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MAPPING SURVEY OF BROOKSVILLE RIDGE CAVE, HERNANDO COUNTY, FLORIDA

by
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Table of Contents

List of Figures

List of Tables

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Introduction

The purpose of this study was to map and describe Brooksville Ridge Cave for World Woods Corporation (WWC). Additionally, information on the cave's speleothems was collected and observations on its fauna were noted. The cave is located in the vicinity of a proposed residential development and the results of this study can help guide future hydrogeological and environmental management research to insure the least probable impact on the cave.

Brooksville Ridge Cave is located within the World Woods Planned Development District in Hernando County, Florida. The district is an area of approximately 8.5 km^2 (2,100 acres) located on the north side of US 98 near the current terminus of the Suncoast Parkway. The district is bordered on the east by CR 491, on the south by US 98, and on the north by Citrus County. The western portion of the district is located in the Candler Sand Ridge and is the location of the World Woods golf complex. The eastern portion of the district consists of hardwood hammock and is the western-most extent of the area generally referred to as the Annutteliga Hammock. The district is located in the Chassohowitzka recharge basin (Hernando County Planning and Zoning Commission, 2005).

Brooksville Ridge Cave was discovered by members of the Tampa Bay Area Grotto (TBAG) on 2 November 2002 at the bottom of a small, abandoned rock quarry on the World Woods property (Turner, 2003). Gaining entry to the cave and its continued exploration required extensive excavation. See Turner (2003) for a detailed description of TBAG's exploration efforts between November 2002 and February 2003.

While Brooksville Ridge Cave has been well known in caving circles due to the 2003 publication, its existence was not known to WWC or the general public until 2005 when TBAG members discovered the property was slated for sale and development. The existence of the cave was announced at a public meeting of the Hernando County Planning and Zoning Commission in January 2005. The commission voted to delay development approval until "scientific information is provided to assure that the subsurface karst geologic features and floral/faunal species will not be adversely impacted" (Hernando County Planning and Zoning Commission, 2005).

Little research has been published about Brooksville Ridge Cave. At an unknown date, Lee Florea, TBAG member and Ph.D. candidate at the University of South Florida (USF) began a survey of Brooksville Ridge Cave (Florea, personal communication, 2005). That information was not available for this study. The Karst Research Group at USF has conducted research in Brooksville Ridge Cave, including a paleoclimate study of speleothems from the cave (Van Beynen et al., 2004; http://uweb.cas.usf.edu/~vacher/Soto/index.htm), and geomorphological, biological, geological, and conservation investigations in and/or near the cave (http://uweb.cas.usf.edu/~vacher/projects.htm).

Field work for this study was conducted by Subsurface Exploration Services from 9 May 2005 through 10 June 2005 under contract to George Veni and Associates (GVA). Jason Gulley, owner of Subsurface Exploration Services, conducted the field work with the assistance of karst technicians Steve Keene and Eric Weaver, and cave ecologist and karst technician Katie Schneider. Beth Fratesi and Jason Gulley drafted the cave map. The project was overseen and directed by Dr. George Veni, hydrogeologist and principle investigator for GVA.

Three appendices are included with this report. Appendix A is a glossary of terms. Appendix B contains the results of the observational biological assessment. Appendix B is a conversion index from the International System of Units used in this report, to English units. Appendix C provides brief biographies of the GVA personnel who conducted fieldwork for and/or wrote this report.

Methodology

The mapping of Brooksville Ridge Cave was conducted in accordance with the guidelines set forth by Carlsbad Caverns National Park. The only variation to the NPS cave mapping protocols was the omission of the sketch. Since the Hernando County Planning and Zoning Commission only required the vertical and horizontal extent of the cave to be delineated, sketching was determined to be beyond the required scope of work.

The cave survey consisted of marking stations in the cave, measuring the distance between them with a fiberglass tape calibrated in decimal feet, and determining the angle and inclination between the stations. Stations were marked with either flagging tape or dots of fingernail polish on the cave walls. Stations marked with fingernail polish can be easily removed from the cave walls by rubbing a hand across the stations. Azimuths were measured using Brunton Sight Master compasses calibrated in one degree increments and inclinations were read using Brunton Clino Master inclinometers also calibrated in one degree increments. Front sights and back sights were employed at each station. When front and back sights varied by more than two degrees, both shots were repeated until agreement was reached. At each station the distances to the left and right walls and floors and ceilings were estimated and recorded; direct measurement of these distances was often impossible due to the constricted nature of most of the passages. All passages observed in the cave were surveyed until they became too small to permit passage of the smallest members of the team. Survey data were entered into Compass, a cave survey software program, to generate computer maps of the three-dimensional geometry of the cave which are used in this report. While the dimensions are accurate at the points of measurement, the passage shapes and geometries generated by the program are approximations and should not be considered accurate representations of the cave; substantial differences with actual passages geometries often occur. The program adjusted all azimuths for magnetic declination. Wherever possible, survey loops were closed to evaluate error. The survey data were also processed in the Walls cave survey data processing program, which has the most powerful available statistical analysis package to evaluate the data and insure that survey errors in loops were minimal. A magnetic induction survey had been planned to further evaluate error in the cave survey, however a combination of daily electrical storms and local geology made such a survey impossible.

