Chapter 3

Affected Environment

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3.1 Physical Resources

3.1.1 Watershed Processes

For the purposes of this document, watershed processes encompass four primary issues: hydrology, flooding, geology/soils/geohazards, and geomorphology. This discussion presents an overview of the major historic and existing watershed processes in the Redwood Creek watershed and at the Big Lagoon site. Watershed functions and processes in the project area have been extensively described in a variety of other documents. Main sources of information describing historic and baseline conditions at the site include:

- The 1994 EA (Philip Williams & Associates et al. 1994)
- The Site Analysis Report (Philip Williams & Associates et al. 2003)
- The Sediment Budget for Redwood Creek Watershed, Marin County, California (Stillwater Sciences 2004)
- The Feasibility Analysis Report (Philip Williams & Associates et al. 2004)
- The Addendum to the Feasibility Analysis Report (Philip Williams & Associates 2004)
- The Draft 2005 Redwood Creek Watershed Assessment (Stillwater Sciences 2005a)

Unless cited otherwise, all of the information below has been distilled from the above reports, and the reader is referred to these documents for a more comprehensive description of site history and conditions.

3.1.1.1 Regional Setting

The 8.9-square mile Redwood Creek watershed is located north of San Francisco, in southwestern Marin County (Figure 1-1). The headwaters of Redwood Creek originate on the southwestern slopes of Mt. Tamalpais. The creek flows through Redwood Canyon into Frank Valley, where the creek and its tributaries enter a relatively broad alluvial floodplain. From Frank Valley, the creek enters the Big

Lagoon site, and then empties into the Pacific Ocean at Muir Beach. Major tributaries in the headwaters include Bootjack, Rattlesnake, Spike Buck, and Fern creeks. Kent Canyon Creek, another major tributary, joins Redwood Creek in Frank Valley. Green Gulch Creek drains the southeastern 1.2 square miles of the watershed, joining Redwood Creek at the Big Lagoon site.

The project site is located at Big Lagoon, at the terminus of the Redwood Creek watershed. Big Lagoon itself is a tiny intermittently tidal lagoon with an open water surface area that fluctuates between 0.1 and 1.7 acres annually (Philip Williams & Associates et al. 2003). This is a fraction of the historic extent of open water habitat on the site. Based on historic maps and sediment cores, the Big Lagoon complex was predominantly a freshwater/brackish marsh consisting of roughly 12 acres of open water, 13 acres of emergent wetlands, and 5 acres of beach dunes (Philip Williams & Associates et al. 2003). From 1853 to the present, a variety of human and accelerated natural processes (including channelization, levee construction, agricultural filling, and parking lot construction) impacted the Big Lagoon environs. Currently 6 feet of fill overlays the historic freshwater lagoon elevation.

3.1.1.2 Watershed Land Use History

The land use history of the Redwood Creek can be roughly divided into four periods, as follows:

Pre-1840

This period was dominated by a combination of natural processes and the influence of Coastal Miwok culture, with human use of fire being a major force shaping the landscape. During this period, upslope sediment production was largely intercepted by deposition in Frank Valley, and some tributaries entering the alluvial valley are thought to have emptied into alluvial fans where the flows percolated and proceeded via shallow subsurface flow to Redwood Creek. This greatly reduced sediment reaching the mainstem of Redwood Creek, resulting in a low sediment yield to Big Lagoon. Figure 3.1.1-1 shows the historic configuration of the Big Lagoon site based on an 1853 U.S. Coast Guard map, and also illustrates Philip Williams & Associates’ conceptual model of the key processes driving the site’s physical configuration at that time.

1841–1920

This period exhibited the greatest land use change as Euroamerican settlement occurred in the watershed, along with associated forms of site disturbance, such as timber harvest, grazing, and dairy farming. Runoff patterns and sediment production in upslope areas were altered by these changes, increasing sediment discharge and in some cases incising a connection between tributaries and the mainstem of Redwood Creek, as well as incision of the Redwood Creek mainstem itself. These factors resulted in greatly increased sediment yield to Big Lagoon. By 1900, Big Lagoon had mostly filled in, and Redwood Creek in the project area was channelized.

1921–1980

This period was characterized by the greatest creek and watershed disturbance as the land use practices identified above intensified, in particular grazing and dairy farming. As a result, changes initiated under the previous period intensified and further elevated sediment yields to the Big Lagoon site. Residential development expanded in the watershed, centered at the existing Muir Beach community. The levee upon which the levee road current resides was built in the 1940s, and fill was brought into the site from upslope areas to raise the pasture for grazing purposes.

1981–Present

This period represents a shift towards watershed protection and active in-channel conservation measures, whereby upslope processes have begun recovery toward predisturbance conditions, but in which the legacy of human disturbance in the channel network continues to elevate sediment yield to Big Lagoon. The watershed during this period has come under mostly public ownership, preventing further large-scale watershed disturbance from agricultural and resource extraction activities. The visitor parking lot was extended and filled early in this period, which has also been characterized by rapid channel aggradation and flooding at the Big Lagoon site. Figure 3.1.1-2 shows the recent configuration of the Big Lagoon site, and illustrates Philip Williams & Associates' conceptual model of the key processes driving the site's current configuration. Figure 3.1.1-3 illustrates Philip Williams & Associates' conceptual model of the key processes anticipated to drive the site's future configuration.

Table 3.1.1-1 further describes major watershed disturbances and hypothesized sediment transport responses.

Table 3.1.1-1. Major Watershed Disturbances and Hypothesized Sediment Transport Responses

Period	Time Period	Characteristics and Activities	Hypothesized Sediment Response
Coast Miwok	7,000 before present –1840	• Oak woodland and meadow floodplain with grassland on hillslopes, maintained by burning • Redwoods in canyons and valley • Upland prairies maintained by natural fires • Riparian fringe along Redwood Creek. • Big Lagoon is lagoon-like, at least seasonally	• Low sediment production, primarily of fine sediment by creep and biogenic processes • Shallow landslides during storm events. • Sediment supply to mainstem channel may be low due to lack of connection to Frank Valley tributaries • Tributary fan deposition and overbank flooding in non-incised channel allows sediment storage and valley alluviation
Euroamerican Arrival and Resource Development	1841–1920	• Lower valley: removal of floodplain woodland, introduction of extensive then intensive grazing and dairy farming, replacement of native perennial grasses with annual exotics	• Reduced tree cover and grazing causes greater volumes and flashy storm flows • Replacement of native grasses with non-natives provides less effective resistance to erosion

Period	Time Period	Characteristics and Activities	Hypothesized Sediment Response
		• Logging of redwoods, late in Redwood Creek due to its relative inaccessibility, soil stripped for clay following logging • Construction of first roads, trails, trains, tourism, triggering of accidental fires • Riparian fringe along Redwood Creek removed, possible local realignment of lower Redwood Creek near Pacific Way • Levees, conversion of Big Lagoon to pasture • Muir Woods National Monument established to save “last remaining redwoods”	• Both factors combine to increase tributary sediment yields, increase tributary connectedness during high flow events and initiate incision of the channel mainstem. • Incision confines flows, reverses former sediment storage and increases sediment yields further; incised channel capable of transporting coarser sediment
Engineering as Management	1921–1980	• Riparian flower and hay farming • Early period of tourism with tavern at Muir Beach and summer cottages (beginning in 1920s). • Pacific Way road and bridge built; creek realigned to fit bridge • Progressive transfer of farms to State and National Parks (1960s–1980). • More exotics (eucalyptus, heather). Tree removal firebreaks, fires suppressed. • Logging of 1,300 acres (Kent Canyon, 1960s) • Muir Woods infrastructure created; parking lots through cut and fill, further trails constructed. • Roads upgraded, Hwy 1 embankment effectively dams lower watershed. • Local water extraction in Frank Valley for irrigation and Muir Beach community. • Redwood Creek in Muir Woods extensively “protected” by riprap and grade control, straightened, LWD removed. • Redwood Creek in Frank Valley locally realigned for roads/bridges (assumed), leveed, subject to small-scale gravel extraction, floodplain leveled and cut off from most flooding at Banducci farm. • Redwood Creek in Big Lagoon dredged, dammed (then dam removed), leveed, Green Gulch channelized, fill placed in Green Gulch pasture, reservoirs constructed,.	• Continuation of previous trends; potential decrease in tributary sediment production as former farmland is converted to parkland, but increases due to riparian farming, from Kent Canyon, due to logging, from Muir Woods due to addition of roads and trails • Engineering measures halt incision in Redwood Canyon but may cause greater flashiness of flows • Sediment production may increase in lower watershed as channels are straightened and leveed • Most sediment production from Green Gulch intercepted by reservoirs • Effective depositional area in Big Lagoon reduced by levees and fill

Period	Time Period	Characteristics and Activities	Hypothesized Sediment Response
Recovery and Restoration	1981–2002	• Land use conversion from grazing to park land. Most of watershed publicly owned; exotic grasslands, forested tributaries, pines in upper watershed. • Prescribed burn experiments. • Irrigation of Green Gulch pasture from Redwood Creek at site ends, followed later by end of water diversion from the creek at Banducci Flower Farm. • Fill placed to raise and extend parking lot at Muir Beach. • Muir Beach Community Services District obtains state water rights for well upstream of Muir Beach. • Riparian and LWD recovery. • Terrestrial wetland species invade Big Lagoon.	• Tributary sediment sources other than from roads and trails may begin to wane as agriculture ceases. • Increasing roughness of mainstem channel as LWD volume increases may act to trap greater sediment volumes. • Continuation of reduced area for sediment deposition in Big Lagoon and interception of Green Gulch sediments

Source: Stillwater Sciences 2004.

3.1.1.3 Hydrology

Climate and Precipitation

The Redwood Creek watershed, on the western slope of Mt. Tamalpais, is characterized by a Mediterranean climate with mild, wet winters and mild, dry summers. Though the region has a two-season Mediterranean climate, the Redwood Creek watershed is strongly influenced by the cool and moist maritime air masses. In the summer season, this moist air is advectively cooled to saturation over the cold surface waters of the California current. This process results in heavy fog over the watershed in the summer season.

Rainfall is measured at Muir Woods, and averages 37.5 inches annually. Fog is significant and can contribute up to 10 inches of precipitation annually. The vast majority (95 percent) of annual precipitation occurs between October 1 and April 30. Average rainfall by month is shown in Table 3.1.1-2.

Table 3.1.1-2. Mean Monthly Precipitation at Muir Woods

Month	Mean Monthly Precipitation (inches)
January	7.7
February	6.2
March	4.9
April	2.4
May	1.1
June	0.4
July	0.1
August	0.1
September	0.4
October	2.0
November	5.3
December	7.3
TOTAL	37.9

Source: Philip Williams & Associates et al. 2003.

Redwood Creek Streamflow

The hydrologic regime of Redwood Creek is similar to that of many northern California coastal streams. Early season storm flows are comprised primarily of direct storm runoff and recede quickly after rainfall ends. By January, in average or wet years, groundwater storage is sufficient to maintain high baseflows, and post-storm recessions can last for over 7 days. Flows in the late spring and summer dry season are derived from groundwater and springs in the upper watershed. Limited groundwater storage is available in the alluvial deposits in the lower valleys, and during the dry season the creek commonly loses water to groundwater in the lower reaches in Frank Valley. By the end of the summer dry season, the creek can have virtually no surface flow. Discussion of "low-flow hydrology" in Chapter 4 refers to these conditions during the dry season.

The estimated peak flood recurrence relationship for Redwood Creek at the Hwy 1 Bridge is shown in Figure 3.1.1-4 and Table 3.1.3-3. Stream flow records for the watershed are discontinuous, with the largest data gap between the early 1970s and late 1980s. Even with the recent addition of nearly seven years of semi-continuous flow measurements, the stream gauging history of Redwood Creek is too short and sporadic for development of a reliable long-term flow-duration curve for peak floods. In an attempt to overcome this limitation, Redwood Creek flow data have been combined with extrapolative analyses of hydrologic data from neighboring watersheds. A statistical analysis of that data yielded the peak flow recurrence relationship displayed in this Final EIS/EIR. Uncertainties in the flood magnitudes, while difficult to quantify precisely, are undoubtedly very high, due to the extrapolative methods that were used to generate the relationship. More recent empirical data, such as flow volumes for the New Year's storms of 2005/2006, have not been incorporated into estimates to date, but are not anticipated to substantially alter the estimates of flood recurrence intervals. For a more complete discussion of streamflow records, as well as stage-discharge relationships, please refer to Stillwater Sciences (2005) and Philip Williams & Associates et al. (2003.)

Table 3.1.1-3. Estimated Peak Flood Recurrence Relationship for Redwood Creek at the Hwy 1 Bridge

Annual Peak Flood Recurrence Interval (years)	Flow (cfs)
2	805
5	1,600
10	2,270
25	3,270
50	4,140
100	5,100

Source: Philip Williams & Associates et al. 2003.

Flow Diversions

Water is diverted from Redwood Creek and its tributaries by the Marin Municipal Water District (MMWD), Green Gulch Farms, and the MBCSD. Green Gulch Farms has developed an elaborate system of reservoirs to store and divert flow from Green Gulch Creek and its tributaries for irrigation, stock watering, fire protection, recreation, and domestic use.

MBCSD operates a well on the Redwood Creek floodplain near the Banducci property, approximately 2.5 miles upstream of the Big Lagoon site, and is permitted to withdraw up to 50.6 acre-feet per year of underflow from Redwood Creek. Groundwater levels and surface flow in Redwood Creek at the project site are affected by MBCSD well operation. Operation of the MBCSD well is believed to induce infiltration from Redwood Creek to the alluvial aquifer, with streamflow depletion accounting for 70–80 percent of the pumping rate of the well. Groundwater modeling concluded that the MBCSD pumping decreased instantaneous downstream flows in Redwood Creek by as much as 0.09 cfs. This decrease in flow is primarily significant in the late dry season, when flows are naturally on the order of 0.1 to 0.2 cfs. Lower Redwood Creek completely dries up naturally approximately once every 4 years; however MBCSD pumping may increase this frequency to approximately once in 3 years. (Philip Williams & Associates et al. 2003.)

For a more complete description of water diversions and water rights, please refer to Section 3.1.3, *Water Supply*.

Flooding

The alluvial valley at Big Lagoon is the floodplain for Redwood Creek, and the majority of the Big Lagoon site is classified by the Federal Emergency Management Agency (FEMA) as being within the inundation area of a 100-year flow event, as shown on Figure 3.1.1-5. As part of this system's natural functioning, flows that exceed the channel capacity of the creek spread out onto this floodplain. In unmodified systems analogous to Redwood Creek, such out-of-bank flows typically occur during the approximate 1.5 to 2-year recurrence interval flow event. However, due to anthropogenically induced sediment deposition, channel aggradation, and subsequent loss of channel conveyance, flows now escape the lower Redwood Creek channel below Hwy 1 on a more frequent basis (several times per winter). Redwood Creek has not occupied the low point of the valley since being realigned along the western edge of the valley in the early part of the 20th century, and so out-of-bank flows naturally concentrate in the low point and flood Pacific Way near the Pelican Inn. During moderate to large flow events, most of Green Gulch pasture is inundated, and floodwaters approach the elevation of the Muir Beach parking lot as flows converge at the south end of the pasture towards the beach. Photos of flood conditions at the site are presented in Figure 3.1.1-6. During many of these events, Pacific Way is not passable by vehicles.

Flood reduction actions were implemented in 2002 by Marin County and NPS, and in 2004 and 2005 by NPS to improve channel conveyance and reduce the frequency of out-of-bank flow. The 2002 actions included:

1. removing sediment from 460 feet of the creek in the vicinity of the Pacific Way Bridge,
2. removing approximately four woody debris jams from the creek,
3. excavating a 300-foot-long pilot channel through a sediment deposit that had closed off the mouth of the creek,
4. constructing two armored dips in a levee road to provide hydraulic connectivity while reducing erosion of the levee,
5. removing a flap gate in a levee culvert to facilitate flood routing from the wetland area to the Pacific Ocean,
6. removing dead trees at risk of falling into the channel, to reduce the likelihood of future obstruction,
7. installing biotechnical bank protection (willow mattresses) upstream of the Pacific Way Bridge to prevent enlargement of floodplain channels,
8. excavating a small trench at the low point on Pacific Way east of the Pacific Way Bridge, and

9. Placing logs at key points that would not obstruct flows but would provide some salmonid habitat.

Flood reduction actions in 2004 were conducted when the channel was dry and consisted of excavating about 120 cubic yards of fine sediment and two large log jams from about 300 linear feet of the right-fork channel through the riparian area next to the parking lot. This action restored the right channel as the primary low-flow channel. A log jam in the left-fork channel adjacent to the levee road was also removed. The 2005 flood reduction actions did not involve work in the low flow channel. About 4,275 square feet of the fill pad that functioned as the picnic area was removed in order to increase the floodplain area available for the passage of high flows. This action increased the floodplain cross-section from 35 feet to 94 feet at the upstream end and from 35 feet to 62 feet at the downstream end of the excavation area. In 2005, a log jam on the bank, which obstructs high flows, but not low flows, was also removed in the riparian area adjacent to the parking lot.

While no quantitative assessment of the effects of the 2002 actions on the magnitude and duration of out-of-bank flows has been completed, the actions are believed to have substantially reduced inundation duration on Pacific Way during the winter of 2002/2003 (Vick pers. comm.). The flood reduction actions in 2004 and 2005 appeared to have similar benefits. More recent sediment deposition in the reach immediately downstream of the Pacific Way Bridge and extending upstream toward the Hwy 1 bridge have caused channel profiles to approach pre-2002 conditions. This potentially results in flooding conditions of Pacific Way that is more similar to prior conditions. Refer to Philip Williams & Associates et al. (2003), Philip Williams & Associates (2005), and Appendices D and E to view figures showing surveys of the channel thalweg in Redwood Creek over time.

Extensive flood modeling at the site has been performed by Philip Williams & Associates. The methodology for this modeling is described in the methodology portion of the *Environmental Consequences* chapter (Section 4.3.1.1, *Watershed Processes*), and in more detail in relevant Philip Williams & Associates technical documents (Philip Williams & Associates et al. 2004; Philip Williams & Associates 2005; Appendix D and Appendix E). This modeling has evaluated water elevations during the 5-year, 10-year, 50-year and 100-year event, with the most recent modeling addressing the 10-year and 100-year events (Appendix D). The modeling presented in Appendix D includes more recent topographic data, refined channel and floodplain roughness values, and refined assumptions regarding the existing Redwood Creek channel. This updated modeling is considered a reasonable representation of flood conditions. However, such hydraulic modeling results should be considered approximate, and used for the primary purpose of providing a relative comparison between existing conditions and various hypothetical scenarios.

Flood elevations throughout the project reach during the 5-year, 50-year and 100-year flow events are presented in the *Environmental Consequences* chapter (Figures 4.3.1-1, 4.3.1-2, and 4.3.1-3). Figure 3.1.1-6 shows the Pacific Way road surface compared to modeled 10-year and 100-year flood elevations. This figure shows how Pacific Way is flooded between Hwy 1 and the Pacific Way Bridge, as well as on portions of the stretch between the Pacific Way Bridge parking lot, during 10-year and greater events. As discussed above, events smaller than the 10-year flow also inundate Pacific Way in these locations, causing significant inundation between Hwy 1 and the Pacific Way Bridge several times per winter.

Spot elevations at Pacific Way and various points upstream were surveyed to compare to modeled flood elevations. The modeled 10-year flood elevation ranges from approximately 15 feet NGVD at the Pacific Way Bridge to nearly 21 feet NGVD at the Hwy 1 bridge. The modeled 100-year flood elevation ranges from approximately 17 feet NGVD at the Pacific Way Bridge to nearly 22 feet at the Hwy 1 bridge. Based on modeling and spot elevation data, it is likely that the finish floors of the two homes on Lagoon Drive (14.9, 15.0 NGVD) and the next home upstream on Hwy 1 (17.8 NGVD at backdoor threshold) are subject to inundation during the 10-year and possibly smaller events. The Pelican Inn finish floor (17.6 NGVD) may be located above the modeled 100-year flood elevations, although only marginally so. Other associated features that are lower in elevation, such as the Pelican Inn parking lot (12.4 NGVD) and steps, and features of the homes that are below the finish floor elevation, would be inundated during more frequent flow events.

Groundwater

The alluvial aquifer in Frank Valley is an alluvial aquifer that is hydrologically connected with surface flow from Redwood Creek. Groundwater data collected in the Green Gulch pasture indicate that groundwater elevations range from approximately 4 feet NGVD at the end of the dry season (September and October) to approximately 8–9 feet NGVD towards the end of the rainy season (February through March). During the dry season, groundwater levels at the Big Lagoon site are set by mean high tide (approximately 3 feet NGVD) and the Redwood Creek thalweg near the beach (approximately 4 feet NGVD). At the onset of the rainy season, as flows in Redwood Creek increase, groundwater levels rise from this minimum elevation until they are close to the ground surface from January through April. Groundwater levels during this period follow the surface topography, with the highest elevations in the upper Green Gulch pasture. Throughout late spring into summer, levels decrease at a rate of about 0.5–1 feet per month through the summer, with the highest water levels adjacent to the levee, as groundwater flows from the upper pasture areas towards the lower pasture. The effects of upstream pumping about 1 mile upstream of the site by MBCSD on groundwater levels have been described under *Flow Diversions*, above.

