Appendix F: Paleontological Resources Technical Report

Appendices

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PALEONTOLOGICAL RESOURCES TECHNICAL REPORT FOR THE SAN BERNARDINO COUNTY GENERAL PLAN UPDATE, SAN BERNARDINO COUNTY, CALIFORNIA

JUNE 2018

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Paleontological Resources Technical Report for the San Bernardino County General Plan Update, San Bernardino County, California

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ABSTRACT/EXECUTIVE SUMMARY

Purpose and Scope: In support of the forthcoming San Bernardino Countywide Plan update, PlaceWorks retained SWCA Environmental Consultants (SWCA) to summarize the existing conditions of paleontological resources within the General Plan Area. The study area corresponds with the approximately 20,105-square-mile county. Methods include a search of the online records of the San Bernardino County Museum, the San Diego Natural History Museum, and the University of California Museum of Paleontology as well as a review of geologic mapping and the scientific literature.

Dates of Investigation: Online museum records were searched on February 12, 2018.

Summary of Findings: The review of online museum records indicates thousands of fossil specimens have been collected from geologic formations within San Bernardino County. A review of the scientific literature provided context for these and other fossil discoveries. Geologic mapping shows the distribution of geologic formations within the county. Analysis of these data allowed the assignment of both Society of Vertebrate Paleontology and Bureau of Land Management paleontological sensitivity rankings to the geologic units present in San Bernardino County, as shown on the California State Geologic Map (Jennings et al., 2010). Paleontological sensitivity varies across the county: igneous and high-grade metamorphic units have no paleontological sensitivity, whereas sedimentary units range from low to high sensitivities. Growth and development will inevitably lead to impacts on paleontological resources, but with the implementation of planning and mitigation measures, impacts to paleontological resources can be managed and minimized.

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1 INTRODUCTION

PlaceWorks retained SWCA Environmental Consultants (SWCA) to provide paleontological resources services in support of the San Bernardino Countywide Plan (project) for San Bernardino County, California (the County). SWCA performed a desktop analysis to assess paleontological conditions throughout the project area and reviewed relevant technical documents and agency-maintained databases on paleontological resources. The desktop research is summarized in this paleontological resources technical report (PRTR), which documents reported paleontological resources within the project area and assesses paleontological sensitivity across the county. This interim technical update to the Countywide Plan, which was last updated in 2007, will ensure that all technical data and policies remain current, and will guide decisions carried out by the County. The study area is composed of all unincorporated lands under the County's land use authority within the approximately 12,861,026-acre (20,105-square-mile) county. The County has jurisdiction over unincorporated areas not otherwise controlled by federal, state, or tribal governments.

SWCA relied upon three main sources of data to conduct this paleontological assessment: 1) geologic mapping, 2) scientific literature, and 3) online records publicly available from the University of California Museum of Paleontology (UCMP), the San Bernardino County Museum (SBCM), and the San Diego Natural History Museum (SDNHM). Due to the large size of San Bernardino County, it is not feasible to analyze every geologic formation within the county. Rather, this analysis focuses on the broad categories of geologic units as recognized on the California State Geologic Map (Jennings et al., 2010), with specific units of either widespread occurrence or unique paleontological significance discussed as appropriate (Section 5.1). These broad categories of geologic units are assigned paleontological sensitivity rankings following the guidelines of the Society of Vertebrate Paleontology (SVP, 1995, 2010) and the Bureau of Land Management (BLM, 2009, 2016) (Section 5.2). Finally, the paleontological sensitivity of each of the geographic regions of the county is discussed separately (Sections 5.2.1–5.2.4).

SWCA used the paleontological assessment conducted here to develop a series of recommendations for the development of appropriate mitigation measures for potential projects within San Bernardino County that could affect paleontological resources (Section 6). Implementation of these recommendations will ensure California Environmental Quality Act (CEQA) compliance and reduce the impacts to fossil resources to less than significant.

1.1 Definition and Significance of Paleontological Resources

Paleontology is a multidisciplinary science that combines elements of geology, biology, chemistry, and physics in an effort to understand the history of life on earth. Paleontological resources, or fossils, are the remains, imprints, or traces of once-living organisms preserved in rocks and sediments. These include mineralized, partially mineralized, or un-mineralized bones and teeth, soft tissues, shells, wood, leaf impressions, footprints, burrows, and microscopic remains. Paleontological resources include not only the fossils themselves, but also the physical characteristics of the fossils' associated sedimentary matrix.

The fossil record is the only evidence that indicates life on earth has existed for more than 3.6 billion years. Fossils are considered nonrenewable resources because the organisms they represent no longer exist. Thus, once destroyed, a fossil can never be replaced (Murphey and Daitch, 2007). Fossils are important scientific and educational resources and can be used to:

- study the phylogenetic relationships among extinct organisms, as well as their relationships to modern groups;

- elucidate the taphonomic, behavioral, temporal, and diagenetic pathways responsible for fossil preservation, including the biases inherent in the fossil record;
- reconstruct ancient environments, climate change, and paleoecological relationships;
- provide a measure of relative geologic dating, which forms the basis for biochronology and biostratigraphy, and is an independent and corroborating line of evidence for isotopic dating;
- study the geographic distribution of organisms and tectonic movements of land masses and ocean basins through time;
- study patterns and processes of evolution, extinction, and speciation; and
- identify past and potential future human-caused effects to global environments and climates (Murphey and Daitch, 2007).

2 REGULATORY SETTING

Paleontological resources are limited, nonrenewable resources of scientific, cultural, and educational value and are afforded protection under federal and state laws and regulations. This study satisfies project requirements in accordance with both federal and state regulations. This analysis also complies with guidelines and significance criteria specified by the SVP (1995, 2010).

2.1 Federal Regulations

2.1.1 Paleontological Resources Preservation, Omnibus Public Lands Act, Public Law 111-011, Title VI, Subtitle D (PRPA), 2009

This legislation directs the Secretaries of the U.S. Department of the Interior (USDI) and U.S. Department of Agriculture (USDA) to manage and protect paleontological resources on federal land using "scientific principles and expertise." To formulate a consistent paleontological resources management framework, the Paleontological Resources Preservation Act (PRPA) incorporates most of the recommendations from the report of the Secretary of the Interior titled "Assessment of Fossil Management on Federal and Indian Lands" (USDI, 2000). In passing the PRPA, Congress officially recognized the scientific importance of paleontological resources on some federal lands by declaring that fossils from these lands are federal property that must be preserved and protected. The PRPA codifies existing policies of the Bureau of Land Management (BLM), National Park Service (NPS), U.S. Forest Service (USFS), Bureau of Reclamation, and U.S. Fish and Wildlife Service (USFWS), and provides the following:

- uniform criminal and civil penalties for illegal sale and transport, and theft and vandalism of fossils from federal lands;
- uniform minimum requirements for paleontological resource-use permit issuance (terms, conditions, and qualifications of applicants);
- uniform definitions for "paleontological resources" and "casual collecting;" and
- uniform requirements for curation of federal fossils in approved repositories.

2.1.2 Federal Land Policy and Management Act (FLPMA) of 1976

The Federal Land Policy and Management Act (FLPMA) of 1976 (43 United States Code [USC] 1712[c], 1732[b]); sec. 2, Federal Land Management and Policy Act of 1962 [30 USC 611]; Subpart 3631.0 et seq.), Federal Register Vol. 47, No. 159, 1982, does not refer specifically to fossils. However, "significant fossils" are understood and recognized in policy as scientific resources. Permits, which authorize the collection of significant fossils for scientific purposes, are issued under the authority of FLPMA. Under FLPMA, federal agencies are charged to:

- manage public lands in a manner that protects the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, archaeological, and water resources, and, where appropriate, preserve and protect certain public lands in their natural condition (Section 102 [a][8][11]);
- periodically inventory public lands so that the data can be used to make informed land-use decisions (Section 102[a][2]); and
- regulate the use and development of public lands and resources through easements, licenses, and permits (Section 302[b]).

2.1.3 The National Environmental Policy Act (NEPA) of 1969

The National Environmental Policy Act of 1969 (NEPA), as amended (Public Law [PL] 91-190, 42 USC 4321-4347, January 1, 1970, as amended by PL 94-52, July 3, 1975, PL 94-83, August 9, 1975, and PL 97-258 Section 4(b), Sept. 13, 1982) recognizes the continuing responsibility of the federal government to "preserve important historic, cultural, and natural aspects of our national heritage…" (Sec. 101 [42 USC Section 4321]) (#382). With the passage of the PRPA, paleontological resources are considered a significant resource and it is therefore now standard practice to include paleontological resources in NEPA studies in all instances where there is a possible impact.

2.1.4 Antiquities Act of 1906

The Antiquities Act of 1906 (16 USC 431-433) states, in part:

> That any person who shall appropriate, excavate, injure or destroy any historic or prehistoric ruin or monument, or any object of antiquity, situated on lands owned or controlled by the Government of the United States, without the permission of the Secretary of the Department of the Government having jurisdiction over the lands on which said antiquities are situated, shall upon conviction, be fined in a sum of not more than five hundred dollars or be imprisoned for a period of not more than ninety days, or shall suffer both fine and imprisonment, in the discretion of the court.

Although there is no specific mention of natural or paleontological resources in the Act itself, or in the Act's uniform rules and regulations (Title 43 Part 3, Code of Federal Regulations [43 CFR 3]), the term "objects of antiquity" has been interpreted to include fossils by the NPS, BLM, USFS, and other federal agencies. Permits to collect fossils on lands administered by federal agencies are authorized under this Act. However, due to the large gray areas left open to interpretation due to the imprecision of the wording, agencies are hesitant to interpret this act as governing paleontological resources.

2.2 State Regulations

2.2.1 California Environmental Quality Act (CEQA)

CEQA is the principal statute governing environmental review of projects occurring in the state and is codified at Public Resources Code (PRC) Section 21000 et seq. CEQA requires lead agencies to determine if a proposed project would have a significant effect on the environment, including significant effects on paleontological resources. Guidelines for the Implementation of CEQA, as amended March 29, 1999 (Title 14, Chapter 3, California Code of Regulations 15000 et seq.), define procedures, types of activities, persons, and public agencies required to comply with CEQA, and include as one of the questions to be answered in the Environmental Checklist (Section 15023, Appendix G, Section XIV, Part a) the following: "Will the proposed project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?"

2.2.2 Public Resources Code (PRC) Section 5097.5

Requirements for paleontological resource management are included in the PRC Division 5, Chapter 1.7, Section 5097.5, and Division 20, Chapter 3, Section 30244, which states:

> No person shall knowingly and willfully excavate upon, or remove, destroy, injure or deface any historic or prehistoric ruins, burial grounds, archaeological or vertebrate paleontological site, including fossilized footprints, inscriptions made by human agency, or any other archaeological, paleontological or historical feature, situated on public lands, except with the express permission of the public agency having jurisdiction over such lands. Violation of this section is a misdemeanor.

