A Comparison Study of the Proper use of Hester-Dendy® Samplers to Achieve Maximum Diversity and Population Size of Benthic Macroinvertebrates Sacramento Valley, California

Juanita Bacey
Environmental Scientist

Terrell Barry
Research Scientist III

April 2008

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
Environmental Monitoring Branch
California Department of Pesticide Regulation
1001 I Street Sacramento, California 95812

Report No. EH08-2

Abstract

Lotic waters within the California Central Valley have been greatly altered to accommodate urban and agricultural development. Physical habitat (aquatic vegetation and stream substrate) is often reduced or removed completely, greatly impacting aquatic organisms within the stream. One method of examining a benthic macroinvertebrate (BMI) community in an impaired watershed is to create an artificial substrate for macroinvertebrate colonization.

In order to determine maximum diversity and population size obtainable using artificial substrate samplers, proper placement and duration within a stream system should be examined first. The objective of this study was to compare taxa richness and abundance of BMI populations when using Hester-Dendy® (HD) artificial substrate samplers placed at various in-stream locations and for various lengths of time. Samplers were placed at three in-stream locations (top, bottom and vegetation) at three sites within the Sacramento Valley ecoregion. We found no significant difference in BMI abundance or taxa richness between the locations ($p=0.097$ and $p=0.272$, respectively). Of the two deployment periods (6 weeks and 4 weeks) we found no significant difference in BMI abundance or taxa richness between the periods ($p = 0.848$ and $p = 0.306$, respectively).

Since no difference was seen between locations or deployment time, these results suggest that the most efficient way to use H-D samplers is with the easiest placement and shortest deployment.

Acknowledgment

We would like to thank the following environmental monitoring personnel who assisted with sample collection during the study, Milanka Ilic and Michael Mamola. Their tireless efforts allow us to report the data presented here. Thanks also to the Bidwell Institute of California State University, Chico for benthic macroinvertebrate taxonomy.

TABLE OF CONTENTS

List of Tables

List of Figures

INTRODUCTION

Biological monitoring and assessment (bioassessment) is becoming a widely used and accepted method for evaluating water quality throughout the United States (SWRCB, 2003). Periphyton, aquatic vertebrate and benthic macroinvertebrates (BMIs) are the common aquatic assemblages used in bioassessment monitoring (U.S. EPA, 1999). In order to conduct a cost-effective, scientifically valid, rapid biological assessment, monitoring may be reduced to one aquatic assemblage (U.S. EPA, 1999). BMIs are the common aquatic assemblages measured in rapid monitoring protocols. They are useful in evaluating the overall health of flowing water systems, because they are affected by changes in a stream's chemical and or physical structure (Karr and Kerans, 1991). Their sensitivity to stresses (temperature, dissolved oxygen, chemical and organic pollution) allows them to be effective indicators of anthropogenic disturbances (House et al., 1993).

Lotic waters within the California Central Valley have been greatly altered to accommodate urban and agricultural development. Physical habitat (aquatic vegetation and stream substrate) is often reduced or removed completely, greatly impacting aquatic organisms within the stream. One method of examining BMI communities in a watershed is to provide uniform artificial substrate for BMI colonization. The effect of water quality alone on a BMI can then be assessed independent of the physical habitat.

In order to determine maximum diversity and population size obtainable using artificial substrate samplers, proper placement and duration within a stream system should be examined first. The objective of this study was to compare taxa richness and abundance of BMI populations using Hester-Dendy® (H-D) artificial substrate samplers placed at various locations within a stream. Additionally, we examined population differences when H-Ds were placed in streams for various lengths of time.

SITE DESCRIPTION

Three sites were selected within the Sacramento Valley ecoregion. Site one (Site1) was located in Auburn Ravine in Sutter County. Site two (Site2) was located in Dry Creek in Placer County and Site three (Site3) was located in Dry Creek in Sacramento County (Figure 1). Site1 was approximately 22 km from Site2 and Site 3, while Site2 was approximately 2.5 km from Site3. All three creeks were considered wadeable streams (<1.2m) and had mean flows ranging from 0.15 to 0.91 m/sec.

Figure 1. Hester-Dendy samplers deployed at three sites in Sacramento Valley, Calif.

MATERIALS AND METHODS

Hester-Dendy Sampler

The Hester-Dendy (H-D) artificial substrate samplers are U.S. EPA recommended for use in bioassessment studies. These samplers consist of 14 round plates of natural, water-resistant Masonite spaced on an 8-inch eyebolt. Each was secured to a cement block to prevent floating downstream, and to a buoy to allow it to float when required.

This artificial substrate sampler is often used in streams where benthic macroinvertebrate variability and abundance may be low due to heavy sedimentation and a lack of sufficient substrate for colonization. Unlike rock baskets or other benthic samplers, heavy sedimentation is not a concern for colonization of H-D samplers because they can be floated just below the water surface.