Saltwater from the ocean is prevented from intruding into the freshwater aquifer as a result of the channel at the downstream end of the Big Lagoon site (downstream of the pedestrian bridge). The channel thalweg in this reach is approximately 4 feet NGVD, and effectively sets groundwater levels during the dry season. Because the tidal range does not extend above this elevation, an effective barrier exists to saltwater migration further inland. Periodic saltwater overwash as a result of high tides and winter storm-induced waves does not substantially affect groundwater salinity.

3.1.1.4 Geology and Geomorphic Processes

Geology and Soils

The Marin Headlands are part of the California Coast Ranges, which were formed over the last several million years in response to crustal shortening associated with compression between the Pacific and North America tectonic plates (Wahrhaftig 1994). Most of the Redwood Creek watershed is underlain by rocks of the Franciscan accretionary assemblage, a highly deformed mixture of sedimentary, metamorphic and igneous rocks of late Jurassic and Cretaceous marine origin (Wahrhaftig 1994; Blake et al. 2000). Incoherent shale and sandstone dominate, with slopes that tend to be highly susceptible to landsliding and debris flows.

In the lower parts of the watershed, surface soils are clay-loams that give way to clay at depth, and ultimately to bedrock. The Frank Valley floor consists of Quaternary alluvial fill, which presumably accumulated in response to rising base level associated with sea level rise over the last 10,000–15,000 years. Alluvial deposits also occur the lower part of Green Gulch Creek, above Big Lagoon. Alluvial deposits are dominated by fine loam, which is interspersed with layers of fine gravel that increase in frequency and grain size with depth. The majority of the low-lying portions of the Big Lagoon site is classified by the U.S. Geological Survey (USGS) Soil Survey as Blucher-Cole complex, 2 percent to 5 percent slopes, with the area surrounding the parking lot classified as a saline hydraquent. Upslope areas are classified as Cronkhite-Barnabe complex.

Muir Beach is a Holocene beach comprised of sand deposits at the mouth of Redwood Creek. Just offshore, the San Andreas Fault forms the strike-slip boundary between the Pacific and North America tectonic plates, running along a roughly North-by-Northwest trend. Earthquakes and tectonism are important episodic events that can strongly influence the Big Lagoon system’s geomorphic processes. Subsidence following an earthquake is often the trigger which deepens coastal lagoons, and provides additional space to accommodate incoming sediment.

Since the early 1800s, four large earthquakes have been recorded along San Andreas Fault zone, including the “Great San Francisco Quake” of 1906 and the Loma Prieta earthquake of 1989. A sizable earthquake along this fault zone could damage structures in the project area through ground shaking, as well as secondary seismic hazards such as liquefaction and related ground failure. Soils and sediments most susceptible to liquefaction and related types of ground failure are well-sorted, sandy, unconsolidated materials within 50 feet of the surface and saturated by groundwater. For areas containing soils and sediments with high liquefaction susceptibility, the main risk during an earthquake is the potential for large ground deformations that could include vertical settlements of the ground surface and lateral spreading (i.e., horizontal mass movement of the liquefied ground toward an open face in sloping areas). These hazards could cause damage to existing or future on-site structures such as the Pacific Way bridge.

The Association of Bay Area Governments (ABAG) website (http://www.abag.ca.gov) was consulted to review potential groundshaking and liquefaction hazards. Based on ABAG mapping, the project site is rated as having the highest groundshaking hazard, defined as being near a major, active fault and on average subject to stronger earthquake shaking more frequently. This intense shaking could damage even strong, modern buildings and structures. Liquefaction susceptibility is rated as high, and the liquefaction hazard assuming a seismic event similar to the 1906 earthquake is rated as high near the beach and along Hwy 1, and moderate on the remainder of the site.

There are no unique geologic or known paleontologic resources in the project area.

Geomorphic Processes

Sediment Sources and Delivery

The morphology and natural maintenance of the Big Lagoon ecosystem has been adversely affected by elevated sediment delivery from the Redwood Creek watershed as a result of the disturbances identified above under Watershed History (Stillwater Sciences 2004). Estimates of the average annual sediment discharge from Redwood Creek watershed for each sediment budget period are summarized in Figure 3.1.1-7. Sediment yields in the periods that post-date Euroamerican land use are up to an order of magnitude higher than the estimated background, natural rate of sediment delivery of the pre-1840 period. In the most recent sediment budget period (1981–2002), total sediment yield dropped by about a factor of two, but is still more than five times greater than estimates for the pre-Euroamerican period. The recent decline in sediment yield, relative to 1841–1980 rates, mainly reflects an inferred reduction in sediment eroded from the floodplain—a change that may be due, at least in part, to the well-documented recent shift from agricultural to parkland uses in the lower watershed. Note that estimates of historic and future sediment yields are subject to uncertainty based on uncertainties in measurement and assumptions. The volumes presented here are from Philip Williams & Associates et al. (2003). Stillwater Sciences (2004) has completed a more comprehensive investigation of sediment yields, but the conclusions of that study do not substantially change the sediment delivery patterns presented on Figure 3.1.1-8. For a complete discussion of the Redwood Creek sediment budget and associated uncertainties, please refer to Stillwater Sciences (2004.)

The majority of sediment deposition in Big Lagoon presumably occurs during and shortly after large floods, rather than on a steady, average-annual basis. Hydrological records and narrative data indicate that notable floods in the watershed occurred approximately once per decade from 1920 to 1970 (i.e., in

1925, 1935, 1946, 1956, 1967), and twice per decade thereafter (i.e., in 1970, 1973, 1982, 1986, 1995, 1998, 2006).

Future sediment yields to Big Lagoon are speculative; however, contemporary rates of erosion from the watershed are roughly similar to pre-disturbance rates, and based on current land management (i.e., parkland), are expected to remain consistent. The effect of past watershed disturbance and more recent conservation activities appear to have resulted in a fundamental shift in the way sediment is routed through the watershed, and have changed the dominant mode from deposition to entrainment. This has resulted in incision and degradation of floodplain deposits replacing the aggradation that seems to have dominated before about 1840.

Sediment transported into the Big Lagoon site by Redwood Creek originates from a variety of sources, including:

- **Hillslope and Streamside Landslides.** Hillslope erosion and sediment transport in the Redwood Creek watershed occurs by landsliding, gullying, and soil creep (e.g., Lehre 1982). Roughly 46 percent of the watershed’s hillslope surfaces have been mapped as landslide deposits (Wentworth et al. 1997). Landslides on watershed slopes sometimes do not affect sediment delivery to the Redwood Creek mainstem due to a lack of connectivity between the landslide scar and the channel network (Stillwater Sciences 2004).
- **Erosion along Tributaries.** This type of sediment input occurs via erosion along the edges of tributaries results from soil creep and landsliding close to the channel, channel enlargement due to changes in upstream runoff, and incision driven by base level changes in Redwood Creek downstream.
- **Road-Related Erosion and Sediment Transport.** Roads, trails and road-crossing failures contribute a significant amount of sediment to Redwood Creek.
- **Sediment Delivery from Green Gulch Creek.** Sediment trapping in Green Gulch reservoirs since the 1950s has made sediment yields to Big Lagoon from Green Gulch slopes negligible during the most recent sediment budget period.
- **Post-1840 Incision of the Redwood Creek Mainstem.** Roughly coincident with Euroamerican arrival in the watershed, Redwood Creek appears to have begun incising into its Holocene alluvial fill—thus enhancing sediment delivery to Big Lagoon.
- **Incision of Tributaries.** Incision of the Redwood Creek mainstem has caused base-level lowering for the watershed as a whole, and thus has led to incision (or gullying) of tributaries into their Holocene fills.

Channel Characteristics and Modifications at Big Lagoon

Channel slope in Frank Valley drops from 0.9 percent at its upstream end to 0.4 percent at the Hwy 1 bridge. Downstream of the Hwy 1 bridge, channel slope decreases to 0.1 percent. Because of elevated sediment supply and delivery, which exceeds sediment transport ability based on channel gradient, the Big Lagoon area is depositional.

In addition, the channel and floodplain in the reach below the Hwy 1 bridge have been modified substantially over the last several decades. Major modifications in the reach have included:

- construction of floodwalls and placement of bank revetment between the Hwy 1 and Pacific Way bridges;
- construction of a levee across Big Lagoon, conversion of a portion of lagoon habitat to pasture, and isolation most of the floodplain from the creek;
- realignment of Redwood Creek and Green Gulch Creek;
- construction of a dirt/gravel fill parking lot in the lagoon;
- construction of the Pacific Way bridge and concrete box culvert across Redwood Creek at the upstream end of Big Lagoon; and
- periodic dredging of the creek channel to maintain conveyance capacity.

These modifications have reduced floodplain area and have altered channel hydraulics and sediment transport capacity. These changes, combined with the naturally low channel gradient and delivery of sediment derived from large storms, have been causing substantial aggradation in the reach. Channel surveys indicate approximately five feet of channel aggradation occurred between 1993 and 2002 (Klein et al. 2002), resulting in increased flooding, an unstable channel alignment and a heightened risk of avulsion to adjacent pasture (which is several feet lower than the creek bed). High flows escape the channel in at least two locations between the Hwy 1 and Pacific Way bridges, following the valley contours and forming a nascent channel along the low point of the valley.

Measures taken by Marin County and NPS in 2002, 2004 and 2005 to reduce flooding and the risk of channel avulsion have been previously described above. In the period since these actions were completed, scour of the Redwood Creek channel in the willow grove downstream of the pedestrian bridge has been observed, while the area in the vicinity of the Pacific Way bridge and upstream has been subject to continued aggradation.

Reach-Specific Geomorphic Conditions

A more specific description of the morphology and geomorphic processes occurring within specific reaches of the Big Lagoon site are as follows.

Upstream of Pacific Way

The area upstream of Pacific Way Bridge is a depositional area, which is likely related to decreases in flow depths when flows overtop the banks towards the new channel that is forming along the low point of the valley. Flow obstructions caused by the bridge also contribute to sediment deposition. The Marin County Department of Public Works estimates that the capacity of the bridge prior to NPS excavation in 2002 was approximately 600 cfs, insufficient to convey a 2-year flow event of 805 cfs (Klein et al. 2002). Klein et al. (2002) also suggest that because the bridge is not oriented parallel to the channel flow, flow velocities are reduced and thus contribute to aggradation. By April 2003, just six months after the dredging actions taken by the County and NPS, over 200 cubic yards of sediment had been trapped in this reach, re-filling about half of the excavated area upstream of Pacific Way Bridge.

Pacific Way to Parking Lot

From 1992 to 2002, 2 to 5 feet of sediment accumulated in the channel between the parking lot and Pacific Way Bridge due to the combined effects of flow constrictions by the levee road and the lower end of the parking lot/picnic area and high channel roughness caused by trees that fell in the channel over this period. The lower end of the parking lot, picnic area, and levee road have reduced the natural floodplain corridor by 80 percent, constricting flows upstream, reducing upstream flow velocities, and contributing to sediment deposition. Initial hydraulic modeling results suggest that the current parking lot configuration effects flows over 750 and 800 feet upstream during the 5-year and 50-year flow events, respectively. During the 5-year flow, for example, the lower end of the parking lot and picnic area fill pad raises water surface elevations in the channel by about 1 foot. Since the 2002 actions, however, sediment conveyance in the channel has increased, and the channel has scoured, a reversal of the prior trend of aggradation.

Willow/Alder Grove

The third area of significant channel deposition is in the Willow/Alder Grove downstream of the footbridge. From 1992 to 2002, maximum elevations in the Willow/Alder Grove increased by 1 to 2 feet. This deposition was probably caused by increased roughness in the channel and reduced flow velocities due to the maturing and spreading of willows and alders. The pilot channel excavated in 2003 has re-invigorated flows and has begun to slowly erode the channel bed.

Ocean and Beach Characteristics

Sea Level Rise

The sea level has risen approximately 400 feet since the peak of the last ice age about 18,000 years ago. The bulk of that occurred before 6,000 years ago (Axelrod 1981). From 3,000 years ago to the start of the 19th century the rate of sea level rise was almost constant; however, rates of sea level rise increased in the 20th century. In the last century, the measured rate of rise near San Francisco is 0.7 feet/century or 0.35 feet/50 years (see Table 3.1.1-4).

It is generally agreed upon in the scientific community that anthropogenically induced global warming will cause the rate of sea level rise to increase from current conditions. A variety of estimates have been presented, and estimates issued by the Intergovernmental Panel on Climate Change (IPCC) anticipate sea level rise of between 0.3 and 2.9 feet between years 1990 and 2100 (Intergovernmental Panel on Climate Change 2001). This range is based on the results of the various models used by the IPCC and includes a substantial amount of uncertainty. The IPCC model range of estimates for global sea level average rise by 2060 is predicted to be 0.2 to 1.3 feet. Using the mid-level of the range of the IPCC models, a predicted global average rise of 0.65 feet would be expected by 2060. However, the models used by the IPCC do not predict uniform global sea level rise and there are substantial regional variations. The IPCC model predictions for the eastern Pacific indicate a range of sea level rise predictions of 0.3 to 1.6 feet by 2100, which is on the lower end of the global range noted above. Most of the sea level rise predictions on the top end of the global range are for the top and bottom of the world, not the middling latitudes in-between. Assuming linear rise by 2060 to be half the rise between 1990 and 2100 (the rise over this period is not linear), the geographic prediction for 2060 from the IPCC models for the eastern Pacific would be 0.15 to 0.8 feet.

Other non-IPCC estimates, such as Overpeck et al. (2006), believe that sea level rise could be much more rapid, and sea levels could be 10 feet or more above current levels by year 2100. However, the IPCC assessments are the most widely accepted basis of knowledge and thus are considered the best scientific data available for project planning purposes.

The hydraulic modeling completed in support of this Final EIS/EIR assumed a sea level rise of 0.7 feet over a 50-year period, which is the mid-range of predictions of global sea-level rise by the IPCC models for the year 2060. This level of increase is twice the historic rate for the last century and near the top of the predicted regional range of rise by 2060 by the IPCC models. Thus, it is considered a reasonable basis of planning for this project.

Table 3.1.1-4. Rates of Sea Level Rise in San Francisco Bay Area

Time Period	Rate (feet per 100 years)
3,500 BP to 1840 A.D.	0.3–0.5
1854–1905	0.4
1906–1999	0.7

Source: Philip Williams & Associates et al. 2003.

Oceanography

Waves on the California coast comprise both seas and swells. Seas consist of short period waves created by local winds, while swells are long period waves that originate from offshore storms, typically in the northern Pacific Ocean. The dominant wave direction is from the northwest (290 to 315 degrees); however, there are periods where seas and, less frequently, swells arrive from a southwesterly direction (Philip Williams & Associates et al. 2003). Wave heights are greatest during winter storms between November and March, when significant wave heights average 9-10 feet and maximum wave heights can reach over 25 feet (Philip Williams & Associates et al. 2003).

Wave erosion potential is primarily controlled by wave power, which is proportional to the square of the wave height (Komar 1998). Given the dominant north-northwesterly wave direction, Muir Beach is generally characterized by significantly lower wave heights than at other locations such as Pt. Reyes, due to wave shadow effects of Pt. Reyes, Pt. Bolinas, and the local northern headland at Muir Beach. Waves from the north-northwest direction must diffract around these headlands to reach the beach, losing considerable energy in the process.

Muir Beach is directly exposed to south-southwesterly swell and seas, but waves from this direction lose energy due to shoaling on the San Francisco Bar. The orientation and morphology of the beach and headlands are also important for sand transport. Along northern California, the net longshore transport (sand movement parallel to the shoreline) is from north to south, due to the north-northwest dominant wave approach. Sediment transport is not well characterized along the Marin County coast, where headlands and irregular rocky nearshore bathymetry create complex sediment transport pathways. The headlands and offshore bedrock topography act as barriers to longshore transport of sand, except during high-energy conditions when sediment can be more easily entrained around these rocky obstacles. Previous studies in nearby Bolinas Bay and in the Santa Cruz littoral cell (Golden Gate to Monterey Bay) have found annual littoral transport volumes on the order of 150,000–250,000 cubic yards oer year (cy/yr) (Best and Griggs 1991; Interstate Electronics Corporation 1968). Annual sand discharge from Redwood Creek is several orders of magnitude less than sand supplies by longshore transport that is part of the larger littoral cell.

Beach and Dunes

Muir Beach is a sandy pocket beach, bounded by rocky headlands at the mouth of Redwood Creek, a very typical morphology for northern California. Muir Beach undergoes significant seasonal changes in shape as wave conditions vary over the year. At the end of the summer or early fall when typically calm seas occur, a well developed beach berm develops, and the beach reaches its peak width. Over the winter, high-energy, steep waves tend to move sand offshore, lowering and flattening the beach profile. As the high-energy conditions subside in late spring and early summer, the beach recovers as sand is moved on-shore, rebuilding the beach berm.

Muir Beach experiences most severe erosion when high-energy wave conditions coincide with elevated sea levels, allowing waves to penetrate a greater distance inshore and dissipate less energy via bottom friction. El Niño winter storms therefore have greater potential for beach and cliff erosion; these events typically occur every 3 to 7 years and will likely cause severe but temporary beach erosion at Muir Beach.

Between 1992 and 2003, Muir Beach appears to have shifted landward by approximately 50 feet. Berm heights are similar, but the berm has shifted landward, filling and narrowing the tidal lagoon. The topographic data for this analysis has uncertainty, so this trend should not be treated as absolute. However, this landward shift is consistent with the conceptual model of the site (Figure 3.1.1-2).

Annual high winter flows scour the backbeach, inhibiting the landward migration of the beach. Since 1992, flows on the beach have been reduced due to flow constrictions and backwater effects caused by the Willow/Alder Grove downstream of the parking lot. The pilot channel, excavated in 2003, has reinvigorated flows, but the channel was excavated more than 100 feet inland of its historical location. Moving the scouring action of the channel further inland has enabled wave overtopping and wind transport to maintain higher beach elevations in the backbeach area.

Muir Beach's morphology also varies in a shore parallel direction, rising from a minimum elevation (approximately +1 to 2 feet NGVD) at the northern end of the beach to the maximum elevation (approximately +17 feet NGVD) at the dune crests at the southern end of the beach. Local winds typically blow from the north-northwest, building up dunes at the southern end of the beach. The low elevation at the northern end of the beach is maintained by flows from Redwood Creek. Historical maps and photos consistently show the mouth of Redwood Creek at the northern end of the beach. The creek flows to the northern end because it is the most sheltered from wave energy (due to refraction around the northern headland) with the least wave power to rebuild the beach and provide resistance to creek flows.

Since a 1992 topographic survey, the beach elevations in the southern dune area have increased by about 3 feet as a result of a dune restoration program initiated in 1995, which fenced off the field and limited slope disturbances from foot traffic.

Backbeach Lagoon

Lagoon outlets are maintained and scoured by a combination of tidal and freshwater flows. In larger systems, the tidal component (quantified by the tidal prism) tends to control lagoon opening and closure frequency. Conversely, the freshwater inflow component is dominant in small lagoon systems. Wave dynamics and sediment transport also play an important role by determining the shape and elevation of the beach berm.

Lagoon closure is driven primarily by low flows from Redwood Creek in summer. These flows are lost to seepage and evaporation, which in combination with wave action pushing sand landward, causes the lagoon to close. In late fall, once flows in Redwood Creek become high enough to fill the lagoon and overtop the beach berm, flows once again reach the ocean and open the lagoon, quickly scouring a channel through the sand. The exact dates associated with lagoon opening and closure vary based on seasonality of flows in Redwood Creek. The backbeach lagoon at Muir Beach exhibits four seasonal modes of behavior, defined as follows:

1. **Fully Closed:** The lagoon outlet is entirely filled with sand, and the beach berm is at +6 feet NGVD or higher. The lagoon may fill initially with freshwater, but eventually diminishes due to evaporation and seepage. This mode occurs following closure in the mid-summer, and persists until the first major winter storms.

2. **Open, Nontidal:** Periods of strong onshore sand transport build the beach berm up to a level that prevents tidal inflow. At the same time, freshwater inflows are sufficient to maintain an open channel across the berm. During the field monitoring of 1992–1993, this occurred in March of 1993.

3. **Open, Tidal on Spring Tides:** The beach berm is built up to a level that allows tidal inflows only during spring higher high tides; neap tides do not enter the lagoon. Freshwater inflows are still sufficient to maintain an open outlet. This occurs in the spring and early summer prior to full closure.

4. **Open, Partially Tidal:** The outlet channel is scoured to as low as +1 feet NGVD, allowing tidal inflow during all tidal cycles. Low tides are still muted. This mode occurs during the winter when flood flows are very high and the beach profile is eroded by winter storm waves.

3.1.2 Water Quality

3.1.2.1 Introduction

In anticipation of the restoration of Big Lagoon there has been extensive examination of water quality in the study area. These background documents provide an extensive base of knowledge pertaining to water quality at the project site and in the upstream reaches of Redwood Creek and its tributaries. These documents are listed below. Main sources of information describing baseline conditions include:

- The 1994 EA (Philip Williams & Associates et al. 1994)
- The Site Analysis Report (Philip Williams & Associates et al. 2003)
- The Feasibility Analysis Report (Philip Williams & Associates et al. 2004)
- The Draft 2005 Redwood Creek Watershed Assessment (Stillwater Sciences 2005a)
- Water Quality Analysis of Redwood Creek Watershed data for 2004–2005 (Stillwater Sciences 2005b)

Unless cited otherwise, all of the information below has been distilled from the above reports, and the reader is referred to these documents for a more comprehensive description of water quality.

