

**Biological Sampling Protocols:
Reference Site Selection and Sampling Methods**

**Richard D. Meyerhoff and Patrice H. Spindler
Water Quality Assessment Unit**

**Arizona Department of Environmental Quality
Water Quality Division
3033 North Central Avenue
Phoenix, AZ 85012
1-800-234-5677**

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Foreword

In accordance with the requirements of the Clean Water Act, Arizona's Department of Environmental Quality has implemented a plan for the development of narrative biological criteria for its surface water quality standards. Although the ultimate goal for all states is to adopt numeric biological criteria into their standards, the development of those standards will be a lengthy process. However, in the interim, narrative criteria can be developed and the Environmental Protection Agency (EPA) is encouraging each state to do so. This draft report documents the biological sampling methods used in the development of biocriteria. This report will remain in draft form, undergoing fine tuning changes, until biological standards have been proposed. Although subject to change, the methods contained herein are recommended for use by other parties to promote consistency in methodology and data interpretation with ADEQ methods.

The sampling methods presented here are general in nature and may be applied to small and medium-sized perennial streams. These methods may be applicable to intermittent waters but were not intended for other waterbodies, especially large rivers, ephemeral waters, or wetlands. Biological criteria should eventually be developed that address the uniqueness of each of these waterbodies. Additional guidance documents will be written to discuss variations in the methodology for sampling these waterbodies.

ADEQ began the process of developing narrative biological criteria in 1992 by sampling small to medium-sized perennial streams throughout the state, but primarily in central and southeastern Arizona. These sites are intended to be reference sites and representative of the least-impacted streams within their respective regions. Biological (macroinvertebrates, algae), habitat and chemical evaluations were conducted at each site for the purpose of addressing the following objectives: 1) Develop an inventory of the aquatic biological resources of Arizona, 2) Test various field and laboratory methods to determine what is the most cost-effective method for biological assessment work in Arizona, 3) Assess the relationships among various habitat or chemical variables and the associated biological communities, 4) Identify regional relationships in biological community structure, 5) Develop narrative biocriteria for inclusion in the state's rules for navigable or surface water quality standards.

Objective 1, developing an aquatic biological inventory for Arizona, is necessary because limited knowledge is available concerning non-fish aquatic resources of Arizona. We must know what taxa are present and their general distribution in order to use them for the development of biological criteria. Objective 2 stems from a need to develop a program that works in all types of streams in a cost-effective manner. Objective 3 will help us in our efforts to determine what constitutes a high quality aquatic habitat for biological communities. The last two objectives are the primary focus of this work, that is, the development of narrative biological criteria. These criteria will be developed on a regional basis if the data show that sufficient regional differences in biological community structure exist.

Data will be collected from least-impacted/reference sites for three to five years before narrative biological criteria are developed. The multiple year data are required to take into account temporal variation in biological communities. These data will comprise the biological reference conditions statewide. Once these conditions are established, potentially impaired stream sites will be investigated to determine the range of impacts on biological communities. By identifying the full range of reference and impacted biological communities, metrics can be calibrated for Arizona streams. These metric scores can then be used to rank other streams statewide in terms of biological integrity. ADEQ will begin work on impaired sites within the Verde River watershed in 1995.

It is important that all methods be thoroughly documented for consistency in biological assessments performed over the long term by both ADEQ personnel and other interested parties. This report provides a detailed description of data collection and processing methods. This information will help standardize all future work and provide comparable data from all biological assessments conducted within Arizona.

Acknowledgments

The development of sampling protocols for the Arizona Department of Environmental Quality's (ADEQ) biological criteria program has been a lengthy process. While the final decision for all field methods were ours, input from people both within and outside of ADEQ has helped to develop these protocols. We wish to acknowledge the contributions of the following people for their help with this document:

Darrell Vodopich (Baylor University), Stuart Fisher (Arizona State University), Joseph Furnish (Bureau of Land Management), Larry Stevens (National Park Service), Rick Hafele (Oregon Department of Environmental Quality), and Lin Lawson (ADEQ) originally provided detailed comments and suggestions that helped improve the overall biocriteria program. The habitat evaluation methods are primarily based on publications by Plafkin et al. (1989) and Barbour and Stribling (1991), and work by Rick Hafele and Samuel Rector of ADEQ. The riparian assessment form was developed with the assistance of Peter Jagow and Kris Randall of ADEQ, and Phil Camp of the Soil Conservation Service. Finally, I wish to acknowledge the many helpful comments received on the contents of this document from ADEQ personnel Lin Lawson, Lucia Machado, Diana Marsh, Kyle Palmer, Sam Rector and Forrest Woodwick.

1. Criteria for Reference Site Selection

Although one of our objectives is to look at the possibility of regionalizing water quality standards, reference sites were not selected on the basis of Omernik and Gallant's (1987) ecoregion designations. Instead sites were selected so that they were distributed over as broad a region as possible within the primary area of perennial waters in the state - the central and southeast portions. The perennial waters within Grand Canyon National Park have also been sampled at 14 different sites by Park Service personnel. Statewide, sites were chosen that provided as broad a geographic coverage as possible, and were distributed as evenly as possible among Arizona's major river basins. However, as the data are analyzed, changes may have to be made in the original choice of sites because: (a) a site was more impacted than first believed; (b) high variation among sites in a region indicates that additional sites are needed in that area; or (c) little variation among sites indicates that fewer sites are needed to characterize that region.

Ideally, reference site selection should be a two step process. The initial selection is done in the office from literature and maps. Literature sources should include other agencies' reports on special waterbodies of the state (eg. Arizona State Parks, Wild and Scenic Rivers Designation). This step should be followed by a visit to confirm that the site fits reference site criteria. Sites that fail to qualify as reference sites are removed from consideration and, if possible, a nearby alternate site is found. Following is the procedure for identifying and assessing reference sites. A list of Biocriteria Program reference sites sampled during 1992-1994 is provided in Appendix A.

1.1 Office Assessment of Potential Reference Sites

Using United States Geological Survey (USGS) 7.5' quadrangle maps, choose sites that meet or nearly meet these criteria:

1. Sites must be reasonably accessible, i.e., it should be within a two hour walk or 3-4 miles from the nearest road passable with a four wheel drive vehicle.
2. Sites should be at least 0.5 km downstream from road crossings, bridges, etc.
3. Sites should be at least 5 km downstream from major dischargers (towns, treatment plants).
4. Sites should be at least 10 km downstream from major impoundments.

1.2 Field Assessment of Potential Reference Sites

1. Determine that the stream meets the primary criterion of the study, i.e., it is truly perennial. This may be determined by looking at riparian vegetation and the biological community. Look for fish, crayfish, or other long-lived organisms that require year-round water.
2. Determine the extent of land use impacts. The sample reach of 100 meters and at least 100 meters above the sample reach should appear to be unimpacted or minimally impacted from land use, especially logging and grazing.
3. Ascertain that channel alterations, e.g., diversions, are minimal or non-existent.
4. Evaluate the habitat. The habitat should be evaluated as optimal or nearly optimal according to the habitat assessment protocols (See Section 2.2). However, some latitude is required for this assessment because what is optimal or less than optimal is still fairly subjective at this time.
5. Collect macroinvertebrate samples. Two one-minute kick samples with a D-frame kick net (500 μ m mesh) are collected from the sample reach. One sample is gathered from a pool; the other sample is collected from a riffle. Each sample is analyzed separately. A sample is deposited in a white tray and invertebrates are identified to family in the field and categorized as abundant, common, or rare. These categorizations are then given a numerical relative abundance of 5, 3, and 1, respectively. The pool and riffle data are weighted according to the relative proportion of each habitat in the sample reach (visually estimated), and these results are used to calculate a family Hilsenhoff Biotic Index (HBI) (Hilsenhoff, 1987):

$$HBI = \frac{\sum (x_i * t_i)}{n}$$

where, x_i = number of individuals of family i

t_i = tolerance value of family i (Hilsenhoff, 1988)

n = total number of animals in the sample

Sites with a family HBI of less than 5.0 are considered best for selection as minimally impacted sites as these values are found in sites that have experienced minimal organic pollution (Hilsenhoff, 1988). However, these HBI scores were developed to address organic pollution for only a localized area and may not be the ideal screening method for Arizona streams. Best professional judgement should always be used in interpreting the adequacy of selected reference sites.

6. If the site under reconnaissance does not meet the requirements of a reference site, then an attempt should be made to find a new site within the same area using the same criteria as described above.

2. Site Assessment Protocols

This section describes the methods that should be used when sampling each site. Because these methods may seem overwhelming at times, an abbreviated version of these protocols (Field Methods-Quick Reference) may be found in Appendix B. The abbreviated version also provides a suggested sequence that should be followed when sampling each site, requiring about two hours of work by a team of two people to complete sampling activities. Sampling can occur concurrently, with one team member completing the habitat assessment form while the other team member begins work on the algae samples. Each sampling team must include at least one formally trained aquatic biologist.

Upon arrival at the sampling site, the plan of action goes as follows: 1) A 100 meter reach of stream having the best possible mixture of riffles and pools is selected for sampling, 2) For reference sites, flag mature trees at both the upper and lower ends of the site with fluorescent pink flagging marked with the site identification, 3) Collect a minimum of four photographs at each site, using the flagging to locate photo points which document temporal changes at the site, 4) Observations are made and recorded on field forms including the Biocriteria Site Investigation Form (Appendix C), the Habitat Assessment Form (Appendix C) that rates the stream habitat according to microhabitat, channel morphology, and upper bank characteristics, and the Riparian Assessment and Channel Morphology Field Form (Appendix C), 5) Collect physicochemical data with the hydrolab, 6) Collect macroinvertebrate, algae and water samples, 7) Estimate discharge. The following sections provide detailed descriptions of these forms and sample collection techniques.

2.1 Site Investigation

The Biocriteria Site Investigation Form, included in Appendix C, lists general site information that needs to be collected. The first section, Site Information, lists locational information which can be obtained prior to the field day. The second section, Physicochemical Evaluation, lists physicochemical data, discussed in Section 3.3.1. The third section, Field Observations, provides an area for noting observations. The fourth section, Habitat Evaluation, provides an area for all scores contained on the Habitat Assessment Form to be listed. The proportion of the reach classified as pool and riffle is also listed here. The last section, Sample Information, provides a place to list the number and type of samples collected. Each of these sections of the Biocriteria Site Investigation Form is discussed in more detail as follows.

2.1.1 Site Information

The first section of the Biocriteria Site Investigation Form provides locational and general site information. The following data should be recorded on the Site Investigation Form and entered into a spreadsheet or database format.

1. Date and time
2. Name of Waterbody
3. Site Code. A site code number should be assigned for each new sampling site. The ADEQ code consists of the following parts: (a) three letter identifier; (b) integer from 1 to 9 (upstream to downstream); (c) 2 digit integer indicating location (stream mileage) above downstream site if the site is located between two sites with consecutive integers (part b); (d) letters 'RF', 'IM', or 'EDW' to indicate reference site, impacted site, or effluent dominated water respectively. For example, we have two sites on the West Fork Little Colorado River. The upper site code is WLC1-00RF; the lower site code is WLC2-00RF. If another site was selected between the two sites the code might be WLC1-05RF indicating it is 5 stream miles above downstream site WLC2-00RF.
4. Elevation
5. USGS 7.5' quadrangle name
6. Ownership (U.S. Forest Service, Bureau of Land Management, National Park Service, State, Private, or Other)
7. Location/Access description - A space is provided to describe any changes to the Site Access description. ADEQ documents the route and hiking trails to each sampling site; any comments listed on this part of the field form is then incorporated into the Site Access document. Other locational information such as latitude/longitude, watershed size (square kilometers) estimated from 7.5' USGS maps, gradient (elevational change (feet) between site and 500 meters above site, estimated from USGS 7.5' quadrangles) and ecoregion are provided in a spreadsheet containing locational information (Section 5, Data Storage).
8. Photograph site. Whenever a site is visited, take a minimum of four photographs (slides) and document them on photo log: two at the base of the reach and two at the top of the reach. At each location take one picture from the middle of the stream (looking upstream {LU} from the base of the reach and looking downstream {LD} from the top of the reach). Two photos should also be taken looking at cross sections of the stream and its banks at the upstream end and downstream end of the reach. NOTE: If the site has not been previously visited, then take photos of the surrounding terrain and land uses.

2.1.2 Physicochemical Evaluation

Field measurements are made at each site with a Scout 2 Hydrolab Multiparameter probe. The Hydrolab is used to measure water temperature, pH, electrical conductivity, dissolved oxygen, percent oxygen saturation, and total dissolved solids at each site. Turbidity is measured with an HF Scientific Turbidimeter. Air temperature is measured with a VWR brand digital stem thermometer (-10 to 100°C). Stream velocity is estimated by the float method (Dunne and Leopold, 1978; Lind, 1979) and discharge calculated. This simple method of estimating discharge is used because only a rough estimation of site conditions is needed to compare sites on a year to year basis. Other quantitative methods are recommended for calculating loadings or other uses of the discharge data.

