National Park Service
U.S. Department of the Interior

Water Resources Division
Natural Resource Program Center

Technical Report NPS/NRWRD/NRTR-2006/348

GOLDEN GATE
NATIONAL RECREATION AREA

CALIFORNIA

WATER RESOURCES FOUNDATION REPORT

The National Park Service Water Resources Division is responsible for providing water resources management policy and guidelines, planning, technical assistance, training, and operational support to units of the National Park System. Program areas include water rights, water resources planning, regulatory guidance and review, hydrology, water quality, watershed management, watershed studies, and aquatic ecology.

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Cover photos:

Top: Golden Gate Bridge, Don Weeks
Middle: Rodeo Lagoon, Joel Wagner
Bottom: Crissy Field, Joel Wagner

Golden Gate National Recreation Area

California

Water Resources Foundation Report

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Technical Report NPS/NRWRD/NRTR- 2006/348

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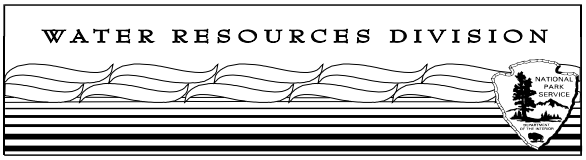

United States Department of the Interior
National Park Service

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EXECUTIVE SUMMARY

This Water Resources Foundation Report is one of several planning products offered by the NPS Water Resources Division that assist national park units with achieving or maintaining water resource integrity.

Following the 2004 Park Planning Program Standards, parks are to prepare a *Foundation for Park Planning and Management* document (Foundation Document), which describes its purpose, significance, primary interpretive themes and special mandates, identifying and analyzing those resources and values determined to warrant primary consideration (*Fundamental Resources and Values*) in park planning and management. The Foundation Document may be developed as the first stage of a park's general management planning or independently of a General Management Plan (National Park Service, 2004a).

This Water Resource Foundation Report is designed to support development of the Foundation Document for Golden Gate National Recreation Area's (GOGA's) planning process and extend as a reference for the General Management Plan, which includes Muir Woods National Monument (MUWO) and Ft. Point National Historic Site (FOPO). Discussions in this report include MUWO since fundamental water resources exist and warrant consideration in GOGA's planning process.

The primary objectives of this report are to 1) provide background for water resources and 2) build from the park's purpose and significant statements, identifying and describing the fundamental water resources at GOGA and MUWO, along with the identification of stakeholders and laws and policies that apply to these fundamental water resources.

Workshops were held to generate *Purpose Statements*, which describe the specific reason(s) for establishing the park and *Significant Statements*, which define what is most important about the park's resources and values and are based on the park purpose.

The *Purpose Statement* for GOGA is, "To offer national park experiences to a large urban population while preserving and interpreting its outstanding natural, historic, scenic, and recreational values."

The *Purpose Statement* for MUWO is, "To preserve the primeval character and ecological integrity of the old growth redwood forest for scientific values and inspiration."

One of the GOGA *Significant Statements* that pertains to water resources is, "An undeveloped remnant coastal corridor of marine, estuarine, and terrestrial ecosystems that support exceptional native biodiversity and provides a refuge of one of the largest concentrations of rare, threatened, and endangered species in the national park system."

A *Significant Statement* for MUWO is, "The last remnant old growth forest close to an urban center that retains its primeval character and supports a relatively intact ecosystem, and Muir Woods is an important manifestation of early 20th Century conservation history."

Building from these *Significant Statements*, water can easily be defined as a fundamental resource at both GOGA and MUWO. The park's fundamental water resources have been grouped into the following four categories, realizing some overlap between categories (i.e., wetlands and coastal water resources):

1. Freshwater streams and ponds
2. Groundwater aquifer and springs
3. Wetlands
4. Coastal and marine water resources

The importance of water at GOGA and MUWO, justifying the resource as fundamental to the both park units, includes:

- Adequate freshwater flows and water quality are important in the preservation of the numerous rare and endangered species at GOGA and MUWO. The water resources have many beneficial uses including water contact and non-water contact recreation, fish migration and spawning, and municipal water supply.

- Groundwater is important for recharge of surface water systems, including wetlands, supporting rare and endangered species habitat and as a source for municipal and agricultural water supplies.

- Wetlands provide water quality protection, flood and drought mitigation, erosion control, and groundwater recharge function. Wetlands support complex food webs, housing a rich biodiversity of wetland-endemic species, providing habitat functions for many aquatic and terrestrial species.

- The intertidal and subtidal zones of GOGA's littoral environments are some of the most diverse and productive ecosystems in the world. Coastal habitats are important for the preservation of several rare and endangered species.

The current conditions and trends of water resources at GOGA and MUWO include:

- GOGA contains five streams and three bays that park waters flow into that are identified as impaired and included on the State 303(d) list: *Lagunitas Creek* with elevated concentrations of nutrients, pathogens and sedimentation/siltation from agriculture and urban runoff/sewers; *Rodeo Creek* and *Coyote Creek* with elevated concentrations of diazinon from urban runoff/sewers; *San Francisquito Creek* with elevated concentrations of diazinon from urban runoff/sewers and

sedimentation from non-point sources*; San Pedro Creek* with high coliform counts from urban runoff/storm sewers and nonpoint sources; *Richardson Bay* with chlordane and DDT from nonpoint sources, deldrin from unknown nonpoint sources, dioxin compounds from atmospheric deposition, high coliform from urban runoff/storm sewers, septage disposal, and boat discharges/vessel wastes, and mercury from municipal point sources, resource extraction, atmospheric deposition, natural sources and nonpoint sources; *Tomales Bay* with mercury from mine tailings, nutrients from agriculture, pathogens from intensive animal feeding operations, and sedimentation/siltation from agriculture and upstream impoundments; *San Francisco Bay (central)* with chlordane, DDT, diazinon and deldrin from nonpoint sources, dioxin compounds and furan compounds from atmospheric deposition, mercury from industrial point sources, municipal point sources, resource extraction, atmospheric deposition, natural sources and nonpoint sources, PCBs from unknown nonpoint sources, and selenium from industrial point sources, agriculture, natural sources and exotic species.

- Nitrogen concentrations in groundwater samples exceeded EPA recommendations in 41% of the samples collected. The likely sources are from wastewater disposal and irrigation return flow.

- Historic and current alterations to wetlands and other aquatic environments have led to a decrease in functions and species abundance and diversity within.

- San Francisco Bay-Estuary receives less than 50 percent of its historical freshwater inflows, altering the biological communities.

Some of the water-related issues that need to be addressed at GOGA and MUWO, including some of the latest thoughts on management approaches, are summarized below:

- The Redwood Creek watershed is one of the most important resource management areas in GOGA. Even though most of the Redwood Creek watershed is protected in public ownership, resources in the watershed are threatened by encroaching landuses, water diversion, non-point source pollution, fire suppression, erosion and sedimentation, and other stressors.

  In 2002-03, public agencies in the watershed collaborated to create a vision for the watershed's future. Two important elements needed for long-term restoration of salmon habitat and the eventual recovery of salmonid populations in the Redwood Creek watershed are: 1) the reduction of accelerated erosion and sediment delivery to the stream channel system and 2) improving estuarine rearing habitat (Pacific Watershed Associates, 2002).

  Impacts of groundwater pumping on Redwood Creek streamflow can be minimized by restricting pumping to nighttime hours when streamflow is not being further depleted by evapotranspiration. Water conservation measures by the Muir Beach community should reduce the water demand, lessening the impact

of groundwater pumping. The Muir Beach Community Services District has recently adopted an Adaptive Management Plan (2005) that is intended to reduce the impact of their operations on streamflow and fishery resources.

- The Rodeo Lagoon watershed is the only estuarine resource which has its watershed completely within the park boundary. A comprehensive restoration project for the lake, lagoon, and watershed is necessary. Actions to support watershed management decisions include: 1) monitor lagoon fish community; 2) investigate the effects of poor water quality on ecology of Rodeo Lagoon; 3) monitor and mitigate water quality and erosion; 4) inventory and monitor other sensitive species; and 4) restore habitat and correct wildlife disturbance problems.

- Lobos Creek provides water to the Presidio. The creek is to be restored as a naturally flowing stream and the valley preserved as a wild area. In order to protect the natural resource values along Lobos Creek (one of the last free-flowing creeks in San Francisco), a minimum creek flow of 0.5 mgd has been established (Presidio Trust, 2002). Watershed goals for the Lobos Creek Valley developed by the NPS and Urban Watershed Project (Urban Watershed Project, 2001) include; 1) enhance, preserve and protect water quality in Lobos Creek, 2) balance instream flow requirements for habitat and wildlife with efficient water supplies to the Presidio community, 3) facilitate natural physical, hydrologic, and biological processes to reestablish the native aquatic and riparian habitats of Lobos Creek, and 4) develop broad community understanding, stewardship and protection of Lobos Creek natural resources, water quality and riparian habitat.

