HABITAT CONSERVATION PLAN
BIOLOGICAL MONITORING PROGRAM
Comal Springs/River Aquatic Ecosystem

ANNUAL REPORT

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EXECUTIVE SUMMARY

The Edwards Aquifer Habitat Conservation Plan (HCP) Biological Monitoring program activities conducted in 2017 continued to track biota and habitat conditions of the Comal Springs/River ecosystem. Sampling efforts specifically targeting HCP species in the Comal system were conducted for the Fountain Darter *Etheostoma fonticola*, multiple endangered Comal Springs invertebrates, and the Comal Springs salamander *Eurycea spp.* Additional community level monitoring data was also collected on aquatic vegetation, benthic macroinvertebrates, and fish communities. This annual summary report presents a synopsis of methodologies used and observations made during comprehensive sampling activities conducted in the Comal system during 2017.

Results from 2017 provided insight into the continued transition from a prolonged drought into subsequent average/wet conditions in the Comal River/Springs ecosystem. Large flood events in late 2015 and continued rainfall in 2016 resulted in a resurgence of recharge and total system discharge in the Comal System. In fact, total system discharge continued above historical long-term averages through most of 2017 with an average daily discharge of 360 cfs. Similar to 2016, water temperature and dissolved oxygen (DO) measurements throughout the system presented no cause for concern. Recreation pressure as recorded by Texas Master Naturalists remained highest in the New Channel during the summer months, which is when swimmers, kayakers, picnickers, and tubers descend on this beautiful spring-fed river to spend time with families and seek relief from summer-time Texas heat.

Total coverage of aquatic vegetation in the Upper Spring Run, Landa Lake, and Lower New Channel Reaches was consistent with long-term study averages at the conclusion of 2017. A similar comparison in the Old Channel study reach is skewed by on-going HCP native aquatic vegetation restoration activities in the Old Channel. However, native aquatic vegetation conditions continue to improve in the Old Channel Reach as direct effect of the HCP vegetation restoration activities. In 2017, the restoration team successfully removed a large portion of nonnative *Hygrophila*, and established native *Ludwigia*, *Cabomba*, and *Sagittaria* in its place. Bryophytes have also voluntarily established around restored native vegetation, and in open spaces, producing a more diverse vegetation community in the Old Channel study reach compared to previous years. Native aquatic vegetation restoration activities sponsored by the HCP continue to provide a boost to the native aquatic plant community of the Comal system. Nonnative aquatic plants have essentially been eliminated from the headwaters throughout Landa Lake and replaced with a mosaic of native aquatic vegetation through restoration efforts.

Fountain Darter populations continue to follow long-term trends and reflect the benefits of a thriving aquatic vegetation community, with the highest densities continually recorded in native aquatic vegetation. Normalized population estimates of Fountain Darters were above the long-term study average in both spring and fall 2017. Timed and Random-station dip netting of Fountain Darters continue to provide an on-going "snapshot" of size-class distributions and an efficient way to assess on-going population and habitat conditions. Results of dip-net surveys in 2017 were at or above long-term averages for the study.

Five years of fish community sampling since 2013 has resulted in enumeration of over 58,700 fishes representing 27 distinct species. Species richness is similar to the long-term drop net database (2000-2016) which has identified approximately 168,000 fishes representing 25 species. However, species composition and relative abundance does differ between the two methods. Although *Gambusia* sp. and Fountain Darters are the dominant taxa within each dataset, the fish community sampling data has a higher relative abundance of minnows and sunfish than the drop net dataset. Seining and visual observation are more effective at enumerating these groups of fishes which are highly mobile and less susceptible to drop net capture. In contrast, drop netting is more successful for Fountain Darters compared to these other techniques as it was designed specifically to capture this species. Per direction of the HCP biological working group, limited fish tissue analysis was added to the HCP biological monitoring program specific to 2017. The objective was to explore if any toxicity concerns exist for different fish trophic levels in the Comal system. Although detections of several constituents were recorded ranging from artificial sweetener to aluminum, no results stood out as a cause for concern at this time. The acquisition of this type of fish tissue data serves well in the establishment of baseline conditions for future comparisons on a local or regional level.

For a second consecutive year Comal salamander *Eurycea* sp. observations were the highest recorded to date with the fall 2017 sampling being the highest documented in a seasonal event. All three federally listed Comal Springs invertebrates (Comal Springs dryopid beetles *Stygoparnus comalensis*, Comal Springs riffle beetles *Heterelmis comalensis*, and Peck's Cave amphipods *Stygobromus pecki*) were collected via drift net sampling over spring orifices in 2017. Lure data indicated that adult Comal Springs riffle beetle densities were again highly variable in 2017. The number of adult Comal Springs riffle beetles collected in 2017 from lures at each of the three sampling locations were lower than the long-term study averages in 2017. As these numbers, following consecutive high flow years, are actually approaching or declining below drought averages at all sites, close attention will be given to Comal Springs riffle beetles in 2018.

Per direction of the HCP biological working group, Benthic Macroinvertebrate Rapid Bioassessment sampling was added to the HCP biological monitoring program in 2017. The goal of this assessment is to track the "condition" of specific reaches over time as an indicator of trends, not necessarily as a comparison between reaches. Overall, areas of more lentic-type habitat (Landa Lake, Upper Spring Run) near spring sources scored lower, as communities there are different when compared to swifter flowing "least disturbed reference streams." Downstream areas with more lotic conditions generally scored higher, as habitat is more similar to reference streams. Continued monitoring may allow development of a reference dataset specific to this unique ecosystem, and potentially development of a specific scoring system for unique large spring environments such as the San Marcos and Comal rivers.

Overall, habitat and species conditions in the Comal system remain in excellent condition with continued improvements being recognized each year through HCP restoration and mitigation activities. The one exception for 2017, as noted above, was the decline in Comal Springs riffle beetle numbers recorded. It is too early to conclude any cause and effect at this time, but highlights the importance of future biological monitoring to assess conditions as well as quantify effects (both positive and negative) in continuing to tell the HCP story.

INTRODUCTION

Section 6.3.1 of the Edwards Aquifer Habitat Conservation Plan (HCP) laid out the path forward for continuation of biological monitoring. Originally, the biological monitoring program's (formerly known as the Edwards Aquifer Authority [EAA] Variable Flow Study) main objective was to evaluate the effects of variable flow on the biological resources (particularly threatened/endangered species) within the Comal and San Marcos spring systems. This fundamental objective is still imperative to the success of the HCP, as is continued monitoring of system conditions over time and filling in important data gaps where appropriate and practical. However, the utility of the HCP biological monitoring program has surpassed this original goal and objective. The biological monitoring data collected through this original program (BIO-WEST 2001a–2014a, b) now also serves as (1) the cornerstone for several underlying sections in the HCP, including long-term biological goals and management objectives (HCP Section 4.1); (2) determination of potential impacts to and incidental take assessment relative to the HCP and Environmental Impact Statement alternatives (HCP Section 4.2); and (3) establishment of core adaptive management activities for triggered monitoring and adaptive management response actions (HCP Sections 6.4.3 [Comal] and 6.4.4 [San Marcos]).

As the HCP proceeds, successful execution of the biological monitoring program is mandatory to adequately assess these topics relative to HCP Phase II decisions and guide management decisions aimed at protection of the species during low-flow conditions. Additionally, the HCP biological monitoring program data, in conjunction with other available information, is essential to assess the effectiveness and efficiency of certain HCP mitigation/restoration activities conducted in both the Comal and San Marcos springs systems and calculate the HCP habitat baseline and net disturbance determination and annual incidental "take" estimate.

Over the years, the EAA Variable Flow Study (now HCP biological monitoring program) has undergone numerous reviews and critiques. Adjustments have been made as appropriate. Most recently, the National Academy of Science conducted a thorough review (NRC 2015), which led to the formation of a HCP Biological Working Group (BWG). The BWG recommended specific modifications to the monitoring program be implemented in 2017. The first was the addition of a preliminary investigation of fish tissue in both the Comal and San Marcos systems to explore the potential for contaminants and impacts to fish health. The second was a modification of the benthic macroinvertebrate community sampling initiated in 2013. The macroinvertebrate sampling effort was adjusted to a rapid bioassessment approach to track invertebrate health within reaches per existing Texas Commission on Environmental Quality (TCEQ) protocols (TCEQ 2014).

It is important to understand that many different sampling components are included in the HCP biological monitoring program and several sampling location strategies are employed. The sampling locations selected are designed to cover the entire extent of endangered species habitats in both systems, but they also allow for holistic ecological interpretation while maximizing resources where practical and when applicable. As such, the current design employs the following five basic sampling location strategies for the Comal system, with associated sampling components.

The five sampling location strategies are as follows:

1. System-wide Sampling
   - Full system aquatic vegetation mapping–once every 5 years (next scheduled for 2018)

2. Select Longitudinal Locations
   - Temperature monitoring—thermistors
   - Water quality sampling—during Critical Period sampling
   - Fixed-station photography
   - Discharge measurements

3. Reach Sampling (five reaches)
   - Aquatic vegetation mapping
   - Fountain Darter *Etheostoma fonticola* drop netting
   - Fountain Darter presence/absence dip netting

4. Springs Sampling
   - Endangered Comal invertebrate sampling
   - Comal Springs salamander sampling

5. River Section/Segment Sampling
   - Fountain darter timed dip-net surveys
   - Benthic Macroinvertebrate sampling
   - Fish community sampling

The following section provides a brief description of methods for 2017 activities, which is followed by a presentation of observations and results. A more detailed description of the gear types used, methodologies employed, and specific GPS coordinates can be found in the Standard Operating Procedures Manual for the HCP biological monitoring program for the Comal Springs/River ecosystem (EAA 2017a).

METHODS

Study Location

Comal Springs, which consists of numerous spring openings, is the largest spring system in Texas. The clear, thermally constant water issues from the downthrown side of the Comal Springs Fault Block. The Comal River extends approximately 5 kilometers to its confluence with the Guadalupe River. Although Comal Springs reportedly has the greatest discharge of any springs in the Southwest, the flows can diminish rapidly during drought conditions. The springs completely ceased to flow for several months in the summer and fall of 1956 during the drought of record. Despite this, Comal Springs is home to several extremely rare, federally listed animal species. This study includes monitoring and applied research efforts directed toward federally listed species and those covered by the HCP. These include one fish, the Fountain Darter, and the following three invertebrates: Comal Springs dryopid beetle, Comal Springs riffle beetle, and Peck's cave amphipod. Three additional HCP-covered species monitored in this study include the Comal Springs salamander, Edwards Aquifer diving beetle *Haideoporus texanus*, and Texas troglobitic water slater *Lirceolus smithii*.

Two full routine comprehensive sampling efforts (spring and fall) were conducted in 2017. Additionally, Texas Master Naturalist volunteers assisted with weekly water quality measurements and recreational counts on the Comal system. A comprehensive sampling event includes the following sampling components and volunteer activities:

Water Quality / Fixed Station Photography
Thermistor Placement and Retrieval
Fixed-station Photographs
Weekly Standard Parameters (volunteer)
Point Water Quality Measurements
Discharge Measurements

Aquatic Vegetation
GPS Mapping

Fountain Darter Sampling
Drop Nets
Dip Nets
Visual Observations

Comal Springs Salamander Observations
SCUBA/Snorkel Surveys

Macroinvertebrate Sampling
Drift Nets
Comal Springs Riffle Beetle Surveys
Benthic Macroinvertebrate Rapid Bioassessment

Recreation Observations
Weekly Recreation Counts (Volunteer)

Fish Community Sampling
SCUBA/Seine Surveys

Comal Springflow

Total system discharge data for the Comal River were acquired from United States Geological Survey (USGS) water resources division. Some of 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 2017). The discharge data for the Comal system were taken from USGS gage 08169000 on the Comal River in New Braunfels. This site represents the cumulative discharge of the springs that form the Comal River.

In addition to the cumulative discharge measurement, USGS maintains gages on the Old Channel and New Channel of the Comal River (gages 08168913 and 08168932, respectively). Specific to each comprehensive sampling effort, discharge was also measured at five specific locations: Upper Spring Run, Spring Run 1, Spring Run 2, Spring Run 3, and Old Channel. These data were used to estimate the contribution of each major Spring Run to total discharge in the river, and to evaluate the relative proportion of water flowing in the Old Channel and New Channel. All biological monitoring program discharge measurements at these locations were taken using a HACH FH950 portable flow meter.

In addition to the five wadeable discharge measurement locations noted above, flow partitioning in Landa Lake was initiated in 2013 and was expanded to five locations the following year. This included adding discharge measurements above and below the Spring Island area and an upstream area of Landa Lake with a SonTek® RiverSurveyor M9 Acoustic Doppler Current Profiler. The objective is to track the contribution of a major upwelling area around Spring Island to the total system discharge in the Comal River.

Low-flow Sampling

Low-flow Critical Period events can prompt an intensive data collection effort that includes triggers and associated activities as outlined in Appendix A. No low-flow critical period events were triggered in 2017.

HCP Species-specific Triggered Sampling

Appendix A provides a detailed list of sampling requirements for HCP species-specific triggered sampling in the Comal system. No species-specific low-flow sampling was triggered in the Comal River in 2017.

Critical Period High-Flow Sampling

Similar to low-flow Critical Period events, high-flows can trigger an intensive data collection effort with triggers and associated activities outlined in Appendix A. No high-flow Critical Period events were triggered in 2017.

Water Quality Sampling and Fixed Station Photography

Conventional parameters (water temperature, conductivity, pH, dissolved oxygen, water depth at sampling point, and observations of local conditions) were taken at all drop-net sampling sites and fish community sampling locations using a calibrated, handheld, water quality sonde. Study locations, methods, sampling schedule, and results of the comprehensive water and stormwater monitoring conducted under the HCP are presented in a standalone report (SWCA 2017a, Draft).

Water Temperature Thermistors

Thermistors (HOBO Tidbit v2 Temp Loggers) set to record water temperature every 10 minutes have been placed at select water quality stations along the Comal River, and are downloaded at regular intervals to provide continuous monitoring of water temperatures in these areas. To provide a more manageable dataset, 10-minute readings are converted into 4-hour averages for analysis in this report. Thermistors were also placed in two deeper locations within Landa Lake using SCUBA. The thermistor locations will not be described in detail here to minimize the potential for tampering.

Water Quality Grab Samples

During Critical Period sampling events, surface-water grab samples are collected at 12 locations along the Comal River to evaluate conventional water chemistry parameters (Figure 1). There were no Critical Period sampling events, and thus no water quality grab sampling events, in 2017.

Fixed Station Photography

In addition to the water quality data collection effort, a long-term record of habitat conditions has been maintained via fixed-station photography. Fixed-station photographs allow temporal habitat evaluations. Photographs included upstream, cross-stream, and downstream photographs and were taken at each water quality site shown in Figure 1.

Texas Master Naturalist Monitoring

Volunteers with the Texas Master Naturalist program continued their monitoring efforts in 2017 at select locations along the Comal system. Volunteers collected water quality and site-use data at five sites: Houston Street site within the Upper Spring Run Reach, Gazebo site within the Landa Lake Reach, Elizabeth Avenue site upstream of the Old Channel Reach, New Channel site within the New Channel Reach, and the downstream-most Union Avenue site (Figure 2). Volunteer monitoring was performed on a weekly basis, with surveys conducted primarily on Friday afternoons between 1200hrs and 1500hrs. At each site, an Oakton Waterproof EcoTestr pH 2 was used to measure pH, and a LaMotte Carbon Dioxide Test Kit was used to measure carbon dioxide (CO_2) concentrations in the water column. In addition to water quality measurements, recreational-use data were collected at each site by counting the number of tubers, kayakers, anglers, etc., within the survey site at the time of sampling. Volunteers also took photographs at each site during each sampling event and occasionally made additional notes on recreational use or condition of the river.

Aquatic Vegetation Mapping

Aquatic vegetation mapping was conducted using a Trimble Geoexplorer 6000 and a Trimble Tempest external antenna capable of submeter accuracy. The antenna and GPS unit were attached, with the antenna on the bow, to a sit-in kayak with a plexiglass window in the bottom. The aquatic vegetation was identified and mapped by gathering coordinates (creating polygons) while maneuvering the kayak around the perimeter of each vegetation type at the water's surface. In 2013, following discussions with the HCP Science Committee, a new protocol assessing all aquatic vegetation species was introduced: this protocol was continued in 2017. All vegetation species in mixed stands were assigned a percentage of cover, which was multiplied by the total area of the stand to calculate the surface area of each species. For vegetation maps (Appendix B), only the dominant vegetation type is presented for each polygon. Vegetation stands that measured between 0.5 and 1.0 meter (m) in diameter were mapped by recording a single point. Vegetation stands less than 0.5 m in diameter were not mapped.

Figure 1. Fish community, water quality, and Fountain Darter timed dip-net surveys within the Comal River study area.

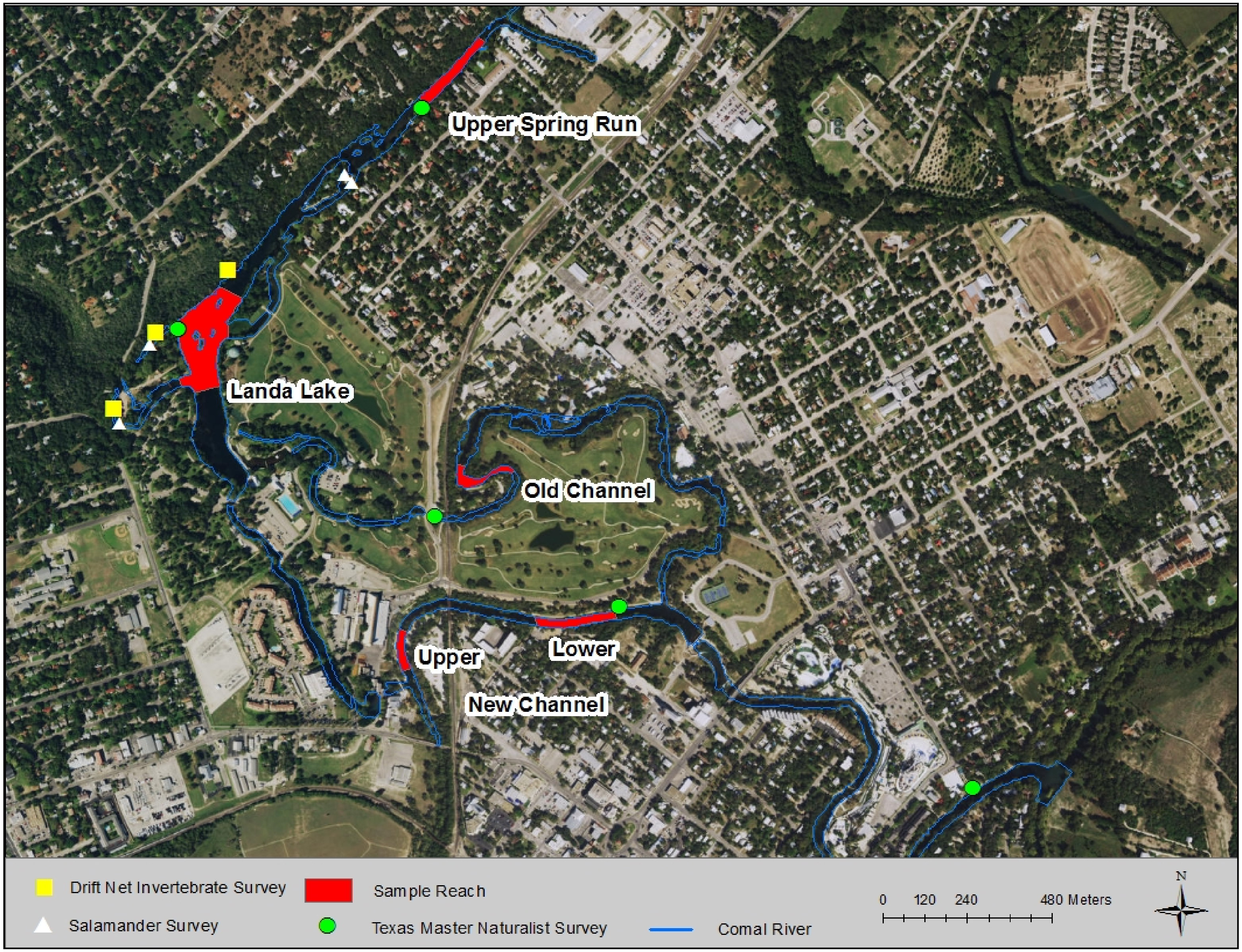


Figure 2. Invertebrate, Comal Springs salamander, Texas Master Naturalist, and biomonitoring (includes aquatic vegetation mapping, drop net sampling, presence/absence dip-net sampling, and macroinvertebrate community sampling) sample areas within the Comal River study area.

Biologist conducting aquatic vegetation mapping in the Comal River.

Fountain Darter Sampling

Drop-net Sampling

A drop-net is a sampling device originally designed by the USFWS to sample Fountain Darter and additional benthic fish species. The net encloses a known area (2 square meters [m^2]), preventing the escape of fish occupying that area and allowing for thorough sample collection. A large dip net (1 m^2) is used within the drop net and is swept along the length of the river substrate 15 times in order to ensure complete enumeration of all fish trapped within the drop net. For sampling during this study, a drop-net was placed in randomly selected sites within specific aquatic vegetation types. The vegetation types sampled in each reach (Figure 2) were those that were defined at the beginning of the study as the dominant species found in that reach. Sampling sites were randomly selected per dominant vegetation type for each sampling event with a random point generator in ArcGIS using the most recent vegetation map (created with GPS-collected data during the previous week) of that reach.

At each location, the vegetation type, height, and areal coverage were recorded, as were substrate type, mean column velocity, velocity at 15 centimeters (cm) above the bottom, water temperature, conductivity, pH, and dissolved oxygen. In addition, vegetation type, height, areal coverage, and substrate type were noted for the adjacent area within 3 m of the drop net. Fountain Darters were identified, enumerated, measured for total length, and returned to the river at the point of collection. The same data were collected for all other fish species, except for abundant species, in which case only the first 25 individuals were measured. Fish species not readily identifiable in the field were preserved for identification in the laboratory. When collected, all live giant ramshorn snails (*Marisa cornuarietis*) were counted, measured, and destroyed, while a categorical abundance level was recorded (i.e., none, slight, moderate, or heavy) for the exotic Asian snails *Melanoides tuberculatus* and *Tarebia 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.

Drop-net sampling in the Old Channel study reach.

Dip-net Sampling

In addition to drop-net sampling for Fountain Darters, a dip net of approximately 40 centimeter (cm) x 40 cm (1.6-millimeter [mm] mesh) was used to conduct two separate types of Fountain Darter sampling (timed surveys, and random-station presence/absence surveys).

Dip-net Timed Surveys

A dip net was used to sample all habitat types within each river section (Figure 1). Collection was generally conducted by personnel moving upstream through a section. Attempts were made to sample all habitat types within each section. Habitats thought to contain Fountain Darters, such as along the edges or within clumps of certain aquatic vegetation, were targeted and received the most effort. Areas deeper than 1.4 m were not sampled. Fountain Darters collected were identified, measured, recorded as number per dip-net sweep, and returned to the river at the point of collection. Occurrence and categorical abundance of native and exotic snails were also recorded for each sweep.

To balance the effort expended across samples, a predetermined time constraint was used for each section (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, Lower River: 1.0 hour). The areas of Fountain Darter collection were marked on a base map of the section, and the same general areas are sampled during each survey (Figure 1). Although information regarding the density of Fountain Darters per vegetation type was not gathered with this method (as in drop-net sampling), it did permit a more thorough exploration of various habitats within each reach. Also, spending a comparable length of time in each reach allowed comparisons between data gathered during each sampling event. Dip-net data were used to identify periods of Fountain Darter reproductive activity because this method was more likely to sample small Fountain Darters (<15 mm).

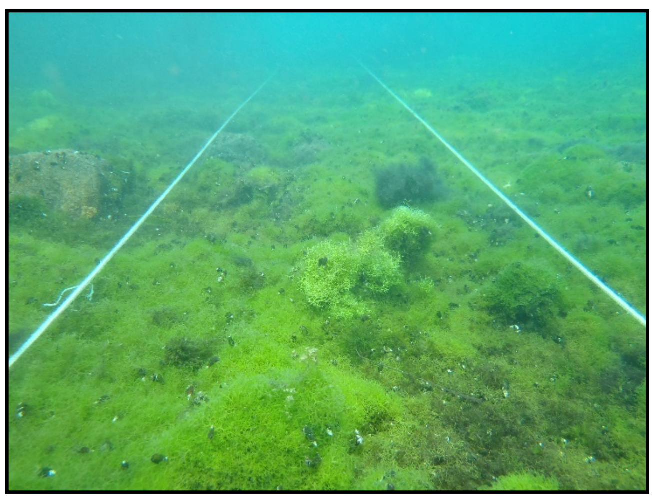
Random-station Dip Netting

Random-station presence/absence dip netting was initiated on the Comal River during fall 2005. It was designed to be a quick, efficient, and repetitive means of monitoring the Fountain Darter population. Also, because it is less destructive than drop netting, it can be conducted during extremely low-flow periods with fewer disturbances to critical habitat.

During each sample, 50 random stations were selected in vegetated areas within each of the 4 study reaches (Figure 2) using a random point generator in ArcGIS and the most recent vegetation map of that reach. The number of sampling stations in each study reach were distributed based on total area, diversity of vegetation, and previous Fountain Darter abundance estimates of each sample reach. Five stations were chosen in the Upper Spring Run Reach, 20 stations were chosen in the Landa Lake Reach, 20 stations in the Old Channel Reach, and 5 stations in the New Channel Reach. At each random station four dips were conducted for a total 200 dips per sample period. After each dip, presence or absence of Fountain Darters was recorded. To avoid recapture, Fountain Darters were placed into a plastic tub filled with river water or moved a sufficient distance away from the dip netter. At each station, the dominant surficial substrate (clay, silt, sand, gravel, cobble, boulder, bedrock) was recorded, along with the dominant type of aquatic vegetation (e.g., *Sagittaria*, bryophytes, open). Also, since bryophytes and algae are key Fountain Darter habitat components and can grow within or attached to other vegetation types, presence/absence of bryophytes and algae at each station was also noted. After four dips were completed and all necessary data were recorded, all organisms were released near the station of capture.

Visual Observations

Visual surveys were conducted in Landa Lake using SCUBA gear to verify continued habitat use in deeper portions of the lake by Fountain Darters and Comal Springs salamanders. Observations were conducted in early afternoon during each sampling event. Since summer 2001, a specially designed grid (0.6 x13.0 m) has been used to quantify the number of Fountain Darters using these deeper habitats. During each survey, all Fountain Darters within the grid were counted and the percentage of bryophyte coverage within the grid was recorded.



Fountain darter visual SCUBA grid in Landa Lake.

Fish Community Sampling

A multifaceted sampling methodology was again employed in 2017 to monitor fish community composition and abundance by using seines in wadeable areas and by conducting visual underwater SCUBA surveys in deeper habitats. This methodology was originally developed by Dr. Timothy H. Bonner and his students at Texas State University during previous fish

Seining for fish community sampling in Blieder's Creek.

community work on the San Marcos River (Behen 2013). Dr. Bonner and crew performed all HCP fish community sampling in the Comal system in 2017. For fish community monitoring, the Comal system was split into the following six segments: (1) Blieder's Creek, (2) Upper Spring Run, (3) Landa Lake, (4) New Channel, (5) Old Channel, and (6) Lower River (Figure 1).

Within the deeper sections of each reach, at least three visual transect surveys were conducted by divers during each sampling event. At each transect, two divers swam across the river, perpendicular to the flow, at approximately mid-column depth. Divers identified and enumerated all fish observed, and relayed the information to a third biologist at the surface who recorded data. After the divers completed this initial transect, four 5-m-long PVC pipe segments (micro-transect pipes) were placed on the stream bottom, spaced evenly along the original transect and oriented parallel to the river's current. The two divers then swam to the bottom and surveyed each of the micro-transect pipes. Divers started at the downstream end and swam up the pipe, with one diver on each side searching through the vegetation (if present) and substrate within approximately 1 m of the pipe to dislodge small benthic-oriented fishes such as darters. Again, all fish observed were identified, counted, and relayed to the data recorder on the surface. Notes on the percent coverage of various substrate and vegetation types were also recorded. After fish surveys were complete, depth and velocity data were collected near the middle of each micro-transect pipe using a Marsh McBirney Model 2000 portable flowmeter and adjustable wading rod. At each micro-transect pipe, velocity measurements were taken at 15 cm from the bottom, mid-column, and near the surface. Standard water quality parameters were also recorded once at each transect using a Hydrotech water quality sonde.

In addition to visual surveys, seining was used to sample the fish community in wadeable areas. At least three seining transects were conducted within each reach during each sampling event, with the exception of Landa Lake, which was too deep for seining. At each transect, multiple seine hauls were pulled until the entire wadeable area at that transect had been covered. For example, seines were pulled along the bank on one side of the river, after which the seining crew moved closer to midchannel, taking caution not to sample the same area. The crew continued to move toward the opposite bank with each successive seine haul until either the other bank was reached or water became too deep to seine effectively. Randomly selecting seining transects within the wadeable portion of each reach and using the protocol above ensured that habitats were sampled in similar proportions to their availability. After each seine haul, fish were identified, measured to the nearest mm of total length and enumerated. Then, to prevent recapture on subsequent seine hauls, captured fish were placed in a bucket containing river water. At each seine haul location, notes on percent coverage of substrate, vegetation, and other cover types were recorded, and water depth and velocity were measured with a portable flowmeter and adjustable wading rod. Velocity measurements were taken at 15 cm, midcolumn, and near the surface. After completion of all seine hauls at each transect, fish were released from holding buckets.

Data from underwater observations were combined with seine hauls to examine overall fish community composition and densities during each event. Densities were calculated by dividing the abundance of each species captured by area sampled (m^2). Individual densities were averaged across each site per season to determine average densities of each species. Data were also collected in a way that allowed calculation of catch-per-unit-effort (CPUE) by gear type and taxa.

Fish Tissue Sampling

In 2017 an exploratory effort to test fish tissue for contaminants was undertaken in the Comal system. Western Mosquitofish *Gambusia affinis* and predator fish such as Sunfish (*Lepomis* spp. and *Micropterus* spp.) and Largemouth Bass *Micropterus salmoides* were collected from the Landa Lake Reach in the upstream portion of the system near spring orifices and from the Lower River, which is the most downstream biomonitoring section in the Comal River (Figure 1). Fish were collected with 40x40 cm dip nets, common sense seines, and by hook and line. Samples were frozen and shipped overnight to the ALS laboratory in Kelso Washington for analysis. Tissues analysis was conducted for the parameters described in Table 1.

Table 1. Parameters for fish tissue analysis at ALS Kelso Laboratory.

PARAMETER	METHOD	METHOD DESCRIPTION	DETECTION LIMIT	REPORTING LIMIT	UNIT[a]
PCBs	8082A	GC	2.8	10	µg/Kg
PAHs	8270D	GC-MS SIM	.01–.1[b]	.1–1[b]	µg/Kg
PPBDEs	8270D	GC-MS	.01–.05[b]	.1–1[b]	µg/Kg
SVOCs	8270D	GC-MS SIM	10–200[b]	40–400	µg/Kg
Metals	1631, 6010C, 6020A, 7742	CVAA, ICPMS, AA	0.1	1	µg/Kg

[a] µg/Kg=micrograms per kilogram.
[b] detection and reporting limits vary by congener or analyte.

Additional fish and water samples were collected from the locations above in addition to the Upper New Channel Reach and sent to Baylor University for testing of fish tissue, plasma and water for pharmaceutical chemicals. The chemicals tested for are shown in Table 2.

Comal Springs Salamander Visual Observations

Visual surveys for the Comal Springs salamanders were conducted by two-person crews in Spring Run 1, Spring Run 3, and near Spring Island during both 2017 sampling events (Figure 2). Each survey began at the downstream-most edge of the sampling area. Crews turned over rocks located on the substrate surface to dislodge salamanders while moving upstream toward the main spring orifice. A dive mask and snorkel or viewing box were utilized to view organisms

Table 2. Pharmaceutical chemicals tested for in fish tissues and plasma at Baylor University.

ANALYTE	COMPOUND CLASS	METHOD DETECTION LIMIT (MDL) [a]		
		Water (ng/L)	Tissue (µg/Kg)	Plasma (ng/ml)
Acetaminophen	Analgesic	0.47	0.49	1.1
Amitriptyline	Antidepressant	0.46	0.47	0.3
Amlodipine	Anti-hypertensive	12.03	1.3	1.98
Aripiprazole	Anti-psychotic	2.21	2.28	1.1
Benzoylecgonine	Cocaine metabolite	0.26	0.10	0.08
Buprenorphine	Narcotic	0.26	0.5	2.16
Caffeine	Stimulant	0.7	0.51	0.88
Carbamazepine	Anti-seizure	0.17	0.16	0.20
Desmethylsertraline	Sertraline metabolite	7.16	2.19	1.11
Diclofenac	Anti-inflammatory	4.74	2.31	2.10
Diltiazem	Anti-hypertensive	0.24	0.06	0.06
Diphenhydramine	Antihistamine	0.08	0.11	0.03
Duloxetine	Antidepressant	0.32	0.32	0.15
Erythromycin	Antibiotic	0.16	0.9	1.03
Fluoxetine	Antidepressant	0.74	0.36	0.14
Ketamine	Anesthetic	0.07	0.32	0.26
Methylphenidate	Psychostimulant	0.17	0.06	0.11
Norfluoxetine	Fluoxetine metabolite	1.77	0.71	0.3
Promethazine	Antihistamine	3.45	0.39	2.33
Propranolol	Anti-hypertensive	0.11	0.19	0.18
Sertraline	Antidepressant	1.1	0.99	0.20
Sucralose	Sweetener	2.62	2.91	0.64
Sulfamethoxazole	Antibiotic	0.06	1.87	0.51
Trimethoprim	Antibiotic	0.07	0.45	0.36

[a] ng/L=nanograms per liter, µg/Kg=micrograms per kilogram, ng/ml=nanograms per milliliter.

as depth permitted. Comal Springs salamander locations were noted, along with time, water depth, and presence/absence of vegetation. To maintain consistency between samples, all surveys were timed and initiated in the morning and terminated by early afternoon.

Within Spring Run 1, a 1-hour survey was conducted from the Landa Park Drive Bridge upstream to just below the head spring orifice. Spring Run 3 was surveyed for 1 hour from the pedestrian bridge closest to Landa Lake upstream to just below the head spring orifice. Surveys in the Spring Island area were divided into the following two sections: (1) one 30-minute survey of Spring Run 6 and, (2) one 30-minute survey of the east outfall upwelling area on the east side of Spring Island near Edgewater Drive.

Biologists conducting visual salamander survey in Spring Run 3.

Comal Springs salamander observed during visual survey.

Additionally, Comal Springs salamander visual observations were made during SCUBA surveys for Fountain Darters of deeper locations within Landa Lake outlined above. These visual surveys have been conducted along a deep water transect in Landa Lake since 2001 in an effort to verify continued habitat use by the Fountain Darter and Comal Springs salamander.

Macroinvertebrate Sampling

Drift-net Sampling

Macroinvertebrate samples were collected via drift net at three sites in the Comal system. During each comprehensive sampling event, drift nets were placed over the major spring openings of Comal Spring Runs 1 and 3 and a moderate-sized spring upwelling (Spring 7) along the western shoreline of Landa Lake (Figure 2). Drift nets were anchored into the substrate directly over each spring opening, with the net faced perpendicular to the direction of flow. Net openings were circular with a 0.45 m diameter, and the mesh size was 100 micrometers (µm). The tail of the drift net was connected to a detachable, 0.28 m long cylindrical bucket (200 µm mesh), which was removed at 6-hour intervals during sampling, after which cup contents were sorted and invertebrates removed in the field. The remaining bulk samples were preserved in ethanol and sorted later in the laboratory, removing minute organisms overlooked in the field. All Comal Springs riffle beetles, Peck's cave amphipods, and Comal Springs dryopid beetles captured via drift net were returned to their spring of origin, with the exception of voucher organisms (fewer than 20 living specimens of each species identifiable in the field). All non-endangered invertebrates were preserved in 70% ethanol. Additionally, water quality measurements (temperature, pH, conductivity, dissolved oxygen, and current velocity) were

Drift net over Spring Run 1 orifice showing net placement and orientation to the spring.

taken at each drift-net site using a Hydrotech multiprobe (MS5) water quality meter and Hach (FH950) handheld flow meter.

Comal Springs Riffle Beetle

In 2017, Comal Springs riffle beetles were collected from three reaches in the Comal River system during two routine sampling events, spring and fall. Sampling followed the methods of the Cotton Lure SOP developed in the summer of 2016 (datasheets including metadata are available to the EAA for archive). This methodology consists of placing lures of 15x15 cm pieces of 60% cotton/40% polyester cloth into spring openings/upwellings in the Comal system, leaving them in situ for approximately 30 days. During this time they become inoculated with local organic and inorganic matter, biofilms, and invertebrates, including Comal Springs riffle beetle. Lures were placed in sets of 10 in 3 areas: (1) Spring Run 3, (2) along the western shoreline of Landa Lake ("Western Shoreline"), and (3) near Spring Island in locations that were previously found to have high densities of Comal Springs riffle beetle (BIO-WEST 2002a). Lures were deployed and collected at all sites in April/May and October/November; the length of time lures were deployed ranged from 28 to 35 days. Lures lost, disturbed, or buried by sedimentation were not included in subsequent analyses.

Processing Comal Springs Riffle Beetle Lures

All Comal Springs riffle beetles collected with cotton lures were identified, counted, and returned to their spring of origin. The sampling crew also recorded counts of another elmid beetle *Microcylloepus pusillus* and Peck's cave amphipods collected on the lures. These and any other spring invertebrates collected on the lures were also placed back into their spring of origin. Crews utilized a mask and snorkel to place and remove lures in deeper areas.

Benthic Macroinvertebrate Rapid Bioassessment

Rapid Bioassessment Protocols (RBPs) are tools for evaluating biotic integrity and overall habitat health, based on the community of organisms residing in them (Barbour et al. 1999). Macroinvertebrates are the most frequently used biological units for RBPs because they are ubiquitous, diverse, and there is an acceptable working knowledge of their taxonomy and life histories (Poff et al. 2006, Merritt et al. 2008).

BIO-WEST performed sampling and processing of freshwater benthic macroinvertebrates, following Texas RBP standards (TCEQ 2014). Macroinvertebrates were sampled with a D-frame kick net (500 µm mesh) by disturbing riffle habitat consisting primarily of cobble-gravel substrate, when available, for 5 minutes while moving in a zig-zag fashion up-stream. When suitable cobble-gravel substrate was not available, the riffle sample was supplemented with a snag sample. Snag sampling entailed collecting submerged wood "snags" 0.5–2.5 cm in diameter and placing them in a sieve bucket. Snag materials were washed thoroughly in the bucket to

Rapid Bioassessment Protocol sampling and processing

remove attached organisms. Invertebrates from riffle and snag samples were then combined in a sorting tray and randomly distributed. Subsamples for riffle or riffle+snag were taken by scooping out random portions of material and placing them into a separate sorting tray. All macroinvertebrates were picked from the tray before another subsample was taken. This process was continued until a minimum of 140 individuals were picked to represent a sample. If the entire sample did not contain 140 individuals, the process was repeated again until this minimum count was reached. Macroinvertebrates were collected in this fashion from Upper Spring Run, Landa Lake, Old Channel, New Channel, and the Lower River reaches, during spring (18–19 May) and fall (19–20 October), separately (Figure 1).

Picked samples were preserved in 70% isopropyl, returned to the laboratory, and identified to TCEQ (2014) taxonomic effort levels, usually genus, though members of the family Chironomidae (non-biting midges) and class Oligochaeta (worms) were retained at those taxonomic levels. The 12 ecological measures or metrics of the Texas RBP benthic index of biotic integrity (B-IBI) were calculated for each sample. Each metric represents a functional aspect of the macroinvertebrate community, related to ecosystem health and sample values are scored 1–4 based on benchmarks set by reference condition streams for the state of Texas. The aggregate of all 12 metric scores for a sample represent the B-IBI score for the reach that sample was taken from. The B-IBI point-scores for each sample are compared to benchmark ranges and are described as having aquatic-life-uses as “Exceptional,” “High,” “Intermediate,” or “Limited.” In this way, point-scores were calculated and the aquatic-life-use for each sample reach was evaluated.

OBSERVATIONS

The project team conducted 2017 comprehensive sampling during three different periods: Spring routine full event (April 21–May 26), Summer Fountain Darter dip netting (August 14–15), and Fall routine full event (October 16–November 13).

Comal Springflow

Total system discharge during the first half of 2017 continued well above historical long-term averages similar to what was observed in most of 2016 (Figure 3). The second half of 2017 showed total system discharge at or slightly above historic long term averages.

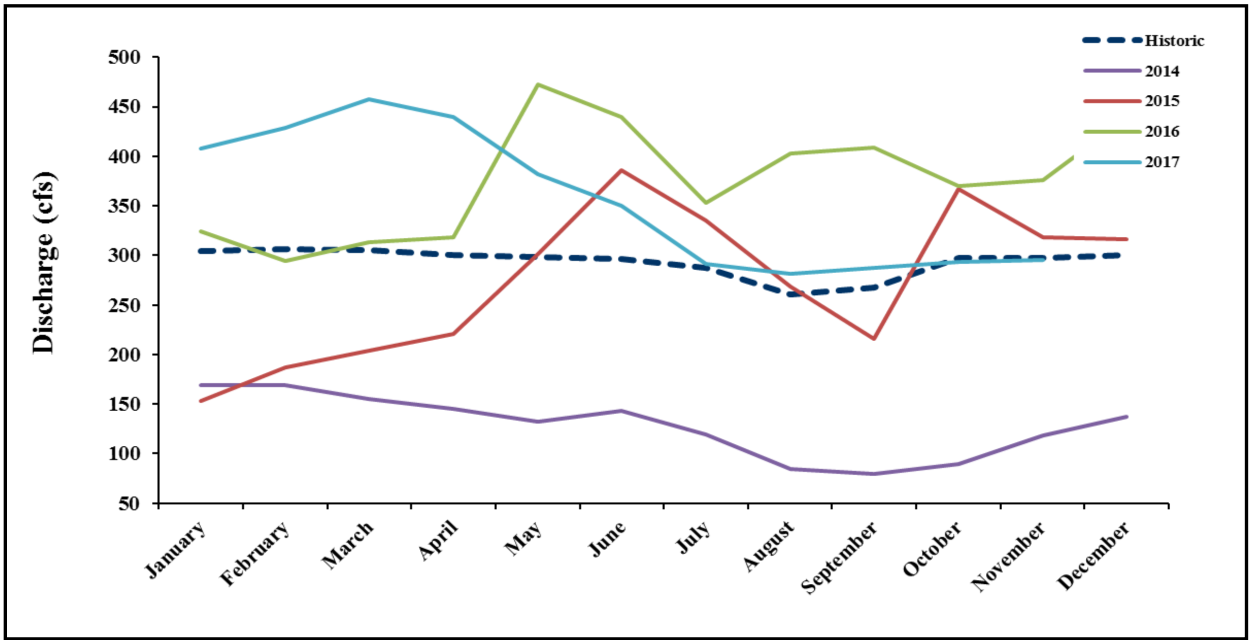


Figure 3. Mean monthly discharge in the Comal River 2014–2017, with historical period of 1934–2017 as dashed line.

Table 3. Lowest discharge during each year of the study (2000–2017), and the date it occurred.

YEAR	DISCHARGE (cubic feet per second)	DATE
2000	138	September 7
2001	243	August 25
2002	247	June 27
2003	351	August 29
2004	335	May 28
2005	339	July 14
2006	202	August 25
2007	251	March 8–10
2008	260	June 30
2009	158	July 2
2010	305	August 26, 30
2011	159	September 14
2012	155	September 13
2013	111	September 4
2014	65	August 29, 30
2015	131	January 1–2,5–6
2016	278	February 22
2017	261	August 2–3

The lowest total springflow (daily average) occurred on August 2, 2017, at 261 cubic feet per second (cfs), which was very similar to the lowest total observed in 2016 (278 cfs) (Table 3). The overall 2017 average daily discharge was 360 cfs and only on one day (March 3, 2017) did the discharge exceed 1,000 cfs. This represents consistent flows compared to the previous years, and the lack of large flood events (peak flows over 3,000 cfs) prevented extensive scouring of vegetation in the Upper Spring Run and New Channel reaches.

During spring and fall routine sampling events in 2017, discharge was measured at nine sites in the Comal River (Figure 4). Measured discharge in Spring Run 1 increased from both spring and fall 2016 (31 cfs, 42 cfs) to spring 2017 (45 cfs) then decreased to 29 cfs in fall 2017. Discharge at Spring Run 2 was approximately 7 cfs in spring and 4 cfs in fall, which is above the long-term average for both seasons (Figure 5). Similar to 2016, discharge in Spring Run 3 was higher in the spring than fall (48 cfs vs. 38 cfs); however, 2017 discharge was higher overall than in 2016 and the long-term average (Figure 5).

Measured discharge in the Old Channel largely reflects the amount of water flowing through the culvert at the downstream end of Landa Lake. As this is a regulated culvert, flows are expected to be more consistent here than the rest of the Comal system. In 2017, discharge for the Old Channel was higher in the spring than in the fall (57 cfs vs. 51 cfs) and slightly lower than the long term historical average.

In 2011 the study team began measuring discharge at Upper Spring Run (Liberty St.). Figure 6 reveals that discharge was higher in spring (33cfs) than fall (24 cfs), with both seasons being higher than the long-term average (2011–2017). In fact, the spring 2017 Upper Spring Run discharge was the highest observed since implementation of these measurements in 2011.

The flow-partitioning effort that began in 2013 continued in 2017. Discharge measurements were collected above and below Spring Island and at the upstream end of Landa Lake (Figure 4). Landa Lake flow portioning measurements in 2017 were conducted by EAA. Spring 2017 measurements were the highest observed at all locations since these measurements began and totals at all locations dropped slightly in the fall (Table 4). This corresponds well with the average daily discharge in the Comal system for 2017 (Figure 3). Of the transects measured from both events in 2017, Spring Island Lower Near contributed the least to overall discharge in spring and fall (approximately 14%) (Table 5). However, areas on the far side of Spring Island contribute substantially to overall springflow. Since 2014 the area around and upstream of Spring Island has contributed approximately 36–54% of the total system discharge, with the majority of that coming down the western (far) channel. Continued data collection under various hydrologic scenarios will be useful in understanding the spatial distribution of springflow in this area.

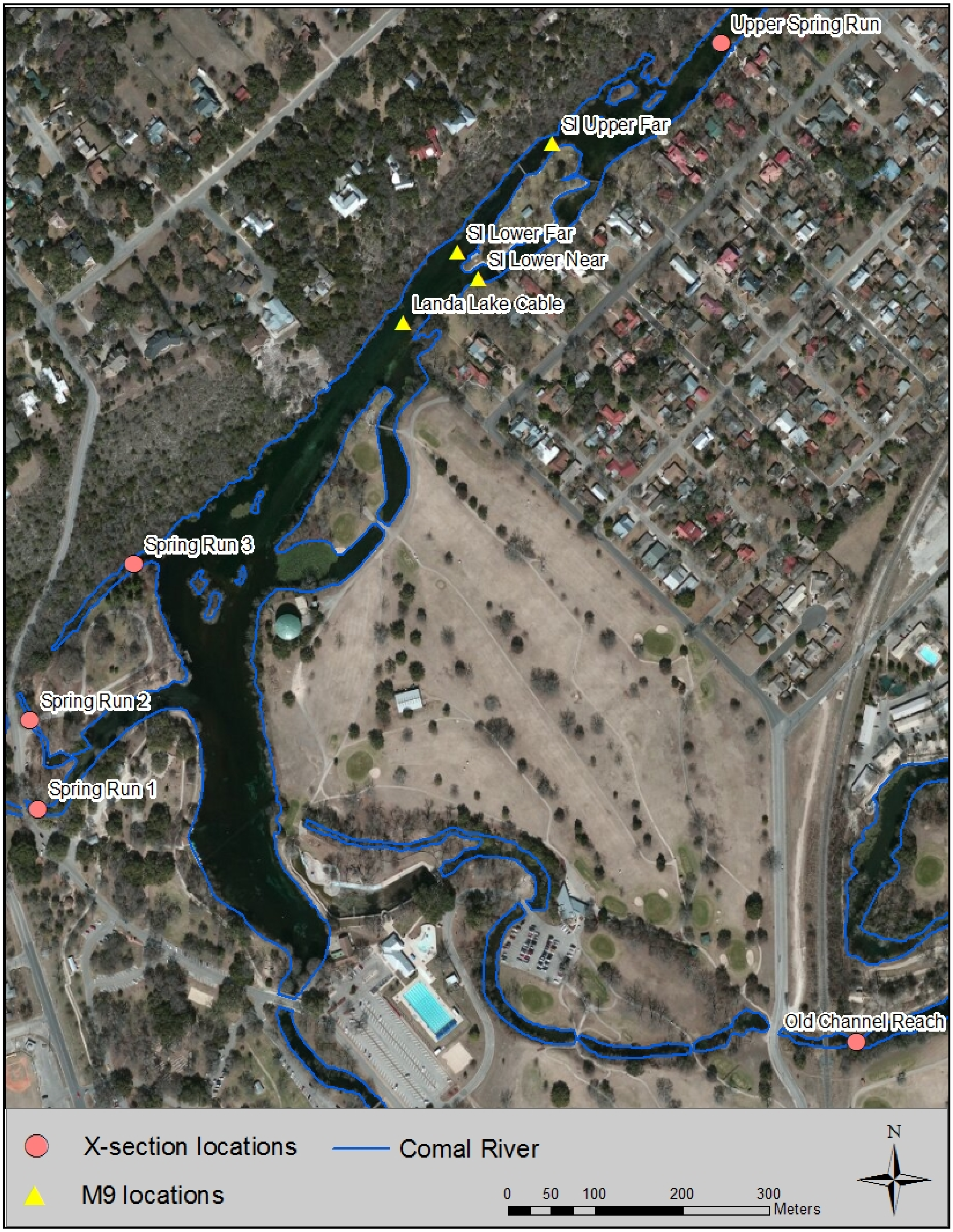


Figure 4. **Cross-section and flow partitioning (M9) discharge collection locations in the Comal River.**

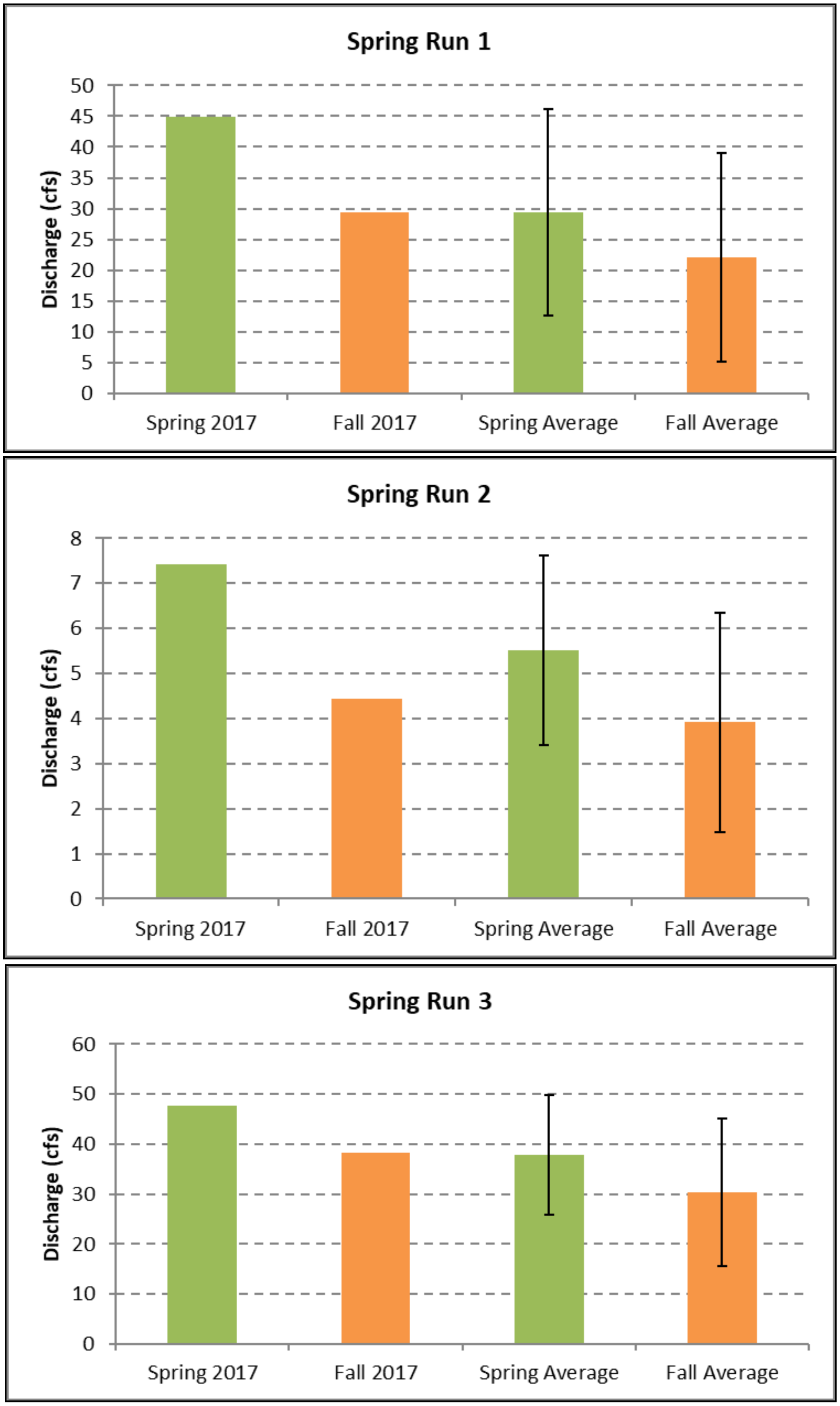


Figure 5. **Measured discharge for Spring runs 1, 2, and 3. Averages represent April / May values (spring) and October / November values (fall) from 2003 to 2017. *Note y-axis differences for discharge.**

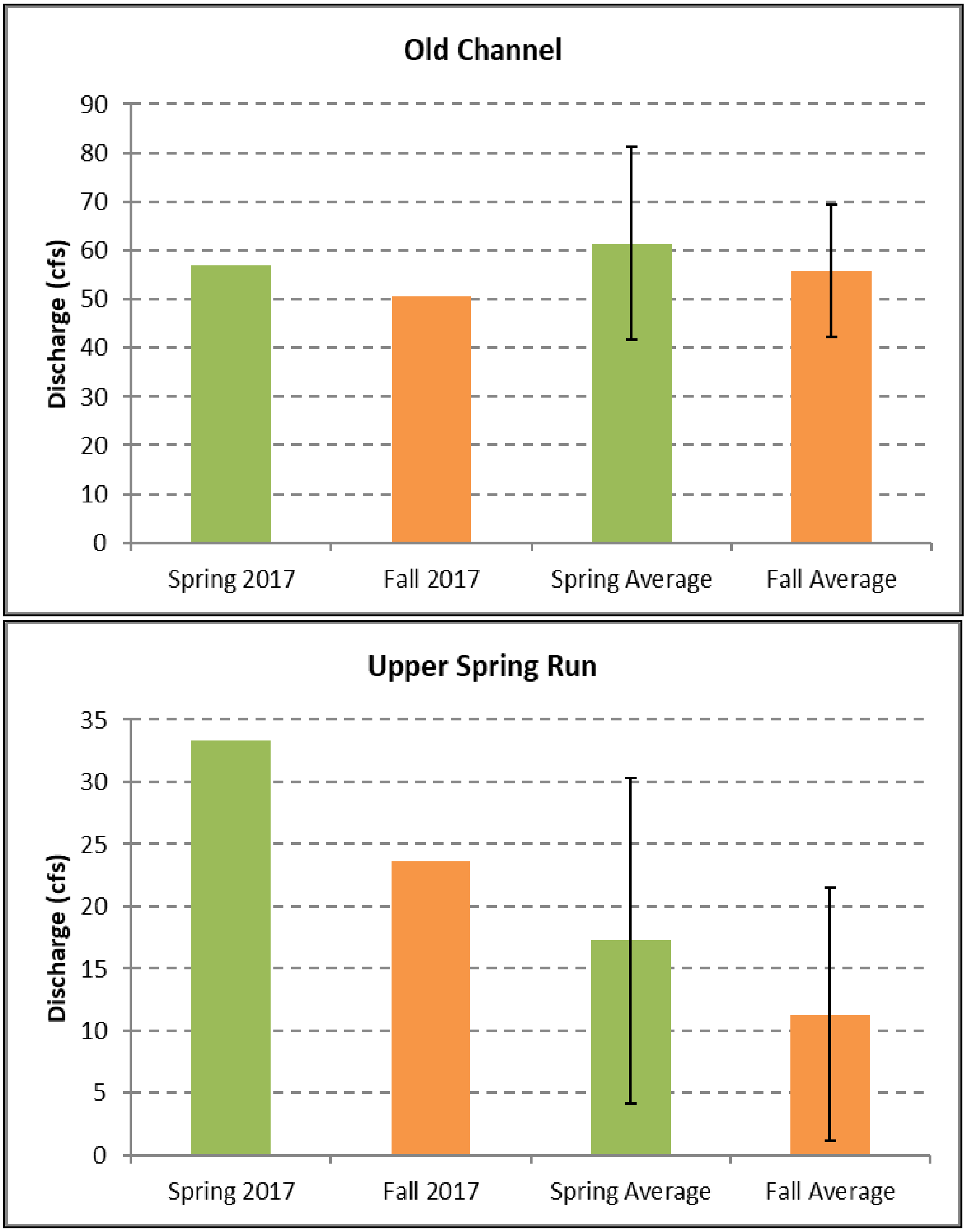


Figure 6. **Measured discharge for the Old Channel and Upper Spring Run reaches. Averages represent April / May (spring) and October / November values (fall) from 2003–2017 for the Old Channel, and 2011–2017 for Upper Spring Run. *Note differences in y-axis for discharge.**

Table 4. Flow partitioning data from five transects in 2014–2017.