Stream discharge measurement:

- a. Find a discrete cross-section, e.g., one with no braiding, no blockages and preferably with a relatively flat bottom and consistent cross-section. Avoid large obstructions, such as boulders.
- b. Measure the width of the cross-section and measure the depth at one foot intervals along the transect (use two foot intervals for channels > 15 feet wide).
- c. Calculate the area of the cross-section by multiplying the average depth x stream width.
- d. Measure off a 5-10 foot length in the center of the stream perpendicular to the transect. Fill a small plastic bottle half full of water. Throw the bottle in the stream and measure the time it takes for the bottle to travel the measured length. Repeat this time measurement three times in the center of flow and average the values to obtain an average velocity. Convert value to units of cubic feet per second. For mean stream velocity, multiply averaged velocity by 0.8 (for measurements made at midstream).
- e. Calculate discharge by multiplying the mean stream velocity x the estimated cross-sectional area of the transect.

2.1.3 Field Observations

1. Flood evidence - document anything of importance that could affect data interpretation. Look for evidence of high water conditions, e.g., terrestrial plants under water, or flood debris in the riparian vegetation. Estimate the width of last flood event. Also, document recent rainfall that might have caused increased stream flows.

2. Streambed structure and big picture remarks - Note characteristics of the streambed that contribute to the stream's structure. Note substrate characteristics, i.e., dominant substrate types such as cobble or boulder, channel characteristics such as the presence of braiding, structures contributing to habitat variety such as large woody debris in channel, bedrock outcroppings, etc. This section may also be used to note anything that may be important in interpreting data from the site. This information might include observations made about the trail access, land use issues (abandoned and active mines, timber cuts, road construction), and characteristics of the overall watershed.
3. Wildlife and fish observed - Keep records of any observed wildlife (at site and along trail access) including amphibians and reptiles. Note the presence of animal scat and identify if known. Also, note evidence of animal usage, e.g., animal trails, browsing evidence.
4. Human activities - Note any evidence of people using site, e.g., trash, fire rings, footprints, etc.
5. Grazing impacts/Livestock observed - Note presence of livestock, animal droppings (including freshness, abundance), effects on vegetation, livestock tracks, damage to banks, etc.
6. Evidence of nonpoint source pollution (NPS) - Note any problems or potential problems, including turbidity, nuisance algal blooms, water color, odors, etc.

2.1.4 Habitat Evaluation

1. Scores listed on the Habitat Assessment Form (Appendix C) are copied onto the Biocriteria Site Investigation Form and a total Habitat Score calculated.
2. Percent Pool/Percent Riffle - Estimate the coverage of pool and riffle habitat (nearest 5%) in the primary channel at each site. Two people should estimate and come to some agreement on these figures. Note: pool = depositional habitat; riffle = erosional habitat.

2.1.5 Sample Collection Information

1. Field investigator names are listed here.
2. The number and type of samples collected are listed, including the number of jars for each sample, and if the sample was field split.

2.2 Habitat Assessment

The purpose of habitat assessments is to relate the biological community structure of reference sites to the habitat in which they live. Consequently, a Habitat Assessment Form (Appendix C) should be completed at the same time as the biological collections regardless of whether or not a habitat assessment was done during site reconnaissance. The habitat assessment considers three groups of parameters which investigate different scales of habitat analysis. The primary parameters look at the factors that affect microhabitat characteristics. Secondary parameters investigate stream reach scale factors and measure large scale features related to channel morphology. Tertiary parameters at the ecosystem scale evaluate riparian and bank features. Primary factors are evaluated only on the 100 meter sample reach; the secondary and tertiary factors are evaluated on the 100 meter sample reach and the area immediately upstream of the sample reach.

The habitat assessment scores are summed for all parameters to yield a total habitat assessment score.

Summary scores are put on the Biocriteria Site Investigation Form. Sites currently are classified in quarter percentiles; optimal (148-180), sub-optimal (147-100), marginal (52-99), or poor (0-51). However, these habitat ratings will be fine-tuned after the three year data set has been evaluated. The increased understanding of the relationship between biological communities and habitat characteristics in Arizona gained through field experience will aid in designing a better classification system.

1. Primary parameters - These parameters are given the greatest weight in the habitat assessment as they are considered to be most important in determining biological community structure. All are considered microhabitat characteristics and are related to substrate and instream conditions. Scores range from 0 to 20.

- ▶ Riffle substrate/Instream cover - This habitat characteristic is used to assess: (a) the availability of microhabitats for the support of a diverse fauna; (b) the availability of cover for life history requirements, e.g., oviposition or refugia from disturbance. A broad variety of substrate particle sizes and types (wood, roots, macrophytes, undercut banks, etc.) is desirable for a balanced macroinvertebrate community. The rock substrate is evaluated by visual observation according to the following criteria (MacDonald, Smart and Wissmar, 1991). The minimum diameter for each substrate type - boulder (256 mm), cobble (64 mm), pebble (4 mm), gravel (2 mm), coarse sand (0.5 mm), medium sand (0.25 mm), fine to very fine sand (0.063 mm), silts and clays (< 0.063 mm).

- ▶ Embeddedness (riffles only) - this parameter is used to estimate the amount of interstitial space available as habitat for organisms. The greater the embeddedness, the more likely that species richness and productivity will decrease. Two factors are considered: (a) The degree (percentage) that the primary substrate is embedded in finer sediments; and (b) the amount that primary substrate surfaces are covered by silt, organic floc or calcium carbonate.
- ▶ Pool substrate - This is a description of pool substrates and the amount of vegetation cover present around pools. Increased diversity of substrate types, with preference for cobble, gravel, sand, or leaf packs generally results in increased biological community diversity. In addition, good vegetation growth along the banks of pools provides cover for predator avoidance, refugia from disturbance, and oviposition.
- ▶ Velocity/Depth - High diversity in flow regimes can support high biological diversity. While ideally a stream habitat should have a range of flow types from very fast to very slow, fast-flowing habitats are considered more conducive to increased diversity than slow-flowing habitats.

2. Secondary Parameters - These factors are directly related to channel morphology and macrohabitat features. Local geological features and human activities affect these factors. Scores are weighted less than primary factors and range from 0 to 15.

- ▶ Shade conditions - Shading affects both daily mean water temperatures and diurnal fluctuations in water temperatures. A diversity of shade conditions (dense, filtered, open) is considered optimal. Visual observation is used to assess this parameter. Some consideration of stream orientation may be necessary as sunlight availability is often less in streams with a north-south orientation as compared to streams with an east-west orientation. Furthermore, canyon walls could enhance shade conditions, and this factor should also be considered when assessing this habitat parameter.
- ▶ Channel shape - this parameter is a measure of channel morphology at the lower bank (bank immediately adjacent to stream). Ideally, the lower bank should be undercut (trapezoidal) to some degree as this undercutting provides beneficial cover for animals. At the opposite extreme (inverse trapezoidal) are banks that are cut deeply. This downcutting is often caused by a loss of riparian vegetation along the banks. In bedrock areas, channel shape is typically rectangular or triangular.

- ▶ Pool/Riffle ratio (habitat variety) - Stream habitats with a good mixture of substrate sizes and types tend to have frequently alternating pools and riffles. Increased biological diversity is related to increased habitat diversity. Consequently, variable stream morphology (substrate as well as flow regime) should result in a more diverse and balanced community. This parameter can be addressed in one of two ways: (1) The pool/riffle ratio can be calculated by dividing the average distance between riffles by the average stream width; (2) Habitat variety can be addressed by subjectively determining frequency of pool/riffle repeat pattern as frequent or infrequent. Less repetitiveness of habitat can lead to decreased biological diversity. Note: As pool/ratios can be difficult to assess in larger streams, it is possible that this parameter will later be modified to only consider habitat variety.
- ▶ Lower bank channel capacity - this parameter is used to evaluate the ability of the lower bank to contain normal peak flows. It is also a measure of the degree of flow fluctuations (flashiness) in the stream. The lower channel bank defines the stream width. Two observations are made: (a) the width-to-depth ratio is calculated by dividing the average top width of the lower bank by the height of the lower bank; (b) the removal or distribution of riparian debris (flood debris as well) on the lower bank.

3. Tertiary Parameters - These parameters focus on the land area from the normal peak flow line (lower bank) to the break in the general slope of the surrounding land. This zone is normally vegetated (except in canyons) and only covered by water under extreme flow conditions. All parameters relate to vegetation, bank stability, and impacts caused by anthropogenic disturbances. Scores are lowest for these parameters and range from 0 to 10.

- ▶ Upper bank stability - The stability of the stream bank affects substrate embeddedness, sediment deposition, channel sinuosity. Visual observation of the potential for, or occurrence of, the movement of soil into the stream channel is used to evaluate this factor. Increased bank slope will reduce stability, unless the slope is comprised primarily of material with low erosion potential such as bedrock. Consideration of the angle of the slope should be tempered by the presence of bedrock or if the site is located within a canyon.
- ▶ Grazing impacts - Bank soil is generally held in place by undisturbed vegetation although bedrock and rocky soils may also provide erosion protection. Grazing impacts are primarily evaluated in terms of the potential plant biomass that a given site may

support. Areas of bedrock should not be considered in this evaluation as this area has no potential plant biomass. Look for evidence of cattle. High numbers of tracks or cowpies is helpful in determining impacts to plant biomass in wet years as plant biomass can appear unusually high following abnormal amounts of moisture.

- ▶ Streamside cover - This parameter is used to evaluate the quality of vegetation as a source of nutrient inputs to the stream. It requires a visual examination of the vegetation types covering the exposed stream bottom, bank, and top of bank. Grass as a dominant vegetation type is least desirable as these materials provide minimal nutrient input to a stream. However, a community of mixed vegetation types is considered ideal as rates of leaf breakdown and therefore nutrient release vary greatly among plant types. Herbaceous leaf material breaks down more quickly than tree leaf material (Platts et.al 1983). A mixed plant community, then, will provide a greater mix of nutrient resources to a stream than a plant community dominated by one vegetative type.

- ▶ Riparian vegetative zone width - This factor is rated for the side of the stream which has the least amount of riparian vegetation. The average width of this vegetative zone is estimated visually. Within canyons where riparian vegetation can be naturally reduced, the evaluation of this parameter should focus on impacts from human activity on the upper bank.

3. Riparian Assessment and Channel Morphology and Substrate composition

A separate field form, which includes both a riparian assessment and a channel morphology and substrate assessment (Appendix C), has been developed to augment the habitat assessment rating scores. This field form incorporates a riparian assessment with a channel morphology and substrate assessment. The riparian assessment includes taxonomic names of principal riparian and upland trees, assesses their regeneration potential, estimates percent stream shade provided, and percent plant cover provided (which includes aquatic plant cover in-stream). The channel morphology and substrate composition is assessed by the following: percent substrate composition of the creek bed and channel bank, percent bank cuts along stream bends, inner and scour channel width, remarks on channel and bank stability and a description of other potential sources of water to the stream reach.

3.1 Riparian Assessment

1. Upland plant associations provide information about the type of leaf litter that may be transported to the stream as well as aiding in the ecoregion classification. Leaf litter from riparian trees is important because leaves from different trees provide different food resources which attract different functional feeding groups of insects. A list of the types of upland plant associations in Arizona can be found in Lowe (1985).
2. Riparian plant associations directly affect stream ecosystems in a variety of ways. They provide bank stability, shade cover, leaf litter, and woody debris which contributes to microhabitat development in streams. The presence of native riparian trees as well as their regeneration potential gives an indication of the health of both the riparian and aquatic environment. The names of riparian community types in Arizona can be found in Szaro (1989).
3. Percent of stream shaded by riparian trees provides a numeric estimate of shade cover to augment the score given on the habitat assessment form. This visual observation should be made between the daytime hours of 10:00 am to 2:00 pm. If site assessments are done at other times, estimate what the cover would be between 10:00 am and 2:00 pm.
4. Percent plant cover on soil (vegetative cover) - This estimate is used to supplement the streamside cover score given on the habitat assessment form. It provides information about the potential for soil erosion and bank failure. It is approximated by estimating the percentage of bare ground and subtracting that from 100 (consider cover provided by grasses and forbs, shrubs and trees).
5. Aquatic plant cover - The presence and abundance of macrophytes and algae can be indicative of natural or anthropogenic nutrient enrichment and sources of pollution. The percent cover of the stream bottom by plant material (submergent, emergent and algal cover) is visually estimated for the 100 m reach. If known the taxonomic name is given (flooded riparian vegetation is not included in this estimate).
6. Regeneration potential - The percentage of mature trees, saplings and seedlings is estimated for each dominant riparian tree species. This estimates community recovery from disturbance; the lack of regeneration indicates potential land use problems. Seedlings are defined as having a diameter of <1 cm or 2 m tall. Saplings are defined as having a diameter of <4 cm or a height greater than 2 m tall. (This method is a modification of the Soil Conservation Service, Riparian assessment method).

