982)
Arthropoda
 Crustacea
 Isopoda: Genus (Pennak 1989)
 Amphipoda: Genus (Pennak 1989)
 Gammarus: Species (Holsinger 1972)
 Decapoda
 Cambarus and Fallicambarus: Species (Jezerinac and Thoma 1984, Jezerinac 1993)
 Palaemonetes: Species (Pennak 1989)
 Arachnoidea: Class (Pennak 1989)
 Insecta
 Ephemeroptera: Genus (Edmunds *et al.* 1976, Merritt and Cummins 1996)
 Baetidae: Genus/species (Morihara and McCafferty 1979, McCafferty and Waltz 1990, Lugo-Ortiz and McCafferty 1998)
 Pseudocloeon: Species (McCafferty and Waltz 1995)
 Heptageniidae
 Stenonema: Species (Bednarik and McCafferty 1979)
 Ephemerellidae
 Dannella: Species (Allen and Edmunds 1962)
 Ephemerella: Species (Allen and Edmunds 1965)
 Eurylophella: Species (Funk and Sweeney 1994)
 Serratella: Species (Allen and Edmunds 1963b)
 Baetiscidae
 Baetisca: Species (Burks 1953)
 Ephemeroidea: Species (McCafferty 1975)
 Odonata: Family/genus (Merritt and Cummins 1996)
 Anisoptera: Genus/species (Needham and Westfall 1955, Walker 1958, Walker and Corbett 1975)
 Plecoptera: Genus (Stewart and Stark 1988)
 Perlidae
 Acroneuria: Species (Hitchcock 1974)
 Paragnetina: Species (Hitchcock 1974)
 Perlinella: Species (Kondratieff *et al.* 1988)
 Perlodidae: Species (Hitchcock 1974)
 Hemiptera: Genus (Hilsenhoff 1995, Merritt and Cummins 1996)
 Megaloptera: Genus (Merritt and Cummins 1996)
 Nigronia: Species (Neunzig 1966)
 Neuroptera: Genus (Merritt and Cummins 1996)
 Trichoptera: Genus (Wiggins 1996, Merritt and Cummins 1996)
 Philopotamidae: Species (Ross 1944)
 Hydropsychidae
 Hvdropsyche and Ceratopsyche: Species (Schuster and Etnier 1978)
 Rhyacophilidae
 Rhyacophila: Species (Flint 1962, Weaver and Sykora 1979)
 Leptoceridae
 Ceraclea: Species (Resh 1976)
 Mytastides: Species (Yamamoto and Wiggins 1964)
 Nectopsyche: Species (Haddock 1977)
 Oecetis: Species (Floyd 1995)
 Triaenodes/Ylodes: Species (Glover 1996)
 Lepidoptera: Genus (Merritt and Cummins 1996)
 Coleoptera: Genus (Hilsenhoff 1995, Merritt and Cummins 1996)
 Dryopoidea: Genus/species (Brown 1972)
 Diptera: Family/genus (Merritt and Cummins 1996)
 Ceratopogonidae
 Atrichopogon: Species (Johannsen 1935)
 Chironomidae: Genus/species groups (Wiederholm 1983)
 Ablabesmyia: Species (Roback 1985)
 Labrundinia: Species (Roback 1987)
 Tanypus: Species (Roback 1977)
 Corvnoneura: Species (Simpson and Bode 1980, Bolton In Prep.)
 Eukiefferiella and Tvetenia: Species groups (Bode 1983)
 Nanocladius: Species (Saether 1977, Simpson and Bode 1980, Bolton In Prep.)
 Parakiefferiella: Species (Bolton In Prep.)
 Rheocricotopus: Species (Saether 1985)
 Thienemanniella: Species (Hestenes and Saether 2000)
 Chironomus: Species groups (Oliver and Roussel 1983)
 Dicrotendipes: Species (Epler 1987)
 Endochironomus and Tribelos: Species (Grodhaus 1987)
 Parachironomus: Species (Simpson and Bode 1980, Bolton In Prep.)
 Polypedilum: Species groups/species (Maschwitz 2000, Bolton In Prep.)
 Tanytarsini: Genus/species groups/species (Simpson and Bode 1980, Bolton In Prep.)
 Muscidae: Species (Johannsen 1935)
 Mollusca
 Gastropoda: Genus/species (Burch 1982)
 Pelecypoda
 Sphaeriidae: Genus (Burch 1972)
 Unionidae: Species (Waters 1995)

Volume III, pp. V-1-11 to V-1-15. Add the following new citations to the References section.

