

## 3.1 GEOLOGY AND SOILS

### 3.1.1 Introduction

#### 3.1.1.1 Definition of Resource

The geologic resources of an area consist of all soil and bedrock materials. This includes sediments and rock outcroppings in the nearshore and open ocean underwater environment. For the purpose of this EIS/OEIS, the terms soil and rock refer to unconsolidated and consolidated material, respectively. Geologic resources can also include mineral deposits, significant landforms, tectonic features, and paleontological remains (i.e., fossils). These resources can have scientific, economic, and recreational value.

#### 3.1.1.2 Regional Setting

##### A - Point Mugu Sea Range

The Point Mugu Sea Range, which encompasses both terrestrial and marine environments, is located in southern California, a region noted for its intense seismic activity. This activity is due primarily to the right lateral motion of the Pacific and North American Plate boundary. Although the study area lies entirely within the Pacific Plate, the tectonic mechanisms controlling this phenomenon have created a complex system of faults that have fragmented the landscape, combining rocks of vastly different source areas.

##### B - Point Mugu

NAS Point Mugu is located in the Ventura Basin, a large syncline or trough that extends over 120 miles (190 km) and includes the Santa Barbara Channel. Like other structural features of the Transverse Ranges, the basin trends east-west. The sediments of this basin are primarily marine. However, the combination of orogenic activity and rising sea level have produced a great diversity of sediments, particularly in the current coastal region.

##### C - San Nicolas Island

San Nicolas Island is the outermost island of the southern Channel Islands in the Peninsular Range geomorphic province. It lies on the Santa Rosa-Cortez Ridge, one of several northwest-trending ridges which characterize the region. The entire region is thought to be underlain by the Franciscan formation which consists of a broad variety of rocks including deep-marine sedimentary rocks as well as metamorphosed igneous rock derived from oceanic crust.

#### 3.1.1.3 Region of Influence

The region of influence for the alternatives addressed in this EIS/OEIS includes ocean bottom sediments in the Point Mugu Sea Range as well as geology and soils at Point Mugu and at San Nicolas Island. Ocean sediments immediately offshore from these areas are addressed where appropriate. The Navy operates instrumentation sites at Santa Cruz, Santa Rosa, and San Miguel islands. However, current activities do not affect geology and soils and the proposed action does not involve construction at these locations, so soils on these islands are not addressed.



### 3.1.2 Point Mugu Sea Range

#### 3.1.2.1 Ocean Bottom Topography

Figure 3.1-1 shows the major bathymetric (i.e., underwater topography) features of the Southern California Bight within the Sea Range. The entirety of the offshore region encompassed by the Sea Range is often referred to as the Continental Borderland. The landforms of this region are characterized by the distinct topographic features of the geomorphic provinces described above. The dominant series of northwest-trending, alternating basins and ranges are cut by the northern Channel Islands and the Santa Barbara Channel. The continental shelf (a shallow, level shelf parallel to the California coast) is particularly narrow, and is often less than 5 miles (8 km) wide. The high relief and numerous basins and ranges of the Continental Borderland distinguish this continental slope from those found in other parts of the world. Rather than having the flat, gently sloping platforms characteristic of most continental slopes, the relief of the Continental Borderland varies by as much as 8,500 feet (2,600 m). The slope area extends west to the Patton Escarpment, a steep ridge that drops approximately 4,900 feet (1,500 m) to the deep ocean floor of the Pacific. Located between the mainland and the Patton Escarpment are a series of submarine canyons, ridges, banks, and seamounts that provide unique marine habitat (see Section 3.5).

#### 3.1.2.2 Ocean Bottom Sediments

The majority of continental shelf sediments in the study area have an average thickness of approximately 100 feet (30 m). During normal years, the predominant sand-sized particles are carried by longshore currents south along the inner shelf into the Hueneme and Mugu canyons. However, years of unusually high flooding have produced a northwest trending submarine delta at the mouth of the Santa Clara River.

Much of the Sea Range ocean floor is composed of soft bottom sediments in the lower slopes and basins. Rocky substrates tend to occur close to the islands or on some of the offshore shelves, ridges, and banks that lead to other basins (see Figure 3.1-1).

