
A Comparison of Surber (COA) and Kicknet (TCEQ) Benthic Macroinvertebrate Sampling Methods



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Table of Contents

Introduction.....	1
Methods.....	3
<i>Study Area</i>	<i>3</i>
<i>Surber samples using City of Austin protocols.....</i>	<i>6</i>
<i>Analysis</i>	<i>8</i>
Results	10
<i>Coefficient of Variation</i>	<i>11</i>
<i>Wilcoxon Matched Pairs Test.....</i>	<i>11</i>
<i>Probability of Occurrence.....</i>	<i>12</i>
Conclusions	14
Literature Cited.....	15



A Comparison of Surber (COA) and Kicknet (TCEQ) Benthic Macroinvertebrate Sampling Methods

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Benthic macroinvertebrate community composition and structure is compared in benthic samples collected by Surber samples taken with City of Austin protocols and kick samples taken with TCEQ protocols. Samples were collected using both methods concurrently from riffles at eight sites in four watersheds in Travis County, Texas. Analysis of the samples collected shows that the qualitative Aquatic Life Use scores are not significantly different between composite Surber and kicknet samples.

Introduction

Monitoring of the biota of a water body is an important component of water quality evaluation. Biological monitoring can effectively screen for problems that are not specifically tested for through the use of conventional methods of water chemistry sampling. For example, the presence of heavy metals, pesticides, herbicides and other toxins may not be revealed in the traditional suite of chemical parameters, but may be indicated by a lack of biodiversity and the composition of the biological community of a water body. Direct measurements of the resident biota that are used to evaluate the relative “health” of a water body are called biological assessments, or bioassessments.

Benthic macroinvertebrates have been used in stream assessments since the 1970’s and since that time numerous methods for collection and evaluation have been developed. Assessments of benthic macroinvertebrate communities became widely used by federal, state and local governments because they are cost-effective, use scientifically tested protocols, provide quick turn-around of results and use environmentally benign procedures (Barbour *et al.* 1999). In fact, the use of benthic macroinvertebrate assemblage has been the most popular set of biological protocols among the state water resource agencies since 1989 (Southerland and Stribling 1995).

The USEPA conducted a survey in 1985 to identify successful bioassessment methods that were used by several State agencies. The product of this effort was the Rapid Bioassessment Protocols (RBPs, Barbour *et al.* 1999). Although the RBPs essentially set the standard for bioassessment procedures for state and local agencies, the intent of the document was to provide guidance, alternative methodologies, and supplemental protocols for existing programs, rather than supersede existing approaches that have been successfully implemented (Barbour *et al.* 1999). State agencies and local entities periodically modify their collection protocols in an effort to find the most appropriate method for project-specific needs and regional differences. The Surface Water Quality Monitoring (SWQM) program of the Texas Commission on Environmental Quality (TCEQ) is endowed with the authority

to adjust the biological monitoring requirements and collection protocols, in part, to obtain quality assured and comparable data that can be used to accurately assess aquatic community composition and integrity throughout the state. While the original concept of the RBPs has been maintained, the SWQM bioassessment procedures have changed over the years. For example, the SWQM procedures for the late 1990's required 100+ organisms per sample once per year, while the procedures for 2006 require the collection of a minimum of 140+ organisms per sample twice per year. Likewise, the sampling methods of local governments, such as the City of Austin (COA), maintain the original concept of the EPA RBPs, periodically refining them based on their expanding knowledge of local stream characteristics. The COA bioassessment protocols have evolved in response to the goal of obtaining the most accurate characterization of the aquatic resources within its jurisdiction using the most efficient and effective methods possible.

The COA Surface Water Evaluation (SWE) team members have been using a Surber sampling method since 1995 in stream riffle habitat in the Austin area. The COA method includes picking macroinvertebrates from a composite of three Surber samples collected at the bottom, middle and top of a riffle. This method was selected based on an extensive literature review and knowledge of local stream characteristics. The Surber method has been used since 1937 and, like all methods, has advantages and disadvantages. Hornig and Pollard's (1978) comparison of Surber and kick methods in semi-arid regions indicated that kick methods yielded more taxa and higher reproducibility compared to single Surber samples; however, Storey et al. (1991) found that average values for replicated Surber samples consistently contained both higher species richness and higher number of low-occurrence taxa than kick net methods. The primary advantages of using a composite Surber sampler include a minimal disruption to riffle habitat and the ability to analyze the data quantitatively for density and spatial richness. Both of these advantages support the SWE goals of assessment of, tracking changes within and protection of, aquatic integrity. The primary disadvantage of the Surber method includes an increased cost per unit effort inherent in the more intensive quantitative methods and a potential bias toward closely adherent taxa (Storey *et al.* 1991).

Biological data collected for the TCEQ is used in the assessments of Texas surface waters in programs such as the Clean Rivers Program (CRP) and for Total Maximum Daily Load (TMDL) assessments. Specifically, data from CRP partners are used in 303(d) and 305(b) assessments to identify "impaired" and "of concern" water bodies across the State of Texas. Future monitoring and remediation efforts are planned based on the 303(d) and 305(b) evaluations. In addition, the designations of Aquatic Life Use (ALU) ratings are used to determine some aspects of water resource policy. Permitting requirements for facilities which discharge wastewater are evaluated based on the pre-existing quality of receiving waters. Higher ALU designations of a receiving water body require more stringent environmental constraints for facilities that intend to discharge to them.

Water quality sampling in the lower Colorado River watershed is coordinated by the Lower Colorado River Authority (LCRA) under the TCEQ CRP. Since 2002, the City of Austin has been a CRP partner, providing water quality data to the LCRA for submittal to the TCEQ. The COA would like to continue participating in the CRP to more accurately and thoroughly characterize the physical, chemical and biological components of Austin surface waters from a state-wide perspective. Although the TCEQ is currently accepting COA benthic data, the TCEQ will not use the data in their full assessment of impairment due to the difference in methods. This report evaluates the comparability of the COA and TCEQ methods. The evaluation is based on samples taken in August 2006 by the SWE team in which eight sites were sampled using both methods in the same habitat. The null hypothesis is that there will be no significant difference in TCEQ index scores using communities sampled with either method.

Methods

Study Area

Samples taken with both Surber and kick methods were collected between August 10th and August 18th 2006. In addition to the biological data collected, flow and physico-chemical parameters (pH, DO, specific conductance, temperature) were measured at all sites by standard field procedures as defined in the Standard Operating Procedures manual (COA SOP 2004). Since the geology, hydrology, substrate composition and stream morphology of Austin streams is highly variable from east to west and from urban to suburban areas, eight sites within four watersheds were selected which were representative of the two main ecological regions (Griffith et al. 2004) and land uses in the Austin area (Figure 1).