- Floyd, M.A. 1995. Larvae of the caddisfly genus Qecetis (Trichoptera: Leptoceridae) in North America. Bulletin of the Ohio Biological Survey Vol. 10, No. 3. 85 pp.
- Funk, D.H. and B.W. Sweeney. 1994. The larvae of eastern North American Eurylophella Tiensuu (Ephemeroptera: Ephemerellidae). Transactions of the American Entomological Society 120(3):209-286.
- Glover, J.B. 1996. Larvae of the caddisfly genera Triaenodes and Ylodes (Trichoptera: Leptoceridae) in North America. Bulletin of the Ohio Biological Survey Vol. 11, No. 2. 89 pp.
- Hestenes, T.C. and O.A. Saether. 2000. Three new Nearctic Thienemanniella Kieffer species with a review of the Nearctic species. Late 20th Century Research on Chironomidae. An Anthology from the 13th International Symposium on Chironomidae: pp. 103-127. Shaker Verlag, Aachen.
- Hilsenhoff, W.L. 1995. Aquatic insects of Wisconsin. Keys to Wisconsin genera and notes on biology, habitat, distribution and species. Publication Number 3 of the Natural History Museums Council. University of Wisconsin - Madison.
- Jezerinac, R.F. 1993. A new subgenus and species of crayfish (Decapoda:Cambaridae) of the genus Cambarus, with an amended description of the subgenus Lacunicambarus. Proc. Biol. Soc. Wash. 106(3): pp. 532-544.
- Kondratieff, B.C., R.F. Kirchner, and K.W. Stewart. 1988. A review of Perlinella Banks (Plecoptera: Perlidae). Annals of the Entomological Society of America 81(1):19-27.
- Lugo-Ortiz, C.R. and W.P. McCafferty. 1998. A new North American genus of Baetidae (Ephemeroptera) and key to Baetis complex genera. Ent. News 109(5): 345-353.
- Maschwitz, D.E. and E.F. Cook. 2000. Revision of the Nearctic species of the genus Polypedilum Kieffer (Diptera: Chironomidae) in the subgenera P. (Polypedilum) Kieffer and P. (Uresipedilum) Oyewo and Saether. Bulletin of the Ohio Biological Survey. New Series.12(3): 1-135.
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- McCafferty, W.P. and R.D. Waltz. 1990. Revisionary synopsis of the Baetidae (Ephemeroptera) of North and Middle America. Transactions of the American Entomological Society 116(4):769-799.
- Merritt, R.W. and K.W. Cummins (editors). 1996. An introduction to the aquatic insects of North America. 3rd edition. Kendall/Hunt Publishing Company, Dubuque, Iowa.
- Pennak, R.W. 1989. Fresh-water invertebrates of the United States. 3rd edition. John Wiley & Sons, New York, New York.
- Saether, O.A. 1985. A review of the genus Rheocricotopus Thienemann & Harnisch, 1932, with the description of three new species (Diptera: Chironomidae). Spixiana Supplement 11:59-108.
- Thorp, J.H. and A.P. Covich (editors). 1991. Ecology and classification of North American freshwater invertebrates. Academic Press, San Diego, California.
- Waters, G.T. 1995. A guide to the freshwater mussels of Ohio. 3rd edition. The Ohio Department of Natural Resources, Division of Wildlife, Columbus, Ohio.

New Citations (cont)

- Weaver, J.S., III and J.L. Sykora. 1979. The Rhyacophila of Pennsylvania with larval descriptions of R. banksi and R. carpenteri (Trichoptera: Rhyacophilidae). *Annals of Carnegie Museum*. Carnegie Museum of Natural History 48(22): 403-423.
- Wiggins, G.B. 1996. Larvae of the North American caddisfly genera (Trichoptera). 2nd edition. University of Toronto Press, Toronto, Canada.
- Yamamoto, T. and G.B. Wiggins. 1964. A comparative study of the North American species in the caddisfly genus Mystacides (Trichoptera: Leptoceridae). *Can. J. Zool.* 42: 1105-1126.

NOTICE TO USERS

All methods and procedures for the use of biological criteria contained and/or referred to in these volumes supercede those described in any previous Ohio EPA manuals, reports, policies, and publications dealing with biological evaluation, designation of aquatic life uses, or the determination and evaluation of aquatic life use attainment. Users of these criteria and the supporting field methods, data analyses, and study design should conform to that presented or referenced in these volumes (and subsequent revisions) in order to be applicable under the Ohio Water Quality Standards (WQS; OAC 3745-1).