These statutes prohibit the removal, without permission, of any paleontological site or feature from lands under the jurisdiction of the state or any city, county, district, authority, or public corporation, or any agency thereof. As a result, local agencies are required to comply with PRC 5097.5 for their own activities, including construction and maintenance, as well as for permit actions (e.g., encroachment permits) undertaken by others. PRC Section 5097.5 also establishes the removal of paleontological resources as a misdemeanor, and requires reasonable mitigation of adverse impacts to paleontological resources from developments on public (state, county, city, and district) lands.

2.3 Resource Assessment Guidelines

The loss of any identifiable fossil that could yield information important to prehistory, or that embodies the distinctive characteristics of a type of organism, environment, period of time, or geographic region, would be a significant environmental impact. Direct impacts on paleontological resources primarily concern the potential destruction of nonrenewable paleontological resources and the loss of information associated with these resources. This includes the unauthorized collection of fossil remains. If potentially fossiliferous bedrock or surficial sediments are disturbed, the disturbance could result in the destruction of paleontological resources and subsequent loss of information (a significant impact). At the project-specific level, direct impacts can be reduced to a less-than-significant level through the implementation of paleontological mitigation.

The CEQA threshold of significance for an impact to paleontological resources is reached when a project is determined to "directly or indirectly destroy a significant paleontological resource or unique geologic feature" (Appendix G, State CEQA Guidelines). In general, for project areas underlain by paleontologically sensitive geologic units, the greater the amount of ground disturbance, the higher the potential for significant impacts to paleontological resources. For project areas that are directly underlain by geologic units with no paleontological sensitivity, there is no potential for impacts on paleontological resources unless sensitive geologic units that underlie the non-sensitive unit are also affected.

2.3.1 Professional Standards

Both the SVP (1995, 2010) and the BLM (2009, 2016) have established standard guidelines that outline professional protocols and practices for conducting paleontological resource assessments and surveys, monitoring and mitigation, data and fossil recovery, sampling procedures, and specimen preparation, identification, analysis, and curation. Most practicing professional vertebrate paleontologists adhere closely to the SVP's assessment, mitigation, and monitoring requirements as specifically provided in its standard guidelines. Most state regulatory agencies with paleontological laws, ordinances, regulations, and standards accept and use the professional standards set forth by the SVP to meet the requirements of CEQA. The BLM's paleontological guidelines are designed to meet the requirements of NEPA and the FLPMA, and are in general only relevant to projects on BLM land or under the oversight of the BLM.

As defined by the SVP (2010:11), significant paleontological resources are:

> …fossils and fossiliferous deposits, here defined as consisting of identifiable vertebrate fossils, large or small, uncommon invertebrate, plant, and trace fossils, and other data that provide taphonomic, taxonomic, phylogenetic, paleoecologic, stratigraphic, and/or biochronologic information. Paleontological resources are considered to be older than recorded human history and/or older than middle Holocene (i.e., older than about 5,000 radiocarbon years).

As defined by the BLM (2009:19), significant paleontological resources are:

> …any paleontological resource that is considered to be of scientific interest, including most vertebrate fossil remains and traces, and certain rare or unusual invertebrate and plant fossils. A significant paleontological resource is considered to be scientifically important because it is a rare or previously unknown species, it is of high quality and well-preserved, it preserves a previously unknown anatomical or other characteristic, provides new information about the history of life on earth, or has identified educational or recreational value. Paleontological resources that may be considered to not have paleontological significance include those that lack provenience or context, lack physical integrity because of decay or natural erosion, or that are overly redundant or are otherwise not useful for research. Vertebrate fossil remains and traces include bone, scales, scutes, skin impressions, burrows, tracks, tail drag marks, vertebrate coprolites (feces), gastroliths (stomach stones), or other physical evidence of past vertebrate life or activities.

These definitions of significant resources are similar in that both recognize any type of fossil (invertebrate, vertebrate, plant, or trace fossils) can be scientifically significant if it is identifiable or well preserved and contributes scientifically valuable data.

A geologic unit known to contain significant fossils is considered sensitive to adverse impacts if there is a high probability that earth-moving or ground-disturbing activities in that rock unit will either disturb or destroy fossil remains directly or indirectly. This definition of sensitivity differs fundamentally from the definition for archaeological resources as follows:

> It is extremely important to distinguish between archaeological and paleontological resources when discussing the paleontological potential of rock units. The boundaries of an archaeological resource site define the areal/geographic extent of an archaeological resource, which is generally independent from the rock unit on which it sits. However, paleontological sites indicate that the containing rock unit or formation is fossiliferous. Therefore, the limits of the entire rock unit, both areal and stratigraphic, define the extent of paleontological potential (SVP, 2010).

Many archaeological sites contain features that are visually detectable on the surface. In contrast, fossils are often contained within surficial sediments or bedrock, and are therefore not observable or detectable unless exposed by erosion or human activity.

In summary, paleontologists cannot know either the quality or quantity of fossils prior to natural erosion or human-caused exposure. As a result, even in the absence of fossils on the surface, it is necessary to assess the sensitivity of rock units based on their known potential to produce significant fossils elsewhere within the same geologic unit (both within and outside the study area), a similar geologic unit, or based on whether the unit in question was deposited in a type of environment that is known to be favorable for fossil preservation. Monitoring by experienced paleontologists greatly increases the probability that fossils will be discovered during ground-disturbing activities and that, if these remains are significant, successful mitigation and salvage efforts may be undertaken to prevent adverse impacts to these resources.

Both the SVP and the BLM have developed a ranking system for assessing the paleontological sensitivity of a geologic formation. These are discussed below.

2.3.1.1 SVP SENSITIVITY RANKINGS

Paleontological sensitivity is defined as the potential for a geologic unit to produce scientifically significant fossils. This is determined by rock type, past history of the geologic unit in producing significant fossils, and fossil localities recorded from that unit. Paleontological sensitivity is derived from the known fossil data collected from the entire geologic unit, not just from a specific survey. In its "Standard Procedures for the Assessment and Mitigation of Adverse Impacts to Paleontological Resources," the SVP (2010:1–2) defines four categories of paleontological sensitivity (potential) for rock units: high, low, undetermined, and no potential:

High Potential. "Rock units from which vertebrate or significant invertebrate, plant, or trace fossils have been recovered are considered to have a high potential for containing additional significant paleontological resources. Rock units classified as having high potential for producing paleontological resources include, but are not limited to, sedimentary formations and some volcaniclastic formations (e.g., ashes or tephras), and some low-grade metamorphic rocks which contain significant paleontological resources anywhere within their geographical extent, and sedimentary rock units temporally or lithologically suitable for the preservation of fossils (e.g., middle Holocene and older, fine-grained fluvial sandstones, argillaceous and carbonate-rich paleosols, cross-bedded point bar sandstones, fine-grained marine sandstones, etc.). Paleontological potential consists of both a) the potential for yielding abundant or significant vertebrate fossils or for yielding a few significant fossils, large or small, vertebrate, invertebrate, plant, or trace fossils and b) the importance of recovered evidence for new and significant taxonomic, phylogenetic, paleoecologic, taphonomic, biochronologic, or stratigraphic data. Rock units which contain potentially datable organic remains older than late Holocene, including deposits associated with animal nests or middens, and rock units which may contain new vertebrate deposits, traces, or trackways are also classified as having high potential."

Low Potential. "Reports in the paleontological literature or field surveys by a qualified professional paleontologist may allow determination that some rock units have low potential for yielding significant fossils. Such rock units will be poorly represented by fossil specimens in institutional collections, or based on general scientific consensus, only preserve fossils in rare circumstances and the presence of fossils is the exception not the rule, e.g. basalt flows or Recent colluvium. Rock units with low potential typically will not require impact mitigation measures to protect fossils."

Undetermined Potential. "Rock units for which little information is available concerning their paleontological content, geologic age, and depositional environment are considered to have undetermined potential. Further study is necessary to determine if these rock units have high or low potential to contain significant paleontological resources. A field survey by a qualified professional paleontologist to specifically determine the paleontological resource potential of these rock units is required before a paleontological resource impact mitigation program can be developed. In cases where no subsurface data are available, paleontological potential can sometimes be determined by strategically located excavations into subsurface stratigraphy."

No Potential. "Some rock units have no potential to contain significant paleontological resources, for instance high-grade metamorphic rocks (such as gneisses and schists) and plutonic igneous rocks (such as granites and diorites). Rock units with no potential require no protection or impact mitigation measures relative to paleontological resources" (SVP, 2010:1–2).

2.3.1.2 BLM SENSITIVITY RANKINGS

The Potential Fossil Yield Classification (PFYC) system was developed to provide baseline guidance for assessing paleontological resources and allow BLM employees to make initial assessments of paleontological resources. The presence of paleontological resources is correlated with mapped geologic units, and the PFYC was based on available geologic maps. The system assigns a class value to each geological unit, representing the potential abundance and significance of paleontological resources that occur in that geological unit. A complete discussion of the background and context for the PFYC system is provided in the BLM (2016) IM2016-124 document. The following descriptions of paleontological sensitivity class rankings pertinent to this project and drawn directly from the BLM Guidelines are provided here:

Class 1–Very Low. Geologic units that are not likely to contain recognizable paleontological resources. Units assigned to Class 1 typically have one or more of the following characteristics:

- Geologic units are igneous or metamorphic, excluding air-fall and reworked volcanic ash units.
- Geologic units are Precambrian in age.

(1) Management concerns for paleontological resources in Class 1 units are usually negligible or not applicable.
(2) Paleontological mitigation is unlikely to be necessary except in very rare or isolated circumstances that result in the unanticipated presence of paleontological resources, such as unmapped geology contained within a mapped geologic unit. For example, young fissure-fill deposits often contain fossils but are too limited in extent to be represented on a geological map; a lava flow that preserves evidence of past life, or caves that contain important paleontological resources. Such exceptions are the reason that no geologic unit is assigned a Class 0.

Overall, the probability of impacting significant paleontological resources is very low and further assessment of paleontological resources is usually unnecessary. An assignment of Class 1 normally does not trigger further analysis unless paleontological resources are known or found to exist. However, standard stipulations should be put in place prior to authorizing any land use action in order to accommodate an unanticipated discovery.

Class 2–Low. Geologic units that are not likely to contain paleontological resources. Units assigned to Class 2 typically have one or more of the following characteristics:

- Field surveys have verified that significant paleontological resources are not present or are very rare.
- Units are generally younger than 10,000 years before present.
- Recent aeolian deposits.
- Sediments exhibit significant physical and chemical changes (i.e., diagenetic alteration) that make fossil preservation unlikely.

(1) Except where paleontological resources are known or found to exist, management concerns for paleontological resources are generally low and further assessment is usually unnecessary except in occasional or isolated circumstances.
(2) Paleontological mitigation is only necessary where paleontological resources are known or found to exist.

The probability of impacting significant paleontological resources is low. Localities containing important paleontological resources may exist, but are occasional and should be managed on a case-by-case basis. An assignment of Class 2 may not trigger further analysis unless paleontological resources are known or found to exist. However, standard stipulations should be put in place prior to authorizing any land use action in order to accommodate unanticipated discoveries.

