The San Antonio River Mammoth Site: Archaeological Testing Investigations for the Interstate 37 Bridge at the San Antonio River Improvement Project, Bexar County, Texas

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ARCHAEOLOGICAL TESTING INVESTIGATIONS FOR THE INTERSTATE 37 BRIDGE AT THE SAN ANTONIO RIVER IMPROVEMENT PROJECT BEXAR COUNTY, TEXAS

CSJ: 0073-09-030

Prepared for

TEXAS DEPARTMENT OF TRANSPORTATION
Environmental Affairs Division
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Austin, Texas 78704

Prepared by

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ARCHAEOLOGICAL TESTING INVESTIGATIONS FOR THE INTERSTATE 37 BRIDGE AT THE SAN ANTONIO RIVER IMPROVEMENT PROJECT BEXAR COUNTY, TEXAS

ABSTRACT

On behalf of the Texas Department of Transportation (TxDOT), SWCA Environmental Consultants (SWCA) conducted test excavations on the San Antonio River Mammoth site (41BX1239) and 41BX1240 and surveys in the area of potential effects (APE) of the Interstate Highway (IH) 37 bridge project at the San Antonio River in southeastern Bexar County, Texas. Work was initiated to address the requirements of Section 106 of the National Historic Preservation Act (1966) as Amended and the Antiquities Code of Texas. The purpose of the investigations was to identify, delineate, and evaluate the significance of all archaeological and historic properties potentially affected by the undertaking and, if warranted, recommend the scope of additional work. Of particular concern, site 41BX1239 contains the remains of at least two mammoths with possible evidence of cultural association based on the initial investigations by Texas A&M in 1997. However, subsequent faunal analysis, conducted by Olga Potapova and Larry D. Agenbroad of the Mammoth Site in Hot Springs, North Dakota, found inconclusive evidence for definite or valid cultural modification to the specimens studied.

The testing investigations on the San Antonio River Mammoth site included the re-exposure of the original Texas A&M 1997 site trench; limited hand-excavated units to further assess the prior interpretations of the deposits and recover a sample of bone; and a detailed geomorphological assessment. The work identified a bone bed consisting of the remains of at least two mammoths. Flotation of recovered sediments from these hand excavations identified flakes of siliceous material that are consistent with micro-debitage produced by the use and retouch of stone tools.

Although at the highest thresholds of certainty, the cumulative evidence is likely yet insufficient to conclusively prove human interaction with the mammoth remains, the additional data gathered herein lend some credence to the prior interpretation of the site as archaeological rather than strictly paleontological. Concurring with the previous determination, the site is considered eligible for inclusion to the National Register of Historic Places (NRHP) and for listing as a State Archeological Landmark (SAL). However, the investigations determined the site deposits are located outside the APE of the current undertaking, and therefore the project will not affect deposits associated with the San Antonio River Mammoth site.

The investigations of 41BX1240 identified only a very sparse scatter of primarily surficial materials in a heavily disturbed context with no associated features or diagnostic materials. Accordingly, the site is not recommended as eligible for listing on the NRHP or for designation as a SAL. The survey identified no new archaeological sites. Based on the avoidance of 41BX1239, it is SWCA's recommendation that no archaeological properties will be affected by the IH 37 bridge rehabilitation.

ACKNOWLEDGEMENTS

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MANAGEMENT SUMMARY

PROJECT TITLE: San Antonio River Mammoth Site: Archaeological Testing Investigations for the Interstate 37 Bridge at the San Antonio River Improvement Project, Bexar County, Texas.

TxDOT CSJ NUMBER: 0073-09-030

SWCA PROJECT NUMBER: 20111-126-AUS.

PROJECT DESCRIPTION: Texas Department of Transportation (TxDOT) proposes to rehabilitate the existing Interstate Highway (IH) 37 crossing structure and reconstruct approaches and structural elements at the crossing of the San Antonio River for increased safety and traffic mobility. The area of potential effects (APE) consists entirely of existing right-of-way (ROW) and is approximately 3,250 feet long with a maximum width of 600 feet. The project does not require new right-of-way.

LOCATION: South of San Antonio in southern Bexar County, the project area is located along the San Antonio River approximately 1.2 to 1.5 miles north of the highway intersection of IH 37 and Loop 1604. Site 41BX1239 is situated in the eastern ROW of IH 37 south and west of the San Antonio River. Site 41BX1240 is north of the San Antonio River in the eastern right-of-way of IH 37. The APE, which lies entirely within existing TxDOT ROW, is depicted on the Losoya, Texas USGS 7.5-minute topographic map.

PRINCIPAL INVESTIGATOR: Kevin A. Miller.

TEXAS ANTIQUITIES PERMIT: 4531.

DATES OF WORK: May to June 2007.

PURPOSE OF WORK: As the construction project will involve federal funds from the Federal Highway Administration (FHWA) and involves state land controlled by the San Antonio District of TxDOT, investigations were conducted in compliance with the Texas Antiquities Code; the National Historic Preservation Act; the Programmatic Agreement among the FHWA, the Advisory Council on Historic Preservation, TxDOT, and the Texas Historical Commission (THC); and the Memorandum of Understanding between TxDOT and the THC.

FINDINGS AND RECOMMENDATIONS: Site 41BX1239, consisting of the remains of at least two mammoths, is eligible for inclusion to the NRHP and for listing as a SAL, though the archaeological nature of the site is still unclear. Site 41BX1240, an open prehistoric occupation site, is not considered eligible for inclusion to the NRHP and no further work is recommended. No other sites were identified. Based on the avoidance of 41BX1239, it is SWCA Environmental Consultants' recommendation that no archaeological properties will be affected by the IH 37 bridge rehabilitation.

CURATION: The faunal remains, artifacts, and records from the project will be curated at the Center for Archaeological Research (CAR), The University of Texas at San Antonio.

CHAPTER 1

INTRODUCTION

Stephen M. Carpenter

INTRODUCTION

On behalf of the Texas Department of Transportation (TxDOT), SWCA Environmental Consultants (SWCA) conducted archaeological investigations for the Interstate Highway (IH) 37 bridge project in Bexar County, Texas (Figure 1.1). Conducted in late May and June 2007, the fieldwork included testing of two sites, the San Antonio River Mammoth site (41BX1239) and 41BX1240, and intensive survey beyond the sites. The investigations were conducted to address the requirements of Section 106 of the National Historic Preservation Act (NHPA) as amended, and the Antiquities Code of Texas. The work was conducted under Texas Antiquities Permit 4531; Kevin Miller served as Principal Investigator. SWCA performed the investigations under General Services Contract No. 577XXSA002, Amended Work Authorization No. 57709SA002.

On the western terraces of the San Antonio River less than 0.5 km downstream from its confluence with the Medina River, the Mammoth site is a bone bed consisting of the remains of at least two mammoths (*Mammuthus*) within the southeastern right-of-way (ROW) quadrant of IH 37's bridge crossing (Figure 1.2). Of principal significance, the site contains possible evidence of human association, a rather uncommon occurrence with these Pleistocene faunal remains. Accordingly, assessing the spatial extent and relationship of the faunal remains to the project's area of potential effects was one of the principal concerns of the investigations. In addition, clearly determining the nature of the site, whether archaeological or paleontological, was a primary goal of the work.

Site 41BX1240 is an open prehistoric occupation on the San Antonio River terraces in the northeastern right-of-way quadrant of IH 37's bridge crossing (see Figure 1.2). The site, consisting of a very light surficial scatter of prehistoric materials, is situated at the juncture of bedrock uplands and alluvial terraces along the river. The area is 50 m east of the northbound highway crossing.

PROJECT DESCRIPTION

The project area is centered on the IH 37 crossing of the San Antonio River in extreme southern Bexar County. The project area is roughly 6.75 miles (10.86 km) south of San Antonio, Texas, about 3.5 miles (5.6 km) west-southwest of Elmendorf, Texas, and 1.36 miles (2.18 km) north of Loop 1604. The investigations were conducted within IH 37 ROW on both the south and north sides of the San Antonio River. At this crossing, the IH 37 roadway runs roughly northeast to southwest while the San Antonio River drains southeastward. Investigated sites 41BX1239 and 41BX1240 are located on the south and north sides of the San Antonio River, respectively.

Within the project area, IH 37 is a divided four-lane paved road with a meridian, shoulders, and bordering frontage roads that loop under the bridge crossing. TxDOT will rehabilitate the existing crossing structure for increased safety and traffic mobility, which entails the reconstruction of approaches and structural elements of the IH 37 bridge over the river. The area of potential effects (APE) consists entirely of existing right-of-way and is approximately 3,250 feet (990 m) long with a maximum width of 600 feet (183 m), confined mainly between existing bridge structures (see Figure 1.2). Based on the design, subsurface impacts will be of varying depths, less than 3 feet in depth along the approaches, but substantial, deep impacts in excess of 5 feet in the areas around columns, abutments and other structural components of the bridge. The project does not require new right-of-way.

As the construction project will involve federal funds from the Federal Highway Administration (FHWA) and involves state land controlled by the San Antonio District of TxDOT, investigations were conducted in compliance with the Texas Antiquities Code; the National Historic Preservation Act (NHPA); the Programmatic Agreement among the FHWA, the Advisory Council on Historic Preservation, TxDOT, and the Texas Historical Commission (THC); and the
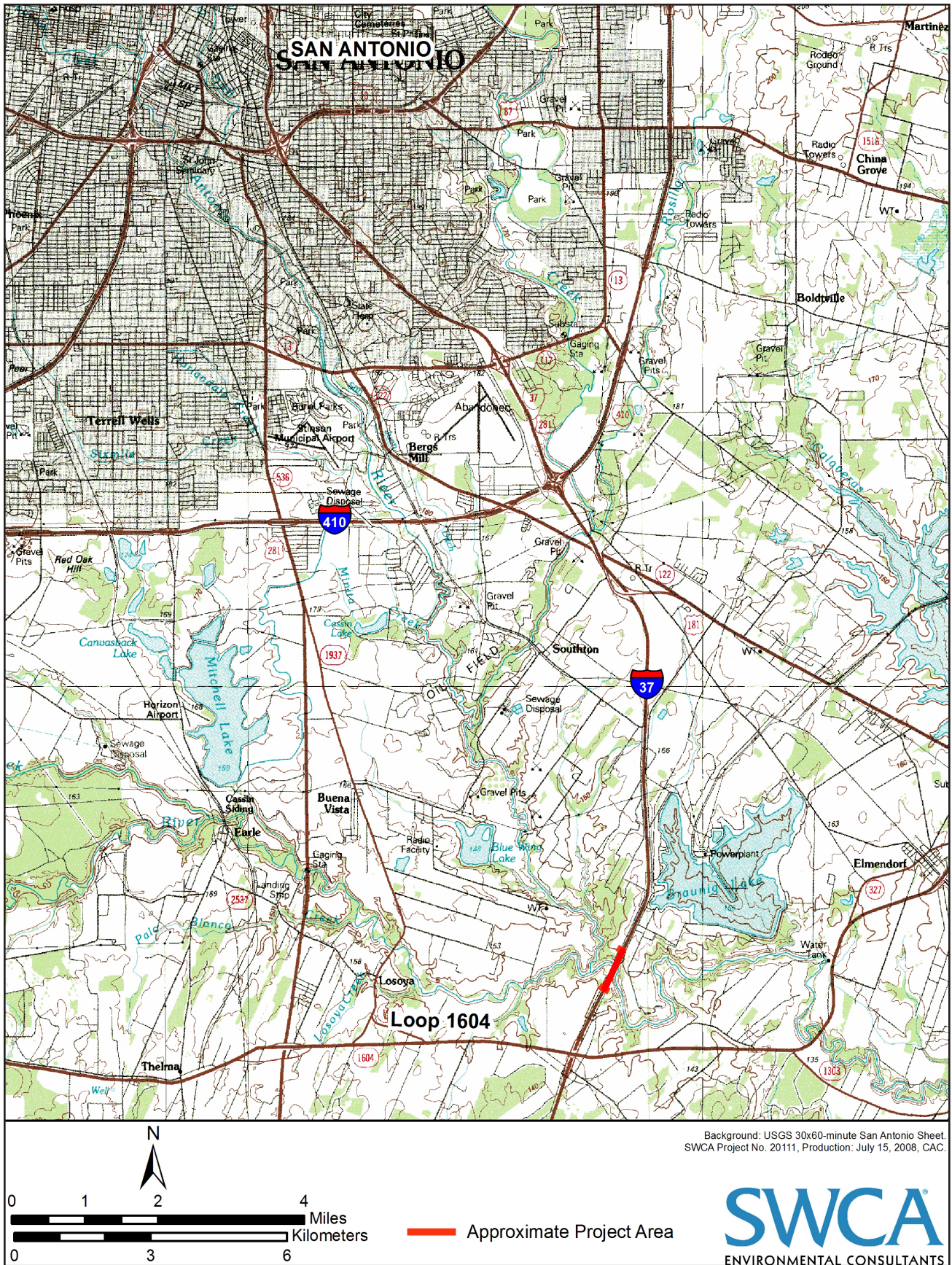
Figure 1.1.   Project location map.

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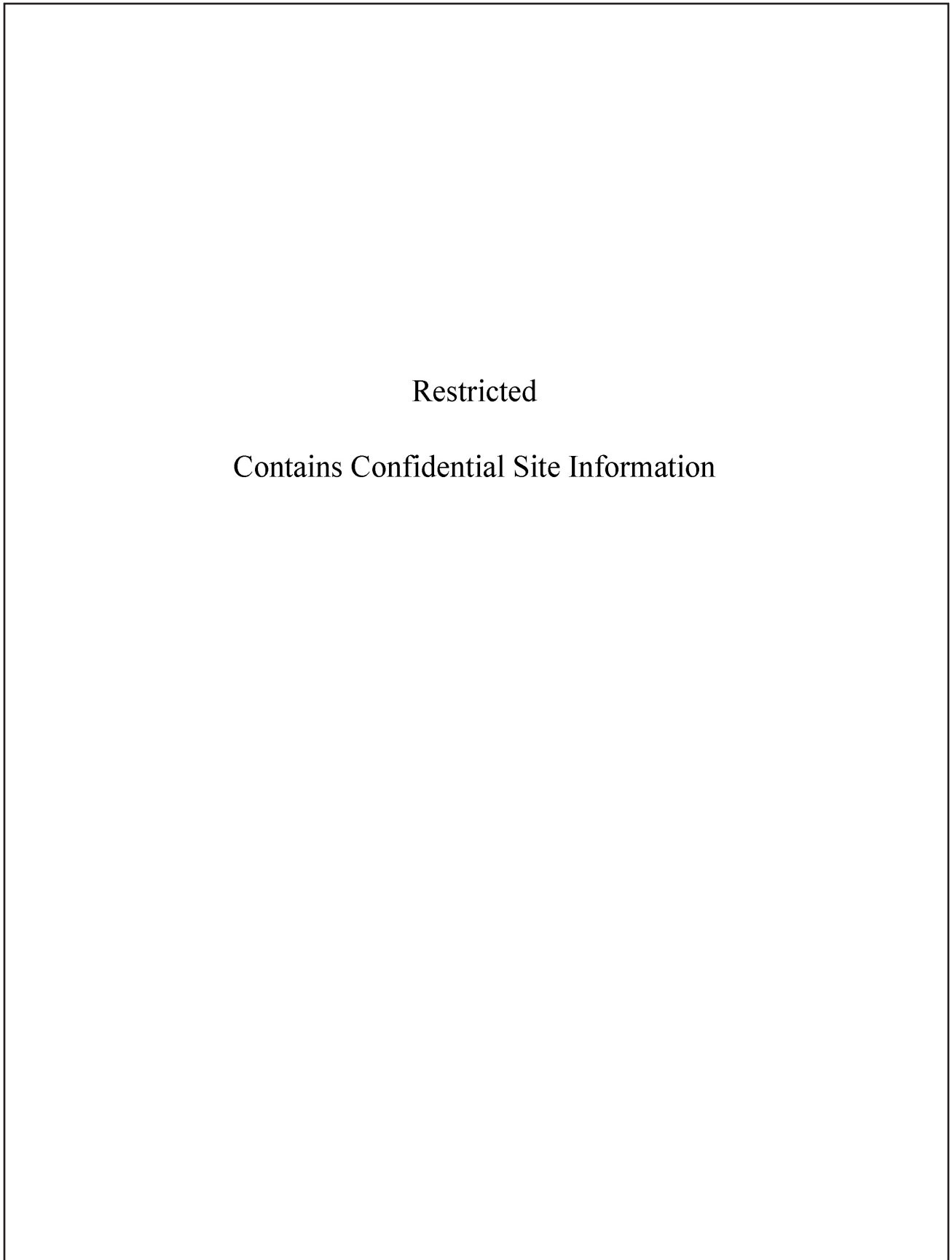
Figure 1.2. Project area with sites locations for 41BX1239 and 41BX1240.

Memorandum of Understanding between TxDOT and the THC.

Overview of Project History and Recorded Sites

In 1997, archaeologists from the Center for Ecological Archaeology (CEA) at Texas A&M University (TAMU) discovered the Mammoth site and 41BX1240 during a waterline survey within TxDOT right-of-way. Site 41BX1239, as noted, includes remains of a mammoth. Based on possible evidence of butchering identified on several bone fragments, CEA considered the Mammoth site to be an archaeological rather than strictly a paleontological site. The stratigraphy of the natural deposits, analogous to better studied areas upstream, suggested the site deposits dated from approximately 15,000 to 10,500 years B.P. CEA investigators recommended the site as eligible for listing on the National Register of Historic Places (NRHP) and for designation as a State Archeological Landmark (SAL). As the full horizontal limits of the site were never determined and it lay within close proximity of the project APE, TxDOT required further investigation to clarify the content, spatial extent, and cultural association of the faunal material.

CEA recorded the nearby prehistoric site 41BX1240 as an open occupation on the San Antonio River terraces, though the nature of the archaeological deposits was poorly understood since it lay primarily beyond their survey corridor. Accordingly, no formal recommendations were made regarding its significance or eligibility at that time.

Objectives – Purpose of Investigations

Based on the previous investigations and the need for clarification on several issues, TxDOT recommended testing on both sites. Additionally, the area of potential effects was recommended for intensive survey to determine the presence of any unrecorded sites. The objectives on the Mammoth site were specifically defined as:

1) Relocate and delineate the site boundaries relative to the project area to ensure avoidance;

2) Conduct limited archaeological and paleontological excavations to clarify the cultural involvement with the remains, if possible; and

3) Further define the depositional context of the site.

Investigations on 41BX1240 were primarily to determine whether the site is eligible for listing on the NRHP and as an SAL, but also to delineate the extent of the site deposits. The survey investigations beyond these sites were designed to locate and assess previously undefined resources in the project area.

Structure of Final Report

This final report provides the results of the investigations, satisfying the final reporting requirements of the work authorization. It is designed to provide the results of processing and analysis of the mammoth bones recovered as well as geoarchaeological assessment from the excavations in 2007.

Chapters 2 and 3 provide the physical and cultural setting for the site, respectively. Chapter 4 presents the methods to stabilize and analyze the mammoth remains, as well as those methods used to process various samples. Chapter 5 provides the results of all cultural resource investigations conducted at the sites. Chapter 6 details the faunal analysis completed by mammoth experts Olga Potapova and Larry D. Agenbroad of the Mammoth Site National Natural Landmark in South Dakota. Chapter 7 presents the results of the geoarchaeological study conducted by C. Brit Bousman of Texas State University. Chapter 8 provides the results of the analysis of cultural involvement with the mammoth remains and is part of the effort to discern whether the site is an archaeological or strictly paleontological site. Finally, Chapter 9 provides a summary of the findings and recommendations.

CHAPTER 2

PHYSICAL SETTING

Ken Lawrence and Stephen M. Carpenter

INTRODUCTION

The following discussion provides an overview of the environmental setting relevant to the current investigation. The discussion is based on the results of the field investigations and a review of relevant literature. In particular, a review of the local geology and soils, as mapped by the Bureau of Economic Geology and the United States Department of Agriculture's Soil Conservation Service; the local USGS topographic maps, aerial photos, and excavation and site profiles, provided the basis for the general site setting descriptions of sites 41BX1239 and 41BX1240.

HYDROLOGY

The project area lies within the San Antonio River drainage basin, a contributor to the Guadalupe River, which drains into the Gulf of Mexico. The project area is bisected by a meander bend in the San Antonio River situated about 0.25 mile (400 m) east of the Medina and San Antonio River confluence. The bend of the river forms an interior flood plain on the south side of the crossing and a prominent elevation drop on the north side where the river cuts into the north bank of the drainage (Figure 2.1). Both of the sites are located along upper alluvial terraces that are bisected by the San Antonio River. Site 41BX1239 extends westward, and 41BX1240 stretches northeasterly, covering the San Antonio and Medina River valley confluence.

With its headwaters in Bexar County, the San Antonio River flows 180 miles southeast into the Guadalupe River at the intersection of the Calhoun, Refugio, and Victoria county lines. The San Antonio River rises in a cluster of springs in north central San Antonio approximately 4 miles north of downtown. The spring flow of the San Antonio and its principal tributaries, the Medina River and Cibolo Creek, makes the volume of the river steadier than that of most Texas streams. The San Antonio River is dammed to form two artificial reservoirs in the San Antonio area. One near the head of the stream, impounded by Olmos Dam, has a capacity of 15,500 acre-feet and is used solely for flood control.

The other reservoir, Lake Blue Wing, 10 miles (16 km) south of San Antonio, has a capacity of 1,000 acre-feet and is used for irrigation. Because of the springs, the San Antonio River in the vicinity of the site has a relatively stable, perennial flow at all times.

GEOLOGY

The geology of the project area is mapped as Pleistocene Leona Formation, fine calcareous silt grading down into coarse gravel (Barnes 1983) (Figure 2.2). These Pleistocene deposits are bordered by a band of Eocene Wilcox Group formation that consists of mostly mudstone with varying amounts of sandstone and lignite. Included within the project area are Holocene-aged fluviatile terrace deposits found mostly above the flood level along the entrenched stream and low terrace deposits of gravel, sand, silt, clay, and organic matter down within the incised San Antonio River channel.

SOILS

Four soil types are present in the APE including Frio and Venus clay loams on the southern side of the river and Venus loam and Duval loamy fine sand to the north (Taylor et al. 1991) (Figure 2.3). Based on geomorphologic studies, Frio and Venus soils are comprised of a series of buried paleosols. On 41BX1239, the mammoth remains are considered to be

Figure 2.1. San Antonio River flowing southeast beneath the IH 37 bridge.

Figure 2.2.   Geologic map.

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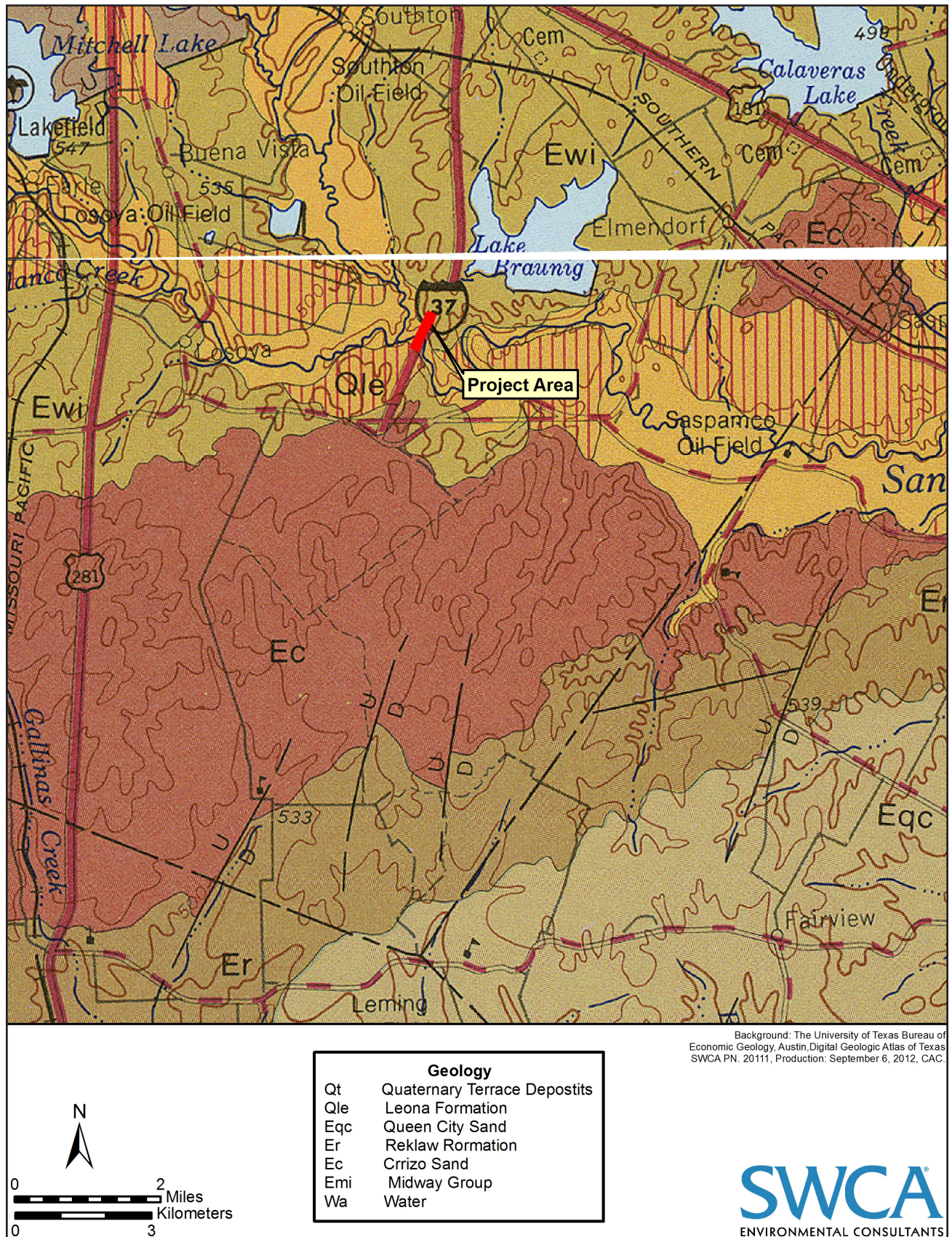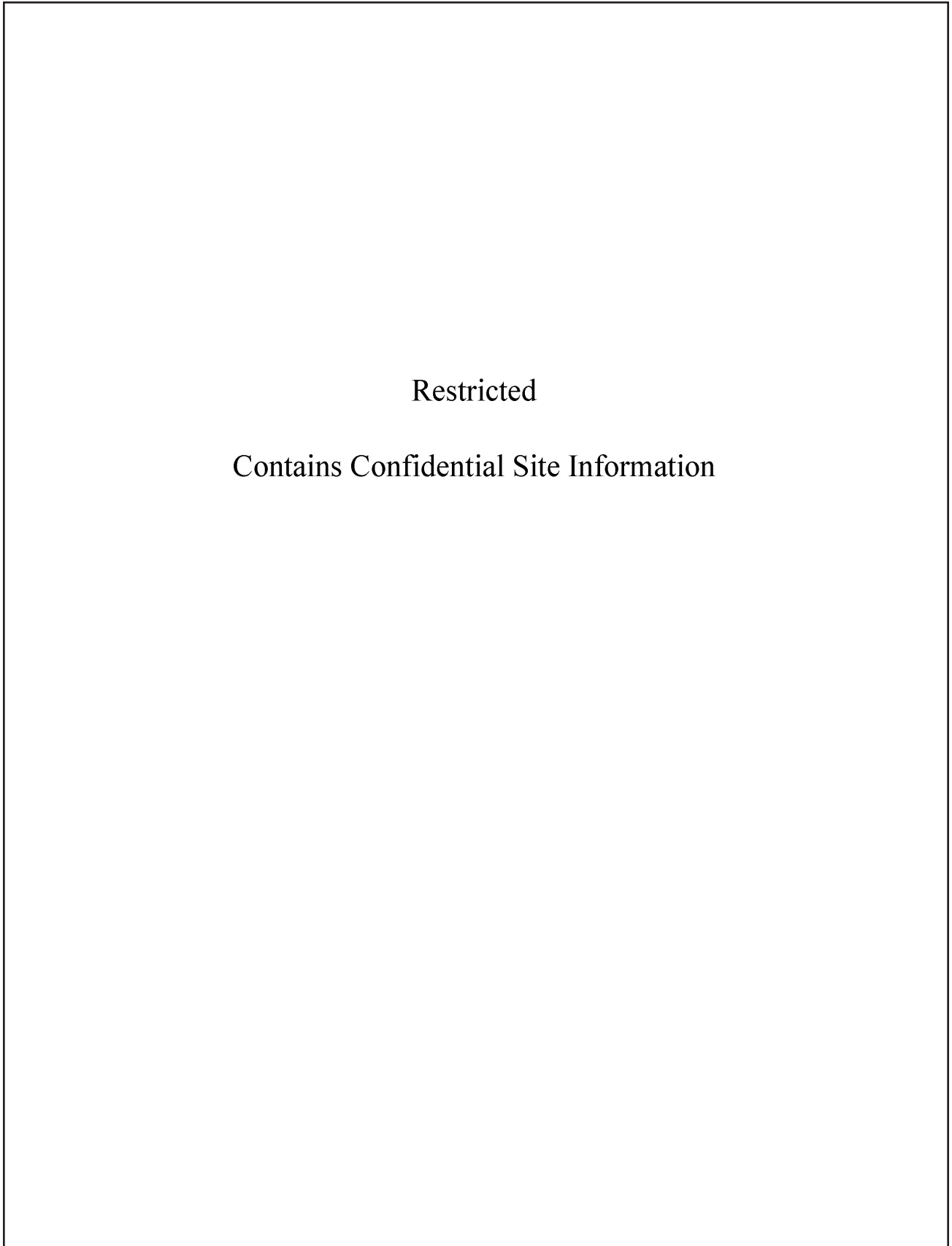
Figure 2.3.   Soils map.

situated on a remnant strath terrace at the juncture of the upper Applewhite-equivalent terrace and the lower Miller-equivalent terrace. Within these are the Perez and Somerset paleosols, or soils that are approximately analogous to these.

FLORA

Broadly defined, the project area is situated at the northern edge of the South Texas Plains region that is described as level to rolling prairies with a growth of mesquite and various cacti. Additionally, the project area lies along the margins of three intermingled floral communities of the Edwards Plateau region to the north and west, the Blackland Prairies region to the north, and Post Oak Savannah to the east (Correll and Johnston 1979:3–10). The Edwards Plateau region is described as rough, rocky areas with a tall- to mid-grass understory and a mixed overstory of oaks, juniper, and mesquite that blends into other vegetative regions along its boundaries. The Blackland Prairies region is composed of grasses with scattered timber, particularly along drainages. The Post Oak Savannah region is characterized as primarily containing grassy plains with confined stands or groves of trees (Kutac and Caran 1994:13).

The most characteristic vegetation observed around the project area includes post oak (*Quercus stellata* var.), pecan (*Carya illinoensis*), eastern red cedar *(Juniperus virginiana)*, southern hackberry (*Celtis laevigata*), cedar elm (*Ulmus crassifolia*), bur oak (*Quercus macrocarpa*), blackjack oak (*Quercus marilandica*), mesquite (*Prosopis glandulosa*), American elm (*Ulmus Americana*), Texas oak (*Quercus texana*), Ashe juniper (*Juniperus ashei*), bitternut hickory (*Carya cordiformis*), and sand post oak (*Quercus margaretta*) with an understory of bunch grasses (e.g., big bluestem, Indian grass, sideoats grama, and silver bluestem), shrubs, laurel greenbriar (*Smilax laurifolia*), yaupon holly (*Ilex vomitoria*), American beautyberry (*Callicarpa americana*), coralbean (*Erythrina herbacea*), saw greenbriar (*Smilax bona-nox*), cedar sedge (*Carex planostachys*), Prairie spiderwort (*Tradescantia occidentalis*), and Texas bluebonnet (*Lupinus texensis*) (Ajilvsgi 2003; Brown 1985; Correll and Johnston 1979; Cox and Leslie 1999; Everitt et al. 2002; Kricher and Morrison 1998; Kutac and Caran 1994; Petrides 1988; Simpson 1988; Stein et al. 2003; Sutton and Sutton 1985; Vines 1997; Wrede 2005).

FAUNA

The intermingled faunal communities of the South Texas Plains, Edwards Plateau, Blackland Prairie, and Post Oak Savannah regions that surround the project area correspond to the convergence of the broader Tamaulipan, Balconian, and Texan biotic provinces of Texas defined by Blair (1950).

Mammals common among these biotic provinces and the project area include striped skunk (*Mephitis mephitis*), white-tailed deer (*Odocoileus virginianus*), opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), armadillo (*Dasypus novemcinctus*), black-tailed jackrabbit (*Lepus californicus*), and deer mouse (*Peromyscus maniculatis*). Less common are the predatory mammals including the coyote (*Canis latrans*), bobcat (*Lynx rufus*), and gray fox (*Urocyon cinereoargenteus*) (Burt and Grossenheider 1976; Schmidly 1983). In addition, bison (*Bison bison*), mountain lion (*Felis concolor*), and black bear (*Ursus americanus*) would have been present prehistorically (Davis and Schmidly 1994).

Bird species composition in the project area is fairly diverse with numerous breeding, migrant, and wintering species present (Kutac and Caran 1994). Typical birds within the project area include northern bobwhite (*Colinus virginianus*), black vulture (*Coragyps atratus*), turkey vulture (*Cathartes aura*), red-tailed hawk (*Buteo jamaicensis*), mourning dove (*Zenaida macroura*), northern mockingbird (*Mimus polyglottos*), American robin (*Turdus migratorius*), and many sparrows (Davis and Schmidly 1994; Kutac and Caran 1994).

In addition to mammals and birds, Blair (1950) identifies a wide variety of amphibians and reptiles within the biotic provinces. Some reptiles common to the project area include the yellow mud turtle (*Kinosternon flavescens flavescens*), common musk turtle (*Sternotherus odoratus*), the ornate box turtle (*Terrapene ornata ornata*), eastern box turtle (*Terrapene carolina carolina*), prairie lizard (*Sceloporus undulatus garmani*), texas spiny lizard (*Sceloporus olivaceus*), eastern yellowbelly racer (*Coluber constrictor flaviventris*), Texas rat snake (*Elaphe obsoleta lindheimeri*), western cottonmouth (*Agkistrodon piscivorus leucostoma*), western diamondback rattlesnake (*Crotalus atrox*), and the timber rattlesnake (*Crotalus horridus*). Amphibians found within the project area include the small mouth

salamander (*Ambystoma texanum*), Woodhouse's toad (*Bufo woodhousii*), Gulf coast toad (*Bufo valliceps*), bullfrog (*Rana catesbeiana*), and the Strecker's chorus frog (*Pseudacris streckeri*) (Kutac and Caran 1994; Conant and Collins 1998; Kutac and Caran 1994; Werler and Dixon 2004).

A Brief Description of Mammoths

In North America, several species of proboscideans have been identified in archaeological contexts (see Grayson and Meltzer 2002). These include two species of mammoth (*Mammuthus)* and one of mastodon (*Mamut americanum*). Of the two mammoth species, the range of woolly mammoth (*Mammuthus primigenius*) is typically considered to have been limited to areas far to the north of Texas, roughly along the Canadian border (Olsen 1971:Figure 36). The Columbian mammoth (*Mammuthus columbi*), which is inferred to be the species at the Mammoth site, ranged throughout the continental United States and into Mexico, is most often found in archaeological sites (Haynes 2002).

Mammuthus columbi

The Columbian mammoth was uniquely a North American species which evolved from the Siberian steppe mammoth (*Mammuthus trogontherii*) approximately 1.5 milllion years ago. In Eurasia, this same ancestor evolved separately into the woolly mammoth. Columbian mammoths were one of the largest species of elephant. It measured up to 4 m (13 feet) tall at the shoulder and up to 10 tons in weight with a life span of 60 to 80 years (Lister and Bahn 2007). The largest tusk ever found was recovered from Texas and measured up to 4.9 m (16 feet) long, making Columbian mammoths world record holders amongst the elephant family.

Physical Description

Comparatively, the Columbian mammoth was similar to a large African elephant but with a more sloping back and long, spiraled tusks (Figure 2.4). There is some debate as to how much hair the Columbian mammoths had, and some scientists suggest they had a full fur coat such as the woolly mammoth. It is more likely that hair grew more extensively on some parts

Figure 2.4.   Artist's depiction of Columbian mammoth showing the distinctive tusk curvature. Adapted from (http://www.bbc.co.uk/nature/wildfacts/fact files/3000.shtml).

of the body, such as the top of the head, but that they were basically elephant-like with exposed naked skin, greyish in color.

DISTRIBUTION AND HABITAT

The Columbian mammoth ranged throughout most of the United States and down into Central Mexico. Its range may have overlapped with several other varieties of mammoth, including the Wooly mammoth, which was found in northern latitudes, and the Jefferson mammoth, which was found on open prairies (Lister and Bahn 2007; Saunders 1992).

DIET

Mammoths were herbivores, eating mainly grasses and other low growing plants. They also browsed on leaves, twigs, and fruit. As a side note, certain plants in North America produce huge fruits that no modern American animals eat and therefore have no natural method of seed dispersal. For example, the Osage orange, with its grapefruit-sized fruit, is believed to have been part of the diets of large, extinct animals such as mammoths, which would have been the natural dispersal agents for this species. The fruit would have been eaten but the seeds would have passed harmlessly through the animal's gut to be ejected with the dung, allowing them to germinate and colonize new areas.

BEHAVIOR

The closest modern comparisons to mammoths of any kind are African and Asian elephants. Whilst developing an accurate model of animal behavior is not possible given that modern elephants inhabit greatly different environments, represent completely different species, and are separated from mammoths by thousands of years, some general observations can be made. African elephants live in matriarchal herds dominated by the eldest female (Saunders 1992). Males do not live within these herds; instead they are usually forced out of the group upon reaching adolescence (Frison 1989). Additionally, as to be expected with animals of this size, African elephants require large amounts of food (upwards of 500 pounds) and water (50 to 90 gallons) per day to survive (Lister and Bahn 2007). As such, it is likely that mammoths spent the majority of their day feeding and watering, traveling between food sources and water sources.

REPRODUCTION

Gestation was 22 months, after which a single young was produced and suckled until 2 to 3 years old. Adult males lived apart from the herds, joining them only during the breeding season to mate with receptive females. Adult males would have fought for access to the female herds at this time.

Chapter 3

Cultural Setting

John Lowe, Stephen M. Carpenter, and Ken Lawrence

Introduction

A brief overview of previous investigations and a review of mammoth sites are presented here to provide a basic context for the investigations, particularly the work on the mammoth remains at the San Antonio River Mammoth site. The review here is not exhaustive but focuses mainly on some of the pertinent sites with aspects relevant to the subsequent discussions and analyses.

Previous Investigations in the Area

Although numerous small-scale archaeological investigations have been conducted in southern Bexar County, the largest, most systematic investigations were conducted in the 2,000-acre Applewhite Reservoir area by UTSA, TAMU and SMU between 1983 and 1993. The report of the earlier work (McGraw and Hindes 1987) identified a complex range of prehistoric and historic sites that were subsequently revisited by TAMU and SMU. The comprehensive results of these later works are currently being published, though several aspects of the reports are still pending. Various study elements, however, including the description of Holocene terraces and investigations at the prehistoric Richard Beene Site are available for review and such data is directly applicable to the current project area.

1997 CEA Investigations

As briefly discussed in Chapter 1, in 1997, CEA archaeologists from TAMU discovered 41BX1239 and 41BX1240 during a waterline survey within TxDOT right-of-way (Thoms et al. 2002). Site 41BX1239, as noted, includes remains of a mammoth, which was discovered in CEA's Trench 7 (designated TAMU BHT 7 in this report) situated at the toeslopes of an upper river terrace. According to the investigators, the remains were identified in shallow pond deposits on a remnant strath terrace at the juncture of the upper Applewhite-equivalent terrace and the lower Miller-equivalent terrace (Caran 2002). Within these are the Perez and Somerset paleosols, or soils that are approximately analogous to these. The stratigraphy

of the natural deposits, analogous to better studied areas upstream, suggested the site deposits dated from approximately 15,000 to 10,500 years B.P.

Among the 1,667 fragments of mammoth bone recovered from the trench, several pieces revealed possible evidence of human modification, notably butcher marks. CEA submitted five samples to Dr. Eileen Johnson at Texas Tech University, who conducted an in depth analysis and determined that three specimens exhibited striations that were very likely caused by human butchering or processing with stone tools. Based on this evidence, CEA considered 41BX1239 to be an archaeological rather than strictly a paleontological site. CEA investigators recommended the site as eligible for listing on the NRHP and for designation as an SAL.

During the same survey, CEA recorded the nearby prehistoric site 41BX1240 as an open occupation on the San Antonio River terraces, though the nature of the archaeological deposits was poorly understood since it lay primarily beyond their survey corridor. Accordingly, no formal recommendations were made regarding its significance or eligibility at that time.

Other Investigations in the Vicinity

The two most recent, relatively large-scale archeological investigations along the Medina River were initiated by UTSA preceding the recent construction of San Antonio's Toyota truck manufacturing plant near the confluence of the Medina River and Leon Creek. A linear survey for the Medina River Sewer Outfall (MRSO) was conducted in 2008 by SWCA. This survey examined 31 miles of the northern bank of the Medina River through deep archaeological trenching and resulted in the documentation of 45 archaeological sites (Hartnett et al. 2012).

Other archaeological properties and previous investigations within one mile of the project area include the prehistoric site of 41BX124 located on private property west of the project area and multiple areal surveys (1977-1982) north and adjacent to

the rivers' confluence prior to the construction of city sewage treatment facilities. Additionally, site 41BX226, located approximately several hundred meters west of the IH 37 overpass, is a prehistoric site situated immediately south of the Medina and San Antonio River confluence. The site reportedly yielded Folsom and Clovis projectile points, which, if true, indicates the antiquity of occupation in the immediate vicinity of the sites.

BRIEF REVIEW OF MAMMOTH SITES

A records search of the Texas Historical Commission Archeological Sites Atlas (Atlas) yielded 34 sites across Texas with mammoth bones, though few have much significant information. A number of these sites are purely paleontological and many more have questionable cultural affiliation. Of the 34 recorded sites, only nine are explicitly stated to have clear association of mammoth remains with cultural materials. Further review of the assembled site forms revealed that several of the most prominent, well-reported mammoth sites in Texas were not among their number (Atlas Database).

In a critical review of 76 sites in North America with scientifically investigated and documented claims of mammoth remains in association with cultural deposits, Grayson and Meltzer (2002) conclude only 14 sites provide *strong* evidence of Clovis-aged association. For varying reasons, the vast majority lack sufficiently compelling information to support such claims. Ten of the 76 sites are located in Texas. Of the ten, only two, including Lubbock Lake and Miami, are considered to have a strong association (Grayson and Meltzer 2002:318). The other eight are problematical in terms of context and associations.

As a general note, Grayson and Meltzer's (2002) study exemplifies the high critical threshold held for claims regarding mammoth-human interaction, placing a relatively weighty burden of proof on the evidence. While, by the most stringent criteria, only two archaeological mammoth sites have been discovered in the state, the archaeological literature often cites about a dozen sites in Texas with relatively compelling evidence of human-mammoth interaction. Some of the more pertinent sites are described here, including those with reasonably strong evidence, but also a few, though poorly studied, are worth noting because of their proximity to the San Antonio River Mammoth site.

In Bexar County, the Richard Beene site, 41BX831, is a multi-component site on the Medina River situated roughly 20 km upstream from the confluence with the San Antonio River. During the initial survey of site 41BX1239, Thoms et al. (2001) utilized the well-studied pedostratigraphy of the Richard Beene site as a frame of reference for interpreting the stratigraphy in their trenches along the San Antonio River. Thoms, Johnson, Caran, and Mandel (2005) report the discovery of a mammoth bone specimen exposed at the Richard Beene site by a major flood in 2003. The bone was identified as "the mid-diaphyseal cylinder portion (ca. 20 cm long) of a proboscidean long bone, probably a *Mammuthus columbi* tibia. It exhibits helical breakage patterns at both ends of a type associated with wet bone fracture through dynamic loading…entirely consistent with bone reduction to obtain raw materials for tools." (Thoms et al. 2005).

As discussed by Grayson and Meltzer (2002), the Miami and Lubbock Lake sites are the most compelling sites in the state regarding mammoth-human interaction. The Miami site (41RB1) in Roberts County was first investigated in 1938 as only the third Clovis kill site at that time. Evans and Sellards excavated the partial remains of five mammoths, recovering three Clovis points and a non-diagnostic stone tool from the bone bed. The Lubbock Lake site is one of several large Paleoindian sites in the High Plains of New Mexico and Texas that have yielded quite a few mammoth remains associated with cultural materials. Lubbock Lake (41LU1), among the most thoroughly investigated, contained a Clovis-age megafaunal processing station with seven identified species, including one adult and two juvenile mammoth. Evidence indicates secondary butchering and bone quarrying activities (Johnson 1987, see also Bousman et al. 2004 and Grayson and Meltzer 2002).

A lesser known site is 41BX1597, situated along Culebra Creek in Bexar County. Recorded in March 2004, in the Cathedral Rock Nature Park, the site reportedly includes a mammoth tusk within a gravel bar deposit 4 m below ground surface (41BX1597 Atlas site form). A chert core and a fire-cracked rock were on an eroded surface 90 cm below the tusk. Both the tusk and the artifacts appeared to be secondarily deposited, but an unidentified bone fragment was noted in a likely primary context 3 m above the mammoth tusk.

In the South Texas Plains, T.C. Hill recorded three mammoth sites in Zavala County. Site 41ZV7 was

discovered in 1969 along Tortugas Creek in a blowout. A partially exposed mammoth tooth was found in the main blowout area and surface collecting in the area yielded Plainview and Golondrina points, which postdate the widely accepted extinction of mammoth in North America but suggest the untapped archaeological potential of the site. Site 41ZV52, likewise situated on Tortugas Creek less than 1 km from 41ZV7, also contained a single, partially exposed mammoth tooth, as well as later dart points. Site 41ZV118 lies ca. 35 km to the northwest along a branch of Chacon Creek. From the limited description on the site form, the site was uncovered during the excavation of a stock tank, which included the construction of a dam from the fill dirt. Mammoth bone, tusk, and tooth fragments were found eroding from the redeposited fill near the top of the dam, along with a large knife and "worked flint." An eroded campsite at the north end of the dam contained possible hearths, flakes, and a Plainview or Golondrina point but no mammoth bone.

Hill also recorded a mammoth site in Dimmit County, just south of Zavala County. Site 41DM75 is located on the bank of a spillway creek associated with the Boynton Reservoir of the Nueces River. Mammoth bones and teeth were found washed out of the west bank of the creek, and informal excavations found small bone fragments in the bank 10-12 feet below the surface. No cultural materials are noted on the form, suggesting this is a paleontological site.

Farther south in Texas, 41NU246 lies 55 km inland from the Gulf coast. This site, located on a bank of Petronilla Creek, was discovered and excavated in 1986 by C.R. Lewis. A 25-cm thick sandy layer, 5 m below ground surface, contained more than 10,000 bones and fragments (Lewis 1988). Extinct megafaunal remains included ground sloth, camel, horse, and mammoth—specifically an intact mammoth femur. Lewis also notes evidence of human modification and use of mammoth teeth on the site as tools, and recovery of "a few small (1 cm) flakes and a few marble-sized rounded pebbles that seem out of place in the gravel-free sediments" (Lewis 1988).

At the edge of the Edwards Plateau in the Blackland Prairie region, the Gault site (41BL323) in Bell County contains extensive Paleoindian deposits, including possible pre-Clovis materials. Mammoth and other extinct megafaunal remains were found associated with projectile points and lithic debitage (Bousman et al. 2004). A report on the Clovis lithic technology at the site, based on excavations done by TAMU, has been published recently. Mammoth remains were identified in gravel deposits underlying the Clovis component, but none were positively identified with the Clovis materials in the Texas A&M excavations (Waters et al. 2011).

In Limestone County, Navarro College students, members of various avocational groups, as well local collectors excavated the Pin Oak Creek Mammoth site intermittently from 1997 to 2004. Numerous mammoth bones, including long bones, ribs, vertebrae, feet, skull, mandible, teeth, and tusks remains were collected, along with a single Edwards chert flake. The site form indicates that the matrix was not screened, but does not say whether the flake was discovered in situ or recovered from excavation backdirt.

Though not an archaeological site, the Waco Mammoth site on the Brazos River contains some of the best-preserved mammoth remains in Texas. Site 41ML207 contains the remains of a family group of at least 15 mammoths that were likely trapped in a cul-de-sac during a flood event. The remains indicate that the herd was clustered tightly enough to have been touching each other, and a juvenile was found lying across the tusks of the herd matriarch. The site dates to between 17,000-27,000 years B.P. No cultural remains have been discovered.

In the Post Oak Savannah region, the Duewall-Newberry site (41BZ76) in Brazos County was investigated by TAMU (Steele and Carlson 1989). The remains of a young adult male *Mammuthus columbi* were found eroding from a bank of the Brazos River. No cultural materials were recovered from the site, nor was any datable materials. However, the stack-like arrangement of the bones, along with marks on the bone said to be impact fractures, provide evidence for human interaction.

Three mammoth sites have been recorded in the Rolling Plains along the Canadian River Basin, which cuts across the Texas Panhandle. The Mammoth Tooth site (41RB54), recorded in 1991, contained mammoth teeth fragments eroding out of a cut above an old stock tank, 30-40 cm below ground surface. A very small flake was found amongst the teeth, but, alas, was lost in a gust of wind. No excavations were done beyond cutting a small soil profile (41RB54 Atlas site form).

Johnson and Holliday recorded the Poverty Hill site, 41HQ1, located west of Lubbock in Hockley County.

Initially discovered by a collector as materials eroded from a dune on the south bank of a playa lake, the Paleoindian deposits at this multi-component site included scattered mammoth tusk and bone. A Clovis point and five small flakes were found among the mammoth remains, which are located in a discrete area at the western end of the site.

Johnson and Holliday were also involved in test excavations at the Sand Creek Mammoth site 41GR631 in Garza County. Mammoth remains, including long bones, vertebra, mandible, teeth, and tusk, were exposed in a blowout, along with a fragment of Potter chert. Excavations uncovered positive evidence of human association with the mammoth, including bone flakes, fractured long bone fragments, and a non-local Edwards chert chip.

The Big Spring Mammoth site in Howard County was first recorded in the 1950s. The site is a large, multiple component site located by a big spring in an otherwise arid setting. Notes from a 1965 investigation by H. Jensen of Southern Methodist University mention mammoth remains eroding out of an arroyo, with flakes in and around mammoth. This information was refined in Jensen's notes from a 1969 revisit, which note that a Clovis point was found 5 m from a mammoth mandible. Test units in the area of the mandible, which was no longer present, recovered a flake. However, Jensen notes that the deposits were probably reworked, which throws into question whether the mammoth remains are actually associated with the cultural deposits.

The Shifting Sand site (41WK21) contained an extensive collection of Folsom age artifacts made of non-local Edwards chert as well as a weathered bison bone bed. A single mammoth molar was also recovered, either as an intrusive deposit or as something collected by the Folsom hunters. Judging from the notes for two other sites in Winkler County, mammoth bones could have been readily available. At 41WK1, the Pete Wheeler No. 1 site, Folsom and Midland points were surface collected in a blowout. The presence of mammoth or mastodon bones was noted in this blowout as well as nearby blowouts. The Vast Sands site (41WK2) consists of a series of campsites across a 10-acre area of blowouts, some of which contain mammoth bones. A variety of projectile points and other stone tools were collected; however no specific types are mentioned, once again calling into question the actual affiliation of the cultural materials to the mammoth remains.

In Briscoe County, 41BI62 is a multiple component site with caliche-lined hearths and lithic material overlying a grey Pleistocene deposit. Mammoth was reported from within these deposits and a Clovis point was recovered from an unspecified portion of the site. Test excavations were undertaken in 1975 by B. R. Harrison. The report title mentions archeological and paleontological resources, which suggests that the Pleistocene faunal remains are non-cultural. No abstract for the report is available online. A survey of the Mackenzie Reservoir area in Briscoe and Swisher counties also reported a paleontological site with mammoth remains.

A final High Plains Texas Panhandle site was reported in Gaines County by landowners in 1965. The site is located in a blowout which was subjected to plowing, gas exploration, and caliche quarrying and included fire-cracked rock and unidentified bone fragments. The landowner's collection included a mammoth tooth fragment and the joint end of a possible mammoth femur, and she had also found and discarded two flint "chips" in the past. No further work appears to have been done in the subsequent 40 years.

In West Texas, the few reports of mammoth remains are all paleontological in nature. A survey in El Paso County reported a locale with fragmentary mammoth tusk and teeth and no cultural materials. A survey of the Petan Ranch in Presidio County found three separate areas of mammoth remains eroding along a half-mile stretch of Wild Horse Draw. Site 41PS429 included a mammoth femur, tusk sheath, and a portion of tusk. Site 41PS340 was a single mammoth pelvis 600 m to the south of the previous site. Another 100 m to the south, mammoth tooth fragments that could be refit into a single tooth were designated 41PS341.

As a general commentary, the background review supports Grayson and Meltzer's observation that, "it is striking how often sites asserted to provide evidence of Clovis hunting are so inadequately published that the claims for that hunting cannot be properly evaluated and thus must be rejected" (Grayson and Meltzer 2002:322). Only 25 percent of the archaeological sites found in an Atlas search for "mammoth" contained direct evidence of human cultural materials or interaction with mammoth remains. However, the level of investigation needed to conclusively assess the possibilities is often unfeasible for myriad reasons, funding being perhaps the most prominent. Among the unsubstantiated claims, there are quite a few inferences

and extrapolations between a mammoth tooth or bone fragment and some cultural material in the vicinity.

METHODS

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INTRODUCTION

The cultural resources investigations were designed to identify and, to the extent possible, recover sufficient information to evaluate the NRHP/SAL eligibility of the cultural sites within the APE. SWCA's initial phase of investigations included background research and field investigations. The methods and level of effort used in these investigations were developed in accordance with standard archaeological procedures, state requirements and protocol specified by the Texas State Historic Preservation Office (SHPO), and in consultation with TxDOT. This chapter details the methods used in each phase of investigation.

BACKGROUND RESEARCH

Background research was conducted to fulfill two primary objectives: 1) to identify previous investigations and recorded sites in the vicinity of the project area, and 2) to gather information on the local and regional historic context to aid in defining research issues and a framework for evaluating significance. Information obtained in the effort formed a basis for the discovery and interpretation of cultural resources within the project area.

In May of 2007, prior to conducting field investigations, SWCA conducted a thorough background archaeological literature and records search of the project area. For this research, an SWCA archaeologist searched site files, records, and maps files housed at the Texas Archaeological Research Laboratory (TARL) and the THC Library. Additionally, an SWCA archaeologist searched the Texas Archeological Sites Atlas (Atlas) online database for any previously recorded surveys and historic or prehistoric archeological sites located in or near the project area. In addition to identifying previously recorded archeological sites, the Atlas review included the following types of information: NRHP properties, SALs, Official Texas Historical Markers (OTHMs), Registered Texas Historic Landmarks (RTHLs), cemeteries, and local neighborhood surveys.

FIELD INVESTIGATIONS

Upon completion of the background review, SWCA conducted field investigations in three stages: (1) an intensive survey of the APE including shovel testing and mechanical trenching; (2) a geoarchaeological and stratigraphic study of deposits, and; (3) archaeological testing of previously recorded sites in the APE.

INTENSIVE SURVEY

SWCA conducted an intensive linear archaeological field survey of the proposed APE. The field survey consisted of two to three SWCA archaeologists walking the breadth of the proposed improvement project area, conducting subsurface investigations where warranted. The survey was of sufficient intensity to determine the nature, extent, and, if possible, potential significance of any cultural resources located within the proposed project area. During the survey, the archaeologist examined the ground surface and erosional profiles for cultural resources.

The proposed bridge rehabilitation project is roughly a 3,250-foot long and 600-foot wide project corridor covering approximately 44.75 acres. The THC's survey standards for a project of this size require roughly 14–16 backhoe trenches and/or 22–23 shovel tests in areas with a potential for buried deposits. However, an estimated 70 percent of the total APE is existing roadway, substantial fill section, water and gas pipelines, bedrock, or other aspects that preclude the possibility of subsurface archaeological materials. Accordingly, only relatively small portions of the overall project area warranted shovel testing or backhoe trenching.

Determination of methods of subsurface excavation was keyed to the level of disturbance of the proposed project and the nature of the soils, geology, and topography. All subsurface explorations were to a depth commensurate with the proposed level of subsurface impacts for the project and the depth of potentially culture-bearing sediments.

Shovel Testing

Shovel testing was primarily used on the southern extremes of the project area where shallow soils overlie limestone bedrock. Shovel tests were excavated in 20-cm arbitrary levels to culturally sterile deposits or bedrock. The matrix was screened through ¼-inch mesh. The location of each shovel test was plotted using a GPS receiver and each test was recorded on appropriate project field forms. Areas with previously recorded sites or other cultural resources revealed in the archival research required additional shovel testing to explore the nature of the cultural deposits. THC survey standards call for 16 shovel tests per mile of project area unless it can be demonstrated that due to disturbances or setting, fewer shovel tests are sufficient to adequately assess the potential for buried cultural resources to be present. In the instance where shovel testing could not adequately explore project impacts in soils with potential to contain buried archaeological materials, then backhoe trench investigation was used.

Backhoe Trenching

Portions of the project encompass topographic settings that have the potential for deeply buried archaeological sites, including portions of 41BX1239. The primary method for quickly and efficiently exploring these areas was backhoe trenching. In these areas, trenches were placed approximately 100 m apart, with tighter intervals along the remnant terrace and in other areas as necessary. Trench placement was both parallel and perpendicular to the IH 37 roadway. The trenches were positioned based on the level of disturbance, the location of buried utilities, the location of any impacted areas (e.g., bridge pilings or road construction), and the preservation potential for archaeological sites as determined by the Principal Investigator.

Backhoe trenches were excavated to a depth sufficient to determine the presence/absence of buried cultural materials and allow the complete recording of all features and geomorphic information to depths of project impacts. Generally, trenches were 2 m deep, 8 m in length, and 1.5 m wide. All trenching was monitored by an experienced archaeologist while excavations were underway. Subsequent to each trench excavation, the area was examined by an archaeologist for cultural materials, anomalies, and geomorphic data. Stratigraphic profile drawings with soils descriptions were recorded for each trench. All features encountered during trenching were mapped and photographed.

A column of soil was excavated and screened down one side of select trenches. Typically, the columns were roughly 30-x-30-cm in size, extended from the ground surface to the base of the trench (Figure 4.1). However, occasionally the columns were truncated to avoid disturbed soils when encountered. Soil from the column was removed in 20 cm levels and screened through ¼-inch hardware screen mesh. SWCA implemented a two-phased approach to artifact collection during the survey. Artifacts recovered from shovel tests and column samples were documented in the field and returned to their original provenience: only diagnostic artifacts were recovered. Diagnostic artifacts from backhoe trenches within site areas were collected.

All work was performed in accordance with Occupational Safety and Health Administration (OSHA) safety regulations (29 CFR Part 1926). In trenches greater than 4 feet in depth, no personnel entered the trench. To assess the potential for buried deposits up to 8 feet below surface, backdirt from the backhoe bucket were sifted and selectively screened to assess presence or absence of cultural materials. The entire process was thoroughly documented and photographed. All trenches were backfilled and leveled upon completion of excavation and returned, as much as possible, to its original state.

Figure 4.1.   Hand excavated column sample along backhoe trench.

ARCHAEOLOGICAL TESTING WITH GEOARCHAEOLOGICAL ASSESSMENT

SWCA conducted test excavations on the two previously recorded archaeological sites 41BX1239 and 41BX1240. The objectives of the testing programs were different for each of the sites. Site 41BX1239 was initially interpreted to contain mammoth remains with evidence of butchering, and was determined potentially eligible for NRHP/SAL listing. Consequently, the objectives for 41BX1239 were primarily to gather data on the status of the remains (it has been 10 years since their discovery), substantiate the site's archaeological (cultural) nature, and define the depositional context and spatial extent, which would inform the development of systematic data recovery, if needed. The objectives for testing of 41BX1240, on the other hand, were to make a determination on its eligibility for NRHP/SAL listing as the previous investigations lacked sufficient data to make such a determination.

TESTING OF SITE 41BX1239

GEOARCHAEOLOGICAL ASSESSMENT

To assess the stratigraphic context of the 41BX1239 site area and beyond, Dr. Britt Bousman of Texas State University served as project geoarchaeologist, providing expertise in Paleoindian environmental settings. Initially, an assessment of the limits of the depositional units that comprise the site-bearing terraces within the APE was undertaken. SWCA and the geoarchaeologist relocated and reopened TAMU's Backhoe Trench (TAMU BHT) 7, which cut through the mammoth bone bed. Additional trenches were excavated as deemed necessary. The assessment also relied upon various available exposures, such as cutbanks.

ARCHAEOLOGICAL TESTING

Upon completion of the intensive survey and geoarchaeological analysis, SWCA began the investigations of prehistoric site 41BX1239. Previous exploration of the site was limited to a 6 m wide corridor in the eastern portion of the IH 37 ROW. Based on the results of the intensive survey and in consultation with the geoarchaeologist, a controlled grid of 1 m increments was laid out across the area where the late Pleistocene terrace deposits were encountered. A series of 1 m² sondage units were excavated at a regular interval to delineate the extent

of the mammoth remains and assess the archaeological nature of the deposits. Overburden sediment was expediently removed and was selectively assessed for cultural materials. Those soils not collected for further analyses in the mammoth-bearing deposits were fine-screened through nested $\frac{1}{8}$- and $\frac{1}{16}$-inch hardware mesh and any encountered non-faunal cultural materials were collected (Figure 4.2). All mammoth remains were exposed to the extent necessary to make a clear identification and, when feasible, left in place in anticipation of further systematic recovery. Remains that might be destroyed by exposure were collected.

Layout of the Excavations

Prior to starting the test excavations at 41BX1239, a formal grid was established (Figure 4.3). Grid north correlated with the orientation of IH 37 and TAMU BHT 7, which is 30˚. The East 1000 baseline ran north-south along this margin. The primary site datum (Datum A), a 24-inch long, half-inch diameter piece of rebar was established at the North (N) 1000 East (E) 1000 grid point. This datum was placed adjacent to and about 1.5 m east of TAMU BHT 7. A 100-m tape was pulled along the E1000 line and secondary datums, as well as rebar, were set every 10 m (at N1010 E1000, N1020 E1000). Excavation units were established initially along the E1000 line, then subsequently on the E999 line. Each 1-x-1 m excavation was designated by the coordinate of the southwestern corner. Units on the western side of the BHT were established on the same grid system.