Three volumes comprise the supporting documentation for setting and using biological criteria in Ohio. All three volumes are needed to use the biological criteria, implement the field and laboratory procedures, and understand the principles behind their development, use, and application. These volumes are:

Ohio Environmental Protection Agency. 1987. *Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment.* Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987. *Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters.* Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989. *Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities.* Division of Water Quality Monitoring and Assessment, Columbus, Ohio.

In addition, one other publication from the Stream Regionalization Project is recommended to all users:

Whittier, T.R., D.P. Larsen, R.M. Hughes, C.M. Rohm, A.L. Gallant, and J.M. Omernik. 1987. *The Ohio stream regionalization project: a compendium of results.* U.S. EPA - Environmental Res. Lab, Corvallis, OR. EPA/600/3-87/025. 66 pp.

These documents can be obtained by writing:

Ohio Environmental Protection Agency
Division of Water Quality Monitoring and Assessment
1800 WaterMark Drive, P.O. Box 1049
Columbus, Ohio 43266-0149

Other recommended and helpful literature is listed in the references of each volume.

FOREWARD

This volume is excerpted from the Ohio EPA Manual of Surveillance Methods and Quality Assurance Practices (6th Update). The macroinvertebrate methods are from section V, subsection 1 and the fish methods are from section V, subsection 4 of this manual. They are produced here to accompany the supporting technical documentation for the establishment and use of biological criteria in Ohio.

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Jeff DeShon, Jack Freda, and Mike Bolton provided the primary input to the macroinvertebrate section. Chris Yoder, Marc Smith, Roger Thoma, Randy Sanders, and Ed Rankin were responsible for the fish section. Ed Rankin was the primary originator of the Qualitative Habitat Evaluation Index (QHEI) which is described in the fish section. Pam Jacques provided typing support.

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Subsection 1. Macroinvertebrates

J.E. DeShon, J.T. Freda, M. J. Bolton

Part A) Field Methods - Quantitative Sampling

Part B) Field Methods - Qualitative Sampling

Part C) Laboratory Methods - Quantitative Sampling

1) Macroinvertebrate Counts and Identifications

2) Macroinvertebrate Data Analysis

a) Invertebrate Community Index

b) Community Similarity Index

c) Rank Correlation Coefficient

d) Coefficient of Variation

Part D) Laboratory and Data Analysis Methods -
 Qualitative Sampling

Part A

Field Methods - Quantitative Sampling

The primary sampling equipment used for the collection of benthic macroinvertebrates is the modified Hester-Dendy multiple-plate artificial substrate sampler. The sampler is constructed of 1/8 inch tempered hardboard cut into three inch square plates and one inch square spacers. A total of eight plates and twelve spacers are used for each sampler. The plates and spacers are placed on a 1/4 inch eyebolt so that there are three single spaces, three double spaces, and one triple space between the plates. The total surface area of the sampler, excluding the eyebolt, is 145.6 square inches.

Samplers placed in streams are tied to a concrete construction block which anchors them in place and prevents the multiple- plates from coming into contact with the natural substrates. In water deeper than four feet, a float (1 qt. cubitainer) is attached to the samplers to keep them within four feet of the surface. Whenever possible, the samplers are placed in runs rather than pools or riffles and an attempt is made to establish stations in as similar an

ecological situation as possible. All samplers are exposed for a six week period. A set of samplers consists of three multiple-plate samplers (three square feet) at National Ambient Water Quality Monitoring Network (NAWQMN) stations and five multiple-plate samplers at all other sampling locations. All NAWQMN stations and most routine monitoring stations are sampled during the time period of June 15 to September 30.

Retrieval of the samplers is accomplished by cutting them from the block and placing them in one quart plastic containers while still submersed. Care is taken to avoid disturbing the samplers and thereby dislodging any organisms. Enough formalin is added to each container to equal an approximate 10% solution. Qualitative samples of macroinvertebrates inhabiting the natural substrates are also collected at the time of sampler retrieval. In shallow water, samples are taken in a stream segment covering all available habitats in the near vicinity where the samplers were placed. Samples are collected using triangular ring frame 30-mesh dip nets and hand picking with forceps. Grab samplers (i.e., Ekman, Peterson, or Ponar) can also be used in deep water. The qualitative sampling continues until, by gross examination, no new taxa are being taken. A station description sheet (Figure V-1-1) is filled out by the collector at the time of sampler retrieval. The substrate is described using the categories for substrate characterization indicated in the USEPA biological field manual (Weber, 1973).

