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# Aquatic Macroinvertebrates and Water Quality in Guaje and Los Alamos Canyons, 1993 and 1994

by
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## ABSTRACT

The Ecological Studies Team (EST) of ESH-20 at Los Alamos National Laboratory (LANL) collected aquatic samples from the streams within Guaje and Los Alamos Canyons during two six-month sampling seasons in 1993 and 1994. The Team measured water quality parameters and collected aquatic macroinvertebrates from permanent sampling stations. In this study, the relatively undisturbed stream in Guaje Canyon was used as a control to evaluate impacts to the stream in Los Alamos Canyon.

EST established and monitored three sampling stations in Guaje Canyon (G1, G2, and G3) and three comparable stations in Los Alamos Canyon (LA1, LA2, and LA3). All monthly pH, conductivity, and dissolved oxygen measurements taken in both streams were within acceptable water quality ranges as defined by Battelle (1972). The Los Alamos Canyon Reservoir impounds all incoming water except for warmed overflow, which significantly elevates water temperatures at the two lower Los Alamos stations. At times, this dam design caused the stream to completely dry up at LA2 and LA3, eliminating resident macroinvertebrate communities at these stations. Undoubtedly, this seasonal drought produces the most significant impact to downstream invertebrate communities in Los Alamos Canyon.

Rapid Biological Protocols (RBP) III analysis shows that aquatic communities are richer and more complex in Guaje than Los Alamos Canyons, supporting EST's use of the Guaje stream as a control. The data also suggest that within each canyon, diversity and density, decrease with distance downstream; but this trend is not as pronounced because the middle Guaje station had higher diversities and densities than Guaje's lowest station. According to RBP III metrics analysis, which are endorsed by the US Environmental Protection Agency (US EPA), water quality is nonimpaired at LA1, severely impaired at LA2, and severely impaired at LA3.

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## 1 INTRODUCTION

In the summers of 1993 and 1994, the Ecological Studies Team (EST) conducted an ecological-risk study comparing aquatic macroinvertebrates and water quality in two Los Alamos County canyons. Los Alamos Canyon is affected by a well-traveled road, a reservoir, and effluents from the Omega Site in Technical Area 2 (TA-2). EST used Guaje Canyon as a control site because public access to this canyon is limited, and it receives no

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effluent discharges. EST collected data on water conditions and aquatic macroinvertebrate samples to assess potential stream impairment.

Physical parameters (water temperature, dissolved oxygen, pH, and conductivity) of both streams were monitored monthly, simultaneously with the collection of aquatic macroinvertebrates. In reviewing these measures, this report refers to many environmental quality ratings developed by Battelle Columbus Laboratories (Battelle 1972). Battelle outlined a comprehensive and interdisclipinary Environmental Evaluation System, which uses physical, chemical, and biological parameters to assess possible environmental impacts of water resource projects.

Water temperature directly influences aquatic organisms' physiological functions such as metabolism, growth, emergence, and reproduction (Anderson and Wallace 1984). Because water absorbs greater amounts of oxygen at lower temperatures, temperature is inversely related to oxygen solubility. While aquatic organisms can tolerate wide fluctuations in pH and conductivity, a change in water temperature of a single degree Celsius can have a significant impact (Lehmkuhl 1979).

The pH scale measures acidity and basicity with low values indicative of acidity, middle values (around 7.0) indicatative of neutrality, and high values indicatative of basicity. A departure of ±1 from the normal pH is considered to be insignificant to aquatic macroinvertebrates (Lehmkuhl 1979). The normal pH of natural surface waters in the United States ranges from 6.5 to 9.0 (Canter and Hill 1979). In general, acidic waters limit species richness, evenness, and abundance. Some aquatic organisms, such as mayflies, are very sensitive to low pH, which can be caused by accidental acid spills or acid rain deposition.

Depressed oxygen environments often indicate the presence of organic wastes. The amount of dissolved oxygen (DO) in water has a direct and immediate effect on invertebrates using tracheal gills for respiration (such as the larvae of mayflies, caddisflies, and stoneflies). Oxygen is present in the atmosphere at levels greater than 200,000 parts

per million (ppm), but its maximum value in water is only 15 ppm (Eriksen et al. 1984). Although aquatic insects require more oxygen for metabolism at elevated temperatures, less is available due to decreased solubility (Gaufin et al. 1974). Certain stages, such as emergence, in the life cycle of aquatic invertebrates will not occur unless sufficient oxygen is present (Bell 1971). Cold-water mayflies and stoneflies cannot tolerate DO concentrations much below 5 mg/l (Nebeker 1972).

Conductivity measures the ability of water to carry an electrical current and reflects the concentration of ionized substance in water. The conductivity of potable water in the United States ranges from 50 to 1,500 micro-mhos per centimeter (μmho/cm), while the conductivity of industrial waste may be as high as 10,000 μmhos/cm. A rough approximation of the total dissolved solids (TDS) of freshwater in mg/l can be obtained by multiplying the conductivity by a factor of 0.66. The upper limit of TDS that aquatic organisms can tolerate ranges from 5,000 to 10,000 mg/l (Battelle 1972).

Aquatic macroinvertebrates have been used extensively as water quality indicators. The term "macroinvertebrate" refers to invertebrates large enough to be seen with the unaided eye. This report uses the terms "macroinvertebrate" and "invertebrate" interchangeably. These organisms, especially the stream-dwelling insects, are well suited to this purpose due to their

- abundance in virtually all freshwater streams,
- small size and total immersion in the water environment,
- relatively sedentary life styles, making them good indicators of local conditions,
- differential sensitivities to various types of impairment, including non-point source pollution,
- life cycles that are frequently at least one-year long, allowing long-term detection of past disturbance, and
- relative ease of collection and identification to family or genus level.

In general, monitoring only the physical and chemical characteristics of water provides little information on conditions before the sampling date. Failure of chemical criteria to protect aquatic life has necessitated incorporating biological criteria into water

resource management (Karr 1991). Shifts in the numbers of individuals, species, and functional feeding groups present may indicate prior disturbances. These disturbances could result from infrequent discharges of waste that might remain undetected through a water quality monitoring program that did not incorporate biological data (Weber 1973). Changes in macroinvertebrate communities thus reflect water quality over a much longer period than chemical monitoring.

Many early water-quality investigators compiled extensive indicator species lists and attempted to measure species-specific tolerances to pollution (Beck 1955). These methods are prone to erroneous interpretations since species-level identification is difficult to ascertain, tolerances of some species vary greatly under differing environmental conditions, and "intolerant" species may be found in polluted areas due to drift, i.e., transport by water currents. Use of a biotic index overcomes these problems by allowing higher level identifications and weighting taxa according to the number present.

Recent studies have emphasized the importance of community structure in evaluating water quality (Gaufin and Tarzwell 1956; Hilsenhoff 1977; Schwenneker and Hellenthal 1984; and Jacobi 1989). Examination of macroinvertebrate functional feeding groups provides an understanding of community structure and complexity. Insects are the overwhelmingly dominant group in most streams; and aquatic research has therefore concentrated on this widespread arthropod class.

When feeding, aquatic insects select organic particles primarily due to their size rather than their origin. Thus, the familiar trophic (feeding) categories of herbivore, carnivore, and omnivore have little application to aquatic macroinvertebrates. To more accurately describe the trophic relations of aquatic insects, a series of functional feeding groups, or trophic categories, has been developed (Cummins and Merritt 1984). These categories are determined by feeding mechanism (Table 1).

**Table 1. Aquatic Insect Functional Feeding Groups**

| Functional Group | Dominant Food |
|---|---|
| Collector-filterers | Water-borne fine particulate organic matter |
| Collector-gatherers | Sedimentary fine particulate organic matter |
| Shredders | Coarse particulate organic matter |
| Scrapers | Attached algae and associated material |
| Predators | Engulfers or piercers feeding on living animal tissue |

Indices of species richness, evenness, and diversity have been developed to allow numerical comparisons of whole communities. Unpolluted environments have greater species richness, evenness, and diversity than polluted environments, which tend to be dominated by relatively few intolerant species.

## 2 DESCRIPTION OF THE SAMPLING STATIONS

The streams in Los Alamos and Guaje Canyons flow through the approximate centers of their canyons and are less than 1 m (3.3 ft) wide. Both streams occur in Los Alamos County, originate in the Jemez Mountains, are impounded at high-elevation reservoirs, and ultimately discharge into the Rio Grande. The approximate elevation at the Los Alamos Reservoir is 2,320 m (7,600 ft) asl (above sea level). The approximate elevation at the Guaje Reservoir is 2,430 m (8,020 ft) asl.

In May 1993, three permanent sample stations were placed in each of the canyons (Fig. 1). A fourth downstream station was monitored in middle Guaje Canyon from July to October 1993. The results obtained from this station are not reported herein because drought prohibited the establishment of a comparable station in Los Alamos Canyon. All stations are referred to by the first letter(s) of the canyon's name and a number. Number 1 is assigned to the station farthest upstream; number 2 is assigned to the middle station; and number 3 is assigned to the station farthest downstream. Hence, LA2 refers to the middle sampling station in Los Alamos Canyon.

The term "sampling station" refers to a 150-m (492-ft) stream reach, while "sampling site" refers to a particular location within a sampling area. All sampling sites were in riffle areas with some shading and a varied substrate. Such sites tend to have high

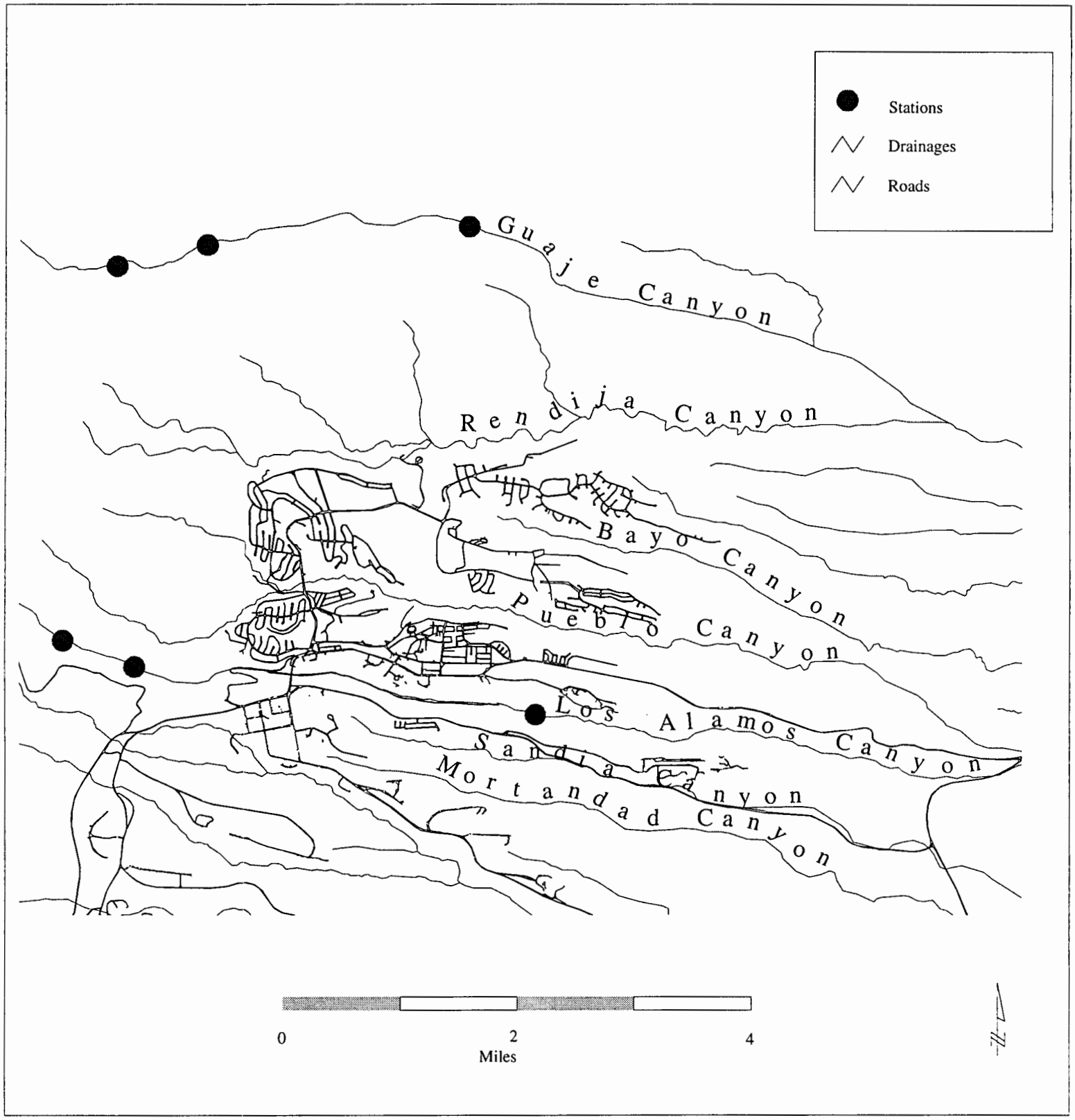



Figure 1. Locations of aquatic invertebrate stations.

macroinvertebrate diversities and provide the best opportunities for collecting the greatest number of taxa that a stream is capable of supporting. In both canyons, sampling sites were selected for similarities in stream reaches, shading, on-bank vegetative cover, substrates, and surrounding plant communities. In each canyon

- sampling station 1 was located in spruce-fir approximately 0.4 km (0.25 mile) above the reservoir,
- sampling station 2 was approximately 1.1 km (0.7 mile) below the reservoir in mixed conifer, and
- sampling station 3 was at least 3.5 km (2.2 mile) below the reservoir in mixed conifer.

Reduced snowfall in Los Alamos County during the winter of 1993–1994 caused a reduction in the subsequent 1994 spring runoff. This runoff was not forceful enough to flush sand, gravel, and other fine sediments downstream as normally occurs. Therefore, all sampling stations had significantly more of these small particles present in 1994 than in 1993. Such fine materials can block the interstitial spaces that aquatic macroinvertebrates require for protection from predators and currents. This can lead to a reductions in the number of available habitats and taxa diversity (March 1976).

## 2.1 Los Alamos Canyon

Upper Los Alamos Canyon is within the Santa Fe National Forest (SFNF) in an area frequented by hikers, joggers, campers, and fishers. In the upper canyon, the stream flows into a fish-stocked reservoir. Middle and lower Los Alamos Canyon pass through LANL property. The lower two sampling stations could be affected by traffic on nearby roads, a public ice-skating rink, and operations at TA-2, which contains the Omega reactor and a wastewater outfall that discharges into the stream.

None of EST's Los Alamos Canyon sampling stations contained exposed bedrock. The stream channel supported little or no emergent vegetation. The 3 stations showed differences in surrounding vegetation, stream flow, and substrate.

At an approximate elevation of 2,380 m (7,860 ft) asl, LA1 is in the SFNF and approximately 0.6 km (0.4 mile) above the Los Alamos Reservoir. A heavily used footpath begins at the approximately 2.0-acre reservoir and runs beside the stream up to and beyond LA1. In this area, several large logs have fallen into the stream which forms a series of alternating riffles and shallow pools. LA1 is in the spruce-fir plant community with Engelmann spruce (*Picia engelmannii*), aspen (*Populus tremuloides*), (*Jamesia americana*) as the dominant trees and shrubs. The streamside understory is primarily cutleaf coneflower (*Rudbeckia laciniata*), nodding brome (*Bromus anomalus*), redtop (*Agrostis alba*), wild raspberry (*Rubus strigosus*), Junegrass (*Koelaria cristata*), and horsetails (*Equisetum* sp.). The stream bed consists of cobbles of various sizes and small amounts of sand and gravel. Stream flow was fairly consistent at this station during our six-month sampling program.

At an approximate elevation of 2,250 m (7,420 ft) asl, LA2 is in the SFNF and approximately 1.1 km (0.7 mile) below the reservoir. An unpaved road runs along the stream, and traffic from this roadway contributes to stream sedimentation. LA2 is within the spruce-fir plant community and is shaded by a nearby steep slope to the south. The dominant trees are white fir (*Abies concolor*), water birch (*Betula occidentalis*), Douglas-fir (*Pseudotsuga menziesii*), and Engelmann spruce. The streamside understory consists of nodding brome, redtop, smooth brome (*Bromus inermis*), cutleaf coneflower, Fendler's rose (*Rosa woodsii*), and horsetails. The flow at LA2 varied greatly during both years and the stream bed was dry in August and October of 1993 and July and October of 1994. Periodic torrents had cut the stream channel much deeper than at LA1. The streambed substrate consisted primarily of large rocks and large amounts of sand.

At an approximate elevation of 2,070 m (6,840 ft) asl, LA3 is in LANL's Operable Unit 1098 and approximately 4.8 km (3.0 miles) downstream from LA2. LA3 is located along a dirt road just downstream from TA-2 where a wastewater outfall empties into the stream. The outfall has introduced radionuclides into the stream during accidental spills, as

recently as 1993. LA3 is within the mixed-conifer plant community. The dominant trees are Ponderosa pine (*Pinus ponderosa*), Douglas-fir, and Gambel's oak (*Quercus gambelii*). The streamside understory vegetation is Canadian wildrye (*Elymus canadensis*), redtop, Colorado barberry (*Berberis fendleri*), and bromegrass (*Bromus* sp.). The stream substrate consisted of rocks, silts, and sands. The flow at LA3 during 1993 was highly variable, and the stream channel was dry in July, September, and October of 1993 and July through August of 1994.

## 2.2 Guaje Canyon

All Guaje Canyon sampling stations are within the SFNF, and access to the area is periodically restricted. It is considerably less disturbed than Los Alamos Canyon and was used as a control in this study. None of the stations within Guaje Canyon contained exposed bedrock. The stream flow at all stations was very consistent, and none of the stations were dry during the two six-month sampling periods. Some logs were in the stream at all stations, but there were differences in surrounding vegetation, stream flow, and substrate.

At an approximate elevation of 2,450 m (8,100 ft) asl, G1 is approximately 0.3 km (0.2 mile) above the Guaje Canyon reservoir. A footpath runs along the stream above the reservoir, but it receives much less use than the path above Los Alamos Reservoir. A steep outcrop of rock to the south shades much of this stream stretch. G1 is within the spruce-fir plant community. Dominant trees and shrubs are white fir, limber pine (*Pinus flexilis*), Engelmann spruce, Rocky Mountain maple (*Acer glabrum*), and cliffbush. The streamside understory is nodding brome, mountain parsley (*Pseudocymopterus montanus*), Junegrass, cutleaf coneflower, and bluebunch wheatgrass (*Agropyron spicatum*). The substrate consisted of various-sized stones with sand accumulating in slower flowing areas.

At an approximate elevation of 2,375 m (7,840 ft) asl, G2 is approximately 1.1 km (0.7 mile) downstream from the approximately 0.125-acre reservoir. Below the reservoir, an infrequently used dirt road is near the stream and it crosses the stream channel several

times. G2 is within the spruce-fir plant community. The dominant trees and shrubs are Douglas-fir, white fir, Engelmann spruce, limber pine, and cliffbush. The streamside understory is common timothy (*Phleum pratense*), bluebunch wheatgrass, cutleaf coneflower, nodding brome, redtop, and gooseberry (*Ribes inerme*). The stream substrate consisted of various-sized cobbles and some gravel.

At an approximate elevation of 2,250 m (7,430 ft) asl, G3 is approximately 2.5 km (1.5 mile) downstream from G2. G3 is within the mixed conifer plant community and is bordered by a northern hillside and a southern level area. The dominant trees and shrubs are water birch, Douglas-fir, ponderosa pine, and cliffbush. The streamside understory consists of nodding brome, redtop, Fendler's rose, mountain parsley, and raspberry. The substrate contained large amounts of sand and gravel with scattered large rocks and pockets of cobbles.

# 3 METHODOLOGY

## 3.1 Habitat Evaluation

In 1993, EST recorded qualitative habitat descriptions at each sampling site monthly. These parameters included substrate composition, bedrock, aquatic vascular plants, logs in the stream, shading, overhanging plant species, and other narrative characteristics. This data may someday be useful in determining specific aquatic macroinvertebrate habitat preferences and associations, but it has not yet been systematically reviewed.

The US EPA has developed a series of measures to assess the quality of aquatic habitat in stream riffle and run areas (Plafkin et al. 1989). These parameters assess conditions at specific sites and larger stream reaches. According to their relative influence on stream habitat, the twelve habitat parameters (Appendix A) are divided into three groups:

- primary — bottom substrate instream cover, embeddedness, flow, and canopy cover (shading);
- secondary — channel alteration, bottom scouring and deposition, pool riffle and run ratio, and lower bank channel capacity;
- tertiary — upper bank stability, bank vegetative protection, streamside cover, and riparian vegetative zone.

The groups are scored so that primary parameters receive the greatest weight and tertiary parameters the least. Each parameter is assigned a score from a table of values, with higher scores reflecting higher quality habitat. The scores are then summed to yield an overall numerical habitat assessment. This sum is not intended to directly translate into narrative categories of habitat quality. Instead, the score provides a means of combining several habitat parameters into a single value that provides a comparative method to evaluate stream habitat.

EPA recommends that a single individual perform all comparative habitat assessments to standardize any prejudices and/or preferences that may influence the scoring. I, therefore, personally conducted all habitat assessments in both canyons. Flow rates at all sampling sites were too low to assess with the provided table of values, and this parameter was discarded from the summations.

### 3.2 Water Quality Measurements

During the 1993 and 1994 sampling seasons, six sampling stations were monitored monthly in Guaje and Los Alamos Canyons. Measurements of water temperature, pH, DO, and conductivity of stream water were taken with calibrated instruments in accordance with the manufacturer's specifications. All measurements were taken at least three times, and the averaged monthly values are reported. If a measurement differed greatly from the other two taken at a site, one or two further measurements were taken and the average computed from all four or five values.

Water temperature was measured in degrees Celsius with the temperature probe of a Yellow Springs Instrument model 57 DO meter. All pH measurements were taken with

an Orion SA 250 pH meter set to the tenths scale. Conductivity was measured with a VWR digital conductivity meter which displays the conductivity in units of µmhos/cm.

DO was measured in units of mg/l with a Yellow Springs Instrument model 57. DO is temperature and altitude dependent. To correct for altitude, we multiplied the calibration readings by 0.78, the compensation value for 2047 m (6717 ft). The percent saturation was calculated by dividing the corrected DO reading by the saturation value at the appropriate water temperature.

### 3.3 Aquatic Macroinvertebrate Sampling

Aquatic macroinvertebrates were collected monthly at the same time that water quality parameters were measured. Sample sites had cobble substrates in stream riffles, which were subjectively determined to be the best available habitats. Aquatic invertebrates were collected with a 0.47-m (18.5-in) wide rectangular kick net with a mesh size of 800 X 800 microns. One person positioned the net across the stream and against the bottom while another agitated the substrate in front of the net. Clinging and attached invertebrates were dislodged and carried by the stream current into the net. We used a scrub brush to remove resistant invertebrates from rocks in the sample site. Larger rocks were visually inspected to ensure that no invertebrates had been overlooked. We sampled a contiguous streambed area measuring approximately 0.25 $m^2$ (0.30 $yd^2$).

Collected debris, sand, gravel, and invertebrates were rinsed into a bucket of stream water. As one person swirled and poured the water from the bucket, the other held the net to catch the lighter debris and suspended invertebrates. Several rinses were made, and the material remaining in the bucket was carefully inspected for invertebrates not washed into the net. All debris and invertebrates washed into the net were placed in a labeled 500-ml Nalgene bottle, preserved in 70% ethanol, and taken to the lab for analysis.

Three replicate samples were taken from each sampling area. These were kept separate from one another, i.e., no compositing occurred. The canyons were sampled monthly and within 7 days of each other. All sampling sites were clearly marked with

flagging to avoid taking consecutive monthly samples at the same site. In general, sites should not be resampled for at least 6 weeks to allow adequate time for recolonization.

The "best" sample, i.e., the one containing the greatest numbers or variety of macroinvertebrates, of the three taken from each sampling site was analyzed. If samples appeared to be similar, the one taken farthest upstream was analyzed. In the lab, the alcohol was carefully poured into a sorting tray and checked for invertebrates. The alcohol was then poured into disposal container labelled as containing hazardous waste. Water was added to the Nalgene bottle and the sample poured into sorting trays. Pickers separated invertebrates from the organic detritus and rocks present in the sample. Invertebrates were placed in scintillation vials of 70% ethanol to await identification. All sorting trays were checked under magnification before being discarded.

Identification was accomplished with a Bausch and Lomb Stereozoom dissecting binocular microscope. A trained entomologist identified specimens using standard references, including Baumann et al. 1977, Edmunds 1976, Merritt and Cummins 1984, Pennak 1978, and Wiggins 1977. Specimens were identified to genus when possible and stored in vials of 70% ethanol in the EST invertebrate collection. Identifications were confirmed by Gerald Z. Jacobi of New Mexico Highlands University, who has conducted numerous aquatic invertebrate studies throughout New Mexico. All macroinvertebrates collected in this study were archived in EST's permanent collection.

### 3.4 Macroinvertebrate Analysis

#### 3.4.1 Rapid Bioassessment Protocols

The US EPA recently published the *Rapid Bioassessment Protocols for Use in Streams and Rivers* (Plafkin et al. 1989). The protocols are a series of integrated analytical techniques for using macroinvertebrate data to assess the degree of stream impact. A primary goal of the Rapid Bioassessment Protocols (RBPs) is to allow nationwide comparisons of streams and stream conditions.

This study uses the RBP III metrics, which require genus-level identifications for most specimens. Seven semi-quantitative measures, or 'metrics,' of the aquatic environment were computed. In all metrics except 'percent contribution of dominant taxon," the study site (in Los Alamos Canyon) is compared to a reference site (in Guaje Canyon). EST calculated all metrics for both Guaje and Los Alamos Canyons monthly to provide a thorough comparison of the streams. The *Rapid Bioassessment Protocols for Use in Streams and Rivers* emphasizes that these measures may require modification for use in a particular area; and the current study modified metrics 2 and 4. A brief explanation of the 7 RBP III metrics follows.