- Several potential disposal, landfill, and industrial sites require environmental investigation in GOGA.

- A sizeable amount of the park's historic wetland and aquatic sites has been altered. Two major wetland and aquatic restoration projects are Crissy Field and Mountain Lake (National Park Service, 1999a). The Crissy Field Marsh needs to be enlarged to increase its viability as a functioning intertidal system.

- The mosaic of wetlands at the mouth of Redwood Creek, once known as Big Lagoon, have been disturbed over the past century by developments including water diversions for community use, levees for agricultural use, the NPS visitor parking lot, agriculture, and stream bank manipulations (e.g., gabions and riprap.) The downstream channel has been extensively modified and has severely aggraded since the early 1990's, causing flooding on local roads under average flow events. The NPS is currently planning a restoration of the Big Lagoon area to remove hydraulic constraints, such as a levee and the configuration of the visitor parking lot, and to allow better conveyance of flows and sediment loads through the channel and more extensive floodplain connection.

- San Francisco Bay-Estuary depends on freshwater inflows from the delta. The bay now receives less than 50 percent of its historical freshwater inflows. The

biological communities of the Bay-Estuary are altered by the disruption of natural flow patterns. The rate and timing of these freshwater flows are among the most important factors influencing physical, chemical, and biological conditions in the Estuary (California Regional Water Quality Control Board, 1995). To the greatest extent feasible, the remaining marshes and mudflats around the Bay, the remaining water volume and surface area of the Bay, and adequate fresh water inflow into the Bay should be maintained (San Francisco Bay Conservation and Development Commission, 1998).

Stakeholders who have an interest in GOGA and MUWO's water resources include:

- Federal:

  National Oceanic and Atmospheric Administration – National Marine Fisheries Services (listed fish)
  National Oceanic and Atmospheric Administration – National Marine Sanctuary Program (Gulf of the Farallones NMS)
  National Resource Conservation Service
  Point Reyes National Seashore
  U.S. Army Corps of Engineers
  U.S. Coast Guard (NRDA, oil spill response)
  U.S. Environmental Protection Agency
  U.S. Fish and Wildlife Service
  U.S. Geological Survey

- State:

  California Coastal Commission (local implementation of federal Coastal Zone Management Act)
  California Department of Fish and Game
  California Department of Parks and Recreation
  California Department of Water Resources
  California Water Resources Control Board

- Regional:

  Farallones Marine Sanctuary Association
  Green Gulch Farm
  Golden Gate Audubon
  Golden Gate National Parks Conservancy
  Marin County Health Department (beach water quality)
  Marin County Municipal Water District
  Marin-Sonoma Mosquito Abatement District
  Marine resource advocacy groups (Bay Institute, Baykeeper, etc.)
  Muir Beach Community Services District
  San Francisco Bay Conservation and Development Commission

San Francisco Bay Regional Water Quality Control Board
San Francisco State University
San Francisco Watershed District
San Mateo Mosquito and Vector Control District
Stanford University
Stinson Beach County Water District
The Presidio Trust
Tomales Bay Watershed Council
University of California, Berkeley, Davis and other campuses

It should be noted that the contents of this report are limited to information acquired by the author during the time this report was prepared. As a result, descriptions of the water resources vary in detail.

INTRODUCTION

Golden Gate National Recreation Area (GOGA), established in 1972, comprises approximately 75,000 acres of primarily coastal lands in the San Francisco Bay area. Water represents the lifeblood at GOGA, supporting natural processes, diverse habitats including federal and state-listed species, and recreation. Water resources range from freshwater streams and ponds to the San Francisco Bay estuary and the marine waters of the Pacific Ocean. Transitional environments also exist between freshwater and saltwater systems (e.g., lagoons) that support a diverse aquatic ecology.

The collision of geologic plates at the continent's edge has produced a complex assemblage of rock types and landforms along California's coast. This phenomenon, in combination with the unique geology, geography and climate of the Golden Gate area, support an exceptional level of plant and animal diversity. GOGA protects this remnant coastal corridor of marine, estuarine, fluvial, and terrestrial ecosystems, which supports this biodiversity and serves as a refuge for one of the largest concentrations of rare, threatened and endangered species in the national park system. In recognition of this ecological significance, lands in GOGA are part of an International Biosphere designated by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and included in lands (The California Floristic Province) recognized by the Conservation International as one of 34 global "hot spots" in the world, containing some of the highest diversity of endemics, plant, and animals found in the world. Part of what makes the California Floristic Province a hotspot is that its spectacular biodiversity is seriously threatened (http://www.calcademy.org/naturalhistory/california_hotspot/overview.htm). A fundamental resource essential toward the preservation of this biodiversity and the threatened and endangered species is *water*.

In 2004, GOGA began the process to update their 1980 General Management Plan (GMP), which includes Muir Woods National Monument (MUWO, established in 1908) and Ft. Point National Historic Site (FOPO, established in 1970). A new GMP is needed to address some of the jurisdictional changes and new information and understanding about the park's resources. Along with GOGA, discussions in the report include MUWO since fundamental water resources exist and warrant consideration in GOGA's planning process.

GOGA is following the 2004 Park Planning Program Standards during this process, which begins with the development of a *Foundation for Park Planning and Management* document (Foundation Document). The first two planning workshops (February and May, 2005) produced both the *Purpose Statements* for GOGA and MUWO, and *Significance Statements* for natural resources, building from the purpose statements presented on the following page.

Purpose Statements

The purpose of Golden Gate National Recreation Area is to offer national park experiences to a large urban population while preserving and interpreting its outstanding natural, historic, scenic, and recreational values.

The purpose of Muir Woods National Monument is to preserve the primeval character and ecological integrity of the old growth redwood forest for scientific values and inspiration.

Significance Statements for Natural Resources

Golden Gate National Recreation Area:

- The convergence of the San Andreas Fault, San Francisco Bay at the Golden Gate, and the California coastline creates a dynamic landscape and environment of exceptional scientific value.

- The undeveloped remnant coastal corridor of marine, estuarine, and terrestrial ecosystems that support exceptional native biodiversity and provide a refuge for one of the largest concentrations of rare, threatened, and endangered species in the national park system.

- The natural scenic landscapes, vistas, and coastal environment of the Golden Gate area are an internationally recognized panoramic backdrop to the metropolitan San Francisco Bay area that contributes to the quality of life of the residents.

- The continuum of lands and resources at the doorstep of the San Francisco Bay area provides an abundant range of recreational and educational opportunities.

Muir Woods National Monument:

- The last remnant old growth forest close to an urban center that retains its primeval character and supports a relatively intact ecosystem, and Muir Woods is an important manifestation of early 20th Century conservation history.

Water Resources Planning

This Water Resources Foundation Report is designed to support development of the Foundation Document for Golden Gate National Recreation Area's (GOGA's) planning process. This section outlines in detail the individual elements of this new NPS planning framework and better describes how this report fits into the framework.

The NPS Water Resources Division initiated a program in 1991 that assists parks with their water resources planning needs. Recent changes in NPS general planning (2004 *Park Planning Program Standards*) and resources planning (draft *Director's Order 2.1: Resource Stewardship Planning*) required programmatic revision to the existing NPS Water Resources Planning Program to assure that its products support the new NPS planning framework within which planning and decision-making are now accomplished. Within this new planning framework, six discrete elements of planning are in place that are captured in six planning-related documents (Figure 1).

