Comprehensive and Critical Period Monitoring Program to Evaluate the Effects of Variable Flow on Biological Resources in the Comal Springs/River Aquatic Ecosystem

FINAL 2001 ANNUAL REPORT

Prepared for:

Edwards Aquifer Authority
1615 N. St. Mary's Street
San Antonio, Texas 78215

Prepared by:

BIO-WEST, Inc
Austin Office
1406 Three Points Road, Suite A-200
Pflugerville, Texas 78660-3155

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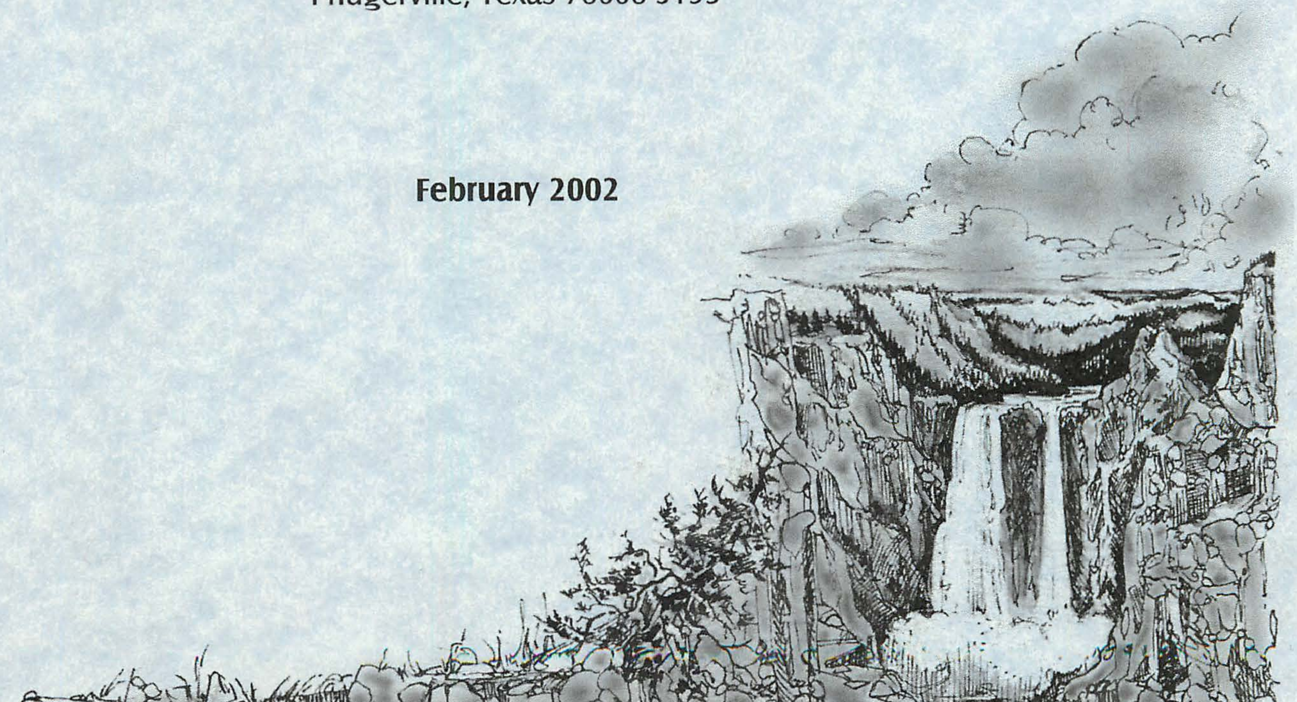

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This annual summary report presents a synopsis of methodology used and an account of sampling activities including sample conditions, locations, and raw data obtained during all four quarterly sampling events (Comprehensive Monitoring Effort) conducted on the Comal Springs / River ecosystem in 2001. In addition, data obtained during the high-flow sampling events conducted on the Comal Springs / River ecosystem in September and November 2001 are presented. As with the annual report prepared for activities conducted in 2000, the data included here have not been subject to stringent data reduction techniques or statistical applications in order to prevent drawing premature conclusions from an incomplete data set. Once the complete range of data has been gathered, these techniques will be applied and presented in a final report to the Edwards Aquifer Authority.

The monitoring program was initiated in summer 2000 when the flows in the Comal ecosystem dropped below 200 cubic feet per second (cfs). The first low-flow event was conducted in August 2000 with flows ranging from 177 - 161 cfs. A second low-flow event was triggered 2 weeks later when flows dipped to below 150 cfs; sampling was conducted in the 145 - 171 cfs flow range. Following this period of low flow, a substantial amount of rainfall increased flows in the river and allowed the aquifer to recharge prior to the fall 2000 quarterly sampling event. In fact, the flows reported during the fall 2000 event were approximately twice those reported during the low-flow events. During 2001 the conditions in the Comal ecosystem were representative of a normal-to-wet winter and spring followed by the typical summertime decline. However, unlike summer 2000, a significant rainfall event occurred in late summer (September 2001) and moderate-to-high rainfall conditions occurred throughout the remainder of the fall, including another major event in November 2001. As a result, no critical period samples were triggered by low-flow events in 2001; yet two sampling events were conducted following the periods of intense flooding in which the 24-hour mean discharge in the Comal River reached levels that have occurred less than 0.5% of the time in the recorded hydrograph. In each case sampling was conducted after the ecosystem had returned to normative conditions in order to evaluate the post-flooding effects, but not so soon that sampling would be influenced by immediate, ephemeral impacts occurring during the elevated flow conditions.

Overall, the Comal ecosystem has experienced a wide range of environmental conditions including variable flows over the first 17 months of the study. Throughout this time period the Comal ecosystem can be characterized as an ecosystem with very high water quality for the chemical and physical variables that were measured. Thermistor data revealed a high degree of thermal uniformity throughout the ecosystem, despite the wide-ranging conditions experienced throughout the study period. Though this is a preliminary judgement, there was no clear or dramatic change in any water quality variables that might raise concern when comparing data from all sampling dates.

Aquatic vegetation remained abundant throughout the study period and provided suitable habitat for biological communities. The green algae that was so abundant during the low-flow conditions of summer 2000 reappeared in the same reaches during summer 2001, although the flow was nearly 100 cfs greater. The algal coverage, particularly related to its depth/thickness in all areas, was considerably greater in late summer 2000, but the heavy rainfall in late summer 2001 scoured the algae, which might have otherwise reached the same density of coverage without that disturbance. Floating mats of vegetation appeared again in summer 2001 but not to the degree experienced in summer 2000. The high-flow events had considerable impacts on the aquatic vegetative communities removing or significantly thinning large areas of vegetation in the upper Spring Run and New Channel Reaches. In the Old Channel Reach, filamentous algae appeared to be declining before the effects of high flow by dying and sloughing off in a systematic fashion; however, the overwhelming effect of the second high-flow event was to hasten this process and leave the area with minimal algae remaining. This is significant because of the importance of this vegetation to fountain darters (*Etheostoma fonticola*). Following that high-flow event, the fountain darters were more concentrated than had been observed during any previous trip. The seasonal maps also show that, in addition to filamentous algae, *Hygrophila*, *Cabomba* and, to a lesser extent, *Ludwigia* responded rapidly to favorable conditions by expanding their coverage in many reaches.

Fountain darters were collected from each reach sampled reach during each sampling event. The overall size class distribution for the Comal ecosystem represents that of a healthy fish assemblage, though some differences in reproduction in individual reaches yielded variable size class distributions by season in some reaches. Large numbers of fountain darters were collected in preferred habitat types. The preferred habitats sampled during this study include *Riccia* (36 fountain darters per square meter), which is primarily found in Landa Lake, and filamentous algae (28 fountain darters per square meter), which is the primary vegetation type in the Old Channel. These vegetation types are likely preferred because of the cover provided at the substrate level and the high numbers of amphipods, which provide fountain darters with an ample food supply. Other vegetation types such as *Ludwigia*, *Cabomba*, and *Hygrophila* in Landa Lake yielded >10 fountain darters per square meter. It is interesting to note that the *Cabomba* in Landa Lake grows in very silty substrate often several centimeters deep. This association of a spring-adapted species with the lentic conditions and silty substrate is unusual and may indicate a greater tolerance of fountain darters to various habitat conditions compared with other spring-adapted species. Our visual observations (SCUBA surveys) continue to reinforce the hypothesis that Landa Lake is an integral component to the habitat of species found in the Comal Springs ecosystem and that a sizable portion of the fountain darter population is found there.

By all indications the densities of giant ramshorn snails (*Marisa cornuarietis*) observed in the Comal ecosystem during the study period to date (including the 2000 low-flow events) pose no serious threat to the aquatic vegetative community. However, because of the impact that this exotic species can have under heavier densities, close monitoring of this species should continue. The gill parasite that has been reported for the fountain darter was evident in a number of collected fountain darters. Through visual observation, the fountain darters collected from the Old Channel Reach exhibited the worst conditions with respect to parasite infections and swollen gills. The caged fountain darter studies planned for 2002 will hopefully help assess the dynamics of the parasite/host cycle and provide information on the accumulation of the parasite over specific periods of time.

Within the spring runs and at the springs' orifices, suitable habitat for the listed invertebrates was observed throughout the study period. Several Comal Springs riffle beetle (*Heterelmis Comalensis*) adults and larvae were collected in the drift nets throughout the year. A major discovery in 2001 concerning invertebrates was the extension of the known range for the Comal Springs riffle beetle. An additional study documented the presence of Comal Springs riffle beetles in (1) areas along the western shoreline of Landa Lake, far removed from the spring runs; (2) along the bottom of Landa Lake; and (3) above Spring Island in an area of upwelling spring activity. The study activities and results of that investigation are detailed in a separate report (BIO-WEST 2002).

Suitable habitat for the Comal Springs salamander (*Eurycea* sp.) was noted in the spring runs and Spring Island area with Comal Springs salamanders observed in each area for each sampling event. Sediment accumulation in Spring Run 3 following high-flow events did appear to have an acute effect on the number of Comal Springs salamanders present. As documented via SCUBA surveys, the Comal Springs salamander population was maintained in the deeper portion of Landa Lake throughout the study period.

The high-flow events conducted in concert with quarterly sampling have provided an excellent opportunity to assess the recovery potential of the Comal ecosystem. The parameters that exhibited the greatest degree of disturbance (aquatic vegetation, sediment accumulation in Comal Springs salamander/riffle beetle habitat in Spring Run 3) also exhibited a quick recovery response following the first high-flow event. The second high-flow event was the final sample conducted in 2001; thus, the recovery potential will not be evaluated until the winter 2002 sampling effort.

As described above the data in this report are preliminary and, although they have been carefully evaluated to determine trends and observations of particular interest, stringent data reduction techniques and/or statistical applications have not yet been applied to this incomplete data set. More data from periods of low-flow (particularly from an extended period of low flow) are essential to fully evaluate the biological risks associated with future critical periods (high *or* low flow). Quarterly sampling will continue to be important to maintain an understanding of the current state of the ecosystem in order to be prepared for a period of low flow and to monitor conditions following such a period.

One conclusion that can be made is that this study is the most comprehensive biological evaluation that has ever been conducted on the Comal ecosystem. The variable flow conditions encountered to date have provided an excellent confirmation that the study design is well suited to address the concerns of variable flow and water quality on the biological resources in the Comal ecosystem. For a study to be scientifically valid in such a complex environment, several key procedures are essential for determining the dynamics dictating both the total population numbers and densities of endangered species under various environmental conditions. When feasible, a study should (1) directly evaluate the endangered species or combination of endangered species, (2) avoid conclusions based on one-time sampling events or limited sampling during particular seasons (understanding the condition of the ecosystem before a critical period [high or low flow] and tracking the recovery of that ecosystem after the critical period [high or low flow] are extremely important) and (3) use multiple collection techniques to evaluate as many components of the overall ecosystem as possible.

METHODS

A quarterly sampling event is typically divided into a 2-week effort and includes the following components:

Water Quality
- Standard Parameters
- Thermistor Placement
- Thermistor Retrieval
- Water Quality Grab Samples
- Habitat Quality Index / Fixed Station Photographs

Aquatic Vegetation Mapping

Fountain Darter Sampling
- Drop Nets
- Dip Nets
- Minnow Traps
- Visual Observations
- Gill Parasite Evaluation

Salamander Observations

Macroinvertebrate Sampling
- Drift Nets

Exotic / Predation Study

High-Flow Sampling

The first high-flow sampling event followed an intense period of rain on August 30, 2001, that resulted in flooding within the Comal Springs ecosystem and a 24-hour mean discharge of 876 cfs with a peak instantaneous discharge of 1,729 cfs. A second high-flow event of even greater intensity occurred on November 15-16, 2001, just over 2 months after the first event. The 24-hour mean discharge for the latter event was 1,275 and 1,342 cfs on November 15 and 16 respectively, with peak instantaneous discharge values of 3,100 and 3,700 cfs. The mean daily discharge of the magnitude observed in the September event is rare in the ecosystem; it has occurred less than 0.5% of the time in the recorded hydrograph. The November high-flow event was of a significantly greater intensity than the first. In both instances sampling was conducted after the ecosystem had been returned to normative conditions in order to evaluate the post-flooding effects, but not so soon that the sample would be influenced by immediate, ephemeral impacts occurring during the elevated flow conditions.

The high-flow sampling efforts were designed to focus on those factors most likely to experience a shift in conditions following the natural disturbance. Aquatic vegetation mapping was conducted first to examine physical changes in vegetative distribution and abundance. Because the presence of various species of vegetation affects the amount of habitat available to fountain darters and other species, this is a vital component of all sampling activities. Vegetation mapping included *Riccia* sp. and other attached algae species similar to the summer and fall quarterly sampling efforts. Fountain darter sampling included standard drop net sampling in randomly selected sites, dip netting, and visual observations, but no minnow traps were deployed, and gill parasites were not examined. Comal Springs salamander observations and the predation study were conducted as in a normal quarterly sampling effort.

The methodology for each component of the high-flow events was exactly the same as used in the quarterly (Comprehensive) sampling regime; however, the water quality and drift net components were not included in these samples. Water quality was undoubtedly influenced in the short-term (e.g., increased turbidity, potentially increased nutrients, potential for increased temperature from runoff inputs) during each high-flow period; however, we expect that a disturbance resulting from a high ratio of runoff to springflow inputs would have been quickly ameliorated when runoff subsided and normative flow conditions were restored. Macroinvertebrate sampling was also omitted because of the labor-intensive nature of drift net sampling. Rather, the assumption was made that any changes in the benthic fauna that may have occurred would likely still have been evident in the subsequent quarterly event.

Springflow

All discharge data were acquired from the U.S. Geological Survey (USGS) water resources division. The data are provisional as indicated in the disclaimer on the USGS website and, as such, may be subject to revision at a later date. According to the disclaimer, "recent data provided by the USGS in Texas – including stream discharge, water levels, precipitation, and components from water-quality monitors – are preliminary and have not received final approval" (USGS 2000). The discharge data for the Comal ecosystem was taken from USGS gage 08169000 from the Comal River at New Braunfels. This site represents the cumulative discharge of the springs that form this river system. In addition to these cumulative discharge measurements that are used to characterize the Comal Springs ecosystem during sampling, spot water velocity measurements were taken during each sampling event using a Marsh McBirney model 2000 portable flowmeter.

Water Quality

The water quality component of this study included measuring standard water quality parameters using a Hydrolab data sonde, gathering water samples for laboratory analyses, and deploying and retrieving thermistors at each of the water quality sites in the Comal Springs ecosystem (Figure 1). The objectives of the water quality analysis are: delineating and tracking water chemistry throughout the ecosystem, monitoring controlling variables (i.e., flow, temperature) with respect to the biology of each ecosystem, monitoring any alterations in water chemistry that may be attributed to anthropogenic activities, and evaluating consistency with historical water quality information. Dr. Alan Groeger of Southwest Texas State University (SWT) supervised all aspects of the water quality component in 2001, and the chemical analyses for each quarterly sampling event was conducted in Dr. Groeger's laboratory at SWT.

Hydrolab measurements included conventional in-situ physico-chemical parameters were collected each time a water and/or biological station was occupied. The parameters included: water temperature, conductivity compensated to 25° C, pH, dissolved oxygen, water depth at sampling point, and observations of local conditions. These data were gathered at the surface, middepth, and near the bottom at all biological stations when there was stratification, but only near the surface at water quality stations. In addition, thermistors were placed in select water quality stations along the Comal River and downloaded at regular intervals to provide continuous monitoring of water temperatures in these areas. The thermistors were placed using SCUBA in deeper locations within the ecosystem and set to record temperature data every 5 minutes. The station locations will not be described in detail here to minimize the potential for unauthorized tampering with the field equipment.

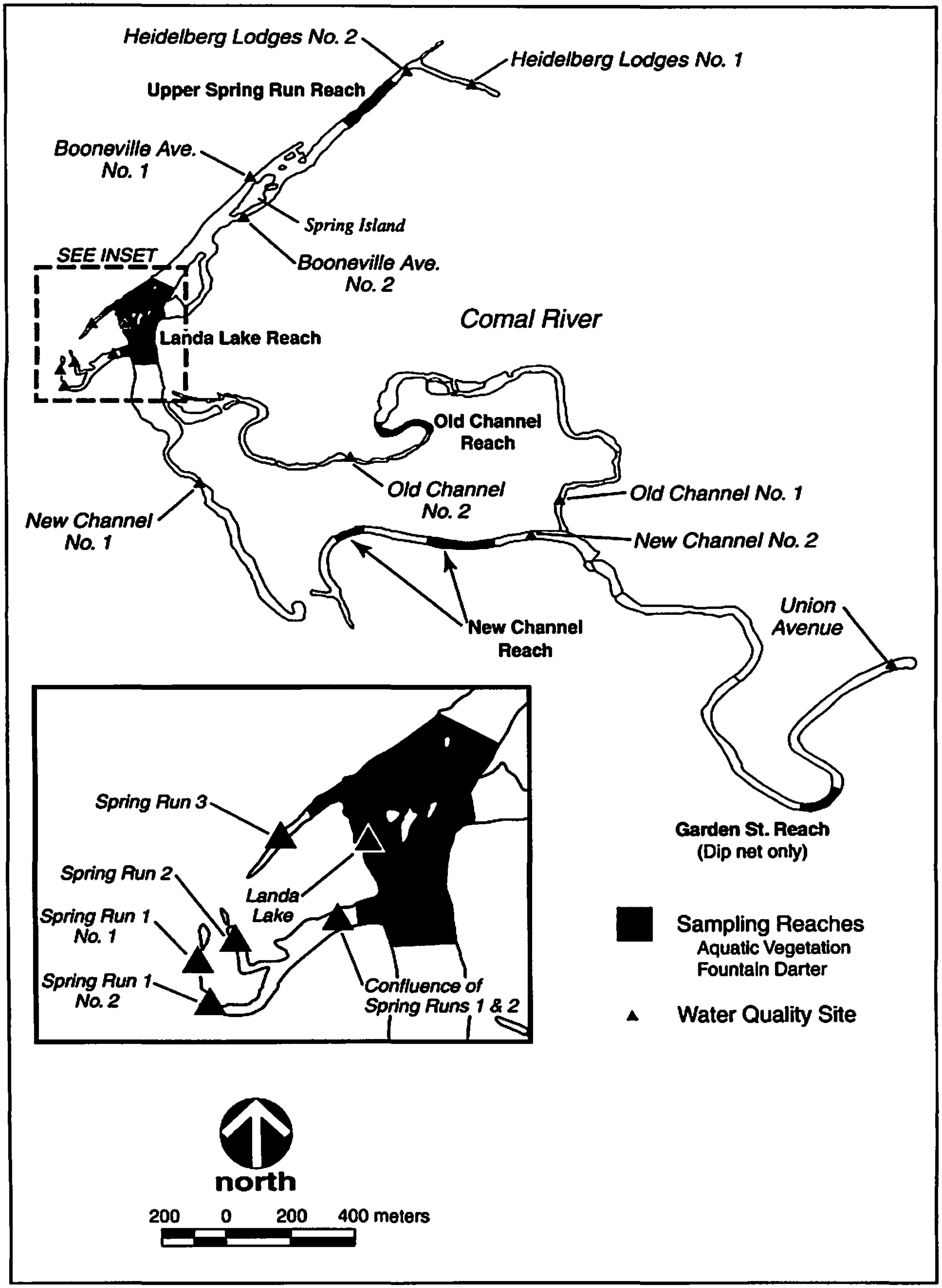

Figure 1. Comal River water quality and biological sampling areas.

Conventional water chemistry parameters from water samples taken at each of the water quality stations were also analyzed in the laboratory. Water "grab" samples were taken in 1-liter polyethylene bottles with caps. Prior to sample collection, the bottles were soaked in Contrad 70 overnight, rinsed repeatedly in DI water, and once in Milli-Q water before being dried for 24 hours. At the sampling site, each bottle was rinsed with sample water prior to collection of the sample; all samples were collected from under the surface of the water to avoid surface-active particulates and floating debris. Samples were then stored in the dark, under ice, for the remainder of the collection period. Samples were transported to the laboratory within 4-6 hours and warmed to room temperature, at which point the samples were partitioned into fractions for the following analyses. Whole water samples were also frozen for a few weeks prior to some analysis; once frozen the samples are stable for many months. Table 1 summarizes the parameters, methodology, minimum analytical levels and detection limits of the data gathered from this chemistry analysis.

Table 1. Parameters, analytical methodology, minimum analytical levels, and minimum detection limits for water chemistry analyses conducted on water quality grab samples.

PARAMETER	METHOD	MINIMUM ANALYTICAL LEVELS (per liter)	MINIMUM DETECTION LIMITS (per liter)
Nitrate	UV Spectroscopy	≈10.0 μg*	≈3.0 μg
Total Nitrogen	UV Spectroscopy	10.0 μg	<5.0 μg
Ammonia	Fluorometric	7 μg	2 μg
Soluble Reactive Phosphorous	Spectroscopy	3 μg	0.5 μg
Total Phosphorous	Spectroscopy	5 μg	3 μg
Alkalinity	Potentiometric	Appropriate	
Total Suspended Solids	Gravimetric	Appropriate	

*micrograms

Alkalinity, Turbidity, and Total Suspended Solids (TSS): All samples were immediately titrated to determine alkalinity, then sampled for nephelometric turbidity units and filtered onto prewashed and preweighed filters for determination of total suspended solids (TSS). Determination of TSS followed the methodology outlined in Standard Methods for the Examination of Water and Wastewater (APHA 1992).

Soluble Reactive Phosphorus (SRP): Soluble reactive phosphorus (SRP) and nitrate were usually analyzed within 48 hours. Soluble reactive phosphorus was measured following Strickland and Parson (1972) in which the filtered sample (0.45 μM) is allowed to react with a composite reagent containing molybdic acid (ammonium molybdate and sulfuric acid), ascorbic acid, and potassium antimonyl tartrate. The resulting complex heterpolic acid is reduced in situ to give a molybdenum blue solution the extinction of which is measured at 885 nm, and plotted on a standard curve.

Nitrate: Nitrate analysis was conducted via the method described by W.G. Crumpton (1992), in which the nitrate concentration is determined by using ultraviolet (UV) spectroscopy to measure the absorbance at 224-228 nm and a second derivative is calculated for that value. This derivative is linear to the concentration of nitrate ion in natural waters, assuming that the samples are reasonably clear. The second derivative function is calculated using a software package designed by Dr. Groeger.

Total Nitrogen and Total Phosphorus: Total Nitrogen was analyzed using the same process as nitrate following a persulfate digestion and autoclave heating period of 30 minutes at 121° C and 15 PSI. Total phosphorus analysis was similar to the method for soluble reactive phosphorus (APHA 1992). The sample was first digested by the persulfate oxidation technique and then subjected to the ascorbic acid method for determination of the total phosphorus content.

Ammonium: The ammonium concentration was determined following the outline of Holmes et al. (1999). The method uses fluorescence of the sample minus background fluorescence and matrix effects against a standard curve. Protocol B was followed for systems with ammonium concentrations generally exceeding 0.5 µmol/L. The method uses a fluorometer equipped with a Turner designs optical kit 10-AU, near UV mercury vapor lamp, a 350 nm interference excitation filter with a 25 nm bandpass, a 410-600 nm combination emission filter, and a 1:75 attenuator plate.

In addition to the water quality collection effort, habitat evaluations were conducted using fixed station photography and a habitat quality index (HQI) developed specifically for this spring ecosystem. Fixed station photographs that included an upstream, across-stream, and downstream picture were taken at each water quality site depicted on Figure 1.

Aquatic Vegetation Mapping

The aquatic vegetation mapping effort consisted of mapping all of the vegetation in each of the four reaches (Upper Spring Run, Landa Lake, New Channel [two sections], and Old Channel; Appendix A). Mapping was conducted using a Trimble Pro-XRS global positioning system (GPS) unit with real-time differential correction capable of submeter accuracy. The GPS unit was linked to a Fujitsu Stylistic 2300 laptop computer with Aspen software that displays field data as it is gathered and improves efficiency and accuracy. The GPS unit and computer were placed in a 3-meter Perception Swifty kayak with the GPS unit antenna mounted on the bow. The aquatic vegetation was identified and mapped by gathering coordinates while maneuvering the kayak around the perimeter of each vegetation type at the water's surface. Vegetation stands that measured between 0.5 and 1.0 meter in diameter were mapped by recording a single point. Vegetation stands less that 0.5 meter in diameter were not mapped.

During the winter and spring sampling events (and all prior vegetation mapping work by others and ourselves), attached algae (primarily *Riccia fluitans*) was not included. This type of vegetation is clearly important fountain darter habitat though, and despite the difficulties associated with this mapping this vegetation type (patchiness, obscured by filamentous algae, etc.), it was included in the summer and fall 2001 quarterly samples, as well as the high-flow events.

Fountain Darter Sampling

Drop Nets

A drop net is a type of sampling device previously used by the U.S. Fish and Wildlife Service (USFWS) to sample fountain darters and other fish species. The design of the net is such that it encloses a known area (2 square meters) and allows a thorough sample by preventing escape of fishes occupying that area. A large dip net (1 square meter) is used within the drop net and is swept along the length of the river substrate 15 times to ensure complete enumeration of all fish trapped within the net. For sampling during this study, a drop net was placed in randomly selected sites within specific aquatic vegetation

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Total Nitrogen	UV Spectroscopy	10.0 µg TN/L	<5.0 µg TN/L
Ammonia	Fluorometric	0.5 µmol/L	≈0.1 µmol/L
Soluble Reactive Phosphorous	Spectroscopy	3 µg P/L	0.5 µg P/L
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At each location the vegetation type, height, and areal coverage were recorded, along with substrate type, mean column velocity, velocity at 15 cm above the bottom, water temperature, conductivity, pH, and dissolved oxygen. In addition, vegetation type, height, and areal coverage, along with substrate type, were noted for all adjacent 3 m cell areas. Fountain darters were identified, enumerated, measured for standard length, and returned to the river at the point of collection. The same measurements were taken for all other fish species, except for abundant species where only the first 25 individuals were measured; a total count was recorded for a drop net sample beyond the first 25 individuals in such instances. Fish species not readily identifiable in the field was preserved for identification in the laboratory. All live giant ramshorn snails were counted, measured, and destroyed, while a categorical abundance was recorded (i.e. none, slight, moderate, or heavy) for the exotic Asian snails (*Melanoides tuberculata* and *Thiara granifera*) and the Asian clam (*Corbicula* sp.). A total count of crayfish (*Procambarus* sp.) and grass shrimp (*Palaemonetes* sp.) was also recorded for each dip net sweep.

Dip Nets

In addition to drop net sampling for fountain darters, a less quantitative, though potentially more thorough, method of sampling was used. A dip net of approximately 40 cm x 40 cm (1.6-mm mesh) was used to sample all habitat types within each reach. Collecting generally was done while moving upstream through a reach. An attempt was made to sample all habitat types within each reach. Habitats thought to contain fountain darters, such as along or in clumps of certain types of aquatic vegetation, were targeted and received the most effort. Areas deeper than 1.4 m were not sampled. Fountain darters collected by this means were identified, measured, recorded as number per dip net sweep, and returned to the river at the point of collection (except for those retained for refugia purposes under the guidance of Dr. Thomas Brandt, USFWS National Fish Hatchery and Technology Center). The abundance of exotic snails was also estimated and recorded per sweep.

To balance the effort expended across samples, a predetermined time constraint was used for each reach (Upper Spring Run - 0.5 hour, Spring Island area - 0.5 hour, Landa Lake - 1.0 hour, New Channel - 1.0 hour, Old Channel - 1.0 hour, Garden Street - 1.0 hour). The areas of fountain darter collection were marked on a base map of the reach. Though information relating the number of fountain darters by vegetation type was not gathered by this method (as in the drop net sampling) it did permit a more thorough exploration of various habitats within the reach. Also, spending a comparable length of time sampling the entirety of each reach allowed comparisons to be made between the data gathered during each sampling event.

Minnow Traps

In an attempt to find a sampling method for fountain darters that is potentially less destructive (and less labor intensive) than drop netting, BIO-WEST explored various minnow trap designs. Gee minnow traps (metal frame) were set over a 12-hour period (overnight) on several occasions with limited results (as with the other collection techniques, once identified, enumerated, and measured, all fountain darters were immediately returned to the water at the point of collection). BIO-WEST has also explored traps built with polyvinyl chloride and with lining the Gee minnow traps using darker mesh material with smaller apertures. These traps were also set in potential fountain darter habitat over extended periods of time (several hours) with limited results. An underwater camera was also employed to view the traps in absentia.

Visual Observations

Visual surveys were conducted using SCUBA in Landa Lake to verify the continued fountain darter and Comal Springs salamander use of habitat in deeper portions of the lake. The locations of these time-constrained surveys were deeper than conventional sampling methods allow. Observations were conducted in the early afternoon for each effort. Subsequently, gill nets were set in these areas for the predation component of the study.

An additional component to these surveys was a grid (0.6 m x 13 m) added in summer 2001, and subsequent sampling that was used to quantify the number of fountain darters using these deeper habitats. To sample the area, all fountain darters within the grid were counted, and larger rocks were moved at the substrate surface to expose any fountain darters.

Gill Parasite Evaluation

Between May 1997 and May 1998, fountain darters were collected monthly from three sections of the Comal River. The intensity of the gill parasite *Centrocestus formosanus* on these fish was determined. The fountain darters were being infected with new parasites year-round with no apparent seasonality. The study provided information on the accumulated effects that the gill parasite have had on the fountain darters since they hatched. However, to understand the dynamics of the parasite/host cycle, information on the accumulation of the parasite over specific periods of time is needed. Therefore, the objectives of this study were to examine the variation in spatial and temporal concentration of *Centrocestus formosanus* in the water column and infection intensity on the gills of caged and resident fountain darters in the Comal ecosystem.

As part of the variable flow study, the BIO-WEST project team is determining if relationships exist among the numbers of *C. formosanus* drifting, the numbers that attach to caged fish, and the numbers attached to resident fountain darters. Hatchery-produced adult fountain darters will be placed in cages in eight sections of the Comal ecosystem.

Comal Springs Salamander Visual Observations

In addition to the visual observations made in the deeper portions of Landa Lake for fountain darters and Comal Springs salamanders, the BIO-WEST project team performed presence/absence surveys for the Comal Springs salamanders in the spring reaches located at the head of the Comal River during all 2001 sampling events. Surveys were conducted in Spring Run 1, Spring Run 3, and the Spring Island area (Figure 1) and performed by two people in each spring reach. Each survey began at the downstream-most edge of the sample area and involved turning over rocks within the spring run located on the substrate surface while moving upstream, toward the main spring orifice. A dive mask and snorkel were utilized when depth permitted. The location of all Comal Springs salamanders was noted, along with the time and water depth. In order to maintain consistency between samples, all surveys were initiated in the morning and terminated before noon.

Within Spring Run 1, surveys were conducted from the first pedestrian bridge below Landa Park Drive up to 9 meters below the head spring orifice. Spring Run 3 was surveyed from the pedestrian bridge closest to Landa Lake up to 9 meters below the head spring orifice. In the Spring Island area, surveys were conducted within the entire spring reach including approximately a 15-meter radius from each spring run outfall. These two areas include the spring outfall on the east side of Spring Island (closest to Edgewater Drive) and the area north of Spring Island (upstream).

Macroinvertebrate Sampling

Drift nets were placed at the downstream end of Comal Spring Runs 1, 2, and 3. Two nets were placed in Spring Run 1 approximately 15 meters downstream of Landa Park Drive. Spring Run 2 had one net placed just upstream of the road crossing before the wading pool. One net was also placed in Spring Run 3 approximately 6 meters downstream of the last footbridge.

Drift nets were anchored into the substrate using rods, with the net face perpendicular to the direction of flow of water. The nets consisted of a 0.45 m by 0.30 m rectangular opening, which connected to a 1-meter-long net with a mesh size of 600 μm. The tail of the net was connected to a detachable 0.15-meter-long cylindrical bucket. The bottoms of the nets were positioned 2-3 cm above the sediment to reduce the possibility of macroinvertebrates crawling into the nets. The depth of the water column entering the net was then measured at three locations across the mouth of the net, and a flowmeter was used to measure water velocity at the mouth of the net. Collecting buckets were then connected to the end of the nets and the time was recorded. The buckets were removed at 3-hour intervals, and the content of the cups was washed into sealable bags. A squirt bottle filled with water was used to remove any macroinvertebrates that were clinging to the inside of the cups. The samples were preserved in 90% ethanol, and the bags were labeled with the date, net number, and the time of the sampling interval. This process was repeated over a 24-hour period and then all samples were transported to the Stream Ecology Lab at SWT and stored for analysis.

In the SWT laboratory, all organisms were separated from the debris contained in the samples with the use of a stereomicroscope. The macroinvertebrates collected were then stored in 70% ethanol in vials for future identification. All identifications were made with the use of Merritt and Cummins' (1996) and Thorpe and Covich's (1996). Upon identification, the organisms were counted, data were recorded, and drift density and drift rate were calculated. Drift rate, the number of organisms drifting past a point per 24-hour-period, drift density, and the number of organisms per 100 cubic meters (m^3) of water were used to estimate drift in the spring runs. Drift rate was calculated by merely summing the total number of organisms collected in a net over a 24-hour period. Drift density was calculated using the following formula:

$$\text{Drift Density} = \frac{(N)\,(100)}{(t)\,(W)\,(H)\,(V)\,(3600\ s/h)},$$

Where N is the number of macroinvertebrates in a sample; t, length of time of sampling (hours), W, net width (m); H, height of water column in the net mouth (m); and V is the mean velocity of water at the mouth of the net (m/s). Drift density was expressed as the number of macroinvertebrates drifting per 100 m^3 of water sampled (Smock 1996).

Exotics / Predation Study

A 150-foot experimental gill net with mesh sizes ranging from 0.75 to 3.0 inches was placed in Landa Lake to collect predatory fish of various species and sizes during each quarterly sample. This sampling was conducted to attempt to determine the density of various exotic fish species in Landa Lake and to perform stomach content analyses with particular emphasis on potential predation on endangered species. The gill net was placed in the area previously identified as supporting fountain darters and Comal Springs salamanders through SCUBA surveys. All fish collected in the gill net were identified, enumerated, weighed, and measured. The original intention was to retain a few representative individuals of each species within different size classes; however, sample sizes were smaller than anticipated so all fishes were used in the stomach analysis. Fishes collected in the field were stored on crushed ice until transferred to the SWT Aquatic Center or the BIO-WEST Nekton Laboratory where the stomachs were removed and contents examined. Although the focus was on fountain darter and/or Comal Springs salamander predation by the various species and size classes, all stomach contents were recorded.

Because of the limited sample sizes obtained during winter and spring quarterly sampling events, rod-and-reel sampling was employed to target larger sunfish and small to intermediate-sized bass, which are the most likely piscine predators on the fountain darter and Comal Springs salamander. In addition, fish trapped in the gill net pose problems unique to that method of capture. Those fish are often partially decomposed if entangled soon after the net is placed; the fish have also been known to regurgitate food items upon entanglement and will continue to digest any remaining food items as long as they are trapped. As a result of incorporating rod-and-reel sampling, sample sizes were much larger and many of the problems with gill net sampling were avoided. Both techniques will continue to be used in future quarterly and critical period sampling on the Comal Springs ecosystem.

OBSERVATIONS

The BIO-WEST project team conducted the 2001 sampling events as shown in Table 2.

High-Flow Sampling

High-flow sampling produced interesting data for each included sampling components. The results and conclusions for each will be discussed in the representative sections.

Springflow

Daily 2001 springflow averages were generally higher than in 2000; for instance, discharge in the Comal ecosystem barely dropped to below 250 cfs in 2001, while it decreased to below 150 cfs in 2000 (Figure 2). As a result the 2001 quarterly sampling events were conducted at higher springflows than those conducted in 2000. Specifically, the winter and fall quarterly sampling events were carried out during higher-than-average springflow conditions for those times of year because of wetter-than-normal conditions and several high-intensity rain events (Figures 2 and 3). The spring and summer sample events were conducted under conditions that were more representative of normal conditions, with a relatively wet spring and decreasing springflow beginning around March. The summer was typical with periods of little-to-no rainfall between June and mid August, which dropped the springflow levels to about average for that time of year. The higher flows experienced overall in 2001 meant that no critical period low-flow sampling events were triggered.

Water Quality

Hydrolab profiles were conducted at all 15 sites during each quarterly sample, while water quality data were collected at only 12 of the sites (Figure 1). The water quality sites were as follows:

Blieder's Creek (BC),
Heildelburg (HMC) (furthest upstream site in Comal River),
Booneville 1 (IPF) (far channel of Island Park),
Booneville 2 (IPN) (near channel of Island Park),
Spring Run 1 (SR1) (spring furthest from the lake proper),
Spring Run 2 (SR2) (spring running parallel Spring 1),
Spring Run 3 (SR3) (spring closest to Landa Lake),
New Channel 1 (NCU) (located across from the park office),
New Channel 2 (NCD) (located upstream of the confluence of the old and new channel),
Old Channel 1 (OCU) (located in the Schlitterbahn employee parking area by the railroad trestle),
Old Channel 2 (OCD) (upstream of footbridge before the confluence with the New Channel), and
"The Other Place" Lodges (OP) (farthest downstream site).

Hydrolab profiles only were taken at the confluence of Spring Runs 1 and 2, the bank of Landa Lake, and a downstream section of Spring Run 1. In the Comal ecosystem, water quality sites were visited from upstream in the early hours of the day toward downstream sites in the late morning and early afternoon.

Table 2. Components of 2001 sampling events.

EVENT	DATES	EVENT	DATES
Winter Sampling		**High-Flow 1 Sampling**	
Water Quality Sampling	Mar 21	Vegetation Mapping	Sep 18-19
Vegetation Mapping	Mar 12-15	Fountain Darter Sampling	Oct 1-3
Fountain Darter Sampling	Mar 19-21	Comal Salamander Observations	Sep 19, 24
Comal Salamander Observations	Mar 15-16	Exotic / Predation Study	Oct 2-3
Macroinvertebrate Sampling	Mar 20		
Exotic / Predation Study	Mar 21-22		
Spring Sampling		**Fall Sampling**	
Water Quality Sampling	May 24	Water Quality Sampling	Nov 8
Vegetation Mapping	May 14-17	Vegetation Mapping	Oct 29, 31; Nov 1
Fountain Darter Sampling	May 21-24	Fountain Darter Sampling	Nov 5-8
Comal Salamander Observations	May 17-18	Comal Salamander Observations	Nov 8-9
Macroinvertebrate Sampling	May 23	Macroinvertebrate Sampling	Nov 6
Exotic / Predation Study	May 22-23	Exotic / Predation Study	Nov 7-8
Summer Sampling		**High-Flow 2 Sampling**	
Water Quality Sampling	Aug 27	Vegetation Mapping	Nov 27
Vegetation Mapping	Aug 20-23	Fountain Darter Sampling	Nov 27-29
Fountain Darter Sampling	Aug 27-30	Comal Salamander Observations	Nov 29-30
Comal Salamander Observations	Aug 23-24	Exotic / Predation Study	Nov 29-30
Macroinvertebrate Sampling	Sep 12		
Exotic / Predation Study	Aug 29-30		

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Heildelburg 2 (furthest upstream site);
Heildelburg 1 (a.k.a. Blieder's Creek);
Spring Run 1 (spring furthest from the lake proper);
Spring Run 2 (spring running parallel Spring 1);
Spring Run 3 (spring closest to Landa Lake);
Booneville 1 (far channel of Island Park);
Booneville 2 (near channel of Island Park);
New Channel 1 (located across from the park office);
New Channel 2 (located upstream of the confluence of the old and new channel);
Old Channel 1 (located in the Schlitterbahn employee parking area by the railroad trestle);
Old Channel 2 (upstream of footbridge before the confluence with the New Channel); and
Iverness Park ("The Other Place" farthest downstream site).

Hydrolab profiles only were taken at the confluence of Spring Runs 1 and 2, the bank of Landa Lake, and a downstream section of Spring Run 1. In the Comal ecosystem, water quality sites were visited from upstream in the early hours of the day toward downstream sites in the late morning and early afternoon.