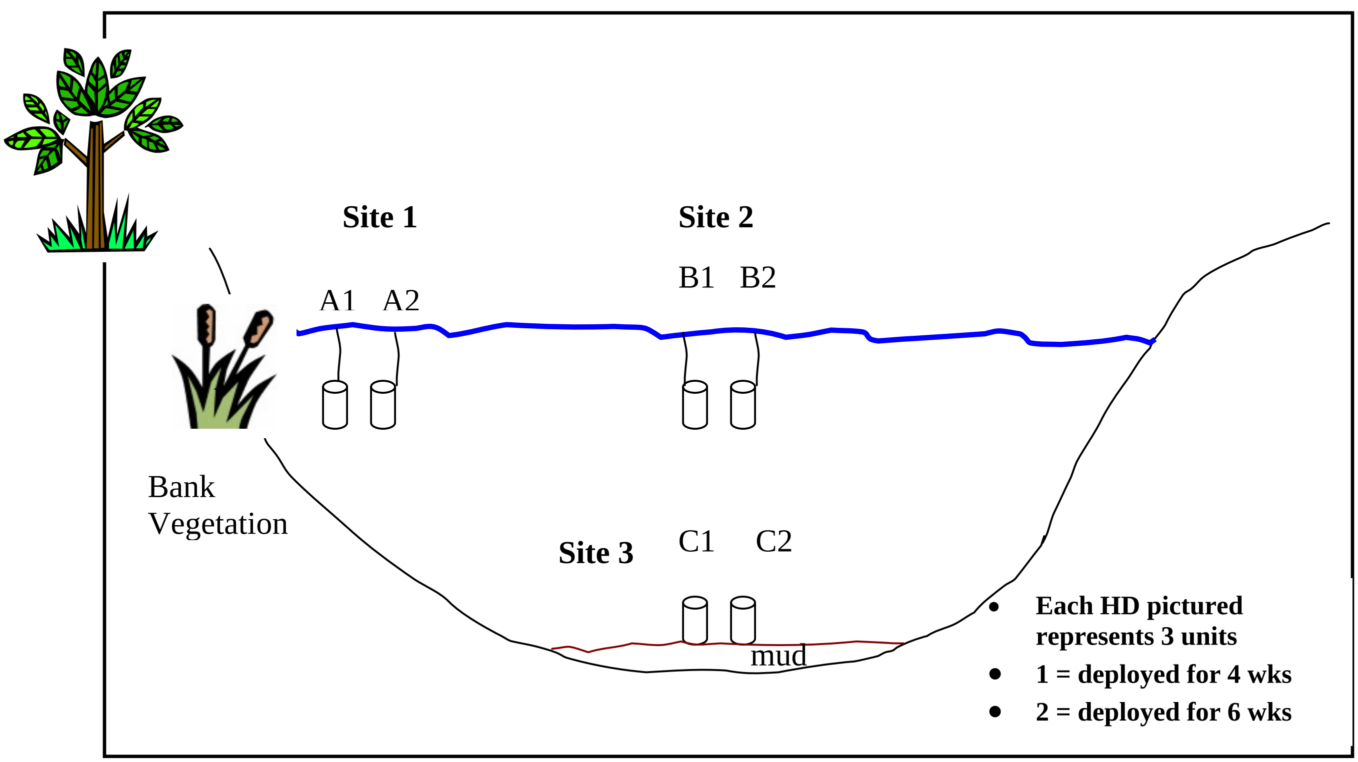
Benthic Macroinvertebrate Sampling Method

Sampling was conducted per DPR SOP EQWA006, "Procedure for Collecting Benthic Macroinvertebrates using a Hester-Dendy® Sampler" (Mamola, 2005).

Study Plan

The H-Ds were deployed at three different microhabitat locations at each site: six along a bank, adjacent to aquatic vegetation (veg); six floating submerged, center stream, 1-foot below the surface of the water (top); and six on the substrate floor of the creek (bottom). They were also deployed for two lengths of time, fifty percent for four weeks and the other fifty percent for six weeks. Those deployed for four weeks were fixed within the six-week time-frame so that the season would be similar for each time period. H-D placement within the creeks is depicted in Figure 2.

Figure 2. Hester-Dendy® placement within the stream



ANALYSES

Macroinvertebrate Analysis

Bidwell Institute at the University of California, Chico, performed macroinvertebrate identification. A sub-sample of 500 macroinvertebrates were identified to genera and, when possible, to species. Macroinvertebrate analysis procedures are based on the U.S. EPA's multi-metric approach to bioassessment data analysis. A taxonomic list of the BMIs identified in each sample is generated along with a summary consisting of BMI metrics (Table 1).

Quality control (QC) was conducted in accordance with the California Department of Fish and Game, Aquatic Bioassessment Laboratory procedures. Ten percent of the samples are randomly selected and then checked for taxonomic accuracy. All taxa from each of the randomly selected samples are re-identified by the QC taxonomist, and the number of specimens in each vial is re-checked. Any errors in taxonomy, including misidentification, multiple taxa per vial, counting errors and deviation from the standard taxonomic effort are recorded in spreadsheet form, and then are analyzed with QC MANAGER, an ACCESS© program that summarizes the types of discrepancy and their frequencies.

Data Analysis

Analysis of variance was used to examine the BMI metrics taxa richness and abundance. Differences in BMI counts between location and deployment period were evaluated using an unbalanced general linear model for a completely randomized design. Both location and deployment time were treated as fixed effects. Taxa richness and abundance were checked for normality. Abundance required logarithmic transformation to meet normal distribution assumptions. Type III sums of squares were used in the ANOVA. Differences were considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

The dominant taxa found at each site were very similar. All three sites had high numbers of the BMI orders Ephemeroptera, Diptera, and Trichoptera, with species of each order being very similar as well (Table 2). These three orders represented 90 percent of the total organisms at Site 1, 94 percent at Site 2 and 84 percent at Site 3.

Table 2. Dominant taxa present at each monitoring site

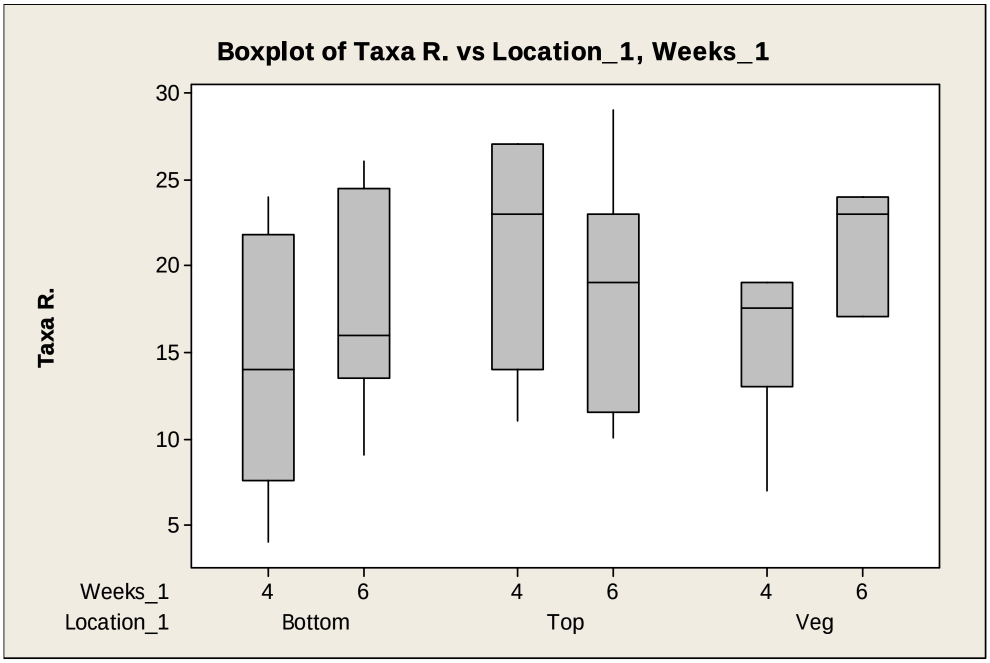
Site 1		Site 2		Site 3	
Order – Family	**Dominant species**	**Order – Family**	**Dominant species**	**Order – Family**	**Dominant species**
Diptera -Chironomidae (36)	- Orthocladiinae (16) - Polypedilum sp. - Rheotanytarsus - Tanytarsus - Rheocricotopus - Thienemanniella	Diptera -Chironomidae (33)	- Orthocladiinae (17) - Rheotanytarsus - Tanytarsus - Rheocricotopus - Thienemanniella	Diptera -Chironomidae (34)	- Orthocladiinae (14) - Rheotanytarsus - Tanytarsus - Ablabesmyia - Pentaneura
Ephemeroptera (20)	Heptagenia sp. (6) Tricorythodes (14)	Ephemeroptera (24)	Heptagenia sp. (2) Tricorythodes (19)	Ephemeroptera (12)	Heptagenia sp. (0) Tricorythodes (12)
Trichoptera (28) -Hydropsychidae (25)		Trichoptera (33) -Hydropsychidae (30)		Trichoptera (39) -Hydropsychidae (35)	

