ANNUAL STATUS REPORT
FY 2000

(October 1999 – September 2000)

BALCONES CANYONLANDS CONSERVATION PLAN

REGIONAL SECTION 10(a) PERMIT NO. PRT-788841

TRAVIS COUNTY - CITY OF AUSTIN

SUBMITTED BY

COORDINATING COMMITTEE SECRETARY

OF THE

BALCONES CANYONLANDS PRESERVE

JANUARY 2001

BALCONES CANYONLANDS ANNUAL REPORT (FY 2000)

1. A LIST OF ALL DEVELOPMENT ACTIVITIES WEST OF MOPAC RAILROAD

The intense development activity in Western Travis County observed during the last few years under the regional permit has continued, although there are some signs of economic leveling in the new high-end residential developments due to slowing in the high tech sector. Details of Travis County development permit applications for the period October 1999 through September 2000 have been submitted to the U.S. Fish and Wildlife Service (USFWS) monthly and duplicates are not being included in this report. The monthly format and submittal appear to have more utility as a planning and enforcement tool for ongoing development activity.

No separate City of Austin development activity report has been compiled for the October 1999-September 30, 2000 time period. Based on comments from USFWS staff concerning the difficulty of using previous annual data compilations to target active clearing projects for assessment of their regulatory status, City staff is investigating the possibility of developing alternative reporting formats that have more utility to USFWS. Part of the problem lies in the fact that Balcones Canyonlands Conservation Plan (BCCP) concerns for endangered species and their habitat were purposefully disconnected at the start from the prescribed City development review process. In addition, state legislation during the past session changed the ability of cities and other political subdivisions to use habitat or species presence to deny development permits based on this condition. This has limited the generation and internal reporting of important habitat data during development reviews. However, an ongoing reorganization and consolidation among those City's staff who handle doing various stages of the development reviews should help in the near future.

2. A LIST OF ALL TRACTS FOR WHICH PARTICIPATION CERTIFICATES WERE PURCHASED.

Participation Certificate Activity

Travis County has developed and operated the BCCP Public Participation process which issues Participation Certificates for eligible properties within the permit area. According to these records, 13 single family residences, 18 subdivisions, one golf course, and one infrastructure project were issued Participation Certificates or paid mitigation fees under the regional permit during the program's fiscal year 99-00. In addition, one single family development project was permitted separately by the USFWS and directed to mitigate through fee payment to the BCCP. In such cases, Travis County received the mitigation fees to benefit the BCCP.

The BCCP participants that received participation certificates for FY 99-00 were as follows:

Date Issued	BCCP #	Name	Category	Amount Paid
11/10/99	0206	B. & C. Medford	Single Family	$1,500
12/1/99	0243	P. McKiernan	Single Family	$1,500
12/3/99	0231	T. & F. Baird	Single Family (7)	$10,500
12/17/99	0137	B. Theriot	Subdivision (karst)	$330
1/5/00	0249	D. Kesslinger	Subdivision	$900
1/14/00	0227	L. Hartman & WD Jones	Single Family	$1,500

2/17/00	0261	L. Holmes / AT&T	Infrastructure	$300
2/18/00	0253	L. & E. Herczeg	Single Family	$1,500
2/23/00	0248	B. Magee	Subdivision	$71,700
2/24/00	0212-1	S. Morse	Subdivision	$17,402
2/24/00	0212-6	S. Morse	Subdivision	1,403
4/28/00	0156	Lane	Single Family	$1,500
5/11/00	0258	CCNG	Golf Course	$242,400
5/11/00	0212-7	S. Morse	Subdivision	$8,698
5/11/00	0212-8	S. Morse	Subdivision	$14,179
5/31/00	0212-9	S. Morse	Subdivision	$10,846
5/31/00	0212-10	S. Morse	Subdivision	$7,014
5/31/00	0212-3	S. Morse	Subdivision	$22,859
5/25/00	0266	Eppright	Subdivision	$45,900
5/31/00	0265	Lago Vista	Subdivision	$18,300
6/2/00	0260	R. Redmond	Subdivision	$25,950
6/9/00	0252	BVD Partners, L.P.	Subdivision	$52,527
6/20/00	0242	D. Burnett	Subdivision	$27,000
6/22/00	0279	M. McGarrah	Single Family	$1,500
7/11/00	0254	Graham Parker	Subdivision	$5,788
8/3/00	0166	Mark Burgessporter	Subdivision	$5,700
TOTAL				**$598,696**

In addition, one project paid mitigation fees to the USFWS based on a 10a permit they issued. A total of $1,500 was directed to the BCCP program from the USFWS for this single-family residence.

Date Paid	BCCP #	Name	USFWS#	Amount Paid
9/13/00	0285	Mark Hogan	TE-005497-0	$1,500.00

Infrastructure Project Mitigation Credit Usage

Infrastructure projects for co-permittees and managing partners with infrastructure development needs are covered for their mitigation needs under the regional permit. Their mitigation requirements are subtracted from accumulated mitigation credits based on their land dedications to the BCP. All acreage units are based on Zone 1 golden-cheeked warbler habitat units or their monetary equivalent in other types of protected habitat categories. During the FY 99-00 period of permit processing and implementation, the following projects used mitigation credits:

- **Lower Colorado River Authority**

Starting LCRA Balance	**2561.5 acres**
Relocation of LCRA electric tower near Quinlan Park Rd.	**(0.3) acres**
City of Leander Water System Improvements (LCRA)	**(9.5) acres**
Joint LCRA/AE transmission line reconductoring – Barton Creek GB/WP	**(1.6) acres**
LCRA waterline along FM 2244 to Seven Oaks development	**(1.6) acres**
Southwestern Travis Co Water Supply Pipeline	**(9.4) acres**
PEC Electric Line Upgrade along Nameless Road	**(0.2) acres**
Tom Miller Dam Improvements	**(0.3) acres**
Rollingwood Wastewater Service Retrofit Project	**(0.4) acres**
Remaining Mitigation Credits	**2538.2 acres**

- **Travis County**

Starting Travis County Balance	**522.3 acres**
New preserve additions (credits)	**581.0**
No project debits	**0.0 acres**
Remaining Mitigation Credits	**1103.3 acres**

- **City of Austin**

Starting City of Austin Balance	**11,469.75 acres**
New preserve additions (credits)	**70.6**
New Water Supply line w/chlorinators at Ullrich WTP	**(0.1) acres**
Buried Utilities into Coldwater Unit along City Park Road	**(0.1) acres**
New Driveway Access into Barton Substation	**(0.2) acres**
Joint LCRA/AE transmission line reconductoring – Barton Creek GB/ WP	**(0. 8) acres**
New AE substation in Steiner Ranch near Mansfield Dam	**(3.0) acres**
Tree removal within AE Bee Creek Substation	**(0.1) acres**
Four Points Dr/Zimmerman Lane Waterline	**(1.8) acres**
Electric Distribution Line Maintenance near Loop 360 & Spicewood Spgs	**(0.3) acres**
Zimmerman Lane Annexation Area Water/Wastewater Improvements	**(3.1) acres**
Barton Creek Wastewater Line Rightsizing Project	**(0.7) acres**
Remaining Mitigation Credits	**11, 528.15 acres**

3. AMOUNT OF FUNDS COLLECTED FOR LAND ACQUISITION THROUGH THE ISSUANCE OF PARTICIPATION CERTIFICATES.

A total of $620,446 was collected over the past fiscal year from all sources for use in future preserve land acquisitions. Participation certificates yielded $618,946, while USFWS project referrals amounted to $1500. The amount of fees received differs from the participation certificate total because two applicants made partial payments; specifically, Travis County has received mitigation payments of $19,950 for BCCP #0239 (partial payment only) and $300 for BCCP #0259, but these applicants have not yet received signed contracts or been issued Participation Certificates. Overall, the funds collected last year represent a far greater use of the BCCP participation process by landowners than experienced in prior years. Specific information on projects that fully paid for their BCCP participation in FY 99-00 is provided under item #2.

4. AMOUNT OF FUNDS EXPENDED FOR LAND ACQUISITION.

City of Austin

The City of Austin continued land acquisitions for the Balcones Canyonlands Preserve (BCP). During FY 99-00, the City of Austin concluded the purchase of the 62-acre Friesenhahn tract which unifies portions of the Barton Creek Wilderness Park. In order to prevent imminent commercial development of this inholding within the Wilderness Park, the City Council authorized the purchase of this key property for $6.9 M, using $350, 000 from the City's share of accrued Participation Certificate revenue as well as other funds from Proposition 2 water quality conservation bonds and undesignated parkland bonds. Despite the majority of the money coming from other sources, the City designated this property to the Balcones Canyonlands Preserve like the adjoining tracts. In addition, the City purchased the Gibson/Nott tract within the Lower Bull Creek Unit near the White Cliff Dr. development. The City paid $250,000 for this 8.6-acre parcel. The funds expended for Gibson/Nott came primarily from the City's share of accrued Participation Certificate revenue.

A $1.0M payment from the Lakeway Partners in September, 2000 covered the final payment of three required mortgage installment payments on the Ivanhoe property. This City-owned property in now clear of any financial obligations.

Travis County

Travis County purchased the Grandview Hills tract during this reporting period for a total purchase price of $5,521,334, plus an additional $58,649 expended on related closing items (appraisals, land planning, boundary surveys, and environmental site assessment [ESA] document) to complete the real estate transaction for Grandview Hills. The phased acquisition of the 581-acre Grandview Hills tract was completed in August 2000 (Phase 2) and October 2000 (Phase 1). Funding came from a combination of Section 6 federal grant funding and matches from County shares of Participation Certificate revenues and other funding sources.

In preparation to acquire the Bunten tract, a total of $5,060 was expended on necessary closing documents, such as an appraisal and preliminary ESA. Acquisition of this 142-acre parcel adjacent to Grandview Hills is expected during FY00-01.

Travis County has continued to receive grant funding for preserve acquisitions over the last three years. After receiving its first $2.0 M grant for land acquisition in FY98 from USFWS, the County submitted its second Section 6 "Habitat Conservation Plan" acquisition grant application in January 1999 and received notice of a $1.5 million award in May 1999. The County submitted its third Section 6 HCP acquisition grant application in January 2000 and received notice of a $4.14 million award in June 2000. The grant contract was signed by Texas Parks and Wildlife on August 24 and by the Commissioners' Court on September 12, 2000. Each of the three grants contributed to the Grandview Hills purchase; the remaining balance of the FY 00 grant is being targeted for the Bunten tract and a variety of others on the grant priority list.

5. AMOUNT OF FUNDS EXPENDED FOR OPERATIONS AND MAINTENANCE.

Travis County expended $299,635 in fiscal year 2000 for operations and maintenance for those Travis County properties included in the Balcones Canyonlands Preserve: Hamilton Pool Preserve, Wild Basin, Romberg, Lake Perspectives, and Grandview Hills Preserve. This figure does not include expenditures by The Committee for Wild Basin Wilderness, Inc., which has a contract with Travis County to conduct educational programming and management activities on the County-owned Wild Basin Preserve.

The City of Austin spent a total of $645,490 for FY 99-00 to fund preserve management expenditures by the Parks and Recreation Department's Natural Resources Division, Balcones Canyonlands Program. Land acquisition costs were appropriated and spent separately from accumulated participation certificate revenue (after distribution of City/County splits). This figure understates the City's total expenditures on this program, since it does not include (1) work by other staff in the Natural Resources Division on program administration and support; (2) operations & maintenance expenditures by PARD's Park Operations on BCP-designated parkland; or (3) land management expenditures by the Water and Wastewater Utility on the two tracts that it owns and manages. Such information cannot be readily determined from their program budgets.

6. AN UPDATED MAP OF THE LANDS DEDICATED TO PRESERVE MANAGEMENT.

An updated BCP ownership map prepared by Travis County is attached showing the new tracts that have been added to the preserve by the permit holders since last year's annual report. In addition, two private tracts with existing USFWS 10(a) permits (Schram Ranch and the Balfour tract) will be added to the preserve ownership map once the precise boundaries of the preserved onsite mitigation has been officially designated by USFWS as required by their 10(a) permits.

7. A LIST OF PUBLIC USE AND HABITAT MANAGEMENT ACTIVITIES THAT HAVE BEEN UNDERTAKEN OR COMPLETED WITHIN THE BOUNDS OF THE PRESERVE UNITS.

TRAVIS COUNTY (5 tracts)

Travis County owns five tracts that are dedicated and managed as preserve land within the Balcones Canyonlands Preserve. Following are brief summaries of top activities for each tract during FY 2000:

Hamilton Pool Preserve: Pre-existing (to the BCCP) public use continued during the reporting period. The Preserve staff maintained approximately 1.5 miles of nature trails for daily public access. Hours were restricted to day use only and user fees were charged; public access was restricted to trails and pool area. Pets, fires, cooking, fishing, and collecting are prohibited.

Habitat management activities included routine trail maintenance, endangered species surveys, and deer survey protocol preparation. During the 2000 nesting season, 9 male golden-cheeked warblers (GCWs) were observed to hold territories at Hamilton Pool Preserve, while a total of 8 female and 20 fledgling GCWs were also observed within the preserve during surveys.

Wild Basin Wilderness Preserve: Pre-existing levels of public use continued during the reporting period. The Preserve is managed by The Committee for Wild Basin Wilderness, Inc., with financial and staff support from the County. Approximately 2.5 miles of nature trails are maintained for daily public and educational tour use. Hours are restricted to day use only and visitor access is restricted to designated trails. Picnicking, pets, and collecting are prohibited.

Habitat management activities at Wild Basin included endangered species surveys, installation of erosion controls, trail improvements, and routine trail maintenance. During the 2000 nesting season, onsite monitoring determined that two male golden-cheeked warblers (GCWs) held territories and also two female GCWs were observed within the preserve.

Romberg Tract: The Romberg tract is not open to the public. Land management activities included boundary checks and endangered species surveys. Two field visits yielded no evidence of GCW activity in 2000, although 2 males were heard singing off property to the east. Historically, warblers have used this preserve for foraging and juvenile dispersal but no nest activity has been documented on the preserve.

Lake Perspectives Tract: The Lake Perspectives tract is not open to the public. Land management activities included endangered species surveys, deer survey protocol preparation, and other biological surveys. During monitoring for the 2000 nesting season, 9 male GCWs held territories (including some partly located in adjacent tracts) and another 7 female and 10 fledgling GCWs were observed within the preserve boundaries.

Grandview Hills Tract: This 581 acre tract within the Cypress Creek macrosite was acquired in two phases in 2000 (August and October). A land management plan for the property will be prepared for the next annual reporting period. The Grandview Hills Tract is not open to the public. Initial management activities for this new acquisition have included: (1) locating boundaries and old roads, (2) estimating fencing status and needs, (3) assessing corrective action alternatives to solve a pre-existing erosion problem, and (4) reviewing historic survey data.

System-Wide Activities by Travis County

In addition to land management activities on specific County-owned BCP lands, Travis County has been involved in certain other program-level activities that affect multiple properties. For example, Travis County managed the regional cowbird trapping program for various preserve properties, both public and private, in the vicinity of known black-capped vireo habitat as well as selected prime golden-cheeked warbler habitat.

Cowbird Trapping Program: There were a total of 8 operational traps for brown-headed cowbirds over the past bird season at or near preserve properties. Travis County operated five traps for this species at Hamilton Pool, Travis County Satellite 2 (at Mansfield Dam), Cortana, River Place, and Steiner Ranch, while City staff were responsible for operation of three traps (Canyon Creek, 3M, and Ivanhoe). A total of 301 brown-headed cowbirds were trapped and removed from the area during the warbler and vireo nesting season. Of these birds caught, 123 were female – potential nest parasites. Non-target bird species were released unharmed when caught in the traps. Results for the 2000 bird season are reported in the Brown-headed Cowbird Report – a separate monitoring report attachment.

Education /Outreach: Travis County has undertaken a variety of education/outreach activities regarding the Balcones Canyonlands Preserve over the past year. Notable education/outreach efforts include:

- Preparation and staffing of the BCP exhibit for Wildlife EXPO (Texas Parks and Wildlife Department's annual event).
- Several presentations about the BCCP Public Participation process made to local real estate professionals.
- Staff led Austin Science Fun Day activities in partnership with Oak Hill Elementary.

LOWER COLORADO RIVER AUTHORITY (3 tracts)

As a BCP managing partner, the Lower Colorado River Authority owns and manages three tracts within the Preserve. A detailed account of FY 99-00 management activities and monitoring results by tract is provided in Attachment A. Brief summaries of the key LCRA activities on each tract are provided below.

Wheless Preserve: Management activities for the Wheless tract this year included efforts to conduct research on natural resources, manage access, and encourage stewardship LCRA staff conducted a deer census with the finding of 16.45 acres/animal. LCRA staff also repaired sections of damaged fence and posted additional boundary signs. Wheless remains closed to unlimited public access.

An LCRA contractor conducted rare bird surveys on three areas (two 100-acre study plots and an area surrounding a proposed black-capped vireo restoration site). During the 2000 bird season, a

total of 24 golden-cheeked warbler territories were identified on the two 100-acre study plots and the additional survey area. The field visits confirmed the presence of 16 fledglings.

The City of Austin staff attempted to collect Jollyville salamanders at Long Hollow, but was unsuccessful, as the subject spring was not emergent.

Westcave Preserve: A two-acre prescribed burn at the Westcave Preserve helped control invasive prickly-pear and pencil cactus. A grant application for a proposed environmental learning center was submitted to Texas Parks and Wildlife. Westcave Preserve staff again hosted thousands of students, teachers, tourists, researchers, and nature-enthusiasts for site visits and gave many off-site presentations.

LCRA staff surveyed this tract for rare birds during the 2000 bird season. At the Westcave site, 6 golden-cheeked warbler territories were identified (including one nest and two family units with fledglings).

McGregor: LCRA staff initiated a volunteer neighborhood preserve stewardship program, called the McGregor Good Neighbor Program. In return for some limited access, preserve neighbors were organized to observe and protect this site. A boundary survey of the McGregor tract was conducted and construction of perimeter high-fence was started. LCRA staff also posted additional boundary signs identifying the property as preserve land.

Travis County staff assisted LCRA staff with rare bird surveys at McGregor. During the 2000 season, 16 golden-cheeked warbler territories were identified and mapped. These data included observations of one warbler nest and three family units with fledglings.

TRAVIS AUDUBON SOCIETY

TAS Sanctuary:

Public access and trail maintenance

- The Sanctuary was open from January 27, 2000 until October 29. Sanctuary visitation is strictly monitored and regulated. All visitors must have permission to visit. At closure, notice was posted on the gate.
- The sanctuary will have restricted access during the Golden-cheeked Warbler nesting season (March 1 to July 1).
- Visitors are expected to sign in observe regulations posted on site and on the Travis Audubon Society web pages.
- By November 2000, 334 people had signed the Sanctuary sign-in list. Two thirds of these guests visited during March, April and May.
- On March 24, Travis Audubon Society held an open house at the Sanctuary with guided tours 9:00 am to noon. Fifty-six visitors toured the Sanctuary.
- Three workdays were held in January, February and March. Volunteers cleared scrub juniper from under hardwoods and stacked the slash stacked over hardwood saplings for deer protection.
- Trail maintenance included removal of fallen branches, rerouting one trail; revising the trail map and trail guide, improving trail markers and improving the parking lot.
- On March 27, a birding tour for an out-of-town birding club took place.

- In early April, a junior high science group sought monarch caterpillars and Jollyville salamanders at the Sanctuary. They found caterpillars but no salamanders.

Boundary control

- The Sanctuary managers planted Opuntia cactus fences with brush barriers at vulnerable locations along the Sanctuary boundary.
- They repaired gaps in existing fences.
- They routinely monitor surrounding development impacts including upcoming highway and roadway projects.

General maintenance

- The Sanctuary managers and assorted volunteers hauled away large trash piles including scrap metal, old appliances and similar debris from around the old residence.
- TAS acquired land management tools including an ATV, a chain saw and fire fighting tools.

Problem animal control

- The Sanctuary managers managed five private deer hunting leases. This year's hunters killed a total of twenty deer including eleven doe and nine bucks, four of which were antlerless. Hunters on the Sanctuary are obligated by a specific set of hunting regulations available from Sanctuary manager John Wilcox.
- Four hogs were killed including a 180-pound boar.
- John Wilcox acquired a license to trap cowbirds from TPWD. A cowbird trap is currently under construction. He plans to begin trapping in 2001.

Endangered species

- Christine Polito surveyed the 100-acre study plot for golden-cheeked warblers in May. She found five to seven territories.

Restoration

- John and Marcie Wilcox planted over 1600 acorns in October.

Cultural resources

- The Sanctuary manager and a volunteer conducted an archaeological survey and filed the results with the appropriate state agency.

THE NATURE CONSERVANCY (2 tracts)

Barton Creek Habitat Preserve: The Nature Conservancy of Texas –Hill Country office is now located at the Barton Creek Habitat Preserve. During FY 99-00, staff continued its vireo management program by creating potential habitat at a new 50-acre site along the south side of Southwest Parkway. The vireo habitat restoration site was first prepared by cutting down all trees over three feet high and then conducting a prescribed burn on March 1 to eliminate vegetation and woody debris. At the Vireo Hill restoration site across the road, post-burn restoration of the Nature Conservancy's initial restoration site continued via supplemental planting of native habitat vegetation, such as shin oak (acorns and seedlings), elbow bush, and evergreen sumac. Staff placed protective cages around seedlings and saplings to deter deer browse. Extensive supplemental watering of restoration plantings was necessary from an onsite 600-gallon water storage tank during the spring-summer drought to keep plants alive.

The Barton Creek Habitat Preserve has continued to conduct field surveys for golden-cheeked warbler and black-capped vireo. There were no observations of vireos onsite during the 2000 bird season. Throughout the BC Habitat Preserve, a total of 60 golden-cheeked warbler territories were documented. This population size appears similar over the past few years of monitoring.

The Nature Conservancy has also undertaken a program of bottomland hardwood restoration at five previously cleared fields near Barton Creek. The first 10-12 acre site was planted with native hardwood saplings this past year. By restoring open fields, a more complete tree canopy can be developed over the long term in those areas near warbler habitat.

Lehman Tract: Management activities on the Lehman property include periodic patrolling and occasional fence repair. This property has an emerging hog problem, similar to the LCRA's Wheless tract and nearby private holdings.

One bird monitoring visit to the Lehman property was conducted by TNC staff during the 2000 bird season. Some warbler presence was noted during that visit, but no quantitative data was recorded. An upgrade in warbler monitoring protocols can be expected during the 2001 bird season, so that all BCP managing partners are collecting similar bird data.

City of Austin staff visited Adobe Springs Cave, a designated BCCP cave, to check the status of fire ants and resident karst invertebrates. An investigation of Adobe Springs for the presence of Jollyville salamanders was not successful due to a lack of water flow from this spring.

CITY OF AUSTIN (33 tracts)

The City of Austin's preserve units and responsible management entities are identified in Table 1. Six biologists within PARD's Natural Resources Division currently manage over 9500 acres of the BCP and assist PARD Park Operations on the other 3200 acres of designated parks and preserves. Management of the two tracts owned by the Water and Wastewater Utility (178 acres) has been internally transferred from the Water Treatment operations group to the land manager handling the Proposition 2 water quality and conservation lands.

TABLE 1
CITY OF AUSTIN BCP PROPERTIES
MANAGEMENT STATUS

Primary Management by PARD/BCP:

Tract	Acres
Bull Creek Macrosite	
Upper Bull Creek (Franklin, Hanks, Lanier, COA Canyon Creek)	608
Middle Bull Creek (Ivanhoe and Beard Trust)	1001
Lower Bull Creek (St. Edward's Park, Jester, Forest Ridge, 3M, Hilltop, Spicewood Springs Park, Gibson/Nott)	1027
Cypress Creek Macrosite	
Lime Creek (inc. 100 acres of Austin-Simon, Ltd.)	594
North Lake Austin Macrosite	
Park West, Coldwater I & II, Long Canyon	1277
Cortana	1752
South Lake Austin Macrosite	
Double J&T	1729
Reicher Ranch	820
Bohls Ranch	462
Senna Hills	35
West Austin	
Vireo Research Area	212
SUBTOTAL	9517

Primary Management by Other City Entities:

Tract	Status	Acres
Bull Creek Macrosite		
Bull Ck District Park, BC Gnblt	* PARD Operations	233
Water Treatment Plant #4	W&WW	138
Spicewood Springs Preserve	PARD Operations	8
Barrow Preserve	PARD Operations	8
North Lake Austin Macrosite		
Emma Long Metro Park	PARD Operations	950
South Lake Austin Macrosite		
Commons Ford Park	PARD Operations	115
Barton Creek Macrosite		
Barton Creek Wilderness	PARD Operations	999
Barton Creek Greenbelt	PARD Operations	813
Friesenhahn	PARD Operations	62
West Austin Macrosite		
Mt. Bonnell	PARD Operations	3
Ullrich Water Treatment Plant	W&WW	40
	SUBTOTAL	**3369**
TOTAL ACREAGE		**12,886**

* PARD Operations does not manage for Endangered Species; they perform regular maintenance, i.e. mowing, trash pickup, and some trail management activities. Species management assistance is provided by PARD's BCP staff.

UPPER BULL CREEK UNIT

Canyon Creek: Illegal trespass from Canyon Creek development remains an ongoing problem. The primary trespass routes appear to come from the adjacent Canyon Creek conservation easements. Management activities for this tract during FY 99-00 have included:

- Filling in low spots on key ranch road that are prone to holding water, using fill dirt that had been illegally dumped on Long Canyon tract;
- Repair of damaged perimeter fence and gates due to unauthorized trespass; and
- Cowbird trapping was conducted on this site with a mega-live trap filled with decoys. See Travis County Brown-headed Cowbird Report for more detail and results.

Monitoring activities continued at the 100-acre study plots for golden-cheeked warblers. This locale is one of the 100-acre plots established for transitional warbler habitat. During the bird season, eight full and partial territories for warblers were identified which was similar to previous seasons. However, no fledglings were observed.

Hanks tract: BCP staff has spent considerable time overseeing mitigation measures on this tract and adjacent City infrastructure land to the north. A portion of the Hanks tract was involved in the construction of a regional flood retention facility on the adjoining Gardens of Bull Creek property. The dam facility destroyed prime golden-cheeked warbler habitat, and the project was required to implement specific mitigation measures, such as:

- Installation of approximately 4200 linear feet of 6 foot high chainlink fence (9 gauge) with an additional foot of barbed wire for a total height of 7 feet. This fence effectively closed off access to BCP lands from adjacent neighborhoods;
- Installation of approximately 2500 linear feet of 8 foot high game fence around a native plant restoration area. This fence was installed to protect newly planted trees from heavy deer browsing; and

- Planted 229 trees and additional shrubs (8 species) with supplemental irrigation provided to all plants. This restoration planting effort was done on formerly cleared land with the desired goal of ultimately recreating golden-cheeked warbler habitat.

The Hank tract has ongoing problems that need future attention. These concerns include:

- **Erosion problems from adjacent development.** This erosion and sedimentation is adversely affecting Bull Creek water quality as well as Jollyville salamander habitat.
- **Illegal trespass and vandalism from the Canyon Creek neighborhood development.** There is no secure boundary fence between Hanks and Canyon Creek Conservation Easement property. The current neighborhood residents easily access Hanks via the conservation easement lands.
- **Over population of deer and hogs.** As is typical of most City preserves, deer browse is preventing any regeneration of key vegetation components within golden-cheeked warbler habitat. In addition, hogs are causing severe soil disturbance and erosion on all Bull Creek preserves.
- **Fire ant control.** The spread of red-imported fire ant is a major problem on all Bull Creek preserves.

Several types of biological monitoring continued during FY 99-00 at Hanks. Monthly monitoring of the presence of the aquatic Jollyville Plateau Salamander was conducted on both tributaries as a joint City effort involving both Watershed Protection and BCP staff. During the bird season, golden-cheeked warbler observations and enumeration were made monthly by both sight and sound. The warbler territories noted here are not mapped precisely as those within study plots are. During both the 1999 and 2000 fall deer seasons, deer census activity included portions of the Hanks tract as part of the Upper Bull Creek route.

Lanier tract: Important management activities for this tract include feral hog trapping and routine patrol of the area for evidence of trespass and preserve damage. Management concerns for the future involve:

- **Perimeter fence upgrade.** The existing fence is an old dilapidated barbed wire fence and, without replacement, increases in illegal trespass from adjacent new development are expected to rise.
- **Creek sedimentation problems.** Ongoing and future development upstream will cause more Bull Creek erosion/sedimentation and resultant degradation of salamander habitat.

Franklin tract: Key management activities for this tract over the past year were:

- Feral hog trapping.
- Sedimentation and erosion work along Bull Creek.
- Routine patrol of site for signs of damage and illegal trespass.

Monitoring activity here includes monthly salamander surveys along a section of the main Bull Creek tributary. A portion of the Franklin tract was included along the five-mile route of the deer census survey in the Upper Bull Creek unit during both 1999 and 2000 white-tailed deer surveys.

LOWER BULL CREEK UNIT

Forest Ridge: The Forest Ridge area is subject to continuing heavy public use by mountain bikers, runners and dog-walkers – activities that are generally prohibited elsewhere in the Preserve. BCP staff conducted a number of projects aimed at informing and redirecting public access here in anticipation of a multi-year recreational impact study. Improved signs, fencing,

and visitor entryways were installed at priority access points. A pilot education project where BCP staff developed an education curriculum and taught two training classes for hikers desiring entry permits for hiking in Forest Ridge during the bird season. The official closure of this site to mountain-biking will not occur until February 15, 2001. Outreach meetings, web site announcements, and notification signs to reach the mountain biking community were conducted in FY 99-00 and will become higher priority in FY 00-01.

Nandina domestica, Lonicera japonica, Alanthus altissima and *Ligustrum japonica* are commonly found in the riparian areas along Bull Creek. Some exotic plant removal was done this year by BCP staff. A volunteer coordination effort is underway to gain additional manpower for a variety of management activities since BCP staff will be undertaking more duties regarding access control. This program will bring volunteers to the site for exotic plant removal, revegetation projects, trail maintenance and other routine site management chores.

Golden-cheeked warbler surveys at the 100-acre prime study plot on Forest Ridge were conducted by BCP staff for the third consecutive year. The 2000 bird season yielded 14 full and partial warbler territories at the 100-acre plot, down from 1999 to the same density as 1998. Production of new fledglings appears to have increased over earlier years. More details regarding warblers onsite is available from the attached 2000 Golden-cheeked Warbler and Black-capped Vireo report (Abbruzzese, October 2000).

Jester tract: Public access has been allowed on a portion of this tract; however, preparations are underway to curtail prohibited mountain bike and horse use. Education programs to permit preserve hikers during the bird season were initiated this year, with increased activity expected next fiscal year. Other management activities on Jester have included:

- Sedimentation and erosion control.
- Trail work and repair.
- Routine patrol of site.
- Repaired boundary fences and installed no trespassing signs.
- Removal of non-native invasive plants.
- Close illegal trails.

Jester, as well as the rest of Lower Bull Creek properties, are experiencing ongoing problems with the following:

- Illegal trail building and access by bikers and horseback riders.
- Runoff problems from adjacent Jester Estates development.
- Neighborhood bird feeders, which are attracting blue jays.

Hilltop: This property immediately north of Forest Ridge continues to experience some illegal trespass from horseback riders and mountain bikers. This situation will not be solved until an adequate perimeter fence is installed. Management activities on Hilltop included:

- Routine patrol of site (infrequently).
- Closure of illegal trails and installation of no trespassing signs.

Gibson /Nott Tract: This 8.6-acre tract between Bull Creek and the Hilltop tract is the newest City preserve acquisition. This property is currently being evaluated regarding future management needs. It serves as a buffer between the White Cliff Dr. residences and the Forest Ridge/Hilltop warbler habitat. Onsite management activities will start in FY 00-01; new perimeter fencing may be needed to prevent any illicit mountain bike, horse, and hiker access.

3M Mitigation Tract: This tract is flanked on the north and west by the City's St. Edward's Park, on the east by a privately-owned tract (Kruger), and on the south by the COA Jester tract. Horse-back riders and motorcyclists are still trespassing onto 3M from trails on the Kruger tract, and wandering mountain-bikers also stray from the path which had been designated for them to use. The closure of Forest Ridge and Jester to biking will be initiated in the spring of 2001. Native hardwood trees grown at the BCP greenhouse have been planted at the "enclosure" located at the Spicewood Springs Road entrance. A contractor-built chainlink fence was completed along the common boundary with St. Edward's Park.

Monitoring for GCW is conducted by COA staff on a 100-acre plot (designated as a prime plot). A total of 17 full and partial warbler territories were identified on the 3M study plot during the 2000 bird season, but only two fledgling groups were noted. (See Abbruzzese, October 2000). A small cowbird trap has been situated on 3M and cowbird trapping is conducted in the spring and early summer. Deer surveys are not conducted on 3M. Evidence of feral hogs is seen throughout the tract.

St. Edwards Park: This area serves as a major public access route (including mountain biking) into adjacent Bull Creek Preserve properties in which mountain biking is prohibited. The major trail through this park continues to be heavily used by dog-walkers, hikers and mountain bikers. However, a new chainlink fence was built in FY 99-00 along the entire St. Edward's and 3M property boundary that will limit illegal access into the rest of the Lower Bull Creek unit. The new fence will funnel users to a new dodgeway entrance point that will exclude mountain bike activity into the Jester tract before the 2001 bird season begins.

MIDDLE BULL CREEK UNIT

Ivanhoe: Endangered bird monitoring activities at Ivanhoe concentrated on the 100-acre study plot for golden-cheeked warblers. The number of territories (19 full and partial) at the study plot has increased incrementally over previous years. Fledgling productivity was down somewhat at Ivanhoe from the 1998-9 bird seasons. Details are available in the City's 2000 Golden-cheeked Warbler and Black-capped Vireo Monitoring Program report.

Staff operated a trap filled with live decoys to capture brown-headed cowbirds dispersing through Ivanhoe during the 2000 bird season. This is one of three cowbird traps operated by the City. See Travis County's Brown- headed Cowbird Report for more detail on capture totals of this songbird nest parasite.

Beard Family Trust: Management activities for this tract include:

- Routine patrol of area.
- Sedimentation and erosion control work.
- Repair of fences.

Horizon, Inc. biologists surveyed a portion of this tract for golden-cheeked warblers.

CYPRESS CREEK TRACTS

Lime Creek: This tract now includes the 100-acre Austin Simon Ltd. mitigation property, bringing the total size to 594 acres. BCP staff conducted a vegetation reconnaissance of this tract to assess the potential of converting it into vireo habitat. While there are extensive stands of shin

oak in certain areas, most of the tract is currently warbler habitat and will remain the same. Discussions with Travis Audubon Society regarding joint management activities involving their Sanctuary (680 acres adjacent to the Lime Creek tract) occurred this year. Because of the mutual problem of overpopulation of deer on these tracts, the COA and TAS are considering installation of a game fence which would surround the perimeter of both tracts of land (the combined total fenced area would total 1274 acres.)

Lime Creek has two caves which harbor endangered karst species. Biannual monitoring of these caves has been conducted for karst fauna and red important fire ant infestations. Neither deer surveys nor cowbird trapping are being conducted on the Lime Creek tract. Feral hogs have been spotted on the TAS Sanctuary, so they are probably also present at Lime Creek.

NORTH LAKE AUSTIN TRACTS

Emma Long Park: City management activities have included:

- Elimination of exotic trees in various habitat locations throughout the park. Fifty to sixty Tree of Heaven, chinaberry and Japanese ligustrum were killed by mechanically girdling them and spraying the cut with Arsenal.

- Working with Park Manager to insure that any grant-funded improvements done within the existing motocross track and mountain biking area did not harm warbler habitat.

- Routinely patrolling main roads and perimeter fencing to look for signs of trespassing, vandalism or illicit dumping.

Monitoring activities for golden-cheeked warblers continued for the third year at the Turkey Creek study plot. Staff identified 21 full and edge territories within this 100-acre plot, an increase over previous years. However, fledgling production declined from previous years. Staff also spent field time enumerating warblers throughout the rest of the park and followed banded birds from a 1999 banding study by an independent researcher. Detailed data is available in the City's Golden-cheeked Warbler and Black-capped Vireo Monitoring Program report (Abbruzzese, October 2000).

BCP staff conducted multiple deer census surveys over a five-mile route through Emma Long Park during the fall and winter season.

Coldwater: Management activities on Coldwater during FY 99-00 include:

- During the summer-fall drought period, provision of supplemental water to 6 transplanted live oak trees that were planted by Austin Energy to remediate vegetation lost during utility construction. These trees were also protected from deer browsing by circling them with protective fencing and anchoring the cage with rebar.

- Worked with Austin Energy personnel and contractors to fence a preserve area along City Park Road that had been inadvertently opened up and vegetation removed while installing underground utilities to existing distribution pole.

- Fixed key access gate that had come off its hinges along City Park Road.

- Distributed native plant seeds on dry eroded slopes in an attempt to revegetate these previously overgrazed areas. A thin layer of bark mulch was placed on top of each seed to protect if from depredation and to retain adequate soil moisture. Native seeds planted include silver and little bluestem grass, mountain laurel, Mexican hat and Lindheimer's senna.

- Controlled a large stand of exotic Tree of Heaven trees (*Ailanthus altissima*) on the Coldwater North property. Girdling them with a chainsaw or weedeater blade and spraying the cut with Arsenal herbicide killed approximately 60 trees. Follow-up visits with volunteer assistance focused on pulling up resprouts and small seedlings. Two months after the exotic vegetation treatment, staff planted native trees like Mexican plum, Texas oak and Mexican Buckeye into the area where the mature exotic trees had been killed. The vegetation control appeared successful as very few Tree of Heaven seedlings still exist at the site.

- Routinely patrolled main roads and perimeter fencing to look for signs of trespassing, vandalism or dumping.

Monitoring for endangered songbirds continued during FY 99-00 at the two Coldwater tracts. BCP staff enumerated golden-cheeked warblers on the Coldwater South tract. Additional survey work sought to map territories of color-banded warblers on Coldwater in the second year of an independent warbler-banding research project in this area.

Long Canyon: City management activities at the Long Canyon tract during FY 99-00 involve the following:

- Access Road Improvements: Installed a new culvert 10 feet in length at a creek crossing where the road had previously washed out. Cut juniper branches infringing along key roads through the preserve. Completed extensive erosion work (installation of erosion bars) with Americorps volunteer assistance along main road. Used hydraulic jackhammer to break up a large rock that was blocking road.

- Public Access Control: Installed new gate and BCP sign at the end of Standing Rock Drive. This site had been key entry point by unauthorized trespassers. Used fill dirt to level interior preserve road.

- Vegetation restoration: Planted several hundred shin oak acorns in open area near creek.

- Restoration Site Maintenance: Protected existing oak seedlings that were planted in 1998. Trees were protected by placing four-foot high fencing around them and anchoring the cages with rebar. Juniper branches were placed over oaks to shade them. Trees were also watered periodically during the dry summer months.

- Seed Plantings: Distributed native seed on dry eroded slopes in an attempt to revegetate overgrazed areas. A thin layer of bark mulch was placed on top of the seed to protect it from depredation and to retain moisture. Native seeds planted include silver and little bluestem grass, mountain laurel, Mexican hat and Lindheimer's senna.

- Routine Patrols: Main roads and perimeter fencing were visited to look for signs of trespassing, vandalism or dumping.

Park West: A variety of management activities were conducted during FY 99-00 at the Park West Tract. Key work efforts included:

- Maintenance and protection of transplanted shin oak seedlings. Trees were protected by placing four-foot high fencing around them and anchoring fencing cages with rebar to stop deer browse. Trees were also watered periodically during the dry summer months.

- Investigation of areas surrounding cave mouths for presence of red imported fire ants. Active fire ant mounds were treated by pouring boiling water over the top of them.

- Worked with Anchor Fence (contractor) to fence a 600-foot section along the western boundary of Park West. This new fence will limit access to potential trespassers from a recently- completed apartment complex adjacent to the preserve. Small trees and branches along the fenceline were cleared by city staff to limit the amount of clearing the fence contractor needed to do.

- Routinely patrolled main roads and perimeter fencing to look for signs of trespass, vandalism or dumping.

Bird monitoring activities by City staff on Park West were limited. Part of this preserve was covered by the endangered bird surveys required of River Place's permit. City staff monitored Spider Cave for fire ant infestation during the spring; however, no fire ants were found inside the cave itself, despite observations of several mounds on the surface near the cave mouth.

Cortana - This large, elongated tract, sandwiched in between two subdivisions (River Place and Steiner Ranch) has been and continues to be a magnet for trespassing by mountain bikers and motorcyclists. It is anticipated that the management of Cortana's western border will be less troublesome, after the Steiner Ranch Conservation Easement is effective in January, 2001. This Conservation Easement will be managed by Travis County, and the COA and TC will be able to jointly address such issues as trespassing, fences, problem entry points, deer control, etc.

The management of Cortana's eastern border, especially along the lower section, will continue to present problems. River Place has been expanding its subdivision area southward, and it will soon include development of the area along the river frontage. Entry points along this newer section of development will need to be addressed.

The COA has not been conducting avian monitoring of Cortana. However, because of a federal Section 7 permit, River Place has been conducting studies (every other year) to determine GCW and BCV territories and reproductive success on adjacent properties within 3,000 ft of the River Place boundaries. These studies include almost the entire portion of Cortana (as well as portions of Park West). The studies have included the years 1994, 1996, 1998, and 2000 and will continue until three years after complete buildout of River Place. River Place is also responsible for monitoring 100 acres of manipulated BCV habitat, a portion of which is at the northern tip of Cortana. The monitoring includes both avian and plant monitoring studies, and has been conducted every year since 1996. All of these studies have been presented to USFWS, via SWCA, Inc. (**Note**: In the spring of 2000, COA staff spotted a breeding pair of black-capped vireos and several fledglings, plus at least one other male BCV on that portion of Cortana which had been manipulated in 1995 for BCV habitat.)

Deer surveys are not being conducted on the Cortana tract. Travis County is conducting cowbird trapping on Cortana with one trap, located at the northern end of the property. Signs of feral hogs have been seen at several locations on Cortana.

SOUTH LAKE AUSTIN TRACTS

Double J&T: This tract extends northward from Reicher Ranch, and part of it has lakefront access. COA staff petitioned Travis County to abandon Kollmeyer Drive, which is a dirt road running east from Hwy 620, crossing the western border of Double J&T, and coming to a dead-end inside of the Double J&T tract. The road was gated and locked at the western boundary in1998, to reduce the amount of trespassing (from mountain bikers, motorcyclist, and off-road vehicles) and dumping of trash on the preserve, and also to reduce potential vandalism of the private Darter cemetery (one acre in-holding). There is also an easement access issue with the adjacent development projects of Medway and Lake Austin West, who wish to use a private easement access to link their development projects with Kollmeyer Drive.

Along Murfin Road, there is the continual problem of trespassing and dumping of trash onto Double J&T. There was also an enforcement event with squatters on the north section, near Kollmeyer Dr. Staff also completed repairs of damaged fenceline along Pecan Drive that had been cut.

Monitoring for GCW is conducted by City BCP staff on a 100-acre plot (designated as a transitional plot). The study site yielded only one full warbler territory and no fledglings were observed (see Abbruzzese, October 2000 for details). Deer surveys are conducted on Double J&T, as part of the five mile SLAM census route (see attached deer census report). Cowbird trapping is not being conducted on Double J&T.

Reicher Ranch: The City's Balcones Canyonlands Preserve staff and offices were relocated to facilities at Reicher Ranch due to loss of downtown office facilities. The group now occupies the gatehouse near the property entrance off RR 620 approximately 0.7 miles north of the Village of Bee Cave. Access to meeting facilities at the main ranch compound has allowed the BCP staff to host meetings and events at the Preserve itself.

BCP staff conducted a late season survey for warblers near the new staff facilities and found a female warbler and three fledglings actively using habitat near the highway which was being considered for a land exchange to allow LCRA and a private sector partner to build a wastewater treatment plant to serve the Village of Bee Cave. This fact led to a decision not to trade this property.

Restoration of endangered species habitats is underway, partly through the Native Seed Rescue and Propagation Project. Use of the greenhouse, located on Reicher Ranch, facilitates the germination of native hardwood trees and shrubs collected on various BCP tracts. Volunteers are extensively used for planting the young saplings on the preserves. The young plants are encircled with wire cages to protect them from deer and rabbit browse. This past year, a grant was received from Partners in Wildlife ($5300), with matching funds to be supplied by in-kind work from volunteers. Funds are used to purchase the wire cages, with an additional purchase of a water tank expected in 2001.

Bohls Ranch: This riverfront tract is bordered on the west by Reicher Ranch and on the east by the Lake Pointe subdivision and its 230-acre mitigation tract. Lake Point's onsite mitigation preserve is under "looser" rules than the COA's BCP tracts; for example, it is open at all times to

the homeowners and experiences significant usage with dogs and bicycles. Since much of the common boundary between Bohls and Lake Pointe mitigation is not fenced, the potential for frequent trespassing onto Bohls still exists. Installation of a fence along this mutual border would greatly reduce future management problems on the eastern border.

Monitoring for GCW is conducted by City BCP staff on a 100-acre plot (designated as a prime plot). A total of five warbler territories (full and partial) were found in the Bohls Hollow study plot, similar to past seasons; however, no fledglings were observed there. (See attached warbler and vireo report by C. Abbruzzese, October, 2000 for details). Deer surveys are conducted on Bohls during the fall of 1999 and 2000 to census the population, as part of the "SLAM Deer Survey" (see separate report). Cowbird trapping is not being conducted on Bohls. Evidence of feral hogs has been observed. A ridgetop portion of Bohls is being considered for creation of BCV habitat.

Commons Ford Ranch Park: The status of exotic vegetation within the designated preserve portion of Commons Ford Park, particularly along the stream corridor that bisects the canyon habitat. A grove of large mature chinaberry trees were girdled and treated with Arsenal to kill them during a staff exotic vegetation eradication project. The larger trees were left standing as dead snags after this December project to encourage use by woodpeckers, as well as other birds and wildlife. Light use of the primary trail by mountain bikes was identified, but no management work was necessary based on preserve patrols. Significant numbers of white-tailed deer at this location have overgrazed the understory vegetation in this unit

No ongoing monitoring sites for golden-checked warbler (GCW) have been set up at this small unit, but observations of the bird community status were routinely made during field visits. No warblers were sighted within the preserve itself, although GCW vocalizations were heard from adjacent canyons.

Senna Hills: City staff held informal talks with Nature Conservancy staff from the Barton Creek Habitat Preserve to undertake periodic checks of this isolated property next to theirs as part of their routine patrolling. Prior episodes of trespassing and damage (bulldozing of a private access road through the preserve by a neighboring landowner) appear to have stopped. Litigation over the preserve damage was completed last year and restitution to the City for vegetation damage ordered by the court from the offending neighbor.

No monitoring activities were conducted on this 35-acre tract during 2000.

BARTON CREEK TRACTS

Barton Creek Wilderness Park- FY 2000 management highlights for the B.C. Wilderness Park include:

- Americorps volunteer projects to refurbish the Trail of Life (Camp Craft Access) , a popular steep hike and bike trail segment near the western end of the Wilderness Park. The work crew also added large rocks to the eroded trail edge near Dam #22 as a safety barrier for park visitors along the busy creekside trail.
- Fire ant boiling treatments at Cave Y and Substation Sink during the spring; and
- Oversight of major infrastructure projects, such as Austin Energy transmission line and electric substation improvements, completion of a cellular phone antennae and base station co-located on an AE tower in the preserve, and planning for a new northside parking lot that facilitates access to Sculptured Falls on Barton Creek.

Golden-cheeked warbler monitoring continued at the 100-acre prime GCW study plot near Barton Creek, while GCW enumerations throughout this unit were also conducted. Seven full and partial territories were determined for the study plot, which was less than found in 1999, but more than observed in 1998. Fledgling production appeared to be less than the previous year, which did not face drought conditions. Existing Streptanthus populations in the Wilderness Park were monitored early in the spring; however, field observations were curtailed by drought conditions which impacted plant and seedpod development.

Barton Creek Greenbelt: Public access within the Greenbelt has been limited during much of this year by the drought, which has caused the creek to dry up. BCP staff has been involved in assessing the status of Dam #22, which has experienced erosion along the north bank. Americorps assistance in moving large rocks to protect trail users from the erosional scarp helped immediate safety concerns at the site; however, engineering and construction contractors will be necessary to complete the necessary dam repairs. BCP staff also provided oversight for a Water and Wastewater Utility project to correct the size of an existing wastewater main whose route follows the creek and active access trail system.

Monitoring of *Streptanthus* populations within the Greenbelt continued; however, the spring-summer drought adversely affected the development of these plants. Staff performed an exotic vegetation assessment that identified areas for future eradication projects. Unauthorized trails from adjoining development were identified and followed to alternative access points that may require signs, fencing, and/or gates.

BCP staff conducted control of the imported red fire ant mounds near Greenbelt caves, such as Substation Sink, Cave Y, and Seibert Sink, using boiling water techniques. Cave entrances were checked periodically for signs of human visitation, trash, and damage. Biannual karst fauna monitoring was conducted at Airman's Cave.

Friesenhahn Tract - This 62-acre preserve inholding along the Capital of Texas Highway across from Barton Creek was acquired by the City Council before the landowner could begin significant development. The purchase was accomplished using a combination of funding sources – BCCP, Proposition 2 water quality conservation funds, and park monies- which reflect a variety of City priorities for the tract. This new parcel connects existing portions of the Barton Creek Greenbelt and Wilderness Park. This forested tract has experienced some recent vegetation disturbances (clearing) along the LCRA/Austin Energy electric transmission line corridor as well as several hydroaxed clearings of unexplained origin created by the prior landowner. One or more unauthorized trails cut through the property which link to other trails accessing the north side of Barton Creek that need to be incorporated into the a more comprehensive trail plan for this preserve unit. After an assessment period, this property will be incorporated into the land management planning for the Barton Creek Greenbelt/Wilderness Park. No monitoring activities were conducted on this property during the 2000 bird season.

WEST AUSTIN PROPERTIES

Vireo Research Area: BCP staff conducted a spring survey to look for black-capped vireo presence. None were found. Staff began a site assessment for possible vireo restoration practices to be implemented in the future. Discussions were held with Wild Basin staff to develop an education program about vireo restoration, using a potential site on City land as a demonstration project open to visitation under Wild Basin programs. The preliminary concept plan has received preliminary approval from USFWS.

Mount Bonnell Park: This small hilltop park overlooking Lake Austin continues to receive high visitation rates, especially by out-of-town visitors seeking a panoramic view of the lake and scenic Texas Hill Country. Over the past year, several clean-ups of trash (mostly beverage bottles and cans) thrown into the native vegetation by park visitors were performed by preserve staff. Despite past work to restore the native vegetation, the plant community at this park has continued to be compromised by exotic vegetation, such as Nandina, ligustrum, Photina, pyracantha, and china berry trees. Staff assessed the location of these plants and performed an invasive exotic plant eradication throughout the park during December, 1999.

Monitoring of the status of bracted twistflower populations within Mount Bonnell Park continued during the spring of 2000. The two populations downslope of the steep cliff (north and south ends of the park boundaries) emerged but both plant growth and seed development were inhibited by the lack of water and high heat during the ongoing drought. No sign of Streptanthus plant presence was observed on the eastern side of the park where prior reseeding efforts had occurred.

Ullrich Water Treatment Plant: Substantial construction activity to expand the water treatment plant has been underway. Plant personnel are now using assistance from a W&WW land manager on management issues facing the Ullrich Habitat Management Area. BCP staff worked on several infrastructure projects (new pipeline with chlorination facilities, telecommunications station, and electrical system improvement in and around the onsite substation. None actually impacted the natural habitat area.

Water Treatment Plant #4: Ullrich plant management, the new W&WW land manager and BCP staff negotiated a Memorandum of Understanding on joint preserve management activities, such as deer and feral hog control. This agreement will allow a regional management approach to all City tracts within the Upper Bull Creek unit. This property was included in the deer census efforts in FY 99-00.

Barrow Preserve:. Management activities at this small creekside preserve included routine patrol and monitoring adjacent new development (Canyon Rim). The main spring on this tract was monitored quarterly by the Watershed Protection Department for the presence of the Jollyville salamander. WPD staff also tested the water for certain pollutants.

Spicewood Springs Preserve: This small 8-acre preserve is probably too small to support a functional golden-cheeked warbler territory. Staff reports observing a solitary male GCW every year, but no evidence of successful nesting has been noted. Management activities include:

- Erosion and sedimentation control.
- Installing barriers, railing and signs to keep preserve visitors on the trail and off the sensitive areas.
- Repair of security fence around Cotterell Cave.
- Red-imported fire ant control (boiling water)
- Trail work and repair.
- Trash removal
- Escorting trespassers back to the trail.

Two research monitoring studies are underway at Spicewood Springs Park involving non-BCP investigators. They involve:

- **Jollyville Plateau salamander:** Monthly surveys are conducted on this preserve and the land immediately downstream. This site is the type locality for the Jollyville Plateau salamander. This population crashed in 1994 and has never really recovered. Some of the remaining salamanders have notable spinal deformities. Watershed Protection Department staff helps monitor this site and at the same time take regular water quality samples for analysis.
- **Native tree water uptake rates.** BCP staff surveys Cotterell Cave yearly, and inspects the entrance at least monthly. Cotterell Cave is the home of the endangered bone cave harvestman. Rob Jackson at Duke University is currently conducting research on the uptake of water from certain species of trees. He has set up scientific probes on some of the roots inside the cave. This monitoring does not require access into the cave and only is done under staff supervision.

Karst Protection

Staff continued efforts to determine and track cave status of 62 **karst features** covered by the BCCP 10(a) permit: including 41"protected" and 21"unprotected" caves, with 21 of the "protected" caves owned by the City of Austin. Many of the caves designated as "protected" with the status of "good" in the following table may not have adequate setbacks to be adequately protected to meet the criteria listed in the new "USFWS Recommendations For Karst Preserve Design". The terms "protected" and "good" listed here refer to caves with *some* amount of setback around the entrance and *some* amount of protection over the footprint of the cave.

Caves on preserve land generally have adequate setbacks and are receiving adequate protection. Threats to private caves continue. Cave X and Get Down Cave are being protected under cave management agreements with the City of Austin, due to development pressures. Pennie's Cave may have been filled (cannot be located) and caves in the McNeil Cluster are under threat of development. A hydrogeological study was done for Flint Ridge Cave relating to possible impacts from the proposed extension of SH 45. Austin caving organizations and volunteers continue to play key and vital roles in researching and protecting caves in the BCP area.

TABLE 2
BCP KARST FEATURES

BCCP permit designated 62 karst features for protection. The 35 endangered species caves are listed as ES and the 27 additional caves for species of concern are listed as SOC.

Cave Name	ES or SOC	Current tract/owner. On BCP Land or private	Cave Cluster	Status
Adobe Springs Cave	SOC	BCP Lehmann/TNC		Good
Airman's Cave	SOC	BCP Barton Creek/COA		Good
Amber Cave	ES	Pending TC (for 10(a) permit)	4 Points Cl (Parke)	Good
Armadillo Ranch Sink	SOC	Private		Unknown
Arrow Cave	SOC	Slaughter Cr. Metro Pk./COA		Good
Bandit Cave	ES	Private		Unknown
Beard Ranch Cave	ES	BCP Ivanhoe/COA		Good
Bee Creek Cave	ES	Private		Unknown
Blowing Sink Cave	SOC	COA		Good
Broken Arrow Cave	ES	BCP Lime Cr. Prs./COA		Good
Buda Boulder Spg.	SOC	Shoal Creek Grblt./COA		Good
Cave X	SOC	Private/COA Protection Agreement		Unknown, New agreement not working smoothly yet
Cave Y	ES	Barton Creek Grblt/COA		Good

Ceiling Slot Cave	SOC	Private		Unknown
Cold Cave	ES	Private	Northwood Cl.	Unknown
Cotterell Cave	ES	BCP Spicewood Spgs. Pk./COA		Good
Disbelievers Cave	ES	BCP Private 10(a)	4 Points Cl. (Perot)	Good
District Park Cave	SOC	D.Nickols Pk./COA		Good
Eluvial Cave	ES	BCP Private 10(a)	4 Points Cl. (Perot)	Good
Flint Ridge Cave	SOC	COA		Good
Fossil Cave	ES	Schroeter Pk./COA		Can't find entrance, park is Protected however
Fossil Garden Cave	ES	Private	McNeil Cl.	Unknown
Gallifer Cave	ES	Private TSNL	4 Points Cl (Parke)	Good
Get Down Cave	SOC	Private/COA Protection Agreement		Good, agreement working, TCMA manag., putting up kiosk
Goat Cave	SOC	Goat Cave Karst Preserve/COA		Good
Hole-in-the-Road	ES	Private	Northwood Cl.	Unknown
Ireland's Cave	SOC	Private Circle C		Poor, watershed probs., golf course
Jack's Joint	SOC	Private		Unknown
Japygid Cave	ES	BCP Private 10(a)	4 Points Cl. (Perot)	Good
Jest John Cave	ES	BCP Forest Ridge/COA		Good
Jester Estates Cave	ES	Private (adj.COA Ivanhoe)		Unknown
Jollyville Plateau Cv.	ES	BCP Private 10(a)	4 Points Cl. (Perot)	Good
Kretschmarr Cave	ES	Private TSNL	4 Points Cl. (Parke)	Good
Kretschmarr Dble. Pit	ES	Private TSNL	4 Points Cl. (Parke)	Good
Lamm Cave	ES	Private Section 7		Good
Little Bee Cr. Cave	ES	BCP Ullrich WTP/COA		Good
Lost Gold Cave	SOC	Private		Unknown, new house on adj. or same lot? (not through BCCP)
Lost Oasis Cave	SOC	Private TCMA		Good
M.W.A. Cave	ES	Private 10(a)	4 Points Cl. (Perot)	Good
Maple Run Cave	SOC	Goat Cave Karst Preserve/COA /COA		Good
McDonald Cave	ES	Private		Unknown
McNeil Bat Cave	ES	Private	McNeil Cl.	Unknown
Midnight Cave	SOC	Slaughter Cr. Met. Pk./COA		Good
Moss Pit	SOC	Private		Unknown
New Comanche Tr. Cave	ES	Private		Unknown
No Rent Cave	ES	Private	McNeil Cl.	Unknown
North Root Cave	ES	Private TSNL	4 Points Cl (Parke)	Good
Pennie's Cave	SOC	Private		Unknown
Pickle Pit	SOC	Private Sec. 7		Unknown
Pipeline Cave	SOC	Private		Unknown
Rolling Rock Cave	ES	BCP Lime Cr. Prs./COA, Sec.10(a)		Good
Root Cave	ES	Private TSNL	4 Points Cl (Parke)	Good
Slaughter Creek Cave	SOC	Slaughter Cr.Metro Pk./COA		Good
Spanish Wells	SOC	Private		Unknown
Spider Cave	ES	BCP Park West/COA		Good
Stark's North Mine	SOC	Private		Unknown
Stovepipe Cave	ES	Private Sec. 7		Good
Talus Springs Cave	SOC	Pending TC (for 10(a) permit)		Only 50' setback from dev., impact unkn

Tardus Hole	ES	Private TSNL	4 Points Cl (Parke)	Good
Tooth Cave	ES	Private TSNL	4 Points Cl (Parke)	Good
Weldon Cave	ES	Private	McNeil Cl.	unknown
Whirlpool Cave	SOC	Private TCMA		Good

Access Status. Caves which are currently gated, fenced and/or open to the public. Under "Public Access", access by permit

Cave Name	ES or SOC	BCP Tract/owner	Gated/Fenced	Public Access
Amber Cave	ES	Pending TC (for 10(a)	Concrete/manhole cover [2]	
Airman's Cave	SOC	Barton Creek/COA		open
Bandit Cave	ES	Private	Gated	
Cave X	**SOC**	Private w/ COA Agreement	**Gated**	
Cotterell	ES	Spicewood Sprgs. Pk./COA	Fenced	
District Park Cave	SOC	D.Nickols Pk./COA	Gated after the 1st room.	1st room open, past the 1st room access by permit*
Gallifer Cave	ES	Private TSNL	Gated [2]	
Get Down Cave	SOC	Private	Gated	
Goat Cave	SOC	Karst Preserve/COA	Gated [1]	access by permit*
Jester Estates Cave	ES	Private, adj. COA Ivanhoe	Gated [2]	
Jollyville Plateau Cv.	ES	Private 10(a)	Gated [2]	
Kretschmarr Cave	ES	Private TSNL	Gated [2] and Fenced	
Lost Gold Cave	SOC	Private	Gated	
Lost Oasis Cave	SOC	Private TCMA	Gated and Fenced	controlled access**
Maple Run Cave	SOC	Karst Preserve/COA	Gated	access by permit*
Midnight	SOC	Slaughter Cr. Pk/COA	Fenced	access by permit*
Pickle Pit	SOC	Private	Gated	
Pipeline Cave	SOC	Private	Metal frame [2]	
Tooth Cave	ES	Private TSNL	Gated [2]	
Whirlpool Cave	SOC	Private TCMA	Gated	controlled access**

* Access by Permit - Permit may be issued by COA - PARD staff.
** Controlled Access - Private cave owners control the access
[1] Future plans will remove the gate and install fence to encourage bats to return.
[2] Needs gate repairs/improved gate.

City of Austin staff worked at selected caves during FY 99-00 including Maple Run Cave, District Park Cave, Midnight Cave, Airman's Cave, and Goat Cave. BCP staff patrolled these sites, cleaned up trash that was left in the cave or that had washed into it, and conducted biannual cave faunal surveys to determine status and any impacts that caver visitation may be having on cave invertebrates. Results of City of Austin karst fauna surveys are available in Attachment H.

Status of Land Management Plans

The final draft of the Balcones Canyonlands Preserve Land Management Plan was approved for submittal on September 8, 1999 by the BCP Coordinating Committee and the document package forwarded to the USFWS the following month for their review and comments. Some additional

sections of the Land Managers' Handbook component were revised after review by technical advisory committees and submitted separately. During the fall of 2000, USFWS staff returned all documents with final comments back to the BCCP as approved. Some minor report changes will be made by staff before report finalization and distribution.

8. A COPY OF ALL RESEARCH OR INVESTIGATION REPORTS THAT HAVE BEEN PREPARED.

Travis County

Bailey, James and Paul Fushille. *Monitoring of the Golden-cheeked Warbler – 2000 Field Season*. Travis County Transportation and Natural Resources. November, 2000. See Attachment B

Bailey, James. *Brown-headed Cowbird Report – 2000 Field Season*. Travis County Transportation and Natural Resources. See Attachment C

Lower Colorado River Authority

Melton, Don. *Endangered Species Surveys on the LCRA's Wheless Natural Resource Preserve*. July, 2000. See Attachment D

City of Austin

Abbruzzese, Carlo. 2000 *Golden-cheeked Warbler and Black-capped Vireo Monitoring Program*. City of Austin, PARD Natural Resources Division, October, 2000. See Attachment E

George Veni & Associates. Hydrogeologic Assessment of Flint Ridge Cave, Travis County, Texas. Prepared for City of Austin PARD, May 10, 2000. See Attachment F

Davis, Jackie. White-tailed Deer Survey Program, Balcones Canyonlands Preserve – Fall 1999 and Fall 2000. City of Austin, PARD . January, 2001. See Attachment G

ATTACHMENT A

LCRA MANAGEMENT ACTIVITIES
(OCTOBER 1997- SEPTEMBER 1998)

- WHELESS
- McGREGOR
- WESTCAVE

WHELESS

MANAGEMENT ACTIVITIES	
VEGETATION MANAGEMENT	
Control non-native species	There was no active control of non-native species during this reporting period.
Monitor and suppress oak wilt	There was no evidence of oak wilt during this reporting period.
Perform prescribed burn, if necessary	There were no prescribed burns during this reporting period. If LCRA staff selects fire as a management tool for BCVI habitat restoration, a burn plan will be written and submitted for approval by USFWS.
Develop fire management plan	A wildfire plan was initiated during this reporting period. LCRA staff will complete it FY01.
Restore BCVI habitat, in stages	LCRA staff identified a portion of the property that may be appropriate for habitat manipulation. LCRA staff will identify and delineate the potential manipulation site on maps and on the ground, after which discussions will be held about techniques(s), funding, and feasibility. All plans will be in concert with efforts of the other BCP land managers and coordinated with USFWS.
Improve GCWA habitat, as needed	There was no active vegetation management during this reporting period. However, staff informally assessed the condition of GCWA habitat during each property visit. GCWA habitat appears to be in good condition at this time.
Inventory plant species of concern	No plant species of concern were encountered during site visits for other activities.
ANIMAL MANAGEMENT	
Participate in BCP monitoring program, as determined by BCP monitoring committee	1) Rare bird surveys were conducted on the two 100 acre plots and a portion of the property adjacent to an area LCRA staff selected for potential BCVI habitat restoration, during upcoming reporting periods. A total of 24 GCWA territories were observed in the three survey areas. See attached letter dated 7/21/00, from Don Melton (contract GCWA surveyor) to Wendy Connally, for survey results.

Inventory karst features	No new karst features were located during site visits for other activities. However, a formal inventory will be conducted during upcoming reporting periods.
Conduct deer surveys and removal, if necessary	The FY00 census revealed 16.45 acres per deer. No deer were removed. Due to poor visibility, to improve the accuracy of the census a trip camera will also be used FY01.
Evaluate BHCO numbers and implement control, as needed	BHCO individuals were noted during site visits. However, no formal monitoring or trapping was conducted during this reporting period.
Evaluate feral animals and implement control, as needed	The presence of feral hogs was evaluated during site visits. There was minimal to no sign of hogs on the property. Therefore, no controls were implemented.
Monitor red imported fire ants and control, as needed	Red imported fire ants do not appear to pose a serious threat at this time, given that no evidence of them was readily apparent during site visits. Therefore, there was no formal monitoring or control during FY00.
PHYSICAL & CULTURAL MANAGEMENT	
Implement water quality protection measures	There were no construction activities on the property that warranted implementation of such measures. Natural revegetation of the waterline right-of-way continues even during drought conditions.
Protect karst sites, as needed	1) At present, known karst features are not threatened by preserve activity. The sites are included in preserve management planning, though. 2) An attempt by City of Austin biologists to collect salamanders at Long Hollow was unsuccessful, as the spring was not emergent for the majority of this reporting period. City staff will return once the spring is flowing again. The LCRA will receive updates from the City, as available, regarding this research.
Inventory and evaluate cultural resource sites	An inventory and evaluation of cultural resources will begin FY01.
VISITOR MANAGEMENT	
Monitor perimeter fencing and repair as needed	Several short sections of fence were repaired. Additional boundary signs were hung along those repaired sections.

	Fence improvements are scheduled for upcoming reporting periods.
Plan and develop trail system and parking area	Wheless does not have unlimited public access. A trail system and parking area are not planned amenities at this time.
Allow limited guided tours and environmental education classes	1) No tours or classes were requested during this reporting period. However, staff biologists continued to review options for public opportunities on the property. 2) Depending on the success of the trial stewardship program at McGregor, staff are assessing the prospect of a similar program at Wheless. 3) LCRA staff will review and monitor the success of and information from the City of Austin's Forest Ridge efforts, as they pertain to recreational opportunities.