**Metric 1: Taxa Richness**

This metric reflects the health of the community by measuring the numbers of taxa present. Taxa richness generally increases with improving water quality, habitat diversity, and/or habitat suitability.

**Metric 2: Modified Hilsenhoff Biotic Index (Community Tolerance Quotient)**

Hilsenhoff's tolerance values range from 0 to 10, increasing as water quality decreases. This metric was performed on the family level because of difficulty in determining genera of Chironomidae (order Diptera) present. The formula for the index is:

$$HBI = \Sigma(xt)/n$$

where
x = number of individuals within a species
t = tolerance value of a taxon (found in a published table of values)
n = total number of organisms in the sample

After computation for all samples collected in 1993, the modified Hilsenhoff biotic index was dropped from further consideration. The calculated values for all stations during all months were very high (even when all other metrics were 0), and thus afforded little insight into the relative condition of the streams. The Hilsenhoff biotic index was developed for higher-order streams of Wisconsin and may have little applicability to first-order streams of New Mexico.

In analyzing the 1994 data, we included a Community Tolerance Quotient developed to assess the impacts of nonpoint source pollution in the western United States (Winget and Mangum 1979). This system has been previously used in the Jemez Mountains to effectively evaluate stream quality (Jacobi 1989, 1990, and 1992). Tolerance quotients for aquatic macroinvertebrate taxa range from 6 (the most sensitive) to 108 (the least sensitive) and are based upon tolerances to alkalinity, sulfates, and sedimentation (see Appendix B). The Community Tolerance Quotient is computed using the HBI formula with Winget and Mangum's list of tolerances. The scoring criteria developed for the HBI are then used to assign a biological condition score.

**Metric 3: Ratio of Scrapers to Filtering Collectors**

The proportion of these feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source. Scrapers increase with increased diatom abundance and decrease as filamentous algae and aquatic mosses increase. However, filamentous algae and aquatic mosses provide good attachment sites for filtering collectors; and the organic enrichment often responsible for overabundance of filamentous algae provide fine particulate organic matter used by the filterers. Therefore, sites subjected to organic enrichment have lower metric 3 values than undisturbed sites.

**Metric 4: Ratio of EPT to Chironomidae Abundances (Total Number of EPT Individuals)**

The Ephemeroptera, Plecoptera, Trichoptera (EPT) and Chironomidae abundance ratio uses relative abundance of these indicator groups as a measure of community balance. Skewed populations with a disproportionate number of the generally tolerant Chironomidae relative to the more sensitive EPT groups may indicate environmental stress. Most of the samples collected in this study contained few, if any, Chironomids. Therefore, this metric was changed to compare totals of EPT individuals collected at the two sites. Henceforth, Metric 4 will be referred to as "Total Number of EPT Individuals".

**Metric 5: Percent Contribution of Dominant Taxon**

This metric gives an indication of community balance at the lowest positive taxonomic level. A community dominated by relatively few species would indicate environmental stress.

**Metric 6: EPT Index**

The EPT Index is the total number of distinct taxa within the pollution-sensitive Ephemeroptera, Plecoptera, and Trichoptera orders. The index value generally increases with increasing water quality.

**Metric 7: Community Loss Index**

The Community Loss Index measures the loss of benthic species between a reference station and a study station. Plafkin (1989) offers three methods of computing community dissimilarity. Based on our preliminary data analysis, the Community Loss Index provided greater discrimination between sites than Jaccard's Coefficient of Community or the Index of Similarity (Klemm 1990). The Community Loss Index is calculated as follows:

$$CLI = (d-a)/e$$

where a = number of taxa common to both samples,
d = total number of taxa present at reference station, and
e = total number of taxa present at study station.

**Biological Condition Score**

Each metric is calculated independently of the others. In most cases, the computed value for the study site is divided by the computed value for the reference site to yield a percent similarity value. This percent value is assigned a biological condition score of either 0, 2, 4, or 6 from a reference chart that evaluates each metric separately. The biological condition score assesses the degree of community impairment. A score of 6 signifies no impairment, while a score of 0 signifies severe impairment.

The biological condition scores from all metrics are totaled and compared to the total possible. This final comparison between total scores provides an overall monthly bioassessment of the study site (Table 2). In order to provide more general comparisons and conclusions, we also reported six-month and two-year averages of the biological condition totals.

**Table 2. Interpretative Chart for the Total Biological Condition Scores and Associated Impairment Categories from Plafkin et al. (1989)**

| Percentage Comparison to Reference Score | Biological Condition Category | Attributes |
|---|---|---|
| >83% | Nonimpaired | Comparable to the best situation to be expected within an ecoregion. Balanced trophic structure. Optimum community structure (composition and dominance) for stream size and habitat quality. |
| 54 - 79% | Slightly impaired | Community structure less than expected. Composition (species richness) lower than expected due to loss of some intolerant forms. Percent contribution of tolerant forms increases. |
| 21 - 50% | Moderately impaired | Fewer species due to loss of most intolerant forms. Reduction in EPT index. |
| <17% | Severely impaired | Few species present. If high densities of organisms, then dominated by one or two taxa. |

### 3.4.2 Other Measures of Macroinvertebrate Communities

Utilization of the EPA RBP's requires two streams: a reference and a study stream. The middle and lower Los Alamos stations were completely dry on several sampling dates, eliminating the possibility of collecting samples there. However, samples were taken in Guaje Canyon throughout the two six-month sampling seasons. In order to compare these collections to the other samples, two additional measures of the aquatic community were computed: standing crop and a biodiversity index.

**Standing Crop**

Standing crop is a measure of macroinvertebrate density expressed as the number of macroinvertebrates/$m^2$. Our sampling methodology is considered to be semi-quantitative: the accuracy of our reported densities is uncertain. Although standing crop is

related to productivity, it should be noted that a single large stonefly (Plecoptera) larva can possess more than fifty times the size and mass of an early-instar midge (Chironomidae) larva.

**Biodiversity Index**

A biodiversity index was calculated monthly for each station using the equation discussed by Wilhm (1967):

$$D = (S-1) / \ln N$$

where D= the taxa diversity index,
S = the number of taxa, and
N = the number of individuals.

The derived number gives a much better single assessment of a site's species richness and evenness than any single RBP metric. A diversity index value of less than 1 indicates heavy pollution, between 1 and 3 indicates moderate pollution, and greater than 3 indicates clean water. However, biodiversity values for low-order montane streams are notoriously low and should not be compared to higher-order and lower elevation streams.

A special effort was made to ensure that taxa were not counted twice; and if a counting error occurred, it was due to under-counting rather than over-counting. Therefore, we only counted one taxon in a sample for the following cases:

- different life stages of a taxon present,
- specimen(s) keyed to the family level and another specimen(s) in the same family identified to a lower level, and
- possible different instars of a genus assigned separate descriptive, rather than taxonomic, identifications.

## 4 RESULTS AND DISCUSSION

### 4.1 Habitat Assessment

In 1994, habitat assessments for riffle and run stream areas were conducted monthly in Los Alamos Canyon from June through September and in Guaje Canyon from July through September (Table 3). All Guaje stations and LA1 were roughly similar in their assessment totals, and I judge the aquatic habitat at these stations to be high quality

when compared to other first-order streams in the area. LA2 and LA3 scored lower than the other stations, and it is significant that these stations were dry on some sampling dates.

**Table 3. Habitat Assessment Summations for the 1994 Sampling Stations**

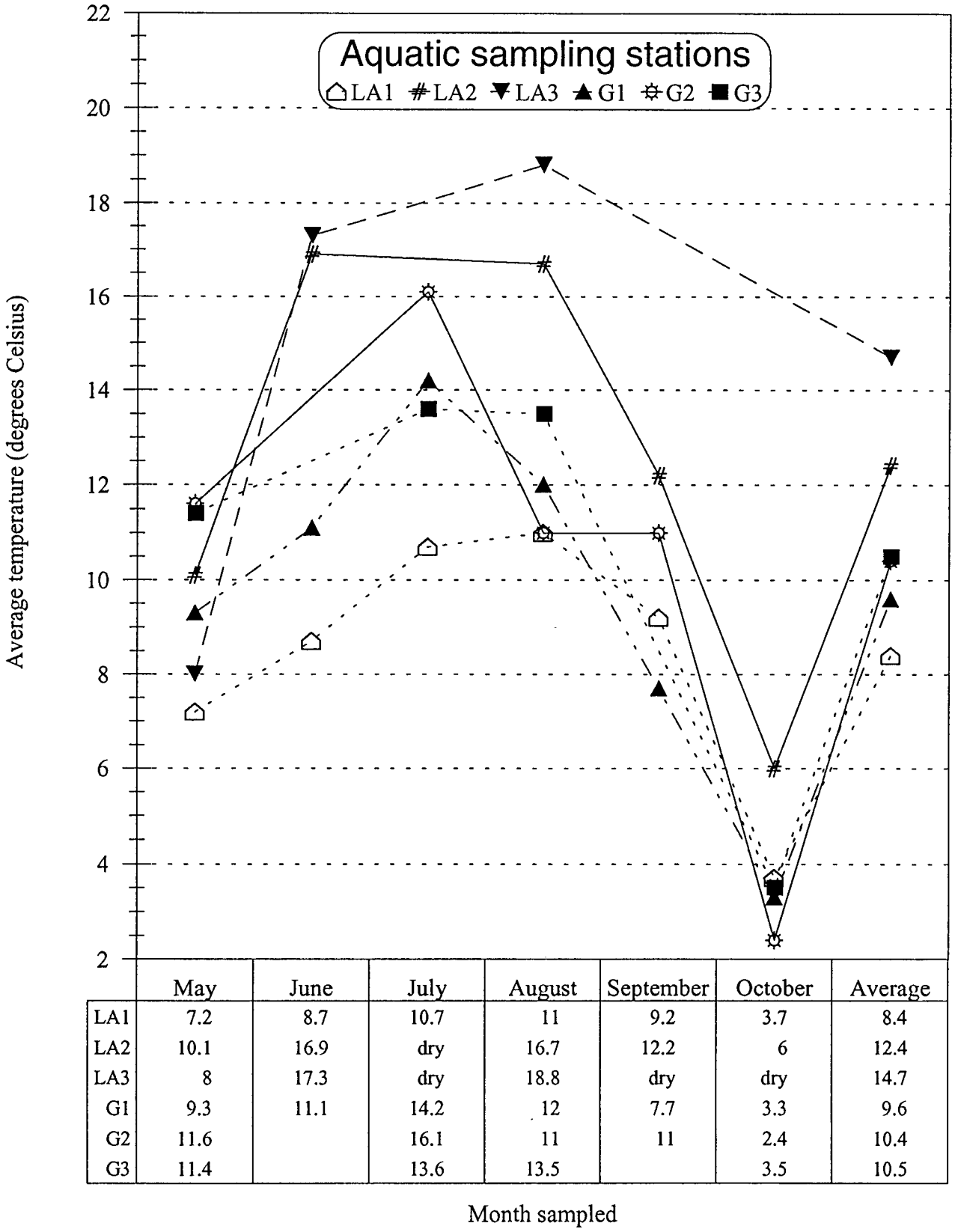
| Station | June | July | August | September | Average* |
|---|---|---|---|---|---|
| LA1 | 112 | 128 | 106 | 122 | 117 |
| LA2 | 91 | dry | 97 | 119 | 102 |
| LA3 | 107 | dry | dry | dry | 107 |
| G1 | not assessed | 121 | 116 | 115 | 117 |
| G2 | not assessed | 113 | 126 | 119 | 119 |
| G3 | not assessed | 115 | 117 | 120 | 117 |

* when water was present

## 4.2 Water Quality Measurements

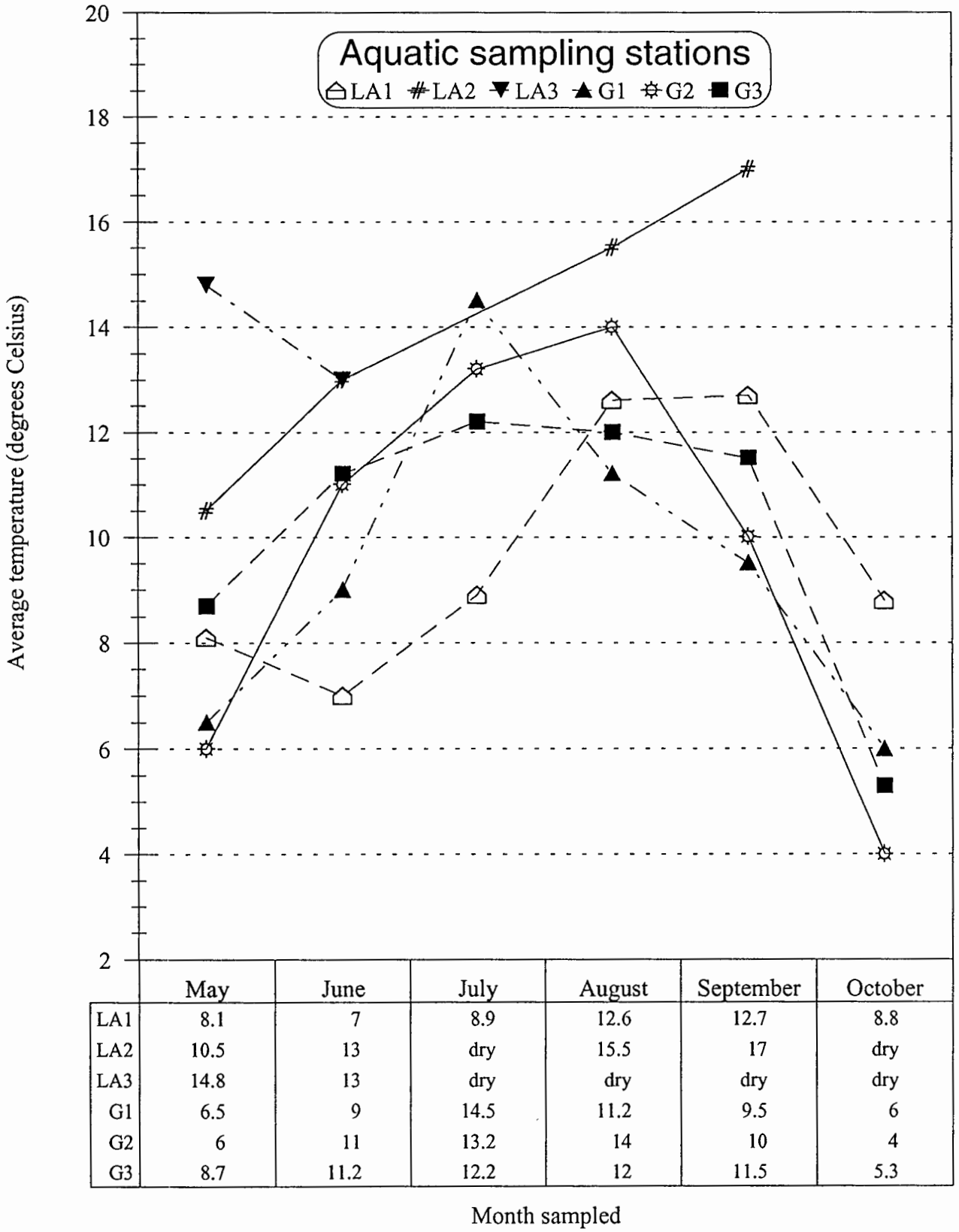
**4.2.1 Temperature.** Figs. 2 and 3 show the monthly water temperatures for both canyons. The six-month and two-year average temperatures are listed in Table 4. In both streams, the lowest temperatures occurred upstream and the highest downstream. In terms of the two-year averages, the temperatures at comparable stations were slightly higher in upper Guaje (0.5°C) and considerably higher in middle (3.2°C) and lower Los Alamos (3.9°C). The differences at the middle and lower stations would be even greater, but the stream completely dried up, preventing temperature readings during some of the warmest months.

The thermal increase at the downstream Los Alamos Canyon stations is not due to LANL operations because the greatest variance occurred between LA1 and LA2, both within the SFNF. Instead, the observed high temperatures are caused by the large reservoir in Los Alamos Canyon, which is situated between LA1 and LA2. The Los Alamos Reservoir impounds water behind a large dam, allowing only warmed surface water to escape over the spillway. The dam is also responsible for the summer stream drought because it impedes water movement downstream except during periods of peak flow. These downstream droughts are undoubtedly the most serious impacts to LA2 and LA3, periodically eliminating their macroinvertebrate communities.




| | May | June | July | August | September | October | Average |
|---|---|---|---|---|---|---|---|
| LA1 | 7.2 | 8.7 | 10.7 | 11 | 9.2 | 3.7 | 8.4 |
| LA2 | 10.1 | 16.9 | dry | 16.7 | 12.2 | 6 | 12.4 |
| LA3 | 8 | 17.3 | dry | 18.8 | dry | dry | 14.7 |
| G1 | 9.3 | 11.1 | 14.2 | 12 | 7.7 | 3.3 | 9.6 |
| G2 | 11.6 | | 16.1 | 11 | 11 | 2.4 | 10.4 |
| G3 | 11.4 | | 13.6 | 13.5 | | 3.5 | 10.5 |

Fig. 2. Monthly 1993 water temperatures.




| | May | June | July | August | September | October |
|---|---|---|---|---|---|---|
| LA1 | 8.1 | 7 | 8.9 | 12.6 | 12.7 | 8.8 |
| LA2 | 10.5 | 13 | dry | 15.5 | 17 | dry |
| LA3 | 14.8 | 13 | dry | dry | dry | dry |
| G1 | 6.5 | 9 | 14.5 | 11.2 | 9.5 | 6 |
| G2 | 6 | 11 | 13.2 | 14 | 10 | 4 |
| G3 | 8.7 | 11.2 | 12.2 | 12 | 11.5 | 5.3 |

Fig. 3. Monthly 1994 water temperatures.

**Table 4. Average Water Temperatures in Degrees Celsius for the 1993 and 1994 Sampling Seasons**

| Sampling Station | Los Alamos 1993, 1994 | Los Alamos, Two-year | Guaje 1993, 1994 | Guaje, Two-year |
|---|---|---|---|---|
| 1 | 8.4, 9.7 | 9.0 | 9.6, 9.4 | 9.5 |
| 2 | 12.4, 14.0 | 13.2 | 10.4, 9.7 | 10.0 |
| 3 | 14.7, 13.9 | 14.3 | 10.5, 10.2 | 10.4 |

**4.2.2 pH.** In Los Alamos Canyon, the pH of natural surface waters ranges between 7.8 and 8.2 (LANL 1990). The average monthly pH readings of both streams showed little overall variance (Figs. 4 and 5), especially in Guaje Canyon. The greatest extreme variance in pH (0.8) recorded at a station in 1 year occurred at LA1. In Los Alamos Canyon, values tended to decrease downstream (Table 5). All pH readings in both canyons fall within the "excellent" range of the environmental water quality index based on pH (Batelle 1972; Fig. 6). The highest (8.5 from LA1 in October 1993) and the lowest (6.7 from LA2 in August 1994) average monthly pH readings are both within the current New Mexico Water Quality Control Commission's limits for high-quality coldwater fisheries (State of New Mexico 1995).

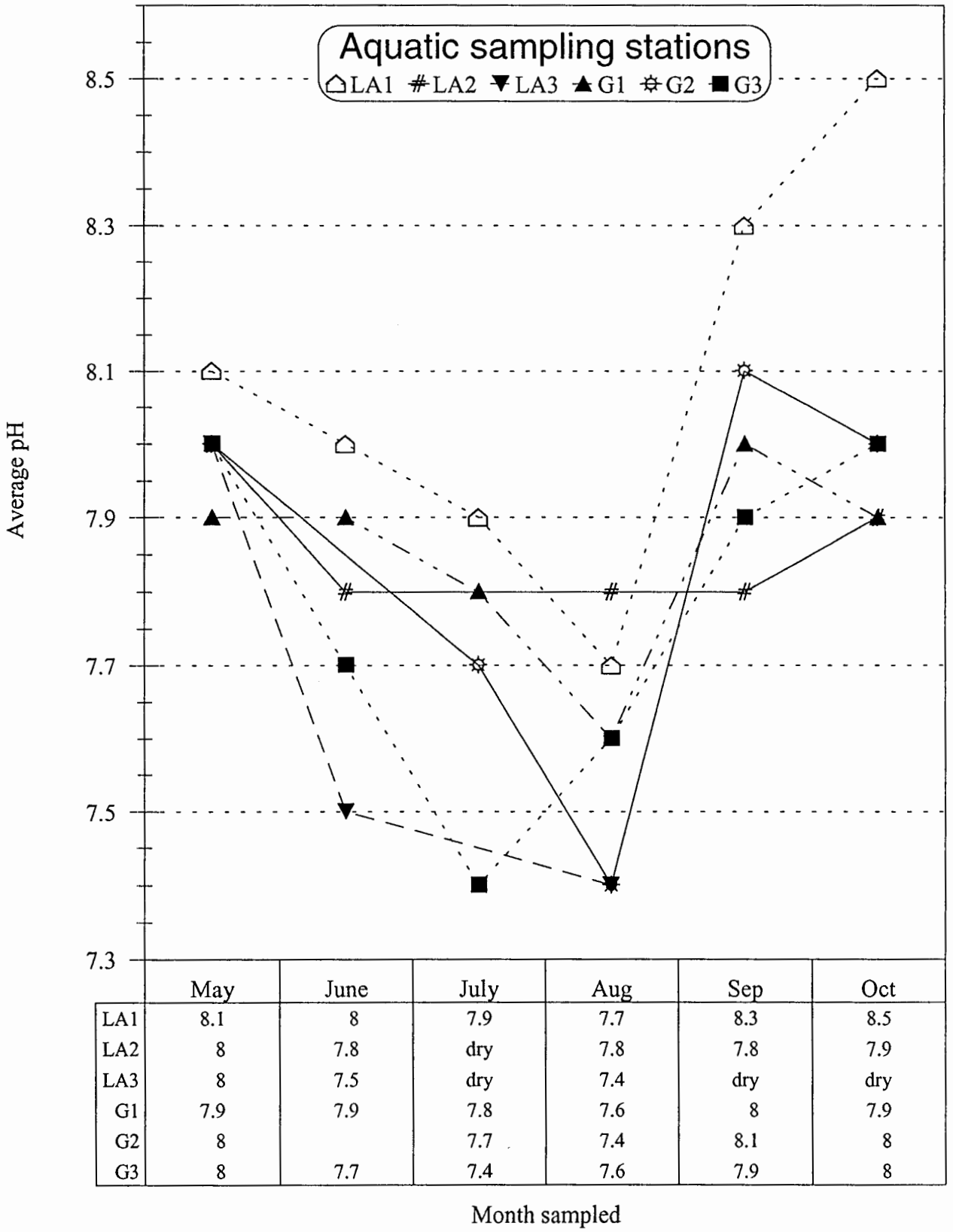
**Table 5. Average pH for the 1993 and 1994 Sampling Seasons**

| Sampling Station | Los Alamos, 1993, 1994 | Los Alamos, Two-year | Guaje, 1993, 1994 | Guaje, Two-year |
|---|---|---|---|---|
| 1 | 8.1, 7.5 | 7.8 | 7.8, 7.6 | 7.7 |
| 2 | 7.9, 7.1 | 7.5 | 7.8, 7.5 | 7.6 |
| 3 | 7.6, 7.2 | 7.4 | 7.8, 7.6 | 7.7 |

**4.2.3 Dissolved Oxygen (DO) and Percent Dissolved Oxygen Saturation.**

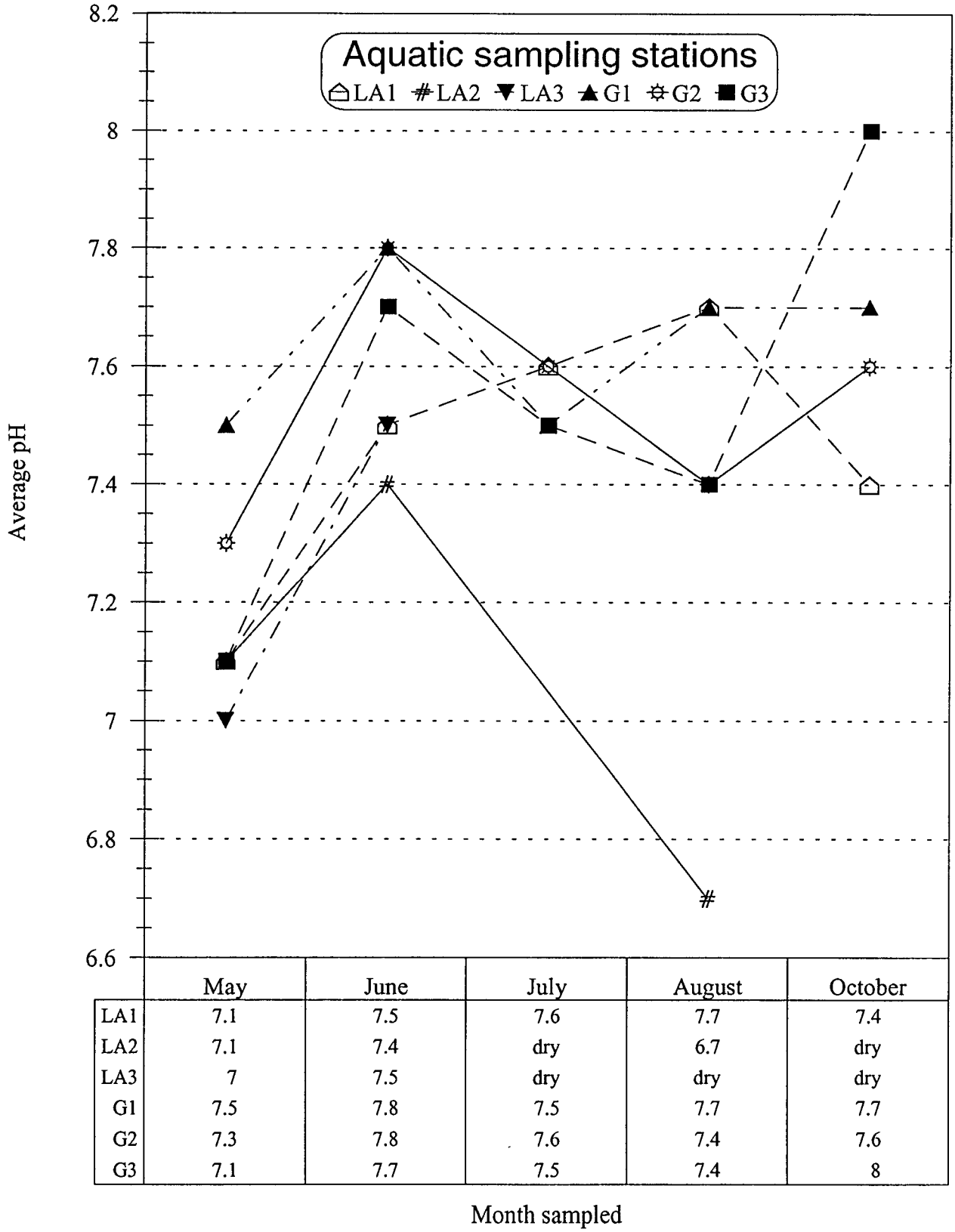
Due to mechanical problems with the EST's DO meter, all 1993 DO measurements were deemed unreliable and are not included in this report.

