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January 28, 2010

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Mr. Rod Jones
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814-5512

Subject: Lodi Energy Center (08-AFC-10)
Geochronological Investigations of the proposed Lodi Energy Center Site, Lodi, California

Dear Mr. Jones:

Attached please find one original and 12 copies of Northern California Power Agency's Geochronological Investigations of the Proposed Lodi Energy Center Site for the Application for Certification for the Lodi Energy Center (08-AFC-10).

If you have any questions about this matter, please contact me at (916) 286-0249 or Andrea Grenier at (916) 780-1171.

Sincerely,

CH2M HILL

Sarah Madams
AFC Project Manager

Attachment

cc: A. Grenier
E. Warner/NCPA

Geochronological Investigations of the proposed Lodi Energy Center Site, Lodi, California

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DATE: January 27, 2010

1.0 Background and Introduction

1.1 Previous Studies

As part of the Application for Certification process for the Northern California Power Agency's (NCPA) Lodi Energy Center (LEC; the "site") project (08-AFC-10), the California Energy Commission (CEC) requested further information on the historical geomorphology of the proposed project site. In CEC Data Request No. 13 Staff wrote:

> *"Please provide a discussion of the historical geomorphology of the project site that evidences consideration of the potential there for buried archaeological deposits. The discussion should include information on the development of Delta sand deposits during and subsequent to the Late Pleistocene era, particularly sands of the Piper series. The primary bases for the discussion should be data on the geomorphology, sedimentology, pedology, and stratigraphy of the project area or the near vicinity during the Late Quaternary period. The sources of these data may be a combination, as necessary, of extant literature or primary field research."*

A report entitled *Historical Geomorphology of the Lodi Energy Center Project Site* prepared and submitted in response to this request (CH2M HILL, 2009). It found that there were no landforms or soils mapped in the immediate vicinity of the site that could be associated with high subsurface archaeological sensitivity, and that "no immediate evidence is available from the vicinity of the project site or the natural gas pipeline right-of-way to suggest substantive subsurface archaeological potential."

Subsequent to Staff review of that document (Appendix A), NCPA's senior geochronologist (WGS) was invited to the California Energy Commission to review a confidential cultural resources report germane to the issue of archaeological sensitivity of the project area. The report is a geoarchaeological study and sensitivity assessment of the lands within Caltrans District 10, entitled *Volume III* of the *Cultural Resources Inventory of Caltrans District 10 Rural Conventional Highways - Geoarchaeological Study Landscape Evolution and the Archaeological Records of Central California* by Jeffrey S. Rosenthal and Jack Meyer (2004). In their Map 1

Rosenthal and Meyer (2004) provide a synthesis of the geoarchaeological data analyzed in their report. It portrays the project area around the Lodi Energy Center as having "very low" subsurface archaeological sensitivity. Thus their (ibid.) report is consistent with the conclusion reached on a more specific data set that the subsurface archaeological potential of the site is low (Appendix A).

1.2 The Current Study

The above findings not withstanding, CEC Staff remained unsatisfied with the lack of site-specific documentation supporting a determination of low subsurface archaeological insensitivity. Therefore in discussions with NCPA's senior geochronologist, staff prepared a Scope of Work for site-specific geoarchaeological testing that included the following requirements:

> Two 10-meter-long trenches, oriented NE-SW so that one wall is best lit by the low winter sun, will be excavated to the greatest depth the project's excavations would reach or to groundwater level if that is encountered first. One trench should be placed where the maximum-depth excavation would be located, and the other should be placed as far away from the first and as far east as possible. The trenches will be shored, so that the Project Geoarchaeologist[1] can enter and document, in detail, subsurface stratigraphy and pedogenic indicators, and collect soil and dating samples.
>
> Using additional illumination, if required, the Project Geoarchaeologist will select one sidewall of each trench for a measured profile drawing and for a complete profile photograph with a metric scale. This recordation will include a detailed description of each lithostratigraphic and pedostratigraphic unit and be used to correlate units between trenches.
>
> A maximum of six radiocarbon samples per measured profile drawing will be submitted for an expedited AMS 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. Samples, in order of preference will be: (1) macroscopic charcoal; (2) shell or bone, (3) bulk organic, and (4) humates.
>
> The Project Geoarchaeologist will identify any Holocene-age paleosols as they are excavated, and these will be targeted for geoarchaeological assessment.
> An archaeologist[2] 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 archaeologist will also assist with the identification and recordation of any encountered buried archaeological deposits.
>
> From each encountered lithostratigraphic unit or major process-related lithostratigraphic sequence in each of the profiles subject to measured drawing, and from the uppermost soil horizon remnant of each found pedostratigraphic unit, material will be removed from the profile wall and screened through ¼-inch hardware mesh. The sample size for screening will be a baseline of three 5-gallon

[1] The Project Geoarchaeologist shall meet the qualification standards of Condition of Certification **CUL-1** in the November, 2009 Staff Assessment for the LEC.

[2] The archaeologist shall meet the qualification standards of Condition of Certification **CUL-2** in the November, 2009 Staff Assessment for the LEC.

buckets per vertical one meter of profile, and the Project Geoarchaeologist will roughly prorate that baseline, to more or fewer buckets, relative to the thickness of the stratigraphic units encountered. Where lithostratigraphic units or sequences or pedostratigraphic units cannot be distinguished, the same amount of material will be screened through the same size mesh at regular intervals not to exceed 50 cm apart, down the wall of each profile. For cases where soil conditions do not allow such sampling, the Project Geoarchaeologist will explicitly articulate in the report of the investigations, for each stratigraphic unit, the field conditions that prevented the collection and screening of a sample. Where lithostratigraphic units or major process-related lithostratigraphic sequences are demonstrably high-energy deposits of large gravel that range in size from pebbles to boulders, no screening will occur.

As long as no archaeological deposits are encountered, the Project Geoarchaeologist may excavate using whatever level thickness he considers appropriate, but staff expects the Project Geoarchaeologist to excavate the trenches in a manner enabling the recognition of the presence of archaeological deposits. For example, the trenches might initially be excavated in 50-cm-thick, horizontal spits using a standard, toothed backhoe bucket. This excavation method has the benefit of enabling the operator to create for each 50-cm spit separate backdirt piles which can be flagged and provenienced for examination by the archaeologist for material culture remains.

If an archaeological deposit should be encountered, the backhoe operator could spot-weld a piece of angle iron across the ends of the bucket teeth, and the archaeologist could monitor the mechanical excavation through the deposit (unless it contained human remains), using arbitrary levels no greater than 20 cm thick. The archaeologist could screen the arbitrary levels through ¼-inch hardware mesh and provenience all artifacts, ecofacts, and other material culture finds to those arbitrary levels. After excavating through the deposit, the operator could knock the angle iron off and proceed with excavation in 50-cm-thick spits to the planned bottom of the trench.

The archaeologist will record any archaeological deposits found during the trenching activities on DPR 523 forms. Formal evaluation of site eligibility and/or data recovery is beyond the scope of this study. Additional consultation with Energy Commission staff would be necessary devise an appropriate treatment plan for any identified archaeological deposits encountered during this geoarchaeological investigation.