DATE	DAILY MEAN DISCHARGE (USGS)	DISCHARGE (CUBIC FEET PER SECOND)				
		Transect 1 Upper Spring Run	Transect 2 SI Upper Far	Transect 3 SI Lower Far	Transect 4 SI Lower Near	Transect 5 Landa lake Cable
15 August 2014	86	1.1	11.9	22.2	9.3	46.5
5 September 2014	67	0.8	11.3	17.3	6.9	29.4
10 September 2014	73	1.1	10.0	21.0	7.5	33.7
17 September 2014	83	1.8	13.0	23.1	7.1	35.3
24 September 2014	85	0.6	12.5	18.9	7.6	32.7
2 October 2014	87	2.0	15.6	25.9	9.3	41.2
8 October 2014	85	1.6	17.3	26.1	8.5	40.1
23 October 2014	91	0.6	12.8	23.8	7.6	39.3
24 April 2015	256	18.9	38.1	54.0	22.0	92.2
3 September 2015	221	18.9	32.0	51.2	29.2	99.1
17 May 2016	343	33.0	51.2	76.7	48.9	141.0
25 October 2016	362	29.1	52.2	79.4	48.8	146.2
3 May 2017	410	42.0	62.5	94.7	56.4	166.0
26 Oct 2017	283	-	49.4	51.3	40.1	120.4

Table 5. Percentage of total discharge in the Comal River (USGS gage 08169000) from each flow partitioning transect in 2014–2017.

DATE	DAILY MEAN DISCHARGE (USGS)	PERCENTAGE OF TOTAL DISCHARGE				
		Transect 1 Upper Spring Run	Transect 2 SI Upper Far	Transect 3 SI Lower Far	Transect 4 SI Lower Near	Transect 5 Landa Lake Cable
15 August 2014	86	1.3	13.8	25.8	10.8	54.1
5 September 2014	67	1.2	16.9	25.8	10.3	43.9
10 September 2014	73	1.5	13.7	28.8	10.3	46.2
17 September 2014	83	2.2	15.7	27.8	8.6	42.5
24 September 2014	85	0.7	14.7	22.2	8.9	38.5
2 October 2014	87	2.3	17.9	29.8	10.7	47.4
8 October 2014	85	1.9	20.4	30.7	10.0	47.2
23 October 2014	91	0.7	14.1	26.2	8.4	43.2
24 April 2015	256	4.6	14.9	21.1	8.6	36.0
3 September 2015	221	8.6	14.5	23.2	13.2	44.8
17 May 2016	343	9.6	14.9	22.4	14.3	41.1
25 October 2016	362	8.0	14.4	21.9	13.5	40.4
3 May 2017	410	10.2	15.2	23.1	13.8	40.5
26 Oct 2017	283	-	17.5	18.1	14.2	42.5

Water Quality Results

Temperature Thermistors

Long-term water temperature data from thermistors (Appendix C.1) provides an overview of the thermal conditions throughout the Comal system from 2000 to 2017. Gaps in readings on some graphs indicate data-quality events (e.g., theft, thermistor failure); therefore, data were excluded from analysis. As expected, water temperatures are most constant at or near the spring inputs and become more variable downstream as other factors (e.g., runoff, precipitation, and ambient temperature) become more influential.

Four-hour average water temperature data for the Comal headwaters (Blieder's Creek and Heidelberg) are presented in Figure 7. These data exhibit the disparity between an area near a spring input (Heidelberg) and a non-spring area (Blieder's Creek). Blieder's Creek is fed by runoff from the surrounding area, and backup from the springs near the upstream end of the Upper Spring Run Reach. As a result, ambient air temperatures and precipitation events are typically more influential on water temperature, causing fluctuations at Blieder's Creek, whereas water temperatures at Heidelberg are relatively constant due to the constant temperature of the spring inputs. During the low flows of 2014, the Heidelberg thermistor was moved approximately 75 feet downstream to deeper water because its original location began to dry up. This new location is below the confluence of a small spring inflow. As a result, when this spring is flowing, temperatures from this thermistor show less variation than during previous years with similar flow conditions.

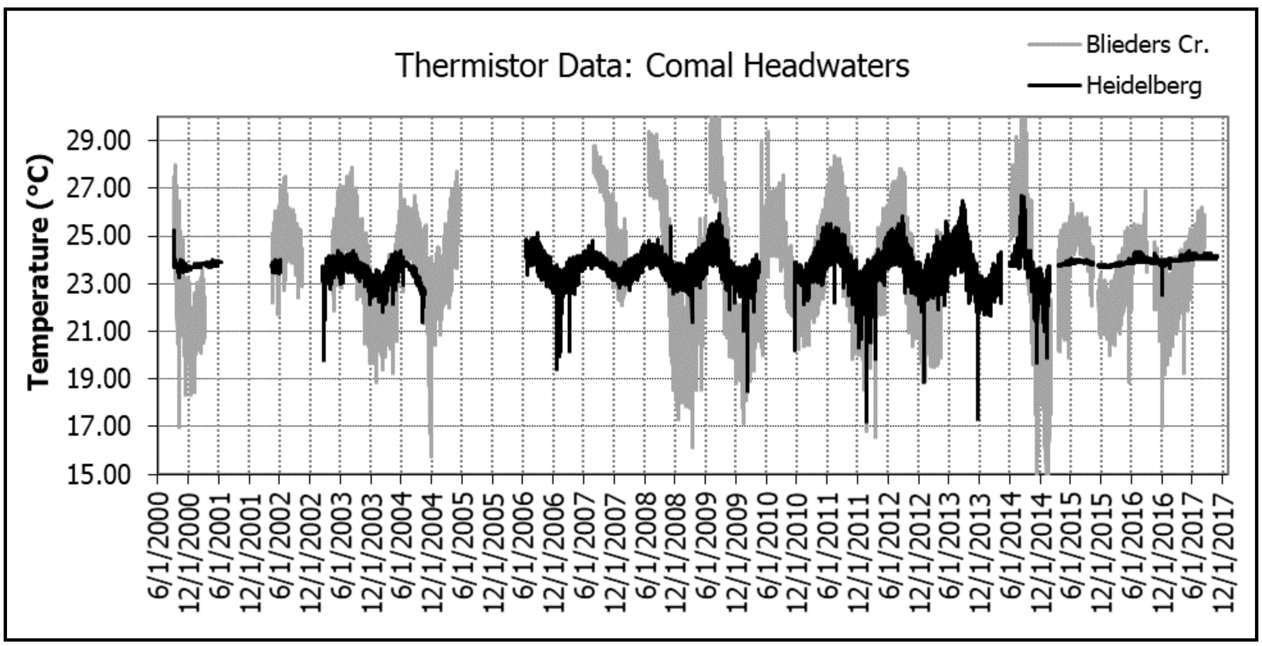


Figure 7. Water temperature (°C) data at Comal headwaters from 2000 to 2017.

Sites like the Other Place, New Channel, and Old Channel had wider temperature fluctuations than sites closer to spring inputs in 2017, but none of the sites exceeded the TCEQ water quality standard of 26.7 ºC (Appendix C.1). Temperatures in the spring runs and Landa Lake vary little (<1 ºC), because most of the water comes from the nearly constant temperatures of the Edward's Aquifer upwellings throughout the lake. Detailed graphs for each site can be found in Appendix C.1.

Water Quality Grab Samples

No water-quality grab samples were collected as part of the biological monitoring program because there were no Critical Period events in 2017. A more in-depth look at water quality can be found in the 2017 EAA HCP Expanded Water Quality Report (SWCA 2017a, Draft). A review of the water quality results provided thus far for 2017 show very few incidents where pollutants were detected, and none were above the TCEQ surface water benchmark for aquatic life or TCEQ human health criteria water and fish consumption values.

EAA Manta 2 Sonde Data

In 2012 EAA installed Eureka Manta 2 multiprobes at three locations in the Comal River (Spring Run 3, Spring 7, and downstream of Dry Comal Creek) (Figure 8). These multiprobes monitor standard parameters (temperature, pH, conductivity, dissolved oxygen, and turbidity) every 15 minutes and the data from 2017 is summarized below. These data were taken directly from the EAA Environet website (EAA 2017b).

Much like the temperature data collected via thermistors for HCP biological monitoring, the EAA water temperature data showed very little variation throughout the year in Spring Run 3 and Spring 7 (Figure 9). There were several notable declines in temperature at Spring Run 3, which are likely due to rainfall events. The temperatures at Spring Run 3 and Spring 7 are typical for areas near spring orifices like those recorded by the thermistors in the spring runs (Appendix C.1). The temperature probe downstream of Dry Comal Creek in the New Channel showed greater fluctuation in temperature as it is influenced more by runoff and ambient air temperatures (Figure 9). None of the three sondes collected readings that exceeded TCEQ water quality standard of 26.67 ºC for the Comal River in 2017. The highest temperature recorded in 2017 was 25.45 at the Dry Comal Creek site on July 29, 2017.

Dissolved oxygen in both Spring Run 3 and Spring 7 varied from 4.43 mg/l to 9.01 mg/l in 2017, whereas dissolved oxygen downstream of Dry Comal Creek showed greater fluctuation throughout the year (Figure 10). Short-term drops in dissolved oxygen below Dry Comal Creek likely result from an influx of nutrients and organic matter in runoff during rainfall events that temporarily increases oxygen demand. The pH and conductivity observations at all three locations also showed little variation throughout the year. The pH values ranged from 6.86 to 8.44 (Figure 11) while conductivity averaged from 581 to 585 uS/cm at all three locations (Figure 12). Short-term drops in conductivity are likely result from an influx of low-conductivity rainwater during precipitation events.

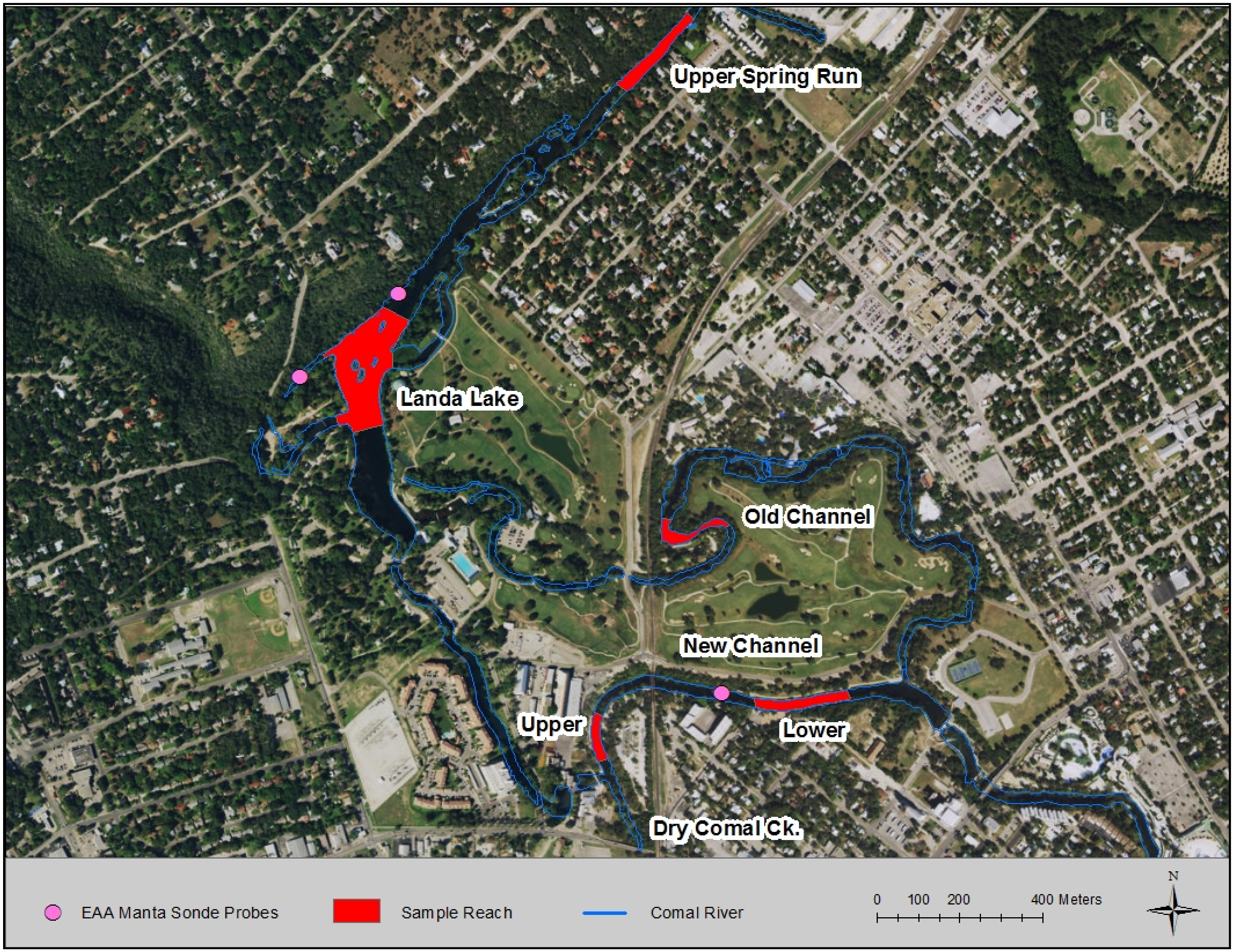


Figure 8. Edwards Aquifer Authority Manta Sonde probe locations in 2016.

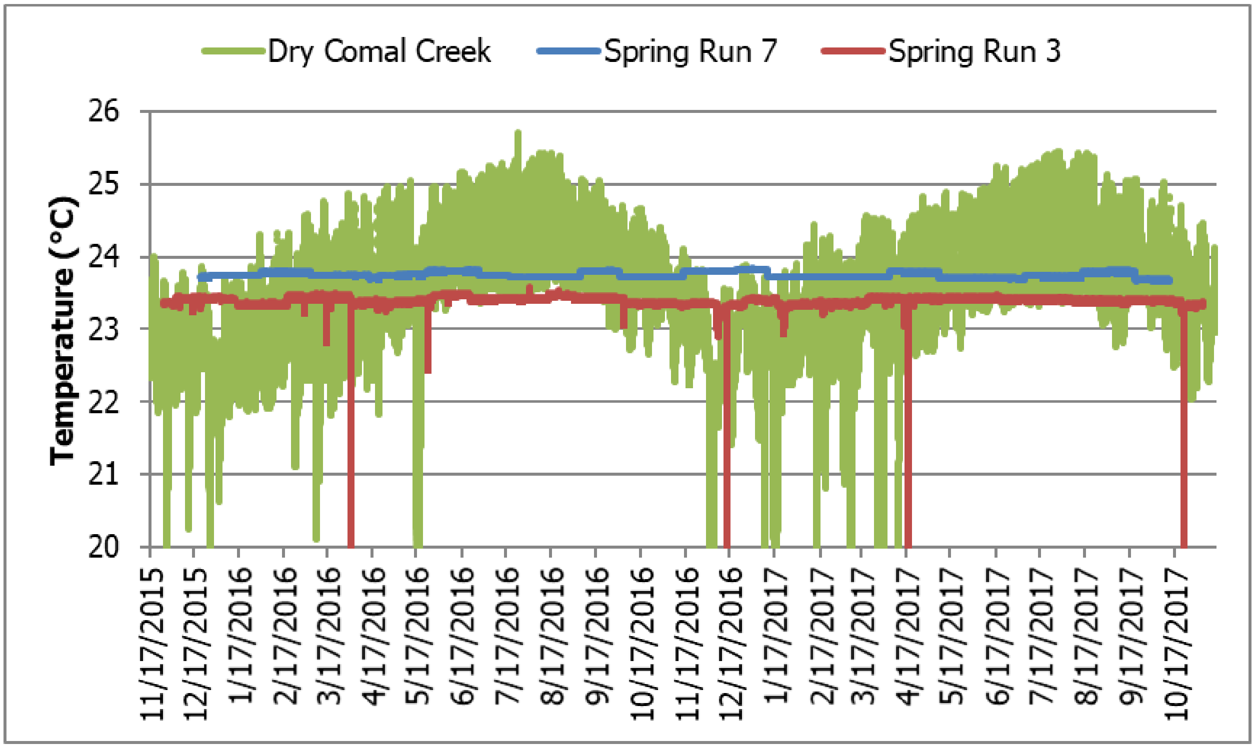


Figure 9. **Edwards Aquifer Authority Manta 2 multiprobe temperature data in Spring Run 3, Spring 7, and downstream of Dry Comal Creek.**

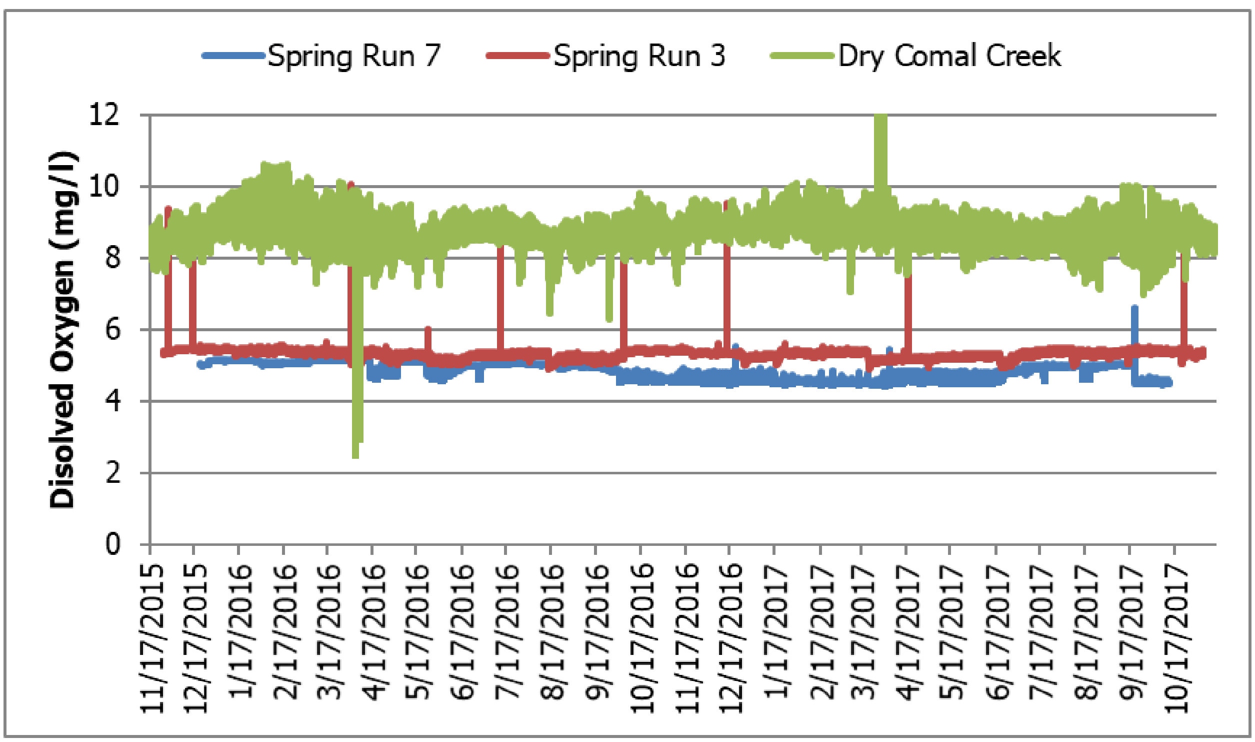


Figure 10. **Edwards Aquifer Authority Manta 2 multiprobe dissolved oxygen data in Spring Run 3, Spring 7, and downstream of Dry Comal Creek.**

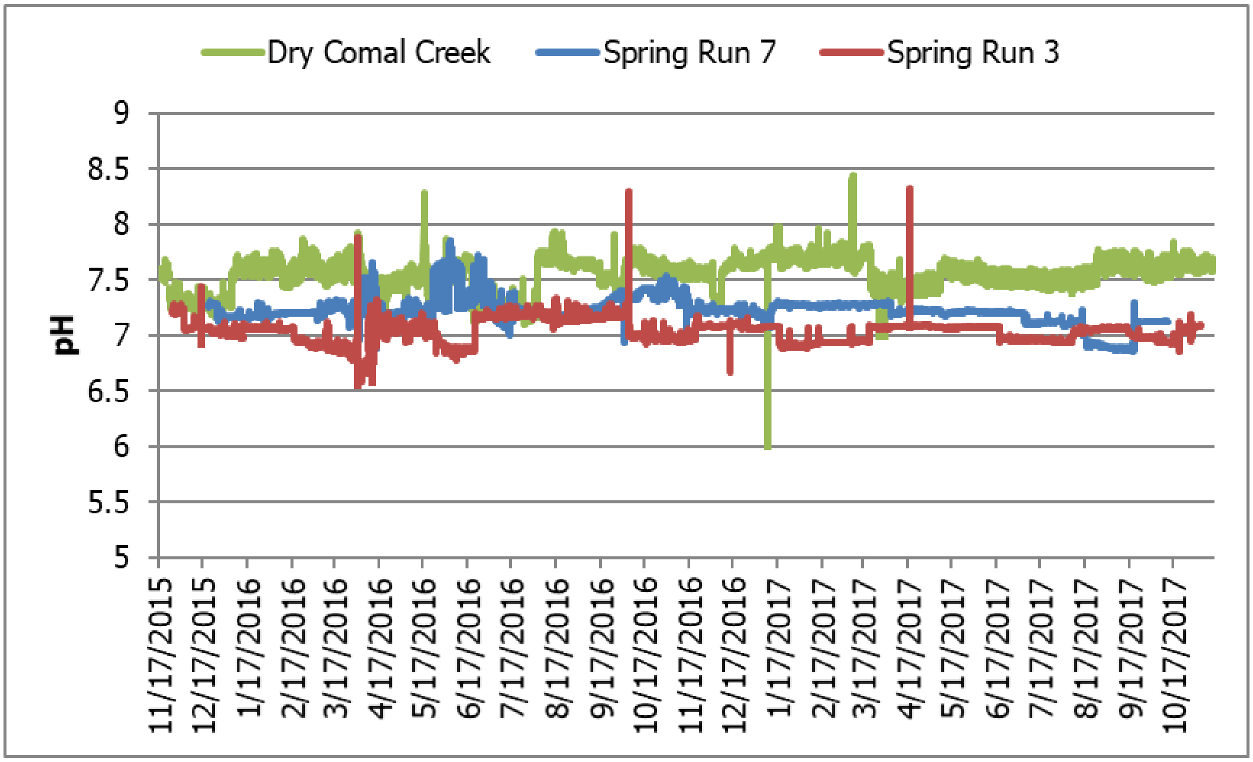


Figure 11. **Edwards Aquifer Authority Manta 2 multiprobe pH data in Spring Run 3, Spring 7, and downstream of Dry Comal Creek.**

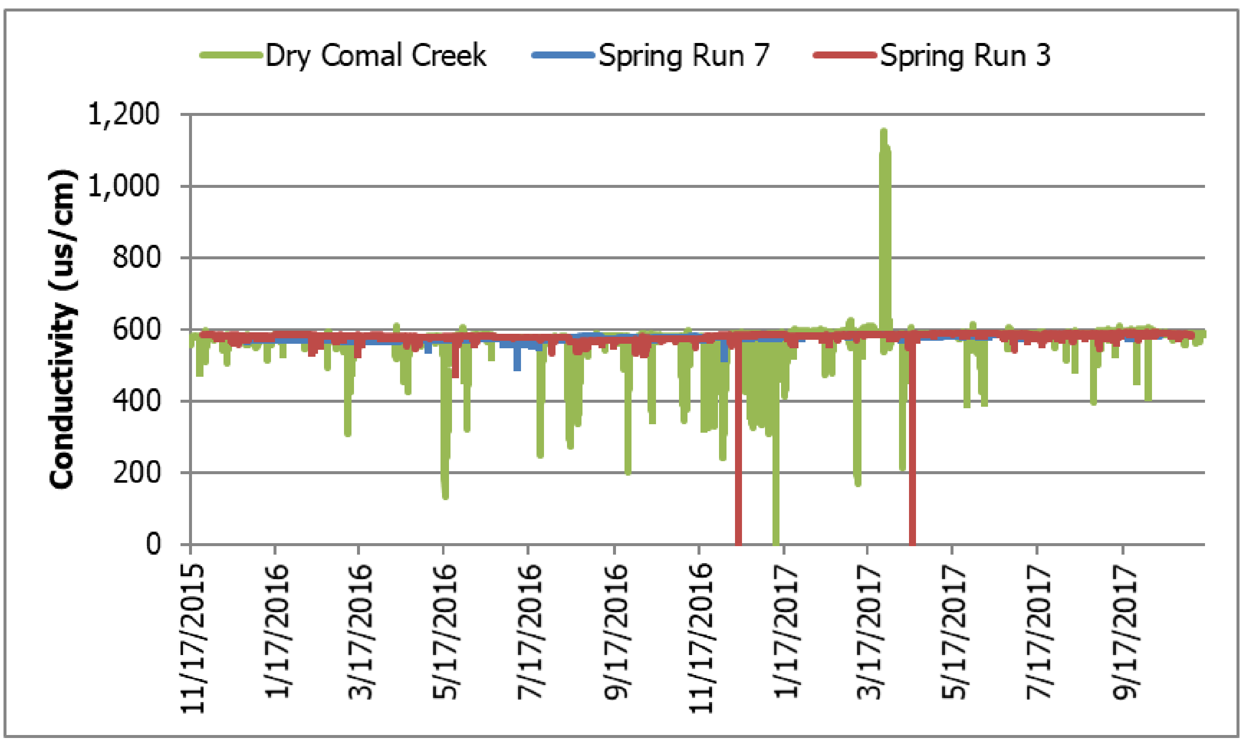


Figure 12. **Edwards Aquifer Authority Manta 2 multiprobe conductivity data in Spring Run 3, Spring 7, and downstream of Dry Comal Creek.**

City of New Braunfels Landa Lake Dissolved Oxygen Monitoring

In addition to point water quality measurements directly associated with biological sampling, and EAA Manta probes discussed above, the City of New Braunfels installed continuous water quality monitoring equipment in Landa Lake in 2013 as part of their HCP dissolved oxygen mitigation project. EAA took over this monitoring in 2017. In summary, the mean water temperature in 2017 at the Landa Lake sonde was 23.56 °C with a standard deviation of 0.44 °C. In 2017, dissolved oxygen ranged from 2.63 to 9.51 mg/L. A full account of 2017 dissolved oxygen monitoring activities and results can be found in SWCA (2017b).

Texas Master Naturalist Monitoring

Water quality data collected by Master Naturalist volunteers in 2017 showed that CO_2 concentrations continue to be highest at sites near springs, such as the Houston Street (Upper Spring Run Reach) and Gazebo (Landa Lake/ Spring Run 3) sample sites (Figure 13), whereas pH increased with distance from the springs (Figure 14). Site locations are shown in Figure 2 and listed from upstream (Houston Street) to downstream (Union Avenue). The inverse relationship between these two variables is due to the presence of carbonic acid in spring waters, so as CO_2 concentrations (and thus, carbonic acid concentrations) decline going downstream, pH rises in the system. Within sites, year-to-year variation was relatively small in both CO_2 concentrations and pH.

To compare recreational use at the various sites, weekly counts of recreation users collected by the Texas Master Naturalist volunteers were converted to monthly averages and plotted over a long-term survey period (Figures 15–19). In 2017 (as in all years), the New Channel received the most recreation pressure, followed by Union Avenue and the Gazebo (Landa Lake). Please note that the y-axis varies for each site for better presentation. As in previous years, recreational use at Elizabeth Street (Old Channel) was low (Figure 15) likely because this site is not located within a city park or advertised for recreational use. Each site, with the exception of Elizabeth Street, saw peaks in recreation use during the warmer summer months.

From 2010 to 2014, the road to the Landa Park Gazebo was closed due to reconstruction of the walls throughout Landa Park. Figure 17 reflects this drop in recreation pressure and its subsequent increase in 2016–2017. This increase in recreation traffic was expected and predicted in earlier reports. The New Channel site has received the most recreation pressure throughout the Texas Master Naturalist monitoring (2006–2017) and is expected to continue. The peak of recreational use is during the summer months of June through September (Figure 18). During the warmer months, the New Channel site becomes a popular destination for tubers and others seeking relief from the heat in the cooler spring-fed water. Much like the New Channel site, recreation pressure at the Union Avenue site can also be substantial during summer because this is a take-out site for many tubers floating the river (Figure 19). However, unlike the New Channel site, this location does not offer long-term attraction such as picnic tables, resulting in fewer alternative or additional recreational activities.

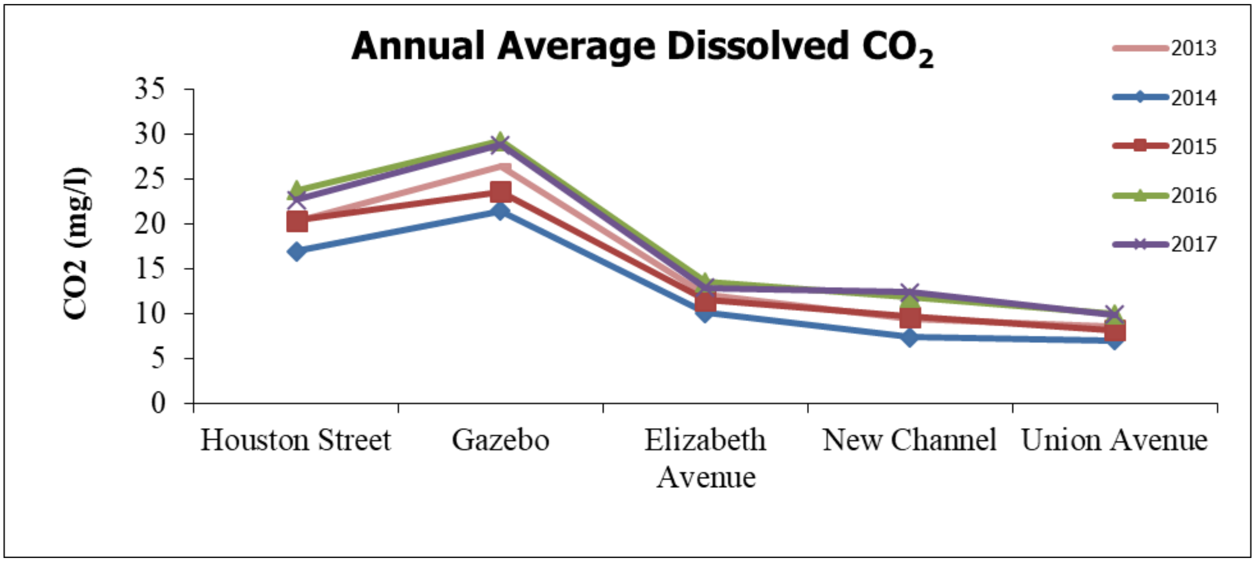


Figure 13. **Annual average dissolved carbon dioxide (CO_2) concentrations at five sites on the Comal River system (2013–2017).**

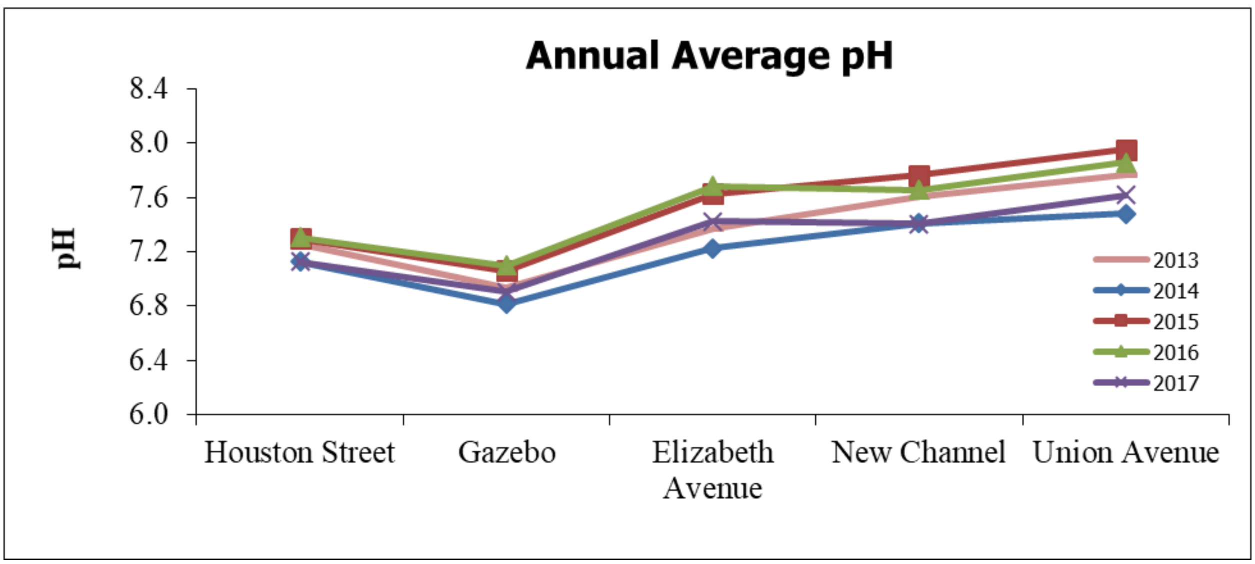


Figure 14. **Annual average pH values at five sites on the Comal River system (2013–2017).**

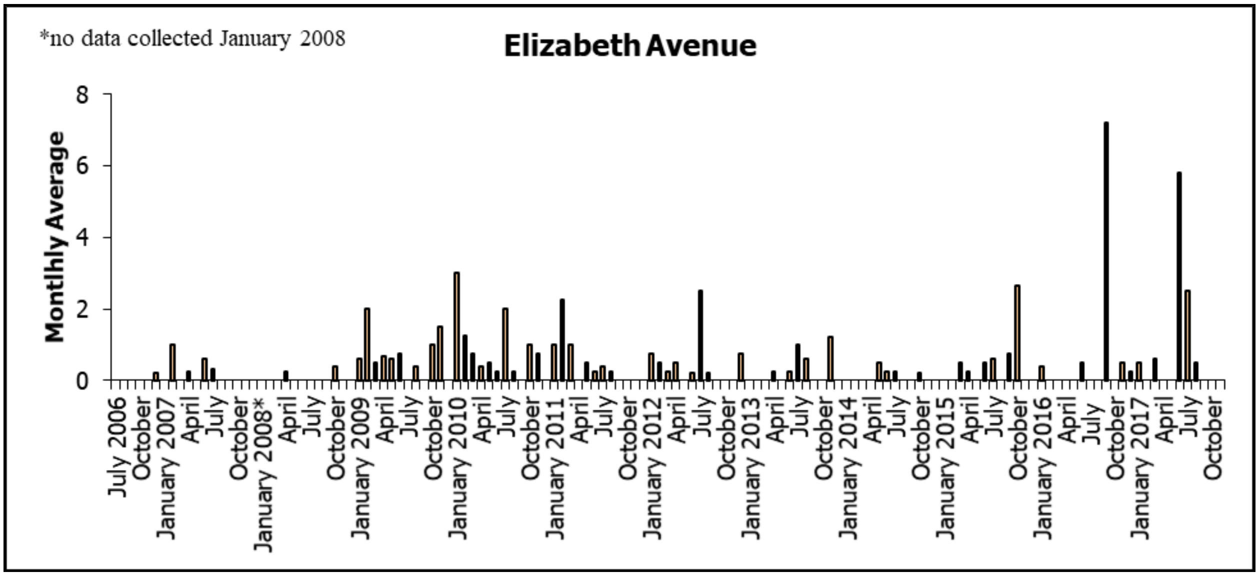


Figure 15. Average recreational use counts at the Elizabeth Avenue site (2006–2017).

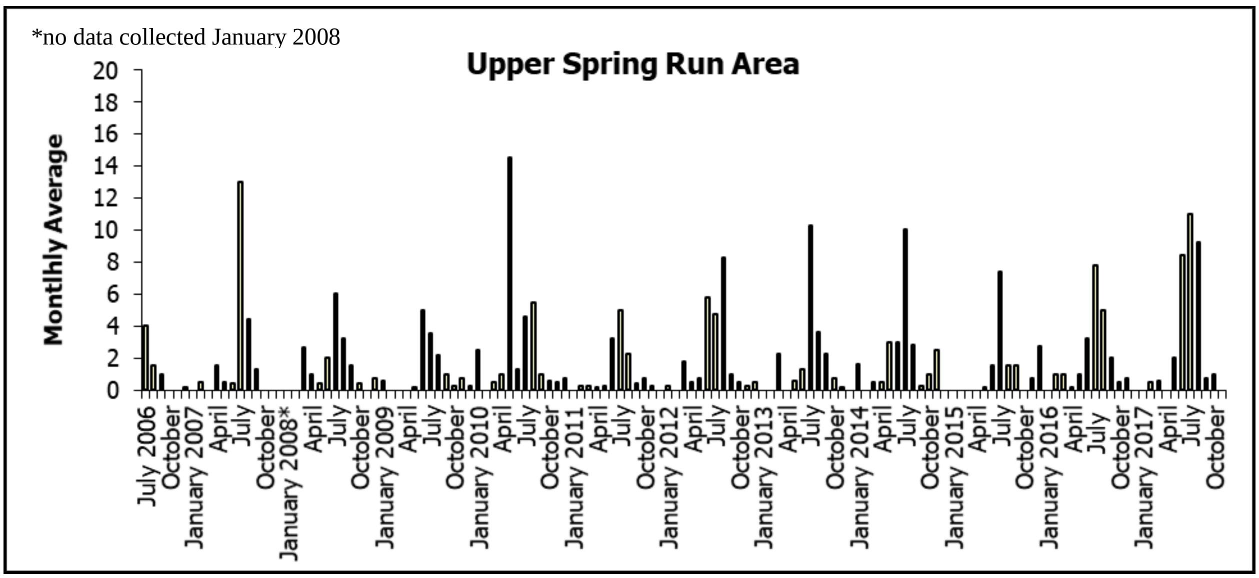


Figure 16. Average recreational use counts at the Upper Spring Run site (2006–2017).

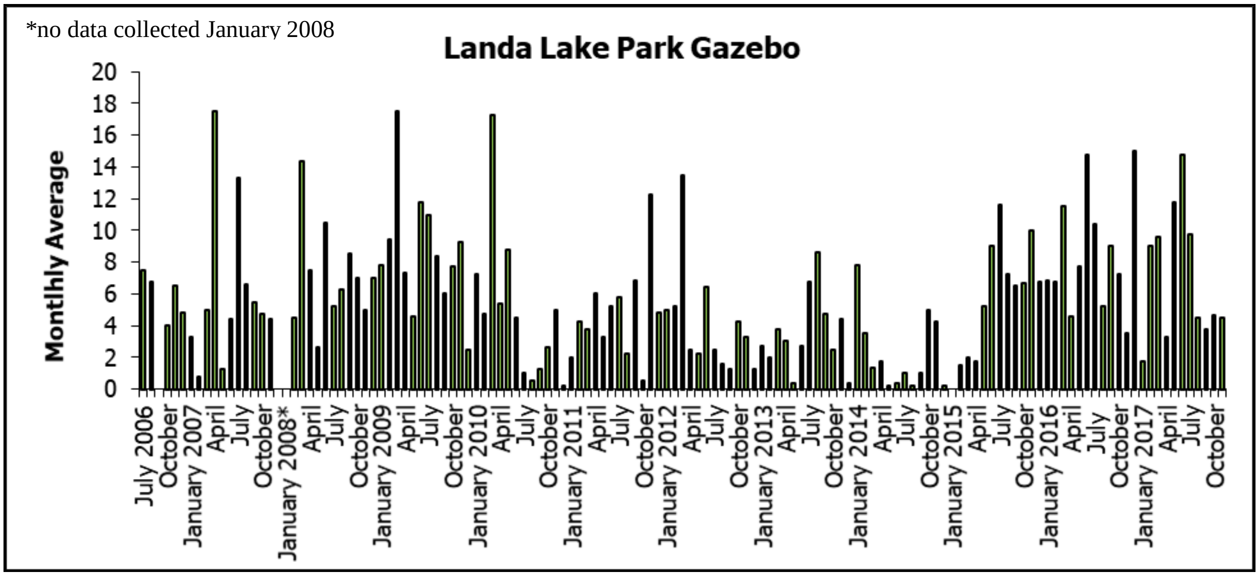


Figure 17. Average recreational use counts at the Landa Lake Park Gazebo site (2006–2017).

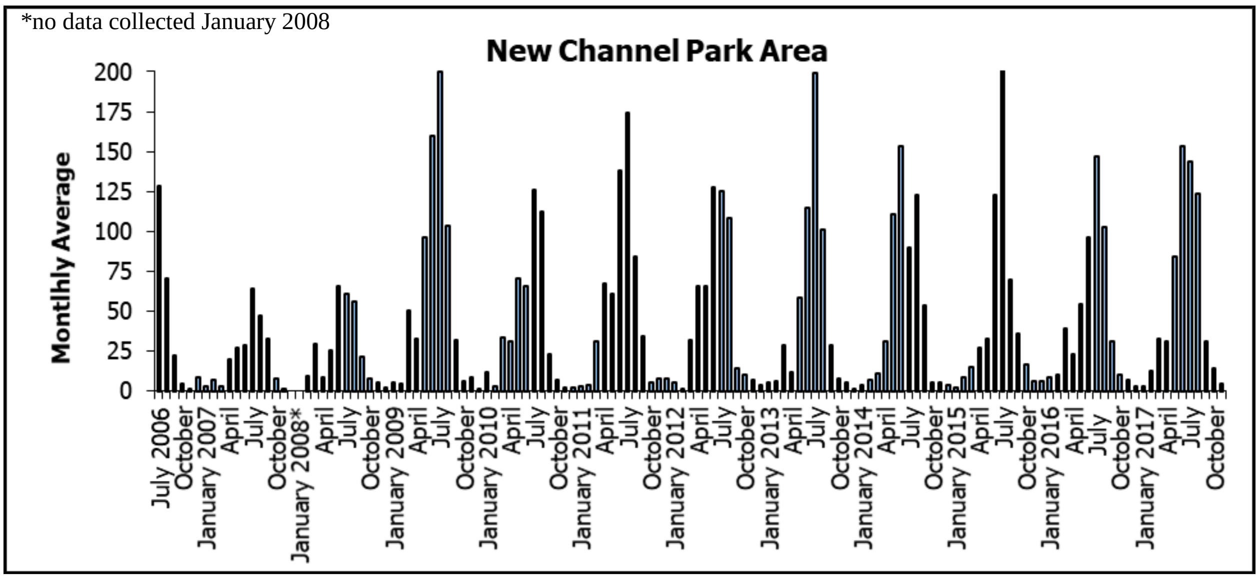


Figure 18. Average recreational use counts at the New Channel site (2006–2017).

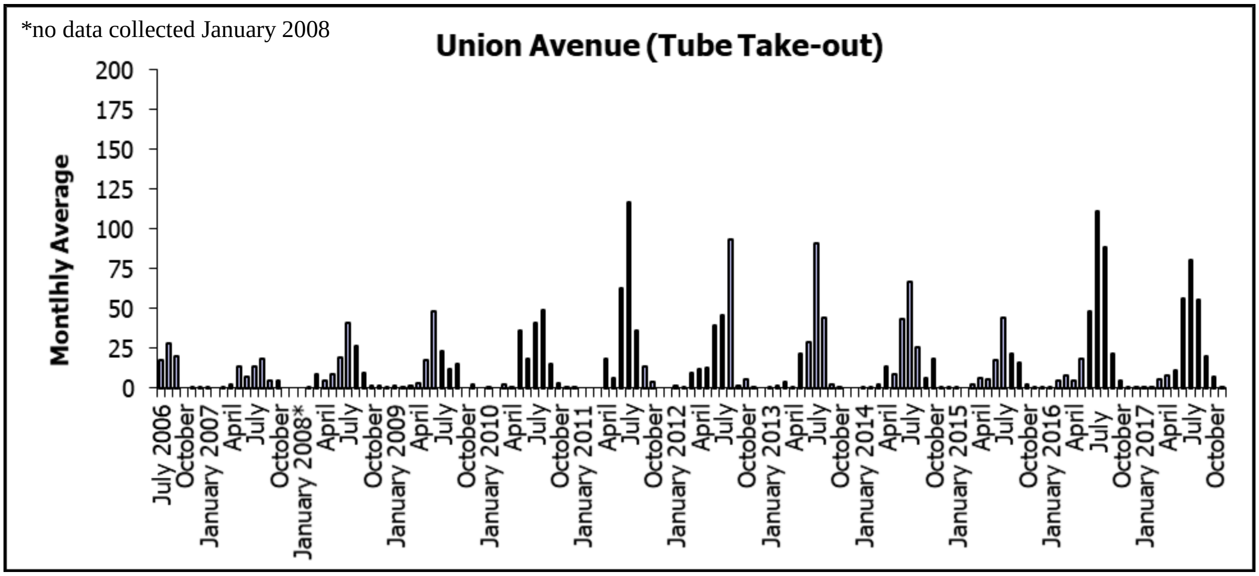


Figure 19. Average recreational use counts at the Union Avenue site (2006–2017).

Aquatic Vegetation Mapping

Aquatic vegetation maps for all study reaches and for both sampling periods are presented in Appendix B. The maps are organized by individual reach with successive mapping events ordered chronologically. It is important to note that maps highlight only the single dominant plant species. While less dominant species may not be represented on the maps their coverage is estimated and included into the total vegetation calculations. This is an important point because the Comal vegetation community has become a mosaic of species since 2013 as restoration activities have successfully decreased the coverage of monospecific stands of nonnative *Hygrophila* and reintroduced multiple native species that have established into mixed species stands.

Aerial picture of the upstream end of the Upper Spring Run Study Reach showing patches of aquatic vegetation.

Upper Spring Run Reach

The Upper Spring Run Study Reach is the most upstream study reach in the Comal System. This reach is characterized by a long, straight channel with water inflow from multiple small peripheral spring runs as well as spring upwellings. During large storm events the Upper Spring Run may also receive flow from Blieder's Creek, a major tributary, as well as direct runoff from nearby city streets and residential lots. Additionally, the Upper Spring Run is also an accessible site for public recreation as multiple private residential lots and one public resort border the reach. The aquatic vegetation community of the Upper Spring Run often responds differently than in other study reaches with expansion and declines in vegetation coverage occurring quite often and rapidly as a result of flow conditions or summer recreational disturbances. The aquatic plant diversity is lower in this reach compared to other study reaches and is typically dominated by *Sagittaria* and bryophytes. Because bryophytes are non-rooted plants, their coverage is more susceptible to disturbances (e.g., low flows, storm water pulses) compared to rooted plant species. However, recovery is typically rapid when site conditions improve and growth is expansive under optimal conditions. Both spring and fall mapping events recorded a higher than average overall vegetation coverage for the respective season (Figure 20). This most likely can be attributed to exceptional conditions for bryophyte growth, as bryophytes accounted for more than half of the total coverage per season. Spring coverage was recorded as 2,979 m^2, which was also a significant increase over spring 2016 at 1,963 m^2. While fall coverage declined from spring it still remained slightly higher than average at 2,047 m^2. This is an increase from the fall 2016 total of 1,610 m^2.