Vertical control across the site investigations was maintained relative to Datum A, a poured concrete

Figure 4.2. Nested screens with mesh sizes ranging from 1/4 to 1/16-inch.
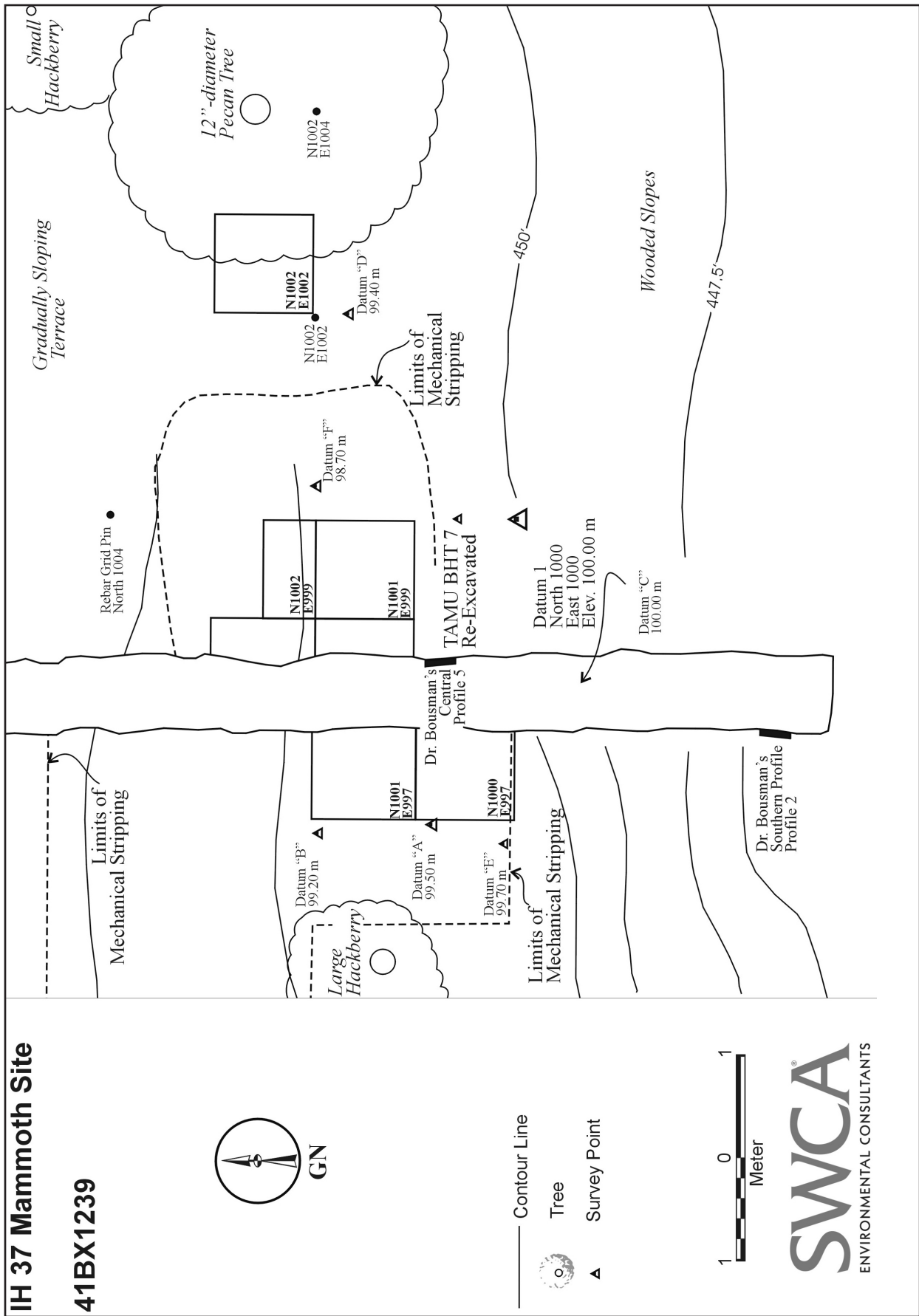
Figure 4.3. Excavation map of site 41BX1239.

casing around a piece of rebar located at approximately N1000 E1000 (Figure 4.4). The datum was assigned an arbitrary elevation of 100.00 m, which correlates with an absolute elevation of about 1832 feet above mean sea level.

Elevation was correlated to Datum A using a Sokkia Laser Level. Vertical information for excavations and recovered bone were taken from various string line datums that were placed adjacent to relevant excavation units. Each string line datum was designated as Datum and given a letter (e.g., Datum B), which correlated to the order in which it was established after the primary datum. Specifically, Datum C was established after Datum B, which was created after Datum A. Again, the elevation of all string line datums were correlated to the primary site datum (Datum A) using the Sokkia Laser Level. Similarly, the recorded stratigraphy of all excavated backhoe trenches were linked to Datum A using the Sokkia Laser Level.

The hand excavations were laid out to systematically investigate and recover the mammoth remains. A total of 5.5 m² units were placed around TAMU BHT 7 and excavated during testing investigations.

Site Mapping

The locations of all excavations and features at 41BX1239 and 41BX1240 were carefully mapped using a survey grade GPS and/or transit during the testing project. All provenience was maintained relative to the formal site grid established for 41BX1239. As a primary consideration, the spatial documentation was designed so that future investigators can precisely

Figure 4.4.   Datum A – a brass cap set in concrete at N1000 E1000 on the eastern side of TAMU BHT 7.

relocate all aspects of the site and its investigations. This was accomplished by the overlap of several different mapping methods that tie into arbitrary (datums), physical (landscape features), and absolute data (UTM coordinates). The excavations and site boundaries were related to existing highway right-of-way, modern construction features, the existing topography, and natural features including the San Antonio River.

Special Samples

In conjunction with the excavations, special samples were systematically collected from appropriate contexts across 41BX1239. Special samples included materials for radiocarbon dating (from features, geomorphic units, and other appropriate contexts, with AMS dating to be used when necessary), matrix samples for flotation and/or fine screening (from features), sediments for soil chemistry and texture analysis, and pollen/phytolith/diatom samples (from features and systematic retrieval from site and controls) to aid in landscape reconstruction. Special samples were assigned *special sample numbers (SS #)* to correspond with plan views and maps from the field. These types of samples are often critical in determining a site's significance and are a common component in site testing.

Faunal Collection

In order to facilitate tracking and reference of the specimens throughout fieldwork and eventually laboratory processing and curation, a numbering system was used to identify each specimen excavated from site 41BX1239. Mammoth remains were first assigned *bag numbers (Bag #)* for the field specimen inventory system during excavation. These bag numbers served as temporary lot numbers. Since the system of lot numbering differs amongst curation facilities—and the destination of the mammoth remains was not yet determined—lot numbers were not assigned to the mammoth bones during excavation or initial laboratory processing. Then the identifiable individual mammoth bone specimens or bone clusters were assigned *bone numbers (Bone #)* and correspond with plan views and maps from the field.

Once the mammoth remains were documented in situ with photographs and plan view sketches, each bone cluster was carefully moved from the excavated bone bed to a bin partially filled with clean, all-purpose

sand (Figure 4.5). Each specimen was then labeled accordingly with assigned numbers, point provenience information, and north arrow indicating original north/south orientation. *Bin numbers (Bin #)* were arbitrarily assigned to the bins in which mammoth bones were placed. These numbers are solely for the purpose of keeping track of the bins during laboratory processing. Placing the mammoth remains in these bins allowed for stabilization during transportation to the SWCA laboratory in Austin, Texas. Mammoth remains recovered in the screen during the excavation of site 41BX1239 were collected and bagged with provenience information. These specimens were assigned bag numbers, but not bone numbers, and transported to the SWCA laboratory to be curated as part of the site 41BX1239 collection.

TESTING OF 41BX1240

SWCA also conducted NRHP significance testing at 41BX1240. Systematic backhoe trenching (n=2) was conducted across the site, though the areas for trench placement were rather limited. SWCA initially proposed to excavate two or more 1 m² test units in areas believed most likely to contain significant, undisturbed subsurface deposits. The investigations of the site determined that an overwhelming majority of the site was surficial with no evident buried cultural horizons. Before the excavation of two or more 1 m² test units was undertaken, a 50-x-50-cm column sample was placed in one of the site trenches. The column sample was excavated in arbitrary 10 cm levels to determine the presence of subsurface cultural materials and to determine if investigation with 1 m² test units was justified. Artifacts and faunal remains were collected, bagged, and labeled accordingly with bag numbers and provenience information.

LABORATORY PROCESSING AND INVESTIGATIONS

STABILIZATION AND PRESERVATION OF MAMMOTH REMAINS FROM 41BX1239

The investigations on 41BX1239 recovered a sample of mammoth faunal remains that warranted meticulous preservation methods to stabilize the remains until a detailed scientific study could be undertaken. Until full analysis and reporting could be conducted, interim preservation methods were warranted to preserve the remains.

The principal goal of the laboratory processing and preparation of mammoth remains from site 41BX1239 was long-term preservation of the specimen for potential future analysis by a third party. This project began with a background research by SWCA archaeologists shortly after their excavation in June 2007. SWCA archaeologist Laura I. Acuña consulted archaeologists and paleontologists familiar with handling mammoth bone. Robert H. Rainey, Chief Preparator of the Vertebrate Paleontology Laboratory at the University of Texas at Austin, first examined two bins of large in situ specimens and one tray of small bagged bone pieces. For optimal long-term conservation, he suggested sealing the bone with StarBond cyanoacrylate EM02 and spraying the coated bone with PaleoBond Activator 304 aerosol. However, this intense level of processing is irreversible and could potentially limit future investigations.

Jess Debusk, paleontologist for the SWCA office in Pasadena, California, advised consolidating all bone in a VINAC B-15 and acetone solution to provide short-term, reversible support while awaiting more intensive laboratory procedure. Regardless, the mammoth bones continued to deteriorate. In August 2007, Acuña contacted Ellie Caston, director of the Mayborn Museum at Baylor University, and Olga Potapova, paleontologist for the Hot Springs Mammoth Site Project in South Dakota. Caston and Potapova agreed that immediate action should be taken and recommended their preferred methods of reversing polymer consolidation of bone in order to continue with further processing. In addition, Dr. C. Wayne Smith, director of the Archaeological Preservation Research Laboratory at TAMU, advised using Paraloid B-72 beads suspended in acetone to better consolidate the bones.

In January 2008, SWCA archaeologist Laura I. Acuña contacted Ernie L. Lundelius, Jr., Director Emeritus of the Vertebrate Paleontology Laboratory at The University of Texas at Austin Department of Geological Sciences, in preparation for a proposed stabilization project. Dr. Lundelius recommended the mammoth remains be preserved with a polymer hardening agent and set in a plaster cast for long-term stability.

Additional materials addressing the handling and long-term preservation of vertebrate paleontological remains were reviewed and a preliminary laboratory procedure was developed. At this point, SWCA archaeologists

Figure 4.5. Photos showing overview of excavations in bone bed. Top: Excavations in progress (facing south). Right: Recovering bone (facing southwest). Bottom: Overview of excavations (facing east).

consulted Cinda Timperley, staff paleontologist for the Gault Project at the Texas Archeological Research Laboratory (TARL), University of Texas at Austin. Timperley examined the mammoth bones from site 41BX1239 and confirmed the methodology in SWCA's proposed procedure to be suitable for the circumstances of this project. Timperley returned the following week to provide additional instruction and advice to SWCA archaeologists concerning proper handling of paleontological remains and logistical issues with specific bins.

Methodology

As mentioned, the primary objective of the mammoth bone stabilization project was long-term preservation of the specimen for potential analysis by a third party in the future. This is reflected in SWCA's proposed laboratory processing procedure, which included continual written and photographic documentation of each bin or bone specimen throughout the process. In addition, original north/south orientation (as recorded by SWCA archaeologists who excavated site 41BX1239 in 2007) was maintained from the initial stages of repair until the specimen was fully processed. Specimens smaller than 20 cm and lacking associated clusters of bone fragments were curated in artifact bags. Larger specimens and clusters of smaller bone fragments were set in plaster jackets. Complete provenience information written on each bag tag and plaster jacket, combined with plan views (Appendix B) and photographs taken of the mammoth while in situ, ensure adequate contextual documentation in the event archaeologists outside of SWCA conduct further analysis.

Bagged mammoth remains recovered from screening during the excavation of site 41BX1239 did not warrant further repair or consolidation and were left in their previously processed state. Along with the remains excavated in situ, these specimens were consolidated with a VINAC B-15 solution and examined under magnification for evidence of anthropogenic alteration. This preliminary examination did not reveal cut-marks or notching, however a more intense analysis is needed to establish the archaeological nature of these bones.

Laboratory processing of each specimen consisted of repair, consolidation, protection, and encasement in a plastic bag or plaster jacket. These procedures were prefaced with a photograph of the entire bin in its original condition with the north arrow visible. A bone preparation form was initiated for recording of procedures in addition to the archaeologists' daily lab journals. Care was taken throughout all stages of processing and preparation to avoid damaging the bone cortex, which is a key subject of analysis when looking for evidence of anthropogenic alteration.

The first stage of processing began with identification of fragmented bone pieces that could feasibly be repaired. Matching joints were marked with red pencil then bonded with an adhesive. The adhesive used in most repairs was a mixture of 50 percent paraloid B-72 acrylic copolymer pellets and 50 percent acetone. Adhesive strength should not exceed strength of the bone or further loss of structural integrity is risked. When necessary, the mixture was diluted with up to 25 percent more acetone. The bonded fracture was held for a few minutes then braced with sandbag supports until the adhesive dried completely. Bone pieces were returned to their bins in original in situ position and photographed.

Consolidation of an entire specimen is necessary in order to prevent further degeneration of cancellous tissue. Mammoth bones from site 41BX1239 were previously consolidated during earlier efforts to examine and preserve the specimen. However, the bone continued to dry and shrink while openly exposed, in most cases necessitating further consolidation. Initial consolidation of bones used VINAC B-15 beads in acetone, both thick ($\frac{1}{4}$ beads and $\frac{3}{4}$ acetone) and thin ($\frac{1}{8}$ beads and $\frac{7}{8}$ acetone) mixtures. Paraloid B-72 is considered by vertebrate paleontologists to absorb and solidify better than other hardening agents (Leiggi and May 1994). A 25 percent B-72 and 75 percent acetone mixture was applied to specimens in layers with a bottle or brush until the bone retained a consistently dark shade. Specimens were allowed to dry and harden completely, until the odor of acetone was no longer detectable. Each bin was then photographed in its repaired and consolidated condition before further processing took place. Smaller specimens were bagged with a provenience information tag; larger specimens continued preparation with a plaster jacket.

Each specimen was protected with padding and support prior to the application of a plaster jacket to ensure no damage was incurred during mobilization and long-term storage. First damp tissue paper and sand was used to fill undercuts and crevices beneath and between the bone pieces. Tissue paper was moistened with regular tap water and packed tightly into voids as a supportive

separator. Sand was generally used around heavily fragmented specimens, often in combination with an aluminum foil wall to retain bone and sand together. After crevices were filled, damp tissue paper was applied in layers over the entire specimen until all bone surfaces were padded at least a half inch. Once covered in tissue paper, the specimen was sprayed with water until saturated. The added moisture will help prevent further drying of the organic remains. Provenience tags were encased in a plastic bag, wrapped in a foil pocket, and placed on top of the specimen. The entire bin was then covered in plastic wrap separator to protect the bone from wet plaster, with a surplus left around the edges. Each bin was then photographed in its current condition prior to applying a plaster jacket.

The final stage of preparation was to encase each specimen in a plaster jacket, which will provide a stable environment during long-term storage. To prepare for the casting process, a roll of burlap material was cut into 2-foot by 5-inch strips. Several strips were cut in half and reduced to 1-foot by 5-inch strips for smaller specimens. First, wet plaster was created from a mix of 0.95 L of water and 1.56 L of plaster of Paris powder. The mixture was allowed to soak for 1 minute then slowly stirred until well blended. Next, burlap strips were individually dipped in wet plaster and wrung of excess mixture. Each burlap strip was applied across the specimen in a woven pattern, leaving a surplus edge for support. This process continued until the specimen was entirely covered with several layers of plaster-soaked burlap strips. Leftover wet plaster mix was smoothed over the burlap-encased specimen, patching thin areas as needed. The entire bin was photographed in its cast condition and allowed to dry at least two nights until the plaster completely hardened and cooled.

Before the plaster cast was flipped, provenience information was written on the top with black permanent ink marker, including the following information: Top, North Arrow, Site No., Project No., Bin No., Bag No., Bone No., Point Provenience North, Point Provenience East, Point Provenience Elevation, and Point Provenience Depth. The entire bin was then photographed to document provenience labeling. The plaster cast was flipped in order to process and stabilize the bottom of the specimen. A sandbox filled with clean, all-purpose sand was placed in the workspace in order to accommodate this procedure. Using the assistance of several lab technicians, the bin was flipped quickly to avoid spilling bone fragments located near the bottom of the bin. Any bone fragments that were damaged or moved in the process were photographed and noted in the bone preparation forms.

Exposed bone at the bottom of the specimen was covered with sand and sprayed until damp. This should protect the bone once it is returned to its original upright position. Plastic wrap and foil were applied over the sand as additional separators. Following the same methodology described in the previous paragraphs, a plaster cast was applied to the bottom half of the specimen. The plaster-soaked burlap strips were arranged in a woven pattern and formed a sealed lip over the edge of the existing plaster cast. The jacket was allowed to dry and harden for at least two nights, after which was returned to its original upright position. Provenience labeling on many casts became partially obscured by plaster and required touching up with a black marker. The complete plaster jacket was then photographed and ready for storage.

PREPARATION, CONSOLIDATION, AND FAUNAL ANALYSES OF MAMMOTH REMAINS FROM 41BX1239

SWCA conducted a detailed analysis on ten of the twenty major elements or clusters of bone recovered from the site. The remaining, unanalyzed specimens or clusters, are curated in plaster jackets for future analyses. Of the ten chosen for analysis, Olga Potopova and Larry Agenbroad of the Mammoth Site (MS) National Monument were subcontracted to conduct analyses on three jackets (or bins) of clusters of bone to assist in faunal study but also curatorial preparation. In accordance with their findings and recommendations, SWCA specialists conducted the work on the remaining elements proposed for the study. After the ten main elements or clusters were re-exposed and cleaned, detailed faunal analyses were conducted on each.

For the preparation, consolidation, and faunal analyses conducted by the MS National Monument, three jackets (or bins) were mutually selected based on the preliminary field bone identifications and the bones' significance for taxonomic identifications. The selected jackets (or bins) were packaged and shipped to North Dakota. The three jackets (or bins) included Bin 8 (consisting of Bones B-37 and B-38), Bin 11 (consisting of Bones B-29E and B-29W), and Bin 16 (consisting of Bone B-30). Upon completion

of the task, MS produced two reports: one regarding the step-by-step preparation of the mammoth bones (Appendix A) and one pertaining to the faunal analyses, including the identification of mammoth bones now in Chapter 6 of this report. SWCA specialists proceeded with work on the remaining elements proposed for the study, emulating the methodology reported by MS. The remaining jackets (or bins) prepared, consolidated, and analyzed by SWCA included Bin 6 (consisting of Bone B-23), Bin 12 (consisting of Bone B-26), Bin 13 (consisting of Bones B-12 and B-22), Bin 14 (consisting of Bones B-24A and B-24B), and Bin 15 (consisting of Bone B-36).

METHODOLOGY

Laboratory processing of each jacket (or bin) consisted of five steps: 1) jacket removal; 2) cleaning, preparation, consolidation, and piecing together; 3) inventory and labeling; 4) documentation and analyses; and 5) final curatorial preparation. Throughout the procedure, the analysts documented the process with written and photographic documentation. The intent in such documentation is, in part, to note the specific conditions of each element and the variation in techniques required to address different elements and preservation conditions. A bone preparation record was compiled for the procedures for each bone number (Appendix B). Caution was taken to avoid damaging the bone throughout all steps involved in laboratory processing.

Supplies used during laboratory processing of the bone specimens from site 41BX1239 included:

Drimmel cutting drill

Vented wash bottles

Acetone

Trays

Cheesecloth (strips or patches)

Bubble wrap

Saran wrap

Brushes

Small dustpan

Soft toothbrushes

Wooden sticks

Butvar 76/acetone adhesive

Gloves

Respirators

Camera and scale

Magnifying glass (lighted)

In preparing the specimens from 41BX1239, Acryloid B-72 was used. The consolidant was applied using vented wash bottles. The following solutions of the consolidant were used:

Solution 1: 2 oz B-72/0.5 gal acetone

Solution 2: 4 oz B-72/0.5 gal acetone

Solution 3: 6 oz B-72/0.5 gal acetone

Solution 4: 8 oz B-72/0.5 gal acetone

Solution 5: 16 oz B-72/0.5 gal acetone

The majority of laboratory processing activities (except cutting plaster jackets) took place in laboratory conditions. When inside the laboratory or building, respirators and/or fans to keep air circulated were used. Gloves were worn while applying acetone or solutions to the bone with fingers.

The five-step process was conducted with these supplies, briefly described here to relate the basic steps, deferring to Appendix B for a more detailed account of the process.

STEP 1. JACKET REMOVAL

Each jacket was cut along the horizontal edge, maintaining the orientation of the jacket with the top (labeled side) up. The main implement used for cutting was a Drimmel tool, which is a handheld device with a rotary blade (Figure 4.6). Once the jacket was cut along the edge into two halves, the top half of the jacket was carefully lifted from the bottom half and flipped over. Results varied among the jackets. In most cases, most of the bone remained in the bottom half of the jacket (Figure 4.7). However, there were jackets in which the majority of the bone remained in the bottom half with some of the bone stuck to the top half within the paper towels/tissue that were used during the previous stabilization and preservation plastering process.

Once the jackets were opened, removing the bone was a meticulous process given the poor preservation conditions of some elements. The analyst used acetone in vented wash bottles to remove bone stuck to the paper towel/tissue in the jacket halves. The paper

Figure 4.6. Bin 15 (Bone B-36) jacket removal utilizing a Drimmel tool for cutting along the edge.

or clusters held together by sediment, to a tray lined with bubble wrap (smooth side up).

In order to remove bone from the bottom half of the jacket with sand, brushes and a small dustpan were used to scoop up the sand and it was placed on a tray. The tray was then sorted through with a magnifying lamp to remove the bone. The bone was then placed on another tray lined with clean cheesecloth.

Step 2. Bone Cleaning, Preparation, Consolidation, and Piecing Together

Cheesecloth rags soaked with acetone or direct acetone were used in cleaning the bone surfaces of adhering sediments, sand and soil stains. In some cases, acetone-soaked rags were applied to the bone for 5, 10, or 15 minutes, depending on each bone's size, structure and condition. The acetone-soaked rags were also covered by plastic wrap to slow the evaporation rate. In other instances, fragments were cleaned without soaking in acetone by rubbing their surfaces with an acetone-soaked rag (Figure 4.8). Additionally, brushes, soft toothbrushes (dry and acetone-soaked), and wooden sticks were used for hardened sediment and sand removal. A magnifying lamp and lighted magnifying glass were used for close examination of bone surfaces in order to avoid possible scratches. Once the surface of the bone was cleaned, it was immediately consolidated with the appropriate solution for the condition of the bone (Figure 4.9). The structure of the overall specimen was maintained and fragments that fit together were tracked.

Different concentrations of B-72 were necessary for preparation due to the different conditions of the bone

towel/tissue surrounding the bone was moistened with acetone for a few minutes along the bone edges, allowing for quick evaporation. Using water (slow evaporation) instead would have jeopardized the integrity of the bones. Once the bone fragments became loose from the paper towel/tissue, the fragments were carefully removed with fingers.

Upon removal, each individual bone fragment was checked for dryness and if dry, was immediately consolidated with the appropriate consolidant solution. The bone fragments had to be completely dry of acetone before consolidation. Each bone fragment removed was tracked. Once removed, bone fragments were transferred to a tray lined with clean cheesecloth or, for larger pieces, such as complete bone elements

Figure 4.7. Bin 15 (Bone B-36) bottom half of jacket cut open.

Figure 4.8. Bin 12 (Bone B-26) cleaning with acetone soaked rag.

Figure 4.9.   Bin 15 (Bone B-36) end product of cleaning, preparation and consolidation.

fragments. For example, bones with a lot of cortical matrix were consolidated with the thinnest solution (Solution 1: 2 oz B-72/0.5 gal acetone), allowing deep penetration and bones with a lot of cancellous structure were consolidated with the thickest solution (Solution 5: 16 oz B-72/0.5 gal acetone).

Fragments were glued together using Butvar 76/acetone mixed in an approximately 50:50 ratio. In addition, the adhesive was applied in the cracks after fragments were glued together to reinforce the bond. Sand bins and sand bags were used to hold the bones in the correct alignment while the adhesive dried.

STEP 3. INVENTORY AND LABELING

The total number of bone fragments for each bone number was tracked. Fragments or groupings of fragments were tracked as A, B, C, etc. For example, Bone B-23 consists of fragments or grouping of fragments A, B, C, D and E. Each fragment or grouping of fragments consists of one unbroken specimen and a cluster of bone or residual fragments that have been pieced or grouped together. The results were summarized in a table.

Distinction of fragments via photos and labeling for recording purposes was maintained. Bone specimens were tagged and labeled with the assigned lot number and tracked fragment or grouping of fragments' letter designation. Clear or white liquid label was used for the labeling.

STEP 4. DOCUMENTATION AND ANALYSES

Preparation of each bin was photo documented. In addition, photographs of the final cleaned, prepared, and consolidated specimens were taken from different angles with the appropriate scales included.

Bones were carefully examined with magnifying glasses to determine if any cut marks or scratches were visible. Specimens that showed evidence of possible cut marks were flagged and reviewed further. Detailed photographs of each identified possible cut mark were taken. The results were summarized in a table.

STEP 5. FINAL CURATORIAL PREPARATION

Once the analysis and review was complete and no additional photographs were required, specimens were prepared for final curation. Specimens returned from MS were given supporting (bedding) half-jackets. Specimens processed by SWCA were boxed with curatorial quality foam as the supporting bedding. As noted, the ten elements not selected for analysis will be curated in the current plaster jackets for possible future analysis.

FLOTATION/FINE SCREENING SEDIMENT SAMPLES FROM 41BX1239

To recover fine fraction artifacts and ecofacts from matrix surrounding the bone, flotation fine screening was conducted on 27 bags of sediment associated with the bone bed from the excavations at 41BX1239. The resulting heavy fraction of each bag was sorted to identify macroartifacts (artifacts retained in 0.25 inch/6.35 millimeter (mm) mesh sieves) and microartifacts (artifacts less than 0.25 inches/6.35 mm). The flotation fine screen mesh (2.0 mm mesh) recovered artifacts between 2.0 mm and 6.35 mm/0.25 inches in size. All possible artifacts, including small siliceous fragments were recovered, inventoried, photographed, and analyzed.

ANALYSIS OF 41BX1240 RECOVERED MATERIALS

SWCA analyzed the three artifacts and ten faunal elements recovered from 41BX1240. The recovered materials were washed, sorted and tabulated into basic artifact categories (lithic, faunal, historic, etc.), and salient aspects of each were quantified.

CHAPTER 5

RESULTS OF FIELD INVESTIGATIONS

Stephen M. Carpenter, Ken Lawrence, and Leland Bement

In 2007, SWCA conducted archaeological testing of two sites along the San Antonio River: the San Antonio River Mammoth site on the southern terraces, and 41BX1240 on the opposite, northern high terrace. Additional intensive surveys were conducted in areas beyond these two sites. The basic objectives on the San Antonio River Mammoth site were three-fold: 1) to relocate and delineate the site deposits relative to the project area to ensure avoidance; 2) to conduct geoarchaeological investigations to determine the depositional context and chrono-stratigraphy if possible, and 3) to gather a sample of the site deposits and mammoth remains in an effort to further assess the archaeological nature of the site. For 41BX1240, the objectives were to determine the eligibility of the site under SAL and NRHP criteria. This chapter provides an overview of the survey followed by the results of the testing investigations on the two sites.

PEDESTRIAN SURVEY RESULTS

On May 21, 23–24, 2007, and June 15 and 20, 2007, SWCA archaeologists conducted an intensive pedestrian survey with subsurface investigations within the project area. The pedestrian survey of the 3,250-foot long and 600-foot wide project corridor generally revealed modern development fill sections, and disturbed soils on the uplands and some deep alluvial soils in the lowland portion of the project corridor.

The proposed bridge rehabilitation project is divided by the San Antonio River into northern and southern sections, each of which is discussed separately for organizational purposes. The roughly 950-foot long portion north of the San Antonio River is almost exclusively uplands. The 2,300-foot long portion south of the river consists of roughly 1,270 feet of uplands and 1,030 feet of alluvial terraces. Due to the varied settings of the project APE, each respective area was investigated differently.

SURVEY ON NORTHERN SIDE OF SAN ANTONIO RIVER

The portion of the project area north of the San Antonio River was examined with pedestrian survey and backhoe trench excavations. Shovel tests were deemed unnecessary in this area due to either deep sediments that were better addressed through backhoe trenches or disturbances that precluded the potential for buried deposits. Excluding the trenches placed in site 41BX1240, five backhoe trenches were used for the general survey of non-site areas on the northern side of the San Antonio River. These are distinguished from the southern survey trenches by an "N" to designate north. Accordingly, the trenches were labeled BHTs 1N through 3N, BHT 5N, and BHT 7N. Three of the backhoe trenches (BHT 1N through 3N) were used to assess the western side of the APE, while two (BHT 5N and BHT 7N) were excavated on the eastern side north of 41BX1240 (Figure 5.1). The depth of these five trenches ranged from 90 to 300 cmbs (Table 5.1). As the investigations approached the northern limits of the project area, the trenches encountered a yellowish, grayish brown to light gray (10YR5/2 to 10YR7/1) clay horizon at increasingly shallower depths. The trenches encountered disturbed soils (e.g., road construction), a horizon with calcium carbonate nodules, or bedrock.

Three of the five trenches (BHT 1N, BHT 2N, and BHT 5N) were column-sampled to determine the presence of cultural materials. Cultural materials were encountered in each of these sampled trenches.

In the eastern wall of BHT 1N, a small clear glass bottle was recovered at 148 cmbs. This artifact has a shape similar to that identified as a shoe polish bottle, but is slightly shorter and may be for medicinal purposes (IMACS 1992:23). The artifact has a wide bead finish and a round profile. The glass bottle is 1.75 inches tall with a 1-inch diameter bore. The side seams extend up the sides and through the finish indicating a fully automatic construction (IMACS 1992). The Owens-Illinois makers' mark on the artifact base indicates that it was manufactured in Gas City, Indiana in 1939
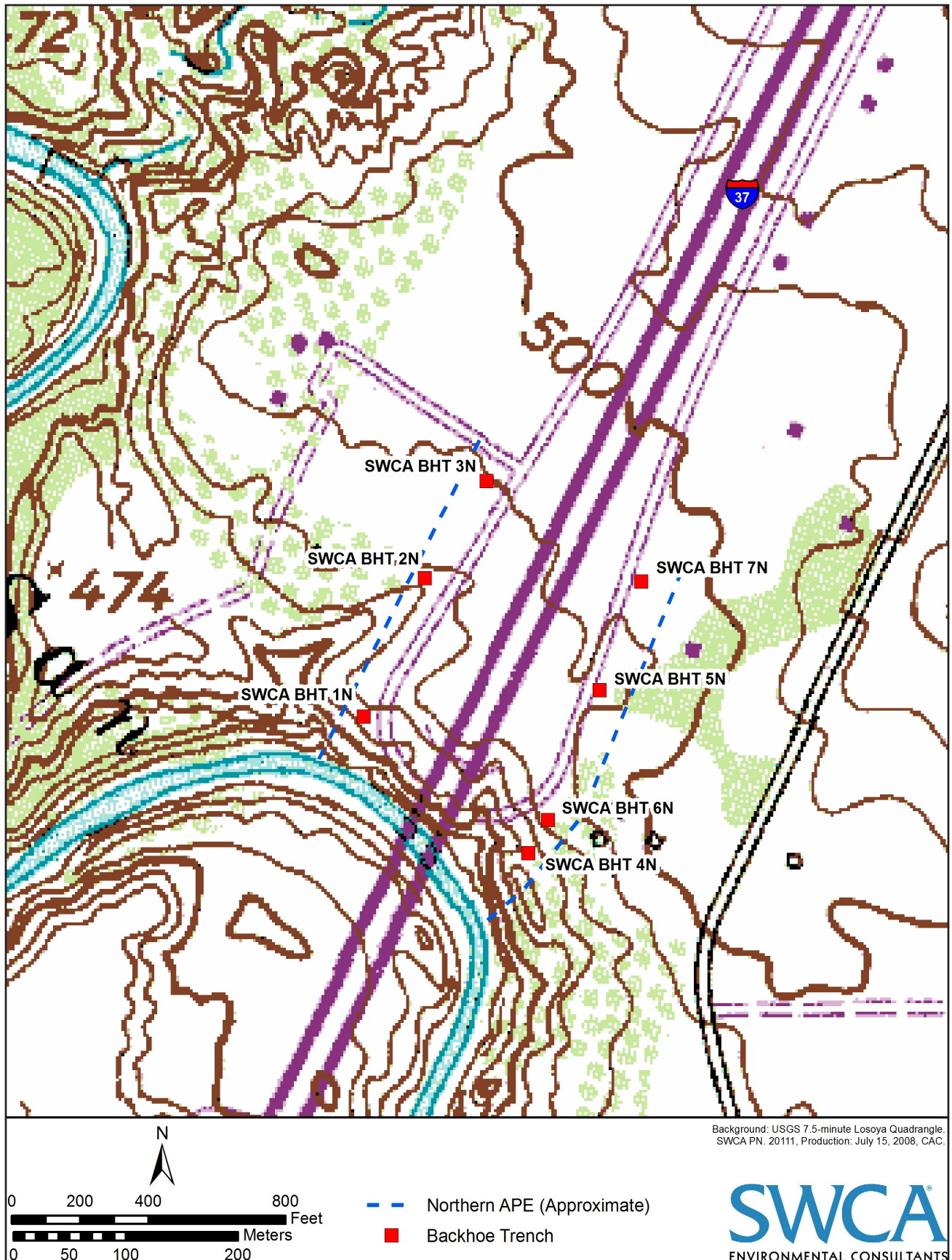
Figure 5.1.   Topographic map with plotted trenches on the northern side of the San Antonio River.

Table 5.1. Backhoe Trench Data from the Northern Side of the San Antonio River (Not Including Trenches Placed in 41BX1240)

Trench	Depth (cmbs)	Munsell	Soil Color	Soil Texture Description	Inclusions	Lower Boundary	Comments
SWCA BHT 1N	0–30	10YR4/3	Brown	Silt loam	None	Clear and smooth	Disturbed, recent trash
	30–58	10YR6/4	Light yellowish brown	Sandy loam	Road gravels	Gradual and smooth	Disturbed
	58–82	7.5YR5/6	Strong brown	Sandy clay loam	Clay	Abrupt and sloping	Disturbed
	82–99	10YR6/4	Light yellowish brown	Sand	None	Clear and smooth	Well sorted
	99–147	10YR7/3	Very pale brown	Sand	None	Clear and smooth	Contains several micro horizons
	147–180	10YR5/4	Yellowish brown	Sand	None	Unknown	Glass bottle @ 148 cm dating to 1939
	180–200	10YR5/4	Yellowish brown	Sand	None	Unknown	Observed from above, too deep
	200–300+	10YR6/6	Brownish yellow	Sand	None	Unknown	Observed from above, too deep
SWCA BHT 2N	0–46	10YR5/4	Yellowish brown	Silt loam	3% gravels	Abrupt and sloping	Disturbed
	46–50	10YR5/3	Brown	Silt loam	None	Clear and sloping	Window glass fragments, probably disturbed
	50–65	10YR5/4	Yellowish brown	Silt loam	10YR5/4 mottles, 4% pea gravels	Clear and sloping	Possibly disturbed
	65–126	10YR4/3	Brown	Silty clay loam	Few $CaCO_3$ concretions	Gradual and smooth	Intact
	126–185+	10YR4/6	Dark yellowish brown	Clay	Common $CaCO_3$ concretions	Unknown	
SWCA BHT 3N	0–22	10YR4/4	Dark yellowish brown	Silt loam	Few small gravels	Abrupt and irregular	Plow zone
	22–36	10YR4/3	Brown	Silt loam	Rootlets	Gradual and smooth	
	36–177+	10YR5/2	Grayish brown	Clay	Few ferrous concretions	Unknown	Very old
SWCA BHT 5N	0–43	10YR4/3	Brown	Silt loam	Heavily mottled, gravels	Abrupt and smooth	Very disturbed
	43–82	10YR3/4 to 10YR 4/3	Dark yellowish brown to Brown	Silt	Roots, few gravels	Abrupt and smooth	1 flake at 82 cmbs, found in column sample
	82–140+	10YR4/1	Dark gray	Clay	Few ferrous nodules	Unknown	Mottled with 10YR6/8 clay
SWCA BHT 7N	0–25	10YR4/4	Dark yellowish brown	Silt loam	Rootlets, ferrous concretions	Abrupt and irregular	
	25–32	10YR6/8 & 10YR7/1	Brownish yellow, light gray	Sandy clay loam	Rootlets, ferrous concretions	Abrupt and smooth	
	32–66	10YR5/4	Yellowish brown	Silt loam	Strong brown mottles	Abrupt and smooth	Rodent burrow
	66–90+	10YR6/8 & 10YR7/1	Brownish yellow, light gray	Clay loam	None	Unknown	

(Lockhart 2004). No other artifacts were observed in BHT 1N.

An occasional artifact was found in the other trenches. In BHT 2N, window glass fragments and recent trash were observed around 50 cmbs within a disturbed context. In BHT 5N, one chert flake was observed at 82 cmbs. This artifact is made of fine-grained chert and is only tentatively identified as cultural. No other artifacts were observed in BHT 5N.

The APE north of the San Antonio River has been almost entirely disturbed by various modern developments, including road construction (e.g., vegetation clearing, fill section, and land modification), buried utilities, off-road vehicle traffic, erosion, and fences. These impacts have left few, if any, areas of intact sediments within the APE. Construction from IH 37 and its frontage roads comprise the majority of the disturbance. Similarly, along the western edge of the ROW, a concrete culvert parallels the roadway that assists in rainwater drainage.

The effects of the culvert and roadway construction are particularly evident in BHT 1N (Figure 5.2). The profile of the trench exhibited an extremely sloped stratigraphy, which was slanted toward the culvert. The fill material in the west wall of the trench extended to about 180 cmbs while in the east wall the disturbance extended to 82 cmbs. Although disturbance was present in the other trenches along the western side of the road (BHT 2N and BHT 3N), the impacts were not as substantial.

Road construction has also affected the eastern side of the ROW north of the San Antonio River. In addition

Figure 5.2.   SWCA BHT 1N showing successive levels of fill, facing south.

to the fill section and grading disturbances, a buried water line parallels the IH 37 roadway, which has affected the APE. This utility is the San Antonio Water System (SAWS) pipeline that, after crossing the San Antonio River attached to the bridge, passes under the northbound IH 37 fill section and trends northeast to the edge of the ROW. At roughly 250 feet from the end of the bridge, the pipeline continues to parallel the roadway up the approach about 2 m from the fence line. This utility, the road construction, and other impacts have significantly disturbed the APE on the northern side of the San Antonio River.

SURVEY OF SOUTHERN SIDE OF SAN ANTONIO RIVER

The portion of the project area south of the San Antonio River was inspected with pedestrian survey that utilized backhoe trench and shovel test excavation. Specifically, six backhoe trenches were used for the general survey of the southern side of the San Antonio River. The southern trenches are formally designated with an *SWCA* prefix to distinguish them from CEA's 1997 trenches, which are designated with a *TAMU* prefix. However, when referring to *BHT 3* herein, the reference is to SWCA's trench; if referring to Texas A&M's trenches, they will be so designated (e.g. TAMU BHT 7). Based on these conventions, the survey trenches are titled BHT 3 through 7, and BHT 10. Backhoe trench excavation primarily targeted the lowland portion in the areas west and north of 41BX1239, but one backhoe trench (BHT 10) and eight shovel tests (ST 1 to ST 8) were placed on the upland ridge overlooking the San Antonio River (Figure 5.3).

In regard to the backhoe trench investigations in the lowland portion, the depths of the trenches ranged from 190–370 cmbs (Table 5.2). The stratigraphy of the trenches on the floodplain revealed deep, recent alluvium, but those trenches closest to the upland ridge (i.e., BHT 3) also exhibited some evidence of colluvial deposition (e.g., wedge-shaped strata pinching out downslope). The trenches typically exhibited a profile that contained discretely bounded, alternating horizons of clay loam, sandy loam, and sand containing micro-horizons. These are intact depositional structures common in young soils that have had insufficient time for pedogenic development that blurs such discrete boundaries.

The stratigraphy varied slightly between the trenches depending on their proximity to the river and the slope

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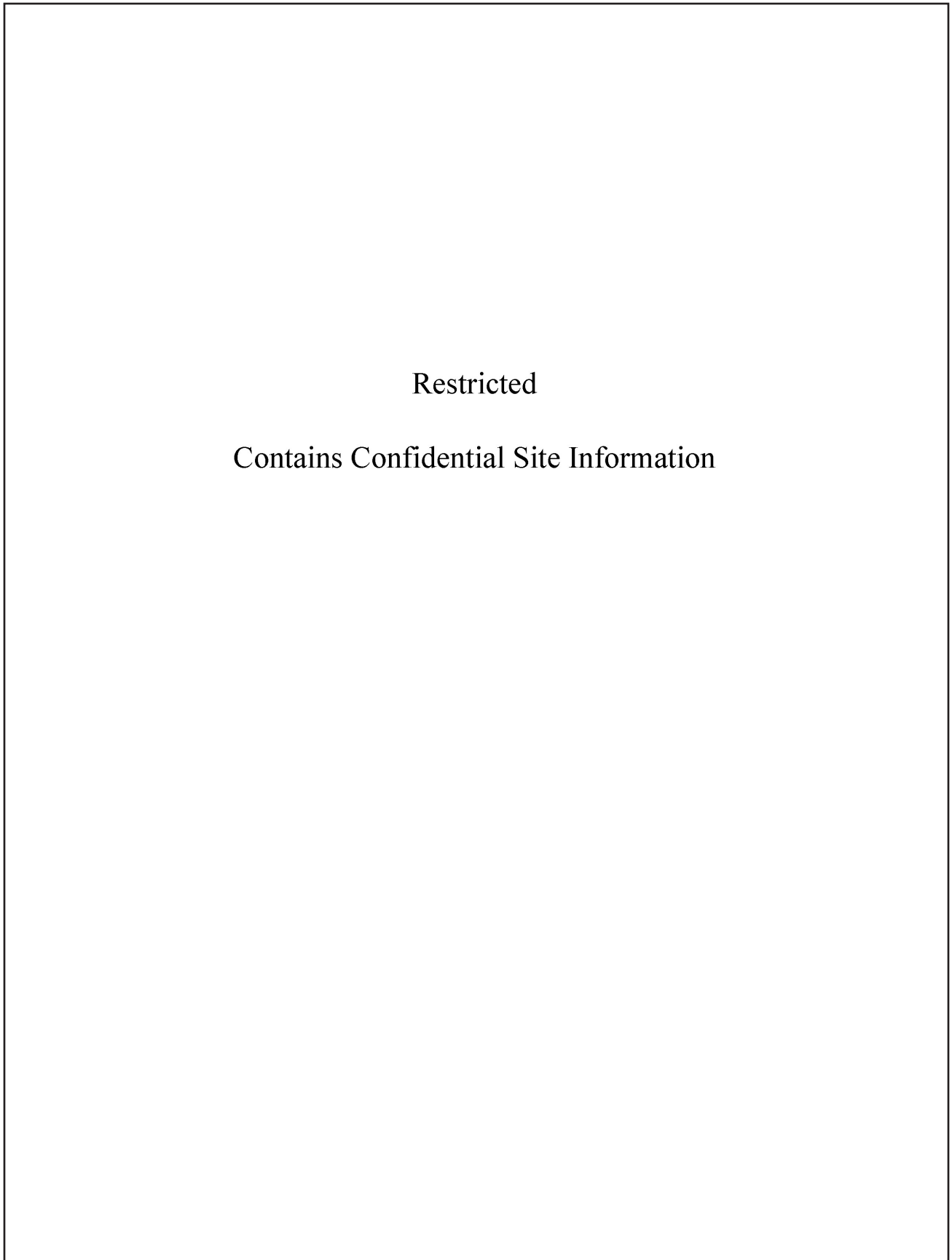
Figure 5.3.   Topographic map with plotted trenches on the southern side of the San Antonio River.

Table 5.2.   Backhoe Trench Data from the Southern Side of the San Antonio River (Not Including Trenches Placed in 41BX1239)

Trench	Location	Depth (cmbs)	Munsell	Soil Color	Soil Texture Description	Inclusions	Lower Boundary	Comments
SWCA BHT 3	On terrace south of the San Antonio River and west of IH 37	0-100	10YR4/2	Dark grayish brown	Clay loam	Roots, occasional snail shell	Abrupt and wavy	Forms a small in-filled channel in profile
		25-140	10YR4/6	Dark yellowish brown	Sand	Roots	Clear and wavy	
		100-160	10YR4/2	Dark grayish brown	Sandy clay loam	7.5YR4/6 mottling, occasional charcoal	Clear and wavy	Burned feature
		160-300	10YR4/6	Dark yellowish brown	Sand	Contains small lenses of clay loam	Unknown	Clay loam lenses
SWCA BHT 4	South of San Antonio River and west of IH 37	0-22	10YR5/2	Grayish brown	Clay loam	Rootlets	Abrupt and smooth	
		22-90	10YR7/4	Very pale brown	Sandy loam	None	Abrupt and smooth	
		90-93	10YR6/2	Light brownish gray	Clay loam	None	Abrupt and wavy	
		93-137	10YR5/4	Yellowish brown	Sand	None	Abrupt and smooth	Discontinuous lens
		137-155	10YR4/3	Brown	Silt loam	None	Clear and smooth	Poorly sorted coarse sands
		155-220	10YR6/4	Light yellowish brown	Sand	None	Unknown	
SWCA BHT 5	South of San Antonio River and west of IH 37	0-24	10YR4/3	Brown	Clay loam	Roots	Abrupt and smooth	Plastic found at 20 cmbs
		24-49	10YR5/2 & 10YR 6/6	Grayish brown / Brownish yellow	Clay loam / sand	None	Abrupt and smooth	Alternating bands of clay loam and sand
		49-61	10YR5/2	Grayish brown	Clay loam	Few ferrous filaments	Abrupt and smooth	Similar to Strat III of SWCA #4
		61-75	10YR6/6	Brownish yellow	Sand	None	Abrupt and smooth	
		75-180	10YR3/3	Dark brown	Clay	Ferrous concretions	Abrupt and smooth	Examined from above
		180-213	10YR6/6	Brownish yellow	Sand	None	Abrupt and smooth	Examined from above
		213-250	10YR6/3	Pale brown	Sandy clay	None	Unknown	Examined from above
SWCA BHT 6	South of San Antonio River and west of IH 37	0-40	10YR5/3	Brown	Clay loam	Common rounded gravels	Gradual and smooth	Recent debris
		40-55	10YR5/4	Yellowish brown	Sandy loam	None	Abrupt and smooth	
		55-67	10YR4/4	Dark yellowish brown	Silt loam	Charcoal flecking	Abrupt and irregular	Discontinuous lens
		67-108	10YR5/4	Yellowish brown	Sandy loam	Common rabdotus	Gradual and smooth	Well sorted
		108-200	10YR6/6	Brownish yellow	Sand	None	Unknown	Poorly sorted

Table 5.2.   Backhoe Trench Data from the Southern Side of the San Antonio River (Not Including Trenches Placed in 41BX1239) (continued)

Trench	Location	Depth (cmbs)	Munsell	Soil Color	Soil Texture Description	Inclusions	Lower Boundary	Comments
SWCA BHT 7	South of San Antonio River, between north and south bound bridges	0-23	10YR6/4	Light yellowish brown	Silt loam	5% pea sized gravels	Abrupt and smooth	Alternating bands of 10YR5/4 sand
		23-63	10YR4/3	Brown	Clay loam	Charcoal flecking and rabdotus shell	Gradual and smooth	
		63-99	10YR5/4	Yellowish brown	Sandy loam	Decomposing vegetation	Clear and smooth	Well sorted
		99-154	10YR4/2	Dark grayish brown	Clay loam	Very few snail shell fragments	Gradual and smooth	
		154-230	10YR5/4	Yellowish brown	Sandy loam	Few snail shell fragments	Unknown	Poorly sorted
SWCA BHT 10	On upland ridge south of San Antonio River	0-27	10YR6/4	Light yellowish brown	Silt loam	Rootlets	Gradual and smooth	
		27-62	10YR6/4	Light yellowish brown	Silt loam	Small snail shells	Very gradual and smooth	Basal clay. No cultural materials
		62-300	10YR5/4	Yellowish brown	Sandy loam	rabdotus shell	Unknown	Alluvial. Some clay content
		300-340	10YR5/4	Yellowish brown	Sandy clay loam	Few calcium carbonate concretions	Unknown	Depths below 216 cm are approximate
		340-370+	10YR5/4	Yellowish brown	Clay	Few small calcium carbonate nodules	Unknown	Could be transition horizon above massive clay stratum

of the upland ridge. However, most of the trenches exhibited a smooth stratigraphy and a relatively consistent horizon of brownish yellow to dark brownish yellow (10YR6/6–4/6) sand that began around 110 to 160 cmbs. This horizon was occasionally the bottom horizon and tended to be at least 160 cm thick. One select trench (BHT 5) was excavated beyond the sand horizon and encountered a pale brown (10YR6/3) sandy clay that extended to over 250 cmbs (Figure 5.4). None of the trenches contained any evidence of disturbance, but some recent debris and trash (i.e., plastic) were observed from the surface to 40 cmbs.

None of the trenches in the modern floodplain were column-sampled due to the clearly recent deposition. The walls were carefully examined, but no cultural materials or features were observed in any of the examined profiles of these trenches.

In regard to the backhoe trench investigation in the upland portion, one backhoe trench (BHT 10) was placed on the east side of the APE. BHT 10 was excavated to 370 cmbs and exhibited a profile of alternating horizons of silt loam and sandy clay loam overlying a deep clay horizon. No evidence of disturbance was observed and no cultural materials were present. Due to the excavation of five backhoe trenches by CEA in 1997 that did not encounter any cultural materials, no additional backhoe trench investigations were conducted by SWCA along the eastern side of the IH 37 ROW.

Regarding the western side of the IH 37 ROW, the upland portion was investigated with eight shovel tests (STs 1 through 8) (Table 5.3). The depth of the shovel tests ranged from 40–85 cmbs. However, the

majority of the shovel tests encountered a calcareous compact horizon of silt loam at 45–50 cmbs, which is likely the upper portion of the Leona Formation. The shovel tests generally encountered silt and sandy loams occasionally overlying the substrate. Also, small pea size nodules of calcium carbonate were commonly observed in the bottom stratum of the shovel tests. Several of the tests contained evidence of disturbance (e.g., concrete fragments), but the surface of all the shovel tests have been affected by grading. No cultural materials were observed in the shovel test excavations of the project area.

Additional shovel tests were not warranted due to the prevalent disturbances observed within the ROW. Similar to the disturbances observed on the north side of the river, the APE on the south side of the river has been affected by road construction (e.g., fill section and land modification), buried utilities, off-road vehicle traffic, erosion, and fences (Figure 5.5). These impacts have moderately to severely affected the APE with road construction and maintenance disturbing the ROW the most.

Figure 5.5.   Overview of southeast quadrant of survey area along uplands. A series of buried utilities runs along the left side of picture, facing south.

Summary of Pedestrian Survey

The intensive survey of the APE, conducted in areas beyond the limits of archaeological sites 41BX1239 and 41BX1240, used shovel testing, mechanical trenching, and inspection of available exposures. These investigations focused on the systematic evaluation of the APE to determine the nature, extent, and, if possible, potential significance of any cultural resources located within the proposed project area.

Figure 5.4.   Deep excavations in SWCA BHT 5 on south side of river.

Table 5.3. Shovel Test Data

ST	Depth (cmbs)	Soil Color (Munsell)	Sediment Texture	Artifacts Recovered	Comments
1	0-15	10YR3/2	Silty loam	None	Located on uplands in SW quad of IH 37 project area.
	15-45	10YR5/4	Sandy loam	None	
	45-85	10YR3/2	Silty clay loam	None	
2	0-25	10YR4/3	Silty loam	None	3% gravels. Concrete fragment at 20 cmbs; disturbed.
	25-40	10YR5/4	Silty loam	None	Very compact. 5% pea-size calcium carbonate nodules.
3	0-15	10YR3/2	Silty loam	None	Located on uplands in SW quad of IH 37 project area.
	15-45	10YR5/4	Sandy loam	None	
	45-85	10YR3/2	Silty clay loam	None	Calcareous clays and caliche
4	0-20	10YR4/3	Silty loam	None	3% gravels; disturbed(?).
	20-45	10YR5/4	Silty loam	None	Very compact. 3% pea-size calcium carbonate nodules.
5	0-15	10YR5/4	Sandy clay loam	None	
	15-35	10YR6/3	Sand	None	
	35-40	7.5YR5/6	Clay	None	Calcareous clays and caliche
6	0-6	10YR4/3	Sandy loam	None	Disturbed(?)
	6-20	10YR4/3	Silty loam	None	3% gravels; disturbed(?).
	20-50	10YR5/4	Silty loam	None	Very compact. 3% pea-size calcium carbonate nodules.
7	0-15	10YR5/4	Sandy clay loam	None	
	15-35	10YR6/3	Sand	None	
	35-40	7.5YR5/6	Clay	None	Calcareous clays and caliche
8	0-25	10YR4/3	Silty loam	None	3% gravels.
	25-45	10YR5/4	Silty loam	None	Very compact. 5% calcium carbonate nodules.

Overall, the disturbances within the APE have moderately to severely affected the ROW and include road construction (fill section and land modification), buried utilities, off-road vehicle traffic, erosion, and fences.

No cultural materials were identified within any of the project area shovel test excavations. The backhoe trenches revealed a few cultural materials in several of the upland trenches. These artifacts consist of a historic glass bottle, window glass fragments, and an indeterminate chert flake observed from trenches BHT 1N, BHT 2N, and BHT 5N, respectively. These artifacts were isolated occurrences and were typically observed within a disturbed context. No evidence of an archaeological site was observed during the intensive survey of the APE.

TEST EXCAVATIONS

SAN ANTONIO RIVER MAMMOTH SITE

Previously recorded, San Antonio River Mammoth site is located on the south side about 240 feet (73 m) west-northwest of the San Antonio River and roughly 75 feet (23 m) east-southeast of northbound IH 37 centerline (Figure 5.6). In late May and June, 2007, SWCA conducted test excavations to relocate the mammoth remains and assess the archaeological nature of the site.

SWCA's investigations at 41BX1239 were designed to address three interrelated and concurrent objectives. First, relocate and delineate the site deposits relative to the APE. Second, conduct geomorphological investigations to determine the depositional/ stratigraphic context of the site. Finally, conduct archaeological testing to assess the nature and potential of the site, particularly regarding the archaeological nature of the mammoth remains. As part of this objective, Dr. Lee Bement conducted an independent reexamination of the mammoth remains from CEA's previous investigations.

BRIEF REVIEW OF CEA'S PREVIOUS INVESTIGATIONS AND PREVIOUS ASSESSMENT OF MAMMOTH REMAINS

During the previously mentioned 1997 waterline survey, CEA excavated a series of backhoe trenches down the slope of the upland rise to the lowland terrace of the San Antonio River. One of these trenches, TAMU BHT 7, encountered mammoth remains on an ancient strath terrace in the toeslopes of the upper terrace. The site was recorded and subsequent examination of small bone fragments identified the presence of striations similar to those formed by the cutting action of stone tools. Thus, the mammoth remains were inferred to

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Figure 5.6. Site location for 41BX1239.

be associated with human occupation (Thoms 2001). TAMU BHT 7 was documented and the area adjacent to the trench was investigated with a series of shovel tests (STs 1–4 and 6–10), which determined that the mammoth remains extended over a 3 x 5-m area (Thoms 2001:15). The CEA investigations concluded with the covering of the trench with black plastic and backfilling to preserve the deposits for future investigations.

Based on stratigraphic correlations with better-studied profiles upstream along the Medina River, site 41BX1239 was interpreted as dating from approximately 15,000 to 10,500 years B.P. Although the CEA investigators recommended the site as eligible for listing on the NRHP and for designation as an SAL, TxDOT had not formally reviewed the investigations and findings. Accordingly, TxDOT required further investigation to clarify the content, extent, and cultural association of the faunal material and make a clear determination of NRHP/SAL eligibility.

INDEPENDENT ASSESSMENT OF MAMMOTH BONES FROM CEA'S INVESTIGATIONS

As noted, one of the objectives of the work on the San Antonio River Mammoth site was to further evaluate the interpretation of the site as archaeological (i.e., having evidence of human involvement) rather than strictly paleontological. Accordingly, part of the site testing entailed an independent assessment of the bones that CEA inferred to retain butcher marks. Prior to the full faunal analysis of remains recovered during the 2007 testing effort (see Chapter 6), SWCA coordinated the shipment of the three mammoth bones from Texas A&M to Dr. Leland Bement of the University of Oklahoma for an examination of the mammoth remains recovered from CEA's 1997 survey.

Dr. Bement viewed the mammoth bones under variable power binocular microscopy ranging between 10x and 400x. The overall condition of the bones was assessed according to taphonomic criteria including pre- and post-burial factors.

The surface of the three bones is powdery. The edges are mostly rounded due to sediment abrasion which is further supported by the sand grains embedded in the bone cracks and crevices. Fine to moderate drying cracks indicate the bones were on the surface at some time in the past and weathered.

Two of the specimens (121 and 122) have been reported to contain cut marks indicating human butchering/scavenging. The third bone (123) has been reported to display chattering marks indicative of fresh bone breakage. Indeed, cut marks displaying the high wall, trough, and striations indicative of stone tool butchery were found on 121 and 122. Some of these marks resulted from multiple, overlapping cutting strokes—another indication of human butchering activity. Also, the locations of many of the marks on 122 are on a concave surface where only deliberate focused activity would be likely. The chattering or hill and valley pattern resulting from dynamic loading creating a helical fracture plane that encountered resistance was found on 123. This telltale sign of fresh bone breakage can be seen in many contexts including animal trampling, gnawing/chewing, and human butchering/bone quarrying. However, no animal agent has been identified that can break mammoth bones in this fashion, leading to the conclusion that this too, is the result of human activity.

Based on the examination of these mammoth specimens, all indications are that these bones were modified by humans during butchering, scavenging, or bone quarrying activity. The marks occurred when the bones were fresh (as opposed to dry) as indicated by the coloring of the interior mark surfaces and the breakage pattern. Some marks are a little lighter in color than the surface of the bone. This is sometimes seen when the bone has weathered slightly before the activity leaving the mark. Such is consistent with scavenging activity. However, the compression associated with forceful cutting can lead to differential staining of the cut surface compared with the general bone surface. In no instance do the marks display the characteristic blocky form of recent marks on a dry bone as one would expect to see if the marks were the result of recent excavation.

TESTING INVESTIGATIONS

As the 2007 fieldwork began, crews returned to the Mammoth site and encountered a dense understory of brush, saplings, and tall grasses. A moderate amount of recent trash and debris was strewn across the site (Figure 5.7), but the central portion of the site appeared intact and undisturbed for the most part. To the west beneath the bridges, various impacts associated with the original road construction (i.e., IH 37 bridge columns and concrete drainage apron), and erosion have likely removed all potential for archaeological

deposits. These impacts appear to be exclusively off site.

The site is topographically situated along the toeslope of the upland terrace at the juncture of the Miller and Applewhite terraces. Though there is no clear surface expression, the late Pleistocene/Early Holocene deposits comprise the erosional remnants of an older terrace (i.e., strath terrace) obscured by slope deposits. These deposits arc slightly to the north, generally paralleling the meander of the San Antonio River. After a brief search, depressions and slight mounds, traces of CEA's backhoe trenches, could be discerned in the locations mapped in their survey report.

BACKHOE TRENCH EXCAVATION

The investigation at site 41BX1239 began with the relocation of TAMU BHT 7. The backhoe gradually scraped the area, eventually uncovering the black plastic that lined the trench (Figure 5.8). The plastic proved to be very effective in allowing the relocation of the trench. Most of the trench was mechanically excavated, though in the vicinity of the bone, the fill was removed by hand to prevent damage to the profile.

Figure 5.7.   Site 41BX1239 prior to clearing and excavations, facing northeast.

Once uncovered, the plastic was pulled back to reveal the profile and mammoth bone, both in a reasonably well-preserved state. Almost all elements depicted in the original survey report could be identified, and the bone appeared not to have seriously degraded as a result of its original uncovering, reburial, and re-exposure (Figure 5.9).

Figure 5.8.   Re-excavation of TAMU BHT 7, note black plastic left by initial excavators.

Subsequent to the re-excavation of TAMU BHT 7, an additional four trenches were excavated (BHTs 1, 2, 8, and 9). Two trenches (BHTs 1 and 8) were placed to the east of TAMU BHT 7 and two (BHTs 2 and 9) were placed to the west (Figure 5.10). These trenches were placed along the toeslopes and oriented parallel to TAMU BHT 7 (i.e., 30˚).

The depths of the SWCA trenches ranged from 140–250 cmbs (Table 5.4). Not unexpectedly, the stratigraphy of the trenches revealed a mix of alluvial and colluvial deposition. The geomorphological report in this chapter primarily addresses TAMU BHT 7, and so a brief overview of the sediments in other trenches is provided here. The trenches typically exhibited a profile that contained alternating horizons of silt loam, clay loam, silty clay loam, and sand. The stratigraphy varied slightly between the trenches, but generally contained a surface horizon of colluvial brown to dark

Figure 5.9.   Mammoth bone in eastern profile of TAMU BHT 7 after removal of plastic.

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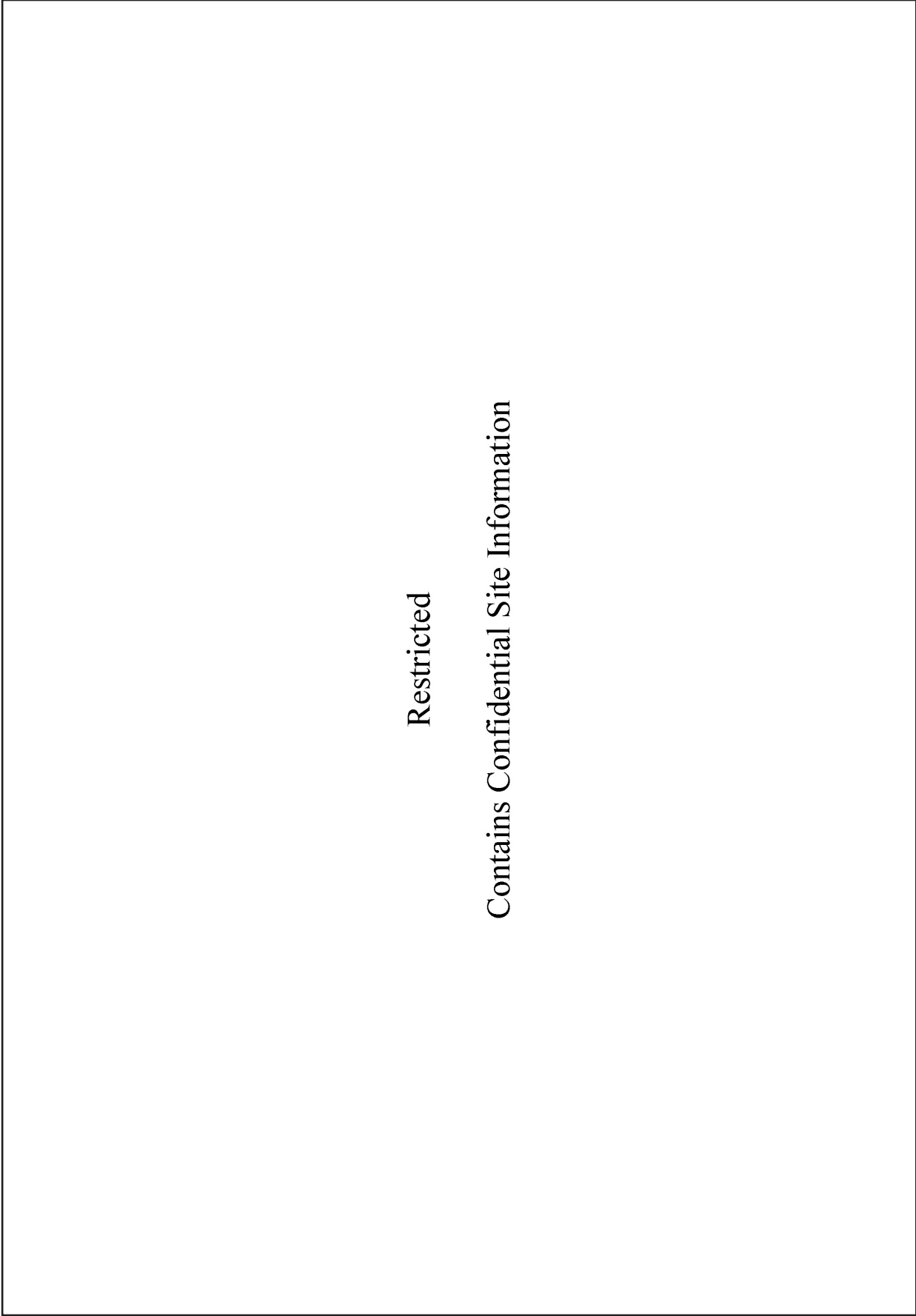
Figure 5.10.   Site map with backhoe trench and profile locations on 41BX1239.