The Lower Colorado River Authority
Annual Status Report for the Balcones Canyonlands Conservation Plan *
October 1999 – September 2000

McGREGOR

MANAGEMENT ACTIVITIES	
VEGETATION MANAGEMENT	
Monitor and suppress oak wilt	There was no evidence of oak wilt during this reporting period.
Inventory and evaluate site vegetation and karst features	No karst features or dramatic changes in vegetation were encountered this reporting period. However, a formal karst survey will be conducted during upcoming reporting periods.
Improve GCWA habitat, as needed	No habitat manipulation was warranted this year. However, LCRA land management staff informally assessed the condition of GCWA habitat after each property visit.
Develop fire management plan	1) LCRA staff worked with Hudson Bend Fire Department and Comanche Trail Community Association (CTCA) to initiate a wildfire management plan. The plan will be completed FY01. 2) There were no prescribed burns. Fire is not a preferred management tool for this preserve.
Fence and gate Bullick Hollow area	A gate at Bullick Hollow was installed during FY98. This area is monitored regularly and staff will review the need for additional work here to secure the property boundary due to dense urban development.
Maintain and monitor revegetation site across from Hippie Hollow	Vegetation at the site persists, even during drought conditions. LCRA staff will continue to visually assess the success of revegetation during surveys for other activities.
Inventory plant species of concern	No plant species of concern were encountered during site visits for other activities.
ANIMAL MANAGEMENT	
Conduct deer surveys and removal, if necessary	A deer census will be conducted fall FY01. Deer management strategies are under review and being discussed with the CTCA
Participate in BCP monitoring program, as	McGregor does not have designated

determined by BCP monitoring committee	monitoring plots. However, LCRA and Travis County staff surveyed for golden-cheeked warblers (GCWA) and black-capped vireos (BCVI). A total of 16 GCWA territories were found. No BCVI individuals were found. A topo map with approximated territory boundaries delineated and a synopsis of survey efforts are attached.
Evaluate feral animals and implement control, if needed	There was no evidence of damage from feral animals. Therefore, no controls were implemented.
Evaluate BHCO numbers and control, as needed	BHCO individuals were noted during site visits. However, no formal monitoring or trapping was conducted during this reporting period.
Monitor red imported fire ants and control, as needed	Red imported fire ants do not appear to pose a serious threat at this time, given that no evidence of them was readily apparent during site visits. Therefore, there was no formal monitoring or control during FY00.
PHYSICAL & CULTURAL MANAGEMENT	
Monitor perimeter fencing and repair as needed	1) Boundary survey conducted. 2) LCRA staff coordinated with the CTCA to determine a mutually agreed upon fencing strategy that would satisfy USFWS guidelines, protect the preserve from deer/trespass, and offer an aesthetically satisfying boundary. 3) Construction of high-fencing began September 2000 along the eastern boundary. Fencing will continue until breeding season begins FY01 along Comanche Trail and Mountain Trail, then resume fall/winter FY02. See attached photo of fence example.
Inventory and evaluate cultural resource sites	An inventory and evaluation of cultural resources will begin FY 01.
Implement water quality protection measures	Vegetation removed for fencing along the eastern boundary was bermed, as necessary, to prevent soil erosion.
VISITOR MANAGEMENT	
Develop access control plan	1) LCRA staff met with CTCA to address local access concerns related to safety, convenience, and management. See description of McGregor Good Neighbor Program

	below. 2) A replacement vehicle gate was hung at the existing access point along Mountain Trail. 3) A pedestrian gate (with combination lock) was installed next to the vehicle gate along Mountain Trail for use by McGregor Good Neighbor Program permittees. 4) Additional signs were hung or posted along the entire boundary, focusing on Comanche Trail, Mountain Trail, and the lake side. Please see attached photos.
Plan and develop trail system and parking area	1) McGregor does not have unlimited public access. A trail system and/or parking area are not planned amenities at this time. 2) Existing roads/trails were incorporated in the new stewardship program. See description of the McGregor Good Neighbor Program below.
Allow limited guided tours and environmental education classes	Staff created the McGregor Good Neighbor Program (McGNP), a trial stewardship program for members of the CTCA interested in helping the LCRA manage McGregor. CTCA members can become a McGNP permittee by completing a two-phased training program (classroom and field) and signing a contract. Permittees have limited access to the preserve and are asked to complete stewardship forms following each visit. There were 44 people permitted spring 2000. More training was scheduled for fall 2000. See attached informational flyer.





Signs installed at McGregor FY00



Two 4' sections were used for McGregor high fence

Balcones Canyonlands Conservation

Information About the McGregor Preserve



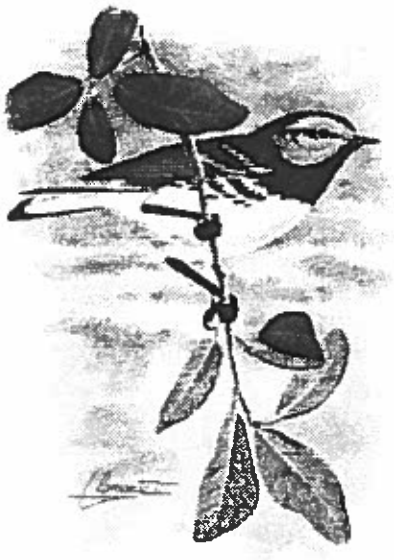
The Lower Colorado River Authority is working with neighbors in the Comanche Trail community to manage the natural area within this community known as the McGregor Preserve. The LCRA and the Comanche Trail Community Association plan to find the best ways to work together to protect this special place.

What is the McGregor Preserve?

The McGregor Preserve is an undeveloped area north of Lake Travis off Comanche Trail Road. The area covers 548 acres, including 362.5 acres that the LCRA has dedicated for the protection of two endangered songbird species — the golden-cheeked warbler and the black-capped vireo. Both species winter in Mexico and Central America and nest here during spring and summer. This site is part of a more extensive Balcones Canyonlands Preserve system.

Why is this area so important?

Suitable habitat for warblers and vireos is diminishing quickly as Travis County becomes more urbanized. In 1996, after many years of planning, several public agencies and private landowners agreed to work together to protect rare species habitat. The McGregor Preserve is one of the areas the LCRA has agreed to protect for these species. It offers mature stands of Ashe juniper, commonly called "cedar," mixed with Texas oak, live oak and elm for the warbler as well as dense low-level vegetation such as sumac, shin oak and Texas persimmon for the vireo.



The golden-cheeked warbler relies on a mix of mature Ashe junipers mixed with Texas oak, live oak and elm.

Illustration courtesy of Texas Parks and Wildlife Department

Who will have access to the area?

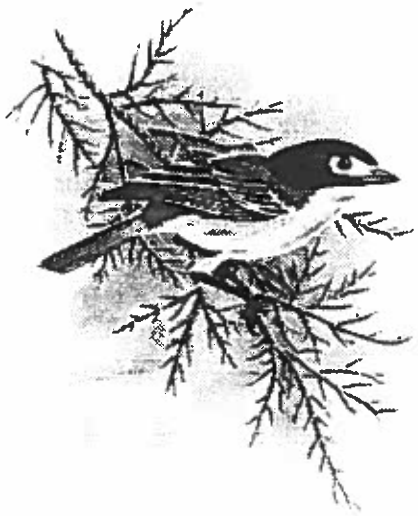
To ensure protection of the warbler and the vireo, the LCRA must limit entry to the McGregor Preserve, especially during the songbirds' March – September nesting period. After this year's nesting season, the LCRA plans to fence the perimeter of the site. Recognizing that many neighbors around the preserve have a strong interest in the area and its natural beauty, the LCRA is developing a trial program to involve neighbors in protecting the habitat. Through the McGregor Preserve Good Neighbor Program, interested neighbors may become conservation stewards after they participate in a two-phased training program to learn about the biology and conservation needs of the birds, habitat identification, field protocol and backyard conservation. Neighbors who complete the program will receive stewardship permits allowing limited access to McGregor Preserve so they can help protect and maintain the site. After LCRA biologists map the birds' territories, permitted stewards will receive notification about which areas of the preserve are accessible. Stewards will be responsible for assisting LCRA's conservation efforts at the preserve. LCRA staff also may conduct public tours for other community members in the future.

Why is access restricted; isn't this public land?

This property is owned by the LCRA, and most of it is reserved for species protection. Recognizing the need for outdoor recreational opportunities, the LCRA has set aside much of its riverfront property and other land for recreational use. However, too much human activity and its effect on the habitat at McGregor Preserve could negatively impact the birds and other wildlife. Fencing also will limit deer access to the area so that vegetation remains sufficient for vireo and warbler needs. In the fall LCRA conservation staff will conduct a deer census to evaluate the deer population at the preserve.

When will plans go into effect?

The LCRA has agreed with neighbors to postpone the fencing project until after this year's nesting season, but implementation of the Good Neighbor Program and preserve signage has begun. Perimeter notification signs are going up around the preserve. Clearing for the fence began earlier this year, but the process currently is suspended to minimize impact during nesting season. LCRA staff recently presented two Phase 1 training sessions and will offer two Phase 2 field days in early April. As time permits, LCRA staff may offer additional training sessions this year. This program is being tested on a trial basis, so future training programs will depend on the pilot project's success. After the birds leave in the fall, the LCRA will resume perimeter clearing and begin installing the fence. The LCRA also is developing a wildfire management plan for the preserve prior to construction of the perimeter fence.



Black-capped vireo habitat requires dense, low-level vegetation such as sumac, shin oak and Texas persimmon.

Illustration courtesy of Texas Parks and Wildlife Department

What is the LCRA?

The LCRA is a conservation and reclamation district that generates electricity, manages the waters of the lower Colorado River, operates parks, and assists communities in economic development. The LCRA operates on revenues from the sale of electricity and water and other services it provides. It cannot levy taxes and receives no tax money.

Why is the LCRA involved?

Among LCRA's many roles in its service area is a commitment to the environment. These efforts generally are geared to water quality conservation, but the LCRA realizes that its responsibilities also include protection of ecosystems on the land within the watershed. As the owner of this property, the LCRA has agreed to participate in the Balcones Canyonlands Conservation Plan agreement to conserve habitat for the golden-cheeked warbler and black-capped vireo.

How can I get involved in preserving species habitat?

Interested neighbors are encouraged to contact John Gosdin at the LCRA, (512) 473-3531, to reserve a spot in training sessions for the McGregor Good Neighbor Program. LCRA conservation staff will present more information about this trial program at the April 4 annual meeting of the Comanche Trail Community Association. There is a potential for more stewardship opportunities at McGregor Preserve and other LCRA parklands.

LCRA
THE POWER TO MAKE A DIFFERENCE.

LOWER COLORADO RIVER AUTHORITY
P.O. Box 220
Austin, Texas 78767-0220
1-800-776-5272 Ext. 3531
(512) 473-3333
www.lcra.org

MARCH 2000

Birds Seen/Heard During FY 2000 Field Surveys on Western 2/3 of McGregor
Surveyors: Shannon Breslin and Wendy Connally

American Coot (*Fulica americana*)
American Robin (*Turdus migratorius*)
Ash-throated Flycatcher (*Mylarchus cinarascens*)
Belted Kingfisher (*Ceryle alcyon*)
Bewick's Wren (*Thryomanes bewickii*)
Black and White Warbler (*Mniotilta varia*)
Black Vulture (*Coragyps atratus*)
Blue-gray Gnatcatcher (*Polioptila caerulea*)
Brown-headed Cowbird (*Molothrus ater*)
Canyon Wren (*Catherpes mexicanus*)
Carolina Chickadee (*Parus carolinensis*)
Carolina Wren (*Thryothorus ludovicianus*)
Cedar Waxwing (*Bombycilla cedrorum*)
Common Poorwill (*Phalaenoptilus nuttallii*)
Double-crested Cormorant (*Phalacrocorax auritus*)
Eastern Phoebe (*Sayornis phoebe*)
European Starling (*Sturnus vulgaris*)
Field Sparrow (*Spizella pusilla*)
Gadwall (*Anas strepera*)
Golden-cheeked Warbler (*Dendroica chrysoparia*)
Great-crested Flycatcher (*Mylarchus crinitus*)
Greater Roadrunner (*Geococcyx californianus*)
House Finch (*Carpodacus mexicanus*)
House Sparrow (*Passer domesticus*)
Inca Dove (*Columbina inca*)
Lark Sparrow (*Chondestes grammicus*)
Lesser Goldfinch (*Carduelis psaltria*)
Mallard (*Anas platyrhynchos*)
Mourning Dove (*Zenaida macroura*)
Nashville Warbler (*Vermivora ruficapilla*)
Northern Bobwhite (*Colinus virginianus*)
Northern Cardinal (*Cardinalis cardinalis*)
Northern Mockingbird (*Mimus polyglottus*)
Painted Bunting (*Passerina ciris*)
Red-tailed Hawk (*Buteo jamaicensis*)
Ring-billed Gull (*Larus delawarensis*)
Rock Dove (*Columba livia*)
Ruby-crowned Kinglet (*Regulus calendula*)
Rufous-crowned Sparrow (*Aimophila ruficeps*)
Rufous-sided Towhee (*Pipilo erythophthalmus*)
Scrub Jay (*Aphelocoma coerulescens*)
Summer Tanager (*Piranga rubra*)
Tufted Titmouse (*Parus bicolor*)
Turkey Vulture (*Cathartes aura*)
White-eyed Vireo (*Vireo griseus*)
White-throated Sparrow (*Zonotrichia albicollis*)
White-winged Dove (*Zenaida asiatica*)
Wild Turkey (*Meleagris gallopavo*)
Yellow-billed Cuckoo (*Coccyzus americanus*)
Yellow-rumped Warbler (*Dendroica coronata*)

Synopsis of Survey Results at McGregor FY00

Travis County assisted the LCRA with warbler surveys at McGregor this year. A total of 16 golden-cheeked warbler territories were identified through the combined survey effort. County biologists surveyed the easternmost third of the property and identified seven territories. LCRA biologists surveyed the other two-thirds and located nine territories.

Due to limited time, the nine territories identified by the LCRA were mapped but not monitored. However, the seven territories identified by the County were mapped and monitored regularly. Five of those seven territories had a mated pair and three were observed with at least one young. One nest was located that successfully fledged three young (details in Travis County annual survey report).

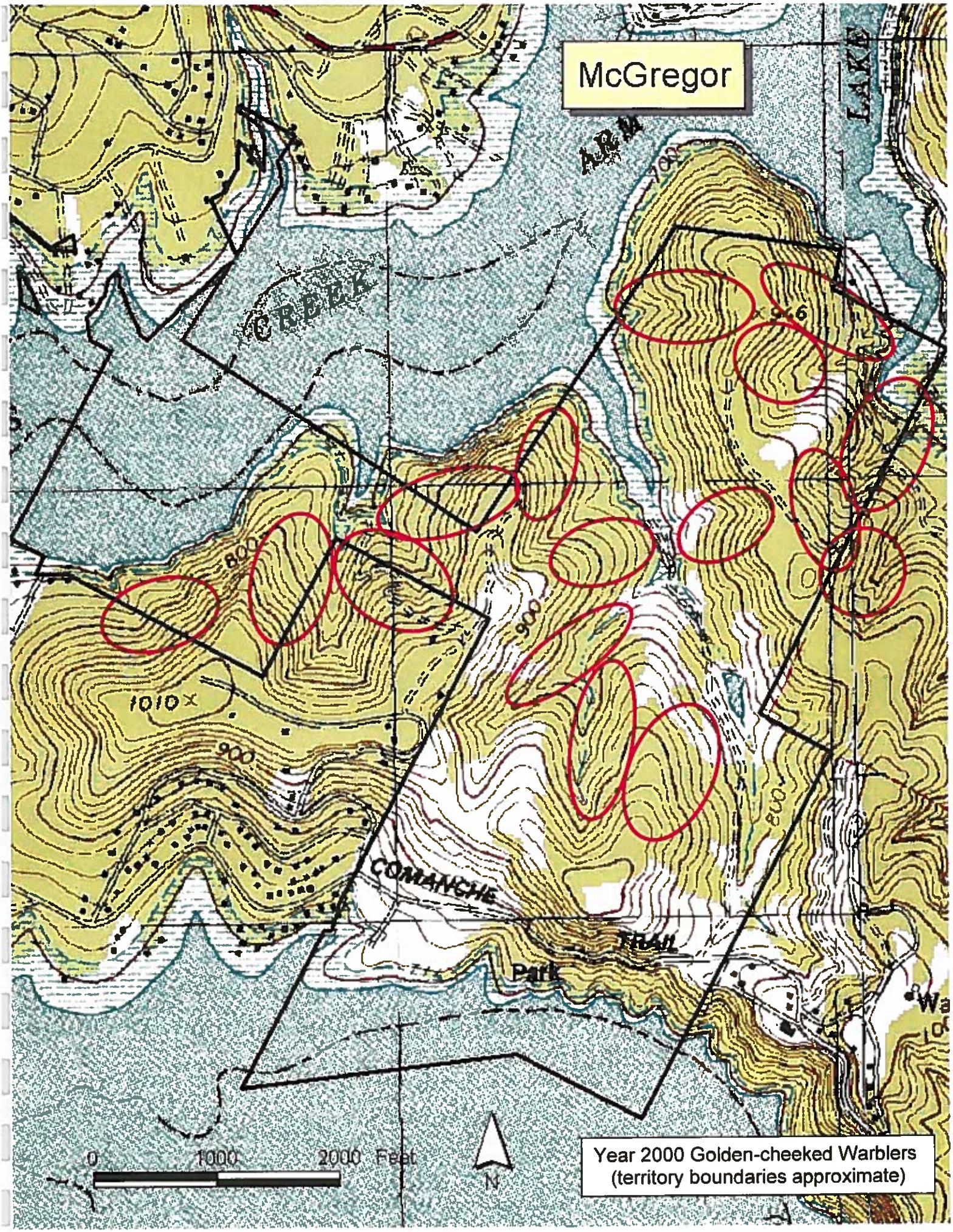
Synopsis of LCRA Survey Effort on Western Two-thirds

LCRA staff spent 46 hours surveying the western two-thirds of the tract during the 2000 breeding season.

March 21, 2000	14 hours	misty/raining on/off throughout day
April 20, 2000	16 hours	sunny 90's
May 5, 2000	8 hours	sunny 90's
May 26, 2000	8 hours	high 80's-low 90's; windy on/off; gusty 10-15
	Total = 46 hours	

Synopsis of Travis County Survey Effort on Easternmost Third

Travis County spent 35 hours surveying the easternmost third of the tract during the 2000 breeding season. Photocopies of relevant sections of the Travis County 2000 Field Season report are attached.


McGregor
LAKE
CREEK
COMANCHE
Park
0
1000
2000 Feet
N
Year 2000 Golden-cheeked Warblers
(territory boundaries approximate)

Monitoring of the Golden-cheeked Warbler - 2000 Field Season

Travis County Parks and Preserves
Project Number 0810-00001

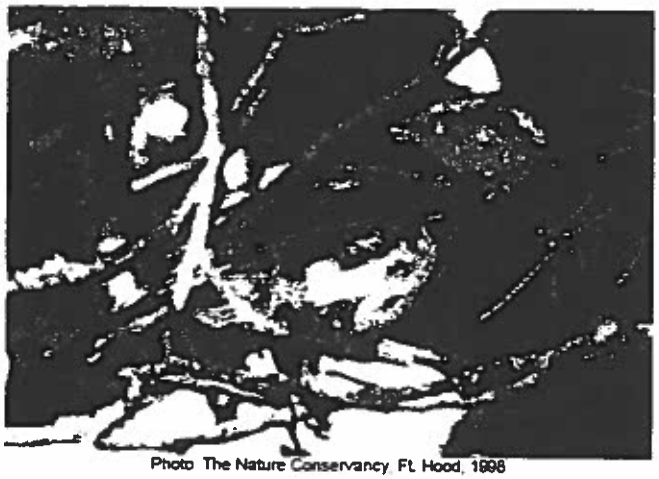


Photo The Nature Conservancy, Ft. Hood, 1998

James W. Bailey & Paul R. Fushille
Travis County Natural Resources

November 2000

the eastern boundary near Bullick Hollow Road. We did not confirm if this bird used both sides of Bullick Hollow nor did we determine if this male established a territory on Lake Perspectives Tract.

As stated earlier, surveys in 1999 were not conducted at Lake Perspectives until mid-May. Results from 1999 indicate that 7 males held territories on Lake Perspectives (Appendix 2). In 1999, 1 male was heard singing to the north on McGregor Tract and 3 females and 7 fledglings were observed for 4 territories. Without a complete data set for 1999, the 2000 field season cannot be compared to 1999. However, the 1999 data was used as a preliminary baseline for 2000.

Sandy Creek Park. We surveyed Sandy Creek Park 3 times during the breeding season (Appendix 1). Only 1 male warbler was detected In the north canyon of the park (Fig. 6). This bird sang two phrases and was not heard again. The last record for a warbler in this canyon was in 1997 (Travis County Natural Resources 1997, unpublished report). A single female warbler was also located within Sandy Creek Park just west of the canyon where the male was heard on a separate visit (Fig. 6). She was foraging along the south rim of the canyon then flew west-southwest and was not observed again. No hatch-years were detected on any surveys during 2000. No surveys were conducted in 1999. However, in 1998, 2 males were recorded outside the park boundary to the south (Appendix 2).

McGregor Tract (LCRA) (BCP). Eleven visits (35 hours) were spent surveying at McGregor (Appendix 1). Twelve unique male warblers were mapped in and around the McGregor-Travis County study area (Fig. 7). Four males were located outside the study area boundary and were not monitored. In the study area, 7 females and 12 fledglings were observed during the season. A total of 7 territories were monitored in 2000. Of these, at least 3 males used both sides of McGregor and Lake Perspectives (Fig. 8). Most warbler activity, 4 territories, occurred on the east facing canyons, especially those directly north of the Lake Perspectives Tract boundary line.

Productivity

The total number of territories in 2000 for all survey sites was 38 (Table 1). Of these territories, 25 (65.7%) were considered monitored as pairs were observed or young were detected. Eighteen (72.0%) of these 25 were observed with HYs during the season.

Hamilton Pool Preserve. In 2000, six of 9 (66.6%) territorial male warblers monitored at Hamilton Pool were mated (observed with hatch years or with a female). Twenty HYs were associated with these 6 territorial males (3.33 young per territorial male [n = 20, SE = 0.07]).

Three nests were located then monitored until a fate could be determined. Of these, 2 (66.6%) failed for unknown reasons, however depredation is suspected for at least one nest. The third nest found was parasitized. Consistent with animal management policy for BCP lands, (Terpening et. al. 1999), the cowbird fledgling was removed.

A fifth year male (banded in 1997 as a second year adult) was observed feeding 2 separate broods during the season. No nests were found for this territory and it is unknown whether the same female remained in the territory after the first clutch fledged.

Lake Perspectives Tract. In 2000, seven of 9 (77.7%) territorial males monitored at Lake Perspectives were mated (observed with hatch years or with a female). Of these 9 territories, only 3 (33.3%) were observed with at least one young. Nine HYs were associated with 3 territorial males (3 young per territorial male [n = 3, SE = 0.03]). One nest was located during the nestling stage and was monitored until a fate could be determined. Three young successfully fledged from the nest.

McGregor Tract. In 2000, five of seven (71.4%) territorial males monitored at McGregor Tract were mated (observed with hatch-years or with a female). Of these seven territories, 3 (42.8%) were observed with at least one young. Twelve HYs were associated with these 3 territorial males (4 young per territorial male [n = 3, SE = 0.04]). In 2000, 1 nest was located and monitored where 3 young successfully fledged.

DISCUSSION

Study Sites

In 2000, we found breeding golden-cheeked warblers at Hamilton Pool Preserve, Lake Perspectives Tract, and McGregor Tract. A total of 38 male golden-cheeked warblers were recorded for 5 of 6 survey sites in 2000. There is little variation in the number of males observed each season (1994-2000) (Appendix 2) within the study areas. For example, warbler densities at Hamilton Pool numbered 15 males in 1999 (including males detected outside the preserve boundaries) compared to 15 males detected in 2000. The differences being 9 territories were found within the preserve boundaries in 2000, while 11 territories were found in 1999. The results are similar for Lake Perspectives Tract. The 1999 survey resulted in approximately 7 males holding territories while in 2000 we found 9 territorial males. Though these variations are evident they may not necessarily reflect actual changes within the population. Variations may be attributed to the following: surveying/monitoring efforts between years, within season territorial shifts that in essence go undetected due to the decreased song activity of males later in the season, or by migrating warblers detected early then, as they move on, not heard again.

Surveying and monitoring efforts have increased each year for areas deemed as intensive study sites, e.g. Hamilton Pool Preserve. Our efforts were greatly increased in 2000 by having the same two observers work the intensive study areas concurrently. This effort, if maintained each survey season, will minimize within season conflicts regarding survey results, thus facilitating comparative data for each breeding season.

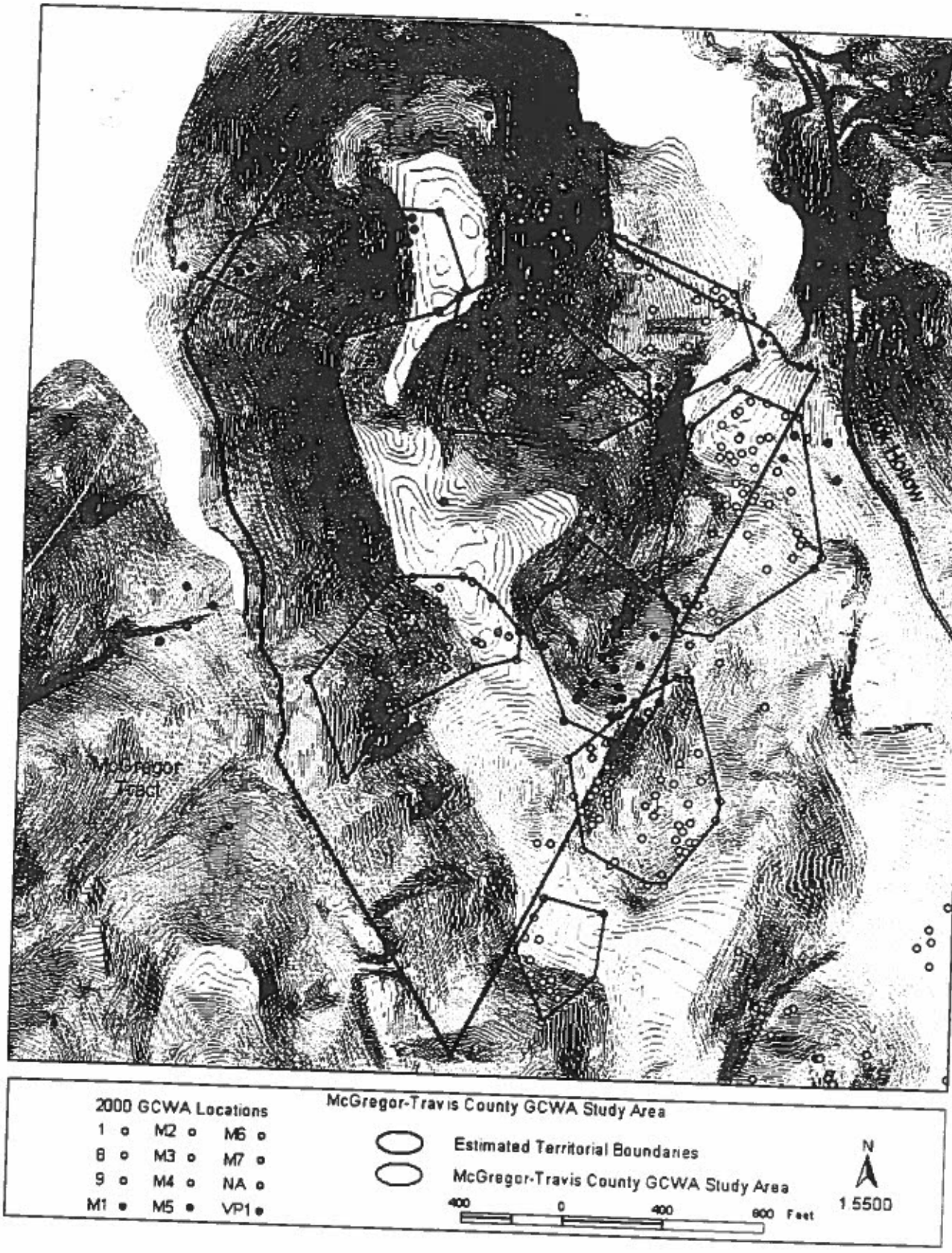


Figure 7. Recorded locations for golden-cheeked warblers at McGregor-Travis County Study Area, Travis County, Texas, 2000.

Appendix 2: Summary of golden-cheeked warbler survey results from selected sites in Travis County.

Park/Preserve	Surveyors	Year	Territorial Males	Females	Young	Other Males	Notes
McGregor	DLS	1993	2+	0	0	0	
McGregor	Travis Co.	1997	10-11	1	0	0	
McGregor	Travis Co.	1998	8	0	5	0	
McGregor	Travis Co.	1999	1	0	0	0	male heard during H. Hollow survey
McGregor	Travis Co.	2000	12	5	12		7 males wilhin sludy area
Sandy Creek	DLS	1993	2	0	2	0	
Sandy Creek	DLS	1994	0	0	0	0	+ 1 male off property
Sandy Creek	DLS	1995	0	0	0	0	
Sandy Creek	Travis Co.	1996	0	0	0	0	+ 3 males off property
Sandy Creek	Travis Co.	1997	1	0	0	0	+ 1 male off property
Sandy Creek	Travis Co.	1998	0	0	0	0	+ 2 males off property
Sandy Creek	Travis Co.	1999	NC	NC	NC	NC	No 1999 Survey Conducted
Sandy Creek	Travis Co.	2000	1	1	0	0	1 male & 1 female, no HYs obs.

Survey effort varies with year and surveyors.
Zeros indicate none reported; esp. for females and young, observers may not have recorded birds thal were present.

WESTCAVE

MANAGEMENT ACTIVITIES	
VEGETATION MANAGEMENT	
Monitor perimeter fencing & repair as needed	The preserve manager routinely monitors the condition of fencing and makes spot repairs, as necessary, with assistance from the LCRA staff assist when requested.
Vegetation enhancement projects	LCRA staff assisted the preserve manager with preparation and application of a 2 acre prescribed burn conducted January 2000. The burn focused on the upland area near the entry road and along a portion of the trail leading to the canyon. The burn successfully reduced the dense cover of Tasajillo (*Opuntia leptocaulis*) and prickly-pear cactus (*Opuntia lindheimeri*), thus encouraging grasses and wildflowers to thrive.
Develop fire management plan	A wildfire management plan was written and implemented FY99.
Monitor for and suppress oak wilt	There was no evidence of oak wilt during this reporting period.
ANIMAL MANAGEMENT	
Participate in BCP monitoring program, as determined by BCP Monitoring Committee	Westcave does not have designated monitoring plots. However, LCRA staff surveyed for golden-cheeked warblers. Six GCWA territories were found. A topo map with approximated territory boundaries delineated and a synopsis of survey results are attached.
PHYSICAL & CULTURAL MANAGEMENT	
If funding is available, acquire additional adjacent land	In light of limited funding, the preserve staff and board continue to work with neighboring landowners to refine the long-term vision for the property and develop strategies for protecting the Heinz Branch watershed and Pedernales River Valley.
VISITOR MANAGEMENT	
Offer guided tours and workshops/classes	Preserve staff provided group tours to thousands of school children, college students, youth groups, professional researchers, and nature enthusiasts from diverse geographic locales.
Offer new workshops/environmental	Preserve staff offered many off-site

education classes	programs for schools and clubs throughout the region.
Develop access plan	An access plan was developed and implemented during FY99.
If funding is available, build new residence and visitor (activity) center	Efforts to develop an on-site educational learning center (visitor/activity center) continue. The LCRA and Westcave Foundation submitted a grant application for the learning center through the Texas Parks and Wildlife indoor recreation program.
Improve ADA accessibility to restroom, upper trail, and deck	Improved ADA accessibility will be incorporated into the new learning center. Existing trails are of sufficient grade, but may be improved, as necessary, during upcoming reporting periods.
Expand parking area and improve drainage	Parking and drainage improvements are major components of the proposed learning center and will be implemented closer to construction.

*** Shaded items represent management activities that were focused on during FY00 (October 1999 – September 2000).**

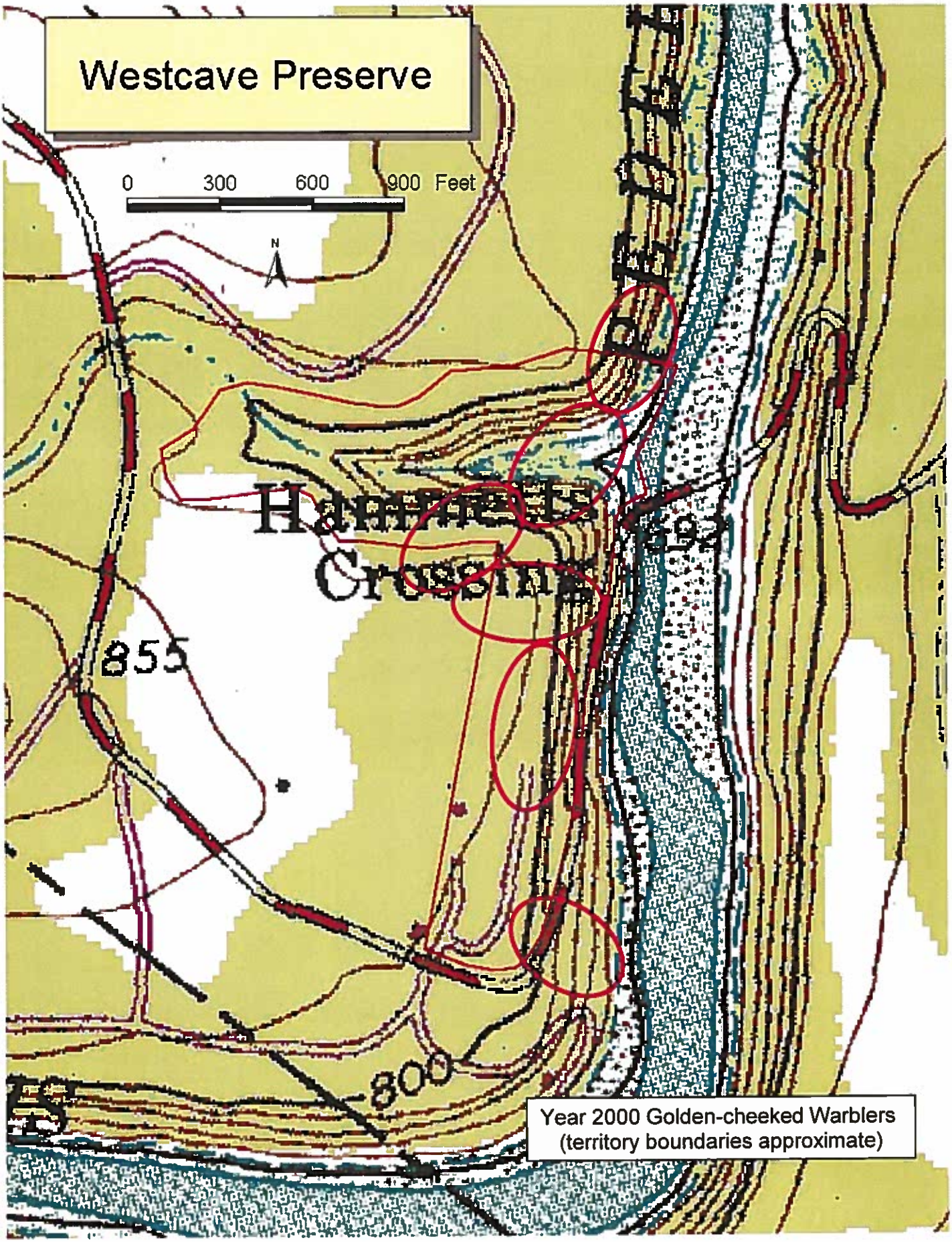
Birds Seen/Heard During FY 2000 Field Surveys at Westcave
Surveyor: Shannon Breslin

Ash-throated Flycatcher (*Myiarchus cinarascens*)
Belted Kingfisher (*Ceryle alcyon*)
Bewick's Wren (*Thryomanes bewickii*)
Black and White Warbler (*Mniotilta varia*)
Black Vulture (*Coragyps atratus*)
Blue-gray Gnatcatcher (*Polioptila caerulea*)
Brown-headed Cowbird (*Molothrus ater*)
Canyon Wren (*Catherpes mexicanus*)
Carolina Chickadee (*Parus carolinensis*)
Carolina Wren (*Thryothorus ludovicianus*)
Cedar Waxwing (*Bombycilla cedrorum*)
Bushtit (*Psaltriparus minimus*)
Cooper's Hawk (*Accipiter cooperii*)
Eastern Phoebe (*Sayornis phoebe*)
Eastern Turkey (*Meleagris gallopavo*)
Field Sparrow (*Spizella pusilla*)
Golden-cheeked Warbler (*Dendroica chrysoparia*)
Great Blue Heron (*Ardea herodias*)
Great-crested Flycatcher (*Myiarchus crinitus*)
Green Heron (*Butorides striatus*)
House Finch (*Carpodacus mexicanus*)
Inca Dove (*Columbina inca*)
Lesser Goldfinch (*Carduelis psaltria*)
Mourning Dove (*Zenaida macroura*)
Nashville Warbler (*Vermivora ruficapilla*)
Northern Bobwhite (*Colinus virginianus*)
Northern Cardinal (*Cardinalis cardinalis*)
Northern Mockingbird (*Mimus polyglottus*)
Northern Parula (*Parula americana*)
Orange-crowned Warbler (*Vermivora celata*)
Painted Bunting (*Passerina ciris*)
Peacock (*Pavo cristatus*)
Red-eyed Vireo (*Vireo olivaceous*)
Red-shouldered Hawk (*Buteo lineatus*)
Ruby-crowned Kinglet (*Regulus calendula*)
Rufous-crowned Sparrow (*Aimophila ruficeps*)
Scrub Jay (*Aphelocoma coerulescens*)
Summer Tanager (*Piranga rubra*)
Tufted Titmouse (*Parus bicolor*)
Turkey Vulture (*Cathartes aura*)
White-eyed Vireo (*Vireo griseus*)
Yellow-billed Cuckoo (*Coccyzus americanus*)
Yellow-rumped Warbler (*Dendroica coronata*)
Yellow-throated Vireo (*Vireo flavifrons*)

Synopsis of Survey Results at Westcave FY00

LCRA staff identified six golden-cheeked warbler territories at Westcave Preserve during the 2000 breeding season. Approximate territory boundaries are noted on the attached topo map. Due to limited time, territories were mapped, but not monitored. However, while there may have been more success than was documented, there were several highlights:

1) Three of the six territories were observed with a mated pair and two with at least two young each.


Westcave Preserve
0
300
600
900 Feet
N
855
800
Year 2000 Golden-cheeked Warblers
(territory boundaries approximate)

2) Two family units with fledglings were observed, both on the uplands portion of the property:
   - One nest was located approximately (ca.) 20 feet (ft) above ground in a live oak (*Quercus fusiformis*) and ca. 25 ft away from the main trail that leads into the canyon. The female was observed sitting on the nest and the male was observed feeding her. Both parents were observed feeding nestlings. The male was observed feeding two fledglings.
   - Another male was observed feeding two fledglings closer to the edge of the canyon, but still in the upland portion of the property.

Synopsis of Survey Effort at Westcave

LCRA staff spent 31.5 hours surveying Westcave during the 2000 breeding season.

April 13, 2000	7 hours	overcast-sunny w/scattered clouds 65-70 all day
April 21, 2000	7.5 hours	sunny 60's-80's
May 12, 2000	8.5 hours	sunny 70's-90's
June 2, 2000	8.5 hours	sunny 70's-90's
	Total = 31.5 hours	

ATTACHMENT B

TRAVIS COUNTY

2000 WARBLER MONITORING REPORT

Monitoring of the Golden-cheeked Warbler - 2000 Field Season

Travis County Parks and Preserves
Project Number 0810-00001



Photo: The Nature Conservancy, Ft. Hood, 1998

James W. Bailey & Paul R. Fushille
Travis County Natural Resources

November 2000

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INTRODUCTION

The golden-cheeked warbler (*Dendroica chrysoparia*, hereafter warbler) is a small, neotropical migrant passerine whose entire breeding range is restricted to central Texas. There is great concern because this species' populations has declined due to large scale reduction and fragmentation of its breeding habitat (Pulich 1976, United States Fish and Wildlife Service 1992). Established to protect the golden-cheeked warbler and black-capped vireo (*Vireo atricapillus*, hereafter vireo) and other species of concern, an assemblage of preserve properties called the Balcones Canyonlands Preserve (BCP) are managed to facilitate the local recovery of these species. Travis County owns and manages 4 preserves and 4 parklands in western Travis County specifically for the warbler and vireo. Travis County Natural Resources staff conducted surveys for warblers and vireos on 5 Travis County parks and preserves during the 2000 breeding season. This work was a continuation of the endangered bird monitoring project ongoing since 1996. In addition to properties managed by Travis County, we surveyed and mapped territories for warblers in the north end of the Lower Colorado River Authority (LCRA), McGregor Tract. We surveyed the same number of parks in 2000 as in 1999. However, fewer visits were made to parks that had a very low probability of having either of the target species (based on past surveys and on available habitat).

We surveyed Hamilton Pool Preserve, Lake Perspectives Tract, and McGregor Tract more intensively than the other sites. Hamilton Pool is now part of a detailed golden-cheeked warbler monitoring study conducted by Balcones Canyonlands Preserve (BCP) partners and the Balcones Canyonlands National Wildlife Refuge. This monitoring plan is based on a set of 100-acre (40-ha) sampling plots in prime and transitional habitat, with varying levels of recreational use and adjacent urbanization (Gass, 1999). The number of territories and reproductive success for each plot will be tracked over 30 years. Each 100-acre plot will be visited 8 to 10 times each breeding season, for 5.5 to 6 hours per visit. Visits are to be spaced equally throughout the survey period (March 20th to mid-June). Survey time is distributed equally throughout the plot at the beginning of the season. Areas found to contain warblers may be focused on later in the season to ascertain nesting success, however all areas are checked on a regular basis. Surveys are conducted between approximately 6:30 a.m. and 2 p.m., depending on temperature and time of sunrise.

Because Lake Perspectives Tract was not purchased until the end of April 1999, a complete set of surveys in 1999 was not conducted. When surveying began on May 13, 1999, several pairs of warblers had fledglings, and territorial boundaries may have been breaking down (Travis County Natural Resources 1999, unpublished report). With new staff and time allotted for thorough site visits, we were able to collect baseline data from the beginning to the end of the warbler's 2000 breeding season.

Surveys for golden-cheeked warblers were initiated on McGregor Tract through a cooperative in-kind service agreement with the LCRA Community Services division. Once warbler occupation was determined, territory and breeding information was collected. Recently limited public access was granted to neighbors surrounding the McGregor Tract. LCRA officials needed to know more detail on warbler use to minimize potential public use impacts. Travis County biologists assisted with the necessary field investigations.

STUDY SITES & METHODS

Surveying was conducted primarily within the Cypress Creek macrosite within the BCP boundary. Hamilton Pool Preserve is located within the Pedernales River macrosite (Fig. 1). General site descriptions, including topography, vegetation, and geology are presented below. See *Botanical Inventory of Travis County Parks, Summer 1996*, by W.R. Carr, for a more detailed description of the vegetation in Travis County parks and preserves. Surveys were limited to baseline data collection of territory locations and productivity.

Bob Wentz Park/Romberg Tract (BCP), consisting of 19.5 ha (48.4 acres) is immediately north of Bob Wentz Park, and across from Comanche Trail (Figs. 1, 2). It is undeveloped except for a septic field near the southeastern corner. The topography includes gentle and steep slopes, which are west-, north-, and south facing. Two small canyons contain intermittent streams. Ashe juniper-Spanish oak (*Quercus buckleyi*) woodland occupies the extreme northern part of the tract, while the rest of the tract includes shrubby junipers, open areas of midgrass, and a few live oak mottes.

Hamilton Pool Preserve (BCP), consisting of 93.8 ha (232 acres), is located east of the Pedernales River, and includes the Hamilton Creek drainage from 300 meters upstream of the collapsed grotto (which forms the pool) and downstream to the confluence with the river (Figs. 1, 3). The terrain is steep on the banks of the river and creek, and relatively flat east of the river and south of the creek. The flat bench is underlain by Hensell Sand, and by the Glen Rose formation in the northeast corner of the property. Cow Creek Limestone, Hammett Shale, and Sycamore Sand are exposed in the Pedernales River and Hamilton Creek canyons. The upland plateau east of the river and south of the creek supports midgrass grassland and plateau live oak-Ashe juniper woodlands. The steep slopes along the river and creek support a mixed evergreen/deciduous woodland with various species of trees, including Ashe juniper, Spanish oak, shin oak (*Quercus sinuata*), Arizona walnut (*Juglans major*), Texas ash (*Fraxinus texensis*), escarpment black cherry (*Prunus serotina* subsp. *eximia*), and cedar elm (*Ulmus crassifolia*). The vegetation along the creek is a gallery woodland dominated by bald cypress (*Taxodium distichum*).

Hipple Hollow Park, consisting of 43.6 ha (109 acres), is located on the shore of Lake Travis, and is underlain by Glen Rose limestone (Figs. 1, 4). The eastern half of the park and the areas along the shoreline are on steep south-facing slopes, while the western, inland area (covered

mostly by a parking lot) is on a gentle slope. Ashe juniper-dominated evergreen woodland covers the steep slopes, while the undeveloped areas in the western part of the park support a mixed evergreen/deciduous shrubland.

Lake Perspectives Tract (BCP), consisting of 51.3 hectares (127 acres), is located on Bullick Hollow Road, south of Cypress Creek and north of Oasis Bluff Road (Figs. 1, 5). The preserve is underlain by the Glen Rose formation. The western part of the preserve contains four hollows that drain to the northeast, as well as some upland/plateau topography. A unnamed tributary to Cypress Creek runs roughly northward and parallel to Bullick Hollow Road, through the relatively flat eastern section of the preserve. Most of the preserve (including the canyons, upland areas, and most of the area surrounding the creek) supports open- and closed-canopy juniper-oak woodlands. An area of about 7.6 hectares (19 acres) in the middle of the preserve supports open grassland interspersed with oak mottes. This preserve was acquired as mitigation at the end of April 1999, and is adjacent to the LCRA's McGregor Tract.

Sandy Creek Park, consisting of 10.1 ha (25 acres), is located on the Sandy Creek arm of Lake Travis, and is underlain by the Glen Rose Formation (Fig. 1). The terrain includes both gentle and moderate slopes, as well as two significant ravines. Ashe juniper-oak woodland covers most of the undeveloped areas of the park. Plateau live oak, Spanish oak, Texas ash, and Ashe juniper are all important tree species in this woodland. The tree canopy is nearly closed, and the understory very open, on the north-facing slopes of the northern end of the park. The vegetation in the rest of the inland areas of the park consists of clusters of trees and shrubs with grassland openings. The shoreline supports a riparian thicket of roughleaf dogwood (*Cornus drummondii*), buttonbush (*Cephalanthus occidentalis*), and winterberry (*Ilex deciduda*).

McGregor Tract (LCRA) (BCP), consisting of 146.9 ha (363 acres), is located on a peninsula in Lake Travis west of Bullick Hollow Road (Fig. 1). It is adjacent to Hippie Hollow Park, Lake Perspectives Tract, and Romberg Preserve. The property contains several plateaus, ridges, and deep canyons. It is underlain by the Glen Rose formation, with outcrops of the Fredericksburg Group (undivided) on the highest points on the east side of the tract (Proctor *et al.* 1974). There are no perennial streams, but a small stock tank retains some runoff water. Oak-Ashe juniper woodland covers most of the preserve, with occasional grassland openings. The woodland is dominated by plateau live oak, Spanish oak, and Ashe juniper, with shrubs such as evergreen sumac (*Rhus virens*), Texas persimmon (*Diospyros texana*), agarita (*Berberis trifoliolata*), and prickly ash (*Zanthoxylum* sp.) in the understory. An exchange of service agreement between the LCRA and Travis County was established in 2000 which outlined a 49.3 ha (121.87 acres) study area in the northeastern portion of the McGregor Tract, north of Lake Perspectives, in which Travis County Natural Resources staff surveyed and mapped territories of warblers.

Distribution

We followed survey methods for golden-cheeked warblers and black-capped vireos described in the "Minimum Procedures for Determining the Presence/Absence of Golden-cheeked Warblers and Black-capped Vireos", as required by the U.S. Fish and Wildlife Service (USFWS) endangered species permit. This method was only used at properties where either species had not been detected within the past few years (e.g. Hippie Hollow). Though we surveyed for both species, efforts were focused primarily on warblers during 2000.

We determined densities of birds by locating territorial males and delineating their territories using a method similar to the "consecutive flush" technique described by Bibby et al. (1993). Staff monitoring warblers at Ft. Hood, as described by Holiman et al. (2000), also used this method. Warblers were viewed through binoculars to determine banding status. If banded, an attempt was made to determine the bird's color combination. Attempts were made to verify band status of all warblers encountered. We recorded up to 5 locations per territory visit in order to eliminate or reduce any human induced behavior and to maximize independence of locations. Additionally, we recorded temperatures for the start and end of each visit from either hourly weather radio broadcasts, or a thermometer permanently mounted in a shady area (at Hamilton Pool). Wind speeds were estimated or recorded from NOAA weather radio broadcasts. Cloud cover was estimated to the nearest five percent. We did not use playback tapes of screech owl or warbler vocalizations this year. Warbler locations were plotted on 1-meter resolution digital orthophoto maps at a scale of 1:4000 generated in ArcView 3.1 Geographic Information System software (Environmental Systems Research Institute, Inc., Redlands, California). Symbology marked on field maps, such as counter-singing, followed International Bird Census Committee (1970) standards. We used two way radios to determine conspecific singing within the study sites. This proved useful in determining the number of males detected by having one observer follow a male while the other listened for counter singing. Confirmed results were then transmitted to the other observer facilitating accurate detection results and territorial boundaries. Other data recorded in field notebooks included study site, date, time, number of males singing, song type, number of females present, territory number, cowbirds present, nest and productivity data if applicable. All males were assigned territory numbers regardless of band status. Territory numbers were assigned once it was determined that a male had a territory by either counter-singing, continued use of a physical area of habitat, or if a female was observed with a male (Koloszar and Bailey, 2000).

During the 2000 field season, avian locations were marked on 1:4000 scale digital 1-meter resolution ortho-photo based field maps. An ArcView project was created for each study area with the same photos used as the base layer. Avian locations were then plotted directly on screen in ArcView thus matching the locations marked on field maps. These locations were then entered into a database via an ArcView GIS script written by Jon Horne (2000), GIS Analyst with The Nature

Conservancy at Fort Hood, Texas. Once an individual location was determined on screen, ArcView prompted for specific data, which was then tabulated and became the database for avian location records. Specific data entered into the database included the following: species, band number (if known), color combination, colors certain, age (if known), sex, mate present, territory number, number of fledglings, date collected, time, date recorded, x-y coordinates, accuracy, scale, observer, macrosite, tract name and comments.

Distribution

The number of warbler locations collected during the 2000 field season determined distribution within study sites. However, warbler location data collected may not represent actual occupation of available habitat in the entire area because our survey efforts were limited to county owned or managed properties. When warblers were detected on properties adjacent to our study sites, their locations were recorded. Males outside the study site boundaries were assigned a territory number to signify them as unique but were not monitored. Methods and analysis used for this section follow those of The Nature Conservancy of Texas, Fort Hood office (Koloszar and Bailey, 2000).

Productivity

Productivity within the study sites was determined by the recorded number of hatch year (hereafter HY) (fledgling) warblers observed with territorial males at each study site. Productivity values are represented for those territories where HYs were observed. Nest searching was initiated when behavioral cues suggested potential nest activity. If a female was observed carrying nesting material or if either adult was carrying food, a search was conducted in and around the area of activity. Once discovered, the nest location was marked on field maps and the nest tree was flagged. Nests were then monitored every 3-5 days until an outcome could be determined. In the event of parasitism, all brown-headed cowbird eggs and/or fledglings were removed. Our methods of measuring productivity and analysis follow those of The Nature Conservancy of Texas, Fort Hood office (Koloszar and Bailey 2000, Holiman and Craft 2000).

RESULTS

Distribution-Study Sites

One thousand two hundred and sixteen observations were recorded for golden-cheeked warblers during the 2000 breeding season (1,034 male, 102 female, 83 hatch year, and 2 unknown observations). Multiple sightings were recorded for individual birds, (e.g. males for territory delineation). Thirty-eight unique males were recorded on 5 study sites (Table 1). Of these 38 males, only one male was banded with a single silver USFWS band (See Below ***Hamilton Pool***

Preserve). No banded female warblers were observed on any Travis County study site. Despite small sample sizes, monitoring unbanded birds challenged us and raised many questions that led to speculations regarding territorial data. For example, 151 recorded observations of males do not have an assigned territory number. This occurred late in the season once territory boundaries began to break down and counter-singing ceased. Regardless, warblers at Hamilton Pool, Lake Perspectives, and McGregor Tract were intensively surveyed and monitored. Variations in the number of territories per study site were minimal. Hamilton Pool had 15 territories, 9 of which were located inside the study area (Fig. 3). Lake Perspectives had 9 territorial males throughout the season and a possible tenth male was discovered late (Fig. 5). McGregor Tract had 7 territories inside the study site boundary and at least 3 outside (Fig. 7). Compared to 1999, Hamilton Pool had 11 territories and Lake Perspectives had approximately 7. McGregor Tract was not surveyed by Travis County biologists in 1999.

Approximately 416 staff hours were spent surveying for golden-cheeked warblers (Appendix 1). Time spent surveying any one area ranged from 2 hours at Hippie Hollow to 202 hours at Hamilton Pool Preserve. Staff hours are calculated by the number of hours each biologist accumulated while at each study area then combined and totalled.

Systematic and repeated monitoring of Hamilton Pool, Lake Perspectives and McGregor Tract allowed for recording multiple locations for some warblers and the calculation of home ranges. A minimum of 10 locations per male was required for home range calculations (Koloszar and Bailey, 1999). Twenty-five males met this measure in 2000. Minimum convex polygons with 95% confidence intervals were used to calculate home ranges (Hooge and Eichenlaub, 1997) (Figs. 3, 5, 7, 8). The mean number of locations was 34.56. Mean home range size was 2.93 ha (7.24 acres) (Table 2). There was no significant difference in home range sizes between Hamilton Pool, Lake Perspectives and McGregor Tract.

Bob Wentz Park/Romberg Preserve (BCP). Limited staff time coupled with higher priority study areas led to fewer surveys on Romberg in 2000 than in 1999. In 2000, 2 visits yielded no warbler activity on Romberg Preserve proper compared to 1999 in which 5 visits and several males were detected (off property) and a female was observed feeding hatch years on site (Travis County Natural Resources 1999, unpublished report). Two males were heard singing off property to the east of Romberg in 2000 (Fig. 2). Compared to other sites within the area (e.g. McGregor Tract to the east), only a small patch of suitable golden-cheeked warbler habitat is found on Romberg Tract, which is contiguous with habitat on the adjacent private property to the east. Historical data suggests that warblers have used Romberg for foraging and juvenile dispersal but no nest activity has been documented.

Hamilton Pool Preserve (BCP). Survey results indicate that 9 male warblers held territories at Hamilton Pool in 2000 (Fig. 3). Eleven males were reported to have held territories in 1998 and in

1999 (Appendix 2). In addition, 5 to 7 males held territories outside the preserve boundaries during 2000 compared to 3 to 4 males in 1999. These areas include the west side of the Pedernales River, at the bend in Hamilton Pool road between the preserve and Hamilton Pool Road bridge, and the confluence of Hamilton Creek. We found 8 females and 20 fledglings in the preserve. In 1999, 9 females and at least 17 HYs were documented. A male that was banded as a second year bird in 1997 returned to the same area he was banded in 1998, 1999, and 2000.

Three nests were found along the Pedernales River side of the preserve. Of these nests, 2 failed for unknown reasons and 1, despite being parasitized (See Below ***Productivity)***, successfully fledged 2 warblers. Unlike the black-capped vireo, the golden-cheeked warbler can successfully fledge young from a nest parasitized by cowbirds (Pulich 1976, Dunn and Garrett 1997).

Males held territories along the canyons along Hamilton Creek and the Pedernales River, but we also saw and heard warblers in the upland areas south of the creek, east of the river, and north of the entry station. There were more sightings of adults with fledglings in the uplands this year than in 1999. These sightings were in the eastern half of the uplands, in an area north and northwest of the entry station. Additional locations were observed south of the entry station along the oak-juniper mottes north of the prairie restoration area, and further east near the maintenance buildings (Fig. 3).

Hippie Hollow Park. Only one visit was made to Hippie Hollow at the end of March 2000 (Fig. 4) (Appendix 1). We spent 2 hours walking the upper and lower trails throughout the park surveying for both warblers and vireos. No black-capped vireos or golden-cheeked warblers were detected on the property. However, one male golden-cheeked warbler was detected on the McGregor Tract, across Comanche Trail from the northeastern boundary of Hippie Hollow Park.

To date, little or no suitable vireo habitat exists within the park. With no known viable vireo populations nearby, combined with poor habitat conditions and heavy visitor use, recolonization at Hippie Hollow is unlikely. However, potential habitat manipulation areas exist on McGregor Tract north of Hippie Hollow. No black-capped vireos have been present at Hippie Hollow since spring 1995 (DLS 1995, Travis County Natural Resources 1996, unpublished reports). Warbler habitat quality varies from marginal to poor. Drainages and small canyons in the western half of the park have potential for foraging and possible hatch year dispersion. No golden-cheeked warblers have been found within the park boundaries since 1991 (DLS 1992, Travis County Natural Resources 1999, unpublished reports) (Appendix 2).

Lake Perspectives Tract (BCP). A total of 9 warbler territories were monitored in 2000. Of these, at least 3 males used both McGregor Tract and Lake Perspectives Tract while 2 other territories in the southeastern corner used both private property and preserve habitat (Figs. 5, 8). No females or hatch-years were observed in either of the 2 southeast corner territories. Seven females and 10 hatch-years were observed for 7 territories. A possible tenth male was heard singing along

the eastern boundary near Bullick Hollow Road. We did not confirm if this bird used both sides of Bullick Hollow nor did we determine if this male established a territory on Lake Perspectives Tract.

As stated earlier, surveys in 1999 were not conducted at Lake Perspectives until mid-May. Results from 1999 indicate that 7 males held territories on Lake Perspectives (Appendix 2). In 1999, 1 male was heard singing to the north on McGregor Tract and 3 females and 7 fledglings were observed for 4 territories. Without a complete data set for 1999, the 2000 field season cannot be compared to 1999. However, the 1999 data was used as a preliminary baseline for 2000.

Sandy Creek Park. We surveyed Sandy Creek Park 3 times during the breeding season (Appendix 1). Only 1 male warbler was detected in the north canyon of the park (Fig. 6). This bird sang two phrases and was not heard again. The last record for a warbler in this canyon was in 1997 (Travis County Natural Resources 1997, unpublished report). A single female warbler was also located within Sandy Creek Park just west of the canyon where the male was heard on a separate visit (Fig. 6). She was foraging along the south rim of the canyon then flew west-southwest and was not observed again. No hatch-years were detected on any surveys during 2000. No surveys were conducted in 1999. However, in 1998, 2 males were recorded outside the park boundary to the south (Appendix 2).

McGregor Tract (LCRA) (BCP). Eleven visits (35 hours) were spent surveying at McGregor (Appendix 1). Twelve unique male warblers were mapped in and around the McGregor-Travis County study area (Fig. 7). Four males were located outside the study area boundary and were not monitored. In the study area, 7 females and 12 fledglings were observed during the season. A total of 7 territories were monitored in 2000. Of these, at least 3 males used both sides of McGregor and Lake Perspectives (Fig. 8). Most warbler activity, 4 territories, occurred on the east facing canyons, especially those directly north of the Lake Perspectives Tract boundary line.

Productivity

The total number of territories in 2000 for all survey sites was 38 (Table 1). Of these territories, 25 (65.7%) were considered monitored as pairs were observed or young were detected. Eighteen (72.0%) of these 25 were observed with HYs during the season.

Hamilton Pool Preserve. In 2000, six of 9 (66.6%) territorial male warblers monitored at Hamilton Pool were mated (observed with hatch years or with a female). Twenty HYs were associated with these 6 territorial males (3.33 young per territorial male [n = 20, SE = 0.07]).

Three nests were located then monitored until a fate could be determined. Of these, 2 (66.6%) failed for unknown reasons, however depredation is suspected for at least one nest. The third nest found was parasitized. Consistent with animal management policy for BCP lands, (Terpening et. al. 1999), the cowbird fledgling was removed.

A fifth year male (banded in 1997 as a second year adult) was observed feeding 2 separate broods during the season. No nests were found for this territory and it is unknown whether the same female remained in the territory after the first clutch fledged.

Lake Perspectives Tract. In 2000, seven of 9 (77.7%) territorial males monitored at Lake Perspectives were mated (observed with hatch years or with a female). Of these 9 territories, only 3 (33.3%) were observed with at least one young. Nine HYs were associated with 3 territorial males (3 young per territorial male [n = 3, SE = 0.03]). One nest was located during the nestling stage and was monitored until a fate could be determined. Three young successfully fledged from the nest.

McGregor Tract. In 2000, five of seven (71.4%) territorial males monitored at McGregor Tract were mated (observed with hatch-years or with a female). Of these seven territories, 3 (42.8%) were observed with at least one young. Twelve HYs were associated with these 3 territorial males (4 young per territorial male [n = 3, SE = 0.04]). In 2000, 1 nest was located and monitored where 3 young successfully fledged.

DISCUSSION

Study Sites

In 2000, we found breeding golden-cheeked warblers at Hamilton Pool Preserve, Lake Perspectives Tract, and McGregor Tract. A total of 38 male golden-cheeked warblers were recorded for 5 of 6 survey sites in 2000. There is little variation in the number of males observed each season (1994-2000) (Appendix 2) within the study areas. For example, warbler densities at Hamilton Pool numbered 15 males in 1999 (including males detected outside the preserve boundaries) compared to 15 males detected in 2000. The differences being 9 territories were found within the preserve boundaries in 2000, while 11 territories were found in 1999. The results are similar for Lake Perspectives Tract. The 1999 survey resulted in approximately 7 males holding territories while in 2000 we found 9 territorial males. Though these variations are evident they may not necessarily reflect actual changes within the population. Variations may be attributed to the following: surveying/monitoring efforts between years, within season territorial shifts that in essence go undetected due to the decreased song activity of males later in the season, or by migrating warblers detected early then, as they move on, not heard again.

Surveying and monitoring efforts have increased each year for areas deemed as intensive study sites, e.g. Hamilton Pool Preserve. Our efforts were greatly increased in 2000 by having the same two observers work the intensive study areas concurrently. This effort, if maintained each survey season, will minimize within season conflicts regarding survey results, thus facilitating comparative data for each breeding season.

Productivity

Warbler productivity estimates were calculated during 2000 for Travis County parks and preserves. Data collected during past surveys summarized the number of young observed for the total study area without calculations for the average number of young per territorial male. By establishing a monitoring scheme, similar to The Nature Conservancy at Fort Hood in which specific HY data can be collected and analyzed, methods for estimating warbler productivity would be consistent for each additional survey season. Female warbler sample sizes were low due to their elusive nature, which led to some females not being observed with male warblers. Therefore, indirect estimates of productivity will continue to be calculated by the number of males observed with young.

Nest sample size (5 total) was too small to calculate nest success. Although one nest was parasitized, a parasitism rate could not be calculated for the same reason. Nest searching may continue but extended efforts will not be initiated unless additional staff become available and the need for such data warrants such actions.

RECOMMENDATIONS

Study Sites

Though thorough surveys and territory mapping efforts were completed for several preserves, one complication occurred throughout the season that hindered data collection. All birds, except one male at Hamilton Pool, in our study areas were unbanded. In order for an intensified monitoring scheme at Hamilton Pool, Lake Perspectives and McGregor Tract to continue, banding of golden-cheeked warblers is imperative. Color banding would allow for data such as survival, demography, dispersal, recruitment, and space utilization to be collected and analyzed. Data on productivity, survivorship and recruitment are essential for understanding dynamics of these populations (Butcher et. al. 1993). In addition, color banding would reduce observer speculation and assumptions regarding the identities of individual birds and their territory status. Travis County should coordinate with The Nature Conservancy's Fort Hood office for banding and territory monitoring protocols.

It is also recommended that in the future Travis County continue the same monitoring efforts as in 2000. Utilization of 2 observers during survey periods at the same study area increases the probability of detecting warblers while covering greater area. This practice along with color-banding will facilitate a more effective monitoring program.

Productivity

It is recommended that Travis County continue productivity estimates by determining the number of young per territorial male. A shift in priority from territories with HY data to those territories where productivity had not been observed should continue so that productivity estimates

can be calculated for the entire study area. Protocols that facilitate productivity estimates (Koloszar and Bailey 2000, Holiman and Craft 2000) should be implemented.

DATA MANAGEMENT

Information regarding the disposition of data sets collected during the 2000 field season is provided below. Data will be archived to facilitate retrieval for further analysis. All data are currently stored in the Travis County Natural Resources office, 9th and Lavaca, Austin, Texas.

Avian Location Data
Data File Name: 00_avian_locn_records.xls
Documentation Update: 06 September 2000
Description: avian location data from 2000 field season
Software: Microsoft Windows NT, Excel 1997
Data File Archive Location:
Main Copy: D:\Users\Wes\Research\gcwa
Storage Location: GCWA computer

Data File Name: 2000avianlocs
Documentation Update: 06 September 2000
Description: shapefile containing avian location data from 2000 field season
Software: Microsoft Windows NT, ArcView 3.1
Data File Archive Location:
Main Copy: D:\GIS projects\bccp\Avian Location Projects\2000 Survey Data
Storage Location: GCWA computer

Data File Name: hp_trtry3
Documentation Update: 06 September 2000
Description: shapefile containing territory polygons for Hamilton Pool
Software: Microsoft Windows NT, ArcView 3.1
Data File Archive Location:
Main Copy: D:\GIS projects\bccp\Avian Location Projects\2000 Survey Data
Storage Location: GCWA computer

Data File Name: lp_territories
Documentation Update: 06 September 2000
Description: shapefile containing territory polygons for Lake Perspectives
Software: Microsoft Windows NT, ArcView 3.1
Data File Archive Location:
Main Copy: D:\GIS projects\bccp\Avian Location Projects\2000 Survey Data
Storage Location: GCWA computer

Data File Name: mcgregor_trtry1
Documentation Update: 06 September 2000
Description: shapefile containing territory polygons for McGregor Tract-Travis County Study Area
Software: Microsoft Windows NT, ArcView 3.1
Data File Archive Location:
Main Copy: D:\GIS projects\bccp\Avian Location Projects\2000 Survey Data
Storage Location: GCWA computer

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TABLES

Table 1. Summary of the number of unique male[a] golden-cheeked warblers in each study site on Travis County Parks and Preserves, Texas in 2000. Abundance is the measure of the total number of unique males reported in 2000.

Macrosite	Study Site	Abundance
Cypress Creek	Hippie Hollow	1[b]
	Lake Perspectives	10
	McGregor	10
	Romberg	2[b]
	Sandy Creek	1
Pedernales River	Hamilton Pool	15
Total		38

[a] All males assigned a territory number were considered unique, regardless of their band status. Each banded male not assigned a territory was also considered unique.

[b] Males that were detected outside study site boundary.

Table 2. Home ranges[a] (ha) for golden-cheeked warblers on Travis County Parks and Preserves, Texas, 2000.

Study Area	No. Territories	Mean Number of Locations	Mean Range Size (Ha)	Standard Deviation of Range (Ha)	Median Range Size (Ha)
Hamilton Pool	11	40.00	2.57	2.73	1.87
Lake Perspectives	9	30.88	3.10	1.41	3.07
McGregor	5	32.80	3.41	0.57	3.37
Total	25	34.56	2.93	1.99	2.57

[a]Home ranges determined by 95% minimum convex polygons for warblers with □10 observations.

Table.3. Productivity (no. fledglings/territory) and pair success (percent successful) for golden-cheeked warbler territories by study area on Travis County Parks and Preserves, Texas, March-July 2000.

Study Site	No. Territories[a]	No. Monitored[b]	Percent Monitored[c]	No. Successful[d]	Percent Successful[e]	No. Fledglings[f]	Observed Productivity[g]
HP	9	6	66.6	6	100	20	3.33
LP	9	7	77.7	3	42.8	9	t.28
McGregor	7	5	71.4	3	60.0	12	2.40
Total	25	20	80.0	12	60.0	41	2.05

[a] No. territories values represent the total number of territories reported from 2000 avian location database.
[b] No. monitored represents the number of territories where productivity data was recorded.
[c] Percent monitored represents the percent of all territories that were monitored.
[d] No. successful represents the number of Monitored that fledged at least one young.
[e] Percent successful represents the percent of all Monitored that were successful.
[f] No. fledglings represents the number of fledglings produced by Monitored territories.
[g] Observed productivity represents the index of fledgling production for each monitored territory (No. Fledglings / No. Monitored).