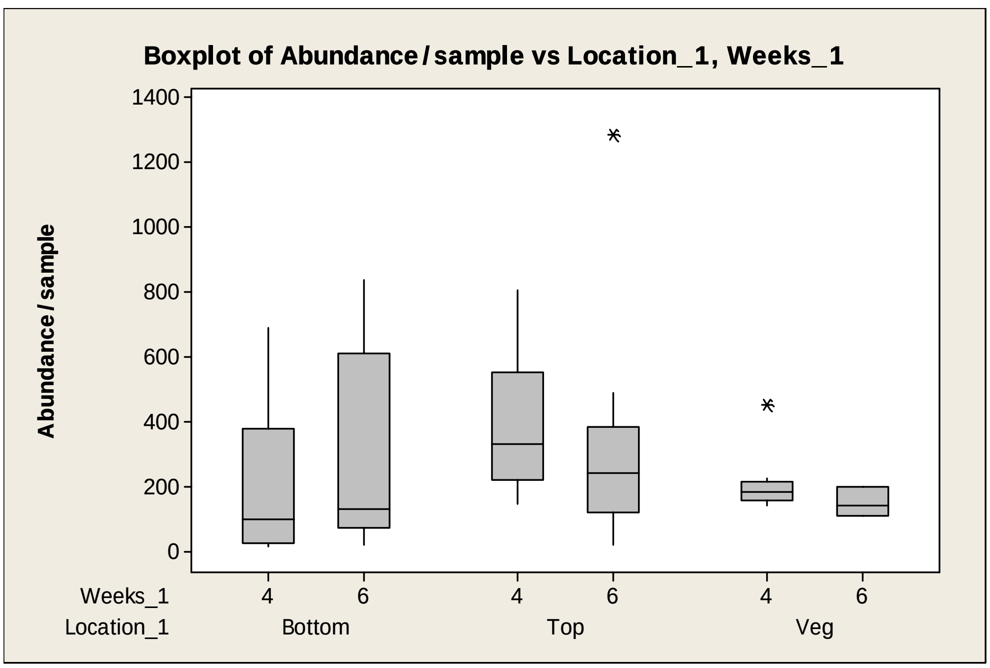
*** (Mean percent of abundance)**
*** Those species with no percent indicated represent < 10 percent of the population.**

Total abundance represents the estimated number of individual organisms in a sample. This is usually calculated by extrapolating from the proportion of organisms counted in the subsample (500). However, all but one of the samples collected had less than 500 organisms. Taxa richness represents the total number of individual taxa in a sample.

Some H-D samplers were lost due to the high public visibility of the samplers and the varied, unpredictable flows of the streams. Therefore, sample size for the treatments (location and deployment period) were not equal. For this reason an unbalanced general linear model was required to analyze BMI differences. We examined differences between location, bottom, top and vegetation. We also examined differences between deployment time, four weeks and six weeks. Mean abundance and taxa richness found within each time variable are presented in Figure 3.

Figure 3. Abundance and Taxa Richness of each site.





Of the three locations (top, bottom and vegetation), we found no significant difference in BMI abundance between locations ($p = 0.097$). We also found no significant difference in taxa richness between locations ($p = 0.272$). We found no significant difference in BMI abundance between deployment periods ($p = 0.848$). We also found no significant difference in taxa richness between deployment periods ($p = 0.306$).

Since no difference was seen between locations, or the deployment period, these results suggest that the most efficient way to use H-D samplers is with the easiest placement and shortest deployment.

Placement within a stream should be the most easily accessible location based on stream conditions. In a stream flow of greater than 0.91 m/sec, placement along the shoreline adjacent to vegetation will reduce the chance of strong currents dislodging the H-D. In a stream with significant suspended sediment or sand, placement on the bottom of a streambed should be avoided because the sampler may become inundated or buried. In a stream with significant vegetation or other free-floating debris, the float of the H-D sampler may become entangled which could cause it to be dragged downstream. Therefore, bottom placement or along a shoreline may be a better choice in this situation.

Deploying the H-D sampler for four weeks rather than six may be beneficial in ecoregions where temperatures stay cooler for longer periods and the BMI emergent season is shorter. It may also be beneficial for studies where samplers are limited and deployment of the maximum number of samplers is required to achieve study objectives.

IX. REFERENCES

House, M.A., J.B. Ellis, E.E. Herricks, T. Hvitved-Jacobsen, J. Seager, L. Lijklema, H. Aalderink, I.T. Clifforde. 1993. Urban Drainage-Impacts on Receiving Water Quality. Wat. Sci. Tech. 27(12), 117-158.