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Comal Salamander Observations	Aug 23-24	Exotic / Predation Study	Nov 29-30
Macroinvertebrate Sampling	Sep 12		
Exotic / Predation Study	Aug 29-30		

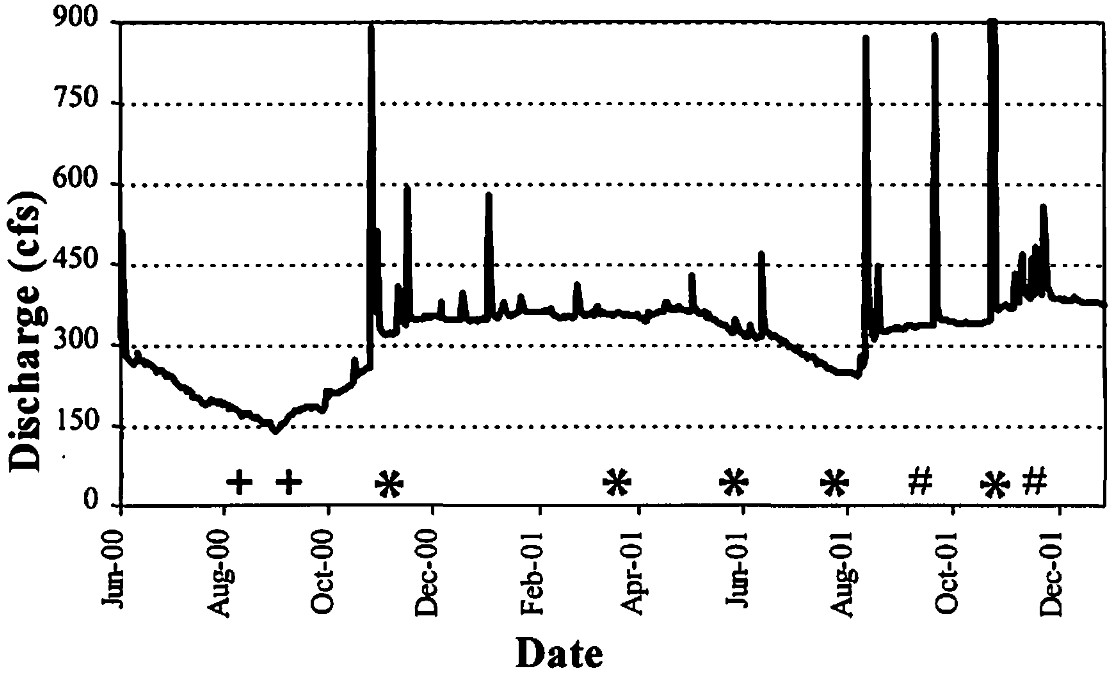

Figure 2. Mean daily discharge in the Comal River during the study period; approximate dates for quarterly (*), low (+), and high-flow (#) sampling events are indicated.

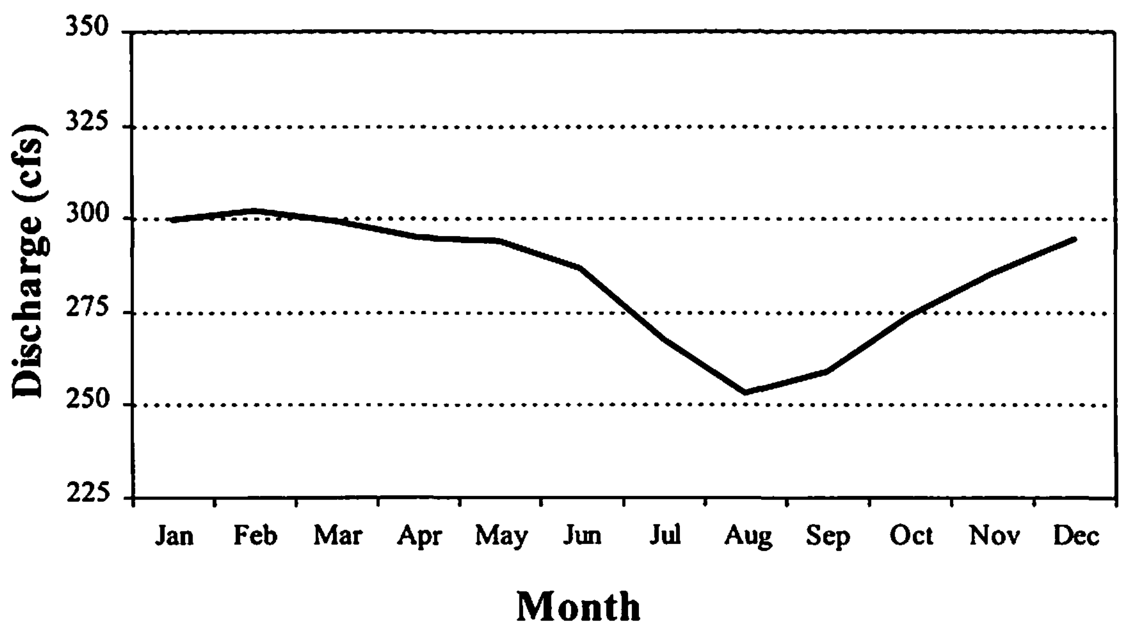

Figure 3. Mean monthly discharge in the Comal River during the 1934-1996 period of record.

A summary of the water quality data for this project is presented in Tables 3 and 4; graphs of thermistor data for important/representative reaches are presented in Figures 4-7. A more detailed list of data for each sample, along with all thermistor graphs can be found in Appendix B.

The period covered by this analysis is less than 2 years, in which the first year (2000) was an extremely dry year and the second year was much closer to a statistical median or "average" year. Therefore, the discussion of this water quality data using any sort of trend analysis is not feasible at this time. The Comal ecosystem can be characterized as an ecosystem of very high water quality for the chemical and physical variables that were measured. Nutrient concentrations were relatively constant, and can be characterized by about 2 mg/L NO3-N and roughly 20 µg/L total phosphorus leaving the springs. There was not a systematic change in these nutrient concentrations as the water moves toward the Guadalupe River. Though this is a preliminary judgement, there is no clear or dramatic change in these variables when comparing the low-flow August and September 2000 data with the following, higher-flow period data.

Water temperature data gathered from thermistors in the Comal ecosystem tend to suggest an ecosystem with high degree of thermal uniformity. Despite some spikes in the data from thermistors being "taken," moved and later recovered, or moved from the water to the air, there is a pretty good seasonal record of temperature variability. In the spring runs it appears that temperatures hardly ever vary more than 1° C throughout the year. Moving downstream, away from the spring sources, variability increases, as would be expected. While the Blieder's Creek station would seem to be the least influenced by the springs (and in fact did exhibit the highest ranges of temperatures of any of our stations), even here temperature and chemical characteristics of the water were apparently moderated by local springs.

Aquatic Vegetation Mapping

Maps of the aquatic vegetation during each sample effort can be found in the Appendix A map pockets. The maps are organized by individual reach with successive sampling trips (quarterly and high flow) ordered chronologically. It is difficult to make sweeping generalizations about seasonal and other trip-to-trip characteristics since most changes occurred in fine detail; however, some of the more interesting observations are described below.

Upper Spring Run Reach

The upper Spring Run Reach appears to be a relatively stable habitat based on these mapping data. There was a significant growth of *Hygrophila* during the springtime, but that species, and all others, remained relatively constant until the high-flow periods. Green algae was common in this stretch during certain periods because of an open canopy and typically slow-moving (lentic) waters; however, the extreme patchiness of that vegetation makes it impossible to map accurately. In general, the algae grew universally throughout the reach during the summer and early fall of both 2000 and 2001, but it was completely washed away during the first high-flow event for each respective year.

Table 3. Summary of physical parameters in the Comal River ecosystem from 2000-2001.

SITE	DEPTH			TEMPERATURE			PH			DISSOLVED OXYGEN			CONDUCTIVITY			TURBIDITY			ALKALINITY		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Spring Run 1	0.54	0.40	0.8	23.39	23.18	23.72	7.23	7.04	7.34	5.53	5.1	6.32	540	504	667	0.74	0.07	1.1	4.066	3.827	4.307
Spring Run 2	0.45	0.30	0.6	23.46	23.14	23.62	7.26	7.13	7.37	5.4	5.02	6.24	540	505	665	0.78	0.09	1.2	4.102	3.937	4.249
Spring Run 3	0.69	0.50	1.3	23.44	23.17	23.58	7.26	7.09	7.42	5.72	5.23	6.84	538	505	665	0.78	0.09	1.2	4.153	4.036	4.293
New Channel, upstream	2.42	2.00	3.0	24	22.61	25.47	7.47	7.32	7.70	8.47	7.17	9.68	540	503	670	1.44	1.1	2	4.157	3.937	4.319
New Channel, downstream	1.86	1.60	2.5	23.87	22.02	25.11	7.66	7.54	7.77	9.41	7.81	10.05	538	502	665	1.43	1.1	2.1	4.232	4.003	4.561
Bleider's Creek	0.86	0.60	1.2	23.37	20.87	25.38	7.36	7.15	7.66	5.93	3.19	10.50	533	500	640	1.77	1.2	3	3.985	3.606	4.118
Heildelburg, Main Channel	0.64	0.40	1.0	24.3	23.67	26.56	7.3	7.19	7.41	5.78	4.48	6.86	544	508	667	1.6	1.1	2.1	4.073	3.937	4.276
Island Park, Far Channel	1.12	0.40	1.5	23.59	22.57	24.11	7.26	7.15	7.37	6.52	5.88	7.88	541	509	672	1.49	1.1	1.7	4.212	3.97	4.356
Island Park, Near Channel	2.39	1.05	3.4	23.66	22.85	23.97	7.26	7.11	7.36	6.11	4.81	8.40	540	508	671	1.21	1	1.5	4.214	3.97	4.381
Old Channel, upstream	0.84	0.60	1.2	23.31	20.39	25.17	7.67	7.48	7.87	7.74	6.12	9.85	543	511	664	1.79	1.4	2.8	4.283	4.003	4.444
Old Channel, downstream	0.68	0.50	1.0	23.72	21.63	26.05	7.63	7.38	7.84	8.34	6.58	9.90	541	505	665	1.83	1.6	2.2	4.218	4.069	4.307
The Other Place (Ivemess)	0.70	0.60	0.8	23.64	21.22	25.51	7.77	7.57	7.89	8.86	6.7	9.75	539	505	662	2.63	1.9	3.2	4.242	4.003	4.405

Table 4. Summary of chemical parameters in the Comal River ecosystem from 2000-2001.

SITE	SOLUBLE REACTIVE PHOSPHORUS (ugP/l)			TOTAL PHOSPHORUS (ug/l)			AMMONIUM (ug/L)			NITRATE (mg/L)			T NITROGEN (mg/L)			TOTAL SUSPENDED SOLIDS (mg/L)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Spring Run 1	7.26	2.79	17.03	20.44	9.48	37.14	87.26	25.12	165.86	2.14	1.98	2.48	2.09	1.24	2.76	0.0071	0.004	0.018
Spring Run 2	6.84	2.61	11.92	18.51	12.35	26.45	58.31	21.00	138.62	2.05	1.84	2.25	1.93	1.06	2.32	0.007	0.0003	0.022
Spring Run 3	6.54	3.31	13.11	14.81	8.52	21.97	86.30	24.96	159.05	2.07	1.74	2.37	2.09	1.21	2.52	0.0093	0.0001	0.021
New Channel, upstream	7.22	1.53	25.08	18.70	6.45	45.41	49.93	11.00	168.00	1.96	1.73	2.19	2.15	1.71	2.39	0.018	0.003	0.038
New Channel, downstream	7.09	2.09	12.09	18.67	8.86	23.35	52.10	29.00	106.84	1.84	1.26	2.25	2.02	1.28	2.34	0.0161	0.004	0.044
Bleider's Creek	8.79	2.21	21.96	22.86	8.17	41.97	142.90	56.00	283.90	1.73	1.32	2.23	1.89	1.36	2.41	0.0204	0.006	0.026
Heildelburg, Main Channel	6.70	2.26	15.67	14.58	7.83	23.35	109.92	20.58	199.91	1.94	1.65	2.21	2.06	1.28	2.38	0.0228	0.018	0.028
Island Park, Far Channel	5.24	2.55	11.32	20.81	10.7	47.83	48.96	10.00	188.56	1.92	1.56	2.24	1.95	0.92	2.4	0.0177	0.004	0.049
Island Park, Near Channel	6.52	1.87	10.80	19.25	7.07	34.03	64.55	13.77	288.44	2.49	1.46	5.97	1.87	0.62	2.37	0.0114	0.005	0.018
Old Channel, upstream	11.45	5.75	26.73	22.39	9.45	35.07	46.07	11.50	131.81	1.81	1.61	2.08	1.87	1.38	2.21	0.0413	0.008	0.164
Old Channel, downstream	6.43	2.44	10.71	46.37	15.59	188.86	43.99	9.00	134.08	1.97	1.64	2.22	1.88	0.63	2.42	0.0653	0.002	0.366
The Other Place (Ivemess)	6.42	1.36	10.71	15.00	2.66	29.55	73.90	20.58	202.00	2.56	1.62	5.83	2.05	1.00	2.55	0.0159	0.005	0.028

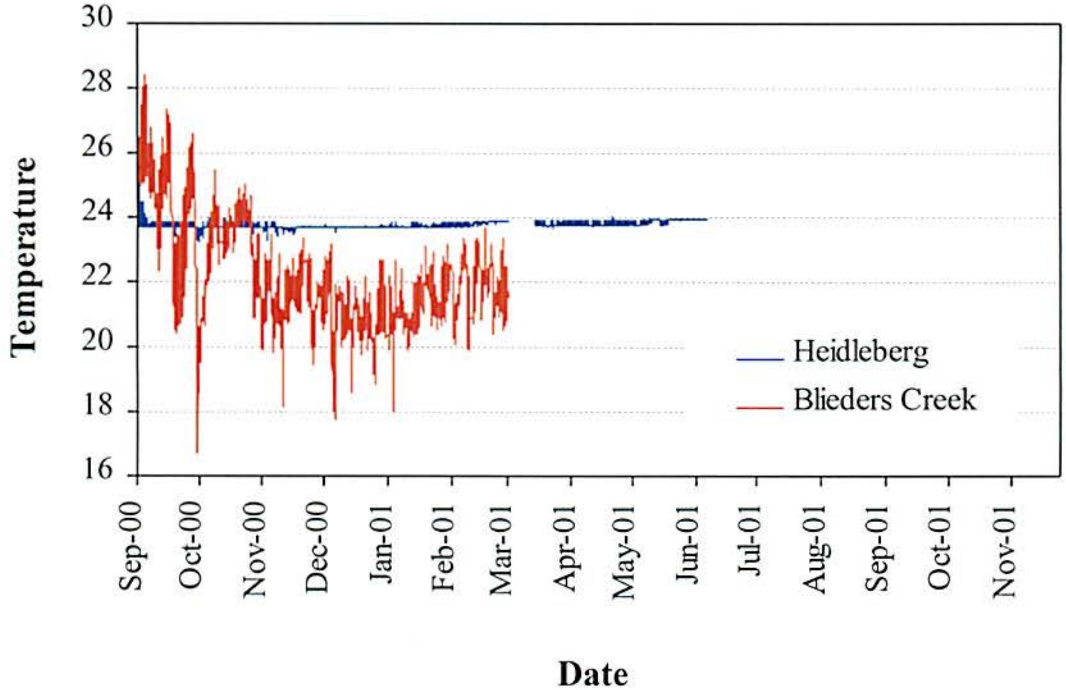

Figure 4. Thermistor data from the Blieder's Creek / Heidleberg Lodge areas.

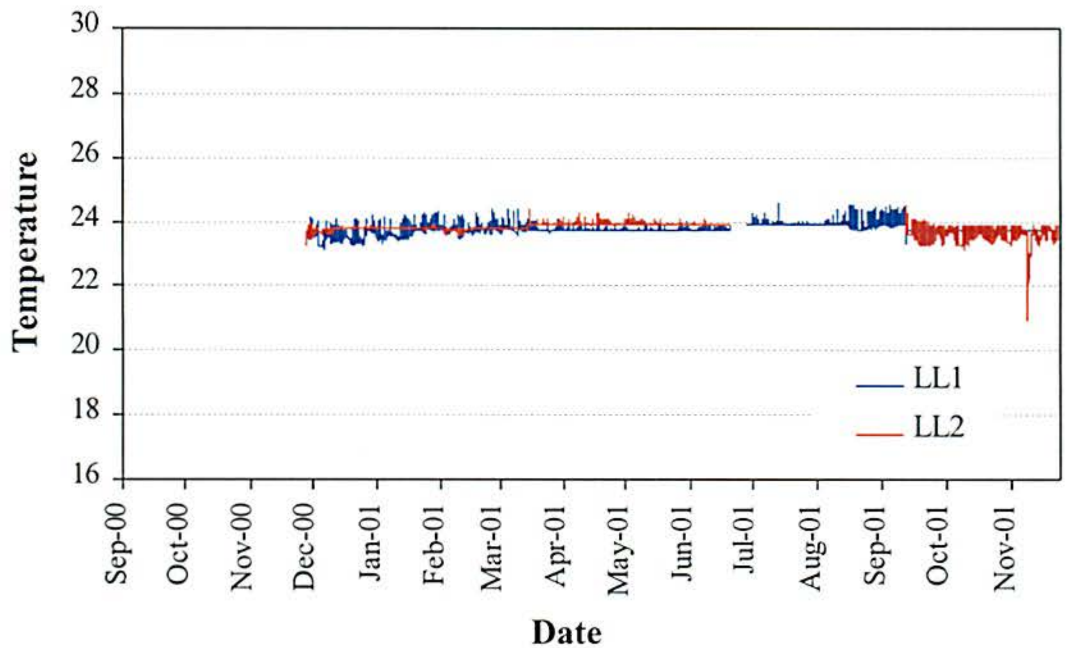

Figure 5. Thermistor data from the two Landa Lake bottom thermistors. Both were located in the deepest portion of Landa Lake at a depth of approximately 2.4 m.

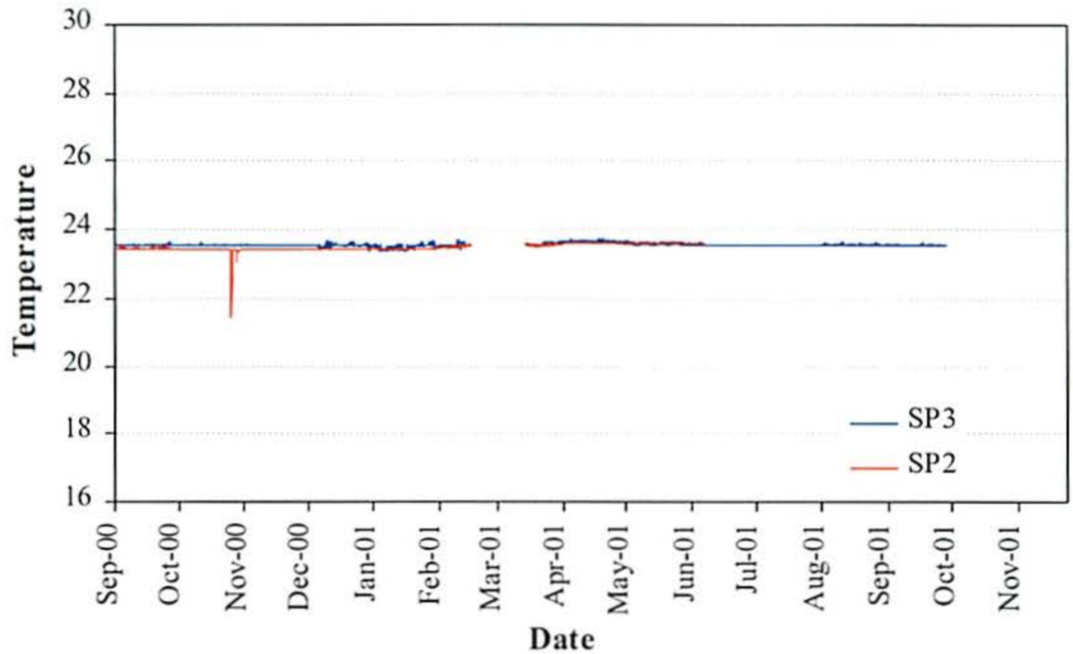

Figure 6. Thermistor data from Spring Runs 2 and 3.

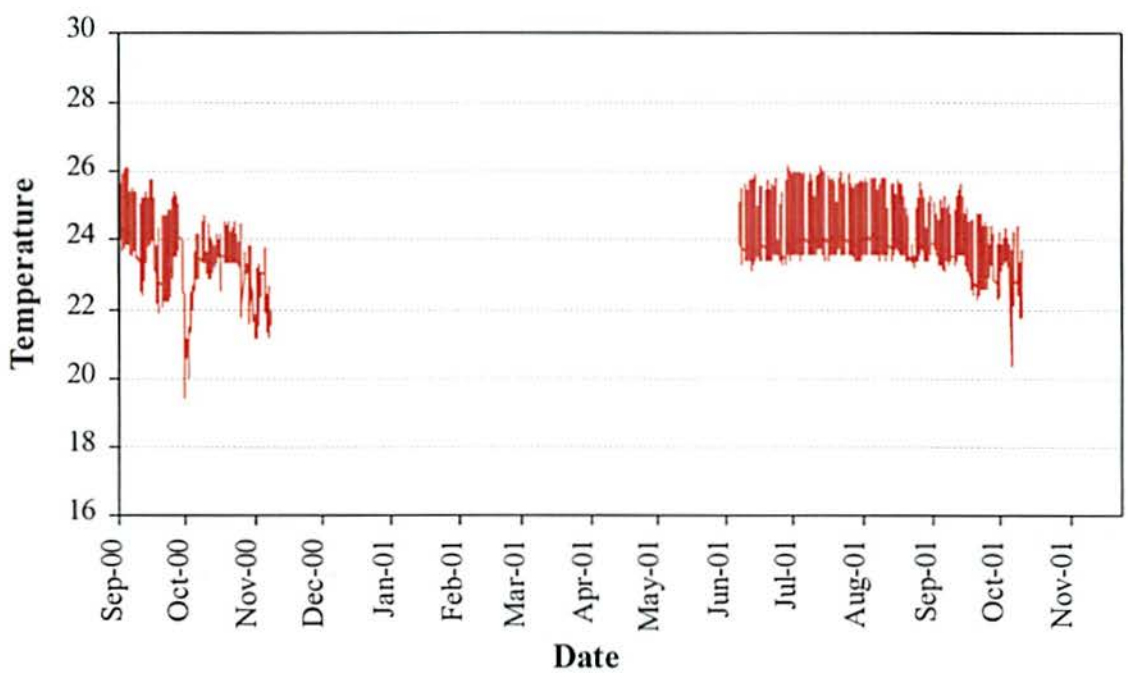

Figure 7. Thermistor data from the Old Channel.

The first high-flow event (2001) also had a significant impact on the *Riccia* coverage. That species was first mapped in the summer (2001) when the green algae was relatively abundant, but some *Riccia* patches were apparently missed. The next time the area was mapped was after the first high-flow event, and the largest patch of *Riccia* had decreased by approximately 75%. A couple of other patches "appeared" during this sample, but these were generally not very dense (i.e., 50% coverage or less). Those patches were apparently overlooked during the summer; most likely, they were covered with green algae at that time. None of the other vegetation appeared to be affected to any degree by the first high-flow event.

In contrast, the second high-flow event had a more drastic impact on all of the vegetation in this reach. There were large areas scoured within larger patches of *Hygrophila* and *Sagittaria*, and a significant portion of the *Riccia* was removed. It should be noted that a large tree covered a portion of the river where *Riccia* had previously been present, but because there was no way to ascertain whether it persisted in this area it was not included. It will be interesting to monitor the recovery of the vegetation in this reach if flows return to more normative conditions in 2002.

Landa Lake Reach

Landa Lake is a complex reach encompassing many different habitat types. There are several vegetation types within the reach, but it is clearly dominated by a pure stand of *Vallisneria*. There is also a large patch of pure *Hygrophila* that is firmly anchored in the middle of the reach between the three islands. Neither of these two patches exhibited much change during the quarterly sampling events. Other, smaller patches of *Hygrophila*, and the similar native species *Ludwigia* did vary seasonally. Between fall 2000 and spring 2001, both *Hygrophila* and *Ludwigia* increased in total coverage. This changed, however, between the spring and summer when both exhibited a marked decrease in coverage. Virtually all *Hygrophila* patches other than the large middle patch disappeared, as did most of the smaller *Ludwigia* patches at the upstream-most edge of the reach. At this time there is no explanation other than natural occurrences and/or the potential of accidental removal by paddleboats in these predominately shallow areas. The large *Hygrophila* patch in the middle is also in shallow water, but the density of the vegetation in this area undoubtedly presents a sufficient deterrent to the paddleboats. Similar to *Hygrophila*, the larger *Lugwigia* patch (found in deeper water) around the center island was relatively unaffected and even expanded during this time period.

The effects of high flows were highly localized in this reach. The first high-flow event had relatively little impact other than displacing green algae and some *Riccia*, which was redistributed to other areas in addition to slightly decreasing the large *Hygrophila* patch. The second high-flow event had a more obvious impact. There was more of a scouring effect on the *Hygrophila* and large *Ludwigia* patches in the middle of the reach where the water apparently attained a high velocity over shallow habitat. *Riccia* was also noticeably altered. In addition to scouring some areas completely and redistributing of the *Riccia*, most areas where the species had been very dense (i.e., <1 m deep) were reduced to minimal coverage. In addition, many places that previously had 100% coverage reduced to 40-70% coverage. Although the total coverage as indicated on the map was not decreased, the distribution and density of the species changed with this event.

Sagittaria, *Nuphar*, and *Vallisneria* were all minimally impacted by high flows. These species often occupy deeper habitats where the water velocity is likely dispersed, but even in shallow areas these species seem resistant to the scouring effects of flooding events. *Cabomba* did show some signs of thinning in areas, but it too was largely unaffected by the increased flow.

Old Channel Reach

Of the four reaches, the Old Channel is the most stable habitat with a structure (culvert) that regulates flow through this section at approximately 40 cfs (P. Connor, USFWS, pers. comm.). This is apparent with the relatively stable distribution and abundance of the two species of macrophytes that are found there. *Nuphar* remained very similar in its distribution throughout all samples and *Ceratopteris* exhibited some variation in distribution between seasons, but the only clear impact was during the second high-flow event. The first high-flow event did not involve a marked increase in flow in this reach, but the second event in November involved enough rain that lateral flow from runoff contributed significantly to this reach. The result of that event was a much more patchy distribution of *Ceratopteris*. In addition, the high-flow event dramatically reduced the amount of filamentous algae present in this ecosystem. We observed the algae was declining through the fall by dying and sloughing off in a systematic fashion, but the overwhelming effect of the flood was to hasten this process and leave the area with minimal algae remaining. This is significant because of the importance of this vegetation to fountain darters. Following that high-flow event, fountain darters were more concentrated than had been observed during any previous trip.

New Channel Reach

The New Channel Reach is divided into two sections, with both being dominated by *Hygrophila*. In the lower reach *Hygrophila* was almost the exclusive vegetation type early in the year, and it increased during the springtime to fill in some of the open areas along the southern shoreline. *Cabomba* also increased during the spring and summer until it was fairly abundant during the summer sampling (August). The effects of the first high-flow event are obvious from the large areas of bare substrate that appear on the map (see Appendix A), but the effect is not necessarily apparent in the change of percent coverage of *Hygrophila* (decreased by only 9.4%). *Cabomba* was relatively unaffected by the higher flows. By the fall sample, though, much of the impact of the flooding is not apparent on the map. This is because the reach had begun to recover and many of the previously bare areas were covered with 30-50% vegetation and thus mapped as a pure stand.

The upper section of the New Channel also exhibited a marked increase in *Cabomba* during the spring and summer months. This was accompanied by some increase in *Hygrophila* and only a minimal increase in *Ludwigia*. The first high-flow event had an obvious scouring effect on the *Hygrophila*, particularly along the northern shoreline (outer edge of the bend) where it became very patchy. There also appeared to be some reduction in the *Cabomba* and *Ludwigia* between the summer and fall sampling events.

The successive rain events following the second high-flow event maintained the New Channel at levels that prevented mapping during that sampling effort. However, the excessive amount of vegetation entangled around light posts, railings, and trash cans along bank areas supported the assumption that considerably more vegetation was removed from this reach during the second high-flow event. In addition, a considerable amount of debris was deposited along the bottom of the New Channel.

Fountain Darter Sampling

Drop Nets

The number of drop net sites and vegetation types sampled per reach is presented in Table 5.

Table 5. Drop net sites and vegetation types sampled per reach.

UPPER SPRING RUN REACH	LANDA LAKE	NEW CHANNEL	OLD CHANNEL
Open / *Riccia*[a] (2)	Open / *Riccia*[a] (2)	*Hygrophila* (3)	Open (2)
Open / *Riccia*[a] (2)	*Hygrophila* (2)		Algae (2)
Hygrophila (2)	*Cabomba* (2)		*Ceratopteris* (2)
	Vallisneria (2)		
	Ludwigia (2)		
Total (6)	**Total (10)**	**Total (3)**	**Total (6)**

[a] Switched to *Riccia*, Summer 2001.

The drop net site locations are depicted on the aquatic vegetation maps (Appendix A) for the respective reaches per sample event. The data sheets for the drop net sampling are presented in Appendix C (bound separately) by reach and specific site, respectively.

The size class distribution for fountain darters collected by drop nets from the Comal ecosystem is presented in Figure 8. The overall distribution is typical of a healthy fish assemblage. As discussed below in the dip net section, the size class distribution in the Old Channel has remained stable throughout the study period, whereas the other reaches have experienced reproductive peaks with corresponding shifts in the size class distribution. It is impossible at this point in the study to discern why this is occurring because of the multiple factors (abundant food supply, preferred vegetation type, consistent flow regime, heaviest parasite infection, etc.) experienced in the Old Channel.

One preliminary trend observed from the number of fountain darters collected during each sampling event (Figure 9) was a decreasing total population in each reach in fall of both years. It is interesting to note that the fall 2000 sample followed a period of low flow while the fall 2001 sample followed a period of considerably higher flow, yet the decreasing trend occurred in all reaches during both sample periods. It should also be noted that although the fall 2000 sampling event followed a period of low flows in the summer, the actual sampling event was conducted immediately following a major rainfall event during which the flows increased significantly. Therefore, the decline in fountain darter numbers observed during the fall 2000 sampling event may be attributed to the distribution of the species relative to a recent high-flow disturbance rather than an actual decrease in the population size. Regardless, the same trend was repeated in fall 2001 under a different set of flow conditions, which raises the possibility that the decrease in fountain darter numbers during the fall is related to other environmental variables or combinations thereof.

The greatest number of fountain darters was collected in spring 2001, which coincides with the reproductive peak for most reaches (only the Old Channel did not appear to have a particular peak in reproduction). Competing theories have been reported in the literature regarding the wild fountain darters reproductive cycles; some researchers support continuous spawning (Strawn 1956, Hubbs 1985) while others have noted peaks in reproductive activity (Schenck and Whiteside 1977). Our data support both theories and suggest that the mode of reproduction may depend upon local conditions. Another shift in the density of fountain darters collected was noted following a change in the sampling protocol in which *Riccia* was added as one of the vegetation types sampled and the open sites were dropped, which is why this vegetation type is presented separately on the graph (Figure 9).

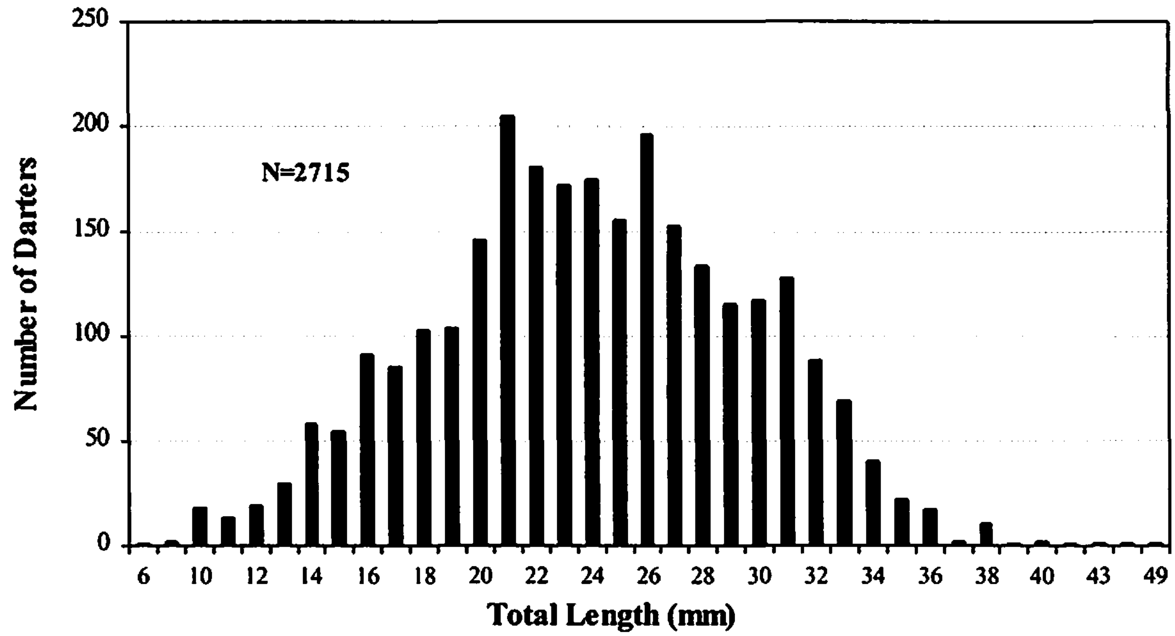

Figure 8. Fountain darter size class distribution among all drop net sampling events.

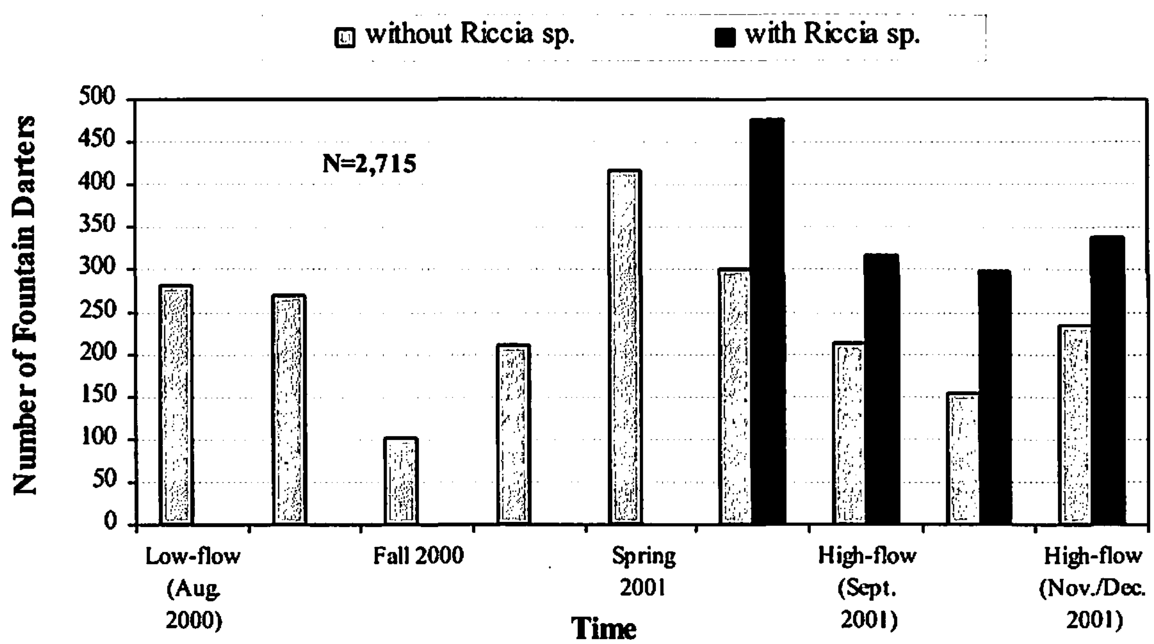

Figure 9. Number of fountain darters collected by drop net sample. When *Riccia* was sampled, the data are displayed separately with and without the *Riccia* sites included in the total for comparison with earlier samples.

At first glance the two high-flow events appear to yield contradictory results in numbers of fountain darters, with fewer collected after high-flow 1 and more collected after high-flow 2. One possible conclusion is that the reduction during the high-flow 1 sampling event may have been somehow related to the aforementioned pattern experienced in the fall of both years, whereas the higher numbers obtained following the second high-flow event represent more of a clumping (concentration) effect resulting from the greater loss of vegetation during that event. It was evident during the high-flow 2 event, especially in the Old Channel, that the amount of preferred habitat was greatly reduced. An approximation of the total population in the Old Channel from the high-flow 2 sample indicates that the total population was less than the prior sample, although the density of fountain darters in the preferred vegetation was greater. This re-emphasizes the importance of detailed examination of a system to determine the dynamics that dictate both the total population numbers and densities of fountain darters under various conditions rather than a one-time sampling event or limited sampling during particular seasons.

A breakdown of fountain darter density per vegetation type is present in Figure 10. The preferred habitats are *Riccia* (36 per m^2), which is primarily found in Landa Lake, and filamentous algae (28 per m^2), which is the primary vegetation type in the Old Channel. These vegetation types are likely preferred because of the cover provided at the substrate level and the high numbers of amphipods, which provide the fountain darters with an ample food supply. Other vegetation types, such as *Ludwigia*, *Cabomba*, and *Hygrophila*, in Landa Lake yielded >10 fountain darters per m^2. It is interesting to note that the *Cabomba* in Landa Lake grows in very silty substrate, often several centimeters deep. This association of a spring-adapted species with the lentic conditions and silty substrate is unusual and may indicate a greater tolerance of fountain darters to various habitat conditions compared with other spring-adapted species. *Sagittaria* was the only vegetation type yielding no fountain darters, although it was only sampled in the upper Spring Run Reach.

Table 6 lists the fish species collected in all 2001 drop net sampling conducted in the Comal ecosystem. In all, 21 species of fish totaling 21,368 individuals were collected. Of the 21 species, 7 are considered introduced (exotic) to the Comal ecosystem.

The giant ramshorn snail was also recorded and measured in each drop net location. Figure 11 shows the densities of live giant ramshorn snails by vegetation type in the Comal ecosystem. The greatest density was 2.53 snails per m^2 in *Ludwigia*, followed by *Vallisneria* (1.38 m^2) and *Hygrophila* (0.89 m^2). The two preferred fountain darter vegetation types (*Riccia* and filamentous algae) had essentially no giant ramshorn snails present. In the past, the giant ramshorn snails were observed in far greater densities than those reported here. For perspective, the maximum value on the y-axis of Figure 11 is 10 m^2, which was among the lowest concentrations reported in the early 1990s when the giant ramshorn snail population was booming (T. Arsuffi, SWT aquatic ecologist, pers. comm.). During that period the greatest giant ramshorn snail density was near 400 snails per m^2, and the vegetative community was literally being devoured (T. Arsuffi pers. comm.). By all indications the densities of giant ramshorn snails observed in the Comal ecosystem during the study period to date (including the 2000 low-flow events) pose no serious threat to the aquatic vegetative community. However, because of the impact that this exotic species can have under heavier densities, close monitoring should continue.

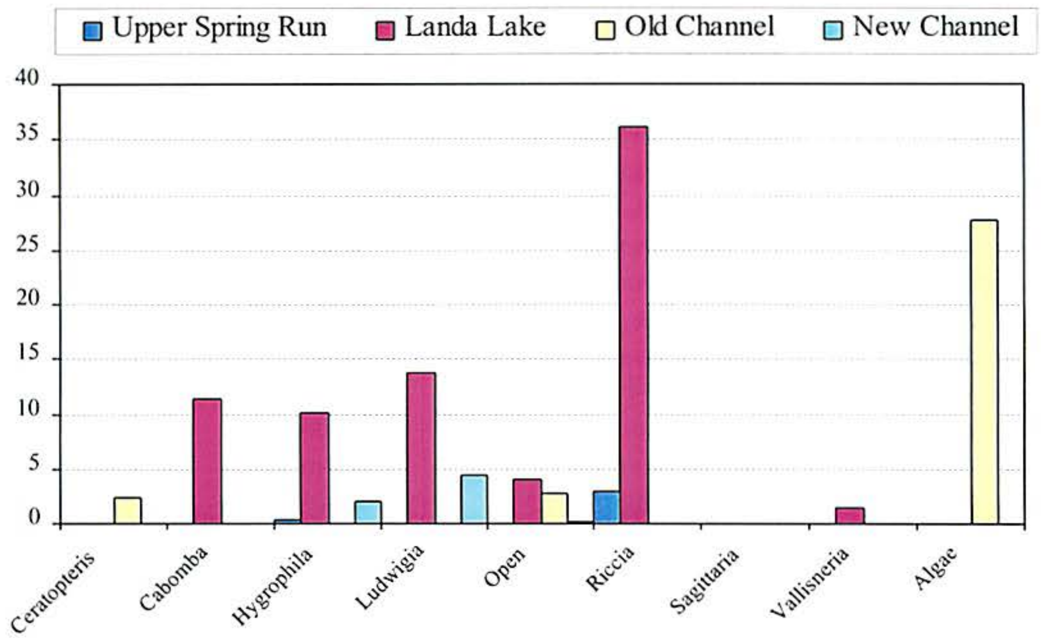

Figure 10. Density of fountain darters collected by vegetation type.

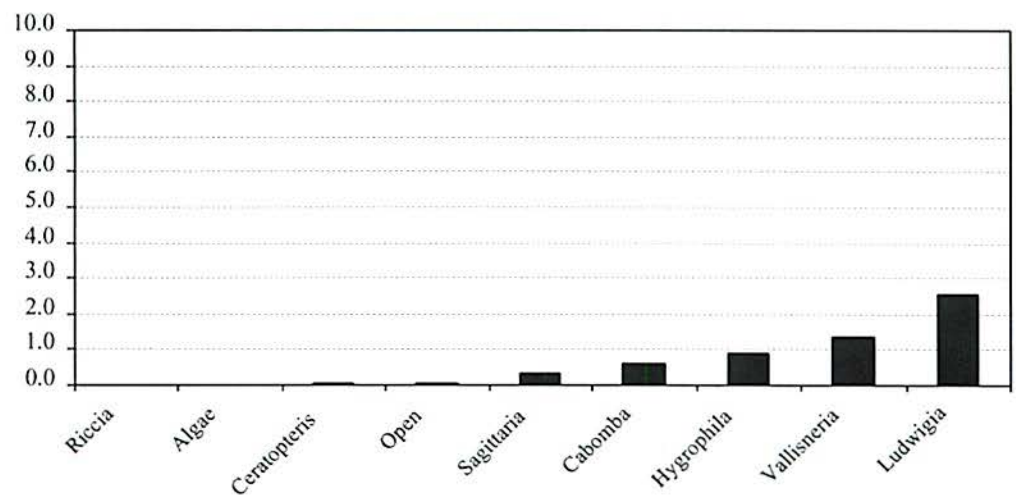

Figure 11. Density of giant ramshorn snail by vegetation type (averaged across all sites).

Table 6. Fish species and the number of each collected during 2001 drop net sampling.