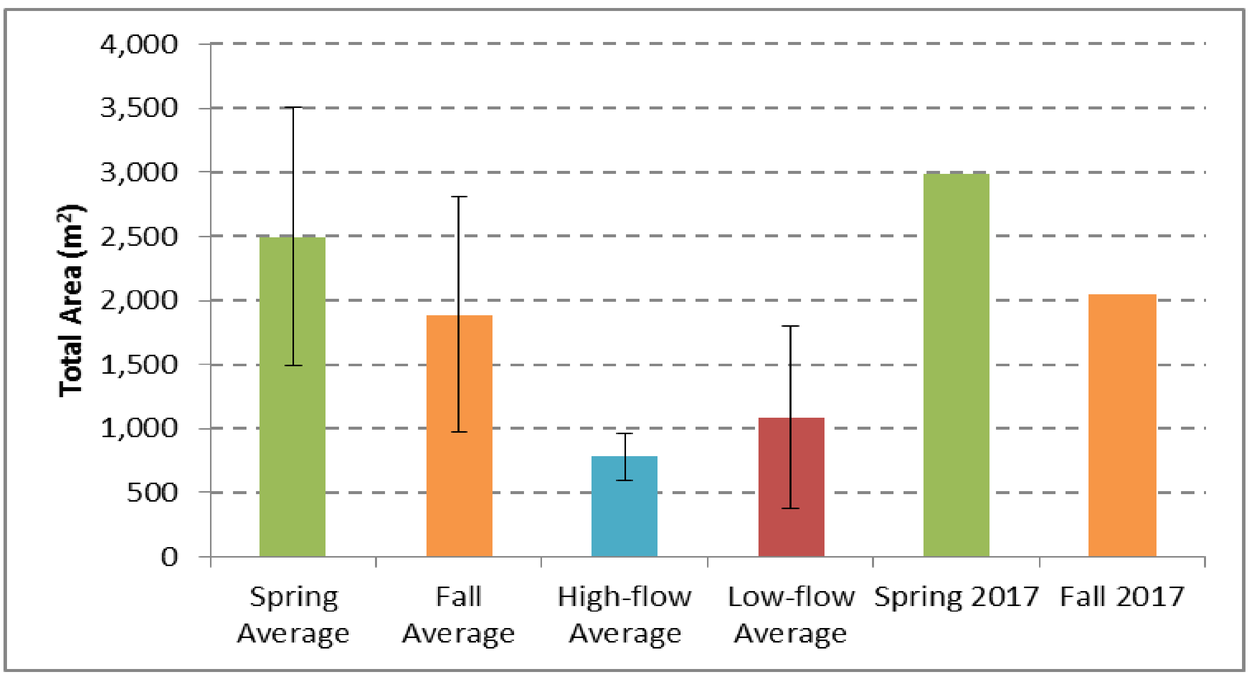


Figure 20. Total surface area (m^2) of aquatic vegetation in the Upper Spring Run Reach. Long-term study averages are provided with bars representing one standard deviation from the mean.

Landa Lake Reach

The Landa Lake Reach contains the most diverse aquatic plant community of all Comal River study reaches. Aquatic vegetation cover here is typically dense and total vegetation coverage tends to be less variable year-to-year, with less impact from high- and low-flow events compared to other study reaches. Total seasonal coverage for both spring and fall 2017 (19,631 m^2 and 18,713 m^2, respectively) were slightly above their respective seasonal averages (Figure 21). Landa Lake is typically dominated by two species: *Vallisneria,* which usually accounts for greater than 50% of the total coverage, and *Sagittaria*. However, HCP restoration activities have been successful at establishing new areas of *Ludwigia* and *Cabomba* in this reach. Also, as part of 2017 restoration activities, *Potamogeton* was established in Landa Lake. While this species has long been present in Spring Run 3 it has not been previously recorded in the Landa Lake Study Reach since the beginning of the biomonitoring program.

Aerial view of a portion of the Landa Lake Reach.

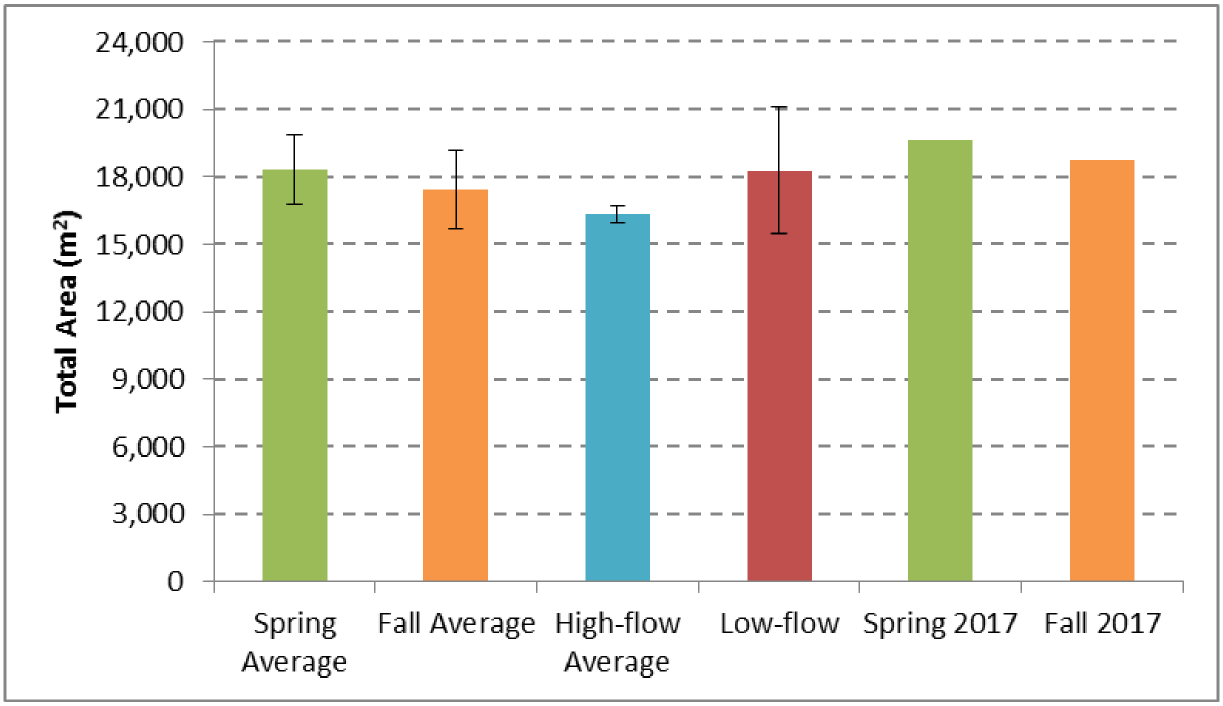


Figure 21. **Total surface area (m^2) of aquatic vegetation in the Landa Lake Reach. Long-term study averages are provided with bars representing one standard deviation from the mean.**

Old Channel Reach

The Old Channel Reach saw perhaps the most dramatic changes in the vegetation community over the course of 2017. In spring this reach was still dominated by nonnative *Hygrophila,* which has been prolific here since 2004. In 2016, the BIO-WEST aquatic restoration team removed *Hygrophila* from this reach, but the plant quickly recolonized in the fall of 2016 soon after initial removal. In 2017, the restoration team concentrated greater effort in this reach. The team successfully removed a large portion of *Hygrophila* in the summer of 2017, and established *Ludwigia*, *Cabomba*, and *Sagittaria* in its place. Bryophytes and algae have also voluntarily established around restored vegetation, and in open spaces, producing a more diverse vegetation community compared to previous years. Although a healthier and more diverse native plant community now exists in this reach, total vegetation coverages were below the seasonal average (Figure 22). As part of the 2016 adaptive management protocol (EAA 2016c), the flow split management regime adopted in 2017 should improve flow characteristics to better promote native vegetation establishment and growth. Additionally, as newly established vegetation takes hold and expands this reach will likely see an increase in vegetation coverage in the future.

Upper New Channel Reach

The Upper New Channel Reach is located directly below the confluence of Dry Comal Creek, a major tributary and urban floodway, which contributes significant and sometimes prolonged flood pulses into the New Channel. In 2015 and 2016, multiple flash flood events contributed to overbanking and scouring of the river bed. This activity, in turn, removed large amounts of aquatic vegetation leading to record minimums of total vegetation cover in 2017. While the

Restored Cabomba in the Old Channel Study Reach

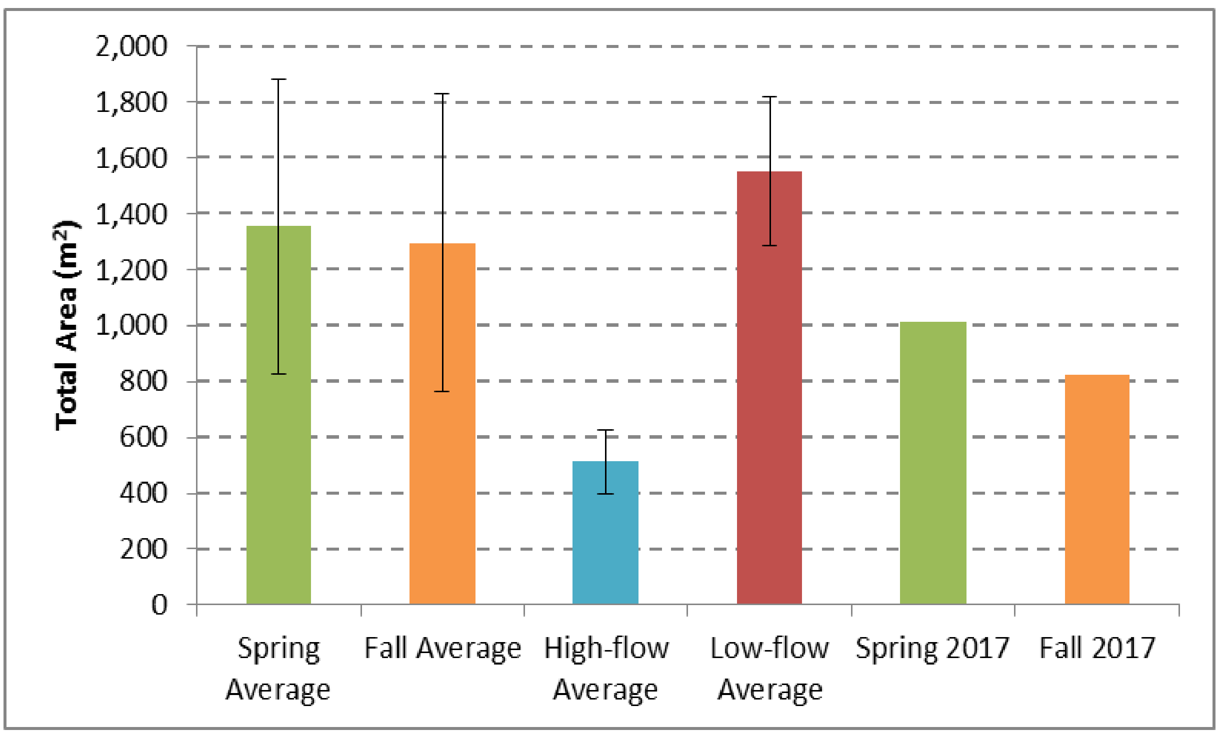


Figure 22. Total surface area (m^2) of aquatic vegetation in the Old Channel Reach. Long-term study averages are provided with error bars representing one standard deviation from the mean.

average vegetation cover for spring is over 1,200 m^2, this year's spring sampling showed a total of just 164 m^2. Due to minimal vegetation cover, annual Fountain Darter sampling sites were greatly restricted and, therefore, the Upper New Channel Study Reach was extended approximately 475 feet (144 m) to encompass more aquatic vegetation downstream for Fountain Darter sampling efforts in fall 2017. Therefore, the increase in total vegetation coverage between spring 2017 and fall 2017 seen in Figure 23 is partially an artifact of study reach expansion and not completely a result of aquatic vegetation expansion.

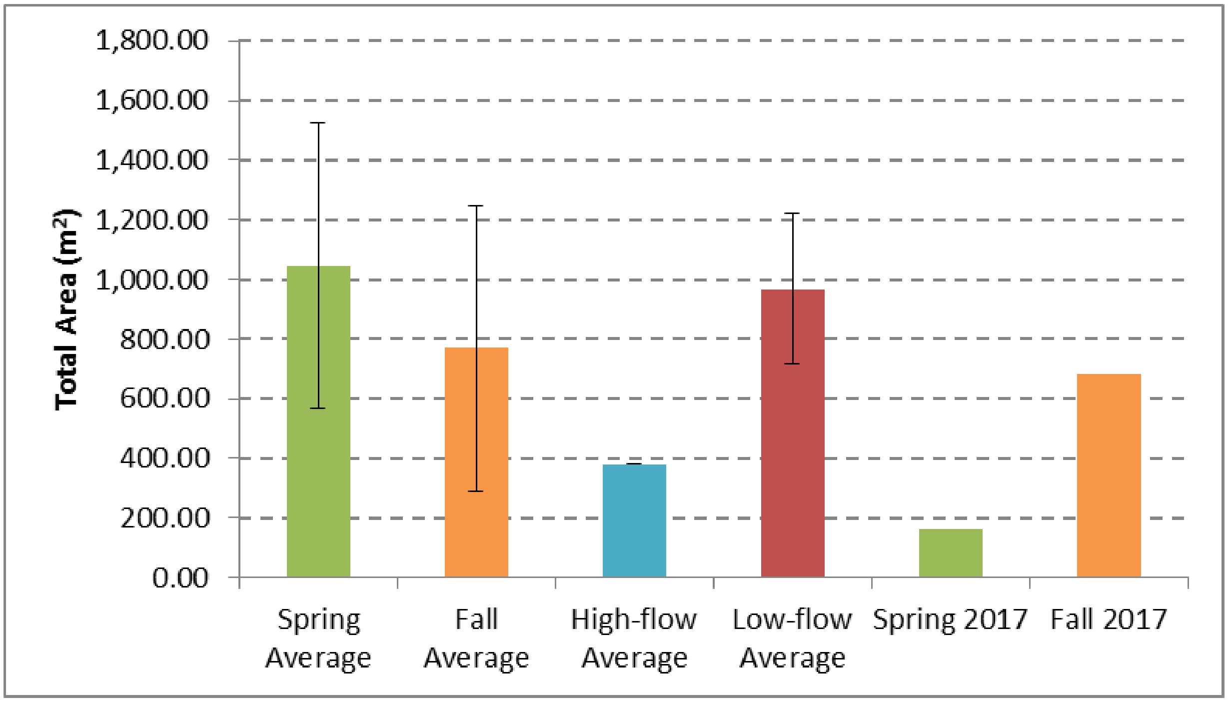


Figure 23. Total surface area (m^2) of aquatic vegetation in the Upper New Channel Reach. Long-term study averages are provided with error bars representing one standard deviation from the mean.

Lower New Channel Reach

Downstream of the Upper New Channel Reach is the Lower New Channel Reach. This reach is highly recreated but also susceptible to loss of vegetation from flood pulses. *Cabomba* and *Hygrophila* dominate this reach. In 2016 both of these species were heavily scoured from repetitive flood pulses, which led to a decrease in total vegetation that continued into the spring of 2017. As a result, total vegetation coverage was well below the average for spring at 1,223 m^2. However, over the course of 2017 *Cabomba* and *Hygrophila* recolonized scoured areas to produce a total vegetation cover of 2,251 m^2, slightly above the seasonal average (Figure 24). With the continued urbanization around Dry Comal Creek, intense flood pulses will most likely increase in frequency leading to more regular and pronounced changes in vegetation coverage in both New Channel study reaches over time.

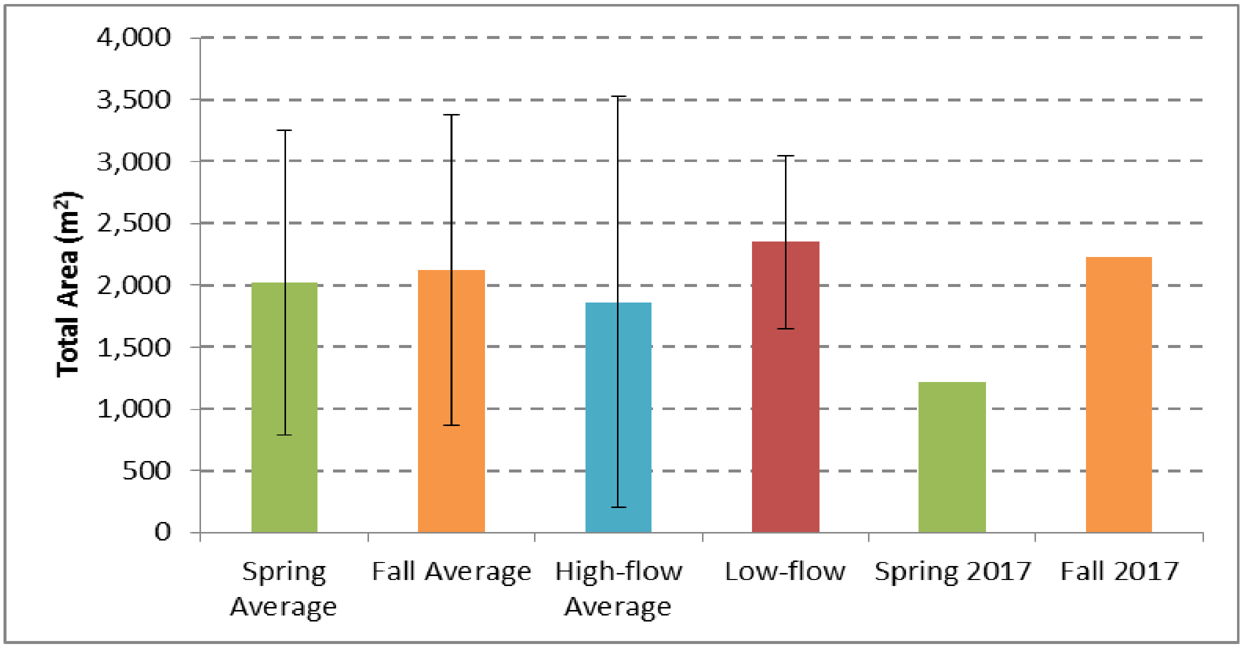


Figure 24. Total surface area (m^2) of aquatic vegetation in the Lower New Channel Reach. Long-term study averages are provided with error bars representing one standard deviation from the mean.

Fountain Darter Sampling Results

Drop Nets

A total of 68 drop-net samples were conducted during 2017 comprehensive sampling in the Comal River system. Table 6 shows the number of drop-net samples taken from each vegetation type in each reach during the two sampling efforts.

Table 6. Number of drop-net samples collected in each vegetation type per reach during 2017 sampling efforts.

VEGETATION	SPRING (May 1–3)				FALL (OCTOBER 23–25)				TOTAL
	Upper Spring Run	Landa Lake	Old Channel	Upper New Channel	Upper Spring Run	Landa Lake	Old Channel	Upper New Channel	
Bryophytes	2	2	2	2	2	2	2	2	16
Ludwigia	2	2	1		2	2	2		11
Hygrophila			3	2				2	7
Sagittaria	2	2			2	2			8
Vallisneria		2				2			4
Cabomba		2				2	2		6
Open	2	2	2	2	2	2	2	2	16
TOTAL	8	12	8	6	8	12	8	6	68

Changing conditions in the Upper New Channel Reach associated with an increase in flows usually allows for only four drop-net samples to be completed as water at the site is generally too deep for effective sampling. However, in fall 2017 the reach was extended downstream to the train track bridge to allow for more area to collect drop-net samples (see Aquatic Vegetation Map Appendix B). Within this extended reach biologists were able to complete 6 drop-net samples during both routine sampling efforts in 2017. Raw drop-net data sheets for 2017 are included in Appendix D. From these drop-net samples, a total of 1,337 Fountain Darters were collected in 2017, with 827 darters collected during spring sampling, and 510 collected during fall sampling. Although effort has varied slightly between events, the number of Fountain Darters captured per sampling event has ranged from 103 to 1,058 (mean=511) in 52 separate sampling events since the beginning of the comprehensive monitoring study in 2000.

Drop-net data collected from 2000 to 2017 show that average densities of Fountain Darters in the various vegetation types ranged from $0.8/m^2$ in open sites to $26.7/m^2$ in bryophyte-dominated sites (Figure 25, Appendix C.2). Although variation is high, native vegetation types that provide thick cover at or near the substrate such as bryophytes and filamentous algae ($26.1/m^2$) tend to have the highest Fountain Darter densities, whereas open substrate with no vegetation has relatively low densities. Filamentous algae and bryophytes, which have provided the highest Fountain Darter density, are also most susceptible to scouring during high-flow events and have shown considerable fluctuation in coverage over the long-term study period. These plants do not firmly root to the substrate, and can be easily uprooted by high water velocities. Bryophytes are a key habitat component because they occupy large areas of the Upper Spring Run and Landa Lake reaches, and thus make up a significant portion of the available habitat. *Cabomba*, *Ludwigia, Sagittaria, and Vallisneria* are also relatively common and, therefore, provide substantial amounts of Fountain Darter habitat. Although nonnative *Hygrophila* was once a dominant vegetation type in many reaches, recent vegetation restoration activities have substantially reduced or removed *Hygrophila* coverage within the study reaches. In particular, this nonnative plant is no longer present in the Upper Spring Run and Landa Lake reaches. Unlike the San Marcos River, the Comal River is dominated by native vegetation, which has become even more prevalent following HCP restoration activities (BIOWEST 2016c).

Estimates of Fountain Darter normalized population abundance in all reaches (Figure 26) were based on the changes in vegetation composition and abundance, and the average density of Fountain Darters found in all vegetation types from 2000–2017. Population abundance estimates are similar for spring, fall, and low-flow events from 2000–2017. However, high flow events usually lead to a decrease in vegetation coverage and a resulting decrease in population estimates. Both the spring and fall 2017 normalized population estimates were higher than the long-term study average but within one standard deviation. The fall 2017 estimate is almost outside of one standard deviation from the mean, but this is partially influenced by the increased reach size in the Upper New Channel Reach in fall 2017 (See Aquatic Vegetation Maps Appendix B).

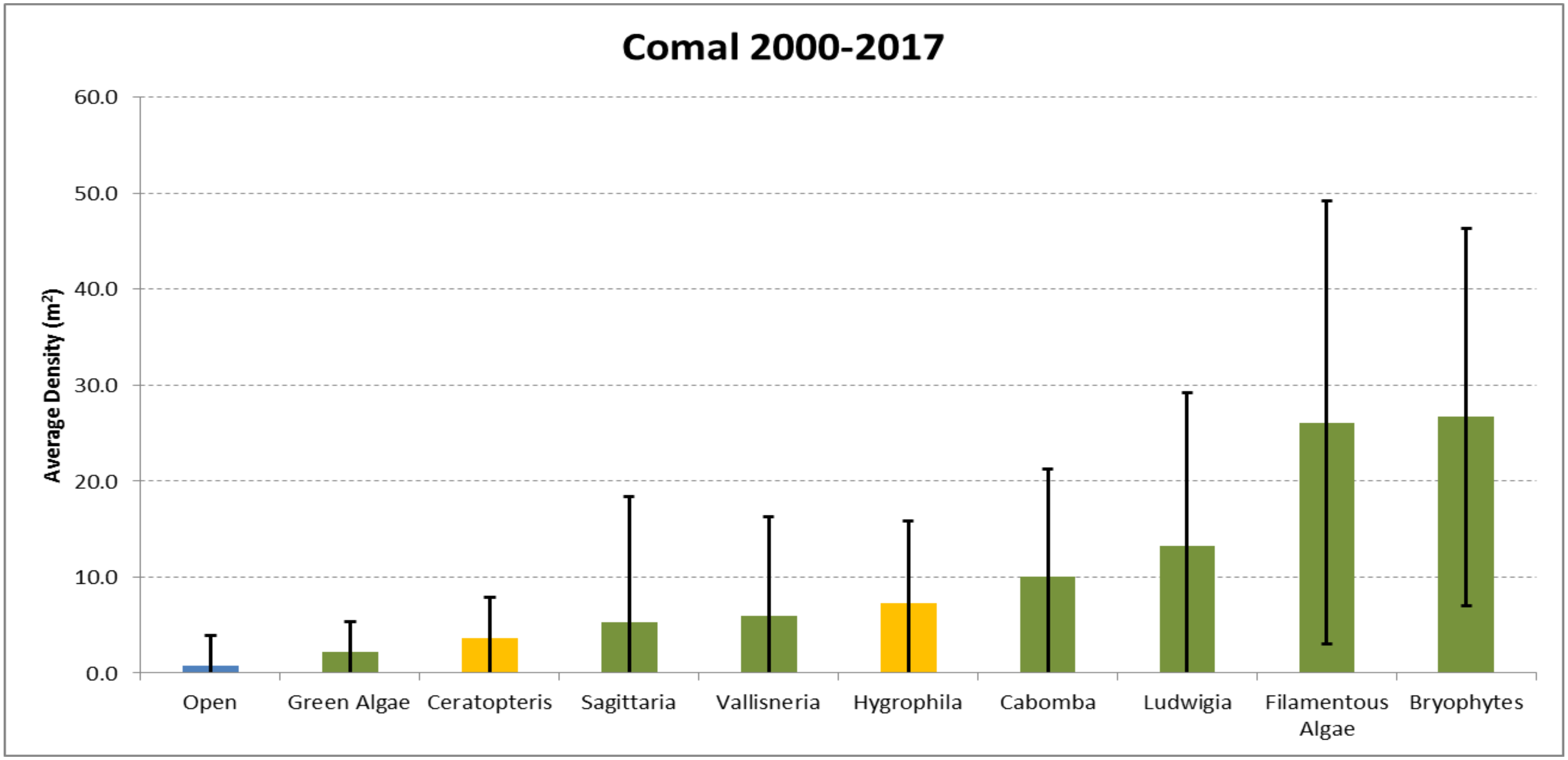


Figure 25. Average density of Fountain Darters collected by vegetation type in the Comal system from 2000 to 2017. Bars provided represent one standard deviation from the mean.

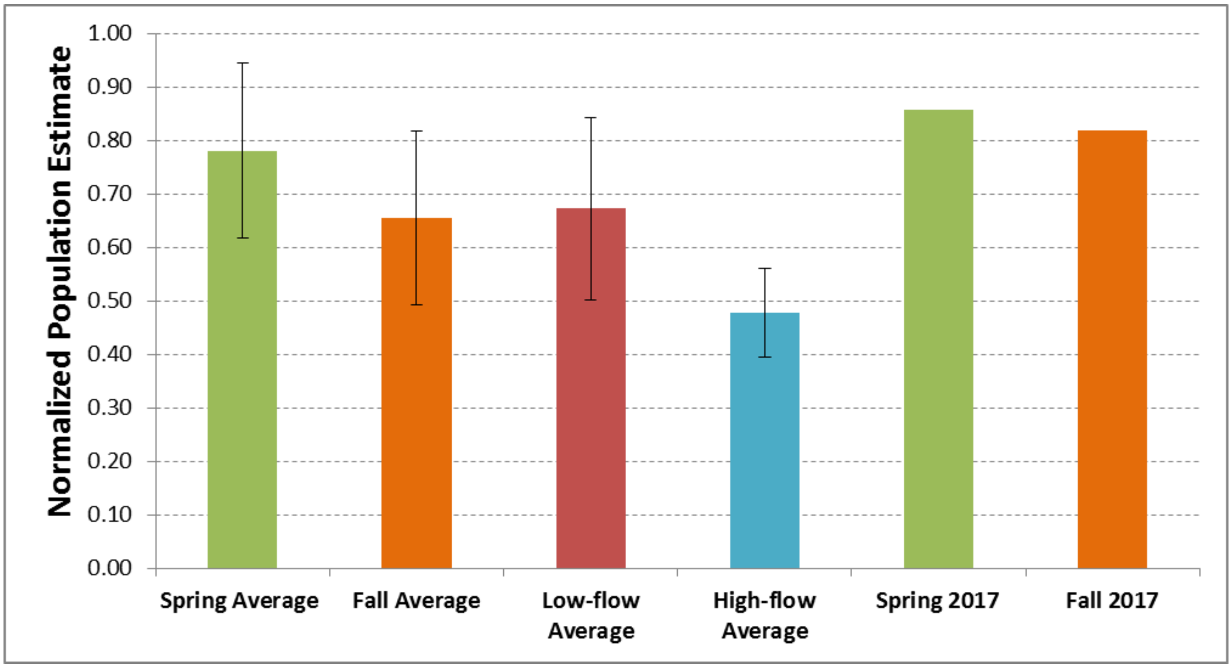


Figure 26. Normalized Fountain Darter population estimates in the Comal River based on coverage of various vegetation types in the study reaches and average density of Fountain Darters in each type. Long-term study averages are provided with bars representing one standard deviation from the mean.

The length frequency distribution for Fountain Darters collected by drop nets from the Comal system during spring (n = 9,965) and fall (n = 8,346) sampling events from 2000 to 2017 is presented in Figure 27 (all data presented in Appendix C.2). Small Fountain Darters (from 12 to 22 mm total length) are more abundant in spring samples, whereas fall is dominated by larger Fountain Darters, from 24 to 38 mm total length. Analysis of length frequency data suggests a strong late winter/early spring reproductive event with ongoing but limited reproduction occurring during other parts of the year. This corresponds well with results of studies on Fountain Darter reproduction completed in 2014 (BIO-WEST 2014d).

Excluding Fountain Darters, approximately 141,900 other specimens representing 24 other fish taxa have been collected by drop netting from the Comal system during the study period (2000–2017). Of these, seven are considered exotic or introduced (Table 7). Although several of these species are potential predators of Fountain Darters, previous data collected during this study suggests that predation by both native and introduced predators is minimal during average discharge conditions. Other than Fountain Darters, Western Mosquitofish and Redspotted Sunfish *Lepomis miniatus* were the most common fish collected in 2017 with 662 and 132, respectively.

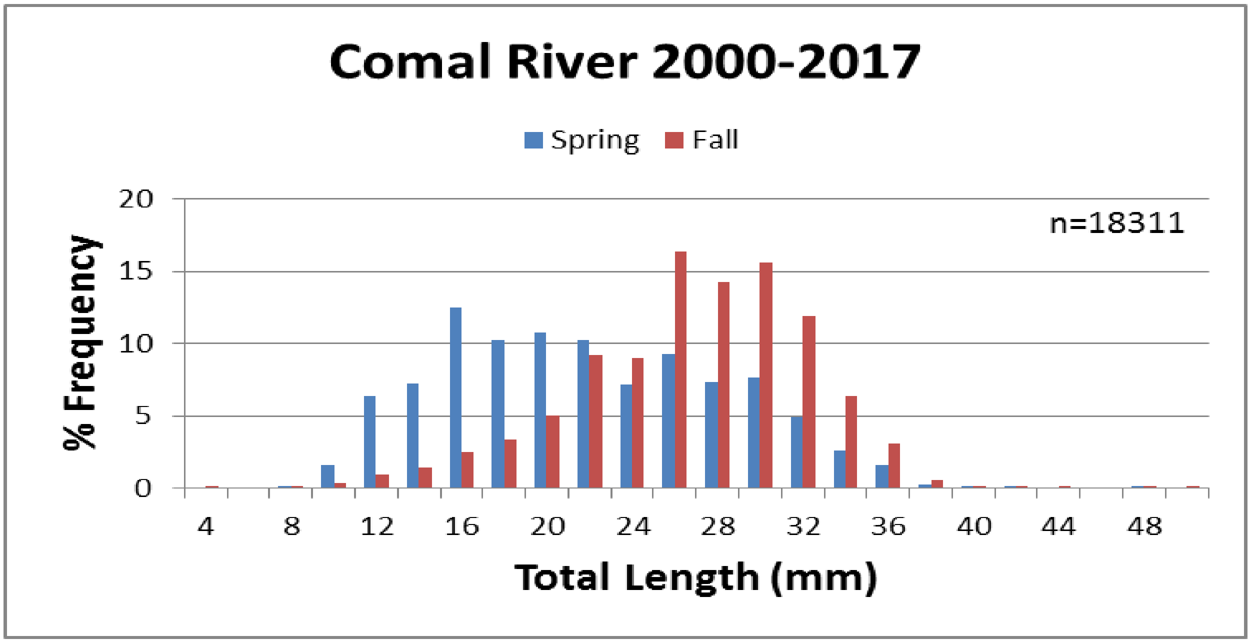


Figure 27. **Length frequency distribution of Fountain Darters collected from the Comal system during spring and fall (2000–2017).**

Table 7. **Fish taxa and the number of each collected during drop-net sampling.**

FAMILY	SCIENTIFIC NAME	COMMON NAME	STATUS[a]	2017	2000–2017
Cyprinidae	*Campostoma anomalum*	Central Stoneroller	N		1
	Dionda nigrotaeniata	Guadalupe Roundnose Minnow	N	14	1,088
	Notropis amabilis	Texas Shiner	N	1	332
	Notropis volucellus	Mimic Shiner	N		34
	Notropis sp.	Shiner	N	3	3
	Pimephales vigilax	Bullhead Minnow	N		4
Characidae	*Astyanax mexicanus*	Mexican Tetra	I	29	469
Ictaluridae	*Ameiurus melas*	Black Bullhead	N		1
	Ameiurus natalis	Yellow Bullhead	N	10	125
Loricariidae	*Pterygoplichthys* sp.	Sailfin Catfish	I	1	90
Poeciliidae	*Gambusia* sp.	Mosquitofish	N	662	129,650
	Poecilia latipinna	Sailfin Molly	I	4	4,713
Centrarchidae	*Ambloplites rupestris*	Rock Bass	I	3	27
	Lepomis auritus	Redbreast Sunfish	I	2	148
	Lepomis cyanellus	Green Sunfish	N	12	57
	Lepomis gulosus	Warmouth	N	1	36
	Lepomis macrochirus	Bluegill	N	14	267
	Lepomis megalotis	Longear Sunfish	N	3	264
	Lepomis microlophus	Redear Sunfish	N	1	3
	Lepomis miniatus	Redspotted Sunfish	N	132	2,382
	Lepomis sp.	Sunfish	N/I	23	859
	Micropterus punctulatus	Spotted Bass	N	1	4
	Micropterus salmoides	Largemouth Bass	N	23	473
Percidae	*Etheostoma fonticola*	Fountain Darter	N	1,337	26,146
	Etheostoma lepidum	Greenthroat Darter	N	8	69
Cichlidae	*Herichthys cyanoguttatus*	Rio Grande Cichlid	I	35	748
	Oreochromis aureus	Blue Tilapia	I	4	71
[b]**Total**				2,323	168,064

[a] N= Native, I=Introduced.
[b] Includes Fountain Darter and unknown fishes.

As mentioned, seven species collected during drop netting from 2000 to 2017 are considered nonnative or introduced to the system. Most of these pose little threat to the Fountain Darter. However, impacts of exotic Sailfin Catfish (Siluriformes: Loricariidae) on algae and vegetation communities that serve as Fountain Darter habitat are possible. Although these fish are rarely captured in drop nets, based on data from fish community sampling (see Fish Community section) they are present in the system. These species have the potential to affect the vegetation community, and thus, impact important Fountain Darter habitats and food supplies. Only one individual was collected in drop nets during 2017. However, ongoing population monitoring and management of this species is important.

Dip Nets

Dip-net Timed Surveys

The locations for each section of the dip-net timed surveys are shown in Figure 1. Timed dip-net collections were conducted three times during routine sampling events in the Comal River during 2017: May (spring), August (summer), and October (fall). Overall, the average number of darters collected from timed dip-net surveys in 2017 was slightly higher than the long-term average for all three sampling occasions. Detailed tables of all data collected for each site are available in Appendix C.3. Size class distributions of Fountain Darters from dip netting correlate well with those of the drop-net method: small Fountain Darters were most abundant in the spring, and larger Fountain Darters dominated fall samples (Appendix C.3). However, small Fountain Darters are occasionally captured in summer, winter, and fall sampling periods as well. This indicates that there is some reproduction occurring in all seasons, although perhaps on a limited basis and only in certain areas. Areas that exhibit more continuous reproduction/recruitment based on length frequency data are relatively close to spring upwellings and contain large amounts of bryophytes such as Landa Lake.

Random Presence / Absence Survey

In 2017, presence/absence dip netting was conducted within four reaches on the Comal River during the routine spring (May), summer (August), and fall (October) sampling efforts. Although this technique does not provide detailed data on habitat use, and does not allow for quantification of population estimates, it does provide a quick and less-intrusive method of examining large-scale trends in the Fountain Darter population. Therefore, data collected thus far provide a good baseline for comparison with other sampling events. The percentage of sites with Fountain Darters was 72% during the spring, 78% during summer sampling efforts, and decreased to 62% by fall (Figure 28). All three sampling events were within the 5th and 95th percentiles for the study. It is important to continue to closely monitor Fountain Darter presence/absence information to assess potential trends over time as results from this analysis can directly influence adaptive management decisions.

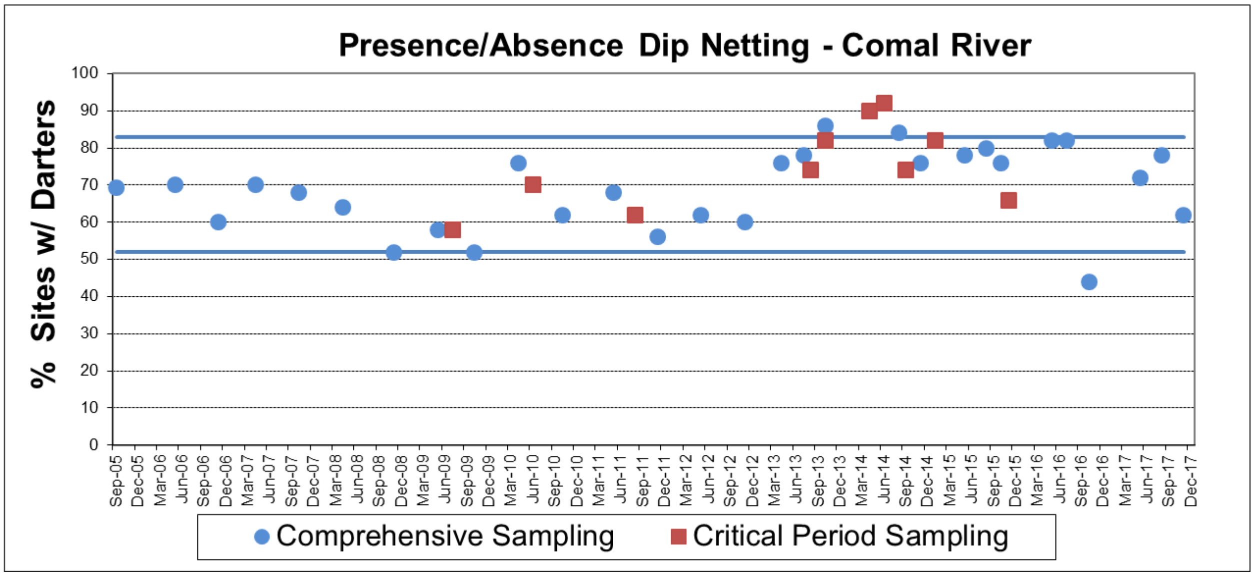


Figure 28. **Percentage of sites (*n*=50) in which Fountain Darters were present. Solid blue lines mark 5th and 95th percentiles for comprehensive sampling.**

Visual Observations

Fountain Darters were again observed in the deepest portions of Landa Lake (depths greater than 2 m) during both 2017 sampling events. Such utilization of deeper habitats within Landa Lake by Fountain Darters has been well documented in all flow conditions observed to date. Specifically, Fountain Darters have been observed in the deepest portions of Landa Lake during every SCUBA survey conducted since the adoption of this methodology in summer 2001. In spring 2017 bryophyte coverage and Fountain Darter observations were slightly lower than in 2016, with only a 20% coverage of bryophytes and 32 Fountain Darters observed. This increased substantially in fall 2017 to 100% coverage of bryophytes and 93 Fountain Darters observed.

Fish Community Sampling

Twenty-two species of fishes and 2,250 individuals were identified and enumerated among four locations on the Comal River in May (Spring) and November (Fall) 2017 (Table 8). Most observed individuals are only reported to the genus level, since species-level identification is often uncertain based on underwater observations. Mosquitofish was the most abundant taxa, representing approximately 30% of all fishes encountered. Largemouth Bass and Fountain Darter ranked second in abundance, each comprising 16% of all individuals encountered. Other abundant taxa included Mexican Tetra *Astyanax mexicanus* (12%), Guadalupe Roundnose Minnow *Diona nigrotaeniata* (6%), and Greenthroat Darter *Etheostoma lepidum* (5%). Uncommon species included Channel Catfish *Ictalurus punctatus* (1 individual), Blue Tilapia *Oreochromis aureus* (1 individual), and Redear Sunfish *Lepomis microlophus* (2 individuals). Unlike last year, where Texas Shiners *Notropis amabilis* were the most dominant species encountered, 2017 sampling efforts yielded no observations of this species. Texas Shiner typically occurs in large schools and, therefore, their abundance fluctuates drastically based on if schools are encountered by surveyors.

Table 8. **Fishes captured in the Comal River/Springs ecosystems in 2000–2017 drop-net sampling and fish community sampling from 2013 to 2017. Total percent relative abundance (Total %) is reported for drop-net dataset and fish community dataset. N=native, I=introduced.**

FAMILY	SCIENTIFIC NAME	COMMON NAME	STATUS	DROP NET (2000–2017)		FISH COMMUNITY (2013–2017)						
				Total #	Total %	2013 #	2014 #	2015 #	2016 #	2017 #	Total #	Total %
Cyprinidae	*Campostoma anomalum*	Central Stoneroller	N	1	0.00	0	0	0	0	0	0	0.00
	Cyprinella lutrensis	Red Shiner	N	0	0.00	1	0	0	0	0	1	0.00
	Cyprinella venusta	Blacktail Shiner	N	0	0.00	7	3	0	21	6	37	0.06
	Dionda nigrotaeniata	Guadalupe Roundnose Minnow	N	1,088	0.65	1,298	372	257	181	126	2,234	3.80
	Notropis amabilis	Texas Shiner	N	332	0.20	1,357	544	416	1,101	0	3,418	5.82
	Notropis volucellus	Mimic Shiner	N	34	0.02	34	273	13	71	32	423	0.72
	Pimephales vigilax	Bullhead Minnow	N	4	0.00	0	0	0	0	0	0	0.00
Characidae	*Astyanax mexicanus*	Mexican Tetra	I	469	0.28	382	766	249	248	262	1,907	3.25
Ictaluridae	*Ameiurus melas*	Black Bullhead	N	1	0.00	0	0	0	0	0	0	0.00
	Ameiurus natalis	Yellow Bullhead	N	125	0.07	0	0	7	0	7	14	0.02
	Ictalurus punctatus	Channel Catfish	N		0.00	1	6	5	0	1	13	0.02
Loricariidae	*Pterygoplichthys* sp.	Suckermouth Armored Catfish	I	90	0.05	6	8	11	8	4	37	0.06
Poeciliidae	*Gambusia affinis*	Western Mosquitofish	N		0.00	14	376	168	2	0	560	0.95
	Gambusia geiseri	Largespring Gambusia	N		0.00	514	249	122	137	37	1,059	1.80
	Gambusia sp.	Mosquitofish	N	129,650	77.14	18,266	11,087	5,549	942	671	36,515	62.16
	Poecilia latipinna	Sailfin Molly	I	4,713	2.80	144	31	27	0	0	202	0.34
Centrarchidae	*Ambloplites rupestris*	Rock Bass	I	27	0.02	3	3	4	2	3	15	0.03
	Lepomis auritus	Redbreast Sunfish	I	148	0.09	179	268	290	114	72	923	1.57
	Lepomis cyanellus	Green Sunfish	N	57	0.03	4	0	6	24	3	37	0.06
	Lepomis gulosus	Warmouth	N	36	0.02	1	17	5	5	0	28	0.05
	Lepomis macrochirus	Bluegill	N	267	0.16	44	194	106	14	31	389	0.66
	Lepomis megalotis	Longear Sunfish	N	264	0.16	37	33	38	40	21	169	0.29
	Lepomis microlophus	Redear Sunfish	N	3	0.00	0	2	0	0	2	4	0.01
	Lepomis miniatus	Redspotted Sunfish	N	2,382	1.42	131	84	100	50	48	413	0.70
	Lepomis sp.	Sunfish	N/I	859	0.51	296	356	369	185	75	1,281	2.18
	Micropterus dolomieu	Smallmouth Bass	I		0.00	0	1	0	0	0	1	0.00
	Micropterus punctulatus	Spotted Bass	N	4	0.00	0	0	0	0	0	0	0.00
	Micropterus salmoides	Largemouth Bass	N	473	0.28	359	266	146	137	353	1,261	2.15
Percidae	*Etheostoma fonticola*	Fountain Darter	N	26,146	15.56	1,474	1,808	1,177	634	352	5,445	9.27
	Etheostoma lepidum	Greenthroat Darter	N	69	0.04	23	277	128	135	124	687	1.17
	Etheostoma sp.	Unidentified darter	N		0.00	0	504	232	100	0	836	1.42
Cichlidae	*Herichthys cyanoguttatus*	Rio Grande Cichlid	I	748	0.45	296	217	69	31	19	632	1.08
	Oreochromis aureus	Blue Tilapia	I	71	0.04	117	19	3	59	1	199	0.34
Total				168,061		24,988	17,764	9,497	4,241	2,250	58,740	

Five years of fish community sampling since 2013 has resulted in enumeration of 58,740 fishes representing 27 species (Table 8). Species richness is similar to the long-term drop-net database (2000–2017), which has identified more than 168,000 fishes representing 25 species. Species composition and relative abundance differs between the two methods as Cyprinids, Centrarchids, and Characids are observed in greater abundances with the fish community sampling than the drop-net sampling (Table 8). Seining and visual observation are more effective at enumerating these groups of fishes, which are highly mobile and less susceptible to drop-net capture. In contrast, drop netting is more successful (16% abundance relative to all species) for Fountain Darters compared to these other techniques (9%) as it was designed specifically to capture this species.

Eight introduced species have been identified based on five years of fish community sampling. Active removal of nonnative blue tilapia and suckermouth catfish is occurring as part of ongoing HCP-sponsored activities (SWCA 2017c). However, relative abundance and CPUE for both of these species has been variable over the past four years, and no distinct trends in abundance are apparent. Continued monitoring will be important to assess the long-term effectiveness of nonnative removal programs.

Fish Tissue Sampling

As described in the methods, exploratory fish tissue sampling and analysis was conducted in 2017 for a wide range of constituents. In the Comal System, samples were collected from Landa Lake and the Lower River Reach on May 31st and sent to the ALS Kelso laboratory for evaluation of PCBs, PAHs, PPBDEs, SVOCs and metals. Table 9 shows the constituents that were detected in either Western Mosquitofish or Largemouth Bass fish tissue from each location. In the Comal system, a total of 19 metals, 1 PAH (Perylene), 1 PCB (Aroclor 1260), and 3 semi-volatiles (Benzoic acid, Benzyl alcohol, and 4-methylphenol) were detected. Overall, detections were consistent among locations and sample types ranging from 16 constituents detected for Largemouth Bass in the Lower River Reach to 21 detections in Western Mosquitofish from Landa Lake. Overall, results were consistent among locations and fish species with the following noted exceptions. Benzoic acid was only detected at the downstream study location in the Comal system. Aluminum, Iron and Zinc were detected in all samples but were consistently higher in Western Mosquitofish than Largemouth Bass.

Mercury was detected in all samples from the Comal River, but was not present in alarming concentrations. A nationwide study of 500 lakes and reservoirs throughout the continental United States published by the EPA in 2009 found mercury present in all fish tissue samples examined, and found concentrations higher than the EPA human health screening value of 0.3 mg/kg in 49% of the lakes examined (EPA 2009). In the Comal River, the maximum concentration observed was 141 ng/g, or 0.141 mg/kg. This is below both the EPA human health screening value of 0.3 mg/kg and the Texas Department of State Health Services (TDSHS) screening value of 0.7 mg/kg (TDSHS 2004). Mercury levels were higher in Largemouth Bass (25.3-141.0) than in Western Mosquitofish (6.4-13.1), which is not unexpected being that it is known to bioaccumulate and is typically most concentrated in top predators within aquatic systems. Although a snapshot in time, this exploratory fish tissue sampling and analysis does provide a starting point for baseline condition establishment for future comparisons.

Table 9. Fish Tissue Constituent Detections from ALS Kelso Laboratory.

Analyte (units)	Landa Lake		Lower River	
	Largemouth Bass	Western Mosquitofish	Largemouth Bass	Western Mosquitofish
Aluminum, Total (mg/kg)	6.08	88.8	1.75	42.9
Antimony, Total (mg/kg)	--	0.02	--	--
Arsenic, Total (mg/kg)	0.14	0.30	--	0.14
Barium, Total (mg/kg)	1.56	3.28	1.43	2.47
Beryllium, Total (mg/kg)	--	0.006	--	--
Boron, Total (mg/kg)	0.19	0.58	--	0.27
Cadmium, Total (mg/kg)	--	0.006	--	0.011
Chromium, Total (mg/kg)	0.268	0.473	0.136	0.618
Copper, Total (mg/kg)	0.789	0.959	0.492	1.03
Iron, Total (mg/kg)	28.8	70.2	11.5	65.6
Lead, Total (mg/kg)	0.012	0.141	0.164	0.121
Manganese, Total (mg/kg)	0.74	3.92	1.03	4.84
Molybdenum, Total (mg/kg)	0.016	0.027	0.012	0.027
Nickel, Total (mg/kg)	0.115	0.247	0.053	0.304
Selenium (mg/kg)	0.850	0.429	0.435	0.549
Vanadium, Total (mg/kg)	--	0.242	--	0.262
Zinc, Total (mg/kg)	16.3	36.2	15.2	37.1
Magnesium, Total (mg/kg)	575	359	--	372
Mercury, Total (ng/g)	25.3	6.4	141	13.1
Perylene (ug/kg)	--	7.4	--	--
4-Methylphenol (ug/kg)	--	67	120	--
Aroclor 1260 (ug/kg)	12	--	89	--
Benzyl Alcohol (ug/kg)	430	--	--	610
Benzoic Acid (ug/kg)	--	--	2,900	2,000

In conjunction with the samples collected and sent to Kelso Labs, Dr. Bryan Brooks of Baylor University collected and analyzed fish tissue, plasma and water samples from the Comal system for pharmaceutical agents. In the Comal system, Caffeine (stimulant), sucralose (artificial sweetener) and sulfamethoxazole (antibiotic) were consistently detected in the water samples at all stations (Appendix C.4). Caffeine, diltiazem (anti-hypertension), and sertraline (anti-depressant) were the only parameters consistently detected in fish plasma while diltiazem was the only constituent consistently detected in fish tissue. (Appendix C.4). As pharmaceutical effects on aquatic organisms is a developing science it is difficult to surmise too much from this exploratory dataset. However, as mentioned above, the acquisition of this type of fish tissue data serves well in the establishment of baseline conditions for future comparisons on a local or regional level.

Comal Springs Salamander Visual Observations

Biologists recorded the most Comal springs salamander observations to-date in 2017 (n=265), with fall sampling having the most salamander observations in a single sampling event (Table 9) since the inception of the monitoring program in 2000. Fall and spring 2017 salamander observations exceeded the long-term average (2001–2017) across all sites (Table 10). Spring sampling yielded less salamander observations than fall sampling, which is a consistent pattern seen throughout our long-term salamander monitoring (Table 10). The greatest difference in observations from the long-term average came from fall sampling in the Spring Island, Spring Run, and Spring Island Outfall where salamander observations where 7 times and 5 times greater, respectively (Table 10). In fall 2017, Spring Island East Outfall had the greatest number of salamander observations in a single sampling event (Figure 29), with Spring Run 1 (Figure 30) having the second most. Spring Run 3 (Figure 31) had the overall most salamander observations for both spring and fall 2017 (n=87), consistent to previous sampling years. Spring Run 3 has several spring heads and fissures along the reach providing quality salamander habitat.

Table 10. Total Comal Springs salamander observations for spring and fall routine sampling 2017 and the long-term average observation.