3.2 Channel Morphology and Substrate Composition

1. Creek bed composition - The percent areal composition of the active stream channel is visually estimated within the 100 m reach. Particle size classes used are (MacDonald, Smart, and Wissmar, 1991):

boulders >256 mm

cobbles <256 and >60 mm

gravel <60 mm and >2 mm

sand <2 mm and >0.062 mm

silt <0.062 mm and >0.004 mm

clay <0.004 mm and >0.00024 mm

2. Channel bank composition - The percent composition of the immediate channel bank is visually estimated within the 100 m reach using the particle sizes listed above.
3. Channel undercutting - The percent of stream bank that is undercut within the 100 m reach is estimated. Bank undercuts provide good cover for invertebrates and fish. This percentage estimation augments information provided on the habitat assessment form.
4. Bank type - The percent of stream edges that are cut by the meandering stream is estimated for the 100 m reach. Instability in channels resulting from changes in discharge, sediment load, and riparian vegetation may be manifest in horizontal migration of the channel. Erosion of one bank and filling on the opposite bank results in lateral movement of the stream.
5. Inner and Scour channel width - The inner channel width is defined by the width of the active, wetted channel, whereas the scour channel width is defined by the 100 year floodplain or high water mark.
6. Comments on channel/bank stability - Observations about localized areas of erosion or general comments about bank stability are recorded here.
7. Description of flowing side drainages, springs and other sources - Note any incoming sources of water within or immediately upstream of the sample reach. Also note hyporheic inputs of water, eg. seeping through a cobbly bank.

4. Chemical Evaluation

4.1 Field Parameter Measurements

As indicated in Section 2.1, physicochemical measurements are collected at each site with a multiparameter probe (ADEQ uses a Scout 2 Hydrolab), which measures water temperature, pH, electrical conductivity, dissolved oxygen, percent oxygen saturation, and total dissolved solids. Turbidity is measured with an HF Scientific Turbidimeter. Prior to its use in the field the Hydrolab

should be calibrated according to the methods provided by the manufacturer. Likewise, after completion of fieldwork the Hydrolab should be post-calibrated. If the post-calibration is >10% off, then data should be correspondingly adjusted by a slope calculation or the water resampled.

4.2 Water Sample Collection and Analysis

Water samples are collected from the top of each sample reach, upstream of where all other activities occurred. Label each sample bottle with the site name, date, time, and collector's name. Program objectives will dictate which analyses are to be performed. The number and type of sample containers will be dictated by the type of analyses requested. For analysis of ions, nutrients and metals, three 1-liter bottles are filled; one bottle contains no preservative, one bottle contains sulfuric acid as the preservative, and one bottle contains nitric acid as the preservative. The "no preservative" bottle is used to fill the other two bottles. Collect the water samples last before leaving each site, and transport them as quickly as possible to an ice chest for storage. Water samples are typically analyzed for three metals of concern in Arizona: arsenic, mercury, and copper. Detection limits for all forms of nitrogen and phosphorus are recommended at the 0.01 mg/L level for consistency with State of Arizona Water Quality Standards.

5. Biological Evaluation

Biological sampling should occur in late spring/early summer. This time is best as it minimizes impact that streams could receive from high flow events. In Arizona the wettest periods are during the winter months and the summer months of July and August. For most purposes spring is typically better than fall for sampling because most macroinvertebrate taxa tend to be larger in the spring and large specimens are easier to identify than small specimens.

Macroinvertebrate and algae sampling focuses on pools, riffles and microhabitats (See Field Methods-Quick Reference in Appendix A). The following sections describe the field collection and laboratory processing methods for these samples.

5.1 Macroinvertebrate Community

5.1.1 Macroinvertebrate Field Methods

1. Sample points (pool/riffle samples) - Sample the same 100 meter reach of stream that was evaluated on the habitat assessment form. If the number of pools or riffles along the sample is greater than four, then randomly select (use random number table) which pools or which riffles will be sampled . If there are fewer than three pools or riffles, then spread out the sample points so that as much area along the sample reach is sampled as possible, e.g., the lower, middle, upper. In all cases an attempt should be made to sample the most productive part of the habitat.
2. Riffle/run (erosional) sample collection - Collect three timed kick samples. For one minute agitate the substrate vigorously (kicking/hand-turning of large substrates) and collect dislodged material in a D-Frame kick net fitted with a 500 μm mesh net. Place the material in the net into a water-filled bucket. Repeat this process until all three one minute samples are composited in the same bucket. After depositing the third sample in the bucket, check the net for attached organisms and remove as many of those as possible with a pair of forceps.
3. Pool/edge (depositional - wadable areas only) sample collection - Collect three timed kick samples. For one minute agitate the substrate vigorously (kicking/hand-turning of large substrates) and collect dislodged material in a D-Frame kick net fitted with a 500 μm mesh net by sweeping the water column. Place the material collected by the net into a water-filled bucket. Repeat this process until all three one minute samples are composited in the same bucket. After depositing the third sample in the bucket, check the net for attached organisms and remove as many of those as possible with a pair of forceps.
4. Processing of pool or riffle samples:
 - ▶ The contents of a bucket with a composited sample (pool or riffle) are swirled and decanted through a 500 μm mesh sieve. This process is repeated (even if additional water must be added to bucket) until the majority of organisms have been rinsed from the bucket.
 - ▶ Before discarding the leftover debris in the bucket a visual inspection is made of the contents for remaining organisms. Remove any organisms found and add them to the material in the sieve. Special care should be made to collect stone-cased caddisflies and substrate-attached organisms.

- ▶ The material collected by the sieve is placed in a sample jar (jars should not be more than three-quarters full of material) and preserved with 100% isopropyl alcohol and a small amount (a capful) of 37% formaldehyde. If necessary, use more than one jar, but not more than two. If more than two jars are required then field split the sample. This is done by spreading out sample debris in a white tray and splitting debris into two halves. Store one half in sample jars and discard the remainder of the material. Note on site investigation form that sample was field split and the number of jars that were used.
- ▶ Two pencil-written labels on write-in-the-rain paper are placed with each sample. One is placed inside the jar before sealing. The second label is taped with clear plastic tape around the sample jar. Both labels should contain the following information: waterbody name, site code number, sample date (spell out), habitat type/sample type (e.g., macroinvertebrate/pool), and the collector's name(s). If more than one jar was used, then label additional jars with the same information, and add jar counts to all labels, e.g., 1 of 2, 2 of 2.

5. Microhabitat Sample Collection and Processing (optional) - Microhabitat samples are collected when the investigator wants to determine the maximum richness and diversity at a site, and for better taxonomic identification. However, microhabitat samples are not necessary for a water quality evaluation. Two investigators each spend 15 minutes (for a total of 30 minutes) visually collecting macroinvertebrates from microhabitats (seeps, backwaters, wood, bedrock surfaces, leaf packs, algal mats, macrophyte beds, moss, etc.). Organisms are collected with handnets, forceps, etc. and composited in a tray of water. Remove the organisms from the tray with forceps and place in a whirlpak bag or jar. Label and preserve the sample in 100% isopropyl alcohol. This method selects for larger organisms that can be seen with the naked eye and thus provides organisms at later life stages that are more easily keyed out to a more specific taxonomic identification.

5.1.2 Macroinvertebrate Laboratory Methods (performed by a qualified taxonomist/biologist)

1. Each sample is placed in a white tray and floated in water to remove large organic and inorganic debris. An estimate of the number of animals in the sample is made, and if the number appears to be more than 600, then the sample is split. No less than 300 organisms per sample should be processed but no less than 12.5% (1/8th) of the sample should be processed for identification. Experience has shown that some samples may need to be cut further, but only on a case by case basis.

2. When a sample is split, large and/or rare macroinvertebrates, e.g., crayfish, are removed and recorded at 100%. Fish may be discarded from the sample. One-half of each split sample is placed back into the original sample container and re-preserved as a back-up.
3. Samples are sorted with a dissecting microscope with a minimum of 6X power. After removing all organisms from the sample, the remaining residue is re-preserved. As a quality control measure, 10% of this material will be analyzed and checked for sorting efficacy.
4. Taxonomic identifications have been performed for ADEQ by nationally recognized taxonomic specialists. Organisms were identified to the following levels:
 - ▶ Insecta (including order Diptera, family Chironomidae) - to genus and, where possible, to species
 - ▶ Mollusca - genus
 - ▶ Annelida - class (or to family, wherever possible without the cost of a specialist)
 - ▶ Turbellaria - order
 - ▶ Nematoda - phylum
 - ▶ Cladocera, Copepoda, Ostracoda - order
 - ▶ Isopoda, Amphipoda, Decapoda - genus
 - ▶ Mites - order
 - ▶ Other taxonomic groups - lowest level possible without the aid of a specialist
5. All specimens of taxonomic groups that are not identified to the genus or species level should be stored in individual, labeled vials in the event that further identification is desired at a later date.
6. After corrections are made for sample splitting, the results are reported as number of animals/taxon/habitat/site/date. The portion of sample analyzed should also be listed with data in spreadsheet format.
7. A reference collection should be prepared. Whenever possible, all reference vials should contain a minimum of ten organisms/taxon properly preserved and labeled. If taxa are slide-mounted (eg. Chironomidae), then two organisms/slide are preserved. The reference collection will include a list that documents all taxonomic names, locations they were collected from, and the identifier's name.
8. Microhabitat samples should be analyzed by a qualified taxonomist/biologist. The entire sample should be sorted with a dissecting microscope. Identifications for all taxa should be made to the levels listed above.

5.2 Algae Community

5.2.1 Algae Field Methods

Two sampling protocols are provided for collecting/analyzing algae samples. Protocols for collecting and analyzing diatoms or non-diatom algae should be selected according to the objectives for sampling. Diatoms are useful indicators of biological integrity because they are ubiquitous in most aquatic environments, tolerances of many species are known, and they are easily collected, preserved and analyzed. Non-diatom algae may be useful biological indicators where they dominate impaired or heavily polluted streams. The advantage of non-diatoms is that various taxa have been associated with different types of pollution such as mine drainage or organic enrichment, but the disadvantage is that the algae decompose rapidly and need to be analyzed within a period of a few weeks. ADEQ sampling has focused on diatoms because of the advantages stated above. Non-diatom algae may be used in site-specific studies in the future.

5.2.1.1 Diatoms

Algae samples are collected from pools and riffles (ADEQ is investigating the value of sampling both habitats). Samples should be collected from the same pools/riffles as the macroinvertebrate samples. Collect algal samples prior to the macroinvertebrate samples because the macroinvertebrate collection methods will disturb the algal community.

1. Sample collection - Two algal samples are collected from each site. One sample consists of a composite of algal scrapings from six riffle rocks (two rocks from each of 3 riffles) and the other sample is a composite of algal scrapings from six pool rocks (two rocks from each of 3 pools). From the appropriate habitat, select rocks that have a relatively flat surface and are representative of typical algal growth for the area (brown slippery surface indicates potential diatom mat, green slippery surface indicates non-diatoms). Riffle rocks should be collected from areas that are representative of the major flow conditions of the riffles at that sample reach. In pools choose rocks from areas that are most representative of the best pool conditions. Avoid glides or runs, and select rocks from depths of less than one meter.
2. Sample processing - Carefully remove six rocks from the appropriate habitat (do each habitat separately to avoid mixing pool/riffle samples together). Then, working with each rock independently (collect sample from the top light-exposed side of the rock), place a 9 cm² template on a relatively flat surface and outline the area to be scraped with an Exacto knife. Remove template and scrape outlined area with ca. 30 one-way strokes (for uniformity always scrape towards your body). Rinse the rock with stream water and collect water and algae in

sample jar. Rotate the rock 90° and again scrape the rock in the same manner. Repeat this process, rotating the rock each time, until all four directions have been scraped and rinsed. After the final direction is scraped and rinsed, rinse any remaining material off of the knife into the sample jar. As a final scraping measure, use a toothbrush and brush the cleared area in a circular motion for ca. 10-15 seconds. Rinse the material on the rock and brush into the sample jar.

3. Sample preservation and storage - If necessary, add more water to sample bottle to create slurry of algae. Preserve with a squirt of 2-4% formalin in alcohol preservative (Smith, 1950). Affix one label to the outside of the sample bottle (stream name, site code number, date, sample type/habitat type, collector's name) and keep sample in a cool, dark place until analyzed. Permanent mounts of diatom samples should be retained in a microscope slide box to serve as a reference collection.