COMMON NAME	SCIENTIFIC NAME	STATUS	TOTAL NUMBER
Rock bass	*Ambloplites rupestris*	Introduced	7
Black bullhead	*Amelurus melas*	Native	1
Yellow bullhead	*Amelurus natalis*	Native	7
Mexican tetra	*Astyanax mexicanus*	Introduced	83
Rio Grande perch	*Cichlasoma cyanoguttatum*	Introduced	113
Roundnose minnow	*Dionda episcopa*	Native	15
Minnow species	*Dionda* sp.	Native	48
Fountain Darter	*Etheostoma fonticola*	Native	2,058
Greenthroat darter	*Etheostoma lepidum*	Native	8
Gambusia	*Gambusia* sp.	Native	17,264
Suckermouth catfish	*Hypostomus plecostomus*	Introduced	36
Redbreast sunfish	*Lepomis auritus*	Introduced	71
Green sunfish	*Lepomis cyanellus*	Native	4
Warmouth	*Lepomis gulosus*	Native	13
Bluegill	*Lepomis macrochirus*	Native	21
Longear sunfish	*Lepomis megalotis*	Native	28
Spotted sunfish	*Lepomis punctatus*	Native	220
Sunfish	*Lepomis* sp.	Native	288
Largemouth bass	*Micropterus salmoides*	Native	28
Bass species	*Micropterus* sp.	Native	2
Texas shiner	*Notropis amabilis*	Native	9
Shiner species	*Notropis* sp.	Native	2
Sailfin molly	*Poecilia latipinna*	Introduced	1,038
Tilapia	*Tilapia* sp.	Introduced	4

Dip Nets

The boundaries for each section of the dip net collection efforts are depicted on Figure 12. Data gathered using dip nets for all sections are graphically represented in Appendix B. High water and turbid conditions prevented the collection activities from the New Channel and Garden Street sites on a few occasions. The dip netting effort resulted in fountain darters being collected from all sections during every sampling event.

As with the drop net results, the stability of the fountain darter population in the Old Channel section (Figure 13) clearly differed from the rest of the sites. To date, there has been a consistent size class distribution in the Old Channel throughout the study period, including during the two low-flow events in 2000 and following the two high-flow events in 2001. The year-round reproductive consistency exhibited in the Old Channel throughout the study period also differs from the other locations. For this analysis reproduction is considered to be occurring if fish 5-15 mm in length are being collected.

Relative to the fountain darter growth curves established by Brandt et al. (1993), our size category of 5-15 mm darters represents darters <58 days old. For the remaining sections, there was an evident peak in reproduction during the spring.

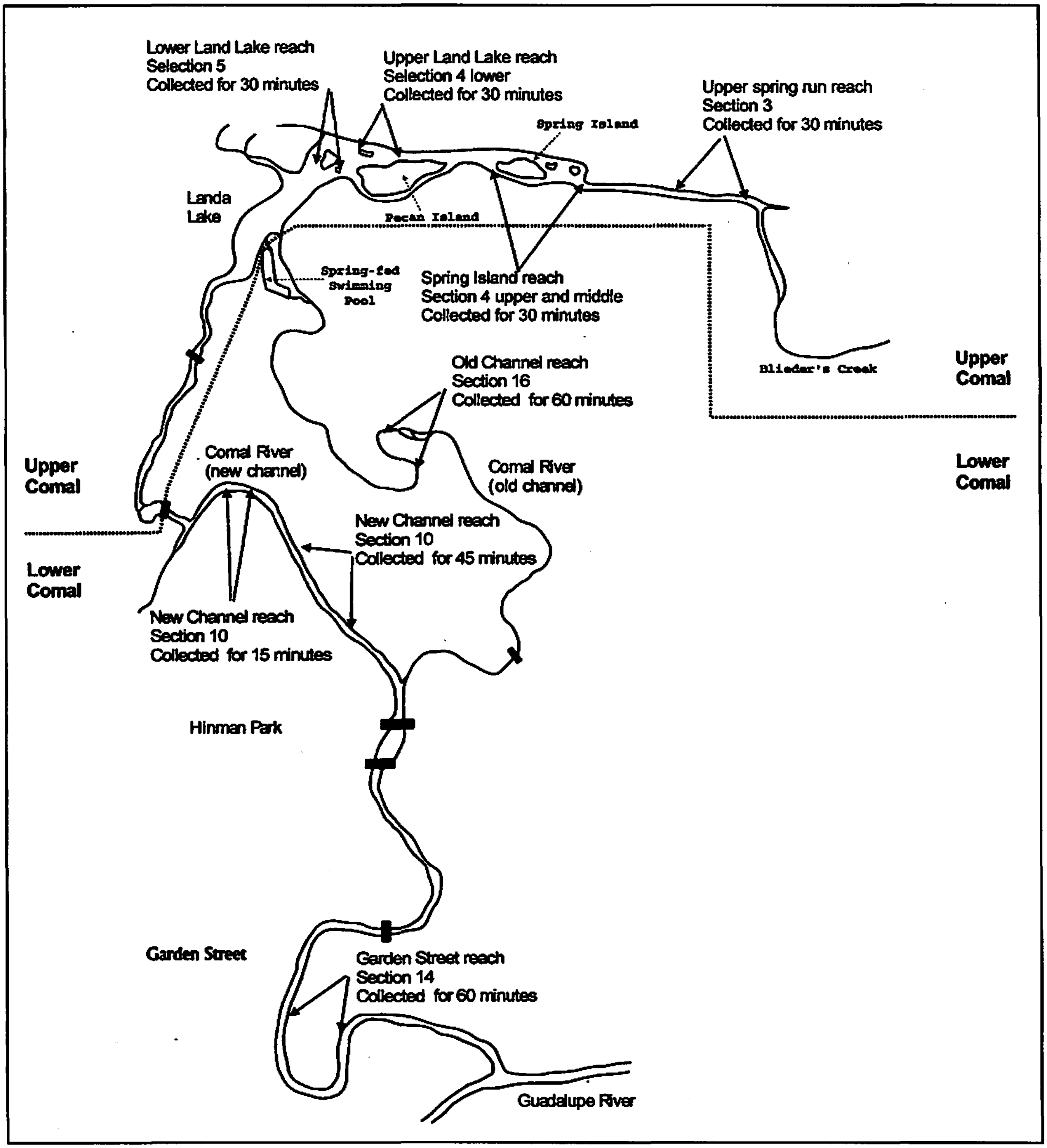

Figure 12. Areas where fountain darters were collected with dip nets, measured, and released in the Comal River.

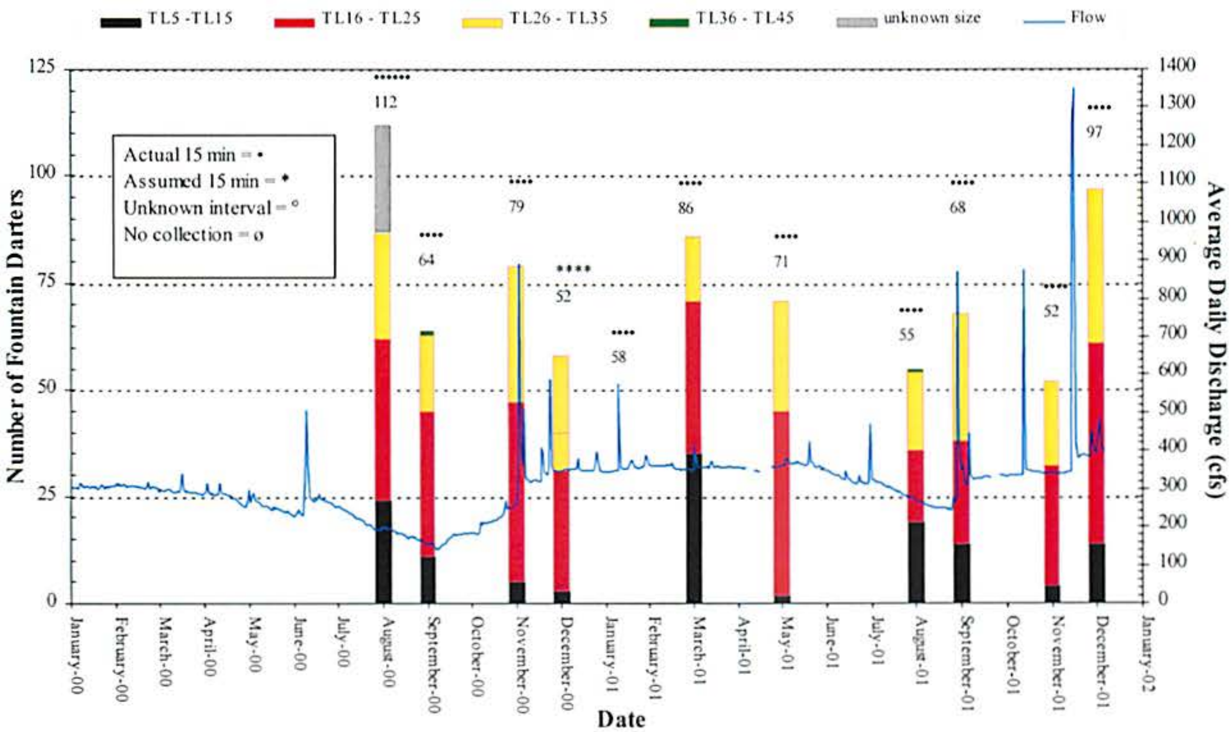

Figure 13. Number of fountain darters collected from the Old Channel Reach (section 16) using dip nets.

Overall, these findings generally coincide with the findings of the drop net sampling. However, it is still premature to try and correlate these data directly with overall flow conditions in the Comal ecosystem.

Minnow Traps

Fountain darters do not appear to be conducive to the capture methods involving minnow traps used to date. Despite the limited success using various trap designs thus far, evaluation of nondestructive sampling methods will continue to be explored during the remainder of this project. Monitoring will be an essential component of any adaptive management plan, and nondestructive methods of sampling will need to be found. The BIO-WEST project team will continue to work with other trap designs and conduct more underwater observations.

Visual Observations

Fountain darters were observed in the deepest portions of Landa Lake (depths greater than 2 m) during each sampling event, including the two low-flow events in 2000 and following the two high-flow events in 2001. Fountain darters were observed throughout the reach in bare areas and surrounding vegetation, with the greatest concentrations occurring near areas with *Riccia*. Throughout the study period, the fountain darter population has remained consistently abundant in these deeper areas of Landa Lake. The quantitative sampling results are limited to a single grid per sampling event (summer, high-flow 1, fall, and high-flow 2); therefore, the numbers are only suggestive of what the true population size might be in the area sampled. Table 7 shows the number of fountain darters observed in the 7.8 m^2 grid per sampling event.

Table 7. The number of fountain darters observed per grid/sampling event.

SAMPLE DATE	NUMBER OF FOUNTAIN DARTERS	PERCENT RICCIA WITHIN GRID
Summer 2001	24	50
High-flow 1	31	50
Fall 2001	44	65
High-flow 2	39	60

These quantitative results support the consistency in the population and importance of aquatic vegetation. Our observations continue to reinforce the hypotheses that (1) Landa Lake is an integral component to the habitat of species found in the Comal Springs ecosystem, and (2) a sizable portion of the fountain darter population is found there.

Visual surveys also were conducted in the New Channel Reach; fountain darters were present in suitable habitat areas during sampling periods. There is a great disparity in the amount of suitable habitat between Landa Lake and the New Channel Reach with significantly less habitat occurring in the latter. Not surprisingly, the number of fountain darters observed was also considerably less in the New Channel Reach.

Gill Parasite Evaluation

During 2001, two preliminary trials, one with fingerling largemouth bass (summer 2001, Figure 14) and the other with adult fountain darters (late fall, Figure 15) were conducted to determine the protocol to be used in the more extensive experiments that will be conducted in 2002. These trials showed that caged fish of both species became infected with the parasite in greater densities over time (R^2 = 0.92 and 0.80 for largemouth bass and fountain darters, respectively). Although both species were infected at a greater

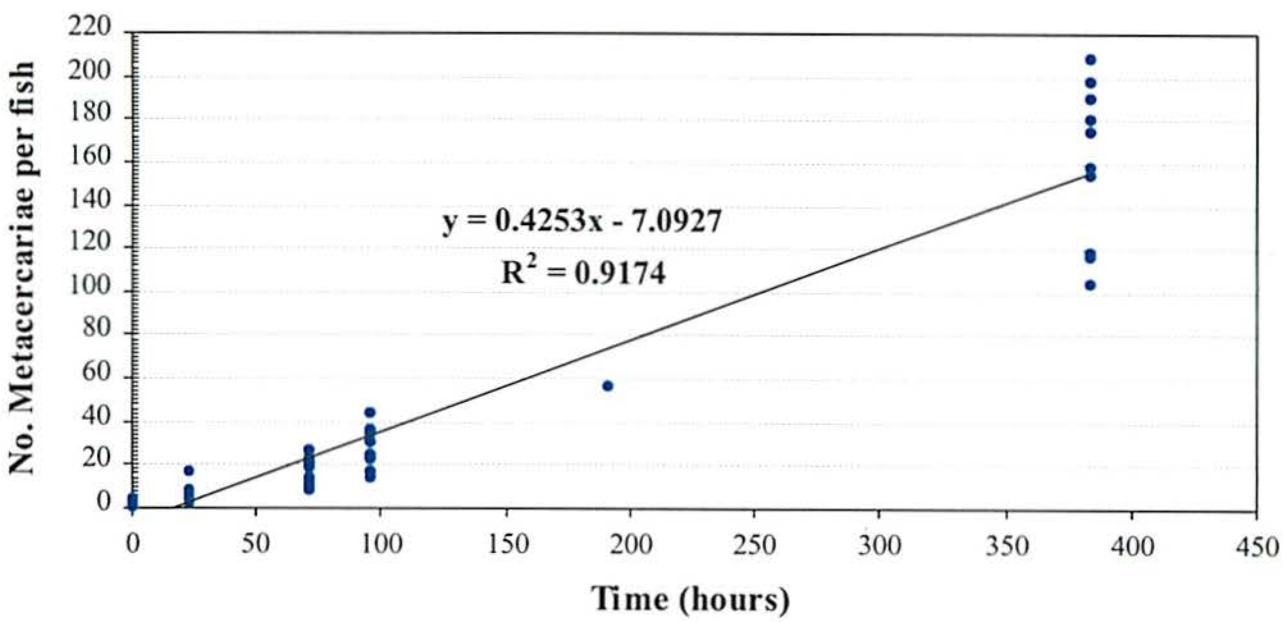

Figure 14. Infection rate of largemouth bass in the Comal River Old Channel Reach (summer 2001).

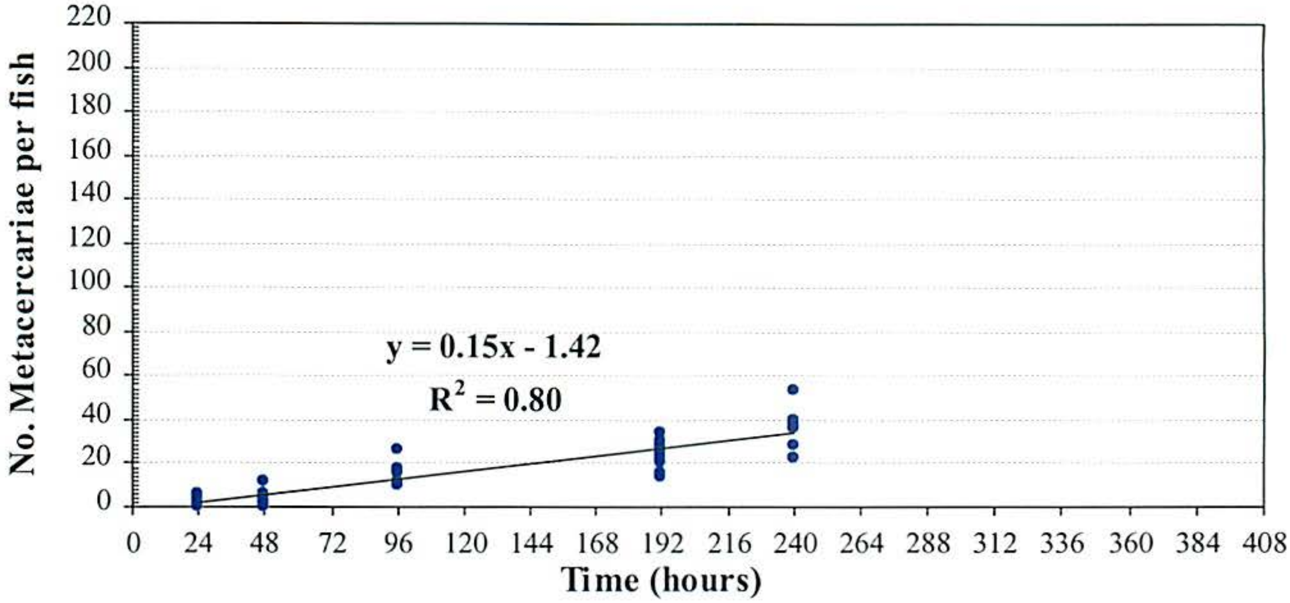

Figure 15. Infection rate of fountain darters in the Comal River Old Channel Reach (fall 2001).

density over time, the increase was much more rapid in largemouth bass; linear regression yielded a slope of 0.425 for largemouth bass and 0.15 for fountain darters. The maximum density of the parasite observed in fountain darters is small enough that they could be held in cages and subjected to the parasite for 1 week with minimal consequence.

Comal Springs Salamander Visual Observations

All Landa Lake SCUBA surveys revealed the presence of Comal Springs salamanders along the lake bottom. Comal Springs salamanders were observed around portions of the springs, under rocks at depths of up to 2.4 m. No Comal Springs salamanders were observed in any areas with sediment. There were no Comal Springs salamanders observed during surveys within the New Channel Reach or in the sample area just north of Spring Island. The latter area was sampled during the early surveys, but abundance of silt and algae there appeared to make the habitat unsuitable for Comal Springs salamanders. Therefore, this area was dropped from the sampling protocol after these initial few samples.

Since the inception of the project, Comal Springs salamanders have been observed in each sample location during each sample period. The total number of Comal Springs salamanders observed at each survey site during each sample period is presented in Table 8.

The greatest cumulative number of Comal Springs salamanders observed for all sites during any one sampling event was 55, which occurred during spring 2001; the fewest (18) occurred during fall 2000. Spring Run 1 had the greatest number of Comal Springs salamanders among all areas sampled during the study to date. This is not surprising since the amount of area covered and time spent searching was the greatest in Spring Run 1.

Table 8. Total number of Comal Springs salamanders observed at each survey site during each sample period.

SAMPLE PERIOD	SPRING RUN 1	SPRING RUN 3	SPRING ISLAND SPRING RUN	SPRING ISLAND EAST OUTFALL
August 2000	9	13	11	1
September 2000	5	14	6	5
Fall 2000	8	4	4	2
Winter 2001	16	9	8	1
Spring 2001	25	7	17	6
Summer 2001	23	15	4	4
High-flow 1 2001	31	12	1	6
Fall 2001	11	8	13	7
High-flow 2001	18	2	6	5
Average	16.2	9.3	7.8	4.1

An interesting note is the decline in Comal Springs salamanders reported in Spring Run 3 following heavy rainfall events (fall 2000, high-flow 1 and high-flow 2). The preferred habitat for the Comal Springs salamander in Spring Run 3 appears to be in the rocks along the edge of water adjacent to the steep embankment. Immediately following heavy rainfall events, a sizable amount of sediment is transported from the embankment into that edge of water habitat. The increased silt results in fewer Comal Springs salamanders observations during subsequent surveys. However, after a short period of time following fall 2000, the constant flow moving through Spring Run 3 cleared the preferred habitat of sediment and the Comal Springs salamanders returned in winter 2001. The continued heavy rainfall in fall 2001 kept the sediment concentration covering preferred habitat during the high-flow 1, fall 2001, and high-flow 2 sampling events, which may be the reason for the lower numbers observed in Spring Run 3 during these three trips. The winter 2002 sampling event will be important in supporting/disproving the preliminary theory that under situations of acute disturbance/habitat modification, the Comal Springs salamanders simply retreat into the substrate and return to the surface when conditions are again suitable.

Macroinvertebrate Sampling

The dominant taxa in drift across all sample dates for Spring Runs 1 and 3 (Tables 9 and 10, respectively) were larvae and adults of *Microcylloepus* (Coleoptera: Elmidae), *Psephenus* (Coleoptera: Psephenidae), *Baetis* (Ephemeroptera: Baetidae), *Tricorythodes* (Ephemeroptera: Trichorythidae), *Helicopsyche* (Trichoptera: Helicopsychidae), *Hydroptila* and *Ochrotrichia* (Trichoptera: Hydroptilidae) and midges (Chironomidae). There were seasonal and spring run differences in dominant taxa. For example, Hydroptilid caddisfly larvae were not common in August, September, and November 2000 drift samples from Spring Run 1, but they became codominant in March and April 2001. Generally, mayflies were far less common in Spring Run 3 than Spring Run 1. All data gathered from drift net samples are presented in tabular format in Appendix B.

Table 9. Dominant taxa in drift net samples from Spring Run 1, with total abundance across all samples and number observed in each sample period.

FAMILY	TAXA	TOTALS	SPRING RUN 1 8/28/00	SPRING RUN 1 9/14/00	SPRING RUN 1 11/21/00	SPRING RUN 1 3/20/01	SPRING RUN 1 5/23/01	SPRING RUN 1 9/12/01	SPRING RUN 1 11/05/01
Baetidae	*Baetis*	1,692	260	121	199	294	423	179	216
Elmidae	*Microcylloepus* (L)	1,277	36	151	128	254	208	252	248
Tricorythidae	*Trichorythodes*	1,106	23	124	121	234	146	322	136
Hydroptilidae	*Leucotrichia*	762	62	7	21	347	269	37	19
Hydroptilidae	*Ochrotrichia*	652	8	31	18	495	83	2	15
Cambaridae		564	180	364	9	1	0	4	6
Psephenidae	*Psephenus* (L)	527	47	105	69	100	93	47	66
Chironomidae	Larvae	386	133	38	40	87	56	16	16
Coenagrionidae	*Argia*	219	9	20	46	7	80	14	43
Pyralidae	*Petrophila*	208	6	26	2	67	99	4	4
Elmidae	*Microcylloepus*	182	4	21	14	24	67	18	34
Chironomidae	Pupae	165	18	65	18	36	28	0	0
Helicopsychidae	*Helicopsyche*	163	19	118	5	4	15	1	1
Baetidae	*Baetodes*	106	3	6	1	22	65	1	8
Veliidae	*Rhagovelia*	101	12	63	6	4	4	9	3

Table 10. Dominant taxa in drift net samples from Spring Run 3, with total abundance across all samples and number observed in each sample period.

FAMILY	TAXA	TOTALS	SPRING RUN 3 8/28/00	SPRING RUN 3 9/14/00	SPRING RUN 3 11/21/00	SPRING RUN 3 3/20/01	SPRING RUN 3 5/23/01	SPRING RUN 3 9/12/01	SPRING RUN 3 11/05/01
Hydroptilidae	*Leucotrichia*	1,575	147	190	96	386	507	117	132
Chironomidae	Larvae	1,321	344	773	64	41	59	17	23
Elmidae	*Microcylloepus* (L)	1,093	63	178	150	246	243	129	84
Psephenidae	*Psephenus* (L)	684	29	68	143	220	224	0	0
Hydroptilidae	*Ochrotrichia*	271	0	23	23	164	57	0	4
Baetidae	*Baetis*	234	24	38	12	36	107	13	4
Baetidae	*Baetodes*	232	17	13	42	67	30	38	25
Pyralidae	*Petrophila*	228	32	26	37	76	31	15	11
Chironomidae	Pupae	227	55	112	10	37	13	0	0
Elmidae	*Microcylloepus* (A)	184	11	30	19	34	58	14	18
Psephenidae	*Psephenus* (A)	169	7	6	12	16	14	62	52
Tricorythidae	*Trichorythodes*	120	19	37	1	49	5	6	3
Hyalellidae	*Hyalella*	107	5	31	17	30	15	3	6
Elmidae	Pupae	102	7	20	23	24	28	0	0

Although they were not one of the dominant taxa, the Comal Springs riffle beetle is of particular concern and was observed in many samples. In Spring Run 1 a total of 28 larvae and 7 adults were observed during the seven sampling events; in Spring Run 3, 42 larvae and 12 adults were collected. In both Spring Run Reaches, the observations appear to be fairly evenly spread out between seasons and time of day, although both larvae and adults were most abundant during Spring Run 3 in fall 2000, winter 2001, and spring 2001 sampling.

Current velocities were generally greater at Spring Run 1 than Spring Run 3, and no clear pattern between current velocity and drift rate was apparent. For example, the lowest current velocity observed occurred in September 2000 in Spring Run 3 corresponded with the second-highest drift rate observed so far during the study. In contrast, the two highest flows observed to date occurred in November 2000 and March 2001 in Spring Run 1, corresponding with the lowest and highest drift rates observed, respectively.

Invertebrate drift was greater (2x) at night than by day, and marked crepuscular peaks in drift activity common in streams throughout the world was generally not observed.

Exotics / Predation Study

A summary of the number of individuals of each species collected and the contents of their stomachs can be found in Tables 11 and 12 for the Comal and San Marcos ecosystems, respectively; a more detailed account of the data by sample period is presented in Appendix B. Very few fountain darters and only a single San Marcos Springs salamander (in 2000) have been found in the stomachs of potential predators. This is despite the increase in sample size that was accompanied by introducing rod-and-reel sampling methods. A summary of results gathered from both the Comal and San Marcos diet data is presented below.

Table 11. Predator diet summary for gill net and rod-and-reel surveyed fish in the Comal ecosystem.

				STOMACH CONTENTS (PERCENTAGE OF PREY ITEM)							
Taxa	Number	Mean Length (mm)	Mean Weight (g)	Empty	Algae	Fountain Darters	Other Fish[a]	Salamanders	Crayfish and Grass Shrimp	Aquatic Invertebrates	Other[b]
C. cyanoguttatum	23	153.1	106.9	34.8	39.1	-	-	-	13.0	30.4	-
L. auritus	9	137.7	45.9	22.2	-	-	11.1	-	11.1	77.8	-
L. cyanellus	1	105.0	57.0	-	-	-	-	-	-	100.0	-
L. gulosus	4	102.5	25.3	25.0	-	-	-	-	-	50.0	25.0
L. megalotis	17	128.3	58.8	29.4	-	-	-	-	17.6	58.8	11.8
L. punctatus	42	125.8	52.6	26.2	2.4	-	-	-	11.9	52.4	7.1
M. salmoides	29	290.1	445.0	27.6	-	6.9	24.1	-	51.7	3.4	3.4
H. plecostomus	1	440	1106	100.0	-	-	-	-	-	-	-
T. aurea	40	367.2	959.3	35.5	54.8	-	-	-	-	25.8	-

[a] Includes unidentifiable fish remains; fountain darter numbers could be higher than indicated.
[b] Terrestrial insects, unidentifiable material, etc.

Table 12. Predator diet summary for gill net and rod-and-reel surveyed fish in the San Marcos ecosystem.

Taxa	Number	Mean Length (mm)	Mean Weight (g)	STOMACH CONTENTS (PERCENTAGE OF PREY ITEM)							
				Empty	Algae	Fountain Darters	Other Fish[a]	Salamanders	Crayfish and Grass Shrimp	Aquatic Invertebrates	Other[b]
C. cyanoguttatum	3	221.3	156.0	100.0	-	-	-	-	-	-	-
L. oculatus	14	689.9	1418.2	57.1	-	-	35.7	-	-	-	7.1
L. auritus	5	174.0	116.1	-	-	-	-	-	-	80.0	40.0
L. gulosus	11	191.7	167.6	54.5	-	9.1	-	-	45.5	-	-
L. machrochirus	14	139.9	69.6	21.4	7.1	-	-	-	7.1	78.6	21.4
L. megalotis	11	183.5	134.1	36.4	-	-	-	-	9.1	54.5	-
L. microlophus	4	170.8	122.5	75.0	-	-	-	-	-	25.0	-
L. punctatus	22	124.2	50.8	36.4	-	-	-	-	-	59.1	4.5
M. salmoides	27	279.6	343.1	18.5	-	-	25.9	3.7	22.2	3.7	29.6

[a] Includes unidentifiable fish remains; fountain darter numbers could be higher than indicated.
[b] Terrestrial insects, unidentifiable material, etc.

The largemouth bass (*Micropterus salmoides*) and warmouth (*Lepomis gulosus*) were the two predator species observed to feed on fountain darters. Other fish prey were found in the stomachs of the largemouth bass. However, no other fish prey were found in any warmouth; they fed primarily on crayfish in the San Marcos River and other aquatic invertebrates in the Comal River. Fish and crayfish were the most common items in the diet of the largemouth bass, although the one instance of a salamander in the diet occurred in a San Marcos largemouth bass.

Fish were found in about 25% of all largemouth bass stomachs, while crayfish were abundant in the diet of Comal individuals (52%), but less common in the San Marcos largemouth bass diet (22%). From this data set, it appears that the fountain darter may be an incidental prey item for the largemouth bass, which tends to be an opportunistic species. The warmouth may, however, be more suited to target the darters as a prey species, given the larger size of the mouth relative to other sunfish and the tendency to focus on benthic fauna (unlike the bass). Nonetheless, the occurrence of fountain darters in the warmouth diet is limited to just the one instance. A greater sample size of this species will determine whether that observation was an anomaly or if the warmouth do prey on fountain darters when the opportunity arises.

Spotted gars (*Lepisosteus oculatus*) are another San Marcos River predator with fish as a common food item; however, no fountain darter was found in their diet. Rio Grande Cichlids (*Cichlasoma cyanoguttatum*) were also sampled in both ecosystems, but both individuals from the San Marcos had empty stomachs and the primary food item in the stomachs of the Comal fish was algae. The remainder of the fish sampled were sunfish species (*Lepomis*), which fed primarily on aquatic invertebrates.

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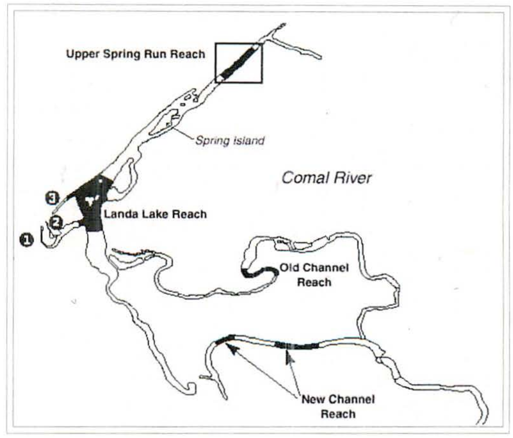
APPENDIX A: MAPS

Comal River
Aquatic Vegetation
Upper Spring Channel Reach
Spring
May 14, 2001

Shore and Islands
River
Study Area (4,565.3 m^2)
Bare Substrate
Colocasia
Drop Net Sample Sites

	Meters^2
Cabomba	13.2
Chara	13.8
Hygrophila	412.7
Limnophila	5.1
Ludwigia	1.8
Sagittaria	236.5

Project Location



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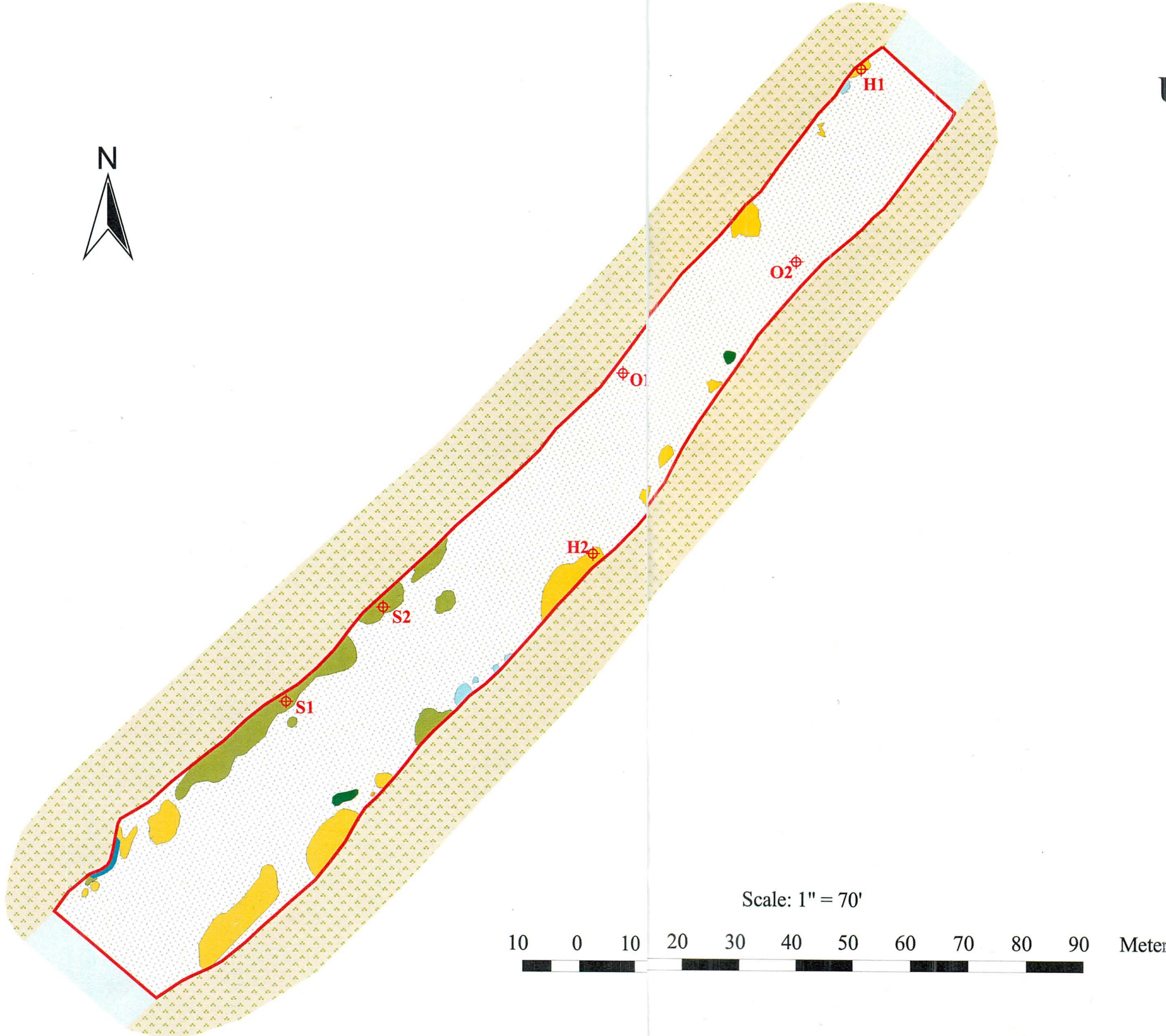
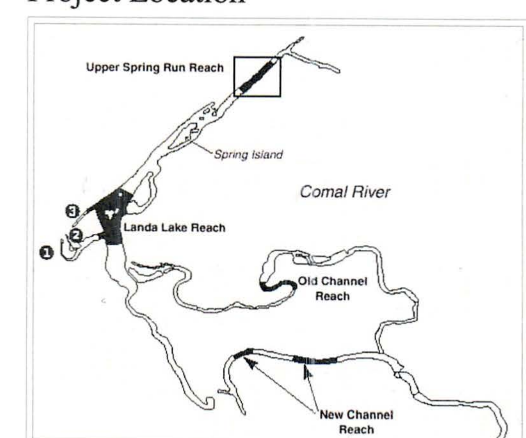
Comal River
Aquatic Vegetation
Upper Spring Channel Reach
Winter
March 12, 2001



- Shore and Islands
- River
- Study Area (4,565.3 m^2)
- Bare Substrate
- *Colocasia*
- Drop Net Sample Sites

	Meters^2
Cabomba	11.0
Chara	14.5
Hygrophila	289.8
Ludwigia	0.4
Sagittaria	210.2

Project Location



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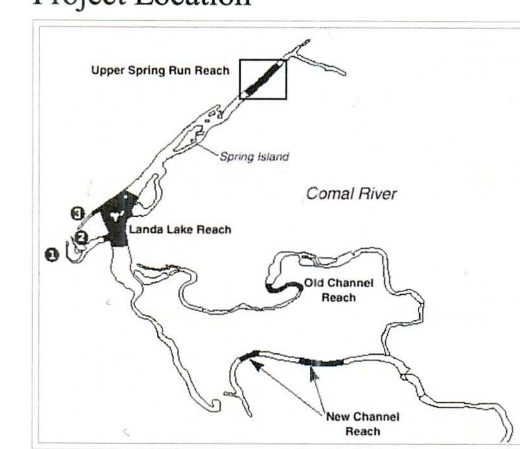
Comal River
Aquatic Vegetation
Upper Spring Channel Reach
Fall

November 8, 2000

- Shore and Islands
- River
- Study Area (4,565.3 m^2)
- Bare Substrate
- *Colocasia*
- Drop Net Sample Sites

	Meters^2
Cabomba	13.4
Chara	6.1
Hygrophila	204.3
Ludwigia	1.3
Nuphar	2.3
Sagittaria	210.6

Project Location



Edwards Aquifer Authority

BIO-WEST, Inc.