The remaining sections of this report detail these investigations, their findings, and conclusions. The reader desiring a more thorough discussion of the regional geology and Quaternary history of the area is referred to Appendix A.

2.0 Physiographic Setting

The proposed Lodi Energy Center (LEC) site (the "site") is located in San Joaquin County, California, near the eastern edge of the delta formed by the confluence of the Sacramento and San Joaquin Rivers, along with the Mokelumne River. The site lies within the Great Valley, a basin approximately 400 miles long and 60 miles wide bounded on the west by low California Coast Ranges and on the east by the lofty Sierra Nevada. The northern third of the Great Valley is the Sacramento Valley, and most of the lower two-thirds is the San Joaquin Valley (Downey and Clinkenbeard, 2005). The project site is located southwest of the city of Lodi, California, about 20 miles east of the Coast Range/Great Valley boundary (Figure 1).

The Great Valley is an asymmetric trough containing a westward thickening and dipping sequence of Late Cretaceous to Eocene marine and non-marine sediments that were eroded, transported and deposited into the basin from regional tectonic uplift of the Sierra Nevada. The sequence is underlain by Jurassic and Cretaceous igneous and metamorphic rocks, and overlain by unconsolidated alluvial sediments of Late Tertiary to Quaternary age. These unconsolidated sediments were laid down in broad, low-angle alluvial fans that extend west from the Sierra Nevada, and represent discharge from the main streams carrying sediment out of the Sierra. The site rests on the distal portion of the Mokelumne River alluvial fan, less than a mile east of the historic (ca. 1850) landward margin of tidal wetland during low river stages (Atwater, 1982).

3.0 Subsurface Geology

Based on previous identification of geologic units (Marchand and Allwardt, 1981; City of Lodi, 2006) in the site vicinity, there are five stratigraphic units below the disturbed soil and artificial fill at the surface of the site. From youngest and shallowest, to oldest and deepest they are:

- The Modesto Formation, closest to the surface, is approximately 0.01 to 0.042 million years in age and correlates with the Wisconsin glacial stage. The Modesto Formation is divided into upper and lower members. The upper member contains the Guard soils and the lower member contains the Devries soils.

- The Riverbank Formation ranges in age from 0.13 to 0.45 million years in age and correlates with the Illinoisian and possibly older glacial stages. This unit underlies the Modesto Formation.

- The Turlock Lake formation sits unconformably beneath the Riverbank Formation and has an estimated age of one million years. This unit contains gravel, sand and silt from granitic and metamorphic rocks of the Sierra Nevada.

- The Laguna Formation unconformably underlies the Turlock Lake Formation with an estimated age of 3-4 million years. This formation is estimated to occur between 100 and 200 foot depth at the site. This unit contains alluvial gravel, sand and silt, with some arkosic finer grained deposits, as opposed to the andesitic deposits of the Mehrten Formation.

- The Mehrten Formation contains andesitic debris from the Sierra Nevada and is estimated to occur at a depth of 800 to 1000 feet below ground surface within the vicinity of the site. The unit is Late Miocene to early Pliocene in age.

At the outset of this study it was anticipated that the lower units dating at least to the Middle Pleistocene and perhaps older (the Turlock Lake, Laguna, and Mehrten Formations), were buried too deeply to play a role in this study.

Based on previous site assessments (Stantec, 2009), the subsurface stratigraphy is mainly composed of fine-grained sandy silt and sandy silty clay. There are hardpan zones encountered around 1 meter at depth and then again further down in the trench. The Modesto Formation was deposited in an alluvial environment during glacial activity in the Sierra Nevada, most likely during the Tioga Glaciation (the Sierran equivalent to the Wisconsin Glacial Stage). Deglaciation in the Sierra was nearly complete by about 16,000 B.P. (e.g. Porter et al., 1983), but it is thought that deposition of the Modesto Formation did not end until later, around 9000 BP. (Marchand and Allwardt, 1981).

4.0 Methods

The locations of two trenches for geoarchaeological investigations were determined based on the guidance provided by Staff (see Sec. 1.2, above) in light of site-specific constraints (chiefly, the presence of buried utilities). After the geoarchaeologist in charge specified the trenches' appropriate locations, they were excavated using a backhoe with a 30-inch[3] bucket by NCPA contractors. The trench excavations were monitored by an archaeologist. The trench locations are shown in Figure 2. Each trench was approximately 15m long with a ramp at one end for easy egress and access, making the length of the trench at depth approximately 10m. The trenches were oriented northeast-southwest and excavated to the level of local ground water, approximately 3.4 to 4.0 meters below ground surface (bgs). The trenches were shored so the field team members were able to safely enter and document subsurface stratigraphy and pedogenic indicators, and collect soil and dating samples.

CH2M HILL's field team consisted of a senior geochronologist, geologist with graduate training in Quaternary geology and sedimentology, and an archaeologist. The field work took place on Tuesday, January 5, and Wednesday January 6, 2010. After shoring was in place, the exposed stratigraphic profile was cleaned with hand tools. A measured-profile drawing of the sediments exposed in each trench was then prepared. To do this a meter tape was run along the length of the trench for base measurement, and then a second scale suspended vertically to measure the depth of exposed strata. Photographs were taken of each trench, the exposed stratigraphic profiles, and the sampling locations.

At both trench locations the upper layer of sediment consisted of disturbed fill, and therefore sediment sampling began below this zone, and continued to the maximum depth of excavation. This overburden was easily distinguishable by the presence of asphalt clasts and exotic rock types used for gravel fill. At Trench 1, two distinct stratigraphic units were evident below a relatively thick layer of overburden. Soil samples for archaeological screening were collected separately from these distinct layers, and at regular intervals where the thickness of the unit exceeded 50 cm (20 inches).

At Trench 2 the overburden layer was relatively thin, and only one stratigraphic unit was evident below that. Therefore the soil samples collected for screening from this trench were taken at regular intervals between the top and bottom of the trench.

Soil samples for radiocarbon dating were taken at regular intervals beginning immediately below the overburden and ending at the floor of each trench, and the location of each recorded on the stratigraphic profile. Stratigraphic integrity was maintained in sampling.

[3] Unless the English system is used as a specification, such as a width of a backhoe bucket, all measurements are in the metric system.

That is, where distinct stratigraphic boundaries (discontinuities particularly evident in Trench 1) were evident care was taken not to mix the two different strata in one sample. During this sampling as well as the screening noted above, careful attention was paid to locate and collect any artifacts, ecofacts, and other material that might be encountered.

The radiocarbon samples were placed in clean Ziploc™ containers and then within Ziploc™ bags. The samples were immediately placed on ice and kept refrigerated to retard fungal growth during storage and transport. After cataloging, fifteen samples were submitted for radiocarbon dating. Seven bulk sediment samples from Trench 1 and seven bulk sediment samples from Trench 2 were submitted, along with a rodent mandible (cf. *Thomomys*) from Trench 1. The samples were shipped to Beta Analytic, Inc. of Miami, FL, for analyses of Carbon-14 (14C or 'radiocarbon') and estimation of consequent radiocarbon age and for determination of the samples' 13C/12C ratio (∂13C), which can sometimes provide additional environmental data. Duplicate splits of each sample were retained.