In 1994, EST purchased a new YSI model 57 DO meter. The field readings of mg/l (Fig. 7) were converted to percent DO saturation (Fig. 8). Using the standards developed by Battelle (Fig. 9), the percent DO saturation was in the excellent range 70%




| | May | June | July | Aug | Sep | Oct |
|---|---|---|---|---|---|---|
| LA1 | 8.1 | 8 | 7.9 | 7.7 | 8.3 | 8.5 |
| LA2 | 8 | 7.8 | dry | 7.8 | 7.8 | 7.9 |
| LA3 | 8 | 7.5 | dry | 7.4 | dry | dry |
| G1 | 7.9 | 7.9 | 7.8 | 7.6 | 8 | 7.9 |
| G2 | 8 | | 7.7 | 7.4 | 8.1 | 8 |
| G3 | 8 | 7.7 | 7.4 | 7.6 | 7.9 | 8 |

Fig. 4. Monthly 1993 pH.




| | May | June | July | August | October |
|---|---|---|---|---|---|
| LA1 | 7.1 | 7.5 | 7.6 | 7.7 | 7.4 |
| LA2 | 7.1 | 7.4 | dry | 6.7 | dry |
| LA3 | 7 | 7.5 | dry | dry | dry |
| G1 | 7.5 | 7.8 | 7.5 | 7.7 | 7.7 |
| G2 | 7.3 | 7.8 | 7.6 | 7.4 | 7.6 |
| G3 | 7.1 | 7.7 | 7.5 | 7.4 | 8 |

Fig. 5. Monthly 1994 pH.

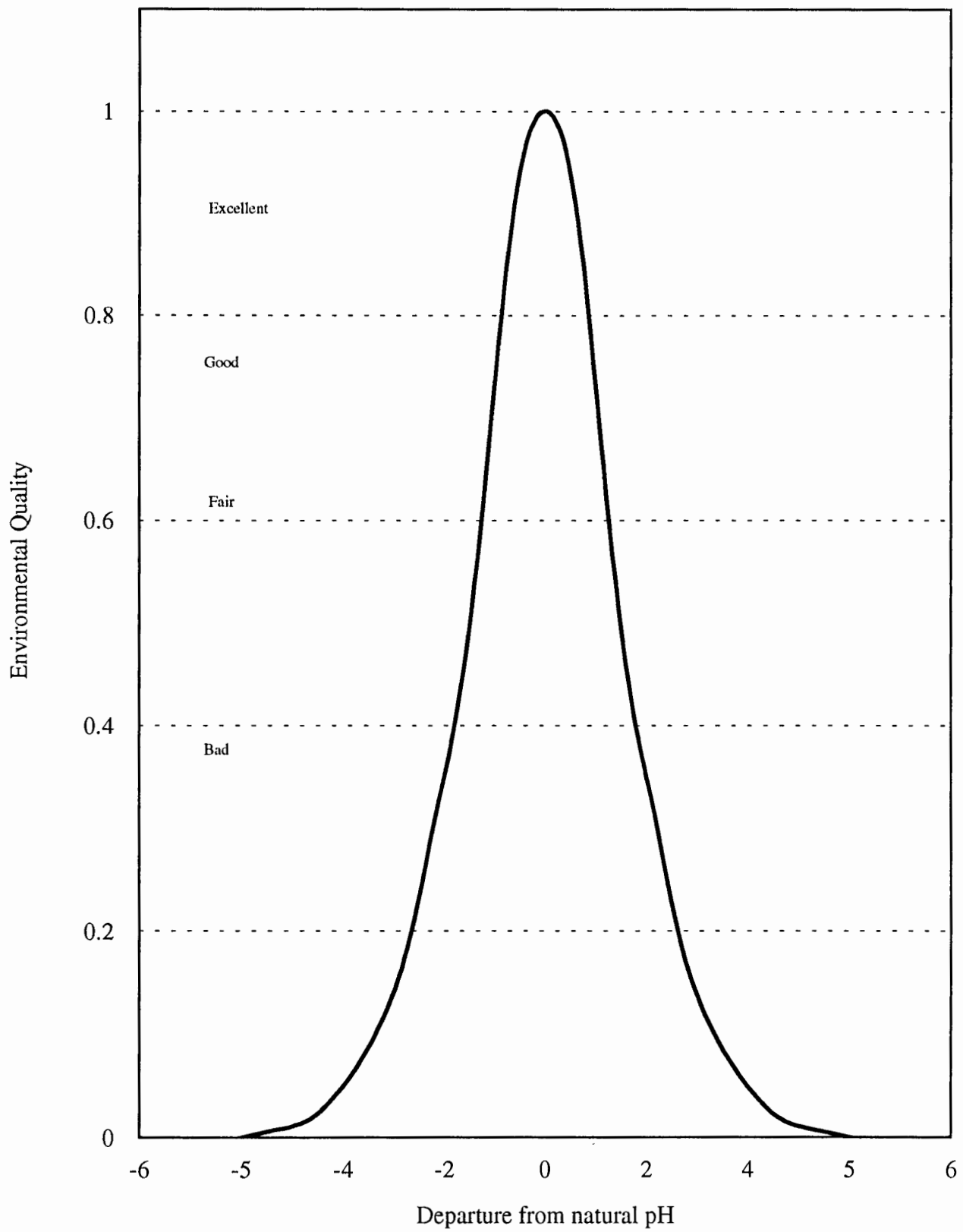
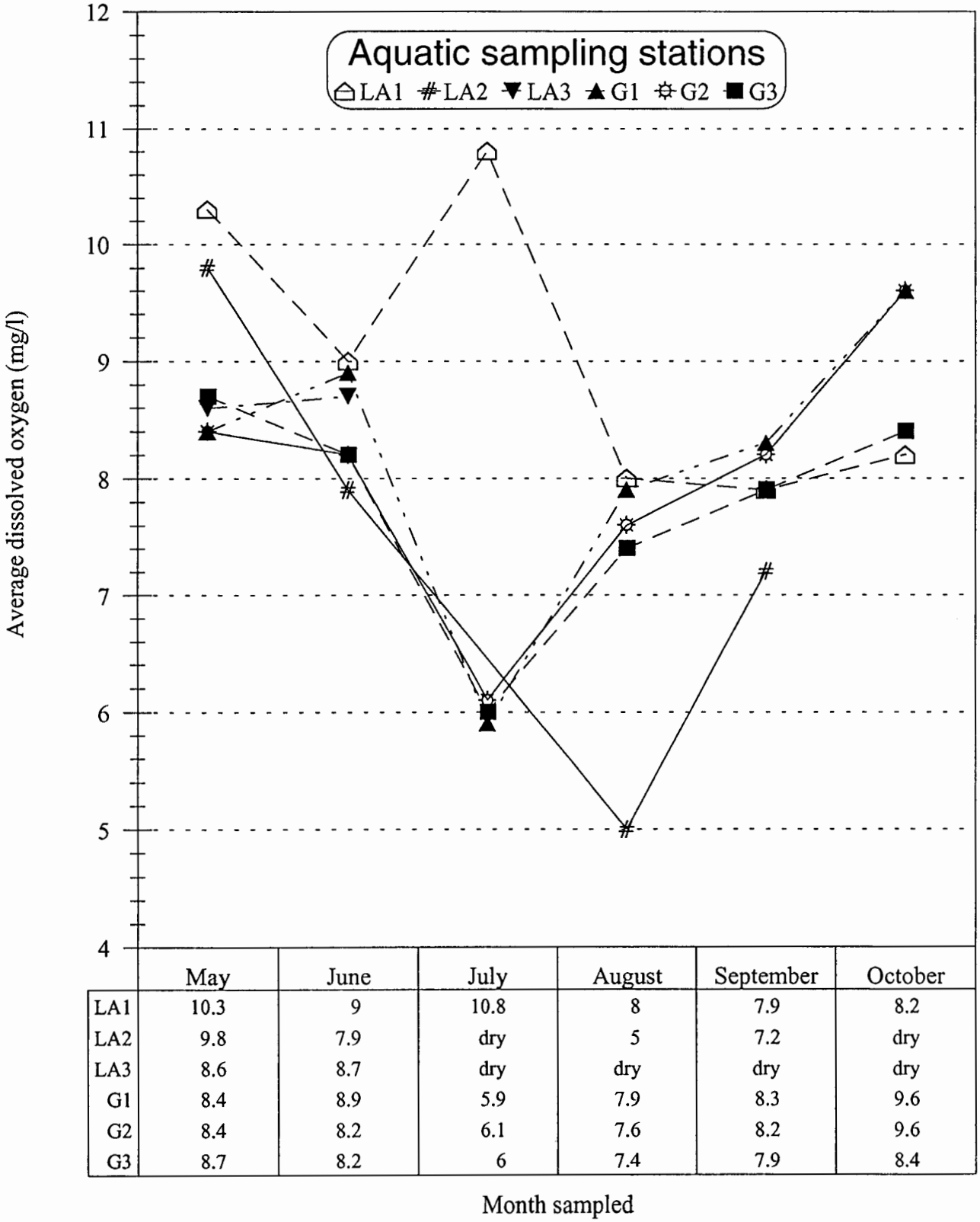
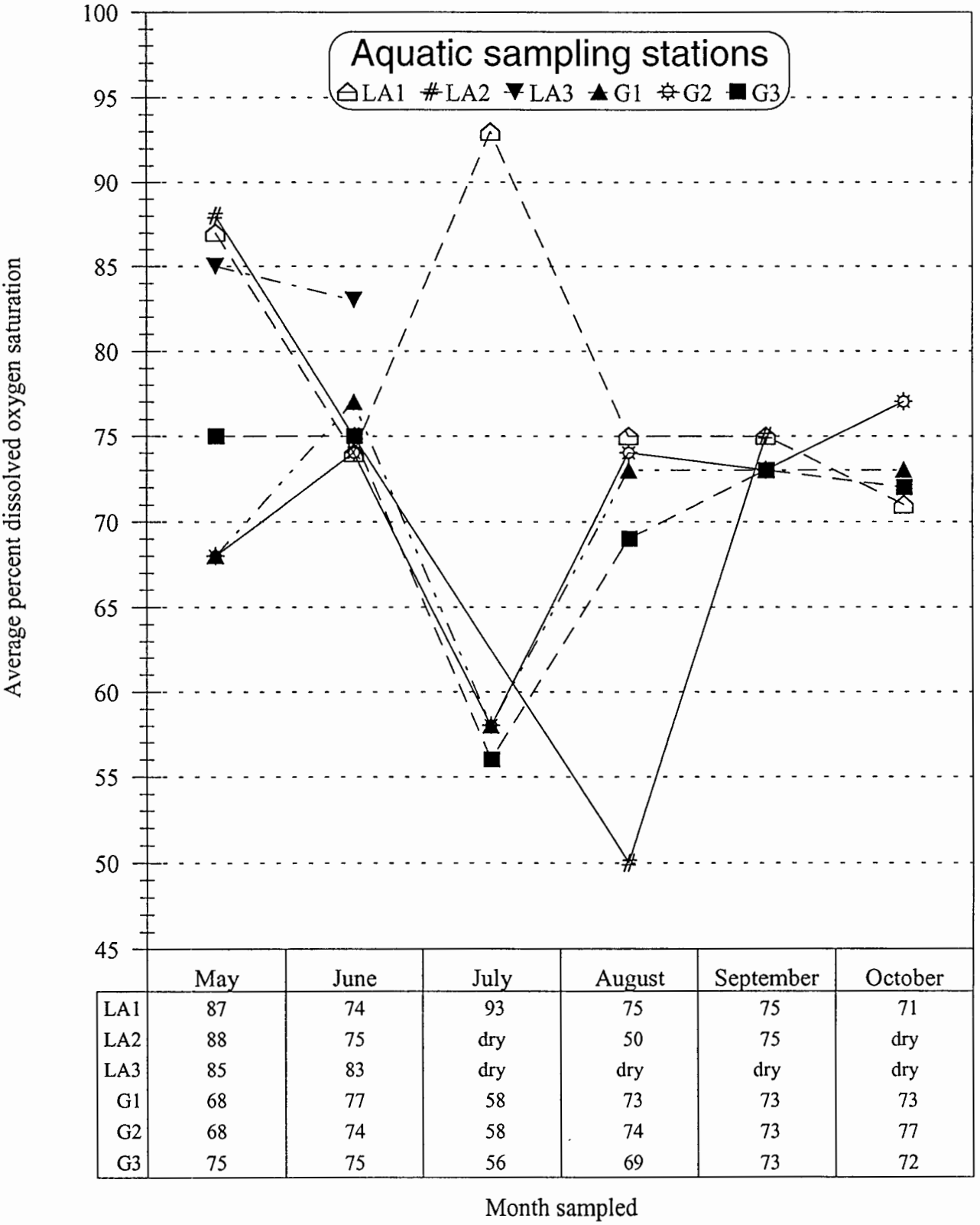



Fig. 6. Departure from natural pH versus an Environmental Quality Index (Battelle 1972).




| | May | June | July | August | September | October |
|---|---|---|---|---|---|---|
| LA1 | 10.3 | 9 | 10.8 | 8 | 7.9 | 8.2 |
| LA2 | 9.8 | 7.9 | dry | 5 | 7.2 | dry |
| LA3 | 8.6 | 8.7 | dry | dry | dry | dry |
| G1 | 8.4 | 8.9 | 5.9 | 7.9 | 8.3 | 9.6 |
| G2 | 8.4 | 8.2 | 6.1 | 7.6 | 8.2 | 9.6 |
| G3 | 8.7 | 8.2 | 6 | 7.4 | 7.9 | 8.4 |

Fig. 7. Monthly dissolved oxygen during 1994.




| | May | June | July | August | September | October |
|---|---|---|---|---|---|---|
| LA1 | 87 | 74 | 93 | 75 | 75 | 71 |
| LA2 | 88 | 75 | dry | 50 | 75 | dry |
| LA3 | 85 | 83 | dry | dry | dry | dry |
| G1 | 68 | 77 | 58 | 73 | 73 | 73 |
| G2 | 68 | 74 | 58 | 74 | 73 | 77 |
| G3 | 75 | 75 | 56 | 69 | 73 | 72 |

Fig. 8. Monthly 1994 percent dissolved oxygen saturation.

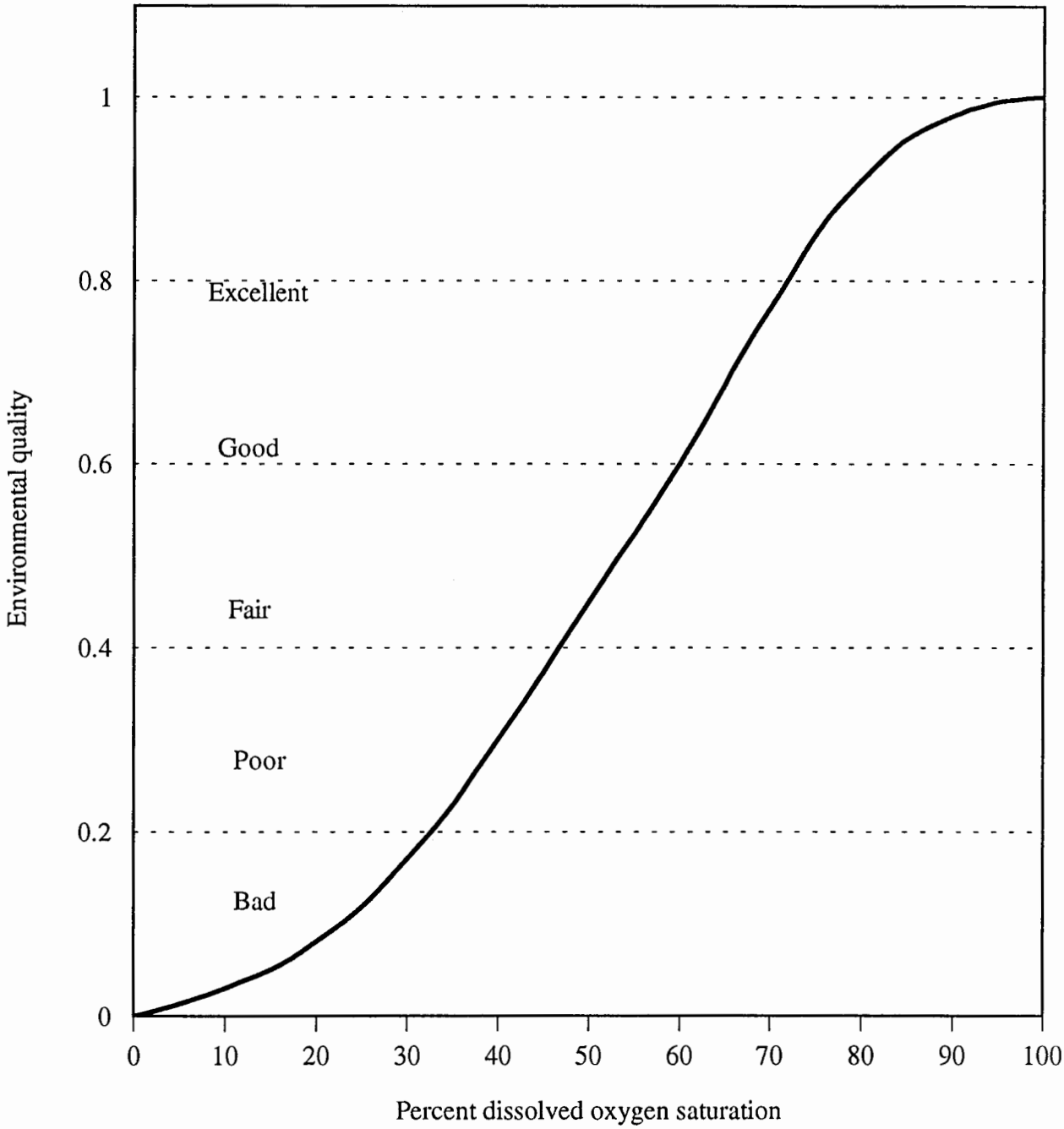



Fig. 9. Percent dissolved oxygen saturation versus an Environmental Quality Index (Battelle 1972).

of the time and the lowest saturation values recorded were in the fair range. The 6-month averages were LA1 79%, LA2 72%, LA3 84%, G1 70%, G2 71%, and G3 70%.

The DO values recorded for all Guaje stations in July were low and lowered the averages for these stations from the excellent range to the good range. Although the new meter was calibrated in the lab before each use, the accuracy of these DO measurements are uncertain. EST has ordered a new DO meter from a different manufacturer and will use it in future field studies.

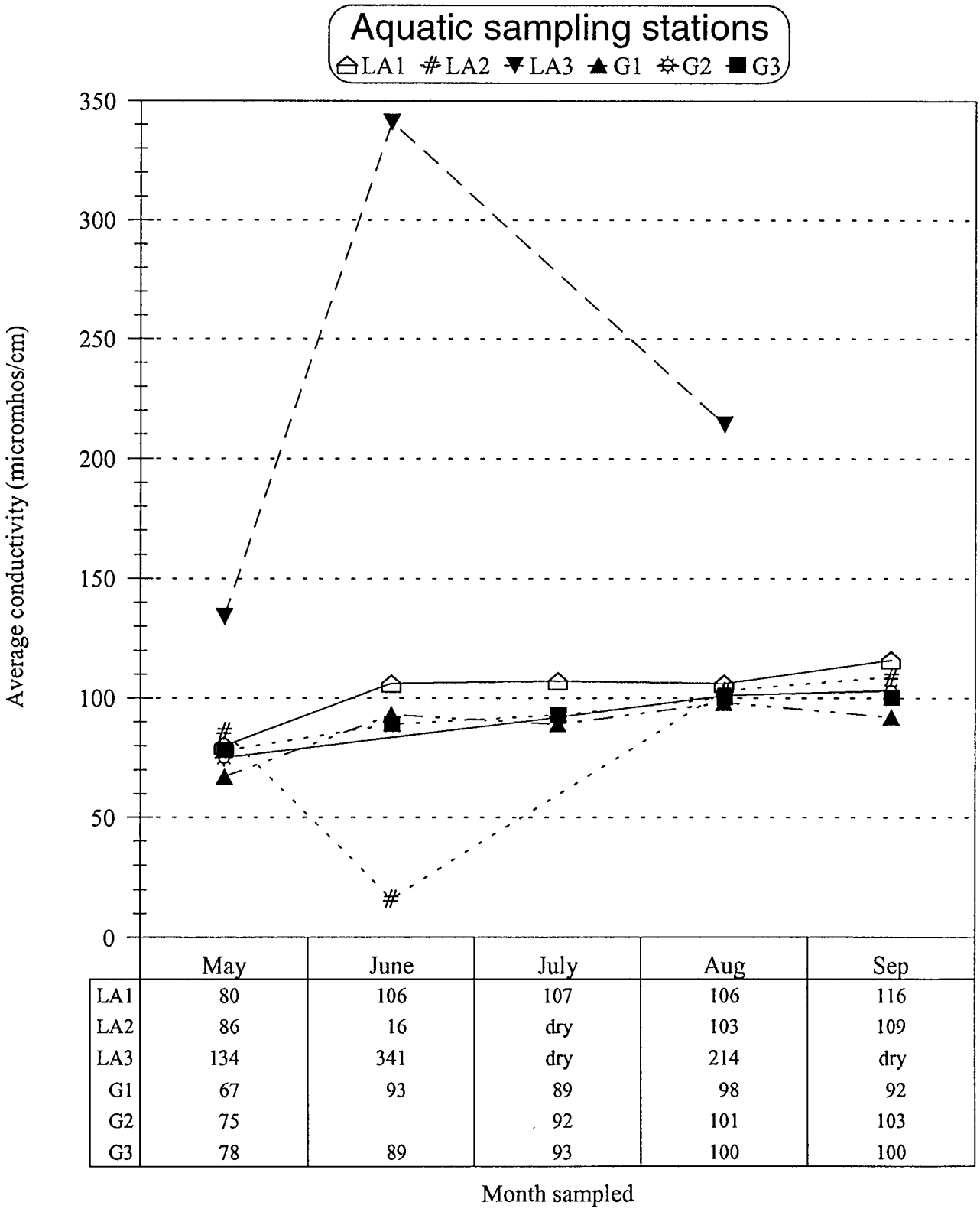
### 4.2.4 Conductivity and Total Dissolved Solids (TDS).

The three highest monthly conductivity averages (225, 341, and 308 µmhos/cm) all occurred at LA3 (Figs. 10 and 11) and may be attributable to the outfall that discharges above the sampling station. However, the current New Mexico Water Quality Control Commission places the upper-permissible-conductivity limits for high-quality coldwater fisheries at 1,500 µmhos/cm (State of New Mexico 1995), depending on natural background levels. Thus, these seemingly high numbers actually represent acceptable conductivity readings.

A rough approximation of milligrams of TDS per liter of freshwater can be obtained by multiplying the conductivity by 0.66. Figures 12 and 13 illustrate estimated monthly TDS concentrations from both streams. Six-month averages clearly show that LA3 had significantly increased TDS values (Table 6). However, the TDS concentrations of all stations are well within the "excellent" range of the environmental water quality index developed by Battelle (1972; Fig. 14). Aquatic organisms can generally tolerate TDS concentrations as high as 5000 mg/l, a concentration much higher than any found at the sample stations.

