CHAPTER 2
GEOARCHAEOLOGY: OVERVIEW AND RESEARCH CONTEXT

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GEOENVIRONMENTAL HISTORY

VALLEY TO BAY

This section describes the environmental history of the San Francisco Bay Area and the potential relationships between environmental changes, human settlements, and the archaeological record. The Bay Area has undergone a series of significant large-scale environmental changes since the late Pleistocene, when people may have first entered and inhabited the region. These changes included rising sea levels, widespread sediment deposition, and corresponding fluctuations in the distribution and availability of important natural resources. As a result, the archaeological record, and the potential for archaeological deposits in the SF-80 Bayshore Project area, is better understood when viewed within the history of Bay Area environmental and landscape changes.

During the last glacial maximum some 22,000 years ago, vast ice sheets covered the northern part of the continent, and the climate in central California was considerably cooler than at any time since. Worldwide sea levels were at least 100 meters (about 328 feet) lower than today, and the California coastline was located some 25 to 50 kilometers (about 15 to 30 miles) west of its current position (Atwater, Hedel, and Helley 1977; Bard et al. 1996). At that time, the combined runoff from the Sacramento and San Joaquin rivers merged to form the “California River” (Howard 1979), which passed through the Carquinez Straits and into the “Franciscan Valley” (Axelrod 1981), now occupied by San Francisco Bay. The smaller streams and rivers draining the Franciscan Valley also joined this massive drainage as it flowed west through the Golden Gate and across the continental shelf, where it eventually emptied into the Pacific Ocean near the modern-day Farallon Islands (Atwater, Hedel, and Helley 1977; Axelrod 1981). Thus, instead of a “bay,” there was a broad inland valley that supported grassland and riparian plant and animal communities.

As the continental ice sheets melted, the oceans of the world began to rise rapidly, which caused the Pacific shoreline to migrate eastward (Figure 2.1). Between 15,000 and 11,000 cal B.P. (calibrated years before present), sea levels rose about 55 m (180 ft.) worldwide, at an average rate of about 13 m (42.6 ft.) every 1,000 years (Bard et al. 1996)—enough to cover most of the continental shelf. The lowest portions of the Franciscan Valley and California River were flooded between 11,000 and 8000 cal B.P., as sea level rose about 25 m (82 ft.) at an average rate of about 8.3 m (27.2 ft.) every 1,000 years. As the waters continued to rise, freshwater marshes began to form and sediments carried by the California River accumulated on the floor of the Franciscan Valley—marking the transition from valley to bay.
Figure 2.1. Timing and extent of Holocene sea-level rise in the San Francisco Bay Area
Between 7000 and 6000 cal B.P., there was a dramatic decrease in the rate of sea-level rise worldwide (Stanley and Warne 1994). During this time, the sea inundated the Franciscan Valley at a more gradual rate of about 1.3 m (4.3 ft.) every 1,000 years, for a total of 8.0 m (26.2 ft.) over the past 6,000 years. This allowed sedimentation to keep pace with inundation, which permitted the formation of extensive tidal-marsh deposits during the middle Holocene (Atwater et al. 1979). As base levels rose, the lower reaches of the stream and river channels became choked with sediments that spilled onto the surface of existing fans and floodplains, forming large alluvial floodplains (Helley et al. 1979). As a result, bay and marsh deposits now cover many formerly stable Holocene-age land surfaces, such as those documented beneath Yerba Buena Cove (Lee and Praszer 1969:60-63), and the San Francisco–Oakland Bay Bridge (Atwater, Hedel, and Helley 1977:Plate 1; Louderback 1951:90; Treasher 1963:Figure 5). During the late Holocene, the Bay grew in size as marshlands expanded in response to higher sea levels and the decomposition, compaction, and subsidence of intertidal deposits. These processes resulted in the formation of large tidal mudflats and peat marshes, which further promoted the deposition of sediment around the margins of the Bay. Radiocarbon dates from southwestern San Francisco Bay (Palo Alto Marsh) indicate that these deposits were generally formed during the past 2,000 years (Atwater et al. 1979:349).