The speleothem diversity and density survey was conducted by recording the presence of any speleothems at each survey station, assigning a category, and a relative density value. Density scores were rated on a scale of 0 to 5, with a zero value denoting that no speleothems were present and a 5 indicating that speleothems in that area were equivalent to the most heavily decorated areas of the cave. While the density rating is somewhat subjective, every attempt was made to be as objective as possible. In cases of uncertainty, the recorded values over-represent the density of speleothems. Additionally, more densely decorated areas of the cave typically required shorter survey shots than non-decorated areas; shorter shots result in more stations in decorated versus non-decorated areas.

Photodocumentation was conducted of the areas of most of the survey stations to create a photographic tour of the cave. A photograph of the cave at each station has been inserted into a Microsoft PowerPoint slide next to a map of the cave showing the position of the station relative to the cave as a whole. Each slide takes the viewer further into the cave. Photography trips were conducted separate from the cave survey in order to minimize task loading and the amount of equipment that had to be transported through the constricted passages. Passages that were mapped but later deemed insufficiently safe to warrant a return trip were omitted from the photodocumentation. One passage, the AKh survey, was not photodocumented due to the risk of damaging the camera equipment. Any speleothems occurring in those areas were documented in the inventory.

A biological assessment of Brooksville Ridge Cave was made in order to determine if any obligate cave animals were present. At the time of this assessment, there have been no published biological inventories of the cave. Fieldwork took place between 29 May 2005 and 10 June 2005. This assessment was based solely on visual census. At each of the 263 inventoried stations, a minimum of ten minutes were spent searching all microhabitats, including the walls, floors, and ceilings. Where applicable, this search included the underside of rocks, fecal material of packrats, and organic debris. If no animals were found, the inventory proceeded to the next station. If an animal was found, its location was recorded. As no collecting permits were obtained, no specimens were collected or preserved for identification time. Over 80 hours were spent on the visual census.

Field Investigation of Brooksville Ridge Cave

Description of Brooksville Ridge Cave

Surveyed for a total length of 1,118.2 m (3,668,8 ft), Brooksville Ridge Cave is a predominantly horizontal cave system. It is best characterized as a single level cave with several collapse features extending toward the surface. The main passage level lies about 15 m (50 ft) below the zero datum point (the top of the southern high wall of the abandoned quarry). It is comprised of low, wide passages with sandy clay floors (Figure 1). On average, passages on this level are 45 cm (1.5 ft) high or less, 4-6 m (15-20 ft) wide, and are largely sediment-filled. In several areas of the cave, this level has collapsed; continued exploration is achieved by squeezing over the top of these frequently-encountered breakdown slabs. Figure 2 shows the top of a typical collapsed passage. The elevations of the breakdown slabs top out at 9.8 m (32 ft) below datum, except where the AKe survey extends up to 4.6 m (15 ft) below datum. Computer-generated plan and profile views of the cave have been included as Figures 3 and 4; to avoid clutter, only every fourth survey station has been labeled; a detailed map of the cave is provided in the pocket of this report. A PowerPoint presentation accompanies this report under separate cover and provides a photographic survey.

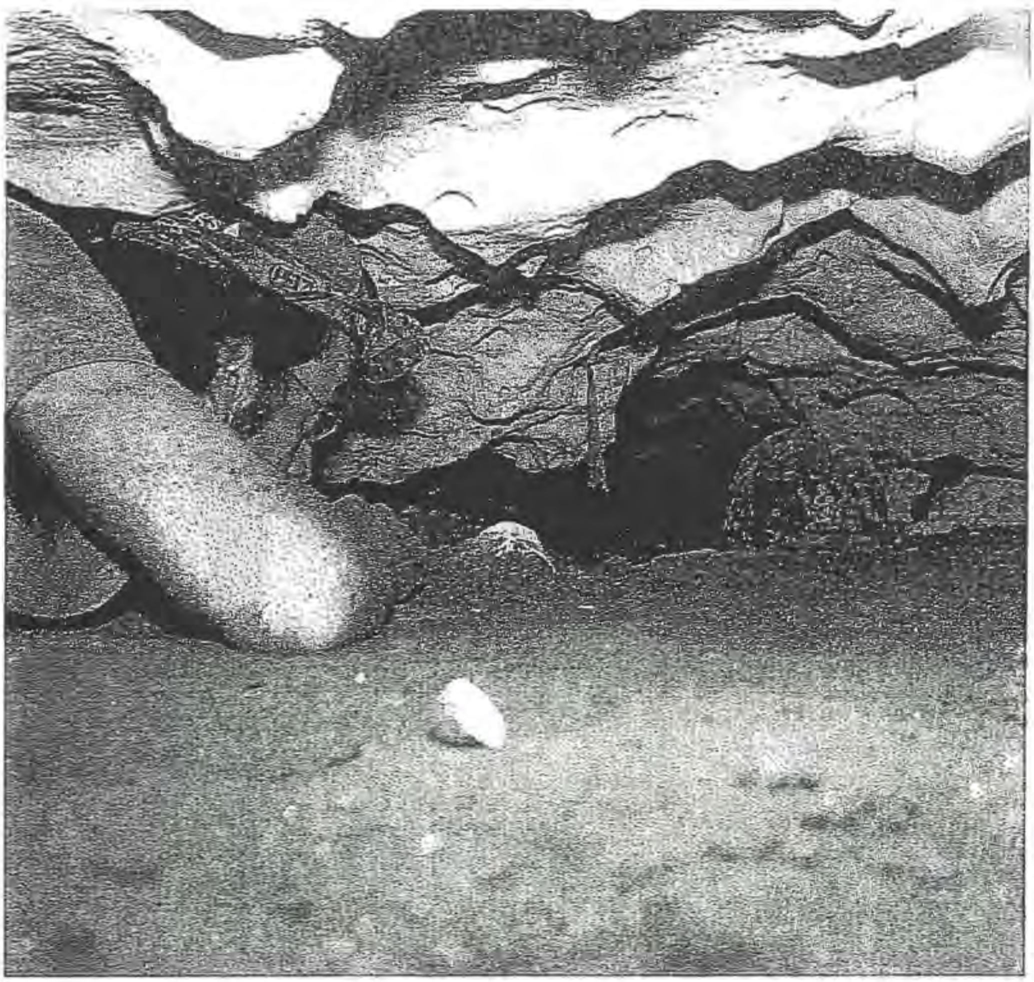

Figure 1. The main passage level of Brooksville Ridge Cave.

