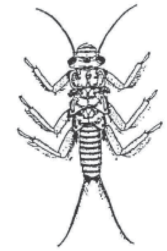
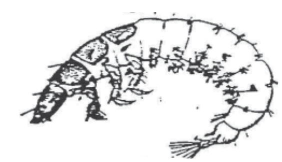
Checklist (for turning in results)

to be sure that we have everything we need to use your data

- ☐ 2 completed "Sampling Protocol" sheets (one for each replicate sample)
- ☐ 5 completed "Reporting Sheets for Sampling" - Physical Survey/Habitat Assessment pages (p.44-48 of HBRW guidance document)
- ☐ 4 Completed BMI Sorting Worksheets OR HBRW Tier 3 "Benthic Macroinvertebrate Family Level Data Sheet"
- ☐ Containers of identified organisms preserved in 70% alcohol, each labeled with sampling location, sampling date and rep #.
- ☐ Container of sorted but unidentified organisms preserved in 70% alcohol labeled with sampling location, sampling date and rep #.



Rough Guide to BMI with CSi



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Compilation by Adrianna Hirtler

Content adapted from a variety of sources

The Community Science Institute works together with community volunteers and participants in the CSI high school/college stream monitoring program to monitor benthic macroinvertebrates in Finger Lakes Streams as indicators of water quality. This "guide" is a compilation from a variety of sources. It is a work in progress meant to assist volunteers and students with this work. Any comments, suggestions, or questions are welcome (*adriannalouise@gmail.com*).

Step-by-step procedures, reporting sheets and explanations of metrics have been adapted from the Hudson Basin River Watch Guidance Document of 2004 (www.hudsonbasin.org/HBRWGD04.pdf). Other sources are cited where appropriate.

Table of Contents

BMI = Benthic Macroinvertebrates

bottom-dwelling organisms
with no backbone
that you can see without a microscope

Notes

Notes

Origin of the Protocols

The following pages outline the protocols involved for sampling, sorting and analysis of benthic macroinvertebrate samples collected as a part of Community Science Institute efforts to monitor water quality. The protocols were developed in the 1990's for use by volunteer stream monitors by Hudson Basin River Watch in cooperation with the New York State Department of Environmental Conservation (who, in order to keep track of water quality in the state, is mandated to engage in bio-monitoring activities by the U.S. Environmental Protection Agency under the Federal Clean Water Act of 1972).

Scientific Rigor

In collecting samples, sorting, identifying and recording data, please strive to be as meticulous as possible, following the protocols as carefully and completely as possible and recording your data thoroughly and legibly. This is what gives all of our data its meaning. To this end, be sure to fill out the BMI Protocol sheet (example on page 32 of this document) and strive for the highest level of QA/QC possible (see discussion on page 32).

Equipment for Benthic Macroinvertebrate Sampling

Essential Items	Purpose
BMI Sample Sheets and appropriate physical survey sheets	For permanent record of collection
Clipboard	To hold data collection sheets and provide writing surface in field
Collection net: 18"x8" w/ 0.8-0.9 mm mesh size	To catch dislodged organisms during collection
Forceps	To pick critters off net and sieve bucket
Small white containers/ice cube trays	To sort live critters into groups
Float (orange or tennis ball)	To measure stream velocity/current
Stop watch	To measure stream velocity/current
Tape measure (50' minimum) or 50' string marked in 10' sections	To measure segment length for current/ velocity msrmnts and for stream width
1 qt. Mason jars w/ rubber seal lids or watertight plastic tubs (perhaps safer, overall)	To hold preserved samples
90% de-natured ethyl alcohol	To preserve samples
Labeling tape and pencils	To label sample containers
4"-6" deep white tray (larger than 18"x8") w/12 equal-sized squares marked on bottom	To remove critters from net for preservation and subsample preserved specimens

Other Recommended Items	Purpose
Waders or high boots	To keep your feet dry
Field magnifiers	To identify critters streamside
Sieve bucket (#30 mesh)	To collect and transfer samples for preservation
USGS topographic map	To help locate collection sites
5-gallon bucket	All purpose container
Life jackets	For safety in deeper water

Collecting BMI Samples

Two replicate samples are collected in a riffle with a substrate of rock, cobble, gravel and sand. The DEC defines a riffle as an area that is shallow enough for the surface to be broken by the substrate. Depth should be less than one meter. Current speed should be between 0.40 and 0.75 meters/second (roughly 1-2 feet/sec).

Each replicate sample is collected by disturbing the stream bottom by foot along a diagonal 5 meter transect, for 5 minutes. The samples are preserved for later analysis.

Step by Step Procedure

Step 1: Assemble collection equipment and supplies (see previous page).

Step 2: Go to your stream and identify a riffle for collection. It should have a velocity somewhere between 0.40 and 0.75 meters/second (roughly 1-2 feet/sec) and be shallow enough for the surface to be broken by the substrate (less than one meter).

Step 3: Measure a 200’ segment that contains the riffle habitat from which the sample will be collected.

Step 4: Conduct physical survey/habitat assessment for this 200’ segment (Complete the 5 pages entitled “Reporting Sheets for Sampling” shown towards the end of this document).

Step 5: Wade into the riffle and look for an appropriate spot to place the net. There should be at least 5 meters of riffle upstream of the net, in a diagonal direction.

Step 6: Have one person place and hold the net on the river bottom at the collection spot, with the opening of the net facing upstream.

Step 7: Have another person stand 0.5 meter directly upstream from the net opening and disturb the stream bottom by foot for 30 seconds so that organisms are dislodged and carried by the current into the net. Use a shuffling motion, disturbing the substrate a few inches down. Avoid kicking the substrate into the net.

Step 8: When you’ve finished at the first spot, carefully lift the net out of the river. Walk upstream 0.5 meter in a diagonal direction, and repeat (see figure 1). Leave the sample in the net. Continue until a total of 5 meters are sampled along a diagonal transect as wide as the net (10 times). This should be completed in a total of 5 minutes. The resulting collection of organisms in your net is one replicate sample. If your stream is narrow, you can modify your transect to be at more of a diagonal upstream to fit in 5 meters. If, however, you reach the other side of the stream before completing your 10 kick-sample sets, start back across the stream (again, working your way at an angle slightly upstream).

Metrics

EPT Richness: An estimate of numbers of mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) taxa represented in a subsample. These are considered to be mostly clean-water organisms and their presence generally is correlated with good water quality.
To calculate this metric, count the number of mayfly, stonefly and caddisfly taxa identified in each replicate subsample.
>7=no impact, 3-7=slight impact, 1-2=moderate impact, 0=severe impact

Taxa Richness: An estimate of the number of different taxa represented in a subsample. It is a rough measure of the diversity of the macroinvertebrate community. In general, the greater the number of taxa (higher richness), the less impacted the stream.
To calculate, count the total number of different taxa identified in each replicate subsample.
>13=no impact, 10-13=slight impact, 7-9=moderate impact, <7=severe impact

Biotic Index: This metric incorporates the various average tolerance values of different groups of benthic macroinvertebrates which range from 0-10 (intolerant to tolerant).
To calculate, multiply the number of organisms in each major group by the corresponding group tolerance value. For each replicate subsample, add the results for all groups and divide by the total number of organisms you picked for that replicate.
0-4.5=no impact, 4.51-5.5=slight impact, 5.51-7=moderate impact, 7.01-10=severe impact

Percent Model Affinity (PMA): This is a measure of similarity to a model non-impacted community for New York State based on percent abundance in 7 major groups. Percent Composition values are compared to a model community established by the NYSDEC for a non-impacted stream. The model is based on a typical summertime community, so this metric may not be useful for samples taken in the early spring or late fall. [40% Ephemeroptera, 5% Plecoptera, 10% Trichoptera, 10% Coleoptera, 20% Chironomidae, 5% Oligochaeta, and 10% Other]
To calculate, use the worksheet entitled “Benthic Macroinvertebrate Major Group Percent Composition & Model Affinity Worksheet” (page 38).
>64=no impact, 50-64=slight impact, 35-49=moderate impact, <35=severe impact

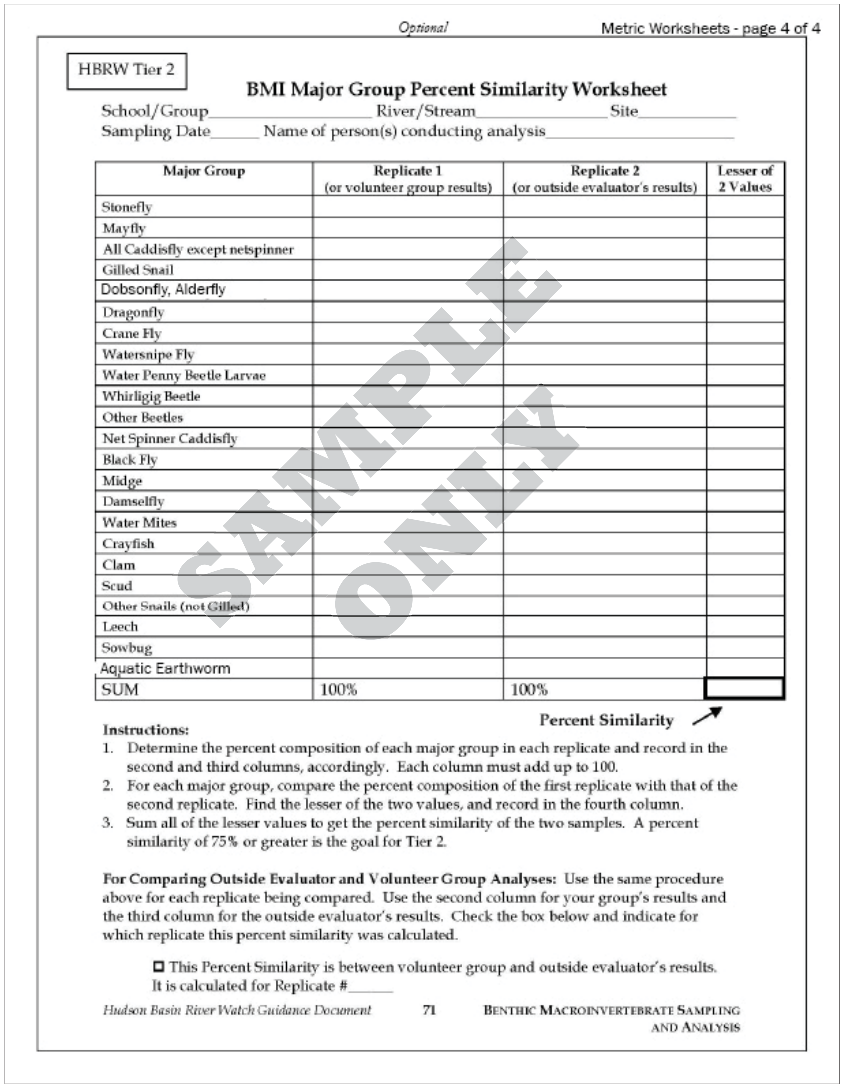
BAP (Biological Assessment Profile): BAP value combines the previous four metrics into a single value between 0 and 10. This number represents the overall assessed impact for each site (0=severely impacted and 10=unimpacted).
10-7.5=no impact, 7.5-5=slight impact, 5-2.5=moderate impact, 2.5-0=severe impact

* Since the BAP value incorporates PMA values, be sure to read its description for the limitations on that metric if sampling any time other than summer.

Optional Metric Calculation Worksheets

To complete during ID sessions (optional)

Get copies of worksheets from the CSI website or at the lab:
www.communityscience.org


Optional Metric Worksheets - page 4 of 4

HBRW Tier 2

BMI Major Group Percent Similarity Worksheet

School/Group__________________ River/Stream________________ Site____________
Sampling Date______ Name of person(s) conducting analysis____________________

Major Group	Replicate 1 (or volunteer group results)	Replicate 2 (or outside evaluator's results)	Lesser of 2 Values
Stonefly			
Mayfly			
All Caddisfly except netspinner			
Gilled Snail			
Dobsonfly, Alderfly			
Dragonfly			
Crane Fly			
Watersnipe Fly			
Water Penny Beetle Larvae			
Whirligig Beetle			
Other Beetles			
Net Spinner Caddisfly			
Black Fly			
Midge			
Damselfly			
Water Mites			
Crayfish			
Clam			
Scud			
Other Snails (not Gilled)			
Leech			
Sowbug			
Aquatic Earthworm			
SUM	100%	100%	

Percent Similarity ↗

Instructions:

1. Determine the percent composition of each major group in each replicate and record in the second and third columns, accordingly. Each column must add up to 100.
2. For each major group, compare the percent composition of the first replicate with that of the second replicate. Find the lesser of the two values, and record in the fourth column.
3. Sum all of the lesser values to get the percent similarity of the two samples. A percent similarity of 75% or greater is the goal for Tier 2.

For Comparing Outside Evaluator and Volunteer Group Analyses: Use the same procedure above for each replicate being compared. Use the second column for your group's results and the third column for the outside evaluator's results. Check the box below and indicate for which replicate this percent similarity was calculated.

☐ This Percent Similarity is between volunteer group and outside evaluator's results. It is calculated for Replicate #______

Hudson Basin River Watch Guidance Document 71 BENTHIC MACROINVERTEBRATE SAMPLING AND ANALYSIS

Collecting BMI Samples

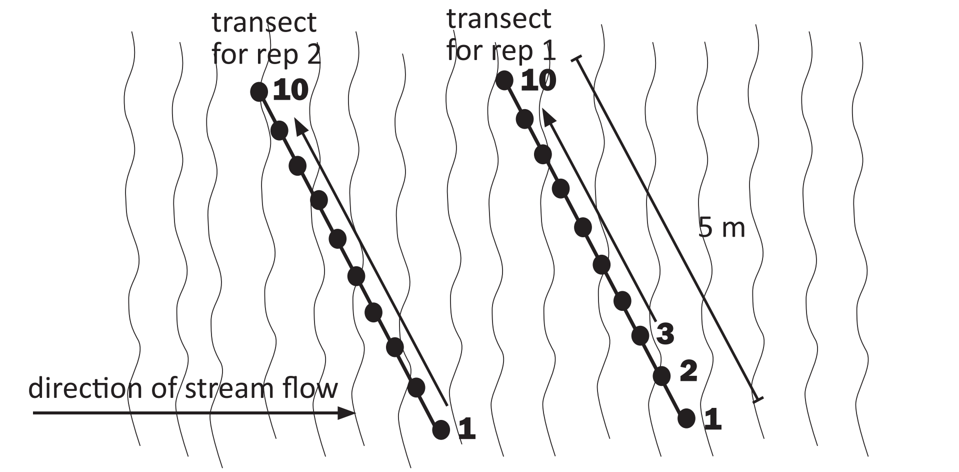


figure 1 - Diagram of riffle area being sampled showing sampling transects. *Note that the diagonal 5 meter transect angles slightly upstream and that the rep 2 transect is upstream of the rep 1 transect.*

Step 9: If there is a lot of fine sediment in your sample, try to remove as much as possible. This can be done easily while the sample is still in the net by submerging the net partially in the stream (keeping the opening completely above the surface of the water), and swirling to rinse sediments out of the net. Be careful not to lose any of your sample.

Step 10: Bring the sample to shore and transfer the contents of the net to a watertight plastic tub using 90% isopropyl alcohol for preservation*. Thoroughly pick the net of all organisms. Make sure the sample is completely submerged in alcohol (not exposed to air). Tightly cap the jar and label with the site name or number, date, replicate, and sampler names. Your sample will keep until you are ready for analysis. Analysis of preserved samples is typically done on a separate day/days after the samples have been collected. It is done in a lab or other location with access to stereo dissecting microscopes.

Step 11: Fill out the "Sampling Protocol" section of the "BMI Protocol Sheet." Complete a separate "BMI Protocol Sheet" for each replicate.

Step 12: Repeat steps 5-11 for your second replicate (upstream of the original transect yet still within the riffle). Make sure the net is thoroughly picked clean of organisms before you collect the second replicate.

** Note on preserving samples: Be sure to drain all water from sample before submerging the sample in 90% isopropyl alcohol. Use about 40 ounces of 90% alcohol for the preservation of each replicate (can be purchased at a few local drugstores...be sure it's 90% for this initial preservation).*

Analysis of Preserved Samples

Analysis may also be done using a live sample, though this requires a modification of procedures (see Hudson Basin River Watch Guidance Document) and is generally not considered to be as accurate.

Step by Step Procedure

Step 1: Mark a shallow (1” or less) white tray into 12 equal size squares with a permanent marker. Number each square from 1-12.

Step 2: Pour the first replicate sample into a 30 mm sieve, pouring off the alcohol (the sampling net could be used if you don’t have a sieve).

Step 3: Place the sample in the tray, rinsing the preservation bucket and sieve off into the tray with water.