Several studies confirm that many of the late Pleistocene and early Holocene land surfaces located near the Bay were overlain by deposits of younger alluvium that are generally less than 6,000 years old (Borchardt 1992; Gmoser et al. 1999; Helley et al. 1979; Meyer 2000, 2001; Stewart, Meyer, and Newland 2002). Stratigraphic and radiocarbon evidence indicate that the Holocene-age alluvial deposits average 2 to 3 m in thickness, with deposits exceeding 10 m in a few areas. These older land surfaces usually exhibit well-developed buried soils (paleosols) that represent a significant stratigraphic boundary in the region (Figure 2.2). As a result, older archaeological sites located in and around the Bay were either submerged by sea-level rise and/or buried by sediment deposition.

Figure 2.2. Typical Bay Area landform-sediment assemblage. Note older buried land surface (Helley et al. 1979:Figure 19).
Isotopic analysis of shell suggests that salinity and discharge levels of the Bay have undergone substantial fluctuations over the past 6,000 years (Ingram and DePaolo 1993; Ingram, Ingle, and Conrad 1996a and 1996b; Wells 1995; Wells and Goman 1994). The mass extinction of large prehistoric oyster beds that flourished in southern San Francisco Bay between 1700 and 1850 cal B.P. indicates that significant changes did occur in the south Bay (Story, Wessels, and Wolfe 1966). Given the potential influence of large-scale environmental changes on the distribution and abundance of certain animal communities, it is likely that prehistoric human populations were forced to respond to periodic (perhaps critical?) shortfalls in the availability of species used for subsistence.

**SAND AND WIND**

Wind-blown sand dunes cover a large part of the San Francisco peninsula and portions of the project area. This vast dune field stretched eastward across the entire peninsula from Ocean Beach to the margins of the Bay (Figure 2.3), making it one of the four most extensive dune complexes on the California coast (Cooper 1967:42). In 1857 W.P. Blake keenly described the highly variable nature of the San Francisco dunes and the importance of wind, topography, and vegetation as factors of dune stability, observing that

Most of the hills in the city and its vicinity, where they were partly sheltered from the wind, are, or were, covered with a thick growth of dwarf trees and shrubs (chamisal), which prevented the wind from acting upon their surfaces and removing the sand. The progress of such hills is not uniform and constant, for, under certain circumstances, they remain stationary for long periods. Whenever the vegetation is removed, or a cutting is made, and the wind is allowed to act upon the surface, or to strike a hill in a new direction, the motion of the sand is rapid, and a large hill is soon carried away and piles up in a protected place, where the sand remains, secure from further violent action [1857:160-161].

Towards the Mission the sand hills are an important feature of the place, being high and steep, and covered in most places by a low growth of vegetation, principally shrubs and evergreen and dwarf oaks . . . [1857:145].

In the 1860s Golden Gate Park was established within an active part of this dune field that was not stabilized by vegetation until the 1880s (Amundson and Tremback 1989:1798). These historic accounts illustrate the relatively mobile nature of these transient landforms, which are largely the result of variations in wind, topography, vegetation, sediment supply, and sea level (Carter, Nordstrom, and Psuty 1990:4-5). The configuration of the San Francisco dunes indicates that they were formed by the prevailing westerly winds that transported loose sand from Ocean Beach across the nearly level and poorly vegetated topography to the east (Schlocker 1974:78-80). In their natural state, these dunes formed a series of transverse-ridges that were characterized by narrow, almost linear dune crests and wide interdune troughs. As Blake noted, the dunes are generally thicker on the eastern or leeward side of prominent bedrock hills and ridges on the
Figure 2.3. Extent of the dune field on northern San Francisco peninsula
peninsula, because they are better protected from the winds in these areas (Schlocker 1974:78-80).