Class 3–Moderate. Sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence. Units assigned to Class 3 have some of the following characteristics:

- Marine in origin with sporadic known occurrences of paleontological resources.
- Paleontological resources may occur intermittently, but abundance is known to be low.
- Units may contain significant paleontological resources, but these occurrences are widely scattered.
- The potential for an authorized land use to impact a significant paleontological resource is known to be low-to-moderate.

(1) Management concerns for paleontological resources are moderate because the existence of significant paleontological resources is known to be low. Common invertebrate or plant fossils may be found in the area, and opportunities may exist for casual collecting.
(2) Paleontological mitigation strategies will be proposed based on the nature of the proposed activity.

This classification includes units of moderate or infrequent occurrence of paleontological resources. Management considerations cover a broad range of options that may include record searches, pre-disturbance surveys, monitoring, mitigation, or avoidance. Surface-disturbing activities may require assessment by a qualified paleontologist to determine whether significant paleontological resources occur in the area of a proposed action, and whether the action could affect the paleontological resources.

Class 4–High. Geologic units that are known to contain a high occurrence of paleontological resources. Units assigned to Class 4 typically have the following characteristics:

- Significant paleontological resources have been documented, but may vary in occurrence and predictability.
- Surface disturbing activities may adversely affect paleontological resources.

- Rare or uncommon fossils, including nonvertebrate (such as soft body preservation) or unusual plant fossils, may be present.
- Illegal collecting activities may impact some areas.

(1) Management concerns for paleontological resources in Class 4 are moderate to high, depending on the proposed action.
(2) Paleontological mitigation strategies will depend on the nature of the proposed activity, but field assessment by a qualified paleontologist is normally needed to assess local conditions.

The probability for impacting significant paleontological resources is moderate to high, and is dependent on the proposed action. Mitigation plans must consider the nature of the proposed disturbance, such as removal or penetration of protective surface alluvium or soils, potential for future accelerated erosion, or increased ease of access that could result in looting. Detailed field assessment is normally required and on-site monitoring or spot-checking may be necessary during land disturbing activities. In some cases avoidance of known paleontological resources may be necessary.

Class 5–Very High. Highly fossiliferous geologic units that consistently and predictably produce significant paleontological resources. Units assigned to Class 5 have some or all of the following characteristics:

- Significant paleontological resources have been documented and occur consistently.
- Paleontological resources are highly susceptible to adverse impacts from surface disturbing activities.
- Unit is frequently the focus of illegal collecting activities.

(1) Management concerns for paleontological resources in Class 5 areas are high to very high.
(2) A field survey by a qualified paleontologist is almost always needed. Paleontological mitigation may be necessary before or during surface-disturbing activities.

The probability for impacting significant paleontological resources is high. The area should be assessed prior to land tenure adjustments. Pre-work surveys are usually needed and on-site monitoring may be necessary during land use activities. Avoidance or resource preservation through controlled access, designation of areas of avoidance, or special management designations should be considered.

Class U–Unknown Potential. Geologic units that cannot receive an informed PFYC assignment. Characteristics of Class U may include:

- Geological units may exhibit features or preservational conditions that suggest significant paleontological resources could be present, but little information about the actual paleontological resources of the unit or area is known.
- Geological units represented on a map are based on lithologic character or basis of origin, but have not been studied in detail.
- Scientific literature does not exist or does not reveal the nature of paleontological resources.
- Reports of paleontological resources are anecdotal or have not been verified.
- Area or geologic unit is poorly or under-studied.

- BLM staff has not yet been able to assess the nature of the geologic unit.

(1) Until a provisional assignment is made, geologic units that have an unknown potential have medium to high management concerns.
(2) Lacking other information, field surveys are normally necessary, especially prior to authorizing a ground-disturbing activity.

An assignment of "Unknown" may indicate the unit or area is poorly studied, and field surveys are needed to verify the presence or absence of paleontological resources. Literature searches or consultation with professional colleagues may allow an unknown unit to be provisionally assigned to another Class, but the geological unit should be formally assigned to a Class after adequate survey and research is performed to make an informed determination.

3 GEOLOGIC SETTING

San Bernardino County is the largest county in the nation, with a diverse geologic and geographic setting. Rocks found in San Bernardino County include some of the oldest rocks in the United States (Precambrian granite and metasedimentary rocks) to Holocene alluvium, the deposition of which is ongoing today (see Figure 1 for geologic time scale).

3.1 Valley Region

The Valley Region is unique in San Bernardino County for its setting within the northeastern-most portion of the Peninsular Ranges Geomorphic Province, one of 11 major provinces in the state. The Peninsular Ranges extend from Los Angeles in the north to the Baja Peninsula in the south, and from the Pacific coastline in the west to the Colorado Desert and Gulf of California in the east (Norris and Webb, 1990). This region is characterized by northwest-trending mountains and valleys, with widespread alluvial fan deposits originating from the mountains to the north and dating to the late Pleistocene (Norris and Webb, 1990). The Valley Region of San Bernardino County is dominated by the San Bernardino Basin, a depression formed between the Jurupa Mountains, Chino Hills, and San Jacinto Mountains to the south and the San Bernardino Mountains to the north and northeast. Sediment accumulates in the San Bernardino Basin from erosion of the surrounding highlands, and represents the primary geology of the area.

3.2 Mountain Region

The Mountain Region of San Bernardino County represents the furthest eastern portion of the Transverse Ranges Geomorphic Province, which consists of a complex series of young, east-west–trending mountain ranges and valleys that contradict the general north-south orientation of California's other mountain ranges, such as the Peninsular Ranges and Coastal Ranges (Matti et al., 1992). The Transverse Ranges begin at Point Conception in Santa Barbara County and extend in an easterly direction, terminating at the San Bernardino Mountains in San Bernardino County. Most of the ranges are bounded to the north and east by the San Andreas Fault System, which separates the ranges from the Coastal Ranges and Peninsular Ranges. Components of the ranges that lie north of the San Andreas Fault are the Tehachapi Mountains and San Bernardino Mountains. The San Bernardino Mountains are the highest mountain range in southern California, with Mount San Gorgonio (3,505 m) and San Bernardino Peak (3,246 m) as the highest peaks. Although a variety of rock types can be found in the San Bernardino Mountains, the most common rock is quartz monzonite that dates to the Late Cretaceous, with metasedimentary rocks such as the Pelona Schist present locally (Norris and Web, 1990). The San Bernardino Mountains are relatively young, dating to the Pleistocene (Matti et al., 1992).

3.3 East and North Desert Regions

The East and North Desert Regions make up the largest land area in San Bernardino County, and constitute almost the entirety of the Mojave Desert Geomorphic Province. The Mojave Desert occupies about 65,000 square km, bounded on the west by the Transverse Ranges, the north by the Basin and Range, and the south by the Colorado Desert, and extends eastward into Arizona and Nevada (Norris and Webb, 1990). The province is characterized by scattered mountain blocks bounded by normal and strike-slip faults and the broad alluvial basins between them (Norris and Webb, 1990). Basin fill ranges from thick sequences of Miocene sediments north of Barstow to more recent Quaternary depressions north of Baker, and even rock-floored pediments in the northeastern Mojave (Norris and Webb, 1990). Lava flows that date from the Cenozoic are also common features across the Mojave, such as Amboy Crater, Cima Dome, and around Pisgah, with volcanic sediments intermixed with terrestrial sediments dating as far back as the Miocene (Norris and Webb, 1990). A more recent feature are the many playas scattered across Mojave, these being particularly numerous in the eastern Mojave (Norris and Webb, 1990).

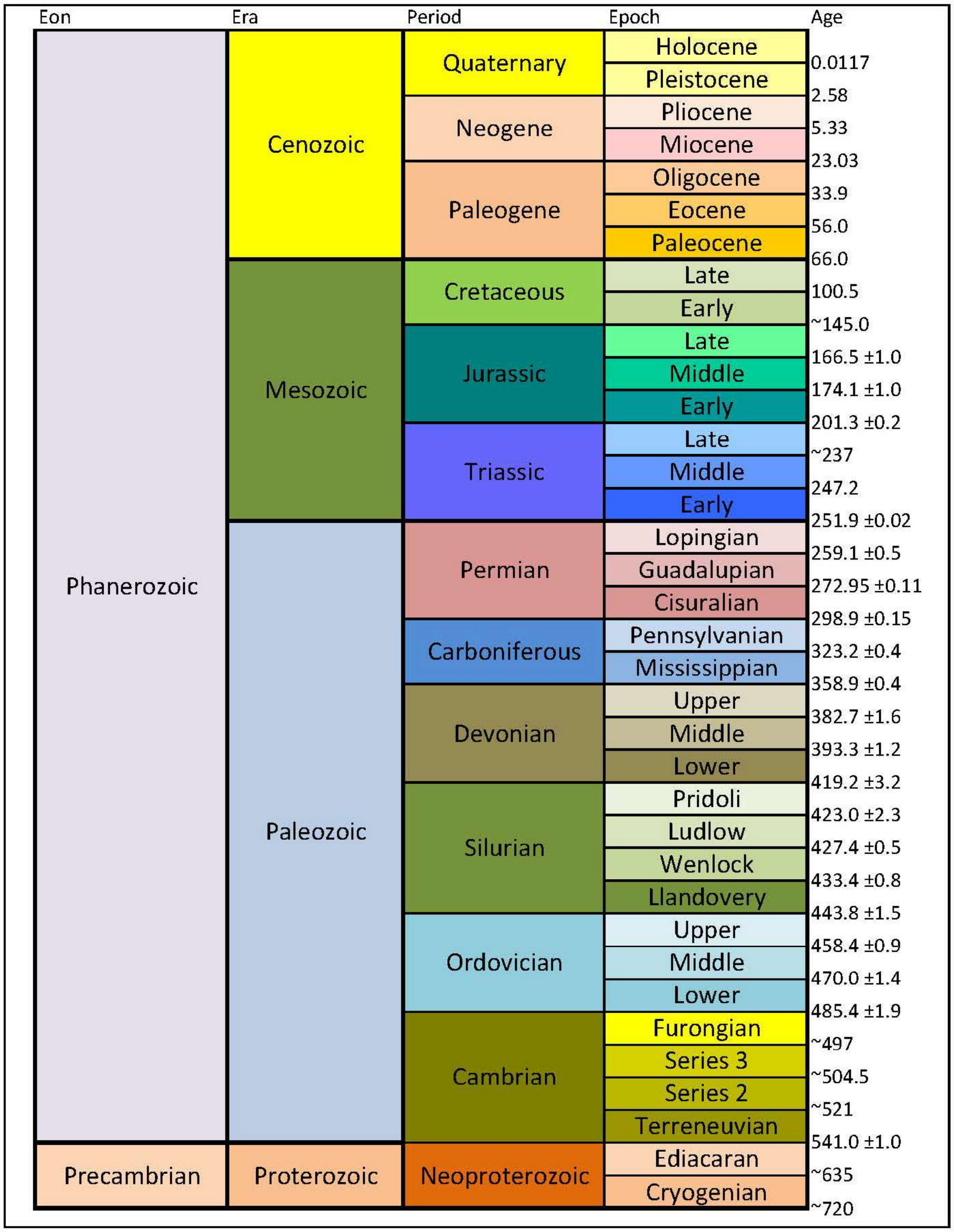

Figure 1. Geologic timescale based on the International Chronostratigraphic Chart (International Commission on Stratigraphy, 2017). Age given in millions of years before present.