### 3.1.3 Point Mugu

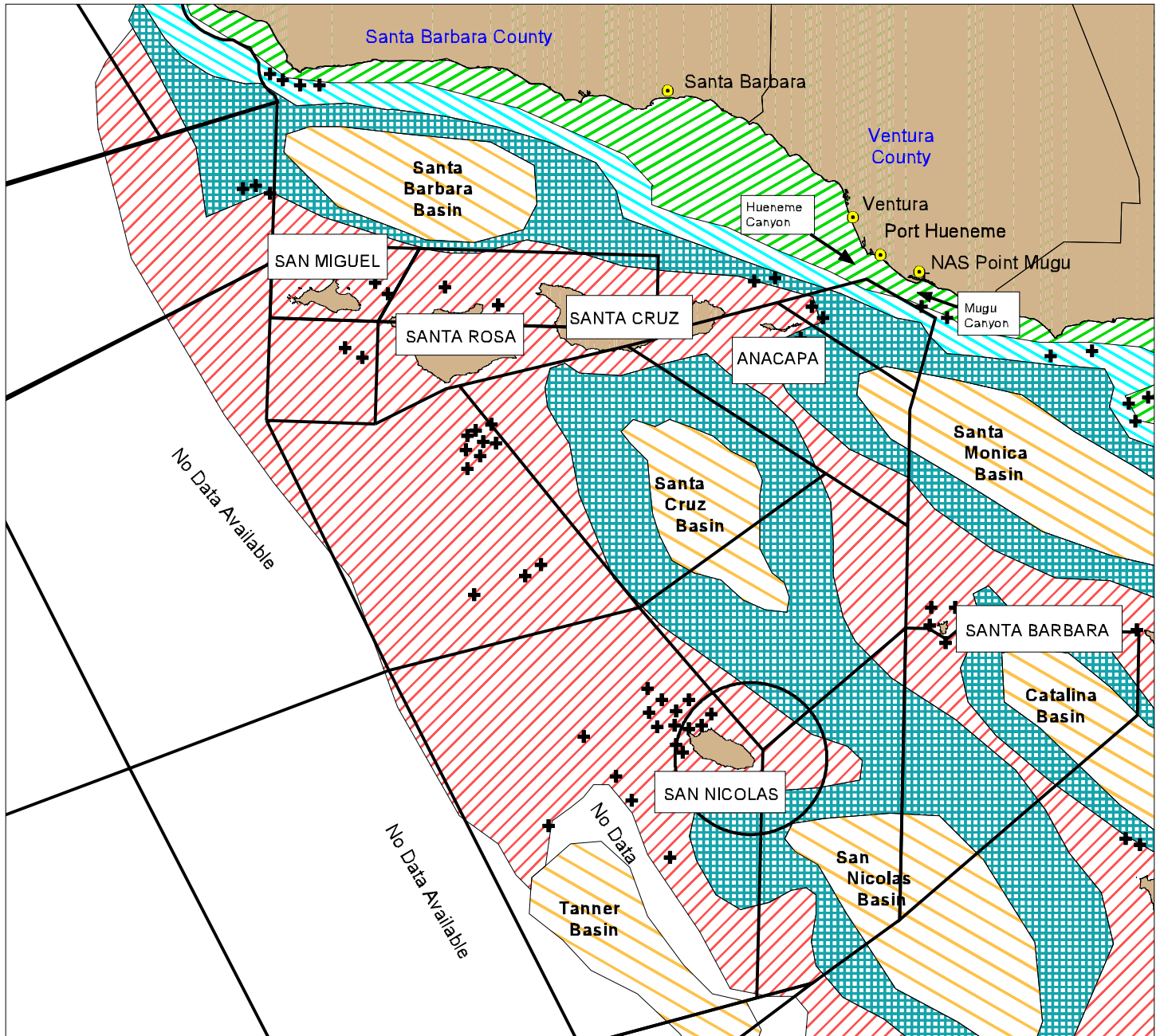
#### 3.1.3.1 Onshore

##### A - Geology

NAS Point Mugu is located on the edge of the Oxnard Plain, which is traversed by the Santa Clara River and by Calleguas Creek. The Oxnard Plain is composed largely of floodplain and marine sedimentary deposits. Unconsolidated sediments underlie the base to an estimated depth of 1,500 feet (460 m). Sedimentary deposition in the form of fluvial (river), tidal, and beach processes continues to dominate the geologic setting of the base. Topographically, NAS Point Mugu is characterized by extremely low relief, with an average slope of approximately 1 foot per 500 feet (1 m per 500 m).

