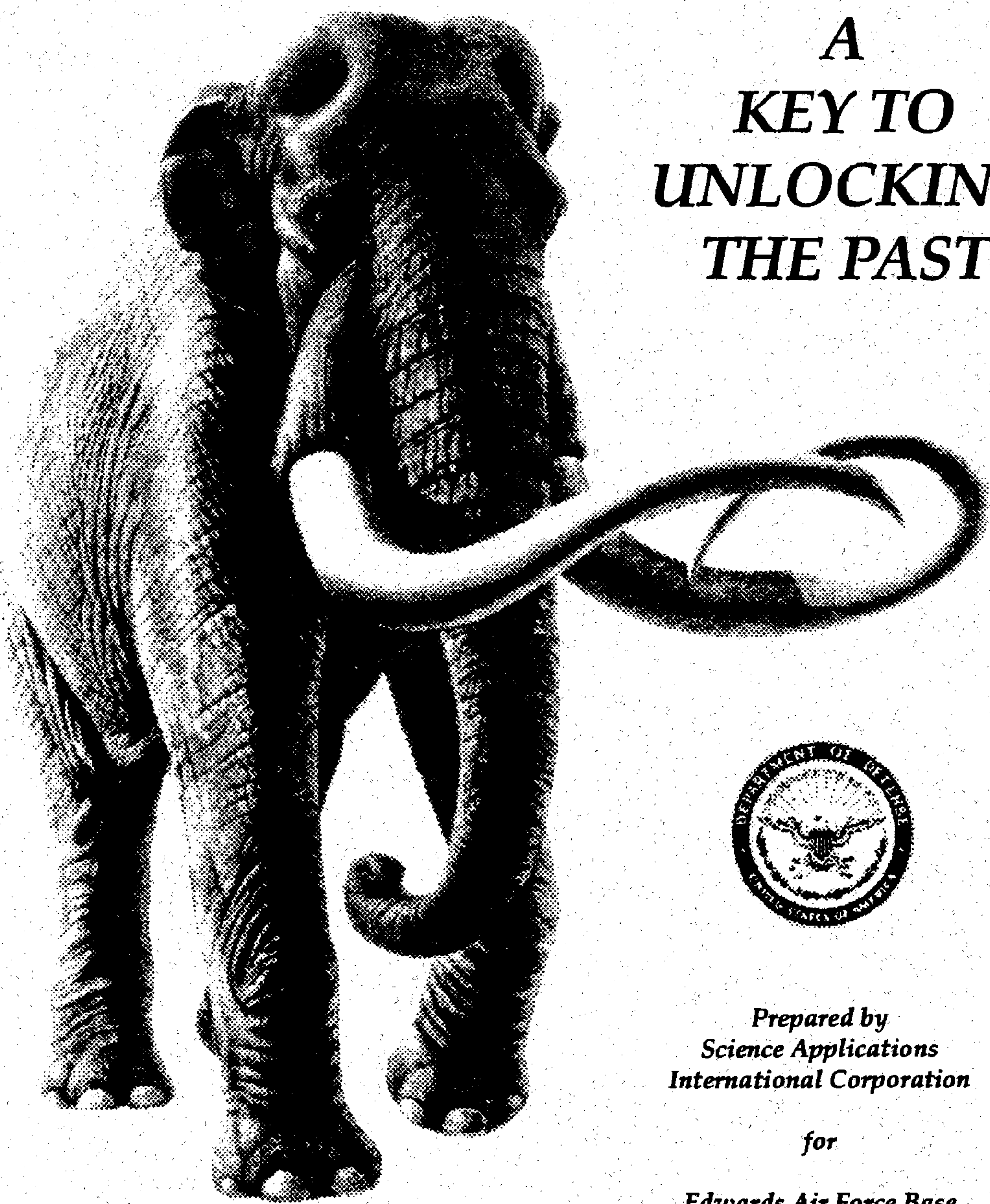
Legacy 92-0482

Legacy # - 9200482

PALEONTOLOGY RESOURCES:

A KEY TO UNLOCKING THE PAST



Prepared by
Science Applications
International Corporation

for

Edwards Air Force Base

CONTENTS

Cover: Mammuthus imperator. Imperial mammoth weighed as much as ten tons with a geographic range that included southern California. Mammoth bone fragments have been recovered from Edwards AFB. (Reconstruction courtesy of the Los Angeles Museum of Natural History).

Sections

CONTENTS
(Continued)

Appendices

List of Figures

1.0 WHY FOSSILS? THE ARGUMENT FOR A RESOURCE PROGRAM

Paleontology, the study of past life, is a scientific attempt at unraveling history that dates as far back as 3 billion years. It is a broad science shedding light on topics such as evolution, climatology, taxonomy, geophysics, and a myriad of other interests.

Dinosaurs, mammoths, saber tooth tigers, and other extinct, exotic life forms capture the public's imagination (Figure 1). However, it is the fossils that grab headlines and the public's attention.

Paleontology, the study of past life, is a scientific attempt at unraveling history that dates as far back as 3 billion years. It is a broad science shedding light on topics such as evolution, climatology, taxonomy, geophysics, and a myriad of other interests.

Although similar in approach, paleontology differs from archaeology. Archaeology and anthropology are the study of man and his civilizations. Paleontology is the study of all life from the beginnings of life at approximately 3 billion years ago to prehistoric man's first appearance. Paleontology and archaeology overlap at that distant point when Homo sapiens first appeared. Both paleontologists and archaeologists claim early man as part of their fields.

Several Federal agencies consider fossils paleontological resources. Historically, action is taken to protect this resource and determine its significance. Currently there are no legislative acts that specifically protect paleontology resources. However, several different legislative initiatives are applied to protect this resource.

The following sections discuss issues pertinent to establishing a paleontological resource program.

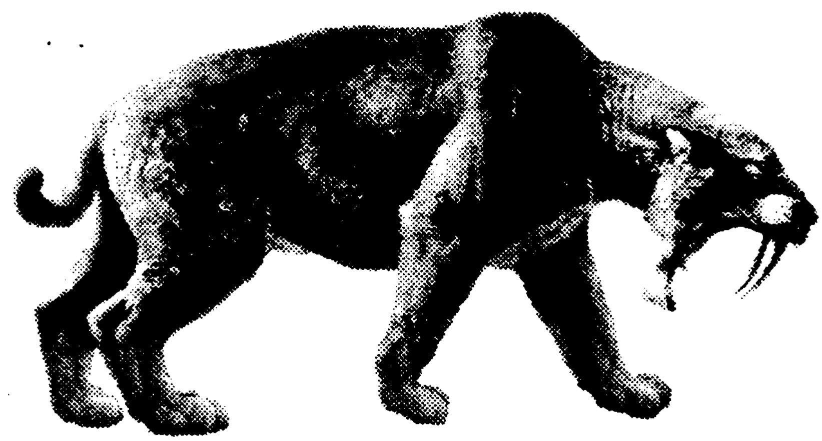


Figure 1. Smilodon californicus. Saber-toothed Tiger (cat) California State fossil (Reconstruction courtesy of the Los Angeles Museum of Natural History)

Extinct fossil groups are a continuing source of discussion and speculation. Why did dinosaurs die? Why did some species, such as cockroaches, survive while others died out so quickly? Is adaptability to environment a survival mechanism?

1.1 Applications of Fossils to Understanding Our World

Man has always speculated on the meaning of fossils. In earlier times, marine fossils found in rocks on tops of mountains were used as evidence of the biblical flood. Strange looking fossils of unknown species were dismissed as life forms unsuitable to the Almighty and therefore discarded. However, fossils have been a key in developing many scientific theories including the theory of stratigraphic succession (correlation of rock units from one place to another), theory of evolution (how species change through time), and, more recently, the theory of plate tectonics. These and other theories helped modern man unravel both earth and man's history.

The systematic study of fossil remains cast an entirely new light on the earth's past history. It did away with old-fashioned, superstitious notions on the subject that prevailed for thousands of years. Fossil records furnished irrefutable proof that life on earth changed through the ages. Although each fossil species is interesting in and of itself, the study of fossil groups and the changes they disclose over time are even more important. The fossil record shows us that past life was balanced and self-sustaining. Nothing came into existence without ancestors or until conditions were suitable. Each new organism found an available food supply, enemies and competitors that drove it forward in the struggle to survive.

Paleontologists, like students of human history, look chiefly backward. They resemble detectives seeking clues to mysterious past events. Scientists think and work backward from available clues, taking into account the nature of the "suspects," "motives," and setting of the event in question. By eliminating various possibilities, one eventually hopes to arrive at a correct solution. One of the fundamental characteristics of paleontology is that conclusions must often be made on the basis of insufficient evidence. If facts are few, it may be necessary to create theories or make "educated guesses" until positive evidence is discovered. All available clues, although some initially appear meaningless, must be carefully collected and preserved. Paleontology involves not only the search for new information in nature, but also the re-evaluation of previously discovered facts recorded in writings, collections, and maps of earlier investigators. Paleontology exemplifies, to a high degree, the cumulative nature of scientific knowledge. It advances by the slow accumulation of facts gathered by many workers in all parts of the globe over a long period of time.

Today paleontology is an active, exciting discipline influencing and encompassing many fields. Traditional paleontologists still work on taxonomic issues seeking to understand the relationships between species of living and extinct forms. How do organisms evolve or speciate, and how fast? Do all species eventually die out/go extinct? Were dinosaurs warm blooded? Can relationships between species be demonstrated by studying either amino acids or perhaps DNA fragments?

Extinct fossil groups are a continuing source of discussion and speculation. Why did dinosaurs die? Why did some species, such as cockroaches, survive while others died out so quickly? Is adaptability to environment a survival mechanism?

Fossils are studied along with the rock strata that encase them (Figure 2). Assemblages or groupings that indicate a type of community or environment (marine, lake, desert, etc.) as well as a climate zone (tropical, temperate, arctic, etc.) are identified. Arguments persist as to the significance of paleotropical assemblages found in the Arctic region today. Was the ocean much warmer long ago or did these rocks ride to shore on a colliding plate from somewhere else? Recently, fossils are being utilized in meteorology and climatology to study climate changes through time. How significant and predictable are climate shifts? Why do some species survive climatic changes and others die out? How does life affect earth's processes? Is the earth a static or dynamic system overall?

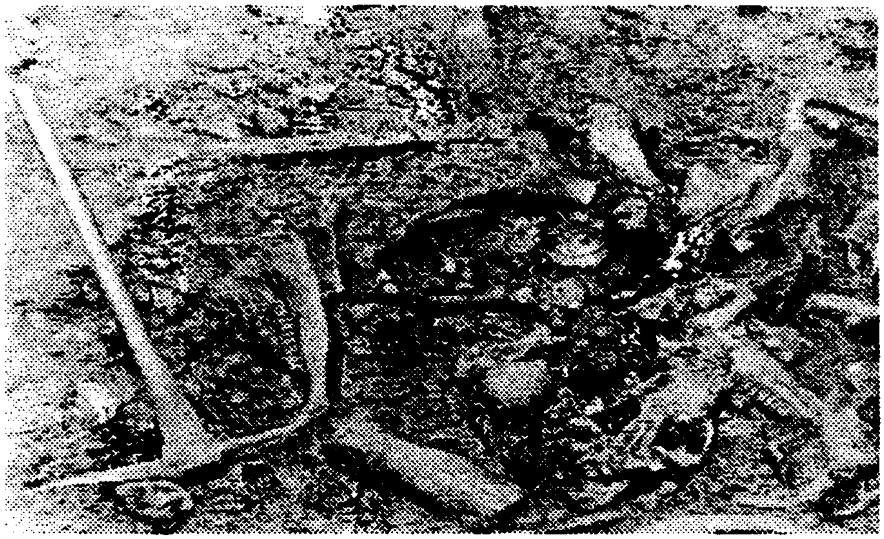


Figure 2. Fossil Assemblage (Photo courtesy of the Los Angeles Museum of Natural History)

Fossils are utilized by several industries. The petroleum industry values the stratigraphic importance of fossils. Fossils may either indicate the correct horizon to find oil; provide a stratigraphic link between oil fields; tell an oil pool's age; or indicate whether mature oil producing horizons are present. Mineral companies utilize fossils to either identify the proper stratigraphic horizon; indicate the formation's age; or indicate fault movement. Some fossils such as diatoms have economic importance and are mined as an industrial mineral. In addition, fossils are actively collected by amateurs and professionals alike as a hobby.

Scientific questions of significance about fossils and their meaning to our lives today remain unanswered. These materials must be protected and managed as a resource in a manner that balances its importance against competing needs.

1.2 Legislative Mandate: Is Our Resource Protected?

No specific, direct legislation or regulation exists to protect paleontological resources. The following discussion and Appendix A identifies laws, regulations, and programs at the federal and state levels that address protection of paleontological resources.

No specific, direct legislation or regulation exists to protect paleontological resources. The following discussion and Appendix A identifies laws, regulations, and programs at the Federal and state levels that address protection of paleontological resources.

The Bureau of Land Management (BLM), National Parks Service (NPS), United States Forest Service (USFS), the Department of Defense, the Department of Energy and other federal agencies are concerned about paleontological resources on the lands they manage. However, unlike biological resources (e.g., Endangered Species Act, Marine Mammal Protection Act, Fish and Wildlife Coordination Act, etc.) or cultural resources (e.g., National Historic Preservation Act, Native American Graves Protection, Repatriation Act, etc.), paleontological resources are not afforded any direct federal legislative protection. Therefore, paleontological resource management programs are inconsistent between agencies. Agencies are divided as to the amount of protection afforded paleontological resources. Often paleontological resources are managed under the jurisdiction of a cultural resources program.

Most agencies invoke the National Environmental Policy Act (NEPA) to protect paleontological resources. Federal agencies are required under NEPA to develop and adopt protection, restoration and enhancement guidelines for the environment. The object of these guidelines is to preserve historic, cultural, and natural aspects of our natural heritage. All federal agencies are required to implement NEPA and develop guidelines. Paleontological resources management falls under this legislation.

Other legislation might be used to protect paleontological resources. This includes the Federal Land Policy and Management Act of 1976 and the Archaeological and Historic Preservation Act of 1974. The State of California requires paleontological resources management under the California Environmental Quality Act. Other states may have similar requirements. However, the state legislation is usually not applicable to activities conducted on federal installations.

2.0 PALEONTOLOGY RESOURCE PROGRAM: DETERMINING THE NEED

Are all fossils significant? How does one determine significance for paleontological resources?