Although the occurrence and extent of the dune fields in San Francisco are well-documented, the age and evolution of these dunes are only partly understood. In his study of dunes along the California, Oregon, and Washington coasts, Cooper (1967) identified two major episodes of dune formation during the Holocene, which he correlated with significant sea-level changes. Cooper suggested that dunes on the east side of the San Francisco peninsula are older than the dunes on the west side, based on the observation that older dunes are generally located farther inland than younger dune along the Pacific coast. At Morro Bay in San Luis Obispo County, however, younger dunes were found to be located farther inland than older dunes because the younger dunes were formed from destabilized older dunes (Orme 1990). At least two phases of dune development are indicated in the San Francisco dunes by “two sections of dune sand separated by bay mud and clay” in the Market Street area east of the Civic Center (Schlocker 1974:80). A radiocarbon date obtained from the bay mud at that location indicates that the overlying dune sands are less than 2000 cal B.P. In the same general area, a buried soil of unknown age was exposed in dune sand during the excavation for Brooks Hall at the Civic Center (Schlocker 1974:Figure 52). Radiocarbon dates of 2085 to 1155 cal B.P. from archaeological sites (SFR-112 and -113) buried in the dunes demonstrate that the San Francisco dune complex was still actively forming during the latter part of the late Holocene (Henn and Schenk 1970:6). It is also possible that some phases of dune activity are associated with widespread dev egetation resulting from fires set either deliberately or accidentally as a result of increased human settlement over the past 2,000 years (Orme 1990:328). As such, it appears that the dunes within the project area have the potential to contain buried archaeological deposits.

HISTORIC CHANGES AND SUMMARY

More recent changes on the northern peninsula include the appearance of introduced (non-native) plant species, which generally coincides with the arrival of the Spanish and other Euroamerican settlers during the 1700s and 1800s (Reidy 2001; West 1989). An intense drought during the late 1800s reduced the vegetation cover and made the landscape susceptible to erosion (Burcham 1982:171), as did many of the activities associated with historic settlement. Hydraulic-mining activities in the Sierra Nevada increased the amount of sediment deposited within the Bay (Gilbert 1917). Lasting evidence of these changes is found in estuarine deposits (Mudie and Byrne 1980) and seen along many stream channels, where the lowest terraces are often composed of historic-age sediments (Knudsen et al. 2000). Finally, thick deposits of artificial fill were placed around the margins of the Bay to reclaim the marshes and wetlands for human development (Lee and Praszker 1969), including parts of Mission Bay within the project area (Schlocker 1974:Plate 1). While some archaeological resources may have been partially or completely destroyed by historic development, others were obviously buried by artificial fill.

This brief overview illustrates that large-scale environmental changes played a major role in the evolution of the Bay Area landscape over the past 15,000 years. Many of these
changes undoubtedly affected the distribution of human populations and buried and/or submerged large segments of the landscape that were once available for human use and occupation, particularly those that are middle Holocene-age and older. Thus, the relatively incomplete nature of the Bay Area archaeological record is almost certainly related to the sequence of changes that led to the formation of the current landscape. Additional evidence related to landscape changes and buried archaeological sites is explored in the following section.

**BAY AREA PREHISTORY AND ARCHAEOLOGY**

This brief overview of human prehistory on the northern San Francisco peninsula emphasizes the effects of Holocene landscape evolution and the potential for buried archaeological deposits. A more detailed overview of ethnographic studies, chronology/taxonomy, early archaeological studies, radiocarbon evidence, and modern archaeological studies is provided in the SF-80 Bayshore Project’s research design and treatment plan (RDT; Mc Ilroy and Praetzelis 1997:18-46).

The prehistory of the San Francisco Bay Area has been the subject of archaeological inquiry for more than a century. Despite the number of archaeological studies that have been conducted in the area, relatively little is known about the prehistory of the northern San Francisco peninsula. This can be attributed partly to the extensive amount of development on the San Francisco peninsula, and to the relatively recent and widespread processes responsible for the formation of the surrounding landscape. Both factors have reduced the visibility of prehistoric sites and hampered archaeological identification and sampling efforts.

A series of rather obvious shell mounds along the eastern shore of the San Francisco Bay caught the attention of the public and archaeological investigators around the turn of the 19th century. It was apparent even then that the number of shell mounds in the San Francisco Bay Area “certainly falls short . . . of the number that originally existed” (Nelson 1909:322). Except for the investigations of the Bayshore Mound (CA-SFR-7) by Nelson in 1910, and of CA-SFR-6 by Loud in 1912, prehistoric sites on northern San Francisco peninsula received little attention from early scholars. This was due in part to the rapid destruction and/or burial of many sites as a result of early Euroamerican settlement and urbanization of the northern peninsula.