Karr, J.R. and Kerans, B.L. 1991. Components of Biological Integrity: Their Definition and Use in Development of an Invertebrate IBI. U.S. EPA Report 905-R-92-003, Environmental Sciences Div., Chicago, IL, 16 p.

Mamola, Michael. 2005. Procedure for collecting benthic macroinvertebrates using a Hester-Dendy sampler. Department of Pesticide Regulation. Environmental Monitoring Program. Sacramento, California. SOP #EQWA006.

State Water Resources Control Board. 2003. The status and future of biological assessment in California streams. [Online]. Available at http://www.swrcb.ca.gov/swamp/docs/bioassess_chapt1.pdf

U.S. EPA 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. EPA; Office of Water: Washington D.C.

Table 1. BMI Results summarized in biological metrics.

Waterbody Name	Auburn Ravine												Dry Creek																	
Site	Site 1												Site 2																	
Deployment Length	4 Weeks								6 Weeks				4 Weeks									6 Weeks								
Sample	1	2	3	4	5	6	7	8	1	2	3	4	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
Top, bottom or veg	T	B	V	B	T	B	T	T	T	B	B	V	V	B	V	V	T	V	B	B	T	B	T	T	T	T	T	B	T	T
EPT Taxa	3	3	5	2	5	0	5	6	1	5	6	4	2	3	2	2	5	2	2	3	3	2	6	4	4	5	6	4	2	4
Number Amphipoda Individuals	0	0	0	0	0	0	0	0	3	0	0	8	8	0	13	8	0	0	1	1	0	0	0	0	0	0	0	0	4	0
Number Baetidae Individuals	0	0	1	0	0	0	13	1	0	2	1	1	0	0	0	0	2	0	0	0	7	1	22	1	14	16	6	3	0	1
Number CF + CG Individuals	108	35	155	20	417	12	336	393	17	109	56	63	424	76	161	120	201	147	83	86	206	18	389	61	199	318	194	115	103	221
Number CF + CG Taxa	9	8	8	6	15	4	15	16	7	9	6	12	13	6	12	12	12	4	7	8	10	8	19	7	9	13	12	10	13	9
Number Chironomidae Individuals	27	16	31	16	232	5	118	203	11	25	10	41	163	21	80	70	62	18	20	50	32	16	248	10	14	75	50	61	63	62
Number Chironomidae Taxa	6	6	6	3	15	2	12	14	5	8	5	9	12	5	11	10	10	3	5	7	8	6	15	3	5	11	10	8	12	8
Number Chironominae Taxa	3	3	3	3	5	2	4	5	3	5	2	7	6	4	7	6	3	2	3	2	4	4	4	2	2	4	3	4	7	4
Number Coleoptera Taxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
Number Collector Filterer Individuals	89	17	142	1	243	0	246	271	6	31	5	34	133	37	52	47	107	116	17	46	152	2	171	53	178	225	137	56	56	177
Number Collector Filterer Taxa	4	3	3	1	4	0	5	4	1	3	2	6	5	4	3	4	4	3	4	3	4	2	4	4	4	3	4	3	5	3
Number Collector Gatherer Individuals	19	18	13	19	174	12	90	122	11	78	51	29	291	39	109	73	94	31	66	40	54	16	218	8	21	93	57	59	47	44
Number Collector Gatherer Taxa	5	5	5	5	11	4	10	12	6	6	4	6	8	2	9	8	8	1	3	5	6	6	15	3	5	10	8	7	8	6
Number Corbicula Individuals	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	6	0	0	0	0	0
Number Crustacea + Mollusca Individuals	0	0	0	0	6	0	2	0	5	4	4	41	21	7	15	12	1	0	2	9	0	0	1	0	6	0	0	3	4	1
Number Crustacea Individuals	0	0	0	0	0	0	0	0	3	0	0	8	8	0	13	11	0	0	1	1	0	0	0	0	0	0	0	0	4	0
Number Diptera Individuals	31	17	31	16	233	5	121	205	11	25	10	42	164	21	80	70	62	18	20	50	32	16	249	12	27	75	50	61	63	62
Number Diptera Taxa	7	7	6	3	16	2	13	15	5	8	5	10	13	5	11	10	10	3	5	7	8	6	16	5	6	11	10	8	12	8
Number Elmidae Individuals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
Number Elmidae Taxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
Number Ephemerellidae Taxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number Ephemeroptera Individuals	33	7	31	0	52	0	59	43	3	72	48	10	70	38	64	28	75	31	62	29	43	1	53	25	21	71	47	46	26	32
Number Ephemeroptera Taxa	2	1	4	0	2	0	3	3	1	2	3	2	1	1	1	1	3	1	1	1	2	1	4	3	3	3	3	2	1	2
Number EPT Individuals	109	20	157	2	243	0	274	238	3	93	71	13	72	59	66	34	154	132	81	61	181	2	174	71	176	256	168	58	47	177
Number Gastropoda Individuals	0	0	0	0	6	0	1	0	2	4	4	32	13	7	2	1	1	0	1	8	0	0	0	0	0	0	0	3	0	1
Number Glossosomatidae Individuals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number Hydropsychidae Individuals	76	12	126	1	184	0	213	193	0	19	0	2	2	20	0	6	78	101	4	11	138	1	120	46	155	177	117	11	21	141
Number Hydropsychidae Taxa	1	1	1	1	1	0	1	1	0	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Number Hydroptilidae Individuals	0	1	0	1	6	0	2	1	0	1	1	0	0	0	2	0	1	0	0	3	0	0	1	0	0	8	3	1	0	4
Number Intolerant Diptera Individuals	0	0	0	0	7	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	9	0	0	0	1	0	0	0
Number Intolerant Ephemeroptera Individuals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number Intolerant EPT Taxa	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Number Intolerant Individuals	0	0	0	0	7	0	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	9	0	0	0	1	0	0	0
Number Intolerant Scraper Individuals	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number Intolerant Taxa	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0
Number Intolerant Trichoptera Individuals	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number Mollusca Individuals	0	0	0	0	6	0	2	0	2	4	4	33	13	7	2	1	1	0	1	8	0	0	1	0	6	0	0	3	0	1
Number Mollusca Taxa	0	0	0	0	1	0	2	0	2	2	2	3	2	3	1	1	1	0	1	3	0	0	1	0	1	0	0	2	0	1
Number Non Baetis Fallceon Ephemeroptera	33	7	29	0	52	0	45	42	3	70	47	9	70	38	64	28	73	31	62	29	36	0	44	24	7	55	41	43	26	31
Number Non Hydro Cheumato Trichoptera	0	0	0	1	6	0	1	2	0	1	23	1	0	1	0	0	1	0	15	18	0	0	1	0	0	8	4	1	0	4
Number Non-Gastropoda Scraper Individuals	31	0	25	0	20	0	24	14	0	0	1	0	0	0	0	2	0	0	0	1	0	0	21	21	6	1	1	1	0	2
Number Non-insect Taxa	1	1	2	2	4	2	4	3	3	2	2	8	5	4	3	5	2	0	2	4	1	1	4	1	2	2	2	3	2	3
Number of Crustacea + Mollusca Taxa	0	0	0	0	1	0	2	0	0	0	0	0	1	2	3	1	1	3	1	1	0	0	0	0	0	0	0	0	0	0
Number Oligochaeta Individuals	3	1	0	3	2	7	6	7	0	0	0	7	187	0	8	12	0	0	0	0	1	0	19	0	0	4	1	1	2	1
Number Oligochaeta Taxa	1	1	0	2	1	2	1	1	0	0	0	1	1	0	1	1	0	0	0	0	1	0	1	0	0	1	1	1	1	1
Number Orthocladiinae Taxa	3	3	3	0	8	0	6	8	2	1	1	0	3	0	1	2	5	1	1	3	3	2	8	1	3	5	5	2	3	2
Number Other FFG Individuals	4	3	8	1	38	0	35	38	0	2	23	1	0	1	2	0	9	3	15	23	5	1	30	0	4	14	17	1	3	13
Number Other FFG Taxa	1	3	1	1	3	0	2	2	0	2	3	1	0	1	1	0	2	1	0	2	1	1	2	0	1	2	3	1	1	2
Number Perlodidae Individuals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number Philopotamidae Individuals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number Plecoptera Individuals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number Plecoptera Taxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number Predator Individuals	0	2	3	0	18	0	12	10	1	13	3	13	12	7	8	17	16	4	4	3	8	0	14	3	1	10	13	4	25	14
Number Predator Taxa	0	2	2	0	7	0	4	5	1	3	3	8	7	3	3	4	5	2	1	1	3	0	7	2	1	4	5	2	4	4
Number Rhyacophilidae Individuals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number Scraper Individuals	31	0	25	0	26	0	25	14	2	4	5	32	13	7	2	3	1	0	1	9	0	0	21	21	6	1	1	4	0	3
Number Scraper Taxa	1	0	2	0	2	0	2	2	2	2	3	2	2	3	1	2	1	0	1	4	0	0	1	1	1	1	1	3	0	2
Number Sensitive EPT Individuals	0	0	0	0	0	0	0	1	0	0	19	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Number Shredder Individuals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number ShredderTaxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number Simuliidae Individuals	4	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13	0	0	0	0	0
Number Tolerant Individuals	0	1	3	0	13	0	6	3	5	2	4	15	24	4	17	13	6	0	2	10	0	0	7	2	7	3	1	3	6	3
Number Trichoptera Individuals	76	13	126	2	191	0	215	195	0	21	23	3	2	21	2	6	79	101	19	32	138	1	121	46	155	185	121	12	21	145
Number Trichoptera Taxa	1	2	1	2	3	0	2	3	0	3	3	2	1	2	1	1	2	1	1	2	1	1	2	1	1	2	3	2	1	2
Percent Amphipoda	0	0	0	0	0	0	0	0	15	0	0	7	2	0	8	6	0	0	1	1	0	0	0	0	0	0	0	0	3	0
Percent Baetidae	0	0	1	0	0	0	3	0	0	2	1	1	0	0	0	0	1	0	0	0	3	5	5	1	7	5	3	2	0	0
Percent CF + CG Individuals	76	88	81	95	84	100	82	86	85	85	64	58	94	84	93	86	89	95	81	71	94	95	86	72	95	93	86	93	79	88
Percent CF + CG Taxa	82	62	62	86	56	100	65	64	70	56	40	52	59	46	71	67	60	57	78	53	71	89	66	70	75	65	57	63	72	53
Percent CF Taxa	36	23	23	14	15	0	22	16	10	19	13	26	23	31	18	22	20	43	44	20	29	22	14	40	33	15	19	19	28	18
Percent CG Taxa	45	38	38	71	41	100	43	48	60	38	27	26	36	15	53	44	40	14	33	33	43	67	52	30	42	50	38	44	44	35
Percent Chironomidae	19	40	16	76	46	42	29	45	55	20	11	38	36	23	46	50	27	12	19	41	15	84	55	12	7	22	22	49	48	25

