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

Subject: Applicant's 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, Rio Mesa Solar II, LLC, and Rio Mesa Solar III, collectively the "Applicant" for the Rio Mesa Solar Electric Generating Facility project ("Rio Mesa SEGF"), submit this Supplemental Data Response to CEC Staff Data Request Set 1B (#97), Geoarchaeological Research Design. This data response supplements the information provided in the response to Data Request #97 in the Applicant's Response to Data Requests, Set 1B (#85-154), which was docketed on March 28, 2012.

Sincerely,

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

Enclosure

cc: POS List
Project File

D R A F T

**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

May 2012

URS

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Compiled by Paul Stone, 2006

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.

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.

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).

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

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). 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).

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 fans. The nature of this contact, as well as the subsurface quality of the younger Qa deposits themselves, has significant implications for the preservation potential of buried archaeology, and is another primary research question for the field study.

A review of recorded prehistoric archaeological sites within the Project area indicates that there is a relatively strong correlation between older alluvial landforms (e.g., QTmw, Qpv, Qa3, and Qa5) and surficial sites. This correlation is likely due to several factors, including the increased presence of larger cobbles suitable for lithic reduction (especially on QTmw, Qa3 and, to a lesser degree, Qa5 landforms) and the length of time which these landforms have been exposed at the surface and thus subject to human activities. As such, the relative lack of prehistoric archaeological sites on the young fan deposits (Qa6) may be due to the lack of available natural resources or may be a simple correlation with age, suggesting a heightened potential for buried archaeological sites.

3.2 RESEARCH ISSUES

1. Confirmation of landform designations and tentative chronological associations developed in the initial Geoarchaeological Assessment.
2. For those landforms determined to have a depositional chronology and regime conducive to potential sensitivity for buried cultural resources (especially younger alluvial fan units Qa6 and Qa5), identify and document the subsurface conditions of those landforms; specifically, the lithostratigraphic and pedostratigraphic units that comprise the landforms, and the age, depositional environment, and subsequent preservation of those units. This will allow for a much more refined estimate of the potential for buried archaeological deposits, and the likely nature, age, and depth of those deposits.
3. In addition to defining the subsurface conditions of potentially sensitive depositional landforms (Research Issue 2), it is necessary to establish the lateral variation in those landforms, 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, it is necessary to define the subsurface relationship between the old landform and any adjacent younger landforms, 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.

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.

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. verifying the geologic correlations that were made in the previous geoarchaeological reconnaissance and resultant geoarchaeological sensitivity map;
- b. assess whether the identified landforms are relatively synchronous or time-transgressive;
- 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 newly acquired data, 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 (Reference). Grain size, depositional environment, and pedogenic indicators of soil/paleosol development will be recorded 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 accreting landform is not conducive to long-term occupation. At most, you 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.

SECTION 4 PROPOSED WORK

4.1 FIELD METHODS

For the majority of the Project area, on Metropolitan Water District (MWD) lands, nine locations have been selected for the placement of exploratory geoarchaeological trenches (Figure 1). These locations were selected based on their applicability to the research questions identified above, and association with landforms identified during the reconnaissance survey as potentially being of appropriate age and depositional nature to harbor buried resources. 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., GAT-1, GAT-6, GAT-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 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.

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. Trenches and excavated spoils will primarily be observed and documented from the surface. If pedogenic or archaeological features are observed 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, 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.

One sidewall of each trench will be selected for profiling and a complete profile photograph with a metric scale. 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.

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, and to constrain the dates of any paleosols or archaeological deposits that are found. Discrete, in-place charcoal samples will be used for dating. In the absence of such deposits, bulk humate samples will be submitted for AMS analysis.

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) amount of material from each found lithostratigraphic unit or major process-related lithostratigraphic sequence, and from the A Horizon of each found pedostratigraphic unit, 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. Archaeological deposits found during the trenching activities will be recorded on DPR 523 forms. Formal evaluation of site eligibility and/or data recovery is beyond the current scope. The geoarchaeological study is not designed to assess eligibility of an archaeological site. Additional scoping and consultation with the CEC will be necessary to complete Phase II analysis of any identified archaeological deposits.

SECTION 5 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 $\geq 1:12,000$); 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).

SECTION 6 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 7 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.