5.2.1.2 Non-diatoms

1. Sample collection - Collect periphyton from all available microhabitats (sand and silt, rocks, woody material, plant material and animal habitats such as snail shells) by sampling microhabitats in roughly the proportion that they occur at the site and compositing these collections into one qualitative sample. Sample both riffles and pools or select one habitat type if it occurs at all study sites (During low flow periods, pool habitats may be the only available habitat).
2. Sample processing - Samples may be collected from substrates with several tools: use a dropper to collect from sand and silt habitats, an exacto-knife to scrape from boulders, woody debris or other hard surfaces, or hand pick macroalgae. Scraping surfaces with an exacto-knife should be followed up by scrubbing with a toothbrush and rinsing into sample containers. Remove algae mats from depositional areas carefully with forceps or by suctioning with a pipette.
3. Sample preservation - Samples should be kept cold and identified as soon as possible; samples will decay with long term storage or chemical preservation.

5.2.2 Laboratory Methods

5.2.2.1 Diatoms

1. Sample pretreatment - Algae samples are initially centrifuged and rinsed in deionized water to remove preservative.

2. Diatom frustules should be cleaned of organic and cellular material by one of the following methods "burn mount" incineration, nitric acid oxidation, or hydrogen peroxide/potassium dichromate oxidation as per Standard Methods (APHA, 1992). Mount aliquots of sample with permanent mounting material.
3. A minimum of 500 cells (or entire sample if less than 500 cells present) should be counted by taxon and recorded on bench sheets to determine relative algal density.
4. Diatoms are identified to species level whenever possible by a qualified phycologist.
5. Results are reported as relative abundance per taxon as well as percent composition and listed along with site codes, lab sample number, sample type (pool or riffle), sampler names and date of collection. Data should be presented in a site by species abundance data matrix (sorted by basin) in electronic and hard copy format.
6. Voucher slides should be prepared by mounting each sample in a permanent medium on glass slides. Dominant taxa in each sample thus preserved constitute the reference collection. Photo images of dominant organisms are also helpful, but optional.

5.2.2.2 Non-diatoms

1. Thoroughly shake sample container to dislodge epiphytic material from filamentous algae and to mix sample. Pour sample contents into a shallow bowl to separate filamentous taxa for identification. Prepare microscope slides with wet mounts of all representative taxa present in the sample.
2. Examine a minimum of three slides per sample by scanning each one thoroughly until no new organisms are seen. Examine slides at 200X then 400X to ensure that small organisms are not overlooked. Record observed taxa on a bench sheet.
3. Identify non-diatoms to the lowest taxonomic level.
4. Counts can be recorded as either cells or units. A unit is considered one unicellular alga, a colony, or a filament. Report counts as relative abundance per each taxon.
5. A photolog of dominant species is helpful but not required.

6. Data Storage

Data should be stored both in electronic and hard copy formats. Electronic storage should include a spreadsheet or database format. Currently ADEQ is storing data in QuattroPro spreadsheet format. There are several categories of spreadsheets in which ADEQ data are stored: 1) Sample site location data, 2) Habitat data, 3) Physicochemical and water chemistry data, 4) Algae abundance data, and 5) Macroinvertebrate abundance data. Examples of these are provided in Appendix D. Eventually, after

quality control checks, the data will be uploaded into STORET/BIOS, the data storage and retrieval system of the U.S. Environmental Protection Agency.

7. Quality Assurance/Quality Control Plan (QA/QC)

7.1 Quality Assurance

As stated in the beginning, a major purpose of this document is to ensure the standardization of methods used for biological assessments in Arizona. Over time, these methods may be updated to reflect improvements in sampling techniques. This document will remain in draft form until data have been fully analyzed for the purposes of the ADEQ Biocriteria program. However, until then this document will serve as the reference for all methods utilized in Arizona's biocriteria program. In addition to the protocols outlined in this document, other measures that have been undertaken to assure the quality of data include:

1. Personnel - Each sampling team must include at least one formally trained aquatic biologist. This person should have training in the following areas: (1) habitat requirements for aquatic organisms; (2) stream sampling methodologies; and (3) a moderate level of expertise in macroinvertebrate identification with the ability to identify most macroinvertebrates to the family level without the aid of a microscope. Each team should also include at least one member who has good map reading skills. Locating sites in the field can be difficult at times and the ability to read a USGS 7.5' quadrangle is critical to this type of work.
2. Training - Each member of a sampling team should be trained in all the methods contained in this document.
3. Equipment calibration - All equipment should be maintained and checked for proper function prior to going into the field. In addition, each member of a sampling team should be knowledgeable in the use of any equipment required for site evaluations.
4. Water quality sampling - Each member of the team should be familiar with the appropriate methods for the collection and preservation of water samples for chemical analysis.
5. Sample storage - Each member of the team should be knowledgeable in the appropriate methods for storage, preservation, and logging of biological samples.

7.2 Quality Control

Various measures have been written into these methods to ensure quality control at different stages of the sampling and analysis. These include:

1. Collection of samples from random locations
2. Standardized (timed) sampling effort
3. Analysis of macroinvertebrate sample residue (on 10% of samples) to check for sorting efficacy
4. Preparation of a reference collection
5. Pre-calibration and post-calibration of the Hydrolab multiparameter probe
6. A data entry check on 10% of all hand entered electronic data.
7. Water quality laboratory data checks (ion balances, etc...)
8. Quality control procedures provided by contractor for handling of samples.

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APPENDIX A

ADEQ Biocriteria Program Sampling Site Summary

(A1 - A5)

ADEQ Biocriteria Program Sampling Site Summary

Attached is a list of sites sampled during 1992, 1993 and 1994 for the ADEQ Biocriteria Program. Most of the sites sampled are intended to serve as reference sites for the development of biological criteria. A few additional sites have been sampled that are believed to be impacted. These sites will serve as comparisons for the reference sites. In the following table these sites can be distinguished by the RF/IM designation in the site code number where RF refers to reference sites and IM refers to impacted sites. The final columns in the table indicate the year(s) sampled. Between year differences in the sites sampled were the result of the following: 1) the site was determined to be impacted and therefore did not meet the criteria for a reference site; 2) problems (e.g., washouts) may have prevented reasonable access; 3) new sites were added within a particular region to replace sites that could not be sampled or to increase geographic coverage.

1994 BIOCRITERIA PROGRAM SITE LIST, sorted by basin

SITE NAME	ADEQ SITE ID	LATITUDE	LONGITUDE	MAJOR BASIN	ECO- REGION	WTRSHD AREA(sqkm)	ELEV. (feet)	GRADIENT (ft/ft)**	YEAR SAMPLED		
									1992	1993	1994
BURRO CR.	BUR1-00RF	344437	1131422	BW	SBR	438.3	3100	0.013	S	S	S
CONGER CR.	CGR1-00RF	344539	1130750	BW	SBR	39.5	4360	0.068	S	S	
COTTONWOOD CR. (COTTONWOOD)	COT1-00RF	344346	1125348	BW	AZNMM		4740	0.019		S	S
DATE CR.	DAT1-00RF	341400	1130050	BW	SBR	201.5	2990	0.011	X		
FRANCIS CR.	FRA1-00RF	344548	1131548	BW	SBR	330.4	3250	0.019	S	S	S
PEEPLER CANYON	PEE1-00RF	342235	1131615	BW	SBR	15.0	2480	0.057	S		
SANTA MARIA R.	SMR1-00RF	342358	1131024	BW	SBR	1995.5	1830	0.011	S	S	S
TROUT CR.	TRT1-00RF	345918	1133114	BW	AZNMP	1330.8	3230	0.027	S		S
BARBERSHOP CANYON (UPPER)	BAR1-00RF	342942	1110951	LCR	AZNMM	19.6	6950	0.013	S	S	S
BARBERSHOP CANYON (LOWER)	BAR2-00RF	343250	1110942	LCR	AZNMM	53.6	6520	0.021	S	S	S
CHEVELON CANYON (CHEVELON RIDGE)	CHV1-00RF	342400	1105200	LCR	AZNMM		6670	0.009		S,F	
CHEVELON CANYON (LONG TOM)	CHV2-00RF	342520	1105109	LCR	AZNMM	121.4	6535	0.008	S		
CHEVELON CANYON (TELEPHONE RIDGE)	CHV3-00RF	342628	1105022	LCR	AZNMM	153.4	6470	0.006	S	S,F	S
CHEVELON CANYON (CHEVELON CROSSING)	CHV4-00IM	343522	1104715	LCR	AZNMM	273.6	6130	0.003	S	F	
EAST CLEAR CR. (KINDER CROSSING)	ECL1-00RF	343400	1110848	LCR	AZNMM	269.8	6450	0.004	S	S	S
EAST CLEAR CR. (MACKS CROSSING)	ECL2-00RF	343710	1110534	LCR	AZNMM	343.3	6265	0.006	S		
EAST FK LITTLE COLORADO R.	ELC1-00RF	335534	1092948	LCR	AZNMM	4.3	9440	0.023	S		
LITTLE COLORADO R. (ABV S. FK.)	LCR1-00RF	340439	1092535	LCR	AZNMM	176.3	7490	0.049	S	S	S
LITTLE COLORADO R. (BLW S. FK.)	LCR2-00IM	340511	1092409	LCR	AZNMM	244.9	7305	0.015	S		
LITTLE COLORADO R. (BLW NUTRIOSO)	LCR3-00IM	341040	1091808	LCR	AZNMM	915.0	6770	0.025	S		
LITTLE COLORADO R. (MOUTH)	LCR9-00RF	361130	1114730	LCR	AZNMP	56731.4	2760	0.004	S		
LILY CR.	LIL1-00RF	335837	1090532	LCR	AZNMM	1.5	8620	0.114	S	S	S
MAMIE CR.	MAM1-00RF	335803	1090456	LCR	AZNMM	5.5	8590	0.061	S	S	S
MINERAL CR.	MIN1-00RF	341050	1093704	LCR	AZNMM	16.3	8070	0.072	S	S	S
PADDY CR.	PAD1-00RF	335504	1090903	LCR	AZNMM	11.5	8485	0.047	S	S	S
RIO DE FLAG	RDF-00EDW	351226	1113433	LCR	AZNMM						S
RUDD CR.	RUD1-00RF	340039	1091651	LCR	AZNMM	13.1	8100	0.049	S	S	S
S. FK. LITTLE COLORADO R.	SLC1-00RF	340424	1092438	LCR	AZNMM	60.1	7620	0.040	S	S	S
WEST FK. LITTLE COLORADO R. (UPPER)	WLC1-00RF	335724	1093103	LCR	AZNMM	14.3	9240	0.013	S	S	S
WEST FK. LITTLE COLORADO R. (LOWER)	WLC2-00RF	335910	1092804	LCR	AZNMM	28.7	8550	0.027	S	S	S
AGUA FRIA R.	AGF1-00RF	341850	1120337	MG	AZNMM	1521.5	3445	0.008	S	S	S
ANTELOPE CR.	ANT1-00RF	341146	1124252	MG	SBR	13.4	3850	0.053	S	S	S
ASH CR.	ASH1-00RF	343818	1120738	MG	AZNMM	8.6	6100	0.053	S		S
HASSAYAMPA R. (UPPER)	HAS1-00RF	342515	1123127	MG	AZNMM	106.2	4750	0.023	S	S	S
HASSAYAMPA R. (WAGONER)	HAS2-00RF	341114	1123222	MG	SBR		3270	0.005		S	S
HASSAYAMPA R. (LOWER)	HAS3-00RF	335536	1124108	MG	SBR	1969.9	1925	0.006	X		
LITTLE ASH CR.	LAC1-00RF	342301	1120130	MG	AZNMM	113.1	3840	0.017	S	S	S
LION CANYON	LIO1-00RF	341016	1124137	MG	SBR	6.0	3850	0.117	S	S	
POLAND CR.	POL1-00RF	341432	1121502	MG	AZNMM	70.1	3080	0.044	S		
QUEEN CR. ABV BOYCE-THOMPSON ARBORETUM	QEN-00EDW	331638	1110912	MG	SBR		2440				S
SALT R. ABV CONFL. W/ GILA R.	SLT-00EDW	332252	1121730	MG	SBR		935				S
SALT R. @107TH AVE	SLT-01EDW	332255	1121732	MG	SBR		935				S
SYCAMORE CR. (DUGAS)	SYD1-00RF	342050	1115654	MG	AZNMM	92.8	4090	0.017	S	S	S
TULE CR.	TUL1-00RF	340043	1121627	MG	SBR		2230	0.032		S	
CAMPAIGN CR.	CGN1-00RF	333127	1110512	MS	AZNMM	24.9	3355	0.044	S		S