Table 5.4.   Backhoe Trench Data from Site 41BX1239

Trench	Location	Depth (cmbs)	Munsell	Soil Color	Soil Texture Description	Inclusions	Lower Boundary	Comments
SWCA BHT 1	South of San Antonio River near eastern edge of ROW	0-45	2.5Y5/4	Light olive brown	Silt loam	None	Gradual and smooth	
		45-85	10YR4/3	Brown	Clay loam	None	Gradual and smooth	Sparse gravel lens at base of strat
		85-120	10YR4/2	Dark grayish brown	Clay loam	None	Gradual and smooth	
		120-250	10YR5/3	Brown	Silty clay loam	None	Unknown	
SWCA BHT 2	South of San Antonio River near SWCA BHT 9	0-75	10YR5/3	Brown	Silty clay loam	Abundant roots and snail shells	Very gradual and sloping	Appears to be primarily colluvial
		20-105	10YR4/3	Brown	Silty clay loam	None	Slightly abrupt and sloping	Strat begins roughly 3 m from south end of trench
		5-170	10YR6/4	Light yellowish brown	Sand	None	Gradual and sloping	Part of the Miller equivalent of the San Antonio River
		40-75	7.5YR7/4	Pink	Clay loam	None	Clear and sloping	Identified as the Perez Horizon
		70-160	10YR7/4	Very pale brown	Silty clay loam	Nodules of calcium carbonate	Unknown	Part of Somerset Horizon
SWCA BHT 8	10 m west of SWCA BHT 1	0-65	10YR5/2	Grayish brown	Silt loam	Occasional gravels	Very gradual and sloping	Historic ceramics, turtle shell, bone and brick fragments
		65-85	10YR5/3	Brown	Silt loam	None	Abrupt and sloping	Part of the Miller equivalent of the San Antonio River
		85-120	10YR6/4	Light yellowish brown	Sand	None	Gradual and sloping	Bone fragments at 130 & 182 cmbs
		120-140	5YR7/4	Pink	Clay loam	None	Unknown	Part of the Perez Horizon
SWCA BHT 9	10 m west of SWCA BHT 1	0-70	10YR3/2	Dark grayish brown	Silt loam	None	Clear and wavy	Lenses of 10YR4/4 sand and 7.5YR4/6 clay
		70-80	10YR2/1	Black	Silt loam	Abundant charcoal, ash, staining and some rock	Abrupt and smooth	Burned zone similar to SWCA BHT 1
		80-140	10YR4/2	Dark grayish brown	Clay loam	None	Clear and wavy	One piece of recent cow bone
		140-160+	10YR4/4	Dark yellowish brown	Sandy clay loam	None	Unknown	Following depths are unknown as strats were observed from above
		70-160	7.5YR4/6	Strong brown	Clay loam	Snail shell fragments	Sloping northward	Perez horizon
		130-190+	10YR5/6	Yellowish brown	Silty clay	Abundant calcium carbonate nodules	Unknown	Somerset formation

grayish brown (10YR5/3 to 3/2) silt loam overlying a brown (10YR5/3 to 4/3) silty clay loam above a fine-grained light yellowish brown to dark yellowish brown (10YR6/4–4/4) sand to sandy clay loam overlying a stratum of pale brown (10YR6/3) clay above a horizon of coarse brownish yellow (10YR6/6) sand.

Three of the 41BX1239 trenches (BHTs 2, 8, and 9) contained older soils identified as Perez and Somerset soils (Figures 5.11 and 5.12). The Perez and Somerset soils observed in the trenches were similar to that observed in TAMU BHT 7, which are in association with the mammoth bones. The Perez and Somerset horizons in BHTs 2, 8, and 9 were observed to terminate near the base of the scarp and did not contain mammoth remains. BHT 1, farthest to the east near the ROW edge, revealed only younger sediments, thereby defining the eastern limits of the strath terrace.

Cultural materials were observed in one of the four SWCA trenches, but all appear to be modern or historic slopewash materials. Specifically, SWCA BHT 8 contained white ware ceramic fragments, a red brick fragment, a turtle shell fragment, and numerous large bone fragments. These items were observed between 50 and 182 cmbs. However, most of the artifacts (excluding the faunal materials) were around 50 to 65 cmbs. All but a few bone fragments were situated at the southern end of the trench and associated with the first horizon, which is primarily colluvial in nature. The exception is a couple of bone fragments situated at the northern end of the trench in the third horizon (light yellowish brown fine-grained sand) that appear to be relatively recent floodplain deposits. None of the artifacts in BHT 8 exhibited temporally diagnostic information. Thus, the temporal affiliation for these cultural materials is unknown, but likely date to the middle to latter part of the twentieth century. Regarding the observed faunal materials in the trench, they primarily consist of long bone fragments with a couple rib bone fragments. All of the bone appears to be from a cow. Most of these artifacts appear to be the result of refuse disposal conducted upslope that has subsequently washed down. This interpretation is supported by the prevalent piles of recent debris and trash observed to have been discarded along the IH 37 frontage road.

No evidence of prehistoric cultural materials or deposits was observed in the SWCA trenches. No evidence of disturbance was observed other than some bioturbation, recent thermal events (e.g., BHT 9),

and flood deposits. All of the trenches were relatively intact and provided the primary exposures for the geomorphological assessment (see Chapter 7).

OVERVIEW OF GEOARCHAEOLOGICAL ASSESSMENT

Five profiles were described in three trenches at 41BX1239 on May 22, 24 and 31, 2007. These BHTs were cut into two terraces immediately east of the IH 37 bridge over the San Antonio River. This occupies a stair-stepped topography on an inside meander of the San Antonio River immediately downstream of its confluence with the Medina River. The older Applewhite terrace (T2) was sampled as well as the younger Miller terrace (T1). This profile documentation provides detailed sediment descriptions and assesses the soil/stratigraphic relationships observed in the sediments. A full geoarchaeological assessment of site 41BX1239 can be found in Chapter 7.

ARCHAEOLOGICAL TESTING – TEST UNITS

Upon completion of geoarchaeological analysis, SWCA expediently removed some of the soils determined to be overburden through mechanical stripping. Specifically, the area above the mammoth remains in the TAMU BHT 7 profile was stripped to about 20 cm above the mammoth elements (roughly 98.75 to 98.70 m). Subsequent to this removal, SWCA began the testing of prehistoric site 41BX1239 with hand-excavated test units. Centered on the exposed deposits in the TAMU BHT 7, seven formally designated 1 m² test units were excavated, though three of the seven were half units, partially truncated by the trench. Accordingly, the excavations covered approximately 5.5 m².

Units N1001 E998 and N1002 E998 were half units positioned along the eastern wall of TAMU BHT 7 (Figure 5.13). Unit N1002 E999, likewise a half unit, was excavated to provide a broader exposure of certain elements. With N1001 E999, these four units comprise a 2.5 m² excavation block that came down on the densest bone deposit, which is collectively referred to as the *bone bed*. Three outlying units, two on the western side of TAMU BHT 7 (N1000 E997 and N1001 E997) and one to the east (N1002 E1002), all encountered relatively minor amounts of bone, possibly indicating the margins of the bone bed (see Figure 5.13). Each of these hand excavation units are discussed below. Beginning with the outlying hand units first, the discussion will conclude with the Bone Bed Excavation Block. The following discussion

I: 10YR5/2 Grey brown silt loam; friable; very gradual lower boundary sloping northward; abundant roots, occasional gravels primarily colluvial in origin
II: 10YR5/3 Brown silt loam with some clay content, friable slightly abrupt lower boundary; some roots. This strat is part of the Miller-Equivalent of the San Antonio River
III: 10YR6/4 Light yellowish brown sand (fine grained), friable, gradual sloping lower boundary. Part of the Miller-Equivalent of the San Antonio River
IV: 5YR7/4 Pink clay loam; friable, sticky; lower boundary is clear and sloping. Strat terminates near mid slope at bioturbation. Part of the Perez-Equivalent
V: 10YR7/3 Very pale brown silty clay loam, friable with common CaCo3 filaments and small nodules. Strat terminates mid slope at turbation. Part of the Somerset-Equivalent. Lower boundary is unknown

Figure 5.11.   West wall profile of SWCA BHT 2.

I: 10YR5/2 Gray brown silt loam; friable; very gradual lower boundary sloping northward; abundant roots, occasional gravels primarily colluvial in origin

II: 10YR5/3 Brown silt loam with some clay content, friable slightly abrupt lower boundary; some roots. This strat is part of the Miller-Equivalent of the San Antonio River

III: 10YR6/4 Light yellowish brown sand (fine grained), friable, gradual sloping lower boundary. Part of the Miller-Equivalent of the San Antonio River

IV: 5YR7/4 Pink clay loam; friable, sticky; lower boundary is clear and sloping. Strat terminates near mid slope at bioturbation. Part of the Perez-Equivalent

V: 10YR7/3 Very pale brown silty clay loam, friable with common CaCo3 filaments and small nodules. Strat terminates mid slope at turbation. Part of the Somerset-Equivalent. Lower boundary is unknown

VI: 10YR10/3 Pale brown clay, clear lower boundary, friable

VII: 10YR4/2 Dark yellowish brown clay loam, friable and sticky; soil appears to be secondary fill from tree throw.

Figure 5.12. West wall profile of SWCA BHT 8.

Figure 5.13. Excavation map of 41BX1239.

generally uses elevations relative to Datum *1*, but when relevant, refers to cm below string line datum (cmbd) or cmbs.

N1000 E997

Unit N1000 E997 is one of the westernmost units intended to assess the extent and nature of the mammoth deposits (see Figure 5.13). The unit was established along the western wall of TAMU BHT 7. A string line datum was established near the southwest corner (Datum *E*) of the unit at an elevation of 99.70 m, roughly 15 cm above the ground surface. The first level was partially disturbed, and excavation in the unit began at 99.10 m, 60 cmbd. A total of six levels was excavated, reaching a bottom depth of 98.50 m, 120 cmbd.

The stratigraphy of unit N1000 E997 was similar to that observed in BHTs 2, 8, and 9. Specifically, after a thin horizon of humate material, the stratigraphy consisted of alternating horizons of silt and silty clay loams identified as associated with the Miller Equivalent of the San Antonio River. These strata extend to about 98.90 m where a stratum of clay loam, the Perez Soil, was encountered that slopes downward sharply to the north and west (Figure 5.14). The Perez stratum extends to the base of N1000 E997 (95.50 m) where the contact with the Somerset is observed in the unit floor and profile. Upon encountering the Somerset horizon, the excavation of the unit terminated.

The six levels excavated in unit N1000 E997 did not encounter any cultural materials or mammoth remains. The unit investigation did reveal evidence of two shovel tests excavated by CEA in 1997 (Figure 5.15). One shovel test (ST 7 as depicted in Thoms 2001:13–14) was observed extending down the south wall of the unit while the second shovel test extended down the north wall (ST 1). These columns of disturbed soil were exactly 50 cm apart along an axis that paralleled TAMU BHT 7, which match the description of STs 1 and 7 (Thoms 2001:13–14). Both of these shovel tests are indicated to have been excavated to 120 cmbs with a mammoth bone present in ST 7, but not ST 1 (Thoms 2001: 19). The depth of the recovered mammoth bone in ST 7 was not indicated.

N1001 E997

Unit N1001 E997 is adjacent to N1000 E997 and is one of the westernmost units used to assess the extent and nature of the mammoth deposits (see Figure 5.13).

The unit was established over the western wall of TAMU BHT 7. A string line datum was established near the southwest corner (Datum *A*) of the unit at an elevation of 99.50 m, roughly 18 cm above the ground surface. The first level was identified as overburden and excavation in the unit began at 98.90 m. A total of eight levels was excavated in reaching a bottom depth of 98.10 m. Of note, at roughly Level 4 (98.60 m) the unit expanded 15–20 cm eastward to further expose mammoth faunal materials. Thus, the unit was 100 cm north-south and 120 cm east-west from Level 4 to the base of excavations in Level 8.

As with unit N1000 E997 just to the south, the stratigraphy of unit N1001 E997 was similar to that observed in BHTs 2, 8, and 9. Specifically, the stratigraphy consists of alternating horizons of silt and silty clay loam identified as part of the Miller Equivalent of the San Antonio River. These strata extend to about 98.60-98.50 m where soils identified as Somerset deposits were identified. Of note, no evidence of the Perez soils was observed in this unit: they were in the unit to the south (i.e., N1000 E997). The Perez soils apparently drop off abruptly in the unit to the south and do not extend into unit N1000 E997. The Somerset was observed to extend from roughly 98.50 to the base of unit excavations.

The eight levels excavated in unit N1001 E997 did not encounter any cultural materials. However, the unit investigation did reveal a few mammoth remains, though in a significantly lower density than in the bone bed to the east. The first mammoth bone was encountered at 98.58–98.55 m in Level 4. The faunal remains were observed just above the soils identified as the Somerset deposit. Thirty-one small mammoth bone fragments were observed in Level 5 in the southeastern portion of the unit at 98.45 m. Notably, these bone fragments were encountered in proximity to a rodent burrow that may have affected the vertical location of these faunal remains. In Level 6, another mammoth bone fragment was recovered in proximity to some carbon fragments at 98.36 m. The carbon and the mammoth were also recovered from the southeastern corner where a rodent burrow was located, which may have affected the vertical integrity of these specimens. The remaining two levels (Levels 7 and 8) also contained mammoth bone fragments (approximately 40 pieces), but these were diffusely spread across the unit, very small (about 2–4 cm), extremely fragmentary, and non-diagnostic. The
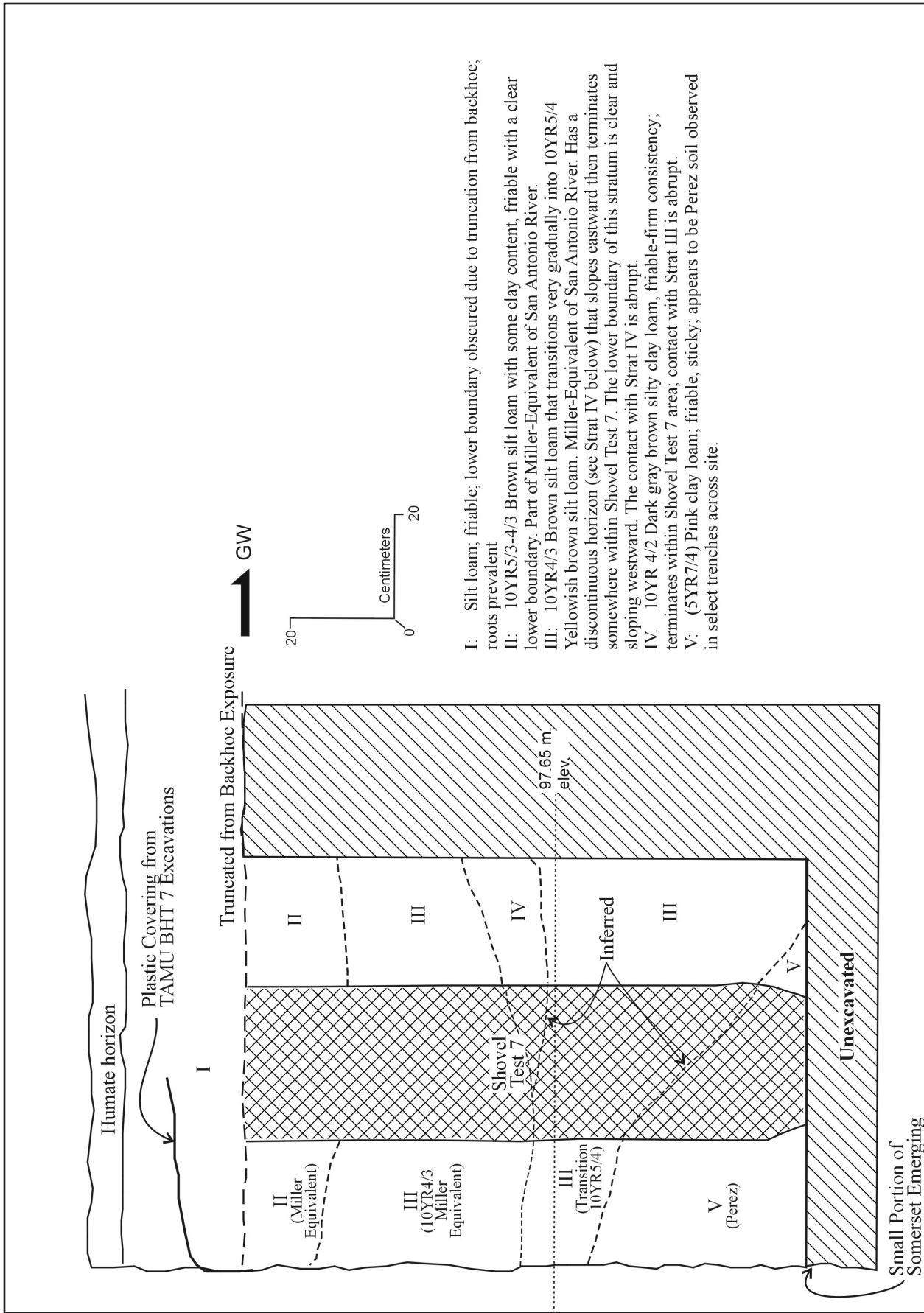
Figure 5.14.   South wall profile of Unit N1000 E997.

Figure 5.15. Southern profile of N1000 E997 showing backfilled shovel test.

presence of the mammoth faunal remains was noted to roughly 98.15 m. None of the mammoth remains recovered from the unit were classified in the field, but subsequent laboratory analysis should identify several of these elements.

Also observed in the N1001 E997 was a disturbed vertical column of soil that indicates previous excavation. This excavation is the aforementioned ST 1 by CEA observed in the unit to the south (i.e., N1000 E997). This shovel test is indicated to have been excavated to 120 cmbs and did not contain mammoth remains (Thoms 2001:19).

N1002 E1002

Unit N1002 E1002 is the easternmost unit intended to assess the extent and nature of the mammoth deposits to the east (see Figure 5.13). The unit was established 3.5 m east of TAMU BHT 7 and roughly 2 m east of the Bone Bed. A string line datum was established near the southwest corner (Datum *D*) of the unit at an elevation of 99.40 m. The first 88 cm of soil were identified as overburden and removed. The excavation of unit N1002 E1002 began at 98.30 m. Four levels were excavated, reaching a bottom depth of 97.90 m.

The stratigraphy of unit N1002 E1002 revealed disturbed overburden around 98.60 to 98.50 m. The intact deposits begin with a possibly truncated horizon of brown (10YR4/3) silty clay loam that dramatically slopes east and south toward the San Antonio River. This horizon extends to roughly 98.40 m and overlies a horizon of yellowish brown (10YR5/4) sandy loam that extended to below the unit's excavation (see Figure 5.12). Both this horizon and the one above appear to be associated with the alluvial deposits of the Miller Equivalent of the San Antonio River. In the southwest corner of the unit a stratum of pale brown (10YR6/8) clay was present that emerged about 98.18 m and ended around 98.10 m. This horizon may be the palustrine deposit identified in TAMU BHT 7 and it sloped east and northward dramatically, diving into the floor of the unit. Beneath this horizon was a stratum of light gray (10R7/2) clay that also dramatically sloped east and northward. This horizon appeared to be the soil identified as the Somerset soil. Upon encountering the Somerset soil (Figure 5.16) the excavation of the unit terminated. No evidence of the Perez soils was observed in this unit.

The four levels excavated in unit N1002 E1002 did not encounter any cultural materials. However, the unit investigation did encounter mammoth remains in the southwestern corner. The first mammoth bone was encountered at 98.14 m in Level 2. The faunal remains (n=6) were observed within the soils identified as the palustrine deposit. In Level 3, about 40 mammoth bone fragments of varying size were recovered from the southwestern corner between 98.10–98.0 m. In the final Level 4, two small mammoth bone fragments were recovered from the palustrine deposits. Almost all of the mammoth remains recovered from N1002 E1002 were small, fragmentary, and unidentifiable. However, at least two bone fragments from Level 3 are large enough for possible identification. Although these elements were not classified in the field, subsequent laboratory analysis should identify these elements. The mammoth bones in this unit represent the easternmost observed during SWCA's excavations.

Figure 5.16.   Photo of western profile of Unit N1002 E1002 showing mammoth bone and Somerset soils in lower left corner of photo.

Bone Bed Excavation Block

The hand excavation units designated *bone bed excavation block* comprise the units placed over the eastern wall of TAMU BHT 7 used to investigate the cluster of mammoth bone exposed in the trench profile. The block consists of units N1001 E998, N1002 E998, N1001 E999, and N1002 E999 (Figure 5.17a–c). The units along the E998 alignment overlap and parallel the eastern profile of TAMU BHT 7. Thus, the western edge of these units are truncated, making the units 100 cm north-south and 40 cm east-west. Similarly, unit N1002 E999 was also a partial unit, only 50 cm north-south and 100 cm east-west. Only unit N1001 E999 was a complete 1 m² excavation unit (see Figure 5.13). Two string line datums were established near the excavation block. One (Datum *C*) was placed at the south end of the block near Datum *1* at an elevation of 100.00 m, roughly 140 cm above the excavation block. The second datum (Datum *F*) was placed at the eastern end of the block at an elevation of 98.70 m.

Prior to the excavation of the hand units, overburden sediment was expediently removed to a depth above the mammoth remains (roughly 98.75–98.70 m), and then hand excavation began. Most of the soils in the mammoth-bearing deposits were collected for further analyses. Those soils not collected (about 25 percent) were fine-screened through nested $^1/_8$ and $^1/_{16}$-inch hardware mesh and any encountered non-faunal cultural materials were collected. All mammoth

remains were exposed to the extent necessary to make a clear identification and a systematic recovery. The excavation of these hand units proceeded in arbitrary 10-cm levels until bone was identified. At that point, arbitrary levels were abandoned and the bone was treated as a feature. Using small, wooden-tipped implements and hand tools, the matrix surrounding the faunal materials were carefully removed (Figure 5.18). The site investigations determined that the bone-bearing deposits were typically thin and the faunal remains were extremely fragile. Therefore, the hand excavations were extremely slow and painstakingly deliberate in the preservation and recovery of the mammoth elements.

Excavation in the bone bed revealed a dense cluster that included a number of identifiable elements: radius, ulna, tusk, tooth, atlas, possible patella, and a cuneiform. Less clearly defined, possible ribs and cranial fragments were also partially uncovered but not fully exposed. The recovered materials include a total of 47 bone elements or clusters and entail all listed elements except the ribs and cranium fragments. The faunal remains were observed to extend from 98.60–98.10 m in the excavation block. However, the majority of the mammoth faunal remains were observed and recovered between 98.40 and 98.30 m.

Conservatively, the horizontal extent of the mammoth remains is 15 m east-west and 5 m north-south. The east-west extent is determined by the absence of mammoth remains in BHTs 8 and 9, which bracket the bone-bearing trench TAMU BHT 7 (see Figure 5.10). Furthermore, the north-south extent is based upon the profile of TAMU BHT 7.

Eight samples, including three bone and five sediment samples, were submitted for dating to the Beta Analytic laboratory (Appendix C). Efforts to extract dateable material from all bone samples proved ineffective. The lab reported that they could recover no organic materials to allow dating. The five sediment dates

Bone Bed Plan View, Level 1

UNEXCAVATED

← TAMU BHT 7 →

N1001
E1000
N1002
N1003
E999

0   20
Centimeters

☐ Bone   ⬚ Fragmented Clusters
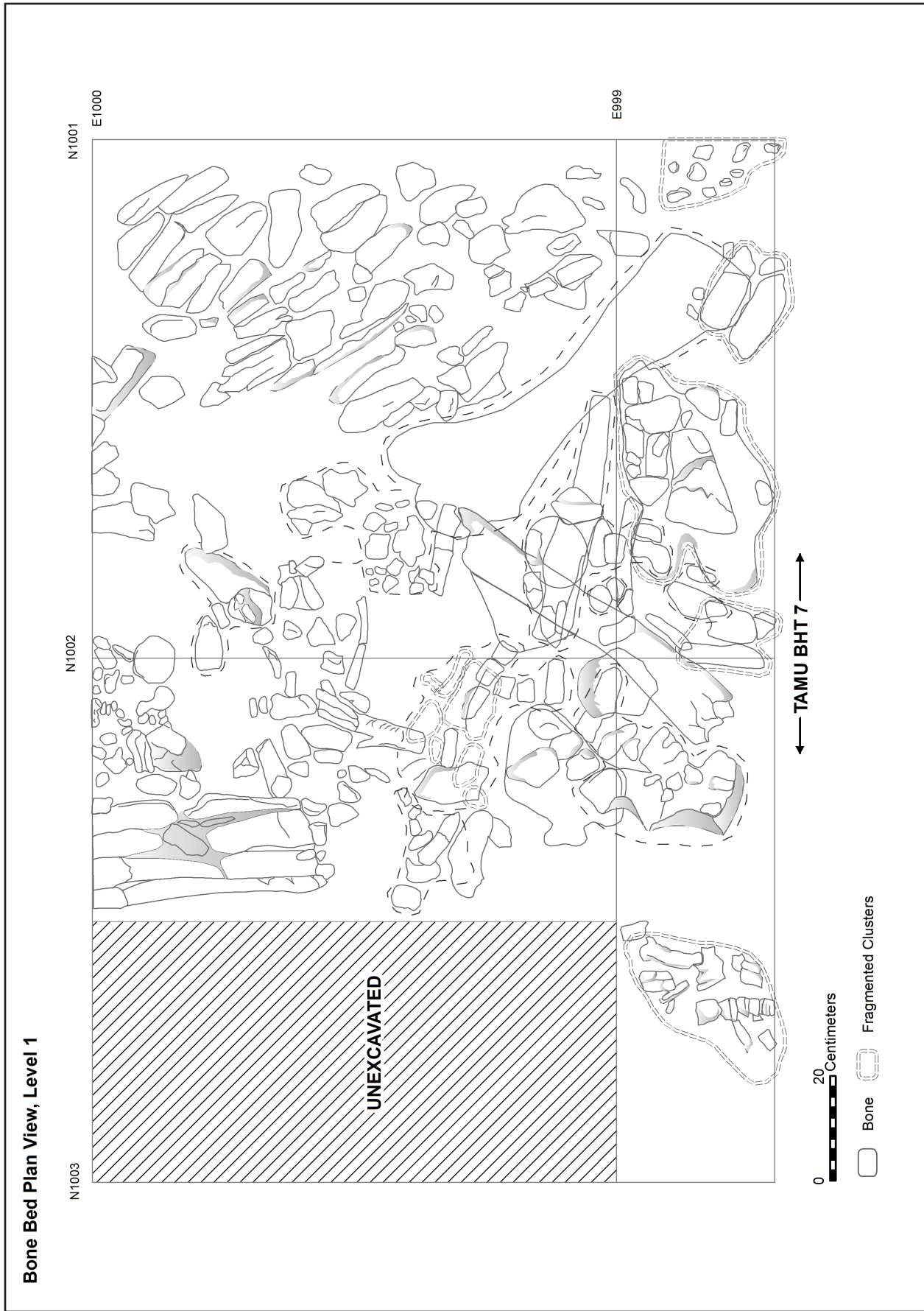
Figure 5.17a. Bone bed Level 1.

Bone Bed Plan View, Level 2

UNEXCAVATED

N1003

N1002

N1001

E1000

E999

TAMU BHT 7

Bone

Fragmented Clusters
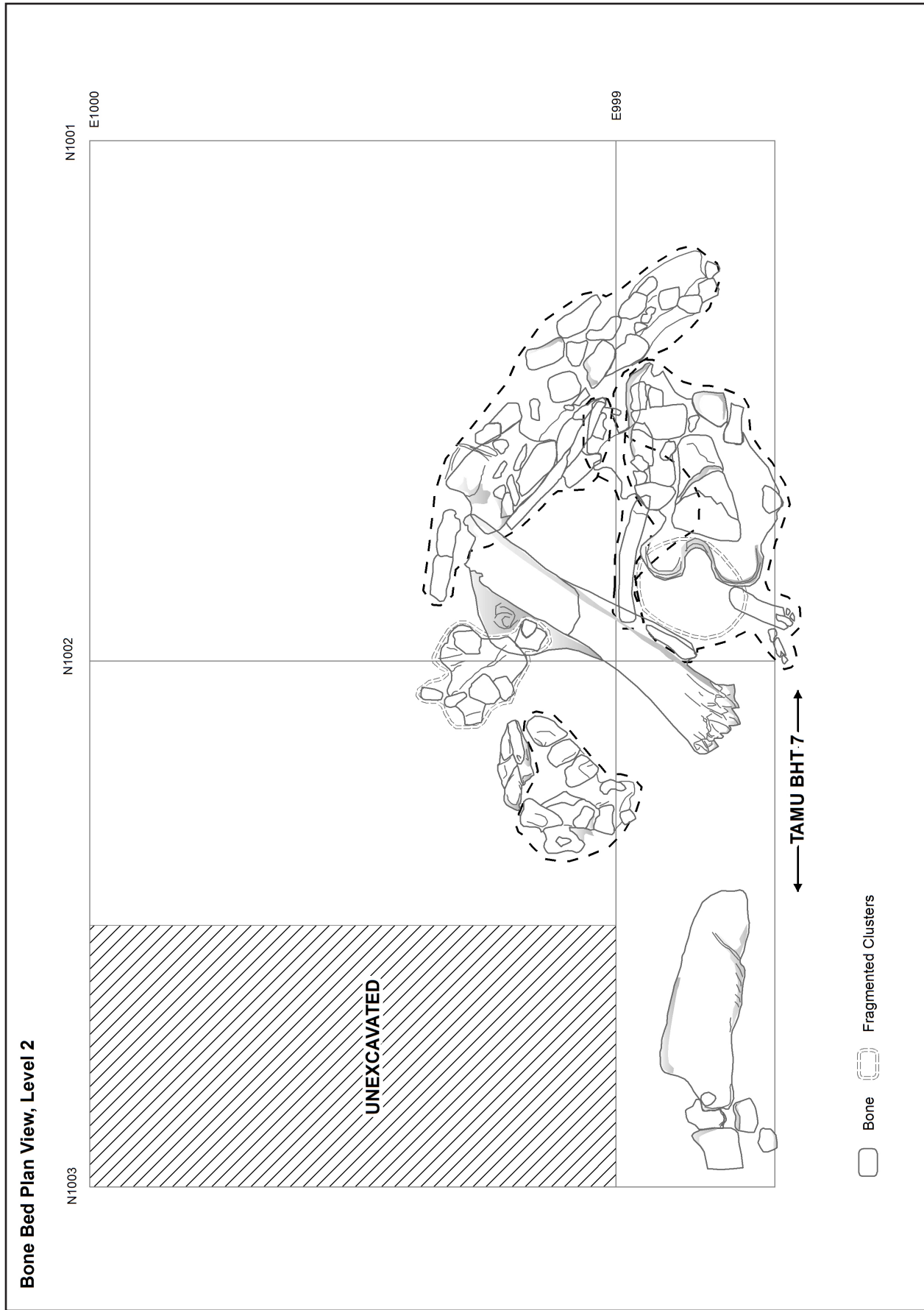
Figure 5.17b. Bone bed Level 2.

Bone Bed Plan View, Level 3

N1001   E1000

N1002

N1003   E999

UNEXCAVATED

TAMU BHT 7 →

0   20
Centimeters

▢ Bone   ⬭ Fragmented Clusters
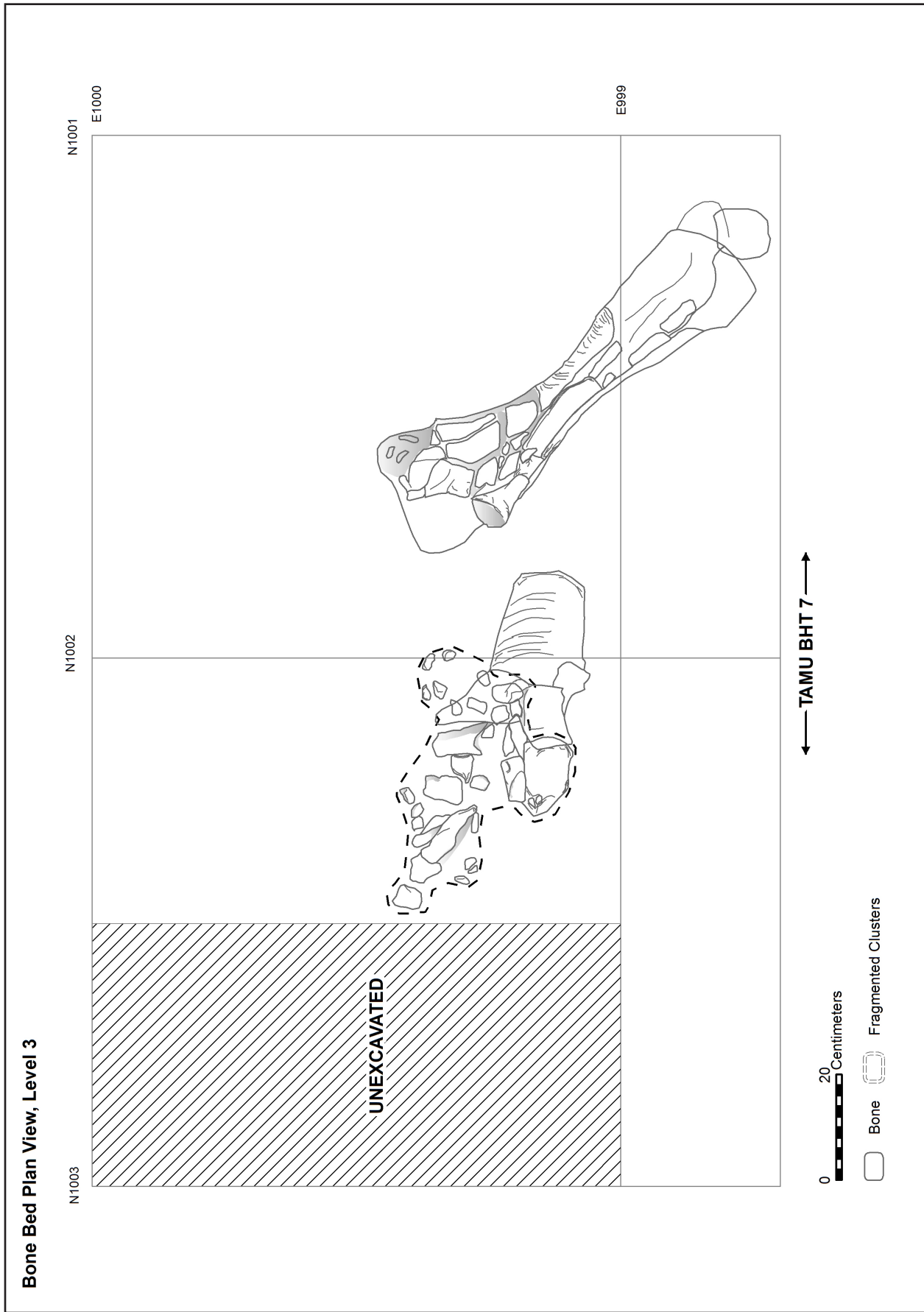
Figure 5.17c.   Bone bed Level 3.

Figure 5.18. Photos showing progressive exposure of bone bed. Top, facing north. Right, facing west. Bottom, facing east.

Figure 5.18 (continued).
Photos of bone bed
exposure in progress.
All photos facing east.

yielded dates, though they seem skewed toward being far too young to be acceptable.

Summary

The investigations defined the limits of the deposits and according to the current project plans, the mammoth deposits are outside the APE. Accordingly, the project will not affect deposits associated with the Mammoth site. Nevertheless, based on this work, the site is considered eligible for inclusion to the NRHP and for listing as a SAL. However, the investigations determined the site deposits are located outside the APE, and therefore the project will not affect deposits associated with 41BX1239.

Site **41BX1240**

Site 41BX1240, a prehistoric lithic scatter with a minor historic component, is located on the northern side of the San Antonio River about 1.36 miles (2.18 km) northeast of the Loop 1604 and IH 37 and roughly 270 feet (82 m) east-southeast of northbound IH 37 centerline.

Background and Previous Investigations at Site *41BX1240*

Site 41BX1240 was recorded as an open occupation with early stage lithic procurement debris and a few informal tools on the high terraces of the San Antonio River. CEA's 1997 investigations identified materials in surface exposures, but the vast majority of the site lay beyond their survey area and could not be extensively investigated. However, they noted that the site is spread across three terraces of the San Antonio River. Closest to the river, overlooking the modern floodplain is the Miller Equivalent terrace followed by the Applewhite Equivalent terrace and then the Leona terrace (Thoms 2001:21). Most of site 41BX1240 is surficially represented on the Leona terrace with bedrock outcrops, with a diffuse scatter of material extending downslope onto the Applewhite and Miller terraces (Figure 5.19).

The CEA investigations included the excavation of one backhoe trench (TAMU BHT 14) and a survey of the site's surface and available eroded profiles. TAMU BHT 14 was excavated at the northwestern corner of the site along the proposed water pipeline. This backhoe trench did not encounter any cultural materials and observed Pleistocene age sediments and road fill material (Thoms 2001:20). The surficial artifact assemblage recorded during CEA's investigation included a small scatter of lithic debitage, several core fragments (n=3), and one utilized flake that exhibited evidence of utilization. Additional artifacts were observed in the upper 60 cm of a cutbank exposure of the Applewhite Equivalent terrace along the edge of the ROW. These artifacts consisted of a chert flake, faunal materials from a large unidentified mammal, burned rock, and a white ware ceramic fragment in an eroding context (Thoms 2001:20).

The CEA investigations concluded that the cultural deposits of site 41BX1240 primarily lay outside of their survey corridor. Therefore, the initial examination of the site did not make any formal recommendations regarding the site's significance or eligibility (Thoms 2001). However, CEA did note that buried portions of 41BX1240 might remain farther east of their survey corridor that may be intact and warranting investigation (Thoms 2001:20).

Testing of *41BX1240*

The SWCA revisit of site 41BX1240 identified the sparse surficial scatter of lithic debitage, particularly evident in the two-track road exposure that crosses the site. The revisit also noted prevalent rounded chert gravels spread across the site that appears to be naturally occurring. The area in and around the site within the APE has been severely affected by numerous impacts associated with road construction, vegetation clearing, land modification (e.g., blading and contouring), vehicular and pedestrian traffic, erosion, several buried utilities, recent trash disposal and burning, and fences (Figure 5.20). Of these disturbances, the cut below grade and contouring of the ROW has affected the site area the most. The site is topographically situated on a southwest trending slope with areas of exposed sandstone bedrock that afforded good surface visibility, typically 40 to 70 percent.

Cultural materials were observed sparsely scattered across the surface along 30 m of the APE. The highest density of surficial artifacts is present at the center of the site in proximity to the exposed sandstone bedrock. The sparse quantity (n=5 to 20) of flakes consists of lithic debitage manufactured from a fine-grained brown to reddish brown chert that is similar to chert gravels observed in the area. The surficial lithic debitage represented early-late stages of reduction with no predominant stage observed. However, a noticeable frequency of shatter was present, which

Restricted

Contains Confidential Site Information
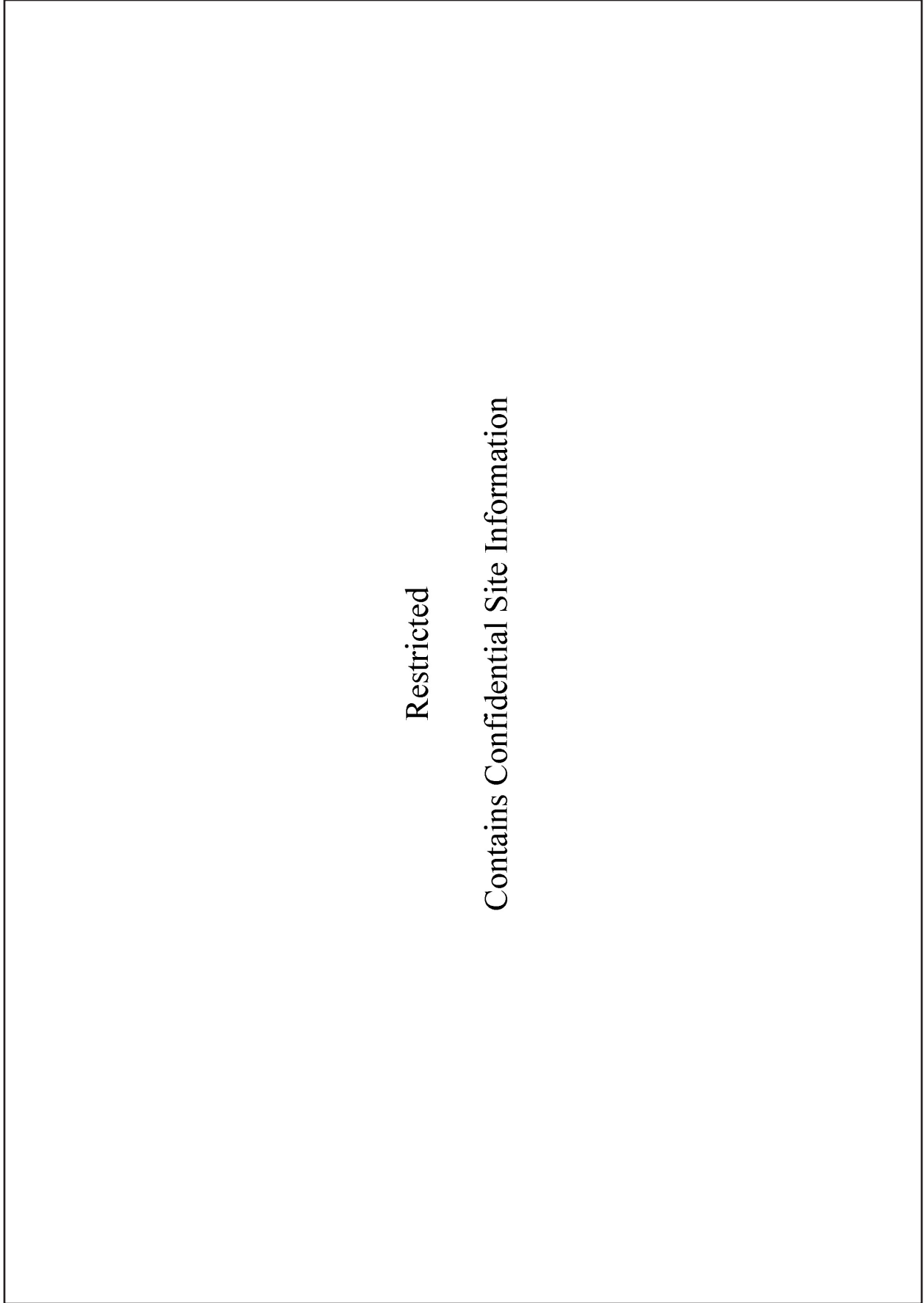
Figure 5.19.   Plan view map of site 41BX1240 with recent investigations plotted (adapted from Thoms 2001).

Figure 5.20.   Dirt road through 41BX1240 with light scatter of artifacts. Several large buried utilities run along ROW in high berm on right side of photo. Additionally, a small line is seen crossing east to west at bottom center of photo. Additional disturbances include landscape modifications associated with original road construction and drainage swale, facing north.

may be attributable to the pervasive disturbances. Also observed across the site's surface were several thermally altered quartzite cobbles. These burned rocks (n=4) were diffusely scattered across the center of the site and were typically small (about 2 to 5 cm in diameter). It is unclear if the rock represents prehistoric or recent activities. The site area has several piles of recent trash that has been burned, which may be attributed to some or all of the fire cracked rock fragments. No temporally diagnostic artifacts were observed on the site's surface.

As with the 1997 CEA fieldwork, the current investigations examined the exposures of the available cutbanks (i.e., Applewhite terrace). The SWCA investigations determined that the Applewhite terrace has eroded roughly 2 to 4 m eastward from the CEA mapped location in 1997, beyond the TxDOT ROW. Thus, the area indicated by CEA to have the bone and white ware about 60 cmbs has subsequently eroded away beyond the ROW. No cultural materials were observed in the current cutbank exposure of the Applewhite terrace.

SWCA's subsurface testing at 41BX1240 used backhoe trenches in areas most likely to contain undisturbed subsurface deposits. Two backhoe trenches (BHTs

4N and 6N) were placed in the site and an additional two, which were part of the survey results, were excavated to the north beyond the site boundaries. These excavations were used to investigate the soils and potential for buried deposits. BHT 4N was placed near the center of the site where the densest amount of cultural materials was present. The second trench, BHT 6N, was placed at the northern edge of the surficial artifact scatter. The backhoe trenches generally revealed varying horizons of light yellowish brown to dark brown (10YR6/4–3/3) silt loam that had increasing amounts of calcium carbonate with depth (Table 5.5). The first two horizons of BHT 4N exhibited evidence of disturbance down to 42 cmbs while BHT 6N contained a basal horizon of pale brown (10YR6/3) clay loam with abundant calcium carbonate nodules overlying a stratum of sandstone bedrock at 100 cmbs. Based on the profiles of BHT 4N and BHT 6N, it appears that BHT 4N is situated on the Applewhite equivalent terrace while BHT 6N is situated in Pleistocene age sediments of the Leona equivalent terrace. Neither of these trenches exhibited evidence of cultural materials or cultural features.

SWCA initially proposed to excavate two or more 1-m² test units at 41BX1240 to be placed along the backhoe trenches. However, based on the degree of disturbances and backhoe trench excavations, only a column sample was excavated. Measuring 50 x 50-cm, the sample was placed along BHT 4N where the site's deepest sediments were found on the southern end of the trench in the eastern profile (Figure 5.21). The column sample was excavated in arbitrary 10 cm levels to determine the presence of subsurface cultural materials (Figure 5.22).

Figure 5.21.   Column sample along SWCA BHT 4N, facing west.

Table 5.5. Backhoe Trench Data from Site 41BX1240

Trench	Depth (cmbs)	Munsell	Soil Color	Soil Texture Description	Inclusions	Lower Boundary	Comments
	0-15	10YR6/4	Light yellowish brown	Silt loam	Rootlets, charcoal, recent debris	Abrupt and sloping	Disturbed
	15-42	10YR5/3	Brown	Silt loam	Small gravels, recent debris	Gradual and smooth	Disturbed
SWCA BHT 4N	42-139	10YR5/4	Yellowish brown	Silt loam	Calcium carbonate filaments	Very gradual and smooth	Subtle transition to next strat
	139-190+	10YR5/4	Yellowish brown	Silt loam	Calcium carbonate filaments	Unknown	More firm than previous strat
	0-12	10YR3/3	Dark brown	Silt loam	Rootlets	Abrupt and sloping	
SWCA BHT 6N	12-42	10YR5/4	Yellowish brown	Silt loam	Large limestone slabs, quartzite pebbles	Abrupt and smooth	
	42-100+	10YR6/3	Pale brown	Clay loam	Abundant calcium carbonate nodules	Unknown	Bedrock at base of strat
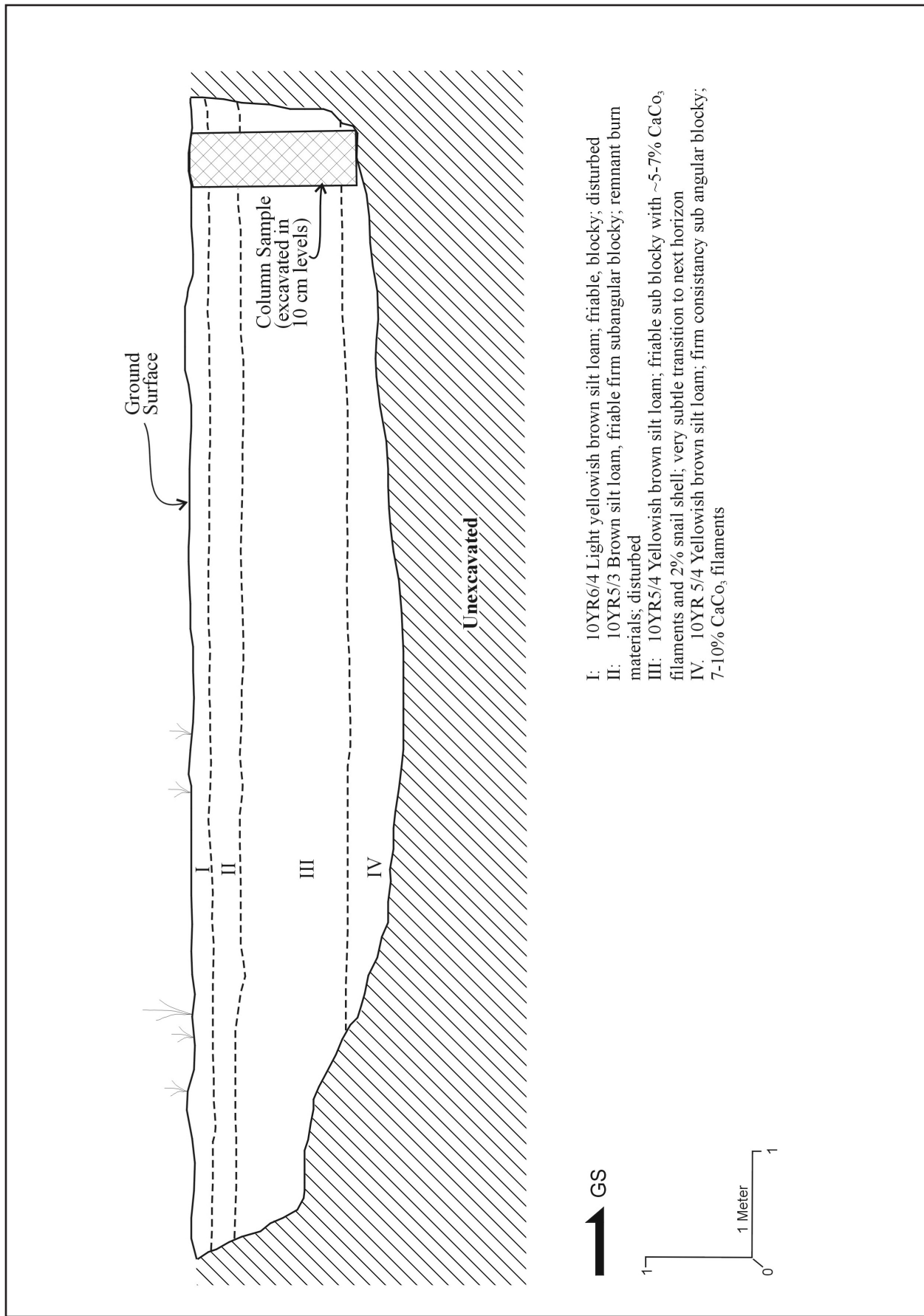
Figure 5.22.   East wall profile of SWCA BHT 4N.

The column sample yielded a white ware ceramic sherd, a glass fragment, and a bone fragment from 20–30 cmbs, and one chert flake from 40–50 cmbs. The white ware fragment is small with no temporally diagnostic information present. The glass fragment consists of clear glass that appears to be a base fragment from a beverage bottle or drinking vessel. No diagnostic markings or makers' marks are present. The faunal remains consist of several (n=11) heavily fragmented pieces that range from 1–3 cm in length and due to the notable thickness of one the bones (i.e., 1 cm), appear to originate from more than one long bone. The faunal remains belong to an unidentified mammal of medium to large size. Of note, the 1-cm thick bone fragment is comparable in size to a cow bone.

In regard to the chert flake, the artifact is made from a dark brown fine-grained chert that is similar in appearance to the chert gravels observed in the area. The chert flake exhibits flake scars down the long axis of the dorsal side while the platform of the artifact is missing. However, the remaining portion of the platform is concave in profile. The flake appears to be early-middle stage in reduction. The lone chert flake did not exhibit any evidence of use along its lateral margins. All of the cultural materials observed in the BHT 4N column sample appear to have been recovered from a disturbed context. Although the level that the chert flake was recovered (Level 5 40–50 cmbs) was only partially disturbed, the flake was observed at the contact of the Strata II and III. No additional cultural materials or evidence of cultural features were observed in the column sample of BHT 4N or along any of the trench wall exposures.

41BX1240 *Artifacts*

The site investigations yielded a total of 13 artifacts ranging in depth from 20 to 50 cmbs (Table 5.6). These artifacts included bone fragments from a medium to large size mammal, aqua bottle glass, white ware, and one tertiary piece of debitage (Chapter 8 provides more detailed descriptions of these artifacts). The flake is from early to middle stage reduction and did not exhibit any evidence of utilization along its lateral margins.

As previously noted, all of the cultural materials observed from SWCA's testing of 41BX1240 were recovered from a disturbed context. Disturbance extended to approximately 30 cmbs and no cultural materials were observed below this point. The surface manifestation of site 41BX1240 consisted of a sparse

and diffuse scatter of early to late stage debitage intermixed with a minimal amount of thermally altered quartzite cobbles. The surface within the APE has been severely affected by numerous impacts associated with road construction, vegetation clearing, land modification, etc.

The presence of burned rock and debitage suggests that the site functioned as a campsite, based upon site type criteria of Collins (2004:34). However, given the diffuse nature of the artifact assemblage on the surface and general paucity of buried material, there was no evidence for site furniture or discrete activity areas. Based on the artifact assemblage observed, the site appears to be a primarily surficial or shallowly buried cultural deposit that has been heavily affected by recent mechanical and erosional forces.

Summary

In general, the artifact assemblage observed at 41BX1240 suggests a primarily surficial or shallowly buried deposit that has been bulldozed, graded, trenched, and otherwise disturbed. All of the subsurface cultural materials observed at the site were in a disturbed or questionable context. Specifically, disturbance was noted in BHT 4N to roughly 45 cmbs. All of the subsurface cultural materials at 41BX1240 were encountered in the first 50 cm of the column sample. No intact cultural horizons or deposits were observed within the APE of 41BX1240. However, the area beyond the ROW fence line to the east of the site appears to be relatively intact.

In summary, the artifacts observed at the site are generally low in quantity and highly fragmented. Furthermore, the cultural materials appear to be overwhelmingly surficial in nature and may have been shallowly buried. The prevalent and significant construction activities have severely affected the site area within the APE. Thus, 41BX1240, as observed within the APE, has a low potential to provide new or important information regarding the history of the region. Due to its limited research value, SWCA does not consider the portion of the site within the APE to be eligible for inclusion in the NRHP or for designation as an SAL. However, if construction activities extend beyond the TxDOT ROW to the east of the site, further investigations to determine the presence of intact buried deposits are warranted.

Table 5.6.   Faunal and Archaeological Materials Recovered from Site 41BX1240

Lot #	BHT	Level*	Depth (cmbs)	Artifact Category	Artifact Sub-category	Artifact Class	Artifact Type	Artifact Description	# of artifacts	Artifact Wt (g)	Comments
1	SWCA BHT 4N	3	20–30	Organics	Faunal Remains	Bone	Bone		10	6.9	Small bone fragments, likely all bone pieces from medium or large mammal
1.1	SWCA BHT 4N	3	20–30	Historic Glass	Bottle	Aqua Bottle	Glass	Bottle Base Fragment	1	4.4	
1.2	SWCA BHT 4N	3	20–30	Historic Ceramic	Sherd	Whiteware	Whiteware	Whiteware Fragment	1	1.3	
2	SWCA BHT 4N	5	20–30	Lithic Artifacts	Chipped Stone	Detritus	Debitage	Complete Flake	1	1.1	Tertiary flake

*Level refers to level within 50-x-50 cm column sample on SWCA BHT 4N

FAUNAL ANALYSES OF SELECT MAMMOTH BONES FROM THE SAN ANTONIO RIVER MAMMOTH SITE

Olga Potapova and Larry D. Agenbroad

Editorial note: The study and preservation of mammoth remains is a fairly narrow scientific niche, and foremost authorities are few a far between. As it is quite likely there will be future studies of the San Antonio River Mammoth site, part of the effort in this study is to establish a foundation for subsequent efforts. Accordingly, as part of the study of the remains, SWCA subcontracted two of the highest authorities in the field, Dr. Olga Potapova and Dr. Larry D. Agenbroad at the Mammoth Site (MS) National Natural Landmark in Hot Springs, South Dakota to conduct detailed analyses on select mammoth bones, providing input on not only the elements, but also the appropriate means of preserving them. This chapter is their analysis report, and Appendix A details their recommendations on preservation and curation. It is important to note that no two sites are alike, and curatorial techniques must be adapted to the specific conditions of each site.

INTRODUCTION

Three jackets (Bins 8, 11, and 16) containing mammoth elements were mutually selected by MS and SWCA out of about 20 jackets for this project (Appendices B and C). The selection was made based on the preliminary bone identification by SWCA in the field, and the bones' significance for taxonomic identifications. The bones in the jackets were preliminarily identified by SWCA investigators as follows:

➢ *Jacket 8* – Patella (bone B-37), astragalus (bone B-38), un-diagnostic cluster

➢ *Jacket 11* – Tooth, mandible (bones B-29E, B-29W)

➢ *Jacket 16* – Proximal humerus (bone B-30)

METHODS

The measurement methods followed general guidance for mammals by Dreisch (1976), Göhlich (1998), both of which were adjusted to fit mammoth morphology by Agenbroad and Potapova (in preparation). Bone morphology terminology followed Smuts and

Bezuidenhout (1993, 1994), and Van-der-Merwe et al. (1995). The measurements (in cm) from the Mammoth Site specimens, and the Woolly mammoth, *M. primigenius* "Hebior" replica were taken using the GPM Anthropological Calipers (101), DKSH Switzerland Ltd.

Morphometrical analyses and comparisons of the 41BX1239 material with other data were performed. Specimens used for comparison included the Columbian mammoth, Mammuthus columbi, from the Mammoth Site (Agenbroad, 1994; Agenbroad and Potapova, in prep.), and published materials on the genus *Mammuthus* (*M. columbi* and *M. primigenius*) from North America and Eurasia (Maglio, 1973; Baigusheva & Garutt, 1987; Garutt, 1992; Kosintsev et al., 2004; Averianov, 1992, 1994 and others).

The Columbian mammoth, *M. columbi* from the Mammoth site included the following specimens: mandible (75HS198, 76HS227, 79HS250, 83HS167, 83HS110, 83HS215, 89HS067, 96HS160, 99HS029, 03HS036); humerus (83HS171, 83HS187, 83HS248, 89HS076, MSL 132, 79HS132, 79HS040, MSL 634, 83HS270, 83HS220 and four specimens without field #), femur (79HS303, 78HS163, 86HS076, 89HS016, 92HS060, MSL 657, MSL 699, 76HS171, MSL 821, and MSL 910) and patella (00HS381, 91HS063, 75HS132, 76HS254, 75HS131, MSL 021, MSL 626, MSL 453).

The following specimens of Woolly mammoths, *M. primigenius*, recovered from North American and Siberian (Russia) sites were used for the comparisons (in the Tables below, only nicknames are used):

➢ *Hebior mammoth* – male, replica mounted at Mammoth Site, of the 85% complete original skeleton, found in the vicinity of the town of Paris in Kenosha County, WI, and kept at the Milwaukee Public Museum, Milwaukee, WI. It is considered to be largest complete Woolly mammoth specimen found in North America (Potomac Museum Group, 1995; Hall, 1995).

No published materials are readily available: the measurements given here were taken from the casts of the left (complete) patella, left humerus, and right femur.

The Woolly mammoths from Siberia included the following specimens, with nickname, catalogue number, location, and current storage (only nicknames are included in the Tables):

- ➤ *Tamyrskii mammoth* – male, neotype ZIN RAN #2710, Mamontovaya River (ZIN RAN #2710), Taimyr Peninsula, Siberia, Zoological Institute/Museum, Rus. Acad. of Sci., St.Petersburg, Russia

- ➤ *Berezovka mammoth* – male, ZIN RAN #5315, Berezovka River, Eastern Siberia, Yakutia, Zoological Institute/Museum, Rus. Acad. of Sci., St.Petersburg, Russia

- ➤ *Yuribei mammoth* – male, PIN # 3941, Gydan Peninsula, Western Siberia; Paleontological Institute, Rus. Acad. of Sci., Moscow, Russia

- ➤ *Kozlovo site* – male, #116/261, Perm District (Ural Mountains), Kazan State University, Russia (Garutt, 1992)

- ➤ *Kutomanov's mammoth* – male, ZIN RAN #31736, Mokhovaya River, Siberia, Zoological Institute/Museum, Rus. Acad. of Sci., St.Petersburg, Russia

- ➤ *Lenskii mammoth* – male, ZIN RAN #71911, Lena River, Siberia, Zoological Institute/ Museum, Rus. Acad. of Sci., St.Petersburg, Russia

- ➤ *Sanga-Yuryakh mammoth* – female, ZIN RAN 31738, Sanga-Yuryakh River, Yakutia, Zoological Institute/Museum, Rus. Acad. of Sci., St. Petersburg, Russia

- ➤ *Oyesh mammoth (female, unknown catalogue #),* Oyesh River, Novosibirsk District, Siberia, Novosibirsk Natural History Museum, Russia

- ➤ *Kamskoe Ustie Specimen #1* - (?) male, ZIN RAN 30873/#173/226; both humerus epiphysis fused, Tatar Autonomous Republic, Zoological Museum, St.Petersburg, Russia

- ➤ *Kamskoe Ustie Specimen #2* – (?) female, ZIN RAN 30873/#185/56; both humerus epiphysis fused, Tatar Autonomous Republic, Zoological Museum, St.Petersburg, Russia

- ➤ *Kamskoe Ustie Specimen #3* – adult female, ZIN RAN 30873/#173/223; both humerus epiphyses fused, Tatar Autonomous Republic, Zoological Museum, St.Petersburg, Russia

- ➤ *Tura River mammoth* – gender unknown, Tumen Natural History Museum, Tumen, Russia

- ➤ *Rostov District specimens* (n=5), vicinity of city of Kamensk, Rostov District, Russia. Large specimens, Late Middle Pleistocene.

MAMMUTHUS TAXONOMY AND SPECIES PRESENCE IN THE LATE PLEISTOCENE OF NORTH AMERICA

The most recent and detailed assessment of the state of knowledge regarding *Mammuthus* taxonomy was performed by Agenbroad (1994, 2005). Unfortunately, the taxonomy of mammoths on the North American continent remains unsolved due to the fragmentary state of material ascribed to new species and lack of new investigations (Osborn, 1942, Maglio, 1973, Kurten and Andersen, 1980, Madden, 1981; Lister, 2007). We support the model with three species for the Late – Middle Wisconsin (65-35 Ka, or oxygen isotope stages 3-2): *Mammuthus columbi* (with synonyms *M. jeffersoni* and *M. jacksoni*), *Mammuthus primigenius*, and *M. exilis*. Interestingly, the preliminary mtDNA analyses of two mammoth specimens indicate that *M. jeffersonii* may represent a hybrid of *M. columbi* and *M. primigenius* (Fisher, 2001; Hoyle, 2004; Enk et al., 2011), but more specimens should be tested genetically to confirm this result.

According the FAUNMAP database, 29 localities with *M. columbi* are known for the United States, with 6 localities in Texas, dated between 10,000-20,000 yrs. B.P. There are 28 localities in the United States known for *M. primigenius*, but none is recorded in Texas (Graham and Lundelius, 1994). Grayson and Meltzer (2002) reported 10 sites with mammoth remains in Texas, with only two sites (Lubbock and Miami) clearly associated with Clovis age hunters. Detailed review of all the sites in Texas yielding mammoth remains (with very few identified to species level) is given in Chapter 3.

Species Identification in Proboscidea

Most extinct species of Proboscidea, and more specifically, the Mammuthinae representatives, including *M. columbi*, and *M. primigenius*, are described from isolated specimens (Falconer, 1957; Osborn, 1942; Blummenbach, 1799; Maschenko, 2010). Few specimens received detailed descriptions of their whole skeletons (Warren, 1852; Zalenskii, 1903; Osborn, 1922; Garutt, 1954; Garutt et al., 1990; Dubrovo, 1982; Tikhonov, 1996; Maschenko et al., 2011) and until now, most of the recovered mammoth remains, especially postcranial elements, are not sufficiently described and measured to form a basis for accurate identification. A very limited metric analysis has been done on the Columbian mammoth (Agenbroad, 1994; Dutrow, 1977). A detailed paper on Columbian mammoth bone measurements, standard methods of measurement, and morphological descriptions is currently in preparation (Agenbroad et al., 2007; Agenbroad and Potapova, in prep.).

