URS

July 20, 2012

Pierre Martinez
Project Manager
Systems Assessment & Facility Siting Division
California Energy Commission
1516 Ninth Street, MS-15
Sacramento, CA 95814

Subject: Applicant's Second Supplemental Data Response, Set 1B (#97)
Rio Mesa Solar Electric Generating Facility (11-AFC-04)

Dear Mr. Martinez:

On behalf of Rio Mesa Solar I, LLC and Rio Mesa Solar II, LLC, collectively the "Applicant" for the Rio Mesa Solar Electric Generating Facility project ("Rio Mesa SEGF"), URS is submitting this Supplemental Data Response to CEC Staff Data Request Set 1B (#97), Revised Geoarchaeological Research Design. This document includes an appendix with Confidential Figures that will be submitted separately under confidential cover. The attachment contains confidential cultural resources locational information; therefore, confidential appendix distribution should be restricted to those with a need to know. This data response supplements the information provided in the initial responses to Data Request #97 in the Applicant's Response to Data Requests, Set 1B (#85-154), docketed on March 28, 2012 and May 29, 2012.

For Staff's reference the following summary indicates to staff where their specific concerns detailed in *Archaeological Resources Evaluation Phase Excavation and Staff Comments to Applicant Response to Data Request No. 96, Geoarchaeological Research Design* are addressed in the attached document.

- **Page 1:** The Applicant would like to provide the following clarifications to Staff's buried archaeological deposit sensitivity characterizations of the following geological contexts (refer to Geoarchaeological Sensitivity Analysis, Section 2.2.4, *Lower Alluvial Fan Piedmont*):

➢ Qa6 = very low to moderate
➢ Qa3 = very low
➢ Qa5 = very low to moderate

Based on these clarifications, the Applicant asserts that evaluation phase excavation of all archaeological sites located within the Qa3 geological context is not warranted. Qa3 fans are correlative to Q2 fans in Bull (1991), which are Pleistocene in age. As such, the Qa3 geological context is too old to contain buried archaeological deposits. Within the Project area, this age correlation is confirmed by the very strong desert pavement development within the Qa3 fan map units. Moreover, the distal margins of the Qa3 fans lack well-developed pavement, but are erosional in nature (i.e., the pavement has eroded away), and, as such, also have very low buried archaeological deposit sensitivity. Therefore, no geoarchaeological trenching has been recommended for Qa3 by the Applicant's Consultant.

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- **Page 3, Comment 1: Staff requests that the Applicant revise either subsections 2.1, *Physiography and Geology*, or 3.1, *Background*, to include an explicit reconstruction of the historical geomorphology of the project area landscape, as it is presently understood, and carry reference to that reconstruction throughout the balance of the revised Research Design attached.**

  The Applicant previously incorporated the requested landscape reconstruction into the Cultural Resources Technical Report (CRTR) under Section 2.2, *Geoarchaeological Assessment*, and Section 2.3, *Geoarchaeological Assessment Findings*. The landscape reconstruction was based on the Geoarchaeological Sensitivity Analysis.

- Additionally, the Applicant provided four copies of the Geoarchaeological Sensitivity Analysis Report to Staff as part of *Applicant's Response to Data Requests, Set 1B (Nos. 85-154)* on March 28, 2012 under confidential cover. The landscape reconstruction is summarized in Section 2.1, Table 2, *Summary of Geoarchaeological Sensitivity of Landforms* and described in detail in Section 2.2, *Findings* of the Geoarchaeological Sensitivity Analysis.

- To facilitate Staff's review, as requested subsection 3.1, *Background* of the revised Research Design has been revised to incorporate the requested landscape reconstruction.

- **Page 3, Comment 2: Staff requests that the Applicant provide a simple graphic overlay of the portions of the proposed project area where ground disturbance will exceed one meter in depth over a landform map. Staff asserts that this map would markedly narrow the geographic area under consideration in the revised Research Design attached.**

- The requested map (Figure 1) has been included in subsection 1.1, *Project Description* of the attached revised Research Design. Ground disturbance will exceed one meter in depth at the following locations: the power block for each solar plant, the common area, each heliostat footing, and the areas along both sides of the main access road that will include trenching for utilities. The maximum depth of ground disturbance on the project site will be 3 meters.

- **Page 3-4, Comment 3, Paragraph 1: Staff asserts that the Applicant's Geoarchaeological Sensitivity Analysis ascribes dates to the landforms shown in Figure 1 of the revised Research Design attached, which appear to come from a number of sources, none of which appear to have been subject to hard verification in the project area.**

- The Applicant would like to bring Staff's attention to the new subsection 3.1.1.3, *Geoarchaeological Assessment Methods* in the revised Research Design attached, which briefly describes the methods used during the hard, visual field verification completed in 2011. The following excerpt is of particular note:

- "*The mapping and assumptions were verified and modified during an initial field reconnaissance through on-the-ground examination of the landscape and key indicators, such as superposition, relative slope, desert pavement development, and subsoil formation. Subsurface examination within the project area was limited to natural exposures within existing washes and drainages*."

- Field correlations were made based on concrete geomorphic/pedogenic indicators of time, such as degree of desert pavement formation, pavement varnish, and calcium carbonate accumulation. These indicators are valid on the gross millennial scale required for making broad landform correlations. Additional refinement of dates on those units determined to be of late Pleistocene to youngest Holocene in age will be completed as part of the additional phase of geoarchaeological research that is described in the attached revised Research Design. In sum, the Geoarchaeological Sensitivity Analysis was not a desktop study; it included field verification of preliminary landform identifications within the project area.

- **Page 4, Comment 3, Paragraph 1 (continued): Staff asserts that no explanations were provided about which landforms the applicant mapped and the basis for the correlation of those landforms with the local and regional landforms mapped and analyzed by others**.

  The Applicant would like to bring Staff's attention to the new Table 3.1-2, *Summary of Geoarchaeological Sensitivity of Landforms within the Project Area* and described in detail in Section 3.2, *Project Landscape Reconstruction* in the revised Research Design attached. The explanations are included in this table and section.

- **Page 4, Comment 3, Paragraph 2: Staff indicated that they were unable to find in the attached revised Research Design any explicit research questions or sampling strategy to facilitate the development of refinements to our understanding of the variability, across each pertinent landform, in landform structure, which reflects the depositional history and the particular energy trajectory that led to the formation of each landform, pertinent landforms being those young enough or of a processual origin where the potential exists for buried archaeological deposits**.

  The Applicant would like to bring Staff's attention to Section 3.4, *Research Issues* of the attached revised Research Design. Some clarifying introductory language has been added to this section and a subsection titled 3.4.1, *Research Questions* and clarifying introductory language has been added to indicate where the Applicant included the research questions.

  Additionally, Section 4.1, *Field Methods* has been expanded to include a new subsection titled 4.1.1 *Sampling Strategy* has been added to indicate where the Applicant included the sampling strategy.

- **Page 5, Comment 4, Paragraph 1: Staff requested that the Applicant increase its sample size from nine, five-meter-long trenches (Staff assumed 1 m wide x 4 meters deep x 5 m long x 9 trenches = 180 cubic meters of stratigraphic excavation) to thirty-six 15-to-20-meter –long trenches (Staff assumed 1 m wide x 4 meters deep x 15 m long x 36 trenches = 2,160 cubic meters of stratigraphic excavation).**

  The Applicant instead proposes to increase its sample size to 20 five-meter-long trenches (1 m wide x 3 meters deep x 5 m long x 20 trenches = 300 cubic meters of stratigraphic excavation), with the option to increase the sample size up to a maximum of 36 five-meter-long trenches (1 m wide x 3 meters deep x 5 m long x 36 trenches = 540 cubic meters of stratigraphic excavation) should the data needed to answer the research questions in the attached revised Research Design are not encountered in the 20 trenches.

  Additionally, the maximum horizontal exposure of the trenches will certainly be larger than the basic working assumption (1 m wide) used above to calculate cubic meters of stratigraphic excavation. This is due to the nature of the benched excavation practices used for compliance with OSHA standards and directives related to trenching and excavation. Benching is a method of protecting workers from cave-ins by excavating the sides of an excavation (e.g., a trench) to form one or a series of horizontal levels or steps, usually with vertical or near vertical surfaces between levels. All estimates of cubic meters of stratigraphic excavation should be used as an estimate of the minimum that will be exposed.

  Moreover, excavating longer trenches per the Staff's request will not provide any additional relevant data, beyond what will be observed in a shorter 5 m long trench. In seeking to understand the variability and formational history of the latest Pleistocene to Holocene landforms on the scale of the landform itself the only observations necessary to derive this information come from documenting a small window at each location along the trench sidewall. Conversely, long trenches are beneficial for identifying discrete geomorphic/geologic features, such as faults, but yield only additional redundant data from that same location in terms of understanding the larger landform's variability and formational history.

  The Applicant's new proposed sample size of 20 trenches has been included in subsection 4.1.1, *Sampling Strategy* in the attached revised Research Design.

- **Page 5-6, Comment 4, Paragraph 2: Staff requested that Section 4.1, *Field Methods* be revised to clarify the protocols for the observation and documentation of each trench as recommended by Staff**.

  The Applicant implemented all of Staff's recommendations in subsection 4.1.2, *Fieldwork Protocols* with two exceptions. First, the creation of trench profiles will be conducted from the ground surface, not from within the trench, for safety reasons and for compliance with OSHA standards and directives related to trenching and excavation For the Applicant's Contractor to safely enter the trench, the trench must be shored using hydraulic speed shoring, which obscures the visibility of the trench profiles.

Second, the maximum amount of radiocarbon samples will not be modified from 6 to 75. Correlations can be made between units observed in the different trenches based on pedogenic and depositional indicators. Only a few radiocarbon dates would be necessary to establish a time scale for these correlated depositional units and to confirm the correlation.

For your convenience, we have provided both a "track changes" and a changes-accepted version of the revised Geoarchaeology Research Design. We look forward to discussing the document at the August 2nd CEC Workshop.

Sincerely,

Angela Leiba, Vice President
Senior Project Manager/ Environmental Department Manager

Arleen Garcia-Herbst, C.Phil., RPA
Cultural Resources Team Manager

Enclosure

cc: POS List
Project File

DRAFT

GEOARCHAEOLOGICAL RESEARCH DESIGN BRIGHTSOURCE ENERGY, INC: RIO MESA SOLAR PROJECT RIVERSIDE COUNTY, CALIFORNIA

Prepared for

Bright Source Energy, Inc.

URS Project No. 27652105.00505

Jay Rehor, M.A.
Principal Investigator

July 2012

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SECTION 1 INTRODUCTION

A Geoarchaeological research design has been prepared to guide fieldwork and the documentation of potential impacts upon cultural resources within the BrightSource Energy, Inc. Rio Mesa Project (RM; also referred to as Project) Area of Potential Effect (APE). Information presented in this research design will govern the geoarchaeological study related to the Project APE. The primary purpose of this research design is to disclose the overall approach the Project will take to comply with state and federal regulations regarding the protection of cultural resources, specifically potential buried cultural resources. In addition, the research design provides the overarching guidance for identification efforts of extant landforms and their potential for subsurface cultural resources.

The content of this research design will include the project description, the definition of the Geoarchaeological Study APE, the fieldwork methods, and the research design, which is intended to guide the identification of potentially archaeologically sensitive landforms and, ultimately, the preliminary evaluation of associated potentially significant cultural resources. The research design is intended to address a range of geomorphic features that occur within the Project APE and provide a preliminary basis for determining the possible presence of subsurface cultural resources.

The Geoarchaeology Study will be based on the direct observation of geotechnical trenches and borings completed as part of a geotechnical evaluation of the project site. A cultural and paleontological monitor will also be present to observe all excavations and identify and document any cultural or paleontological resources discovered by the excavation.

Upon the completion of the field work, a Geoarchaeological Technical Report (Technical Report) will be prepared and submitted to the CEC and BLM for review. The primary purpose of the Technical Report will be to provide, for review by the CEC and BLM, the results of the study and initial conclusions regarding the potential for the Project to affect buried cultural resources. The Technical Report will serve as the data response for the CEC. The CEC will be responsible for submitting the data response to the BLM if deemed appropriate.

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Additionally, a Paleontological Letter Report will be prepared and submitted to the CEC and BLM for review which will summarize the testing results for all areas as part of Data Request 128.

Lastly, buried archaeological deposits found during the trenching activities will be recorded on DPR 523 forms by the Cultural Monitor. Formal evaluation of site eligibility and/or data recovery is beyond the current scope. The geoarchaeological study is not designed to assess the eligibility of buried archaeological sites identified during trenching. Additional scoping and consultation with the CEC and BLM will be necessary to complete a Phase II analysis of any identified archaeological deposits.

1.1 PROJECT DESCRIPTION

The project site is located in Riverside County approximately 13 miles southwest of Blythe, California (Figure 1). The Project will consist of two solar plants: the southernmost plant will be known as Rio Mesa I and the northernmost plant will be known as Rio Mesa II. The plants will be constructed in separate phases. Rio Mesa Solar I, LLC and Rio Mesa Solar II, LLC, the owners of the two separate solar plants, are jointly known as the "Applicant."

Each plant will include a power block area surrounded by an array of approximately 85,000 heliostats, and will require approximately 1,850 acres (or 2.9 square miles) of land to operate. The nominal capacity of each solar plant will be 250 megawatts (MW), for a total Project nominal output of 500 MW. Certain facilities for the Project will be shared by the two plants and located in a common area. These facilities will include a combined administration, control, maintenance, and warehouse building, and mobile equipment maintenance facilities for the maintenance crew and operators. The total area required for both plants, including the common area, is approximately 3,805 acres.

The Project will deliver power at 220 kilovolts (kV) to Southern California Edison's (SCE's) Colorado River Substation (CRS), located approximately 9.7 miles to the northwest. From the plant switchyards, power will be transmitted underground, at 220 kV, to the Project switchyard (located in the common area).

1.2 FEDERAL AND STATE AGENCIES

BLM will be the lead agency under the National Environmental Policy Act (NEPA), since the road access and transmission line are proposed on federal lands managed by BLM. The California Energy Commission (CEC) is the lead agency under California Environmental Quality Act (CEQA) and has a certified regulatory program under CEQA. This work plan has been designed to accommodate both the CEC/BLM Memorandum of Understanding (MOU) and the separate permitting requirements of CEC and BLM, should the processes be separated. Per the CEC-BLM MOU, the Technical Report will be reviewed and approved exclusively by the BLM.

1.3 AREA OF POTENTIAL EFFECT (APE)

The geoarchaeological study APE is currently assumed to be equivalent to the Archaeological APE or direct effects APE. The delineation of cultural resources survey areas was determined based on the CEC Rules of Practice and Procedure and Power Plant Site Regulations and Designation of Transmission Corridor Zones, Appendix B (g)(2)(C) (CEC 2008). For the purpose of this Project, the geoarchaeological survey areas also are equivalent to the Archaeological APE found in the BLM 8100 Manual, and are in compliance with the Section 106 process [36 CFR §800.16 (d)].

SECTION 2 ENVIRONMENTAL SETTING

2.1 PHYSIOGRAPHY AND GEOLOGY

The project area is bounded to the south and west by the volcanic and plutonic rocks that form the Mule Mountains, to the north by an extension of the Chuckwalla Valley that separates the Mule and McCoy Mountains, and to the east by the broad floodplain of the Colorado River. The immediate project area is characterized by gently sloping alluvial fans that emanate from these mountains. Gullies and washes, running approximately west to east, dissect the site, primarily on the north and south sides. The rock outcrops of the Mule Mountains are heavily eroded and mantled by a Quaternary fan piedmont. Alternatively, the Colorado River floodplain is composed of more recent alluvial material deposited by the river. Between these two areas lies the Palo Verde Mesa, which is primarily composed of inset Pleistocene terraces of the Colorado River. All of these Quaternary landforms are comprised of numerous older remnants and more recent deposits of varying ages. Additional information regarding the geomorphological setting and conditions of the Project area can be found in the initial Geoarchaeological Assessment (URS 2011), as well as in subsection 3.1, *Background* below.

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2.2 CURRENT PHYSICAL SETTING

The project area is predominately in a rural setting with land uses that include agricultural (e.g., grains/ hay); historic period military training (e.g., 1942-1944 Desert Training Center or DTC, tank tracks, trenches, and graded areas); dirt roads (e.g., Bradshaw trail, Opal Mine Road, Hodge Mine Road, transmission line road/corridor, and other unnamed unpaved roads); approximately 40 previous ground water test wells and numerous dry well casings; utilities (e.g., four transmission towers and one underground pipeline); and recreational use (e.g., off-highway vehicles [OHVs] and camping). Despite these surficial disturbances, the landscape and topography generally resemble the natural environment.

The following activities are primarily responsible for the previous surface and subsurface disturbance in and adjacent to the project area:

- agriculture,
- historic-period military training (DTC),
- transmission lines and underground gas lines,
- ground water testing,
- recreation use (OHV tracks and camping), and
- road construction, use, and maintenance (e.g., Bradshaw Trail, Opal and Hodge Mine Roads).

SECTION 3 RESEARCH DESIGN

The research design provides a framework and theoretical context for project goals, field methods, discussion and interpretations of geomorphic features, and recommendations for future studies (and data needs). The research design provided herein is for a geoarchaeological study conducted through monitoring of geotechnical borings and geoarchaeological test excavations.

3.1 BACKGROUND

The following discussion is largely focused on identifying those portions of the project area that have the potential for harboring archaeological deposits that do not exhibit surface manifestation. Through the completion of a geoarchaeological assessment a background model of landscape development can be formulated, as can major landforms be identified and mapped. Through this assessment, geological deposits can be dated and conclusions ascertained regarding areas with an increased likelihood of subsurface archaeological deposits. The following sections summarize the project landscape development based on the findings associated with the geoarchaeological assessment conducted for the Project AFC, Cultural Resources Technical Report (Nixon et al. 2011) and Geoarchaeological Sensitivity Assessment (Rehor 2011))

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Per Staff request, the description of quaternary geomorphic landforms and geologic units from Stone (2006)—which was used in conjunction with more detailed metrics outlined in Bull (1991)—is attached for reference to this research design as Attachment 1, and is available in complete form online (http://pubs.usgs.gov/sim/2006/2922/SIM2922_pamphlet.pdf).

Deleted: A preliminary geoarchaeological assessment of the Rio Mesa Solar Project was completed (URS 2011) based on existing geologic studies specific to the Blythe/Palo Verde area (Metzger et al. 1973; Stone 2006). Given the lack of specific geomorphic/geologic mapping for the project area, a preliminary geoarchaeological reconnaissance survey was also conducted, which resulted in a new combined geomorphic map and geoarchaeological sensitivity map. This map is the result of direct observation and correlation with existing mapping of surficial deposits just north of the Project area (Stone 2006), as well as correlation with broader landforms identified throughout the Mojave Desert region (e.g., Bull 1991).

3.1.1 Models of Landscape Development

It has been shown that some alluvial landforms (e.g., desert pavements that have evolved through accretion of eolian silts and sands, and the gradual bearing of larger clasts to the surface) have the potential for containing buried archaeology (Ahlstrom and Roberts 2001). However, a representative portion (if not the vast majority) of these archaeological deposits will be incorporated into the surface pavement through the same accretionary process. Thus, these older surfaces are not likely to contain archaeology that is not at least partially evident on the surface (URS 2010).

Geomorphic processes have played a major role in the differential preservation of archaeological sites in the Colorado and Mojave deserts. For example, early cultural sites related to the San Dieguito and Lake Mojave cultural complexes are almost exclusively known from surface contexts on terminal Pleistocene and Early Holocene geomorphic surfaces (Sutton 1996:229). These early sites are typified by sparse remains on desert pavements, often on mesas and terraces overlooking larger washes or paleo-lake shorelines. Schaefer (1994:64) suggests that "these are zones where a variety of plant and animal resources could be located and where water would at least be seasonally available." However, it is much more likely that this is simply a matter of landscape development since the Late Pleistocene; these mesas and terraces, with well-developed desert pavements, represent the differential preservation of older land surfaces at higher elevations. Older sites are preserved on these relict landforms, with other sites of similar age likely buried by subsequent depositional processes, or destroyed by erosional processes. These same processes have also affected the distribution of resources (i.e., lithic raw material, water, biotic

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communities, etc.) across the landscape and, thus, the placement of archaeological sites in relationship to those resources. The primary factors effecting geomorphic processes in the region are the underlying structural geology and climate change. In addition to these local factors, the Colorado River—affected by extra-regional factors upstream— has had a major impact on landscape evolution within the project area.

Regional climatic trends through the Late Pleistocene and Holocene are important to this current study because of effects on the production of material for alluvial deposition and the concomitant susceptibility of the landscape to erosion. Regional correlations between periods of alluvial fan deposition during the Latest Pleistocene and Holocene indicate that climatic changes superseded other factors as the primary force driving alluvial deposition (McDonald, McFadden, and Wells 2003:203). Within the Mojave Desert, several major intervals of alluvial deposition have been identified and appear roughly correlative across the region, largely transcending geomorphic variation (Anderson and Wells 2003; Harvey and Wells 2003; McDonald, McFadden and Wells 2003). Figure 3.1-1 shows a summary of the timing of these major depositional events across numerous mountain fronts in the Mojave. Insufficient data exists to assess the direct correlation of these events to the Colorado Desert, but, given the broad correlation of climatically induced geomorphic responses throughout California (Meyer et al. 2009), such an assumption is reasonable.

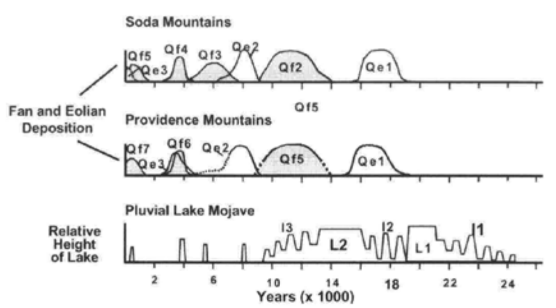

Figure 3.1-1. Correlation of Mojave Desert Geomorphic Events
(Qf designates period of alluvial fan deposition, Qe eolian dune formation, and L pluvial lake highstands; from McDonald, McFadden and Wells 2003:198)

In general, the Pleistocene-Holocene transition, ca. 13,000 to 9,000 years before present (B.P.), represents a major period of fan deposition, followed by subsequent periods during the Holocene at approximately 8,000 to 5,000 B.P., 4,000 to 3,000 B.P., and after approximately 1,500 B.P.. It was initially conjectured that these periods, especially around the Pleistocene-Holocene transition, correlated with general environmental desiccation, a decrease in soil moisture and vegetation, and an increase in sediment supply and erosion (e.g., Bull 1991; Wells et al. 1987). However, recent field studies have demonstrated that changes in vegetation cover alone do not explain increased sediment mobility. Instead, the most plausible hypothesis points towards a northward shift in the dominant late summer/early fall jet stream, allowing tropical Pacific cyclones from southern Mexico into the region and causing unusually large amounts of precipitation over short periods (McDonald, McFadden and Wells 2003:202). A biannual monsoonal weather pattern is still present in the lower elevations of the Colorado Desert, including Palo Verde, where February and August are the two wettest months (Western Regional Climate Center 2011). It is likely that the summer rainy season was more intense during these periods, but precipitation during the remainder of the year would have been similar to the very low levels present today (approximately 2 inches during non-summer months).

Pollen and lake-level records suggest general trends in Late Pleistocene and Holocene climate change, but these records do not make clear what meteorological changes are responsible for the trends. Pleistocene climate was wetter and cooler than today, with extensive lakes (including Ford and Palen lakes northwest of the project area), and pinyon-juniper woodlands extending into much lower elevations (Spaulding 1990). The vegetation transition from the Pleistocene through Early Holocene appears to have been relatively gradual, with woodlands retreating and giving way to desert scrub. During the middle Holocene (ca. 8,000 to 4,000 B.P.) climate appears to have been generally warmer and drier than today, though there are some indications of significant oscillations in climatic patterns (Spaulding 1990), possibly akin to those suggested by McDonald, McFadden, and Wells (2003), that were responsible for the middle Holocene Qf3 fan deposition in the Soda Mountains (see Figure 3.1-1, above). The Late Holocene climate was generally similar to modern conditions. However, given the higher resolution record for this more recent period, it appears that several periods of extended drought (including the Medieval Climatic Anomaly, ca. 1150 to 600 B.P.) as well as at least one cooler wetter period (the Little Ice Age, ca. 600 to 150 B.P.; Grove 1988) marked the Late Holocene.

The project area and lower elevations within the Colorado Desert in general, appear to have experienced vegetation regimes similar to today for most of the Holocene (ca. 11,000 years; Schaefer 1994:60-63). The creosote-scrub habitat that typifies the project area would have been established at lower elevations by the Late Pleistocene, providing prehistoric inhabitants with access to similar natural resources throughout much of prehistory. As discussed above, numerous studies, particularly in higher elevation portions of the Colorado and Mojave deserts, have demonstrated relatively significant climatic, precipitation, and vegetation fluctuations throughout the Holocene (Kaijnkoski 2008). Nonetheless, regional climatic trends through the Late Pleistocene and Holocene are important to the current study because of effects at higher elevations and the production of material for alluvial fan deposition.

Periodic increases in effective moisture likely resulted in higher seasonal wash flow, improving the exploitable habitat for human residents, but also accelerating the geomorphic processes that led to the burial or erosion of archaeological sites. These climatic changes also increased the sediment supply available for wind-blown (eolian) transport on dry lake beds and former stream channels during intervals of decreased effective moisture. Eolian processes deflated sediment source areas and deposited that material elsewhere. Taken together, these processes created, destroyed, and buried landforms that humans may have occupied across the Colorado and Mojave Deserts.

3.1.1.1 Geologic Mapping and Identification of Major Landforms

An in-depth geologic study of the northern portion of the project area was conducted by the United States Geological Survey (USGS). This study included a synthesis and description of geologic units and mapping at a 1:24,000 scale (Stone 2006). This information was incorporated into an online GIS database which was used as the basis for additional geologic mapping for the southern portions of the project area, as shown in Figure 3.1-1. The additional mapping effort was initially conducted through GIS, using aerial and topographic imagery to correlate with the existing mapped geologic units. This mapping was then field verified during a primary field study conducted by URS geoarchaeologist, Jay Rehor, from March 28 to 31, 2010. The purpose of the field study was to verify and modify the desktop mapping effort, assess the veracity of the units previously mapped by Stone (2006) within the project area, and assess those units for geoarchaeological sensitivity through examination of soil profiles and other indicators of landform age and processual development.

By examining the relationship among the landform components, we can develop relative age estimates, conclusions as to the depositional history of that landform, and the potential of each landform to harbor buried paleosols of appropriate age.

Before beginning such a discussion, however, it is necessary to define a common set of descriptive landscape terms and definitions used in the following paragraphs. Many different terms are used to describe desert geomorphology, with vastly different implications of scale, accuracy, and implied formation processes. “Alluvial fan” and “bajada” are two common terms that are often misleading because they are used to refer to different types of depositional and erosional landscapes, and they subsume numerous smaller landform components. The terminology adopted in this study follows after Peterson (1981) because the classification system emphasizes the temporal and spatial relationship between landform components, and was devised in relation to the study and classification of Basin and Range soils, thus making it highly relevant to the current geoarchaeological study. Diagrams showing the basic major landforms are provided in Figure 2.3-2. A discussion of these various landforms is provided in the following sections, with direct reference to the project area and the geologic units classified by Stone (2006).