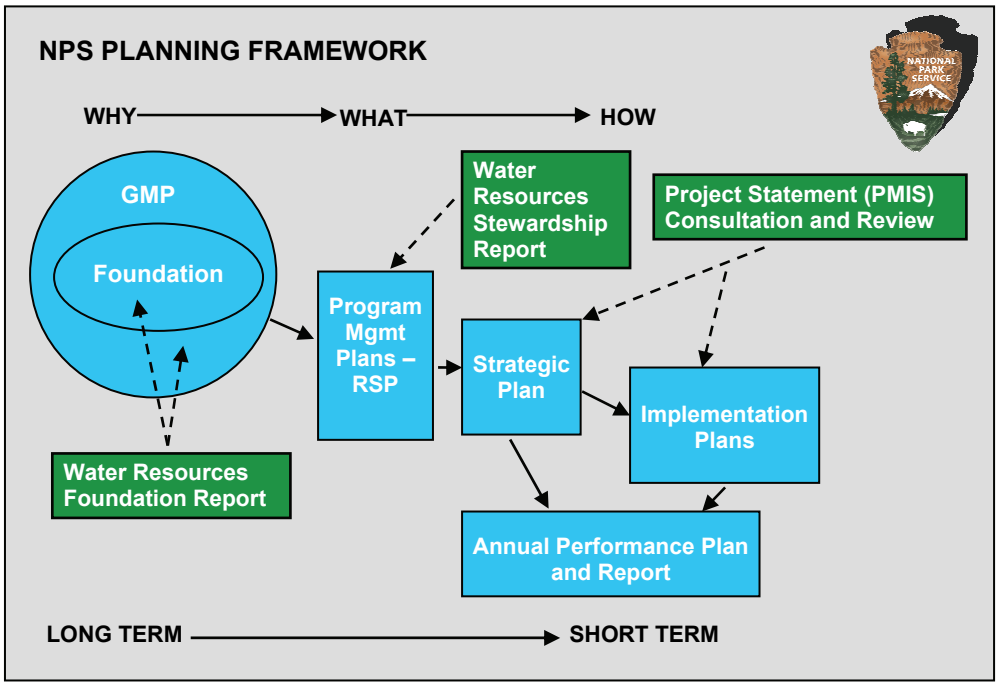

Figure 1. The 'new" NPS framework for planning and decision making (blue boxes). Green boxes represent WRD planning or assistance. RSP = Resource Stewardship Plan.

The *Foundation for Planning and Management* (Foundation) document defines the legal and policy requirements that mandate the park's basic management responsibilities, and identifies and analyzes the resources and values that are fundamental to achieving the park's purpose or otherwise important to park planning and management.

The *General Management Plan* (GMP) uses information from the Foundation document to define broad direction for resource preservation and visitor use in a park, and serves as

the basic foundation for park decision-making, including long-term direction for *desired conditions* of park resources and visitor experiences.

The *Program Management Plans* tier off the GMP, identifying and recommending the best strategies for achieving the desired resource conditions and visitor experiences presented in the GMP. Program planning serves as a bridge to translate the qualitative statements of *desired conditions* established in the GMP into measurable or objective indicators that can be monitored to assess the degree to which the *desired conditions* are being achieved. Based on information obtained through this analysis, comprehensive strategies are developed to achieve the *desired conditions*. The Program Management Plan component for natural and cultural resources is the Resource Stewardship Plan (RSP) (Figure 1).

The *Strategic Plan* tiers off the Program Management Plan identifying the highest-priority strategies, including measurable goals that work toward maintaining and/or restoring the park's *desired conditions* over the next 3 to 5 years.

Implementation Plans tier off the Strategic Plan describing in detail (including methods, cost estimates, and schedules) the high-priority actions that will be taken over the next several years to help achieve the *desired conditions* for the park.

The *Annual Performance Plan and Report* measures the progress of projects from the Implementation Plan with objectives from the Strategic Plan.

The *Water Resources Foundation Report* and the *Water Resources Stewardship Report* will support this new planning framework. The Water Resources Foundation Report (Figure 1) addresses the needs of either the Foundation Document or phase one of the GMP. The Water Resources Stewardship Report (Figure 1) is designed specifically to address the water resource needs in a park's RSP.

Water Resources Foundation for Planning and Management Objectives and Structure

This report is a *Water Resources Foundation Report* for GOGA. The primary objectives of this report are to; 1) provide background for water resources and 2) identify and describe the fundamental water resources at GOGA, including MUWO, along with the identification of stakeholders and laws and policies that apply to these fundamental water resources. An expanded section on water rights is also included for background information. The water-related information contained in this report is designed to assist GOGA with development of the Foundation Document, which ultimately supports the preparation of a new park General Management Plan.

The report is divided into two major parts. The first part contains a brief description of the parks' natural resources, with emphasis on water resources. This section provides the reader with a brief overview of GOGA's diverse environments. The second part summarizes the park's fundamental water resources and values. Watershed stakeholders

who have an interest in the park's water resources and values are also identified, along with water-related laws and policies.

Location and Demography

The Golden Gate National Recreation Area (GOGA) is one of the largest urban national parks in the world. The park encompasses approximately 75,000 acres of land and water that extends north of the Golden Gate Bridge to Tomales Bay in Marin County and south to San Mateo County, including close to 60 miles of bay and ocean shoreline (Figure 2). These lands represent one of the nation's largest coastal preserves and attract 16 million visitors each year, making GOGA one of the National Park Service's most highly visited units (National Park Service, 2005a).

Figure 2. Location map for Golden Gate National Recreation Area.

DESCRIPTION OF NATURAL RESOURCES

Climate

The climate of GOGA and the surrounding coastal region is characterized by hot, dry summers and rainy, mild winters typical of a moderate Mediterranean climate (National Park Service, 2004b). Most precipitation falls as rain, and about 90 percent of the rainfall occurs between November 1st and April 30th (Wahrhaftig and Lehre, 1974a). Mean annual precipitation ranges from 20 inches in San Francisco to 50 inches in Kentfield, although it varies greatly from year to year. Precipitation increases abruptly with altitude, especially on windward slopes (see Figure 3). Fog drip can contribute 10 to 20 inches of moisture to vegetation. Mean annual temperatures (57º to 60º F) depend greatly on exposure to fog (National Park Service, 1990a).

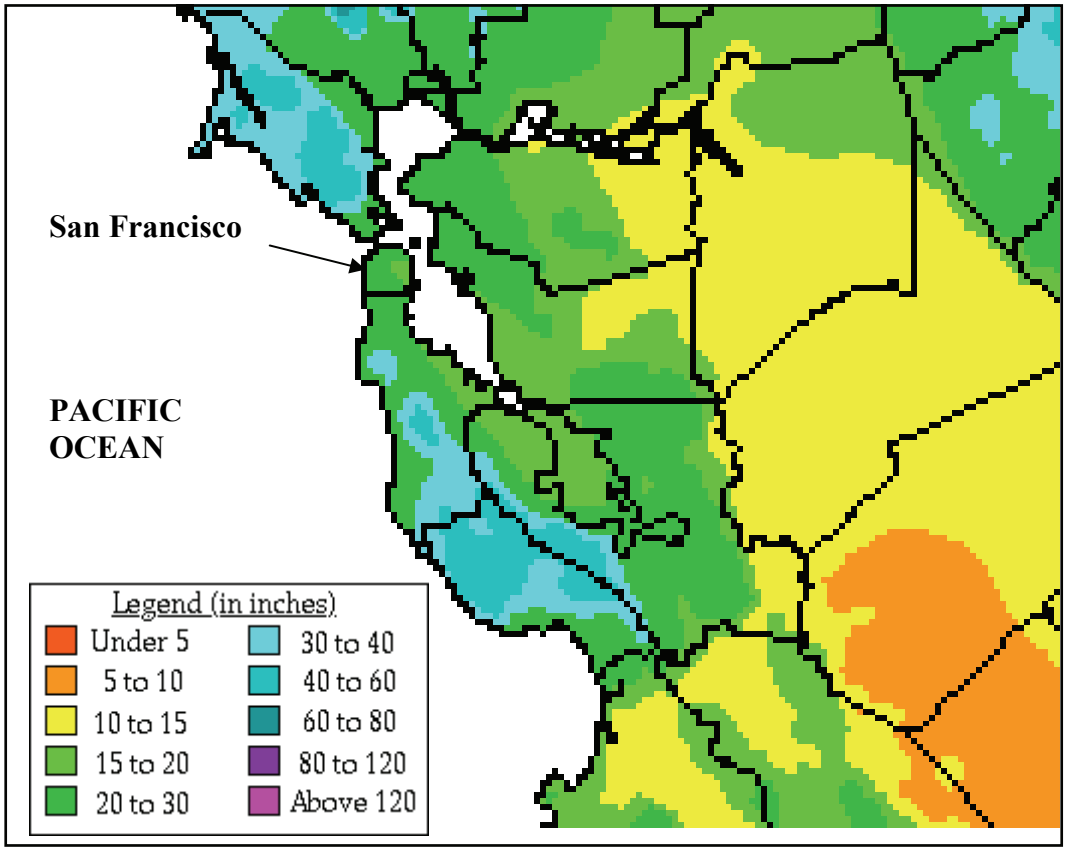

Figure 3. Average annual precipitation for the San Francisco Bay Area.

Physiography

The topographical relief of the park ranges from sea level to 2,300 feet above mean sea level (msl) near the top of Mt. Tamalpais. The long and narrow park is divided by the Golden Gate entrance to the San Francisco Bay, which separates the northern Marin

County lands from the southern San Francisco and San Mateo County lands (National Park Service, 1990a). Hillslopes range from almost flat marine terraces and alluvial deposits to steep canyons along some creeks, and near vertical bluffs above some beaches (National Park Service, 1999a).