There are no guides available to compare any of the mammoth species with one another. However, comparison of skeletal elements from the American mastodon and the Woolly mammoth was conducted by Olsen (1979), allowing paleontologists and archeologists to recognize the basic differences between the species.

Species Identification of Mammoth Remains from Site 41BX1239

The bones recovered from jackets #8, #11, and #16 from site 41BX1239 include mandible fragments, a humerus shaft, a patella, and distal condyles of femur. Unfortunately, no teeth were recovered, and the rest of the bones are very fragmentary (missing epiphysis, etc.). This situation makes it extremely difficult to assign with certainty the recovered remains to a *Mammuthus* species level; and allows identification of the bones only with reasonable probability.

Individual Age and Gender Identification in *Mammuthus*

Individual Age

Individual age identification in *Mammuthus* is predominantly based on tooth generation and wear in studies done in African elephants (Laws, 1966). Bone maturation (fusion of epiphysis on long bones)

is also reflected in mammoth skeletons (Roth, 1984; Haynes, 1991).

According our preliminary observations, the sesamoid bones (metapodials, sesamoids, and patella), as well as carpal and tarsal bones, mature early in individual mammoth development. The bone maturation most likely occurs at the time of sexual maturity of the animal, at about 12-14 years of age.

Lister (1994, 1999) provided long bone maturation data for Woolly mammoth males in African elephant years (AEY) and Asian elephant years, comparing those to dental aging based on Lawes' (1966) charts. This study allowed him to compare those species' rates of maturation with that of Columbian mammoths, based on his studies of the Mammoth Site specimens. Lister concluded that in comparison to Eurasian Woolly mammoth and modern elephants, the Columbian mammoth species had a different relationship of the fusion sequence to tooth eruption. The possible reason could be the larger body size of *M. columbi* (10 tons vs. 6 tons), which would suggest a significantly longer life span for *M. columbi*. Lister (1994) suggested that in Columbian mammoths bone fusion occurs at younger dental ages than in smaller species. Significant differences in growth patterns are also observed in modern African and Asian elephants (Hanks, 1972).

However, there is a further complication. A study by Averianov (1994), that was unknown to Lister (1994, 1999), demonstrated that similar dental-aged Woolly mammoths (Oyesh and Kozlov mammoths have different (younger) bone ages, based on the epiphyseal fusion. The same situation (older age based on teeth, but younger age based on the bones) is observed in the Lenskii (male), Taimyr and Sanga-Yuraykh (female) mammoths (Averianov, 1994).

Thus, aging specimens based on their epiphyseal fusion should be used with caution, and conclusions based on these data would be only preliminary.

Gender Identification

Mammoth gender determination on the basis of skeletal remains is somewhat limited, due to considerable overlapping of males and females, especially if male individuals are young. With regard to Woolly mammoths, when compared within a local population (area), the tusks in males and females differ significantly in size and level of curvature (Vereschagin and Tikhonov, 1986; Kuzmina, 2000). Unfortunately, no

such research has been performed for the Columbian mammoth. Nor would it be useful in this case.

Gender can also be determined from bones belonging to very large or very small animals. The smallest individuals with fused epiphyses are females, and the largest individuals, with or without fused epiphyses, are males (Baryshnikov 1977). The differences in long bones were studied for the Woolly mammoth from the Late Pleistocene "Berelekh" graveyard in Yakutia, which is thought to have accumulated during a relatively short time period and belong roughly to the same population of mammoths. Averianov (1994) provided descriptions of Woolly mammoth male and female skulls, mandibles, and atlases. Unfortunately, the individual sizes of postcranial bones remain unpublished (Vereschagin 1977; Baryshnikov et al., 1977).

Finally, the morphology of the pelvis can determine gender (Lister and Agenbroad, 1994; Lister, 1996).

The minimum requirements for valid identification of the mammoth gender based on the skeletal elements received for analyses would be at least the complete humerus (with epiphyses present), the complete mandible, and a complete distal end of a femur. Without these complete or partially complete (not fragments!) bones, identification of mammoth remains from site 41BX1239 cannot be done with certainty.

The individual age (in AEY) available for the Woolly mammoth dental maturation is used in Table 6.1 for humerus.

RESULTS

After the bones from jackets 8, 11, and 16 were prepared and stabilized, the bones were identified as follows (Table 6.2 and Figure 6.1).

BONE IDENTIFICATIONS AND DESCRIPTIONS

MANDIBLE (JACKET 11, BONE B-29E/29W, FRAGMENTS A, B, AND C)

MORPHOLOGICAL DESCRIPTION

When glued together, fragments A, B and C measured: length 328 mm, and height 154 mm. The reassembled fragments represent the lateral side of the right ramus with remnants of tooth roots (Figures 6.2 and 6.3). This portion of the mandible comes from the area of connection of *corpus mandibulae* and *processus coronoideus*.

AGE AND SEX

Not applicable. The fragment is not sufficient to provide this information.

PATHOLOGY

No pathological morphology was observed on any of the fragments.

TAPHONOMY/MODIFICATION

The lateral surface of the lower part of the mandibular ramus is covered by a mosaic of fragments that were flaked off and then "jammed" into the ramus body. The lateral surface of A, B and C is covered with numerous cracks. All fragment edges are abraded, and demonstrate no fresh bone breaks. The lateral surface of the bone does not display any cutting or butchering marks.

The medial side of the alveoli is also heavily abraded. Lower parts of the tooth roots are attached to the caudal portion of the fragment. Remnants of at least nine plates are present.

All the fragmented parts of the bone demonstrate dry breaks, i.e., breakages that occurred after the animal's burial. The condition of this mandible corresponds to weathering stage 1 in the scale developed by Behrensmeyer (1987), which is typical for bones exposed to the elements for up to three years.

None of the bone modifications on this bone cluster could be validly assigned to human activity.

UNIDENTIFIED BONE FRAGMENTS CLUSTER (JACKET 11, BONE B-29E/29W, FRAGMENT D)

MORPHOLOGICAL DESCRIPTION

The cluster is 237 mm long and 137 mm wide. It is composed of fragments with thick cortical bone, possibly ribs (better preserved on side 1, Figure 6.4) and possibly from flat bone (perhaps the coronoid process of the mandible, side 1, Figure 6.4), held together by sediment.

Due to extremely poor condition, none of the skeletal elements can be validly determined.

AGE AND SEX

Not applicable.

Faunal Analyses of Select Mammoth Bones from the San Antonio River Mammoth Site   69

Table 6.1.   Measurements (mm) and Comparisons of Humerus Parameters of Mammuthus. The ages of the M. columbi in AEY are given in accordance with Lister (1994, 1999), and M. primigenius in accordance with Zalenskii (1905); Dubinin & Garutt (1954), Dubrovo (1982), Averianov (1992b, 1994), Garutt & Lister (1999).

Species	Specimins	SD (latero-medial diameter)	Minimum Diaphysis	Gender	Individual Age (AEY)
Mammuthus sp.	Bone-30	97	85	Unknown	Unknown
Mammuthus columbi	83HS171 (sin)	166	-	Unknown	Unknown
	83HS187	168	-	Unknown	Unknown
	83HS248	-	115	Unknown	Unknown
	90HS076	158	-	Unknown	Unknown
	MSL 132	164	-	Male	47-49
	79HS040 (MSL 689), complete; proximal and distal ends fused, no fusion lines visible	126	96	(?) Male	Adult ≥41
	MSL 634 (dex), proximal end broken off, distal end present, unkown if fusion line is present	145	111	(?) Male	Adult >26
	No cat. # (sin), unfused proximal and distal ends	105	98	Unknown	Subadult, >6 – 26
	No cat. # (sin), unfused proximal end (missing), distal end present: unknown if fusion line is present)	141	120	(?) Male	Adult, >26 – 41
	No cat. # (dex), unfused prox. End (dist. end broken off)	127	94	(?) Male	Young adult <41
	83HS220 (sin)	-	82	Male	>41
	83HS270 (dex)	-	-	Male	>41
	No field #	-	-		>41
M. primigenius	✦ Hebior (sin)	108*	-	Male	Unknown
	✦ Taimyrskii	102	-	Male	43 – 47
	✦ Yuribei	83/86	-	Female	12
	✦ Kutomanov	116	-	Male	43
	✦ Kozlovo	88	-	Male	40 – 45
	✦ Berezovkskii	99, 110	-	Male	30 – 35
	✦ Lena River	120, 127	-	Male	43 – 47
	✦ Sanga-Yuryakh	88	-	Female	60
	✦ Oyesh	85	-	Female	Unknown
	✦ Kamskoe Ustie (#1)	116	-	(?) Male	22 – 24 (±2)
	✦ Kamskoe Ustie (#2)	105	-	(?) Female	22 – 24 (±2)
	Kamskoe Ustie (#3)	98	-	Female	Unknown
	Tura River	128	-	Unknown	Unknown
	Rostov District (n=5)	98-2-147.6	-	Unknown	Unknown

* The measurement is a very close estimate, due to the inaccuracies in the replica (the minimum diameter of the mold is 113mm, but the mold has a ridge on the cranial surface, which does not belong there and adds ~ 5mm more to the diameter).

✦ Complete or almost complete skeltons

Table 6.2.   Tabulated Results of the Faunal Study, According to Received Plaster Jackets

Jacket (bin #)	Bone #	Field Bone ID by SWCA	Bone ID in this Study	Comments
8	B-37	Patella, Un-diagnostic cluster	Right Patella	Complete element
	B-38	Astragalus (possible) And Bone-large cluster	A. Right femur lateral condyle, large fragment with portion of the shaft	No astragalus was recovered/ identified Right femur condyle fragments B and C are glued together
			B. Right femur lateral condyle, large fragment	
			C. Femur condyle small fragment, possibly portion of the fragment B	
			D. (?) Femur shaft fragments	
			E. Rib fragment	
11	B-29E B-29W	Mandible And Tooth	A. Right mandible large fragment	Three pieces of mandible A, B, and C are glued together
			B. Right mandible large fragment	
			C. Small mandible fragment	
			D. Right large bone cluster (including small rib fragments)	
16	B-30	Proximal humerus	A, B. Right humerus diaphysis with large distal portion	A and B not glued together (missing pieces), but are placed in one jacket
			B. Rib fragments	
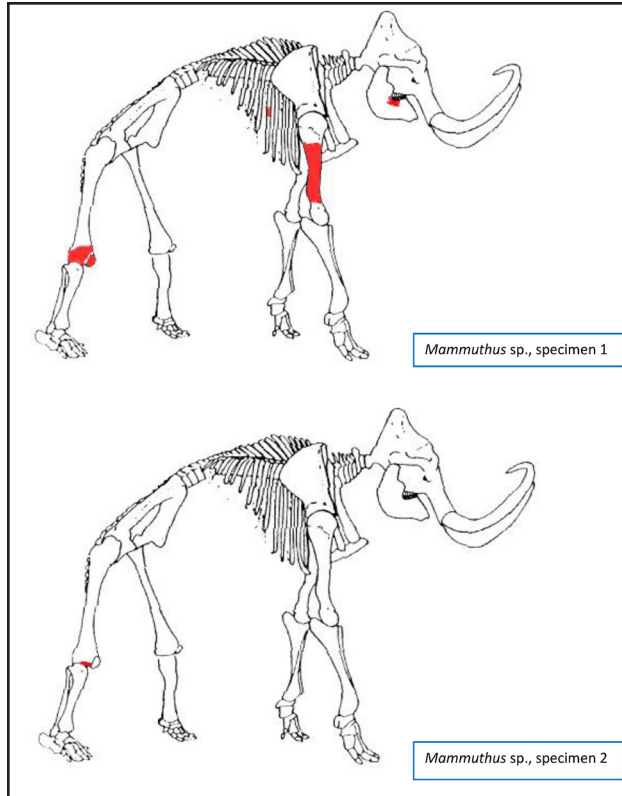
Figure 6.1. Simplified representation of recovered mammoth skeletal elements from jackets #8, #11, and #16 (there is not enough data to associate the bones with each other and within two specimens).

Figure 6.2. Reassembled mandible fragments.

PATHOLOGY

No pathological morphology was observed on any of the fragments in the cluster.

TAPHONOMY/MODIFICATION

The cluster of bones consists of flat fragments from 10 mm to 90 mm, representing a remnant of a pile of bones accumulated at one spot. The edges of the fragments in this cluster are heavily abraded, and all represent dry breaks, i.e., breakages that occurred after the animal(s) were buried.

None of the bone modifications on this bone cluster could be validly assigned to human activity.

RIGHT HUMERUS (JACKET 16, BONE B-30, FRAGMENTS A AND B)

MORPHOLOGICAL DESCRIPTION

The specimen B-30 is composed of two large fragments: A, the shaft, the larger fragment, and B, its proximal end (Figure 6.5). The two fragments were already separated in the jacket. The proximal end also fell apart along the large transverse crack, but was glued back together.

The humerus *diaphysis* (shaft) is characterized by massive *crista humeri*, *sulcus radialis*, and a portion of *crista supracondylaris lateralis*. The blood vessel foramen on the medial surface of the bone is also present. Both proximal and distal epiphyses are broken off. Since both the proximal and distal epiphyses are missing (and with no additional material), it cannot be determined if the epiphyses were fused to the shaft.

Diameters of humerus shafts in species *M. columbi* and *M. primigenius* significantly overlap. It is obvious even for the small sample of specimens (Table 6.1, Figures 6.6 and 6.7). Humerus shafts of *M. primigenius* females may exceed in size not only those of males of the same species, but can also be close to those of young Columbian mammoths. This is especially apparent among the populations of Middle Pleistocene mammoths: *M. primigenius* from the (Eurasian) late Middle Pleistocene is larger (Baigusheva, 1980) and closer in size to *M. columbi*. The size of the humerus shaft from the 41BX1239 site is very close to the young Columbian mammoth specimen, but its identification as *M. primigenius* also cannot be ruled out.
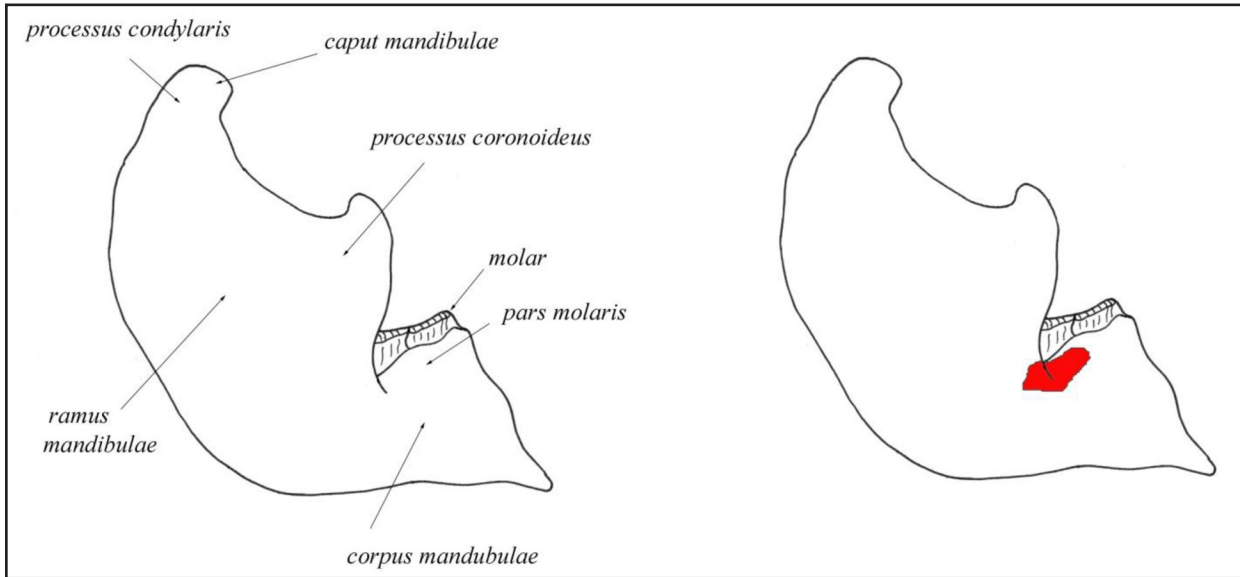
Figure 6.3.   The mammoth mandible morphology and approximate location of the bone #B-29E/29W,

Figure 6.4.   Unidentified bone fragments cluster.

AGE AND SEX

The intermediate size of the humerus does not allow its gender identification. Since the proximal and distal ends are missing, it is also impossible to identify the individual's age.

PATHOLOGY

No pathological morphology was observed on this bone.

TAPHONOMY/MODIFICATION

Bone condition is very poor. The bone's proximal part is covered by multiple cracks: it is flattened (crushed) latero-medially, probably due to the weight of sediments. The bone is composed of more than hundred fragments, especially on the proximal end. The fragmented parts of the humerus are supported and held together by sediments. The cracks developed on the lateral side extend into the cancellous interior, so the fragments are separated in patches and at different depths forming a mosaic pattern (see Behrensmeyer, 1987). This bone condition corresponds to weathering stage 1 in the scale developed by Behrensmeyer (1987), which is typical for bones exposed to the elements for up to three years. Similar condition of some bones (including a femur) was recorded at the Colby Mammoth site, indicating that the bones were

| Cranial view | Caudal view | Medial view | Lateral view |
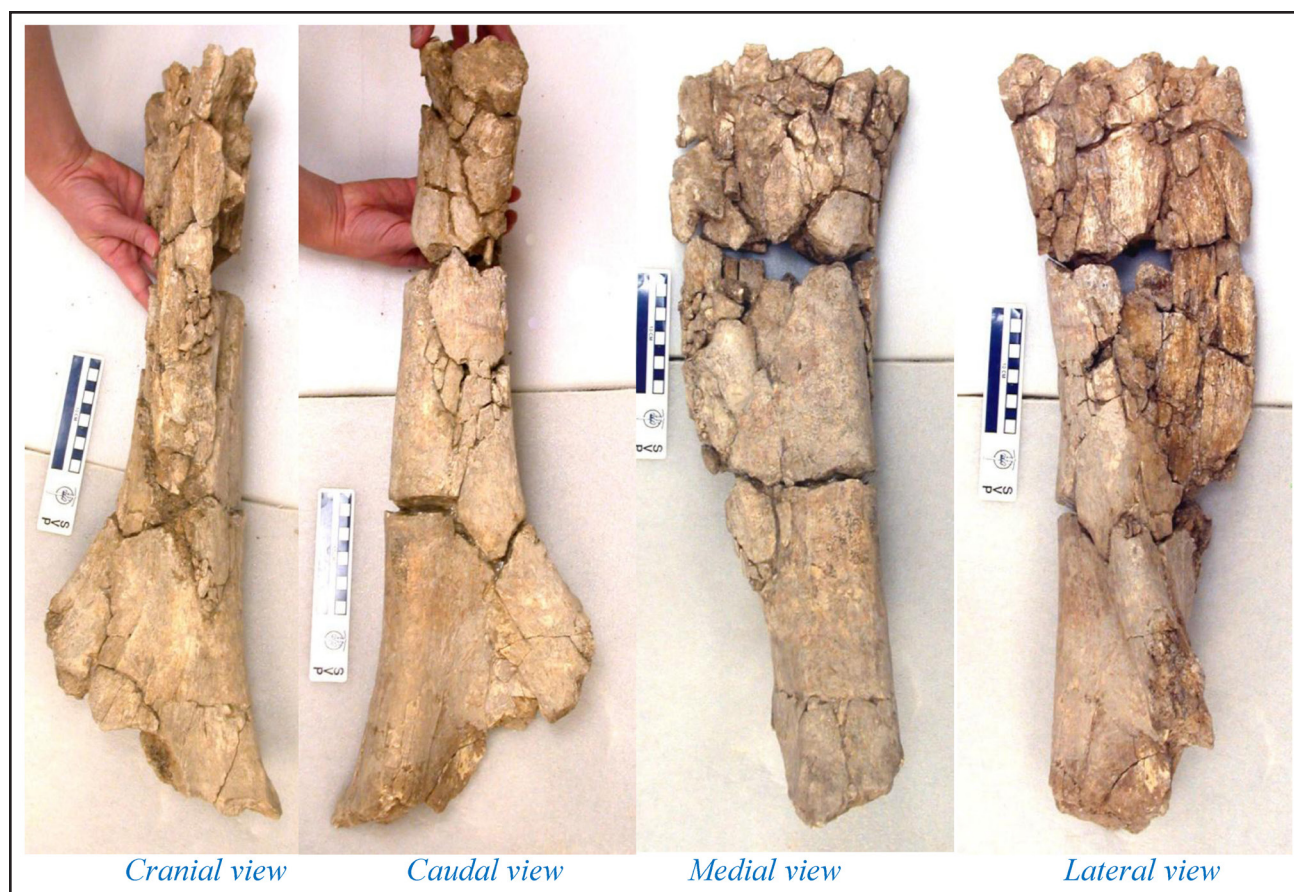
Figure 6.5. Right humerus fragments.

not buried in a wet environment, such as swamp or bog (Todd and Frison, 1987).

Most of the cracks developed in dry bone: the crack walls are straight and do not demonstrate any flaking edges.

Thorough observations of the shaft ends allowed us to find two spiral-type flaked marks on the bone: one (length 42 mm) is located on proximal side of the bone -right on the edge of fragment B, where the bones pieces fell apart; and the other (length 54 mm) occurs at another fracture on the distal end. The edges of these spiral flaked marks are heavily abraded and do not allow us to definitely consider them as cultural modifications. However, cultural modification cannot be completely ruled out: 96% of the humeri found in the Hudson-Meng Alberta Bison Kill site bonebed had major damage in the epiphyseal area, with partially or totally missing heads, necks, and lateral tuberosities (Agenbroad 1978).

None of the bone modifications on this humerus could be validly assigned to human activity.

RIB FRAGMENT (JACKET 16, BONE B-30, C)

MORPHOLOGICAL DESCRIPTION

The rib fragment belongs to a medial portion of the rib (Figure 6.8). Distal and proximal ends are missing. The rib is crushed into several dozen fragments, and broken into two parts, which are slightly superimposed on each other, all held together by sediments. The fragment is 125 mm long and 85 mm wide, at its widest point. Based on its poor state and size, the rib fragment cannot be identified at the species level and assigned to the *Mammuthus* sp.

AGE AND SEX

The specimen is too fragmentary to provide any information on age and sex.

PATHOLOGY

No pathological morphology was observed on this bone.

TAPHONOMY /MODIFICATION

The rib is heavily fragmented and crushed after the bone's burial, most likely under the weight of sediments or possibly trampling. The rib broke into two parts, which were displaced at an approximate 150° angle from one another, and preserved supported by sediments. All cracks seem to have occurred in the bone's dry stage.

None of the bone modifications on this fragment could be validly assigned to human activity.

LEFT FEMUR LATERAL CONDYLE FRAGMENT (JACKET #8, BONE B-38, FRAGMENT A)

MORPHOLOGICAL DESCRIPTION

The mammoth femur lateral condyle is considerably smaller (shorter and narrower) than the medial condyle (Figure 6.9). In ventral view it has an extended oval shape, slightly bulging in the middle, or has straight sides. It slightly narrows caudally and sometimes forms a lip separated from the shaft by shallow groove. Medially this shallow groove (which never forms an overhanging lip) continues into the *fossa intercondylaris*. The lateral side of the lateral condyle between the condyle surface and *epicondylus lateralis* is straight or slightly widened dorsally, but it never forms a deep concavity.

By contrast, the medial condyle has a trapezoid form in the ventral view, with the caudal lip widening caudally, or having a broad edge. Its medial lip significantly extends medially, forming a deep concave area between the condyle surface and *epicondylus medialis*. The medial condyle surface is caudally separated from the shaft by a deep groove with rounded walls. The groove continues into the lateral side of the condyle surface, forming a large overhanging lip.

B-38, fragment A, consists of 1) the femur lateral condyle, *condylus lateralis*; 2) a remaining small (medial) portion of the medial condyle, *condylus medialis* shifted upward and crushed; and 3) a fragmented portion of the lateral side of the femur shaft. *Trochlea ossis femoris* for articulation with the patella, and both epicondylesi, *epicondylus medialis* and *epicondylus lateralis* are missing.

On the caudal side of the fragment, there is a shallow groove where the shaft meets the lip of the lateral condyle and continues into *fossa intercondylaris*. The lateral side (wall) of the condyle has characteristic morphology with multiple pits and grooves; it is relatively straight, and there is no indication of a concave area. The surface is preserved by fragments held together by sediment, which fills the bone cavity inside. The contact zone between the wall and the condyle lateral ridge, represented by cancellous bone is somewhat abraded. The medial ridge of the trochlea though is preserved, together with the medial and dorsal portion of the inter-condyle groove, *fossa intercondylaris*.

The preserved caudal portion of the shaft is crushed and shifted distally, replacing the (missing) lateral condyle, and held by sediment.

Unfortunately, the *M. primigenius* metric data relevant to B-38 is not available in published literature. It is highly probable that the lateral condyle sizes of the Columbian mammoth (especially in younger animals) and Woolly mammoth overlap.

The studied bone is very close to the lower limit of size for the Columbian mammoth, and possibly may belong to young (or female) Columbian mammoth individual (Table 6.3, Figures 6.10 and 6.11). However, its assignment to the Woolly mammoth cannot be ruled out.

AGE AND SEX

The specimen is too fragmentary to provide any information on age and sex.

PATHOLOGY

No pathological morphology was observed on this bone.

TAPHONOMY/MODIFICATION

Location of cut marks and butchering marks on the distal parts of long bones have been observed in mammoth, American mastodon and bison bones (Agenbroad, 1978; Binford, 1978; 1981; 1984, 1987; Zeimens, 1982; Fisher, 1984; Frison and Todd, 1987). Distal ends of the long bones, as well as the shafts, usually carry cut marks indicative of filleting and dismembering (Binford, 1981; Crader, 1983).

The femur shaft of B-38 is partially gone. Its remaining lateral side was broken off and shifted down in the caudal direction, and is being held there by sediments. This is definitely a postmortem modification, which occurred due to heavy weight of sediments applied to the bone.
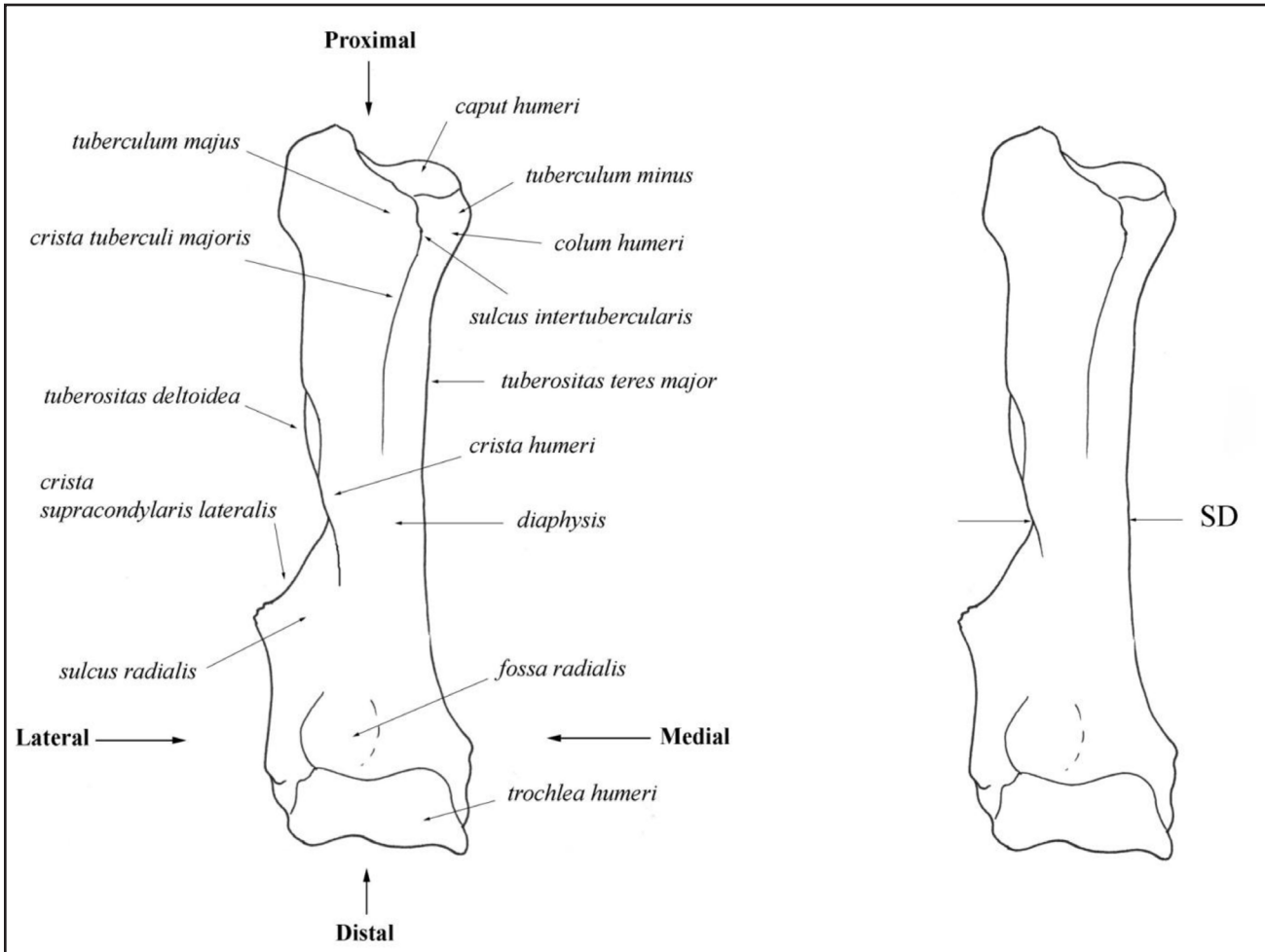
Figure 6.6. Mammuthus humerus morphology and methods of measurement.
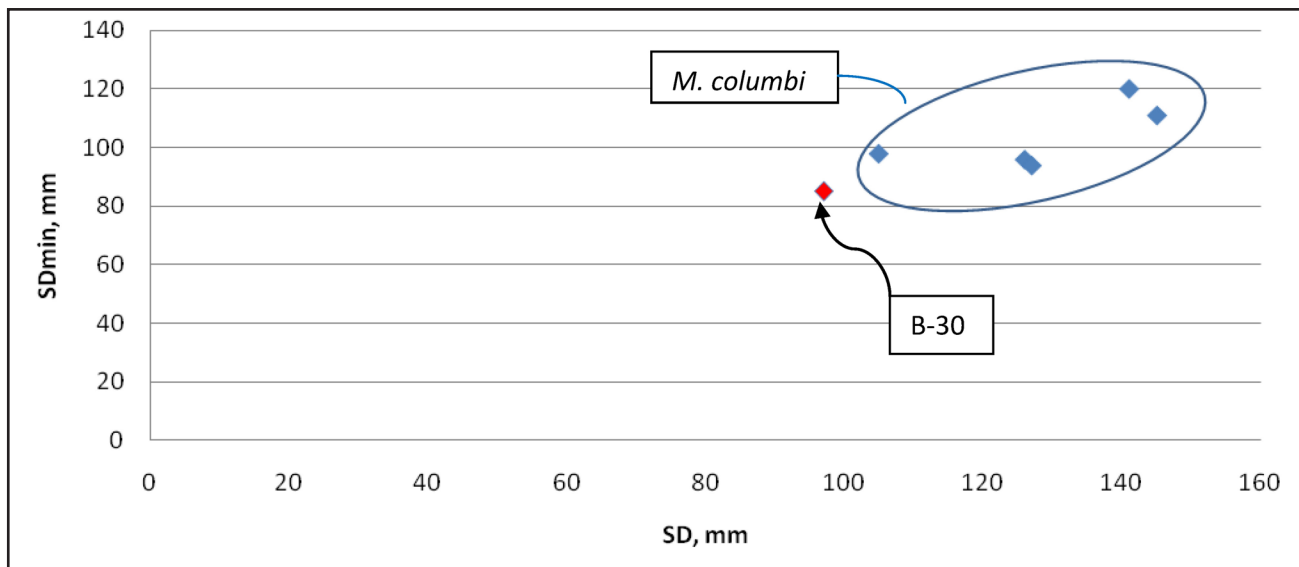
Figure 6.7. Plotted diagram of M. columbi humerus parameters.

Figure 6.8.   Rib fragment lateral and medial views.

The surface of the lateral condyle is covered by cracks, multiple small scratches (mostly developed in the anterior portion), pits, and a series of pits forming an irregular groove on the ventral-caudal side consistent with sediment abrasion. The cracks developed on the lateral side extend into the cancellous interior and form a mosaic pattern described on deteriorating bones by Behrensmeyer (1987): as splits and cracks reach the concentric separations, the bone surface separates in patches and at different depths. The condition of this lateral condyle corresponds to weathering stage 1 in the scale developed by Behrensmeyer (1987), which is similar to the stage observed for the studied humerus (B-30) and mandible (B-29). Similar condition of some bones (including a femur) was recorded at the Colby Mammoth site, Wyoming indicating that the bones from 41BX1239 were not buried in a wet environment, such as swamp or bog (Todd and Frison, 1987).

A large conical dent (25 mm in diameter, and 15 mm deep) is located on the lateral side of the condyle. Its walls of grooves, pits, and dents are heavily abraded. Its presence could possibly be attributed to cultural modification, as this would be the appropriate location for using shafts as pry bars or wedges for disarticulation of joints. Such dents in similar locations were discovered on distal femurs in the Black Water mammoth, New Mexico but the latter had multiple applications and clear cut marks on the bone (Saunders et al., 1994). In this case, the occurrence of this dent alone and the absence of cut marks made by artifacts on the bone prohibits our considering the modification as a cultural modification.

None of the bone modifications on this fragment could be validly assigned to human activity. However, a potential cultural modification of this bone cannot be ruled out: distally broken-off femur epiphyses were occasionally found among butchered bison at the Folsom Agate Basin Site (Ziemens, 1982).

Left Femur Lateral Condyle Fragments (2) (Jacket 8, Bone B-38, Fragments B and C)

Morphological Description

These two bone fragments most likely come from the same element, a single femur condyle, even though the fragments lack ideal contact between them (both cancellous and cortical components are abraded). The two fragments are glued together where they most likely belong (Figure 6.12).

The bone's morphology is almost identical to B-38, fragment A. The straight wall without concavity is preserved on the lateral side of the condyle, and a portion of the intercondyle groove, *fossa intercondylaris*, is preserved on the medial side. The shallow *fossa intercondylaris* continues into the groove located under the caudal side of the condyle lip.

The morphology and size of this condyle (width 87 mm in the middle) fragment is comparable with the lateral
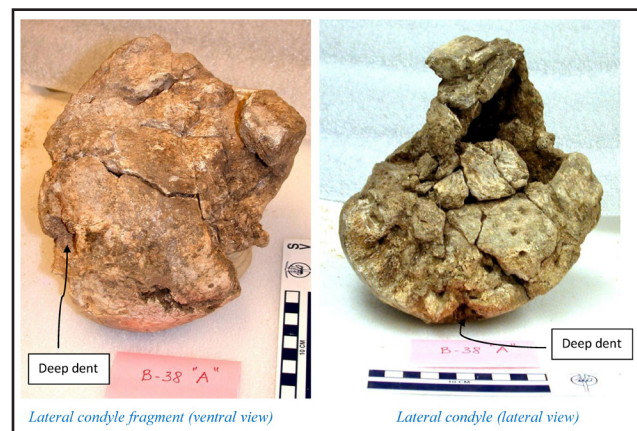
Figure 6.9.   Left femur lateral condyle fragment.

Table 6.3. Sizes (mm) of the Femur Lateral Condyle in Mammuthus

Specimen	Side	Blc	Bmc	Distal Epiphysis State
Mammuthus sp. (41BX1239 site)				
Fragment A	dex	102.00	-	unknown
Fragment B-C	dex	87.00	-	unknown
M. columbi (Mammoth Site of Hot Springs, SD)				
92HS060 (HS00402)	dex	108.00	115	unfused
MSL 657	sin	118.00	141	unfused
MSL 699	sin	115.00	126	unfused
76HS171 (MSL 880)	dex	97.00	117	unfused
MSL 821	dex	98.00	133	unfused
MSL 910	dex	111.00	140	unfused

condyle B-38, fragment A (see above for description of B-38, fragment A morphology). Its size is somewhat smaller than fragment A, but possibly may belong to an animal of the same age and/or sex.

AGE AND SEX

The specimen is too fragmentary to provide any information on age and sex.

PATHOLOGY

No pathological morphology was observed on this bone.

TAPHONOMY/MODIFICATION

Location of cut marks and butchering marks on the distal parts of long bones have been observed in mammoth, American mastodon and bison bones (Agenbroad, 1978; Binford, 1978; 1981; 1984, 1987; Zeimens, 1982; Fisher, 1984; Frison and Todd, 1987). Distal ends of the long bones, as well as the shafts, usually carry cut marks indicative of filleting and dismembering (Binford, 1981; Crader, 1983).

The bone B-38, glued fragments B+C, is abraded on most of its sides, but one (lateral or medial) side with part of the intercondyle groove is partially preserved. The condyle's articulation surface has multiple damage (dents less than 4 mm in diameter) caused by sediments. The largest five round-shaped dents are 5 to 7 mm in diameter. The caudal part of the condyle has three larger (diameter ~5 x 10 mm) round notches; two diagonally crossing, v-shaped grooves; and one wide (15 mm) groove with uneven edges. All grooves and notches are heavily abraded and do not allow identification as being made in dry or green bone conditions.
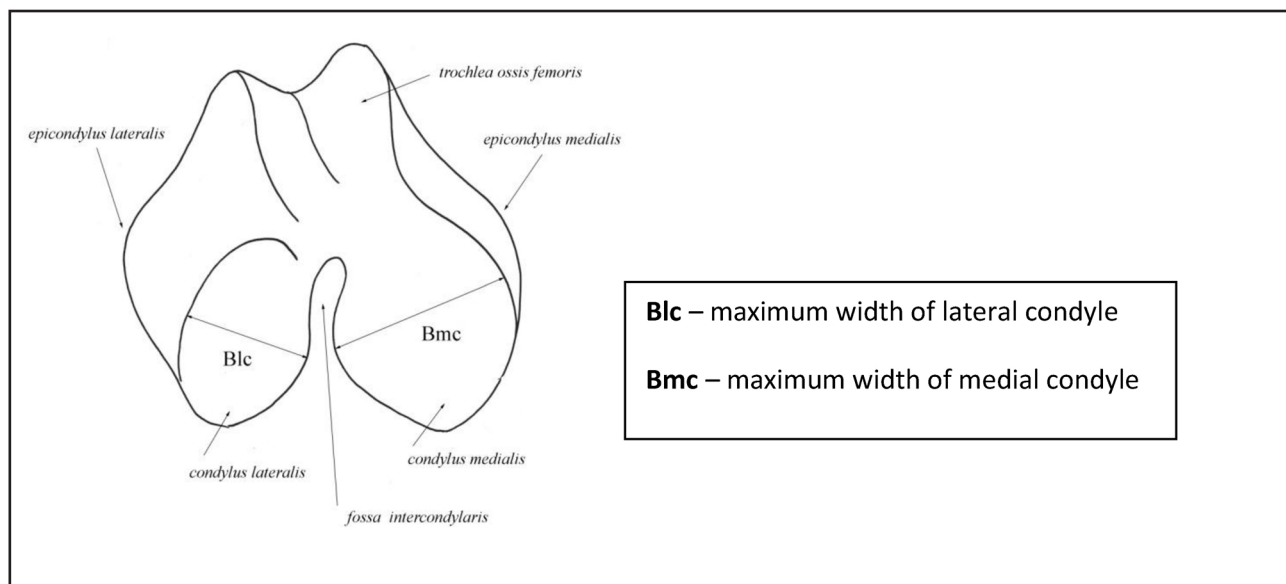
Figure 6.10. Method of measurement and morphology of mammoth distal epiphysis.
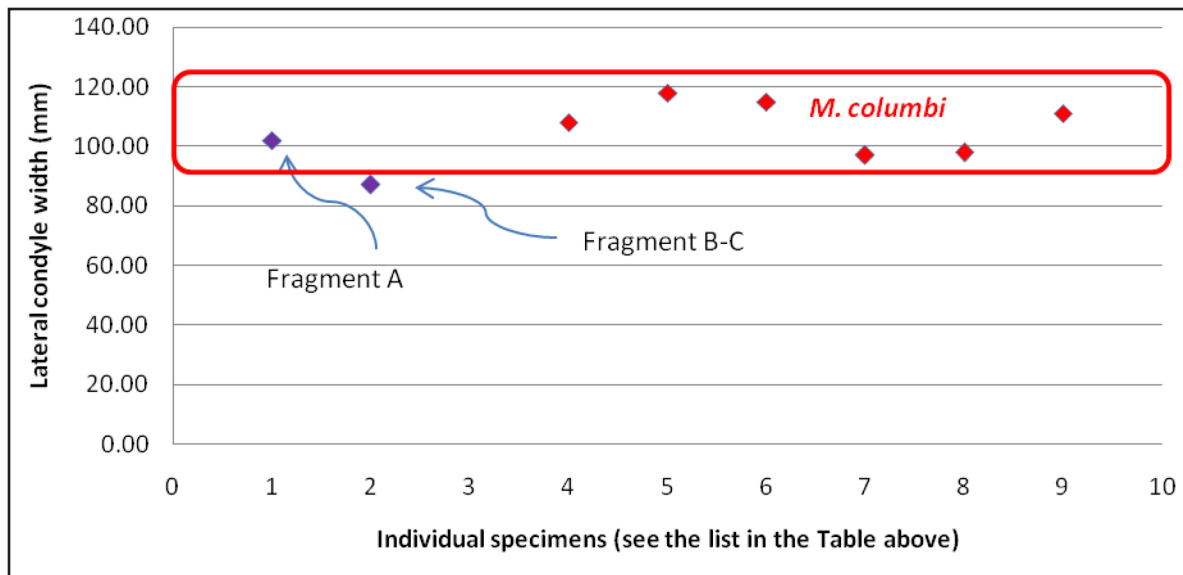
Figure 6.11.   Plotted diagram of lateral condyle widths in Mammuthus.

The dents are scattered randomly on the condyle surfaces and do not indicate the purposeful activity of dismemberment, which is convincingly demonstrated on mammoth carpals from the Black Water site 1 in New Mexico (Saunders et al., 1994). The occurrence of the large grooves on the caudal side of the condyle, their abraded state, and the absence of cut marks made by artifacts on the bone do not permit our identifying the modifications as cultural.

None of the bone modifications on this fragment could be validly assigned to human activity.

Right Patella (Jacket 8, Bone B-37)

Morphological Description

The patella is a sesamoid bone attached by tendons to the femur trochlea and located in the frontal joint between the femur and tibia (Figure 6.13). Specimen B-37 represents a complete, albeit damaged, relatively small right patella (Table 6.4, Figures 6.14 and 6.15). The articular surface (*facies articularis*) is rounded (flanging) on its lateral side and relatively straight on the medial side, which allows identification as belonging to the right limb. The apex (*apex patellae*) and base (*basis patellae*) extend dorsally beyond the articular surfaces, forming a shelf at the articular edges; each is distinguishable from the medial (base) and lateral (apex) sides of the bone. The base of the bone, in comparison to the apex, has greatest depth. Its anterior surface is covered with multiple vertical grooves.

Age and Sex

Eight patellae belonging to Columbian mammoths from the Mammoth Site collection were examined for this study, and compared to published Woolly mammoth bone parameters (Averianov, 1992; Garutt, 1992; Kosintsev et al., 2004). The patella B-37 appears to be closer in all three parameters to the Woolly mammoth, rather than the Columbian mammoth. However, since the stage of specimen maturity of the patella B-37 cannot be determined, its identification as a young Columbian mammoth cannot be completely ruled out.

Pathology

No pathological morphology was observed on this bone.

Taphonomy/Modification

The bone has hardly any cracks, and was preserved in a very good condition. Its weathering condition corresponds to weathering stage 0 on the scale developed by Behrensmeyer (1978). Weathering stage 0 is typical of bones exposed to the elements for no longer than one year.

The basis (dorsal end) and distal portion of the articular surface of the bone are somewhat damaged, exposing cancellous structure. While the basis is just abraded on its top and shelf on the lateral side, the medial edge of the articular surface is broken off exposing a zigzag line of breakage on the cortical part of the bone, and
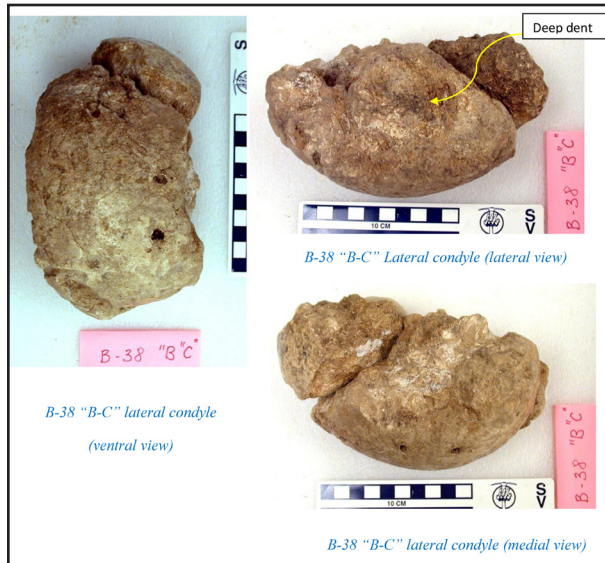
Figure 6.12. Left femur lateral condyle fragments.

two deep notches in the cancellous part of the bone, below the breakage line. The surface of the edges is abraded by sediment.

The proximal portion of the articular surface displays two small (10 mm and 14 mm long, 2-3 mm wide) vertically extended grooves. The distal end of the larger groove is connected to two very shallow, intersecting cuts (?), the longer of which is 15 mm. The grooves' profile is rounded, not V-shaped, which would be characteristic of cut marks. The grooves were most likely caused by sediment pressure or impact by other bones during trampling.

The breakage on the medial side of the patella is most likely dry breakage, caused postmortem.

None of the bone modifications on this fragment could be validly assigned to human activity.

Long Bone Fragments (Jacket #8, Bone B-38, Fragment Cluster D)

Morphological Description

There are six fragments, which we assigned to a long bone shaft, possibly a femur (Figure 6.16). The two largest fragments are definitely attribuTable to a long bone; and one of these has a thick cancellous matrix, which is typical for distal or proximal diaphysis. The fragment sizes of this cluster range between 40mm and 100mm in length.

Age and Sex

Not applicable

Taphonomy/Modification

The bones are split transversally and longitudinally, and have weathered surfaces. All the bone edges have heavy abrasions, and none of them displays anything other than dry" break modification. The condition of the bones matches Behrensmeyer's (1978) weathering stage 1, matching the condition of the mandible (B-29), humerus (B-30), and femur lateral condyle (B¬38, A).

None of the bone modifications on this fragment could be validly assigned to human activity.

Rib Fragments (Jacket #8, Bone 38, Fragment Cluster E)

Morphological Description

There are six rib fragments identified reliably, with sizes ranging from 25mm to 120 mm (Figure 6.17). All the fragments come from the rib shaft area, and it is impossible to identify the number or the side of the rib.

Figure 6.13. Right patella.

Table 6.4.   Sizes (mm) of the Patella in the Late Pleistocene Mammuthus

Species	Specimens	Gender	GL	GB	GT	Age (AEY)
Mammuthus sp.	B-37, 41HX1239		>	100	80	
Mammuthus columbi	Mammoth Site, N=8	Males	144-162	107-127	79-99	unknown
M. primigenius	Hebior	Male	123	139	-	unknown
	Lenskii	Male	143	124	-	43-47
	Taimyrskii	Male	123	99	-	43-47
	Kutomanov	Male	138	110	-	43-47

* The length of the bone (GL) is estimated to be between 123mm - 130mm

AGE AND SEX

Not applicable.

TAPHONOMY/MODIFICATION

The fragments come from ribs split transversally and longitudinally. All the bones demonstrate dry breaks that occurred after the animal's death and burial. The bones edges are heavily abraded. The bone condition corresponds to weathering stage 1 in Behrensmeyer's (1978) scale, matching the conditions of the mandible (B-29), humerus (B-30), femur lateral condyle (B-38, A), and (?) femur shaft (B-38, E).

None of the bone modifications on this fragment could be validly assigned to human activity.

SUMMARY AND RECOMMENDATIONS

The following mammoth bone remains are identified from three jackets (8, 11 and 16):

1. Mandible (B-29E, 29W, fragments A, B, and C)

2. Unidentified cluster of fragmented bones (B-29E, B-29W, fragment D)

3. Right humerus shaft (B-30, fragments A (a+b), and B)

4. Rib fragment (B-30, fragment C)

5. Right femur lateral condyle (B-38, fragment A)

6. Right femur lateral condyle (B-38, fragments B and C)
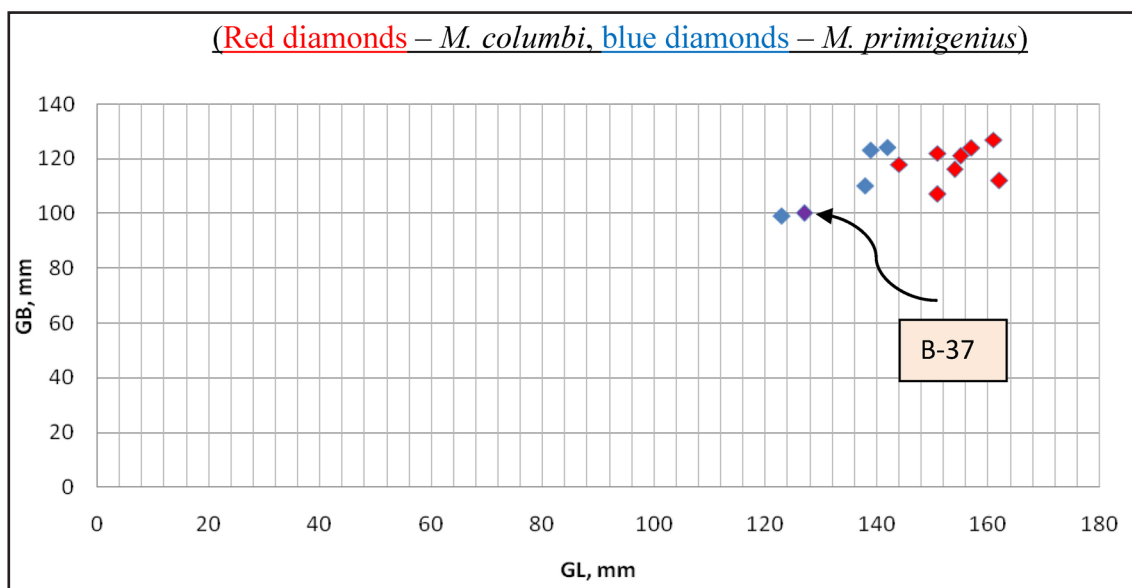
Figure 6.14.   Plotted graph of distribution of the length (GL) and width (GB) for patella in Mammoths.
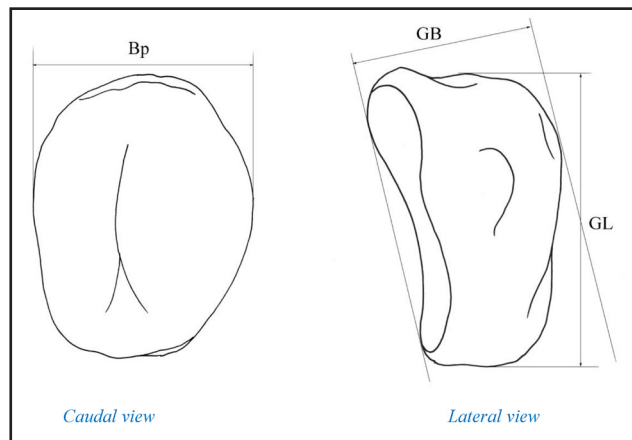
Figure 6.15.   Method of measurements of patella.

7.   (?) Right femur shaft fragment (B-38, fragment D)

8.   Rib fragments (B-38, fragment E)

9.   Right complete patella (B-37)

The species identification based on prepared bones from the jackets is *Mammuthus* sp. (Woolly, *M. primigenius*, or Columbian, *M. columbi*, mammoth). Identification of age and sex of the animal(s), based on the examined bones listed above, is impossible.

No definite or valid cultural modification was observed on these bones. The grooves, pits, and other damages observed on the bone surfaces could be a result of animal trampling (based on taphonomical studies (Behrensmeyer et al., 1986; Fiorillo, 1989),

and probably are attribuTable to post-depositional processes. However, the possibility that some bones (femur distal condyles) could be culturally modified cannot be completely ruled out.

Taphonomical observations on at least the humerus and femur indicate that the bones were not entombed in wet environmental conditions. Most of the examined bones demonstrate weathering stage 1 on the Behrensmeyer (1978) scale, created for large mammals in Amboseli Basin, Kenya. The condition of the mammoth bones from site 41BX1239 provides evidence that they were exposed to the elements for up to three years before they were entombed in sediments.

No pathological modifications on the bones were discovered.

Based on the femur condyle identifications, the bone remains from site 41BX1239 come from *two mammoths*. While one specimen might be represented by an almost complete skeleton, the other may be represented by few skeletal elements. This would not be an unusual situation, especially if there evidence of human activity, or cultural modification present. The closest example could be the account of the Clovis Lange-Ferguson Mammoth Site in South Dakota: remains of two specimens were recorded, one an adult male (almost a complete skeleton with butcher and cut marks), and the other a sub-adult male or female individual (only a few bone remains) (Martin, 1983, 1984, 1987; Hannus, 1985, 1990). Close attention is recommended while preparing and identifying the skeletal elements in the future. This could reveal more information on the number of mammoth specimens recovered on the site, and whether or not cultural modification occurred.

Figure 6.16.   Long bone fragments.
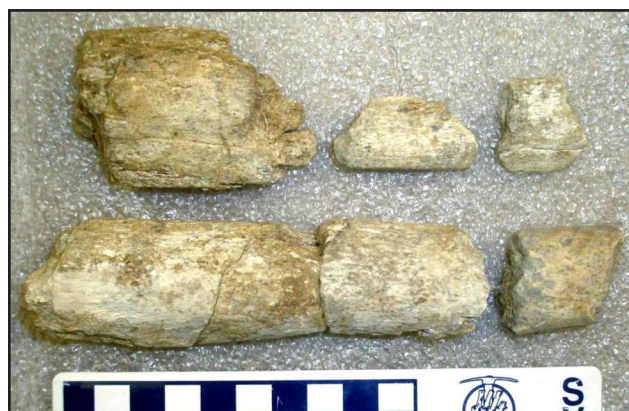
Figure 6.17.   Rib fragments.

Geomorphic Investigations at the San Antonio River Mammoth Site

C. Britt Bousman

Introduction

One of the major emphases of this project is the use of geomorphic investigations to help understand the development of the local landscape and the context in which the mammoth remains occur. This is of critical importance for this investigation. This chapter consists of four sections. The first outlines the objectives of these investigations and the methods used. The second discusses the geomorphic processes relevant to this study. The third, primary part of the chapter, presents the evidence from 41BX1239. The final section summarizes the previous results and integrates this with the pollen and phytolith study.

Objectives and Methods

The geological investigations at 41BX1239 had three objectives. The first was to establish the sequence of deposits at the site. The second objective was to identify the geological contexts of the mammoth remains, which requires identifying the depositional environments represented by the stratigraphy and sediments. The general depositional contexts could be fluvial, colluvial, or eolian, although mostly alluvial contexts were expected, as this site is in a floodplain setting. The third objective was to assess the dynamic nature of the landscape.

In order to accomplish these objectives, a number of procedures were applied. First, a review of the background geological literature indicated that the sediments in the project area were derived from parent material of varying particle size and primarily of fluvial origin (Barnes 1983; Mandel et al 2007; Plummer et al 1932; Taylor 1987; Websoilsuvey.nrcs.usda.gov/app/WebSoilSurvey.aspx, downloaded January 22, 2012). It was expected that most of the sediments encountered would be sand and silts; however clays and a low percentage of gravel or larger clasts could be expected. Second, profiles were documented and selected profiles were sampled for sediments. Third, selected sediment samples were submitted for textural, chemical and other analysis and the results interpreted.

A general approach that was applied throughout the geological investigations was the use of multiple working hypotheses (Chamberlin 1965 [1890]). For example, during the assessment of depositional environment, each site was compared to a group of modern environments. These comparisons utilized as many different lines of evidence as possible, and a final assessment was not made until all lines of evidence had been considered.

Sediment Descriptions and Soil Formation Processes

Detailed descriptions of five backhoe trench profiles are provided in Appendix A (Figure 7.1). The descriptions of the deposits use the geologically neutral concept of "zone" to avoid prejudicing interpretation by attaching specific labels such as "soil," "sediment," "stratum," etc. to whatever was observed in a given profile. Zone changes are based on any change in the color, particle size, cohesiveness, structure, boundaries, inclusions, and sorting. Each recorded entity meets the definition of a zone as "any regular or irregular layer of earth materials characterized as distinct from surrounding parts by some particular property or content" (Gary et al. 1972:80). This versatile concept permits the designation of any perceived "layer" in a profile as a zone whether it resulted from pedogenesis, sedimentation, cultural activity, or an unidentified process as long as it is homogeneous in character and readily distinguishable from adjacent zones. When sufficient information was at hand, then a zone was assigned a specific soil horizon designation.

All sediment colors were recorded when the samples were moist in the field using a Munsell Soil Color Chart. All sediment textures were estimated in the field by "feel" following the guidelines set forth by Olson (1981:23–24). Sedimentary structures, including evidence of bioturbation, as discussed by Reineck and Singh (1975) were identified when possible. Surficial topographic features were used to assist in identifying environments of deposition. Additionally, subsurface

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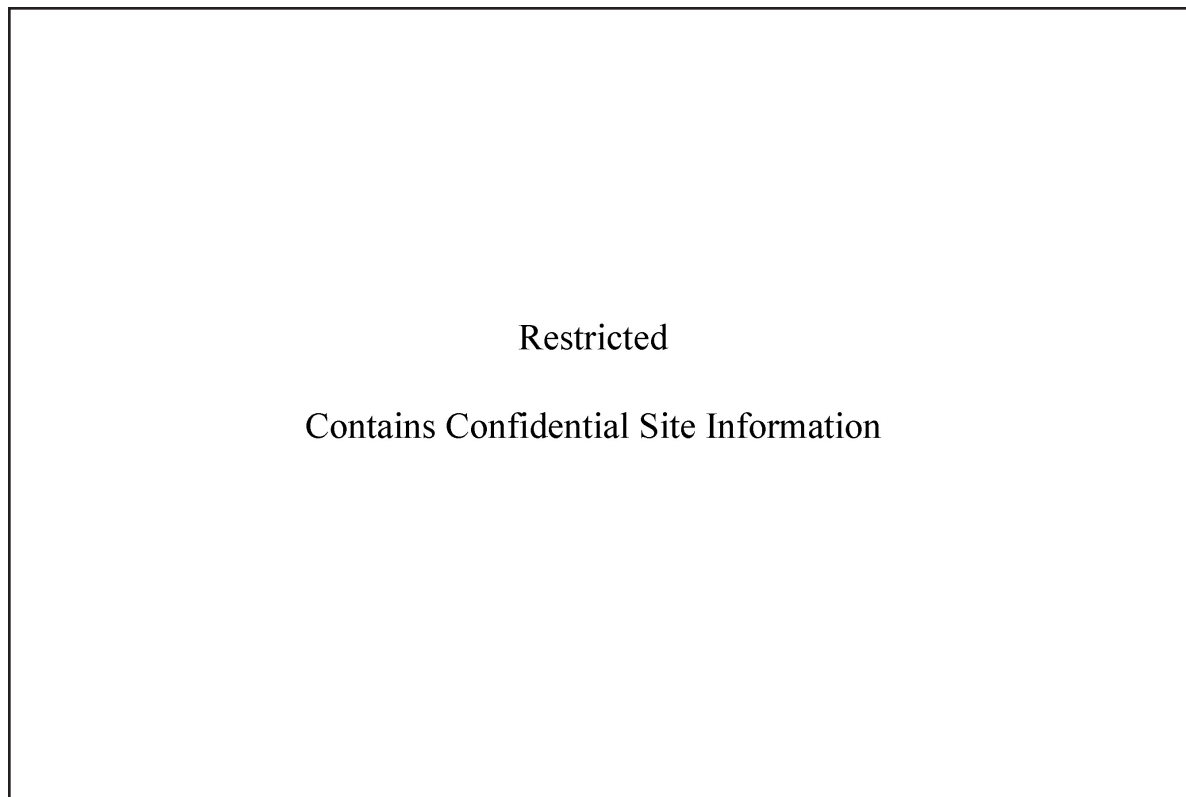
Figure 7.1.   Site map with backhoe trench and profile locations on 41BX1239.

evidence such as buried soils and particle size changes were used to identify geomorphic features.

After description and assessment, standard soil horizons as defined in Soil Survey Staff (2010:313–321, http://soils.usda.gov/technical/classification/tax_keys/index.html) were applied. Standard master soil horizons (0, L, A, E, B, C, and R) were augmented with a subordinate classification system that is denoted by adding a small-letter suffix to the master symbol marked by a capital letter. The 0 horizons refer to the uppermost zone of a soil that still has identifiable organic material such as leaf litter. The L horizons are limnic horizons composed of organic and mineral materials that were deposited by water or through the actions of aquatic organisms. These deposits consist of sedimentary peat, diatomaceous earth and marl. The A horizons have no identifiable organic material, but decomposed organic matter is present as well as mineral components. The A horizons are usually darker than 0 horizons and may be depleted of clay and carbonates due to a downward movement of water, i.e., eluviation. Some horizons are characterized by an even greater loss of material, usually clay or minerals. These are E horizons and normally have a lighter color than overlying A horizons. The B horizons

have less organic matter and more mineral constituents than A or E horizons, including the minerals that moved down from A or E horizons into the B horizons. The B horizons may have increased clay, iron, aluminum, humus, carbonate, gypsum or silica contents through illuviation and are usually not as dark as A horizons and may be a redder hue than either an A horizon or E horizon. In C horizons, the parent material is relatively less affected by pedogenesis than the overlying A, E or B soil horizons, but some indication of soil formation does exist. R horizons refer to bedrock. In some cases, two master horizon designations are used together, and this marks a transitional zone.

Several subordinate designations (Soil Survey Staff 2010: 317–319) were used in these investigations. Horizons with clay accumulations due to illuviation or in situ genesis are listed with a "t" suffix. Normally these are associated with B horizons and they are represented as Bt horizons. Buried horizons are noted by a "b." The use of "k" denotes the accumulation of secondary pedogenic calcium carbonates. Arabic numerals prefixes preceding master horizon designations indicate lithological discontinuities (Soil Survey Staff 2010:320). In all cases these lithological discontinuities, which are marked by unconformities, indicate shifts to older

sedimentary units and are numbered sequentially by depositional unit. Horizons without an Arabic numeral prefix are the most recent or only geological unit, i.e., A1 versus 2A1. The reader should consult Chapter 18, Designations for Horizons and Layers, in *Keys to Soil Taxonomy* for a more complete explanation of the notation system (Soil Survey Staff 2010).

SEDIMENT ANALYSIS

An assessment of the geological deposits at an archeological site is crucial for understanding the sequence and nature of the events that resulted in the formation of the sedimentary matrix that contains archeological remains. An analysis of the sediments allows for an assessment of the depositional contexts and processes that created a site, and provides a measure of the integrity of the archeological record at a specific site. Other factors such as bioturbation from animal burrowing or plant growth, and post-depositional geological processes such as compaction or warping, to name just a few, can greatly alter the integrity of a site as well. However, the first step toward assessing site integrity is an analysis of the sedimentary environment in which the site occurs. The environment of burial can best be identified through a detailed analysis of sediments. All other factors being equal, certain environments deposit certain particles in terms of differing sizes, and an analysis of the distribution of particle sizes along with other stratigraphic information can be used to deduce many parameters of sediment deposition.