At least 33 prehistoric archaeological sites have been recorded on the northern San Francisco peninsula; most are located in sheltered coves or near streams within 1/2 mile or less from the historic margins of San Francisco Bay. Important archaeological excavations have been conducted at several of these sites that resulted in the identification of a wide variety of cultural materials, residential features, and/or human remains (e.g., Baker, Horvath, and Carlson 1978a; Holman et al. 1977; Moratto and Hegler 1972; Pastron 1990; Pastron and Walsh 1988a, 1988b, 1988c). Five prehistoric sites (SFR-2, -28, -112, -113, and -114) have been recorded within 1 mile of the Bayshore Project corridor, with SFR-2 being located about one block northeast of the APE (Figure 2.4). In addition, the Ramaytush Costanoan villages of *Amuctac, Chutchui, Petlenuc, Stilintac, Tubsinte,* and
Figure 2.4. Location of prehistoric archaeological sites within 1 mile of the SF-80 Bayside Project corridor
Figure 2.5. Known archaeological sites in relation to geologic landform deposits along a transect near the northwestern side of the corridor
Yelamu were located within 2 miles or less miles of the project area, although their exact locations remain uncertain (Milliken 1983:72-74, Map 4). Thus it is clear that creeks (e.g., Mission Creek) and the San Francisco Bay margins attracted prehistoric people as favorable locations for human settlement and subsistence.

Except for SFR-2, each of these sites was “discovered” during construction projects over the past 35 years or so. Four of these sites appear to represent permanent or semi-permanent residential locales that contain diverse artifacts, midden debris, intact features, and/or human burials. All of these sites were found to occur at depths of 2 m (6 ft.) or more below the modern ground surface. Four of the sites (SFR-2, -112, -113, and -114) are known to be associated with dune sand, as shown in Figure 2.5. Site SFR-28 consisted of an isolated human skeleton (“BART Man”) that was overlain by about 14 m (45 ft) of “Bay Mud.” and about 9 m (30 ft) of historic artificial fill (Henn, Jackson, and Schlocker 1972; Henn and Schenk 1970); additional information about several of the excavated sites on the peninsula is provided in Table 2.1. The age and distribution of these sites indicates that people were present more than 5,000 years ago and that long-term occupation sites were established less than 1 mile from the project corridor as early as 2,000 years ago. Additional unidentified prehistoric sites are almost certainly associated with dunes or other landforms that have been buried by natural geologic processes near the margins of San Francisco Bay, such as those that have occurred within the project area.

Previous researchers have recognized that large-scale geological processes have likely buried, destroyed, or submerged many older archaeological sites in the Bay Area (Atwater 1979; Banks, Orlins, and McCarthy 1984; Bickel 1978a, Louderback 1951:87). Indeed, the recent discovery of several buried archaeological deposits around the margins of the Bay suggests this is likely the case (Gmoser 1998; Gmoser et al. 1999; Meyer 2000; Tiley 2001). A radiocarbon date of 9430 cal B.P. recently obtained from buried archaeological deposits at site CA-SCL-178 (Blood Alley) near San Jose confirms that people used and/or occupied the Bay Area during the early Holocene (Fitzgerald and Porcasi 2003). Given the timing and extent of sea-level rise during the Holocene, prehistoric populations likely shifted occupation sites in response to the advancing sea, which suggests that older archaeological sites may be associated with landforms that are submerged below present sea level (Bickel 1978a). An analysis of radiocarbon dates from Bay Area natural and cultural contexts indicates that most early and middle Holocene-age archaeological sites and land surfaces (paleosols) have been buried by sediment deposition (Meyer 1998:26). This is even true for many late Holocene-age sites and paleosols, particularly those located near the margins of San Francisco Bay Taken together, this evidence suggests that the apparent lack of older archaeological sites is not an accurate reflection of human occupation, but instead reflects the large-scale environmental changes that reduced the visibility and accessibility of these sites in the Bay Area (Rosenthal et al. 2003). For these reasons, this geoarchaeological study was primarily designed to identify prehistoric archaeological sites that may be buried within the project area.
Table 2.1. Excavated Archaeological Sites on the Northern San Francisco Peninsula