Protection of paleontology resources includes: 1) assessment of the potential for property to contain significant nonrenewable paleontological resources that might be directly or indirectly impacted by development; and 2) the formulation and implementation of measures to mitigate such adverse impacts, including permanent preservation in an established museum or university.

2.1 What is Significant?

Fossils are nonrenewable paleontological resources. The potential for construction impacts to paleontological resources on public lands must be assessed prior to conducting the activity. Are all fossils significant? How does one determine significance for paleontological resources? These questions are not only applicable to management of paleontological resources but also to cultural and biological resources.

There is no clear legislative mandate defining paleontological resources, so the discussion of significance is speculative and discretionary. There is no clear standard of "significance" for paleontological resources. No standard of "significance" has been enacted by any federal or state agency regarding paleontological resources. The Society of Vertebrate Paleontology published guidelines in 1991 and recommended that "high sensitivity" areas not only include the "... potential for yielding abundant vertebrate fossils, but also for production of a few significant fossils, large or small, vertebrate, or plant that may provide new and significant taxonomic, phylogenetic, ecological, and/or stratigraphic data. Areas that may contain datable organic remains older than "Recent," including *Neotoma* middens, areas which may contain unique new vertebrate deposits, traces, and/or trackways are also considered to be significant." This definition is not clear enough for the non-paleontologist to determine whether or not he/she has a significant resource. Agencies including BLM, NPS, and the United States Geological Survey (USGS) are creating guidelines for determining paleontological significance.

The BLM, NPS, and state and local agencies use a BLM memorandum developed by Mr. Grissold E. Petty, Acting Associate Director of the Bureau of Land Management (1978). It is used as a guideline to determine significance of a paleontological resource. The memorandum specifies that:

> *"There is no universally accepted definition for a significant scientific paleontological resource. A definite determination can only be made by a qualified, trained paleontologist. Using the following guidelines, a paleontology resource is of significant, scientific, and educational value if it:*

1. *Provides important information of the evolutionary trends among organisms, relating living inhabitants of the earth to extinct organisms.*

2. *Provides important information regarding development of biological communities or interaction between botanical and zoological biotas.*

3. *Demonstrates unusual or spectacular circumstances in the history of life.*

4. *Is in short supply and in danger of being depleted or destroyed by the elements, vandalism, or commercial exploitation, and is not found in other geographic locations.*

All vertebrate fossils have been categorized as being of significant scientific value."

The NPS (personal communication, Huddelston, 1993) and BLM (personal communication, Piortillo, 1993) stated that legislation is being developed to identify a uniform set of guidelines to prioritize paleontological resources and establish a standard of significance. Additionally, BLM staff in Salt Lake City, UT are currently developing a draft-set of criteria for evaluating paleontological resources (personal communication, Spencer, 1993).

Perhaps the following broad definition encompasses all significant paleontological resources. Significant-nonrenewable paleontological resources are fossils or assemblages of fossils that are unique, unusual, rare, or uncommon either diagnostically, taxonomically, or regionally. Significant paleontological resources include: 1) fossil remains of large to very small aquatic and terrestrial vertebrates; 2) remains of plants and animals (invertebrates and vertebrates) not previously represented in certain portions of the stratigraphy; and 3) assemblages of fossils vertebrates and invertebrates that might aid stratigraphic correlations, particularly those offering data for the interpretation of tectonic events, geomorphologic evolution, paleoclimatology, paleobiology, stratigraphy, and aquatic and terrestrial species' relationships.

2.2 Assessing the Resource: Are There Fossils?

Paleontological resource delineation is different from other resource delineation, such as biological or archaeological, because paleontological resources are not necessarily site-specific. The boundaries of an entire fossiliferous or fossil-rich formation may, therefore, define the limit of the paleontological resource.

Not all rock types contain fossils. Rock units are broken into three broad categories: 1) sedimentary; 2) igneous; and 3) metamorphic. Sedimentary rocks are rocks formed from sediments by mechanical, chemical, or organic actions. They are formed through the agency of water, wind, glacial ice or organisms and are deposited at or near the surface of the earth. These rocks may be rich in fossils. Igneous rocks are formed during volcanic and intrusive (magmatic) events. These rocks do not contain fossils. Metamorphic rocks have been deformed by high temperatures and pressures deep within the earth. They are formed from original sedimentary and igneous rocks, and rarely contain fossils.

Sedimentary rock units include common rock types such as sandstone, mudstone, shale, conglomerate, limestone, etc. These various rock types indicate different kinds of depositional environments and have a varying fossil collection potential. Fossil preservation relies on a variety of different conditions including: the nature and type of specimen (hard parts such as skeletons or shells are more readily preserved than soft body parts); and immediate burial. Weathering, erosion, decay, and disintegration impede fossilization. Fossils are more readily preserved in fine grained sediments (e.g., mudstone, shale, limestone) than coarse grained sediments (e.g., sandstones and conglomerates). Fine grained sediments are less abrasive. Not all sedimentary rocks contain fossils.

In order to identify potential fossil horizons, it is important to know what rock types are in the area. This is accomplished by researching a local geological map that identifies a variety of rock types. This information is available at either the local college or university, the USGS, and/or state geologic maps.

Potential paleontological resource delineation is different from other resource delineation, such as biological or archaeological, because paleontological resources are not necessarily site-specific. The boundaries of an entire fossiliferous or fossil-rich formation may, therefore, define the limit of the paleontological resource.

2.3 Protecting the Resource

A mitigation plan must be developed to protect paleontological resources from authorized and unauthorized actions.

Significant, nonrenewable paleontological resources receive adverse impacts from natural causes as well as through land use and development. Natural impacts occur directly through erosion and weathering of rock units. These processes can expose subsurface fossils, potentially transport them, and, once exposed, subject them to eventual destruction.

Impacts from land use can occur directly by destruction of fossils on or near the surface during brushing, grading, road construction, and other ground disturbing activities; by excavation for foundations, trenches, towerpads, footings, wells or other subsurface activity in fossiliferous areas; and indirectly by increased erosion from vehicle and human activity which can cause impacts through compaction and unauthorized collecting.

A mitigation plan must be developed to protect paleontological resources from authorized and unauthorized actions. A standardized plan may be developed with further designations by the level of disturbance to allow subdivision of mitigation activities. The Mitigation Plan should include at least the following elements:

- Review of sensitivity/potential maps and previous paleontology locality data;

- Development of a project-specific impact mitigation plan;

- Predisturbance surveys of high sensitivity/potential areas by a qualified paleontologist to assess the resource and salvage surface fossils;

- Full or part-time monitoring, depending on level of disturbance and fossil potential, by a qualified paleontologist equipped to salvage fossils as they are exposed;

- Stabilization, shipment, identification, and curation of specimens at a retrievable storage locality; and

- A final report summarizing findings of significance. This report should include a summary of the field and laboratory methodologies, site geology and stratigraphy, an itemized inventory of recovered specimens and site records, and a faunal list. The report should discuss the significance of recovered materials.

The above mitigation measures must be tailored to the particular installation as well as to the type of disturbance activity.

Impacts from unauthorized activities must also be mitigated. Many people enjoy "off road" vehicle driving which can destroy exposed fossils. Fossil collecting for nonscientific reasons is an active past time for hobbyists. Keeping the locations of fossil specimens secret, establishing off limit areas, and fencing significant locations are different ways to mitigate unauthorized collection and potential vehicle damage.

3.0 PALEONTOLOGY RESOURCE PROGRAM: DEVELOPING A BASELINE

A paleontology resource program needs three basic elements: 1) maps/literature identifying potential areas of paleontology resources; 2) survey, assessment, and monitoring to gather additional information; and 3) summary report of findings and mitigation measures.

After a cursory examination of geological maps to identify a paleontological resource potential based on the correct rock types (e.g., sedimentary or metamorphic units), it will be necessary to identify the presence or absence of a resource at the installation.

3.1 Literature Analysis Deciding Where to Look

The first step is to search the geological and paleontological literature at relevant institutions to determine if fossils have been found within your geographic area. Local universities, colleges or even some public libraries may have information available. Most universities and colleges have an earth science department or at least teach earth science. Contact a local professor to discuss the potential for paleontological resources in the geographic region. One day at the appropriate library should be enough to determine if the potential for paleontological resources exists at an installation. Other resources are identified in Section 5.

If academic institutions are not close, the USGS or state geological survey should be able to help you determine if there is a potential for fossils at your facility.

The first step is to search the geological and paleontological literature.

All sedimentary rock units are not created equal. For a variety of reasons some units may not contain any fossils at all. It is important during the literature gathering phase that some determination be made concerning the potential for fossils in each sedimentary rock unit. Try to rank the probability of finding fossils within each of your sedimentary units (most likely to least likely).

3.2 Designing Your Program

Fossils are significant paleontological resources that are afforded protection by federal, state and local environmental laws and guidelines as discussed in Section 1. As a nonrenewable resource they need protection from construction impacts, unauthorized collection, and other land use impacts to the extent possible.

A paleontology resource program needs three basic elements: 1) maps/literature identifying potential areas of paleontology resources; 2) survey, assessment, and monitoring to gather additional information; and 3) summary report of findings and mitigation measures.

3.2.1 Sensitivity Determination

Paleontological sensitivity maps can be drawn based upon the information gathered from the literature search. This data should be reviewed whenever a new project is proposed.

After determining that fossils may be present on your installation, paleontological resource sensitivity maps should be made from the literature analysis. Sedimentary rock units may be described as having a measurable sensitivity for containing significant paleontological resources. These measurements are classified into three categories. They are:

1. High Potential/Sensitivity. Sedimentary units with a high potential for containing significant paleontological resources are rock units composed of vertebrate or significant invertebrate fossils. Previous studies have determined fossils to be present. These units include sedimentary formations containing fossils anywhere within its geographical extent, and sedimentary rock units temporally or lithologically suitable for the preservation of fossils. High sensitivity includes not only the potential for yielding abundant vertebrate fossils, but also production of a few significant fossils or assemblages.

2. Undetermined Potential/Sensitivity. Specific project areas underlaid by sedimentary rock units about which the literature and unpublished studies are not available have undetermined potential for containing fossils. A field survey may be required to determine its potential.

3. Low Potential/Sensitivity. Following literature and records checks and/or field surveys, an area may be determined to have low potential for containing significant resources. No further analyses necessary.

Paleontological sensitivity maps can be drawn based upon the information gathered from the literature search. Sensitivity maps should be placed on topographic sheets and/or a computer database. This data should be reviewed whenever a new project is proposed. A first-cut analysis can be made from the published literature and geological maps and information should be added as the program matures. Additional information may include all site and survey localities.

3.2.2 Surveys, Assessments, and Monitoring

Pre-construction surveys and monitoring during construction projects should be required for salvage of any fossils in high potential areas.

After conducting a literature search and identifying potentially sensitive areas, additional field reconnaissance surveys may be necessary to further delineate any paleontological resources. Pre-construction surveys and monitoring during construction projects should be required for salvage of any fossils in high potential areas (Figure 3). These surveys should be conducted by trained paleontologists; preferably those experienced with regional paleontological resources. The following outlines what is involved:

Surveys. Conduct surface reconnaissance surveys. An outcrop/ground survey can be conducted to spot check potential paleontological resource areas identified by the sensitivity maps. Additional surveys are necessary to find areas identified as "undetermined" potential on the sensitivity maps. More surveys may be conducted to define specific boundaries of high sensitivity areas.

Pre-construction/Activity Assessments. Pre-construction or activity field surveys should be conducted in high sensitivity areas to define specific boundaries of fossil bearing units. Some significant vertebrate resources (e.g., rodent, insectivore, bird, and reptile remains) range in size from small to microscopic and may not be readily apparent. Bulk/matrix samples may need to be taken. These samples are washed through screens to determine if significant specimens are present. If necessary, this information can determine mitigation measures.

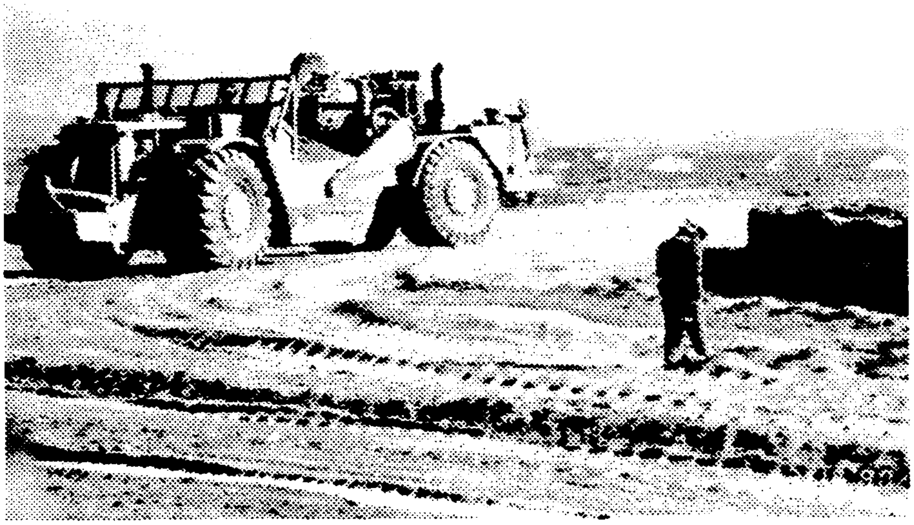


Figure 3. Paleontologist Examining Fresh Cut During Construction Activities (Photo courtesy of San Bernardino County Museum)

Monitoring. In known-high-sensitivity sedimentary units, a paleontologist should monitor activity during ground-disturbing activities so specimens are salvaged, if necessary. Monitoring should be 100 percent of the time unless the project paleontologist determines that reduced monitoring is adequate. Bulk/matrix sampling from predetermined horizons should be conducted to ensure adequate recovery of resources.

3.2.3 Fossil Recovery and Identification

During field investigations, specimens recovered are prepared to a point of gross identification.

During field investigations, specimens recovered are prepared to a point of gross identification then stabilized for preservation and shipment (Figures 4, 5, and 6). Various fossil field collecting, documentation, and preparation methods are discussed in Appendix B. Bulk/matrix samples may be taken to recover smaller fossils and processed at the laboratory (Figure 7).

Fossils are shipped for identification confirmation by a trained paleontologist to a laboratory or facility. Further specimen cleaning and stabilizing may occur.

Arrangements for adequate permanent storage and curation of specimens must be addressed prior to any field activities.