4 METHODS

This PRTR is based on a desktop review of available scientific literature, geologic maps, and a review of the online collections databases of the University of California Museum of Paleontology (UCMP), the San Bernardino County Museum (SBCM), and the San Diego Natural History Museum (SDNHM). The purpose of this report is to evaluate the paleontological sensitivity of the geologic units found within each of the geographic regions of San Bernardino County (Valley, Mountain, East Desert, and North Desert) as shown on the California State Geologic Map (Jennings et al., 2010). Geologic formations of particular paleontological significance are discussed in more detail. The guidelines of the SVP (2010) and BLM (2009, 2016) were used to assign paleontological sensitivity rankings and develop recommended mitigation measures. In general, SVP guidelines are applicable for state CEQA projects, while BLM guidelines are applicable to federal projects operating under NEPA.

4.1 Project Personnel

SWCA Lead Paleontologist Alyssa Bell, Ph.D., conducted the paleontological analysis and authored this report. Geographic Information Systems (GIS) Specialist Jeremy Huey produced the figures. SWCA Paleontological Resources Principal Investigator Paleontologist Russell Shapiro, Ph.D., reviewed this report. SWCA Project Managers Alex Wesson, B.A., and Chris Millington, M.A., provided oversight on this project.

5 RESULTS (EXISTING CONDITIONS)

5.1 Geologic Units within San Bernardino County

Although the different regions of San Bernardino County have distinctive geologic profiles, there are a number of units that are commonly found in all of the regions, as shown on the geologic maps of each region (Appendix B). These units are described below.

Holocene Surficial Sediments (mapped as Q, Qs, Qg, Qls). These sediments date from modern times to the Pleistocene (11,000 years ago), and form as a result of alluvial or fluvial activity (Q), wind deposition of sand (Qs), glacial till (Qg), or landslide deposits (Qls) (Jennings et al., 2010). As recent sediments, none of these units are old enough to preserve fossil resources at the surface (5,000 years, as defined by the SVP 2010). However, these sediments increase in age with depth; in the subsurface they may be old enough to preserve fossils similar to those described below for Older Alluvium. Moreover, these units may overlie older sediments with high paleontological sensitivity. The depth at which Holocene sediments are old enough to preserve fossil resources (i.e., more than 5,000 years old) or transitions to Older Alluvium is highly variable and often unknown for any specific area. One study of inland valley fossil deposits in Riverside and San Bernardino counties identifies this transition as relatively shallow in many areas, with fossil-bearing sediments occurring as little as 1.5 m (5 feet) below the surface (Reynolds and Reynolds, 1991). These deposits are mapped as covering large surface areas across the Valley, East Desert, and North Desert Regions, and as scattered deposits in the Mountain Region.

Older Alluvium (Qoa). Older alluvium is very similar to younger Holocene alluvium (Q) in terms of lithology and depositional setting; however, it is much older, dating to the Pleistocene (11,000–2.58 million years old; Jennings et al., 2010). As such, these sediments are of an appropriate age to preserve fossil resources. These sediments are found in all regions of San Bernardino County, and form a main component of the surficial geology of the East and North Desert Regions.

Pleistocene sediments have a rich fossil history in southern California (Hudson and Brattstrom, 1977; Jefferson, 1991a, 1991b; McDonald and Jefferson, 2008; Miller, 1941, 1971; Roth, 1984; Scott, 2010; Scott and Cox, 2008; Springer et al., 2009). The most common Pleistocene terrestrial mammal fossils include the bones of mammoth, horse, bison, camel, and small mammals, but other taxa, including lion, cheetah, wolf, antelope, peccary, mastodon, capybara, and giant ground sloth, have been reported (Graham and Lundelius, 1994), as well as birds, amphibians, and reptiles such as frogs, salamanders, snakes, and turtles (Hudson and Brattstrom, 1977). In addition to illuminating the striking differences between Southern California in the Pleistocene and today, this abundant fossil record has been vital in studies of extinction (e.g., Sandom, et al., 2014; Scott, 2010), ecology (e.g., Connin et al., 1998), and climate change (e.g., Roy et al., 1996). The online collections database of the UCMP shows records of 3,719 fossil specimens from 48 localities (UCMP, 2018), whereas the online collections database of the SBCM shows 3,248 fossil specimens from an unspecified number of localities (SBCM 2018; see Appendix A). The Natural History Museum of Los Angeles County (LACM) also has extensive collections of Pleistocene fossils; however, their database is not publicly accessible.

An excellent example of the striking abundance and diversity of these Pleistocene sediments comes from Riverside County, just south of San Bernardino County, where nearly 100,000 identifiable fossil specimens representing 105 vertebrate, invertebrate, and plant species were collected from more than 2,000 individual localities during the construction of the dam at Diamond Valley Lake (Springer et al., 2009), and are now housed at the Western Science Center in Hemet, California. This site represents the second largest late Pleistocene fossil assemblage known from the American Southwest after the La Brea Tar Pits in Los Angeles (Springer et al., 2009). Other Ice Age fossils have been found throughout the inland valleys (Miller, 1971; Reynolds and Reynolds, 1991; Reynolds et al., 2012) and the Mojave Desert (Jefferson, 1987, 1988; Scott et al., 2004, 2006; Scott and Cox, 2008). Other exceptionally preserved Pleistocene sedimentary deposits include the Manix and Searles Lake Formations.

Manix Formation. The Manix Formation consists of around 40 m of lacustrine, fluvial, and alluvial sediments deposited in and around the middle to late Pleistocene Lake Manix (Jefferson, 2003). This formation occurs to the east of Barstow in the central North Desert Region (Dibblee and Minch, 2008c, 2008d, 2008e). The lacustrine and fluvial deposits in this formation have yielded a diverse fauna, preserving invertebrates such as mollusks and ostracods as well as aquatic and terrestrial vertebrates such as fish, birds, and numerous Ice Age mammals (Jefferson, 2003). The UCMP has records of 315 fossil specimens collected from 39 localities in the Manix Formation (UCMP 2018), and the SBCM has records of 15 specimens recorded from the Manix Formation (SBCM 2018) (Appendix A).

Pliocene-Pleistocene Nonmarine Sediments (QPc). This unit consists of loosely consolidated sandstone, shale, and gravel deposits that reflect deposition in continental settings and were deposited from the Pliocene through the Pleistocene (Jennings et al., 2010). This unit is of an appropriate age and range of lithologies to preserve fossil resources. Outcrops of this unit are found scattered throughout the Valley, Mountain, and North Desert Regions of the county. These deposits may preserve the same iconic Ice Age fauna as discussed above, including mammoths, ground sloths, camels, and dire wolves, as well as abundant small mammals, reptiles, and birds. The San Timoteo and Tulare Formations are included in QPc on the Calfiornia State Geologic Map (Jennings et al., 2010).

San Timoteo Formation. The San Timoteo Formation dates from the Pleistocene to the Pliocene and consists of stream-deposited alluvial sediments made up of detritus eroded from the San Bernardino Mountains (Dibblee and Minch, 2003a, 2003b, 2004). The San Timoteo Formation is present in the Valley Region, where it crops out at the surface along the southern border in San Timoteo Canyon (Dibblee and Minch, 2003a). However, the formation may also be present underlying the northern and eastern deposits of Quaternary alluvium (Q, Qoa). A number of significant fossil deposits have been discovered in the San Timoteo. The construction of the El Casco Substation in San Timoteo Canyon between September 2009 and January 2011 produced numerous fossils, including riparian and aquatic plants, insects, slugs and snails, fish, tortoise, lizards, snakes, small mammals, birds, a giant camel, a llama, two ground sloths, and two different types of saber tooth cats (Reynolds et al., 2012). The Shutt Ranch fauna is a collection of hundreds of significant fossils belonging to 37 species of small mammals as well as larger macrofauna such as sloth, camel, deer, horse, and others, found in the San Timoteo beds (Albright, 1999). The scientific literature records a rich fossil history from this unit that includes fossils of more than 30 plant taxa (Axelrod, 1966, 1979) and more than 40 animal taxa, including camels, deer, sloth, elephants, bears, rabbits, and rodents (Albright, 1999) that have been the subject of study for almost 100 years (Frick, 1921, 1933; Matti and Morton, 1975; Reynolds and Reeder, 1991). In addition, the SBCM has records of 846 fossil specimens collected from an undisclosed number of localities in the San Timoteo Formation in San Bernardino County (SBCM, 2018).

Tulare Formation. The Tulare dates from the Pleistocene to the latest Pliocene and is marine in origin, not continental (0.6–2.2 million years ago [Mya]; Boessenecker and Poust, 2015). The Tulare Formation has yielded a number of significant fossils across California, such as fish (Gobalet and Fenenga, 1993; Hilton and Grande, 2006), dolphins (Boessenecker and Poust, 2015), birds (Fisher, 1967), tortoises (Biewer et al., 2016), and the largest assemblage of clams and snails known from this era along the Pacific Coast (Page, 1983). In addition, the online records of the SBCM indicate they have 1,922 fossil specimens from undisclosed locations of the Tulare Formation (SBCM, 2018).

Pliocene Marine Sediments (P). This unit consists of mostly consolidated siltstone, sandstone, shale, and conglomerate deposited in a marine setting during the Pliocene (Jennings et al., 2010). There are a variety of geologic units likely included in this unit on the California State Map (Jennings et al., 2010), the paleontological potential of which vary. The marine portions of the Tropico Group are thus far unfossiliferous (Dibblee and Minch, 2008f). However, the Bouse Formation is known to preserve fossils.

Bouse Formation. The Bouse Formation spans the Late Miocene to Early Pliocene and has been interpreted to represent either a marine estuarian or lacustrine depositional environment (Spencer and Patchett, 1997). The Bouse Formation is found in the northeastern-most corner of the North Desert Region and consists of calcareous clay, silt, and sand (Carr and Dickey, 1980). Abundant common invertebrate fossils such as gastropods, ostracods, barnacles, and foraminifera as well as fish and plants are known from the Bouse Formation (Carr and Dickey, 1980; Spencer and Patchett, 1997).

Miocene Marine Sediments (M). This unit consists of sandstone, shale, siltstone, conglomerate, and breccia deposited in a marine setting during the Miocene (Jennings et al., 2010). This unit only occurs in the Valley Region of San Bernardino County, where most of the southwestern corner is mapped as Miocene Marine Sediments. The Vaqueros and Puente Formations are likely included in this unit on the California State Geologic Map (Jennings et al., 2010).

Vaqueros Formation. The Vaqueros Formation consists of predominately limey sandstone interbedded with siltstone and shale deposited in an offshore basin (Bartow, 1974; Morton and Miller, 2006). The Vaqueros Formation ranges in age from the Early Miocene to the Late Eocene (Morton and Miller, 2006). Common fossils in the Vaqueros include marine invertebrates such as barnacles, ostreids, and pectinids and marine ichnofossils (Bartow, 1974) as well as terrestrial vertebrates (Whistler and Lander, 2003) and marine megafauna (Morton and Miller, 2006).