Step 4: Add H_20 to an inch or so deep and spread out the sample evenly.

Step 5: Randomly choose a square (pick number out of a hat) and pick all the organisms in that square. As you pick, sort them using petri dishes or labeled ice cube trays with enough 70% isopropyl alcohol to keep them wet at all times.

Step 6: Pick at least 1/4 of the squares in the tray (3 out of 12), selecting each square at random.

Step 7: If you do not have at least 100 organisms after picking the first 3 squares, continue randomly picking a square at a time, until you have at least 100 organisms. This is your “sub-sample.” Note: Pick the entire square once you start—do not pick 1/2 a square!

Step 8: Once you have at least a 100 organism sub-sample (or have picked the entire sample), review the sorting that you have done and organize the categories more accurately.

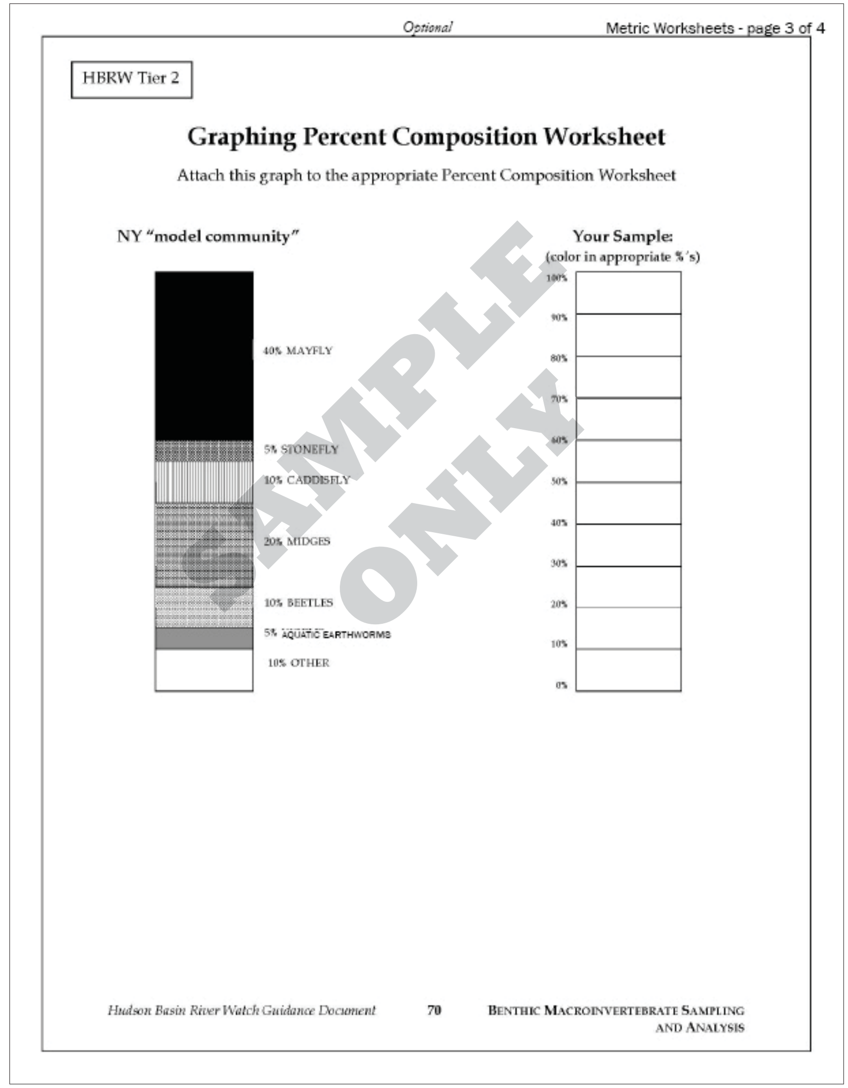
Step 9: Using the ID to Order guide on pages 7-10 of this booklet, the Sorting Worksheets at the end of this document and a stereo dissecting microscope, further sort organisms, putting “likes” together. Record numbers of each organism in tally boxes, including descriptions under “Other” category for organisms that don’t already have a designated box.

Step 10: Once you’ve recorded your tallies on the sorting worksheets, preserve identified specimens in 70% isopropyl alcohol in containers labeled with the sampling date, site name and rep 1 or rep 2. Put any organisms you were unable to identify into a separate “unknown” container (in 70% alcohol). All of these organisms will be retained at the CSI BMI lab temporarily in case further investigation is warranted.

Step 12: Fill out the “Sample Analysis Protocol” section of the “BMI Protocol Sheet.” Complete a separate “BMI Protocol Sheet” for each replicate.

Step 13: Repeat for the second replicate and have an outside evaluator analyze your samples.

Get copies of worksheets from the CSI website or at the lab:
www.communityscience.org



Get copies of worksheets from the CSI website or at the lab:
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HBRW Tiers 2 & 3 — *Optional* — Metric Worksheets - page 2 of 4

% Composition + Model Affinity Worksheet

School/Group________________ River/Stream________________
Site________________ Sampling Date________________
Name of person(s) conducting analysis________________

Percent Composition = # Individuals of Major Group / Total # of all organisms in sub-sample x 100 = ________

REP 1

Major Group	# Individuals of Major Group in rep 1		Total # of all organisms in sub-sample rep 1		Percent Composition	NYSDEC Model Community	Absolute Difference
Mayfly		÷	T1=______	x 100 =		40%	
Stonefly		÷	T1=______	x 100 =		5%	
Caddisfly		÷	T1=______	x 100 =		10%	
Midge		÷	T1=______	x 100 =		20%	
Beetle		÷	T1=______	x 100 =		10%	
Aquatic Earthworms		÷	T1=______	x 100 =		5%	
Others		÷	T1=______	x 100 =		10%	
Rep 1 Total # organisms	T1					**Rep 1 Sum =**	

REP 2

Major Group	# Individuals of Major Group in rep 2		Total # of all organisms in sub-sample rep 2		Percent Composition	NYSDEC Model Community	Absolute Difference
Mayfly		÷	T2=______	x 100 =		40%	
Stonefly		÷	T2=______	x 100 =		5%	
Caddisfly		÷	T2=______	x 100 =		10%	
Midge		÷	T2=______	x 100 =		20%	
Beetle		÷	T2=______	x 100 =		10%	
Aquatic Earthworms		÷	T2=______	x 100 =		5%	
Others		÷	T2=______	x 100 =		10%	
Rep 2 Total # organisms	T2					**Rep 2 Sum =**	

Using the "BMI Sorting Worksheets," count the number of organisms for each major group identified in your sub-sample and record in the first column (do this separately for each replicate sample). Sum the total number of organisms in your sub-sample (T1 or T2). For each major group, divide the number of individuals of that group by the total number in your sub-sample. Multiply by 100 to calculate percent composition. To Calculate the absolute difference between percentages for the NYSDEC model community and your sub-sample subtract the lower percent from the higher percent. For each replicate, multiply the sum by 0.5 and subtract this number from 100 to find the Percent Model Affinity. Take the average of your results for rep 1+2 for your final PMA value. Note that impact level is only relevant to summer sampling. For a visual comparison, graph the percent composition in the "Graphing Percent Composition Worksheet."

Rep 1 Percent Model Affinity = 100 - (sum of absolute differences [ ] x 0.5) = ________

Rep 2 Percent Model Affinity = 100 - (sum of absolute differences [ ] x 0.5) = ________

PERCENT MODEL AFFINITY = (Rep 1 PMA + Rep 2 PMA) / 2 = [ ]

Percent Model Affinity (PMA)	>64% non-impacted	50-64% slightly impacted	35-49% moderately impacted	<35% severely impacted

Taxonomy

Kingdom (Animalia)
–Phylum (Arthropoda)
–Class (Insecta, Oligochaeta, Hirudinae...etc.)
–Order (Ephemeroptera, Plecoptera, Trichoptera...etc.)
– Family (Heptageniidae, Perlidae, Hydropsychidae...etc.)
– Genus
– species

Aquatic Insect Orders

Ephemeroptera (Mayflies)
Odonata (Dragonflies & Damselflies)
Plecoptera (Stoneflies)
Hemiptera (True Bugs)
Trichoptera (Caddisflies)
Lepidoptera (Moths)
Coleoptera (Beetles)
Megaloptera (Dobsonflies, fishflies, alderflies)
Neuroptera (Spongillaflies)
Diptera (True flies)

EPT=

Ephemeroptera (Mayflies) - [Gr] the temporary winged ones
Plecoptera (Stoneflies) - [Gr] the twisted winged ones
Trichoptera (Caddisflies) - [Gr] the hairy winged ones

Some Good References for ID to Family

A Guide to Common Freshwater Invertebrates of North America, by J. Reese Voshell, Jr., with Illustrations by Amy Bartlett Wright - Least technical- has colorful illustrations and highlights important features of different families

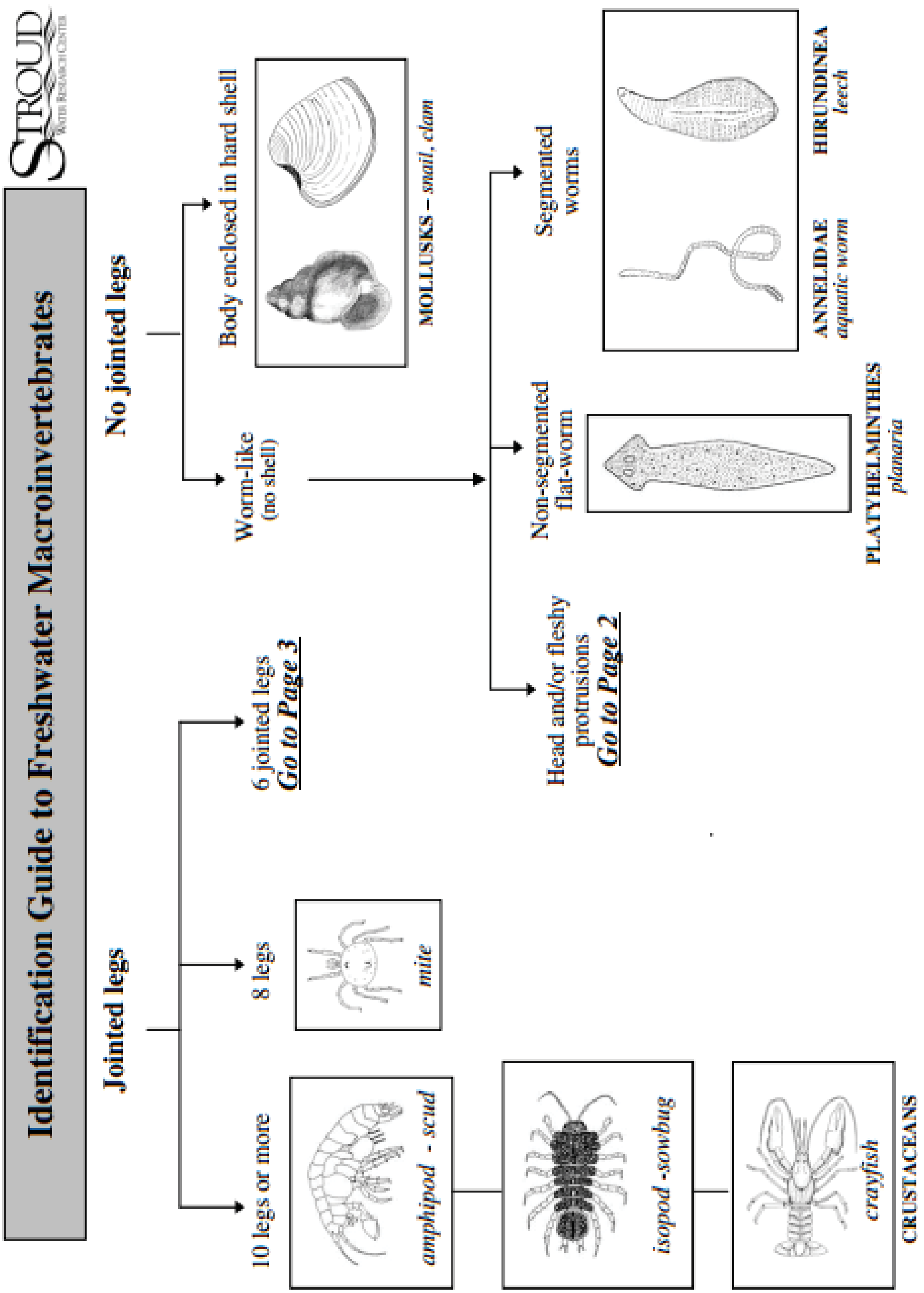
Aquatic Entomology: The Fisherman's and Ecologists' Illustrated Guide to Insects and Their Relatives, by W. Patrick McCafferty, with illustrations by Arwin V. Provonsha - More technical and thorough, but also gives interesting ecological discussion of different families of organisms

Freshwater Invertebrates of Northeastern North America, by Barbara L. Peckarsky, Pierre R. Fraissinet, Marjory A. Penton, and Don J. Conclin, Jr.- Much more technical - helpful because it is specialized to our region

An Introduction to the Aquatic Insects of North America, by R.W. Merritt, K.W. Cummins and M.B.Berg (eds)- Most technical and very thorough - especially useful for harder to identify families and taking ID beyond family-level

Identification to Order

from Stroud Water Resource Center Leaf Pack Network Manual



Get copies of worksheets from the CSI website or at the lab:
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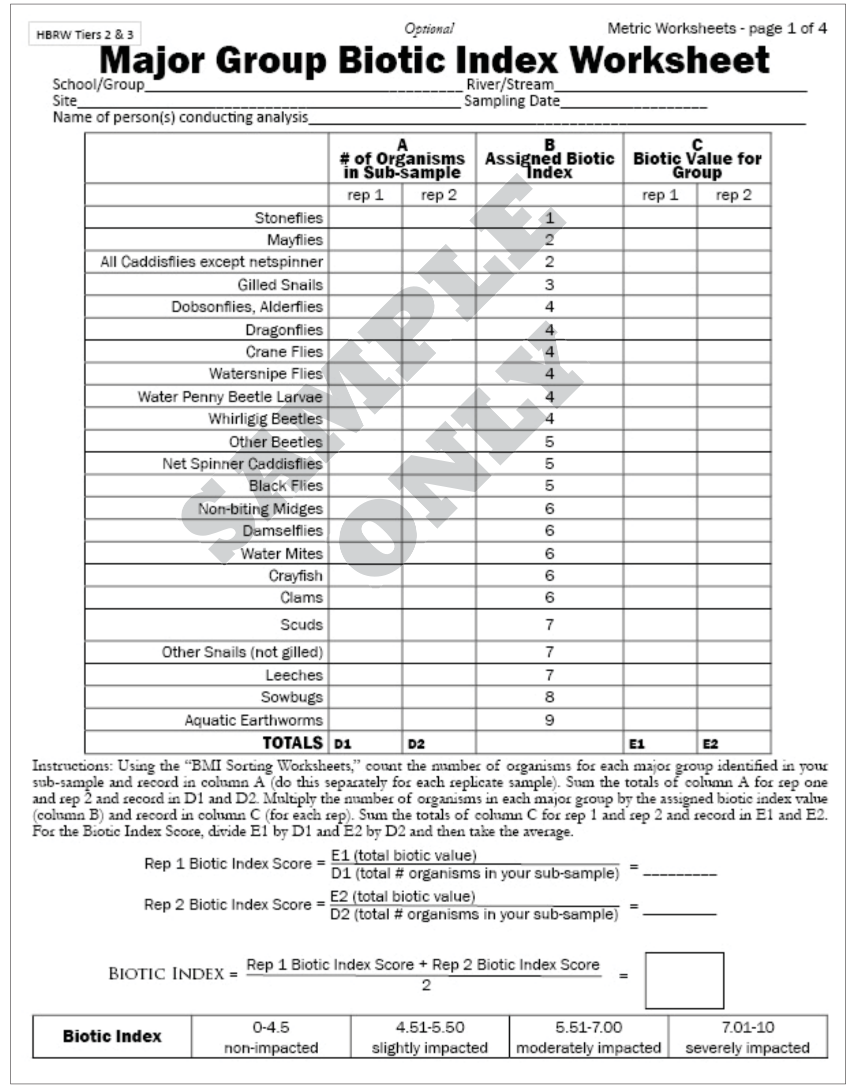


HBRW Tiers 2 & 3 *Optional* Metric Worksheets - page 1 of 4

Major Group Biotic Index Worksheet

School/Group______________ River/Stream______________
Site______________ Sampling Date______________
Name of person(s) conducting analysis______________