Figure 2: The top of a typical breakdown pile in Brooksville Ridge Cave; helmet included for scale.

The cave entrance is located at the bottom of a small, abandoned rock quarry. The quarry pit is 15 m (50 ft) long, 8 m (26 ft) wide, and 6.1 m (20 ft) deep. The dates of operation and the operator of the quarry are unknown. Entrance to the cave is gained via a small, excavated hole in the quarry's northeast corner. Squeezing through a series of two small chambers less than 50 cm (1.6 ft) high and 3 m (10 ft) wide, entry is gained to the first room of the cave (Speleothem Area 1 in Figures 3 and 4). This room is a large, highly decorated collapse chamber. While it is possible to make a short circuit around the top of the breakdown chamber, the rest of Brooksville Ridge Cave is accessed through a small vertical crack in the floor along the west wall of Speleothem Area 1. Descending 6.5 m (21.3 ft), one emerges from the crack into a small room formed at the edge of a breakdown chamber. This chamber is 4 m 13 ft) wide and 3 m (10 ft) high. Circling around the edge of the breakdown pile, access is gained to the main passage level at station A22. This passage is 17 m (56 ft) below datum and is the deepest level in the cave.

The passage between stations A22 and A25 averages 3.5 m (11.5 ft) wide and 1.5 m (5 ft) high and is largely sediment free. Despite the breakdown-covered floor, the floor, walls, and ceiling of the cave appear to be solutionally formed and are best characterized as having Swiss-cheese appearance.

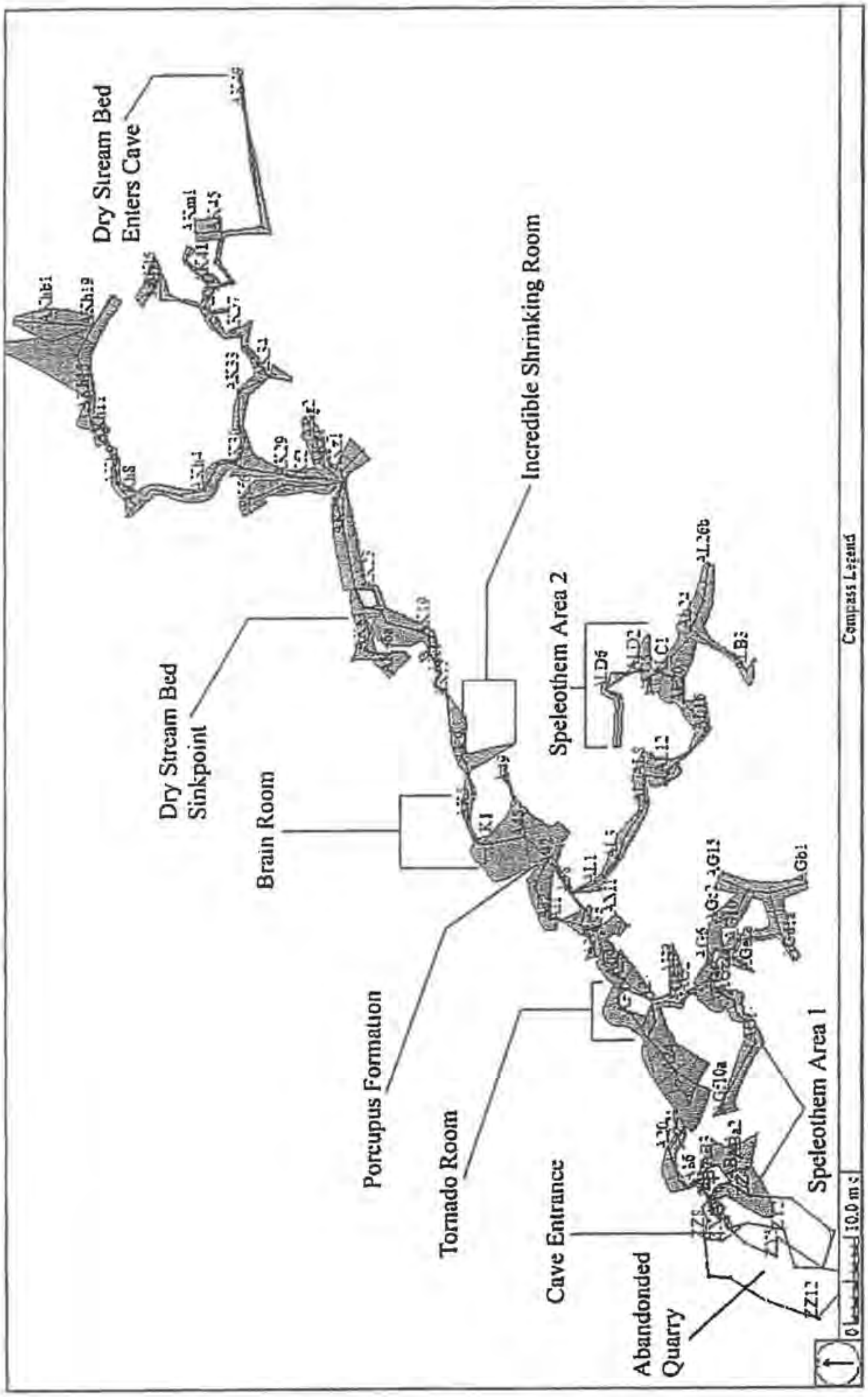

Figure 3. Simplified plan view of Brooksville Ridge Cave with major features notes; every fourth survey station has been included on the map.