In those situations where quantitative biological samples are collected from the natural substrates using a Surber square foot sampler (30-mesh netting), the collector stands on the downstream side of the sampler and works the substrate using a hand cultivator with two inch tines. Large rocks are gently scrubbed with a brush. The material collected is placed in sealed containers, preserved in 10% formalin, and transported to the laboratory. Three to five Surber samples are taken at each site.

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Figure V-1-1. Station description sheet used by macroinvertebrate field crews (Front).

Ohio EPA Surface Water Section
 Macroinvertebrate Field Sheet

Stream _____ Stream Code _____ RM _____ Date Collected _____
 Location _____ Date Set _____
 _____ Collected By _____

Sampling Method: HD(No. _____) - DN/HP - Surber - Grab (Type _____) - Other _____
 HD Sampler Site: Depth _____ Canopy _____ Current (Set) _____ Current (Ret) _____
 HD Condition: Disturbed Yes/No Comment: _____
 Debris Yes/No Comment: _____
 Silt/Solids None - Slight - Moderate - Heavy
 DN/HP Sampling: Total Time _____ Habitats: Pool - Riffle - Run - Margin - Backwater

Physical Characteristics

Flow Condition: High - Moderate - Low - Interstitial - Intermittent - Dry
 Current Velocity: Fast - Moderate - Slow - ND
 Channel Morphology: Natural - Channelized - Channelized (Recovered) - Impounded
 Bank Erosion: Extensive - Moderate - Slight - None
 Riffle Development: Extensive - Moderate - Sparse - Absent
 Riffle Quality: Good - Fair - Poor Embedded: Yes/No
 Clarity: Clear - Murky - Turbid
 Color: None - Green - Brown - Grey - Other()
 Canopy: Open - 75% - 50% - 25% - Closed

Substrate Characteristics

Percent of:	Pool	Riffle	Run
Bedrock()	_____	_____	_____
Boulder()	_____	_____	_____
Rubble()	_____	_____	_____
Coarse Gravel	_____	_____	_____
Fine Gravel	_____	_____	_____
Sand	_____	_____	_____
Silt	_____	_____	_____
Clay/Hardpan	_____	_____	_____
Detritus	_____	_____	_____
Peat	_____	_____	_____
Muck	_____	_____	_____
Other()	_____	_____	_____
Macrophytes()	_____	_____	_____
Algae()	_____	_____	_____
Artifacts()	_____	_____	_____
Compaction(F,M,S)	_____	_____	_____
Depth (Average)	_____	_____	_____
Width (Average)	_____	_____	_____

Predominant Land Use (L,R,B)

Forest	Open Pasture	Wetland
Shrub	Closed Pasture	Other
Old Field	Urban	()
Rowcrop	Residential/Park	
Industrial	Mining/Construction	

Riparian Vegetation

Left	Width	Right	Width	Type
_____	_____	_____	_____	Large trees
_____	_____	_____	_____	Small trees
_____	_____	_____	_____	Shrubs
_____	_____	_____	_____	Grass/Weeds
_____	_____	_____	_____	None

Margin Habitat

Undercut Banks	Root Mats
Grass	Water Willow
Shallows	Clay/Hardpan
Rip Rap	Bulkhead
Other()	

Margin Quality: Good - Fair - Poor

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Figure V-1-1 (Continued). Station description sheet used by macroinvertebrate field crews (Back).

Biological Characteristics

Riffle

Predominant Organisms: _____

Other Common Organisms: _____

Density: High - Moderate - Low

Diversity: High - Moderate - Low

Run

Predominant Organisms: _____

Other Common Organisms: _____

Density: High - Moderate - Low

Diversity: High - Moderate - Low

Pool

Predominant Organisms: _____

Other Common Organisms: _____

Density: High - Moderate - Low

Diversity: High - Moderate - Low

Margin

Predominant Organisms: _____

Other Common Organisms: _____

Density: High - Moderate - Low

Diversity: High - Moderate - Low

Other Notable Collections: _____

Potential Pollution Sources: _____

Evidence of Pollution: _____

Photo Numbers: _____

Comments: _____

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In those situations where Ekman, Peterson, or Ponar grab samples are used for quantitative purposes, three to five samples are collected and then treated in essentially the same manner as the Surber samples. The material collected with the grab is washed through a bucket with a 30-mesh screen bottom, placed in sealed containers, preserved in 10% formalin, and returned to the laboratory.