3.1.2.2 Existing Conditions

The following is a description of the existing water quality in the Redwood Creek watershed. This discussion summarizes results from sampling efforts conducted by the USGS, Harding-Lawson and Associates (HLA), Philip Williams & Associates, Stillwater Sciences and NPS. The focus of this water quality discussion is on temperature, salinity, dissolved oxygen, nutrients, bacteria, and sediment.

Temperature

Temperature affects aquatic organisms and their biological processes. Extreme water temperatures can have deleterious effects on organism life history and reproduction, especially for sensitive species such as salmonids. The San Francisco RWQCB considers an increase of more than 5°F (2.8°C) above natural receiving water temperature to be an adverse affect on water quality (San Francisco Regional Water Quality Control Board 1995). As described in Section 3.2.3, *Fisheries*, temperatures between 10° and 13.9°C are appropriate for salmonids, with temperatures from 13.9° to 15.5°C classified as “at risk,” and temperatures exceeding 18.3°C for any length of time being generally lethal to juvenile coho salmon. According to Philip Williams & Associates (2003), water temperatures at the project site generally range from 11 to 15°C, with higher temperatures in the summer and early fall months. Sampling conducted by Stillwater Sciences in 2004–2004 confirmed these results, with the highest recorded temperatures in Redwood Creek being in the 12 to 13°C range during the early fall when flows were only 0.4 cfs. Temperature ranges are considered adequate to fulfill beneficial uses and support aquatic life.

Salinity

Salinity is typically measured by the amount of anions, or salts dissolved in water. This is measured by determining total dissolved solids (TDS) and electrical conductivity (EC). As regulated by the RWQCB, an increase in TDS or salinity that adversely affects fish migration or estuarine habitat constitutes a negative impact on water quality (San Francisco Regional Water Quality Control Board 1995). Elevated salinity in the lower part of the project area that is subject to tidal influence is expected and is a natural characteristic of an estuarine system. In general, elevated salinity levels as a result of tidal influence extend to the pedestrian bridge near the beach. Periodic influxes from salt water in the lower, tidal portions of the project site during storm surges can increase salinity in waters upstream of the existing footbridge. Salinity levels at the project site are also influenced by the characteristics of freshwater discharges from Redwood Creek. Water quality monitoring indicates that TDS in freshwater inflows is generally low (in the 100–200 milligrams per liter [mg/l] range).

Dissolved Oxygen

Dissolved oxygen (DO) is an important water quality parameter for aquatic invertebrates and fish, which depend on such oxygen to survive. DO levels depend on various factors, such as temperature, aeration factors (inflow, wind, waves), salinity, and the extent of aquatic plant life respiring in the water. Minimum concentrations of 5 mg/l of dissolved oxygen is considered protective for warm water habitat, while 7 mg/l of dissolved oxygen is considered protective for cold water habitat (San Francisco Regional Water Quality Control Board 1995). Dissolved oxygen sampling efforts conducted in the lower Redwood Creek watershed indicates that dissolved oxygen can fall below 7 mg/l during summer and fall but are generally above the 5 mg/L threshold for warm water. During sampling conducted during 2004–2005 by Stillwater Sciences, the lowest recorded dissolved oxygen levels (approximately 5 mg/l) occurred during early fall during low-flow conditions of 0.4 cfs. Low DO levels during low flow conditions are expected due to the relatively higher temperatures and absence of mixing from inflows, and are not considered problematic but rather a natural characteristic of the system.

Hypersaturated conditions (saturation of DO that is well above 100%) can be indicative of excessive plant growth and eutrophic conditions; such conditions have not been observed at the site. Large diurnal fluctuations in DO can also be an indicator of eutrophication, as DO levels drop to toxic levels at night as aquatic plants respire; continuous measurements have not been taken to evaluate such fluctuations. As discussed below, it is possible based on nutrient inputs that excessive biological activity could lead to depressed DO levels, and that mildly eutrophic conditions may exist on the site.

Nutrients

Nutrient concentrations change seasonally, as aquatic plants respond to the extent of sunlight and either sequester or release nutrients as they grow or decompose. Agricultural fertilizers, animal waste (e.g., manure), and human waste (e.g., leaky septic systems) can lead to elevated nutrients above background levels, and stimulate plant growth. Rainfall, stream flow, and air and water temperature all influence nutrient concentrations in the watershed. The Basin Plan states that waters shall not contain biostimulatory substances which promote aquatic growths in concentrations that cause nuisance or adversely affects beneficial uses (San Francisco Regional Water Quality Control Board 1995). Nutrient levels are measured by analyzing for ammonia, nitrate, nitrite, and phosphorus concentrations in water. Sampling indicates that nutrient levels are elevated above background concentrations, although still meeting drinking water standards. Sources potentially include leaky septic systems from the Muir Beach community and residences upstream in the watershed, waste from horses stabled at the Golden Gate Dairy, and inputs from Green Gulch Farm. Improved horse management practices at the Golden Gate Dairy are thought to have reduced inputs from that source, although sampling conducted in 2004–2005 indicate that the Golden Gate Dairy Tributary continues to exhibit elevated phosphorus levels. Both nitrogen and phosphorus levels in the project area are of concern in terms of being at levels that can lead to nuisance aquatic growths and eutrophic conditions, although other evidence (e.g., depressed DO levels) does not point to the presence of eutrophic conditions on the site.

Bacteria

To protect recreational uses of water bodies, bacterial water quality objectives are regulated by the RWQCB. Thresholds for coliform bacteria indicate presence of water quality contamination that could result in adverse affects to human health (see San Francisco Regional Water Quality Control Board 1995). For the period of record, bacterial data from a number of sites in the watershed indicate that coliform levels are generally higher at sites downstream of the Golden Gate Dairy and within the project site. Bacterial levels on the Big Lagoon site and at Muir Beach routinely exceed applicable standards, and beach postings to warn the public of a potential health risk are common. Sources of bacteria are believed to be similar to the sources of nutrients identified above (leaky septic systems, and horse and other agricultural inputs from Golden Gate Dairy and Green Gulch Farm). The project site generally does not support beneficial uses related to municipal water supply and water contact recreation.

Sediment

The concentration of suspended sediment in the water column is influenced by stream inflows, bank erosion, and resuspension of sediments by wind or tidal mixing. Water quality contaminants, such as metals or toxic chemicals, sequestered in bottom sediments or adjacent upland areas can adsorb to suspended sediments in the water column. Where contaminants can be adsorbed to suspended sediments, higher concentrations of suspended sediment can lead to higher concentrations of contaminants in the water. Because suspended sediments are highly mobile, they provide a transport mechanism that can cause spreading and deposition of water quality contaminants.

While limited monitoring has been conducted, sediment contaminants are not believed to be present at concentrations that exceed human health or water quality criteria within the project site. As such, the potential for adverse water quality impacts resulting from contaminated sediment at the project site is not considered further.

3.1.3 Water Supply

3.1.3.1 Surface Water Diversions

This section describes the surface diversions and users in the project area. This includes Redwood Creek and its tributaries, including Rattlesnake Creek, West Fork Rattlesnake Creek, Spike Buck Creek, Laguna Creek, Fern Creek, Green Gulch Creek, and unnamed tributaries. Groundwater pumped from surface water underflow (i.e., MBCSD well) is described in the section below on groundwater pumping.

Marin Municipal Water District

MMWD is a public agency that provides drinking water to 190,000 people in a 147-square-mile area of Marin County. The MMWD has pre-1914 appropriative surface water rights for seven locations in the upper Redwood Creek watershed on the following creeks: Fern, Laguna, Spike Buck, and West Fork Rattlesnake. Surface water diversions on Fern and Laguna Creeks are used to supply the West Point Inn and to fight fires. In recent years, the other diversions have not been actively used (Philip Williams & Associates et al. 2003).

San Francisco Zen Center Green Gulch Farm

The SFZC owns and operates the Green Gulch Farm, an organic farm and garden. The Zen Center has an appropriative water right to divert up to 47 acre-feet from Redwood Creek annually within the project site. This diversion has not been used since 1989. The Zen Center also has a water right to divert up to 17 acre-feet from Green Gulch Creek. The Zen Center operates its farm from a system of reservoirs to store and divert surface flows for irrigation, stock watering, fire protection, domestic use, and recreation.

National Park Service

NPS does not provide running water at Muir Beach, and does not have any surface water diversions at the project site.

3.1.3.2 Groundwater Pumping

The Frank's Valley aquifer underlying the Big Lagoon project site and areas upstream in Frank's Valley is a heterogeneous alluvial basin that is hydrologically interconnected with Redwood Creek.

Muir Beach Community Service District

The MBCSD is a local government agency responsible for providing potable water to the residents of the Muir Beach community. The MBCSD services 147 service potable water connections supplying water to approximately 350 people (Martin 2000). The MBCSD operates a groundwater well 1 mile upstream of the project site. The well is approximately 80 feet from Redwood Creek, at the edge of NPS and State Parks property.

The MBCSD received a permit from the State Water Resources Control Board in 2001 to withdraw up to 50.6 acre-feet from this well annually. According to the conditions of the permit, well pumping is limited during the dry season to a maximum gross water production rate of 45,000 gallons per day (gpd). To meet this requirement, well production typically averages 40,000 gpd (Muir Beach Community Services District 2005).

Aquifer tests conducted in 2000 induced infiltration from Redwood Creek to the alluvial aquifer, with streamflow depletion accounting for 70 to 80 percent of the pumping rate of the well. Groundwater modeling indicates that pumping decreases instantaneous flows in Redwood Creek by as much as 0.09 cfs. This decrease is important during the late dry season when natural flows are typically as low 0.1 to 0.2 cfs. (Philip Williams & Associates et al. 2003.)

On-Site and Nearby Wells

Green Gulch Farm has a well at the edge of Field 4, approximately 150 feet from Green Gulch Creek and off of the project site, that is used as a backup well for the farm.

3.1.4 Air Quality

This section discusses federal and state ambient air quality standards and existing air quality conditions in the project area, identifies sensitive receptors in the project area, and describes the overall regulatory framework for air quality management in California and the region. Information presented in this section is based in part on communication with the Bay Area Air Quality Management District (BAAQMD).

The project site is located within Marin County, which is located in the San Francisco Bay Area Air Basin (SFBAAB). The SFBAAB consists of Marin County and six other counties—Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, and Santa Clara, as well as portions of Solano and Sonoma Counties.

3.1.4.1 Regional Climate and Meteorological Conditions

Marin County is bounded on the west by the Pacific Ocean, on the east by the San Pablo Bay, on the south by the Golden Gate, and on the north by the Petaluma Gap. The County is mostly hilly, with most of the population located in small, sheltered valleys on the eastern side of the hills. Western Marin County is usually subject to cool marine air. During summer months, incoming marine air is cooled as it passes over the offshore upwelling region, forming a fog layer along the coast. During winter months, the coastal regions stay relatively warm due to their proximity to the ocean. At these coastal areas, temperatures do not vary much over the year—high 50s in the winter and low 60s in the summer. During the warmest months, September and October, temperatures are typically in the mid to high 60s.

Along the west coast of Marin, wind speeds average 8 to 10 miles per hour (mph). Although most of the terrain throughout central Marin County is not high enough to act as a barrier to the marine airflow, friction caused by the complex terrain is sufficient to slow the airflow. The prevailing wind direction throughout Marin County is generally from the northwest.

Air pollution potential is highest on the eastern side of Marin County, where the semisheltered valleys and largest population centers are located. Currently, most of the development has been along the bay, particularly in southern Marin. In the project area, the influence of the marine air keeps the pollution levels low (Bay Area Air Quality Management District 1999)

3.1.4.2 Criteria Pollutants

The federal and state governments have established ambient air quality standards for six criteria pollutants: ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter, and lead. Ozone, NO_2, and particulate matter are generally considered to be "regional" pollutants, as these pollutants or their precursors affect air quality on a regional scale. Pollutants such as CO, SO_2, lead, and particulate matter are considered to be local pollutants that tend to accumulate in the air locally. Particulate matter is considered to be a localized pollutant as well as a regional pollutant. In the area where the proposed project is located, ozone and particulate matter are of particular concern. CO and toxic air contaminants (TACs) are also discussed below, although no state or federal ambient air quality standards exist for TACs.

Ozone

Ozone is a respiratory irritant that increases susceptibility to respiratory infections. It is also an oxidant that can cause substantial damage to vegetation and other materials. Ozone is a severe eye, nose, and throat irritant. Ozone also attacks synthetic rubber, textiles, plants, and other materials. Ozone cause causes extensive damage to plants by leaf discoloration and cell damage.

Ozone is not emitted directly into the air, but is formed by a photochemical reaction in the atmosphere. Ozone precursors—reactive organic gases (ROG) and oxides of nitrogen (NO_X)—react in the atmosphere in the presence of sunlight to form ozone. Because photochemical reaction rates depend on the intensity of ultraviolet light and air temperature, ozone is primarily a summer air pollution problem. The ozone precursors, ROG and NO_X, are mainly emitted by mobile sources and by stationary combustion equipment.

State and federal standards for ozone have been set for an 8-hour averaging time. The state 8-hour standard is 0.07 parts per million (ppm), not to be exceeded, while the federal 8-hour standard is 0.08 ppm, not to be exceeded more than three times in any 3-year period. The state has established a 1-hour ozone standard of 0.09 ppm, not to be exceeded, while the federal 1-hour ozone standard of 0.12 ppm has recently been replaced by the 8-hour standard. State and federal standards for ozone are summarized in Table 3.1.4-1.

Carbon Monoxide

CO is essentially inert to plants and materials but can have significant effects on human health. CO is a public health concern because it combines readily with hemoglobin and reduces the amount of oxygen transported in the bloodstream. CO can cause health problems such as fatigue, headache, confusion, dizziness, and even death.

Motor vehicles are the dominant source of CO emissions in most areas. High CO levels develop primarily during winter when periods of light winds combine with the formation of ground-level temperature inversions (typically from the evening through early morning). These conditions result in reduced dispersion of vehicle

Table 3.1.4-1. Ambient Air Quality Standards Applicable in California

			Standard (ppm)		Standard (μg/m^3)		Violation Criteria	
Pollutant	Symbol	Average Time	California	National	California	National	California	National
Ozone*	O_3	1 hour	0.09	NA	180	NA	If exceeded	NA
		8 hours	0.070	0.08	137	157	If exceeded	If fourth highest 8-hour concentration in a year, averaged over 3 years, is exceeded at each monitor within an area
Carbon monoxide	CO	8 hours	9.0	9	10,000	10,000	If exceeded	If exceeded on more than 1 day per year
		1 hour	20	35	23,000	40,000	If exceeded	If exceeded on more than 1 day per year
(Lake Tahoe only)		8 hours	6	NA	7,000	NA	If equaled or exceeded	NA
Nitrogen dioxide	NO_2	Annual average	NA	0.053	NA	100	NA	If exceeded on more than 1 day per year
		1 hour	0.25	NA	470	NA	If exceeded	NA
Sulfur dioxide	SO_2	Annual average	NA	0.03	NA	80	NA	If exceeded
		24 hours	0.04	0.14	105	365	If exceeded	If exceeded on more than 1 day per year
		1 hour	0.25	NA	655	NA	If exceeded	NA
Hydrogen sulfide	H_2S	1 hour	0.03	NA	42	NA	If equaled or exceeded	NA
Vinyl chloride	C_2H_3Cl	24 hours	0.01	NA	26	NA	If equaled or exceeded	NA
Inhalable particulate matter	PM10	Annual geometric mean	NA	NA	20	NA	If exceeded	NA
		Annual arithmetic mean	NA	NA	NA	50	NA	If exceeded at each monitor within an area
		24 hours	NA	NA	50	150	If exceeded	If exceeded on more than 1 day per year
	PM2.5	Annual geometric mean	NA	NA	NA	NA	If exceeded	NA
		Annual arithmetic mean	NA	NA	12	15	NA	If 3-year average from single or multiple community-oriented monitors is exceeded
		24 hours	NA	NA	NA	65	NA	If 3-year average of 98th percentile at each population-oriented monitor within an area is exceeded
Sulfate particles	SO_4	24 hours	NA	NA	25	NA	If equaled or exceeded	NA
Lead particles	Pb	Calendar quarter	NA	NA	NA	1.5	NA	If exceeded no more than 1 day per year
		30-day average	NA	NA	1.5	NA	If equaled or exceeded	NA

Notes: All standards are based on measurements at 25ºC and 1 atmosphere pressure. National standards shown are the primary (health effects) standards. NA = not applicable.

* The U.S. Environmental Protection Agency recently replaced the 1-hour ozone standard with an 8-hour standard of 0.08 part per million. EPA issued a final rule that revoked the 1-hour standard on June 15, 2005. However, the California 1-hour ozone standard will remain in effect.

Source: California Air Resources Board 2003.

emissions. Motor vehicles also exhibit increased CO emission rates at low air temperatures.

State and federal CO standards have been set for both 1-hour and 8-hour averaging times. The state 1-hour standard is 20 ppm by volume, and the federal 1-hour standard is 35 ppm. Both state and federal standards are 9 ppm for the 8-hour averaging period. State and federal standards for CO are summarized in Table 3.1.4-1.

Particulate Matter

Particulates can damage human health and retard plant growth. Health concerns associated with suspended particulate matter focus on those particles small enough to reach the lungs when inhaled. Particulates also reduce visibility and corrode materials. Particulate emissions are generated by a wide variety of sources, including agricultural activities, industrial emissions, dust suspended by vehicle traffic and construction equipment, and secondary aerosols formed by reactions in the atmosphere.

The federal and state ambient air quality standard for particulate matter applies to two classes of particulates: particulate matter 10 microns in diameter or less (PM10) and particulate matter 2.5 microns in diameter or less (PM2.5). The state PM10 standards are 50 micrograms per cubic meter ($\mu g/m^3$) as a 24-hour average and 20 $\mu g/m^3$ as an annual geometric mean. The federal PM10 standards are 150 $\mu g/m^3$ as a 24-hour average and 50 $\mu g/m^3$ as an annual arithmetic mean. The federal PM2.5 standards are 15 $\mu g/m^3$ for the annual average and 65 $\mu g/m^3$ for the 24-hour average. The State PM2.5 standard is 12 $\mu g/m^3$ as an annual geometric mean. State and federal standards for particulate matter are summarized in Table 3.1.4-1.

Toxic Air Contaminants

Although ambient air quality standards exist for criteria pollutants, no standards exist for TACs. Many pollutants are identified as TACs because of their potential to increase the risk of developing cancer or because of their acute or chronic health risks. For TACs that are known or suspected carcinogens, the California Air Resources Board (ARB) has consistently found that there are no levels or thresholds below which exposure is risk-free. Individual TACs vary greatly in the risk they present. At a given level of exposure, one TAC may pose a hazard that is many times greater than another. For certain TACs, a unit risk factor can be developed to evaluate cancer risk. For acute and chronic health risks, a similar factor called a Hazard Index is used to evaluate risk. In the early 1980s, the ARB established a statewide comprehensive air toxics program to reduce exposure to air toxics. The Toxic Air Contaminant Identification and Control Act (Assembly Bill [AB] 1807; Tanner 1983) created California's program to reduce exposure to air toxics. The Air Toxics "Hot Spots" Information and Assessment Act (AB 2588; Connelly 1987) supplements the AB 1807 program by requiring a statewide air toxics inventory, notification of people exposed to a significant health risk, and facility plans to reduce these risks. ARB has identified diesel exhaust particulate matter as a TAC.

3.1.4.3 Existing Air Quality Conditions

Existing air quality conditions in the project area can be characterized in terms of the ambient air quality standards that the federal and state governments have established for various pollutants (Table 3.1.4-1) and by monitoring data collected in the region. Monitoring data concentrations are typically expressed in terms of ppm or μ/m^3. The nearest air quality monitoring station in the vicinity of the proposed project area is located in San Rafael. The San Rafael monitoring station monitors ozone, CO, and PM10, but does not monitor PM2.5. Air quality monitoring data from the San Rafael monitoring station is summarized in Table 3.1.4-2. This data represents air quality monitoring data for the last three years (2003–2005) in which complete data is available. As indicated in Table 3.1.4-2, the San Rafael monitoring station experienced 6.1 violations of the state 24-hour PM10 standard during the last 3 years for which complete data are available. No other violations were observed for any other pollutants monitored

If monitored pollutant concentrations meet state or federal standards over a designated period of time, the area is classified as being in attainment for that pollutant. If monitored pollutant concentrations violate the standards, the area is considered a nonattainment area for that pollutant. If data are insufficient to determine whether a pollutant is violating the standard, the area is designated unclassified.

The EPA has classified Marin County as a marginal nonattainment area for the 8-hour ozone standard. For the CO standard, areas within urbanized areas (described in the Technical Support document from March 29, 1985, 50 CFR 12540) are classified as a moderate (≤12.7 ppm) maintenance area, while the rest of the County is classified as an unclassified/attainment area. The EPA has classified the County as an unclassified/attainment area for the PM10 and PM2.5 standards.

The ARB has classified the County as a serious nonattainment area for the 1-hour ozone standard. For the CO standard, the ARB has classified the County as an attainment area. The ARB has classified the County as a nonattainment area for the PM10 and PM2.5 standards. The County's attainment status for each of these pollutants relative to the NAAQS and CAAQS is summarized in Table 3.1.4-3.

