

# CHAPTER 3

## GEOARCHAEOLOGICAL METHODS, FINDINGS, AND INTERPRETATIONS

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*Jack Meyer*

The geoarchaeological study was designed to locate potentially buried archaeological resources in the project corridor by targeting depositional landforms that may contain buried Holocene-age soils. This was initially accomplished by reviewing relevant geologic studies and logs of previous cores and borings obtained from in or near the project corridor. In doing so, the study attempted to increase the likelihood that potentially buried archaeological resources would be identified by reducing the area and/or volume of sediments that need to be searched. Ultimately, the ability to locate buried sites depends on the whether or not appropriate methods are used to explore sensitive landforms for evidence of past human activity. Given the limited scope of this study, the presence of artificial fill deposits throughout the project area, and the many methodological constraints in the field, it was only possible to search for buried sites within very small portions of the study area. This chapter describes the methods used for the geoarchaeological study, presents the results of the fieldwork, and interprets the results according to the research questions, data needs, and regional issues outlined above in Chapter 2.

### **FIELD AND LABORATORY METHODS**

#### **Subsurface Coring and Sampling**

A hydraulic coring device, known commercially as a “Geoprobe,” was used to explore subsurface deposits for buried archaeological resources. A Geoprobe was used as an alternative to excavating backhoe trenches because (1) the anticipated depths of former ground surfaces were often greater than those that can normally be reached by a backhoe (i.e., >15 ft., or 4.6 m), and (2) Caltrans prohibited the use of trenches in response to a variety of logistical, safety, and engineering concerns. A total of 27 “prehistorically sensitive” locations were initially selected for subsurface sampling based on a general understanding of the nature and extent of geologic deposits in the project area, and on the limited information obtained from previous core logs. Two of these locations (Block 3 R64C1, and Block 4 L64C1) were not tested; instead, alternative locations were selected based on the results of nearby cores. However, 14 locations not originally specified in the RDTP were also tested at the request of Caltrans Archaeologist Glenn Gmoser, because the initial coring results indicated that buried soils could be present in other areas. Information about all 39 of the tested locations is provided in Appendix F. Samples of subsurface deposits were obtained from each block in the project area except for Block 7, which was not originally targeted as part of the RDTP, nor was it accessible when coring was conducted in the area.

The samples from subsurface deposits were recovered and stored in hard plastic (PVC) liners that were either 36 or 48 inches long, and 1.25 or 2 inches in diameter. Each liner was placed in a dual-walled push tube that was hydraulically driven to the appropriate

depth then opened to capture a continuous core sample from the desired interval. The liners were then extracted from the push tube and labeled to indicate their location, depth, and orientation (i.e., top or bottom), with details noted on core logs. All samples were transported to the laboratory at the ASC, where they were stored and allowed to air-dry in a protected place until they could be described and subsampled. All of the cores were grouped by block and compared to determine which ones contained the most complete (i.e., deepest) stratigraphic sequences and/or materials suitable for radiocarbon dating. At least one core from each explored block was selected for detailed description and/or radiocarbon dating; Block 7 was not explored. Although relatively small, the core samples were large enough to determine: (1) the nature and extent of the subsurface deposits; (2) if they contained archaeological materials; and (3) to yield samples suitable for radiocarbon dating.

### **Stratigraphic Identification and Description**

At the laboratory, stratigraphic units (strata) and soil horizons were identified in the cores on the basis of their physical composition, superposition, textural transitions (fining-upward sequences), and the relative degree of near-surface weathering (soil development). Master soil horizons were designated by upper-case letters (O, A, B, or C) and proceeded by Arabic numerals (2, 3, etc.) when the horizon is associated with a different stratum (i.e., 2Cu); number 1 is understood but not shown. Buried paleosols were identified on the basis of color, structure, horizon development, bioturbation, and the nature of the upper boundary with the overlying deposit (Birkeland, Machette, and Haller 1991; Retallack 1988). The paleosols often exhibited abandoned root and insect holes, or other indications of bioturbation.

Master soil horizons include O horizons, dominated by organic remains such as peat; A horizons, or mineral soils enriched by organics near the surface; B horizons, or zones of increased subsurface structure and/or mineral accumulation; and C horizons, or relatively unweathered parent materials. Lower-case letters were used to designate subordinate soil horizons as follows:

- “b” is a buried horizon at the location where it was described (not used with C horizons);
- “t” is a subsurface accumulation of silicate clays;
- “u” is relatively unweathered parent material (i.e., C horizon); and
- “ox” is oxidized parent material.

Combinations of these numbers and letters were used to indicate the important characteristics of each major stratum and soil horizon. The colors of the deposits were determined using the Munsell Soil Color Charts (Macbeth 1992). These techniques and designations are consistent with those outlined by Birkeland et al. (1991), Schoeneberger et al. (1998), and the Soil Survey Staff (1998).

### **Radiocarbon Samples and Dating**

Radiometric analysis was conducted to establish and refine the chronology of natural and cultural contexts in the project area. Radiocarbon ( $^{14}\text{C}$ ) is produced primarily by the interaction of cosmic radiation with nitrogen in the earth’s atmosphere. After mixing with carbon dioxide ( $\text{CO}_2$ ),  $^{14}\text{C}$  is readily assimilated by plants and other living organisms. When plants and animals die, however,  $^{14}\text{C}$  levels start to decrease because they no longer absorb

new carbon. Since  $^{14}\text{C}$  is known to decay at a rate that approaches a half-life of 5,730 years, the amount of decay reflects the age of biogenic carbon as compared to modern levels of  $^{14}\text{C}$  activity (Geyh and Schleicher 1990). For consistency, the half-life of  $^{14}\text{C}$  is set at 5,568 years by international convention.