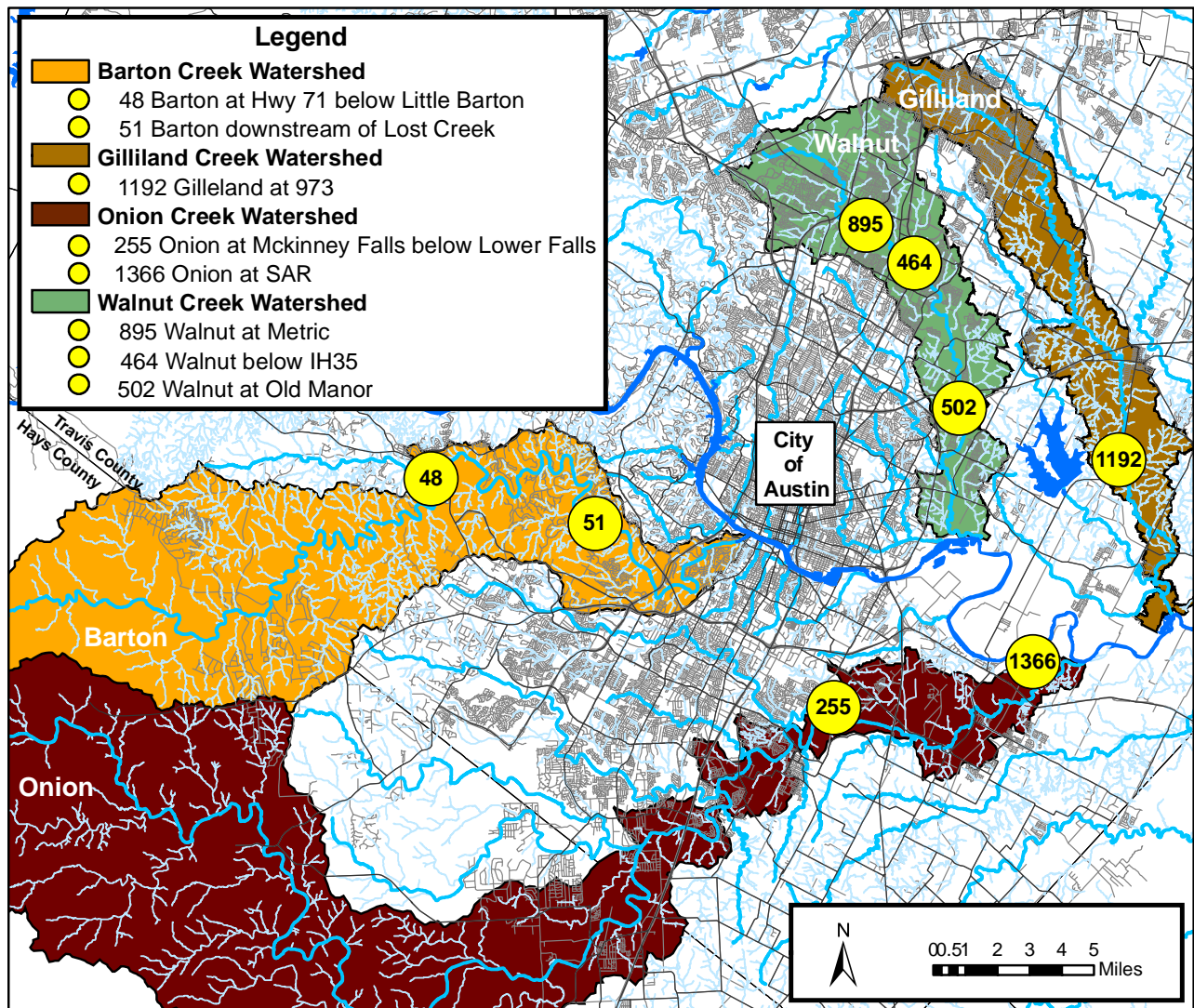


Figure 1. Sample sites were chosen at locations which were characterized by large watersheds with stable and perennial riffle habitat.

Four sites were located in the Balcones Canyonlands ecoregion in the western half of Austin (Figure 2). Streams in this area are generally higher gradient with frequent riffles separated by limestone bedrock runs and shallow pools. The Barton Creek sites 48 and 51 are well inside the Balcones Canyonlands ecoregion on the west side of Austin. Land use near these two sites is primarily low density residential and although historical development has been slow, it is increasing. Although the Walnut Creek sites 464 and 895 are located in a transition zone between the Balcones Canyonlands and the Northern Blackland Prairie ecoregions, the physical stream attributes are more characteristic of Balcones Canyonlands. Land use near these two sites is high density residential and light commercial. The other four sites were located in the Northern Blackland Prairies ecoregion in the eastern half of Austin (Figure 3). Streams in this area are generally lower gradient with infrequent riffles separated by sandy soft-bottomed runs and deep pools. The land use adjacent to all four sites has historically been agricultural, but is experiencing a transition to suburban residential.

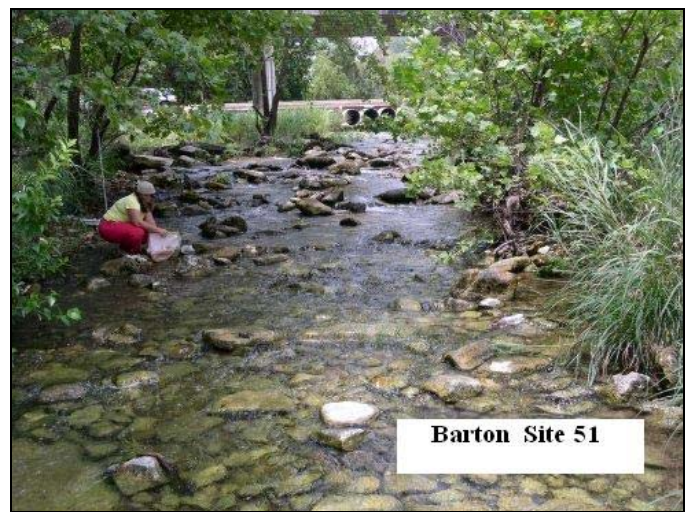


Figure 2. Photographs of four of the eight sampling sites located in the Balcones Canyonlands ecoregion (Site # 48, 51, 464 and 895).

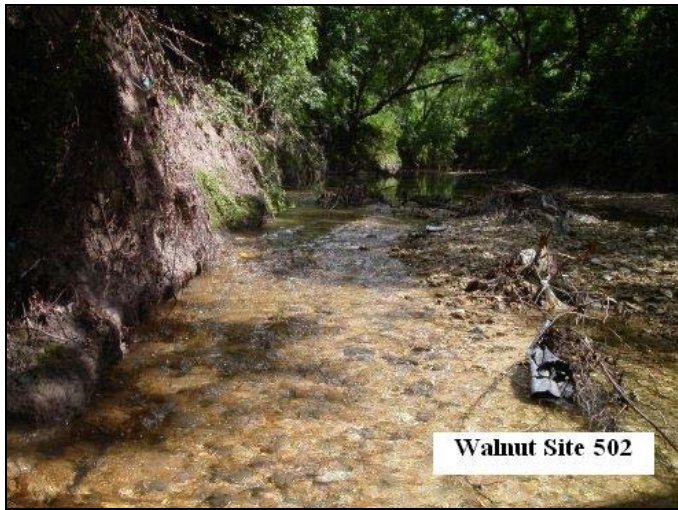


Figure 3. Photographs of sample sites located in the Northern Blackland Prairie ecoregion (Site # 502, 1192, 255 and 1366).

Surber samples using City of Austin protocols

A complete description of collection methods and materials for screening level programs and intensive study programs is maintained in the WRE Standard Operating Procedures manual (COA SOP 2004). Surber sampler protocols used in this study are those described for intensive study programs of the COA and are summarized below.

At each site, three Surber (1 ft², 500 μm mesh-size) samples were collected from transects across the bottom, middle and top parts of the riffle, in that order. The bottom riffle sample was designated as Surber “A,” the middle was Surber “B” and the top was Surber “C” (Figure 4), so that sample data can be analyzed for spatial variation. The samples (detritus inclusive) were retained discretely and deposited into three white sorting pans.