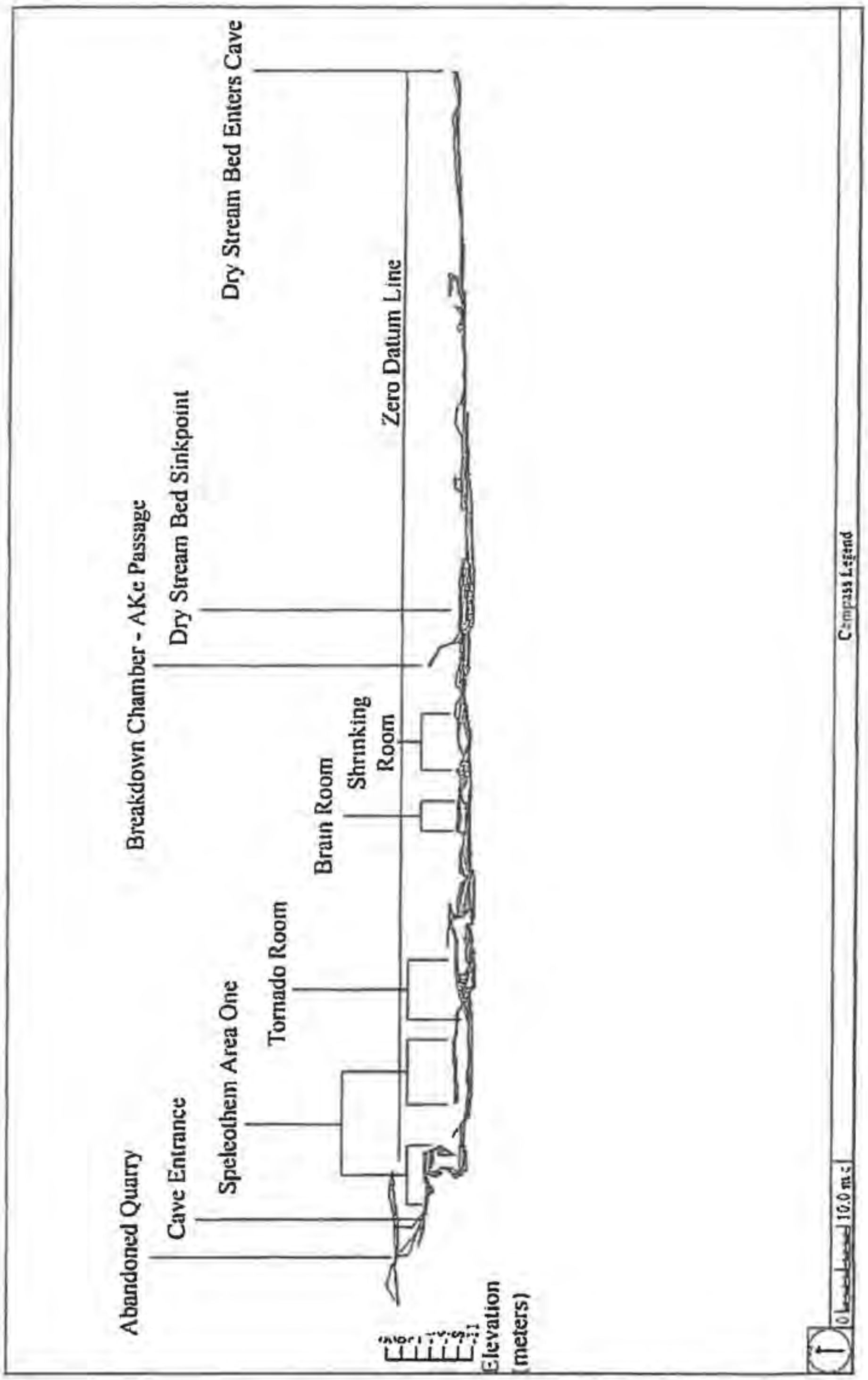

Figure 4: Simplified profile of Brooksville Ridge Cave.
The zero datum line indicates the elevation of the ground surface at top of the southern quarry wall and does not represent the actual surface profile over the cave; elevation is relative to the cave's entrance.

Brooksville Ridge Cave's second breakdown chamber, named the Tornado Room by the cave's original explorers, is encountered at station A26. The room was reportedly named for its signature speleothem, a 1-m-high (3.3 ft) column that reportedly resembled a Texas twister (Turner, 2003). The breakdown pile forming the Tornado Room is 5.5 m (18 ft) high. It is possible to make a circuit around the periphery of the room following the AF survey.

Continuing along the A survey to station A27, which is located near the southeast wall of the Tornado Room, two passages are encountered, the AG and the AH. The AH is a low, short passage about 1.5 m (5 ft) high and 2 m (6.6 ft) wide that terminates in breakdown after extending east for 17 m (56 ft). The AG passage is much more extensive.