Percent Chironomidae Taxa	55	46	46	43	56	50	52	56	50	50	33	39	55	38	65	56	50	43	56	47	57	67	52	30	42	55	48	50	67	47
Percent Chironominae Taxa	27	23	23	43	19	50	17	20	30	31	13	30	27	31	41	33	15	29	33	13	29	44	14	20	17	20	14	25	39	24
Percent Collector-Filterers	62	43	74	5	49	0	60	60	30	24	6	31	30	41	30	34	47	75	17	38	69	11	38	62	85	66	61	45	43	71
Percent Collectors Gatherers	13	45	7	90	35	100	22	27	55	61	59	27	65	43	63	52	41	20	64	33	25	84	48	9	10	27	25	48	36	18
Percent Corbicula	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Percent Crustacea	0	0	0	0	0	0	0	0	15	0	0	7	2	0	8	8	0	0	1	1	0	0	0	0	0	0	0	0	3	0
Percent Diptera	22	43	16	76	47	42	30	45	55	20	11	39	37	23	46	50	27	12	19	41	15	84	55	14	13	22	22	49	48	25
Percent Diptera Taxa	64	54	46	43	59	50	57	60	50	50	33	43	59	38	65	56	50	43	56	47	57	67	55	50	50	55	48	50	67	47
Percent Dominant Taxon	51	28	62	52	36	33	47	39	30	55	53	28	42	42	37	20	34	65	60	24	58	37	25	53	73	50	48	35	20	55
Percent Elmidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Percent Ephemeroptera	23	18	16	0	10	0	14	9	15	56	55	9	16	42	37	20	33	20	60	24	20	5	12	29	10	21	21	37	20	13
Percent Ephemeroptera Taxa	18	8	31	0	7	0	13	12	10	13	20	9	5	8	6	6	15	14	11	7	14	11	14	30	25	15	14	13	6	12
Percent EPT Taxa	27	23	38	29	19	0	22	24	10	31	40	17	9	23	12	11	25	29	22	20	21	22	21	40	33	25	29	25	11	24
Percent Gastropoda	0	0	0	0	1	0	0	0	10	3	5	29	3	8	1	1	0	0	1	7	0	0	0	0	0	0	0	2	0	0
Percent Glossosomatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Hydropsychidae	53	30	66	5	37	0	52	42	0	15	0	2	0	22	0	4	34	66	4	9	63	5	26	54	74	52	52	9	16	56
Percent Hydroptilidae	0	3	0	5	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	2	0	0	0	0	0	2	1	1	0	2
Percent Intolerant	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Percent Intolerant Diptera	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Percent Intolerant Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Intolerant Scrapers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Intolerant Taxa (0-2)	0	0	0	0	8	0	0	8	0	0	0	0	0	0	0	0	5	0	0	0	0	0	3	0	0	0	5	0	0	0
Percent Intolerant Trichoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Mollusca	0	0	0	0	1	0	0	0	10	3	5	30	3	8	1	1	0	0	1	7	0	0	0	0	3	0	0	2	0	0
Percent Non Baetis Fallceon Ephemeroptera	23	18	15	0	10	0	11	9	15	55	54	8	16	42	37	20	32	20	60	24	16	0	10	28	3	16	18	35	20	12
Percent Non Hydro Cheumato Trichoptera	0	0	0	5	1	0	0	0	0	1	26	1	0	1	0	0	0	0	15	15	0	0	0	0	0	2	2	1	0	2
Percent Non-Gastropoda Scrapers	22	0	13	0	4	0	6	3	0	0	1	0	0	0	0	1	0	0	0	1	0	0	5	25	3	0	0	1	0	1
Percent Non-Hydropsyche Hydropsychidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Non-Insecta Taxa	9	8	15	29	15	50	17	12	30	13	13	35	23	31	18	28	10	0	22	27	7	11	14	10	17	10	10	19	11	18
Percent of Ephemeroptera that are Intolerant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent of Trichoptera that are Intolerant	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Oligochaeta	2	3	0	14	0	58	1	2	0	0	0	6	42	0	5	9	0	0	0	0	0	0	4	0	0	1	0	1	2	0
Percent Oligochaeta Taxa	9	8	0	29	4	50	4	4	0	0	0	4	5	0	6	6	0	0	0	0	7	0	3	0	0	5	5	6	6	6
Percent Orthocladiinae Taxa	27	23	23	0	30	0	26	32	20	6	7	0	14	0	6	11	25	14	11	20	21	22	28	10	25	25	24	13	17	12
Percent Other FFG	3	8	4	5	8	0	9	8	0	2	26	1	0	1	1	0	4	2	15	19	2	5	7	0	2	4	8	1	2	5
Percent Other FFG Taxa	9	23	8	14	11	0	9	8	0	13	20	4	0	8	6	0	10	14	0	13	7	11	7	0	8	10	14	6	6	12
Percent Perlodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Philopotamidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Plecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent Plecoptera Taxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Predator Taxa	0	15	15	0	26	0	17	20	10	19	20	35	32	23	18	22	25	29	11	7	21	0	24	20	8	20	24	13	22	24
Percent Predators	0	5	2	0	4	0	3	2	5	10	3	12	3	8	5	12	7	3	4	2	4	0	3	4	0	3	6	3	19	6
Percent Rhyacophildae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Scraper Taxa	9	0	15	0	7	0	9	8	20	13	20	9	9	23	6	11	5	0	11	27	0	0	3	10	8	5	5	19	0	12
Percent Scrapers	22	0	13	0	5	0	6	3	10	3	6	29	3	8	1	2	0	0	1	7	0	0	5	25	3	0	0	3	0	1
Percent Shredder Taxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Shredders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent Simuliidae	3	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0	0	0	0	0
Percent Tolerant	0	3	2	0	3	0	1	1	25	2	5	14	5	4	10	10	3	0	2	8	0	0	2	2	3	1	0	2	5	1
Percent Tolerant Taxa (8-10)	0	8	15	0	8	0	13	8	30	13	13	27	23	17	25	29	11	0	25	33	0	0	14	10	17	5	5	13	12	6
Percent Trichoptera	53	33	66	10	38	0	53	43	0	16	26	3	0	23	1	4	35	66	18	26	63	5	27	54	74	54	54	10	16	58
Percent Trichoptera Taxa	9	15	8	29	11	0	9	12	0	19	20	9	5	15	6	6	10	14	11	13	7	11	7	10	8	10	14	13	6	12
EPT Index (%)	76	50	82	10	49	0	67	52	15	73	82	12	16	65	38	24	68	86	79	50	83	11	38	84	84	75	75	47	36	71
Sensitive EPT Index (%)	0	0	0	0	0	0	0	0	0	0	22	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shannon Diversity	1.6	2.4	1.4	1.5	2.4	1.4	2.2	2.3	2.1	1.8	1.7	2.4	1.7	1.9	2.0	2.5	2.0	1.2	1.5	2.2	1.6	1.8	2.7	1.5	1.2	1.9	1.9	2.0	2.4	1.7
Simpsons Index	0.3	0.1	0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.3	0.3	0.1	0.3	0.2	0.2	0.1	0.2	0.5	0.4	0.1	0.4	0.2	0.1	0.3	0.5	0.3	0.3	0.2	0.1	0.3
Taxonomic Richness	11	13	13	7	27	4	23	25	10	16	15	23	22	13	17	18	20	7	9	15	14	9	29	10	12	20	21	16	18	17
Tolerance Value	4.5	5.0	4.4	5.9	5.1	5.6	4.8	4.9	6.3	4.6	4.3	6.0	5.4	4.8	5.4	5.7	4.7	4.3	4.4	5.2	4.4	5.8	5.3	4.4	4.5	4.6	4.6	5.1	5.3	4.6