Arrangements for adequate permanent storage and curation of specimens must be addressed prior to any field activities. A local museum or university are likely candidates for permanent curation if space is not readily available on-site. All notes, geological maps, and stratigraphic sections accompany fossil collections. Specimens are stored in a fashion that allows researchers future retrieval of specific, individual specimens.

Not all specimen material recovered during a field investigation needs to be curated. Often, material is not identifiable to family, class, or genus. This material may be only identified as vertebrate bone material or teeth. A decision needs to be made as to whether or not to permanently curate and store this type of material, or whether written field notes and summary report identifying the locality is enough detail.

Figure 4. Fossil Preparation and Stabilization Prior to Removal from Site (Photo courtesy of San Bernardino County Museum)

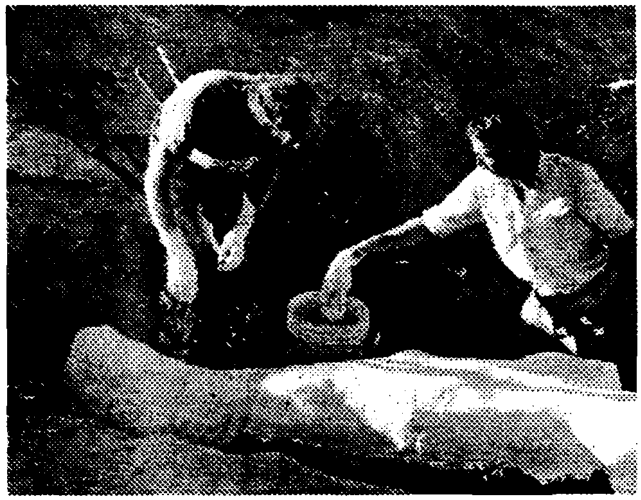


Figure 5. Fossil Preparation and Stabilization with Plaster Prior to Removal from Site (Photo courtesy of San Bernardino County Museum)

Figure 6. Plaster Cast Completed Fossil Ready for Extraction (Photo courtesy of San Bernardino County Museum)

Figure 7. Matrix Sample Extraction (Photo courtesy of Edwards AFB)

3.2.4 Summary Report

The project paleontologist's report will summarize the field program and identify any known specimens (see example, Appendix C). This report will include a field and laboratory methodology summary, site geology, site stratigraphy, faunal list, paleoenvironmental analysis, and a brief statement of significance that includes the relationship between the site and other similar fossil localities. An itemized inventory list of curated specimens will be appended to the report. The report may be prepared subsequent to salvage, preparation, identification, curation, and storage of the recovered specimens. A checklist provided in Appendix D, may help the nonpaleontologist review the contents of a paleontology report.

The summary report needs to be accessible for future investigators and researchers. The summary report should be sent to an installation technical library, kept in the environmental department library, or kept in an appropriate environmental office (historic and preservation office, ecology office, biologic office, etc.). The fossil specimens should be kept in an appropriate depository and be made available to researchers. Preferably the fossil material and summary report will be kept in close proximity. If desired, fossil material and summary reports may be sent to a state repository or local university/college to assure ready access for all interested researchers.

3.3 Selecting Paleontologists

When selecting a paleontologist one must remember that paleontology is a very broad field and, depending on the types of fossils at your

One of the most difficult assignments for a professional is to select another professional in a field where they are not knowledgeable. Many times this is the case for resource professionals assigned resource management functions outside their field of expertise. When selecting a paleontologist one must remember that paleontology is a very broad field and, depending on the types of fossils at your *installation, different individuals are needed.*

installation, individuals with differing expertise may needed.

Paleontologists have subspecialties in various fossil groups. Paleontologists, like biologists, are placed into two main categories: 1) vertebrate; and 2) invertebrate. Paleobotanists are a separate group specializing in fossil plants and plant remains. Knowledge of what types of fossils are found on your installation will help guide you in the selection.

Academic credentials and regional experience are essential to selecting a paleontologist or paleontology company. Ask for and investigate references. If they published technical papers, ask for copies. Request a project or work plan for the proposed investigation as part of their submittal package. Request their procedures on fossil salvage, identification, and curation.

3.4 Conducting a Field Investigation

Prior to ground disturbing activities, a walkover survey is conducted.

Prior to commencing ground disturbing activities, the paleontologist prepares a work plan or survey design to address field activities in high or unknown sensitivity areas. Specific measures for paleontology mitigation in areas of low sensitivity/potential are not needed. Pregrade surveys are conducted to identify high potential horizons for fossils within the high sensitivity areas. Monitoring during ground disturbing activities will be necessary to salvage specimens. This prevents damage to known resources and avoids construction schedule delays. The level of monitoring may change during the field survey.

Prior to ground disturbing activities, a walkover survey is conducted. This type of survey is best for sites where the exposure to fossil bearing units is good; either by rock outcrops or exposures from the ground surface. An area is identified on a topographic map and systematically surveyed by one or two paleontologists, at minimum. Survey transects are established and conducted at established widths of 10 meters (m) to 50m, depending on the fossil concentration and terrain. Foot surveys should allow for intuitive deviations; consequently, exposures likely to contain paleontology resources are identified. Resource locations should be plotted on photocopies of topographic quadrangle maps using the brunton compass, pacing or tapes, and references to established geographic points. Each resource locality is assigned a field number, recorded in field notes, and described briefly. Although subsurface excavation is not included, occasional bulk/matrix samples may be necessary to recover very small to microscopic fossils.

Subsurface excavations may be desirable if, either at depth, from literature analyses, or through previous field work, a particular site appears to contain substantial resources.

Subsurface excavations may be desirable if, either at depth, from literature analyses, or through previous field work, a particular site appears to contain substantial resources. A site will be staked, identified on a topographic map, and carefully excavated. Material is processed by several methodologies; washing material through sieves, sifting material through screens of various sizes, and carefully excavating fossils by use of casts/molds that are further excavated at a laboratory. Fossil excavation, preparation, stabilization and shipment must be carefully done in order to preserve the material. Appendix B discusses a variety of techniques.

4.0 PALEONTOLOGICAL RESOURCE STUDY: EDWARDS AIR FORCE BASE

Edwards Air Force Base is surrounded by fossil bearing rock units.

Edwards Air Force Base (EAFB), California is an aeronautical research and development testing facility, located in the Antelope Valley, approximately 60 miles northeast of Los Angeles. The Antelope Valley includes the cities of Lancaster and Palmdale and is located at the western edge of the geomorphologic Mojave Desert province, part of the Great Basin.

The western Mojave Desert province contains a geologic history dating back prior to 600 million years ago (mya). Rocks that outcrop within and immediately surrounding EAFB include Mesozoic crystalline rocks (approximately 90 mya); Tertiary volcanic and sedimentary rocks (approximately 20-2 mya); Quaternary sediments (approximately 2 mya-5,000 years before present); and Recent sediments (deposited within the last 5,000 years) (Diblee, 1968). Geologic and paleontological exploration in the Mojave Desert was not initiated in-depth until the twentieth century, and early in the century the rigors of the desert environment and the lack of reliable transportation severely limited the extent of study. By the 1920s, researchers had identified significant paleontological materials in the foothills of the San Gabriel Mountains south of EAFB.

The establishment of the Air Force Base and its closure to casual use precluded systematic exploration later in the century, although Dibblee described formations during geologic mapping in the area published from the early 1950s. Rock units within EAFB known to contain paleontologic resources are Tertiary formations within the Tropico Group and Quaternary old alluvium, laustrine sediments, and paleosols.

4.1 EAFB Identifies A Need

EAFB has an active program in natural and cultural resource management. As environmental stewards for the American people, EAFB developed programs and procedures which aided in the identification and protection of significant cultural and biological sites prior to ground disturbance activities. Specific guidelines for protection of these significant areas were developed in accordance to Federal, state, and Air Force requirements. Since, no specific mandate exists for the identification or protection of paleontologic resources, EAFB personnel were left to develop a suitable program of their own.

EAFB maintains records of cultural resource sites within its boundaries, and surveys have been and continue to be conducted to identify these resources both in response to environmental protection relative to specific development and land use status on base, and as reconnaissance surveys. Paleontological materials encountered during these surveys were reported on a limited basis; their localities have been recorded in the EAFB database located in the base Historic Preservation Office's file. These specimens are predominantly fragments of Pleistocene large mammal tooth enamel and limb bone; some small bone and occasional invertebrates and plant remains. Prior to 1987, 150 paleontological localities were recorded in the database records.

In 1977, in response to Air Force Regulation (AFR)-19-2 requiring the base to "locate and place on the master plan all paleontological sites," Base Archaeologist Mark Q. Sutton requested data on paleontological localities recorded within EAFB from the Museum of Paleontology at the University of California, Berkeley (Hutchison, written communication to Sutton, 1977) and from the Los Angeles County Museum (Dock, written communication to Sutton, 1977). Neither institution had records of localities within the base boundaries. In that year, Sutton also contacted the U.S. Geological Survey for identification of specimens recovered on the base: of these, one specimen was modern and others were unidentifiable bone fragments washed from their source to their discovery site (Repenning, written communication to Sutton, 1977).

No systematic paleontological survey is known to have occurred within the confines of EAFB prior to survey and subsequent salvage mitigation of the All-American Pipeline just within the northern base boundary (Reynolds, 1986, 1988). The San Bernardino County Museum conducted a pre-excavation field survey and excavation monitoring for the All-American Pipeline just within the north boundary of EAFB. A total of 21 paleontological resources localities were located near Rogers Lake that contained remains of Pleistocene camelids, antelope, horse, rabbits, rodents, and plant remains as well as bone and tooth fragments of indeterminate large and medium-sized mammals (Reynolds, 1986; 1988).

In 1987 the San Bernardino County Museum was contracted to develop a paleontologic resource overview and management plan for EAFB. The museum prepared a literature review, conducted a records search, conducted field surveys, evaluated the significance of the survey findings, and suggested guidelines for evaluation of paleontologic sites. Two hundred and four paleontologic resource localities were identified during this study.

Pertinent literature was reviewed and site records checks were initiated to ascertain if paleontological resource localities other than those recorded in database files had been recorded. The combined results of these records searches and literature review showed that vertebrate and invertebrate paleontological localities had not been recorded within the boundaries of EAFB. Relatively abundant site records exist for Tertiary localities north of the base in the Horned Toad Formation, the Philips [Phillips] Ranch fauna, and near Cache Peak in the Tehachapi Range. University of California, Riverside records the Boron locality to the immediate northeast of the base. South of the base and south of the San Andreas Fault in the foothills near Palmdale and Little Rock, a single specimen of the cetacean Eurhinodelphidae was recorded by the University of California, Berkeley. A Tertiary dolphin from the Vaqueros Formation which was recovered in Little Rock Wash. The Regional Paleontological Locality Inventory at the San Bernardino County Museum shows localities to the east and south of EAFB in Miocene sediments at Boron and Kramer Junction and in Pleistocene sediments at Kramer Junction, Harper Lake, Hawes, Helendale, along the Mojave River, and in the Old Alluvium near Cajon Summit.

Science Applications International Corporation (SAIC) was contracted in 1993 to conduct additional site surveys, prepare a survey summary report, and prepare a paleontology resource document. Funding for this project was granted to EAFB under the DoD Legacy Program. SAIC identified 42 paleontologic localities during the surveys.

4.2 EAFB Develops a Paleontologic Resource Program

Since 1977, EAFB has identified 415 paleontologic localities. Recognizing that this resource must be managed, EAFB cultural resource personnel took a proactive approach and proceeded to develop a paleontologic management program.

EAFB has relied on paleontologists to recommend steps in creating an integrated paleontologic resource management program. After a literature investigation identified potential areas of sensitivity, maps were prepared identifying potential sensitivity areas throughout the base. Surveys have been conducted to identify potentially highly sensitive areas. EAFB has developed a paleontologic database of all localities from information gathered in the field (see Appendix E). Paleontologic localities have yielded a variety of vertebrate bones and teeth from: mammoths, camelids, sheep, pronghorn, horse, rabbits, mice, birds, tortoises, snails, fish, and ostracodes. This material is curated on base.

Paleontologic resource management is conducted currently with cultural resource investigations. Monetary support for paleontology surveys is sporadic as paleontologic resources are afforded limited Federal protection. Surveys have been conduced in highly sensitive areas, funding permitting. Survey summary reports are necessary for identification and management of the resource and determining the significance of the resource (Appendix C).

Fossil specimens recovered at EAFB are in a variety of preservation states. Some bone and teeth material are identifiable to the genus and species level; other material allows only for a mammalia or vertebrate class designation. Fossil material at EAFB is widespread throughout the surface Pleistocene sediments and tantalizes the imagination as to what specimens might be buried below the surface. A few localities, Piute Ponds for example, have abundant specimens. One matrix sample (55-gallon drum size) from Piute Ponds yielded over 2,000 specimens.

EAFB is continuing to identify sensitive areas and manage their paleontologic resources. Efforts are being made to identify highly sensitive areas on base. In addition, decisions are occurring as to which material should be permanently curated and what material may be discarded. EAFB personnel are trying to determine what is the significance of their resource and identify the best methods to manage their legacy.

4.3 References

Reynolds, R.E. 1986; All American Pipeline, California section, paleontologic resource assessment technical report, Redlands, San Bernardino County Museum.

Reynolds, R.E. 1988; Paleontologic mitigation, All American Pipeline, California Section, Redlands, San Bernardino County Museum.

5.0 ADDITIONAL RESOURCES

For further information, contact:

1. Tom King, Geology Program Specialist, USFS Headquarters, Washington, D.C.
2. Greg Greenway, USFS, Willows, CA, 916-934-3316
3. Garth Portillo, BLM State Office, Salt Lake City, UT, 801-539-4276
4. Superintendent, State Park Service, San Francisco, CA 415-726-8800
5. Walt Cassidy, Cultural Resource Specialist, Ft. Irwin, CA, 619-386-3737
6. Bonnie Murchey, USFS, Branch Paleontology and Stratigraphy, Menlo Park, CA, 415-329-4975

5.1 General References

Andrews, H.N., Jr. 1946. Preservation of plants as fossils. Earth Sci. Digest, v. 1, no. 5, p.3-7.

Compton, R.R. 1961. Manual of Field Geology, John Wiley and Sons, N.Y. N.Y., 378 p.

Darrah, W.C. 1939. Principles of paleobotany. Chronica Botanica, Leiden, Holland, 239 p.

Dodson, P. 1973. The significance of small bones in paleoecological interpretation. Univ. Wyoming Contr. to Geol. 12:15-19.