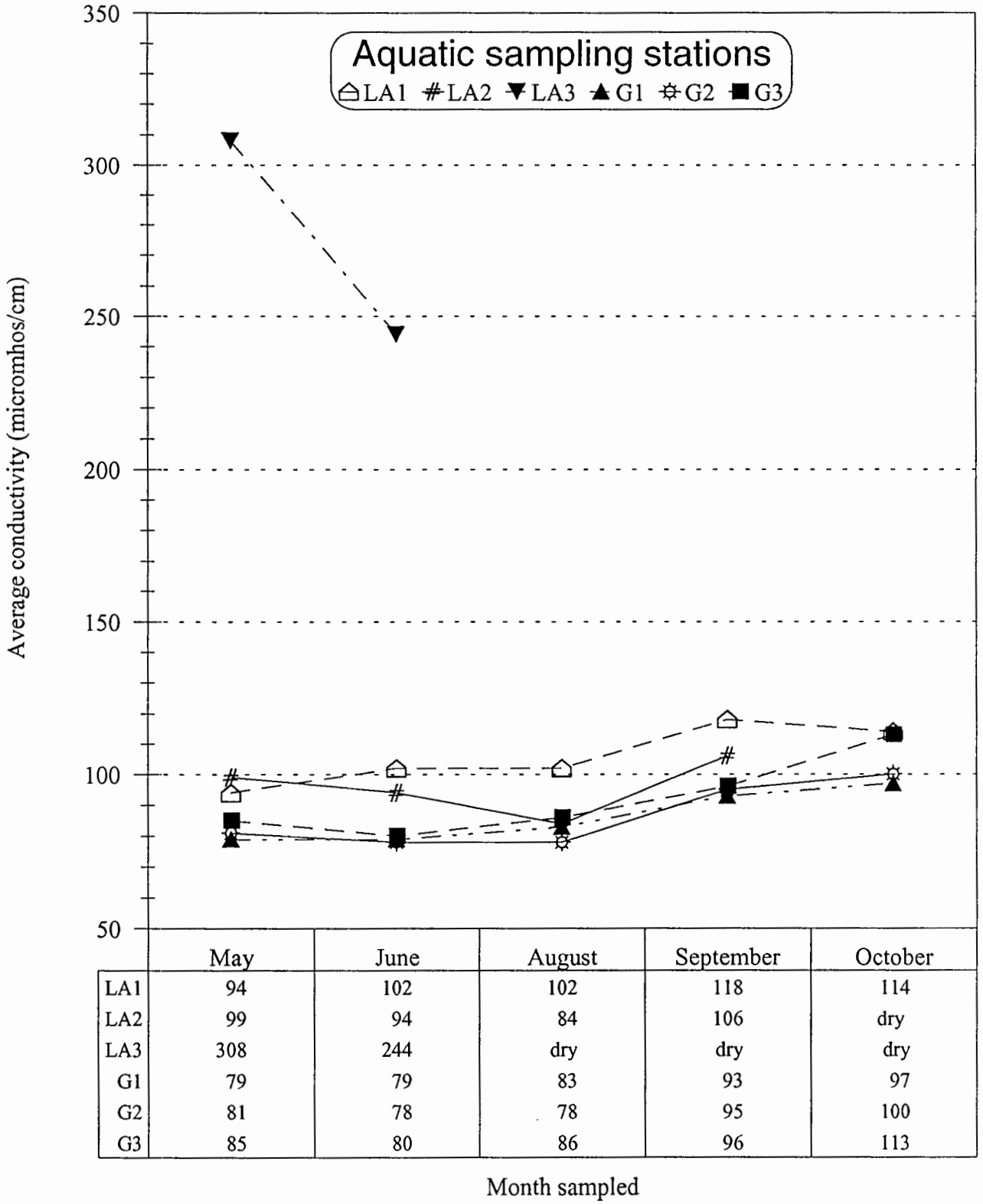
## 4.3 Macroinvertebrate Sampling

Our sampling program collected, identified, and analyzed over 35,000 aquatic macroinvertebrates. A total of 81 taxa of aquatic macroinvertebrates were collected in Guaje Canyon (Appendix C) and 63 were collected in Los Alamos Canyon (Appendix D).



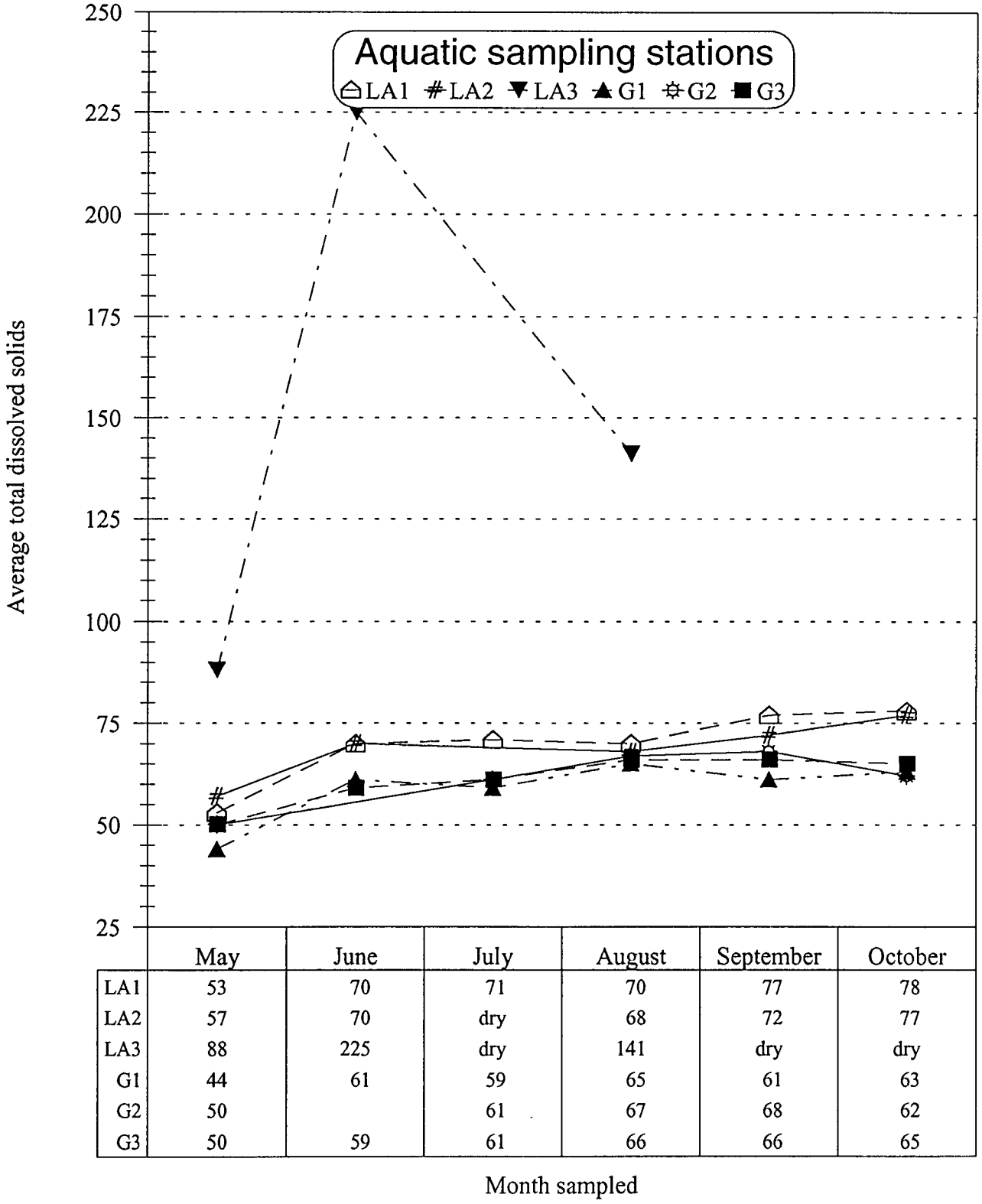

| | May | June | July | Aug | Sep |
|---|---|---|---|---|---|
| LA1 | 80 | 106 | 107 | 106 | 116 |
| LA2 | 86 | 16 | dry | 103 | 109 |
| LA3 | 134 | 341 | dry | 214 | dry |
| G1 | 67 | 93 | 89 | 98 | 92 |
| G2 | 75 | | 92 | 101 | 103 |
| G3 | 78 | 89 | 93 | 100 | 100 |

Fig. 10. Monthly 1993 conductivity.



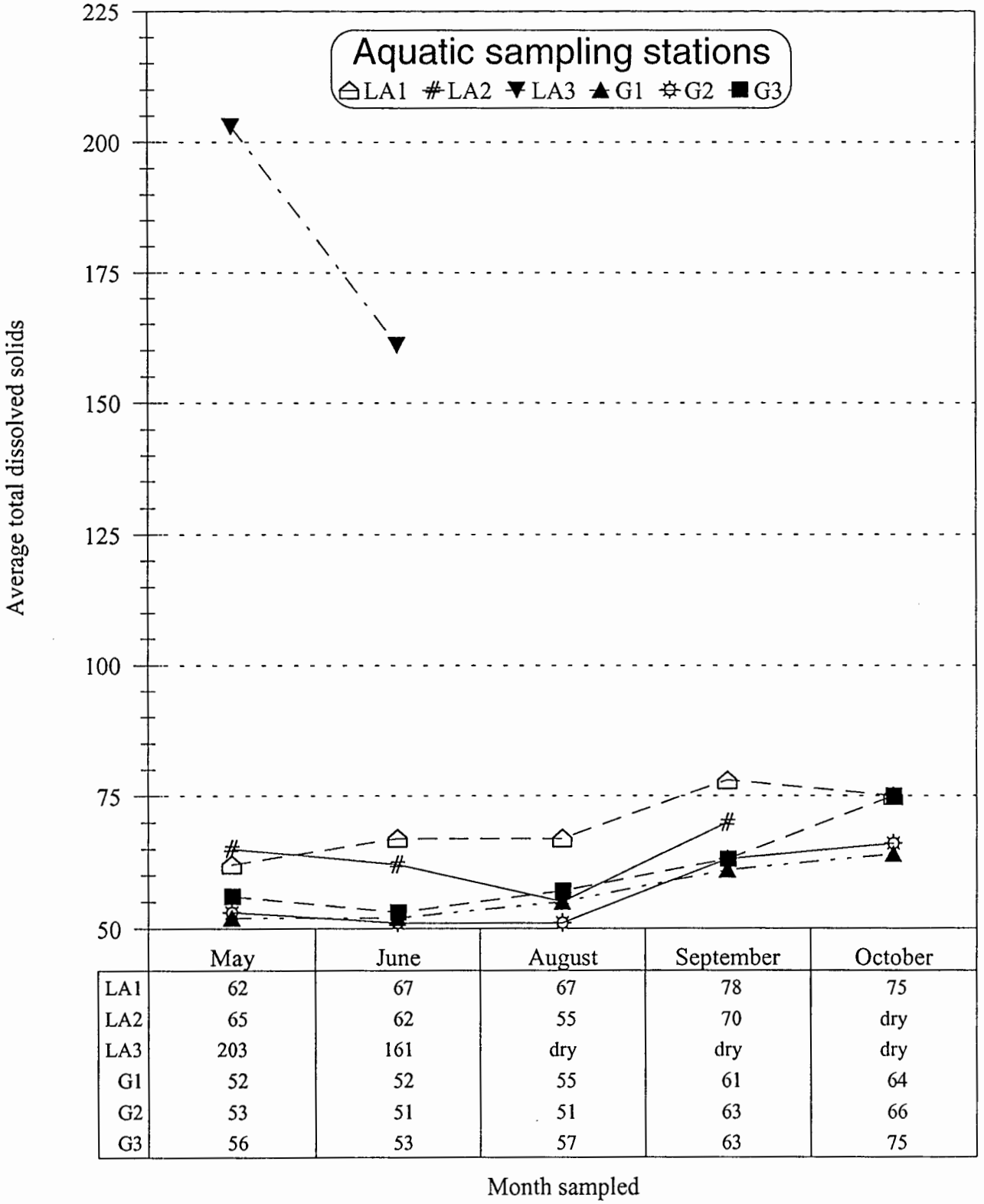

| | May | June | August | September | October |
|---|---|---|---|---|---|
| LA1 | 94 | 102 | 102 | 118 | 114 |
| LA2 | 99 | 94 | 84 | 106 | dry |
| LA3 | 308 | 244 | dry | dry | dry |
| G1 | 79 | 79 | 83 | 93 | 97 |
| G2 | 81 | 78 | 78 | 95 | 100 |
| G3 | 85 | 80 | 86 | 96 | 113 |

Fig. 11. Monthly 1994 conductivity.




| | May | June | July | August | September | October |
|---|---|---|---|---|---|---|
| LA1 | 53 | 70 | 71 | 70 | 77 | 78 |
| LA2 | 57 | 70 | dry | 68 | 72 | 77 |
| LA3 | 88 | 225 | dry | 141 | dry | dry |
| G1 | 44 | 61 | 59 | 65 | 61 | 63 |
| G2 | 50 | | 61 | 67 | 68 | 62 |
| G3 | 50 | 59 | 61 | 66 | 66 | 65 |

Fig. 12. Monthly 1993 total dissolved solids.




| | May | June | August | September | October |
|---|---|---|---|---|---|
| LA1 | 62 | 67 | 67 | 78 | 75 |
| LA2 | 65 | 62 | 55 | 70 | dry |
| LA3 | 203 | 161 | dry | dry | dry |
| G1 | 52 | 52 | 55 | 61 | 64 |
| G2 | 53 | 51 | 51 | 63 | 66 |
| G3 | 56 | 53 | 57 | 63 | 75 |

Fig. 13. Monthly 1994 total dissolved solids.

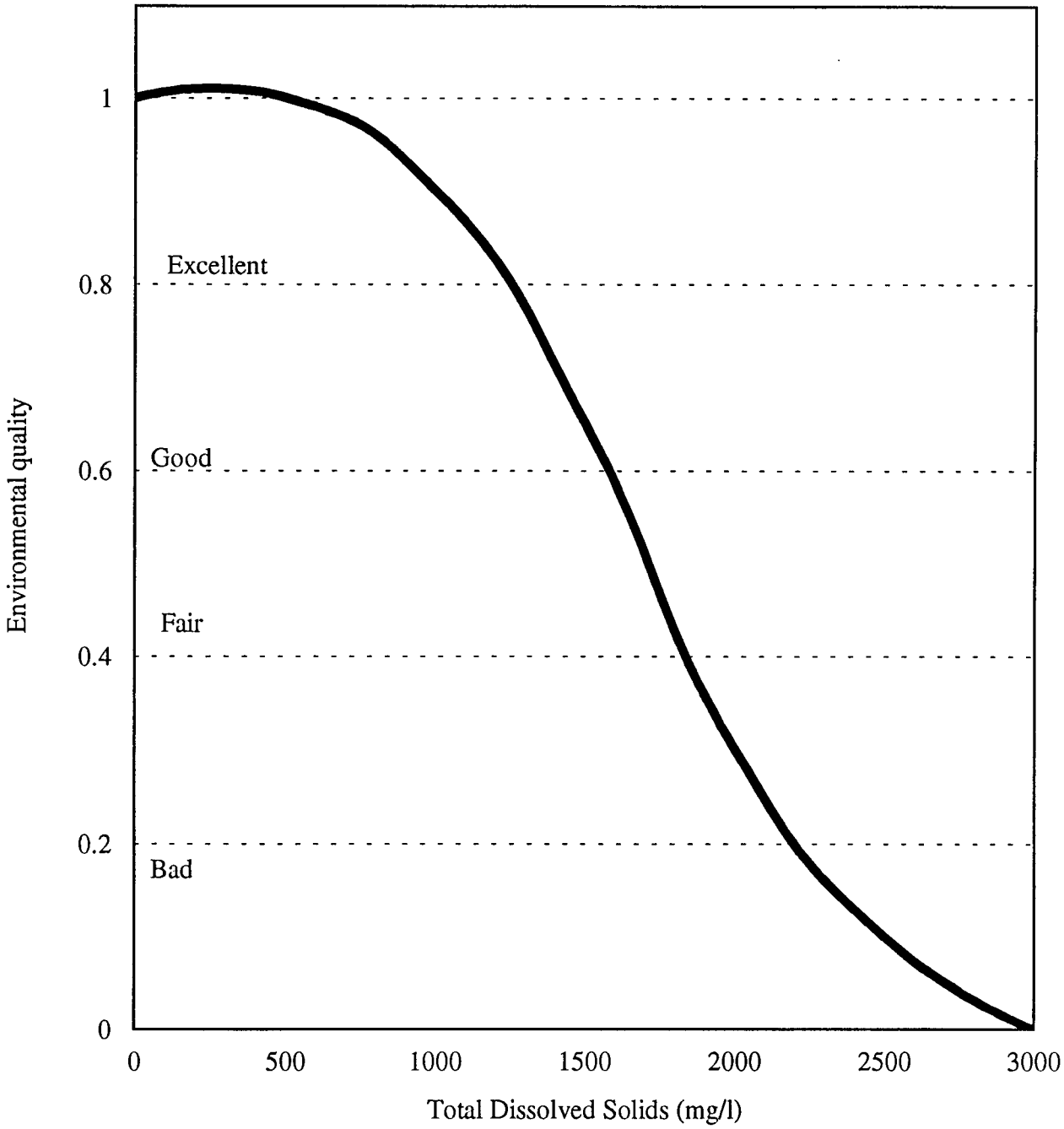



Fig. 14. TDS versus an Environmental Quality Index (Battelle 1972).

**Table 6. Average TDS (mg/l) for the 1993 and 1994 Sampling Seasons**

| Sampling Station | Los Alamos, 1993, 1994 | Los Alamos, Two-year | Guaje, 1993, 1994 | Guaje, Two-year |
|---|---|---|---|---|
| 1 | 70, 70 | 70 | 59, 57 | 58 |
| 2 | 69, 63 | 66 | 62, 57 | 60 |
| 3 | 151, 182 | 166 | 62, 61 | 61 |

Many of these taxa have been previously reported from Los Alamos County and its surrounding watersheds (Appendix E).

The samples included 48 taxa that were present in a canyon during 1, but not both, of the sampling years. In 42% (20/48) of these cases, the taxon was represented by a single individual. These rare taxa underscore the importance of maintaining yearly collections to accurately document resident aquatic communities.

**Table 7. Monthly Standing Crop per Square Meter and Yearly Averages**

| Month Year | G1 | G2 | G3 | LA1 | LA2 | LA3 |
|---|---|---|---|---|---|---|
| **May 1993** | 736 | 2204 | 1140 | 668 | 1710 | 182 |
| **June 1993** | 1412 | 860 | 976 | 640 | 2624 | 588 |
| **July 1993** | 2684 | 1336 | 960 | 612 | dry | dry |
| **Aug 1993** | 2808 | 1424 | 940 | 820 | 136 | 92 |
| **Sept 1993** | 2340 | 2872 | 1652 | 1232 | 248 | dry |
| **Oct 1993** | 2664 | 2856 | 2196 | 3172 | dry | dry |
| **1993 Average *** | **2107** | **1925** | **1311** | **1191** | **786** | **144** |
| **May 1994** | 2228 | 3108 | 5348 | 2676 | 4228 | 280 |
| **June 1994** | 1840 | 2620 | 2568 | 2104 | 10440 | 576 |
| **July 1994** | 2368 | 1768 | 3604 | 7304 | dry | dry |
| **Aug 1994** | 4016 | 3056 | 1760 | 1968 | 252 | dry |
| **Sept 1994** | 2540 | 1748 | 2216 | 2788 | 1196 | dry |
| **Oct 1994** | 3516 | 2536 | 3760 | 4088 | dry | dry |
| **1994 Average*** | **2751** | **2473** | **3209** | **3488** | **2686** | **143** |
| **Two-year average** | **2429** | **2199** | **2260** | **2340** | **1736** | **144** |

* dry months counted as 0

### 4.3.1 Standing Crop

The six-month averages of standing crop per square meter show a pattern of decreasing macroinvertebrate numbers downstream except at G3 in 1994 (Table 7). In 1993, greater numbers of macroinvertebrates were collected at each of the Guaje Canyon stations when compared to their Los Alamos Canyon counterparts. In 1994, two of the Los Alamos stations had higher six-month averages, although the high LA2 average is primarily due to the large number of blackflies (Simulidae) present in the June sample.

Both streams contained significantly more sands and silts in 1994 than the previous year. The subsequent reduction of interstitial spaces required by many aquatic macroinvertebrates for protection from dislodgment by streamflow and refugia from predators was expected to be reflected in lower standing crops and taxa richness. However, the standing crop averages from both canyons were much higher overall in 1994 (taxa richness was also higher at the "best" sampling stations - G1, G2, G3, and LA1). The standing crop totals from each station are shown graphically for 1993 (Fig. 15) and 1994 (Fig. 16).

The Los Alamos Reservoir restricts the movement of fish downstream, and no fish were observed below its spillway during our sampling season. In contrast, numerous small brook trout (*Salvelinus fontinalis*) were seen throughout the length of the Guaje Canyon stream. A study conducted in Colorado (Allan 1975) found invertebrate densities to be two to six times greater in stream reaches from which trout were absent than in adjacent reaches containing trout. However, a later Colorado study by the same researcher (Allan 1982) found that trout exclusion had no significant effect on resident prey populations. At present, it is unclear what effect, if any, brook trout in Guaje Canyon have on macroinvertebrate densities.

### 4.3.2 Biodiversity

Wilhm's biodiversity index was computed monthly for each sampling site that was not dry (Table 8). The Guaje stations had higher diversity indices than their Los Alamos

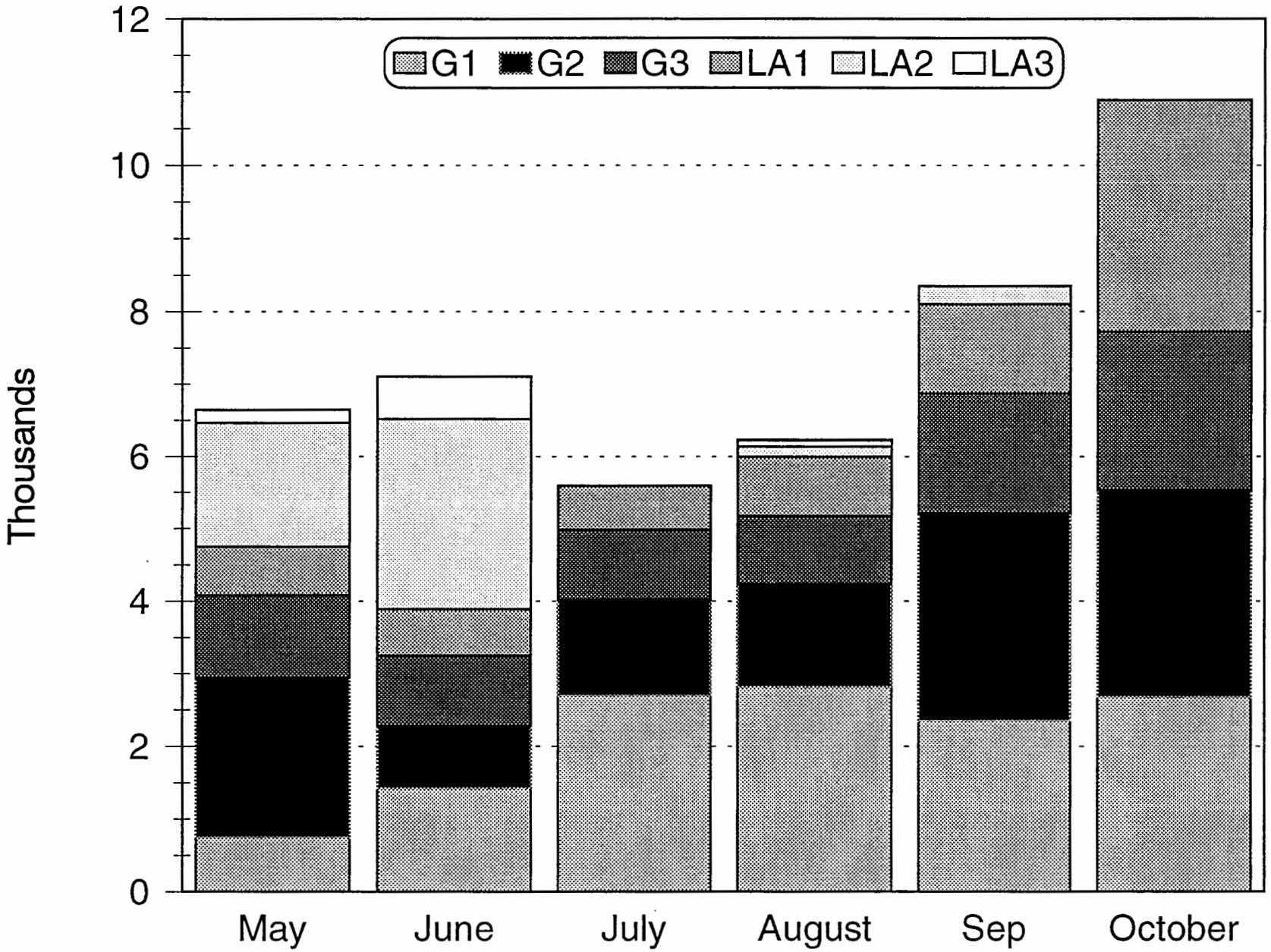



Fig. 15. Monthly 1993 standing crop per square meter.

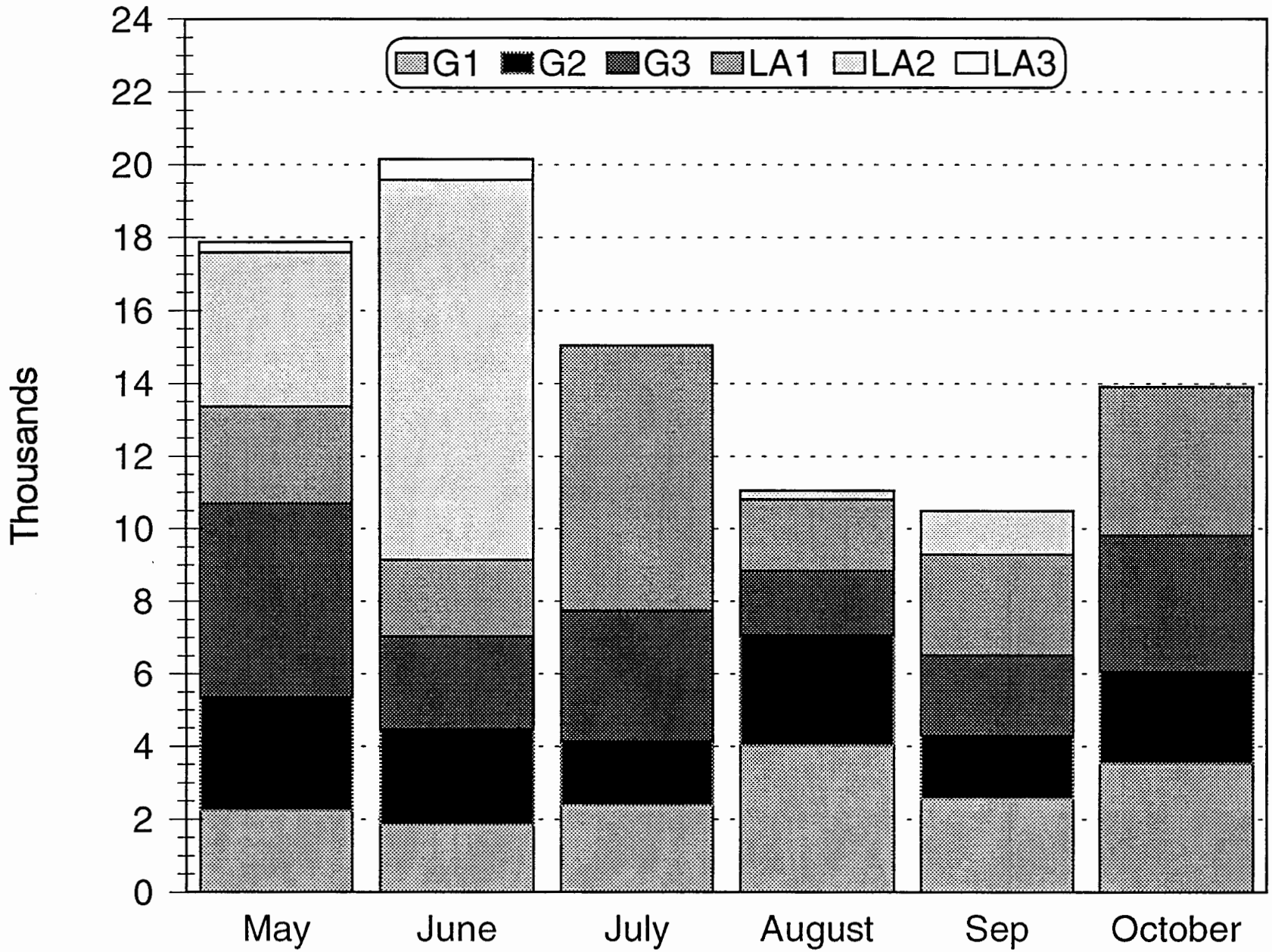



Fig. 16. Monthly 1994 standing crop per square meter.

counterparts in 22 of 25 comparisons, the 3 exceptions all occurring at Station 1. This finding coupled with the higher standing crops recorded in Guaje validates our selection of Guaje as a reference site. With only one exception (G2), the highest biodiversities occurred at the upstream stations and the lowest occurred at the downstream stations.