The California Division of Mines and Geology (CDMG) classifies faults as either active or potentially active depending on the age of most recent known activity. A fault is considered active if displacement has occurred within the Holocene Epoch (last 11,000 years) and potentially active if the last displacement was within the Quaternary (last 1.6 million years). The majority of the unnamed faults in the offshore area are considered active.

# Major Bathymetric Features of the Southern California Bight



## Legend

- Point Mugu Sea Range
- Major Bathymetric Features**
- Mainland Shelf (30 - 150 m)
- Offshore Shelves, Ridges, and Banks (30 - 500 m)
- Upper Slope (150 - 750 m)
- Lower Slope (500 - 1500 m)
- Basins
- Deep Rocky Substrate



Projection: Universal Transverse Mercator, Zone 11  
 North American Datum of 1927  
 Scale shown is 1:1,200,000  
 Source: Dailey et al. 1993.

20 0 20 Nautical Miles

Figure

3.1-1

There are four named faults in the vicinity of NAS Point Mugu: the Bailey, Sycamore Canyon, Boney Mountain, and Malibu Coast faults (the Bailey and Sycamore Canyon faults are shown in [Figure 3.1-2](#)). Additionally, there are several scattered unnamed, smaller faults in the offshore area. According to the CDMG convention, the Bailey, Boney Mountain, and Sycamore Canyon faults are classified as potentially active. The segment of the Malibu Coast Fault nearest the base is also considered potentially active. The Bailey and Sycamore Canyon faults possibly cut through the base, although their precise locations can only be inferred due to the prevalence of recent sediments. The Boney Mountain Fault lies approximately 2.5 miles (4 km) to the east and trends roughly north-south. Of the four faults, the Malibu Coast Fault is probably the most significant in terms of size and activity. It lies just offshore to the south of Point Mugu and is estimated to be at least 17 miles (27 km) long. This fault trends east-west with a fault zone as wide as one third of a mile (0.5 km). It is believed to have caused the 1973 Point Mugu earthquake.

### B - Geologic Hazards

Although the faults listed in the previous section represent those nearest to NAS Point Mugu, they are not the only faults that could potentially affect the base. However, for the purposes of this report, individual faults beyond those described above will not be discussed.