<table>
<thead>
<tr>
<th>Site Designation</th>
<th>Depth (cm)</th>
<th>Material Remains</th>
<th>Cal Years B.P.</th>
<th>Obsidian Hydration</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA-SFR-2*</td>
<td>180-300</td>
<td>Shell, bone, cooking stones, bifaces, bowl mortars, human burials</td>
<td>-</td>
<td>-</td>
<td>Gifford 1929; Rudo 1982</td>
</tr>
<tr>
<td>(Nelson No. 439)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA-SFR-5, -21, 24 (Sutro Baths)</td>
<td>?</td>
<td>Shell, bone, chert &amp; obsidian flaked stone, heat-altered rocks</td>
<td>-</td>
<td>-</td>
<td>Holman et al. 1977</td>
</tr>
<tr>
<td>CA-SFR-6 (Presidio)</td>
<td>180-300</td>
<td>Mica ornaments</td>
<td>-</td>
<td>-</td>
<td>Voy 1872 (in Rudo 1982)</td>
</tr>
<tr>
<td>CA-SFR-6 (Presidio)</td>
<td>15</td>
<td>Modified bone</td>
<td>-</td>
<td>-</td>
<td>Loud 1912a, 1912b</td>
</tr>
<tr>
<td>CA-SFR-7 (Nelson No. 387)</td>
<td>60</td>
<td>Shell, bone, groundstone, hearths, human burials</td>
<td>-</td>
<td>-</td>
<td>Nelson 1911</td>
</tr>
<tr>
<td>CA-SFR-23 (Hyde/Beach St.)</td>
<td>Cutbank</td>
<td>Human burial</td>
<td>-</td>
<td>-</td>
<td>Alta California 1861 (Rudo 1982:11-12)</td>
</tr>
<tr>
<td>CA-SFR-26 (Presidio)</td>
<td>190-250</td>
<td>Human burial, cut/polished bird bone</td>
<td>1145</td>
<td>-</td>
<td>Moratto and Heglar 1972</td>
</tr>
<tr>
<td>CA-SFR-28* (Civic Center/BART)</td>
<td>2300</td>
<td>Human burial</td>
<td>5640</td>
<td>-</td>
<td>Henn and Schenk 1970</td>
</tr>
<tr>
<td>CA-SFR-29, -30, -31 (Fort Mason)</td>
<td>50-80</td>
<td>Beads, hearth, obsidian, flaked stone, heat-altered rocks</td>
<td>1050, 1350</td>
<td>-</td>
<td>Baker 1978; Baker, Horvarth, and Carlson 1978a-c</td>
</tr>
<tr>
<td>CA-SFR-112* (Stevenson Street)</td>
<td>510-580</td>
<td>Beads, bone, modified bone, shell, flaked stone, milling tools, charmstones</td>
<td>1155-1645</td>
<td>1.6-3.6 µ NV</td>
<td>Pastron and Walsh 1988a</td>
</tr>
<tr>
<td>CA-SFR-113* (Emporium Street)</td>
<td>290-520</td>
<td>Bone tools, flaked stone, groundstone</td>
<td>1910-2085</td>
<td>2.4-4.5, 7.3 µ NV</td>
<td>Pastron and Walsh 1988b</td>
</tr>
<tr>
<td>CA-SFR-114* (Howard Street)</td>
<td>300-630</td>
<td>Bone tools, obsidian bifaces, features, shell beads &amp; ornaments, human burials</td>
<td>-</td>
<td>-</td>
<td>Pastron 1990; Walsh 1986</td>
</tr>
</tbody>
</table>