Soils and sediments can be dated if they contain certain amounts of biogenic carbon in the form of organic matter or secondary carbonates (i.e., soil organic matter, or SOM). The differential decomposition, humification, and translocation of biogenic carbon in a given deposit determine the type and amount of SOM available for dating. The accuracy of soil dates depends on the researcher's ability to select samples that will minimize potential contaminants (Scharpenseel 1979) and to properly interpret the context of the sample (Matthews 1985). The  $^{14}\text{C}$  age of a soil or sediment reflects the apparent mean residence time (AMRT) of the total organic content of the analyzed material. Since soil formation is time-transgressive, AMRT dates are usually younger than the true age of the soil. Understood in this way, the  $^{14}\text{C}$  age of a soil does not mark a single time or event, but reflects the influence of multiple processes that affect the soil-carbon system over time.

Measured  $^{14}\text{C}$  ages also reflect the enrichment or depletion (fractionation) of stable carbon isotopes  $^{12}\text{C}$  and  $^{13}\text{C}$ , as determined by the metabolic and environmental history of a sample (Geyh and Schleicher 1990). For this reason,  $^{13}\text{C}/^{12}\text{C}$  ratios are often used to correct measured  $^{14}\text{C}$  ages to conventional  $^{14}\text{C}$  ages, which are expressed in years before present (B.P.), with "present" equaling A.D. 1950. Due to fluctuations in the concentration of atmospheric  $^{14}\text{C}$  over time (the de Vries effect), conventional  $^{14}\text{C}$  ages can differ from the actual ages in solar years. This difference amounts to only  $\pm 200$  years over the past 2,000 years, but increases to a minus of 800 years between 2,000 and 7,300 years ago, and a minus of 1,100 years between 8,000 and 11,000 years ago (Geyh and Schleicher 1990:168). To compensate for these differences, high-precision calibration programs have been developed that convert conventional  $^{14}\text{C}$  ages into calibrated years (cal B.P.).

A total of 17 samples from the Bayshore Geoprobes were submitted to Beta Analytic, Inc., in Coral Gables, Florida, for radiocarbon-dating analysis; these included 1 shell sample, 4 peat samples, and 12 samples of soil or organic sediments—some with small amounts of peat or shell. All of the radiocarbon dates obtained by this study are reported in calibrated years as determined by the radiocarbon lab (Beta Analytic, Inc.), while dates obtained by other studies were calibrated using the CALIB software program (version 4.3) developed by Stuiver and Reimer (1993). Additional information and the specific laboratory calibration methods used for the radiocarbon analysis of samples from the project area are provided in Appendix G (Radiocarbon).

## **FIELD AND LABORATORY FINDINGS**

This section describes the results and findings of the field and laboratory investigations. ASC employees conducted the geoarchaeological fieldwork between 29 June 1999 and 1 May 2001. This work was performed in accordance with the RDTP (Mc Ilroy and Praetzellis 1997) and in response to initial coring results as requested by Caltrans. The laboratory work was conducted at the ASC between 1 July 1999 and 3 March 2004.

The subsurface deposits were described and radiocarbon-dated, which resulted in the identification of four major stratigraphic units and one minor unit. The age, nature, and extent of these units are described below, from oldest to youngest. The archaeological significance of the units is addressed in the Analysis and Interpretations section below.

## **Subsurface Stratigraphy**

### **Early to Middle Holocene Dunes**

Sand dunes were found in cores placed beneath Blocks 1, 3, 8, 9, and 10, at depths below surface that ranged from about 2.3 m (7.5 ft.) on Block 9 to about 10.6 m (34.7 ft.) on Block 1—generally at or below mean sea level (see Figure 3.1). These deposits consist of moderately consolidated sandy clay, which grades downward into weakly consolidated, well-sorted fine to medium sand. A well-developed soil profile, with A, B, and C horizons, marks the upper portion of the deposit. The A horizon is about 60- to 80-cm thick, exhibits a dark gray color (10YR 4/1) in the most shallow locations (Blocks 9 and 10) and a gleyed greenish gray color (5G 5/1) at deeper locations, where it is covered by bay or marsh deposits (Blocks 1, 3, 8), and contains numerous abandoned root and insect holes. The B horizon is about 80- to 160-cm thick, exhibits an olive-brown color (2.5Y 4/3), a moderate subangular blocky structure, and common clay films coating ped faces and bridging sand grains. The underlying C horizon consists of weakly consolidated, brown (7.5YR 4/3) sand that displays many iron-oxide mottles. In Block 9, these deposits formed part of the historic ground surface but were later covered by artificial fill deposits (Figure 3.1). The total thickness of this deposit was not determined because the lower boundary was not encountered in any of the cores. No prehistoric archaeological materials were identified in these deposits.

Soil samples collected from the buried A horizon of this deposit yielded radiocarbon dates of 6750, 6300, and 4210 cal B.P. (see Table 3.1 for date and sample details), indicating that the dunes are at least middle Holocene in age. These dates are considered the minimum age of the deposit because organic matter that accumulated not long before the deposit was buried likely dominates the soil samples. Differential burial likely explains the 2540-year difference between the oldest and youngest dates from this deposit—older surfaces were simply buried earlier than younger ones. As such, the dates do not reflect the maximum age of the deposit, but are most representative of the last major period of stability associated with different parts of the same dune surface.

The soils that formed in these dunes are similar to those described in the Colma formation, which is generally thought to be late Pleistocene-age elsewhere on the San Francisco peninsula (Schlocker 1974:84, 96). Indeed, the stratigraphic position of these dunes, which lie immediately below bay and marsh deposits, is identical to the Colma Formation as identified by Schlocker near the project area (see Figure 2.5); note that one of Schlocker's cores was located just north of the project area, at the intersection of Seventh and Harrison streets, between Blocks 3 and 4. Given the late Pleistocene age previously assigned to the Colma formation and the radiocarbon evidence generated by this study, these older dunes are conservatively estimated to be early to middle Holocene in age. It is probable, however, that these deposits were originally formed by a phase of dune activity that occurred prior to the Holocene.