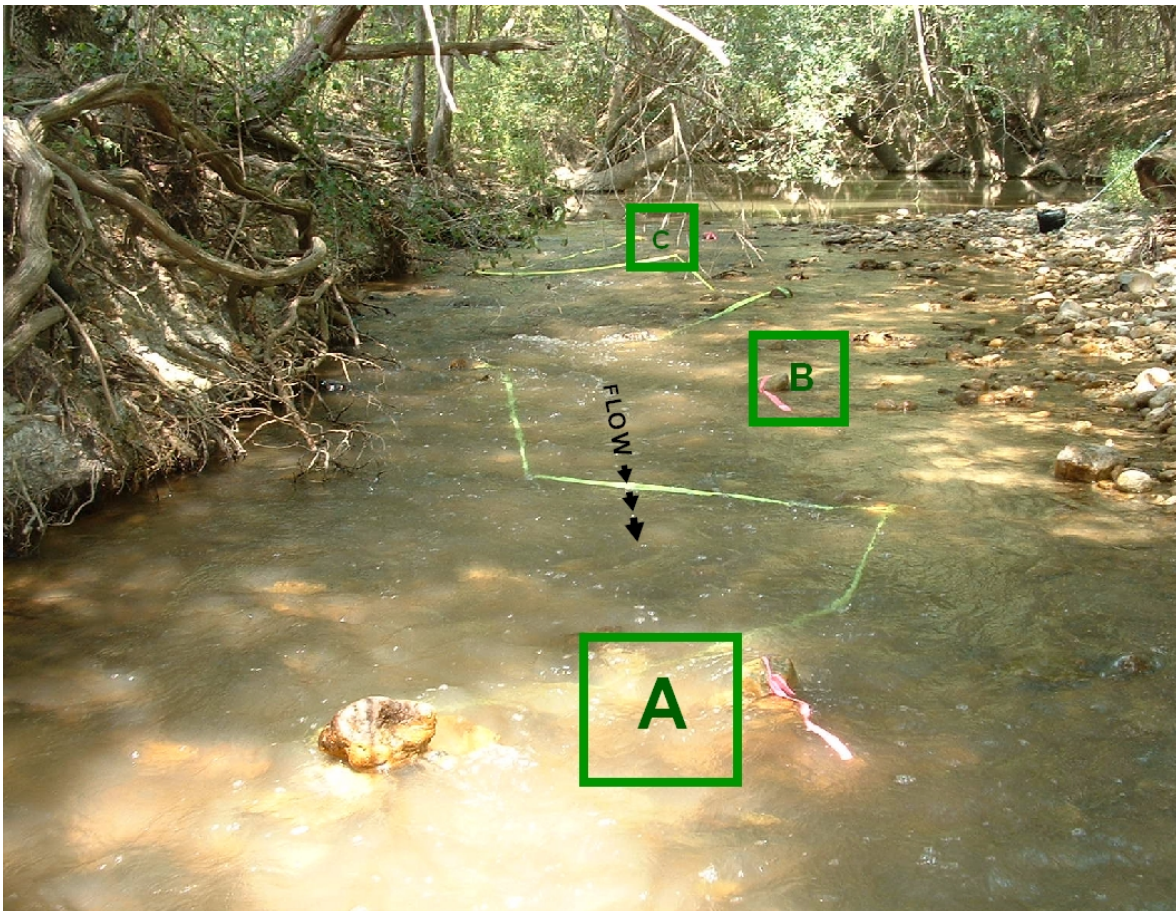


Figure 4. Approximate locations of Surber samples A, B and C at the bottom, middle and top of the riffle of site 1192 (Gilleland Creek at FM973). At each of the eight sample sites, three Surber sample locations were chosen to be representative of the habitat composition of the riffle.

Each sample was picked in its entirety in the field unless preliminary inspection of a sample indicated high abundance (>1000 organisms for all three Surbers). In which case, each sample was sub-sampled with a USEPA sample processing tray (Caton 1991). Subsampling procedures

began with depositing the entire contents of a single Surber in a Caton subsampling tray and agitating to produce a homogeneous distribution of material. Four Caton grids (out of 30) were chosen at random by a second member of the team and transferred to separate sorting pans to be enumerated and sorted. Additional Caton grids were selected and picked in their entirety until a minimum of 100 organisms (per Surber) was reached, resulting in a minimum of 300 organisms per site. The number of grids extracted was recorded on the field sheets. The remaining detritus in each of the sorted pans was reviewed by a second sorter to insure sufficient percent recovery. Specimens were preserved in vials of 70% ethanol, labeled and transported to the COA lab for identification. Benthic Macroinvertebrates were identified to the lowest practical taxa (usually genera) as defined by the SWQM manual (TCEQ 2005).

Kick samples using TCEQ protocols

The Rapid Bioassessment Protocol (RBP) currently used by TCEQ programs in establishing the ALU for classified and unclassified water bodies can be found in the Surface Water Quality Monitoring Procedures manual, Volume 2 (TCEQ 2005). The kick sample protocols used in this study are those described for streams that are primarily composed of gravel and cobble substrate and are summarized below.

At each site, a standard kicknet (500 μ m mesh-size, 46 cm width 25 cm height) was placed in the stream facing upstream at the bottom of the riffle. Approximately 0.3 m² of streambed substrate was thoroughly disturbed with the foot (and sometimes hand) immediately upstream so that dislodged material flowed into the net. This procedure was repeated 5-6 times for a total of 5 minutes of “kick time” (Figure 5). Areas that had been disturbed by Surber samplers and areas immediately downstream of previous Surber samples were avoided.

After completion of the 5-minute kick, the contents of the net were deposited into a white sorting pan. The net was inspected for clinging organisms which were moved to the sample pan. Large debris was rinsed over the pan and inspected thoroughly for adhering organisms, which were also placed into the sample. The complete sample was then visually inspected to estimate the total number of organisms. This estimate was used to determine if additional samples or subsampling would be conducted. At each of the eight study sites, the contents of the sample appeared to contain more than the 210 organisms, as a result, all kicknet samples were subsampled using a USEPA sample processing tray (Caton 1991) as described above to a sample size target of 175 organisms (+/- 20%). Specimens were preserved in vials of 70% ethanol, labeled and transported to the City of Austin lab for identification. Benthic Macroinvertebrates were identified to the lowest practical taxa as defined by the SWQM manual (TCEQ 2005).

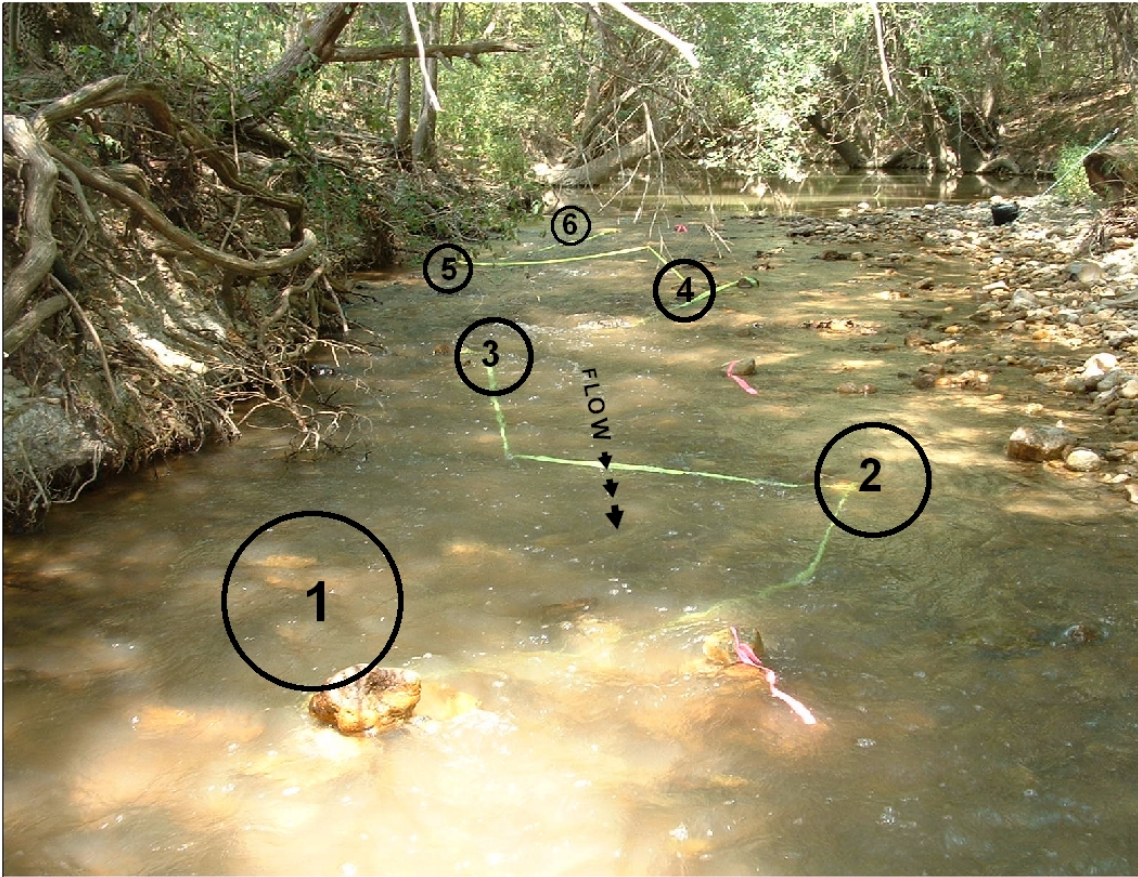


Figure 5. Approximate locations of kicknet samples in the riffle at site 1192 (Gilleland Creek at FM973). At each of the eight sample sites a “kick” effort was repeated 5 to 6 times throughout the riffle for 5-minutes of “kick time” proceeding upstream in a zigzag pattern in order to represent the longitudinal and cross-sectional heterogeneity of the riffle.