Figure 7.2. Profile 5 on eastern wall of TAMU BHT 7 along southern margin of mammoth bone bed excavations.

Twenty-one samples from Profile 5 in BHT 7 (Figure 7.2) were submitted to the Soil Characterization Laboratory at Texas A&M University for textural and chemical analysis. The same samples were measured for magnetic susceptibility at the Center for Archaeological Studies at Texas State University. A subsample of ten samples from the original 21 samples was analyzed for carbon and nitrogen stable isotopes at the Center for Archaeological Research (CAR) at The University of Texas at San Antonio (UTSA) and the Colorado Plateau Stable Isotope Laboratory at Northern Arizona University. Subsamples of these same ten samples were submitted to Dr. Linda Scott Cummings at the PaleoResearch Institute for pollen, diatom and phytolith analysis (Scott Cummings and Yost 2011).

PARTICLE SIZE ANALYSIS

Sediment samples were taken at varying intervals from Profile 5 in BHT 7, and these samples were measured for grain size characteristics (Appendix B). In the late nineteenth century, a size classification of clastic sediments was developed based on a ratio scale of two. That is, each next largest class is twice as large as the size class below it. The scale uses millimeters, and, for example, the lower size limit for very fine sand is 0.0625 mm while the upper size limit is 0.125 mm (Folk 1980). Wentworth (1922) later modified this scale, and it is his divisions and terminology that are used today. Krumbein (1934) suggested that the millimeter sizes could be converted to a logarithmic scale which is known as the phi scale. The formula for this measure is phi = -log2 mm. Thus, a phi value of zero equals a sieve size of 1 mm, -1 phi equals 2 mm, 1 phi equals 0.5 mm, 4 phi equals 0.063 mm, and so on (Lewis 1984:58-59). As the phi value increases, the particle size decreases and vice versa. The use of logarithmic ratio scales for grain sizes results in more normally distributed sediment populations, which are easier to analyze statistically.

The bulk sediment samples used for textural and chemical analysis were dried in a forced-draft oven at about 35º C and crushed between electric motor-driven wooden rollers, which were spring loaded to allow passage of coarse fragments. The soil fines were passed through a 2-mm diameter sieve and mixed, and a representative sample was stored in a liter cardboard or plastic

carton. Any significant quantities of coarse fragments were soaked overnight in water and washed upon a 2 mm sieve, collected, dried, weighed and related back to the quantity of soil as a percentage by weight.

Particle-size distribution was obtained in duplicate using the pipette method of Kilmer and Alexander (1949). Samples (10 g) were dispersed in 400 ml of distilled water containing 5 ml of 10 percent sodium hexametaphosphate by shaking overnight on a horizontal oscillating shaker. Aliquots of 5 ml were taken at a 5-cm depth following a settling time as calculated by Stokes' equation (Baver 1965). Water from the aliquots was evaporated; the fines dried at 105º C and the amount of suspended solids weighed. The remaining dispersed sample was passed through a 300-mesh sieve; the retained sands were washed, dried at 105º C, and fractionated using a nest of sieves mounted on an oscillating shaker (Table 7.1). The samples were divided into coarse fragments (>2 mm), very coarse sand (2-1 mm) coarse sand (1-0.5 mm), medium sand (0.5-0.25 mm), fine sand (0.25-0.1 mm), very fine sand (0.1-0.05 mm), total silt (0.05-0.002 mm), fine silt (0.02-0.002 mm), total clay (<0.002 mm) and fine clay (<0.0002 mm). The raw percentages of these texture classes are presented in Appendix B. Any soluble salts or gypsum in the samples were removed prior to particle-size analysis. Gypsum was removed by heating the sample to 105º C and dialysis (Rivers et al. 1982). Soluble salts were removed by dialysis against water.

CHEMICAL ANALYSIS

Percentages of calcite and dolomite were determined using the gasometric procedure of Dreimanis (1962). The $CaCO_3$ equivalent was calculated from calcite and dolomite percentages. Total carbon was determined by dry combustion in a medium-temperature resistance furnace (Nelson and Sommers 1982). Organic carbon was calculated as the difference of total carbon and inorganic carbon as quantified in the $CaCO_3$ equivalent analyses.

The percent of organic carbon increases during the formation of A horizons developing in limnic environments. As plants grow, die, and decompose in these deposits, the percent of organic carbon increases. The percent of calcium carbonate ($CaCO_3$) can increase because of a couple of factors. First, $CaCO_3$ precipitation occurs when CO_2 pressure declines in the soil air, or when pH rises, or when the ion concentration increases to a point that the soil moister is saturated. These changes can occur because of root and microorganism respiration or organic matter decomposition. Also the amount of water leaching down through the soil can increase the amount of dissolved $CaCO_3$ within it. With depth, the CO_2 pressure increases and the calcium carbonate becomes more concentrated; however water is lost by evapotranspiration. At some point—the average depth of rainwater leaching—calcium carbonate is precipitated in the soil along root pores and other voids.

Gile et al. (1966; Birkeland 1974:272) has recognized four stages in calcium carbonate accumulation. In nongravelly parent

Table 7.1.   Divisions of Sediment Textures (adapted from http://soildata.tamu.edu/methods.pdf)

Fraction		Technique of Obtaining Fraction
Name	Size Range, microns	
Gravel — Granuals to pebbles to gravels	>2000	Sieve, round-hole, greater than 2mm
Sand — Very coarse sand	2000 – 1000	Sieve, round-hole, on 1mm – 2mm
Sand — Coarse sand	1000 – 500	Sieve, round-hole, on 0.5mm
Sand — Medium sand	500 – 250	Sieve, screen, on 0.25mm (60 meshes per inch)
Sand — Fine sand	250 – 100	Sieve, screen, on 0.1mm (140 meshes per inch)
Sand — Very fine sand	100 – 50	Sieve, screen, on 0.05mm (300 meshes per inch)
Silt — Coarse silt	50 – 20	Sieve, decantation
Silt — Medium silt	20 – 5	Decantation, centrifuge
Silt — Fine silt	5 – 2	Decantation, centrifuge
Clay — Coarse clay	2 – 0.2	Decantation, centrifuge
Clay — Medium clay	0.2 – 0.08	Decantation, supercentrifuge
Clay — Fine clay	<0.08	Decantation, supercentrifuge

material, Stage I consists of few filaments or faint coatings on sand grains. Stage II has few to common nodules of varying hardness and the matrix is calcareous. In Stage III, internodular matrix grains are coated and voids filled with carbonates. Stage IV consists of laminar horizon of nearly pure carbonate overlies a horizon of Stage III carbonates. This is also known as a petrocalcrete.

DEPOSITIONAL PROCESSES

Sedimentologists have developed a series of concepts, methodologies, and techniques for analyzing depositional environments using grain size distributions (Lewis 1984), and a short discussion of the development of these is worthwhile. Inman (1949) recognized three modes of sediment transport in fluvial contexts: traction, saltation, and suspension. Sediments moved by traction are rolled over the surface or, in terms of stream channel morphology, over the streambed. The energy level of the transportation process is not strong enough to lift traction particles off the surface, but it is strong enough to roll the particles along the bottom of the streambed. Particles moved by saltation are smaller than those moved by traction, and the energy level of the transportation process (i.e., flowing water) is great enough to actually pick up the particles, but only for short distances. Thus, particles moved by saltation actually bounce along the bottom of the channel. Particles moved by suspension are small enough that the energy of the water flow keeps the particles from settling down to the surface until flow stops and the particles begin to settle out. Obviously, any change in transportation energy (stream flow) will affect the sediments moved by the three transportation processes. While Inman recognized these three transportation processes, he made no association between grain size and transportation process.

A series of papers in the 1950s investigated the relationships between fluid mechanics and sediment transport (Chien 1956; Sundborg 1956; Vanoni and Brooks 1957; Brooks 1958), but again, these studies failed to integrate grain size into their analyses. At about the same time, Sindowski (1958) plotted grain size distribution curves from known modern depositional environments on log probability graphs in an attempt to identify different depositional environments, but no relationship was established between modes of transport and the grain size curves. A significant advance was made by Moss (1962, 1963), who related grain size and shape to mechanisms of sediment transport and deposition.

Thus, a link was finally established between transportation, deposition, and sediment texture. The three transportation and deposition mechanisms identified were the same as Inman's—traction, saltation, and suspension—and each transported different grain sizes. Subsequently, Visher (1969) combined the use of log probability plots of grain size and the three transportation/deposition processes to argue that the often-found three distinct populations on the log probability plots represented sediments deposited by traction, saltation, and suspension processes. Log probability plots are a graphical technique for assessing if the grain sizes, or for that matter any raw data, have a Gaussian (i.e., normal) distribution by plotting the frequencies as a cumulative distribution on log probability graphs. If the resultant line drawn through the plotted points is fairly straight, then the distribution is a single normal distribution. However, usually in sedimentology only portions of a curve, often consisting of three line segments, are straight and these straight plots are believed to represent separate distinct normally distributed sediment populations which resulted from different modes of transportation.

Moss and Walker (1978) successfully argued that colluvial transportation and deposition processes are, in reality, small-scale fluvial process and thus should reflect the same three transportation processes. They argued that the rate or degree of suspension transportation is controlled by material availability, whereas the bed load or traction population is sensitive to slope angle and length. Additional approaches pioneered by Folk (Folk and Ward 1957; Mason and Folk 1958) used standard statistical measures of moment such as mean, standard deviation, skewness, and kurtosis to analyze sediments from different depositional environments. The mean grain size is the average grain size. Standard deviation or sorting is a measurement of central tendency and illustrates how well a depositional process selects specific grain sizes. Standard deviations below 0.35 phi are considered very well sorted; well-sorted values range from 0.50 to 0.35 phi; moderately sorted values are from 1.00 to 0.50 phi; poorly sorted standard deviations range from 2.00 to 1.00 phi; and very poorly sorted values are greater than 2.00 phi (Folk 1980:103). Skewness measures the symmetry of the distribution in relation to the mean. A positive skewness value indicates that an extended distributional tail extends above the mean, and a negative skewness value indicates that a tail extends below the mean. Kurtosis is an indication of a peaked or flat distribution. The

higher the value, the greater the distribution is peaked. Skewness and kurtosis, while informative in some studies, have not been used in the analyses presented here. With the application of these methods and techniques, the analyses of sediments have allowed for relatively accurate assessments of depositional processes, the most important of which is fluvial deposition in alluvial settings.

EROSION PROCESSES

A great deal of research on erosion exists. These studies indicate that sediment loss can be estimated through an equation adapted from Wischmeier and Smith (1978): $A = (RKLS[l/C])$. This equation states that soil loss (A) increases as rainfall and runoff (R), soil erodibility (K), slope length (L), and slope steepness (S) increase, and as vegetation cover (C) decreases as measured by the reciprocal of vegetation cover. Soil erodibility for sediments with different particle size characteristics has been estimated by Ahn (1978), and this indicates that silts are the most susceptible and clays the least susceptible to erosion. Sands occupy an intermediate position in terms of erodibility. Also, as silt is added to sand, the sediment becomes more easily eroded, but as clay is added to sand, erosion of the sediments requires more energy. Any factor that might alter any of the above variables would influence erosion rates.

Moss and Walker (1978) argue that slope erosion (i.e., overland flow transportation of sediment) is a constant hydraulic process that, when unimpeded, establishes an equilibrium. They indicate that with rainfall, all slopes undergo erosion and slopes can be divided into zones of net erosion and net deposition. As stated above, erosion is a fluvial process and the same transportation mechanisms exist as in any other fluvial transportation system, i.e., traction, saltation, and suspension. Moss and Walker (1978) add that dense plant cover can significantly suppress overland flow transportation and allow pedogenesis. Once plant cover is reduced, a hydraulic imbalance results in rapid sediment erosion on the slope and colluvial sediment build-up in the zone of net deposition. Generally a significant decrease in slope angle, as normally occurs at the base of the toe slope, results in sediment deposition. Moss and Walker (1978) go on to say that the suspension load is controlled by the availability of material, and the bed load (i.e., traction population) is limited by bed load capacity, which is extremely slope sensitive. In other words, if the slope sediments in the net erosion zone have no particles small enough to be suspended (generally silts and clays), then no suspension load will be present, and as slopes steepen the traction load increases. However, given a constant slope angle, as slope distance increases one would expect that overland flow will increase and so would the traction population.

FACIES MODELS

Sedimentologists and quaternary geologists have developed a series of facies models that help interpret the past sedimentary environments that were responsible for creating sites. There are many different types of facies and definitions, but Reineck and Singh (1975:4) state "a sedimentary facies is the result of deposition in a given environment and thus possess characteristics of that specific environment." In the landmark paper by Walther (1894), it became clear that distinct horizontal and contemporary depositional environments produce unique sediment packages that are often found stacked vertically in a repetitive sequence (Middleton 1973). In other words, a specific sediment package is often followed by another distinctive sediment package. Facies models have been developed for virtually all possible depositional environments such as glaciers, coast lines, lakes, and floodplains. The model illustrated in Figure 7.3 shows simplified facies that are known to form in river floodplains. This diagram also incorporates the development of soil horizons as integral to the geological facies model. The primary elements of this model include a meandering river that deposits point bar sediments on the insides of the meanders and natural levees on the outside meander curves. Coarse sediments transported along the channel bottoms occur in the form of gravel beds and bars. During floods, natural levees are breached and the resulting spillage is known as a crevasse splay. Meanders migrate downstream due to cutbank erosion on the outside of the meanders where downstream flow directly collides with cutbanks. Within the channels there often exist deeper pools and intervening shallow rapids known as riffles. Streams often abandon channels to form new channels. If this happens rapidly, this is known as stream avulsion. When channels are abandoned they can fill with water and form oxbow lakes. During flood events, the coarser sediments are deposited near the channel—known as a thalweg—and finer-grained sediments are carried away from the channel into the adjoining flat floodplain. After large floods, floodplains can stay submerged for fairly long periods and all the sediment that was transported in suspension will eventually settle out and be deposited. Eventually the floodplains dry out,
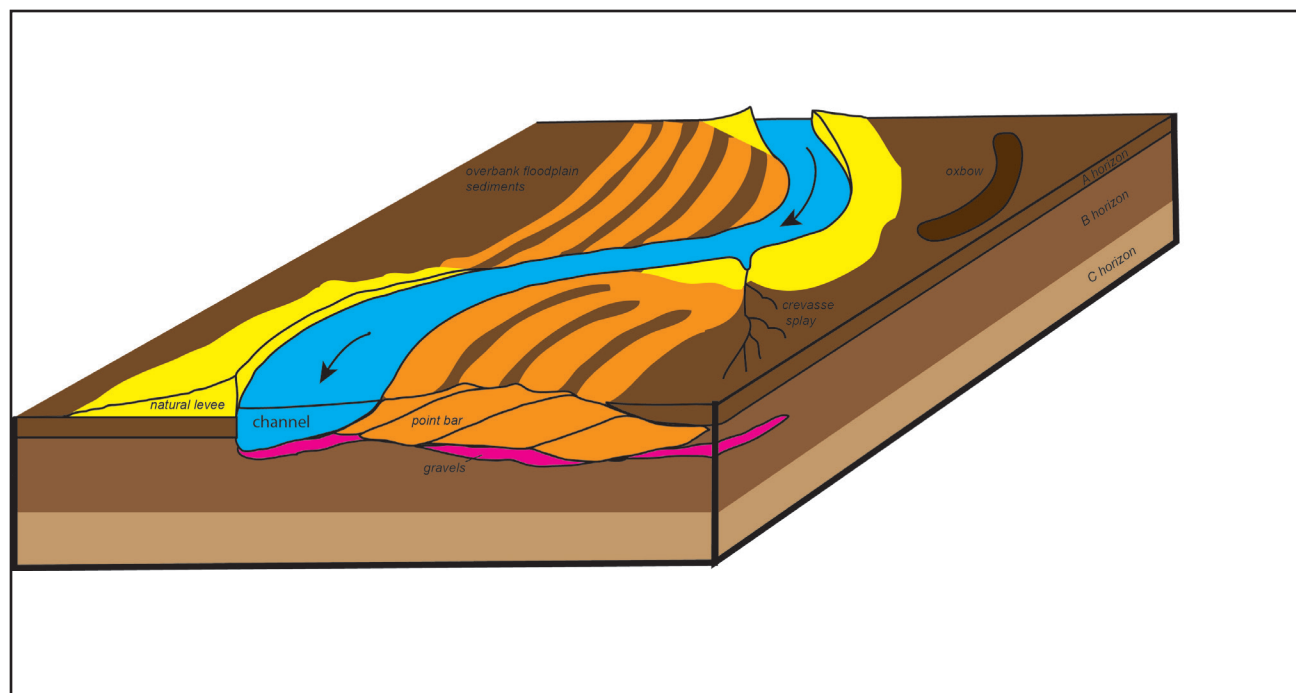
Figure 7.3.   Facies model for floodplain depositional environments (adapted from Singh 1972).

vegetation is reestablished, and soils form. In reality, the overall process is much more complex than this simple model but it provides a picture of how sediment and pedogenic facies fit together to form a model of floodplain development. Larger streams and rivers often have multiple packages of facies sets preserved and stacked vertically in a single terrace.

Stable Isotope Analysis in Archaeology

The use of stable isotopes in archaeology and geology has grown exponentially over the last 30 years. The number of uses has also expanded greatly. Still, there is a degree of confusion and poor understanding in archaeology on its uses in geoarchaeology. The following discussion is intended to provide the conceptual foundation on which these studies are based.

What is an Isotope?

Everything in nature is composed of atoms of individual elements and all atoms are composed of three types of particles known as protons, neutrons and electrons. Protons and neutrons are the largest and heaviest particles in an atom and they comprise the nucleus of an atom, which is surrounded by one or more electrons that orbit the nucleus. The electrons are very small and light in weight and they rotate around the nucleus similarly to the way the moon orbits the earth. Protons have a positive electrical charge and electrons have a

negative charge, so they attract each other; but neutrons have no charge. The number of protons determines the type of element (see periodic table). For example, carbon has six protons, nitrogen has seven, oxygen has eight, and hydrogen has only one. Usually atoms have an overall neutral charge and the number of electrons matches the number of protons. When an atom loses or gains an electron, then the atom attains a positive or negative charge respectively, and these are known as ions of an element. Thus isotopes of a single element are not determined by either protons or electrons. The only difference between isotopes of a single element is the number of neutrons in the nucleus of its atom. As a neutron is slightly heavier than a proton and much, much heavier than an electron, the number of neutrons in the nucleus can significantly affect the weight of the atom. The different weights of isotopes are very important since the weight of the atom influences how it is used in chemical reactions. Heavy isotopes (with more neutrons) are not used as readily as light ones. Nature does not like to work any harder than it must.

Chemists have a special notation for different isotopes of the same element, which indicates the number of neutrons and protons in an isotope. For example oxygen, always has eight protons, and two of its stable isotopes that are of interest to us have eight and 10 neutrons. These are identified as ^{16}O and ^{18}O, respectively. The superscript number immediately preceding

the element symbol is known as the mass number and refers to the total number of neutrons and protons. Thus the mass number serves to identify the specific isotope of that element and for the most part its weight.

CARBON ISOTOPES

Three carbon isotopes are most commonly used in isotopic analysis: ^{12}C, ^{13}C, and ^{14}C. Each carbon atom has six protons. ^{12}C has six neutrons, ^{13}C has seven neutrons, and ^{14}C has eight neutrons. As is well known through the use of radiocarbon dating, ^{14}C is an unstable radioactive isotope with a half-life of approximately 5,700 years. It is created by cosmic ray bombardment of ^{14}N in the atmosphere where the molecule loses a proton and adds a neutron so that the atomic number (14) remains the same. ^{14}C changes back to ^{14}N through the process of radioactive ß- particle decay (Taylor 1987: 1-2) where a neutron turns into a proton and produces an electron and an electron antineutrino ($^{14}_{6}C \rightarrow {}^{14}_{7}N + e^{-} + \bar{\nu}_e$). The other two carbon isotopes are stable, and thus allow for the study of their distribution in nature without the complication of radioactive decay.

Most researchers agree that changes in $^{12}C/^{13}C$ ratios in terrestrial ecosystems are most strongly influenced by plant photosynthesis. Three types of photosynthetic pathways are known to occur: C_3, C_4, and CAM (the subscripted number that follows an element symbol refers to molecule numbers and should not be confused with superscripted mass numbers of different isotopes). C_3 and C_4 plants are distinguished by the chemical composition of the energy molecules produced by their respective photosynthetic pathways. The terms C_3 and C_4 originate from products of the photosynthetic pathways. C_3 plants include all trees and woody shrubs and some of the grasses, and they use a photosynthetic pathway that produces a three-carbon molecule. This pathway is called the Calvin-Benson pathway and it is named after its discoverers. C_4 plants consist mostly of the remaining grasses (known as Krantz grasses, named after a unique anatomical structure in leaves) and a small variety of other plants. These plants use the Hatch-Slack pathway, with a four-carbon molecule produced during photosynthesis. It is significant that grasses are both C_3 species and C_4 species.

During the production of these three or four carbon molecules a plant may use any of the three stable carbon isotopes: ^{12}C, ^{13}C or ^{14}C. As noted above, the first two isotopes of carbon are stable, do not change, and are readily available in the atmosphere. Also these two stable carbon isotopes, as all isotopes do, have slightly different weights, and because of their weight difference the chemical reactions and physical process in the two photosynthetic pathways use ^{12}C and ^{13}C in slightly different ratios. This is because lighter isotopes have higher vibrational frequencies and thus form weaker bonds and are more reactive in chemical processes than heavier isotopes. (Vibrational frequencies are inversely related to the square root of an element's mass, i.e., v = $1/m^2$; thus the vibration frequencies of ^{12}C and ^{13}C are approximately equal to 0.083 and 0.077, respectively). The most important difference between the two photosynthetic pathways is that the C_4 photosynthetic pathway has the same basic steps as the C_3 pathway, but also the C_4 pathway has additional steps which allow it to more efficiently use all the available carbon. This does two things. First, C_4 plants are usually more resistant to water stress, but less capable of withstanding cold temperatures, especially minimum temperatures during the growing season (Vogel et al. 1978). This means that C_3/C_4 plant biomass ratios reflect climatic parameters. Second, the heavier isotope, ^{13}C, occurs in greater relative abundance in C_4 plants than it does in C_3 plants. Thus the ratios of the two stable carbon isotopes in C_3 and C_4 plants can be accurately measured with a mass spectrometer). Carbon isotope ratios in materials that form in soils and sediments thus provide a measurement of C_4 plants versus C_3 plants in the overall biota (Stuiver 1975; Flexor and Volkoff 1977; Vogel 1978; Krishnamurthy et al. 1982; Cerling 1984; Dzurec et al. 1985; Cerling and Hay 1986; Guillet et al. 1986; Haas et al. 1986; DeLaune 1986; Nakai and Koyama 1987; Schwartz et al. 1986; Volkoff and Cerri 1987; Natelhoffer and Fry 1988; Goodfriend 1988; Cerling et al. 1989).

One complicating factor to this situation is the existence of a third group of plants, CAM plants, which have the ability to switch back and forth between C_3 and C_4 pathways in response to climatic changes. If this occurs in significant amounts and degrees, CAM plants could blur the clear C_3/C_4 signals. CAM plants are mostly succulents and cacti and these occur in large numbers in Texas, plus a study of two of the most common CAM plants in Texas, prickly pear (Opuntia spp.) and lecheguilla (Agave lecheguilla), suggests that these plants normally produce isotopic ratios similar to C_4 pathways (Eickmeier and Bender 1976; Marino and DeNiro 1987).

The measurement of carbon isotope ratios is calibrated to the $^{13}C/^{12}C$ ratio in a special piece of marine belemnite limestone from the Pee Dee Formation in South Carolina. As this marine limestone, known as the PDB standard, has an enormous amount of ^{13}C in relation to ^{12}C, most materials from terrestrial sources such as living plants have much less ^{13}C. Thus, most materials are called *light*. This usually results in measurements of terrestrial materials attaining a negative number. The measurement is represented by the notation $\delta^{13}C$, i.e., delta ^{13}C, and is expressed in parts per mil or ‰. The formula for calculating $\delta^{13}C$ values is:

$$\delta^{13}C = \left[(^{13}C/^{12}C\text{-sample})/(^{13}C/^{12}C\text{-standard}) -1 \right] \text{ x } 1000$$

The preindustrial atmospheric $\delta^{13}C$ value is estimated at -6.0‰, but C_3 plants have much less ^{13}C and their $\delta^{13}C$ value is approximately -26‰ after the fractionation that occurs in soils (Nordt et al. 2008). C_4 and CAM plants have more ^{13}C and their average $\delta^{13}C$ value is near -12‰. In other words, C_4 and CAM plant $\delta^{13}C$ values are higher, less negative, but heavier, which reflects more ^{13}C than is present in C_3 plants (Figure 7.4). In materials that represent an accumulation between both types of plants, such as the organic fraction in soils, the $\delta^{13}C$ value should range between -26‰ and -12‰, and given no further chemical changes, the value should reflect the relative biomass contribution of C_3 and C_4 plants to this material.

Unfortunately, additional chemical reactions, known as fractionation effects, alter the isotope ratios. Fractionation effects occur in most materials such as soils, calcium carbonate nodules, or bone and this complicates the picture—but not hopelessly. In fact, the assimilation of carbon isotopes from the atmosphere into plants through the process of photosynthesis is the first major fractionation step. Thus, C_3 plants fractionate the atmospheric source of carbon isotopes to a lesser extent than C_4 plants. Additional fractionation steps occur as carbon isotopes pass from plants into animals, soils, and other materials and the degree of fractionation change varies by material. However, all stable isotopes, including oxygen and nitrogen, undergo fractionation due to unequal weights and it is this process that allows stable isotope analysis. At this point it is easiest to discuss the application of stable carbon isotope analysis by material.

$\delta^{13}C$ value	Isotopes	Plants
-12‰ (heavy)	^{13}C	C_4
-26‰ (light)	^{12}C	C_3

Figure 7.4. Illustration of relationships between carbon isotope measurements, isotopes and plants.

SOIL HUMATES AND CARBON ISOTOPES

Carbon isotope measurements on bulk soil or sediment humates have been used for assessing botanic changes between C_3 and C_4/CAM plants (Stuiver 1975; Flexor and Volkoff 1977; Krishnamurthy et al. 1982; Cerling 1984; Dzurec et al. 1985; Cerling and Hay 1986; Guillet et al. 1988; Haas et al. 1986; Nakai and Koyama 1987; Schwartz et al. 1987; Volkoff and Cerri 1987; Natelhoffer and Fry 1988; Cerling et al. 1989). Nordt et al. (2008) present a revised mass balance equation to estimate the percent of C_4 biomass represented by the soil stable carbon isotope measurement. Their formula is:

$$\delta^{13}C = -12(x) + -26(1-x)$$

where x represents the percent of C_4 biomass in a soil. This formula can be converted algebraically to:

$$\% \ C_4 \text{ plant biomass contribution to soil} = (\delta^{13}C + 26)/14.$$

This formula assumes that the average $\delta^{13}C$ value for C_3 plants is -26.0‰ and the average $\delta^{13}C$ value for C_4/CAM plants is -12.0‰. Additionally the soil humate model assumes that carbon isotopes in bulk soil humates are not significantly fractionated from the ratios inherited from plants. It should be noted that there is disagreement among various researchers on the actual $\delta^{13}C$ values for C_3 and C_4/CAM plants, and the degree of fractionation. Nevertheless, it is doubtful that these figures will change by a significant amount and the estimates presented below are probably fairly accurate. It should also be noted that the carbon in the soils represent an average of all the carbon in the soil. Temporally this represents the mean residence time (MRT) of the organic carbon in radiocarbon dating. Stable carbon

isotope ratios also represent a range of carbon reflected by the accumulation of the total amount of carbon that has built up in the soil (Hillaire-Marcel et al. 1989).

NITROGEN ISOTOPES

Two stable nitrogen isotopes are used in paleoenvironmental and dietary analysis: ^{15}N and ^{14}N. The $^{15}N/^{14}N$ ratios are calculated by the formula:

$$\delta^{15}N = \left[(^{15}N/^{14}N\text{-sample})/(^{15}N/^{14}N\text{-standard}) -1 \right] x \\ 1000$$

This formula indicates that as the amount of ^{15}N increases in the sample then the resulting $\delta^{15}N$ value will be higher (i.e., heavier). The standard for $^{15}N/^{14}N$ ratio measurements is air, and it is given an arbitrary value of 0‰.

In terrestrial botanic communities $^{15}N/^{14}N$ ratios can be used to divide plants into two groups: legumes and all other plants (Virginia and Delwiche 1982). Legumes have slightly less ^{15}N and their corresponding $\delta^{15}N$ values are consistently lower (Figure 7.5). The difference is not due to isotopic fractionation by plants, such as occurs with carbon isotopes by photosynthesis, but rather it is due to the ability of legumes to extract or to fix nitrogen from two sources: gaseous N_2 from the atmosphere, as well as nitrate and ammonium ions from the soil. Other plants, non-legumes, can only fix nitrogen from soil nitrate and ammonium. Atmospheric $\delta^{15}N$ values average 0‰, while nitrate and ammonium have higher $\delta^{15}N$ values (Letolle 1980). As atmospheric N_2 has lower $\delta^{15}N$ values than soil nitrogen, this difference is transferred to plants with very little change in the $^{15}N/^{14}N$ ratios. On average, legumes have $\delta^{15}N$

$\delta^{15}N$ value	Isotopes	Plants
9‰ (heavy)	^{15}N	non-legumes
↕	↕	↕
1‰ (light)	^{14}N	legumes

Figure 7.5.   Illustration of relationships between nitrogen isotope measurements, isotopes and plants.

values near 1‰ and $\delta^{15}N$ values of nonlegume plants are close to 9‰ (DeNiro 1987).

Adapting the same mass balance equation presented by Nordt et al. (2002) for nitrogen, the basic equation is:

$$\delta^{15}N = 1x+9(1-x)$$

Where x = the percent of legumes in biomass. This can be algebraically converted to:

$$x = (\delta^{15}N-9)/-8$$

Initially, $^{15}N/^{14}N$ ratios from scrapings taken from the interiors of prehistoric ceramic vessels or $^{15}N/^{14}N$ ratios from human bone were used in paleodietary studies to measure the introduction of beans as agricultural products through North America (DeNiro and Epstein 1981; Farnsworth et. al. 1985), but a number of new studies have discovered complications to this approach (DeNiro and Epstein 1981; Schoeninger et al. 1982; DeNiro and Hastorf 1985; Heaton et al. 1986; Heaton 1987; Sealy et al. 1987). The first complication is the enrichment of ^{15}N as nitrogen isotopes pass from primary producer (plants) to consumer (animals). This effect increases $\delta^{15}N$ values by approximately 3‰ for each trophic level and it occurs in both terrestrial and marine food webs (DeNiro and Epstein 1981; Schoeninger et al. 1982). Recently, this has been used to estimate the high consumption of meat in Neanderthals' diet (Bocherens 2009; Richards and Trinkhaus 2009).

Additional complications consist of environmental effects on $\delta^{15}N$ values in ecological systems (Heaton et al. 1986; Heaton 1987; Sealy et al. 1987). Two environmental effects are known: aridity and salinity. Heaton et al. (1986) and Sealy et al. (1987) have shown that stable nitrogen isotope ratios in human and mammal bone collagen are negatively correlated with mean annual rainfall, while Heaton (1987) has demonstrated that $\delta^{15}N$ values in plants are also negatively correlated with mean annual rainfall. Even though the higher $\delta^{15}N$ values in plants would be passed on to animals, the rate of nitrogen fractionation correlated to aridity is greater in animals than in plants. Higher $\delta^{15}N$ values in animals appears to be a metabolic response to water stress, but this response has not been demonstrated for plants. In fact, Shearer et al.(1978) have shown that $\delta^{15}N$ values in total soil nitrogen is strongly correlated with aridity. This suggests that the nitrogen isotopic ratios of soils are transferred to plants and animals and it is possible that no nitrogen fractionation by plants due to water stress occurs.

Research has shown also that plant $\delta^{15}N$ values are elevated near coasts (Virginia and Delwiche 1982, Heaton 1987). As $\delta^{15}N$ values of ocean water are generally higher than terrestrial sources, it seems likely that sea-spray could introduce nitrates with high $\delta^{15}N$ values and that this would influence $^{15}N/^{14}N$ ratios of plants growing near coasts. In addition, Heaton (1987) has demonstrated that plants growing at inland saline environments, for example near a salt dome, also have high $\delta^{15}N$ values. It is known that salt can influence a number of metabolic, physical, and chemical processes and reactions, and one or a combination of these apparently accounts for the elevated $\delta^{15}N$ values of plants near saline environments. The mechanisms that control soil ^{15}N amounts are poorly known.

Given a good sequence of well-dated bone, it might be possible to construct a water stress curve using $\delta^{15}N$ values. This has been done with the bones of modern animals (Heaton et al. 1986), but a well-documented prehistoric example is lacking. Future research could address the questions on fractionation of nitrogen isotopes by plants in different environmental situations and more useful relationships with environmental parameters could lead to more accurate estimates of paleoenvironmental conditions.

Stable Isotope Analysis Methods

Stable isotope samples were prepared at the CAR, UTSA and then sent to the Colorado Plateau Stable Isotope Laboratory at Northern Arizona University in Flagstaff for measurement. At CAR, each sample was visually scanned and all roots and gravels were removed (there were none in these samples). As these samples were already well ground, the processing lab did not grind them any finer. Three grams of sediment were weighed for each sample. These samples were placed in glass test tubes, and 1N HCL added to saturate the sample. The acid was changed multiple times over a 10-day period until no further chemical reaction was observed. The samples were washed until neutral in ultra-pure water and dried at 50°C. This procedure removed all the carbonate carbon, leaving the organic carbon. Samples were then ground a final time in a mortar and pestle, weighed, and shipped to the Colorado Plateau Stable Isotope Laboratory. At the Northern Arizona University, the samples were reweighed and measured in a Thermo-Electron Delta V Advantage IRMS configured through the CONFLO III using a Carlo Erba NC2100 elemental analyzer for automated continuous-flow analysis of C, N, and S

isotopes in solid inorganic/organic samples. Shipped sample weights are as follows, with sample number in parenthesis: .621 g (S2), .540 g(S4) .917g (S6), .953g (S8), 1.011 g (S9), 0.721 g (S10), 1.512 g (S12), 0.993 g (S15), 1.40g (S17), and 1.07g (S20). All samples were 3.0g before the acid treatment. Some sample is always lost in cleaning and washing, but comparing these final sent weights with the 3.0 starting weight gives an idea of the amount of carbonates in the sample—50 percent (S12) to over 80 percent (S4). The calculations of stable carbon isotope ratios used the following formula: $\delta^{13}C$sample = $\{(^{13}C/^{12}C$ sample) / $(^{13}C/^{12}C$ standard) - 1\} x 1000, and the standard for measurement was the Vienna Pee Dee Belemnite (VPDB) measured at $^{13}C/^{12}C=0.0112372$. The calculations of stable nitrogen isotope ratios used the following formula: $\delta^{15}N$ sample = $\{(^{15}N/^{14}N$ sample) / $(^{15}N/^{14}N$ standard) - 1\} x 1000, and the standard for measurement was air measured at $^{15}N/^{14}N=0.003676$.

Magnetic Susceptibility Methods

Magnetic susceptibility measures the magnetic potential of the sediments. It is a reflection of the concentration of magnetic minerals in a sediment or soil (Mullins 1977; Dearing et al. 1996), and this method has a long history of use in archaeology (Tite and Mullins 1971). Magnetic susceptibility is influenced by many natural and anthropogenic factors. Magnetic susceptibility of sediment can increase if ferromagnetic grains increase in a soil during pedogenesis and weathering. This phenomenon allows soil scientists to identify soil horizons and unconformities in a sedimentary sequence (Williams and Cooper 1990). Different ferromagnetic minerals have different levels of magnetic intensity. For example, magnetite and maghemite have higher magnetic potentials than hematite or goethite (Maher and Thompson 1995). Smaller sediment clast sizes also have higher magnetic potential than larger clasts, even when it is the same mineral. These patterns are more visible when low frequency (lf) and high frequency (hf) values are measured. Fine et al. (1992) have shown that eluvial horizons (leached horizons) may have higher values than illuvial horizons (horizons where materials accumulate). The XFD (the ratio between lf and hf values) provides the clearest expression of this pattern. Human activities, especially burning, can significantly increase the magnetic susceptibility values of a layer or sediment (Crowther 2003; Weston 2002; Peters and Thomson 1999).

Sediment samples were placed in 1cm³ plastic cubes and were analyzed in a Bartington MS2B Magnetic Susceptibility Meter and Dual Frequency Detector. Both low frequency (lf) and high frequency (hf) measurements were recorded. Low frequency measurements are made at 0.465 kHz and high frequency measurements are taken at 4.65 kHz. Samples were analyzed by mass and the data entered directly into an excel spreadsheet using Multisus 2° software. Each sample was measured twice and averaged. Sample weights were taken to the nearest 0.1 g. The MS2B dual frequency detector induces an oscillating magnetic field at both high and low frequencies. The sample oscillations are compared to a neutral sample to calculate the value of the sample's magnetic susceptibility. The units used to express magnetic susceptibility are dimensionless and are calculated using either mass or volume. Since accurate volume measurements of sediment are very difficult to measure, mass, i.e., weight, was used. The scale of measurement is SI and calculated by the formula: MS x 10^{-8} m^3kg^{-1}. MS is the raw reading from the MS2B device. The low and high frequency variations are used to compute a coefficient of frequency dependence using the formula: XFD% = (Xlf-Xhf)/Xlf.

Local Topography, Geology, and Soils

The project area is south of the Balcones Escarpment in the incised San Antonio River channel. The mammoth remains were discovered in the north face of the eroding Applewhite Terrace adjacent to the lower Miller Terrace, which forms a flat shelve between the river and the Applewhite Terrace (Figure 7.6)

The Balcones Escarpment is an east-west trending fault line that forms a dominant topographic feature north of the project area. North of the escarpment, surface deposits consist of mostly Cretaceous limestone and south of the escarpment are Cenozoic marine and terrestrial sandstones and mudstones (Barnes 1983). Previous research (Plummer 1932; Barnes 1983) describes a number of Cenozoic deposits exposed on the surface in the general area of 41BX1239 (Figure 7.7). The oldest mapped deposits are known as the Wilcox Group. The Wilcox Group was first identified and named by Crider (1906). It is now known to consist of ~60-m-thick heterogeneous stream-deposited, cross-bedded sands, lignitiferous littoral sandy clays, non-calcareous lacustrine and lagoonal clays, and stratified

deltaic silts (Plummer 1932:573; Barnes 1983). These are overlain by the Eocene-aged Carrizo Formation (Ec) which was first identified and named at Midway Landing in Alabama. Hill and Vaughan (1902) identified similar deposits in Central Texas but called them Lytton. Plummer (1932) has since re-identified these in Texas as the Carrizo Formation. Originally they were thought to be older than the Wilcox Formation, but now known to stratigraphically overlay the Wilcox. These are probably shallow marine deposits. Both the Carrizo and the Wilcox formations have been eroded to form gently rolling interfluves between valleys in the area around 41BX1239.

The next youngest surface deposits mapped in the general area but not immediately near the project are the Uvalde Gravels (Byrd 1971). Almost 120 years ago, Hill (1891:368) described upland gravels in South and Central Texas and named these deposits the Uvalde Gravels. These deposits consist mostly of lag chert, quartzite, limestone and igneous gravels, cobbles and boulders on interfluves, and ancient upland surfaces on the highest hills south of the Balcones Escarpment (Plummer 1932:776-779). In a few areas, the cross-bedded gravels are contained in a marl and caliche that range up to 10 m in thickness. These deposits cannot be associated with the modern stream systems. The age of the Uvalde Gravels is poorly constrained. Byrd (1971) believed them to date to the late Miocene and/or Pliocene, while Ozuna and Small (1993), Blom et al. (2004) and Page et al. (2009) believe they are Pliocene or Pleistocene in age. No temporally diagnostic fossils or absolute dates are available.

Stratigraphically younger, the Leona Formation was first described by Hill and Vaughan (1898) as high terrace deposits along major streams composed of red and reddish gray silts and fine gravels. Holt (1959) describes the Leona Formation as consisting of lenticular beds of limestone and chert gravel, sand, silt and clay. These terraces are from 6 to 35 m above the modern streams, up to 15 m thick and cover extensive areas, especially south and east of the Balcones Escarpment (Arnow 1959; Barnes 1983). The Leona Formation consistently is found in lower topographic positions than the Uvalde Gravels and is certainly younger. Also the thickest portions of the Leona Formation are usually closer to modern stream valleys, suggesting they are related to the current drainage basins but represent an older set of their fluvial deposits. Based on fossil content, Hay (1923) suggested that the Leona Forma-
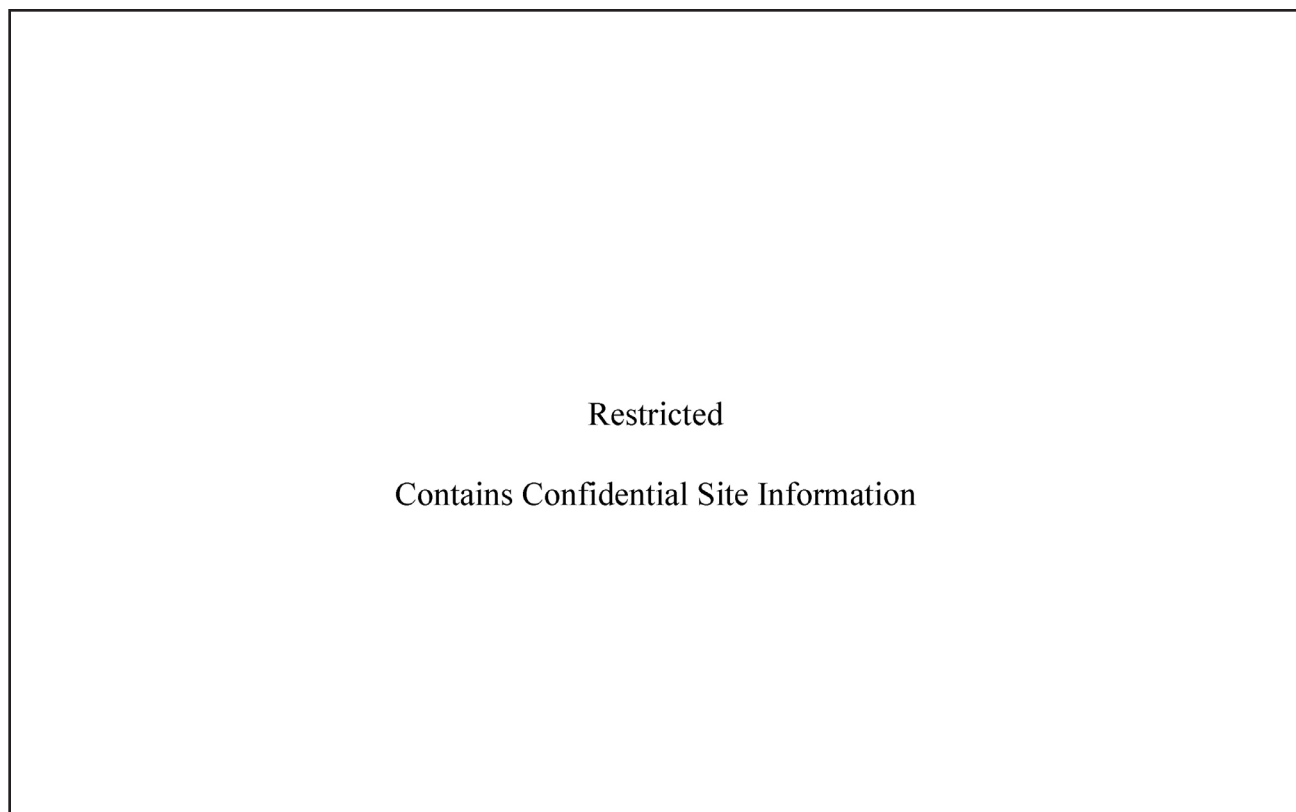
Figure 7.6. Topographic map of the immediate area surrounding 41BX1239 showing the topographic setting of the site (black circle).
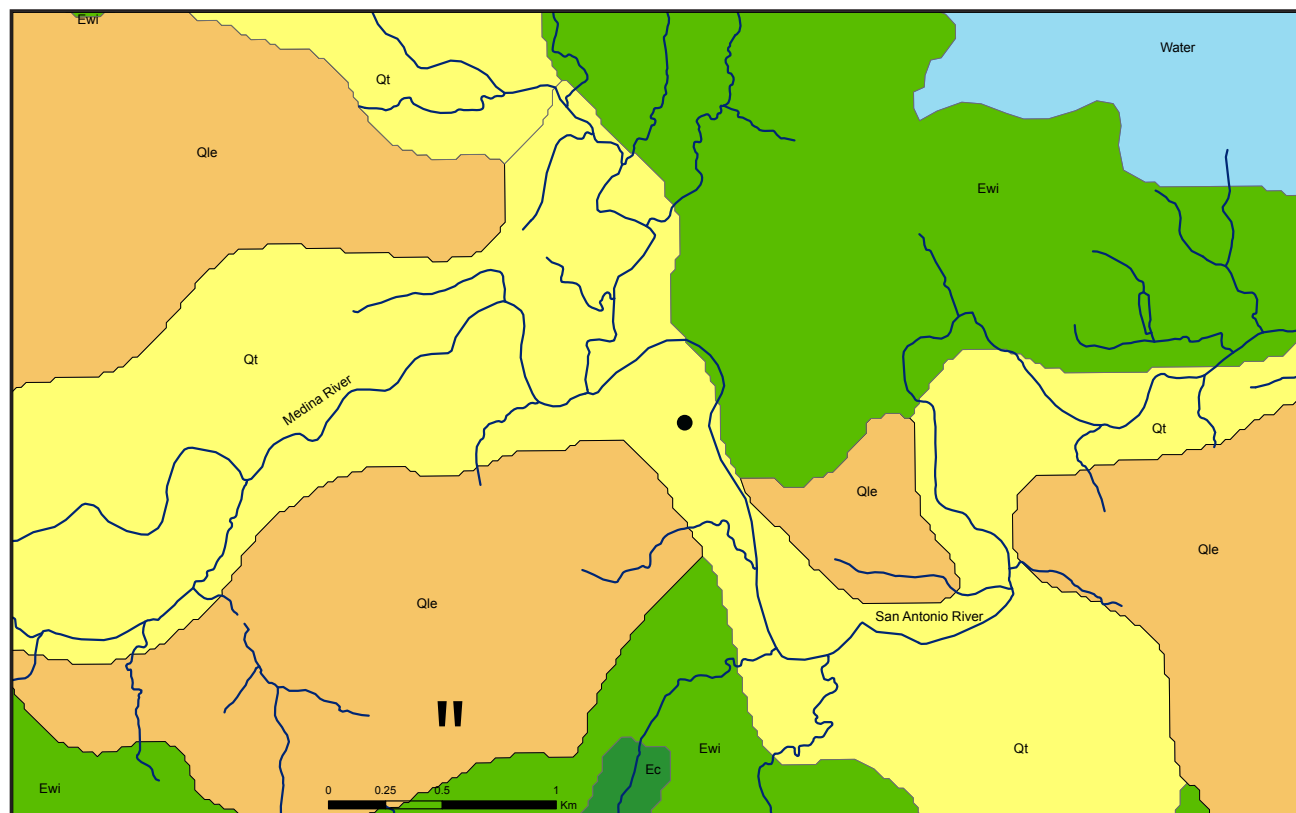
Figure 7.7. Geological map of bedrock and terrace deposits (after Barnes 1983; source Geological Atlas of Texas, http://www.tnris.org/get-data).

tion dates to the Early Pleistocene, but a more current evaluation is clearly warranted. No radiometric dates are available.

Barnes (1983) maps three fluvial deposits clearly associated with San Antonio River. These are Qal (modern floodplain alluvium), Qt (fluvial terrace deposits), and Qle (Leona Formation). The mammoth remains at 41BX1239 were plotted in an area mapped as Qt (see Figure 7.7).

Medina River Terraces

Mandel (Mandel et al. 2007; Mandel et al. 2008) has established the presence of five fluvial terraces (Walsh, Leona, Applewhite, Miller and modern floodplain) in the Medina River valley. These studies greatly clarify the fluvial geological record for the Medina River valley and by extension to the San Antonio River at the project area. Unfortunately, the Medina River terraces have not been mapped in the San Antonio River basin and the geological map provided by Barnes et al. (1983) does not distinguish these terraces. Nevertheless, Mandel's five terraces will be used in this study.

The Walsh Terrace is 18 to 20 m (59 to 65 feet) above the modern Medina River floodplain, 6-8 m above the Applewhite Terrace, and the highest fluvial deposit recorded by Mandel in the Medina valley. This unpaired fluvial terrace sits on eroded bedrock, grades from sand and gravel to a sandy loam, which is weathered into a well-oxidized paleosol capped by an eolian sandy mantle. The uppermost 2Btb horizon is truncated by erosion. The absolute age is unknown, but this terrace is below (younger than) the Uvalde Gravel Formation and certainly dates to the Pleistocene Epoch.

The Leona Terrace forms an extensive surface of unpaired terraces 9 to 10 m (29 to 33 feet) above the Medina River floodplain and ~2-3 m (6-10 feet) above the Applewhite Terrace. Mandel et al (2008) correlate this to the Leona Formation. The Leona Terrace consists of course-grained (gravel and sand) channel facies and a fine-grained (silt loam and silty-clay loam) overbank facies. The fine-grained facies is capped by a thick (2 m) A-Bk solum. No absolute ages are available for the Leona Terrace but it is chronologically placed between the Walsh and Applewhite terraces and clearly Pleistocene in age. It is also unclear how closely the distribution of the Leona Formation as mapped by Mandel et al (2007, 2008) is with the distribution of the Leona Formation as mapped by Barnes et al (1983).

The Applewhite Terrace is much better known, with seven depositional units (A1-A7) and multiple buried soils (Mandel et al. 2007; Mandel et al. 2008). This terrace forms an extensive, broad and flat tread distributed as paired surfaces ~7 m (~23 feet) above the Medina River floodplain, and most of the Medina valley's archaeological record is contained within it (Mandel et al. 2008:133). The Applewhite Terrace is marked by a ~4 m (~12 to 13 foot) scarp above the lower Miller Terrace and forms a prominent feature in the Medina Valley and San Antonio River valley near their confluence. This scarp forms an incision point for a number of narrow deep gullies eroded into the terrace.

Unit A1 extends across the valley floor and forms the base of the Applewhite Terrace. It consists of 3 to 5-m-thick stratified sand and gravel channel deposits, but no absolute dates are available. Unit A2 consists of a 3 to 4-m-thick fining upward sequence of very fine sand to silty clay loam capped by a strongly developed truncated petrocalcic soil (Bkm horizon) called the Somerset paleosol. Charcoal from the bottom of Unit A2 was dated to 32,850±350 B.P. and decalcified organic carbon from the Somerset paleosol was dated to 20,080±560 B.P.

Unit A3 consists of 5 to 6-m-thick fine sandy loam to silty clay fining upward sequence of overbank deposits. Three weakly developed and truncated soils (soils 6-8) were documented at the Richard Beene site in this sedimentary unit, but they have not been documented elsewhere (Mandel et al. 2007). Soil carbon from Soil 8 was dated to 13,390±150 B.P. and 15,270±170 B.P. Soil 7 has yielded a 13,640±210 B.P. age and a 12,745±190 B.P. age on soil carbon and charcoal, respectively. A 13,480±360 B.P. radiocarbon age estimate was derived on soil carbon from Soil 6. Soil carbon ages generally date the mean residence time of the dispersed carbon is the soils and is not considered as accurate as charcoal for radiocarbon dating. In general, these dates suggest that the soils date to the very Late Pleistocene and to a Pre-Clovis time frame. Approximately 1.5 m of fine sandy loam to silty clay loam make up the uppermost sediments in Unit A3. The top of Unit A3 is altered by the Perez paleosol, a cumlic soil that formed as alluvium was deposited. Three radiocarbon ages measured from charcoal were obtained from the Richard Beene site. These were 8805±75 B.P., 8810±60 B.P., and 8640±60 B.P. These dates, which mark the termination of Unit A3, are associated with an Angostura component and considered Early Archaic by Thoms (2007).

Unit A4 is, on average, 3 m thick and consists of thin beds of calcareous silt loam, loam, fine sandy loam and very-fine sand overbank sediments. The upper portion of Unit A4 has been weathered to form the Elm Creek pedocomplex, which represents a weak truncated soil. Four charcoal samples were radiocarbon dated to 7645±70 B.P., 8080±130 B.P., 7910±60 B.P., 7740±50 B.P. Six radiocarbon assays on bulk soil carbon range in age from 9780±120 B.P. to 8010±70 B.P. and all but one radiocarbon assay are clearly too old in comparison to the charcoal dates from the Perez paleosol and the Elm Creek pedocomplex (Mandel et al 2007:48-50).

Unit A5 consists of a ~4-5-m-thick calcareous fine-grained overbank deposit. It is capped by the Medina pedocomplex, a cumlic soil up to 4.5 m thick. This distinct soil serves as a prominent stratigraphic marker in the Applewhite Terrace. Fifteen radiocarbon assays were run from Unit A5. Charcoal assays in the lower portion of the Medina soil are dated to 6930±65 B.P., 7000±70 B.P., 6900±70 B.P., 6985±65 B.P., and 6700±110 B.P.Charcoal assays in the upper portion of the Medina pedocomplex are 4510±110 B.P., 4430±55 B.P., 4380±100 B.P., and 4570±70 B.P. Taken together these dates suggest that Unit A5 began to accumulate by at least 7000 B.P. and continued until at least 4400 B.P. and represents a very important set of fairly rare Middle Holocene sediments.

Unit A6 is ~3-4-m-thick fining upward fine sand to loam to silty clay and clay loam floodplain deposit. Thick to thin sandy lamina is preserved in the lower half meter of this unit. In the top of Unit A6 is the sandy Leon Creek paleosol. This is a truncated paleosol that has welded with the modern surface mollisol and is wide spread in the Medina valley sediments. A charcoal based radiocarbon dates in the lower portion of the Leon Creek soil is dated to 4135±70 B.P. and a charcoal assay in the upper portion of this soil is dated to 3090±70 B.P.

The last depositional unit in the Applewhite Terrace is Unit A7. This levee deposit ranges from 0.5-1.5 m in thickness, and it thins and becomes more fine-grained laterally away from the terrace scarp. This sediment is weathered to form the surface soil and is welded onto the Leon Creek paleosol in Unit A6. No radiocarbon dates were assayed from this depositional unit, but Late Prehistoric artifacts dating to at least 900 years B.P. were recovered from these sediments.

The Miller Terrace stands ~3 m (~10 feet) above the modern floodplain. Three stratigraphic units were identified by Mandel et al. (2007) and Mandel et al. (2008) in the Miller Terrace. Unit M1 fines upperward from a calcareous fine sand to a silt loam. The top of Unit M1 is capped by a buried soil with a cumuli A horizon. Two radiocarbon assays on decalcified bulk soil carbon produced ages of 1380±60 B.P. and 1410±70 B.P. Unit M2 covers Unit M1 and consists of a calcareous fine sandy loam grading up to a silt loam. It is also capped by a weakly developed buried soil. No radiocarbon ages are available for this unit or its capping soil. Unit M3 is recent flood deposits that form the surface of the Miller Terrace. This surface is weathered by pedogenesis similar to the modern soil in the floodplain deposits.

MEDIO CREEK TERRACES

Geoarchaeological research upstream of the project area at Medina Annex, Lackland Air Force Base on Medio Creek, a tributary of the Medina River, identified three terraces above the floodplain consisting of four depositional units (Nordt 1997), but it also has Uvalde Gravels deposited on the highest topographic interfluves. The highest terrace, T2, sits 7–8 m (23–26 feet) above the floodplain. The T2 Terrace is composed a black silty surface soil that grades down to silty clays with up to 10 percent volume of carbonate nodules. No absolute dates were run on Unit I materials, but Nordt (1997: 32) suggests these are Late Pleistocene in age. Unit I sediments were eroded to form the incision of Medio Creek and Unit II sediments were deposited. Unit II sediments consist of channel gravels and pebbles and silty clay loam overbank alluvium capped by a buried soil. Radiocarbon dates, on bulk humates, from the upper portion of Unit II, are 4890±80 B.P. and 3620±70 B.P. A more recent age of 1830±70 B.P. on bulk humates from a soil in the top of Unit II gives a terminal age for Unit II. Unit III forms the upper portion of the T1 Terrace and sits unconformably on Unit II. This deposit represents a fining-upward sequence from gravels at the bottom to clay loams with matrix supported pebbles at the top. No radiocarbon dates were obtained from Unit III sediments.

The Medio Creek T0 Terrace is composed of Unit IV sediments. Two radiocarbon assays on bulk humates provide age control. The older date is 1780±90 B.P. and the younger age is 1220±70 B.P. If these dates are accurate, then the age for Unit III is very brief. It is more likely that these ages reflect the mean residence

time of the carbon in the sediment samples and are not entirely accurate age estimates as there is also an erosional unconformity between Unit III and Unit IV that separates the T1 Terrace from the T0 Terrace. Unit IV sediments consist of a more complex package of sediments that contains multiple coarse-to-fining upward sequences; each capped by pedogenic alteration. The two radiocarbon dates were collected from the lower of three soils in two separate backhoe trenches.

TERRACE CORRELATIONS AND AGE ESTIMATES

Even though many of the formal characteristics differ between the Medina and Medio valleys, it appears that the terraces of the Medina River can be correlated to the Medio Creek terraces. Table 7.2 presents the correlation of terraces and fluvial deposits in both stream systems. The segregation of depositional units and soils in the Applewhite Terrace is more complex and age estimates are provided in Table 7.3 for these. Both tables provide the foundation for correlations to sediments described on the current project.

Table 7.2.   Tentative Correlation of Fluvial Deposits and Depositional Units in the Medina River and the Medio Creek Valleys and Radiocarbon Age Ranges

Age	Medina River Terraces and Depositional Units	Medio Creek Terraces
Recent	Floodplain (F1)	T0
Late Holocene (<1400 B.P.)	Miller (M1-M3)	T1
Holocene-Pleistocene (900->33,000 B.P.)	Applewite Terrace (A1-A7)	T2
Pleistocene (>33,000 B.P.)	Leona Terrace (L1)	-
Pleistocene	Walsh Terrace (W1-W2)	-
Plio-Pleistocene	Uvalde Gravels	Uvalde Gravels

Table 7.3.   Depositional Units, Radiocarbon Age and Associated Soils in Applewhite Terrace

Depositional Unit	Thickness (meters)	Radiocarbon Age Range	Soil
A7	1.5	2400 – 900	Modern
A6	3 – 4	4200 – 2600	Leon Creek
A5	4 – 5	7000 – 4400	Medina
A4	3	8200 – 7000	Elm Creek
A3	5 – 6	15,000 – 8800	Perez 6 – 8 soils
A2	3 – 4	33,000 – 20,000	Somerset
A1	3 – 5	>33,000	-

SOILS

Soils mapped in the vicinity of 41BX1239 include many types (Taylor et al. 1991). These show differences in the surface horizons, topography, and parent material. These soils have been grouped by parent material and distributions illustrated on Figure 7.8. Four groups were formed. These are upland soils, calcareous alluvial soils, Quaternary alluvial soils and Holocene and Loamy alluvial soils. Upland soil group includes Miguel fine sandy loam (Cf), Duval loamy fine sand (Dm), Duval fine sandy loam (Dn), Wilco loamy fine sand (Hk), Houston black clay (Hs), Rock Outcrop-Olmos complex (Hg), Laparita clay loam (Or), Pits and Quarries (Pt), Stephen silty clay (Sc), and Floresville fine sandy loam (Wb and We). Calcareous alluvial soils consist of Atco loam (Ka) and Willacy loam (Wm). Quaternary alluvial soils include Gullied land-Sunev complex (Gu), Branyon clay (Ht), Lewisville silty clay (Lv), Patrick soils (Pa), San Antonio clay loam (Sa), and Sunev clay loam (Vc). Holocene and loamy alluvial soils consist of Loire clay loam (Fr), Leming loamy fine sand (Lf), Tinn and Frio soils (Tf), Zavala fine sandy loam (Za), and Zavala and Gown soils (Zg). The mammoth remains at 41BX1239 are found just behind the beveled edge of the Applewhite Terrace mapped as Sunev clay loam and adjacent to the lower Miller Terrace mapped as Loire clay loam (see Figure 7.8). At present it is unclear if these soil series consistently reflect the terraces identified by Mandel in the Medina River valley. More field research will be necessary to make that determination.

PROFILE SEQUENCE RESULTS

Five profiles were described in three backhoe trenches (BHT) at 41BX1239 on May 22, 24 and 31, 2007. These BHTs were excavated into two terraces immediately east of the Interstate 37 bridge over the San Antonio River (Figure 7.9). This occupies a stair-stepped topography on an inside meander of the San Antonio River immediately downstream of its confluence with the Medina River. As defined by Mandel et al. (2007, 2008), the older, Applewhite Terrace (T2) as well as the younger Miller Terrace (T1) was exposed. This profile documentation provides detailed field sedi-
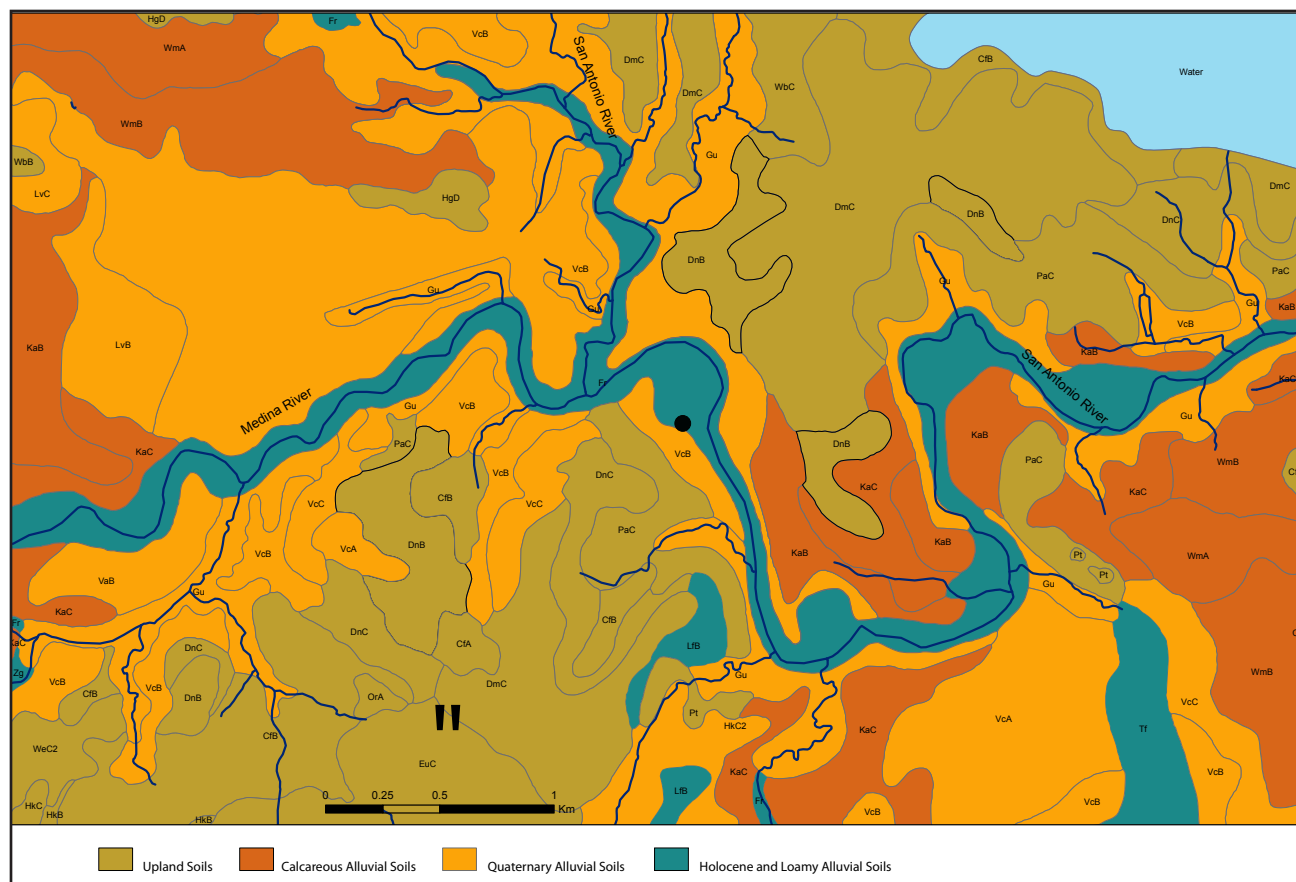
Figure 7.8. Soils mapped in the vicinity of 41BX1239.

ment descriptions and assesses the soil/stratigraphic relationships and sedimentary context of the mammoth bones excavated at 41BX1239 (Table 7.4). The younger Miller Terrace is identified by sedimentary Units I and II. These sedimentary units were observed in the upper sediments of all profiles.