SEASON	2017 SAMPLING EVENT				
	Spring Run 1	Spring Run 3	Spring Island Run	Spring Island Outfall	Totals
Spring	20	43	7	23	93
Fall	53	44	21	54	172
Total	73	87	28	77	265
Average 2001–2017	19	14	3	11	

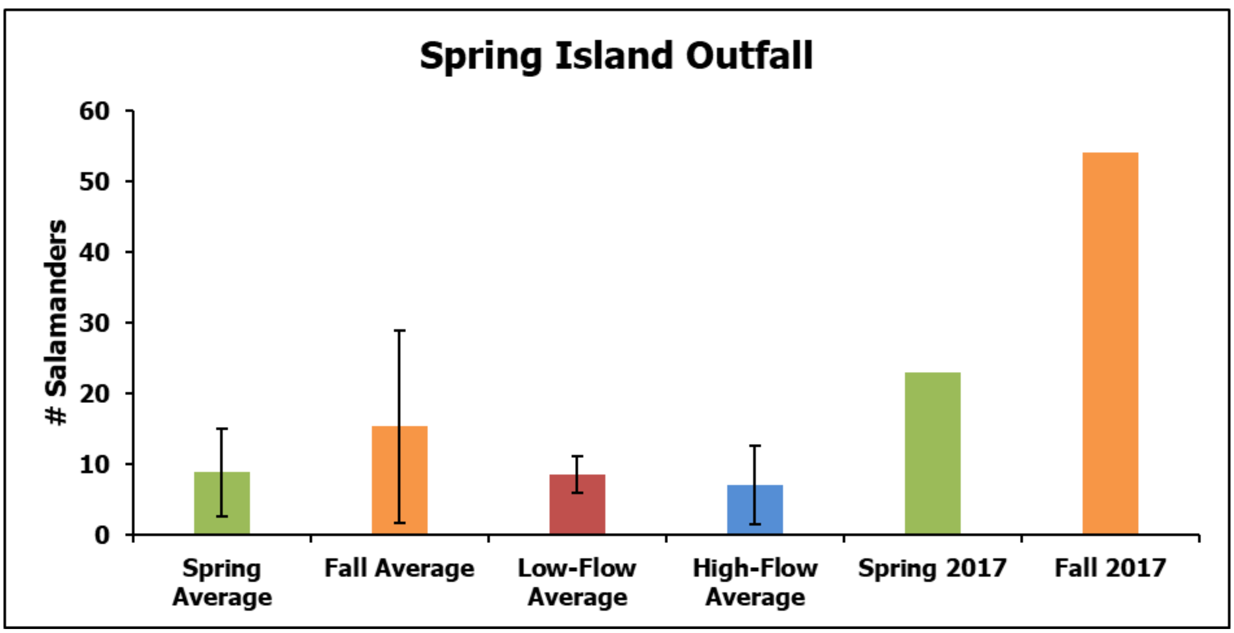


Figure 29. Comal Springs salamander observations at the Spring Island East Outfall in 2017, with the long-term average for each sampling event. Long-term study averages are provided with error bars representing the standard deviation of the mean.

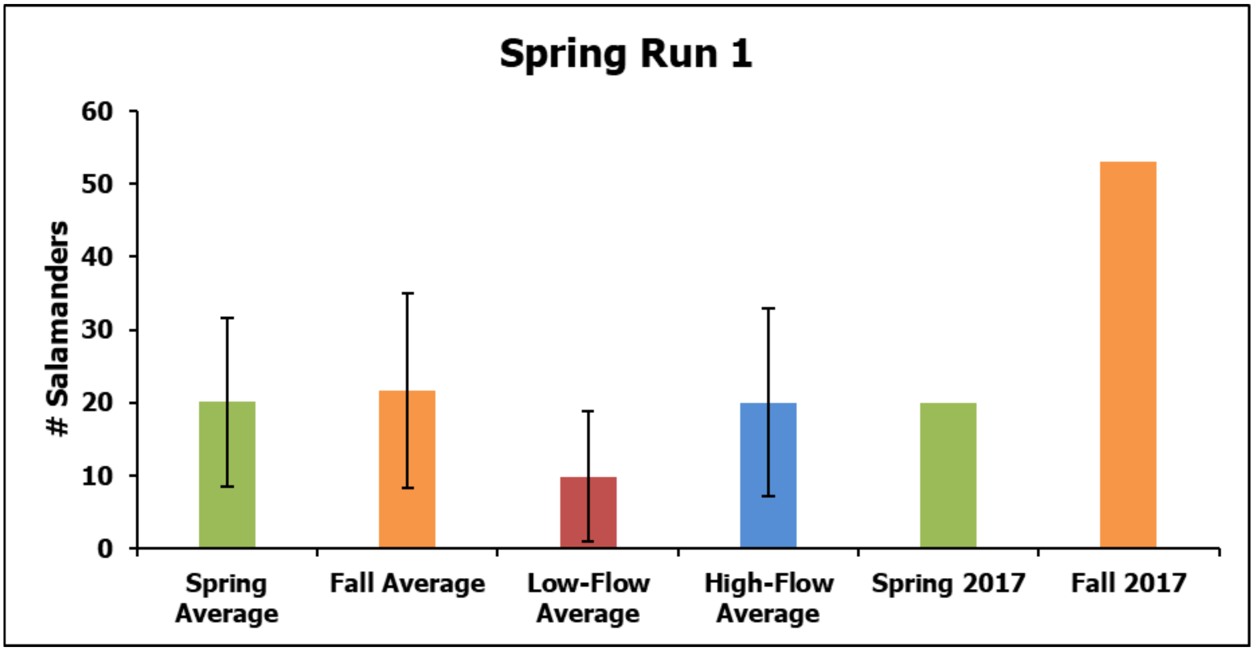


Figure 30. Comal Springs salamander observations at Spring Run 1 in 2017, with the long-term average for each sampling event. Long-term study averages are provided with error bars representing the standard deviation of the mean.

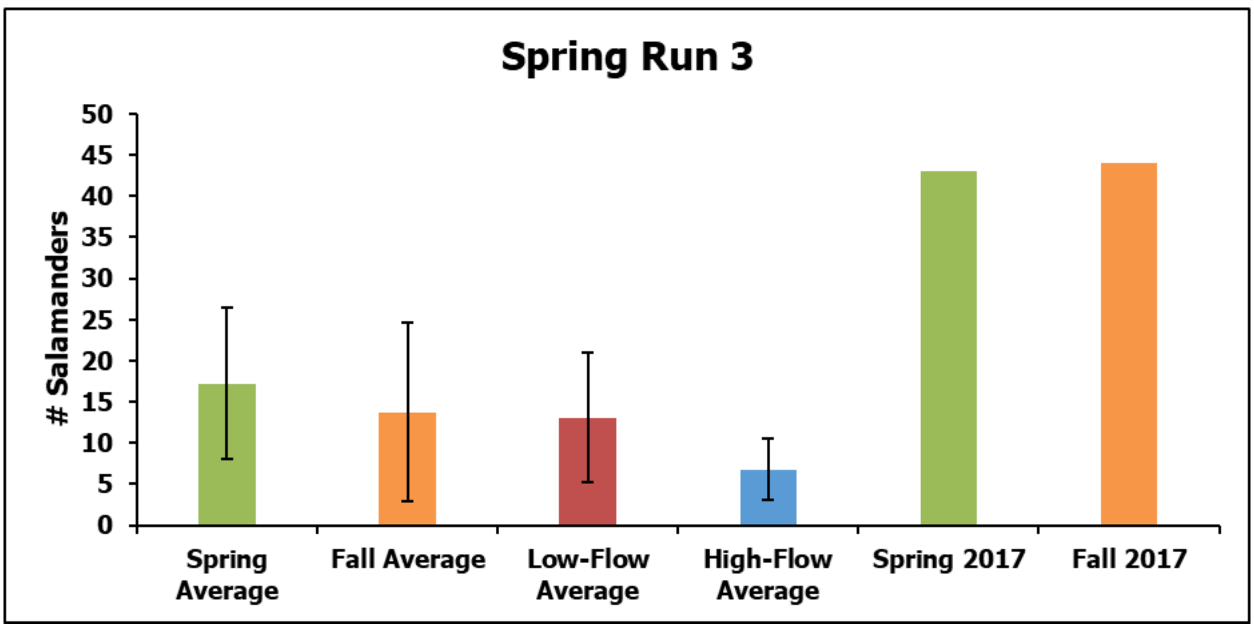


Figure 31. Comal Springs salamander observations at the Spring Run 3 in 2017, with the long-term average for each sampling event. Long-term study averages are provided with error bars representing the standard deviation of the mean.

Spring Island Spring Run (Spring Run 6) was above the long-term average and higher than previous years (Table 10 and Figure 32). Historically, Spring Island East Outfall has contributed low observations of salamanders, which has been attributed to disturbance (i.e., swimmers and waders). However, the higher than average post-drought discharge conditions have stimulated high abundances of bryophytes, which provides refuge for young salamanders. Also, the human activity coupled with appropriate refuge may limit the pressure of predatory fish on young salamanders.

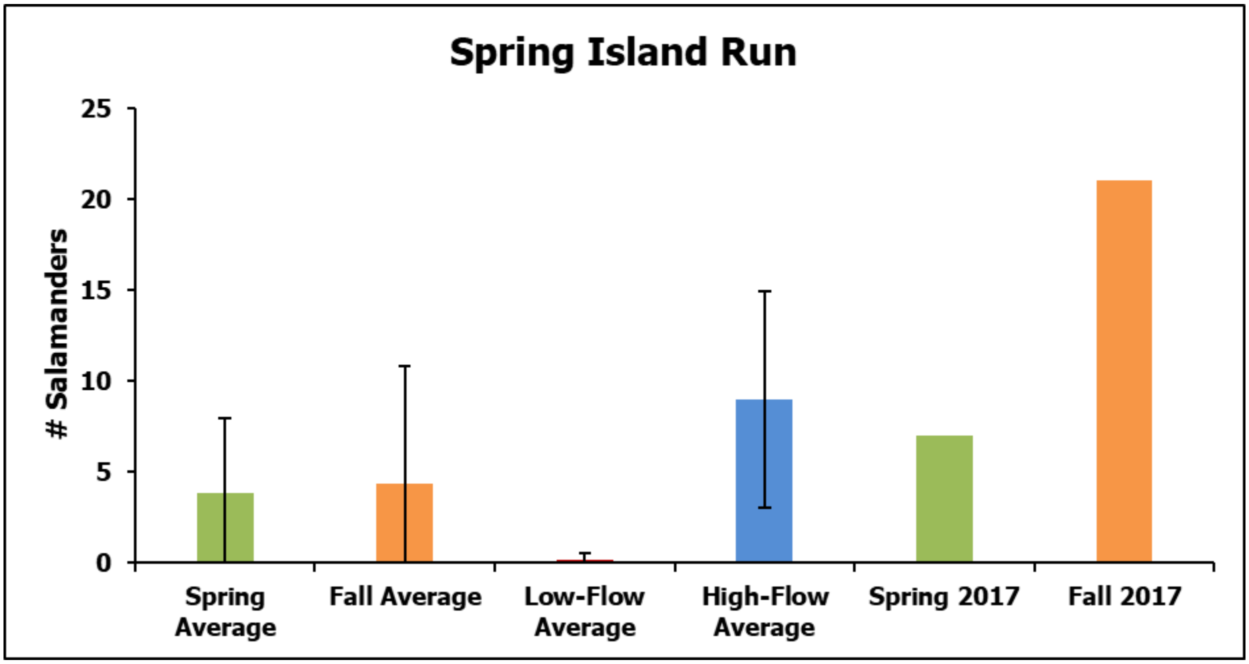


Figure 32. Comal Springs salamander observations at the Spring Island Spring Run (Spring Run 6) in 2017, with the long-term average for each sampling event. Long-term study averages are provided with error bars representing the standard deviation of the mean.

Higher-than-normal observations in 2017 could be attributed to increased recruitment or prey abundance in recent times; however, this is speculation at this time. Additional monitoring is needed to understand the exact mechanisms leading to the increase in salamander abundance observed in 2017.

Comal Macroinvertebrate Sampling

Both drift-net and cotton-lure sampling were used to assess population dynamics and habitat requirements of federally listed Comal invertebrate species in 2017. Drift net sampling was conducted around spring openings at three sites (Figure 2) in fall and spring, and cotton lures were deployed and collected two times within the three sample areas.

Drift-net Sampling

Water quality and current velocity data with each 2017 drift net sampling event are presented in Table 11. Water quality conditions showed little variation among springs and sampling events.

Table 11. Results of water quality measurements performed in 2017 at Comal Springs, New Braunfels, Comal County, Texas.

WATER QUALITY PARAMETER	SPRING RUN 1		SPRING RUN 3		WEST SHORE UPWELLING	
	May	Nov	May	Nov	May	Nov
Temperature (°C)	23.0	23.0	23.2	23.2	23.7	23.7
Conductivity (µS/cm)	513	504	508	501	499	492
pH	6.6	6.9	6.6	6.8	6.6	7.2
Dissolved oxygen (mg/L)	5.5	5.5	5.4	5.3	5.1	4.9
Current Velocity (m/s)	0.31	0.20	0.45	0.50	0.27	0.20

[a] C=Celsius, µS/cm=microsiemens per centimeter, mg/L=milligrams per liter, m/s=meters per second.

In 2017 a total of 1,470 groundwater invertebrates were collected during drift net sampling efforts among both seasons, with 409 (Spring Run 1), 537 (Spring Run 3), and 524 at the upwelling along the Western Shoreline of Landa Lake (Spring 7) (Table 12). Across all sites, *Stygobromus* species were the most commonly captured organisms with *Lirceolus* (isopods) having the second-most observations in drift net collections. Two adult Comal Spring riffle beetles were collected at Spring Run 1 and one adult collected at Spring Run 3. Four adults and one larvae of Comal Springs dryopid beetle were collected from Spring Run 1 and one larvae from Spring Run 3. No Edwards Aquifer diving beetles were collected in drift net sampling in 2017.

Comal Springs riffle beetle and Comal Springs dryopid beetle were not collected at the Western Shoreline upwelling. However, this site did have the greatest number of Peck's Cave amphipod (88), and the highest number of immature *Stygobromus* species (401).

Comal Springs Riffle Beetle

There were two cotton lure sampling efforts (spring, fall) in 2017 for Comal Springs riffle beetle. Data presented below summarizes densities of adult Comal Springs riffle beetle from 2017 in the context of the long-term study. Densities on lures at sampling locations were again variable in 2017 (Figures 33–34). In 2017 the number of adult Comal Springs riffle beetle collected from lures at Spring Island were lower than the long-term average from previous years. Spring Run 3 had the highest variance of adult Comal Springs riffle beetle density of all sites sampled, ranging from 0 to 34. The average number of adult Comal Springs riffle beetle per lure was slightly lower but within the range of historic conditions at Spring Run 3. The lures at the Western Shoreline produced fewer adult Comal Springs riffle beetles than the long-term average. As these numbers, following consecutive high flow years, have approached or declined below drought averages at all sites (Figures 33-34), close attention will be given to Comal Springs riffle beetles in 2018. It is too early to conclude any cause and effect for this apparent decline in Comal Springs riffle beetle numbers at this time. However, hypotheses such as increased disturbance from increased HCP program sampling / collection activities or increased predation from the large increase in salamanders this year will be investigated.

Benthic Macroinvertebrate Rapid Bioassessment

A total of 670 and 1,313 macroinvertebrate individuals, representing 31 and 32 unique taxa were sampled in spring and fall, respectively (raw data presented in Appendix C.5). Altogether, 45 unique taxa were represented among all samples from 2017. Metric values for each metric are reported, while metric scores for calculating the B-IBI can be found in Table 13. Figures for each metric can be found in Appendix C.6.

Table 12. Total numbers of troglobitic and endangered species collected at each site during May and November 2017. Federally endangered species are designated with (E). A=adult; L=larvae; P=probable pupae.

TOTAL DRIFT NET TIME (HOURS)	RUN 1	RUN 3	SPRING 7	TOTAL
	48	48	48	144
Taxa				
Crustaceans				
Amphipoda				
Crangonyctidae				
Stygobromus pecki (E)	21	32	88	141
Stygobromus russelli	2	1		3
Stygobromus spp.	199	219	401	819
All *Stygobromus*	222	252	489	963
Hadziidae				
Mexiweckelia hardeni	19	75	1	95
Sebidae				
Seborgia relicta	5	47	8	60
Bogidiellidae				
Artesia subterranea	2	4		6
Parabogidiella americana		1		1
Ingolfiellidae				
Ingolfiella n. sp		12		12
Isopoda				
Asellidae				
Lirceolus (2 spp.)	125	138	24	287
Cirolanidae				
Cirolanides texensis	1			1
Cirolanides n. sp.			2	2
Turbellaria				
Kenkiidae				
Sphalloplana mohri	2	1		3
Arachnids				
Hydrachnoidea				
Hydryphantidae				
Almuerzothyas comalensis	24			24
Insects				
Coleoptera				
Dytiscidae				
Comaldessus stygius	1 L : 1 A	2 L : 3 A		7
Dryopidae				
Stygoparnus comalensis (E)	4 L : 1 A	1 L		6
Elmidae				
Heterelmis comalensis (E)	2A	1A		3

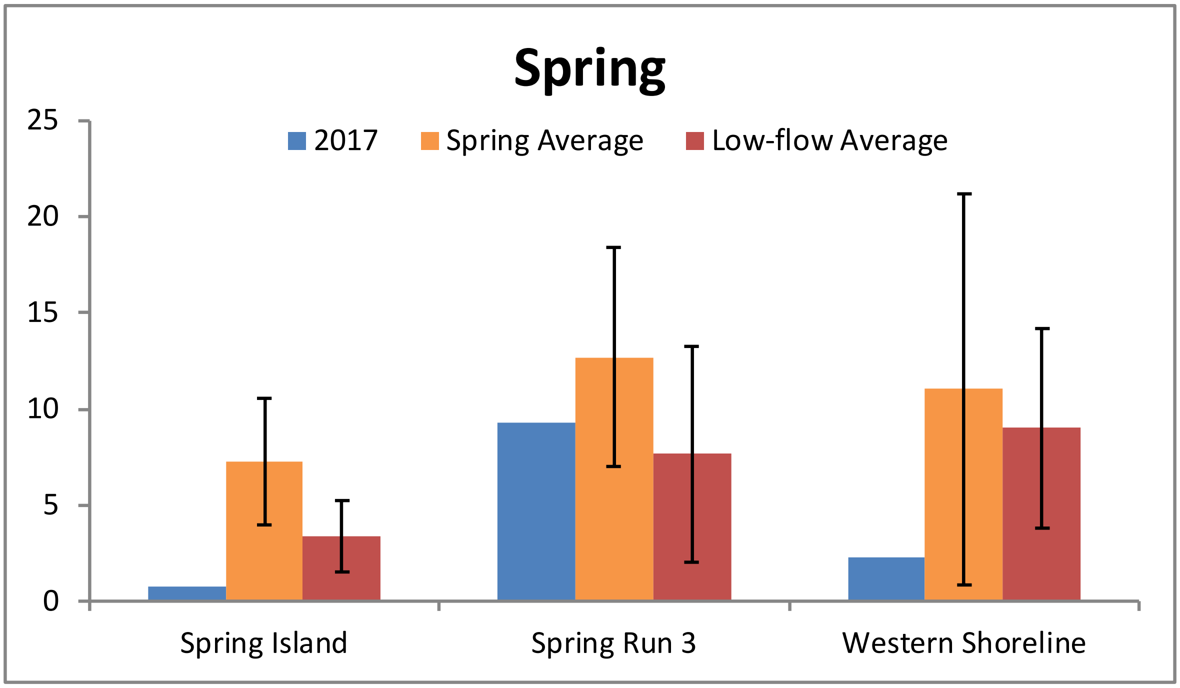


Figure 33. **Mean densities of adult Comal Springs riffle beetles sampled during the spring season of 2017 at Spring Island, Spring Run 3, and Western Shoreline of the Comal Spring system. Long-term (2004-2017) mean densities are given to the right of the 2017 means. Error bars represent the standard deviation of the mean.**

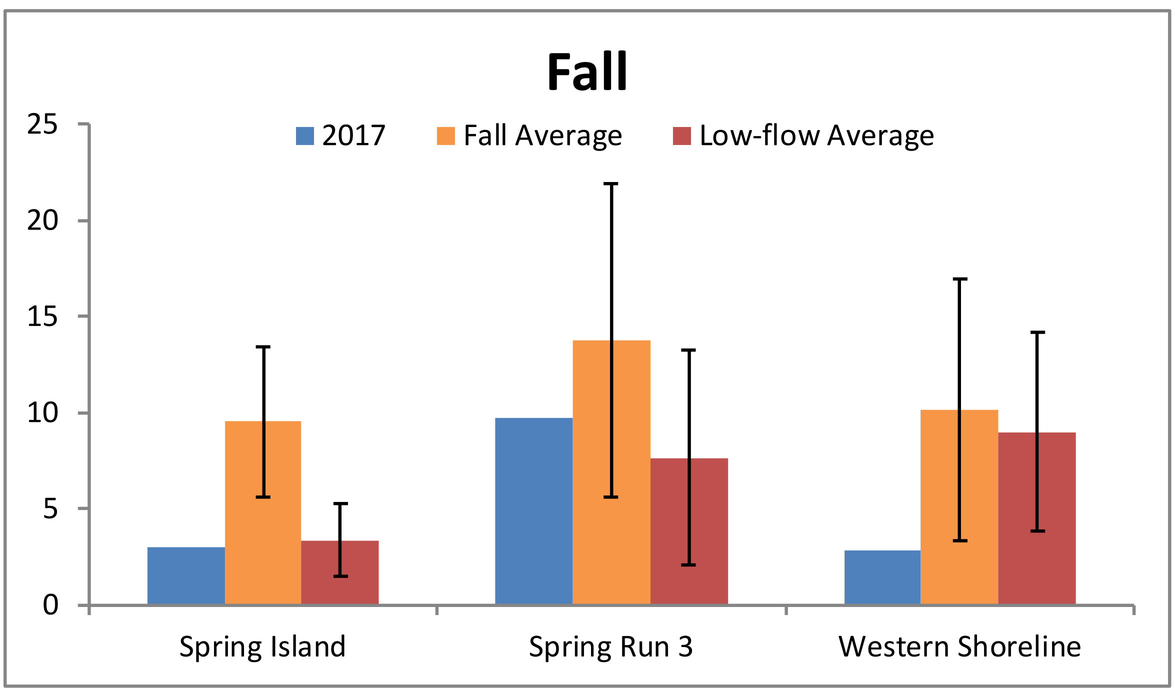


Figure 34. **Mean densities of adult Comal Springs riffle beetles sampled during the fall season of 2017 at Spring Island, Spring Run 3, and Western Shoreline of the Comal Spring system. Long-term (2004-2017) mean densities are given to the right of the 2017 means. Error bars represent the standard deviation of the mean.**

Table 13. Metric value scoring ranges for calculating the Texas RBP B-IBI (TCEQ 2014).

METRIC	SCORING CRITERIA 4	3	2	1
Taxa richness	>21	15–21	8–14	<8
EPT taxa abundance	>9	7–9	4–6	<4
Biotic index (HBI)	<3.77	3.77–4.52	4.56–5.27	>5.27
% Chironomidae	0.79–4.10	4.11–9.48	9.49–16.19	<0.79 or >16.19
% Dominant taxon	<22.15	22.15–31.01	31.02–39.88	>39.88
% Dominant FFG	<36.50	36.50–45.30	45.31–54.12	>54.12
% Predators	4.73–15.20	15.21–25.67	25.68–36.14	<4.73 or >36.14
Ratio of intolerant: tolerant taxa	>4.79	3.21–4.79	1.63–3.20	<1.63
% of total Trichoptera as Hydropsychidae	<25.50	25.51–50.50	50.51–75.50	>75.50 or no Trichoptera
# of non–insect taxa	>5	4–5	2–3	<2
% Collector–gatherers	8.00–19.23	19.24–30.46	30.47–41.68	<8.00 or >41.68
% of total number as Elmidae	0.88–10.04	10.05–20.08	20.09–30.12	<0.88 or >30.12

The overall results of this metric analysis contribute to the B-IBI scores and assessment of the aquatic-life-use (Figure 35). Upper Spring Run was assessed as a “Limited” habitat in spring but showed qualities of a “High” supporting habitat in fall. Landa Lake is described from these assessments as being “Limited” in supporting a balanced, integrated, adaptive community of organisms. New Channel showed “Intermediate” and “High” support of a healthy community for spring and fall, respectively. Old Channel showed “Limited” and “Intermediate” support for aquatic life in spring and fall, respectively. The Lower River Reach was found to have “High” support for aquatic life in both seasons. It is also important to note that although it is easy to focus on the differences between reaches, the goal of this assessment is to track the “condition” of specific reaches over time as an indicator of trends.

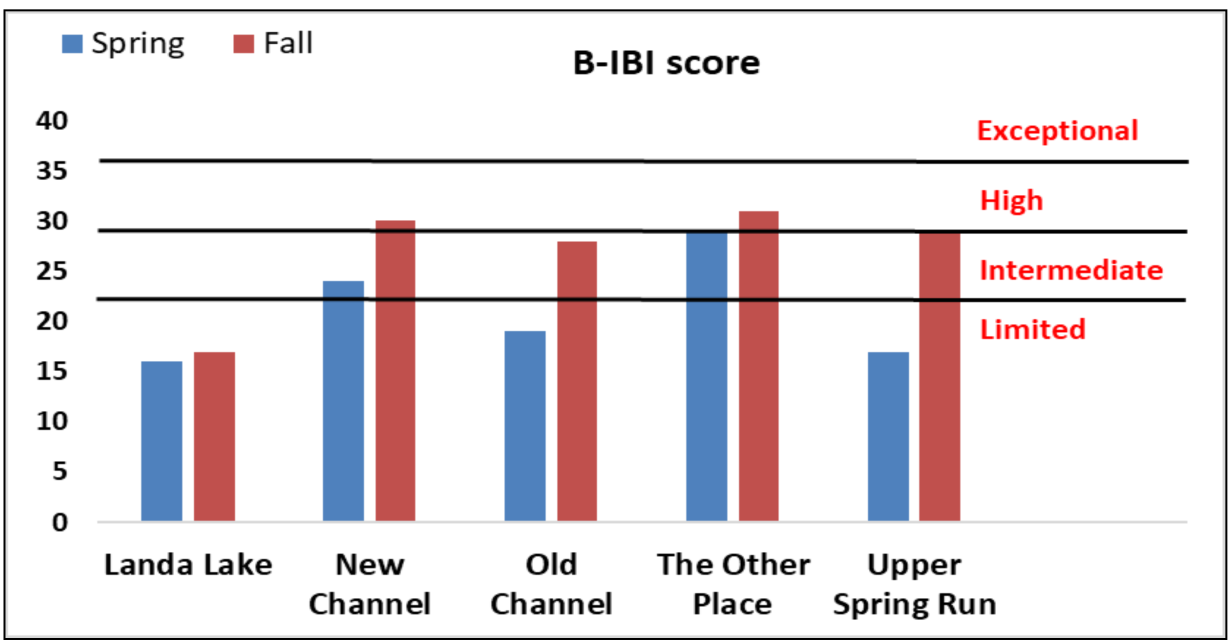


Figure 35. **Benthic macroinvertebrate Index of Biotic Integrity (B-IBI) scores and aquatic-life-use point-score ranges for Comal Springs sample sites. “Exceptional” indicates highest quality habitats relative to reference streams used to develop the index.**

In summary, areas of more lentic-type habitat (Landa Lake, Upper Spring Run) near spring sources scored lower, as communities there are different when compared to swift flowing "least disturbed reference streams." Downstream areas with more lotic conditions generally scored higher, as habitat is more similar to reference streams. It should also be noted that most reference streams do not exhibit the stenothermal conditions present within the upper Comal River, and this may result in differing community composition. Additional monitoring may allow development of a reference dataset specific to this unique ecosystem, and potentially development of a specific IBI scoring system for unique large spring environments such as the San Marcos and Comal rivers.

CONCLUSION

The HCP Biological Monitoring program activities conducted in 2017 continued to track biota and habitat conditions of the Comal Springs/River ecosystem. Results from 2017 provided insight into the continued transition from a prolonged drought into subsequent average/wet conditions in the Comal River/Springs ecosystem. In fact, total system discharge continued above historical long-term averages through most of 2017. Similar to 2016, water temperature and dissolved oxygen (DO) measurements throughout the system presented no cause for concern. Total coverage of aquatic vegetation in the Upper Spring Run, Landa Lake, and Lower New Channel Reaches was consistent with long-term study averages at the conclusion of 2017 and native aquatic vegetation conditions continue to improve in the Old Channel Reach. Overall, native aquatic vegetation restoration activities sponsored by the HCP continue to provide a boost to the native aquatic plant community of the Comal system. Nonnative aquatic plants have essentially been eliminated from the headwaters throughout Landa Lake and replaced with a mosaic of native aquatic vegetation through restoration efforts.

Fountain Darter populations tracked via multiple techniques continue to follow long-term trends and reflect the benefits of a thriving aquatic vegetation community, with the highest densities continually recorded in native aquatic vegetation. Although detections of several parameters were recorded in the exploratory fish tissue analysis conducted in 2017, no results reflect cause for concern at this time. For a second consecutive year, Comal salamander observations were the highest recorded to date. All three federally listed Comal Springs invertebrates were collected via drift net sampling over spring orifices in 2017. Lure data indicated that adult Comal Springs riffle beetle densities have declined in recent years. The benthic macroinvertebrate RBA sampling initiated the development of a baseline to track the "condition" of specific reaches over time.

Overall, habitat and species conditions in the Comal system remain in excellent condition with continued improvements being recognized each year through HCP restoration and mitigation activities. The one exception for 2017, as noted above, was the decline in Comal Springs riffle beetle numbers recorded. It is too early to conclude any cause and effect at this time, but highlights the importance of future biological monitoring to assess conditions as well as quantify effects (both positive and negative) in continuing to tell the HCP story.

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Texas Department of State Health Services (TDSHS). 2004. Fish Consumption Advisories & Bans, 2004. Potential Health Effects from Common Chemical Contaminants Found in Fish and Shellfish.

U. S. Environmental Protection Agency (U.S. EPA). 2009. The National Study of Chemical Residues in Lake Fish Tissue. EPA 823-R-09-006. September 2009.

U.S. Geological Survey (USGS). 11/2017. Provisional data for Texas. Location: http://tx.waterdata.usgs.gov/niwis/help/provisional.

APPENDIX A: CRITICAL PERIOD MONITORING SCHEDULES

COMAL RIVER/SPRINGS
Critical Period Low-Flow Sampling – Schedule and Parameters

FLOW TRIGGER (+ or - 10 cfs)	**PARAMETER**
200 cfs	Full Sampling Event
150 cfs	Full Sampling Event
120 cfs - 80 cfs	Riffle Beetles and spring discharge - Every 10 cfs decline (maximum weekly)
100 cfs	Full Sampling Event
100 cfs - 50 cfs	Habitat Evaluations - Every 10 cfs decline (maximum weekly)
50 cfs	Full Sampling Event
50 cfs - 0 cfs	Habitat Evaluations - Every 10 cfs decline (maximum weekly)
10 - 0 cfs	Full Sampling Event
RECOVERY	
25 cfs - 100 cfs	Full Sampling Event (dependant on flow stabilization)
100 cfs - 200 cfs	Full Sampling Event (dependant on flow stabilization)

PARAMETER DESCRIPTION

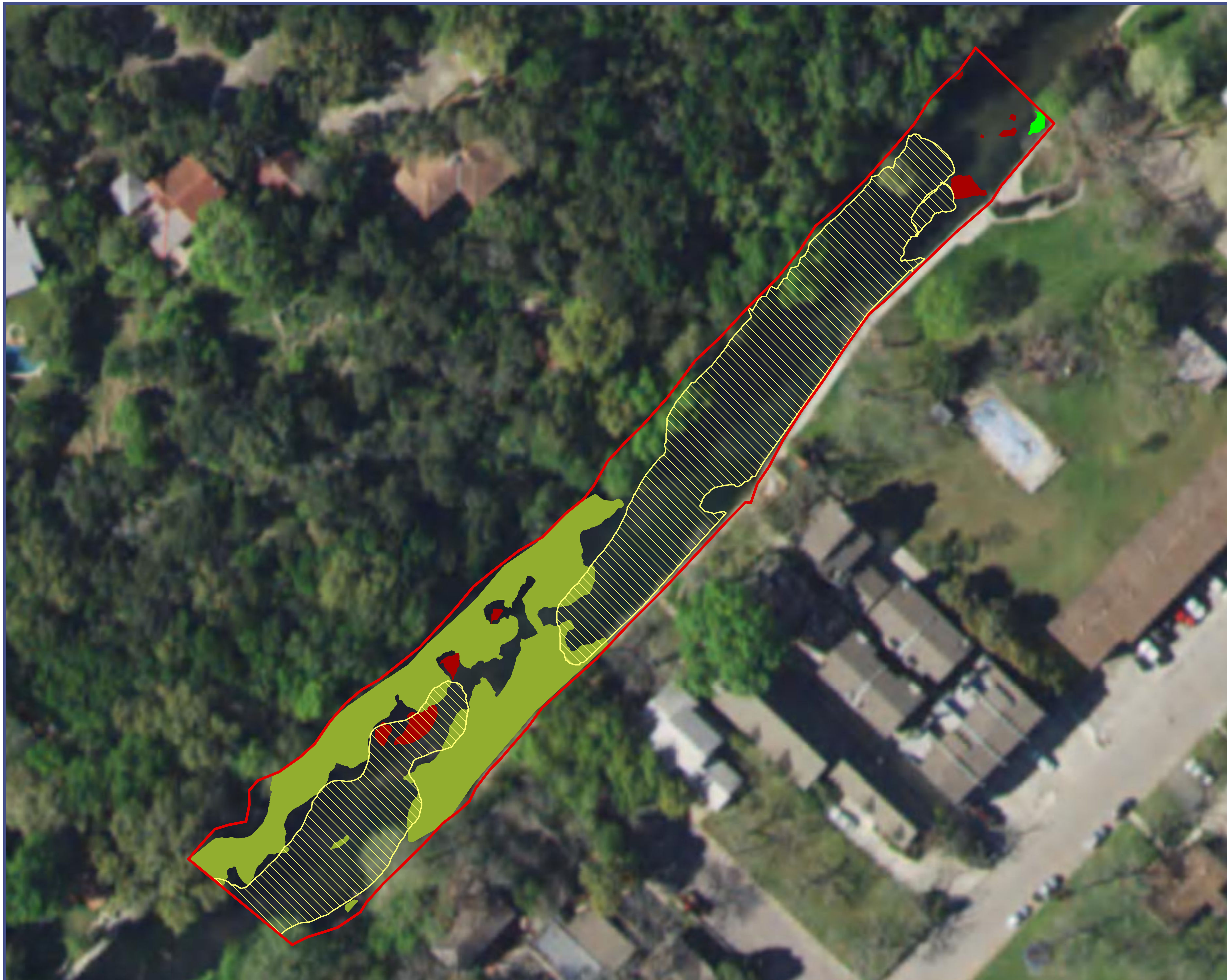
Full Sampling Event	Aquatic Vegetation Mapping Fountain Darter Sampling Drop Net, Dip net (Presence/Absence), and Visual Parasite evaluations Fish Community Sampling Salamander Sampling - Visual Riffle beetle - Cotton lure sampling Fish sampling - Exotics / Predation (100 cfs and below) Water Quality - Suite I and Suite II Flow partitioning - Landa Lake
Riffle Beetle Monitoring	Spring Discharge and wetted perimeter measurements
Habitat Evaluations	Photographs

COMAL RIVER / SPRINGS
Species-Specific Triggered Sampling (New HCP component 2013)

Flow Rate (+ or - 5 cfs)	Species	Frequency	Parameter
≤150 or ≥80 cfs	fountain darter	every other month	Aquatic vegetation mapping to include Upper Spring Run reach, Landa Lake, Old Channel reach, and New Channel reach
≤150 or ≥80 cfs	fountain darter	every other month	Conduct Dip net sampling/visual parasite evaluations at five (5) sites in the Upper Spring Reach; twenty (20) sites in Landa Lake; twenty (20) sites in the Old Channel reach and; at five (5) sites in the New Channel reach.
≤60 cfs	fountain darter	weekly	Conduct Dip net sampling/visual parasite evaluations at five (5) sites in the Upper Spring Reach; twenty (20) sites in Landa Lake; twenty (20) sites in the Old Channel reach and; at five (5) sites in the New Channel reach.
≤60 cfs	fountain darter	monthly	Aquatic vegetation mapping at Upper Spring Run reach, Landa Lake, Old Channel reach, and New Channel reach
≤120 cfs	riffle beetle	every 2 weeks	Monitoring via cotton lures at Spring Run 3, western shore of Landa Lake, and Spring Island upwelling
≤120 cfs or ≥80 cfs	salamander	every other week	Salamander snorkel surveys will be conducted at three sites (Spring Runs 1 and 3 and the Spring Island area)
≤80 cfs	salamander	weekly	Salamander snorkel surveys will be conducted at three sites (Spring Runs 1 and 3 and the Spring Island area)

APPENDIX B: AQUATIC VEGETATION MAPS

Upper Spring Run Reach



COMAL RIVER

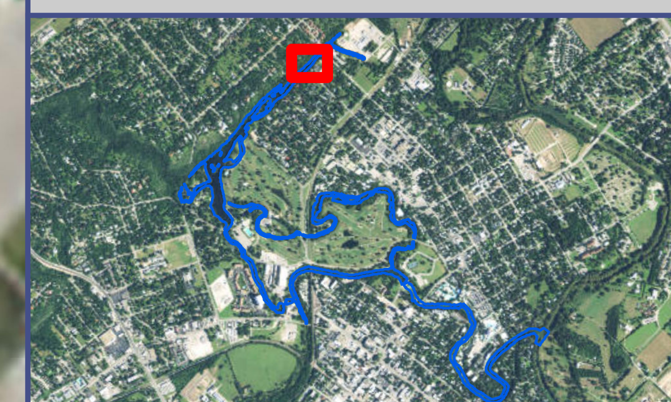
New Braunfels, Texas

Aquatic Vegetation Study Reach
April 2017

Surveyed: April 24, 2017

Upper Spring Run

Study Reach	4,835.4 m^2
Vegetation Types	
Bryophytes	1,944.2 m^2
Cabomba	7.2 m^2
Ludwigia	45.8 m^2
Sagittaria	982.1 m^2



0 25 50 100 Feet

0 10 20 Meters

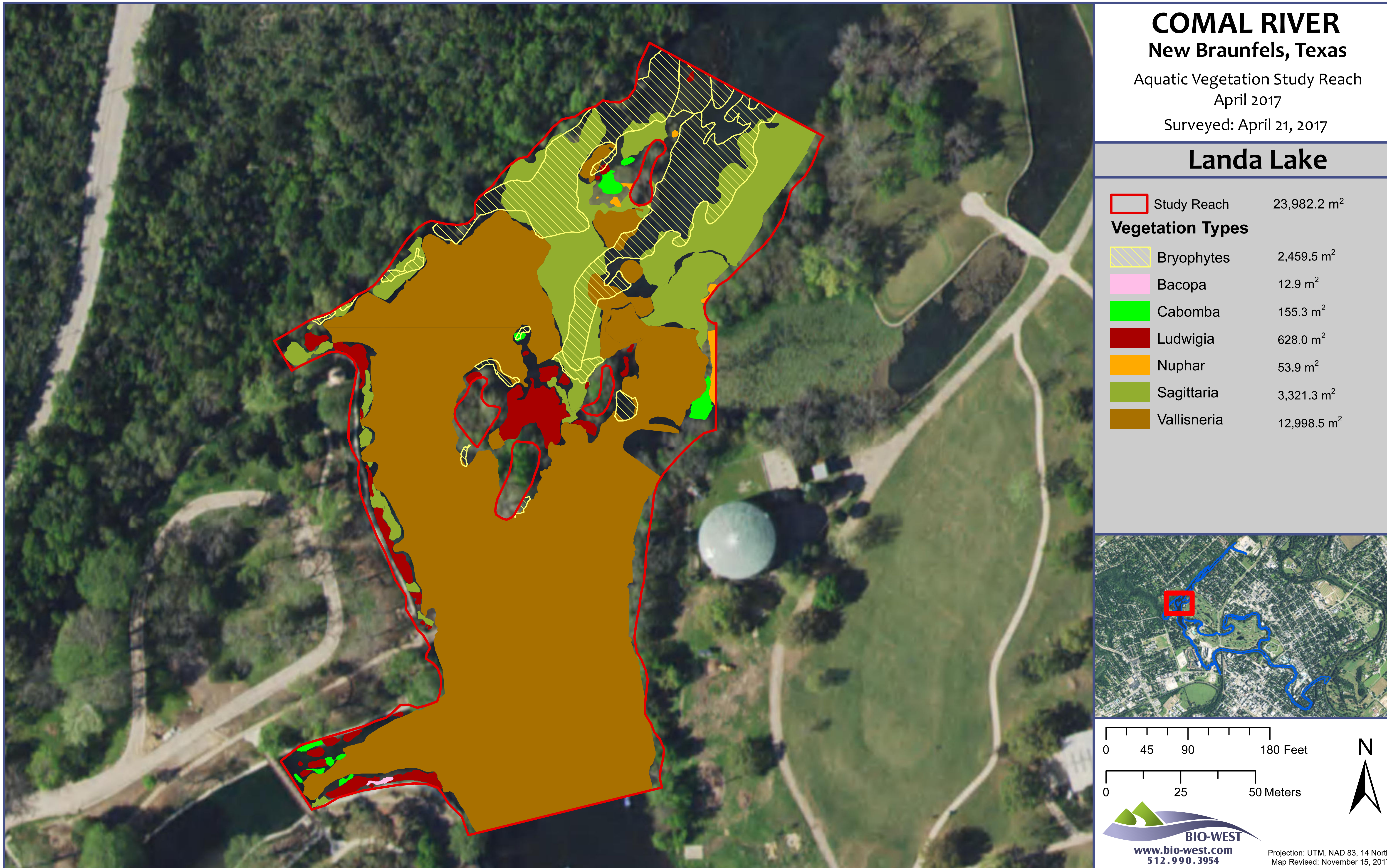
N

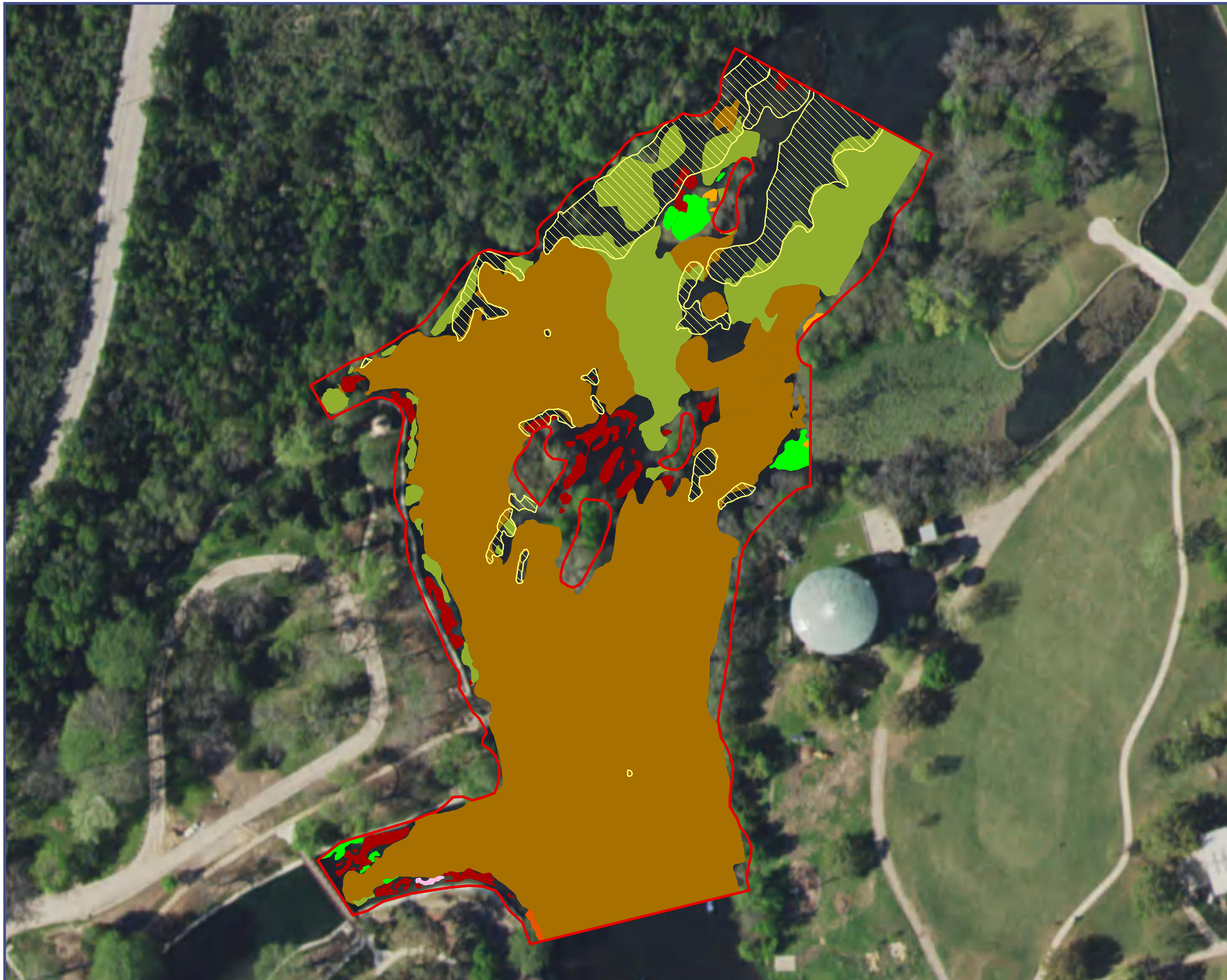
BIO-WEST
www.bio-west.com
512.990.3954

Projection: UTM, NAD 83, 14 North
Map Revised: July 24, 2017


COMAL RIVER
New Braunfels, Texas
Aquatic Vegetation Study Reach
October 2017
Surveyed: October 16, 2017
Upper Spring Run
Study Reach 4,835.4 m^2
Vegetation Types
Bryophytes 1,065.7 m^2
Cabomba 4.3 m^2
Ludwigia 21.1 m^2
Sagittaria 956.2 m^2
0 25 50 100 Feet
0 10 20 Meters
N
BIO-WEST
www.bio-west.com
512.990.3954
Projection: UTM, NAD 83, 14 North
Map Revised: November 3, 2017

Landa Lake Reach


COMAL RIVER
New Braunfels, Texas
Aquatic Vegetation Study Reach
April 2017
Surveyed: April 21, 2017
Landa Lake
Study Reach 23,982.2 m^2
Vegetation Types
Bryophytes 2,459.5 m^2
Bacopa 12.9 m^2
Cabomba 155.3 m^2
Ludwigia 628.0 m^2
Nuphar 53.9 m^2
Sagittaria 3,321.3 m^2
Vallisneria 12,998.5 m^2
0 45 90 180 Feet
0 25 50 Meters
N
BIO-WEST
www.bio-west.com
512.990.3954
Projection: UTM, NAD 83, 14 North
Map Revised: November 15, 2017



COMAL RIVER

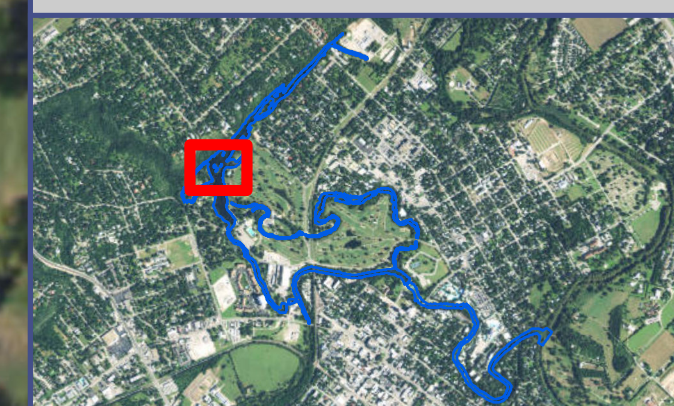
New Braunfels, Texas

Aquatic Vegetation Study Reach
October 2017

Surveyed: October 16, 2017

Landa Lake

Study Reach	23,982.2 m^2
Vegetation Types	
Bryophytes	2,347.9 m^2
Bacopa	8.4 m^2
Cabomba	194.2 m^2
Ludwigia	495.2 m^2
Nuphar	20.3 m^2
Potamogeton	17.5 m^2
Sagittaria	3,033.3 m^2
Vallisneria	12,597.1 m^2



0 45 90 180 Feet

0 25 50 Meters

N

BIO-WEST
www.bio-west.com
512.990.3954

Projection: UTM, NAD 83, 14 North
Map Revised: November 15, 2017

Upper New Channel Reach

COMAL RIVER

New Braunfels, Texas

Aquatic Vegetation Study Reach
April 2017

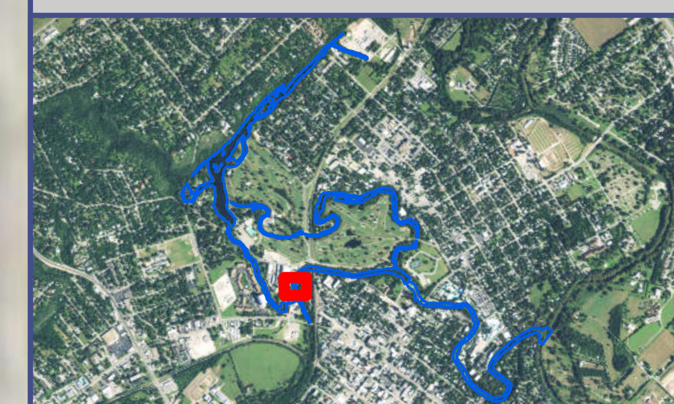
Surveyed: April 26, 2017

Upper New Channel

Study Reach	2,023.0 m^2

Vegetation Types

Cabomba	5.3 m^2
Hygrophila	134.6 m^2
Ludwigia	24.5 m^2



BIO-WEST
www.bio-west.com
512.990.3954

Projection: UTM, NAD 83, 14 North
Map Revised: July 24, 2017

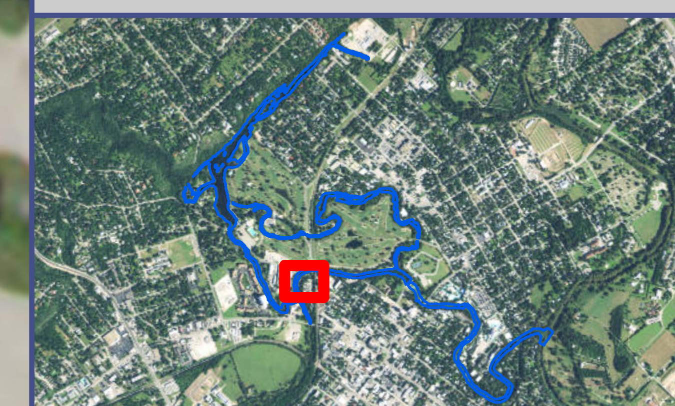
COMAL RIVER
New Braunfels, Texas

Aquatic Vegetation Study Reach
October 2017

Surveyed: October 18, 2017

Upper New Channel

Study Reach	4,996.3 m^2
Vegetation Types	
Bryophytes	166.6 m^2
Cabomba	25.5 m^2
Hygrophila	622.7 m^2
Ludwigia	33.0 m^2