The AG begins a low, 0.5 m (1.6 ft) high, sharply inclined passage up a fracture. At the top of the fracture is a small room. The obvious passage continuing to the southwest (AGa passage) quickly terminates in collapse. An easily overlooked 30-cm-wide (1 ft) crack in the floor along the eastern passage wall at station AG4 was the only passage found to continue. Descending 3 m (10 ft), the main passage level of the cave is reached again. The AG passage continues east over two small breakdown piles. This passage leads to a short section of walking-height passage. All passages in this area terminated in breakdown. At the bottom of the 30-cm-wide (1 ft) crack, the AGf passage takes off in a westerly direction. It begins as 40 cm (1.3 ft) high over breakdown and climbs 4 m (13 ft) over a distance of 11.5 m (37.7 ft) where it emerges at the top of a breakdown pile. The AGf passage continues west along the top of the breakdown chamber, passing several dense speleothem assemblages before terminating in breakdown. The small room at the terminus of the AGf passage contains one of the more dense assemblages of speleothems discovered in the cave. No passages were discovered to extend from this part of the cave.

The only remaining passage found leading out of the Tornado Room was a 50-cm-high (1.6 ft) passage over breakdown extending from the room's northeast corner. At station A35, the passage descends the rear of the breakdown pile responsible for the formation of the Tornado Room and reaches the main passage level at station A37. The passage splits in two directions at station A36. The AJ survey heads northeast as a 50-cm-high (1.6 ft) sediment-floored passage that winds through a small speleothem area before looping back into the A survey in a small room at station A44. The other passage, the continuation of the A survey, continues over a breakdown floor before turning sharply northeast. This passage climbs over a large breakdown slab before connecting with the AJ passage at station A44. This room is entirely floored with sediment and contains the Porcupus Formation (Turner, 2003).

The AL survey extends to the southeast from station A38. It begins as a 2-m-high vertical fissure that quickly changes to a 30-cm-high (1 ft) by 3 to 4-m-wide (10-13 ft) sediment-floored passage that is interrupted by a large section of breakdown at station AL5. The passage continues over, around and through breakdown piles until splitting in two directions at station AL21. Departing from the AL survey, the ALC passage climbs up a flowstone-encrusted breakdown pile. The top of this breakdown chamber contains a dense assemblage of speleothems and has been designated on Figure 3 as Speleothem Area 2. At station AL24, the passage resumes as a low, sediment-floored passage before terminating in fill next to a small speleothem-filled alcove at AL26. The only other passage associated with the AL survey is the short, small, sediment-floored ALB tunnel that ends in fill after four stations.

Returning to the A survey, that passage continues away from the Porcupus for 5.5 m (18 ft) with a height of 40 cm (1.3 ft) before emerging in the Brain Room. The Brain Room was named by the cave's original explorers due to the uncanny resemblance of one of the room's speleothem deposits to a human brain. The Brain Room is essentially another collapse chamber and the two passages associated with it circle around the edges of the 4.5-m-high pile of breakdown. The A survey continues as an extremely tight passage that was apparently excavated by the cave's original explorers, much of this passage is about 20 cm (0.7 ft) high, and ultimately terminates in a very constricted breakdown pile at station A51. A strong breeze issues through the breakdown.

Branching north from the A survey at station A45, the AK passage goes around the breakdown pile in the center of the Brain Room and turns east at station AK2. A sediment floor is reached again at station AK8.

Turner (2003) had described a small passage leading from the Brain Room to another chamber they christened the Incredible Shrinking Room. Initial attempts locate this passage were unsuccessful. Upon closer examination, the continuation of the AK passage was discovered to have been deliberately filled in. The passage was re-excavated and the survey continued.

Stations AK8 through AK13 of the AK passage consist of a series of tortuous squeezes and contortions through the middle of a large and unstable pile of breakdown – the Incredible Shrinking Room. On the back side of the Incredible Shrinking Room a 25-cm-high (0.8 ft), inclined slide over breakdown drops into a 50-cm-high (1.6 ft), 3-m-wide (10 ft), sediment-floored passage. This passage has the same Swiss cheese-like ceilings that are characteristic of the main passage level. At AK24, this passage intersects a dry stream bed trending to the northeast. At some unknown point in time, a stream perched on a bed of clayey-sand incised through the floor sediment before disappearing in a pile of breakdown. The footprints of previous explorers were still evident in the stream bed and did not appear to have been disturbed by water flow.

The AKe passage is the southeastern continuation of the AK passage and begins at station AK 24. The passage passes a pure white piece of rimstone, 1 m (3.3 ft) high by 7 m (23 ft) long, before climbing 10 m (33 ft) up an extremely unstable pile of breakdown. Pieces of breakdown more than 2 m in diameter shifted under the weight of the survey team. At the top of the pile, two exceptionally large (about 75 cm [2.5 ft] long and 15 cm [0.5 ft] in diameter), carrot-shaped stalactites were observed. The ceiling of the small room at the top of the breakdown pile is 6 m (19.7 ft) below datum. No other passages were observed to extend from this area.