Part B
Field Methods -
Qualitative Sampling

When only qualitative samples are collected the methods are similar to those employed when collecting qualitative samples in conjunction with artificial substrate samples except that:

- a) A more intensive sampling effort is required.
- b) The sampling area is more rigidly defined.
- c) More extensive field notes concerning the biological and physical condition of each station are required.
- d) A preliminary biological community assessment is made on site.

Each station is sampled at least once between June 15 and September 30. Organisms are collected from the natural substrates using triangular ring frame 30-mesh dip nets and forceps, and are preserved in 70% alcohol. Collections are made for a minimum of 30 minutes, then continue until no new taxa are evident in gross examinations. Whenever possible, a riffle, run, margin, and pool habitat are sampled at each station and an attempt is made to sample areas which are physically similar from site to site. Stations should be sampled in order, moving from upstream to downstream, to detect any changes between

sites.

As in quantitative sampling, the station description sheet (Figure V-1-1) is filled out at each station at the time of collection. In addition, the length of sampling time and the presence of riffle, run, margin, and pool habitats are noted. Predominant populations and estimates of community density and diversity in each habitat type are noted on the sheet. A preliminary biological community assessment is made after each station is sampled.

Part C
Laboratory Methods -
Quantitative Sampling

Samples are coded and sample numbers are immediately entered into a log book upon arrival at the laboratory. Samples are given a log number derived from the date, e.g., 871108-10, where 87 represents the year, 11 represents the month, and 08 the day. The number following this six digit date, i.e., the number 10 in the previous example, indicates that this was the 10th sampled logged that day. Other information in the log book includes the name(s) of field personnel that collected the sample, date, stream or lake name, basin name, entity (where applicable), general location, sample type, sampling method(s) used, the person who conducted the analyses, and any other comments considered pertinent to the collection and analysis of the sample.

1) *Macroinvertebrate Counts and Identifications*

Composite samples consisting of five multiple-plate samplers are used in station evaluations for routine monitoring. However, replicate samples (three multiple-plate samplers) are reported to the USEPA for NAWQMN stations. Replicate sets of five multiple-plate samplers can be used if deemed necessary in those cases where sampling is for litigation purposes. In all cases, the multiple-

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plate(s) is (are) disassembled in a bucket of water, cleaned of organisms and debris, and discarded. The organism/debris mixture is then passed through U.S. Standard Testing Sieves number 30 (0.589 mm openings) and number 40 (0.425 mm openings). The material retained in each sieve is preserved in properly labeled and coded jars of 70% alcohol.

The following procedures are used during the course of analyzing an artificial substrate, Surber, or grab sample:

a) Sorting of the sample is done in a white enamel pan followed by scanning under the dissecting microscope (10x magnification). Subsamples are produced using the following guidelines:

1) The Folsom sample splitter is used for all subsampling. (In an effort to determine the accuracy of the Folsom sample splitter, a sample composed of 200 individuals of five frequently collected organisms was prepared and repeatedly split. Statistical analysis of the data yielded a chi-square value of 2.56, $df=4$, which was not significant at the 95% probability level.)

2) After an entire sample has been sorted, subsampling within families containing unmanageable numbers is acceptable.

3) Very large samples may be subsampled prior to sorting - but only after examination in a white enamel pan to remove obvious rare taxa, e.g., crayfish, hellgramites, non-hydropsychid caddisflies.

4) A minimum of 250 organisms is identified, with at least 50-100 midges, 70 caddisflies, 70 mayflies.

b) Dipterans of the family Chironomidae are prepared for identification by clearing the larvae in hot 10% KOH for 30 minutes and then mounting in water on microscope slides. Permanent slides for the voucher collection are mounted in Euparal mounting medium.

c) Material retained in the # 40 screen is counted and identified or counted and extrapolated when identification is impossible or impractical. (Artificial substrate sample only.)

d) Organisms determined to be dead before the time of collection are discarded.

e) When only one sex or life stage can be identified it is assumed that the other sex or stage is the same species.

f) Sections of bryozoan colonies are removed from the plates and saved for identification. Only colonies, not individuals, are counted. (Artificial substrate sample only.)

g) Early instars that cannot be identified are extrapolated where possible.

h) Species level identifications are made where possible and practical. Generic or higher level classifications are made if specimens are damaged beyond identification, in those cases where taxonomy is incomplete or laborious and time-consuming, or where the specimen is an unidentifiable early instar.

i) Organisms are listed in tables following the laboratory table format (Table V-1-1).

j) Two end fragments of an oligochaete are counted as one individual. Fragments without ends are not counted.

k) Any taxonomic key in the laboratory may be used as an aid in the identification of an organism. However, the final identification and name used are taken from the asterisked references in Table V-1-2. Also indicated is the level of taxonomy attainable with the keys listed.