At the broadest scale, the larger Palo Verde Mesa study area has many features that would classify it as a “semi-bolson” (Figure 3.1-2). Common in desert regions of the Basin and Range, semi-bolsons differ from true bolsons in that they lack a playa or floodplain, on which alluvial fans normally terminate, and instead are cut through by an axial drainage that marks the termination of the various piedmont landforms. However, the Palo Verde semi-bolson is anything but typical, due to the fact that the axial channel is not an intermittent stream or wash as usually found in Basin and Range semi-bolsons, but rather is the Colorado River, a perennial river that has a drainage basin of approximately 250,000 square miles. The Palo Verde Mesa area represents a mixture of typical semi-bolson desert landforms and features that are more typical of semi-arid and sub-humid river valleys. For the purposes of this discussion, we will employ the terminology used by Peterson (1981:30-34) to describe semi-bolson landforms, with some additional terminology more typical of river valleys (e.g., “inset terrace”).

The project area semi-bolson can be further divided into two dominant structural sections. The western half consists of the Mule Mountains and associated coalescing alluvial fan piedmont gradually sloping down to the east. The second dominant structural section is formed by several inset alluvial terraces which form Palo Verde Mesa, and includes the modern floodplain formed by successive aggradations and degradations of the Colorado River. This fluctuation in the base level of the Palo Verde valley has dramatic implications for the preservation of Quaternary deposits. Gradual base level rise in typical internally drained desert basins has favored the burial of Quaternary piedmont deposits by successively younger alluvium. The Colorado River, on the other hand, has experienced net downcutting of over 100 meters during the Quaternary (Bull 1991:50). This downcutting causes a drop in local base level, incision of tributary streams on the piedmont, and promotes erosion and transport of piedmont alluvium to the floodplain (new base level). Backfilling of the river valley, which has likely occurred through much of the Holocene (Metzger et al 1973:G28), gradually increases the base level, but only encourages aggradation and backfilling of the tributary drainages a short distance upslope from the height of the floodplain. The net result of this base level fluctuation is that erosion has played a greater role across the project area than in typical Basin and Range bolsons.

3.1.1.2 Dating Alluvial Desert Deposits

The ages of the various geomorphic surfaces within the project area are of central concern because age is one of the most important factors in constraining the possibility of buried archaeological deposits. Older land surfaces– those that were deposited prior to human occupation in the Americas (ca. 13,000 years ago) and which are still exposed on the surface– have very little possibility of containing buried archaeological deposits. On the other hand, younger land surfaces, if deposited in the right location, with low enough energy, may bury and preserve archaeological material previously deposited on an older surface. However, if these younger deposits unconformably overlie heavily eroded older formations, any archaeology that may have originally been deposited on the older surface would be effectively destroyed. Determining the nature of any subsurface contacts is thus integral to understanding the potential for buried archaeology within the younger landforms.

Unfortunately, dating of desert geomorphic surfaces is difficult and there is significant variation in the precision of various methods used in determining relative and numerical ages (McDonald, McFadden, and Wells 2003:190). Two primary, non-chronometric methods (e.g., not carbon-14, thermo-luminescence, etc.) are used for determining the age of desert landforms: soil development and desert pavement development. Figure 3.1-3 provides a graphic representation of pavement and subsoil horizon development through time in desert environments. Both of these methods are heavily dependent on environmental factors, such as temperature, precipitation, and parent material. As such, they are most effective within a confined homogeneous area.

Early investigations into the development of desert pavements hypothesized that they were formed through fluvial and eolian erosion of fine-grain sediments, leaving a deflated lag deposit of coarser material at the surface (Cooke 1970). More recent work– particularly on volcanic lava surfaces where fine-grain alluvial sediments are largely absent– indicates that desert pavements are instead formed through a process of fine-grain eolian sand and silt accretion (Wells et al. 1995). As dust blows onto a surface, it accumulates between larger surface clasts and, over time, infiltrates below the clasts and causes them to “float” on a fine-grain layer that thickens over time. This process may partially explain the upper vesicular A-horizon (see below) noted in most older desert soils. However, erosion may still play a role in the formation of pavements in some contexts, such as eolian dune complexes (McAuliffe and McDonald 1995:61-62).

While desert pavement formation is dependent on factors of time and climate, parent material also plays a major role. In general, alluvium derived from plutonic (e.g., granitic) sources form much weaker pavement– with fewer interlocking stones and less evident varnish– than volcanic and limestone sources (McDonald, McFadden, and Wells 2003:193). Along a Mojave Desert mountain front, it was determined that “minimal, if any, pavement formation occurs on alluvial fan surfaces in the granite-derived piedmont, regardless of age” (Eppes, McDonald, and McFadden 2003:109).

Given these factors, perhaps a more reliable estimate of landform age within the project area is soil horizon development. Due to the time-transgressive nature of soil development in arid environments, the stage of calcium carbonate (CaCO3 or "k") illuviation and development, and the degree of B horizon development are identifiable markers of age. In this study of the project area, the degree of desert pavement formation and calcic horizon formation were used together as indicators of landform age during field studies. In addition, more typical soil classifications were made on the limited exposed profiles in order to assess pedogenic processes at play in the project area.

In general, soils on older Pleistocene alluvium are characterized by a strongly cemented (Stage III), well-developed calcium carbonate B or K horizon (Figure 3.1-4). Conversely, Holocene alluvial fan deposits typically exhibit a bar and swale surface morphology lacking prominent desert pavement development. Early Holocene alluvial fan deposits typically exhibit moderate B-horizon development and Stage II calcium carbonate morphology. Middle to Late Holocene alluvial fan deposits tend to have very weakly developed B horizons and Stage I calcium carbonate morphology. Latest Holocene surfaces, which are generally active washes, exhibit no soil development (Dohrenwend et al. 1991:328; McDonald, McFadden, and Wells 2003:193).

Very few natural subsurface exposures were observed during the field reconnaissance. As such, few soil profiles were recorded and described, and are not discussed extensively in the following analysis. However, a brief review of soil terminology is necessary to allow better understanding of the few figures that contain soil profiles. For this study, master soil horizons were defined using standard United States Department of Agriculture (USDA) soil taxonomy (Soil Survey Staff 2006) and techniques specific to desert soils (Birkeland, Machette, and Haller 1991). This organizational system uses upper-case letters (A, B, C) to describe in-place weathering characteristics. Most horizons and layers are given a single capital letter symbol where: "A" is the organic-rich upper horizon developed at or near the original ground surface; "B" is the horizon formed in the middle of a profile, with concentrations of illuviated clays, iron, etc., and general changes in soil structure; and "C" is the relatively unweathered parent material upon which the other soil horizons formed. These master horizons are preceded by Arabic numerals (2, 3, etc.) when the horizon is associated with a different stratum, where number 1 is understood but not shown, and lower numbers indicate superposition over larger numbers. Lower-case letters are used to designate subordinate soil horizons (Table 3.1-1). Combinations of these numbers and letters indicate the important characteristics of each major stratum and soil horizon from which inferences can be drawn.

Table 3.1-1
Subordinate Distinctions within Master Soil Horizons

Subordinate Horizon	Description
c	Cementation or induration of the soil matrix
k	Accumulation of pedogenic carbonates, commonly calcium carbonate
m	Strong cementation

Table 3.1-1
Subordinate Distinctions within Master Soil Horizons

Subordinate Horizon	Description
Ox	Oxidized iron and other minerals in parent material (C-horizon)
t	Accumulation of subsurface silicate clay (illuviation)
v	Vesicular soil development
w	Development of color or structure with little apparent illuvial accumulation

3.1.1.3 Georchaeological Assessment Methods

Major landforms within the project area were initially identified using both color and black-and-white aerial photography (Microsoft 2010, Digital Globe 2009), in combination with existing geologic maps of the area (Hamilton 1984; Jennings 1967; Metzger, Loeltz, and Irelna 1973; Stone 1990, 2006). Given these designations, certain broad assumptions could be made about the age and depositional history of each portion of the project area. The mapping and assumptions were verified and modified during an initial field reconnaissance through on-the-ground examination of the landscape and key indicators, such as superposition, relative slope, desert pavement development, and subsoil formation. Subsurface examination within the project area was limited to natural exposures within existing washes and drainages. Due to the gradient of these drainages, the majority of exposures were present in the eastern portions of the project area and diminished to the west. The majority of the drainages in the western portions of the project area are relatively small with only minor incision. No archaeological material was observed in any of the subsurface exposures.

The combined results of this study are shown in Figure 3.1-5 and summarized in Table 3.1-2. The following paragraphs provide a discussion of these results.

Table 3.1-2
Summary of Geoarchaeological Sensitivity of Landforms within the Project Area

Geologic Map Unit	Landform	Age	Depositional Regime*	Sensitivity
TRqm, TRd, Tv, Pgn, Jp, Jv	Rock Outcrops	Tertiary or older	Erosional	None
QTmm and QTa2	Upper Alluvial Fan Piedmont	Early Pleistocene or older	Erosional	None
QTmw	Relict Colorado River Gravel Terrace	Pliocene to Pleistocene	Erosional	None

Table 3.1-2
Summary of Geoarchaeological Sensitivity of Landforms within the Project Area

Geologic Map Unit	Landform	Age	Depositional Regime*	Sensitivity
Qa3, Qa5, and Qa6	Alluvial Fan Piedmont	Pleistocene to Late Holocene	Variable	Very Low to Moderate
Qpv	Colorado River Terrace	Pleistocene	Erosional	Very Low
Qs, Qa6	Alluvial Flat	Late Holocene	Depositional	Moderate to High
Qw	Active Washes (and associated minor landforms)	Pleistocene to Holocene	Erosional	Low
Qm	Modern Alluvial Fan	Recent	Depositional	Moderate to High
Qr	Floodplain	Holocene	Depositional	Moderate to High

3.2 PROJECT LANDSCAPE RECONSTRUCTION

The following sections summarize the project landscape reconstruction based on the findings associated with the geoarchaeologial assessment conducted for the Project AFC, Cultural Resources Technical Report (Nixon et al. 2011) and Geoarchaeological Sensitivity Assessment (Rehor 2011).

3.2.1 Rock Outcrops (Sensitivity: None)

Rock outcrops are present at the higher reaches of the piedmont, along the western side of the project area (Figure 3.1-5 and Figure 3.1-6). These rock outcrops form the Mule and Palo Verde Mountains and are composed of highly dissected bedrock that form steep, highly-eroded hills (inselbergs) sticking up out of the alluvial fans. Within the project area, rock outcrops are limited to the northwestern portions of the project site (Section 16) and are comprised of Triassic quartz monzonite and monzodiorite, designated by map unit TRqm (Stone 2006). While other types of bedrock that form the Mule Mountains are not present within the boundaries of the project area, they are worth noting because they provide portions of the parent material that forms the fans of the alluvial fan piedmont. These other local rock types include gneiss and amphibolite (Pgn), diorite and gabbro (TRd), porphyritic granitics (granodiorite and quartz monzonite; Jp), and volcanics (including rhyolite, dacite, and amphibole; Jv). Rock outcrops have little or no potential for harboring buried archaeological deposits.

3.2.2 Upper Alluvial Fan Piedmont (Sensitivity: None)

The fan piedmont, which makes up the majority of the western half of the project area and the slopes west of the project area (Figure 3.1-5), is actually a complex of component landforms composed of stable fans, erosional fan remnants, erosional sideslopes, gullies, and inset fans, which themselves have been further eroded and redeposited downslope. The fan piedmont can be subdivided into two broad categories, which are roughly correlative with relative age: the older upper alluvial fan piedmont and the younger lower alluvial fan piedmont.

The oldest major alluvial fan structure on the piedmont is also associated with the highest elevations of the fan piedmont. Map units QTa2 and QTmm (only a very small portion of which enters the ROW corridor in the northern portion of the project area) are very old remnant alluvial fan deposits. These units have steep gradients adjacent to the mountain fronts and form heavily eroded ballenas, fan remnants having a distinctively-rounded surface of fan alluvium, as they move away from the mountains. Although some very well-developed desert pavements may be preserved at the crest of the ballenas, the majority of the shoulder, sideslope, and footslopes have been heavily eroded and no longer preserve the original pavement surface. Profiles observed on the sideslopes of these units showed significant over-thickened carbonate development (Stage III+), though the amount of carbonate accumulation may be less than the equivalent age of the landform due to ongoing erosion. Stone (2006:11) concludes that the units are probably equivalent to the geomorphic surface Q1 of Bull (1991), which are presumed to have been deposited over 1.2 million years ago (Ma). As such, the QTa2 and QTmm units of the upper alluvial fan piedmont are assumed to have no potential for buried archaeological resources.

3.2.3 Relict Colorado River Gravel Terrace (Sensitivity: None)

Located within the fan piedmont, this landform in many ways resembles a remnant alluvial fan deposit, with very well formed desert pavement at the surface, and rounded erosional sideslopes similar to the older fan units. However, this landform, designated by map unit QTmw, is composed of large, well rounded gravels and cobbles. The clasts are almost exclusively non-local rock types, with a wide variability including cherts and other silicious rocks, cryptocrystalline quartzites and mudstones, and only minor amounts of gravels derived from the Mule Mountains. This rounded cobble and gravel deposit is identical to the one identified by Stone (2006) in the McCoy Wash area approximately 12 miles (approximately 19.3 kilometers) north, and at almost the exact same elevation approximately(443 to 476 feet (135 to 145 meters) above mean sea level [AMSL]). The well rounded cobbles and their exotic origin clearly demonstrate that they were deposited by the paleo-Colorado River during an aggradational event when the river flowed at much higher elevations than today. Superposition above Palo Verde Mesa indicates that the formation predates the incision and subsequent emplacement of the Qpv river terrace (see Figure 3.1-5). This relict Colorado River gravel terrace may represent the upper portion of Metzger et al's Unit B; if so, the landform likely dates to the Pliocene or early Pleistocene (Metzger et al. 1973:G22; Stone 2006:12).

As noted above, the surface characteristics of this landform appear similar to an older Pleistocene fan, suggesting that the original Colorado River gravel deposit was likely subjected to post-depositional erosion followed by stabilization sometime during the Pleistocene—perhaps correlative with the deposition of the Palo Verde Mesa (Qpv) alluvium. The rounded gravels and cobbles of the relict Colorado River terrace have been reworked and redeposited, to varying degrees, in the younger alluvial fan units of the lower fan piedmont. Some higher elevation portions of the Qa3 fans have mantled on top of the QTmw terrace (Figure 3.1-6), while other portions have eroded through and bisected the terrace, thus transporting the rounded cobble material further downslope. Based on limited field observations, these redeposited cobbles appear to have been the primary source for lithic artifacts identified on the Qa6 (and to a lesser degree Qa3) fans. Due to the age of the landform, the relict Colorado River gravel terraces are presumed to have no sensitivity for buried archaeological resources, although some artifacts have been incorporated into the desert pavement surface of the landform and are likely of considerable antiquity.

3.2.4 Lower Alluvial Fan Piedmont (Sensitivity: Very Low to Moderate)

The lower portions of the alluvial fan piedmont within the project area are composed of geologic units Qa3, Qa5, and Qa6. Each of these units represents a period of fan building. These periods have coalesced to form the fan piedmont. Compared to the older upper portions of the piedmont, these fans form a more gradual slope. These Late Pleistocene to Late Holocene alluvial fans are equivalent to Q2, Q3, and Q4a units of Bull (1991).

Qa3 is the oldest of the lower piedmont fan units. These fans are typically covered with a smooth, well varnished desert pavement composed primarily of angular to subangular locally derived gravels and cobbles. The landform generally lacks evidence of bar and swale topography, but is heavily dissected in places by erosional gullies and channels. Figure 3.1-7 shows a typical surface pavement for the Qa3 fans, though the degree of desert varnish is inconsistent due to variability in parent material across the Mule Mountains and variability in timing of deposition (i.e., Late Pleistocene to earliest Holocene). Vegetation is largely absent except in the erosional gullies. Stage II to III carbonate development is evident in the limited subsurface profiles observed on the Qa3 fans within the project area.

The Qa3 fans likely formed roughly coincident to the emplacement of the Palo Verde mesa alluvium (Qpv; see below) and prior to subsequent incision by the Colorado River. The Qpv alluvium was deposited as the floodplain of the river, and, as such, acted as the local base level at the time the Qa3 fans were deposited. This is demonstrated by the interfingering of Qa3 and Qpv sediments (Stone 2006:11). As such, the Qa3 fans were primarily deposited during the Pleistocene, prior to the incision of the Colorado River below the Qpv terrace deposits (see below). This correlates with Bull's (1991) Q2 fan units which date from 12 to 730 thousand years ago (ka). The fans are primarily as old as, or older than, the first documented evidence for humans in the New World, and, as a result, have a very low potential for buried archaeological deposits.

Qa5 is the next youngest fan unit present on the alluvial fan piedmont within the project area. The unit is not well represented within the project area, but is gradational to the older portions of the Qa6 fan unit (i.e., some minor areas mapped as Qa6 may be closer to Qa5 in both morphology and age). These fans are typified by bar and swale morphology that decreases in intensity further from the apex of the fan. The fans are only partially dissected by erosional gullies and have a weak to moderately packed surface pavement with light varnish. The bars are dominated by gravels while the intervening swales are dominated by smaller pebbles and sands that have infilled the original channels. Vegetation is larger within the swales, but also present on some bars. Subsurface profiles observed within the project area have Stage I to weak Stage II carbonate development. This morphology and subsurface carbonate accumulation is equivalent to Bull's (1991:86) Q3c and Q3b fan units which date from 2 to 8 ka.

It is difficult to assess the sensitivity for paleosols and associated buried archaeological deposits without knowing the nature of the stratigraphic contacts between the Qa5 alluvial fans and any underlying older geomorphic units. No paleosols were noted in any of the natural exposures observed in the project area. Based on previous studies in the Basin and Range, alluvial fans are often underlain by an erosional unconformity that precedes deposition of the fan (URS 2010; Bull 1991:68, 73). This effect is less pronounced at the foot of the fans, where sediments are usually more fine-grained and erosional/depositional energy is lower. As such, the Qa5 portions of the fan piedmont are presumed to have a generally low sensitivity for buried archaeological resources, with slightly increased (moderate) sensitivity at the distal margins of the fans, where they mantle older deposits of the Palo Verde Mesa (Qpv; see below).

Qa6 is the youngest fan unit represented on the alluvial fan piedmont. As discussed above, this unit is gradational to the Qa5 unit, but generally exhibits a morphology that is indicative of a younger geomorphic surface. This includes a surface that exhibits bar and swale morphology grading to recently abandoned bar and channels in some locations. Surfaces closer to the Mule Mountains and older fan units are characterized by loosely packed cobbles, coarse gravels, and sands, while the distal portions of the fans are dominated by finer grained sediments (pebbles and sands; Figure 3.1-8). Little or no varnish is present. Vegetation is present across the fan surface, but varies from sparse to moderately dense. Subsurface profiles exhibit Stage I carbonate development or none at all. This morphology and subsurface carbonate accumulation is consistent with Bull's (1991:86) Q4a fan unit which dates to 0.1 to 2 ka, but may be more similar to Q3c (2-4 ka) in places. Sensitivity for buried archaeological resources is presumed to be similar to that of the Qa5 map unit.

Within the majority of the project area—except for the northwestern extent of the transmission line and substation alternatives where the fan piedmont grades out to a broad alluvial flat (see below)- the Qa6 fans terminate at a topographical barrier created by the Palo Verde Mesa. In profile, the western extent of the mesa crests and then forms an almost imperceptible backslope (dipping to the west; Figure 3.1-9). This backslope was likely created through erosion rather than tectonic tilting, as tectonic activity is thought to have been dormant in the area prior to emplacement of the Colorado River sediments (Metzger et al. 1973:G36). In many locations, a very small erosional gully has formed at the contact between the toe of the Qa6 fan and the backslope of the Palo Verde Mesa, draining north or south to the nearest active wash (Qw; see below). This distal margin contact of the Qa6 fan represents the most likely location for preservation of paleosols.

3.2.5 Colorado River Terrace (Sensitivity: Very Low)

Palo Verde Mesa, which forms the 70-foot-high cliff along the edge of the modern Colorado River floodplain (Palo Verde Valley), is the result of a series of aggradation and progradation events by the paleo-Colorado River. A diagram of the series of events that led to the multiple terraces and floodplain landforms observed today in the Palo Verde region was developed by Metzger et al. (1973:Plate 4) and is reproduced here in Figure 3.1-5. The landform mapped here as a Colorado River terrace and designated by map unit Qpv (Figure 3.1-2) is equivalent to Units D and E of Metzger et al. (1973:G24). The break in slope in the middle of the Palo Verde Mesa, evident in cross section (Figure 3.1-5), is designated by the dotted line on Figure 3.1-5.

The Colorado River terrace deposits are characterized by a very thick deposit of stratified clays, silts, and sands, with minor gravels. The surface of the landform is characterized by tan to light-gray, sandy and pebbly alluvium. This overlies the cliff-forming unit of light-reddish-brown bedded fine-grained material. There is considerable variability in the surface expression of the terrace deposits, with some areas containing sand and pebbly sand with a mixture of local and river gravels (equivalent to Unit E of Metzger et al. 1973), and other areas largely lacking clasts (equivalent to Unit D; Figure 3.1-10). The terrace deposits mostly devoid of the bar and swale morphology of the younger fan units, but are minimally dissected by erosional gullies. An extensive marker bed, consisting of well-developed, blocky red clay, was observed in several of the larger wash profiles near the top of the Qpv strata (Figure 3.1-11). This bed is consistent with other locations along Palo Verde Mesa where vertebrate Pleistocene fossils have been found and that are interpreted as having been deposited in small, shallow floodplain lakes (Metzger et al. 1973:G25).

Due to the unconsolidated, fine-grain nature of the surface of this landform, it is often very difficult to distinguish Qpv in the field from the distal margins of the Qa6 alluvial fans. The surface of the Qpv terrace deposits have begun to erode down into underlying pedogenic carbonate soil horizons in some locales. As a result, small carbonate pebbles have eroded out and been incorporated into the surface of the landform. These carbonate pebbles, or peds, are absent on the Qa6 fans. The change in slope between the backslope of the terrace deposits and the distal edge of the Qa6 fans, described above (and shown in Figure 3.1-9), is readily identifiable in the GIS and is, perhaps, the best means of identifying the contact.

The Colorado River terrace deposits have been assigned a date of middle to Late Pleistocene based on the presence of fossils (Metzger et al. 1973:G25). As such, they are considered too old to contain buried archaeological deposits. The only caveat to this assessment lies in the unconsolidated nature of much of the Qpv surficial deposits. While these unconsolidated fine-grain deposits are conducive to erosion and transport into the larger washes and off of the Palo Verde Mesa, it is also possible that some of this transported material has been redeposited on the mesa surface as thin eolian and/or alluvial deposits. Such deposits observed within the project area are limited (1 to 2 meters across) and are generally very thin (a few centimeters). While there is potential that these areas of redeposited fine-grain sediment could obscure archaeological deposits, it is unlikely that they would completely obscure an archaeological site. Furthermore, buried artifacts and/or features are likely to be similar to those found across the rest of the site. As such, the Colorado River terrace landform of Palo Verde Mesa has a very low sensitivity for buried archaeological resources.

3.2.6 Alluvial Flat (Sensitivity: Moderate to High)

The alluvial flat, located in the northwestern portion of the project area near the transmission line and substation alternatives, represents the eastern extent of the Chuckwalla Valley. The majority of the alluvial flat is composed of the distal portions of the Qa6 fans. As such, this area could also be considered an apron of the lower fan piedmont. However, alluvial flat is preferred here because it describes the properties of the geomorphic surface– a nearly level alluvial surface at the base of the piedmont– without assuming genesis from a single parent landform, and without inherent morphological assumptions. Within this area, the Qa6 fan surface is composed of primarily fine-grain material with limited gravels and little or no relief. Also present on the alluvial flat are areas that have been mapped as eolian sands (Qs). These are unconsolidated sand dunes and sheets that have blown east from the Chuckwalla Valley and Ford Dry Lake, and mantle the Qa6 alluvial deposits. Areas mapped as Qs on Figure 2.3-7 are dominated by these recent sand deposits. Smaller areas of eolian sand occur locally in other portions of the alluvial flat but have not been mapped due to their limited areal extent.

As with other portions of the distal Qa6 fans and Palo Verde Mesa river terrace deposits, differentiation between the two units can be difficult in the northwest portion of the project area. This is further complicated by the presence of eolian sands that, when deposited as a small, thin sheet, are similar to the unconsolidated, fine grain portions of the river terrace landform. The alluvial flat generally is a very young landform at the surface. The flat, distal portions of the lower alluvial fan piedmont are presumed to be dominated by the latest Holocene alluvium, while the eolian sand that mantles it is even younger. No subsurface exposures were observed within the alluvial flat, thus, the presence and condition of any paleosols is unknown. However, the geoarchaeological sensitivity is considered to be similar to those portions of the Qa6 fans that mantle the Palo Verde Mesa terrace deposits (i.e., moderate). A higher sensitivity can be assumed for those areas mapped as Qs, as these are very recent deposits that can easily obscure surface artifacts. Small unmapped areas of eolian sand, while potentially obscuring isolated artifacts or features, are small and thin enough that they are unlikely to obscure complete sites. Any sites obscured by Qs deposits are likely to be relatively young (less than ca. 1 ka) due to the age of the underlying Qa6 deposits.

3.2.7 Active Wash (Sensitivity: Low)

This landform, mapped as unit Qw, is comprised of unconsolidated sand, gravel, and boulder deposits of the larger active channels, as well as component landforms related to the active channel. While the active wash is primarily an erosional structure, small depositional features, such as inset fans and terraces and fine overbank deposits, are the result of deposition by the channel and are subsumed in this map unit. The active washes are dominated by gravel bar and sandy channel surface morphology (Figure 3.1-8). Mapped areas include both large individual washes and closely spaced smaller washes. Vegetation within the washes is greater than anywhere else in the project area due to the greater availability of water. The active washes are modern in age, equivalent to the Q4b geomorphic surface of Bull (1991), but, for the most part, have no sensitivity for buried archaeological resources as the result of ongoing active erosion.

Certain minor component landforms of the active washes are depositional. The largest of these component landforms are the inset fans or stream terraces. These landforms are created through deposition along the margins of the active channel, and are confined by the channel and adjacent older higher elevation landforms (e.g., the erosional sideslope of Qpv or Qa3). Although these component landforms are young and depositional in nature, they are generally considered to have a low potential for paleosols and associated buried archaeological resources due to their deposition on an erosional unconformity. As demonstrated on Figure 3.1-9, the inset fans and terraces of the active washes are laid down in areas that were previously scoured by the active channel—thus creating an unconformity and significantly reducing the likelihood of preservation of archaeological resources. In general, the active washes and component landforms are considered to have a low sensitivity for paleosols and associated buried archaeological deposits.