Analysis

For each site, raw metrics and ALU scores were calculated based on the multi-metric TCEQ Qualitative method (SWQM 2006) for (1) the kicknet samples, (2) the composite of three Surber samples and (3) on each individual Surber samples. In addition, metric calculations were also performed (4) on a computer derived 175-organism subsample of the 3-Surber composite samples in order to make abundances comparable to the TCEQ method. This subsample was generated by averaging 25 replicates of the random subsamples using the DBMS_RANDOM PL/SQL function in SAS (SAS 2004). The metrics used in this method include; number of taxa, Hilsenhoff Biotic Index, % of total as Chironomidae, % dominance (top 1 taxa), % of total as dominant guild, % total as predator, ratio of intolerant to tolerant, % of Trichoptera as Hydropsychidae, number of non-insect taxa, % of total as collector/gatherer, and % of total as Elmidae. Statistical analysis used on the taxa, metrics and ALU scores include percent coefficient of variation, Wilcoxon matched pairs test and probability of occurrence (SAS 2004).

The percent coefficient of variation (COV) is the ratio of the standard deviation to the mean expressed as a percentage. It is a measure of the dispersion of data points in a data series around the mean, and can be used as a general measure of the variability of each method. In this type of analysis, a low COV indicates less variability within the data set. Data sets that have similar COV values are presumed to be comparable, since they have approximately the same quantitative variability between sites.

Due to an uneven or patchy spatial distribution of organisms in streams there is natural variability in sample composition intrinsic when collecting benthic macroinvertebrates. Paired tests, such as the Wilcoxon matched pairs test, are used to control for experimental variability outside of the treatment effect by analyzing only the differences between pairs of data sets (Sokal and Rohlf 1995). The magnitude of the result from the matched pairs test provides an indication of the statistical significance of method differences. Two samples taken from the same site will naturally differ even if the protocol is identical. Therefore, to determine whether two methods are different, the magnitude and direction of the differences are compared using the Wilcoxon matched pairs test.

The probability of occurrence was also used as a tool to compare methods. The equation is expressed as:

$$\text{Probability of taxa } i = (\# \text{ samples where taxa } i \text{ was observed}) / (\text{total } \# \text{ of samples})$$

and is the statistical likelihood of finding at least one individual for each of the 77 taxa found during this study by each of the methods. The probability of occurrence is expressed as a decimal ranging from zero to one. A probability near 0 indicates that it is unlikely that a taxon would be represented by a certain method. If it is likely that a taxon would be represented by a certain method, it will have probability near 1.

Results

Raw data from benthic samples for each method is located in Appendix A. ALU scores were calculated for discrete samples collected from the eight test sites for the each of the methods used (Figure 6).

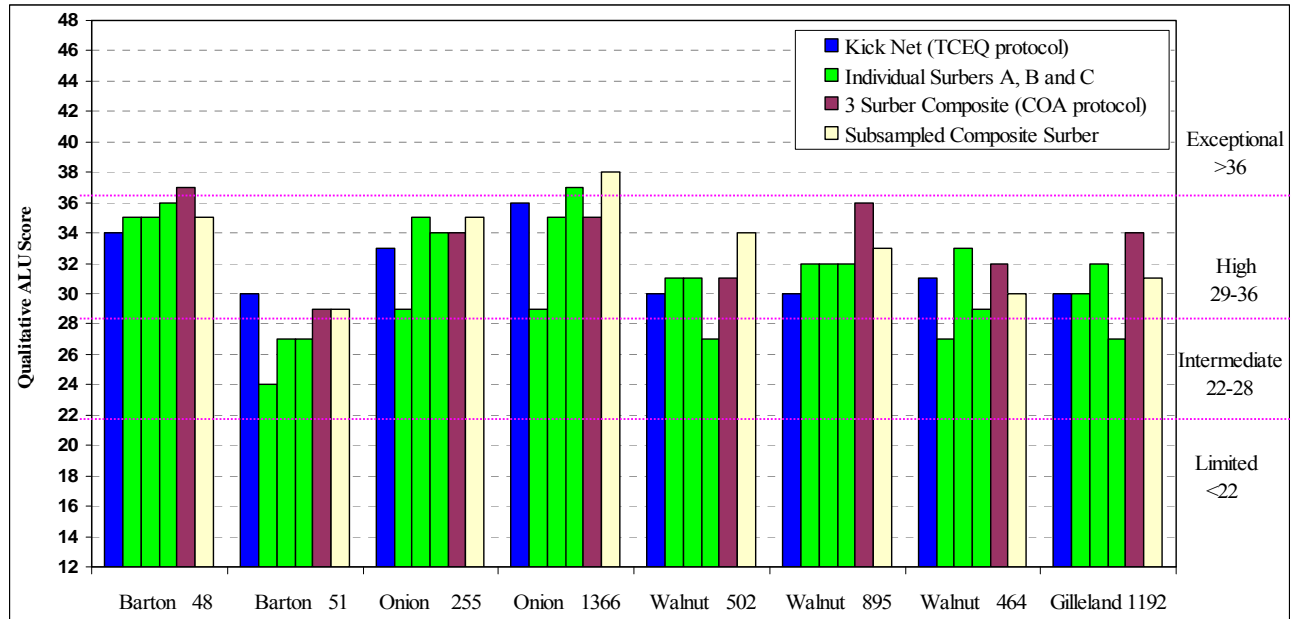


Figure 6. Aquatic Life Use scores for each method at the eight sample sites. Average size of kicknet samples was 208 individuals. Average sample size of a single Surber was 180 individuals while a 3-Surber composite was 540 individuals. Programmatically derived random subsamples of the 3-Surber composite were 175 individuals each.

Although the individual Surbers (■) were frequently similar to each other, and occasionally identical, they varied by up to eight points within a site (site 1366). The subsampled composite Surbers (■) were generally in agreement with the composite Surber (■). Subsampled composite Surber scores were always within three points of the composite score. The two most similar groups were the composite Surber and the kicknet method (■). ALU scores for the composite Surber method were within one point of the kicknet method for five of the eight sites. The largest difference in scores between composite Surber and kicknet was six points at site 895. Despite this discrepancy at site 895, both methods resulted in the same ALU designation of “High”. At six of the eight sites, the ALU score of the composite Surber was higher than that of the kicknet ALU score. In addition, the scores of the kicknet and composite Surber were in the same ALU range (“High” designation) for seven out of eight sites.

Coefficient of Variation

The average COV of the metrics and the ALU score were calculated in order to compare variability among the four sampling methods (Table 1). COV values from the individual Surber samples (A, B and C) showed a wide range among individual metrics as well as a wide variability between ALU scores, indicating high variability within the method. The COV for the ALU score of the kicknet (7.29) and composite Surber methods (7.98) were very close.

Table 1. Average percent Coefficient of Variation for metrics and ALU scores for each sampling method from eight sample sites.

Metric Parameter	Kick net	Surber A	Surber B	Surber C	3-Surber Composite	Subsample of Composite Surber
Number of Taxa	22.00	15.94	19.12	17.79	23.02	18.62
Number of EPT Taxa	17.97	37.64	31.16	12.42	25.12	18.90
Hilsenhoff Biotic Index (HBI)	12.05	15.47	7.53	11.12	10.74	10.45
% of Total as Chironomidae	76.88	76.44	73.31	63.20	56.13	64.62
% Dominance (Top 1 Taxa)	37.47	44.95	27.44	24.76	62.27	34.97
% of Total as Dominant Guild (FFG)	13.29	25.18	11.16	13.13	15.53	19.04
% of Total as Predator	39.73	58.33	30.12	55.35	46.26	38.74
Ratio of Intolerant to Tolerant	55.38	52.89	33.80	56.30	44.79	44.61
% of Trichoptera as Hydropsychidae	35.85	73.03	21.33	31.52	30.70	30.35
Number of Non-insect Taxa	70.95	55.64	51.75	45.82	47.97	49.88
% of Total as Collector/Gatherer	35.56	44.26	37.51	26.08	25.26	25.53
% of Total as Elmidae	48.01	88.29	51.74	55.51	49.18	48.84
TCEQ Qualitative ALU Score	7.29	11.11	8.39	13.46	7.98	9.64

Wilcoxon Matched Pairs Test

Each of the individual Surbers (three per site) were compared to the kicknet samples at each of the eight sites (n=24) using the Wilcoxon matched pairs test. The 3-Surber composite samples (one per site) were compared to the kicknet samples at each of the eight sites (n=8) and the programmatically subsampled Surber composite samples (25 replicates per site) were compared to the kicknet samples at each of the eight sites (n=200) also using the Wilcoxon matched pairs test. Results showed that the composite Surber method was statistically similar for 11 out of the 13 biological measures (Table 2). The individual Surber samples also produced statistically similar results (10 out of 13). However, a significant difference was shown between the subsampled Surber vs. the kicknet method for most measures.