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Table V-1-1. Phylogenetic order for macroinvertebrate listing including level of taxonomy generally used.

Porifera:	Species	Plecoptera	
Coelenterata:	Genus	Pteronarcyidae:	Genus
Platyhelminthes:	Class	Peltoperlidae:	Genus
Nematomorpha:	Genus	Taeniopterygidae:	Genus
Bryozoa:	Species	Nemouridae:	Species
Entoprocta:	Species	Leuctridae:	Genus
Annelida		Capniidae:	Genus
Oligochaeta:	Class	Perlidae:	Species
Hirudinea:	Species	Perlodidae:	Species
Arthropoda		Chloroperlidae:	Genus
Crustacea		Hemiptera	
Isopoda:	Genus	Belostomatidae:	Genus
Amphipoda:	Genus/Species	Nepidae:	Genus
Decapoda:	Species	Pleidae:	Genus
Arachnoidea		Naucoridae:	Genus
Hydracarina:	Class	Corixidae:	Genus
Insecta		Notonectidae:	Genus
Ephemeroptera		Megaloptera	
Siphonuridae:	Genus	Sialidae:	Genus
Baetidae:	Genus	Corydalidae:	Species
Oligoneuriidae:	Genus	Neuroptera:	Genus
Heptageniidae:	Genus/Species	Trichoptera	
Leptophlebiidae:	Genus	Philopotamidae:	Genus/Species
Ephemerellidae:	Species	Psychomyiidae:	Species
Tricorythidae:	Genus	Polycentropodidae:	Genus
Caenidae:	Genus	Hydropsychidae:	Genus/Species
Baetiscidae:	Species	Rhyacophilidae:	Genus/Species
Potamanthidae:	Genus	Glossosomatidae:	Genus
Ephemeridae:	Genus	Hydroptilidae:	Genus/Species
Polymitarcyidae:	Species	Phryganeidae:	Genus
Odonata		Brachycentridae:	Genus
Zygoptera		Limnephilidae:	Genus
Calopterygidae:	Genus	Lepidostomatidae:	Genus
Lestidae:	Species	Beraeidae:	Genus
Coenagrionidae:	Family/Genus	Sericostomatidae:	Genus
Anisoptera		Odontoceridae:	Genus
Aeshnidae:	Species	Molannidae:	Genus
Gomphidae:	Species	Helicopsychidae:	Species
Cordulegastridae:	Species	Calamoceratidae:	Genus
Macromiidae:	Species	Leptoceridae:	Genus/Species
Corduliidae:	Species	Lepidoptera:	Genus
Libellulidae:	Species		

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Coleoptera

Gyrinidae:	Genus
Halplidae:	Genus
Dytiscidae:	Genus
Noteridae:	Genus
Hydrophilidae:	Genus
Hydraenidae:	Genus
Psephenidae:	Species
Dryopidae:	Genus
Scirtidae:	Family
Elmidae:	Genus/Species
Limnichidae:	Genus
Heteroceridae:	Family
Ptilodactylidae:	Family
Chrysomelidae:	Family
Curculionidae:	Family
Lampyridae:	Family

Diptera

Tipulidae:	Genus
Psychodidae:	Genus
Ptychopteridae:	Genus
Dixidae:	Genus
Chaoboridae:	Genus
Culicidae:	Genus
Thaumaleidae:	Genus
Simuliidae:	Genus
Certopogonidae:	Family/Genus/Species
Chironomidae	
Tanypodinae:	Genus/Species
Diamesinae:	Genus/Species
Prodiamesinae:	Genus/Species
Orthocladinae:	Genus/Species
Chironominae	
Chironomini:	Genus/Species
Pseudochironomini:	Genus/Species
Tanytarsini:	Genus/Species
Tabanidae:	Genus/Species
Athericidae:	Species
Stratiomyidae:	Genus
Empididae:	Family
Dolichopodidae:	Family
Syrphidae:	Family/Genus
Sciomyzidae:	Family/Genus
Ephydriidae:	Family/Genus
Muscidae:	Species

Mollusca

Gastropoda:	Family/Genus/Species
Pelecypoda:	Family/Genus/Species

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Table V-1-2 Level of macroinvertebrate taxonomy attainable using keys (Asterisked references are used for final identifications)