**Table 8. Wilhm's Monthly Biodiversity Values and Yearly Averages**

| Month Year | G1 | G2 | G3 | LA1 | LA2 | LA3 |
|---|---|---|---|---|---|---|
| **May 1993** | 2.49 | 3.64 | 3.36 | 2.41 | 1.78 | 1.33 |
| **June 1993** | 3.23 | 2.61 | 2.91 | 3.15 | 2.00 | 2.20 |
| **July 1993** | 4.92 | 2.93 | 3.20 | 3.43 | dry | dry |
| **Aug 1993** | 5.19 | 3.91 | 4.21 | 3.76 | 0.85 | 1.91 |
| **Sept 1993** | 4.08 | 3.91 | 3.98 | 4.71 | 1.94 | dry |
| **Oct 1993** | 3.85 | 3.65 | 4.91 | 4.49 | dry | dry |
| **1993 Average*** | **3.96** | **3.44** | **3.76** | **3.66** | **1.64** | **1.81** |
| **May 1994** | 4.59 | 4.05 | 4.17 | 4.30 | 0.86 | 1.18 |
| **June 1994** | 5.38 | 4.01 | 3.87 | 4.15 | 1.27 | 1.41 |
| **July 1994** | 3.76 | 3.45 | 3.97 | 4.13 | dry | dry |
| **Aug 1994** | 4.20 | 4.82 | 4.60 | 3.72 | 1.45 | dry |
| **Sept 1994** | 4.50 | 3.45 | 4.75 | 3.66 | 2.98 | dry |
| **Oct 1994** | 3.98 | 4.96 | 4.23 | 3.61 | dry | dry |
| **1994 Average*** | **4.40** | **4.12** | **4.26** | **3.92** | **1.64** | **1.30** |
| **Two-year average*** | **4.18** | **3.78** | **4.01** | **3.79** | **1.64** | **1.56** |

* dry months not included in averages

The diversity of a community relates to the density of organisms (standing crop), the number of taxa present (taxa richness), and the proportion of individuals occurring in each taxa (taxa diversity). Grouping related aquatic macroinvertebrate taxa into large faunal assemblages can also elucidate community structure. We conducted such an analysis by grouping collected macroinvertebrates into 5 insect orders and a category of non-insects. During both years, all Guaje sampling stations and LA1 contained a variety of aquatic macroinvertebrate groups (Figs. 17, 18, 19, and 20), indicative of a healthy community. In contrast, LA2 contained a great preponderance of Dipterans (Figs. 18 and

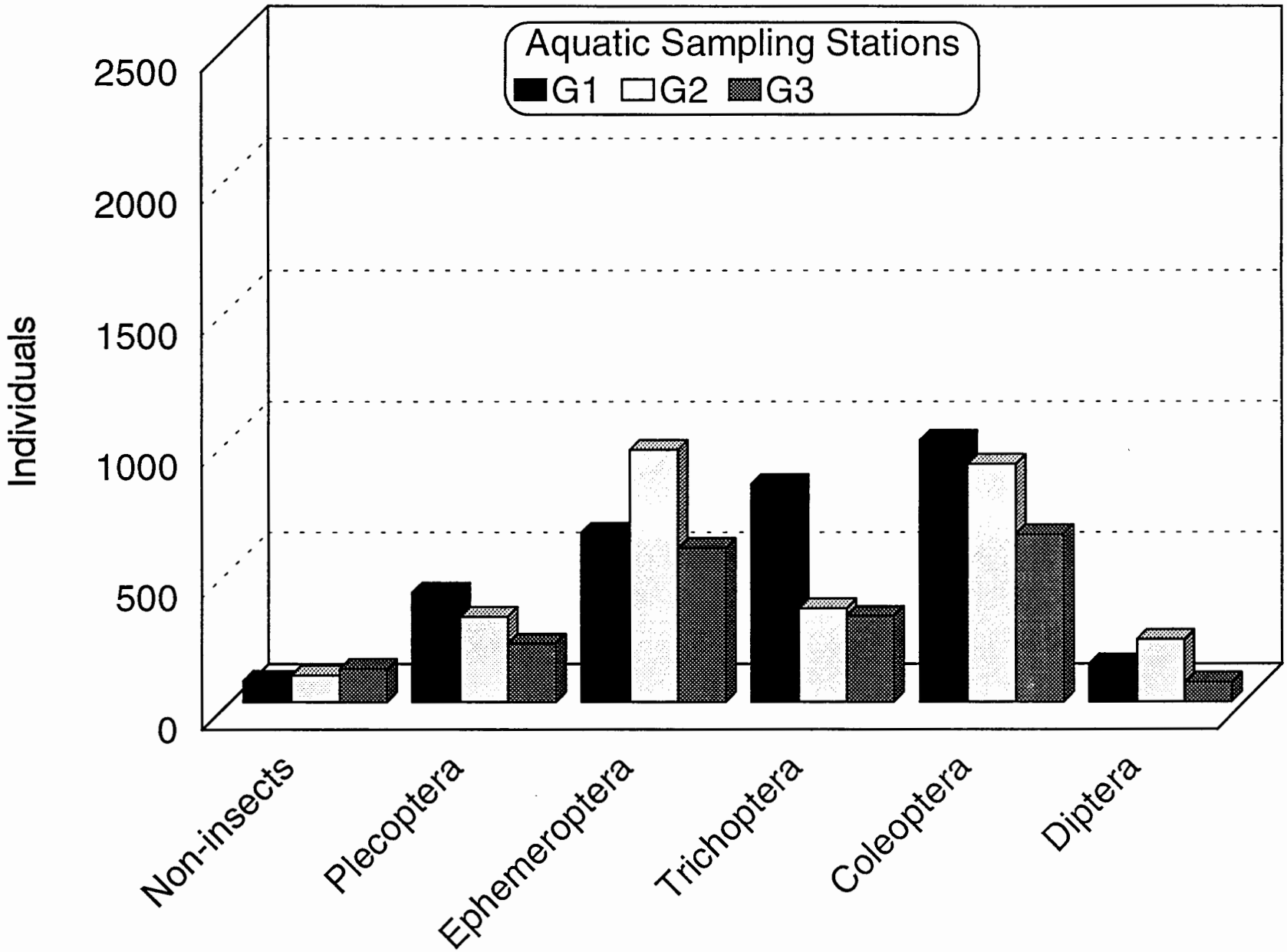



Fig. 17. 1993 Guaje Canyon aquatic invertebrate groups.

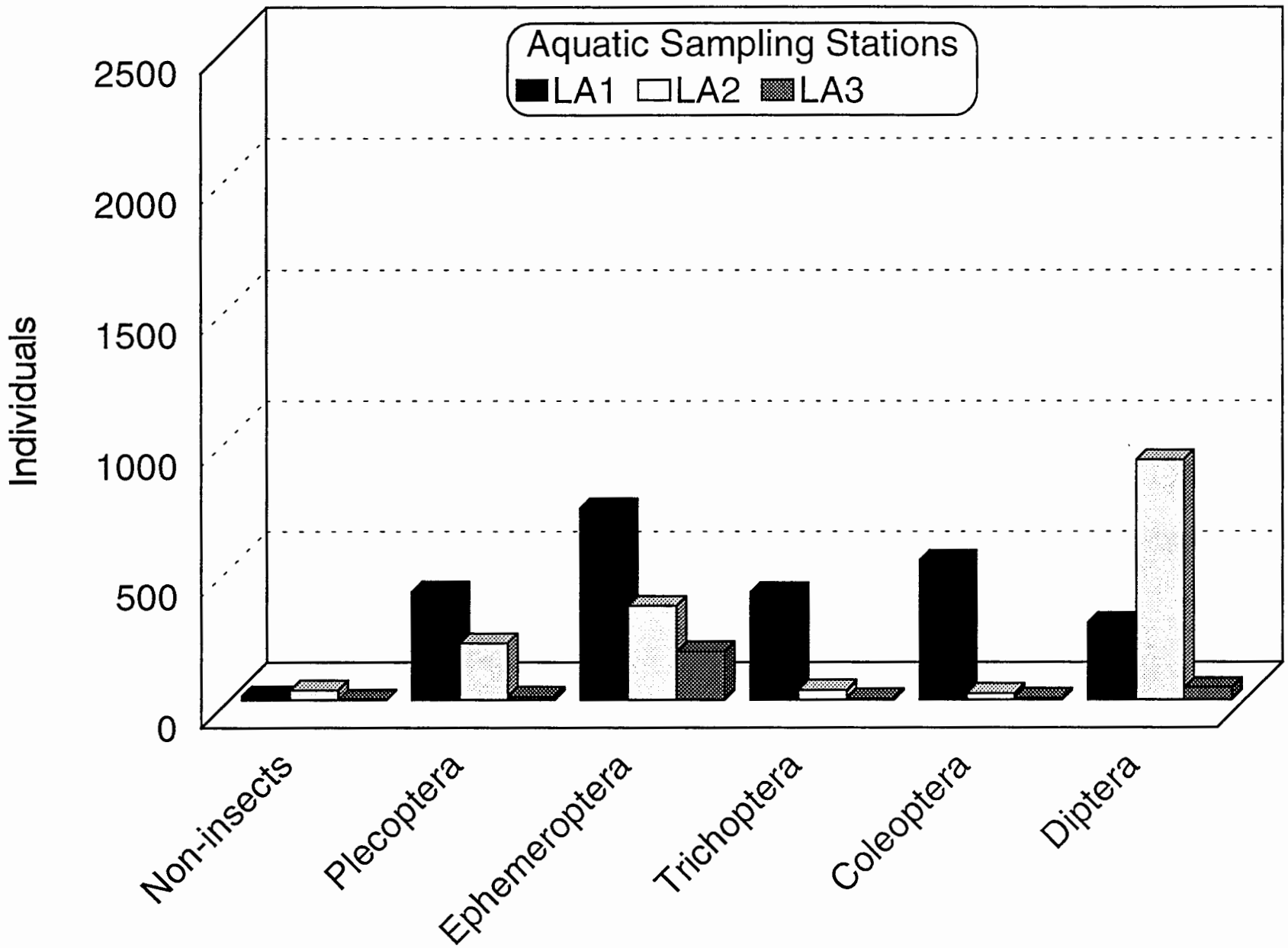



Fig. 18. 1993 Los Alamos Canyon aquatic invertebrate groups.

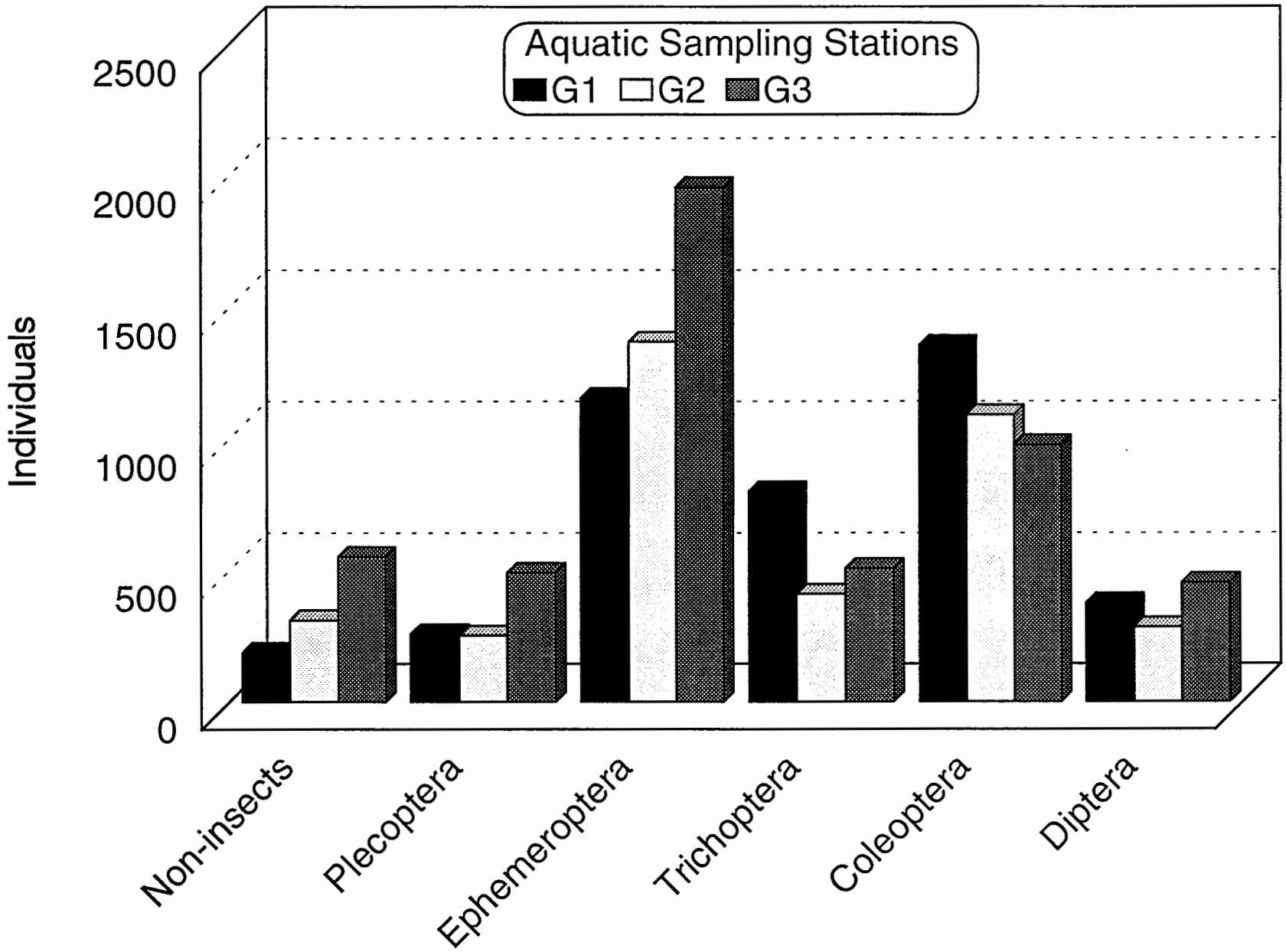



Fig. 19. 1994 Guaje Canyon aquatic invertebrate groups.

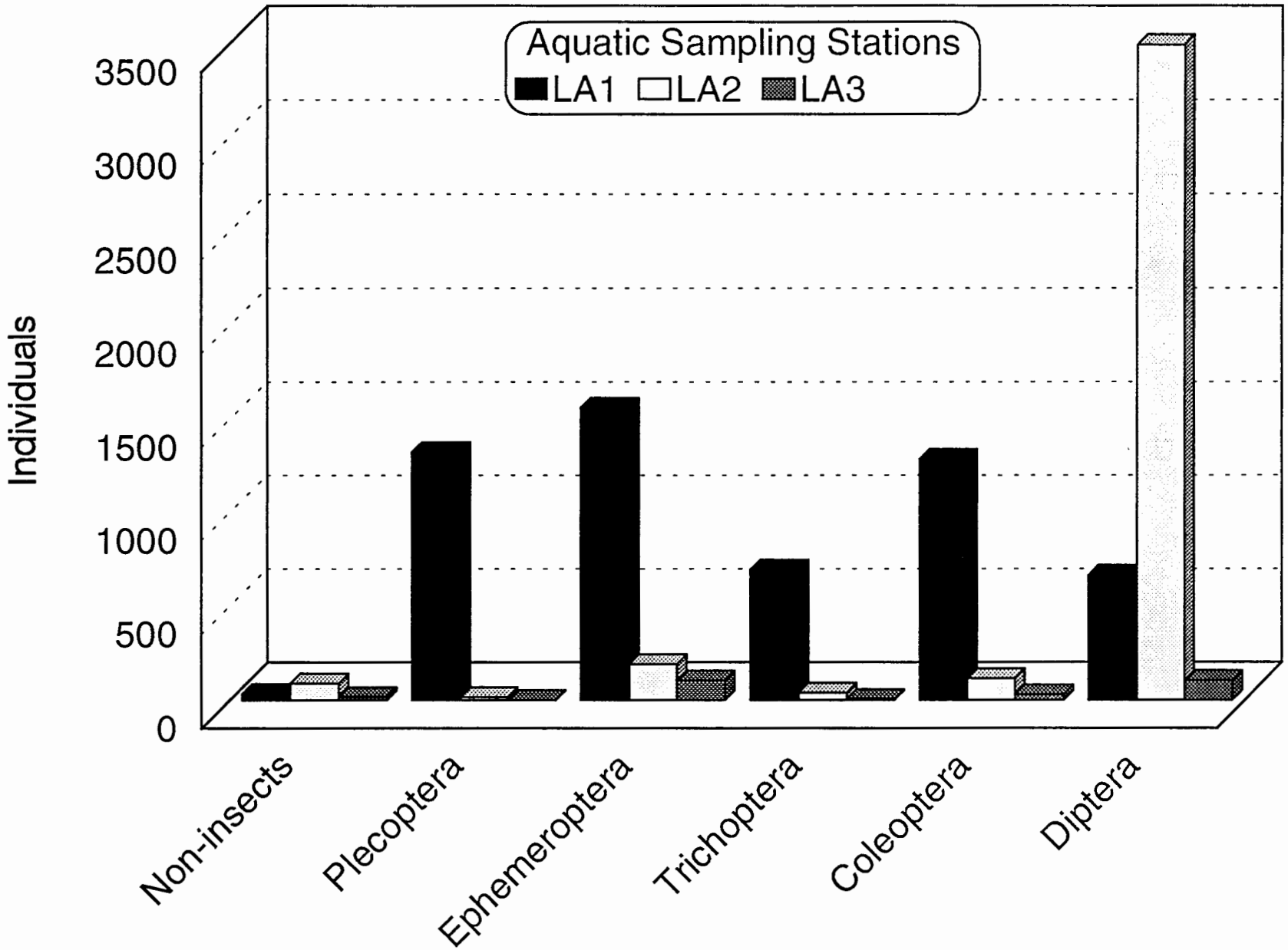



Fig. 20. 1994 Los Alamos Canyon aquatic invertebrate groups.

20), flies that tend to be rapid colonizers and indicators of previous disturbance. LA3 had the lowest numbers of collected macroinvertebrates in all categories during both sampling seasons.

### 4.3.3 Rapid Biological Protocol Metrics

Several RBP metrics require analysis of functional feeding groups. Appendix E lists these groups for the aquatic insects collected in Guaje and Los Alamos Canyons. Several taxa have more than one feeding group, reflecting diversity of species or feeding behaviors within the taxon. The primary feeding group is listed first and is used to analyze community complexity. Only aquatic insects are used in functional feeding group comparisons, but non-insects are included in the computation of other metrics (taxa richness, percentage contribution of dominant taxon, and community loss index).

A station completely dominated by a single functional feeding group, as LA2 was dominated by collector-filterers in 1994 (Fig. 22), has a poorly developed community structure and usually indicates a high level of disturbance. In 1994, over 99% of the insects collected at LA3 were from only two groups, another example of a depauperate community. Collector-gatherers were the most numerous functional feeding group at the other four stations, but not to the exclusion of other groups (Figs. 21 and 22). These last stations (G1, G2, G3, and LA1) have comparatively balanced communities, denoting an absence of recent disturbance.

Table 9 lists the RBP III biological condition scores and totals by month (More complete data is included in Appendix G). The RBP metrics are comparative measures requiring two sampling areas: a reference site (Guaje) and a study site (Los Alamos). The scores range from 0 to 6, with 0 indicative of severe impairment at the Los Alamos station and 6 indicative of an unimpaired condition at the Los Alamos station. The biological condition score is intended to reflect aquatic community health, with total elimination of aquatic life as the most degraded condition. Therefore, when drought in Los Alamos

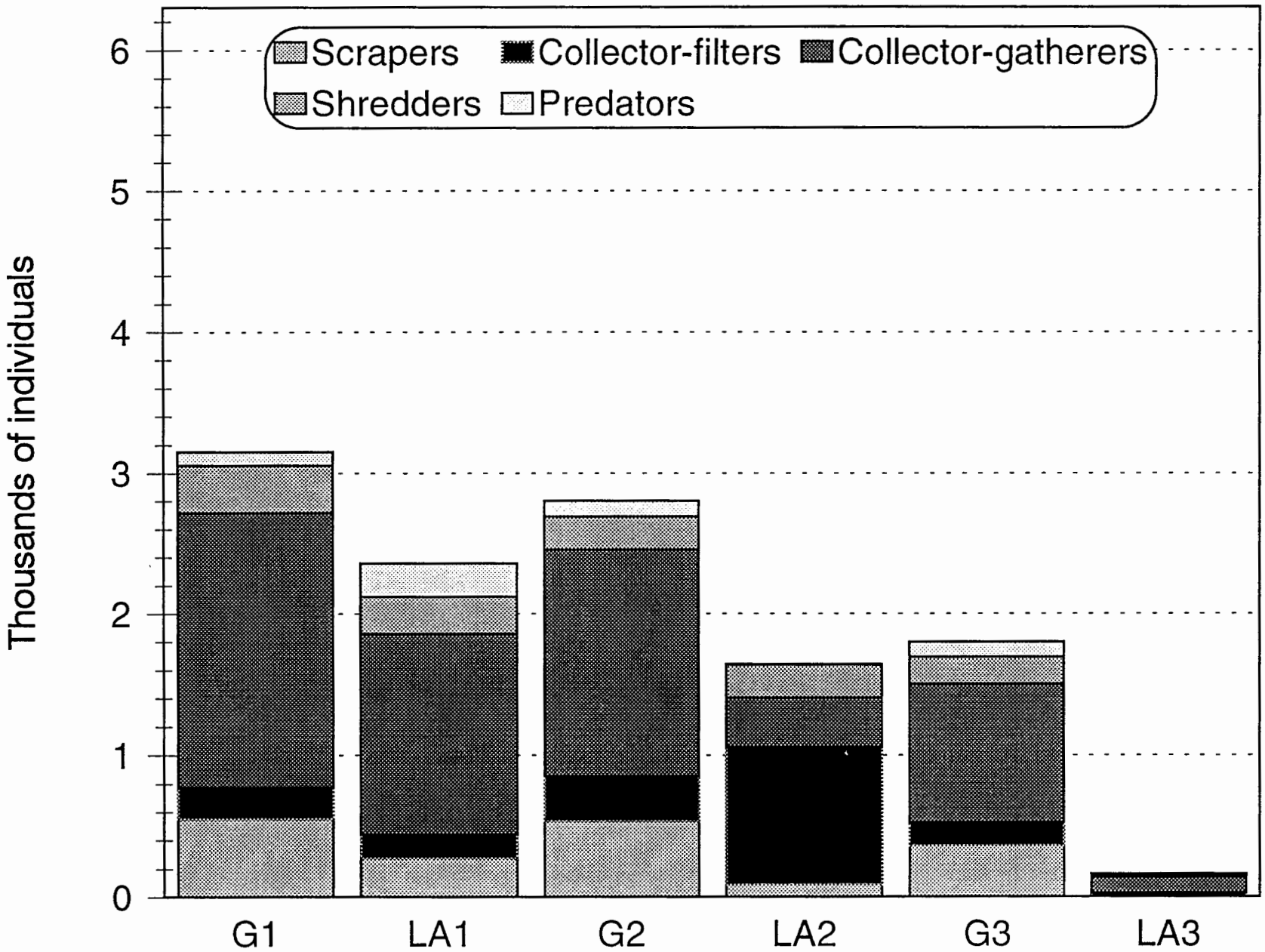



Fig. 21. 1993 Functional feeding groups by sampling station.