3.2.8 Modern Alluvial Fan and Floodplain (Sensitivity: Moderate to High)

These distinct landforms are discussed together here because of their close functional relationship and because they both have very limited presence within the project area. Modern alluvial fan deposits are mapped as Qm and represent the depositional equivalent of the active washes, where the washes débouché from the Palo Verde Mesa onto the modern alluvial floodplain of the Colorado River. The modern floodplain deposits are mapped as Qr. Both units are composed of unconsolidated clay, silt, and sand, and are largely undifferentiable in the field due to the interfingering of the deposits and the degree of agricultural disturbance across the Palo Verde Valley up to the base of the mesa. For the purposes of this study, the modern alluvial fan landform was mapped from the edge of Palo Verde Mesa to the beginning of agricultural fields. Due to the young age of both of these landforms (latest Holocene to modern), and their depositional nature, they are considered to have a high potential for containing paleosols and associated buried archaeological resources.

The modern floodplain deposits (Qr) represent the most recent aggradational cycle of the Colorado River, and are equivalent to “younger alluvium” defined by Metzger et al. (1973) (Figure 3.1-5). The scale of the river’s degradation and aggradation is demonstrated by the presence of charcoal from 57 feet (± 17.4 meters) below the floodplain sediments near Blythe that was dated to 5,400 before present (BP), and to 8,600 BP from 110 feet (± 33.5 meters) below surface (Metzger et al. 1973:G28). If the surface of the Palo Verde Mesa terrace deposits (Qpv) represent the Late Pleistocene floodplain surface, this means that well over 200 vertical feet (± 61 meters) of sediment was eroded out of the Palo Verde Valley during the Late Pleistocene, and over 100 feet (± 30.5 meters) of sediment has filled the entire Blythe-Palo Verde Valley since the river began to aggrade again at the onset of the Holocene. In many ways, the scale and rapidity of this deposition precludes the accumulation of large stratified archaeological sites, and suggests that buried archaeological sites are more likely to be smaller, temporally discreet deposits. Nonetheless, the potential for paleosols and buried archaeological deposits is considered to be high.

Buried sites within the modern floodplain are likely to be located within close proximity to paleo-channels of the Colorado River. It has been well documented throughout California that sites tend to cluster near important resources, such as rivers and lakes, and the effect is only heightened in arid environments where water is a highly valuable resource. The same is true in buried contexts (Meyer et al. 2009). Therefore, the identification of archaeological deposits within the modern fan and floodplain landforms will be facilitated by the identification of paleochannel deposits. These deposits will be characterized by coarser grain channel bed forms that are distinct from the surrounding fine-grain alluvium. These paleochannels are more likely to be located within the body of the floodplain than on the margins. Therefore, the geoarchaeological potential of the Qr and Qm deposits within the project area (i.e., directly adjacent to Palo Verde Mesa) may be diminished compared to other locations further afield in the floodplain.

3.3 SUMMARY

The field verified findings from this geoarchaeological study of the Rio Mesa SEGF project area are consistent with previous findings from the other Basin and Range contexts. In a recent summary of the nearby Mojave Desert region, Sutton (1996) concludes that, contrary to the popular belief that all archaeological sites exist in surface contexts, “there are… many depositional environments [within the Basin and Range], and there is a great potential for buried sites in many areas… e.g., along the Mojave River, along lakeshores, and in cave sites” (1996:225). Given results from other locations (e.g., Roberts, Warren, and Eskenazi 2007), dune complexes, springs, and other areas with widespread episodic and stabilized eolian deposition should also be added to the list. All of these landform types are largely absent from the current study area, which is consistent with an overall low sensitivity for buried archaeological sites within the landforms of the project area.

The fine grain distal margin of the lower alluvial fan piedmont (unit Qa6), which is mantled on top of Pleistocene Colorado River terrace deposits of Palo Verde Mesa (Qpv), may represent the most extensive geomorphic feature in the project area that has the potential for buried archaeological deposits (with no surface manifestation). However, the degree of this potential is largely unknown due to a lack of subsurface exposures at this contact. Based on observation of surface sites on the fan piedmont, one of the primary natural resources attracting prehistoric populations to the project area was the extensive quartzite, chert, and cryptocrystalline river cobbles that have been redeposited across the fans from the relict Colorado River gravel terrace (QTmw). Similar rounded, exotic materials are present in smaller amounts on limited portions of the Qpv surface (in areas equivalent to Unit E of Metzger et al. 1973). These gravels and cobbles tend to be smaller and less frequent than those observed on the fan piedmont, but, nonetheless, may have acted as an attractive tool material prior to deposition of the younger portions of the fan piedmont. As such, any sites buried by the Qa6 and Qa5 fans are likely to be similar to those observed on the fan surface (i.e., dominated by lithic assays and associated expedient tools) but of greater antiquity.

Although composing a much smaller portion of the project area, places where unconsolidated and active eolian sands (Qs) have obscured alluvial landforms also have the potential for burying archaeological resources. The most extensive of these sand sheets is present at the very northern extent of the project area on the alluvial flat landform. Smaller localized eolian features, found on the Colorado River terrace (Palo Verde Mesa) and the northern alluvial flat, appear to be so limited that they are unlikely to obscure any significant portion of an archaeological site.

Finally, the young actively aggrading alluvial sediments of the modern alluvial fan (Qm) and alluvial floodplain (Qr) generally have a high potential for burial of archaeological sites. These landforms have a very limited presence in the Project area and their sensitivity is further diminished by their distance from the Colorado River, as well as presumed paleochannels of the river.

A secondary conclusion of this geoarchaeological study is that prehistoric site locations within the Rio Mesa Solar study area seem to be largely dictated by the availability of raw lithic materials. The series of coalescing fans that make up the alluvial fan piedmont west of Palo Verde Mesa have their source in the Mule Mountains. The dominant parent material present above these fans is quartz monzonite, with more limited outcrops of gneiss, diorite, granodiorite, with limited other volcanics (rhyolite, dacite, and amphibole). Much of this material has little utility for prehistoric tool making. At the same time, the quartzite, cryptocrystalline, and chert cobbles and gravels of the relict Colorado River terrace (QTmw) have been eroded and reworked into the lower fan piedmont and are more conducive to prehistoric tool production. This is demonstrated by the widespread lithic scatters present on these landforms. Areas of similar materials are also present on the Palo Verde Mesa terraces (Qpv).

3.4 RESEARCH ISSUES

This section explicitly enumerates the research questions, data needs and sampling strategy used to facilitate the development of refinements to our initial, field verified understanding of the variability, across each pertinent landform, in landform structure, based on the Applicant's consultant's visual field verification completed in 2011.

Deleted: The dominant geomorphic feature of the Project area is the Palo Verde Mesa, which consists of an inset Pleistocene terrace of the Colorado River, up to 100' above the Holocene floodplain deposits which fill the Palo Verde Valley. A widespread marker-bed paleosol was identified at or near the surface of this geologic unit during the geoarchaeological and paleontological reconnaissance surveys. This distinct paleosol marks the surface of the fine-grain facies of the Palo Verde Mesa formation (Qpv), which was described by Metzger et al. (1973; "Unit D"), and which has recently been interpreted as a local variation of the more widespread Chemehuevi Formation (Malmon et al. 2011). These formations are interpreted as a very large scale aggradation of the Colorado River, and are believed to date to the Late Pleistocene. Dates, using various techniques, from throughout the range of the broader Chemehuevi Formation are consistently greater than 40,000 years before present (BP; Malmon et al. 2011:39, 47). As such, the formation, and associated paleosol marker bed appears to be far too old to contain buried archaeological deposits. A date obtained by URS on a fossil tortoise shell, burrowed into the surface of the paleosol, returned a date of approximately 13,700 BP. This latest Pleistocene date indicates that the paleosol was potentially exposed at the surface early in the span of human occupation of the Americas (as well as more recently, in areas where the paleosol is currently exposed at the surface). This suggests that there is the potential for archaeological sites at the surface of this distinct paleosol marker bed (attested to by the numerous prehistoric sites recorded at the exposed surface of the Qpv landform). One question to be answered by the geoarchaeological field investigations is what the nature of the surface of this paleosol is and its contact with any overlying sediments. Past studies have consistently demonstrated an unconformity at the surface of the Chemehuevi/Palo Verde Mesa formation, but the nature (i.e., erosional vs. nondepositional) and the timing of any erosional unconformity (i.e., predates or postdates human occupation) is a question to be addressed by the field study.¶
The other primary landforms present within the Project area are Quaternary alluvial fan deposits of varying lithology, surficial pedogenic development (desert pavement, varnish, etc.), and presumed age. Of these, the most widespread is a relatively fine-grain fan unit with minor gravels, little to no pavement or varnish development, and no observable upper vesicular horizon (Av). This landform is correlated with Stone's (2006) late Holocene Qa6 fan. The transition between the Qa6 fans, to the west, and the Qpv deposits, to the east, is difficult to distinguish in the field, due to the presence of a discontinuous Pleistocene sand unit with minor gravels at the surface of much of the Palo Verde Mesa/Chemehuevi Formation (Unit E of Metzger et al. 1973; Malmon et al. 2011:3). The transition is largely identifiable by a gentle and minor concavity perpendicular to the formations, where the backslope of the Qpv deposits meets the toe of the Qa deposits. Due to the obscured character of this contact, it is unclear whether the Qa deposits form a mantle over buried Qpv deposits, or if a different and perhaps older geologic unit is present below the alluvial fa ...

3.4.1 Research Questions

The following research questions will guide the Applicant's implementation of the Research Design to further refine the field verified identifications and the geographic extents of the project area landscape's constituent landforms and to further document and refine the genetic and historical relationships among them. The research questions will also guide the documentation of each pertinent landform's particular stratigraphy; interpretation of the energy regimes that led to the sedimentary deposition of each landform; interpretation of the chronology and duration of pedogenic processes that may have occurred for each landform; and discern whether the deposition of particular landform components was synchronous or may have been time transgressive (tempo).

1. Can further refinement of landform designations and tentative chronological associations developed in the initial Geoarchaeological Assessment be achieved?

2. For those landforms determined to have a depositional chronology and energy regime conducive to potential sensitivity for buried cultural resources (especially younger alluvial fan units Qa6 and Qa5), the subsurface conditions of those landforms be identified and documented? Specifically, can the lithostratigraphic and pedostratigraphic units that comprise the landforms, the age, duration and tempo of pedogenic processes, energy regimes and depositional environment, and subsequent preservation of those units be identified and documented?. This will allow for a refined estimate of the potential for buried archaeological deposits, and the likely nature, age, and depth of those deposits.

3. In addition to refining the subsurface conditions of potentially sensitive depositional landforms (Research Issue 2can the lateral variation in those landforms be established and documented, in order to better define spatial variability in the geoarchaeological sensitivity within each landform?

4. For those landforms that may contain surface archaeological sites, but are too old or high energy to contain buried archaeological deposits, can the subsurface relationship between the old landform and any adjacent younger landforms be defined, as there is the potential for buried archaeological sites at that subsurface contact? Specifically, for landforms that have been determined to be older than the latest Pleistocene (c.a. 16,000 BP) (e.g., the Qpv landform) and are buried by younger deposits, the nature of the buried surface (whether stable or erosional) is of particular import to the potential for buried archaeology.

3.4.2 Data Needs

1. Representative subsurface profiles of potentially sensitive depositional landforms, with adequate spacing to demonstrate lateral variation within each landform.

2. Representative profiles at or near the intersection of different landforms.

3. Datable material to establish the chronology of Project landform evolution.

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3.4.3 Summary

The primary focus of the new phase of geoarchaeological research will be the excavation and exposure of representative landform profiles for those portions of the project area where the sedimentary landforms identified during the initial geoarchaeological reconnaissance assessment are of an age and appropriate depositional nature, where a potential for buried archaeological deposits was identified, and where the construction and operation of the proposed project would disturb native ground to a depth of greater than one meter. These excavations will allow for the collection of data which is useful in:

a. refining the geologic correlations that were field verified during the initial geoarchaeological reconnaissance and resultant Geoarchaeological Sensitivity Analysis and geoarchaeological sensitivity map;

b. assess whether the identified landforms are relatively synchronous or time-transgressive (tempo);

c. establish and refine the age of the lithostratigraphic and pedostratigraphic units that

d. compose the landforms; and

e. establish the lateral variation in the depositional energy responsible for the development of each landform.

This refined data set, and the interpretation of it, will allow for a more complete understanding of the geomorphic evolution of the Project area, and the association of surficial archaeological sites to that landform development, as well as the relative potential for the Project to impact buried archaeological resources.

CEC Staff indicated that during the initial geoarchaeological assessment too much emphasis was placed on the identification of paleosols as convenient stratigraphic markers of past land surfaces, where archaeological sites could potentially be subject to erosional processes; and not enough emphasis on the identification of areas of high-rate low-energy deposition, where archaeological sites would potentially be delicately buried and preserved (Rio Mesa Solar Electric Generating Facility Licensing Case Documents, Docket Number: 11-AFC-04, WebEx Recording of the March 1, 2012, Data Request and Issues Resolution Workshop, Posted March 5, 2012.). Grain size, depositional environment and energy regime, and pedogenic indicators of soil/paleosol development will be further refined for each of the subsurface exposures excavated during the geoarchaeological subsurface investigation. While the Applicant agrees that the quality of archaeological preservation is higher in relatively low energy depositional environments that have high depositional rates, it is not the most likely place to encounter buried archaeology. Cumulic soils (landforms where deposition outpaces soil development; i.e., where paleosols are not formed) do not lend themselves to the accumulation of large complex archaeological sites. A constantly acreting landform is not conducive to long-term occupation. At most, one could expect very ephemeral sites, spread-out more or less randomly throughout the vertical and horizontal extent of the cumulic landform. In trying to reduce the "needle in the haystack" problem of identifying buried archaeological sites across a large project area, paleosols are the best option because they would have been exposed at the surface for a sufficient amount of time to increase the chances of site formation (and

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subsequent burial). On any horizontal slice of a landform, a paleosol is more likely to have an archaeological site on it than an equivalent slice of unweathered alluvium. Necessarily, the geoarchaeological research will focus on areas that may contain paleosols of appropriate age (latest Pleistocene through Holocene) as well as those with fine-grain deposition that is more conducive to preservation.Proposed Work

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3.5 FIELD METHODS

The following sampling strategy and fieldwork protocols will guide the Applicant's implementation of the Research Design to further refine the field verified identifications and the geographic extents of the project area landscape's constituent landforms and to further document and refine the genetic and historical relationships among them. The strategies and protocols will also guide the documentation of each pertinent landform's particular stratigraphy; interpretation of the energy regimes that led to the sedimentary deposition of each landform; interpretation of the chronology and duration of pedogenic processes that may have occurred for each landform; and discern whether the deposition of particular landform components was synchronous or may have been time transgressive (tempo).

3.5.1 Sampling Strategy

For the majority of the Project area, on Metropolitan Water District (MWD) property, twenty (20) locations have been selected for the placement of exploratory 1-meter-wide by five-meters-long geoarchaeological/paleontological trenches (Figure 3.1-12). These locations were selected based on their applicability to the research questions identified above, association with landforms identified and field verified during the reconnaissance survey as potentially being of appropriate age and depositional nature to harbor buried resources, and to yield a minimum of 300 cubic meters of stratigraphic excavation. This number of trenches should provide an adequate sample of the project area stratigraphy to accurately document it. It should also provide the data needed for the Project Paleontologist to further define the thickness and extent of the paleosol identified within the project area.

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The maximum horizontal exposure of the trenches will certainly be larger than the basic working assumption (1-meter-wide) used above to calculate cubic meters of stratigraphic excavation. This is due to the nature of the benched excavation practices used for compliance with OSHA standards and directives related to trenching and excavation. Benching is a method of protecting workers from cave-ins by excavating the sides of an excavation (e.g., a trench) to form one or a series of horizontal levels or steps, usually with vertical or near vertical surfaces between levels. Therefore, all estimates of cubic meters of stratigraphic excavation should be used as an estimate of the minimum area that will be exposed.

The Applicant's construction practice for installation of pylons in the solar field minimizes impacts to biological, soil/water, and cultural resources. However, in an effort to help further define the thickness and extent of the paleosol, the Applicant has agreed to do additional paleontological testing within the project site as part of Data Request 128. In order to minimize additional impacts to the resources mentioned above, all the trenches and borings being excavated by the Applicant's Geotechnical Contractor will be observed by the Project Geoarchaeologist, as well as a Paleontological and Cultural Monitor. The placement of all the trenches and most of the borings was determined by the Project

Geoarchaeologist and Paleontologist, with the exception of the borings labeled "MWD Exploratory Borings" which were determined by the Project Geotechnical Contractor (Figure 3.1-12).

Trenches are primarily focused on the landforms identified as younger alluvial fans (Qa6 and Qa5) which are considered to have the greatest potential for harboring buried cultural resources. Trenches within this landform type extend east-west, from the head to the toe of the landform, as well as laterally north-south, in order to document structural changes across the landform, and variability in the potential for preservation of archaeological materials.

Several of these trenches (e.g., GPT-1, GPT-6, GPT-8) have been sited near the interface between the younger alluvial fan units and other identified older and/or coarser-grained landforms. These locations are intended to demonstrate the subsurface interaction between the adjacent landform types and provide data on the nature of any subsurface contacts between the two units.

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Although many of these landforms have sufficient observable surface characteristics (e.g., clast size, degree of desert varnish, degree of pavement formation) or have been sufficiently dated and documented by other researchers (e.g., the Qpv landform, see discussion above), a small number of trenches have been placed within these landforms to confirm assumptions made during the reconnaissance field study. In particular, trenches placed within the Pleistocene Colorado River inset terrace deposits (Qpv) have been placed in locations where project related impacts will exceed 1 meter below surface, and will be used to assess near-surface conditions and the veracity of assumptions regarding the lack of geoarchaeological potential.

3.5.2 Fieldwork Protocols

Each geoarchaeological trench will be excavated using a full-size backhoe fitted with a 2- to 3-foot wide bucket. Each trench will be approximately 5 meters long at the surface and excavated to the maximum reach of the backhoe (approximately 4 meters), unless conditions are present (e.g., extremely coarse or indurated sediments) that preclude the need or ability to complete the trench. The backhoe excavation of trenches and excavated spoils will primarily be observed from the surface and then be documented from the surface, for safety reasons and for compliance with OSHA standards and directives related to trenching and excavation. If pedogenic or archaeological features are observed from the surface, which require closer inspection and/or sampling, the trench will be shored using hydraulic speed shoring, so that the Project Geoarchaeologist can enter the trench safely, document subsurface stratigraphy and pedogenic indicators, in detail, and collect soil and dating samples.

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In addition to the geoarchaeological trenches, numerous geotechnical and paleontological mechanical excavations (backhoe excavated pot-holes and corkscrew augers) have been planned (Figure 1). In order to gather the maximum amount of data regarding subsurface conditions, these excavations will also be observed, documented, and sampled by the Project Geoarchaeologist.

The Project Geoarchaeologist will produce a measured profile drawing, using a metric scale, on one sidewall from each excavated trench, where the drawings are produced on the basis of observation from the surface. Observed stratigraphic units will be described based on physical characteristics such as composition (grain size, parent material), color, superposition, textural transitions, and pedogenic properties (i.e., relative soil development). Each profile, including all observable textural and soil

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transitions, will be logged on standard soil recordation forms and photographed. These will include a detailed description of each lithostratigraphic and pedostratigraphic unit and be used to correlate units identified in other trenches.

The information collected in the soil recordation forms (Attachment 2) will be used to produce reasonable detailed written descriptions, appropriate to the character of each type of stratigraphic unit, of each lithostratigraphic and pedostratigraphic unit down a one-meter-wide, shaved profile section along the sidewall for which the measured profile drawing is made. Each measured profile sidewall will be photographed with a metric scale and north arrow.

A maximum of 6 radiocarbon samples will be submitted for analysis, in order to determine the depositional rates and approximate ages of the major process-related lithostratigraphic sequences present, constrain the dates of any paleosols or archaeological deposits that are found, and collect enough soil humate samples, in the absence of other reliable chronometric data, to reliably assay and radiocarbon date the master stratigraphic column for each landform and each major landform feature. Discrete, in-place charcoal samples will be used for dating. At least one additional archaeologist will be on-site to assist in the monitoring and sorting of spoils excavated from the geoarchaeological trenches. Rakes and other hand tools will be used to actively sort through material as it is excavated from each trench. The Project Geoarchaeologist will assist in identifying paleosols and sensitive depositional horizons as they are excavated, and these will be targeted for monitoring. Additionally, a small (three 5-gallon buckets) sample of sediment from the major lithostratigraphic units in the measured profile, or, where lithostratigraphic units are not apparent, from arbitrary levels in each measured profile, every 0.5 meters of depth, will be screened through ¼-inch hardware mesh.

The Project Geoarchaeologist will mechanically excavate through any buried archaeological deposits encountered, unless such deposits contain human remains, using arbitrary levels no greater than 20 cm thick, screen the arbitrary levels through ¼-inch hardware mesh, and provenience all artifacts, ecofacts, and other material culture finds to those arbitrary levels.

3.5.3 Geotechnical Evaluation Procedures

The following section provides a brief summary of the geotechnical study details that are relevant to this Study.

Backhoe excavating, logging and sampling of exploratory trenches to depths of 3 meters will be completed by the Geotechnical Contractor. A JCB 215 backhoe with a 2-foot bucket and an extendahoe will be used for the trenches.

The Geotechnical Contractor will also drill, log and sample all exploratory borings to depths of approximately 15 feet and 20 feet (4.5 and 6 meters). The borings will be performed by a track-mounted CME-75 drill rig utilizing 8-inch diameter hollow stem augers. The purposes of the borings labeled "MWD Exploratory Borings" will be to evaluate the general subsurface soil and groundwater conditions, and to obtain soil samples for laboratory testing. The boring will be performed with an all-terrain drill rig.

For the borings labeled "Paleo Boring Transect", the best method for acquiring relatively undisturbed samples is to continuous sample with a 2-foot split-barrel sampler.

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Generally, the Geotechnical Contractor will proceed with the trenching and boring from north to south, starting with the explorations in the eastern portion of the site along the WAPA 115kV power line first. Then they will continue south to north to complete the trenching and boring in the western portion of the site.

3.5.4 Curation

Artifact and fossil collection, retention/disposal, and curation will follow standard protocols and policies. The Applicant commits to curate all archaeological materials, in accordance with the California State Historical Resources Commission's *Guidelines for the Curation of Archaeological Collections*, into a retrievable storage collection in a public repository or museum. Additionally, the Applicant commits to curate all paleontological materials, in accordance with the Society for Vertebrate Paleontology guidelines, into a retrievable storage collection in a public repository or museum. Moreover, the Applicant commits to pay all curation fees for artifacts and fossils recovered and for related documentation.

SECTION 4 TECHNICAL REPORT

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A report describing the results of the geoarchaeological field study, and implications for assumptions made during the initial assessment, will be produced. This report will include: mapping of the surface geomorphology of the project area (map scale of ≥1:12,000); maps and descriptions of all excavated trench locations; graphic and written descriptions of the stratigraphic profiles of the project area including an analysis of the depth and extent of any potentially sensitive paleosols; a processual geologic interpretation and the approximate age of subdivisions of the master column that reflect shifts in local depositional regimes or depositional history, and that reflect time ranges that correspond to the prehistory and history of the region, as presently understood; DPR 523 forms, and descriptions and preliminary interpretations of any encountered archaeological deposits. Formal reporting of radiocarbon analysis results will be included as an appendix. The report will also provide: an interpretation of the character of the prehistoric or historic land use that each encountered archaeological deposit represents; an interpretation, with reference to the information gathered and developed above, of the likelihood that buried archaeological deposits are present in each of the identified landforms or portions thereof; on the basis of the current understanding of the prehistory and history of the region, what site types are most likely to be found; and recommendations, based on the present geoarchaeological study, on the locations and extent (horizontal and vertical) of potential mitigation measures that would be most consistent with CEQA requirements for mitigation of impacts through avoidance, when possible, and with the historic preservation goal of recovering valid scientific data from CRHR-eligible archaeological deposits whose destruction cannot be avoided.

This report will also seek to more securely establish the physical contexts of the surface archaeological sites in the proposed project area, and to reliably assess both the likelihood that project area landforms may contain buried archaeological deposits and the likely character of any such deposits. The results of the geoarchaeological study should allow the CEC to better assess the potential impacts of the proposed project to buried archaeological resources, and to design a more targeted, limited, and effective mitigation monitoring plan (if warranted by the results of the geoarchaeological study).

Additionally, a Paleontological Letter Report will be prepared and submitted to the CEC and BLM for review which will summarize the testing results for all areas as part of Data Request 128.

Lastly, buried archaeological deposits found during the trenching activities will be recorded on DPR 523 forms by the Cultural Monitor. Formal evaluation of site eligibility and/or data recovery is beyond the current scope. The geoarchaeological study is not designed to assess the eligibility of buried archaeological sites identified during trenching. Additional scoping and consultation with the CEC and BLM will be necessary to complete a Phase II analysis of any identified archaeological deposits.

SECTION 5 PROJECT PERSONNEL AND MANAGEMENT

All cultural resources work will be carried out under the direct supervision of archaeologists who meet the Secretary of Interior's Standards and Guidelines for Archaeology and Historic Preservation, and will be consistent with the procedures for compliance with NEPA, Section 106 of the NHPA, and CEQA Section 15064.5. All decisions on level of effort or discretionary actions described in the CRWP will be approved by BLM/CEC prior to implementation.

The key cultural resources personnel who will conduct the study and prepare the technical report are:

- Jay Rehor, M.A. (URS Principal Investigator)

SECTION 6 REFERENCES

Bull, W. 1991. Geomorphic Responses to Climate Change. Oxford University Press, New York.

Metzger, D. G., Loeltz, O. J., and Irelan, Burdge. 1973. Geohydrology of the Parker-Blythe-Cibola area, Arizona and California: U.S. Geological Survey Professional Paper 486-G, 130 p.

Nixon, Rachael A., Arleen Garcia-Herbst, Jay Rehor, Melanie Lytle, Kimberly Maeyama, Mark Neal, and Sarah Mattiussi. 2011. *Cultural Resources Technical Report for the Rio Mesa Electric Generating Facility*, *Riverside County*, *California*, URS Corporation, San Diego, for BrightSource Energy, Oakland.

Rehor, Jay. 2011. Geoarchaeological Sensitivity Analysis, Rio Mesa Solar Generating Electric Facility Project. Prepared by Jay Rehor, URS Corporation, Oakland, for BrightSource Energy, Oakland.

Stone, P. 2006. Geologic Map of the West Half of the Blythe 30' by 60' Quadrangle, Riverside County, California and La Paz County, Arizona. Scientific Investigations Map 2922. U.S. Geological Survey, Menlo Park, California.

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Non-Confidential Figures

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Attachment 1
Quaternary Geologic Unit Descriptions From:

**Geologic Map of the West Half of the Blythe 30' by 60' Quadrangle, Riverside County, California and La Paz County, Arizona. Pamphlet to accompany Scientific Investigations Map 2922"
Compiled by Paul Stone, 2006**

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Attachment 2

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GEOARCHAEOLOGICAL RESEARCH DESIGN BRIGHTSOURCE ENERGY, INC: RIO MESA SOLAR PROJECT RIVERSIDE COUNTY, CALIFORNIA

Prepared for

Bright Source Energy, Inc.