The Miller Terrace sediments are well exposed in Profile 1 where two sedimentary units were described in the 155cm of exposed sediments. In the lower 83 cm Sedimentary Unit II consists of a light yellowish brown silty loam C horizon capped by a dark grayish brown clay loam A horizon. This probably correlates with the M2 sedimentary unit from the Medina River sequence (Mandel et al. (2007) and Mandel et al. (2008). Unconformably overlaying this lower sedimentary unit was Unit I a 72-cm-thick recent fluvial deposit with a buried A horizon between 46 and 60 cmbs and a surface A horizon. These sediments may correlate with Mandel's M3 sedimentary units. The Miller Terrace sedimentary units would probably be thinning as they overlapped the buried and beveled portion of the Applewhite Terrace but it is unlikely that M1 sediments were uncovered this close to the surface of the Miller

Figure 7.9. TAMU BHT 7, originally excavated by Texas A&M in 1997, as re-exposed for the current investigations. Facing south while standing on Miller Terrace tread with mammoth excavation block on left (east) side and Applewhite Terrace eroding face in background.

Table 7.4.   Soil Horizon Classifications and Correlations of Profiles

Zone	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5
1	Ap	A	A	A	A
2	A	AB	B	AB	B
3	AB	B	C	C	2Ab
4	Ab	2Ab	2Ab1	3Ab	2ABb
5	C	3Ab1	2Ab2	3B1	3Bk
6	2Ab	3Ab2	2Ab3	3B2	3Bt1*
7	2B	3B	2B	3Bk	3Bt2*
8		3Btk1		3Btk	4Btk1
9		3Btk2		4Bk	4Btk2
10		4Btk			4Btk3

* indicates the presence of mammoth bone. Thick horizontal lines indicate unconformities. Thickest horizontal line marks boundaries between the Miller and Applewhite terrace deposits. Perez soil in Applewhite Terrace sediment zones shown in light grey. Somerset soil in Applewhite Terrace shown in dark grey. Dashed line represents bottom of profile.

Terrace. Another good exposure of the Miller Terrace was described in Profile 3. The recent Sedimentary Unit I was exposed in the upper 35 cm and still preserved geological structures of alternating lamina in the lower portion. These certainly correlate to the M3 sediments Below this was Unit II, a thick dark grayish-brown clay loam buried A horizon conformably overlying a yellowish brown silt loam to clay loam C horizon. Unit II most likely represents M2 sediments. Similar but thinner sediments were uncovered in Profile 2, 4 and 5 (see sediment descriptions for more details).

In the lower portions of Profiles 2, 4 and 5 the Applewhite Terrace sediments were exposed and described as two separate sedimentary units. Unit III is capped by a buried A horizon and contains the mammoth remains Within Unit III Caran (2001) originally identified pond deposits (Profile 5, Zone 7, 3Bt3 horizon) with associated mammoth bone. Some mammoth bone was also observed in Zone 6 (3Bt1 horizon) and on the contact between depositional Units II and III down slope in a derived position. In both contexts the poorly preserved bone appears

to be in a slightly disturbed context but still semi-articulated. At this point there is evidence that Zone 7 and 8 in Profile 5 are separated by an unconformity, but clear evidence to separate the pond deposits from the overlying deposits (Zone 7 from Zone 6), as suggested by Caran, was not observed. The main difference observed between Unit III and Unit IV sediments was the increased amount of calcium carbonate in Unit IV and the increased degree of weathered sediments in Unit IV evidenced by the olive colored sediments.. At 41BX1239 Sedimentary Unit III can be correlated tentatively with Depositional Unit A3 from the Applewhite Terrace. It seems likely that the soil in Zone 4 in Profile 4 probably correlates with Soil 6, 7 or 8 in the Applewhite Depositional Unit A3. The Perez Soil is too young to contain in situ mammoth remains. Unit IV at 41BX1239 can be correlated with Unit A2 from the Applewhite Terrace and the Somerset Soil. Further sediment analyses should be able to provide additional data that can be used to refine these interpretations.

CHRONOLOGICAL ASSESSMENT

Samples of mammoth bone were submitted for radiocarbon dating but these were too poorly preserved for radiocarbon dating. As an alternative six bulk sediment samples were submitted for radiocarbon dating (Table 7.5). One limitation with radiocarbon dating of sediments is that carbon matter is continuously leached down from the ground surface which means that younger carbon is added to older carbon at depth. Thus radiocarbon ages of buried organic layers in sediments do not necessarily represent the true age of the deposit, but rather radiocarbon ages represent the mean residence time (MRT) of the carbon in the deposit. Depending on the source and age of the contaminating carbon this can result in radiocarbon ages that are too young or, more rarely, too old. Care

Table 7.5.   Radiocarbon Dates and OxCal Calibrated Ages in Years BP (before AD 1950).

Province	Radiocarbon Age BP	Mean Age cal BP	Upper Age cal BP	Lower Age cal BP	Range Probability
Zone 1	70±40	125	5	285	99.7
Zone 3	1100±40	1010	925	1175	99.7
Zone 4	4930±40	5660	5580	5885	99.7
Zone 5	6410±50	7345	7170	7460	99.7
Zone 6	6980±50	7815	7670	7955	99.7
Zone 7	8060±60	8935	8635	9260	99.7

must be taken when interpreting radiocarbon dates obtained from carbon within sediments. Organic matter in soils can be divided into humic and nonhumic substances (Schnitzer 1982: 581-582). Nonhumic materials include carbohydrates, proteins, peptides, amino acids, lipids, waxes, alkanes and some organic acids. Microorganisms in the soil rapidly decompose these materials. Humic material, itself, can be divided into different fractions, i.e.. humic acid, fulvic acids, and humins (Duchaufour 1982:29–31; Schnitzer 1982:582–583). Fulvic acid is soluble in hydrochloric acid (HCL), humic acid is soluble in a base solution of sodium hydroxide (NaOH), and humins are insoluble in these solutions. It is possible to date the bulk carbon or different fractions of humic material from single samples, but a number of studies fail to demonstrate that one humic fraction or bulk sediments yield consistently more reliable radiocarbon dates than the other fraction (Haas et al. 1986: 480; Lowe et al 1988; Jones 1989).Thus the MRT of the carbon in each sample will vary in response to the unique events that have affected the carbon in that sample. There is no way to estimate back to the original age of the sedimentary event that deposited the sediments. The most conservative interpretation of sediment dates, especially those from soils, is that they represent a minimum age of the deposit and it is this assumption that is used here.

A review of terminal ages on mammoth remains in North America (Agenbroad 2005; Buck and Bard 2007) suggest that mammoth became extinct at approximately 13,000 cal B.P.. The few younger radiocarbon ages were conducted on bone or lack good associations with the mammoth remains. Bone dates are highly problematic because of contamination (Stafford et al. 1991). The most reliable method, extraction of amino acids from collagen in the bone and date the amino acids with AMS methods, has been rarely used and none of the recent ages published by Agenbroad were done in this manner. Thus all the ages within the Holocene, <11.650 cal B.P., are suspect and even Agenbroad (2005:84) is skeptical of their accuracy. At 41BX1239 the single sediment sample that was directly associated with the mammoth remains was dated to 8060±60 B.P. and calibrated to 8935-9260 cal B.P. at three standard deviations (99.7 percent probability, OxCal). This is not coeval with the extinction of mammoths in North America and cannot be considered as an accurate age of the mammoth remains at 41BX1239.

To obtain a reasonable estimate of the age of these mammoth remains we must use the chronological results from the Applewhite project (Mandel et al. 2007). Two terraces were identified there and dated. The younger terrace is the Miller Terrace and the older terrace is the Applewhite Terrace. At this time, the uppermost deposits in the Miller Terrace can be divided into two units. Based on soil development, both of these units appear to be younger and probably date to the Late Holocene. A radiocarbon date from a buried horizon in the Miller Terrace was estimated to date to 1479±70 ^{14}C yrs B.P. (Mandel et al. 2007; Mandel et al 2008).

The Applewhite Terrace deposits can also be divided into at least two sedimentary units. The lowermost sediments are correlated tentatively with the Somerset Soil and the uppermost sedimentary unit is correlated with the Perez Soil (Mandel et al. 2007; Mandel et al 2008). Seven radiocarbon determinations from the Perez Soil range in age from 9800±140 ^{14}C yrs B.P. to 11,240±210 ^{14}C yrs B.P. Three soils stratified below the Perez Soil and above the Somerset Soil range in age from 13,480±360 ^{14}C yrs B.P. to 15,270±170 ^{14}C yrs B.P. The Somerset Soil has not been dated but organic silts 4m below the Somerset Soil produced an age of 20,080±560 ^{14}C yrs B.P. and a burned zone in a similar stratigraphic position produced an assay of 32,850±530 ^{14}C yrs B.P. These age estimates can be used to hypothesize that the mammoth bearing deposit at 41BX1239 probably dates between 12,580 cal B.P. and 26,335 cal B.P.. and possibly correlates to one of the poorly developed soils within the age range of 14,520 to 18,965 cal BP. Unless further field work was undertaken, it is not possible to accuracy calculate a more precise age estimation.

If additional samples were to be undertaken, then other dating methods should be employed. The first method suggested would be single-grain optical stimulated luminescence (OSL) (Jacobs et al. 2008). The single grain OSL method would allow for the identification of sediments of different ages and the more accurate calculation of the correct age of the sediments. If well preserved mammoth tooth enamel could be recovered, electron spin resonance might be possible using new methods of sample irradiation which promise to significantly improve dating accuracy (Joannes-Boyau and Grün 2010).

RESULTS

SEDIMENT ANALYSIS RESULTS

Figure 7.10 shows the percentages of total sand, silt and clay by depth along with the percent of organic carbon and soil zones (numbered on left) and strati-graphic units numbered by Roman numerals (on the right) and boundaries plotted by dashed horizontal lines. These data demonstrate that there is a steady increase in clay accompanied first by a decrease in sand in Unit IV and then second by a decrease in silt in Unit III. Clay progressively increases through Unit IV and III. Unit II is characterized by marked fluctuations in sand accompanied by inverse fluctuations in silt and clay. This boundary between Unit III and Unit II probably represents a truncation event with very different depositional patterns on either side of the Zone 4-5 boundary. In Units I and II we can see rapid fluctuations in sand, silt and clay showing at least three sets of fine to coarse grain fluctuations (S13-S15, S16-S18 and S19-S21) where increases in sand are marked by declines in silt and clay. These sedimentary fluctuations are cross-cut by two peaks in organic carbon which indicate soil formation events. The amount of organic carbon peaks in the uppermost sample (S16) in Zone

3, Unit II and the top sample in Zone 1 (Unit I). These data clearly show that the depositional patterns in the lower two units are distinctly different from the nature and tempo of deposition in the two upper units.

Figure 7.11 presents the relative frequency of different sand fractions within the total sand population. The very coarse, coarse, and medium sands have high values in the bottom of the profile in Unit IV (Zones 9 and 10) sediments then vary in a random pattern until the top (Unit I, Zone 1). The percentage of very fine sand is uniquely low in the lower four samples (Unit IV, Zones 9 and 10) and then is uniquely high in sample S19 (Unit I, Zone 2). Sample S19 the high frequency of very fine sand occurs in the sample with the highest amount of silt and a moderate amount of clay. This suggests a low but continuous flow. Samples S1-S4 in Unit IV have the greatest amount of sand and the coarsest sand suggesting higher energy flows for sediment deposition.

A scatterplot of total sand percentages plotted against very fine sand percentages in Figure 7.12 shows that the relationship is a negative linear pattern, but an analysis of the residuals (Figure 7.13) using a log-normal probability plot shows that the lower four samples (S1-S4)
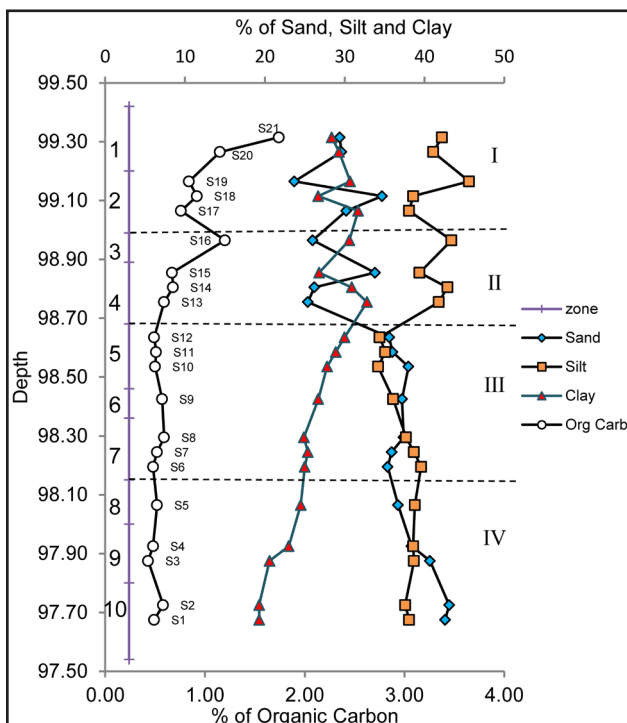
Figure 7.10. Vertical distribution of sand, silt and clay.
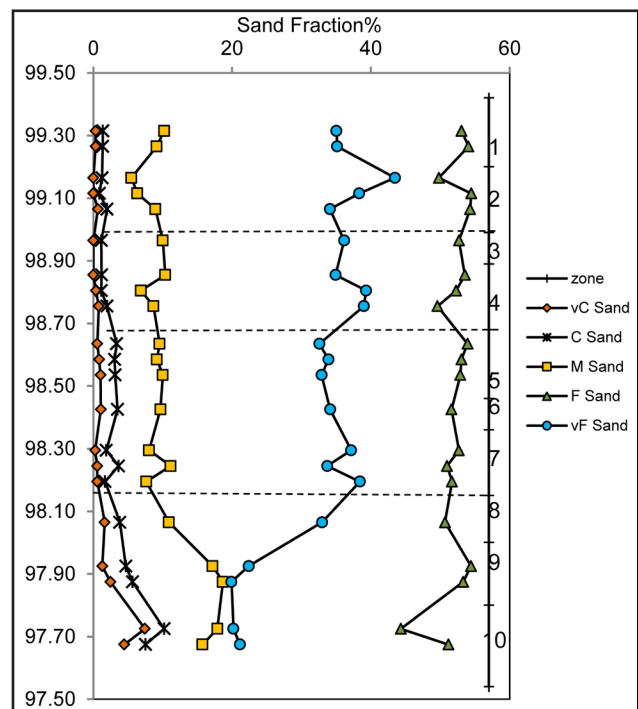
Figure 7.11. Frequency distribution of very coarse sand, coarse sand, medium sand, fine sand and very fine sand fractions.
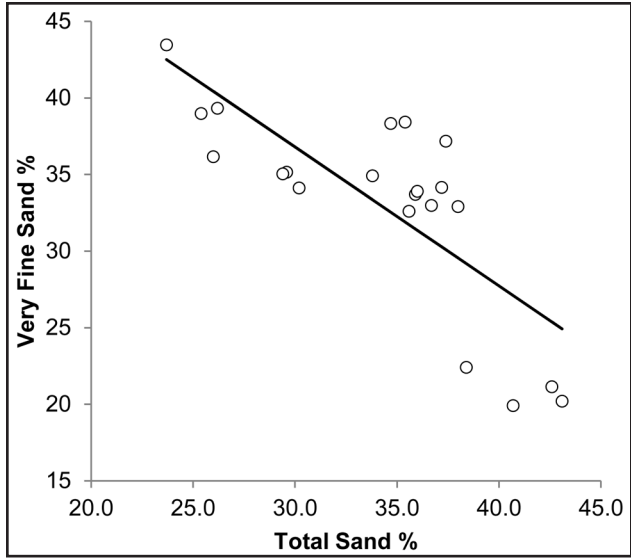
Figure 7.12. Scatter plot of total sand and very fine sand. Adjusted R2 = 0.579, p value = 0.00004.

Figure 7.13. Log normal plot of very fine sand showing three possible populations.

and sample S19 are in different populations which probably represent different depositional environments as suggested above. This is the strongest evidence that Unit IV is distinct from Unit III.

Figure 7.14 is a plot of fine clay as a percent of total clay, coarse silt as a percent of total silt and percent of organic carbon. The fine clays reflect the differential effects of illuviation. As clay is translocated down-profile by water percolating through the matrix, the finer clays move down in a greater proportion than the coarser clays. A lower percentage of the fine clays may reflect horizons with depleted fine clay percentages. This is most clearly evident in the uppermost samples (S21-S20) in Zone 1 which also have elevated organic carbon percentages. There is an increase in fine clay percentages accompanied with a decline in organic carbon percentages in Zone 2 even in Sample S18 where sand percentages are high. This is exactly the pattern expected for A-B soil horizons. The data are not as clear in Zones 3 and 4 in Unit II. The abrupt increase in fine clay from Zone 4 to Zone 5 in Unit III probably represents a truncation event as indicated in the sand-silt-clay percentages (see Figure 10). The nature and tempo of deposition again appears to change in Unit IV suggesting another truncation event between Zones III and IV.

Figure 7.15 shows the vertical distribution of calcium carbonate ($CaCO_3$) along with the distribution of organic carbon and percentage of sand. In the up-

per two sedimentary units (I and II) $CaCO_3$ is low at the top of the zone, increases toward the middle, and then declines in the bottom of the zone. This is a common pattern in fairly young depositional units where calcium carbonate is actively being transported down-profile. In the lower sedimentary units (III and
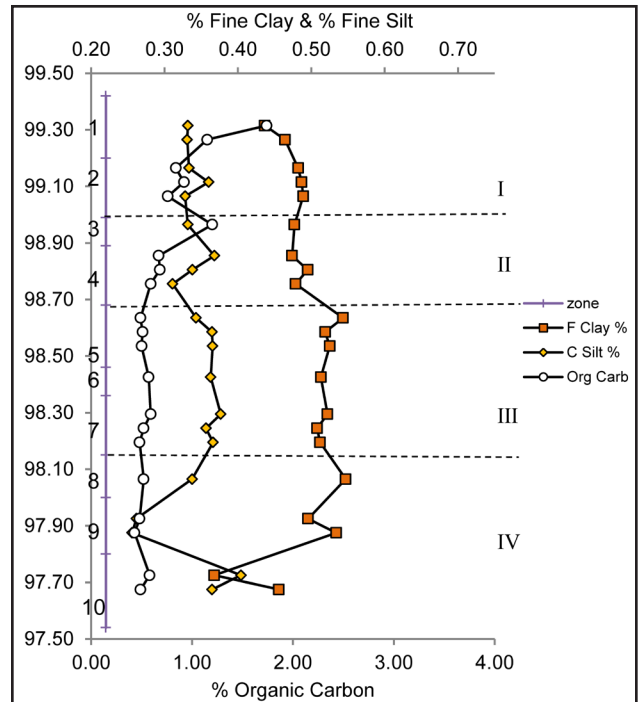
Figure 7.14. Distribution of fine clay and fine silt plotted with percent of organic carbon.
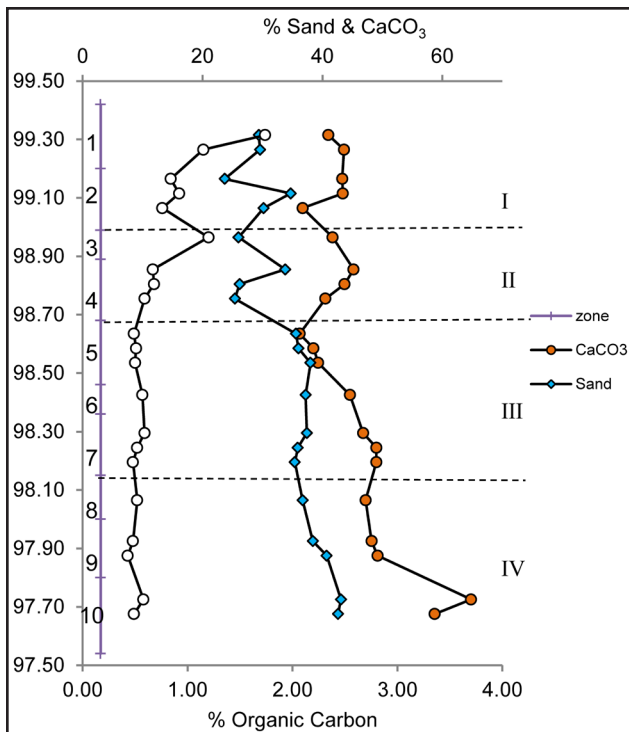
Figure 7.15.   Distribution of organic carbon, CaCO3 and total sand.

IV) CaCO₃ increases with depth but the topmost starting point is different for each unit. This suggests that CaCO₃ is depleted in the A horizons of Unit I and Unit II, but that movement of CaCO₃ has not reached the lower portions of these units (lower Zone 2 and lower Zone 4). Unit III (Zones 5-7) show a steady increase in calcium carbonate with greater depth and then after the slight decline in the top of Zone 8 the same general pattern is present in Unit IV (Zones 8-10). This suggests separate cycles of carbonate translocation in each of these sedimentary units.

MAGNETIC SUSCEPTIBILITY RESULTS

Figure 7.16 presents the magnetic susceptibility data. Low (lf) and high (hf) frequency measurements were taken. The low frequency measurements are often considered the most informative. Usually as soils weather the magnetic susceptibility values increase. Also human occupations and especially burning can dramatically increase the magnetic susceptibility values. The low frequency values increase in Unit IV and also in Unit III and these are consistent with the interpretations above regarding the depositional history of these units. The results from Units I and II are unusual. In both cases the susceptibility values in the lower samples of each unit are much higher than

expected. The progressive increase in lf in Unit IV and Unit III could be used to suggest that these are a single depositional unit. However, as discussed above, the sediments suggest they are different depositional environments. It may be that there was little lapsed time between Unit IV and Unit III and thus little time for the magnetic susceptibility values to change. The dramatically fluctuating values in Unit II and Unit I are most likely caused by the variations in deposited minerals and not a clear indication of soil weathering. The one exception to this pattern is the clear increase down-profile of XFD percent in Unit I which is probably due to the illuviation of fine clays and other magnetic minerals in this depositional unit.

STABLE ISOTOPE RESULTS

Stable carbon and nitrogen isotopes do not show dramatic changes (Figure 7.17), however some fluctuations are present. In Unit IV and Unit III stable carbon isotopes show small increases from bottom to top. These data suggest significant increases in the total biomass of C_4/CAM plants occurred from a low in the bottom of Unit IV (Zone 10, Sample S2 $\delta^{13}C$ = -24.3‰, % C_4/CAM = 12%) toward the top of Unit IV and again in the top of Unit III. The highest $\delta^{13}C$ value occurs in Sample S15 in Zone 4, Unit II $\delta^{13}C$ = -21.0‰) with an estimated % C_4/CAM = 36%, but the values drop
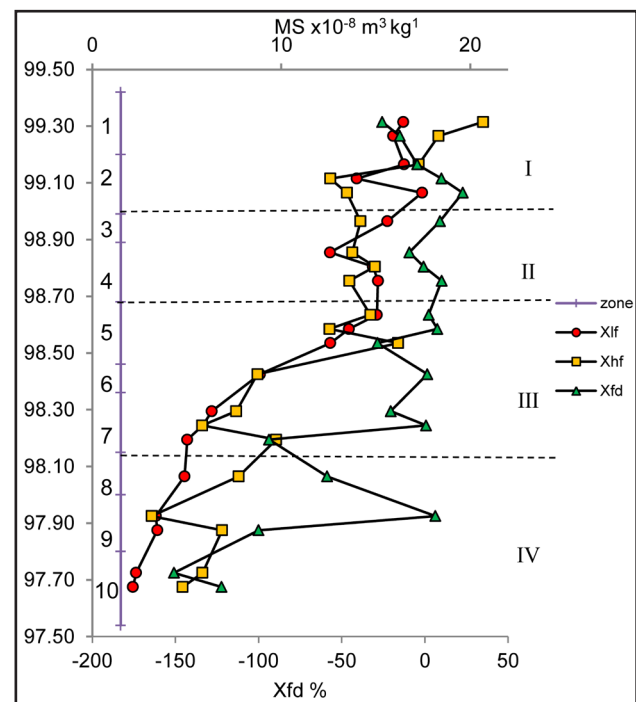
Figure 7.16.   Magnetic susceptibility values.

in Unit I. This represents a ~24 percent increase in C_4/CAM biomass from the bottom of Unit IV to Unit II.

Unit II also has the lowest $\delta^{15}N$ value at $\delta^{15}N = 5.8‰$ resulting in an estimate of 40 percent legumes. In this portion of Texas the most important nitrogen fixing plant would be mesquite (Proposis sp.). The highest $\delta^{15}N$ values are in the middle of Unit IV in Zone 9($\delta^{15}N = 6.9‰$) and the upper portion of Unit III in Zone 5 ($\delta^{15}N = 6.91‰$). Both with a 26 percent legume biomass estimate. This suggests that nitrogen fixing plants varied by 14 percent during the period marked by the accumulation of these sediments.

As each sedimentary unit is characterized by a decrease in the frequency of nitrogen fixing plants and an increase in the frequency a plant community shift of C_4/CAM plants, it is possible that this represents links to the geological/pedological facies changes. When the lower portions of each unit are deposited, this is a period of more active flooding and greater amounts of silt and clays are deposited, representing lower energy flood accumulations and finally, soils form, representing greater stability and less sediment deposition. This final facies phase is marked by clay illuviation. These sedimentary and soil processes seem to be linked with systematic, although not dramatic, changes in stable carbon and nitrogen isotopes.
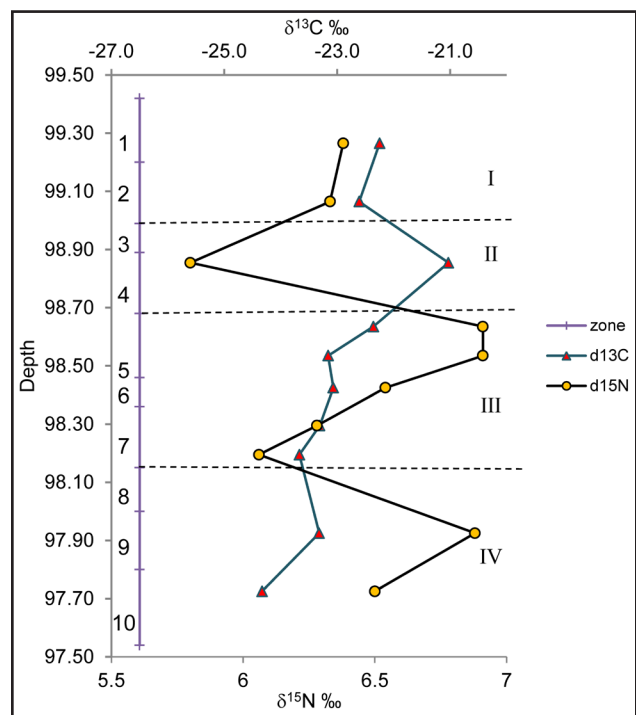
Figure 7.17.   Carbon and nitrogen stable isotope results from sediments.

DECOMPOSITION OF ANIMAL CARCASSES

When an animal dies the taphonomic processes that result in the formation of fossilized bone are complex (Farlow and Argast 2006). A great deal is known about the decomposition of human bodies due to the research of forensic scientists and we will use those investigations as a guide. First, mammal bodies are composed of roughly 64 percent water, 20 percent protein, 10 percent fat, five percent minerals, and one percent carbohydrate. During the decomposition of mammal bodies, there occurs a chemical breakdown of proteins, carbohydrates, lipids, nucleic acids, and bone. If left on the surface and exposed to the elements, this process can be fairly quick, but if the body is buried, this process is dramatically slowed down.

On the surface, the decomposition of an animal's body goes through five stages. These are 1) fresh, 2) bloated, 3) active decay, 4) advanced decay and, 5) dry or skeletonized remains. Decomposition begins as soon as the animal dies and two chemical processes occur. The first is autolysis, also known as self-digestion, which is the destruction of the soft tissues by the action of the body's own enzymes. The second is known as putrefaction, which is the decomposition of proteins due to invasive microbial actions. If microbial bio-erosion takes place, it often occurs early on during the process of diagenesis and it often completely destroys bone (Farlow and Argast 2006).

When the body becomes skeletonized, the decomposition or diagenesis of the bone is accelerated. Bone consists primarily of collagen, a protein, and hydroxyapatite, a mineral composed of calcium and phophorous (Tucker 1991). The collagen and hydroxyapatite have a protein-mineral bond that survives long after the soft tissues have decomposed (Dent et al. 2004). This bond provides the strength and durability of bone. Bacteria begin to break down collagen into peptides and then further into amino acids that are removed by leaching. Then calcium is removed by weathering the remaining hydroxyapatite. Once the calcium is removed, the bone structure weakens and eventually disintegrates (Forbes 2008).

FOSSILIZATION OF BONE

The petrification or fossilization of bone takes place by two related processes. The first is mineral replacement and the second is perimineralization (Orr and Kearns 2011). Mineral replacement occurs when the

hydroxyapatite is removed by leaching and the structure replaced by minerals in solution such as calcite, silica, pyrite, or hematite. This may reproduce the microscopic structure of the bone and, in rare cases, the softer tissues such as horns or hoofs. Perimineralization occurs when the minerals in solution fill in the pores, cavities, and sometimes on the surface of bone, but leave the original structure (Farlow and Argast 2006).

There are a number of processes that can influence digenesis and fossilization. If predators or scavengers dismember a carcass or if geological processes mechanically break up a carcass, this can impede microbial decomposition and increase the likelihood of fossilization. Burial in waterlogged sediments can also diminish microbial decomposition. The pH of the soil can influence fossilization. Slightly alkaline sediments are best for fossilization and as Figure 7.15 illustrates, the amounts of calcium carbonate in the sediments that encased the mammoth bones at 41BX1239 would have only occurred in alkaline sediments.

Potapova and Agenbroad (2011) provide detailed descriptions and analysis of the mammoth bone. This information plus the field drawings (see Figures 7.18a-7.18c) show the fragmentary nature of these remains. While no chemical analysis was undertaken on the bones, it seems clear that the bones partially retain some of their anatomical positions, but their physical structure was degraded to the point that single bones had fragmented and weathered. It is likely that one or two processes caused the bones to be moved from their original positions. Geological processes such as flowing water or predators/scavengers may have moved the bones. The process was not so invasive so as to have transported the bones a great distance.

Summary

The sediment analysis shows that at least four sedimentary units were deposited and further altered by pedogenesis. Within each sediment package, unique patterns of deposition can be used to characterize the unit. It is likely that the sediments in Unit IV represent a point bar deposit that gradually shifts from deposits dominated by coarse-medium sands to very fine sands, silt, and clay. The presence of gravels in Unit IV supports this interpretation. Unit III sediments shift from dominated by silts to a significant increase in clays. This suggests that these deposits began as the outer edge of a point bar or natural levee and then shifted to finer-grained floodplain deposits toward the top of the

unit. The pond deposit identified by Caran could not be isolated. There is a dramatic shift in the depositional pattern above Unit III. In both Unit II and Unit I, the deposits alternate rapidly from coarser to fine with the loam to clay loam textural classes which are dominated by silts. Along with the near absence of gravels, these patterns suggests near stream margin sediments. More distally located floodplain sediments would have greater proportions of clay and stream margins would be dominated by sands and gravels. The organic carbon percentages, the documented soil colors and the distribution of $CaCO_3$ concentrations along with the vertical distribution of fine clays in relation to the medium and coarse clays suggest that the tops of Unit I and Unit II were altered by pedogenic processes that translocated clays and carbonates down-profile and increased organic carbon amounts in the A horizons. The absence of clear A horizons in the top of Unit III and Unit IV suggest that these soils horizons had been removed by erosion which created unconformities on the top of each unit.

The data presented above can be used to argue that the mammoth bones at site 41BX1239 occur in Late Pleistocene alluvial deposits, but the exact age is unknown. The bones appear to have been deposited on the outer edge of a point bar or natural levee. It is possible that the bones were transported by fluvial processes, but given the semi-articulated condition, they would not have moved a great distance and predators/scavengers as transporters cannot be ruled out. The taphonomic patterns identified by Potapova and Agenbroad (2011) suggest that most of the mammoth bones were exposed for 1 to 3 years and then covered by sediments. The geological data support this interpretation. During this period of exposure, further physical damage by trampling would have been possible. Also during this period, much of the collagen in the bones would have decomposed and the physical structure of the bones would have been compromised but these processes would have continued after burial due to water leaching through the sediments.

The environment at the time of deposition was a strongly C_3 plant environment in Zones 7 and 6. These sediments also contain pine pollen and phytoliths that probably are associated with palmetto palms (Scott Cummings and Yost 2011).These plant associations do not occur during the Holocene locally, although what are considered to be relict Pleistocene plant communities at Lost Pines in Bastrop and Palmetto State
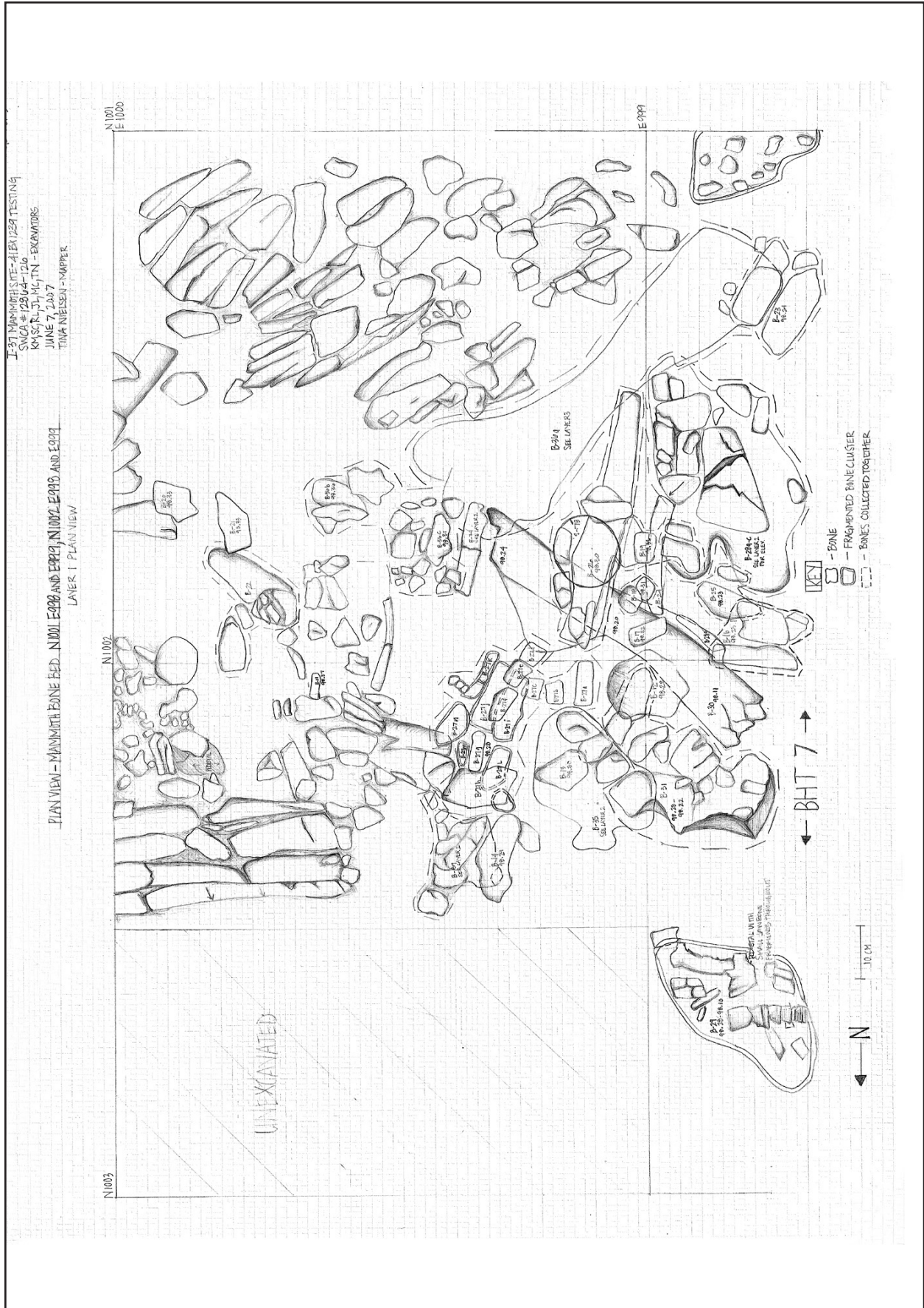
Figure 7.18a. Field drawing.
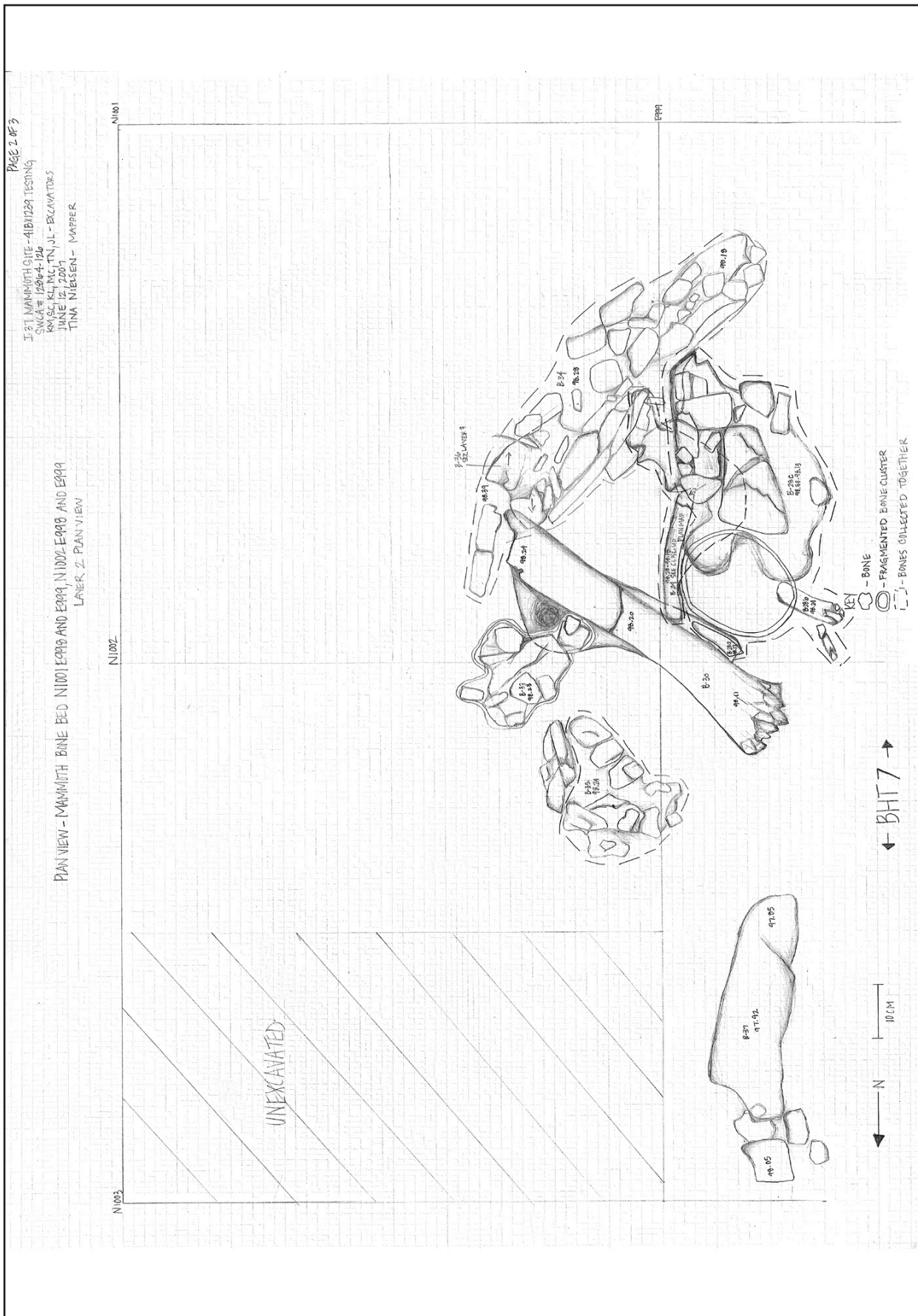
Figure 7.18b. Field drawing.
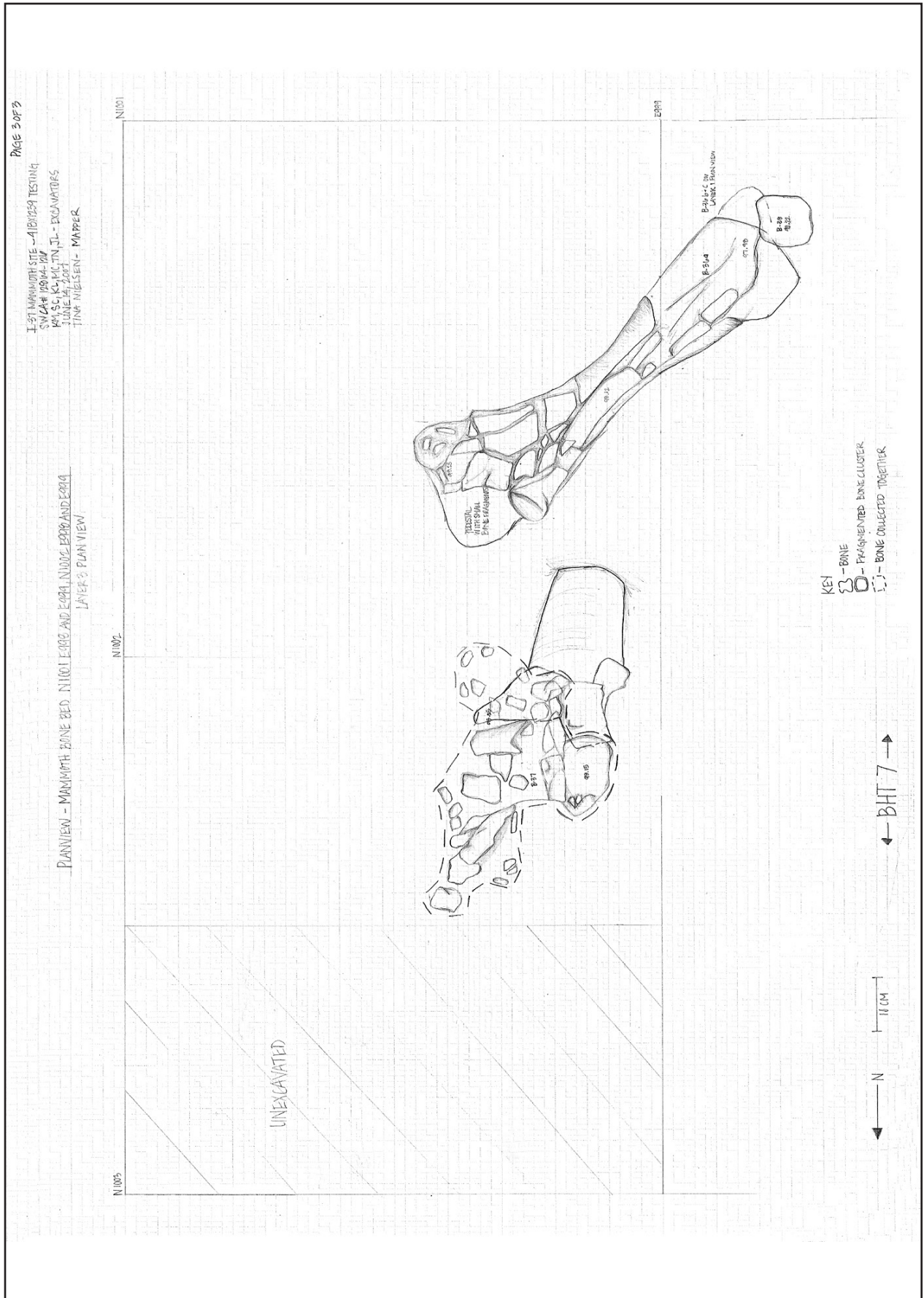
Figure 7.18c. Field drawing.

Parks in Ottine on the San Marcos River still retain elements of these associations. If the sediments date to ~17,000-15,000 ^{14}C yrs B.P., then this is a period when conditions are still fairly cool as evidenced by Bryant's (1977) identification of spruce pollen in the deposits at Boriack Bog at this time. The unique plant associations reflected by communities at Lost Pines and Palmetto State Parks may have been much more widely dispersed in the Late Pleistocene.

In a recent paper, Behrensmeyer et al (2012) studied the taphonomic patterns created during a catastrophic mass die-off of large and medium bovids during a drought in Ambroseli National Park in Kenya in 2009. The resultant pattern was that animal carcasses were isolated and scattered near water sources. The animals had not died of thirst but rather starved due to poor feeding conditions in the uplands. Surprisingly, the age of death profile was not a catastrophic age profile. The most recognizable diagnostic feature was existence of fairly complete semi-articulated carcass scattered, not clustered, near water sources. The degree of carcass articulation was in part a function of the density of scavengers. Interestingly, the Boriack Bog pollen record (Bousman 1998) documents two significant extreme declines in arboreal pollen, one at ~12,800 ^{14}C years B.P. (~14,395 cal B.P.) and another at ~15,000 ^{14}C years B.P. (~18,045 cal B.P.). The most recent event corresponds to a spike in the glacial meltwater record (Fairbanks et al. 1989; Aharon 2003). Both most certainly reflect the plant community responses to major droughts. Either could be the same age as the 41BX1239 mammoth. Unfortunately, there is little in the sedimentary record reported here to suggest a dramatic environmental change at this point.

Future investigations should focus on dating, especially OSL single grain methods, and collecting more information to conclusively determine if humans were possible predators/scavengers, if the animal died during a severe drought or if other as yet unidentified factors contributed to the death of this mammoth.

Chapter 8

Search for Cultural Traces on the Mammoth Site

Stephen M. Carpenter, Christian T. Hartnett, and J. Kevin Hanselka

One of the overarching objectives of the archaeological testing, which followed Texas A&M's initial work in 1997, was to determine, if possible, whether the site contained evidence of human involvement, or conversely whether it is strictly a paleontological site. Based on the interpretation of striations in bone as butcher marks, Texas A&M interpreted the site as yielding evidence of human-mammoth interaction, a rare occurrence in the Americas. To address the objective, the site analysis pursued two primary lines of evidence: 1) cultural modification of the mammoth bones, and 2) the association of artifacts with the remains.

Assessment of Faunal Remains for Cultural Modification

In collaboration with Olga Potopova and Larry Agenbroad, SWCA archaeologists analyzed ten element clusters to identify cut marks or other signs of intentional, cultural modification. The analysis was conducted in two phases: 1) an initial scan to inventory all modifications, whether natural or cultural, and 2) a more intensive phase of documentation on those with a potential to be anthropogenic. The first level entailed macro- and microphotography, as well as tabulated descriptions and measurements. As noted, the initial step covered all modifications, even clearly recent marks (likely incurred from the two phases of excavations) and rodent gnawing. More detailed analysis was reserved for the few that are considered candidates for prehistoric cultural modification.

Evidence for cultural modification of bone in general has been broadly treated (e.g., Binford 1981; Hesse and Wapnish 1985), and for mammoths in particular the subject is a particularly robust field of study given the long debate regarding the interaction of humans with Pleistocene megafauna. The report by Potopova and Agenbroad on the 41BX1239 remains provides a discussion and references for pertinent mammoth studies regarding expectations and interpretations of butchery marks. More specifically, Thoms (2001), Thoms et al. (2007), and Thoms and Mandel (2005)

have identified numerous modifications on mammoth remains recovered from San Antonio River Mammoth site and nearby Richard Beene site (41BX831) that they interpret as resulting from butchering and bone quarrying. Based on these studies, the analysis of the 41BX1239 elements focused on two primary attributes:

- Helical fracturing, indicative of breakage while bone was "green."

- Striations that could be attributable to cutting.

The study identified a total of 24 post-mortem modifications in the collection (Table 8.1). In drawing distinctions between natural and cultural or recent and old, the criteria discussed in the works cited above were applied. To illustrate some of the main points, Figures 8.1a and 8.1b show an example that was determined to be of recent origin based on several criteria. When the bone was uncovered, it was quite soft, the consistency of dense wet chalk, and therefore prone to inadvertent incision during trenching and excavation despite all diligence to avoid such effects. Marks I and II on element B-23. A cut through the weathered bone cortex, creating a contrastive surface (Figures 8.2a and 8.2b). There is neither sand nor calcium carbonate inclusion within the marks and consequently, these marks are inferred to be recent.

Comparatively, Mark III on element B-22.A shows modifications that reveal greater consistency between the external bone cortex and the internal surface of the mark (Figures 8.2a and 8.2b). The higher magnification photographs reveal sand and calcium carbonate within the striation, consistent with the accretions and weathering on the adjacent cortex. Based on these considerations, consistent with Johnson's criteria, these marks are considered to be of greater antiquity and therefore better candidates for culturally induced modifications.

Based on these criteria, the process of exclusion narrowed the field down to five modifications that are candidates for being anthropogenic. These include one green fracture and four striations. Compared to the

Table 8.1.   Tabulated Results of Marks on the Ten Major Elements or Bone Clusters from 41BX1239 Examined During Task 1 Faunal Analysis (Only elements with modifications are listed.)

Specimen #	Bone ID/Element	Mark	Location on element*	Length (mm)	Description	Interpretations
B-23	A. Long bone diaphysis fragment, top half (two fragments)	I	S portion/half within E half	11.12	1 distinct, short, wide, deep, linear trough	Recent modification
		II	S portion/half immediately W of Mark I	37.03	1 distinct, long, wide, deep, linear trough	Recent modification
		III	S portion/half along central area near bottom fracture margin	7.90	1 distinct, short, wide, deep, fairly straight trough	Indeterminate, faint linear mark
		IV	S portion/half within W half near bottom fracture margin	11.42	1 distinct, short, narrow, deep, linear trough	Characteristics indicate antiquity, possible cultural modification
		V	S portion/half near central area at bottom fracture margin	~ 24.82	1 helical fracture	Green bone fracture, can be caused by trampling or bone harvesting
	B.Long bone diaphysis fragment, bottom half	I	S portion/half along top/inside E bottom fracture margin	18.42	1 distinct, short, narrow, deep trough	Recent modification
	E. Undetermined fragments	I	N/A	9.85	8 closely spaced sub-parallel, distinct, short, wide, deep, linear troughs	Rodent gnawing
B-26	A. Long bone diaphysis fragment	I	E side/vertical face	9.05	1 distinct, short, wide, shallow, linear mark	Indeterminate, faint linear mark
		II	E side/vertical face	8.46	1 distinct, short, narrow to wider at base, deep, linear trough	Indeterminate, faint linear mark
		III	E side/vertical face	8.28	1 distinct, short, wide & flat, fairly deep, linear mark	Indeterminate, faint linear mark
		IV	E side/vertical face	5.37	1 distinct, short, narrow, fairly deep, linear trough	Indeterminate, faint linear mark
	C. Cortical fragments	I	N/A	6.05	1 distinct, short, fairly wide, fairly deep, linear trough	Indeterminate, faint linear mark

Table 8.1. Tabulated Results of Marks on the Ten Major Elements or Bone Clusters from 41BX1239 Examined During Task 1 Faunal Analysis (Only elements with modifications are listed.) (continued)

Specimen #	Bone ID/Element	Mark	Location on element*	Length (mm)	Description	Interpretations
B-22	A. Distal radius fragment	I	Posterior face	9.19	1 distinct, short, wide, deep, fairly straight trough	Indeterminate, faint linear mark
		II	Posterior face	5.26	1 clear, short, narrow, fairly deep, fairly straight with slight curve mark	Indeterminate, faint linear mark
		III	Posterior face	12.13	1 distinct, short, narrow, deep, linear trough	Characteristics indicate antiquity, possible cultural modification
		IV	Posterior face	10.91	1 distinct, short, wide, deep, fairly straight trough	Indeterminate, faint linear mark
		V	Posterior face	12.89	1 distinct, short, fairly wide, deep, linear trough	Indeterminate, faint linear mark
	B. Long bone fragments	I	N/A	10.63	1 faint, short, narrow, shallow, fairly straight yet wavy mark	Indeterminate, faint linear mark
		II	N/A	9.01	1 clear, short, narrow, fairly deep, linear trough	Characteristics indicate antiquity, possible cultural modification
B-36	A. Left Ulna	I	Mid-shaft section lateral face	5.38	1 clear, short, narrow, shallow, linear mark	Indeterminate, faint linear mark
		II	Mid-shaft section lateral face	11.08	1 clear, short, narrow, fairly deep, linear trough	Indeterminate, faint linear mark
		III	Mid-shaft section lateral face	14.35	1 clear, short, narrow, fairly deep, linear trough	Indeterminate, faint linear mark
		IV	Mid-shaft section lateral face	6.34	1 clear, short, narrow, shallow, linear mark	Indeterminate, faint linear mark
	B. Left Radius	I	Mid-shaft section proximal fragment lateral face	4.55	1 clear, short, narrow, fairly deep, linear mark	Characteristics indicate antiquity, possible cultural modification

*cardinal directions, referring to disposition of element in original context, are used when element orientation (e.g. proximal, distal) cannot be determined because of fragmentation.

Please note orange highlighted cells denote possible culturally modified elements.
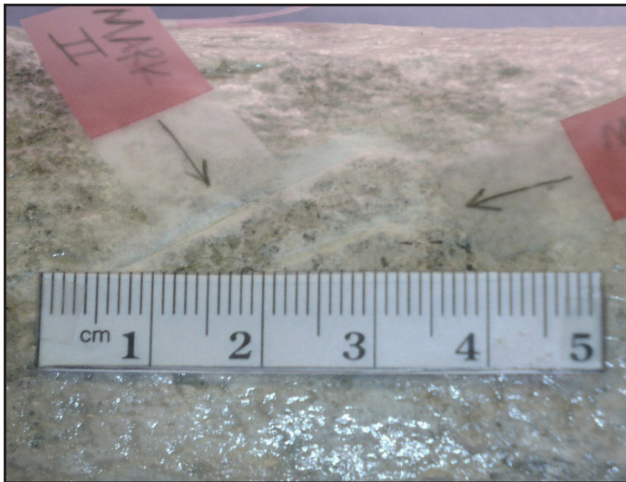
Figures 8.1a (upper) and 8.1b (lower).
Marks I and II on element B-23.A showing examples of modifications that are interpreted as recent. Figure 1B is magnified 45x, scale in mm.

Figures 8.2a (upper) and 8.2b (lower). Mark III on Specimen B-22.A showing an example of modifications interpreted as having greater antiquity. Note weathering in the interior of the mark, as well as sand grains and calium carbonate accumulation. Magnification at 28.5x and 45x, respectively from top to bottom. Scale in mm.

modifications on elements recovered by Texas A&M, we identified nothing as substantial, no markings with the consistent patterning of parallel linear striations as on bone specimen 121 (Thoms 2001:31). Nevertheless, these linear striations were inventoried and documented in accordance with the protocols established by Dr. Eileen Johnson for the site remains as specified in Thoms et al. (2001).

All of the five modifications are on long bone fragments. None were identified on ribs, mandible, or foot bones though these parts are far less represented than the long bone fragments. Of the five modifications, the four striations are isolated marks on four different elements; there are no sequential parallel marks among those four. If some of the faint, indeterminate marks are considered, perhaps a few clusters can be discerned.

But as stated, a rather conservative tack is taken here, relying mainly on marks with a relatively high degree of confidence in their antiquity.

Specimen B-23.A has the highest concentration of alterations (Figure 8.3). The large medial long bone fragment has a green bone fracture and a series of striations, one of which is considered among the four with sufficient antiquity.

In the final determination, based on the current level of analysis, a number of marks were identified that likely occurred shortly after deposition of the bone.

Figure 8.3. Specimen B-23 with green fractures on bottom side of element and striations marked by red flags.

Additional levels of analyses beyond the current scope would contribute to stronger arguments on the origin of the marks. The faunal analysis identified a minimum of two individuals represented in the bone bed. Past studies have identified trampling as a cause of both green fractures and striations. As a single line of evidence, the post-mortem modifications are not conclusive one way or the other based on the current samples, but need to be considered in light of the cumulative evidence.

FINE-SCREENING MATRIX SURROUNDING MAMMOTH REMAINS

To recover artifacts, if present, associated with the bone bed, 27 5-gallon bags of sediment from the excavations at 41BX1239 were flotation screened. The resulting heavy fraction of each bag was sorted to identify macroartifacts (artifacts retained in 1/4-inch [6.35 millimeter] mesh sieves) and microartifacts (artifacts less than 0.25 inches). The fine screen mesh (with 2.0 millimeter mesh) recovered artifacts between 2.0 millimeters and 6.35 millimeter/0.25 inches in size. All possible artifacts, including small siliceous fragments that cannot be conclusively determined to be culturally modified, were recovered, inventoried, photographed, and analyzed (Appendix A).

Table 8.2 presents the findings. In discussing the recovery, we maintain a precise terminology to avoid assuming precisely what we are trying to determine (i.e., cultural involvement). The terms *debitage* and even *flake* are laden with connotations of cultural lithic reduction. To avoid these implications, *siliceous stone fragments* offers a more interpretive-neutral phrasing that covers the possibilities of naturally or culturally fractured lithic materials. That said, a total of 57 small fragments, the vast majority ranging in size from 2 to 5 mm in maximum diameter, were recovered from 12 individual provenience lots. The fragments are not rounded, stream-rolled pebbles, but rather, angular, lenticular fragments that lack cortex (i.e., tertiary) on most if not all sides. A few samples exhibit many of the classic fracture-mechanic attributes such as bulb of percussion and conchoidal rings. Figures 8.4 through 8.7 are representative samples that show typical characteristics of the fragments recovered from the site.

The raw materials are chert-like or quartzite siliceous materials. Variation in color and texture suggest at least six different raw material types, ranging in color from a pale white to reddish brown. However, the variation in any given raw material nodule makes it quite difficult to preclude a more limited or diverse number of raw materials represented by the collection.

In an effort to determine whether these were clearly related to human lithic reduction and tool use, a careful microscopic examination of the apparent micro-debitage using an Omano 6.5-45x stereoscopic microscope. Examination under high magnification is especially important in areas with more (Figures 8.8 to 8.10).

Table 8.2.   Tabulated Results of Siliceous Material Recovered From Sediment Samples From 41BX1239

Table does not include screened proveniences with no recovery.

Lot #	Northing	Easting	Elev (m)	# of siliceous materials	Comments
17.C	1001	999	98.75-98.6	9	All recovered from 2 mm screen
20.C	1001	998	98.5-98.4	10	All recovered from 2 mm screen
24.C	1001	997	98.4-98.3	2	All recovered from 2 mm screen
55.C	1001	999	98.6-98.5	9	All recovered from 2 mm screen
56.B	1002	999	98.6-98.5	3	All recovered from 2 mm screen
56.C	1002	999	98.6-98.5	5	All recovered from 2 mm screen
57.C	1002	999	98.5-98.4	5	All recovered from 2 mm screen
76.C	1001	999	98.4-98.3+	2	Irregular level in bone bed, collected beneath limb bone B-26; recovered from 2 mm residual
209.C	1001-1002	998-999	98.3-98.1	1	Sediment surrounding B-30, B-31 & B-33; originally missing from specimen inventory; recovered from 2 mm screen
215.C	1001	998-999	98.39-98.18	5	Sediment surrounding B-34 fragmented limb bone, point prov. is B-34 centroid; recovered from 2 mm screen
218.C	1002	999	98.25-98.15	3	Sediment surrounding B-37 bone cluster with Patella, point prov. Is B-37 centroid; recovered from 2 mm residual
224.C	1002	998	98.05-97.85	3	Sediment surrounding B-39 tusk, point prov is B-39 centroid; recovered from 2 mm residual

Figure 8.4.   Specimen 55.C.2, scale at bottom in millimeters. Magnification approximately 15X.

Figure 8.5.   Specimen 224.C.2, scale at bottom in millimeters. Magnification approximately 15X.

Figure 8.6. Specimen 18.C.6, scale at bottom in millimeters. Magnification approximately 15X.

Figure 8.7. Specimen 18.C.7, scale at bottom in millimeters. Magnification approximately 15X.

While there is an absence of characteristics typical of intentional stone tool manufacture (e.g., platforms), the possibility must be considered that the tiny lithic fragments originated during butchering activities shortly after the mammoth was killed. The examined fragments exhibit sharp edges; one would expect that naturally occurring tiny gravels would have rounded or worn edges due to natural erosional processes. Tiny fragments of a chipped stone tool may flake off during butchering, and the pieces associated with the 41BX1239 are consistent in appearance with this function.

While it is equally possible that the miniscule fragments of stone are present due to natural processes such as alluvial or colluvial deposition, the general appearance of the flakes is also suggestive of fragmenting during the use of stone tools, perhaps to butcher the mammoth. But at this level of analysis, it is difficult to say for sure.

Because of the high level of skepticism and critical threshold of certainty imposed on claims of human-mammoth interaction, there is a substantial need to present the data as objectively and clearly as possible, drawing clear lines between the data and interpretations. Nevertheless, to offer a preliminary interpretation, many characteristics are consistent with microdebitage produced by stone tool use or sharpening.

INFERRING ASSOCIATION BETWEEN MAMMOTH REMAINS AND ARTIFACTS

The siliceous materials are clearly in the sediments surrounding the mammoth bones, but inferring association (i.e., a causal linkage of some sort) is an interpretive step. Several competing scenarios present possibilities that the flakes were secondarily deposited by natural processes, and therefore not associated with the mammoth remains. One scenario is that the micro-debitage from among the bones originated from the strata above and gradually moved down the profile from subsequent cultural occupations. One supporting piece of evidence for such a scenario is a piece of glass recovered from the same unit and level that yielded the highest number of micro-debitage (N 1001 E 998 from 98.5 to 98.4 m). However, while the overlying sediments were not flotation screened for small artifacts, none of the excavation units recovered artifacts from the levels above the bone bed. The glass is an enigma.
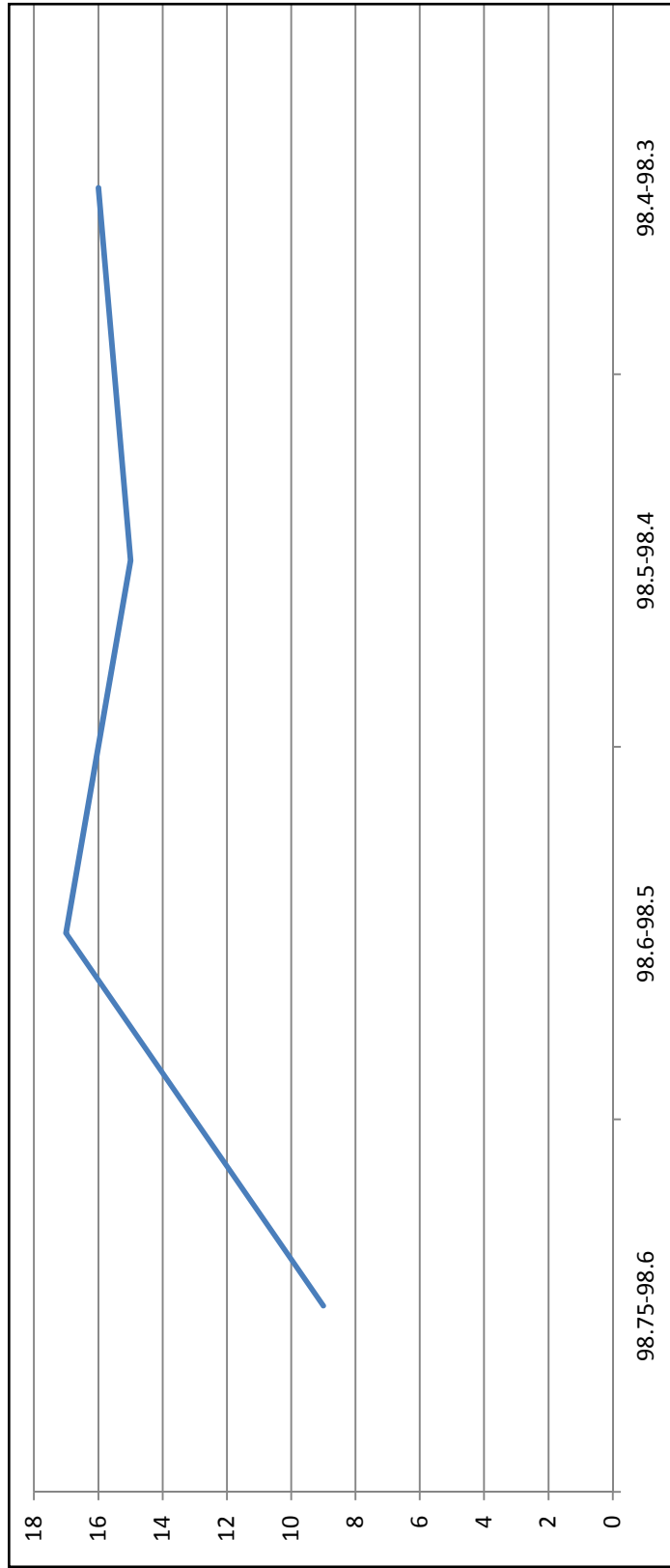
Figure 8.8.   Count of siliceous materials.