Table 3.1.4-2. Ambient Air Quality Monitoring Data Measured at the San Rafael Monitoring Station

Pollutant Standards	2003	2004	2005
Ozone			
Maximum 1-hour concentration (ppm)	0.087	0.091	0.081
Maximum 8-hour concentration (ppm)	0.067	0.063	0.059
Number of days standard exceeded[a]			
NAAQS 1-hour (>0.12 ppm)	0	0	0
CAAQS 1-hour (>0.09 ppm)	0	0	0
NAAQS 8-hour (>0.08 ppm)	0	0	0

Carbon Monoxide (CO)			
Maximum 8-hour concentration (ppm)	2.03	1.96	1.66
Maximum 1-hour concentration (ppm)	3.8	3.2	3.0
Number of days standard exceeded[a]			
NAAQS 8-hour (≥9.0 ppm)	0	0	0
CAAQS 8-hour (≥9.0 ppm)	0	0	0
NAAQS 1-hour (≥35 ppm)	0	0	0
CAAQS 1-hour (≥20 ppm)	0	0	0
Particulate Matter (PM10)[b]			
National[c] maximum 24-hour concentration (µg/m^3)	39.1	51.0	37.1
National[c] second-highest 24-hour concentration (µg/m^3)	32.8	36.0	31.0
State[d] maximum 24-hour concentration (µg/m^3)	40.5	52.3	39.1
State[d] second-highest 24-hour concentration (µg/m^3)	33.4	37.9	32.6
National annual average concentration (µg/m^3)	17.0	17.4	16.0
State annual average concentration (µg/m^3)[e]	17.6	17.9	16.5
Number of days standard exceeded[a]			
NAAQS 24-hour (>150 µg/m^3)[f]	0.0	0.0	0.0
CAAQS 24-hour (>50 µg/m^3)[f]	0.0	6.1	0.0

Sources: California Air Resources Board 2006; U.S. Environmental Protection Agency 2006.

Notes: CAAQS = California ambient air quality standards.
NAAQS = national ambient air quality standards.
– = insufficient data available to determine the value.

a An exceedance is not necessarily a violation.

b Measurements usually are collected every 6 days.

c National statistics are based on standard conditions data. In addition, national statistics are based on samplers using federal reference or equivalent methods.

d State statistics are based on local conditions data, except in the South Coast Air Basin, for which statistics are based on standard conditions data. In addition, State statistics are based on California approved samplers.

e State criteria for ensuring that data are sufficiently complete for calculating valid annual averages are more stringent than the national criteria.

f Mathematical estimate of how many days concentrations would have been measured as higher than the level of the standard had each day been monitored.

Table 3.1.4-3. 2005 Marin County Attainment Status for State and Federal Standards

Pollutant	Federal	State
1-hour O_3	NA[1]	Serious non-attainment
8-hour O_3	Marginal nonattainment	NA[2]
CO	Moderate (≤ 12.7 ppm) maintenance area for the Urbanized Areas (3/29/85, 50 CFR 12540), unclassified/attainment area for rest of the County	Attainment
PM10	Unclassified/attainment	Non-attainment
PM2.5	Unclassified/attainment	Non-attainment

Notes:
1 Previously in non-attainment area; no longer subject to the 1-hour standard as of June 15, 2005.
2 ARB approved the 8-hour ozone standard on April 28, 2005. It is expected to become effective in early 2006.

3.1.4.4 Sensitive Land Uses

The BAAQMD generally defines a sensitive receptor as a facility or land use that house or attract members of the population that are particularly sensitive to the effects of air pollutants, such as children, the elderly and people with illnesses. Examples of sensitive receptors include schools, hospitals, convalescent facilities, and residential areas. Sensitive receptors located in the vicinity of the project area include: residences located west of the project area; the Pelican Inn, located at the corner of Pacific Way and Hwy 1; Golden Gate Dairy, across Hwy 1 from the Pelican Inn; Green Gulch Farm, located east of the project site; and recreational users of Muir Beach. Figure 1-3 shows the project site and adjacent sensitive receptors.

3.2 Biological Resources

3.2.1 Vegetation Communities and Wetlands

The GGNRA is part of the California Floristic Province, characterized by Mediterranean vegetation, and a zone of overlapping marine provinces (Californian and Oregonian), leading to a wide diversity of terrestrial and aquatic habitats (Bakker 1984). Historic and existing vegetation communities and wetlands, and ecological functions and processes in the project area have been extensively described in a variety of other documents. Documents consulted for the site included a review of historic aerial photographs and site maps from 1853 and 1892 that include notes on vegetation. Main sources of information describing historic and baseline conditions at the site include:

- The 1994 EA (Philip Williams & Associates et al. 1994)
- The 2003 Site Analysis Report (Philip Williams & Associates et al. 2003), including a classification of wetlands at the site according to Cowardin *et al.* (1979)
- The Draft 2005 Redwood Creek Watershed Assessment (Stillwater Sciences 2005a)
- Site reconnaissance.

This affected environment section focuses on the existing rather than historic vegetation communities and wetlands.

Vegetation Communities

Big Lagoon Site

Existing vegetation at the project site is largely composed of riparian forest and scrub (referred to as "riparian wetland"), and seasonally to semi-permanently flooded emergent wetlands (Figure 2-1), containing both native and nonnative plant species. Major plant associations described below include tidal lagoon, open water, riparian wetland, other wetland, dune habitat, upland habitat, and developed areas. Beach and near-shore ocean habitats would not be directly affected by the project, and so are not described in this chapter. Relative acreages of the vegetation communities that have been quantitatively mapped are presented in Table 2-3.

Fill Disposal Sites

The Unused Reservoir Pit is composed of upland habitat, including modified coastal scrub, annual grassland, and ruderal vegetation communities. The upper Banducci field consists of riparian wetland and disturbed/ruderal (agricultural) vegetation communities.

Open Water

Tidal Lagoon

A tidal backbeach lagoon is present immediately upstream of the confluence of Redwood Creek with the Pacific Ocean. This backbeach lagoon is a seasonally variable feature, changing in response to the relative influence of wave action that builds up the beach and stream flows that scour and maintain a channel across the beach. The lagoon is a partially tidal water body in winter when the mouth is open. By mid to late summer, waves have constructed a beach berm above tidal elevations, closing off the lagoon from tidal input. By November or December, the first winter storms arrive, with large swells eroding the beach berm and rainfall-elevating stream flows to the lagoon. Stream flows scour a channel through the beach berm and deepen the lagoon bed during storms, expanding the areal extent and depth of the lagoon. The tidal lagoon is unvegetated.

Freshwater and Brackish Areas

Open water upstream of the tidal lagoon includes permanently flooded or intermittently exposed habitat, including the Redwood Creek channel and the unnamed tributary through the Green Gulch pasture. Redwood Creek is brackish to approximately the existing pedestrian bridge.

Nineteen of the 52 species (37%) recorded in permanently flooded or intermittently exposed habitat within the Big Lagoon project area were nonnative. Nonnative species are concentrated along the lower creek edges; the dominant cover includes ox-tongue, creeping bent grass, and pennyroyal. The nonnative knotgrass covers much of the shallow water flats downstream of the footbridge. Three emergent native plants are most common: three-square rush, cattail, and species of bulrush. Other native wetland species that grow in the area include water plantain, tall cyperus, monkey flower, and small red alders. Other species include water parsley, dotted smartweed, floating marsh pennywort, silverweed, and Baltic rush.

Riparian Wetland

Due to historic disturbances (i.e., agriculture), most of the riparian vegetation in the project area is no more than 40 to 50 years old. Riparian vegetation at the site is composed primarily of a dense canopy of red alder, arroyo willow, and yellow willow, and an understory of thimbleberry, blackberry, and red elderberry mixed with thick stands of nettles , water parsley, hedgenettle, native morning glories, and nonnative cape ivy and English ivy. Patches of cattail and other emergent vegetation grow at the waters edge. Fifteen of the 49 species (31%) identified in riparian areas are nonnative. Most of the nonnative species occupied the riparian edge; however, a relatively high cover of nonnative English and cape ivy occurred well within the forest.

Other Wetlands

Green Gulch Pasture

As described in Section 3.1.1, *Watershed Processes*, in the 19th century, the Green Gulch pasture area was historically a wetland. From the 1840s onwards, it was filled with as much as 6 feet of sediment through deposition and mechanical fill. The Green Gulch pasture area has since transitioned from a relatively dry, elevated, flat grazing area dominated by grasses, back to a seasonal wetland as surface and groundwater levels have risen over the past 10 years. Management activities conducted by NPS in late 2002 to excavate the channel have probably lowered groundwater elevations, but NPS still manages a weir structure to pond water in the pasture during the spring and early summer for CRLF.

There are currently three distinct water regimes and corresponding vegetation communities in the pasture, moving from west to east, including (1) a semi-permanently flooded region that runs adjacent to the levee road and is dominated by cattails transitioning into (2) a seasonally flooded emergent wetland area; and (3) the seasonally saturated rectangular field between Green Gulch Creek and an unnamed tributary. In addition to cattails, dominant native species include obligate or facultative wetland species such as spikerush, water plantain, silverweed, and water parsley.

Of the 56 plant species recorded, 30 (54%) were nonnative. These nonnative species, including annual grasses, penny royal, creeping bent, clustered dock, bull thistle, poison hemlock, and ox-tongue are concentrated around disturbed areas (e.g., adjacent to the levee road, trail, or horse paddock area) and areas that are more elevated and dry (e.g., the pasture between Green Gulch Creek and the unnamed tributary, which is dominated by annual bluegrass). A few native trees grow along the pasture side of the levee, including black cottonwood (native to coastal California but not historically locally native), California buckeye, shore pine, and an elderberry.

Brackish Marsh

A brackish marsh area is present between the tidal lagoon and the parking lot, divided by a former beach access trail, and bounded by the willow/alder grove and the hillside residential area. A buried retaining wall (built in conjunction with the former tavern) appears to serve as a barrier between the brackish marsh community and the disturbed area dominated by Kikuyu grass located immediately adjacent to the parking lot. Recent wetland mapping shows the area between the tidal lagoon and the parking lot, excluding the willow/alder grove, as a mix of seasonally to semipermanently flooded emergent wetland, with a small strip of permanent tidal emergent wetland. The species composition is currently dominated by salt rush, salt grass, and silverweed.

Dune Habitat

Dune habitat is located in the southwestern portion of the project site, occupying the narrow fringe between the intertidal zone and the lower creek channel. The lobed dunes at Muir Beach are characterized by very low species diversity. Sixteen species of plants have been observed on dune habitat. The predominant species are the most common of dune plants, such as beach bur, yellow sand verbena, and sea rocket. Dune grasses at the foredunes such as native dune grass and creeping wild-rye (possibly beach wild-rye) also occur. Some areas of the dunes grade into wetter areas and occur with riparian species such as mugwort and California bee plant. Nonnative grasses such as ripgut brome have a greater area of cover in some dunes than native species. (Shoulders pers. comm.)

The lobes that occur at Muir Beach are disconnected from one another by well-used visitor paths across the beach, preventing natural dune formation processes from occurring. Fencing in some areas has allowed for recruitment of dune formations and species.

Upland Habitats

Upland habitat, consisting of modified coastal scrub, while not present on the site itself, grows adjacent to the site on the surrounding hills. While no attempt has been made to generate a comprehensive species list, areas sampled have resulted in 49 recorded plant species. Areas sampled are comprised of a high cover of nonnative annual species, including hair grass, soft chess, cut-leaved geranium, annual fescues, hedgehog dogtail, and plantain. These nonnatives comprise 47%of the species recorded in upland sites. Needle grass, blue wild rye and yarrow are the most common natives recorded. In addition, dense thickets of nonnative Harding grass, thistles, and poison hemlock grow in swales where cattle grazing likely occurred in the past.

Developed Areas

Developed portions of the project area include Pacific Way, the levee and perimeter roads, the parking lot and associated facilities, hiking trails, and other anthropogenically disturbed areas that do not sustain vegetation, or are made up of ruderal vegetation communities.

Wetlands and Other Waters of the United States

USACE-jurisdictional wetlands have been mapped at the site according to the methods described in the Corps of Engineers Wetland Delineation Manual (U.S. Army Corps of Engineers 1987), which showed no substantial differences in wetland acreages compared to the USACE wetland map. The most recent update to the Corps delineation was completed in July 2006, based on a field verification by the USACE. The map, pending certification by USACE, classified 26.5 acres as potential jurisdictional wetlands and 2.6 acres as waters of the United States. This included the riparian wetland immediately upstream of Pacific Way, the entire Green Gulch pasture, and additional areas south and east of the parking lot. Most of the project area lies within jurisdictional wetlands, except the levees, parking lot, and small areas along Hwy 1. Figure 3.2.1-1 shows a map of delineated wetlands. As previously discussed, wetlands at the site have also been mapped using the Cowardin classification system (Cowardin et al. 1979) in 2002 and 2003. Refer to Figure 23 in the Site Analysis Report (Philip Williams & Associates et al. 2003) for a map of Cowardin-delineated wetlands. When overlain, the area delineated by each wetland mapping protocol is almost exactly the same. Because of this, characterization and impact disclosure of wetlands throughout this document would be applicable to both Cowardin and USACE delineated wetlands.

Plant Species

A variety of common plant species occur at the project site, including both native and nonnative species. For a complete compilation, including associated habitats, please refer to Appendix C of the Site Analysis Report (Philip Williams & Associates et al. 2003). Of the 219 species reported, 64 percent (n = 140) were native and 36% (n = 79) were nonnative. Predictably, most nonnative vegetation grows in disturbed areas currently impacted by human activity (e.g., roadsides, trailsides, and picnic areas). In contrast, species diversity and cover of native species are greater in less-impacted riparian, aquatic, and upland sites. In general, nonnative species, including nonnative perennial grasses such as Harding grass and tall fescue, dominate the higher, drier areas of the Green Gulch pasture, and a mix of native species and nonnative weeds (particularly invasive Mediterranean annual grasses) have established on habitat edges such as the levee. Riparian, aquatic, dune, and marsh habitats are typically dominated by native species, with nonnative species varying in their importance between these communities (see “Vegetation Communities” above) (Philip Williams & Associates et al. 2003).

Special-Status Plants

No special-status plant species are known to occur at the project site (Faden 2002, Philip Williams & Associates et al. 2003, Taylor 2003, and field reconnaissance conducted as part of preparation of this EIS/EIR). Special-status species recognized by CNPS that may have historically occurred at the project site consist of Sonoma alopecurus, California bottlebrush grass, Thurber's reed grass, San Francisco wallflower, Point Reyes bird's-beak), beach layia, Point Reyes lupine, Marin knotweed, nodding semaphore grass, and swamp bellflower (Philip Williams & Associates et al. 2003). Surveys have also included searches for San Francisco spineflower, Lobb's water-crowfoot, and pink sand verbena (Faden 2002).

Two CNPS 4 (watch list) plant species were found in the hills near Muir Beach outside of the project site: California bottlebrush grass (found in riparian habitat), and San Francisco wallflower (found on coastal dunes) (Philip Williams & Associates et al. 2003). California bottlebrush grass has been found as recently as 2003 on nearby Green Gulch trail (Van Noord pers. comm.).

Invasive Nonnative Plants

A variety of nonnative plant species occur at the project site. Key invasive nonnative species of concern at the site include cape ivy, Himalayan blackberry, and nonnative invasive perennial grasses, such as Kikuyu grass, Harding grass, and tall fescue. As described above, most nonnative vegetation grows in disturbed or drier (i.e., upland) areas. Appendix C of the Site Analysis Report (Philip Williams & Associates et al. 2003) contains a comprehensive list of nonnative species and associated habitats.

3.2.2 Wildlife and Wildlife Habitat

In anticipation of the restoration of Big Lagoon there has been extensive examination of the ecological attributes of the study area (Philip Williams & Associates et al. 1993; Golden Gate National Parks Association 2004; Golden Gate National Recreation Area 2005). Each of those documents and several others describe the existing conditions of the study area at length. Following is a summary of these descriptions; for a more detailed description, please refer to the referenced documents themselves.

3.2.2.1 Habitat Types

See Section 3.2.1, *Vegetation Communities and Wetlands*, for a description of habitat types found at the project site.

3.2.2.2 Wildlife Assemblages

The following is a summary of the wildlife assemblages that have been documented at Big Lagoon. The summary is adapted from Philip Williams & Associates et al. (2003), in which a more thorough discussion can be found in that document, along with complete lists of all surveys conducted and species observed. A list of special-status species and habitat occurring at the site is presented in Table 3.2.2-1.

Table 3.2.2-1. Special-Status Wildlife Known to Occur or That May Occur in the Study Area

Species	Status[a] Federal	Status[a] State	Habitat	Observed at Project Site
Invertebrates				
California freshwater shrimp *Syncaris pacifica*	E	E	Pool areas of low-elevation, low-gradient streams, among exposed live tree roots (e.g., willows and alders) of undercut banks, overhanging woody debris, or overhanging vegetation.	No
Myrtle's silverspot butterfly *Speyeria zerene myrtlaeae*	E	–	Coastal dune, coastal terrace prairie, coastal bluff scrub, and associated non-native grassland habitats.	No
Ricksecker's water scavenger beetle *Hydrochara rickseckeri*	SC	–	Seasonally ponded wetlands.	No
Amphibians				
CRLF *Rana aurora draytonii*	T	SSC	Dense, shrubby riparian vegetation associated with deep (0.7 m), still or slow-moving water. The shrubby riparian vegetation that structurally seems to be most suitable is that provided by arroyo willow; cattails and bulrushes also provide suitable habitat.	Yes
Reptiles				
Western pond turtle *Emys [Clemmys] marmorata*	SC	SSC	Ponds, marshes, rivers, steams, and irrigation ditches with aquatic vegetation.	Yes
Birds				
California brown pelican *Pelecanus occidentalis californicus*	E	E, FP	Bays, estuaries, beaches, and ocean habitats.	Yes
American Peregrine Falcon *Falco peregrinus anatum*	–	E, FP	Nesting and wintering habitats are varied, including wetlands, woodlands, other forested habitats, cities, agricultural areas and coastal habitats.	Yes
Willow flycatcher *Empidonax traillii*	–	E	Deciduous thickets, especially willows and often near water	Yes

Species	Status[a] Federal	State	Habitat	Observed at Project Site

[a] Status explanation:

Federal:

E = listed as endangered under the federal Endangered Species Act.

T = listed as threatened under the federal Endangered Species Act.

SC = species of concern; species for which existing information indicates it may warrant listing but for which substantial biological information to support a proposed rule is lacking.

– = no listing.

State:

E = listed as endangered under the California Endangered Species Act.

FP = fully protected under the California Fish and Game Code.

SSC = species of special concern in California.

– = no listing.

Invertebrates

Potential habitat exists for the federally endangered California freshwater shrimp in the project area (Fong 1999). However, surveys in March and August 1997 found no shrimp in lower Redwood Creek (Fong 1999), and no sensitive invertebrate taxa were encountered during surveys in April 2002 (Fong et al. 2003).

Monarch butterflies were historically present in great numbers in the vicinity of the project area, but now are only present in small numbers and likely only use the site for foraging rather than overwintering. They utilize eucalyptus, cypress, and Monterey pine trees for clustering sites during winter. At the project site, they primarily use the Monterey pine trees on the hill above (to the north of) Pacific Way.

Other special-status invertebrate species that depend on coastal or marsh communities and may be locally present include the Myrtle’s silverspot butterfly, Ricksecker’s water scavenger beetle, and the San Francisco fork-tailed damselfly. Myrtle’s silverspot butterfly is found in coastal dunes, scrub, and grassland, and is closely associated with larval and food plants e.g., as violet) in areas sheltered from the wind below 820 feet, within 3 miles of the coast. It has not been observed in GGNRA and is not likely to be present in the project area.

Amphibians

Amphibian species observed at the site have been documented primarily at ponded or channelized areas. These standing water locations are essential to the viability of the amphibian assemblage at the site. It is typically these localized wet spots that support wetland vegetation that provides necessary cover for reproductive activities to occur. The current assemblage of amphibians at the site both in terms of numbers and species reflects the size and health of available wetland habitat (Philip Williams & Associates et al. 2003). At present, much of the wetland habitat on the site is artificially maintained by a flashboard structure along the levee road, which holds ponded water from draining to Redwood Creek.

Several amphibian surveys (Philip Williams & Associates et al. 1994, Ely 1993) have been done within the study area. During these surveys, several of the amphibian species historically thought to persist in the area were present. During subsequent surveys (Cook 1998, Fong 2000, Fellers and Kleeman 2005~~2003~~, Fellers and Guscio 2004~~2003~~) fewer species were detected. Two species not detected include the California giant salamander and the foothill yellow-legged frog. It is thought that the California giant salamander likely persists in the upper watershed of Redwood Creek and occasionally washes down into the study area (Fong pers. comm.). Although no foothill yellow-legged frogs have been recorded in the study area, habitat conditions remain suitable for this species. . No nonnative species (e.g., bullfrogs) were observed during surveys up Redwood Creek and in the ponds at the Green Gulch Farm (Philip Williams & Associates et al. 1994). California newts were the most abundant adult individuals observed. Other adult amphibian species occurred in low numbers year round (Philip Williams & Associates et al. 1994). Adult Pacific tree frogs were seen or heard from December through May. The ensatina and slender salamander were occasionally encountered on the margins of wetland habitat in the winter and spring months.

Herpetological surveys documented that the site currently supports at least one special-status species: the CRLF (federally listed threatened, state listed species of special concern). The study site is not within Critical Habitat as designated by the USFWS (71 FR 19244–19346). The size of the CRLF population at Big Lagoon has been variable, and the species was not observed at the site during 2004 and 2005, leading to the conclusion that it was potentially no longer present at the site. However, a CRLF was sighted at Big Lagoon in early 2006. The frog observed appeared to be a juvenile, suggesting that successful breeding had occurred in the previous year when no frogs were observed during the surveys (Wood 2006).