Guidelines for Paleontological Collecting, National Academy of Sciences, 1987.

Maisey, J.G. 1991. Fossils, an illustrated atlas. AMNH, Vertebrate Paleo. Dept., p. 98-105, IGCP Project, #242.

U. S. Government Code 36CFR261- Penalties for Illegal Collection of Paleontological Artifacts.

Wolff, R.G. 1975. Sampling and sample size in ecological analyses of fossil Mammals, Paleobiology, v.1, p. 195-204.

5.2 Collecting References

American Malacological Union 1961. How to collect shells. 2nd ed., Marienette. Wisc.

Hibbard, C.W. 1949. Techniques of collecting microvertebrate fossils. Univ. Michigan Mus. Paleont. Contr. 8:7-19.

Waters, B.T. 1978. Modified bulk sampling of fossils. Univ. of CA Museum of Paleontology, Berkeley, 21(2), p. 136-148.

Wolf, C.A. 1980. Bulk Sampling. Earth Sciences, 33(2) p. 68-70.

Wood, J.M., and K.L. Segroves 1963. Method for collecting coal and shale samples. Micropaleontology, v. 9, no. 3, p. 340.

5.3 Labeling and Storage

Daeschler, T. 1990. Materials and techniques for storage fossil vertebrates. Abstracts Society of Vertebrate Paleontology, Jour. Vert. Paleo. 10 (3 supp.), p. 19A.

Richards, H.G. 1954. Analysis of the methods of storing invertebrate fossils. J. Paleontology, v. 28, no. 4, p. 486.

Schenck, E.T., and McMasters, J.H. 1948. Types and storage of type material, in Procedure *in* taxonomy. Stanford Univ. Press (2nd ed. revised by A.M. Keen and S.W. Muller), p. 6-12.

Wilson, J.H. 1949. Labels which last. Mus. J., London, v. 49, no. 5, p. 114-116.

5.4 Preparation Techniques

Baird, D. 1951. Latex molds in paleontology. Compass of Sigma Gamma Epsilon, v. 28, no. 4, p. 339-345.

Esing, J.F. 1950. A new technique for removing bones from limestone breccia. Antig., v. 24, p. 102-105.

Feldman, R.M. and Chapman, H. 1989. Glues and other stick 'ums and patch 'ums, stabilizing compounds for strengthening fossils. In Paleotechniques. Kent State Univ., Dept. Geology, Special Pub. Paleo Society 4, p. 249-259.

Funkhouser, J.W., and Evitt, W.R. 1959. Preparation techniques for acid-insoluble microfossils. Micropaleontology, v. 5, no. 3, p. 369-375.

Grant, R.E. 1989. Extraction of fossils from $CaCo_3$ by acids. In Paleotechniques. Kent State Univ., Dept. Geology, Special Pub. Paleo Society 4.

Jensen, J.A. 1961. A new casting medium for use in flexible and rigid molds. Curator, v. 4, no. 1, p. 76-90, 12 figs.

Keyes, I.W. 1959. Paleontological casting and moulding techniques. New Zealand J. Geol. and Geophysics, v. 2, no. 1, kp. 56-65, 10 figs.

Knights, A.J. 1951. Micropaleontological technique. Geol. Mag., v. 88, no. 2, p. 150. [Shale disintegration by heat.]

Layne, N.M., Jr. 1950. A procedure for shale disintegration. Micropaleontologist, v. 4, no. 1, p. 21. [Gasoline technique.]

Palmer, A.R. 1989. Techniques for mechanical preparation of smaller fossils. GSA Centennial Science Project. In Paleotechniques. Kent State Univ., Dept. Geology, Special Pub. Paleo Society 4.

Stevens, C.H., Jones, D.H., and Todd, R.G. 1960. Ultrasonic vibrations as a cleaning agent for fossils. J. Paleontology, v. 34, p. 727-730, 2 pls.

Williams, S.J. 1991. Cleaning fossils - specimens in shale. Bulletin of Southern California Paleontological Society, 23 (9-10), p. 103-105.

6.0 ACRONYMS

ACEC	Areas of Critical Environmental Concern
AFB	Air Force Base
AFR	Air Force Regulation
BLM	Bureau of Land Management
CDCA	California Desert Conservation Area
CDCAP	California Desert Conservation Plan
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
DCRC	Defense Cultural Resources Council
DNRC	Defense Natural Resources Council
DoD	Department of Defense
EA	Environmental Assessment
EAFB	Edwards Air Force Base
EIS	Environmental Impact Statement
FLPMA	Federal Land Policy and Management Act
Kg	Kilograms
M	Meters
MYA	Million years ago
MOU	Memorandum of Understanding
NEPA	National Environmental Policy Act
NPDB	National Paleontological Data Base
NPS	National Parks Service
ODASD[E]	The Office of the Deputy Assistant Secretary of Defense for the Environment
SAIC	Science Applications International Corporation
TNC	The Nature Conservancy
U.S.	United States
USFS	United States Forest Service
USGS	United States Geological Survey

APPENDIX A: Federal and State Laws, Regulations and Programs

APPENDIX A. FEDERAL AND STATE LAWS, REGULATIONS, AND PROGRAMS

Department of Defense (DoD) Legacy Resource Management Program

The federal legislature, through the Defense Appropriations Act of 1991, established the *Legacy Resource Management Program* (DoD, 1991). It allows DoD to work jointly with other federal and state agencies, The Nature Conservancy (TNC), and other private and public agencies to preserve, plan, and manage natural and cultural resources. The Legacy Program intends to implement demonstration projects that: 1) identify and manage significant resources on DoD lands; 2) establish methodologies for the collection, storage, and retrieval of information used at all DoD facilities; and 3) develop educational public access and awareness programs.

Since the Program's initiation in early 1991, DoD has been actively involved in numerous demonstration projects to inventory, protect, and manage biological, cultural, and geophysical resources on lands owned or used by DoD. Demonstration project development at Edwards Air Force Base that involves paleontological resources is consistent with the Legacy Resource Management Program's intent. Inventory and management of paleontological resources located on Edwards Air Force Base and other defense installations is a resource addressed under the Legacy Program.

The Office of the Deputy Assistant Secretary of Defense for Environment (ODASD[E]) oversees the Legacy Program and is supported by two councils: 1) the Defense Natural Resources Council (DNRC); and 2) the Defense Cultural Resources Council (DCRC). Projects involving paleontological resources fall under DCRC authority. Demonstration project development on Edwards Air Force Base should focus on resource stewardship, inventory needs, and increased public awareness. Information obtained from such a project could then be integrated into DoD policies and programs.

Memorandum of Understanding, Management of Fossils on Public Lands, 1991A

Memorandum of Understanding (MOU) between the U.S. Geological Survey (USGS), Bureau of Land Management (BLM), National Parks Service (NPS), and U.S. Forest Service (USFS) was drafted in 1992. The MOU is designed to enhance communication and cooperation, and promote a consistent flow of paleontological information between the four agencies. It provides guidance on paleontological resource management issues of common concern; defines the land and resource management responsibilities of the BLM, NPS, and USFS; facilitates research conducted by USGS paleontologists; and supports expansion and enhancement of the National Paleontological Data Base (NPDB) maintained by the USGS.

Base Closure and Realignment Act of 1989

Several defense installations may receive military divisions from other bases that will be closed or have activity reductions. The *Base Closure and Realignment Act of 1989* (10 USC 2687, 102 Stat. 2623, PL 100-526-October 24, 1988), identifies procedures and programs for the closing or realigning of military installations. Proposed projects (closure or realignment of personnel or lands) under this Act are subject to the provisions of the National Environmental Policy Act (NEPA). The ultimate increase in manpower and the schedule for implementation is not known at this time.

A requirement of this Act specifies, "As a part of each annual budget request for the DoD, the Secretary shall transmit to the appropriate committees of Congress a description of the military installation to which military functions are to be transferred as a result of such closures and realignment, together with the Secretary's assessment of the environmental effects of such transfer." This inventory and environmental effects assessment can be included as part of the formal environmental review required by NEPA. Discussions of specific NEPA requirements are included in the subsequent analysis sections.

Restoration and Revocations of Lands by the Bureau of Land Management

Public lands under the jurisdiction of BLM may be withdrawn for use by other federal departments or agencies. BLM established regulations (43 CFR 2370) regarding Restoration and Revocations of Lands. According to Section 102 of the Federal Land Policy and Management Act of 1976 (FLPMA), P.L. 94-579, public lands must be managed in a manner that will "protect the quality of scientific and related values." Section 307 authorizes the Secretary of the Interior to "enter into cooperative agreements involving the management of public lands." These regulations apply to land interests, withdrawn or reserved from the public domain, that are no longer needed by the agency and are returned to BLM. Before returning any acreage to BLM, an "Intent to Relinquish" notice to BLM must be prepared and submitted. This notice must report lands or resources that are disturbed, and the measures taken or proposed to recondition the property. Paleontological resources located on lands that the Air Force returns to BLM requires inventory and mitigation where appropriate.

Council on Environmental Quality (CEQ) Regulations for Implementing NEPA (amended 1970)

One of the primary goals of *NEPA (amended 1970)*, (42 USC 4371 and 40 CFR Parts 1500-1508), is to provide environmental information to public officials and citizens so they can take actions to protect, restore, and enhance the environment (40 CFR Part 1500, §1500.1). This information includes accurate scientific analysis, expert agency comments, and public review. Officials are better equipped to make decisions based on an understanding of environmental consequences.

Federal laws, and DoD and Air Force actions are subject to the NEPA process. It is the responsibility of all federal agencies to develop and adopt their own guidelines for the implementation of NEPA (40 CFR Part 1500, §1500.3). DoD has promulgated such guidelines (42 USC 4321, 4331-4335, 4341-4347 [1976]), and applies them when reviewing Air Force projects and programs. This environmental review process involves the preparation of an Environmental Assessment (EA) and/or an Environmental Impact Statement (EIS). Environmental analyses includes paleontological resources, where appropriate. For paleontological resources on defense installations, the proposed action and alternatives, mitigation measures are identified and implemented. These reports specify any environmental effects that cannot be avoided, should the proposal be implemented. These guidelines are discussed in the following section.

DoD Procedures for Implementing NEPA

The objective of these guidelines is to preserve important historic, cultural, and natural aspects of our natural heritage. Subsection 214.5 (7)(6)(1-6) specifies that, "The DoD must act with care to ensure to the maximum extent possible that, in carrying out its mission of providing for the national defense, it does so in a manner consistent with national environmental policies." *DoD Implementing Procedures of the Council on Environmental Quality Regulations* (40 CFR Parts 1500-1508) complies with CEQ requirements in Section 102[2] regarding NEPA implementation guidelines.

Assessment of paleontological resources, as well as all other environmental consequences, should utilize a systematic and interdisciplinary approach ensuring the integrated use of natural and social sciences, and environmental considerations in planning and decision making where there may be an impact on the environment. The Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics) serves as the responsible official for all DoD environmental matters.

Federal Land Policy and Management Act of 1976

It is the policy of the United States (U.S.) that all public lands be managed in a manner that will protect the quality of scientific, historical, ecological, environmental, air and atmospheric, water resource, and archaeological values; and where appropriate, the U.S. will preserve and protect certain public lands in their natural conditions, according to the *Federal Land Policy Act of 1976*, (43 USC §1701, 90 Stat. 2745, PL 94-579-October 21, 1976). Subsection 1701 (a)(2) of this Act specifies that, "The national interest will be best realized if the public lands and their resources are periodically and systematically inventoried and their present and future is protected through a land use planning process coordinated with other federal agencies and state planning efforts." Completion of such a resource inventory includes paleontological resources consistent with the Act's intent. Resource inventories can be included as part of NEPA or other federal laws and regulations.

Subsection 1701 (a)(8) specifies that, "The public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archaeological values." Identification, management, and protection of these resources in compliance with this subsection could be accomplished either through other federal laws and regulations or undertaken in compliance with this Act alone.

The Federal Land Policy Management Act, Subchapter VI, Designated Management Areas, designates the California Desert Conservation Area (CDCA) (43 USC 1781, Dec. 1980), that includes some defense installations. Subsection 1781 (h) states, "The Secretary of Agriculture and Secretary of Defense shall manage lands in or adjacent to the California Desert Conservation Area, in accordance with the laws relating to such lands and wherever practicable, in a manner consonant with the purpose of this section. The Secretary of Agriculture and Secretary of Defense are authorized and directed to consult among themselves and take cooperative actions to carry out the provisions of this subsection, including a program of law enforcement in accordance with applicable authorities to protect archaeological and other values of the California Desert Conservation Area and adjacent lands." The California Desert Conservation Area Plan (CDCAP) (as amended) identifies paleontological resources within the planning Area. This regulation requires future long-range land use modification plans to be compatible with Areas of Critical Environmental Concern (ACEC) and other land use policies designated in the CDCAP. This Plan was revised in 1990 and will continue to be updated periodically by the BLM.

National and International Monuments and Memorials Act

Paleontological resources, if determined to be of significant scientific interest, can be preserved under this Act. Seven national monuments have been designated under this Act due to their paleontological significance. Protection of paleontological resources under the *National and International Monuments and Memorials Act* (16 USCA 431) is granted to the President of the United States, and managed by the NPS. At his discretion, he is authorized to declare, by public proclamation, historic landmarks, historic, prehistoric structures, and other objects of historic scientific interest situated upon lands owned or controlled by the U.S.

If during the process of identifying paleontological resources on defense installations or other federal land holdings it is determined that such resources represent a significant scientific record, the National and International Monuments and Memorials Act would provide one potential option for their preservation.

Archaeological and Historic Preservation Act of 1974

The intent of this Act is to make authorized federal construction programs and all projects licensed or assisted by federal agencies responsive to the damage they will cause to scientific, prehistoric, historic, and archaeological resources. The *Archaeological and Historic Preservation Act of 1974* (40 CFR 18117) amends the Reservoir Salvage Act of 1960 (74 Stat. 200) and further implements the policies and purposes of the Historic Sites Act of 1935 (49 Stat. 666). This Act provides a mechanism and funding authority that salvages resources. Paleontological remains are considered a scientific resource. In the event that any remains are identified on defense installations as a result of federal law or regulation implementation, this Act provides the mechanism and funding source for its salvage. However, the Act indicates that resource salvage is less-than-preferable-to preservation "in situ." *After paleontological resources are identified, federal agencies should give full consideration to courses of action that do not necessitate salvage.*

The Archaeological and Historic Preservation Act was not designed to relieve any federal agency of their responsibilities under NEPA. This Act designates the Secretary of Interior as having the key role of coordinator and oversight of BLM activities authorized by this Act.