1994 BIOCRITERIA PROGRAM SITE LIST, sorted by basin

SITE NAME	ADEQ SITE ID	LATITUDE	LONGITUDE	MAJOR BASIN	ECO-REGION	WTRSHD AREA(sqkm)	ELEV. (feet)	GRADIENT (ft/ft)**	YEAR SAMPLED		
									1992	1993	1994
CHERRY CR. (UPPER)	CHE1-00RF	335903	1105300	MS	AZNMM	249.8	4390	0.009	S	S	S
CHERRY CR. (LOWER)	CHE2-00RF	335034	1105136	MS	AZNMM	446.5	3190	0.013	S	S	S
CANYON CR.	CYN1-00RF	341515	1104742	MS	AZNMM	74.3	6270	0.013	S	S	S
DEER CR.	DEE1-00RF	340235	1112511	MS	AZNMM	20.9	3630	0.059	S	S	S
DEVILS CHASM	DEV1-00RF	334923	1105137	MS	AZNMM		3420			S	S
GORDON CR.	GOR1-00RF	341428	1105903	MS	AZNMM		5340	0.061		S	S
GREENBACK CR.	GRE1-00RF	335036	1110914	MS	AZNMM	48.1	3640	0.034	S		
HAIGLER CR.	HAI1-00RF	341212	1110028	MS	AZNMM	91.9	4870	0.044	S	S	S
PINAL CR.	PNL-00EDW	332645	1104907	MS	AZNMM		3275				S
REYNOLDS CR.	REY1-00RF	335232	1105917	MS	AZNMM	37.2	5065	0.028	S	S	S
SALOME CR.	SAL1-00RF	335430	1110214	MS	AZNMM	49.8	4820	0.021	S	S	S
SPRING CR.	SPG1-00RF	340450	1110432	MS	AZNMM	226.9	4260	0.013	S	S	S
TONTO CR. (GISELA)	TON1-00RF	340739	1111557	MS	AZNMM	1062.2	2950	0.013	S		
TONTO CR. (HELLSGATE)	TON1-14RF	341254	1110556	MS	AZNMM		3940	0.027		S	S
WORKMAN CR.	WOR1-00RF	334926	1105618	MS	AZNMM	7.2	6160	0.098	S	S	S
BEAVER DAM WASH (@ GOLF COURSE)	BDW5-00IM	365357	1135546	NCOL						S	S
BEAVER DAM WASH (ABV CONFL. W/ VIRGIN R.)	BDW7-00IM	365344	1135515	NCOL							S
BEAVER DAM WASH (WELCOME CR)	BDW8-00RF	365822	1135901	NCOL							S
BRIGHT ANGEL CR.	BRA1-00RF	360608	1120550	NCOL	AZNMP	267.5	2520	0.027	S	S	S
CRYSTAL CR.	CRY1-00RF	360800	1121400	NCOL						S	S
HAVASU CR.	HAV1-00RF	361815	1124530	NCOL	AZNMP	7681.7	1840	0.023	S		
HERMIT CR.	HER1-00RF	360450	1121310	NCOL	AZNMP	25.2	2920	0.246	S	S	S
KANAB CR.	KAN0-00RF			NCOL							S
KANAB CR.	KAN1-00RF	362335	1123755	NCOL	AZNMP	5987.0	1880	0.011	S	S	S
MATKATAMIBA CR.	MAT1-00RF	362030	1124015	NCOL	AZNMP	85.4	1900	0.030	S		
NANKOWEAP CR.	NAN1-00RF	361835	1115135	NCOL	AZNMP	91.5	2800	0.072	S	S	
NATIONAL CR.	NAT1-00RF	361500	1125200	NCOL						S	S
NORTH CANYON CR.	NCC1-00RF			NCOL	CP						S
PARIA R.	PAR1-00RF	365148	1113600	NCOL	AZNMP	3260.6	3120	0.008	S		
ROYAL ARCH CR.	ROY1-00RF	361150	1122700	NCOL	AZNMP	39.8	2160	0.250	S	S	S
SPRING CANYON	SPC1-00RF	360107	1132109	NCOL	SBR	57.3	1500	0.053	S	S	S
TAPEATS CR.	TAP1-00RF	362215	1122750	NCOL	AZNMP	217.9	2000	0.042	S	S	S
THREE SPRINGS CR.	THR1-00RF	355200	1131800	NCOL						S	S
VIRGIN R. (REST STOP)	VRG1-00RF			NCOL							S
VIRGIN R. (LITTLEFIELD)	VRG2-00IM			NCOL							S
CAVE CR.	CAV1-00RF	314254	1104936	SCR	SD	2.4	6340	0.193	S		
CANADA DEL ORO CR.	CDO1-00RF	323100	1104700	SCR	SBR	38.7	4600	0.040	S	S	S
CIENEGA CR.	CIE1-00RF	315306	1103313	SCR	SD	516.3	4050	0.008	S	S	S
GARDNER CR.	GAR1-00RF	314206	1104903	SCR	SD	3.8	6070	0.106	S		
MADERA CR.	MAD1-00RF	314216	1105158	SCR	SD	2.7	6060	0.191	S	S	S
RED ROCK CROSSING	RRC1-00RF			SCR						S	
SABINO CR.	SAB1-00RF	322213	1104703	SCR	SBR	47.1	3720	0.045	S	S	S
SANTA CRUZ R.	SCR1-00RF	312057	1103524	SCR	SD	252.9	4630	0.004	S	S	
SANTA CRUZ R. @ RANCHO SANTA CRUZ	SCR2-00ED	313243	1110215	SCR	SD		3280				S
SYCAMORE CR. (SONORA)	SYS1-00RF	312440	1111139	SON	SD	29.1	3790	0.021	S	S	S

1994 BIOCRITERIA PROGRAM SITE LIST, sorted by basin

SITE NAME	ADEQ SITE ID	LATITUDE	LONGITUDE	MAJOR BASIN	ECO- REGION	WTRSHD AREA(sqkm)	ELEV. (feet)	GRADIENT (ft/ft)**	YEAR SAMPLED		
									1992	1993	1994
ARAVAIPA CANYON (UPPER)	ARA1-00RF	325412	1102740	SPR	SD	1036.6	2980	0.006	S	S	S
ARAVAIPA CANYON (LOWER)	ARA2-00RF	325436	1103300	SPR	SD	1278.1	2650	0.006	S	S	S
BASS CANYON	BAS1-00RF	322106	1101405	SPR	SD	87.1	4040	0.021	S	S	S
GOUDY CR.	GOU1-00RF	323912	1095712	SPR	SD	17.8	5400	0.085	S	S	
HOT SPRINGS CANYON	HSC1-00RF	322118	1101616	SPR	SD	246.2	3830	0.009	S	S	S
RAMSEY CANYON	RAM1-00RF	312612	1101908	SPR	SD	7.2	6175	0.114	S	S	S
REDFIELD CANYON	RED1-00RF	322705	1101854	SPR	SD	95.0	3900	0.025	S	S	S
SAN PEDRO R.	SPR1-00RF	313842	1101042	SPR	SD	3196.0	3920	0.003	S	S	S
WARD CANYON	WAR1-00RF	315152	1091952	SPR	SD	7.7	6260	0.091	S	S	S
BLUE R. (UPPER)	BLU1-00RF	334100	1090456	UG	AZNMM	298.4	6110	0.009	S	S	S
BLUE R. (LOWER)	BLU4-00RF	331940	1091124	UG	AZNMM	1268.3	4310	0.009	S	S	S
BONITA CR.	BON1-00RF	325408	1092854	UG	SD		3180	0.009		S	S
CAMPBELL BLUE R.	CMB1-00RF	334418	1090600	UG	AZNMM	122.4	6670	0.017	S	S	S
COLEMAN CR.	COL1-00RF	334620	1091113	UG	AZNMM	24.4	7850	0.038	S	S	S
EAGLE CR. (HONEYMOON)	EAG1-00RF	332844	1092839	UG	AZNMM	261.9	5435	0.017	S	S	S
EAGLE CR. (SHEEP WASH)	EAG3-00RF	331738	1092940	UG	AZNMM	985.3	4645	0.008	S	S	S
EAST TURKEY CR.	ETK1-00RF	315430	1091516	UG	SD	5.2	6520	0.136	S	S	S
FRYE CR.	FRY1-00RF	324437	1095018	UG	SD	10.4	5800	0.121	S	S	S
GRANT CR. (BLUE)	GRB1-00RF	333445	1091119	UG	AZNMM	48.0	5580	0.038	S	S	S
GRANT CR. (PINALENO)	GRP1-00RF	323903	1095530	UG	SD	25.0	5600	0.114	S	S	S
LANPHIER CANYON	LAN1-00RF	333510	1090744	UG	AZNMM	26.8	5725	0.047	S	S	S
MARIJILDA CR.	MAR1-00RF	324101	1094842	UG	SD	12.7	5520	0.144	S	S	S
PIGEON CR.	PIG1-00RF	331634	1091338	UG	AZNMM		4300	0.015		S	
SOUTH FK CAVE CR.	SFC1-00RF	315113	1091132	UG	SD	28.8	5510	0.030	S	S	S
SAN FRANCISCO R. NEW MEXICO	SFNM-00RF			UG						S	
SAN FRANCISCO R.	SFR1-00RF	330814	1091642	UG	AZNMM	7132.9	3595	0.004	S		
CONKLIN CR.	CKN1-00RF	334054	1092642	US	AZNMM	18.9	7200	0.049	S	S	
EAST FORK BLACK R.	EFB1-00RF	334926	1091746	US	AZNMM	264.3	7920	0.015	S	S	S
HORTON CR.	HOR1-00RF	334209	1091855	US	AZNMM	9.8	7995	0.047	S	S	
N. FK. BEAR WALLOW CR.	NBW1-00RF	333546	1092600	US	AZNMM	16.1	7740	0.045	S	S	S
RESERVATION CR.	RES1-00RF	334145	1092836	US	AZNMM	58.9	6790	0.042	S	S	S
WEST FORK BLACK R.	WFB1-00RF	334746	1092524	US	AZNMM	90.1	7800	0.015	S	S	S
AMERICAN GULCH	AMG-00EDW	341405	1112210	VER	AZNMM						S
BLACK CANYON	BLC1-00RF	343914	1120629	VER	AZNMM	11.9	6000	0.042	S,F	S,F	
BEAVER CR. (CAMP VERDE)	BVR4-00IM	343625	1114955	VER	AZNMM		3180			F	
EAST VERDE R. (ELLISON)	EVD1-00RF	342128	1111655	VER	AZNMM	135.6	5165	0.013	S,F		
EAST VERDE R. (BRUSHY CANYON)	EVD3-00RF	341710	1112200	VER	AZNMM	388.9	4325	0.011	S,F	F	
OAK CR. (PINE FLAT)	OAK1-00RF	350054	1114413	VER	AZNMM	222.8	5550	0.027	S,F	S,F	
OAK CR. (BLW CAVE SPRINGS CAMPGROUND)	OAK2-00RF	345935	1114410	VER	AZNMM		5400				S
OAK CR. (RED ROCK STATE PARK)	OAK7-00IM			VER	AZNMM					F	
PINE CR.	PIN1-00RF	341330	1112912	VER	AZNMM	119.2	3360	0.021	S,F	S,F	S
ROUNDTREE CR.	ROU1-00RF	340808	1115053	VER	AZNMM	28.6	3300	0.030	S,F	S,F	
SYCAMORE CR. (HORSESHOE)	SYH1-00RF	340448	1114206	VER	AZNMM	75.9	2080	0.023	S,F	S,F	
SYCAMORE CR. (MAZATZAL)	SYM1-00RF	334415	1113055	VER	AZNMM	291.1	2060	0.008	S,F		S
SYCAMORE CR. (WILDERNESS)	SYW1-00RF	345256	1120357	VER	AZNMM		3625	0.008		S,F	S

1994 BIOCRITERIA PROGRAM SITE LIST, sorted by basin

SITE NAME	ADEQ SITE ID	LATITUDE	LONGITUDE	MAJOR BASIN	ECO- REGION	WTRSHD AREA(sqkm)	ELEV. (feet)	GRADIENT (ft/ft)**	YEAR SAMPLED		
									1992	1993	1994
VERDE R. (PERKINSVILLE)	VER1-00RF	345338	1121244	VER	AZNMM	6614.2	3820	0.003	S,F,	S,F	S
VERDE R. (COTTONWOOD)	VER3-00IM	344055	1115725	VER	AZNMM		3200			F	
VERDE R. (CAMP VERDE)	VER6-00IM	343022	1115005	VER	AZNMM		3000			F	
VERDE R. (SHEEP BRIDGE)	VER8-00IM	340450	1114230	VER	AZNMM		2040			F	
WET BEAVER CR.	WBV1-00RF	344026	1114012	VER	AZNMM	286.9	4025	0.025	S,F,	S,F	S
WEST CLEAR CR. (UPPER)	WCC1-00RF	343320	1112432	VER	AZNMM	350.4	5985	0.009	S,F,	S,F	S
WEST CLEAR CR. (LOWER)	WCC3-00RF	343220	1114100	VER	AZNMM	579.1	3660	0.011	S,F,	S,F	S
WEST CLEAR CR. (CLEAR CR. CAMPGROUND)	WCC4-00IM	343050	1114530	VER	AZNMM		3260			F	
WEBBER CR.	WEB1-00RF	342356	1112151	VER	AZNMM	26.7	5380	0.025	S,F,	S,F	S
WEST FORK OAK CR.	WFO1-00RF	345954	1114512	VER	AZNMM	111.5	5310	0.027	S,F,	S,F	S
RUCKER CR.	RUC1-00RF	314707	1091705	YAQ	SD	18.7	6220	0.030	S	S	S