Reptiles

Five reptile species were observed during 1992 and 1993 herpetological surveys at the site (Philip Williams & Associates et al. 1994; Ely 1993): the western pond turtle, western fence lizard, western terrestrial garter snake, northern alligator lizard, and the western aquatic garter snake.

Western pond turtles (state listed species of special concern) were seen throughout the year during 1992–1993 surveys by Philip Williams & Associates et al. (1994) in two locations along the dredged portion of Redwood Creek, but were not observed during species-specific surveys conducted in 1996 (Fong 2002b). This species has not been observed at the site for several years and is not considered to currently occur at the project site.

The western fence lizard occurred as an upland resident, and the coast garter snake was observed foraging in upland as well as wetland and riparian habitats. While garter snakes were less common in the afternoon amphibian surveys (Philip Williams & Associates et al. 1994), they were seen in substantial numbers during qualitative reptile surveys.

Three reptile species were incidentally observed in 2002 during surveys for CRLF (Fellers and Guscio 2004): yellow-bellied racer, western fence lizard, and western terrestrial garter snake.

Birds

Listed below are four primary sources of information on birds that exist for the Big Lagoon project area and were reported in Philip Williams & Associates et al. (2003). For a more detailed list of the species that can be found in each of the existing habitat types, refer to Philip Williams & Associates et al. (1994).

1. Philip Williams & Associates et al. (1994) conducted seasonal surveys for 1.25 years, in 1992/1993. A total of 11 surveys at 16 stations were conducted in all seasons. Survey stations were stratified by general habitat type. The objective was to measure seasonal use of a range of habitats that would potentially be affected by restoration activities.
2. Stallcup (1995) produced an annotated bird list for the site by surveying the entire area once per month for one year (May 1994 to April 1995) and summarizing the National Audubon Society's Christmas Bird Census from 1978 to 1992. These data represent an excellent inventory of the avifauna of the site and immediate environs.
3. Point Reyes Bird Observatory (PRBO) and GGNRA have been monitoring breeding bird populations in the project area using nationally standardized protocols from 1997 to the present. This study focuses on passerines and near passerines and is part of a much larger monitoring effort along Point Reyes National Seashore (Gardali and Geupel 1997; Gardali et al. 1999; Holmes et al. 1999; Scoggin et al. 2000; Gardali et al. 2001).
4. Dybala (2002) conducted surveys for waterbirds at the site beginning on December 12, 2001, and continuing approximately every two weeks until February 12, 2002. In total, five surveys were conducted at the site in the Green Gulch pasture and horse paddock. Surveys were conducted at three sites: Pasture A, Pasture B, and the Riding Ring. Visual surveys were conducted from a fixed point at each site. The duration of each survey was at least 15 minutes per site.

Stallcup (1995) reported that 185 bird species were identified in the area. Of these, three are not native to North America, 45 were documented as breeders, 6 others were noted as possible breeders, and 12 were considered accidental. Riparian habitats were identified as “the most thoroughly used” in all seasons, which is in agreement with Philip Williams & Associates et al. (1993). Stallcup (1995) did not quantify species abundance. However, he notes that some of the most common nesting species were Swainson’s thrush, Wilson’s warbler, song sparrow, Brewer’s blackbird, and American goldfinch.

PRBO documented a total of 51 species during point count efforts from 1998 to 2002 along Redwood and Lagunitas Creeks. This did not include species observed flying over the area during surveys. Red-winged blackbird, song sparrow, Swainson’s thrush, cedar waxwing, Wilson’s warbler, American robin, and black-headed grosbeak were the most commonly detected species. All of these species breed at the site with the exception of cedar waxwing (see references listed above).

Most of the bird species that have been observed in the study area are protected under the Migratory Bird Treaty Act. In addition, one species, the California brown pelican, is federally listed as endangered, and three species—California brown pelican, American peregrine falcon, and willow flycatcher—are state listed as endangered. The special-status species mostly likely to be affected (positively or negatively) by changes to the project area are those that use the riparian and freshwater marsh habitats.

Mammals

Columbian black-tailed deer have been seen frequently in the study area, as have other common mammalian species such as coyote, striped skunks, brush rabbit**,** and western gray squirrels. Both bobcats and gray foxes have been seen infrequently along the riparian corridor. Gray foxes likely use the dense willow thicket as a denning area and both species used riparian areas as movement corridors.

Live trapping for small mammals was conducted at the site from October 28 to November 1, 2002, by the USGS (Takekawa et al. 2003). Traps were set in dune, pasture, riparian, tidal lagoon, and wetland areas. The following four species were captured, in order of abundance: western harvest mouse, deer mouse, California vole, and roof rat. Deer mice were captured only in the dune area. No special-status species (e.g., salt marsh harvest mouse, Point Reyes jumping mouse) were detected, despite careful examination of tail characteristics that distinguish the more common western harvest mouse from the endangered salt marsh harvest mouse. No small mammals were captured in the tidal lagoon area, presumably because of lack of tidal wetland vegetation (e.g., cord grass and glasswort).

Several bat species that are federally listed as species of concern or are protected by the Migratory Bird Treaty Act could occur in the project area. Hollow snags are important roosting habitat for bats. Fresh emergent marsh, including associated open water (e.g., reservoirs) habitat, is also important because it offers a permanent water source, food, and cover to a variety of wildlife species. Marshes generally support high insect densities, and therefore are also important foraging areas for many bats.

3.2.3 Fisheries

This section discusses the current setting of the fisheries resources in the study area. The purpose of this information is to establish the existing environmental context against which the reader can comprehend the environmental changes caused by the proposed action. The environmental setting information will ultimately be directly or indirectly relevant to the subsequent discussion of impacts.

3.2.3.1 Existing Conditions

In anticipation of the restoration of Big Lagoon, the ecological attributes of the study area have been examined extensively. The following background documents, which were prepared by NPS to provide a base of knowledge pertaining to fisheries in the lagoon and the upstream reaches of Redwood Creek, are listed below.

- *Big Lagoon Wetland and Creek Restoration Project, Muir Beach, California, Part 1. Site Analysis Report* (Philip Williams & Associates et al. 2003)
- *Redwood Creek Watershed Assessment. Draft. Chapter 1: Watershed* Characterization (Stillwater Sciences 2005a)
- *Long-term coho salmon and steelhead trout monitoring program in Coastal Marin County – Redwood Creek summer basinwide monitoring report.* (Reichmuth et al. 2006)
- Summary of Fish Surveys at Big Lagoon and Tributaries (With Emphasis on Tidewater Goby (*Eucyclogobius newberryi*), Marin Co., Golden Gate National Recreation Area (Fong 2006)

Each of these documents and several others describe at length the existing conditions for key fisheries within the study area. What follows is a summary of these descriptions; for a more detailed analysis please refer to the documents themselves.

Aquatic Habitat

The Redwood Creek watershed encompasses 8.9 square miles extending from the peaks of Mt. Tamalpais, through Muir Woods National Monument, to the Pacific Ocean at Muir Beach. Ninety-five percent of the watershed is owned and managed by three public agencies: MMWD, California Department of Parks and Recreation (Mt. Tamalpais State Park), and the NPS (Muir Woods National Monument and GGNRA).

The project area is located at Big Lagoon, at the terminus of the Redwood Creek watershed. Big Lagoon itself is a tiny intermittently tidal lagoon with an open water surface area that fluctuates between 0.1 and 1.7 acres annually (Philip Williams & Associates et al. 2003). This is a fraction of the historic extent of open water habitat on the site. Based on historic maps and sediment cores, the Big Lagoon complex was predominantly a freshwater/brackish marsh consisting of roughly 12 acres of open water, 13 acres of emergent wetlands, and 5 acres of beach dunes (Philip Williams & Associates et al. 2003). From 1853 to the present, a variety of human and accelerated natural processes (including channelization, levee construction, agricultural filling, and parking lot construction) impacted the Big Lagoon environs. Currently 6 feet of fill overlays the historic freshwater lagoon elevation.

Species

The Redwood Creek watershed is known to harbor at least nine native fish species, including coho salmon, steelhead trout, Sacramento perch, Sacramento blackfish, topsmelt, threespine stickleback, prickly sculpin, coast range sculpin, riffle sculpin, Pacific staghorn sculpin, and starry flounder. Sacramento perch and Sacramento blackfish are native California fish but would not normally inhabit Redwood Creek. Both of these species have been introduced into the Green Gulch watershed. Two nonnative fish species, striped bass and yellowfin goby, have also been recorded. All of these fish species have been documented in the watershed during investigations of Redwood Creek and its estuary from 1992 through the present.

In addition to the species surveyed in the background documents cited above, NPS has observed Sacramento blackfish and yellowfin gobies in the tidal lagoon. Special-status fish species are discussed in more detail below.

Coho Salmon and Steelhead Trout

Redwood Creek supports critical habitat for two special-status fish species listed by NMFS: the Central California Coast Distinct Population Segment (DPS) steelhead trout and Central California Coast Evolutionary Significant Unit (ESU) coho salmon. The Central California Coast DPS of steelhead trout is listed as federally threatened. The Central California Coast ESU of coho salmon is listed as federally endangered (70 FR 37160, June 28, 2005) and as a species proposed endangered; in addition, the project site has been designated as essential fish habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act. Redwood Creek watershed is one of four watersheds in Marin County that supports coho salmon (California Department of Fish and Game 18, 2002). Redwood Creek is considered one of the most productive and restorable basins for anadromous salmonid habitat in Marin County. During surveys from the years 2000 to 2002, coho salmon were found consistently in the creek (California Department of Fish and Game 44, 2004).

As identified above, NMFS classifies and lists salmon by ESU and trout by DPS. To be considered an ESU/DPS, a population or group of populations must be substantially reproductively isolated from other populations, and contribute substantially to the ecological or genetic diversity of the biological species.

Genetic analyses have been conducted using coho salmon tissue sampled from different watersheds in each ESU (Hedgecock 2002) and from the Central California Coast ESU area (Garza and Gilbert-Horvath 2003). A phylogeographic tree derived from these analyses indicates that coho salmon found in Redwood Creek are a distinct subgroup that does not show close genetic relationship with any other coho salmon subgroup in the Central California Coast ESU (Hedgecock 2002; Garza and Gilbert-Horvath 2003).

According to NMFS, essential habitat features for the various life stages of steelhead and coho salmon include the following:

- juvenile rearing areas;
- juvenile migration corridors;
- areas for growth and development to adulthood;
- adult migration corridors; and
- spawning areas.

Juvenile Salmonid Rearing and Areas For Growth and Development

One of the primary limiting factors to salmonid production in the Redwood Creek watershed is a lack of juvenile rearing habitat. A basin-wide habitat inventory was conducted by NPS in 1995 to describe in-stream and riparian habitat conditions from the mouth of Redwood Creek into Muir Woods. When water is present, Redwood Creek supports juvenile coho and steelhead of various ages throughout the year. Lack of secondary channels and backwater areas, woody debris, exposed tree roots, or other features that can provide refugia from high velocity flows, limits summer and winter salmonid rearing habitat in the Redwood Creek, upstream of Pacific Way. Key sections in Redwood Creek that lack good rearing habitat include human-altered sections of Redwood Creek and Fern Creek in Muir Woods National Monument.

It is important to have good rearing habitat distributed throughout the watershed. The inability of altered stream reaches to provide adequate rearing habitat results in displacement of juveniles to downstream areas. This places a burden on already crowded downstream areas and reduces the overall salmonid carrying capacity of the watershed. Researchers investigating winter habitat use in the Lagunitas Creek watershed found low site fidelity in a high gradient stream lacking floodplain features, whereas a low gradient area with adjacent side channels had high use during the winter (Sloat pers. comm. 2006).

Downstream of Pacific Way, Redwood Creek and Big Lagoon provide generally poor salmonid rearing habitat. Under normal to dry years, portions of this area are dry. Even when water is present, the tidal lagoon lacks sufficient cover for juvenile salmonids. Past flood control activities have resulted in localized losses of instream cover between the Pacific Way Bridge and parking lot. Recorded water temperatures at the lower Redwood Creek pedestrian bridge are typically below 20°C (Fong 2002) which are below the reported growth thresholds limits noted in McMahon (1983).

For many small coastal streams with flashy streamflows (such as Redwood Creek), poor winter survivorship can be a major factor affecting population size. Understanding the winter survivorship of this stream compared to similar systems can help determine whether winter habitat is limiting. For coho juveniles born in 2005, NPS estimated a winter survivorship of 11–20% based on the ratio between trapped outmigrating coho and summer basinwide estimates of juveniles (National Park Service unpub. data 2006, Reichmuth et al. 2006). By comparison, four tributaries of the Russian River (Sonoma County) had winter survivorship of hatchery coho over the same time period from between 1–25% (Obedzinski pers. comm. 2006).

Migration Corridors and Spawning Areas

Current conditions are likely adequate for movement of juvenile fish both upstream and downstream under most flow conditions. Previous trapping data indicate that most outmigration activity of juvenile salmonids occurs in the spring and early summer. Adult coho and steelhead typically migrate upstream during the late winter through spring, with run-back steelhead seen as late as late-April and May. Since upstream movements are associated with storm events, no barriers are likely to occur within the project area that could impede upstream adult fish passage. However, there is an absence of large pools that could function as holding sites for adult salmonids before their journey upstream. In coho spawner surveys conducted from the winter season of 1997–1998 through 2001–2002, no redds have been reported within the project area. Most redds are observed more than 1 mile upstream of Pacific Way.

Tidewater Goby

The tidewater goby is a small benthic fish (<50 mm standard length) found in coastal waters in California from San Diego to Del Norte counties. It is listed as federally endangered and as a state species of special concern. It is most commonly found in slightly brackish waters (0–10 parts per thousand), although experimental studies have shown the goby to tolerate hypersaline conditions for short periods (Swift et al. 1989). While tidewater goby has not been observed at the site, it is possible that Big Lagoon was a historic home of the tidewater goby, given that it is a species endemic to coastal lagoons along the California coast. Currently, Rodeo Lagoon and lower Tomasini Creek, within the GGNRA, are the only locales within the Bay Area counties that have extant goby populations. In summary of Darren Fong's 2006 analysis of potential habitat suitability for tidewater goby, the absence of this fish from Big Lagoon is likely the result of the small and ephemeral nature of brackish lagoon habitat in this watershed and its limited recolonization capabilities.

3.3 Cultural Resources

3.3.1 Introduction

Leo Barker, NPS archaeologist, and Jack Meyer, geoarchaeologist at the Sonoma State University Anthropological Studies Center, have undertaken extensive cultural resources surveys for the area of potential effect (APE) for the Big Lagoon Wetland and Creek Restoration Project. Barker et al. (2005) and Meyer (2002, 2003, 2005) have provided the basis for the cultural resources analysis contained in this Final EIS/EIR. Barker's 2005 report provides in-depth descriptions of the known resources within the APE as well as background settings for precontact, ethnographic, historic, and cultural landscape features within the APE and surrounding area.

This section provides a brief summary of the precontact period, history, and ethnography of the site, and then gives a summary of the significant or potentially significant resources that have been identified within the APE: CA-MRN-333 (Muir Beach Site), CA-MRN-674 (the Pelican Site), and the Fan Site.

3.3.1.1 Area of Potential Effect

Barker used an APE for the project that combined areas of direct and indirect impacts (Barker 2005). The APE for direct impacts includes all of the alternatives for the proposed project and the entire physical space encompassed within those alternatives. The indirect APE is described by Barker et al. (2005) as

> …a somewhat larger historic preservation APE defined for the purposes of the NHPA, and scaled to capture the full historic boundary of the ranches whose component parts may be within the narrower project impact area. The historic preservation based definition has also been used to frame the cultural resource survey conducted for the Big Lagoon Wetland and Creek Restoration Project.

The indirect APE was created to allow analysis of a broad spectrum of all cultural resources, including precontact, historic, and cultural landscape resources.

3.3.1.2 Precontact Setting[1]

Native people lived throughout present-day Marin and southern Sonoma Counties for an estimated 7,000 years prior to European colonization (Duncan 1989). At the point of contact with Europeans, the Redwood Creek watershed was apparently controlled by the Huimen, the southernmost of about fifteen

[1] The information presented regarding precontact and historic setting has been adapted from Stillwater Sciences (2005).

Coast Miwok tribes (see, for example, Bennett 1998). Archaeological sites, including at least three shell middens on the perimeter of the former Big Lagoon at Muir Beach, attest to its Coast Miwok heritage (Meyer 2003), and prominent nearby places bear names derived from the Coast Miwok language. For example, the name “Tamalpais” is a Spanish adaptation of a Coast Miwok word meaning “west hill” or “coast hill.”

The Coast Miwok managed the land with fire, burning large areas to drive—and sometimes kill—game animals, and to manage vegetation for grazing, travel, camping, the growth of desirable species, and the collection of acorns and seeds (Duncan 1989; Marin Municipal Water District 1995). Over thousands of years, these management practices shaped the distribution and species composition of native plant communities. Anecdotal accounts suggest that hillsides were dominated by native perennial bunch grasses, with trees and woody vegetation occurring mainly in ravines and canyons. For example, after ascending slopes near Big Lagoon, Lieutenant Henry Wise of the U.S. Navy reported in 1849 that “there was no timber to be seen, and except the stunted undergrowth netted together in valleys and ravines, all was one rolling scene of grass, wild oats, and flowers” (e.g., Toogood 1980). By the time of this account, in the late 1840s, the onset of cattle grazing in the region was probably already affecting vegetation distributions locally (see next section). It nevertheless seems safe to assume that, at the coarse scale of the observation, landscape conditions were still largely reflecting the prolonged influence of Coast Miwok culture, rather than exhibiting the effects of the recent shift in management practice.

3.3.1.3 Historic Setting

Cattle Grazing and Timber Harvesting

The Spanish founded the Presidio at San Francisco in 1776 and began establishing the mission communities that ultimately supplanted the tribal cultures of the Coast Miwok and other indigenous Bay Area peoples. Parts of the Redwood Creek watershed may have been grazed by cattle and harvested for timber starting in about 1817, with the formation of Mission San Rafael Arcangel, which is reported to have had 8,000 cattle, horses, and other grazing animals at its peak of productivity (Munro-Fraser 1880).

Cattle grazing and timber harvesting intensified after 1838, when the Redwood Creek watershed was officially deeded to William Richardson (Auwaerter 2005), as part of a grant that included much of the Marin peninsula (19,571 acres or 7,920 hectares in all). Richardson named the area “Rancho Saucelito” (using the Spanish word for “willow,” from which “Sausalito” is derived) and began grazing longhorn cattle on it. According to an 1847 census, as many as 2,800 head—the largest herd in Marin County—roamed the open range of Richardson’s rancho. Richardson and his neighbor, David Reed, of the Rancho de Corte Madera del Presidio, harvested redwoods and other trees from the east side of Mt. Tamalpais, and, as partners, opened the first timber mill in Marin County in the 1840s (Golden Gate National Recreation Area 2003). By the 1850s, all of the easily accessible large timber on the bay-side of the mountain had been harvested. Timber harvesters began to focus on old growth redwoods from the hills around Bolinas Lagoon and the Lagunitas Creek watershed, to the north of Redwood Creek, while continuing to harvest smaller trees along Richardson Bay for cordwood to heat homes and brick kilns. Logging had spread to the ridges above Muir Woods by the late 1800s. By the early 20th century, most of the old growth redwoods in the region had been harvested. Exceptions were the stand in present-day Muir Woods and 1,300 acres in Kent Canyon, which was selectively logged by tractors by its agricultural owner in the 1960s prior to sale of the land to State Parks (Philip Williams & Associates 2000).

Dairy Farming

In 1856, the Richardson family sold Rancho Saucelito to San Francisco financier Samuel Throckmorton, who subdivided parts of it into 500- to 1,500-acre parcels for dairy farming (Auwaerter 2005). Demand for dairy products was growing with San Francisco’s expanding population, and by 1880, the Rancho Saucelito had been carved into 24 dairies, most of which were leased by Portuguese and Swiss immigrants. The beach was the center of the community, with farmhouses scattered throughout the valleys under an agrarian culture that reflected the European heritage of the immigrants (Philip Williams & Associates et al. 2003).

In 1889, 6 years after Throckmorton’s death, the rancho was acquired by the Tamalpais Land and Water Company (Auwaerter 2005). Much of the land was sold for tenant dairy farming. The biggest were the Dias (or Hill) Ranch, which extended from Homestead Valley across Dias Ridge to the Pacific Ocean; the Brazil brothers’ ranch, which extended from Frank Valley up Mt. Tamalpais past the Dipsea Trail; the Silva Ranch, located in lower Frank Valley; and the Bello Ranch (a.k.a., Golden Gate Dairy), which included Green Gulch, Muir Beach, and a portion of Frank Valley (Livingston 1994; Spitz 1997; Baron 2001; summarized in Jebens 2001). Many of the tenant dairy farms continued operating into the mid-twentieth century.

Other Agricultural Uses

The dairies of Green Gulch and Frank Valley were eventually converted to other agricultural uses. In Frank Valley, Amadeo Banducci Sr. began leasing portions of the Silva dairy in the 1930s for flower and vegetable farming (Livingston 1994). In 1948, Banducci purchased the property and operated the entire parcel as a flower farm (Culp 1998). Three years earlier, Green Gulch and Muir Beach had been purchased by George Wheelwright, who raised beef cattle. Wheelwright planted New Zealand grasses on new pastures that he had reclaimed by building levees in the Big Lagoon area along Redwood Creek. In an effort to increase the area available for grazing, he burned and chained the pervasive shrub vegetation, and, for 3–4 years in the late 1950s, sprayed herbicides by helicopter over his property. By 1969 Wheelwright had donated Muir Beach to the State Park system, and by 1972 had sold Green Gulch to the San Francisco

Zen Center under terms that would keep the area in agriculture with only minimal construction of buildings and facilities (Jebens 2001).