From AK24 to AK27 the dry stream bed continues as a passage nearly 2 m (6.6 ft) high and 4 m (13 ft) wide. Four passages radiate from station AK27: the continuation of the AKf, the continuation of the AK, the AKg and the AKz. The AKf passage climbs 2 m up a large breakdown block and continues as an 80-cm-high (2.6 ft) passage on top of breakdown. The AKf ends in sediment fill after descending a steep breakdown slope and no continuation was observed. The AK continues due north as a dry stream bed. The AKg consists of a 40-cm-high by 4-m-wide sediment floored passage that quickly ended in sediment fill and the AKz trends southeast for 8 m (26 ft) before ending in sediment fill.

At station AK30, the AK passage and the dry stream bed turn 90 degrees and change direction to head almost due east. Another passage, the AKh, abandons the stream bed to continue north as a very constricted 30-cm-high (1 ft) tunnel winding its way through gaps in the honeycombed ceiling. At station AKh8, the passage turns northeast, winds through another very constricted breakdown area before dropping back into a low, but very wide, sediment-floored room roughly 18 m (59 ft) long and wide and 0.4 m (1.3 ft) high. The only passage observed to extend out of this room headed southeast and terminated in a breakdown chamber just a few meters short of connecting with the AKl passage, which also terminated in breakdown. The short distance between the terminal stations of the AKh and AKl surveys, coupled with the slight breeze from the terminal breakdown at AKh20, suggests the passages are connected though not humanly passable.

Returning to station AK30, the dry stream bed continues, meandering slightly along its easterly trend. The dry stream bed makes one loop that became too small to physically traverse before terminating in fill at station AK50. Shovels and other digging implements as well as evidence of digging were observed at station AK50. Continued exploration of the AK tunnel would require massive excavation.

Although rain occurred during this study, the only water observed in Brooksville Ridge Cave was drips associated with speleothems.

Speleothem survey

Nine types of speleothems were observed in Brooksville Ridge Cave: flowstone, stalactites, stalagmites, columns, helictites, spar, rimstone, soda straws and bacon. Figure 5 illustrates the relative density of speleothem occurrence near the survey stations, with zero indicating no speleothems and five representing the highest concentrations seen in the cave. In general, most of the cave lacks speleothems. The areas of dense speleothem occurrence are restricted to two areas, the entrance chamber and rooms associated with the ALC and ALD surveys (Figures 3 and 4).

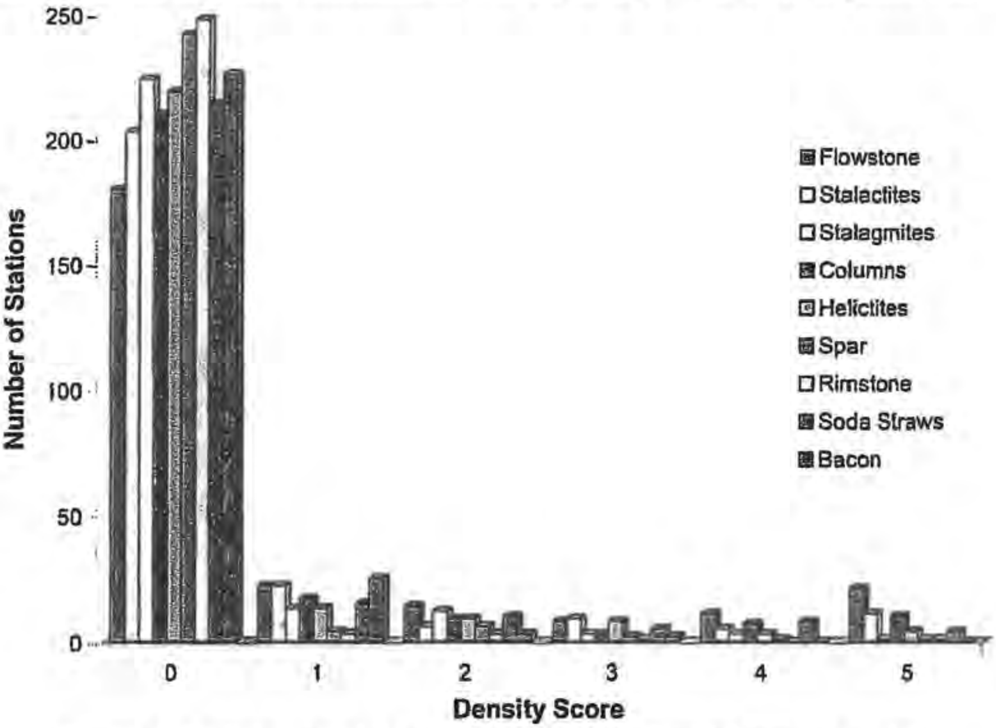

Figure 5: Relative density of speleothems inventoried at each station in Brooksville Ridge Cave.

During the course of this study, prior damage to speleothems was observed, recorded during the inventory, and in some cases photodocumented. Those data are not presented. Some represent intentional damage necessary to explore the cave (Turner, 2003) and probably some accidental damage. It is beyond the scope of this study to evaluate the causes of the speleothem damage or how it compares to exploration and general traffic through other caves with small passages.

Biological assessment

Caves are typically divided into three major zones based on physical conditions. These are the entrance zone, the twilight zone, and the dark zone. The entrance zone is characterized by direct sunlight and is slightly cooler and more humid than the surface. Mosses, ferns, birds, salamanders, and a variety of invertebrates such as fungus gnats, spiders, millipedes, and crickets are common inhabitants of the entrance zone. The twilight zone is characterized by indirect light, less variable temperature, and higher humidity than the entrance zone, and is also characterized by a decrease in resource availability (Prous et al., 2004). No plants and fewer animal species are found in the twilight zone. The physical condition is relatively constant in the dark zone, characterized by the absence of light. Temperature rarely fluctuates and is usually equal to the average mean surface temperature (Barr 1967). Humidity is high and evaporation rates low. Few species can survive in the aphotic, food-poor, stable environment of the dark zone. Species that can survive have highly evolved morphological and physiological adaptations. Such obligate cave dwelling animals are termed troglobites (terrestrial) and stygobites (aquatic).