Puente Formation. The Puente Formation consists of marine sandstone, siltstone, and shale that dates from the early Pliocene to the Miocene (Critelli et al., 1995; Morton and Miller, 2006). The Puente Formation has a history of preserving both invertebrate and vertebrate marine fossils, such as cephalopods (Saul and Stadum, 2005), crustaceans (Feldman, 2003), fishes (Carnevale et al., 2008; David, 1943; Hilton and Grande, 2006; Huddleston and Takeuchi, 2006), and other marine and terrestrial vertebrates (Barboza et al., 2017; Leatham and North, 2017). The records of the SBCM indicate they have 430 fossil specimens collected from the Puente Formation in San Bernardino County (SBCM, 2018).

Miocene Nonmarine Sediments (Mc). This unit is composed of moderately consolidated sandstone, shale, conglomerate, and fanglomerate deposited in a continental setting during the Miocene (Jennings et al., 2010). This unit is common across the western and central area of the North Desert Region, where it is often interbedded with Tertiary volcanics; one large outcrop is found in the northwestern area of the Mountain Region. There are a number of geologic formations likely included in this unit on the California State Geologic Map (Jennings et al., 2010), nearly all of which are well known for preserving significant vertebrate fossils. The only formation that may be mapped as Mc that does not preserve fossils is the nonmarine portion of the Tropico Group (Jennings et al., 1962). Two of the most prolific of these formations in terms of fossils are the Avawatz and Barstow Formations, discussed in detail below. However, other formations also have an extensive record of fossil preservation, such as the Crowder Formation, present in the southeast North Desert Region and northwestern Mountain Region (Dibblee and Minch 2003a, 2003b, 2008a; Hernandez and Tan, 2007); Cajon Valley Formation, also called the Punchbowl Formation, present around Hesperia and in the Cajon Pass (Dibblee and Minch 2003a, 2004, 2008a); and the Ricardo Formation, present in the northwestern North Desert Region (Jennings et al., 1962). The UCMP and SBCM have records of numerous fossil localities in these formations, as detailed in Appendix A.

Avawatz Formation. The Avawatz Formation consists of four members: conglomerate, siltstone and sandstone, breccias, and sandstone, siltstone, and tuff deposited in alluvial fans, floodplains, and lakes spanning a period of around 40 million years during the late Miocene (Spencer, 1977). The Avawatz Formation occurs in the Avawatz Mountains in the central Northern Desert Region (Spencer, 1977). The Avawatz preserves a typical Miocene mammalian fauna of early ancestors of horses and camels as well as abundant rodents and some reptiles (UCMP, 2018). In addition, the Avawatz is known for preserving exceptional fossil trackways from dozens of different types of animals, including birds, camels, and cats (Lofgren et al., 2006; Reynolds and Milner, 2012; Sarjeant and Reynolds, 2001). Trackways are significant fossil resources, and provide valuable information on not only foot morphology, but also how an animal moved and potentially whether it was part of a herd. The UCMP has records of 98 fossil specimens collected from eight localities in the Avawatz (UCMP, 2018), whereas the Raymond M. Alf Museum in Claremont, California, has more than 100 fossil trackways collected from the Avawatz (Lofgren et al., 2006), all in San Bernardino County.

Barstow Formation. The Barstow Formation is composed of fluvial and lacustrine sediments interbedded with air-fall tuff beds deposited in lakes, and dates from around 14.8 to 19.3 million years old (Woodburne et al., 1990). This formation crops out across the Gravel Hills, Mud Hills, Calico Mountains, Yermo Hills, Alvord Mountain, and the West Cronese Basin (Dibblee and Minch, 2008b, 2008c, 2008d, 2008e, 2008f, 2008g; Woodburne et al., 1990). The fossil mammal fauna of the Barstow is so abundant it has been used to define a biostratigraphic portion of the Middle Miocene called the Barstovian North American Land Mammal Age (Pagnac, 2009; Wood et al., 1941). The University of California, Berkeley, conducted extensive excavations of the mammal fossils shortly after they were first discovered in the Mud Hills (Baker, 1911), and today the UCMP has records of 3,833 fossil specimens from 219 localities in San Bernardino County

(UCMP, 2018; see Appendix A). In addition, the SBCM has records of 95 fossil specimens from an undisclosed number of localities in the Barstow (SBCM, 2018). The most common fossils in these museums include early ancestors of horses, antelope, and camels, as well as small mammals such as mice and rabbits, with birds, fish, invertebrates, reptiles, and early ancestors of canines and elephants less common but well represented (SBCM, 2018; UCMP, 2018). In addition to the vertebrate fauna an extensive record of exceptionally preserved small organisms, such as insects and arthropods, are known from the Barstow (Leggitt, 2006; Miller and Lubkin, 2001; Park and Downing, 2001). These fossils have been extensively studied and reported on in the scientific literature, leading to a better understanding of the early evolution of many modern animals ranging from horses (Forsten, 1973; MacFadden, 1986) and camels (Pagnac, 2005) to insects (Lister, 1981) as well as paleoecology (Brattstrom, 1961; Park and Downing, 2001).

Tertiary Nonmarine Sediments (Tc). These sediments range widely in lithology, including sandstone, shale, conglomerate, breccia, and ancient lake deposits and are poorly constrained in age, ranging from the Paleocene to the Pliocene (Jennings et al., 2010). These deposits are likely to vary locally in their paleontological sensitivity; finer grained deposits are more likely to have high sensitivity, and coarse-grained deposits such as breccia have low sensitivity. Locality-specific studies are necessary to assess the paleontological sensitivity of these deposits using finer scale geologic mapping.

Triassic Marine Sediments (Tr). This unit consists of sedimentary (sandstone, conglomerate, limestone, dolomite) and metasediments (slate, hornfels, quartzite), with minor pyroclastic volcanic rocks deposited in Triassic seas (Jennings et al., 2010). This unit occurs as scattered outcrops in San Bernardino County, found in the Soda and Panamint mountains and the Mescal Range and Old Woman Mountains in the North Desert Region. Geologic formations likely included in this unit on the California State Map (Jennings et al., 2010) in the North Desert Region likely include the Butte Valley, Soda Mountain, and Warm Spring Formations in the northwestern area (Jennings et al., 1962) and the Chinle and Moenkopi formations in the northeastern area (Evans, 1971; Hewett, 1956). In the East Desert Region, Triassic sediments include the Buckskin Formation (Howard, 2002). Although many of these units are marine, the Chinle Formation is nonmarine in origin, and the Moenkopi Formation has alternating beds of marine and terrestrial origin (Evans, 1971; Walker, 1988). The potential for fossils in most of these rocks is unknown in San Bernardino County.

Marine Units. In northern California, a variety of marine fossils such as ammonites, corals, and a diverse microfossil assemblage of radiolarians and conodonts are known from Triassic marine sediments similar to those found in the northwestern North Desert Region (Irwin and Blome, 2004; Silberling and Irwin, 1962). However, there are no records in the UCMP or the SBCM of Triassic fossils from San Bernardino County, and a search of the scientific literature did not return any results.

Chinle Formation. The Chinle Formation consists of well-indurated sandstone cemented with hematite, calcite, and silica deposited in a continental setting (Evans, 1971) and occurs around Kokoweef Peak in San Bernardino County (Hewett, 1956). The Chinle is best known from Arizona and New Mexico, where it is famous for the preservation of entire ecosystems, with trees, ancient amphibians, early dinosaurs, and smaller organisms such as insects preserved at sites like Petrified Forest National Park in Arizona (Therrien and Fastovsky, 2000) and thousands of *Coelophysis* specimens, a small theropod dinosaur, preserved as a mass death assemblage along with other animals at Ghost Ranch in New Mexico (Irmis et al., 2007). The Chinle preserves the time period in which the first dinosaurs evolved and diversified, coming to dominate the terrestrial ecosystem over older animals that had been prominent, primarily large amphibians and primitive archosaurs. It is unclear if the outcrops in San Bernardino County preserve similar fossils, as there are no records in the UCMP or SBCM, and a review of the literature did not find any publications of such finds.

Moenkopi Formation. The Moenkopi Formation in San Bernardino County represents the seaward margin of the unit and consists of an upper marine unit of thin-bedded buff sandy limestone and dolomite and a lower terrestrial unit of sandy shale (Evans, 1971), and occurs primarily in the Spring Mountains and around State Line Pass in the North Desert Region (Hewett, 1956). The Moenkopi Formation is best known from Arizona and Utah, where it has an exceptional fossil record, with numerous animals, arthropods, invertebrates, and plants well preserved, as well as exceptional tracksites (Morales, 1987). Like the Chinle, the Moenkopi preserves the time period in which the first dinosaurs evolved and diversified, coming to dominate the terrestrial ecosystem over older animals that had been prominent, primarily large amphibians and primitive archosaurs. The only record of Moenkopi fossils in San Bernardino County appears to be a small collection of bivalves and gastropods collected from the limestone units in the Spring Mountains (Hewett, 1956). There are no records of specimens in the collections of the UCMP or SBCM.

Jurassic Marine Sediments (J). This unit consists primarily of shale and sandstone with minor conglomerate, chert, slate, and limestone deposited in Jurassic seas (Jennings et al., 2010). This unit is rare in San Bernardino County, found as two small outcrops in the North Desert Region. Although described on the California State Map as marine in origin (Jennings et al., 2010), local mapping shows that this unit also includes the terrestrial Aztec Sandstone in the Mescal Range and Cowhole Mountains (e.g., Barca, 1966; Evans, 1971).

Aztec Sandstone. The Aztec Sandstone is an eolian-deposited quartzose sandstone at the westernmost margin of the Navajo-Nugget sand sea that dates to the early Jurassic (Porter, 1987). The Aztec is well known for the preservation of numerous animal trackways. These tracksites are the only known Jurassic trackways from California. Although identifying which specific animals made the tracks is often not possible, 13 distinct types of tracks have been identified in the Mescal Range, nine belonging to a small quadrupedal animal, three belonging to a small bipedal theropod dinosaur (Reynolds, 1991, 2006), and one made by pterosaurs (Reynolds and Mickelson, 2006). The diversity and abundance of these trackways are unusual and unique in the California rock record from this time period.

Cretaceous Marine Sediments & Metasediments (K). This unit consists of sandstone, shale, and conglomerate deposited in Cretaceous seas (Jennings et al., 2010). There is a single outcrop of this unit in the North Desert Region, in the Ivanpah Mountains on the California State Map (Jennings et al., 2010). However, regional-scale mapping shows very small outcrops across the North Desert Region (Howard, 2002; Jennings et al., 1962) and Mountain Region (Dibblee and Minch, 2003a). Cretaceous sediments also crop out to the immediate southwest of the Valley Region, and thus may also be present in the subsurface in the southeastern area of that region. Aside from the San Francisquito Formation, little is known about the specific formations assigned to this unit or their paleontological sensitivity. Elsewhere in California, Cretaceous-aged marine sediments have yielded numerous marine reptiles such as Plesiosaurs and Mosasaurs as well as one dinosaur, *Augustynolophus*, from the Moreno Formation in the Panoche Hills (Preito-Marquez et al., 2017) and the Chico Formation (Hilton, 2003), Williams Formation (Morris, 1973), and others.