California Environmental Quality Act (CEQA), State CEQA Guidelines

The intent of CEQA is to provide decision makers and the public with sufficient information regarding a project's potential impact on environmental resources to determine possible ways to reduce or avoid potential environmental damage. *CEQA* (California Public Resources Code Section 21000 et seq.) and the *State Guidelines for Implementation of CEQA* (14 CCR Section 15000 et seq.) are similar in intent and purpose to NEPA.

However, the two Acts address their environmental analysis using different methodologies and structure. Paleontological resources are included in a CEQA environmental assessment (i.e., Environmental Impact Report, Initial Study/Environmental Evaluation) for a proposed project. CEQA is not applicable to activities conducted on federal installations unless jurisdiction of federal activities require state regulatory approval. If lands owned within California by either BLM or DoD are conveyed to the state or other local jurisdictions, they will be subject to CEQA requirements.

Federal Antiquities Act of 1906

The Federal Antiquities Act establishes penalties for disturbance of any object of antiquity on federal land without a permit issued by a certified authority.

APPENDIX B:
Primary Acquisition: Collecting, Documentation, and Fossil Preparation

APPENDIX B. PRIMARY ACQUISITION: COLLECTING, DOCUMENTATION, AND FOSSIL PREPARATION

THE PRINCIPLES OF COLLECTING

The prime consideration must be that collecting is done in such a way as to maintain or further the best interests of paleontology. This does not mean that individual specimens or suites of material that are collected must in themselves show great scientific interest - other criteria may apply. Collecting should be done with a clear purpose in mind, whether by institution or private collectors. However, it must be recognized that chance will always play a major role in determining what is found and what is collected.

Collecting, at its best, is the prime form of geological specimen conservation, and at its worst a prime threat to other forms of geological site conservation. These conflicts of interest need to be reconciled. Collecting represents a serious, but necessary violation of the intimate relationship between the potential specimen and the natural situation/association in which it is found. To mitigate the consequences of this violation the curator should collect specimens with exhaustive field records to ensure the optimum potential scientific use of the material.

Scientific Evaluation

It is clear that in the field, and in the laboratory, there must be evaluation of paleontological specimens. It is recognized that such evaluations will be subjective to a greater or lesser extent. The criteria of value given below are those that the collector should consider while in the field.

Value based on the function of the specimen

Is it a...

- specimen with specific research potential, such as a possible new species or variety, a rare species, or species with other research potential?
- species from a particular location, horizon or geological situation of special interest?
- specimen showing exceptional preservation, features, or association of features?
- specimen filling a gap in the collections, for reference purposes?
- specimen that may be used for education or display?

Value of the specimen by association

For example is it part of a suite specimens-

- from a particular locality, horizon, palaeoecological situation, association, etc?
- from a borehole, or temporary section?
- from or associated with the collections of an important worker?

It must be remembered that the value of the specimen as defined here is directly proportional to the precision and completeness of the associated field data.

FUNDAMENTAL PRINCIPLES OF PRIMARY ACQUISITION

Good collecting practice in the field consists of the three R's: (i) restraint, (ii) wrapping and labeling, and (iii) recording.

Restraint

Before setting hammer to rock the following points should be considered:

- Assess and evaluate the purpose of the collecting; is it necessary?
- If you are collecting for a special purpose, do you know the collecting techniques that are required?
- Will the material be used and can you assume proper accessibility of the material in the future?
- Assess and evaluate the collecting site; will it yield the specimens appropriate for the purpose you have in mind?
- Respect vulnerable sites. Respect sites where special collecting restrictions exist.
- How many specimens are required? Can you reconcile your requirements with the abundance of the specimens?
- Will loose *ex-situ* material do?
- Avoid trying to collect the uncollectible.
- Avoid, particularly in the case of fossils, trying to 'develop' the specimen in the field.
- Seek expert advice where a particular specimen is beyond your collecting skills.

All specimens and parts of specimens need to be individually wrapped and packaged to prevent bruising and breakage. This should be done at the collecting site. Linen bags are good but expensive. Newspapers offer a suitable alternative. Self-sealing plastic bags, while suitable in the field, may pose problems for the long term stability in storage of certain types of material. Use cellulose wadding, for delicate specimens, or, less satisfactorily, domestic soft tissue. Never use cotton wool (removal of loose fibers may damage the specimens and the decay of cotton under conditions of high relative humidity (rh) and temperature may produce organic acids which attack calcareous specimens). Delicate specimens should be individually wrapped and packed firmly into protective containers, such as card or plastic boxes. Large specimens may require wood or metal boxes or crates and are likely to require special handling techniques

Record

At the time of collecting, each specimen or group of specimens should be clearly and indelibly labelled with a unique field reference number. Preferably, the number should be on the specimen either directly using indelible waterproof ink, or on a piece of sticking plaster. Use of metal, plastic or synthetic paper tags for field labels will reduce the chances of loss of data. Beware of damaging the specimen itself or of obscuring important details. It may be preferable to number the wrapping. Any field numbering system should be well considered so that it can be understood by others, avoiding unnecessarily complex coding. Research programs may require other procedures for numbering that may vary depending on the purpose. It may, for instance, be useful if the field reference number itself contains certain information, such as an indication of the collector, and the date of collection. The following is a will-tried format:

ABC.1994>XY.12

(where ABC=initial of collector, 1994=year, XY=code letters for locality or region,

12=serial number unique within locality or region category).
For many purposes it is useful if the specimen is clearly marked to show its original orientation in a geological and topographical context when in situ. this includes way-up, younging direction, dip and strike.

The following information should be entered into your field notebook at the time of collecting

- Field reference number and convenient field identification/description of the specimen.
- Detailed and complete geological localization, including a clear indication of whether it was collected loose or in situ, etc. Thus, for example, a specimen may referred to a specified part of a numbered bed in a measured section, aim to achieve millimeter scale precision. In addition, it is often useful to indicate the location of collected specimens on sketches.
- Detailed and complete geographical localization expressed clearly and unambiguously including, if possible, district or county. Remember also be supplemented by annotated field sketches or photographs, especially important when collecting vertebrate remains.
- Any other pertinent data, such as orientation, associations with other specimens, cross-cutting relationships, etc.
- If the field reference number does not include the data, this must be recorded, as should the names of any other collectors. documentation must be as complete as possible to allow for other unforeseen uses of the material.

COLLECTING HINTS

General Paleontology

- Delicate fossils may require the use of consolidants in the field.
- Fossils require precise detail of geological horizon.
- Orientation, articulation/disarticulation, associations, etc. are all relevant information to be recorded.
- Collect part and counterpart of specimens-particularly for small vertebrates, plants and invertebrate material. Wrap part and counter-part separately, but in association.

Large Vertebrates

- Often require very specialized techniques; get advice.
- Extraction, preparation, and conservation of large vertebrates is very expensive.
- Always record the exact geological horizon.
- Record the orientation and disposition of the remains as a whole and of the individual parts.
- Record in detail the interrelationships of individual bones; this can sometimes be done on a transparent overlay.
- Number everything.
- Record everything, including details of preservation and paleoecology.
- Collect associated macroinvertebrates, plants, and samples for micro-fossil analysis.

Micropaleontology

- Record exact horizon of each sample.
- Sample only a narrow stratigraphic thickness of sediment-never more than 15 cm-preferably much less. A quantity of 1Kg is usually sufficient.
- Avoid contamination during collecting. Clear away all surface material from the part of the rock face to be sampled. Collect preferably coherent blocks of 'fresh' rock.

- Normally avoid decalcified of over-weathered material. Use suitable strong clean bags to avoid post-collecting contamination.

THE PRINCIPLES OF DOCUMENTATION

Proper documentation ensures that a curator can quickly discover the complete history of a specimen, its identity and its whereabouts. In practice, these concepts can be embodied in a list of 'musts'.

- It must be possible to locate every specimen.
- Any information about each specimen must be recorded and its accurate retrieval ensured.
- Every specimen must be uniquely identifiable by means of a permanently attached number.
- Every specimen must be identified and classified to degrees appropriate to circumstances.
- Every significant event affecting a specimen must be recorded.

All aspects of geological curation relate to these five points, which should form the basis for solutions to the diverse problems commonly encountered. In order to produce a set of guidelines from this list that will be useful to the working curator, it is necessary to classify in some way the complex inter-relationships of curator and specimen. An analysis of the documentary activities surrounding any specimen will show a frightening number of permutations of information flow. In order to aid practicality, five stages of documentary activity are identified in the Part:

- material entering a repository both temporarily and permanently: Entry Documentation
- material being processed into the repository's "permanent" collections by transferring ownership: Acquisition Documentation
- curating individual specimens: Cataloging
- material being moved within the repository
- material leaving the repository both temporarily and permanently

Marking and Labelling

MARKING is used to describe the process of recording information on a specimen itself either directly by pen, brush or tool, or indirectly by a tag or other device "permanently" attached by an appropriate glue.

The term LABEL is used to describe any unattached document which carries information about a specimen and which is designed to be maintained in intimate, and when required, permanent association with the material to which it relates.

Specimen marks and labels serve joint purposes. They provide immediate access to important information about a specimen, or the key by which further information may be obtained.

Primary Documentation: Field Labels and Marks

Field recording necessitates simple, speedy, but none-the-less effective methods of linking specimens to their data. These requirements are best served by the use of self-adhesive tags, 'Elastoplast', or similar material, capable of receiving written numbers or codes and which will withstand field conditions. Some geological materials will accept writing direct from a pen; a waterproof felt or fibre tip marker is easiest to use.

Cataloguing: Specimen Marks and Label7s

Probably the first job of a curator engaged in specimen cataloguing is to give each specimen a unique number. In all practical circumstances it is recommended that this number be marked on the specimen. Some principles to be observed are:

- take care not to obscure or destroy significant features of the specimen;
- apply numbers with sympathy for the aesthetic appeal of specimens, yet in readily accessible positions;
- beware of ambiguous numbers, e.g. 10691 is 16901 upside down: underline to indicate correct interpretation;
- the size of the number and figures should be commensurate with the size of the specimen.

Other marks may be necessary. In particular, type, figured and cited specimens should be marked with colored spots. A recommended convention is that all type and figured specimens should be marked in green, referred and cited specimens in red, and that primary types, in addition, should have yellow Specimen Labels.

A Specimen Label provides the opportunity to present this information in summary form and for immediate use.

The Specimen Label should allow for the recording of the following information:

- specimen identification (at any level)
- stratigraphical information
- geographical information
- collector/acquisition information
- storage location
- Specimen Identity Number
- status (type,figured or cited material)
- name of cataloguer/recorder/identifier, etc. as appropriate, and date
- name institution.

These minimum requirements may, of course, be exceeded if necessary or according to practice. It is, however, necessary to avoid the accomplishments of the miniaturist who endeavors to squeeze the maximum information into the smallest space. Such a practice is not one generally appreciated by users. It is good practice to record a lack of specific information in one of the foregoing categories, e.g. non-loc, non-det.

Marking the Specimen

Direct engraving: marks on specimens may be using a pneumatic or an electric engraver.

Inscription: direct, materials of a pale color will accept writing direct from a pen, a waterproof permanent ink such as India ink being best.

Inscription: on a painted ground. Often the most satisfactory results of inscription rely upon applying a daub of fast drying white paint or a spirit-based correcting medium to the specimen. The number is then written on this white ground in black india ink or other permanent waterproof medium.

Affixing a paper 'tag' the required mark, is written on a small rectangle or disc of acid-free paper in waterproof drawing ink.

Specimen Labels

The nature of labels varies greatly, particularly in terms of the range of methods and techniques used over the last two centuries. Perhaps the only general rule that should normally apply to modern labels is that they be made from acid-free rag-based paper or card and written in a permanent medium.

Loose labels. The convenience and simplicity of writing out a label and placing it with a specimen in its container explains the widespread use of the system.

Other methods include: folded or pinned labels, labels fixed to mounting boards, machine-produced labels, self-adhesive labels.

FOSSILS PREPARATION TECHNIQUES

Field methods. The conservation of fossils should start during their excavation. Damage caused by poor procedures or materials may be difficult to rectify during latter laboratory processing. It is most important to use reversible treatments for the consolidation of wet or loose sediments and specimens in the field. The excavation of unstable fossil material presents special problems, (e.g. sub-fossil tusks, teeth, lignitic material, pyritic specimens, etc). To prevent warping, splitting, etc., of hygroscopic material it is essential to prevent drying out during storage of cocoons etc. and again early processing amy prevent deterioration. A variety of techniques are recommended for field work conservation.

Mechanical methods. The mechanical preparation of fossils essentially involves the physical removal of matrix attached to or enclosing them, in order to expose the specimen. Very rarely it may be necessary to remove some portion or even all of an original specimen to expose hidden features (e.g. brain casts). The prime requirement is to enhance the information value of the specimen with a minimum of risk or damage to the fossil. As little work as possible should be carried out since preparation invariably causes the specimen to become more fragile, less easy to handle and difficult to store safely. Experience becomes the guiding principle in deciding the type and extent of preparation that is acceptable for a particular specimen and matrix. In practice there should be consultation between preparators and researchers or curators at all stages. Mechanical methods include the use of hammer and chisel, pneumatic or electric engraver, abrasive wheel, diamond saw, etc. for the rough reduction of matrix; for finer work, where matrix and specimen separate easily, fine pneumatic or electric, percussive or rotary tools with diamond burrs, air-abrasive equipment and ultrasonic probes may be employed: the finest work on fragile and delicate material may be carried out using powered delicate diamond burrs, brushes, fine pins and animal bristles. All these methods require much time for preparators to develop the necessary skills and manual dexterity. These techniques misused or misapplied can be disastrous!

Chemical methods. Chemical preparation relies on the differential action of a reagent, or mixture of reagents, upon the matrix and the specimen. In general the objective is to dissolve away or soften the matrix from the fossil without risk to the specimen. In very rare instances where, for example, rotted bone is enclosed in a particularly intractable matrix, a reagent is selected which will dissolve away the specimen cleanly from the matrix leaving the option of taking a cast from the external mould so formed. The use of chemicals is less labour intensive and more subtle than mechanical preparation and is usually more complete in terms of the extent of specimen exposure. However most of the reagents in use now act by being corrosive (acid or alkaline) and thus present problems of storage and safe handling or application by the user. In addition, steps are necessary to provide support and protection for the progressively more fragile specimen whilst it is undergoing preparation. A suitable plastic may be used. The reactive reagent must be neutralized and removed meticulously form the specimen otherwise conservation problems will be used. Last but not least, acid-prepared material is always fragile and may specimens require permanent support; whilst in storage, all large specimens require some form of cushioning using a suitable plastic foam (never cotton-wool, such as cut pieces of polyethylene foam or expanded polystyrene. Polyester and polyurethane may not beusable over the long term and tend to stick to the surfaces with which they are in contact, so impermeable separator membranes must be used. A fire inhibitor must always be added during the production of polyurethane, and note that in fires toxic fumes are given off.