Table 2. Results from Wilcoxon Matched Pairs Test comparing individual Surber, composite Surber and subsampled composite Surber methods to kick-net methods for 13 biological measures. The composite Surber showed significant differences for only two out of the thirteen parameters.

* = significant difference between compared methods ($p < 0.05$)

Metric Parameter	Individual Surber vs Kicknet (n=24)	3-Surber Composite vs Kicknet (n=8)	Subsampled Composite Surber vs Kicknet (n=200)
Number of Taxa	0.0002*	0.0180*	<0.0001*
Number of EPT Taxa	0.0538	0.4008	0.0001*
Hilsenhoff Biotic Index (HBI)	0.8314	0.6744	0.6529
% of Total as Chironomidae	0.0119*	0.2076	<0.0001*
% Dominance (Top 1 Taxa)	0.2301	0.0117*	<0.0001*
% of Total as Dominant Guild (FFG)	0.7642	0.4838	<0.0001*
% of Total as Predator	0.4237	0.4008	0.0001*
Ratio of Intolerant to Tolerant	0.0455*	0.1763	<0.0001*
% of Trichoptera as Hydropsychidae	0.4073	0.2076	<0.0001*
Number of Non-insect Taxa	0.1165	0.1056	0.0002*
% of Total as Collector/Gatherer	0.7103	0.3270	0.0009*
% of Total as Elmidae	0.8415	0.7794	0.3978
TCEQ Qualitative ALU Score	0.3083	0.0929	<0.0001*

Probability of Occurrence

The probability of occurrence of the 77 taxa collected in the survey by each method (Appendix B) can be used to determine the comprehensiveness of each method relative to each other. The probability of occurrence for all taxa for the composite Surber method was greater than, or equal to that of the kicknet method for 80% of the taxa found (Table 3). This implies that samples collected with the composite Surber method will produce a more comprehensive set of taxa than the kicknet method. However, the kicknet method had higher probability of occurrences for these taxa than either the single Surber or subsampled composite Surber methods (61 vs. 30% and 58 vs. 35%, respectively).

Method	Number of Taxa with Probability of Occurrence Greater than Kick	Number of Taxa with Probability of Occurrence Equal to Kick	Number of Taxa with Probability of Occurrence Less than Kick
Single Surber	23	7	47
3-Surber Composite	39	23	15
Subsample of Composite Surber	27	5	45

Table 3. Surber methods compared to kicknet method using the probability of occurrence for 77 discrete taxa encountered in this study

The composite Surber method resulted in higher taxa richness than the kicknet method at 7 out of the 8 sites and equal taxa richness at one site (see Appendix A). In order to determine if certain taxonomic groups were more likely to be collected by a specific method, the probability of occurrence for discrete taxa within major taxonomic groups (primarily at the level of Order) were compared (Table 4). The composite Surber method proved to be more likely to collect a greater number of representative taxa from eight of the ten taxonomic groups, and just as likely to collect an equal number of representatives from the remaining two taxonomic groups. This indicates that based on the samples in this study; there are no major taxonomic groups in which the kicknet method is likely to produce a greater number of taxa.

Table 4. Probability of occurrence of taxa within major taxonomic groups. Composite Surber method versus kicknet method.

Taxonomic Group	Number of taxa for which the probability of occurrence of the composite Surber was <u>GREATER</u> than that of the Kicknet method	Number of taxa for which the probability of occurrence of the composite Surber was <u>EQUAL</u> to that of the Kicknet method	Number of taxa for which the probability of occurrence of the composite Surber was <u>LESS</u> than that of the Kicknet method
Ephemeroptera (12 taxa)	5	3	4
Trichoptera (11 taxa)	6	4	1
Odonata (5 taxa)	2	1	2
Diptera (14 taxa)	7	3	4
Coleoptera (15 taxa)	7	6	2
Hemiptera (4 taxa)	4	0	0
Lepidoptera (1 taxa)	1	0	0
Megaloptera (1 taxa)	0	1	0
Mollusca (8 taxa)	4	2	2
Other non-insect orders (6 taxa)	3	3	0
Total	39	23	15

The pollution tolerance value (PTI) is an indicator of the organism's tolerance to physicochemical degradation (TCEQ 2005). It is expressed as a number from 0 to 10 in which larger PTI values indicate increasing tolerance. PTI values for aquatic macroinvertebrates commonly collected in Texas stream are provided by the TCEQ in the SWQM manual (TCEQ 2005). It can be determined if one or more of the methods have a bias to collect intolerant or tolerant taxa by grouping taxa into categories based on their tolerance and evaluating the probability of occurrence of each taxa for each method. The probability of occurrence was predominantly higher for intolerant, intermediately tolerant and tolerant taxa for the composite Surber method compared to the kicknet method (Table 5). This indicates that samples collected using the composite Surber method produce a greater number of taxa along the entire gradient of tolerance levels. The Surber method had higher probability of occurrence for a total of 39 taxa, which were relatively evenly distributed among three general groups of tolerance. The Kick method had only 15 taxa which had a higher probability of occurrence than the Surber.

Table 5. The probability of occurrence of intolerant, intermediate and tolerant taxa was higher for the composite Surber method than the kicknet method. This shows that taxa collected from the composite surber method is not biased toward a tolerance group.

Tolerance Category	Number of taxa for which the probability of occurrence of the composite Surber was GREATER than that of the Kicknet method	Number of taxa for which the probability of occurrence of the composite Surber was Equal to that of the Kicknet method	Number of taxa for which the probability of occurrence of the composite Surber was Less than that of the Kicknet method
Intolerant (PTI = 0 - 3)	8	7	2
Intermediate (PTI = 4 - 6)	20	10	9
Tolerant (PTI = 7 - 10)	11	6	4
Total	39	23	15

Conclusions

Qualitative Aquatic Life Use (ALU) scores for the composite Surber method were within 1 point of the kicknet method for five of the eight sites (Figure 6). In addition, the scores of the kicknet and composite Surber were in the same ALU range (“High” designation) for seven of the eight. Although the ALU scores did not differ considerably, the composite Surber ALU score was typically slightly higher than that of the kicknet score. This suggests that it would be unlikely that impairment would be incorrectly identified through the use of the composite Surber method (False-positive).

Based on the similarity of the COV values of individual metric parameters and overall ALU scores, the most similar method to the kicknet protocol is the composite Surber, which is the predominant method used by the City of Austin. As shown by the Wilcoxon matched pairs comparison, the qualitative ALU scores are not significantly different between the composite Surber and the kicknet. Of the 12 metric parameters compared, there were only two that showed significant differences. Probability of Occurrence for each discrete taxa showed that the composite Surber method was greater than, or equal to that of the kicknet method for the majority of taxa. This is not surprising because the composite Surber method resulted in higher taxa richness than the kicknet method at seven out of the eight sites and equal taxa richness at one site. This supports the assertion that the composite Surber method is as good as the kicknet method in collecting a representative species list for the riffle benthic community, but was decidedly better for the Austin area streams studied.

Although the SWQM manual states that the kicknet is the primary method for sampling benthic macroinvertebrate, it also states that “alternatively, benthic macroinvertebrate samples may be collected using a Surber sampler” and that “Surber samples are used mainly for special studies where an objective is a density estimate” (TCEQ 2005). While it may be more cost effective to advocate the use of kicknet protocols for qualitative rapid bioassessments and Surber protocols for quantitative intensive bioassessments, it does not negate the validity and apparent comparability of the results that Surber protocols provide in Austin area streams. The authors of this paper assert that use of the composite Surber method results in accurate and comparable assessments of aquatic community composition and integrity. While kicknet sampling may be more appropriate for a

typical Texas stream or river, the COA has found that Surber sampling is more appropriate for Austin creeks, which are typically shallow, narrow and hydraulically controlled by frequent riffles.

The authors also assert that the Surber method is preferable to the kicknet method because of the reduced impact to riffle environments. Based on SWE team experience, a composite Surber disturbs only approximately three square feet of substrate, while a kicknet sample is more invasive and typically disturbs five to ten square feet of substrate during sample collection plus several more square feet of substrate trampled along the transect. Although this may seem to be a negligibly small area in the context of most rivers, it is frequently a substantial portion of the narrow and short riffles of many of Austin's small creeks and streams. Minimizing the area of disturbance becomes increasingly important in areas which are habitat to sensitive and/or rare species such as the Jollyville salamander (*Eurycea tonkawae*) and the caddisfly genus *Austrocinodes*, both of which are found in the Austin area. Several Austin streams are sampled by the SWE team twice annually, which increases the need to reduce adverse impacts on riffle habitat. The SWE team asserts that minimizing disruption to frequently sampled riffles is of value in protecting the integrity of aquatic resources in the Austin area.