* Sites within 1 mile of the project corridor
RESEARCH FRAMEWORK

Research Orientation

As noted in the Geoenvironmental History section above, the Bay Area landscape is composed of different deposits, soils, and landforms that were formed at different times and/or by different processes. Soil formation is a by-product of sustained or prolonged land stability. The degree of soil formation is directly related to the amount of time a landform has been stable and subject to near-surface weathering processes. In this regard, landforms with well-developed soils have been stable and available for human use or occupation longer than those with weakly or moderately developed soils. Conversely, landscape instability is evidenced by erosional unconformities or by a lack of soil formation, which indicates relatively rapid deposition. Because soils are formed during sustained periods of land stability, archaeological materials are most often associated with soils, whether they are buried or at the surface. Since archaeological evidence of past human alteration and/or occupation of a landscape is subject to the same processes that affect the preservation, distribution, and visibility of geological deposits (Bettis 1992:119), the nature and timing of landscape evolution ultimately determines whether soils and archaeological remains will be buried, destroyed, or redeposited (Kuehn 1993; Waters 1992).

Most Pleistocene-age landforms have little potential to contain buried archaeological remains because they formed prior to the arrival of humans in North America. Conversely, most Holocene-age landforms have some potential to contain buried remains because they either formed during or after people first occupied the region. The occurrence of buried soils in Holocene-age alluvial and colluvial landforms is significant because they represent formerly stable ground surfaces that were available for human use and occupation in the past. Regional evidence discussed in the previous section indicates there is a strong correlation between Holocene-age landforms, buried soils, and buried archaeological remains.

Although it has long been known that natural processes have buried many archaeological sites in California (Heizer 1949:39-40, 1950, 1952:9; Moratto 1984:214), archaeological visibility has not been treated as a significant archaeological problem in the same way it has in other parts of North America (Meyer 2000). The biases imposed by landscape evolution have only been exacerbated over the last 25 years as research in central California has gradually shifted toward techno-economic concerns related to resource optimization and intensification, and away from culture-historical issues and the search for antecedent archaeological assemblages (Rosenthal et al. 2003:8). Theoretical models emphasizing population-resource imbalances usually assert that economic and sociopolitical development in prehistoric central California was ultimately driven by changes in human population density and resource availability (Bagsall 1987; Bouey 1987; Broughton 1994a, 1994b; Jones 1992). In the context of these current models, the abundance of late Holocene archaeological sites in this region has frequently been considered prima facie evidence for human population growth (Bagsall 1987:43; Beaton 1991; Broughton 1994a, 1994b; Glassow 1999; Hildebrandt 1983, 1997; Jones 1992; Schulz 1981:181-188).
While it is reasonable to assume that late Holocene populations were greater than those of preceding periods, it is not clear whether the relative paucity of middle and early Holocene archaeological sites indicates that human populations were substantially lower or that it reflects a sampling bias related to landscape changes. If natural geological processes have shaped the archaeological record in a manner that is consistent with prevailing assumptions about late Holocene human population growth, then it is inappropriate to use site frequencies in support of demographic-driven theoretical models (Rosenthal et al. 2003:8). Without a systematic consideration of the ways in which landscape changes may have affected the preservation, accessibility, and representativeness of the full range of archaeological deposits (e.g., up to 14,000 years old), it is premature to assume that the frequency and distribution of sites is necessarily a true reflection of prehistoric demographic and settlement/subsistence patterns, especially for earlier time periods. Thus, the lack of geoarchaeological studies is an ongoing problem for researchers seeking to understand the relationship between regional site-distribution patterns and demographic and settlement—subsistence changes in central California (Meyer and Rosenthal 1997; Rosenthal et al. 2003).

At the same time, the potential for buried archaeological sites is a practical problem for resource managers who must ensure that previously unknown sites are identified and that potentially important archaeological resources are not inadvertently affected by project activities. This can be a problem in any area where archaeological sites may have been buried or obscured by natural sediments and/or deposits of artificial fill, such as found within the project area. Consequently, buried sites are most often discovered after they are inadvertently exposed by natural erosion or mechanical earthmoving, and only rarely are they intentionally found as a result of conventional archaeological surveys. The discovery and analysis of buried archaeological sites, particularly those from early time periods, is crucial for archaeological inquiry because without new or comparative data, important questions regarding chronology, settlement, and subsistence change cannot be properly addressed or answered, and many existing research questions cannot be confirmed, denied, or refined beyond the present understanding. It is critical that a reasonable and good-faith effort be made to identify archaeological resources that may be buried within a given project area.