With the exception of Unit 2 in Trench 1, the strata were evidently free of macroscopic carbon or staining that would indicate organic compounds, and therefore low carbon content of the samples was anticipated. For this reason as well as desiring quick turn-around, accelerator mass spectrometry (AMS) dating was specified. AMS technology allows for the dating of milligram-scale sample sizes, roughly one-thousandth the sample requirement of conventional radiocarbon dating. Instructions to Beta Analytic's laboratory personnel were to recover and date, in order of priority, (1) organic remains such as bone or shell, (2) disseminated carbon, and (3) humic acids. Since they are water soluble and therefore mobile in the soils column, humic acids ("humates") would yield the least reliable radiocarbon dates. This is to the extent that the "reliability" of a radiocarbon date is the extent to which it reflects the age of deposition of that sediment, and not the apparent age of organic molecules which may be migrating through that soils column.

During processing at the radiocarbon laboratory, it was determined that the rodent mandible did not contain sufficient collagen[4] for dating. All sediment samples contained sufficient total organic carbon for dating and, therefore, the radiocarbon results are on fourteen samples of organic sediment from bulk samples.

5.0 Trench Stratigraphy

Each trench was oriented northeast-southwest so that one trench wall (the northwest wall) would be in the sun for most of the day to optimize visibility. Global positioning system points were taken for each trench and the resultant measurements are:

Trench 1: Lat 38°5'18"N, Long 121°23'12"W

Trench 2: Lat 38°5'14"N, Long 121°23'13"W

The surface elevation at the site is estimated to be about 6 ft above mean sea level, consistent with geological mapping of the area (Atwater, 1982). The depth of the overburden (do) and total depth (td) of the trenches at the sediment sample columns are:

[4] Collagen consists of organic macromolecules unique to animals and therefore is ideal for radiocarbon dating. The mineral portion of bone (apatite) is an "open-system" with respect to soils carbonates, and hence is not considered a suitable material for radiocarbon dating.

Trench 1: do: 50-55 cm bgs; td: 305 cm bgs

Trench 2: do: 0-5 cm bgs; td: 285 cm bgs

5.1 Trench 1

Trench 1 was located near the southern margin of the site, as close as feasible to the cooling tower sump of the planned new facility, which will necessitate some of the deepest excavations for the project. Trench 1 contains 3 rather distinct stratigraphic units (Figure 3), defined from top to bottom as:

Unit 1: Disturbed soil and construction fill

Unit 2: Mokelumne River deposits, dark grey, organic rich, silty sandy soil

Unit 3: Modesto Formation, greenish to grayish clayey sand

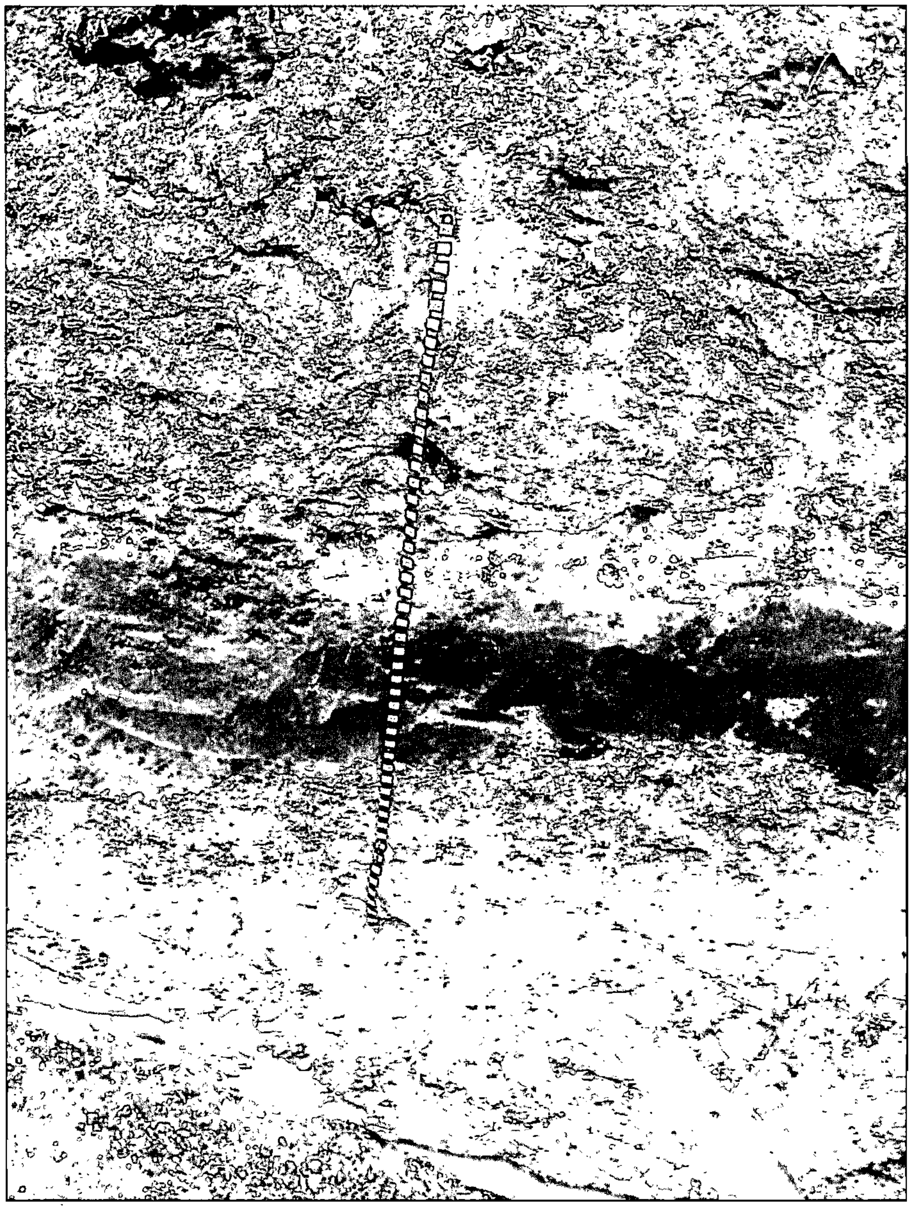

Figure 3: Trench 1 stratigraphy. The dark peaty layer (Unit 2 in the middle of the sequence) unconformably overlies Unit 3, identified as the Modesto Formation (bottom). An asphalt clast can be seen immediately to the right of the scale at the base of Unit 1, the recent overburden. Scale graduated in cm (1cm = 0.39 inch).