Waterbody Name	**Dry Creek**											
Site	**Site 3**											
Deployment Length	**4 Weeks**						**6 Weeks**					
Sample	1	2	3	4	5	6	1	2	3	4	5	6
Top, bottom or veg	V	B	V	T	V	B	V	T	B	V	T	B
EPT Taxa	3	4	4	7	7	7	5	4	4	3	4	6
Number Amphipoda Individuals	0	0	0	0	0	0	0	0	0	0	0	6
Number Baetidae Individuals	0	12	4	1	4	28	0	19	19	11	3	1
Number CF + CG Individuals	90	382	113	215	151	412	121	420	349	73	230	260
Number CF + CG Taxa	12	13	10	13	9	11	11	14	13	9	11	12
Number Chironomidae Individuals	105	137	86	176	84	41	89	90	116	26	78	151
Number Chironomidae Taxa	12	11	9	13	9	8	10	11	10	7	10	9
Number Chironominae Taxa	6	4	4	6	4	4	4	4	4	3	4	4
Number Coleoptera Taxa	0	0	1	0	0	0	0	0	0	0	0	0
Number Collector Filterer Individuals	53	263	69	117	123	364	30	352	255	45	160	76
Number Collector Filterer Taxa	3	4	3	4	3	4	3	3	3	3	3	2
Number Collector Gatherer Individuals	37	119	44	98	28	48	91	68	94	28	70	184
Number Collector Gatherer Taxa	9	9	7	9	6	7	8	11	10	6	8	10
Number Corbicula Individuals	0	1	0	0	0	0	1	0	0	0	0	0