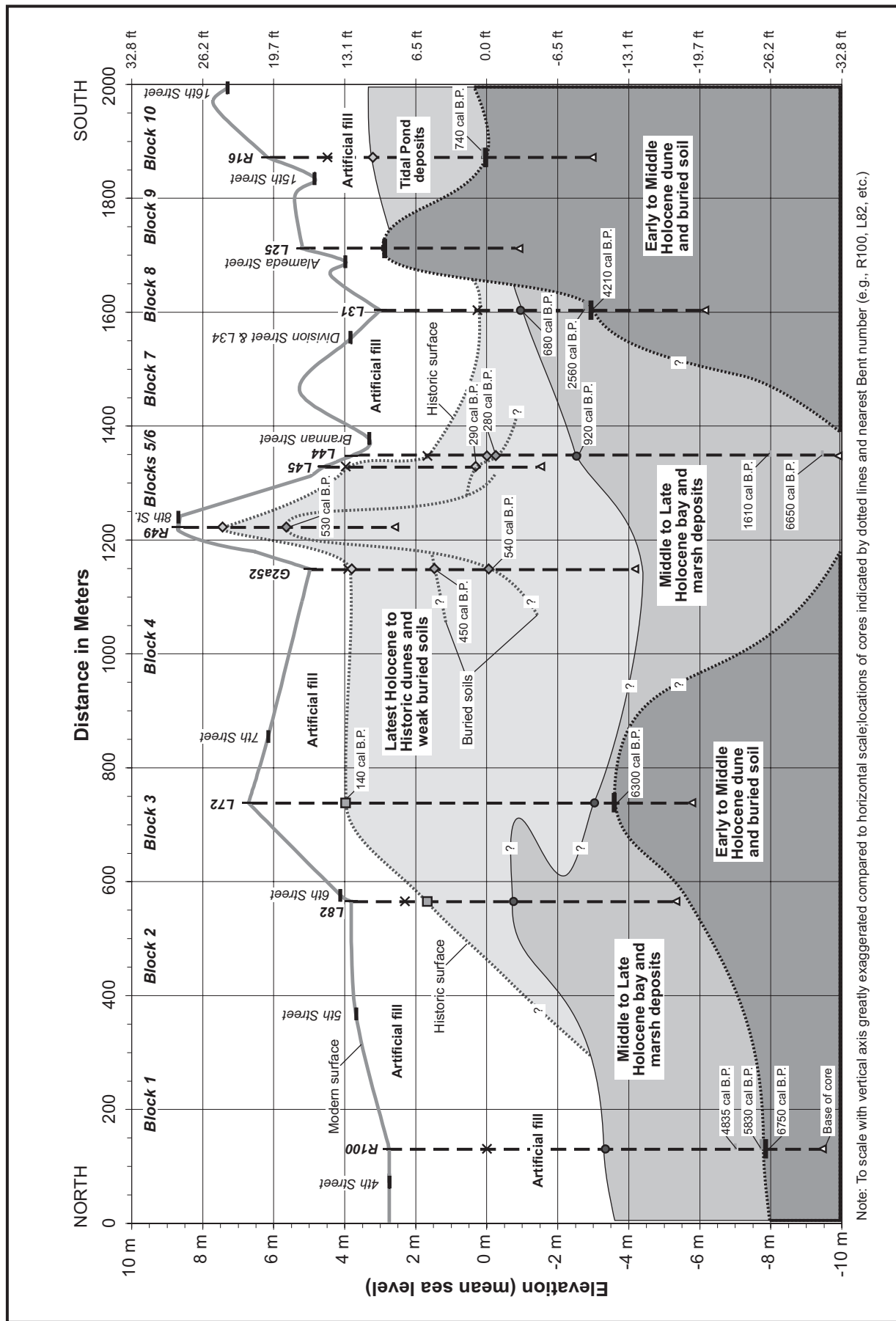


Figure 3.1. Generalized stratigraphic cross section of deposits beneath the SF-80 Bayshore Viaduct, San Francisco

**Table 3.1. Radiocarbon-Dating Results from SF-80 Bayshore Project  
(listed from oldest to youngest)**

Block, Bent No., Deposit, Soil Horizon	Material	Min. Depth (cm)	Max. Depth (cm)	<sup>14</sup> C B.P.	±	<sup>12</sup> C/ <sup>13</sup> C Ratio	Cal B.P.	Lab. No.
Block 1, Bent R100, buried soil, 5Ab	Soil (SOM*)	1060	1067	5940	120	-25.3	6750	Beta-189259
Block 6, Bent L44L, bay mud/clam shells, 5Cg	Organic sediment (w/shell)	1326	1326	5820	70	-24.1	6650	Beta-189269
Block 3, Bent L72C2, buried soil, 5Ab	Soil (SOM)	1030	1036	5530	50	-25.2	6300	Beta-189261
Block 1, Bent R100, peat on buried soil, 4Ob	Peat (bulk)	1050	1055	5050	60	-22.7	5830	Beta-189258
Block 1, Bent R100, bay mud, 3Cu2	Organic sediment	975	991	4250	70	-26.5	4835	Beta-189257
Block 8, Bent L31, buried soil, 5Ab	Soil (SOM)	594	610	3810	60	-25.2	4210	Beta-189272
Block 8, Bent L31, peat on buried soil, 4Ob	Peat (bulk)	579	585	2500	70	-22.2	2560	Beta-189271
Block 6, Bent L44L, clam shell in bay mud, 5Cg	Shell ( <i>Macoma</i> clam)	1180	1180	2270	40	2.3	1610**	Beta-189268
Block 6, Bent L44L, peat on bay mud, 5Ob	Soil (SOM w/peat)	634	655	970	50	-28.9	920	Beta-189267
Block 10, R16, peat on buried soil, 5Oab	Peat (bulk)	610	613	840	40	-26.0	740	Beta-189273
Block 8, Bent L31, peat on bay mud, 3Oab	Soil (SOM w/peat)	396	405	760	60	-26.1	680	Beta-189270
Block 4, Bent G2a52, buried dune soil, 5Ab	Soil (SOM)	502	518	530	40	-25.9	540	Beta-189262
Block 5, Bent R49C1, buried dune soil, 3Ab	Soil (SOM)	304	335	520	40	-25.9	530	Beta-189264
Block 4, Bent G2a52, buried dune soil, 4Ab	Soil (SOM)	350	366	360	40	-26.4	450	Beta-189263
Block 6, Bent L45L, buried dune soil, 3OAb	Soil (SOM w/peat)	426	457	240	50	-26.0	290	Beta-189265
Block 6, Bent L44L, buried dune soil, 4OAb	Peat (bulk)	411	442	200	60	-26.4	280	Beta-189266
Block 3, Bent L72C2, buried dune soil, 3Ab	Soil (SOM)	274	283	150	40	-25.6	140	Beta-189260