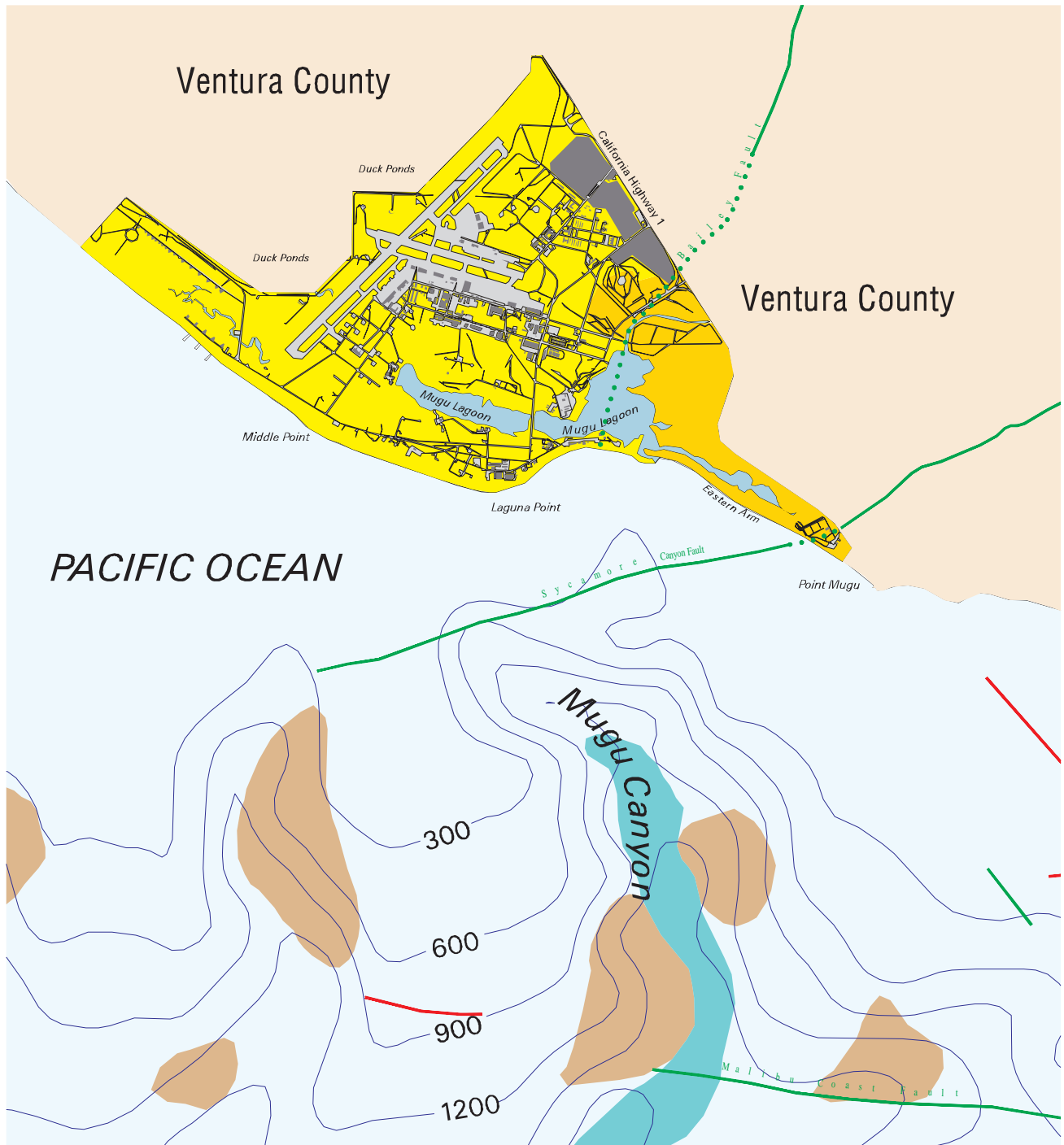
Fault activity causes damage in a variety of ways. Hazards can include landsliding, ground shaking, surface displacement and rupture, and the triggering of tsunamis. In general, the type of damage caused at a particular location depends on: a) the location's proximity to active faults, b) the frequency and severity of the disturbance, c) the potential for surface rupture, d) the composition of the location's surface and subsurface materials, and e) topography. Thus far, NAS Point Mugu has not experienced damage due to landsliding, surface displacement or rupture, or tsunamis.

The primary seismic threat to the base is ground shaking. This is particularly true east of Calleguas Creek and Mugu Lagoon where the shaking would be manifested as liquefaction. Liquefaction is defined as "the transformation of a granular material from a solid state into a liquefied state as a consequence of increased pore-water pressures." Following the Point Mugu earthquake of 1973, several sand boils and lurch cracks were observed at the Calleguas Creek stream channel and along the banks of Mugu Lagoon. The areas most at risk are those with fine to medium-grained sedimentary deposits of the very recent age (less than 1,000 years) and a shallow water table. The unconsolidated sediments onbase are thick and are of the age and texture described as most susceptible to liquefaction. In addition, the depth to the water table is exceptionally shallow, often less than 15 feet (5 m).

### C - Soils

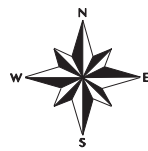
The soils at NAS Point Mugu generally fall into four categories: fill material, coastal beach sands, tidal flats, and the loamy sands and silty clay loams typical of the Oxnard Plain. Fill material constitutes a large portion of the base soils, but its properties are not well documented. Most of the fill was dredged from the lagoon and is presumed to have similar properties to the other soils onbase. Generally, base soils exhibit poor drainage and slow runoff characteristics, which contributes to ponding and occasional flooding. The erosion hazard of most soils is slight, except for the coastal beaches.

# NAS Point Mugu and Offshore Geologic Hazards



## Legend

- Areas of Sediment Slump\*
- Paleo Sediment Channel
- Areas of High Relative Liquefaction Susceptibility
- Areas of High to Moderate Relative Liquefaction Susceptibility
- Holocene Fault
- Quaternary Fault\*\*  
(dashed where inferred)



Scale shown is 1:70,000

Universal Transverse Mercator Coordinate System, Zone 11

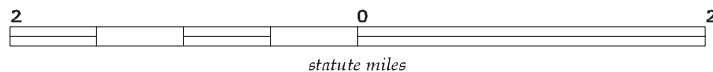
North American Datum of 1927

Contour interval is 300 feet (91 m)

Source: NAWCWPNS.