* - Letter code assigned if no stream segment number currently assigned

** - Measured from sample site to 0.5 miles above site.

S1 - Sample collection and family level analysis performed at ADEQ

X - SITE RECONN. BUT NO SAMPLES COLLECTED

S, F, W = SPRING, FALL, WINTER SEASONAL SAMPLE COLLECTIONS

MAJOR BASIN CODES

BW - Bill Williams River
 LCR - Little Colorado River
 MG - Middle Gila River
 MS - Middle Salt River
 NCOL - Northern Colorado River Mainstem
 SCR - Santa Cruz River
 SON - Sonora Basin
 SPR - San Pedro River
 UG - Upper Gila River
 US - Upper Salt River
 VER - Verde River
 YAQ - Yaqui Basin

ECOREGION CODES

AZNMM - Arizona-New Mexico Mountains
 AZNMP - Arizona-New-Mexico Plateau
 CP - Colorado Plateau
 SBR - Southern Basin and Range
 SD - Southern Deserts

APPENDIX B

Field Methods-Quick Reference
Field Equipment Checklist

(B1 - B3)

FIELD METHODS (QUICK REFERENCE)

1. Upon reaching the site choose a reach with the best possible mixture of riffles and pools over a 100 meter stretch. Set up the work station at the top of the sample reach.
2. Walk the 100 meter (estimate with 100 long paces) reach and estimate the percent areal coverage of pools and riffles.
3. Walk additional 100 meters (estimate) upstream of sample reach to assess habitat characteristics.
4. Fill out field forms - 1) site investigation form, 2) habitat assessment form, and 3) substrate and riparian assessment field form (the habitat and riparian forms should be completed after sampling).
5. Take four photos (document on photo log): two at base of reach and two at the top of the reach (50 mm angle, program mode). At each location take one picture from the middle of the stream (looking upstream {LU} from the base of the reach and looking downstream {DS} from the top of the reach). The second picture should look at a cross section of the stream and its banks. NOTE: If the site has not been previously visited, then take the normal complement of photos to provide an indication of the surrounding terrain.
6. If needed, number the riffles and pools on paper from the downstream end of the sample reach. If there are more than four pools/riffles, randomly select which pools or riffles to sample from a random number table.
7. Collect physicochemical data with a multiparameter probe. Collect a water sample in a separate container for a turbidity measurement. Collect water samples as needed.
8. Estimate velocity and discharge using a Marsh McBirney flow meter if site is reasonably accessible. If site is not reasonably close to parking, then estimate flow by the float method.
9. Collect algae samples (if collected, should be done prior to macroinvertebrates). Algae samples should be collected from pools first, then riffles, if collecting from both habitats.
 - a. Collect six relatively flat rocks from the selected pools. Rocks should be in water of less than 1 meter deep and have no apparent current. For each rock:
 - (1) Outline 3 cm² area on each rock with template.
 - (2) Scrape outlined area with 30 strokes of exacto knife - make single direction strokes in the direction of your body. Put scrapings on knife into sample jar. Rotate rock clockwise 90° and again scrape with 30 strokes. Repeat until all four directions scraped on each rock.
 - (3) Rinse scraped area of rock into sample jar with squeeze bottle of de-ionized water. Rinse knife into sample jar.
 - (4) Scrub with toothbrush for 10-15 seconds.
 - b. Repeat the above process for each rock. Composite all rock scrapings into the same jar.
 - c. Add about 1 mL of iso-propyl alcohol preservative to sample jar.
 - d. Seal jar and make sure it is properly labeled (see labeling guidelines below).
 - e. Repeat steps a-d for riffles. Again, start at the bottom of the sample reach. Avoid dislodging much substrate when stepping into riffles to remove rocks. Riffle sample should be bottled and labeled separately.
 - f. Store the samples in a dark place until analyzed.
10. Macroinvertebrate sampling consists of a compositing of three timed kick samples collected from three riffle or pool habitats within the sample reach. To collect a kick sample, place the D-frame net in the path of flowing water, then for one minute agitate the substrate vigorously by kicking or hand turning larger substrates to collect dislodged material. Place the material collected by the net into a water-filled bucket. Repeat this process until all three one minute samples are composited in the same bucket. After depositing the third sample in the bucket, check the net for attached organisms and remove as many as possible with a pair of forceps.

a. Pool Samples (Collect prior to riffle samples):

- (1) Begin at the bottom of the reach.
- (2) Fill bucket with water.
- (3) Each pool sample should consist of 1 minute of kicking effort. If near the stream edge, split this time between the bottom and the edge. For the bottom, kick the substrate up with your feet and sweep water column repeatedly with net. Attempt to sample large and small substrates. For the edge, use the net to scrape and disturb edge vegetation. Then use net to sweep water column along edge.
- (4) Deposit contents of the net into bucket. At this point there is no need to pick the net clean.
- (5) Repeat sampling procedure for second and third pools. After last pool, use forceps to remove organisms attached to kick net.
- (6) Swirl the contents of the bucket and pour into a 500 μm mesh sieve. Add water, swirl and pour several more times until all insects and organic debris are emptied and only sediment remains.
- (7) After finishing swirl and pour process, dump remaining sediment into pan and search sediment for remaining organisms, especially cased Trichoptera, then discard remaining sediment.
- (8) Using a spoon or hands, scoop sample from sieve into appropriate sample jar. Do not fill jar more than three-quarters full; use extra jars if necessary. Rinse leftover material in sieve into corner and spoon out as much as possible. Check sieve for remaining animals. If sample does not fit into one jar, then add remainder to a second jar. If sample will not fit into two jars, then field split the sample. Do this by evenly spreading the entire sample on a white tray and then divide sample in two parts. Place one half in sample jars; discard the other half. Note that the sample was field split on the data form.
- (9) Place label(s) (use pencil on "write-in-rain" paper) in jar(s), add 100% alcohol (fill until alcohol covers sample material by about 1 inch) and one solid squirt of 37% formaldehyde.
- (10) Seal jar(s), and affix a second "write-in-the-rain" label to outside of jar(s) with clear plastic tape.

b. Riffle Samples

- (1) Begin at bottom of reach
- (2) For each riffle, sample as much variation of the flow and substrate as possible, keeping total sample for each riffle to 1 minute of effort. This effort should include the edge where riffle habitat includes the edge.
- (3) Deposit material in net in bucket of water. Repeat process for other two riffles.
- (4) Follow same swirl and pour procedures as for pools.
- (5) Label and preserve sample as described above.

c. Microhabitat Samples

- 1) Discuss microhabitats of the sample reach - note wood, backwaters, seeps, algal mats, leaf packs, macrophytes, etc.
- 2) Have samplers sample different microhabitats.
- 3) Hand sample the microhabitats for a total of 30 minutes (15 minutes for each of two samplers). Carry pans or sieves (mesh no large than 500 μm) and with forceps and handnets collect insects from microhabitats. Take care not to collect extra organic debris.
- 4) Combine collections into one properly labelled sample jar or Whirlpak and preserve with 100% isopropyl alcohol.

Labeling Guidelines

1. Each macroinvertebrate and algae samples should have an two identification labels penciled on "write-in-the-rain" paper: one placed inside the jar, visible on the outside, and one affixed to the outside of the jar, attached with clear plastic tape.
2. Each tag should have the following information at a minimum:
 - a. Site code number
 - b. Waterbody name
 - c. Type of sample (macroinvertebrates or algae)/habitat sampled (riffle or pool)
 - d. Collector's names
 - e. Date (spelled out, e.g., April 1, 1992)
4. If more than one jar is used for a sample, put jar numbers on all labels, e.g., 1 of 2, 2 of 2.
5. If using a Whirlpak, label bag on outside with permanent marker; place a pencil label on the inside.

BIOCRITERIA FIELD EQUIPMENT CHECKLIST

A. Administrative Details

Field-routing form	Prepare LAR (if necessary)
Lodging reservations	Contact appropriate interested parties
Arrange 4-WD Vehicle	Check spare tire, jack, tire key
Check site access	

B. Field Forms

Habitat evaluation (1/site) Site investigation (1/site) Riparian assessment (1/site)

C. General Supplies and Equipment

Camera and film	Pocket knife	Sample jar tags
Pens, markers, pencils	Field notebooks	Rubber bands (heavy duty)
Clipboards	Wading shoes	Hand lens
Maps (topos., regional)	Large Ziploc bags	Forceps (2)
Bungee cords (2)	Measuring tape	Plastic spoons
Backpacks (2)	Nylon rope (for net)	Heavy rope
Compass	Tarp	Insect repellent
Ice chests/ice stopwatch	Trash bags	Water bottles (drinking)

D. Biological Sampling

Macroinvertebrate

Kick net (500 μ m mesh)
Sieve (500 μ m mesh)
Sample containers:
 500 ml jars (3/site)
 Whirlpaks (2/site)
100% isopropyl alcohol (ca. 1 liter/site)
Formaldehyde
1 liter bottles for alcohol
Small white ca. 8" x 10" pan
Gridded 11" x 14" white pan (only for special project)
Bucket

Algae

Exacto knife w/ extra blades
Toothbrush
9 cm² template
250 ml sample jars (2/site)
Lugol's preservative
Squeeze bottle
Eye dropper
Funnel

E. Chemical Equipment

Turbidity meter	Hydrolab	pH paper
Kimwipes	Screwdriver	Thermometer
Chem-set holder	Batteries (10 AA cells)	Three bottle chem-sets (1 set/site)

E. Safety Equipment

First Aid Kit/Manual	Emergency phone numbers	Snake bite kit	Matches
Shovel	Flashlight/batteries	Water (5 gallons)	Flares

APPENDIX C

FIELD FORMS

Biocriteria Site Investigation Form - (C1)

Habitat Assessment Form - (C2 - C4)

Riparian Assessment & Channel Morphology Field Form - (C5)

**ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY
BIOCRITERIA SITE INVESTIGATION FORM**

Site Information:

Date (spell out): _____ Time (24 hrs): _____ Name of Water Body: _____
 Site Code #: _____ Elev (ft): _____ Photos: LU _____ LD _____
 U.S.G.S. 7.5' Quadrangle: _____ Ownership: _____
 Location/Access/Description: _____

Physico-chemical Evaluation:

Air T (C): _____ Water T (C): _____ DO (mg/l): _____ DO (% Sat) _____ Conductivity: _____
 TDS (g/l): _____ pH: _____ Turbidity: _____ Redox: _____ Battery: _____
 Velocity/Discharge: Reach Length (ft): _____ Time (sec): _____ Channel Width (ft): _____
 Depth (inches) (at one foot intervals, left → right bank): _____

Field Observations:

Recent flood evidence (circle all that apply): Fresh debris line, grasses laid over, fresh debris suspended in bushes/trees
 Estimated width of flood (ft): _____ Other flood evidence: _____
 Streambed structure and big picture remarks (e.g., logs, macrophytes, sediment, braiding, boulders, fresh downcutting, etc.):

Wildlife/Fish Observed: _____

Human Activities: _____

Grazing Impacts/Livestock Observed: _____

Evidence of NPS pollution (turbidity, large green algal blooms, fish kills, odors, surface films, trash, color): _____

Habitat Evaluation Scores:

1. Riffle substrate/cover	_____	7. Pool/Riffle ratio	_____	Rating Guide:	
2. Embeddedness	_____	8. Lower bank	_____		
3. Pool substrate	_____	9. Upper bank	_____		Optimal: 180 - 148
4. Velocity/Depth	_____	10. Grazing impacts	_____		Sub-optimal: 147 - 100
5. Shade conditions	_____	11. Streamside cover	_____		Marginal: 99 - 52
6. Channel shape	_____	12. Riparian zone	_____		Poor: 51 - 0

Total Habitat Score: _____ Habitat Rating: _____ Percent Pool: _____ Percent Riffle: _____

Sample Collection Information

Collector(s): _____

Samples Collected (indicate with checkmark, note number of jars, and if sample was field split):

Macroinvertebrate - Pool: _____ Algae - Pool: _____
 Macroinvertebrate - Riffle: _____ Algae - Riffle: _____
 Macroinvertebrate - Microhabitat: _____ Other Sample: _____