Literature Cited

- Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Striblin. 1999. *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers: Periphyton, Benthic Macroinvertebrates and Fish*. Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.
- Caton, L.W. 1991. *Improving subsampling methods for the EPA "Rapid Bioassessment" benthic protocols*. Bulletin of the N. Am. Benthol. Soc. 8(3): 317-319.
- City of Austin (COA). 2004. Water Resource Evaluation Standard Operating Procedures Manual. City of Austin Watershed Protection & Development Review Environmental Resource Management Division. August, 2004.
- Griffith, G. E., Bryce, S.A., Omernik, J. M., Comstock, J. A. Rogers, A. C., Harrison, B., Hatch, S. L., and Bezanson, D. 2004. Ecoregions of Texas (color poster with map, descriptive text, and photographs): Reston Virginia, U. S. Geological Survey (map scale 1:2,500,000)
- Hornig, C.E., and J.E. Pollard. 1978. Macroinvertebrate sampling techniques for streams in semi-arid regions: comparison of the Surber method and a unit-effort traveling kick method. Environmental Monitoring Services of the United States Environmental Protection Authority No. 600/4-78-040, pp 20.

- Karr, J.R., and E.W. Chu, 1999. Restoring life in running waters: better biological monitoring. Island Press, Washington D.C.
- SAS Institute Inc (SAS). 2004. SAS OnlineDoc® 9.1.3. SAS Institute, North Carolina.
- Sokal, R.R., and F.J. Rohlf. 1995. Biometry: the principles and practice of statistics in biological research. W.H. Freeman and Company, New York.
- Southerland, M.T., and J. B. Stribling. 1995. Status of biological criteria development and implementation. Pages 81-96 in W.S. Davis and T.P. Simon (editors). Biological assessment and criteria: Tools for water resource planning and decision making. Lewis Publishers, Boca Raton, Florida.
- Storey A.W., D.H.D. Edward, and P. Gazey. 1991. Surber and kick sampling: a comparison for the assessment of macroinvertebrate community structure in streams of south-western Australia. *Hydrobiologia* 211:111-21.
- Tait, C.K., J.L. Li, G.A. Lamberti, T.N. Pearsons, and H.W. Li. 1994. Relationships between riparian cover and the community structures of high desert streams. *J. N. Am. Benthol. Soc.* 13: 45-56.
- Texas Commission on Environmental Quality (TCEQ). 2003. Surface Water Quality Monitoring Procedures , Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment, and Tissue. December 2003. RG-415. Texas Commission on Environmental Quality, Monitoring Operations Division. Austin, Texas
- Texas Commission on Environmental Quality (TCEQ). 2005. Surface Water Quality Monitoring Procedures , Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data. August 2005. RG-416. Texas Commission on Environmental Quality, Monitoring Operations Division. Austin, Texas

Appendix A

Benthic Macroinvertebrate Data by Site

Barton Creek @ Hwy 71 Below Little Barton (Site 48)					
PARAMETER	Kicknet	Surber A	Surber B	Surber C	3 Surber Composite
AMBRYBUS	3	2	1	4	7
ARGIA	6	3	2	2	7
CAENIS	1				
CAMELOBAETIDIUS	1		2	2	4
CHEUMATOPSYCHE	19	31	9	11	51
CHIMARRA	59	134	7	12	153
CHIRONOMIDAE	10	4	1	2	7
CORBICULA FLUMINEA			15		15
CORYDALUS CORNUTUS	2	5	4	4	13
DASYHELEA				1	1
DUGESIA TIGRINA				1	1
ERPETOGOMPHUS			1		1
FALLCEON QUILLERI	2	1	4	6	11
HEXACYLLOEPUS FERRUGINEUS	2		1	2	3
HYDRACARINA (ACARI)			1	1	2
ISONYCHIA	1	1		1	2
LEPTOHYPHES	19	11	14	4	29
LUTROCHUS LUTEUS	2		1		1
MICROCYLLOEPUS PUSILLUS	7	4	12	4	20
NEOELMIS CAESA	1		1		1
OLIGOCHAETA			2	2	4
PETROPHILA	1		1		1
PHYSA (PHYSELLA)	2	4	1	2	7
PYRALIDAE				1	1
RHAGOVELIA	1	3	1	1	5
SIMULIUM	1				
SMICRIDEA	13	23		6	29
SURAGINA CONCINNA	5		3	1	4
TRICORYTHODES	21	3	17	17	37
TROPISTERNUS		1			1
VACUPERNIUS PACKERI			1		1
Number of Individuals	179	230	102	87	419
Number of Taxa	22	15	23	22	29

Barton Creek Downstream of Lost Creek Blvd (Site 51)					
PARAMETER	Kicknet	Surber A	Surber B	Surber C	3 Surber Composite
AMBRYBUS	6	7	1	7	15
ARGIA	16	3	6	3	12
ATRICHOPOGON		1		1	2
BRECHMORHOGA MENDAX	1	2			2
CAENIS		1			1
CALOPARYPHUS	1				
CAMELOBAETIDIUS	2		3	4	7
CERATOPOGONIDAE				1	1
CHEUMATOPSYCHE	1		3	14	17
CHIRONOMIDAE	10	16	3	6	25
CININNATIA CININNATIENSIS	2	3	3	2	8
CORBICULA FLUMINEA	6	4	1		5
CORYDALUS CORNUTUS	1		3	6	9
DASYHELEA				1	1
DUGESIA TIGRINA	7	5	4	15	24
ERPETOGOMPHUS	1				
FALLCEON QUILLERI	1				
FOSSARIA		1			1
HELICOPSYCHE	2		1		1
HETAERINA				1	1
HEXACYLLOEPUS FERRUGINEUS	10	12	5	1	18
HIRUDINEA		1			1
HYDRACARINA (ACARI)	7	1		1	2
HYDROPTILA	1			1	1
LEPTOHYPHES			1		1
MACRELMIS	5	9	7	1	17
MICROCYLLOEPUS PUSILLUS	13	9	5	8	22
NECTOPSYCHE	1				
NEOELMIS CAESA	4	9	7		16
OECETIS	1				
OLIGOCHAETA			1		1
OSTRACODA	2	1	2		3
PETROPHILA	11	4	2	4	10
PHYSA (PHYSELLA)		1			1
POLYCENTROPUS	1			1	1
PSEPHENUS	2	1	1		2
RHAGOVELIA	8	18	5	6	29
SMICRIDEA	3			3	3
THRAULODES GONZALESII				1	1
TRICORYTHODES	66	11	5	14	30
VACUPERNIUS PACKERI	2				
Number of Individuals	194	120	69	102	291
Number of Taxa	30	22	21	23	35

Onion Creek @ McKinney Falls Below Lower Falls (Site 255)					
PARAMETER	Kicknet	Surber A	Surber B	Surber C	3 Surber Composite
AMBRYBUS			1	1	2
ANOPHELES	1				
ARGIA	9	7	24	13	44
BEROSUS		3			3
BEZZIA (PALPOMYIA)	1	1			1
BRECHMORHOGA MENDAX			2	4	6
CAENIS	1	2			2
CALLIBAETIS		1			1
CAMELOBAETIDIUS	3				
CHEUMATOPSYCHE	35		73	41	114
CHIMARRA	27	1	24	40	65
CHIRONOMIDAE	27	6	11	18	35
CININNATIA CININNATIENSIS	3	6	1	3	10
CORBICULA FLUMINEA	2		16	5	21
CORYDALUS	1		1	1	2
CULICOIDES	2				
DASYHELEA	2			1	1
DUBIRAPHIA		1			1
DUGESIA TIGRINA	6		39	40	79
ERPETOLOMPHUS	1	1	2		3
EUPERA CUBENSIS	1				
FALLCEON QUILLERI			7	1	8
FARRODES TEXANUS			1	1	2
FERRISSIA		1	1		2
HAGENIUS BREVISTYLUS		1			1
HELICOPSYCHE	1			1	1
HELISOMA ANCEPS	2	6	1		7
HEXACYLLOEPUS FERRUGINEUS	4	4	22		26
HIRUDINEA	1				
HYALLELA	2			1	1
HYDRACARINA (ACARI)	1	3	1		4
HYDROPTILA	1	1	3		4
MACRELMIS	3		23	6	29
MICROCYLLOEPUS PUSILLUS	1		9	2	11
NECTOPSYCHE	3	3	1	1	5
NEOELMIS CAESA	1		2		2
OLIGOCHAETA		1			1
OSTRACODA	6	10	2	1	13
PELTODYTES	1				
PHYSA (PHYSELLA)	7	3	3	1	7
PROBEZZIA	1				
PSEPHENUS	18	14	65	15	94
RHAGOVIELIA				5	5
RHEUMATOBATES				1	1
STENELMIS	4		10	1	11
THRAULODES GONZALESII	1		4		4
TRICORYTHODES	20	46	4	1	51
VACUPERNIUS PACKERI	4		13	1	14
Number of Individuals	204	122	366	206	694
Number of Taxa	36	22	29	26	41