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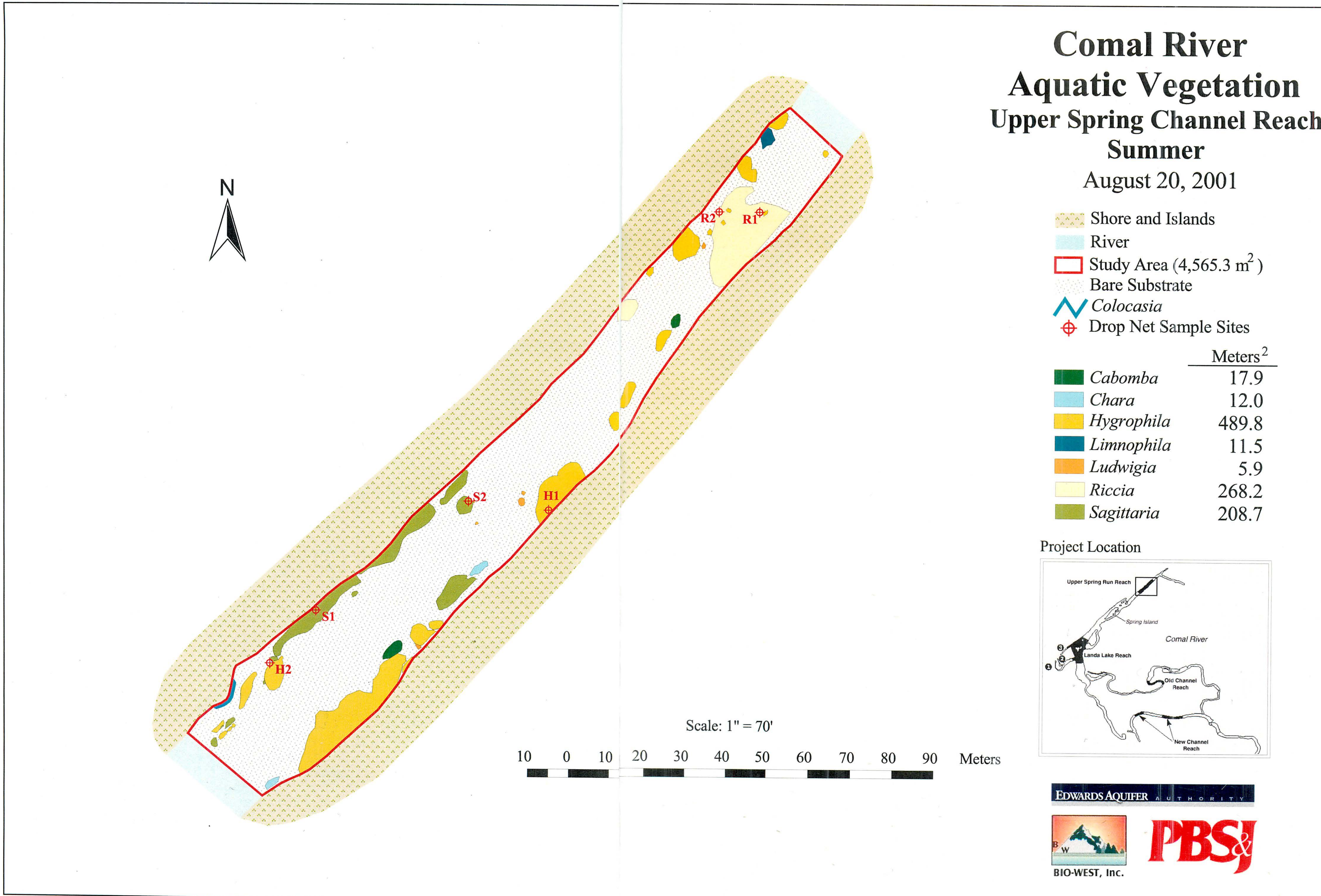

Comal River
Aquatic Vegetation
Upper Spring Channel Reach
Summer
August 20, 2001
Shore and Islands
River
Study Area (4,565.3 m²)
Bare Substrate
Colocasia
Drop Net Sample Sites
Meters²
Cabomba 17.9
Chara 12.0
Hygrophila 489.8
Limnophila 11.5
Ludwigia 5.9
Riccia 268.2
Sagittaria 208.7
Project Location
Upper Spring Run Reach
Spring Island
Comal River
Landa Lake Reach
Old Channel Reach
New Channel Reach
N
R2
R1
S2
H1
S1
H2
Scale: 1" = 70'
10 0 10 20 30 40 50 60 70 80 90 Meters
EDWARDS AQUIFER AUTHORITY
BIO-WEST, Inc.
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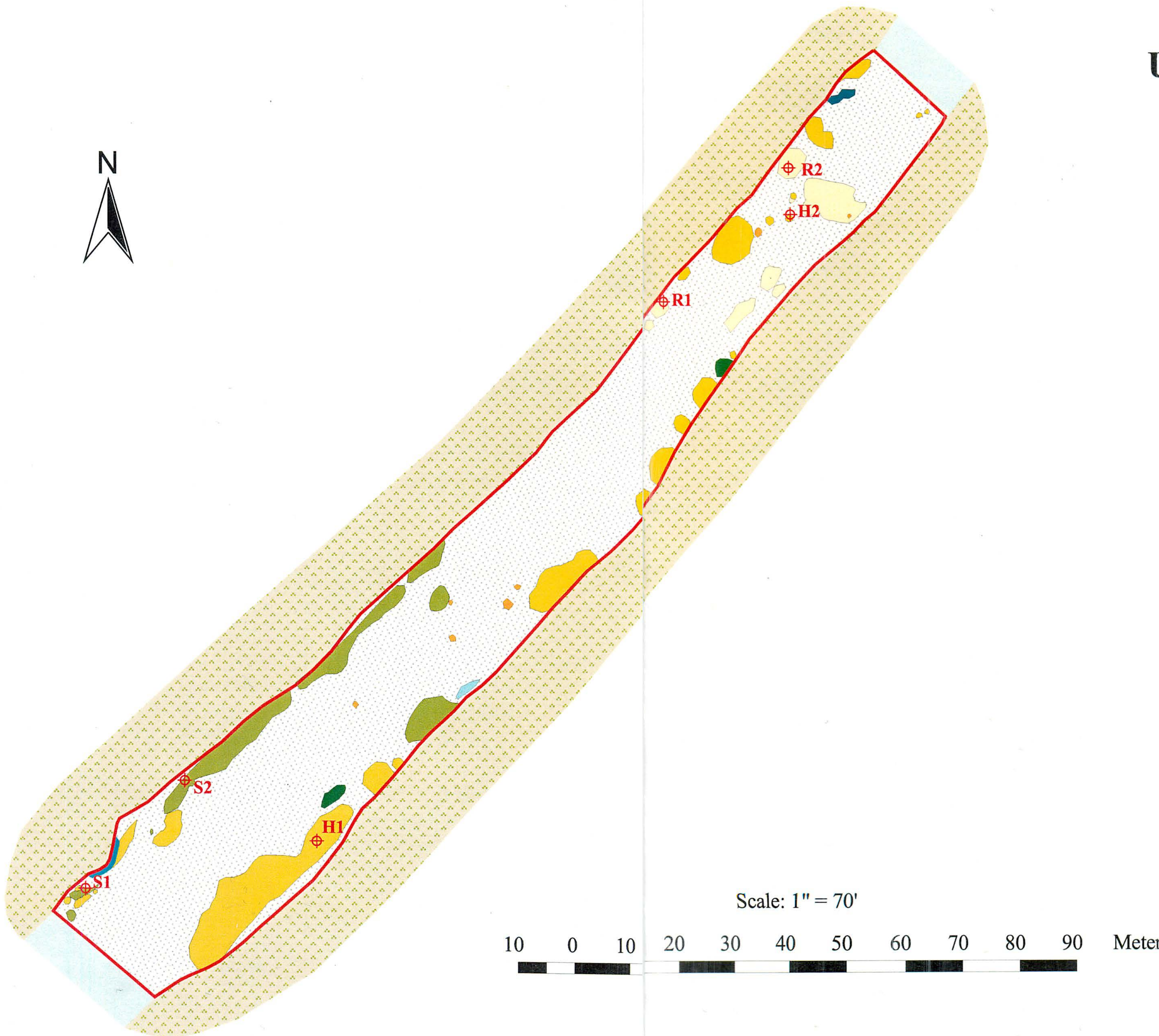
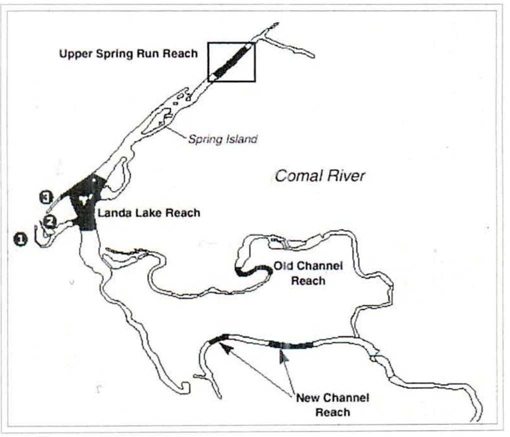


Comal River
Aquatic Vegetation
Upper Spring Channel Reach
High Flow 1
September 18, 2001

- Shore and Islands
- River
- Study Area (4,565.3 m^2)
- Bare Substrate
- *Colocasia*
- Drop Net Sample Sites

	Meters^2
Cabomba	16.2
Chara	5.0
Hygrophila	479.8
Limnophila	6.6
Ludwigia	7.1
Riccia	119.3
Sagittaria	215.7

Project Location



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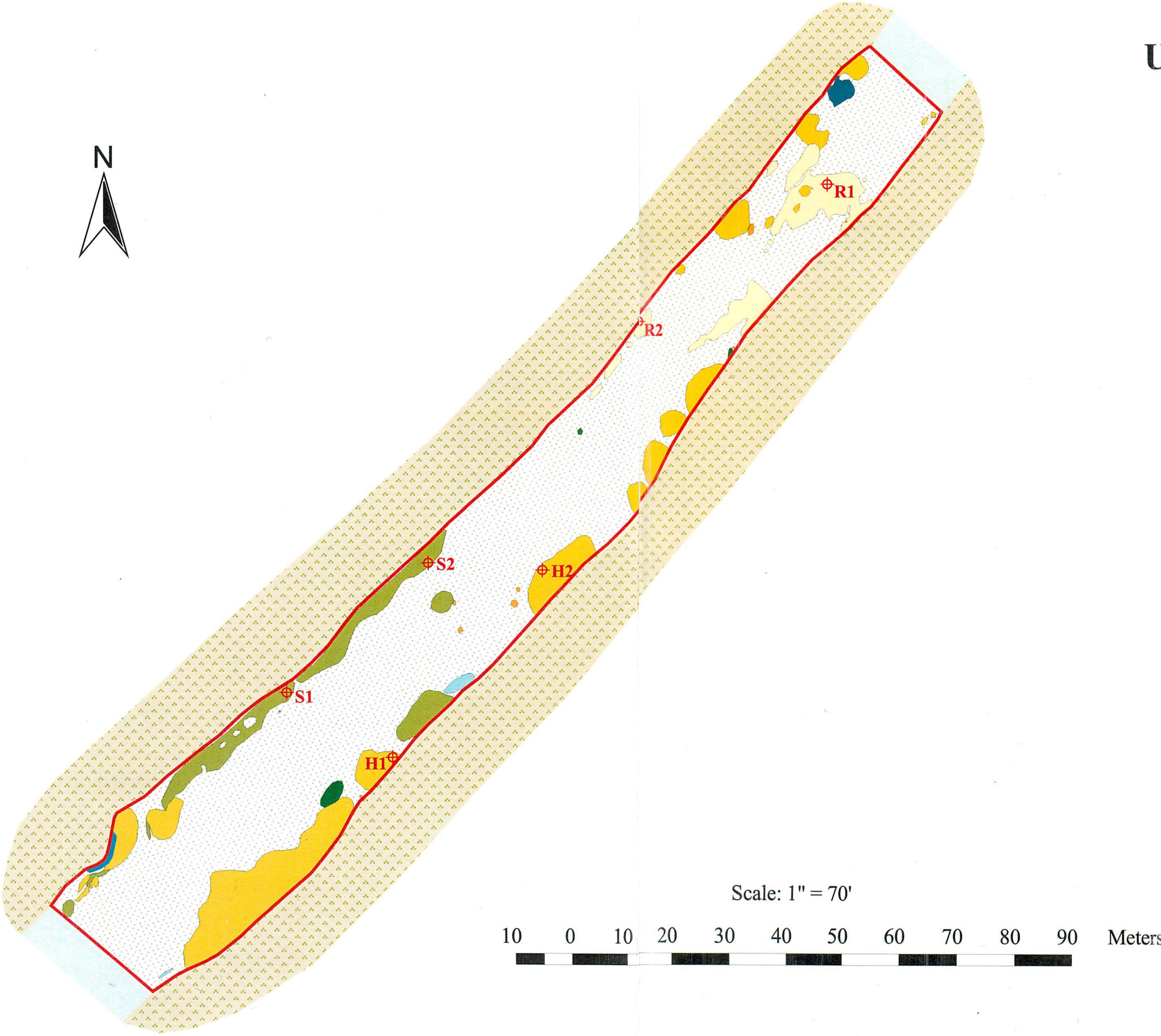
Comal River
Aquatic Vegetation
Upper Spring Channel Reach
Fall

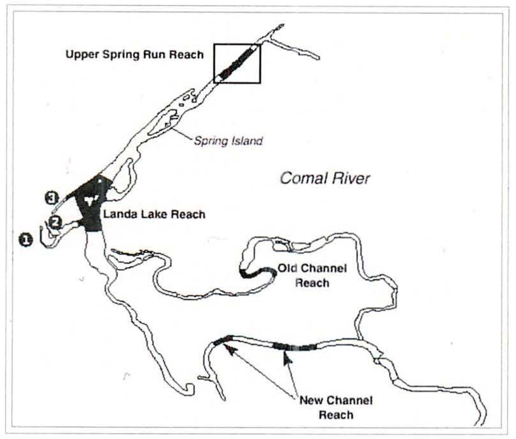
October 31, 2001



Shore and Islands
River
Study Area (4,565.3 m²)
Bare Substrate
Colocasia
Drop Net Sample Sites

	Meters²
Cabomba	13.5
Chara	9.9
Hygrophila	597.4
Limnophila	15.8
Ludwigia	4.7
Riccia	202.1
Sagittaria	226.9

Project Location



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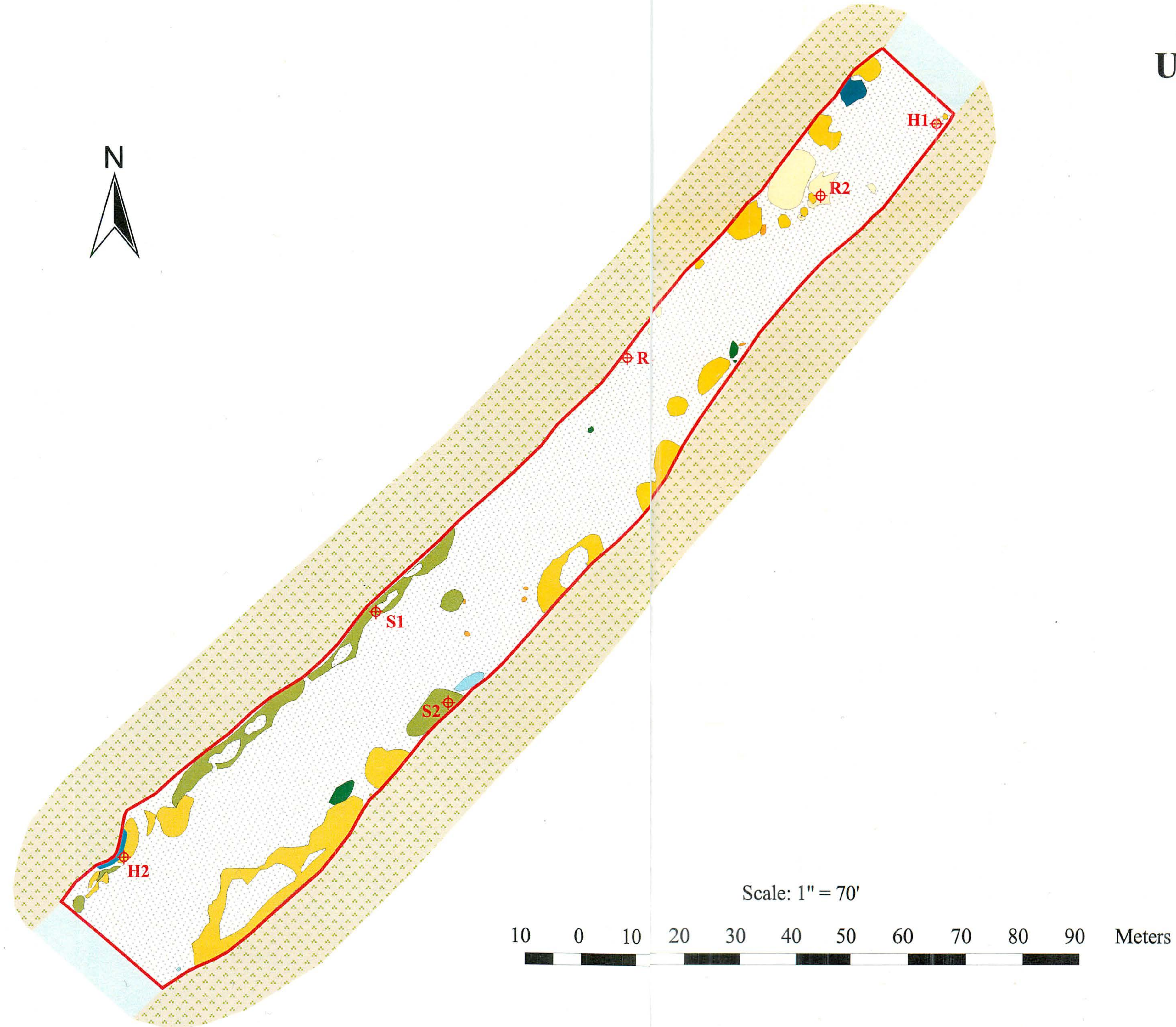
Comal River
Aquatic Vegetation
Upper Spring Channel Reach
High Flow 2

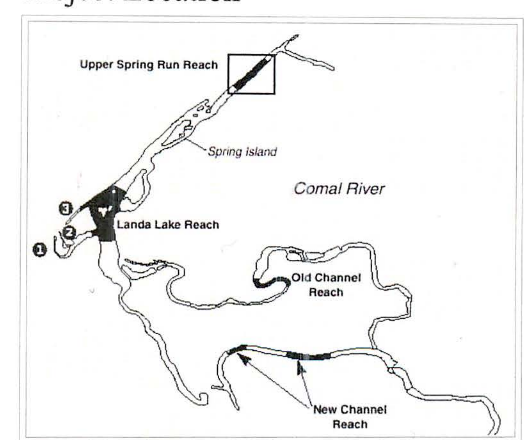
November 26, 2001



Shore and Islands
River
Study Area (4,565.3 m^2)
Bare Substrate
Colocasia
Drop Net Sample Sites

	Meters^2
Cabomba	14.6
Chara	9.1
Hygrophila	460.3
Limnophila	15.8
Ludwigia	4.2
Riccia	87.3
Sagittaria	187.7

Project Location



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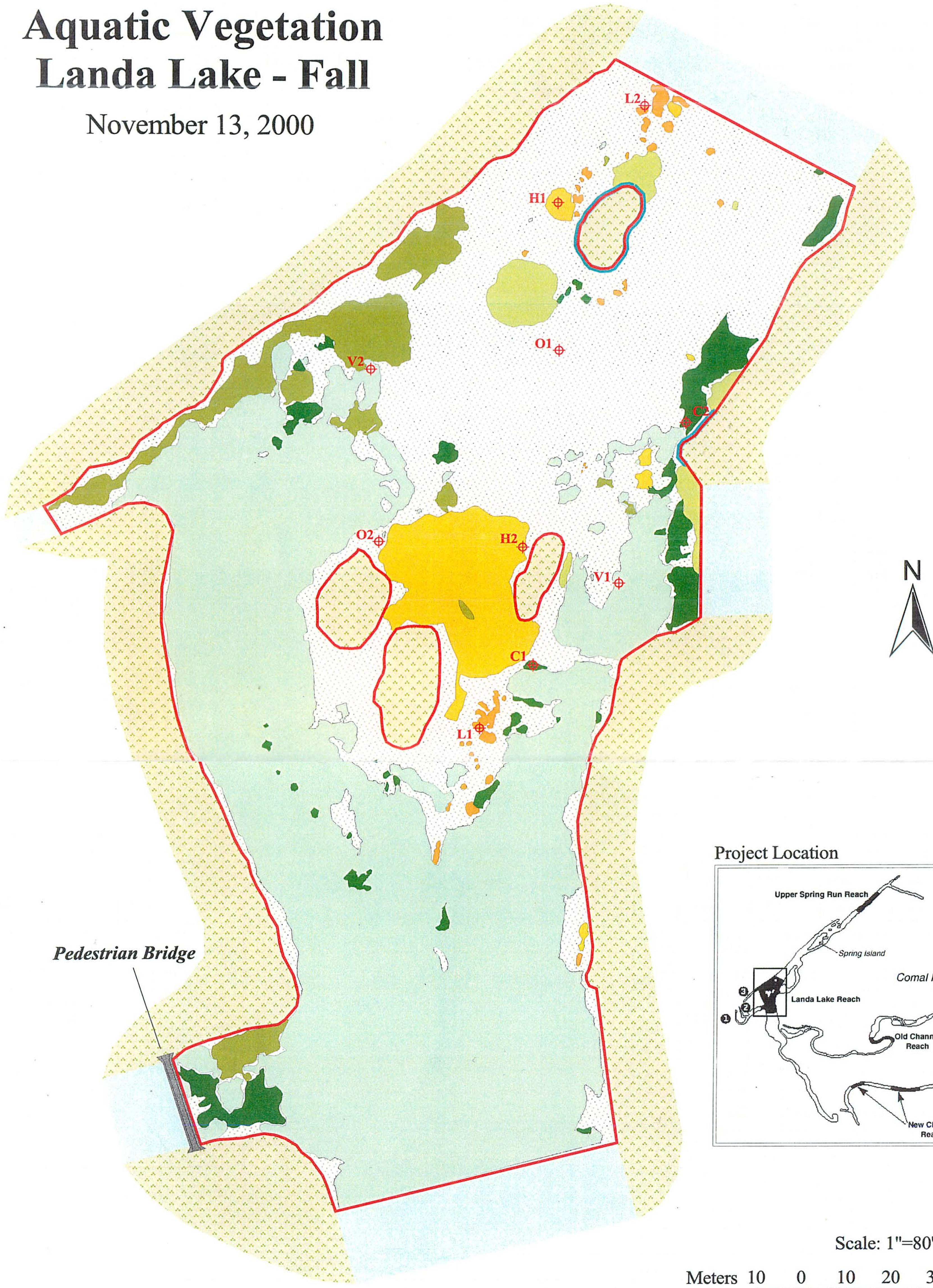
Comal River
Aquatic Vegetation
Landa Lake - Fall

November 13, 2000



Scale: 1"=80'

Meters 10 0 10 20 30 40 50

	Meters^2
Cabomba	685.2
Hygrophila	995.4
Ludwigia	125.1
Nuphar	376.0
Sagittaria	935.7
Vallisneria	10,525.6

- Shore and Islands
- River
- Study Area (22,476.7 m^2)
- Bare Substrate
- *Colocasia*
- Drop Net Sample Sites

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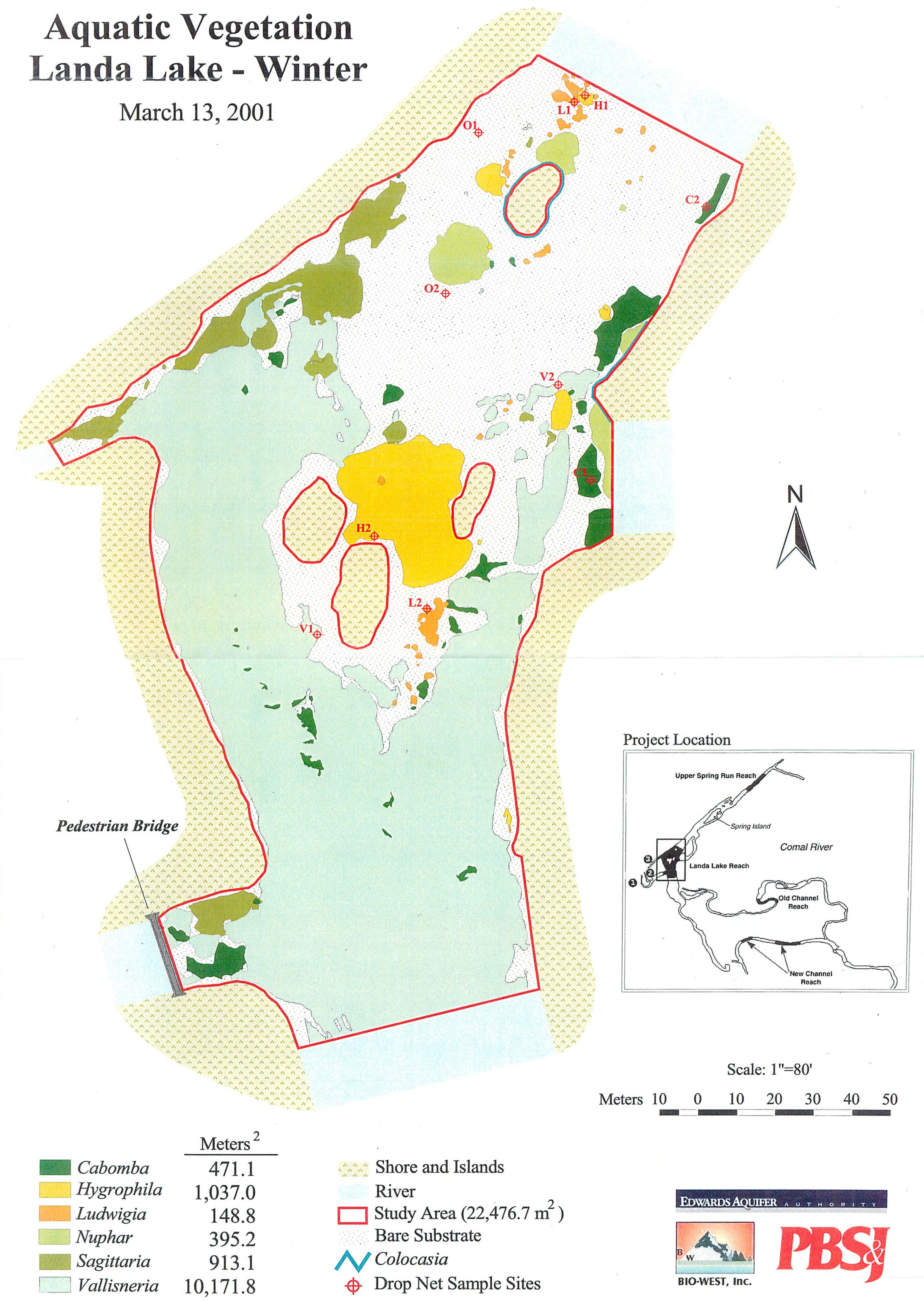
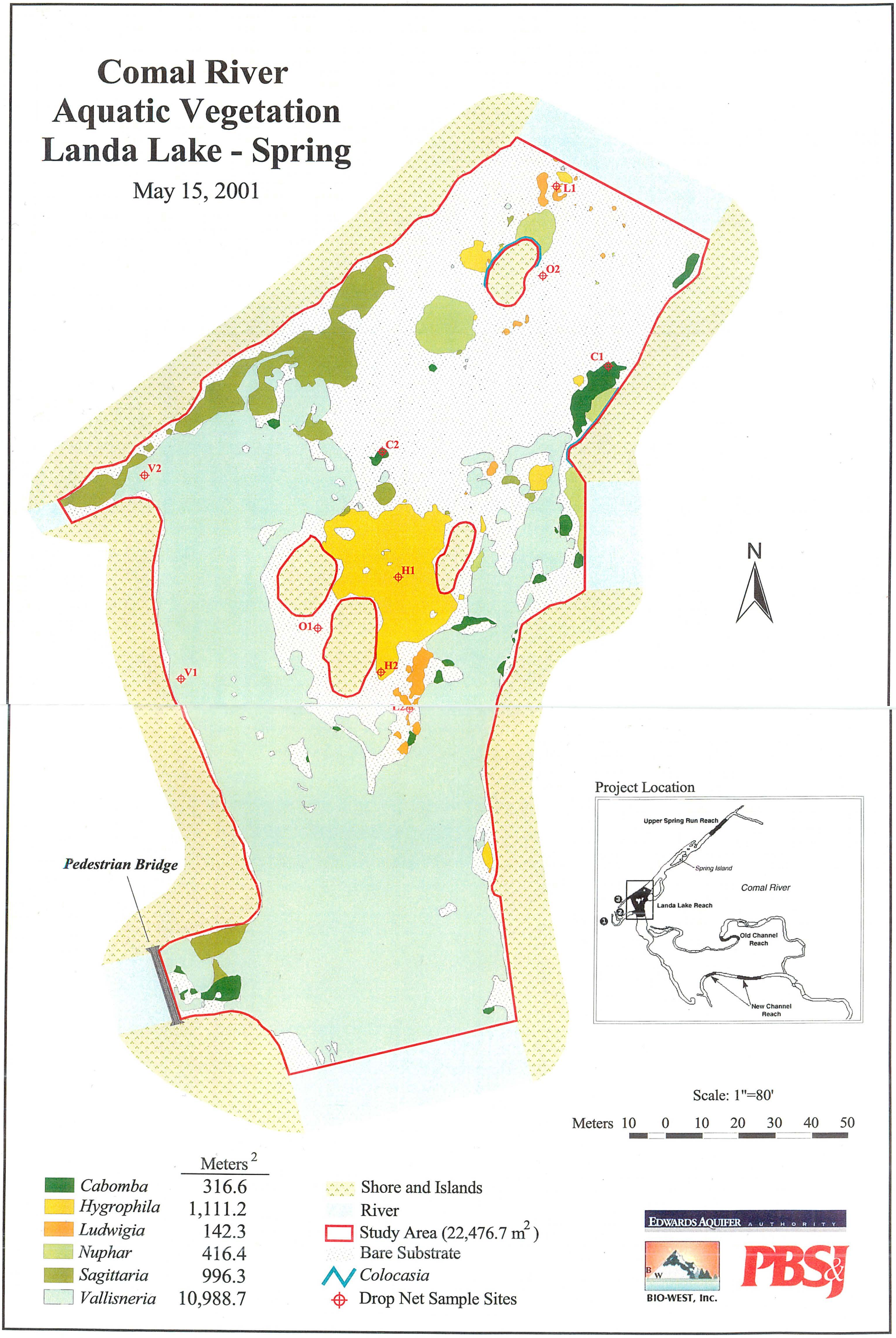
Comal River
Aquatic Vegetation
Landa Lake - Winter

March 13, 2001




Comal River
Aquatic Vegetation
Landa Lake - Spring
May 15, 2001
L1
O2
C1
C2
V2
H1
O1
H2
V1
Pedestrian Bridge
N
Project Location
Upper Spring Run Reach
Spring Island
Comal River
Landa Lake Reach
Old Channel Reach
New Channel Reach
Scale: 1"=80'
Meters 10 0 10 20 30 40 50
Meters 2
Cabomba 316.6
Hygrophila 1,111.2
Ludwigia 142.3
Nuphar 416.4
Sagittaria 996.3
Vallisneria 10,988.7
Shore and Islands
River
Study Area (22,476.7 m2)
Bare Substrate
Colocasia
Drop Net Sample Sites
EDWARDS AQUIFER AUTHORITY
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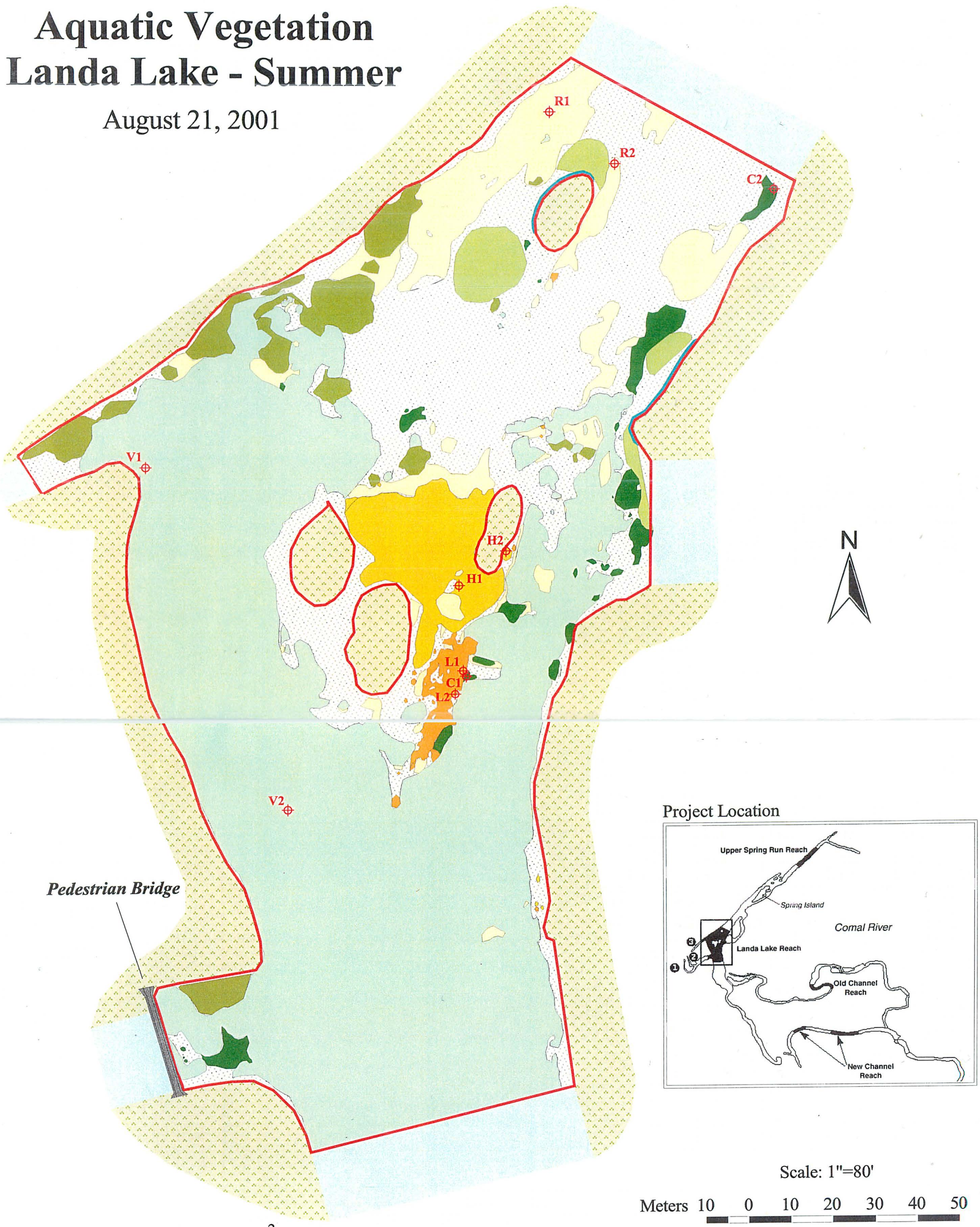
Comal River
Aquatic Vegetation
Landa Lake - Summer

August 21, 2001



	Meters^2
Cabomba	373.1
Hygrophila	872.0
Ludwigia	204.9
Nuphar	450.8
Riccia	1,796.4
Sagittaria	863.3
Vallisneria	12,516.7

- Shore and Islands
- River
- Study Area (22,476.7 m^2)
- Bare Substrate
- *Colocasia*
- Drop Net Sample Sites

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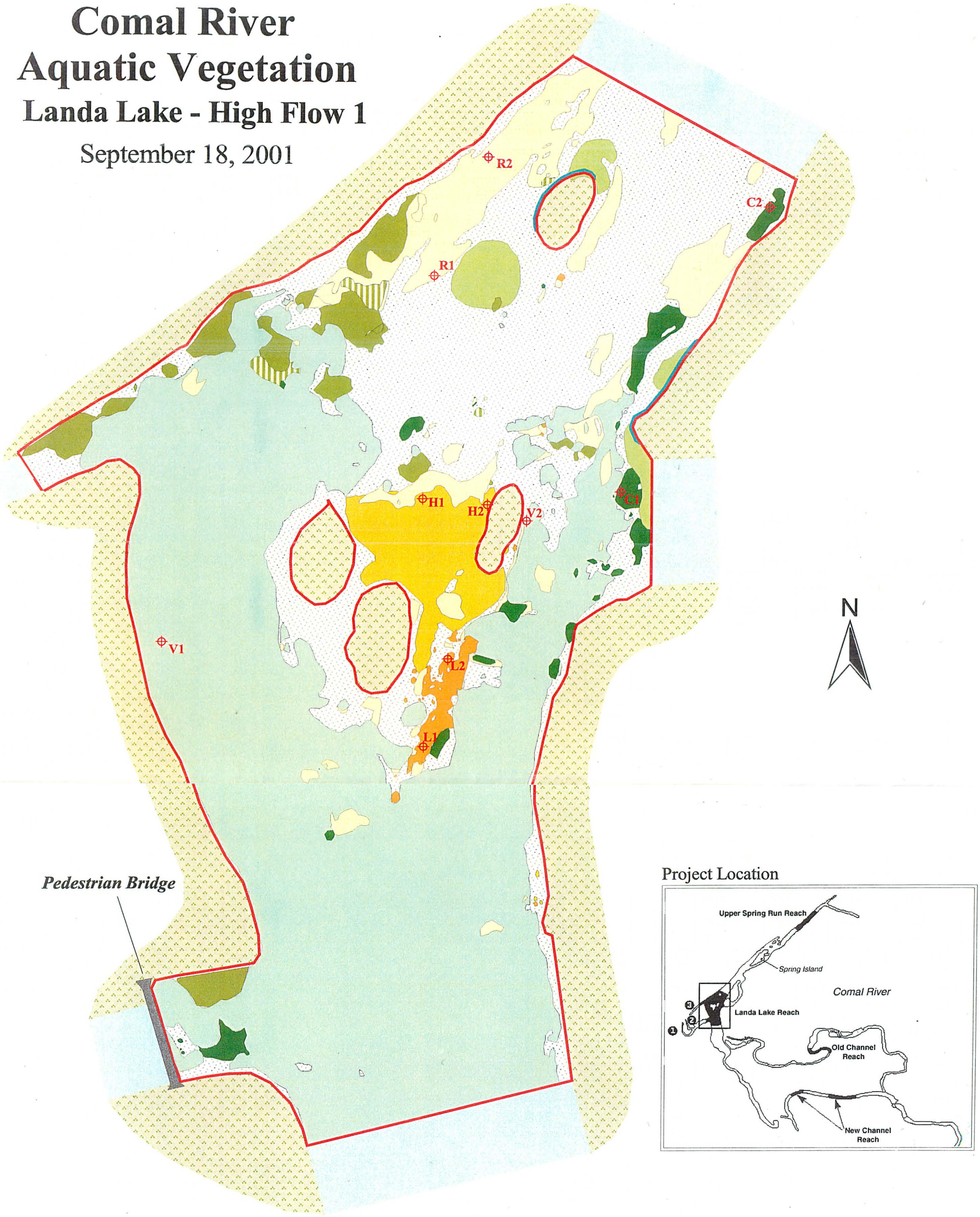
Comal River
Aquatic Vegetation
Landa Lake - High Flow 1
September 18, 2001



	Meters^2
Cabomba	377.4
Hygrophila	806.0
Ludwigia	177.5
Nuphar	415.4
Riccia	1,791.3
Sagittaria	749.1
Vallisneria	12,401.9
Riccia / Algae	1.7
Riccia / Sagittaria	84.7

- Shore and Islands
- River
- Study Area (22,476.7 m^2)
- Bare Substrate
- *Colocasia*
- Drop Net Sample Sites

Scale: 1"=80'

Meters 10 0 10 20 30 40 50

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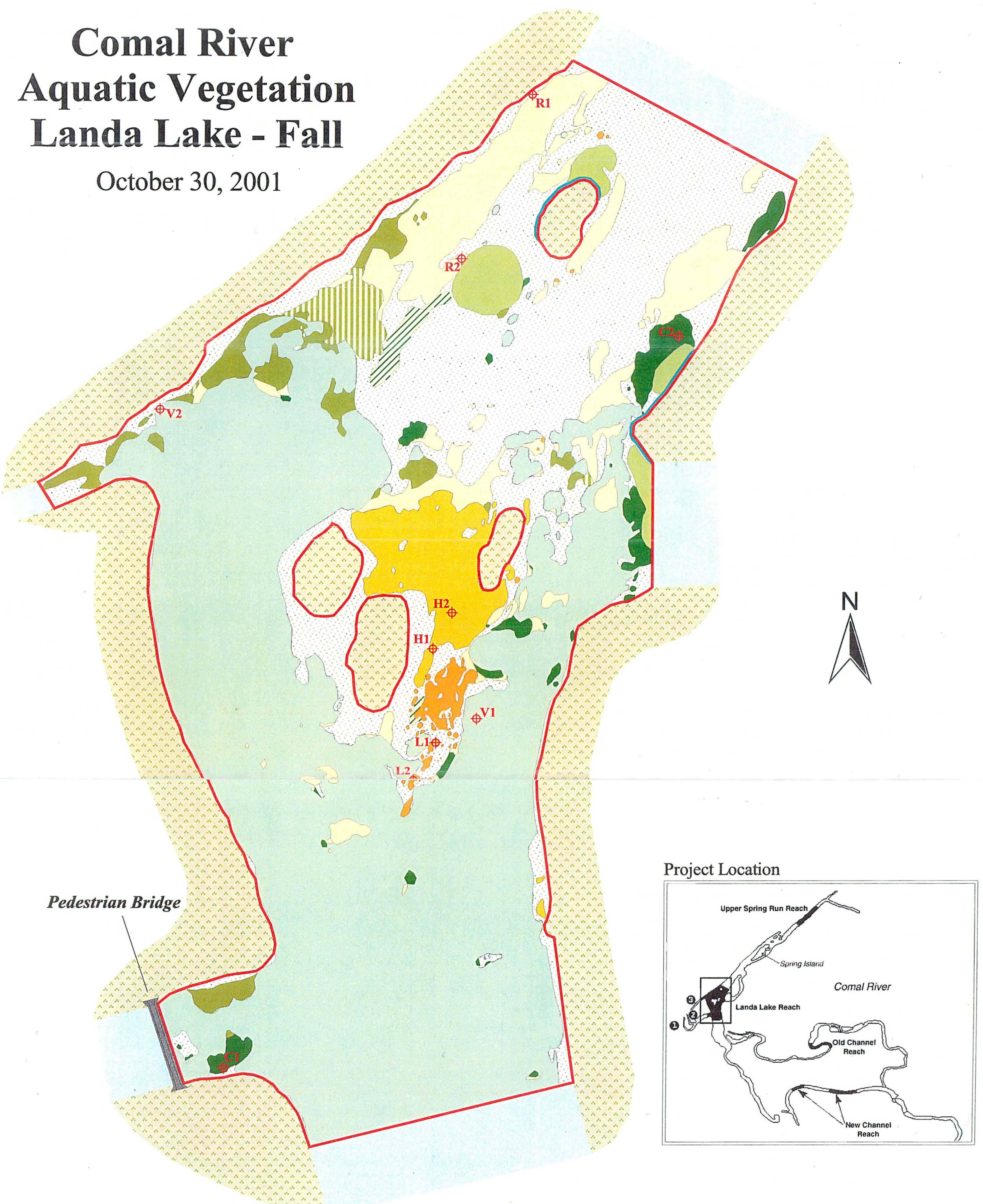
Comal River
Aquatic Vegetation
Landa Lake - Fall

October 30, 2001



Scale: 1"=80'

Meters 10 0 10 20 30 40 50

	Meters^2
Cabomba	429.5
Hygrophila	836.8
Ludwigia	168.4
Nuphar	434.0
Riccia	1,939.1
Sagittaria	559.6
Vallisneria	11,894.9
Riccia / Algae	112.7
Riccia / Sagittaria	266.5

- Shore and Islands
- River
- Study Area (22,476.7 m^2)
- Bare Substrate
- *Colocasia*
- Drop Net Sample Sites

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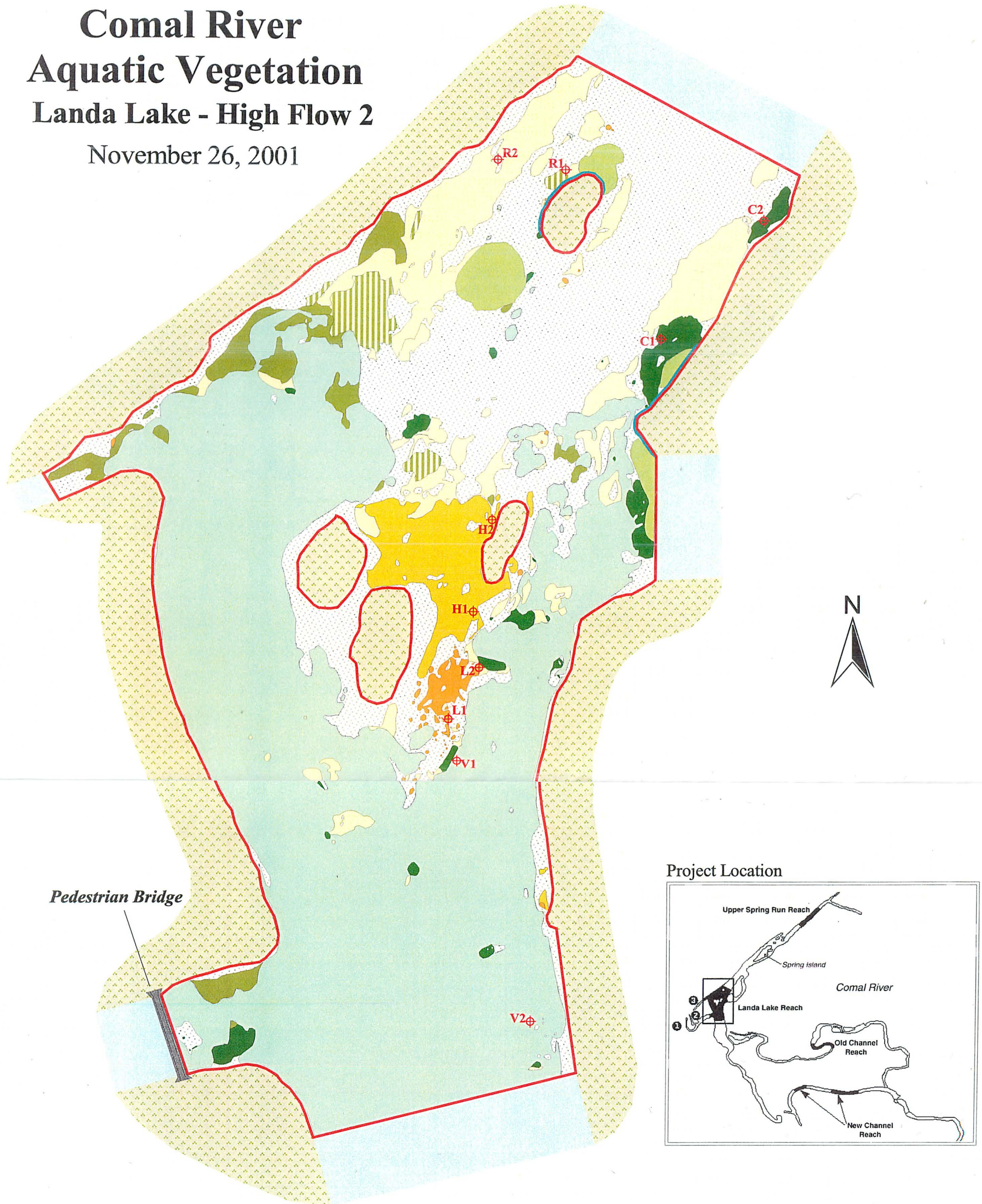
Comal River
Aquatic Vegetation
Landa Lake - High Flow 2
November 26, 2001