FIGURES

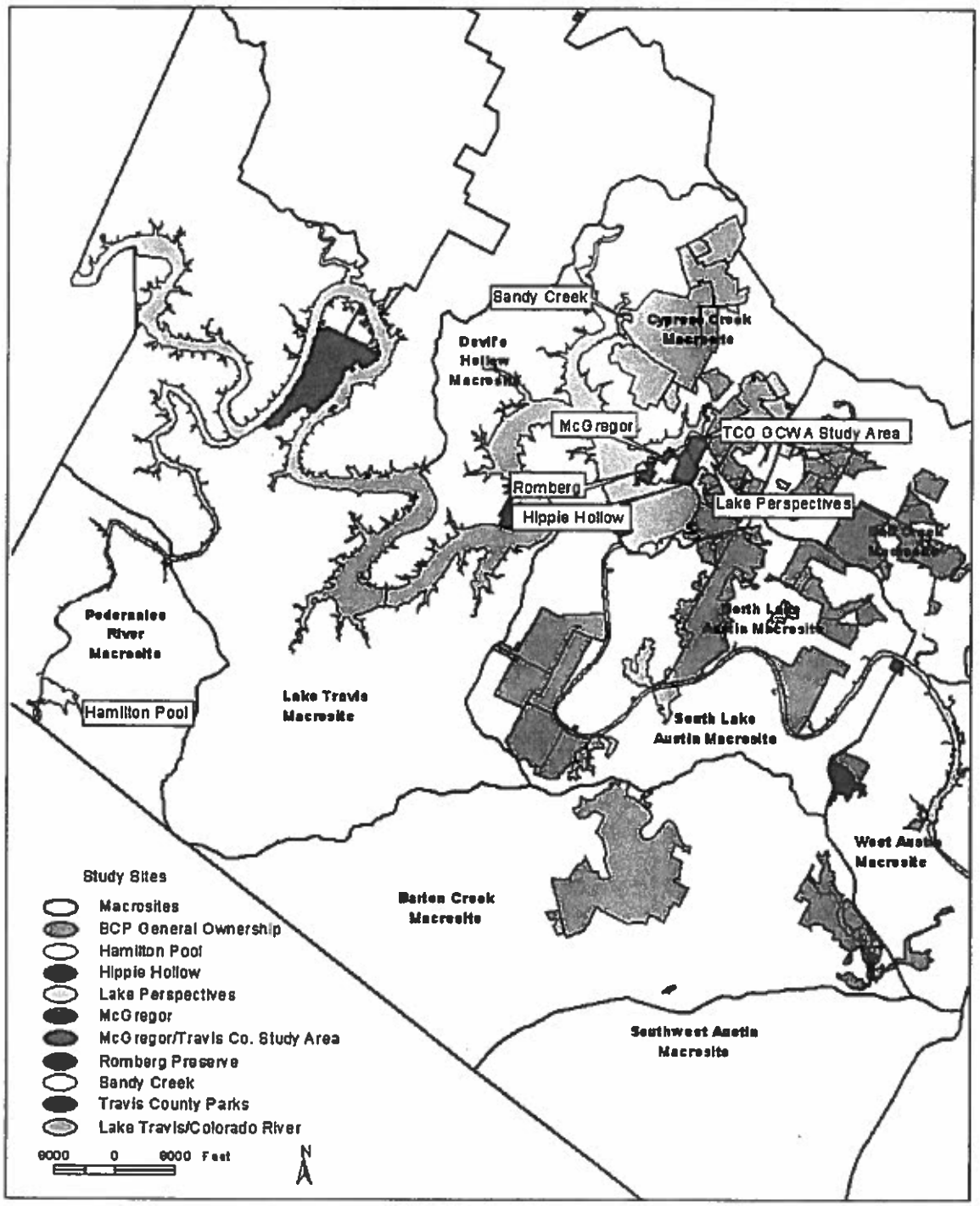

Figure 1. Study area locations for golden-cheeked warbler surveys in Travis County, Texas, 2000.

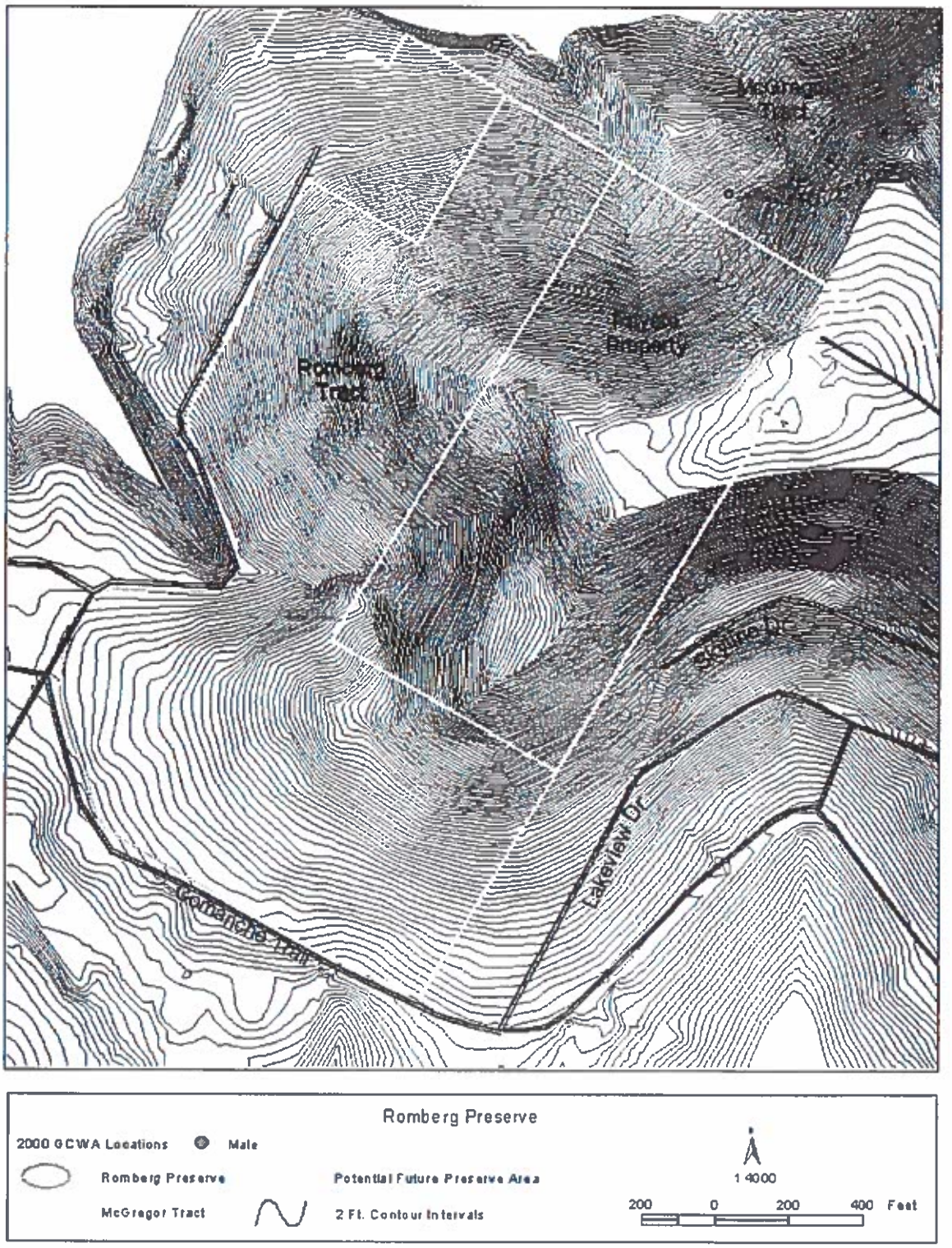

Figure 2. Recorded locations for golden-cheeked warblers on Romberg tract, Travis County, Texas, 2000.

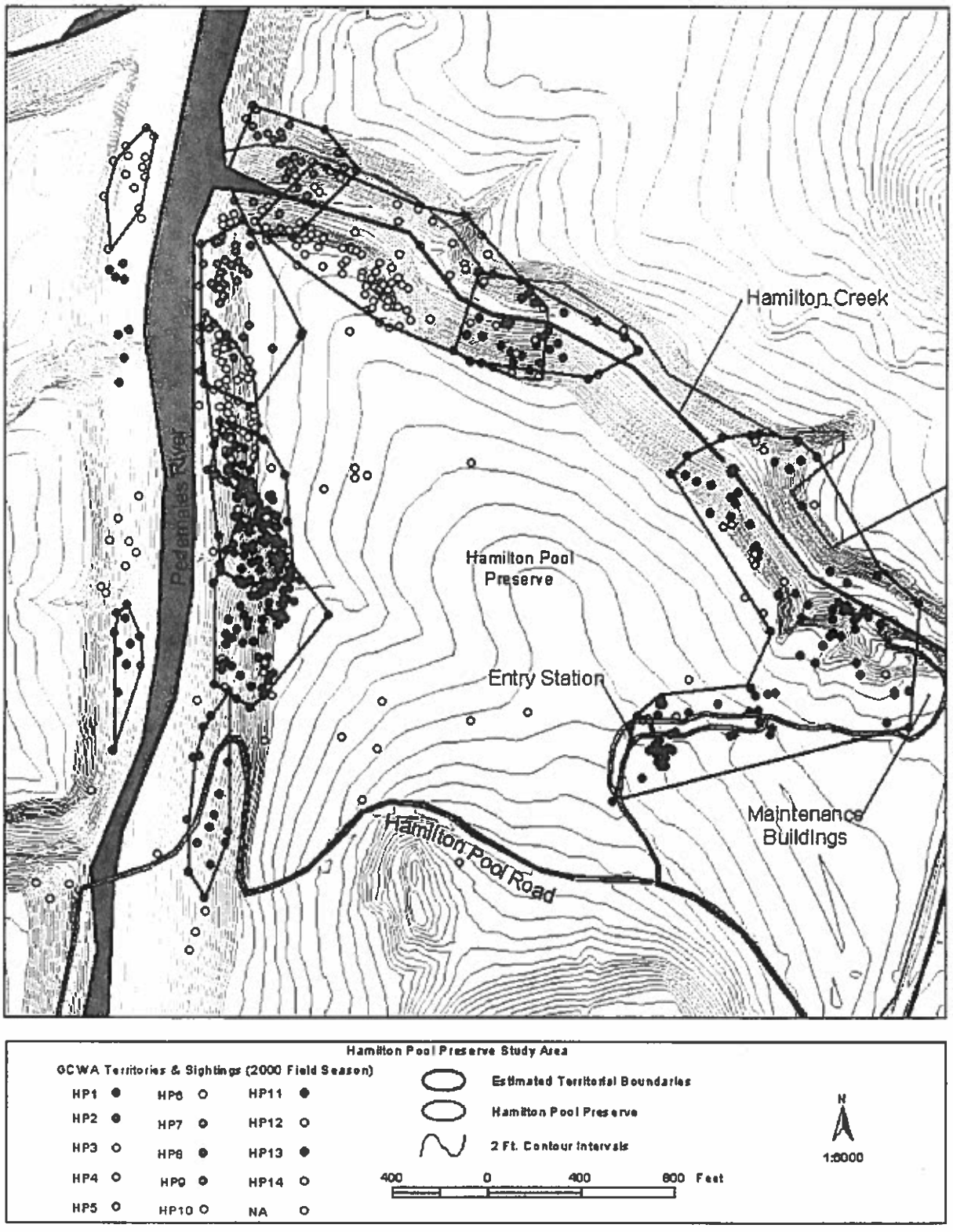

Figure 3. Recorded locations for golden-cheeked warblers at Hamilton Pool Preserve, Travis County, Texas, 2000

rded locations for golden-cheeked warblers at Sandy Creek Park, Travis County,

Figure 4. Reported locations for golden-cheeked warblers at Hippie Hollow Park, Travis County, Texas, 2000.

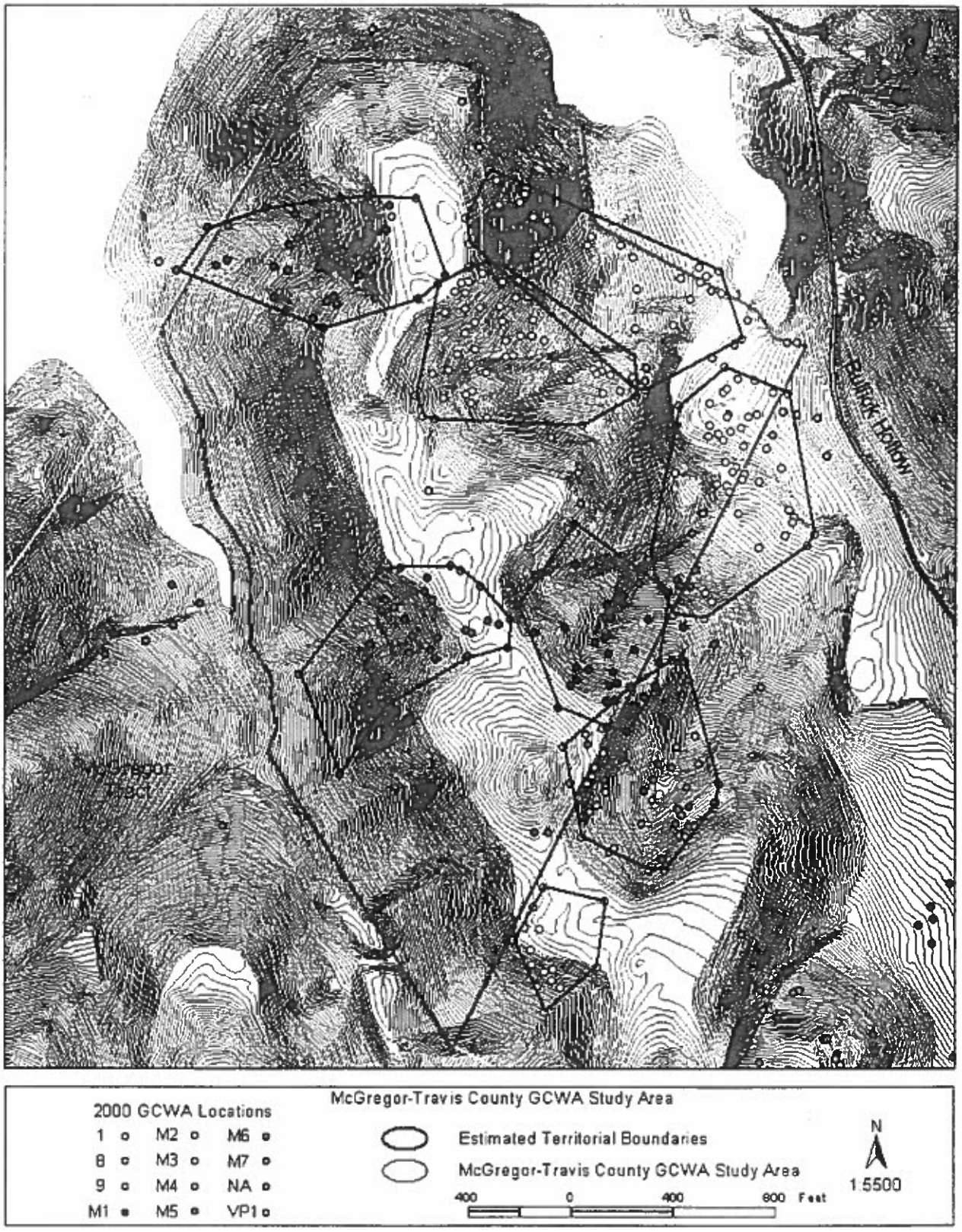

Figure 7. Recorded locations for golden-cheeked warblers at McGregor-Travis County Study Area, Travis County, Texas, 2000.

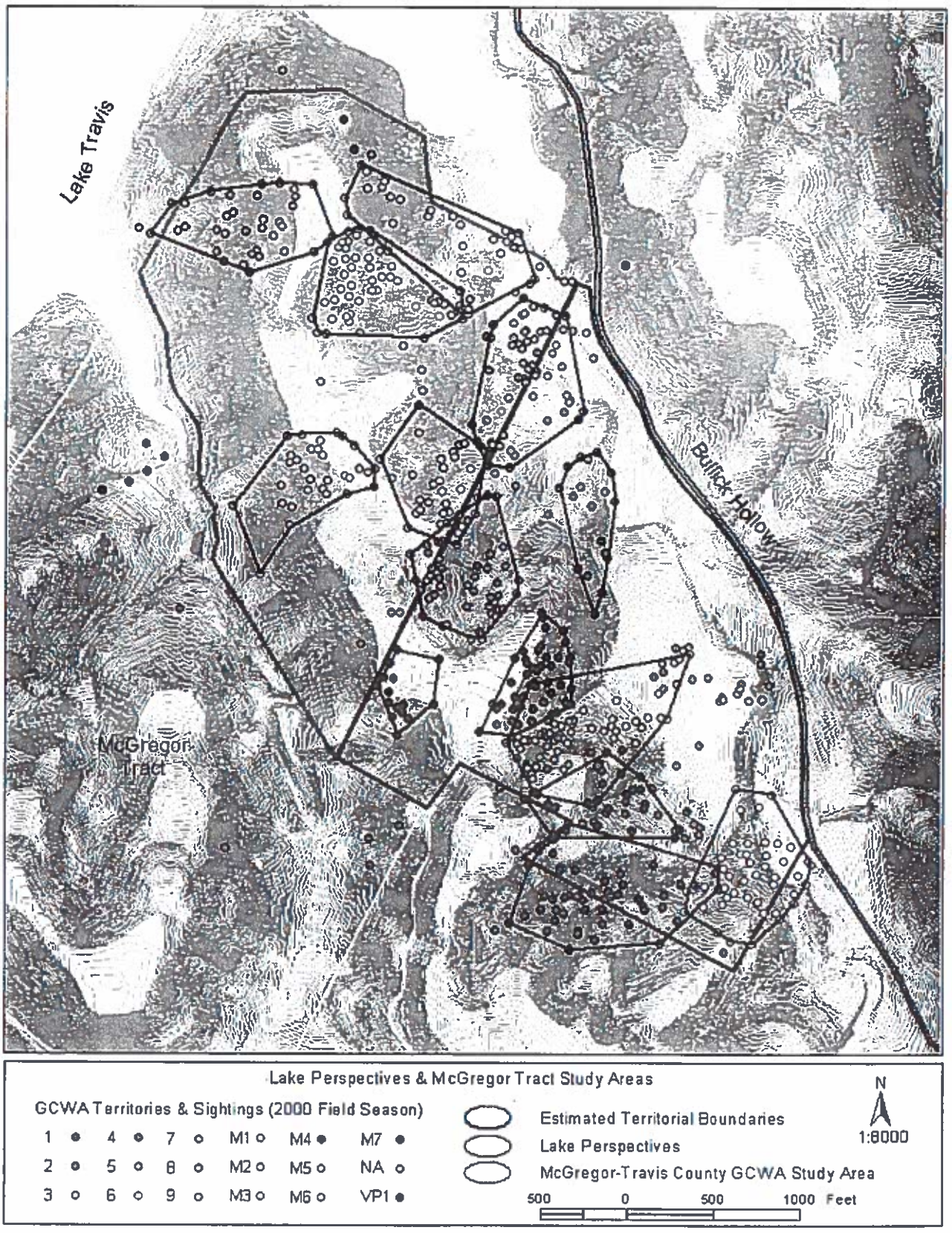

Figure 8. Recorded locations for golden-cheeked warblers at Lake Perspectives Tract and McGregor-Travis County Study Area, Travis County, Texas, 2000.

Appendix 1: Survey effort, weather, and results.

Bob Wentz Park/Romberg Preserve

Date	Time (h:mm)			Temperature (degrees F)		Wind Direction		Wind Speed (mph)		Cloud Cover (percent)		Personnel	Results/comments
	Start	End	Total	Start	End	Start	End	Start	End	Start	End		
4/21/00	7:15	8:30	1:15	50	na	calm	na	calm	na	20	na	PF,WB	2 male GCWAs off property
6/6/00	9:45	10:45	1:00	na	na	na	na	na	na	na	na	PF,WB,PK	no GCWAs detected
	Total time:		4:30										
	No. of visits:		2										

Hippie Hollow Park

Date	Time (h:mm)			Temperature (degrees F)		Wind Direction		Wind Speed (mph)		Cloud Cover (percent)		Personnel	Results/comments
	Start	End	Total	Start	End	Start	End	Start	End	Start	End		
3/30/00	7:00	9:00	2:00	55	na	N	N	2-5	5-8	10	30	PF,WB	1 GCWA detected off property
	Total time:		4:00										
	No. of visits:		1										

Appendix 1: Survey effort, weather, and results.

Hamilton Pool Preserve Plot

Date	Time (h:mm)			Temperature (degrees F)		Wind Direction		Wind Speed (mph)		Cloud Cover (percent)		Personnel	Results/comments
	Start	End	Total	Start	End	Start	End	Start	End	Start	End		
3/9/00	12:10	1:40	1:30	85	na	na	na	na	na	na	na	PF	1 male GCWA in River canyon, 1 off property; preliminary survey
3/13/00	10:00	1:00	3:00	62	71	NE	SE	5-10	5-10	100	100	PF,WB	5-6 males detected; front blew through, temp had reached 76
3/20/00	7:40	11:00	3:20	55	74	SW	SE	5-10	10-15	10	10	PF,WB	8 males (2 off prop), 1 female off property
3/24/00	7:45	11:45	4:00	66	89	calm	S	calm	5-8	40	50	PF,WB	12 males (5 off prop), 2 females
3/28/00	7:30	12:15	4:45	70	83	S	S	8-10	8-10	90	50	PF,WB	8-9 males (3 off prop), 1 female
3/31/00	7:15	11:15	4:00	54	71	NE	N	2-5	8-10	60	70	PF,WB	10 males (3 off prop), 3 females; nest located
4/6/00	10:30	12:30	2:00	na	80	SE	SE	10-12	10-12	0	0	PF	4 males, 2 females (1 on nest)
4/10/00	7:30	12:30	5:00	65	72	SW	SW	10-12	5-10	100	100	PF,WB	11 males, 1 female
4/13/00	7:30	1:30	6:00	55	70	NE	NE	5-8	5-8	100	30	PF,WB	13 males (5 off prop), 1 female
4/18/00	7:30	12:30	5:00	68	80	SE	SE	2-5	8-10	40	100	PF,WB	7 males (1 off prop)
4/24/00	7:30	12:00	4:30	66	na	N	na	8-10	na	10	na	PF,WB	10 males (2 off prop), 2 females, 2 HYs
4/28/00	7:30	12:30	5:00	70	84	calm	E	calm	8-10	100	20	PF,WB	4 males, 3 females, 2 HYs
5/2/00	8:00	1:00	5:00	61	73	calm	E	calm	5-8	80	90	PF,WB	6 males (1 off prop), 3 females, 5 HYs, nest located
5/5/00	10:30	1:30	3:00	77	84	S	S	8-10	8-10	100	90	PF,WB	4 males (1 off prop), 1 female, 6 HYs
5/10/00	7:15	11:15	4:00	72	na	NE	na	2-5	na	100	na	PF,WB	5 males (1 off prop), 1 female, 8 HYs
5/12/00	7:30	12:00	4:30	78	87	S	S	5-8	8-10	50	70	PF,WB	7 males (1 off prop), 2 females (1 on nest), 5 HYs
5/15/00	7:30	12:30	5:00	68	85	calm	S	calm	10-12	10	70	PF,WB	8 males (1 off prop), 2 females, 2 HYs
5/19/00	7:15	11:15	4:00	76	75	E	E	2-5	8-10	90	100	PF	5 males (1 off prop), 2 females, 3 HYs; nest destroyed /abandoned

Appendix 1: Survey effort, weather, and results.

Hamilton Pool Preserve Plot-continued

Date	Time (h:mm)			Temperature (degrees F)		Wind Direction		Wind Speed (mph)		Cloud Cover (percent)		Personnel	Results/comments
	Start	End	Total	Start	End	Start	End	Start	End	Start	End		
5/22/00	7:00	11:00	4:00	70	86	calm	SW	calm	5-8	10	20	PF,WB	5-6 males, 1 female, 5 HYs
6/2/00	6:45	11:45	5:00	76	90	calm	S	calm	5-8	50	60	PF,WB	6 males, 2 females; new nest discovered-parasitized by BHCO HY
6/8/00	7:00	10:00	3:00	64	73	SW	calm	2-5	calm	90	100	PF,WB	4 males; 1 female (after survey)
6/13/00	7:00	12:00	5:00	73	84	SW	W	2-5	8-10	30	30	PF,WB	2-3 males, 2 females, 5 HYs (1 second brood HY, 2 from earlier parasitized nest)
6/19/00	9:00	11:30	2:30	75	82	calm	S	calm	5-8	100	100	PF	2 males, 2 females, 4 HYs
6/23/00	7:00	12:00	5:00	77	88	SW	SW	10-12	15-20	10	10	PF,WB	1 male, 2 HYs
6/26/00	7:15	10:15	3:00	76	84	S	S	2-5	8-10	30	40	PF,WB	1 male, 1 HY
	Total time:		192:10										
	Total visits:		25										

Appendix 1: Survey effort, weather, and results.

Lake Perspectives

Date	Time (h:mm)			Temperature (degrees F)		Wind Direction		Wind Speed (mph)		Cloud Cover (percent)		Personnel	Results/comments
	Start	End	Total	Start	End	Start	End	Start	End	Start	End		
3/10/00	10:15	12:15	2:00	na	na	na	na	na	na	na	na	WB	3 males detected, preliminary survey
3/14/00	7:45	11:45	4:00	60	61	NE	NE	2-5	2-5	100	100	PF/WB	5 males detected
3/21/00	7:30	10:00	2:30	63	65	E	E	5-10	5-10	100	100	PF/WB	5-6 males (1 on McGregor), 1 female
3/23/00	7:30	10:30	3:00	70	74	S	S	5-10	5-10	100	100	PF/WB	7 males
3/27/00	7:15	11:30	4:15	65	77	N	NE	8-10	10-15	10	30	PF/WB	3 males, 2 females
3/30/00	10:30	1:00	2:30	65	70	N	N	5-8	10-15	50	30	PF/WB	5 males, 2 females
4/3/00	9:00	12:00	3:00	56	65	N	NW	2-5	8-12	10	80	PF/WB	4 males, 3 females
4/14/00	7:15	11:15	4:00	55	59	E	S	5	5-8	100	100	PF/WB	6 males, 2 females
4/17/00	7:30	11:30	4:00	65	72	N	var	5-8	3	20	10	PF	3 males, 1 female detected
4/25/00	7:30	11:15	3:45	56	na	na	na	na	na	na	na	WB	3 males, 1 female
4/26/00	7:00	10:30	3:30	56	na	calm	calm	calm	calm	0	na	WB	4 males, 2 females, active nest located, 2 separate HYs
5/3/00	7:15	11:15	4:00	63	69	S	SE	2-5	5-10	100	80	PF/WB	5 males, 1 female, 3 HYs
5/8/00	7:30	10:30	3:00	71	78	S	S	8-10	8-10	30	10	PF/WB	3 males, 2 HYs
5/9/00	7:30	10:30	3:00	73	77	S	S	5-8	10-12	90	90	PF	3 males, 1 female, 2 HYs detected
5/16/00	7:15	10:15	3:00	74	79	S	S	12-15	12-15	80	20	PF/WB	2 males
5/23/00	7:00	10:00	3:00	73	81	S	S	5-8	8-10	100	10	PF	4-5 males, 3 females, 5-6 HYs
5/31/00	6:45	10:15	3:30	73	82	S	S	2-5	8-10	10	20	PF/WB	6 males, 1 female, 3 HYs
6/5/00	6:45	10:45	4:00	74	76	N	N	5-8	5-8	60	40	PF/WB	5 males, 2 females
6/12/00	7:15	8:45	1:30	76	78	S	SE	2-5	5-8	80	70	PF/WB	1 male, 2-3 HYs
6/20/00	6:45	9:45	3:00	78	81	S	S	5-8	8-10	40	30	PF/WB	1 HY
6/22/00	6:30	8:15	1:45	76	na	S	na	10-15	na	90	90	WB/PK	no GCWAs detected
	Total time:		113:15										
	No. of visits:		21										

Appendix 1: Survey effort, weather, and results.

McGregor (Northern section survey area)

Date	Time (h:mm)			Temperature (degrees F)		Wind Direction		Wind Speed (mph)		Cloud Cover (percent)		Personnel	Results/comments
	Start	End	Total	Start	End	Start	End	Start	End	Start	End		
3/27/00	9:00	11:15	2:15	na	77	na	NE	na	10-15	na	30	PF/WB	10 males (2 off prop., 2 out of study area), 1 female
4/5/00	7:30	11:30	4:00	50	68	SE	SE	2-5	8-10	na	na	PF/WB	12 males (3 off prop.), 1 female
4/12/00	7:30	11:00	3:30	60	66	N	N	2-8	10-12	90	90	PF/WB	8 males (2 out of study area), 1 female
4/20/00	7:30	11:30	4:00	66	74	var	SE	2-5	10-15	20	10	PF/WB	6 males (1 off prop.), 1 female, active nest located
4/27/00	7:15	10:45	3:30	61	73	na	SW	na	10-12	20	10	PF/WB	4 males (2 off prop.), 1 female, 2 HYs
5/4/00	7:15	10:15	3:00	70	74	S	S	5-8	9	90	100	PF/WB	6-7 males, 1 HY
5/11/00	7:00	10:30	3:30	74	79	S	S	10-12	10-15	80	90	PF/WB	3 males, 1 female, 3 HYs (1 off prop.)
5/17/00	7:15	10:15	3:00	73	79	S	S	17-26	25+	50	50	PF/WB	6 males (3 off prop.), 1 female, 6 HYs
5/24/00	7:00	10:15	3:15	75	85	na	S	na	5-10	10	na	PF/WB/PK	4 males (1 off prop.), 2 females, 3 HYs
6/6/00	6:45	8:45	2:00	60	71	na	N	na	8-10	na	na	PF/WB/PK	2 males, 1 female, 2-4 HYs
6/27/00	6:45	9:45	3:00	76	79	calm	S	calm	5-8	70	20	PF/WB	1-2 males, 1-2 female, 3-5 HYs
	Total time:		70:00										
	No. of visits:		11										

Sandy Creek

Date	Time (h:mm)			Temperature (degrees F)		Wind Direction		Wind Speed (mph)		Cloud Cover (percent)		Personnel	Results/comments
	Start	End	Total	Start	End	Start	End	Start	End	Start	End		
6/1/00	7:45	9:15	1:30	74	80	S	S	5-8	8-10	10	30	PF/WB/PK	1 male GCWA detected
6/14/00	6:45	9:15	2:30	76	78	S	S	8-10	8-10	90	100	PF/WB	1 female GCWA
6/22/00	8:30	9:30	1:00	na	na	na	na	na	na	na	na	WB/PK	no GCWAs detected
	Total time:		10:00										
	No. of visits:		3										

Appendix 2: Summary of golden-cheeked warbler survey results from selected sites in Travis County.

Park/Preserve	Surveyors	Year	Territorial Males	Females	Young	Other Males	Notes
Bob Wentz	DLS	1990	0	0	0	1	+ 2 males off property
Bob Wentz	DLS	1991	0	0	0	0	+ 7 or 8 males off property
Bob Wentz	DLS	1992	0	0	0	0	+ 5 males off property
Bob Wentz/Romberg	Travis Co.	1996	0	0	0	1	
Bob Wentz/Romberg	Travis Co.	1997	0	0	0	0	+ 1 male off property
Bob Wentz/Romberg	Travis Co.	1998	0	0	0	0	+ 2 males off property
Bob Wentz/Romberg	Travis Co.	1999	1?	2	4+	0	1 male crossing fenceline
Bob Wentz/Romberg	Travis Co.	2000	0	0	0	0	2 males off property
Hamilton Pool	Travis Co.	1990	7 or 8	1 or 2	0	0	+ 4 males off property
Hamilton Pool	Travis Co.	1991	10	0	0	0	+ 3 males off property
Hamilton Pool	DLS	1992	10-13	1+	2+	0	+ 3 males off property
Hamilton Pool	DLS	1993	8-9	3	5	1	+ 1 male off property
Hamilton Pool	Travis Co.	1994	12	1	0	0	+ 3 males off property
Hamilton Pool	Travis Co.	1995	10-12	1	0	0	
Hamilton Pool	Travis Co.	1996	10-12	1	0	0	+ 1 male off property
Hamilton Pool	Travis Co.	1997	10-11	4	16+	0	+ 1 male off property
Hamilton Pool	Travis Co.	1998	11	7	8+	0	+ 3-4 males off property; 1 bhcb fl
Hamilton Pool	Travis Co.	1999	11	9	17+	0	+ 3-4 males off property
Hamilton Pool	Travis Co.	2000	9	8	20	0	5-7 males off property
Hippie Hollow	DLS	1992	0	0	0	0	some males off property
Hippie Hollow	DLS	1993	0	0	0	0	+ 4 males off property
Hippie Hollow	DLS	1995	0	0	0	0	
Hippie Hollow	Travis Co.	1996	0	0	0	0	
Hippie Hollow	Travis Co.	1997	0	0	0	0	+ 1 male off property
Hippie Hollow	Travis Co.	1998	0	0	0	0	
Hippie Hollow	Travis Co.	1999	0	0	0	0	1 male heard on McGregor
Hippie Hollow	Travis Co.	2000	0	0	0	0	1 male heard on McGregor
Lake Perspectives	Travis Co.	1999	7	3	7	1	1 male heard on McGregor
Lake Perspectives	Travis Co.	2000	9	7	10	1	possible 10th male

Appendix 2: Summary of golden-cheeked warbler survey results from selected sites in Travis County.

Park/Preserve	Surveyors	Year	Territorial Males	Females	Young	Other Males	Notes
McGregor	DLS	1993	2+	0	0	0	
McGregor	Travis Co.	1997	10-11	1	0	0	
McGregor	Travis Co.	1998	8	0	5	0	
McGregor	Travis Co.	1999	1	0	0	0	male heard during H. Hollow survey
McGregor	Travis Co.	2000	12	5	12		7 males within study area
Sandy Creek	DLS	1993	2	0	2	0	
Sandy Creek	DLS	1994	0	0	0	0	+ 1 male off property
Sandy Creek	DLS	1995	0	0	0	0	
Sandy Creek	Travis Co.	1996	0	0	0	0	+ 3 males off property
Sandy Creek	Travis Co.	1997	1	0	0	0	+ 1 male off property
Sandy Creek	Travis Co.	1998	0	0	0	0	+ 2 males off property
Sandy Creek	Travis Co.	1999	NC	NC	NC	NC	No 1999 Survey Conducted
Sandy Creek	Travis Co.	2000	1	1	0	0	1 male & 1 female, no HYs obs.

Survey effort varies with year and surveyors.
Zeros indicate none reported; esp. for females and young, observers may not have recorded birds that were present.

ATTACHMENT C

TRAVIS COUNTY

BROWN-HEADED COWBIRD REPORT
2000 FIELD SEASON

Brown-headed Cowbird Control Program

Travis County Natural Resources
Project Number 0905-00906



James W. Bailey
Travis County Natural Resources

December 2000

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INTRODUCTION

Throughout North America songbird numbers are declining. Parasitism by the brown-headed cowbird (*Molothrus ater*) has become one of the major threats to neotropical migratory songbirds during the breeding season (Mayfield 1977). The brown-headed cowbird (hereafter cowbird) is an obligate brood parasite known to have laid its eggs in the nests of 226 different species, the majority of which are neotropical migrants (Ortega 1998). As the range of the cowbird has expanded by clearing of woodlands and introduction of livestock, new host species of the cowbird have no defense mechanism towards parasitism (Mayfield 1965, Brittingham and Temple 1983). Cowbirds have contributed to declines in other species by reducing host nesting success through egg removal, nest abandonment, out competing host young, and declines in hatching success (Ortega 1998).

The Balcones Canyonlands Conservation Plan (BCCP) was initiated in fall 1988 to protect habitat for eight federally endangered species and 27 Species of Concern (REC-USDI 1996). The Regional 10a permit, signed May 2, 1996, designated Travis County and the City of Austin (COA) as co-permit holders. The two bird species included for protection under the BCCP are the black-capped vireo (hereafter vireo) (*Vireo atricapillus*) and the golden-cheeked warbler (hereafter warbler) (*Dendroica chrysoparia*). Both are parasitized by the brown-headed cowbird. The recovery plans for the golden-cheeked warbler (USFWS 1992) and black-capped vireo (USFWS 1991) list nest parasitism by the brown-headed cowbird under reasons for listing and current threats. Cowbird trapping is recommended as an important management technique for the vireo (USFWS 1991, USFWS 1996a, REC-USDI 1996) and to a lesser extent for the warbler (USFWS 1992, REC-USDI 1996, USFWS 1996b). The Black-capped Vireo Population and Habitat Viability Assessment (PHVA) report lists brood parasitism as the most immediate threat to the vireo, with loss and fragmentation of nesting habitat contributing additional threats (USFWS 1996a). Consistent with animal management policy (Terpening et. al 1999), Travis County is obliged as a managing partner for the Balcones Canyonlands Preserve, to enact cowbird control efforts on County managed lands.

Cowbird trapping was initiated in 1988 to aid in the reduction of parasitism of black-capped vireo nests at Davenport Vireo Preserve (now the City of Austin Vireo Preserve), the Uplands, and Steiner Ranch. Several entities have operated the cowbird trapping program for the Balcones Canyonlands Preserve (BCP) since 1988: Espey, Huston, and Associates (1989), Texas Animal and Damage Control (TADC) (1990-1996), and to a lesser extent, DLS Associates in 1989 (Terpening 1998). Travis County Natural Resources began managing the cowbird control program for the BCP in 1997. Travis County did not operate cowbird traps during 1998 due to limited personnel and resources, however trapping commenced during 1999. The 1999 trap season was managed and operated solely by Travis County Natural Resources, however the City of Austin provided funds for the construction of new traps.

STUDY AREA AND METHODS

Study Area

In 2000, cowbird control efforts resumed in western Travis County from the beginning of March to the first week of July. Trap sites were located primarily on COA tracts and on mitigation lands owned by private entities (Steiner Ranch and Riverplace) (Fig. 1). A new trap location was added during 2000 at Hamilton Pool Preserve (Fig. 2), in the western part of Travis County. The site was chosen because of the presence of cowbird feeding and breeding locations in and near the warbler population at Hamilton Pool Preserve.

Trapping

Trap operations began on March 6, 2000. The following traps were opened on this date: Canyon Creek Mega, Ivanhoe Mega, Mansfield Hybrid, Riverplace #2 decoy, Steiner Ranch #2 decoy, and 3M #1 Hybrid (Appendix 1). The 3M #1 Hybrid was moved on March 16 to COA property adjacent to Spicewood Stables and then was renamed to 3M #2 for data management purposes (Fig. 1). Cortana Hybrid was moved from the Satellite Two office and opened on March 16 (Fig. 1). Hamilton Pool modified Australian crow trap was the last trap opened on April 8 (Fig. 2). The need for this trap became apparent while County Natural Resource personnel conducted warbler surveys at Hamilton Pool and recognized the continued presence of cowbirds at the preserve.

A total of 8 traps were used during the 2000 trap season. Five of these 8 traps were added to the cowbird control program in 1999: 3 Hybrid design and 2 Mega traps (both designed at Fort Hood (Cornelius et. al. 1997)). The two Mega traps were positioned in areas with low grass and open space near powerline corridors. One Mega was placed at Ivanhoe (Fig. 1), and the other Mega was placed at Canyon Creek (Fig. 1), both City of Austin BCP tracts. In 1999, the 3 Hybrid traps were placed on Lower Colorado River Authority (LCRA) and Travis County lands (Fig. 1). One Hybrid was used as a holding trap during 1999 at Travis County's Satellite Two office, however, in 2000 this trap was moved to the City's Cortana tract (Fig. 1). The remaining 3 traps were 2 United States Fish and Wildlife Service (USFWS) decoy traps (USFWS 1973), one at Riverplace the other at Steiner Ranch, and 1 modified Australian crow trap (Hamilton Pool) (Figs. 1 & 2). The slot width on these traps was reduced to 3.2cm (1 1/4 inches) as per the Hybrid design to reduce the number of non-targets captured in traps.

Initially, 61 cowbirds (37 males, 24 females) were obtained from The Nature Conservancy's Fort Hood office to be used as decoys for the 2000 trapping season. Most traps were stocked with the minimal number of decoys recommended per trap type, for Hybrids the minimum is 5, while for Mega traps is 20 (Cavanagh et. al 2000). The premise being that as the season progressed, additional cowbirds would be captured thus increasing the number of cowbirds kept as decoys per trap type. Specific sex ratio targets were not followed for decoy stocking. Eckrich et al. (1999) found sex ratios to be irrelevant in regards to capture rates. However, we tried to have at least 1-5 females per Hybrid trap and 5-8 females for Mega traps regardless of the number of males. We would however remove females from traps as their numbers began to increase,

especially when the numbers surpassed that of males. Female numbers were also kept low so that in the event of vandalism or severe weather, the number of potential females to escape would be kept to a minimum as recommended by Summers et. al (2000). We followed trapping protocols established by The Nature Conservancy's Fort Hood office (Cavanagh et. al 2000). Traps were checked 3 times a week until the end of May and then checked everyday from June 1 until the first week of July.

All cowbirds captured were euthanized by cervical dislocation. However, 6 birds were dispatched by thoracic compression so that study skins could be prepared from them by Texas A&M University wildlife students. Cowbirds were dispatched only when their numbers became too high for efficient trap management. Each trap had a separate data sheet on which data was recorded for each visit. Data collected included the following: date, observer, the number of males, females, and immatures captured, the number of males, females, and immatures dead (those found dead and those dispatched), number and species of non-targets released and/or found dead, number of cowbirds transferred from traps as seed birds, and comments (Appendix 2). Non-native species such as European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*) were dispatched when found in traps. Non-targets were released immediately when discovered in traps. The number of cowbirds in each trap was recorded during trap visits. When accurate counts were difficult to obtain, especially in Mega traps, the number of cowbirds were estimated. Trap days (# day open per trap) were calculated for each trap. Adding up the number of active trap days facilitated trap capture rates. Trap capture rates were calculated by the number of females caught per active trap day (Summers et. al 2000). Banding data was collected for banded males found in traps. Distances from banding to recapture locations were calculated for all banded males recovered in trap during 2000 (Table 4). As in the case of all captured cowbirds, each bird was dispatched. Band recovery data was sent to the Breeding Bird Laboratory at Patuxent Wildlife Research Center. Methods and data analysis used for this report follow those of The Nature Conservancy of Texas, Fort Hood office (Summers et. al 2000, Cavanagh et. al 2000).

RESULTS

Trapping

Three hundred-seven cowbirds were captured during the 2000 trap season (156 males, 133 females, 18 juveniles) (Table 1). During 2000, a total of 133 females were removed by trapping during 704 trap days (trap capture rate = 0.188 females/trap/day) for the period of March 6 to July 7, 2000 (Tables 1 & 2). The mean trap capture rate for the same period of March 6 to July 7, 2000 was 0.205 females/trap/day (Table 2). The month of April was the most productive for female captures for 5 of 7 traps. No cowbirds were caught at Steiner Ranch (SR2) consequently this trap was shut down at the end of March. The highest efficiency rate occurred at Canyon Creek Mega with a rate of 1.000 females/trap/day while the lowest rate occurred at Ivanhoe Mega with 0.100 females/trap/day (Table 2).

Trap capture rates by trap type were also calculated. The mean trap capture rate for all traps by type was 0.197 females/trap/day (Table 3). Mega traps, as expected, had the greatest trap efficiency with a mean

of 0.267 females/trap/day. Hybrid traps had a mean efficiency of 0.161 females/trap/day, Hamilton Pool crow trap rated at 0.096 females/trap/day while the 2 USFWS traps mean rate was 0.199 females/trap/day (Table 3).

Band Returns

In 1997, male cowbirds were banded and released by Travis County in an effort to determine within season movements and yearly return rates. This practice was discontinued after the 1999 field season. In 2000, 13 banded males were caught in traps (Table 4). Of these, 3 were banded at Canyon Creek Mega in 1999. Two of these males returned to Canyon Creek Mega in 2000, while the third male was found in Cortana Hybrid. Two males were also banded at the COA Canyon Creek tract, but these males were banded in 1997 and were released from Canyon Creek One. Six males returned to the same traps in which they were banded and subsequently released. The greatest distance of all recaptures was 7.43 km (4.62 miles). This male was banded at 3M #1 and was recovered in Cortana Hybrid.

Non-targets

In 2000, 10 species of non-targets totaling 45 individuals were caught in BCP traps (Table 5). Of these 45 non-targets, 34 (75.0%) were released alive and 11 (24.0%) were found dead, or killed by cervical dislocation as in the case of house sparrows (Table 6). However, one European starling and 8 house sparrows were released from City operated traps. Northern mockingbirds were the most common species caught (42.0%). All juvenile cowbirds were dispatched immediately upon discovery in order to prevent non-target species from entering the traps. Entering traps to feed juvenile cowbirds can cause mortalities to non-target species (Terpening 1999).

DISCUSSION

Trapping

Travis County has removed fewer cowbirds per unit area than other control programs. As a result, our control program likely has diminished affects compared to the other programs such as Kerr Wildlife Management Area (WMA) and Fort Hood. Three hundred-one cowbirds were removed from BCP lands in 2000. In contrast, The Nature Conservancy at Fort Hood removed 9854 cowbirds in 1999 (Summers et. al 2000) and Kerr WMA removed 1633 in 1993 (Armstrong 1993). Most importantly, both Fort Hood and Kerr WMA are large contiguous tracts of land under single management and have livestock on site or adjacent. This increases the control programs ability to place traps in locations where efforts are most successful. Ideal trap locations are on cowbird feeding areas where livestock are present. Trap locations in Travis County are distributed on discontiguous tracts of BCP properties where there are no livestock present. Most BCP properties offer few sites where optimum trap conditions exist for cowbirds. The result is fewer traps dispersed over a large area on less than optimum sites.

In addition to property constraints, development throughout western Travis County has increased potential feeding sites for cowbirds where none existed before. Rothstein et. al (1987) suggested that

"cowbird control may be more difficult in landscapes where human activities have created many potential feeding areas". Rothstein et. al (1987) also states that "data of local feeding areas is essential for designing and predicting effectiveness of cowbird control efforts".

Because so few nests of warblers or vireos were found it is difficult to estimate the effects Travis County's trapping program is having on parasitism. We cannot correlate the number of cowbirds removed by trapping to nest success of songbird populations, especially warblers and vireos on BCP lands. However, larger control programs have seen reductions in parasitism from 90% to 5% (Tazik and Cornelius 1993, Koloszar and Bailey 2000). Minimizing the amount of edge habitat where parasitism levels are generally higher (Brittingham and Temple 1983, Temple and Cary 1988) has always been a priority of the BCP managing partners. Large preserve tracts may not appreciably affect the nesting success of warblers and other species, but paired with trapping, may affect parasitism to a level that populations of endangered songbirds may be sustained. Regardless, when managing for endangered songbirds, cowbird monitoring and data on parasitism should be collected, especially if cowbird trapping is a management option (Robinson et. al 1993).

RECOMMENDATIONS

- Trap placement continues to be the limiting factor in our control program. The nature of the landscape on BCP lands is not conducive to effective trapping. Therefore, it is recommended that new trap locations continue to be sought by using GIS and site visits. This will obviously involve coordination with private landowners in order to establish more optimal trap sites.
- Travis County should continue to operate cowbird traps. However, we recommend that older traps such as the Australian crow trap at Hamilton Pool and the 2 USFWS decoy traps, be replaced with either Hybrid traps or Mega traps. Newer and larger traps may increase trap efficiency and limit predation.
- Another management option Travis County should pursue is shooting cowbirds in habitat. Female cowbirds can be lured in by using taped vocalizations and then shot. Fort Hood has established a methodical shooting program to remove female cowbirds. The removal of territorial females from vireo habitat has had an appreciable effect on parasitism rates in selected study areas. Shooting in conjunction with trapping can be effective in removing female cowbirds from habitat (Summers et.al 2000). Shooting may be more cost effective in some areas where scattered or isolated populations of sensitive species occur (Robinson et. al 1993). Cowbird control personnel shot 102 females during the 1999 breeding season on Fort Hood (Summers et. al 2000).
- Currently, Travis County does not have data on parasitism rates. Therefore we do not know what effect trapping has on local populations of black-capped vireos and golden-cheeked warblers. However, in 2000, Travis County purchased a 581 acre tract near Lake Travis, known as the Parke tract, that

historically has held a small population of black-capped vireos (Fig. 1). We suggest monitoring this vireo population to determine parasitism rates as well as vireo and cowbird abundance.

DATA MANAGEMENT

Information regarding the disposition of data sets collected during the 2000 field season is provided below. Data will be archived to facilitate retrieval for further analysis. All data are currently stored in the Travis County Natural Resources office, 9th and Lavaca, Austin, Texas.

COWBIRD TRAP DATA
Data File Name: 00_avian_locn_records.xls
Documentation Update: 19 December 2000
Description: cowbird trap data from 2000 field season
Software: Microsoft Windows NT, Excel 1997
Data File Archive Location:
Main Copy: D:\Users\Wes\Research\bhco\2000\2000 trap data\00_trap_summary.xls
Storage Location: GCWA computer

AVIAN LOCATION DATA
Data File Name: 2000avianlocs
Documentation Update: 06 September 2000
Description: shapefile containing avian location data from 2000 field season
Software: Microsoft Windows NT, ArcView 3.1
Data File Archive Location:
Main Copy: D:\GIS projects\bccp\Avian Location Projects\2000 Survey Data
Storage Location: GCWA computer

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TABLES

Table 1. Number of brown-headed cowbirds trapped during the 2000 breeding season on BCP tracts.

Month	Males	Females	Immatures	Total
March	35	16	0	51
April	58	64	0	122
May	44	43	0	87
June	17	8	12	37
July	2	2	6	10
Total	156	133	18	307

Table 2. Individual trap capture rates (# females/trap/day) for female brown-headed cowbirds trapped during 2000 breeding season on BCP tracts.

Trap Name	Trap Type	Trap Efficiency					
		March	April	May	June	July	Mean
Canyon Creek*	Mega	0.269	1.000	0.516	0.071	0.286	0.429
Cortana	Hybrid	0.000	0.266	0.064	0.033		0.090
Hamilton Pool	Australian Crow		0.136	0.032	0.133		0.100
Ivanhoe	Mega	0.038	0.100	0.096	0.000		0.058
Mansfield	Hybrid	0.076	0.133	0.500			0.236
Riverplace	USFWS	0.038	0.133	0.611	0.033		0.203
Steiner Ranch	USFWS	0.000					0.000
3M #1	Hybrid	0.000					0.000
3M #2	Hybrid	0.312	0.400	0.258	0.000		0.242
Totals (Mean)		0.092	0.309	0.296	0.045	0.286	0.205

* Only trap open in July.

Table 3. Trap capture rates (# females/trap/day) by trap type for brown-headed cowbirds trapped during the 2000 breeding season on BCP tracts.

Trap Type (n)	Trap Capture Rate					
	March	April	May	June	July	All
Hybrid (4)	0.093	0.267	0.182	0.020		0.161
Mega (2)	0.154	0.550	0.306	0.041	0.286	0.267
USFWS (2)	0.019	0.133	0.611	0.033		0.199
Australian Crow (1)	0.000	0.136	0.032	0.133		0.096
Totals (Mean)	0.089	0.272	0.283	0.057	0.286	0.197

Table 4. Banded brown-headed cowbirds recaptured during the 2000 breeding season in traps on BCP tracts.

Band Number	Sex	Year Banded	Age[a] When Banded	Age in 2000	Banding Location	Recapture Location	Distance from Banding to Recapture Location (m)
8051-03378	M	1999	AHY	ASY	Canyon Creek Mega	Cortana Hybrid	4328
8051-03382	M	1999	ASY	ATY	3M #1	Cortana Hybrid	7437
8051-03384	M	1999	SY	TY	3M #1	3M #2 Hybrid	88
8051-03388	M	1999	NC	UK	SR2	RP2 USFWS	2194
8051-03396	M	1999	AHY	ASY	Ivanhoe Mega	Ivanhoe Mega	0
8051-03416	M	1997	SY	5Y	Canyon Creek 1[b]	Canyon Creek Mega	274
8051-03432	M	1997	ASY	A5Y	Canyon Creek 1[b]	Canyon Creek Mega	274
8051-03475	M	1999	AHY	ASY	Ivanhoe Mega	Ivanhoe Mega	0
8051-03502	M	1999	AHY	ASY	Ivanhoe Mega	Ivanhoe Mega	0
8051-03508	M	1999	ASY	ATY	Ivanhoe Mega	RP2 USFWS	4511
8051-03511	M	1999	AHY	ASY	Ivanhoe Mega	Ivanhoe Mega	0
8051-03520	M	1999	ASY	ATY	Canyon Creek Mega	Canyon Creek Mega	0
8051-03525	M	1999	ASY	ATY	Canyon Creek Mega	Canyon Creek Mega	0

[a] AHY = after hatch year; SY = second year; ASY = after second year; TY = third year; ATY = after third year, etc. NC = not collected; UK = unknown

[b] Trap no longer in service.

Table 5. Total number of non-target avian species caught & released during 2000 breeding season on BCP tracts.

Species	Month					
	March	April	May	June	July	Total
Carolina Wren	0	0	0	0	1	1
European Starling*	0	0	0	1	0	1
House Finch	0	0	1	0	0	1
House Sparrow*	0	3	1	4	0	8
Ladder-backed Woodpecker	0	0	0	1	0	1
Northern Cardinal	0	0	1	2	0	3
Northern Mockingbird	1	0	1	15	0	17
Tufted Titmouse	1	0	0	0	0	1
Western Scrub Jay	0	0	0	1	0	1
Total	2	3	4	24	1	34

*Introduced species should have been dispatched.

Table 6. Total number of non-target avian species found dead in traps during 2000 breeding season on BCP tracts.

Species	Month					
	March	April	May	June	July	Total
House Finch	0	0	0	1	0	1
House Sparrow	0	0	3	4	0	7
Northern Mockingbird	1	0	0	1	0	2
Rufous-crowned Sparrow	0	0	0	1	0	1
Total	1	0	3	7	0	11

FIGURES

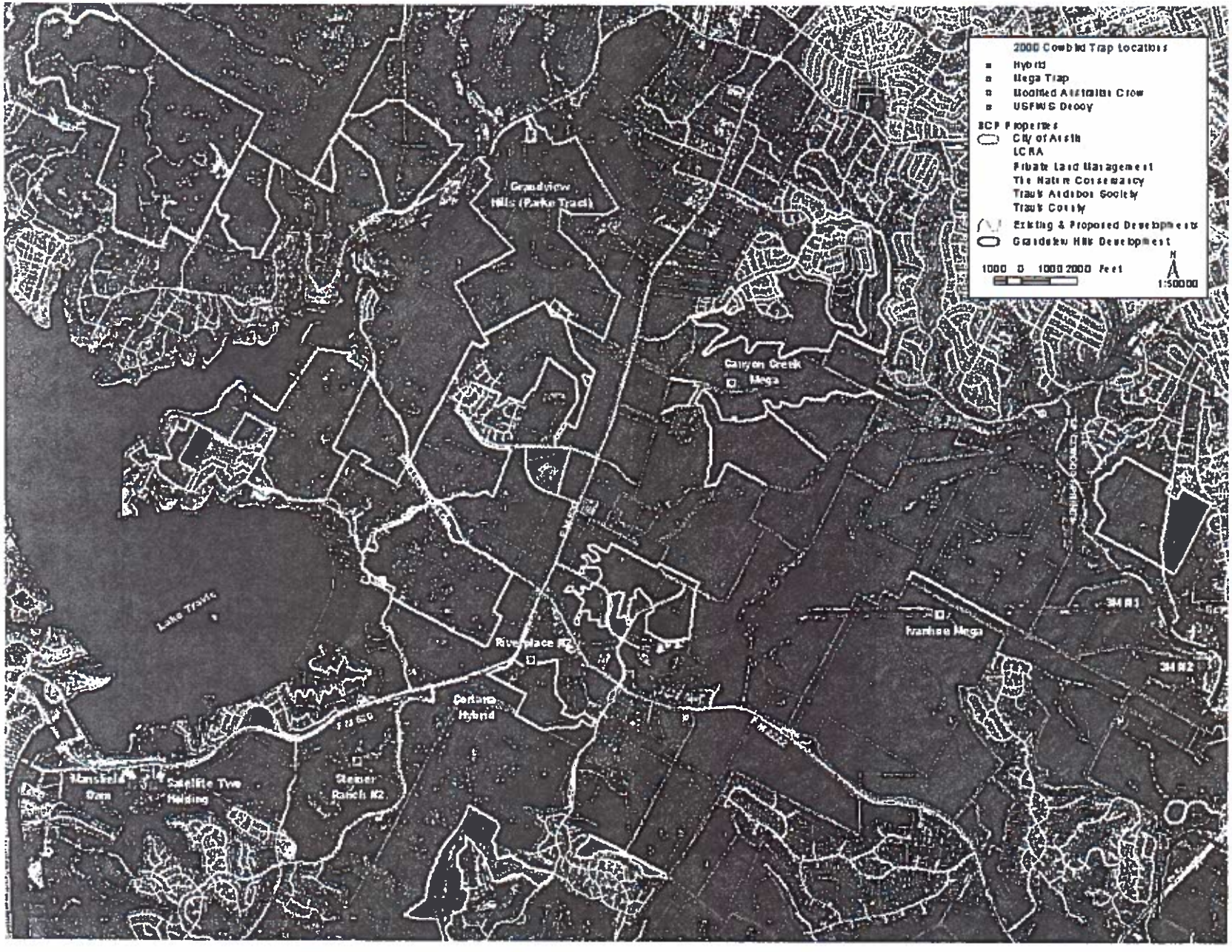

Figure 1. Cowbird trap locations used during 2000 breeding season on BCP lands, Travis County, Texas, 2000.

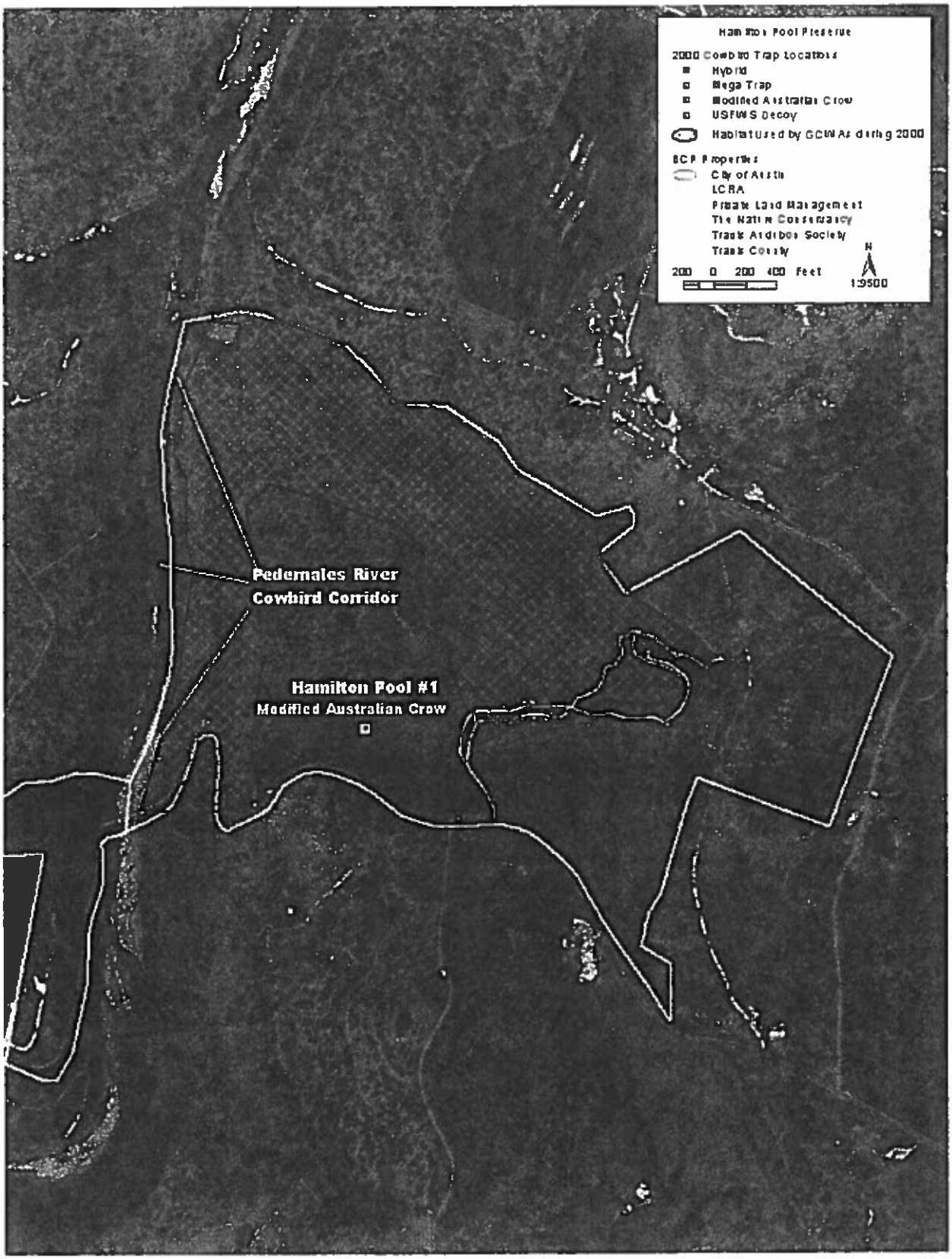

Figure 2. Trap location at Hamilton Pool Preserve during 2000, Travis County, Texas, 2000.

Appendix 1. 2000 Cowbird Trap Summaries

Trap Name	Tract	Month	Year	Total Trap Days	#_begin decoys			Total Dead			Total Killed			Total Seed			Total Captures			
					M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	
CC Mega	Canyon Creek	March	2000	26	7	7	0	4	1	0	0	0	0	4	4	0	16	7	0	
		April	2000	30				1	1	0	4	4	0	10	8	0	18	30	0	
		May	2000	31				0	0	0	11	27	0	6	5	0	7	16	0	
		June	2000	28				0	0	0	3	3	4	0	0	0	5	2	7	
		July	2000	7				0	0	0	12	9	10	0	0	0	2	2	6	Total Captures
CC Mega Totals				122				5	2	0	30	43	14	20	17	0	48	57	13	118

Trap Name	Tract	Month	Year	Total Trap Days	#_begin decoys			Total Dead			Total Killed			Total Seed			Total Captures			
					M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	
Cortana Hybrid	Cortana	March	2000	1	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	
		April	2000	30				1	1	0	3	3	0	4	7	0	11	8	0	
		May	2000	31				4	2	0	4	0	0	0	0	0	8	2	0	
		June	2000	30				1	1	0	11	3	2	0	0	0	5	1	2	
		July	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	Total Captures
Cortana Hybrid Totals				92				6	4	0	18	6	2	4	7	0	24	11	2	37

Trap Name	Tract	Month	Year	Total Trap Days	#_begin decoys			Total Dead			Total Killed			Total Seed			Total Captures			
					M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	
HP1	Hamilton Pool	March	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		April	2000	22	4	4	0	4	1	0	9	6	0	0	0	0	10	3	0	
		May	2000	31				0	0	0	6	3	0	0	0	0	6	1	0	
		June	2000	30				4	4	1	9	3	0	0	0	0	2	4	1	
		July	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	Total Captures
Hamilton Pool Aus. Crow Totals				83				8	5	1	24	12	0	0	0	0	18	8	1	27

Trap Name	Tract	Month	Year	Total Trap Days	#_begin decoys			Total Dead			Total Killed			Total Seed			Total Captures			
					M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	
Ivanhoe Mega	Ivanhoe	March	2000	26	12	3	0	1	0	0	0	0	0	0	0	0	4	1	0	
		April	2000	30				0	0	0	0	0	0	0	0	0	1	2	0	3,1 escape
		May	2000	31				0	1	0	6	0	1	0	0	0	3	2	0	0,1 escape
		June	2000	21				0	0	0	7	5	0	0	0	0	2	0	0	
		July	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	Total Captures
Ivanhoe Mega Totals				108				1	1	0	13	5	1	0	0	0	10	5	0	15

Trap Name	Tract	Month	Year	Total Trap Days	#_begin decoys			Total Dead			Total Killed			Total Seed			Total Captures			
					M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	
Mansfield Hybrid	Sat 2	March	2000	26	4	3	0	1	2	0	0	0	0	10	2	0	5	2	0	
		April	2000	30				0	0	0	0	4	0	0	0	0	3	4	0	
		May	2000	4				2	1	0	5	4	0	0	0	0	0	2	0	
		June	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	
		July	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	Total Captures
Mansfield Hybrid Totals				60				3	3	0	5	8	0	10	2	0	8	8	0	16

Appendix 1. 2000 Cowbird Trap Summaries

Trap Name	Tract	Month	Year	Total Trap Days	#_begin decoys			Total Dead			Total Killed			Total Seed			Total Captures			
					M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	
RP2	Riverplace	March	2000	26	4	2	0	2	1	0	0	0	0	1	3	0	5	1	0	
		April	2000	30				2	0	0	7	5	0	0	0	0	9	4	0	
		May	2000	18				1	0	0	0	0	0	0	0	0	1	4	0	8,7 escaped
		June	2000	30				1	0	0	8	6	2	0	0	0	2	1	2	
		July	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	Total Captures
Riverplace USFWS Totals				104				6	1	0	15	11	2	1	3	0	17	10	2	29

Trap Name	Tract	Month	Year	Total Trap Days	#_begin decoys			Total Dead			Total Killed			Total Seed			Total Captures			
					M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	
SR2	Steiner Ranch	March	2000	26	4	4	0	1	0	0	0	0	0	3	4	0	0	0	0	
		April	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	
		May	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	
		June	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	
		July	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	Total Captures
Steiner USFWS Totals				26				1	0	0	0	0	0	0	0	0	0	0	0	0

Trap Name	Tract	Month	Year	Total Trap Days	#_begin decoys			Total Dead			Total Killed			Total Seed			Total Captures			
					M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	
3M Hybrid 1	3M	March	2000	11	6	4	0	1	0	0	0	0	0	6	6	0	0	0	0	
		April	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	
		May	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	
		June	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	
		July	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	Total Captures
3M#1 Hybrid Totals				11	6	4	0	1	0	0	0	0	0	6	6	0	0	0	0	0

Name	Tract	Month	Year	Total Trap Days	#_begin decoys			Total Dead			Total Killed			Total Seed			Total Captures			
					M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	
3M Hybrid 2	3M/Whitecliff	March	2000	16	6	6	0	1	2	0	0	0	0	0	0	0	4	3	0	1,2 escaped
		April	2000	30				3	1	0	0	0	0	6	10	0	3	12	0	
		May	2000	31				2	1	0	9	13	0	0	0	0	11	8	0	
		June	2000	21				2	1	0	5	2	0	0	0	0	1	0	0	
		July	2000	0				0	0	0	0	0	0	0	0	0	0	0	0	Total Captures
3M#2 Hybrid Totals				98				8	5	0	14	15	0	6	10	0	19	23	0	42
																				307

TOTAL CAPTURES
284 plus 23 escapes
equals 307

Appendix 2..2000 Cowbird Trapping Form

Trap Name _____ Tract: _____ Month/Yr. _____

Date Day/ Initial Ex: 6 WBA	In Trap* M F I	Dead in Trap or Killed			Removed Live Band/Release/ Escapeex: 5_B			Seed #/Sex ex: 5M	Added M F I	Remaining* M F I	Recapture		Non-Target Dead/Released: # species Ex: D:2 NOMO	Comments
		M	F	I	M	F	I				Sex	Band		
		d												
		k												
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Total Trap Days		M d	k	M	
		F		F	
		I		I	

Total Non Targets Released (Spec/#)

_____

Dead (Spec/#)_____

ATTACHMENT D

LOWER COLORADO RIVER AUTHORITY

ENDANGERED BIRD SPECIES SURVEY
WHELESS NATURAL RESOURCE PRESERVE

Donald J. Melton
301 Rancho Bueno Dr.
Georgetown, TX 78628
(512) 930-4884

July 21, 2000

Wendy Conally
Lower Colorado River Authority
P.O. Box 220
Austin, Texas 78767-0220

Subject: Endangered Species Surveys on the LCRA's Wheless Natural Resource Preserve

Wendy:
This report documents the activities and findings of the endangered species surveys for golden-cheeked warbler on the LCRA's Wheless Natural Resource Preserve. I conducted these surveys during the period of March 21 through June 21, 2000.

OBJECTIVES

Map golden-cheeked warbler (*Dendroica chrysoparia*) nesting territories on golden-cheeked warbler study plots 1 and 2 and on the survey area specified on the map you sent me on March 3. The area actually surveyed is shown on Figure 1. This area was expanded slightly from that shown on your map for convenience in mapping and to include the entirety of some contiguous patches of nesting habitat.

The area surveyed as specified on your map includes all of golden-cheeked warbler study plots 1 and 2. Study plot 1 is the emerging habitat plot and is included entirely within the study area on the north side of the property. Study plot 2 constitutes most of the study area on the eastern side of the property along Long Hollow Creek.

The LCRA selected an additional survey area for the 2000 surveys. This area extends along the ridge on the north side of the property and includes an area on the plateau that has some potential for development as habitat for the black-capped vireo. I refer to this area, including all of study plot 1, as the "north ridge survey area" in this report.

ORGANIZATION OF THIS REPORT

This report is organized to cover the entire scope of this survey as an entity. Since territory mapping for study plots 1 and 2 is a part of a long-term study, I have provided separate habitat descriptions, discussion of findings and territory maps for the study plots for convenience in comparing data from the 2000 surveys with past and future surveys. While this redundance may be

confusing to the reader, I hope it will prove useful in dealing with evaluation of data for the study plots.

METHODS

SELECTION OF STUDY PLOTS

Two golden-cheeked warbler study plots were selected, mapped and surveyed in 1997. Study plot 1 represented emerging golden-cheeked warbler habitat and study plot 2 represented prime nesting habitat. The plot locations and descriptions and a detailed discussion of site selection criteria and procedures were reported in the 1997 survey report dated June 18, 1997. Both study plots were surveyed in 1997. For the 1998 and 1999 seasons, the LCRA elected to survey only study plot 2. Both plots were surveyed during the 2000 season.

DETERMINATION OF POPULATION AND NESTING TERRITORIES

Survey protocols established for the study plots in 1997 required a survey intensity of 20 manhours for plot 1 and 60 manhours for plot 2, divided equally into ten separate trips, with the last two trips being scheduled for late season to look for evidence of nesting success. This protocol was followed for study plot 2 for the 2000 surveys. Study plot 1 is included within the study area on the north ridge and survey routes and procedures for this study plot were incorporated in the procedures for the balance of the area for efficiency. As a consequence, study plot 1 received a higher survey intensity than the two manhours per trip provided for under the 1997 protocol for the first eight trips. Survey intensity for study plot 1 was two manhours per trip for the ninth and tenth trips.