Big Picture Remarks Continued: _____

HABITAT ASSESSMENT FORM: Page 1

Site: _____

Date: _____

Name: _____

Habitat Parameter

Habitat Rating Criteria

Riffle substrate/ instream cover	> 50% mix of cobble, gravel, submerged logs undercut banks, or other stable habitat (other than bedrock). _____ 16-20	30-50% mix of cobble, gravel, or other stable habitat. Overall habitat is adequate. _____ 11-15	10-30% mix of small cobble, gravel or other stable habitat. Available habitat less than desirable. _____ 6-10	< 10 % cobble, gravel, or other stable habitat. Lack of habitat availability is obvious. _____ 0-5
Embeddedness (Riffles only)	Gravel, cobble, and boulder particles are between 0-25% surrounded by fine sediment. _____ 16-20	Gravel, cobble, and boulder particles are between 25-50% surrounded by fine sediment. _____ 11-15	Gravel, cobble, and boulder particles are between 50-75% surrounded by fine sediment. _____ 6-10	Gravel, cobble, and boulder particles are over 75% surrounded by fine sediment. _____ 0-5
Pool Substrate	Mixture of all substrate types with cobble, gravel, and firm sand prevalent; vegetation common in water and/or along banks. _____ 16-20	Mixture of all substrate types with firm sand most common; vegetation common in water and/or along banks. _____ 11-15	Substrate tends towards mud, clay, shifting sands; relatively little vegetation present in and around pools. _____ 6-10	Hard-pan clay or bedrock; little or no vegetation present around pools. _____ 0-5
Velocity/Depth	Slow/deep; slow/shallow; fast/deep; fast/shallow; good mix of 4 habitats present. _____ 16-20	Only 3 of 4 habitats present (loss of fast habitats results in lower score). _____ 11-15	Only 2 of the 4 habitats present (loss of fast habitats results in lower score). _____ 6-10	Dominated by 1 velocity/depth habitat type. _____ 0-5

HABITAT ASSESSMENT FORM: Page 2

Site: _____

Date: _____

Name: _____

Habitat Parameter	Habitat Rating Criteria			
Shade Conditions	A mixture of all conditions - shade, full sun exposure, and various degrees of filtered light. _____ 12-15	Covered by sparse canopy; entire surface receives filtered light, OR site is within canyon and orientation allows full sunlight on surface only a few hours/day. _____ 8-11	Water surface completely shaded, OR nearly full sunlight reaching water surface. Shading limited to < 3 or 4 hours per day. _____ 4-7	Full sun almost always reaches water surface regardless of canopy or canyon conditions. _____ 0-3
Channel Shape (wetted channel)	Trapezoidal (undercutting banks) _____ 12-15	Rectangular (historic erosion, natural or recovering) _____ 8-11	Triangular (active erosion, with head cutting) _____ 4-7	Inverse trapezoid (Active erosion, poor riparian, not natural) _____ 0-3
Pool/Riffle Ratio (Distance between riffles divided by stream width)	Ratio: 5-7; Variety of habitat. Repeat pattern of sequence relatively frequent. _____ 12-15	Ratio: 7-15; Infrequent repeat pattern. Variety of macrohabitat < optimal. _____ 8-11	Ratio: 15-25; Occasional riffle or bend. Bottom contours provide some habitat. _____ 4-7	Ratio: > 25; Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. _____ 0-3
Lower Bank Channel Capacity	Overbank flows rare. Lower bank W/D ratio < 7. _____ 12-15	Overbank flows occasional. W/D ratio 8-15. _____ 8-11	Overbank flows common. W/D ratio 15-25. _____ 4-7	Peak flows not contained or contained through channelization. W/D ratio > 25. _____ 0-3

HABITAT ASSESSMENT FORM: Page 3

Site: _____

Date: _____

Name: _____

Habitat Parameter

Habitat Rating Criteria

Upper Bank Stability	Upper bank stable. No evidence of erosion or bank failure. Side slopes generally < 30 [°] . Little potential for future problems.	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40 [°] on one bank. Slight potential in extreme floods.	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60 [°] on some banks. High erosion potential during extreme high flows.	Unstable. Many eroded areas. "Raw" areas frequent along straight sections and bends. Side slopes > 60 [°] common.
	_____ 9-10	_____ 6-8	_____ 3-5	_____ 0-2
Grazing Impacts	Vegetation minimally disturbed. Almost all potential plant biomass present.	Disruption evident but not affecting community vigor. Vegetative use is moderate, and at least 50% of potential plant biomass remains.	Disruption obvious; some patches of bare soil/closely cropped vegetation present. < 50% of potential plant biomass remains.	Disruption of streambank vegetation is very high. Vegetation has been removed to two inches or less in average stubble height.
	_____ 9-10	_____ 6-8	_____ 3-5	_____ 0-2
Streamside Cover	Mixture of shrubs and trees make up dominant vegetation. (Taxa richness good, regeneration evident)	Dominant vegetation is in tree form. (Overstory tree richness low, low regeneration evident)	Dominant vegetation is in shrub form. (Grasses dominate, overstory richness poor, no regeneration)	Dominant vegetation is in form of grasses or forbes, or no vegetation cover at all.
	_____ 9-10	_____ 6-8	_____ 3-5	_____ 0-2
Width of Riparian Vegetative Zone	Width of riparian vegetative zone (each side) is at least four times the width of the stream [°] . Man's activities have not impacted this zone at all. (>1 age class dominant trees)	Width of riparian vegetative zone (each side) is at least two times the width of the stream. Man's activities have minimally impacted this zone. (only 1 age class of dominants)	Width of riparian vegetative zone (each side) is at least as wide as the stream. Man's activities have impacted the riparian zone a great deal. (Few trees, poor cond.,no regen.)	Little or no streamside vegetation due to man-induced activities. (No native riparian trees)
	_____ 9-10	_____ 6-8	_____ 3-5	_____ 0-2

[■] - Within canyons - focus on evidence of erosion and potential for future problems.

[°] - Within canyons - focus on evidence of man's activities.

RIPARIAN ASSESSMENT FIELD FORM

SITE ID _____

DATE _____

I. TAXA IDENTIFICATION

- A. Upland plant association _____
- B. Primary riparian association _____
- C. Other riparian species noted _____
- D. Plant specimens collected (Y/N) _____

II. RIPARIAN QUALITY

A. Percent of stream shaded _____

- B. Percent plant cover on soil
 - 1. Overall cover _____
 - 2. % trees _____
 - 3. % shrub _____
 - 4. % grasses/forbes _____
- C. Aquatic plants (y/n)
 - 1) % submergent _____
 - 2) % emergent _____
 - 3) % algal cover _____

C. Regeneration potential (% composition within each species)

	% Mature Trees	% Saplings	% Seedlings
Species #1	_____	_____	_____
Species #2	_____	_____	_____
Species #3	_____	_____	_____
Species #4	_____	_____	_____

CHANNEL MORPHOLOGY AND SUBSTRATE COMPOSITION

SITE ID _____

DATE _____

- I. Creek Bed Composition

	%Bedrock _____	(> 2 mm) %Gravel _____
(> 256 mm)	%Boulders _____	(> 0,5 mm) %Sand/Silt _____
(> 64 mm)	%Cobbles _____	(< 0.063mm) %Organic/soil _____
- II. Channel Bank Comp.

	%Bedrock _____	%Gravel _____
	%Boulders _____	%Sand/Silt _____
	%Cobbles _____	%Organic/soil _____
- III. Channel Undercutting: %Undercut _____ %Not undercut _____
- IV. Bank Type % Cut _____ % Uncut _____
- V. Inner Channel Width (meters) _____
Scour Channel Width (100 yr.) _____
- VI. Comments on channel/bank stability: _____
- VII. Description of flowing side drainages, springs, other sources _____

APPENDIX D

QuattroPro Spreadsheet Examples

Locational - See Appendix A

Habitat - (D1)

Water Quality - (D2)

Algae - (D3)

Invertebrates - (D4)

SAMPLE SITES - 1992	HABITAT PARAMETERS														TOTAL HABITAT SCORES			
	RIFFLE SUBSTRATE	EMBEDED	POOL SUBSTRATE	VELOCITY/ DEPTH	SHADE CONDITIONS	CHANNEL SHAPE	HABITAT VARIETY	LOWER BANK	UPPER BANK	GRAZING IMPACTS	STREAM COVER	RIPARIAN ZONE	PERCENT POOL	PERCENT RIFFLE	PRIMARY	SECONDARY	TERTIARY	TOTAL
LITTLE COLORADO BASIN																		
Barbershop Canyon (Lower)	18	18	20	14	9	11	12	12	8	10	10	8	60	20	88	44	38	148
Barbershop Canyon (Upper)	19	19	20	15	11	11	13	13	9	10	10	10	70	30	73	48	39	160
Chevelon Canyon (Chevelon Crossing)	0	0	18	8	10	8	8	12	7	9	5	9	100	0	28	38	30	84
Chevelon Canyon (Long Tom)	19	19	20	14	12	14	15	12	10	10	10	10	70	30	72	53	40	165
Chevelon Canyon (Telephone Ridge)	19	19	19	15	10	12	14	12	8	10	10	8	50	50	72	48	38	158
East Clear Cr. (Kinder Crossing)	18	18	18	13	10	12	13	11	10	10	10	10	80	20	67	48	40	153
East Clear Cr. (Macks Crossing)	18	18	16	14	10	12	14	10	10	10	10	8	70	30	66	48	38	150
East Fk Little Colorado R.	18	15	15	13	10	10	12	14	10	8	8	8	20	80	61	46	34	141
Lilly Cr.	15	16	16	16	15	13	14	12	10	10	8	10	30	70	63	54	38	155
Little Colorado R. (Mouth)	5	4	6	11	2	2	6	7	6	10	5	6	90	10	28	17	27	70
Little Colorado R. (abv S. Fk.)	19	18	18	18	12	14	13	10	10	10	10	10	40	60	73	49	40	162
Little Colorado R. (blw Nutrioso)	12	8	10	16	2	8	13	9	8	6	3	4	40	60	46	32	21	99
Little Colorado R. (blw S. Fk.)	18	16	10	16	0	8	10	10	4	5	2	2	15	85	60	28	13	101
Mamie Cr.	18	18	15	15	13	14	11	12	9	10	8	8	10	90	68	50	35	151
Mineral Cr.	18	18	16	16	14	14	12	12	10	9	8	7	30	70	68	52	34	154
Paddy Cr.	18	18	16	15	15	15	10	13	9	10	8	8	20	80	65	53	35	153
Rudd Cr.	18	13	11	15	15	13	13	12	7	10	9	9	25	75	57	53	35	145
S. Fk. Little Colorado R.	19	20	16	16	12	10	12	10	8	9	9	8	25	75	71	44	34	149
West Fk. Little Colorado R. (Lower)	19	16	17	20	14	13	11	15	10	10	8	10	25	75	72	53	38	163
West Fk. Little Colorado R. (Upper)	18	18	16	16	7	11	12	14	10	10	8	8	20	80	68	44	36	148
UPPER GILA BASIN																		
Blue R. (Lower)	18	16	12	20	7	11	14	9	10	10	8	8	40	60	68	41	36	143
Blue R. (Upper)	16	13	13	18	10	9	14	9	8	8	8	5	40	60	60	42	29	131
Campbell Blue R.	16	16	17	11	7	8	13	8	5	8	8	5	30	70	60	38	28	122
Coleman Cr.	20	18	18	16	15	14	12	14	10	10	9	10	30	70	72	55	39	166
Eagle Cr. (Honeymoon)	18	18	17	16	14	11	14	11	9	10	8	8	40	60	69	50	35	154
Eagle Cr. (Sheep Wash)	18	20	16	20	7	11	12	7	10	9	8	7	40	60	74	37	34	145
East Turkey Cr.	14	17	18	15	14	10	13	12	9	10	9	9	30	70	64	49	37	150
Frye Cr.	20	20	20	18	15	15	13	13	10	10	10	10	40	60	78	58	40	174
Grant Cr. (Blue)	18	13	16	19	10	10	9	10	8	8	8	9	10	90	68	39	33	138
Grant Cr. (Pinaleno)	18	18	16	15	13	14	12	10	8	10	10	9	20	80	67	49	37	153
Lanphier Canyon	18	13	18	16	14	10	12	10	8	9	9	10	30	70	65	49	38	150
Marjilda Cr.	20	18	18	16	15	15	14	12	10	10	8	10	50	50	72	58	38	166
San Francisco R. (Blue)	18	13	11	18	5	9	13	10	7	9	7	4	40	60	60	37	27	124
South Fk Cave Cr.	18	17	16	18	14	13	13	12	9	10	10	10	20	80	70	52	39	161
UPPER SALT BASIN																		
Conklin Cr.	19	19	18	14	13	12	12	14	8	10	10	10	30	70	70	51	38	159
East Fork Black R.	19	19	20	18	7	12	13	13	8	10	9	5	40	60	78	45	32	153
Horton Cr.	20	19	18	16	14	13	11	13	10	10	8	10	25	75	73	51	38	162
N. Fk. Bear Wallow Cr.	20	18	16	19	14	12	13	13	10	10	8	10	50	50	73	52	38	163
Reservation Cr.	19	18	18	15	7	10	10	13	8	10	10	5	10	90	70	40	33	143
West Fork Black R.	18	18	18	16	10	11	12	13	10	10	8	8	30	70	70	48	38	152