	Meters^2
Cabomba	417.3
Hygrophila	704.8
Ludwigia	139.9
Nuphar	396.3
Riccia	1,956.0
Sagittaria	533.6
Vallisneria	11,664.6
Riccia / Algae	82.6
Riccia / Sagittaria	290.2

Shore and Islands
River
Study Area (22,476.7 m^2)
Bare Substrate
Colocasia
Drop Net Sample Sites

Scale: 1"=80'

Meters 10 0 10 20 30 40 50

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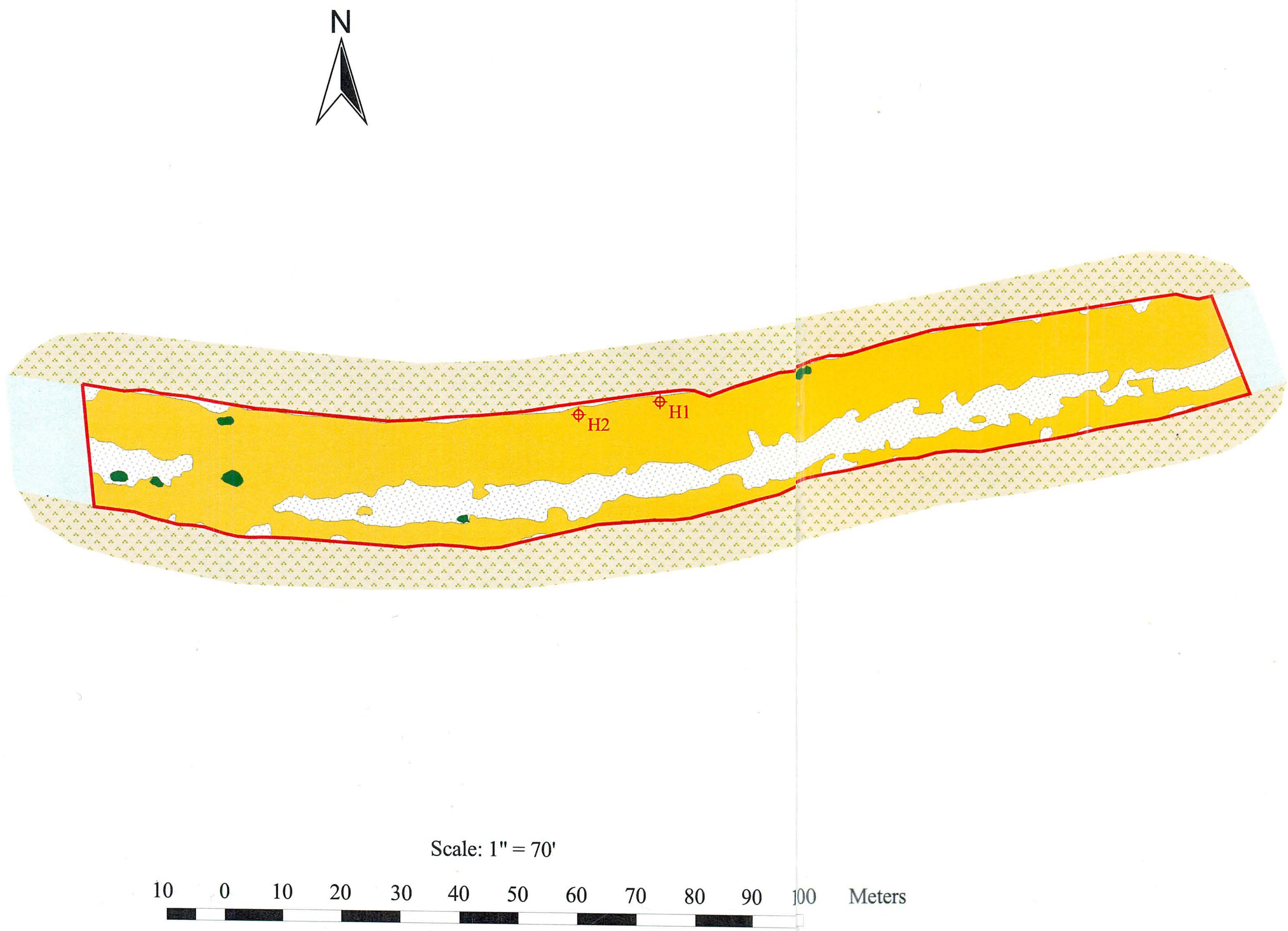
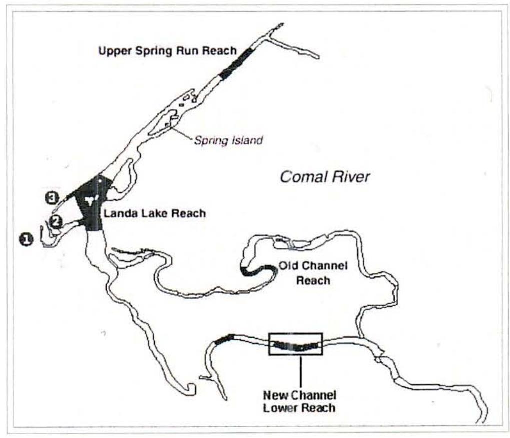
Comal River
Aquatic Vegetation
New Channel Lower Reach
Fall
November 14, 2000



Shore and Islands
River
Study Area (4,133.4 m^2)
Bare Substrate
Drop Net Sample Sites

	$Meters^2$
Cabomba	24.4
Hygrophila	3,057.9

Project Location



Edwards Aquifer Authority
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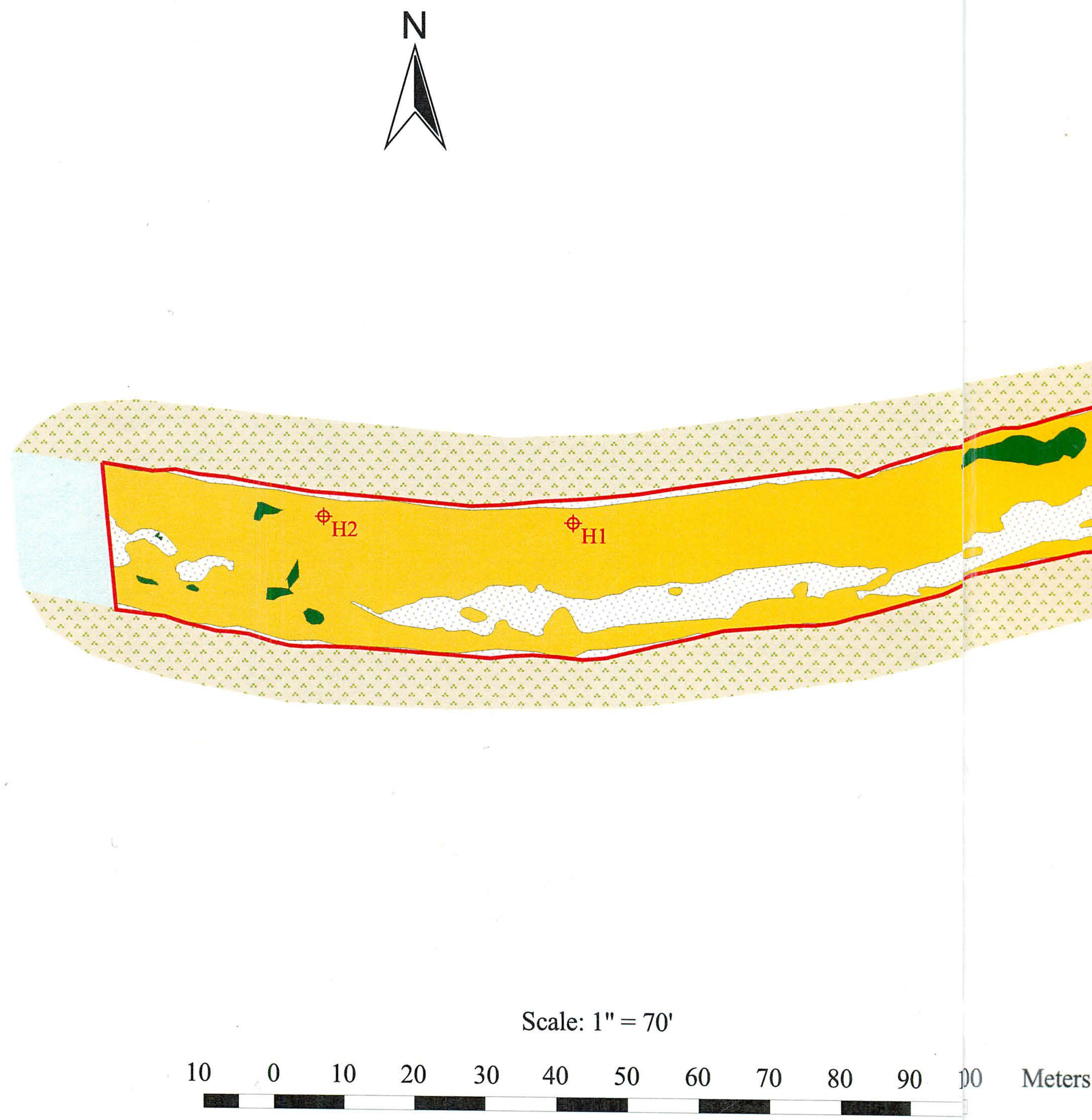
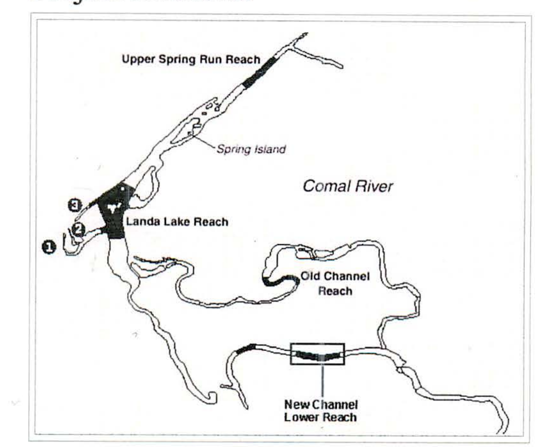
Comal River
Aquatic Vegetation
New Channel Lower Reach
Winter
March 14, 2001



Shore and Islands
River
Study Area (4,133.4 m^2)
Bare Substrate
Drop Net Sample Sites

	Meters ^{2}
Cabomba	146.0
Hygrophila	3,083.2

Project Location



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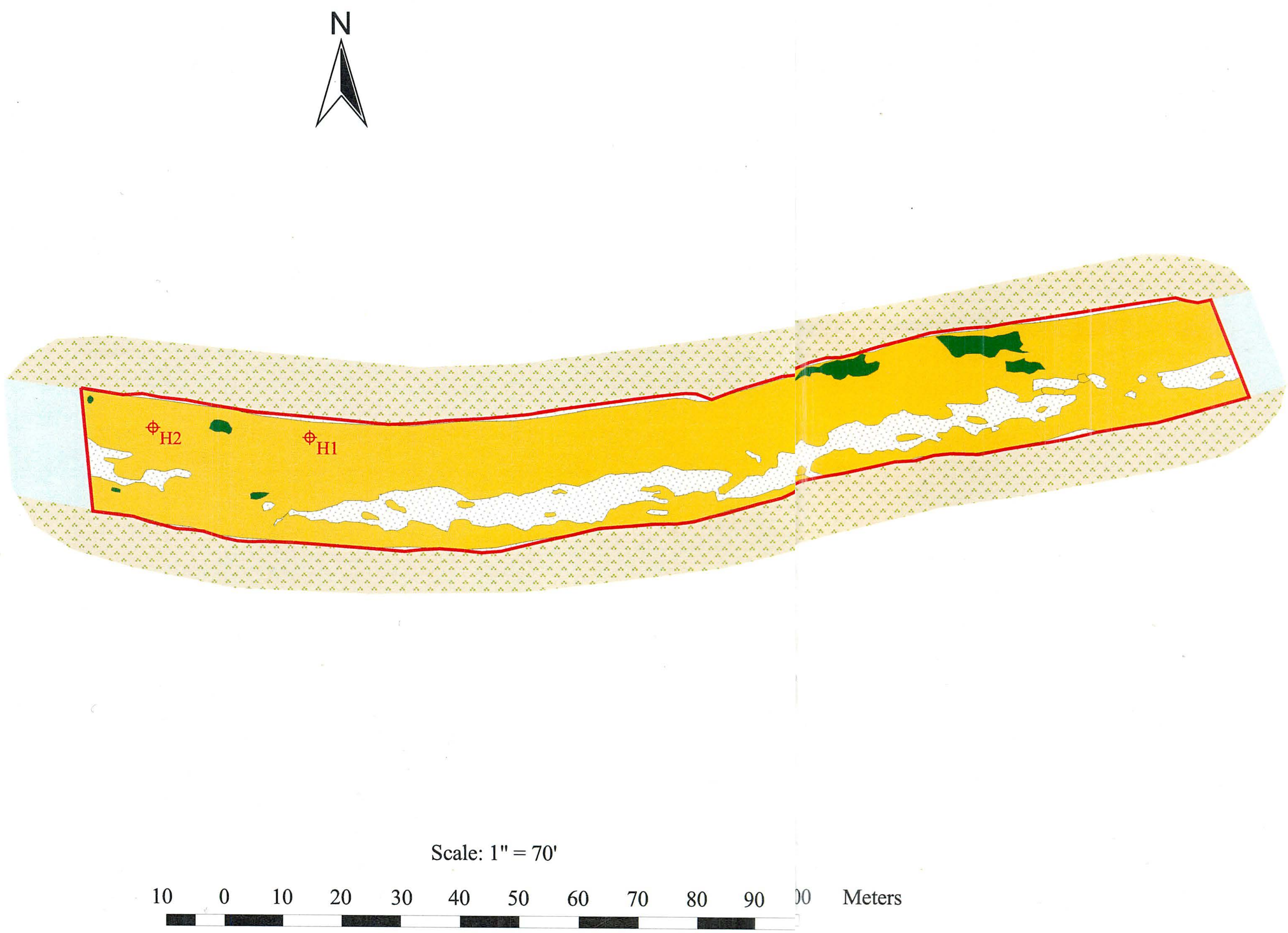
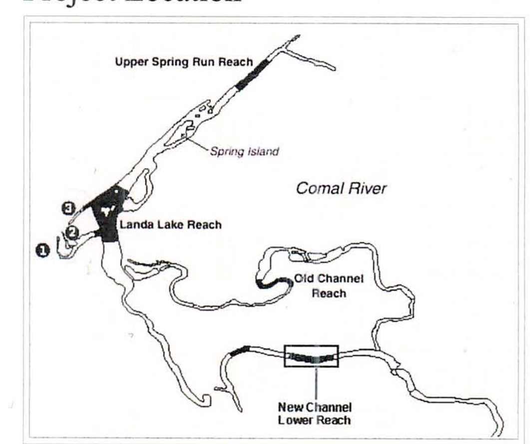
Comal River
Aquatic Vegetation
New Channel Lower Reach
Spring
May 16, 2001



Shore and Islands
River
Study Area (4,133.4 m^2)
Bare Substrate
Drop Net Sample Sites

	Meters^2
Cabomba	95.9
Hygrophila	3,176.9

Project Location



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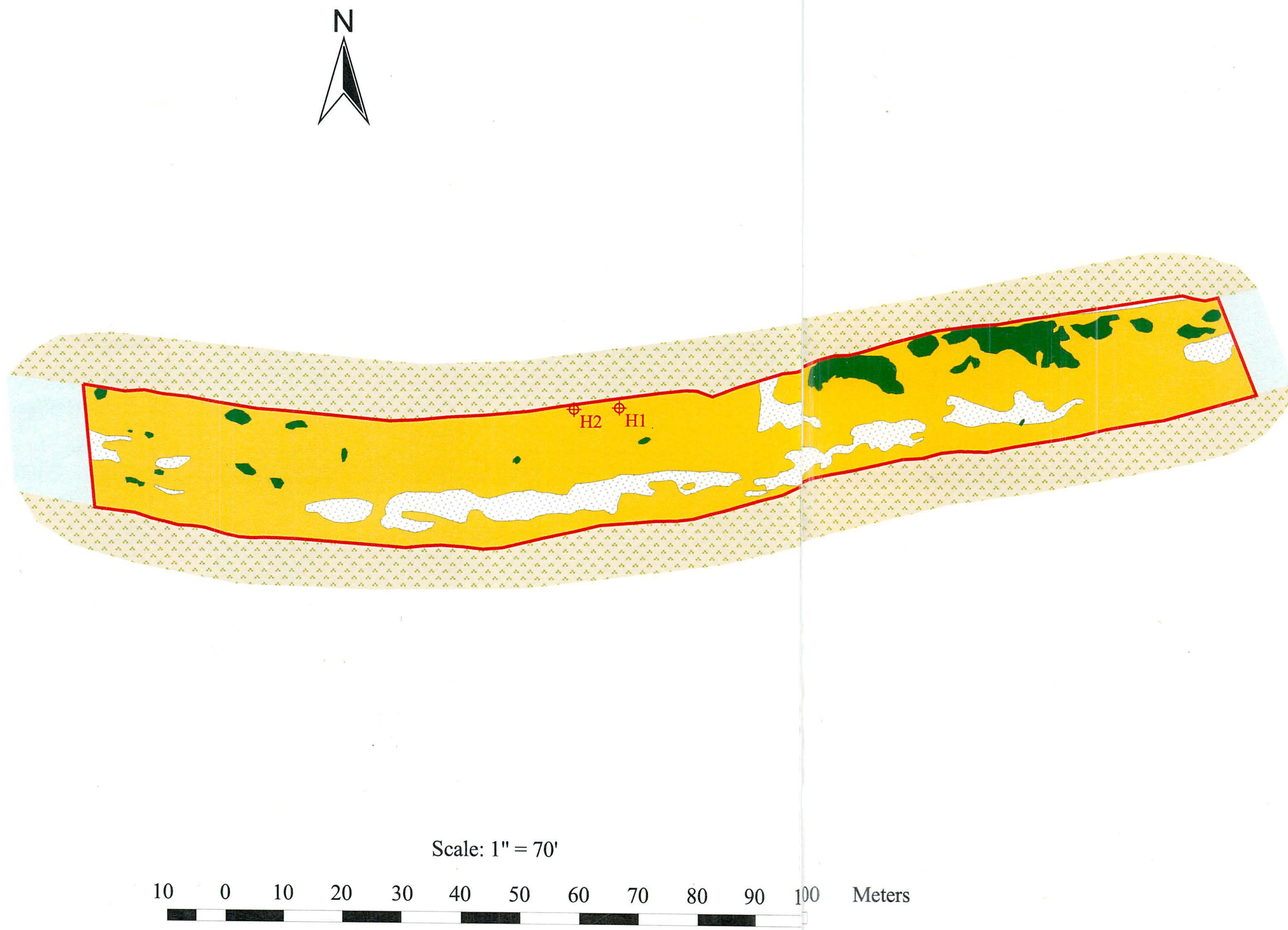
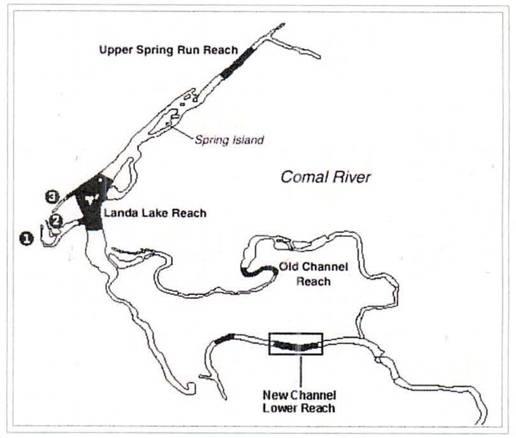
Comal River
Aquatic Vegetation
New Channel Lower Reach
Summer
August 22, 2001



Shore and Islands
River
Study Area (4,133.4 m^2)
Bare Substrate
Drop Net Sample Sites

	Meters ^{2}
Cabomba	264.1
Hygrophila	3,310.7

Project Location



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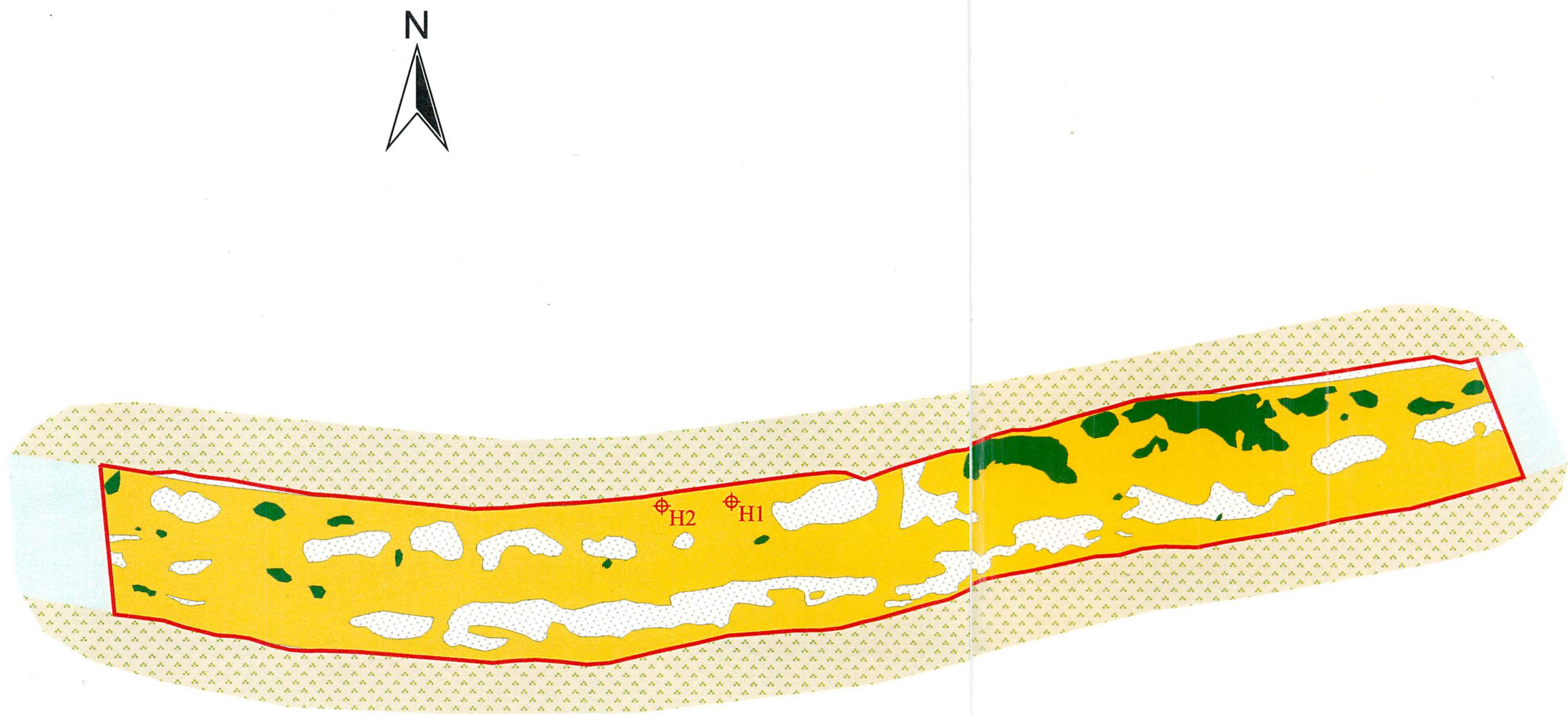
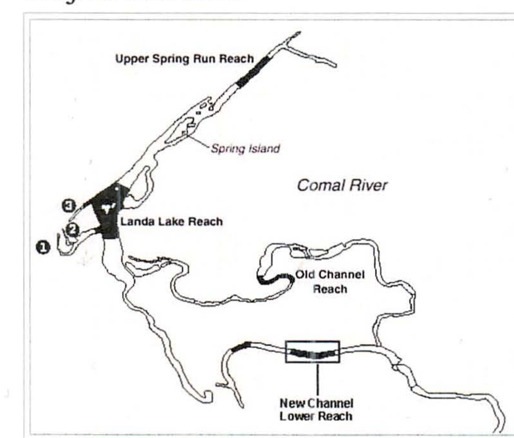
Comal River
Aquatic Vegetation
New Channel Lower Reach
High Flow 1
September 19, 2001



- Shore and Islands
- River
- Study Area (4,133.4 m^2)
- Bare Substrate
- Drop Net Sample Sites

	Meters ^{2}
Cabomba	267.7
Hygrophila	2,998.1

Project Location



Scale: 1" = 70'

10 0 10 20 30 40 50 60 70 80 90 100 Meters

EDWARDS AQUIFER AUTHORITY

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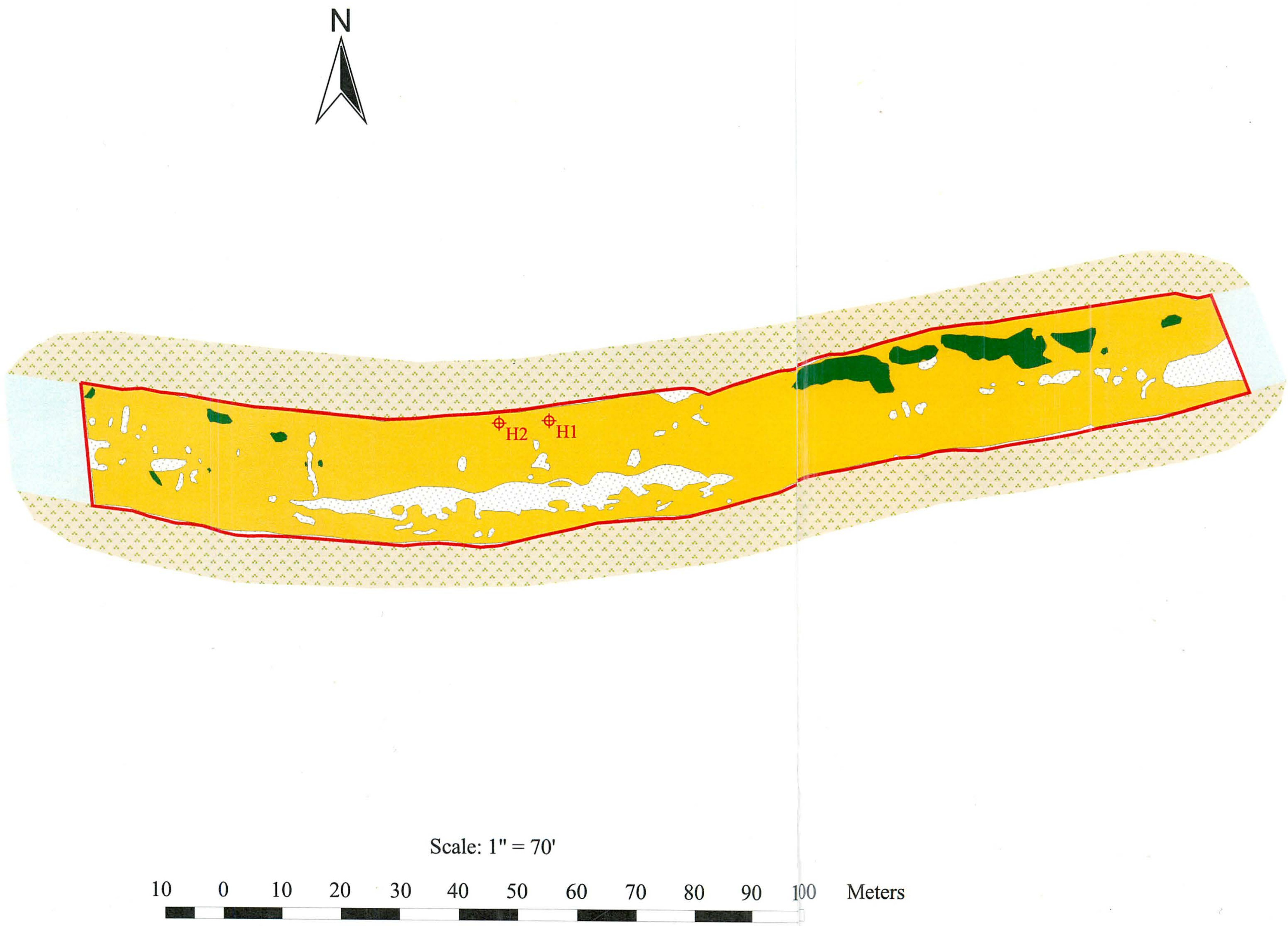
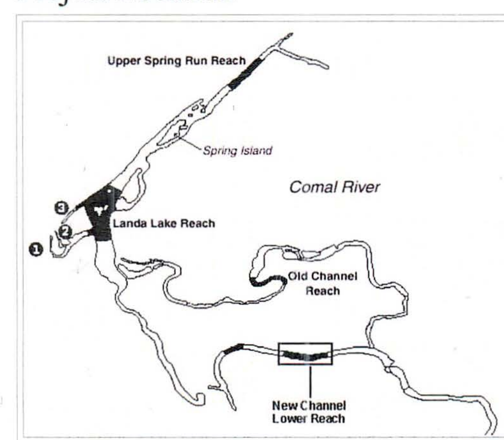
Comal River
Aquatic Vegetation
New Channel Lower Reach
Fall
October 31, 2001



Shore and Islands
River
Study Area (4,133.4 m^2)
Bare Substrate
Drop Net Sample Sites

	Meters ^{2}
Cabomba	210.7
Hygrophila	3,363.1

Project Location



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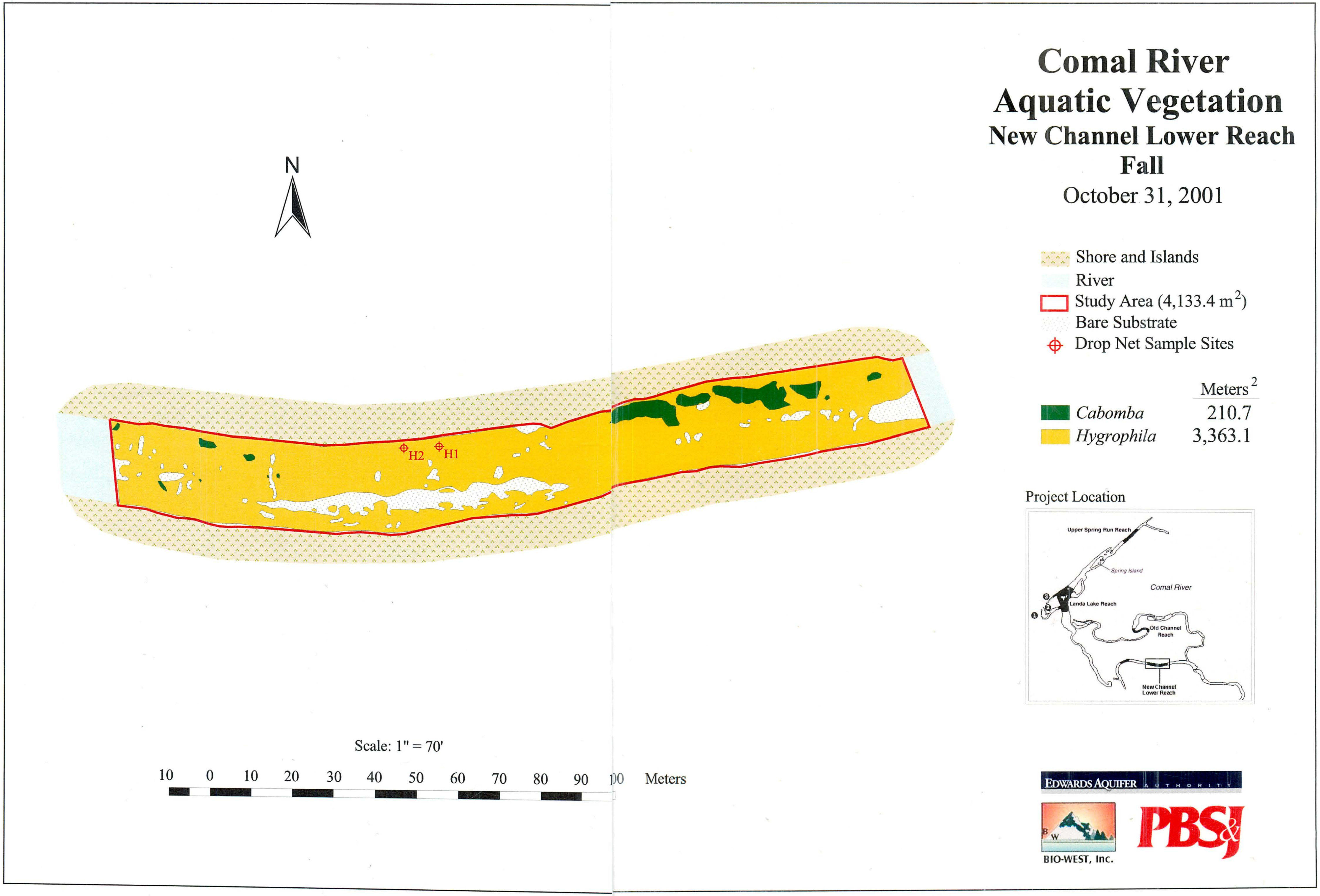
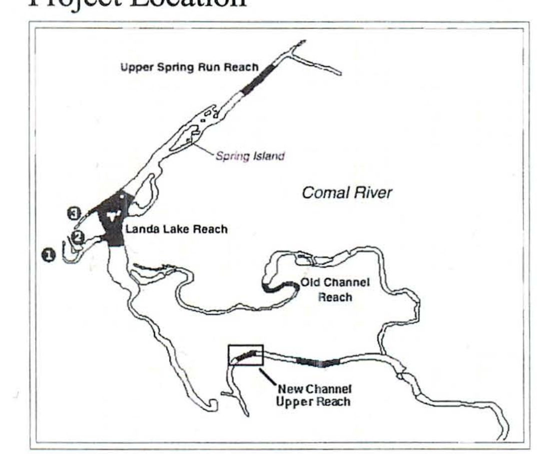

Comal River
Aquatic Vegetation
New Channel Lower Reach
Fall
October 31, 2001
N
H2
H1
Shore and Islands
River
Study Area (4,133.4 m2)
Bare Substrate
Drop Net Sample Sites
Meters 2
Cabomba 210.7
Hygrophila 3,363.1
Project Location
Upper Spring Run Reach
Spring Island
Comal River
Landa Lake Reach
Old Channel Reach
New Channel Lower Reach
Scale: 1" = 70'
10 0 10 20 30 40 50 60 70 80 90
Meters
EDWARDS AQUIFER AUTHORITY
BIO-WEST, Inc.
PBS&J

Comal River
Aquatic Vegetation
New Channel Upper Reach
Fall
November 15, 2000

- Shore and Islands
- River
- Study Area (3,171.2 m^2)
- Bare Substrate
- Drop Net Sample Sites

	Meters^2
Cabomba	41.0
Hygrophila	656.7
Ludwigia	69.6

Project Location

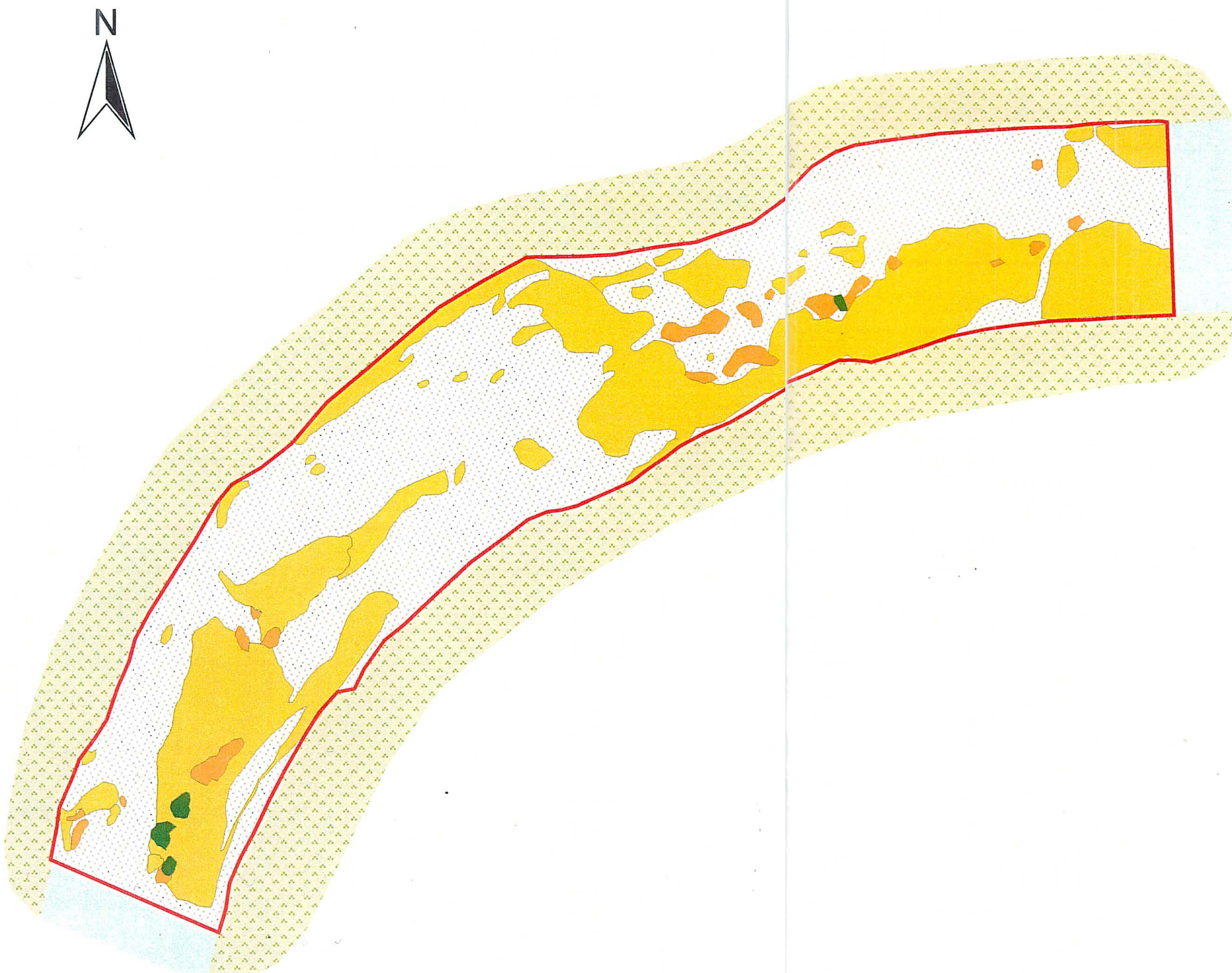


EDWARDS AQUIFER AUTHORITY

BIO-WEST, Inc.

PBS&J

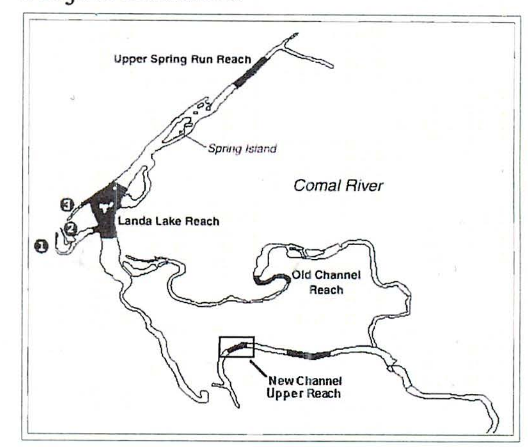
Comal River
Aquatic Vegetation
New Channel Upper Reach
Winter
March 14, 2001



Shore and Islands
River
Study Area (3,171.2 m^2)
Bare Substrate
Drop Net Sample Sites

	Meters^2
Cabomba	13.5
Hygrophila	1,205.8
Ludwigia	75.8

Project Location



Scale: 1" = 50'

10 0 10 20 30 40 50 60 70 Meters

EDWARDS AQUIFER AUTHORITY

BIO-WEST, Inc.