At the top of the profile is Unit 1 overburden consisting of construction debris and recent fill. It extends to a depth of 53 cm bgs in the sampling zone (Figure 3), with a lithology consisting of disturbed soil characterized by poorly sorted, reddish (7.5YR 5/6) silty sand, mottled, with occasional asphalt clasts and angular pebbles. The base is wavy and very abrupt. The silty sand is poorly consolidated with no soil development evident and occasional rootlets near the base. Unit 1 unconformably overlies Unit 2.

Unit 2 is subdivided into units 2A and 2B, and represents post-Modesto Formation Mokelumne River deposits. Unit 2A contains dark grey (10YR 3/2), silty, sandy, peaty clay. It is mottled with inclusions of Unit 1, and contains illuvial clay. This unit thins westward, and its depth varies from 53-64 cm bgs. Unit 2B is still a dark grey silty clay, massive, alluvial (not pedogenic), with no macroscopic remains evident. There are some disruptions by krotovina, and possible loading (push) structures. The unit is sticky and cohesive, and grades downward into a distinctive pedogenic CCa horizon with a platy carbonate hardpan. There are roots to the base of Unit 2 which bottom out on the hardpan. Unit 2 dips to the west and becomes significantly darker (10 YR 2/1). The dark color (Figure 3) could be caused by the accumulation of organics from a reducing environment in a persistently slack-water, swampy setting. The lower contact of Unit 2 is highly wavy, with an abrupt unconformable contact.

Below the unconformity marking the base of Unit 2 lies Unit 3, which we identify as the Upper Modesto Formation. This unit contains greenish to grayish clayey sand. Near the top, the sediments comprise a clay-rich, pedogenically altered unit (7.5YR 5/6) with a moderately imbricated CCa horizon (caliche). This soil grades conformably over 5 cm into a vesicular, partially lithified caliche horizon at 120 cm that exhibits platy structure and ferruginous staining with silty sand (2.5Y 6/3). The silty clayey fine sand is micaceous indicating Sierran alluvium, and massively bedded with no evident bedding structure. There are carbonate stringers and nodules throughout but not abundant, and some millimeter thick carbonate laminae. The sand is moderately consolidated and becomes more vesicular and lighter in color at depths greater than 170 cm. There is a B-C horizon at this depth with erosional truncation. The unit becomes gradually less consolidated with depth to approximately 200 cm, when sediments grade from brownish to buff/cream color (2.5 Y 7/3). At 220 cm clay content begins to increase to 270 cm where a second indurated horizon occurs that extends from 270 cm to the bottom of the trench (305 cm bgs).

5.2 Trench 2

At Trench 2 the overburden layer was quite thin, and therefore it was considered to constitute part of the A-horizon of the soil column evident in the trench profile. Aside from this anthropogenic veneer, only one stratigraphic unit was evident in the Trench 2 profile; no dark, organic rich stratum similar to Unit 2 in Trench 1 was present. For the sake of stratigraphic description then it was subdivided from top to bottom based on soil development and more subtle variations in lithology, not on major discontinuities characterizing different sediment packets as was evident at Trench 1.

It was noted that the deeper sediments in Trench 2 were markedly less consolidated than those of Trench 1. Lack of induration led to sloughing of the side walls in a few places before shoring was completed. The uppermost stratum at Trench 1, Unit 1A, was a dark gray (7.5YR 3/1), silty clayey sand, mottled, with a distinctly platy structure extending down to about 10 cm depth (Figure 4). The A horizon contains common anthropogenic cobbles and gravels. Roots are abundant. The unit exhibits massive bedding and crumbly prismatic structure, and extends to about 15 cm bgs.

Unit 1B is a dark gray (10 YR 3/1) silty sand, mottled with buff colored inclusions. There is increasing carbonate content with depth to the contact with Unit 1C. The pedogenic B and C horizons in this unit are treated collectively as stratigraphic Unit 1B. The bottom of Unit 1B is wavy, and disrupted by abundant krotovina, and is gradational from 40-50 cm bgs.

Between the top of Unit 1C and a depth of about 102 cm bgs, the unit is further subdivided into units $1C_1$ and $1C_2$. In general, unit 1C is reddish brown silty sandy clay, evidently pedogenic. Unit $1C_1$ contains sandy, silty clay, the sand poorly sorted and fine to medium grained, (7.5YR 4/3). There is no gravel in this unit while the underlying Unit $1C_2$ is made up of gravelly sandy clay, with clasts up to 5 cm diameter. This unit is lighter in color (7.5YR 5/3) than Unit $1C_1$. Unit 1C is separated from Unit 1D below by a highly wavy, unconformable contact (Figure 4).

Below Unit 1C there are three additional strata that grade conformably into one another, and that may represent merely facies changes in the context of a single depositional episode. These are:

> Unit 1D, a massive, brown (10YR 4/3) silty clay, with trace sand extending from approximately 100 to 180 cm bgs, which grades into….
>
> Unit 1E, a brown (10 YR 5/4) silty sand, and is medium grained, sticky, and cohesive, extending from approximately 180 to 220 cm bgs, which grades into…
>
> Unit 1F, a reddish brown (7.5YR 4/2) micaceous silty clay, with trace sand. The unit also contains trace gravel with clasts up to 2 cm diameter, and extends to the bottom of Trench 2 at 285 cm depth.