Onion Creek @ South Austin Regional WWTP (Site1366)					
PARAMETER	Kicknet	Surber A	Surber B	Surber C	3 Surber Composite
ARGIA	16	1	18	8	27
BEROSUS	2	1	1	1	3
BEZZIA (PALPOMYIA)	1	1	1		2
CAENIS	23	22	8	9	39
CALLIBAETIS	1				
CALOPARYPHUS			1		1
CAMELOBAETIDIUS			1		1
CHEUMATOPSYCHE	9	2	15	8	25
CHIMARRA	28		16	21	37
CHIRONOMIDAE	13	2	13	2	17
CININNATIA CININNATIENSIS	7	13	4		17
CORBICULA FLUMINEA	1	2	3		5
DUGESIA TIGRINA	3		1	1	2
FALLCEON QUILLERI	7		1	1	2
FARRODES TEXANUS	14		10	3	13
HELICHUS	3	5	2	1	8
HETAERINA	1				
HEXACYLLOEPUS FERRUGINEUS	46	12	37	6	55
HIRUDINEA	6	9		1	10
HYALLELA	3		1	2	3
HYDRACARINA (ACARI)	12		3	1	4
HYDROPTILA			1		1
ITHYTRICHA CLAVATA			1		1
MARILIA			1		1
MICROCYLLOEPUS PUSILLUS			1		1
NECTOPSYCHE		1			1
NEOCHOROTERPE	1				
OECETIS		1	1		2
OLIGOCHAETA	2		1	1	2
OSTRACODA	2	2			2
PELTODYTES	1	1		1	2
PETROPHILA			3	1	4
PSEPHENUS	42	28	40	12	80
RHAGOVELIA	1			1	1
RHEUMATOBATES		1	1	2	4
SMICRIDEA	5			2	2
STENACRON	1		1		1
STENELMIS	8		4	2	6
THRAULODES GONZALES			3	1	4
TRICORYTHODES	6	1		1	2
VACUPERNIUS PACKERI	18	1	17	7	25
Number of Individuals	283	106	211	96	413
Number of Taxa	30	19	31	25	38

Gilleland Creek @ FM 973 (Site 1192)					
PARAMETER	Kicknet	Surber A	Surber B	Surber C	3 Surber Composite
ARGIA	6	7	7	4	18
BRECHMORHOGA MENDAX				1	1
CAMELOBAETIDIUS	1	1	1		2
CHEUMATOPSYCHE	31	48	64	65	177
CHIMARRA			1		1
CHIRONOMIDAE	1	1	2	2	5
DUGESIA TIGRINA	4	5	14	15	34
FALLCEON QUILLERI	23	11	5	32	48
FARRODES TEXANUS	1				
FERRISSIA		2			2
GYRINUS	2				
HELICOPSYCHE	2	14	15	4	33
HETERELMIS	3	1			1
HEXACYLLOEPUS FERRUGINEUS	7	7	15	16	38
ISONYCHIA	21	7	16	35	58
MICROCYLLOEPUS PUSILLUS	2		2		2
NEOELMIS CAESA	2	3	1	7	11
OECETIS		2	1		3
OLIGOCHAETA		1	1		2
PETROPHILA		2		1	3
PROTOPTLIA	3	3	7	2	12
PSEPHENUS	19	19	27	7	53
RHAGOVELIA			8	1	9
SMICRIDEA	23	22	43	18	83
STENELMIS	6	5	1	3	9
THRAULODES GONZALESII	28	48	26	96	170
TRICORYTHODES	1				
VACUPERNIUS PACKERI	2				
Number of Individuals	188	209	257	309	775
Number of Taxa	21	20	20	17	24

Walnut Creek Below IH35 (Site 464)					
PARAMETER	Kicknet	Surber A	Surber B	Surber C	3 Surber Composite
ARGIA	16	17	13	6	36
BRECHMORHOGA MENDAX	2	1	1	1	3
CAMELOBAETIDIUS	4	2	5	1	8
CHEUMATOPSYCHE	29	41	39	39	119
CHIMARRA	16	6	39	27	72
CHIRONOMIDAE	19	11	15	8	34
DASYHELEA				1	1
DUGESIA TIGRINA	5	15	9	6	30
FALLCEON QUILLERI	8	7	3	4	14
FARRODES TEXANUS	6	3	3	2	8
FERRISSIA	1				
HELICOPSYCHE	3		1		1
HEMERODROMIA		1			1
HETAERINA	6		3	1	4
HYDRACARINA (ACARI)	3	2	3	3	8
MACRELMIS	24	16	14	27	57
MICROCYLLOEPUS PUSILLUS	8	4	8	10	22
NEOELMIS CAESA	4	7	1	3	11
OECETIS	1				
OSTRACODA	1	1		2	3
PETROPHILA	4	4	3	7	14
PSEPHENUS	14	13	12	2	27
RHAGOVELIA	2	2	1	10	13
STENELMIS	1	4	2		6
THRAULODES GONZALESII	5	5	7	4	16
TRICORYTHODES	14	10	1	3	14
Number of Individuals	196	172	183	167	522
Number of Taxa	24	21	21	21	24




Walnut Creek @ Old Manor Rd (Site 502)					
PARAMETER	Kicknet	Surber A	Surber B	Surber C	3 Surber Composite
ARGIA	21	9	15	9	33
BEZZIA (PALPOMYIA)		1			1
BRECHMORHOGA MENDAX	5	3	3	5	11
CAMELOBAETIDIUS		1			1
CHEUMATOPSYCHE	36	31	68	10	109
CHIMARRA	22	20	51	2	73
CHIRONOMIDAE	5	20	3	3	26
DUGESIA TIGRINA	5	16	7	7	30
ERPETOGOMPHUS	1				
FALLCEON QUILLERI	6	20	6	2	28
FARRODES TEXANUS	9	56	17	9	82
HEMERODROMIA	1				
HETAERINA	1				
HYDRACARINA (ACARI)	37	4	15	11	30
HYDROPTILA	1				
MACRELMIS	25	9	14	8	31
MICROCYLLOEPUS PUSILLUS	10	4	9		13
NEOELMIS CAESA	6	2	8	3	13
OLIGOCHAETA		1			1
PSEPHENUS			7	3	10
RHAGOVELIA	1	3	9	15	27
SCIRTES		1			1
SMICRIDEA			2		2
TABANUS			1		1
THRAULODES GONZALESII	40	31	24	6	61
TRICORYTHODES	20	23	1	5	29
Number of Individuals	252	255	260	98	613
Number of Taxa	19	19	18	15	22

Walnut Creek @ Metric Blvd (Site 895)					
PARAMETER	Kicknet	Surber A	Surber B	Surber C	3 Surber Composite
ARGIA	16	23	16	17	56
BRECHMORHOGA MENDAX	6	9	8	11	28
CAENIS				2	2
CALLIBAETIS	1				
CAMELOBAETIDIUS		3			3
CHEUMATOPSYCHE	47	84	45	42	171
CHIMARRA	17	13	23	12	48
CHIRONOMIDAE	28	21	8	10	39
CININNATIA CININNATIENSIS	1				
CORBICULA FLUMINEA	2		1	2	3
DUGESIA TIGRINA	2	7	3	2	12
ERPETO GOMPHUS	1				
FALLCEON QUILLERI	1	5	1	5	11
FARRODES TEXANUS	2	6		1	7
FERRISSIA	1				
GYRAULUS			1	1	2
HELICOPSYCHE		3	1		4
HEMERODROMIA	1		2		2
HETAERINA	2		1	1	2
HYDRACARINA (ACARI)	5	1	1		2
HYDROPTILA	1				
MACRELMIS	5	11	11	12	34
MARILIA		3		2	5
MICROCYLLOEPUS PUSILLUS	1	3		1	4
NEOELMIS CAESA		1			1
OECETIS		1			1
OLIGOCHAETA		1			1
OSTRACODA	2	6	1		7
PETROPHILA	1	6			6
PHYSA (PHYSELLA)	5		4	1	5
PSEPHENUS	16	39	25	33	97
RHAGOVELIA		3	1	1	5
STENACRON		3	1		4
STENELMIS	4	8	7	8	23
THRAULODES GONZALESII		4	2		6
TREPOBATES		1			1
TRICORYTHODES	4	2		8	10
Number of Individuals	172	267	163	172	602
Number of Taxa	25	26	21	20	32