Geology

Bedrock parent materials within the park are jumbled, as a result of grinding movement along the converging plate boundary and San Andreas Fault. Sandstone, pillow basalts, shale, chert, greenstone (basalt), serpentine, and metamorphic rocks are among the bedrock types present. These rocks belong to the Franciscan Assemblage and were originally deposited on the ocean floor 80 to 140 million years ago (National Park Service, 1999a). The rocks were greatly deformed and partly metamorphosed as the ocean floor (Pacific Plate) was thrust under the western edge of the North American Plate. This resulted in a landscape of easily eroded sandstone and shale, with occasional blocks of more resistant rock forming prominent outcrops (National Park Service, 1999a). The Marin Headlands contain some of these more resistant rocks, producing a prominent landscape of relatively high topographic relief.

Structurally, GOGA is located in a seismically active zone. The San Andreas Fault, which extends most of the length of California, defines many of the major recognizable landforms in the park. The fault zone in GOGA is evident along Tomales Bay, the Olema Valley, and Bolinas Lagoon in Marin County, then extends offshore and makes landfall again at Fort Funston in San Francisco and is highlighted to the south by the lakes and reservoirs within San Francisco watershed lands in San Mateo County. The San Andreas is the major fault in the area, but smaller faults do exist. Movement of the San Andreas continues at an average of about 1 to 2 cm/year (National Park Service, 1999a). Earthquakes are associated with this movement along the length of the fault.

Soils

Within GOGA, the parent rock determines the type of soil that develops over it and affects characteristics such as landslide and erosion potential. Soils at the park are particularly susceptible to landslides (e.g., Franciscan Formation). Most have a high erosion potential. The county soil survey maps are available at the USDA/Natural Resources Conservation Service (NRCS). These maps detail the soils for the counties, providing information on the characteristics of individual soil types (Natural Resources Conservation Service, 2005).

Hydrology

Watersheds

According to the NPS Management Policies, the NPS will manage watersheds as complete hydrologic systems, and will minimize human disturbance to the natural upland processes that deliver water, sediment, and woody debris to streams (National Park

Service 2001). Watersheds are delineated by the U.S. Geological Survey using a nationwide system based on surface hydrologic features. This system divides the country into 21 regions, 222 subregions, 352 accounting units, and 2,262 cataloguing units. A hierarchical hydrologic unit code (HUC) consisting of 2 digits for each level in the hydrologic unit system is used to identify any hydrologic area. The 6-digit accounting units and the 8-digit cataloguing units are generally referred to as basin and sub-basin, respectively. HUC is defined as the Federal Information Processing Standard (FIPS) and generally serves as the backbone for the country's hydrologic delineation. GOGA, including MUWO, is located within the San Francisco Bay Basin (180500). The 8-digit cataloguing sub-basin units that include GOGA are San Pablo Bay (18050002), San Francisco Bay (18050004), Tomales-Drake Bays, which also includes MUWO (18050005), and San Francisco Coastal South (18050006) located in the San Francisco Bay watershed basin (180500) (see Figure 4; U.S. Geological Survey 2005). It should be noted that the San Francisco Bay Regional Water Quality Control Plan (Basin Plan) uses different names for the same basins (California Regional Water Quality Control Board, 1995).

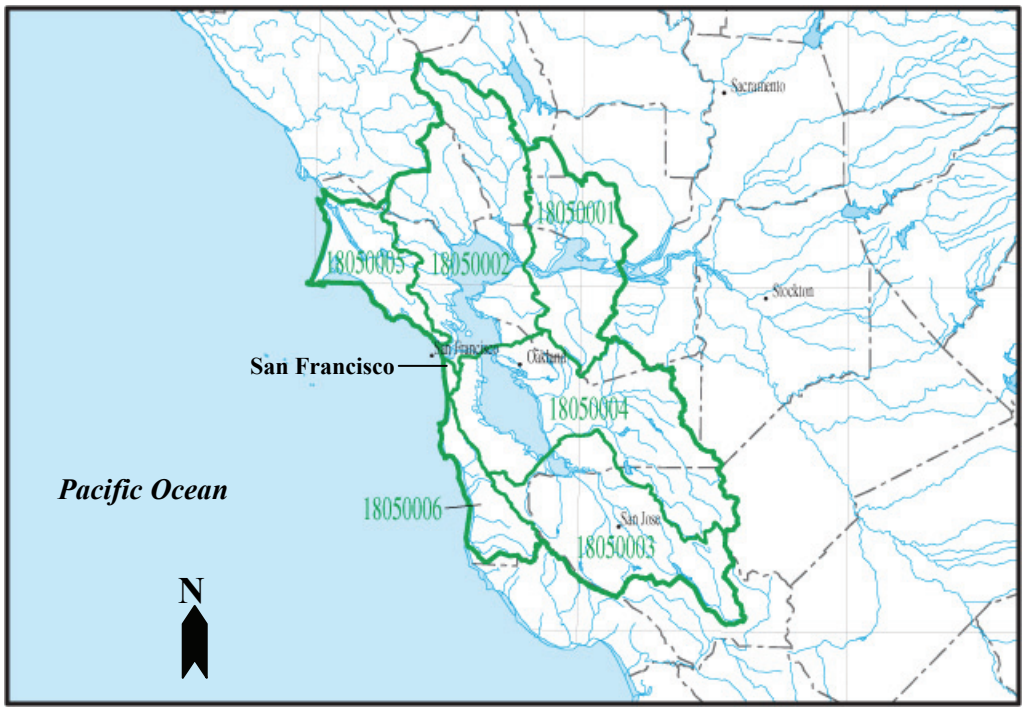

Figure 4. San Francisco Bay Basin with Sub-Basins identified. (modified after U.S. Geological Survey, 2005)

Most watersheds within the sub-basins are less than one square mile in area, and flow through narrow V-shaped stream beds cut through bedrock (National Park Service, 1999a). Portions of seven significant watersheds are located within the park. They are, from north to south: Lagunitas Creek*, Olema Creek*, Bolinas Lagoon, Redwood Creek, Elk Creek, Rodeo Creek, Lobos Creek, Milagra Creek, Calera Creek and San Pedro

Creek (* located in GOGA's north district lands and managed by Point Reyes National Seashore).

Surface Water

In GOGA, most runoff occurs during the 50 to 70 days of winter storms. Maximum flows occur during and immediately after winter storms. Flashy stormflow is caused by the steep basins and shallow soils, promoting rapid runoff. After the last significant rain of the season (around April), streamflow steadily declines. Dry season baseflow is low and flow ceases in some streams in the summer (National Park Service, 1990a). Lobos Creek is a notable exception, being fed by groundwater from an extensive aquifer.

Lakes and Ponds

Mountain Lake, one of the last remaining natural lakes in San Francisco, is the only natural lake managed by GOGA. Enhancement of Mountain Lake is being implemented by the Presidio Trust. There are several small dammed impoundments in GOGA.

Rivers and Streams

Five moderately-sized drainages in GOGA are contained in the northern lands of Marin County. These drainages from the northern boundary of the park are: Lagunitas Creek, Olema Creek, Redwood Creek, Elk Creek (in Tennessee Valley) and Rodeo Creek. Historically, Redwood and Lagunitas creeks had significant salmon and steelhead runs, which are now a fraction of their former magnitude (National Park Service, 1990a). Lagunitas Creek, which flows into Tomales Bay, provides habitat for several rare species (e.g., California freshwater shrimp (*Syncaris pacifica*), tidewater goby (*Eucyclogorius newberryi*)). Olema Creek is a major tributary to Lagunitas Creek, flowing north up Olema Valley into Lagunitas Creek. Many small creeks (Copper Mine Gulch, Wilkins Gulch, Pike County Gulch, Morses Gulch, McKinnan Gulch, Stinson Gulch, and Easkoot Creek) exist on Bolinas Ridge and flow into Bolinas Lagoon. Redwood Creek flows down the south side of Mount Tamalpais, through Muir Woods, to Muir Beach where it empties into the Pacific Ocean. The creek once emptied into Big Lagoon, but due to alterations, Big Lagoon is greatly diminished in size (National Park Service, 1990a). Elk Creek travels down Tennessee Valley and empties into a manmade pond before entering the Pacific Ocean. Rodeo Creek has two major tributaries, one flowing through Rodeo Valley and one through the Gerbode Valley. The creek flows into Rodeo Pond, which was artificially created by a dam and weir, and then to Rodeo Lagoon before entering the Pacific Ocean (National Park Service, 1990a).