Note: \*SOM is soil organic matter; \*\*marine correction factor of minus 220 years applied to the *Macoma* clam sample (Beta-189268)

### **Middle to Late Holocene Bay and Marsh Deposits**

Bay and marsh deposits were found in cores placed beneath Blocks 1, 2, 3, 6, and 8, at depths below surface that ranged from about 3.0 m (10 ft.) on Block 2 to about 6.4 m (21 ft.) on Block 6—all below mean sea level (Figure 3.1). These deposits consist of weakly consolidated silty to sandy clay that lacks indications of near-surface weathering and soil development. The upper portion of the deposit is sometimes marked by an O horizon that consists of a thin layer (<30 cm) of peat or peaty clay, which displays a very dark-brown color (10YR 3/3). The central part of the deposit exhibits a gleyed greenish gray (5G 5/1) or bluish gray (5B 5/1) color, and occasionally contains a few marine shells or concentrations of carbonized plant remains. At a few locations, a very thin (<10 cm) O horizon is present at the base of the deposit, which consists of a very dark-brown (10YR 3/3) peat or peaty clay. Thus, these deposits were formed within bay or marsh environments created as sea levels rose into the area. The thickness of the deposit ranged from only about 60 cm near Bent L72 in Block 3, to more than 7.5 m near Bent L44 in Block 6, where the lower boundary was not penetrated (Figure 3.1). No prehistoric archaeological materials were identified in these deposits.

Samples of peat, shell, and organic sediments collected from this deposit produced radiocarbon dates that range from 6650 to 680 cal B.P. (Table 3.1), indicating they are middle Holocene to late Holocene in age. These dates are considered to be relatively accurate, because they reflect the age of organic materials that accumulated during the formation and progressive growth of the bay and marsh environments. The oldest date (6650 cal B.P.) was obtained on organic sediment that contained a thin layer (<5 cm) of small, unidentified clamshells from the lower part of the deposit. Dates of 5830 and 2560 cal B.P. were obtained from a thin layer (<5 cm) of peat at the base of the deposit. The middle part of the deposit yielded a date of 4835 cal B.P. on organic sediment with carbonized plant remains, and a date of 1610 cal B.P. on a *Macoma* clamshell contained within bay mud. Dates of 920 and 680 cal B.P. were obtained from peat layers located at the top of the deposit. Together this suite of dates records the arrival, development, and subsequent burial of the bay and marsh at various locations within the project area.

These deposits are the same as those described elsewhere in the area as Bay Mud (Schlocker 1974:83-84). The stratigraphic position of these deposits, above the Colma formation and below dune sand and artificial fill, is identical with the Bay Mud deposits identified by Schlocker near the project area (Figure 2.5). In addition, Bay Mud was identified as filling a basin beneath Blocks 5 through 7, which is likely the same Bay Mud-filled basin identified below Tenth and Harrison streets by Schlocker. The age and distribution of these deposits indicates that the bay had reached and extended inland beyond the project area more than 6,600 years ago, and remained a constant feature of the area up to the historic period.

### **Latest Holocene to Historic Dunes**

Younger sand dunes were consistently found to underlie artificial fill deposits in cores placed beneath Blocks 2, 3, 4, 5, 6, and 8, at depths below surface that ranged from about 1.2 m (4 ft.) on Block 4 to about 4 m (13 ft.) on Block 8 (Figure 3.1). These deposits consist of a very weakly consolidated sandy loam, which grades downward into loose, well-sorted fine to medium sand. The upper portion of the deposit is marked in most

places by a weakly developed soil profile with A and C horizons, but the A horizon was truncated at some locations within Blocks 4 and 5 by artificial cutting. Localized disturbances include the excavation of numerous wells, privies, and foundations, though none of these were identified within any of the cores. Additional weakly developed A horizons were found to occur within the dunes beneath Blocks 4, 5, and 6. These A horizons range from about 10- to 35-cm thick, exhibit a dark-gray (5Y 4/1) or olive-gray (5Y 5/2) color, and contain common abandoned roots or root holes. The underlying C horizon consists of loose sand that displays a light-yellowish brown (10YR 4/3) to light-olive-brown (2.5Y 6/3) color, with a few iron-oxide mottles. Thinly bedded layers (<1 cm) of well-sorted and stratified sand and organic materials were observed in a few of the C horizons (e.g., Bent R49 on Block 5). The total thickness of this deposit ranged from about 1.8 m (6 ft.) at Bent L31 in Block 8 to at least 7.7 m (25 ft.) at Bent G2a52 in Block 4, though it is more than 11 m (36 ft.) thick at Bent R49 in Block 5 (Figure 3.1). No prehistoric archaeological materials were identified in these deposits.

Soil samples collected from the buried A horizons of this deposit yielded radiocarbon dates ranging from 140 to 540 cal B.P. (Table 3.1), indicating that the dunes are latest Holocene in age. These dates are considered to be relatively accurate, because they reflect the age of organic materials that accumulated during successive and relatively brief periods of dune formation. A date of 140 cal B.P. was obtained from soil formed in the upper part of the deposit (3Ab), which confirms that it represents the former historic land surface. The first buried A horizon (3Ab or 3OAb) within the dunes yielded dates of 290, 450, and 530 cal B.P., while the second buried A horizon (4Ab or 5Ab) dates of 280 and 540 cal B.P. Based on the dates obtained from bay and marsh deposits that lie immediately under the dunes in Blocks 6 and 8 (Figure 3.1), it appears that these dunes were deposited sometime after 920 to 680 cal B.P. Therefore, the minimum and maximum ages of these dunes are constrained by this suite of dates as being latest Holocene to Historic.