Railroads, Roads, and Other Infrastructure

The natural beauty and resources of Mt.Tamalpais and the Marin Coast have attracted recreationists from San Francisco and other nearby areas since the late 1800s (Auwaerter 2005). The first ferry service to Marin began in 1855, providing transportation from San Francisco to Point San Quentin. Ferry service to Sausalito was added in 1868. The area's first wagon road, completed in 1870, extended from Sausalito to Bolinas, along the present grade of Hwy 1. The Eldridge Grade road, from San Rafael to the summit of Mt Tamalpais, was completed in 1879.

Recreation at the peak expanded in 1896, with the opening the Mill Valley and Mt. Tamalpais Scenic Railway by the Tamalpais Land and Water Company—which had backing from local financiers Sidney Cushing and Albert Kent. Dubbed "The Crookedest Railroad in the World," it carried tourists up 8.2 miles (13.2 km) of track, through 281 curves, from Mill Valley to the East Peak of Mt. Tamalpais. Once at the top, tourists could climb to the Marine Exchange lookout on East Peak, visit the Weather Bureau station (opened in 1898) and follow hiking trails to outlying areas.

In 1907, Albert Kent's son William built a spur to connect Muir Woods to the Mill Valley and Mt Tamalpais Scenic Railway line. In 1913, the railroad was incorporated and named the Mt. Tamalpais and Muir Woods Railway.

Muir Woods Road was built in 1893, and from roughly 1905 to 1910, was extended to Frank Valley (Jebens 2001). Pacific Way was connected to Muir Beach in 1908. In 1925 and 1926, the Frank Valley and Muir Woods Roads were upgraded (Jebens 2001). Panoramic Highway was opened in 1928.

The "Great Tamalpais Fire" of 1929 put an end to the railroad, which had been in decline due to the rising popularity of automobiles (Auwaerter 2005). The railroad was abandoned in the summer of 1930, and its rails, ties, engines, cars, and other equipment were removed from the watershed.

In 1937, when the Golden Gate Bridge was completed, annual visitation to Muir Woods tripled, to more than 180,000 visitors per year. By 1947, an estimated total of 58 miles (93 km) of roads and trails had been constructed in the watershed, many for ranching purposes (Pacific Watershed Associates 2002). An additional 5 miles (8 km) of roads and trails were built between 1953 and 1965, and 4 more miles were added between 1971 and 1982 (Pacific Watershed Associates 2002).

Hunting and Hiking

In the mid 1800s, Redwood Creek owner William Richardson and his family and friends hunted extensively in the area. Accounts from his hunting expeditions tell of abundant elk, deer, bears, and mountain lions on the slopes of Mt. Tamalpais (Golden Gate National Recreation Area 2003). After acquiring the land and leasing parcels of it for dairy farming, Samuel Throckmorton lined much of his remaining property with fences, guarding it for personal use as a game refuge and allowing access to only a select group of friends (Auwaerter 2005).

Hunting became increasingly popular as public access expanded after Throckmorton's death in 1883. However, efforts to reserve the land for private recreational use and limited public access continued as members-only hunting and outdoor clubs began leasing large sections of the mountain slopes from local ranchers. By the end of the 1880s, most of the large game animals had been wiped out (Golden Gate National Recreation Area 2003). With large predators gone, the deer population grew and became a chief target of hunters.

As access improved with increasing infrastructure, hikers inevitably transformed the mountain into an outdoor recreation center (Auwaerter 2005). The Tamalpais Club (founded before 1880) maintained a summit register on East Peak. The first volume, spanning 1880–1887, records more than 850 names of men, women, and children from throughout the United States and Europe (Golden Gate National Recreation Area 2003). In the 1890s and early 1900s, several hiking clubs were formed (Auwaerter 2005). Among them were the Sight-Seers in 1887, the Cross-County Club in 1890, the California Camera Club in 1890, the Columbia Park Boy's Club in 1894, the Sempervirens Club in 1900, the Sierra Club Local Walks Committee in 1906, the Tourist Club in 1912, and the California Alpine Club in 1914. These clubs organized hikes, built and maintained trails, established camps, and built a "Trailman's Cabin" at Bootjack Camp. In 1904, hikers from San Francisco's Olympic Club held a foot race from Mill Valley to the Dipsea Inn in Bolinas, along the Lone Tree Trail. This was the first Dipsea Race, a still-popular annual event.

The first trail map of the mountain, published in 1898, shows several trails—the Lone Tree (a portion of today's Dipsea), Cataract, Kent, Throckmorton, Bootjack, and West Point (now Rock Spring) trails—which still exist today. By the 1920s, hiking and overnight camping on the mountain were so popular that the San Francisco Examiner newspaper published daily weather predictions for Mt. Tamalpais. Hiking continues to be an important activity in the watershed today.

Commercial Recreation

Muir Beach has long been a popular tourist stopover. In 1919, Antonio Bello, a Portuguese dairyman, established a hotel at Muir Beach (Golden Gate National Recreation Area 2003). The hotel later burned down and was replaced in 1928 by a tavern and small cabins. The tavern closed in the 1960s after it came into ownership by State Parks and was torn down by State Parks over protest by local residents. All of the cabins were also torn down. Accommodations at Muir Beach are now provided by the Pelican Inn bed and breakfast, which was built on a fill pad in the 1970s.

Conservation Efforts

By the end of the 1800s, recreationists had begun supporting efforts to preserve the area's natural and scenic resources from impending urban encroachment. A local water company had identified Redwood Canyon as a potential reservoir site, and housing and road developers were becoming increasingly interested in the as yet untouched hillslopes of Mt. Tamalpais. The watershed was defended by a succession of local and regional conservation-minded groups, including the Mt Tamalpais Forestry Association, the local hikers of the "Hill Tribe," the Mt. Tamalpais National Park Association, the Tamalpais Conservation Club, the Sempervirens Club, the Sierra Club, and the California Club. William Kent, namesake of Kentfield, became a key participant in the conservation efforts. In 1905, he purchased Redwood Canyon and, in December 1907, donated much of it to the federal government. Just days after Kent's grant, President Theodore Roosevelt invoked the Antiquities Act and designated Redwood Canyon a national monument, with the name "Muir Woods," in honor of the famous conservationist and writer. Kent eventually went on to serve in Congress and introduce the legislation that established the National Park Service in 1916.

The establishment of Muir Woods National Monument was the first in a series of notable conservation actions in the Redwood Creek watershed. In 1912, the Marin Municipal Water District was formed to protect the natural resources of land in the upper part of the watershed and use it to provide water to the citizens of Marin. In July 1917, after years of conflict between hunters and hikers, the Mt. Tamalpais Game Refuge was established, ending hunting on most of the mountain—as well as in the Lagunitas Creek watershed, from Alpine Lake downstream to the outlet. In 1928, Mt. Tamalpais State Park was established after three decades of pressure from conservation groups. Only 200 acres at its inception, Mt. Tamalpais State Park has since acquired, among other holdings, the Dias and Brazil dairy farms (in the 1960s) and has grown to include more than 6,300 acres of land on the mountain. The Golden Gate National Recreation Area was founded in 1972. The National Park Service began purchasing existing and defunct farms and incorporating them into GGNRA. By 1995, cattle grazing and farming within the watershed had been completely phased out, and the GGNRA had grown to include Muir Beach, Coyote Ridge, a portion of Dias Ridge, and the lower parts of Frank Valley.

3.3.1.4 Known Resources in the APE

Resources Determined Not to Be Significant or Potentially Significant

The following cultural resources were evaluated but were determined not eligible for listing in the National Register of Historic Places (NRHP) by Golden Gate NRA staff and as such are not discussed further. These conclusions concerning National Register eligibility remain to be concurred with by the California State Historic Preservation Officer.

- **Monterey Pine and concrete curb at Hwy 1 and Pacific Way.** These two features at the corner of Hwy 1 and Pacific Way were determined not to be contributing features to the Golden Gate Dairy complex discussed below.
- **Banducci Flower Farm.** This site, within which the Upper Banducci Fields sediment disposal site is located, has been determined to be of local historic significance but is not considered eligible for NRHP listing.
- **Green Gulch Zen Center/Wheelright Ranch.** The project site and the Zen Center located east of the project site were both part of Wheelwright Ranch. However, the remaining elements of Wheelright Ranch are few, and the resource lacks integrity and therefore is not eligible for listing in the NRHP.
- **The Tavern (i.e., the Muir Beach Tavern Farallones East, Denocarlo Naval Base).** The tavern that was historically located near the beach has been mostly removed; the remnants lack integrity, and therefore the site is not eligible for listing in the NRHP.
- **Modern corrals, cattle chute.** These structures, located near the corner of Pacific Way and Hwy 1, are not old enough to be considered historic.

For information regarding all resources evaluated; in-depth precontact, ethnographic, and historic settings; and detailed results of the investigations, please refer to Barker et al. (2005) and Meyer (2002, 2003, and 2005.)

CA-MRN-333

According to the research conducted by Baker and Meyer, this is a relatively intact precontact archaeological site located within the APE. This shell midden site was first recorded by Nels Nelson in 1909 and later listed on the NRHP in 1979. Boundaries of this site have been well defined as a result of hand augering and surface survey (Barker et al. 2005). Project activities are anticipated to avoid the site; as a result, no impacts are anticipated as a result of the project.

CA-MRN-674

Recent archaeological investigations at CA-MRN-674 (P-21-2615), also known as the "Pelican Site," have confirmed the presence of intact precontact archaeological deposits between 110–140 cm (3.6–4.6 feet) below the existing ground surface, with a thickness of 40–65 cm (Psota 2006). The archaeological deposit contained a diverse array of shellfish remains, dietary faunal remains, chert and obsidian flaked stone artifacts, a small diagnostic obsidian projectile point, and two small chert drills. Based on the quantity and variety of the artifact assemblage and integrity of the deposit, Psota (2006) concludes that CA-MRN-674 is likely to yield important information in prehistory and therefore appears eligible for listing in the NRHP under Criterion D.

The Fan Site

The fan site has been locally known for years, but was first formally recorded in 2002 (Meyer). The boundaries of the site have been fairly well established through survey and limited subsurface investigation (Meyer 2002, 2003). There are both surface and buried components to this precontact shell midden. Cultural materials present include a variety of shellfish remains, dietary faunal remains, heat-altered rock, and a few pieces of chert flaked stone. A single carbon date, approximately 230 Before Present, from the site places it in the late period of prehistory. Additional archaeological investigation is needed to formally make a determination of the site's eligibility for listing in the NRHP under Criterion D. However, it is likely that the site would be determined eligible due to the scarcity of such sites along the Marin County coast and the variety of artifacts present at the site.

Golden Gate Dairy Ranch Complex

The Golden Gate Dairy is a significant historic property that has been determined by Golden Gate NRA staff to be eligible for listing in the NRHP for both its structures and cultural landscape (Barker et al. 2005). Golden Gate will be seeking concurrence with this determination from the California State Historic Preservation Officer. This property is located adjacent to the upstream project elements in the project APE and on the east side of Hwy 1.

Ethnographic Resources

Research within the APE has resulted in the determination that the project area was used extensively by cultural groups such as the Coast Miwok in the precontact period and Azorean dairy ranchers in the historic period. The activities of these groups helped to shape the landscape of Big Lagoon, and project activities could potentially cause indirect effects on the heritage and cultural values of the groups involved in the history and prehistory of the project area (Barker et al. 2005).

Cultural Landscapes

Cultural landscapes are the result of the long interaction between people and the natural landscape. Shaped through time by historic and precontact land-use and management practices, as well as culture, politics and property laws, levels of technology, and economic conditions, cultural landscapes provide a living record of an area's past—a visual chronicle of its history. NPS has identified two cultural landscapes that may be affected by the proposed project: Golden Gate Dairy Ranch Complex, portions of which are clearly visible from the project area and physically adjacent to the APE. The other cultural landscape identified within the APE is that associated with the Coast Miwok, which is discussed under Ethnographic Resources, above. However, it does not appear that the Coast Miwok cultural landscape has retained its integrity through time from the point of contact to the present day due to the numerous historic and modern modifications of the area.

Precontact Archaeological District

Recent archaeological investigations and completed identification efforts (Psota 2006) at CA-MRN-674, have resulted in the determination that the site is eligible for listing in the NRHP, under Criterion D. Previous identification efforts at the Fan Site (Meyer 2002, 2003, 2005) have also resulted in the assumption that the site is also eligible under Criterion D.

There is the potential that these precontact archaeological sites, along with previously recorded and NRHP listed CA-MRN-333, could comprise a precontact archaeological district associated with the mouth of Redwood Creek, because sites are eligible for listing in the NRHP. NPS, in consultation with the SHPO, is in the process of determining whether the archaeological sites comprise an eligible district under NRHP. NPS will submit a letter to SHPO with information about the potential archaeological district.

3.4 Social Resources

3.4.1 Recreation and Visitor Experience

To many people, the scenic northern California coast is synonymous with nature-based recreation, and the Muir Beach area is no exception. Diverse recreational and tourism opportunities in the vicinity of Big Lagoon include Muir Beach itself, as well as nearby Stinson Beach, Muir Woods National Monument, about 4 miles inland, and various other open space areas managed by the National Park Service, State of California, and County of Marin (see Figure 3.4.1-1). Open space activities in the larger Muir Beach–Stinson Beach area thus include beach walking, hiking, trail running, mountain biking, horseback riding, birding, and wildlife and wildflower viewing. The Pelican Inn at Muir Beach offers bed-and-breakfast accommodations, and the town of Stinson Beach offers additional dining opportunities. Contemplative retreats are available at the San Francisco Zen Center's Green Gulch Farm facility. Additional coastal recreation access can be found at Point Reyes National Seashore, about an hour's drive to the north.

This section provides additional information on principal recreational opportunities and uses in the immediate project vicinity, and how they fit into the broader regional recreation context. The final discussion describes recreational use patterns in the project area, including recreational visitor motivation in selecting the Muir Beach area as a destination. Note that approximately half of the area proposed for restoration is within NPS's GGNRA, with the remainder owned by the SFZC.

3.4.1.1 Key Recreational Opportunities and Uses in the Project Area

Golden Gate National Recreation Area

Overview

The GGNRA was established in 1972 in response to an identified need to "bring national parks to the people," making national park resources more accessible to city dwellers. With a total area of more than 75,000 acres, encompassing 59 miles of Bay and ocean shoreline that extend from San Mateo County to Tomales Bay in Marin County, GGNRA is one of the nation's largest coastal preserves and one of the largest primarily urban national parks in the world (National Park Service 2006b).

The GGNRA's rich natural resources comprise 19 different ecosystems in seven separate watersheds. The GGNRA is home to as many as 80 rare, threatened, or endangered species, including the coho salmon, California red-legged frog, and northern spotted owl (National Park Service 2006b). One of the park's highlights—and a key draw for visitors from around the world—is the old growth coast redwood forest preserved at Muir Woods National Monument (see National Park Service 2006c).

GGNRA also includes cultural resources that document the Bay area's complex heritage, including sites at the Marin headlands; the disused federal prison at Alcatraz, occupied by Native American protesters from 1969 to 1971; Fort Point National Historic Site; the Presidio of San Francisco; and Fort Mason. Collectively, these sites chronicle more than 200 years of Bay area history, from prehistoric Native American culture to the Spanish Empire frontier, Mexican Republic, development of American coastal fortifications and maritime expansion, the California Gold Rush, and the growth of San Francisco as an urban center (National Park Service 2006b).

Reflecting the extent and diversity of its holdings, the GGNRA attracts some 16 million visitors each year (National Park Service 2006b).

Muir Beach

Muir Beach is one of the GGNRA's most popular destinations, combining easy access with spectacular beach scenery. At present, it serves an estimated ~~440,000~~ 260,000 visitors annually (Bignardi pers comm.).

Muir Beach consists of a sandy coastline at the mouth of Redwood Creek, bordered to the north and south by rugged cliffs. Behind the beach proper are the existing wetland and lagoon areas. The beach is open to visitors year-round, from sunrise to one hour after sunset each day. The nearby Muir Beach Overlook, also part of the GGNRA, provides outstanding panoramic views of the coastline (National Park Service 2006d).

Figure 1-2 shows existing facilities at Muir Beach. These include parking for 175 cars, and a developed picnic area south of the existing parking area, offering tables and grills, along with portable chemical toilets and garbage cans. Three additional fire rings are located on the beach near the south end of the parking lot (National Park Service 2006d).

Activities at Muir Beach include picnicking, beachcombing, dog walking, and birding. Water recreation access is available, and limited ocean swimming is feasible, but no lifeguards are provided, and visitors are cautioned to beware of rogue waves, undertow, and sharks. In addition, bacteriological contamination discourages water contact recreation (see Section 3.1.2, *Water Quality*). To protect wildlife habitat, swimming and wading are prohibited in the lagoon. Pets are permitted on the beach and in the picnic area, but must be on leash in parking and picnic areas, and under voice control or on leash on the beach. Dog management throughout GGNRA is being evaluated through an ongoing federally-sanctioned negotiated rulemaking process and a concurrent NPS environmental analysis (separate from the Big Lagoon project). The outcome of these processes will determine how dogs will be managed on lands under NPS jurisdiction within the project area. More information on this planning process can be found at http://www.nps.gov/goga and http://parkplanning.nps.gov/goga.

Fires are permitted only in grills and fire rings (National Park Service 2006d).

Muir Beach is adjacent to a County beach located immediately to the north, and offshore areas are part of the Gulf of the Farallones National Marine Sanctuary managed by NOAA.

Regional and Local Trail Network

Several important trails lead to the Muir Beach area, including the Coastal Trail, the Redwood Creek Trail, the Green Gulch Trail, and the Dias Ridge Trail (Figure 3.4.1-2). In general, the regional trails are multi-use routes that serve hikers, equestrians, and mountain bikers, although mountain bike use is restricted or prohibited in some areas, including the Redwood Creek Trail and portions of the Green Gulch Trail (Philip Williams & Associates et al. 2003).

The existing parking lot at Muir Beach provides trailhead access to the Green Gulch Trail and southern portion of the Coastal Trail. However, the other trails are difficult or dangerous to access from the parking lot, primarily due to travel on non-NPS property between NPS trails that terminate on local roads. Connections between the trails are largely absent, although the Green Gulch Trail and southern Coastal Trail merge on the valley floor before connecting to the beach via the existing bridge. Nonetheless, the southern and northern portions of the Coastal Trail are disconnected, and there is no connection from the project area to the Redwood Creek Trail, Dias Ridge Trail, or other trails to the north. The existing trail discontinuities are confusing and potentially dangerous for trail users, who must use the shoulders of narrow roadways such as Hwy 1 to access one segment from another, if they do so at all. Both NPS and the public have expressed the desirability of better trail integration in the project vicinity (Philip Williams & Associates et al. 2003).

Formalized trail access to Muir Beach is available only from the south end of the Muir Beach parking lot, via the existing pedestrian trail and bridge. An informal beach access route that crossed the tidal lagoon was closed in 2003. The beach can also be accessed from the regional trails to the south (Philip Williams & Associates et al. 2003). The existing road along the levee is also heavily used by hikers and equestrians, forming part of a popular loop route.

San Francisco Zen Center

Overview

Established in 1962, the San Francisco Zen Center is one of the largest Buddhist communities outside Asia. It operates three “practice places”—City Center in San Francisco; Tassajara Zen Mountain Center, the first Zen training monastery in the West, in Big Sur’s Ventana Wilderness; and Green Gulch Farm, adjacent to Muir Beach (San Francisco Zen Center 2006b). All three centers offer daily meditation, classes, lectures, workshops, and longer-term monastic retreats. The Zen Center serves a diverse population that includes not only priests and monks, but also students, lay members of the community, and visitors. The Zen Center also conducts a variety of community outreach programs, including homeless relief, mindfulness training for prison inmates, mindfulness and meditation training for the recovery/rehabilitation community, and social issues advocacy (San Francisco Zen Center 2006b).

Green Gulch Farm

Founded in 1972 as an offshoot of the San Francisco Zen Center's City Center, Green Gulch Farm (also called the Green Dragon Temple) is a Zen monastery and working organic farm. It also offers guesthouse and conference center facilities (San Francisco Zen Center 2006c). Portions of the property are private land located within the GGNRA boundary.

The zendo at Green Gulch Farm offers weekly instruction in meditation methods, monthly 1-day Zen sittings, and quarterly 1-week extended sittings. It also offers extended "practice period" residencies in the spring and fall, and a special 3.5-week intensive instruction in January of each year. The Farm's guest student program offers short-term (1–6 weeks) residencies for students who wish to explore Zen practice through full participation in the life of the community. Guest students take part in all activities, including sitting meditation, services, work, informal study, and group meals (San Francisco Zen Center 2006c).

Green Gulch Farm also offers a residential apprenticeship in organic gardening and farming methods. The apprenticeship combines an emphasis on meditation practice and Buddhist study with hands-on experience in organic gardening/farming techniques; apprentices are expected to follow a daily schedule of meditation and work. Work and seminar topics include a variety of topics, such as soil fertility and soil preparation; sowing, transplanting, cultivating, and harvesting vegetable crops; raised-bed flower, herb, and fruit culture; composting; care of perennial fruit crops and ornamental plants; integrated pest management techniques; farm management; and distribution via farmers' markets (San Francisco Zen Center 2006c).