Number Crustacea + Mollusca Individuals	2	4	11	24	1	4	73	7	12	22	25	71
Number Crustacea Individuals	1	0	0	8	0	0	30	1	3	0	5	29
Number Diptera Individuals	105	137	86	176	84	41	91	90	117	26	78	152
Number Diptera Taxa	12	11	9	13	9	8	11	11	11	7	10	10
Number Elmidae Individuals	0	0	0	0	0	0	0	0	0	0	0	0
Number Elmidae Taxa	0	0	0	0	0	0	0	0	0	0	0	0
Number Ephemerellidae Taxa	0	0	0	0	0	0	0	0	0	0	0	0
Number Ephemeroptera Individuals	7	98	16	60	17	42	6	33	65	21	23	86
Number Ephemeroptera Taxa	1	2	2	3	2	4	1	2	2	2	2	3
Number EPT Individuals	42	340	74	103	133	396	10	369	328	55	175	158
Number Gastropoda Individuals	1	3	11	16	1	4	42	6	9	22	20	42
Number Glossosomatidae Individuals	0	0	0	0	0	1	0	0	0	0	0	0
Number Hydropsychidae Individuals	30	214	48	34	108	350	1	326	217	34	144	19
Number Hydropsychidae Taxa	1	1	1	1	1	1	1	1	1	1	1	1
Number Hydroptilidae Individuals	5	28	10	8	6	3	1	10	43	0	8	52
Number Intolerant Diptera Individuals	0	0	0	0	0	0	0	1	0	0	0	0
Number Intolerant Ephemeroptera Individuals	0	0	0	0	0	0	0	0	0	0	0	0
Number Intolerant EPT Taxa	0	0	0	0	1	1	1	0	0	0	0	0
Number Intolerant Individuals	0	0	0	0	1	1	1	1	0	0	0	0
Number Intolerant Scraper Individuals	0	0	0	0	0	1	0	0	0	0	0	0
Number Intolerant Taxa	0	0	0	0	1	1	1	1	0	0	0	0
Number Intolerant Trichoptera Individuals	0	0	0	0	0	1	1	0	0	0	0	0
Number Mollusca Individuals	1	4	11	16	1	4	43	6	9	22	20	42
Number Mollusca Taxa	1	4	3	3	1	3	4	2	2	3	3	3
Number Non Baetis Fallceon Ephemeroptera	7	86	12	58	13	15	6	14	46	10	20	84
Number Non Hydro Cheumato Trichoptera	1	25	1	4	4	0	1	3	17	0	3	32
Number Non-Gastropoda Scraper Individuals	0	0	0	2	0	1	4	0	0	0	1	2
Number Non-insect Taxa	2	7	3	4	1	5	7	6	7	5	7	8
Number of Crustacea + Mollusca Taxa	0	0	0	0	0	0	0	0	0	0	0	0
Number Oligochaeta Individuals	0	3	0	0	0	0	3	3	7	1	5	23
Number Oligochaeta Taxa	0	1	0	0	0	0	1	1	1	1	1	1
Number Orthocladiinae Taxa	3	4	3	4	2	3	2	6	3	1	3	2
Number Other FFG Individuals	17	64	25	26	28	15	2	40	64	0	19	55
Number Other FFG Taxa	2	2	3	4	4	2	2	2	2	0	2	3
Number Perlodidae Individuals	0	0	0	0	0	0	0	0	0	0	0	0
Number Philopotamidae Individuals	0	0	0	0	0	0	0	0	0	0	0	0
Number Plecoptera Individuals	0	0	0	0	1	0	0	0	0	0	0	0
Number Plecoptera Taxa	0	0	0	0	1	0	0	0	0	0	0	0