	A # of Organisms in Sub-sample		B Assigned Biotic Index	C Biotic Value for Group	
	rep 1	rep 2		rep 1	rep 2
Stoneflies			1		
Mayflies			2		
All Caddisflies except netspinner			2		
Gilled Snails			3		
Dobsonflies, Alderflies			4		
Dragonflies			4		
Crane Flies			4		
Watersnipe Flies			4		
Water Penny Beetle Larvae			4		
Whirligig Beetles			4		
Other Beetles			5		
Net Spinner Caddisflies			5		
Black Flies			5		
Non-biting Midges			6		
Damselflies			6		
Water Mites			6		
Crayfish			6		
Clams			6		
Scuds			7		
Other Snails (not gilled)			7		
Leeches			7		
Sowbugs			8		
Aquatic Earthworms			9		
TOTALS	D1	D2		E1	E2

Instructions: Using the "BMI Sorting Worksheets," count the number of organisms for each major group identified in your sub-sample and record in column A (do this separately for each replicate sample). Sum the totals of column A for rep one and rep 2 and record in D1 and D2. Multiply the number of organisms in each major group by the assigned biotic index value (column B) and record in column C (for each rep). Sum the totals of column C for rep 1 and rep 2 and record in E1 and E2. For the Biotic Index Score, divide E1 by D1 and E2 by D2 and then take the average.

$$\text{Rep 1 Biotic Index Score} = \frac{\text{E1 (total biotic value)}}{\text{D1 (total \# organisms in your sub-sample)}} = \_\_\_\_\_$$

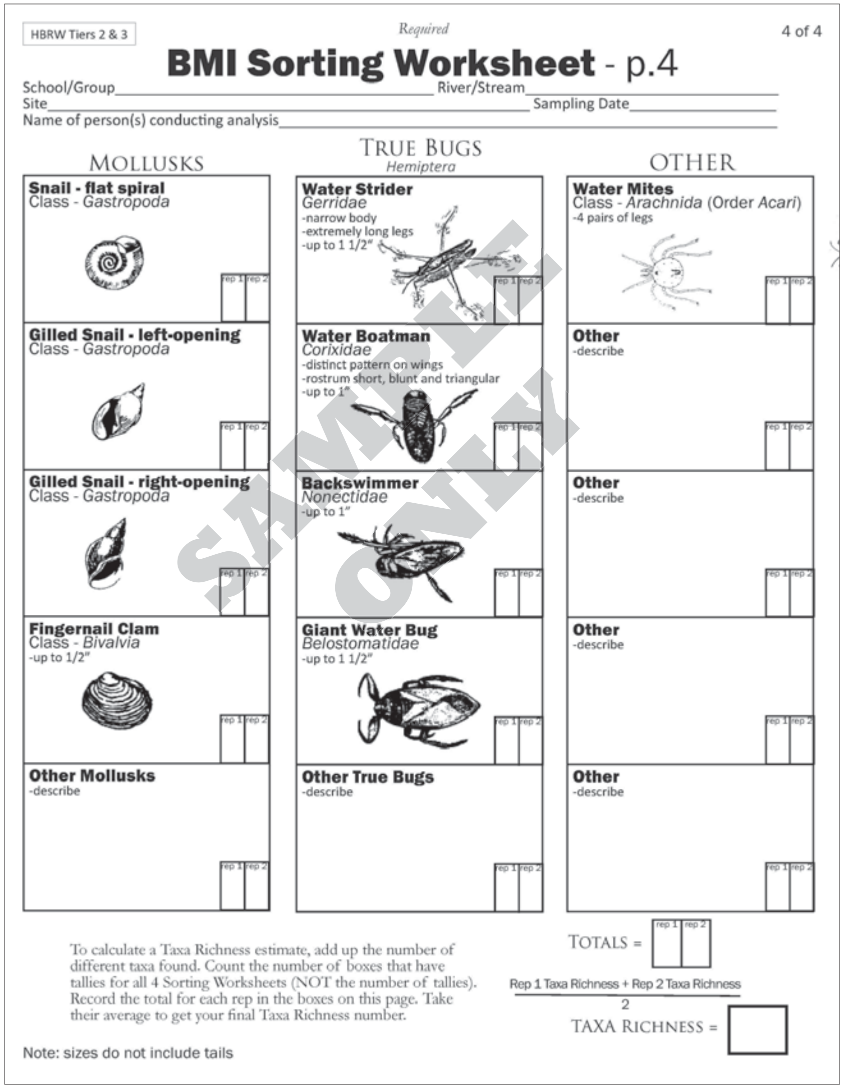
$$\text{Rep 2 Biotic Index Score} = \frac{\text{E2 (total biotic value)}}{\text{D2 (total \# organisms in your sub-sample)}} = \_\_\_\_\_$$

$$\text{BIOTIC INDEX} = \frac{\text{Rep 1 Biotic Index Score} + \text{Rep 2 Biotic Index Score}}{2} = \square$$

Biotic Index	0-4.5 non-impacted	4.51-5.50 slightly impacted	5.51-7.00 moderately impacted	7.01-10 severely impacted

The following 4 worksheets are optional when turning your results in to the lab. Our spreadsheets will do most of these calculations automatically when we enter the data from the sorting worksheets, but this is a way to figure something out on your own if you're so inclined. If your goal for your sample is family-level ID, then you'll probably want to just wait for the metrics from our spreadsheets as the results should better reflect water quality.

Get copies of worksheets from the CSI website or at the lab:
www.communityscience.org


HBRW Tiers 2 & 3 — Required — 4 of 4

BMI Sorting Worksheet - p.4

School/Group______ River/Stream______
Site______ Sampling Date______
Name of person(s) conducting analysis______

MOLLUSKS	TRUE BUGS *Hemiptera*	OTHER
Snail - flat spiral Class - *Gastropoda* (rep 1, rep 2)	**Water Strider** *Gerridae* -narrow body -extremely long legs -up to 1 1/2" (rep 1, rep 2)	**Water Mites** Class - *Arachnida* (Order *Acari*) -4 pairs of legs (rep 1, rep 2)
Gilled Snail - left-opening Class - *Gastropoda* (rep 1, rep 2)	**Water Boatman** *Corixidae* -distinct pattern on wings -rostrum short, blunt and triangular -up to 1" (rep 1, rep 2)	**Other** -describe (rep 1, rep 2)
Gilled Snail - right-opening Class - *Gastropoda* (rep 1, rep 2)	**Backswimmer** *Nonectidae* -up to 1" (rep 1, rep 2)	**Other** -describe (rep 1, rep 2)
Fingernail Clam Class - *Bivalvia* -up to 1/2" (rep 1, rep 2)	**Giant Water Bug** *Belostomatidae* -up to 1 1/2" (rep 1, rep 2)	**Other** -describe (rep 1, rep 2)
Other Mollusks -describe (rep 1, rep 2)	**Other True Bugs** -describe (rep 1, rep 2)	**Other** -describe (rep 1, rep 2)

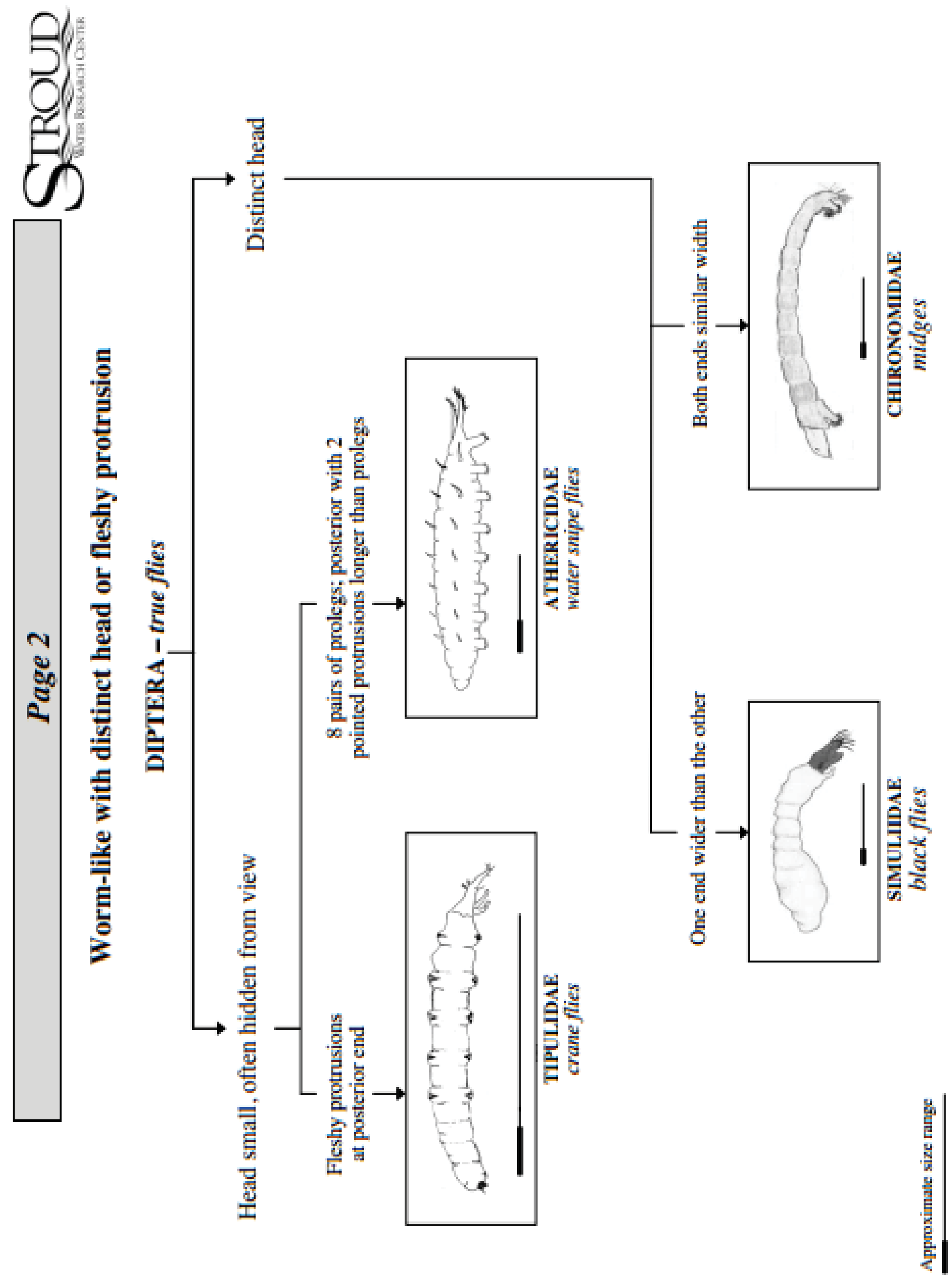
To calculate a Taxa Richness estimate, add up the number of different taxa found. Count the number of boxes that have tallies for all 4 Sorting Worksheets (NOT the number of tallies). Record the total for each rep in the boxes on this page. Take their average to get your final Taxa Richness number.

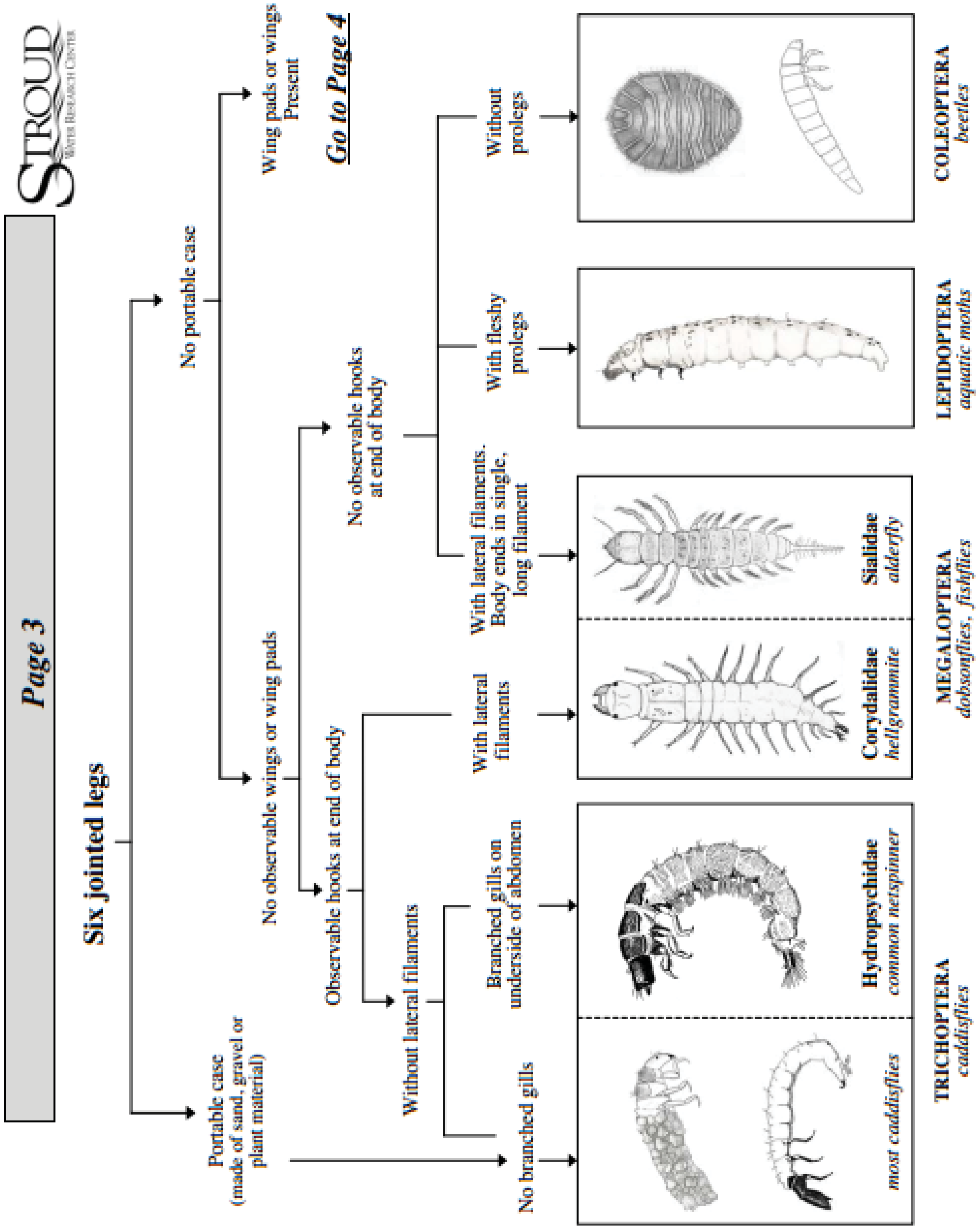
TOTALS = rep 1 | rep 2

(Rep 1 Taxa Richness + Rep 2 Taxa Richness) / 2

TAXA RICHNESS =

Note: sizes do not include tails





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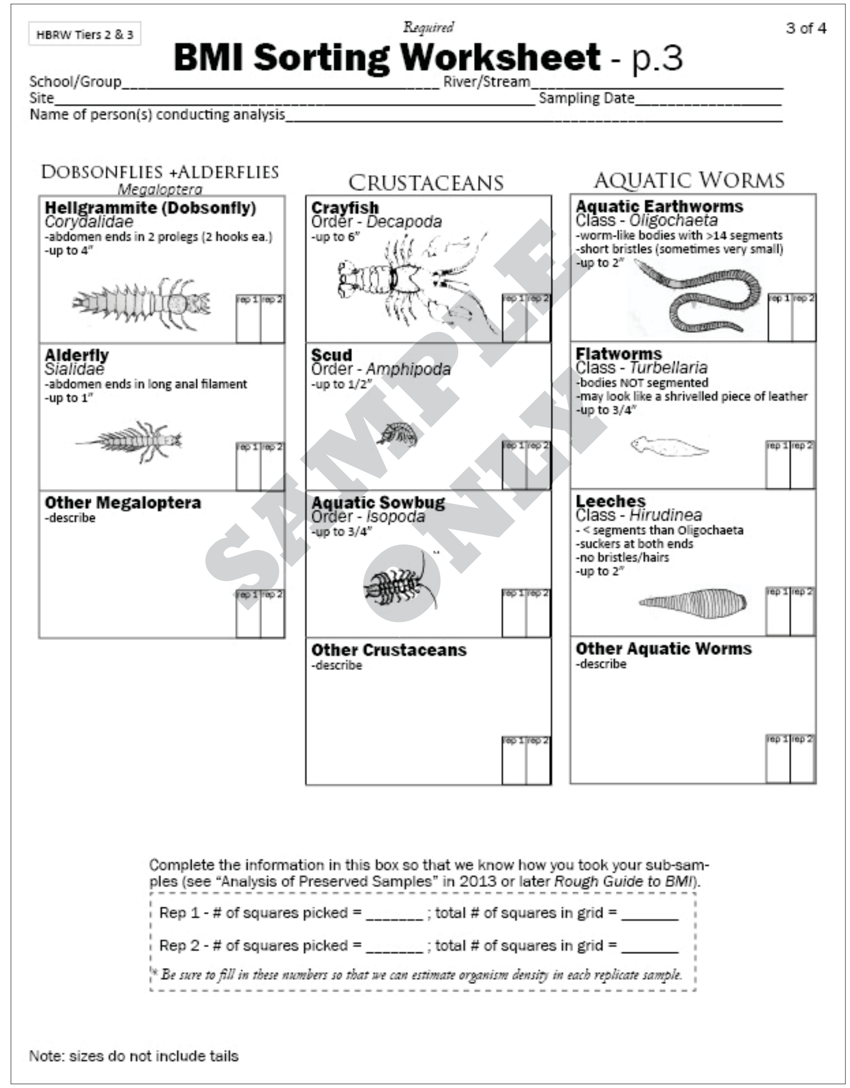