0 30 60 120 Feet

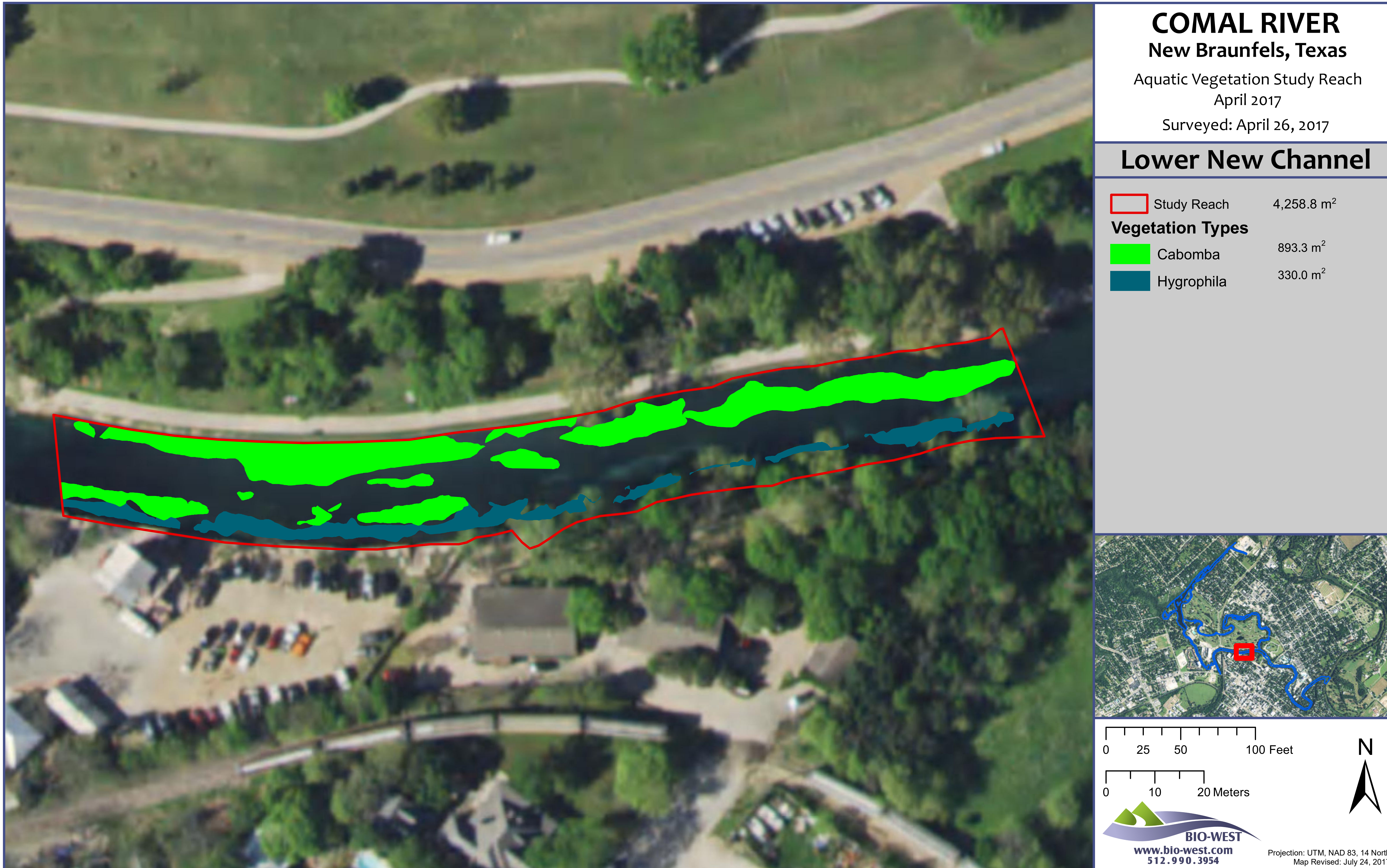
0 10 20 Meters

N

BIO-WEST
www.bio-west.com
512.990.3954

Projection: UTM, NAD 83, 14 North
Map Revised: November 15, 2017

Lower New Channel Reach


COMAL RIVER
New Braunfels, Texas
Aquatic Vegetation Study Reach
April 2017
Surveyed: April 26, 2017
Lower New Channel
Study Reach 4,258.8 m^2
Vegetation Types
Cabomba 893.3 m^2
Hygrophila 330.0 m^2
0 25 50 100 Feet
0 10 20 Meters
N
BIO-WEST
www.bio-west.com
512.990.3954
Projection: UTM, NAD 83, 14 North
Map Revised: July 24, 2017

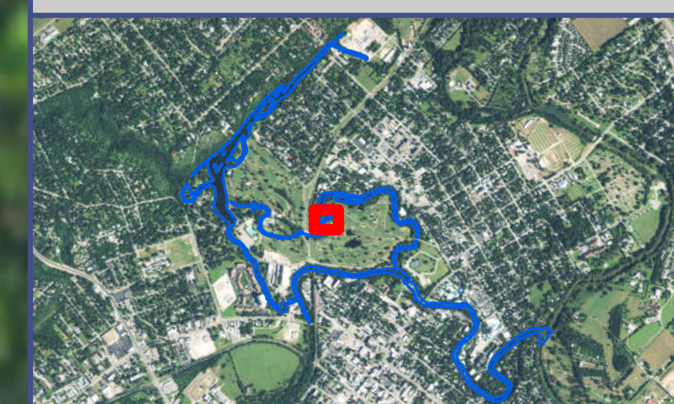
COMAL RIVER
New Braunfels, Texas
Aquatic Vegetation Study Reach
October 2017
Surveyed: October 18, 2017
Lower New Channel
Study Reach 4,258.8 m2
Vegetation Types
Cabomba 1,664.6 m2
Hygrophila 558.3 m2
Sagittaria 1.1 m2
0 25 50 100 Feet
0 10 20 Meters
N
BIO-WEST
www.bio-west.com
512.990.3954
Projection: UTM, NAD 83, 14 North
Map Revised: November 11, 2017

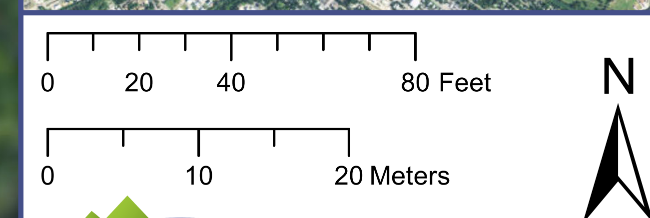
Old Channel Reach

COMAL RIVER
New Braunfels, Texas
Aquatic Vegetation Study Reach
April 2017
Surveyed: April 25, 2017

Old Channel

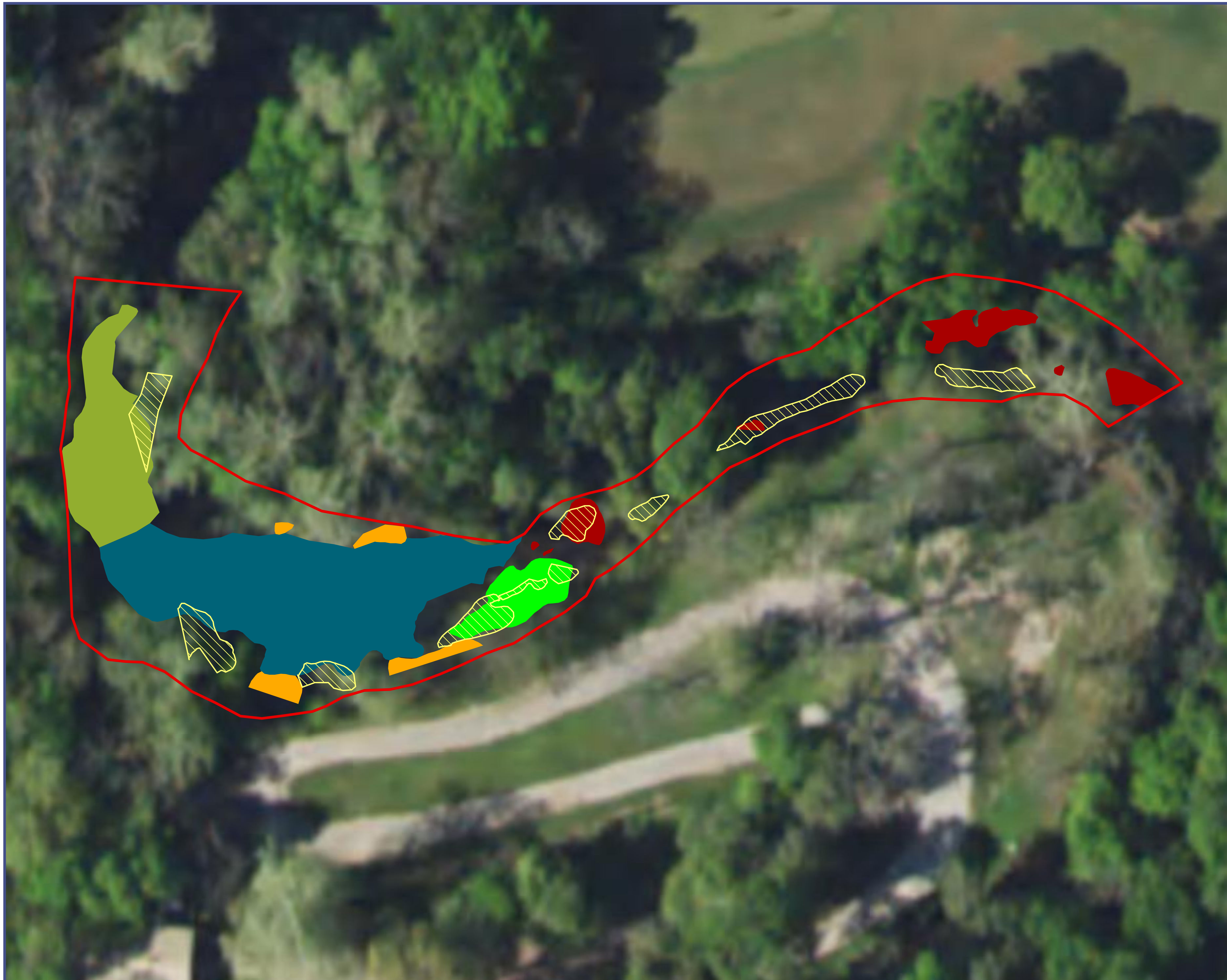
Study Reach	2,797.4 m^2
Vegetation Types	
Bryophytes	123.2 m^2
Hygrophila	961.9 m^2
Ludwigia	10.0 m^2
Nuphar	38.9 m^2





BIO-WEST
www.bio-west.com
512.990.3954

Projection: UTM, NAD 83, 14 North
Map Revised: July 24, 2017



COMAL RIVER

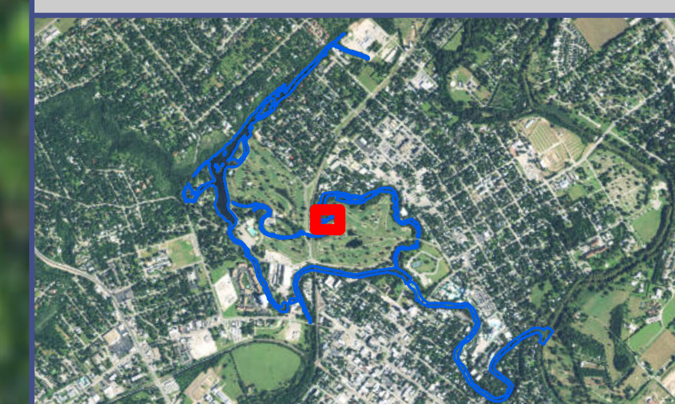
New Braunfels, Texas

Aquatic Vegetation Study Reach
October 2017

Surveyed: October 17, 2017

Old Channel

Study Reach	2,797.4 m^2
Vegetation Types	
Bryophytes	134.0 m^2
Cabomba	72.8 m^2
Hygrophila	586.0 m^2
Ludwigia	83.6 m^2
Nuphar	33.4 m^2
Sagittaria	38.9 m^2



0 20 40 80 Feet

0 10 20 Meters

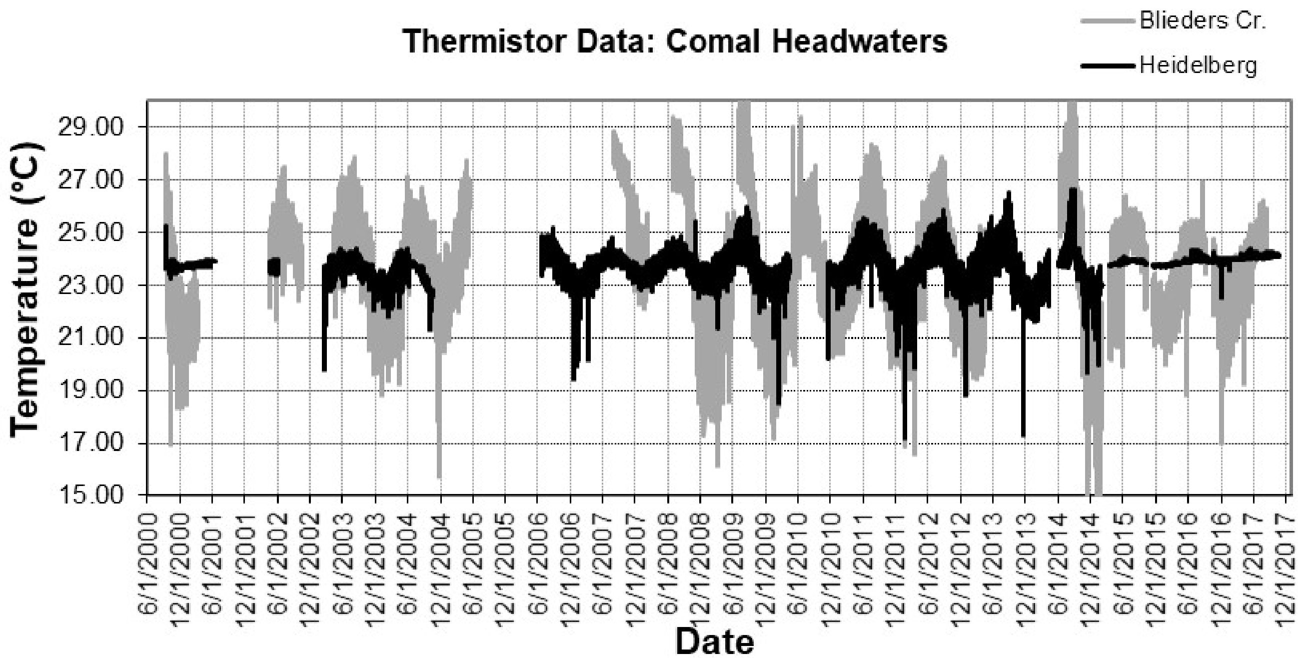
N

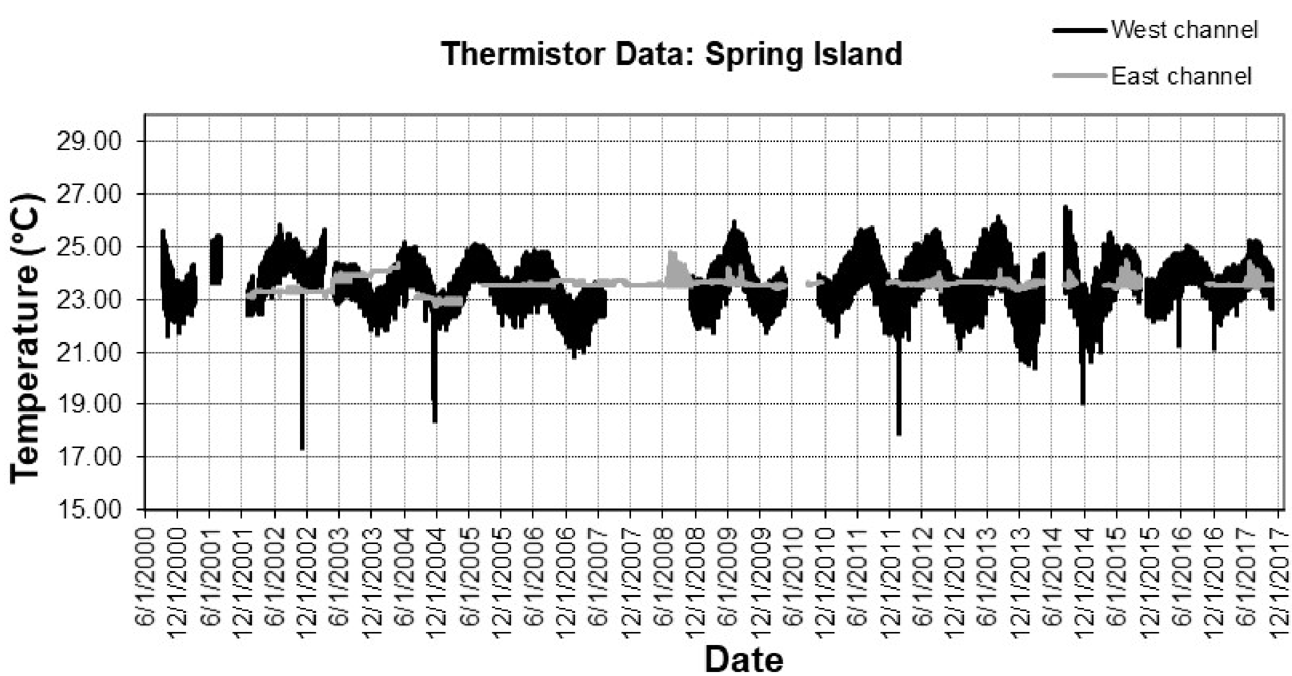
BIO-WEST
www.bio-west.com
512.990.3954

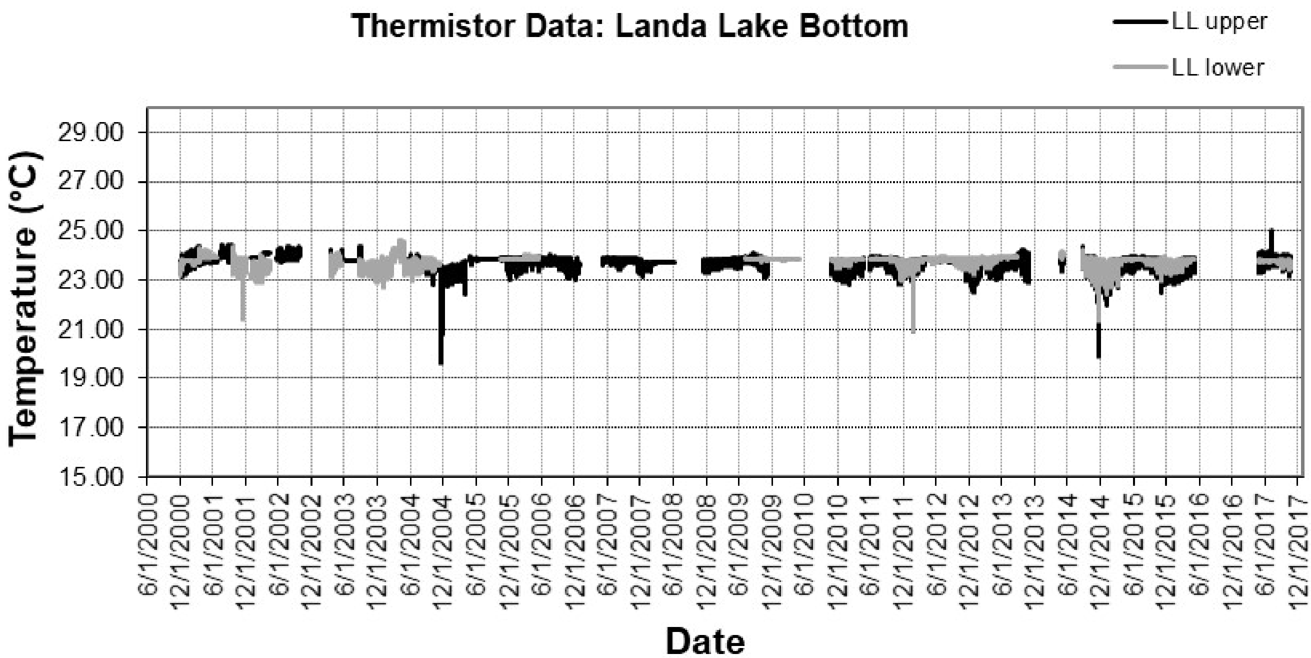
Projection: UTM, NAD 83, 14 North
Map Revised: November 7, 2017

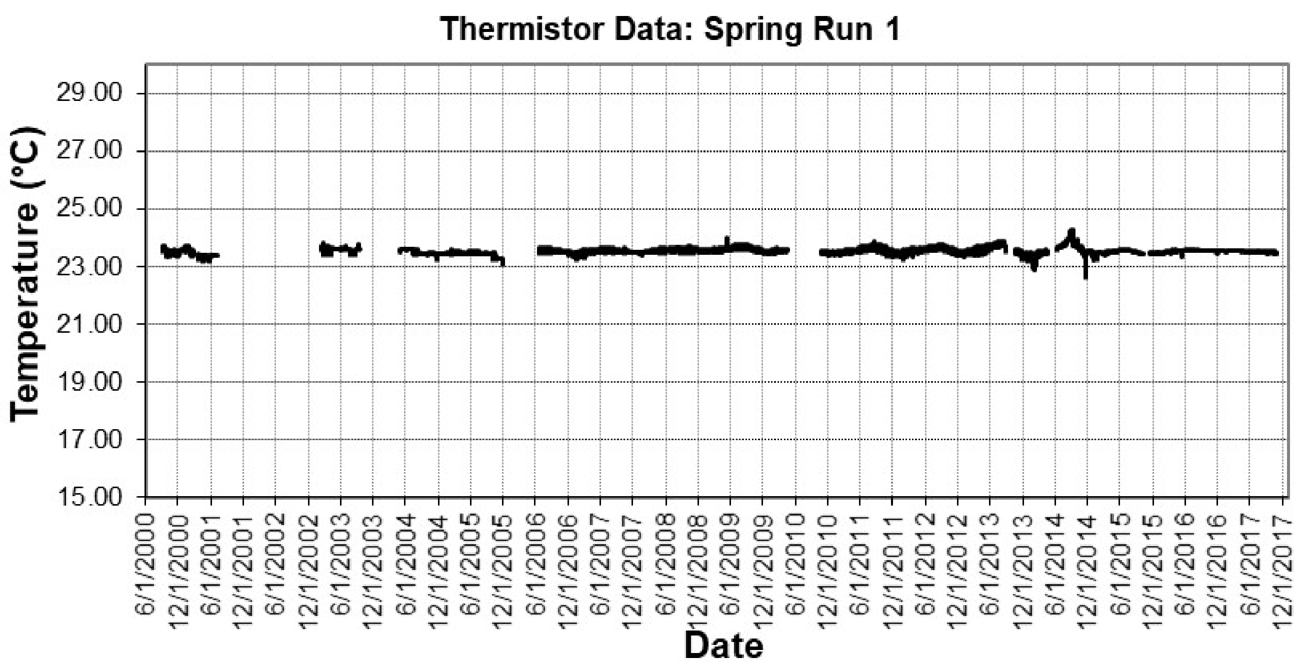
APPENDIX C: DATA AND GRAPHS

C.1: Thermistor Graphs


Thermistor Data: Comal Headwaters
Blieders Cr.
Heidelberg
Temperature (°C)
29.00
27.00
25.00
23.00
21.00
19.00
17.00
15.00
6/1/2000
12/1/2000
6/1/2001
12/1/2001
6/1/2002
12/1/2002
6/1/2003
12/1/2003
6/1/2004
12/1/2004
6/1/2005
12/1/2005
6/1/2006
12/1/2006
6/1/2007
12/1/2007
6/1/2008
12/1/2008
6/1/2009
12/1/2009
6/1/2010
12/1/2010
6/1/2011
12/1/2011
6/1/2012
12/1/2012
6/1/2013
12/1/2013
6/1/2014
12/1/2014
6/1/2015
12/1/2015
6/1/2016
12/1/2016
6/1/2017
12/1/2017
Date


Thermistor Data: Spring Island
West channel
East channel
Temperature (°C)
29.00
27.00
25.00
23.00
21.00
19.00
17.00
15.00
6/1/2000
12/1/2000
6/1/2001
12/1/2001
6/1/2002
12/1/2002
6/1/2003
12/1/2003
6/1/2004
12/1/2004
6/1/2005
12/1/2005
6/1/2006
12/1/2006
6/1/2007
12/1/2007
6/1/2008
12/1/2008
6/1/2009
12/1/2009
6/1/2010
12/1/2010
6/1/2011
12/1/2011
6/1/2012
12/1/2012
6/1/2013
12/1/2013
6/1/2014
12/1/2014
6/1/2015
12/1/2015
6/1/2016
12/1/2016
6/1/2017
12/1/2017
Date


Thermistor Data: Landa Lake Bottom
LL upper
LL lower
Temperature (°C)
29.00
27.00
25.00
23.00
21.00
19.00
17.00
15.00
6/1/2000
12/1/2000
6/1/2001
12/1/2001
6/1/2002
12/1/2002
6/1/2003
12/1/2003
6/1/2004
12/1/2004
6/1/2005
12/1/2005
6/1/2006
12/1/2006
6/1/2007
12/1/2007
6/1/2008
12/1/2008
6/1/2009
12/1/2009
6/1/2010
12/1/2010
6/1/2011
12/1/2011
6/1/2012
12/1/2012
6/1/2013
12/1/2013
6/1/2014
12/1/2014
6/1/2015
12/1/2015
6/1/2016
12/1/2016
6/1/2017
12/1/2017
Date


Thermistor Data: Spring Run 1
Temperature (°C)
29.00
27.00
25.00
23.00
21.00
19.00
17.00
15.00
6/1/2000
12/1/2000
6/1/2001
12/1/2001
6/1/2002
12/1/2002
6/1/2003
12/1/2003
6/1/2004
12/1/2004
6/1/2005
12/1/2005
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12/1/2009
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6/1/2012
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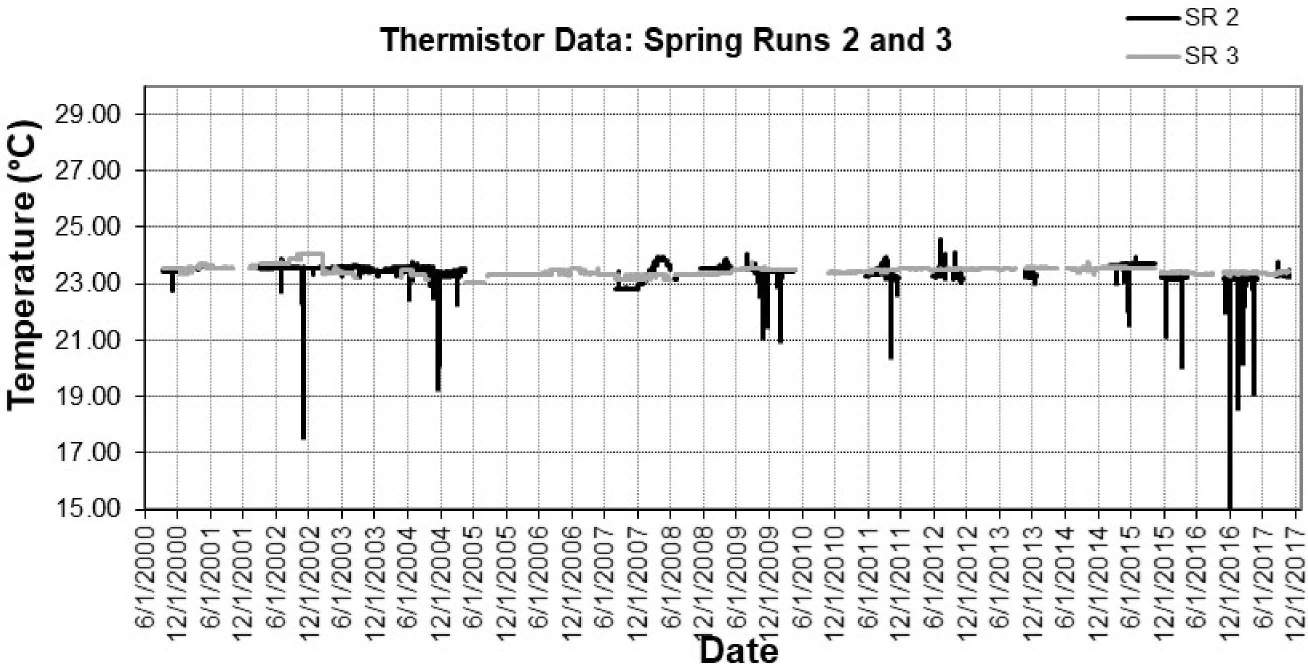
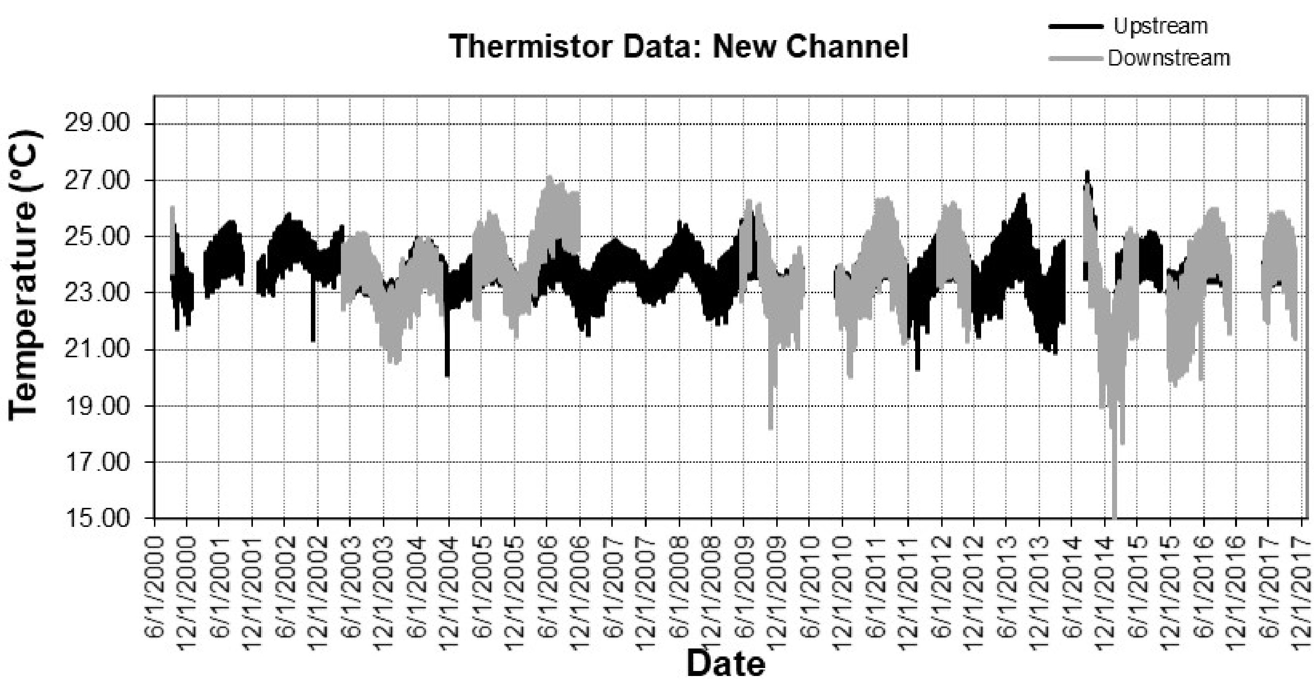
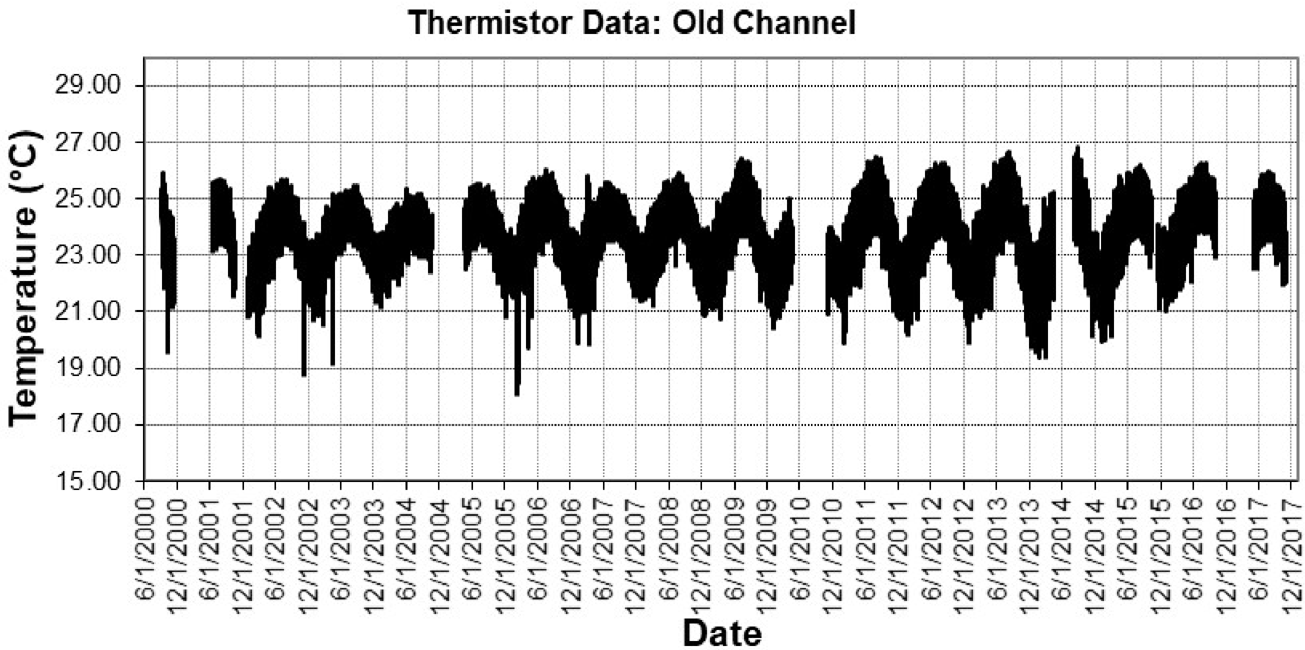
6/1/2013
12/1/2013
6/1/2014
12/1/2014
6/1/2015
12/1/2015
6/1/2016
12/1/2016
6/1/2017
12/1/2017
Date

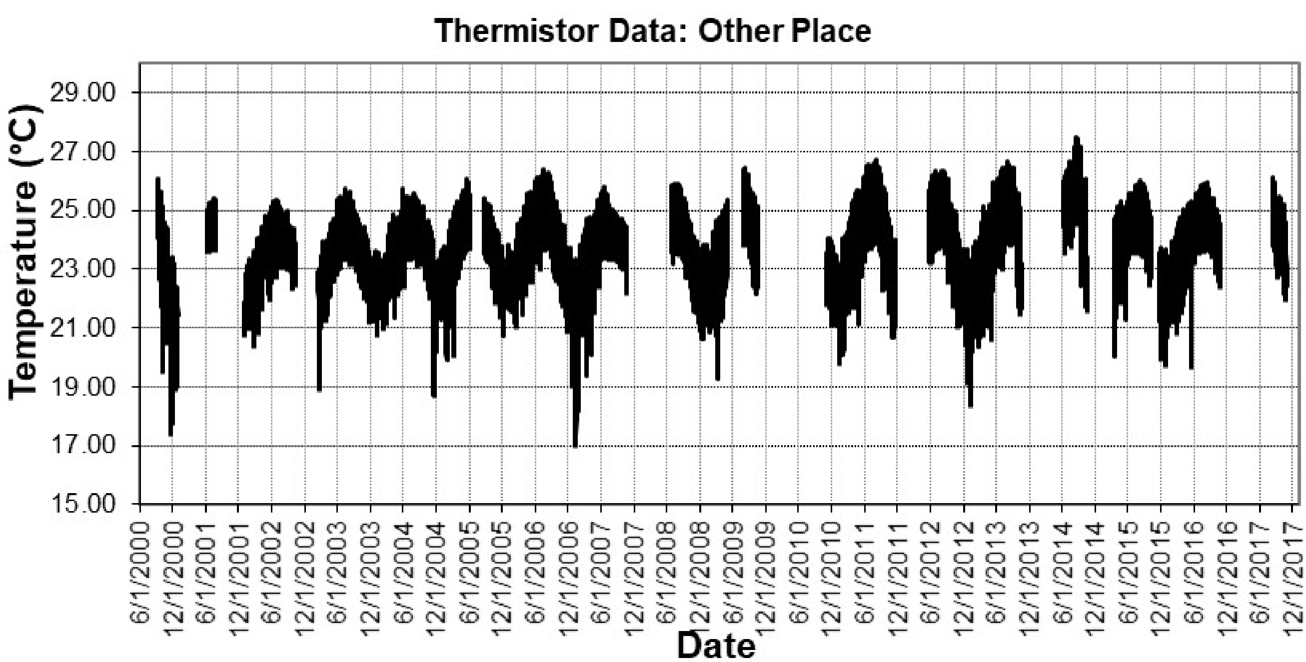


Thermistor Data: Spring Runs 2 and 3
SR 2
SR 3
Temperature (°C)
29.00
27.00
25.00
23.00
21.00
19.00
17.00
15.00
6/1/2000
12/1/2000
6/1/2001
12/1/2001
6/1/2002
12/1/2002
6/1/2003
12/1/2003
6/1/2004
12/1/2004
6/1/2005
12/1/2005
6/1/2006
12/1/2006
6/1/2007
12/1/2007
6/1/2008
12/1/2008
6/1/2009
12/1/2009
6/1/2010
12/1/2010
6/1/2011
12/1/2011
6/1/2012
12/1/2012
6/1/2013
12/1/2013
6/1/2014
12/1/2014
6/1/2015
12/1/2015
6/1/2016
12/1/2016
6/1/2017
12/1/2017
Date



Thermistor Data: New Channel
Upstream
Downstream
Temperature (°C)
29.00
27.00
25.00
23.00
21.00
19.00
17.00
15.00
6/1/2000
12/1/2000
6/1/2001
12/1/2001
6/1/2002
12/1/2002
6/1/2003
12/1/2003
6/1/2004
12/1/2004
6/1/2005
12/1/2005
6/1/2006
12/1/2006
6/1/2007
12/1/2007
6/1/2008
12/1/2008
6/1/2009
12/1/2009
6/1/2010
12/1/2010
6/1/2011
12/1/2011
6/1/2012
12/1/2012
6/1/2013
12/1/2013
6/1/2014
12/1/2014
6/1/2015
12/1/2015
6/1/2016
12/1/2016
6/1/2017
12/1/2017
Date


Thermistor Data: Old Channel
Temperature (°C)
29.00
27.00
25.00
23.00
21.00
19.00
17.00
15.00
6/1/2000
12/1/2000
6/1/2001
12/1/2001
6/1/2002
12/1/2002
6/1/2003
12/1/2003
6/1/2004
12/1/2004
6/1/2005
12/1/2005
6/1/2006
12/1/2006
6/1/2007
12/1/2007
6/1/2008
12/1/2008
6/1/2009
12/1/2009
6/1/2010
12/1/2010
6/1/2011
12/1/2011
6/1/2012
12/1/2012
6/1/2013
12/1/2013
6/1/2014
12/1/2014
6/1/2015
12/1/2015
6/1/2016
12/1/2016
6/1/2017
12/1/2017
Date

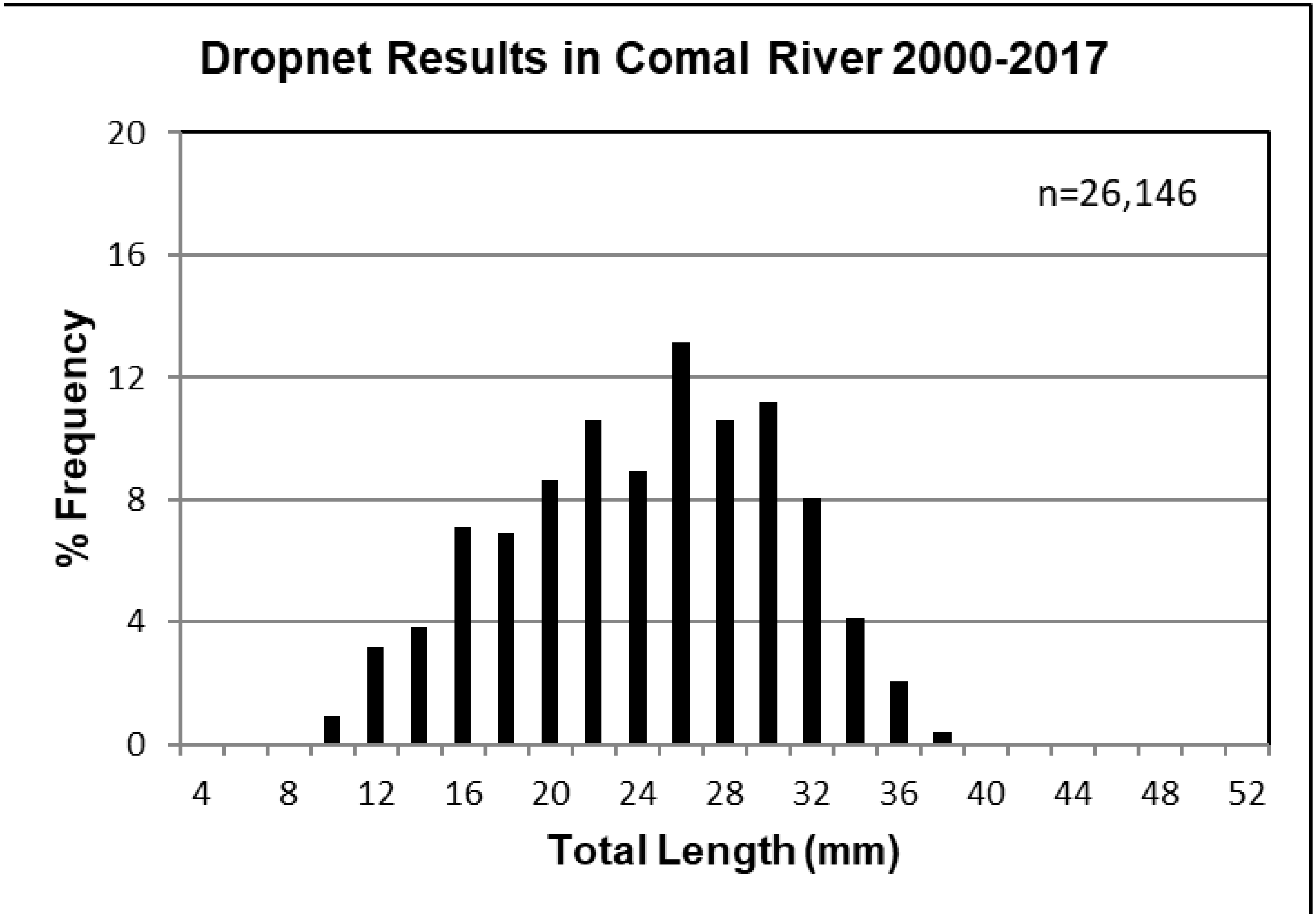

Thermistor Data: Other Place
Temperature (°C)
29.00
27.00
25.00
23.00
21.00
19.00
17.00
15.00
6/1/2000
12/1/2000
6/1/2001
12/1/2001
6/1/2002
12/1/2002
6/1/2003
12/1/2003
6/1/2004
12/1/2004
6/1/2005
12/1/2005
6/1/2006
12/1/2006
6/1/2007
12/1/2007
6/1/2008
12/1/2008
6/1/2009
12/1/2009
6/1/2010
12/1/2010
6/1/2011
12/1/2011
6/1/2012
12/1/2012
6/1/2013
12/1/2013
6/1/2014
12/1/2014
6/1/2015
12/1/2015
6/1/2016
12/1/2016
6/1/2017
12/1/2017
Date

C.2: Drop Net Table and Graph

Fountain Darter mean densities and one standard deviation from the mean per aquatic vegetation per meter squared (m^2) for all drop net samples collected in the Comal Springs / River system from 2000 through 2017*.

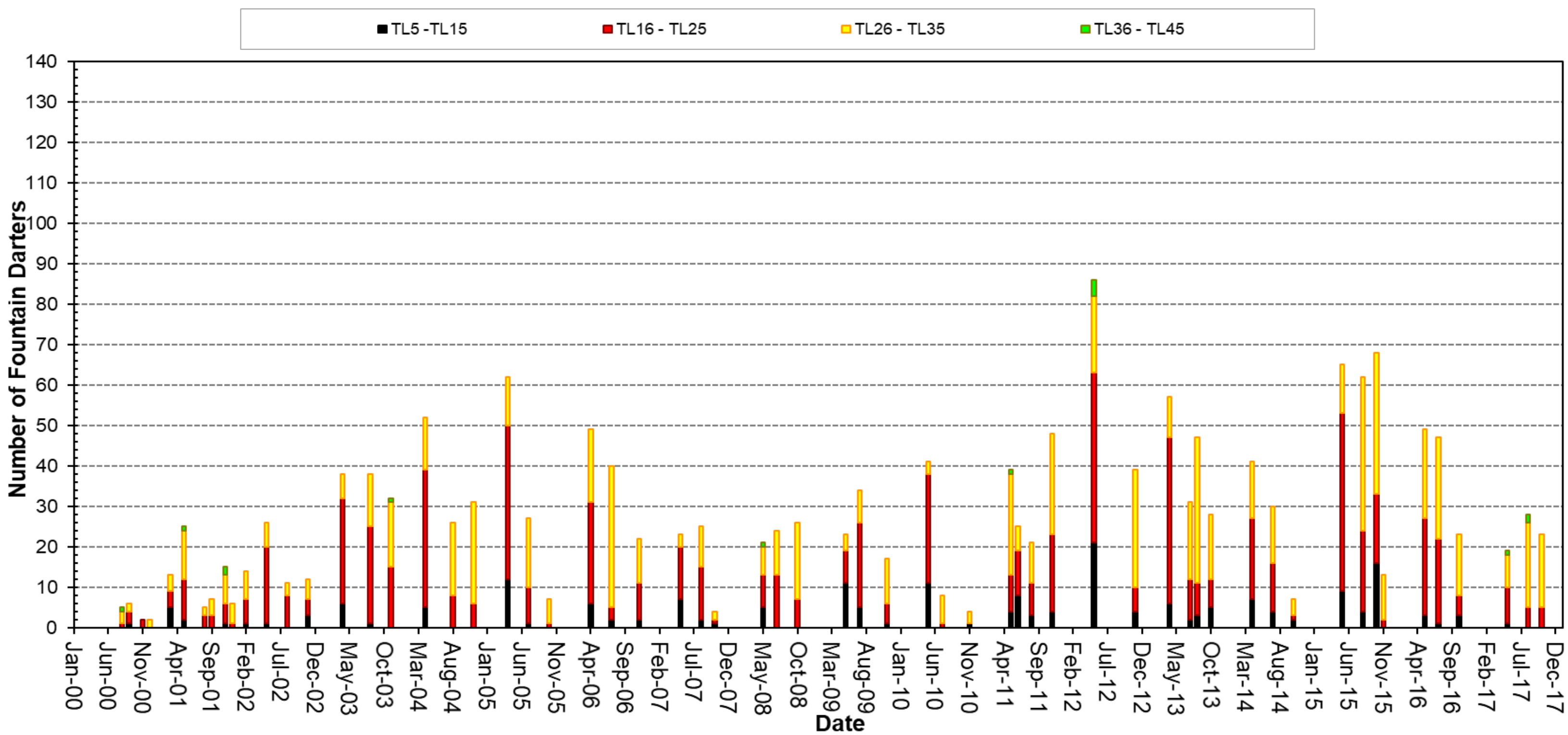
Sample type	Mean Density (m^2)	Standard Deviation
Open	0.8	3.10
Green Algae	2.2	3.19
Ceratopteris	3.6	4.32
Sagittaria	5.3	13.11
Vallisneria	6.0	10.24
Hygrophila	7.3	8.58
Cabomba	10.1	11.14
Ludwigia	13.3	15.91
Filamentous Algae	26.1	23.05
Bryophytes	26.7	19.65

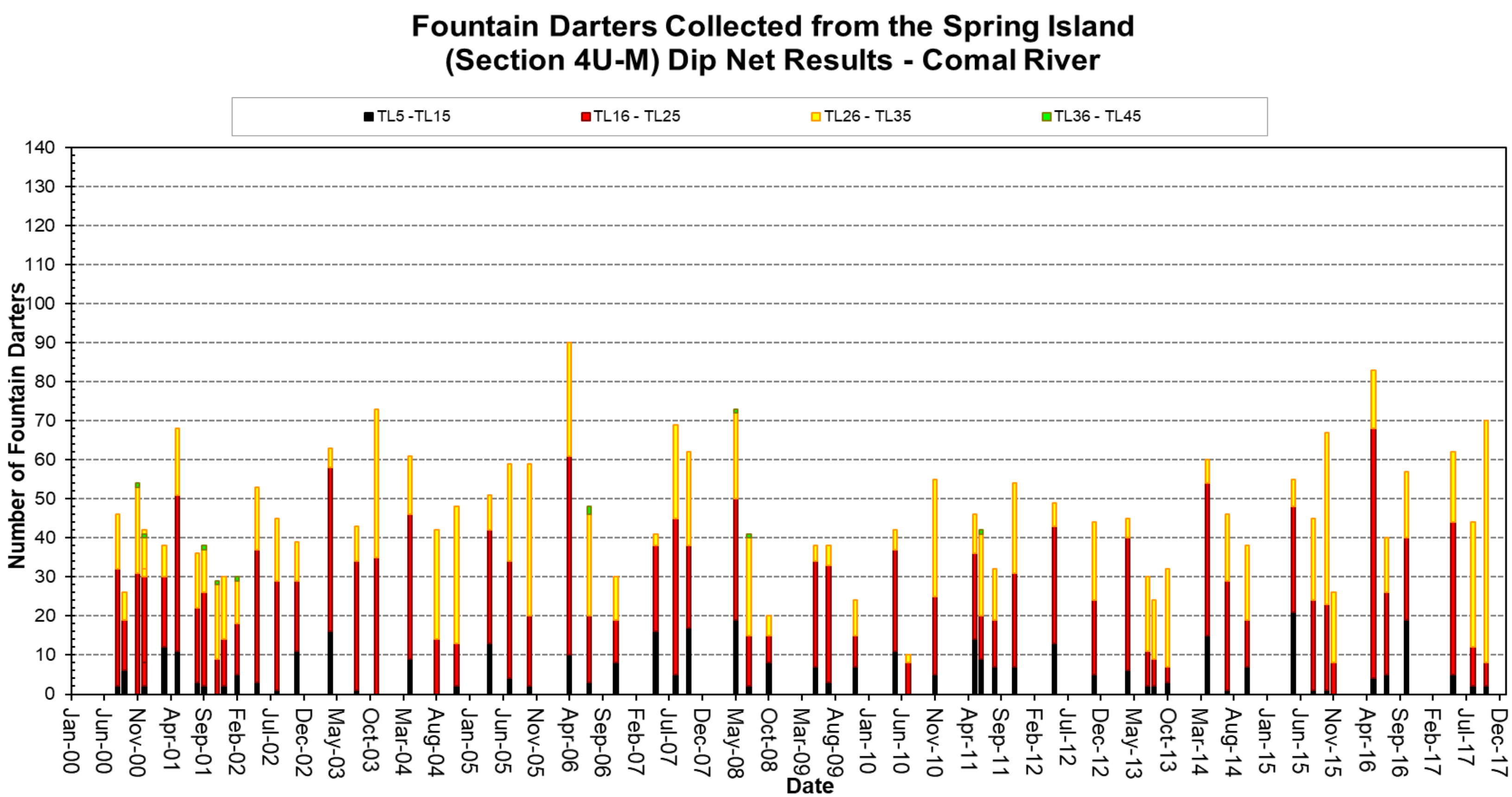
* Corresponds with Figure 25 in main body of the report.