Very few free-flowing streams still exist in San Francisco County. Lobos Creek flows through the Presidio of San Francisco. The creek empties into the Pacific Ocean at Baker Beach in GOGA. Much of the water is diverted near the mouth, treated, and used for potable water supply for the Presidio. This spring-fed creek has the highest summer-fall baseflow within GOGA (approximately 3 ft^3/sec). Also on the Presidio, the Tennessee

Hollow watershed and Dragonfly Creek, which flow to Crissy Marsh and the San Francisco Bay, respectively, are undergoing riparian restoration.

In San Mateo County, an unnamed intermittent stream flows through the GOGA lands at Milagra Ridge. San Pedro Creek, a San Mateo County park, is within the GOGA boundary and has a steelhead trout (*Oncorhynchus mykiss*) migration (National Park Service, 1990a). Sanchez Creek, a heavily altered urban stream flows along the park boundary at Mori Point, and supports both native and introduced fish, as well as amphibians. Drainages in Phleger Estates are tributaries to San Francisquito Creek, which flows to San Francisco Bay and supports steelhead habitat.

Stream channel gradients in GOGA range from 3% in Elk Creek to 35% in steep tributaries on Bolinas Ridge (National Park Service, 1999a).

Wetlands

The goals of the California Wetlands Conservation policy include ensuring "no overall net loss", achieving a "long-term net gain in the quantity, quality, and permanence of wetlands acreage and values…" (California Regional Water Quality Control Board, 1995).

Wetlands represent transitional environments between terrestrial and aquatic systems where the water table is at or near the surface or the land is covered by shallow water (Cowardin et al., 1979). Flora within these wetland systems exhibit extreme spatial variability, triggered by very slight changes in elevation. Temporal variability is also great because the surface water depth is highly influenced by changes in precipitation, evaporation and/or infiltration. Cowardin and colleagues (1979) developed a wetland classification system that is now the standard in the federal government. In this system, a wetland must have one or more of the following attributes: (1) at least periodically, the land supports predominately hydrophytes; (2) the substrate is predominately undrained hydric soil; and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year. There are four federal government agencies responsible for identifying and delineating wetlands: the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and Natural Resources Conservation Service.

The U.S. Fish and Wildlife Service developed wetlands data through the National Wetlands Inventory (NWI) program. NWI maps that included lands in GOGA are available in a digital format, but these maps typically have less accuracy than on-site delineation and often miss smaller wetlands completely (U.S. Fish and Wildlife Service, 2005). Because of this, GOGA has initiated field wetland mapping at high priority sites and has developed a park-wide wetland map based on a park-wide vegetation survey.

There are numerous wetlands throughout GOGA, including wetlands located at Crissy Field, Stinson Beach, Mountain Lake, Easkoot Creek, Nike Swale, Sweeney Ridge, Mori Point, Tennessee Valley, Rodeo Valley, and Big Lagoon to name a few. These wetlands

provide important habitats in the park. For example, the seasonal wetland-upland complex at Mori Point is suitable habitat for the federally-listed San Francisco garter snake (*Thamnophis sirtalis tetrataienia*). The park is engaged in several wetlands restoration projects to address impacts to these important environments. One of the larger and more visible wetlands restoration projects is located at Crissy Field, where wetlands and marsh existed prior to being filled by the military as an airfield. GOGA has since created Crissy Marsh within the footprint of this historic wetland system and is exploring opportunities for expanding and enhancing the marsh.

Groundwater

The geology and shallow soils in GOGA do not support widespread groundwater resources, but local aquifers are important for water supply. Lobos Creek, a groundwater-fed stream, provides water for the Presidio. The City and County of San Francisco is evaluating use of the sand aquifer in the vicinity of Fort Funston. Some of the flat alluvial valleys in Marin County provide local groundwater supply outside the park (National Park Service, 1990a).

There are springs in several areas of the park. In southern Marin County, springs are located near trails where construction revealed the presence of a high water table. Seeps and springs in Tennessee Valley were developed for domestic and ranch use prior to the creation of the park. South of the Golden Gate Bridge in San Francisco County, there is a year-round spring at the Sutro Baths ruins. The spring was once tapped for a fresh water pool in the Sutro Baths. Several seeps exist in the Fort Scott and Lands End area, and along the bluffs at the Presidio. Many of the seeps and springs within the park support important wetland habitat.

Coastal and Marine Water Resources

A major resource of the GOGA is the more than 25 miles of coastline. The intertidal and subtidal zones of the littoral environment are some of the most diverse and productive ecosystems in the world. Ocean Beach stretches 3.3 miles along the west coast of San Francisco, where a highway parallels the foredune system for the entire length of the beach. Problems with erosion from wave attack and wind-blown sand have persisted since development of the area (National Park Service, 1990a). The park encompasses 0.6 miles of Stinson Beach, a 2.7-mile-long sand spit about 10 miles north of San Francisco Bay. Considerable wave-induced erosion can occur on the beach deposits during major winter storms. Smaller beaches also exist with GOGA's boundary: Tennessee Cove, Rodeo Beach and the beaches of Bonita and Kirby Coves. None of the beaches in GOGA are being naturally replenished with any sizeable quantity of sand from local streams or long-shore deposits, thus erosion of sand is not likely to be replaced in sufficient quantities (National Park Service, 1990a).

Horizontal and vertical movement of water along the coast varies by season and brings changes in local weather and climate such as fog. These conditions also lead to the seasonal appearance of upwelling, which brings nutrient-rich waters to the sunlit zone

resulting in one of the five most productive marine environments in the world. The seasonal changes in coastal current patterns create dynamic beaches and dunes through the coastal erosion and transport of sand.

Two large bays and two major lagoons are affected by GOGA management in Marin County. They include; San Francisco Bay, Tomales Bay, Bolinas Lagoon and Rodeo Lagoon. An additional lagoon, Big Lagoon, at the mouth of Redwood Creek was once a substantial resource but has been diked and filled to where it is virtually gone.

Tomales Bay is an estuary that is 12.6 miles long, approximately 12 feet deep, and varies from 0.5 to 1.5 miles wide covering approximately 10 square miles in surface area. Bolinas Lagoon is a natural lagoon of about 1,400 acres. It is not within the park boundaries but is fed by park waters and influenced by park management (National Park Service, 1990a). Rodeo Lagoon is located at Rodeo Beach and fed by Rodeo Creek. The lagoon provides habitat for the federally-listed tidewater goby (*Eucyclogorius newberri*).

The San Francisco Bay is a complex estuarine system consisting of several smaller bays. The area of the bay ranges from approximately 400 square miles at low tide to 460 square miles at high tide (National Park Service, 1990a). This large body of water is relatively shallow, with a depth less than 18 feet for more than half of the bay. Fresh water flowing into the Bay dilutes the salt water of the ocean flowing into the Bay through the Golden Gate. The Bay waters thus provide a gradual change from the salt water of the ocean to the fresh water flows of the Sacramento and San Joaquin Rivers. This delicate relationship between fresh and salt water helps to determine the ability of the Bay to support a variety of aquatic life and wildlife (San Francisco Bay Conservation and Development Commission, 1998).

Water Quality

The pollution of surface waters and groundwaters by point and non-point sources can impair the natural function of aquatic and terrestrial ecosystems and diminish the utility of park waters for visitor use and enjoyment. Water pollution is a continuing threat to NPS units located close to large urban areas. According to the NPS Management Policies, the NPS will determine the quality of GOGA water resources and avoid, whenever possible, the pollution of park waters by human activities occurring within and outside park boundaries (National Park Service, 2001).

The NPS Water Resources Division completed a comprehensive summary of existing surface water quality data for GOGA, the *Baseline Water Quality Inventory and Analysis, Golden Gate National Recreation Area* (National Park Service, 2005b). This document presents the results of surface water quality data retrievals for GOGA from six of the United States Environmental Protection Agency's (EPA) national databases: (1) Storage and Retrieval (STORET) water quality database management system; (2) River Reach File (RF3); (3) Industrial Facilities Discharge (IFD); (4) Drinking Water Supplies (DRINKS); (5) Water Gages (GAGES); and (6) Water Impoundments (DAMS).

The results of the GOGA water quality criteria screen found 21 groups of parameters that exceeded screening criteria at least once within the study area. Dissolved oxygen, pH, chloride, cadmium, copper, lead, mercury, and zinc exceeded their respective EPA criteria for the protection of freshwater aquatic life. Dissolved oxygen, pH, chlorine, cadmium, copper, mercury and zinc exceeded their respective EPA criteria for the protection of marine aquatic life. Chloride, fluoride, sulfate, nitrate, arsenic, cadmium, chromium, lead, mercury, nickel, and dibromochloropropane (DBCP) exceeded EPA drinking water criteria. Fecal-indicator bacteria concentrations (total coliform, fecal coliform, E.coli, and enterococci) and turbidity exceeded the WRD screening limits for freshwater and marine water bathing and aquatic life, respectively (National Park Service, 2005b).