Obligate cave animals are species of concern, with 95% of all cave animals considered vulnerable or imperiled in the United States (Culver et al., 2000). Aside from their small population sizes (McKenzie, 2002), obligate cave animals have highly restricted ranges (Sket, 1999), with 60% of described cave species in the United States known from a single county (Culver, 2001). Due to this numerical and geographic rarity, these species are threatened by such hazards as groundwater contamination (Pride et al., 1998), over-collection (Elliott, 2000), careless human visitation, and disruption of the flow of organic material into the cave (Culver et al., 2000). Additional threats to the subterranean habitat include erosion, land development, destruction of habitat, overgrazing, the introduction of bacteria, fertilizers, highway chemicals, trash, and human/livestock waste, and decreasing water quantity as a result of water withdrawal (U.S. Fish and Wildlife Service, 1997; Elliott, 2000; McKenzie, 2002).

Northern and central Florida are considered regions of medium total cave biodiversity compared to the rest of the United States (Peck, 1998). There are eight stygobite genera known from Florida, including three crayfish, two isopods, an amphipod, a salamander, and a shrimp (Table 1). The crayfish *Procambarus erythrops* Relyea & Sutton, 1975 and the salamander *Haideotriton wallacei* Carr, 1939 are both listed by the Florida Fish and Wildlife as species of special concern. The shrimp, *Palaemonetes cummingi* is a federally listed threatened species. The two amphipod species and two additional species of *Procambarus* are candidate species, meaning that existing data suggest federal listing is warranted but more data are needed before the U.S. Fish and Wildlife can make a final determination (Florida Fish and Wildlife Conservation Commission, 2005).

Florida caves are generally depauperate of troglobites and typically contain very little terrestrial habitat (D.C. Culver, personal comm.). There is only one troglobite known from Florida caves. The collembolan, *Pseudosinella pecki* Christiansen & Bellinger, 1980 is known from Jackson County, Florida. It is also recorded from caves in adjacent counties in Alabama and Georgia (Hobbs, Culver, and Elliott, 2003). Five of the seven Florida stygobites have been recorded from Hernando County (Table 1); no troglobites recorded from caves in this county.

Table 1. List of obligate cave genera previously found in Florida caves and specifically from Hernando County.

	Class	Order	Family	Genus	Number of spp.	Spp. in Hernando Couny
Stygobionts	Amphibia	Urodela	Plethodontidae	*Haideotriton*	1	0
	Malacostraca	Amphipoda	Crangonyctidae	*Crangonyx*	2	2
		Decapoda	Cambaridae	*Cambarus*	1	0
				Procambarus	12	2
				Troglocambarus	1	1
			Palaemonidae	*Palaemonetes*	1	0
		Isopoda	Asellidae	*Caecidotea*	1	0
				Remasellus	1	0
Troglobiont	Hexapoda	Collembola	Entomobryidae	*Pseudosinella*	1	0

The observational survey for fauna in Brooksville Ridge Cave found millipedes, ants, gnats, spiders, springtails, and crickets within the entrance and twilight zones. All were troglophiles typical of that ecological zone. A large number of packrats was observed at station AKL1. No animals were found on fecal material and no organic debris outside of the entrance zone was noted. Several crickets were found not far into the dark zone. One large surface millipede and one ant were found deep in the cave. One pale, small, web-building spider was found under a rock in the AKG section of the cave; it is not known if it was a troglobite or not. No aquatic habitat was found, thus no stygobites were observed.

Conclusions

The mapping, speleothem, and observational biological survey of Brooksville Ridge Cave yielded the following conclusions:

1) The cave has a surveyed length of 1,118.2 m (3,668.8 ft), it extends 11.6 m (38 ft) below its entrance, and reaches a depth of 17 m (56 ft) below the top edge of the quarry that surrounds the entrance.

2) Much of the cave was made accessible by excavation prior to this project. No new excavations were conducted during this investigation (excavation was needed to regain access to one section of the cave). Continued excavation seems likely to yield additional currently undiscovered passages, but the effort needed will likely be extensive.

3) Two areas of dense speleothem growth were discovered in the cave. Most of the cave has few speleothems. Some speleothem damage was present from exploration prior to this study.

4) Drips associated with speleothems were the only water observed in the cave during this investigation, although evidence of past flowing water was observed in some passages.

5) The cave does not appear likely to contain troglobites, although collection and identification of species found in the cave is needed to be certain.

6) The very small dimensions of the cave make it unsuitable for development as a tourist attraction.

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APPENDIX A
Glossary of 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 geological dictionary of Jackson (1997); for biospeleological terms see Culver (1982).

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

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).

Cave bacon: A calcite speleothem that grows from cave walls and ceilings, usually composed of alternating bands of light and dark crystals.

Column: A speleothem that extends from the cave ceiling to the floor; often the result of stalactites and stalagmites growing until they merge.

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.

Flowstone: A speleothem, usually of calcite and formed by sheets of water depositing successive thin layers of mineral over horizontal to steeply sections of cave floors and sediments.