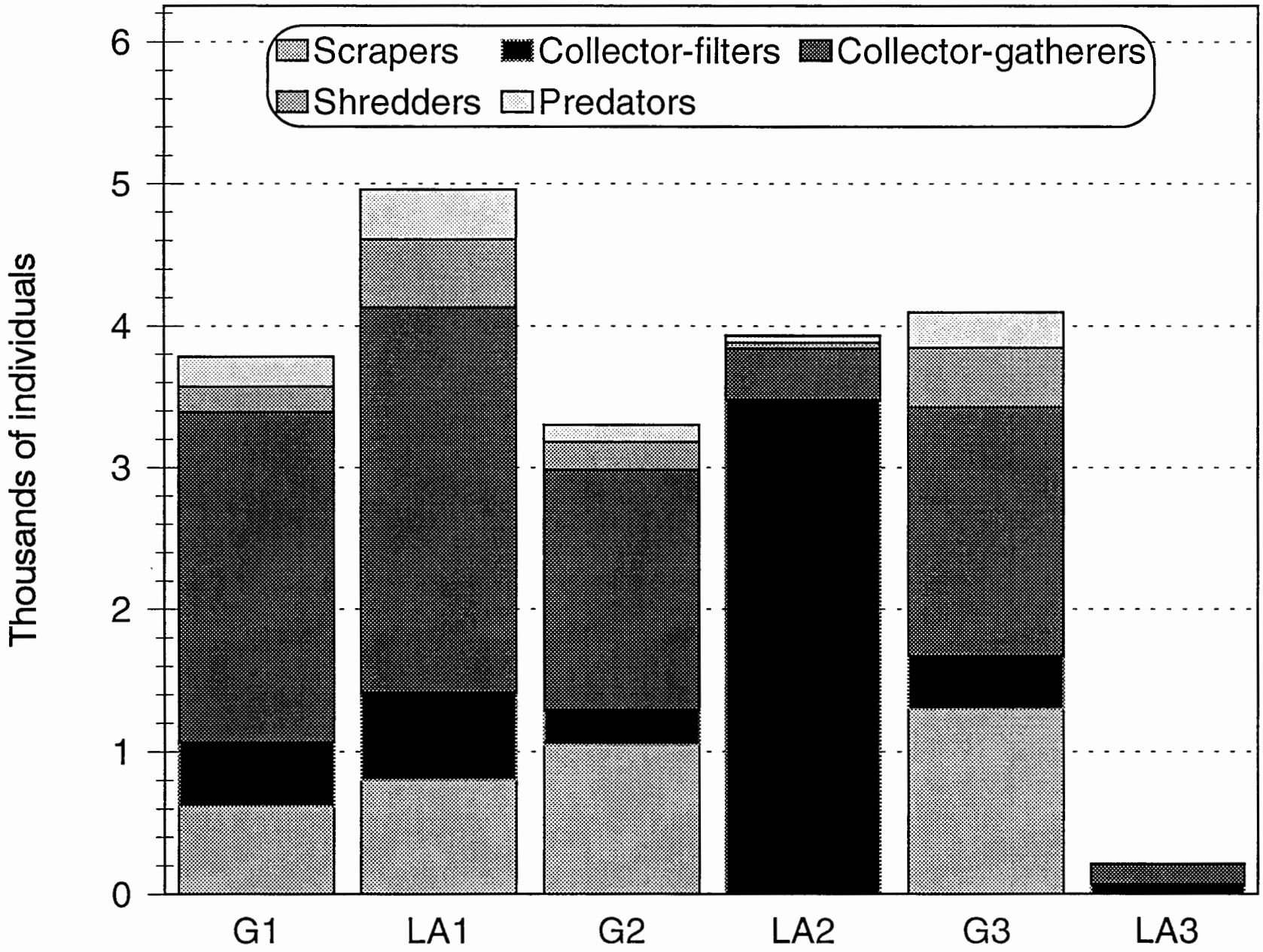



Fig. 22. 1994 Functional feeding groups by sampling station.

**Table 9. Monthly Biological Condition Scores for the Los Alamos Canyon Sampling Stations**

| Date - Station | Metric 1 | Metric 2 | Metric 3 | Metric 4 | Metric 5 | Metric 6 | Metric 7 | Total score |
|---|---|---|---|---|---|---|---|---|
| 5/93-1 | 6 | 6 | 6 | 6 | 4 | 0 | 4 | 32 |
| 5/93-2 | 4 | 2 | 0 | 2 | 0 | 2 | 4 | 14 |
| 5/93-3 | 0 | 2 | 0 | 2 | 2 | 0 | 2 | 8 |
| 6/93-1 | 4 | 4 | 0 | 2 | 2 | 6 | 4 | 22 |
| 6/93-2 | 6 | 6 | 0 | 6 | 2 | 6 | 4 | 30 |
| 6/93-3 | 4 | 6 | 6 | 4 | 0 | 2 | 4 | 26 |
| 7/93-1 | 4 | 4 | 6 | 6 | 6 | 4 | 4 | 34 |
| 7/93-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/93-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8/93-1 | 4 | 6 | 6 | 0 | 2 | 0 | 4 | 22 |
| 8/93-2 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 6 |
| 8/93-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9/93-1 | 6 | 6 | 4 | 4 | 2 | 4 | 6 | 32 |
| 9/93-2 | 0 | 2 | 0 | 0 | 2 | 0 | 2 | 6 |
| 9/93-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10/93-1 | 6 | 6 | 4 | 6 | 4 | 6 | 4 | 36 |
| 10/93-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10/93-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/94-1 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 40 |
| 5/94-2 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 4 |
| 5/94-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/94-1 | 6 | 6 | 2 | 6 | 4 | 0 | 4 | 28 |
| 6/94-2 | 2 | 2 | 0 | 4 | 0 | 0 | 2 | 10 |
| 6/94-3 | 0 | 4 | 0 | 0 | 0 | 0 | 2 | 6 |
| 7/94-1 | 6 | 2 | 6 | 6 | 4 | 6 | 6 | 36 |
| 7/94-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7/94-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8/94-1 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 36 |
| 8/94-2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| 8/94-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9/94-1 | 6 | 4 | 2 | 6 | 2 | 2 | 6 | 28 |
| 9/94-2 | 4 | 4 | 0 | 2 | 4 | 0 | 4 | 18 |
| 9/94-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10/94-1 | 6 | 6 | 0 | 6 | 4 | 4 | 6 | 32 |
| 10/94-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10/94-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Canyon eliminated a sampling station and its resident macroinvertebrate community, each metric was assigned a zero.

Averages of the biological condition scores for each station throughout the sampling seasons show a clear pattern of increasing downstream impairment in Los Alamos Canyon (Table 10). This pattern persisted throughout the two-year sampling period, with little change.

**Table 10. Summary of Total RBP Biological Condition Scores for Los Alamos Canyon**

| Station, Year | Lowest Total Monthly Score (42 possible) | Highest Total Monthly Score (42 possible) | Percent of Possible Total (216) for All Months | Biological Condition Category |
|---|---|---|---|---|
| **LA1, 93** | 22 | 36 | 82 | Nonimpaired |
| **LA2, 93** | 0 | 30 | 26 | Moderately impaired |
| **LA3, 93** | 0 | 26 | 16 | Severely impaired |
| **LA1, 94** | 22 | 34 | 79 | Slightly impaired |
| **LA2, 94** | 0 | 14 | 12 | Severely impaired |
| **LA3, 94** | 0 | 6 | 3 | Severely impaired |
| **LA1, 93 & 94** | 22 | 34 | 81 | Nonimpaired |
| **LA2, 93 & 94** | 0 | 30 | 19 | Severely impaired |
| **LA3, 93 & 94** | 0 | 26 | 9 | Severely impaired |

The sampling season was drier in 1994 than in 1993, due in large part to a small snowpack. In comparing the two years, the total biological condition scores fell at all Los Alamos sampling stations, with the greatest reduction occurring downstream: LA1 lowered by 4%, LA2 by 14%, and LA3 by 16%. Thus, the aforementioned effects of the reservoir dam in Los Alamos Canyon on downstream sites appear to be magnified in dry years.

In 1993, the total biological condition score for LA1 fell between the range of slight impairment and nonimpairment. This author assigned it to the nonimpaired category because many of the individual RBP scores throughout the year exceeded the scores of its

Guaje reference site. The lowest scores recorded at LA1 in 1993 were in metrics 4 (EPT abundances), 5 (percent contribution of dominant taxon), and 6 (EPT index). In 1994, LA1 was in the upper range of slight impairment, its lowest scores recorded in metrics 3 (ratio scrapers to filtering-collectors), 4 (number of EPT individuals), and 5 (percent contribution of dominant taxon). The two-year average at LA1 again fell between nonimpairment and slight impairment, and I assigned LA1 to the nonimpaired category.

In 1993, LA2 scored in the lower range of moderate impairment, each metric receiving a score of zero at least once. In 1994, the station was evaluated as severely impaired; and each metric again received a zero score at least once. The two-year average places LA2 between the moderate and severe impairment categories. I assigned it to the severe impairment category because the streambed was completely dry in 4 of the 12 sampling months.

The streambed at LA3 was too dry to sample in three of the six sampling months in 1993 and in four of the six sampling months in 1994. LA3 received a total biological condition score in the high range of severe impairment in 1993 and in the mid-range of severe impairment in 1994. Even during the months when the stream flowed at the lowest station, only two metrics received a score higher than zero during 1994 (in May, the Community Tolerance Quotient was 4 and the Community Loss Index was 2). Although the two-year average clearly places LA3 in the severe impairment rating, it probably could support a diverse macroinvertebrate community if the hydrology there had more consistent flows and water temperatures.

## 5 CONCLUSIONS

All monthly pH measurements taken during 1993 and 1994 were within the ranges currently defined for high quality coldwater fisheries (State of New Mexico 1995) and the excellent range as defined by Batelle (Batelle 1972). No monthly conductivity measurements exceeded the upper permissable limit for New Mexico high-quality

coldwater fisheries and all fell within the excellent range as defined by Batelle. Dissolved oxygen levels were usually in the excellent range (Batelle 1972) and were never less than "fair". The temperatures at the two lower Los Alamos stations were significantly elevated due to the spillway nature of the reservoir dam. The Los Alamos dam also accounted for stream drought at LA2 (four of twelve sampling months) and LA3 (seven of twelve sampling months), which eliminated their resident macroinvertebrate communities. This artificial seasonal drought is undoubtedly the most significant impact to these downstream communities.

The data show that aquatic communities are more diverse and richer in Guaje than Los Alamos, justifying EST's use of the Guaje stream as a control in RBP III analysis. The data also suggest that within each canyon, diversity and density decrease with distance downstream. However, this trend is not as pronounced since the middle station in Guaje had higher diversities and densities than the downstream station. The EPA sanctioned RBP III metrics rates water quality as nonimpaired at LA1, severely impaired at LA2, and severely impaired at LA3.

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# APPENDIX A

## Habitat Assessment Field Date Sheet

## Riffle/Run Prevalence

| Habitat Parameter | Category | | | |
|---|---|---|---|---|
| | Optimal | Sub-Optimal | Marginal | Poor |
| 1. Bottom substrate-instream cover (a) | Greater than 50% mix of rubble, gravel, submerged logs, undercut banks, or other stable habitat. 16–20 | 30–50% mix of rubble, gravel, or other stable habitat. Adequate habitat. 11–15 | 10–30% mix of rubble, gravel, or other stable habitat. Habitat availability less than desirable. 6–10 | Less than 10% rubble, gravel, or other stable habitat. Lack of habitat is obvious. 0–5 |
| 2. Embeddedness (b) | 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 |
| 3. >0.15 cms (5 cfs)— Flow at reg. low | Cold >0.05 cms (2 cfs) Warm >0.15 cms (5 cfs) 16–20 | 0.03–0.05 cms (1–2 cfs) 0.05–0.15 cms (2–5 cfs) 11–15 | 0.01–0.03 cms (.5–1 cfs) 0.03–0.05 cms (1–cfs) 6–10 | <0.01 cms (.5 cfs) <0.03 cms (1 cfs) 0–5 |
| OR >0.15 cms (5 cfs)— velocity-depth | Slow (<0.3 m s), deep (>0.5 m); slow, shallow (<0.5 m); fast (>0.3 m/s), deep; fast, shallow habitats all present. 16–20 | Only 3 of the 4 habitat categories present (missing riffles or runs receive lower score than missing pools). 11–15 | Only 2 of the 4 habitat categories present (missing riffles or runs receive lower score). 6–10 | Dominated by 1 velocity depth category (usually pools). 0–5 |
| 4. Canopy cover (shading) (c) (d) (g) | A mixture of conditions where some areas of water surface fully exposed to sunlight, and other receiving various degrees of filtered light. 16–20 | Covered by sparse canopy; entire water surface receiving filtered light. 11–15 | Completely covered by dense canopy; water surface completely shaded OR nearly full sunlight reaching water surface. Shading limited to <3 hours per day. 6–10 | Lack of canopy, full sunlight reaching water surface. 0–5 |
| 5. Channel alteration (a) | Little or no enlargement of islands or point bars, and/or no channelization. 12–15 | Some new increase in bar formation, mostly from coarse gravel; and or some channelization present. 8–11 | Moderate deposition of new gravel, coarse sand on old and new bars; and or embankments on both banks. 4–7 | Heavy deposits of fine material, increased bar development; and or extensive channelization. 0–3 |
| 6. Bottom scouring and deposition (a) | Less than 5% of the bottom affected by scouring and or deposition. 12–15 | 5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8–11 | 30–50% affected. Deposits and or scour at obstructions, constrictions, and bends. Filling of pools prevalent. 4–7 | More than 50% of the bottom changing frequently. Pools almost absent due to deposition. Only large rocks in riffle exposed. 0–3 |
| 7. Pool riffle, run-bend ratio (a) (distance between riffles divided by stream width) | Ratio: 5–7. Variety of habitat. Repeat pattern of sequence relatively frequent. 12–15 | 7–15. Infrequent repeat pattern. Variety of macrohabitat less than optimal. 8–11 | 15–25. Occasional riffle or bend. Bottom contours provide some habitat. 4–7 | >25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 0–3 |
| 8. Lower bank channel capacity (b) | Overbank (lower) flows rare. Lower bank W/D ratio <7. (Channel width divided by depth or height of lower bank.) 12–15 | Overbank (lower) flows occasional. W/D ratio 8–15. 8–11 | Overbank (lower) flows common. W/D ratio 15–25. 4–7 | Peak flows not contained or contained through channelization. W/D ratio >25. 0–3 |

| Habitat Parameter | Category: Optimal | Sub-Optimal | Marginal | Poor |
|---|---|---|---|---|
| 9. Upper bank stability (a) | Upper bank stable. No evidence of erosion or bank failure. Side slopes generally <30°. Little potential for future problems. 9–10 | Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40° on one bank. Slight potential in extreme floods. 6–8 | Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60° on some banks. High erosion potential during extreme high flow. 3–5 | Unstable. Many eroded areas. "Raw" areas frequent along straight sections and bends. Side slopes >60° common. 0–2 |
| 10. Bank vegetative protection (d) | Over 90% of the streambank surfaces covered by vegetation. 9–10 | 70–89% of the streambank surfaces covered by vegetation. 6–8 | 50–79% of the streambank surfaces covered by vegetation. 3–5 | Less than 50% of the streambank surfaces covered by vegetation. 0–2 |
| OR Grazing or other disruptive pressure (b) | Vegetative disruption minimal or not evident. Almost all potential plant biomass at present stage of development remains. 9–10 | Disruption evident but not affecting community vigor. Vegetative use is moderate, and at least one-half of the potential plant biomass remains. 6–8 | Disruption obvious; some patches of bare soil or closely cropped vegetation present. Less than one-half of the potential plant biomass remains. 3–5 | Disruption of streambank vegetation is very high. Vegetation has been removed to 2 inches or less in average stubble height. 0–2 |
| 11. Streamside cover (b) | Dominant vegetation is shrub. 9–10 | Dominant vegetation is of tree form. 6–8 | Dominant vegetation is grass or forbes. 3–5 | Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 0–2 |
| 12. Riparian vegetative zone width (least buffered side) (e) (f) (g) | >18 meters. 9–10 | Between 12 and 18 meters. 6–8 | Between 6 and 12 meters. 3–5 | <6 meters. 0–2 |
| Column Totals | ___ | ___ | ___ | ___ |

_____ Score _____

(a) From Ball 1982.
(b) From Platts et al. 1983.
(c) From EPA 1983.
(d) From Hamilton and Bergersen 1984.
(e) From Lafferty 1987.
(f) From Schueler 1987.
(g) From Bartholow 1989.

# APPENDIX B

**Tolerance Quotients for the Aquatic Invertebrates of Guaje and Los Alamos Canyons**

(modified from Winget and Mangum 1989)

| Order | Family | Genus (species) | Tolerance quotient |
|---|---|---|---|
| **Plecoptera** | Chloroperlidae | | 24 |
| | Nemouridae | Amphinemura | 6 |
| | Nemouridae | Malenka | 36 |
| | Nemouridae | Podmosta | 12 |
| | Nemouridae | Zapada | 16 |
| | Perlidae | Hesperoperla (pacifica) | 18 |
| | Perlodidae | Cultus (aestivalis) | 12 |
| | Perlodidae | Isoperla | 24 |
| | Perlodidae | Kogotus (modestus) | 18 |
| | Pteronarcyidae | Pteronarcella (badia) | 24 |
| | Pteronarcyidae | Pteronarcys | 21 |
| **Ephemeroptera** | Baetidae | Baetis | 72 |
| | Baetidae | Callibaetis | 72 |
| | Ephemerellidae | Drunella (coloradensis) | 18 |
| | Ephemerellidae | Drunella (doddsi) | 4 |
| | Ephemerellidae | Drunella (grandis) | 24 |
| | Ephemerellidae | Ephemerella (inermis) | 48 |
| | Ephemerellidae | Ephemerella (infrequens) | 48 |
| | Heptageniidae | Cinygmula | 21 |
| | Heptageniidae | Epeorus | 21 |
| | Leptophlebiidae | Paraleptophlebia | 24 |
| | Siphlonuridae | Ameletus | 48 |
| | Siphlonuridae | Siphlonurus | 72 |
| | Tricorythidae | Tricorythodes | 108 |
| **Odonata** | Aeshnidae | | 72 |
| **Hemiptera** | Gerridae | Gerris | 72 |
| | Veliidae | Microvelia | 72 |
| **Trichoptera** | Brachycentridae | Micrasema | 24 |
| | Glossosomatidae | | 32 |
| | Glossosomatidae | Glossosoma | 24 |
| | Hydropsychidae | Arctopsyche | 18 |
| | Hydropsychidae | Cheumatopsyche | 108 |
| | Hydropsychidae | Hydropsyche | 108 |
| | Lepidostomatidae | Lepidostoma | 18 |
| | Leptoceridae | | 54 |

| Order | Family | Genus (species) | Tolerance quotient |
|---|---|---|---|
| | Limnephilidae | Hesperophylax | 108 |
| | Limnephilidae | Limnephilus | 108 |
| | Limnephilidae | Oligophlebodes | 24 |
| | Philopotamidae | Dolophilodes | 24 |
| | Rhyacophilidae | Rhyacophila | 18 |
| **Lepidoptera** | Pyralidae | | 72 |
| **Coleoptera** | Amphizoidae | Amphizoa | 24 |
| | Dytiscidae | Agabus | 72 |
| | Dytiscidae adults | Laccophilus | 72 |
| | Dytiscidae adults | | 72 |
| | Elmidae | all genera found | 108 |
| | Elmidae adults | all genera found | 108 |
| | Hydrophilidae | Ametor | 72 |
| | Hydrophilidae adults | Ametor | 72 |
| | Hydrophilidae | Helophorus | 72 |
| | Hydrophilidae | Hydrobius | 72 |
| | Hydrophilidae | | 72 |
| **Diptera** | Ceratopogonidae | | 108 |
| | Chironomidae | all taxa found | 108 |
| | Dixidae | Dixa | 108 |
| | Dixidae | Dixa A | 108 |
| | Empididae | | 108 |
| | Empididae | Hemerodromia | 108 |
| | Muscidae | Limnophora | 108 |
| | Psychodidae | Maruina | 36 |
| | Psychodidae | Pericoma | 36 |
| | Simulidae | | 108 |
| | Stratiomyiidae | | 108 |
| | Tipulidae | Antocha | 24 |
| | | Dicranota | 24 |
| | | Tipula | 36 |
| | | Tipula B | 36 |

**Non-Insect Macroinvertebrates of Guaje Canyon, 1993 and 1994**

| Phylum | Class, etc. | Tolerance Quotient |
|---|---|---|
| **Annelida** | Lumbriculidae | 108 |
| **Mollusca** | Gastropoda | 108 |
| **Platyhelminthes** | Turbellaria | 108 |

# APPENDIX C

**Aquatic Macroinvertebrate Taxa of Guaje Canyon, 1993 and 1994**

All specimens are larval unless otherwise noted.

| Order | Family | Genus (species) | Station |
|---|---|---|---|
| **Plecoptera** | Chloroperlidae | | 1, 2, 3 |
| | Nemouridae | Amphinemura | 1, 2, 3 |
| | Nemouridae | Malenka | 1, 3 |
| | Nemouridae | Podmosta (delicatula) | 3 |
| | Perlodidae | Cultus (aestivalis) | 1, 2, 3 |
| | Perlodidae | Isoperla | 1, 2, 3 |
| | Perlodidae | Kogotus (modestus) | 1, 2, 3 |
| | Pteronarcyidae | Pteronarcella (badia) | 1, 2, 3 |
| | Pteronarcyidae | Pteronarcys | 1, 2, 3 |
| **Ephemeroptera** | Baetidae | Baetis | 1, 2, 3 |
| | Baetidae | Callibaetis | 3 |
| | Ephemerellidae | Drunella (coloradensis) | 1, 2, 3 |
| | Ephemerellidae | Drunella (doddsi) | 1, 2, 3 |
| | Ephemerellidae | Drunella (grandis grandis) | 3 |
| | Ephemerellidae | Ephemerella (inermis) | 1, 2, 3 |
| | Ephemerellidae | Ephemerella (infrequens) | 1, 2, 3 |
| | Heptageniidae | Cinygmula | 1, 2, 3 |
| | Heptageniidae | Epeorus (longimanus) | 1, 2, 3 |
| | Leptophlebiidae | Paraleptophlebia | 3 |
| | Siphlonuridae | Ameletus | 2, 3 |
| | Tricorythidae | Tricorythodes (minutus) | 1 |
| **Hemiptera** | Gerridae | Gerris | 2, 3 |
| | Veliidae | Microvelia | 3 |
| **Trichoptera** | Brachycentridae | Micrasema | 1, 2, 3 |
| | Brachycentridae pupae | Micrasema | 2 |
| | Glossosomatidae | Agapetus | 2, 3 |
| | Glossosomatidae | Glossosoma | 1, 2, 3 |
| | Hydropsychidae | Arctopsyche (grandis) | 1, 2, 3 |
| | Hydropsychidae | Cheumatopsyche | 2 |
| | Hydropsychidae | Hydropsyche | 1, 2, 3 |
| | Lepidostomatidae | Lepidostoma | 1, 2, 3 |
| | Leptoceridae | Oecetis? | 1, 2, 3 |
| | Limnephilidae | Hesperophylax | 3 |
| | Limnephilidae pupae | Hesperophylax | 3 |
| | Limnephilidae | Limnephilus | 2, 3 |
| | Limnephilidae | Oligophlebodes | 1, 2, 3 |
| | Limnephilidae pupae | Oligophlebodes | 2, 3 |
| | Odontoceridae | Namamyia | 1 |

| Order | Family | Genus (species) | Station |
|---|---|---|---|
| | Philopotamididae | Dolophilodes | 1, 2, 3 |
| | Rhyacophilidae | Rhyacophila (brunnea complex) | 1, 2, 3 |
| | Rhyacophilidae pupae | Rhyacophila (brunnea complex) | 1, 2, 3 |
| **Lepidoptera** | Noctuidae | | 2 |
| | Pyralidae | | 3 |
| **Coleoptera** | Amphizoidae | Amphizoa | 3 |
| | Curculionidae adult | | 3 |
| | Dryopidae adult | Helichus | 1, 2, 3 |
| | Dytiscidae adult | Hydaticus | 2 |
| | Elmidae | Heterlimnius (corpulentis) | 1, 2, 3 |
| | Elmidae adults | Heterlimnius (corpulentis) | 1, 2, 3 |
| | Elmidae | Narpus | 1, 2, 3 |
| | Elmidae adults | Narpus | 1, 2, 3 |
| | Elmidae | Zaitzevia | 1, 2, 3 |
| | Elmidae adults | Zaitzevia | 1, 2, 3 |
| | Helodidae | Prionocyphon | 3 |
| | Hydrophilidae | Ametor | 1, 2, 3 |
| | Hydrophilidae adult | Ametor | 2, 3 |
| | Hydrophilidae adult | Enochrus? | 3 |
| | Hydrophilidae | Hydrochus | 2 |
| | Psephenidae | | 1 |
| **Diptera** | Chironomidae | A | 1, 2, 3 |
| | Chironomidae | B | 1, 2 |
| | Chironomidae | C | 1, 2 |
| | Chironomidae | E | 1, 2, 3 |
| | Chironomidae | F | 1, 2, 3 |
| | Chironomidae | F | 1 |
| | Chironomidae | G | 1, 2, 3 |
| | Chironomidae pupae | G | 1 |
| | Chironomidae pupae | | 1, 2, 3 |
| | Chironomidae pupae | PA | 3 |
| | Dixidae | Dixa | 1, 2, 3 |
| | Dixidae | Dixa A | 2, 3 |
| | Empididae | Chelifera | 2 |
| | Empididae | Oreogeton | 1, 2 |
| | Empididae pupae | Hemerodromia | 3 |
| | Psychodidae | Maruina | 1 |
| | Psychodidae | Pericoma | 1, 2, 3 |
| | Ptychopteridae | Ptychoptera | 3 |
| | Simulidae | | 1, 2, 3 |

| Order | Family | Genus (species) | Station |
|---|---|---|---|
| | Simulidae pupae | | 1, 2, 3 |
| | Simulidae pupae | PA | 2 |
| | Stratiomyidae | Odontomyia | 2 |
| | Stratiomyidae | | 1 |
| | Tipulidae | Antocha | 1, 2, 3 |
| | Tipulidae | Dicranota | 1, 2, 3 |
| | Tipulidae | Tipula | 1, 2, 3 |
| | Tipulidae | Tipula B | 1, 2, 3 |