<p>Porifera: Pennak* (1978)/Species Coelenterata: Pennak* (1978)/Species Platyhelminthes: Pennak* (1978)/Species Nematomorpha: Pennak* (1978)/Genus Bryozoa: Pennak* (1978)/Species Annelida Hirudinea: Klemm* (1982)/Species Isopoda <i>Asellus</i>: Williams* (1972)/Species Amphipoda Specific Keys: Pennak* (1978)/Species Gammaridae: Holsinger* (1972)/Species Decapoda <i>Cambarus</i> and <i>Fallicambarus</i>: Jezerinac and Thoma* (1982)/Species <i>Procambarus</i> and <i>Orconectes</i>: Jezerinac* (1978)/Species Ephemeroptera Generic Keys: Edmunds et al. (1976), Merritt and Cummins* (1984)/Genus <i>Baetis</i>: Morihara and McCafferty* (1979)/Species <i>Stenonema</i>: Bednarik and McCafferty* (1979)/Species <i>Attenella</i>: Allen and Edmunds* (1961)/Species <i>Dannella</i>: Allen and Edmunds* (1962)/Species <i>Drunella</i>: Allen and Edmunds* (1962)/Species <i>Ephemerella</i>: Allen and Edmunds* (1965)/Species <i>Eurylophella</i>: Allen and Edmunds* (1965)/Species <i>Serratella</i>: Allen and Edmunds* (1963)/Species <i>Ephemeroidea</i>: McCafferty* (1975)/Species Other Species Keys: Burks* (1953)/Species Odonata Generic Keys: Merritt and Cummins* (1984)/Genus Zygoptera: Walker* (1953)/Species Anisoptera: Needham and Westfall* (1955), Walker (1958), Walker and Corbett (1975)/Species Plecoptera Generic Keys: Stewart and Stark* (1988)/Genus Species Keys: Hitchcock* (1974)/Species <i>Agnatina</i>: Stark* (1986)/Species Hemiptera Generic Keys: Hilsenhoff (1982), Merritt and Cummins* (1984)/Genus Megaloptera Generic Keys: Merritt and Cummins* (1984)/Genus <i>Chauliodes</i>: Cuyler* (1958)/Species <i>Nigronia</i>: Neunzig* (1966)/Species</p>	<p>Neuroptera Generic Keys: Merritt and Cummins* (1984)/Genus Trichoptera Generic keys: Wiggins* (1977)/Genus <i>Hydropsyche</i>: Scheffer et al.* (1986)/Genus Schuster and Etnier (1978)/Species <i>Rhyacophila</i>: Flint* (1962)/Species <i>Nectopsyche</i>: Haddock* (1977)/Species Lepidoptera Generic Keys: Merritt and Cummins* (1984)/Genus Coleoptera Generic Keys: Hilsenhoff (1982), Merritt and Cummins* (1984)/Genus Dryopoidea: Brown* (1972)/Species Diptera Generic Keys: McAlpine et al.* (1981) (exc. Chironomidae)/Genus Simuliidae: Stone* (1964)/Species Chironomidae Generic Keys: Wiederholm* (1983)/Genus <i>Ablabesmyia</i>: Roback* (1985)/Species <i>Clinotanypus</i>: Roback* (1976)/Species <i>Coelotanypus</i>: Roback* (1974)/Species <i>Labrundinia</i>: Roback* (1987)/Species <i>Natarsia</i> and <i>Psectrotanypus</i>: Roback* (1978)/Species <i>Nilotanypus</i>: Roback* (1986)/Species <i>Tanypus</i>: Roback* (1977)/Species <i>Pagastia</i>: Oliver and Roussel* (1982)/Species <i>Monodiamesa</i>: Saether* (1973)/Species <i>Brillia</i>: Oliver and Roussel* (1983)/Species <i>Eukiefferiella</i> and <i>Tvetenia</i>: Bode* (1983)/Species group <i>Nanocladius</i>: Saether* (1977)/Species <i>Orthocladius</i> (<i>Orthocladius</i>): Soptonis* (1977)/Species <i>Axarus</i>: Roback* (1963)/Species <i>Dicrotendipes</i>: Epler* (1987)/Species <i>Endochironomus</i>, Tribelos, and <i>Endotribelos</i>: Grodhaus* (1987)/Species <i>Paracladopelma</i> and <i>Saetheria</i>: Jackson* (1977)/Species <i>Polypedium</i> (<i>Polypedilum</i>): Maschwitz* (1976)/Species Other Species keys: Simpson and Bode* (1980)/Species Tabanidae: Pechuman et al.* (1983)/Species Athericidae: Webb (1977)*/Species Muscidae: Johannsen* (1935)/Species Mollusca Gastropoda: Burch* (1982)/Species Pelecypoda: Burch* (1972)/Species</p>
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2) Macroinvertebrate Data Analysis