Pelican Inn

The Pelican Inn is located on private land adjacent to GGNRA at Muir Beach. A local landmark and highly rated bed and breakfast, it offers guests an atmospheric 16th-century English country inn and pub experience. The Pelican Inn has seven guest rooms furnished with antiques. It also has a pub/restaurant that offers dining, as well as special event rooms appropriate for weddings and other private gatherings for as many as 100 people (Pelican Inn 2006).

Equestrian Uses and Facilities

Equestrian use is a well-established recreational activity in southern Marin County, and equestrian use is established in three locations within GGNRA southern Marin lands. As identified above, most of the regional trails in the project vicinity are multi-use facilities that equestrians share with hikers and mountain bikers, although mountain bike use is restricted or prohibited in some areas (Philip Williams & Associates et al. 2003). Equestrians also make heavy use of local trails in the project vicinity, in particular the “loop route” accessed via the levee road.

The former Golden Gate Dairy facility, an NPS site located within GGNRA at the intersection of Pacific Way and Hwy 1, is currently used by local equestrians (Figure 1-3). Managed by Ocean Riders under permit, it offers boarding and short-term paddock use and serves as a trailhead for equestrian outings, including group trail rides. Manure from the Golden Gate Dairy is supplied to Green Gulch Farm for use in their organic farming operations. The Golden Gate Dairy also plays a broader role as a community center; it currently accommodates the local mobile veterinary clinic, and in the past has been used as a County bookmobile stop and currently houses activities, equipment, and vehicles of the Muir Beach Volunteer Fire Department (Philip Williams & Associates et al. 2003).

In addition, Green Gulch Farm makes some of its facilities available to equestrians, including Ocean Riders as well as visiting equestrians, particularly riders passing through the area from other stables in the GGNRA. These include the “small paddock,” located at the southeast corner of Hwy 1 and Pacific Way on the project site; Field 7, located on the easternmost portion of the project site, which currently provides pasturage for four horses; and some of the farm’s hillside areas (Figures 1-2 and 1-3). During the summer, the fenced riding ring near the small paddock is also available for equestrian use (Philip Williams & Associates et al. 2003). Both the small paddock and riding ring are too wet to use in seasons other than summer, due to the high water table.

3.4.1.2 Recreational Use Patterns in the Project Area

Recreational visitors in the Muir Beach area comprise a diverse mix of local and regional residents, tourists in the area for short visits, and longer-term guests at Green Gulch Farm. In a 2003 survey of Muir Beach users, most respondents (94%) identified themselves as from the United States; of those, 74% were from California, with 6% of usage generated by the local Muir Beach community and an additional 8% of visitors identifying as residents or guests at Green Gulch Farm (Manning and Budruk 2003). Overall, an estimated 70% of usage at Muir Beach is by Bay Area residents, but the Muir Beach area’s proximity to other well-known tourist draws means that it is also heavily used by interstate and international tourists—surveys suggest that as many as 20% of visitors combine a visit to Muir Beach with a visit to nearby Muir Woods National Monument in the same day (Philip Williams & Associates et al. 2003).

Most (93%) visitors access the site by vehicle (car, truck, van, or sport-utility vehicle [SUV]). A small percentage arrive on foot (4%), by bicycle (1%), or by other means (Manning and Budruk 2003).

Recreational visitor surveys indicate that visitors have a wide range of motivations for choosing Muir Beach. Consistent with the breakdown for local/Bay Area/out-of area usage summarized above, these include:

- visiting the beach, coast, or ocean—56.9%
- hiking or jogging—23.4%
- general rest and relaxation—20.7%
- picnicking—14.4%
- seeing views from the mountains—10.4%
- seeing redwood trees—7.5%
- seeking solitude—6.1%
- going for a drive—3.1%
- biking, including mountain biking—2.7%
- nature study—2.0%
- surfing—0.9% (Philip Williams & Associates et al. 2003).

The beach and trails in particular are key resources for local residents (Philip Williams & Associates et al. 2003). Surveys suggest that more than half of the site's users are returnees, and many users report repeated visits to the site (Manning and Budruk 2003), reflecting their loyalty to a recreational resource that meets their needs.

3.4.2 Traffic and Circulation

This section presents standard traffic terminology; discusses patterns of visitor and local-user access to Muir Beach; and describes the transportation network that provides access to the site. Since visitors primarily access the site by vehicle, with a smaller number accessing the site on foot, by bicycle, or on horseback (Manning and Budruk 2003), and the proposed project is not expected to affect rail transport, air traffic, or mass transit, this section focuses on roadways along with pedestrian, bicycle, and equestrian access routes.

3.4.2.1 Traffic Terminology

Following are definitions of key terms used in this section, based on materials published by the Transportation Research Board (2000) and Caltrans (1999).

The quality of service provided by a roadway or intersection is usually measured in terms of three parameters.

- **Level of service (LOS):** A qualitative measure describing operational conditions within a traffic stream, based on service measures such as speed and travel time, freedom to maneuver, traffic interruptions, comfort, and convenience.
- **Volume to capacity (V/C) ratio:** The number of vehicles that travel on a transportation facility divided by the full vehicular capacity of that facility (the number of vehicles the facility is designed to convey).
- **Delay:** The additional travel time experienced by a vehicle or traveler because of inability to travel at optimal speed, and/or stops due to congestion or traffic control.

Table 3.4.2-1 shows the relationship between V/C ratio, delay, driving conditions, and LOS.

Table 3.4.2-1. V/C Ratio, Delay, and Traffic Flow Conditions for LOS Designations

		Average Delay (seconds per vehicle)		
LOS	Approximate Maximum V/C	Stop-Controlled Intersection	Signalized Intersection	Traffic Flow Conditions
A	0.3	≤10	≤10	Free-flow operations; vehicles unimpeded in ability to maneuver in traffic stream.
B	0.5	11–15	11–20	Reasonable free-flow conditions; only slightly restricted ability to maneuver.
C	0.7	16–25	21–35	Flows still near free-flow speed but noticeably restricted ability to maneuver.
D	0.9	26–35	36–55	Speeds begin to decline; maneuverability limited and queues begin to form.
E	1.0	36–50	56–80	Operation at capacity of roadway; maneuverability extremely limited and queues form with any disruption.
F	>1.0	>50	>80	Failure conditions indicating breakdowns in vehicular flow with long queues forming at breakdown points.

Sources: CalTrans 1999 (V/C ratio and flow conditions); Transportation Research Board 2000 (delay).

Following are terms describing the types of roadways in the project area.

- **Freeway:** A multilane divided highway with a minimum of two lanes in each direction and full access control, with no interruption in traffic flow. Freeways are used exclusively by vehicular traffic.
- **Highway:** A roadway with two or more lanes that is not completely access-controlled, and may have at-grade crossings and/or occasional traffic signals. Multilane highways may be divided. Two-lane highways are typically undivided. Highways may accommodate bicycle traffic.
- **Local access roadway, local roadway:** A roadway designed with the primary function of providing access to an adjacent site or development; a roadway that connects local points but does not accommodate through traffic.

3.4.2.2 Environmental Setting

Patterns of Site Access

As discussed in Section 3.4.1, *Recreation and Visitor Experience*, Muir Beach users include local residents, guests of Green Gulch Farm and the Pelican Inn, visitors from other parts of the greater Bay Area, and out-of-area tourists. Overall, an estimated 70% of usage at Muir Beach is by Bay Area residents, including residents of the local community, for whom the beach and trails are an important resource (Philip Williams & Associates et al. 2003). Consistent with this breakdown, visitor surveys suggest that more than half of the site's users are returnees, and many users report repeated visits to the site (Manning and Budruk 2003). However, because of the site's proximity to other well-known tourist draws, it is also heavily used by interstate and international tourists (Philip Williams & Associates et al. 2003). Some of these users may also visit the site more than once.

Most (93%) visitors access the site by vehicle (car, truck, van, or SUV). A small percentage arrive on foot (4%), by bicycle (1%), or by other means (Manning and Budruk 2003), including equestrian access.

Roadway Network and Vehicle Access to Muir Beach

Regional access to the Muir Beach Area is provided by US-101, Interstate 580 (I-580; the Richmond–San Rafael Bridge), Hwy 1 (also known as Shoreline Highway), and several local roadways. The regional roadway network is shown on Figure 3.4.1-1. Both US-101 and I-580 are freeways that ultimately connect to Hwy 1 at Tam Junction, east of the project site. Hwy 1, a two-lane, proceeds west over a hill to Muir Beach. Hwy 1 passes Panoramic Highway, a two-lane highway that provides access to Muir Woods, at the top of the hill. From Muir Woods, which is often visited in the same day as Muir Beach (see related discussion in Section 4.2.1, *Recreation and Visitor Experience*), the most direct route to Muir Beach is via the Muir Woods Road, a two-lane highway that connects with Hwy 1 immediately north of Muir Beach. Hwy 1, Panoramic Highway, and Muir Woods Road are winding roadways with narrow shoulders, limited visibility, and restricted passing opportunities.

The section of Hwy 1 that approaches Pacific Way is straight, and therefore is known to have fast-moving traffic. Pacific Way provides the only public vehicle access to Muir Beach from Hwy 1. Pacific Way is a narrow, winding two-lane local access roadway, with a one-lane bridge that crosses Redwood Creek. The road passes the existing Muir Beach parking lot and proceeds uphill to terminate in the residential community adjacent to Muir Beach. Congestion along Pacific Way has been identified as a concern, particularly during peak use periods; the maximum arrival rate documented by recent studies of visitor use patterns was 122 vehicles per hour, which represents a traffic volume in excess of the roadway's capacity. Accessibility along Pacific Way is also vulnerable to flooding between Hwy 1 and the existing bridge, which either makes the road impassible or forces vehicles to slow down as they ford submerged portions of the roadway, worsening the effects of congestion. Heavy traffic on Pacific Way in turn causes delays at the Pacific Way–Hwy 1 intersection (Philip Williams & Associates et al. 2003). In addition, because the existing Pacific Way Bridge can accommodate travel in only one direction at a time~~, it is unsafe, and~~ at times it is frustrating for drivers who are forced to wait during peak use periods.

Emergency vehicles access Muir Beach via public roadways, and are also authorized to use the levee roadway for access. The levee road is a single-lane unsurfaced roadway that is graded to maintain it in driveable condition, and accesses the portions of Muir Beach that are east of Redwood Creek.

Table 3.4.2-2 summarizes the existing LOS at several key intersections in the vicinity of Muir Beach, based on traffic counts performed between 2001 and 2004 (see Appendix F).

Table 3.4.2-2. Approach Delay* and LOS at Key Area Intersections During Weekday Peak Traffic Hours

	Peak Season		Shoulder Season		Off-Peak Season	
Intersection	Delay (seconds)*	LOS	Delay (seconds)	LOS	Delay (seconds)	LOS
Weekday Peak Hours						
Shoreline Highway/Muir Woods Road	16.5	C	13.1	B	12.4	B
Shoreline Highway/Pacific Way	14.8	B	11.5	B	11.0	B
Shoreline Highway/Panoramic Highway	>50	F	>50	F	28.9	D
Weekend Peak Hours						
Shoreline Highway/Muir Woods Road	>50	F	>50	F	24.3	C
Shoreline Highway/Pacific Way	17.9	C	15.2	C	11.3	B
Shoreline Highway/Panoramic Highway	>50	F	>50	F	>50	F

* *Approach delay* is the approximate wait time experienced by each vehicle arriving at an intersection, measured in seconds.

Source: DKS Associates 2006, Appendix F.

3.4.2.3 Pedestrian, Bicycle, and Equestrian Access

Figure 3.4.1-2 shows trail access to the Muir Beach area and Muir Beach itself. As discussed in Section 3.4.1, *Recreation and Visitor Access*, most of the area’s regional trails are multi-use routes that serve hikers, equestrians, and mountain bikers, although mountain bike use is restricted or prohibited in some areas, including the Redwood Creek Trail and portions of the Green Gulch Trail (Philip Williams & Associates et al. 2003). These uses are therefore discussed together. However, in addition to the hikers, bikers, and equestrians who access Muir Beach from outside the immediate area via the regional trail system, local residents also walk, bike, and horseback ride to the site. Because of the difficulty of parking at the site, local users may represent an important component of the non-vehicular access population.

Several important Marin Headlands trails provide access to the Muir Beach area, including the Coastal Trail, the Redwood Creek Trail, the Green Gulch Trail, and the Dias Ridge Trail (Figure 3.4.1-2), although only the Green Gulch Trail and southern portion of the Coastal Trail provide a direct connection to the parking lot. It is difficult and potentially dangerous to access the parking lot from the other regional trails, largely because of discontinuities in the trail system, which force pedestrians and bicyclists onto the shoulders of narrow roadways such as Hwy 1 to move from one trail segment from another (Philip Williams & Associates et al. 2003). Considering the speed at which vehicles travel along Hwy 1, the potential hazard to trail users is increased. In addition, visitors who access the site from the immediate Muir Beach Area may arrive via Pacific Way, which does not provide a separate pedestrian path; pedestrians and bicyclists compete with vehicles for space along this route. This is particularly hazardous where the roadway narrows to cross the bridge.

Once at the Muir Beach facility, visitors access the beach itself from the eastern end of the parking lot, via a pedestrian trail and footbridge across Redwood Creek. An informal route that crossed the tidal lagoon was closed in 2003. The beach can also be accessed from the regional trails to the south (Philip Williams & Associates et al. 2003).

3.4.2.4 Public Transit

Until recently, the Marin County Transit District ran the West Marin Stagecoach, a flag-stop coach service along Hwy 1. South Routes 61 and 61e (Bolinas to Mill Valley) stopped at the corner of Hwy 1 and Pacific Way, near the Pelican Inn. The routes connected with Mill Valley, Tam Junction, and the Marin City Golden Gate Transit transfer point. The routes operated Monday through Friday only. Service along Shoreline Highway was discontinued in April 2007 because of low ridership; the Stagecoach route has been realigned along Panoramic Highway.

3.4.2.5 Parking

Figure 1-3 shows the parking lot at Muir Beach. The existing gravel-surfaced lot has no delineated parking spaces, but offers space to accommodate 175 cars.

Table 3.4.2-3 summarizes current parking demand at Muir Beach, based on studies conducted for the proposed project between 2001 and 2004 (Appendix F).

Table 3.4.2-3. Parking Demand at Muir Beach

	Peak Season		Shoulder Seasons		Off-Peak Season	
	Number of Vehicles	Available Parking (%)	Number of Vehicles	Available Parking (%)	Number of Vehicles	Available Parking (%)
Weekdays	159	91	115	66%	30	17%
Weekends	**201**	115	160	91%	120	69%

Bold = demand exceeds number of available spaces.
Source: DKS Associates 2006, Appendix F.

As Table 3.4.2-3 shows, existing parking capacity at Muir Beach is insufficient to accommodate current demand for parking during the periods of heaviest use (peak season weekends). Thus, on average, parking capacity is exceeded on most weekend days during June through August, or about 25 days out of each year. When parking capacity is exceeded, overflow vehicles often illegally park on the shoulders of Pacific Way, where they worsen congestion and increase the hazard to pedestrians, and on streets in the adjacent residential neighborhood, where they may create a nuisance by impeding resident access. Illegal overflow parking on Hwy 1 also creates congestion and safety hazards (Philip Williams & Associates et al. 2003).

Green Gulch Farm, the Golden Gate Dairy stables, and the Pelican Inn all provide separate parking for their users. The Pelican Inn in particular, which is located at the intersection of Pacific Way and Hwy 1, receives some illegal parking overflow from Muir Beach, creating a nuisance for guests and staff at the Inn (Philip Williams & Associates et al. 2003).

3.4.3 Aesthetics

3.4.3.1 Introduction

The discussion below describes the current visual resources setting in the project area. The purpose of this information is to establish the existing environmental context, or background, against which the reader can then understand the environmental changes caused by the project. The environmental setting information is intended to be directly or indirectly relevant to the subsequent discussion of impacts. For example, the setting identifies groups of people who have views of the project area because the project could change their views and experiences.

Criteria for Visual Assessment

Identification of existing conditions with regard to visual resources entails three steps (based on Federal Highway Administration 1983).

1. Objective identification of the visual features (visual resources) of the landscape.
2. Assessment of the character and quality of those resources relative to overall regional visual character.
3. Identification of the importance to people, or *sensitivity*, of views of visual resources in the landscape.

With an establishment of the baseline (existing) conditions, a proposed project or other change to the landscape can be systematically evaluated for its degree of impact.

Concepts and Terminology

Visual Character

Both natural and artificial landscape features make up the *character* of a view. Character is influenced by geologic, hydrologic, botanical, wildlife, recreational, and urban features. Urban features include those associated with landscape settlement and development, such as roads, utilities, structures, earthworks, and the results of other human activities. The perception of visual character can vary significantly seasonally and even hourly as weather, light, shadow, and the elements that compose the visible landscape change. Form, line, color, and texture are the basic components used to describe visual character and quality for most visual assessments (U.S. Forest Service 1974; Federal Highway Administration 1983). The appearance of the landscape is described in terms of the dominance of each of these components.

Visual Quality

Visual *quality* is evaluated using the well-established approach to visual analysis adopted by the Federal Highway Administration (FHWA), employing the concepts of vividness, intactness, and unity (Jones et al. 1975; Federal Highway Administration 1983), as defined below.

- ***Vividness*** is the visual power or memorability of landscape components as they combine in striking or distinctive visual patterns.
- ***Intactness*** is the visual integrity of the natural and human-built landscape and its freedom from encroaching elements; this factor can be present in well-kept urban and rural landscapes, as well as in natural settings.
- ***Unity*** is the visual coherence and compositional harmony of the landscape considered as a whole; it frequently attests to the careful design of individual components in the artificial landscape.

Visual quality is evaluated based on the relative degree of vividness, intactness, and unity, as modified by its visual sensitivity. High-quality views are highly vivid, relatively intact, and exhibit a high degree of visual unity. Low-quality views lack vividness, are not visually intact, and possess a low degree of visual unity.

Visual Sensitivity and Viewer Response

The measure of the quality of a view must be tempered by the overall *sensitivity* of the viewer. Viewer sensitivity is based on the visibility of resources in the landscape, the proximity of viewers to the visual resource, the elevation of viewers relative to the visual resource, the frequency and duration of viewing, the number of viewers, and the type and expectations of individuals and viewer groups.

The criteria for identifying the importance of views are related in part to the position of the viewer relative to the resource. An area of the landscape that is visible from a particular location (e.g., an overlook) or series of points (e.g., a road or trail) is defined as a *viewshed*. To identify the importance of views of a resource, a viewshed may be broken into distance zones of foreground, middleground, and background. Generally, the closer a resource is to the viewer, the more dominant it is and the greater its importance to the viewer. Although distance zones in viewsheds may vary between different geographic regions or types of terrain, a commonly used set of criteria identifies the *foreground* zone as 0.25–0.5 mile from the viewer, the *middleground* zone as extending from the foreground zone to 3–5 miles from the viewer, and the *background* zone as extending from the middleground zone to infinity (U.S. Forest Service 1974).

Judgments of visual quality and viewer response must be made based in a regional frame of reference (U.S. Soil Conservation Service 1978). The same type of visual resource in different geographic areas could have a different degree of visual quality and sensitivity in each setting. For example, a small hill may be a significant visual element in a flat landscape, but have very little significance in mountainous terrain.

Generally, visual sensitivity is higher for views seen by people who are driving for pleasure; people engaging in recreational activities such as hiking, biking, or camping; and homeowners. Sensitivity tends to be lower for views seen by people driving to and from work or as part of their work (U.S. Forest Service 1974; U.S. Soil Conservation Service 1978; Federal Highway Administration 1983). Commuters and nonrecreational travelers have generally fleeting views and tend to focus on commute traffic and not on surrounding scenery, and therefore they are generally considered to have low visual sensitivity. Residential viewers typically have extended viewing periods and are concerned about changes in the views from their homes; therefore, they generally are considered to have moderate to high visual sensitivity. Viewers using recreation trails and areas, scenic highways, and scenic overlooks are usually assessed as having high visual sensitivity.

3.4.3.2 Environmental Setting

Regional Character

Muir Beach is located in the southwest portion of Marin County on the Pacific Ocean approximately 8 miles northwest of San Francisco. The greater San Francisco Bay region is a complex system of mountain ranges, valleys, and waterways that together create areas that are visually unique. These features not only define the character of the region but also contribute to the overall character of California. Some of these notable areas include the wine country of the Napa and Sonoma Valleys, the distinctive urban center of San Francisco, and the vertical cliffs of the Marin Headlands' Pacific coastline. In addition, the region is characterized by panoramic views from hilltops and ridgelines; rolling hillsides whose grasslands range from green and sprinkled with wildflowers in the spring to brown in the summer, contrasting against stately valley oaks with dark green foliage; and numerous waterways, the larger of which are traversed by vessels ranging from tankers to small sailboats.

A mix of industrial, commercial, residential, agricultural, and public open space uses characterizes the project region; only a subset of these (residential, agricultural, public open space, and limited commercial) are found near the project site. Most industrial, commercial, and residential development is located close to the bay. The region's public open space areas are many; the most notable in the vicinity of the project site is the Golden Gate National Recreation Area, which includes the project site itself, as well as Muir Woods, the Marin Headlands, and the Presidio in San Francisco.