These radiocarbon dates indicate that the dunes in the project area are at least 1,000 years younger than the dunes between Market and Mission streets, which contained buried archaeological sites (CA-SFR-112, -113, and 114). The ages and distribution of the buried dune soils suggests that a relatively stable dune ridge had formed near the intersection of Eighth and Bryant streets more than 500 years ago, and that younger dunes formed and stabilized on either side of this ridge about 450 to 300 years ago (Figure 3.1). The older dune ridge and the younger dunes were buried by a final phase of dune activity that occurred sometime between about 300 and 150 years ago. It appears that this youngest dune was primarily deposited along the northeast side of the older dune ridge in Blocks 2, 3, and 4 (Figure 3.1), resulting in the formation of the dune ridge depicted in the earliest Coast Survey map (Figure 4.1). Thus, it appears that the eastward migration of sand formed these dunes during the latest Holocene to Historic period — making them relatively youthful landscape features.

### **Latest Holocene to Historic Tidal Pond**

Tidal floodplain deposits were found in a core at Bent 16 beneath Block 10, at a depth of about 2.9 to 6.1 m (9.8 to 20 ft.), or about 3.3 to 0.1 m (10.8 to 0.3 ft) above mean sea level (Figure 3.1). The upper part of this deposit consisted of weakly consolidated brown (10YR 4/3) loam that graded downward into gleyed gray (Gley N5/) silty clay

near the base. Except for a weakly developed A horizon in the upper 20 cm, the deposit lacked indications of near-surface weathering and soil development. A 10-cm-thick layer of bone fragments was identified in the deposit at a depth of about 4.4 m (14.4 ft.), but examinations revealed saw-cut marks on a few of the bones. Carbonized peat remains were common in the lower part of the deposit. A thin (<10 cm) layer of very dark-brown (10YR 3/3) peat (5Ob horizon) underlies the deposit, which is in turn underlain by early to middle Holocene-age dunes at this location (Figure 3.1). No prehistoric archaeological materials were identified in this deposit.

The peat layer produced a radiocarbon date of 740 cal B.P. (Table 3.1), confirming that the overlying floodplain is latest Holocene in age, while the saw-cut bones indicate that the upper portion of the deposit accumulated during the Historic period. The early Coast Survey maps show that this part of Block 10 was part of a small tidal floodplain that was situated along the western edge of Mission Bay near the base of Potrero Hill (Figures 4.1 and 4.2). By 1899 a small pond occupied the northeast corner of Block 10, as shown on the Sanborn Map (Figure 5.16). It is possible that the concentration of bone fragments in these deposits originated from the former “Soap Works” that was located adjacent to the pond in the northwest corner of Block 10, though this association cannot be demonstrated. As such, the deposit is a relatively localized and minor stratigraphic unit within the project area.

### **Artificial Fill Deposits**

Deposits of artificial fill were found in the upper part of each core placed within the project area. The depth (thickness) of the fill ranged from about 0.6 m (2 ft.) at Bent L45 in Block 6 to about 6.1 m (20 ft.) at Bent R100 on Block 1 (see Figure 3.1). These deposits consist of loose sand and one or more layers of modern construction debris and/or historic materials and structural remains. In Blocks 1 and 2, these deposits were dominated by relatively clean sand that appears to have been used as fill within that part of Mission Bay. On the remaining blocks, the fill in the upper 1 to 3 m (3– to 10–ft.) was dominated by sand and modern construction debris, while the fill in the lower 1 to 2 m (3– to 6–ft.) contained a mixture of sand and disturbed historic remains, including charred debris that is likely derived from the 1906 earthquake and fire. As such, it appears that deposits of artificial fill now cover every natural (i.e., Historic) surface in the project corridor. No prehistoric archaeological materials were identified in these deposits.

### **Analysis and Interpretations**

The sequence of stratigraphic units outlined above provides information about the nature, timing, and extent of paleoenvironmental and landscape changes within the SF-80 Bayshore Project area. This section provides a brief comparative analysis of the stratigraphic and radiocarbon evidence obtained from the project area, with similar evidence from the surrounding Bay Area. The analysis focuses on the paleoenvironmental and archaeological significance of the evidence, particularly as it relates to the research issues outlined above in *Chapter 2*.

During the middle Holocene, the project area experienced a prolonged period of land stability, as indicated by the presence of “older sand dunes” with well-developed buried soils. With sea levels 5 to 10 m (16.4 to 32.8 ft.) lower than today (Figure 3.2),

these dunes formed an undulating surface, with the high points near Alameda Street and between Sixth and Seventh streets; the channel of Mission Creek incised these dunes near Brannan Street (Figure 3.1). The age and elevation of these formerly stable land surfaces indicate that they were available for human use and occupation throughout the early Holocene and part of the middle Holocene (Figure 3.2). The middle Holocene-age radiocarbon dates obtained from these dune soils are similar to dates obtained from buried soils formed on older dunes beneath the Central Freeway (Figure 3.3), in the Mission Creek drainage west of the project area (Mc Ilroy, Meyer, and Praetzellis 2001). In the project area, the highest part of the older dune was exposed at the ground surface (Block 9 south of Alameda Street) until it was covered by artificial fill in the Historic period (Figure 3.1). While no archaeological materials were recovered, these older dunes are estimated to have a moderate to high potential to contain buried prehistoric archaeological remains.