**Non-Insect Macroinvertebrates of Guaje Canyon, 1993 and 1994**

| Phylum | Class, etc. | Station |
|---|---|---|
| **Annelida** | Lumbriculidae | 1, 2, 3 |
| **Annelida** | Naididae | 1, 3 |
| **Arthropoda** | Arachnoidea, Hydracarina | 1, 2, 3 |
| **Mollusca** | Gastropoda A | 2, 3 |
| **Mollusca** | Gastropoda, Gyralus parvus | 3 |
| **Mollusca** | Sphaeriidae, Pisidium casertanum | 1, 2, 3 |
| **Nematoda** | | 1, 2, 3 |
| **Nematomorpha** | Gordioidea, Gordiidae, Gordius | 1 |
| **Nematomorpha** | | 1, 2 |
| **Platyhelminthes** | Turbellaria | 1, 2, 3 |

# APPENDIX D

## Aquatic Macroinvertebrate Taxa of Los Alamos Canyon, 1993 and 1994

All specimens are larval unless otherwise noted.

| Order | Family | Genus (species) | Station |
|---|---|---|---|
| **Plecoptera** | Chloroperlidae | | 1, 2 |
| | Nemouridae | Amphinemura | 1, 2, 3 |
| | Nemouridae | Zapada (frigida) | 1 |
| | Perlidae | Hesperoperla (pacifica) | 1 |
| | Perlodidae | Cultus (aestivalis) | 1 |
| | Perlodidae | Kogotus (modestus) | 1 |
| **Ephemeroptera** | Baetidae | Baetis | 1, 2, 3 |
| | Baetidae | Callibaetis | 1, 3 |
| | Ephemerellidae | Drunella (coloradensis) | 2 |
| | Ephemerellidae | Ephemerella (inermis) | 1 |
| | Heptageniidae | Cinygmula | 1, 2, 3 |
| | Heptageniidae | Epeorus (longimanus) | 1, 2, 3 |
| | Leptophlebiidae | Paraleptophlebia | 1, 2 |
| | Siphlonuridae | Ameletus | 1, 2, 3 |
| | Siphlonuridae | Siphlonurus | 2, 3 |
| **Odonata** | Aeshnidae | Boyeria | 2, 3 |
| **Hemiptera** | Gerridae | Gerris | 2 |
| | Veliidae | Microvelia | 1, 2 |
| **Trichoptera** | Brachycentridae | Micrasema | 1, 2 |
| | Glossosomatidae | Glossosoma | 1 |
| | Hydropsychidae | Arctopsyche (grandis) | 1, 2 |
| | Hydropsychidae | Hydropsyche | 1 |
| | Lepidostomatidae | Lepidostoma | 1 |
| | Leptoceridae | Oecetis? | 1 |
| | Limnephilidae | Hesperophylax | 1, 2, 3 |
| | Limnephilidae | Limnephilus | 1, 2 |
| | Limnephilidae | Oligophlebodes | 1 |
| | Limnephilidae | | 1, 2, 3 |
| | Philopotamidae | Dolophilodes | 1 |
| | Rhyacophilidae | Rhyacophila (brunnea complex) | 1, 2 |
| | Rhyacophilidae pupae | Rhyacophila (brunnea complex) | 1 |
| **Lepidoptera** | Noctuidae | | 2 |
| **Coleoptera** | Dytiscidae | Agabus | 2 |
| | Dytiscidae | Copelatus? | 1 |
| | Dytiscidae adults | | 2, 3 |
| | Dryopidae adults | Helichus | 1, 3 |

| Order | Family | Genus (species) | Station |
|---|---|---|---|
| | Elmidae | Heterlimnius (corpulentus) | 1, 2 |
| | Elmidae adults | Heterlimnius (corpulentus) | 1, 2 |
| | Elmidae | Narpus | 1, 2, 3 |
| | Elmidae adults | Narpus | 1, 3 |
| | Elmidae | Zaitzevia | 1, 2 |
| | Elmidae adults | Zaitzevia | 1, 2, 3 |
| | Hydrophilidae | Ametor | 1 |
| | Hydrophilidae | Helophorus | 1 |
| | Hydrophilidae | Hydrobius | 1 |
| **Diptera** | Ceratopogonidae | Bezzia | 1 |
| | Chironomidae | A | 1, 2, 3 |
| | Chironomidae pupae | A | 1 |
| | Chironomidae | B | 1, 2, 3 |
| | Chironomidae | C | 1, 2, 3 |
| | Chironomidae | E | 1 |
| | Chironomidae | F | 1 |
| | Chironomidae pupae | F | 1 |
| | Chironomidae | G | 1 |
| | Chironomidae | H | 3 |
| | Chironomidae pupae | | 1, 2, 3 |
| | Dixidae | Dixa | 1, 2 |
| | Empididae | Oreogeton | 1 |
| | Muscidae | Limnophora | 3 |
| | Psychodidae | Maruina | 1 |
| | Psychodidae | Pericoma | 1, 3 |
| | Simulidae | | 1, 2, 3 |
| | Simulidae | pupae | 1, 2 |
| | Tipulidae | Antocha | 1 |
| | Tipulidae | Dicranota | 1, 2, 3 |
| | Tipulidae | Tipula | 1 |
| | Tipulidae | Tipula B | 1 |

**Non-Insect Macroinvertebrates of Los Alamos Canyon, 1993 and 1994**

| Phylum | Class, etc. | Station |
|---|---|---|
| **Annelida** | Lumbriculidae | 1, 2, 3 |
| **Annelida** | Naididae | 1, 2 |
| **Arthropoda** | Arachnoidea, Hydracarina | 1 |
| **Mollusca** | Gastropoda A | 1 |
| **Mollusca** | Sphaeriidae, Pisidium casertanum | 1 |
| **Nematomorpha** | | 1, 2, 3 |
| **Nematomorpha** | Gordiidae, Gordius | 1, 2 |

# APPENDIX E

**Aquatic Insects Collected**
**from Los Alamos County and Adjacent Watersheds**
(* = life stage not known, all specimens are larval unless otherwise noted)

| ORDER | FAMILY | GENUS | SPECIES | LOCA. . ** |
|---|---|---|---|---|
| Plecoptera (Stoneflies) | Capniidae | *Capnia* | | F |
| | Capniidae | | | F |
| | Chloroperlidae | *Chloroperla* | | F |
| | Chloroperlidae | *Paraperla* | *frontalis* | G,L |
| | Chloroperlidae | *Paraperla* | | F |
| | Chloroperlidae | *Sweltsa* | *coloradensis* | F |
| | Chloroperlidae | *Sweltsa a* | *lamba* | F |
| | Chloroperlidae | *Sweltsa* | | F,G |
| | Chloroperlidae | *Suwallia* | | G,L |
| | Chloroperlidae | | | F,G,L,SG |
| | Leuctridae | *Paraleuctra* | *vershina* | F |
| | Nemouridae | *Amphinemura* | | F |
| | Nemouridae | *Amphinemura* | *banksi* | F,G,L,PW,SG |
| | Nemouridae | *Malenka* | *coloradensis* | F |
| | Nemouridae | *Malenka* | | G,L |
| | Nemouridae | *Nemoura* | | F |
| | Nemouridae | *Zapada* | *cinctipes* | F |
| | Perlidae | *Acroneuria* | *abnormis* | F |
| | Perlidae | *Hesperoperla* | *pacifica* | F,L,SG |
| | Perlodidae | *Cultus* | | G |
| | Perlodidae | *Isoperla* | *fulva* | F |
| | Perlodidae | *Isoperla* | *quinquepunctata* | F |
| | Perlodidae | *Isoperla* | | F,G,L,S |
| | Perlodidae | *Kogotus* | *modestus* | G,L |
| | Perlodidae | *Skwala* | *parallela* | G |
| | Pteronarcyidae | *Pteronarcella* | *badia* | F,G |
| | Pteronarcyidae | *Pteronarcella* | | F |
| | Pteronarcyidae | *Pteronarcys* | *californica* | G |
| | Taeniopterygidae | *Taenionema* | | F |
| Ephemeroptera (Mayflies) | Baetidae | *Baetis* | *bicaudata* | F |

| | | | | |
|---|---|---|---|---|
| | Baetidae | *Baetis* | *insignificans* | F |
| | Baetidae | *Baetis* | *tricaudatus* | A,D,F,G,L, PS,S |
| | Baetidae | *Baetis* | | A,C,F,G,H,L, PW,PS,S,SG, 128 |
| | Baetidae | *Callibaetis* | | G,L,PW,PS,S, 48 |
| | Ephemerellidae | *Drunella* | *coloradensis* | G,L |
| | Ephemerellidae | *Drunella* | *doddsi* | F,G |
| | Ephemerellidae | *Drunella* | *grandis* | F,G |
| | Ephemerellidae | *Ephemerella* | *grandis grandis* | F |
| | Ephemerellidae | *Ephemerella* | *inermis* | F,G,L |
| | Ephemerellidae | *Ephemerella* | *infrequens* | F,G |
| | Ephemerellidae | *Ephemerella* | | F |
| | Heptageniidae | *Cinygmula* | | F,G,L |
| | Heptageniidae | *Epeorus* | *longimanus* | F,G |
| | Heptageniidae | *Epeorus* | | F,G,L |
| | Heptageniidae | *Heptagenia* | | G |
| | Heptageniidae | *Nixe* | *simplicoides* | L |
| | Heptageniidae | *Rhithrogena* | | F |
| | Leptophlebiidae | *Paraleptophlebia* | | F,G,L |
| | Siphlonuridae | *Ameletus* | | F,G,L,S,SG |
| | Siphlonuridae | *Siphlonurus* | *occidentalis* | F,L |
| | Siphlonuridae | *Siphlonurus* | | F |
| | Siphlonuridae | | | A |
| | Tricorythidae | *Tricorythodes* | *minutus* | S |
| | Tricorythidae | *Tricorythodes* | | A,F |
| Odonata | | | | |
| suborder Anisoptera (Dragonflies) | Aeshnidae | *Aeshna* | | A,C,F,I,S |
| | Aeshnidae | *Anax* | | H,P,S,48 |
| | Aeshnidae | *Boyeria* | | S |
| | Cordulegastridae | *Cordulegaster* | | F,S |
| | Corduliidae | *Belonia*? | | A,C,PW |
| | Gomphidae | | | L,PW |
| | Libellulidae | *Leuchorrhina* | | I |
| | Libellulidae | *Libellula* | | PS |
| | Libellulidae | *Pantala* | | A,C |
| | Libellulidae | *Platyhemis*? | | PW |
| | Libellulidae | *Sympetrum*? | | PS |

| | | | | |
|---|---|---|---|---|
| | Libellulidae | | | A,F,PS |
| suborder Zygoptera (Damselflies) | Agriidae | *Argion* | | A |
| | Agriidae | *Hetaerina* | | A,PS |
| | Coenagrionidae | *Argia* | | A,C,F,PW,S, PS |
| | Coenagrionidae | *Enallagma* | | I |
| | Coenagrionidae | *Hyponeura* | | F |
| | Coenagrionidae | *Ishnura* | *perparua* | F |
| | Coenagrionidae | *Ishnura* | | H,S |
| | Coenagrionidae | *Zoniagrion* | | S |
| | Lestidae | *Archilestes* | | PS,S |
| Hemiptera (True bugs) | Corixidae | *Corisella* | | F |
| | Corixidae | *Sigara* | | F |
| | Corixidae | *Trichocorixa* | | A,PW,S |
| | Gerridae | *Gerris* | *marginatus* | F |
| | Gerridae | *Gerris* | *notabilis* | F |
| | Gerridae | *Gerris* | | A,D,F,G,H,I, L,PS,S |
| | Gerridae | *Metrobates* | | PS |
| | Gerridae | *Trepobates* | | H |
| | Naucoridae | *Ambrysus* | *mormon* | A,C,PS |
| | Notonectidae | *Notonecta* | *undulata* | F |
| | Notonectidae | *Notonecta* | | C,S |
| | Veliidae | *Microvelia* | | F,G |
| | Veliidae | *Rhagovelia* | | S |
| | Veliidae | | | A,PS |
| Trichoptera (Caddisflies) | Brachycentridae | *Amiocentrus* | | F |
| | Brachycentridae | *Brachycentrus* | *americanus* | F |
| | Brachycentridae | *Brachycentrus* | | F |
| | Brachycentridae | *Micrasema* | | F,G,L |
| | Calamoceratidae | *Phylloicus* | | F |
| | Glossomatidae | *Agapetus* | | G |
| | Glossosomatidae | *Anagapetus* | | G |
| | Glosssosomatidae | *Glossosoma* | | F,G,L |
| | Helicosychidae | *Helicopsyche* | *borealis* | G,L,PS |
| | Helicopsychidae | *Helicopsyche* | | F |
| | Hydropsychidae | *Arctopsyche* | *grandis* | A,F,G,L,S,PS |
| | Hydropsychidae | *Cheumatopsyche* | | G,PS |
| | Hydropsychidae | *Hydropsyche* | *occentalis* | PS |

| | | | | |
|---|---|---|---|---|
| | Hydropsychidae | *Hydropsyche* | *oslari* | A,F |
| | Hydropsychidae | *Hydropsyche* | | F |
| | Hydrospsychidae | *Hydropsyche* | | F,G,PS,S,SG |
| | Hydroptilidae | *Alisotrichia* | | PS |
| | Hydroptilidae | *Hydroptila* | | A,PW,PS,S |
| | Hydroptilidae | *Leucotrichia* | | PS |
| | Hydroptilidae | *Ochrotrichia* | | F,G,L |
| | Hydroptilidae | *Stactobiella* | | A,PS |
| | Lepidostomatidae | *Lepidostoma* | | F,G,L,S,SG |
| | Lepidostomatidae | | | G |
| | Leptoceridae | *Oecetis* | | L,PW,S |
| | Limnephilidae | *Dicosmoecus* | | F |
| | Limnephilidae | *Hesperophylax* | | G,L,PW,S,SG |
| | Limnephilidae | *Limnephilus* | | F,G,L,PW,S |
| | Limnephilidae | *Oligophlebodes* | | F,G,L,PW,S |
| | Limnephilidae | *Psychoronia* | | F,G |
| | Limnephilidae | | | G,L,PW |
| | Philopotamidae | *Chimarra* | | A,PS |
| | Philopotamidae | *Dolophilodes* | *aequalis* | F |
| | Philopotamidae | *Dolophilodes* | *sortosa* | F,G |
| | Philopotamidae | *Dolophilodes* | | G,L |
| | Philopotamidae | *Wormaldia* | | F,PS |
| | Polycentropidae | *Polycentropus* | | F |
| | Rhyacophilidae | *Rhyacophila* | *acropedes* | F,G |
| | Rhyacophilidae | *Rhyacophila* | *brunnea* complex | F,G |
| | Rhyacophilidae | *Rhyacophila* | *hyalinata* | F,G |
| | Rhyacophilidae | *Rhyacophila* | *valuma* | F,G |
| | Rhyacophilidae | *Rhyacophila* | | F |
| | Rhyacophilidae | *Rhyacophila* | Type A | A |
| Megaloptera (Nerve-wings) | Corydalidae | *Neohermes*? | | G,L |
| Lepidoptera (Butterflies and moths) | Noctuidae | | | G,PS |
| | Pyralidae | | | S |
| | Pyralidae | *Paraponyx* | | PS |
| | Pyralidae | *Parargyractis* | *kearfottalis* | F,PS |
| | Pyralidae | *Petrophyla* | | PS |
| Coleoptera (Beetles) | Curculionidae | *Phytonomus* | | G,L,S |
| | Curculionidae | | | D,F |
| | Dryopidae | *Helichus* | *suturalis** | F |

| | | | | |
|---|---|---|---|---|
| | Dryopidae | *Helichus* | *striatus** | F |
| | Dryopidae (adults) | *Helichus* | | F,L,PW,PS |
| | Dryopidae (adults) | | | S |
| | Dytiscidae | *Agabus* | *cordatus** | F |
| | Dytiscidae | *Agabus* | *tristus** | F |
| | Dytiscidae | *Agabus* | | A,C,D,L,PW, S |
| | Dytiscidae | *Deronectes* | *striatellus** | F |
| | Dytiscidae | *Deronectes** | | L |
| | Dytiscidae | *Dytiscus** | | F |
| | Dytiscidae | *Hydroporus* | *vilis** | F |
| | Dytiscidae | | | L,S |
| | Dytiscidae (adults) | | | G,PS,S |
| | Dytiscidae (adults) | | Type A | M |
| | Dytiscidae (adults) | | Type B | M |
| | Dytiscidae (adults) | *Hydaticus* | | G,L,PS,S |
| | Elmidae | *Cleptelmis addenda** | | F |
| | Elmidae | *Cylloepus* | | F |
| | Elmidae | *Dubiraphia** | | G |
| | Elmidae | *Heterlimnius* | *corpulentis* | F,G,L,PS,SG |
| | Elmidae (adults) | *Heterlimnius* | *corpulentis* | G,L,PS,SG |
| | Elmidae | *Microcylloepus** | | PS |
| | Elmidae | *Narpus* * | *concolor* | F |
| | Elmidae | *Narpus* | | F,G,L |
| | Elmidae (adults) | *Narpus* | | G,L |
| | Elmidae | *Optioservus* | *castanipennis* * | F |
| | Elmidae | *Optioservus* | *divergens** | F |
| | Elmidae | *Optioservus** | | D,F,L,PS,S |
| | Elmidae | *Rhizelmis* | | F |
| | Elmidae | *Zaitzevia* | *parvula* | D,F,L |
| | Elmidae | *Zaitzevia* | | G,L |
| | Elmidae (adults) | *Zaitzevia* | | C,G,L,S |
| | Elmidae | | | G,L,S |
| | Elmidae (adults) | | | C,S,PS |
| | Gyrinidae (adults) | *Gyrinus* | | A,F,S,PS |

| | | | | |
|---|---|---|---|---|
| | Haliplidae | *Haliplus* | | IC |
| | Haliplidae | *Peltodytes* | | G |
| | Haliplidae (adults) | | | S |
| | Helodidae | | | PW |
| | Hydrophilidae | *Ametor* | *scabrosus** | F |
| | Hydrophilidae | *Ametor* | | A,C |
| | Hydrophilidae (adults) | *Ametor* | | G |
| | Hydrophilidae | *Berosus* | *styliferous* | F |
| | Hydrophilidae | *Crenitis** | | F |
| | Hydrophilidae | *Cymbiodyta* | *dorsalis** | F |
| | Hydrophilidae (adults) | *Hydrochus* | | G |
| | Hydrophilidae | | | G,L,PW |
| | Hydrophilidae (adults) | | | G |
| | Psephenidae | *Psphenus*? | | C,PW,48 |
| Diptera (Flies) | Blephariceridae | | | F |
| | Ceratopogonidae (Heleidae) | *Bezzia* | | G,S |
| | Ceratopogonidae (Heleidae) | | | F,G,PW,PS,S |
| | Chironomidae | *Ablabesmyia* | | F |
| | Chironomidae | *Brillia* | | F,L,S |
| | Chironomidae | *Cardiocladius* | | F,G |
| | Chironomidae | *Crichotopus* | | F |
| | Chironomidae | *Chironomus* | | F |
| | Chironomidae | *Corynoneura* | | PS |
| | Chironomidae | *Cricotopus* | | A,F,G,PS |
| | Chironomidae | *Cryptochironomus* | | F |
| | Chironomidae | *Eukiefferiella* | | A,F,G,L |
| | Chironomidae | *Micropsectra* | | A,F |
| | Chironomidae | *Microtendipes* | | D,F |
| | Chironomidae | *Nanocladius* | | F |
| | Chironomidae | *Pagastia* | | L |
| | Chironomidae | *Polypedilum* | | A,F |
| | Chironomidae | *Procladius* | | F |
| | Chironomidae | *Pseudochironomus* | | A |
| | Chironomidae | *Pseudosmittia* | | G |
| | Chironomidae | *Rheotanytarsus* | | A,F,PS |
| | Chironomidae | *Thienemannimyia* | | A,S |
| | Chironomidae | *Thienimanniella* | | A |

| | | | | |
|---|---|---|---|---|
| | Chironomidae | *Zavrelia* | | F |
| | Chironomidae | Type A | | C,H,L,PW, PS,S,SG, 128 |
| | Chironomidae | Type B | | G,L,PW,S,PS |
| | Chironomidae | Type C | | H,PW,S,128 |
| | Chironomidae | Type D | | G,L,PW,PS,S |
| | Chironomidae | Type E | | L,PS |
| | Chironomidae | Type F | | G,L,S |
| | Chironomidae | Type G | | A,C,G,H,L,PW,PS,S |
| | Chironomidae | Type H | | S |
| | Chironomidae | Type I | | SG |
| | Chironomidae (pupae) | | | C,I,S |
| | Chironomidae (pupae) | Type PB | | S |
| | Culicidae | *Aedes* | | F |
| | Culicidae | *Chaoborus* | | I,48 |
| | Culicidae | *Culex* | | F,H,128 |
| | Culicidae | *Culiseta* | | D,H,M,48,128 |
| | Culicidae (pupae) | | | H,M,G,L,128 |
| | Culicidae | | | S |
| | Dixidae | *Dixa* | *californica* | F |
| | Dixidae | *Dixa* | | F,G,L,PS |
| | Dixidae | *Dixa* | Type A | G,L,PW,PS |
| | Empididae | *Chelifera* | | F,G,L |
| | Empididae | *Oreogeton* | | C,F,G,PW,S |
| | Empididae | | | H |
| | Ephydridae | *Brachydeutera* | | S |
| | Ephydridae (pupae) | | | S |
| | Muscidae | *Limnophora* | *aequifrons* | F |
| | Muscidae | *Limnophora* | | A,D,L,S,SG |
| | Psychodidae | *Maruina* | | G,L |
| | Psychodidae | *Pericoma* | | F,G,L |
| | Psychodidae (pupae) | | | S |
| | Ptychopteridae | *Bittacomorpha* | | A,G,L,S |
| | Ptychopteridae | | | F |
| | Simuliidae | *Prosimilium* | | A,F,G,L,S |
| | Simuliidae | *Simulium* | | F,L |
| | Simuliidae | | | D,F,G,L,S,SG |

| | | | | |
|---|---|---|---|---|
| | Simuliidae (pupae) | | | S |
| | Stratiomyidae | *Eulalia* | | F |
| | Stratiomyidae | *Odontomyia*? | | PS,S |
| | Stratiomyidae | | | A,F |
| | Syrphidae | *Tubifera* | *bastardii* | F |
| | Tabanidae | *Chrysops* | | H,M |
| | Tabanidae | *Tabanus* | | 128,PW |
| | Tabanidae | | | F,G,L |
| | Tanyderidae | *Protanyderus* | | F |
| | Tipulidae | *Antocha* | *monticola* | F,G |
| | Tipulidae | *Antocha* | | G,L |
| | Tipulidae | *Dicranota* | | F,G,L,PS,S,SG |
| | Tipulidae | *Hexatoma* | | F |
| | Tipulidae | *Holorusia* | *grandis* | F |
| | Tipulidae | *Limonia* | | F |
| | Tipulidae | *Pedicia* | | F |
| | Tipulidae | *Tipula* | | D,F,G,L,PS,S |
| | Tipulidae | *Tipula* | Type B | S |

**Non-Insect Aquatic Invertebrates Collected in Los Alamos County and Adjacent Watersheds**

| PHYLUM or SUBPHYLUM | CLASS, ETC | COMMON NAME | LOCATION ** |
|---|---|---|---|
| Annelida (Segmented worms) | Naididae | Coil worms | F,L,S |
| | Oligochaeta, Lumbriculidae *Eiseniella tetraedra* | Aquatic earthworms | F |
| | Oligochaeta, Lumbriculidae | Aquatic earthworms | A,F,G,L,PS, S,SG |
| | Oligochaeta B, Lumbriculidae | Aquatic earthworms | G |
| | Hirudinea | Leeches | A,F |
| Arthropoda, Arachnoidea (Spiders, ticks, and mites) | family Hydracarina | Water mites | C,F,G,PS,SG |
| Aschelminthes (Round worms and hairworms) | Nematomorpha | Horsehair worm | C,F,G,L,PW, |

| | | | |
|---|---|---|---|
| | Nematomorpha, *Gordius* | Horsehair worm | F |
| Crustacea (Crustaceans) | Amphipoda, *Hyatella azteca* | Scuds | A,C,PS |
| | Cladocera | Water fleas | O |
| | Copepoda | Copedpods | S |
| | Ostracoda, Candoniidae | Seed shrimp | S |
| | Ostracoda, Cyprididae | Seed shrimp | C,S,SG |
| | family Palaemonidae | Scuds | A,C |
| Mollusca (Mollusks) | Gastropoda, *Gyralus parvus* | Snails | G,IC,S |
| | Lymnaeidae, *Lymnaea* | Snails | A,G,L,PW,S |
| | Physidae, *Physella* | Snails | A |
| | Physidae, *Physa* | Snails | F,S |
| | Gastropoda | Snails | SG |
| | Pelecypodae, *Pisidium casertanum* | Clams | F,G,L |
| | Pelecypoda, *Pisidium compressa* | Clams | H |
| | Sphaeridae | Clams | F |
| Nematoda (Round worms) | | Free-living round worm | F,S |
| Platyhelminthes (Flatworms) | Turbellaria | Planaria | A,C,F,G,PS, S,SG |

****Locations:**

A = Ancho Canyon
C = Chaquehui Canyon
D = DP Canyon
F = Rio Frijoles and Frijoles Canyon
G = Guaje Canyon
H = High Explosives wastewater stream
I = Ice House pond, off West Jemez Road
L = Los Alamos Canyon
O = Otowi firestation pond
M = Mortandad
PW = Pajarito Wetlands
PS = Pajarito Springs
S = Sandia Canyon
SG = Starmer's Gulch
48 = TA-48 pond
128 = outfall 128

# APPENDIX F

**Functional Feeding Groups for the Aquatic Insects of Guaje and Los Alamos Canyons**

(modified from Merrit and Cummins 1984)

All specimens are larval unless otherwise noted.