HBRW Tiers 2 & 3 — Required — 3 of 4

BMI Sorting Worksheet - p.3

School/Group________ River/Stream________
Site________ Sampling Date________
Name of person(s) conducting analysis________

DOBSONFLIES +ALDERFLIES *Megaloptera*	CRUSTACEANS	AQUATIC WORMS
Hellgrammite (Dobsonfly) Corydalidae -abdomen ends in 2 prolegs (2 hooks ea.) -up to 4" (rep 1, rep 2)	**Crayfish** Order - *Decapoda* -up to 6" (rep 1, rep 2)	**Aquatic Earthworms** Class - *Oligochaeta* -worm-like bodies with >14 segments -short bristles (sometimes very small) -up to 2" (rep 1, rep 2)
Alderfly Sialidae -abdomen ends in long anal filament -up to 1" (rep 1, rep 2)	**Scud** Order - *Amphipoda* -up to 1/2" (rep 1, rep 2)	**Flatworms** Class - *Turbellaria* -bodies NOT segmented -may look like a shrivelled piece of leather -up to 3/4" (rep 1, rep 2)
Other Megaloptera -describe (rep 1, rep 2)	**Aquatic Sowbug** Order - *Isopoda* -up to 3/4" (rep 1, rep 2)	**Leeches** Class - *Hirudinea* - < segments than Oligochaeta -suckers at both ends -no bristles/hairs -up to 2" (rep 1, rep 2)
	Other Crustaceans -describe (rep 1, rep 2)	**Other Aquatic Worms** -describe (rep 1, rep 2)

SAMPLE ONLY

Complete the information in this box so that we know how you took your sub-samples (see "Analysis of Preserved Samples" in 2013 or later *Rough Guide to BMI*).

Rep 1 - # of squares picked = ______ ; total # of squares in grid = ______

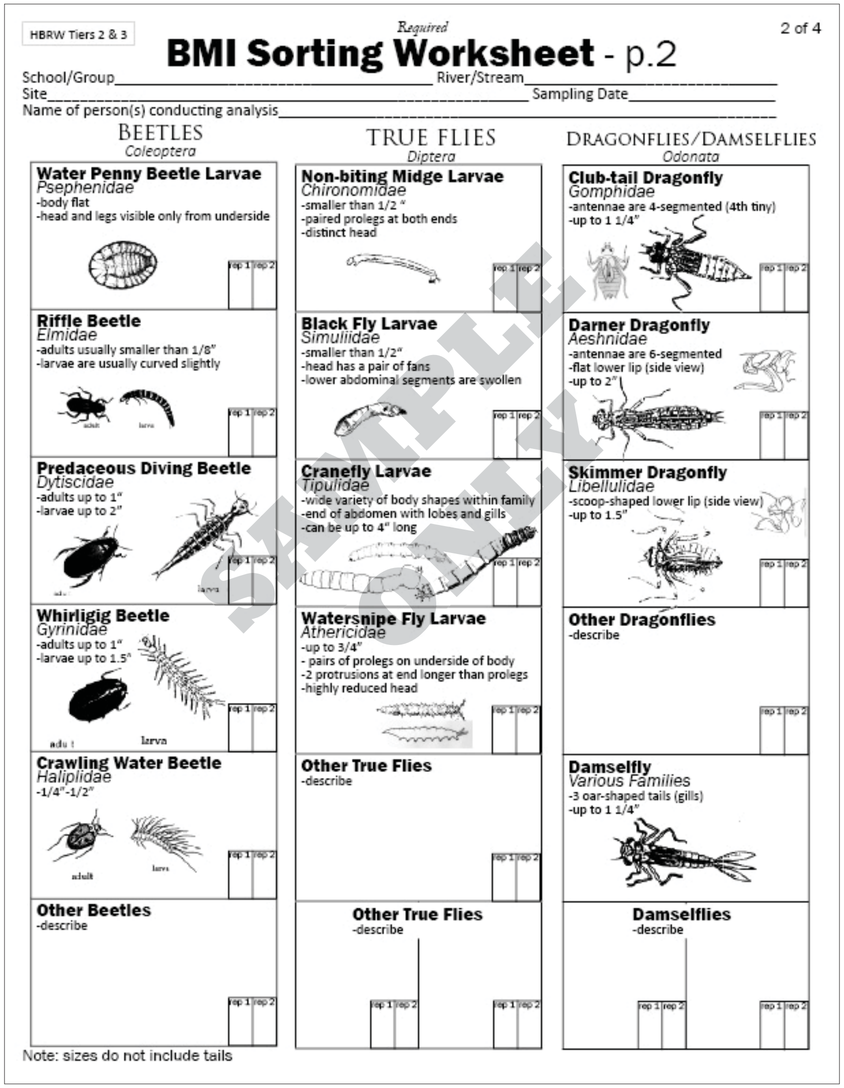
Rep 2 - # of squares picked = ______ ; total # of squares in grid = ______

** Be sure to fill in these numbers so that we can estimate organism density in each replicate sample.*

Note: sizes do not include tails

* Be sure to record the number of squares picked (and how many total squares were used) on this page in addition to your tallies for Megaloptera, Crustaceans and Aquatic Worms.

Get copies of worksheets from the CSI website or at the lab:
www.communityscience.org


HBRW Tiers 2 & 3

Required

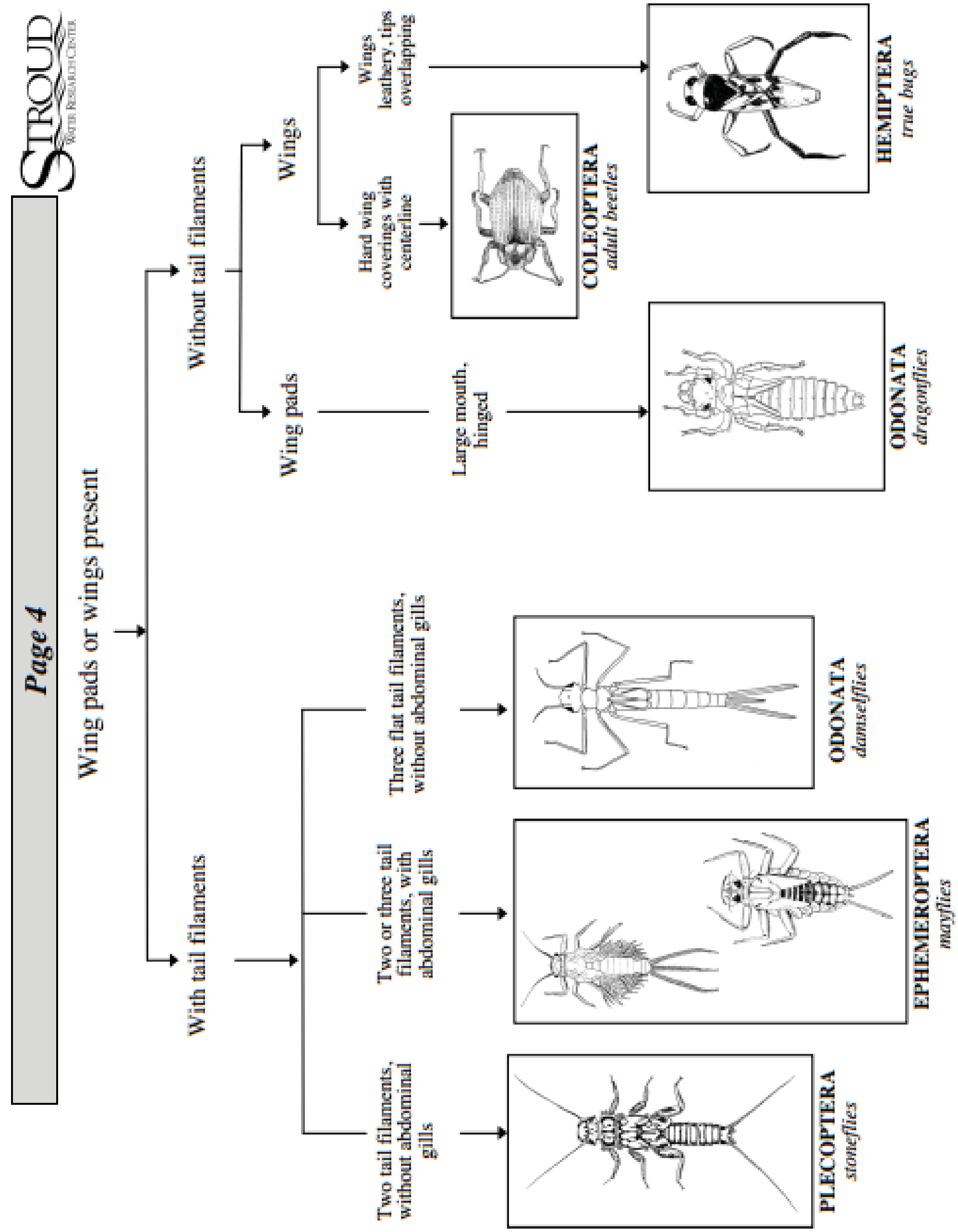
BMI Sorting Worksheet - p.2

2 of 4

School/Group________ River/Stream________
Site________ Sampling Date________
Name of person(s) conducting analysis________

BEETLES *Coleoptera*	TRUE FLIES *Diptera*	DRAGONFLIES/DAMSELFLIES *Odonata*
Water Penny Beetle Larvae *Psephenidae* -body flat -head and legs visible only from underside (rep 1, rep 2)	**Non-biting Midge Larvae** *Chironomidae* -smaller than 1/2" -paired prolegs at both ends -distinct head (rep 1, rep 2)	**Club-tail Dragonfly** *Gomphidae* -antennae are 4-segmented (4th tiny) -up to 1 1/4" (rep 1, rep 2)
Riffle Beetle *Elmidae* -adults usually smaller than 1/8" -larvae are usually curved slightly (adult, larva) (rep 1, rep 2)	**Black Fly Larvae** *Simuliidae* -smaller than 1/2" -head has a pair of fans -lower abdominal segments are swollen (rep 1, rep 2)	**Darner Dragonfly** *Aeshnidae* -antennae are 6-segmented -flat lower lip (side view) -up to 2" (rep 1, rep 2)
Predaceous Diving Beetle *Dytiscidae* -adults up to 1" -larvae up to 2" (adult, larva) (rep 1, rep 2)	**Cranefly Larvae** *Tipulidae* -wide variety of body shapes within family -end of abdomen with lobes and gills -can be up to 4" long (rep 1, rep 2)	**Skimmer Dragonfly** *Libellulidae* -scoop-shaped lower lip (side view) -up to 1.5" (rep 1, rep 2)
Whirligig Beetle *Gyrinidae* -adults up to 1" -larvae up to 1.5" (adult, larva) (rep 1, rep 2)	**Watersnipe Fly Larvae** *Athericidae* -up to 3/4" - pairs of prolegs on underside of body -2 protrusions at end longer than prolegs -highly reduced head (rep 1, rep 2)	**Other Dragonflies** -describe (rep 1, rep 2)
Crawling Water Beetle *Haliplidae* -1/4"-1/2" (adult, larva) (rep 1, rep 2)	**Other True Flies** -describe (rep 1, rep 2)	**Damselfly** *Various Families* -3 oar-shaped tails (gills) -up to 1 1/4"
Other Beetles -describe (rep 1, rep 2)	**Other True Flies** -describe (rep 1, rep 2) (rep 1, rep 2)	**Damselflies** -describe (rep 1, rep 2) (rep 1, rep 2)

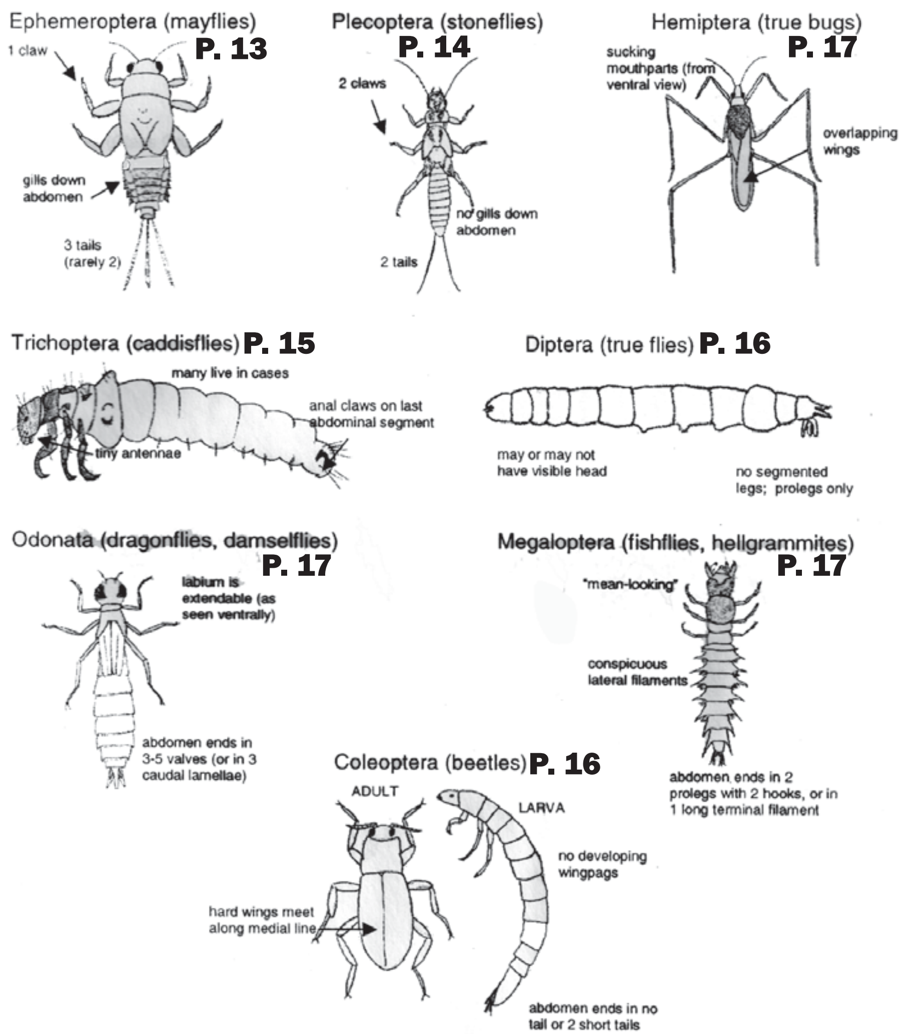
Note: sizes do not include tails



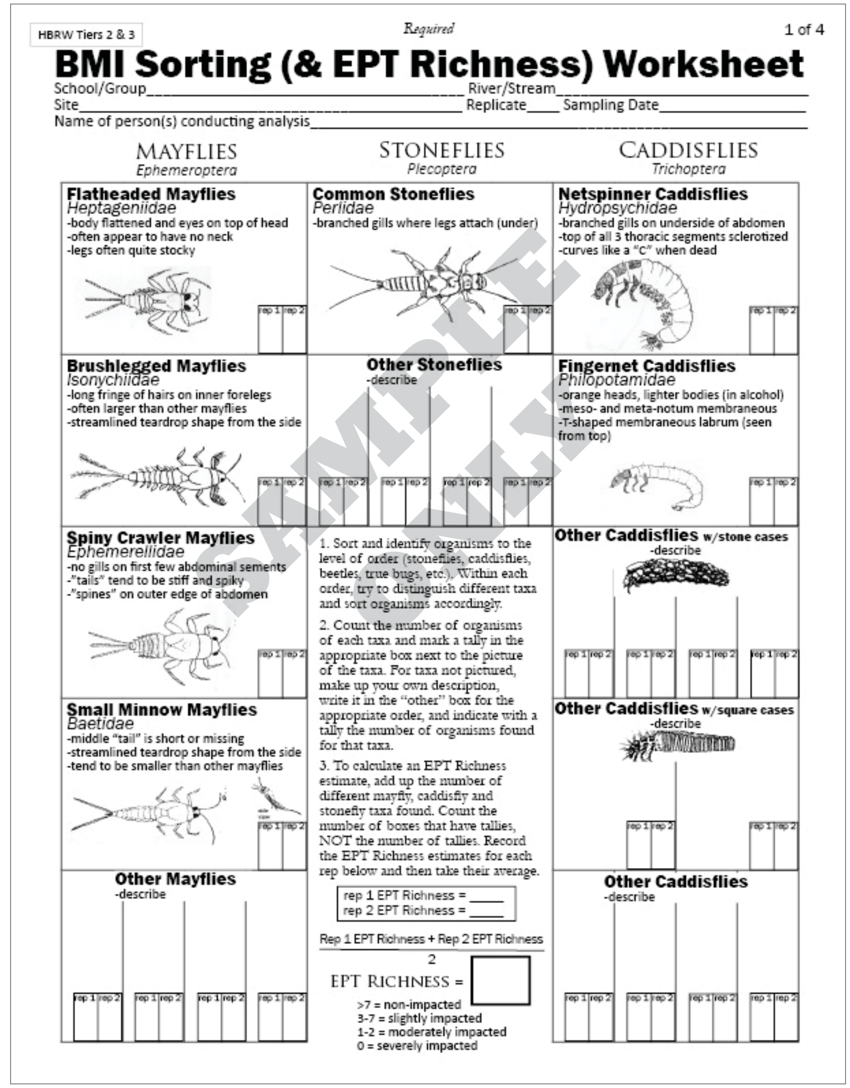
Identification to Family (rough guide)

modified from Anne Gallagher Stream BioAssessment Kit

For anyone wanting to try family-level identification (for tier 3 HBRW protocols) or simply get a sense of some of the diversity found within the different Orders of aquatic invertebrates, on the following pages you will find brief descriptions of the most common families of BMI. Non-insects are only identified to Class. Here we tried to keep the language as simple as possible, but you can refer to the Anatomy section on page 19 if you need some help with terminology. **Note that this collection does not cover all local benthic macroinvertebrate families and you may have to go to other sources for identification (and likely will want to refer to multiple sources anyway).**