Beginning in the middle Holocene (>6650 cal B.P.), rising sea levels inundated the lower parts of Mission Creek and the older dunes, which eventually led to their burial by bay and marsh deposits. By about 5,800 years ago, marsh and bay deposits were accumulating in the northern arm of Mission Bay, where Blocks 1 and 2 are located today. This arm of the bay extended all the way to the Civic Center at Market Street, where the BART skeleton was found (Henn, Jackson, and Schlocker 1972). The date of 5640 cal B.P. from the skeleton is

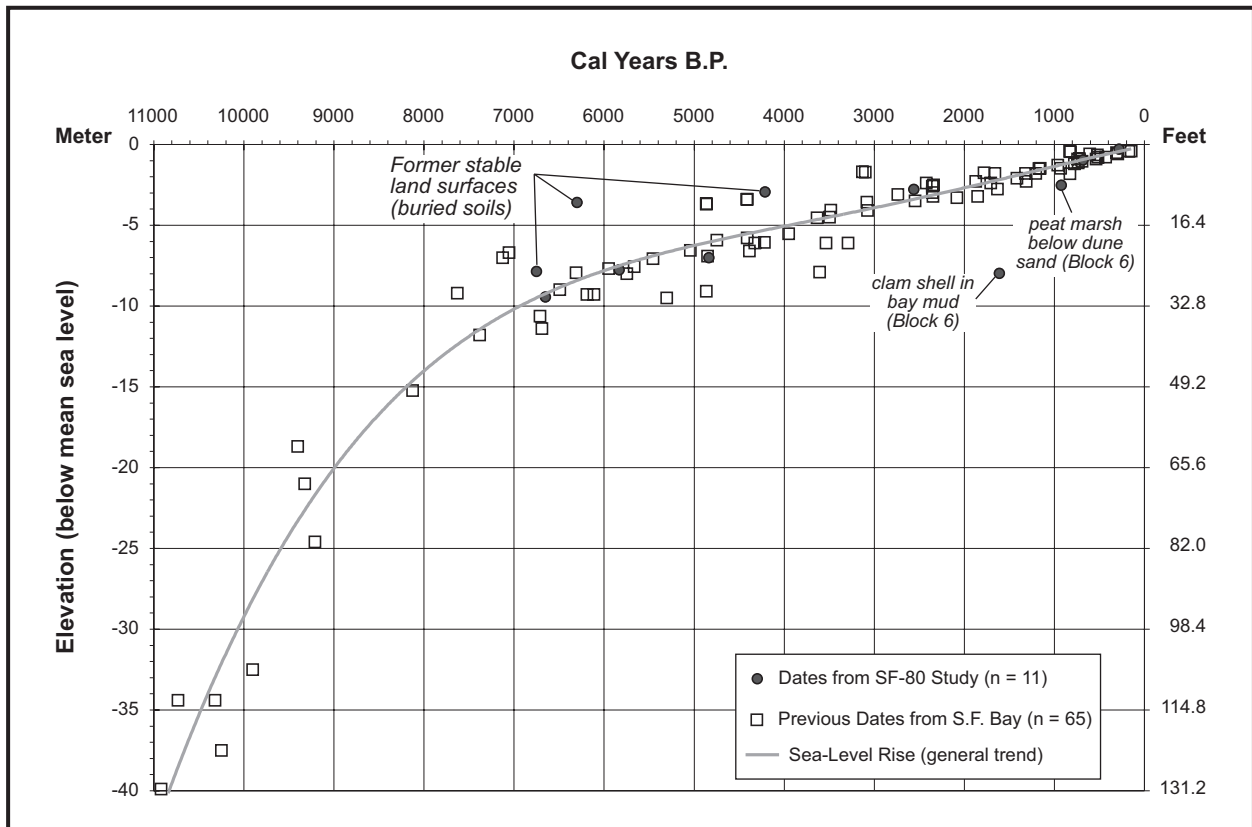


Figure 3.2. Radiocarbon dates from San Francisco Bay and the SF-80 Project, showing trend of Holocene sea-level rise