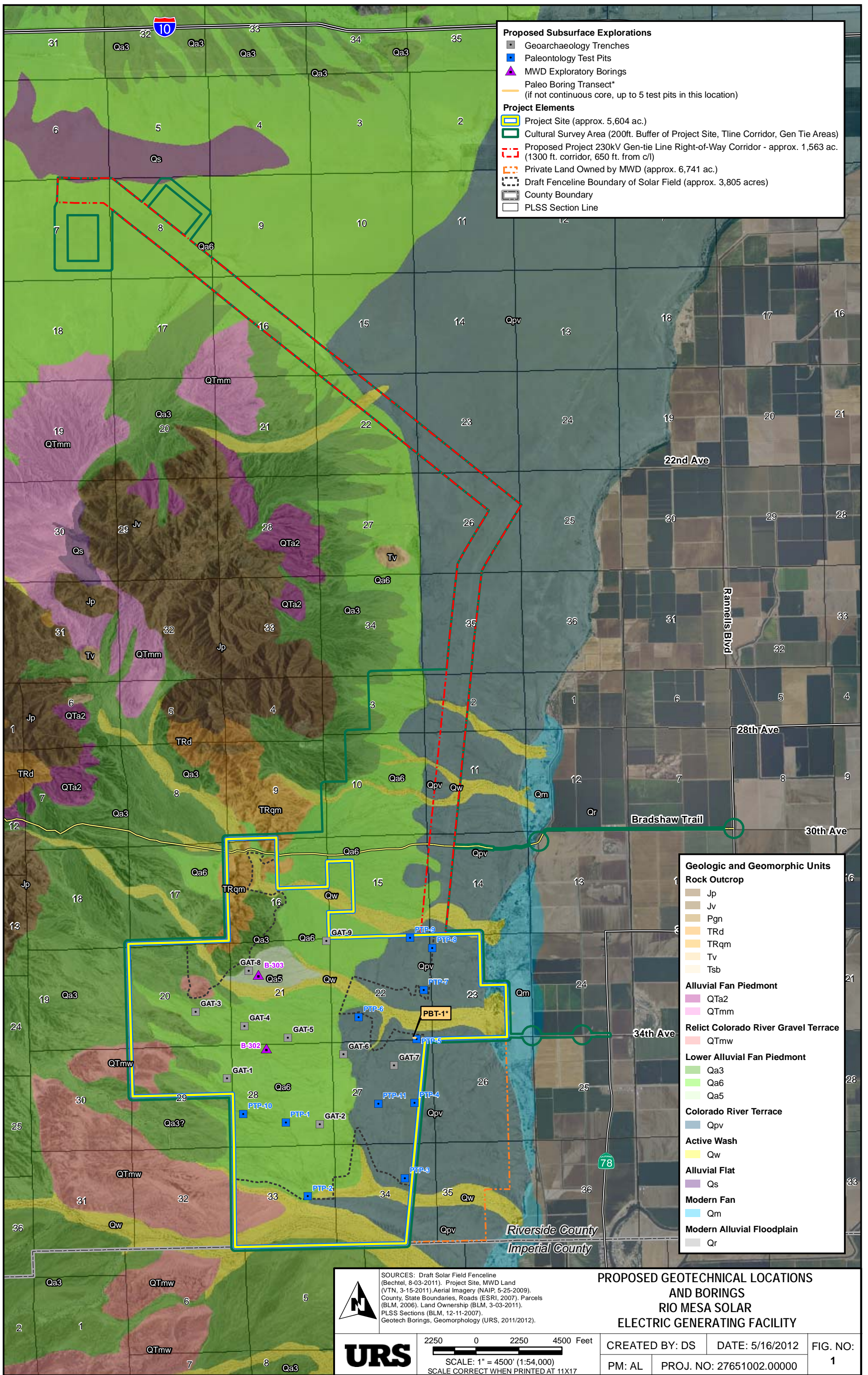
Stone, P. 2006. Geologic Map of the West Half of the Blythe 30' by 60' Quadrangle, Riverside County, California and La Paz County, Arizona. Scientific Investigations Map 2922. U.S. Geological Survey, Menlo Park, California.