Appendix B

Probability of Occurrence for Each Taxon by Method

Parameter	PTI	FFG	Group	Kicknet	Single Surber	3 Surber Composite	Subsampled Composite Surber
MARILIA	0	SH	Trichoptera	0.000	0.125	0.250	0.155
ERPETOATOMPHUS	1	P	Odonata	0.500	0.167	0.375	0.095
PROTOPTLIA	1	SC	Trichoptera	0.125	0.125	0.125	0.125
CHIMARRA	2	FC	Trichoptera	0.750	0.750	0.875	0.780
FARRODES TEXANUS	2	CG, SC	Ephemeroptera	0.625	0.500	0.625	0.545
HELICOPSYCHE	2	SC	Trichoptera	0.500	0.333	0.625	0.320
HEXACYLLOEPUS FERRUGINEUS	2	CG, SC	Coleoptera	0.625	0.542	0.625	0.590
HYDROPTILA	2	PI, SC	Trichoptera	0.500	0.167	0.375	0.190
LEPTOHYPHES	2	CG	Ephemeroptera	0.125	0.167	0.250	0.175
MICROCYLLOEPUS PUSILLUS	2	CG, SC	Coleoptera	0.875	0.708	1.000	0.815
NEOELMIS CAESA	2	CG, SC	Coleoptera	0.750	0.583	0.875	0.575
THRAULODES GONZALESI	2	CG, SC	Ephemeroptera	0.500	0.625	0.875	0.785
HAGENIUS BREVISTYLUS	3	P	Odonata	0.000	0.042	0.125	0.030
ISONYCHIA	3	FC	Ephemeroptera	0.250	0.208	0.250	0.200
NECTOPSYCHE	3	SH, CG, P	Trichoptera	0.250	0.167	0.250	0.100
POLYCENTROPUS	3	FC, P	Trichoptera	0.125	0.042	0.125	0.075
SURAGINA CONCINNA	3	P	Diptera	0.125	0.083	0.125	0.095
CALIBAETIS	4	CG	Ephemeroptera	0.250	0.042	0.125	0.015
CAMELOBAETIDIUS	4	CG	Ephemeroptera	0.625	0.500	0.875	0.535
FALLCEON QUILLERI	4	CG	Ephemeroptera	0.875	0.792	0.875	0.790
HELICHUS	4	CG, SC	Coleoptera	0.125	0.125	0.125	0.125
HETERELMIS	4	CG, SC	Coleoptera	0.125	0.042	0.125	0.025
ITHYTRICHIA CLAVATA	4	SC	Trichoptera	0.000	0.042	0.125	0.035
MACRELMIS	4	CG, SC	Coleoptera	0.625	0.583	0.625	0.625
NEOCHOROTERPE	4	CG	Ephemeroptera	0.125	0.000	0.000	0.000
OSTRACODA	4	FC, CG	Non-insect	0.625	0.417	0.625	0.450
PSEPHENUS	4	SC	Coleoptera	0.750	0.792	0.875	0.820
SIMULIUM	4	FC	Diptera	0.125	0.000	0.000	0.000
SMICRIDEA	4	FC	Trichoptera	0.500	0.333	0.625	0.480
STENACRON	4	CG, SC	Ephemeroptera	0.125	0.125	0.250	0.085
VACUPERNIUS PACKERI	4	CG	Ephemeroptera	0.500	0.250	0.375	0.300
AMBRYUSUS	5	P	Hemiptera	0.250	0.333	0.375	0.280
CERATOPOGONIDAE	5	P, CG	Diptera	0.000	0.042	0.125	0.070
CININNATIA CININNATIENSIS	5	SC	Non-insect	0.500	0.333	0.375	0.360
DASYHELEA	5	CG, SC	Diptera	0.125	0.167	0.500	0.160
DUBIRAPHIA	5	CG, SC	Coleoptera	0.000	0.042	0.125	0.040
LUTROCHUS LUTEUS	5	CG	Coleoptera	0.125	0.042	0.125	0.020
OECETIS	5	P, SH	Trichoptera	0.250	0.208	0.375	0.130
PETROPHILA	5	SC	Lepidoptera	0.500	0.500	0.750	0.545
RHEUMATOBATES	5	P	Hemiptera	0.000	0.167	0.250	0.145
TRICORYTHODES	5	CG	Ephemeroptera	1.000	0.792	0.875	0.795
ARGIA	6	P	Odonata	1.000	1.000	1.000	0.990
ATRICOPOGON	6	P	Diptera	0.000	0.083	0.125	0.075
BRECHMORHOGA MENDAX	6	P	Odonata	0.500	0.542	0.750	0.520
CHEUMATOPSYCHE	6	FC	Trichoptera	1.000	0.917	1.000	1.000
CHIRONOMIDAE	6	P, FC	Diptera	0.875	0.958	1.000	0.925
CORBICULA FLUMINEA	6	FC	Non-insect	0.500	0.375	0.625	0.535
CORYDALUS CORNUTUS	6	P	Megaloptera	0.250	0.208	0.250	0.250
FOSSARIA	6	SC	Non-insect	0.000	0.042	0.125	0.065
GYRINUS	6	P	Coleoptera	0.125	0.000	0.000	0.000
HEMERODROMIA	6	P, CG	Diptera	0.250	0.083	0.250	0.090
HETAERINA	6	P	Odonata	0.500	0.208	0.375	0.180
HYDRACARINA (ACARI)	6	P	Non-insect	0.750	0.667	0.875	0.635
PROBEZZIA	6	P	Diptera	0.125	0.000	0.000	0.000
RHAGOVELIA	6	P	Hemiptera	0.625	0.792	1.000	0.835
TANYPODINAE	6	P	Diptera	0.750	0.708	0.875	0.745
BEZZIA (PALPOMYIA)	7	P, CG	Diptera	0.250	0.167	0.375	0.145
CAENIS	7	CG, SC	Ephemeroptera	0.375	0.250	0.500	0.310
CALOPARYPHUS	7	CG	Diptera	0.125	0.042	0.125	0.055
CULICOIDES	7	P, CG	Diptera	0.125	0.000	0.000	0.000
FERRISSIA	7	SC	Non-insect	0.250	0.125	0.250	0.080
GYRAULUS	7	SC	Non-insect	0.000	0.083	0.125	0.055
HELISOMA ANCEPS	7	SC	Non-insect	0.125	0.083	0.125	0.105
SCIRTES	7	SC	Coleoptera	0.000	0.042	0.125	0.020
STENELMIS	7	CG, SC	Coleoptera	0.625	0.500	0.625	0.600
TABANUS	7	P	Diptera	0.000	0.042	0.125	0.020
DUGESIA TIGRINA	7.5	P, CG	Non-insect	0.875	0.833	1.000	0.865
ANOPHELES	8	FC	Diptera	0.125	0.000	0.000	0.000
EUPERA CUBENSIS	8	SC	Non-insect	0.125	0.000	0.000	0.000
HIRUDINEA	8	P	Non-insect	0.250	0.125	0.250	0.175
HYALLELA	8	CG, SH	Non-insect	0.250	0.125	0.250	0.135
OLIGOCHAETA	8	CG	Non-insect	0.125	0.417	0.875	0.370
PELTODYTES	8	PI, SH, P	Coleoptera	0.250	0.083	0.125	0.055
BEROSUS	9	CG	Coleoptera	0.125	0.167	0.250	0.135
PHYSA (PHYSELLA)	9	SC	Non-insect	0.375	0.375	0.500	0.390
TREPOBATES	10	P	Hemiptera	0.000	0.042	0.125	0.020
TROPISTERNUS	10	CG	Coleoptera	0.000	0.042	0.125	0.015

 Probability greater than that of kick method
 Probability equal to that of kick method
 Probability less than that of kick