Adhesives. the adhesives, consolidants and supports used during preparation should all be necessary, also in the long term. Many commonly used natural and synthetic resins become unstable or are liable to become intractable after even a few years exposure to the atmosphere. In particular the use of shellac, animal glues, cellulose nitrate, epoxy resins, and polyesters, and products containing them, should be avoided. Cyano-acrylates ('Superglue'), although in common use, require careful application, and their aging characteristics are poorly known. It is always advisable to consult the manufacturer or supplier about the durability of their products before using them on irreplaceable specimens. the use of new material should always be checked by the reference to current conservation literature.

Specimen support. Specimens undergoing mechanical preparation are exposed to per sive shock and vibration during development and therefore time and effor uld be expanded in providing adequate support and protection. Temporary supporting media (e.g. water-soluble wax, thermo-plastics with a low temperature melting point, sand bagging and embedding techniques, etc.) can be used but the selection of the most appropriate is dependent upon the characteristics of the specimen and this must rely upon the judgement of an experienced preparator.

Conclusion. Even the more basic preparation, chemical or mechanical, requires both specialist knowledge and considerably time if it is to be carried out effectively. Of paramount importance during preparation is the maintenance of records of the processes and materials involved; these together with drawings, photographs and notes or observations should be properly filed and not stored with the specimen concerned. While in the laboratory, specimens not being actively worked upon should be kept in a location that is both secure and meets the environmental requirements of the material or returned to the main collection or exhibition.

APPENDIX C:
Example Survey Report

(EXAMPLE OF
PRELIMINARY SURVEY REPORT)

Task Directive # S2R0602
Document # A0011-037-01

An Employee-Owned Company

Paleontology Technical Report
(Survey)

Paleontology Legacy Project

Task Directive # S2R0602

Contract Number F04611-89-C-0019

U.S. Air Force Flight Test Center

CDRL A0011
Document # A0011-037-01

DISTRIBUTION NOTICE

FURTHER DISSEMINATION IS ONLY AS DIRECTED BY THE AFFTC TASK MANAGER LISTED BELOW AS OF THE PUBLISHING DATE OF THIS DOCUMENT OR HIGHER DoD AUTHORITY. ALL FINANCIAL DATA CONTAINED HEREIN AND ANY TECHNICAL DATA OR COMPUTER SOFTWARE MARKED WITH THE LEGENDS PRESCRIBED BY DFARS 52.227-7013, SHALL NOT, WITHOUT THE WRITTEN PERMISSION OF SAIC, BE RELEASED OR DISCLOSED OUTSIDE THE GOVERNMENT.

DESTRUCTION NOTICE

FOR UNCLASSIFIED, LIMITED DOCUMENTS, DESTROY BY ANY METHOD THAT WILL PREVENT DISCLOSURE OF CONTENTS OR RECONSTRUCTION OF THE DOCUMENT.

Submitted:________________________

AFFTC Task Manager: Mr. Richard Norwood
Phone: (805) 277-1447

SE/TA Task Manager: Mr. John Delaney
Phone: (805) 277-3162

Draft
09 September 1993

Table of Contents

List of Figures

List of Tables

1.0 Introduction

Science Applications International Corporation (SAIC), is developing a model paleontological management program for Edwards Air Force Base (EAFB). This program is an attempt to better identify and integrate the conservation of non-renewable paleontological resources with respect to Federal and state laws, guidelines and policies. This report is a summary of the field survey activities conducted at EAFB from 07 June to 11 June 1993, and includes a review of site records and relevant literature, the identification of sedimentary deposition units within the EAFB boundaries, and the location, identification, retrieval, preservation and documentation of paleontological resources.

This report summarizes the prominent Cenozoic stratigraphy near EAFB, presents and reports the preliminary results of the field investigation.

2.0 Cenozoic Stratigraphy Near Edwards Air Force Base

2.1 Tertiary Formations

Tertiary rocks in the Mojave Desert, CA are mostly non-marine conglomerates, sandstones, shales, as well as volcanic sills, flows, breccial masses, and pyroclastic materials of basaltic and andesitic composition (Dibblee 1967). These rocks are well-indurated and deformed by folding and faulting. Tertiary rocks in the Rosamond Hills, CA, north and northwest of Rosamond, CA, were originally described and referred to as the Rosamond Series (Hersey 1902). However, because the indiscriminate use of the name Rosamond for so many incongruous Tertiary strata in the Mojave Desert, CA, the U.S. Geological Survey does not recognize the application of this name to a stratigraphic unit (Wilmarth 1938 as cited in Dibblee 1958). Dibblee (1958) named the Tertiary rocks in the Rosamond Hills, CA, the Kramer Borate area, and the Kramer Hills as part of the Tropico Group, which is differentiated locally into several formations as shown on Table 1. Some Pliocene sedimentary conglomerates, sandstones, shales and volcanics occur near the margins of the Mojave Desert. A 50 foot thick diatomaceous limestone, of limited extent, outcrops approximately 2 miles west of Castle Buttes and 6 miles north of EAFB, is indicative of a Pliocene deposition (Dibblee 1967).

Only the Kramer Beds and the Bissell Formation of the Tropico Group are reported to contain fossils. At one time, the Kramer Beds were erroneously presumed to be part of the Pliocene Ricardo Formation by Gale (1946). The Arkose Member of the Kramer Beds contains a fauna locally know as the "Boron Fauna" which was discovered in the open pit Boron Mine a few miles north of EAFB. These fossils are of Early Hemmingfordian land mammal age (early Miocene) (Dibblee 1967; Wistler 1984; Reynolds 1988). "Boron Fauna" type fossils have not been found outcropping on EAFB. Some silicified reeds, palms(?), and other plants were found in a chert layer of the upper part of the Tropico Group, near the eastern boundary of EAFB and approximately 5 miles southeast of Kramer Junction (Dibblee 1967). The Saddleback Basalt, which locally forms the underlying middle part of the Tropico Group, has given K-Ar dates ranging from 18.3 to 20.3 million years ago (m.y.a.) (Wistler 1984). Dibblee (1960 and 1967) considers the Bissell Formation unfossiliferous. However, Reynolds (1988) reports that fossil fish skeletal elements have been found in a magnesite layer in the Bissell Formation, north of Bissell and near the western boundary of EAFB.

Table 1 - Nomenclature of Tertiary Units Near Edwards Air Force Base

		Hershey (1902) Simson (1934)	Gale (1946)	Dibblee (1958, 1967)						Barnard and Kistler (1966) Wislter (1984)		
		Rosamond Hills	Krammer Hills	Rosamond Hills		Bissel Hills		Krammer Hills		Krammer Hills		
Tertiary	Pliocene	Rosamond Series	Ricardo Fm									
	Miocene	(No Local Subdivisions)	Saddleback Basalt Rosamond Fm of Simson	Tropico Group	Fiss Fanglomerate Gem Hill Fm and Bobtail Quarts Latite Member	Tropico Group	Bissell Fm Gem Hill Fm and Bobtail Quarts Latite Member	Tropico Group	Unnamed Upper Part Saddleback Basalt Unnamed Lower Part	Tropico Group	Krammer Beds	Arkose Member Shale Member Saddleback Basalt Unnamed Lower Part

2.2 Quaternary Formations

Quaternary-aged sedimentary units near EAFB consist primarily of alluvial fan sediments which are derived from the Transverse Ranges and Tehachapi Mountains and deposited in the closed Antelope, Mojave, and Kramer Basins of the Western Mojave Desert. Prior to the uplift of the San Gabriel Mountains, approximately 1 to 2 m.y.a. streams generally flowed from east to west through the Mojave Desert region and ultimately emptied into the Pacific Ocean. As a result of the uplift of the San Gabriel "Arch" and active faulting in the Mojave Desert, locally over 5500 feet of alluvial sediments may have been deposited near EAFB during the Quaternary (Dibblee 1967; Ponti 1985).

Dibblee (1960) mapped 3 alluvial units of apparently different ages in the Western Mojave Desert region (Table 2). Ponti and others (1980, 1981) mapped and further subdivided the unconsolidated upper Quaternary sediments in the Eastern Antelope Valley, south of EAFB. Six major late Quaternary alluvial units were recognized including upper, middle and lower members of the Tylerhorse and Palmdale Formations (Q1 through Q6), which are correlatable throughout the region and are similar to upper Pleistocene Riverbank and Modesto Formations in the Eastern San Joaquin Valley, CA. The correlation of these sediments from the 2 different regions suggests that the deposition of these sediments is climatically controlled where major local and perhaps regional alleviation reflect transitions from glacial to interglacial periods (Ponti 1985). In addition, 5 other Quaternary alluvial units are locally present and include: Post-Palmdale I alluvial and playa sediments (Q7), Post-Palmdale II stream channel deposits (Qs), alluvial deposits rich in calcium carbonate (Quca), lacustrine deposits (Qpl), and Holocene dune sands (Qds). The correlations of the Tylerhorse, Palmdale, and Post-Palmdale with interpluvial alleviation periods (or even numbered marine oxygen isotope stages) and sediments from San Joaquin Valley and Searles Lake are summarized in Figure 1.

2.2.1 Harold Crowder Phelon Formations

Dibblee's oldest Quaternary alluvial unit (Qof) has been mapped in the eastern portion of EAFB. It is a widespread, poorly to moderately indurated fanglomerate consisting of angular to rounded pebbles, cobbles, and boulders in a sandy matrix (Dibblee 1960, 1967). Locally, approximately 200 feet of this fanglomerate rests on quartz monzonite. An "older" alluvial unit (Qoa) locally lies unconformably over the fanglomerate.

Table 2 - Nomenclature of Quarternary Units Near Edwards Air Force Base

	Nobel (1953, 1954)	Dibblee (1960, 1967)	Weldon (1984)		Ponti and Others (1980, 1981, 1985)	
Holocene	Victorville Fan	Western Mojave Desert	Victorville Fan, age given is for northwest (youngest)		Antelope Valley	
	"Young Alluvium"	Qa/Qs		"very young units"	Qs/Qsd	
		Qc			Q7/Quca	
Pleistocene	"Old Alluvium"	Qa/Qpl	pinches out (NA)	Noble's Old alluvium	Q6/Qpl	Palmdale Formation
	Shoemaker/Nadeu Gravels	Qoa	<0.6 m.y.	Whoemaker/ Nadeu Gravels	Q5	
	Harold Fm	Qof/Qoa	<1.0 m.y.	Harold Fm	Q4	
	Crowder Fm	Crowder and other Fms	1.5-4.1 .m.y.	Phelan Fm (new name)	Q3	Tylenhorse Formation
					Q2	
					Q1	
					QTcs (undivided)	

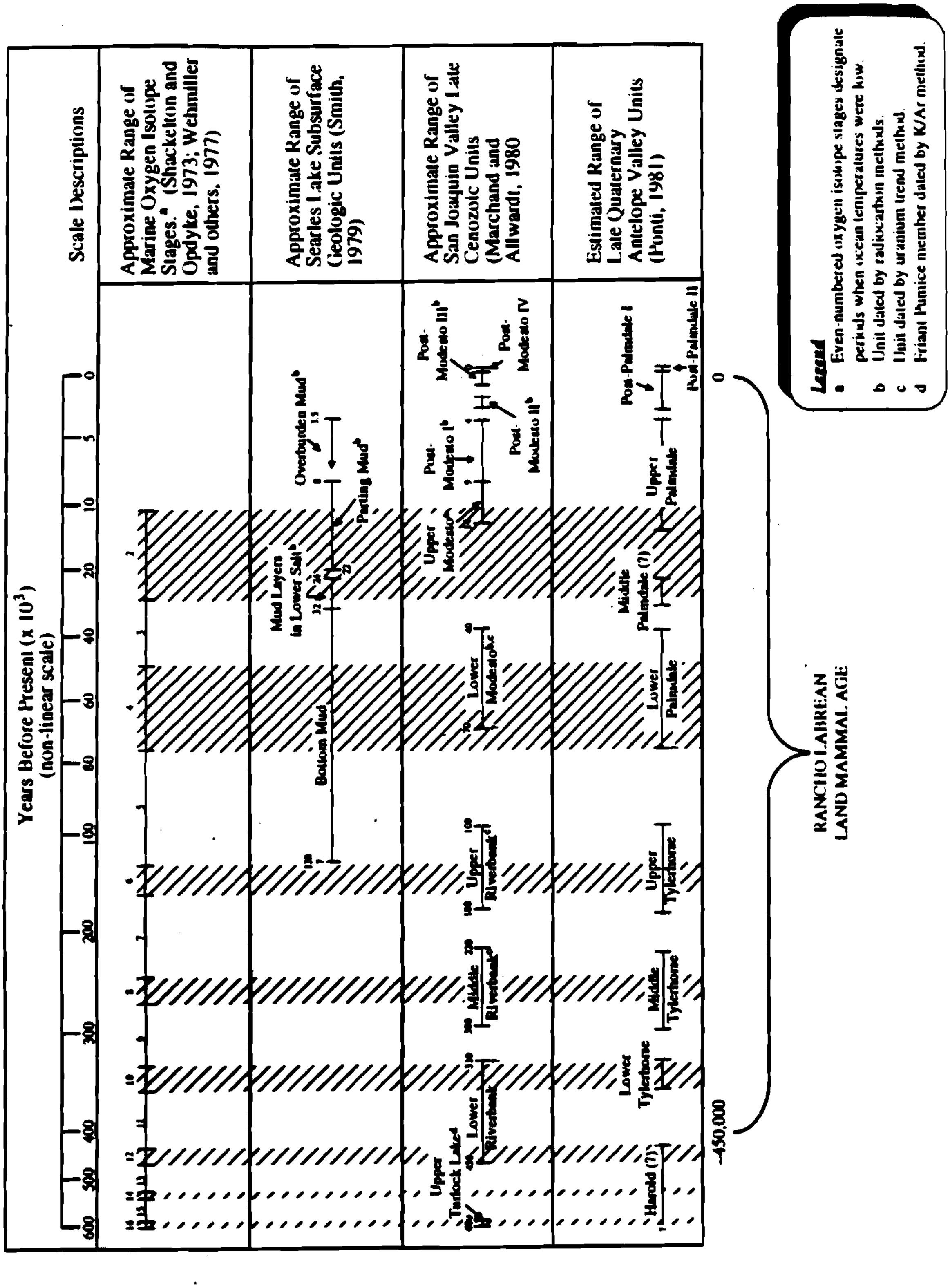


Figure 1 - Tylerhorse, Palmdale and Post-Palmdale Interpluvial Alleviation Periods and Sediments from San Joaquin Valley and Searles Lake Correlations

Approximately 40 miles south-southeast of EAFB, upper Quaternary sediments unconformably overlie the middle Pleistocene Harold Formation near the mouth of the Victorville, CA fan. The Harold Formation and at least some part of the Phelan Formation mark the beginning of sedimentation from the San Gabriel Mountains. These sediments form the base of the Victorville Fan (Woodburne, 1975; Weldon, 1984). Based on paleomagnetic stratigraphy, the bottoms of the Harold and Tylerhorse Formations appear to range in age from 1.0 to 1.5 m.y.a. and from 0.6 to 1.1 m.y.a. respectively. Younger ages are found to the northwest because of movement of the sediment source along the San Andreas Fault Zone (Weldon 1984). A vertebrate fossil assemblage from the Harold Formation near Palmdale is approximately 0.7 to 1.2 m.y.a. and provides a maximum age for the overlying Tylerhorse sediments (cited from Repenning [1982] in Ponti 1985). Dibblee (1967) mapped both the Harold and Tylerhorse Formations as Qoa. Dibblee's Qoa outcrops near the valley margins and bedrock topographic highs, is locally dissected by younger alluvium, and thickens up to several hundred feet towards valley centers.