Get copies of worksheets from the CSI website or at the lab:
www.communityscience.org



HBRW Tiers 2 & 3 — *Required* — 1 of 4

BMI Sorting (& EPT Richness) Worksheet

School/Group________________ River/Stream________________
Site________________ Replicate____ Sampling Date________________
Name of person(s) conducting analysis________________

MAYFLIES *Ephemeroptera* | STONEFLIES *Plecoptera* | CADDISFLIES *Trichoptera*

Flatheaded Mayflies *Heptageniidae*
-body flattened and eyes on top of head
-often appear to have no neck
-legs often quite stocky

Common Stoneflies *Perlidae*
-branched gills where legs attach (under)

Netspinner Caddisflies *Hydropsychidae*
-branched gills on underside of abdomen
-top of all 3 thoracic segments sclerotized
-curves like a "C" when dead

Brushlegged Mayflies *Isonychiidae*
-long fringe of hairs on inner forelegs
-often larger than other mayflies
-streamlined teardrop shape from the side

Other Stoneflies
-describe

Fingernet Caddisflies *Philopotamidae*
-orange heads, lighter bodies (in alcohol)
-meso- and meta-notum membraneous
-T-shaped membraneous labrum (seen from top)

Spiny Crawler Mayflies *Ephemerellidae*
-no gills on first few abdominal sements
-"tails" tend to be stiff and spiky
-"spines" on outer edge of abdomen

1. Sort and identify organisms to the level of order (stoneflies, caddisflies, beetles, true bugs, etc.). Within each order, try to distinguish different taxa and sort organisms accordingly.

2. Count the number of organisms of each taxa and mark a tally in the appropriate box next to the picture of the taxa. For taxa not pictured, make up your own description, write it in the "other" box for the appropriate order, and indicate with a tally the number of organisms found for that taxa.

3. To calculate an EPT Richness estimate, add up the number of different mayfly, caddisfly and stonefly taxa found. Count the number of boxes that have tallies, NOT the number of tallies. Record the EPT Richness estimates for each rep below and then take their average.

rep 1 EPT Richness = _____
rep 2 EPT Richness = _____

$$\frac{\text{Rep 1 EPT Richness} + \text{Rep 2 EPT Richness}}{2}$$

EPT RICHNESS = ☐

>7 = non-impacted
3-7 = slightly impacted
1-2 = moderately impacted
0 = severely impacted

Other Caddisflies w/stone cases
-describe

Small Minnow Mayflies *Baetidae*
-middle "tail" is short or missing
-streamlined teardrop shape from the side
-tend to be smaller than other mayflies

Other Caddisflies w/square cases
-describe

Other Mayflies
-describe

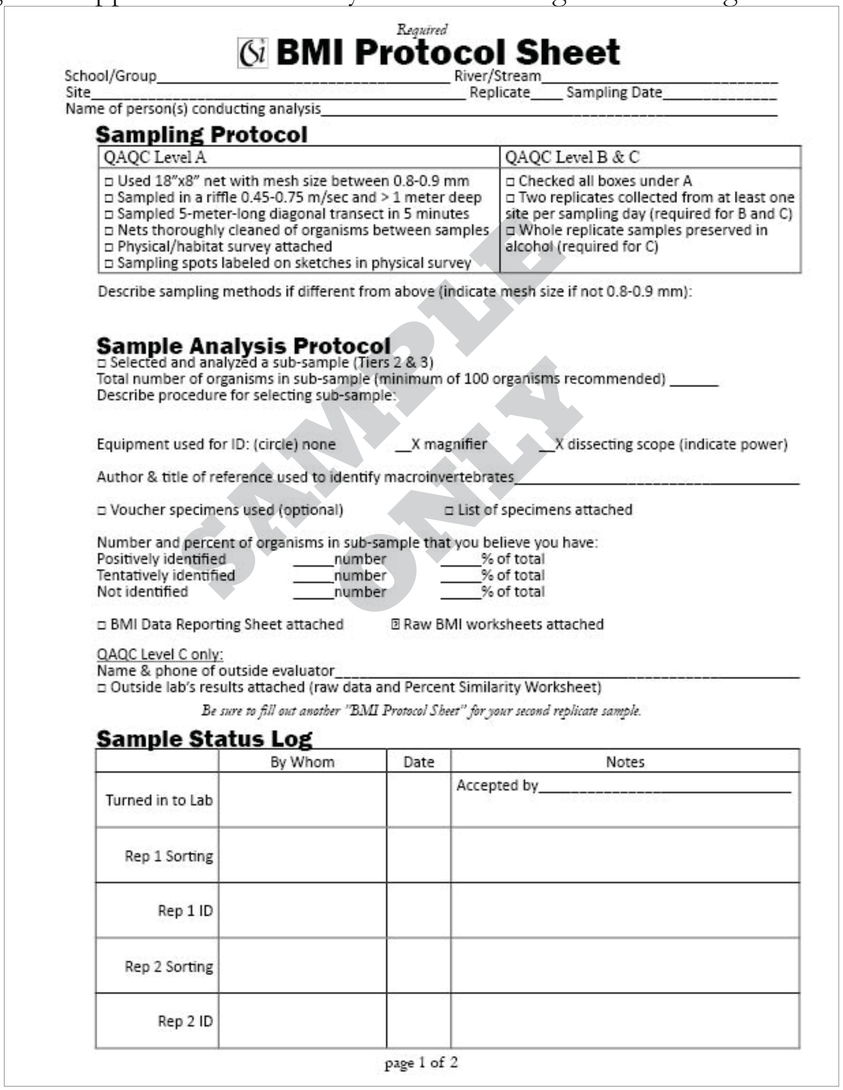
Other Caddisflies
-describe

Fill out the 4 BMI Sorting Worksheets for each sample analyzed. Record numbers of like organisms matching descriptions (provided or created by you) in tally boxes on the following 4 sheets. Save organisms in 70% alcohol for verification and temporary storage at the CSI lab. Turn these sheets in with preserved specimens. Turn in any unidentified organisms at the same time in a separate container.

Sampling Protocol Sheet

To complete during sampling event and ID sessions

Quality Assurance/Quality Control (QAQC) refers to activities that allow data users to associate a level of confidence to the information provided. The HBRW QAQC Guidelines are organized into three levels, A, B, and C. As the level of QAQC increases (C being the highest), so does the level of confidence in the information. Information with higher levels of confidence will generally have greater applications for use by local and state government agencies.



Required

BMI Protocol Sheet

School/Group________________________ River/Stream____________________
Site________________________ Replicate____ Sampling Date__________
Name of person(s) conducting analysis______________________________

Sampling Protocol

QAQC Level A	QAQC Level B & C
□ Used 18"x8" net with mesh size between 0.8-0.9 mm □ Sampled in a riffle 0.45-0.75 m/sec and > 1 meter deep □ Sampled 5-meter-long diagonal transect in 5 minutes □ Nets thoroughly cleaned of organisms between samples □ Physical/habitat survey attached □ Sampling spots labeled on sketches in physical survey	□ Checked all boxes under A □ Two replicates collected from at least one site per sampling day (required for B and C) □ Whole replicate samples preserved in alcohol (required for C)

Describe sampling methods if different from above (indicate mesh size if not 0.8-0.9 mm):

Sample Analysis Protocol

□ Selected and analyzed a sub-sample (Tiers 2 & 3)
Total number of organisms in sub-sample (minimum of 100 organisms recommended) ______
Describe procedure for selecting sub-sample:

Equipment used for ID: (circle) none ___X magnifier ___X dissecting scope (indicate power)

Author & title of reference used to identify macroinvertebrates____________________

□ Voucher specimens used (optional) □ List of specimens attached

Number and percent of organisms in sub-sample that you believe you have:
Positively identified _____number _____% of total
Tentatively identified _____number _____% of total
Not identified _____number _____% of total

□ BMI Data Reporting Sheet attached □ Raw BMI worksheets attached

QAQC Level C only:
Name & phone of outside evaluator______________________________
□ Outside lab's results attached (raw data and Percent Similarity Worksheet)

Be sure to fill out another "BMI Protocol Sheet" for your second replicate sample.

Sample Status Log

	By Whom	Date	Notes
Turned in to Lab			Accepted by______________
Rep 1 Sorting			
Rep 1 ID			
Rep 2 Sorting			
Rep 2 ID			

page 1 of 2

SAMPLE ONLY

*Fill out one of these sheets for each replicate sample.

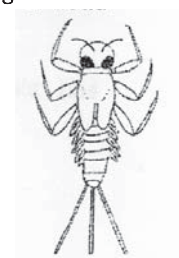
The first part of this sheet is to be completed at the time of sampling and the second part at the time of sample analysis. A separate sheet should be filled out for each replicate sample (total of 2). The "Sample Status Log" at the bottom of the page will be used to track the status of each sample. This page will be kept in a binder at the lab and updated as the sample is processed.

ID to Family (rough guide)

some of our more common
MAYFLIES
the *Ephemeroptera*

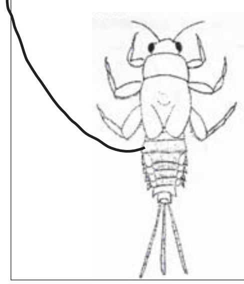
Flatheaded Mayfly
Heptageniidae

- body flattened
- often no apparent "neck"
- easy to get them lay flat to get view from top



Spiny Crawler Mayfly
Ephemerellidae

- no gills on abdominal segment 2 (sometimes also 1 and/or 3) so may look like it has a waist



Prongilled Mayfly
Leptophlebiidae

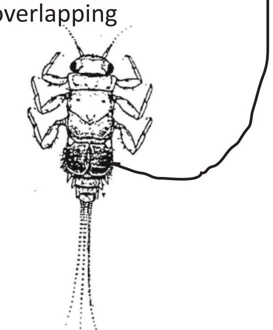
- abdominal gills 2-7 are forked, fringed or with double lamellae ending in points (often many have fallen off but any remaining gills are usually dark and unmistakeably threadlike

Small Minnow Mayfly
Baetidae

- streamlined body shape in profile (can be difficult to get them to lay flat to get view of top
- middle "tail" may be short or absent
- antennae are long

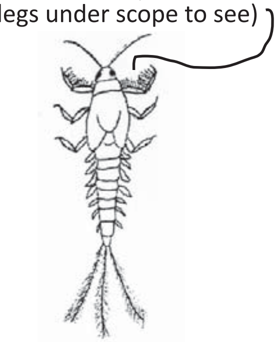
Small Squaregill Mayfly
Caenidae

- gills on abdominal segment 2 are squarish and overlapping



Brushlegged Mayfly
Isonychiidae

- streamlined body shape in profile (can be difficult to get them to lay flat to get view of top
- typically larger than Small Minnow Mayflies
- long fringe of hairs on inner fore legs (often have to manipulate fore-legs under scope to see)

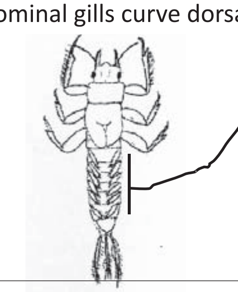


Little Stout Crawler Mayfly
Tricorythidae or Leptohyphidae

- gills on abdominal segment 2 are large and triangular and do not overlap

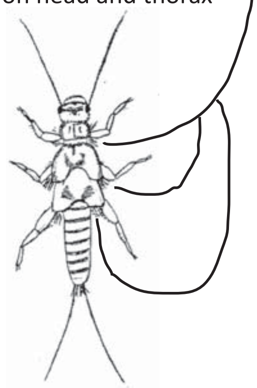
Common Burrower Mayfly
Ephemeridae

- often pale and ghostlike - different than most other mayflies
- has tusks that curve upward
- abdominal gills curve dorsally

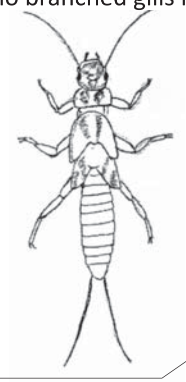


some of our more common
STONEFLIES
the *Plecoptera*

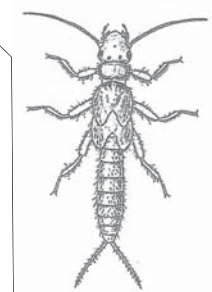
Common Stonefly
Perlidae
- *branched* gills in "armpits" unmistakeable for this family (look on underside)
- often brown and tan pattern on head and thorax



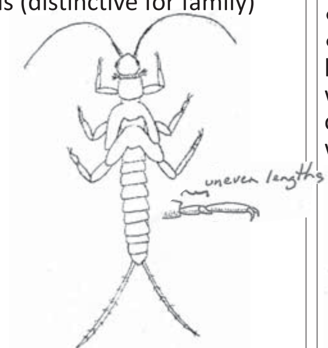
Perlodid Stonefly
Perlodidae
- predator mouthparts
- "tails" at least as long as abdomen
- no branched gills in "armpits"



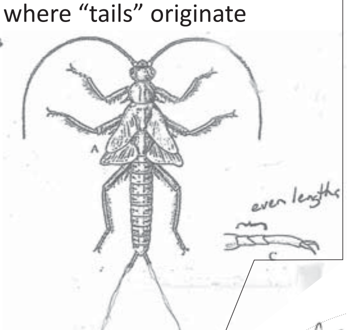
Green Stonefly
Chloroperlidae
- predator mouthparts (look on underside of head)
- "tails" shorter than length of abdomen (3/4 length or so)



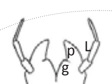
Nemourid Stonefly
Nemouridae
- non-predator mouth parts (look on underside of head)
- divergent wing pads
- may have branched cervical gills (distinctive for family)



Winter Stonefly
Taeniopterygidae
- non-predator mouthparts (look on underside of head)
- divergent wing pads
- either with *single*, finger-like gills in "armpits" OR with large triangular plate on underside of abdomen where "tails" originate

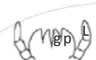


Rolled-winged Stonefly
Leuctridae
- long abdomen - extended legs don't reach the end of it
- non-predator mouth parts (look on underside of head)



p=paraglossa
g=glossa
L=labial palp

predator mouthparts
glossae sit well behind paraglossae
(look on underside of head)