a) Invertebrate Community Index

The principle measure of overall macroinvertebrate community condition used by the Biological Field Evaluations Group is the Invertebrate Community Index (ICI), a measurement derived in-house from information collected over many years. The ICI is a modification of the Index of Biotic Integrity (IBI) for fish developed by Karr (1981). The ICI consists of ten structural community metrics, each with four scoring categories of 6, 4, 2, and 0 points (Table V-1-3). The point system evaluates a sample against a database of 247 relatively undisturbed reference sites throughout Ohio. Six points will be scored if a given metric has a value comparable to those of exceptional stream communities, 4 points for those metric values characteristic of more typical good communities, 2 points for metric values slightly deviating from the expected range

Table V-1-3. Invertebrate Community Index (ICI) Metrics and Scoring Criteria Based on Macroinvertebrate Community Data From 247 Reference Sites Throughout Ohio.

Metric	Scoring Criteria			
	0	2	4	6
1. Total Number of Taxa	Scoring of each metric varies with drainage area; see Ohio EPA (1987).			
2. Total Number of Mayfly Taxa				
3. Total Number of Caddisfly Taxa				
4. Total Number of Dipteran Taxa				
5. Percent Mayflies				
6. Percent Caddisflies				
7. Percent Tribe Tanytarsini Midges				
8. Percent Other Dipterans and Non-Insects				
9. Percent Tolerant Organisms				
10. Total Number of Qualitative Ephemeroptera, Plecoptera, and Trichoptera (EPT) Taxa				

of good values, and 0 points for metric values strongly deviating from the expected range of good values. The summation of the individual metric scores (determined by

the relevant attributes of an invertebrate sample with some consideration given to stream drainage area) results in the ICI value. Metrics 1-9 are all generated from the artificial substrate sample data while Metric 10 is based solely on the qualitative sample data. More discussion of the derivation of the ICI including descriptions of each metric and the data plots and other information used to score each metric can be found in Ohio EPA (1987).

b) Community Similarity Index

A coefficient of similarity (*c*) between two stations can be calculated using Van Horn's (1950) equation modified from the general formula described by Gleason (1920):

$$c = \frac{2w}{a + b}$$

The variables in this expression can be based either on the number of taxa present or absent at each station or on actual numerical data collected at each site. If the presence/absence method is being used:

- a** = the number of taxa collected at one station,
- b** = the number of taxa collected at the other station, and
- w** = the number of taxa common to both stations.

When actual numerical data are being used, each taxon is assigned a prominence value calculated by multiplying the density of the taxon by the square root of its frequency of occurrence (Beals, 1961; Burlington, 1962). In this case:

- a** = the sum of the prominence values of all of the taxa at one station,
- b** = the sum of the prominence values of all of the taxa at the other station, and
- w** = the sum of the prominence values of all of the taxa of one station which it has in common with the other station. The lower of the two resulting values of *w* is used in the equation.

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c) Rank Correlation Coefficient

A rank correlation coefficient between measured biological, chemical, or other physical data can be calculated using the formula defined by Spearman (1904):

$$r_s = 1 - \frac{6 \sum_{i=1}^n D_i^2}{n(n^2 - 1)}$$

where n = the number of paired observations (x_i, y_i) and
 D_i = the rank of x_i minus the rank of y_i .

d) Coefficient of Variation

In cases where replicate analyses are conducted (e.g., litigation purposes or NAWQMN stations), a coefficient of variation between replicates is determined following the procedures outlined by Li (1964) using the formula:

$$CV = \frac{s}{\bar{x}} \times 100$$

where s = the sample standard deviation and:
 \bar{x} = the sample mean.

Part D

Laboratory Methods and Data Analysis - Qualitative Sampling

Samples are entered and logged as outlined in Subsection 1, part c. Samples are examined using a dissecting microscope and a tabulated listing of the organisms identified is compiled. Dipterans of the family Chironomidae are prepared as outlined in Subsection 1, Part c. Taxonomic guides used for final identifications are the same as listed in Subsection 1, Part c. Assessment of the macroinvertebrate community condition is finalized

using the preliminary assessment made in the field tempered with information on taxa richness and composition from the laboratory identified sample.

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