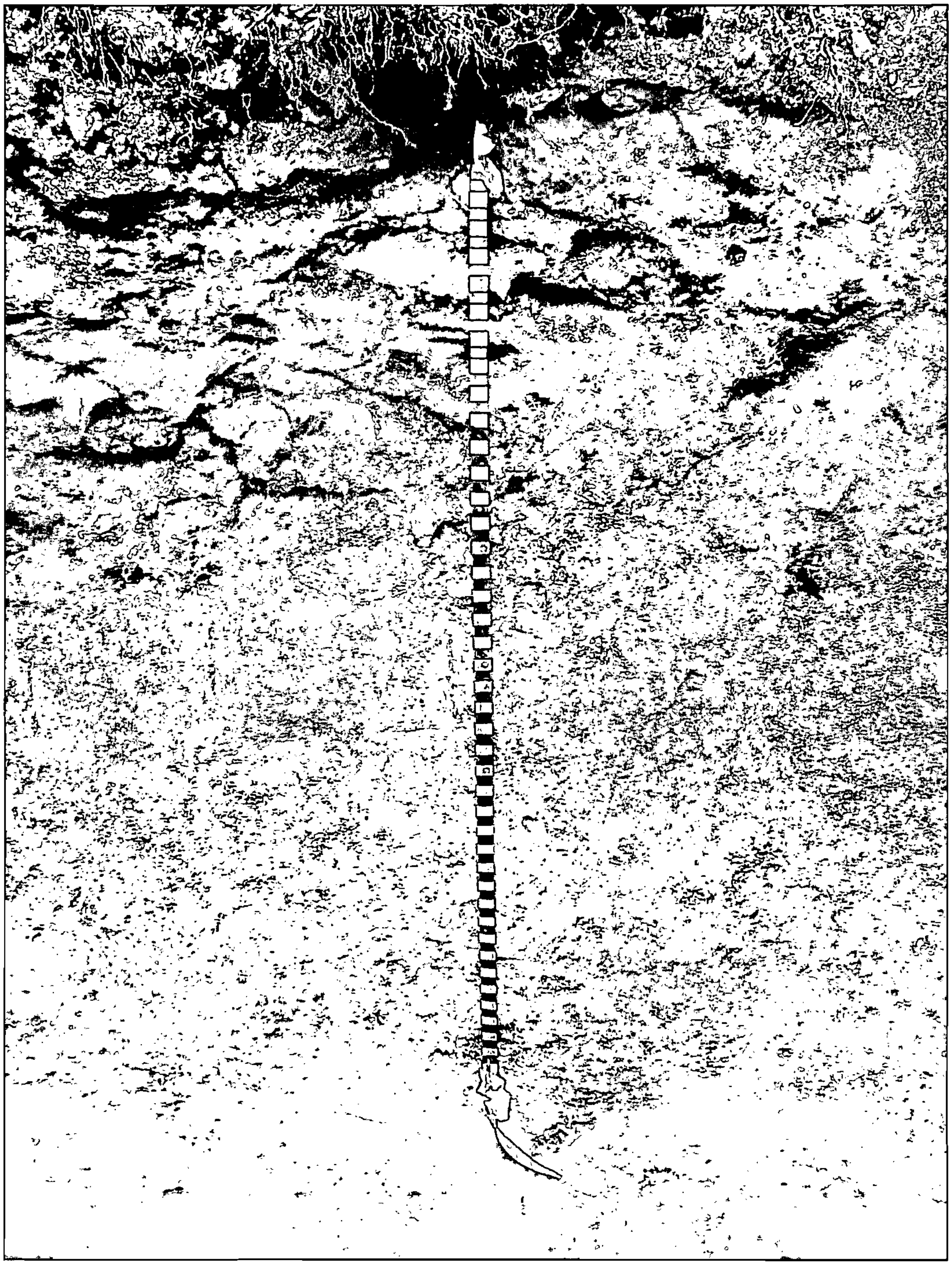

Figure 4: Trench 2 stratigraphy. Clearly shown is the gradational nature of the transitions from (top to bottom in this exposure) Units 1A, 1B, and 1C. The base of the scale is at the top of Unit 1D. Scale graduated in cm (1cm = 0.39 inch).

6.0 Results of Sampling and Chronological Analyses

No macroscopic organic remains or lithic materials were encountered during sampling or screening other than the pocket gopher mandible from Trench 1 discussed previously. No other type of ecofact was encountered. Screening of the material from the trenches was easier in the silty sand but more difficult for clay layers.

Results of the radiocarbon dating and ∂13C analyses of the samples collected from Trench 1 are presented below in Table 1. They show that the two units lying below the disturbed fill (Unit 1) are markedly different in age. Unit 2A, the nearly black stratum (Fig. 3) is very late Holocene in age. It apparently[5] spans the last several centuries of the Medieval Climatic Anomaly (ca. AD 800 - 1350; Jones et al., 1999) and most of the Little Ice Age (ca. AD 1450 - 1850; Grove, 1988). The discontinuity at its base is profound, and the radiocarbon dates from underlying Unit 3 indicate that it is roughly 11,000 older. With an apparent age of 12,000 to 14,000 B.P., Unit 3 is evidently correlative with the Upper Modesto Formation.

TABLE 1
Results of radiocarbon dating sediment samples from Trench 1

BETA lab no.	Sample	Depth (cm bgs)	Stratigraphic Unit	13C/12C (∂13C in o/oo)	Conventional Age	2 Sigma Calibration
272067	LODI.T1.2A	54-62	2A	-23.8	80 +/- 40 BP	Cal AD 1680 to 1740 (Cal BP 270 to 210),Cal AD 1800 to 1940 (Cal BP 150 to 20),Cal AD 1950 to 1960 (Cal BP 0 to 0)
272068	LODI.T1.2B	66-74	2B	-24.7	780 +/- 40 BP	Cal AD 1200 to 1280 (Cal BP 750 to 670)
272069	LODI.T1.2B	78-87	2B	-24.9	1040 +/- 40 BP	Cal AD 900 to 920 (Cal BP 1050 to 1030), Cal AD 950 to 1040 (Cal BP 1000 to 920)
272070	LODI.T1.3	95-120	3	-23.9	12,010 +/- 70 BP	Cal BC 12,060 to 11,800 (Cal BP 14,010 to 13,740)
272071	LODI.T1.3	160-180	3	-21.7	12,870 +/- 70 BP	Cal BC 13,390 to 13,080 (Cal BP 15,340 to 15,030)
272072	LODI.T1.3	190-210	3	-25.9	14,160 +/- 80 BP	Cal BC 15,150 to 14,740 (Cal BP 17,100 to 16,690)
272073	LODI.T1.3	220-240	3	-25.9	11,620 +/- 70 BP	Cal BC 11,700 to 11,360 (Cal BP 13,650 to 13,310)

Results of the radiocarbon dating and ∂13C analyses of the samples collected from Trench 2 are presented below in Table 2. They suggest that Units 1B and Unit 1C may represent one or two Late Holocene strata, and that Units 1D through 1F may represent a separate Middle

[5] Radiocarbon dates on undifferentiated organic residue are subject to error due to the migration of water-soluble organic compounds. They do not represent dates on "closed systems" relative to the soils environment.

Holocene depositional event. The $\partial^{13}C$ value of the two samples from Unit 1C are anomalously heavy (-20.1‰ and -20.5‰) compared to the rest of the results, which may suggest the presence of a somewhat different biomass on the soil surface at that time. Given the site's proximity to the historic autumnal tide line, perhaps the stable carbon isotopes reflect the presence of CAM- or C4-dominated vegetation[6] in an edaphically arid setting, such as the edge of a salt marsh.

TABLE 2
Results of radiocarbon dating sediment samples from Trench 2

BETA lab no.	Sample	Depth (cm bgs)	Stratigraphic Unit	13C/12C (∂13C in o/oo)	Conventional Age	2 Sigma Calibration
272075	LODI.T2.1B	25-40	1B	-23.6	360 +/- 40 BP	Cal AD 1440 to 1640 (Cal BP 510 to 310)
272076	LODI.T2.1C1	55-70	1C1	-20.1	1630 +/- 40 BP	Cal AD 340 to 540 (Cal BP 1610 to 1410)
272077	LODI.T2.1C2	80-100	1C2	-20.5	1930 +/- 40 BP	Cal BC 10 to Cal AD 140 (Cal BP 1960 to 1810)
272078	LODI.T2.1D	110-130	1D	-24.5	6790 +/- 50 BP	Cal BC 5740 to 5620 (Cal BP 7690 to 7570)
272079	LODI.T2.1D	160-180	1D	-25.4	5330 +/- 50 BP	Cal BC 4320 to 4040 (Cal BP 6280 to 5990) Cal BC 4010 to 4000 (Cal BP 5960 to 5950)
272080	LODI.T2.1E	200-220	1E	-22.5	4770 +/- 40 BP	Cal BC 3640 to 3510 (Cal BP 5590 to 5460), Cal BC 3420 to 3380 (Cal BP 5380 to 5330)
272081	LODI.T2.1F	260-280	1F	-23.6	7260 +/- 50 BP	Cal BC 6230 to 6020 (Cal BP 8180 to 7970)

7.0 Conclusions

Evidence from the sediments exposed under the recent fill in both trenches (Trench 1- Units 2 and 3, and Trench 2–Unit) support the conclusion that they are Mokelumne River deposits based on lithological similarities with Sierran fluvial deposits near the toes of these alluvial fans studied by others (e.g. Florsheim and Mount, 2003; Marchand and Atwater, 1979).