URS Project No. 27652105.00505

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SECTION 1 INTRODUCTION

A Geoarchaeological research design has been prepared to guide fieldwork and the documentation of potential impacts upon cultural resources within the BrightSource Energy, Inc. Rio Mesa Project (RM; also referred to as Project) Area of Potential Effect (APE). Information presented in this research design will govern the geoarchaeological study related to the Project APE. The primary purpose of this research design is to disclose the overall approach the Project will take to comply with state and federal regulations regarding the protection of cultural resources, specifically potential buried cultural resources. In addition, the research design provides the overarching guidance for identification efforts of extant landforms and their potential for subsurface cultural resources.

The content of this research design will include the project description, the definition of the Geoarchaeological Study APE, the fieldwork methods, and the research design, which is intended to guide the identification of potentially archaeologically sensitive landforms and, ultimately, the preliminary evaluation of associated potentially significant cultural resources. The research design is intended to address a range of geomorphic features that occur within the Project APE and provide a preliminary basis for determining the possible presence of subsurface cultural resources.

The Geoarchaeology Study will be based on the direct observation of geotechnical trenches and borings completed as part of a geotechnical evaluation of the project site. A cultural and paleontological monitor will also be present to observe all excavations and identify and document any cultural or paleontological resources discovered by the excavation.

Upon the completion of the field work, a Geoarchaeological Technical Report (Technical Report) will be prepared and submitted to the CEC and BLM for review. The primary purpose of the Technical Report will be to provide, for review by the CEC and BLM, the results of the study and initial conclusions regarding the potential for the Project to affect buried cultural resources. The Technical Report will serve as the data response for the CEC. The CEC will be responsible for submitting the data response to the BLM if deemed appropriate.

Additionally, a Paleontological Letter Report will be prepared and submitted to the CEC and BLM for review which will summarize the testing results for all areas as part of Data Request 128.

Lastly, buried archaeological deposits found during the trenching activities will be recorded on DPR 523 forms by the Cultural Monitor. Formal evaluation of site eligibility and/or data recovery is beyond the current scope. The geoarchaeological study is not designed to assess the eligibility of buried archaeological sites identified during trenching. Additional scoping and consultation with the CEC and BLM will be necessary to complete a Phase II analysis of any identified archaeological deposits.

1.1 PROJECT DESCRIPTION

The project site is located in Riverside County approximately 13 miles southwest of Blythe, California (Figure 1). The Project will consist of two solar plants: the southernmost plant will be known as Rio Mesa I and the northernmost plant will be known as Rio Mesa II. The plants will be constructed in separate phases. Rio Mesa Solar I, LLC and Rio Mesa Solar II, LLC, the owners of the two separate solar plants, are jointly known as the “Applicant.”

Each plant will include a power block area surrounded by an array of approximately 85,000 heliostats, and will require approximately 1,850 acres (or 2.9 square miles) of land to operate. The nominal capacity of each solar plant will be 250 megawatts (MW), for a total Project nominal output of 500 MW. Certain facilities for the Project will be shared by the two plants and located in a common area. These facilities will include a combined administration, control, maintenance, and warehouse building, and mobile equipment maintenance facilities for the maintenance crew and operators. The total area required for both plants, including the common area, is approximately 3,805 acres.

The Project will deliver power at 220 kilovolts (kV) to Southern California Edison's (SCE's) Colorado River Substation (CRS), located approximately 9.7 miles to the northwest. From the plant switchyards, power will be transmitted underground, at 220 kV, to the Project switchyard (located in the common area).

1.2 FEDERAL AND STATE AGENCIES

BLM will be the lead agency under the National Environmental Policy Act (NEPA), since the road access and transmission line are proposed on federal lands managed by BLM. The California Energy Commission (CEC) is the lead agency under California Environmental Quality Act (CEQA) and has a certified regulatory program under CEQA. This work plan has been designed to accommodate both the CEC/BLM Memorandum of Understanding (MOU) and the separate permitting requirements of CEC and BLM, should the processes be separated. Per the CEC-BLM MOU, the Technical Report will be reviewed and approved exclusively by the BLM.

1.3 AREA OF POTENTIAL EFFECT (APE)

The geoarchaeological study APE is currently assumed to be equivalent to the Archaeological APE or direct effects APE. The delineation of cultural resources survey areas was determined based on the CEC Rules of Practice and Procedure and Power Plant Site Regulations and Designation of Transmission Corridor Zones, Appendix B (g)(2)(C) (CEC 2008). For the purpose of this Project, the geoarchaeological survey areas also are equivalent to the Archaeological APE found in the BLM 8100 Manual, and are in compliance with the Section 106 process [36 CFR §800.16 (d)].

SECTION 2 ENVIRONMENTAL SETTING

2.1 PHYSIOGRAPHY AND GEOLOGY

The project area is bounded to the south and west by the volcanic and plutonic rocks that form the Mule Mountains, to the north by an extension of the Chuckwalla Valley that separates the Mule and McCoy Mountains, and to the east by the broad floodplain of the Colorado River. The immediate project area is characterized by gently sloping alluvial fans that emanate from these mountains. Gullies and washes, running approximately west to east, dissect the site, primarily on the north and south sides. The rock outcrops of the Mule Mountains are heavily eroded and mantled by a Quaternary fan piedmont. Alternatively, the Colorado River floodplain is composed of more recent alluvial material deposited by the river. Between these two areas lies the Palo Verde Mesa, which is primarily composed of inset Pleistocene terraces of the Colorado River. All of these Quaternary landforms are comprised of numerous older remnants and more recent deposits of varying ages. Additional information regarding the geomorphological setting and conditions of the Project area can be found in the initial Geoarchaeological Assessment (URS 2011), as well as in subsection 3.1, *Background* below.

2.2 CURRENT PHYSICAL SETTING

The project area is predominately in a rural setting with land uses that include agricultural (e.g., grains/ hay); historic period military training (e.g., 1942-1944 Desert Training Center or DTC, tank tracks, trenches, and graded areas); dirt roads (e.g., Bradshaw trail, Opal Mine Road, Hodge Mine Road, transmission line road/corridor, and other unnamed unpaved roads); approximately 40 previous ground water test wells and numerous dry well casings; utilities (e.g., four transmission towers and one underground pipeline); and recreational use (e.g., off-highway vehicles [OHVs] and camping). Despite these surficial disturbances, the landscape and topography generally resemble the natural environment.

The following activities are primarily responsible for the previous surface and subsurface disturbance in and adjacent to the project area:

- agriculture,
- historic-period military training (DTC),
- transmission lines and underground gas lines,
- ground water testing,
- recreation use (OHV tracks and camping), and
- road construction, use, and maintenance (e.g., Bradshaw Trail, Opal and Hodge Mine Roads).

SECTION 3 RESEARCH DESIGN

The research design provides a framework and theoretical context for project goals, field methods, discussion and interpretations of geomorphic features, and recommendations for future studies (and data needs). The research design provided herein is for a geoarchaeological study conducted through monitoring of geotechnical borings and geoarchaeological test excavations.

3.1 BACKGROUND

The following discussion is largely focused on identifying those portions of the project area that have the potential for harboring archaeological deposits that do not exhibit surface manifestation. Through the completion of a geoarchaeological assessment a background model of landscape development can be formulated, as can major landforms be identified and mapped. Through this assessment, geological deposits can be dated and conclusions ascertained regarding areas with an increased likelihood of subsurface archaeological deposits. The following sections summarize the project landscape development based on the findings associated with the geoarchaeological assessment conducted for the Project AFC, Cultural Resources Technical Report (Nixon et al. 2011) and Geoarchaeological Sensitivity Assessment (Rehor 2011).

Per Staff request, the description of quaternary geomorphic landforms and geologic units from Stone (2006)—which was used in conjunction with more detailed metrics outlined in Bull (1991)—is attached for reference to this research design as Attachment 1, and is available in complete form online (http://pubs.usgs.gov/sim/2006/2922/SIM2922_pamphlet.pdf).

3.1.1 Models of Landscape Development

It has been shown that some alluvial landforms (e.g., desert pavements that have evolved through accretion of eolian silts and sands, and the gradual bearing of larger clasts to the surface) have the potential for containing buried archaeology (Ahlstrom and Roberts 2001). However, a representative portion (if not the vast majority) of these archaeological deposits will be incorporated into the surface pavement through the same accretionary process. Thus, these older surfaces are not likely to contain archaeology that is not at least partially evident on the surface (URS 2010).

Geomorphic processes have played a major role in the differential preservation of archaeological sites in the Colorado and Mojave deserts. For example, early cultural sites related to the San Dieguito and Lake Mojave cultural complexes are almost exclusively known from surface contexts on terminal Pleistocene and Early Holocene geomorphic surfaces (Sutton 1996:229). These early sites are typified by sparse remains on desert pavements, often on mesas and terraces overlooking larger washes or paleo-lake shorelines. Schaefer (1994:64) suggests that “these are zones where a variety of plant and animal resources could be located and where water would at least be seasonally available.” However, it is much more likely that this is simply a matter of landscape development since the Late Pleistocene; these mesas and terraces, with well-developed desert pavements, represent the differential preservation of older land surfaces at higher elevations. Older sites are preserved on these relict landforms, with other sites of similar age likely buried by subsequent depositional processes, or destroyed by erosional processes. These same processes have also affected the distribution of resources (i.e., lithic raw material, water, biotic communities, etc.) across the landscape and, thus, the placement of archaeological sites in relationship to those resources. The primary factors effecting geomorphic processes in the region are the underlying structural geology and climate change. In addition to these local factors, the Colorado River—affected by extra-regional factors upstream— has had a major impact on landscape evolution within the project area.

Regional climatic trends through the Late Pleistocene and Holocene are important to this current study because of effects on the production of material for alluvial deposition and the concomitant susceptibility of the landscape to erosion. Regional correlations between periods of alluvial fan deposition during the Latest Pleistocene and Holocene indicate that climatic changes superseded other factors as the primary force driving alluvial deposition (McDonald, McFadden, and Wells 2003:203). Within the Mojave Desert, several major intervals of alluvial deposition have been identified and appear roughly correlative across the region, largely transcending geomorphic variation (Anderson and Wells 2003; Harvey and Wells 2003; McDonald, McFadden and Wells 2003). Figure 3.1-1 shows a summary of the timing of these major depositional events across numerous mountain fronts in the Mojave. Insufficient data exists to assess the direct correlation of these events to the Colorado Desert, but, given the broad correlation of climatically induced geomorphic responses throughout California (Meyer et al. 2009), such an assumption is reasonable.

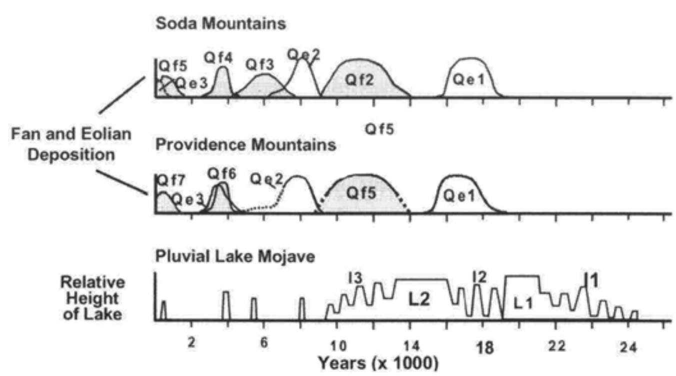


Figure 3.1-1. Correlation of Mojave Desert Geomorphic Events
(Qf designates period of alluvial fan deposition, Qe eolian dune formation, and L pluvial lake highstands; from McDonald, McFadden and Wells 2003:198)

In general, the Pleistocene-Holocene transition, ca. 13,000 to 9,000 years before present (B.P.), represents a major period of fan deposition, followed by subsequent periods during the Holocene at approximately 8,000 to 5,000 B.P., 4,000 to 3,000 B.P., and after approximately 1,500 B.P.. It was initially conjectured that these periods, especially around the Pleistocene-Holocene transition, correlated with general environmental desiccation, a decrease in soil moisture and vegetation, and an increase in sediment supply and erosion (e.g., Bull 1991; Wells et al. 1987). However, recent field studies have demonstrated that changes in vegetation cover alone do not explain increased sediment mobility. Instead, the most plausible hypothesis points towards a northward shift in the dominant late summer/early fall jet stream, allowing tropical Pacific cyclones from southern Mexico into the region and causing unusually large amounts of precipitation over short periods (McDonald, McFadden and Wells 2003:202). A biannual monsoonal weather pattern is still present in the lower elevations of the Colorado Desert, including Palo Verde, where February and August are the two wettest months (Western Regional Climate Center 2011). It is likely that the summer rainy season was more intense during these periods, but precipitation during the remainder of the year would have been similar to the very low levels present today (approximately 2 inches during non-summer months).

Pollen and lake-level records suggest general trends in Late Pleistocene and Holocene climate change, but these records do not make clear what meteorological changes are responsible for the trends. Pleistocene climate was wetter and cooler than today, with extensive lakes (including Ford and Palen lakes northwest of the project area), and pinyon-juniper woodlands extending into much lower elevations (Spaulding 1990). The vegetation transition from the Pleistocene through Early Holocene appears to have been relatively gradual, with woodlands retreating and giving way to desert scrub. During the middle Holocene (ca. 8,000 to 4,000 B.P.) climate appears to have been generally warmer and drier than today, though there are some indications of significant oscillations in climatic patterns (Spaulding 1990), possibly akin to those suggested by McDonald, McFadden, and Wells (2003), that were responsible for the middle Holocene Qf3 fan deposition in the Soda Mountains (see Figure 3.1-1, above). The Late Holocene climate was generally similar to modern conditions. However, given the higher resolution record for this more recent period, it appears that several periods of extended drought (including the Medieval Climatic Anomaly, ca. 1150 to 600 B.P.) as well as at least one cooler wetter period (the Little Ice Age, ca. 600 to 150 B.P.; Grove 1988) marked the Late Holocene.

The project area and lower elevations within the Colorado Desert in general, appear to have experienced vegetation regimes similar to today for most of the Holocene (ca. 11,000 years; Schaefer 1994:60-63). The creosote-scrub habitat that typifies the project area would have been established at lower elevations by the Late Pleistocene, providing prehistoric inhabitants with access to similar natural resources throughout much of prehistory. As discussed above, numerous studies, particularly in higher elevation portions of the Colorado and Mojave deserts, have demonstrated relatively significant climatic, precipitation, and vegetation fluctuations throughout the Holocene (Kaijnkoski 2008). Nonetheless, regional climatic trends through the Late Pleistocene and Holocene are important to the current study because of effects at higher elevations and the production of material for alluvial fan deposition.

Periodic increases in effective moisture likely resulted in higher seasonal wash flow, improving the exploitable habitat for human residents, but also accelerating the geomorphic processes that led to the burial or erosion of archaeological sites. These climatic changes also increased the sediment supply available for wind-blown (eolian) transport on dry lake beds and former stream channels during intervals of decreased effective moisture. Eolian processes deflated sediment source areas and deposited that material elsewhere. Taken together, these processes created, destroyed, and buried landforms that humans may have occupied across the Colorado and Mojave Deserts.

3.1.1.1 Geologic Mapping and Identification of Major Landforms

An in-depth geologic study of the northern portion of the project area was conducted by the United States Geological Survey (USGS). This study included a synthesis and description of geologic units and mapping at a 1:24,000 scale (Stone 2006). This information was incorporated into an online GIS database which was used as the basis for additional geologic mapping for the southern portions of the project area, as shown in Figure 3.1-1. The additional mapping effort was initially conducted through GIS, using aerial and topographic imagery to correlate with the existing mapped geologic units. This mapping was then field verified during a primary field study conducted by URS geoarchaeologist, Jay Rehor, from March

28 to 31, 2010. The purpose of the field study was to verify and modify the desktop mapping effort, assess the veracity of the units previously mapped by Stone (2006) within the project area, and assess those units for geoarchaeological sensitivity through examination of soil profiles and other indicators of landform age and processual development.

By examining the relationship among the landform components, we can develop relative age estimates, conclusions as to the depositional history of that landform, and the potential of each landform to harbor buried paleosols of appropriate age.

Before beginning such a discussion, however, it is necessary to define a common set of descriptive landscape terms and definitions used in the following paragraphs. Many different terms are used to describe desert geomorphology, with vastly different implications of scale, accuracy, and implied formation processes. "Alluvial fan" and "bajada" are two common terms that are often misleading because they are used to refer to different types of depositional and erosional landscapes, and they subsume numerous smaller landform components. The terminology adopted in this study follows after Peterson (1981) because the classification system emphasizes the temporal and spatial relationship between landform components, and was devised in relation to the study and classification of Basin and Range soils, thus making it highly relevant to the current geoarchaeological study. Diagrams showing the basic major landforms are provided in Figure 2.3-2. A discussion of these various landforms is provided in the following sections, with direct reference to the project area and the geologic units classified by Stone (2006).

At the broadest scale, the larger Palo Verde Mesa study area has many features that would classify it as a "semi-bolson" (Figure 3.1-2). Common in desert regions of the Basin and Range, semi-bolsons differ from true bolsons in that they lack a playa or floodplain, on which alluvial fans normally terminate, and instead are cut through by an axial drainage that marks the termination of the various piedmont landforms. However, the Palo Verde semi-bolson is anything but typical, due to the fact that the axial channel is not an intermittent stream or wash as usually found in Basin and Range semi-bolsons, but rather is the Colorado River, a perennial river that has a drainage basin of approximately 250,000 square miles. The Palo Verde Mesa area represents a mixture of typical semi-bolson desert landforms and features that are more typical of semi-arid and sub-humid river valleys. For the purposes of this discussion, we will employ the terminology used by Peterson (1981:30-34) to describe semi-bolson landforms, with some additional terminology more typical of river valleys (e.g., "inset terrace").

The project area semi-bolson can be further divided into two dominant structural sections. The western half consists of the Mule Mountains and associated coalescing alluvial fan piedmont gradually sloping down to the east. The second dominant structural section is formed by several inset alluvial terraces which form Palo Verde Mesa, and includes the modern floodplain formed by successive aggradations and degradations of the Colorado River. This fluctuation in the base level of the Palo Verde valley has dramatic implications for the preservation of Quaternary deposits. Gradual base level rise in typical internally drained desert basins has favored the burial of Quaternary piedmont deposits by successively younger alluvium. The Colorado River, on the other hand, has experienced net downcutting of over 100 meters during the Quaternary (Bull 1991:50). This downcutting causes a drop in local base level, incision of tributary streams on the piedmont, and promotes erosion and transport of piedmont alluvium to the floodplain (new base level). Backfilling of the river valley, which has likely occurred through much of the

Holocene (Metzger et al 1973:G28), gradually increases the base level, but only encourages aggradation and backfilling of the tributary drainages a short distance upslope from the height of the floodplain. The net result of this base level fluctuation is that erosion has played a greater role across the project area than in typical Basin and Range bolsons.

3.1.1.2 Dating Alluvial Desert Deposits

The ages of the various geomorphic surfaces within the project area are of central concern because age is one of the most important factors in constraining the possibility of buried archaeological deposits. Older land surfaces– those that were deposited prior to human occupation in the Americas (ca. 13,000 years ago) and which are still exposed on the surface– have very little possibility of containing buried archaeological deposits. On the other hand, younger land surfaces, if deposited in the right location, with low enough energy, may bury and preserve archaeological material previously deposited on an older surface. However, if these younger deposits unconformably overlie heavily eroded older formations, any archaeology that may have originally been deposited on the older surface would be effectively destroyed. Determining the nature of any subsurface contacts is thus integral to understanding the potential for buried archaeology within the younger landforms.

Unfortunately, dating of desert geomorphic surfaces is difficult and there is significant variation in the precision of various methods used in determining relative and numerical ages (McDonald, McFadden, and Wells 2003:190). Two primary, non-chronometric methods (e.g., not carbon-14, thermo-luminescence, etc.) are used for determining the age of desert landforms: soil development and desert pavement development. Figure 3.1-3 provides a graphic representation of pavement and subsoil horizon development through time in desert environments. Both of these methods are heavily dependent on environmental factors, such as temperature, precipitation, and parent material. As such, they are most effective within a confined homogeneous area.

Early investigations into the development of desert pavements hypothesized that they were formed through fluvial and eolian erosion of fine-grain sediments, leaving a deflated lag deposit of coarser material at the surface (Cooke 1970). More recent work– particularly on volcanic lava surfaces where fine-grain alluvial sediments are largely absent– indicates that desert pavements are instead formed through a process of fine-grain eolian sand and silt accretion (Wells et al. 1995). As dust blows onto a surface, it accumulates between larger surface clasts and, over time, infiltrates below the clasts and causes them to “float” on a fine-grain layer that thickens over time. This process may partially explain the upper vesicular A-horizon (see below) noted in most older desert soils. However, erosion may still play a role in the formation of pavements in some contexts, such as eolian dune complexes (McAuliffe and McDonald 1995:61-62).

While desert pavement formation is dependent on factors of time and climate, parent material also plays a major role. In general, alluvium derived from plutonic (e.g., granitic) sources form much weaker pavement– with fewer interlocking stones and less evident varnish– than volcanic and limestone sources (McDonald, McFadden, and Wells 2003:193). Along a Mojave Desert mountain front, it was determined that “minimal, if any, pavement formation occurs on alluvial fan surfaces in the granite-derived piedmont, regardless of age” (Eppes, McDonald, and McFadden 2003:109).

Given these factors, perhaps a more reliable estimate of landform age within the project area is soil horizon development. Due to the time-transgressive nature of soil development in arid environments, the stage of calcium carbonate (CaCO3 or “k”) illuviation and development, and the degree of B horizon development are identifiable markers of age. In this study of the project area, the degree of desert pavement formation and calcic horizon formation were used together as indicators of landform age during field studies. In addition, more typical soil classifications were made on the limited exposed profiles in order to assess pedogenic processes at play in the project area.

In general, soils on older Pleistocene alluvium are characterized by a strongly cemented (Stage III), well-developed calcium carbonate B or K horizon (Figure 3.1-4). Conversely, Holocene alluvial fan deposits typically exhibit a bar and swale surface morphology lacking prominent desert pavement development. Early Holocene alluvial fan deposits typically exhibit moderate B-horizon development and Stage II calcium carbonate morphology. Middle to Late Holocene alluvial fan deposits tend to have very weakly developed B horizons and Stage I calcium carbonate morphology. Latest Holocene surfaces, which are generally active washes, exhibit no soil development (Dohrenwend et al. 1991:328; McDonald, McFadden, and Wells 2003:193).

Very few natural subsurface exposures were observed during the field reconnaissance. As such, few soil profiles were recorded and described, and are not discussed extensively in the following analysis. However, a brief review of soil terminology is necessary to allow better understanding of the few figures that contain soil profiles. For this study, master soil horizons were defined using standard United States Department of Agriculture (USDA) soil taxonomy (Soil Survey Staff 2006) and techniques specific to desert soils (Birkeland, Machette, and Haller 1991). This organizational system uses upper-case letters (A, B, C) to describe in-place weathering characteristics. Most horizons and layers are given a single capital letter symbol where: “A” is the organic-rich upper horizon developed at or near the original ground surface; “B” is the horizon formed in the middle of a profile, with concentrations of illuviated clays, iron, etc., and general changes in soil structure; and “C” is the relatively unweathered parent material upon which the other soil horizons formed. These master horizons are preceded by Arabic numerals (2, 3, etc.) when the horizon is associated with a different stratum, where number 1 is understood but not shown, and lower numbers indicate superposition over larger numbers. Lower-case letters are used to designate subordinate soil horizons (Table 3.1-1). Combinations of these numbers and letters indicate the important characteristics of each major stratum and soil horizon from which inferences can be drawn.

Table 3.1-1
Subordinate Distinctions within Master Soil Horizons

Subordinate Horizon	Description
c	Cementation or induration of the soil matrix
k	Accumulation of pedogenic carbonates, commonly calcium carbonate
m	Strong cementation

Table 3.1-1
Subordinate Distinctions within Master Soil Horizons

Subordinate Horizon	Description
Ox	Oxidized iron and other minerals in parent material (C-horizon)
t	Accumulation of subsurface silicate clay (illuviation)
v	Vesicular soil development
w	Development of color or structure with little apparent illuvial accumulation

3.1.1.3 Geoarchaeological Assessment Methods

Major landforms within the project area were initially identified using both color and black-and-white aerial photography (Microsoft 2010, Digital Globe 2009), in combination with existing geologic maps of the area (Hamilton 1984; Jennings 1967; Metzger, Loeltz, and Irelna 1973; Stone 1990, 2006). Given these designations, certain broad assumptions could be made about the age and depositional history of each portion of the project area. The mapping and assumptions were verified and modified during an initial field reconnaissance through on-the-ground examination of the landscape and key indicators, such as superposition, relative slope, desert pavement development, and subsoil formation. Subsurface examination within the project area was limited to natural exposures within existing washes and drainages. Due to the gradient of these drainages, the majority of exposures were present in the eastern portions of the project area and diminished to the west. The majority of the drainages in the western portions of the project area are relatively small with only minor incision. No archaeological material was observed in any of the subsurface exposures.

The combined results of this study are shown in Figure 3.1-5 and summarized in Table 3.1-2. The following paragraphs provide a discussion of these results.

Table 3.1-2
Summary of Geoarchaeological Sensitivity of Landforms within the Project Area

Geologic Map Unit	Landform	Age	Depositional Regime*	Sensitivity
TRqm, TRd, Tv, Pgn, Jp, Jv	Rock Outcrops	Tertiary or older	Erosional	None
QTmm and QTa2	Upper Alluvial Fan Piedmont	Early Pleistocene or older	Erosional	None
QTmw	Relict Colorado River Gravel Terrace	Pliocene to Pleistocene	Erosional	None

Table 3.1-2
Summary of Geoarchaeological Sensitivity of Landforms within the Project Area

Geologic Map Unit	Landform	Age	Depositional Regime*	Sensitivity
Qa3, Qa5, and Qa6	Alluvial Fan Piedmont	Pleistocene to Late Holocene	Variable	Very Low to Moderate
Qpv	Colorado River Terrace	Pleistocene	Erosional	Very Low
Qs, Qa6	Alluvial Flat	Late Holocene	Depositional	Moderate to High
Qw	Active Washes (and associated minor landforms)	Pleistocene to Holocene	Erosional	Low
Qm	Modern Alluvial Fan	Recent	Depositional	Moderate to High
Qr	Floodplain	Holocene	Depositional	Moderate to High

3.2 PROJECT LANDSCAPE RECONSTRUCTION

The following sections summarize the project landscape reconstruction based on the findings associated with the geoarchaeologial assessment conducted for the Project AFC, Cultural Resources Technical Report (Nixon et al. 2011) and Geoarchaeological Sensitivity Assessment (Rehor 2011).

3.2.1 Rock Outcrops (Sensitivity: None)

Rock outcrops are present at the higher reaches of the piedmont, along the western side of the project area (Figure 3.1-5 and Figure 3.1-6). These rock outcrops form the Mule and Palo Verde Mountains and are composed of highly dissected bedrock that form steep, highly-eroded hills (inselbergs) sticking up out of the alluvial fans. Within the project area, rock outcrops are limited to the northwestern portions of the project site (Section 16) and are comprised of Triassic quartz monzonite and monzodiorite, designated by map unit TRqm (Stone 2006). While other types of bedrock that form the Mule Mountains are not present within the boundaries of the project area, they are worth noting because they provide portions of the parent material that forms the fans of the alluvial fan piedmont. These other local rock types include gneiss and amphibolite (Pgn), diorite and gabbro (TRd), porphyritic granitics (granodiorite and quartz monzonite; Jp), and volcanics (including rhyolite, dacite, and amphibole; Jv). Rock outcrops have little or no potential for harboring buried archaeological deposits.