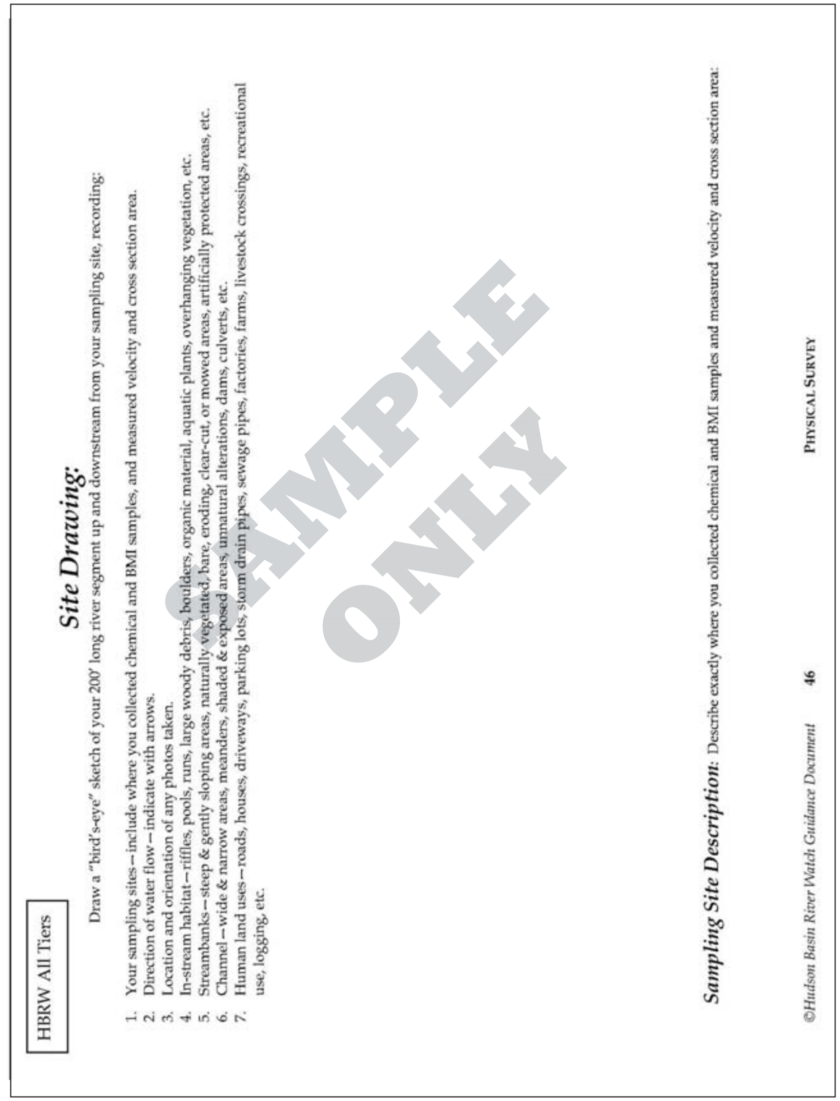


p=paraglossa
g=glossa
L=labial palp

non-predator mouthparts
glossae and paraglossae are same height
(look on underside of head)

Reporting Sheets for Sampling
To complete during sampling event

Get copies of worksheets from the CSI website or at the lab:
www.communityscience.org


HBRW All Tiers

Site Drawing:

Draw a "bird's-eye" sketch of your 200' long river segment up and downstream from your sampling site, recording:

1. Your sampling sites—include where you collected chemical and BMI samples, and measured velocity and cross section area.
2. Direction of water flow—indicate with arrows.
3. Location and orientation of any photos taken.
4. In-stream habitat—riffles, pools, runs, large woody debris, boulders, organic material, aquatic plants, overhanging vegetation, etc.
5. Streambanks—steep & gently sloping areas, naturally vegetated, bare, eroding, clear-cut, or mowed areas, artificially protected areas, etc.
6. Channel—wide & narrow areas, meanders, shaded & exposed areas, unnatural alterations, dams, culverts, etc.
7. Human land uses—roads, houses, driveways, parking lots, storm drain pipes, sewage pipes, factories, farms, livestock crossings, recreational use, logging, etc.

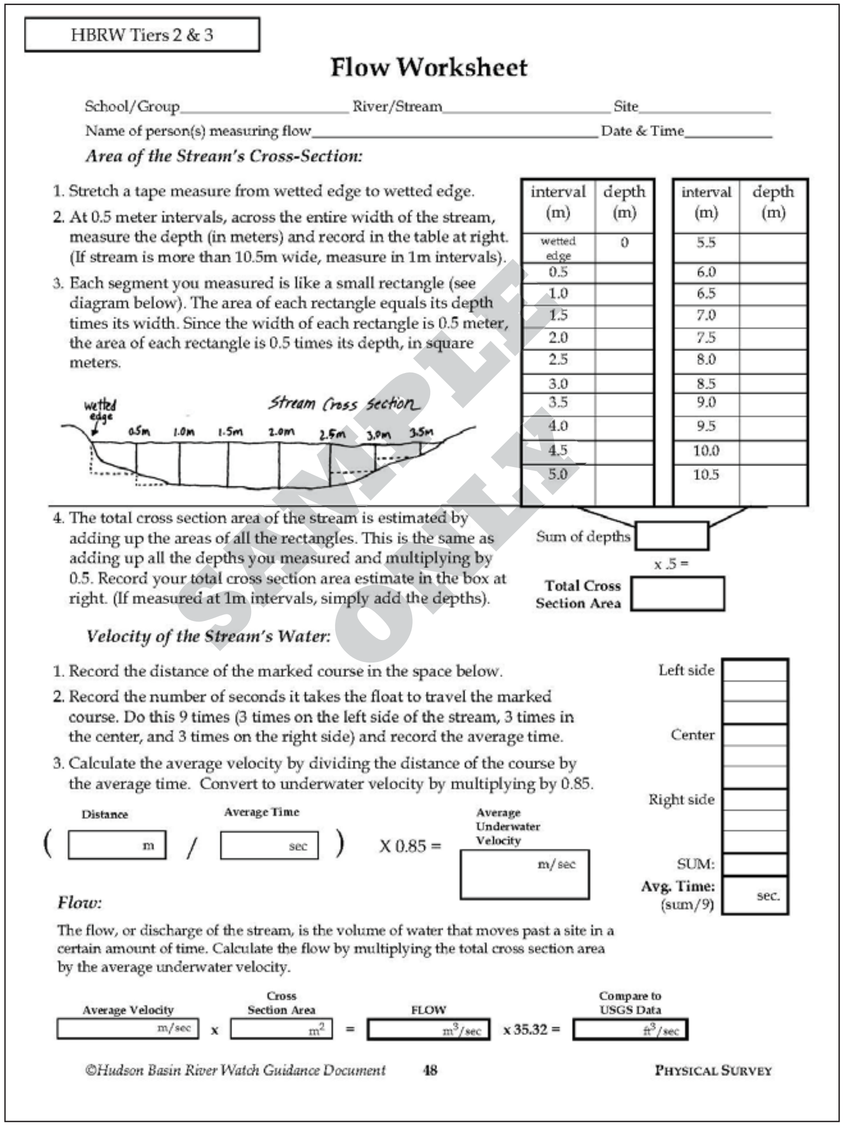
Sampling Site Description: Describe exactly where you collected chemical and BMI samples and measured velocity and cross section area:

©*Hudson Basin River Watch Guidance Document* 46 PHYSICAL SURVEY

SAMPLE ONLY

It is important to complete a site drawing (part of the physical survey) to record features visually and document the location of your specific collection site(s). If you prefer to document features visually with photographs, a site map is still important for documenting the specific location of your collection site(s).

Get copies of worksheets from the CSI website or at the lab:
www.communityscience.org



HBRW Tiers 2 & 3

Flow Worksheet

School/Group______ River/Stream______ Site______
Name of person(s) measuring flow______ Date & Time______

Area of the Stream's Cross-Section:

1. Stretch a tape measure from wetted edge to wetted edge.
2. At 0.5 meter intervals, across the entire width of the stream, measure the depth (in meters) and record in the table at right. (If stream is more than 10.5m wide, measure in 1m intervals).
3. Each segment you measured is like a small rectangle (see diagram below). The area of each rectangle equals its depth times its width. Since the width of each rectangle is 0.5 meter, the area of each rectangle is 0.5 times its depth, in square meters.

interval (m)	depth (m)	interval (m)	depth (m)
wetted edge	0	5.5	
0.5		6.0	
1.0		6.5	
1.5		7.0	
2.0		7.5	
2.5		8.0	
3.0		8.5	
3.5		9.0	
4.0		9.5	
4.5		10.0	
5.0		10.5	

4. The total cross section area of the stream is estimated by adding up the areas of all the rectangles. This is the same as adding up all the depths you measured and multiplying by 0.5. Record your total cross section area estimate in the box at right. (If measured at 1m intervals, simply add the depths).

Sum of depths ____ x .5 =
Total Cross Section Area ____

Velocity of the Stream's Water:

1. Record the distance of the marked course in the space below.
2. Record the number of seconds it takes the float to travel the marked course. Do this 9 times (3 times on the left side of the stream, 3 times in the center, and 3 times on the right side) and record the average time.
3. Calculate the average velocity by dividing the distance of the course by the average time. Convert to underwater velocity by multiplying by 0.85.

Left side ____
Center ____
Right side ____
SUM: ____
Avg. Time: (sum/9) ____ sec.

(Distance ____ m / Average Time ____ sec) X 0.85 = Average Underwater Velocity ____ m/sec

Flow:

The flow, or discharge of the stream, is the volume of water that moves past a site in a certain amount of time. Calculate the flow by multiplying the total cross section area by the average underwater velocity.

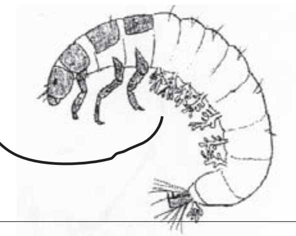
Average Velocity ____ m/sec x Cross Section Area ____ m^2 = FLOW ____ m^3/sec x 35.32 = Compare to USGS Data ____ ft^3/sec

©Hudson Basin River Watch Guidance Document 48 PHYSICAL SURVEY

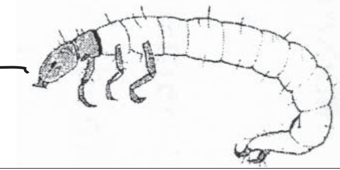
* Note: If you don't have a way to measure in metric, record in English units and convert later.

some of our more common (and "easier"-to-identify)
CADDISFLIES
the *Trichoptera*

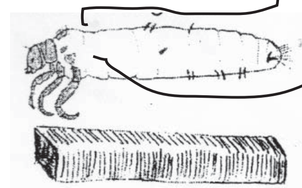
Common Netspinner
Hydropsychidae
- branched gills on underside of abdomen
- "plates" (usually darker) on top of all thoracic segments
- curves like C when dead



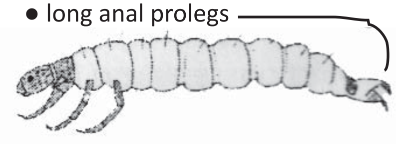
Fingernet
Philopotamidae
- longish orange head and pale body (no pigmentation on head)
- only first thoracic segment sclerotized
- T-shaped membranous labrum (seen on front of head from above)



Humpless Case Make
Brachycentridae
- often make a 4-sided case of vegetation
- no dorsal or lateral "humps" on first abdominal segment

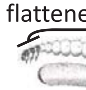


Freeliving Caddisfly
Rhyacophilidae
- only first thoracic segment sclerotized
- tend to look like "Michelin man" with constrictions between abdominal segments
- long anal prolegs



Snailcase Maker
Helicopsychidae
- coiled case of small rocks like a snail shell

Micro Caddisfly
Hydroptilidae
- very tiny
- dark "plates" on top of all thoracic segments
- usually with bulging abdomen
- may have flattened purse-like case



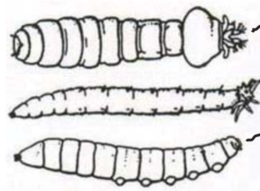
Note on the Caddisflies

The common families shown here have features that are *relatively* easy to distinguish. Many of the other caddisflies can be rather tricky. Don't despair! Most caddisflies that you will find will probably be Common Netspinners or Fingernets. Try your best with any others, trying to keep ones that look alike together and feel free to ask for help from Adrianna or Michi.

some of our more common
TRUE FLIES
the *Diptera*

Non-biting Midge
Chironomidae
- paired prolegs at each end
- distinctive head
- great diversity of species - mostly they're quite small

Crane Fly
Tipulidae
- end of abdomen with lobes and gills
- can vary significantly in size with some quite large
- very diverse body forms
- most that we see don't have prolegs



these 3 illustrations from Merrit and Cummins - to show some of the diversity of body forms for crane flies

Black Fly
Simuliidae
- lower abdominal segments are swollen (so looks somewhat like a bowling pin)
- head has a pair of "fans"

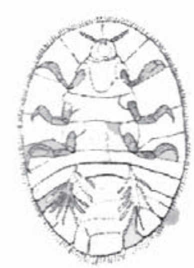
Aquatic Snipe Fly
Athericidae
- paired prolegs
- pair of terminal processes on end are longer than last pair of prolegs

Dance Fly
Empididae
- paired prolegs
- 1-4 terminal processes on end which are shorter than last pair of prolegs

some of our more common
BEETLES
the *Coleoptera*

Riffle Beetle
Elmidae larvae: dorsal side of all abdominal segments sclerotized; adult: long, slender antennae

Water Penny Beetle larva
Psephenidae body oval and flat; head and legs visible only ventrally



Get copies of worksheets from the CSI website or at the lab:
www.communityscience.org

HBRW Tier 3

Stream Bottom Survey

Evaluate your specific BMI collection site (riffle area)

School/Group____________________ River/Stream____________________
Survey Site____________________ Survey Date & Time____________________
Name of person(s) completing survey____________________

1. Set up 2-4 transects across the stream, in riffle habitats.
2. Starting at the water' s edge, take one step at a time toward the opposite bank. With each step, reach over the toe of your wader with your forefinger without looking down and feel the substrate material closest to your large toe (could be mud or sand; does not have to be a rock). Pick it up (if possible), measure its size, and mark a tally in the appropriate column in the "Substrate Size Table" below.
3. If the substrate is a cobble, be careful as you pick it up out of the stream bottom so you can estimate how much it is covered up by silt or sand. Feel with your fingers for the edge of the cobble where it emerges from the silt or sand, and keep your fingers on that edge as you pick it up. Often there will be a "bathtub ring" line on the cobble where the level of the silt or sand was. There is also often algae growing on the top surface of the cobble down to that line. Estimate the percentage that the cobble is embedded and check the appropriate box in the "Cobble Embeddedness Table" below.
4. Continue until you have sampled approximately 50 substrate sizes and 20 cobbles.
5. In the "Substrate Size Table," total the tallies for each substrate type and record these numbers in the second row. Calculate the percentage of each substrate size by dividing the number of tallies by the total number (this should be approximately 50) and multiplying by 100.

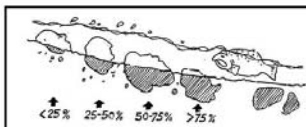
Substrate Size Table

Substrate Type	Silt/Clay/Mud (makes the water cloudy if disturbed)	Sand (up to 0.1")	Gravel (0.1-2")	Cobbles (2-10")	Boulders (>10")	Bedrock (solid rock covers stream bottom)
Tallies						
# of Tallies						
Percentage						

Cobble Embeddedness Table

Cobble #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0-25%																				
25-50%																				
50-75%																				
75-100%																				

50% embeddedness indicates doubtful habitat for many macroinvertebrates, trout, and egg survival



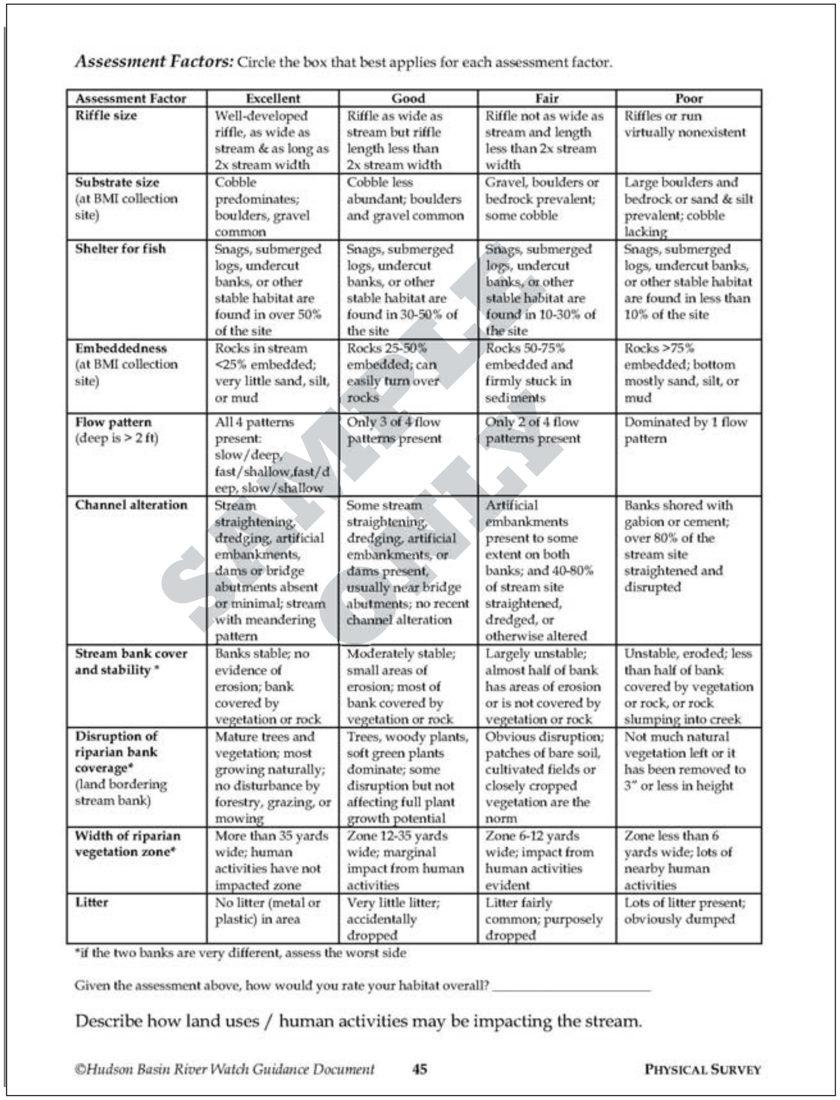
Based on your results, estimate the average embeddedness of the whole site:

Average Embeddedness: ____________ %
(record on physical survey/habitat assessment form)

 47 PHYSICAL SURVEY

The "Stream Bottom Survey" form provides you with more specific information about the most important element of BMI habitat in the stream.