Number Predator Individuals	52	55	40	66	42	30	31	16	64	32	28	105
Number Predator Taxa	4	6	3	5	5	4	7	5	7	5	6	6
Number Rhyacophilidae Individuals	0	0	0	0	0	0	1	0	0	0	0	0
Number Scraper Individuals	1	3	11	18	1	5	46	6	9	22	21	44
Number Scraper Taxa	1	3	3	5	1	4	4	2	2	3	4	5
Number Sensitive EPT Individuals	0	0	0	2	3	1	1	0	0	0	0	0
Number Shredder Individuals	0	0	0	0	0	0	0	0	0	0	0	0
Number ShredderTaxa	0	0	0	0	0	0	0	0	0	0	0	0
Number Simuliidae Individuals	0	0	0	0	0	0	0	0	0	0	0	0
Number Tolerant Individuals	15	21	27	34	3	23	98	10	19	24	45	78
Number Trichoptera Individuals	35	242	58	43	115	354	4	336	263	34	152	72
Number Trichoptera Taxa	2	2	2	4	4	3	4	2	2	1	2	3
Percent Amphipoda	0	0	0	0	0	0	0	0	0	0	0	1
Percent Baetidae	0	2	2	0	2	6	0	4	4	9	1	0
Percent CF + CG Individuals	56	76	60	66	68	89	61	87	72	57	77	56
Percent CF + CG Taxa	63	54	53	48	47	52	46	61	54	53	48	46
Percent CF Taxa	16	17	16	15	16	19	13	13	13	18	13	8
Percent CG Taxa	47	38	37	33	32	33	33	48	42	35	35	38
Percent Chironomidae	66	27	46	54	38	9	45	19	24	20	26	33
Percent Chironomidae Taxa	63	46	47	48	47	38	42	48	42	41	43	35
Percent Chironominae Taxa	32	17	21	22	21	19	17	17	17	18	17	15
Percent Collector-Filterers	33	52	37	36	55	79	15	73	52	35	54	16
Percent Collectors Gatherers	23	24	23	30	13	10	46	14	19	22	23	40
Percent Corbicula	0	0	0	0	0	0	1	0	0	0	0	0
Percent Crustacea	1	0	0	2	0	0	15	0	1	0	2	6
Percent Diptera	66	27	46	54	38	9	46	19	24	20	26	33
Percent Diptera Taxa	63	46	47	48	47	38	46	48	46	41	43	38
Percent Dominant Taxon	23	36	25	24	47	70	17	43	30	20	40	18
Percent Elmidae	0	0	0	0	0	0	0	0	0	0	0	0
Percent Ephemeroptera	4	19	8	18	8	9	3	7	13	17	8	19
Percent Ephemeroptera Taxa	5	8	11	11	11	19	4	9	8	12	9	12
Percent EPT Taxa	16	17	21	26	37	33	21	17	17	18	17	23
Percent Gastropoda	1	1	6	5	0	1	21	1	2	17	7	9
Percent Glossosomatidae	0	0	0	0	0	0	0	0	0	0	0	0
Percent Hydropsychidae	19	42	25	10	49	76	1	68	45	27	48	4
Percent Hydroptilidae	3	6	5	2	3	1	1	2	9	0	3	11
Percent Intolerant	0	0	0	0	0	0	1	0	0	0	0	0
Percent Intolerant Diptera	0	0	0	0	0	0	0	0	0	0	0	0
Percent Intolerant Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0

Percent Intolerant Scrapers	0	0	0	0	0	0	0	0	0	0	0	0
Percent Intolerant Taxa (0-2)	0	0	0	0	5	5	4	4	0	0	0	0
Percent Intolerant Trichoptera	0	0	0	0	0	0	1	0	0	0	0	0
Percent Mollusca	1	1	6	5	0	1	22	1	2	17	7	9
Percent Non Baetis Fallceon Ephemeroptera	4	17	6	18	6	3	3	3	9	8	7	18
Percent Non Hydro Cheumato Trichoptera	1	5	1	1	2	0	1	1	3	0	1	7
Percent Non-Gastropoda Scrapers	0	0	0	1	0	0	2	0	0	0	0	0
Percent Non-Hydropsyche Hydropsychidae	0	0	0	0	0	0	0	0	0	0	0	0
Percent Non-Insecta Taxa	11	29	16	15	5	24	29	26	29	29	30	31
Percent of Ephemeroptera that are Intolerant	0	0	0	0	0	0	0	0	0	0	0	0
Percent of Trichoptera that are Intolerant	0	0	0	0	0	0	25	0	0	0	0	0
Percent Oligochaeta	0	1	0	0	0	0	2	1	1	1	2	5
Percent Oligochaeta Taxa	0	4	0	0	0	0	4	4	4	6	4	4
Percent Orthocladiinae Taxa	16	17	16	15	11	14	8	26	13	6	13	8
Percent Other FFG	11	13	13	8	13	3	1	8	13	0	6	12
Percent Other FFG Taxa	11	8	16	15	21	10	8	9	8	0	9	12
Percent Perlodidae	0	0	0	0	0	0	0	0	0	0	0	0
Percent Philopotamidae	0	0	0	0	0	0	0	0	0	0	0	0
Percent Plecoptera	0	0	0	0	0	0	0	0	0	0	0	0
Percent Plecoptera Taxa	0	0	0	0	5	0	0	0	0	0	0	0
Percent Predator Taxa	21	25	16	19	26	19	29	22	29	29	26	23
Percent Predators	33	11	21	20	19	6	16	3	13	25	9	23
Percent Rhyacophildae	0	0	0	0	0	0	1	0	0	0	0	0
Percent Scraper Taxa	5	13	16	19	5	19	17	9	8	18	17	19
Percent Scrapers	1	1	6	6	0	1	23	1	2	17	7	9
Percent Shredder Taxa	0	0	0	0	0	0	0	0	0	0	0	0
Percent Shredders	0	0	0	0	0	0	0	0	0	0	0	0
Percent Simuliidae	0	0	0	0	0	0	0	0	0	0	0	0
Percent Tolerant	10	4	14	10	1	5	50	2	4	19	15	17
Percent Tolerant Taxa (8-10)	26	25	21	19	16	19	33	17	25	24	22	19
Percent Trichoptera	22	48	31	13	52	77	2	70	54	27	51	16
Percent Trichoptera Taxa	11	8	11	15	21	14	17	9	8	6	9	12
EPT Index (%)	26	67	39	32	60	86	5	77	67	43	59	34
Sensitive EPT Index (%)	0	0	0	1	1	0	1	0	0	0	0	0
Shannon Diversity	2.5	2.2	2.6	2.6	1.9	1.4	2.7	2.0	2.5	2.6	2.5	2.8
Simpsons Index	0.1	0.2	0.1	0.1	0.3	0.5	0.1	0.2	0.1	0.1	0.2	0.1
Taxonomic Richness	19	24	19	27	19	21	24	23	24	17	23	26
Tolerance Value	5.5	4.8	5.4	5.5	4.7	4.4	6.8	4.4	4.7	5.6	5.1	5.6