3.2.2 Upper Alluvial Fan Piedmont (Sensitivity: None)

The fan piedmont, which makes up the majority of the western half of the project area and the slopes west of the project area (Figure 3.1-5), is actually a complex of component landforms composed of stable fans, erosional fan remnants, erosional sideslopes, gullies, and inset fans, which themselves have been further eroded and redeposited downslope. The fan piedmont can be subdivided into two broad categories, which are roughly correlative with relative age: the older upper alluvial fan piedmont and the younger lower alluvial fan piedmont.

The oldest major alluvial fan structure on the piedmont is also associated with the highest elevations of the fan piedmont. Map units QTa2 and QTmm (only a very small portion of which enters the ROW corridor in the northern portion of the project area) are very old remnant alluvial fan deposits. These units have steep gradients adjacent to the mountain fronts and form heavily eroded ballenas, fan remnants having a distinctively-rounded surface of fan alluvium, as they move away from the mountains. Although some very well-developed desert pavements may be preserved at the crest of the ballenas, the majority of the shoulder, sideslope, and footslopes have been heavily eroded and no longer preserve the original pavement surface. Profiles observed on the sideslopes of these units showed significant over-thickened carbonate development (Stage III+), though the amount of carbonate accumulation may be less than the equivalent age of the landform due to ongoing erosion. Stone (2006:11) concludes that the units are probably equivalent to the geomorphic surface Q1 of Bull (1991), which are presumed to have been deposited over 1.2 million years ago (Ma). As such, the QTa2 and QTmm units of the upper alluvial fan piedmont are assumed to have no potential for buried archaeological resources.

3.2.3 Relict Colorado River Gravel Terrace (Sensitivity: None)

Located within the fan piedmont, this landform in many ways resembles a remnant alluvial fan deposit, with very well formed desert pavement at the surface, and rounded erosional sideslopes similar to the older fan units. However, this landform, designated by map unit QTmw, is composed of large, well rounded gravels and cobbles. The clasts are almost exclusively non-local rock types, with a wide variability including cherts and other silicious rocks, cryptocrystalline quartzites and mudstones, and only minor amounts of gravels derived from the Mule Mountains. This rounded cobble and gravel deposit is identical to the one identified by Stone (2006) in the McCoy Wash area approximately 12 miles (approximately 19.3 kilometers) north, and at almost the exact same elevation approximately(443 to 476 feet (135 to 145 meters) above mean sea level [AMSL]). The well rounded cobbles and their exotic origin clearly demonstrate that they were deposited by the paleo-Colorado River during an aggradational event when the river flowed at much higher elevations than today. Superposition above Palo Verde Mesa indicates that the formation predates the incision and subsequent emplacement of the Qpv river terrace (see Figure 3.1-5). This relict Colorado River gravel terrace may represent the upper portion of Metzger et al’s Unit B; if so, the landform likely dates to the Pliocene or early Pleistocene (Metzger et al. 1973:G22; Stone 2006:12).

As noted above, the surface characteristics of this landform appear similar to an older Pleistocene fan, suggesting that the original Colorado River gravel deposit was likely subjected to post-depositional erosion followed by stabilization sometime during the Pleistocene—perhaps correlative with the deposition of the Palo Verde Mesa (Qpv) alluvium. The rounded gravels and cobbles of the relict Colorado River terrace have been reworked and redeposited, to varying degrees, in the younger alluvial fan units of the lower fan piedmont. Some higher elevation portions of the Qa3 fans have mantled on top of the QTmw terrace (Figure 3.1-6), while other portions have eroded through and bisected the terrace, thus transporting the rounded cobble material further downslope. Based on limited field observations, these redeposited cobbles appear to have been the primary source for lithic artifacts identified on the Qa6 (and to a lesser degree Qa3) fans. Due to the age of the landform, the relict Colorado River gravel terraces are presumed to have no sensitivity for buried archaeological resources, although some artifacts have been incorporated into the desert pavement surface of the landform and are likely of considerable antiquity.

3.2.4 Lower Alluvial Fan Piedmont (Sensitivity: Very Low to Moderate)

The lower portions of the alluvial fan piedmont within the project area are composed of geologic units Qa3, Qa5, and Qa6. Each of these units represents a period of fan building. These periods have coalesced to form the fan piedmont. Compared to the older upper portions of the piedmont, these fans form a more gradual slope. These Late Pleistocene to Late Holocene alluvial fans are equivalent to Q2, Q3, and Q4a units of Bull (1991).

Qa3 is the oldest of the lower piedmont fan units. These fans are typically covered with a smooth, well varnished desert pavement composed primarily of angular to subangular locally derived gravels and cobbles. The landform generally lacks evidence of bar and swale topography, but is heavily dissected in places by erosional gullies and channels. Figure 3.1-7 shows a typical surface pavement for the Qa3 fans, though the degree of desert varnish is inconsistent due to variability in parent material across the Mule Mountains and variability in timing of deposition (i.e., Late Pleistocene to earliest Holocene). Vegetation is largely absent except in the erosional gullies. Stage II to III carbonate development is evident in the limited subsurface profiles observed on the Qa3 fans within the project area.

The Qa3 fans likely formed roughly coincident to the emplacement of the Palo Verde mesa alluvium (Qpv; see below) and prior to subsequent incision by the Colorado River. The Qpv alluvium was deposited as the floodplain of the river, and, as such, acted as the local base level at the time the Qa3 fans were deposited. This is demonstrated by the interfingering of Qa3 and Qpv sediments (Stone 2006:11). As such, the Qa3 fans were primarily deposited during the Pleistocene, prior to the incision of the Colorado River below the Qpv terrace deposits (see below). This correlates with Bull’s (1991) Q2 fan units which date from 12 to 730 thousand years ago (ka). The fans are primarily as old as, or older than, the first documented evidence for humans in the New World, and, as a result, have a very low potential for buried archaeological deposits.

Qa5 is the next youngest fan unit present on the alluvial fan piedmont within the project area. The unit is not well represented within the project area, but is gradational to the older portions of the Qa6 fan unit (i.e., some minor areas mapped as Qa6 may be closer to Qa5 in both morphology and age). These fans are typified by bar and swale morphology that decreases in intensity further from the apex of the fan. The fans are only partially dissected by erosional gullies and have a weak to moderately packed surface pavement with light varnish. The bars are dominated by gravels while the intervening swales are dominated by smaller pebbles and sands that have infilled the original channels. Vegetation is larger within the swales, but also present on some bars. Subsurface profiles observed within the project area have Stage I to weak Stage II carbonate development. This morphology and subsurface carbonate accumulation is equivalent to Bull’s (1991:86) Q3c and Q3b fan units which date from 2 to 8 ka.

It is difficult to assess the sensitivity for paleosols and associated buried archaeological deposits without knowing the nature of the stratigraphic contacts between the Qa5 alluvial fans and any underlying older geomorphic units. No paleosols were noted in any of the natural exposures observed in the project area. Based on previous studies in the Basin and Range, alluvial fans are often underlain by an erosional unconformity that precedes deposition of the fan (URS 2010; Bull 1991:68, 73). This effect is less pronounced at the foot of the fans, where sediments are usually more fine-grained and erosional/depositional energy is lower. As such, the Qa5 portions of the fan piedmont are presumed to have a generally low sensitivity for buried archaeological resources, with slightly increased (moderate) sensitivity at the distal margins of the fans, where they mantle older deposits of the Palo Verde Mesa (Qpv; see below).

Qa6 is the youngest fan unit represented on the alluvial fan piedmont. As discussed above, this unit is gradational to the Qa5 unit, but generally exhibits a morphology that is indicative of a younger geomorphic surface. This includes a surface that exhibits bar and swale morphology grading to recently abandoned bar and channels in some locations. Surfaces closer to the Mule Mountains and older fan units are characterized by loosely packed cobbles, coarse gravels, and sands, while the distal portions of the fans are dominated by finer grained sediments (pebbles and sands; Figure 3.1-8). Little or no varnish is present. Vegetation is present across the fan surface, but varies from sparse to moderately dense. Subsurface profiles exhibit Stage I carbonate development or none at all. This morphology and subsurface carbonate accumulation is consistent with Bull's (1991:86) Q4a fan unit which dates to 0.1 to 2 ka, but may be more similar to Q3c (2-4 ka) in places. Sensitivity for buried archaeological resources is presumed to be similar to that of the Qa5 map unit.

Within the majority of the project area—except for the northwestern extent of the transmission line and substation alternatives where the fan piedmont grades out to a broad alluvial flat (see below)- the Qa6 fans terminate at a topographical barrier created by the Palo Verde Mesa. In profile, the western extent of the mesa crests and then forms an almost imperceptible backslope (dipping to the west; Figure 3.1-9). This backslope was likely created through erosion rather than tectonic tilting, as tectonic activity is thought to have been dormant in the area prior to emplacement of the Colorado River sediments (Metzger et al. 1973:G36). In many locations, a very small erosional gully has formed at the contact between the toe of the Qa6 fan and the backslope of the Palo Verde Mesa, draining north or south to the nearest active wash (Qw; see below). This distal margin contact of the Qa6 fan represents the most likely location for preservation of paleosols.

3.2.5 Colorado River Terrace (Sensitivity: Very Low)

Palo Verde Mesa, which forms the 70-foot-high cliff along the edge of the modern Colorado River floodplain (Palo Verde Valley), is the result of a series of aggradation and progradation events by the paleo-Colorado River. A diagram of the series of events that led to the multiple terraces and floodplain landforms observed today in the Palo Verde region was developed by Metzger et al. (1973:Plate 4) and is reproduced here in Figure 3.1-5. The landform mapped here as a Colorado River terrace and designated by map unit Qpv (Figure 3.1-2) is equivalent to Units D and E of Metzger et al. (1973:G24). The break in slope in the middle of the Palo Verde Mesa, evident in cross section (Figure 3.1-5), is designated by the dotted line on Figure 3.1-5.

The Colorado River terrace deposits are characterized by a very thick deposit of stratified clays, silts, and sands, with minor gravels. The surface of the landform is characterized by tan to light-gray, sandy and pebbly alluvium. This overlies the cliff-forming unit of light-reddish-brown bedded fine-grained material. There is considerable variability in the surface expression of the terrace deposits, with some areas containing sand and pebbly sand with a mixture of local and river gravels (equivalent to Unit E of Metzger et al. 1973), and other areas largely lacking clasts (equivalent to Unit D; Figure 3.1-10). The terrace deposits mostly devoid of the bar and swale morphology of the younger fan units, but are minimally dissected by erosional gullies. An extensive marker bed, consisting of well-developed, blocky red clay, was observed in several of the larger wash profiles near the top of the Qpv strata (Figure 3.1-11). This bed is consistent with other locations along Palo Verde Mesa where vertebrate Pleistocene fossils have been found and that are interpreted as having been deposited in small, shallow floodplain lakes (Metzger et al. 1973:G25).

Due to the unconsolidated, fine-grain nature of the surface of this landform, it is often very difficult to distinguish Qpv in the field from the distal margins of the Qa6 alluvial fans. The surface of the Qpv terrace deposits have begun to erode down into underlying pedogenic carbonate soil horizons in some locales. As a result, small carbonate pebbles have eroded out and been incorporated into the surface of the landform. These carbonate pebbles, or peds, are absent on the Qa6 fans. The change in slope between the backslope of the terrace deposits and the distal edge of the Qa6 fans, described above (and shown in Figure 3.1-9), is readily identifiable in the GIS and is, perhaps, the best means of identifying the contact.

The Colorado River terrace deposits have been assigned a date of middle to Late Pleistocene based on the presence of fossils (Metzger et al. 1973:G25). As such, they are considered too old to contain buried archaeological deposits. The only caveat to this assessment lies in the unconsolidated nature of much of the Qpv surficial deposits. While these unconsolidated fine-grain deposits are conducive to erosion and transport into the larger washes and off of the Palo Verde Mesa, it is also possible that some of this transported material has been redeposited on the mesa surface as thin eolian and/or alluvial deposits. Such deposits observed within the project area are limited (1 to 2 meters across) and are generally very thin (a few centimeters). While there is potential that these areas of redeposited fine-grain sediment could obscure archaeological deposits, it is unlikely that they would completely obscure an archaeological site. Furthermore, buried artifacts and/or features are likely to be similar to those found across the rest of the site. As such, the Colorado River terrace landform of Palo Verde Mesa has a very low sensitivity for buried archaeological resources.

3.2.6 Alluvial Flat (Sensitivity: Moderate to High)

The alluvial flat, located in the northwestern portion of the project area near the transmission line and substation alternatives, represents the eastern extent of the Chuckwalla Valley. The majority of the alluvial flat is composed of the distal portions of the Qa6 fans. As such, this area could also be considered an apron of the lower fan piedmont. However, alluvial flat is preferred here because it describes the properties of the geomorphic surface– a nearly level alluvial surface at the base of the piedmont– without assuming genesis from a single parent landform, and without inherent morphological assumptions. Within this area, the Qa6 fan surface is composed of primarily fine-grain material with limited gravels and little or no relief. Also present on the alluvial flat are areas that have been mapped as eolian sands (Qs). These are unconsolidated sand dunes and sheets that have blown east from the Chuckwalla Valley and Ford Dry Lake, and mantle the Qa6 alluvial deposits. Areas mapped as Qs on Figure 2.3-7 are dominated by these recent sand deposits. Smaller areas of eolian sand occur locally in other portions of the alluvial flat but have not been mapped due to their limited areal extent.

As with other portions of the distal Qa6 fans and Palo Verde Mesa river terrace deposits, differentiation between the two units can be difficult in the northwest portion of the project area. This is further complicated by the presence of eolian sands that, when deposited as a small, thin sheet, are similar to the unconsolidated, fine grain portions of the river terrace landform. The alluvial flat generally is a very young landform at the surface. The flat, distal portions of the lower alluvial fan piedmont are presumed to be dominated by the latest Holocene alluvium, while the eolian sand that mantles it is even younger. No subsurface exposures were observed within the alluvial flat, thus, the presence and condition of any paleosols is unknown. However, the geoarchaeological sensitivity is considered to be similar to those portions of the Qa6 fans that mantle the Palo Verde Mesa terrace deposits (i.e., moderate). A higher sensitivity can be assumed for those areas mapped as Qs, as these are very recent deposits that can easily obscure surface artifacts. Small unmapped areas of eolian sand, while potentially obscuring isolated artifacts or features, are small and thin enough that they are unlikely to obscure complete sites. Any sites obscured by Qs deposits are likely to be relatively young (less than ca. 1 ka) due to the age of the underlying Qa6 deposits.

3.2.7 Active Wash (Sensitivity: Low)

This landform, mapped as unit Qw, is comprised of unconsolidated sand, gravel, and boulder deposits of the larger active channels, as well as component landforms related to the active channel. While the active wash is primarily an erosional structure, small depositional features, such as inset fans and terraces and fine overbank deposits, are the result of deposition by the channel and are subsumed in this map unit. The active washes are dominated by gravel bar and sandy channel surface morphology (Figure 3.1-8). Mapped areas include both large individual washes and closely spaced smaller washes. Vegetation within the washes is greater than anywhere else in the project area due to the greater availability of water. The active washes are modern in age, equivalent to the Q4b geomorphic surface of Bull (1991), but, for the most part, have no sensitivity for buried archaeological resources as the result of ongoing active erosion.

Certain minor component landforms of the active washes are depositional. The largest of these component landforms are the inset fans or stream terraces. These landforms are created through deposition along the margins of the active channel, and are confined by the channel and adjacent older higher elevation landforms (e.g., the erosional sideslope of Qpv or Qa3). Although these component landforms are young and depositional in nature, they are generally considered to have a low potential for paleosols and associated buried archaeological resources due to their deposition on an erosional unconformity. As demonstrated on Figure 3.1-9, the inset fans and terraces of the active washes are laid down in areas that were previously scoured by the active channel—thus creating an unconformity and significantly reducing the likelihood of preservation of archaeological resources. In general, the active washes and component landforms are considered to have a low sensitivity for paleosols and associated buried archaeological deposits.

3.2.8 Modern Alluvial Fan and Floodplain (Sensitivity: Moderate to High)

These distinct landforms are discussed together here because of their close functional relationship and because they both have very limited presence within the project area. Modern alluvial fan deposits are mapped as Qm and represent the depositional equivalent of the active washes, where the washes débouché from the Palo Verde Mesa onto the modern alluvial floodplain of the Colorado River. The modern floodplain deposits are mapped as Qr. Both units are composed of unconsolidated clay, silt, and sand, and are largely undifferentiable in the field due to the interfingering of the deposits and the degree of agricultural disturbance across the Palo Verde Valley up to the base of the mesa. For the purposes of this study, the modern alluvial fan landform was mapped from the edge of Palo Verde Mesa to the beginning of agricultural fields. Due to the young age of both of these landforms (latest Holocene to modern), and their depositional nature, they are considered to have a high potential for containing paleosols and associated buried archaeological resources.

The modern floodplain deposits (Qr) represent the most recent aggradational cycle of the Colorado River, and are equivalent to "younger alluvium" defined by Metzger et al. (1973) (Figure 3.1-5). The scale of the river's degradation and aggradation is demonstrated by the presence of charcoal from 57 feet (± 17.4 meters) below the floodplain sediments near Blythe that was dated to 5,400 before present (BP), and to 8,600 BP from 110 feet (± 33.5 meters) below surface (Metzger et al. 1973:G28). If the surface of the Palo Verde Mesa terrace deposits (Qpv) represent the Late Pleistocene floodplain surface, this means that well over 200 vertical feet (± 61 meters) of sediment was eroded out of the Palo Verde Valley during the Late Pleistocene, and over 100 feet (± 30.5 meters) of sediment has filled the entire Blythe-Palo Verde Valley since the river began to aggrade again at the onset of the Holocene. In many ways, the scale and rapidity of this deposition precludes the accumulation of large stratified archaeological sites, and suggests that buried archaeological sites are more likely to be smaller, temporally discreet deposits. Nonetheless, the potential for paleosols and buried archaeological deposits is considered to be high.

Buried sites within the modern floodplain are likely to be located within close proximity to paleo-channels of the Colorado River. It has been well documented throughout California that sites tend to cluster near important resources, such as rivers and lakes, and the effect is only heightened in arid environments where water is a highly valuable resource. The same is true in buried contexts (Meyer et al. 2009). Therefore, the identification of archaeological deposits within the modern fan and floodplain landforms will be facilitated by the identification of paleochannel deposits. These deposits will be characterized by coarser grain channel bed forms that are distinct from the surrounding fine-grain alluvium. These paleochannels are more likely to be located within the body of the floodplain than on the margins. Therefore, the geoarchaeological potential of the Qr and Qm deposits within the project area (i.e., directly adjacent to Palo Verde Mesa) may be diminished compared to other locations further afield in the floodplain.

3.3 SUMMARY

The field verified findings from this geoarchaeological study of the Rio Mesa SEGF project area are consistent with previous findings from the other Basin and Range contexts. In a recent summary of the nearby Mojave Desert region, Sutton (1996) concludes that, contrary to the popular belief that all archaeological sites exist in surface contexts, "there are… many depositional environments [within the Basin and Range], and there is a great potential for buried sites in many areas… e.g., along the Mojave River, along lakeshores, and in cave sites" (1996:225). Given results from other locations (e.g., Roberts, Warren, and Eskenazi 2007), dune complexes, springs, and other areas with widespread episodic and stabilized eolian deposition should also be added to the list. All of these landform types are largely absent from the current study area, which is consistent with an overall low sensitivity for buried archaeological sites within the landforms of the project area.

The fine grain distal margin of the lower alluvial fan piedmont (unit Qa6), which is mantled on top of Pleistocene Colorado River terrace deposits of Palo Verde Mesa (Qpv), may represent the most extensive geomorphic feature in the project area that has the potential for buried archaeological deposits (with no surface manifestation). However, the degree of this potential is largely unknown due to a lack of subsurface exposures at this contact. Based on observation of surface sites on the fan piedmont, one of the primary natural resources attracting prehistoric populations to the project area was the extensive quartzite, chert, and cryptocrystalline river cobbles that have been redeposited across the fans from the relict Colorado River gravel terrace (QTmw). Similar rounded, exotic materials are present in smaller amounts on limited portions of the Qpv surface (in areas equivalent to Unit E of Metzger et al. 1973). These gravels and cobbles tend to be smaller and less frequent than those observed on the fan piedmont, but, nonetheless, may have acted as an attractive tool material prior to deposition of the younger portions of the fan piedmont. As such, any sites buried by the Qa6 and Qa5 fans are likely to be similar to those observed on the fan surface (i.e., dominated by lithic assays and associated expedient tools) but of greater antiquity.

Although composing a much smaller portion of the project area, places where unconsolidated and active eolian sands (Qs) have obscured alluvial landforms also have the potential for burying archaeological resources. The most extensive of these sand sheets is present at the very northern extent of the project area on the alluvial flat landform. Smaller localized eolian features, found on the Colorado River terrace (Palo Verde Mesa) and the northern alluvial flat, appear to be so limited that they are unlikely to obscure any significant portion of an archaeological site.

Finally, the young actively aggrading alluvial sediments of the modern alluvial fan (Qm) and alluvial floodplain (Qr) generally have a high potential for burial of archaeological sites. These landforms have a very limited presence in the Project area and their sensitivity is further diminished by their distance from the Colorado River, as well as presumed paleochannels of the river.

A secondary conclusion of this geoarchaeological study is that prehistoric site locations within the Rio Mesa Solar study area seem to be largely dictated by the availability of raw lithic materials. The series of coalescing fans that make up the alluvial fan piedmont west of Palo Verde Mesa have their source in the Mule Mountains. The dominant parent material present above these fans is quartz monzonite, with more limited outcrops of gneiss, diorite, granodiorite, with limited other volcanics (rhyolite, dacite, and amphibole). Much of this material has little utility for prehistoric tool making. At the same time, the quartzite, cryptocrystalline, and chert cobbles and gravels of the relict Colorado River terrace (QTmw) have been eroded and reworked into the lower fan piedmont and are more conducive to prehistoric tool production. This is demonstrated by the widespread lithic scatters present on these landforms. Areas of similar materials are also present on the Palo Verde Mesa terraces (Qpv).

3.4 RESEARCH ISSUES

This section explicitly enumerates the research questions, data needs and sampling strategy used to facilitate the development of refinements to our initial, field verified understanding of the variability, across each pertinent landform, in landform structure, based on the Applicant's consultant's visual field verification completed in 2011.

3.4.1 Research Questions

The following research questions will guide the Applicant's implementation of the Research Design to further refine the field verified identifications and the geographic extents of the project area landscape's constituent landforms and to further document and refine the genetic and historical relationships among them. The research questions will also guide the documentation of each pertinent landform's particular stratigraphy; interpretation of the energy regimes that led to the sedimentary deposition of each landform; interpretation of the chronology and duration of pedogenic processes that may have occurred for each landform; and discern whether the deposition of particular landform components was synchronous or may have been time transgressive (tempo).

1. Can further refinement of landform designations and tentative chronological associations developed in the initial Geoarchaeological Assessment be achieved?

2. For those landforms determined to have a depositional chronology and energy regime conducive to potential sensitivity for buried cultural resources (especially younger alluvial fan units Qa6 and Qa5), the subsurface conditions of those landforms be identified and documented? Specifically, can the lithostratigraphic and pedostratigraphic units that comprise the landforms, the age, duration and tempo of pedogenic processes, energy regimes and depositional environment, and subsequent preservation of those units be identified and documented?. This will allow for a refined estimate of the potential for buried archaeological deposits, and the likely nature, age, and depth of those deposits.

3. In addition to refining the subsurface conditions of potentially sensitive depositional landforms (Research Issue 2can the lateral variation in those landforms be established and documented, in order to better define spatial variability in the geoarchaeological sensitivity within each landform?

4. For those landforms that may contain surface archaeological sites, but are too old or high energy to contain buried archaeological deposits, can the subsurface relationship between the old landform and any adjacent younger landforms be defined, as there is the potential for buried archaeological sites at that subsurface contact? Specifically, for landforms that have been determined to be older than the latest Pleistocene (c.a. 16,000 BP) (e.g., the Qpv landform) and are buried by younger deposits, the nature of the buried surface (whether stable or erosional) is of particular import to the potential for buried archaeology.

3.4.2 Data Needs

1. Representative subsurface profiles of potentially sensitive depositional landforms, with adequate spacing to demonstrate lateral variation within each landform.

2. Representative profiles at or near the intersection of different landforms.

3. Datable material to establish the chronology of Project landform evolution.

3.4.3 Summary

The primary focus of the new phase of geoarchaeological research will be the excavation and exposure of representative landform profiles for those portions of the project area where the sedimentary landforms identified during the initial geoarchaeological reconnaissance assessment are of an age and appropriate depositional nature, where a potential for buried archaeological deposits was identified, and where the construction and operation of the proposed project would disturb native ground to a depth of greater than one meter. These excavations will allow for the collection of data which is useful in:

a. refining the geologic correlations that were field verified during the initial geoarchaeological reconnaissance and resultant Geoarchaeological Sensitivity Analysis and geoarchaeological sensitivity map;

b. assess whether the identified landforms are relatively synchronous or time-transgressive (tempo);

c. establish and refine the age of the lithostratigraphic and pedostratigraphic units that

d. compose the landforms; and

e. establish the lateral variation in the depositional energy responsible for the development of each landform.

This refined data set, and the interpretation of it, will allow for a more complete understanding of the geomorphic evolution of the Project area, and the association of surficial archaeological sites to that landform development, as well as the relative potential for the Project to impact buried archaeological resources.

CEC Staff indicated that during the initial geoarchaeological assessment too much emphasis was placed on the identification of paleosols as convenient stratigraphic markers of past land surfaces, where archaeological sites could potentially be subject to erosional processes; and not enough emphasis on the identification of areas of high-rate low-energy deposition, where archaeological sites would potentially be delicately buried and preserved (Rio Mesa Solar Electric Generating Facility Licensing Case Documents, Docket Number: 11-AFC-04, WebEx Recording of the March 1, 2012, Data Request and Issues Resolution Workshop, Posted March 5, 2012.). Grain size, depositional environment and energy regime, and pedogenic indicators of soil/paleosol development will be further refined for each of the subsurface exposures excavated during the geoarchaeological subsurface investigation. While the Applicant agrees that the quality of archaeological preservation is higher in relatively low energy depositional environments that have high depositional rates, it is not the most likely place to encounter buried archaeology. Cumulic soils (landforms where deposition outpaces soil development; i.e., where paleosols are not formed) do not lend themselves to the accumulation of large complex archaeological sites. A constantly acreting landform is not conducive to long-term occupation. At most, one could expect very ephemeral sites, spread-out more or less randomly throughout the vertical and horizontal extent of the cumulic landform. In trying to reduce the "needle in the haystack" problem of identifying buried archaeological sites across a large project area, paleosols are the best option because they would have been exposed at the surface for a sufficient amount of time to increase the chances of site formation (and subsequent burial). On any horizontal slice of a landform, a paleosol is more likely to have an archaeological site on it than an equivalent slice of unweathered alluvium. Necessarily, the geoarchaeological research will focus on areas that may contain paleosols of appropriate age (latest Pleistocene through Holocene) as well as those with fine-grain deposition that is more conducive to preservation.