Get copies of worksheets from the CSI website or at the lab:
www.communityscience.org



Assessment Factors: Circle the box that best applies for each assessment factor.

Assessment Factor	Excellent	Good	Fair	Poor
Riffle size	Well-developed riffle, as wide as stream & as long as 2x stream width	Riffle as wide as stream but riffle length less than 2x stream width	Riffle not as wide as stream and length less than 2x stream width	Riffles or run virtually nonexistent
Substrate size (at BMI collection site)	Cobble predominates; boulders, gravel common	Cobble less abundant; boulders and gravel common	Gravel, boulders or bedrock prevalent; some cobble	Large boulders and bedrock or sand & silt prevalent; cobble lacking
Shelter for fish	Snags, submerged logs, undercut banks, or other stable habitat are found in over 50% of the site	Snags, submerged logs, undercut banks, or other stable habitat are found in 30-50% of the site	Snags, submerged logs, undercut banks, or other stable habitat are found in 10-30% of the site	Snags, submerged logs, undercut banks, or other stable habitat are found in less than 10% of the site
Embeddedness (at BMI collection site)	Rocks in stream <25% embedded; very little sand, silt, or mud	Rocks 25-50% embedded; can easily turn over rocks	Rocks 50-75% embedded and firmly stuck in sediments	Rocks >75% embedded; bottom mostly sand, silt, or mud
Flow pattern (deep is > 2 ft)	All 4 patterns present: slow/deep, fast/shallow,fast/deep, slow/shallow	Only 3 of 4 flow patterns present	Only 2 of 4 flow patterns present	Dominated by 1 flow pattern
Channel alteration	Stream straightening, dredging, artificial embankments, dams or bridge abutments absent or minimal; stream with meandering pattern	Some stream straightening, dredging, artificial embankments, or dams present, usually near bridge abutments; no recent channel alteration	Artificial embankments present to some extent on both banks; and 40-80% of stream site straightened, dredged, or otherwise altered	Banks shored with gabion or cement; over 80% of the stream site straightened and disrupted
Stream bank cover and stability *	Banks stable; no evidence of erosion; bank covered by vegetation or rock	Moderately stable; small areas of erosion; most of bank covered by vegetation or rock	Largely unstable; almost half of bank has areas of erosion or is not covered by vegetation or rock	Unstable, eroded; less than half of bank covered by vegetation or rock, or rock slumping into creek
Disruption of riparian bank coverage* (land bordering stream bank)	Mature trees and vegetation; most growing naturally; no disturbance by forestry, grazing, or mowing	Trees, woody plants, soft green plants dominate; some disruption but not affecting full plant growth potential	Obvious disruption; patches of bare soil, cultivated fields or closely cropped vegetation are the norm	Not much natural vegetation left or it has been removed to 3" or less in height
Width of riparian vegetation zone*	More than 35 yards wide; human activities have not impacted zone	Zone 12-35 yards wide; marginal impact from human activities	Zone 6-12 yards wide; impact from human activities evident	Zone less than 6 yards wide; lots of nearby human activities
Litter	No litter (metal or plastic) in area	Very little litter; accidentally dropped	Litter fairly common; purposely dropped	Lots of litter present; obviously dumped

*if the two banks are very different, assess the worst side

Given the assessment above, how would you rate your habitat overall? ____________________

Describe how land uses / human activities may be impacting the stream.

some of our more common
DRAGONFLIES/DAMSELFLIES

Darner Dragonfly
Aeshnidae antennae are 6-segmented

Clubtail Dragonfly
Gomphidae antennae are 4-segmented, and 4th segment is tiny (also usually paddle-like)

some of our more common
FISHFLIES/ALDERFLIES
the *Megaloptera*

Hellgrammite
Corydalidae abdomen ends in 2 prolegs, each with 2 hooks

Alderfly
Sialidae abdomen ends in a long terminal anal filament

some of our more common
TRUE BUGS
the *Hemiptera*

Water Boatman
Corixidae distinct pattern on wings; rostrum short, blunt, and triangular

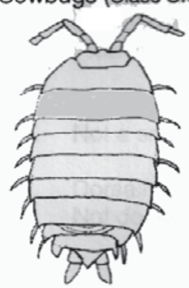
Water Strider
Gerridae narrow body; extremely long legs

some of our more common
NON-INSECTS

Snails (Class Gastropoda)

Clams (Class Bivalvia)

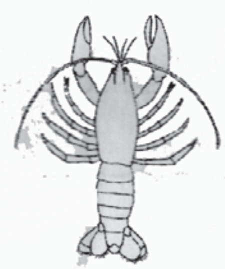
Sowbugs (Class Crustacea, Order Isopoda)



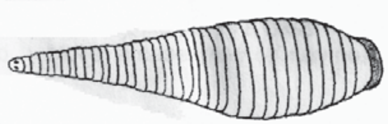
Scuds (Class Crustacea, Order Amphipoda)

Aquatic worms (Class Oligochaeta)

* Crayfish (Class Crustacea, Order Decapoda)



* Leeches (Class Hirudinea)



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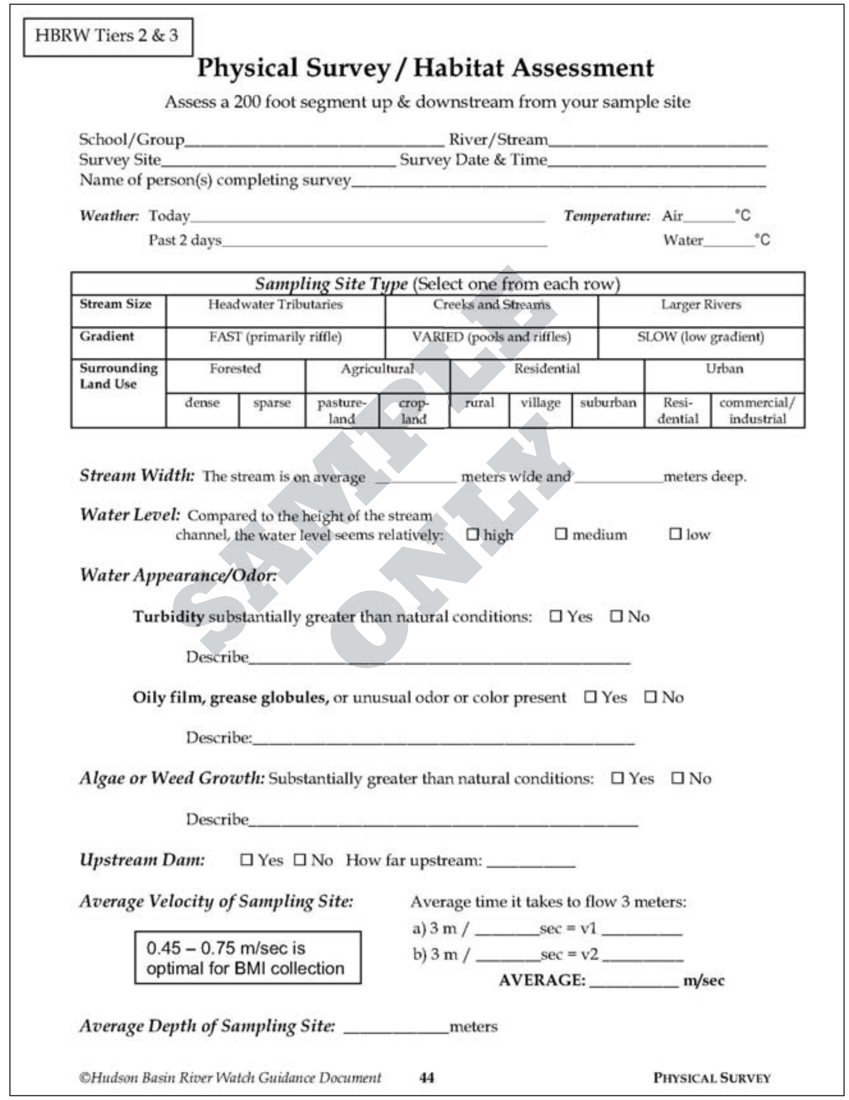


HBRW Tiers 2 & 3

Physical Survey / Habitat Assessment

Assess a 200 foot segment up & downstream from your sample site

School/Group__________ River/Stream__________
Survey Site__________ Survey Date & Time__________
Name of person(s) completing survey__________

Weather: Today__________ *Temperature:* Air_____°C
Past 2 days__________ Water_____°C

Sampling Site Type (Select one from each row)									
Stream Size	Headwater Tributaries			Creeks and Streams			Larger Rivers		
Gradient	FAST (primarily riffle)			VARIED (pools and riffles)			SLOW (low gradient)		
Surrounding Land Use	Forested		Agricultural		Residential			Urban	
	dense	sparse	pasture-land	crop-land	rural	village	suburban	Resi-dential	commercial/industrial

Stream Width: The stream is on average _______ meters wide and _______ meters deep.

Water Level: Compared to the height of the stream channel, the water level seems relatively: ☐ high ☐ medium ☐ low

Water Appearance/Odor:

Turbidity substantially greater than natural conditions: ☐ Yes ☐ No

Describe__________

Oily film, grease globules, or unusual odor or color present ☐ Yes ☐ No

Describe:__________

Algae or Weed Growth: Substantially greater than natural conditions: ☐ Yes ☐ No

Describe__________

Upstream Dam: ☐ Yes ☐ No How far upstream: _______

Average Velocity of Sampling Site: Average time it takes to flow 3 meters:

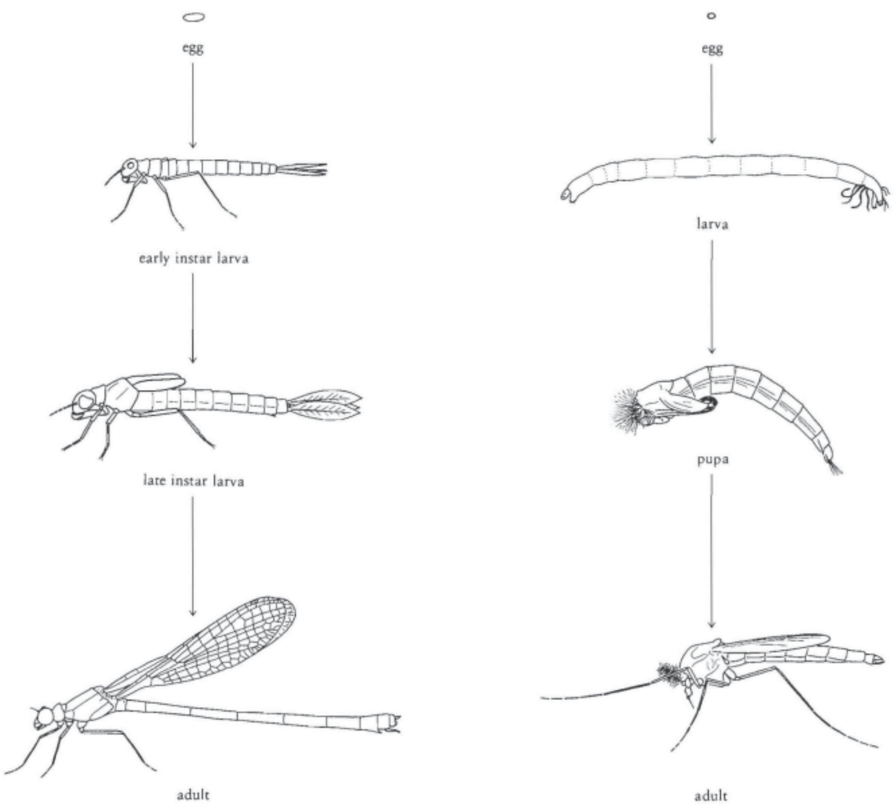
0.45 – 0.75 m/sec is optimal for BMI collection

a) 3 m / _______sec = v1 _______
b) 3 m / _______sec = v2 _______
AVERAGE: _______ m/sec

Average Depth of Sampling Site: _______meters

©Hudson Basin River Watch Guidance Document 44 PHYSICAL SURVEY

Fill out the 5 "Physical Survey/Habitat Assessment" forms every time you collect a BMI sample. The habitat of the river greatly affects the nature of the BMI community. Without habitat information, your BMI data is less valuable. Calculate flow and velocity using the Flow Worksheet.



A B

Figure 2.6. Metamorphosis. A. Incomplete metamorphosis, damselfly. B. Complete metamorphosis, midge.

possess well-developed compound eyes and wing pads (in species that have wings as adults). The degree of morphological and ecological difference between larvae and adults varies considerably from one insect group to the next.

The terms **nymph** and **naiad** are sometimes used for the larval stage of insects with incomplete metamorphosis. The term *larva*, however, is more universally accepted in the zoological sciences.

COMPLETE METAMORPHOSIS

Aquatic insects that possess a pupal stage have a complete kind of metamorphosis, which is generally regarded to be a more advanced kind of development (see Fig. 2.6B). In these insects growth takes place mainly in the larval stages, and maturation takes place mainly in the pupal stage. Larvae lack wing pads and compound eyes; their eyes are either highly reduced or composed of a single facet or group of single facets. Differences between larvae and adults are usually extreme.

Anatomy and Life Stages Of Aquatic Insects

From ***Aquatic Entomology: The Fisherman's and Ecologists' Illustrated Guide to Insects and Their Relatives***, by W. Patrick McCafferty, with illustrations by Arwin V. Provonsha

Anterior: Refers to the head end of the body or that part of a structure closest to the head of the body.

Posterior: Refers to the tail end of the body or that part of a structure closest to the tail of the body.

Dorsal: Refers to the upper or top part of the body or structure.

Ventral: Refers to the lower or bottom part of the body or structure.

Lateral: Refers to the side of the body or structure.

Medial: Refers to the longitudinal midline of the body or structure.

Basal: Refers to the origin of a structure, generally closest to the point of attachment to the body.

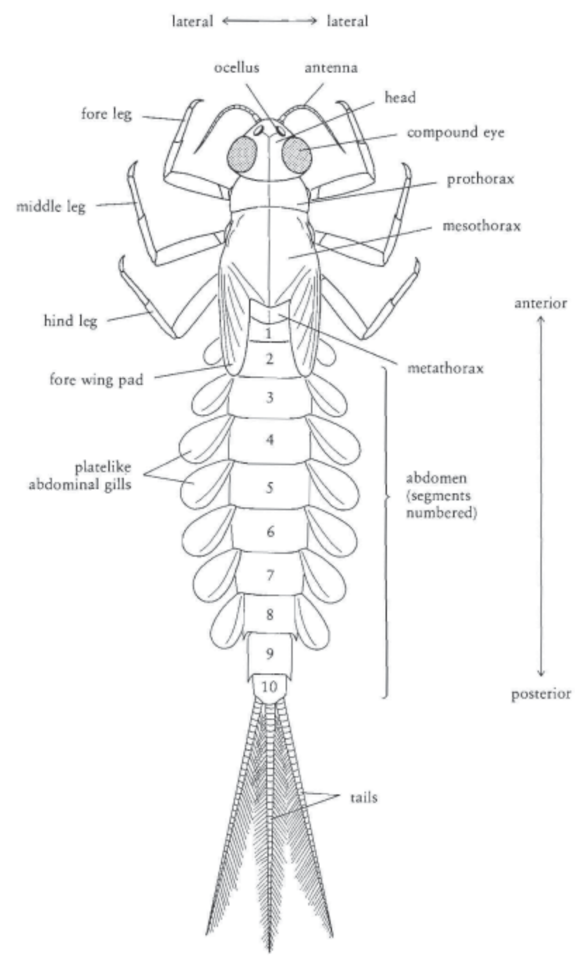


Figure 2.1. Mayfly larva, dorsal view.