GOGA contains five streams and three bays that park waters flow into that are identified as impaired and included on the State 303(d) list (San Francisco Bay Regional Water Quality Board, 2002):

- *Lagunitas Creek* with elevated concentrations of nutrients, pathogens and sedimentation/siltation from agriculture and urban runoff/sewers;
- *Rodeo Creek* with elevated concentrations of diazinon from urban runoff/sewers;
- *Coyote Creek* with elevated concentrations of diazinon from urban runoff/sewers;
- *San Francisquito Creek* with elevated concentrations of diazinon from urban runoff/sewers and sedimentation from non-point sources*;*
- *San Pedro Creek* with high coliform counts from urban runoff/storm sewers and nonpoint sources;
- *Richardson Bay* with chlordane and DDT from nonpoint sources, deldrin from unknown nonpoint sources, dioxin compounds from atmospheric deposition, high coliform from urban runoff/storm sewers, septage disposal and boat discharges/vessel wastes, and mercury from municipal point sources, resource extraction, atmospheric deposition, natural sources and nonpoint sources;
- *Tomales Bay* with mercury from mine tailings, nutrients from agriculture, pathogens from intensive animal feeding operations, and sedimentation/siltation from agriculture and upstream impoundments;
- *San Francisco Bay (central)* with chlordane, DDT, diazinon and deldrin from nonpoint sources, dioxin compounds and furan compounds from atmospheric deposition, mercury from industrial point sources, municipal point sources, resource extraction, atmospheric deposition, natural sources and nonpoint sources, PCBs from unknown nonpoint sources, and selenium from industrial point sources, agriculture, natural sources and exotic species.

Air Quality

The NPS is responsible to preserve, protect and enhance air quality and air quality related values of the National Park System units under both the Organic Act (16 U.S.C. 1, 1a-1) and the Clean Air Act (National Park Service, 2001).

Air quality is linked to many natural processes (i.e., soil and water nutrients, photosynthesis, acidification of lakes and streams). Air quality degradation encompasses several different sources of stress including acid deposition, ozone, and increase in the concentration and/or type of toxins and heavy metals, visibility/haze, and nitrification. Air quality is an important issue for GOGA due to the close proximity to highly urbanized areas. The air pollutants of greatest concern in the San Francisco Bay Area Air Basin (AFBAAB) are ozone, carbon monoxide, and inhalable particulate matter (particulate matter < 10 microns).

Pinnacles National Monument (PINN) and Point Reyes National Seashore (PORE) are rated as Class 1 areas by the Clean Air Act and are protected by strict air quality regulations. The rest of the parks in the San Francisco Bay Network (SFAN) including GOGA and MUWO are Class 2 areas and pollution regulations are less strict. However, in some instances federal land managers apply the "precautionary principle" and treat Class 2 areas with the same standards as Class 1 Areas. Within the NPS, a majority of parks show improvements in visibility on clear days and in the concentration of sulfates present in precipitation. Nearly all parks show degradation or no change in nitrate levels in precipitation. Almost half of the parks show significant degradation in ozone levels, with only few showing an improvement (National Park Service, 2004b).

Biological Resources

Water resources are critical to the sustenance of GOGA's populations of flora and fauna with biological resources intimately linked to hydrological systems. GOGA is a place of great biological diversity, a result of the wide variety of environmental conditions found in the area. On the San Francisco Peninsula, conditions leading to high biological diversity and species with limited distributions (endemic species) include; 1) the interaction of maritime weather and Mediterranean climate to produce localized climatic zones, 2) the development of diverse habitats and barriers to dispersal by mountains and bays, and 3) the presence of a variety of geologic and soil conditions, such as nutrient-poor sand dunes and serpentine-derived soils. This combination of conditions allowed for an adaptive flourishing of many closely related species (National Park Service, 2005c). As such, the park is rich in biological resources and home to 1,273 plant and animal species. With 80 sensitive, rare, threatened, or endangered species, the park has the fourth largest number (33) of federally protected or endangered species of all units in the national park system (National Park Service, 2005a).

Flora

Many plant communities are associated with GOGA's water resources. Riparian plant communities found along the streams of the park are dominated by willows (*Salix sp*.) and alders (*Alnus sp*.) and a great mix of associated plant species. Freshwater ponds are dominated by cattails (*Typha sp*.) and water weed (*Elodea sp*.). Shallow wetlands are often dominated by Oenanthe (*Oenanthe sarmentosa*) or potentilla (*Potentilla egedii*). Lagoon areas are dominated by *Salicornia virginia* and cordgrass (*Spartina foliosa*) (National Park Service, 1990a). Estuarine and marine areas contain varying amounts of macroalgae (although kelp beds are largely absent) and vascular plant (*Zostera marina* and *Phyllospadix sp*.).

Dune communities are the subject of much visitor impact and native flora is suffering. However, a native dune grass (*Elymus mollis*) and many native herbs can still be observed (National Park Service, 1990a).

Special Status Species

Candidate species for listing that are associated with park waters include: the Franciscan thistle (*Cirsium andrewsii*), which is associated with seeps and wetlands at Ft. Point and the Marin Headlands; salt marsh bird's beak (*Cordylanthus maritimus*) associated with salt water lagoons; and western leatherwood (*Dirca occidentalis*) associated with moist areas and known to exist at Devils Gulch (National Park Service, 1990a). Other federally-listed plant species of concern in the region, typically found in wet habitats (marsh, seeps, etc.) include; Maison's Lilacopsis (*Lilaeopsis masonii*) (state listed as "rare"), Point Reyes meadowfoam (*Limnanthes douglasii ssp. sulphurea*) (state listed as "endangered"), Marin knotweed (*Polygonum marinese*), California beaked-rush (*Rhynchospora californica*), Thurber's reed grass (*Calamagrostis crassiglumis*), and Swamp harebell (*Campanula californica*) (Marin County, 2004).

Fauna

Threatened and Endangered Species

The Federally listed species associated with water resources in GOGA include: the California freshwater shrimp (*Syncaris pacifica*) located in Lagunitas Creek; the southern bald eagle (*Haliaeetus leucocephalus*) that feed in the park waters; coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*) present in Lagunitas Creek and Redwood Creek; Sacramento River winter-run chinook salmon (*Oncorhynchus tshawytscha*) only present in the San Francisco Bay portions of GOGA; California red-legged frog (*Rana aurora draytonii*) present in the wetlands in Marin and San Mateo county lands of GOGA; tide water goby (*Eucyclogobius newberryi*) in Rodeo Lagoon and a new locale in Giacomini Ranch; Stellar sea lion (*Eumetopias jubatus*) along the coast; and the San Francisco garter snake (*Thamnophis sirtalis tetrataenis*) at the upland complexes in San Mateo County (National Park Service, 1990a; National Park Service, 1999a; Marin County, 2004).

FUNDAMENTAL WATER RESOURCES AND VALUES

It is important for NPS units to identify the fundamental resources and values critical to achieving the park's purpose and maintaining its significance. The reasons for identifying fundamental and other important resources and values are:

1. To define and understand the most important resources and values that support the park's purpose and significance. If these resources and values are degraded or eliminated, they then jeopardize the park's purpose and significance.
2. To ensure the planning team and public understand the key elements that sustain the park's purpose and significance.
3. To help planning and management activities focus on larger issues and concerns regarding protection of the resources and values that support the park's purpose and significance.
4. To allow the planning team to test out alternatives and estimate how they will influence the fundamental resources and values of the park.
5. To become the building blocks in creating a future vision and management strategy for the park while being responsive to the park's needs.

Identifying the fundamental resources and values at GOGA and MUWO helps ensure that all planning is focused on what is truly most significant about the park. The following sections follow a format provided by the NPS Denver Service Center (DSC) Planning Division. This includes six questions that are answered for fundamental resources (water resources) at the park. The first two questions are centered on water resources in general:

1. Who are the stakeholders who have an interest in GOGA and MUWO's water resources and values?
2. Which laws and policies apply to GOGA and MUWO's water resources and values, and what guidance do the laws and policies provide?