In the field it was noted that the deeper strata in each trench differed in terms of their degree of induration as well as stratification, and this difference is further reinforced by the radiocarbon dating results (Tables 1, 2). Trench 1 (Unit 3) contains the oldest stratum encountered, which we correlate with the Upper Modesto Formation based on radiocarbon dates ranging from 11,620 to 14,160 B.P. These dates correlate with the waning phase of the Tioga Glaciation of the Sierra Nevada (Marchand and Allwardt, 1981).

6 These are plant metabolic pathways that preferentially fix the heavier isotopes of carbon, and are typical of saline and arid habitats such as salt grass (*Distychlis* spp.) and saltbush (*Atriplex* spp.).

The deeper strata of Trench 2 (Units 1D, 1E, and 1F) consists of middle Holocene age sediment dated between 4,790 and 7,260 B.P. Unit 1D, at the top of this sequence, is separated from the overlying Late Holocene strata by an unconformity. The time period represented by these sediments is after the last glaciation, and may represent an aggradational response to Holocene sea level rise in the Sacramento-San Joaquin River Delta, which culminated at about 6,000 BP (Marchand and Allwardt, 1981). In the absence of diagnostic bedding structures it is possible that these Middle Holocene sediments also represent eolian sands. Other workers (e.g. Atwater, 1982; see Appendix A) have recorded relict sand dunes mantling the Mokelumne River fan in the region west of Lodi.

There are out of sequence sediments at the bottom of each trench which may be related to regional geomorphic adjustments at the end of the last glaciation, and to the development and distribution of Quaternary fluvial fans subject to varying stream discharge ratios (Weissmann et al., 2005). Basin subsidence and basin width changes resulting from either tectonics or climate change could also have contributed to the development of the sequences at the site. These factors aside, the different-age sediments indicate that there was a paleotopographic high in the vicinity of Trench 1, where Modesto Formation sediments were preserved. In the vicinity of Trench 2 there was a pronounced topographic low, most likely a channel, what was filled with younger Middle Holocene sediment.

Regardless of the age of sediments encountered below disturbed soil in these two trenches, and regardless of the nuances of topographic and habitat variability across the site, no evidence was found of terrestrial environments in the profiles. Nor was there any evidence of anthrosols or cultural material found during these investigations. The nature of the sediment is consistent with glacial outwash of Sierra Nevada provenance and latter, post-glacial Mokelumne River fluvial deposition. Examination of these sediments and their contacts between the Modesto Formation and overlying units affirms the lack of subsurface archaeological potential in this site area.

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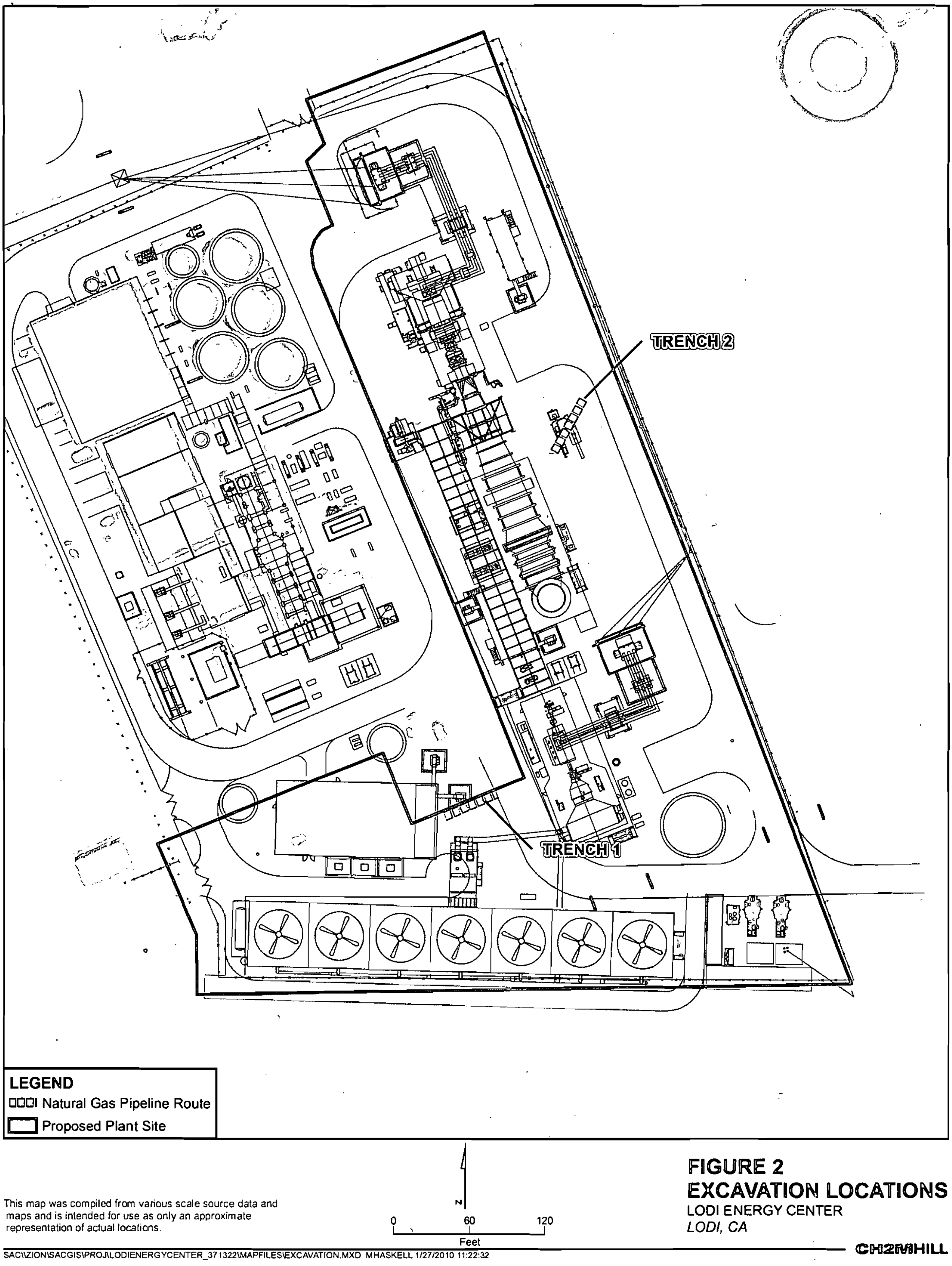
Figures

This map was compiled from various scale source data and maps and is intended for use as only an approximate representation of actual locations.