The study area not included within the study plots was surveyed at the rate of six manhours per 100 acres per trip for eight trips. This intensity of survey is comparable to that used for the study plots for the first eight trips.

Each "trip" required three days to complete. Coverage on each day of the trip was varied to assure coverage of each area at different times of the day. Survey routes were also varied on each trip to cover each segment of the habitat at different times of the day as well as to reduce systematic undercoverage of any specific area. Eight of the trips were completed as soon as possible after the project was approved. For study plots 1 and 2, two additional trips were made later in the season to seek indications of nesting success.

SITE DESCRIPTION

Wheless Natural Resource Preserve is located on the north side of Lake Travis along the Sandy Creek arm of the lake. It is part of a large block of golden-cheeked warbler habitat along the east side of Sandy Creek, including the Travis Audubon Society Preserve on the north side of the property and potential preserves on the south side. Wheless has very little lake shore, most of which (25 acres)

is leased to Travis County for a recreational park. The remainder consists of a set of ridges at an elevation of about 1000 feet, which are part of the Jollyville Plateau. These ridges are deeply cut by steep canyons and side canyons, producing a large number of relatively moist microenvironments that support mature stands of Ashe juniper-oak woodlands that have many of the characteristics of the Texas oak plant community. The deciduous component of these woodlands is quite varied. Dominated by plateau live oak (*Quercus fusiformis*), it includes Texas oak (*Quercus texana*), scalybark oak (*Quercus sinuata* var. *breviloba*), Texas ash (*Fraxinus texensis*), wafer ash (*Ptelea trifoliata*), escarpment black cherry (*Prunus serotina serotina*), little walnut (*Juglans microcarpa*), hackberry (*Celtis* spp.), cedar elm (*Ulmus crassifolia*) and sycamore (*Plataganus occidentalis*). The understory is open and is not a significant part of the woodland except at the edges.

With three exceptions, the ridges harbor an open stand of Ashe juniper from 10 to 20 feet in height with occasional small motts of live oak or single specimens of live oak or ash to 30 feet tall. The extreme northeast and southeast portions of the area support a mature oak-juniper woodland with 100 percent canopy cover that is similar in composition to the woodlands of the steep slopes of the canyon heads but not as varied in the deciduous component. Part of the long ridge extending southeast from the water tank on the Cedar Park water line supports a similar woodland except canopy cover is about 80 percent.

HABITAT DESCRIPTION

NORTH RIDGE SURVEY AREA

The north ridge study area lies along the northern boundary of the property. It consists of a ridge, part of the Jollyville Plateau, and steep slopes on the north and south side. This area encompasses about 350 acres, 100 of which is golden-cheeked warbler study plot 1.

The ridge or plateau part of the study area begins at an elevation of about 1020 feet above mean sea level. It is fairly level, with a maximum elevation of 1055 feet. The portion of the ridge east of the "isthmus" shown on Figure 2 is vegetated with an open stand of almost pure Ashe juniper shrubland as described under study plot 2 below. A small patch of Ashe juniper-oak woodland is located just east of the fence road as shown on Figure 2. This woodland is relatively immature and is isolated from nearby warbler nesting habitat by about 200 to 400 feet of juniper shrubland. This woodland is approximately two to four acres in size and includes plateau live oak, Texas oak, Texas ash, escarpment black cherry, and scaleybark oak. The understory is open. One Ashe juniper with a trunk diameter at breast height of about 18 inches was noted along with numerous specimens with a dbh of eight to 15 inches.

West of the isthmus vegetation is similar except that there is a larger proportion of deciduous brush. Brush species include Texas

persimmon (*Diospyros texana*), scaleybark oak and agarita (*Berberis trifoliolata*) with a small representation of flame sumac (*Rhus lanceolata*), elbow bush (*Forestiera pubescens*) and wafer ash. Brush clumps are supplemented by shrub-sized specimens of plateau live oak and hackberry. Prickly pear (*Opuntia lindheimeri*) is abundant throughout the plateau area.

The extreme northeast corner of the property is an extension of the north ridge but vegetation here differs significantly from that of the western portion of the ridge. This area is in a mature Ashe juniper-oak woodland with good diversity of the deciduous species. Dominated by plateau live oak, deciduous species include Texas oak, scaleybark oak, Texas ash, hackberry and cedar elm. Scaleybark oak is much more prevalent here than in the canyon woodlands. This woodland has been found to support a significant population of golden-cheeked warblers in past surveys. The extreme eastern tip of the north ridge study area lies within this woodland.

The north and south slopes of the ridge in the study area consist of steep canyons and side canyons containing a large number of relatively moist microenvironments that support mature stands of Ashe juniper-oak woodlands that have many of the characteristics of the Texas oak plant community. The deciduous component of these woodlands is quite varied. Dominated by plateau live oak, it includes Texas oak, scaleybark oak, Texas ash, wafer ash, escarpment black cherry, hackberry, cedar elm and sycamore. The understory is open and is not a significant part of the woodland except at the edges.

All of the north- and east-facing drainages on the north side of the north ridge survey area are almost completely covered with ideal golden-cheeked warbler nesting habitat. On the south side of the ridge, most of the drainages face west and south except on the extreme southeast corner of the survey area. The two drainages on the east end contain a significant patch of good nesting habitat extending down the drainage to the access road. In the rest of the upper drainages, vegetation suitable for nesting is absent or present only in small patches of less than one-half acre. In the middle part of the main drainage is a stand of fair nesting habitat which is mapped as unoccupied habitat on Figure 2. This patch has fairly good diversity of deciduous species and a few large junipers but mostly has a dense understory of small junipers in contrast to the open understory of good nesting habitat. It is surrounded by mesic juniper shrubland on caliche soils.

STUDY PLOT 1

The transitional habitat plot is located on the north side of the property. About 60 percent of the plot is located on a fairly level ridge at an elevation of about 1040 feet above mean sea level. This area was clear cut and burned in the past, perhaps thirty or more years ago. It now stands in an open Ashe juniper

shrubland with a canopy cover averaging about 50 per cent. Analysis of four square plots of 1.6 acres each on an aerial photograph made in June of 1996 indicated that canopy cover ranges from 40 to 70 per cent in the shrubland portion of this tract. This includes small meadows and rock fields less than one acre in size that are brush-free and some brushy areas that have nearly 100 per cent canopy cover. The thickest brush is oriented along topographic contours where there is a significant change in slope. Soils are thin and rocky and there is a large amount of vuggy rock in evidence. There is also some evidence of underground cavities. Tree species on this area include scattered groves or individual specimens of scalybark oak, plateau live oak, Texas oak, Texas ash and Mexican ash (*Fraxinus berlandieriana*). The presence of a large number of burned juniper stumps six to twelve inches in diameter, with some as large as 20 inches in diameter, indicates that this area was once capable of supporting a mature Ashe juniper woodland. No evidence of the past presence of deciduous tree species was found. Any stumps of deciduous species remaining after the clearing and burning have probably long since decomposed.

The remaining 40 per cent of the plot, located on its southwest corner, has fairly steep slopes facing to the south and west and includes several small drainages. One set of these drainages, located on the south side of the plot, contains approximately 15 acres of prime golden-cheeked warbler nesting habitat and is contiguous to other nesting habitat off the plot. Drainages on the remaining 25 acres are rather narrow and contain small patches of vegetation characteristic of warbler nesting habitat. The ridges between the small drainages tend to be scrubby.

STUDY PLOT 2

Golden-cheeked warbler study plot 2 is located along two drainages and the intervening narrow ridge just east of Long Hollow Creek on the east side of the property. Canopy cover on this plot is near 100 per cent. Vegetation on the steeper slopes is typical of the canyons on the property (described above) and elsewhere woody species diversity is lower. Woody species tend to be shrubby in a few areas of caliche soils with western exposure. Cedar posts were harvested from the property long (probably over thirty years) ago and some clearing was done within the more recent past for fencing. This clearing included clearing along the fence lines and along roads for access to the fence. In addition, several one-way dozer "walks" were found on the ridge just east of Long Hollow Creek. These trails caused a break in the canopy and are still recovering.

FINDINGS

Golden-cheeked warblers were observed on 88 occasions during the surveys. Many of these occasions represent observation of one bird at several locations over a continuous period of time. Six of these observations were females and 16 were juveniles. The first juveniles were observed on May 16.

Twenty-four nesting territories were mapped for the entire survey area, including 15 for the north ridge survey area and nine for study plot 2 on the east side of the property. In addition, one hypothetical territory was mapped for the north ridge survey area.

The location of the survey areas are shown on Figure 1. Territory maps and locations of golden-cheeked warbler observations are shown on Figures 2, 3 and 4. Details for the survey trips are provided in Table 1.

NORTH RIDGE SURVEY AREA

Golden-cheeked warblers were observed on the north ridge survey area on 48 occasions during the surveys. Many of these occasions represent observation of one bird at several locations over a continuous period of time. Two of these observations were females and nine were juveniles.

Fifteen golden-cheeked warbler nesting territories were identified and mapped in and near the north ridge survey area. In addition, one hypothetical territory is mapped along the access road on the south side of the survey area. The locations of the observations and territories are shown on Figure 2. The extent of the hypothetical territory is based on vegetation. Golden-cheeked warblers were observed in this area on two occasions and included a male and two juveniles. They may have come from habitat outside of the survey area.

Two of the territories were located in the upland habitat on the extreme east end of the north ridge survey area and the balance were found in moist canyonland habitat. With the exception of the two territories on the east end of the survey area, no nesting activity was noted above the 1020 foot contour. Golden cheeked warblers were observed on two occasions above the 1020 foot contour on June 8. One of these observations was a female accompanied by one juvenile feeding, along with a Carolina chickadee (*Parus carolinensis*), in a small grove consisting of two Texas ash and three or four scaleybark oaks. The other observation consisted of a male, female and one juvenile golden-cheeked warbler feeding in a small grove of plateau live oak with chickadees, tufted titmice (*Baeolophus bicolor, Parus b.*) and chipping sparrows (*Spizella paserina*). In both cases the warblers were within 200 feet of the edge of the ridge.

The one area of unoccupied habitat on the south slope, discussed under "habitat description" above, was searched intently on every trip, using tapes of golden-cheeked warbler songs on the sixth visit and screech owl tapes on the seventh and eighth visits. No golden-cheeked warblers were found in this area. All of the remaining golden-cheeked warbler nesting habitat on the north ridge survey area may be considered occupied during the 2000 season based on the survey findings.

STUDY PLOT 1
These findings are included in full in the discussion of findings for the north ridge survey area above. They are summarized here for convenience in comparing these findings to those for study plot 1 in preceding or subsequent years.

Golden-cheeked warblers were observed on or near study plot 1 on 8 occasions during the surveys. Many of these occasions represent observation of one bird at several locations over a continuous period of time. One of these observations was a female and one was a juvenile in the company of the female.

One golden-cheeked warbler nesting territory was identified and mapped on study plot 1 and one was partially on study plot 1. The locations of the observations and territories are shown on Figure 3. Almost all of the golden-cheeked warbler nesting habitat on the north plot may be considered occupied during the 2000 season based on the survey findings.

In 1997, one nesting territory was found partially on study plot 1 in the lower part of the drainage on the southeast corner. Golden-cheeked warbles were observe twice in the upper part of this drainage the but data was insufficient to identify and map a territory. This plot was not surveyed in 1998 and 1999.

STUDY PLOT 2
Golden-cheeked warblers were observed on study plot 2 on 40 occasions during the surveys. Many of these occasions represent observation of one bird at several locations over a continuous period of time. Four of these observations were females and seven were juveniles.

Six golden-cheeked warbler nesting territories were identified and mapped entirely on study plot 2 and three were partially on the plot. The locations of the observations and territories are shown on Figure 4.

In 1997 and 1998, ten nesting territories were found on study plot 2 and nine were found in 1999. Comparisons of territory maps for the four survey years indicates significant difference in the arrangements of the territories over the years.

Don

TABLE 1
GOLDEN-CHEEKED WARBLER SURVEY TRIP DATA
WHELESS NATURAL RESOURCE PRESERVE

Observer: Don Melton
Survey Period: March 21 through June 21, 2000

Trip: 1-1

Date: March 21, 2000

	Beginning	Ending
Time	0700	1610
Temperature, degrees F	64	65
Wind: direction, mph	SE 0-5	Variable 0-10
Cloud cover	low overcast	low overcast

Weather comment: Light rain 1030-1130, intermittent mist all day
Observations: 3 male GCW

Trip: 1-2

Date: March 22, 2000

	Beginning	Ending
Time	0815	1700
Temperature, degrees F	68	76
Wind: direction, mph	SE 0-10	SE 5-10
Cloud cover	overcast	overcast

Observations: 8 male GCW

Trip: 1-3

Date: March 23, 2000

	Beginning	Ending
Time	0640	1620
Temperature, degrees F	70	82
Wind: direction, mph	SE 5-10	calm
Cloud cover	overcast	partly cloudy

Observations: 2 male GCW

Trip: 2-1

Date: March 28, 2000

	Beginning	Ending
Time	0650	1615
Temperature, degrees F	55	83
Wind: direction, mph	S 5	S 10
Cloud cover	overcast	partly cloudy

Observations: 8 male GCW

Trip: 2-2

Date: March 29, 2000

	Beginning	Ending
Time	0750	1615
Temperature, degrees F	68	90
Wind: direction, mph	calm	NW 10-15
Cloud cover	clear	clear

Weather comment: Brief thunderstorm ending 0630
Observations: 4 male GCW

Trip: 2-3 Date: March 30, 2000

	Beginning	Ending
Time	0625	1605
Temperature, degrees F	52	77
Wind: direction, mph	calm	E 3
Cloud cover	clear	clear

Observations: two male GCW

Trip: 3-1 Date: April 3, 2000

	Beginning	Ending
Time	0825	1630
Temperature, degrees F	57	62
Wind: direction, mph	calm	NW 5-15
Cloud cover	clear	mostly cloudy

Observations: none

Trip: 3-2 Date: April 4, 2000

	Beginning	Ending
Time	0725	1600
Temperature, degrees F	38	75
Wind: direction, mph	calm	N 5
Cloud cover	clear	clear

Observations: 5 male GCW

Trip: 3-3 Date: April 6, 2000

	Beginning	Ending
Time	0710	1530
Temperature, degrees F	52	75
Wind: direction, mph	calm	S 10-15, G 20
Cloud cover	clear	clear

Weather comment: Wind S 10-15 by 0900
Observations: 3 male GCW

Trip: 4-1 Date: April 14, 2000

	Beginning	Ending
Time	0745	1600
Temperature, degrees F	58	73
Wind: direction, mph	calm	S 10
Cloud cover	overcast	overcast

Observations: 1 male GCW

Trip: 4-2 Date: April 16, 2000

	Beginning	Ending
Time	0715	1540
Temperature, degrees F	69	85
Wind: direction, mph	calm	E 5
Cloud cover	overcast	partly cloudy

Weather comment: Clouds clearing beginning 0830
Observations: 4 male GCW

Trip: 4-3 Date: April 7, 2000

Time	Beginning 0720	Ending 1600
Temperature, degrees F	64	88
Wind: direction, mph	calm	SE 5
Cloud cover	partly cloudy	clear

Observations: 4 male GCW

Trip: 5-1 Date: May 3, 2000

Time	Beginning 0655	Ending 1535
Temperature, degrees F	63	82
Wind: direction, mph	calm	S 3
Cloud cover	mostly cloudy	partly cloudy

Weather comment: Light fog until 0930
Observations: 1 male GCW

Trip: 5-2 Date: May 4, 2000

Time	Beginning 0655	Ending 1510
Temperature, degrees F	70	84
Wind: direction, mph	calm	calm
Cloud cover	overcast	partly cloudy

Observations: 3 male GCW

Trip: 5-3 Date: May 5, 2000

Time	Beginning 0705	Ending 1545
Temperature, degrees F	64	84
Wind: direction, mph	calm	calm
Cloud cover	overcast	overcast

Observations: 2 male GCW

Trip: 6-1 Date: May 15, 2000

Time	Beginning 0650	Ending 1530
Temperature, degrees F	61	88
Wind: direction, mph	calm	S 5-10
Cloud cover	clear	partly cloudy

Observations: none
Comment: used GCW tape on unoccupied habitat on south slope of north ridge survey area

Trip: 6-2 Date: May 16, 2000

Time	Beginning 0700	Ending 1545
Temperature, degrees F	72	89
Wind: direction, mph	S 5-10, gusty	S 5-10
Cloud cover	partly cloudy	clear

Observations: 2 male, 1 female and 2 juvenile GCW. Juveniles were with female and were recently fledged (still showing down).

Trip: 6-3 Date: 0650, 2000

	Beginning	Ending
Time	0650	1535
Temperature, degrees F	72	90
Wind: direction, mph	S 15, G 25	S 20, G 30
Cloud cover	mostly cloudy	partly cloudy

Observations: 2 male, 2 juvenile GCW. Juveniles were with one of the males.

Trip: 7-1 Date: May 29, 2000

	Beginning	Ending
Time	0640	1515
Temperature, degrees F	70	93
Wind: direction, mph	calm	S 5
Cloud cover	low overcast	partly cloudy

Weather comment: Partly cloudy by 0930
Observations: 3 male, 1 female GCW. Female carrying food.

Trip: 7-2 Date: May 30, 2000

	Beginning	Ending
Time	0645	1515
Temperature, degrees F	77	96
Wind: direction, mph	calm	S 5
Cloud cover	clear	partly cloudy

Observations: none
Comment: Used screech owl tape on south slope.

Trip: 7-3 Date: May 31, 2000

	Beginning	Ending
Time	0645	1520
Temperature, degrees F	72	94
Wind: direction, mph	calm	S 10
Cloud cover	partly cloudy	partly cloudy

Observations: 2 male, 3 juvenile GCW

Trip: 8-1 Date: June 6, 2000

	Beginning	Ending
Time	0700	1530
Temperature, degrees F	67	87
Wind: direction, mph	calm	NE 5
Cloud cover	clear	clear

Observations: 1 male, 1 juvenile GCW

Trip: 8-2

Date: June 7, 2000

	Beginning	Ending
Time	0645	1530
Temperature, degrees F	57	87
Wind: direction, mph	calm	E 0-5
Cloud cover	clear	clear

Observations: none
Comment: Used screech owl tape on unoccupied habitat on south slope.

Trip: 8-3

Date: June 8, 2000

	Beginning	Ending
Time	0650	1530
Temperature, degrees F	67	80
Wind: direction, mph	calm	calm
Cloud cover	overcast	overcast

Observations: 3 male, 2 female and 4 juvenile GCW
Comment: one juvenile recently fledged.

Trip: 9

Date: June 16, 2000

	Beginning	Ending
Time	0710	1600
Temperature, degrees F	77	90
Wind: direction, mph	S 5	S 10
Cloud cover	partly cloudy	partly cloudy

Observations: 4 male, 1 female and 2 juvenile GCW. One juvenile was with female, one with male.

Trip: 10

Date: June 21, 2000

	Beginning	Ending
Time	0705	1545
Temperature, degrees F	78	90
Wind: direction, mph	S 5	S 5
Cloud cover	partly cloudy	partly cloudy

Observations: 2 juvenile GCW. These birds not accompanied by adult GCW but were with a feeding flock of chickadees and titmice.

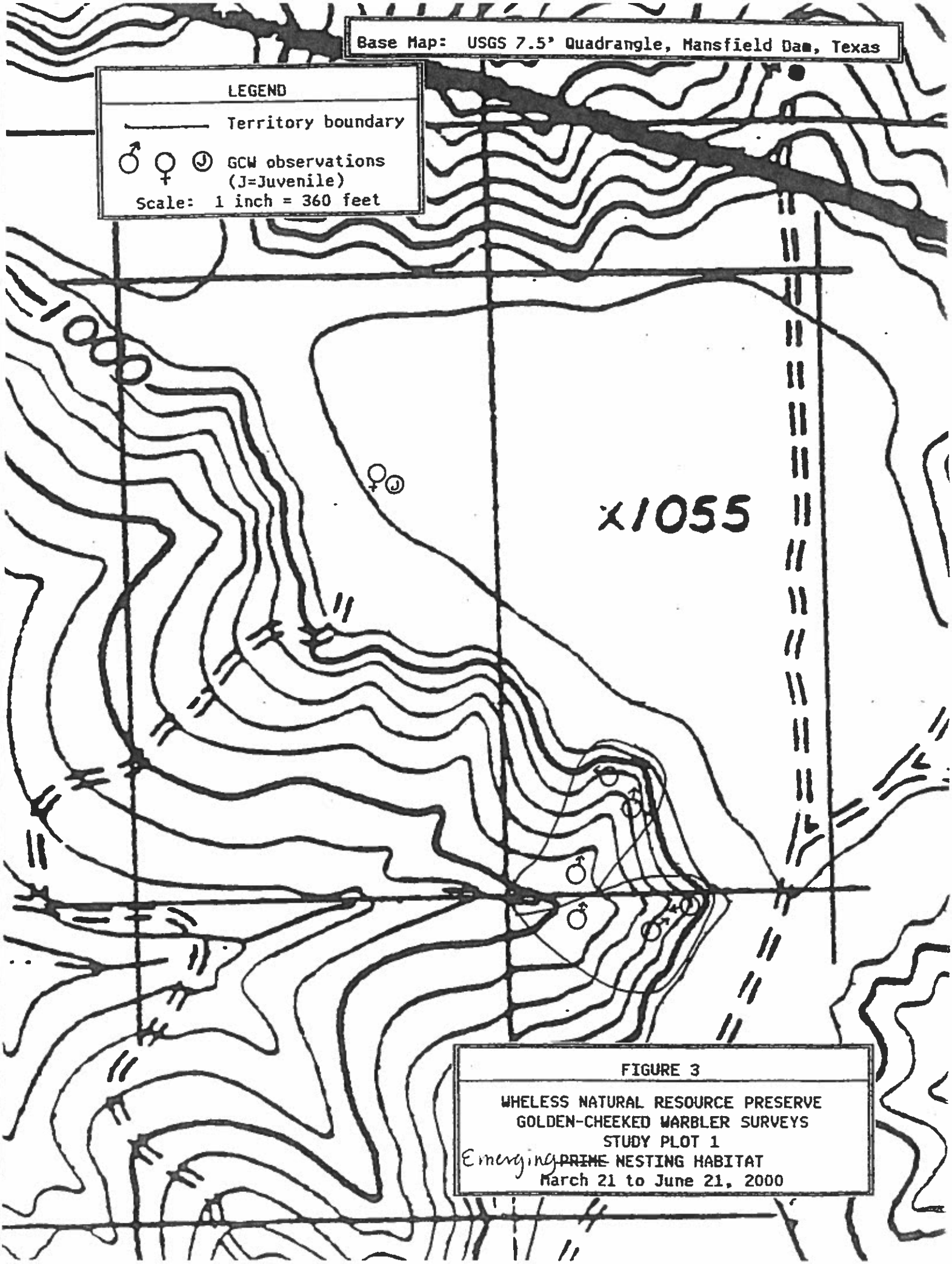
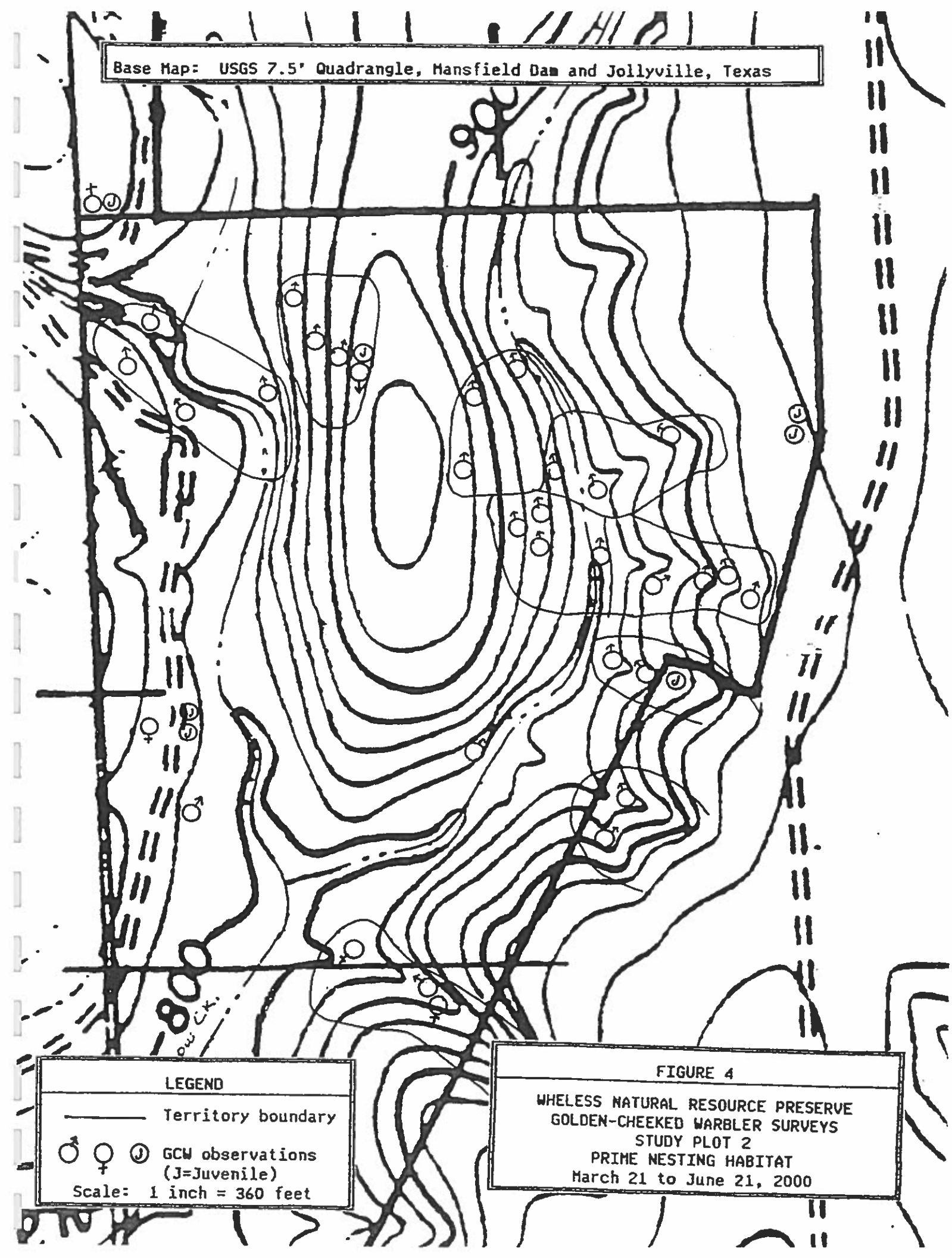


FIGURE 3

WHELESS NATURAL RESOURCE PRESERVE
GOLDEN-CHEEKED WARBLER SURVEYS
STUDY PLOT 1
Emerging ~~PRIME~~ NESTING HABITAT
March 21 to June 21, 2000

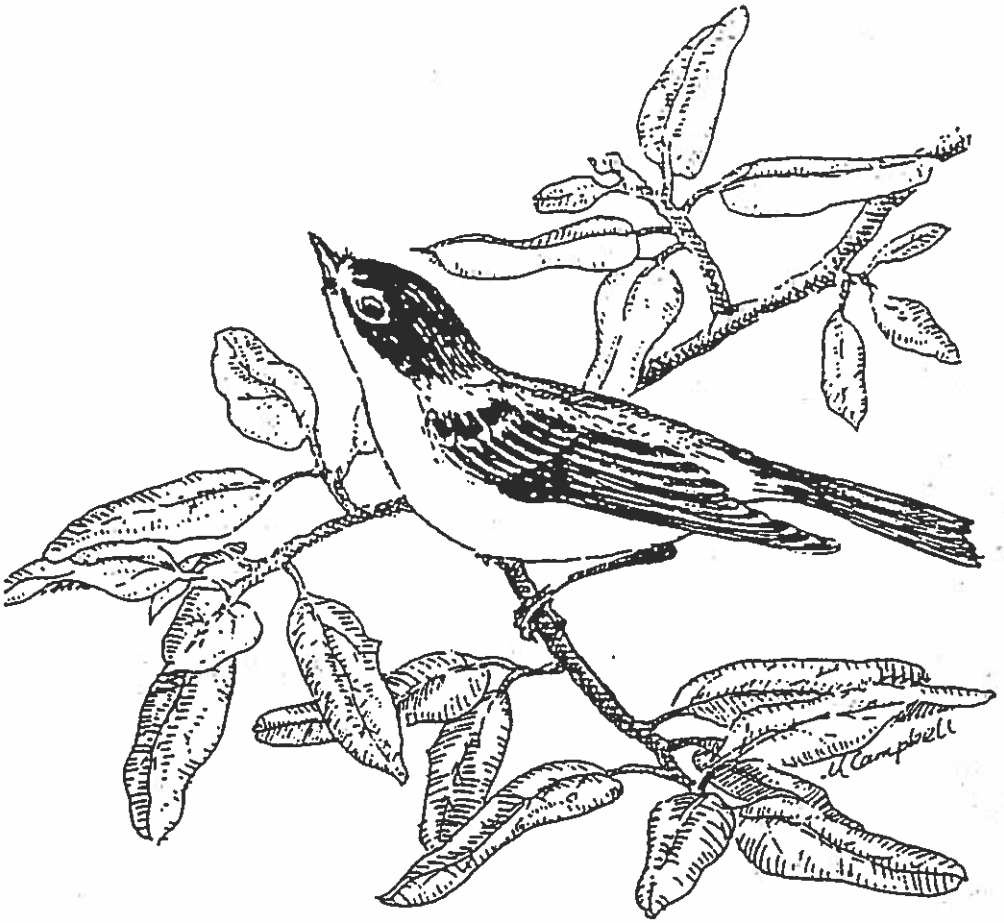

Base Map: USGS 7.5' Quadrangle, Mansfield Dam and Jollyville, Texas
LEGEND
Territory boundary
GCW observations (J=Juvenile)
Scale: 1 inch = 360 feet
FIGURE 4
WHELESS NATURAL RESOURCE PRESERVE
GOLDEN-CHEEKED WARBLER SURVEYS
STUDY PLOT 2
PRIME NESTING HABITAT
March 21 to June 21, 2000

ATTACHMENT E

CITY OF AUSTIN

2000 WARBLER AND VIREO REPORT

2000 Golden-cheeked Warbler and Black-capped Vireo Monitoring Program



Balcones Canyonlands Preserve

The City of Austin

Natural Resources Division

Prepared by Carlo Abbruzzese

October 2000

2000 Golden-cheeked Warbler and Black-capped Vireo Monitoring Program

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Territory Mapping

Golden-cheeked Warbler territories were mapped using methods described by the IBCC (1970). Surveys were conducted on "days when weather conditions are suitable for the detection of bird singing" (USFWS 1994). Warbler surveys were conducted when the ambient temperature was above 55° F, as GCWs are thought to sing less frequently below this temperature (DLS 1994). All GCW monitoring was undertaken by personnel who are familiar with local bird vocalizations, and are adept at orienteering and mapping. Visits were equally distributed throughout the field season, including late season visits to obtain brood counts. Singing males were often best differentiated from one another by following individual males and by listening for countersinging between nearby males. Singing males were mapped on copies of 7.5' USGS topography maps. Locations of male were then transferred to a digital topography map which was superimposed on an aerial photo using Arcview 3.2. Prime plots were visited ten times while transitional plots were visited three times each; each for six hours per visit. For each visit the time, temperature, wind direction, wind speed, and percent cloud cover were recorded at the beginning and ending of each visit. Playback of taped GCW or Eastern Screech-owl vocalizations were not used to elicit a response. Fieldwork was conducted by the following personnel; David Hernandez (Barton Creek), Daniel Thompson (Emma Long), Mark Sanders (Ivanhoe and Canyon Creek), Carlo Abbruzzese (Bohls and Forest Ridge), and Jackie Davis (3M/St Eds and Double J and T).

Analysis of territories differs slightly in this report from IBCC recommendations. IBCC methodology recommends that edge territories "be counted as belonging to the plot only if more than half of the registrations lie within the plot or on the boundary. Otherwise they will not be counted" (IBCC 1970). However, since observers tend to spend more time within plot boundaries, the number of edge territories may be overestimated (Verner 1985). Verner (1985) suggests that this bias can be reduced by assigning only half of the edge territories to the plot. We follow Verner's recommendation and we also provide a low estimate (a count of territories that fall entirely within the plot or "full territories") and a high estimate (counts of both "full" and edge territories) for each plot. Territory size was estimated only for the 2000 field season by drawing a polygon around each territory boundary using Arcview 3.2. Arcview 3.2 automatically calculates the area within the polygon.

Productivity and Mated Status

Researchers also recorded observations of females and numbers of fledglings produced within territories. Because females and juveniles are often difficult to detect, estimates of their numbers are minimum estimates at best. In addition, because young warblers tend to wander outside of their territories as they age and become independent from their parents, observers were more confident that fledgling groups came from a particular territory if the young observed had recently fledged. Productivity and mated status was estimated only for territories that were completely within the plot. Fecundity was estimated by

dividing the total number of fledglings produced by the number of territories that were entirely within plot boundaries.

Enumeration/Colorbanding Studies

In addition to territory monitoring, observers also enumerated GCW territories at several other sites (see figures 9-13). Territory enumeration is a count of the total number of singing males in a given area. Because of the limited number of visits GCW territory boundaries are approximate. Enumeration of territories required 3-4 visits per study area during good weather conditions. GCW territories were enumerated around or adjacent to 100-acre plots in Emma Long Park, and Lower Bull Creek. Enumeration also included follow-up visits to colorbanded birds in the Emma Long Park and Coldwater tracts, as part of an independent colorbanding project initiated by Dean Keddy-Hector and Maria Tolle in 1999. Warbler enumeration was conducted by Daniel Thompson, Jackie Davis, Melody Lytle, Carlo Abbruzzese, and Mary Ruth Holder.

Site and Plot Descriptions

The topography and vegetation throughout the study site typify the eastern edge of the Edwards Plateau. Drier uplands are intermixed with humid, steep, canyon slopes and riparian habitats. Most of the streams that flow through these canyons are intermittent, though a few have a permanent water source such as a perennial spring. It is thought that woodlands in western Travis county were logged in the late 1800s and early 1900s and are in various stages of recovery (Keddy-Hector 1996). In addition, after clearing, much of the topsoil was lost due to chaining and subsequent goat and cattle overgrazing. On some steep slopes this soil loss has greatly reduced the revegetation potential. Also, current and past overbrowsing by white-tailed deer (*Odocoileus virginianus*) has greatly reduced the understory and a distinct browse line is visible throughout. Conspicuously absent in the study area are saplings of deciduous trees such as oaks (*Quercus* sp.), escarpment black cherry (*Prunus serotina serotina*), rusty black-haw (*Viburnun rufidulum*), cedar elm (*Ulmus crassifolia*), Texas ash (*Fraxinus texensis*) and Texas mulberry (*Morus microphylla*).

The forest canopy in the study area is primarily composed of Texas oak (*Quercus texana*), Ashe juniper (*Juniperus ashei*), plateau live oak (*Quercus fusiformis*), escarpment black cherry, Texas ash (*Fraxinus texensis*), and cedar elm (*Ulmus crassifolia*). Common understory species include Ashe juniper, Carolina buckthorn (*Rhamnus caroliniana*), yaupon holly (*Ilex vomitoria*), red buckeye (Aesculus *pavia pavia*), white shin oak (*Quercus sinuata* var. *breviloba*), Mexican buckeye (*Ungnadia speciosa*), Lindheimer silk-tassel (*Garrya Lindheimeri*) and elbow bush (*Foristiera pubescens*). Ashe juniper is one of the most common understory species.

Individual plots are described as follows:

Barton Creek (Prime Habitat): The Barton Creek plot lies roughly 2 km northwest of the intersection of Capital of Texas Highway and Mopac. The Barton Creek hike and bike trail runs roughly though the center

of the plot. This area experiences high numbers of hikers, joggers, swimmers, tubers, and mountain bikers with peak use occurring primarily on weekends and after 5pm. Approximately 85% of the plot is composed of closed canopy juniper-oak woodland, while portions of the uplands are more open (65% canopy cover).

Emma Long (Prime Habitat): The Emma Long plot straddles the Turkey Creek trail near the center of Emma Long Metropolitan Park. The eastern boundary runs parallel to and within 10-30m from City Park Road. The majority of this plot contains unfragmented, full canopied, juniper-oak woodland that appears to be excellent GCW habitat. The understory throughout much of the plot, particularly the uplands, is very dense and difficult to walk through. Terrain varies from steep canyon slopes along Turkey creek to relatively gentle slopes. Approximately 5% of the plot was cleared in the past and is in early stages of plant succession. The riparian habitat along Turkey creeks contains fairly high numbers of exotic plants such as heavenly bamboo (*Nandina domestica*), Japanese privet (*Ligustrum japonicum*) and Chinaberry (*Melia azedarach*). The Turkey Creek trail receives light use by hikers (some with dogs) mostly on weekends.

Ivanhoe (Prime Habitat): The Ivanhoe plot occurs approximately four km. to the northwest of the intersection of Spicewood Springs road and Capital of Texas Highway. With a few minor exceptions, the canopy remains intact throughout the plot. The northern plot boundary is marked by a powerline and its' associated 20m wide clearing.

St. Edwards/ 3M (Prime Habitat): This plot occurs on both the St. Edwards and 3M tracts located about 3 km west of the intersection of Spicewood spring road and Capital of Texas Highway. Three powerlines and their associated 20m wide cleared areas beneath, cross the center of the plot. Recreational hiking and biking takes place on designated trails in the northwest corner of the plot (roughly 20% of the entire plot). Unauthorized hiking and biking occasionally occur on the rest of the plot. Roughly 1-2% of the plot contains cleared open areas that were probably used for livestock grazing in the past.

Forest Ridge (Prime Habitat): This plot occurs on the Forest ridge tract and is approximately 0.5 kilometer southwest of the intersection of Spicewood Springs Road and Capital of Texas Highway. Roughly one quarter of the plot contains drier upland habitat containing primarily plateau live oak, Ashe juniper and white shin oak. In the early 1980's, portions of the plot were hydroaxed in preparation for road and waterline construction. This hydroaxed portion accounts for approximately 5% of the total plot. These areas are currently recovering and vegetation stands at about 3-4 meters. This plot also contains numerous largely unauthorized trails that are used by mountain bikers and hikers. Recreational use of the two authorized trails takes place primarily after 5 p.m. and on weekends.

Bohls Hollow (Prime Habitat): The Bohls Hollow plot lies approximately 2 km northeast of the town of Bee Cave. Roughly 60% of this plot is made up of full canopied, steep canyon slopes and drainage bottoms.

The remaining 40% of uplands contain more open juniper-oak woodland (canopy closure of about 70%). The uplands appear to have undergone some type of clearing in the past. The majority of this area is composed of more than 90% juniper trees that are probably less than 20 years old. Regeneration of oaks and other hardwoods has been prevented by heavy browse pressure for many years.

Double J and T (Transitional Habitat): The Double J and T plot occurs roughly one km to the East of the intersection of FM 620 and Kollmeyer Rd. Currently, approximately 40-50% of the plot is woodland, which is primarily made up of young juniper. For the most part, deciduous hardwoods occur in drainage bottoms. Past chaining and overgrazing appear to have greatly reduced the density of deciduous trees in this plot. Though the land is no longer grazed, oak regeneration appears to have been hindered by deer browse for many years.

Canyon Creek (Transitional Habitat): The Canyon Creek plot can be found approximately 3.5 km from the intersection of RR 2222 and FM 620. In the mid 1980's, in preparation for development, most Ashe juniper within the plot was hydroaxed while the oak component was left largely untouched. Regrowth juniper is approximately 2-3 meters in height. One section of the plot (roughly 10%) appears to have been chained and heavily grazed and is now largely covered with Ashe Juniper, King Ranch Bluestem (*Bothriochloa ischaemum*), and prickly pear cactus (*Opuntia macrorhiza*). Approximately 5-7% of the plot was not recently hydroaxed and contains closed canopied juniper oak woodland. In general, the canopy closure throughout the plot is roughly 40-50%. Most of this plot is upland habitat though it is adjacent to heavily wooded canyons.

RESULTS AND DISCUSSION

Overall Distribution and Abundance

A total of 85 male GCWs held territories either fully (42) or partially (43) within the eight study plots. This represents an average of 9.8 territories per 100 acres (24.5 per 100 ha) in prime habitat and 2.5 territories per 100 acres (6.25 per 100 ha) in transitional habitat.

In general, higher warbler densities were found in larger tracts of full-canopied, mature woodland such as the Ivanhoe, Forest Ridge, and St. Edwards/3M plots. This is not surprising since most authorities consider the GCW a forest interior species that requires large blocks of unfragmented habitat (Biological Advisory Team 1990, Wahl et. al. 1990).

Of the six prime plots, the Bohls plot had the lowest density with three territorial males. These lower densities might be explained by Bohls' lower percentage of full canopied, mature woodlands.

As expected, the two transitional plots had lower warbler densities than the prime plots, with the exception of the Bohls plot, which had fewer territories than the Canyon Creek plot. As previously mentioned, much of the Canyon Creek plot was selectively hydroaxed leaving high numbers of Texas oak,

and live oak intact. This plot was also adjacent to prime warbler habitat to the north and south. This oak component and nearby high quality habitat may account for the slightly higher number of warblers using this transitional plot. Of all plots, the Double J and T plot appears to have the least amount of habitat favored by the GCW, so it is not surprising that warbler densities were lowest in this plot.

Figures 1-8 illustrate locations of GCW territories, females and fledgling groups. See Table 1 for a summary of findings for individual plots.

Pairing, Nesting, and Productivity

Of the 39 territories that occurred fully within the plots, at least 17 contained females (Table 2). Assuming that all females seen were paired, this represents a minimum estimate of 43% warblers paired. However, the number of fledgling groups observed on several plots was higher than the number of females observed. This suggests that the number of females in all plots was at least 19; a 49% pairing rate. Again, this is likely an underestimate of pairing success, as females are difficult to detect. Pairing success was 49% on prime plots and 0% on transitional plots.

Overall, a minimum of 30 fledglings from 12 fledgling groups were observed on all ten plots or 2.5 fledglings per successful nesting attempt. This represents 0.38 male fledglings per singing male (assuming a 50:50 male/female sex ratio). This figure is considerably less than the fecundity estimate (defined as the number of male fledglings per singing male) of 0.75 for second year GCWs and 1.08 for after second year GCWs used in a model to estimate the probability of extinction in 100 years in the GCW population and habitat viability assessment (US Fish and Wildlife Service 1996). Prime plots were more productive than transitional plots with 0.68 fledglings per territory in prime plots and 0 fledglings per territory in transitional plots.

Eight warbler nests were found while surveying plots or during enumeration; two on the Forest Ridge tract, one on the Jester tract, one on Canyon Creek tract, and four in Emma Long Metropolitan Park. It is believed that five of the seven nests successfully fledged 14 young. This represents a 63% nesting success rate and 2.8 fledglings per successful pair.

Nest Predators and Parasites

For the most part, observers found little evidence of parasitism by Brown-headed Cowbirds (*Molothrus ater*). There were three sightings of an adult GCW feeding a fledgling Brown-headed Cowbird. These took place on the Emma Long and Forest Ridge plots. Interestingly, a pair of warblers on the Forest Ridge tract cared for one cowbird fledgling while also looking after three of their own. Brown-headed Cowbirds were observed on numerous occasions in both prime and transitional plots and were most often seen following utility corridors, trails or in open fields. In 2000, three cowbird traps were employed on the Ivanhoe, Canyon Creek and 3M tracts. Observers noted fewer cowbirds in their plots soon after trapping started.

Table 1: 2000 City of Austin Golden Cheeked Warbler Surveys --Summary of Findings

Density and Territory Size

Plot Name	Number of Full Territories[1]	Number of Full and Edge Territories[2]	Number of Full Territories plus 50% of edge Teritories[3]	Number of Territories per 100HA	Average Territory Size (HA)[4]
Prime Plots					
Barton Creek					
1998	2	8	5	12.5	
1999	6	12	9	22.5	
2000	5	9	7	17.5	2.3
Emma Long					
1998	6	11	8.5	21.3	
1999	7	12	9.5	23.8	
2000	12	21	16.5	41.3	.97
Ivanhoe					
1998	7	13	10	25	
1999	8	17	12.5	31.3	
2000	7	19	13	32.5	2.02
St. Eds/3M					
1998	6	12	9	22.5	
1999	7	15	11	27.5	
2000	7	17	12	30	2.77
Forest Ridge					
1998	7	14	10.5	26.3	
1999	11	17	14	35	
2000	7	14	10.5	26.3	1.8
Bohls Hollow					
1998	3	6	4	10	
1999	1	4	4	10	
2000	1	5	3	7.5	7.6
TOTALS				Avg.	
1998	31	64	47	19.6	
1999	40	77	60	25.0	
2000	39	85	62	25.9	2.9
Transitional Plots					
Double J and T					
1998	0	1	.5	1.3	
1999	0	1	.5	1.3	
2000	0	1	.5	1.3	0
Canyon Creek					
1998	0	8	4	10	
1999	2	7	4.5	11.3	
2000	0	8	4	10	0
TOTALS				Avg.	
1998	0	9	4.5	5.7	
1999	2	8	5	6.3	
2000	0	9	4.5	5.7	0

[1] Entire territory boundary fell within plot.

[2] Includes edge territories.

[3] Includes %50 of edge territories. See Verner (1985).

[4] Calculated only for full territories.

Table 2: 2000 City of Austin Golden Cheeked Warbler Surveys - Summary of Findings-

Paring and Productivity

Plot Name	Females Observed (inferred)[1]	Number of Fledgling Groups[2]	Number of Fledglings Per Successful Pair[2]	Number of fledglings per territory[2]
Prime Plots				
Barton Creek				
1998	1(1)	1	2	1.3
1999	3(6)	6	2.2	2.2
2000	4(4)	2	1.5	.6
Emma Long				
1998	3(6)	6	2.3	1.3
1999	3(6)	6	2.3	2.0
2000	5 (5)	2	2	.33
Ivanhoe				
1998	2(3)	3	2.7	1.3
1999	3(4)	4	2.8	1.3
2000	1(1)	1	3	.43
St. Eds/3M				
1998	5(5)	2	2.5	0.8
1999	4(5)	3	1.7	0.7
2000	1(3)	2	2.5	.71
Forest Ridge				
1998	4(4)	3	2.3	1.1
1999	5(7)	6	2.7	1.5
2000	6(6)	5	2.8	2.0
Bohls Hollow				
1998	0	0	0	0
1999	0	0	0	0
2000	3	0	0	0
TOTALS				
1998	15(19)	15	1.97	.97
1999	18(28)	25	1.95	1.3
2000	17(19)	12	1.97	.68
Transitional Plots				
Double J and T				
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
Canyon Creek				
1998	0(0)	0	0	0.6
1999	1(1)	1	2	1.0
2000	0(0)	0	0	0
TOTALS				
1998	0	0	0	0.3
1999	1(1)	1	2	0.5
2000	0	0	0	0

[1] Presence of female inferred by the presence of juveniles.

[2] Calculated only for full territories.

Several potential nest predators were observed including, Blue Jay (*Cyanocitta cristata*), Western Scrub Jay (*Aphelocoma coerulescens*), Great-tailed Grackles (*Quiscalus mexicanus*), Common Grackle (*Quiscalus quiscula*), Texas rat snake (*Elaphe obsoleta lindheimeri*), eastern fox squirrel (*Sciurus niger*), and red imported fire ants (*Solenopsis invicta*). A Blue Jay was observed carrying food just outside the Forest Ridge plot and may have been nesting nearby. Many of the above predators thrive in urban and edge habitat and their numbers are likely unnaturally higher than they would be in less disturbed settings (Wilcove 1985). Large flocks of Common Grackles, a bird that is typically uncommon in western Travis County, were often seen near the Jester Estates subdivision on the Forest Ridge and Ivanhoe plots.

Notes on Specific Areas

Emma Long

Four nests were found in Emma Long Park, one within the plot and three within the motocross area. Only one nest (one within the motocross area) successfully fledged three young. One newly fledged GCW was found sitting on a small rock in the middle of Turkey Creek. The bird was slightly wet and appeared to be stranded. The observer picked up the bird and moved it to a safe location (the branch of a small tree). One GCW pair was observed feeding one cowbird fledgling.

Ivanhoe -- Due to the relocation of Austin's airport there was little or no airplane noise, making it easier to hear distant singing birds. On a few occasions noise from leaf blowers was high enough to make hearing birds difficult. A pair of Red-eyed Vireos (*Vireo olivaceus*) was observed carrying nesting material within the plot. Evidence of feral hog activity was seen throughout the plot. Common Grackles were observed on one occasion. Two female GCWs were observed fighting while a male GCW sang nearby. One of the GCW males had a very distinctive song (loud and rough).

St. Edwards/3M -- Two female warblers were seen fighting within one territory. Signs of feral hog (*Sus scrofa domesticus*) activity were noted throughout the plot. Unsanctioned use of the tract by horseback riders and mountain bikers was noted throughout the plot.

Forest Ridge -- One nest was found near the center of the plot. This nest was located about 15 feet above a trail that was likely an old ranch road. The trail is currently not a sanctioned trail though it may receive some illegal access at times. The nest was placed in an Ashe juniper about 15 feet off the ground and successfully fledged three young.

A second nest was found just west of the plot. This nest was constructed in a live oak tree and was unusually high at about 30-35 feet high. The nest also looked much larger than most golden-cheeked warbler nests. The nest tree was located in an area that had been hydroaxed sometime in the early 1980s. hydroaxed area was approximately 15 meters wide. This nest also fledged three young.

Surprisingly, a male warbler was found feeding two fledgling Black-and-white Warblers (*Mniotilta varia*). The male cared for the fledglings for at least nine days. The observer returned to the area several times to photograph the event, but was unsuccessful. The Black-and White Warbler fledglings were considerably shier than GCW fledglings and would not allow a close enough approach for pictures.

A male GCW was observed to stop singing after an accipiter sp. flew overhead.

Bolls Hollow -- Construction noise, coming from the Lake point Subdivision at the southeast, was generally high during the weekday work hours, and could be heard throughout the canyon. Two Black-and White Warbler nests were found, presumably from the same pair. Several GCW fledglings were observed on the plot but since they were fully feathered and independent of adults the observer was not able to assign them to a territory.

Double J and T -- While only one GCW spent time within the Double J and T plot, additional GCWs were heard further down the drainage to the east of the plot.

Canyon Creek -- On 3/26/00 A molting Yellow-rumped Warbler (*Dendroica coronata*) was seen beside a female GCW without any form of aggression from either bird. A male and female GCW were observed scolding a sleeping eastern fox squirrel. The squirrel was near the pairs' nest which was located high in a live oak tree. This nest was in a small (approx. 50 acres) strip of habitat near areas that were either hydroaxed or chained in the past. Evidence of feral hogs was observed throughout the plot.

II. BLACK-CAPPED VIREO MONITORING

INTRODUCTION

Black-capped Vireos (*Vireo atricapillus*) (BCV) have been known to occur on several City of Austin BCP properties in the past 15-20 years. Probably the best-known and studied vireo colony occurred at the Black-capped Vireo Research Area (BCVRA) off Loop 360. This group declined steadily from a high of 60 adults in 1985 to just one pair in 1997 (DLS 1988, Abbruzzese 1997). Other recent records (i.e. the past 10 years) of BCVs on COA land include sightings on the Forest Ridge, Park West, and Cortaña tracts.

Approximately 80 acres of an upland portion of the Cortaña tract was managed for vireo habitat in the winter of 1995. Juniper-oak woodland was cleared using both hand clearing and hydroaxing. In the past 3-4 years several vireos have been observed by SWCA Inc. staff in this managed area but none appeared to stay for any length of time (D. Booher pers. com. 1999).

METHODS

Vireos were surveyed on the BCVRA, and on the managed area on Cortaña following methods described in the "minimum procedures for determining the Presence/Absence of Golden-cheeked Warblers and Black-capped Vireos" (USFWS 1984) with the exception that the BCVRA only received three visits. When a vireo was encountered its territory was mapped using methods described by the IBCC (1970).

RESULTS AND DISCUSSION

Three male vireos were observed defending territories on the managed portion of the Cortaña tract. All three males on the Cortaña tract were thought to be older than two years based on the jet-black color on the nape of the neck (Grzybowski 1995). At least one male was mated and produced at least two young. Based on field observations it is believed that this pair nested along the northern boundary of the Cortaña tract near RR 620. A pair of Yellow-breasted Chats was also believed to be nesting in this managed area. Yellow-breasted Chats were not previously known to nest on city owned BCP properties however they are common in areas managed for the vireo on the BCNWR. Other regionally declining species like Painted Buntings (*Passerina cirus*), Black-chinned Hummingbirds (*Archilochus alexandri*), Rufous-crowned Sparrows (*Aimophila ruficeps*) and Northern Bobwhites (*Colinus virginianus*) were also observed on both the BCVRA and the managed area of Cortaña (Shackleford and Lockwood 2000).

No Black-capped Vireos were observed on the BCVRA property during the 2000 field season. This is not surprising considering the continual decline of vireos on that preserve and the fact that only one pair remained in 1997. In addition, the male of this pair (nicknamed "Switchbags") was banded as an adult in 1986 so he was at least 11 years old: making him one of the longest lived BCVs known. This decline is likely caused by a number of factors which have degraded the habitat, including encroachment of surrounding development which has led to high numbers potential predators such as feral and tame cats, raccoons, and jays. Natural regrowth of the habitat may have also been a factor in the decline of the colony. These same factors are probably responsible for the general decline of BCVs throughout Travis County and may explain the lack of vireos on other COA properties.

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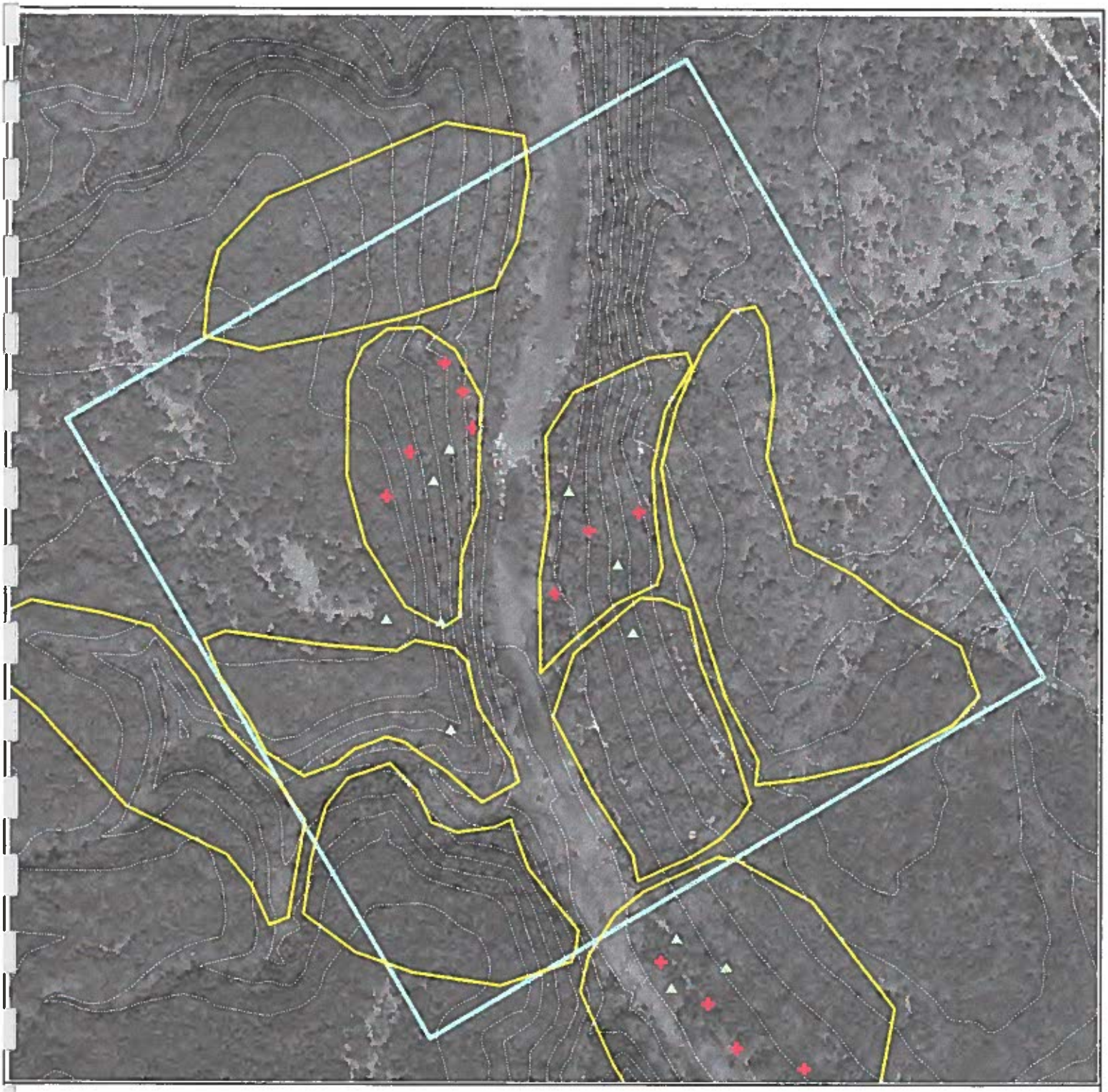


2000 Golden-Cheeked Warbler Surveys
Barton Creek 100-acre Plot

Figure 1

Legend

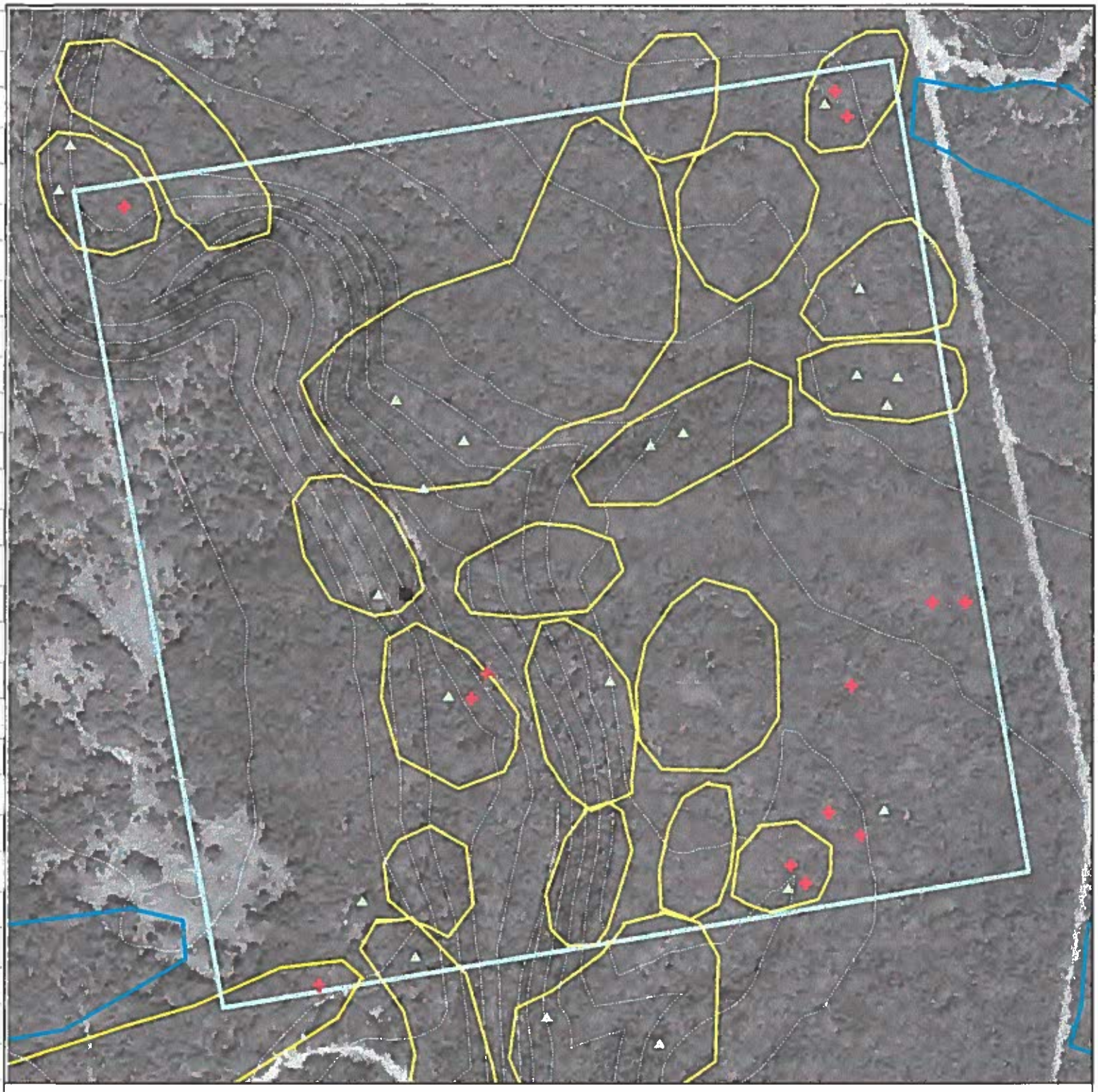
- GCW Fledglings
- GCW Females
- GCW Territory Boundary
- Plot Boundary

N
W E
S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Austin West, Tex.
Observer: David Hernandez



2000 Golden-Cheeked Warbler Surveys
Emma Long 100-acre Plot

Figure 2

Legend

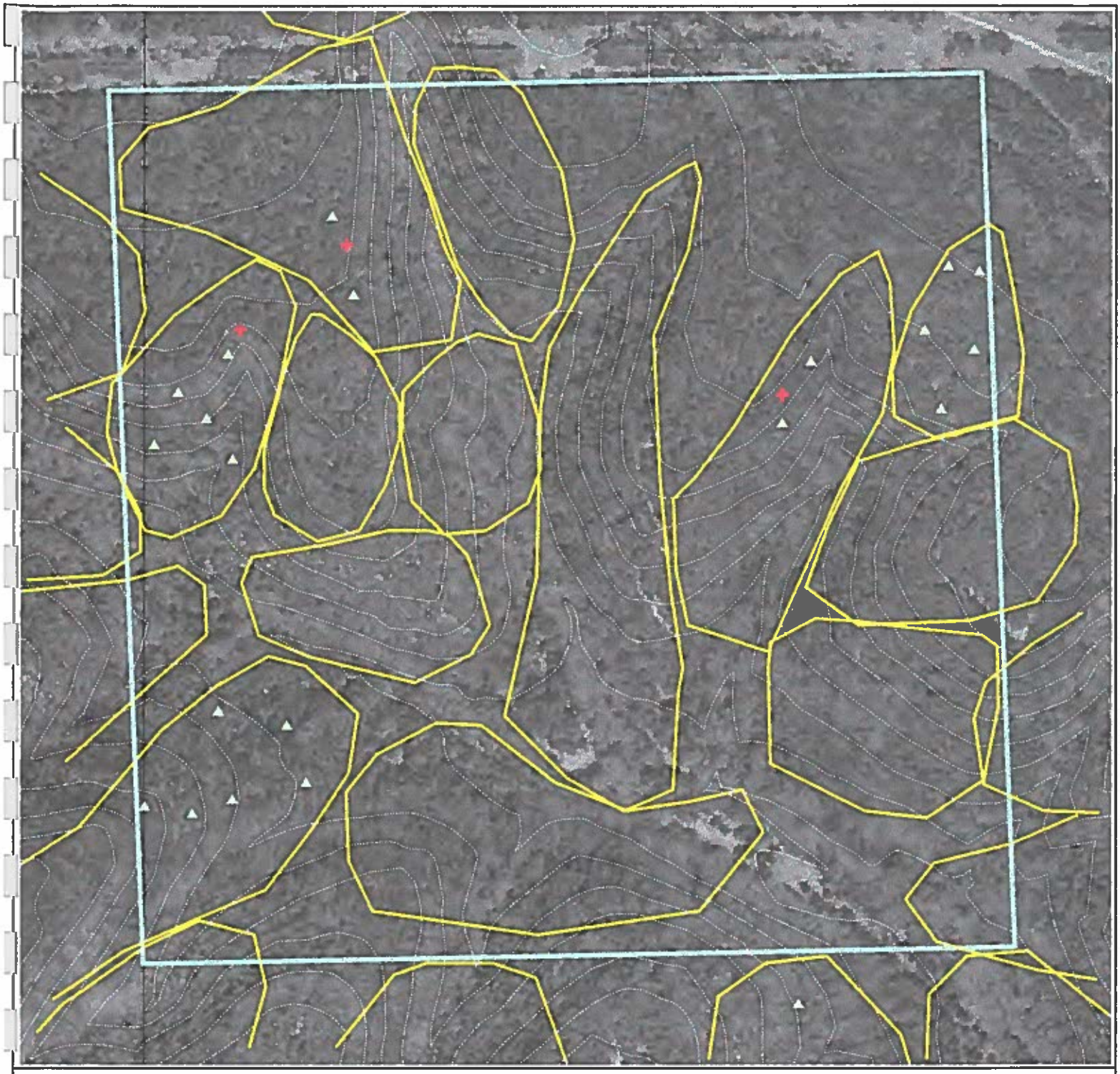
- GCW Nest
- GCW Fledglings
- GCW Females
- GCW Territory Boundary
- Plot Boundary
- Enumeration

N
W E
S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Austin West Tex.
Observer: D.Thompson



2000 Golden-Cheeked Warbler Surveys
Ivanhoe 100-acre Plot

Figure 3

Legend

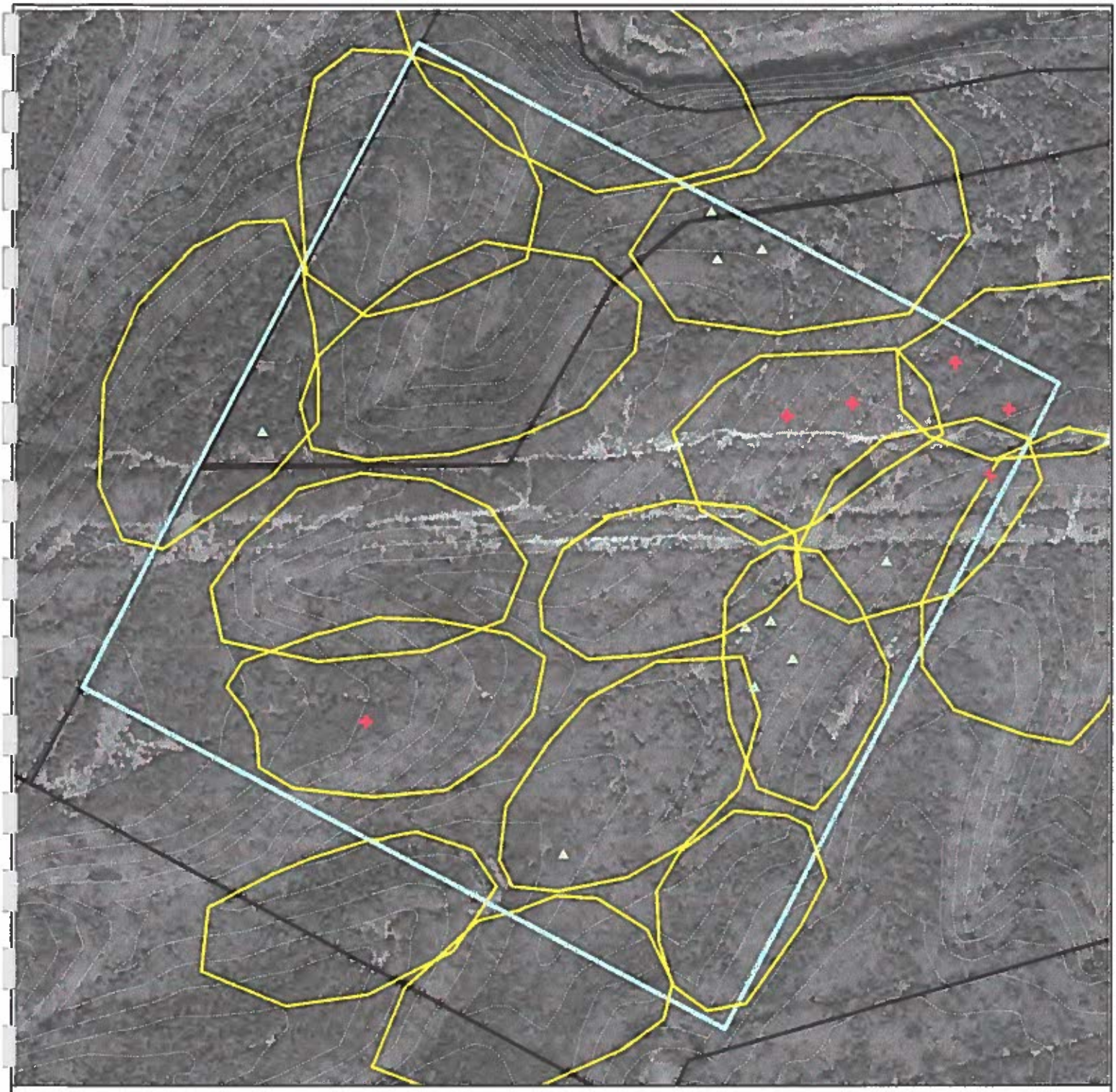
- GCW Fledglings
- GCW Females
- GCW Territory Boundary
- Plot Boundary