2.2.2 Tylerhorse Formation

The Shoemaker and Nadeau Gravels of Noble (1953, 1954), which are probably coeval, and much of the "older" Qoa mapped by Dibblee (1967) are included in the Tylerhorse formation and are observed to unconformably overlie the Harold Formation (Ponti, 1985). Soils on the Tylerhorse deposits are well-developed and are typically reddish brown. Lower Tylerhorse deposits (Q1) are exposed near the mountain fronts along the southern margin of Antelope Valley, are generally uplifted and dissected, contain little original surface morphology and do not appear to be related to modern drainages. The lower member ranges in thickness from several to more than 200 feet. The middle Tylerhorse member (Q2) outcrops somewhat further away from the mountain front, but is still restricted to the foothills. The paleosurface of the Q2 is better preserved than Q1, but as much as 50 percent of the original surface may have eroded away. Q2 ranges in thickness from several to more than 90 feet and appears to thicken to the east. The upper Tylerhorse member (Q3) was deposited either in channels cut through Q1 and Q2 or as broad fans further out into the basin. Q3 deposits are moderately uplifted and dissected, have 10-30 percent of the original surfaces eroded away, and appear to conform with modern drainages. Q3 ranges in thickness from several to as much as 60 feet.

2.2.3 Palmdale Formation

The Palmdale Formation is primarily composed of weakly-developed, pale to dark brown soils, and has been previously mapped as young Qa and old

Qoa (Noble 1953, 1954; Dibblee, 1967). Palmdale deposits comprise the bulk of the Antelope Valley's low land and margin area. The deposits are slightly dissected, and form alluvial fans with slightly uplifted terraces which conform with modern drainages. The lower member (Q4) is slightly uplifted and tilted, and is commonly deeply entrenched but relatively continuous (only slightly dissected). The Q4 member exhibits well developed B profiles not found in the younger Palmdale members. The middle Palmdale (Q5) sediments are of limited extent and only recognized in areas where both the lower and upper Palmdale members are present. The upper Palmdale (Q6) member consists of unconsolidated deposits, forms low terraces along modern channels and covers most of the Eastern Antelope Valley floor. Q6 grades laterally into aprons of colluvium around low lying bedrock hills and interfingers with lacustrine sediments from Lake Thompson (Qpl).

2.2.4 Holocene Post-Palmdale Formations

The Palmdale Formation is unconformably overlain by Post-Palmdale I alluvial and playa sediments (Q7) and Post-Palmdale II stream channel sediments (Qs). Q7 sediment have very weakly developed soils and Qs sediments consist of unvegetated, poorly sorted flash-flood deposits.

Dibblee noted that undissected, undeformed latest Pleistocene to Recent alluvium fills the majority of the low-lying valley floors in the area (Dibblee 1967). The youngest alluvium was subdivided into 5 mapable facies: alluvial gravel and sand (Qa), playa clay (Qc), windblown sand (Qs), playa clay and windblown sand (Qcs), and bars of wave-deposited sand (Qsb) from Lake Thompson. These alluvial facies grade laterally into one another. In general, however, the coarser grained alluvial sands and gravels occur near the valley margins. Much of Dibblee's Qa correlates with Ponti's Q6, Q7, and Qs.

3.0 Field Survey

3.1 Methodology

A field survey was conducted during the week of June 07-11 1993 in an attempt to determine the nature and distribution of paleontologic localities within and adjacent to EAFB boundaries. SAIC, in conjunction with the San Bernardino County Museum, performed the survey in 3 pre-determined areas located in the Jack Rabbit Hill Quadrangle, Piute Ponds and Redman Quadrangle. The planned field work is summarized in the workplan. The areas were selected with respect to lithology, known and recorded distribution of paleontologic localities, and elevation relative to indications of late Pleistocene Lake Thompson. The survey was conducted by 3 SAIC scientists, including a Primary Paleontology Investigator, and were assisted by 2 experienced paleontologists from the San Bernardino County Museum. Traverses were conducted throughout these 3 areas in a systematic manner, when feasible, and were established in widths of 30 m. A total of 1,200 acres (1.9 square miles) were surveyed along these transects over a period of 5 days, and more than 40 paleontologic localities were located during the survey.

The primary resources recovered were isolated bone or tooth fragments of vertebrate mammals. When encountered, fossil specimens were removed from the surface, wrapped in tissue, placed in a zip lock bag and assigned a field number. The field number is composed of the date and finder's initials and was recorded directly onto topographic quadrangle maps with reference to prominent geophysical features. In each of the 3 areas, a matrix sample of approximately 3 cubic yards was collected to be screened for the presence of small rodent remains. Matrix samples were collected at areas of exposed Pleistocene paleosol or lakebed sediments. Elsewhere, no subsurface excavation was performed. The samples were returned to the San Bernardino County Museum laboratory where they will be inventoried, identified and eventually returned to EAFB for curation.

3.1.1 Transect 1 - Jack Rabbit Hill Quadrangle

Approximately 760 acres were surveyed during this transect, and 27 fossil-bearing locations were identified. Though earlier investigations in 1987-1988 indicated the presence of hominid remains, no recognizable hominid fossils were discovered in this transect. Site locations are indicated in Figure 2.

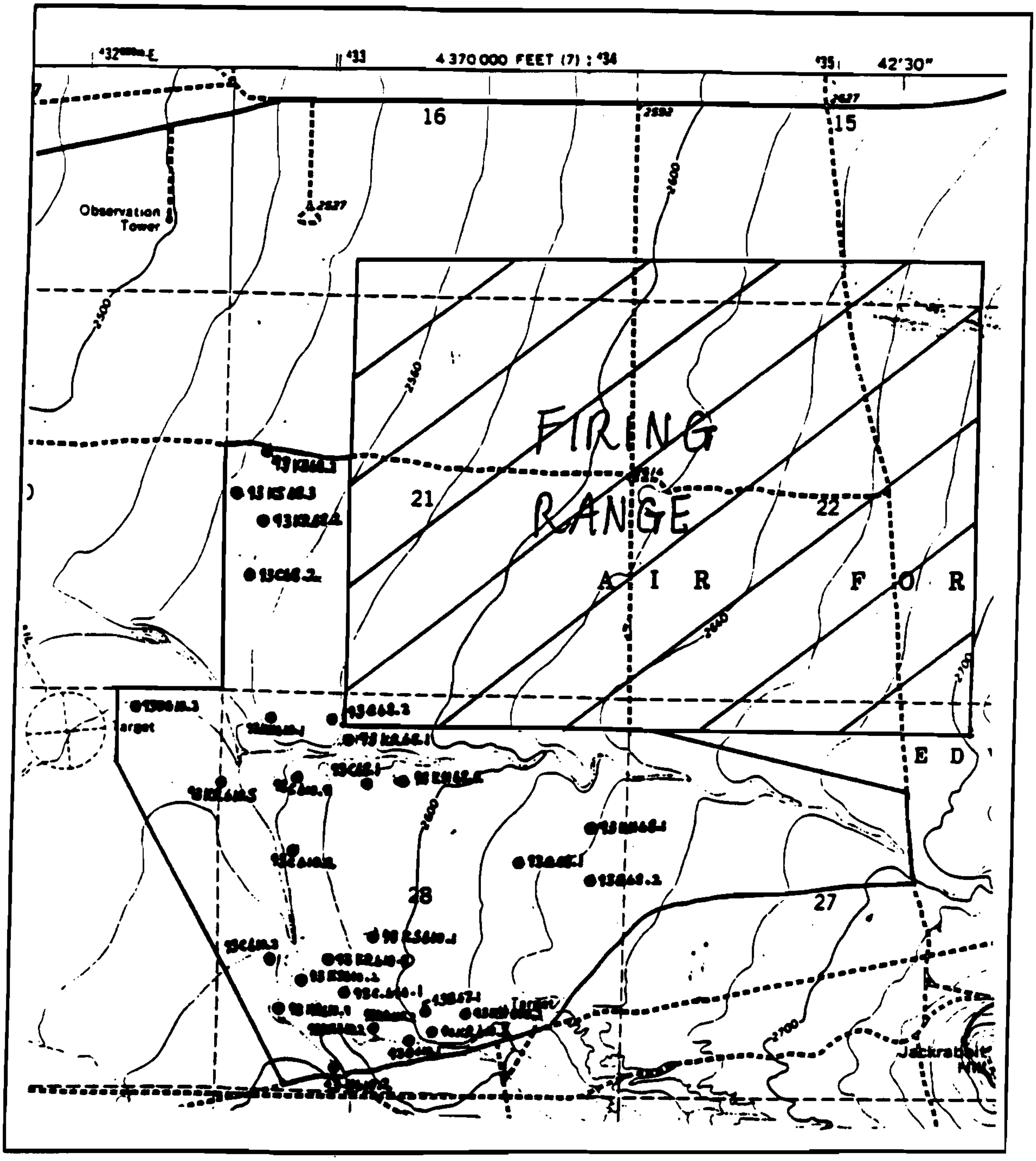


Figure 2 - Jack Rabbit Hill Quadrangle Site Locations

3.1.2 Transect 2 - Piute Ponds

Approximately 140 acres were surveyed during this transect and 7 fossil-bearing locations were identified. A fossil-rich exposure was discovered in this area, with many bone and tooth fragments, including microscopic rodent remains. A matrix sample was also collected and photo-documented. Fossils in this area were generally brown or black as if stained by manganese oxide, as opposed to the sun-bleached bone and tooth fragments found in the other 2 transects. Site locations are indicated in Figure 3.

3.1.3 Transect 3 - Redman Quadrangle

The west-southwestern portion of the proposed transect could not be accessed, as it lies within an active firing range of EAFB. As a result, the transect was redefined and expanded to the northeast within the Edwards Quadrangle to include paleontologic locations identified in the 1987-1988 surveys. Two matrix samples were collected; one in exposed lake sediments in a burrow pit in the southwest portion of the redefined transect, and one along the shore of a small ephemeral lake, south of a residential area (see Figure 4). A total of 8 sites were identified including the 2 matrix sites. A fragmented leg bone without terminal ends was discovered at the northeast portion of the transect. The fragment was cast in plaster and removed for further study. A total of 300 acres was covered in this transect. Site locations are indicated in Figure 4.

3.2 Deviations from Proposed Work Plan

- The original proposed Jack Rabbit transect outlined in the Workplan was modified upon reconnaissance of the site. Prospects for fossil collection appeared poor south of the east-west-trending West Range Road. In addition, a large cleared rectangular target area which did not appear on the topographic sheet (Jack Rabbit Hill) overlapped part of the original transect. The ensuing transect was modified to the west and north of the target area. Survey operations were also interrupted several times in the Jack Rabbit Quadrangle area, due to routine flight patterns including laser and ammunitions testing. The area identified by the San Bernardino County Museum personnel and the 1987-1988 fossil location map as the site of the Hominid location was reexamined. Unfortunately, no additional Hominid material was found.