Dropnet Results in Comal River 2000-2017
n=26,146
% Frequency
0
4
8
12
16
20
4
8
12
16
20
24
28
32
36
40
44
48
52
Total Length (mm)

C.3: Dip Net Graphs

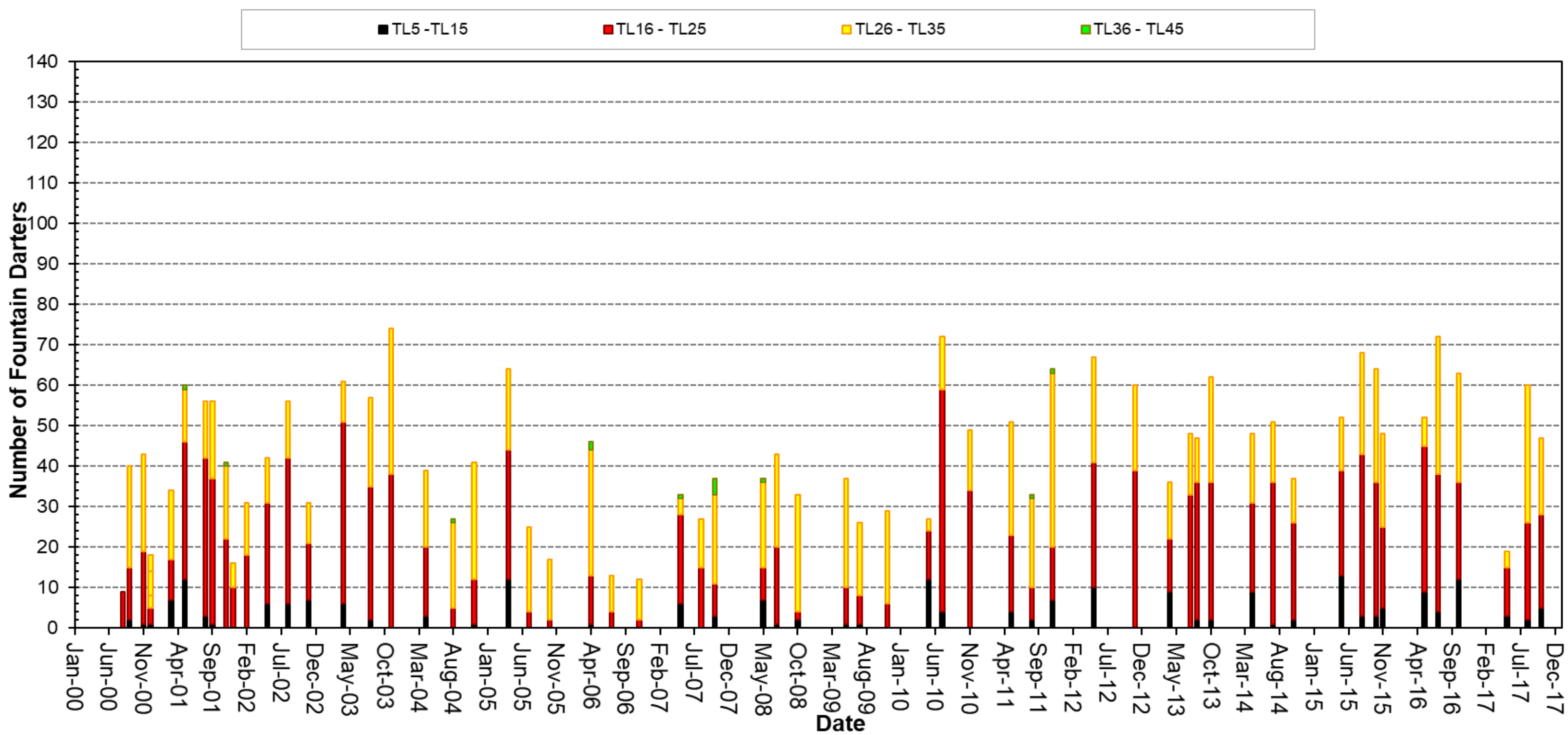
Fountain Darters Collected from the Upper Spring Run (Section 3) Dip Net Results - Comal River

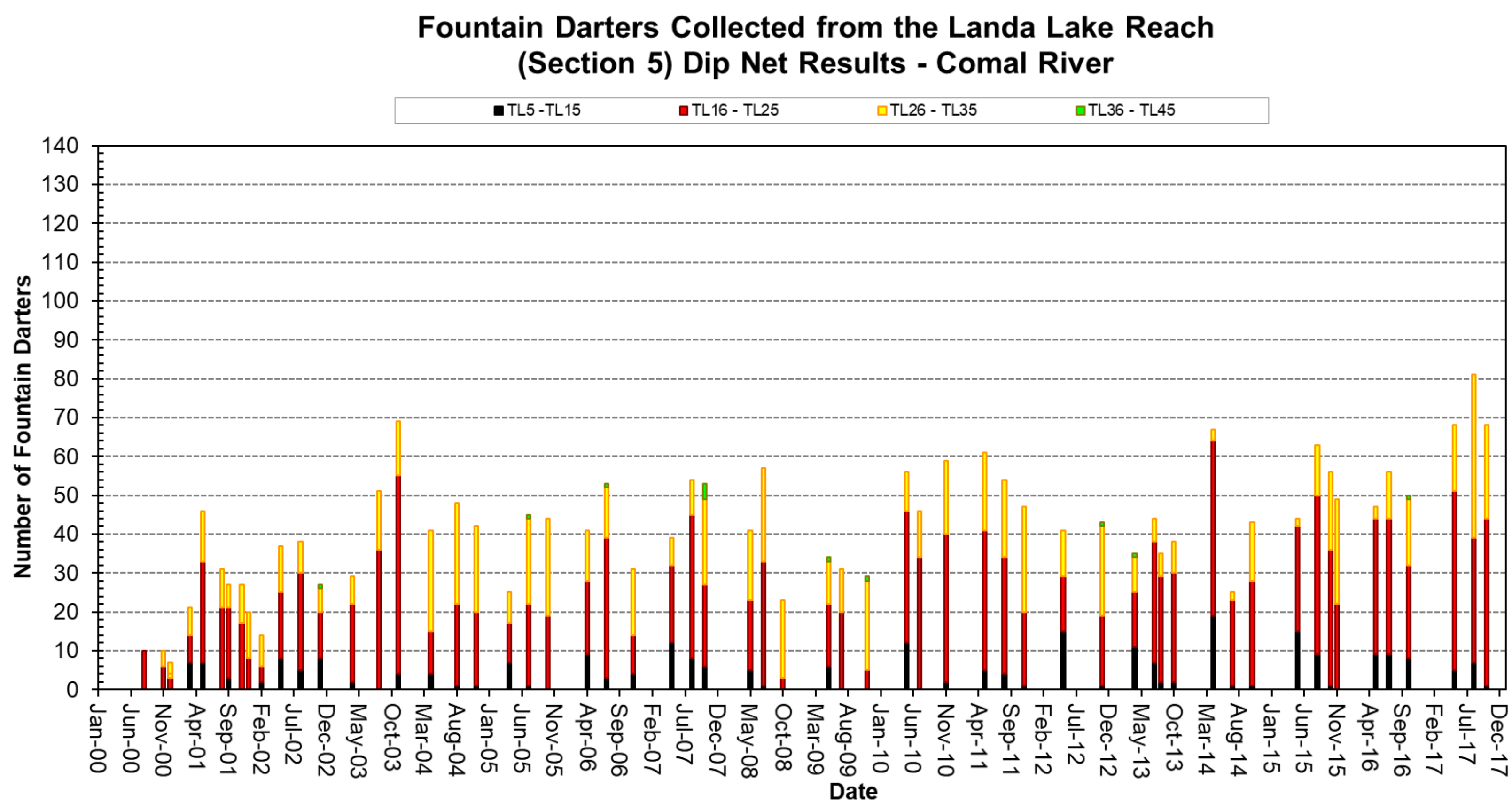




Fountain Darters Collected from the Spring Island
(Section 4U-M) Dip Net Results - Comal River
TL5 -TL15
TL16 - TL25
TL26 - TL35
TL36 - TL45
Number of Fountain Darters
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan-00
Jun-00
Nov-00
Apr-01
Sep-01
Feb-02
Jul-02
Dec-02
May-03
Oct-03
Mar-04
Aug-04
Jan-05
Jun-05
Nov-05
Apr-06
Sep-06
Feb-07
Jul-07
Dec-07
May-08
Oct-08
Mar-09
Aug-09
Jan-10
Jun-10
Nov-10
Apr-11
Sep-11
Feb-12
Jul-12
Dec-12
May-13
Oct-13
Mar-14
Aug-14
Jan-15
Jun-15
Nov-15
Apr-16
Sep-16
Feb-17
Jul-17
Dec-17
Date

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





Fountain Darters Collected from the Landa Lake Reach
(Section 5) Dip Net Results - Comal River
TL5 -TL15
TL16 - TL25
TL26 - TL35
TL36 - TL45
Number of Fountain Darters
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Jan-00
Jun-00
Nov-00
Apr-01
Sep-01
Feb-02
Jul-02
Dec-02
May-03
Oct-03
Mar-04
Aug-04
Jan-05
Jun-05
Nov-05
Apr-06
Sep-06
Feb-07
Jul-07
Dec-07
May-08
Oct-08
Mar-09
Aug-09
Jan-10
Jun-10
Nov-10
Apr-11
Sep-11
Feb-12
Jul-12
Dec-12
May-13
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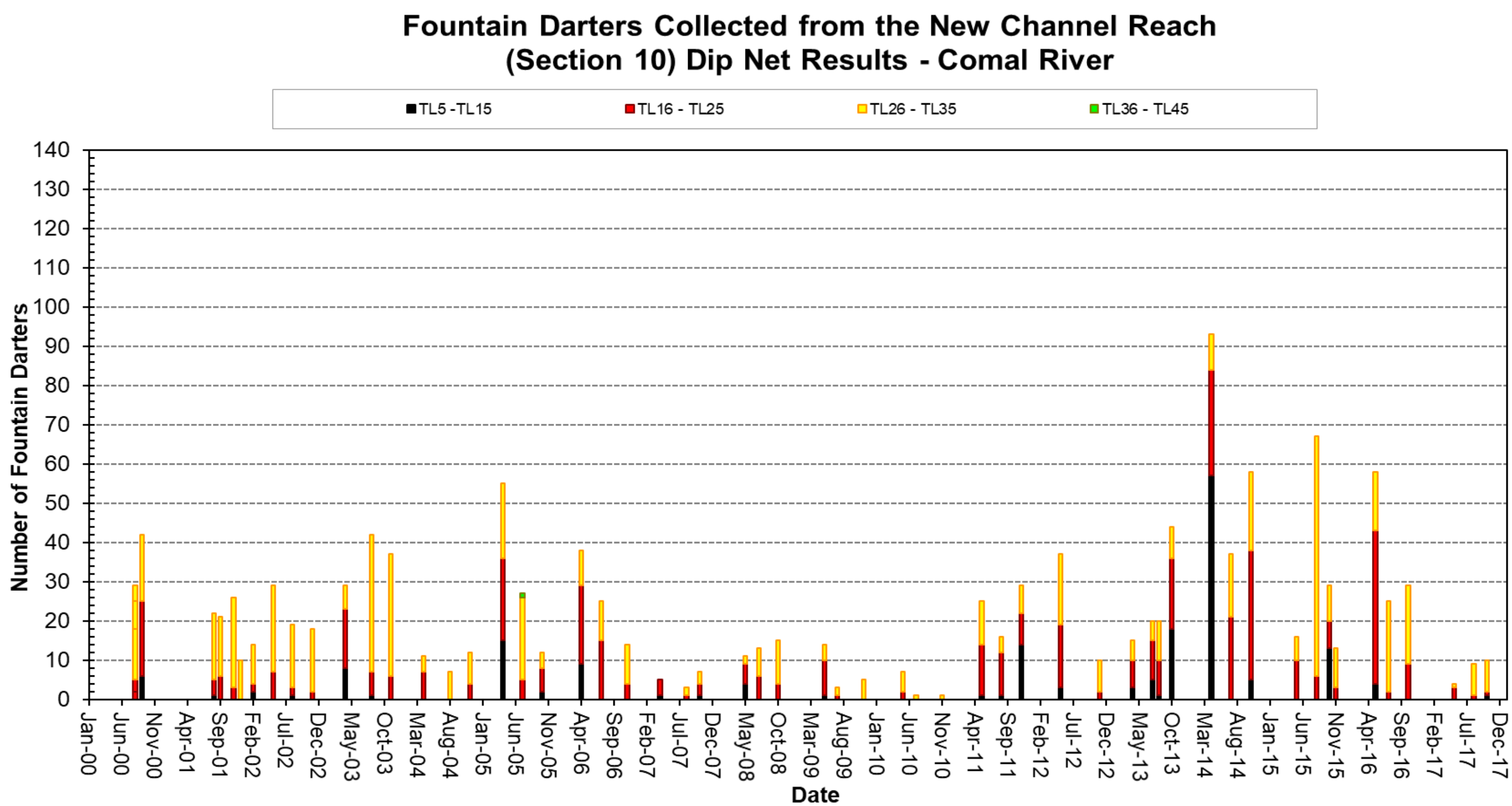
Jun-15
Nov-15
Apr-16
Sep-16
Feb-17
Jul-17
Dec-17
Date



Fountain Darters Collected from the New Channel Reach
(Section 10) Dip Net Results - Comal River
TL5 -TL15
TL16 - TL25
TL26 - TL35
TL36 - TL45
Number of Fountain Darters
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan-00
Jun-00
Nov-00
Apr-01
Sep-01
Feb-02
Jul-02
Dec-02
May-03
Oct-03
Mar-04
Aug-04
Jan-05
Jun-05
Nov-05
Apr-06
Sep-06
Feb-07
Jul-07
Dec-07
May-08
Oct-08
Mar-09
Aug-09
Jan-10
Jun-10
Nov-10
Apr-11
Sep-11
Feb-12
Jul-12
Dec-12
May-13
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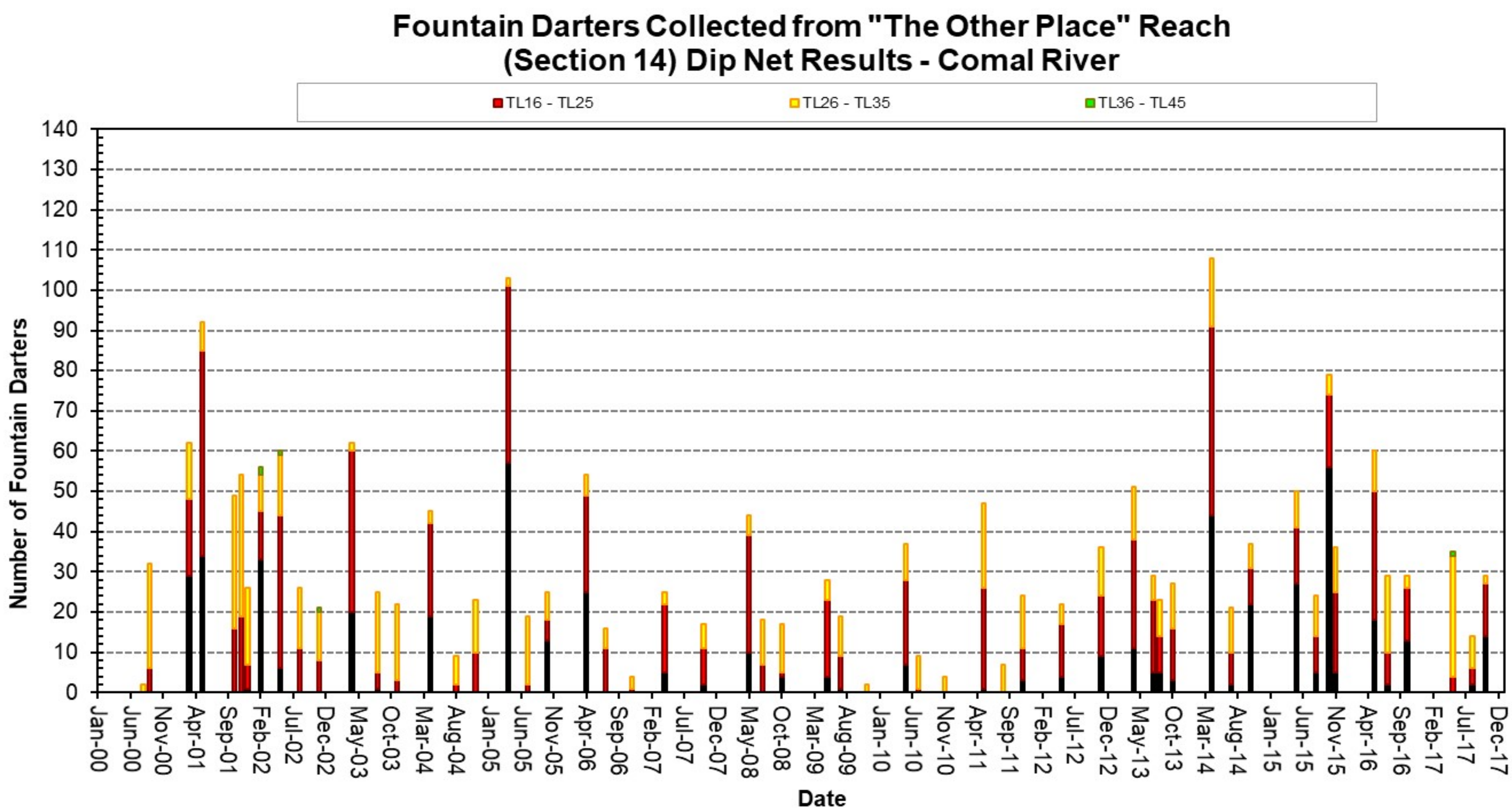
Feb-17
Jul-17
Dec-17
Date


Fountain Darters Collected from "The Other Place" Reach
(Section 14) Dip Net Results - Comal River
TL16 - TL25
TL26 - TL35
TL36 - TL45
Number of Fountain Darters
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Jan-00
Jun-00
Nov-00
Apr-01
Sep-01
Feb-02
Jul-02
Dec-02
May-03
Oct-03
Mar-04
Aug-04
Jan-05
Jun-05
Nov-05
Apr-06
Sep-06
Feb-07
Jul-07
Dec-07
May-08
Oct-08
Mar-09
Aug-09
Jan-10
Jun-10
Nov-10
Apr-11
Sep-11
Feb-12
Jul-12
Dec-12
May-13
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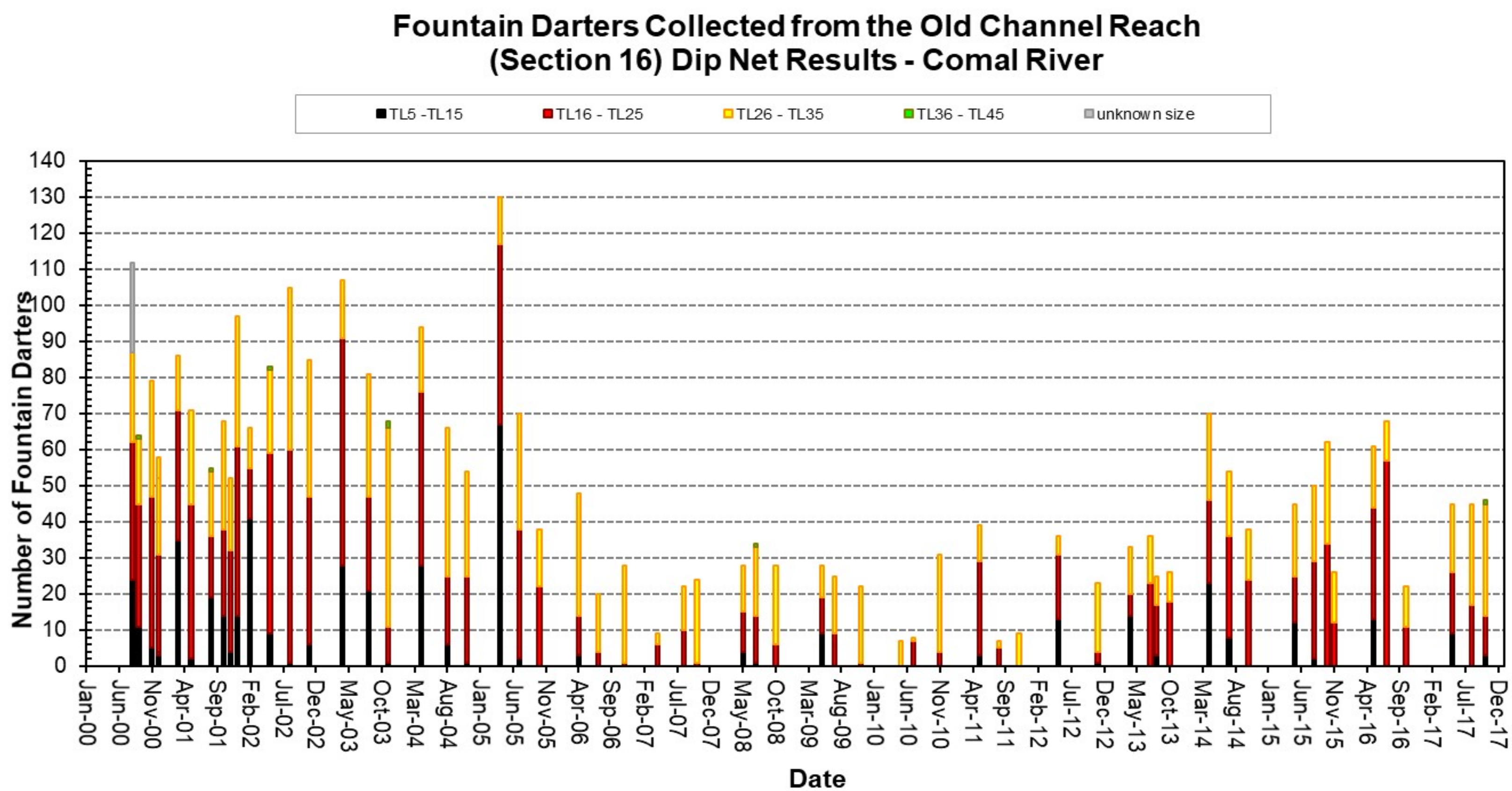
Aug-14
Jan-15
Jun-15
Nov-15
Apr-16
Sep-16
Feb-17
Jul-17
Dec-17
Date



Fountain Darters Collected from the Old Channel Reach
(Section 16) Dip Net Results - Comal River
TL5 -TL15
TL16 - TL25
TL26 - TL35
TL36 - TL45
unknown size
Number of Fountain Darters
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Jan-00
Jun-00
Nov-00
Apr-01
Sep-01
Feb-02
Jul-02
Dec-02
May-03
Oct-03
Mar-04
Aug-04
Jan-05
Jun-05
Nov-05
Apr-06
Sep-06
Feb-07
Jul-07
Dec-07
May-08
Oct-08
Mar-09
Aug-09
Jan-10
Jun-10
Nov-10
Apr-11
Sep-11
Feb-12
Jul-12
Dec-12
May-13
Oct-13
Mar-14
Aug-14
Jan-15
Jun-15
Nov-15
Apr-16
Sep-16
Feb-17
Jul-17
Dec-17
Date

C.4: Fish Tissue Sampling for Pharmaceutical Chemicals

Water Sample Detections									
System	Sample Location	Sample Type (n=2)	Acetaminophen (ng/L)	Benzoylecgonine (ng/L)	Caffeine (ng/L)	Diphenhydramine (ng/L)	Sucralose (ng/L)	Sulfamethoxazole (ng/L)
Comal	Landa Park Gazebo	water			*0.35**	0.46	199.50	0.62
Comal	Landa Park USGS gage	water			*0.35**		134.80	0.77
Comal	Lower River	water	0.65	*0.13*	1.83	0.19	7.22	0.67
Comal	Comal River RV Park	water	*0.235**		1.66	0.22	136.00	0.73

Notes: *Values indicate samples with detections below the method detection limit (MDL). In these cells, 1/2 MDL value has been inserted.

Not detected:
Amitriptyline
Amlodipine
Aripiprazole
Buprenorphine
Carbamazepine
Desmethylsertraline
Diclofenac
Diltiazem
Duloxetine
Erythromycin
Fluoxetine
Ketamine
Methylphenidate
Norfluoxetine
Propranolol
Promethazine
Sertraline
Sucralose
Trimethoprim

Plasma Sample Detections								
System	Sample Location	Fish Type	Sample type	Volume (µL)	Caffeine (ng/mL)	Diltiazem (ng/mL)	Sertraline (ng/mL)	Trimethoprim (ng/mL)
Comal	Landa Park	Largemouth Bass	plasma	500	*0.44**	0.39	0.57	
Comal	Landa Park	Largemouth Bass	plasma	500	*0.44**	0.41	0.53	
Comal	Landa Park	Largemouth Bass	plasma	434	*0.44**	0.46	0.72	5.63
Comal	Landa Park	Largemouth Bass	plasma	330	*0.44**	0.70	0.92	*0.18**

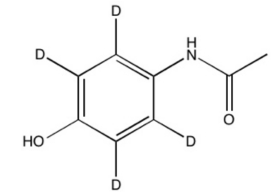
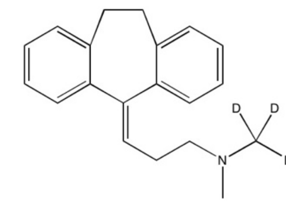
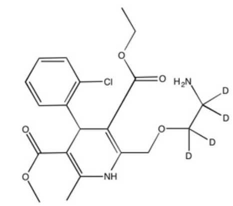
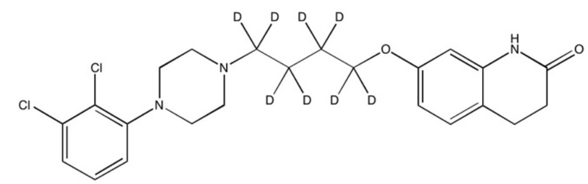
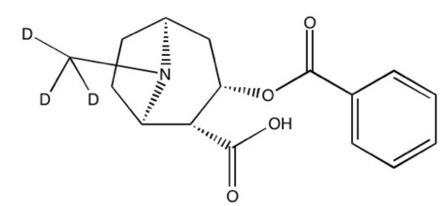
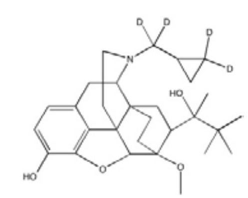
Notes: *Values indicate samples with detections below the method detection limit (MDL). In these cells, 1/2 MDL value has been inserted.

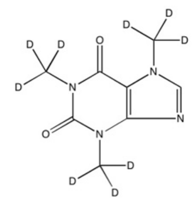
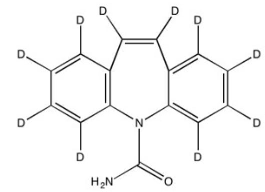
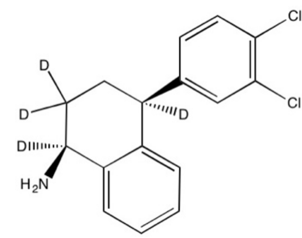
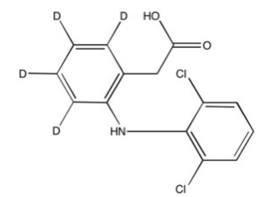
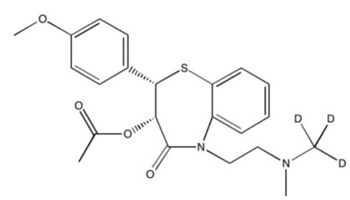
Not detected:
Acetaminophen
Amitriptyline
Amlodipine
Aripiprazole
Benzoylecgonine
Buprenorphine
Carbamazepine
Desmethylsertraline
Diclofenac
Diphenhydramine
Duloxetine
Erythromycin
Fluoxetine
Ketamine
Methylphenidate
Norfluoxetine
Promethazine
Propranolol
Sucralose
Sulfamethoxazole

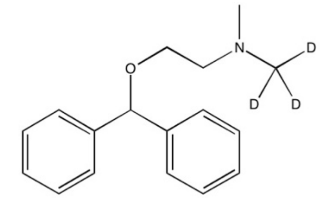
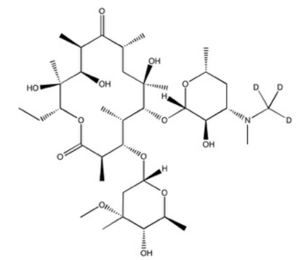
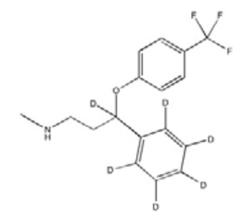
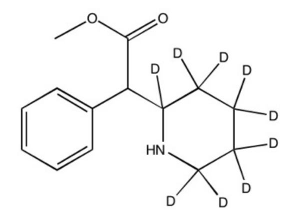
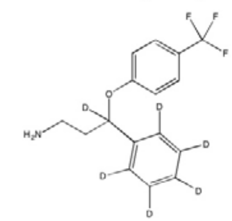
Tissue Sample Detections												
System	Sample Location	Fish Type	Sample type	Length (cm)	Weight (g)	Caffeine (µg/kg)	Diltiazem (µg/kg)	Diphen-hydramine (µg/kg)	Fluoxetine (µg/kg)	Norfluox-etine (µg/kg)	Sertra-line (µg/kg)	Trimetho-prim (µg/kg)
Comal	Landa Park	Largemouth Bass	tissue	20.80	105.10		0.46	0.24	0.70	1.09	1.15	
Comal	Landa Park	Largemouth Bass	tissue	24.30	161.00		0.41	0.25	0.48	*0.355**	1.07	
Comal	Landa Park	Largemouth Bass	tissue	20.20	99.50		0.34				*0.495**	0.65
Comal	Landa Park	Largemouth Bass	tissue	20.40	96.30		0.33		0.40	*0.355**	1.06	
Comal	Landa Park	Largemouth Bass	tissue									
Comal	Landa Park	Gambusia sp.	tissue, pooled			1.28		0.18				0.58
Comal	Comal River RV Park	Sunfish sp.	tissue	14.10	52.00		0.69					
Comal	Comal River RV Park	Sunfish sp.	tissue	12.90	39.20		0.29	0.21	0.37			
Comal	Comal River RV Park	Sunfish sp.	tissue	13.10	40.00		0.33					
Comal	The Other Place	Largemouth Bass	tissue				0.23					0.65
Comal	The Other Place	Gambusia sp.	tissue, pooled			0.76		0.32				

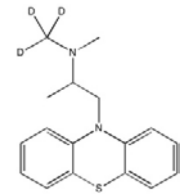
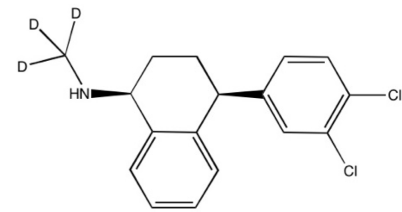
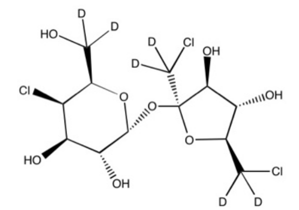
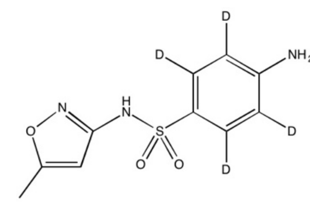
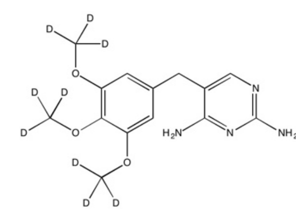
Notes: *Values indicate samples with detections below the method detection limit (MDL). In these cells, 1/2 MDL value has been inserted.

Not detected:
Acetaminophen
Amitriptyline
Amlodipine
Aripiprazole
Benzoylecgonine
Buprenorphine
Carbamazepine
Desmethylsertraline
Diclofenac
Duloxetine
Erythromycin
Ketamine
Methylphenidate
Promethazine
Propranolol
Sucralose
Sulfamethoxazole

Analyte	Precursor Ion (m/z)	Product Ion (m/z)	Fragmentor (V)	Collision Energy (V)	Retention Time	Class	Structure (deuterated)
Acetaminophen	152.1 $[M+H]^+$	**110**, 65.2	100	**16**, 36	2.4	Analgesic	
Acetaminophen-d_4	156.1 $[M+H]^+$	114.1	100	16			
Amitriptyline	278.2 $[M+H]^+$	**117**, 105.1	120	24	8.8	Antidepressant	
Amitriptyline-d_3	281.2 $[M+H]^+$	117	120	24			
Amlodipine	409.2 $[M+H]^+$	**294**, 238	100	12	9.7	Calcium Channel Blocker	
Amlodipine-d_4	413.2 $[M+H]^+$	238	110	12			
Aripiprazole	448.2 $[M+H]^+$	**285**, 176	170	**28**, 36	9.1	Antipsychotic	
Aripiprazole-d_8	456.2 $[M+H]^+$	293.1	170	28			
Benzoylecgonine	290.1 $[M+H]^+$	**168**, 105	125	**20**, 32	4.5	Cocaine Metabolite	
Benzoylecgonine-d_3	293.2 $[M+H]^+$	171	120	20			
Buprenorphine	468.3 $[M+H]^+$	**396.1**, 55.2	170	**44**, 50	6.9	Narcotic	
Buprenorphine-d_4	472.3 $[M+H]^+$	59.3	170	50			

Analyte	Precursor Ion (m/z)	Product Ion (m/z)	Fragmentor (V)	Collision Energy (V)	Retention Time	Class	Structure (deuterated)
Caffeine	195.1 $[M+H]^+$	**138**, 110.1	120	**20**, 24	4.3	Stimulant	
Caffeine-d_9	204.1 $[M+H]^+$	144	120	20			
Carbamazepine	237.1 $[M+H]^+$	**194**, 179	120	**20**, 40	8.2	Anti-seizure	
Carbamazepine-d_{10}	247.2 $[M+H]^+$	204.1	125	20			
Desmethylsertraline	275 $[M+H-NH3]^+$	**158.9**, 129	100	**20**, 12	11	Sertraline Metabolite	
Desmethylsertraline-d_4	279.1 $[M+H-NH3]^+$	160.3	105	20			
Diclofenac	294 $[M+H]^-$	**249.8**	75	8	14.3	Anti-inflammatory	
Diclofenac-d_4	299 $[M+H]^-$	254.8	80	8			
Diltiazem	415.2 $[M+H]^+$	**150**, 178	140	**50**, 25	7.3	Anti-hypertension	
Diltiazem-d_3	418.2 $[M+H]^+$	177.9	135	28			

Analyte	Precursor Ion (m/z)	Product Ion (m/z)	Fragmentor (V)	Collision Energy (V)	Retention Time	Class	Structure (deuterated)
Diphenhydramine	256.2 $[M+H]^+$	**167**, 152	80	**8**, 44	6.1	Antihistamine	
Diphenhydramine-d_3	259.2 $[M+H]^+$	167	85	8			
Erythromycin	717.5 $[M+H-H_2O]^+$	**559.3**, 158	152	**17**, 33	11.3	Antibiotic	
Erythromycin-d_3	721.5 $[M+H-H_2O]^+$	363.3	152	17			
Fluoxetine	310.1 $[M+H]^+$	**148**, 44.3	90	**4**, 12	9.6	Antidepressant	
Fluoxetine-d_6	316.2 $[M+H]^+$	154	90	4			
Methylphenidate	234.1 $[M+H]^+$	**84.2**, 56.2	110	**20**, 50	4.7	Psychostimulant	
Methylphenidate-d_9	243.2 $[M+H]^+$	93.2	110	24			
Norfluoxetine	296.1 $[M+H]^+$	**134**, 105	80	**0**, 29	9.6	Fluoxetine Metabolite	
Norfluoxetine-d_6	302.2 $[M+H]^+$	140	75	0			

Analyte	Precursor Ion (m/z)	Product Ion (m/z)	Fragmentor (V)	Collision Energy (V)	Retention Time	Class	Structure (deuterated)
Promethazine	285.1 $[M+H]^+$	**198**, 86.2	100	**28**, 16	7.2	Antihistamine	
Promethazine-d_3	288.2 $[M+H]^+$	198	105	28			
Sertraline	306.1 $[M+H]^+$	**274.9**, 158.9	80	**8**, 28	10.6	Antidepressant	
Sertraline-d_3	309.1 $[M+H]^+$	274.9	80	8			
Sucralose	419 $[M+NA]^+$	**238.9**, 220.9	140	20	4.3	Artificial Sweetener	
Sucralose-d_6	425 $[M+NA]^+$	242.9	140	20			
Sulfamethoxazole	254 $[M+H]^+$	**155.9**, 92	103	**13**, 33	4.4	Antibiotic	
Sulfamethoxazole-d_4	258 $[M+H]^+$	159.9	103	13			
Trimethoprim	291.1 $[M+H]^+$	**230**, 123	152	**25**, 41	4.0	Antibiotic	
Trimethoprim-d_9	300.2 $[M+H]^+$	234	152	25			

C.5: Macroinvertebrate Rapid Bioassessment Data

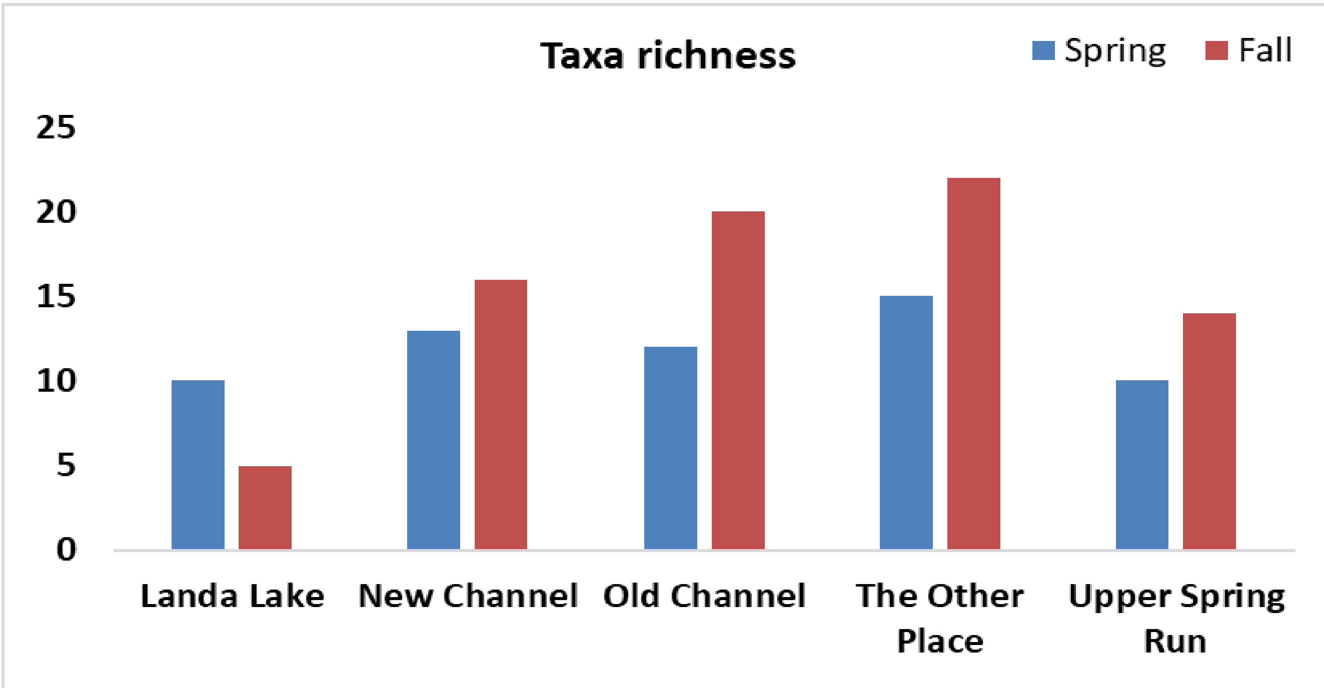
Spring

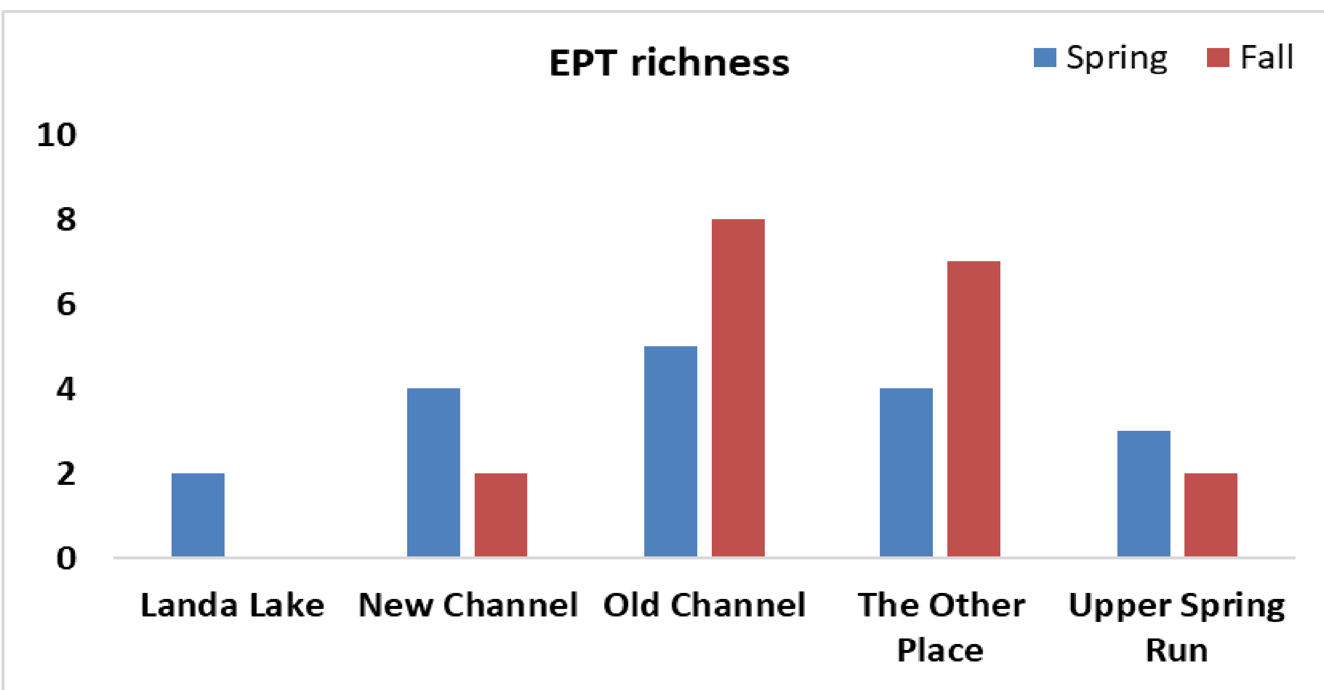
Date	Site	Class	Order	Family	FinalID	No.	Tolerance Value	Functional Feeding Guild 1	Functional Feeding Guild 2
5/18/2017	New Channel	Insecta	Odonata	Coenagrionidae	Enallagma	1	6	Predator	
5/18/2017	New Channel	Insecta	Coleoptera	Hydrophilidae	Helochares	1	5	Gather/Collector	
5/18/2017	New Channel	Insecta	Trichoptera	Hydroptilidae	Hydroptila	1	2	Scraper	
5/18/2017	New Channel	Insecta	Lepidoptera	Pyralidae	Parapoynx	1	5	Shredder	
5/18/2017	New Channel	Insecta	Diptera	Simuliidae	Simulium	1	4	Filterer/Collector	
5/18/2017	New Channel	Insecta	Odonata	Coenagrionidae	Argia	2	6	Predator	
5/18/2017	New Channel	Insecta	Trichoptera	Hydrobiosidae	Atopsyche	2	0	Predator	
5/18/2017	New Channel	Clitellata			Oligochaeta	2	8	Gather/Collector	
5/18/2017	New Channel	Insecta	Coleoptera	Elmidae	Microcylloepus	4	2	Gather/Collector	Scraper
5/18/2017	New Channel	Insecta	Coleoptera	Psephinidae	Psephenus	7	4	Scraper	
5/18/2017	New Channel	Insecta	Trichoptera	Hydroptilidae	Leucotrichia	8	3	Gather/Collector	Scraper
5/18/2017	New Channel	Malacostraca	Amphipoda	Talitridae	Hyalella	31	8	Gather/Collector	Shredder
5/18/2017	New Channel	Insecta	Ephemeroptera	Baetidae	Fallceon	88	4	Gather/Collector	Scraper
5/18/2017	Upper Spring Run	Insecta	Ephemeroptera	Baetidae	Fallceon	1	4	Gather/Collector	Scraper
5/18/2017	Upper Spring Run	Insecta	Odonata	Coenagrionidae	Enallagma	1	6	Predator	
5/18/2017	Upper Spring Run	Gastropoda	Neotaenioglossa	Thiaridae	Melanoides tuberculata	1		Scraper	
5/18/2017	Upper Spring Run	Clitellata			Oligochaeta	1	8	Gather/Collector	
5/18/2017	Upper Spring Run	Insecta	Ephemeroptera	Tricorythidae	Tricorythodes	4	5	Gather/Collector	
5/18/2017	Upper Spring Run	Gastropoda	Neotaenioglossa	Thiaridae	Terabia	13		Scraper	
5/18/2017	Upper Spring Run	Insecta	Ephemeroptera	Baetidae	Callibaetis	14	4	Gather/Collector	
5/18/2017	Upper Spring Run	Gastropoda	Neotaenioglossa	Pleuroceridae	Elimia	15	2.5	Scraper	
5/18/2017	Upper Spring Run		Decopoda	Cambaridae	Cambaridae	65	5	Gather/Collector	
5/18/2017	Upper Spring Run	Malacostraca	Amphipoda	Talitridae	Hyalella	74	8	Gather/Collector	Shredder
5/19/2017	Landa Lake	Gastropoda	Neotaenioglossa	Thiaridae	Melanoides tuberculata	1		Scraper	
5/19/2017	Landa Lake	Clitellata			Oligochaeta	1	8	Gather/Collector	
5/19/2017	Landa Lake	Gastropoda	Neotaenioglossa	Pleuroceridae	Elimia	2	2.5	Scraper	
5/19/2017	Landa Lake	Insecta	Ephemeroptera	Tricorythidae	Tricorythodes	3	5	Gather/Collector	
5/19/2017	Landa Lake	Gastropoda	Neotaenioglossa	Thiaridae	Terabia	3		Scraper	
5/19/2017	Landa Lake		Decopoda	Cambaridae	Cambaridae	6	5	Gather/Collector	
5/19/2017	Landa Lake	Malacostraca	Decapoda	Palaemonidae	Palaemonetes	6	4	Gather/Collector	
5/19/2017	Landa Lake	Insecta	Coleoptera	Psephinidae	Psephenus	14	4	Scraper	
5/19/2017	Landa Lake	Insecta	Ephemeroptera	Baetidae	Callibaetis	21	4	Gather/Collector	
5/19/2017	Landa Lake	Malacostraca	Amphipoda	Talitridae	Hyalella	71	8	Gather/Collector	Shredder
5/19/2017	Old Channel	Insecta	Ephemeroptera	Leptohyphidae	Vacupernius packeri	1	4	Gather/Collector	
5/19/2017	Old Channel	Insecta	Ephemeroptera	Leptophlebiidae	Thraulodes	1	2	Gather/Collector	
5/19/2017	Old Channel	Insecta	Ephemeroptera	Heptageniidae	Stenacron	1	4	Gather/Collector	Scraper
5/19/2017	Old Channel	Clitellata			Hirudinea	1	8	Predator	
5/19/2017	Old Channel	Insecta	Ephemeroptera	Tricorythidae	Tricorythodes	2	5	Gather/Collector	
5/19/2017	Old Channel	Insecta	Odonata	Coenagrionidae	Argia	2	6	Predator	
5/19/2017	Old Channel	Insecta	Diptera	Chironomidae	Chironomidae	2	6	Gather/Collector	Filterer/Collector
5/19/2017	Old Channel	Clitellata			Oligochaeta	2	8	Gather/Collector	
5/19/2017	Old Channel	Gastropoda	Neotaenioglossa	Thiaridae	Terabia	4		Scraper	
5/19/2017	Old Channel		Decopoda	Cambaridae	Cambaridae	15	5	Gather/Collector	
5/19/2017	Old Channel	Malacostraca	Amphipoda	Talitridae	Hyalella	38	8	Gather/Collector	Shredder
5/19/2017	Old Channel	Insecta	Ephemeroptera	Ephemeridae	Hexagenia	49	6	Gather/Collector	
5/19/2017	The Other Place	Insecta	Trichoptera	Leptoceridae	Nectopsyche	1	3	Shredder	Gather/Collector
5/19/2017	The Other Place	Insecta	Trichoptera	Heliocopyschidae	Helicopsyche	1	2	Scraper	
5/19/2017	The Other Place	Insecta	Odonata	Calopterygidae	Hetaerina	1	6	Predator	
5/19/2017	The Other Place	Insecta	Odonata	Coenagrionidae	Argia	1	6	Predator	
5/19/2017	The Other Place	Insecta	Odonata	Coenagrionidae	Ischnura	1	9	Predator	
5/19/2017	The Other Place	Clitellata			Hirudinea	1	8	Predator	
5/19/2017	The Other Place	Insecta	Odonata	Coenagrionidae	Enallagma	3	6	Predator	
5/19/2017	The Other Place		Decopoda	Cambaridae	Cambaridae	3	5	Gather/Collector	
5/19/2017	The Other Place	Insecta	Diptera	Chironomidae	Chironomidae	5	6	Gather/Collector	Filterer/Collector
5/19/2017	The Other Place	Gastropoda	Neotaenioglossa	Thiaridae	Terabia	5		Scraper	
5/19/2017	The Other Place	Insecta	Ephemeroptera	Tricorythidae	Tricorythodes	6	5	Gather/Collector	
5/19/2017	The Other Place	Clitellata			Oligochaeta	6	8	Gather/Collector	
5/19/2017	The Other Place	Arachnida	Trombidiformes		Acari	13	6	Predator	
5/19/2017	The Other Place	Malacostraca	Amphipoda	Talitridae	Hyalella	14	8	Gather/Collector	Shredder
5/19/2017	The Other Place	Insecta	Ephemeroptera	Baetidae	Fallceon	25	4	Gather/Collector	Scraper