San Francisquito Formation. The San Fransisquito spans the Late Cretaceous to middle of the Paleocene and consists of up to 4 km of deep-marine sediments (Kooser, 1982) found in the westernmost Mountain Region (Dibblee and Minch, 2003a). There are marine invertebrate fossils, primarily gastropods (Prothero and Vacca, 2001; Squires 1993), as well as one marine reptile (UCMP, 2018) recorded from this formation in San Bernardino County.

Permian Marine Sediments & Metasediments (Pm). This unit consists of a variety of sedimentary (shale, sandstone, conglomerate, limestone, dolomite) and metasedimentary (slate, hornfels, quartzite) rocks with small amounts of pyroclastic volcanic rocks deposited in Permian seas (Jennings et al., 2010). Rocks assigned to this unit occur as small, isolated outcrops scattered across the North Desert Region. Geologic formations likely included in this unit on the California State Map (Jennings et al., 2010) in the North Desert Region likely include the Anvil Spring and Bird Spring Formations (Jennings et al., 1962), the Kaibab Limestone (Evans, 1971; Hewett, 1956), and the Coconino Sandstone and Hermit Shale (Howard, 2002). Many of these units are more famously known from the Grand Canyon, where they are well exposed and studied (e.g., the Kaibab Limestone, Coconino Sandstone, and Hermit Shale). Of these formations, the Bird Spring and Kaibab Limestone have records of fossil collections from San Bernardino County in the UCMP.

Bird Spring Formation. The Bird Spring Formation records shallow-water marine carbonates (limestone and dolomite) deposited during the early Permian (Stevens and Stone, 2007). Outcrops of this formation occur in the Cowhole, Old Dad, and Providence mountains in the eastern Northern Desert Region (Hewett, 1956; Jennings et al., 1962). Invertebrate fossils of corals and microfossils of fusulinids are common in the Bird Spring (Stevens and Stone, 2007). The UCMP has records of 12 fossil corals collected from nine localities in the Bird Spring in San Bernardino County (UCMP, 2018).

Kaibab Limestone. The Kaibab Limestone consists of three members in San Bernardino County: two thick limestone units (each 60–75 m thick) separated by a thin sandstone layer (10–30 m thick; Hewett, 1965). Fossils are found in both limestone units, and consist of typical Permian invertebrate fauna, primarily brachiopods, corals, crinoids, echinoids, and trilobites (Hewett, 1956).

Carboniferous Marine Sediments & Metasediments (C). This unit consists of a variety of sedimentary (shale, sandstone, conglomerate, limestone, dolomite) and metasedimentary (chert, hornfels, marble, quartzite) rocks with small amounts of pyroclastic volcanic rocks deposited in Carboniferous seas (Jennings et al., 2010). Rocks assigned to this unit are found as small outcrops scattered across the Northern Desert Region and concentrated along the northeastern flank of the San Bernardino Mountains in the Mountain and southern North Desert Regions. Reports of fossils from the Carboniferous of San Bernardino County are rare. Neither the UCMP nor the SBCM list any Carboniferous fossils in their online databases. A review of the scientific literature does not reveal any reported occurrences of fossils in Carboniferous-aged sediments in San Bernardino County; however, elsewhere in the state such sediments do preserve fossils such as corals and brachiopods (Kawamura and Stevens, 2012; Watkins, 1973, 1974).

Devonian Marine Sediments & Metasediments (D). This unit consists of limestone, dolomite, sandstone, and shale, with tuff in some areas, deposited in Devonian seas (Jennings et al., 2010). This unit is limited to the Mescal Range and Ivanpah Mountains in the northeastern area of the North Desert Province (Hewett, 1956). Rocks in this unit are primarily assigned to the Sultan Limestone.

Sultan Limestone. The Sultan Limestone consists of three members: the Ironside Dolomite, which preserves abundant fossil sponges; the Valentine Member, which preserves a wide variety of invertebrate fossils, such as sponges, corals, brachiopods, gastropods, and ostracods; and the Crystal Pass Limestone, which only preserves microfossils such as conondonts (Bereskin, 1982; Harrington, 1987). Although abundant in some members, these fossils are primarily common invertebrate fossils.

Paleozoic-Mesozoic Marine Sediments & Metasediments (ls). This unit consists of poorly constrained limestone, dolomite, and marble that dates from either the Paleozoic or Mesozoic (Jennings et al., 2010). It is uncommon in San Bernardino County, occurring in a handful of outcrops in the eastern Northern Desert Region. It is unclear which geologic formations are included in this unit; however, the general lithology and age is consistent with fossil preservation.

Cambrian Marine Sediments and Metasediments (Ca). This unit includes marine deposits made up of sedimentary (sandstone, shale, limestone, dolomite) and metasedimentary (chert, quartzite, and phyllite) rocks that date to the Cambrian or uppermost Precambrian (Jennings et al., 2010). They are found as scattered outcrops across the Mojave in the East and North Desert Regions, with large outcrops restricted to the mountains of the northernmost and easternmost North Desert Region. There are many geologic formations likely included in this unit on the California State Geologic Map (Jennings et al., 2010), including the Bonanza King Formation, Bright Angel Shale, Cadiz Formation, Carrara Formation, Chambless Limestone, Cornfield Springs Formation, Latham Shale, Lotus Formation, Nopah Formation, Pioche Shale, Prospect Mountain Quartzite, Wood Canyon Formation, and the Zabriskie Quartzite. These formations are highly variable in their paleontological sensitivity; some preserve excellent examples of some of the earliest modern-type animals known, whereas others are not known to preserve significant fossils. These rocks have the potential to record one of the most important intervals in the history of life, the Precambrian-Cambrian boundary, a time when the first metazoans and the oldest ancestors of many modern groups of organisms evolved (Corsetti and Hagadorn, 2000). For example, the Wood Canyon Formation has been documented as preserving fossils of trilobites (an extinct group of early arthropods), archaeocyathids (an extinct group of earliest reef-building organisms like corals), echinoderms (the earliest representatives of the modern group that includes crinoids and sea stars), and brachiopods (shelled animals similar to bivalves) (Corsetti and Hagadorn, 2000). The UCMP has records of fossils of this age in their collections from the Chambless Limestone, Nopah Formation, Cadiz Formation, and Latham Shale in San Bernardino County, collected in the Bristol, Clark, Marble, and Providence mountains (UCMP, 2018; see Appendix A). In addition, the San Diego Natural History Museum has records of 99 specimens of trilobites and brachiopods collected from an undisclosed number of localities in the Latham Shale of San Bernardino County (SDNHM, 2018; see Appendix A). Microbialites are also documented in these rocks from the Bonanza King and Nopah Formations, among others (Shapiro and Awramik, 2006). Rare Ediacaran fossils, examples of the earliest complex multicellular life on earth, are also known from the Wood Canyon Formation (Hagadorn and Waggoner, 2000). Although some trilobites are quite common fossils, other organisms represented in some of these units are rare, and therefore scientifically significant. Locality-specific studies are necessary to assess the paleontological sensitivity of these deposits using finer scale geologic mapping and possibly field surveys.

Paleozoic Marine Sediments & Metasediments (Pz). This unit consists of a wide variety of sedimentary (sandstone, shale, conglomerate, limestone, dolomite) and metasedimentary (slate, quartzite, hornfels, marble, phyllite, etc.) rocks poorly constrained in age to the Paleozoic (Jennings et al., 2010). This unit occurs as widely scattered and very small outcrops across the Mountain, North Desert, and East Desert Regions, with the largest outcrops found to the north and east of Barstow and in the San Bernardino Mountains. The sedimentary deposits in this unit may preserve fossil resources. The metasedimentary units may also preserve fossils; however, the degree of metamorphism will control how well preserved the fossils are. Sediments that have been highly metamorphosed are unlikely to preserve recognizable fossils.

A number of different geologic formations are likely mapped as Pz on the California State Geologic Map (Jennings et al., 2010). These include the Saragossa Quartzite and the Oro Grande Formation. The Oro Grande Formation is a crudely bedded dolomitic limestone that dates to the late Paleozoic and preserves fragments of brachiopods, gastropods, and echinoids; however, all are poorly preserved and represent commonly known fauna (Dibblee, 1960a, 1960b; Dibblee and Minch, 2008b, 2008c).

Precambrian Marine Sediments & Metasediments (Pc). This unit consists of a variety of sedimentary (conglomerate, shale, sandstone, limestone, dolomite) and metasedimentary (marble, gneiss, hornfels, quartzite) rocks that date to the Precambrian (Jennings et al., 2010). They occur as small, scattered outcrops across the Mojave and along the northern flanks of the San Bernardino Mountains in the East and North Desert and Mountain Regions. The preservation potential for fossils varies among the different formations that make up this unit, with smaller grain sizes and lower levels of metamorphism favoring fossil preservation. Examples of formations included in this unit include the Stirling Quartzite, Johnnie Formation, Noonday Dolomite, and the Pahrump Group (Kingston Peak Formation, Beck Spring Formation, Horse Thief Springs Formation, Crystal Spring Formation). One fossil group of note in some of these rocks are the Ediacarans. The Ediacarans are an enigmatic group of soft-bodied organisms that represent the earliest known complex multicellular organisms on earth. Fossils of these organisms are very rare in the continental United States, but have been documented from the Stirling Quartzite (Hagadorn and Waggoner, 2000), Johnnie Formation, the Noonday Dolomite, and the Beck Springs and Crystal Spring Formations of the Pahrump Group (Corsetti and Hagadorn, 2000). Alternatively, units such as the Kingston Peak Formation are not known to preserve significant fossils (Corsetti and Hagadorn, 2000). Therefore, locality-specific studies are necessary to assess the paleontological sensitivity of areas mapped as Pc using finer scale geologic mapping and possibly field surveys.

Volcanic and Metavolcanic Rocks (Qrv, Qrvp, Qv, Qvp, Ti, Tv, Tvp, m, mv, Mzv, Pzv). Evidence of volcanic activity dating from recent times (Qrv, Qrvp, Qv, Qvp) to the Paleozoic (Pzv) is widespread across San Bernardino County (Jennings et al., 2010). These include lava flows as well as pyroclastic volcanic rocks and geographic features such as cinder cones. Because of the high temperature of lava, these sediments will not usually preserve fossil resources. Exceptions can be rare fossils preserved in tuff or volcanic ash deposits; however, these are not common components of the Quaternary volcanic units mapped across San Bernardino County.

Plutonic Igneous Rocks (grCz, um, grMz, gb, gr, gr-m, grPz, grpC, pCc). Plutonic igneous rocks form from the slow crystallization of cooling magma in the Earth's crust. As such, they will not contain fossil resources. These rocks are widespread across San Bernardino County, forming the core of the San Bernardino Mountains as well as the many scattered smaller ranges across the Mojave Desert, and date from the Precambrian to the Cenozoic.