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

Figure 1

Project Site with Geotechnical Boring Locations

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Proposed Subsurface Explorations

- Geoarchaeology Trenches
- Paleontology Test Pits
- MWD Exploratory Borings
- Paleo Boring Transect* (if not continuous core, up to 5 test pits in this location)

Project Elements

- Project Site (approx. 5,604 ac.)
- Cultural Survey Area (200ft. Buffer of Project Site, Tline Corridor, Gen Tie Areas)
- Proposed Project 230kV Gen-tie Line Right-of-Way Corridor - approx. 1,563 ac. (1300 ft. corridor, 650 ft. from c/l)
- Private Land Owned by MWD (approx. 6,741 ac.)
- Draft Fenceline Boundary of Solar Field (approx. 3,805 acres)
- County Boundary
- PLSS Section Line

Geologic and Geomorphic Units

Rock Outcrop

- Jp
- Jv
- Pgn
- TRd
- TRqm
- Tv
- Tsb

Alluvial Fan Piedmont

- QTa2
- QTmm

Relict Colorado River Gravel Terrace

- QTmw

Lower Alluvial Fan Piedmont

- Qa3
- Qa6
- Qa5

Colorado River Terrace

- Qpv

Active Wash

- Qw

Alluvial Flat

- Qs

Modern Fan

- Qm

Modern Alluvial Floodplain

- Qr

PROPOSED GEOTECHNICAL LOCATIONS AND BORINGS RIO MESA SOLAR ELECTRIC GENERATING FACILITY

SOURCES: Draft Solar Field Fenceline (Bechtel, 8-03-2011). Project Site, MWD Land (VTN, 3-15-2011). 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).

URS

2250 0 2250 4500 Feet
SCALE: 1" = 4500' (1:54,000)
SCALE CORRECT WHEN PRINTED AT 11X17

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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

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 (Ta₁). These gravels are overlain by limestone and fine-grained clastic deposits assigned to the late Miocene and (or) Pliocene Bouse Formation (Tb₁, Tb_s). 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; Busing, 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 (Busing, 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 (QTa₂, Qa₃–Qa₆) 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 (QTa₂, 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 Ta₁. Alluvium of primarily middle and late Pleistocene age (Qa₃ and Qa₄, mostly equivalent to the Q2 surfaces of Bull) forms smooth, varnished pavements, whereas Holocene alluvium (Qa₅ and Qa₆, 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 Qa₃ on the map presented here; it appears to be overlapped by younger sediments mapped here as Qa₅. 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 Qa₆. 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:

Qa₆ **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 **Qa₅**. 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

Qa₅ **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 (**Qa₆**). 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

Qa₄ **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 (**Qa₃**) 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 **Qa₃**. Covers small areas flanking northwestern Little Maria and southeastern Big Maria Mountains

Qa₃ **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 (**Qa₅**) 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

QTa₂ **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 **Qa₃**, 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 (**Qa₃**); the oldest deposits assigned to this unit may be coeval with **Ta₁**. 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

Ta₁ **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 **QTa₂**. Observed contacts with overlying limestone (**Tbl**) are concordant. Equivalent to the conglomerate of Metzger and others (1973) and the conglomerate 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 **Qa₆** 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 **Qa₅** and may interfinger with alluvial-fan deposits assigned to unit **Qa₃**. 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 **Qa₃**. 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 **Qa₃**. 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 **Qa₃**
- 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 **Qa₃**
- 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 25° 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 **QTa₂**; 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; Busing, 1990), but interpreted as lake deposits by Spencer and Patchett (1997). Regionally, unit may range in age from late Miocene to Pliocene (Busing, 1990); exposures 40 km south of map area contain a tuff considered to be about 5.0 Ma based on $^{40}\text{Ar}/^{39}\text{Ar}$ 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 (**Ta₁**) composed predominantly of angular schist and gneiss pebbles; overlain by locally derived gravel deposits assigned to **QTa₂**. 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 (**Ta₁**). 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 (**Ta₁**). 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 (Busing, 1990), commonly form large patches in the upper few centimeters of the tufa. Bedded limestone overlying unit **Ta₁** 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 monolithologic. 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 siltstone; 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, recrystallized 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?).
- J \overline{R} u** **Volcanic and sedimentary rocks, undivided (Jurassic and Triassic)**—Mapped where units JV and J \overline{R} s 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**
- J \overline{R} s** **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)

- Tqm** **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)
- Td** **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
- PCs** **Sedimentary rocks (Permian to Cambrian)**—Complete, or nearly complete, sequences of metamorphosed Permian to Cambrian strata equivalent to units PIPs and MČs 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
- MČs** **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
- Epg** **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 MČs)
- Egn** **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 **MzPfg** a short distance to the east