3.5 FIELD METHODS

The following sampling strategy and fieldwork protocols will guide the Applicant's implementation of the Research Design to further refine the field verified identifications and the geographic extents of the project area landscape's constituent landforms and to further document and refine the genetic and historical relationships among them. The strategies and protocols will also guide the documentation of each pertinent landform's particular stratigraphy; interpretation of the energy regimes that led to the sedimentary deposition of each landform; interpretation of the chronology and duration of pedogenic processes that may have occurred for each landform; and discern whether the deposition of particular landform components was synchronous or may have been time transgressive (tempo).

3.5.1 Sampling Strategy

For the majority of the Project area, on Metropolitan Water District (MWD) property, twenty (20) locations have been selected for the placement of exploratory 1-meter-wide by five-meters-long geoarchaeological/paleontological trenches (Figure 3.1-12). These locations were selected based on their applicability to the research questions identified above, association with landforms identified and field verified during the reconnaissance survey as potentially being of appropriate age and depositional nature to harbor buried resources, and to yield a minimum of 300 cubic meters of stratigraphic excavation. This number of trenches should provide an adequate sample of the project area stratigraphy to accurately document it. It should also provide the data needed for the Project Paleontologist to further define the thickness and extent of the paleosol identified within the project area.

The maximum horizontal exposure of the trenches will certainly be larger than the basic working assumption (1-meter-wide) used above to calculate cubic meters of stratigraphic excavation. This is due to the nature of the benched excavation practices used for compliance with OSHA standards and directives related to trenching and excavation. Benching is a method of protecting workers from cave-ins by excavating the sides of an excavation (e.g., a trench) to form one or a series of horizontal levels or steps, usually with vertical or near vertical surfaces between levels. Therefore, all estimates of cubic meters of stratigraphic excavation should be used as an estimate of the minimum area that will be exposed.

The Applicant's construction practice for installation of pylons in the solar field minimizes impacts to biological, soil/water, and cultural resources. However, in an effort to help further define the thickness and extent of the paleosol, the Applicant has agreed to do additional paleontological testing within the project site as part of Data Request 128. In order to minimize additional impacts to the resources mentioned above, all the trenches and borings being excavated by the Applicant's Geotechnical Contractor will be observed by the Project Geoarchaeologist, as well as a Paleontological and Cultural Monitor. The placement of all the trenches and most of the borings was determined by the Project

Geoarchaeologist and Paleontologist, with the exception of the borings labeled “MWD Exploratory Borings” which were determined by the Project Geotechnical Contractor (Figure 3.1-12).

Trenches are primarily focused on the landforms identified as younger alluvial fans (Qa6 and Qa5) which are considered to have the greatest potential for harboring buried cultural resources. Trenches within this landform type extend east-west, from the head to the toe of the landform, as well as laterally north-south, in order to document structural changes across the landform, and variability in the potential for preservation of archaeological materials.

Several of these trenches (e.g., GPT-1, GPT-6, GPT-8) have been sited near the interface between the younger alluvial fan units and other identified older and/or coarser-grained landforms. These locations are intended to demonstrate the subsurface interaction between the adjacent landform types and provide data on the nature of any subsurface contacts between the two units.

Although many of these landforms have sufficient observable surface characteristics (e.g., clast size, degree of desert varnish, degree of pavement formation) or have been sufficiently dated and documented by other researchers (e.g., the Qpv landform, see discussion above), a small number of trenches have been placed within these landforms to confirm assumptions made during the reconnaissance field study. In particular, trenches placed within the Pleistocene Colorado River inset terrace deposits (Qpv) have been placed in locations where project related impacts will exceed 1 meter below surface, and will be used to assess near-surface conditions and the veracity of assumptions regarding the lack of geoarchaeological potential.

3.5.2 Fieldwork Protocols

Each geoarchaeological trench will be excavated using a full-size backhoe fitted with a 2- to 3-foot wide bucket. Each trench will be approximately 5 meters long at the surface and excavated to the maximum reach of the backhoe (approximately 4 meters), unless conditions are present (e.g., extremely coarse or indurated sediments) that preclude the need or ability to complete the trench. The backhoe excavation of trenches and excavated spoils will primarily be observed from the surface and then be documented from the surface, for safety reasons and for compliance with OSHA standards and directives related to trenching and excavation. If pedogenic or archaeological features are observed from the surface, which require closer inspection and/or sampling, the trench will be shored using hydraulic speed shoring, so that the Project Geoarchaeologist can enter the trench safely, document subsurface stratigraphy and pedogenic indicators, in detail, and collect soil and dating samples.

In addition to the geoarchaeological trenches, numerous geotechnical and paleontological mechanical excavations (backhoe excavated pot-holes and corkscrew augers) have been planned (Figure 1). In order to gather the maximum amount of data regarding subsurface conditions, these excavations will also be observed, documented, and sampled by the Project Geoarchaeologist.

The Project Geoarchaeologist will produce a measured profile drawing, using a metric scale, on one sidewall from each excavated trench, where the drawings are produced on the basis of observation from the surface. Observed stratigraphic units will be described based on physical characteristics such as composition (grain size, parent material), color, superposition, textural transitions, and pedogenic properties (i.e., relative soil development). Each profile, including all observable textural and soil transitions, will be logged on standard soil recordation forms and photographed. These will include a detailed description of each lithostratigraphic and pedostratigraphic unit and be used to correlate units identified in other trenches.

The information collected in the soil recordation forms (Attachment 2) will be used to produce reasonable detailed written descriptions, appropriate to the character of each type of stratigraphic unit, of each lithostratigraphic and pedostratigraphic unit down a one-meter-wide, shaved profile section along the sidewall for which the measured profile drawing is made. Each measured profile sidewall will be photographed with a metric scale and north arrow.

A maximum of 6 radiocarbon samples will be submitted for analysis, in order to determine the depositional rates and approximate ages of the major process-related lithostratigraphic sequences present, constrain the dates of any paleosols or archaeological deposits that are found, and collect enough soil humate samples, in the absence of other reliable chronometric data, to reliably assay and radiocarbon date the master stratigraphic column for each landform and each major landform feature. Discrete, in-place charcoal samples will be used for dating. At least one additional archaeologist will be on-site to assist in the monitoring and sorting of spoils excavated from the geoarchaeological trenches. Rakes and other hand tools will be used to actively sort through material as it is excavated from each trench. The Project Geoarchaeologist will assist in identifying paleosols and sensitive depositional horizons as they are excavated, and these will be targeted for monitoring. Additionally, a small (three 5-gallon buckets) sample of sediment from the major lithostratigraphic units in the measured profile, or, where lithostratigraphic units are not apparent, from arbitrary levels in each measured profile, every 0.5 meters of depth, will be screened through ¼-inch hardware mesh.

The Project Geoarchaeologist will mechanically excavate through any buried archaeological deposits encountered, unless such deposits contain human remains, using arbitrary levels no greater than 20 cm thick, screen the arbitrary levels through ¼-inch hardware mesh, and provenience all artifacts, ecofacts, and other material culture finds to those arbitrary levels.

3.5.3 Geotechnical Evaluation Procedures

The following section provides a brief summary of the geotechnical study details that are relevant to this Study.

Backhoe excavating, logging and sampling of exploratory trenches to depths of 3 meters will be completed by the Geotechnical Contractor. A JCB 215 backhoe with a 2-foot bucket and an extendahoe will be used for the trenches.

The Geotechnical Contractor will also drill, log and sample all exploratory borings to depths of approximately 15 feet and 20 feet (4.5 and 6 meters). The borings will be performed by a track-mounted CME-75 drill rig utilizing 8-inch diameter hollow stem augers. The purposes of the borings labeled "MWD Exploratory Borings" will be to evaluate the general subsurface soil and groundwater conditions, and to obtain soil samples for laboratory testing. The boring will be performed with an all-terrain drill rig.

For the borings labeled "Paleo Boring Transect", the best method for acquiring relatively undisturbed samples is to continuous sample with a 2-foot split-barrel sampler.

Generally, the Geotechnical Contractor will proceed with the trenching and boring from north to south, starting with the explorations in the eastern portion of the site along the WAPA 115kV power line first. Then they will continue south to north to complete the trenching and boring in the western portion of the site.

3.5.4 Curation

Artifact and fossil collection, retention/disposal, and curation will follow standard protocols and policies. The Applicant commits to curate all archaeological materials, in accordance with the California State Historical Resources Commission's *Guidelines for the Curation of Archaeological Collections*, into a retrievable storage collection in a public repository or museum. Additionally, the Applicant commits to curate all paleontological materials, in accordance with the Society for Vertebrate Paleontology guidelines, into a retrievable storage collection in a public repository or museum. Moreover, the Applicant commits to pay all curation fees for artifacts and fossils recovered and for related documentation.

SECTION 4 TECHNICAL REPORT

A report describing the results of the geoarchaeological field study, and implications for assumptions made during the initial assessment, will be produced. This report will include: mapping of the surface geomorphology of the project area (map scale of ≥1:12,000); maps and descriptions of all excavated trench locations; graphic and written descriptions of the stratigraphic profiles of the project area including an analysis of the depth and extent of any potentially sensitive paleosols; a processual geologic interpretation and the approximate age of subdivisions of the master column that reflect shifts in local depositional regimes or depositional history, and that reflect time ranges that correspond to the prehistory and history of the region, as presently understood; DPR 523 forms, and descriptions and preliminary interpretations of any encountered archaeological deposits. Formal reporting of radiocarbon analysis results will be included as an appendix. The report will also provide: an interpretation of the character of the prehistoric or historic land use that each encountered archaeological deposit represents; an interpretation, with reference to the information gathered and developed above, of the likelihood that buried archaeological deposits are present in each of the identified landforms or portions thereof; on the basis of the current understanding of the prehistory and history of the region, what site types are most likely to be found; and recommendations, based on the present geoarchaeological study, on the locations and extent (horizontal and vertical) of potential mitigation measures that would be most consistent with CEQA requirements for mitigation of impacts through avoidance, when possible, and with the historic preservation goal of recovering valid scientific data from CRHR-eligible archaeological deposits whose destruction cannot be avoided.

This report will also seek to more securely establish the physical contexts of the surface archaeological sites in the proposed project area, and to reliably assess both the likelihood that project area landforms may contain buried archaeological deposits and the likely character of any such deposits. The results of the geoarchaeological study should allow the CEC to better assess the potential impacts of the proposed project to buried archaeological resources, and to design a more targeted, limited, and effective mitigation monitoring plan (if warranted by the results of the geoarchaeological study).

Additionally, a Paleontological Letter Report will be prepared and submitted to the CEC and BLM for review which will summarize the testing results for all areas as part of Data Request 128.

Lastly, buried archaeological deposits found during the trenching activities will be recorded on DPR 523 forms by the Cultural Monitor. Formal evaluation of site eligibility and/or data recovery is beyond the current scope. The geoarchaeological study is not designed to assess the eligibility of buried archaeological sites identified during trenching. Additional scoping and consultation with the CEC and BLM will be necessary to complete a Phase II analysis of any identified archaeological deposits.

SECTION 5 PROJECT PERSONNEL AND MANAGEMENT

All cultural resources work will be carried out under the direct supervision of archaeologists who meet the Secretary of Interior's Standards and Guidelines for Archaeology and Historic Preservation, and will be consistent with the procedures for compliance with NEPA, Section 106 of the NHPA, and CEQA Section 15064.5. All decisions on level of effort or discretionary actions described in the CRWP will be approved by BLM/CEC prior to implementation.

The key cultural resources personnel who will conduct the study and prepare the technical report are:

- Jay Rehor, M.A. (URS Principal Investigator)

SECTION 6 REFERENCES

Bull, W. 1991. Geomorphic Responses to Climate Change. Oxford University Press, New York.

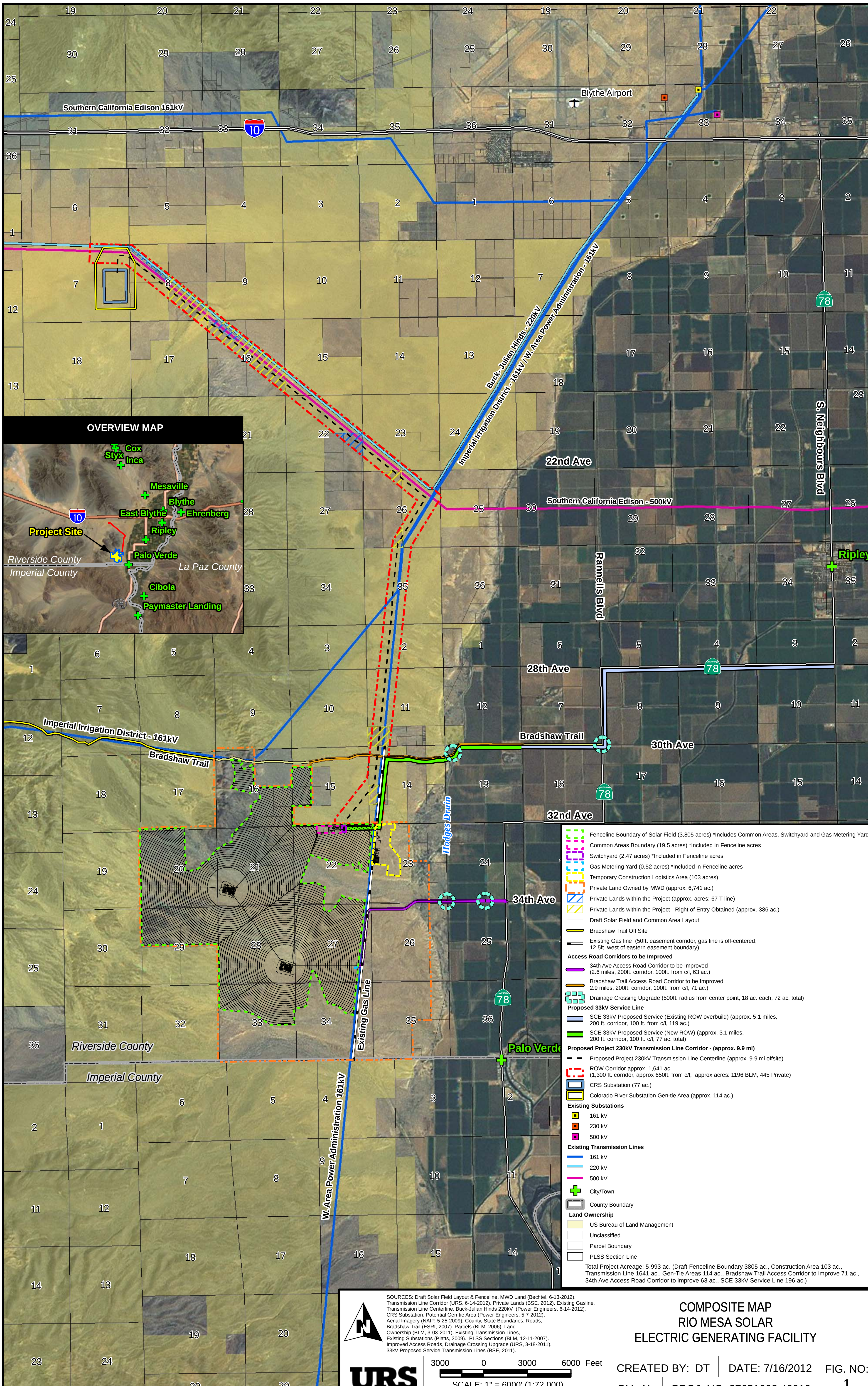
Metzger, D. G., Loeltz, O. J., and Irelan, Burdge. 1973. Geohydrology of the Parker-Blythe-Cibola area, Arizona and California: U.S. Geological Survey Professional Paper 486-G, 130 p.

Nixon, Rachael A., Arleen Garcia-Herbst, Jay Rehor, Melanie Lytle, Kimberly Maeyama, Mark Neal, and Sarah Mattiussi. 2011. *Cultural Resources Technical Report for the Rio Mesa Electric Generating Facility, Riverside County, California*, URS Corporation, San Diego, for BrightSource Energy, Oakland.

Rehor, Jay. 2011. Geoarchaeological Sensitivity Analysis, Rio Mesa Solar Generating Electric Facility Project. Prepared by Jay Rehor, URS Corporation, Oakland, for BrightSource Energy, Oakland.

Stone, P. 2006. Geologic Map of the West Half of the Blythe 30' by 60' Quadrangle, Riverside County, California and La Paz County, Arizona. Scientific Investigations Map 2922. U.S. Geological Survey, Menlo Park, California.

Non-Confidential Figures



SOURCES: Draft Solar Field Layout & Fenceline, MWD Land (Bechtel, 6-13-2012). Transmission Line Corridor (URS, 6-14-2012). Private Lands (BSE, 2012). Existing Gasline, Transmission Line Centerline, Buck-Julian Hinds 220kV (Power Engineers, 6-14-2012). CRS Substation, Potential Gen-tie Area (Power Engineers, 5-7-2012). Aerial Imagery (NAIP, 5-25-2009). County, State Boundaries, Roads, Bradshaw Trail (ESRI, 2007). Parcels (BLM, 2006). Land Ownership (BLM, 3-03-2011). Existing Transmission Lines, Existing Substations (Platts, 2009). PLSS Sections (BLM, 12-11-2007). Improved Access Roads, Drainage Crossing Upgrade (URS, 3-18-2011). 33kV Proposed Service Transmission Lines (BSE, 2011).

COMPOSITE MAP
RIO MESA SOLAR
ELECTRIC GENERATING FACILITY

URS

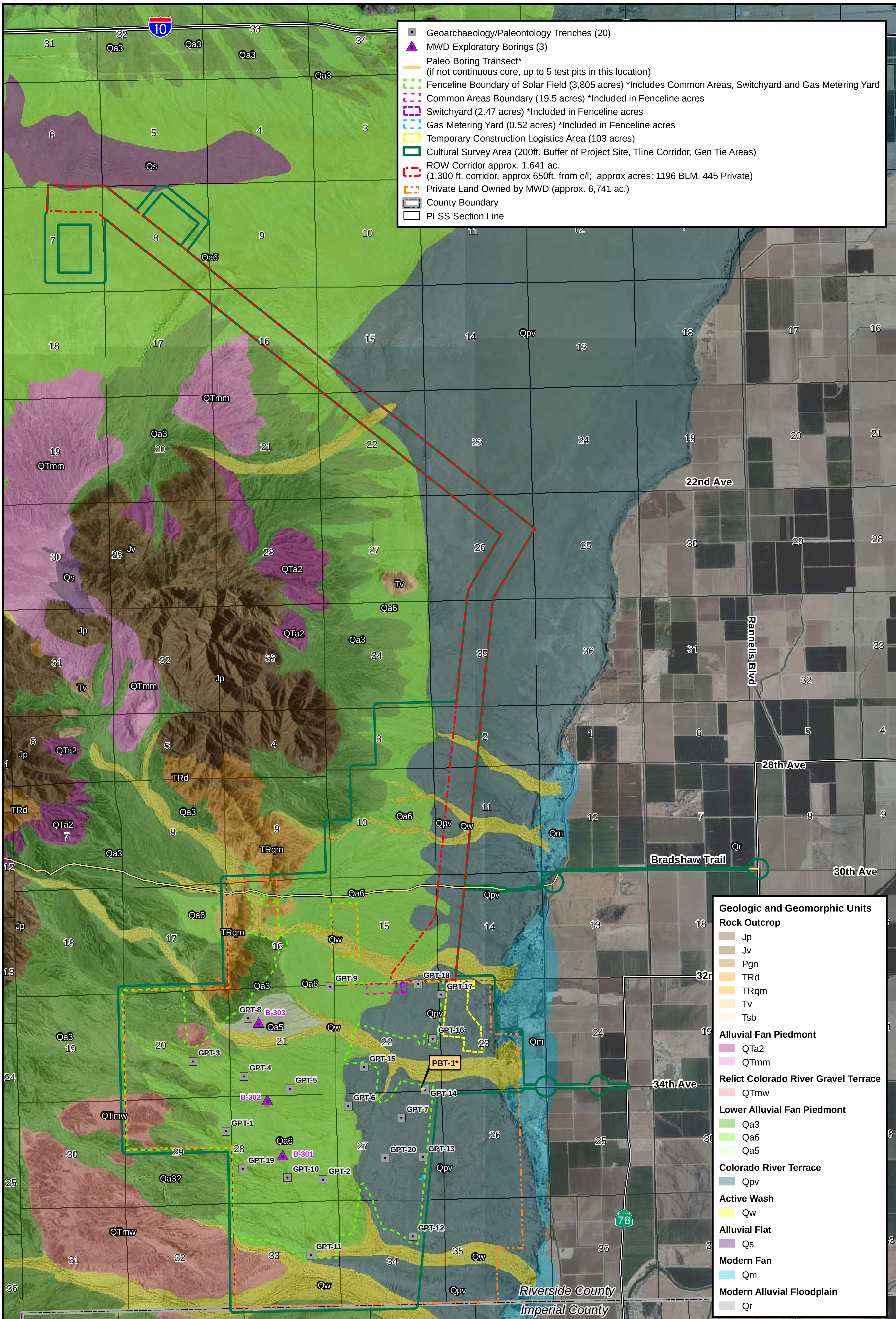
3000 0 3000 6000 Feet

SCALE: 1" = 6000' (1:72,000)
SCALE CORRECT WHEN PRINTED AT 11X17

CREATED BY: DT	DATE: 7/16/2012	FIG. NO: 1
PM: AL	PROJ. NO: 27651003.40010	

Path: G:\gis\projects\1577\27651002\map_docs\mxd\Project_Features_NO_NORTH_TOWER\RMS_Composite_Map.mxd, colin_mattison, 7/16/2012, 1:39:30 PM

DRAFT - Internal Planning Use Only



SOURCES: Draft Solar Field Layout & Fenceline, MWD Land (Bechtel, 6-13-2012).
Transmission Line Corridor (URS, 6-14-2012).
Aerial Imagery (NAIP, 5-25-2009).
County, State Boundaries, Roads (ESRI, 2007). Parcels (BLM, 2006). Land Ownership (BLM, 3-03-2011).
PLSS Sections (BLM, 12-11-2007).
Geotech Borings, Geomorphology (URS, 2011/2012).

PROPOSED GEOTECHNICAL LOCATIONS AND BORINGS RIO MESA SOLAR ELECTRIC GENERATING FACILITY

URS

2250 0 2250 4500 Feet

SCALE: 1" = 4500' (1:54,000)

SCALE CORRECT WHEN PRINTED AT 11X17

CREATED BY: DS	DATE: 7/20/2012	FIG. NO: 3.1-12
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Attachment 1
Quaternary Geologic Unit Descriptions Form:

Geologic Map of the West Half of the Blythe 30' by 60' Quadrangle, Riverside County, California and La Paz County, Arizona. Pamphlet to accompany Scientific Investigations Map 2922" Compiled by Paul Stone, 2006

of dextral slip and an arcuate, east-dipping fault with about 1.5 km of normal displacement have been mapped and described by Hamilton (1982, 1984). These faults are interpreted to record post-detachment fault extension (Hamilton, 1982). Two prominent northwest-striking faults in the northern Little Maria Mountains were shown as right-lateral strike-slip faults by Emerson (1982) but also could be dip-slip faults with the east side down. Several faults offset strata of the McCoy Mountains Formation in the McCoy Mountains; some of these are clearly normal faults, and three of the faults have Tertiary sedimentary breccia deposits in their hanging walls (Stone and Pelka, 1989).

In addition to these exposed faults, gravity anomalies (Rotstein and others, 1976; Mariano and others, 1986) suggest the presence of several subsurface faults of presumed Tertiary age in the southern part of the map area. On the basis of the gravity anomalies, northwest-trending faults are inferred beneath Quaternary alluvium on both sides of the McCoy Mountains, along McCoy Wash, and on the southwest sides of the Big Maria and Little Maria Mountains; northeast-trending faults are inferred on the west side of the Mule Mountains and beneath Chuckwalla Valley (fig. 1). The gravity anomalies reflect abrupt changes in basement elevation strongly suggestive of dip-slip fault movements (Rotstein and others, 1976). In addition, some of the faults may have undergone right-lateral strike-slip movement as interpreted by Richard (1993). The aligned hills of sedimentary breccia (Tbx; Tu in fig. 1) between the Big Maria and Little Maria Mountains do not appear to coincide with a major gravity anomaly or subsurface fault zone, but this breccia may have been deposited in a shallow structural depression that branched northwestward from the inferred major fault zone on the southwest side of the Big Maria Mountains.

Latest Tertiary and Quaternary Surficial Deposits

Surficial deposits of late Miocene to Holocene age form most of the land surface in the west half of the Blythe 30' by 60' quadrangle. Most of these deposits are composed of alluvium either derived from local mountain ranges or transported into the area by the Colorado River.

The oldest surficial deposits in the map area are locally derived gravels of probable late Miocene age (Ta_1). These gravels are overlain by limestone and fine-grained clastic deposits assigned to the late Miocene and (or) Pliocene Bouse Formation (Tbl, Tbs). Foraminifera, mollusks, and ostracodes from Bouse sediments suggest a marine to brackish-water environment (Smith, 1970), and most workers have interpreted the Bouse Formation to represent deposition in an estuary or marine embayment connected to the proto-Gulf of California (Metzger and others, 1973; Buising, 1990). Alternatively, Spencer and Patchett (1997) have shown that strontium isotope data from the Bouse Formation indicate a lacustrine rather than a marine or estuarine environment, and they have suggested that the Bouse fauna was introduced to the lacustrine environment through transport by birds. The depositional setting of the Bouse Formation remains debatable (Spencer and Pearthree, 2001; Patchett and Spencer, 2001; Lucchitta and others, 2001). Regionally, the Bouse Formation is gradationally overlain by fluvial deposits of the ancestral Colorado River (Buising, 1990), although this relation is not exposed in the map area.

Most of the locally derived alluvial-fan and alluvial-valley deposits in the map area are divided into five units (QTa_2, Qa_3–Qa_6) based primarily on their surface morphology and their appearance on aerial photographs. Each of these units corresponds to one or more of nine regionally widespread alluvial geomorphic surfaces distinguished by Bull (1991). The oldest and thickest unit (QTa_2, equivalent to Q1 of Bull) forms deeply dissected hills and ridges adjacent to the range fronts. Parts of this unit could be as old as late Miocene and equivalent to Ta_1. Alluvium of primarily middle and late Pleistocene age (Qa_3 and Qa_4, mostly equivalent to the Q2 surfaces of Bull) forms smooth, varnished pavements, whereas Holocene alluvium (Qa_5 and Qa_6, mostly equivalent to the Q3 and Q4a surfaces of Bull) forms rough surfaces that preserve relict depositional bars and channels. Most of the middle Pleistocene to Holocene alluvial units are interpreted as the products of aggradation events that took place during interglacial climatic environments (Bull, 1991). The youngest locally derived alluvium is that of modern washes (Qw, equivalent to Q4b of Bull), which commonly are incised many meters into the older alluvial-fan deposits.