\*Movement of slope sediments offshore from the mouth of Mugu Lagoon causes measurable changes to the bathymetry of Mugu Canyon each year.

\*\*Inferred location of Bailey Fault was adapted from the Pacific Missile Test Center Master Plan, 1986.



Figure

3.1-2

## D - Paleontological Resources

There are no known paleontological resources at NAS Point Mugu. In addition, no paleontological resources are anticipated at NAS Point Mugu due to its geologic history.

### 3.1.3.2 Offshore

The shelf off the coast of Point Mugu is extremely narrow, approximately 0.9 mile (1.5 km) wide. Beyond the shelf, the terrain drops off rapidly into Mugu Canyon (see [Figure 3.1-2](#)). Slope failures (i.e., rapid movement of slope sediments) in Mugu Canyon are common. They typically occur at depths of 160 to 2,000 feet (50 to 600 m) and are less than 0.4 square miles (1 km<sup>2</sup>) in area. In addition, there are several known areas of sediment creep (areas where the sediment has “sagged” but not broken free). It is believed that instances of slope failure as well as documented shoreline retreat are related to the erosion of the rock rip-rap wall constructed along the shoreline of Point Mugu.

Little documentation is available regarding offshore erosion. The following discussion has been derived from a variety of documents describing general sedimentary processes in submarine canyons in southern California. A combination of factors creates a high erosion potential in the area offshore from Point Mugu. Longshore currents transport sediments from the Santa Clara and Ventura rivers south along the coast. When these currents reach the Hueneme and Mugu canyons, much of this material washes down the sides of the canyon into deeper ocean. These currents, deprived of their normal sediment load, scour the coast to replenish the sediment supply. This has the dual effect of both eroding the shoreline and increasing slope instability in Mugu Canyon by increasing the sediment load. Slope stability is further decreased by: a) the proximity of faults with known recent activity, and b) suspected gas accumulation in the nearshore sediments (this causes increased pore pressure and decreased shear strength). Thus, seismic activity along the faults is likely to cause landsliding or slumping in the nearshore sediments. Finally, although Mugu Lagoon is subject to seasonal tidal flushing, sediment input in Mugu Lagoon has increased dramatically in recent years.