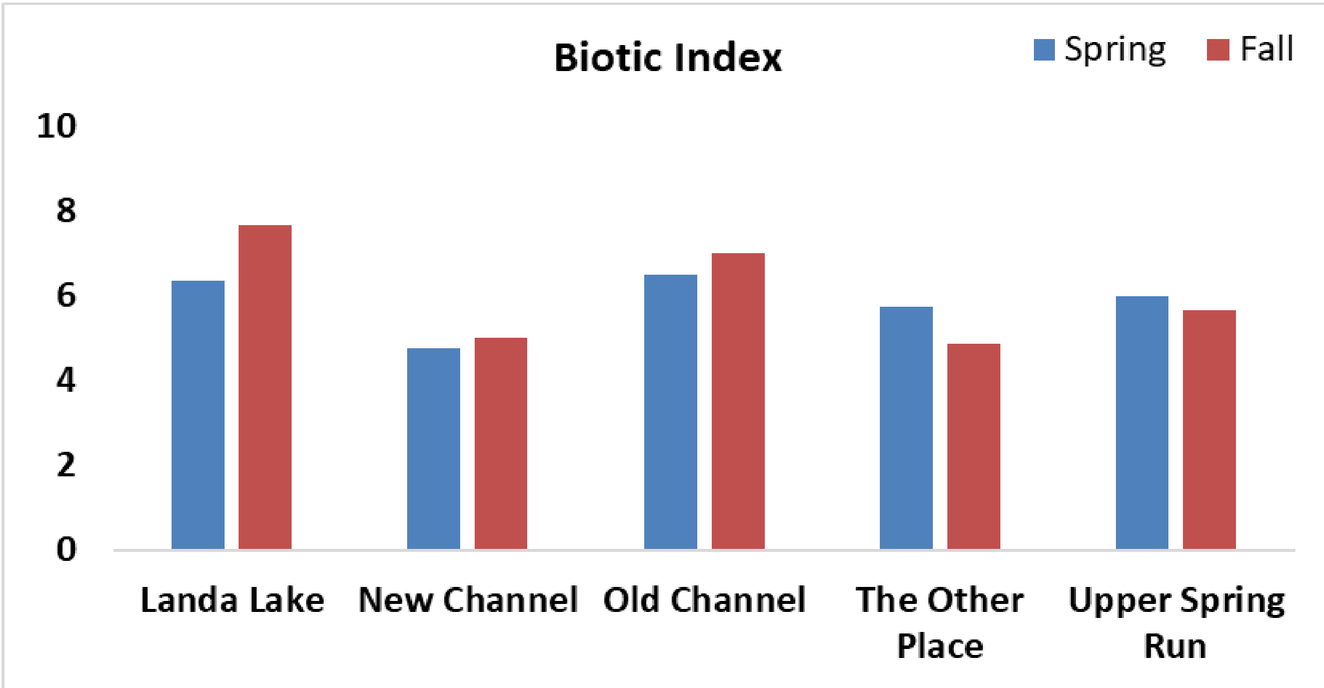
Fall

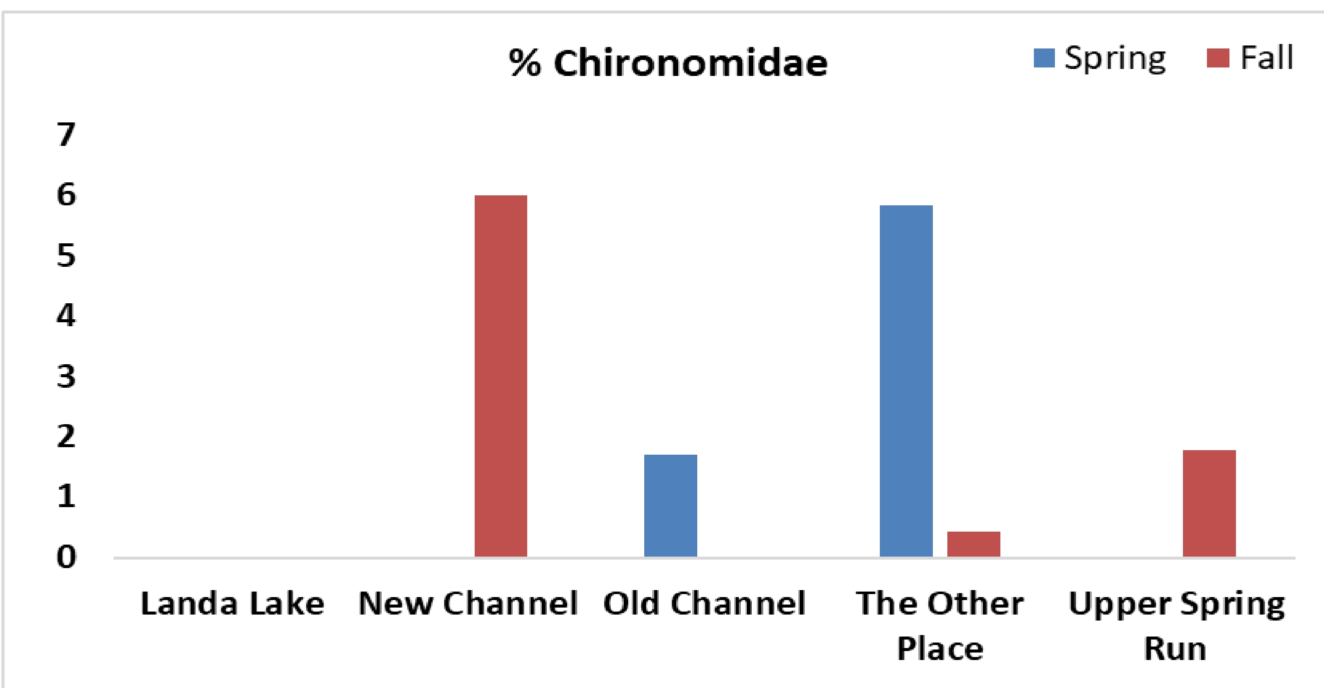
Date	Site	Class	Order	Family	FinalID	No.	Tolerance Value	Functional Feeding Guild 1	Functional Feeding Guild 2
10/19/2017	New Channel	Malacostraca	Amphipoda	Talitridae	Hyalella	7	8	Gather/Collector	Shredder
10/19/2017	New Channel	Insecta	Coleoptera	Psephinidae	Psephenus	36	4	Scraper	
10/19/2017	New Channel	Insecta	Coleoptera	Elmidae	Macrelmis	61	4	Scraper	
10/19/2017	New Channel	Gastropoda	Neotaenioglossa	Pleuroceridae	Elimia	4	2.5	Scraper	
10/19/2017	New Channel	Gastropoda	Neotaenioglossa	Thiaridae	Terabia	10		Scraper	
10/19/2017	New Channel	Insecta	Odonata	Libellulidae	Libellulidae	1		Predator	
10/19/2017	New Channel	Insecta	Odonata	Coenagrionidae	Argia	6	6	Predator	
10/19/2017	New Channel	Insecta	Coleoptera	Elmidae	Stenelmis	1	7	Gather/Collector	Scraper
10/19/2017	New Channel	Insecta	Coleoptera	Psephenidae	Ectopria	1	4	Scraper	
10/19/2017	New Channel	Clitellata			Hirudinea	2	8	Predator	
10/19/2017	New Channel	Insecta	Trichoptera	Heliocopyschidae	Helicopsyche	7	2	Scraper	
10/19/2017	New Channel	Turbellaria	Tricladida		Planariidae	6			
10/19/2017	New Channel	Insecta	Coleoptera	Elmidae	Microcylloepus	9	2	Gather/Collector	Scraper
10/19/2017	New Channel	Clitellata			Oligochaeta	21	8	Gather/Collector	
10/19/2017	New Channel	Insecta	Diptera	Chironomidae	Chironomidae	11	6	Gather/Collector	Filterer/Collector
10/19/2017	New Channel	Insecta	Ephemeroptera	Baetidae	Fallceon	5	4	Gather/Collector	Scraper
10/19/2017	Old Channel	Malacostraca	Amphipoda	Talitridae	Hyalella	127	8	Gather/Collector	Shredder
10/19/2017	Old Channel	Gastropoda	Neotaenioglossa	Thiaridae	Terabia	53		Scraper	
10/19/2017	Old Channel	Insecta	Coleoptera	Psephinidae	Psephenus	2	4	Scraper	
10/19/2017	Old Channel	Insecta	Odonata	Libellulidae	Libellulidae	1		Predator	
10/19/2017	Old Channel	Insecta	Ephemeroptera	Leptophlebiidae	Thraulodes	3	2	Gather/Collector	
10/19/2017	Old Channel	Insecta	Ephemeroptera	Tricorythidae	Tricorythodes	9	5	Gather/Collector	
10/19/2017	Old Channel	Insecta	Odonata	Coenagrionidae	Argia	7	6	Predator	
10/19/2017	Old Channel	Insecta	Ephemeroptera	Ephemeridae	Hexagenia	2	6	Gather/Collector	
10/19/2017	Old Channel	Insecta	Lepidoptera	Pyralidae	Petrophila	1	5	Scraper	
10/19/2017	Old Channel	Gastropoda	Neotaenioglossa	Hydrobiidae	Hydrobiidae	2	7	Scraper	
10/19/2017	Old Channel	Insecta	Ephemeroptera	Leptohyphidae	Vacupernius packeri	2	4	Gather/Collector	
10/19/2017	Old Channel	Insecta	Trichoptera	Heliocopyschidae	Helicopsyche	7	2	Scraper	
10/19/2017	Old Channel	Insecta	Ephemeroptera	Baetidae	Fallceon	2	4	Gather/Collector	Scraper
10/19/2017	Old Channel	Insecta	Diptera	Chironomidae	Chironomidae	1	6	Gather/Collector	Filterer/Collector
10/19/2017	Old Channel	Clitellata			Hirudinea	2	8	Predator	
10/19/2017	Old Channel	Arachnida	Trombidiformes		Acari	1	6	Predator	
10/19/2017	Old Channel	Clitellata			Oligochaeta	10	8	Gather/Collector	
10/19/2017	Old Channel	Insecta	Trichoptera	Hydropsychidae	Smicridea	1	4	Filterer/Collector	
10/19/2017	Old Channel	Insecta	Ephemeroptera	Heptageniidae	Stenacron	4	4	Gather/Collector	Scraper
10/19/2017	Old Channel	Insecta	Coleoptera	Elmidae	Hexacylloepus ferrugineus	3	2	Scraper	
10/19/2017	The Other Place	Malacostraca	Amphipoda	Talitridae	Hyalella	34	8	Gather/Collector	Shredder
10/19/2017	The Other Place	Bivalvia	Veneroida	Corbiculidae	Corbicula fluminea	1	6	Filterer/Collector	
10/19/2017	The Other Place	Insecta	Odonata	Aeshnidae	Basiaeschna janata	1	2	Predator	
10/19/2017	The Other Place	Gastropoda	Neotaenioglossa	Thiaridae	Terabia	81		Scraper	
10/19/2017	The Other Place	Insecta	Ephemeroptera	Tricorythidae	Tricorythodes	19	5	Gather/Collector	
10/19/2017	The Other Place	Insecta	Ephemeroptera	Baetidae	Fallceon	2	4	Gather/Collector	Scraper
10/19/2017	The Other Place	Insecta	Odonata	Coenagrionidae	Argia	4	6	Predator	
10/19/2017	The Other Place	Insecta	Coleoptera	Psephenidae	Ectopria	1	4	Scraper	
10/19/2017	The Other Place	Insecta	Coleoptera	Elmidae	Macrelmis	1	4	Scraper	
10/19/2017	The Other Place	Clitellata			Hirudinea	6	8	Predator	
10/19/2017	The Other Place	Insecta	Trichoptera	Heliocopyschidae	Helicopsyche	24	2	Scraper	
10/19/2017	The Other Place	Insecta	Coleoptera	Psephinidae	Psephenus	3	4	Scraper	
10/19/2017	The Other Place	Turbellaria	Tricladida		Planariidae	1			
10/19/2017	The Other Place	Insecta	Coleoptera	Elmidae	Microcylloepus	1	2	Gather/Collector	Scraper
10/19/2017	The Other Place	Arachnida	Trombidiformes		Acari	1	6	Predator	
10/19/2017	The Other Place	Gastropoda	Neotaenioglossa	Pleuroceridae	Elimia	8	2.5	Scraper	
10/19/2017	The Other Place	Clitellata			Oligochaeta	8	8	Gather/Collector	
10/19/2017	The Other Place	Insecta	Ephemeroptera	Leptophlebiidae	Thraulodes	6	2	Gather/Collector	
10/19/2017	The Other Place	Insecta	Trichoptera	Leptoceridae	Nectopsyche	19	3	Shredder	Gather/Collector
10/19/2017	The Other Place	Insecta	Diptera	Chironomidae	Chironomidae	1	6	Gather/Collector	Filterer/Collector
10/19/2017	The Other Place	Insecta	Trichoptera	Hydroptilidae	Oxyethira	1	2	Gather/Collector	
10/19/2017	The Other Place	Insecta	Ephemeroptera	Leptohyphidae	Vacupernius packeri	9	4	Gather/Collector	
10/20/2017	Landa Lake	Malacostraca	Amphipoda	Talitridae	Hyalella	210	8	Gather/Collector	Shredder
10/20/2017	Landa Lake	Gastropoda	Neotaenioglossa	Thiaridae	Terabia	198		Scraper	
10/20/2017	Landa Lake	Clitellata			Oligochaeta	6	8	Gather/Collector	
10/20/2017	Landa Lake	Gastropoda	Neotaenioglossa	Pleuroceridae	Elimia	13	2.5	Scraper	
10/20/2017	Landa Lake	Insecta	Coleoptera	Psephinidae	Psephenus	1	4	Scraper	
10/20/2017	Upper Spring Run	Insecta	Coleoptera	Psephinidae	Psephenus	86	4	Scraper	
10/20/2017	Upper Spring Run	Insecta	Odonata	Coenagrionidae	Argia	3	6	Predator	
10/20/2017	Upper Spring Run	Insecta	Coleoptera	Elmidae	Stenelmis	2	7	Gather/Collector	Scraper
10/20/2017	Upper Spring Run	Insecta	Coleoptera	Elmidae	Microcylloepus	1	2	Gather/Collector	Scraper
10/20/2017	Upper Spring Run	Malacostraca	Amphipoda	Crangonyctidae	Stygobromus	7			
10/20/2017	Upper Spring Run	Turbellaria	Tricladida		Planariidae	1			
10/20/2017	Upper Spring Run	Clitellata			Oligochaeta	16	8	Gather/Collector	
10/20/2017	Upper Spring Run	Insecta	Ephemeroptera	Baetidae	Fallceon	1	4	Gather/Collector	Scraper
10/20/2017	Upper Spring Run	Gastropoda	Neotaenioglossa	Thiaridae	Terabia	7		Scraper	
10/20/2017	Upper Spring Run	Gastropoda	Neotaenioglossa	Pleuroceridae	Elimia	17	2.5	Scraper	
10/20/2017	Upper Spring Run	Insecta	Diptera	Chironomidae	Chironomidae	4	6	Gather/Collector	Filterer/Collector
10/20/2017	Upper Spring Run	Insecta	Ephemeroptera	Tricorythidae	Tricorythodes	2	5	Gather/Collector	
10/20/2017	Upper Spring Run	Insecta	Coleoptera	Dytiscidae	Liodessus	8	5	Predator	
10/20/2017	Upper Spring Run	Malacostraca	Amphipoda	Talitridae	Hyalella	70	8	Gather/Collector	Shredder

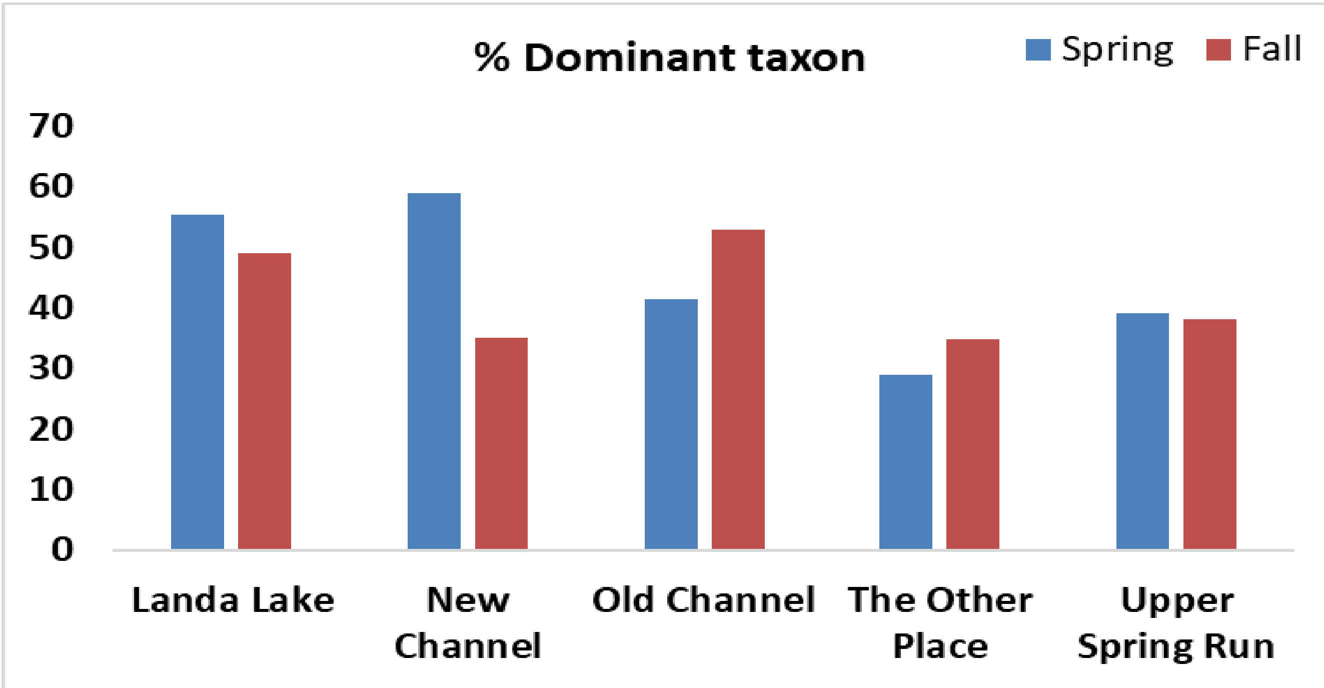
C.6: Benthic Macroinvertebrate Rapid Bioassessment Metrics

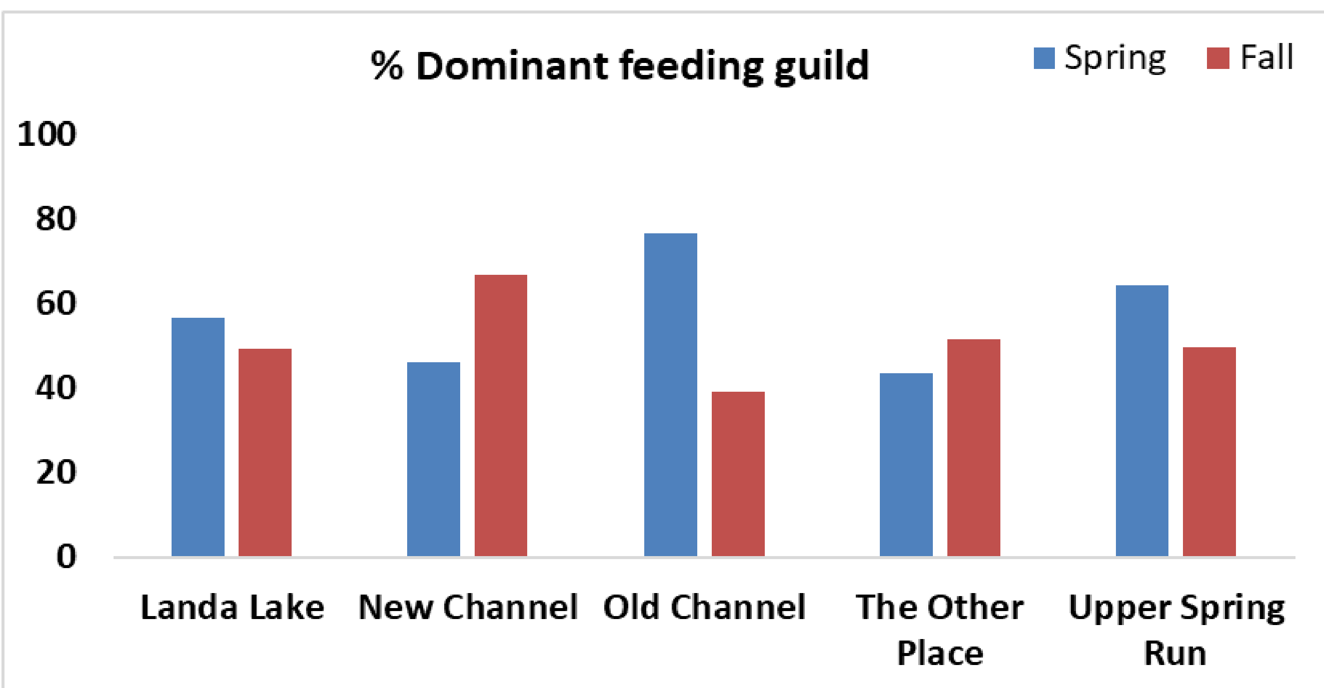

Taxa richness
Spring
Fall
25
20
15
10
5
0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run

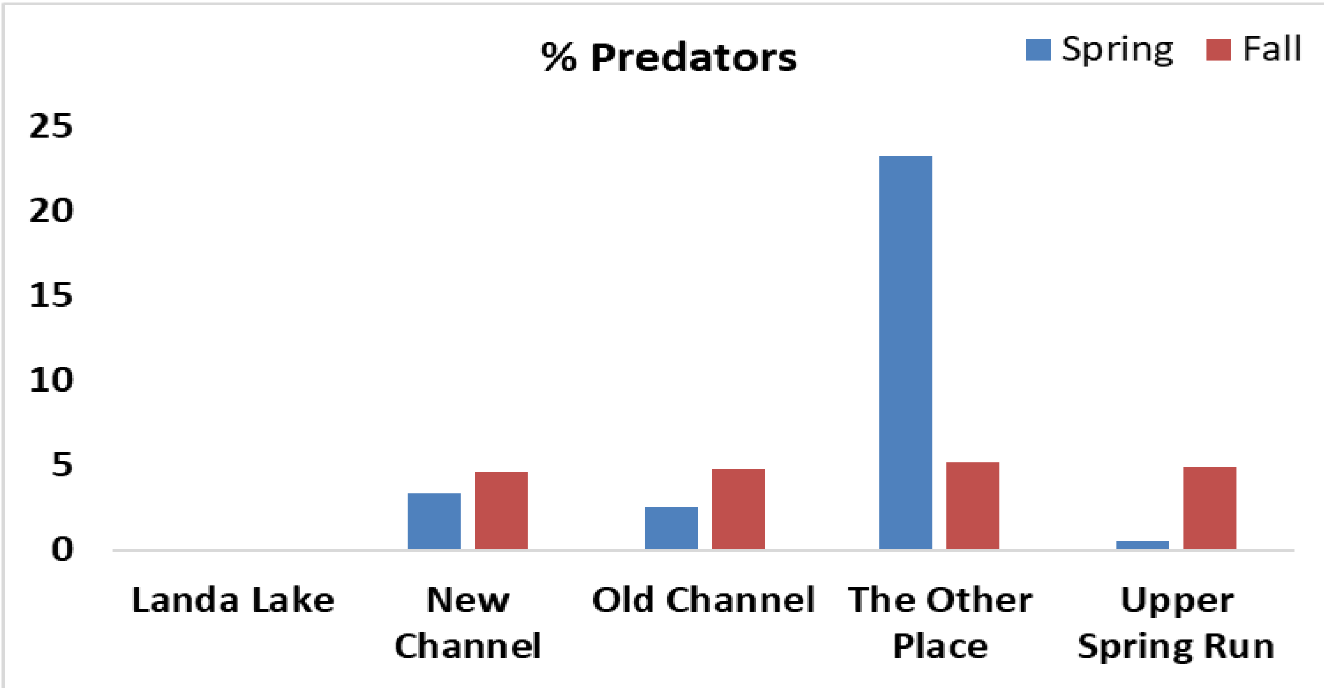

EPT richness
Spring
Fall
10
8
6
4
2
0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run

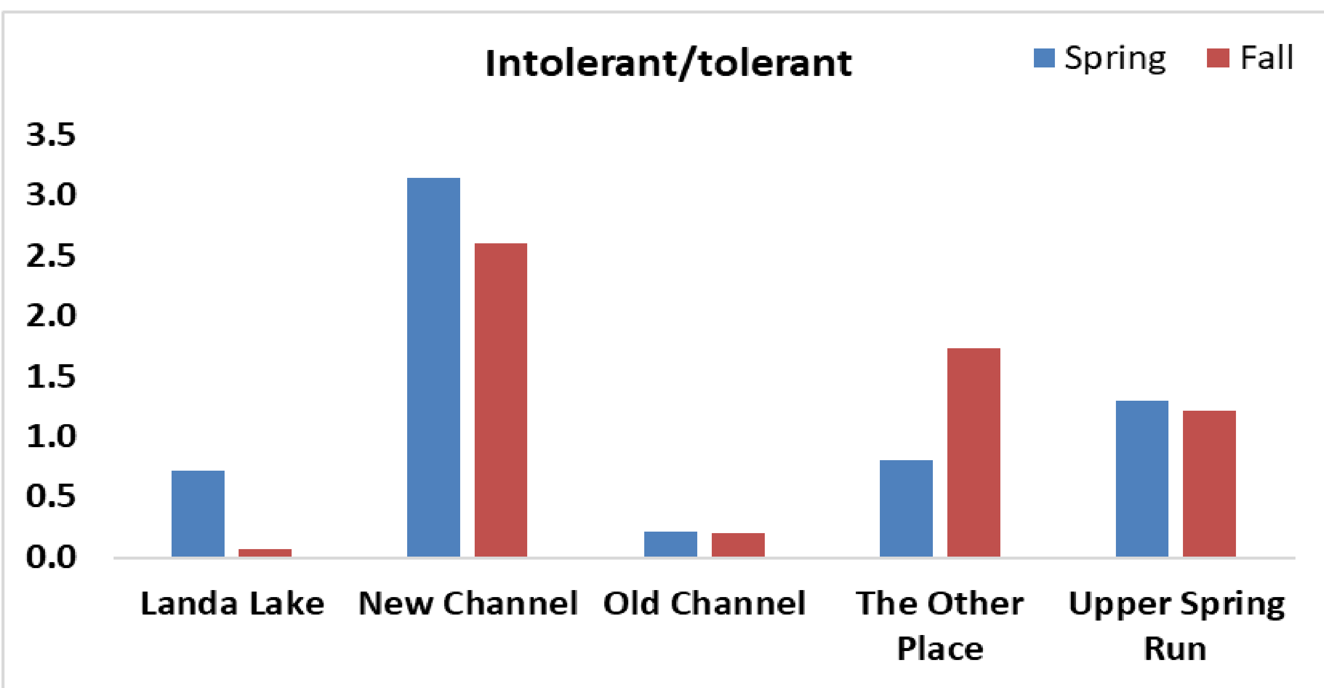

Biotic Index
Spring
Fall
10
8
6
4
2
0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run

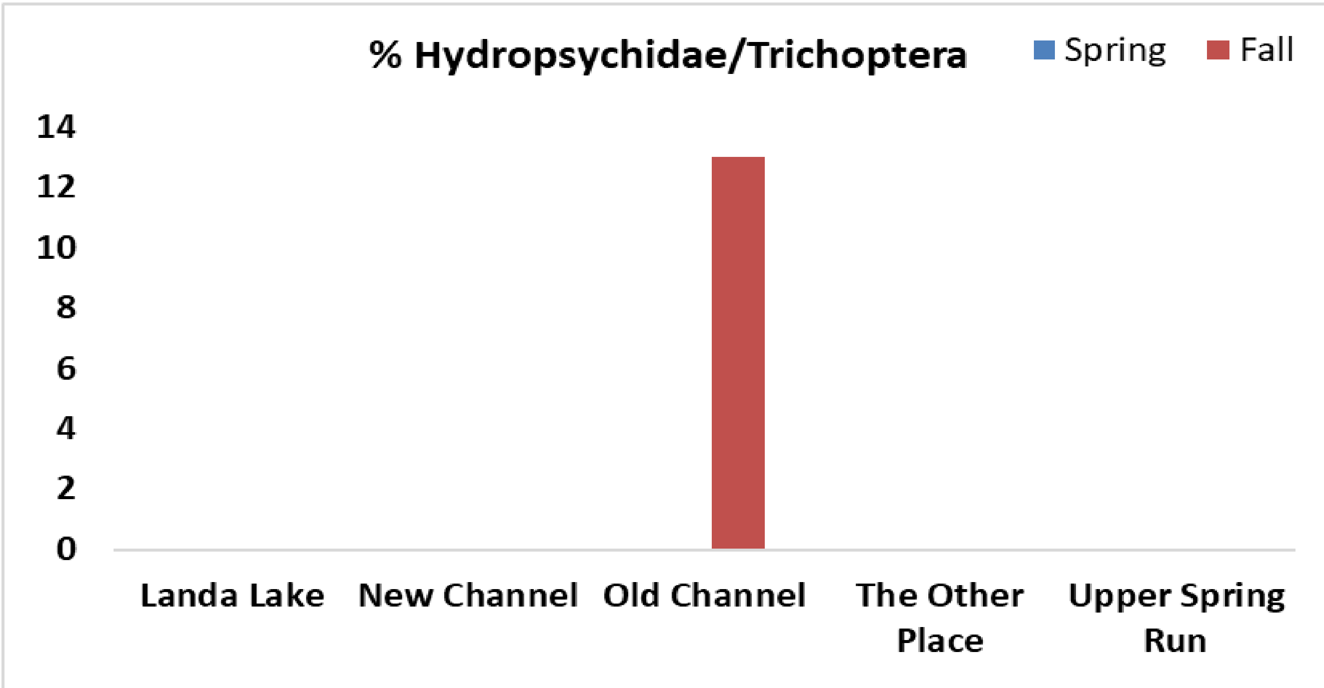

% Chironomidae
Spring
Fall
7
6
5
4
3
2
1
0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run

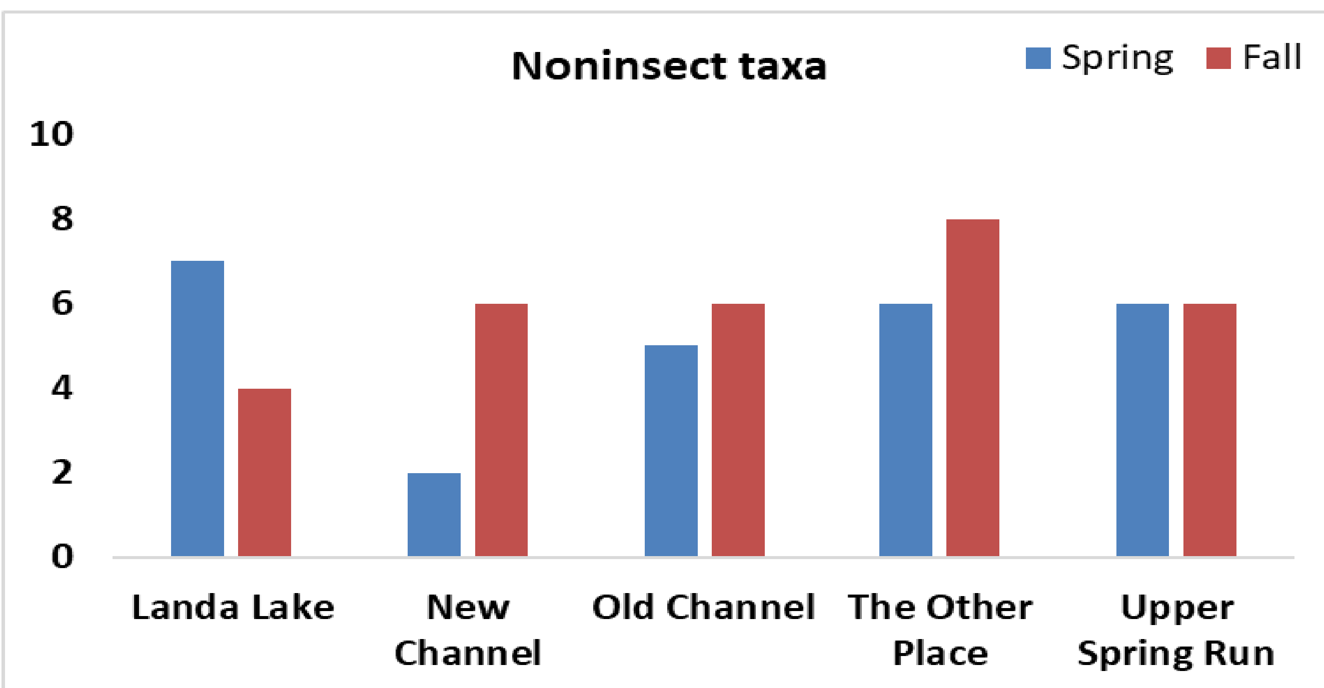

% Dominant taxon
Spring
Fall
70
60
50
40
30
20
10
0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run

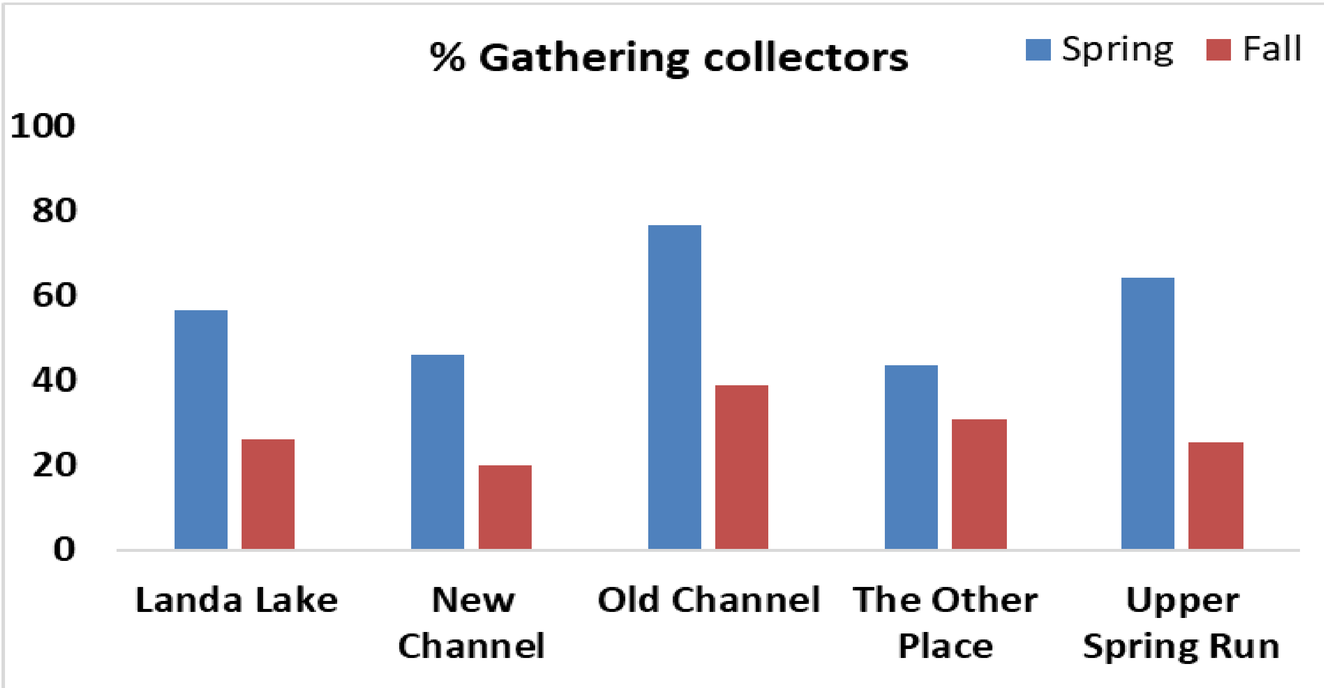

% Dominant feeding guild
Spring
Fall
100
80
60
40
20
0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run


% Predators
Spring
Fall
25
20
15
10
5
0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run

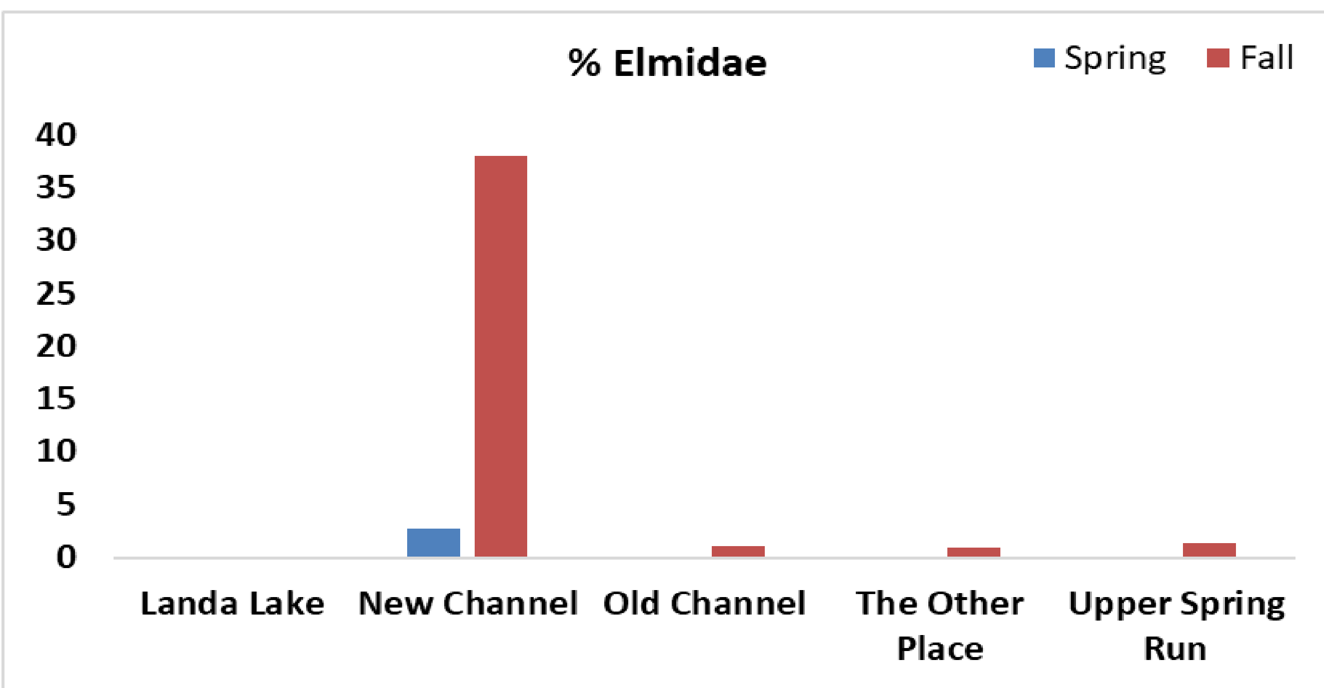

Intolerant/tolerant
Spring
Fall
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run


% Hydropsychidae/Trichoptera
Spring
Fall
14
12
10
8
6
4
2
0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run


Noninsect taxa
Spring
Fall
10
8
6
4
2
0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run



% Gathering collectors
Spring
Fall
100
80
60
40
20
0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run



% Elmidae
Spring
Fall
40
35
30
25
20
15
10
5
0
Landa Lake
New Channel
Old Channel
The Other Place
Upper Spring Run

APPENDIX D: DROP NET RAW DATA

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2129	Upper Spring Run	L1	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Astyanax mexicanus	2	37, 31
	Gambusia sp.	1	10
	Lepomis miniatus	1	32
	Micropterus salmoides	1	40
2	Astyanax mexicanus	2	36, 32
	Dionda nigrotaeniata	1	26
	Etheostoma fonticola	1	11
	Lepomis miniatus	2	29, 28
	Lepomis sp.	1	19
	Micropterus salmoides	2	61, 51
3	Astyanax mexicanus	2	45, 35
	Etheostoma fonticola	3	22, 26, 16
	Gambusia sp.	1	12
	Lepomis miniatus	3	26, 31, 30
	Procambarus sp.	7	-
4	Palaemonetes sp.	1	-
5	Astyanax mexicanus	1	30
	Etheostoma fonticola	2	29, 16
	Palaemonetes sp.	3	-
6	Micropterus salmoides	1	46
7	Etheostoma fonticola	1	20
	Lepomis miniatus	1	25
	Procambarus sp.	2	-
8	Etheostoma fonticola	2	32, 37
	Gambusia sp.	1	10
	Lepomis miniatus	3	18, 24, 31
	Palaemonetes sp.	1	-
	Procambarus sp.	3	-
9	Etheostoma fonticola	3	30, 20, 24
10	Procambarus sp.	1	-
11	Procambarus sp.	1	-
12	Lepomis miniatus	1	23
	Procambarus sp.	2	-
13	Etheostoma fonticola	1	16
14	Etheostoma fonticola	1	28
	Procambarus sp.	1	-

15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2130	Upper Spring Run	L2	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Astyanax mexicanus	1	40
	Etheostoma fonticola	1	30
	Herichthys cyanoguttatus	1	23
	Lepomis miniatus	2	38, 34
	Lepomis sp.	1	16
	Micropterus salmoides	1	49
	Palaemonetes sp.	2	-
	Procambarus sp.	1	-
2	Lepomis macrochirus	1	36
	Lepomis miniatus	3	39, 35, 42
	Micropterus salmoides	1	64
	Procambarus sp.	3	-
3	Etheostoma fonticola	1	30
	Lepomis miniatus	1	95
	Lepomis sp.	1	9
4	Lepomis miniatus	2	56, 62
	Lepomis sp.	1	12
	Procambarus sp.	3	-
5	Dionda nigrotaeniata	1	32
	Lepomis miniatus	1	25
	Micropterus salmoides	1	60
	Procambarus sp.	1	-
6	Astyanax mexicanus	1	27
7	No fish collected	-	-
8	Etheostoma fonticola	1	27
	Lepomis miniatus	1	40
9	Etheostoma fonticola	1	22
	Lepomis miniatus	1	42
	Procambarus sp.	1	-
10	Procambarus sp.	2	-
11	No fish collected	-	-
12	No fish collected	-	-
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2131	Upper Spring Run	S1	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Lepomis sp.	1	12
	Notropis sp.	1	12
	Procambarus sp.	12	-
2	Procambarus sp.	14	-
3	Procambarus sp.	5	-
4	Lepomis miniatus	1	96
	Procambarus sp.	13	-
5	Procambarus sp.	11	-
6	Procambarus sp.	8	-
7	Herichthys cyanoguttatus	1	69
	Procambarus sp.	7	-
8	Lepomis miniatus	1	42
	Procambarus sp.	2	-
9	Lepomis sp.	1	13
	Procambarus sp.	5	-
10	Procambarus sp.	5	-
11	Lepomis miniatus	2	82, 70
	Procambarus sp.	2	-
12	Procambarus sp.	1	-
13	Procambarus sp.	3	-
14	No fish collected	-	-
15	Procambarus sp.	2	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2132	Upper Spring Run	S2	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Astyanax mexicanus	1	42
	Dionda nigrotaeniata	1	69
	Etheostoma fonticola	1	30
	Lepomis miniatus	5	58, 82, 60, 93, 82
	Procambarus sp.	52	-
2	Ameiurus natalis	1	112
	Astyanax mexicanus	3	55, 51, 44
	Etheostoma fonticola	1	26
	Lepomis miniatus	2	81, 85
	Procambarus sp.	18	-
3	Astyanax mexicanus	3	45, 46, 45
	Dionda nigrotaeniata	3	80, 52, 47
	Etheostoma fonticola	2	32, 29
	Procambarus sp.	37	-
4	Dionda nigrotaeniata	2	62, 36
	Procambarus sp.	21	-
5	Astyanax mexicanus	1	51
	Dionda nigrotaeniata	1	48
	Etheostoma fonticola	1	32
	Lepomis miniatus	1	40
	Poecilia latipinna	1	55
	Procambarus sp.	30	-
6	Astyanax mexicanus	1	42
	Dionda nigrotaeniata	1	75
	Lepomis miniatus	1	65
	Procambarus sp.	11	-
7	Astyanax mexicanus	1	24
	Procambarus sp.	14	-
8	Procambarus sp.	9	-
9	Lepomis miniatus	1	41
	Procambarus sp.	9	-
10	Dionda nigrotaeniata	1	72
	Procambarus sp.	4	-
11	Procambarus sp.	7	-
12	Procambarus sp.	6	-
13	Procambarus sp.	7	-
14	Astyanax mexicanus	1	49

14	Procambarus sp.	3	-
15	Etheostoma fonticola	1	26
	Procambarus sp.	3	-
16	Procambarus sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2133	Upper Spring Run	R1	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	19	16, 16, 21, 29, 24, 15, 12, 17, 30, 24, 31, 18, 10, 17, 26, 30, 20, 16, 16
	Procambarus sp.	15	-
2	Etheostoma fonticola	4	30, 15, 16, 16
	Notropis sp.	1	10
	Procambarus sp.	8	-
3	Etheostoma fonticola	17	16, 22, 19, 16, 22, 15, 24, 15, 21, 26, 18, 15, 16, 12, 11, 21, 12
	Procambarus sp.	27	-
4	Etheostoma fonticola	6	18, 22, 24, 10, 21, 19
	Notropis sp.	1	8
	Procambarus sp.	27	-
5	Etheostoma fonticola	1	26
	Procambarus sp.	2	-
6	Etheostoma fonticola	14	18, 15, 18, 14, 19, 20, 13, 20, 13, 27, 17, 22, 17, 26
	Procambarus sp.	12	-
7	Etheostoma fonticola	5	15, 20, 25, 11, 16
	Procambarus sp.	2	-
8	Etheostoma fonticola	1	17
	Procambarus sp.	2	-
9	Etheostoma fonticola	6	21, 16, 32, 16, 11, 21
	Procambarus sp.	2	-
10	Etheostoma fonticola	3	28, 22, 25
	Procambarus sp.	3	-
11	Etheostoma fonticola	4	21, 20, 13, 21
12	Procambarus sp.	2	-
13	Etheostoma fonticola	5	28, 20, 22, 17, 26
	Procambarus sp.	2	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2134	Upper Spring Run	R2	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	19	24, 21, 25, 27, 24, 20, 21, 19, 26, 28, 23, 19, 25, 26, 27, 27, 24, 19, 23
	Procambarus sp.	20	-
2	Etheostoma fonticola	22	25, 27, 27, 25, 16, 23, 16, 15, 22, 28, 25, 12, 30, 22, 22, 23, 24, 26, 28, 24, 26, 28
	Etheostoma lepidum	2	45, 41
	Procambarus sp.	59	-
3	Etheostoma fonticola	12	26, 29, 27, 35, 28, 20, 24, 28, 24, 19, 28, 19
	Procambarus sp.	34	-
4	Etheostoma fonticola	3	20, 23, 20
	Procambarus sp.	35	-
5	Etheostoma fonticola	4	30, 20, 26, 22
	Procambarus sp.	6	-
6	Etheostoma fonticola	5	22, 18, 14, 16, 29
	Procambarus sp.	9	-
7	Etheostoma fonticola	2	27, 26
	Procambarus sp.	6	-
8	Etheostoma fonticola	1	15
	Procambarus sp.	5	-
9	Etheostoma fonticola	1	30
	Procambarus sp.	3	-
10	Etheostoma lepidum	1	40
	Procambarus sp.	3	-
11	Procambarus sp.	2	-
12	No fish collected	-	-
13	Etheostoma fonticola	3	27, 13, 12
	Procambarus sp.	2	-
14	No fish collected	-	-
15	Etheostoma fonticola	1	26
	Procambarus sp.	3	-
16	Etheostoma fonticola	2	27, 30
17	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2135	Upper Spring Run	O1	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2136	Upper Spring Run	O2	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2137	Landa Lake	V1	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Gambusia sp.	50	21, 21, 26, 28, 30, 31, 16, 15, 14, 15, 17, 21, 25, 28, 17, 22, 36, 20, 28, 15, 18, 20, 23, 15, 18
2	Gambusia sp.	152	-
	Palaemonetes sp.	2	-
	Procambarus sp.	6	-
3	Gambusia sp.	23	-
	Lepomis miniatus	1	72
	Palaemonetes sp.	1	-
	Procambarus sp.	4	-
4	Gambusia sp.	30	-
	Procambarus sp.	6	-
5	Gambusia sp.	16	-
	Procambarus sp.	6	-
6	Gambusia sp.	21	-
	Procambarus sp.	5	-
7	Gambusia sp.	13	-
	Procambarus sp.	4	-
8	Gambusia sp.	10	-
	Procambarus sp.	10	-
9	Gambusia sp.	11	-
10	Procambarus sp.	2	-
11	Gambusia sp.	6	-
	Palaemonetes sp.	1	-
	Procambarus sp.	2	-
12	Gambusia sp.	9	-
	Procambarus sp.	6	-
13	Etheostoma fonticola	1	33
	Gambusia sp.	3	-
	Procambarus sp.	2	-
14	Gambusia sp.	5	-
	Procambarus sp.	7	-
15	Gambusia sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2138	Landa Lake	V2	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	11	25, 29, 21, 16, 31, 15, 18, 15, 15, 17, 11
	Gambusia sp.	8	34, 22, 15, 24, 34, 21, 9, 10
	Lepomis macrochirus	1	57
	Lepomis miniatus	1	35
	Palaemonetes sp.	10	-
	Procambarus sp.	12	-
2	Etheostoma fonticola	7	19, 20, 22, 20, 26, 29, 14
	Gambusia sp.	1	12
	Procambarus sp.	8	-
3	Etheostoma fonticola	14	28, 29, 20, 27, 14, 18, 17, 27, 15, 20, 22, 18, 14, 14
	Lepomis miniatus	1	32
	Palaemonetes sp.	5	-
	Procambarus sp.	3	-
4	Etheostoma fonticola	2	26, 29
	Gambusia sp.	3	14, 12, 15
	Palaemonetes sp.	2	-
	Procambarus sp.	4	-
5	Etheostoma fonticola	6	22, 17, 25, 22, 28
	Etheostoma lepidum	1	28
	Procambarus sp.	8	-
6	Etheostoma fonticola	1	12
	Micropterus punctulatus	1	40
	Procambarus sp.	2	-
7	Etheostoma fonticola	2	25, 24
	Procambarus sp.	1	-
8	Etheostoma fonticola	2	24, 30
	Procambarus sp.	1	-
9	Lepomis miniatus	1	39
	Procambarus sp.	3	-
10	Etheostoma fonticola	1	16
	Procambarus sp.	2	-
11	Gambusia sp.	2	17, 19
	Procambarus sp.	1	-
12	Etheostoma fonticola	5	26, 19, 30, 16, 17
	Gambusia sp.	2	21, 12
	Procambarus sp.	3	-

13	No fish collected	-	-
14	No fish collected	-	-
15	Etheostoma fonticola	1	10
16	Procambarus sp.	2	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2139	Landa Lake	L1	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	9	24, 17, 22, 17, 20, 17, 19, 31, 15
	Gambusia sp.	10	15, 20, 20, 11, 26, 16, 18, 10, 12, 10
	Lepomis miniatus	1	35
	Palaemonetes sp.	6	-
	Procambarus sp.	9	-
2	Etheostoma fonticola	4	22, 23, 13, 14
	Gambusia sp.	1	26
	Lepomis miniatus	1	74
	Palaemonetes sp.	2	-
	Procambarus sp.	4	-
3	Etheostoma fonticola	9	20, 31, 19, 29, 26, 27, 19, 22, 30
	Gambusia sp.	2	16, 12
	Procambarus sp.	12	-
4	Etheostoma fonticola	10	16, 21, 31, 18, 31, 19, 29, 26, 23, 16
	Gambusia sp.	3	21, 15, 7
	Procambarus sp.	2	-
5	Etheostoma fonticola	16	14, 24, 18, 21, 27, 23, 24, 17, 28, 26, 14, 14, 13, 21, 20, 23
	Gambusia sp.	2	11, 18
	Lepomis sp.	1	10
	Procambarus sp.	4	-
6	Etheostoma fonticola	9	26, 22, 19, 13, 23, 16, 11, 22, 10
	Gambusia sp.	3	25, 10, 10
	Lepomis miniatus	1	-
7	Etheostoma fonticola	4	27, 12, 12, 27
	Gambusia sp.	1	11
8	Etheostoma fonticola	6	17, 26, 27, 12, 17, 16
	Gambusia sp.	2	24, 29
9	Etheostoma fonticola	3	16, 22, 21
	Gambusia sp.	8	28, 34, 15, 21
	Lepomis miniatus	1	130
10	Etheostoma fonticola	5	27, 19, 28, 29, 27
11	Etheostoma fonticola	4	34, 21, 26, 20
12	Etheostoma fonticola	1	19
13	Gambusia sp.	1	-
	Procambarus sp.	2	-
14	Procambarus sp.	1	-

15	Etheostoma fonticola	1	24
	Procambarus sp.	1	-
16	Procambarus sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2140	Landa Lake	L2	5/1/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	2	25, 20
	Gambusia sp.	20	32, 20, 20, 17, 20, 20, 25, 19, 21, 22, 19, 20, 19, 28, 21, 11, 20, 20, 18, 19
	Palaemonetes sp.	4	-
	Procambarus sp.	6	-
2	Ameiurus natalis	1	57
	Etheostoma fonticola	5	26, 17, 29, 24, 29
	Gambusia sp.	19	30, 29, 33, 36, 27
	Palaemonetes sp.	3	-
	Procambarus sp.	12	-
3	Etheostoma fonticola	1	22
	Gambusia sp.	9	-
	Lepomis miniatus	1	36
	Procambarus sp.	2	-
4	Etheostoma fonticola	8	22, 20, 29, 21, 27, 28, 26, 24
	Gambusia sp.	27	-
	Palaemonetes sp.	1	-
5	Etheostoma fonticola	5	27, 27, 21, 32, 22
	Gambusia sp.	14	-
	Lepomis miniatus	1	23
	Palaemonetes sp.	6	-
6	Etheostoma fonticola	3	18, 29, 23
	Gambusia sp.	21	-
	Lepomis miniatus	2	136, 32
	Marisa cornuarietis	1	23
7	Etheostoma fonticola	2	26, 22
	Gambusia sp.	6	-
8	Etheostoma fonticola	2	19, 18
	Gambusia sp.	13	-
9	Gambusia sp.	4	-
	Lepomis miniatus	1	45
10	Procambarus sp.	2	-
11	Etheostoma fonticola	2	27, 22
	Gambusia sp.	32	-
12	Gambusia sp.	4	-
13	Etheostoma fonticola	2	26, 21
	Procambarus sp.	1	-

14	Etheostoma fonticola	1	20
	Palaemonetes sp.	1	-
15	Gambusia sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2141	Landa Lake	C1	5/2/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	2	30, 23
	Gambusia sp.	95	21, 20, 22, 21, 19, 21, 15, 25, 18, 34, 15, 20, 21, 15, 15, 15, 18, 15, 33, 17, 19, 19, 32, 18, 22
	Lepomis miniatus	3	48, 68, 34
	Palaemonetes sp.	31	-
	Procambarus sp.	7	-
	Pterygoplichthys disjunctivus	1	19
2	Gambusia sp.	86	-
	Palaemonetes sp.	8	-
	Procambarus sp.	2	-
3	Etheostoma fonticola	11	20, 25, 20, 25, 22, 25, 26, 17, 19, 28, 18
	Gambusia sp.	80	-
	Lepomis miniatus	2	70, 55
	Palaemonetes sp.	44	-
	Procambarus sp.	3	-
4	Etheostoma fonticola	10	25, 24, 26, 20, 23, 28, 20, 32, 23, 26
	Gambusia sp.	64	-
	Lepomis miniatus	1	33
	Palaemonetes sp.	15	-
5	Etheostoma fonticola	7	23, 24, 26, 25, 10, 25, 23
	Gambusia sp.	72	-
	Palaemonetes sp.	12	-
	Procambarus sp.	2	-
6	Gambusia sp.	11	-
	Palaemonetes sp.	2	-
7	Etheostoma fonticola	3	22, 26, 25
	Gambusia sp.	6	-
	Lepomis miniatus	1	32
	Palaemonetes sp.	11	-
8	Etheostoma fonticola	1	23
	Gambusia sp.	4	-
	Palaemonetes sp.	2	-
	Procambarus sp.	1	-
9	Astyanax mexicanus	1	22
	Gambusia sp.	1	-
	Palaemonetes sp.	2	-
10	Astyanax mexicanus	1	19
	Etheostoma fonticola	1	26