Metamorphic Rocks (sch, gr-m, pCc). A variety of metamorphic rocks, primarily schist (sch), are found across San Bernardino County, often mapped inclusively with granitic (gr-m) or plutonic (pCc) rocks. The most well described of these is the Pelona Schist, present throughout the San Bernardino Mountains. These rocks form from the alteration of a parent rock at high temperatures and pressures, such that fossils that might have been present in the parent rocks will no longer be recognizable. Other types of less altered metamorphic rocks that may still preserve fossils are also present in San Bernardino County, and are discussed separately above.

5.2 Paleontological Sensitivity Analysis

The results of the desktop analysis presented above were used to assign each geologic unit present in the County of San Bernardino SVP and BLM paleontological sensitivity rankings (SVP, 2010) (Table 1; see Appendix C). The BLM sensitivity rankings are more specific than those of the SVP, ranging from Class 1 (very low) to Class 5 (very high) (BLM, 2016), whereas SVP only recognizes undetermined, none, low, and high (SVP, 2010). Because the level of data necessary to assign a specific BLM ranking was not available for most of the units in this study, a range of BLM rankings is used instead. Also, the BLM PFYC rankings take into account the potential for looting or destruction, factors not considered as part of the current study. Locality-specific studies will be necessary to further refine the BLM sensitivity assessments (see recommendations below for more detail).

In general, the Valley Region is characterized by a broad valley floor deposit of Younger Alluvium (Q) that is too young to preserve fossil resources in the upper layers; however, the deeper layers and underlying sediments have high paleontological sensitivity, as do the Miocene Marine Sediments (M). The Mountain Region consists predominantly of granitic bedrock and high-grade metamorphic rocks that have no potential to preserve fossil resources. However, a number of high-sensitivity units are present as scattered outcrops, primarily Older Alluvium (Qoa), Pleistocene-Pliocene Nonmarine Sediments (QPc), and Miocene Nonmarine Sediments (Mc), mapped locally as the Cajon Valley (Punchbowl) and Crowder Formations (Dibblee and Minch, 2003a). The East and North Desert regions are characterized by broad alluvial plains between scattered mountain outcrops. In general, the mountains consist of granitic bedrock or volcanic deposits and will have no paleontological potential. The alluvial plains between the mountains generally have low to high sensitivity where Younger Alluvium (Q, Qs, Qg, Qls) is mapped at the surface and likely overlies older, high-sensitivity sediments.

No Sensitivity (SVP)/Class 1, Very Low (BLM). Igneous and high-grade metamorphic rocks form in ways that are not conducive to fossil preservation. Therefore, the SVP regards these rocks as having no sensitivity (SVP, 2010), whereas the BLM assesses them as having Class 1 (very low) sensitivity (BLM, 2016). Therefore, the following units in San Bernardino County are assessed as having no or Class 1 sensitivity: Holocene volcanics (Qrv, Qrvp), Quaternary volcanics (Qv, Qvp), Cenozoic granite (grCz), Tertiary volcanics (Ti, Tv, Tvp), Metavolcanics (m, mv, Mzv, Pzv), Plutonic rocks (um, grMz, gb, gr, gr-m, grPz, grpC, pCc), and Metamorphic rocks (sch).

Low Sensitivity (SVP)/Class 2, Low–Class 3, Moderate (BLM). Some rock units are of an age to preserve fossil resources, but specimens are poorly represented in the literature and in museums, and the presence of fossils is the exception and not the rule (BLM, 2016; SVP, 2010). The BLM also highlights that rocks in this category may have been diagenetically altered, such as by low-grade metamorphism, such that the likelihood of recovering significant fossils is low (BLM, 2016). Using these guidelines, Paleozoic-Mesozoic Marine Sediments & Metasediments (Is), Permian Marine Sediments & Metasediments (Pm), Carboniferous Marine Sediments & Metasediments (C), Devonian Marine Sediments & Metasediments (D), and Paleozoic Marine Sediments & Metasediments (Pz) are all assigned SVP low sensitivity, or BLM Class 2 (low) or Class 3 (moderate). Although fossils are known from a number of geologic formations included in these units, such as the Kaibab Limestone, Bird Spring Formation, and Sultan Limestone, they consist of common marine fossils (see geologic descriptions above for details).

Table 1. Paleontological Sensitivity of Geologic Units in San Bernardino County

California State Map Unit	California State Map Symbol	Included Geologic Formations of Note	Regions	SVP Sensitivity	BLM Sensitivity
Holocene Surficial Sediments	Q, Qs, Qg, Qls	—	All	Low to High	Class 2 to Class 4 or 5
Older Alluvium	Qoa	Manix Formation, Searles Lake Formation, Chemehuevi Formation	All	High	Class 4 or 5
Pliocene-Pleisocene Nonmarine Sediments	QPc	San Timoteo Formation, Tulare Formation	Valley, Mountain, North Desert	High	Class 4 or 5
Pliocene Marine Sediments	P	Bouse Formation	North Desert	Varies	Varies
Miocene Marine Sediments	M	Vaqueros Formation, Puente Formation	Valley, North Desert	Varies	Varies

California State Map Unit	California State Map Symbol	Included Geologic Formations of Note	Regions	SVP Sensitivity	BLM Sensitivity
Miocene Nonmarine Sediments	Mc	Avawatz Formation, Barstow Formation, Crowder Formation, Cajon Valley/Punchbowl Formation, Ricardo Formation	Mountain, East Desert, North Desert	High	Class 4 or 5
Cretaceous Marine Sediments & Metasediments	K	—	North Desert	Undetermined	Class U
Jurassic Marine Sediments	J	Aztec Sandstone	North Desert	High	Class 4 or 5
Triassic Marine Sediments	Tr	Buckskin Formation, Chinle Formation, Moenkopi Formation	North Desert	Undetermined	Class U
Tertiary Nonmarine Sediments	Tc	—	Mountain, North Desert	Varies	Varies
Paleozoic-Mesozoic Marine Sediments & Metasediments	ls	—	North Desert	Low	Class 2 or 3
Permian Marine Sediments & Metasediments	Pm	Bird Spring Formation, Kaibab Limestone	North Desert	Low	Class 2 or 3
Carboniferous Marine Sediments & Metasediments	C	—	Mountain, North Desert	Low	Class 2 or 3
Devonian Marine Sediments & Metasediments	D	Sultan Limestone	North Desert	Low	Class 2 or 3
Cambrian Marine Sediments & Metasediments	Ca	Bonanza King Formation, Cadiz Formation, Chambless Limestone, Cornfield Springs Formation, Latham Shale, Lotus Formation, Nopah Formation, Pioche Shale, Prospect Mountain Quartzite, Wood Canyon Formation, Zabriskie Quartzite	East Desert, North Desert	Varies	Varies
Paleozoic Marine Sediments & Metasediments	Pz	Oro Grande Formation	Mountain, East Desert, North Desert	Low	Class 2 or 3
Volcanic & Metavolcanic Rocks	Qrv, Qrvp, Qv, Qvp, Ti, Tv, Tvp, m, mv, Mzv, Pzv	—	All	None	Class 1
Plutonic Igneous & Metamorphic Rocks	grCz, um, grMz, gb, gr, gr-m, grPz, grpC, pCc, sch	—	All	None	Class 1

Low to High Sensitivity, increasing with depth (SVP)/Class 2, Low to Class 4, High or 5, Very High (BLM). A number of sedimentary deposits in the county are too young to preserve fossil resources at the surface or in the shallow subsurface (i.e., younger than 5,000 years before present), but may preserve fossils at depth or overlie older units that have high paleontological sensitivity. These units are widespread across the county, and consist of younger alluvium (Q), sand deposits (Qs), Glacial Till (Qg), and Landslide Deposits (Qls). In assessing the sensitivity and determining mitigation measures for areas mapped as these units, it is important to establish the thickness of these surficial, low-sensitivity sediments (those less than 5,000 years old that have low sensitivity). This can be accomplished through museum records searches, which may include information about the depth at which fossils were found in the area and geotechnical studies, which often identify geologic formations in bore log reports

High Sensitivity (SVP)/Class 4, High or Class 5, Very High (BLM). Many of the geologic formations in the project area are known to preserve abundant or scientifically significant fossils, thus giving them high paleontological sensitivity (BLM, 2016; SVP, 2010). The difference between BLM Classes 4 and 5 depends on the consistency of fossils: Class 4 is inconsistent in its occurrence and has the likelihood of disturbed fossils; Class 5 is more likely to be disturbed by illegal activities (BLM, 2016). These factors are locality specific, and so further delimiting an area as Class 4 or Class 5 is best left to locality-specific studies. The following units are identified as high sensitivity (SVP) or Class 4 or 5 sensitivity (BLM): older alluvium (Qoa), Pliocene-Pleistocene Nonmarine Sediments (QPc), Miocene Nonmarine Sediments (Mc), and Jurassic Marine Sediments (J). All of these units are well known to preserve abundant significant fossil resources, such as the iconic Ice Age fauna of the Manix and San Timoteo Formations (Qoa), the mammalian fauna that form the basis of the Barstovian North American Land Mammal Age (Mc), or the numerous Jurassic trackways of the Aztec Sandstone (J).

Variable Sensitivity. For some of the units mapped on the California State Map (Jennings et al., 2010), a number of geologic formations are mapped inclusively that have varying paleontological sensitivities, some with low sensitivity and some with high. Locality-specific studies will be needed in areas mapped as these units to determine which formations are present in the area. These units are listed below.

> ***Pliocene Marine Sediments (P).*** The fossiliferous unit with High (SVP) or Class 4 or 5 (BLM) sensitivity included in this unit is the Bouse Formation. Other formations are also likely present; however, the resolution of geologic mapping is not sufficient to identify these formations, and they should be considered as having unknown sensitivity.

> ***Miocene Marine Sediments (M).*** Fossiliferous units with High (SVP) or Class 4 or 5 (BLM) sensitivity included in this unit are the Vaqueros and Puente Formations. However, portions of the Tropico Group are also likely included in this group, and are unfossiliferous, with Low (SVP) or Class 2, Low (BLM) sensitivity. Other specific formations may also be present that have unknown sensitivity.

> ***Tertiary Nonmarine Sediments (Tc).*** The specific geologic formations that make up this unit on the California State Map have not been identified; however, the variety of lithologies present in this unit indicates variable paleontological sensitivity. Fine-grained deposits such as sandstone, siltstone, or ancient lake beds will be more likely to have well-preserved fossils, as established by the excellent Tertiary deposits in fine-grained sediment known from the better defined Manix Formation and Searles Lake Formation, as well as from the Barstow Formation. Alternatively, the conglomerate and breccia deposits in this unit indicate deposition in a high-energy environment less conducive to the preservation of well-preserved fossils.

> ***Cambrian Marine Sediments & Metasediments (Ca).*** There are more than 13 geologic formations included in this unit (see geologic results above). Some, like the Wood Canyon Formation, have preserved examples of the very rare but significant Ediacaran fossils, and should be assigned a sensitivity of High (SVP) or Class 4, High (BLM). Others, like the Bright Angel Shale, have a low abundance of common marine fossils, and should be assigned a Low (SVP) or Class 2, Low (BLM) sensitivity. Other formations in this unit may have unknown sensitivity. Locality-specific studies are the best way to assess which formations are likely to be present in any given area, at which time appropriate mitigation measures can be applied.