N
W E
S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Jollyville, Tex.
Observer: Mark Sanders



2000 Golden-Cheeked Warbler Surveys
3M/St. Edwards 100-acre Plot

Figure 4

Legend

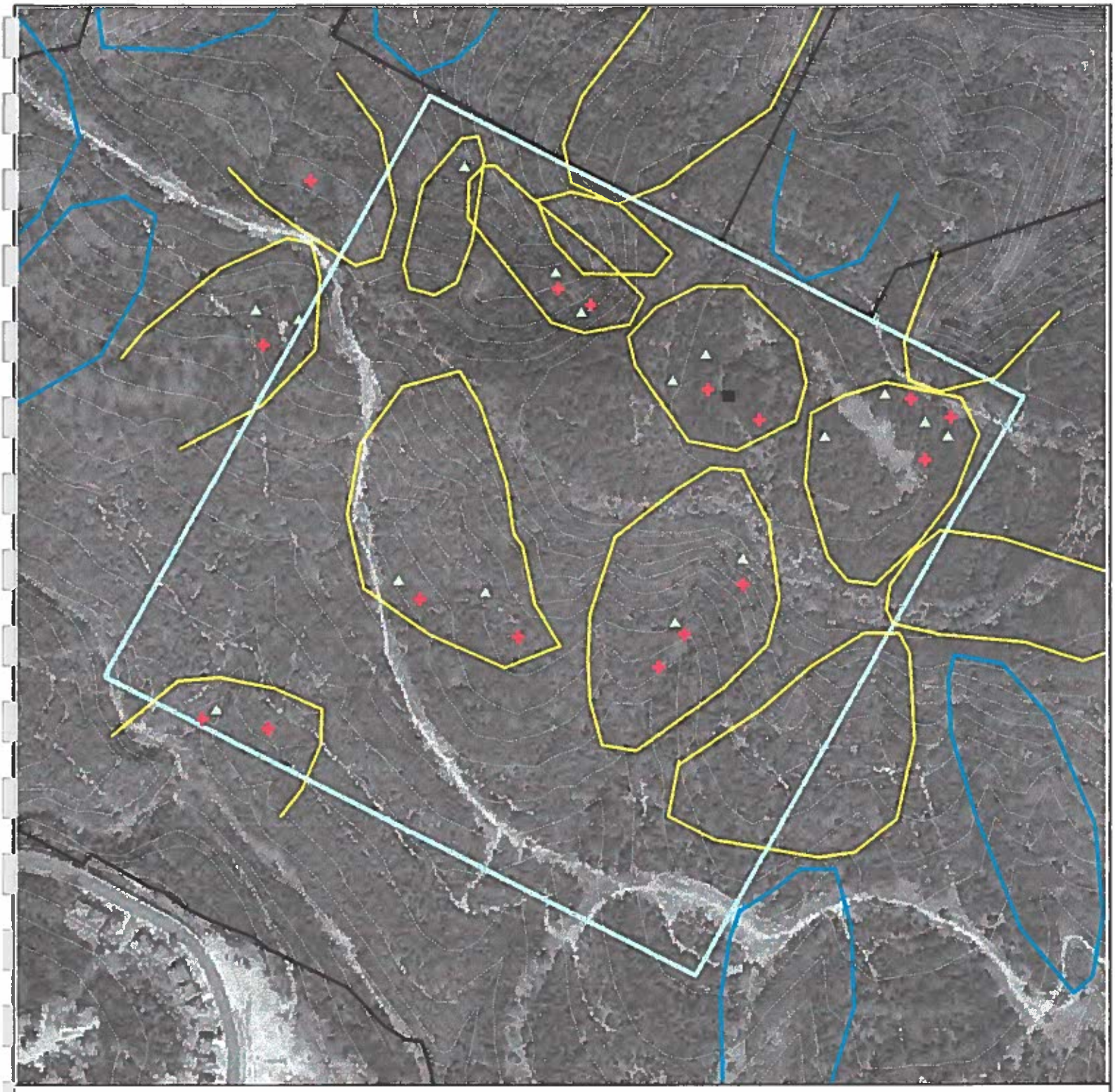
- Property Boundary
- GCW Fledglings
- GCW Females
- GCW Territory Boundary
- Plot Boundary

N
W E
S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Jollyville, Tex.
Observer: Jackie Davis



2000 Golden-Cheeked Warbler Surveys
Forest Ridge 100-acre Plot

Figure 5

Legend

- GCW Nest
- GCW Fledglings
- GCW Females
- GCW Enumeration
- GCW Territory Boundary
- Plot Boundary
- Property Boundary

N
W E
S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Jollyville, Tex.
Observer: Carlo Abbbruzzese



2000 Golden-Cheeked Warbler Surveys
Bohls100-acre Plot

Figure 6

Legend

- GCW Fledglings
- GCW Females
- Property Boundary
- GCW Territory Boundary
- Plot Boundary

N
W E
S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Bee Cave, Tex.
Observer: Carlo Abbruzzese



2000 Golden-Cheeked Warbler Surveys
Double J & T 100-acre Plot

Figure 7

Legend

GCW Territory Boundary

Plot Boundary

Property Boundary

N

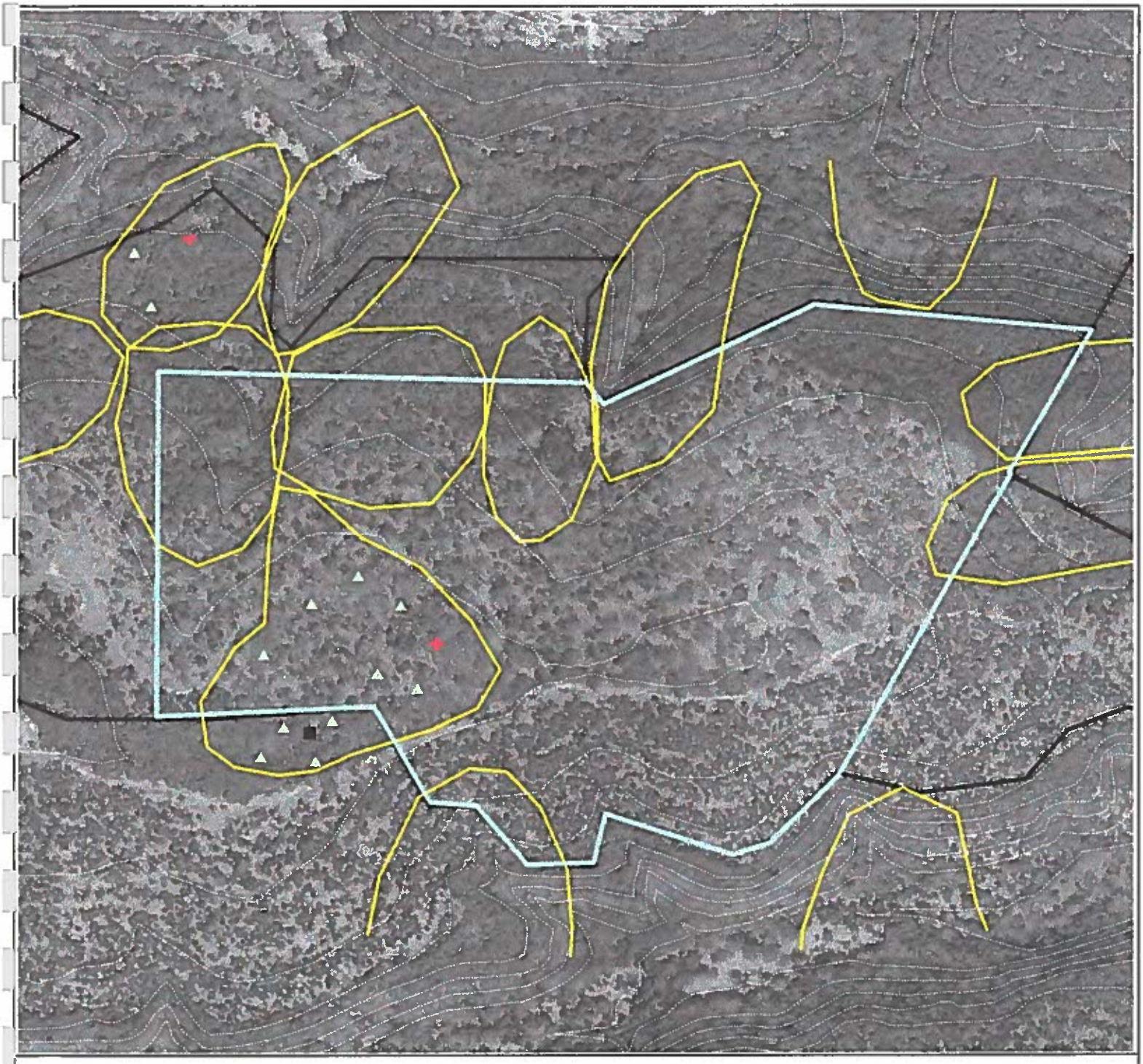
W E

S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Bee Cave, Tex.
Observer: Jackie Davis



2000 Golden-Cheeked Warbler Surveys
Canyon Creek 100-acre Plot

Figure 8

Legend

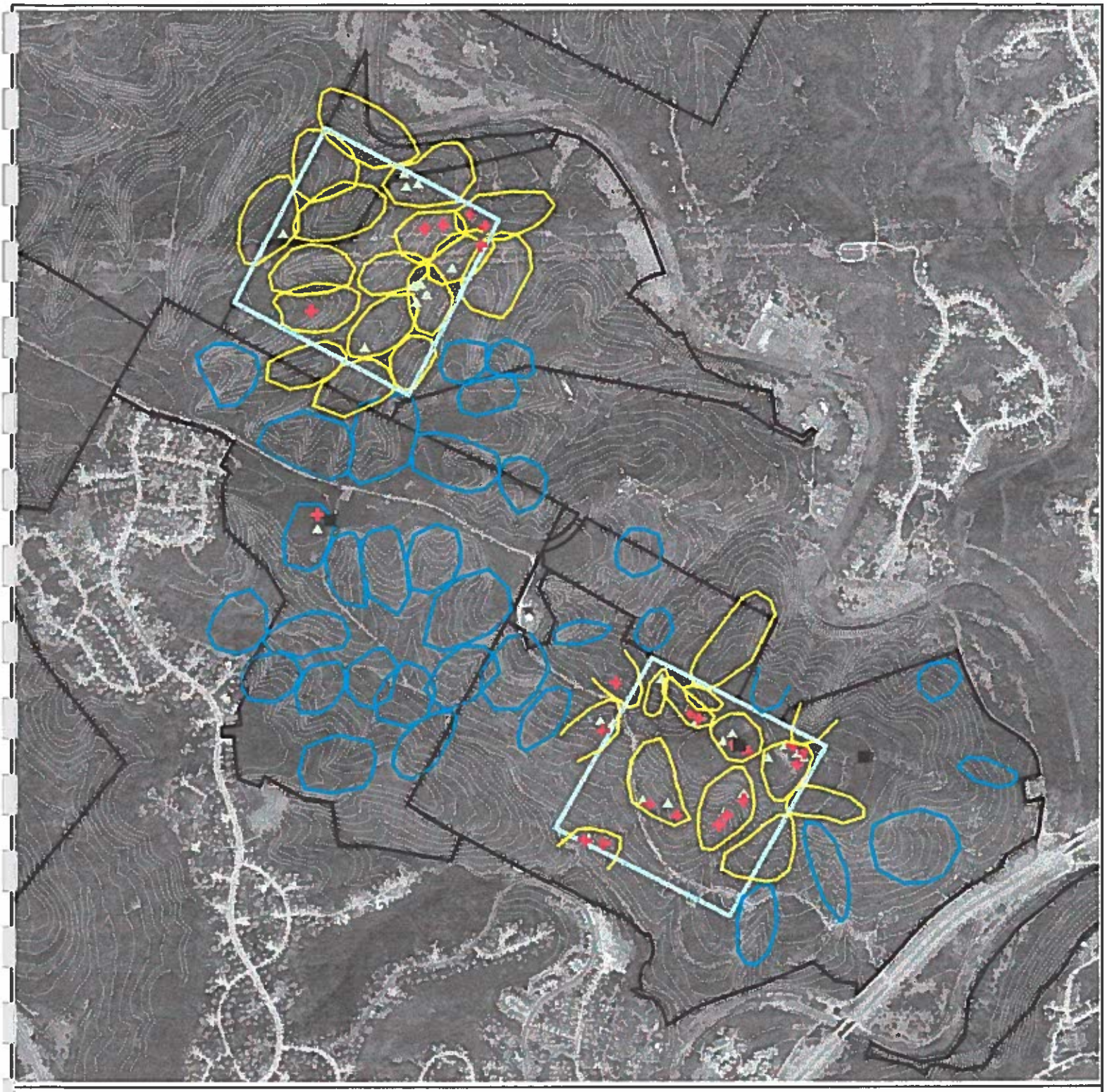
- GCW Nest
- GCW Fledglings
- GCW Females
- GCW Territory Boundary
- Plot Boundary
- Property Boundary

N
W E
S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Jollyville, Tex.
Observer: Mark Sanders



2000 Golden-Cheeked Warbler Surveys
Bull Creek Enumeration

Figure 9

Legend

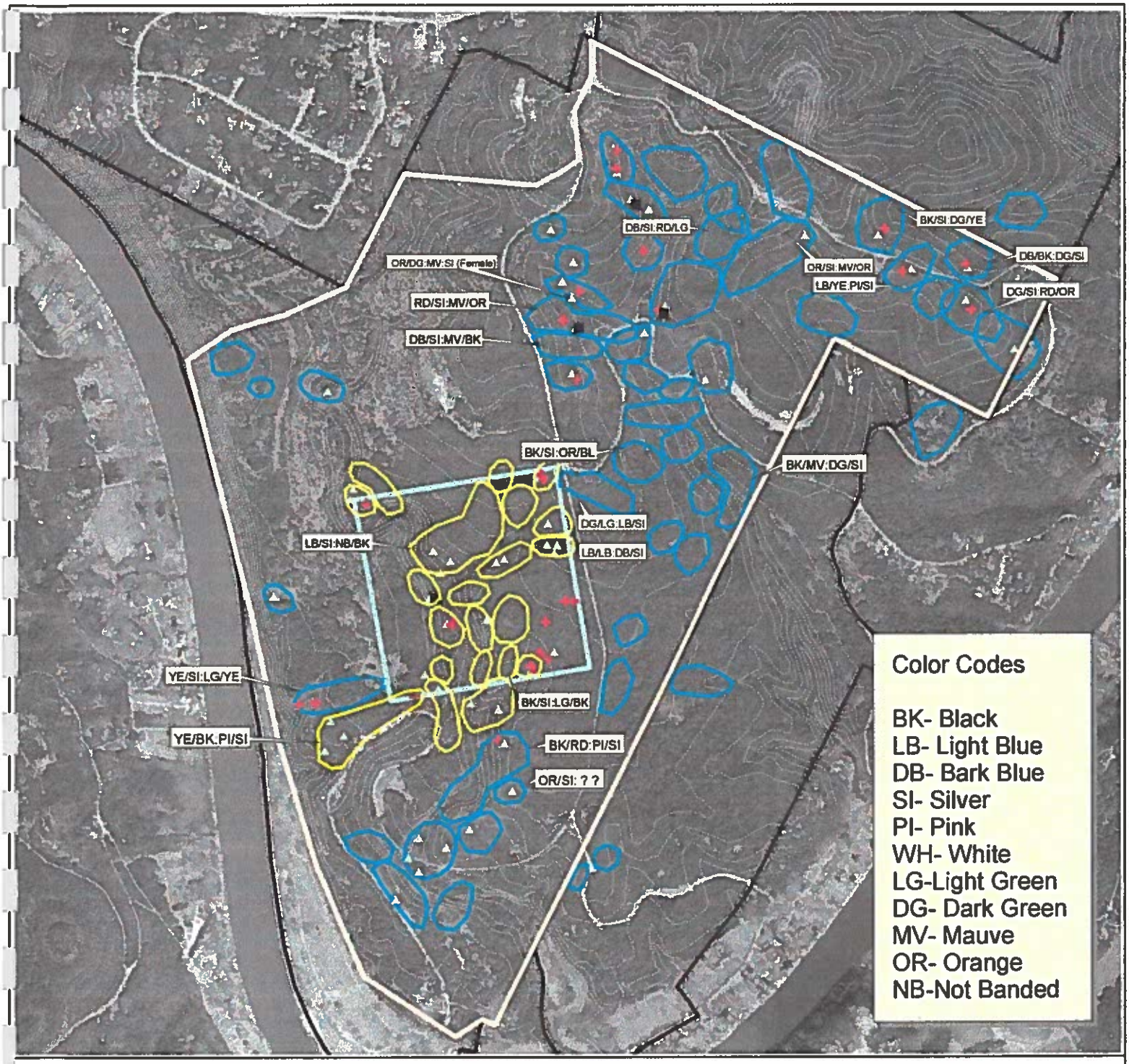
- GCW Nest
- GCW Fledglings
- GCW Females
- GCW Enumeration
- GCW Territory Boundary
- Plot Boundary
- Property Boundary

N
W E
S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Jollyville, Tex.
Observers: Jackie Davis, Melody Lytle



2000 Golden-Cheeked Warbler Surveys
Emma Long Enumeration

Figure 10

Legend

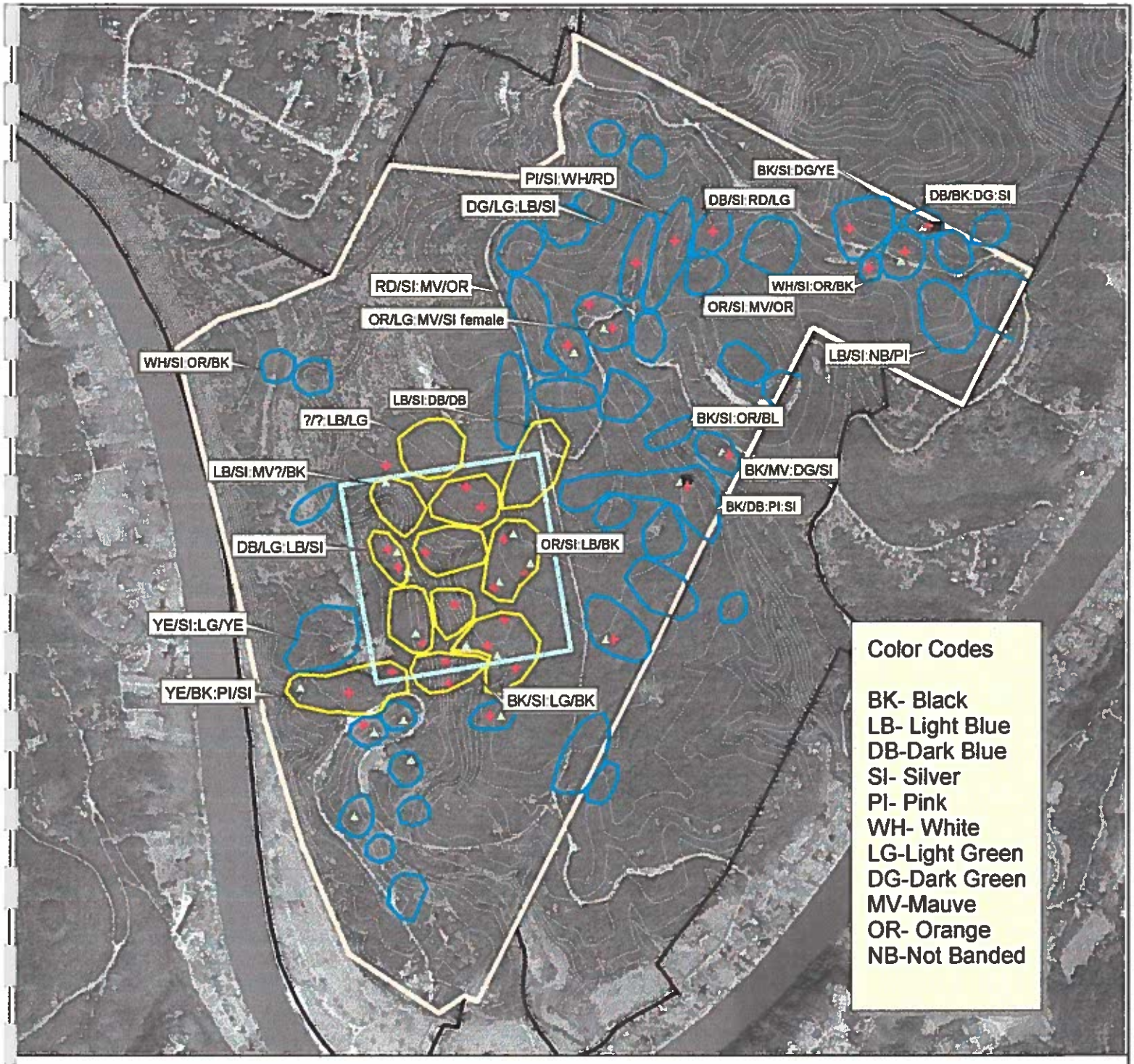
- Plot Boundary
- GCW Nest
- GCW Fledglings
- GCW Females
- YE/BK:PI/Si Colorbanded GCW
- GCW Territory Boundary
- Property Boundary
- Survey Area
- Enumeration

N W E S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Austin West Tex.
Observer: D.Thompson, C. Abbruzzese, M. R. Holder



1999 Golden-Cheeked Warbler Surveys
Emma Long Enumeration

Figure 11

Legend

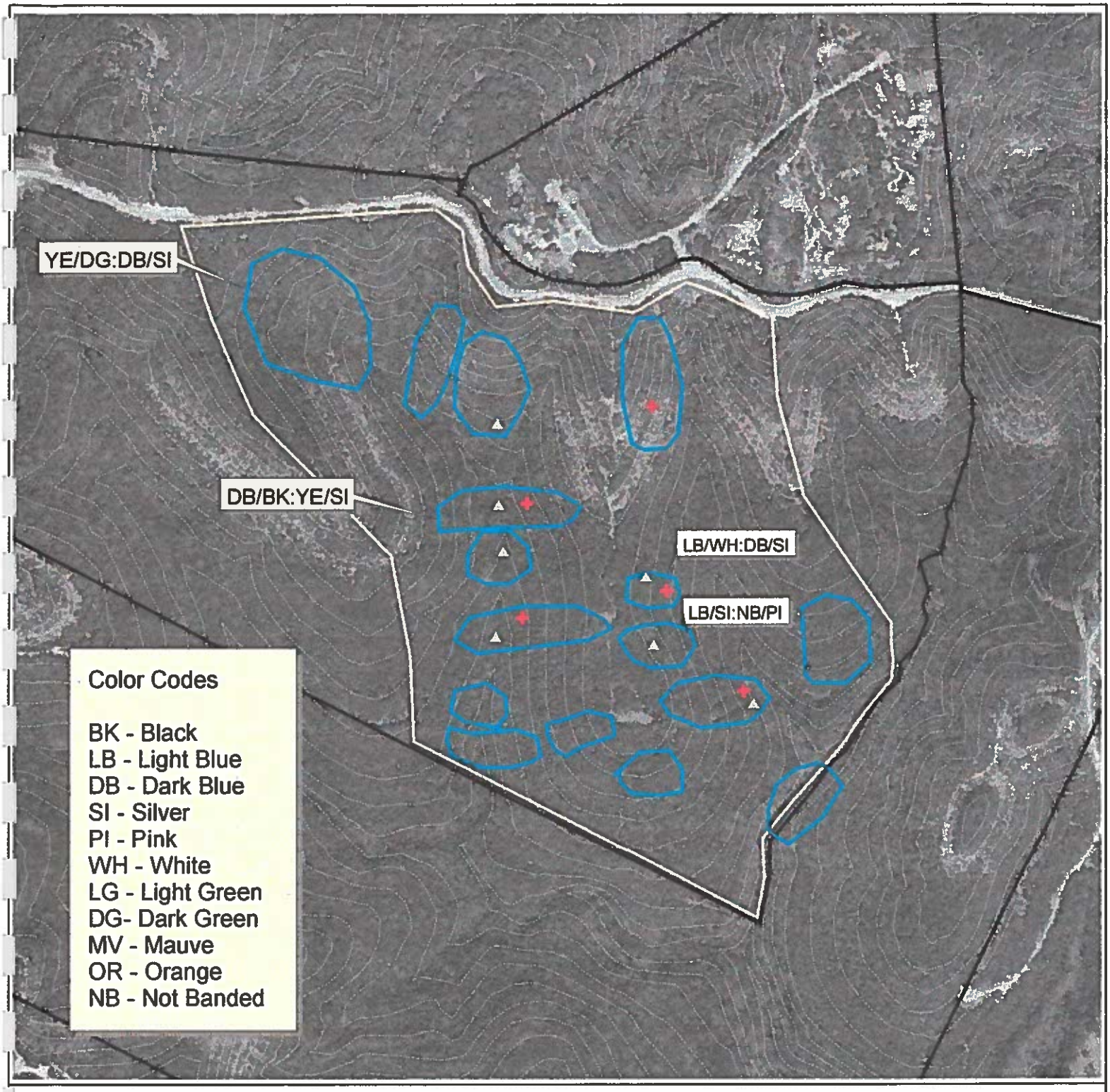
- Plot Boundary
- GCW Nest
- GCW Fledglings
- GCW Females
- YE/BK:PI/SI Colorbanded GCW
- GCW Territory Boundary
- Property Boundary
- Survey Area
- Enumeration

N W E S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Austin West Tex.
Observer: D.Thompson, C. Abbruzzese, M. R. Holder



2000 Golden-Cheeked Warbler Surveys
Coldwater Enumeration

Figure 12

Legend

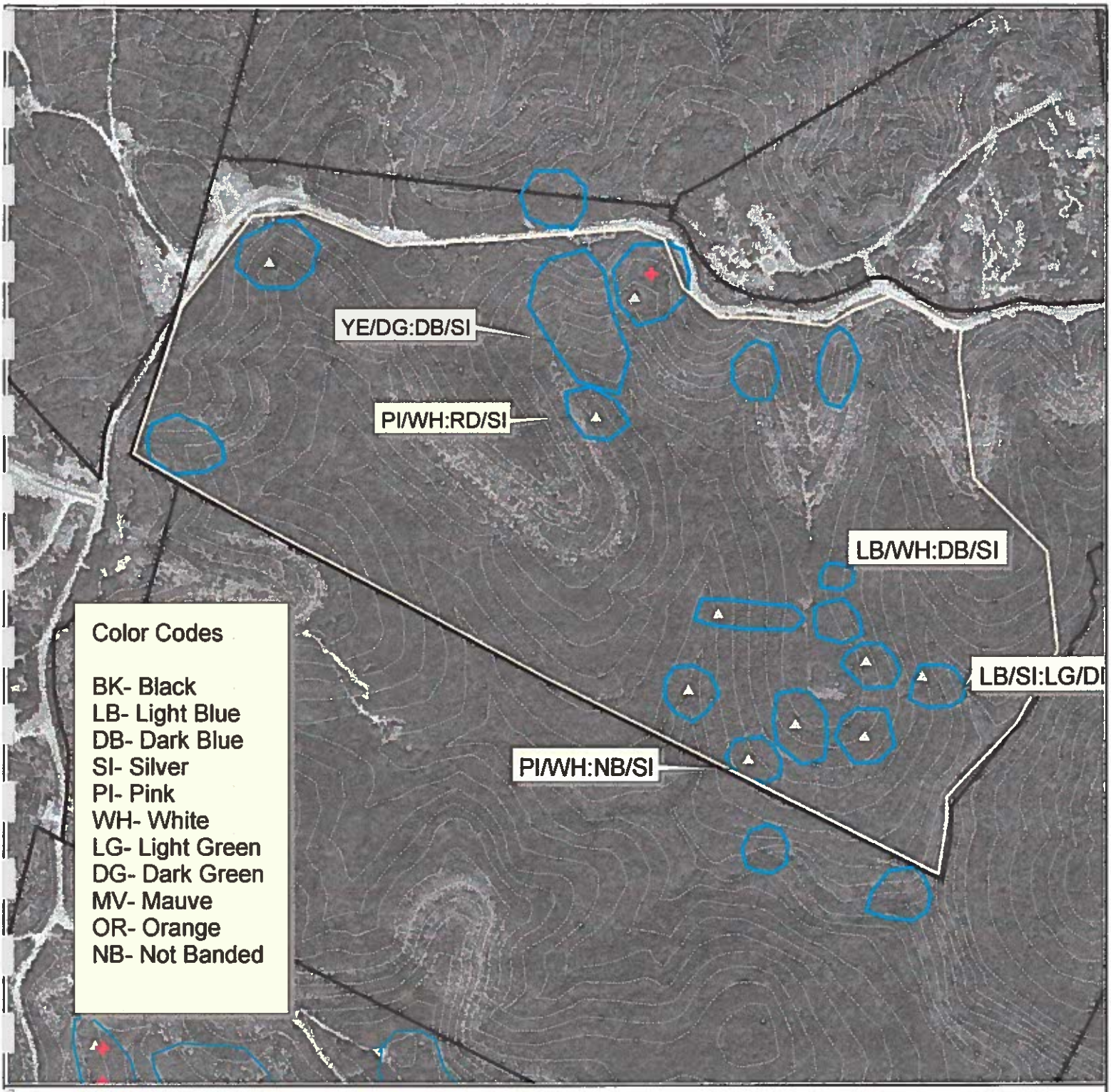
- GCW Nest
- GCW Fledglings
- GCW Females
- YE/DG:DB/SI Colorbanded GCW
- GCW Enumeration
- Survey area
- Property Boundary

N W E S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Austin West, Tex.
Observer: D. Thompson, C. Abbruzzese



1999 Golden-Cheeked Warbler Surveys
Coldwater Enumeration

Figure 13

Legend

- GCW Nest
- GCW Fledglings
- GCW Females
- YE/DG:DB/SI Colorbanded GCW
- GCW Enumeration
- Survey area
- Property Boundary

N W E S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Austin West, Tex.
Observer: S. Haywood, C. Abbruzzese



2000 Black-capped Vireo Surveys
Black-capped Vireo Research Area

Figure 14

Legend

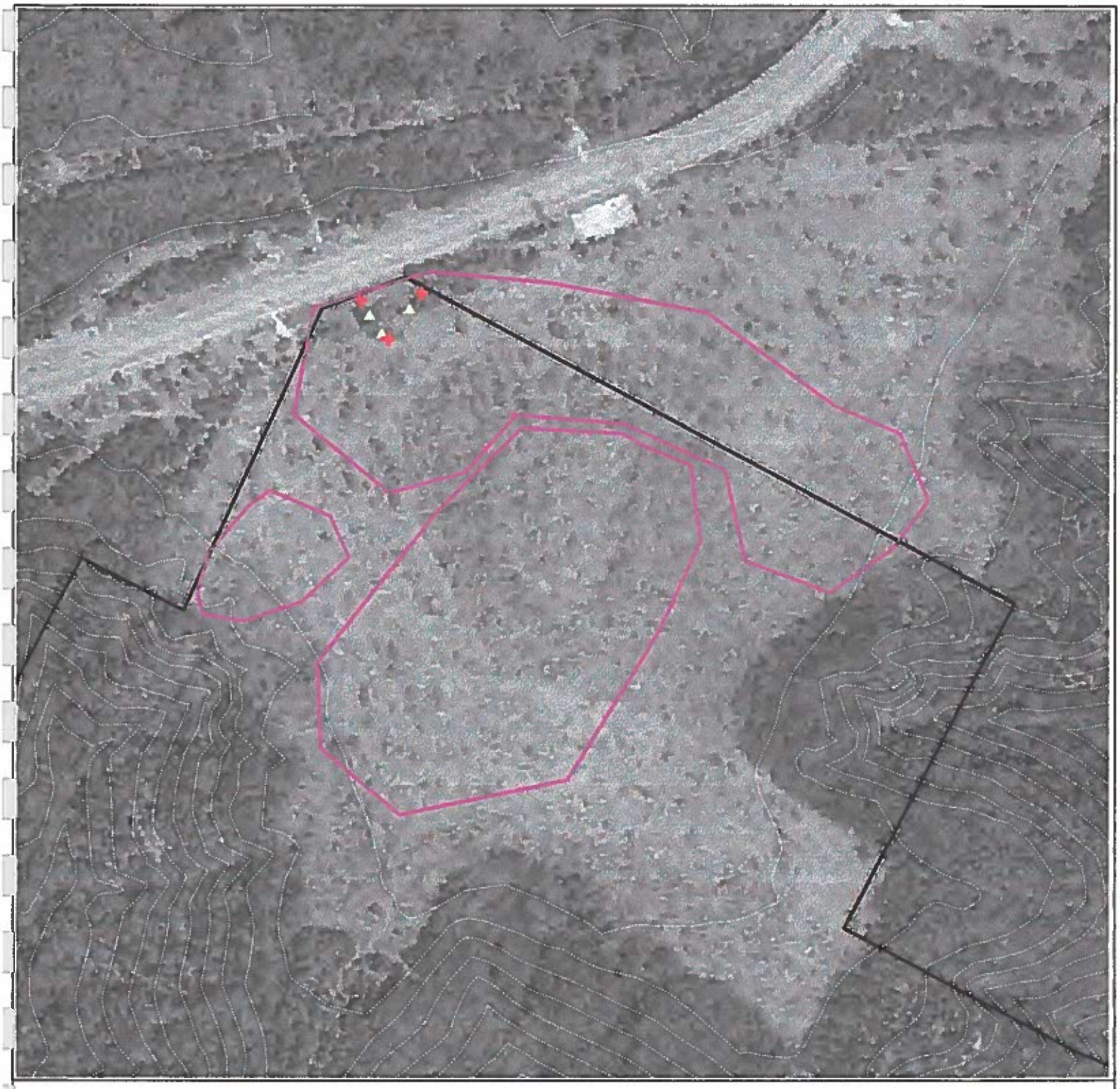
- BCV Territory Boundary
- BCV Fledglings
- BCV Females
- Property Boundary
- Survey Area

N W E S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Austin West Tex.
Observer: M.Reimer, C. Abbruzzese



2000 Black-capped Vireo Surveys
Cortana Tract

Figure 15

Legend

- BCV Fledglings
- BCV Females
- BCV Territory Boundary
- Property Boundary

N
W E
S

Scale

400 0 400 Meters

Base Map: USGS 7.5' Jollyville, Tex.
Observer: M. Reimer, D. Thompson, C. Abbruzzese

APPENDIX I. 1998 Golden-cheeked Warbler Surveys- Summary of Survey Effort, Weather Conditions and Findings.

Barton Creek-Prime Plot

Date	Time (Start-end)	Temperature (Deg. F) (Start-end)	Wind Dir. (Start/end)	Wind Speed (mph) (Start/end)	Cloud Cover (%) (Start-End)	Personnel	Comments
3/25/00	7:30-2:30	73-82	*	0-5	20-100	David Hernandez	4 Males observed
4/8/00	8:00-2:00	57-67	*	0-10	0-0	DH	4 Males observed
4/16/00	7:30-2:00	73-83	*	0-5	90-20	DH	5 Males observed
4/24/00	7:45-1:30	73-87	*	0-5	10-10	DH	5 Males observed
4/30/00	8:00-2:00	72-87	*	5-15	100-100	DH	5 males observed
5/7/00	7:30-2:00	73-82	*	0-5	80-20	DH	8 males, observed
5/13/00	7:00-12:45	67-77	*	5-15	100-100	DH	2 males, observed
5/28/00	7:30-1:30	72-87	*	0-5	100-60	DH	1 male observed
6/3/00	7:00-1:00	72-90	*	0-10	100-100	DH	2 males observed

* Data not collected

Emma Long-Prime Plot

Date	Time (Start-end)	Temperature (Deg F) (start-end)	Wind Dir. (start-end)	Wind Speed (mph) (start/end)	Cloud Cover (%) (start-end)	Personnel	Comments
3/27/00	6:35-1:40	68-82	E/E	2/14	50/10	Daniel Thompson	10 males observed
4/7/00	7:34-1:57	61-79	S/S	6/14	100/0	DT	9 males, 1 female observed
4/18/00	7:23-2:30	65-77	S/S	3/5	50/100	DT	7 males, 3 Females, 2 Fledglings observed
4/23/00	7:13-1:34	71-93	SE/W	6/16	50/0	DT	8 males, 3 females, nest observed
4/28/00	7:28-1:50	71-85	-/W	-/5	100/0	DT	6males, 3females, 8 fledlings.
5/3/00	6:45-1:36	61-75	-/S-SW	-/5	100/30	DT	11 males, 1 female, 3 fledglings observed
5/8/00	7:32-2:32	71-88	S/S	3/10	75/10	DT	12 males, 3 females,5 fledglings observe
5/16/00	7:15-2:00	73-88	S/S	12/17	100/10	DT	14 males, 0 females, and 9 fledglings observed
5/22/00	7:10-1:10	69-92	S/S	2/5	0/0	DT	11 males, 0 females,15 fledglings observed
6/5/00	7:10-2:00	70-82	-/N	-/10	100/75	DT	13 males, 1 female, 4 fledglings observed

Ivanhoe –Prime Plot

Date	Time (Start-end)	Temperature (Deg. F) (Start-end)	Wind Dir. (Start/end)	Wind Speed (mph) (Start/end)	Cloud Cover (%) (Start-End)	Personnel	Comments
3/27/00	7:00-1:20	70-81	NE-W/E-NE	5-12/5-15	100/100	Mark Sanders	15 males, 2-3 females observed,
4/5/00	7:45-2:00	56-78	S/S-SW	0-5/15 Gusty at times	100/100	MS	10 males observed, 1-2 females
4/13/00	7:45-1:45	62-73	E/E	0-5/0-5	100/0	MS	13 males, 1-2 female
4/20/00	7:25-1:30	74-80	NW-E/N	5-15/5-15 Gusty at times	100/0	MS	9 males, 2 females, one or more fledglings.
4/27/00	7:20-1:20	71-82	E /SE	0-10/5-15 Gusty at times.	50/0	MS	10-12 males, 1 female, 4-6 fledglings observed
5/3/00	7:35-1:40	63-78	N/S	0-2/0-10 Gusty	100/0	MS	13 males, 1 female, 4-6 fledglings observed
5/10/00	7:30-1:30	72-82	SE	0-3/5-15 Gusty	100/50	MS	8-10 males, 1 female, 5-8 fledglings observed
5/19/00	7:55-2:00	76-85	E-SE/W-SW	0-5/5-10	100/100	MS	8 males, 2-3 female, 6-10 fledglings.
5/26/00	7:35-1:35	77-85	S/SE	5/15 gusty at times		MS	7 males, 3-4 fledglings
6/2/00	7:30-1:30	74-84	S-SE/S	2-10/5-15	100/50	MS	5-6 Males, 2-3 fledglings observed

St. Edwards/3M- Prime Plot

Date	Time (Start-end)	Temperature (Deg. F) (Start-end)	Wind Dir. (Start/end)	Wind Speed (mph) (Start/end)	Cloud Cover (%) (Start-End)	Personnel	Comments
3/21/00	7:30-1:30	63-71	SE/SE	5-10/5	100/100	Jackie Davis	13 males, 2 females observed
3/28/00	7:00-1:30	69-79	SE/SE	0-3/0-3	100/50	JD	12 males, 2 females together
4/5/00	8:00-2:00	57-80	SE/SE	0-5/5-10	0/0	JD	DST Starts-7 males, 1female observed.
4/13/00	7:45-1:45	59-80	NE/NE	0-3/0-3	100-20	JD	8 males, 2 females observed
4/20/00	7:30-1:30	69-85	SE/SE	5-10/10-15	10/0	JD	7 males, 1 female observe
4/24/00	7:00-1:00	68-90	NE/-	10/3-8	0/0	JD	10 males observed
5/2/00	7:30-1:30	59-72	-/NW	0/3-5	100/50	JD	8 males, 1 female observed
5/8/00	7:00-1:00	70-90	SE/SE	5-10/10	50/50	JD	8 males, 6 fledlings (3 pairs) observed
5/11/00	7:30-1:30	70-88	S/S	5-10/5-10	40/35	JD	9 males, 2 fledglings observed.
5/23/00	7:30-1:30	68-91	S/S	5-10/5-10	10/0	JD	9 Males, 1 female, 1 fledgling observed.

Forest Ridge-Prime Plot

Date	Time (Start-end)	Temperature (Deg. F) (Start-end)	Wind Dir. (Start/end)	Wind Speed (mph) (Start/end)	Cloud Cover (%) (Start-End)	Personnel	Comments
3/30/00	7:06-1:15	60-75	SW/W	0-5/0	0-25	Carlo Abbruzzese	9 Males, 4 Females observed
4/13/00	7:15-1:10	65-70	-/SW	0/5	100-60	CA	13 Males, 2 Females Observed
4/21/00	7:05-1:25	60-75	-/SW	0/0-5	0-10	CA	9 Males, 1Female, 2-3 Fledglings
4/27/00	7:00-1:10	68-80	S/SE	0-5/0-5	100/25	CA	7 Males, 2 Females, 3 Fledglings
5/5/00	7:15-1:25	70-80	-/SE	0/10	100/40	CA	9 Males, 2 Females, 4 Fledglings, Nes found.
5/12/00	7:15-1:30	70-85	-/S	0/5	100/80	CA	9 Males, 1 Female, 3-4 Fledglings.
5/18/00	7:15-1:15	75-85	SE/E	0-5/0-10	90/60	CA	7 Males, 2 Females, 3 fledglings
5/23/00	7:10-1:20	78-85	-/SW	0/5	90/40	CA	7 Males, 3 Females, 6 Fledglings, 1 BHCO HY fed by GCW.
5/26/00	7:00-1:15	75-88	-/S	0/10	100/20	CA	8 Males, 2 Females, 1Males feeding 2HY BWWA.
6/2/00	7:15-1:20	75-85	S/SW	5/10	100/30	CA	7 Males, 1 Female, GCW males still feeding 2 HY BWWA

Bohls Hollow-Prime Plot

Date	Time (Start-end)	Temperature (Deg. F) (Start-end)	Wind Dir. (Start/end)	Wind Speed (mph) (Start/end)	Cloud Cover (%) (Start-End)	Personnel	Comments
3/27/00	7:00-1:00	70-84	NE/E	5-10/5-10	100/100	Carlo Abbruzzese	6 Males observed, 1-2 females observed.
4/7/00	7:30-1:30	65-78	-/SE	-/5-10	100/100	CA	4 Males, 1 Female observed
4/18/00	7:15-1:15	70-85	-/S	-/5	90/50	CA	2 Males observed
4/26/00	7:08-1:08	60-75	-/NE	-/5-10	0/0	CA	3 Males, 1 Females observed
5/4/00	7:10-1:10	70-85	-/SW	-/10	100/20	CA	5 Males, 1 Female Observed
5/9/00	7:20-1:20	72-87	-/W	-/5	100/0	CA	2 Males, 1 female Observed
5/15/00	7:15-1:20	66-80	-/-	-/-	10/25	CA	2 Males, common grackles observed
5/24/00	7:18-1:25	75-88	E/SE	0-5/5-10	10/0	CA	2 Males, BWWA nest Observed
5/29/00	7:10-1:15	70-87	-/NW	-/0-5	100/20	CA	1Male Observed, 1 Fledgling
6/7/00	7:20-1:25	70-85	-/S	-/5-10	0/0	CA	4 Fledglings (2 groups) Observed

Canyon Creek – Transitional Plot

Date	Time (Start-end)	Temperature (Deg. F) (Start-end)	Wind Dir. (Start/end)	Wind Speed (mph) (Start/end)	Cloud Cover (%) (Start-End)	Personnel	Comments
3/26/00	7:00-1:00	71-88	SE to S	0-5/5-10	100 misty/50	Mark Sanders	4 to 5 males, 1 female observed.
4/30/00	7:30-1:30	75-84	SE-S/SE-SW	0-7/15 gusty at times	100/50	MS	4 males
5/28/00	7:45-1:45	78-85	N to N-NW	0-3 to 5-10	50/50	MS	2 to 3 males, 1 female, 3-4 fledglings observed.

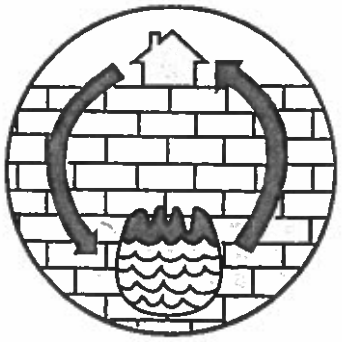
Double J and T – Transitional Plot

Date	Time (Start-end)	Temperature (Deg. F) (Start-end)	Wind Dir. (Start/end)	Wind Speed (mph) (Start/end)	Cloud Cover (%) (Start-End)	Personnel	Comments
4/19/00	7:00-1:00	68-90	SE/SE	5-10/10	80/90	Jackie Davis	1 male observed
5/15/00	7:30-1:30	65-90	S/S	5-10/10	10/0	JD	1 male observed
5/24/00	7:30-1:30	72-92	SE/SE	0-5/5	0/0	JD	1 male observed

ATTACHMENT F

GEORGE VENI

HYDROGEOLOGIC ASSESSMENT OF FLINT RIDGE CAVE



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Cave and Karst Specialists

HYDROGEOLOGIC ASSESSMENT OF FLINT RIDGE CAVE, TRAVIS COUNTY, TEXAS

Prepared for:

City of Austin
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10 May 2000

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HYDROGEOLOGIC ASSESSMENT OF FLINT RIDGE CAVE, TRAVIS COUNTY, TEXAS

by
George Veni, Ph.D.

Introduction

State Highway 45 is proposed for construction in southern Travis County, Texas. Its proposed right-of-way includes Flint Ridge Cave, which is listed in the Balcones Canyonlands Conservation Plan (BCCP) regional 10(a) permit as one of 62 caves that will be protected by the City of Austin and Travis County (USFWS, 1996). The cave is the second deepest and fifth longest known in the county (Russell, 1996a), and it is hydrologically significant by draining a relatively large area of surface runoff into the Barton Springs Segment of the Edwards Aquifer (hereafter called the "Edwards Aquifer"). The cave is biologically significant because it provides habitat to two of the 25 karst invertebrate species of concern listed under the BCCP permit. The species of concern present in Flint Ridge Cave are troglobites, the spider *Cicurina cueva* and the ground beetle *Rhadine austinica* (Elliott, 1997).

The purpose of this study is to hydrogeologically evaluate Flint Ridge Cave and potentially associated hydrogeologic features to determine the routes of drainage into the cave. This information will help guide the City of Austin and Travis County in locating proposed State Highway 45 and associated protective structures in places where they would prevent or minimize adverse impacts from the highway on the quality and quantity of water entering the Edwards Aquifer, and to prevent or minimize adverse impacts on the cave's ecosystem.

The Flint Ridge Cave study area is located at the southern edge of Travis County, Texas. It is about 2 km north and northeast of Bear Creek, which locally flows southeast, roughly parallel to and about 1.5 km north of the Hays County line. The general area examined during this investigation extends about 600 m north and 400 m south, east, and west of the cave's entrance. The City of Austin Parks and Recreation Department contracted this study and arranged access to the property. State Highway 45 is proposed to extend northwest through the area, with its approximately 320-m-wide right-of-way located on the small ridge containing the cave.

This project was coordinated by Dr. George Veni, hydrogeologist. The fieldwork was conducted on 22-23 December 1999 with the assistance of field biologist and environmental chemist Allan Cobb, and karst technicians Lee Jay Graves and Bruce Johnson. Peter Sprouse was the project cartographer. Valuable assistance was provided to the project through several other sources. Mel Hinson of the City of Austin's Parks and Recreation Department, and Sylvia Pope, of the City's Watershed Protection Department, provided technical information on the proposed highway alignment and local geologic and karst feature data. Julie Jenkins and William H. Russell, of the Texas Cave Management Association (TCMA), provided maps and information on Flint Ridge Cave, including recent survey data and reports on the cave and

nearby karst features; Russell granted permission for the redrafting and updating of his map of the cave for this report. Hinson, Pope, and Russell also provided valuable review comments on the draft version of this report. Nico Hauwert, hydrogeologist for the Barton Springs/Edwards Aquifer Conservation District, but in his role as TCMA volunteer, provided additional site-specific information on the geology at the cave and access to Lost Oasis Cave.

The study area is located in the recharge zone of the Edwards Aquifer. The aquifer's Barton Springs Segment has been the topic of numerous studies. Notable hydrogeologic overviews and data compilations include work by Slade et al. (1980, 1982, 1983, 1984), Brune and Duffin (1983), Senger (1983, 1984), Senger and Kreitler (1984), Slade (1984), Woodruff (1984), Woodruff and Slade (1984), Baker et al. (1986), Slagle, Ardis, and Slade (1986), and Couch et al. (1997). Groundwater modeling of flow through the aquifer has been conducted by Slade, Ruiz, and Slagle (1985), and Wanakule (1989). Hauwert, Johns, and Aley (1998) initiated a series of tracer tests to better delineate the aquifer's conduit flowpaths, which were continued by Hauwert (1999). Significant water quality studies of the aquifer include research by St. Clair (1979), Andrews et al. (1984), Slade, Dorsey, and Stewart (1986), Clement (1989), Flores (1990), Veenhuis and Slade (1990), City of Austin (1991), and Hauwert and Vickers (1994).

Barnes (1974) prepared a regional geologic map that includes the study area. Garner and Young (1976) and Kolb (1981) conducted more detailed geologic mapping for the area, but did not subdivide the members of the Edwards Limestone Group, which was later done by Small, Hanson, and Hauwert (1996) and the Barton Springs/Edwards Aquifer Conservation District (1997). Several other geologic studies have been performed in the vicinity of the study area that contain information potentially pertinent to the investigation of Flint Ridge Cave. McReynolds (1958) examined the structural geology of what was then the southwest Austin area, 8 km to the northeast. Rodda (1970) and Rodda, Garner, and Dawe (1970) took a closer look at that same area, plus the area immediately west of downtown Austin and the Colorado River. Meanwhile, Grimshaw (1970) investigated the geology of the Wimberley area 20 km southwest of the cave. Smith (1978) studied the Buda-Kyle area's geology about 7 km south of Flint Ridge Cave.

Information about caves in the region, including portions of nearby Hays County, includes work by Reddell and Russell (1961), Russell (1974, 1975, 1984, 1988, 1996a, 1996b), and Elliott (1997). Veni and Associates (1992) defined the study area as "Zone 2," where it is highly probable that rare or endemic invertebrate species will be found in caves. Biological reports specifically addressing species in Flint Ridge Cave include Reddell (1989), Gertsch (1992), and Ubick (1992). Other geologic and biological studies relating to caves in the vicinity containing federally listed endangered species and species of concern include Elliott and Reddell (1989), Biological Advisory Team (1990), Reddell (1991), and Elliott (1997). O'Donnell, Elliott, and Stanford (1994) presented a recovery plan for the endangered karst invertebrates. Elliott (1993, 1994) and Reddell (1994) provided overviews of issues and research on Texas cave fauna. For information on general cave biology and ecology see Culver (1982). For general information on caves and karst processes see White (1988) and Ford and Williams (1989). Appendix A is a glossary of geologic, biological, and karst terms used in this report. Appendix B is a conversion index from the International System of Units, used in this report, to English units. Appendix C is a list of cave map symbols.

Methodology

The karst of the study area is evaluated per the methodology proposed by Veni (1999) as the standard for karst environmental impact assessments. Fieldwork outside of Flint Ridge Cave included searching for and examining karst features that might be directly related to Flint Ridge Cave and visiting nearby caves for comparative observations. The other caves visited were Lost Oasis Cave and Sand Burr Cave.

The search for karst features was conducted with a team of four people walking about 15 m apart in a given direction to a defined destination. Upon reaching that goal, they shifted to one side of their transect and walked back in the opposite direction searching the adjacent area. This technique discovers most karst features within an area, although some small features with little surface expression may still be missed. The 15-m-spacing can be changed if warranted by local conditions, but it is effective for most terrains. Wider spacing usually misses too many features and narrower spacing significantly increases search costs for generally little additional information. The area searched extended approximately 300 m west, south, and east of the cave's entrance and about 100 m to the north. This area included a 100 to 450-m-radius from the footprint of the cave and assured as best as reasonably possible that the area of groundwater drainage into the known portions of the cave was examined. Any features discovered were flagged with long strips of red and white striped survey tape, with their identification numbers marked in waterproof ink. With some features, small amounts of sediment were excavated by hand for more accurate evaluations.

The karst features' locations were marked as best as could be estimated with aerial photographs on detailed topographic maps. The location of one feature was verified by an overland survey. The locations of two caves and one karst feature were established by published overland surveys (Russell, 1988). All features, as represented in this report, are probably within 10 m of their actual locations. The area map produced for this study was electronically drafted through use of the CorelXARA computer drawing program, version 1.5, and was based on digitally stored topographic and geologic data provided by the City of Austin. The data were initially read by and then exported from ArcView, version 3.0, to CorelXARA, then digitally overlain by areal photographs and highway right-of-way maps.

The karst features discovered were quantitatively assessed by assigning point values to feature characteristics and conducting calculations that determine a feature's relative permeability. Veni (1999) has shown this method is effective in identifying the permeability of a control set of known features. Features of moderate to high relative permeability are likely to be or open to caves. The quantitative assessment method is currently being refined (Veni, in preparation), but data analyzed so far for this and other projects appear to support its efficacy.

The hydrologic assessment within Flint Ridge Cave, Lost Oasis Cave, and Sand Burr Cave recorded and/or examined interior conditions and layout of the caves, in addition to descriptions and measurements of hydrogeologic features including strata, fractures, flow features (including but not limited to scallops, pitting, ponding, and enlarged bedding planes and fractures), sediments, speleothems, bone presence and/or distribution, water flow, air flow, air quality, and resolution features. Aerial photographs were also examined for fractures, sinkholes,

stratigraphic contacts, and other features that may prove useful to the geologic assessments and understanding of the overall study area. Orientations of fractures and other features measured in the field with magnetic compasses are presented in this report relative to true north following calculation and correction for magnetic declination. Water samples were collected in Flint Ridge Cave and analyzed by the City of Austin. Conductivity, pH, and temperature of the water were measured in the cave with a Hannah model HI 9033 conductivity meter with a resolution of $\pm$0.1 mS/cm and automatic temperature calibration, pH with a Hannah model HI 9025 pH meter with a resolution of $\pm$0.01 pH, and temperature with the pH meter's temperature probe which has a rated resolution of 0.1°C, and was checked against a glass thermometer graduated in units of 1°C. Barometric pressure was measured concurrently in the cave and at the surface with a set of Oregon Scientific 12-hour recording barometers with a rated resolution of 0.03 mb in mercury. Cave fauna were also observed, since their distribution between and within caves can sometimes be correlated to hydrogeologic factors. Although not within the initial scope of work, collections of invertebrate fauna were made in Flint Ridge Cave per the verbal request of the City of Austin (Mark Sanders, personal communication, 1999), with all specimens going to James Reddell of the Texas Memorial Museum for identification and curation. Analysis of all data used in this report was based on principles of karst hydrogeology, as in the texts of White (1988) and Ford and Williams (1989), with consideration of local factors as discussed by Veni and Associates (1992).

Field Investigation

Surface and Regional Geology

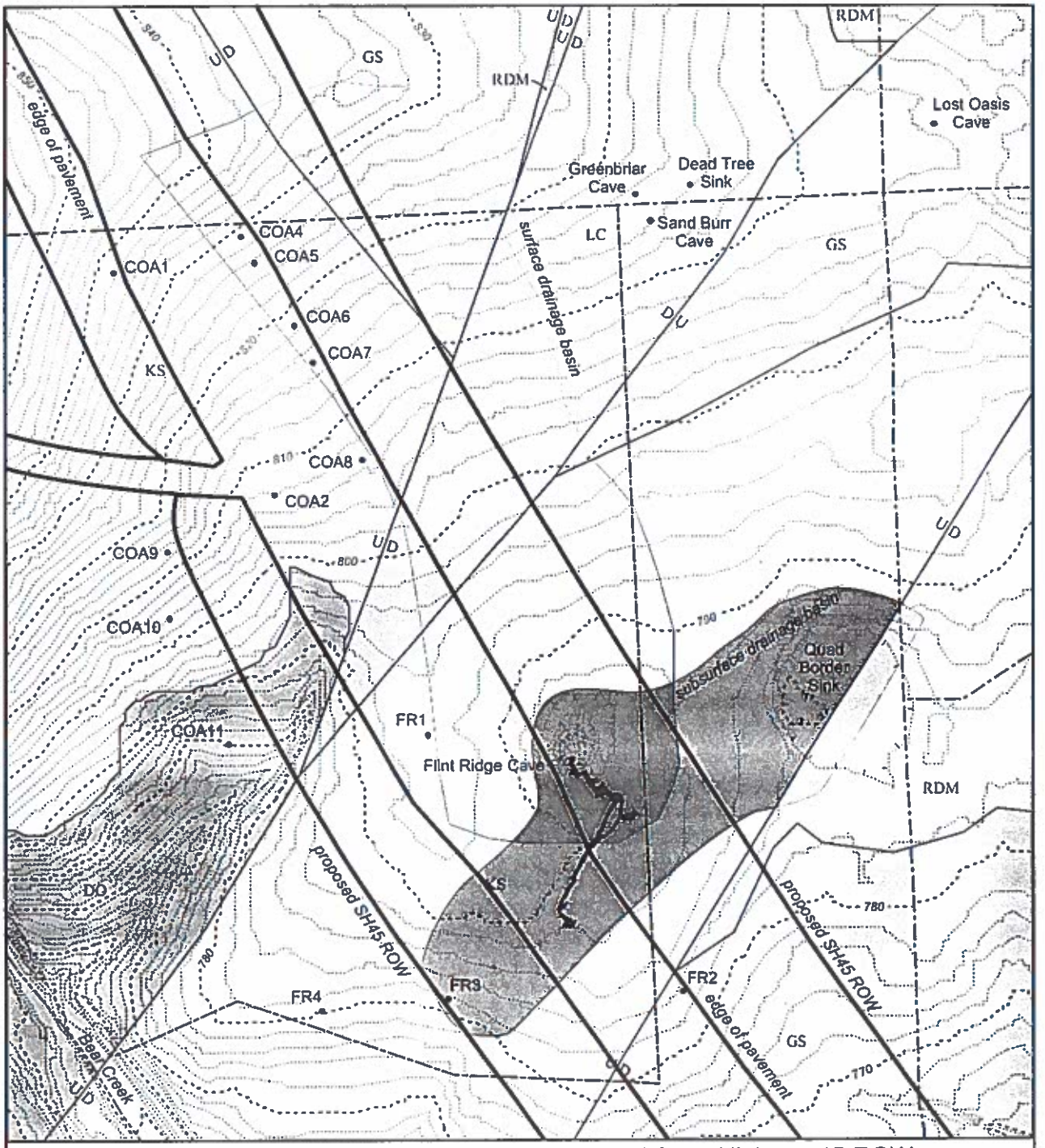
The study area is a nearly level upland karst surface that gently slopes down southward into Bear Creek (Figure 1). The ridge on which Flint Ridge Cave is located is about 600 m long north to south and roughly 400 m wide, east to west. On the Signal Hill 7.5' U.S. Geological Survey (USGS) topographic quadrangle, the northeast part of the ridge appears as a broad flat area, when in fact it is occupied by the cave's entrance sinkhole. Drainage on the west side of the ridge flows into a 400-m-long southwest-flowing tributary of Bear Creek. Drainage on the east side of the ridge flows either into the cave's sinkhole, into an east then southeast flowing 600-m-long tributary to Bear Creek, or into a 120-m-diameter sinkhole known as Quad Border Sink located 130 m west of the cave's entrance sinkhole; Quad Border Sink and this second tributary to Bear Creek are located on the Oak Hill 7.5' USGS topographic quadrangle. Runoff on the south side of the ridge flows as sheetwash to Bear Creek. Elevations range from 242 m above mean sea level at the northernmost edge of the ridge 160 m northwest of the cave's entrance, to 222 m at the bed of Bear Creek 2 km south of the entrance.

Cultivation, bulldozing and/or other earth-moving activities have disturbed some of the area. Many depressions are present, some of which superficially appear to be karst features but are in fact stump holes. Werchan, Lowther, and Ramsey (1974) identified the soil in the study area as Speck stony clay. The soil is patchy and where present averages 15-28 cm thick; in a few places the soil is more than 50 cm thick. The Speck soil has low permeability that generally promotes runoff, but it is sufficiently discontinuous to not significantly mitigate against groundwater pollution should contaminants be present on the surface. When dry and cracked, it may allow rapid infiltration into the underlying limestone. Most runoff enters recharging streambeds or karst features which breach the thin soil. Mixed alluvium is another soil type that Werchan, Lowther, and Ramsey (1974) identified in the study area, but only in the bed of Bear Creek where it has no known relationship to Flint Ridge Cave.

The surface outcrop is the Edwards Limestone Group, a generally hard, crystalline, fossiliferous, and cavernous rock. The Edwards at Flint Ridge Cave is about 70 m thick, but ranges from approximately 49-107 m thick in adjacent fault blocks (Small, Hanson, and Hauwert, 1996). The Edwards Limestone Group is locally comprised of the Person and Kainer formations. The Person is the upper formation and is comprised, in descending order, of the Cyclic, Marine, Leached, Collapsed, and Regional Dense members (the Cyclic and Marine members are not locally exposed, having been removed by erosion during the Cretaceous Period soon after deposition). The Kainer is the lower formation and is comprised of the Grainstone, Kirschberg, Dolomitic, and Basal Nodular members. Figure 1 shows the entrance of Flint Ridge Cave in the Kirschberg Member of the Kainer Formation; adjacent outcrops expose sections of the Edwards Limestone as high as the Leached and Collapsed members (undivided during mapping by Small, Hanson, and Hauwert, 1996) and as low as the Dolomitic Member. A stratigraphic column of the units is presented in Appendix D.

Permeability and cave development vary considerably between members of the Person and Kainer formations. Additionally, lithologic changes occur throughout the Edwards Limestone region and spatially change the hydrologic characteristics of the members; thus

Figure 1



Karst and hydrogeologic features along the proposed State Highway 45 ROW near Flint Ridge Cave, Travis County, Texas

Legend: *Person Formation*

- LC Leached-Collapsed members
- RDM Regional Dense Member
- *Kainer Formation*
- GS Grainstone Member
- KS Kirschberg Member
- DO Dolomitic Member
- Outline of cave
- U/D Fault, D side moved down relative to U side
- Fence line
- Surface drainage basin
- Subsurface drainage basin

0 100 200
METERS
contour interval 2 feet

Highway alignment and topographic base map: City of Austin (2000)
Geology base map: Small, Hanson, and Hauwert (1996)
Cave map outline: modified from Russell (1988)
Locations for Dead Tree Sink, Greenbriar Sink, and Sand Burr Cave: Russell (1988)

NT

George Veni & Associates, 2000 Drawn by Peter Sprouse

typical characteristics in one area may not apply to another area. Small, Hanson, and Hauwert (1996) described general permeability and cave development in the Barton Springs recharge zone, but Russell (1996c) provided a more useful analysis by plotting the volumes of the five longest caves surveyed in the Oak Hill and Signal Hill 7.5' USGS topographic quadrangles, including Flint Ridge Cave, against the stratigraphic section in which each cave passage segment occurs. While the absolute volumes measured by Russell are not meant to represent all cavernous permeability within that area, they provide a means for relative comparison of conduit development within and between the stratigraphic units.

Russell's (1996c) results that are pertinent to Flint Ridge Cave show cavernous permeability increases fairly steadily down through the Kirschberg Member, from about 57 m^3 per 30 vertical centimeters of stratigraphic section at its upper contact to about 368 m^3 near its base. The upper 8 m of the Dolomitic Member contain mainly pits of high vertical permeability along fractures, but relatively little horizontal permeability with only about 42 m^3 per 30 cm of stratigraphic section. However, a horizon of apparently greater solubility occurs from 8-15 m in the unit where the volume of cave development reaches 538 m^3 per 30 cm of stratigraphic section and is probably perched on the rhythmic bed that Small, Hanson, and Hauwert (1996) suggest is a minor confining unit. Except for a 2- to 3-m-thick zone where cave development reaches 283 m^3 per 30 cm of stratigraphic section at the contact with the underlying Basal Nodular Member, Russell (1996c) described no significant volume of cave development in the lower half of the Dolomitic Member or in the Basal Nodular Member.

Structurally, the Flint Ridge Cave study area is located in an intensely faulted section of the Balcones Fault Zone. Locally, the fault zone is made up of a series of narrow fault blocks that are typically 600-1,200 m wide and usually down-drop en echelon to the east and southeast toward the Gulf of Mexico (Small, Hanson, and Hauwert, 1996; Barton Springs/Edwards Aquifer Conservation District, 1997). Faults in the middle to southern section of the Barton Springs recharge zone, where Flint Ridge Cave is located, primarily trend between 35-50°, secondarily around 10°, and occasionally at approximately 60°. Most of the faults are generally displaced less than 15 m, but faults with less than 3 m of displacement are usually not shown on geologic maps. Joints north of the Flint Ridge study area, closer to the Colorado River, are oriented primarily at 40° and secondarily at 135°, but in the study area they bear closer to 60° with secondary joint sets oriented between 90-100° and 110-130° (Rodda, Garner and Dawe, 1970; Smith, 1978; Kolb, 1981).

Veni and Associates (1992) found that nearly 41% of the caves in the general area of Flint Ridge Cave are formed along fracture trends of 40-59°, with little preferential development at orientations not parallel to Balcones faulting. However, this does not mean that most caves form along faults. Senger, Collins, and Kreitler (1990) reviewed structural data for the Balcones Fault Zone in northern Travis County and found 60% of the faults were filled with calcite and were thus generally impermeable to groundwater flow and unlikely sites for cave development. A few caves or segments of caves are known in the area to form along faults, such as Airman's Cave and Blowing Sink Cave (Russell, 1975, 1996b); in contrast, Cave X ends at a major fault (Russell, 1974). Caves and parts of caves commonly form along joints parallel to faults. Several local caves are formed along tensional fractures along the upper bends of monoclines, simple drag folds that may split into faults. Some of these caves include Airman's Cave, District Park Cave, Get Down

Cave and Goat Cave (Veni and Associates, 1992). Typically these caves extend deeper down the dip of drag-folded beds and extend horizontally along strike-oriented fractures; deep pits tend to be present where fractures breach less soluble strata of low lateral permeability.

There is little hydrogeologic information on the Edwards Aquifer that is specific to the study area. Except for speleological discussions of Flint Ridge Cave and for discharge measurements along Bear Creek, near all reports cover the study area as part of their overviews of the aquifer. Water table mapping for the study area is based on wells spaced about 2-5 km apart, which is too wide to interpret anything more than a mean depth to water of about 60 m, and a general flow gradient to the east and northeast. Much of the water flowing under Flint Ridge Cave is probably recharged nearby in Bear Creek. There have been insufficient observations of water in the cave to correlate the cave's hydrology to fluctuations in any nearby water wells. Tracer studies by Hauwert, Johns, and Aley (1998) and Hauwert (1999) show that water entering caves and sinkholes can flow through the aquifer toward the Colorado River at rates of more than 8 km/day. The nearest site of a tracer test is about 4 km north of Flint Ridge Cave. A tracer test at the cave would probably flow at similar speeds and discharge from Barton Springs.