FIGURE 1
SITE LOCATION
LODI ENERGY CENTER
LODI, CALIFORNIA

SAC\\ZION\SACGIS\PROJ\LODIENERGYCENTER_371322\MAPFILES\SITELOCATION.MXD MHASKELL 1/15/2010 09:52:23

CH2MHILL



This map was compiled from various scale source data and maps and is intended for use as only an approximate representation of actual locations.

FIGURE 2
EXCAVATION LOCATIONS
LODI ENERGY CENTER
LODI, CA

CH2MHILL

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APPENDIX A

Historical Geomorphology of the Lodi Energy Center Project Site

TECHNICAL MEMORANDUM **CH2MHILL**

Historical Geomorphology of the Lodi Energy Center Project Site

PREPARED FOR: Ed Warner / NCPA
Scott Galati / GalatiBlek
Andrea Grenier / Grenier & Assoc

PREPARED BY: W. Geoffrey Spaulding, Ph. D.

COPIES: Sarah Madams / CH2M HILL

DATE: February 10, 2009

PROJECT NUMBER: 371322.DI.DR

Introduction

As part of the Application for Certification process for the Northern California Power Agency's (NCPA) Lodi Energy Center (LEC) project (08-AFC-10), the California Energy Commission (CEC) requested further information on the historical geomorphology of the proposed project site. This technical memorandum is a response to CEC Data Request No. 13:

> *"Please provide a discussion of the historical geomorphology of the project site that evidences consideration of the potential there for buried archaeological deposits. The discussion should include information on the development of Delta sand deposits during and subsequent to the Late Pleistocene era, particularly sands of the Piper series. The primary bases for the discussion should be data on the geomorphology, sedimentology, pedology, and stratigraphy of the project area or the near vicinity during the Late Quaternary period. The sources of these data may be a combination, as necessary, of extant literature or primary field research."*

Context

Soils and Sediments

The Natural Resource Conservation Service (NRCS) (1998) defines the Piper series as very deep, poorly drained soils that formed in alluvium from granitic rock sources. Piper soils are on natural levees and flood plains, typically on sloping natural levees 15 feet below to 5 feet above sea level or at elevation of up to 300 feet. They formed in sandy or coarse-loamy alluvium mostly from granitic sources along streams in low basins and in the Sacramento-San Joaquin Delta. Geographically associated soils are the Kingile, Shima, and Sacramento soils. Kingile and Shima soils are organic soils. Diagnostic horizon recognized in the Piper Series pedon is an ochric epipedon present from the surface to a depth of 10 inches (A1, A2 zones) (NRCS, 1998). Soils in the vicinity of the project site and the natural gas pipeline right-of-way are classified as Devries sandy loam, a soil of historic flood-basins and basin rims (NRCS, 1992).

Geomorphology and Topography

The trunk streams of the Great Valley converge with each other and the Mokelumne River at the Sacramento-San Joaquin Delta. Prior to the middle 19th century the delta possessed all the features of a classical delta with anastomosing channels, low levees, broad flood basins, and many channel segments both abandoned and submerged. The LEC project area lies on the eastern margin of the delta, at the toe of the delta-fan of the Mokelumne River less than a mile east of the high water limit of the historic autumnal tides (Marchand and Atwater, 1979).

The overarching control of sedimentation in the delta, including in the vicinity of the project area, has been the interplay between glacio-eustatic sea-level fluctuations and glacial outwash borne by Sierra Nevada streams (Lettis and Unruh, 1991; Shlemon, 1971; Shlemon and Begg, 1975). Episodic sea level declines during Middle and Late Quaternary glaciations led to fluvial down-cutting and westward migration of the delta-fan system[1], while subsequent deglacial sea-level rise led to eastward migration of the estuarine and delta-fan system, and aggradation within the current limits of the Sacramento-San Joaquin Delta. The last period of deglaciation and sea-level rise, followed by encroachment of estuarine habitats and accretion of the current Mokelumne River fan-delta, began approximately 15,000 years ago (B.P.; Bloom, 1983). Marine/estuarine environments entered San Francisco Bay by 10,000 B.P. and prograded eastward occupying most of the current delta by about 6,000 B.P. (Atwater et al., 1977; Shlemon and Begg, 1975).

Soil survey classifications are generally for agronomic purposes and the designations are seldom employed to great extent in geomorphological or geological investigations. The nuance here is that a soil, as used in these studies, is a suite of chemical and physical characteristics developed by weathering of the parent sediment after it is laid down. Therefore, one might encounter a suite of soil characteristics (such as color, alteration of physical properties with depth, vertical distribution of clays and elements such as iron, aluminum, and calcium) developed to a very similar degree on two sediments of different origin, for example, a fluvial sand and an eolian (dune) sand. In the vicinity of the project area, Marchand and Atwater (1979) have identified limited relict dunes about a mile north of the project site, with a more extensive dune field approximately 4 miles to the north-northeast. In their (Marchand and Atwater, 1979) stratigraphic inventory they note that, according to the USDA. soil survey of San Joaquin County in preparation at the time, these dune sands support (among other soils) the Piper series.

The relict dune area about a mile north of the project site is characterized by about 3.5 feet of loose sand overlying compact sandy silt and silty sand (Atwater, 1982). It possesses minimal topographic relief (Thornton and Lodi South 7.5′ topographic series, U.S. Geological Survey), although its relative height was no doubt greater prior to intensive farming in the area. These sands mantle the Modesto Formation and represent its uppermost stratum in this area (Atwater, 1982). The Modesto Formation is typically assigned to the Late Pleistocene (ca. 78,000 to 10,000 B.P.; Atwater, 1982; Marchand and Allwardt, 1979), although there is no *a priori* reason that this sand might not also date to the early Holocene (10,000 - 7,000 B.P.) period of maximum aridity in western California (e.g., Davis, 1999;

[1] During glacial-maximum times the mouth of the Sacramento River lay west of the Farallon Islands, some 30 miles west of the current coastline. The consequent reduction of maritime influence on the local climate led to increased aridity (see Thompson et al., 1993).

Anderson, 1990; Davis and Moratto, 1988). Relict dunes and sand sheets along coastal California and in areas such as the Sacramento-San Joaquin Delta have usually been related to a more arid (albeit cold) Late Pleistocene climate when the sea had retreated far to the west due to glacio-eustatic sea-level decline (Dupré et al., 1991). The climate was more arid and, at the same time, rivers issuing from the glaciated Sierra Nevada were discharging enormous sediment loads that would have been a ubiquitous source of wind-blown sand in the lowlands of the Great Valley and Delta (Atwater and Marchand, 1980; Lettis and Unruh, 1991). With more recent paleoclimatic reconstructions indicating aridity well into to the middle Holocene (Davis, 1999; Malamud-Roam et al., 2006), it is reasonable to suggest that the uppermost, eolian facies of the Modesto Formation may in some places post-date the Pleistocene.