> ***Precambrian Marine Sediments & Metasediments (Ca).*** There are several formations likely included in this unit that are known to preserve rare but significant Ediacaran fossils, such as the

Stirling Quartzite and the Pahrump Group, and therefore should be assigned a sensitivity of High (SVP) or Class 4, High (BLM). Other units with Low (SVP) or Class 2, Low (BLM) sensitivity are also included, such as the Kingston Peak Formation, which is not known to preserve fossils.

Undetermined Sensitivity. For some geologic units in the project area, paleontological sensitivities cannot be determined at this time because they have little to no record in the scientific literature (SVP, 2010). Within San Bernardino County, Cretaceous Marine Sediments and Metasediments (K) and Triassic Marine Sediments (Tr) have undetermined sensitivity. Locality-specific studies including a museum collections records search, a more focused review of the scientific literature, and field surveys will likely be better able to assess the sensitivities of local geologic formations.

5.2.1 Paleontological Sensitivity of the Valley Region

The Valley Region is characterized by a broad valley floor deposit of Younger Alluvium (Q), which is likely underlain by Older Alluvium (Qoa) and Pleistocene-Pliocene Nonmarine Sediments (QPc), such the San Timoteo Formation, that also occur as scattered outcrops along the valley margins. A large area of Miocene Marine Sediments (M), including the Vaqueros and Puente Formations, is present in the southwestern corner, whereas the northern margins of the region abut the granitic rocks of the San Bernardino Mountains. The Younger Alluvium (Q) across the valley floor is too young to preserve fossil resources in the upper layers, but the deeper layers and underlying sediments have high paleontological sensitivity, as do the Miocene Marine Sediments (M).

5.2.2 Paleontological Sensitivity of the Mountain Region

The Mountain Region consists predominantly of granitic bedrock and high-grade metamorphic rocks that have no potential to preserve fossil resources. However, a number of high-sensitivity units are present as scattered outcrops, primarily Older Alluvium (Qoa), Pleistocene-Pliocene Nonmarine Sediments (QPc), and Miocene Nonmarine Sediments (Mc), mapped locally as the Cajon Valley (Punchbowl) and Crowder Formations (Dibblee and Minch, 2003a). The largest area of these outcrops occurs in the northwestern area and smaller outcrops occur in the northeastern area around Big Bear Lake and Seven Oaks. There are also several small areas where low-sensitivity Carboniferous (C) and Paleozoic (Pz) Marine Sediments and Metasediments occur to the north and east of Big Bear Lake.

5.2.3 Paleontological Sensitivity of the East Desert Region

The East Desert Region consists of the eastern margin and foothills of the San Bernardino Mountains flattening out westward in broad alluvial plains and scattered mountain ranges very similar to that seen in the North Desert Region. The eastern area is similar in overall sensitivity to the Mountain Region, with primarily unfossiliferous granite and scattered outcrops of high-sensitivity Older Alluvium (Qoa). As the topography flattens out, the sensitivity comes to be more similar to that of the North Desert Region, with alluvial plains of low- to high-sensitivity Younger Alluvium (Q) overlying high-sensitivity Older Alluvium (Qoa).

5.2.4 Paleontological Sensitivity of the North Desert Region

The North Desert Region is characterized by broad alluvial plains between scattered mountain outcrops. In general, the mountains consist of granitic bedrock or volcanic deposits and will have no paleontological potential. Small exposures of sediments and low-grade metamorphosed sediments are also present in the mountains and have highly variable paleontological sensitivities, as discussed individually above. In particular, outcrops of the Aztec Sandstone (mapped as Jurassic Marine Sediments, J) as well as certain formations mapped as Cambrian (Ca) and Precambrian (pC) Marine Sediments and Metasediments, have high paleontological sensitivity. Outcrops of Paleozoic Marine Sediments and Metasediments (Is, Pm, D, Pz) have generally low sensitivity.

The broad alluvial plains between the mountains generally have low to high sensitivity where Younger Alluvium (Q, Qs, Qg, Qls) is mapped at the surface and likely overlies older, high-sensitivity sediments. These older, high-sensitivity sediments are often exposed along the margins of these alluvial plains as they approach the intervening mountain ranges, and consist of formations well known to preserve fossil resources, such as Older Alluvium (Qoa) and the Manix Formation, Pliocene-Pleistocene Nonmarine Sediments (QPc), and Miocene Nonmarine Sediments (Mc) (Avawatz, Barstow, Crowder, Cajon Valley/Punchbowl, and Ricardo Formations, among others).

6 POTENTIAL IMPACTS AND MITIGATION MEASURES

As discussed above, numerous federal and state regulations have been established to protect paleontological resources. If it can be demonstrated that a project will cause damage to a unique paleontological resource, mitigation measures are required (CEQA, Appendix G). Impacts to paleontological resources most commonly occur from damage or destruction during ground-disturbing activities. Fossils are most commonly buried in sediment or rock, and so are often undetectable from surface observations until excavations uncover them. This can result in damage to the fossil if measures are not taken during ground-disturbing activities to identify and protect fossils as they are encountered.

6.1 Thresholds of Significance

The General Plan provides a framework within which future development projects can be considered. The potential for future proposed projects to result in impacts associated with cultural resources is based on the CEQA thresholds of significance outlined in Appendix G of the State CEQA Guidelines, which asks the question, “Will the proposed project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?” In addition, the federal regulations PRPA and NEPA establish penalties for the theft or destruction of fossils (PRPA) and mandate that significant fossil material be protected and curated at an accredited repository (NEPA).

6.1.1 Impacts to Paleontological Resources

The review of the UCMP, SBCM, and SDNHM online paleontological collections, geologic mapping, and the scientific literature presented here indicate that the General Plan Area contains paleontological resources. Although portions of the General Plan Area have been previously studied, future development or improvements related to changes in land use could potentially affect and cause significant adverse impacts to paleontological resources. The following measures are recommended to assist in the avoidance and mitigation of potential impacts from future projects in the General Plan Area to paleontological resources.

The guidelines of the SVP (1995, 2010) and the BLM (2009, 2016) have been used to develop general recommendations for proposed projects in San Bernardino County. With the implementation of the following mitigation measures, construction projects in San Bernardino County will be mitigated against directly or indirectly destroying unique paleontological resources or sites or unique geologic features. The intent of these recommendations is to ensure that potential adverse impacts to paleontological resources as a result of project implementation are reduced to a less-than-significant level. These mitigation measures are only general guidelines, and all projects should develop a project-specific paleontological mitigation and monitoring plan, as discussed below.

6.1.2 Paleontological Resources Mitigation Measure 1

The mapping provided in this report is based on the California State Geologic map at a scale of 1:250,000. At this large scale, project-specific assessments are not possible. A Qualified Paleontologist meeting the standards of SVP (2010) will be designated to conduct all paleontological mitigation measures associated with construction activities. The Qualified Paleontologist should initially conduct a desktop assessment of the paleontological sensitivity of the project area, including a review of higher-resolution geologic mapping and updated museum records searches. The results of this assessment will be used to develop project-specific mitigation measures, such as the development of a paleontological resources monitoring and mitigation plan (PRMMP) for projects in high sensitivity sediments. This plan will address specifics of monitoring and mitigation to that project area and construction plan, and will take into account updated geologic mapping, geotechnical data, updated paleontological records searches, and any changes to the regulatory framework. This PRMMP should usually meet the standards of the SVP (2010), unless the project is on BLM land or subject to federal jurisdiction, in which case the BLM standards (2009) should be used. The following provisions should be made for units mapped with the different levels of paleontological sensitivity:

High (SVP)/Class 4–5 (BLM)—All projects involving ground disturbances in previously undisturbed sediments mapped as having high paleontological sensitivity will be monitored by a qualified paleontological monitor (BLM, 2009; SVP, 2010) on a full-time basis under the supervision of the Qualified Paleontologist. Undisturbed sediments may be present at the surface, or present in the subsurface, beneath earlier developments. This monitoring will include inspection of exposed sedimentary units during active excavations within sensitive geologic sediments. The monitor will have authority to temporarily divert activity away from exposed fossils to evaluate the significance of the find and, should the fossils be determined to be significant, professionally and efficiently recover the fossil specimens and collect associated data. Paleontological monitors will use field data forms to record pertinent location and geologic data, will measure stratigraphic sections (if applicable), and collect appropriate sediment samples from any fossil localities.

Low to High (SVP)/Class 2 to Class 4–5 (BLM)—All projects involving ground disturbance in previously undisturbed areas mapped with low-to-high paleontological sensitivity will only require monitoring if construction activity will exceed the depth of the low sensitivity surficial sediments. The underlying sediments may have high paleontological sensitivity, and therefore work in those units might require paleontological monitoring, as designated by the Qualified Paleontologist in the PRMMP. When determining the depth at which the transition to high sensitivity occurs and monitoring becomes necessary, the Qualified Paleontologist should take into account: a) the most recent local geologic mapping, b) depths at which fossils have been found in the vicinity of the project area, as revealed by the museum records search, and c) geotechnical studies of the project area, if available.

Low (SVP)/Class 2–3 (BLM)—All projects involving ground disturbance in previously undisturbed areas mapped as having low paleontological sensitivity should incorporate worker training to make construction workers aware that while paleontological sensitivity is low, fossils might still be encountered. The Qualified Paleontologist should oversee this training as well as remain on-call in the event fossils are found. Paleontological monitoring is usually not required for sediments with low (Low/Class 2–3) paleontological sensitivity.

None (SVP)/Class 1 (BLM)—Projects determined by the Qualified Paleontologist to involve ground-disturbing activities in areas mapped as having no paleontological sensitivity (i.e., plutonic igneous or high-grade metamorphic rocks) will not require further paleontological mitigation measures.

Unknown (SVP)/Class U (BLM): All projects involving ground disturbance in previously undisturbed areas mapped as having unknown paleontological sensitivity should retain a Qualified Paleontologist to conduct a field survey of the proposed project area to determine the sensitivity of the geologic units, after which the relevant mitigation measures can be applied.

6.1.3 Paleontological Resources Mitigation Measure 2

In the event of any fossil discovery, regardless of depth or geologic formation, construction work will halt within a 50-ft. radius of the find until its significance can be determined by a Qualified Paleontologist. Significant fossils will be recovered, prepared to the point of curation, identified by qualified experts, listed in a database to facilitate analysis, and deposited in a designated paleontological curation facility in accordance with the standards of the SVP (2010) and BLM (2009). A repository will be identified and a curatorial arrangement will be signed prior to collection of the fossils. Although the San Bernardino County Museum is specified as the repository for fossils found in the county in the current General Plan (San Bernardino County, 2007), the museum is currently not accepting new collections and does not have a paleontological staff. Therefore, any accredited institution may serve as a repository until such time as the SBCM begins accepting new material. The LACM is an alternative to the SBCM for fossil material collected in San Bernardino County.

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