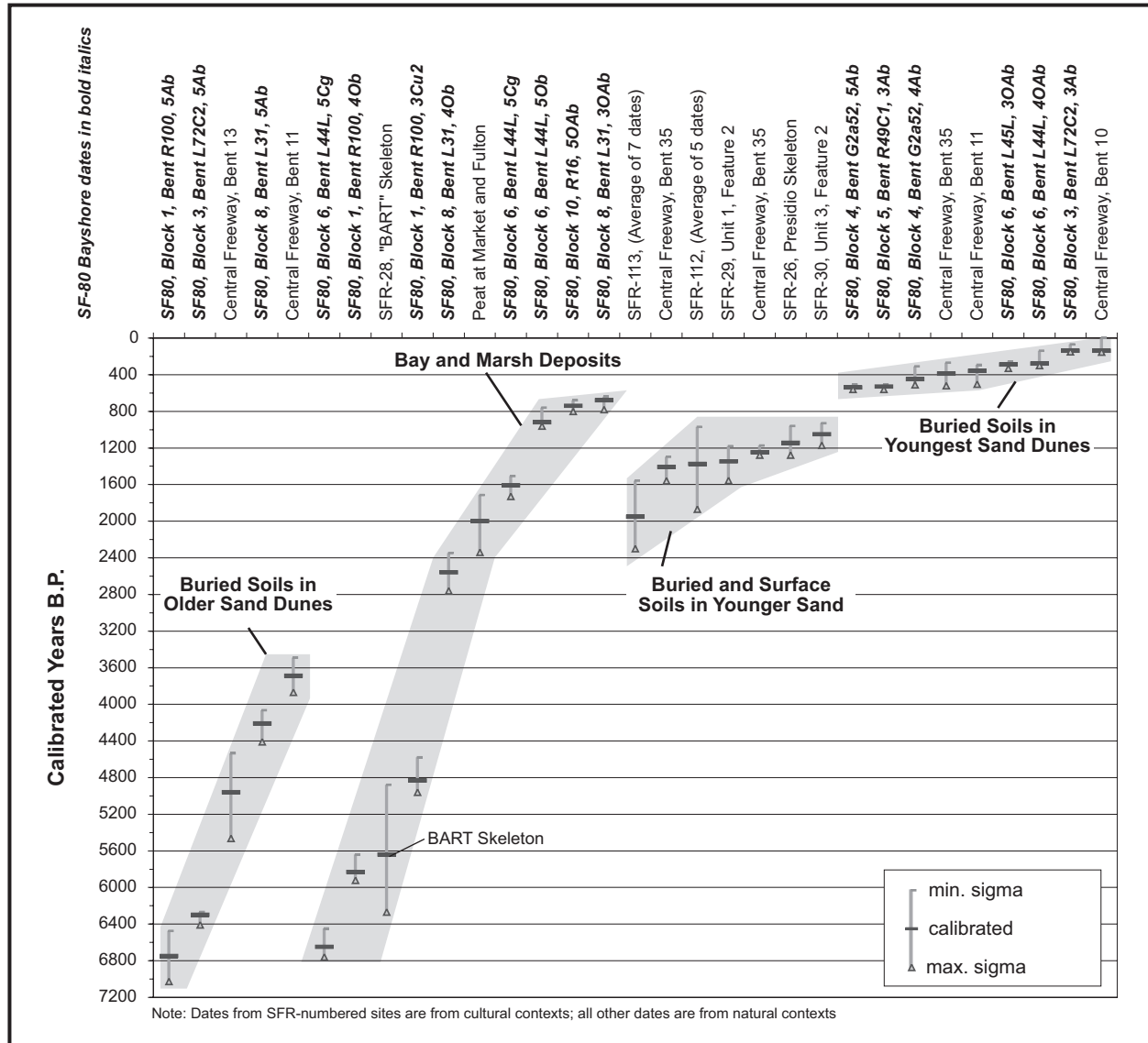


Figure 3.3. Radiocarbon dates from northern San Francisco peninsula contexts

bracketed by dates of 5830 and 4835 cal B.P. obtained from marsh and bay deposits in Block 1 of the project area, though there is significant overlap given the large sigma range for that date (Figure 3.3). It seems likely that during life of the BART individual, the older dunes would have formed much of the habitable landscape. As sea-level rise progressed more gradually, the higher portions of the older dunes were not buried until the late Holocene in the project area. The timing of these changes is demonstrated by the close correspondence between the age and elevation of bay and marsh deposits in the project area with those obtained from beneath San Francisco Bay (Figure 3.2). Except for unusual isolated discoveries like the BART skeleton, however, these deposits have very little potential to contain buried archaeological remains.

As noted above, radiocarbon dates from buried dune soils indicate that dunes on the northern San Francisco peninsula were relatively stable between about 6800 and

3600 cal B.P. (Figure 3.3). This stable period was interrupted by active dune migration around 2,000 years ago, based on a date from marsh deposits that underlie dune sand at Market and Fulton streets (Kelly, Spiker, and Meyer 1978). Dates from buried dune soils and archaeological deposits (SFR-112, -113) point to another period of dune stability between about 2000 and 1000 cal B.P., which are identified as the “younger sand dunes” in Figure 3.3. Given that no dunes of this age were identified in the project area, it appears that the eastward migration of the younger dunes may have been slowed by the presence of bay and marsh deposits to the west. Thus, Upper Archaic period archaeological materials are probably not present within the project area, except perhaps in those portions of Blocks 9 and 10 where the older dunes were not buried until the latest Holocene or Historic period.

During the latest Holocene, the dunes continued their migration east into Mission Bay, where they eventually reached and buried marsh deposits in the project area between about 920 and 680 cal B.P. Radiocarbon dates from buried soils formed in these “youngest dunes” indicate that portions of the dune had stabilized as early as 540 cal B.P. (Figure 3.3). The occurrence of multiple, thin, buried dune soils dating between 450 and 280 cal B.P. demonstrate, however, that the periods of stability were repeatedly interrupted by active dune migration and deposition in the project area. It appears that the last major episode of dune activity occurred sometime before about A.D. 1810, based on a radiocarbon date of 140 cal B.P. from a dune soil overlain by artificial fill deposits in Block 3 (Bent L72). The stratigraphic and radiocarbon evidence indicates that the youngest dunes were not available for human use until Phase 1 of the Emergent period. The unstable nature of the dunes, however, suggests that they would have been a rather unattractive location for prolonged human occupation. As such, the youngest dunes are estimated to have a low potential to contain buried prehistoric archaeological remains.

### **Prehistoric Research Themes, Questions, and Data Needs**

As noted in Chapter 2, the identification and recovery of certain types of data from the project area were required for addressing the most relevant research theme—Human Occupation and Landscape Evolution (Theme A). This section briefly compares the findings of the geoarchaeological study with the original research questions and data needs (*in italics below*), first described in the RDTP (Mc Ilroy and Praetzelis 1997) and noted above in Chapter 2.

**Question 1.** *Does the corridor contain, or have the potential to yield, buried land surfaces (paleosols) that were available for prehistoric human occupation, and are these land surfaces of sufficient vertical and horizontal extent to serve as stratigraphic markers and be searched for archaeological remains?*

This study determined that one or more formerly stable land surfaces exist beneath each of the blocks explored in the project corridor (Block 7 was not explored). The stratigraphic and radiocarbon evidence clearly indicates that these buried soils were variously available for human use or occupation during the most of the Holocene and Historic periods. One of these buried soils is associated with early to middle Holocene dunes that have extensive lateral continuity within the corridor. The widespread occurrence and consistent physical nature of this buried soil makes it a useful stratigraphic marker that can be targeted and searched for buried archaeological remains. The middle to late Holocene bay and marsh

deposits that occur beneath most of the project area are another distinctive stratigraphic marker, but they do not represent a formerly stable land surface. A series of buried dune soils dating to the latest Holocene (<540 cal B.P.) and Historic period (<140 cal A.D.) were also identified, but they are either too thin and/or horizontally discontinuous to be used as stratigraphic markers within the corridor. Therefore, the older dunes are the most significant stratigraphic marker recognized in the project area.

**Question 2.** *Does the corridor contain, or have the potential to yield, organics (in the form of charcoal, ash, bone, antler, soil humates, etc.) that may be radiocarbon-dated, or other chronometrically datable materials suitable for determining the age and depositional history of natural geological deposits?*

The project corridor was found to contain a variety of datable materials that included peat, marine shells, organic sediment, and soil humates. Seventeen radiocarbon dates, ranging from 6750 to 140 cal B.P. (Table 3.1), were obtained from the subsurface cores. The dates confirmed that the older dunes, bay and marsh deposits, and youngest dunes are all Holocene in age. The age and elevation of dates obtained from the bay and marsh deposits correspond with the general timing of sea-level rise within San Francisco Bay (Figure 3.2). One date of 1610 cal B.P. obtained from a single *Macoma* clam shell appears to represent an exception to this pattern, as it is located at a lower elevation than would be expected based on the rate of sea-level rise. It is possible that the date is in error, or that the shell may have been deposited within a deeper part of the bay that had not yet filled with sediments. Finally, the dates of 920 and 680 cal B.P. obtained from marsh deposits that lie immediately below the youngest dune deposits are important because they demonstrate that these dunes migrated eastward into Mission Bay after the initial formation of the bay itself. As such, the radiocarbon dating was crucial for understanding the timing and significance of the depositional sequence identified within the project area.