UNITS OF MIXED OR UNCERTAIN AGE

- MzPgn** **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**, **Pgn**, and **Ppg** (Hamilton, 1982, 1984; Ballard, 1990)
- MzPs** **Schist (Mesozoic or Proterozoic)**—Quartz-rich, epidote-muscovite schist that structurally underlies overturned Paleozoic rocks and structurally overlies fine-grained gneiss (**MzPfg**) 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
- MzPfg** **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 (**JTs**) 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 (**Pgn**) near Styx

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**BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT
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**APPLICATION FOR CERTIFICATION
FOR THE RIO MESA SOLAR
ELECTRIC GENERATING FACILITY**

DOCKET NO. 11-AFC-04
PROOF OF SERVICE
(Revised 5/3/12)

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DECLARATION OF SERVICE

I, Sarah Champion declare that on May 29, 2012, I served and filed a copy of the attached Data Responses, dated May 29, 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:

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

Served by delivering on this date, either personally, or for mailing with the U.S. Postal Service with first-class postage thereon fully prepaid, to the name and address of the person served, for mailing that same day in the ordinary course of business; that the envelope was sealed and placed for collection and mailing on that date to those addresses **NOT** marked "e-mail preferred."

AND

For filing with the Docket Unit at the Energy Commission:

by sending electronic copies to the e-mail address below (preferred method); **OR**

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:

CALIFORNIA ENERGY COMMISSION – DOCKET UNIT
Attn: Docket No. 11-AFC-4
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512
docket@energy.ca.gov

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:

California Energy Commission
Michael J. Levy, Chief Counsel
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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 Sarah Champion

CALIFORNIA ENERGY COMMISSION

1516 NINTH STREET
SACRAMENTO, CA 95814-5512
www.energy.ca.gov



TO: *All Parties*

Date: May 3, 2012

RE: **RIO MESA SOLAR ELECTRIC GENERATING FACILITY**

Proof of Service List

Docket No. 11-AFC-04

Attached is the **newly revised** Proof of Service List for the above-mentioned project, current as of May 3, 2012. Please pay particular attention to the **new** filing instructions.

Energy Commission regulations (Cal. Code Regs., tit. 20, § 1210) require, in addition to any electronic service, that a paper copy be served in person or by first class mail except where a party requests to receive an electronic copy when one is available. Individuals and groups on the Proof of Service list who prefer to receive filings by e-mail and do not require a paper copy shall inform the Hearing Adviser assigned to the proceeding.

The Proof of Service list for this matter will delineate those individuals and groups and it is sufficient to serve those individuals with an e-mailed copy only. Those not so delineated must be served with a paper copy in addition to any e-mailed copy that the filing party chooses to provide. Signatures may be indicated on the electronic copy by “**Original Signed By**” or similar words. The original signed copy or an electronic copy shall be filed with the Energy Commission’s Dockets Unit.

Unless otherwise specified in a regulation, all materials filed with the Commission must also be filed with the Docket Unit. (Cal. Code Regs., tit. 20, § 1209(d).) Some regulations require filing with the Commission’s Chief Counsel instead of the Docket Unit. For example, Section 1720 requires a petition for reconsideration to be filed with the Chief Counsel and served on the parties. Service on the attorney representing Commission staff does not satisfy this requirement. This Proof of Service form is not appropriate for use when filing a document with the Chief Counsel under Title 20, sections 1231 (Complaint and Request for Investigation) or 2506 (Petition for Inspection or Copying of Confidential Records). The Public Advisor can answer any questions related to filing under these sections.

New addition(s) to the Proof of Service are indicated in **bold font** and marked with an asterisk (*). Additionally, if two or more persons are listed on a Proof of Service List with a single address, only one physical copy of a document need be mailed to the address.

Use this newly revised list for all future filings and submittals. This Proof of Service List will also be available on the Commission's Project Web Site at:

[\[http://www.energy.ca.gov/sitingcases/riomesa/index.html\]](http://www.energy.ca.gov/sitingcases/riomesa/index.html)

Please review the information and contact me at jacqueline.clay@energy.ca.gov or (916) 654-3893, if you would like to be removed from the Proof of Service or if there are any changes to your contact information.

Jacqueline Clay
Hearing Adviser's Office