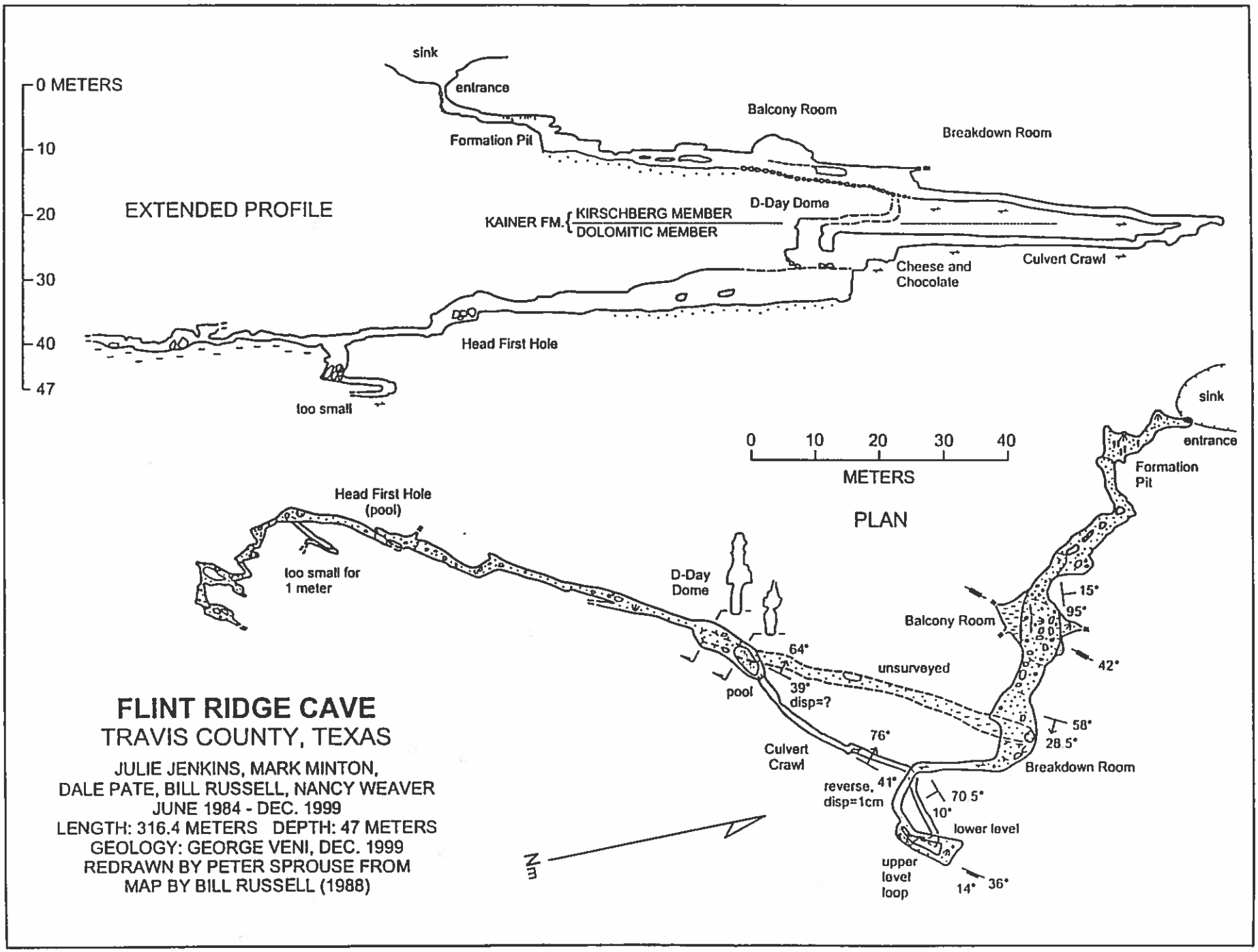
Descriptions of Caves and Karst Features

Below is a description of Flint Ridge Cave, followed alphabetically by descriptions of the three other caves and 16 karst features shown in Figure 1. Several other caves and karst features are located on the prominent hill 900 m northwest of Flint Ridge Cave but are not considered significant to this report and are not discussed. They occur in the Grainstone Member of the Kainer Formation, which is topographically and stratigraphically higher and unrelated to Flint Ridge Cave, and a review of their maps, locations, and descriptions further suggests no relationship to the cave. Caves and karst features shown in Figure 1 that are also formed in units stratigraphically higher than Flint Ridge Cave are discussed below since they are much closer to Flint Ridge Cave and have a greater probability of being hydrologically related. Where such caves and features have no direct relationship to the cave, their evaluation, coupled with general knowledge of the caves on the nearby hill, allow for a better interpretation of cave development in the area and at Flint Ridge Cave in particular.

Flint Ridge Cave

Synopsis: This cave is the second deepest and fifth longest known in Travis County with a surveyed depth of 47 m (Russell, 1996a) and a length recently extended to 316.4 m (Jenkins and Russell, 1999). The cave has an "L" shape, with a relatively large passage heading about 82 m southeast from the entrance along the base of the "L" and then turning southwest toward the top the "L" while becoming smaller and extending deeper. A large sinkhole drains into the cave, which is known habitat for the spider *Cicurina cueva* and the ground beetle *Rhadine austinica*, both species of concern listed in the BCCP.

Description (Figure 2): The entrance to Flint Ridge Cave is in the southeast corner and bottom of a 100-m-diameter by 2.7-m-deep sinkhole (Figure 1). The floor of the sinkhole is covered by soil at least 1 m thick. When first examined for the presence of caves, a soil and root mat covered the entrance. However, flood debris indicated its location as the drain for runoff entering the sinkhole. Access to the cave was gained after removing root mats, soil, and rocks to


0 METERS
10
20
30
40
47
EXTENDED PROFILE
sink
entrance
Formation Pit
Balcony Room
Breakdown Room
D-Day Dome
KAINER FM.
KIRSCHBERG MEMBER
DOLOMITIC MEMBER
Cheese and Chocolate
Culvert Crawl
Head First Hole
too small
0 10 20 30 40
METERS
PLAN
Head First Hole (pool)
too small for 1 meter
D-Day Dome
pool
64°
39°
disp=?
unsurveyed
76°
Culvert Crawl
reverse, 41°
disp=1cm
70 5°
10°
lower level
upper level loop
14°
36°
sink
entrance
Formation Pit
15°
95°
Balcony Room
42°
58°
28.5°
Breakdown Room
FLINT RIDGE CAVE
TRAVIS COUNTY, TEXAS
JULIE JENKINS, MARK MINTON,
DALE PATE, BILL RUSSELL, NANCY WEAVER
JUNE 1984 - DEC. 1999
LENGTH: 316.4 METERS DEPTH: 47 METERS
GEOLOGY: GEORGE VENI, DEC. 1999
REDRAWN BY PETER SPROUSE FROM
MAP BY BILL RUSSELL (1988)

a depth of about 1.3 m. The passage at the base of the 3-m-deep entrance pit heads southeast, initially about 1 m high by 2 m wide and generally enlarging as it steadily slopes downward. Fifty meters from the entrance, the passage reaches its largest dimensions in the Balcony Room at 10 m long by about 8 m wide by up to 5 m high. About 15 m further down the passage is the cave's second largest room, the Breakdown Room, which is about 8 m long by 6 m wide and up to 4 m high. Two passages lead off this room. One is a narrow hole in the floor that was dug open to an unsurveyed passage that is 44 m long, about 2 m wide, generally less than 0.5 m high, and ends at the top of D-Day Dome. The other passage off the Breakdown Room is the more commonly followed path of water and exploration. The passage corkscrews south, east, and north for 31 m through a clean-washed, dipping, bedrock-floored passage that averages 0.5 m high by 1.5 m wide, to two short drops leading 3 m down to Culvert Crawl, which turns west and southwest under the clean-washed, dipping section. A 30-cm-deep pool is present at Culvert Crawl's northeast end, and its baseflow moves as a trickle down the roughly 1-m-high and wide passage for 40 m to where it enlarges to 5 m then 15 m high 8 m further at D-Day Dome. Beyond the dome, the passage continues to the southwest, at first about 5 m high and 1.4 m wide, gradually decreasing in size to less than 0.5 m high by 1.2 m wide where it reaches the top of a 3.7-m-deep pit. Two passages extend from the pit. One is a series of small rooms and crawlways that head 34 m to the south and southeast from the top of pit before ending in clay fill, with airflow coming from inaccessibly small voids. The other is at the bottom of the pit. It heads 6 m northeast, drops 1.3 m, then doubles-back underneath for 3 m before pinching down as an impassibly small bedrock tube at the deepest known point in the cave. However, the deposition of cobbles and other sediments have recently blocked human access to last 5-6 m of this deepest passage. For other details about the cave, see Russell (1988), Elliott (1997), and Jenkins and Russell (1999).

History: In March 1984, Bill Russell was first to check the cave's sinkhole for the presence of a cave entrance. He soon returned with several cavers who helped dig open and explore the cave. Most of the cave was accessible with only a few and minor excavations needed inside. Except for the crawlway between the Breakdown Room and the top of D-Day Dome, Russell, along with Mark Minton, Dale Pate, and Nancy Weaver surveyed the known cave between June 1984 and February 1985. On 17 August 1995, Bill Larsen and Jim Wolff dug into the southbound passage at the bottom of the 3.7-m-deep pit. On 18 and 19 December 1999, Julie Jenkins and Bill Russell opened more of that area by excavation and surveyed the passage. For more details about the history of the cave, see Russell (1988), Elliott (1997), and Jenkins and Russell (1999).

Biology: The cave is habitat for the troglobitic spider, *Cicurina cueva*, and the ground beetle *Rhadine austinica*, which are listed as species of concern on the BCCP. Elliott (1997) provided a preliminary list of 27 species known at the cave, of which seven are troglobites. By verbal request of the City of Austin (Mark Sanders, personal communication, 1999), additional collections were made during this investigation. The material is currently being identified. One new and significant record for the cave was the collection of troglobitic amphipods from the Culvert Crawl pool and its downstream reaches. It will likely be identified as *Stygobromus russelli*, a relatively widespread cave-dwelling amphipod (James Reddell, personal communication, 2000). Since biological studies were not included within the original scope of this research, James Reddell, of the Texas Memorial Museum, should be

contacted for the full results of the collection and for an updated fauna list for the cave.

Geology/Stratigraphy: Figure 1 places the entrance of Flint Ridge Cave in the Kirschberg Member of the Kainer Formation, 6.7 m below the contact with the Grainstone Member. This position relative to the Grainstone assumes no changes in the elevation of the contact between where it is exposed in the cave's fault block, and the cave's entrance 280 m to the south. During the examination of the cave, Hanson's (1995) detailed lithologic description of the local Edwards Limestone was used to attempt to correlate cave passage levels to mapped strata. This was partially accomplished. Even with as small an area as Hanson described, there is sufficient variation in the thickness and character of the units to prevent a full and always clear correlation. Additionally, marker beds may be covered in caves by sediment and speleothems. Hanson's "brown chert bed" in the middle of the Kirschberg was found from near the base of Formation Pit to the ceiling near the Breakdown Room, and was correlated with a rhythmic bed 2 m below at the southeast end of the Breakdown Room. Tracing the chert bed updip toward the entrance and extrapolating the stratigraphy upward places the entrance of the cave about 1 m below the top of the Kirschberg, which does not match other observations and the general mapping shown in Figure 1. If the chert bed is accurately identified, it may suggest the presence of unrecognized faults within the first 10-15 m of the cave, where there is extensive speleothem growth. The faults would account for the difference in observed versus extrapolated stratigraphy at the entrance. The distance below the chert bed to the top of the Dolomitic Member is close to the distance reported by Hanson (1985). The Dolomitic begins approximately at the top of pit to Culvert Crawl and is present through the lower half of the cave (Figure 2). Culvert Crawl's smooth walls, strong fracture control, and small passage size are consistent with the typical morphology of passages in the Dolomitic. The passage beyond D-Day Dome may be perched for about 30 m on a 0.4-m-thick mudstone bed described by Hanson, while the passage beyond Head First Hole is likely perched on a 2-m-thick rhythmic mudstone, which is breached by the 3.7-m-deep pit. The deepest section of the cave is approximately 15 m above the base of the Dolomitic.

Geology/Structure: The entrance of Flint Ridge Cave is located within a fault block of the Balcones Fault Zone, and midway between two faults. About 195 m southeast of the entrance is a fault that locally bears 31.5°. The fault drops approximately 17 m to the east with the Kirschberg Member of the Kainer outcropping on the upthrown side and the Grainstone Member of the Kainer and the Regional Dense Member of the Person outcropping on the downthrown side (fault displacements given in this report are interpreted from unit thicknesses and geologic mapping provided by Small, Hanson, and Hauwert [1996] and Barton Springs/Edwards Aquifer Conservation District [1997]). The fault to the northwest is located 180 m from the cave's entrance. Overall, it has a bearing 37.5°, but due west of the cave, the fault trace bends slightly northwest where another fault splits off on a bearing of 20°. The wedge between the faults is a graben, a down-thrown block, with the Leached and Collapsed members (undivided) exposed at the surface. Along the boundary with the cave's fault block, displacement along the fault is about 21 m, downthrown to the west. Southwest of the graben along the main fault, displacement has increased slightly to 22 m, downthrown to the east, with the Kirschberg on the east side and the Dolomitic Member on the west.

The development of Flint Ridge Cave shows some of the best and most varied structural control in Travis County. The southeast trend of the upper half of the cave, from the entrance to the top of Culvert Crawl, runs down a dip of about 4°, based on plotting the position of the brown chert bed on the profile of the cave. Some variations occur. The northern half of the Balcony Room is formed along beds striking 95° and dipping 15°N. In the Breakdown Room, a monocline lowers the strata 20 cm over a 60-cm distance. The 58° strike of the monocline seems to reflect the overall strike of the dipping passage in the upper half of the cave. The section of clean-washed dipping passage leading deeper from the Breakdown Room turns from the general southeast dip direction due to drag-folding as the cave approaches a small fault. It initially runs down the southward 10° dip of beds striking 70.5°, then turns southeast as it approaches the probable fault, which appears as a fractured zone bearing 36° through the pit into Culvert Crawl. Drag folds on the west side of the fracture zone dip 14°E.

As suggested in the previous paragraph, one or more faults may occur in the first 10-15 m of the cave. The 3-m-deep Formation Pit is a possible fault locality. Minor joints intersect the upper half of the cave but have little overall influence on its development. A joint swarm bearing a mean 42° crosses the Balcony Room and in part accounts for the room being the widest place in the cave. The lower half of the cave generally follows roughly strike-oriented fractures and is not significantly affected by the dip of the beds. About 14 m of Culvert Crawl is formed along a small reverse fault bearing 41°, dipping 76°W, and having 1 cm of displacement. D-Day Dome and much of the passage heading southwest from the dome are formed along a fault bearing 39° and dipping 64°W; the amount of displacement could not be accurately measured. Fractures bearing to the northeast guide the development of some of the passages at the bottom of the cave, but they were not measured during this investigation.

Geology/Hydrology: Flint Ridge Cave has one of the larger interstream surface drainage basins known for Travis County caves. The drainage basin mainly extends northwest from the cave and mostly captures sheetwash. It is 760 m long by an average 210 m wide, and covers an area of 163,300 m^2. The volume of water entering the cave and recharging the Edwards Aquifer has not been gauged. Recharge throughout the cave's drainage basin can be approximated by determining the percent of rainfall in interstream areas that becomes recharge.

Woodruff (1984) calculated that only 0.09% of mean rainfall recharges the aquifer through upland areas. However, his figures included rainfall on the large contributing zone for the aquifer, where most water is lost to evapotranspiration and diminishes the actual percentage of recharge from rain that falls on the recharge zone alone. Slade, Dorsey, and Stewart (1986) conducted similar calculations, but did not distinguish between recharge in streams and in interstream areas in a manner that could be applied to this study.

Using data from Woodruff (1984) and Slade, Dorsey, and Stewart (1986), the percent of interstream recharge from precipitation can be approximated. The mean discharge from the aquifer is 44,406,000 m^3/year. Ignoring for simplicity leakage from adjacent aquifers and other minor variables, that discharge value also represents mean recharge since recharge and discharge must balance in a natural steady-state groundwater system. The aquifer recharge zone receives an average of 0.82 m/year of precipitation (Larkin and Bomar, 1983) and has an area of 233,100,000 m^2. Most recharge enters the aquifer via streams and Slade, Dorsey, and Stewart (1986) estimate

that only 15% of total recharge enters via interstream areas, therefore the mean total interstream recharge is 6,661,000 m^3/year (0.15 x 44,406,000 m^3/year). While streams are extensive features across a landscape, they occupy relatively little area. Using the digital topographic map provided by the City of Austin of a 9.79-km^2 section of the Edwards Aquifer recharge zone that included the study area, approximately 4% of that area was occupied by streambeds. The percent appears representative of the recharge zone in general, and will be considered as such for the purposes of this report, allowing the interstream areas to be calculated as 96% of the recharge zone or an area of 223,780,000 m^2 (0.96 x 233,100,000 m^2). Maximum possible mean annual recharge for the interstream areas equals mean precipitation multiplied by the size of the areas, or 183,500,000 m^3/year (0.82 m/year x 223,780,000 m^2). Dividing total mean annual recharge for the interstream areas by maximum possible mean annual recharge produces the percent of precipitation that on average, given the range of rainfall amounts and intensities that occur within the area, which becomes interstream recharge or 3.63% (6,661,000 m^3 per year/183,500,000 m^3 per year).

With the mean interstream recharge rate of 3.63% and mean precipitation of 0.82 m/year, mean recharge in Flint Ridge Cave's drainage basin is estimated at 4,860 m^3/year (163,300 m^2 x 0.82 m/year, x 0.0363), but most of this does not recharge through the cave's entrance. In principle, typical intense storms of 7-10 cm of precipitation would on average yield 415 to 593 m^3 of runoff to recharge the aquifer via the cave's entrance; the City of Austin's Watershed Protection Department uses 3 inches, or 7.62 cm, of rainfall as the minimum trigger to initiate water sampling (Sylvia Pope, personal communication, 2000). Many such storms have occurred in the study area since the cave was dug open in 1984. However, if the volume of recharge into the cave were as high as those estimates suggest, a channel would have certainly been cut by now into the deep soil at the base of the sinkhole that leads to the cave's entrance. Efforts by TCMA to minimize erosion at the entrance have been helpful, but probably would not have been effective if runoff into the cave was so high. Instead, the total estimated recharge enters the aquifer throughout the cave's surface drainage area via karst features COA4 through COA7, plus other small sinkholes, fractures, and recharge features, many of which are probably hidden below the soil. These features capture and recharge most of the runoff before it reaches the cave entrance.

There is insufficient information and too many variables to accurately estimate the volume of water entering the cave's entrance during storms. The City of Austin's Drainage Criteria Manual (1999) recommends use of the Rational Method or the Variable Rainfall Intensity Method for watersheds the size of Flint Ridge Cave's. Attempts to verify the Rational Method with field data have not been fully successful. However, the technique has gained success as a probability model rather than a model of actual physical behavior (Viessmann, 1977). The Variable Rainfall Intensity Method, which depends on calculated results of the Rational Method, consequently suffers the same limitations. Furthermore, the Rational Method is not designed to accurately predict runoff in karst terrains. Rational Method runoff coefficients do not account for the highly variable rates of infiltration in karst, from essentially impermeable bedrock and poorly permeable clayey soils to open fractures, sinkholes, and solutionally formed features where all runoff is captured to interrupt surface drainage patterns and flow models. Soil Conservation Service methods discussed in the City's Drainage Criteria Manual have similar problems by providing curve numbers for maximum infiltration rates of 0.8 to 1.1 cm/hour,

which are far less than those which often occur in the Edwards Aquifer recharge zone. The City of Austin's Environmental Criteria Manual (2000) provides a runoff coefficient for the Edwards Aquifer recharge zone of 0.025 for areas with 0-5% impervious cover. Use of this value would suggest that of the 4,860 m^3/year of recharge throughout the cave's surface water drainage basin, that 3,348 m^3/year (163,300 m^2 x 0.82 m/year, x 0.025) would runoff into the entrance. This volume seems much too high to be consistent with morphologic features observed at the cave entrance. As a result, it does not appear that these measures can be used to meaningfully estimate recharge into the entrance of Flint Ridge Cave.

Hydrologic features observed in Flint Ridge Cave could potentially be used to make rough estimates of recharge via the cave's entrance, but the variables are also great enough to make the calculated values unreliable. For example, blockage at the bottom of the cave has decreased the rate at which water enters the aquifer and increased the level of flooding up the cave (Jenkins and Russell, 1999). During this investigation, the maximum flood line was observed about 1 m below the ceiling of the Breakdown Room. It is not known which storm that flood level represents, but it probably resulted from the 17-18 October 1998 storm event that locally dropped 20 cm of rain in less than 24 hours (Slade and Persky, 1999). Approximately 660 m^3 of passages are known below the maximum flood level. Total recharge must have exceeded that volume to account for water that must also fill unmapped voids and leak past the blockage, and may be close to 1,000 m^3. Assuming 3.63% is a representative recharge percentage for the study area, total recharge in the cave's surface water drainage basin would have been 1,185 m^3 from that storm, which could account for the observed flood levels. However, there is no clear evidence of that much water flowing into the cave's entrance. Some of the water that filled the cave must have been derived from other recharge features; there are several locations in the cave, especially the long passage that heads southwest from D-Day Dome, where substantial recharge probably enters along solutionally enlarged fractures unrelated to drainage in the cave's entrance. Also, much of the floodwater was almost certainly derived from a general rise in the water table and local groundwater mounding through recharge in nearby Bear Creek, which is a known major recharge feature. Consequently, as with the Rational Method and other techniques to estimate runoff, reliable estimates based on available data cannot currently be made without gauging recharge at the cave's entrance.

Since the cave has been opened by excavation, the flood pulses entering the cave have increased. This does not mean that the volume of water entering the cave has increased, but only that the rate that volume moves through the cave has increased. Consequently, erosion of sediments in the cave has increased as well. Jenkins and Russell (1999) described how, especially in the vicinity of Head First Hole and at the bottom of the cave, sediments have washed deeper into the aquifer and new pits and passages are washing open. The removal of sediments from even the deepest sections of the cave indicates that it is at least a couple of meters above the local water table. However, while the bottom of the cave is surveyed at an elevation of 187.7 m, the "low-flow" water table for the aquifer determined by Couch et al. (1997) shows its elevation at the cave as about 189 m. This discrepancy is probably the result of the coarse scale of mapping the aquifer. Additionally, troughs in the water table usually form around conduits and often do not appear at the scale of even detailed well-based water table mapping. In either case, it is likely that the distance from the bottom of the cave to the water table is small, probably less than 5-6 m but possibly extends as much as 15 m to the contact with the Basal Nodular Member of the

Kainer where significant conduit development is known at the bottom of the Dolomitic Member (Russell, 1996c).

Perennial or nearly perennially flowing water occurs in the cave in two locations. The uppermost location is in Culvert Crawl. Depending on rainfall, water trickles or flows from the fracture zone at its northeast end. The passage trends toward Quad Border Sink, which with its seasonally ponded water and slow release of stored water from its sediments, could prove the source of the perennial flow. The second location of frequently flowing water is in the flowstone area near the top of the 3.7-m-deep pit near the bottom of the cave. This water also ranges in discharge from dripping to flowing, and may be derived in part from karst features found on the surface southwest of the cave. The presence of flowstone suggests the water is usually saturated with respect to calcite, and thus probably derived from permeable fractures that may have no expression on the surface.

Currently, the cave is being vadosely enlarged and subjected primarily to the action of vadose groundwater; rising phreatic water when the aquifer's water table is high probably affects the lowest parts of the cave occasionally. Phreatically formed features occur in the cave and demonstrate the presence of an earlier and considerably different past hydrologic regime.

Geology/Hydrochemistry: One water sample was collected in the cave from the pool at the bottom of D-Day Dome. The water flowed down to that location from its source in Culvert Crawl, and then flowed past the pool and sank into sediments on the passage floor. Attempts to collect a sample of storm water runoff into the cave's entrance failed due insufficient rainfall during the study period. Collection protocols and containers were provided by the City of Austin's Laboratory Services Division, which also analyzed the sample. The results are printed in Table 1 in the column listing parameters measured in the field. Geochemical equilibria calculations were made of those data through the use of the computer program PCWATEQ version 2.13 developed by Larry Rollins in 1989 and distributed through ShadoWare. PCWATEQ is based on WATEQ, developed by Truesdell and Jones (1974) and Plummer, Jones, and Truesdell (1976), but modified for use on personal computers. The results are printed in Table 1 under the heading for calculated parameters.

The results of the groundwater analysis are typical of what would be expected from rural vadose karst groundwater in Texas, and especially from the Dolomitic Member of the Kainer Formation. Concentrations of dissolved carbonate minerals are slightly low. The water is a little undersaturated with respect to calcite, and progressively more undersaturated with respect to dolomite and gypsum. The lack of precipitated calcite speleothems on the passage floor indicates that the water remains undersaturated most if not all of the time. The ratio of calcium to magnesium demonstrates flow through a dolomitic limestone. P_{CO_2} is high compared with some karst groundwater, but it is within the range for central Texas where the climate is warmer and more soil carbon dioxide is generally produced than in cooler regions. However, the value seems a little high given the wintertime sampling when carbon dioxide production should be at a minimum. The relatively warm winter should not have had much impact on the results because most plants remained dormant or only marginally active. Sources for high carbon dioxide levels that could be sustained through the winter would include areas of deep soil and concentrated plant growth. Quad Border Sink is the only such locale near Flint Ridge Cave, further

supporting it as the source of water flowing down Culvert Crawl. This hypothesis should be considered tentative until supported with either additional geochemical analyses or tracer tests.

Table 1
Geochemical Analysis of Groundwater from Pool in D-Day Dome,
Flint Ridge Cave, Travis County, Texas
22 December 1999

Measured parameters		Calculated parameters	
Parameter	*Value*	*Parameter*	*Value*
Ca	61.55 mg/L	Hardness, mg/L $CaCO_3$	252.4
Mg	24.00 mg/L	Ion balance	8.33%
K	3.03 mg/L	Total dissolved solids	354.6
Na	3.94 mg/L	Ca^{+2}/Mg^{+2}	1.55
Fe	0.49 mg/L	Log P_{CO_2}	-1.4802
As	<6 ug/L	Ionic strength	0.00722
Zn	<6 ug/L	Calcite saturation	-0.478
Cu	<4 ug/L	Dolomite saturation	-1.059
Ni	<3 ug/L	Gypsum saturation	-2.999
Pb	<3 ug/L		
Alkalinity	248 mg/L		
NH_3-N	0.11 mg/L		
NO_3+NO_2-N	0.22 mg/L		
F	0.06 mg/L		
Cl	9.27 mg/L		
SO_4	3.98 mg/L		
Total Nitrates	0.29 mg/L		
Total Phosphorus	0.07 mg/L		
PH	6.84		
Conductivity	447 mS/cm		
Temperature	21.5°C		

While analyses for contaminants were not conducted, low to imperceptible levels of nitrates, chloride, sulfates, lead, and other dissolved solids strongly suggest that no significant contaminants are present. This is further supported by an apparently thriving community of aquatic amphipods, which also indicates moderate to high levels of dissolved oxygen in the water.

The nearest potential sources of contaminants that might impact the cave are several homes located about 400 m to the east. They are not specifically marked on Figure 1, but are east of the north-south fenceline at the east end of Quad Border Sink; the housing subdivision continues east and northeast more than 3 km to the east edge of the Edwards Aquifer recharge zone. Possible pollutants from the subdivision could include, but not be limited to pesticides and fertilizers from yards, improperly stored or disposed household chemicals and solid waste, sewage from leaking lines or inefficient and/or improperly maintained septic systems, and heavy metals and petrochemicals from roads. If State Highway 45 were built near the cave, it would

also introduce heavy metals and petrochemicals to local runoff and recharge, but also a much wider array of chemicals, in greater quantities, and possibly with higher toxicities due to motor vehicle accidents and spills. The volume, speed, and greater presence of trucks on highways make accidents and spills far more likely than on low-traffic residential streets.

The chance of contaminants from the homes reaching the cave is low because their low density generally equates to reduced contaminant load, and because the cave is up the topographic slope and generally up the hydrologic gradient from these homes. If contaminants from these sources do not impact the cave, they may still impact the Edwards Aquifer. Homes along Quad Border Sink pose the highest risk of impact to Flint Ridge Cave. The sink appears to be a tributary to the cave, and runoff from the homes and leakage from their sewage systems could reach the sink and enter Flint Ridge Cave. The chances of contaminants from the proposed route of State Highway 45 entering the cave are high because the highway's proposed location is directly adjacent to the cave, up the topographic slope and up the hydrologic gradient and dip direction.

One additional source of possible contaminants is Bear Creek. If contaminants enter Bear Creek during a significant recharge event when the water table is rising into Flint Ridge Cave, there is a small chance that the contaminants could enter the cave if recharge down through the cave is insufficient to stop the upwelling.

Geology/Climatology: Airflow has been discussed in all reports on the cave (Russell, 1988; Elliott, 1997; Jenkins and Russell, 1999), but has not been quantified. The presence of airflow from a cave or karst feature is a well-recognized indicator of a potential significantly large cave (Veni, 1999). The occurrence of good airflow at the bottom of Flint Ridge Cave suggests that significant additional sections of the cave remain to be found. To comply with the scope of work defined by the City of Austin, barometric pressure was measured in the cave. Little research has been conducted on implications of barometric pressure changes in a cave, although it is generally recognized as an important factor in underground air movement. Rather than simply take barometric readings in the cave, to make the results more useful, twin recording barometers were used for comparative readings inside and outside of the cave. The cave barometer was carried throughout the cave and the readings were not taken from any single location. The barometers were set to take hourly readings, and set to the same initial pressure. The results are provided in Table 2.

Before assessing the meaning of the data, their accuracy must first be discussed. The barometers had a rated resolution of 0.03 mb Hg from actual barometric pressure. However, as time went on, the two instruments deviated considerably from each other. Within the 9-hour period in Table 2, their difference was triple the rated resolution. Continued side-by-side monitoring of the barometers in the office for the next few days produced as much as 0.27 mb Hg difference. Clearly, those particular instruments used cannot be used for precise barometric readings or for long-term comparative readings, but their short-term data from Flint Ridge Cave are useful for general interpretation of events affecting the cave's microclimate.

Table 2 has some interesting data. The immediate increase in atmospheric pressure upon entering Flint Ridge Cave was consistent with air blowing from the entrance. After about 1

hour in the cave, barometric pressure on the surface began to drop, but a difference in the cave was not recorded for another 3 hours. This lag is a factor of the difference in surface versus subsurface air pressure, and how the size and shape of the cave's entrance and passages limit air movement. During the last hour in the cave, barometric pressure on the surface rose slightly but had no immediate effect underground. Unfortunately, a relatively significant 0.20 mb Hg increase in pressure occurred within a hour of exiting the cave. The response of the cave to this change, rather than to the small changes recorded near the limit of the instruments' resolution, would have produced more definitive and meaningful results. With the higher pressure on the surface, the direction of air movement should have reversed and entered the cave, but no one was present to confirm it.

Table 2
Barometric Pressure at Flint Ridge Cave, Travis County, Texas
22 December 1999

Time (CST)	Cave Barometer, Pressure (mb Hg)	Surface Barometer, Pressure (mb Hg)	Direction of Airflow
1100	30.30	30.30	out of cave
1200	30.33 (in cave)	30.30	out of cave
1300	30.33 (in cave)	30.27	out of cave
1400	30.33 (in cave)	30.24	out of cave
1500	30.33 (in cave)	30.24	out of cave
1600	30.30 (in cave)	30.24	out of cave
1700	30.30 (in cave)	30.27	out of cave
1800	30.56	30.47	into cave (postulated; not observed)
1900	30.56	30.50	into cave (postulated; not observed)
2000	30.59	30.50	into cave (postulated; not observed)

Geology/Speleogenesis: Caves are dynamic hydrogeological features and can significantly change over time. Evidence of perhaps the earliest phases of the cave's evolution are the small phreatically formed passages and conduits near what are now the ceilings of the Balcony Room and the Breakdown Room. Possibly broad scallops were seen in the upper walls of the Balcony Room, suggesting slow groundwater flow. Anastomotic passages in the upper walls of the Breakdown Room are definite evidence of slowly moving groundwater and are possible remnants of groundwater flow before a preferred route was developed. The passages and conduits generally trend along the strike of the beds, which is consistent with low gradient phreatic flow, but they are insufficiently exposed to draw a definite conclusion.

As groundwater levels descended, a sinkhole began to form on the surface and channeled water underground. It is not clear if the location of the sinkhole was in response to the local zone of higher permeability created by the phreatic conduits. The section of the cave leading to the Formation Pit does not show evidence of a phreatic episode in its development, although that area is also covered by considerable speleothem growth. The passage almost certainly

extended headward into the sinkhole and was later collapsed by the sinkhole's enlargement. Over time, multiple entrances to the cave formed this way, opening by water flow and/or collapse, then closing by sedimentation or additional collapse only to reopen again at a later date and by collapse a little further down the passage. Erosion patterns in the cave walls and speleothems near the current entrance indicate earlier periods when larger volumes of water readily flowed into the entrance. However, the lack of observed bones in the cave's older sediments may indicate that the entrance was more often blocked by breakdown and soil than open so that animals could enter or be washed in.

"Phreatic" features in the upper level of the bi-level crawlway below the Formation Pit probably reflect a perched water table on the brown chert bed early in the modern development of the cave. Except for near the bottom of the cave and the conduits discussed in the two rooms, all phreatic-appearing features in the cave probably formed in water-filled perched levels until drained by vadose incision. The bi-level crawlway is an example where the incision did not completely remove the original perched floor.

The size of the cave's passages is primarily a factor of lithology, sedimentation, and groundwater piracy. The relatively large passages that trend southeast from the cave's entrance are formed in sections of the Kirschberg Member that are more soluble and more easily mechanically eroded. Only in the Balcony Room and Breakdown Room do the early-stage phreatic conduits clearly contribute to the cave's size. The cave's narrower and more fracture-controlled passages occur in the Dolomitic Member.

Although the passage in the upper half of the cave is relatively large, much of it is filled by sediment. Originally the cave drained through the crawlway below the Breakdown Room to D-Day Dome. The floor of the passage leading to the crawlway must have been incised to or near its elevation. Collapse later blocked the crawlway, formed a dam, and a mix of fine to coarse sediment filled much of the passage headward toward the entrance. Continued recharge into the cave opened the route to Culvert Crawl, pirating the water to D-Day Dome and bypassing the crawlway. Headward incision into Culvert Crawl from the dome demonstrates that this route has carried either a greater flow and/or for a longer time than the crawlway, which has little headward erosion from the dome. Other piracies in the cave include the pits in the passage beyond Head First Hole, and possibly the proposed capture of water from Quad Border Sink.

Sedimentation and piracy were also responsible for the configuration of passages at the bottom of the cave. When clay and silt sediments blocked the original southeast-bound passage, water was pirated to form a new, more hydraulically efficient route into the aquifer, and which is now the 3.7-m-deep pit and the passage at its base that leads to the deepest point in Flint Ridge Cave. The small size of this passage is due to its recent development, but it must lead to larger passages, otherwise it would not have had a steep enough gradient to form. Continued excavation of the sediment-blocked southeast-bound passage should also lead to those larger passages. This hypothesis is supported by airflow, and that the water table is probably not much deeper. Thus the airflow and the hydraulic gradient that flushes sediments and creates new passages are mostly from an at least moderately extensive conduit at or near the water table.

Dead Tree Sink

Synopsis: A broad, shallow sinkhole of no probable significance to Flint Ridge Cave.

Description: This sinkhole is about 12 m long north to south, 9 m wide east to west, and 0.3 m deep. It deepens slightly at its north and south ends. No airflow has been reported, but it appears that it may open to a cave with excavation (Russell, 1988).

History: The sinkhole was surveyed in either February or March 1985 during surveys of nearby Greenbriar Cave and Sand Burr Cave by Margaret Edwards, Bill Russell, John Spence, and Nancy Weaver (Russell, 1988).

Geology: The sinkhole is developed in the Leached and Collapsed members (undivided) of the Person Formation (Figure 1). Other than draining into the Edwards Aquifer, the sinkhole has no apparent relationship to Flint Ridge Cave. The size of the drainage area is not known, but its location on Figure 1 suggests it is small and only captures sheetwash.

Greenbriar Cave

Alternate name: Green Briar Cave

Synopsis: A short, possibly collapse-formed cave at the edge of a large sinkhole, and of no probable significance to Flint Ridge Cave.

Description: The entrance to the cave is along the north edge of a sinkhole that east to west measures about 18 m long, by roughly 12 m wide north to south, and less than 0.6 m deep. The approximately 2 m long by 1 m wide entrance narrows to less than a meter as it slopes down about 2 m into 8 m of passage that wraps around the edge of the sinkhole and reaches a total depth of 4.6 m. Airflow from the breakdown floor indicates that a significant portion of the cave remains undiscovered (Russell, 1988).

History: Bill Russell dug open the cave's entrance in early 1985 and surveyed the cave soon afterward with Mary Standifer. The cave's survey was tied into an overland survey of other nearby karst features in February or March 1985, which was conducted by Margaret Edwards, Bill Russell, John Spence, and Nancy Weaver (Russell, 1988).

Geology: The cave is developed in the Leached and Collapsed members (undivided) of the Person Formation (Figure 1). Based on the cave's description and surveyed depth, its base is in what Russell (1988) described in nearby Sand Burr Cave as a solution zone of a loose mix of limestone blocks, chert nodules, and lumps of clay around which substantial volumes of air blow through small holes. This zone is almost certainly the burrowed, punky, highly solutioned unit that Hanson (1995) described as locally occurring at the base of the Leached and Collapsed members. For this to occur requires the fault block containing the cave to dip down to the west to place the underlying Regional Dense Member at a lower elevation than where it outcrops 235 m to the northeast. Such a dip is consistent with the fault block's downthrown western margin. The highly solutioned nature of the limestone is probably in large part due to the presence of the Regional Dense Member having perched groundwater to develop a honeycombed to anastomotic flow network until the water could find or create and drain through a high

permeability conduit that breached the Dense Member. The large sinkhole at the cave's entrance may be part of a collapse into a wide room, a subsurface feature that might form in a highly solutioned zone. Most of the known section of the cave seems to be a gap between intact bedrock and rock fallen into an underlying void, although without visiting the cave this isn't certain. Airflow in the cave, plus water entering the sinkhole and forming a small seasonally active channel in the cave floor, suggests that much of the cave is probably not yet accessible. While some of the cave's airflow is stored in and derived from the honeycombed solution zone, a substantial portion is probably derived from conduits that breached the Regional Dense Member and drained groundwater from the solution zone. However, the information currently available does not indicate how much excavation would be required to reach one of those conduits. A pit through the Regional Dense Member would likely be exposed by excavation of the cave floor and provide access to solutionally developed and more extensive parts of the cave. Other than draining into the Edwards Aquifer, Greenbriar Cave has no apparent relationship to Flint Ridge Cave. The size of the drainage area is not known, but its location on Figure 1 suggests it is small and only captures sheetwash.

Karst Features COA1 to COA11

Synopsis: Minor karst features reported by the City of Austin of no probable significance to Flint Ridge Cave.

Description and history: These 11 karst and geologic features were found by and/or reported to the City of Austin. City staff provided this investigation unauthored field notes about the features with their locations marked on an aerial photograph; the locations have been transferred to Figure 1. The features were apparently found during a search for critical environmental features along the proposed State Highway 45 right-of-way. Since the available descriptions are brief, the features are described together here. COA1, COA4, and COA5 are shallow, small-diameter closed depressions, possibly sinkholes, at the base of a tree or within a grove of trees. COA2 and COA8 are solution cavities; their sizes are not described, but such features are typically less than 20 cm in diameter. COA3 is a sinkhole described in more detail below as Karst Feature FR1. COA6 and COA11 are, respectively, a fracture zone and fractured outcrop; the size of the fractured areas and the predominant fracture bearings were not described. COA7, COA9, and COA10 are listed as depressions and may be sinkholes. COA7 is relatively small, COA9 has a fracture that probably drains runoff that enters the depression, and COA10 is vegetated.

Geology: COA11 is developed in the Dolomitic Member of the Kainer about 3 m below the contact with the overlying Kirschberg Member. The remaining karst and geologic features are developed in the Kirschberg from about 4-13 m above the Dolomitic (Figure 1). Other than draining into the Edwards Aquifer, these features have no apparent relationship to Flint Ridge Cave. Based on their topographic locations, all drainage into these features is probably sheetwash; the sizes of the drainage areas were not listed, but are probably small.

Karst Feature FR1

Alternate name: Karst Feature COA3

Synopsis: A broad, shallow, intermittently ponded sinkhole of probably little significance to Flint Ridge Cave.

Description: This sinkhole is located on the ridge-top 140 m west of the entrance of Flint Ridge Cave (Figure 1). It is 12 m long, 8 m wide, 0.25 m deep, with its long axis oriented north to south. The floor of the sinkhole is covered with a black, clayey soil that is at least 0.3 m thick.

History: The sinkhole was first reported at an unspecified date as Karst Feature COA3 and was reevaluated during this investigation on 23 December 1999.

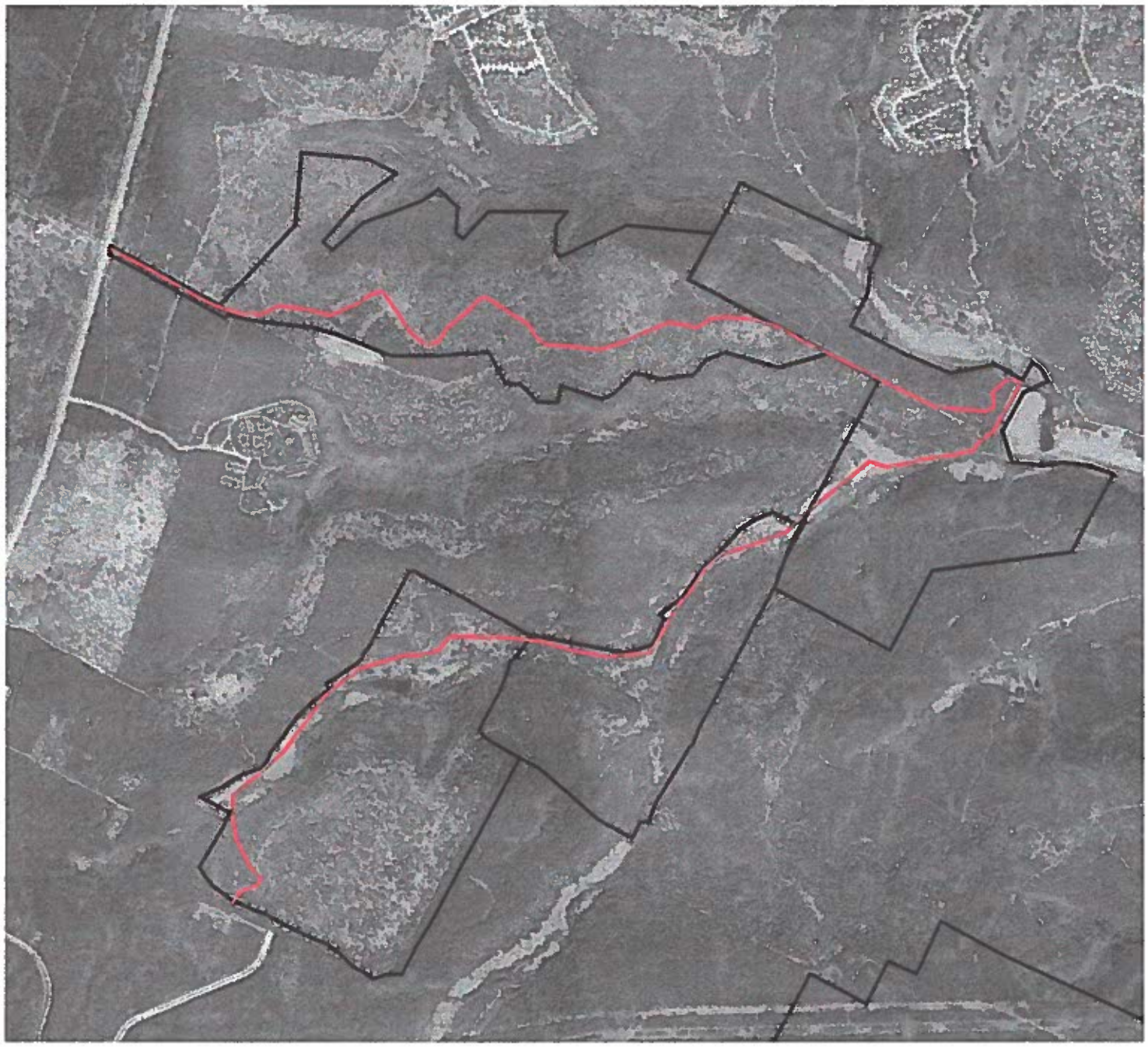
Geology: The sinkhole is formed in the Kirschberg Member of the Kainer Formation, about 10 m below its contact with the Grainstone Member. The lack of vegetation in the sinkhole, coupled with deep, hardened mud hoof-prints in the clayey soil are typical of sinkholes with effectively impermeable floors. Broad, shallow sinkholes are known to form over poorly permeable horizons in the Edwards Limestone, such as the Regional Dense Member, as described by Veni (1987). However, such horizons are not locally known within the Kirschberg, suggesting a second known cause of sinkhole floors becoming impermeable. In these cases, the floor was initially permeable. However, following European settlement of the region, short-term ponding of rainfall attracted livestock that increased soil erosion into the sinkhole, trampled and compacted the clayey soils, and rendered them less permeable. Following subsequent rains, the sinkhole would hold water for longer periods of time, allowing greater trampling and compaction until its current, effectively impermeable condition was reached. The sinkhole has no clear relationship to Flint Ridge Cave, although if recharge through the sinkhole is reactivated, one likely flowpath could have it flow southeast (downdip) toward the cave. The sinkhole drains sheetwash from an area roughly estimated as 50 m long by 20 m wide.

Karst Feature FR2

Synopsis: An impassably small conduit with airflow that probably drains into portions of Flint Ridge Cave beyond the limit of exploration and may open to humanly accessible passages by excavation.

Description: The entrance to this karst feature is a 1.2-m-long by 0.4-m-wide by 0.25-m-deep pit divided by a 0.3-m-wide by 0.2-m-thick natural bridge. At the base of the pit, a 1-m-wide by 0.1-m-high conduit heads northeast along a bearing of about 25° for at least 1 m. The impassably low conduit continues further, but out of visual range and the reach of the longest stick that could fit into the hole and be used to probe the walls. The rock floor at the base of the pit is probably collapsed from the entrance. Probing the floor of the conduit found a washed-in soil deposited at least 15 cm deep. Pulsing airflow was felt from the feature, indicating that a cave might be found by excavation. However, this inhaling and exhaling of air over a 10-minute period is not as reliable an indicator of an underlying cave as a steady inward or outward air current.

History: The karst feature was found and evaluated during this investigation on 23 December 1999.

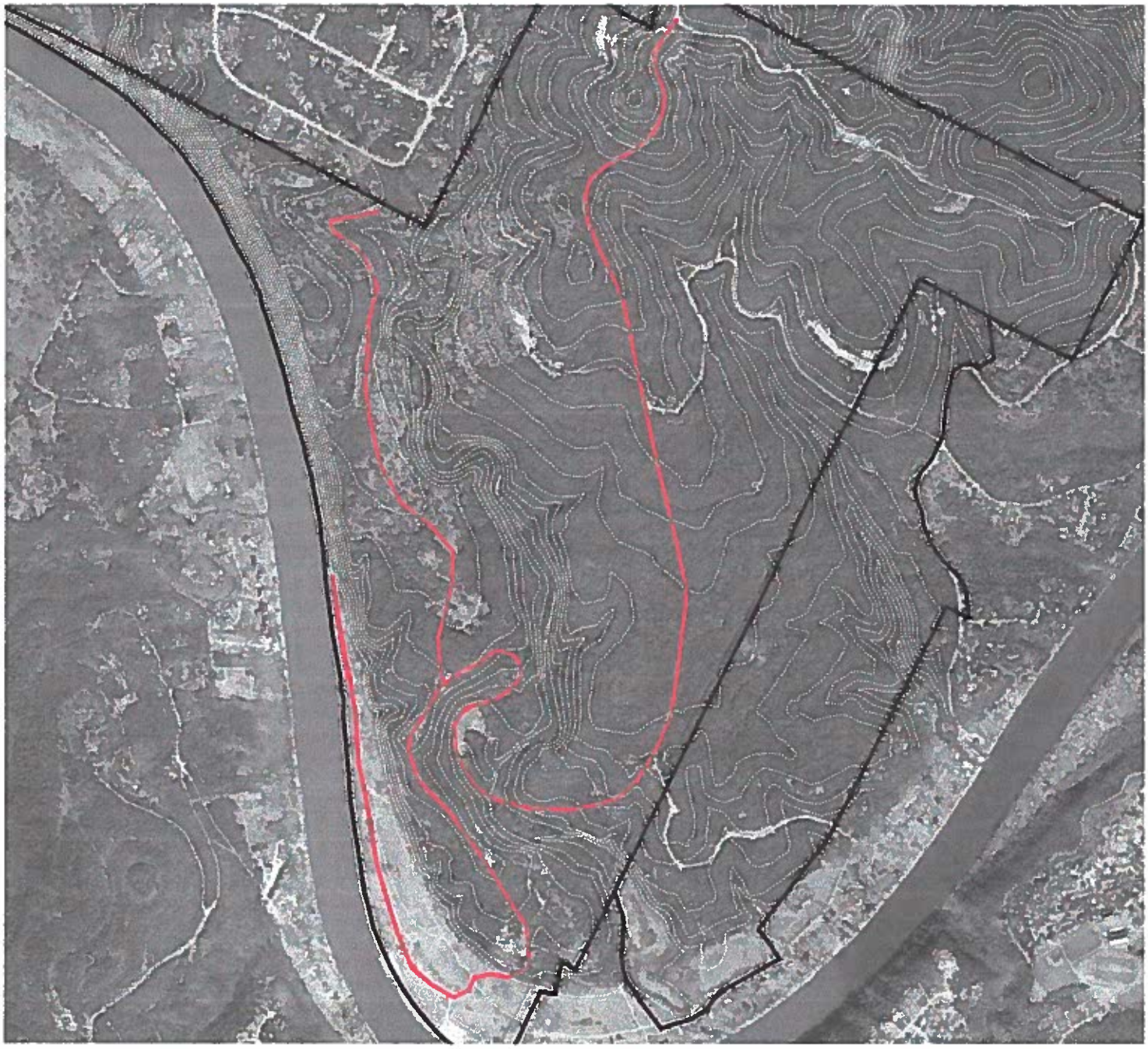


2000 White-tailed Deer Surveys
Upper Bull Creek

Legend
- Property Boundary
- Survey Route

Scale
0.5 0 0.5 1 1.5 Miles

N
W E
S

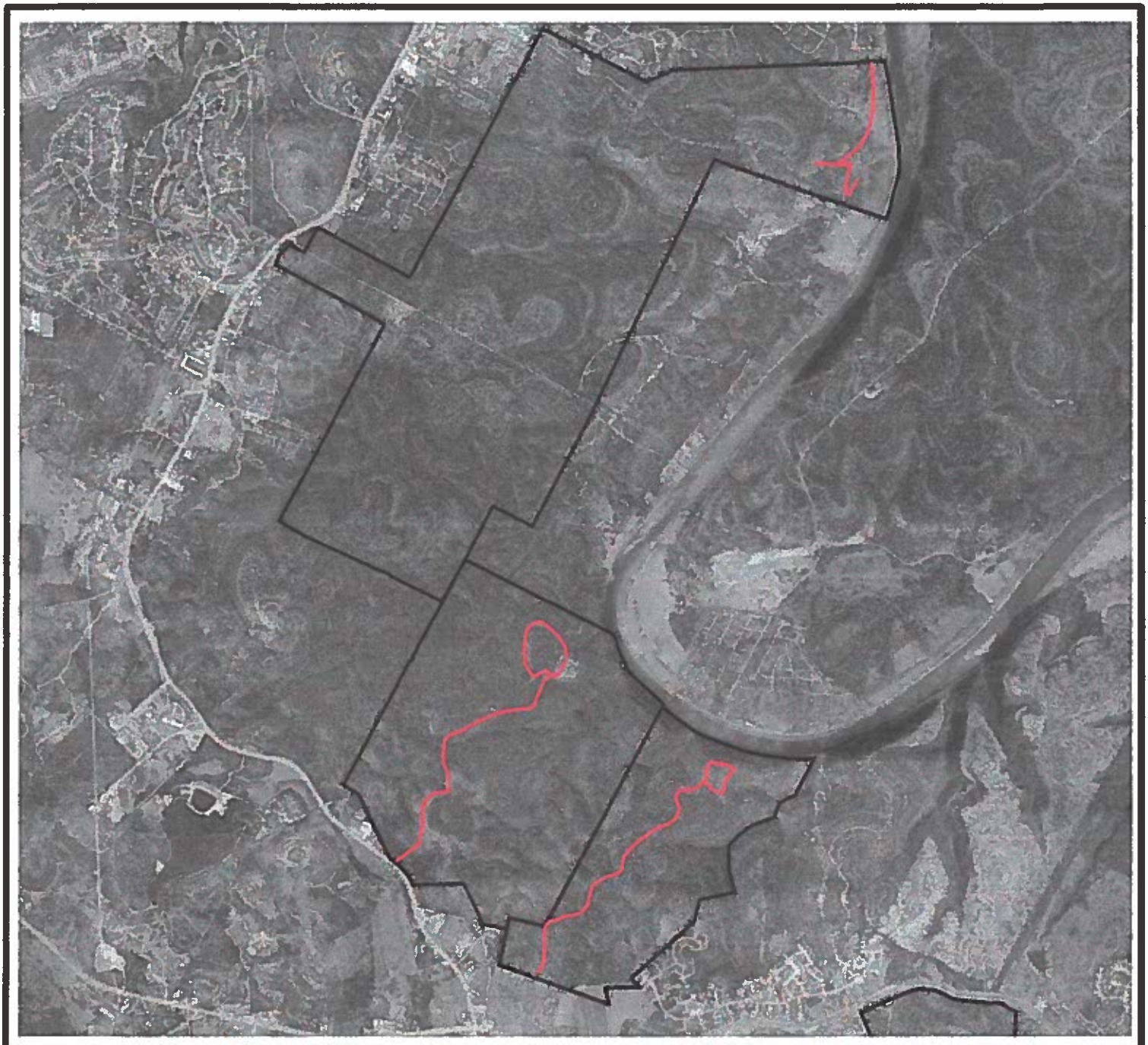


2000 White Tailed Deer Surveys
Emma Long Tract

Legend
Survey Route
Property Boundary

Scale
0.5 0 0.5 1 1.5 Miles

N
W E
S



2000 White Tailed Deer Surveys
Bohls, Reicher, and Double J and T Tracts

Legend
- Survey Route
- Property Boundary

Scale
0.5 0 0.5 1 1.5 2 2.5 3 Miles

N
W E
S

ATTACHMENT H

CITY OF AUSTIN

KARST FAUNA SURVEYS

Geology: The location of this feature on Figure 1 shows it within the Grainstone Member of the Kainer Formation, about 1 m below the Regional Dense Member of the Person Formation, and also about 15 m from a fault that locally bears 31.5°. The fault drops approximately 17 m to the east with the Kirschberg Member of the Kainer outcropping on the upthrown side and the Grainstone outcropping on the downthrown side. Karst Feature FR2 captures sheetwash from an area roughly 5 m long by 1 m wide. The small observable portion of the feature provides few definitive insights to its origin. The feature has been used as an animal den, but it is clearly a karst feature. It looks somewhat like a solutionally enlarged bedding plane, but the same general morphology could result from collapse along a bedding plane and peering along the resulting gap. Barker Bat Cave, located in the hill 900 m northwest of Flint Ridge Cave, demonstrates that large rooms can locally form in the Grainstone that could stope upwards to produce the karst feature and account for its airflow. The position of FR2 close to a major fault and in the general downgradient direction of Flint Ridge Cave suggests it drains into portions of the cave beyond the current limits of exploration.

Karst Feature FR3

Synopsis: A possible small sinkhole of undetermined significance to Flint Ridge Cave.

Description: This feature is 2.2 m long by 1.1 m wide by 0.25 m deep. Its long axis follows a bearing of roughly 355°. No bedrock is exposed, and probing the soil on its floor reached a compact clay and cobble fill within 20 cm.

History: The karst feature was first found by persons unknown at an unknown date. When it was rediscovered and evaluated during this investigation on 23 December 1999, it was found tagged with plastic survey flagging. The flagging was marked "possible C.E.F." to indicate it was a possible critical environmental feature, a term that probably refers to the City of Austin's usage and definition of the term. This feature was not marked in the notes the City staff provided for this investigation, and no other comments were written on the flagging from which to determine its origin.

Geology: The location of this feature on Figure 1 shows it within the Kirschberg Member of the Kainer Formation, about 6 m below the contact with the Grainstone Member. The appearance of the feature and the type of mixed clay-cobble fill is common in some stump holes and artificially created depressions. If the feature is a sinkhole, the compact clay may indicate low permeability; the presence of cobbles makes this uncertain. Sheetwash drainage from an area roughly 10 m long by 1 m wide enters this feature, which, if it is a sinkhole, could in part supply the drip water into the 3.7-m-deep pit near the surveyed end of the cave. Excavation is needed to definitively determine if it is a karst or artificial feature and to better assess its permeability if it is the former.

Karst Feature FR4

Synopsis: A cluster of five solutionally formed sinkholes that probably drain into Flint Ridge Cave but possibly beyond the limit of exploration.

Description: This feature is comprised of five solutionally formed sinkholes that occur within an approximately 26-m-long by 12-m-wide area. The individual features are described

here as FR4a through FR4e. The location for FR4 shown in Figure 1 is that of FR4a. This feature is the largest of the five and possibly the most significant. It is about 2.3 m in diameter and was initially 0.2 m deep with a floor of loose soil and leaf litter. At a depth of 0.3 m, excavation revealed a 0.25-m-diameter solutionally formed pit within the bedrock. The pit is centered in the sinkhole and was excavated another 0.4 m, where its floor was probed 0.2 m deeper and found to be a moderately compact soil and rock fill. FR4b is located 14 m due east of FR4a. It is about 1.3 m in diameter, 0.15 m deep, and covered by a soil that becomes clayey and compact at a depth of 0.2 m. FR4c is located 6 m northeast of FR4a. It is the same as FR4b, except slightly larger with a diameter of about 1.6 m. Eight meters away and nearly due north of FR4a, FR4d is a 1.8-m-diameter sinkhole. No bedrock is exposed in the sinkhole, but it steeply funnels to a depth of 0.6 m at its west end to indicate a hole in bedrock is present below. The floor of the funnel was probed 0.3 m deeper to a moderately compact soil fill. The final feature of the group, FR4e, is located about 8 m west of FR4d. It is a 15-cm-diameter pit that extended through a 20-cm-thick cap of soil and a 20-cm-thick bed of limestone into what appears to be a 10-cm-high conduit. The floor of the conduit was probed 0.3 m to continuing loose soil fill.

History: This group of karst features was found and evaluated during this investigation on 23 December 1999.

Biology: The white-throated slimy salamander *Plethodon albagula* was discovered in the soil and leaf litter of FR4b.

Geology: The location of this feature group on Figure 1 shows it within the Kirschberg Member of the Kainer Formation about 6-7 m below the contact with the Grainstone Member. An area that is roughly 60 m long by 5 m wide drains sheetwash into the five karst features. Two of the features appear to be at least moderately permeable and one may be highly permeable. Based on their relative structural and hydrologic location, drainage into these features should almost certainly join the flow of Flint Ridge Cave, but there is no structural or other indication whether it joins the known part of the cave or some part beyond the limit of exploration.

Lost Oasis Cave

Synopsis: A shallow, one-room cave with significant airflow that indicates significant additional sections of the cave may be present and discovered by excavation. The cave has no apparent direct relationship to Flint Ridge Cave, but is a known locality for the BCCP species of concern, the ground beetle *Rhadine austinica*.

Description: The entrance to the cave is a gated hole about 0.7 m in diameter by 0.6 m deep. A 1-m-wide by 0.3-m-high passage leads north for about 2 m, widening and opening into the southeast end of the single room that essentially makes up the cave. The room is largest at its southwest end, sloping down from a large collapse at the northeast side of the room. The room measures about 12 m long by 10 m wide and reaches up to 2.4 m in height. Many speleothems are present and cover much of the cave. Holes have been excavated 2 to 2.5 m down into the breakdown floor on the north and south sides of the cave in attempts to follow the airflow into undiscovered passages (Elliott, 1997).

History: The cave was discovered in early 1985 during a survey for the extension of Lost Oasis Hollow road. In March 1985, Bill Russell enlarged the entrance and was first to explore the cave. Eventually, construction plans were revised and the cave was donated to the Texas Cave Management Association in 1991, when it was gated by Mike Warton and Associates. Elliott (1997) indicated the cave was mapped at an unspecified date, possibly by Bill Russell.

Biology: Several invertebrate species are reported from the cave, including three troglobites. Two are species of millipedes and one is the ground beetle *Rhadine austinica*, which is listed as a species of concern by the BCCP (Elliott, 1997).

Geology: The location of this cave on Figure 1 shows it is within the Grainstone Member of the Kainer Formation, about 2 m above the contact with the Kirschberg Member. The cave's main floor level approximately marks the contact between the members. Elliott (1997) wrote that the lowest levels about 2-3 m deeper were reported to appear similar to those of Greenbriar Cave and Sand Burr Cave, and were hypothesized to all represent a "solution zone" at a common stratigraphic interval. Subsequent detailed geologic mapping has disproved that hypothesis by placing the other caves in the Leached and Collapsed members of the Person Formation. The deepest portions of Lost Oasis Cave could not be examined during the scope of this study in sufficient detail to be certain if its "solution zone" is in fact highly solutioned bedrock or old collapse obscured by solution and sediment. Given the cave's position atop the Kirschberg, it seems more likely than not that continued excavation will open significant, currently unknown parts of Lost Oasis Cave. If old collapse is what underlies the room, that is consistent with the observed collapse and that large rooms sometimes occur in the Grainstone. If solutioned bedrock is what occurs below the collapse, it is likely the result of dispersed groundwater flow through the collapse, creating multiple routes to an underlying shaft. That is the most likely type of cave development locally in the uppermost Kirschberg, as interpreted from Russell's (1996c) results; the shaft will probably not be deep, but a relatively short drop into underlying section of the Kirschberg where horizontal cave development is more prevalent. Lost Oasis Cave is formed along tensional fractures aligned along a monocline bearing 41° and dipping 15° northwest, which is probably related to the reverse fault 80 m to the northwest that bears 46°. The cave has no apparent relationship to Flint Ridge Cave other than draining into the Edwards Aquifer along at least the same probable general flowpath and in a more downgradient location. Sheetwash from a roughly 30-m-diameter area appears to drain into Lost Oasis Cave.

Quad Border Sink

Synopsis: A 120-m-diameter by 1.4-m-deep sinkhole that periodically holds ponded water. It may be the source of the perched groundwater found in Flint Ridge Cave.

Description: This sinkhole is 120 m in diameter and about 1.4 m deep. Bedrock is exposed on its north and west flanks, but deep soil covers its floor. Drainage flows to its slightly deeper western edge. A compact, poorly permeable, medium brown color clay covers the floor; its depth is undetermined but suspected to exceed at least 1 m. Deep, hardened mud footprints, lines of flood silt, and vegetation consistent with greater moisture than normally available in the area demonstrate periodic, probably seasonal flooding.

History: The feature is shown partly on the Signal Hill 7.5' USGS topographic quadrangle, but mainly on the Oak Hill 7.5' quadrangle. Bill Russell named the sinkhole for overlapping the quadrangles' borders.

Geology: The sinkhole is formed along a fault that locally bears 31.5° and has approximately 17 m of drop to the east, with the Kirschberg Member of the Kainer Formation outcropping on the upthrown side and the Regional Dense Member of the Person Formation outcropping on the downthrown side. Much of the sinkhole's broad diameter and shallow depth is consistent with the model developed by Veni (1987). Water is locally ponded, but the poorly permeable Regional Dense Member hampers efficient downward solution of the limestone, which is further mitigated by the deposition of clayey sediments and the insoluble residues of limestone that has been dissolved. Since the limestone along the sides of the sinkhole is better exposed to solution, the sinkhole is widened more rapidly than deepened. The fact that the sinkhole crosses two significantly different members of the Edwards Limestone modifies this basic model. The Kirschberg section of the sinkhole should be much more permeable, as is suggested by the lowest point of the sinkhole occurring over that member. The scope of work for this project did not allow sufficient examination of the sinkhole to determine if the probable drain into underlying conduits in the Kirschberg has been consistently blocked, or if it has been open throughout much of the sinkhole's history and is only recently plugged. The latter circumstance seems more likely considering the Edwards Plateau and Balcones Fault Zone regions have been experiencing significant and sustained soil erosion during the past 10,000 years, exacerbated by the recent phase of accelerated soil erosion associated with European settlement and overgrazing (Toomey, Blum, Valastro, 1993); soil compaction by livestock, as described for Karst Feature FR1, probably also significantly contributed to reducing the permeability of the sinkhole sediments. Quad Border Sink drains sheetwash, predominantly from the northwest, over an area covering 154,150 m^2. The significant volume of water that drains into the sinkhole and the storage within its sediments makes it a probable source for the perched groundwater found in Flint Ridge Cave; a passage following the same fracture trend and flow direction as the main southwest-bound passage in the cave, and extending approximately the same distance as the passage's surveyed length, would reach from the sinkhole to the cave.

Sand Burr Cave

Synopsis: A cave with about 16 m of small passages that lead to a depth of 6.4 m. Significant airflow indicates significant additional sections of the cave may be present and discovered by excavation, but it has no apparent direct relationship to Flint Ridge Cave.

Description: The entrance to the cave was originally a small depression filled with loose rocks, which when removed, revealed a bedrock pit that is 1.3 m long by 1 m wide by 2 m deep. A 0.6-m-high and wide passage leads south and after 4 m opens to a 6-m-long by 3-m-wide by 1-m-high room. The dirt and rubble floor of the room was dug 3 m downward into a small northbound passage that turns back under the entrance passage to lead 8 m to a 3-m-long by 1.5-m-wide by 0.7-m-high room. A large volume of air frequently blows from the cave. Excavations followed the air to where it emerged from many small holes within a loose mix of limestone blocks, chert nodules, and lumps of clay (Russell, 1988).

History: Bill Russell discovered the unexcavated entrance to the cave in 1984 and dug it and its passages open with Margaret Edwards, John Spence, and Nancy Weaver, probably in 1984 or early 1985. They also surveyed the cave, possible in February or March 1985 when the cave was tied into an overland survey of other nearby karst features (Russell, 1988).

Geology: The cave is developed in the Leached and Collapsed members (undivided) of the Person Formation (Figure 1). The lower half of the cave, which Russell (1988) described as a solution zone of a loose mix of limestone blocks, chert nodules, and lumps of clay around which substantial volumes of air blow through small holes, is almost certainly the burrowed, punky, highly solutioned unit that Hanson (1995) described as locally occurring at the base of the Leached and Collapsed members. For this to occur requires the fault block containing the cave to dip down to the west to place the underlying Regional Dense Member at a lower elevation than where it outcrops 245 m to the northeast. Such a dip is consistent with the fault block's downthrown western margin. The highly solutioned nature of the limestone is probably in large part due to the presence of the Regional Dense Member having perched groundwater to develop a honeycombed to anastomotic flow network until the water could find or create a drain through a high permeability conduit that breached the Dense Member. Much of the cave's small breakdown is a solution breccia formed by intensive dissolution of that section of the limestone. While some of the airflow is stored in and derived from the honeycombed solution zone, a substantial portion is probably derived from extensive conduits that breached the Regional Dense Member and drained groundwater from the solution zone. However, the information currently available does not indicate how much excavation would be required to reach one of those conduits. Other than draining into the Edwards Aquifer, Sand Burr Cave has no apparent relationship to Flint Ridge Cave. The size of its sheetwash drainage area was not carefully determined, but it is probably less than 10 or 20 m^2.

Hydrogeology and Karst Groundwater and Ecosystem Management

Understanding the hydrogeologic setting of the study area and its karst features is important to the management of groundwater resources and karst species of concern by defining potential routes of contaminant inflow to caves, interstitial zones, and ultimately into the aquifer, and defining the geologic barriers and pathways for the distribution of the species.

Polluted water can enter caves in three ways. First, contaminants in a cave's surface drainage basin could run off into its entrance or an associated feature that directly contributes recharge to the cave. Second, contaminants might also enter a cave by non-point flowpaths, where they would first enter the ground through soil-covered fractures or sinkholes and then join the cave at locations away from its entrance, such as water from the epikarst dripping along fractures or moving along interstitial voids. Some of these features may occur within a cave's surface water drainage basin, and some may extend outside of that area. Third, trash or hazardous material can be dumped in caves and karst features; no such materials were found in the Flint Ridge Cave study area.

Of the karst features evaluated during this investigation (not including the COA karst features for which there is insufficient information), all except FR1 and FR3 offer potentially significant pathways for available pollutants to enter local groundwater and the karst ecosystems. Flint Ridge Cave, Greenbriar Cave, Lost Oasis Cave, and Sand Burr Cave are parts of conduit drainage systems. Even if some caves don't capture significant volumes of water, they remain as open channels directly into the Edwards Aquifer for any contaminants that may enter. Dead Tree Sink is a high-permeability sinkhole that must also drain directly into the aquifer. Quad Border Sink is poorly permeable at its base, but high-level flooding could recharge the aquifer through permeable fractures along its flanks. Also, some recharge is almost certainly stored and released from its soils, the volume of which could be determined by a study comparing the draining of the sinkhole to evapotranspiration rates. FR2 and FR4 could use further study, but appear to be parts of a permeable conduit drainage network. Caves and features within the proposed highway right-of-way are: COA1, COA2, COA4-8, Flint Ridge Cave, and FR1-3.

This report has focused on caves and surface karst features, but its analyses include consideration of the surrounding epikarst and interstitial zones. As shown in the hydrology discussion for Flint Ridge Cave, significant volumes of water may enter a cave's entrance but even larger volumes may be recharged from epikarst and interstitial features that show little or no evidence of solutional enlargement at the surface. Delineation of subsurface drainage into a cave and of the inaccessibly small areas where species of concern may occur thus requires consideration of the interstitial zone and epikarst. For an overview of the interstitial zone in the Austin area, see Veni and Associates (1992).

Currently, most published data for the study area that relate to epikarst are soil studies. As described earlier in this report, most local soils are stony, thin to patchy, poorly to moderately permeable, and they lack sufficient thickness and lateral extent to retard groundwater recharge. This rapid and nearly unimpeded recharge illustrates the region's largely underdeveloped epikarst. Further evidence is that active dripstone speleothems seldom occur near the surface, although they were probably active during the Pleistocene Epoch when

there was sufficient epikarstic storage. Most vadose groundwater is stored well below the epikarst within and along fractures, bedding plane partings, and other minor voids within about 15-30 m of the top of the water table or major groundwater perching horizon. This water usually appears in caves as seeps, drips, or moisture on cave walls, and provides the baseflows of some cave streams. White (1969) described this type of flow in the phreatic zone as the diffuse flow component of karst aquifers.