**Question 3.** *Does the corridor contain, or have the potential to yield, one or more landform–sediment assemblages that can be compared and correlated with other local or regional depositional sequences?*

The 6,800-year-old sequence of dunes separated by bay and marsh deposits identified in the project area can readily be compared and correlated with similar depositional sequences identified in other parts of the San Francisco Bay Area. For instance, the older dunes of this study were tentatively correlated with the Colma formation that is documented at numerous locations on the San Francisco peninsula (Schlocker 1974). These older dunes appear to correlate with the Merritt sand identified by Trask and Rolston (1951) in the eastern part of the Bay Area, and sand deposits identified by Treasher (1963) beneath San Francisco Bay (Atwater, Hedel, and Helley 1977:9). Radiocarbon dates of 8410 and 5390 cal B.P. have been obtained from buried soils located in areas mapped as Merritt sand in the city of Oakland (Meyer n.d.), which demonstrates that there was at least one phase of dune activity in the East Bay during the middle to late Holocene. The bay and marsh deposits identified by this study clearly correlate with the Bay Mud of Trask and Rolston (1951), the younger bay mud of Treasher (1963), and the estuarine deposits of Atwater, Hedel, and Helley (1977). The youngest dune deposits identified by this study are similar to those identified by Meyer (2001) near the intersection of Oak and Octavia streets (Block 10 of Central Freeway), of which there are likely many counterparts across the northern San Francisco

peninsula. As such, the landform–sediment assemblages in the project area are directly comparable with other deposits that are already recognized in San Francisco and in the surrounding region.

**Question 4.** *Does the corridor contain, or have the potential to yield, evidence that contributes to an understanding of the timing and extent of local or regional landscape evolution and the effects of these processes on the location, duration, and mode of prehistoric human land use?*

The findings indicate that the project area has undergone a series of significant Holocene landscape changes that would have resulted in the burial of any prehistoric archaeological deposits in the project corridor. The depositional sequence identified by this study indicates that progressive sea-level rise, successive dune migrations, and artificial fill deposits have buried the prehistoric land surfaces once available for human use. Thus, the geologic history of the project area has determined what portions of the archaeological record may have been buried.

With this understanding, the preservation potential for buried archaeological deposits can be estimated based on the age of a given landform and the duration of a cultural period. In most places, the older dunes have the potential to contain buried archaeological components that range in age from the Lower Archaic to the Upper Archaic periods, and may even contain older components. However, they have the potential to contain younger buried components in Blocks 9 and 10, where latest Holocene or Historic-age deposits cap them (Figure 3.1). The bay and marsh deposits, in turn, have a very low potential to contain buried components ranging from the Lower Archaic to the Emergent periods, though these would likely be unusual or isolated finds like the BART skeleton. The youngest dunes have a low potential to contain buried Emergent-period components, and appear to lack the potential to contain older components.

Because no prehistoric cultural materials were identified or recovered by this study, there are no data to address the other prehistoric research issues proposed by the RDTP. While no significant concentrations of buried prehistoric archaeological remains were identified, this does not mean that such deposits are not yet present in some of the unexplored portions of the study area (see below).

### **Research Conclusions and Recommendations**

The project area was found to contain the quantity and variety of data needed to address the important research issues of human occupation and landscape evolution. Together, the findings of this study demonstrate that the apparent absence of prehistoric sites in the project area is most easily explained by the timing and extent of landscape changes that have buried virtually all of the formerly stable prehistoric land surfaces. For these reasons, future archaeological studies should consider the potential effects of landscape evolution on the nature and completeness of the archaeological record on the northern San Francisco peninsula.

The stratigraphic framework developed by this study represents an archaeological sensitivity model that can be systematically tested by identifying and exploring landforms expected to contain buried soils (paleosols) in order to determine if archaeological deposits are also present. By adopting this framework, it will be possible to review and revise the sensitivity model to improve its accuracy in a given area or in the north San Francisco peninsula as a whole, and thereby overcome some of the biases imposed by landscape changes on the

archaeological record. By using the appropriate methods to explore potentially sensitive landforms for buried cultural remains, archaeologists and cultural resource managers can address the problem of buried sites and gaps in the archaeological record.

Because subsurface coring was conducted at only 27 widely spaced locations in the study area, it is still highly possible that buried prehistoric deposits are present in portions of the study area that were not or could not be explored. Furthermore, given that the cores themselves were less than 2 inches in diameter, it is also possible that one or more of these cores was placed within a portion of an archaeological site that simply did not contain any cultural remains, as is the case at many sites. The findings of this study, along with the well-demonstrated association between human settlement and water sources, supports the interpretation that the potential for buried archaeological deposits in the study area is high.

This is particularly true in those areas where the early to middle Holocene-age land surfaces were located within 1/2-mile of Mission Creek and/or the former Bay margin, which encompasses much if not all of the study area. It will not be possible to provide a more exact sense of where buried prehistoric sites may be found until (1) archaeologists have opportunities to further develop and refine models of human settlement patterns for the San Francisco Bay area, and (2) geoarchaeologists have opportunities to further identify and refine the timing and extent the landscape changes that have affected the nature and completeness of the Bay Area archaeological record (Rosenthal et al. 2003).

If further subsurface explorations are conducted in the project area, they should attempt to repeatedly target and search the buried soils associated with the older dunes in an effort to identify archaeological resources that are almost certainly associated with these deposits. Because most of these deposits are located at or below the present mean sea level, it will make such explorations difficult. This predictable constrain can generally be overcome by developing and implementing appropriate sampling techniques that are designed to create opportunities for archaeological discovery.