The remaining four questions focus on specific water resources at GOGA and MUWO, taking a look at four categories; 1) *freshwater streams and ponds*, 2) *groundwater aquifer and springs*, 3) *wetlands*, and 4) *coastal and marine water resources*, which includes some unavoidable overlap between categories (e.g., wetlands and coastal water resources). For each category, the following questions are answered from existing technical references provided to the author, forming the justifications as fundamental park resources and including the current status of these resources:

3. What is the importance of these water resources and values?
4. What are the current state or conditions and the related trends of these water resources and values?
5. What are the potential threats to these water resources and values?
6. What are the issues that need to be addressed through the consideration of GMP alternatives?

Looking at the first two questions centered on GOGA and MUWO's water resources in general:

1. **Who are the stakeholders who have an interest in GOGA and MUWO's water resources and values?**

Federal:

National Oceanic and Atmospheric Administration – National Marine Fisheries Services (listed fish)
National Oceanic and Atmospheric Administration – National Marine Sanctuary Program (Gulf of the Farallones NMS)
National Resource Conservation Service
Point Reyes National Seashore
U.S. Army Corps of Engineers
U.S. Coast Guard (NRDA, oil spill response)
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Geological Survey

State:

California Coastal Commission (local implementation of federal Coastal Zone Management Act)
California Department of Fish and Game
California Department of Parks and Recreation
California Department of Water Resources
California Water Resources Control Board

Regional:

Farallones Marine Sanctuary Association
Green Gulch Farm
Golden Gate Audubon
Golden Gate National Parks Conservancy
Marin County Health Department (beach water quality)
Marin County Municipal Water District
Marin-Sonoma Mosquito Abatement District
Marine resource advocacy groups (Bay Institute, Baykeeper, etc.)
Muir Beach Community Services District
San Francisco Bay Conservation and Development Commission
San Francisco Bay Regional Water Quality Control Board
San Francisco State University
San Francisco Watershed District
San Mateo Mosquito and Vector Control District
Stanford University

Stinson Beach County Water District
The Presidio Trust
Tomales Bay Watershed Council
University of California, Berkeley, Davis and other campuses

2. Which laws and policies apply to GOGA and MUWO's water resources and values, and what guidance do the laws and policies provide?

The management of GOGA and MUWO's water resources is guided by many federal and state laws and policies.

Park specific

Public Law 92-589: "**In order to preserve** for public use and enjoyment certain areas of Marin and San Francisco counties, California, **possessing outstanding natural**, historic, **scenic, and recreational values**, and in order to provide for the maintenance of needed recreational open space necessary to urban environment and planning, the Golden Gate National Recreation Area is herby established." (National Park Service, 1980).

The GMP Amendment for the Presidio (National Park Service, 1994) lays out the following water resource management objective: *Manage onsite water resources to protect ground and surface water resources and natural wetland and riparian values and to efficiently supply water to the Presidio community*.

State lands are leased by the NPS, which includes well over half of the submerged coastal lands within GOGA's boundary. The NPS agrees to manage the leased tide and submerged lands to protect and conserve the environment and any cultural and historical resources that may be present. The NPS is to preserve the lands in their natural state and protect them from development and uses which would destroy their scenic beauty and natural character. Fishing, including the taking of mollusk or crustacean shall be permitted in accordance with the regulations imposed by the State Department of Fish and Game.

Federal

Management of GOGA and MUWO's water resources is also guided by many additional federal laws and NPS policies.

- The *National Park Service Organic Act* of 1916 created the NPS and includes a significant management provision stating that the NPS *shall promote and regulate the use of the federal areas known as national parks, monuments, and reservations by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for future generations*. The Organic Act also authorizes

the NPS to *regulate the use* of national parks and develop rules, regulations and detailed policies to implement the broad policies provided by Congress. Rules and regulations for the national park system are described in the *Code of Federal Regulations* (Title 36).

- The *General Authorities Act* of 1970 strengthened the 1916 *Organic Act*, stating that lands in all NPS units, regardless of title or designation, shall have a common purpose of preservation. All water resources in the national park system, therefore, are equally protected by federal law. It is the primary duty of the NPS to protect those resources unless otherwise indicated by Congress.

- The *Redwood National Park Act* of 1978 amended the *General Authorities Act* of 1970, identifying the *high public value and integrity of the national park system* as reason to manage and protect all park system units. The act further stated that no activities should be allowed that will compromise the *values and purposes for which these various areas have been established*, except where specifically authorized by law or provided for by Congress.

- The *National Parks Omnibus Management Act* of 1998 outlined a strategy to improve the ability of the NPS to provide high-quality resource management, protection, interpretation and research in the national park system by:

    - Fostering the collection and application of the highest quality science and information to enhance management of units of the national park system;
    - Authorizing and initiating cooperative agreements with colleges and universities, including but not limited to land grant schools, along with creating partnerships with other Federal and State agencies, to construct cooperative study units that will coordinate multi-disciplinary research and develop integrated information products on the resources in national park system units and/or the larger region surrounding and including parks;
    - Designing and implementing an inventory and monitoring program of national park system resources to collect baseline information and to evaluate long-term trends on resource condition of the national park system, and;
    - Executing the necessary actions to fully and properly apply the results of scientific study to park management decisions. Additionally, all NPS actions that may cause a significant adverse effect on a park resource must conduct unit resource studies and administratively record how study results were considered in decision making. The trend in resource condition in the national park system shall be a critical element in evaluating the annual performance of the NPS.

- The 1972 *Federal Water Pollution Control Act*, also known as the *Clean Water Act*, strives to restore and maintain the integrity of U.S. waters. The Clean Water Act grants authority to the states to implement water quality protection through best management practices and water quality standards. Section 404 of the act

requires that any dredged or fill materials discharged into U.S. waters, including wetlands, must be authorized through a permit issued by the U.S. Army Corps of Engineers, which administers the Section 404 permit program. Additionally, Section 402 of the act requires that pollutants from any point source discharged into U.S. waters must be authorized by a permit obtained from the National Pollutant Discharge Elimination System (NPDES). All discharges and storm water runoff from major industrial and transportation activities, municipalities, and certain construction activities generally must be authorized by permit through the NPDES program. NPDES permitting authority typically is delegated to the state by the U.S. Environmental Protection Agency.

- *Safe Drinking Water Act* (42 USC 3001 et seq.) applies to developed public drinking water supplies. It sets national minimum water quality standards and requires testing of drinking water.

- *2001 NPS Management Policies*: The NPS will determine the quality of park surface and groundwater resources and avoid, whenever possible, the pollution of park waters by human activities occurring within and outside of parks.

    - ❖ Work with appropriate governmental bodies to obtain the highest possible standards available under the Clean Water Act for the protection of park waters.
    - ❖ Take all necessary actions to maintain or restore the quality of surface waters and groundwaters within the parks consistent with the Clean Water Act and all other applicable federal, state, and local laws an regulations; and
    - ❖ Enter into agreements with other agencies and governing bodies, as appropriate, to secure their cooperation in maintaining or restoring the quality of park water resources.

- *2001 NPS Management Policies:* The NPS will manage watersheds as complete hydrologic systems, and will minimize human disturbance to the natural upland processes that deliver water, sediment, and woody debris to streams. The NPS will achieve the protection of watershed and stream features primarily by avoiding impacts to allow watershed processes to proceed unimpeded.

- *Executive Order* 11990: *Wetlands Protection* requires the NPS to 1) exhibit leadership and act to minimize the destruction, loss, or degradation of wetlands; 2) protect and improve wetlands and their natural and beneficial values; and 3) to refrain from direct or indirect assistance of new construction projects in wetlands unless there are no feasible alternative to such construction and the proposed action includes all feasible measures to minimize damage to wetlands.

    2001 NPS Management Policies: The NPS will manage wetlands in compliance with NPS mandates and the requirements of Executive Order

11990 (Wetland Protection), the Clean Water Act, and the Rivers and Harbors Appropriation Act of 1899, and the procedures described in Directors Order 77-1. The service will 1) provide leadership and take action to prevent the destruction, loss, and degradation of wetlands; 2) preserve and enhance the natural and beneficial values of wetlands; and 3) avoid direct and indirect support of new construction in wetlands unless there are not practicable alternatives and the proposed action includes all practicable measures to minimize harm to wetlands. The NPS will implement a "no net loss of wetlands" policy.

- *Executive Order* 11988: *Floodplain Management* has a primary objective *...to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is an practicable alternative*. For non-recurring actions, the order requires that all proposed facilities must be located outside the boundary of the 100-year floodplain. Barring any feasible alternatives to construction within the floodplain, adverse impacts are to be minimized during the design phase of project planning. NPS guidance for this executive order can be found in D.O. 77-2.