- The original proposed Redman transect outlined in the Workplan was also altered to permit safe and proper fossil collection. The crew encountered warning signs indicating an active firing range in the west-southwest portion of the proposed transect. The firing range had not been indicated

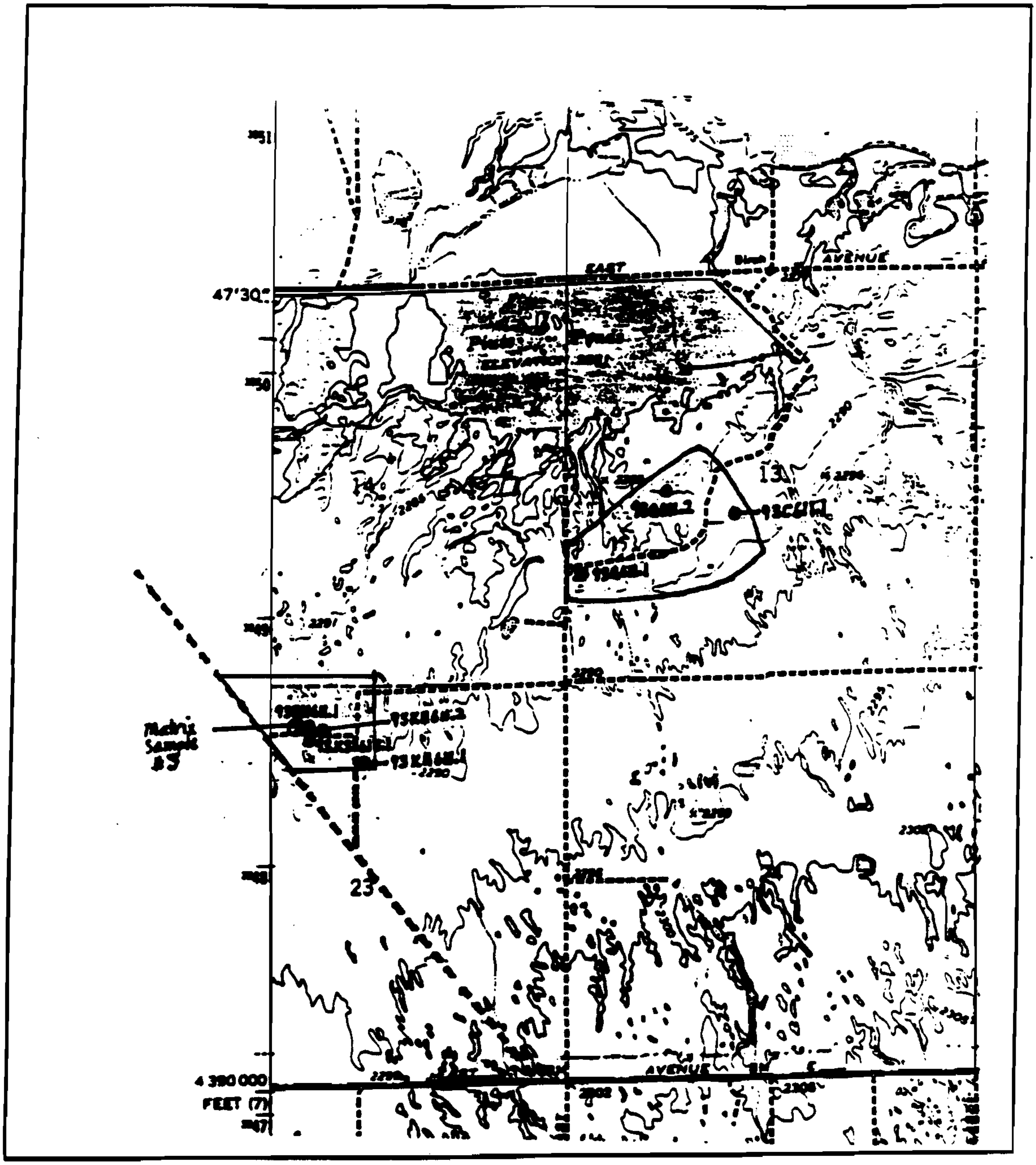


Figure 3 - Piute Ponds Site Locations

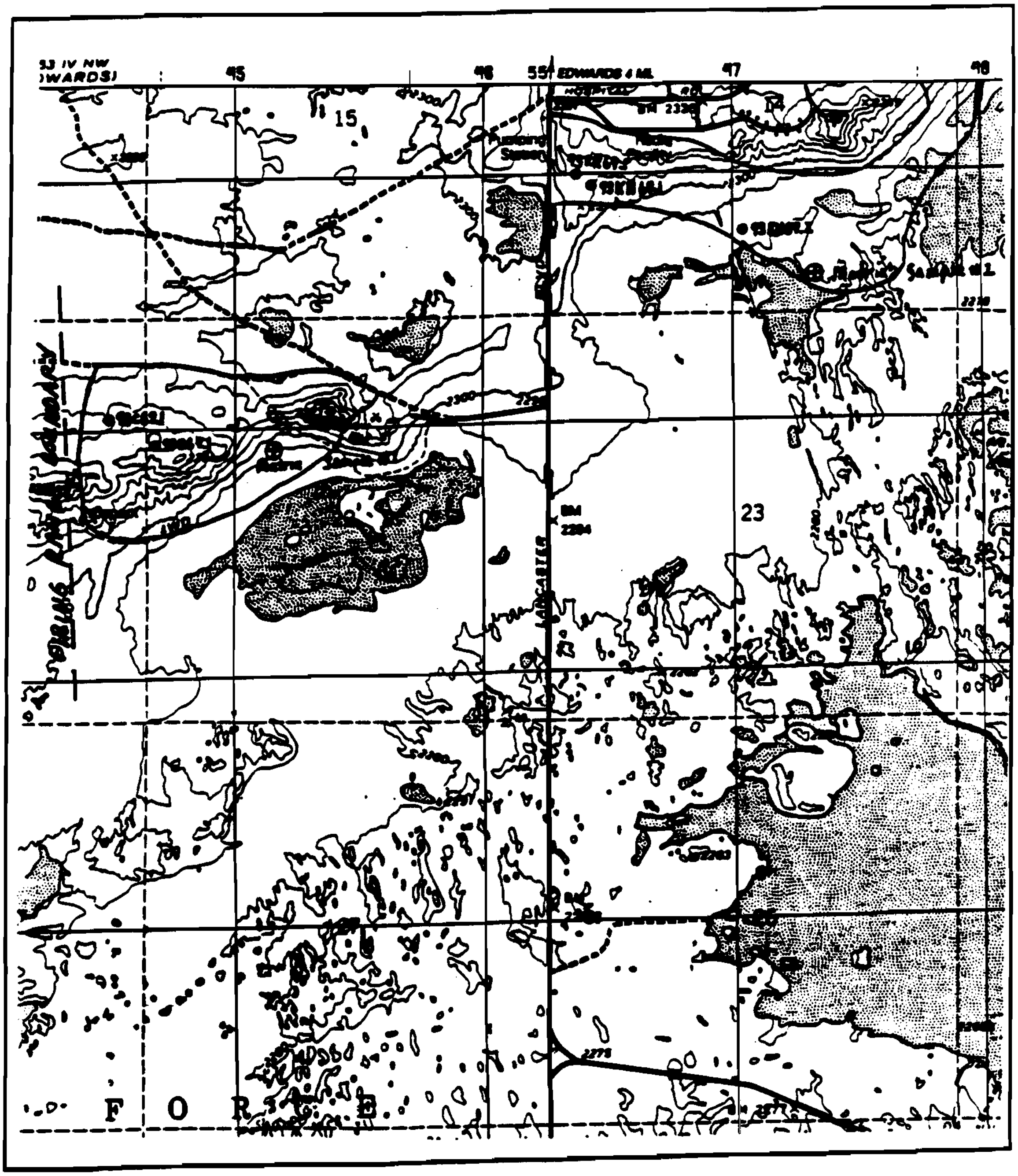


Figure 4 - Redman Quadrangle Site Locations

on any of the site maps. Thus, transect boundaries in the Redman Quadrangle had to be redrawn to exclude the firing range area and were subsequently expanded to the east-northeast to include potential localities identified in the 1987-1988 surveys.

4.0 Preliminary Results

Forty-two fossil localities were sampled, including 3 areas where a bulk matrix sample was collected. With the exception of 1 locality containing 1 long bone, all localities contained samples of fragmented bone or teeth. Preliminary field identification indicated the presence of Pleistocene camelid, bovid, and other large mammals. The bulk matrix samples were collected to asses and quantify the presence of small mammal remains since smaller mammals, such as rodents, occupy a shorter stratigraphic range and are beneficial in correlating units and identifying geologic time frame.

Further identification and processing of samples is being conducted at the San Bernardino County Museum. Matrix examples are being processed and all fossil material has been catalogued and curated.

5.0 References

Christenson, G.E. and Purcell, C., 1985. Correlation and age of Quaternary alluvial-fan sequences, Basin and Range province, southwestern United States, in Weide, D.L., ed., Soils and Quaternary geology of the southwestern United States. Geological Society of America Special Paper 203:115-122.

Ponti, D.J., 1980. Stratigraphy and engineering characteristics of upper Quaternary sediments in the eastern Antelope Valley and vicinity, California [MS thesis]. Stanford, Stanford University: 157p.

Ponti, D.J. and Burke, D.B., 1980. Map showing Quaternary geology of the eastern Antelope Valley and vicinity, California. U.S. Geological Survey Open-File Report 80-1064, scale 1:62, 500.

Ponti, D.J., Burke, D.B., and Hedel, C.W., 1981. Map showing Quaternary geology of the central Antelope Valley and vicinity, California. U.S. Geological Survey Open-File Report 81-737, scale 1:L62, 500.

Weldon, R.J., 1985. Implications of the age and distribution of the late Cenozoic stratigraphy in Cajon Pass, southern California, in Geologic investigations along Interstate 15, Cajon Pass to Manix Lake, R.E. Reynolds, ed. Redlands, San Bernardino County Museum: 59-68.

Whistler, D.P., 1984, An early Hemingfordian (early Miocene) fossil vertebrate fauna from Boron, western Mojave Desert, California. Los Angeles County Museum of Natural History, Contributions in Science 355. pp. 1-36. [Boron fauna description]

Woodburne, M.O., Miller, S.T., and Tedford, R.H., 1982. Stratigraphy and geochronology of Miocene strata in the central Mojave Desert, California. Geological Society of America, Cordilleran section Guidebook: 47-64.

Dibblee, T.W. Jr., 1958a. Tertiary stratigraphic units of western Mojave Desert, CA. American Association of Petroleum Geologists Bulletin 42(1):135-144.

Dibblee, T.W. Jr., 1960b. Geology of the Rogers Lake and Kramer quadrangles, California. U.S. Geological Survey Bulletin 1089-B: 139 p.

Dibblee, T.W. Jr., 1963. Geology of the Willow Springs and Rosamond quadrangles, California. US Geological Survey Bulletin 1089-C.

Dibblee, T.W. Jr., 1967. Areal geology of the western Mojave Desert, California. U.S. Geological Survey Professional Paper 522.

Dibblee, T.W. Jr., 1985. The Quaternary alluvial sequence of the Antelope Valley, California, in Soils and Quaternary geology of the southwestern United States, D.L. Weide, ed. Geological Society of America Special Paper 203: 79-96.

Dibblee, T.W. Jr., 1985a. Stratigraphy and geologic history of the Pleistocene Lake Manix Formation, central Mojave Desert, California, in Geological investigations along Interstate 15, Cajon Pass to Manix Lake, R.E. Reynolds, ed. Redlands, San Bernardino County Museum: 157-169.

APPENDIX D: Review Checklist

Science Applications International Corporation

TECHNICAL AND EDITORIAL QUALITY REVIEW CHECKLIST

Principal Investigator/Task Manager: ______________________

Date Deliverable Due: ______________________

Document Title: ______________________

Date on Document: ______________________

Document Type: *(Check one from each column)*

☐ Letter ☐ Report ☐ Final

☐ Work Plan ☐ 1st Draft

	(circle one)			(Comment No.)
PURPOSE/SCOPE				
• Is goal/objective clearly stated?	Yes	No	N/A	______
• Does the document comply with the Work Assignment/Task Order/SOW?	Yes	No	N/A	______
• Does report comply with work plan and statement of work?	Yes	No	N/A	______
• Does report explain discrepancies between work plan and client instructions?	Yes	No	N/A	______
METHODS/APPROACH				
• Are assumptions stated?	Yes	No	N/A	______
• Are methods and technical approach well defined?	Yes	No	N/A	______
• Are methods and technical approach adequate and appropriate?	Yes	No	N/A	______
• Is relevant prior work referenced?	Yes	No	N/A	______
ANALYSIS/INFORMATION PROCESSING				
• Is technical information clearly explained and documented?	Yes	No	N/A	______
• Are regulations properly cited?	Yes	No	N/A	______
• Is site background information presented clearly? (i.e., maps, stratigraphic columns)	Yes	No	N/A	______
• Are maps, figures, or tables properly referenced?	Yes	No	N/A	______
• Are support documents properly cited?	Yes	No	N/A	______
RESULTS/CONCLUSIONS/RECOMMENDATIONS				
• Are results clearly stated?	Yes	No	N/A	______
• Are conclusions supported?	Yes	No	N/A	______
• Does the information presented lead to the conclusions that are drawn?	Yes	No	N/A	______
• Are recommendations practicle and pertinent?	Yes	No	N/A	______
• Is the technical premise or legal precedent presented and discussed along with the results?	Yes	No	N/A	______
• If fossils are found, is there a species list?	Yes	No	N/A	______
STYLE				
• Is the report logically organized and well written?	Yes	No	N/A	______
• Does the Table of Contents match the text?	Yes	No	N/A	______
• Is the report written in standard English with proper grammatical usage?	Yes	No	N/A	______
• Is the report written to the proper audience/professional level?	Yes	No	N/A	______
• Are words spelled correctly?	Yes	No	N/A	______
• Are acronyms properly defined and is there an acronym list, if necessary?	Yes	No	N/A	______
• Are the figures legible and do they contain reference information?	Yes	No	N/A	______
• Are tables in the proper format, logically organized, and do they contain all referenced information?	Yes	No	N/A	______
• Are the references properly cited in the text and included in a reference page?	Yes	No	N/A	______
• Is there an introduction explaining objectives, scope, document organization?	Yes	No	N/A	______
• Is there a summary of the approach, conclusions, and recommendations?	Yes	No	N/A	______

Reviewer's Name: ______________________

☐ Acceptable

☐ Unacceptable

TECHNICAL AND EDITORIAL QUALITY REVIEW CHECKLIST

(use additional pages, if necessary)

Comment Number *(from Page 1)*	**Comment Incorporate** *(YES or NO*	**Recommendation** *(Comment Resolution)*
1.		**1.**
2.		**2.**
3.		**3.**
4.		**4.**
5.		**5.**
6.		**6.**
7.		**7.**
8.		**8.**

APPENDIX E: Example Data Sheet

Paleontologic Locality -- Edwards AFB, CA

Project Paleontology Legacy Project

U.S. Air Force Contract #F04611-89-C-0019

Site No ______

Field/Temp No 93KR6-19.5/SBCM #01.155.289

Isocat 5049- 5050

Task Directive #S2R0602

Type of Locality Vertebrate ✓, Invertebrate ______, Plant ______, Trace ______, Geologic ______, Other ______

7 1/2 USGS Quad Jackrabbit Hill, CA; 1973 Photorevised ______

UTM Coordinates 432580 Easting 3856340 Northing

Township 9 N. Range 8 W. NW 1/4 of NW 1/4 of Sect 28

County Kern/ LA / San Bern. Elevation 2,550' feet above MSL

11,000 feet along Bearing W 20.5 from Jackrabbit Hill

Location Description ______

Potential Age Quaternary

Specimens Observed ______

Specimens Collected mammalia (lg) bone & enamel fragments

Weight of Bulk Samples ______ Lbs Depth ______

Geology/Formation Older Alluvium Topography ______

Comments/Remarks ______

Field Book Page ______

References ______

Recorded by Katherine Roster Field Date 6-10.93

Principle Investigator SAIC/SBCM

Curation Location EAFB