Figure 8.9.   Lot 17.C.4 20x power, ventral view.

Figure 8.10.   Lot 17.C.8 20x power, ventral view.

Figure 8.11.   Lot 17.C.1 20x power.

Another scenario is that the microdebitage occurs naturally in the alluvial sediments as inclusions within the matrix. These small flakes could be the byproduct of bedload gravel tumbling creating natural, attritional micro-debitage. Both the San Antonio and Medina Rivers have their headwaters in chert-bearing Cretaceous formations such as Edwards Limestone. Accordingly, siliceous materials are expectedly part of the gravel bedload, but also at finer scales of sand, silt, and clay. There are several ways of testing this possibility, though they are generally beyond the current scope. Off-site archaeology could be used to assess the natural occurrence of siliceous materials in the same depositional unit beyond the mammoth bone bed. If the horizontal and vertical patterns show the micro-debitage only occurs in the vicinity of the mammoth bones, such a pattern would tend to strengthen the argument for association. The distribution of siliceous material in the screened samples show a lesser amount of fragments recovered above the mammoth. Within the mammoth bearing layers, there is a higher but consistent level of siliceous material (Figure 8.11). However, since much of the overburden was stripped prior to hand excavation, a robust sample of overlying sediments was not obtained. Future studies may provide clarification along these lines.

If the flakes are secondarily deposited and byproducts of natural processes, transport would necessarily create an array of variation in the degree of rounding and edge damage to the flakes. That is not found in the sample, however, and nearly all observed specimens retains sharp, fine tapered edges indicative of little if any transport after flake formation.

The depositional context provides additional consideration for the scenario that the flakes are naturally occurring in the alluvial sediments. As noted in the previous chapter, sediments over 2 mm in diameter are defined as gravels, or *coarse fragments*. All of the flakes greater than 2 mm are gravels. According to the texture analysis results, coarse fragments are present, but in low quantities (1 percent or less) in sediments surrounding the mammoth (Zones 5, 6, and 7; Appendix G). As deposition within Unit III occurred, the sediments shift from one dominated by silts to ones dominated by clays, suggesting a decrease in depositional energy and a concurrent decrease in particle size. The energy affecting clast deposition decreased subsequent to the placement of the faunal remains. This line of analysis is entirely circumstantial,

but gravels are uncommon in the natural matrix, lending a bit of credence to anthropogenic origins.

Given the above evidence, additional work is needed to clarify the relationship of the flakes with the mammoth, but the prima facie evidence shows micro-debitage in the sediments surrounding the bone. Different scenarios of secondary deposition cannot be entirely dismissed, but the characteristics of the flake population and other findings suggest these scenarios are less parsimonious interpretations. Clarifying the association with the mammoth remains is a testable hypothesis that future studies should continue to assess.

CONCLUSION

The central question regarding 41BX1239 revolves around whether the site represents an archaeological site, particularly one of a rare example of human interaction with Pleistocene mega-fauna, namely two mammoths. To review the cumulative evidence to date:

➤ Texas A&M recovered 1,660 mammoth bone fragments, of which three reveal human-made cutmarks based on study by Eileen Johnson (Thoms et al. 2001).

➤ One flake was recovered from backdirt during Texas A&M investigations, though association with mammoth remains is uncertain (Thoms et al. 2001).

➤ Cutmarks and helical fractures from original Texas A&M excavations was further interpreted as evidence of bone quarrying/human processing (Thoms et al. 2005).

➤ Independent assessment of the anthropogenic interpretation of marks on three Texas A&M specimens was conducted by Lee Bement of the University of Oklahoma. This new study concurs with previous findings that the marks were made by human butchering (this report).

➤ Though no clearly discernible artifacts were recovered in direct association of mammoth remains during the 2007 TxDOT-sponsored SWCA excavations, fine-screening of sediments revealed micro-debitage in sediments surrounding mammoth remains. Both the cultural origins of the debitage and association with mammoth bones warrants further study (this report).

➤ Analysis of faunal remains from 2007 excavations revealed five marks or clusters of marks on four different elements that are consistent with those interpreted by Johnson, Bement and others to be caused by human activity. All five marks are on long bone fragments; none are identified on ribs, mandible, vertebrae, or otherwise (this report).

By the highest thresholds of scrutiny used by Grayson and Meltzer (2002), there are only 14 sites in North America that have strong or conclusive evidence of human interaction with mammoths (12 sites) or mastodons (two sites). By their standards, the San Antonio River Mammoth site would not be included among these sites, based on the current information. However, the trends are suggestive and at the very least provide a strong basis for recommending preservation of and further work on the site. An apparently substantial portion of the site remains intact.

CHAPTER 9

SUMMARY AND CONCLUSIONS

Stephen M. Carpenter, C. Britt Bousman, and Christian T. Hartnett

On behalf of TxDOT, SWCA conducted test excavations on the San Antonio River Mammoth site and 41BX1240 and intensive survey in the APE of the IH 37 bridge project at the San Antonio River. Conducted in compliance with state and federal regulations, the purpose of the investigations was to identify, delineate and evaluate the significance of all archaeological and historic properties affected by the undertaking. Of particular concern, the Mammoth site contains the remains of a mammoth that yielded possible evidence of cultural association based on the initial investigations by the CEA at TAMU in 1997.

INTENSIVE PEDESTRIAN SURVEY

On May 21, 23–24, and June 15 and 20, 2007, archaeologists conducted an intensive pedestrian survey with subsurface investigations in the project area. The proposed bridge rehabilitation project is divided between the northern and southern sides of the San Antonio River. The roughly 950-foot-long portion north of the San Antonio River is almost exclusively uplands. The remaining 2,300-foot- long portion south of the river consists of roughly 1,270 feet of uplands and 1,030 feet of lowlands.

The pedestrian survey of the 3,250-foot-long and 600-foot-wide project corridor generally revealed extensive modern modifications with disturbed soils on the uplands and deep alluvial soils in the lowland portion of the project corridor.

The portion of the project area north of the San Antonio River was examined with pedestrian survey and backhoe trench excavation. Much of the area had been heavily affected by modern developments, such as existing roadway, large fill sections, concrete-lined ditches, and a series of buried utilities.

Excluding the trenches placed in and around the sites, for the survey, a total of 11 trenches were excavated to assess the potential for buried materials. On the northern side, a total of five trenches were excavated. None yielded cultural material except modern roadside debris. South of the San Antonio River, backhoe trenches and shovel tests identified no new sites. Six backhoe trenches on the southern side of the San Antonio River, as well as all shovel tests, were negative for cultural material.

SAN ANTONIO RIVER MAMMOTH SITE TESTING

Testing of the Mammoth site began with the relocation of Texas A&M's 1997 survey trenches, notably their BHT 7, which yielded the mammoth remains. Almost all elements depicted in the original survey report could be identified, and the bone appeared not to have degraded too much as a result of its original uncovering, reburial, and re-exposure.

After the previous trench was re-excavated, an additional four trenches were excavated, two located to the west and two to the east. Three trenches revealed the older deposits—Perez and Somerset soils—but no mammoth bone. Trench 1, farthest to the east, revealed only younger sediments, thereby defining the eastern limits of the strath terrace. These trenches provided the primary exposures for the geomorphological assessment.

Upon completion of geoarchaeological analysis, SWCA began the testing of prehistoric site 41BX1239 with hand excavated test units. Centered on the exposed deposits in the TAMU BHT 7, seven formally designated 1 m^2 test units were excavated, though three of the seven were half units. Accordingly, the excavations covered approximately 5.5 m^2. Units N998 E1001 and N998 E1002 were located along the eastern wall of BHT 7, which removed the western half of each unit. Unit N1002 E999 was arbitrarily laid out as a half unit to further expose certain elements found in the adjacent unit to the south. With N1001 E999, these four units comprise a 2.5-m^2 block that came down on the densest bone deposits, which is collectively referred to as the *bone bed*. Three outlying units, two on the western side of Trench 7 and one to the east (N1002 E1002), all encountered relatively minor amounts of bone, possibly indicating the margins of the bone bed.

The excavations exposed a portion of what initially appeared to be a single individual, probably a Columbian mammoth (*Mammuthus columbi*). However, the subsequent faunal study revealed at least two individuals are represented.

FAUNAL ANALYSIS

Faunal analysis of a sample of the recovered mammoth bones was conducted by Olga Potapova and Larry D. Agenbroad at the Mammoth Site National Natural Landmark in Hot Springs, North Dakota. Based on their analysis of three bins (8, 11, and 16), mammoth remains attributed to two separate individuals were identified. Additional analysis was conducted by SWCA on additional specimens.

The analysis could not confirm the species beyond the Mammuthus genera, but in terms of the known temporal and spatial distribution of the various mammoth species, Columbian mammoth is the inferred identification. The age and sex of the individuals are undetermined based on the studied sample. No definite cultural modification was observed on these bones, although the analysis of marks on several long bones reveal grooves and other post-mortem modifications consistent with those that the previous analysis interpreted as derived from human butchering. The possibility that some bones (femur distal condyles) recovered during the 2007 investigations could be culturally modified cannot be ruled out.

GEOARCHAEOLOGICAL ANALYSIS

The sediment analysis shows that at least four sedimentary units were deposited and further altered by pedogenesis. Each of these units is further subdivided into zones. The earliest unit, Unit IV, likely represents a point bar deposit that gradually shifts from deposits dominated by coarse-medium sands to very fine sands, silt, and clay. The overlying Unit III sediments change from the predominance of silts to a significant increase in clays, suggesting these deposits began as the outer edge of a point bar or natural levee and then shifted to finer-grained floodplain deposits toward the top of the unit. The pond deposit identified by Caran (in Thoms et al. 2001) could not be isolated. Units II and I represent a distinctive shift in depositional processes, as the deposits alternate rapidly from coarser to fine with the loam to clay loam textural classes, which are dominated by silts. Along with the near absence of gravels, these patterns suggest near stream margin sediments.

The data indicate that the mammoth bones at site 41BX1239 occur in Late Pleistocene alluvial deposits, but the exact age is unknown. The bones appear to have been deposited on the outer edge of a point bar or natural levee. It is possible that the bones were transported by fluvial processes, but given the semi-articulated condition, they would not have moved a great distance and predators/scavengers as transporters cannot be ruled out. The taphonomic patterns identified by Potapova and Agenbroad suggest that most of the mammoth bones were exposed for 1 to 3 years and then covered by sediments. The geological data support this interpretation. During this period of exposure, further physical damage by trampling would have been possible. Also during this period, much of the collagen in the bones would have decomposed and the physical structure of the bones would have been compromised, but these processes would have continued after burial due to water leaching through the sediments.

The environment at the time of deposition was a strongly C_3 plant environment in Zones 7 and 6. These sediments also contain pine pollen and phytoliths that probably are associated with palmetto palms (Scott Cummings and Yost 2011). These plant associations do not occur during the Holocene locally although there are what are considered to be relict Pleistocene plant communities located to the east.

ARCHAEOLOGICAL ANALYSIS

The archaeological analysis entailed several aspects, including the independent assessment of the evidence of human modification on the elements discovered in 1997 by TAMU, examination of mammoth bones recovered during the more recent 2007 excavations, and the assessment of artifacts in association with the bone bed.

CULTURAL MODIFICATION OF MAMMOTH BONES

Regarding the first of these, the study by Dr. Bement concurs with the interpretations of TAMU's study that there is evidence of cultural modifications on certain elements. Concerning the assessment of the bones recovered during SWCA's 2007 investigations for similar evidence of human involvement, Potopova and Agenbroad did not discern conclusive evidence on the elements from the three bins that they inspected. However, several elements from the seven bins studied by SWCA revealed striations and helical fractures

consistent with the evidence that both the TAMU study and Dr. Bement interpret as culturally induced.

SEARCH FOR ARTIFACTS IN MATRIX SURROUNDING MAMMOTH REMAINS

To recover artifacts, if present, associated with the bone bed, sediments from the excavations at 41BX1239 were bagged and brought back to the laboratory for flotation screening through 2-mm mesh screens to recover the smallest possible artifacts. Once processed, the resulting heavy fraction of each bag was sorted to identify microartifacts. All possible artifacts, including small siliceous fragments, were recovered, inventoried, photographed, and analyzed.

A total of 57 small fragments of siliceous material, the vast majority ranging in size from 2 to 5 mm in maximum diameter, were recovered from 12 individual provenience lots. All proveniences were from mammoth-bearing deposits. The fragments are not rounded, stream-rolled pebbles, but rather, angular, lenticular fragments that lack cortex (i.e., tertiary) on most, if not all, sides. A few samples exhibit many of the classic fracture-mechanic attributes such as bulb of percussion and conchoidal rings. To confirm that these are the byproducts of stone tool use would take a sustained statistical analysis beyond the scope of the current study. Furthermore, corroboration of clear association between the mammoth remains and flakes would also require additional corroboration. The small pieces could be secondarily deposited among the bones by moving down the profile from overlying sediments. Despite all such considerations, the presence of microdebitage in the matrix surrounding the mammoth bones—some of which have evidence of butchering, according to two independent studies—contribute to multiple lines of evidence supporting the plausibility of the archaeological nature of the site.

RECOMMENDATIONS FOR FUTURE STUDIES AT THE MAMMOTH SITE

Numerous aspects of the Mammoth site warrant clarification, but the potential to address significant patterns of prehistory is quite high if the trends identified by TAMU's investigations and those reported here continue to pan out. The objectives of the 2007 investigations were limited to a specific set of objectives related to the project impacts, and many worthwhile avenues of study were not pursued. The primary imperatives were to relocate and delineate the

deposits to ensure avoidance. From our current vantage point and level of understanding of the site, a few observations on viable directions, from the technical to theoretical, are offered here as fodder for future study.

On the technical side, it is important to note that the preservation conditions among sites are highly variable and highly unique. Consequently, standard techniques have to be tailored to new circumstances, often through trial and error. The San Antonio River Mammoth site faunal remains are preserved by moisture and a stable surrounding matrix. There is no collagen and not much fossilization (mineral displacement of organic elements). Upon removal from these two conditions, a continuous post-recovery curatorial process is needed to prevent disintegration. The combined use of three different dilution ratios of the B-72 acryloid allows flexibility and differing degrees of penetration of the preservative. The effectiveness of the acryloid is somewhat lessened by the moisture in the bone.

Regarding dating, optically-stimulated luminescence of single quartz grains appears to be the most viable means of dating the deposits based on the array of current methods. It would provide relative dating (e.g., *terminus post quem* and *terminus antes quem*) of the depositional context, but would not directly date the remains. It is possible that more extensive excavations may yield denser elements with better preservation of the organic fraction of bone for radiocarbon dating, but none were recovered in the current study. Preservation processes would need to be tailored to these possibilities. Acryloid B-72 and many other preservatives are organic compounds that would affect radiocarbon assays.

The piecemeal removal of individual elements is quite difficult in limited excavation units, as overlapping elements typically extend into nearby walls. The ideal circumstances would be either larger areal exposures of the bone bed to allow documentation of association, or the excision of arbitrary blocks of the bonebed (such as 1-m squares), for meticulous excavation under laboratory conditions.

Regarding the fineries of excavation techniques, some elements can be exposed by using the natural cleavage plane between the bone and surrounding matrix. However, some of the more porous bone interdigitates with the sediments, creating difficulties in discerning where the sediment ends and bone begins. The bone is very soft, often the consistency of wet chalk. Metal

tools will etch the bone at the slightest touch. Wooden tools are much more effective and less damaging. Bamboo is often used, but wooden tools used by ceramicists proved by far the most effective because of the diversity of rounded edges.

Summer conditions are oppressive, to the point of imposing quite a few practical hindrances. The potential for torrential rains, as we discovered, is a problem, particularly on the toe of a steep slope. Subsurface drainage also contributes to inundate excavations. The exceedingly high humidity in the riparian terraces foster permanently saturated hands and clothes, which, coupled with wet sediments, take their tolls on all phases of documentation from paperwork to GPS to cameras, which fog up quickly. If at all possible, late fall through winter conditions would be much more amenable.

A few broad research topics are briefly mentioned here as possible research directions for the further consideration. Several important issues include the effect of human peopling on the natural setting of the Americas (e.g., Pleistocene extinctions), the organization of early societies, and role of mammoth in human subsistence.

Until fairly recently, megafauna such as mammoth, and to a lesser degree mastodon, were considered to be rather central to early Paleoindian subsistence, providing a basis, it was thought, for the structure of Paleoindian technology and mobility. The validity of that notion has been increasingly reconsidered over the last 20 years and many now consider it to be, at best, poorly substantiated (Grayson and Meltzer 2002:314; Johnson 1991). The preponderance of evidence indicates more of an opportunistic exploitation of large mammals within a substantially diverse subsistence strategy. Regarding the San Antonio River Mammoth site, some of these issues could be addressed by clarifying the nature of human involvement, if confirmed, regarding the death of the animals. Was it opportunistic scavenging, post-mortem bone quarrying, or active hunting of the animals, perhaps by miring and dispatching them?

Relatedly, large numbers of mammoth at some archaeological sites have been interpreted as evidence of intensive predation, which contributed to the extinction of a number of species of large mammal. The argument hinged on the assumption that the sites, specifically Blackwater Draw, Dent, and Miami,

represented mass killings, which would have entailed related animals. The main controversy surrounded Dent and Miami sites, since most conceded Blackwater Draw was attritional. However, based on recent isotopic analysis from these sites that "Clovis hunters in this region [Great Plains] did not slaughter entire family groups of mammoths en masse, but rather hunted, or at least scavenged, mammoths on an individual basis" (Hoppe 2004:140). In regard to the San Antonio River site, the nature of the mammoth's taphonomy and demise, the human agency in these aspects, and whether the two mammoths derived from separate events or the same one could contribute to the broader debate on the issues.

NRHP Testing of 41BX1240

The backhoe trench excavations revealed surficial site deposits with no buried cultural horizons. A 50-x-50-cm column sample was placed in BHT 4N. The column sample was excavated in arbitrary 10-cm levels to determine the presence of subsurface cultural materials and to determine if investigation with 1-m² test units was justified. The lack of cultural materials and common disturbances indicated that further excavations were not warranted. Materials found on the site included a single flake, an exceedingly sparse amount of burned rock, and a light scatter of historic and modern debris. The many roadside disturbances have removed all integrity.

Conclusions and Recommendations

The Mammoth site was previously deemed eligible as an SAL and for listing on the NRHP. The various lines of evidence detailed in this report lend a degree of support to archaeological interpretation of the site and its eligibility for inclusion in the NRHP and for listing as a SAL, although further investigations are clearly needed to support such an interpretation. The primary objective of the current study was to relocate and delineate the deposits to ensure avoidance by the IH 37 bridge project. That goal was attained and the project avoided impacts to the site.

Additionally, while opening the site up, limited additional data was gathered to address the geomorphological context and clarify the inferred archaeological nature of the site. In the final analysis of the Mammoth site, no clearly discernible artifacts, such as a projectile point or biface, were identified in association with the mammoth remains. However, the

matrix immediately surrounding the bones revealed numerous siliceous flakes that are consistent with micro-debitage from use and resharpening of stone tools. Caution is warranted in inferring this as direct evidence of human involvement until other plausible interpretations can be ruled out. Concerning evidence of cultural modification of the bone, the independent study conducted by Dr. Bement concurred with the previous interpretations in the TAMU study: several attributes, such as striations and helical fractures, are attributable to human activity. Several bones recovered during the 2007 excavations have modifications consistent with those that the two studies identify as cultural in origin.

The investigations of the portion of site 41BX1240 within the project area identified only a very sparse scatter of primarily surficial materials in a heavily disturbed context with no associated features or diagnostic materials. Accordingly, the site is not recommended as eligible for listing on the NRHP or for designation as a SAL. The survey identified no new archaeological sites. Based on the avoidance of 41BX1239, it is SWCA's recommendation that no archaeological properties will be affected by the IH 37 bridge rehabilitation.

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APPENDIX A - STEP-BY-STEP PREPARATION OF MAMMOTH BONES (JACKETS #8, #11, AND #16) FROM SITE 41BX1239, BEXAR COUNTY, TEXAS

THE MAMMOTH SITE OF HOT SPRINGS, SD, INC.

REFER TO ACCOMPANYING DISC

APPENDIX B - BONE PREPARATION FORMS

SWCA ENVIRONMENTAL CONSULTANTS

REFER TO ACCOMPANYING DISC

APPENDIX C - RADIOCARBON DATING RESULTS FROM BETA ANALYTIC

APPENDIX C

RADIOCARBON DATING RESULTS FROM BETA ANALYTIC

FROM: Darden Hood, Director (mailto:mailto:dhood@radiocarbon.com)
(This is a copy of the letter being mailed. Invoices/receipts follow only by mail.)

July 17, 2007

Dr. James Abbott
Texas Department of Transportation
Cultural Resource Management
Environmental Affairs Division
125 East 11th Street
Austin, TX 78701
USA

RE: Radiocarbon Dating Results For Samples 41BX123931S52, 41BX123933S71, 41BX123933S72, 41BX123933S73, 41BX123933S75, 41BX123953S89

Dear Jim:

Enclosed are the radiocarbon dating results for six samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us.   We are always available to answer your questions.

Our invoice is enclosed. Please, forward it to the appropriate officer or send VISA charge authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Dr. James Abbott   Report Date: 7/17/2007

Texas Department of Transportation   Material Received: 6/26/2007

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 232030	30 +/- 40 BP	-22.6 o/oo	70 +/- 40 BP

SAMPLE : 41BX123931S52
ANALYSIS : AMS-ADVANCE delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION :   Cal AD 1680 to 1740 (Cal BP 270 to 210) AND Cal AD 1810 to 1930 (Cal BP 140 to 20)
           Cal AD 1950 to beyond 1960 (Cal BP 0 to 0)

Beta - 232031	8040 +/- 60 BP	-24.0 o/oo	8060 +/- 60 BP

SAMPLE : 41BX123933S71
ANALYSIS : AMS-ADVANCE delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION :   Cal BC 7170 to 6810 (Cal BP 9120 to 8760)

Beta - 232032	6360 +/- 50 BP	-21.7 o/oo	6410 +/- 50 BP

SAMPLE : 41BX123933S72
ANALYSIS : AMS-ADVANCE delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION :   Cal BC 5480 to 5310 (Cal BP 7430 to 7260)

Beta - 232033	6950 +/- 50 BP	-23.3 o/oo	6980 +/- 50 BP

SAMPLE : 41BX123933S73
ANALYSIS : AMS-ADVANCE delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION :   Cal BC 5990 to 5740 (Cal BP 7940 to 7690)

Beta - 232034	1060 +/- 40 BP	-22.4 o/oo	1100 +/- 40 BP

SAMPLE : 41BX123933S75
ANALYSIS : AMS-ADVANCE delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION :   Cal AD 880 to 1020 (Cal BP 1070 to 930)

Dr. James Abbott   Report Date: 7/17/2007

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 232035	4880 +/- 40 BP	-22.0 o/oo	4930 +/- 40 BP

SAMPLE : 41BX123953S89
ANALYSIS : AMS-ADVANCE delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION :   Cal BC 3790 to 3640 (Cal BP 5740 to 5590)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.6:lab. mult=1)

Laboratory number: **Beta-232030**

Conventional radiocarbon age: **70±40 BP**

2 Sigma calibrated results²: **Cal AD 1680 to 1740 (Cal BP 270 to 210) and**
(95% probability)   **Cal AD 1810 to 1930 (Cal BP 140 to 20) and**
     Cal AD 1950 to beyond 1960 (Cal BP 0 to 0)

² *2 Sigma range being quoted is the maximum antiquity based on the minus 2 Sigma range*

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1960 (Cal BP 0)

1 Sigma calibrated results: Cal AD 1700 to 1720 (Cal BP 250 to 230) and
(68% probability)   Cal AD 1820 to 1840 (Cal BP 130 to 110) and
     Cal AD 1880 to 1920 (Cal BP 70 to 40) and
     Cal AD 1950 to 1960 (Cal BP 0 to 0)
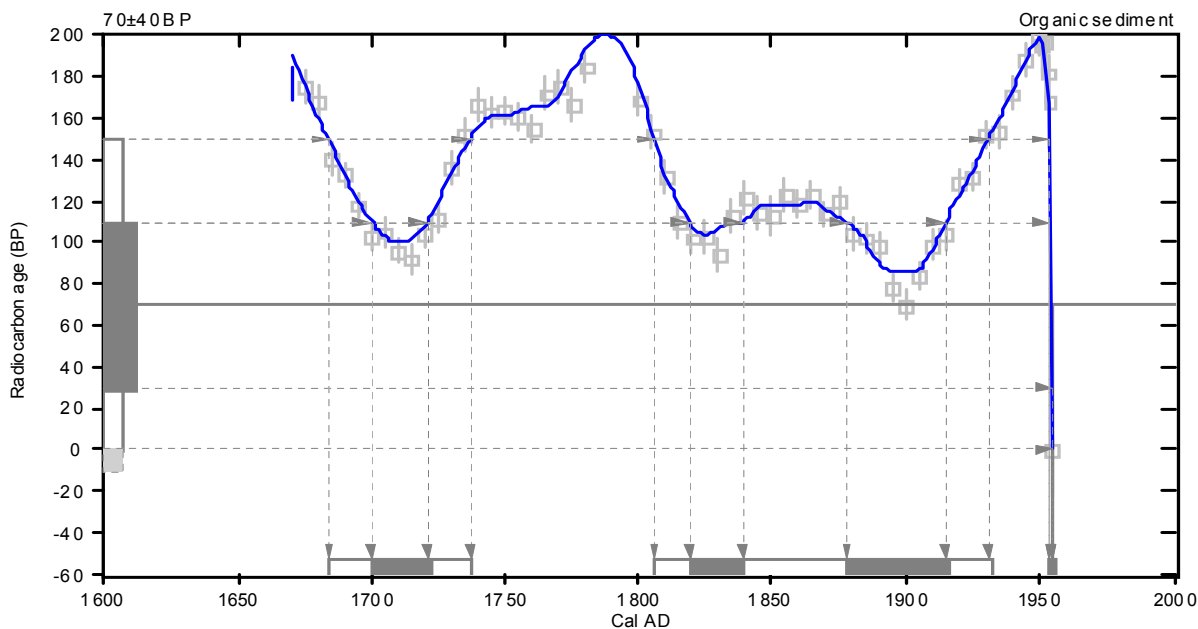
References:
Database used
    INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
    IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
    Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35 (2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24:lab. mult=1)

Laboratory number: Beta-232031

Conventional radiocarbon age: 8060±60 BP

2 Sigma calibrated result: Cal BC 7170 to 6810 (Cal BP 9120 to 8760)
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 7050 (Cal BP 9000)

1 Sigma calibrated result: Cal BC 7070 to 7030 (Cal BP 9020 to 8980)
(68% probability)
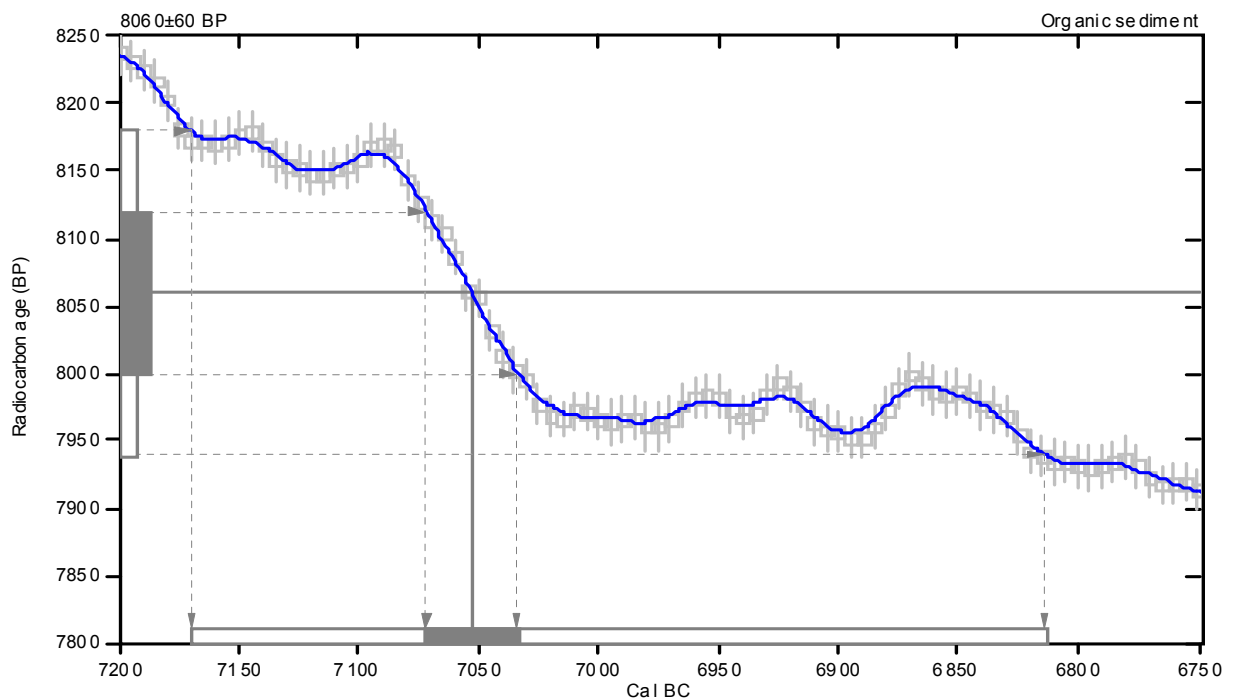
References:
Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35 (2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.7:lab. mult=1)

Laboratory number:	**Beta-232032**
Conventional radiocarbon age:	**6410±50 BP**
2 Sigma calibrated result: **(95% probability)**	**Cal BC 5480 to 5310 (Cal BP 7430 to 7260)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 5370 (Cal BP 7320)
1 Sigma calibrated result: (68% probability)	Cal BC 5470 to 5320 (Cal BP 7420 to 7270)
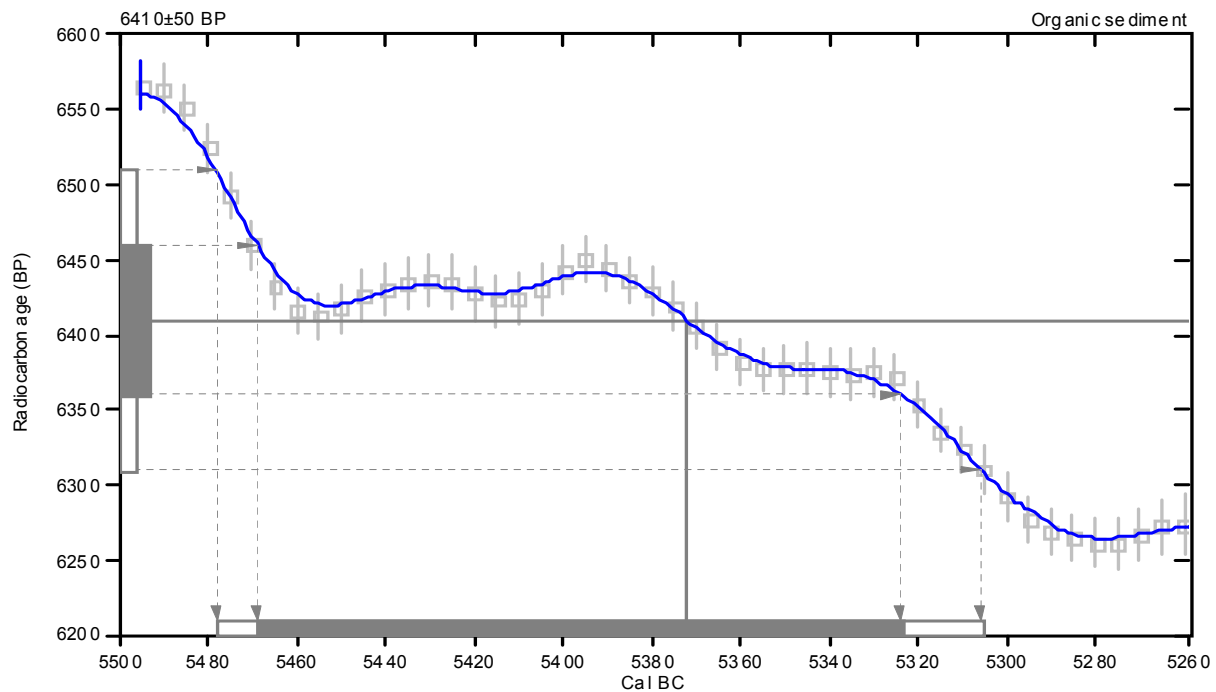
References:
Database used
    INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
    IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
    Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35 (2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.3:lab. mult=1)

Laboratory number: **Beta-232033**

Conventional radiocarbon age: **6980±50 BP**

2 Sigma calibrated result: **Cal BC 5990 to 5740 (Cal BP 7940 to 7690)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 5880 (Cal BP 7830)

1 Sigma calibrated results: Cal BC 5970 to 5950 (Cal BP 7920 to 7900) and
(68% probability)   Cal BC 5910 to 5800 (Cal BP 7860 to 7750)
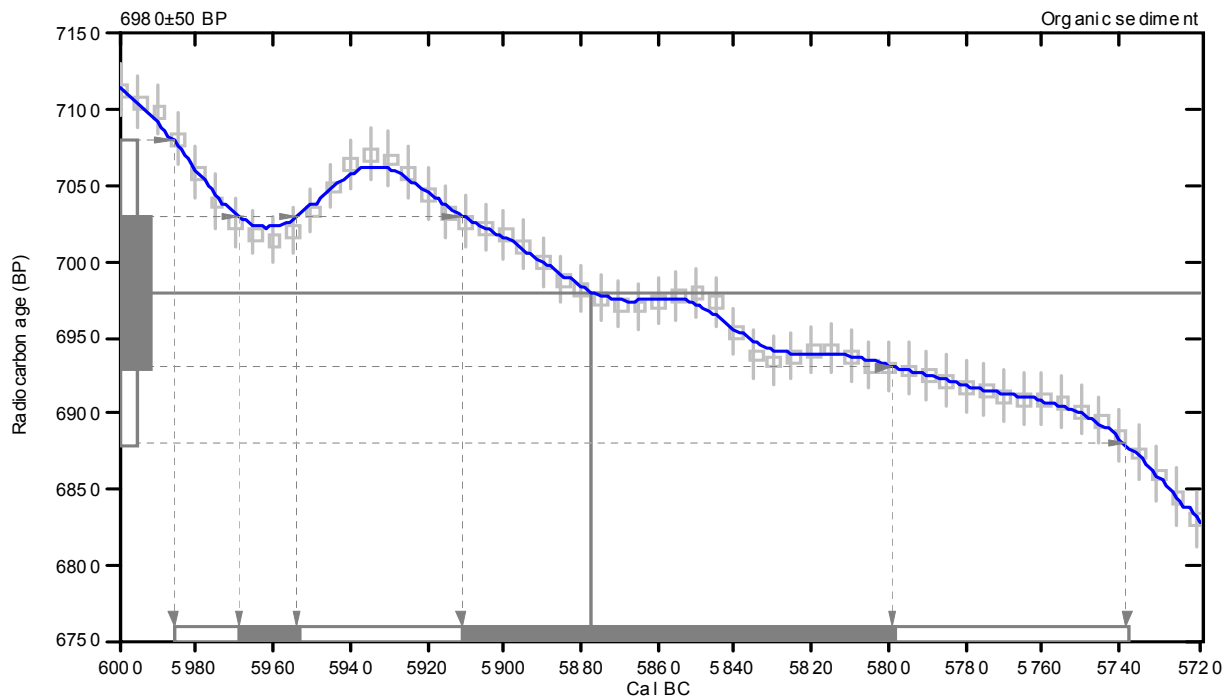
References:
Database used
    INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
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Mathematics
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    Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35 (2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.4:lab. mult=1)

Laboratory number: **Beta-232034**

Conventional radiocarbon age: **1100±40 BP**

2 Sigma calibrated result: **Cal AD 880 to 1020 (Cal BP 1070 to 930)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 970 (Cal BP 980)

1 Sigma calibrated result: Cal AD 890 to 990 (Cal BP 1060 to 960)
(68% probability)
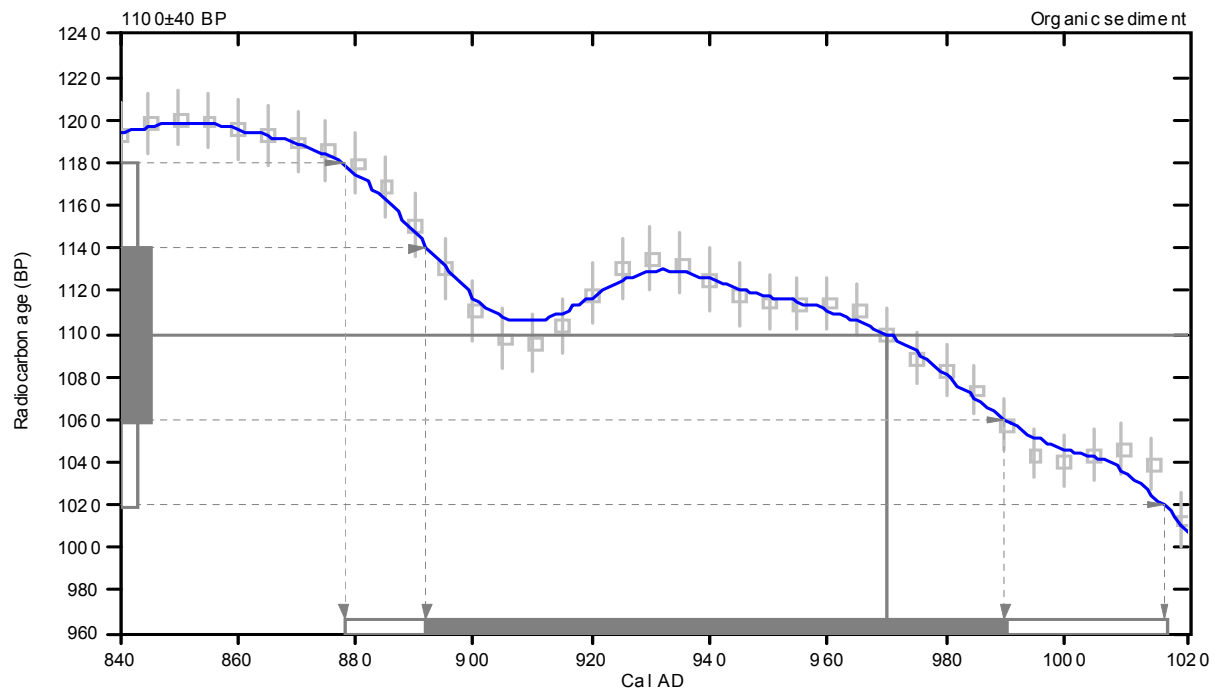
References:
Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35 (2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22:lab. mult=1)

**Laboratory number:** **Beta-232035**

Conventional radiocarbon age: **4930±40 BP**

2 Sigma calibrated result: **Cal BC 3790 to 3640 (Cal BP 5740 to 5590)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 3700 (Cal BP 5650)

1 Sigma calibrated result: Cal BC 3720 to 3660 (Cal BP 5670 to 5600)
(68% probability)
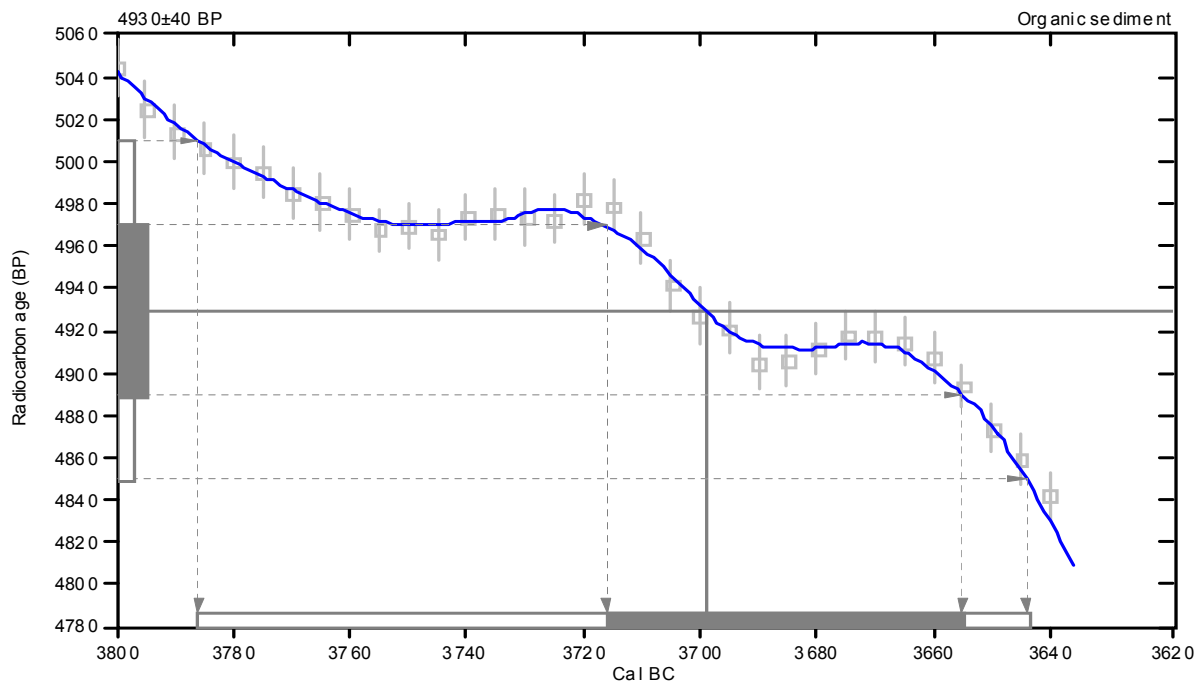
References:
Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
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Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35 (2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

APPENDIX D - SITE 41BX1239 SPECIMEN INVENTORY
REFER TO ACCOMPANYING DISC

APPENDIX E - SITE 41BX1240 SPECIMEN INVENTORY

REFER TO ACCOMPANYING DISC

Appendix F - Stratigraphic Descriptions
Dr. Britt Bousman

APPENDIX F

STRATIGRAPHIC DESCRIPTIONS

Dr. Britt Bousman

PROFILE DESCRIPTIONS

PROFILE 1, TAMU BHT 7, WEST WALL IN YOUNGER DEPOSITS IN LOWER TERRACE

Zone	Depth	Description
1	0-20	Dark grayish brown (2.5Y 4/2) clay loam to yellowish brown (10YR 5/4) sandy loam, very abrupt irregular lower boundary marked by black plastic, fill from previous excavations. Ap Horizon.
2	20-30	Dark grayish brown (10YR 4/2) silt loam, medium weak subangular blocky structure, abundant earthworm casts throughout, common rootlets, clear smooth lower boundary. A Horizon.
3	30-46	Light olive brown (2.5Y 5/4) silt loam, coarse weak subangular blocky structure, common earth worm casts filled with dark grayish brown (10YR 4/2) clay loam abrupt wavy lower boundary. AB Horizon.
4	46-60	Dark grayish brown (10YR 4/2) clay loam, few roots, few charcoal flecks, few snail shells, small calcium carbonate nodule gravels, abrupt smooth lower boundary. Ab Horizon.
5	60-72	Alternating very thin beds and lamina of yellowish brown (10YR 5/4) silt loam and dark grayish brown (10YR 4/2) clay loam, thickness varies between 5mm to 20mm, rare charcoal flecks and snail shells, abrupt smooth lower boundary. C Horizon.
6	72-105	Dark grayish brown (10YR 4/2) slightly firm clay loam, medium weak to moderate subangular blocky structure, rare charcoal fragments, snail shells and rootlets,, gradual smooth lower boundary. 2Ab Horizon.
7	105-155+	Light yellowish brown (10YR 6/4) silt loam, few discontinuous and irregular thin grayish brown (10YR 5/2) clay lenses, lower boundary not observed. 2B Horizon.

PROFILE 2, TAMU BHT 7, WEST WALL AT BASE OF HIGHER TERRACE

Zone	Depth	Description
1	0-10	Dark brown (10YR 3/3) clay loam, common earthworm casts and rootlets, abrupt irregular sloping lower boundary. A Horizon.
2	10-35	Brown (10YR 4/3) silt loam, few to many earthworm casts, common rootlets, clear smooth sloping lower boundary. AB Horizon.

2 Appendix F Mammoth Site Stratigraphic Descriptions

3	35-60	Dark yellowish brown (10YR 4/4) silt loam, weak coarse subangular blocky structure, common rootlets, few snail shells, few insect burrows, very abrupt irregular slightly sloping lower boundary. <u>B Horizon.</u>

4	60-64/67	Black (10YR 2/1) and white (G 8/1) heavily oxidized clay loam/burnt organic layer with white ash with reddish brown (5YR 4/4) heavily oxidized clay clasts, abrupt irregular slightly sloping lower boundary. <u>2Ab Horizon.</u>

5	64/67-72	Very dark grayish brown (10YR 3/2) clay loam, fine medium subangular blocky structure, many earthworm casts, common snail shells, few unburned hackberry seeds charcoal flecks and rootlets, clear smooth lower boundary.<u>3Ab1 Horizon.</u>

6	72-105	Brown (10YR 4/3) clay loam, medium moderate subangular blocky structure, common snail shells and shell fragments, many earthworm casts, gradual smooth lower boundary.<u>3ABt1 Horizon.</u>

7	105-135	Light olive brown (2.5Y 5/3) silt loam, medium moderate subangular blocky structure, few rootlets, insect burrows, and snail shell fragments, clear smooth lower boundary. <u>3B Horizon.</u>

8	135-153/ 167	Brown (7.5YR 5/4) clay loam with pinkish white (7.5YR 8/2) fine mottles surrounding small $CaCO_3$ nodules (less than 1%), $CaCO_3$ filaments along root pores, few manganese flecks on ped faces and small nodules, shiny clay films on ped faces, clear irregular lower boundary. <u>3Btk1 Horizon.</u>

9	153/167- 187	Brown (7.5YR 5/4) clay loam, medium moderate subangular blocky structure, 3-5% $CaCO_3$ medium soft nodules and filaments, common snail shells fragments, rare small manganese flecks, clear smooth lower boundary, <u>3Btk2 Horizon.</u>

10	187-207+	Pale brown (10YR 6/3) silty clay loam, medium moderate subangular blocky structure, common medium faint brownish yellow (10YR 6/8) mottles, ~20% $CaCO_3$ small hard nodules, larger soft nodules and filaments, few snail shells, ≤1% manganese flecks, lower boundary not observed. <u>4Btk Horizon.</u>

PROFILE 3, SWCA BHT 1, *IN YOUNGER DEPOSITS IN LOWER TERRACE*

Zone	Depth	Description
1	0-10	Brown (10YR 4/3) clay loam, medium moderate subangular blocky structure, common earthworm casts and rootlets, few roots, clear smooth lower boundary. A <u>Horizon</u>.
2	10-30	Yellowish brown (10YR 5/4) clay loam, medium moderate subangular blocky structure, common rootlets, few snail shells, common earthworm casts, clear smooth lower boundary. B <u>Horizon</u>.
3	30-35	Brown (10YR 4/3) clay loam thick lamina up to 10mm thick alternating with thin brownish yellow (10YR 5/6) fine sand lamina up to 3mm thick, at least 15 alternating lamina, very abrupt irregular to wavy lower boundary. C <u>Horizon</u>.

4	35-59	Dark grayish brown (10YR 4/2) clay loam, medium subangular blocky structure, few rootlets, snail shell fragments and charcoal fragments and flecks, rare lenses of light yellowish brown (10YR 6/4) sand, clear smooth lower boundary. 2Ab1 Horizon.
5	59-67	Dark grayish brown (10YR 4.5/2) clay loam, slightly more sand than zone 4, few snails and rootlets, smooth clear lower boundary. 2Ab2 Horizon.
6	67-115	Dark grayish brown (10YR 4/2) clay loam, moderate coarse subangular blocky structure, few rootlets and charcoal flecks, abundant snail shells, mammal bone at 78cm, clear smooth lower boundary. 2Ab3 Horizon.
7	115-132+	Yellowish brown (10YR 5/4) silt loam and clay loam in pockets.2B Horizon.

PROFILE 4, SOUTH WALL, SWCA BHT 2

Zone	Depth	Description
1	0-9	Dark grayish Brown (10YR 4/2) clay loam with light yellowish brown (10YR 6/4) sandy loam, lenses dispersed throughout, surface leaf litter cover, common rootlets, clear smooth lower boundary, A Horizon.
2	9-25	Brown (10YR 4/3) slightly firm silt loam, weak medium subangular blocky structure, common earthworm casts, few earthworm burrows, common rootlets, few roots, few ≤ 1 cm CaCO3 nodules, clear smooth, sloping lower boundary, AB Horizon.
3	25-32	Yellowish brown (10YR 5/4) friable sandy loam, coarse medium subangular blocky structure, common rootlets, few roots, few earthworm burrows, few ≤ 1 cm CaCO3 nodules, abrupt smooth sloping lower boundary (unconformity), C Horizon.
4	32-52	Brown (7.5YR 5/4) slightly firm clay loam, medium weak subangular blocky structure, common earthworm casts, few rootlets and roots (mostly on upper boundary), few snail shells and shell fragments, few fine faint pinkish gray (7.5YR 6/2) mottles, clear smooth lower boundary, 3A Horizon.
5	52-79	Strong brown (7.5YR 5/5) firm clay loam, with ~5% brown (7.5YR 6/2) mottles, <1% CaCO3 nodules (≤ 1 cm dia.) few rootlets, few mottles along root molds, few snail shells and fragments, few rounded limestone casts (≤ 2 cm dia.), clear smooth lower boundary, 3B1 Horizon.
6	79-99	Brown (7.5YR 5/4) slightly firm silt loam, medium weak subangular blocky structure, mottles as above increasing to 2%, few snail shells and fragments, few sub-rounded limestone clasts (≤ 1mc dia.), clear smooth lower boundary, 3B2 Horizon.
7	99-127	Reddish yellow (7.5YR 6/6) silt loam, few roots and rootlets, few snail shells and fragments, mottles as above that increase in size and frequency (common) with some surrounding CaCO3 nodules, ≤ 1% CaCO3, clear smooth lower boundary, 3Bk Horizon.
8	127-156	Light brown (7.5YR 6/4) slightly firm clayey silty loam, many firm medium to coarse distinct pinkish gray (7.5YR 7/2) mottles, some mottles grade into very firm

4 *Appendix F Mammoth Site Stratigraphic Descriptions*

subhorizontal CaCO3 bands, 10% CaCO3, few small manganese flecks surrounded by few medium distinct strong brown (7.5YR 5/8) mottles, very abrupt smooth lower boundary marked by CaCO3 band, 3Btk Horizon.

9   156-190   Light brownish gray (2.5Y 6/2) silt loam, common strong brown (7/5YR 5/6) medium distinct mottles, some mottles surround small root pores, mottles increase in size and frequency down profile and some surround small ($\leq$ 1 cm) CaCO3 nodules ($\leq$ 1%), few snail shells and fragments, rare subrounded small ($\leq$ 5mm) chert pebbles, lower boundary not observed, 4Bk Horizon.

PROFILE 5, EAST WALL TAMU BHT 7, AT MAMMOTH BONES, APPROXIMATELY 20CM OF FILL ABOVE PROFILE

Zone	Depth	Description
1	0-22	Dark grayish brown (10YR 4/2) clay loam, fine moderate subangular blocky structure, , common earthworm casts, few rootlets, few snail shell fragments and charcoal fragments, clear smooth sloping lower boundary, A Horizon.
2	22-43	Brown (10YR 5/5) silt loam with strong brown (7.5YR 5/6) clay loam, casts, few rootlets, few snail shell fragments, rare small ($\leq$ 1cm) chert pebbles, clear smooth sloping lower boundary, B Horizon.
3	43-53	Brown (10YR 4/3) silt loam, common small charcoal flecks, clear smooth lower boundary, 3A Horizon.
4	53-74	Yellowish brown (10YR 5/4) clay loam, weak course subangular blocky structure, few snail shell fragments, few CaCO3 nodules that possibly washed into place, clear smooth to wavy strongly sloping lower boundary (unconformity), 3B Horizon.
5	74-96	Brown (7.5YR 5/4) silt loam, weak fine-medium subangular blocky structure, few ($\leq$1%) pinkish gray (7.5YR 6/2) mottles that increase in frequency down profile, few charcoal flecks (Sample C-3 taken at 91cm) common snail shell, few ($\leq$ 1%) CaCO3 filaments coating root pores, few small ($\leq$ 1cm dia.) CaCO3 nodules surrounded by pinkish gray mottles, clear smooth lower boundary, 3Bk Horizon.
6	96-106	Yellowish brown (10YR 5/4) silty clay loam, medium weak subangular blocky structure, few snail shell fragments and charcoal flecks, common mammoth bone in lower portion of zone but may be disturbed, clear smooth lower boundary, 3Bt1 Horizon.
7	106-127	Light brownish gray (2.5Y 6/2) friable clay loam, fine moderate subangular blocky to crumb structure, common medium distinct yellowish brown (10YR 5/6) mottles, well preserved snail shell, common *in situ* mammoth bone in zone, clear smooth slightly sloping lower boundary, 3Bt2 Horizon.
8	127-142	Light brownish gray (10YR 6/2) friable silty clay loam, fine moderate subangular blocky to crumb structure, few medium faint yellowish brown (10YR 5/8) mottles, common CaCO3 filaments along root pores, few poorly preserved small shell fragments-many with chemically leached and pitted surfaces, clear smooth slightly sloping lower boundary, 4Btk1 Horizon.

9   142-162   Pale yellow (2.5Y 7/3 to 8/3) firm silty clay loam with many olive yellow (2.5Y 6/8) medium distinct mottles, common very small manganese flecks dispersed throughout, few larger manganese films on ped faces, few small ($\leq$ 4mm dia.) CaCO3 nodules, few small ($\leq$ 2mm dia.) chert and quartz pebbles, clear smooth lower boundary, 4Btk2 Horizon.

10   162-188+   Pale yellow (2.5Y 7/8) silty clay loam, fine moderate subangular blocky structure, few large manganese films on ped faces, common (~10%) fine to medium distinct yellowish brown (10YR 5/8) mottles that often surround manganese films, few ($\leq$1%) small ($\leq$ 2mm dia.) CaCO3 nodules, few small subangular to subrounded chert pebbles, lower boundary not observed, 4btk3 Horizon.

Appendix G - Soil Chemistry and Particle Size Analyisis of Samples from the Mammoth Site (41BX1239), Bexar County, Texas

C.T. Hallmark, Senior Professor and PG

Texas A&M University Soil and Crop Sciences Department

APPENDIX G

SOIL CHEMISTRY AND PARTICLE SIZE ANALYSIS OF SAMPLES FROM THE MAMOTH SITE (41BX1239), BEXAR COUNTY, TEXAS

C.T. Hallmark, Senior Professor and PG, Texas A&M University, Soil and Crop Sciences Department

SOIL CHARACTERIZATION LABORATORY
SOIL AND CROP SCIENCES DEPT., THE TEXAS AGRICULTURAL EXPERIMENT STATION
12/16/2011

LOCATION: Bexar County, San Antonio River - Site 41BX1239
SWCA/Britt Bousman

| | | | | PARTICLE SIZE DISTRIBUTION (mm) | | | | | | | | | | | | | | | |
| | | | | SAND | | | | | | SILT | | CLAY | | | | | | | |
LAB NO	ID	zone	Depth	VC (2.0-1.0)	C (1.0-0.5)	M (0.5-0.25)	F (0.25-0.10)	VF (0.10-0.05)	TOTAL (2.0-0.05)	FINE (0.02-0.002)	TOTAL (0.05-0.002)	FINE (<0.0002)	TOTAL (<0.002)	TEXTURE CLASS	COARSE FRAG-MENTS %	ORGN Carbon %	CAL-CITE	DOLO-MITE %	CACO3 EQ
E4274	S21	1	99.32	0.1	0.4	3.0	15.6	10.3	29.4	28.2	42.2	12.4	28.4	CL	1	1.74	40.8	0.2	41.0
E4273	S20	1	99.27	0.1	0.4	2.7	16.0	10.4	29.6	27.5	41.1	13.6	29.3	CL		1.15	43.1	0.5	43.6
E4272	S19	2	99.17	0.0	0.3	1.3	11.8	10.3	23.7	30.4	45.6	14.8	30.7	CL		0.84	42.9	0.4	43.3
E4271	S18	2	99.12	0.0	0.3	2.2	18.9	13.3	34.7	24.7	38.6	13.0	26.7	L		0.92	42.9	0.5	43.4
E4270	S17	2	99.07	0.2	0.6	2.7	16.4	10.3	30.2	25.6	38.1	15.5	31.7	CL		0.76	36.6	0.1	36.7
E4269	S16	3	98.97	0.0	0.3	2.6	13.7	9.4	26.0	29.0	43.4	14.6	30.6	CL		1.20	41.6	0.1	41.7
E4268	S15	4	98.86	0.0	0.4	3.5	18.1	11.8	33.8	24.9	39.4	12.7	26.8	L		0.67	45.0	0.2	45.2
E4267	S14	4	98.81	0.1	0.3	1.8	13.7	10.3	26.2	28.4	42.9	15.3	30.9	CL		0.68	43.5	0.2	43.7
E4266	S13	4	98.76	0.2	0.5	2.2	12.6	9.9	25.4	28.8	41.8	15.7	32.8	CL	1	0.59	40.4	0.1	40.5
E4265	S12	5	98.64	0.2	1.2	3.4	19.2	11.6	35.6	22.6	34.4	16.3	30.0	CL	1	0.49	35.9	0.3	36.2
E4264	S11	5	98.59	0.3	1.1	3.3	19.1	12.2	36.0	22.3	35.1	15.0	28.9	CL	1	0.51	38.2	0.3	38.5
E4263	S10	5	98.54	0.4	1.2	3.8	20.1	12.5	38.0	21.7	34.2	14.6	27.8	CL		0.50	39.3	0.0	39.3
E4262	S9	6	98.43	0.4	1.3	3.6	19.2	12.7	37.2	23.0	36.1	13.7	26.7	L		0.57	44.4	0.2	44.6
E4261	S8	7	98.3	0.1	0.7	3.0	19.7	13.9	37.4	23.5	37.7	13.0	24.9	L	1	0.59	46.8	0.0	46.8
E4260	S7	7	98.25	0.2	1.3	4.0	18.3	12.1	35.9	24.9	38.7	12.9	25.4	L	1	0.52	48.9	0.1	49.0
E4259	S6	7	98.2	0.2	0.6	2.7	18.3	13.6	35.4	25.1	39.6	12.8	25.0	L	1	0.48	48.8	0.2	49.0
E4258	S5	8	98.07	0.6	1.4	4.0	18.6	12.1	36.7	25.7	38.8	13.4	24.5	L	1	0.52	47.0	0.2	47.2
E4257	S4	9	97.93	0.5	1.8	6.6	20.9	8.6	38.4	28.5	38.6	11.4	23.0	L	2	0.48	48.2	0.0	48.2
E4256	S3	9	97.88	1.0	2.3	7.6	21.7	8.1	40.7	28.8	38.7	11.0	20.6	L	7	0.43	48.9	0.3	49.2
E4255	S2	10	97.73	3.2	4.4	7.7	19.1	8.7	43.1	22.4	37.6	7.1	19.3	L	3	0.58	64.3	0.5	64.8
E4254	S1	10	97.68	1.9	3.2	6.7	21.8	9.0	42.6	24.2	38.1	8.8	19.3	L	1	0.49	58.5	0.2	58.7

Appendix H - Stratigraphic Pollen, Phytolith, and Diatom Analysis of Samples from the Mammoth Site (41BX1239), Bexar County, Texas

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STRATIGRAPHIC POLLEN, PHYTOLITH, AND DIATOM ANALYSIS OF SAMPLES FROM THE MAMMOTH SITE (41BX1239), BEXAR COUNTY, TEXAS

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STRATIGRAPHIC POLLEN, PHYTOLITH, AND DIATOM ANALYSIS
OF SAMPLES FROM THE MAMMOTH SITE (41BX1239), TEXAS

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INTRODUCTION

Sample were collected stratigraphically from the west wall of Backhoe Trench 7 at the Mammoth Site (41BX1239) in Bexar County, Texas. These samples were originally designated for diatom and/or phytolith analysis. Upon review of soil conditions at the site, pollen analysis was recommended as the first priority. Due to high sediment pH, diatom and phytolith dissolution was identified as a potential problem. Analysis proceeded on these sediments for the recovery and identification of pollen, phytoliths, and diatoms.

METHODS

Pollen

A chemical extraction technique based on flotation is the standard preparation technique used in this laboratory for removing pollen from the large volume of sand, silt, and clay with which it is mixed. This particular process was developed for extracting pollen from soils where the preservation has been less than ideal and the pollen density is lower than in peat. It is important to recognize that it is not the repetition of specific and individual steps in the laboratory, but rather mastery of the concepts of extraction and how the desired result is best achieved, given different sediment matrices, that results in successful recovery of pollen for analysis.

Hydrochloric acid (10%) was used to remove calcium carbonates present in the soil, after which the samples were screened through 250-micron mesh. The samples were rinsed until neutral by adding water, letting the samples stand for 2 hours, then pouring off the supernatant. A small quantity of sodium hexametaphosphate was added to each sample once it reached neutrality, then the samples were allowed to settle according to Stoke's Law in settling columns. This process was repeated with ethylenediaminetetraacetic acid (EDTA). These steps remove clay prior to heavy liquid separation. The samples then were freeze dried. Sodium polytungstate (SPT), with a density 1.8, was used for the flotation process. The samples were mixed with SPT and centrifuged at 1500 rpm for 10 minutes to separate organic from inorganic remains. The supernatant containing pollen and organic remains was decanted. SPT again was added to the inorganic fraction to repeat the separation process. The supernatant was decanted into the same tube as the supernatant from the first separation. This supernatant was then centrifuged at 1500 rpm for 10 minutes to allow any remaining silica to be separated from the organics. Following this, the supernatant was decanted into a 50-ml conical tube and diluted with distilled water. These samples were centrifuged at 3000 rpm to concentrate the organic fraction in the bottom of the tube. This pollen-rich organic fraction was rinsed, then all samples received a short (20–30 minute) treatment in hot hydrofluoric acid to remove any remaining inorganic particles. The samples then were acetylated for 3–5 minutes to remove any extraneous organic matter.