PBS&J

Comal River
Aquatic Vegetation
New Channel Upper Reach
Spring
May 16, 2001

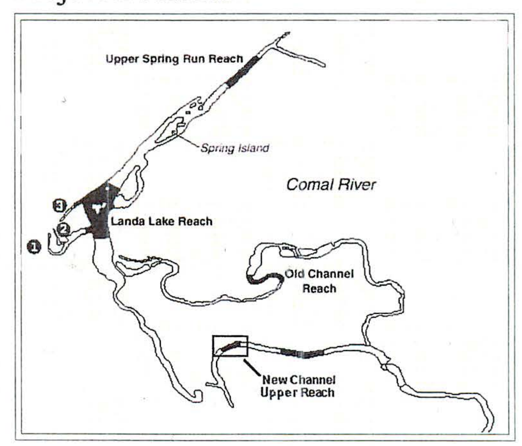
Scale: 1" = 50'

10 0 10 20 30 40 50 60 70 Meters

Shore and Islands
River
Study Area (3,171.2 m^2)
Bare Substrate
Drop Net Sample Sites

	Meters^2
Cabomba	21.8
Hygrophila	1,539.0
Ludwigia	87.9

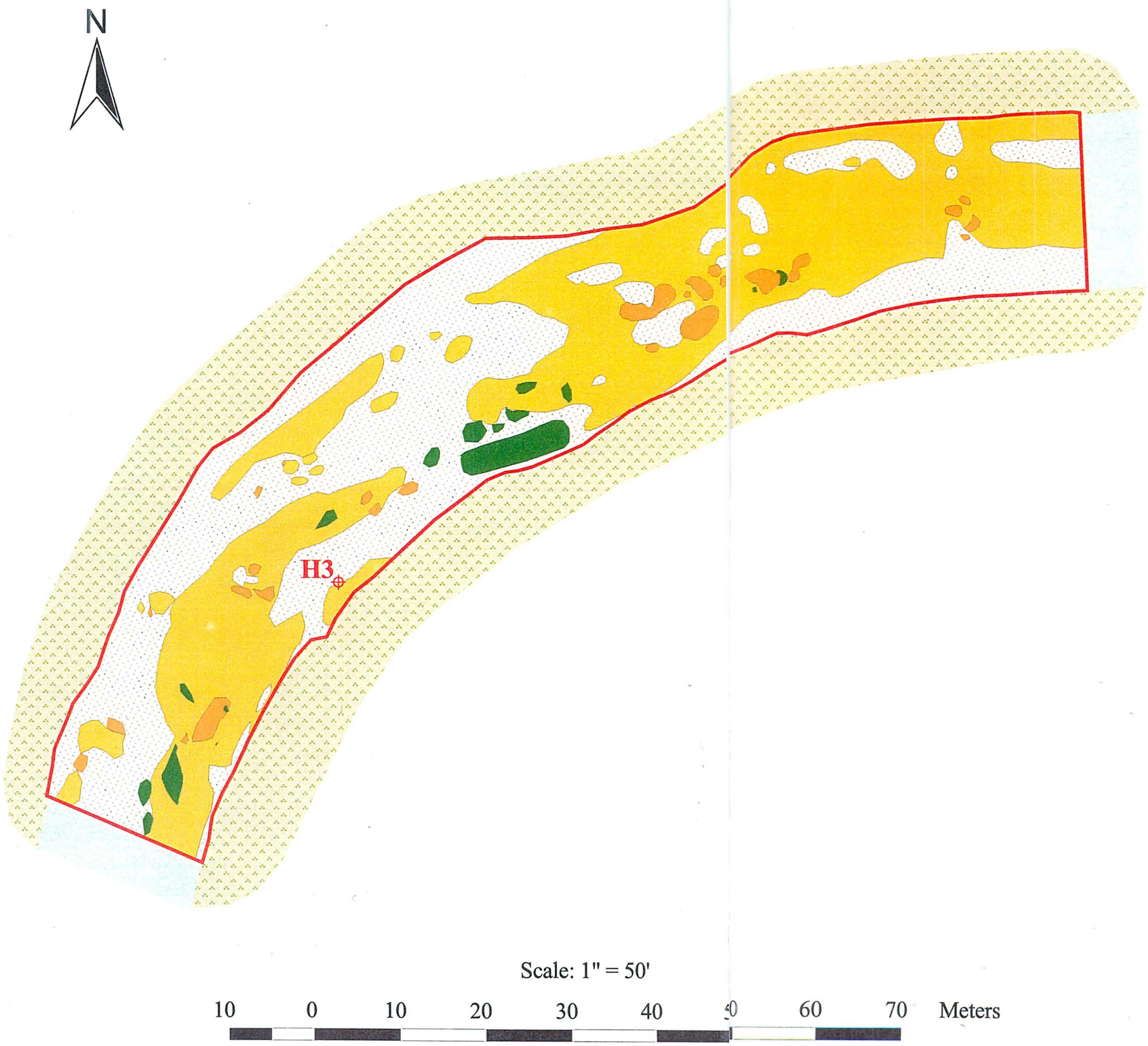
Project Location



EDWARDS AQUIFER AUTHORITY

BIO-WEST, Inc.

PBS&J



Comal River Aquatic Vegetation

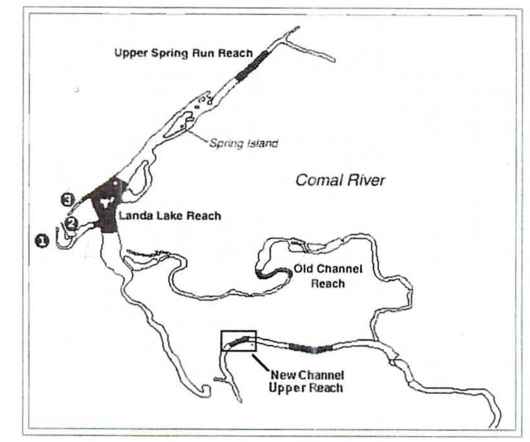
New Channel Upper Reach Summer

August 22, 2001

Shore and Islands
River
Study Area (3,171.2 m^2)
Bare Substrate
Drop Net Sample Sites

	Meters^2
Cabomba	80.6
Hygrophila	1,558.4
Ludwigia	90.2

Project Location



EDWARDS AQUIFER AUTHORITY

BIO-WEST, Inc.

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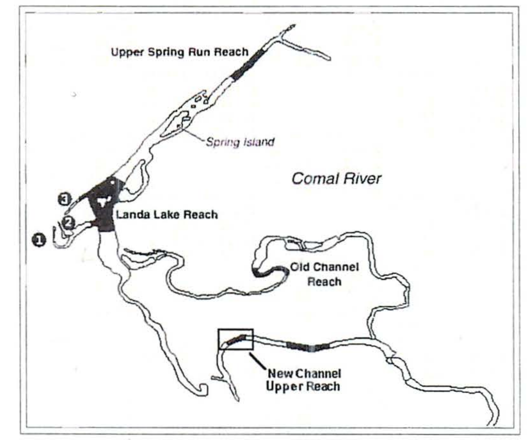
Comal River
Aquatic Vegetation
New Channel Upper Reach
High Flow 1
September 19, 2001

Shore and Islands
River
Study Area (3,171.2 m^2)
Bare Substrate
Drop Net Sample Sites

	Meters^2
Cabomba	82.7
Hygrophila	1,353.8
Ludwigia	87.5

Project Location



EDWARDS AQUIFER AUTHORITY

BIO-WEST, Inc.

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Comal River Aquatic Vegetation

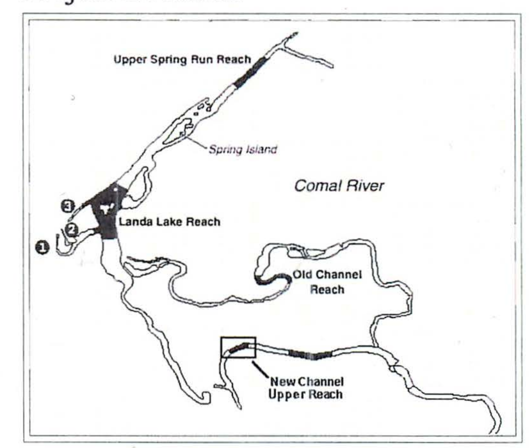
New Channel Upper Reach Fall

October 31, 2001

- Shore and Islands
- River
- Study Area (3,171.2 m^2)
- Bare Substrate
- Drop Net Sample Sites

	Meters^2
Cabomba	59.175
Hygrophila	1,476.237
Ludwigia	41.413

Project Location



EDWARDS AQUIFER AUTHORITY

BIO-WEST, Inc.

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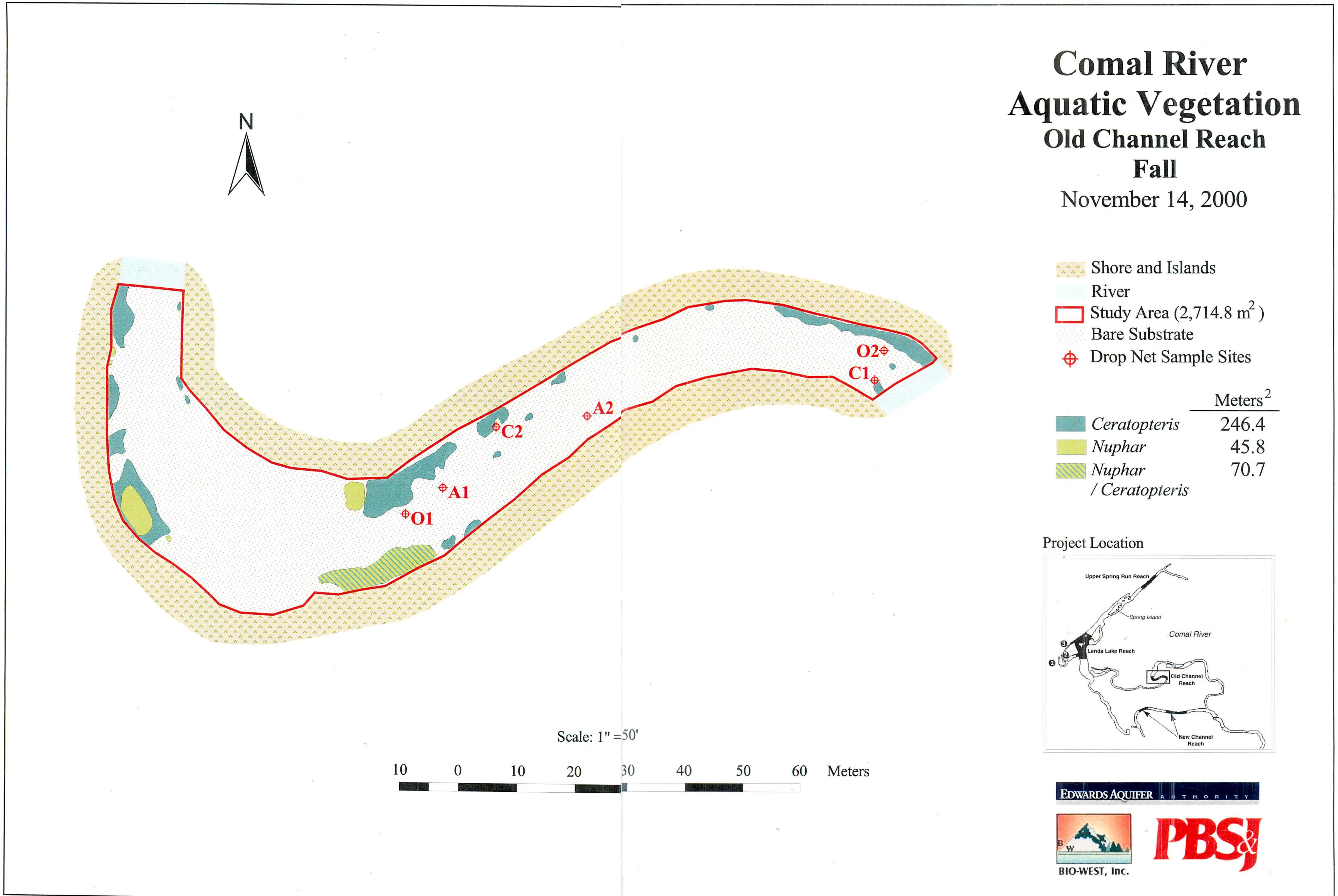
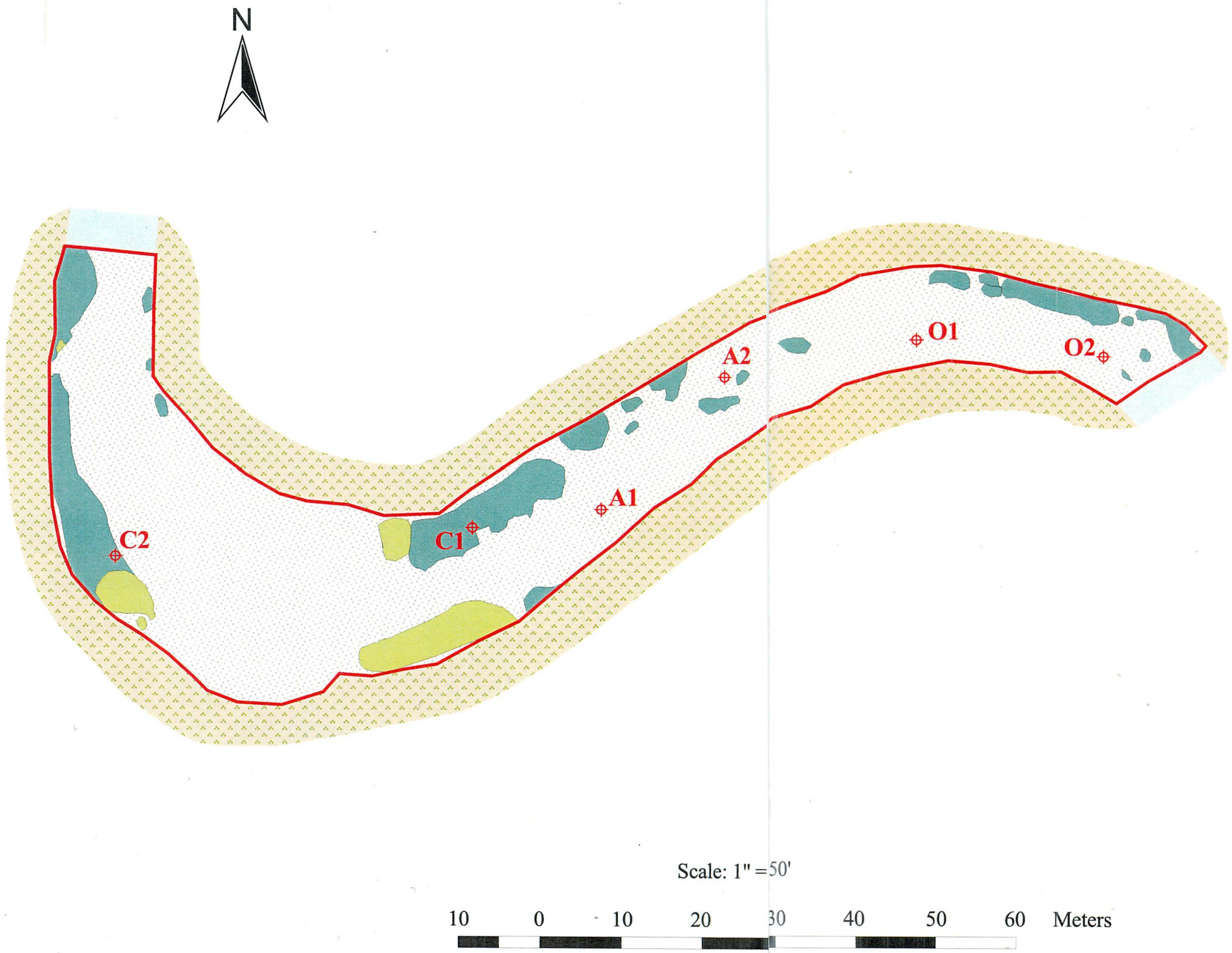

Comal River
Aquatic Vegetation
Old Channel Reach
Fall
November 14, 2000
N
Shore and Islands
River
Study Area (2,714.8 m²)
Bare Substrate
Drop Net Sample Sites
Meters²
Ceratopteris 246.4
Nuphar 45.8
Nuphar / Ceratopteris 70.7
O2
C1
A2
C2
A1
O1
Scale: 1" = 50'
10 0 10 20 30 40 50 60 Meters
Project Location
Upper Spring Run Reach
Spring Island
Comal River
Landa Lake Reach
Old Channel Reach
New Channel Reach
EDWARDS AQUIFER AUTHORITY
BIO-WEST, Inc.
PBS&J

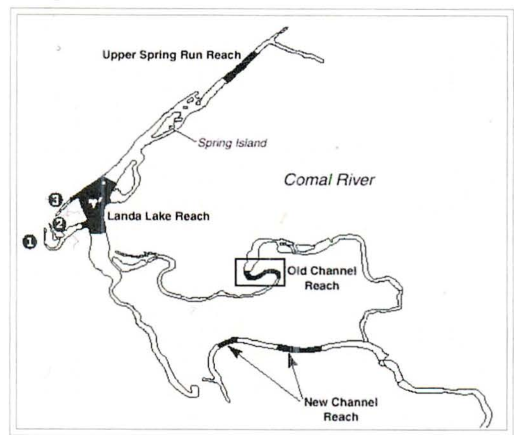
Comal River
Aquatic Vegetation
Old Channel Reach
Winter
March 15, 2001



Shore and Islands
River
Study Area (2,714.8 m^2)
Bare Substrate
Drop Net Sample Sites

	Meters^2
Ceratopteris	389.7
Nuphar	125.8

Project Location



EDWARDS AQUIFER AUTHORITY

BIO-WEST, Inc.

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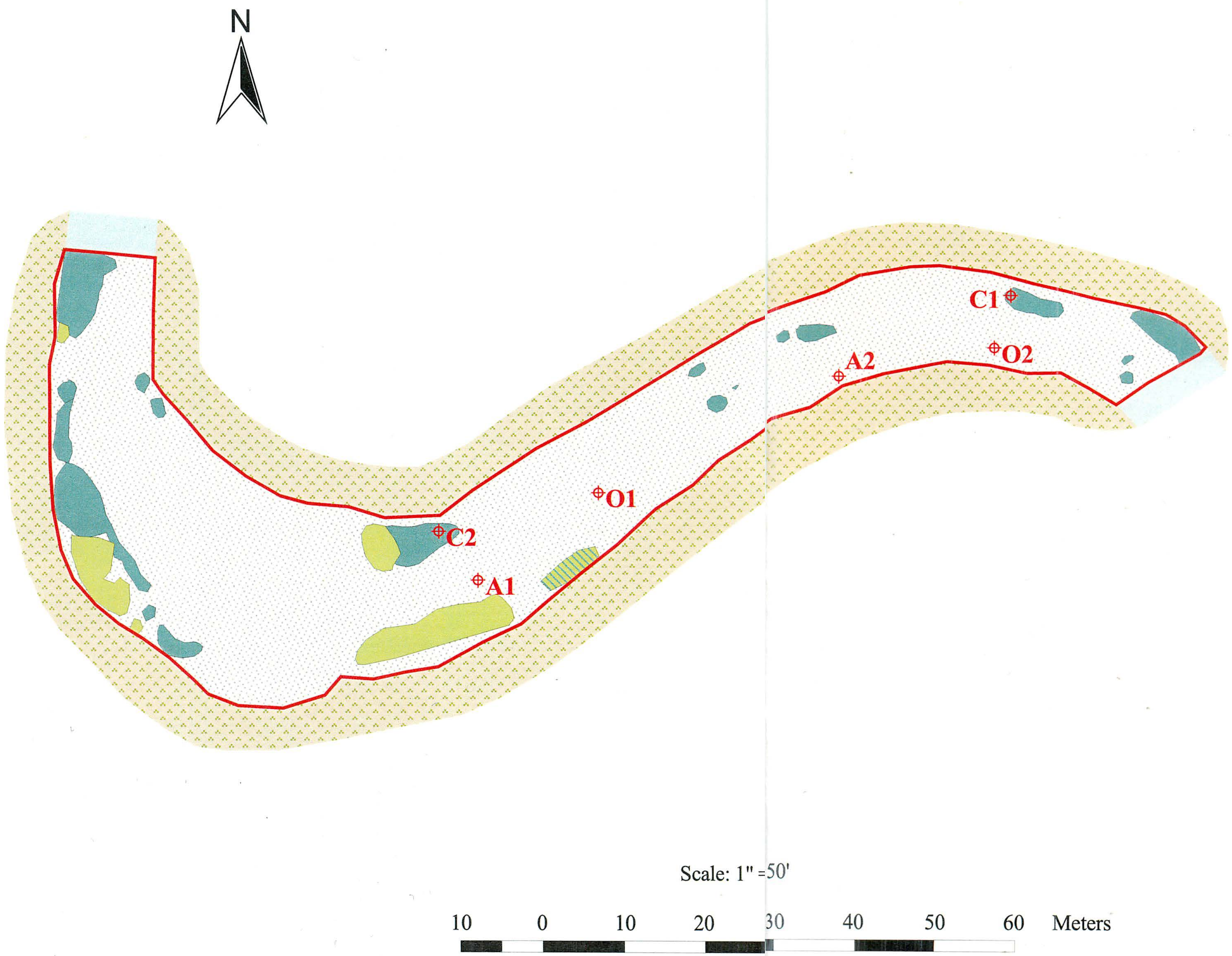
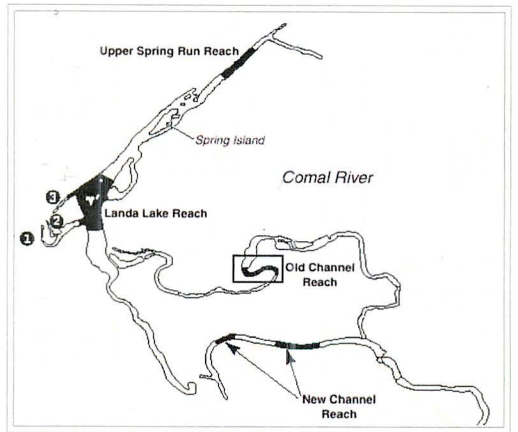
Comal River
Aquatic Vegetation
Old Channel Reach
Spring
May 17, 2001



Shore and Islands
River
Study Area (2,714.8 m^2)
Bare Substrate
Drop Net Sample Sites

	Meters^2
Ceratopteris	229.6
Nuphar	137.7
Nuphar / Ceratopteris	16.7

Project Location



EDWARDS AQUIFER AUTHORITY
BIO-WEST, Inc.
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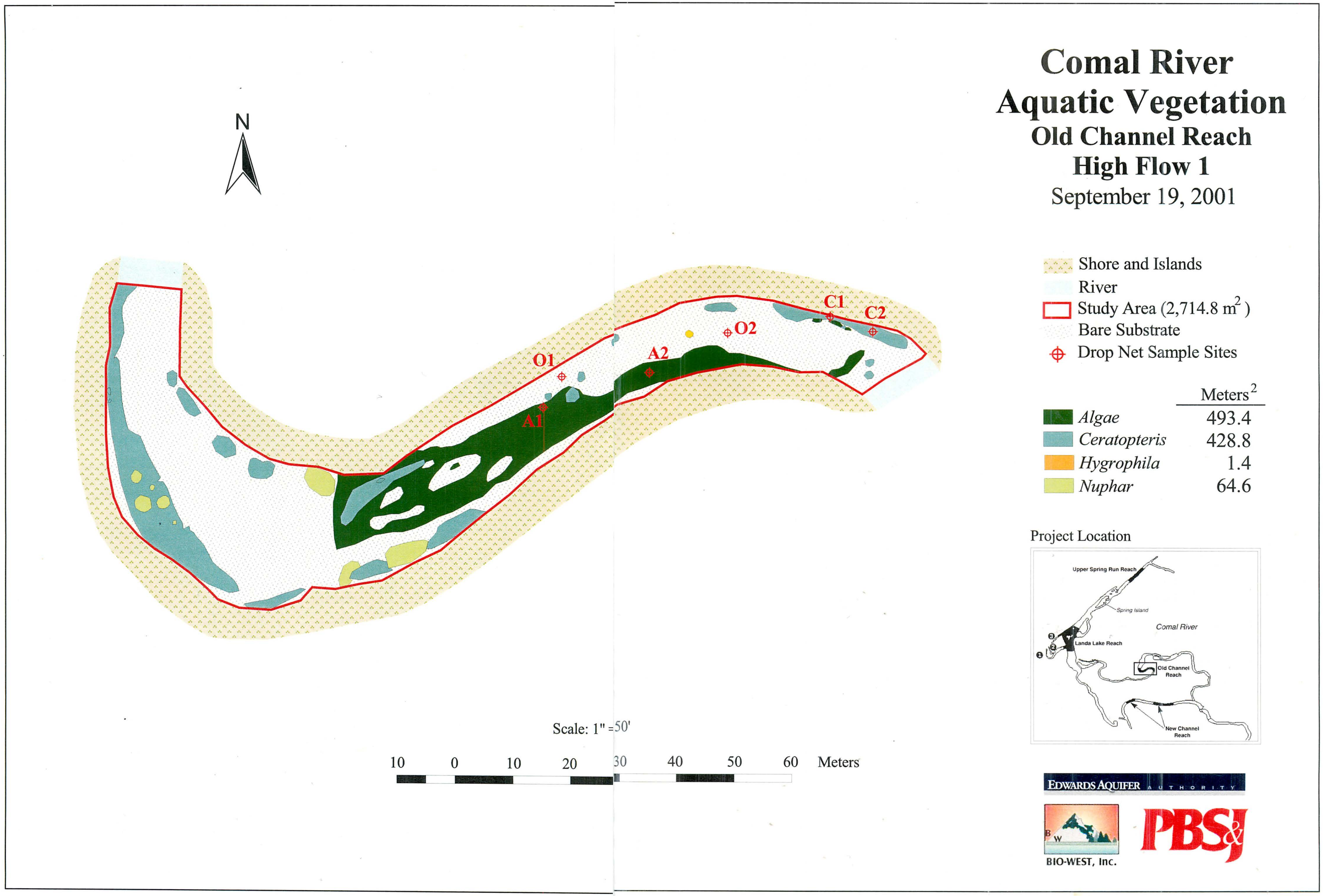
N
C1
A1
A2
O1
C2
O2
Scale: 1" =50'
10 0 10 20 30 40 50 60 Meters
Comal River
Aquatic Vegetation
Old Channel Reach
Summer
August 23, 2001
Shore and Islands
River
Study Area (2,714.8 m²)
Bare Substrate
Drop Net Sample Sites
Meters²
Algae 493.4
Ceratopteris 428.8
Hygrophila 1.4
Nuphar 64.6
Project Location
Upper Spring Run Reach
Spring Island
Comal River
Landa Lake Reach
Old Channel Reach
New Channel Reach
EDWARDS AQUIFER AUTHORITY
BIO-WEST, Inc.
PBS&J

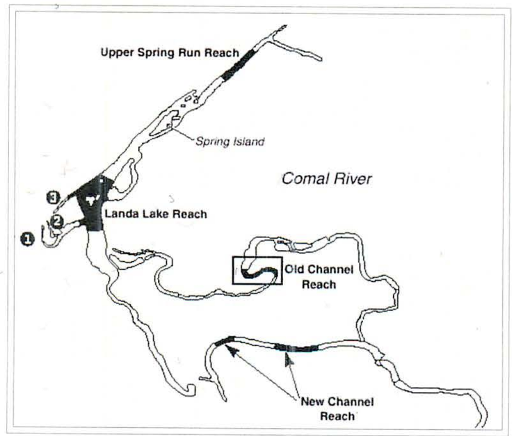

Comal River
Aquatic Vegetation
Old Channel Reach
High Flow 1
September 19, 2001
Shore and Islands
River
Study Area (2,714.8 m^2)
Bare Substrate
Drop Net Sample Sites
Meters^2
Algae 493.4
Ceratopteris 428.8
Hygrophila 1.4
Nuphar 64.6
Project Location
Upper Spring Run Reach
Spring Island
Comal River
Landa Lake Reach
Old Channel Reach
New Channel Reach
N
O1
O2
A1
A2
C1
C2
Scale: 1" = 50'
10 0 10 20 30 40 50 60 Meters
EDWARDS AQUIFER AUTHORITY
BIO-WEST, Inc.
PBS&J

Comal River Aquatic Vegetation
Old Channel Reach
Fall
October 31, 2001

Shore and Islands
River
Study Area (2,714.8 m^2)
Bare Substrate
Drop Net Sample Sites

	$Meters^2$
Algae	479.0
Ceratopteris	433.4
Nuphar	25.8
Nuphar / Ceratopteris	86.1

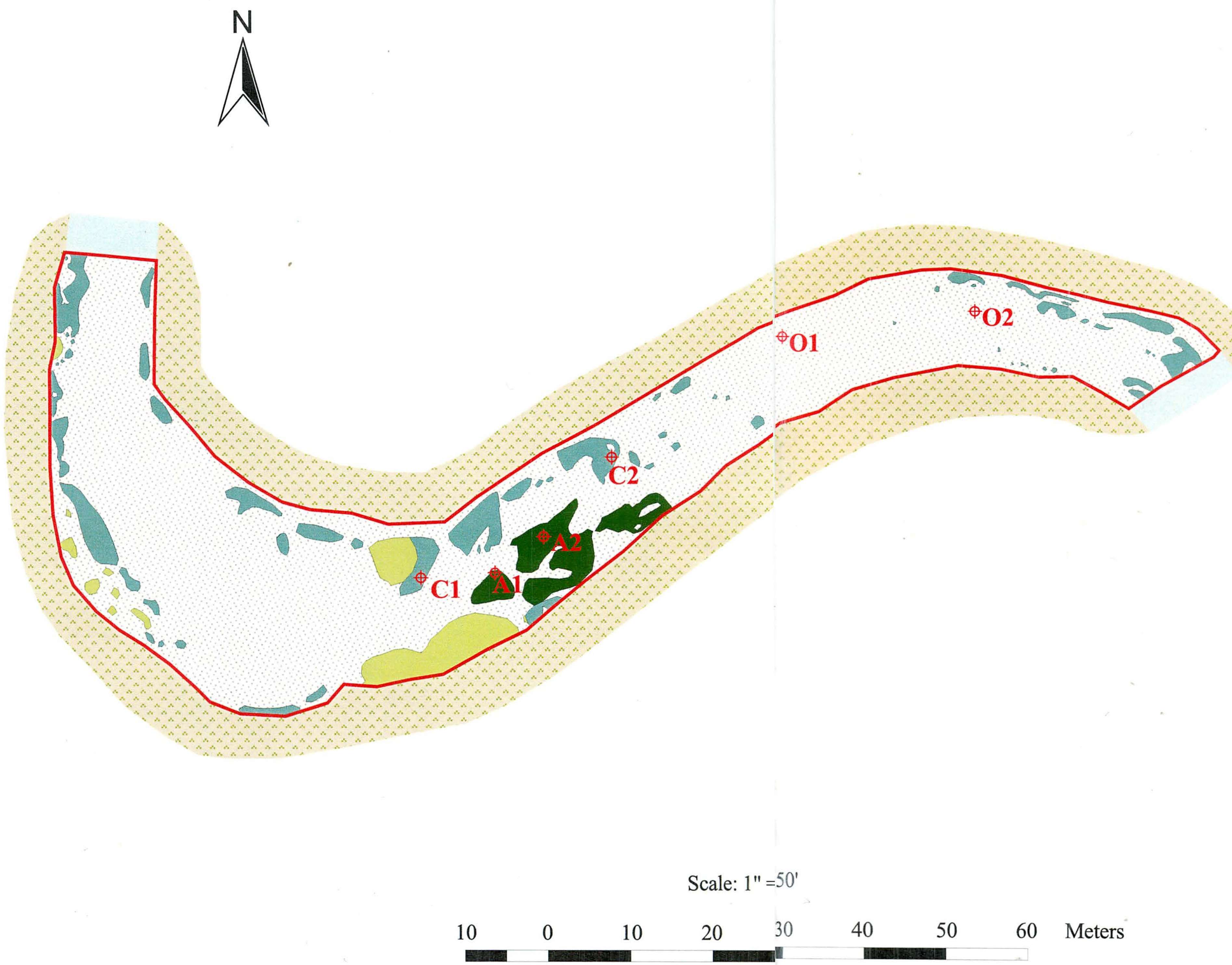
Project Location



EDWARDS AQUIFER AUTHORITY

BIO-WEST, Inc.

PBS&J

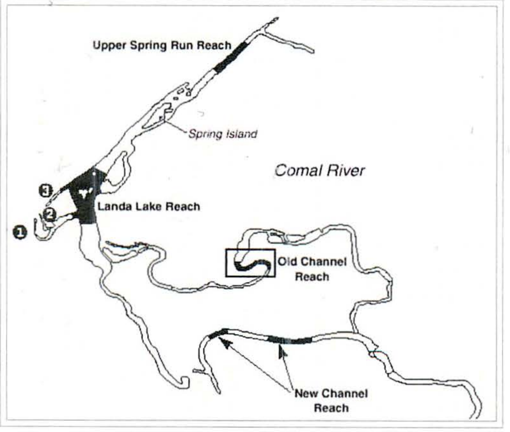


Comal River
Aquatic Vegetation
Old Channel Reach
High Flow 2
November 27, 2001

- Shore and Islands
- River
- Study Area (2,714.8 m^2)
- Bare Substrate
- Drop Net Sample Sites

	Meters^2
Algae	101.3
Ceratopteris	243.9
Nuphar	115.2

Project Location



EDWARDS AQUIFER AUTHORITY

BIO-WEST, Inc.

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APPENDIX B: DATA AND GRAPHS

Water Quality Data

Physical water quality and nutrient measurements for the Comal River system from 2000 to 2001.

Site	Date	Depth	Temp	pH	D.O.	Cond	Turb.	Alkalinity	SRP ugP/l	TP ug/l	NH4-N (ug/L)	N03-N (mg/L)	TN-N (mg/L)	TSS (mg/L)
spring run one	8/29/2000	0.76	23.72	7.23	5.1	508	1.1	4.08	2.786	19.9	25.12	2.08	2.13	0.018
spring run one	9/12/2000	0.42	23.5	7.04	5.12	504	0.9	3.827	3.657	18.52	165.86	2.38	1.24	0.004
spring run one	11/14/2000	0.4	23.18	7.32	6.32	531	0.6	4.307	6.095	22.66	131.81	1.98	2.11	0.004
spring run one	3/22/2001	0.7	23.19	7.32	5.6	531	0.9	4.072	9.665	10.83	75	2.48	2.76	0.006
spring run one	5/25/2001	0.5	23.27	7.22	5.35	518	0.8	4.072	8.343	37.14	90	1.99	2.18	0.009
spring run one	8/28/2001	0.5	23.42	7.34	5.81	667	0.07	4.036	3.235	9.48	72	2.01	2.11	0.005
spring run one	11/9/2001	0.5	23.45	7.17	5.38	521	0.8	4.069	17.027	24.56	51	2.05	2.1	0.004
	MEAN	0.54	23.39	7.23	5.53	540	0.74	4.066	7.258	20.44	87.26	2.14	2.09	0.0071
	MAX	0.76	23.72	7.34	6.32	667	1.1	4.307	17.027	37.14	165.86	2.48	2.76	0.018
	MIN	0.4	23.18	7.04	5.1	504	0.07	3.827	2.786	9.48	25.12	1.98	1.24	0.004
spring run two	8/29/2000	0.6	23.62	7.17	5.08	507	0.9	4.118	4.702	20.93	21	2.12	1.06	0.0003
spring run two	9/12/2000	0.45	23.53	7.13	5.02	505	1.2	4.042	2.612	26.45	70.52	1.99	1.38	0.022
spring run two	11/14/2000	0.3	23.14	7.34	6.24	532	0.8	4.249	7.314	21.97	138.62	1.9	2.13	0.004
spring run two	3/22/2001	0.3	23.44	7.37	5.35	531	0.9	4.136	10.449	13.29	21	2.08	2.21	0.006
spring run two	5/25/2001	0.5	23.45	7.26	5.22	518	0.7	4.195	7.151	18.52	52	1.84	2.1	0.002
spring run two	8/28/2001	0.5	23.55	7.36	5.56	665	0.09	4.036	3.746	12.35	56	2.17	2.32	0.009
spring run two	11/9/2001	0.5	23.48	7.19	5.3	520	0.9	3.937	11.919	16.06	49	2.25	2.32	0.006
	MEAN	0.45	23.46	7.26	5.4	540	0.78	4.102	6.842	18.51	58.31	2.05	1.93	0.007
	MAX	0.6	23.62	7.37	6.24	665	1.2	4.249	11.919	26.45	138.62	2.25	2.32	0.022
	MIN	0.3	23.14	7.13	5.02	505	0.09	3.937	2.612	12.35	21	1.84	1.06	0.0003
spring run three	8/29/2000	0.6	23.55	7.17	5.23	506	1.1	4.137	3.309	17.83	24.96	2.34	2.5	0.017
spring run three	9/12/2000	0.58	23.47	7.09	5.37	505	1	4.042	6.095	19.55	159.05	1.98	1.21	0.021
spring run three	11/14/2000	0.5	23.17	7.37	6.84	525	0.6	4.229	3.657	21.97	134.08	1.74	1.87	0.0001
spring run three	3/22/2001	1.25	23.58	7.42	5.95	524	0.8	4.129	11.32	10.71	91	2.33	2.52	0.004
spring run three	5/25/2001	0.9	23.44	7.24	5.51	519	0.7	4.293	4.257	8.52	58	1.85	2.11	0.012
spring run three	8/28/2001	0.5	23.43	7.36	5.56	665	0.09	4.203	4.006	10.98	76	1.89	1.96	0.006
spring run three	11/9/2001	0.5	23.43	7.17	5.58	521	1.2	4.036	13.111	14.1	61	2.37	2.43	0.005
	MEAN	0.69	23.44	7.26	5.72	538	0.78	4.153	6.536	14.81	86.3	2.07	2.09	0.0093
	MAX	1.25	23.58	7.42	6.84	665	1.2	4.293	13.111	21.97	159.05	2.37	2.52	0.021
	MIN	0.5	23.17	7.09	5.23	505	0.09	4.036	3.309	8.52	24.96	1.74	1.21	0.0001
New Channel, upstream	8/29/2000	2.5	25.47	7.41	8.6	503	1.7	4.156	2.264	27.14	N.D.	1.73	1.71	0.03
New Channel, upstream	9/12/2000	2	24.01	7.54	7.81	507	2	4.092	25.078	45.41	N.D.	1.86	1.95	0.02
New Channel, upstream	11/14/2000	3	22.61	7.47	9.04	529	1.1	4.319	6.792	22.31	29.66	2.09	2.1	0.018
New Channel, upstream	3/22/2001		24.06	7.5	9.52	530	1.1	4.189	8.882	11.62	168	1.92	2.38	0.038
New Channel, upstream	5/25/2001	2.5	23.81	7.32	7.17	518	1.5	4.286	4.427	6.45	25	1.77	2.23	0.003
New Channel, upstream	8/28/2001	2.3	24.05	7.7	7.46	670	1.4	4.118	1.532	8.1	11	2.19	2.3	0.009
New Channel, upstream	11/9/2001	2.2	23.99	7.34	9.68	521	1.3	3.937	1.532	9.88	16	2.18	2.39	0.008
	MEAN	2.42	24	7.47	8.47	540	1.44	4.157	7.215	18.7	49.93	1.96	2.15	0.018
	MAX	3	25.47	7.7	9.68	670	2	4.319	25.078	45.41	168	2.19	2.39	0.038
	MIN	2	22.61	7.32	7.17	503	1.1	3.937	1.532	6.45	11	1.73	1.71	0.003

Physical water quality and nutrient measurements for the Comal River system from 2000 to 2001 (continued).

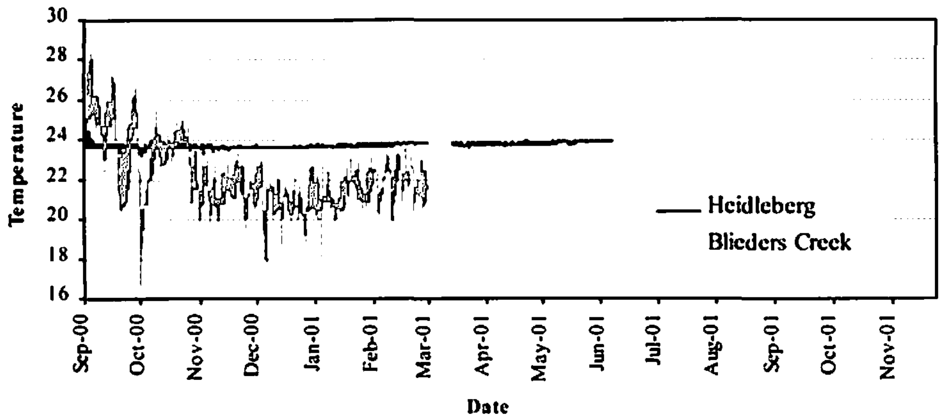
Site	Date	Depth	Temp	pH	D.O.	Cond	Turb.	Alkalinity	SRP ugP/l	TP ug/l	NH4-N(ug/L)	N03-N(mg/L)	TN-N(mg/L)	TSS (mg/L)
New Channel, downstream	8/29/2000	2.5	25.11	7.66	9.98	502	1.5	4.213	2.09	18.52	31.93	1.79	2.11	0.044
New Channel, downstream	9/12/2000	>1.5	24.01	7.54	7.81	507	2.1	4.08	2.438	23.35	106.84	1.26	1.28	0.022
New Channel, downstream	11/14/2000	1.6	22.02	7.72	10.1	523	1.1	4.561	7.14	23.34	31.93	1.83	1.84	0.012
New Channel, downstream	3/22/2001	1.9	24.3	7.77	9.93	531	1.1	4.363	8.795	8.86	93	1.95	2.34	0.012
New Channel, downstream	5/25/2001		23.75	7.59	8.77	516	1.3	4.396	9.424	17.83	40	1.74	2.01	0.004
New Channel, downstream	8/28/2001	1.7	23.98	7.74	9.54	665	1.5	4.006	7.662	19.73	29	2.25	2.32	0.009
New Channel, downstream	11/9/2001	1.6	23.93	7.63	9.82	520	1.4	4.003	12.089	19.06	32	2.09	2.21	0.01
	MEAN	1.86	23.87	7.66	9.41	538	1.43	4.232	7.091	18.67	52.1	1.84	2.02	0.0161
	MAX	2.5	25.11	7.77	10.1	665	2.1	4.561	12.089	23.35	106.84	2.25	2.34	0.044
	MIN	1.6	22.02	7.54	7.81	502	1.1	4.003	2.09	8.86	29	1.26	1.28	0.004
Bleider's Creek	8/29/2000	1.02	24.97	7.15	3.91	510	2.6	4.099	10.101	33	261.2	1.79	1.96	0.026
Bleider's Creek	9/12/2000	0.62	25.38	7.19	3.19	507	3	4.024	2.786	25.41	283.9	1.32	1.36	0.026
Bleider's Creek	11/14/2000	0.8	20.87	7.51	8.4	529	1.2	4.054	5.573	41.97	93.22	1.77	1.8	0.022
Bleider's Creek	3/22/2001	0.8	21.67	7.66	10.5	523	1.3	4.059	10.884	8.17	77	2.23	2.41	0.006
Bleider's Creek	5/25/2001	0.6	23.96	7.31	5.12	500	1.6	4.118	8.003	16.79	120	1.34	1.66	0.024
Bleider's Creek	8/28/2001	1	24.4	7.37	3.72	640	1.4	3.937	2.213	9.6	109	1.41	1.63	0.018
Bleider's Creek	11/9/2001	1.2	22.35	7.35	6.7	521	1.3	3.606	21.964	25.06	56	2.22	2.4	0.021
	MEAN	0.86	23.37	7.36	5.93	533	1.77	3.985	8.789	22.86	142.9	1.73	1.89	0.0204
	MAX	1.2	25.38	7.66	10.5	640	3	4.118	21.964	41.97	283.9	2.23	2.41	0.026
	MIN	0.6	20.87	7.15	3.19	500	1.2	3.606	2.213	8.17	56	1.32	1.36	0.006
Heildelburg, Main Channel	8/29/2000	0.4	24.09	7.19	4.99	513	1.4	3.967	2.264	17.14	20.58	1.7	1.8	0.028
Heildelburg, Main Channel	9/12/2000	0.62	26.56	*	6.25	508	2.1	4.042	4.005	23.35	199.91	1.65	1.28	0.021
Heildelburg, Main Channel	3/22/2001	1	23.7	7.41	6.86	531	1.6	4.099	9.927	7.83	93	2.08	2.38	0.018
Heildelburg, Main Channel	5/25/2001	0.5	23.85	7.26	4.48	519	1.9	4.276	5.449	11.97	153	1.94	2.3	0.024
Heildelburg, Main Channel	8/28/2001	0.8	23.95	7.39	6.31	667	1.5	4.118	2.895	10.13	128	2.03	2.22	0.02
Heildelburg, Main Channel	11/9/2001	0.5	23.67	7.25	5.79	523	1.1	3.937	15.665	17.05	65	2.21	2.37	0.026
	MEAN	0.64	24.3	7.3	5.78	544	1.6	4.073	6.701	14.58	109.92	1.94	2.06	0.0228
	MAX	1	26.56	7.41	6.86	667	2.1	4.276	15.665	23.35	199.91	2.21	2.38	0.028
	MIN	0.4	23.67	7.19	4.48	508	1.1	3.937	2.264	7.83	20.58	1.65	1.28	0.018
Island Park, Far Channel	8/29/2000	1.5	23.84	7.16	5.97	509	1.6	4.269	4.876	22.31	16.04	1.56	1.68	0.049
Island Park, Far Channel	9/12/2000	1.2	24.06	7.15	5.88	509	1.4	4.138	4.528	22.31	188.56	1.62	0.92	0.011
Island Park, Far Channel	11/14/2000	1.1	22.57	7.36	7.88	522	1.7	4.257	5.747	47.83	25.12	1.93	1.99	0.01
Island Park, Far Channel	3/22/2001	0.4	23.58	7.3	6.01	532	1.6	4.221	11.32	13.69	71	2.06	2.4	0.04
Island Park, Far Channel	5/25/2001		23.53	7.24	6.31	521	1.6	4.356	4.767	17.72	16	1.92	2.14	0.005
Island Park, Far Channel	8/28/2001	1.2	24.11	7.37	6.92	672	1.4	4.276	2.554	10.7	10	2.14	2.25	0.004
Island Park, Far Channel	11/9/2001	1.3	23.45	7.26	6.68	521	1.1	3.97	2.895	11.1	16	2.24	2.3	0.005
	MEAN	1.12	23.59	7.26	6.52	541	1.49	4.212	5.241	20.81	48.96	1.92	1.95	0.0177
	MAX	1.5	24.11	7.37	7.88	672	1.7	4.356	11.32	47.83	188.56	2.24	2.4	0.049
	MIN	0.4	22.57	7.15	5.88	509	1.1	3.97	2.554	10.7	10	1.56	0.92	0.004

Physical water quality and nutrient measurements for the Comal River system from 2000 to 2001 (continued).