Research Themes, Questions, and Data Needs

The Research Themes presented in the SF-80 Bayshore Project RDTP include Human Occupation and Landscape Evolution, Culture Chronology, Culture History, Vertebrate Archaeofauna Variability, Invertebrate Archaeofauna Variability, Coastal Colonization Patterns, Resource Intensification and Adaptive Change, Interaction and Social Change, and Research Potential of Redeposited Sites (Mc Ilroy and Praetzellis 1997:32-47). Given the environmental setting and history of the project area, only the research questions related to Human Occupation and Landscape Evolution (Theme A) are reiterated here, as they are the most relevant for this study. Below are the specific research questions and data requirements related to this theme.

**Theme A. Human Occupation and Landscape Evolution**

One of the most difficult issues faced by archaeological investigations is the problem of locating sites that may be buried by natural depositional processes, such as those
documented in the San Francisco Bay Area. This problem is compounded in areas where sites may be covered by pavement, standing structures, or artificial fill deposits, such as occurs in many portions of the project area. Identifying previously unknown sites is critical, as noted above, in order to avoid project-related impacts, as well as to advance knowledge regarding the archaeological record.

Several significant research issues have emerged from considering the prehistoric archaeological sites in the project area and vicinity as rich repositories of geomorphologic and paleoenvironmental information. For example, it is notable that all of the archaeological deposits were buried beneath sterile dune sands and rested in clayey silt (CA-SFR-28) or dark, clayey sands (SFR-2, -112, -113, -114). It appears that the BART skeleton was associated with tidal marsh deposits that were buried during the late Holocene by active dune migration, as sand was blown eastward across the peninsula. Sites SFR-2, -112, -113, and -114 were formed on and, in some cases, buried by continued dune migration. This suggests that occupation occurred during periods when the dunes were relatively stable, which may correspond with periods of increased vegetation growth (ground cover) and/or changes in wind speed or direction. Conversely, occupation is not associated with episodes of dune instability and eolian deposition, which may correspond with periods of decreased vegetation growth and/or changes in wind speed or direction. As such, it will be important to determine the timing and extent of these stable (soil-forming) and unstable (e.g., erosional, depositional) periods, and to determine if these landscape changes correlate with climatic fluctuations documented in the region. If archaeological deposits are identified within the dunes, it may be possible to determine if dune-specific plants or animals were part of the subsistence resources used or preferred by prehistoric people.

In addition, the presence of these buried sites indicates that, “other shell middens or other prehistoric sites probably occur elsewhere south of Market Street along the former shores of Mission Bay” (Holman & Associates 1995:5). The existing data suggest that both residential and nonresidential sites may occur within the former dunes and—at greater depth—on the former, pre-transgression land surface underlying the dune sands. Figure 2.5, which shows the relationship between the age and depth of the radiocarbon-dated samples from CA-SFR-112 and SFR-113, demonstrates that these late Holocene-age samples occur at depths that range from 4 to 5.8 m (approximately 13 to 19 ft.) below the present ground surface. While no clear age-versus-depth function is apparent, the variable age and depth of these samples suggest that the former dunes were characterized by undulating surfaces.

While previous soil borings were available from several locations along the project corridor, most of these did not extend to depths that were adequate to test for the presence of buried land surfaces, nor were the subsurface deposits described in enough detail to assess the nature or age of the deposits. The placement and driving of piles, however, extended to depths sufficient to impact potential archaeological resources that are deeply buried. At the same time, the corridor passes through areas that were subject to extensive cutting and filling during the historic period. It was considered possible that previous excavation had removed sterile overburden in some areas, thus lowering the modern surface closer to the former land surfaces that are most likely to contain intact deposits. This was particularly true in those areas where thick deposits of dune sand were present.
on the surface at the time of historic contact. It is also possible that archaeological remains may have been removed from some areas and incorporated within artificial fill in other areas. In recognition of these issues and circumstances, the following research questions were posed to address this theme.

**Research Questions and Data Needs (Theme A)**

- 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?

- 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?

- 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?

- 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?

These questions are addressed in Chapter 3, Geoarchaeological Methods, Findings, and Interpretations.