It also should be noted that another enormous sediment-discharge pulse took place in the late 19th and early 20th century in response to placer mining in the Sierra Nevada. The radical downstream geomorphic adjustments that resulted were noted early in the last century (e.g., Bryan, 1923), and the stratigraphic impact of this has been discussed recently by Florsheim and Mount (2003). Although not possessing an ochric epipedon, a reddish-brown sediment layer overlying late Holocene basin deposits is widespread in the area of the confluence of the Cosumnes and Mokelumne rivers, about 10 miles north, and likely elsewhere. Its thickness ranges from about a half-meter to more than 2.5 meters (1.6 to 8.2 feet). This red-brown sandy-silt has been termed the "anthropogenic layer" by Marchand and Atwater (1979). However, its character and color should be distinguishable from the deep oxidation profile of the eolian sands described by Atwater (1982; Atwater and Marchand, 1980).

Analysis

A brief review of the archaeological literature of the Sacramento-San Joaquin Delta area and the subdued topography of the fan toes of the Mokelumne and Cosumnes Rivers indicates that major archaeological sites were located on topographic (or paleotopographic) highs. The relative elevation of village mounds and other sites of intense habitation would have increased from simple accretion of anthropogenic debris, but natural levees and other natural topographic highs commonly hosted prehistoric sites (Beardsley, 1948). However, this does not hold true for the oldest sites, which are actually found below adjacent terrain, frequently in marshlands some distance from current river courses and within indurated alluvium (Moratto, 1984). Some prehistoric sites were recorded as occurring on "clay mounds," which might be erosional remnants of flood-basin deposits. Many older sites are in alluvium that is "well-indurated" with carbonate deposition, suggesting relatively rapid rates of soil formation (that is, considerably less than 7,000 years to form a well-developed carbonate (CCa) soil horizon). It should be noted as well that at least one previous analysis does not appear to support the relationship between topographic highs and archaeological sites (e.g., West and Welch, 1996), but this is due more to a lack of geomorphological rigor in the use of "landform codes" than a reflection of what may actually be the case[2].

[2] Table 1 in West and Welch (1996) lumps sediment descriptors such as "peats and muds," "organic soils," and "valley fill" with topographic descriptors such as "alluvial fans," "low terraces," and "basins and basin rims" (*sic*) confounding any attempt to understand the relationship between site occurrence and topography alone.

The study of lowland sedimentation processes during the late Holocene and historic periods in the Sacramento-San Joaquin Delta by Florsheim and Mount (2003) is germane to this discussion. Their study area lies only 11 miles north of the LEC project area, and is in an area that hosts a number of important sites near the confluence of the Cosumne River, Mokelumne River, and Dry Creek (Figure 4.6 in Moratto, 1984). Florsheim and Mount (2003) describe the geological facies changes in the delta-fan subsurface in terms of habitats and energy regimes of a low-gradient riverine system entering a prograding delta. Chief among these processes in prehistoric and early historic (pre-20th century) times were the seasonal overbank flows of the perennial rivers (the Mokelumne, Sacramento, and Cosumnes rivers in this area) creating floodplain lakes and seasonal marshes that slowly drained through multiple channels in the flood basin. Relatively coarse-grained sands were suspended in the energetic channel flows and deposited on the levees or as splay deposits adjacent to levee breaches. Finer clays and silts were carried farther into the basins and deposited in relatively less energetic habitats as flood-basin sediments. Flood-basin deposits generally are clay-rich sediment derived from overbank flood flows trapped between natural levees and the edges of fans (Bryan, 1923; Florsheim and Mount, 2003).

Conclusions

Atwater (1982) and Marchand and Atwater (1979) have identified relict dunes and sand sheets on the eastern periphery of the Sacramento-San Joaquin Delta. The closest that have been mapped lie about a mile north of the project site, with a more extensive dune field approximately 4 miles to the north-northeast. In their stratigraphic inventory, Marchand and Atwater (1979) note that, according to the USDA soil survey of San Joaquin County in preparation at the time, these dune sands support (among other soils) the Piper series. Many relict dune systems in western California have been assigned a Pleistocene age, although clarification of the degree of early- to middle Holocene drought in western California raises the question of whether some might be younger than 10,000 B.P. Some eolian landforms may therefore post-date the beginning of the PaleoIndian Period (ca. 12,000 B.P.). Dunes offered windbreaks in what otherwise was a generally flat landscape, and later in the Holocene would have offered topographically elevated sites in a seasonally waterlogged region. Thus, an archaeological record at depth can be expected from these features absent significant historic disturbance. The most intriguing strata for investigation would be those displaying the contact between overlying eolian sand and underlying Modesto Formation alluvium. Younger archaeological materials atop older eolian strata, which would occur if a dune provided well-drained ground for later Holocene occupation, could be evinced by organic rich and finer-grained (silts and clays) strata overlying the older sands.

It is doubtful, however, that circumstances will arise in the course of this project that will allow for a test of any of these hypotheses. Neither Atwater (1982) nor Marchand and Atwater (1979) map relict dunes or other eolian landforms within a mile of the project site or the natural gas pipeline route. Other sands are present at depth, but the deeply oxidized ochric horizon characteristic of the Piper series was not noted in prior geotechnical studies (Carlton Engineering, 2008; Kleinfelder, 1993). Silty sands to sandy silty clays extend to a depth of 2 to 8 feet below the surface of the project area. The range of horizontally bedded sediments encountered below that depth, alternating from fluvial sands to silty clays, is consistent with the facies changes described by Florsheim and Mount (2003) for the fluvially dominated sedimentation of the delta-fan area not far to the north. Therefore, no immediate evidence is available from the vicinity of the project site or the natural gas pipeline right-of-way to suggest substantive subsurface archaeological potential.

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BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA
1516 NINTH STREET, SACRAMENTO, CA 95814
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APPLICATION FOR CERTIFICATION FOR THE *Lodi Energy Center*

DOCKET NO. 08-AFC-10

PROOF OF SERVICE
(Revised 1/27/10)

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DECLARATION OF SERVICE

I, Sarah Madams, declare that on January 28, 2010, I served and filed copies of the attached Lodi Energy Center (08-AFC-10), Geochronological Investigations. The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at: **[www.energy.ca.gov/sitingcases/lodi]**. The document has been sent to both the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit, in the following manner:

(***Check all that Apply***)

FOR SERVICE TO ALL OTHER PARTIES:

__x_ sent electronically to all email addresses on the Proof of Service list;

__X__ by personal delivery or by depositing in the United States mail at Sacramento, CA with first-class postage thereon fully prepaid and addressed as provided on the Proof of Service list above to those addresses **NOT** marked "email preferred."

AND

FOR FILING WITH THE ENERGY COMMISSION:

__x__ sending an original paper copy and one electronic copy, mailed and emailed respectively, to the address below (***preferred method***);

OR

_____ depositing in the mail an original and 12 paper copies, as follows:

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 08-AFC-10
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512

docket@energy.state.ca.us

I declare under penalty of perjury that the foregoing is true and correct.

Haneefah Walker

Haneefah Walker