A light microscope was used to count pollen at a magnification of 500x. The pollen preservation in these samples varied from good to poor. Comparative reference material collected at the Intermountain Herbarium at Utah State University and the University of Colorado Herbarium was used to identify the pollen to the family, genus, and species level, where possible.

Pollen aggregates were recorded during identification of the pollen. Aggregates are clumps of a single type of pollen and may be interpreted to represent either pollen dispersal over short distances or the introduction of portions of the plant represented into an archaeological setting. The aggregates were included in the pollen counts as single grains, as is customary. The presence of aggregates is noted by an "A" next to the pollen frequency on the pollen diagram. The pollen diagram was produced using Tilia 2.0 and TGView 2.0.2. Total pollen concentrations were calculated in Tilia using the quantity of sample processed in cubic centimeters (cc), the quantity of exotics (spores) added to the sample, the quantity of exotics counted, and the total pollen counted and expressed as pollen per cc of sediment.

"Indeterminate" pollen includes pollen grains that are folded, mutilated, or otherwise distorted beyond recognition. These grains were included in the total pollen count since they are part of the pollen record. The microscopic charcoal frequency registers the relationship between pollen and charcoal. The total number of microscopic charcoal fragments was divided by the pollen sum, resulting in a charcoal frequency that reflects the quantity of microscopic charcoal fragments observed, normalized per 100 pollen grains.

Pollen analysis also included examination for starch granules and, if they were present, their assignment to general categories. Starch granules are a plant's mechanism for storing carbohydrates. Starches are found in numerous seeds, as well as in starchy roots and tubers. The primary categories of starches include the following: with or without visible hila, hilum centric or eccentric, hila patterns (dot, cracked, elongated), and shape of starch (angular, ellipse, circular, eccentric). Some of these starch categories are typical of specific plants, while others are more common and tend to occur in many different types of plants.

Phytoliths

Extraction of phytoliths from these sediments was based on heavy liquid floatation. Hydrochloric acid (HCl) was first used to remove calcium carbonates and iron oxides from a 30-ml sediment sample. The addition of HCl resulted in a vigorous reaction, indicating the presence of a significant quantity of calcium carbonate material. Next, nitric acid was added to each sample and boiled for 3 hours to destroy the organic fraction of the sediment. Very little reaction with nitric acid was observed, indicating low organic levels. Once this reaction was complete, the samples were rinsed to neutral pH. Next, a 5% solution of sodium hexametaphosphate was added to each sediment sample to suspend the clays. Each sample was mixed thoroughly and allowed to settle by gravity for 2 hours. After two hours, the clays (which were in suspension) were decanted and water was added back to the samples and allowed to settle for two more hours. These mixing and settling steps were repeated for a total of 10 times to adequately remove all of the clay-sized particles.   Once most of the clays were removed, the silt- and sand-size fraction was dried under vacuum. The dried silts and sands were then mixed with sodium polytungstate (SPT, density 2.3 g/ml) and centrifuged to separate the phytoliths, which will float, from most of the inorganic silica fraction, which will not. Because a lot of silt-sized inorganic silica was floated with SPT, each sample was again dried under vacuum and then mixed with potassium cadmium iodide (density 2.3 g/ml). The addition of potassium cadmium iodide greatly improved the recovery of the phytolith fraction; however, the samples were still overwhelmed with silt-sized inorganic material. A decision was then made to dry the samples and re-float them in potassium cadmium iodide at a density of 2.2 g/ml. Reducing the density of the heavy liquid significantly improved the recovery and concentration

of the phytolith fraction. Because phytoliths have a density range of 1.8 to 2.3, some phytoliths may have been lost; however, the samples were uncountable at 2.3 g/ml and were actually countable now at 2.2 g/ml. After the heavy liquid steps, the samples were rinsed with alcohol to remove any remaining water. After several alcohol rinses, the samples were mounted in optical immersion oil for counting with a light microscope at a magnification of 500x. A phytolith diagram was produced using Tilia 2.0 and TGView 2.0.2.

Diatoms

Phytoliths were extracted first to observe the concentration of diatoms within that extract before customizing the diatom extraction method. Extensive searching of the phytolith slides yielded no diatoms, so separate diatom extraction was abandoned when it was determined that it would not be productive.

DISCUSSION

The Mammoth Site (41BX1239) is located in Bexar County, Texas. It is situated along the San Antonio River south of San Antonio in the southern portion of the county. The project area is located at the northern edge of the South Texas plains region, characterized by rolling prairies and vegetation that includes mesquite and cacti. Three major floral communities intersect in this area. The Edwards Plateau region lies to the north and west. The Blackland Prairies region is located to the north, and the Post Oak Savannah lies to the east (Lawrence et al. 2007:2-2). The local vegetation at the present includes a variety of oak trees (*Quercus*), pecan and hickory (*Carya*), eastern red cedar and other juniper (*Juniperus*), southern Hackberry (*Celtis laevigata*), elm (*Ulmus*), and mesquite (*Prosopis*). The local understory includes a variety of grasses (Poaceae), greenbrier (*Smilax*), holly (*Ilex*), American beauty berry (*Callicarpa*), coralbean (*Erythrina*), sedge (*Carex*), spiderwort (*Tradescantia*), and Texas bluebonnet (*Lupinus texensis*) (Lawrence, et al. 2007:2-2).

The recovery of mammoth bones at this site indicates the presence of Pleistocene deposits. This site also contains possible evidence of human association with the Pleistocene faunal remains. The sediment samples submitted for pollen, phytolith, and diatom analysis were removed from Profile 5 in Backhoe Trench 7. The samples represent primarily Zones 5 and 6, although the uppermost sample was collected from the lowest portion of Zone 7 (Table 1). These zones represent 3Bk (Zone 5, 74–96 cmbs), 3Bt1 (Zone 6, 96–106 cmbs), and 3Bt2 (Zone 7, 106–127 cmbs) deposits. No dates are available for this site.

Phytolith and Diatom Preservation

Phytoliths are generally considered to be fairly robust and resistant to degradation in a wide variety of environmental conditions. However, alkaline conditions, particularly in the presence of moisture, have been known to severely degrade or even completely dissolve phytoliths. Soil pH values approaching 9 and above tend to rapidly accelerate phytolith dissolution. Phytolith preservation and dissolution depends on 1) the particular type of phytolith and 2) the chemical and physical characteristics of the depositional environment (Piperno

2006). A third factor in preservation is the resident time in a particular environment. Relatively young calcareous sediments may still yield well-preserved phytoliths. Thinly silicified phytoliths, particularly epidermal sheet elements and cell casts, are readily dissolved in some paleoecological contexts. More robust infillings of specialized plant silica cells, such as grass silica short cells and vascular tissue buliform cells and elongates, are much more resistant to dissolution. In fact, buliform cells and elongates are often the only identifiable phytoliths in highly alkaline soils subjected to periodic moisture. In extreme cases, such as perennially moist calcareous soils, phytoliths will often be completely dissolved, with no recovery possible. Fossil diatoms (silicified algae frustules) have very thin silica walls and surfaces, and are also readily broken and dissolved in high pH soils and sediments, similar to the less robust phytoliths.

The sediment samples from site 41BX1239 contained a very high amount of calcareous (calcium carbonate) material. There is also evidence that these sediments were saturated for extended periods of time. Thus, these sediment samples were not only high in pH (alkaline), but also saturated with water, conditions extremely detrimental to phytolith and diatom preservation. Therefore, the low phytolith recovery achieved from these samples was not surprising. Large buliform and elongated phytoliths, morphotypes with very limited taxonomic resolution, were the biogenic silica bodies encountered most frequently. Grass silica short cell phytoliths and other small and thinly silicified silica bodies were rarely observed; however, enough of them were recovered to make some broad paleoenvironmental interpretations. Diatoms were completely absent in these sediments and were most likely lost due to dissolution in the alkaline, water-saturated sediments. Thus, none of these sediment samples were processed further for diatom identification. The phytolith record was severely affected by dissolution; however, some larger silica bodies and those more resistant to dissolution were recovered and are discussed below.

Pollen and Phytolith Analysis

The pollen record was the best preserved of the proxies examined (Table 2, Figure 1). Although the pollen counts were not high, they do provide valuable information concerning local and regional vegetation. The variety of pollen recovered represents trees, shrubs, and herbaceous plants. The total pollen concentration varied from approximately 10 to 40 pollen per cubic centimeter (cc) of sediment. Given these values, it is likely that some of the complexity of the pollen record was lost, although it is likely that the trends in the pollen record are valid.

In the lower three samples, representing Zone 7 and the lower two samples from Zone 6, *Quercus* pollen dominates the record, suggesting the probability that local and regional vegetation included large quantities of oak, possibly similar to the Post Oak communities of today. Other pollen reflecting trees in the samples includes *Carya*, *Juniperus*, and *Pinus*, reflecting local growth of hickory or pecan, juniper or cedar, and pine. Understory vegetation is represented by Low-spine Asteraceae, High-spine Asteraceae, Liguliflorae, Brassicaceae, Cheno-am, Fabaceae, and Poaceae pollen, representing various members of the sunflower and mustard families, plants in the Cheno-am group, legumes, and grasses.   Evidence for the presence of ferns is minimal. Algal spores and fungal spores, however, are very abundant in the sediments from Zones 7 and 6. The total pollen concentration for these three samples varies between 16 and 18 pollen per cc of sediment.

The phytolith record (Figure 2) from the lowest position (S-57, Zone 7) was represented by a total of 26 phytoliths. This is a very low number, reflecting the fact that a portion of the phytolith record was lost due to dissolution from high soil pH and moist soil conditions. Despite this, some interpretations can be made. Globular echinate phytoliths derived from a member of the palm family (Arecaceae) were the most abundant phytolith morphotype in this sample and in most of the other sediment samples analyzed here. Dwarf palmetto, *Sabal minor*, is the most likely source for these phytoliths. Dwarf palmetto does not occur naturally in Bexar County today, but evidently was present here in the past. Dwarf palmetto can be found today in several counties north, northeast, and east of Bexar county ((Turner et al. 2003). Dwarf palmetto grows along streams and is common to freshwater wetlands and floodplain forests, where it often forms dense thickets. It rarely occurs in upland woodlands. In Texas, dwarf palmetto can reach sub-dominant to dominant status in certain floodplain forests within the East Texas Pineywoods and the Gulf Coastal Prairies and Marshes (Bezanson 2000).

A unique aspect of the phytolith record from sample S-57 was the presence of several parallelepipedal phytoliths derived from members of the pine family (Pinaceae). The presence of these phytoliths suggests that pines were growing in the vicinity of this site at this time. It is also interesting to note that pine pollen was at its highest levels in this sample. Although pine pollen is known to be capable of long distance transport, the presence of pine phytoliths indicates that pine trees were growing at or very near to this site. Although it is possible that the East Texas Pineywoods was situated further west during the late Pleistocene, the pollen record suggests that Post Oak Savanna was more likely to have dominated the surrounding landscape. Within the Post Oak Savanna vegetation type, there is a rare Loblolly Pine-Post Oak association that occurs on water-retaining, gravelly clay soils derived from the Weches Formation in the southern Post Oak Belt (Bezanson 2000:48).

A final aspect of the phytolith record from sample S-57 worth discussing is the relatively high abundance of saddle phytoliths. Saddle phytoliths are produced by members of the Chloridoideae and some members of the Bambusoideae, in particular river cane (*Arundinaria* sp.). The saddle phytoliths observed here have a slightly longer length, a characteristic of *Arundinaria*, as opposed to the shorter length saddles derived from short grass prairie taxa of the Chloridoideae subfamily. Today, river cane can be found mostly in the East Texas Pineywoods region within the floodplain forest association. Thus, we have phytolith evidence for several taxa that are associated with pineywoods floodplains. The pollen record suggests that oak was common on the landscape. It is possible that the late Pleistocene vegetation community at this site comprised a mixture of taxa not commonly associated today.

The phytolith record from the bottom of Zone 6, represented by samples S-58, S-59, and S-60, show a clear affinity towards other samples from within Zone 6, and a clear separation of the Zone 7 phytolith assemblage. This is in opposition to the pollen record, in which S-57 from Zone 7 shows a clear affinity with the pollen record from S-58 and S-59 in Zone 6. A possible explanation for this is that floodplain conditions along the San Antonio River during the time period represented by sample S-57 (Zone 7) may have changed more quicky than for the upland areas situated further away from the river. The phytolith record is likely to contain a much greater proportion of phytoliths derived from the immediate vicinity of the site (river terrace) than from upstream and upslope locations, while the pollen record contains a mix of river terrace, upslope, and regionally derived pollen. The phytolith record for the bottom of Zone 6 (S-58, S-59, S-60), shows a decrease in saddle phytoliths most likely derived from river cane (*Arundinaria gigantea*) and a rise in C3-metabolism Pooideae grasses. Pooideae grasses are

cool-season taxa that today are found mostly in northern latitudes and at higher elevations. They typically thrive under cool and moist conditions. In southern and western portions of the US, they are typically restricted to riparian habitats. Trapeziform sinuate phytoliths, which are commonly produced by wetland Pooideae taxa, occur exclusively within the Zone 6 samples. It is possible that this signifies an opening of the floodplain forest canopy due to a decrease in arboreal taxa, or a change in the river bed, allowing for more wetland grasses to colonize suitable habitat. An interesting aspect of sample S-59 was the anomalous spike in xylem fragments from woody tissue. One of these fragments with three bordered pits can be seen in Figure 3 A. This suggests that the river cane growing in the floodplain or at the edge of the river was replaced by woody trees or shrubs such as willow or birch, neither of which is represented in the pollen record from these two samples.

For the pollen record near the middle of Zone 6, evidence for oak decreases dramatically, and evidence for understory plants in the High-spine Asteraceae and Cheno-am groups expands. Poaceae pollen frequencies decline, then increase, suggesting variations in the local grass population through time. Evidence for other trees recovered in Zone 6 includes *Betula*, *Carya*, *Juniperus*, and *Ulmus*, representing birch, hickory or pecan, juniper or cedar, and elm. It is interesting to note that evidence of pine trees has dropped from the record, suggesting a change in composition of the woodland. Pollen representing understory vegetation is marked by a dramatic rise in High-spine Asteraceae pollen, followed by a rapid decline in this pollen and a rise in Cheno-am pollen. Low-spine Asteraceae pollen is absent from the upper three samples from this zone. The recovery of small quantities of *Artemisia*, Brassicaceae, *Ephedra nevadensis*-type, *Eriogonum*, and Poaceae pollen indicates that sagebrush, members of the mustard family, ephedra, wild buckwheat, and grasses also grew in the area. The recovery of a *Ephedra* pollen in sample S-60 suggests that ephedra was part of the upland vegetation community during the late Pleistocene. Once again, evidence for ferns was minimal. Quantities of fungal spores increased rather dramatically, peaking in sample S-61. It is likely that the rise first in High-spine Asteraceae pollen, then in Cheno-am pollen, was in response to disturbance of sediments in this area. The total pollen concentration for these samples varied from 15 to 22 pollen per cc of sediment.

Like the pollen record, the phytolith record from the middle portion of Zone 6 is indicative of some type of change or disturbance. Sample S-60 yielded an opaque perforated plate phytolith from the inflorescence of a member of the Asteraceae family (Figure 3 B). This is the same sample that showed the major peak in High-spine Asteraceae pollen. Other than this anomaly, the overall phytolith assemblage from S-60 continues the trend of decreasing saddles (cf. *Arundinaria*) and increasing Pooideae (cf. wetland grasses) for the bottom half of Zone 6. Sample S-61 exhibits some potentially important changes in the phytolith record that are suggestive of some type of disturbance. This is the same sample with the rapid peak in Chenopodiaceae/*Amaranthus* (Cheno-am) pollen, which is also a disturbance marker. The phytolith concentration in sample S-61 was the highest for all of the samples, with 172 phytoliths tallied. Most of these were large-sized buliform and elongate phytoliths that were resistant to complete dissolution. There is a complete absence of trapeziform sinuate phytoliths from the Pooideae subfamily. And interestingly, the two *Stipa*-type bilobates (short-grass prairie grasses) were darkened from being burned. It is possible that wildfire activity within upland areas resulted in increased erosion and runoff within the San Antonio River drainage. This may explain the absence of wetland grass phytoliths and the increase in large buliform phytoliths. This increase may be due to two completely different processes: 1) the loss of smaller phytoliths by wind and water erosion or 2) re-deposition of phytoliths from upland areas and the

subsequent loss of the smaller forms due to dissolution. The low abundance of microscopic charcoal in the pollen record appears to contradict the fire hypothesis; however, these levels of microscopic charcoal seem too low, and they may be attributed to the breakdown of and loss of charcoal in the soil over time due to conditions unfavorable to microscopic charcoal preservation. And finally, the phytolith record from the uppermost sample from Zone 6 suggests that wetland Pooideae grasses returned to the immediate vicinity of the river drainage, which is in concordance with the increase in Poaceae pollen noted in that sample. This suggests that the vegetation community may have briefly returned to "pre-disturbance" conditions within the river drainage, despite the pollen evidence for the persistence of landscape-level change.

An interesting aspect of the middle portion of Zone 6 is the steady rise in fungal spores, especially after the drop in *Pinus* and *Quercus* pollen. Many coniferous and deciduous trees such as pine and oak form symbiotic relationships with soil fungi that form sclerotia. Sclerotia are persistent propagules which can withstand unfavorable conditions for years (fires, drought, heavy metals in the soil, etc.), longer than any other resistance structure formed by fungi. These resistance structures, whose functions include recolonizing after natural disasters, play an important role in reestablishing vegetation after a fire. After a disturbance such as fire, the number of sclerotia present in the soil increases to a significantly greater or lesser extent (Torres and Honrubia 1997). The tendency of sclerotia to appear in greater numbers in fire-affected areas may be provoked by the mortality of root systems with which ectomycorrhizal fungi are associated. The slow death of roots after a fire would favor the formation of fungal resistant structures (Mataix-Solera et al. 2009). Thus, the dramatic increase and eventual crash in fugal spore abundance exhibited within Zone 5 may be related to a major, probably long term, disturbance event responsible for the apparent reduction in arboreal taxa on the landscape. This event may have been coupled with or even caused by changes in the regional climate.

There is sufficient difference in both the pollen and phytolith records from Zones 6 and 5 to suggest a hiatus. The relatively small quantity of *Quercus* pollen reported in the upper portion of Zone 6 was further reduced in Zone 5. Other pollen representing trees included *Betula*, *Carya*, *Juniperus*, *Pinus*, *Tilia*, and *Ulmus*, representing birch, hickory or pecan, juniper or cedar, pine, basswood, and elm trees growing at least intermittently in the region. The quantity of High-spine Asteraceae pollen in the lowest sample from this zone is elevated when compared with that in the upper portion of Zone 6, which is one of the factors leading to the suggestion that there is a hiatus in the vegetation record between these zones.

The phytolith assemblage also changes dramatically from Zone 6 to Zone 5, with the complete loss of C3-metabolism Pooideae grasses, the dramatic rise in C4 Chloridoideae grasses, and the sudden appearance of C4 Panicoideae grasses in the record. This suggests that conditions became warm enough to discourage the growth of C3 Pooideae grasses and promote the growth of C4 Panicoideae grasses. Panicoid grasses are typically associated with tallgrass prairie, and thrive under warm and humid conditions. Some panicoids are adapted to dry conditions; however, most require moderate soil moisture. Although conditions appear to have become increasingly dry across the region, soils adjacent to the river were moist enough to support the growth of panicoid grasses. Saddle phytoliths derived from C4 chloridoideae grasses also rise in the transition from Zone 6 to Zone 5. Chloridoid grasses are typically associated with dry short-grass prairie habitats, and are an indication of dry conditions further away from the river corridor. Sample S-63 also yielded a dendriform phytolith (Figure 3 C). Dendriforms originate in the bract material (lemmas, paleas, and glumes) that surrounds the seed (caryopsis) of some wild and domesticated grasses. When they are present in relatively

high proportions in feature fill, ceramic residue, and groundstone tools, they can be an indicator of grass seed processing and consumption.

Quantities of High-spine Asteraceae pollen decline throughout the samples examined from Zone 5, after their dramatic rise in the lowest sample, compared to the quantity noted in Zone 6. Pollen representing other understory plants includes *Artemisia*, Low-spine Asteraceae, Liguliflorae, Brassicaceae, Cheno-am, *Eriogonum*, Fabaceae, *Hoffmanseggia*, Poaceae, and Rosaceae, representing sagebrush, members of the sunflower family, members of the mustard family, Cheno-ams, wild buckwheat, legumes, hog potato, grasses, and a member of the rose family. Recovery of *Hoffmanseggia* pollen was surprising, and given the evidence for the presence of modern contaminants noted in the phytolith record (below), it is likely that this very well preserved *Hoffmanseggia* pollen grain recorded in a 51-grain pollen count also represents contamination from the modern vegetation. Recovery of even a small quantity of *Hoffmanseggia* pollen is significant, since the flowers are insect pollinated, and the pollen is rarely recovered in pollen records from sediments. The total pollen concentration was highest in sample S-63 at the bottom of this zone, at 40 pollen per cc of sediment. The total pollen concentration in the remaining three samples varied between 10 and 22 pollen per cc of sediment.

Even the pollen record from Zone 5, representing the most recent interval examined, is significantly different than one would expect from vegetation on the edge of the Edwards Plateau today. Although *Larrea* (creosote) pollen is generally under-represented in sediments even when the shrubs are abundant on the landscape, none of this pollen type was observed in the sediments. A study of modern pollen rain for the Edwards Plateau (Shaw et al. 1980) reports a mixture of *Quercus*, *Juniperus*, *Prosopis*, *Pinus*, and *Diospyros* pollen, representing trees. *Celtis*, *Berberis*, and *Larrea* pollen represent woody, shrubby plants. Of these pollen taxa, *Prosopis*, *Diospyros*, *Celtis*, *Berberis*, and *Larrea* are missing from this record of the late Pleistocene, suggesting that these trees and shrubs may not have been present during the late Pleistocene but rather entered the vegetation community for this portion of Texas later during the Holocene.

Samples from this zone are further marked by a dramatic rise in algal spores and a significant reduction in the uppermost sample. The peak in algal spores in sample S-65 is accompanied by a decline in, then absence of, *Pinus* pollen from the record. It is also accompanied by a spike in microscopic charcoal. This might represent a period of increased natural wildfires that resulted in temporary decimation of the pine population. If vegetation had been reduced by natural fires, it is possible that sediment movement and slope wash or sheet wash provided an environment suitable for increases in algal spores in the sediments.

The phytolith record from Zone 5 is characterized by a rise in globular echinate phytoliths derived from dwarf palmetto (*Sabal minor*) and the absence of C3 Pooideae grass phytoliths. Sponge spicules rise in abundance in the upper portion of Zone 5, suggesting a return to slightly wetter conditions for the time represented by samples S-65 and S-66, which is consistent with recovery of an elevated quantity of algal spores in sample S-65. It is also characterized by some anomalous occurrences such as those already discussed for zone transition sample S-63.

The most peculiar occurrence was the recovery of numerous cystolith phytoliths from sample S-64 (Figure 3 D and E). Cystoliths are delicate forms that rarely preserve in

sediments. They are outgrowths of the epidermal cell wall impregnated with silica and/or calcium carbonate. Cystoliths sometimes extend into the ground tissue of the leaf, and often have a characteristic stalk where they were attached to the cell wall (Piperno 2006). The verrucate sculpturing and stalk-like projection on the cystoliths seen here are distinctive and possibly diagnostic of hackberry (*Celtis* sp.) leaf material. Very similar forms have been observed in false-nettle (*Boehmeria cylindrica*); however, these cystoliths are reported to be mostly stalkless forms, and when they do have a stalk, they are short and lack the remnants of any type of cell wall material that they were attached to (Bozarth 1992). We do not have false-nettle leaf material in our phytolith reference collection, so we cannot independently verify the differences between *Celtis* and *Boehmeria* cystoliths. Since both *Celtis* sp. and *Boehmeria cylindrica* occur in Bexar county, we need to remain conservative at this point and ascribe the cystoliths observed here to either *Celtis* or *Boehmeria* leaf material. It should be mentioned that with phytolith preservation very poor in this and all of the other samples, the presence of cystoliths in this sample (S-64) is very anomalous, and it is suggestive of modern contamination. The pollen record from S-64 also contained an anomalous type, *Hoffmannseggia* pollen, which is rarely recovered from sediments. This also suggests that modern soil or debris from the site may have somehow become incorporated into the collection bag for sample S-64.

The phytolith record from the uppermost samples (S-65 and S-66) of Zone 5 are characterized by a dramatic rise in dwarf palmetto (*Sabal minor*) phytoliths and freshwater sponge spicules, and the sudden occurrence of saddle phytoliths possibly derived from river cane (*Arundinaria gigantea*) in sample S-66. The pollen record for sample S-66 exhibited a rise in oak pollen, the return of pine pollen, and the occurrence of basswood pollen (*Tilia*) to the record. Thus, the pollen and phytolith records from sample S-66 suggest an increase in moisture and arboreal taxa. In fact, the combined pollen and phytolith records exhibit some similarity with those from sample S-57 (Zone 7). As previously mentioned, within the Post Oak Savanna vegetation type, there is a now rare Loblolly Pine-Post Oak association that occurs on water-retaining, gravelly clay soils, which may have been more common in the past. It is possible that this type of vegetation community existed at or near to this location at the time represented by this sample. It is also possible that the apparent increase in moisture and arboreal taxa may have been restricted to the riparian corridor along the San Antonio River and may not have occurred in upland areas away from the river corridor. Thus, the combined phytolith and pollen records suggest that conditions during the lowest samples from Zone 5 were more open and dryer than that for Zone 6, but that there was then an increase in moisture, supporting arboreal taxa and a dwarf palmetto understory in the upper portion of Zone 5. Despite the low recovery of taxonomically significant phytoliths, the phytolith record does suggest that conditions were warmer and dryer during the time period represented by the Zone 5 samples.

SUMMARY AND CONCLUSIONS

The sediments submitted for pollen, phytolith, and diatom analyses from site 41BX1239 were very challenging to work with. High pH and prolonged exposure to moisture over time was very detrimental to microfossil preservation, in particular the biogenic silica (phytolith and diatom) fraction. Diatoms were completely absent in these sediments and were most likely lost due to dissolution over time in these wet, alkaline sediments. Thus, none of these sediment samples were processed further for diatom identification. The phytolith record was severely

affected by dissolution; however, some larger silica bodies and those more resistant to dissolution were recovered. Despite the poor phytolith recovery, valuable paleoenvironmental interpretations were made. The pollen record was the best preserved of the proxies examined. Although the pollen counts were not high, they did provide valuable information concerning local and regional vegetation. Vegetation change signals within the river corridor and regionally across the landscape are most likely not synchronized with one another. Because these samples were collected along a terrace of the San Antonio River, the phytolith record is generally providing a signal within the river corridor, with some input from upslope vegetation. The pollen record is providing both site-specific and regional vegetation signals. This, taken together with differences in preservation, results in a rather complex and challenging pollen and phytolith record to interpret here.

Zone 7

One sample from Zone 7 was submitted for analysis. The pollen evidence suggests that a Post Oak forest association with pines and hickory was present in the uplands, perhaps typical of the Post Oak–Loblolly Pine association, discussed above. Understory vegetation included members of the sunflower family, grasses, and a few Cheno-ams. Plants in the marshelder group of the sunflower family probably grew in the wetlands along the river.

There is phytolith evidence for the occurrence of two taxa that today are associated with pineywoods floodplains. These are dwarf palmetto (*Sabal minor*) and river cane (*Arundinaria gigantea*). Dwarf palmetto grows along streams and is common to freshwater wetlands and floodplain forests, where it often forms dense thickets. It rarely occurs in upland woodlands. In Texas, dwarf palmetto can reach sub-dominant to dominant status in certain floodplain forests within the East Texas Pineywoods. Today, river cane can be found mostly within the East Texas Pineywoods region within the floodplain forest association. Pine phytoliths were also observed and recovered from only this sample, suggesting the local growth of pine. However, pine pollen percentages were too low to suggest an upland landscape dominated by pine. Thus, it is possible that the riparian corridor along the river contained elements found today within the East Texas Pineywoods Floodplains association, and that upland areas contained a mixture of oaks, pines, and grassy openings. It is likely that the late Pleistocene vegetation community at this site comprised a mixture of taxa not commonly associated today, which is known as a no-analog vegetation community.

Zone 6

Zone 6 was represented by five sediment samples. The pollen record suggests that the Post Oak–pine association continued in the uplands, mixed with hickory and eventually juniper for at least the time period represented by the lowest two samples. A dramatic change is recorded in the upland vegetation between samples S-59 and S-60, when quantities of arboreal pollen, primarily *Quercus*, were reduced dramatically. Pine trees ceased to grow in the area, and the vegetation community appears to have opened significantly with a rapid decline in oaks, as witnessed by the dramatic rise in High-spine Asteraceae pollen. Increases in Cheno-am may reflect growth of goosefoot in the wetlands along the river, or shrubby plants that grow in dryer sediments in the uplands. A dramatic change in the grass population, noted by the severe reduction in Poaceae pollen between samples S-59 and S-60, followed by gradual increases in

Poaceae pollen to the top of this zone, suggests changes in the population of grasses growing along the river, which will be further clarified in the phytolith record. The recovery of small quantities of Brassicaceae, *Eriogonum*, and Fabaceae pollen intermittently in these deposits suggests the local growth of a member of the mustard family, wild buckwheat, and legumes.

Algal spores declined and fungal spores increased during this interval, until the peak in fungal spores, which was noted in sample S-61. It is possible that a rapid-onset, severe change in climate conditions is responsible for this change in the composition and density of the pine and oak trees in the woodlands in the uplands. Whatever the reason for the change, conditions appear to have persisted over at least a moderate to moderately long period of time. It is possible that the severe reduction in trees on the landscape provided a suitable habitat of rotting roots, logs, and branches to support sclerotia and other fungal bodies, as noted in the rise of fungal spores in the sediments.

The phytolith record suggests that cool-season, C3-metabolism wetland grasses from the subfamily Pooideae grew along the riparian corridor. Dwarf palmetto continued to grow as well, but it diminished slightly towards the top of the zone. This may have been in response to some type of disturbance that occurred during the time period represented by samples S-60 and S-61. There is some phytolith evidence for wildfire in the uplands and increased erosion within the river corridor. The Pooideae wetland grass community appears to become established again in the uppermost sample from Zone 6.

Zone 5

Zone 5 was represented by four sediment samples. The pollen record suggests that trees were sparse and included hickory, juniper, pine, oak, and occasional basswood in the uplands. Birch and elm probably grew in the floodplain along the river. Sagebrush appears to have grown at a moderate density on the landscape in the uplands, while members of the sunflower family were the most dominant element of the understory, possibly growing fairly densely along the river. Marsh elder–type plants in the sunflower family were not particularly abundant. Declines in High-spine Asteraceae pollen throughout this zone are not matched by increases in any particular individual pollen taxon. Instead, small increases in several different pollen types such as *Artemisia*, *Eriogonum*, and Poaceae suggest that in some areas, vegetation might have become less dense, since there is no evidence of a replacement of members of the sunflower family by specific plants on the landscape. The increase in indeterminate pollen does account for the replacement of some of the decline in High-spine Asteraceae pollen. This indicates deteriorating conditions for pollen preservation near the upper portion of Zone 5. Often, these include drying, since fluctuating conditions between dry and wet create more opportunity for pollen oxidation. The spike in microscopic charcoal and algal spores noted in sample S-65 probably represent a short-lived event, such as a local fire, that probably affected vegetation distribution on the landscape. This fire may have been responsible for the loss of *Juniperus* and *Pinus* pollen in this portion of the record, since each sample represents a depth of sediment that would include a time span of at least multiple years, and probably a few decades.

The phytolith record indicates that conditions at the beginning of the Zone 5 time period were dryer, warmer, and possibly more open than those for the Zone 6 time period. Cool-season, wetland Pooideae grasses are completely absent from the Zone 5 record. However,

soil moisture appears to increase at the top of the Zone 5 samples, with dramatic increases in freshwater sponge spicules, dwarf palmetto, and possibly river cane. This suggests an increase in precipitation and continued warm conditions. Arboreal taxa probably increased as well along the river corridor, as dwarf palmetto is a forest understory plant. Interestingly, the phytolith record from S-57 (Zone 7) has a similarity to that from S-66 (top of Zone 5), although the pollen does not.

TABLE 1
PROVENIENCE DATA FOR SAMPLES FROM SITE 41BX1239, BEXAR COUNTY, TEXAS

Lot No.	SS No.	BHT	Zone	PP Elev	Provenience/ Description	Analysis
105	S-66	7	5	98.53-98.51	Soil from east wall profile 5, Column diatom sample, 10x2x3 cm sample	Pollen Phytolith Diatom
106	S-65	7		98.51-98.49		Pollen Phytolith Diatom
107	S-64	7		98.49-98.47		Pollen Phytolith Diatom
108	S-63	7		98.47-98.45		Pollen Phytolith Diatom
109	S-62	7	6	98.45-98.43		Pollen Phytolith Diatom
110	S-61	7		98.43-98.41		Pollen Phytolith Diatom
111	S-60	7		98.41-98.39		Pollen Phytolith Diatom
112	S-59	7		98.37-98.39		Pollen Phytolith Diatom
113	S-58	7		98.35-98.37		Pollen Phytolith Diatom
114	S-57	7	7	98.33-98.35		Pollen Phytolith Diatom

TABLE 2
POLLEN TYPES OBSERVED IN SAMPLES FROM SITE 41BX1239
SEDIMENT SAMPLES, BEXAR COUNTY, TEXAS

Scientific Name	Common Name
ARBOREAL POLLEN:	
Betula	Birch
Carya	Hickory, Pecan
Juniperus	Juniper
Pinus	Pine
Quercus	Oak
Tilia	Linden, Basswood
Ulmus	American Elm or, White Elm, Water Elm
NON-ARBOREAL POLLEN:	
Asteraceae:	Sunflower family
Artemisia	Sagebrush
Low-spine	Includes ragweed, cocklebur, sumpweed
High-spine	Includes aster, rabbitbrush, snakeweed, sunflower, etc.
Liguliflorae	Chicory tribe, includes dandelion and chicory
Brassicaceae	Mustard or cabbage family
Cheno-am	Includes the goosefoot family and amaranth
Ephedra nevadensis-type (includes *E. clokeyi, E. coryi, E. funera, E. viridis, E. californica, E. nevadensis,* and *E. aspera*)	Ephedra, Jointfir, Mormon tea
Eriogonum	Wild buckwheat
Fabaceae:	Bean or Legume family
Hoffmannseggia	Rushpeas
Poaceae	Grass family
Rosacea	Rose family
Indeterminate	Too badly deteriorated to identify
SPORES:	
Monolete	Fern

TABLE 2 (Continued)

Scientific Name	Common Name
Trilete	Fern
Algal spore	Algal spore
Fungal spore	Fungal spore
Charcoal	Microscopic charcoal
Total pollen concentration	Quantity of pollen per cubic centimeter (cc) of sediment
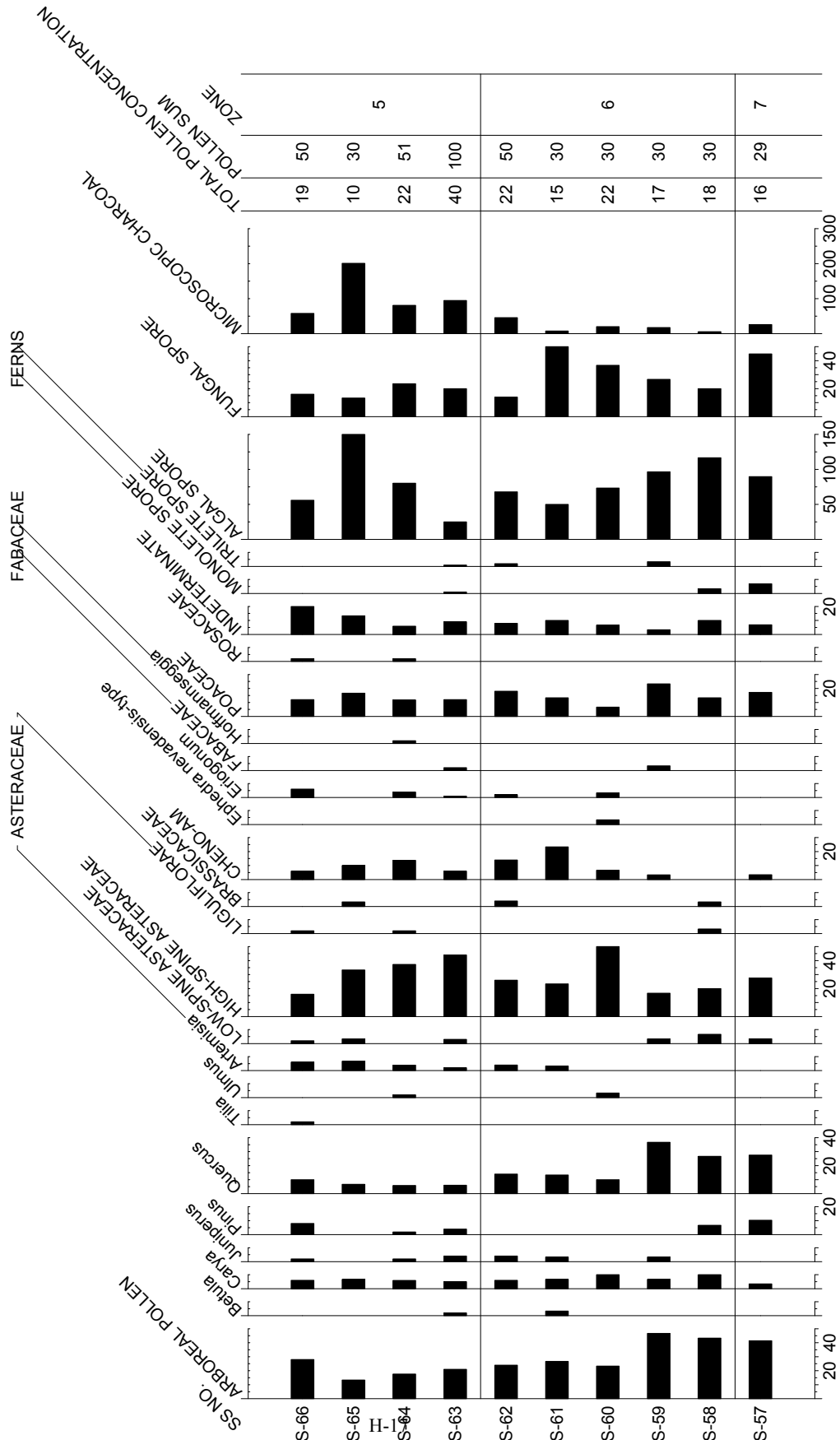
FIGURE 1. POLLEN DIAGRAM FOR STRATIGRAPHIC SAMPLES FROM SITE 41BX1239, BEXAR COUNTY, TX.
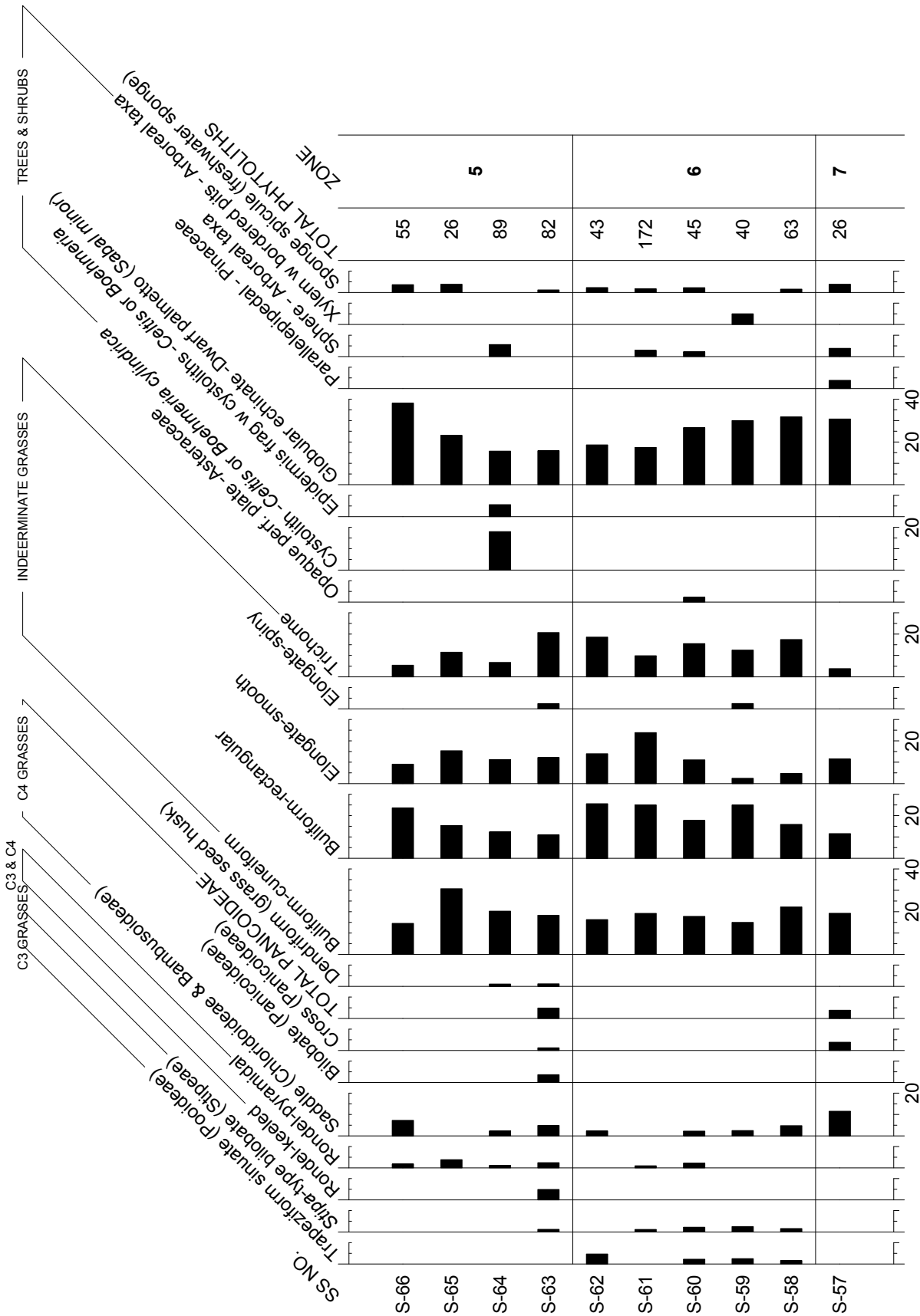
FIGURE 2. PHYTOLITH DIAGRAM FOR STRATIGRAPHIC SAMPLES FROM SITE 41BX1239, BEXAR COUNTY, TX.
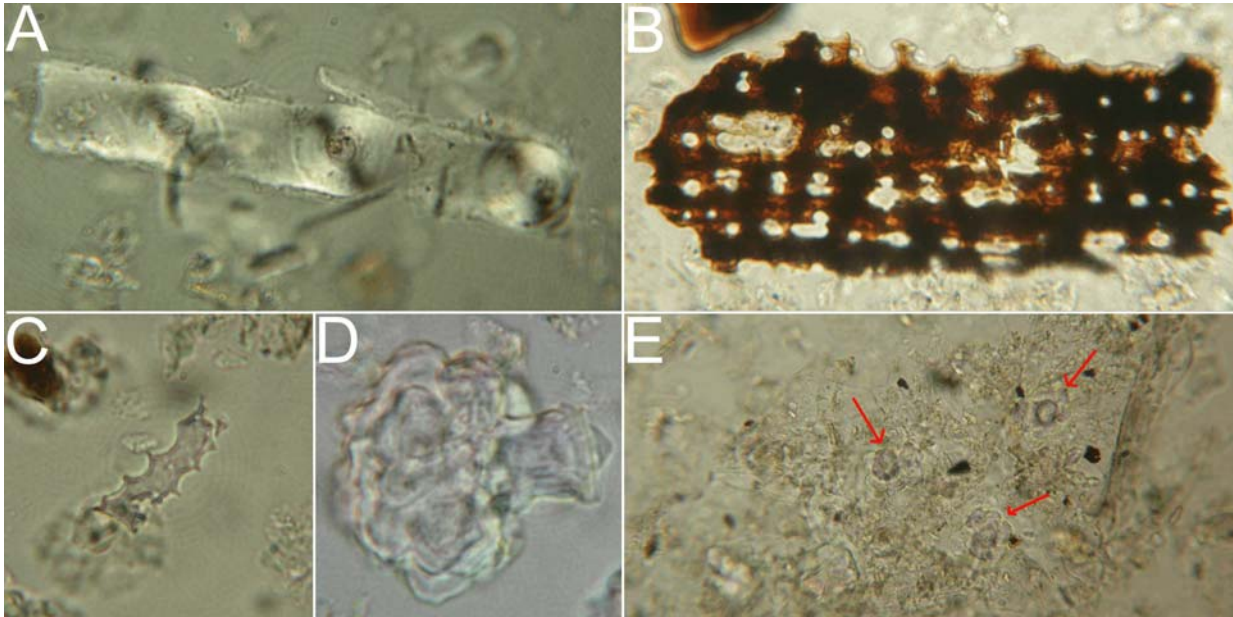
FIGURE 3. SELECTED MICROFOSSIL MICROGRAPHS RECOVERED FROM SITE 41BX1239
SEDIMENT SAMPLES, BEXAR COUNTY, TEXAS.

Micrographs A–D taken at 500x magnification. Micrograph E taken at 250x magnification.

A)   Fragment of plant xylem tissue with three bordered pit vessels, from S-59.
B)   Opaque perforated plate phytolith diagnostic of Asteraceae inflorescence material, from S-60.
C)   Fragment of a dendriform phytolith derived from the bract material that surrounds grass seed,
        recovered from S-63.
D)   Cystolith-type phytolith most likely derived from either *Celtis* or *Boehmeria cylindrica* leaf material,
        recovered from S-64.
E)   Silicified epidermis fragment with three cystoliths *in situ*, recovered from S-64.

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Appendix I - Carbon Isotope Analysis of Samples from the Mammoth Site (41BX1239), Bexar County, Texas

Dr. Raymond Mauldin
University of Texas at San Antonio
Center for Archaeological Research

and

Northern Arizona University
Colorado Plateau Stable Isotope Laboratory

APPENDIX I

CARBON ISOTOPE ANALYSIS OF SAMPLES FROM THE MAMMOTH SITE (41BX1239), BEXAR COUNTY, TEXAS

Dr. Raymond Mauldin, University of Texas at San Antonio Center for Archaelolgical Research and Northern Arizona University Colorado Plateau Stable Isotope Laboratory

Colorado Plateau Stable Isotope Laboratory
-- Results for Raymond Mauldin, UTSA --
CPSIL report# FY12-106 (sediments)

Sample	Date	Position	Mass (mg)	CO2 Ampl (volts)	N2 Ampl (volts)	CO2 Area (V/s)	N2 Area (V/s)	δ13C (‰)	δ15N (‰)	%C	%N	C/N	Comments
2	21-Dec-11	70	74.745	0.86	0.30	16.43	6.01	-24.48	6.54	0.18	0.02	9.40	
2	21-Dec-11	71	75.183	0.78	0.31	14.88	6.18	-24.18	6.46	0.16	0.02	8.28	
4	21-Dec-11	72	74.695	0.82	0.39	15.36	7.69	-23.32	6.88	0.17	0.02	6.87	
6	21-Dec-11	73	75.248	1.23	0.44	23.73	8.96	-23.64	5.84	0.26	0.03	9.10	
6	21-Dec-11	74	74.732	1.23	0.44	23.77	8.88	-23.70	6.28	0.26	0.03	9.20	
8	21-Dec-11	75	75.293	0.87	0.43	16.48	8.51	-23.31	6.28	0.18	0.03	6.66	
9	21-Dec-11	76	75.135	1.16	0.61	21.93	11.81	-22.96	6.63	0.24	0.04	6.39	
9	21-Dec-11	77	74.454	1.15	0.59	21.92	11.61	-23.18	6.46	0.24	0.04	6.49	
10	21-Dec-11	78	74.712	1.54	0.76	30.61	15.46	-23.16	6.91	0.34	0.05	6.81	
12	21-Dec-11	80	74.997	1.05	0.54	19.98	10.59	-22.40	6.80	0.22	0.03	6.49	
12	21-Dec-11	81	74.095	1.03	0.54	19.55	10.59	-22.32	7.02	0.22	0.03	6.35	
15	21-Dec-11	82	74.745	2.44	0.97	48.84	19.22	-21.03	5.80	0.53	0.06	8.74	
17	21-Dec-11	83	75.189	3.49	1.41	70.87	27.26	-22.56	6.32	0.77	0.09	8.94	
17	21-Dec-11	84	74.824	3.57	1.42	72.66	27.28	-22.67	6.33	0.79	0.09	9.16	
20	21-Dec-11	85	75.329	6.22	2.64	139.57	50.54	-22.25	6.38	1.52	0.16	9.50	
			min	0.78	0.30	14.88	6.01	-24.48	5.80	0.16	0.02	6.35	
			max	6.22	2.64	139.57	50.54	-21.03	7.02	1.52	0.16	9.50	
Drift and linearity standards													
NIST peach leaves	21-Dec-11	3	2.040	5.35	1.18	118.93	23.79	-26.13	1.72	46.20	2.84	16.26	
NIST peach leaves	21-Dec-11	13	2.005	5.27	1.18	115.93	23.70	-26.07	1.61	45.84	2.88	15.92	
NIST peach leaves	21-Dec-11	25	1.981	5.21	1.15	114.57	23.12	-26.11	1.76	45.89	2.85	16.13	
NIST peach leaves	21-Dec-11	37	1.942	5.05	1.11	112.07	22.58	-26.10	1.71	45.87	2.84	16.17	
NIST peach leaves	21-Dec-11	49	2.046	5.56	1.26	120.07	24.49	-26.07	1.69	46.41	2.91	15.93	
NIST peach leaves	21-Dec-11	61	2.050	5.54	1.27	119.71	24.57	-25.97	2.02	46.18	2.92	15.84	
NIST peach leaves	21-Dec-11	69	2.018	5.38	1.20	117.69	23.78	-26.01	1.98	46.20	2.87	16.10	
NIST peach leaves	21-Dec-11	79	1.966	5.36	1.21	115.22	23.51	-26.06	1.99	46.45	2.91	15.95	
NIST peach leaves	21-Dec-11	86	6.000	12.97	3.90	371.24	73.07	-26.09	1.82	46.58	2.88	16.15	
NIST peach leaves	21-Dec-11	87	5.001	11.30	3.23	306.15	60.31	-26.01	1.69	46.43	2.87	16.16	
NIST peach leaves	21-Dec-11	88	4.010	9.58	2.57	242.69	48.04	-26.01	2.11	46.34	2.87	16.13	
NIST peach leaves	21-Dec-11	89	2.993	7.64	1.88	178.88	35.72	-26.04	1.66	46.37	2.88	16.08	
NIST peach leaves	21-Dec-11	90	2.010	5.47	1.23	118.04	23.95	-26.02	1.78	46.49	2.90	16.03	
NIST peach leaves	21-Dec-11	91	1.501	4.16	0.90	86.66	17.79	-26.04	1.98	46.47	2.90	16.04	
NIST peach leaves	21-Dec-11	92	0.998	2.76	0.58	56.36	11.77	-26.12	1.97	46.62	2.89	16.11	
NIST peach leaves	21-Dec-11	93	0.500	1.36	0.28	26.87	5.82	-25.98	1.63	46.43	2.87	16.18	
NIST peach leaves	21-Dec-11	94	0.259	0.68	0.14	13.16	3.02	-26.01	1.91	46.16	2.88	16.02	
NIST peach leaves	21-Dec-11	112	1.988	5.39	1.20	116.23	23.37	-25.98	1.69	46.32	2.86	16.17	
							avg	-26.05	1.82	46.29	2.88	16.08	
							sd	0.05	0.16	0.24	0.02	0.11	
Isotope calibration standards													Expected
IAEA CH6	21-Dec-11	95	1.245	3.09		63.37		-10.43		41.63			d13C = -10.45
IAEA CH7	21-Dec-11	96	0.744	3.78		77.98		-32.20		86.07			d13C = -32.15
IAEA N1	21-Dec-11	97	0.326		1.41		28.94		0.53		21.16		d15N = 0.43
IAEA N2	21-Dec-11	98	0.320		1.39		28.67		20.39		21.36		d15N = 20.41
Elemental calibration standards													
Acetanilide	21-Dec-11	99	0.820	3.43	1.75	70.98	35.07	-33.82	-1.10	71.12	10.22	6.96	C/N = 71.09/10.36 = 6.86
BBOT	21-Dec-11	100	0.774	3.33	1.05	68.54	20.90	-26.47	-10.72	72.86	6.49	11.22	C/N = 72.53/6.51 = 11.14
Cystine	21-Dec-11	101	1.021	1.80	2.48	36.02	49.96	-16.69	8.70	30.18	11.66	2.59	C/N = 29.95/11.61 = 2.57
Methionine	21-Dec-11	102	0.974	2.32	1.90	46.73	38.19	-25.11	-1.07	40.04	9.37	4.28	C/N = 40.21/9.39 = 4.28
Sulfanilamide	21-Dec-11	103	0.749	1.85	2.54	37.10	51.37	-28.91	-1.57	42.00	16.33	2.57	C/N = 41.84/16.27 = 2.57

Colorado Plateau Stable Isotope Laboratory
-- Results for Raymond Mauldin, UTSA --
CPSIL report# FY12-106 (sediments)

Sample	Date	Position	Mass (mg)	CO2 Ampl (volts)	N2 Ampl (volts)	CO2 Area (V/s)	N2 Area (V/s)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	%C	%N	C/N	Comments
Cyclohexanone	21-Dec-11	104	0.621	1.88	2.60	37.97	52.79	-27.11	-3.59	51.65	20.23	2.55	C/N = 51.79/20.14 = 2.57
Nicotinamide	21-Dec-11	105	0.588	2.02	2.77	40.97	56.53	-33.03	-1.43	58.57	22.87	2.56	C/N = 59.01/22.94 = 2.57
Secondary check standards													
NIST pine needles	21-Dec-11	106	5.001	11.78	1.35	325.37	24.21	-26.13	0.30	49.52	1.21	40.76	
NIST apple leaves	21-Dec-11	107	2.974	7.71	1.40	182.11	26.96	-26.86	0.23	47.57	2.22	21.45	
NIST tomato leaves	21-Dec-11	108	2.990	6.27	1.92	139.25	37.21	-27.04	3.79	35.94	3.00	11.96	
NIST bovine liver	21-Dec-11	109	1.026	3.03	2.21	62.20	44.12	-17.55	8.19	49.81	10.26	4.86	
NIST mussel tissue	21-Dec-11	110	0.972	2.28	1.61	46.06	32.22	-18.50	7.56	39.59	7.94	4.99	
Caffeine - Aldrich	21-Dec-11	111	0.523	1.50	3.11	30.13	63.71	-39.10	-3.35	49.37	28.96	1.70	
Soil standards													
B2150	21-Dec-11	113	12.058	4.51	1.19	95.16	22.98	-19.93	4.93	6.45	0.45	14.24	C/N = 6.40/0.45 = 14.19
NIST 2710	21-Dec-11	114	19.998	3.66	1.27	75.33	24.87	-24.97	5.00	3.08	0.30	10.42	C/N = 3.08/0.29 = 10.55
NIST 2711	21-Dec-11	115	40.005	4.19	1.15	86.09	22.21	-17.06	7.46	1.76	0.13	13.33	C/N = 1.77/0.13 = 13.32
B2152	21-Dec-11	116	59.966	4.47	1.34	93.39	25.94	-26.83	6.88	1.27	0.10	12.38	C/N = 1.28/0.10 = 12.28

Appendix J - Glossary of Archaeological and Osteological Terms

GLOSSARY OF ARCHAEOLOGICAL AND OSTEOLOGICAL TERMS

Glossary of archaeological and osteological terms

Compiled from myriad sources including websites of the Mammoth Site National Natural Landmark (mammothsite.com) and Archaeological Institute of America (archaeological.org).

Absolute dating - collective term for techniques that assign specific dates or date ranges, in calendar years, to artifacts and other archaeological finds. Dates are determined by a variety of processes, including chemical analyses (as in radiocarbon dating and thermoluminescence), data correlation (as in dendrochronology), and a variety of other tests. See Relative Dating

Alluvial deposit - soil deposited by running water, such as streams, rivers, and flood waters.

Analysis - the process of studying and classifying artifacts, usually conducted in a laboratory after excavation has been completed.

Anthrogenic – from *anthro,* meaning of or relating to humans, and *genic,* meaning origins. Human caused or induced. Not to be confused with anthropogenic, which pertains to the origins and evolution of the human species.

Archaeology - the scientific study of past human cultures by analyzing the material remains (sites and artifacts) that people left behind.

Archaeological site - a place where human activity occurred and material remains were deposited.

Artifact - any object made, modified, or used by people.

Assemblage - artifacts that are found together and that presumably were used at the same time or for similar or related tasks.

Attribute - a characteristic or property of an object, such as weight, size, or color.

B.P. - years before present; as a convention, 1950 is the year from which B.P. dates are calculated.

Biface - a chipped stone tool which has been formed by reduction on both sides or faces. A spear point is a specialized form of biface.

Bulb of percussion - a small, rounded protrusion on a flake resulting from the blow that separated the flake from its core or another flake.

Chronology - an arrangement of events in the order in which they occurred.

Classification - a systematic arrangement in groups or categories according to criteria.

Colluvial deposit – sediments accumulated through the action of gravity.

Condyle - rounded elevation on osteological elements.

Context - the relationship of artifacts and other cultural remains to each other and the situation in which they are found.

Cortex - the rough outer surface of a stone, usually removed to reveal the smooth interior during flint knapping (the making of stone tools).

Culture - a set of learned beliefs, values and behaviors--the way of life--shared by the members of a society.

Debitage - the by-products or waste materials left over from the manufacture of stone tools.

Diagnostic artifact - an item that is indicative of a particular time period and/or cultural group.

Ecofact - Material which can demonstrate the interaction between the environmental of the locality and the human exploitation within the locality, such as pollen samples, grain, nuts, fish etc. (see Artifact).

Excavation - the systematic digging and recording of an archaeological site.

Feature - a type of material remain that is a non-mobiliary site fixture that cannot be removed from a site such as roasting pits, fire hearths, house floors or post molds.

Flake - A piece of stone removed from a core for use as a tool or as debitage.

Flotation - The soaking of an excavated matrix (usually dirt) in water to separate and recover small ecofacts and artifacts, such as pollen samples, that cannot be recovered through traditional sieving.

Formation processes - Human-caused or natural processes by which an archaeological site is modified during or after occupation and abandonment. These processes have a large effect on the provenience of artifacts or features found by archaeologists. Geological processes, disturbances by animals, plant growth, and human activities all contribute to site formation.

Geoarchaeology - Archaeological research using the methods and concepts of the earth sciences. Geoarchaeologists often study soil and sediment patterns and processes of earth formation observed at archaeological sites. This form of reasearch provides a wealth of information about context and human activity.

Global Positioning System (GPS) - An instrument that determines (by triangulation) the location of features, using data from orbiting satellites.

Grid - a network of uniformly spaced squares that divides a site into units; used to measure and record an object's position in space.

In situ - in the original place.

Level - an excavation layer, which may correspond to natural strata. Levels are numbered from the top to bottom of the excavation unit, with the uppermost level being Level 1.

Lithic - stone, or made of stone.

Mammoth: large proboscidean, abundant during the Pleistocene. The Columbian Mammoth, (*Mammuthus columbi*), which quite likely the species found on the San Antonio River Mammoth site, was a descendent of *Mammuthus meridionalis* the ancestral mammoth that entered North America via the Bering Land Bridge about one million years ago. The Columbian mammoth ranged from Alaska, and the Yukon, across the mid-western United States south into Mexico and Central America. Standing almost 14 foot at the shoulder (420 cm), and weighing 8-10 tons, the Columbian mammoth could consume about 700 pounds of vegetation a day. The life span for a Columbian mammoth was 60 to 80 years. The longest Columbian mammoth tusk was found in Texas and is 16 feet (almost 5 m) and weighs 208 lb. (almost 94 kg).

The woolly mammoth (*Mammuthus primigenius*), distinctive for its hairy coat and large curved tusks, was a descendent of the steppe mammoth (*Mammuthus trogontherii*). The woolly mammoth, living south of the ice sheets, ranged from northern Europe, across Siberia, and into North America. Smaller in comparison with the Columbian mammoth, the woolly stood 11 foot at the shoulder (330 cm), and weighed 6 to 8 tons.

Mastodon: large prehistoric browsing proboscidean known from the Pleistocene of North America; the term mastodon is also applied to other species, some of which (such as Gomphotheres) were unrelated.

Material remains - artifacts, features and other items such as plant and animal remains that indicate human activity.

Matrix - The physical material (often dirt) in which archaeological objects are located.

National Register of Historic Places – The official list but also administrative branch of the Department of Interior that officially reviews nominations of archaeological and historic sites and structures, and guides the federal implementation of cultural resources legislation.

Osteological descriptive terms –

anterior - towards the front

dorsal - at the back

distal - away from the trunk

lateral - toward the sides

external - outside

inferior - below

costal - associated with the ribs

cranial - towards the head

ala - wing-like

conoid - cone shaped

diploy - lattice-like structure

axillary - towards the armpit

carpus - wrist

chondral - assoc. w/ cartilage

posterior - towards the back

ventral - at the front

proximal - towards the trunk

medial - toward the midline

internal - inside

superior - above

vertex - top or highest point

superficial - near the surface

styloid - needle-like

coronoid - crows-beak shaped

corpus - body

plantar - sole of the foot

cervical - neck

concha - shell shaped

Paleontology - the scientific study of ancient life (*palaeos* = ancient, *ontos* = being, *logos* = speech, reason, hence study of), through examination of fossil remains and the fossil record.

Palynology – the study of plant pollen and spores. Since pollen may be preserved thousands of years it can be used to reconstruct the plant ecology of the past.

Prehistoric - the period of time before written records; the absolute date for the prehistoric period varies from place to place but generally began in Central Texas during the final millennia of the Pleistocene, ending around 11,500 years ago, and continued through the Holocene until European contact.

Primary context - the context of an artifact, feature, or site that has not been disturbed since its original deposition.

Proboscidean - elephants and their extinct relatives, including mammoths, mastodonts, and deinotheres

Projectile point - a general term for stone points that were hafted to darts, spears or arrows; often erroneously called "arrowheads".

Provenience - The three-dimensional context (including geographical location) of an archaeological find, giving information about its function and date.

Radiocarbon dating - an absolute dating technique used to determine the age of organic materials less than 50,000 years old. Age is determined by examining the loss of the unstable carbon-14 isotope, which is absorbed by all living organisms during their lifespan. The rate of decay of this unstable isotope after the organism has died is assumed to be constant, and is measured in half-lives of 5730 + 40 years, meaning that the amount of carbon-14 is reduced to half the amount after about 5730 years. Dates generated by radiocarbon dating have to be calibrated using dates derived from other absolute dating methods, such as dendrochronology and ice cores.

Relative dating – A system of dating archaeological remains and strata in relation to each other. By using methods of typing or by assigning a sequence based on the Law of Superposition, archaeologists

organize layers or objects in order from "oldest" to "most recent." Relative dating methods help archaeologists establish chronologies of finds and types (compare to Absolute dating).

Secondary context - Context of an artifact that has been wholly or partially altered by transformation/site formation processes after its original deposit, as in disturbance by human activity after the artifacts' original deposition.

Site - a place where human activity occurred and material remains were deposited.

Strata - many layers of earth or levels in an archaeological site (singular stratum).

Stratigraphy - The study of the layers (strata) of sediments, soils, and material culture at an archaeological site (also used in geology for the study of geological layers).

Survey - the systematic examination of the ground surface in search of archaeological sites.

terminus ante quem, terminus post quem: reference points in the dating of a stratigraphic sequence on a site **before** which (ante) or **after** which (post) a context was formed. (similar to relative dating)

Test pit - a small excavation unit dug to learn what the depth and character of the stratum might be, and to determine more precisely which strata contain artifacts and other material remains.

Tuberosity - large rounded elevation on bone.