Vicinity Character

The project vicinity is defined as the area within 0.5 mile of the project area. The character of the Big Lagoon project area is influenced by its geographic setting on the Pacific Ocean and its surrounding natural beauty. The northern approach to the project area is provided by Hwy 1, which approaches the site over the last coastal ridge west of Mill Valley and descends to Muir Beach. Muir Beach is a small but picturesque, crescent-shaped beach on the Pacific Ocean, and forms the southern boundary of the project area. Directly adjacent to the beach is a small tidal lagoon, and behind this is the NPS visitor parking lot and associated picnic area. Redwood Creek flows through the center of the project area and is paralleled by the Levee Road.

Existing vegetation at the project site is largely composed of riparian forest and scrub near the parking lot and near Redwood Creek. The Green Gulch pasture is flanked by the creek and Hwy 1 and is characterized as a seasonal wetland. Wildlife in the area includes monarch butterflies in the pine trees, salmon in Redwood Creek, frogs in the pasture, and fox, birds, deer, and coyotes.

Pacific Way crosses the project site from Hwy 1 and then borders the west side of the project area, where the residential community of Muir Beach is located. To the south and southeast, NPS trails climb up along the bluffs of the Golden Gate National Recreation Area. The signature local business is the Pelican Inn, a Tudor-style lodge and restaurant. Muir Beach Overlook is located approximately 0.2 mile west of Muir Beach. From this location, on a clear day, one can see San Francisco's Ocean Beach to the south, Bolinas and Point Reyes to the north, the top of Mt. Tamalpais to the east, and the Farallone Islands to the west.

Viewer Groups and Viewer Responses

Viewer groups in the vicinity of the action area and their sensitivity to visual changes in the area are characterized below.

Residents

The community of Muir Beach is located immediately adjacent to the Big Lagoon project site. Views of the project area, Pacific Ocean, and Muir Beach vary based on the viewer's location in the community. Some views are limited to the immediate foreground because they are obstructed by the built environment. Residents who reside on Lagoon Drive, Pacific Way, Sunset Way, Cove Lane, Ahab Drive, and Seascape Drive are considered to have high sensitivity to visual changes at the Big Lagoon project site because they likely have the best views of the site.

Recreational Users

Many recreational users of Muir Beach run, jog, walk, hike, or bicycle along the numerous trails in Muir Beach and the surrounding areas, including Golden Gate National Recreation Area, Zen Center-Green Gulch Farm, Muir Woods National Monument, and Mount Tamalpais State Park. Hwy 1 is a popular road biking route. The project area is also a popular place for horseback riding, picnicking, wildlife watching, sightseeing, and even boogie boarding on days when the waves are calm. Many tourists eat or stay at the Pelican Inn.

Viewer sensitivity is high among recreational visitors using Muir Beach because they are likely to value the natural environment highly, appreciate the visual experience, and be sensitive to changes in views.

Roadway Travelers

The entire segment of Hwy 1 in Marin County is an eligible state scenic highway under the Caltrans Scenic Highway Program. Motorists traveling along Hwy 1 include area residents, commuters, and Muir Beach users from the region and beyond. Travelers use roadways at varying speeds; normal highway and roadway speeds differ based on the traveler's familiarity with the route and roadway conditions (e.g., presence/absence of rain and/or traffic). Particular views typically are of short duration, except on straighter stretches where views last slightly longer. Viewers who frequently travel these routes generally possess moderate visual sensitivity to their surroundings.

Viewer sensitivity is low among most roadway travelers anticipated to view the action area. The passing landscape becomes familiar to frequent viewers; further, at standard roadway speeds, views are of short duration and roadway users are fleetingly aware of surrounding traffic, road signs, their immediate surroundings within the automobile, and other visual features. Viewers who travel local routes for their scenic quality generally possess a higher visual sensitivity to their surroundings because they are likely to respond to the natural environment with a high regard and as a holistic visual experience.

3.4.4 Energy, Public Services, Utilities, and Service Systems

This section discusses the utility and public service providers to the unincorporated Muir Beach community in Marin County. Discussion of *energy* refers to use of electricity in the project area. *Public services* include emergency response and protection by fire and police, maintenance of public facilities, and other governmental services. Discussion of *utilities and service systems* include power and natural gas, communication systems, water treatment and distribution facilities, sewer and septic tank services, and solid waste disposal.

3.4.4.1 Utilities

Electricity for Marin County is provided by the Pacific Gas & Electric Company. Approximately 9 percent of the County's electricity is used in unincorporated areas of the county, including the Muir Beach community (Marin County 2004). Within the project area, electricity is supplied to the approximate 150 residences by overhead power lines. Power poles run along Pacific Way and the levee road (the latter of which runs to a water pump which is no longer used). The lines are jointly owned by the Pacific Gas and Electric Company (PG&E) and AT&T, with PG&E being the primary user.

Telephone service for the majority of Marin County is currently provided by AT&T. A utility box that supports the phone company's infrastructure is located adjacent to Pacific Way. A telephone booth exists in the northwest corner of the Muir Beach parking lot, but its telephone has recently been removed due to infrequent use.

Water service for residences in the Muir Beach community is provided by MBCSD. An MBCSD water line runs along the north side of Pacific Way. MBCSD relies on groundwater pumped from wells located in the Frank Valley, approximately 1 mile upstream of the project site (Marin County 2003). In addition, the project site near the existing flashboard weir structure along the levee road contains an electric hook-up for a former groundwater pump that used to service the Wheelwright Farm and Green Gulch Farm. To reduce demand on upstream resources, no running water is provided by NPS at the Muir Beach visitor parking lot. More information on water supply for the project area can be found in Section 3.1.3, *Water Supply*.

All residences in the project area use septic systems to dispose of wastewater, and the area does not have centralized natural gas or cable service. Portable bathrooms are provided for Muir Beach visitors.

3.4.4.2 Solid Waste

Marin County's solid waste is taken to the Redwood Sanitary Landfill in Novato for disposal. As of June 2001, the landfill had remaining capacity for 12.9 million cubic yards of waste, an estimated disposal capacity through the year 2039 (California Integrated Waste Management Board 2005). A secondary alternative is the Bay Cities Refuse Service in Richmond, CA.

3.4.4.3 Park Maintenance

Maintenance of the extensive GGNRA parklands and facilities in Marin, San Francisco, and San Mateo counties is a major, ongoing task. Structures, historic and non-historic, need basic maintenance and repair; utilities must be kept up; trails, roadways, and parking lots require periodic maintenance and repair. At Muir Beach, vegetation management, maintenance of fences, operation of gates, restroom cleaning, and trash pick-up constitute the majority of tasks needed to maintain park facilities and resources at an acceptable level.

3.4.4.4 Fire

Fire protection for the GGNRA is currently operating under the 1993 Fire Management Plan (National Park Service 1993) and managed by the Office of Fire Management. Major NPS firefighting bases are located at Fort Cronkite and at the Main Post of the Presidio of San Francisco.

Local fire protection is provided by the Muir Beach Volunteer Fire Department (MBVFD), which includes 17 members who are all EMT or first responder trained, including an elected volunteer fire chief, and assistant fire chief. The department has two emergency vehicles, which are compatible for use with County vehicles. All volunteers are certified by the state as emergency fire fighters and are trained in CPR. In addition to Muir Beach and the surrounding community, the department is generally the first emergency responder to the Muir Woods National Monument and half the highway distance from Muir Beach to Stinson Beach in the north and Mill Valley to the east. The Department has an average response time of 5 minutes. Several of the department's volunteers are also qualified in cliff-side rescue. Funding for fire protection services is through the Muir Beach Community Services District (Marin County 2003). The local MBVFD station is housed at Golden Gate Dairy, across Hwy 1 from the project site. Regional fire protection and emergency response is provided by Marin County Fire Department. They maintain a facility on Panoramic Highway, on the Throckmorton ridge of Mount Tamalpais.

Pacific Way provides emergency access to the residential neighborhood. The levee road provides emergency access to the southern side of the project site.

3.4.4.5 Police

Muir Beach is protected by National Park Service Rangers of the San Francisco Field Office and based primarily at Fort Winfield Scott and the Cavalry Stables at the Presidio and at Fort Cronkite in the Marin Headlands. The NPS Protection Rangers are trained for horse, motorcycle, bicycle, and ATV beach patrols. They are trained in law enforcement, search and rescue, and emergency medical services.

Local police protection is also provided by the Marin County Sheriff's Department. Deputies from the substation in Marin City serve the unincorporated communities of southern Marin, from the Golden Gate Bridge to Corte Madera and from the Tiburon Peninsula to Muir Beach. Current staffing at the Marin City substation includes 16 officers, with three on duty at all times, four sergeants, one lieutenant, and three complaint takers.

3.4.5 Human Health and Safety

3.4.5.1 Hazardous Substances

Proper handling and disposal of hazardous substances is dictated by NPS policies (discussed in Chapter 4) and the California Department of Toxic Substances Control (DTSC).

The Marin Hazardous and Solid Waste Joint Powers Authority is the countywide agency responsible for implementing household hazardous waste collection in Marin County. Marin Sanitary Service operates a household hazardous waste collection facility in San Rafael that services all of Marin's jurisdictions, except for the City of Novato (Marin Hazardous and Solid Waste Joint Powers Authority 2005).

Exposure of hazardous substances to people can occur from release or improper handling of contaminated soils or waters. Potential human health effects from exposure to hazardous substances can include respiratory or reproductive problems. According to the DTSC's Cortese List, the project area does not contain sites that were previously contaminated by a release of hazardous substances (California Department of Toxic Substances Control 2005). In addition, since the project area does not have a history of land use involving chemicals, hazardous substances are not expected to be present on-site.

3.4.5.2 Fire

NPS Director's Order 18 requires that each park with vegetation capable of burning prepare a plan to guide a fire management program or FMP (National Park Service 1998). The GGNRA completed a Fire Management Plan (FMP), with a ROD signed in 2006 (National Park Service 2006d). The provision of fire protection services in the project area is described in Section 3.4.4, *Energy, Public Services, Utilities, and Service Systems*.

The principal impacts of fire on public health are burns (less common) and the inhalation of particulate matter generated as smoke from unintended fires. Particulate matter is considered such a significant health hazard that it is one of the six criteria pollutants monitored under the Clean Air Act. (See also the discussion in Section 3.1.4, *Air Quality*.) Particulate matter, found in the air-liquid droplets and small solid particles of minerals and soot, can penetrate deep into the lungs.

Healthy adults are not usually at risk from particulate matter; they may experience runny noses and coughing but these symptoms usually subside as the smoke disperses. People with heart or lung diseases, such as congestive heart disease, chronic obstructive pulmonary disease, emphysema, or asthma, can be at risk. People with these conditions may find it difficult to breathe, or may cough or feel short of breath. Children and the elderly are generally more susceptible to the harmful effects of smoke (California Air Resources Board 2003).

3.4.5.3 Mosquito Abatement

Vector-borne disease control is administered by NPS in cooperation with U.S. Public Health Service; Centers for Disease Control; California Department of Health Services, Vector-Borne Disease Section; and Marin County Department of Health Services. The Marin-Sonoma Mosquito Abatement District (MSMAD), a member of the MVCAC, works under the direct supervision of the GGNRA to assist in addressing vector-borne disease issues following guidelines stated in NPS 77 and 2001 Management policies. MSMAD maintains a small unit responsible for the prevention, elimination, or control of mosquitoes and other arthropods known to be potential carriers of infectious diseases, or that present a public nuisance (Marin-Sonoma Mosquito Abatement District 2005).

Mosquitoes, fleas, ticks, and anthropods can transport diseases such as viral encephalitis (including West Nile virus), malaria, lyme disease, ehrliciosis, babesiosis, plague, and American typanosomiasis. Together with the California Department of Health Services, local mosquito abatement districts monitor the presence and spread of these diseases through use of sentinel chicken flocks, water samples, and traps.

Seasonal, semi-permanent, and permanent wetlands that remain flooded for periods of 2–3 weeks or longer during late summer and early fall provide optimal conditions for mosquito production. In optimal conditions, mosquitoes can rapidly reproduce within 1 to 2 weeks and many species can produce multiple generations during a season. Mosquitoes commonly found in wetland areas generally prefer to breed in warm stagnant water that is rich in organic matter, or within soil and at the base of vegetation along the edges of drying pools of water. The larvae of some species hide among aquatic vegetation for protection against predators.

Integrated pest management methods are used to control mosquito and anthropod populations. It is far less costly and more effective to control mosquito populations as larvae, before they mature and disperse into the environment. The MSMAD’s primary emphasis is on cataloging, reducing and abating larval sources. Adult mosquito control, in the form of ultra-low-volume spray, is used only as a temporary measure in non-sensitive natural areas, or when other methods are not feasible. Any application of adulticides only occurs after GGNRA, U.S. Public Health Service, and the NPS Washington office agree that there is a need for such application. All pesticide application must be approved by the NPS IPM program. MSMAD works closely with NPS to provide any needed information to assist in decision-making. Abatement methods employed by the MSMAD are habitat modification, microbial or bacterial insecticides, growth-regulating hormones, and chemical larvicides. Habitat modification, the preferred control method, involves reducing areas of stagnant of water by modifying channel networks to allow flow exchange (e.g., daily tidal flows) into potential breeding areas (Marin-Sonoma Mosquito Abatement District 2005).

GGNRA will further inform and educate the public by placing educational materials about avoiding mosquito bites at park kiosks and on its web site.

3.4.5.4 Pesticide Use

Fire management and vegetation management activities conducted by the NPS within the GGNRA use pesticides, on a case-by-case approval basis, to control nonnative plant species within specific management areas. Pesticides are used when other alternatives are not feasible to prevent resprouting of cut tree stumps within nonnative evergreen forests or shrub lands, especially on blue gum eucalyptus, acacias, cotoneaster, and various brooms. Foliar applications are approved in limited scenarios where nonnative vine or shrub species create a dense and dominant component of the site, and have included Cape-ivy and eupatory. These species can form dense thickets of impenetrable vegetation near developments and other critical resources, posing a fire hazard.

All pesticide use is administered through each park's integrated pest management coordinator. All pesticides must be applied by a state-licensed pesticide applicator. All use is reported monthly to the coordinator, the county, and the State of California and yearly to the NPS Washington office.

3.4.5.5 Toxic Substances

A Phase I site investigation for potential toxic substances was conducted at the project site by Geocon Environmental Consultants for Caltrans in 1996. Groundwater and soil samples were collected and analyzed for petroleum hydrocarbons, heavy metals and a suite of volatile organic compounds. Lab results showed no substances that exceeded EPA standards or California Department of Toxic Substances Control standards. Based on the Phase I results, additional investigation was not warranted. Soils are considered suitable for hauling and use in other natural areas.

3.4.6 Land Use, Planning, and Agricultural Resources

The project site is located in unincorporated Marin County. The site is composed of both private property and GGNRA lands. The portion of the project site to the east of the existing levee road is owned by the San Francisco Zen Center, which operates Green Gulch Farm, whereas the project area to the west of the levee road is owned by GGNRA. Private property in the project vicinity includes the Pelican Inn and two homes along Lagoon Drive. Pacific Way itself is owned and maintained by the County. The following sections describe the land uses, including agricultural activities, that surround the project site, most of which are shown on Figure 1-3. Relevant land use and zoning designations are provided in Section 4.3.4.6, *Land Use, Planning, and Agricultural Resources*, which describes the guiding regulations and policies related to land use, planning, and agricultural resources.

3.4.6.1 Muir Beach Community

Established in the 1920s, the Muir Beach Community comprises approximately 150 residences and 300 people. It is located on the hillside west of the project site. It is predominantly surrounded by the GGNRA, but shares a small border with Mount Tamalpais State Park to the east. The community also includes Golden Gate Dairy, Green Gulch Farm, the Banducci Flower Farm, and the Pelican Inn, all of which are discussed in more detail below.

3.4.6.2 Green Gulch Farm

Green Gulch Farm is located to the east of project site in Green Gulch, and extends onto portions of the project site as described both above and below. Green Gulch Farm is a 111-acre property owned and managed by the San Francisco Zen Center. Green Gulch Farm, which is private land located within the GGNRA boundary and is designated as a Special Use Zone in the GGNRA General Management Plan (1980), was established in 1972. Approximately 45 permanent residents live there, where Zen training, meditation practice, and programs are their primary focus. On the site, approximately 10–15 acres are used for agriculture, planted with organic herbs, flowers and vegetables. Also on site, approximately 9 acres are used to pasture approximately 12 horses. A portion of this pasturage is on the project site east of the levee road. Green Gulch Farm also includes a riding arena and small paddocks for temporary horse stabling, both of which are located on the project site.

3.4.6.3 Golden Gate Dairy

Golden Gate Dairy is an NPS historic site located to the north of the project site, across Hwy 1 from the Pelican Inn. A local equestrian group, Ocean Riders, is currently permitted to use the barn and stalls to board horses.. Approximately 11 privately owned horses are boarded at this facility, including several owned by residents of the Muir Beach community. The horses are not permitted to pasture on the adjacent hillsides.. The Muir Beach Volunteer Fire Department uses a building at this site for its headquarters and its fire engine.

3.4.6.4 Pelican Inn

The Pelican Inn is located on the southwest corner of the junction of Pacific Way and Hwy 1. This bed-and-breakfast inn provides seven rooms of lodging and a restaurant.

3.4.7 Noise

3.4.7.1 Noise Terminology

Sound is mechanical energy transmitted by pressure waves in a compressible medium such as air. Noise can be defined as unwanted sound. Sound is characterized by various parameters that include the rate of oscillation of sound waves (frequency), the speed of propagation, and the pressure level or energy content (amplitude). In particular, the sound pressure level is the most common descriptor used to characterize the loudness of an ambient sound level. The decibel (dB) scale is used to quantify sound intensity. Because sound pressure can vary enormously within the range of human hearing, this logarithmic loudness scale is used to keep sound intensity numbers at a convenient and manageable level. The human ear is not equally sensitive to all frequencies in the entire spectrum, so noise measurements are weighted more heavily for frequencies to which humans are sensitive in a process called *A-weighting*, written dBA.

Different types of measurements are used to characterize the time-varying nature of sound. These measurements include the equivalent sound level (L_{eq}), the minimum and maximum sound levels (L_{min} and L_{max}), percentile-exceeded sound levels (L_{xx}), the day-night sound level (L_{dn}), and the community noise equivalent level (CNEL). Below are brief definitions of these measurements and other terminology used in this chapter:

- **Sound.** A vibratory disturbance created by a vibrating object, which, when transmitted by pressure waves through a medium such as air, is capable of being detected by a receiving mechanism, such as the human ear or a microphone.
- **Noise.** Sound that is loud, unpleasant, unexpected, or otherwise undesirable.
- **Ambient Noise.** The composite of noise from all sources near and far in a given environment exclusive of particular noise sources to be measured.
- **Decibel (dB).** A unitless measure of sound on a logarithmic scale, which indicates the squared ratio of sound pressure amplitude to a reference sound pressure amplitude. The reference pressure is 20 micro-pascals.
- **A-Weighted Decibel (dBA).** An overall frequency-weighted sound level in decibels that approximates the frequency response of the human ear.
- **Equivalent Sound Level (L_{eq}).** The average of sound energy occurring over a specified period. In effect, L_{eq} is the steady-state sound level that, in a stated period, would contain the same acoustical energy as the time-varying sound that actually occurs during the same period.
- **Exceedance Sound Level (L_{xx}).** The sound level exceeded XX percent of the time during a sound level measurement period. For example, L_{90} is the sound level exceed 90 percent of the time, and L_{10} is the sound level exceeded 10 percent of the time.

- **Maximum and Minimum Sound Levels (L_{max} and L_{min}).** The maximum or minimum sound level measured during a measurement period.
- **Day-Night Level (L_{dn}).** The energy average of the A-weighted sound levels occurring during a 24-hour period, with 10 dB added to the A-weighted sound levels occurring during the period from 10:00 p.m. to 7:00 a.m.
- **Community Noise Equivalent Level (CNEL).** The energy average of the A-weighted sound levels occurring during a 24-hour period with 5 dB added to the A-weighted sound levels occurring during the period from 7:00 p.m. to 10:00 p.m. and 10 dB added to the A-weighted sound levels occurring during the period from 10:00 p.m. to 7:00 a.m.

L_{dn} and CNEL values rarely differ by more than 1 dB. As a matter of practice, L_{dn} and CNEL values are considered to be equivalent and are treated as such in this assessment.

3.4.7.2 Ambient Noise Environment

Short-term noise monitoring in various parts of the county was conducted for Marin County’s Countywide Plan update in 2001. Long term noise monitoring conducted on Hwy 1, north of Stinson Beach, indicates that traffic noise along Hwy 1 is approximately 60 dBA, L_{dn} (Marin County Community Development Agency 2002). Ambient noise levels at Muir Beach and in the adjacent areas are generally low (i.e., at or below 60 dBA, L_{dn}). Primary noise sources in the project area include traffic from the roadways, noise generated by residences and park visitors, and near the beach at the Pacific Ocean.

3.4.7.3 Noise-Sensitive Land Uses

Sensitive land uses are generally defined as locations where people reside or where the presence of noise could adversely affect the use of the land. Typical noise-sensitive land uses include residences, schools, hospitals, and parks. Noise-sensitive land uses the vicinity of the project area include residences located west of the project area, particularly those on Pacific Way and Lagoon Drive that are immediately adjacent to the project area; the Pelican Inn, a bed-and-breakfast lodging that provides a quiet setting for vacationers, located at the corner of Pacific Way and Hwy 1; San Francisco Zen Center’s Green Gulch Farm, located to the east of Field 7, which provides a quiet setting for visitors and residents; and recreational users of Muir Beach. Residences and other noise-sensitive land uses also occur along the haul routes to the various fill disposal sites. Figure 1-3 shows the project site and adjacent sensitive receptors.