	Gambusia sp.	3	-
	Lepomis miniatus	1	75
	Palaemonetes sp.	4	-
	Procambarus sp.	3	-
11	Etheostoma fonticola	3	30, 24, 19
12	Etheostoma fonticola	4	22, 22, 23, 20
	Gambusia sp.	11	-
	Palaemonetes sp.	5	-
13	Etheostoma fonticola	4	30, 23, 15, 26
	Gambusia sp.	8	-
	Palaemonetes sp.	2	-
	Procambarus sp.	4	-
14	Gambusia sp.	7	-
	Palaemonetes sp.	1	-
	Procambarus sp.	1	-
15	Gambusia sp.	3	-
	Procambarus sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2142	Landa Lake	C2	5/2/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	58	16, 27, 26, 27, 26, 26, 13, 15, 15, 22, 27, 29, 26, 20, 25, 17, 16, 29, 17, 19, 30, 32, 35, 29, 22, 27, 25, 29, 26, 25, 24, 26, 17, 26, 18, 29, 17, 22, 19, 27, 28, 30, 32, 35, 22, 27, 10, 20, 23, 29, 26, 26, 18, 26, 15, 19, 28, 12
	Gambusia sp.	13	31, 16, 10, 18, 18, 15, 10, 15, 12, 16, 16, 16, 10
	Lepomis sp.	1	12
	Palaemonetes sp.	12	-
	Procambarus sp.	5	-
2	Etheostoma fonticola	6	26, 26, 18, 29, 26, 26
	Gambusia sp.	5	14, 21, 15, 11, 11
	Palaemonetes sp.	3	-
3	Etheostoma fonticola	11	26, 22, 30, 25, 30, 16, 20, 15, 26, 20, 15
	Gambusia sp.	1	12
	Oreochromis aureus	1	17
	Palaemonetes sp.	7	-
	Procambarus sp.	15	-
4	Etheostoma fonticola	2	26, 28
	Gambusia sp.	3	16, 17, 12
	Palaemonetes sp.	4	-
	Procambarus sp.	13	-
5	Etheostoma fonticola	10	26, 16, 26, 25, 19, 30, 25, 15, 15, 18
	Gambusia sp.	18	18, 16, 25
	Palaemonetes sp.	4	-
	Procambarus sp.	13	-
6	Etheostoma fonticola	3	29, 28, 24
	Gambusia sp.	5	-
	Palaemonetes sp.	1	-
	Procambarus sp.	4	-
7	Etheostoma fonticola	5	27, 27, 22, 14, 21
	Gambusia sp.	5	-
	Oreochromis aureus	1	17
	Procambarus sp.	1	-
8	Etheostoma fonticola	2	21, 28
	Gambusia sp.	5	-
	Procambarus sp.	4	-
9	Etheostoma fonticola	10	32, 30, 25, 22, 19, 25, 29, 26, 18, 19
	Gambusia sp.	6	-

	Palaemonetes sp.	4	-
	Procambarus sp.	3	-
10	Etheostoma fonticola	2	26, 30
	Gambusia sp.	4	-
	Procambarus sp.	5	-
11	Etheostoma fonticola	4	20, 17, 16, 19
11	Gambusia sp.	5	-
	Oreochromis aureus	1	15
	Palaemonetes sp.	2	23, 28
	Procambarus sp.	4	-
12	Etheostoma fonticola	2	23, 28
	Gambusia sp.	2	-
	Lepomis miniatus	1	94
	Palaemonetes sp.	2	-
	Procambarus sp.	5	-
13	Etheostoma fonticola	2	20, 19
	Palaemonetes sp.	2	-
14	Procambarus sp.	3	-
15	Gambusia sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2143	Landa Lake	S1	5/2/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	15	10, 29, 15, 15, 19, 22, 22, 13, 35, 17, 14, 17, 15, 15, 15
	Gambusia sp.	7	19, 24, 9, 15, 20, 11, 10
	Procambarus sp.	2	-
2	Etheostoma fonticola	14	20, 19, 27, 28, 22, 11, 9, 23, 11, 15, 16, 25, 16, 16,
	Etheostoma lepidum	1	31
	Gambusia sp.	8	10, 18, 20, 17, 11, 15, 10, 15
	Micropterus salmoides	1	141
3	Etheostoma fonticola	10	22, 30, 19, 12, 22, 26, 28, 16, 11, 13
	Gambusia sp.	3	20, 35, 11
	Procambarus sp.	6	-
4	Etheostoma fonticola	8	29, 17, 18, 22, 31, 19, 22, 17
	Gambusia sp.	4	11, 10, 10, 34
	Procambarus sp.	20	-
5	Etheostoma fonticola	1	26
	Procambarus sp.	21	-
6	Etheostoma fonticola	3	25, 31, 25
	Gambusia sp.	1	11
7	Procambarus sp.	8	-
8	Etheostoma fonticola	4	18, 30, 27, 18
	Procambarus sp.	7	-
9	Etheostoma fonticola	1	20
10	Etheostoma fonticola	3	30, 23, 16
	Procambarus sp.	4	-
11	Etheostoma fonticola	1	21
	Procambarus sp.	1	-
12	Etheostoma fonticola	1	17
13	Etheostoma fonticola	1	24
14	Procambarus sp.	1	-
15	Etheostoma fonticola	1	18
	Procambarus sp.	2	-
16	Etheostoma fonticola	1	22
	Gambusia sp.	1	19
	Procambarus sp.	1	-

17	Etheostoma fonticola	1	22
18	Etheostoma fonticola	1	26
	Procambarus sp.	2	-
19	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2144	Landa Lake	S2	5/2/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Gambusia sp.	39	18, 18, 17, 17, 21, 15, 26, 23, 16, 25, 20, 20, 25, 26, 15, 15, 17, 15, 20, 16, 25, 9, 17, 20, 22
	Lepomis sp.	2	12, 12
2	Gambusia sp.	13	-
	Marisa cornuarietis	1	37
3	Etheostoma fonticola	1	10
	Gambusia sp.	24	-
	Palaemonetes sp.	1	-
	Procambarus sp.	1	-
4	No fish collected	-	-
5	Gambusia sp.	18	-
	Lepomis miniatus	1	79
	Procambarus sp.	2	-
6	Gambusia sp.	2	-
	Procambarus sp.	1	-
7	Gambusia sp.	2	-
	Procambarus sp.	2	-
8	Procambarus sp.	2	-
9	Procambarus sp.	1	-
10	Procambarus sp.	2	-
11	Procambarus sp.	1	-
12	No fish collected	-	-
13	Procambarus sp.	1	-
14	No fish collected	-	-
15	Procambarus sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2145	Landa Lake	R1	5/2/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	25	21, 25, 22, 15, 29, 29, 16, 19, 25, 15, 21, 24, 16, 15, 12, 17, 21, 24, 15, 10, 15, 17, 17, 13, 13
	Gambusia sp.	10	28, 16, 15, 22, 20, 30, 10, 7, 9, 10
	Palaemonetes sp.	8	-
	Procambarus sp.	7	-
2	Etheostoma fonticola	18	21, 31, 22, 25, 20, 24, 22, 26, 22, 19, 22, 27, 21, 23, 24, 20, 18, 12
	Gambusia sp.	2	12, 10
	Procambarus sp.	12	-
3	Etheostoma fonticola	4	16, 20, 21, 19
	Gambusia sp.	2	27, 12
	Procambarus sp.	2	-
4	Etheostoma fonticola	3	24, 22, 12
	Gambusia sp.	1	14
	Procambarus sp.	4	-
5	Etheostoma fonticola	6	21, 12, 21, 20, 18, 10
	Gambusia sp.	4	11, 15, 12, 9
	Procambarus sp.	2	-
6	Gambusia sp.	1	19
	Procambarus sp.	8	-
7	Gambusia sp.	1	18
	Procambarus sp.	4	-
8	Procambarus sp.	1	-
9	No fish collected	-	-
10	No fish collected	-	-
11	Procambarus sp.	2	-
12	No fish collected	-	-
13	Etheostoma fonticola	1	8
14	No fish collected	-	-
15	Procambarus sp.	1	-

DROP NET-FIELD DATA SHEETS
COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2146	Landa Lake	R2	5/2/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	23	16, 15, 19, 28, 20, 20, 28, 15, 20, 22, 23, 20, 25, 18, 17, 18, 17, 11, 20, 16, 20, 20, 13
	Gambusia sp.	2	13, 15
	Palaemonetes sp.	3	-
	Procambarus sp.	4	-
2	Etheostoma fonticola	22	20, 24, 15, 28, 15, 15, 17, 18, 22, 20, 21, 17, 20, 19, 20, 20, 21, 22, 18, 22, 19,
	Gambusia sp.	2	9, 11
	Procambarus sp.	5	-
3	Etheostoma fonticola	11	17, 22, 22, 26, 22, 20, 20, 18, 21, 19, 22
	Gambusia sp.	1	8
	Procambarus sp.	4	-
4	Etheostoma fonticola	10	17, 20, 20, 18, 21, 17, 20, 16, 19, 20
	Procambarus sp.	3	-
5	Etheostoma fonticola	4	23, 25, 20, 12
	Procambarus sp.	1	-
6	Etheostoma fonticola	2	18, 19
7	No fish collected	-	-
8	Etheostoma fonticola	2	20, 18
9	Gambusia sp.	1	15
10	Etheostoma fonticola	2	20, 13
11	No fish collected	-	-
12	No fish collected	-	-
13	Etheostoma fonticola	2	22, 20
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2147	Landa Lake	O1	5/2/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	1	24
2	Etheostoma fonticola	1	10
3	No fish collected	-	-
4	Etheostoma fonticola	1	20
5	No fish collected	-	-
6	Palaemonetes sp.	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-
11	No fish collected	-	-
12	Etheostoma fonticola	1	20
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2148	Landa Lake	O2	5/2/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	1	12
2	Etheostoma fonticola	1	18
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-
11	No fish collected	-	-
12	Etheostoma fonticola	1	17
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2149	Old Channel Reach	R1	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	6	30, 29, 16, 31, 29, 17
	Palaemonetes sp.	1	-
	Procambarus sp.	2	-
2	Etheostoma fonticola	1	17
	Gambusia sp.	4	13, 13, 14, 11
	Procambarus sp.	4	-
3	Etheostoma fonticola	1	15
	Procambarus sp.	1	-
4	Procambarus sp.	1	-
5	Etheostoma fonticola	2	20, 26
	Procambarus sp.	2	-
6	Etheostoma fonticola	1	12
	Procambarus sp.	1	-
7	Etheostoma fonticola	4	30, 20, 26, 16
	Procambarus sp.	1	-
8	Etheostoma fonticola	2	17, 26
9	Etheostoma fonticola	2	30, 15
10	Procambarus sp.	1	-
11	No fish collected	-	-
12	Etheostoma fonticola	1	19
	Gambusia sp.	1	13
13	Gambusia sp.	1	16
14	Procambarus sp.	1	-
15	Etheostoma fonticola	1	26
16	Etheostoma fonticola	3	28, 28, 30
17	Palaemonetes sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2150	Old Channel Reach	R2	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	4	28, 26, 13, 21
	Palaemonetes sp.	6	-
	Procambarus sp.	11	-
2	Palaemonetes sp.	1	-
3	Etheostoma fonticola	2	30, 31
4	Etheostoma fonticola	1	20
	Procambarus sp.	2	-
5	Etheostoma fonticola	3	28, 27, 16
	Gambusia sp.	1	17
	Procambarus sp.	4	-
6	Etheostoma fonticola	1	25
7	Etheostoma fonticola	1	20
	Procambarus sp.	2	-
8	Etheostoma fonticola	2	28, 26
9	Etheostoma fonticola	3	20, 30, 20
	Procambarus sp.	3	-
10	Procambarus sp.	1	-
11	Etheostoma fonticola	3	15, 27, 23
	Procambarus sp.	1	-
12	Etheostoma fonticola	1	32
13	No fish collected	-	-
14	Etheostoma fonticola	1	24
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS
COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2151	Old Channel Reach	H1	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Astyanax mexicanus	1	26
	Etheostoma fonticola	2	23, 24
	Lepomis miniatus	2	59, 38
	Palaemonetes sp.	12	-
	Procambarus sp.	8	-
2	Astyanax mexicanus	1	37
	Etheostoma fonticola	2	26, 29
	Gambusia sp.	2	15, 29
	Lepomis sp.	1	20
	Notropis amabilis	1	40
	Palaemonetes sp.	8	-
	Procambarus sp.	4	-
3	Etheostoma fonticola	2	25, 15
	Gambusia sp.	2	20, 31
	Palaemonetes sp.	7	-
	Procambarus sp.	3	-
4	Gambusia sp.	1	11
	Lepomis miniatus	1	58
	Procambarus sp.	1	-
5	Gambusia sp.	9	20, 22, 16, 34, 29, 28, 21, 18, 22
	Procambarus sp.	2	-
6	Astyanax mexicanus	1	65
	Etheostoma fonticola	1	22
	Gambusia sp.	2	13, 14
	Lepomis miniatus	1	24
	Palaemonetes sp.	3	-
7	Palaemonetes sp.	4	-
	Procambarus sp.	1	-
8	Gambusia sp.	1	20
	Lepomis miniatus	2	64, 28
	Palaemonetes sp.	2	-
9	Etheostoma fonticola	4	30, 26, 28, 18
	Gambusia sp.	5	33, 15, 21, 28, 26
	Lepomis miniatus	1	43
10	Gambusia sp.	1	15
	Lepomis miniatus	1	74
	Palaemonetes sp.	1	-
11	Etheostoma fonticola	1	26
12	Procambarus sp.	1	-

13	No fish collected	-	-
14	Procambarus sp.	1	-
15	Procambarus sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2152	Old Channel Reach	H2	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	5	30, 31, 30, 26, 30
	Gambusia sp.	7	30, 20, 26, 30, 21, 9, 10
	Lepomis miniatus	1	55
	Lepomis sp.	1	17
	Palaemonetes sp.	16	-
2	Gambusia sp.	3	12, 12, 20
	Lepomis miniatus	1	45
	Palaemonetes sp.	12	-
	Procambarus sp.	5	-
3	Herichthys cyanoguttatus	1	45
	Palaemonetes sp.	1	-
	Procambarus sp.	1	-
4	Palaemonetes sp.	2	-
	Procambarus sp.	2	-
5	Lepomis miniatus	1	55
	Procambarus sp.	2	-
6	Procambarus sp.	4	-
7	Palaemonetes sp.	1	-
	Procambarus sp.	4	-
8	Gambusia sp.	1	35
	Lepomis miniatus	1	55
9	Etheostoma fonticola	1	31
	Palaemonetes sp.	1	-
	Procambarus sp.	1	-
10	No fish collected	-	-
11	No fish collected	-	-
12	No fish collected	-	-
13	No fish collected	-	-
14	Gambusia sp.	1	32
	Palaemonetes sp.	1	-
	Procambarus sp.	1	-
15	Gambusia sp.	1	15

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2153	Old Channel Reach	O1	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2154	Old Channel Reach	O2	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	Etheostoma fonticola	1	22
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	Astyanax mexicanus	1	65
11	No fish collected	-	-
12	No fish collected	-	-
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2155	Old Channel Reach	L1	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Procambarus sp.	2	-
2	Etheostoma fonticola	3	30, 33, 28
3	Gambusia sp.	1	16
3	Procambarus sp.	1	-
4	Etheostoma fonticola	1	20
4	Gambusia sp.	1	17
5	Gambusia sp.	1	22
6	Etheostoma fonticola	1	26
7	Etheostoma fonticola	2	30, 25
8	No fish collected	-	-
9	No fish collected	-	-
10	Etheostoma fonticola	1	12
11	Etheostoma fonticola	2	29, 31
12	No fish collected	-	-
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2156	Old Channel Reach	H3	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	Etheostoma fonticola	2	22, 16
	Gambusia sp.	13	26, 16, 22, 12, 12, 12, 12, 12, 15, 16, 14, 20, 20
	Procambarus sp.	6	-
3	Astyanax mexicanus	1	40
4	No fish collected	-	-
5	Astyanax mexicanus	1	52
	Palaemonetes sp.	1	-
	Procambarus sp.	1	-
6	Gambusia sp.	2	32, 21
	Procambarus sp.	2	-
7	Astyanax mexicanus	1	42
	Palaemonetes sp.	1	-
	Procambarus sp.	2	-
8	No fish collected	-	-
9	Gambusia sp.	3	22, 17, 20
10	No fish collected	-	-
11	No fish collected	-	-
12	No fish collected	-	-
13	No fish collected	-	-
14	No fish collected	-	-
15	Dionda nigrotaeniata	1	21

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2157	Upper New Channel Reach	H2	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Gambusia sp.	5	17, 42, 34, 18, 22
	Procambarus sp.	3	-
2	Gambusia sp.	2	26, 43
	Lepomis miniatus	1	52
	Procambarus sp.	6	-
3	Gambusia sp.	3	42, 45, 20
	Lepomis cyanellus	1	45
	Procambarus sp.	5	-
4	Gambusia sp.	3	24, 24, 13
	Procambarus sp.	2	-
5	Gambusia sp.	2	30, 20
	Lepomis miniatus	1	85
	Procambarus sp.	4	-
6	Ameiurus natalis	1	23
	Procambarus sp.	1	-
7	Lepomis megalotis	1	40
	Procambarus sp.	1	-
8	Gambusia sp.	1	33
	Procambarus sp.	6	-
9	Herichthys cyanoguttatus	1	55
	Procambarus sp.	2	-
10	Gambusia sp.	1	17
	Procambarus sp.	2	-
11	Procambarus sp.	1	-
12	Gambusia sp.	1	40
13	Gambusia sp.	1	25
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2158	Upper New Channel Reach	H1	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Ameiurus natalis	1	45
	Herichthys cyanoguttatus	1	45
	Procambarus sp.	5	-
2	Lepomis cyanellus	1	50
	Lepomis gulosus	1	85
	Procambarus sp.	9	-
3	No fish collected	-	-
4	Procambarus sp.	19	-
5	Procambarus sp.	6	-
6	Procambarus sp.	7	-
7	Procambarus sp.	4	-
8	Procambarus sp.	3	-
9	Procambarus sp.	3	-
10	Lepomis cyanellus	1	58
11	Procambarus sp.	1	-
12	Procambarus sp.	4	-
13	No fish collected	-	-
14	Procambarus sp.	1	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2159	Upper New Channel Reach	O1	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2160	Upper New Channel Reach	O2	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2161	Upper New Channel Reach	R1	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Gambusia sp.	3	12, 12, 12
	Procambarus sp.	7	-
2	No fish collected	-	-
3	Ameiurus natalis	1	21
	Procambarus sp.	28	-
4	Gambusia sp.	2	10, 11
	Procambarus sp.	5	-
5	Lepomis cyanellus	1	35
	Procambarus sp.	6	-
6	Procambarus sp.	7	-
7	Gambusia sp.	4	14, 11, 11, 15
8	Gambusia sp.	2	11, 10
9	Procambarus sp.	1	-
10	No fish collected	-	-
11	Lepomis cyanellus	1	45
	Procambarus sp.	1	-
12	Etheostoma fonticola	1	30
	Lepomis cyanellus	1	44
13	Etheostoma fonticola	1	34
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-SPRING 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2162	Upper New Channel Reach	R2	5/3/2017

COMAL RIVER-SPRING 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	4	32, 19, 19, 17
	Gambusia sp.	2	11, 10
	Lepomis cyanellus	1	42
	Lepomis macrochirus	1	32
	Procambarus sp.	2	-
2	Etheostoma fonticola	6	31, 30, 26, 15, 16, 16
	Palaemonetes sp.	1	-
	Procambarus sp.	10	-
3	Etheostoma fonticola	1	21
	Gambusia sp.	2	12, 11
	Procambarus sp.	2	-
4	Etheostoma fonticola	3	20, 28, 15
	Gambusia sp.	2	10, 11
	Procambarus sp.	1	-
5	Etheostoma fonticola	2	25, 17
	Gambusia sp.	1	13
	Procambarus sp.	2	-
6	Etheostoma fonticola	1	16
	Procambarus sp.	1	-
7	Etheostoma fonticola	2	15, 16
	Gambusia sp.	1	12
8	Etheostoma fonticola	2	12, 17
	Gambusia sp.	2	9, 10
	Procambarus sp.	2	-
9	Etheostoma fonticola	1	19
10	No fish collected	-	-
11	Etheostoma fonticola	1	16
12	Etheostoma fonticola	1	26
13	No fish collected	-	-
14	Etheostoma fonticola	1	19
	Gambusia sp.	1	10
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2192	Upper Spring Run	R1	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	7	35, 26, 30, 35, 19, 21, 23
	Procambarus sp.	16	-
2	Etheostoma fonticola	15	21, 20, 32, 32, 34, 34, 32, 31, 27, 31, 30, 30, 32, 22, 29
	Procambarus sp.	17	-
3	Etheostoma fonticola	5	33, 32, 18, 33, 29
	Procambarus sp.	4	-
4	Etheostoma fonticola	9	27, 22, 27, 30, 32, 32, 30, 31, 22
	Procambarus sp.	10	-
5	Etheostoma fonticola	2	23, 11
	Procambarus sp.	10	-
6	Etheostoma fonticola	3	24, 35, 23
	Procambarus sp.	1	-
7	Etheostoma fonticola	1	30
	Procambarus sp.	1	-
8	Etheostoma fonticola	1	33
	Procambarus sp.	1	-
9	Etheostoma fonticola	1	37
10	Etheostoma fonticola	2	28, 23
11	Procambarus sp.	1	-
12	No fish collected	-	-
13	Dionda nigrotaeniata	1	14
	Etheostoma fonticola	1	26
	Procambarus sp.	1	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2193	Upper Spring Run	R2	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	9	36, 27, 26, 32, 33, 30, 26, 29, 35
	Procambarus sp.	35	-
2	Etheostoma fonticola	16	31, 15, 14, 26, 32, 31, 31, 32, 27, 32, 28, 35, 31, 22, 26, 31
	Procambarus sp.	26	-
3	Etheostoma fonticola	8	28, 26, 30, 28, 32, 32, 28, 33
	Herichthys cyanoguttatus	1	20
	Procambarus sp.	26	-
4	Etheostoma fonticola	12	30, 28, 30, 31, 30, 28, 21, 30, 25, 25, 29, 15
	Procambarus sp.	19	-
5	Etheostoma fonticola	3	25, 33, 28
	Procambarus sp.	12	-
6	Etheostoma fonticola	2	30, 30
	Procambarus sp.	3	-
7	Palaemonetes sp.	1	-
	Procambarus sp.	1	-
8	No fish collected	-	-
9	No fish collected	-	-
10	Etheostoma fonticola	1	32
11	Etheostoma fonticola	1	27
	Procambarus sp.	3	-
12	No fish collected	-	-
13	Etheostoma fonticola	1	32
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2194	Upper Spring Run	S1	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Lepomis miniatus	2	35, 26
	Micropterus salmoides	2	71, 45
2	Micropterus salmoides	1	52
3	No fish collected	-	-
4	Lepomis miniatus	3	90, 30, 55
5	Lepomis miniatus	1	30
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-
11	No fish collected	-	-
12	Procambarus sp.	1	-
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2195	Upper Spring Run	S2	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Procambarus sp.	7	-
2	Lepomis miniatus	3	86, 55, 65
	Palaemonetes sp.	1	-
	Procambarus sp.	8	-
3	Lepomis miniatus	1	102
	Procambarus sp.	4	-
4	Procambarus sp.	2	-
5	Lepomis miniatus	1	140
	Procambarus sp.	2	-
6	Lepomis miniatus	1	95
7	No fish collected	-	-
8	Lepomis miniatus	1	76
	Procambarus sp.	1	-
9	No fish collected	-	-
10	Procambarus sp.	5	-
11	No fish collected	-	-
12	Procambarus sp.	1	-
13	No fish collected	-	-
14	No fish collected	-	-
15	Procambarus sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2196	Upper Spring Run	O1	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-

DROP NET-FIELD DATA SHEETS
COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2197	Upper Spring Run	O2	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2198	Upper Spring Run	L1	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Herichthys cyanoguttatus	3	24, 27, 28
	Lepomis miniatus	1	35
	Micropterus salmoides	2	42, 40
	Palaemonetes sp.	80	-
	Procambarus sp.	60	-
2	Etheostoma fonticola	1	30
	Etheostoma lepidum	1	50
	Herichthys cyanoguttatus	1	30
	Lepomis miniatus	2	80, 30
	Micropterus salmoides	1	45
	Palaemonetes sp.	30	-
	Procambarus sp.	10	-
3	Lepomis sp.	1	15
	Palaemonetes sp.	50	-
4	Etheostoma lepidum	1	50
	Herichthys cyanoguttatus	1	25
	Micropterus salmoides	1	47
	Palaemonetes sp.	10	-
	Procambarus sp.	5	-
5	Ameiurus natalis	1	26
	Etheostoma fonticola	1	30
	Palaemonetes sp.	10	-
6	Herichthys cyanoguttatus	1	25
	Lepomis miniatus	1	55
	Micropterus salmoides	1	40
	Palaemonetes sp.	15	-
7	Procambarus sp.	2	-
8	Lepomis miniatus	1	37
	Palaemonetes sp.	3	-
9	Palaemonetes sp.	1	-
10	Etheostoma fonticola	1	31
11	Etheostoma fonticola	1	33
	Palaemonetes sp.	3	-
12	Lepomis miniatus	1	30
13	Etheostoma fonticola	1	29
14	No fish collected	-	-

15	Lepomis sp.	1	12

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2199	Upper Spring Run	L2	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Herichthys cyanoguttatus	1	22
	Lepomis miniatus	2	32, 30
	Micropterus salmoides	3	65, 44, 45
2	Micropterus salmoides	1	60
3	No fish collected	-	-
4	Lepomis miniatus	1	35
5	No fish collected	-	-
6	No fish collected	-	-
7	Etheostoma fonticola	1	32
8	Lepomis miniatus	3	36, 40, 40
9	Lepomis miniatus	1	35
10	Lepomis miniatus	2	52, 53
	Lepomis sp.	1	20
11	No fish collected	-	-
12	Lepomis miniatus	1	53
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2200	Landa Lake	L1	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Gambusia sp.	3	15, 16, 10
	Palaemonetes sp.	4	-
2	Ameiurus natalis	2	65, 15
	Gambusia sp.	8	22, 18, 18, 22, 22, 12, 12, 14
	Lepomis miniatus	1	83
	Palaemonetes sp.	1	-
3	Gambusia sp.	4	17, 11, 18, 15
	Palaemonetes sp.	6	-
4	Etheostoma fonticola	1	32
	Gambusia sp.	10	20, 20, 15, 18, 18, 13, 26, 10, 22, 14
5	No fish collected	-	-
6	No fish collected	-	-
7	Etheostoma fonticola	1	35
	Gambusia sp.	3	-
8	No fish collected	-	-
9	Ameiurus natalis	1	15
	Gambusia sp.	1	-
10	No fish collected	-	-
11	No fish collected	-	-
12	Ameiurus natalis	1	30
	Etheostoma fonticola	1	17
	Gambusia sp.	3	-
13	No fish collected	-	-
14	Gambusia sp.	3	-
	Palaemonetes sp.	2	-
15	Gambusia sp.	2	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2201	Landa Lake	L2	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	5	20, 26, 23, 26, 21
	Gambusia sp.	26	31, 33, 12, 14, 22, 26, 15, 15, 22, 20, 14, 20, 19, 21, 11, 15, 21, 20, 12, 12, 22, 26, 25, 11, 16, 38
	Palaemonetes sp.	8	-
	Procambarus sp.	3	-
2	Etheostoma fonticola	2	20, 30
	Gambusia sp.	53	-
	Lepomis miniatus	2	146, 29
	Procambarus sp.	42	-
3	Etheostoma fonticola	8	26, 30, 32, 30, 35, 32, 31, 15
	Gambusia sp.	9	-
	Palaemonetes sp.	2	-
	Procambarus sp.	2	-
4	Gambusia sp.	9	-
	Herichthys cyanoguttatus	1	25
	Palaemonetes sp.	11	-
	Procambarus sp.	6	-
5	Etheostoma fonticola	2	32, 23
	Gambusia sp.	37	-
	Palaemonetes sp.	20	-
6	Gambusia sp.	9	-
7	Etheostoma fonticola	3	21, 29, 7
	Gambusia sp.	21	-
8	Gambusia sp.	9	-
9	Etheostoma fonticola	4	14, 32, 23, 15
	Gambusia sp.	10	-
	Procambarus sp.	3	-
10	Etheostoma fonticola	1	23
	Palaemonetes sp.	1	-
	Procambarus sp.	3	-
11	Etheostoma fonticola	2	25, 18
12	Etheostoma fonticola	1	32
	Gambusia sp.	3	-
13	No fish collected	-	-
14	Gambusia sp.	1	-

15	Gambusia sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2202	Landa Lake	V1	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	26	30, 20, 30, 30, 25, 21, 25, 22, 26, 28, 25, 30, 25, 30, 25, 25, 30, 30, 30, 27, 30, 28, 22, 20, 16, 23
	Gambusia sp.	9	10, 15, 10, 15, 10, 10, 10, 11, 10
	Lepomis miniatus	1	30
	Palaemonetes sp.	13	-
	Procambarus sp.	11	-
2	Etheostoma fonticola	2	31, 30
	Gambusia sp.	16	25, 30, 26, 24, 16, 18, 26, 23, 22, 17, 21, 25, 25, 27, 17, 26
	Lepomis miniatus	1	40
	Lepomis sp.	1	15
	Palaemonetes sp.	9	-
	Procambarus sp.	23	-
3	Etheostoma fonticola	1	30
	Gambusia sp.	5	-
	Palaemonetes sp.	4	-
	Procambarus sp.	12	-
4	Etheostoma fonticola	3	28, 31, 27
	Lepomis miniatus	1	70
	Procambarus sp.	6	-
5	Etheostoma fonticola	5	23, 26, 19, 20, 28
	Procambarus sp.	4	-
6	Etheostoma fonticola	5	27, 30, 33, 32, 34
	Procambarus sp.	8	-
7	Etheostoma fonticola	3	23, 26, 25
	Gambusia sp.	4	-
	Palaemonetes sp.	1	-
	Procambarus sp.	7	-
8	Etheostoma fonticola	1	20
	Gambusia sp.	3	-
	Procambarus sp.	5	-
9	Etheostoma fonticola	1	15
	Procambarus sp.	8	-
10	Etheostoma fonticola	1	30
	Gambusia sp.	1	-
	Palaemonetes sp.	2	-
	Procambarus sp.	7	-
11	Procambarus sp.	3	-

12	Procambarus sp.	2	-
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2203	Landa Lake	V2	10/23/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	27	33, 32, 27, 31, 29, 25, 25, 30, 25, 14, 35, 19, 25, 15, 27, 25, 28, 28, 27, 23, 20, 26, 26, 28, 20, 26, 23
	Gambusia sp.	26	10, 10, 20, 16, 22, 28, 17, 10, 8, 14, 15, 10, 15, 12, 10, 15, 15, 10, 15, 11, 7, 11, 10, 25, 10
	Palaemonetes sp.	21	-
	Procambarus sp.	8	-
2	Etheostoma fonticola	15	25, 20, 30, 24, 27, 31, 21, 24, 20, 26, 13, 28, 25, 26, 26
	Gambusia sp.	9	-
	Micropterus salmoides	1	60
	Procambarus sp.	9	-
3	Etheostoma fonticola	6	21, 30, 34, 20, 15, 16
	Palaemonetes sp.	1	-
	Procambarus sp.	6	-
4	Etheostoma fonticola	8	17, 20, 22, 26, 25, 38, 21, 16
	Gambusia sp.	18	-
	Lepomis sp.	1	10
	Procambarus sp.	4	-
5	Etheostoma fonticola	3	30, 25, 27
	Gambusia sp.	1	-
	Procambarus sp.	4	-
6	Etheostoma fonticola	2	27, 29
	Gambusia sp.	2	-
7	Etheostoma fonticola	1	35
	Gambusia sp.	4	-
	Procambarus sp.	3	-
8	Palaemonetes sp.	4	-
	Procambarus sp.	3	-
9	Etheostoma fonticola	1	35
	Palaemonetes sp.	1	-
	Procambarus sp.	3	-
10	Etheostoma fonticola	1	28
	Gambusia sp.	1	-
	Palaemonetes sp.	2	-
	Procambarus sp.	2	-
11	Etheostoma fonticola	1	27
	Procambarus sp.	8	-

12	Etheostoma fonticola	8	26, 24, 28, 17, 34, 26, 26, 27
	Procambarus sp.	3	-
13	Procambarus sp.	2	-
14	Etheostoma fonticola	2	26, 30
	Procambarus sp.	5	-
15	Procambarus sp.	3	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2204	Landa Lake	R1	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	7	30, 25, 28, 27, 28, 29, 34
	Palaemonetes sp.	6	-
	Procambarus sp.	4	-
2	Etheostoma fonticola	2	30, 20
	Gambusia sp.	10	21, 26, 17, 20, 19, 25, 11, 18, 31, 10
	Palaemonetes sp.	8	-
	Procambarus sp.	7	-
3	Etheostoma fonticola	3	15, 20, 20
	Gambusia sp.	33	25, 20, 20, 25, 18, 18, 21, 22, 22, 25, 25, 16, 17, 20, 20, 15
	Palaemonetes sp.	3	-
	Procambarus sp.	4	-
4	Etheostoma fonticola	2	18, 32
	Gambusia sp.	8	-
	Palaemonetes sp.	4	-
	Procambarus sp.	5	-
5	Etheostoma fonticola	1	22
	Gambusia sp.	5	-
	Procambarus sp.	1	-
6	Etheostoma fonticola	1	13
	Procambarus sp.	1	-
7	Etheostoma fonticola	1	30
8	No fish collected	-	-
9	Etheostoma fonticola	1	28
10	No fish collected	-	-
11	Etheostoma fonticola	1	30
	Palaemonetes sp.	1	-
12	No fish collected	-	-
13	Gambusia sp.	1	-
14	No fish collected	-	-
15	Procambarus sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2205	Landa Lake	R2	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	2	15, 31
2	Etheostoma fonticola	2	16, 15
3	Etheostoma fonticola	1	21
4	No fish collected	-	-
5	Etheostoma fonticola	1	25
6	No fish collected	-	-
7	Etheostoma fonticola	1	25
8	Etheostoma fonticola	1	18
9	No fish collected	-	-
10	No fish collected	-	-
11	No fish collected	-	-
12	No fish collected	-	-
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2206	Landa Lake	O1	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	Gambusia sp.	1	20
	Lepomis miniatus	2	33, 31
6	Gambusia sp.	1	24
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-
11	No fish collected	-	-
12	No fish collected	-	-
13	No fish collected	-	-
14	No fish collected	-	-
15	Etheostoma fonticola	1	18
16	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2207	Landa Lake	O2	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	No fish collected	-	-
3	Etheostoma fonticola	1	20
	Gambusia sp.	1	12
	Palaemonetes sp.	3	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	Etheostoma fonticola	1	17
11	No fish collected	-	-
12	No fish collected	-	-
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2208	Landa Lake	C1	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	5	22, 35, 23, 26, 12
	Gambusia sp.	47	35, 22, 32, 10, 22, 25, 20, 20, 15, 25, 20, 20, 15, 25, 15, 15, 26, 21, 16, 20, 16, 25, 21, 12, 15, 25
	Oreochromis aureus	1	26
	Palaemonetes sp.	12	-
	Procambarus sp.	1	-
2	Dionda nigrotaeniata	1	24
	Etheostoma fonticola	8	30, 30, 31, 27, 29, 30, 25, 31
	Gambusia sp.	29	-
	Palaemonetes sp.	1	-
3	Etheostoma fonticola	1	30
	Gambusia sp.	32	-
4	Etheostoma fonticola	3	30, 26, 19
	Gambusia sp.	53	-
	Micropterus salmoides	1	52
	Palaemonetes sp.	8	-
	Procambarus sp.	4	-
5	Etheostoma fonticola	2	26, 30
	Gambusia sp.	39	-
6	Etheostoma fonticola	4	25, 30, 30, 23
	Gambusia sp.	4	-
7	Etheostoma fonticola	2	26, 25
	Gambusia sp.	18	-
8	Gambusia sp.	3	-
9	Etheostoma fonticola	2	20, 30
	Gambusia sp.	7	-
10	Gambusia sp.	12	-
	Palaemonetes sp.	1	-
11	Etheostoma fonticola	1	30
	Gambusia sp.	1	-
12	Etheostoma fonticola	1	27
13	Procambarus sp.	1	-
14	Gambusia sp.	2	-
15	Etheostoma fonticola	1	28

16	Gambusia sp.	2	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2209	Landa Lake	C2	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	2	30, 23
	Gambusia sp.	4	15, 16, 10, 9
	Lepomis miniatus	1	37
	Lepomis sp.	3	15, 22, 12
2	Gambusia sp.	1	10
	Micropterus salmoides	1	69
	Palaemonetes sp.	1	-
3	Etheostoma fonticola	2	23, 31
	Gambusia sp.	1	13
4	Etheostoma fonticola	1	35
	Procambarus sp.	1	-
5	No fish collected	-	-
6	Etheostoma fonticola	3	31, 28, 22
	Procambarus sp.	2	-
7	Gambusia sp.	1	12
	Lepomis sp.	1	13
8	Etheostoma fonticola	1	21
9	No fish collected	-	-
10	Etheostoma fonticola	1	24
	Procambarus sp.	1	-
11	Etheostoma fonticola	1	12
	Gambusia sp.	1	10
12	Etheostoma fonticola	1	21
	Procambarus sp.	1	-
13	Procambarus sp.	1	-
14	Etheostoma fonticola	1	30
15	Gambusia sp.	1	10

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2210	Landa Lake	S1	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	1	21
	Gambusia sp.	2	19, 22
	Procambarus sp.	2	-
2	Lepomis miniatus	2	50, 62
	Procambarus sp.	2	-
3	Lepomis miniatus	2	85, 62
4	Lepomis miniatus	1	72
5	Lepomis miniatus	1	120
	Marisa cornuarietis	1	32
6	Procambarus sp.	3	-
7	Procambarus sp.	5	-
8	Procambarus sp.	2	-
9	Procambarus sp.	1	-
10	Lepomis miniatus	1	52
11	Procambarus sp.	1	-
12	Lepomis miniatus	1	100
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS
COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2211	Landa Lake	S2	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Procambarus sp.	11	-
2	Gambusia sp.	1	30
2	Procambarus sp.	7	-
3	Lepomis miniatus	1	82
3	Procambarus sp.	2	-
4	Lepomis miniatus	1	100
4	Procambarus sp.	3	-
5	Palaemonetes sp.	1	-
6	No fish collected	-	-
7	Procambarus sp.	4	-
8	Procambarus sp.	1	-
9	Gambusia sp.	1	21
10	Lepomis miniatus	1	50
11	No fish collected	-	-
12	No fish collected	-	-
13	No fish collected	-	-
14	No fish collected	-	-
15	Procambarus sp.	4	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2212	Old Channel Reach	C1	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	7	34, 22, 15, 25, 24, 18, 15
	Gambusia sp.	9	20, 12, 12, 10, 11, 35, 19, 16, 11
	Herichthys cyanoguttatus	2	34, 30
	Palaemonetes sp.	35	-
	Procambarus sp.	24	-
2	Etheostoma fonticola	2	26, 31
	Gambusia sp.	1	10
	Palaemonetes sp.	13	-
	Procambarus sp.	6	-
3	Etheostoma fonticola	3	25, 26, 17
	Gambusia sp.	3	32, 12, 15
	Palaemonetes sp.	10	-
	Procambarus sp.	2	-
4	Etheostoma fonticola	1	25
	Gambusia sp.	3	10, 12, 16
	Lepomis miniatus	1	33
	Palaemonetes sp.	6	-
	Procambarus sp.	3	-
5	Etheostoma fonticola	3	22, 28, 18
	Gambusia sp.	1	26
	Lepomis macrochirus	1	56
	Palaemonetes sp.	4	-
	Procambarus sp.	4	-
6	Etheostoma fonticola	4	26, 21, 30, 26
	Palaemonetes sp.	1	-
	Procambarus sp.	3	-
7	No fish collected	-	-
8	No fish collected	-	-
9	Gambusia sp.	1	10
10	Etheostoma fonticola	2	28, 25
	Lepomis macrochirus	1	50
	Lepomis miniatus	1	38
	Procambarus sp.	2	-
11	Etheostoma fonticola	1	23
12	No fish collected	-	-
13	Gambusia sp.	1	21
14	Procambarus sp.	3	-

15	Palaemonetes sp.	3	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2213	Old Channel Reach	C2	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	5	29, 19, 17, 27, 22
	Gambusia sp.	4	15, 17, 13, 12
	Herichthys cyanoguttatus	1	30
	Lepomis macrochirus	1	45
	Palaemonetes sp.	30	-
2	Etheostoma fonticola	9	26, 25, 26, 30, 26, 20, 26, 20, 16
	Gambusia sp.	4	27, 20, 17, 19
	Herichthys cyanoguttatus	2	23, 26
	Palaemonetes sp.	47	-
	Procambarus sp.	5	-
3	Etheostoma fonticola	9	31, 26, 22, 32, 34, 29, 27, 19, 23
	Gambusia sp.	5	21, 15, 15, 14, 12
	Lepomis miniatus	1	40
	Palaemonetes sp.	20	-
	Procambarus sp.	4	-
4	Palaemonetes sp.	5	-
5	Etheostoma fonticola	5	31, 24, 25, 27, 13
	Gambusia sp.	1	16
	Palaemonetes sp.	21	-
	Procambarus sp.	4	-
6	Palaemonetes sp.	11	-
	Procambarus sp.	8	-
7	Etheostoma fonticola	6	20, 27, 28, 27, 25, 25
	Palaemonetes sp.	7	-
	Procambarus sp.	6	-
8	Etheostoma fonticola	3	30, 20, 30
	Palaemonetes sp.	6	-
	Procambarus sp.	2	-
9	Procambarus sp.	3	-
10	Procambarus sp.	3	-
11	No fish collected	-	-
12	Etheostoma fonticola	1	26
	Procambarus sp.	5	-
13	Procambarus sp.	4	-
14	Gambusia sp.	1	13
15	Palaemonetes sp.	3	-

	Procambarus sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2214	Old Channel Reach	L1	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	4	22, 26, 24, 26
	Gambusia sp.	1	18
	Herichthys cyanoguttatus	1	28
	Palaemonetes sp.	8	-
2	Etheostoma fonticola	11	26, 26, 14, 20, 27, 23, 26, 30, 20, 20, 28
	Gambusia sp.	1	27
	Palaemonetes sp.	20	-
	Procambarus sp.	12	-
3	Etheostoma fonticola	3	26, 26, 20
	Gambusia sp.	1	16
	Palaemonetes sp.	9	-
	Procambarus sp.	2	-
4	Etheostoma fonticola	3	29, 31, 22
	Palaemonetes sp.	10	-
	Procambarus sp.	6	-
5	Etheostoma fonticola	3	22, 32, 31
	Gambusia sp.	1	27
	Palaemonetes sp.	4	-
	Procambarus sp.	2	-
6	Etheostoma fonticola	2	28, 30
	Palaemonetes sp.	4	-
	Procambarus sp.	3	-
7	Etheostoma fonticola	1	22
	Gambusia sp.	2	24, 26
	Palaemonetes sp.	2	-
8	Gambusia sp.	1	15
	Lepomis macrochirus	1	50
	Palaemonetes sp.	2	-
	Procambarus sp.	2	-
9	Etheostoma fonticola	4	25, 26, 29, 26
	Procambarus sp.	1	-
10	Etheostoma fonticola	1	26
11	Procambarus sp.	1	-
12	No fish collected	-	-
13	Etheostoma fonticola	1	23
14	Procambarus sp.	1	-

15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2215	Old Channel Reach	L2	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Gambusia sp.	1	15
	Palaemonetes sp.	5	-
2	Palaemonetes sp.	3	-
3	Lepomis auritus	1	41
4	Lepomis auritus	1	81
5	No fish collected	-	-
6	Palaemonetes sp.	1	-
7	Palaemonetes sp.	1	-
8	Procambarus sp.	1	-
9	Palaemonetes sp.	1	-
10	Gambusia sp.	1	16
11	Gambusia sp.	1	15
12	No fish collected	-	-
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS
COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2216	Old Channel Reach	O1	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	No fish collected	-	-
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	**Location (Reach):**	**Site:**	**Date:**
2217	Old Channel Reach	O2	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	**Species**	**Number**	**Length (mm)**
1	No fish collected	-	-
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2218	Old Channel Reach	R1	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	17	31, 30, 22, 27, 29, 37, 30, 26, 23, 16, 26, 24, 31, 27, 29, 27, 31
	Gambusia sp.	2	12, 15
	Palaemonetes sp.	58	-
	Procambarus sp.	9	-
2	Etheostoma fonticola	1	18
	Palaemonetes sp.	6	-
	Procambarus sp.	6	-
3	Etheostoma fonticola	1	30
	Lepomis sp.	1	10
	Palaemonetes sp.	6	-
	Procambarus sp.	8	-
4	Etheostoma fonticola	4	30, 30, 28, 26
	Gambusia sp.	1	12
	Palaemonetes sp.	3	-
	Procambarus sp.	2	-
5	Etheostoma fonticola	5	24, 28, 31, 25, 22
	Palaemonetes sp.	4	-
	Procambarus sp.	7	-
6	Etheostoma fonticola	4	30, 30, 27, 26
	Procambarus sp.	3	-
7	Etheostoma fonticola	3	28, 32, 26
	Procambarus sp.	2	-
8	Procambarus sp.	1	-
9	Etheostoma fonticola	1	28
	Palaemonetes sp.	2	-
	Procambarus sp.	2	-
10	Gambusia sp.	1	26
11	Etheostoma fonticola	1	30
	Procambarus sp.	2	-
12	Marisa cornuarietis	1	11
	Palaemonetes sp.	2	-
13	Etheostoma fonticola	1	30
	Procambarus sp.	1	-
14	Gambusia sp.	1	26
	Procambarus sp.	2	-

15	Gambusia sp.	1	12
	Procambarus sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2219	Old Channel Reach	R2	10/24/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	5	25, 26, 22, 20, 12
	Palaemonetes sp.	2	-
	Procambarus sp.	5	-
2	Etheostoma fonticola	2	22, 32
	Procambarus sp.	1	-
3	Etheostoma fonticola	5	27, 31, 30, 26, 21
	Procambarus sp.	5	-
4	Etheostoma fonticola	3	30, 29, 30
	Procambarus sp.	3	-
5	Etheostoma fonticola	5	30, 33, 28, 27, 34
	Procambarus sp.	3	-
6	Gambusia sp.	1	25
	Palaemonetes sp.	1	-
	Procambarus sp.	2	-
7	No fish collected	-	-
8	Etheostoma fonticola	3	26, 26, 27
9	Etheostoma fonticola	8	28, 31, 26, 28, 30, 19, 30, 29
	Procambarus sp.	2	-
10	Etheostoma fonticola	1	31
	Procambarus sp.	3	-
11	Etheostoma fonticola	1	29
12	No fish collected	-	-
13	No fish collected	-	-
14	Etheostoma fonticola	2	26, 27
15	Procambarus sp.	1	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2220	Upper New Channel Reach	R1	10/25/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma lepidum	1	50
	Gambusia sp.	2	10, 12
	Procambarus sp.	13	-
2	Herichthys cyanoguttatus	2	38, 31
	Lepomis macrochirus	1	37
	Procambarus sp.	9	-
3	Lepomis cyanellus	1	60
	Procambarus sp.	7	-
4	Lepomis cyanellus	1	70
	Procambarus sp.	4	-
5	Procambarus sp.	3	-
6	Herichthys cyanoguttatus	2	44, 32
	Procambarus sp.	6	-
7	Gambusia sp.	1	16
8	Procambarus sp.	6	-
9	Herichthys cyanoguttatus	1	48
	Procambarus sp.	4	-
10	Herichthys cyanoguttatus	1	55
	Procambarus sp.	4	-
11	Etheostoma fonticola	1	14
	Gambusia sp.	1	17
	Herichthys cyanoguttatus	1	22
	Lepomis cyanellus	1	65
12	Lepomis cyanellus	1	56
	Procambarus sp.	2	-
13	Procambarus sp.	1	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2221	Upper New Channel Reach	R2	10/25/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Gambusia sp.	1	11
	Herichthys cyanoguttatus	2	42, 50
2	Etheostoma fonticola	1	32
3	Etheostoma fonticola	1	20
	Procambarus sp.	9	-
4	Procambarus sp.	2	-
5	Herichthys cyanoguttatus	1	26
5	Procambarus sp.	1	-
6	No fish collected	-	-
7	No fish collected	-	-
8	Procambarus sp.	3	-
9	Etheostoma fonticola	1	16
10	No fish collected	-	-
11	No fish collected	-	-
12	No fish collected	-	-
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2222	Upper New Channel Reach	O1	10/25/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Gambusia sp.	1	25
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	Gambusia sp.	1	14
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-
11	No fish collected	-	-
12	No fish collected	-	-
13	No fish collected	-	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	**Location (Reach):**	**Site:**	**Date:**
2223	Upper New Channel Reach	O2	10/25/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	**Species**	**Number**	**Length (mm)**
1	No fish collected	-	-
2	No fish collected	-	-
3	No fish collected	-	-
4	No fish collected	-	-
5	No fish collected	-	-
6	No fish collected	-	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2224	Upper New Channel Reach	H1	10/25/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Gambusia sp.	2	41, 22
	Herichthys cyanoguttatus	2	36, 26
	Lepomis macrochirus	1	32
	Poecilia latipinna	2	34, 32
2	Ambloplites rupestris	1	65
	Gambusia sp.	3	24, 20, 22
	Lepomis megalotis	1	48
	Lepomis miniatus	1	30
3	Herichthys cyanoguttatus	2	49, 25
	Lepomis miniatus	1	32
	Palaemonetes sp.	55	-
	Procambarus sp.	3	-
4	Ambloplites rupestris	1	62
	Lepomis microlophus	1	55
	Lepomis miniatus	1	36
	Procambarus sp.	3	-
5	Ambloplites rupestris	1	68
	Gambusia sp.	1	12
	Lepomis miniatus	1	30
	Procambarus sp.	2	-
6	Herichthys cyanoguttatus	1	38
	Palaemonetes sp.	2	-
	Procambarus sp.	1	-
7	No fish collected	-	-
8	No fish collected	-	-
9	Procambarus sp.	1	-
10	No fish collected	-	-
11	No fish collected	-	-
12	No fish collected	-	-
13	Lepomis cyanellus	1	35
	Lepomis macrochirus	2	40, 30
	Palaemonetes sp.	4	-
14	No fish collected	-	-
15	No fish collected	-	-

DROP NET-FIELD DATA SHEETS

COMAL RIVER-FALL 2017 SAMPLING

SiteCode	Location (Reach):	Site:	Date:
2225	Upper New Channel Reach	H2	10/25/2017

COMAL RIVER-FALL 2017 SAMPLING

Dip Net Sweep	Species	Number	Length (mm)
1	Etheostoma fonticola	2	36, 22
	Lepomis macrochirus	3	30, 35, 27
	Procambarus sp.	3	-
2	Lepomis miniatus	1	97
	Procambarus sp.	1	-
3	Procambarus sp.	1	-
4	Gambusia sp.	1	32
	Lepomis miniatus	1	33
	Lepomis sp.	1	14
	Procambarus sp.	1	-
5	Etheostoma fonticola	1	31
6	Procambarus sp.	3	-
7	No fish collected	-	-
8	No fish collected	-	-
9	No fish collected	-	-
10	Lepomis miniatus	1	40
11	No fish collected	-	-
12	No fish collected	-	-
13	No fish collected	-	-
14	Etheostoma fonticola	1	18
	Procambarus sp.	1	-
15	Etheostoma fonticola	1	15
16	Lepomis megalotis	1	51