Management of aquifer recharge and species of concern requires at least a conceptual understanding of the extent of this diffuse flow or interstitial zone in the study area. In the Kirschberg Member of the Kainer Formation, interstitial development is extensive and complex. Initially it appears two-dimensional, limited to horizontal solutionally enlarged bedding planes, but further inspection shows it is three-dimensionally complex, with intricate interconnected levels and flowpaths throughout the Kirschberg's soluble matrix. These interstitial voids extend broadly from Kirschberg caves, but not to any great distances. In contrast, interstitial development in the Dolomitic is more narrowly confined horizontally and vertically to fractures, and may extend significant distances in either dimension.

Management of the invertebrate karst species in the Austin area has been guided primarily by the U.S. Fish and Wildlife Service's (USFWS) recovery plan for the listed species (O'Donnell, Elliott, and Stanford, 1994). However, more recent studies by USFWS suggest larger areas are needed to better protect the surface plant and animal communities that the subsurface species depend on. A significant factor in the new guidance is the consideration of edge effects, the degradation of habitat quality along its perimeter and establishing an adequate edge buffer to maintain an undisturbed and ecologically viable core habitat area. Draft guidance for the listed karst species requires karst preserve areas to be at least 0.28 to 0.40 km^2 (68 to 100 acres) in size (Sybil Vosler, USFWS, personal communication, 2000).

Evaluation of Caves and Karst Features Relative to the Proposed Highway Corridor

Caves and karst features of the study area are quantitatively evaluated in this section of the report to determine where placement of the proposed highway will have the least likely impact on Flint Ridge Cave, its ecosystem, and the groundwater it recharges into the Edwards Aquifer. Of the karst features discussed in this report, Flint Ridge Cave, FRC1-4, and Quad Border Sink are quantitatively evaluated below using field observations to determine their probable significance. Karst features COA1-2 and 4-11 are not included due to insufficient information. Dead Tree Sink, Greenbriar Sink, Lost Oasis Cave, and Sand Burr Cave are not directly related to Flint Ridge Cave and are also not evaluated. FR4 is evaluated as its five individual karst features. The general evaluation method was discussed and successfully applied by Veni (1999), and the exact procedure is currently being refined (Veni, in preparation). This technique is used as a screening method for identifying the features of greatest probable hydrological and biological significance.

Table 3 lists the quantitatively evaluated caves and karst features and tallies their characteristics with point values commensurate with each characteristic's significance in demonstrating the permeability of a feature, and hence the feature's likelihood to be a hydrologically significant cave. The sum of these points is multiplied by a point value assigned to the feature type, with a total that can range from 0-720 points. Based on comparison with known and well studied karst features (Veni, 1999), the significance of a feature is ranked as 0 points for "none" (or effectively impermeable), 1-150 points for low, 151-250 points for moderate, and 251-720 points for high significance. These categories are further divided on a scale of 0-10 for a more quantitative and precise means of comparison and analysis (Veni, in preparation). In that scale, 0 is "none," 1-3 is low, 4-7 is moderate, and 8-10 is high significance. The equivalent point ranges are:

0: 0-25 points	6: 191-210 points
1: 26-80 points	7: 211-250 points
2: 81-120 points	8: 251-350 points
3: 121-150 points	9: 351-450 points
4: 151-170 points	10 > 450 points
5: 171-190 points	

The assigned values are not evenly distributed among the point groups. The modest range of low point values (150), the small range of moderate point values (100), and the large range of high point values (470) effectively models known features because it represents the range of permeabilities and stages in karst development. Initially, permeability increases slowly, but once it reaches a certain threshold, it quickly increases to the broad range of high permeability regimes.

The quantitative assessment method was designed and tested in some but not all members of the Edwards Limestone in the San Antonio area. Some lithologic changes occur between San Antonio and Austin, so based on field observations and knowledge of how the assessment method was designed, the value for the Kirschberg Member was raised by one point to better reflect actual conditions in the study area. This adjustment produces results

Table 3: Quantitative assessment of karst features in the Flint Ridge Cave study area (draft Karst Feature Assessment Table (GVA 2/98))

Feature name or number	Feature Characteristics																						Feature Type															Results			Recharge area, sq. meters (only recharging features)						
			Recharge type				Size		Fracture			Lithology				Sediment infill				Topography				Artificial		Cave					Sinkhole		Solution cavity				Spring											
	Airflow (10)	Cave fauna (8)	None (0)	Sheetflow (1)	Channelized (5)	Streambed (9)	Length or width >2 m (3)	Depth >1 m (4)	Present (2)	Guides feature (4)	Balconies (6)	Upper Glen Rose (3)	Basal Nodular (4)	Dolomitic (8)	Kirschberg (8)	None (10)	Loose (7)	Moderate (4)	Compact (1)	0-5° (8)	5-20° (3)	20-90° (1)	Feature characteristics total	Depression (2)	Well (10)	Paleospring (0)	Phreatic (8)	Spring (2)	Transitional (9)	Vadose (10)	Collapse (6)	Solutional (7)	Enlarged bedding plane (3)	Enlarged fracture (5)	Epikarst (2)	Honeycomb voids (2)	Paleospring (0)	Spring (0)	Total (0-720)	"None" (0), Low (1-150), Moderate (151-250), High (>250)	Significance (0-10)	<10	10-100	100-1000	1,000-10,000	10,000-100,000	100,000-1,000,000	>1,000,000 (>1 sq. km)
FlintRdgCav	10	8			5		3	4							8	10				8			56							10									560	High	10						X	
FR1				1			3								8				1	8			21									7							147	Low	3		X					
FR2	10			1											8	10				8			37								6								222	Mod	7	X						
FR3				1			3								8				1	8			21									7							147	Low	3	X						
FR4a				1			3								8			4		8			24									7							168	Mod	4	X						
FR4b				1											8				1	8			18									7							126	Low	3	X						
FR4c				1											8				1	8			18									7							126	Low	3	X						
FR4d				1											8			4		8			21									7							147	Low	3	X						
FR4e				1											8	10				8			27									7							189	Mod	5	X						
Quad B Snk					5		3	4	2	4	6				8				1	8			41									7							287	High	8						X	

that are consistent with field estimates of the features' significance.

Based on Table 3, Flint Ridge Cave is clearly the most hydrogeologically significant karst feature in the study area, followed by Quad Border Sink; both are ranked as highly significant. Karst Feature FR2 is rated as the next most significant and in the high range of moderate probable hydrologic significance. Considering the difference in size between Quad Border Sink and FR2 when compared to their point values in the assessment, it important to repeat that "significance" is used here to primarily reflect permeability and likelihood of leading to a cave or conduit flow conditions; volume of recharge is a minor consideration. FR4e and FR4a are ranked in the low to moderate range of probable hydrologic significance, and the remaining features are listed as having low probable significance.

Conclusions

Flint Ridge Cave is one of the more significant caves in Travis County. It is an important recharge site into the Edwards Aquifer, provides extensive access into the conduit drainage network of the aquifer, and is habitat for two invertebrate troglobites that are listed as species of concern on the BCCP. A field and literature search found nine karst features (counting FR4 as five individual features) that are potentially related to the cave. Evaluation of these karst features, hydrogeologic features in Flint Ridge Cave, and an analysis of all available information has led to the following conclusions:

1) The surveyed extent of Flint Ridge Cave leads close to the water table, but it is likely that extensive and significant undiscovered passages continue beyond the constrictions that currently impede exploration and research.

2) The surface water drainage basin for Flint Ridge Cave covers an area of 163,300 m^2. The volume of recharge into the Edwards Aquifer in that area is estimated as 4,860 m^3/year.

3) Most of the recharge into the Edwards Aquifer within that area does not flow into the cave's entrance, but recharges through other features. The volume of water that recharges the aquifer through the entrance of Flint Ridge Cave cannot be reliably estimated with the available information. The surface water drainage basin in Figure 1 reflects an area that may potentially impact the cave by overland flow into the cave's entrance, but without gauged flow into the entrance, it is impossible to accurately estimate what portion of the drainage basin contributes how much water into the cave and during what conditions. Based on field observations at the cave and other similar sites, probably 80-90% of all water flowing into the cave's entrance is derived from the 71,900 m^2 area below the 244 m (800 ft) contour line, but this is not proven or empirically determined. Assuming this estimate is correct, then mean annual recharge through the entrance is 1,470 to 2,140 m^3/year (71,900 m^2 area x 0.82 m/year precipitation, x either the recharge zone runoff coefficient of 0.025 or the mean recharge rate of 0.0363). This value should not be considered reliable until recharge rates are quantified at the cave or comparable sections of the Edwards Aquifer recharge zone.

4) No contaminants are apparent in the water samples collected inside Flint Ridge Cave.

5) Previously unrecorded troglobitic aquatic amphipods were found in the small perched stream passage in Flint Ridge Cave.

6) Quad Border Sink is the probable source of water for the small perched stream passage in Flint Ridge Cave.

7) Karst Feature FR3 is of undetermined origin and formed near the main fracture trend of Flint Ridge Cave; if it is a karst feature, it may add a small amount of recharge to the cave.

8) Recharge into Karst features FR2 and FR4 probably flows to Flint Ridge Cave but

into conduits beyond the current limits of exploration.

9) Karst Feature FR1 contributes little or no significant recharge into the Edwards Aquifer or Flint Ridge Cave.

10) Based on the above conclusions and related analyses of this study, the subsurface drainage area for Flint Ridge Cave is defined as shown in Figure 1. This only includes drainage into the known portion of the cave and not into downgradient sections, although some downgradient drainage areas may coincidentally be included. The summary factors defining the basin boundaries are:

> Entrance area. The cave once extended further north into the entrance sinkhole where tributary conduits may still flow into and through the now collapsed part of the passage. Small conduits drain to the main passage near the entrance.
>
> Southwest area. The 60-m northwest and southeast distance from the cave includes drainage flowing downdip, modern drainage through old, high-level phreatic conduits, and significant fracture drainage paths. The 130-m distance southwest along the axis of the cave includes drainage along the main guiding fracture, is equal in length to known conduit development along that fracture, and includes any recharge from Karst Feature FR3.
>
> Northeast area. Northwest and southeast distances are set 60 m from the trend of the cave to include the same features as in the southwest area, except extrapolated and curved northeastward to include Quad Border Sink. Drainage from Quad Border Sink includes the flanks of the sinkhole where moderate to high permeability fractures and recharge features may exist, and a 30-m-wide section of the Regional Dense Member where permeability along a major fault is higher.

These boundaries delineate the minimum areas through which recharge is likely to enter Flint Ridge Cave. Recharge from beyond these areas may also reach the cave, but there is presently insufficient information to accurately extend the boundaries.

11) The proposed route for State Highway 45 will place about a third of Flint Ridge Cave below impermeable pavement and the rest of the cave parallel to and immediately downgradient of the highway. Adverse impacts on the cave are probable if that route is implemented. The volume of sediments that typically escape from highway construction sites will produce at least short-term and possibly long-term adverse impacts on the cave. Sedimentation within the cave will slow drainage into the Edwards Aquifer resulting in more intense and frequent flooding of the cave. The flooding will probably adversely impact habitat for the terrestrial species of concern. Blasting over the cave may result in collapse of cave passages. Given the depth of the cave and other geologic factors, such collapse is unlikely to extend to the surface or pose a threat to the highway, but it could clog the cave making it less accessible for study, and perhaps less suitable for the species of concern by temporarily impounding recharge in normally dry passages. Petrochemical contaminants that are often present with highway construction will be carried into the cave by floodwaters, and because they will be adsorbed onto sediments, they may prove a long-term contamination threat to the cave's fauna, if not to the aquifer. During operation of the highway, the proposed route

would drain onto the entire length of the cave's surface water drainage basin, including the entrance sinkhole, and cover or drain onto about 60% of the subsurface drainage basin. The probable consequences would be diminution or cessation of flow for perennial seeps flowing into the southwest end of the cave, and degraded quality of all water entering the cave. Berms and other diversions may be used to prevent highway runoff from entering the cave, but will also prevent recharge and diminish the quantity of water entering the aquifer and the quality of habitat for the cave's ecosystem. Any runoff not diverted away from the cave or which leaks or spills past diversion structures runs of the risk of introducing potentially significant levels of contaminants that may harm the quality of groundwater in the Edwards Aquifer, Flint Ridge Cave, and their ecosystems. It is beyond the scope of this research to quantify the potential degrees of water quality or ecological impacts.

12) The proposed route for State Highway 45 will be inadequate to meet the draft USFWS guidance, as described by Sybil Vosler (personal communication, 2000), for protecting karst ecosystems. The two primary failings are:

a) The edge of the pavement extends into the highly sensitive entrance sinkhole and within 18 m of the cave entrance. Even under the prior and less restrictive guidance, a distance of 50 m from the cave entrance was generally considered a minimum distance for major impacts.
b) Only 0.17 km^2 are preserved in the combined surface and subsurface drainage areas, which is 39.3% less than the minimum recommended area of 0.28 km^2.

Recommendations

Karst areas are well known to have complex groundwater flow paths that are very sensitive to contamination, which can impact human groundwater supplies and rare karst ecosystems. The following recommendations are based on this premise and the data of this study, and are presented in descending order of priority.

1) The proposed route of State Highway 45 should be shifted west away from Flint Ridge Cave, as shown in Figure 3, to prevent or minimize adverse impacts to the cave, its fauna, and to the Edwards Aquifer. The recommended diversion would have the actual roadway cover:

a) the low-significance features FR1 and FR3, instead of FR1, the moderately significant FR2, and the east edge of the cave's highly significant sinkhole;

b) 7.2% of the cave's surface drainage basin instead of 16.9%, by removing the roadway from the highly sensitive area nearest the cave's sinkhole and completely removing it from within the sinkhole;

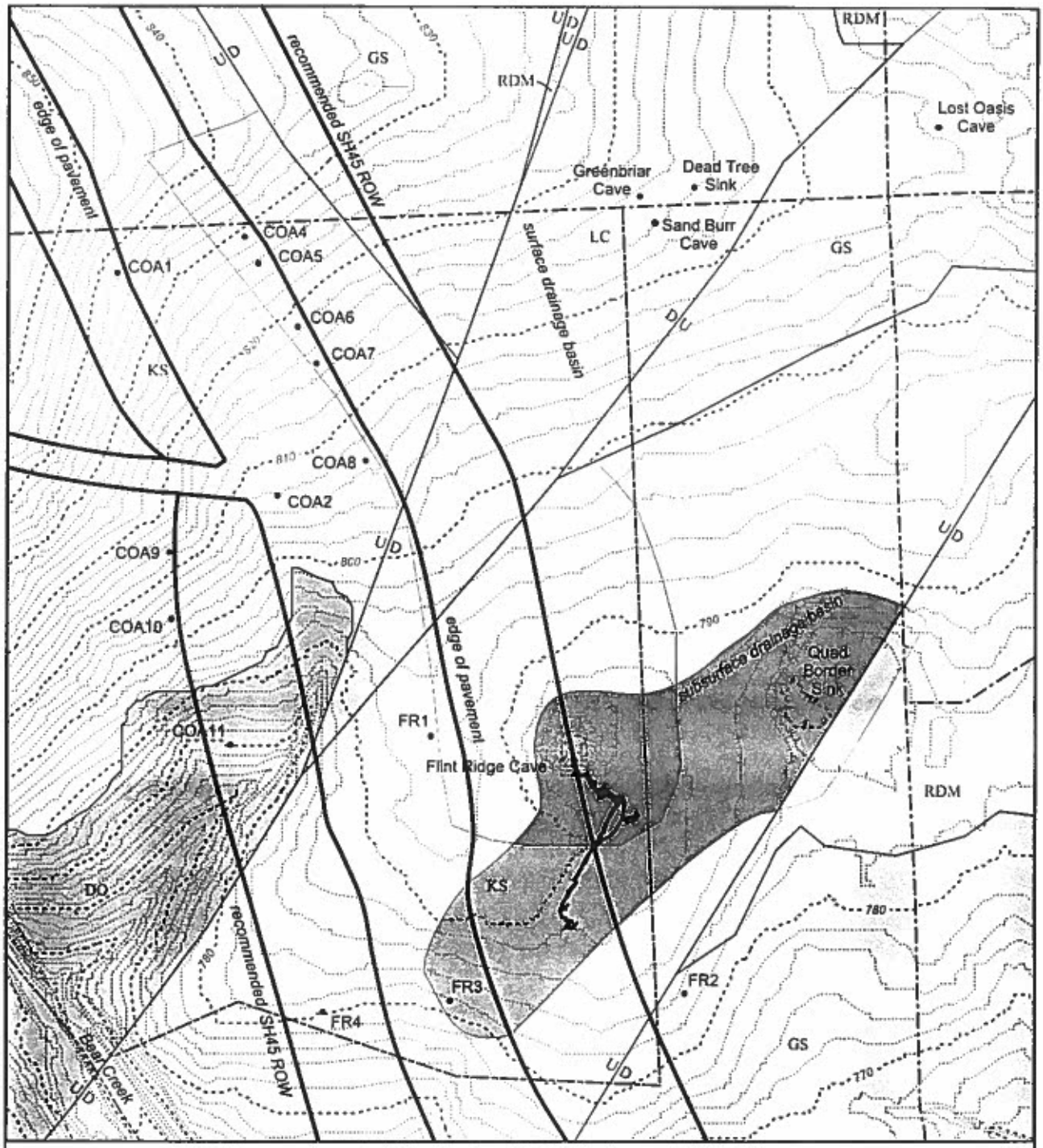
c) 8.3% of the cave's subsurface drainage basin instead of 20.2%, with all of the covered area moved to the southwest corner of the drainage area where the volume of inflow to the cave is smallest and probably the least sensitive.

2) Whether the recommended diversion of the proposed highway is implemented or not, the highway should be designed so that runoff from the road is curbed and diverted west, away from the cave, into the 400-m-long southwest-flowing tributary of Bear Creek. Even with the original proposed route, the approximately 20-28% volume of water diverted away from the cave (28% if assuming that most runoff into the cave entrance occurs below the 244 m [800 ft] contour elevation) should pose less of an impact to the cave's recharge and ecosystem than highway contaminated runoff. If the original route is maintained, runoff on the west side of the highway should be curbed and diverted away from the cave's subsurface drainage area.

3) The original route for the proposed highway will not provide adequate buffer for the cave's ecosystem, as determined per draft guidance by the USFWS (Sybil Vosler, personal communication, 2000) for the listed invertebrate karst species. The combined surface and subsurface drainage areas that would not be covered by pavement, as recommended and shown in Figure 3 to preserve drainage into the cave, would provide 75% of the area needed to protect the cave's ecosystem with a total of 0.21 km^2. The City of Austin should coordinate with the U.S. Fish and Wildlife Service to determine if additional areas are definitely needed to preserve the ecosystem and on the optimal locations for those areas.

4) Drainage diverted to flow west from the proposed highway should be channeled through the best available designs of stormwater runoff sedimentation and filtration basins, to include adequately sized hazardous materials traps, in order to protect the quality of the Edwards Aquifer. This western area is also upgradient from Flint Ridge Cave where recharge

Figure 3



Recommended Route for State Highway 45 ROW near Flint Ridge Cave, Travis County, Texas

Legend: *Person Formation*

- LC Leached-Collapsed members
- RDM Regional Dense Member
- *Kainer Formation*
- GS Grainstone Member
- KS Kirschberg Member
- DO Dolomitic Member
- Outline of cave
- U/D Fault, D side moved down relative to U side
- Fence line
- Surface drainage basin
- Subsurface drainage basin

0 100 200
METERS
contour interval 2 feet

Highway alignment and topographic base map: City of Austin (2000)
Geology base map: Small, Hanson, and Hauwert (1996)
Cave map outline: modified from Russell (1988)
Locations for Dead Tree Sink, Greenbriar Sink, and Sand Burr Cave: Russell (1988)

George Veni & Associates, 2000 Drawn by Peter Sprouse

NT

may potentially reach and impact the cave through unknown routes or by entering the aquifer and rising into the cave from the water table during floods.

5) If hazardous materials transportation routes are not already proposed as restricted from the study area's section of State Highway 45, such regulations should be enacted before the highway is opened for traffic. Restrictions on the transportation of hazardous materials do not mean that hazardous materials traps would not be needed in stormwater sedimentation and filtration basins. The traps would be needed to capture spilled gasoline and diesel fuels.

6) Advance planning should be developed prior to highway construction to avoid or minimize possible adverse impacts. Equipment and activities that may utilize or contain hazardous materials should be minimized within the drainage areas of the cave and the karst features, and no such materials should be stored in those areas. The placement of construction roads and use of heavy equipment in the drainage areas should be minimized to prevent soil erosion and sedimentation in the cave. The recommended diversion of the highway would significantly reduce the risk and actual loss of soil into the cave because the topography would divert most of the runoff elsewhere. Any karst features discovered or opened by construction in the study area should be hydrogeologically and biologically evaluated as soon as possible, and construction adjusted appropriately if and as warranted.

7) The portions of the surface and subsurface drainage basins not covered by the proposed highway should be maintained in their natural condition, to include protection of any karst features in those areas.

8) A biologist experienced in the ecology of local cave ecosystems should be consulted to verify recommendations in this report as appropriate and adequate in protecting the fauna of Flint Ridge Cave.

9) Water that is episodically ponded in Quad Border Sink should be analyzed for contaminants to determine if Flint Ridge Cave may be impacted and if any remedial actions are needed to stop or minimize any pollutant inflow.

10) Karst features FR2 and FR4 and their drainage areas should be preserved and protected if possible. Diversion of the original proposed route of the roadway only 10-20 m west would avoid covering FR2. If the diversion recommended in Figure 3 is accepted, FR2 would be outside of the right-of-way and FR4 would be within the right-of-way.

11) Prior to highway construction, limits should be established on blasting in the vicinity of Flint Ridge Cave based on the best available geotechnical studies. The Center for Water Research (1992) conducted some investigations on the effects of blasting on engineered structures in the San Antonio Segment of the Edwards Aquifer. Limits should be established on the magnitude of detonation, firing sequence, type of explosive, and directional forces relative to the distance from the cave.

12) Flint Ridge Cave and any other cave found within the highway right-of-way should be gated if discovery and unrestricted access by the public is likely. Gates will limit landowner

liability from unauthorized visitation, and limit trash, vandalism, and excessive traffic that would be harmful to the caves ecosystems and water quality. All gates should allow the unimpeded passage of water, air and cave life. Signs should be placed at gated caves providing educational information on the purpose of the gates and significance of the caves, and a warning on penalties for harming either. A schedule should be established for regular inspection and maintenance of the gates and signs, and coordinated with the Texas Cave Management Association, which is assisting the City of Austin with the management of Flint Ridge Cave.

13) Flint Ridge Cave appears that it might be suitable bat habitat. A cave biologist should confirm if this is likely, and if designing bat access into the cave is desirable. If it is likely, then key questions that must be answered about allowing bats into the cave are if alterations to the entrance are needed, if they would adversely alter the microclimate and hydrology of the cave relative to the species of concern, and if bats would adversely affect the species of concern by contributing too many nutrients into an ecosystem evolved for nutrient-poor conditions?

14) Continued research at Flint Ridge Cave and other karst features in the study area will be useful to better understand and manage these resources and the Edwards Aquifer. The excavation, exploration, and survey of karst features is of first importance by identifying and defining the features of significance. Excavation of passages at the bottom of Flint Ridge Cave should be conducted. FR2 and FR4 should be excavated. Volunteer cave explorers with the Texas Speleological Association and Texas Cave Management Association, who found and surveyed Flint Ridge Cave and other area caves, could continue much of this work. Additional baseline water data are needed for Flint Ridge Cave. These include both quality and quantity of flow entering the cave's entrance and inside the cave to look for changes following the development of State Highway 45, and to take corrective actions if problems are identified. Runoff into the cave was not sampled during this investigation, although planned, due to insufficient rainfall. To accurately gauge recharge into the cave, a weir should be built, and could be incorporated into a gate if one is planned. Float gauges could be installed to record maximum stage height, from which peak discharge could be calculated; this should be in addition to or combined with a staff gauge. A water quantity study at Quad Border Sink, comparing loss of ponded water to evapotranspiration rates, would measure how much water is recharged into the aquifer. A tracer test could be attempted between Quad Border Sink and Flint Ridge Cave, but a tracer test between the cave and Barton Springs is more important at this stage of research for the cave and the Edwards Aquifer.

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APPENDIX A
Glossary of Geologic, Karst, and Biological Terminology

This glossary is broad in scope to assist nonspecialists reviewing this report, but is not meant to cover all possible terms. Additional karst definitions and geologic terms can be found in the geologic dictionary of Jackson (1997); for biospeleological terms see Culver (1982).

Alluvium: Stream-deposited sediments, usually restricted to channels, floodplains, and alluvial fans.

Anastomoses: Small interconnecting conduits that fork and rejoin, usually along bedding planes and joints.

Antecedent precipitation: Precipitation (usually rainfall) that occurred prior to a given time or event. Usually refers to the amount of rain prior to a storm whose effect is measured on a stream, spring, or water well hydrograph.

Aquifer: Rocks or sediments, such as cavernous limestone and unconsolidated sand, which store, conduct, and yield water in significant quantities for human use.

Attitude: The position of a bed of rock with respect to the horizontal plane; typically measured as strike and dip.

Base level: The level to which drainage gradients (surface and subsurface) are adjusted, usually a surface stream, relatively impermeable bedrock, or water table. Sea level is the ultimate base level.

Baseflow: The "normal" discharge of stream when unaffected by surface runoff; derived from groundwater flowing into the stream channel.

Bearing: The azimuthal direction of a linear geologic feature, such as the axis of a fold or the orientation of a fracture; commonly used to denote specific orientations rather than average or general orientations. See trend for comparison.

Beds: See strata.

Bedding plane: A plane that divides two distinct bedrock layers.

Breakdown: Rubble and boulders in a cave resulting from collapse of the cave ceiling.

Breccia: A rock composed of broken, angular fragments of a pre-existing rock that were cemented to form the present rock unit.

Calcite: The predominant mineral in limestone. It is relatively soluble compared to other common minerals, and allows for the dissolution of limestone and the precipitation of calcite

speleothems.

Cave: A naturally occurring, humanly enterable cavity in the earth, at least 5 m in length and/or depth, in which no dimension of the entrance exceeds the length or depth of the cavity (definition of the Texas Speleological Survey).

Chert: A microcrystalline silica rock, often found as nodules or small lens in limestone and dolomite; it is essentially the same as "flint."

Conduit: A subsurface bedrock channel formed by groundwater solution to transmit groundwater; often synonymous with cave and passage, but generally refers to channels either too small for human entry, or of explorable size but inaccessible. When used to describe a type of cave, it refers to base level passages that were formed to transmit groundwater from the influent, upgradient end of the aquifer to the effluent, downgradient end.

Conduit flow: Groundwater movement along conduits; usually rapid and turbulent.

Cretaceous: A period of the geologic time scale that began 135 million years ago and ended 65 million years ago.

Depression: A sinkhole-like feature that is not formed by karst processes or has not yet been proven karstic in origin.

Depth: In relation to the dimensions of a cave or karst feature, it refers to the vertical distance from the elevation of the entrance of the cave or feature to the elevation of its lowest point. See vertical extent for comparison.

Dip: The angle that joints, faults or beds of rock make with the horizontal; colloquially described as the "slope" of the fractures or beds. "Updip" and "downdip" refer to direction or movement relative to that slope.

Diffuse flow: Laminar and very slow groundwater movement within small voids of primary and secondary porosity, excluding conduit and fissure flow; "intergranular" flow.

Discharge: The water exiting an aquifer, usually through springs or wells; also the amount of water flowing in a stream.

Downdip: See dip.

Drag fold: A localized bending of strata along a fault, caused by frictional tension adjacent to the fault plane; the fold bends toward where the opposite side of the fault has moved.

Drainage basin: A watershed; the area from which a stream, spring, or conduit derives its water.

Drainage divide: Location where water diverges into different streams or watersheds. On the surface they usually occur along ridges or elevated areas. In aquifers, they occur along highs in

the potentiometric surface between groundwater basins.

Dye trace: The injection of a non-toxic dye into a groundwater system, and its recovery at a downgradient location (usually a spring). This technique is commonly used in karst areas to define groundwater flow paths and travel times.

Endemic: Biologically, refers to an organism that only occurs within a particular locale.

Epikarst: The highly solutioned zone in karst areas between the land surface and the predominantly unweathered bedrock.

Fault: Fracture in bedrock along which one side has moved with respect to the other.

Footprint: The outline of the cave in plan view; generally refers to defining the horizontal limits of the cave as they relate to the land surface.

Fracture: A break in bedrock that is not distinguished as to the type of break (usually a fault or joint).

Geomorphology: The branch of geology that studies the shape and origin of landforms.

Graben: A section of rock between faults that has dropped downward relative to strata on the opposite side of the faults.

Grade: The continuous descending profile of a stream; graded streams are stable and at equilibrium, allowing transport of sediments while providing relatively equal erosion and sedimentation. A graded profile generally has a steep slope in its upper reaches and a low slope in its lower reaches.

Groundwater trough: A steep furrow-shaped feature in the potentiometric surface, usually indicative of high groundwater transmissivity through an underlying conduit.

Head: The difference in water level elevations that creates the pressure for water movement down a gradient.

Headward: In the direction of greater elevation; typically refers to upstream or up a hydraulic gradient.

Homoclinal hinge: The axis of a single, uniform bend in strata.

Honeycomb: An interconnected series of small voids in rock, commonly formed in karst by near-surface (epikarstic) solution, or by phreatic groundwater flow.

Hydrogeology: The study of water movement through the earth, and the geologic factors that affect it.

Hydrograph: A graph illustrating changes in water level or discharge over time.

Hydrology: The study of water and its origin and movement in atmosphere, surface, and subsurface.

Impermeable: Does not allow the significant transmission of fluids.

Interstitial zone: Conduits of an aquifer and/or cave that are too small for human access; can be located both above and below the water table. Generally used to describe a type of habitat for cavernicole fauna. May include inferred conduits of probable humanly passable dimensions, but which are inaccessible for study.

Joint: Fracture in bedrock exhibiting little or no relative movement of the two sides.

Karst: A terrane characterized by landforms and subsurface features, such as sinkholes and caves, which are produced by solution of bedrock. Karst areas commonly have few surface streams; most water moves through cavities underground.

Karst feature: Generally, a geologic feature formed directly or indirectly by solution, including caves; often used to describe features that are not large enough to be considered caves, but have some probable relation to subsurface drainage or groundwater movement. These features typically include but are not limited to sinkholes, enlarged fractures, noncavernous springs and seeps, soil pipes, and epikarstic solution cavities.

Length: In relation to the dimensions of a cave or karst feature, it refers to the summed true horizontal extent of the cave's passages or the feature's extent.

Lineament: A linear feature, usually observed in aerial photographs, which likely represents a geologic feature such as a fault, joint, or lithologic contact.

Lineation: A linear alignment of features that may indicate control by fractures or other geologic features or processes.

Lithology: The description or physical characteristics of a rock.

Magnetic declination: The difference between true or geographic north axis around which the earth rotates, and the magnetic north to which magnetic compasses point to as north; it changes constantly, but slowly with the changing location of the magnetic north pole.

Normal fault: A fault where strata underlying the fault plane are higher in elevation than the same strata on the other side of the fault plane.

Paleodrainage: An earlier pattern or condition of surface or groundwater flow.

Passage: An elongate, roofed portion of a cave or karst feature; usually a conduit for groundwater flow.

P_{CO_2}: Partial pressure of carbon dioxide; the part of the total gas pressure that can be attributed to carbon dioxide.

Perched groundwater: Relatively small body of groundwater at a level above the water table; downward flow is impeded within the area, usually by impermeable strata.

Permeable: Allows the significant transmission of fluids.

Permeability: Measure of the ability of rocks or sediments to transmit fluids.

Phreatic: The area below the water table, where all voids are normally filled with water.

Piracy: The natural capture of water from a watershed, stream, aquifer, or cave stream, and its transmission to a different watershed, stream, aquifer, or cave stream.

Pit: A vertical cavity extending down into the bedrock; usually a site for recharge, but sometimes associated with collapse.

Pleistocene: An epoch of the Quaternary Period of the geologic time scale that began 2 million years ago and ended about 10,000 years ago. Colloquially called the "Ice Age" due to its episodes of continental glaciation.

Porosity: Measure of the volume of pore space in rocks or sediments as a percentage of the total rock or sediment volume.

Potentiometric surface: A surface representing the level to which underground water confined in pores and conduits would rise if intersected by a borehole. See water table.

Punky: Partially cemented and/or leached rock.

Reach: The length of a stream or stream segment; often used to denote similar physical characteristics.

Recharge: Natural or artificially induced flow of surface water to an aquifer.

Resolution: The dissolving or solution of speleothems, usually due to their submergence by or changes in their source flow to chemically undersaturated groundwater. Sometimes called redissolving.

Reverse fault: A fault where strata underlying the fault plane are lower in elevation than the same strata on the other side of the fault plane.

Room: An exceptionally wide portion of a cave, often at the junction of passages; commonly indicative of either the confluence of groundwater flowpaths or of slow, nearly ponded, groundwater flow. Generally synonymous with chamber, except that chamber is usually reserved for relatively large rooms.

Seep: A spring that discharges a relatively minute amount of groundwater to the surface at a relatively slow rate; typically a "trickle."

Shaft: See pit.

Sheetwash: Surface water runoff that is not confined to channels but moves across broad, relatively smooth surfaces as thin sheets of water.

Sink: See sinkhole.

Sinkhole: A natural indentation in the earth's surface related to solutional processes, including features formed by concave solution of the bedrock, and/or by collapse or subsidence of bedrock or soil into underlying solutionally formed cavities.

Solution: The process of dissolving; dissolution.

Speleogenesis: The process of cave origin and development.

Speleothem: A chemically precipitated secondary mineral deposit (e.g., stalactites and stalagmites) in a cave; usually calcite but can form from gypsum and other minerals.

Spring: Discrete point or opening from which groundwater flows to the surface; strictly speaking, a return to the surface of water that had gone underground.

Stage: The water level elevation or height measured in a stream or a well.

Strata: Layers of sedimentary rocks; usually visually distinguishable. Often called beds. The plural of stratum.

Stratigraphic: Pertaining to the characteristics of a unit of rock or sediment.

Stratigraphy: Pertaining to or the study of rock and sediment strata, their composition and sequence of deposition.

Strike: The direction of a horizontal line on a fracture surface or on a bed of rock; perpendicular to dip.

Structure: The study of and pertaining to the attitude and deformation of rock masses. Attitude is commonly measured by strike and dip; deformational features commonly include folds, joints, and faults.

Stump hole: A depression that resembles a sinkhole, but is formed by tree growth and is present after the tree has rotted away; often maintains a sinkhole-like appearance by burrowing mammals.

Trend: The azimuthal direction of a linear geologic feature, such as the axis of a fold or the

orientation of a fracture; commonly used to denote average or general orientations rather than specific orientations.

Troglobite: A species of animal that is restricted to the subterranean environment and which typically exhibits morphological adaptations to that environment, such as elongated appendages and loss or reduction of eyes and pigment.

Troglophile: A species of animal that may complete its life cycle in the subterranean environment but which may also be found on the surface.

Trogloxene: A species of animal that inhabits caves but which must return to the surface for food or other necessities.

Updip: See dip.

Vadose: Pertaining to the zone above the water table where all cavities are generally air-filled, except during temporary flooding.

Vertical extent: In relation to the dimensions of a cave, refers to the vertical distance from the highest elevation to the lowest elevation of the cave. Generally used when a portion of a cave extends above its entrance. See depth for comparison.

Vug: A small cavity in rock, often lined with crystals, and generally not significantly related to groundwater movement.

Water table: The boundary of the phreatic and vadose zones. A potentiometric surface but the term is used only in unconfined aquifers.

Weir: A dam with a notch or upper surface shaped to carry water such that the stream's discharge over the dam can be calculated from the stream's height behind (upstream of) the dam.

APPENDIX B

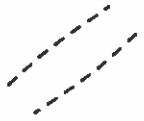
Conversions:
International System of Units to English Units

MULTIPLY	BY	TO GET
Length		
centimeters (cm)	0.3937	inches (in)
meters (m)	3.281	feet (ft)
kilometers (km)	0.621	miles (mi)
Area		
square meters (m^2)	10.76	square feet (ft^2)
square kilometers (km^2)	0.3861	square miles (mi^2)
square kilometers (km^2)	247.1	acres (ac)
Volume		
liters (L)	0.264	gallons (gal)
cubic meters (m^3)	264.17	gallons (gal)
cubic meters (m^3)	0.00081	acre-feet (a-f)
Flow		
liters per second (L/s)	0.0353	cubic feet per second (cfs)
liters per second (L/s)	15.85	gallons per minute (gpm)
cubic meters per second (m^3/s)	35.31	cubic feet per minute (cfm)
cubic meters per second (m^3/s)	0.000158	gallons per minute (gpm)
cubic meters per second (m^3/s)	70.05	acre-feet per day (a-f/d)
Temperature		
degrees Celsius	multiply by 1.8 then add 32	degrees Fahrenheit

APPENDIX C

Cave Map Symbols

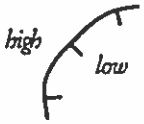

passage walls


lower level passage

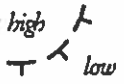

upper level passage


breakdown walls


unexplored or impassable passage



drop in floor



drop in ceiling


large breakdown


small breakdown or talus


bedrock floor


stream cobbles

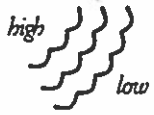

sand or soil


mud or clay

stalactite


stalagmite


column



flowstone


water, with flow direction


cross section, with view direction

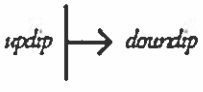

vertical joint



dipping joint



fault, D side moved down relative to U side



dipping fault



strike and dip of bedding

APPENDIX D

Stratigraphic Column of Cretaceous Rocks in or near Flint Ridge Cave, Travis County, Texas*

Group	Formation	Member(s)	Thickness (m)
Edwards			97 - 128
	Person		15 - 34
		Cyclic & Marine	0**
		Leached & Collapsed	9 - 24
		Regional Dense	6 - 9
	Kainer		82 - 94
		Grainstone	12
		Kirschberg	21
		Dolomitic	34 - 46
		Basal Nodular	15
Trinity			
	Glen Rose		107 - 152

* Based on ranges by Small, Hanson, and Hauwert (1996) and mapping by Barton Springs/Edwards Aquifer Conservation District (1997).

** Locally not present; removed by Cretaceous Period erosion.

ATTACHMENT G

CITY OF AUSTIN

WHITE-TAILED DEER CENSUS
FALL 1999 and FALL 2000

Attachment G

WHITE-TAILED DEER SURVEY PROGRAM

Balcones Canyonlands Preserve

Fall 1999
and
Fall 2000

The City of Austin
Parks & Recreation Department
Natural Resources Division

Prepared by Jackie Davis
January 2001

I. DEER CENSUS METHODS

There are several census techniques which can be used to perform ground deer censusing, i.e. the Hahn, Spotlight, and Mobile Line techniques. Through consultation with Texas Parks and Wildlife Department biologist Trey Carpenter, it was decided that the City of Austin would use the Spotlight technique to census deer on the Balcones Canyonlands Preserve tracts. The Spotlight technique determines deer populations by counting the number of deer spotted along a census line, calculating the number of acres seen along this census line, and dividing the number of acres by the number of deer observed to give an estimate of the deer population (expressed as acres per deer).

A form, kindly provided by Trey Carpenter, allows the census taker to calculate the number of acres observed along the route of the census. At intervals of 0.2 mile, the distance in yards which can be seen to the right and to the left are noted on the form. When this distance (usually 5 miles for the BCP census) is divided by the number of stops (usually 26), an average width of the census strip is determined. Through a formula provided by TPWD, the total number of acres seen for that specific survey can then be determined. The number of deer seen during that survey will then be expressed as *x acres per deer*. The formula is expressed as:

_____	/	_____	X	_____	/	4840	=	_____
Total visible yards (n miles)		No. of readings (5n + 1)		Length of line in yards (1760 n)		Sq. yards / acre		Acres of visibility

The Spotlight technique involves using high intensity spotlights to count deer at night. The City of Austin survey biologists usually use a pickup, with two crew members sitting in the back of the pickup, counting the deer, and the driver of the pickup marking the data on the form. We begin the count between 30 to 45 minutes after sundown. The vehicle speed is generally between 2 mph to 6 mph, and visibility readings are taken every 0.2 mile. We determine sex and age (fawns) when possible. We also note all other animals (invertebrates, reptiles, birds, mammals) which we encounter along the route.

II. RESULTS AND DISCUSSION

A. Fall 1999 Survey

The surveys conducted in the fall of 1999 were the first formal studies performed by COA biologists to determine the relative numbers of deer on the COA BCP tracts. Three different locations in the City's Balcones Canyonlands Preserve were chosen for the surveys, and each area constituted a five-mile census line: (1) **Upper Bull Creek**, extending from the west side of Canyon Creek, crossing through the uplands and lowlands of the Hanks tract, then traversing through the lowlands of the Franklin and Lanier tracts. (Note: for the fall 2000 survey, the lowlands of Hanks were not available for surveys, and the WTP#4 tract was substituted. Permission to enter the WTP #4 and survey deer was given by Jean Schultz of W&WW.); (2) **Emma Long City Park**, extending from City Park Road on the northern side down to an off-road trail on the uplands portion, then continuing down City Park Road into the campgrounds area along the river; (3) **South Lake Austin Macrosite**, extending from the Baldwin tract south of Bohls and traversing the uplands on the west side of Bohls up to the river overlook; the survey then resumes on the private road which bisects Reicher Ranch; and lastly, the survey resumes on a portion of Double J&Tat the very eastern end of Kollmeyer Drive, traversing the lowlands along the river.

Three surveys were conducted for the Upper Bull Creek location, producing an average density of one deer for every 11.5 acres. A deer survey of this area was performed in 1995 by an officer of the PARD police staff, with results of one deer for every 7-8 acres. During the 1999 survey period, the Upper Bull Creek survey route was also used several times a week, both during the night and day, by a contractor who was hired to trap and hunt feral hogs. It is not known if this intrusion affected the 1999 deer density data.

Two surveys were conducted for the Emma Long City Park location, producing an average density of one deer for every 1.2 acres. This is an extremely high deer density, and the impacts of these conditions of severe over-population were evident on the deer herd. Most of the deer were very small in stature and weight (visual determinations), and a few showed evidence of blue tongue. The majority of the herd was consistently found down along the flat campground area along the riverfront.

Two surveys were conducted for the South Lake Austin Macrosite location, producing an average density of one deer for every 3.17 acres. Again, this is an extremely high deer density, and the average weight of the deer, per visual inspections, appeared to be much lower than the average field-dressed weight for a four and a half year-old buck, which is about 84 pounds for bucks in the Edwards Plateau region (vs. 112 pounds for bucks in the South Texas Plains region). (1)

B. Fall Survey 2000

The surveys conducted in the fall of 2000 were the second of a series of formal studies conducted by COA biologists to determine the relative numbers of deer on the COA Balcones Canyonlands Preserve tracts. The same three locations and routes were surveyed, with the exception of Upper Bull Creek, where the WTP#4 tract was substituted for the lowlands of the Hanks tract.

Three surveys were conducted for the Upper Bull Creek location, producing an average density of one deer for every 5.4 acres. This deer density is more than twice that shown for the 1999 survey in the Upper Bull Creek location, which lends credence to the suspicion that the intrusion by a hog trapper during the 1999 surverys skewed the results of the 1999 data.

Three surveys were conducted for the Emma Long City Park location, producing an average density of one deer for every 1.34 acres. These data, when compared with the 1999 data, confirms that the Emma Long City Park has a severe problem with over-population of the deer herd. Again, the deer were small in stature and weight (visual determinations).

Three surveys were conducted for the South Lake Austin Macrosite location, producing an average density of one deer for every 4.13 acres. This density of deer at this location is similar to that found in the 1999 survey.

III. CONCLUSIONS

All of the surveys for the fall of 2000 produced densities of deer which are unacceptably high for the well-being of the endangered species habitat of the Balcones Canyonlands Preserve. Biologists for TPWD indicate that deer densities approaching one deer for every 15 acres would be an acceptable average number of deer in relation to the carrying capacity of the land. Data from the Kerr Wildlife Management Area indicates that regrowth and regeneration of hardwood trees and woody shrubs occurs with a deer density of one deer for every 11 to 14 acres. Whether regeneration will begin to occur, once the density of the deer population is reduced to these numbers, remains to be seen. Perhaps the density of deer will need to be reduced to an even lower number, during the initial stages of regeneration of habitat.

As joint holders of a federal Endangered Species Act Section 10(a) endangered species permit, the City of Austin and Travis County are obligated to protect, preserve, and enhance the habitat for the Golden-cheeked warbler and Black-capped vireo within the 30,428 acres of the Balcones Canyonlands Preserve. Because of the severe browsing by the over-populated deer herd here in central Texas, most of the mature hardwoods and woody shrubs on the BCP tracts are **not being replaced** with younger generations of their species. (See Leland Russell's dissertation: "Effects of White-tailed Deer on the Dynamics and Structure of Spanish Oak Populations on the Eastern edwards Plateau, Texas" and his paper "Rarity of Oak Saplings in Savannas and Woodlands of the Eastern edwards Plateau, Texas" for further discussions o the effects of deer browse on hardwoods.)

An effective deer management and cull program, along with proper game fencing, should be initiated immediately. If an effective deer management program, concurrent with a revegetation program (which has already been initiated), is undertaken, then the permit holders will be fulfilling their obligations as permit holders.

(1) *White-Tailed Deer, Ecology & Management*, Halls, 1984

DEER SURVEYS
COA/BCP
FALL SEASON, 1999

Date	Upper Bull	Emma Long	So. Lk. Austin
8/5/99	6.23 acres/deer		
9/8/99		1.28 acres/deer	
9/14/99	13.32 acres/deer		
9/28/99			2.63 acres/deer
10/6/99		1.09 acres/deer	
10/12/99	14.96 acres/deer		
10/22/99			3.7 acres/deer

DEER SURVEYS
COA/BCP
FALL SEASON, 2000

Date	Upper Bull	Emma Long	So. Lk. Austin
9/19/00		1.26 acres/deer	
9/29/00	6.06 acres/deer		
10/5/00			1.8 acres/deer
10/31/00		1.16 acres/deer	
11/6/00	6.3 acres/deer		
11/21/00			6.2 acres/deer
11/30/00		1.6 acres/deer	
12/6/00	3.85 acres/deer		
12/18/00			4.4 acres/deer

INCIDENTAL ANIMALS OBSERVED DURING SURVEYS

Mammals:	
Opossum	*Didelphis marsupialis*
Ringtail cat	*Bassariscus astutus*
Striped skunk	*Mephitis mephitis*
Grey fox	*Urocyon cinereoargenteus*
Coyote	*Canis latrans*
Feral cat	*Felis domesticus*
Nutria	*Myocastor coypus*
Black-tail jackrabbit	*Lepus californicus*
E. Cottontail rabbit	*Sylvilagus floridanus*
Feral hog	*Sus scrofa*
Armadillo	*Dasypus novemcinctus*
Birds:	
Night heron, black-crowned	*Nycticorax nycticorax*
N. Bobwhite quail	*Colinus virginianus*
Inca doves	*Columbina inca*
E. Screech owl	*Otus asio*
Common Poorwill	*Phalaenoptilus nuttallii*
Painted bunting	*Passerina ciris*
Reptiles:	
W. Diamondback rattlesnake	*Crotalus atrox*

ME OF LINE_____COUNTY_____DATE_____

	VISIBILITY							COMMENTS
E	LEFT	RIGHT	TOTAL	BUCKS	DOES	FAWNS	UNDETERMINED	TOTAL
RT								
0.2								
0.4								
0.6								
0.8								
1.0								
L								
1.2								
1.4								
1.6								
1.8								
2.0								
L								
2.2								
2.4								
2.6								
2.8								
.0								
L								
3.2								
3.4								
3.6								
3.8								
.0								
4.2								
4.4								
4.6								
4.8								
.0								
5.2								
5.4								
5.6								
5.8								
.0								
6.2								
6.4								
6.6								
6.8								
0								
7.2								
7.4								
7.6								
7.8								
0								

BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: M. Sanders, C. Abbruzzese Agency:PARD Date:3/14/00 No. of pages:2

Location: District park cave Section No. 1 (Aquifer Room)

Time Started: 11:19am Time ended: 11:53am

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 18° C Outside: 16° C @ 10:55am

Humidity Inside: 98% Outside: 92% @ 10:55am

FAUNAL SURVEY

Species	No. seen	Comments
Spiders: Cicurina sp	1	
wall web	8	
Millipedes: Cambala speobia	9	One found dead
* Speodesmus sp.	1	
* Texella mulaiki		
Springtails: Collembolids	20	
Crickets: Ceuthophilus sp. B	15	
Ceuthophilus secretus		
Ceuthophilus cunicularis		
Ceuthophilus nymphs	30	
Texoreddellia texensis		
* Rhadine austinica		
Rove beetles: Aleocharinae sp.		
Snails: Gastropoda		
gnats: sp.	6	
terrestial isopods		
raccoon (Procyon lotor)		
moth	1	

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

☐ Photographs taken? How many? ____ If so, attach to this report.

There was a small amount of trash near the entrance and a little bit of gang graffiti scratched into rocks at the entrance. We removed the trash and erased the graffiti. We did not take any photos in the 2 sections because we forgot the compass.

Survey section #1 (Aquifer Room)

Length = 5m

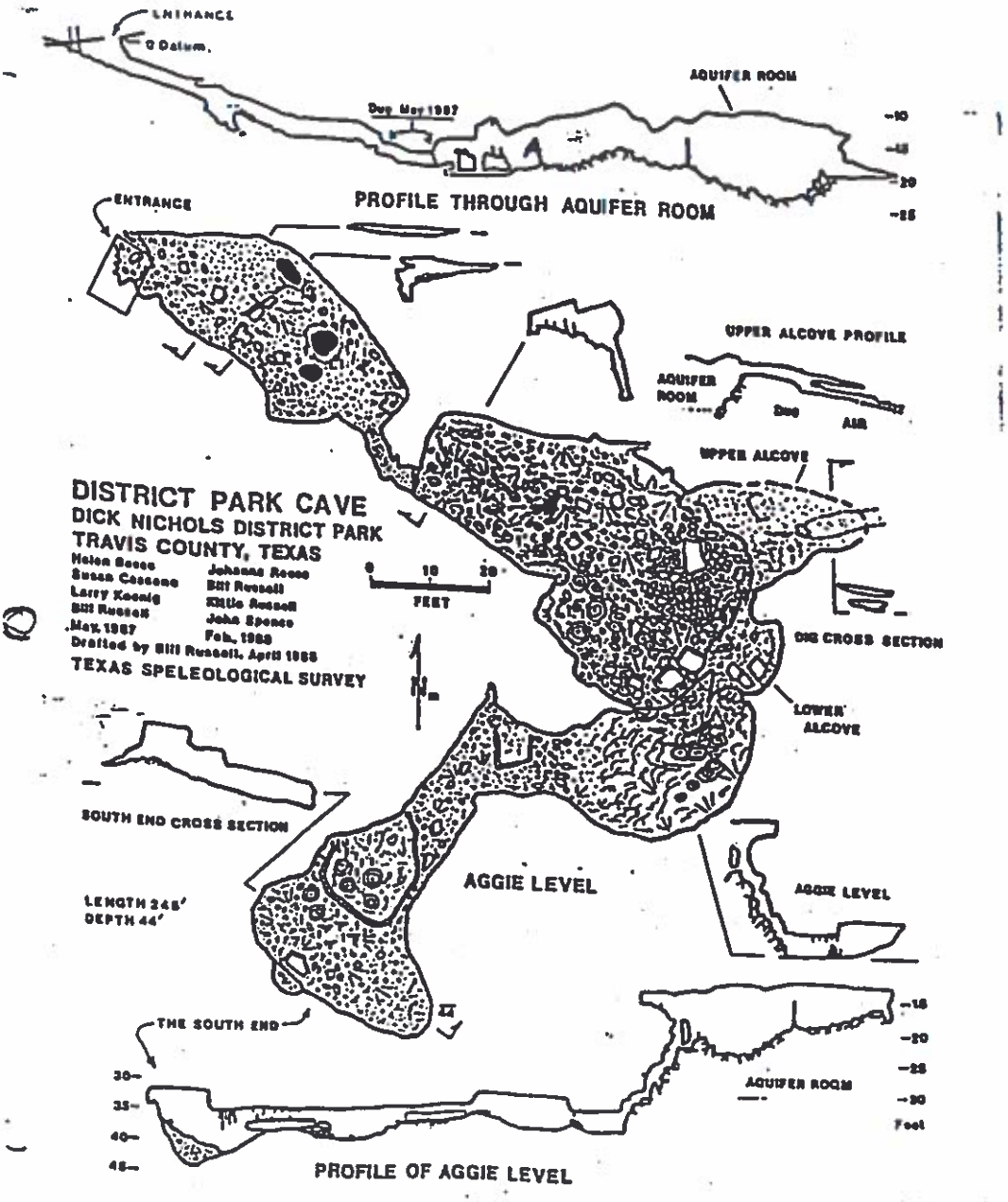
height = 2.3m

width = 5.1m

A = photo station - taken from sitting position on a (Natural, 1.53m from large stalagmite (camera in horizontal position)

237°N

Setting: 200 ASA - fully automatic - green box - auto focus



BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: M. Seabury, C. Abbruzzese Agency:PARD Date:3/14/00 No. of pages:2

Location: District park cave Section No. 2 (Aggie Level)

Time Started: 12:20pm Time ended: 1:10pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 20° C Outside: _____ Humidity Inside: 91% Outside: _____

FAUNAL SURVEY

Species	No. seen	Comments
Spiders: Cicurina sp	3	All were same species, delicate, long legs, harvestman like
wall web		
Millipedes: Cambala speobia		
* Speodesmus sp.	1	
* Texella mulaiki	2	
Springtails: Collembolids		
Crickets: Ceuthophilus sp. B		
Ceuthophilus secretus		
Ceuthophilus cunicularis		
Ceuthophilus nymphs	1	
Texoreddellia texensis		
* Rhadine austinica		
Rove beetles: Aleocharinae sp.		
Snails: Gastropoda		
gnats: sp.	1	Fungus gnat larvae in web
terrestial isopods		
raccoon (Procyon lotor)		

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

☐ Photographs taken? How many? _____ If so, attach to this report.

[4] = survey section #2 (Aggie level)

base of entry. length 5.3m, width, 2.4m, h. = .9m.

Photo station A = camera angle: horizontal, aimed at 2 prominent club stalactites. taken from a sitting position at base of a vertical drop (6m into Aggie level.

Direction: 218°N, - 7' from subject.

Settings: 200ASA - fully automatic - green box, autofocus.

Photo station B = camera angle (vertical) from small stalagmite

Direction: 54°N kneeling on my knees - aimed at (clublike) stalactites. 5' from subject.

Settings: 200ASA - green box, fully automatic - auto focus.

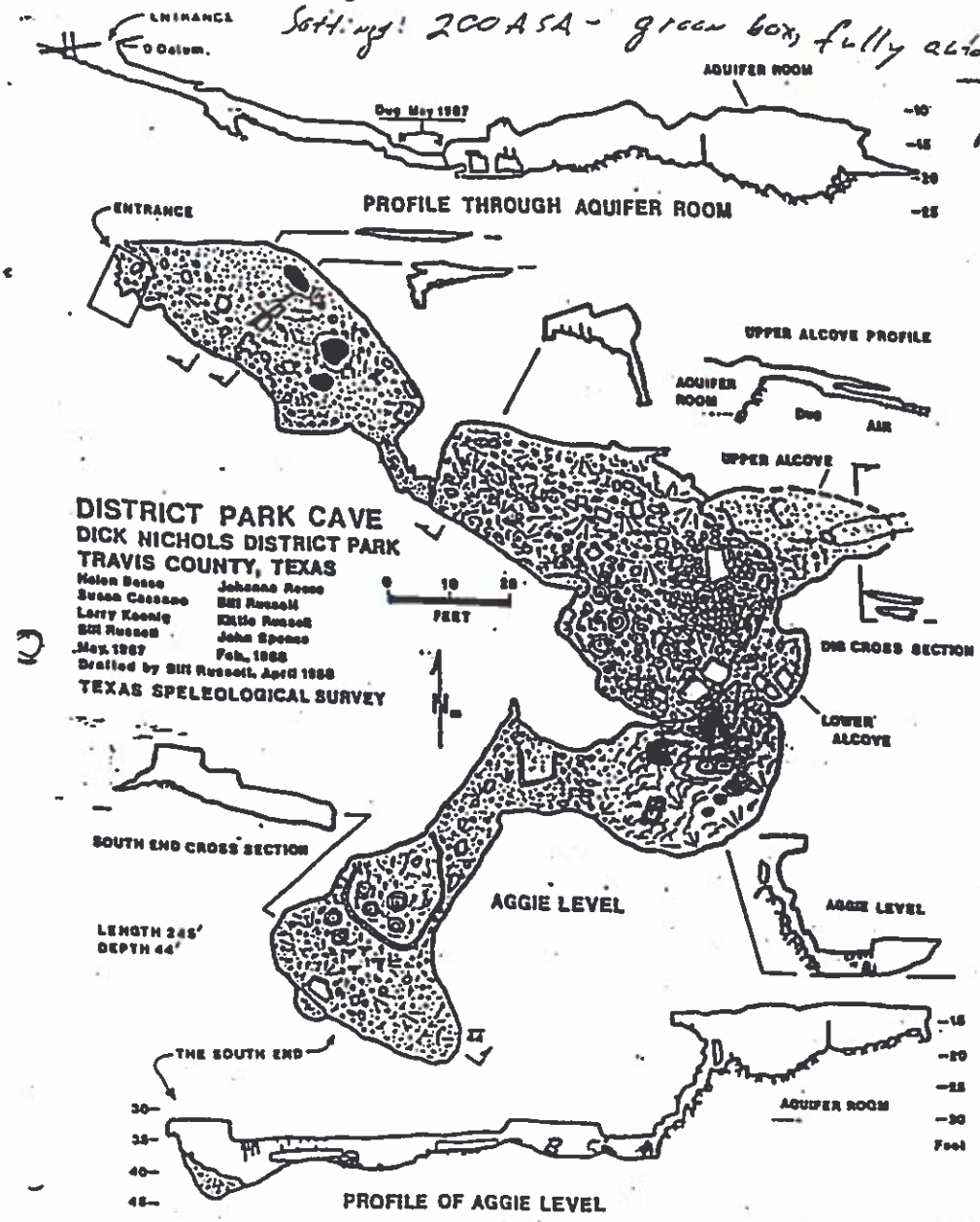
Photo station C = angle horizont

Direction = 44°N - kneeling posit

aimed at numerous stalactites

point = at small broke stalagm

Settings = 200ASA - fully autom



BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: M. Sanders, C. Abbruzzese Agency:PARD Date:3/14/00 No. of pages:2

Location: Maple Run Cave Section No. 1

Time Started: 2:35pm Time ended: 3pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 20.25° C Outside: 16.5° C @ 2:18pm
Humidity Inside: 98% Outside: 92% @ 2:18pm

FAUNAL SURVEY

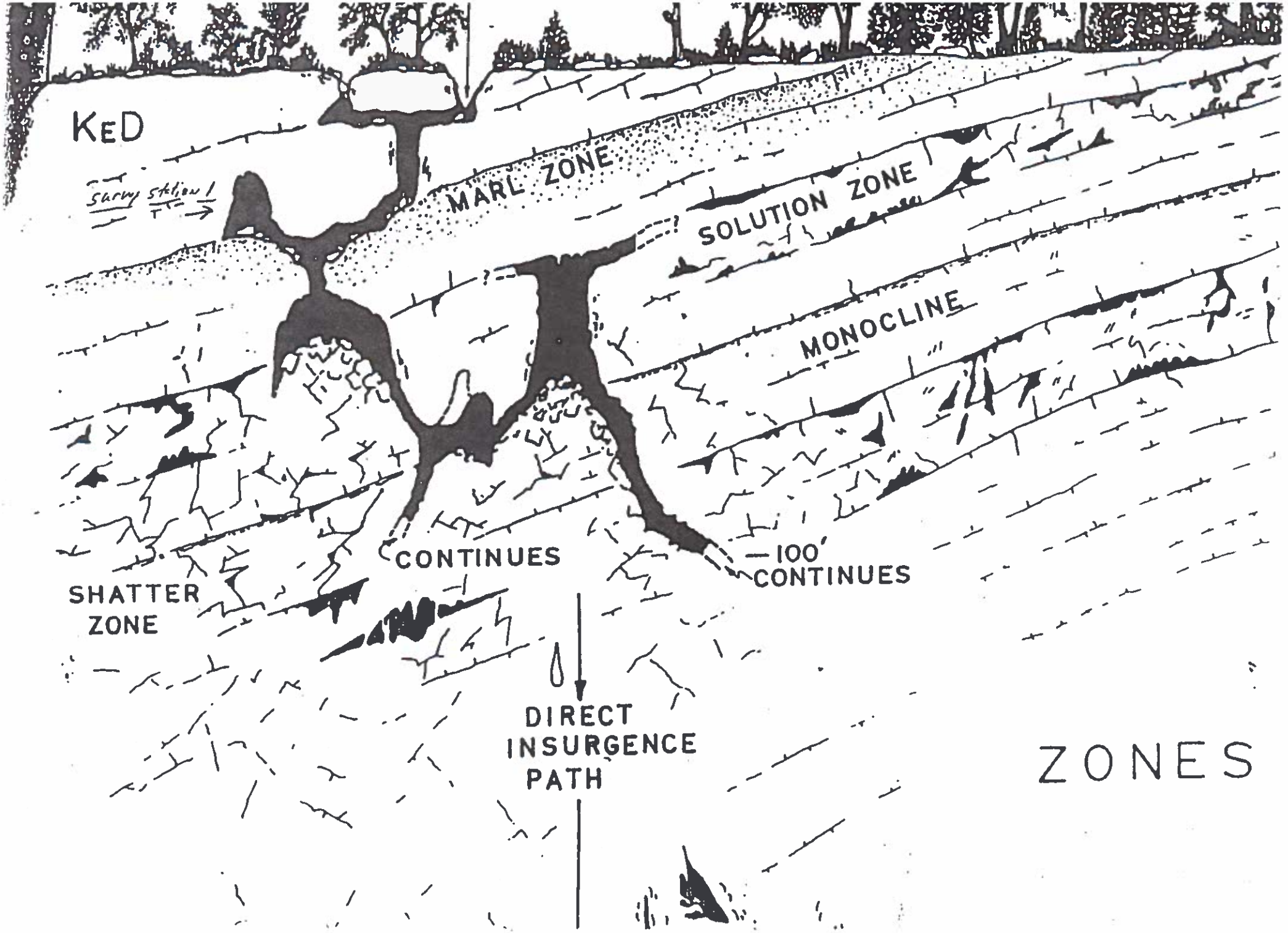
Species	No. seen	Comments
Snails: Gastropoda sp	1	
Scorpions: Vaejovis reddelli	2	
Spiders: Cicurina sp.	2	
wall web	2	
Texella mulaiki	1	
* Millipedes: Speodesmus sp.		
Cambala speobia		
Springtails: Pseudosinella sp.	1	
Texoreddellia texensis	3	
Crickets: Ceuthophilus sp. B		
Ceuthophilus secretus		
Ceuthophilus cunicularis		
Ceuthophilus nymphs	13	
* Rhadine austinica		
Flies: Diptera		

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

☐ Photographs taken? How many? ____ If so, attach to this report.

There was a small amount of trash on and near the gate and entrance. We removed it.


KED
Survey Station 1
MARL ZONE
SOLUTION ZONE
MONOCLINE
CONTINUES
100' CONTINUES
SHATTER ZONE
DIRECT INSURGENCE PATH
ZONES

BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: M. Sanders, C. Hinrichsen Agency:PARD Date:3/14/00 No. of pages:2

Location: Maple Run Cave Section No. 2

Time Started: 3:30pm Time ended: 4:01pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 21° C Outside: _____ Humidity Inside: 98% Outside: _____

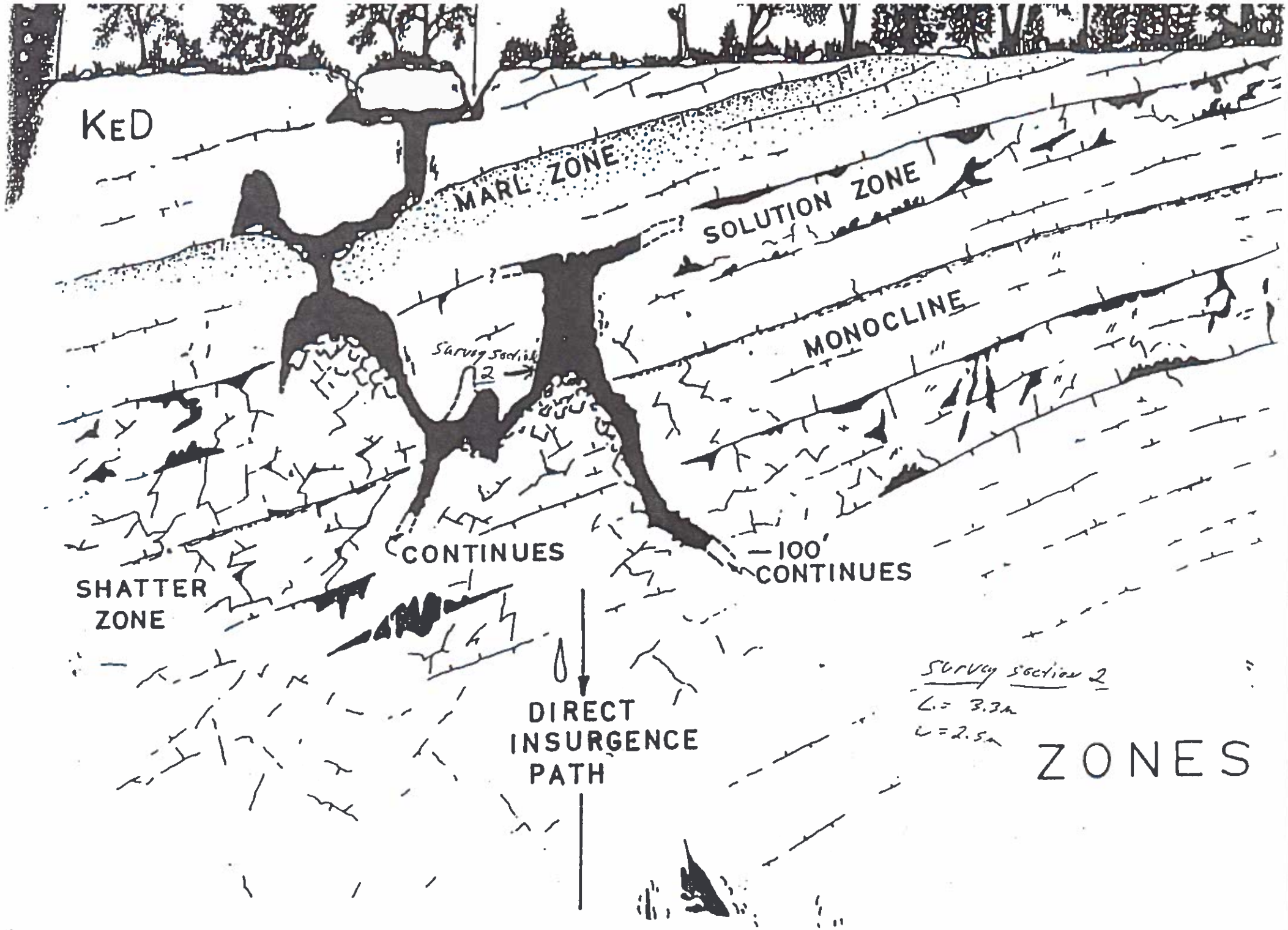
FAUNAL SURVEY

Species	No. seen	Comments
Snails: Gastropoda sp		
Scorpions: Vaejovis reddelli		
Spiders: Cicurina sp.		
wall web	2	
Texella mulaiki	2	
* Millipedes: Speodesmus sp.	1	3 more were observed inbetween sections 1 and 2 (one right in the middle of the trail)
Cambala speobia		
Springtails: Pseudosinella sp.	2	
Texoreddellia texensis		One noted just outside of section 2 survey area
Crickets: Ceuthophilus sp. B		
Ceuthophilus secretus		
Ceuthophilus cunicularis		
Ceuthophilus nymphs	5	
* Rhadine austinica		
Flies: Diptera		

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

☐ Photographs taken? How many? _____ If so, attach to this report.