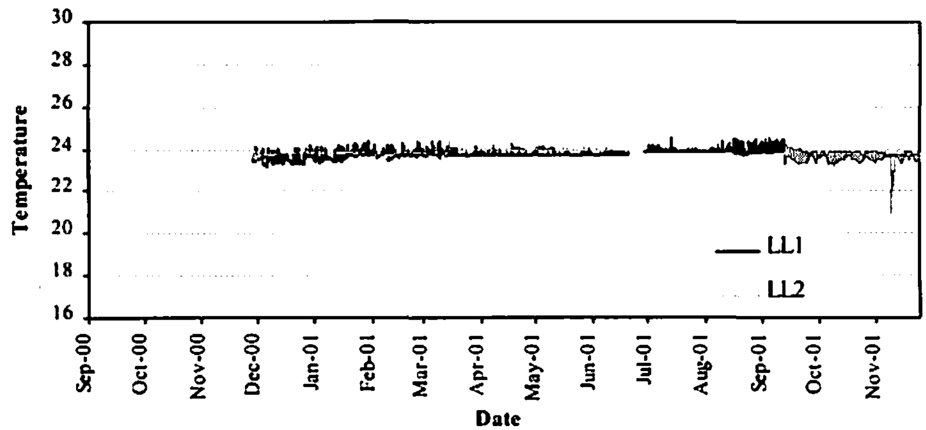
Site	Date	Depth	Temp	pH	D.O.	Cond	Turb.	Alkalinity	SRP ugP/l	TP ug/l	NH4-N(ug/L)	N03-N(mg/L)	TN-N(mg/L)	TSS (mg/L)
Island Park, Near Channel	8/29/2000	3.4	23.8	7.11	4.81	508	1.1	4.289	3.483	19.21	29.66	5.97	0.62	0.018
Island Park, Near Channel	9/12/2000		23.96		5.08	508	1.1	4.118	10.101	26.1	288.44	1.46	1.7	0.018
Island Park, Near Channel	11/14/2000	2.4	22.85	7.28	6.9	524	1.1	4.366	6.792	34.03	13.77	1.82	1.91	0.01
Island Park, Near Channel	3/22/2001	1.05	23.97	7.36	8.4	530	1.3	4.257	10.797	27.4	46	1.89	2.14	0.016
Island Park, Near Channel	5/25/2001	2.6	23.61	7.24	5.32	520	1.5	4.381	6.3	8.86	18	1.86	2.07	0.006
Island Park, Near Channel	8/28/2001	2.5	23.84	7.34	6.05	671	1.4	4.118	1.873	7.07	24	2.24	2.37	0.005
Island Park, Near Channel	11/9/2001	2.4	23.61	7.23	6.18	520	1	3.97	6.3	12.06	32	2.18	2.32	0.007
	MEAN	2.39	23.66	7.26	6.11	540	1.21	4.214	6.521	19.25	64.55	2.49	1.87	0.0114
	MAX	3.4	23.97	7.36	8.4	671	1.5	4.381	10.797	34.03	288.44	5.97	2.37	0.018
	MIN	1.05	22.85	7.11	4.81	508	1	3.97	1.873	7.07	13.77	1.46	0.62	0.005
Old Channel,Upstream	8/29/2000	0.76	25.17	7.6	7.1	511	2.2	4.401	5.747	25.41	11.5	1.77	1.7	0.023
Old Channel,Upstream	9/12/2000	0.65	24.4	7.48	6.12	512	2.8	4.231	7.488	30.24	131.81	1.82	1.38	0.022
Old Channel,Upstream	11/14/2000	0.7	20.39	7.87	8.99	533	1.6	4.444	9.927	35.07	34.2	1.65	1.7	0.052
Old Channel,Upstream	3/22/2001		22.51	7.86	9.85	534	1.4	4.359	10.449	9.45	57	1.72	1.99	0.164
Old Channel,Upstream	5/25/2001	1.1	22.93	7.62	6.57	525	1.5	4.343	8.343	12.31	34	1.61	2	0.008
Old Channel,Upstream	8/28/2001	1.2	23.92	7.7	7.09	664	1.5	4.203	N.D.	11.02	29	2.04	2.11	0.01
Old Channel,Upstream	11/9/2001	0.6	23.82	7.58	8.46	522	1.5	4.003	26.732	33.26	25	2.08	2.21	0.01
	MEAN	0.84	23.31	7.67	7.74	543	1.79	4.283	11.448	22.39	46.07	1.81	1.87	0.0413
	MAX	1.2	25.17	7.87	9.85	664	2.8	4.444	26.732	35.07	131.81	2.08	2.21	0.164
	MIN	0.6	20.39	7.48	6.12	511	1.4	4.003	5.747	9.45	11.5	1.61	1.38	0.008
Old Channel,Downstream	8/29/2000	0.61	26.05	7.6	8.38	505	2	4.269	2.438	21.28	25.12	1.64	0.63	0.021
Old Channel,Downstream	9/12/2000	0.74	24.18	7.38	6.58	508	2.2	4.194	2.786	24.38	38.74	1.87	1.27	0.023
Old Channel,Downstream	11/14/2000	0.5	21.63	7.62	9.9	530	1.7	4.307	5.399	38.52	134.08	2.2	2.34	0.03
Old Channel,Downstream	3/22/2001		24.17	7.8	9.81	531	1.6	4.269	10.71	188.86	75	2.02	2.39	0.366
Old Channel,Downstream	5/25/2001	0.6	23.48	7.52	7.46	520	1.6	4.303	8.684	18.86	16	1.75	1.99	0.002
Old Channel,Downstream	8/28/2001	0.6	24.21	7.84	7.86	665	1.8	4.118	4.597	15.59	9	2.09	2.11	0.006
Old Channel,Downstream	11/9/2001	1	22.29	7.65	8.4	527	1.9	4.069	10.386	17.11	10	2.22	2.42	0.009
	MEAN	0.68	23.72	7.63	8.34	541	1.83	4.218	6.429	46.37	43.99	1.97	1.88	0.0653
	MAX	1	26.05	7.84	9.9	665	2.2	4.307	10.71	188.86	134.08	2.22	2.42	0.366
	MIN	0.5	21.63	7.38	6.58	505	1.6	4.069	2.438	15.59	9	1.64	0.63	0.002
The Other Place,(Ivemess	8/29/2000	>1.0	25.51	7.79	9.51	505	1.9	4.289	2.786	17.14	25.12	5.83	1	0.019
The Other Place,(Ivemess	9/12/2000	VAR.	24.3	7.57	6.7	509	2.8	4.118	3.483	23.35	138.62	1.92	1.89	0.025
The Other Place,(Ivemess	11/14/2000	VAR.	21.22	7.85	9.18	525	3.2	4.405	10.449	29.55	20.58	1.78	1.81	0.028
The Other Place,(Ivemess	3/22/2001	deep	23.12	7.88	9.75	532	3.1	4.27	10.71	2.66	50	2.28	2.53	0.018
The Other Place,(Ivemess	5/25/2001	0.8	23.7	7.71	8.52	516	2.7	4.404	6.13	9.21	202	1.62	2.27	0.007
The Other Place,(Ivemess	8/28/2001	0.7	24.33	7.89	9.27	662	2.5	4.203	1.362	9.03	36	2.31	2.55	0.005
The Other Place,(Ivemess	11/9/2001	0.6	23.29	7.72	9.1	521	2.2	4.003	10.046	14.07	45	2.19	2.31	0.009
	MEAN	0.7	23.64	7.77	8.86	539	2.63	4.242	6.424	15	73.9	2.56	2.05	0.0159
	MAX	0.8	25.51	7.89	9.75	662	3.2	4.405	10.71	29.55	202	5.83	2.55	0.028
	MIN	0.6	21.22	7.57	6.7	505	1.9	4.003	1.362	2.66	20.58	1.62	1	0.005

Thermistor Graphs

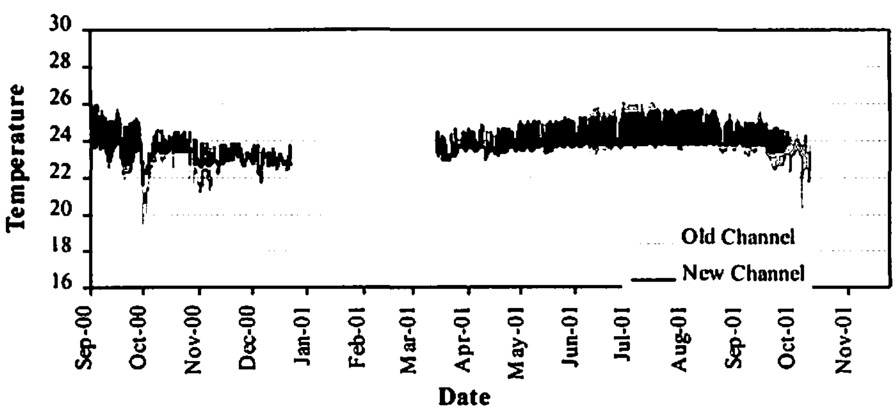
Thermistor Data: Comal Headwaters



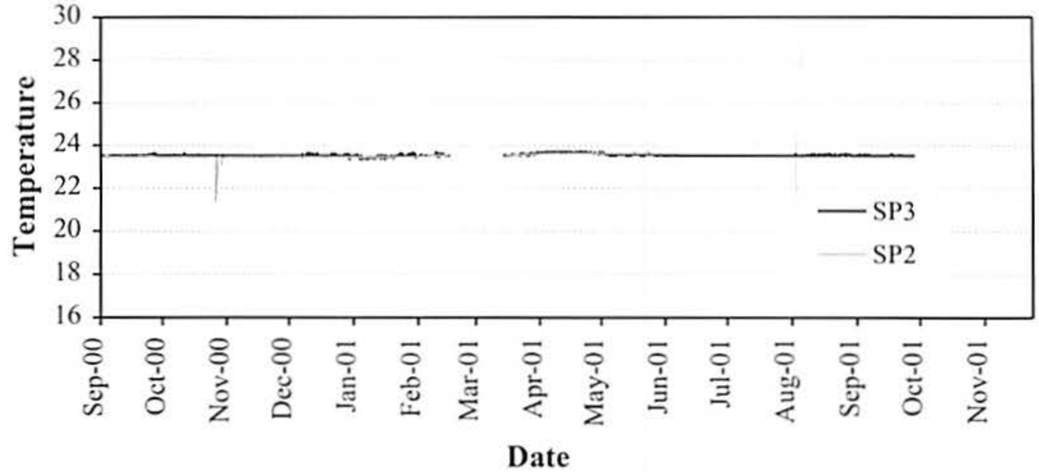
Thermistor Data: Landa Lake Bottom



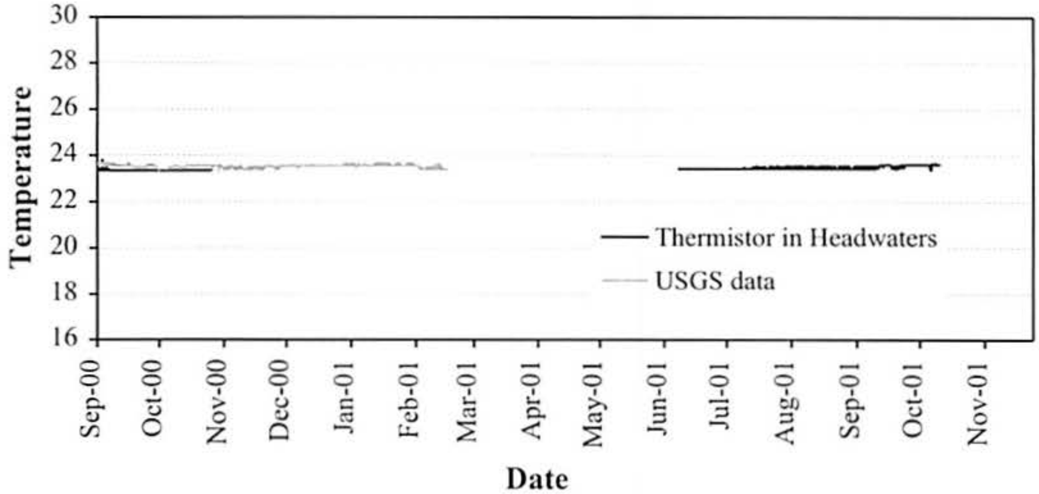
Thermistor Data: Old Channel



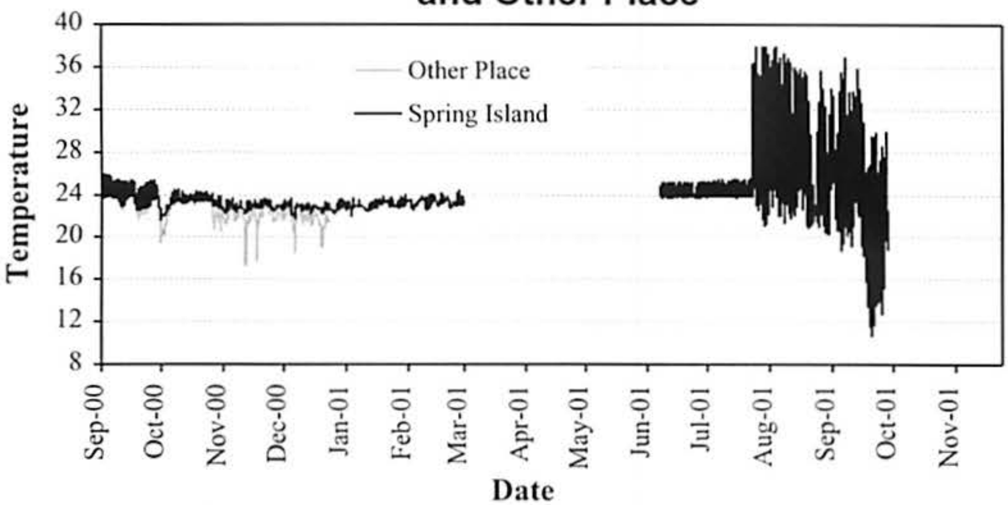
Thermistor Data: Spring Runs 2 & 3



Thermistor Data: Spring Run 1

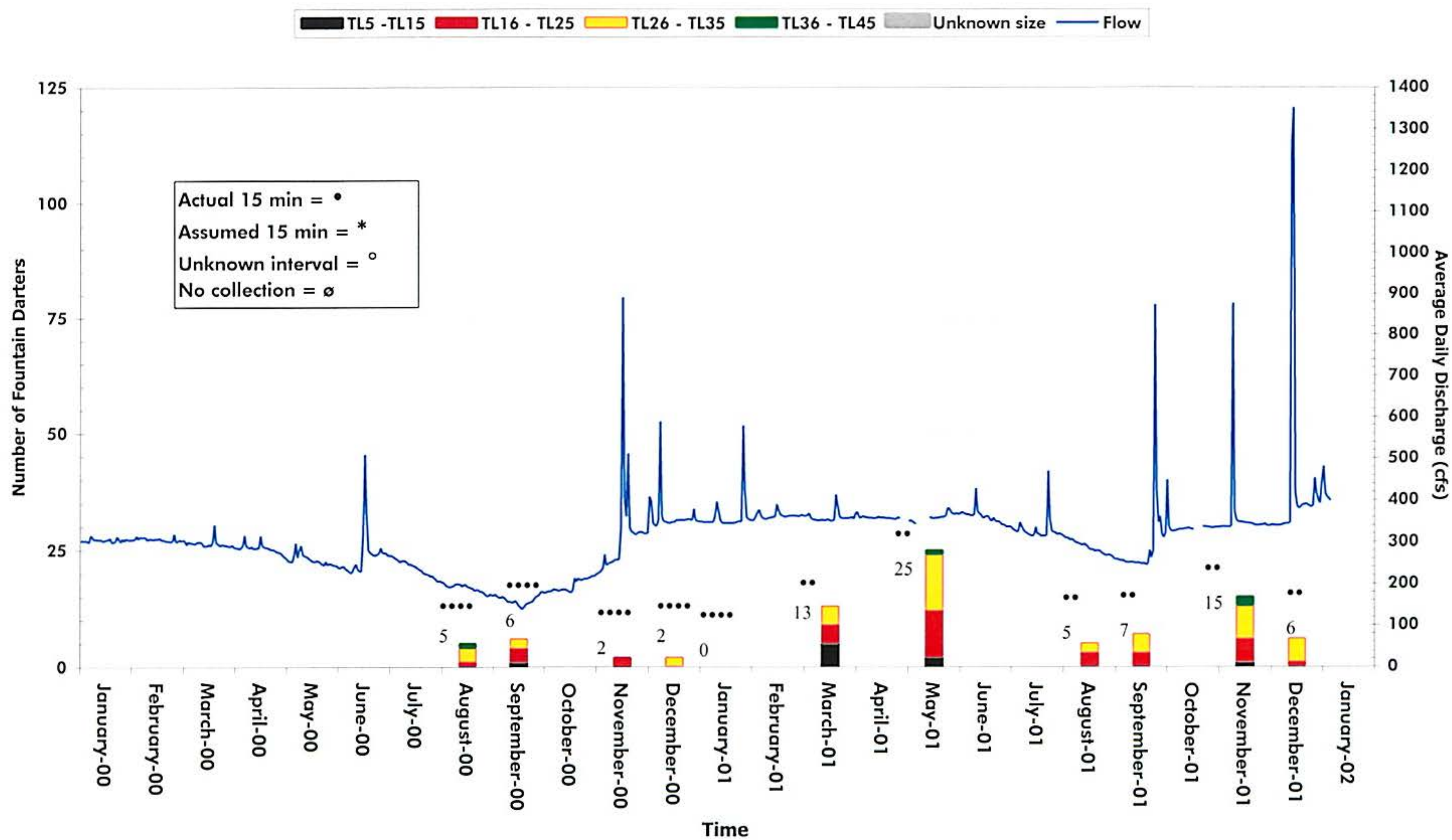


Thermistor Data: Spring Island and Other Place

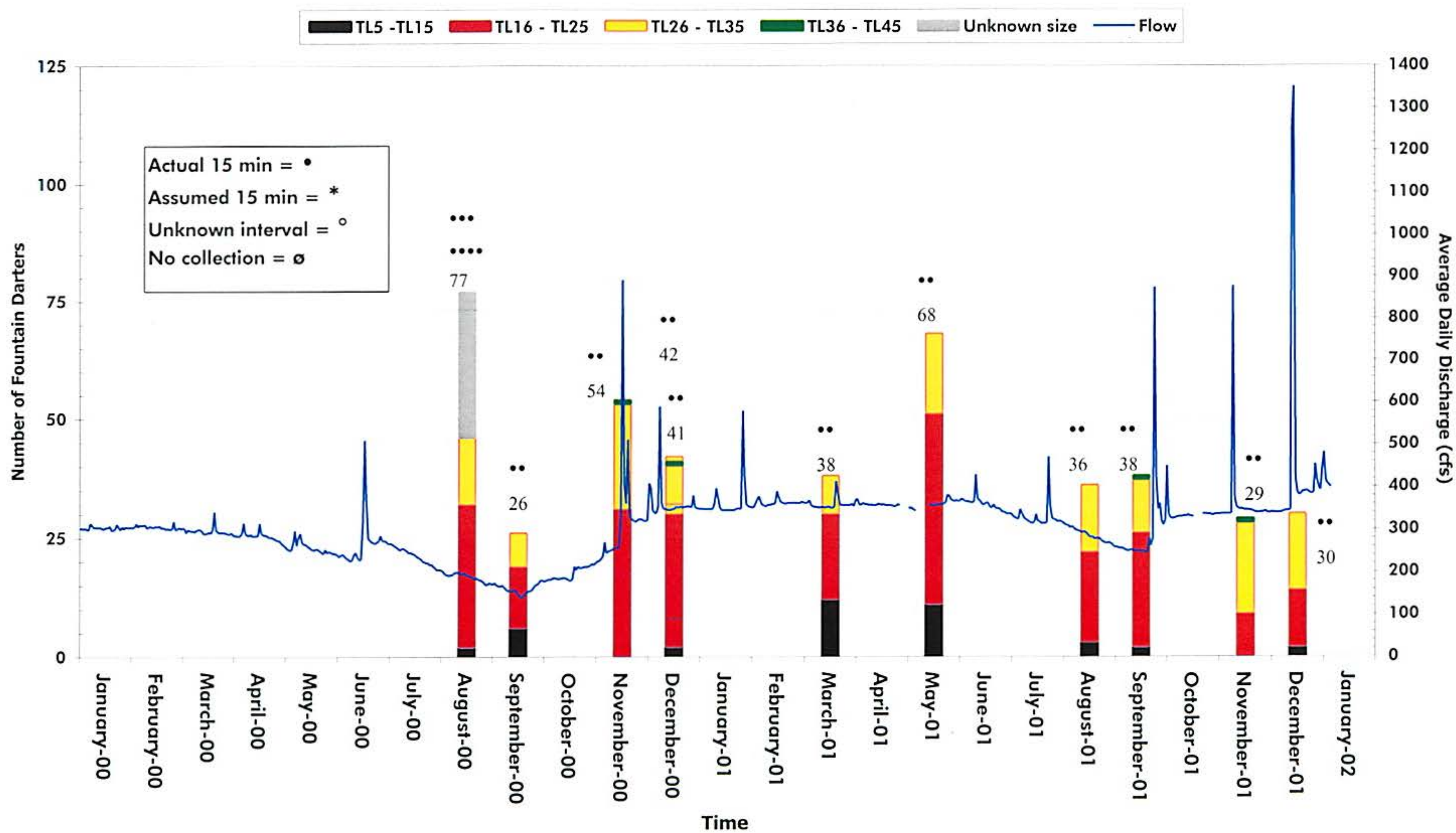


Dip Net Graphs

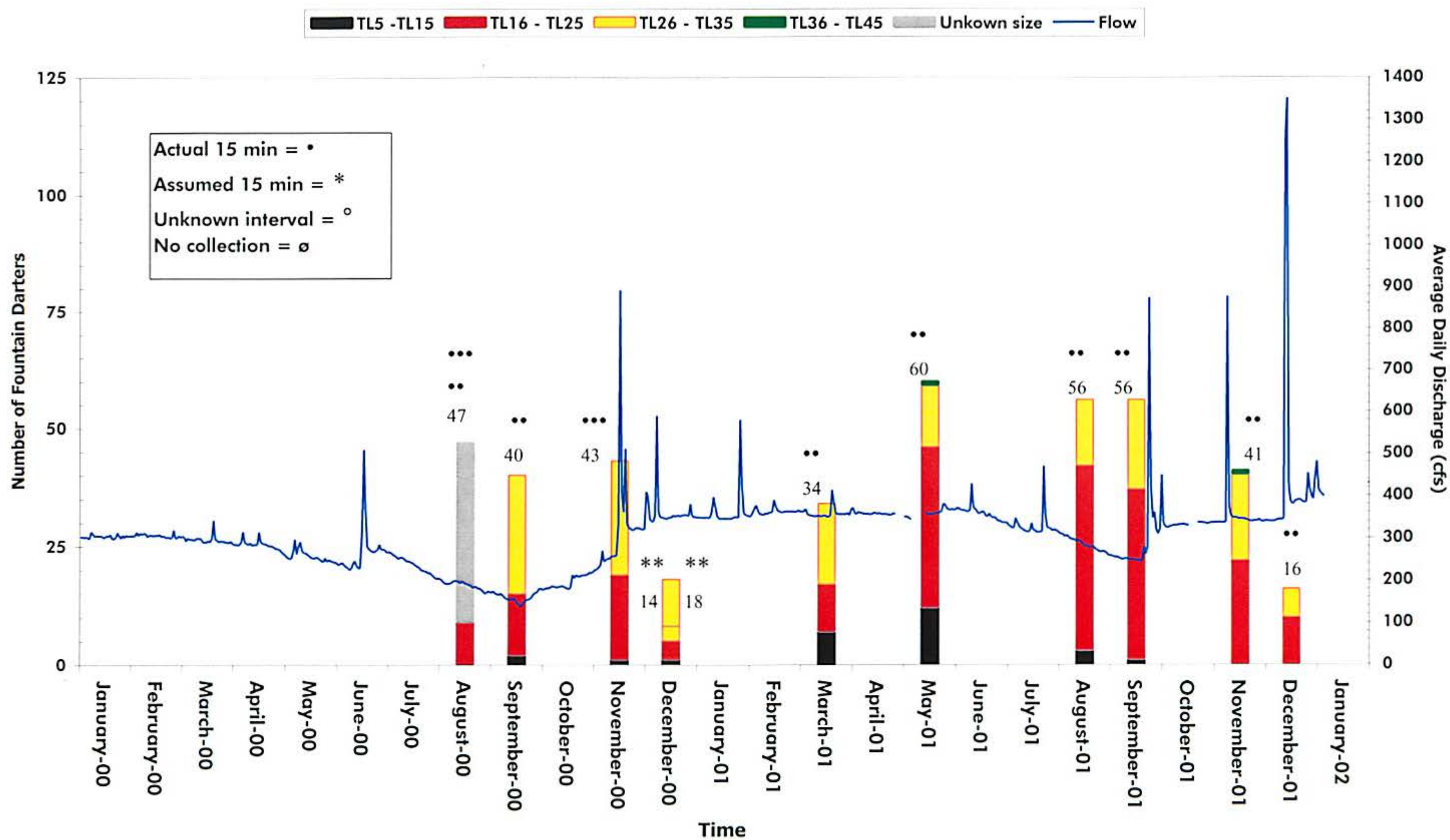
Fountain Darters Collected from Upper Spring Run Reach (Section 3)
Dip Net Results - Comal River



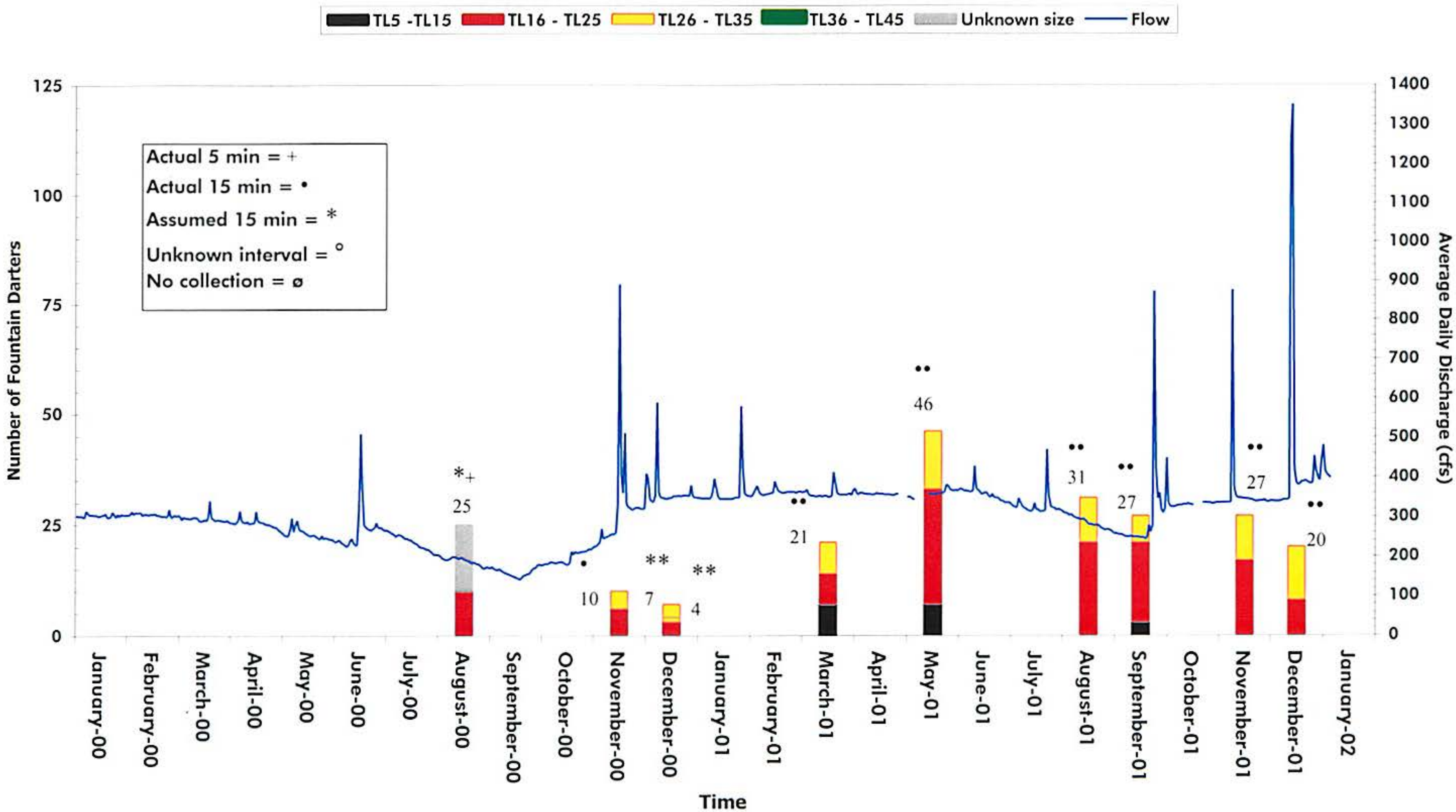
Fountain Darters Collected from Spring Island Area (Section 4U-M)
Dip Net Results - Comal River



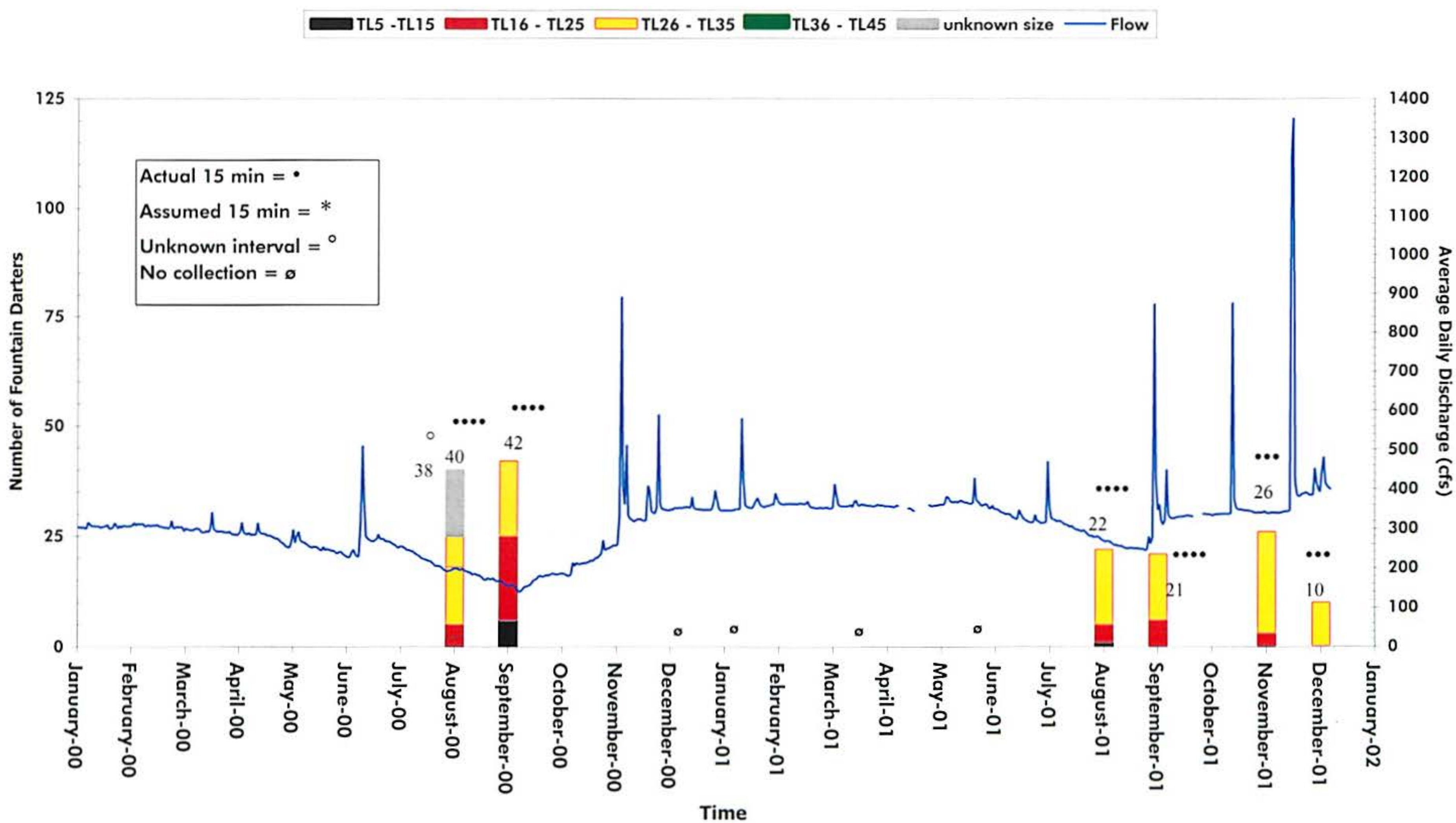
Fountain Darters Collected from Landa Lake Reach (Section 4L)
Dip Net Results - Comal River



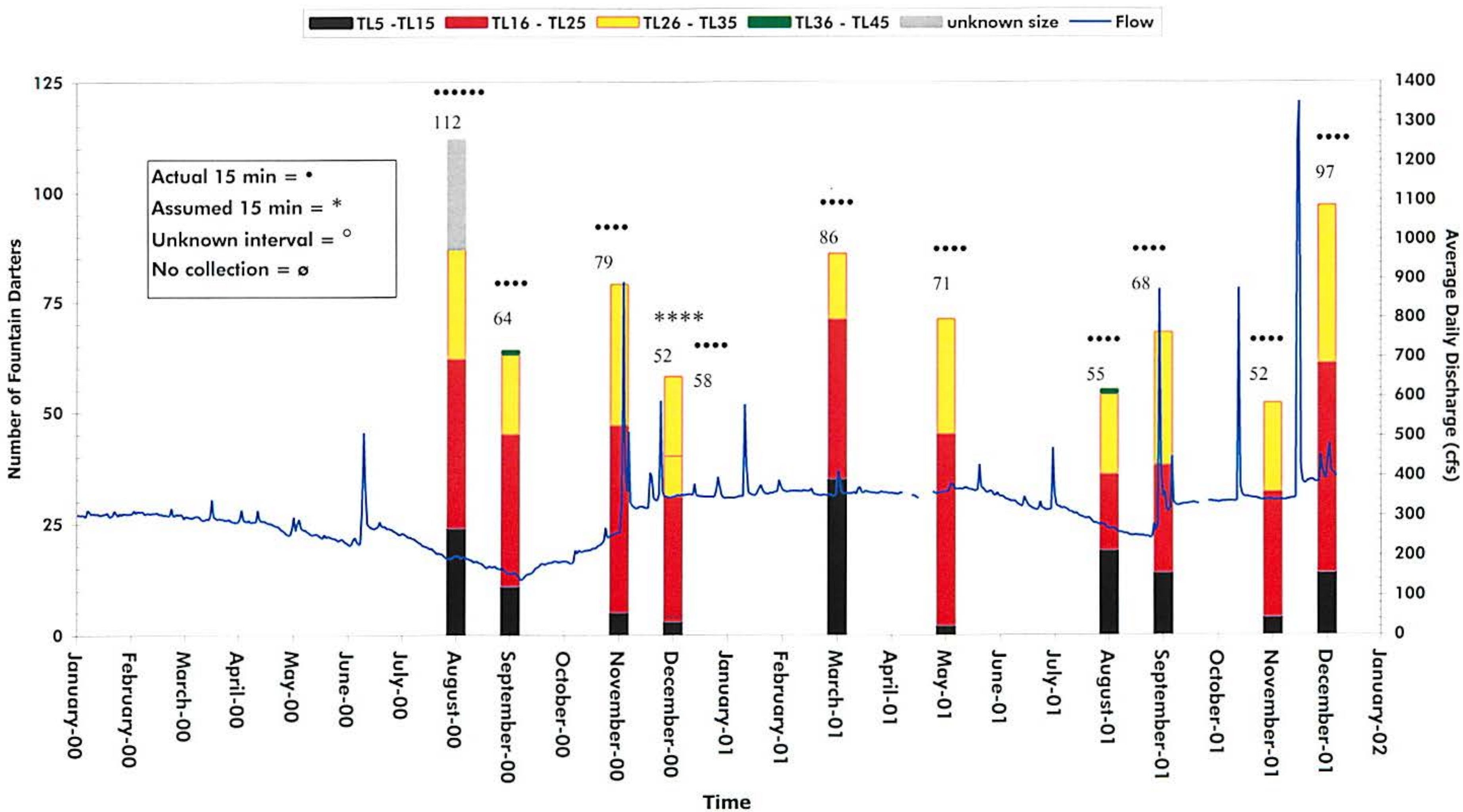
Fountain Darters Collected from Landa Lake Reach (Section 5)
Dip Net Results - Comal River



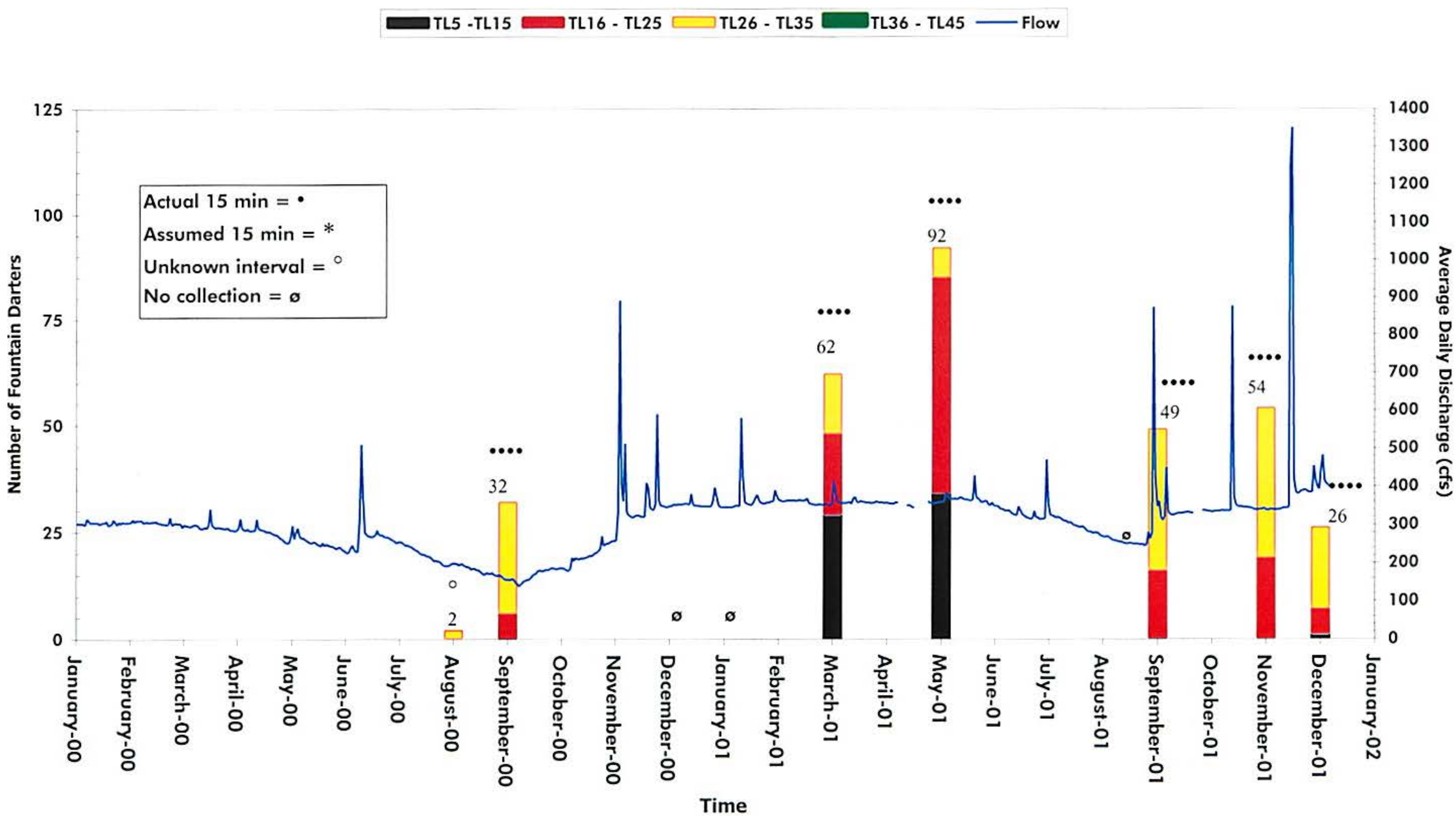
Fountain Darters Collected from New Channel Reach (Section 10)
Dip Net Results - Comal River