| Order | Family | Genus (species) | Feeding grp* | Canyon |
|---|---|---|---|---|
| **Plecoptera** | Chloroperlidae | | CG, SC | G, LA |
| | Nemouridae | Amphinemura | SH | G, LA |
| | Nemouridae | Malenka | ? | G |
| | Nemouridae | Podmosta (delicatula) | ? | G |
| | Nemouridae | Zapada (frigida) | SH | LA |
| | Perlidae | Hesperoperla (pacifica) | P | LA |
| | Perlodidae | Cultus (aestivalis) | P | G, LA |
| | Perlodidae | Isoperla | P | G, LA |
| | Perlodidae | Kogotus (modestus) | P | G, LA |
| | Pteronarcyidae | Pteronarcella (badia) | SH | G |
| | Pteronarcyidae | Pteronarcys | SH | G |
| **Ephemeroptera** | Baetidae | Baetis | CG, SC | G, LA |
| | Baetidae | Callibaetis | CG | G, LA |
| | Ephemerellidae | Drunella (coloradensis) | SC, P? | G, LA |
| | Ephemerellidae | Drunella (doddsi) | SC, P? | G |
| | Ephemerellidae | Drunella (grandis grandis) | SC | G |
| | Ephemerellidae | Ephemerella (inermis) | CG, SC | G, LA |
| | Ephemerellidae | Ephemerella (infrequens) | SH | G |
| | Heptageniidae | Cinygmula | SC, CG | G, LA |
| | Heptageniidae | Epeorus (longimanus) | CG, SC | G, LA |
| | Leptophlebiidae | Paraleptophlebia | CG, SH | G, LA |
| | Siphlonuridae | Ameletus | CG | G, LA |
| | Siphlonuridae | Siphlonurus | CG, SH, P | LA |
| | Tricorythidae | Tricorythodes (minutus) | CG | G |
| **Odonata** | Aeshnidae | Boyeria | P | LA |
| **Hemiptera** | Gerridae | Gerris | P | G, LA |
| | Veliidae | Microvelia | P | G, LA |
| **Trichoptera** | Brachycentridae | Micrasema | CG | G, LA |
| | Glossosomatidae | Agapetus | SC, CG | G |
| | Glossosomatidae | Glossosoma | SC | G, LA |
| | Hydropsychidae | Arctopsyche (grandis) | CF | G, LA |
| | Hydropsychidae | Cheumatopsyche | CF | G |
| | Hydropsychidae | Hydropsyche | CF | G, LA |

| Order | Family | Genus (species) | Feeding grp* | Canyon |
|---|---|---|---|---|
| | Lepidostomatidae | Lepidostoma | SH | G, LA |
| | Leptoceridae | Oecetis ? | P, SH | G, LA |
| | Limnephilidae | Hesperophylax | SH | G, LA |
| | Limenphilidae | Limnephilus | SH, CG | G, LA |
| | Limnephilidae | Oligophlebodes | SC, CG | G, LA |
| | Odontoceridae | Namamyia | CG? | G |
| | Philopotamidae | Dolophilodes | CF | G, LA |
| | Rhyacophilidae | Rhyacophila brunnea complex | P | G, LA |
| **Lepidoptera** | Noctuidae | | SH | G, LA |
| | Pyralidae | | SH | G |
| **Coleoptera** | Amphizoidae | Amphizoa | P | G |
| | Curculionidae adult | | SH | G |
| | Dryopidae adult | Helichus | SC | G, LA |
| | Dytiscidae | Agabus | P | LA |
| | Dytiscidae | Copelatus? | P | LA |
| | Dytiscidae | Hydaticus | P | G, LA |
| | Dytiscidae adults | Laccophilus | P | LA |
| | Dytiscidae adults | | P | LA |
| | Elmidae | all genera found | CG, SC | G, LA |
| | Elmidae adults | all genera found | CG, SC | G, LA |
| | Helodidae | Prionocyphon | SC, CG | G |
| | Hydrophilidae | Ametor | P | G, LA |
| | Hydrophilidae adults | Ametor | P | G |
| | Hydrophilidae | Helophorus | SH | LA |
| | Hydrophilidae | Hydrobius | ? | LA |
| | Hydrophilidae | Hydrochus | SH | G |
| | Hydrophilidae | | P | G |
| | Psephenidae | | SC | G |
| **Diptera** | Ceratopogonidae | Bezzia | P | LA |
| | Chironomidae | all taxa found | CG, CF | G, LA |
| | Dixidae | Dixa | CG | G, LA |
| | Dixidae | Dixa A | CG | G |
| | Empididae | Chelifera | ? | G |
| | Empididae | Hemerodromia | P, CG | G |
| | Empididae | Oreogeton | P | G, LA |
| | Muscidae | Limnophora | P | LA |
| | Psychodidae | Maruina | SC, CG | G, LA |
| | Psychodidae | Pericoma | CG | G, LA |
| | Ptychopteridae | Ptychoptera | CG | G, LA |

| Order | Family | Genus (species) | Feeding grp* | Canyon |
|---|---|---|---|---|
| | Simulidae | | CF | G, LA |
| | Stratiomyiidae | Odontomyia | CG | G |
| | Tipulidae | Antocha | CG | G, LA |
| | | Dicranota | P | G, LA |
| | | Tipula | SH, CG | G, LA |
| | | Tipula B | SH, CG | G, LA |

***Codes For Functional Feeding Groups:**

CF = collector filterer
CG =collector gatherer
P = predator
PH = piercer-herbivore
SC = scraper
SH = shredder

# APPENDIX G

## Rapid Bioassessment Protocol Worksheets for Guaje and Los Alamos Canyons

**Month, Year: May, 1993**

| Samples: | G1 √ | G2 √ | G3 √ |
|---|---|---|---|
| | LA1 √ | LA2 √ | LA3 √ |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 15 | 16 | 94 | 6 |
| 2 | 17 | 23 | 74 | 4 |
| 3 | 7 | 19 | 37 | 0 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 44.0 | 51.2 | 86 | 6 |
| 2 | 65.6 | 103.4 | 63 | 2 |
| 3 | 54.5 | 80.7 | 68 | 2 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 7.8 | 14.4 | 54 | 6 |
| 2 | 0.09 | 1.7 | 5 | 0 |
| 3 | 1.1 | 8.0 | 14 | 0 |

Month, Year: May, 1993

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 260 | 144 | 8 | 6 |
| 2 | 93 | 162 | 2 | 2 |
| 3 | 46 | 98 | 3 | 2 |

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 28.7 | 4 |
| 2 | 85.8 | 0 |
| 3 | 37.3 | 2 |

**Metric: 6. EPT Index** = (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 6 | 10 | 60 | 0 |
| 2 | 10 | 13 | 77 | 2 |
| 3 | 3 | 12 | 25 | 0 |

**Metric: 7. Community Loss Index**

| Station | Loss Index | Score |
|---|---|---|
| 1 | 0.64 | 4 |
| 2 | 0.87 | 4 |
| 3 | 2.14 | 2 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 32 | 76 | Slightly impaired |
| 2 | 14 | 33 | Moderately impaired |
| 3 | 8 | 19 | Severely impaired |

Month, Year: June, 1993

| Samples: | G1 √ | G2 √ | G3 √ |
|---|---|---|---|
| | LA1 √ | LA2 √ | LA3 √ |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 15 | 21 | 71 | 4 |
| 2 | 14 | 16 | 88 | 6 |
| 3 | 13 | 19 | 68 | 4 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 56.6 | 72 | 79 | 4 |
| 2 | 46.9 | 45.9 | 102 | 6 |
| 3 | 43.8 | 37.1 | 118 | 6 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 0.64 | 109.7 | 0.6 | 0 |
| 2 | 2.7 | 88.5 | 3 | 0 |
| 3 | 42 | 31.8 | 132 | 6 |

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 74 | 219 | 34 | 2 |
| 2 | 519 | 165 | 315 | 6 |
| 3 | 138 | 187 | 74 | 4 |

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 37 | 2 |
| 2 | 32 | 2 |
| 3 | 63 | 0 |

**Month, Year: ,June, 1993**

**Metric: 6. EPT Index** = (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 11 | 11 | 100 | 6 |
| 2 | 10 | 11 | 91 | 6 |
| 3 | 7 | 10 | 70 | 2 |

**Metric: 7. Community Loss Index**

| Station | Loss Index | Score |
|---|---|---|
| 1 | 0.65 | 4 |
| 2 | 0.50 | 4 |
| 3 | 0.91 | 4 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 22 | 52 | Slightly impaired |
| 2 | 30 | 71 | Slightly impaired |
| 3 | 26 | 62 | Slightly impaired |

**Month, Year: July, 1993**

| Samples: | G1 | √ | G2 | √ | G3 | √ |
|---|---|---|---|---|---|---|
| | LA1 | √ | LA2 | Dry | LA3 | Dry |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 24 | 34 | 71 | 4 |
| 2 | 0 | 32 | 0 | 0 |
| 3 | 0 | 18 | 0 | 0 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 57.3 | 74.1 | 77 | 4 |
| 2 | 64.4 | 0 | 0 | 0 |
| 3 | 39.9 | 0 | 0 | 0 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 2.40 | 4.35 | 55 | 6 |
| 2 | 0 | 11.1 | 0 | 0 |
| 3 | 0 | 1.02 | 0 | 0 |

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 348 | 375 | 93 | 6 |
| 2 | 0 | 165 | 0 | 0 |
| 3 | 0 | 188 | 0 | 0 |

**Month, Year: July, 1993**

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 18 | 6 |
| 2 | 0 | 0 |
| 3 | 0 | 0 |

**Metric: 6. EPT Index** = (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 12 | 15 | 80 | 4 |
| 2 | 0 | 11 | 0 | 0 |
| 3 | 0 | 14 | 0 | 0 |

**Metric: 7. Community Loss Index** = (d-a)/e

where

d = # G taxa
e = # LA taxa
a = # taxa in common

| Station | d | a | e | Loss Index | Score |
|---|---|---|---|---|---|
| 1 | 33 | 16 | 24 | 0.71 | 4 |
| 2 | 32 | 0 | 0 | - | 0 |
| 3 | 18 | 0 | 0 | - | 0 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 34 | 81 | Nonimpaired |
| 2 | 0 | 0 | Severely impaired |
| 3 | 0 | 0 | Severely impaired |

**Month, Year: August, 1993**

| Samples: | G1 √ | G2 √ | G3 √ |
|---|---|---|---|
| | LA1 √ | LA2 √ | LA3 √ |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 21 | 35 | 60 | 4 |
| 2 | 4 | 24 | 17 | 0 |
| 3 | 6 | 24 | 25 | 0 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 61.7 | 72.9 | 85 | 6 |
| 2 | 62.8 | 66.9 | 94 | 6 |
| 3 | 68.2 | 0 | 0 | 0 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 23.5 | 3.82 | 6.15 | 6 |
| 2 | 0 | 6.31 | 0 | 0 |
| 3 | 0 | 60 | 0 | 0 |

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 94 | 396 | 24 | 0 |
| 2 | 0 | 196 | 0 | 0 |
| 3 | 18 | 110 | 16 | 0 |

Month, Year: August, 1993

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 31 | 2 |
| 2 | 76 | 0 |
| 3 | 70 | 0 |

**Metric: 6. EPT Index** = (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 9 | 15 | 60 | 0 |
| 2 | 0 | 13 | 0 | 0 |
| 3 | 4 | 14 | 29 | 0 |

**Metric: 7. Community Loss Index** = (d-a)/e

where

d = # G taxa
e = # LA taxa
a = # taxa in common

| Station | d | a | e | Loss Index | Score |
|---|---|---|---|---|---|
| 1 | 35 | 11 | 21 | 1.1 | 4 |
| 2 | 25 | 2 | 4 | 5.8 | 0 |
| 3 | 24 | 3 | 5 | 4.2 | 0 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 22 | 62 | Slightly impaired |
| 2 | 6 | 14 | Severely impaired |
| 3 | 0 | 0 | Severely impaired |

**Month, Year: September, 1993**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Samples:** | **G1** | √ | **G2** | √ | **G3** | √ |
| | **LA1** | √ | **LA2** | √ | **LA3** | **Dry** |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 27 | 28 | 96 | 6 |
| 2 | 9 | 35 | 26 | 0 |
| 3 | 0 | 25 | 0 | 0 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 57.0 | 53.4 | 107 | 6 |
| 2 | 58.6 | 105.4 | 56 | 2 |
| 3 | 68.0 | 0 | 0 | 0 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 5.54 | 15.24 | 36 | 4 |
| 2 | 0.51 | 6.09 | 8 | 0 |
| 3 | 0 | 3.48 | 0 | 0 |

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 238 | 345 | 69 | 4 |
| 2 | 1 | 90.6 | 0.2 | 0 |
| 3 | 0 | 220 | 0 | 0 |

**Month, Year: September, 1993**

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 32 | 2 |
| 2 | 36 | 2 |
| 3 | 0 | 0 |

**Metric: 6. EPT Index =** (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 15 | 17 | 88 | 4 |
| 2 | 1 | 17 | 6 | 0 |
| 3 | 0 | 16 | 0 | 0 |

**Metric: 7. Community Loss Index**

| Station | Loss Index | Score |
|---|---|---|
| 1 | 0.32 | 6 |
| 2 | 2.7 | 2 |
| 3 | - | 0 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 32 | 76 | Slightly impaired |
| 2 | 6 | 14 | Severely impaired |
| 3 | 0 | 0 | Severely impaired |

**Month, Year: October, 1993**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Samples:** | **G1** | √ | **G2** | √ | **G3** | √ |
| | **LA1** | √ | **LA2** | **Dry** | **LA3** | **Dry** |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 32 | 26 | 123 | 6 |
| 2 | 0 | 24 | 0 | 0 |
| 3 | 0 | 19 | 0 | 0 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 59.8 | 52.9 | 113 | 6 |
| 2 | 67.0 | 0 | 0 | 0 |
| 3 | 71.2 | 0 | 0 | 0 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 3.13 | 8.93 | 35 | 4 |
| 2 | 0 | 0.15 | 0 | 0 |
| 3 | 0 | 0.02 | 0 | 0 |

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 544 | 438 | 124 | 6 |
| 2 | 0 | 341 | 0 | 0 |
| 3 | 0 | 227 | 0 | 0 |

**Month, Year: October, 1993**

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 23 | 4 |
| 2 | 0 | 0 |
| 3 | 0 | 0 |

**Metric: 6. EPT Index** = (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 19 | 18 | 105 | 6 |
| 2 | 0 | 15 | 0 | 0 |
| 3 | 15 | 15 | 0 | 0 |

**Metric: 7. Community Loss Index** = (d-a)/e

where

d = # G taxa
e = # LA taxa
a = # taxa in common

| Station | d | a | e | Loss Index | Score |
|---|---|---|---|---|---|
| 1 | 26 | 18 | 32 | 0.25 | 4 |
| 2 | 24 | 0 | 0 | - | 0 |
| 3 | 19 | 0 | 0 | - | 0 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 36 | 86 | Nonimpaired |
| 2 | 0 | 0 | Severely impaired |
| 3 | 0 | 0 | Severely impaired |

**Month, Year: May, 1994**

| Samples: | G1 √ | G2 √ | G3 √ |
|---|---|---|---|
| | LA1 √ | LA2 √ | LA3 √ |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 30 | 30 | 100 | 6 |
| 2 | 7 | 28 | 25 | 0 |
| 3 | 6 | 30 | 20 | 0 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 66 | 52 | 127 | 6 |
| 2 | 56 | 108 | 52 | 2 |
| 3 | 50 | 107 | 47 | 0 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 2.09 | 1.15 | 182 | 6 |
| 2 | 0 | 3.65 | 0 | 0 |
| 3 | 0 | 6.91 | 0 | 0 |

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 474 | 299 | 156 | 6 |
| 2 | 4 | 476 | 0.8 | 0 |
| 3 | 1 | 931 | 0.1 | 0 |

Month, Year: May, 1994

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 28 | 4 |
| 2 | 95 | 0 |
| 3 | 51 | 0 |

**Metric: 6. EPT Index** = (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 16 | 15 | 107 | 6 |
| 2 | 2 | 17 | 12 | 0 |
| 3 | 1 | 17 | 6 | 0 |

**Metric: 7. Community Loss Index** = (d-a)/e

where

d = # G taxa
e = # LA taxa
a = # taxa in common

| Station | d | a | e | Loss Index | Score |
|---|---|---|---|---|---|
| 1 | 30 | 17 | 30 | 0.43 | 6 |
| 2 | 28 | 4 | 7 | 3.43 | 2 |
| 3 | 30 | 3 | 6 | 4.5 | 0 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 40 | 95 | Nonimpaired |
| 2 | 4 | 0.1 | Severely impaired |
| 3 | 0 | 0 | Severely impaired |

**Month, Year: June, 1994**

| Samples: | G1 √ | G2 √ | G3 √ |
|---|---|---|---|
| | LA1 √ | LA2 √ | LA3 √ |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 29 | 34 | 85 | 6 |
| 2 | 12 | 27 | 44 | 2 |
| 3 | 9 | 27 | 30 | 0 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 54 | 51 | 106 | 6 |
| 2 | 65 | 105 | 62 | 2 |
| 3 | 65 | 81 | 80 | 4 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 6.9 | 28.4 | 24 | 2 |
| 2 | 0.0004 | 2.79 | 0.014 | 0 |
| 3 | 0.03 | 0.76 | 3.95 | 0 |

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 432 | 250 | 173 | 6 |
| 2 | 178 | 336 | 53 | 4 |
| 3 | 0 | 106 | 0 | 0 |

**Month, Year: June, 1994**

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 29 | 4 |
| 2 | 87 | 0 |
| 3 | 72 | 0 |

**Metric: 6. EPT Index** = (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 13 | 19 | 68 | 0 |
| 2 | 11 | 19 | 58 | 0 |
| 3 | 8 | 18 | 44 | 0 |

**Metric: 7. Community Loss Index** = (d-a)/e

where

d = # G taxa
e = # LA taxa
a = # taxa in common

| Station | d | a | e | Loss Index | Score |
|---|---|---|---|---|---|
| 1 | 34 | 18 | 29 | 0.55 | 4 |
| 2 | 27 | 8 | 12 | 1.58 | 2 |
| 3 | 27 | 5 | 8 | 2.75 | 2 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 28 | 67 | Slightly impaired |
| 2 | 10 | 24 | Moderately impaired |
| 3 | 6 | 14 | Severely impaired |

**Month, Year: July, 1994**

| Samples: | G1 √ | G2 √ | G3 √ |
|---|---|---|---|
| | LA1 √ | LA2 Dry | LA3 Dry |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 33 | 25 | 132 | 6 |
| 2 | 0 | 22 | 0 | 0 |
| 3 | 0 | 28 | 0 | 0 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 54 | 77 | 70 | 2 |
| 2 | 53 | 0 | - | 0 |
| 3 | 59 | 0 | - | 0 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 2.64 | 4.26 | 62 | 6 |
| 2 | 0 | 204.00 | 0 | 0 |
| 3 | 0 | 38.67 | 0 | 0 |

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 906 | 384 | 236 | 6 |
| 2 | 0 | 300 | 0 | 0 |
| 3 | 0 | 530 | 0 | 0 |

**Month, Year: July, 1994**

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 28 | 4 |
| 2 | 0 | 0 |
| 3 | 0 | 0 |

**Metric: 6. EPT Index** = (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 12 | 13 | 92 | 6 |
| 2 | 0 | 13 | 0 | 0 |
| 3 | 0 | 16 | 0 | 0 |

**Metric: 7. Community Loss Index** = (d-a)/e

where

d = # G taxa
e = # LA taxa
a = # taxa in common

| Station | d | a | e | Loss Index | Score |
|---|---|---|---|---|---|
| 1 | 25 | 16 | 33 | 0.27 | 6 |
| 2 | 22 | 0 | 0 | - | 0 |
| 3 | 28 | 0 | 0 | - | 0 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 36 | 86 | Nonimpaired |
| 2 | 0 | 0 | Severely impaired |
| 3 | 0 | 0 | Severely impaired |

**Month, Year: August. 1994**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Samples:** | **G1** | √ | **G2** | √ | **G3** | √ |
| | **LA1** | √ | **LA2** | √ | **LA3** | **Dry** |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 24 | 30 | 80 | 4 |
| 2 | 7 | 33 | 21 | 0 |
| 3 | 0 | 30 | 0 | 0 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 75 | 71 | 106 | 6 |
| 2 | 51 | 108 | 47 | 0 |
| 3 | 51 | 0 | - | 0 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 90 | 78 | 115 | 6 |
| 2 | 0 | 7067 | 0 | 0 |
| 3 | 0 | 2.55 | 0 | 0 |

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 286 | 374 | 76 | 6 |
| 2 | 5 | 409 | 1.2 | 0 |
| 3 | 0 | 303 | 0 | 0 |

**Month, Year: August, 1994**

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 24 | 4 |
| 2 | 32 | 2 |
| 3 | 0 | 0 |

**Metric: 6. EPT Index** = (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 15 | 15 | 100 | 6 |
| 2 | 1 | 20 | 5 | 0 |
| 3 | 0 | 17 | 0 | 0 |

**Metric: 7. Community Loss Index** = (d-a)/e

where

d = # G taxa
e = # LA taxa
a = # taxa in common

| Station | d | a | e | Loss Index | Score |
|---|---|---|---|---|---|
| 1 | 30 | 16 | 24 | 0.58 | 4 |
| 2 | 33 | 4 | 7 | 4.14 | 0 |
| 3 | 30 | 0 | 0 | - | 0 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 36 | 86 | Nonimpaired |
| 2 | 2 | 5 | Severely impaired |
| 3 | 0 | 0 | Severely impaired |

**Month, Year: September, 1994**

| Samples: | G1 √ | G2 √ | G3 √ |
|---|---|---|---|
| | LA1 √ | LA2 √ | LA3 Dry |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 25 | 30 | 83 | 6 |
| 2 | 16 | 22 | 73 | 4 |
| 3 | 0 | 28 | 0 | 0 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 57 | 78 | 73 | 4 |
| 2 | 68 | 92 | 74 | 4 |
| 3 | 75 | 0 | - | 0 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 0.10 | 0.41 | 24 | 2 |
| 2 | 0 | 4.88 | 0 | 0 |
| 3 | 0 | 2.56 | 0 | 0 |

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 355 | 407 | 87 | 6 |
| 2 | 67 | 198 | 34 | 2 |
| 3 | 0 | 326 | 0 | 0 |

Month, Year: September, 1994

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 35 | 2 |
| 2 | 25 | 4 |
| 3 | 0 | 0 |

**Metric: 6. EPT Index** = (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 12 | 17 | 71 | 2 |
| 2 | 7 | 12 | 58 | 0 |
| 3 | 0 | 12 | 0 | 0 |

**Metric: 7. Community Loss Index** = (d-a)/e

where

d = # G taxa
e = # LA taxa
a = # taxa in common

| Station | d | a | e | Loss Index | Score |
|---|---|---|---|---|---|
| 1 | 30 | 18 | 25 | 0.48 | 6 |
| 2 | 22 | 10 | 16 | 0.75 | 4 |
| 3 | 28 | 0 | 0 | - | 0 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 28 | 67 | Slightly impaired |
| 2 | 18 | 43 | Moderately impaired |
| 3 | 0 | 0 | Severely impaired |

**Month, Year: October, 1994**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Samples:** | **G1** | √ | **G2** | √ | **G3** | √ |
| | **LA1** | √ | **LA2** | **Dry** | **LA3** | **Dry** |

**Metric: 1. Taxa Richness** = (LA/G) X 100

| Station | Los Alamos taxa | Guaje taxa | Percentage | Score |
|---|---|---|---|---|
| 1 | 26 | 29 | 90 | 6 |
| 2 | 0 | 32 | 0 | 0 |
| 3 | 0 | 30 | 0 | 0 |

**Metric: 2. Community Tolerance Quotient** = (G/LA) X 100

| Station | Guaje Tolerance Quotient | Los Alamos Tolerance Quotient | Percentage | Score |
|---|---|---|---|---|
| 1 | 58 | 53 | 109 | 6 |
| 2 | 66 | 0 | - | 0 |
| 3 | 66 | 0 | - | 0 |

**Metric: 3. Ratio Scrapers/Filtering Collectors** = (LA/G) X 100

| Station | Los Alamos SC/FC | Guaje SC/FC | Percentage | Score |
|---|---|---|---|---|
| 1 | 0.21 | 1.73 | 12 | 0 |
| 2 | 0 | 0.31 | 0 | 0 |
| 3 | 0 | 0.39 | 0 | 0 |

**Metric: 4. Total Number of EPT Individuals** = (LA/G) X 100

| Station | Los Alamos EPT individuals | Guaje EPT individuals | Percentage | Score |
|---|---|---|---|---|
| 1 | 781 | 496 | 157 | 6 |
| 2 | 0 | 311 | 0 | 0 |
| 3 | 0 | 504 | 0 | 0 |

**Month, Year: October, 1994**

**Metric: 5. Percent Contribution of Dominant Taxon**

| Station | Los Alamos percentage | Score |
|---|---|---|
| 1 | 30 | 4 |
| 2 | 0 | 0 |
| 3 | 0 | 0 |

**Metric: 6. EPT Index** = (LA/G) X 100

| Station | Los Alamos EPT Index | Guaje EPT Index | Percentage | Score |
|---|---|---|---|---|
| 1 | 13 | 16 | 81 | 4 |
| 2 | 0 | 18 | 0 | 0 |
| 3 | 0 | 18 | 0 | 0 |

**Metric: 7. Community Loss Index** = (d-a)/e

where

d = # G taxa

e = # LA taxa

a = # taxa in common

| Station | d | a | e | Loss Index | Score |
|---|---|---|---|---|---|
| 1 | 29 | 17 | 26 | 0.46 | 6 |
| 2 | 32 | 0 | 0 | - | 0 |
| 3 | 30 | 0 | 0 | - | 0 |

**Bioassessment**

| Station | Total biological condition score | Percentage score | Assessment |
|---|---|---|---|
| 1 | 26 | 72 | Slightly impaired |
| 2 | 0 | 0 | Severely impaired |
| 3 | 0 | 0 | Severely impaired |