### **3.1.4 San Nicolas Island**

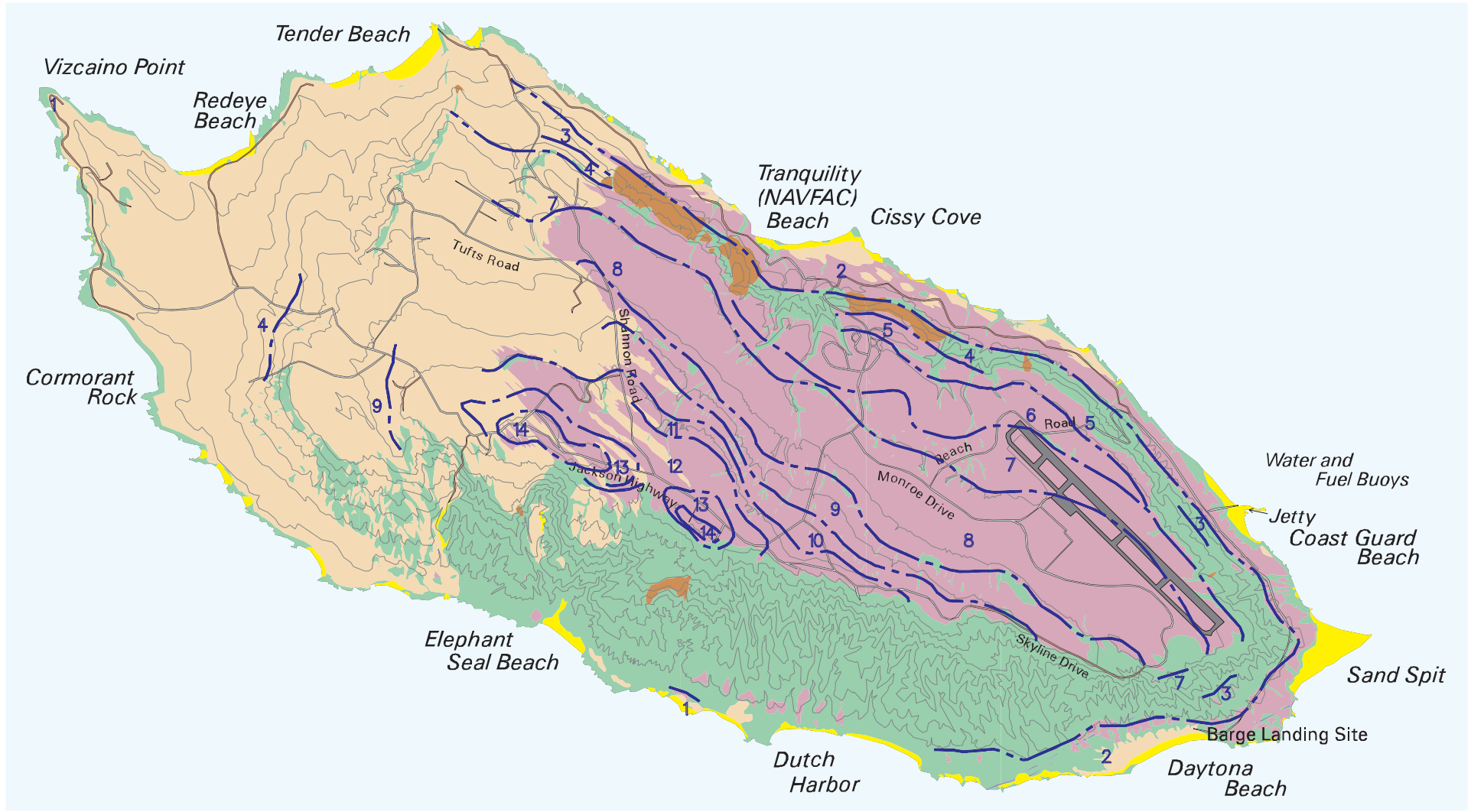
#### 3.1.4.1 Geology

The most notable geologic feature of San Nicolas Island is the series of Eocene marine terraces that formed as a result of sea level changes and tectonic uplift. A map of the geologic features and inner margins of marine terraces is shown in [Figure 3.1-3](#). The numerous terrace levels range from underwater depths of approximately 400 feet (120 m) to an elevation of over 900 feet (270 m). The terraces are covered by windblown sand (dune) deposits that decrease in depth from northwest to southeast. Underlying both dune sands and marine terrace deposits are alternating layers of Tertiary marine sandstone and siltstone. All units have been folded into a broad anticline (downward facing fold). The axis of this fold runs parallel to the length of the island, plunges slightly southeast, and is offset by several Pre-Quaternary faults.

#### 3.1.4.2 Soils

San Nicolas Island soils are extremely diverse, due largely to the varied terrain. Soils generally form a thin layer over bedrock material. Along the steep southern edge of the island, the soil layer is virtually nonexistent. Longitudinal sand dune deposits cover the west end of the island and are composed of wind-transported quartzitic sand. The majority of the rest of the island is covered by sandy loams with

# Generalized Geologic Map of San Nicolas Island



## Legend

- Unconsolidated Beach Sand
- Dune Sand Deposits
- Marine Terrace Deposits
- Consolidated Tertiary Sediments
- Known Landslide Areas
- 100' Contour Intervals
- Inferred Inner Margins of Marine Terrace Platforms

Projection: Universal Transverse Mercator, Zone 11  
 North American Datum of 1927  
 Scale shown is 1:60,000  
 Source: Burnham et al. 1963.

Figure

**3.1-3**

scattered sandy beaches along the coast. Most of the island soils are rated as severely limited for construction, are highly susceptible to erosion by wind, and are moderately erodable by water.

#### 3.1.4.3 Paleontological Resources

Fossils occur throughout the Eocene sedimentary units and marine terrace deposits on San Nicolas Island, and thus occur extensively throughout surface and subsurface units. The fossils of the Eocene rocks are predominantly foraminifera, and can be correlated with those of other geologic formations throughout southern California. Fossils of the marine terrace deposits consist of over 250 species of mollusks and other invertebrates. These assemblages are presumed to occur throughout all the marine terraces on San Nicolas Island and are unique in their completeness. The fossils "... represent one of the most complete sequence of fossil assemblages from successive terrace levels in southern California and contain the largest faunas reported from terrace levels higher than 500 feet (150 m)" (Vedder and Norris 1963).