Fountain Darters Collected from Old Channel Reach (Section 16)
Dip Net Results - Comal River



Fountain Darters Collected from Garden Street Reach (Section 14)
Dip Net Results - Comal River



Macroinvertebrate Data

Date:	Location	Beg. Flow (m/s):	End Flow (m/s):	Drift rate (# ind/day):	Drift Density (# ind/100 m^3):
8/28/2000	Spring Run: #1	0.44	0.43	899	36.7
9/14/2000	Spring Run: #1	0.4	0.37	1418	72.9
11/21/2000	Spring Run: #1	0.75	0.82	751	8.2
3/20/2001	Spring Run: #1	0.69	0.68	1839	19.8
5/23/2001	Spring Run: #1	0.54	0.52	1382	17.3
9/13/2001	Spring Run: #1	0.65	0.67	919	10.8
11/6/2001	Spring Run: #1	0.71	0.7	840	9.4
8/28/2000	Spring Run # 3	0.38	0.36	799	20.6
9/14/2000	Spring Run # 3	0.3	0.29	1633	57
11/21/2000	Spring Run # 3	0.54	0.52	785	13.4
3/20/2001	Spring Run # 3	0.49	0.49	1503	38.9
5/23/2001	Spring Run # 3	0.45	0.46	1540	36.8
9/12/2001	Spring Run # 3	0.38	0.39	451	9.4
11/6/2001	Spring Run # 3	0.26	0.26	400	14.4

Family	Taxa	Spring Run 1 8/28/00 0600-0900	Spring Run 1 8/28/00 0900-1200	Spring Run 1 8/28/00 1200-1500	Spring Run 1 8/28/00 1500-1800	Spring Run 1 8/28/00 1800-2100	Spring Run 1 8/28/00 2100-2400	Spring Run 1 8/28/00 2400-0600	Totals
Coleoptera									
Elmidae	Microcylloepus(L)	1	16	3	7	1	4	4	36
Elmidae	Microcylloepus			1		1	1	1	4
Elmidae	Heterelmis (L)		1		1			1	3
Elmidae	Heterelmis								
Elmidae	Phanocerus(L)						1		1
Elmidae	Phanocerus								
Elmidae	Pupae		1	1		1			3
Psephenidae	Psephenus (L)	11	2	2	2	1	10	19	47
Psephenidae	Psephenus (A)		1	4		1		1	7
Dytiscidae									
Dytiscidae	Larvae		1						1
Helophoridae	Helophorus								
Hydrophilidae	Berosus								
Hydrophilidae	Tropisternus (L)								
Ptilodactilydae	Anchycteis								
Curcutionidae									
Staphylinidae	Bledius								
Staphylinidae	Thinobus								
Ephemeroptera									
Baetidae	Baetis	17	10	8	15	35	91	84	260
Baetidae	Baetodes		2	1					3
Tricorythidae	Trichorythodes	1			1	1	10	10	23
Tricorythidae	Leptohyphes	2					2	1	5
Helophoridae	Helophorus								
Ephemeridae	Hexagenia								
Trichoptera									
Hydroptilidae	Leucotrichia	15	16	2	4	1	11	13	62
Hydroptilidae	Agraylea								
Hydroptilidae	Ochrotrichia	1	4	1				2	8
Hydroptilidae									
Helicopsychidae	Helicopsyche	4			2		8	5	19
Leptoceridae	Nectopsyche							1	1
Hydrobiosidae	Atopsyche								
Philopotamidae	Wormaldia					1			1
Hydropsychidae	Smicridea								
Odonata									
Corduliidae									
Libelluliidae	Brechmorhoga								
Libelluliidae	Perithemus	5	2	2	7	3	8	3	30
Coenagrionidae	Argia		1	1			1	6	9
Aeshnidae	Anax								
Libellulidae	Perithemis								
Gomphidae									
Hemiptera									
Gerridae	Metrobates		1	4	1	1		1	8
Gerridae	Trepobates								
Veliidae	Rhagovelia	3	1		2	2	3	1	12
Mesoveliidae									
Notonectidae	Notonecta								
Saldidae									
Lepidoptera									
Pyralidae	Petrophila	1		1		1	1	2	6
Pyralidae	Parapoynx		1						1
Diptera									
Chironomidae	Pupae	1	10	1		1	2	3	18
Chironomidae	Larvae	10	96	10	1	3	5	8	133
Empididae	Hemerodromia		3			1	1		5
Ceratopogonidae	Pupae		1						1
Ceratopogonidae	Culicoides								
Ceratopogonidae	Forcipomyia								
Ceratopogonidae	Forcipomyia (pupae)								
Ceratopogonidae	Dasyelea								
Culicidae	Anopheles	1					1	1	3
Psychodidae	Pericoma								
Stratiomyidae									
Stratiomyidae	Caloparyhus								
Simuliidae	Simulium								
Muscidae									
Tipulidae	Tipula								
Decapoda									
Cambaridae							178	2	180
Ostracoda									
Amphipoda									
Crangonycitae	Stygobromus								
Hyalellidae	Hyalella								
HIRUDINEA								1	1
COLLEMBOLA		1							1
HYDRACARINA									
OLIGOCHAETA		1			1		1		3
ISOPODA									
Nematodo									
Copepoda	Cyclopoida	1							1
		76	170	42	44	55	339	170	

Family	Taxa	Spring Run 1 9/14/00 1300-1600	Spring Run 1 9/14/00 1600-1900	Spring Run 1 9/14/00 1900-2200	Spring Run 1 9/14/00 2200-0100	Spring Run 1 9/14/00 0100-0700	Spring Run 1 9/14/00 0700-1000	Spring Run 1 9/14/00 1000-1300	Totals
Coleoptera									
Elmidae	Microcylloepus(L)	12	8	3	2	54	37	35	151
Elmidae	Microcylloepus	3			3	8	4	3	21
Elmidae	Heterelmis (L)	1				1	1		3
Elmidae	Heterelmis	1			1				2
Elmidae	Phanocerus(L)					1		1	2
Elmidae	Phanocerus								
Elmidae	Pupae	2	1						3
Psephenidae	Psephenus (L)	22	3	8	25	20	17	10	105
Psephenidae	Psephenus (A)	3			9	1	3	2	18
Dytiscidae									
Dytiscidae	Larvae								
Helophoridae	Helophorus								
Hydrophilidae	Berosus								
Hydrophilidae	Tropisternus (L)								
Ptilodactlydae	Anchycteis								
Curculionidae				2					2
Staphylinidae	Bledius								
Staphylinidae	Thinobus								
Ephemeroptera									
Baetidae	Baetis	11	1	27	39	23	17	3	121
Baetidae	Baetodes	1		2		2	1		6
Tricorythidae	Trichorythodes	2	4	7	13	53	31	14	124
Tricorythidae	Leptohyphes	1		2	2	10	5	1	21
Helophoridae	Helophorus								
Ephemeridae	Hexagenia								
Trichoptera									
Hydroptilidae	Leucotrichia	1	1	1		2	1	1	7
Hydroptilidae	Agraylea								
Hydroptilidae	Ochrotrichia	1	3	2	1	13	6	5	31
Hydroptilidae								1	1
Helicopsychidae	Helicopsyche	7	10	17	49	14	11	10	118
Leptoceridae	Nectopsyche							1	1
Hydrobiosidae	Atopsyche								
Philopotamidae	Wormaldia								
Hydropsychidae	Smicridea								
Odonata									
Corduliidae									
Libelluliidae	Brechmorhoga		1						1
Libelluliidae	Perithemus	13	4	2	4	1	1	3	28
Coenagrionidae	Argia	1	1		2	10	4	2	20
Aeshnidae	Anax								
Libellulidae	Perithemis								
Gomphidae		1	3		1	2	1		8
Hemiptera									
Gerridae	Metrobates	10		4	1		2	6	23
Gerridae	Trepobates								
Veliidae	Rhagovelia	17	2	29	13	2			63
Mesoveliidae			1			1			2
Notonectidae	Notonecta								
Saldidae								1	1
Lepidoptera									
Pyralidae	Petrophila		1	1	3	10	7	4	26
Pyralidae	Parapoynx	1				1			2
Diptera									
Chironomidae	Pupae	5			3	22	16	19	65
Chironomidae	Larvae	3	5	4		26			38
Empididae	Hemerodromia		3			6		1	10
Ceratopogonidae	Pupae	2			1	1		2	6
Ceratopogonidae	Culicoides								
Ceratopogonidae	Forcipomyia								
Ceratopogonidae	Forcipomyia (pupae)								
Ceratopogonidae	Dasyelea								
Culicidae	Anopheles	1				2			3
Psychodidae	Pericoma	1				3		1	5
Stratiomyidae						3			3
Stratiomyidae	Caloparyhus								
Simuliidae	Simulium					1		2	3
Muscidae									
Tipulidae	Tipula								
Decapoda									
Cambaridae				361	2	1			364
Ostracoda									
Amphipoda									
Crangonycitae	Stygobromus								
Hyalellidae	Hyalella							2	2
HIRUDINEA				3	2				5
COLLEMBOLA		1		1				1	3
HYDRACARINA									
OLIGOCHAETA									
ISOPODA									
Nematode									
Copepoda	Cyclopoida								
		124	52	476	176	294	165	131	

Family	Taxa	Spring Run 1 11/21/00 1300-1600	Spring Run 1 11/21/00 1600-1900	Spring Run 1 11/21/00 1900-2200	Spring Run 1 11/21/00 2200-0100	Spring Run 1 11/21/00 0100-0400	Spring Run 1 11/21/00 0400-0700	Spring Run 1 11/21/00 0700-1000	Spring Run 1 11/21/00 1000-1300	Totals
Coleoptera										
Elmidae	Microcylloepus(L)	13	23	22	7	17	25	13	8	128
Elmidae	Microcylloepus	2	3	4		1	4			14
Elmidae	Heterelmis (L)	1	2	1	1	2	1	1	1	10
Elmidae	Heterelmis			1						1
Elmidae	Phanocerus(L)								6	6
Elmidae	Phanocerus									
Elmidae	Pupae					2				2
Psephenidae	Psephenus (L)	7	13	17	10	15	5	2		69
Psephenidae	Psephenus (A)	2			1					3
Dytiscidae										
Dytiscidae	Larvae									
Helophoridae	Helophorus									
Hydrophilidae	Berosus									
Hydrophilidae	Tropisternus (L)									
Ptilodactilydae	Anchycteis									
Curculionidae										
Staphylinidae	Bledius									
Staphylinidae	Thinobus									
Ephemeroptera										
Baetidae	Baetis	3	63	58	29	21	21	1	3	199
Baetidae	Baetodes				1					1
Tricorythidae	Trichorythodes		12	50	14	22	20	3		121
Tricorythidae	Leptohyphes		2	4	2	5	7			20
Helophoridae	Helophorus									
Ephemeridae	Hexagenia									
Trichoptera										
Hydroptilidae	Leucotrichia	3	4	7	1		4	2		21
Hydroptilidae	Agraylea									
Hydroptilidae	Ochrotrichia	1	6	2	1	3	2	2	1	18
Hydroptilidae										
Helicopsychidae	Helicopsyche		1	1		3				5
Leptoceridae	Nectopsyche									
Hydrobiosidae	Atopsyche									
Philopotamidae	Wormaldia									
Hydropsychidae	Smicridea				1					1
Odonata										
Corduliidae		1	2		1				1	5
Libelluliidae	Brechmorhoga									
Libelluliidae	Perithemus									
Coenagrionidae	Argia	1	14	3	11	12	2	3		46
Aeshnidae	Anax					1				1
Libellulidae	Perithemis									
Gomphidae		1			1					2
Hemiptera										
Gerridae	Metrobates	9	5			1			2	17
Gerridae	Trepobates									
Veliidae	Rhagovelia		5						1	6
Mesoveliidae										
Notonectidae	Notonecta									
Saldidae										
Lepidoptera										
Pyralidae	Petrophila		1		1					2
Pyralidae	Parapoynx									
Diptera										
Chironomidae	Pupae	2	2	3	4	2	1	2	2	18
Chironomidae	Larvae	3	7	9	6	6	6	2	1	40
Empididae	Hemerodromia		1			1		2	1	5
Ceratopogonidae	Pupae	1							1	2
Ceratopogonidae	Culicoides									
Ceratopogonidae	Forcipomyia									
Ceratopogonidae	Forcipomyia (pupae)									
Ceratopogonidae	Dasyelea									
Culicidae	Anopheles									
Psychodidae	Pericoma									
Stratiomyidae										
Stratiomyidae	Caloparyhus									
Simuliidae	Simulium									
Muscidae						1				1
Tipulidae	Tipula									
Decapoda										
Cambaridae			4		1	3		1		9
Ostracoda			2			1	2			5
Amphipoda										
Crangonycitae	Stygobromus									
Hyalellidae	Hyalella									
HIRUDINEA										
COLLEMBOLA										
HYDRACARINA										
OLIGOCHAETA										
ISOPODA										
Nematodo										
Copepoda	Cyclopoida									
		50	172	182	93	119	100	34	28	

Family	Taxa	Spring Run 1 3/20/01 0600-0900	Spring Run 1 3/20/01 0900-1200	Spring Run 1 3/20/01 1200-1500	Spring Run 1 3/20/01 1500-1800	Spring Run 1 3/20/01 1800-2100	Spring Run 1 3/20/01 2100-2400	Spring Run 1 3/20/01 2400-0300	Spring Run 1 3/20/01 0300-0600	Totals
Coleoptera										
Elmidae	Microcylloepus(L)	38	29	33	25	30	23	51	25	254
Elmidae	Microcylloepus	4	2	1	7	1	5	2	2	24
Elmidae	Heterelmis (L)			1	1		1			3
Elmidae	Heterelmis							2		2
Elmidae	Phanocerus(L)									
Elmidae	Phanocerus									
Elmidae	Pupae	2	1	4	4	2	5	5	1	24
Psephenidae	Psephenus (L)	12	14	10	15	9	21	12	7	100
Psephenidae	Psephenus (A)		1	5	2	1			1	10
Dytiscidae										
Dytiscidae	Larvae									
Helophoridae	Helophorus									
Hydrophilidae	Berosus						1			1
Hydrophilidae	Tropisternus (L)									
Ptilodactilydae	Anchycteis									
Curculionidae						1				1
Staphylinidae	Bledius									
Staphylinidae	Thinobus									
Ephemeroptera										
Baetidae	Baetis	14	13	16	21	103	62	43	22	294
Baetidae	Baetodes		1		10		6	5		22
Tricorythidae	Trichorythodes	14	7	1		52	70	36	54	234
Tricorythidae	Leptohyphes	2	1			8	5	2	4	22
Helophoridae	Helophorus									
Ephemeridae	Hexagenia									
Trichoptera										
Hydroptilidae	Leucotrichia	45	36	51	63	50	48	32	22	347
Hydroptilidae	Agraylea									
Hydroptilidae	Ochrotrichia	60	65	68	48	49	89	50	66	495
Hydroptilidae										
Helicopsychidae	Helicopsyche	1	2						1	4
Leptoceridae	Nectopsyche	1					2		1	4
Hydrobiosidae	Atopsyche									
Philopotamidae	Wormaldia									
Hydropsychidae	Smicridea									
Odonata										
Corduliidae										
Libelluliidae	Brechmorhoga									
Libelluliidae	Perithemus		1							1
Coenagrionidae	Argia	1	1	1			3	1		7
Aeshnidae	Anax									
Libellulidae	Perithemis									
Gomphidae										
Hemiptera										
Gerridae	Metrobates									
Gerridae	Trepobates									
Veliidae	Rhagovelia	1		1			1		1	4
Mesoveliidae										
Notonectidae	Notonecta									
Saldidae										
Lepidoptera										
Pyralidae	Petrophila	4	5	10	5	1	17	14	11	67
Pyralidae	Parapoynx									
Diptera										
Chironomidae	Pupae	2	6	8	2	8	4	4	2	36
Chironomidae	Larvae	20	15	12	6	9	10	12	3	87
Empididae	Hemerodromia	2		1	1		1		1	6
Ceratopogonidae	Pupae			2			1			3
Ceratopogonidae	Culicoides									
Ceratopogonidae	Forcipomyia									
Ceratopogonidae	Forcipomyia (pupae)									
Ceratopogonidae	Dasyelea									
Culicidae	Anopheles									
Psychodidae	Pericoma									
Stratiomyidae										
Stratiomyidae	Caloparyhus									
Simuliidae	Simulium									
Muscidae		2			1				4	7
Tipulidae	Tipula									
Decapoda										
Cambaridae						1				1
Ostracoda										
Amphipoda										
Crangonycitae	Stygobromus			1			1		1	3
Hyalellidae	Hyalella						1			1
HIRUDINEA									1	1
COLLEMBOLA					1	1				2
HYDRACARINA										
OLIGOCHAETA					2				2	4
ISOPODA										
Nematode										
Copepoda	Cyclopoida									
		225	200	226	214	326	377	271	232	

Taxa	Spring Run 1 5/23/01 0600-0900	Spring Run 1 5/23/01 0900-1200	Spring Run 1 5/23/01 1200-1500	Spring Run 1 5/23/01 1500-1800	Spring Run 1 5/23/01 1800-2100	Spring Run 1 5/23/01 2100-2400	Spring Run 1 5/23/01 2400-0300	Spring Run 1 5/23/01 0300-0600	Totals
Microcylloepus(L)	15	19	13	13	17	37	36	58	208
Microcylloepus	4	6	9	2	6	11	9	20	67
Heterelmis (L)			1			1	1	1	4
Heterelmis				1				1	2
Phanocerus(L)									
Phanocerus				1	2	1			4
Pupae	1	7	4	2	5	2			21
Psephenus (L)	8	6	3	6	9	24	32	5	93
Psephenus (A)	1	5	24	8	3	2	2		45
Larvae									
Helophorus		1							1
Berosus									
Tropisternus (L)				1					1
Anchycteis									
		3	5	3	2			1	14
Bledius									
Thinobus									
Baetis	7	11	17	16	47	103	112	110	423
Baetodes	1	6	1	2	6	13	15	21	65
Trichorythodes	4	2	2			46	40	52	146
Leptohyphes	1					6	8	6	21
Helophorus									
Hexagenia									
Leucotrichia	18	26	40	39	36	30	36	44	269
Agraylea									
Ochrotrichia	5	9	4	2	11	22	18	12	83
Helicopsyche	2	1	1	5	3	1	2		15
Nectopsyche		1		1			1		3
Atopsyche					1				1
Wormaldia									
Smicridea									
Brechmorhoga									
Perithemus	1	1		4		1	2	6	15
Argia	7	4	2	6	10	3	6	42	80
Anax									
Perithemis									
Metrobates			4	3			2		9
Trepobates									
Rhagovelia			1	1			1	1	4
		6	1		2				9
Notonecta									
Petrophila	8	2	6	2	3	21	24	33	99
Parapoynx									
Pupae	6	3	3	5	1	6	4		28
Larvae	7	9	6	2	6	12	13	1	56
Hemerodromia					2	2	1	9	14
Pupae									
Culicoides									
Forcipomyia									
Forcipomyia (pupae)									
Dasyelea									
Anopheles									
Pericoma									
	1	2					1	1	5
Caloparyhus									
Simulium									
						1			1
Tipula									
Stygobromus									
Hyalella									
Cyclopoida									
	97	130	147	125	172	345	366	424	

Family	Taxa	Spring Run 1 9 13 01 0000-0300	Spring Run 1 9 13 01 0300-0600	Spring Run 1 9 12 01 0600-0900	Spring Run 1 9 12 01 0900-1200	Spring Run 1 9 12 01 1200-1500	Spring Run 1 9 12 01 1500-1800	Spring Run 1 9 12 01 1800-2100	Spring Run 1 9 12 01 2100-2400	Totals
Coleoptera										
Elmidae	Microcylloepus(L)	37	52	36	25	26	21	32	23	252
Elmidae	Microcylloepus	5	1	3	2	3	1	2	1	18
Elmidae	Heterelmis (L)				1					1
Elmidae	Heterelmis									
Elmidae	Phanocerus(L)									
Elmidae	Phanocerus									
Elmidae	Pupae									
Psephenidae	Psephenus (L)	11	4	10	7	6	1	1	7	47
Psephenidae	Psephenus (A)									
Dytiscidae										
Dytiscidae	Larvae									
Helophoridae	Helophorus									
Hydrophilidae	Berosus									
Hydrophilidae	Tropisternus (L)									
Ptilodactilydae	Anchycteis									
Curculionidae										
Staphylinidae	Bledius									
Staphylinidae	Thinobus									
Ephemeroptera										
Baetidae	Baetis	31	59	7		3		30	49	179
Baetidae	Baetodes	1								1
Tricorythidae	Trichorythodes	79	131	13	1		3	11	84	322
Tricorythidae	Leptohyphes							1		1
Helophoridae	Helophorus									
Ephemeridae	Hexagenia									
Trichoptera										
Hydroptilidae	Leucotrichia	4	7		9	6	4	4	3	37
Hydroptilidae	Agraylea									
Hydroptilidae	Ochrotrichia	2								2
Hydroptilidae										
Helicopsychidae	Helicopsyche						1			1
Leptoceridae	Nectopsyche									
Hydrobiosidae	Atopsyche									
Philopotamidae	Wormaldia									
Hydropsychidae	Smicridea									
Odonata										
Corduliidae										
Libelluliidae	Brechmorhoga									
Libelluliidae	Perithemus									
Coenagrionidae	Argia	2	3	2	1			2	4	14
Aeshnidae	Anax									
Libellulidae	Perithemis			1						1
Gomphidae										
Hemiptera										
Gerridae	Metrobates									
Gerridae	Trepobates									
Veliidae	Rhagovelia			3	2	1		1	2	9
Mesoveliidae										
Notonectidae	Notonecta									
Saldidae										
Lepidoptera										
Pyralidae	Petrophila	1			1	1	1			4
Pyralidae	Parapoynx	2	2						2	6
Diptera										
Chironomidae	Pupae									
Chironomidae	Larvae	3	3	1	2			4	3	16
Empididae	Hemerodromia									
Ceratopogonidae	Pupae									
Ceratopogonidae	Culicoides							1		1
Ceratopogonidae	Forcipomyia									
Ceratopogonidae	Forcipomyia (pupae)									
Ceratopogonidae	Dasyelea									
Culicidae	Anopheles									
Psychodidae	Pericoma									
Stratiomyidae								1		1
Stratiomyidae	Caloparyhus									
Simuliidae	Simulium									
Muscidae										
Tipulidae	Tipula									
Decapoda										
Cambaridae								2	2	4
Ostracoda										
Amphipoda										
Crangonycitae	Stygobromus			1						1
Hyalellidae	Hyalella									
HIRUDINEA										
COLLEMBOLA										
HYDRACARINA				1						1
OLIGOCHAETA										
ISOPODA										
Nematode										
Copepoda	Cyclopoida									
		125	205	29	16	11	9	57	149	

Family	Taxa	Spring Run 1 11 06 01 0000-0300	Spring Run 1 11 06 01 0300-0600	Spring Run 1 11 05 01 0600-0900	Spring Run 1 11 05 01 0900-1200	Spring Run 1 11 05 01 1200-1500	Spring Run 1 11 05 01 1500-1800	Spring Run 1 11 05 01 1800-2100	Spring Run 1 11 05 01 2100-2400	Totals
Coleoptera										
Elmidae	Microcylloepus(L)	32	38	28	32	14	28	31	45	248
Elmidae	Microcylloepus	9	6		3	1	2	6	7	34
Elmidae	Heterelmis (L)	1							3	4
Elmidae	Heterelmis									
Elmidae	Phanocerus(L)		1							1
Elmidae	Phanocerus									
Elmidae	Pupae									
Psephenidae	Psephenus (L)	21	7	3	2	2	6	8	17	66
Psephenidae	Psephenus (A)									
Dytiscidae										
Dytiscidae	Larvae									
Helophoridae	Helophorus									
Hydrophilidae	Berosus									
Hydrophilidae	Tropisternus (L)									
Ptilodactlydae	Anchycteis									
Curculionidae										
Staphylinidae	Bledius					1				1
Staphylinidae	Thinobus									
Ephemeroptera										
Baetidae	Baetis	49	23	12		2	6	63	61	216
Baetidae	Baetodes	1	1				1	4	1	8
Tricorythidae	Trichorythodes	40	27	5	5	1		18	40	136
Tricorythidae	Leptohyphes		1						1	2
Helophoridae	Helophorus									
Ephemeridae	Hexagenia									
Trichoptera										
Hydroptilidae	Leucotrichia	5	4	3		2	2	1	2	19
Hydroptilidae	Agraylea									
Hydroptilidae	Ochrotrichia	6	1	3			1	3	1	15
Hydroptilidae										
Helicopsychidae	Helicopsyche	1								1
Leptoceridae	Nectopsyche									
Hydrobiosidae	Atopsyche									
Philopotamidae	Wormaldia									
Hydropsychidae	Smicridea									
Odonata										
Corduliidae										
Libelluliidae	Brechmorhoga									
Libelluliidae	Penthemus									
Coenagrionidae	Argia	15	14	1	1	2		5	5	43
Aeshnidae	Anax									
Libellulidae	Perithemis									
Gomphidae										
Hemiptera										
Gerridae	Metrobates									
Gerridae	Trepobates	1							1	2
Veliidae	Rhagovelia		1					1	1	3
Mesoveliidae										
Notonectidae	Notonecta									
Saldidae										
Lepidoptera										
Pyralidae	Petrophila	1				1		1	1	4
Pyralidae	Parapoynx	1							1	2
Diptera										
Chironomidae	Pupae									
Chironomidae	Larvae	2	3		3	2	1	1	4	16
Empididae	Hemerodromia	1			1					2
Ceratopogonidae	Pupae									
Ceratopogonidae	Culicoides									
Ceratopogonidae	Forcipomyia		1	1	1					3
Ceratopogonidae	Forcipomyia (pupae)									
Ceratopogonidae	Dasyelea	1								1
Culicidae	Anopheles									
Psychodidae	Pericoma									
Stratiomyidae										
Stratiomyidae	Caloparyhus									
Simuliidae	Simulium									
Muscidae										
Tipulidae	Tipula									
Decapoda										
Cambaridae		1	2					2	1	6
Ostracoda										
Amphipoda										
Crangonycitae	Stygobromus									
Hyalellidae	Hyalella									
HIRUDINEA										
COLLEMBOLA		1				1			1	3
HYDRACARINA		1			1					2
OLIGOCHAETA										
ISOPODA			1					1		2
Nematode										
Copepoda	Cyclopoida									
		127	79	25	12	11	11	100	121	

Family	Taxa	Spring Run 3 8/28/00 0900-1200	Spring Run 3 8/28/00 1200-1500	Spring Run 3 8/28/00 1500-1800	Spring Run 3 8/28/00 1800-2100	Spring Run 3 8/28/00 2100-2400	Spring Run 3 8/28/00 2400-0600	Spring Run 3 8/28/00 0600-0900	
Coleoptera									
Elmidae	Microcylloepus (L)	1	5	11	10	8	20	8	63
Elmidae	Microcylloepus (A)	1	3	3	1		2	1	11
Elmidae	Heterelmis (L)		1						1
Elmidae	Heterelmis (A)								
Elmidae	Phanocerus (L)				1				1
Elmidae	Phanocerus (A)								
Elmidae	Pupae				1	4	2		7
Psephenidae	Psephenus (L)	2	1	1	3	4	13	5	29
Psephenidae	Psephenus (A)		1		2	2	2		7
Dytiscidae									
Dytiscidae	Larvae								
Helophoridae	Helophorus								
Hydrophilidae	Berosus								
Hydrophilidae	Tropisternus (L)								
Ptilodactilydae	Anchycteis								
Curculionidae			1					1	2
Staphylinidae	Bledius								
Staphylinidae	Thinobus					1			1
Ephemeroptera									
Baetidae	Baetis	1	2	2	1	6	9	3	24
Baetidae	Baetodes		1		3	4	8	1	17
Tricorythidae	Trichorythodes	2	1	2	3	5	5	1	19
Tricorythidae	Leptohyphes					1			1
Helophoridae	Helophorus								
Ephemeridae	Hexagenia								
Trichoptera									
Hydroptilidae	Leucotrichia	5	29	15	19	27	33	19	147
Hydroptilidae	Agraylea								
Hydroptilidae	Ochrotrichia								
Hydroptilidae									
Helicopsychidae	Helicopsyche						3		3
Leptoceridae	Nectopsyche								
Hydrobiosidae	Atopsyche								
Philopotamidae	Wormaldia								
Hydropsychidae	Smicridea								
Odonata									
Corduliidae									
Libellulidae	Brechmorhoga								
Libellulidae	Perithemus	1		2		2	2	3	10
Coenagrionidae	Argia		1		1				2
Aeshnidae	Anax								
Libellulidae	Perithemis								
Gomphidae									
Hemiptera									
Gerridae	Metrobates	1			2		2		5
Gerridae	Trepobates								
Veliidae	Rhagovelia	3	2						5
Mesoveliidae									
Notonectidae	Notonecta								
Saldidae									
Lepidoptera									
Pyralidae	Petrophila		1		4	6	15	6	32
Pyralidae	Parapoynx								
Diptera									
Chironomidae	Pupae	3	7	8	11	5	17	4	55
Chironomidae	Larvae	12	18	52	61	44	86	71	344
Empididae	Hemerodromia			2					2
Ceratopogonidae	Pupae								
Ceratopogonidae	Culicoides								
Ceratopogonidae	Forcipomyia								
Ceratopogonidae	Forcipomyia (Pupae)								
Ceratopogonidae	Dasyclea								
Culicidae	Anopheles								
Psychodidae	Pericoma								
Stratiomyidae									
Stratiomyidae	Caloparyhus								
Simuliidae	Simulium								
Muscidae									
Tipulidae	Tipula								
Decapoda									
Cambaridae						6			6
Ostracoda									
Amphipoda									
Crangonycitae	Stygobromus								
Hyalellidae	Hyalella	1	2			2			5
HIRUDINEA									
COLLEMBOLA									
HYDRACARINA									
OLIGOCHAETA									
ISOPODA									
Nematode									
Copepoda	Cyclopoida								
		33	76	98	123	127	219	123	

Family	Taxa	Spring Run 3 9/14/00 1300-1600	Spring Run 3 9/14/00 1600-1900	Spring Run 3 9/14/00 1900-2200	Spring Run 3 9/14/00 2200-0100	Spring Run 3 9/14/00 0100-0400	Spring Run 3 9/14/00 0400-0700	Spring Run 3 9/14/00 0700-1000	Spring Run 3 9/14/00 1000-1300	
Coleoptera										
Elmidae	Microcylloepus (L)	9	13	12	27	47	31	16	23	178
Elmidae	Microcylloepus (A)	5	1	1	3	7	9	3	1	30
Elmidae	Heterelmis (L)				1	2				3
Elmidae	Heterelmis (A)								1	1
Elmidae	Phanocerus (L)									
Elmidae	Phanocerus (A)									
Elmidae	Pupae	1	3	3	3	2	3	3	2	20
Psephenidae	Psephenus (L)	3	5	6	6	20	16	5	7	68
Psephenidae	Psephenus (A)	2	2		1		1			6
Dytiscidae						2			1	3
Dytiscidae	Larvae									
Helophoridae	Helophorus									
Hydrophilidae	Berosus									
Hydrophilidae	Tropisternus (L)									
Ptilodactilydae	Anchycteis									
Curculionidae										
Staphylinidae	Bledius									
Staphylinidae	Thinobus									
Ephemeroptera										
Baetidae	Baetis	1	2	12	9	5	6	2	1	38
Baetidae	Baetodes	1		2		4	5		1	13
Tricorythidae	Trichorythodes			15	12	5	4		1	37
Tricorythidae	Leptohyphes			3	1					4
Helophoridae	Helophorus							1		1
Ephemeridae	Hexagenia									
Trichoptera										
Hydroptilidae	Leucotrichia	19	12	23	21	41	37	22	15	190
Hydroptilidae	Agraylea									
Hydroptilidae	Ochrotrichia	3	2	1	1	6	6	2	2	23
Hydroptilidae										
Helicopsychidae	Helicopsyche	1		1			1			3
Leptoceridae	Nectopsyche									
Hydrobiosidae	Atopsyche									
Philopotamidae	Wormaldia									
Hydropsychidae	Smicridea									
Odonata										
Corduliidae										
Libellulidae	Brechmorhoga									
Libellulidae	Perithemus		1	1			1			3
Coenagrionidae	Argia	1								1
Aeshnidae	Anax									
Libellulidae	Perithemis									
Gomphidae										
Hemiptera										
Gerridae	Metrobates	7	1		1		1	1	11	22
Gerridae	Trepobates									
Veliidae	Rhagovelia	2	1	5	2		1	3	2	16
Mesoveliidae										
Notonectidae	Notonecta									
Saldidae										
Lepidoptera										
Pyralidae	Petrophila		1	2	6	10	5	1	1	26
Pyralidae	Parapoynx									
Diptera										
Chironomidae	Pupae	22	18	2	12	15	17	16	10	112
Chironomidae	Larvae	37	106	72	148	136	121	61	92	773
Empididae	Hemerodromia		1	1	1	4	1	1	4	13
Ceratopogonidae	Pupae						1	1		2
Ceratopogonidae	Culicoides									
Ceratopogonidae	Forcipomyia									
Ceratopogonidae	Forcipomyia (Pupae)									
Ceratopogonidae	Dasyelea									
Culicidae	Anopheles									
Psychodidae	Pericoma									
Stratiomyidae										
Stratiomyidae	Caloparyhus									
Simuliidae	Simulium									
Muscidae										
Tipulidae	Tipula									
Decapoda										
Cambaridae				1	3		1			5
Ostracoda										
Amphipoda										
Crangonycitae	Stygobromus					1				1
Hyalellidae	Hyalella	3	3	1	7	7	6		4	31
HIRUDINEA										
COLLEMBOLA		3	3	2			1	1		10
HYDRACARINA										
OLIGOCHAETA										
ISOPODA										
Nematode										
Copepoda	Cyclopoida									
		120	175	166	265	314	275	139	179	

Exotics / Predation Data

LANDA LAKE GILL NET DATA
COMAL RIVER - WINTER 2001 QUARTERLY SAMPLING

Species	Total Length (mm)	Total Weight (gr)	Stomach Contents
Cichlasoma cyanoguttatum	141	67.9	unident. Insect parts
	192	181.1	algae; adult diptera
Lepomis punctatus	102	25	water pennies; amphipods
	130	30	empty
	141	45	unident. Insect parts
Lepomis megalotis	115	30	water pennies
Micropterus salmoides	457	1179	snail; unk. Fish
Tilapia aurea	171	90.6	algae; unident. Bone
	299	318	Empty
	305	454	algae
	320	408	alage; chironomids
	323	408	algae; chironomid
	338	771	algae; chironomids
	339	816	algae; chironomids
	364	907	algae; snails; amphipod
	369	970	algae; chironomids; snail
	383	970	algae
	393	771	Empty
	400	1134	Empty
	401	1089	Empty
	413	1361	algae; unident. Insect parts
	432	1497	algae; snail
	434	1134	Empty

LANDA LAKE GILL NET DATA
COMAL RIVER - SPRING 2001 QUARTERLY SAMPLING

Species	Total Length (mm)	Total Weight (gr)	Stomach Contents
Micropterus salmoides	175	85	1 gambusia
	187	85	3 grass shrimp, 1 crayfish, 1 *E. fonticola*, 1 Gambusia, 7 unidentifiable fish
	210	113	1 grass shrimp
	213	142	1 crayfish
	216	142	2 *E. fonticola, 1 Gambusia*
	235	198	1 crayfish , 2 grass shrimp
	279	369	empty
	289	312	1 crayfish
	292	312	2 crayfish
	365	652	3 crayfish
	394	907	1 crayfish
	425	1134	1 crayfish, 1 spotted sunfish
Tilapia aurea	419	1361	empty
	371	964	empty
	406	1361	algae
Cichlasoma cyanoguttatum	242	312	algae
	189	142	algae
	184	142	empty
	125	57	empty
	125	57	algae
	123	57	algae
	86	28	algae
Lepomis punctatus	156	113	1 Hexagenia, 1 odonate, 1 crayfish
	131	57	1 crayfish
	128	57	1 crayfish
	132	57	2 Hexagenia
	125	43	empty

LANDA LAKE GILL NET DATA
COMAL RIVER - SUMMER 2001 QUARTERLY SAMPLING

Species	Total Length (mm)	Total Weight (gr)	Stomach Contents
Plecostoma sp.	440	1106	empty
Micropterus salmoides	208	113	crayfish remains
	231	198	empty
	233	198	empty
	245	227	1 crayfish
	252	227	1 *Gambusia*
	272	283	4 grass shrimp, 2 crayfish
	281	312	1 crayfish
	282	340	empty
	284	340	empty
	341	539	crayfish remains
	467	1673	empty
Lepomis cyanellus	105	57	1 Odonate (damselfly), 1 amphipod
Lepomis punctatus	104	28	1 Hexagenia mayfly
	105	28	unident. insect remains
	105	28	1 copepod
	106	28	2 water pennies, 6 amphipods, unident. insect remains
	110	28	2 snails. 3 water pennies, 2 amphipods, other unident. insect remains
	118	57	5 water pennies, unident. Insect remains
	128	57	1 caddisfly, 1 dipteran, unident. insect remains
	138	57	1 snail
	142	85	1 Odonate larvae (damselfly)
	142	57	empty
	145	85	1 snail, 1 baetid mayfly
	148	113	empty
	149	85	empty
	152	85	1 terrestrial insect
	~130-145	28	1 crayfish
	~135	57	1 snail
Lepomis megalotis	136	57	3 amphipods, 8 water pennies
	140	85	empty
	146	85	1 Odonate (damselfly), 1 grass shrimp, 1 crayfish
	152	85	crayfish remains
	155	85	1 Hexagenia mayfly, crayfish remains
	156	113	2 unidentified insects
	~130	57	1 Hexagenia, 7 amphipods, 1 terrestrial insect, 1 snail, 3 water pennies
Tilapia aurea	355	907	algae
	385	1134	empty
	399	1132	algae
	400	1191	algae

LANDA LAKE GILL NET DATA
COMAL RIVER - HIGH FLOW 1 SAMPLING

Species	Total Length (mm)	Total Weight (gr)	Stomach Contents
Lepomis auritus	171	85	1 crayfish, water penny, diptera pupae, small unident. fish (TL~7mm), unident. insect parts
	95	28	water pennies, amphipods, snails, unident insect parts
	80	28	snails, water pennies, diptera, unident insect parts
	85	28	water pennies, amphipods, coleoptera, unident insect parts
	65	28	Empty
	94	28	1 riffle beetle, water pennies, annelids, amphipods, snails, unident insect parts
Lepomis punctatus	135	28	algae
	141	57	unident yellow substance, 6 eggs
	95	28	too decomposed
	63	28	snails, water pennies, unident insect parts
	115	28	Empty
	140	57	terrestrial coleoptera, ant
Tilapia aurea	345	794	Empty

LANDA LAKE GILL NET DATA
COMAL RIVER - FALL 2001 QUARTERLY SAMPLING

Species	Total Length (mm)	Total Weight (gr)	Stomach Contents
Micropterus salmoides	306	425	empty
	422	1304	5 crayfish
Lepomis punctatus	95	28	water pennies, unident insect parts
	102	28	amphipod, water pennies, 1 mayfly
	104	28	water pennies, amphipods, other insect parts
	105	28	empty
	113	57	1 Baetid mayfly
	121	57	amphipods, 2 baetid mayflies, diptera
	131	57	empty
	131	57	1 crayfish
	134	57	empty
	149	85	1 isopod, 1+ Hexagenia mayfly
Lepomis megalotis	103	28	water pennies, 1 baetid mayfly
	126	57	empty
	131	85	water pennies, 1 Hexagenia mayfly
	156	85	empty
Cichlasoma cyanoguttatum	124	57	algae
	126	57	unident insect parts
	131	57	crayfish remains, amphipod, algae
	151	85	empty
	246	312	2 crayfish, 1-2 Hexagenia mayflies, amphipods, snail
Tilapia aurea	270	397	algae?
	363	1106	not examined
	410	1474	not examined
	413	1361	algae?
	420	1219	not examined

LANDA LAKE GILL NET DATA
COMAL RIVER - HIGH FLOW 2 SAMPLING

Species	Total Length (mm)	Total Weight (gr)	Stomach Contents
Cichlasoma cyanoguttatum	120	57	water pennies, amphipods
	124	57	*Microcylloepus* (1 adult, 1 larvae), water pennies
	262	369	9 small crayfish, Hexagenia, snail, riccia pieces
	N/A	N/A	unident insect parts
Lepomis punctatus	123	57	Empty
Micropterus salmoides	365	794	Empty
Tilapia aurea	382	1304	Stomach not taken
	403	1417	Stomach not taken
	403	1304	Stomach not taken
	413	1361	Stomach not taken
	415	1559	Stomach not taken
	419	1417	Stomach not taken
	420	1304	algae
	421	1304	algae