Several units composed largely or entirely of alluvium deposited by the Colorado River have been distinguished in the map area. These units are characterized by the presence of light-colored, locally crossbedded sand and rounded gravel of resistant rock types exotic to the area. Most of these deposits (Qpv, Qbm, QTe) are concentrated along the margins of the modern Colorado River flood plain, where they apparently interfinger with locally derived alluvium. One unit (QTmw), however, crops out high on Palo Verde Mesa as much as 8 km from the flood plain, and another (QTmm) surrounds the northeastern part of the Mule Mountains. These high-standing units represent one or more major aggradational events when the ancestral Colorado River flowed across the area at much higher elevations than the modern river. Metzger and others (1973) recognized two major pre-Holocene aggradations, one of probable Pliocene-Pleistocene age and the other probably middle to late Pleistocene, each of which was followed by a period of degradation. The last degradation was followed by Holocene aggradation that has deposited the sediments of the modern flood plain (Qr) (Metzger and others, 1973).

Much of Rice Valley near the north edge of the map area is covered by eolian sand. This large sand field is characterized by abundant, partially stabilized linear dunes with an average orientation of east-southeast. These dunes are conspicuous on aerial photographs and have been accurately mapped, although they have not been studied in detail. The Rice Valley sand field is at the end of a prominent pathway of southeastward sand transport that begins near Bristol Dry Lake 100 km to the northwest (Zimbelman and Williams, 2002). To the south, smaller areas of eolian sand in Chuckwalla Valley are at the southeast end of another sand pathway that begins near Dale Dry Lake, also about 100 km to the northwest.

The only other surficial deposits in the area are playa sediments that cover the floor of Ford Dry Lake and another small dry lake in Chuckwalla Valley. A brief visit to Ford Dry Lake showed that these deposits consist largely or entirely of fine-grained clastic sediments and apparently lack evaporites.

Quaternary Faults

There is little evidence of Quaternary faulting in the map area. The only faults known to cut Quaternary deposits in the area are those that form the northwest-trending Blythe Graben on the southwest side of the Big Maria Mountains (Fugro, Inc., 1975). As described by Purcell and Miller (1980), this graben is about 5.5 km long, 92 m wide, and has about 3 m of vertical relief. The graben cuts alluvial-fan deposits dated as 6 to 31 ka (Purcell and Miller, 1980) and shown as Qa_3 on the map presented here; it appears to be overlapped by younger sediments mapped here as Qa_5. The tectonic significance of the Blythe Graben is unknown, although it does approximately coincide with a geophysically delineated subsurface fault (fig. 1). The graben was not examined during the present study.

DESCRIPTION OF MAP UNITS

Qw **Alluvium of modern washes (Holocene)**—Unconsolidated, angular to subangular gravel and sand derived from local mountain ranges. Boulder- and cobble-rich wash deposits proximal to mountain fronts grade downstream into pebbly and sandy distal deposits. Mapped areas include both large individual washes and closely spaced smaller washes. Wash deposits commonly grade laterally and downstream into young alluvial sand and gravel of Qa_6. Equivalent to deposits forming geomorphic surface Q4b of Bull (1991)

Qr **Alluvium of the modern Colorado River flood plain (Holocene)**—Unconsolidated clay, silt, and sand. Mostly covered with thick vegetation or converted to farm land

Qp **Playa lake deposits (Holocene)**—Unconsolidated clay, silt, and sand. Vegetative cover sparse. Locally includes thin veneer of eolian sand

Qs **Eolian sand (Holocene)**—Unconsolidated sand dunes and sheets. Dunes are partially stabilized by vegetation. Brown lines mark dune crests mapped from aerial photographs

Alluvial-fan and alluvial-valley deposits (Holocene to Miocene)—Angular to subangular gravel and sand derived from local mountain ranges. Mostly unconsolidated to weakly consolidated; oldest deposits are locally well consolidated. Divided into six units distinguished by contrasting surficial and geomorphic characteristics:

Qa_6 **Unit 6 (Holocene)**—Young alluvial-fan and alluvial-valley deposits characterized by a lack of desert varnish, generally fine grain size, and evidence of recent sediment transport. Consists mostly of sand, pebbly sand, and sandy pebble-gravel; forms very gently sloping to nearly flat valley floors marginal to older, varnished alluvial-fan deposits. Surfaces are covered by sparse to moderately dense vegetation and commonly are transected by shallow channels of active sediment transport. Thin accumulations of eolian sand, not mapped separately, are present locally. Near mountains, unit includes relatively coarse, youthful, unvarnished gravel deposits of alluvial fans that grade downslope into the fine-grained deposits; some of these gravels form surfaces that may be inactive and equivalent to some deposits mapped elsewhere as Qa_5. Unit also includes deposits of many minor washes and channels (equivalent to Qw) too small to be mapped separately. Probably equivalent primarily to deposits forming geomorphic surface Q4a of Bull (1991), which is interpreted to range in age from 0.1 to 2 ka

Qa_5 **Unit 5 (Holocene)**—Alluvial-fan deposits of gravel and sand that form relatively young, undissected to little-dissected, unvarnished to lightly varnished surfaces typically displaying bars and swales modified from original depositional bars and channels. Bars are composed of poorly sorted gravel commonly as coarse as 20 cm in diameter; swales are composed of sand and fine gravel typically 2 cm in diameter or smaller. Vegetation can be moderately dense in swales but is sparse on bars. Surfaces generally appear to be depositionally inactive, but some surfaces may have been modified by recent stream flow and sedimentation and thus may be correlative with some surfaces of unit 6 (Qa_6). Probably equivalent primarily to deposits forming geomorphic surfaces Q3c and Q3b of Bull (1991), which are interpreted to range in age from 2 to 8 ka

Qa_4 **Unit 4 (Holocene and Pleistocene)**—Relatively old, dissected, pavement-forming alluvial-fan deposits of gravel and sand that are similar to the much more extensive unit 3 (Qa_3) but are composed primarily of light-colored, unvarnished granitic rock fragments and thus form surfaces much lighter in color than the varnished pavements typical of Qa_3. Covers small areas flanking northwestern Little Maria and southeastern Big Maria Mountains

Qa_3 **Unit 3 (Holocene and Pleistocene)**—Alluvial-fan deposits of gravel and sand that form relatively old, dissected surfaces mostly characterized by smooth, varnished desert pavement. Typical pavements have little or no surface relief and are composed of tightly to moderately packed, angular to subangular rock fragments averaging 2 to 10 cm across and generally less than 30 percent interstitial sand. Most surfaces have a dark brown to nearly black desert varnish, but some surfaces are lighter in color owing either to a relative abundance of unvarnished or lightly varnished granitic gravel or to vehicular or other human disturbances that have disrupted and crushed the original pavement. Pavement surfaces are dissected and drained by dendritic networks of sandy channels that vary in depth from less than 1 m to several meters; vegetation is typically dense in these channels but is sparse to absent on the pavement surfaces. Unit includes surfaces that range from only slightly dissected to deeply dissected, and that probably represent a wide range in age. Unit also includes some bar-and-swale surfaces similar morphologically to those of unit 5 (Qa_5) but most of which are moderately to darkly varnished, probably older than most surfaces of that unit, and difficult to distinguish on aerial photographs from the smoother desert pavements. Probably equivalent primarily to deposits forming geomorphic surfaces Q3a to Q2a of Bull (1991), which are interpreted to range in age from 8 to 730 ka

QTa_2 **Unit 2 (Pleistocene to Miocene)**—Alluvial-fan deposits of fine to coarse, poorly sorted gravel and sand that typically form high, deeply dissected, narrow ridges extending away from mountain fronts. Some ridge crests are relatively flat, narrow plateaus that preserve small tracts of smooth desert pavement like that of Qa_3, but most ridge crests are sharp to rounded and presumably have been eroded to a level below that of any preexisting alluvial surface. The youngest deposits assigned to this unit may overlap in age with the oldest deposits assigned to unit 3 (Qa_3); the oldest deposits assigned to this unit may be coeval with Ta_1. In two places, alluvium assigned to this unit depositionally overlies limestone or tufa of the Bouse Formation (Tbl). Probably largely equivalent to deposits forming geomorphic surface Q1 of Bull (1991), which is interpreted to be older than 1.2 Ma

Ta_1 **Unit 1 (Miocene)**—Alluvial-fan deposits of gravel and sand that demonstrably underlie limestone or tufa of the Bouse Formation (Tbl); recognized only in a few places on the east sides of the Riverside and Big Maria Mountains. Best exposed in bare washes east of the Riverside Mountains where unit consists of well consolidated, reddish-brown, sandy conglomerate containing abundant clasts of gneiss and schist. Away from these wash exposures, unit forms hills and ridges of poorly sorted gravel similar to those of QTa_2. Observed contacts with overlying limestone (Tbl) are concordant. Equivalent to the fanglomerate of Metzger and others (1973) and the fanglomerate of Osborne Wash of Carr and Dickey (1980)

Alluvial deposits of the ancestral Colorado River (Pleistocene and Pliocene)—Unconsolidated to well consolidated alluvial deposits of moderately to well sorted clay, silt, sand, and gravel derived from distant sources and deposited by the ancestral Colorado River; exposed primarily along bluffs and mesas bordering the modern Colorado River flood plain. Clay, silt, and sand deposits are light in color, commonly well laminated, and typically friable; gravels and conglomerates consist of rounded pebbles and cobbles of resistant lithology, primarily quartzite and other siliceous rock types. As mapped, some units also include locally derived alluvial-fan deposits. Divided into the following units:

Qpv **Alluvial deposits of Palo Verde Mesa (Pleistocene)**—Unconsolidated to weakly consolidated deposits of sand, pebbly sand, silt, and clay that are locally well exposed along the scarp of Palo Verde Mesa, which bounds the flood plain of the Colorado River. Scarp exposures, typically about 20 to 30 m thick, show an upper, slope-forming unit of tan to light-gray, sandy and pebbly alluvium and a lower, cliff-forming unit of light-reddish-brown, interbedded fine-grained sand, silt, and clay. The upper unit extends westward from the top of the scarp to form the surface of Palo Verde Mesa, which is composed of unconsolidated sand and pebbly sand containing a mixture of local and river pebbles generally less than 4 cm in diameter. South of McCoy Wash, a prominent terrace is developed in Qpv at a height of about 20 to 25 m above the flood plain and about 20 m below the upper surface of Palo Verde Mesa. The subtle contact between units Qpv and Qa_6 is placed at the western limit of river pebbles present at the surface of Palo Verde Mesa; this contact approximately coincides with the slight break in slope that marks the distal margins of alluvial fans and valleys extending from the mountains to the west. Northeasternmost exposures of Qpv apparently are overlain by alluvial-fan deposits assigned to unit Qa_5 and may interfinger with alluvial-fan deposits assigned to unit Qa_3. Deposits herein assigned to Qpv represent units D and E of Metzger and others (1973, p. G24-G25), which are interpreted to be of probable middle to late Pleistocene age

Qbm **Alluvial deposits east of the Big Maria Mountains (Pleistocene)**—Sand and gravel deposits containing a mixture of rounded river gravel and angular to subangular, locally derived gravel.

Sand is tan to light reddish brown and locally is associated with minor silt and clay; river gravel is mostly 4 cm or less in diameter and varnished to various shades of brown. Unit typically forms dissected hills with light- to medium-brown surfaces distinct from the generally more darkly varnished surfaces of alluvial-fan unit Qa_3. West of Hall Island, unit forms at least four distinct terraces ranging from about 10 to 40 m in height above the Colorado River flood plain. Unit is undated but probably is middle to late Pleistocene based on observed relations of subunits (described below) with unit Qa_3. In part equivalent to river gravel of Hamilton (1964). Includes the following subunits:

Qbmg **Gravel-dominated deposits**—Deposits composed almost entirely of rounded river pebbles and cobbles due west of Hall Island. Forms an elevated ridge representing the upper 1 to 2 m of the local alluvial sequence; overlies Pleistocene, pavement-forming alluvial-fan deposits assigned to unit Qa_3

Qbms **Sand-dominated deposits**—Unconsolidated to weakly consolidated, tan to light-reddish-brown sand and pebbly sand forming several small hills southwest of Hall Island. Gravel in these sandy deposits is largely of local origin but includes about 10 percent rounded river pebbles. In at least one place, sandy deposits overlie alluvial-fan gravel deposits of Qa_3

QTmm **Alluvial deposits of the Mule Mountains (Pleistocene or Pliocene)**—Weakly to moderately consolidated sand and pebbly sand deposits, interbedded with locally derived gravel deposits. Sand and pebbly sand deposits are light gray, tan, and light reddish brown, fine to coarse grained, well to moderately well sorted, generally thin bedded where well exposed, and locally cross bedded. Cross beds measured at two localities dip about 25º southwest to southeast, suggesting generally southward sediment transport. Rounded river pebbles, mostly quartzite and chert, are locally associated with the sandy deposits. The thin-bedded and crossbedded sands of this unit are similar to those of unit QTe (alluvial deposits of the Ehrenberg area) and are tentatively interpreted as coeval with that unit. Unit forms deeply dissected hills and ridges capped by coarse cobble to boulder gravels of local derivation that may be equivalent to unit QTa_2; these gravels are mapped as part of QTmm and form much of the surface area included in the unit. Unit is exposed at elevations ranging from about 150 to 240 m and extends through a broad depression in the Mule Mountains; this depression may mark a former course of the ancestral Colorado River

QTmw **Alluvial deposits of the McCoy Wash area (Pleistocene and/or Pliocene)**—Deposits of rounded river gravel and minor locally derived gravel that form several broad hills standing 15 to 25 m above Palo Verde Mesa in the vicinity of McCoy Wash and the southeast side of the McCoy Mountains. River gravel averages 2 to 4 cm and is as large as 15 cm in diameter; most is varnished. Rare hillside exposures show that the surface gravels are underlain by brown, well consolidated calcareous or gypsiferous sandstone. Stratigraphic relations of QTmw with adjacent deposits of Palo Verde Mesa (Qpv) are unclear. Metzger and others (1973, p. G22) considered deposits here mapped as QTmw as part of their unit B of presumed Pleistocene and Pliocene age

QTe **Alluvial deposits of the Ehrenberg area (Pleistocene and/or Pliocene)**—Heterogeneous deposits of sand and gravel forming dissected bluffs and mesas that bound the east side of the Colorado River flood plain near the southeast corner of the map area. Well exposed in cliff faces along edge of flood plain and on sides of tributary washes. Unit consists largely of weakly to moderately consolidated, light-gray to brownish-gray, fine- to coarse-grained sandstone that commonly exhibits well developed horizontal and cross stratification. Some sandstone weathers into thin plates defined by horizontal stratification. Much of the sandstone is cemented by calcite. The sandstone commonly contains scattered pebbles and conglomeratic lenses composed of both rounded river gravel and angular gravel of local derivation. Conglomeratic sequences several meters thick are present locally. A well exposed section in a cliff face along the edge of the flood plain 10 km south of Ehrenberg consists of about 8 m of gray, partly crossbedded sandstone overlain by 15 to 20 m of conglomerate predominantly composed of river gravel as much as 25 cm in diameter. These Colorado River sand and gravel deposits are capped by locally derived gravel deposits that form the surface of most of the area included in the unit. Age unknown; considered part of unit B of Pleistocene and Pliocene age by Metzger and others (1973). Includes the following subunit:

QTes **Sand-dominated deposits**—Unconsolidated to very weakly consolidated deposits composed mainly of tan sand and pebbly sand; these deposits form two large areas near Ehrenberg. Both river and locally derived gravel is present; rounded river gravel is mostly less than 4 cm in diameter and angular local gravel commonly is as much as 10 cm across. Patch south of Ehrenberg overlies QTe; patch northeast of Ehrenberg underlies locally derived gravel deposits assigned to QTe

Bouse Formation (Pliocene and/or Miocene)—Fine-grained clastic sedimentary rocks and limestone commonly interpreted to have been deposited in an marine embayment of the Gulf of California (Metzger, 1968; Metzger and others, 1973; Buising, 1990), but interpreted as lake deposits by Spencer and Patchett (1997). Regionally, unit may range in age from late Miocene to Pliocene (Buising, 1990); exposures 40 km south of map area contain a tuff considered to be about 5.0 Ma based on $^{40}Ar/^{39}Ar$ geochronologic data (Spencer and others, 2001). Consists of the following units:

Tbs **Fine-grained clastic sedimentary rocks**—Pink to green, unlithified, horizontally bedded mud, silt, and sand shown in two small areas on southeast side of Riverside Mountains and one small area on east side of Big Maria Mountains. Overlies fanglomerate (Ta_1) composed predominantly of angular schist and gneiss pebbles; overlain by locally derived gravel deposits assigned to QTa_2. Maximum exposed thickness about 10 to 15 m. Mapped as unnamed lake deposits by Hamilton (1964) and as Bouse Formation by Metzger and others (1973). Locally contains foraminifera and ostracodes (Hamilton, 1960; Smith, 1970; Warren Hamilton, written commun., 2004, citing paleontological reports prepared by Patsy Smith and I.G. Sohn in 1958)

Tbl **Limestone**—Light-gray to light-brown, locally fossiliferous limestone found at numerous places along the eastern flanks of the Big Maria and Riverside Mountains. Occurs both as resistant tufa rinds on slopes and hillcrests and as bedded limestone that overlies very old alluvium (Ta_1). Tufa rinds generally are less than 0.5 m thick and cover areas ranging from a few square meters to several hundred square meters in size. Most rinds are formed on bedrock surfaces but some drape hills composed of very old alluvium (Ta_1). The tufa ranges from dense to porous and locally contains branching tubular structures typically 2 to 3 mm in diameter and 1 cm long. These structures, which may have been built by annelid worms (Buising, 1990), commonly form large patches in the upper few centimeters of the tufa. Bedded limestone overlying unit Ta_1 is found in the canyon north of Black Point (southeastern Big Maria Mountains), where sandy to gravelly limestone beds form a sequence 15 to 20 m thick; some of this limestone is crossbedded. The gravel, as much as 5 cm in diameter, is angular and probably derived from local bedrock sources. Tufa with tubular structures is present locally at the base of the sequence. Fossils identified from the limestone at various localities in the map area include algae, ostracodes, barnacles, clams, and snails (Hamilton, 1960; Warren Hamilton, written commun., 2004, citing paleontological reports prepared by Richard Rezak and Wendell Woodring in 1958)

Tbx **Sedimentary breccia (Miocene and Oligocene?)**—Unbedded, unsorted deposits of angular gravel and slide blocks, commonly monolitholigic. Interpreted as landslide deposits. Largest slide blocks are shown separately (Tsb)

Tsb **Slide blocks (Miocene and Oligocene?)**—Large, angular blocks and slabs of Mesozoic(?) and Paleozoic carbonate rocks and quartzite probably deposited by landslides. Generally brecciated

Tfbx **Fanglomerate, sedimentary breccia, and slide blocks, undivided (Miocene and Oligocene?)**—Fanglomerate in association with sedimentary breccia and slide blocks like those mapped separately as units Tbx and Tsb, exposed in Riverside Mountains. Fanglomerate consists of distinctly to indistinctly bedded, poorly to well sorted conglomerate and sandstone containing angular to rounded clasts of local derivation. Includes basal red sandstone unit 100 to 150 m thick. Total thickness of unit more than 1 km (Hamilton, 1964)

Ti **Felsic intrusive rocks (Miocene and Oligocene?)**—Light-colored, fine-grained, hypabyssal intrusive rocks of rhyolitic to dacitic composition. In Big Maria Mountains, includes dacite that has a hornblende potassium-argon age of about 22 Ma (Martin and others, 1982)

Tv **Volcanic rocks (Miocene and Oligocene?)**—Rhyolitic to basaltic volcanic rocks including lava flows, flow breccia, airfall tuff, and ashfall tuff. Exposed in small outcrops in Mule and Riverside Mountains. In Riverside Mountains, includes andesite that has a whole-rock potassium-argon age of about 23.5 Ma (Martin and others, 1982)

Kgp **Gneissic porphyritic granite (Cretaceous)**—Distinctly to indistinctly foliated and lineated, medium- to coarse-grained biotite granite to granodiorite containing phenocrysts of potassium feldspar 1 to 5 cm long. Exposed in northwestern Little Maria Mountains. Considered part of the Late Cretaceous Cadiz Valley batholith (K.A. Howard, oral commun., 1990), parts of which intrude rocks as young as the McCoy Mountains Formation in the Coxcomb Mountains 30 km west of the map area. A biotite potassium-argon age of about 55 Ma indicates the minimum age of crystallization (Martin and others, 1982)

KJa **Andesite (Cretaceous or Jurassic)**—Highly foliated, fine-grained, dark-green to black andesite interpreted as sills intrusive into member A(?) of the McCoy Mountains Formation (KJma?) at the south end of the McCoy Mountains. Possibly correlative with diorite that intrudes units as young as member F of the McCoy Mountains Formation in the Dome Rock Mountains 15 km east of the map area (Tosdal, 1988; Stone, 1990)

McCoy Mountains Formation (Cretaceous and Jurassic?)—Primarily sandstone and conglomerate; minor shale, mudstone, and siltstone. In map area, exposed only in McCoy Mountains. Largely or entirely of fluvial origin (Harding and Coney, 1985). Weakly metamorphosed; beds commonly exhibit crosscutting foliation or cleavage. Age bracketed by underlying Late Jurassic volcanic rocks (Jv) and by Late Cretaceous (~73 Ma) plutonic rocks that intrude formation in Coxcomb Mountains 30 km west of map area (Barth and others, 2004). Detrital-zircon uranium-lead age determinations in map area indicate that members C through L were deposited after 116 Ma (Barth and others, 2004); members A and B could be as old as Late Jurassic (Fackler-Adams and others, 1997). In Dome Rock Mountains to the east, upper part of the formation contains a tuff having a uranium-lead zircon age of about 79 Ma (Tosdal and Stone, 1994). Formation in map area is about 8 km thick. Divided into the following informal members:

Kml **Member L (Cretaceous)**—Light-gray arkosic sandstone, conglomerate, and minor shale, all micaceous and phyllitic. Conglomerate clasts are quartzite, volcanic rocks, and granitic rocks.

Base and top faulted; exposed thickness about 300 m. Contains detrital zircons as young as 84 Ma (Barth and others, 2004)

Kmk **Member K (Cretaceous)**—Dark-gray, fine-grained arkosic to volcanic-lithic sandstone, light-gray phyllitic shale, and minor conglomerate containing clasts of volcanic and granitic rocks. Exposed thickness about 300 m

Kmj **Member J (Cretaceous)**—Dark-gray, medium- to coarse-grained arkosic to volcanic-lithic sandstone and conglomerate; lowermost part contains minor light-gray arkosic sandstone. Coarsens upward; uppermost 100 m consists of massive conglomerate. Conglomerate clasts are granitic and volcanic rocks. Thickness about 350 m

Kmi **Member I (Cretaceous)**—Light-gray, medium- to coarse-grained arkosic and micaceous sandstone, conglomeratic sandstone, and conglomerate. Massive ledges of conglomerate are present at base. Conglomerate clasts are quartzite, carbonate rocks, and granitic rocks. Thickness about 300 m

Kmh **Member H (Cretaceous)**—Light-gray, fine-grained arkosic sandstone, conglomeratic sandstone, and shale, all micaceous and phyllitic. Thickness about 50 to 250 m. Contains detrital zircons as young as 87 Ma (Barth and others, 2004)

Kmg **Member G (Cretaceous)**—Upper part consists of dark-greenish-gray, fine-grained arkosic to volcanic-lithic sandstone; lower part consists of light-gray to tan phyllitic and calcareous shale, tan calcareous sandstone, and conglomerate containing clasts of quartzite and carbonate rocks. Lower contact truncates beds in member F (unit Kmf) at a low angle and is interpreted as an intraformational unconformity. Thickness about 200 to 600 m. Locally contains fragments of late Early Cretaceous or younger fossil wood (Pelka, 1973; Stone and others, 1987). Contains detrital zircons as young as 93 Ma (Barth and others, 2004)

Kmf **Member F (Cretaceous)**—Light- to medium-gray, fine- to coarse-grained arkosic sandstone and conglomerate interbedded with less abundant light-gray phyllitic shale. Dark-gray to dark-greenish-gray, very fine grained to fine-grained volcanic-lithic sandstone and siltstone present in upper part. Conglomerate clasts are granitic rocks, quartzite, volcanic rocks, and minor carbonate rocks. Grades upward from conglomerate and sandstone in lower part to very fine grained sandstone and siltstone in upper part. Thickness about 2,600 m. Equivalent strata in Palen Mountains 3 km west of map area contain fragments of late Early Cretaceous or younger fossil wood (Pelka, 1973; Stone and others, 1987). Uppermost part of member contains detrital zircons as young as 91 Ma (Barth and others, 2004)

Kme **Member E (Cretaceous)**—Light-gray phyllitic shale; light-gray, dark-gray, and greenish-gray arkosic and volcanic-lithic sandstone; and minor conglomerate and calcareous rocks. Conglomerate clasts are quartzite, volcanic rocks, and granitic rocks. Grayish-orange, calcareous shale present near top. Thickness about 1,500 m. Contains detrital zircons as young as 165 Ma (Barth and others, 2004)

Kmd **Member D (Cretaceous)**—Dark-maroon phyllitic shale and silty to sandy shale interbedded with minor volcanic-lithic sandstone and conglomerate containing clasts of quartzite and volcanic rocks. Locally intruded by foliated diorite (not mapped). Thickness about 300 m

Kmc **Member C (Cretaceous)**—Dark-gray to dark-greenish-gray, very fine grained to fine-grained volcanic-lithic sandstone and siltstsone; dark-gray to dark-greenish-gray mudstone; and minor conglomerate. Mudstone commonly contains brown calcareous pods and lenses of unknown origin. Conglomerate clasts are quartzite and volcanic rocks. Thickness about 1,200 m. Contains detrital zircons as young as 109 Ma (Barth and others, 2004)

KJmb **Member B (Cretaceous or Jurassic)**—Maroon mudstone and siltstone, commonly containing brown calcareous pods and lenses of unknown origin. Interbedded with minor tan quartzite and brown, recystallized limestone. Thickness about 100 m

KJma **Member A (Cretaceous or Jurassic)**—Tan, fine- to medium-grained quartzite and minor chert- and quartzite-clast conglomerate; interbedded with less abundant maroon mudstone and siltstone that commonly contain brown calcareous pods and lenses of unknown origin. Thickness about 350 m. In Palen Mountains, equivalent strata are interpreted to interfinger with the underlying Late Jurassic volcanic rocks (Fackler-Adams and others, 1997); in Dome Rock Mountains, however, equivalent strata are disconformable on the underlying volcanic rocks, which were cut by faults prior to deposition of McCoy Mountains Formation (Tosdal and Stone, 1994). Youngest known detrital zircons are 179 Ma (Barth and others, 2004). Queried outcrops at south end of McCoy Mountains consist of strongly foliated and folded phyllite and minor quartzite that overlie metamorphosed volcanic rocks (Jv?).