SAMPLE SITES - 1992	GENERAL PARAMETERS				MAJOR ANIONS						MAJOR CATIONS				
	PARAMETER	Hardness	Tot. Diss. Solids	Tot. Susp. Solids	Total Alkalinity	HCO3	CO3	Cl	FI	NO2/NO3	SO4	Ca	Mg	Na	K
	UNITS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	DETECTION LEVEL	10.0		4.0			2.0	1.0	0.2	0.1	10.0	1.0	1.0	5.0	0.5
LITTLE COLORADO BASIN															
Barbershop Canyon (Lower)	96.0	107.0	5.0	93.7	114.0	ND	1.2	ND	ND	ND	18.8	9.8	ND	0.4	
Barbershop Canyon (Upper)	76.0	90.0	7.0	65.2	79.5	ND	1.0	ND	ND	ND	14.7	7.4	ND	0.4	
Chevelon Canyon (Chevelon Crossing)	69.0	83.0	14.0	62.8	76.8	ND	1.3	ND	ND	ND	14.5	5.4	ND	0.7	
Chevelon Canyon (Long Tom)	67.0	84.0	7.0	64.8	79.1	ND	1.8	ND	ND	ND	15.7	5.0	ND	0.7	
Chevelon Canyon (Telephone Ridge)	107.0	119.0	8.0	105.0	128.0	ND	2.1	ND	ND	ND	23.3	9.4	ND	0.8	
East Clear Cr. (Kinder Crossing)	135.0	142.0	6.0	128.0	157.0	ND	2.0	ND	ND	ND	26.7	14.0	ND	0.8	
East Clear Cr. (Macks Crossing)	147.0	153.0	6.0	142.0	168.0	3.4	2.8	ND	ND	ND	27.1	15.8	ND	0.6	
East Fk Little Colorado R.	16.0	50.0	6.0	20.0	24.4	ND	ND	ND	ND	ND	5.3	1.1	ND	1.9	
Lily Cr.	90.0	151.0	18.0	90.0	110.0	ND	1.2	ND	ND	ND	23.8	7.6	6.5	1.0	
Little Colorado R. (Mouth)	NA	2300.0	2200.0	NA	NA	NA	1150.0	0.2	0.3	160.0	78.8	61.0	693.0	6.4	
Little Colorado R. (abv S. Fk.)	30.0	82.0	18.0	36.9	45.0	ND	1.4	ND	ND	ND	8.4	2.0	ND	2.1	
Little Colorado R. (blw Nutrioso)	165.0	210.0	15.0	209.0	233.0	11.0	6.9	0.3	ND	ND	40.0	18.2	25.8	3.9	
Little Colorado R. (blw S. Fk.)	33.0	88.0	18.0	39.4	48.1	ND	1.3	ND	ND	ND	9.6	2.9	ND	2.1	
Mamie Cr.	58.0	112.0	19.0	49.3	60.1	ND	1.9	ND	ND	ND	10.3	4.6	ND	0.8	
Mineral Cr.	43.0	78.0	6.0	45.0	54.9	ND	ND	ND	ND	ND	14.0	4.6	ND	0.8	
Paddy Cr.	52.0	94.0	ND	53.0	64.7	ND	ND	ND	ND	ND	9.0	4.8	ND	0.7	
Rudd Cr.	78.0	96.0	10.0	88.9	108.0	ND	2.2	ND	ND	ND	12.3	4.4	ND	0.9	
S. Fk. Little Colorado R.	77.0	130.0	5.0	97.0	118.0	ND	1.2	ND	ND	ND	10.6	19.6	7.0	10.3	
West Fk. Little Colorado R. (Lower)	17.0	39.0	ND	22.5	27.5	ND	ND	ND	ND	ND	18.6	7.8	8.7	2.2	
West Fk. Little Colorado R. (Upper)	ND	10.0	5.0	13.5	16.5	ND	ND	ND	ND	ND	LT	1.4	ND	1.9	
											LT	ND	ND	1.5	
UPPER GILA BASIN															
Blue R. (Lower)	165.0	291.0	ND	158.0	185.0	3.7	28.5	0.3	ND	23.2	43.8	11.8	28.7	2.0	
Blue R. (Upper)	123.0	184.0	7.0	127.0	148.0	3.5	2.5	0.2	ND	ND	35.2	9.1	11.5	0.9	
Campbell Blue R.	70.0	118.0	9.0	80.7	98.5	ND	2.0	ND	ND	ND	18.0	7.3	6.9	0.9	
Coleman Cr.	54.0	97.0	8.0	50.7	61.9	ND	2.0	ND	ND	ND	11.1	5.9	ND	0.7	
Eagle Cr. (Honeymoon)	115.0	190.0	ND	127.0	155.0	ND	3.2	ND	ND	ND	24.2	11.8	7.4	2.9	
Eagle Cr. (Sheep Wash)	117.0	195.0	5.0	130.0	129.0	14.8	3.1	0.2	ND	ND	28.8	11.4	8.3	3.2	
East Turkey Cr.	39.0	82.0	7.0	28.3	34.5	ND	1.8	ND	ND	ND	14.7	10.9	2.1	ND	
Frye Cr.	25.0	47.0	ND	21.0	25.6	ND	1.0	ND	ND	ND	7.1	1.3	ND	1.1	
Grant Cr. (Blue)	70.0	114.0	ND	71.8	87.6	ND	2.0	ND	ND	ND	17.2	6.9	ND	0.9	
Grant Cr. (Pinaleno)	20.0	40.0	9.0	14.1	17.2	ND	1.2	ND	ND	ND	5.3	1.2	ND	0.8	
Lanphier Canyon	91.0	144.0	5.0	91.6	112.0	ND	2.5	ND	ND	ND	22.2	8.9	ND	1.4	
Marjilda Cr.	24.0	47.0	5.0	19.2	23.4	ND	1.2	ND	ND	ND	7.2	1.2	ND	0.8	
San Francisco R. (Blue)	139.0	287.0	ND	141.0	158.0	7.8	38.4	0.8	ND	20.3	38.5	9.5	38.5	4.3	
South Fk Cave Cr.	27.0	80.0	ND	15.7	19.2	ND	1.7	0.4	ND	14.4	8.3	1.0	ND	1.2	
UPPER SALT BASIN															
Conklin Cr.	37.0	60.0	28.0	35.4	43.2	ND	3.4	ND	ND	ND	7.7	4.3	ND	0.7	
East Fork Black R.	43.0	71.0	20.0	48.7	52.3	3.5	4.0	ND	ND	ND	10.3	4.5	ND	1.0	
Horton Cr.	36.0	73.0	ND	33.1	40.4	ND	3.8	ND	ND	ND	7.3	4.2	ND	0.7	
N. Fk. Bear Wallow Cr. Reservation Cr.	28.0	62.0	12.0	28.0	34.2	ND	3.0	ND	ND	ND	6.6	3.3	ND	0.7	
West Fork Black R.	19.0	60.0	ND	23.1	28.2	ND	4.0	ND	ND	ND	5.0	1.7	ND	1.1	
	22.0	53.0	17.0	22.4	27.3	ND	2.9	ND	ND	ND	5.6	1.9	ND	1.0	

ALGAE ABUNDANCE - RIFFLE/POOL SAMPLES (WEIGHTED ACCORDING TO
RELATIVE DOMINANCE IN STREAM REACH

TOP SPREADSHEET = WEIGHTED ABUNDANCE; BOTTOM SPREADSHEET = ABUNDANCE LOG X+1 TRANSFORMED

RIFFLE PROPORTION	0.3	1	0	0.8	0.35	0.3	0.7	0.5	0.85	0.6	0.6	0.35	0.6	0.35	0.5	0.4	0.3	0.6
POOL PROPORTION	0.7	0	1	0.2	0.65	0.7	0.3	0.5	0.15	0.4	0.4	0.65	0.4	0.65	0.5	0.6	0.7	0.4
Genus	AGF1	ANT1	ARA1	ARA2	ASH1	BAR1	BAR2	BAS1	BLC1	BLU1	BLU4	BUR1	CAV1	CDO1	CGN1	CGR1	CHE1	CHE2
Achnanthes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Amphipleura	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Amphora ovalis	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anabaena	7.00	19.00	0.00	0.00	0.00	57.18	0.00	0.00	1.50	0.00	0.00	0.00	0.00	19.25	0.00	0.00	5.60	0.00
Ankistrodesmus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.50	0.00	0.70	0.00
Aphanocapsa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aulosira	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
Batrachospermum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	122.50	0.00	0.00	0.00	0.00
Bulbochaete	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Caloneis	0.00	0.00	0.00	1.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80	0.00
Calothrix	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20
Campylodiscus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chaetophora	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chlamydomonas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chlorococcum	0.00	0.00	0.00	0.00	19.50	33.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.80
Chlorophyta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chroococcus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.97	0.00	1.95	0.00	0.00	0.00	1.20
Chrysophyta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cladophora	1.60	198.00	0.00	16.00	19.50	3.00	1.40	0.00	0.00	0.00	0.60	8.35	0.00	0.00	0.00	21.60	1.00	0.00
Closterium	1.00	0.00	0.00	0.00	0.00	2.21	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cocconeis pediculus	19.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	13.60	0.00	4.60
Cocconeis placentula	14.30	306.00	0.00	0.00	0.00	1.43	3.60	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	203.60	0.00	6.40
Cocconeis spp.	0.00	0.00	0.00	1.00	0.00	0.00	59.50	0.00	5.30	0.80	59.20	0.00	0.00	0.00	12.00	0.00	15.30	0.00
Cosmarium	0.00	0.00	0.00	0.00	1.30	0.00	0.00	1.00	0.15	0.00	0.00	7.35	0.00	0.00	5.00	0.00	0.00	0.00
Cyclotella	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cylindrocapsa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cylindrocystis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cylindrotheca	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	1.60
Cymatopleura	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella affinis	77.70	30.00	0.00	68.00	0.00	10.80	22.20	109.00	0.00	78.60	130.80	0.00	0.00	0.00	15.00	0.00	58.80	111.40
Cymbella cymbiformis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella minuta	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella prostrata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cymbella tumida	0.00	0.00	0.00	0.00	1.30	11.50	1.20	1.00	0.00	0.00	4.00	1.05	0.00	0.00	5.00	2.40	0.00	3.60
Cymbella spp.	1.40	35.00	0.00	0.00	0.00	0.00	0.00	0.00	50.30	9.60	0.00	31.10	1.20	11.15	0.00	0.00	12.30	0.00
Denticula	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00	148.20	0.00	0.00
Desmidiium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diatoma	10.80	3.00	0.00	0.00	0.00	1.50	0.00	2.00	4.65	56.40	4.00	0.00	0.00	1.75	2.50	0.00	2.60	0.00
Diploneis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Draparnaldia	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00

Arizona Benthic Macroinvertebrates 1992-1993

DATE (Month/Year)		592	592	592	592	592	592
HABITAT		R	R	R	R	R	R
FRACTION (%)		12.5	25	3.13	50	25	25
SITE IDENTIFICATION #		BUR1	CGR1	FRA1	PEE1	SMR1	TRT1
ECOREGION		SOBR	SOBR	SOBR	SOBR	SOBR	ANMP
RIVER BASIN		BWIL	BWIL	BWIL	BWIL	BWIL	BWIL
TAXON	PRI						
Hydra	MIS	0	0	0	0	0	0
Turbellaria	MIS	0	36	0	0	0	0
Nematoda	MIS	0	4	0	0	0	0
Nematomorpha	MIS	0	0	0	0	0	0
unknown vermiform	MIS	0	0	0	0	0	0
Oligochaeta	MIS	0	12	32	0	0	0
Lumbricoldea	MIS	0	0	0	0	0	0
Hirudinea	MIS	0	0	0	0	0	0
Erpobdella	MIS	0	0	0	0	0	0
Erpobdella dubia	MIS	0	0	0	0	0	0
Erpobdella montezuma	MIS	0	0	0	0	0	0
Erpobdella parva	MIS	0	0	0	0	0	0
Glossiphonia complanata	MIS	0	0	0	0	0	0
Helobdella stagnalis	MIS	0	0	0	0	0	0
Pelecypoda	MIS	0	0	0	0	0	0
Corbiculidae	MIS	0	0	0	0	0	0
Corbicula	MIS	0	0	0	0	0	0
Corbicula fluminea	MIS	0	0	0	0	0	0
Sphaeriidae	MIS	0	0	0	0	0	0
Pisidium	MIS	0	0	0	0	0	0
Pisidium casertanum	MIS	0	0	0	0	0	0
Pisidium compressum	MIS	0	0	0	0	0	0
Pisidium punctatum	MIS	0	0	0	0	0	0
Pisidium variable	MIS	0	0	0	0	0	0