KED
MARL ZONE
SOLUTION ZONE
MONOCLINE
Survey Section 2
CONTINUES
100'
CONTINUES
SHATTER
ZONE
DIRECT
INSURGENCE
PATH
Survey section 2
L = 3.3m
L = 2.5m
ZONES

BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: M. Sinclair, C. Abbruzzese Agency:PARD Date:3/14/00 No. of pages:2

Location: Goat Cave Section No. 1 (landing zone)

Time Started: 4:59pm Time ended: 5:19pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☒ Vandalism If so, ☒ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 17.5° C Outside: 18° C @ 4:45pm
Humidity Inside: 99% Outside: 82% @ 4:45pm

FAUNAL SURVEY

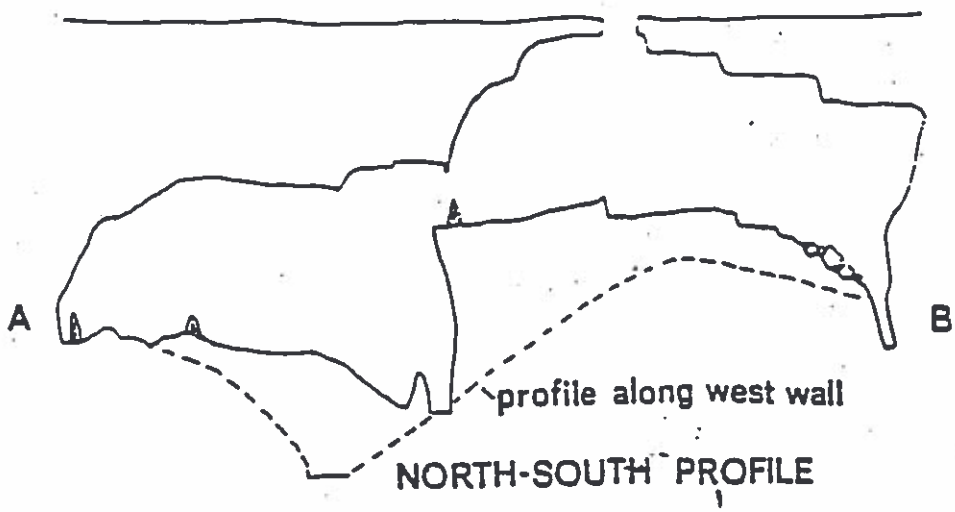
Species	No. seen	Comments
Snails: Gastropoda	2	
Earthworms: Haplotaxida	3	
Isopods: Oniscoidea	1	
Scorpions: Vaejovis reddelli		
Scorpions: surface	2	
Spiders: wall web	1	
Cicurina sp.		
* Texella mulaiki		
Cambala speobia		
* Speodesmus sp.		
* Rhadine austinica		
Texoreddellia texensis		
Springtails: Collembola	5	
Crickets: Ceuthophilus secretus		
Ceuthophilus sp. B		
Ceuthophilus cunicularis		
Ceuthophilus nymphs		
Blow flies: Calliphora accident	1	
gnat	1	
Plethodon glutinosus albagula	111	Approximately half had broken tails.
Syrrhophus marnocki		
Bufo valliceps valliceps	1	

(*) signifies species of concern

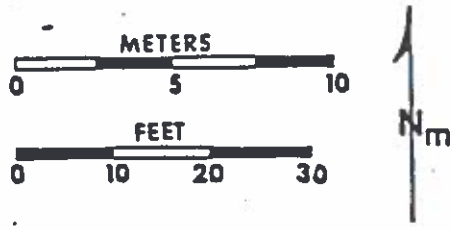
See back for additional Field Notes and Comments? ☐ Section map attached? ☒

☐ Photographs taken? How many? ____ If so, attach to this report.

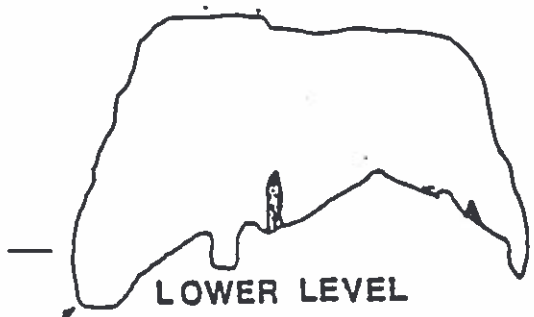
There was the regular amount of trash that is usually thown in, we removed the trash and talked with neighborhood kids urging them not to throw trash in the cave.

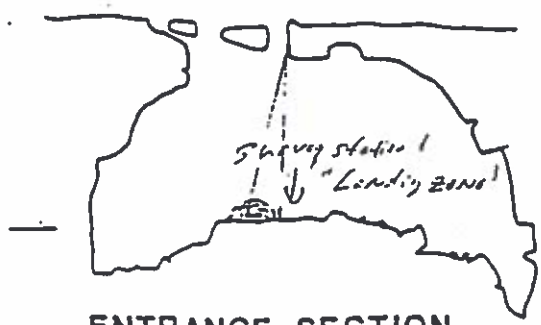


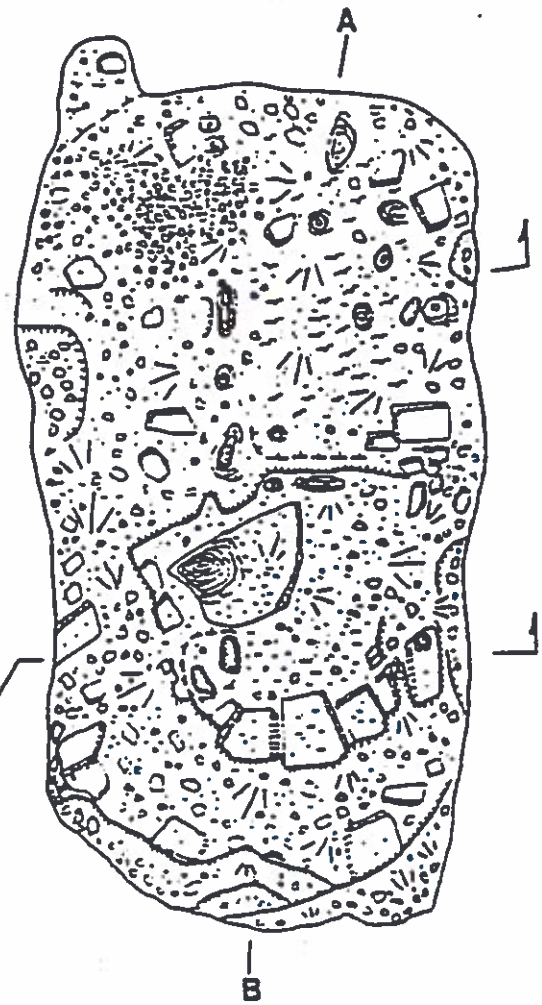
GOAT CAVE



TRAVIS COUNTY, TEXAS
Craig Bittinger, Bill Russell Sept 10 83
Original Survey: B. Bell, L. Larremore, J. Reddell, A. Weiss May 6 61
Drafted by Bill Russell







BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: M. Sanders, C. Abbruzzese Agency: PARD Date: 3/14/00 No. of pages: 2

Location: Goat Cave Section No. 2 (alcove)

Time Started: 5:28pm Time ended: 5:48pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 19.5° C Outside: _____ Humidity Inside: 96% Outside: _____

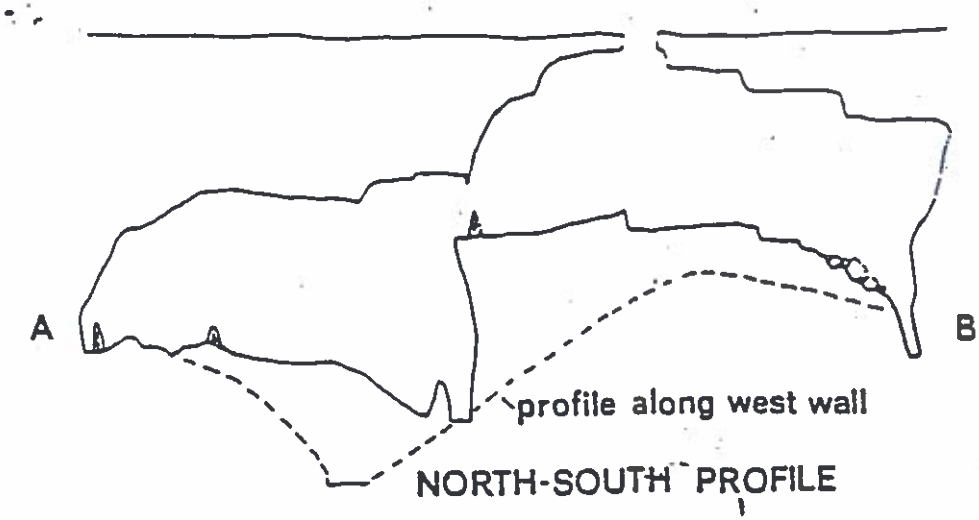
FAUNAL SURVEY

Species	No. seen	Comments
Snails: Gastropoda		
Earthworms: Haplotaxida		
Isopods: Oniscoidea		
Scorpions: Vaejovis reddelli	2	
Spiders: wall web		
Cicurina sp.	3	
* Texella mulaiki		
Soft ticks		
Mites		
Millipedes: Diplopoda accident		
Cambala speobia		
* Speodesmus sp.	2	
* Rhadine austinica		
Rove beetles: Orus rubens		
Texoreddellia texensis		
Springtails: Collembola		
Crickets: Ceuthophilus secretus		
Ceuthophilus sp. B	5	
Ceuthophilus cunicularis		
Ceuthophilus nymphs	20	
Blow flies: Calliphora accident		
Plethodon glutinosus albagula		
Syrrhophus marnocki		
Bufo valliceps valliceps		

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

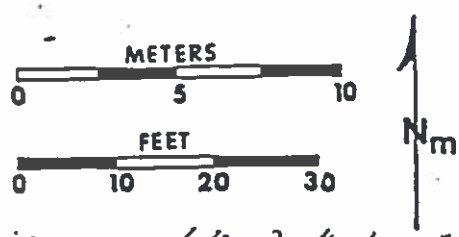
☐ Photographs taken? How many? _____ If so, attach to this report.



GOAT CAVE

TRAVIS COUNTY, TEXAS
Craig Bittinger, Bill Russell Sept 10 83
Original Survey: B. Bell, L. Larremore, J. Reddell, A. Weiss May 6 61

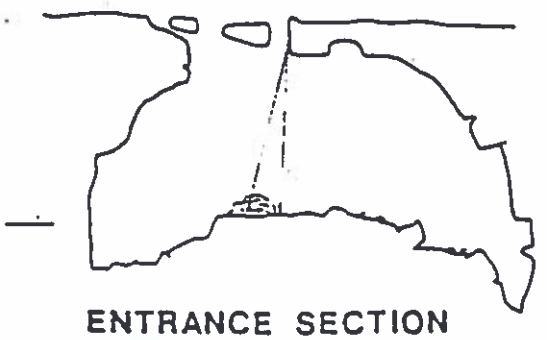
Drafted by Bill Russell



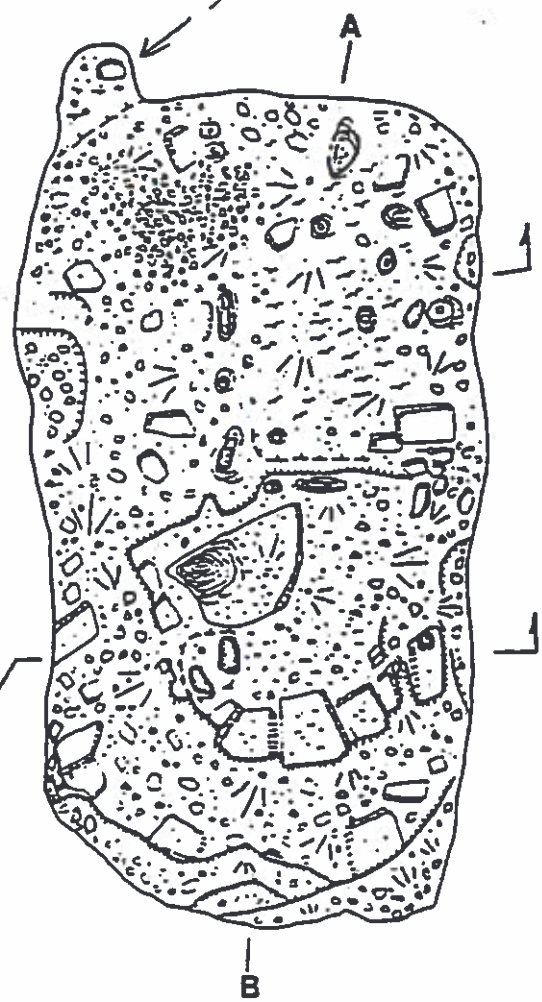
survey station 2 "alcove 5"



LOWER LEVEL
Deepest Point 43ft, 13m



ENTRANCE SECTION
Entrance Drop 19ft. 5.8m



BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: M. Sanders, C. Allmaras Agency:PARD Date:3/15/00 No. of pages:3

Location: Airman's Cave Section No. 1

Time Started: 12:18pm Time ended: 12:50pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☒ Vandalism If so, ☒ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 17° C Outside: 19.25° C @ 12:01pm
Humidity Inside: 99% Outside: 72% @ 12:01pm

FAUNAL SURVEY

Species	No. seen	Comments
Snails: Gastropoda		
Scorpion: Vaejovis reddelli	1	Found cricket legs directly by scorpion
Spiders: Cicurina	5	
Wall web	5	
*Pseudoscorpion: Tartarocreag.		
Millipedes: Abacion texense	1	
Cambala speobia		
Cave crickets: Ceuthophilus B	5	
Ceuthophilus nymphs	38	
*Groundbeetle: Rhadine austin.		
Rove beetle: Eustilicus condei	2	
Frog:Syrrhophus guttialatus		
Plethodon glutinosus albagula		1 just outside of section
Bat: Pipistrellus subflavus	2	Found side by side
Raccoon: Procyon lotor		2 found dead near this section
Blow fly	2	
gnats	7	

(*) signifies species of concern

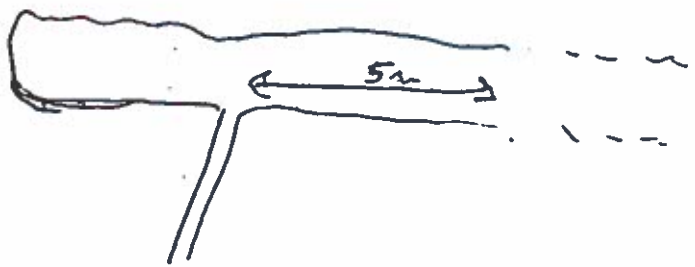
See back for additional Field Notes and Comments? ☐ Section map attached? ☒

☐ Photographs taken? How many? _____ If so, attach to this report.

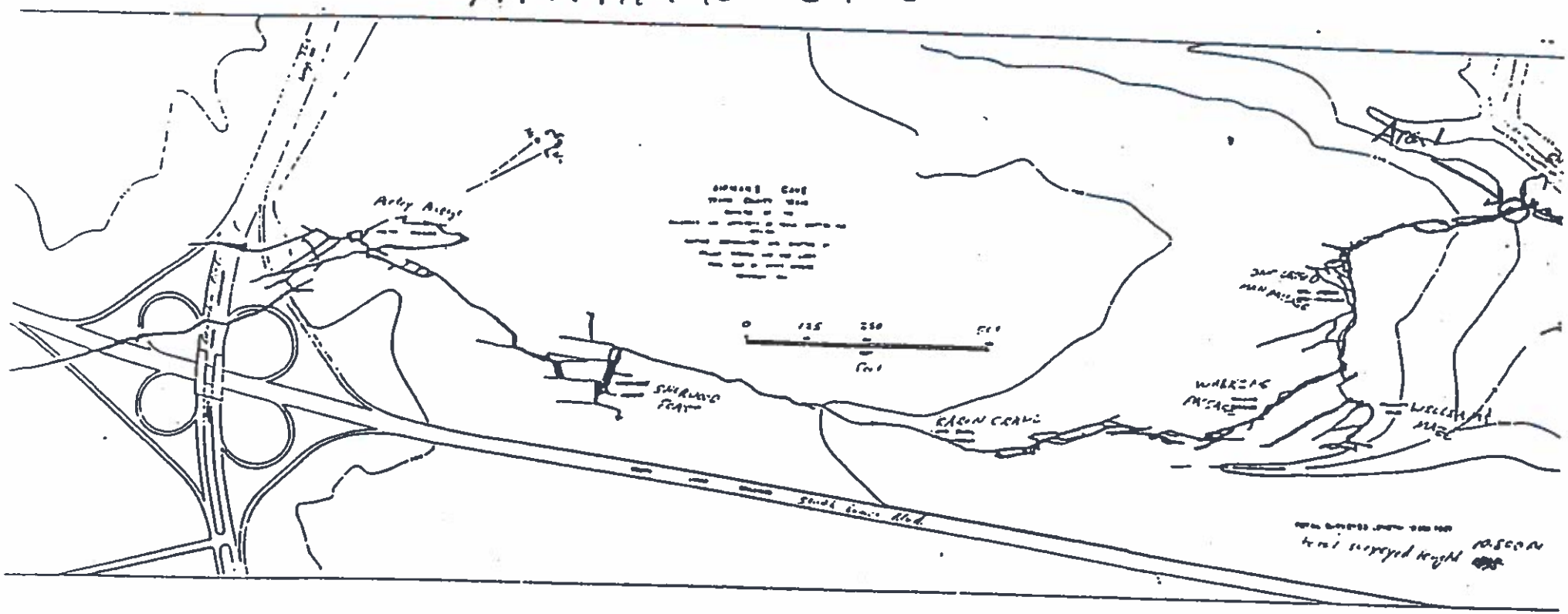
There was a very small amount of trash, and one lead weight and one battery were found in the key hole, we removed the trash. One dead raccoon was just on the inside of the key hole, it was difficult to breathe without throwing up. The other raccoon was located between stations 1 and 2. It was also very difficult to breathe. Both raccoons were loaded with rove beetles, fly larvae, dermestid beetles, and other beetle larvae. The second raccoon also had numerous Ceuthophilus cunicularis on it.

Section 1

L: 5m
W: 3m
h: 1m



AIRmans Cave



BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: M. Sandberg, C. Abbruzzese Agency:PARD Date:3/15/00 No. of pages:3

Location: Airman's Cave Section No. 2

Time Started: 1:21pm Time ended: 2:02pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 19° C Outside: _____ Humidity Inside: 99% Outside: _____

FAUNAL SURVEY

Species	No. seen	Comments
Snails: Gastropoda	1	
Scorpion: Vaejovis reddelli	1	Found eating an adult cunicularis
Spiders: Cicurina	8	
Wall web	7	
*Pseudoscorpion: Tartarocreag.	1	
Harvestman: Leiobunum town.		
*Texella spinoperca	1	
Millipedes: Abacion texense		
Cambala speobia	1	
*Speodesmus bicornourus	7	
Springtails: Pseudosinella sp.	Approx 300	
Silverfish: Texoreddellia sp.	1	
Cave crickets: Ceuthophilus B		
Ceuthophilus secretus		
Ceuthophilus cunicularis	2	One dead, consumed by the scorpion
Ceuthophilus nymphs	30	
*Groundbeetle: Rhadine austin.	2	
Rove beetle: Eustilicus condei	8	1 larvae was observed
Frog:Syrrhophus guttialatus		
Plethodon glutinosus albagula		
Bat: Pipistrellus subflavus		
Raccoon: Procyon lotor		
gnats	1	

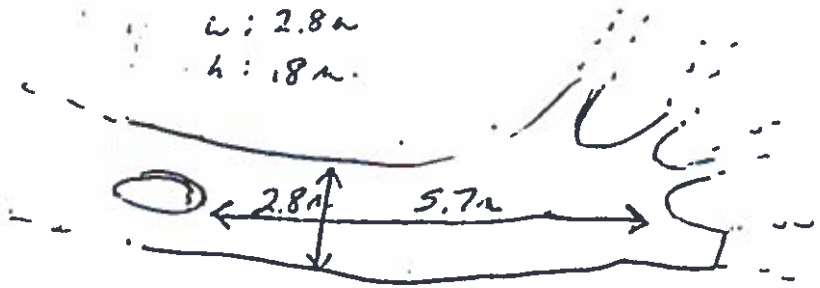
(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

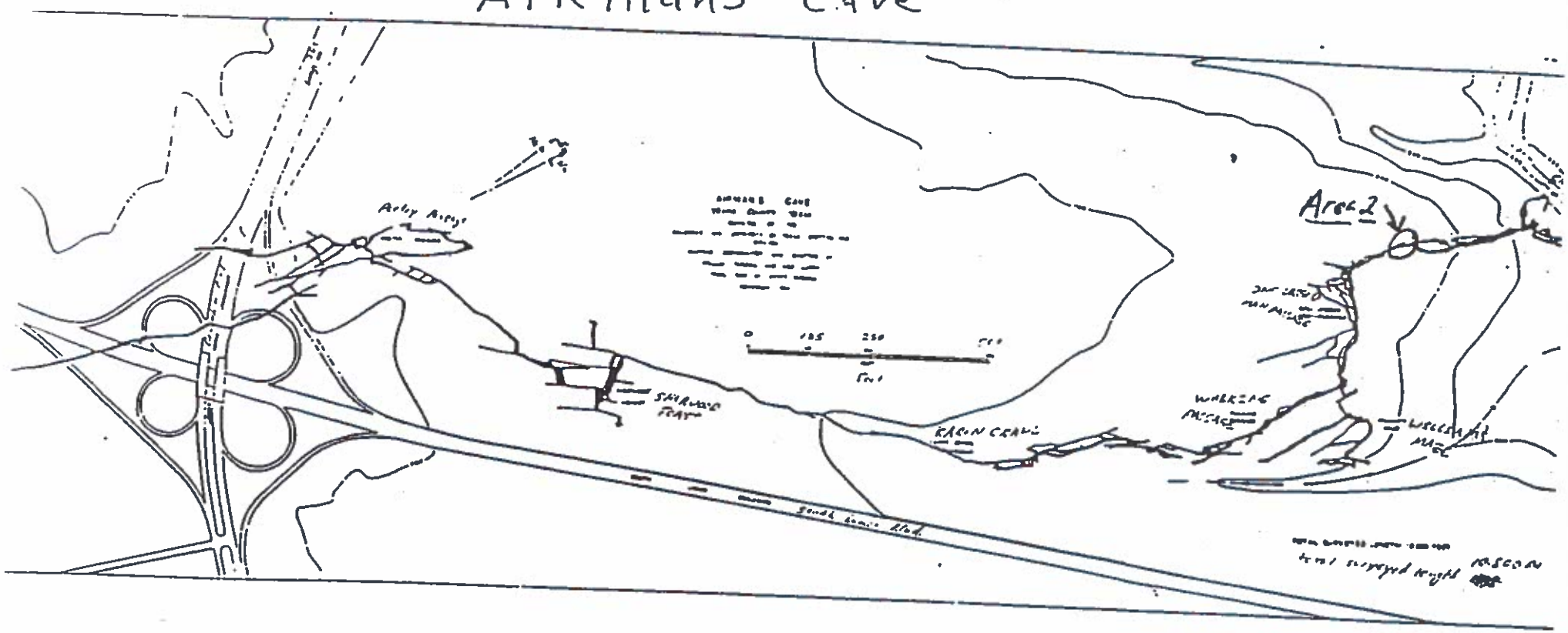
☐ Photographs taken? How many? ____ If so, attach to this report.

Section 2

L : 5.7m
W : 2.8m
h : 18m.



AIRmans Cave



BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: M. Sanders, C. Addington Agency:PARD Date:3/15/00 No. of pages:3

Location: Airman's Cave Section No. 3

Time Started: 3:07pm Time ended: 3:29pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☒ Vandalism If so, ☒ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 21° C Outside: _____ Humidity Inside: 99% Outside: _____

FAUNAL SURVEY

Species	No. seen	Comments
Snails: Gastropoda		
Scorpion: Vaejovis reddelli		
Spiders: Cicurina	10	
Wall web	1	
*Pseudoscorpion: Tartarocreag.		
Harvestman: Leiobunum town.		
*Texella spinoperca		
Millipedes: Abacion texense		
Cambala speobia		
*Speodesmus bicornourus	8	
Springtails: Pseudosinella sp.	Approx 50	
Silverfish: Texoreddellia sp.		
Cave crickets: Ceuthophilus B		
Ceuthophilus secretus		
Ceuthophilus cunicularis		
Ceuthophilus nymphs	1	
*Groundbeetle: Rhadine austin.		
Rove beetle: Eustilicus condei		
Frog:Syrrhophus guttialatus		
Plethodon glutinosus albagula		
Bat: Pipistrellus subflavus		
Raccoon: Procyon lotor		
gnats		

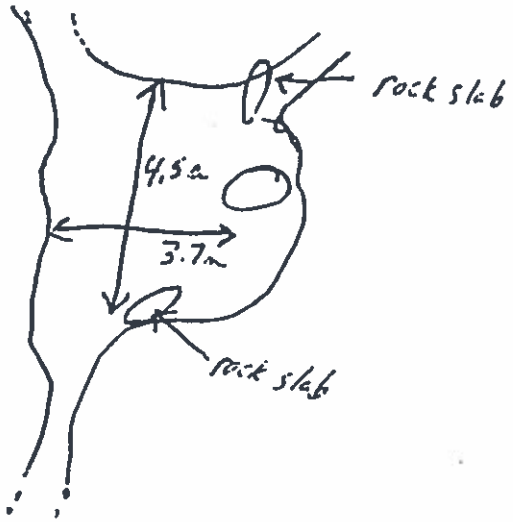
(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

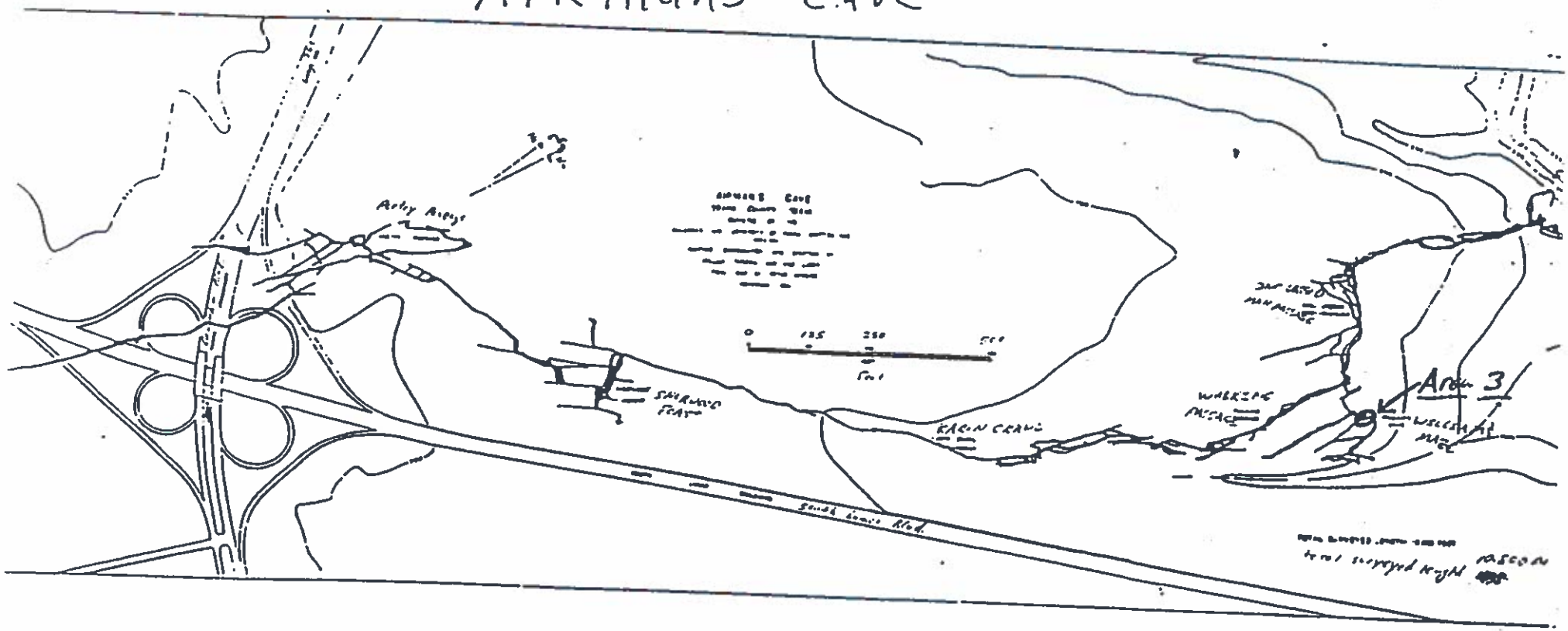
☐ Photographs taken? How many? ____ If so, attach to this report.

The trash in this section was string, (a lot of it) we removed it. There was also a small amount of trash in the aggie art gallery and we removed 2 more batteries.
5 Rhadine austinica were seen between sections 2 and 3.

New Area: Section 3 – Williams maze



AIRmans Cave



BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name:	Agency:PARD	Date:6/22/00	No. of pages:1

Location: Broken Arrow cave Section No. portions of entire cave

Time Started: 3:15 pm Time ended: 4:30pm

☒ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☒ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: ? Outside: ? Humidity Inside: ? Outside: ?

FAUNAL SURVEY

Species	No. seen	Comments
Spiders: wall web	5	
cicurina	2	
Leiobunum townsendii	~1000	
* Rhadine persephone	2	
Rove beetle	1	
Cambala speobia	~70	
Giant centipede	1	
Crickets: Ceuthophilus secretus	~3000	
Ceuthophilus cunicularis[2]	3	
Ceuthophilus nymphs	~ 1000	
Aquatic amphipods	~30	
Aquatic isopods	~30	
Collembola sp	~ 2000	

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☐

☐ Photographs taken? How many? ____ If so, attach to this report.

The main purpose of this visit was to show Rob Jackson (professor at Duke university) this site for his research regarding water uptake of tree species. He took root samples of a large hackberry tree with roots growing inside of the cave. My survey was not very thorough because I was helping Dr. Jackson.
The fire ants were limited to the entrance sink, and I tried to find active mounds near the cave without any luck. I will go back this fall, try to locate the fire ant mounds and boil them.

BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name:	Agency:PARD	Date:6/22/00	No. of pages:1

Location: Cotterell cave Section No. portions of the entire cave

Time Started: 11:30am Time ended 12:30pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: ? Outside: ?
Humidity Inside: ? Outside: ?

FAUNAL SURVEY

Species	No. seen	Comments
cicurina	4	
Texella reyesi	1	
Speodesmus sp	1	
Cambala speobia	5	
Crickets: Ceuthophilus secretus	~30	
Ceuthophilus nymphs	= 50	
Pheidole sp	~50	Observed around entrance
Crematogaster sp	~30	ditto
Monomorium minimunum	~ 10	ditto
Earth worms	5	
Syrrhophus marnocki	1	

(*) signifies species of concern
See back for additional Field Notes and Comments? ☐ Section map attached? ☐
☐ Photographs taken? How many? ____ If so, attach to this report.

The main purpose for this visit was to inspect and assess Rob Jackson's (professor at Duke University) research in the cave. He along with a graduate student are determining the amount of water uptake on certain species of trees. My survey was not very thorough, however the cave was lacking in abundance and diversity of life. I made this assessment by noting the lack of ceiling crickets and lack of life under randomly selected rocks. In one of Jackson's reports he did an analysis on the soil in the cave and found it to be very high in nitrates, much higher than other caves in his study. Cotterell cave is a major recharge feature and takes runoff directly from several homes approximately 200 feet to the south. My concern is that pesticides or other contaminants may have migrated into the cave via rain water runoff or carried in by cave crickets. We visited Broken Arrow cave the same day, and I visited Jest John the next day, both caves had extremely high numbers of cave crickets.
I removed a lot of broken glass, wires, metal fragments, a beer can, and plastic. This was all old trash that continues to get exposed after rain events.
I have not found any Solenopsis invicta in the vacinity of the cave this year, however, I did boil numerous fire ant mounds around the parking lot this spring.

BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: Agency:PARD Date:6/23/00 No. of pages:1

Location: Forest Ridge (Jest John) Section No. portions of entire cave

Time Started: 2 pm Time ended: 5pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 21.5° C @ 3pm Outside: 34° C @ 2pm
Humidity Inside: 96% @ 3pm Outside: 50% @ 2pm

FAUNAL SURVEY

Species	No. seen	Comments
Spiders: wall web	8	
cicurina	15	
*Texella reddelli ?	6	2 adults were collected for James Reddell to ID
Leiobunum townsendii	approx. 3000	all were observed in and around the entrance.
*Millipedes: Speodesmus N.S.	21	
House millipede	1	
Cambala speobia	~ 200	
Reduviidae: Assassin beetle	1	
Staphylinidae: Rove beetles	3	
Crickets: Ceuthophilus secretus	~ 4000	
Ceuthophilus cunicularis[2]	5	
Ceuthophilus nymphs	~ 1000	
Collembola sp	~ 2000	
Texoreddellia texensis	2	1 collected for James Reddell to ID
Fungus gnats	8	
Vaejovis reddelli	2	
Haplotaxida sp	5	
Gastropoda sp.		All found were dead empty shells
Crematogaster sp		found outside of the cave near entrance.
Camponotus sp.		ditto
Pheidole sp		ditto
Syrrhophus marnocki	1	Was observed near the cave the day before.
Sceloporus olivaceus	1	Captured and removed from cave.

(*) signifies endangered or species of concern,

See back for additional Field Notes and Comments? ☐ Section map attached? ☐

☒ Photographs taken? How many? 10 If so, attach to this report.

The cave had not been entered in several years. The large rock placed in the entrance now had roots growing on top of it and really appeared to be contiguous with the adjacent rock formation. We were careful to place the rock back and put the soil and leaves back on top of it leaving enough space for small mammals to access the cave. Most of the cave floor/soil was very dry due to the fact that it is so shallow.

BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: Agency:PARD Date:10/20/99 No. of pages:2

Location: District park cave Section No. 1 (Aquifer Room)

Time Started: 1:50pm Time ended: 2:30pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 22.5° C Outside: 24° C @ 1:07pm
Humidity Inside: 96% Outside: 32% @ 1:07pm

FAUNAL SURVEY

Species	No. seen	Comments
Spiders: Cicurina sp	4	
wall web	4	
Millipedes: Cambala speobia	2	
* Speodesmus sp.	1	2 were noted just outside of survey area at 3:45pm
house centipede	1	
* Texella mulaiki		
Springtails: Collembolids	95	
Crickets: Ceuthophilus sp. B	2	
Ceuthophilus secretus	3	
Ceuthophilus cunicularis	2	
Ceuthophilus nymphs	7	
Texoreddellia texensis		
* Rhadine austinica		
Rove beetles: Aleocharinae sp.		
Snails: Gastropoda	1	
gnats: sp.	4	
moths	2	
terrestial isopods	1	
fleas	3	
raccoon (Procyon lotor)		

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

☒ Photographs taken? How many? 1 If so, attach to this report.

A few fire ants were noticed right at the entrance. On 10/18/99 there was approximately 1/2 " rain, which broke a draught of 2 months.

= Survey section #1 (Aquifer Room)

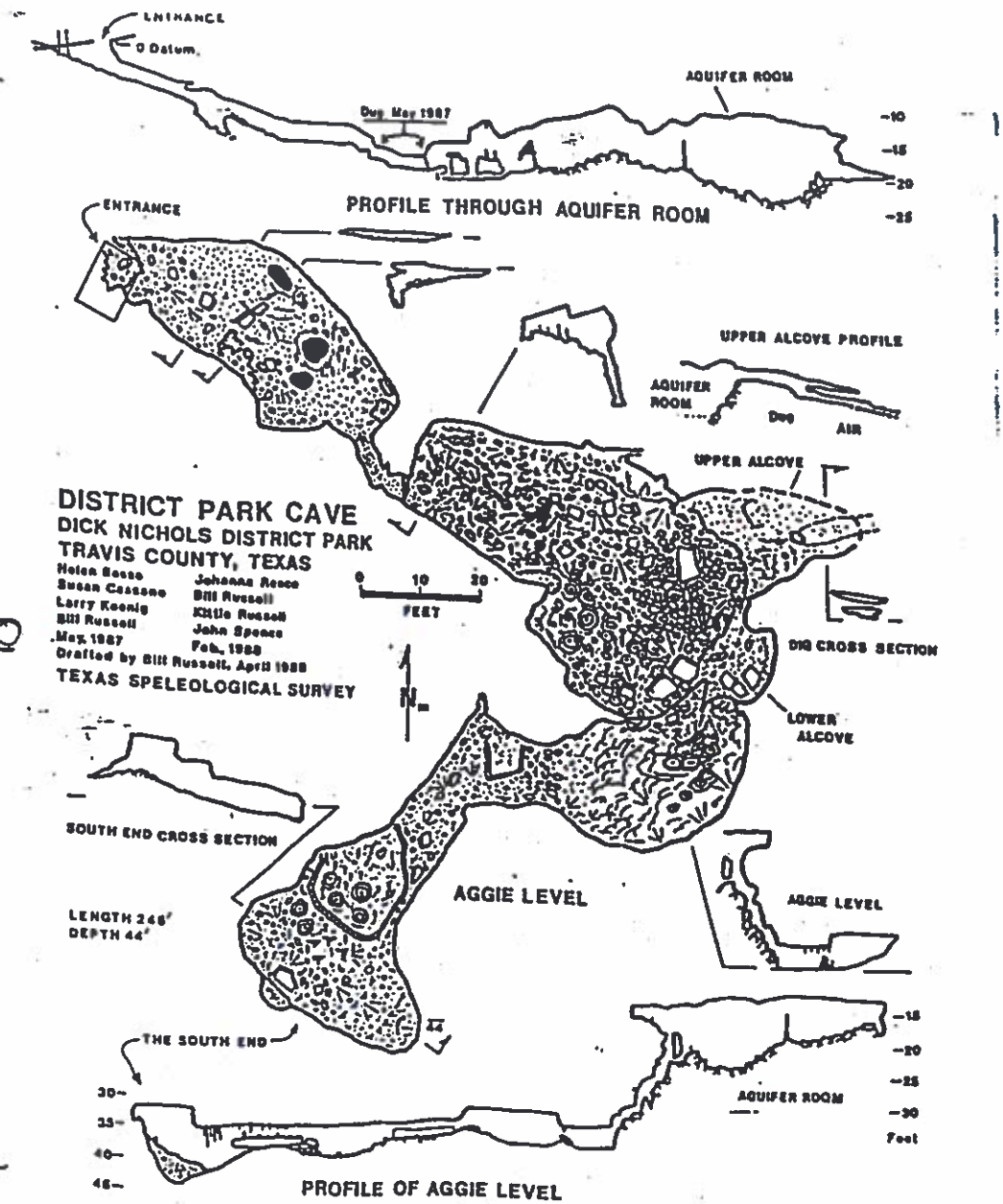
Length = 5m

height = 2.3m

width = 5.1m

A = photo station - taken from sitting position on a (Natural ro
1.53m from large stalagmite (camera in horizontal position)
237°N

Setting: 200 ASA - fully automatic - green box - auto focus



BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name:	Agency:TNC	Date:12/21/99	No. of pages:1

Location: Adobe Springs Cave Section No. All

Time Started: 3:20pm Time ended: 4:25pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 16° C Outside: 8° C @ 3:05pm
Humidity Inside: 95% Outside: 70% @ 3:05pm

FAUNAL SURVEY

Species	No. seen	Comments
cicurina	20	2 were collected for James Reddell to ID
tick sp	1	collected
Millipedes: Cambala speobia		
Centipede sp	1	troglobitic sp, attempted to collect but disappeared in the floor
slender springtails: Pseudosinella	≈ 200	one or two collected
Crickets: Ceuthophilus secretus	5	one collected
Ceuthophilus cunicularis	3	one collected
Ceuthophilus nymphs	≈ 30	
*Rhadine subterranea?		
Rove beetles: Eustilicus condei	8	one collected
Snails: Gastropoda	~ 50	2 were collected
Ostracods: Cypridopsis sp.		
Stygobromus russelli	~ 300	2 were collected, one was observed to be encrusted in calcium carbonate deposits alive, still moving slightly
Terrestrial flatworm: Terricola		
earth worms	~ 50	
Crotalus atrox		
Bats: Pipistrellus subflavus		
Plethodon glutinosus albagula	10	
? undetermined springtail, like?	15	collected 3 for James to ID

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☐

☒ Photographs taken? How many? 6 If so, attach to this report.

Highly decorated cave with very active formations, highly agitated water is quickly depositing calcium bi-carbonate over everything. We entered the cave a few days after a cold front, the entrance is very large, allowing the outside cold/heavy air to sink into the cave. We believe that we did not find many troglobitic species due to the low temperatures.
A small amount of old broken glass was removed from the cave.

BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: Agency:PARD Date:10/20/99 No. of pages:2

Location: District park cave Section No. 2 (Aggie Level)

Time Started: 2:59pm Time ended: 3:35pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 20.25° C Outside: Humidity Inside: 94% Outside:

FAUNAL SURVEY

Species	No. seen	Comments
Spiders: Cicurina sp	2	2 were noted just outside of survey area
wall web		
Millipedes: Cambala speobia		
* Speodesmus sp.		1 just outside of survey area
* Texella mulaiki	2	3 were noted inbetween stations 1 and 2.
Springtails: Collembolids	10	
Crickets: Ceuthophilus sp. B	1	
Ceuthophilus secretus		
Ceuthophilus cunicularis		
Ceuthophilus nymphs	2	
Texoreddellia texensis		
* Rhadine austinica		
Rove beetles: Aleocharinae sp.		
Snails: Gastropoda		
gnats: sp.	2	
terrestial isopods		
Plethodon glutinosus albagula	1	
raccoon (Procyon lotor)		

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

☒ Photographs taken? How many? 3 If so, attach to this report.

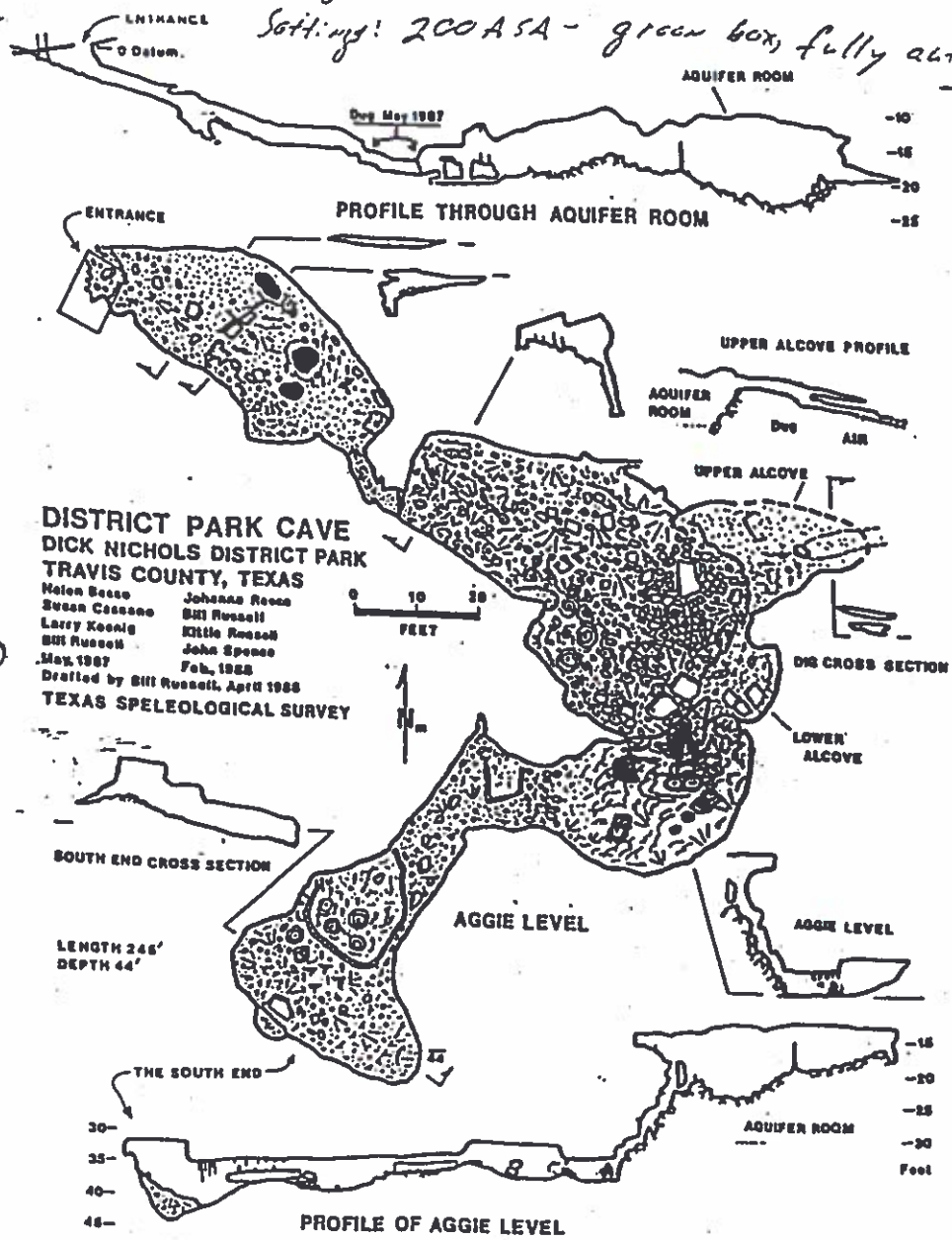
There was a small amount of fresh "mud balls splatted on the ceiling in the middle room, I removed them and questioned the last group to enter the cave. They (UT rec center) claimed that they had nothing to do with it, and had visual contact with the group at all times. I trust the group leader and will look back to groups before them.

A1 = Survey section #2 (Aggie level)
base of entry. length 5.3m, width, 2.4m, h. = .9m.

Photo station A = camera angle: horizontal, aimed at 2 prominent club, stalactites. taken from a sitting position at base of a vertical drop (6m into Aggie level.
Direction: 218°N, - 7' from subject.
Settings: 200ASA - fully automatic - green box, autofocus.

Photo station B = camera angle (vertical) from small stalagmite
Direction: 54°N kneeling on my knees - aimed at (clublike) stalactites. 5' fr
subject.
Settings: 200 ASA - green box, fully automatic - auto focus.

Photo station C = angle horizontal
Direction = 44°N - kneeling positio
aimed at numerous stalactites
point = at small broke stalagmit
Settings = 200 ASA - fully automat



BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name:	Agency:PARD	Date:10/21/99	No. of pages:3

Location: Airman's Cave Section No. 1

Time Started: 12:40pm Time ended: 1:12pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☒ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☒graffiti

Temperature Inside: 17.5° C Outside: 19.25° C @ 12:15pm
Humidity Inside: 98% Outside: 46% @ 12:15pm

FAUNAL SURVEY

Species	No. seen	Comments
Scorpion: Vaejovis reddelli	2	
Spiders: Cicurina	2	
Wall web	4	4 or 5 were surface spiders, "wolf-like" spiders
*Pseudoscorpion: Tartarocreag.		
*Texella spinoperca		
Millipedes: Abacion texense	1	
*Speodesmus bicornourus		
Springtails: Pseudosinella sp.	78	
Cave crickets: Ceuthophilus B	5	
Ceuthophilus cunicularis	2	
Ceuthophilus nymphs	20	
*Groundbeetle: Rhadine austin.		
Rove beetle: Eustilicus condei	2	
gnats	16	
Plethodon glutinosus albagula	3	one just outside of plot
Bat: Pipistrellus subflavus	1	
Raccoon: Procyon lotor		fresh scat just outside of survey area, scat noted thru out cave
gnats	16	

(*) signifies species of concern

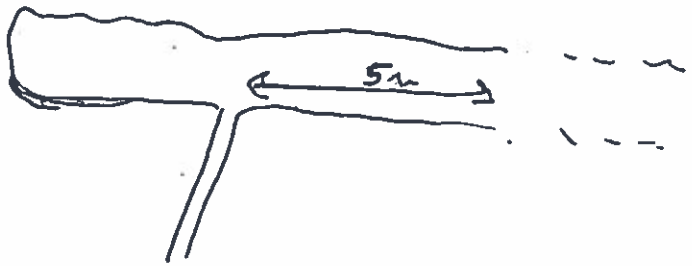
See back for additional Field Notes and Comments? ☐ Section map attached? ☒

☐ Photographs taken? How many? ____ If so, attach to this report.

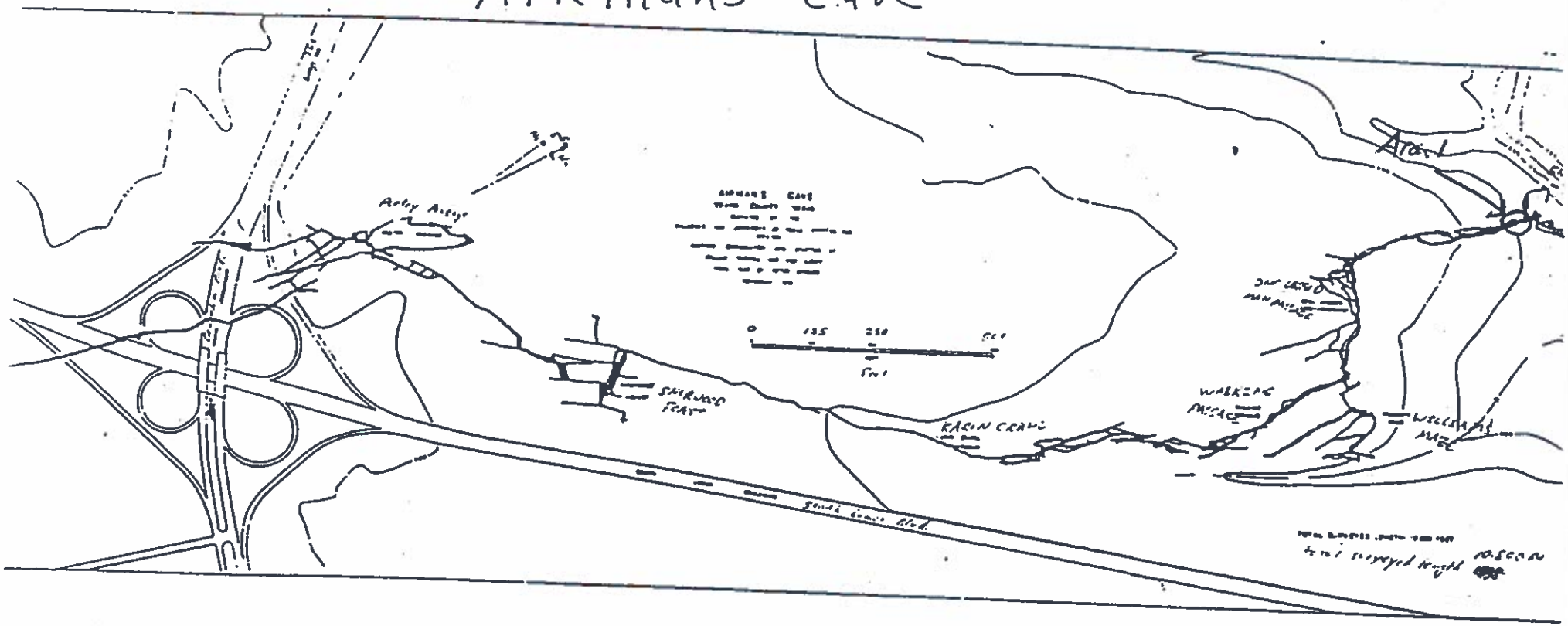
The graffiti was orange paint that was used as markers,which was found throughout the cave, sometimes stone cairns were used with the paint. One cairn was in survey area one which might have affected the survey count. We removed all graffiti and cairns, including old graffiti with steel wire brushes. There was also gang type graffiti at the entrance which we removed. We found a small amount of trash including one old battery which was removed. Until this survey count the most recent graffiti was in 1996. I am planning on installing a sign in the cave noting cave rules, whenever I have time. If problems continue to occur the cave will be gated.

Section 1

L: 5m
W: 3m
h: 1m



AIRmans CAVE



BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name:	Agency:PARD	Date:10/21/99	No. of pages:3

Location: Airman's Cave Section No. 2

Time Started: 1:42pm Time ended: 2:10pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☒ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☒ graffiti

Temperature Inside: 19.5° C Outside: _____ Humidity Inside: 98% Outside: _____

FAUNAL SURVEY

Species	No. seen	Comments
Snails: Gastropoda		
Scorpion: Vaejovis reddelli		
Spiders: Cicurina	6	
Wall web	6	We noticed 2 carrying egg cases
*Pseudoscorpion: Tartarocreag.		
Harvestman: Leiobunum town.		
*Texella spinoperca		
Millipedes: Abacion texense		
Cambala speobia	1	
*Speodesmus bicornourus		
Springtails: Pseudosinella sp.		
Silverfish: Texoreddellia sp.		
Cave crickets: Ceuthophilus B		
Ceuthophilus secretus		
Ceuthophilus cunicularis	7	
Ceuthophilus nymphs	4	
*Groundbeetle: Rhadine austin.		2 were noted inbetween sections 1 and 2
Rove beetle: Eustilicus condei		
? Mold beetle	1	It was collected for James Reddell to identify.
gnats	3	
Frog:Syrrhophus guttialatus		
Plethodon glutinosus albagula	1	
Bat: Pipistrellus subflavus		
Raccoon: Procyon lotor		a lot of fresh scat was noted inbetween sections 1 and 2
gnats		

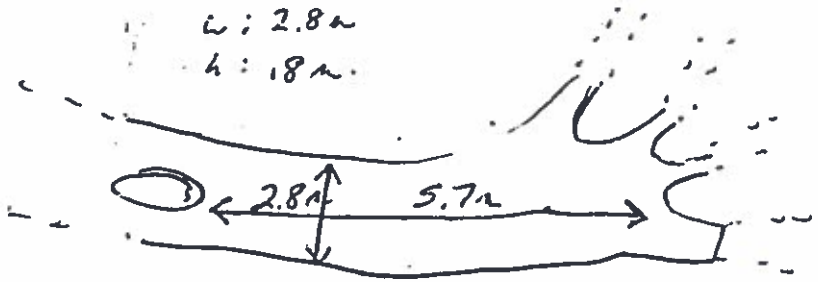
(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

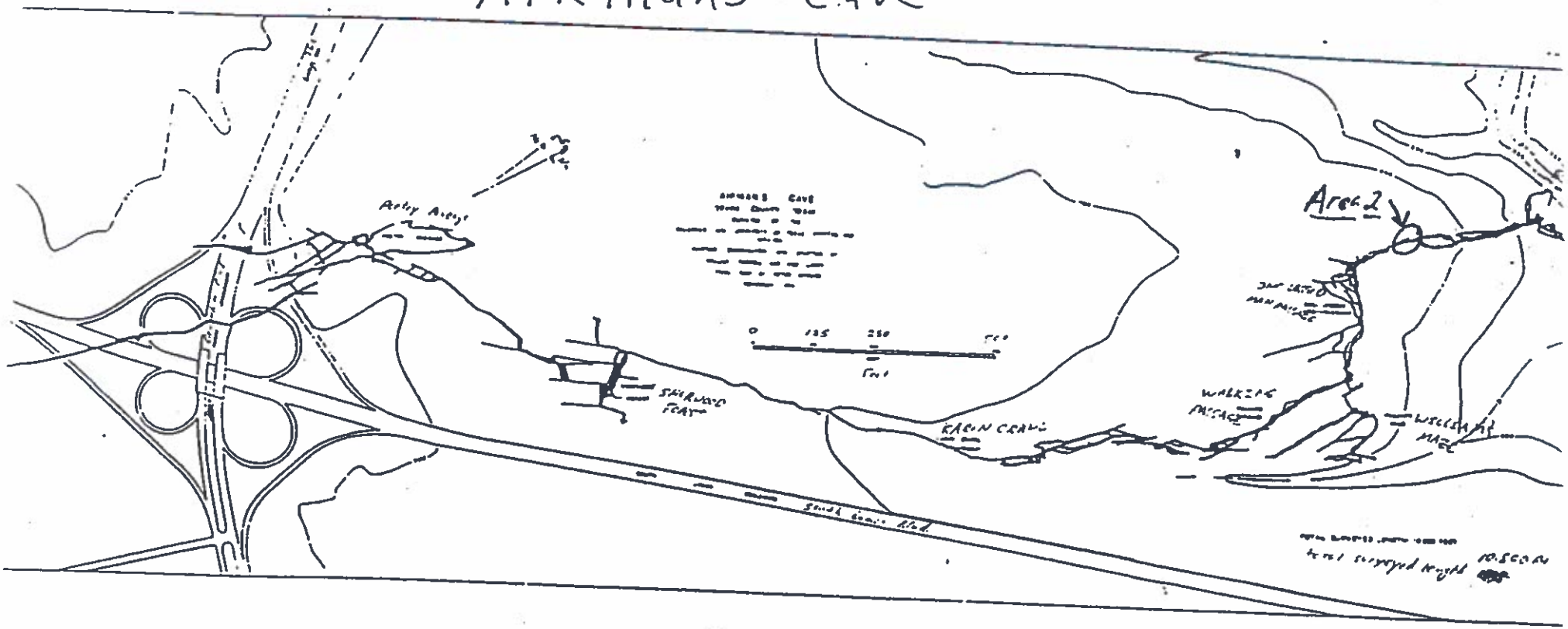
☐ Photographs taken? How many? _____ If so, attach to this report.

Section 2

L : 5.7m
W : 2.8m
H : 18m.



AIRmans Cave



BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name: Agency:PARD Date:10/21/99 No. of pages:3

Location: Airman's Cave Section No. 3

Time Started: 3:50pm Time ended: 4:12pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 21.3° C Outside: _____ Humidity Inside: 96% Outside: _____

FAUNAL SURVEY

Species	No. seen	Comments
Snails: Gastropoda		
Scorpion: Vaejovis reddelli		
Spiders: Cicurina	2	4 were just outside of survey area near raccoon scat.
Wall web	2	
*Pseudoscorpion: Tartarocreag.		
Harvestman: Leiobunum town.		
*Texella spinoperca		
soft bodied tick	1	was found dead
Millipedes: Abacion texense	3	
Cambala speobia	1	
*Speodesmus bicornourus	1	2 were just outside of survey area.
Springtails: Pseudosinella sp.	70	10 just outside of survey area
Silverfish: Texoreddellia sp.		
Cave crickets: Ceuthophilus B		
Ceuthophilus secretus		
Ceuthophilus cunicularis	1	
Ceuthophilus nymphs	3	
*Groundbeetle: Rhadine austin.		2 were noted inbetween sections 2 and 3.
Rove beetle: Eustilicus condei	1	
gnats	3	
Frog:Syrrhophus guttialatus		
Plethodon glutinosus albagula		
Bat: Pipistrellus subflavus		
Raccoon: Procyon lotor		

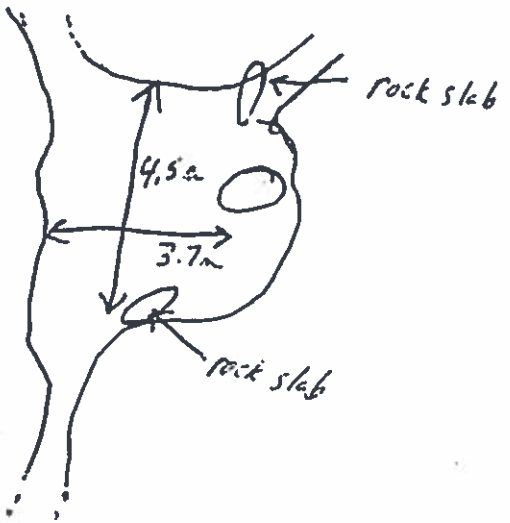
(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

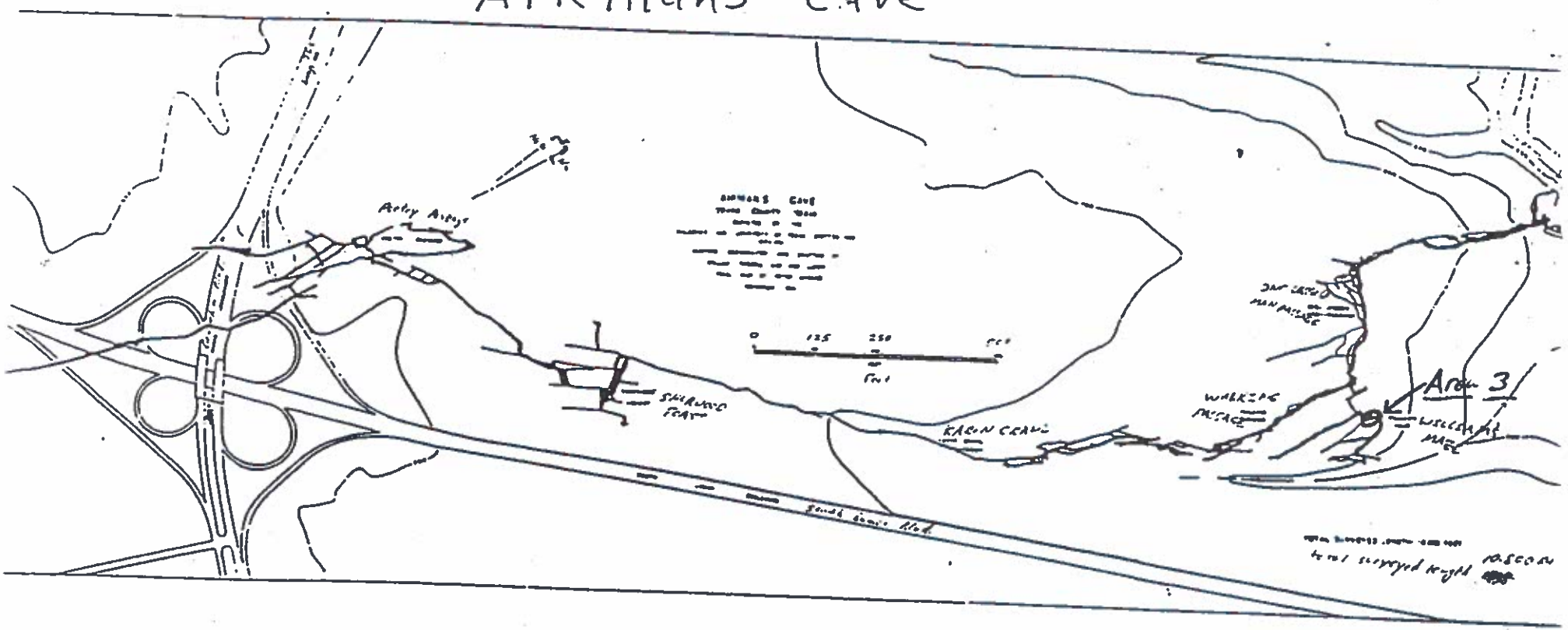
☐ Photographs taken? How many? _____ If so, attach to this report.

This is the second time we have done this area as section 3, it is just beyond the aggie art gallery, (so very near real heavy traffic, but the actual area receives very little traffic).

Now Area: Section 3 – Williams maze



AIRmans Cave



BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name:	Agency:PARD	Date:10/20/99	No. of pages:2

Location: District park cave Section No. 1 (Aquifer Room)

Time Started: 1:50pm Time ended: 2:30pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 22.5° C Outside: 24° C @ 1:07pm
Humidity Inside: 96% Outside: 32% @ 1:07pm

FAUNAL SURVEY

Species	No. seen	Comments
Spiders: Cicurina sp	4	
wall web	4	
Millipedes: Cambala speobia	2	
* Speodesmus sp.	1	2 were noted just outside of survey area at 3:45pm
house centipede	1	
* Texella mulaiki		
Springtails: Collembolids	95	
Crickets: Ceuthophilus sp. B	2	
Ceuthophilus secretus	3	
Ceuthophilus cunicularis	2	
Ceuthophilus nymphs	7	
Texoreddellia texensis		
* Rhadine austinica		
Rove beetles: Aleocharinae sp.		
Snails: Gastropoda	1	
gnats: sp.	4	
moths	2	
terrestial isopods	1	
fleas	3	
raccoon (Procyon lotor)		

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

☒ Photographs taken? How many? 1 If so, attach to this report.

A few fire ants were noticed right at the entrance. On 10/18/99 there was approximately 1/2 " rain, which broke a draught of 2 months.

BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name:	Agency:PARD	Date:10/20/99	No. of pages:2

Location: District park cave Section No. 2 (Aggie Level)

Time Started: 2:59pm Time ended: 3:35pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 20.25° C Outside: _____ Humidity Inside: 94% Outside: _____

FAUNAL SURVEY

Species	No. seen	Comments
Spiders: Cicurina sp	2	2 were noted just outside of survey area
wall web		
Millipedes: Cambala speobia		
* Speodesmus sp.		1 just outside of survey area
* Texella mulaiki	2	3 were noted inbetween stations 1 and 2.
Springtails: Collembolids	10	
Crickets: Ceuthophilus sp. B	1	
Ceuthophilus secretus		
Ceuthophilus cunicularis		
Ceuthophilus nymphs	2	
Texoreddellia texensis		
* Rhadine austinica		
Rove beetles: Aleocharinae sp.		
Snails: Gastropoda		
gnats: sp.	2	
terrestial isopods		
Plethodon glutinosus albagula	1	
raccoon (Procyon lotor)		

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☒

☒ Photographs taken? How many? 3 If so, attach to this report.

There was a small amount of fresh "mud balls splatted on the ceiling in the middle room, I removed them and questioned the last group to enter the cave. They (UT rec center) claimed that they had nothing to do with it, and had visual contact with the group at all times. I trust the group leader and will look back to groups before them.

BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name:	Agency:PARD	Date:10/29/99	No. of pages:1

Location: Midnight Cave Section No. portions of cave

Time Started: 1:35pm Time ended: 2:20pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 18.5° C Outside: 27° C Humidity Inside: 95% Outside: 55%

FAUNAL SURVEY

Species	No. seen	Comments
cicurina	4	
surface spiders	13	
* Speodesmus N.S.	5	
Cambala speobia	approx. 300	
surface millipede	44	one very tiny specimen was collected for James Reddell to ID
surface centipede	1	
* Rhadine austinica	1	
rove beetle	1	
? black beetle	1	
Crickets: Ceuthophilus secretus	approx. 500	
Ceuthophilus sp. B[1]	approx 1000	
Ceuthophilus cunicularis[2]	35	
Ceuthophilus nymphs	approx 2000	
terrestrial cricket	1	
cockroach nymph	1	
Texoreddellia texensis	1	
terrestial isopod	1	
snails	8	
springtails	approx 3250	
earth worms	18	
fungus gnats	11	
Plethodon glutinosus albagula	12	
Bufo valliceps valliceps	1	very large. Several tadpoles were noted in pool area.
Elaphe gutatta emoryi	1	juvenile captured and released on surface, healthy.

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☐

☐ Photographs taken? How many? ____ If so, attach to this report.

Survey area included landing zone (former trash pit area) and a upper alcove/ old bat roust. A few fire ants were encountered on surface.

BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name:	Agency:PARD	Date:11/09/99	No. of pages:2

Location: Maple Run Cave Section No. 1

Time Started: 3:15pm Time ended: 3:40pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 22.5° C Outside: 25.5° @ 2:46pm
Humidity Inside: 92% Outside: 41% @ 2:46pm

FAUNAL SURVEY

Species	No. seen	Comments
Snails: Gastropoda sp	5	
Scorpions: Vaejovis reddelli		
? pseudoscorpion?	1?	unable to confirm, it was very tiny all white, we lost our magnifying lense and then we could no longer find it.
Spiders: Cicurina sp.	4	
wall web		
Texella mulaiki	1	another was noted just outside of survey area.
* Millipedes: Speodesmus sp.	6	
Cambala speobia		
Springtails: Pseudosinella sp.	10	
Texoreddellia texensis		
Crickets: Ceuthophilus sp. B	2	
Ceuthophilus secretus	7	
Ceuthophilus cunicularis	6	
Ceuthophilus nymphs		
* Rhadine austinica		
mold beetle	1	collected
Flies: Diptera		

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☐

☐ Photographs taken? How many? ____ If so, attach to this report.

There was a lot more "old" broken glass and metal scraps in the first part of the cave, I removed it all.

BALCONES CANYONLANDS PRESERVE

CAVE REPORT

Name:	Agency:PARD	Date:11/09/99	No. of pages:2

Location: Maple Run Cave Section No. 2

Time Started: 4:15pm Time ended: 4:55pm

☐ *Solenopsis invicta* If so, ☐ heavy infestation ☐ moderate ☐ light

☐ Vandalism If so, ☐ trash ☐ speleothems ☐ gate ☐ graffiti

Temperature Inside: 21.5° C Outside: _____ Humidity Inside: 98% Outside: _____

FAUNAL SURVEY

Species	No. seen	Comments
Snails: Gastropoda sp		
Scorpions: Vaejovis reddelli		
Spiders: Cicurina sp.		
wall web	2	extremely tiny
Texella mulaiki		one specimen was noted just outside of survey area
* Millipedes: Speodesmus sp.		
Cambala speobia		
Springtails: Pseudosinella sp.	10	
Texoreddellia texensis		
Crickets: Ceuthophilus sp. B		
Ceuthophilus secretus		
Ceuthophilus cunicularis		
Ceuthophilus nymphs		
* Rhadine austinica		
Flies: Diptera		

(*) signifies species of concern

See back for additional Field Notes and Comments? ☐ Section map attached? ☐

☐ Photographs taken? How many? _____ If so, attach to this report.