JŦu **Volcanic and sedimentary rocks, undivided (Jurassic and Triassic)**—Mapped where units Jv and JŦs have not been distinguished owing to metamorphism and deformation

Jv **Volcanic rocks (Jurassic)**—Mainly light-gray to light-greenish-gray, rhyodacitic volcanic and metavolcanic rocks composed of a microcrystalline, felsic groundmass and phenocrysts of plagioclase, quartz, potassium feldspar, and minor biotite averaging about 2 mm in diameter. Generally unbedded; commonly foliated and metamorphosed to greenschist and lower amphibolite facies. Interpreted to have originated as ash-flow tuff, flows, and hypabyssal porphyry (Tosdal, 1988; Tosdal and others, 1989; Fackler-Adams and others, 1997). In McCoy Mountains, upper 50 m includes volcanic sandstone, conglomerate composed of rhyodacite clasts, and highly altered, schistose metavolcanic rocks that may represent a metamorphosed paleosol. Considered part of the Middle to Late Jurassic Dome Rock sequence of Tosdal and others (1989). Sample near top of unit in McCoy Mountains has a uranium-lead zircon age of about 165 Ma (Barth and others, 2004). Uranium-lead zircon ages from unit in Palen Mountains to the west range from about 175 to 155 Ma (Fackler-Adams and others, 1997). In Riverside Mountains, includes greenstone of Hamilton (1964)

Jp **Plutonic rocks (Jurassic)**—Porphyritic granitoid rocks ranging in composition from granodiorite and quartz monzonite to quartz syenite, and equigranular rocks of varied composition including leucocratic granite, granodiorite, diorite, and gabbro. Commonly metamorphosed and foliated. Most abundant rock type is medium- to coarse-grained, strongly foliated to unfoliated, porphyritic granodiorite characterized by potassium feldspar phenocrysts 1 to 5 cm long and by clotted mafic minerals, primarily biotite. Leucocratic granite is fine to coarse grained and unfoliated to weakly foliated; it commonly intrudes the porphyritic granitoid rocks. Fine-grained, foliated granodiorite and diorite (Jpgd) are present locally. Considered part of the Middle to Late Jurassic Kitt Peak-Trigo Peaks superunit of Tosdal and others (1989). Uranium-lead zircon ages from rocks in map area are about 160 Ma in Big Maria Mountains (L.T. Silver, oral commun. *in* Hamilton, 1982) and 165 Ma in Mule Mountains (Tosdal, 1988). Locally includes the following units:

Jpgd **Foliated granodiorite and diorite**

Jpgb **Hornblende gabbro**

JŦs **Sedimentary rocks (Jurassic and Triassic)**—Variably metamorphosed sedimentary rocks generally consisting of, in ascending order: (1) greenschist, gypsiferous schist, and calcareous quartzite correlated with the Triassic Moenkopi Formation; (2) conglomeratic rocks containing clasts of quartzite, carbonate rocks, and granite; and (3) fine-grained, locally crossbedded quartzite (Hamilton, 1982; Ballard, 1990). The quartzite has been correlated with the Early Jurassic Aztec Sandstone (Hamilton, 1982, 1987) but more recently was interpreted as Middle Jurassic in age based on an interfingering relationship with the overlying volcanic rocks (equivalent to Jv) in the Palen Mountains to the west (Fackler-Adams and others, 1997). Locally on west side of Big Maria Mountains, the quartzite unconformably overlies marble correlated with the Permian Kaibab Limestone (part of PIPs)

Ƭqm **Quartz monzonite and monzodiorite (Triassic)**—Porphyritic biotite quartz monzonite and hornblende monzodiorite exposed in Mule Mountains near south edge of map. Age is about 213 Ma on the basis of uranium-lead analysis of zircon (Barth and others, 1990). Lithologically similar to the Late Triassic Mount Lowe Granodiorite of the San Gabriel Mountains in southwestern California (Tosdal, 1988)

Ƭd **Diorite and gabbro (Triassic?)**—Hornblende diorite and gabbro, locally metamorphosed to amphibolite. Exposed near southwest corner of map. Age alternatively could be Proterozoic (Tosdal, 1988; R.E. Powell, written commun., 1989). In Little Chuckwalla Mountains, mixed with gneiss of probable Proterozoic age (R.M. Tosdal, written commun., 1990)

Pzs **Sedimentary rocks, undivided (Paleozoic)**—Metamorphosed sedimentary rocks of presumed Paleozoic age consisting primarily of calcitic marble, dolomitic marble, calc-silicate rocks, quartzite, and schist. May include some rocks of Triassic and Jurassic age

P€s **Sedimentary rocks (Permian to Cambrian)**—Complete, or nearly complete, sequences of metamorphosed Permian to Cambrian strata equivalent to units PIPs and M€s combined, but too thin to subdivide at map scale

PIPs **Sedimentary rocks (Permian and Pennsylvanian)**—Metamorphosed sedimentary rocks consisting of, in ascending order: (1) massive, dark-brown-weathering calcareous quartzite and calc-silicate rocks correlated with the Permian and Pennsylvanian Supai Group; (2) quartzitic calc-silicate schist correlated with the Permian Hermit Formation; (3) fine-grained quartzite correlated with the Permian Coconino Sandstone; and (4) cherty and non-cherty calcitic and minor dolomitic marble correlated with the Permian Kaibab Limestone (Hamilton, 1982; Stone and others, 1983; Ballard, 1990). Thickness highly variable because of deformation

M€s **Sedimentary rocks (Mississippian to Cambrian)**—Metamorphosed sedimentary rocks consisting of, in ascending order: (1) feldspathic quartzite and conglomeratic quartzite correlated with the Cambrian Tapeats Sandstone; (2) schist and thin-bedded quartzite correlated with the Cambrian Bright Angel Shale; (3) massive dolomitic marble of probable Devonian and Cambrian age; and (4) massive calcitic marble correlated with the Mississippian Redwall Limestone (Hamilton, 1982; Stone and others, 1983; Ballard, 1990). Thickness highly variable because of deformation

Ᵽpg **Porphyritic granite and augen gneiss (Proterozoic)**—Coarse-grained granite and augen gneiss characterized by phenocrysts or porphyroblasts of potassium feldspar 1 to 5 cm long. In Big Maria Mountains, unit consists primarily of augen gneiss; in Riverside Mountains, unit consists of variably altered, mostly red, porphyritic granite in the upper plate of a Cenozoic detachment fault (Hamilton, 1982, 1984). Uranium-lead zircon age is about 1.4 Ga based on two analyses from the southeastern Big Maria Mountains (L.T. Silver, oral commun. *in* Hamilton, 1982). Depositionally overlain by strata correlated with the Tapeats Sandstone (basal part of M€s)

Ᵽgn **Gneiss and amphibolite (Proterozoic)**—In Riverside Mountains and northernmost Big Maria Mountains, including Quien Sabe Point, unit consists of varied gneissic and plutonic rocks known or inferred to overlie Cenozoic detachment faults (Hamilton, 1964, 1982, 1984). These rocks, which are varicolored, pervasively altered, and brecciated, include biotite gneiss, hornblende gneiss, aplitic granite, schist, and amphibolite. Below detachment fault in Big Maria Mountains, unit consists of dark, unaltered biotite and hornblende gneiss. Near Styx (a railroad siding in the northwestern part of the map area), unit consists of dark, phyllonitic gneiss interpreted to stratigraphically underlie overturned Paleozoic rocks (Ballard, 1990). Some of this gneiss lithologically resembles rocks assigned to unit MzƁfg a short distance to the east

UNITS OF MIXED OR UNCERTAIN AGE

MzƁgn **Gneissic rocks, undivided (Mesozoic and Proterozoic)**—Strongly foliated and lineated mylonitic gneiss, augen gneiss, and migmatitic gneiss. Probably includes rocks equivalent to those mapped elsewhere as Jp, Ɓgn, and Ɓpg (Hamilton, 1982, 1984; Ballard, 1990)

MzƁs **Schist (Mesozoic or Proterozoic)**—Quartz-rich, epidote-muscovite schist that structurally underlies overturned Paleozoic rocks and structurally overlies fine-grained gneiss (MzƁfg) in northwestern Big Maria Mountains (Ballard, 1990). Interpreted as Jurassic and Triassic metasedimentary rocks by Hamilton (1984) and Ballard (1990). In this report, unit also is considered to be of possible Proterozoic age because definite evidence of Mesozoic age is lacking

MzƁfg **Fine-grained gneiss (Mesozoic or Proterozoic)**—Fine-grained, dark-gray to grayish-green, strongly foliated and lineated quartzofeldspathic gneiss of uncertain age and origin (Ballard, 1990). Mapped as Jurassic and Triassic metasedimentary rocks (JTRs) by Hamilton (1984); tentatively correlated with Jurassic plutonic rocks (Jp) by Ballard (1990). In this report, unit also is considered to be of possible Proterozoic age because of lithologic resemblance to gneiss of apparent Proterozoic age (Ɓgn) near Styx

REFERENCES CITED

Anderson, J.L., 1983, Proterozoic anorogenic granitic plutonism of North America, *in* Medaris, L.G., Jr., Byers, C.W., Mickelson, D.M., and Shanks, W.C., eds., Proterozoic geology—selected papers from an international Proterozoic symposium: Geological Society of America Memoir 161, p. 133–154.

Ballard, S.N., 1990, The Mesozoic structural evolution of the Little Maria Mountains, Riverside County, California: Santa Barbara, University of California, Ph.D. dissertation, 380 p.

Barth, A.P., Tosdal, R.M., and Wooden, J.L., 1990, A petrologic comparison of Triassic plutonism in the San Gabriel and Mule Mountains, southern California: Journal of Geophysical Research, v. 95, no. B12, p. 20,075–20,096.

Barth, A.P., Tosdal, R.M., Wooden, J.L., and Howard, K.A., 1997, Triassic plutonism in southern California—southward younging of arc initiation along a truncated continental margin: Tectonics, v. 16, p. 290–304.

Barth, A.P., Wooden, J.L., Jacobson, C.E., and Probst, K., 2004, U-Pb geochronology and geochemistry of the McCoy Mountains Formation, southeastern California: A Cretaceous retroarc foreland basin: Geological Society of America Bulletin, v. 116, p. 142–153.

Buising, A.V., 1990, The Bouse Formation and bracketing units, southeastern California and western Arizona—implications for the evolution of the proto-Gulf of California and the lower Colorado River: Journal of Geophysical Research, v. 95, no. B12, p. 20,111–20,132.

Bull, W.B., 1991, Geomorphic responses to climatic change: New York, Oxford University Press, 326 p.

Carr, W.J., and Dickey, D.D., 1980, Geologic map of the Vidal, California, and Parker SW, California-Arizona quadrangles: U.S. Geological Survey Miscellaneous Investigations Series Map I-1125, scale 1:24,000.

Ellis, M.J., 1982, Structural analysis of the Big Maria Mountains, Riverside County, California, *in* Frost, E.G., and Martin, D.L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River region, California, Arizona, and Nevada: San Diego, Calif., Cordilleran Publishers, p. 222–233.

Emerson, W.S., 1982, Geologic development and late Mesozoic deformation of the Little Maria Mountains, Riverside County, California, *in* Frost, E.G., and Martin, D.L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River region, California, Arizona, and Nevada: San Diego, Calif., Cordilleran Publishers, p. 245–254.

Fackler-Adams, B.N., Busby, C.J., and Mattinson, J.M., 1997, Jurassic magmatism and sedimentation in the Palen Mountains, southeastern California—implications for regional tectonic controls on the Mesozoic continental arc: Geological Society of America Bulletin, v. 109, p. 1464–1484.

Fugro, Inc., 1975, Sundesert Nuclear Plant Units 1 & 2 Early Site Review Report, v. 2, sec. 2.5—Geology and Seismology: San Diego Gas & Electric Company, 161 p.

Hamilton, Warren, 1960, Pliocene(?) sediments of salt water origin near Blythe, southeastern California, *in* Geological Survey research 1960—short papers in the geological sciences: U.S. Geological Survey Professional Paper 400-B, p. B276–B277.

Hamilton, Warren, 1964, Geologic map of the Big Maria Mountains NE quadrangle, Riverside County, California and Yuma County, Arizona: U.S. Geological Survey Geologic Quadrangle Map GQ-350, scale 1:24,000.

Hamilton, Warren, 1982, Structural evolution of the Big Maria Mountains, northeastern Riverside County, southeastern California, *in* Frost, E.G., and Martin, D.L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River region, California, Arizona, and Nevada: San Diego, Calif., Cordilleran Publishers, p. 1–27.

Hamilton, Warren, 1984, Generalized geologic map of the Big Maria Mountains region, northeastern Riverside County, southeastern California: U.S. Geological Survey Open-File Report 84-407, scale 1:48,000, 7 p.

Hamilton, Warren, 1987, Mesozoic geology and tectonics of the Big Maria Mountains region, southeastern California, *in* Dickinson, W.R., and Klute, M.A., eds., Mesozoic rocks of southern Arizona and adjacent areas: Arizona Geological Society Digest 18, p. 33–48.

Harding, L.E., and Coney, P.J., 1985, The geology of the McCoy Mountains Formation, southeastern California and southwestern Arizona: Geological Society of America Bulletin, v. 96, p. 755–769.

Hoisch, T.D., Miller, C.F., Heizler, M.T., Harrison, T.M., and Stoddard, E.F., 1988, Late Cretaceous regional metamorphism in southeastern California, *in* Ernst, W.G., ed., Metamorphism and crustal evolution of the western United States: Englewood Cliffs, N.J., Prentice Hall, p. 538–571.

Howard, K.A., 2002, Geologic map of the Sheep Hole Mountains 30’ x 60’ quadrangle, San Bernardino and Riverside Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-2344, scale 1:100,000.

Howard, K.A., and John, B.E., 1987, Crustal extension along a rooted system of imbricate low-angle faults—Colorado River extensional corridor, California and Arizona, *in* Coward, M.P., Dewey, J.F., and Hancock, P.L., eds., Continental extensional tectonics: Geological Society Special Publication 28, p. 299–311.

Lucchitta, Ivo, McDougall, Kristin, Metzger, D.G., Morgan, Paul, Smith, G.R., and Chernoff, Barry, 2001, The Bouse Formation and post-Miocene uplift of the Colorado Plateau, *in* Young, R.A., and Spamer, E.E., eds., Colorado River—origin and evolution: Grand Canyon, Ariz., Grand Canyon Association, p. 173–178.

Mariano, John, Helferty, M.G., and Gage, T.B., 1986, Bouguer and isostatic residual gravity maps of the Colorado River region, including the Kingman, Needles, Salton Sea, and El Centro quadrangles: U.S. Geological Survey Open-File Report 86-347, scale 1:250,000.

Martin, D.L., Krummenacher, Daniel, and Frost, E.G., 1982, K-Ar geochronologic record of Mesozoic and Tertiary tectonics of the Big Maria-Little Maria-Riverside Mountains terrane, *in* Frost, E.G., and Martin, D.L., eds., Mesozoic-Cenozoic tectonic evolution of the Colorado River region, California, Arizona, and Nevada: San Diego, Calif., Cordilleran Publishers, p. 519–557.

Metzger, D.G., 1968, The Bouse Formation (Pliocene) of the Parker-Blythe-Cibola area, Arizona and California, *in* Geological Survey Research 1968: U.S. Geological Survey Professional Paper 600-D, p. D126–D136.

Metzger, D.G., Loeltz, O.J., and Irelna, Burdge, 1973, Geohydrology of the Parker-Blythe-Cibola area, Arizona and California: U.S. Geological Survey Professional Paper 486-G, 130 p.

Patchett, P.J., and Spencer, J.E., 2001, Application of Sr isotopes to the hydrology of the Colorado River system waters and potentially related Neogene sedimentary formations, *in* Young, R.A., and Spamer, E.E., eds., Colorado River—origin and evolution: Grand Canyon, Ariz., Grand Canyon Association, p. 167–171.

Pelka, G.J., 1973, Geology of the McCoy and Palen Mountains, southeastern California: Santa Barbara, University of California, Ph.D. dissertation, 162 p.

Powell, R.E., 1993, Balanced palinspastic reconstruction of pre-late Cenozoic paleogeology, southern California—geologic and kinematic constraints on evolution of the San Andreas fault system, *in* Powell, R.E., Weldon, R.J., III, and Matti, J.C., eds., The San Andreas fault system—displacement, palinspastic reconstruction, and geologic evolution: Geological Society of America Memoir 178, p. 1–106.

Purcell, Charles, and Miller, D.G., 1980, Grabens along the lower Colorado River, California and Arizona, *in* Fife, D.L., and Brown, A.R., eds., Geology and mineral wealth of the California desert: Santa Ana, Calif., South Coast Geological Society, p. 475–484.

Reynolds, S.J., Spencer, J.E., Richard, S.M., and Laubach, S.E., 1986, Mesozoic structures in west-central Arizona, *in* Beatty, Barbara, and Wilkinson, P.A.K., eds., Frontiers in geology and ore deposits of Arizona and the southwest: Arizona Geological Society Digest, v. 16, p. 35–51.

Richard, S.M., 1993, Palinspastic reconstruction of southeastern California and southwestern Arizona for the middle Miocene: Tectonics, v. 12, p. 830–854.

Richard, S.M., Ballard, S.N., Boettcher, S.S., Hamilton, W.B., Hoisch, T.D., and Tosdal, R.M., 1994, Mesozoic tectonics of the Maria belt, west-central Arizona and southeastern California, *in* McGill, S.F., and Ross, T.M., eds., Geological investigations of an active margin (guidebook for Geological Society of America Cordilleran Section 27th Annual Meeting): Redlands, Calif., San Bernardino County Museum Association, p. 272–292.

Rotstein, Yair, Combs, Jim, and Biehler, Shawn, 1976, Gravity investigation in the southeastern Mojave Desert, California: Geological Society of America Bulletin, v. 87, p. 981–993.

Saleeby, J.B., and Busby-Spera, Cathy, 1992, Early Mesozoic tectonic evolution of the western U.S. Cordillera, *in* Burchfiel, B.C., Lipman, P.W., and Zoback, M.L., eds., The Cordilleran orogen—conterminous U.S.: Boulder, Col., Geological Society of America, The Geology of North America, v. G-3, p. 107–168.

Smith, P.B., 1970, New evidence for a Pliocene marine embayment along the lower Colorado River area, California and Arizona: Geological Society of America Bulletin, v. 81, p. 1411–1420.

Spencer, J.E., and Patchett, P.J., 1997, Sr isotopic evidence for a lacustrine origin for the upper Miocene to Pliocene Bouse Formation, lower Colorado River trough, and implications for timing of Colorado Plateau uplift: Geological Society of America Bulletin, v. 109, p. 767–778.

Spencer, J.E., and Pearthree, P.A., 2001, Headward erosion versus closed-basin spillover as alternative causes of Neogene capture of the ancestral Colorado River by the Gulf of California, *in* Young, R.A., and Spamer, E.E., eds., Colorado River—origin and evolution: Grand Canyon, Ariz., Grand Canyon Association, p. 215–219.

Spencer, J.E., Peters, Lisa, McIntosh, W.C., and Patchett, P.J., 2001, $^{40}Ar/^{39}Ar$ geochronology of the Hualapai Limestone and Bouse Formation and implications for the age of the lower Colorado River, *in* Young, R.A., and Spamer, E.E., eds., Colorado River—origin and evolution: Grand Canyon, Ariz., Grand Canyon Association, p. 89–91.

Stone, Paul, 1990, Preliminary geologic map of the Blythe 30' by 60' quadrangle, California and Arizona: U.S. Geological Survey Open-File Report 90-497, scale 1:100,000.

Stone, Paul, Howard, K.A., and Hamilton, Warren, 1983, Correlation of metamorphosed Paleozoic strata of the southeastern Mojave Desert region, California and Arizona: Geological Society of America Bulletin, v. 94, p. 1135–1147.

Stone, Paul, and Pelka, G.J., 1989, Geologic map of the Palen-McCoy Wilderness Study Area and vicinity, Riverside County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-2092, scale 1:62,500.

Stone, Paul, Page, V.M., Hamilton, Warren, and Howard, K.A., 1987, Cretaceous age of the upper part of the McCoy Mountains Formation, southeastern California and southwestern Arizona, and its tectonic significance—reconciliation of paleobotanical and paleomagnetic evidence: Geology, v. 15, p. 561–564.

Tosdal, R.M., 1988, Mesozoic rock units along the Late Cretaceous Mule Mountains thrust system, southeastern California and southwestern Arizona: Santa Barbara, University of California, Ph.D. dissertation, 365 p.

Tosdal, R.M., 1990, Constraints on the tectonics of the Mule Mountains thrust system, southeast California and southwest Arizona: Journal of Geophysical Research, v. 95, no. B12, p. 20,025–20,048.

Tosdal, R.M., Haxel, G.B, and Wright, J.E., 1989, Jurassic geology of the Sonoran Desert region, southern Arizona, southeastern California, and northernmost Sonora: Construction of a continental-margin magmatic arc, *in* Jenney, J.P., and Reynolds., S.J., eds., Geologic evolution of Arizona: Arizona Geological Society Digest 17, p. 397–434.

Tosdal, R.M., and Stone, Paul, 1994, Stratigraphic relations and U-Pb geochronology of the Upper Cretaceous upper McCoy Mountains Formation, southwestern Arizona: Geological Society of America Bulletin, v. 106, p. 476–491.

Wooden, J.L., and Miller, D.M., 1990, Chronologic and isotopic framework for Early Proterozoic crustal evolution in the eastern Mojave Desert region, SE California: Journal of Geophysical Research, v. 95, no. B12, p. 20,133–20,146.

Zimbelman, J.R., and Williams, S.H., 2002, Geochemical indicators of separate sources for eolian sands in the eastern Mojave Desert, California, and western Arizona: Geological Society of America Bulletin, v. 114, p. 490–496.

Attachment 2
Blank Soil Form

Table A-2.—Work sheet for recording soil properties in the field
[In the note column, one can record properties not universal to all soils. Courtesy of D. Jorgenson, 1989]

Soil Description: Location ____

Site No. _____ Date _________ Time ___________ Vegetation ______________________________

Elevation __________ Slope ____________ Aspect _________ Geomorphic Surface ______________________

Parent Material(s) ______________________________ Described by ______________________

Depth (cm)	Horizon	Color (moist / dry)	Structure	Gravel %	Consistence: Wet	Consistence: Moist	Consistence: Dry	Texture	pH	Clay films	Boundaries	notes
		- - - - - - - -	m vf gr sg f pl 1 m pr 2 c cpr 3 vc abk sbk	0 50 <10 75 10 >75 25	so po ss ps s p vs vp	lo vfr fr fi vfi efi	lo so sh h vh eh	S SiCL LS SiL SL Si SCL SiC L C CL SC		v1 f pf 1 po 2 d br 3 co p cobr	a s c w g i d b	
		- - - - - - - -	m vf gr sg f pl 1 m pr 2 c cpr 3 vc abk sbk	0 50 <10 75 10 >75 25	so po ss ps s p vs vp	lo vfr fr fi vfi efi	lo so sh h vh eh	S SiCL LS SiL SL Si SCL SiC L C CL SC		v1 f pf 1 po 2 d br 3 co p cobr	a s c w g i d b	
		- - - - - - - -	m vf gr sg f pl 1 m pr 2 c cpr 3 vc abk sbk	0 50 <10 75 10 >75 25	so po ss ps s p vs vp	lo vfr fr fi vfi efi	lo so sh h vh eh	S SiCL LS SiL SL Si SCL SiC L C CL SC		v1 f pf 1 po 2 d br 3 co p cobr	a s c w g i d b	
		- - - - - - - -	m vf gr sg f pl 1 m pr 2 c cpr 3 vc abk sbk	0 50 <10 75 10 >75 25	so po ss ps s p vs vp	lo vfr fr fi vfi efi	lo so sh h vh eh	S SiCL LS SiL SL Si SCL SiC L C CL SC		v1 f pf 1 po 2 d br 3 co p cobr	a s c w g i d b	
		- - - - - - - -	m vf gr sg f pl 1 m pr 2 c cpr 3 vc abk sbk	0 50 <10 75 10 >75 25	so po ss ps s p vs vp	lo vfr fr fi vfi efi	lo so sh h vh eh	S SiCL LS SiL SL Si SCL SiC L C CL SC		v1 f pf 1 po 2 d br 3 co p cobr	a s c w g i d b	
		- - - - - - - -	m vf gr sg f pl 1 m pr 2 c cpr 3 vc abk sbk	0 50 <10 75 10 >75 25	so po ss ps s p vs vp	lo vfr fr fi vfi efi	lo so sh h vh eh	S SiCL LS SiL SL Si SCL SiC L C CL SC		v1 f pf 1 po 2 d br 3 co p cobr	a s c w g i d b	
		- - - - - - - -	m vf gr sg f pl 1 m pr 2 c cpr 3 vc abk sbk	0 50 <10 75 10 >75 25	so po ss ps s p vs vp	lo vfr fr fi vfi efi	lo so sh h vh eh	S SiCL LS SiL SL Si SCL SiC L C CL SC		v1 f pf 1 po 2 d br 3 co p cobr	a s c w g i d b	
		- - - - - - - -	m vf gr sg f pl 1 m pr 2 c cpr 3 vc abk sbk	0 50 <10 75 10 >75 25	so po ss ps s p vs vp	lo vfr fr fi vfi efi	lo so sh h vh eh	S SiCL LS SiL SL Si SCL SiC L C CL SC		v1 f pf 1 po 2 d br 3 co p cobr	a s c w g i d b	
		- - - - - - - -	m vf gr sg f pl 1 m pr 2 c cpr 3 vc abk sbk	0 50 <10 75 10 >75 25	so po ss ps s p vs vp	lo vfr fr fi vfi efi	lo so sh h vh eh	S SiCL LS SiL SL Si SCL SiC L C CL SC		v1 f pf 1 po 2 d br 3 co p cobr	a s c w g i d b	
		- - - - - - - -	m vf gr sg f pl 1 m pr 2 c cpr 3 vc abk sbk	0 50 <10 75 10 >75 25	so po ss ps s p vs vp	lo vfr fr fi vfi efi	lo so sh h vh eh	S SiCL LS SiL SL Si SCL SiC L C CL SC		v1 f pf 1 po 2 d br 3 co p cobr	a s c w g i d b	

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APPLICATION FOR CERTIFICATION FOR THE *RIO MESA SOLAR ELECTRIC GENERATING FACILITY*

DOCKET NO. 11-AFC-04
PROOF OF SERVICE
(Revised 7/11/12)

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DECLARATION OF SERVICE

I, Darin Neufeld, declare that on July 24, 2012, I served and filed a copy of the attached document Applicant's Supplemental Data Response to CEC Staff Data Request Set 1B (#97), Revised Geoarchaeological Research Design Dated July 20, 2012. This document is accompanied by the most recent Proof of Service list, located on the web page for this project at: http://www.energy.ca.gov/sitingcases/riomesa/index.html.

The document has been sent to the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit or Chief Counsel, as appropriate, in the following manner:

(*Check all that Apply*)

For service to all other parties:

__X__ Served electronically to all e-mail addresses on the Proof of Service list;

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AND

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____ by depositing an original and 12 paper copies in the mail with the U.S. Postal Service with first class postage thereon fully prepaid, as follows:

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OR, if filing a Petition for Reconsideration of Decision or Order pursuant to Title 20, § 1720:

____ Served by delivering on this date one electronic copy by e-mail, and an original paper copy to the Chief Counsel at the following address, either personally, or for mailing with the U.S. Postal Service with first class postage thereon fully prepaid:

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I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct, that I am employed in the county where this mailing occurred, and that I am over the age of 18 years and not a party to the proceeding.

___Original Signed By:____
Darin Neufeld

*indicates change