Helictite: A curving, often branching calcite speleothem that may protrude into a cave at any angle; formed by capillary groundwater flow.

Karst: A terrain 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.

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.

Magnetic declination: The difference between the 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

Rimstone dam: A hard, dense, crystalline calcite deposit that forms along the edge of a cave pool or stream, commonly maintaining the water it contains at a higher elevation than the adjacent floor. See *travertine dam*.

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.

Soda straw: A thin, hollow, type of stalactite with the general appearance and diameter of a drinking straw.

sp.: Taxonomic abbreviation for "species;" when following a genus name, it indicates lack of identification to species level. Plural is spp.

Spar: In caves, typically speleothems expressed as minerals with easily discernable crystal faces, usually formed of calcite or gypsum.

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.

Stalactite: A speleothem attached to a cave wall or ceiling formed by water dripping off the wall or ceiling; growth is downward and generally in a cone shape.

Stalagmite: A speleothem formed by water dripping onto the cave floor or sediments; growth is upward and may take a variety of shapes, although a broad inverted cone is most common.

Stygobite: A species of animal that is restricted to the aquatic subterranean environment and which typically exhibits morphological adaptations to that environment, such as elongated appendages and loss or reduction of eyes and pigment.

Travertine dam: A hard, dense, crystalline calcite deposit, often synonymous with rimstone dam. Recent usage associates it with surface streams where its development may in part be affected by plants and organic materials. Its soft, spongy and porous variety is called tufa.

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. It can generally apply to either an aquatic or terrestrial species, or when used specifically it refers to terrestrial animals; see *stygobite*.

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.

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.

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 second (cfs)
cubic meters per second (m^3/s)	1,585	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

Biographies of Research Personnel

The appendix provides brief biographical information on the personnel who conducted the fieldwork for this investigation or wrote or conducted key research for the report.

Jason Gulley is a 4th-year geology student at Eastern Kentucky University and owner and operator of Subsurface Exploration Services. His firm was established in 2002 and has focused on mapping and exploring dry and especially underwater caves. His projects have included locations in the Bahamas and Mexico, plus Florida and Kentucky in the United States. He is certified as a cave diver and worked for seven years as a U.S. Army National Guard combat medic. He has worked as a geoscience technician for Purdue University, the University of Cincinnati, and the Kentucky Geological Survey operating an accelerator mass spectrometer, preparing geological samples for analysis, conducting karst inventories, and assisting with groundwater tracer studies. His skills include groundwater tracing, cave diving on air and mixed gases, and surveying, conducting radio locations, cave cartography, collecting and analyzing hydrogeological samples in both air-filled and water-filled caves.

Steve Keene is the owner and operator of Aquatek Diving and Karst Services, an Indiana-based firm specializing in mapping water-filled caves. Projects he has lead or participated in since 1994 range from Mexico to the Bahamas, and include U.S. work in Florida, Kentucky, and Missouri. He began exploring and studying caves in 1987 and is certified as a cave diving instructor, technical cave diving instructor, emergency first responder, underwater archeological site technician, and underwater archeological photo mosaic technician. Additionally, he is a Regional Safety Officer of the National Association for Cave Diving. His skills include cave diving on air and mixed gases, and surveying, conducting radio locations, and biological collecting in both air-filled and water-filled caves.

Katie Schneider is a biologist currently completing her Ph.D. research, specializing in karst ecology. She graduated Magna Cum Laude with her Bachelor's degree from American University and her master's thesis evaluated the biogeography of subterranean invertebrates in West Virginia. In 2001, she began exploring and studying caves, focusing on West Virginia but including California, Florida, Indiana, Kentucky, and Virginia. Since then she has since received seven grants, scholarships, and awards to support her cave biology research, which has been published and presented in several papers. She primarily works as a biology Teaching Assistant. Her skills include the collection and study invertebrate karst species and mapping caves.

Dr. George Veni is an internationally recognized hydrogeologist specializing in caves and karst terrains (Texas registered professional geologist license no. 682). He received his Master's degree from Western Kentucky University in 1985 and his Ph.D. from the Pennsylvania State University in 1994. Since 1987 he has owned and served as principal investigator of George Veni and Associates. Much of his work has been in central Texas, but he has also conducted extensive karst research throughout the United States and in several other countries. Among his organizational activities, he is currently President of the Texas Speleological Survey, Executive Secretary of the National Speleological Society's Section of Cave Geology and Geography, and is a member of the governing board of the International Union of Speleology. He serves as a doctoral committee advisor for geological and biological dissertations at The University of Texas and teaches karst geoscience courses as an adjunct professor for Western Kentucky University. He has taken college level biology courses, including Karst Ecology at Western Kentucky University, and has been collecting cave species and assisting in the study of cave ecosystems since 1976. Three cave-dwelling species have been named in his honor. He has published and presented over 100 papers, including four books, on hydrogeology, biology, and environmental management in karst terrains. He holds U.S. Fish and Wildlife Service Permit TE026436-0 (expires 31 August 2005) to collect and study federally listed endangered Texas karst invertebrate species.

Eric Weaver began exploring and studying caves in 1972, which currently includes caves in 16 U.S. states, Canada, and Guatemala. He has a Bachelors of Science and Masters of Science degree. His primary employment is at the University of Cincinnati. He has assisted with cave biological and geological investigations and is especially skilled in cave rescue. He is nationally certified as an Emergency Medical Technician, Level 2 Cave Rescue, and is the current Chairman of the Cave Rescue Section of the National Speleological Society. His skills include cave surveying and rescue.