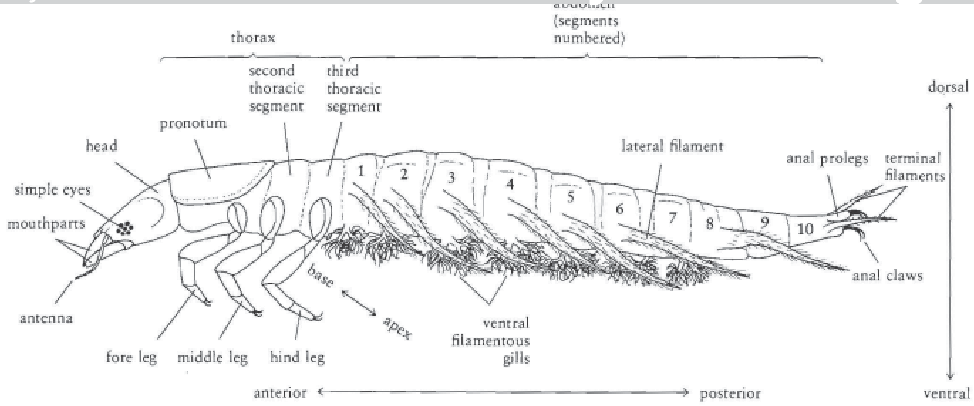


Figure 2.2. Dobsonfly larva, lateral view.

Distal: Refers to that part of a structure furthermost from its point of attachment to the body. The **apex** is the distal end or tip of a structure. The term **apical** is generally synonymous with *distal*.

Shapes of bodies or body parts are often important in describing insects. A **dorsoventrally flattened** body or structure is flattened or depressed from top to bottom and is generally wider (side to side) than it is thick (top to bottom). A **laterally flattened** body or structure is flattened or compressed from the sides and is generally thicker (top to bottom) than it is wide (side to side).

Other important terms refer to the shape of a margin or end of a structure. A **rounded** or **convex** structure is more or less evenly curved outwardly. An **emarginate** or **concave** structure is notched or hollowed out or has an inwardly curved margin. A **truncate** structure is more or less square-shaped or has a blunt apex. An **acute** structure has a more or less pointed apex.

Body Divisions

The generalized insect body (Figs. 2.1, 2.2) is divided into many ringlike **segments** and three major **regions**. The first region is the **head**, which appears to be a single segment but is actually composed of six or seven fused segments. The head is usually capsulelike and contains the feeding apparatus and many of the sensory organs.

The second region, or **thorax**, is posterior to the head and is composed of three segments: the **prothorax** (anterior or first thoracic segment), the **mesothorax** (second or middle segment), and the **metathorax** (posterior or third segment). Appendages used for moving the body are located on the thorax.

Posterior to the thorax is the third body region, or **abdomen.** The abdomen is generally the longest region and is composed of several segments (often from 8 to 11). Various appendages and external structures are located on the abdomen of some insects.

Body regions are not distinguishable in some insects. When the thorax and abdomen are undifferentiated, they are together known as the **trunk.**

During the postembryonic phase of development, insects can generally be referred to as **immatures**, even though there may be either one or two major stages during this phase, depending on the kind of insect and the kind of metamorphosis it undergoes. These postembryonic stages are discussed below.

LARVA

The **larval** stage occurs in all aquatic insects. It follows the egg stage and is followed by either the adult stage or a transitional stage that precedes the adult. Growth (and maturation to varying degrees) occur during the larval stage, and there are three or more instars (larval instars). The relative terms "young larvae" and "mature larvae" refer to early instar larvae and late instar larvae, respectively. Larval instars may vary considerably from one to another in many aquatic insects and are sometimes given special names.

SUBIMAGO

The **subimago** (or subimaginal stage) is a unique transitional stage found only in mayflies. It follows the larval stage and precedes the adult stage. Unlike other pre-adult stages known among insects, it is a fully winged form. The subimago is a maturation stage and includes only one instar.

PUPA

The **pupal stage** is a transitional stage that occurs in more advanced groups of insects. It is primarily a maturation stage and includes only one instar. Depending on the kind of insect, the pupa may be quiescent or active. It also may be either free-living or encased in a cocoon or puparium. A **puparium** is found in some advanced groups of Diptera and is made from the modified skin of the last larval instar.

Kinds of Metamorphosis

Two basic kinds of metamorphosis occur among aquatic insects (see Table 2.1). The kinds of postembryonic stages involved in development determine the kind of metamorphosis. Larvae conveniently reflect these different kinds of metamorphosis by their possession of certain morphological traits.

INCOMPLETE METAMORPHOSIS

Aquatic insects that do not possess a pupal stage have an incomplete kind of metamorphosis, which is generally regarded to be a more primitive kind of development (see Fig. 2.6A). The larvae of these insects undergo both growth and maturation. The larvae (except for very young larvae)

TABLE **2.1** KINDS OF METAMORPHOSIS FOUND AMONG AQUATIC INSECTS

Incomplete Metamorphosis	Complete Metamorphosis
Ephemeroptera	Megaloptera
Odonata	Neuroptera
Plecoptera	Coleoptera
Hemiptera	Trichoptera
	Lepidoptera
	Diptera

sess segmented, tail-like structures at the end of the abdomen, and although these are known to specialists by various technical terms, they are herein simply referred to as **tails. Genitalia** (the primary external reproductive organs) are located on the abdomen of adult insects, but they are not generally used for the level of identification covered in this book.

Metamorphosis and Life Stages

During its life cycle (Fig. 2.5) every aquatic insect goes through a series of changes in form (the process of metamorphosis) as it develops from egg to adult. These different forms of the insect are known as life **stages**, and they make up two distinct phases of development. The first phase—embryonic development—occurs in the **egg** stage. The second phase—postembryonic development—includes all stages between the time the egg hatches and the time the insect becomes reproductively mature. Reproductive maturity is reached in the **adult** stage (sometimes also called the **imago**), which possesses functional sexual organs and is able to reproduce. The ecological requirements and associated morphological and behavioral adaptations of the different stages of an aquatic insect may be quite different; usually one or more stages are terrestrial. A knowledge of life cycles and stages is therefore very important to the student of aquatic entomology.

Postembryonic Development

Postembryonic development includes both growth and maturation of the individual. **Growth** is generally considered to be increase in size, whereas **maturation** is the progressive morphological and physiological attainment of adult attributes (wings, genitalia, etc.), which are fully developed at adulthood.

Since insects have an exoskeleton, it must be periodically shed, and a new, larger one reformed to accommodate the growing individual. The process of shedding the exoskeleton is known as **molting**, and the shed exoskeleton is commonly referred to as a **cast skin**. The period between any two molts is known as a stadium, and the individual during this interval is referred to as an **instar**. The number of developmental instars may be constant or variable, depending on the species or group of insects. The number of instars during postembryonic development may range from 4 to 40 or more.

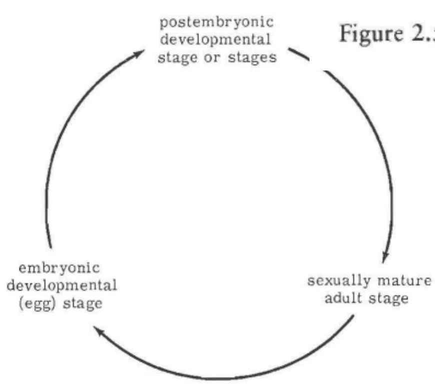


Figure 2.5. Insect life cycle.

The Body Wall

The outer skin of insects is actually an external skeleton known as the **exoskeleton.** The exoskeleton can be relatively hard (**sclerotized** or **platelike**) or thin and soft (**membranous** or **fleshy**), depending on the kind of insect or part of the body. The texture of the exoskeleton and the presence or absence of various kinds of outgrowths are often diagnostic.

SCLERITES

Any piece of body wall is a **sclerite.** A sclerite is bounded by membranous areas or lines known as **sutures. Tergites** are dorsal sclerites (often platelike areas) of a body segment. **Sternites** are the ventral sclerites of a segment. Some insects also have sclerites on the sides of the body, or **pleural** area.

OUTGROWTHS OF THE BODY WALL

Socketed outgrowths are **setae**, and these are referred to in this book by the descriptive terms **hairs**, **bristles**, **spurs**, or **scales**, depending on their thickness and shape. **Spines** and **processes** are robust, often acute, unsocketed outgrowths or extensions of the exoskeleton. The location and density of any of the above outgrowths can be important in identifying insects. The presence and location of punctures, furrows, and sutures can also be important.

Aquatic insects sometimes have additional outgrowths, such as **gills**, **filaments**, and **papillae**. These are often thin-walled and of various shapes and are most often located on the abdomen, but sometimes on the thorax, head, or appendages. Gills may be platelike (Fig. 2.1) or filamentous (Fig. 2.2) and branched or unbranched. Papillae are sometimes eversible.

Structures of the Head

The insect head possesses the eyes, antennae, and mouthparts. These structures vary considerably and thus are important for identification.

EYES

A pair of **compound** eyes (multifaceted) is present laterally on the heads of many insects (Fig. 2.1). Compound eyes are reduced to a single facet or group of single facets in many other insects (Fig. 2.2). In addition to the eyes, many insects possess two or three **ocelli** (single-faceted organs), which appear as spots on the dorsal or anterior part of the head.

ANTENNAE

Antennae are paired, segmented appendages of the head that usually arise between the eyes. They are highly variable in size and shape, often being filamentous (Figs. 2.1, 2.2) or variously expanded or clubbed.

MOUTHPARTS

Because mouthparts are highly variable, depending on the feeding adaptations of the insect, only a generalized plan is discussed here (Fig. 2.3). The **labrum** is a platelike "upper lip" that is attached to the front margin of the head and is the most anterior mouthpart. Posterior to the labrum and at the sides of the mouth is a pair of **mandibles**, followed by a pair of **maxillae.** Each maxilla possesses a lateral armlike appendage known as the **maxillary palp**. At the posterior of the mouth is the "lower lip," or **labium.** The labium can generally be divided into the body of the labium and the **labial** palps, which are lateral, segmented, armlike appendages. An additional

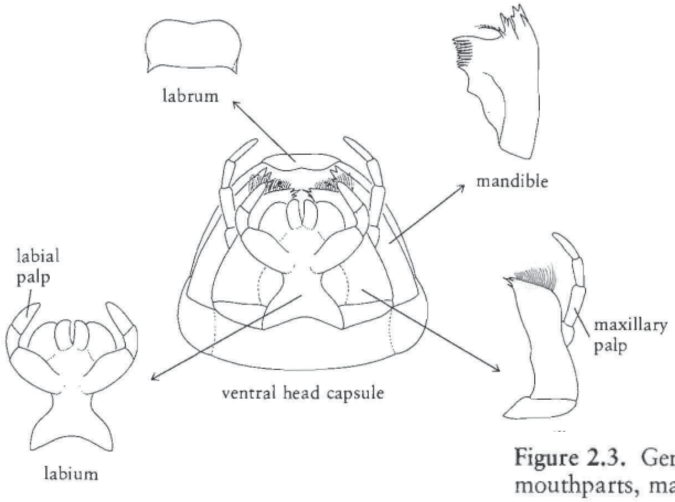


Figure 2.3. Generalized mouthparts, mayfly larva.

mouthpart present in some insects is the **hypopharynx**, a medial structure closely associated with the base of the labium and generally located between the maxillae.

Structures of the Thorax

Segments of the thorax are often relatively robust, since they encase muscles used to move the wings and legs. The terms **notum** or **notal** refer to the dorsal portion of a segment; the size, shape, and degree of sclerotization of the **pronotum** (dorsal portion of the first thoracic segment) and other nota are often diagnostically important.

LEGS

In the generalized insect (Figs. 2.1, 2.2), each thoracic segment possesses a pair of segmented legs. The basal leg segment, the **coxa**, is followed distally by the **trochanter**, **femur**, **tibia**, and **tarsus** (Fig. 2.4A). The tarsus is often subdivided into tarsal segments (segment 1 is always the most basal). A **claw** or pair of claws is usually present at the end of the leg. The pairs of legs are referred to as the fore, **middle**, and **hind legs**. Filamentous gills are present at the base of one or more pairs of legs in certain aquatic insects.

Many immature insects do not possess thoracic legs, but some possess prolegs. **Prolegs** are fleshy, usually unsegmented, leglike (usually short) outgrowths. Thoracic prolegs are present most often as a single ventral pair on the first thoracic segment.

WINGS

One or two pairs of wings are present in most adult insects. The generalized wing is a membranous, flaplike structure that articulates with the side of the thorax. The **fore wings**, or first pair of wings, are located on the second thoracic segment, and the **hind wings**, or second pair of wings, are located on the third thoracic segment. When only one pair of wings is present, the wings are located on the second thoracic segment.

Rigidity of membranous wings is maintained in part by the **wing veins** (Fig. 2.4B); **longitudinal veins** run from the base lengthwise, and **crossveins** connect longitudinal veins. The anterior margin of the wing is known as the

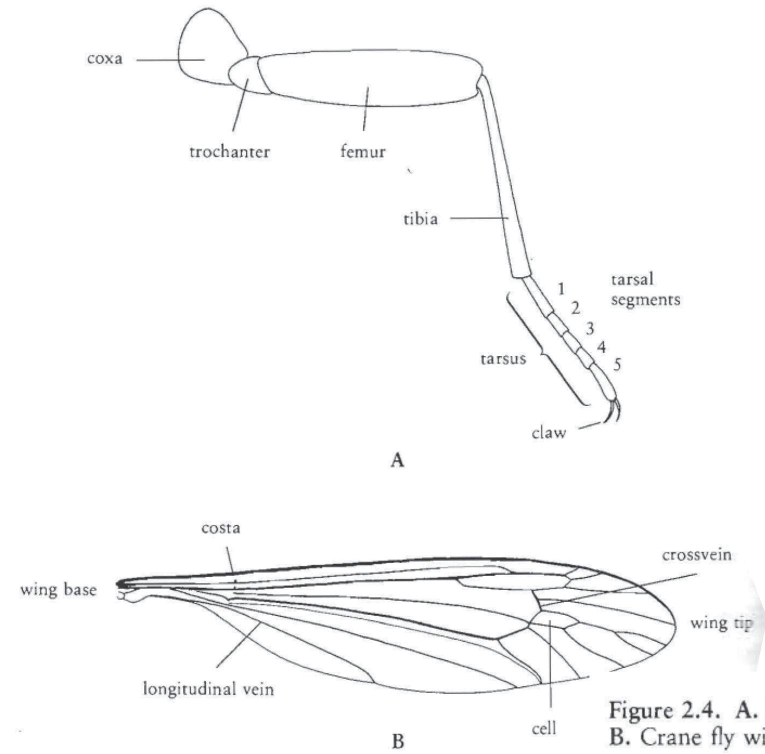


Figure 2.4. A. Beetle leg. B. Crane fly wing.

costa. Cells are areas of the wing enclosed by veins. The complex terminology of wing veins differs somewhat from group to group; veins are illustrated and labeled in parts of this book where they must be used.

Fore wings are sometimes variously modified into structures that, when folded over the back of the insect, protect the hind wings. Wings of certain species of aquatic insects never become fully developed. Immature insects may or may not have externally developing wings. These developing wings, including their encasements when present, are referred to as **wing pads**.

Structures of the Abdomen

The number of abdominal segments and an indication of the exact segments on which certain structures occur are often important for identification. Segments are consistently numbered, beginning with the most anterior segment as segment 1. Abdominal segments may appear to be subdivided in some insects.

Paired structures that sometimes occur on the abdomen include lateral filaments, gills of various kinds, and prolegs (Figs. 2.1, 2.2). These occur only on certain segments or serially on several segments. Those that occur at the end of the abdomen are often referred to as **terminal** or anal (e.g., **anal prolegs**).

Diagnostically important structures often occur at the end of the abdomen. These include **breathing tubes** or **siphons**, **caudal lamellae**, anal prolegs, various lobes, gills, filaments, and papillae. Many aquatic insects pos-