  2001 NPS Management Policies: In managing floodplains on park lands, the NPS will 1) manage for the preservation of floodplain values; 2) minimize potentially hazardous conditions associated with flooding; and 3) comply with the NPS Organic Act and all other federal laws and executive orders related to the management of activities in flood-prone areas, including Executive Order 11988 (Floodplain Management), NEPA, applicable provisions of the Clean Water Act, and the Rivers and Harbors Appropriation Act of 1899. Specifically the NPS will:

  - ❖ Protect, preserve, and restore the natural resources and functions of floodplains;
  - ❖ Avoid the long-and short-term environmental effects associated with the occupancy and modifications of floodplains; and
  - ❖ Avoid direct and indirect support of floodplain development and actions that could adversely affect the natural resources and functions of floodplains or increase flood risks.

- *Coastal Zone Management Act* (16 USC 1451 et seq.) requires permits for work in the coastal zone and also mandates that consistency determinations be carried out for projects and activities that affect the coastal zone. This program is administered by the California Coastal Zone Commission.

  2001 NPS Management Policies: Natural shoreline processes (such as erosion, deposition, dune formation, shoreline migration) will be allowed to continue without interference. Where human activities have altered the nature or rate of natural shoreline processes, the NPS will, in consultation

with appropriate state and federal agencies, investigate alternatives for mitigating the effects of such activities or structures and for restoring natural conditions. New developments will not be placed in areas subject to wave erosion or active shoreline processes unless 1) the development is required by law; or 2) the development is essential to meet the parks' purposes, as defined by its establishing act of proclamation, and

- ❖ No practicable alternative locations are available,
- ❖ The development will be reasonably assured by surviving during its planned life span, without the need for shoreline control measures, and
- ❖ Steps will be taken to minimize safety hazards and harm to property and natural resources.

National Park Service Ocean Stewardship Goals (Davis, 2004):

1. Preserve unimpaired ocean wildlife, natural processes, cultural resources, and recreational opportunities in the National Park System.
2. Restore or rehabilitate impaired ocean wildlife, natural processes, cultural resources, and recreational opportunities in the National Park System.
3. Increase National Park Service capacity for stewardship of ocean natural and cultural heritage.
4. Improve National Park Service partnerships for stewardship of the nation's ocean-related natural and cultural heritage.

- The *Clean Air Act* of 1970 (as amended in 1990) regulates airborne emissions of a variety of pollutants from area, stationary, and mobile sources. The amendments to the act were added primarily to fill gaps in earlier regulations pertaining to acid rain, ground level ozone, stratospheric ozone depletion and air toxics, and also to identify 189 hazardous air pollutants. The act directs the U.S. Environmental Protection Agency to study these pollutants, identify their sources, determine the need for emissions standards and develop and enforce appropriate regulations.

- The *National Environmental Policy Act* (NEPA) of 1969 requires that any action proposed by a federal agency that may have significant environmental impacts shall *utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment*.

- The *Endangered Species Act* of 1973 requires the NPS to identify all federally listed endangered, threatened and candidate species that occur within each park unit and promote their conservation and recovery. The act requires that any activity funded by federal monies that has the potential to impact endangered

biota must be consulted through the Secretary of Interior. It requires agencies to protect designated critical habitats upon which endangered and threatened species depend. Although not required by law, it also is NPS policy to identify, preserve and restore state and locally listed species of concern and their habitats.

- *Invasive Species* (Executive Order 13112): enhances and furthers the existing authority of the federal government to assist in preventing and controlling the spread of invasive species.

State of California

Porter-Cologne Water Quality Control Act: activities and factors which may affect the quality of the waters of the state shall be regulated to attain the highest water quality that is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible. The state board and each regional board shall be the principal state agencies with primary responsibility for the coordination and control of water quality.

The California State Water Resources Control Board (SWRCB) and nine Regional Water Quality Control Boards (RWQCB) are responsible for protecting and enhancing California's water resources under the Porter-Cologne Water Quality Control Act. The San Francisco Regional Water Quality Control Board regulates GOGA. Each RWQCB adopts Basin Plans, which contain beneficial use designations, water quality objectives and implementation programs. Under sections 305(b) and 303(d) of the Clean Water Act, California must assess overall health of the state's waters and identify waters that are not attaining water quality standards. The State must compile water quality limited waters in a 303(d) list and initiate a process to bring listed waters back into compliance. GOGA contains five streams and three bays that park waters flow into that are identified as impaired and included on the 303(d) list 2002 (it should be noted that the 303(d) list is currently being updated). See *Water Quality* section for specific list of impaired streams and bays.

The State also has authority to designate waters as Outstanding Natural Resource Waters - the highest level of protection afforded to a water body. GOGA does not have any Outstanding Natural Resource Waters, but national park waters can be strong candidates for this designation.

The laws and regulations governing California's water quality can be retrieved at (http://www.swrcb.ca.gov/water_laws/index.html). Many entities, including federal, state and local agencies and private landowners, have an interest, mandated or otherwise, in GOGA's water resources. Effective protection of water resources requires these entities to understand the various policy, regulatory and management designations associated with the parks' waters in order to foster coordination and cooperation in GOGA.

Both federal and state agencies have authority for the enforcement of appropriate regulations. Water laws and regulations at the state and local level are often patterned after federal laws, or serve in response to federal directives.

Water Quality Control Policy: The "State Policy for Water Quality Control" declares the State Board's intent to protect water quality through the implementation of water resources management programs. It serves as the general basis for subsequent water quality control policies (California Regional Water Quality Control Board, 1995).

California Water Code Section 13142.5 states, "Highest priority shall be given to improving or eliminating discharges that adversely affect…wetlands, estuaries, and other biologically sensitive sites." (California Regional Water Quality Control Board, 1995).

The goals of the *California Wetlands Conservation policy* include ensuring "no overall net loss", achieving a "long-term net gain in the quantity, quality, and permanence of wetlands acreage and values…" (California Regional Water Quality Control Board, 1995).

Senate Concurrent Resolution No. 28 states, "It is the intent of the legislature to preserve, protect, restore, and enhance California's wetlands and multiple resources which depend on them for the benefit of the people of the state." (California Regional Water Quality Control Board, 1995).

Bays and Estuaries Policy: The "Water Quality Control Policy for the Enclosed Bays and Estuaries of California" provides water quality principles and guidelines for the prevention of water quality degradation and the protection of beneficial uses of waters. (California Regional Water Quality Control Board, 1995).

Ocean Plan: The "Water Quality Control Plan for Ocean Waters of California" establishes beneficial uses and water quality objectives for waters of the Pacific Ocean adjacent to the California coast outside of enclosed bays, estuaries, and coastal lagoons (California Regional Water Quality Control Board, 1995).

Water Rights (McGlothlin, pers. comm., 2005)

Water rights are created by Congressional action or through compliance with state law. They become fully established when their characteristics are determined and affirmed either by a court or state water resources administrator. Characterization involves identifying the water-dependent purposes of a park unit, any other water uses necessary for park resources and visitors, and determining the quantity of water necessary to support those purposes and uses. Once established, the NPS must participate in administrative and legal processes to protect its water rights against injury by existing or proposed water uses. Water rights, whether federal or state law-based, are needed by the park to meet administrative needs of the park and to protect the park's natural, water-dependent resources. The following discussion addresses NPS water rights policy,

authorities for securing and protecting GOGA water rights, and a general discussion of state appropriative and Federal reserved rights.

NPS Policy and Authorities

Water for the preservation and management of GOGA will be obtained and used in accordance with legal authorities. These authorities include California Water Commission Act, NPS Organic Act, and GOGA enabling legislation. The NPS will obtain and use water in accordance with these legal authorities. The NPS will consider authorities under California and federal law on a case-by-case basis and will pursue those that are most appropriate to accomplish the purposes and protect water-related resources at GOGA. While preserving its legal remedies, the NPS will work with state water administrators to protect park resources and, if conflicts amongst multiple water users arise, will seek their resolution through good faith negotiations.

All rights to the use of water diverted from or used on federal lands within GOGA by the NPS or its concessionaires, lessors, or permittees will be perfected in the name of the National Park Service. Surface water and groundwater sources within GOGA will be withdrawn for consumptive only when such withdrawal is absolutely necessary for the use and management of the park. NPS will follow the requirements of Director's Order #35A, when considering the sale or lease of park water to persons or to State of California political subdivisions that provide public accommodations or services for park visitors outside the park. (National Park Service, 2001).

Authority for the determination and adjudication of water rights under California law is given to the California State Water Resources Control Board (SWRCB), which issues water rights for surface water and groundwater flowing in known and definite channels, pursuant to the Water Commission Act or the Water Code, initiated on December 19, 1914. California law also recognizes other water rights to use surface waters other than rights initiated under the water code, including rights initiated before December 19, 1914, and riparian water rights. All rights, regardless of type, are limited to reasonable use (California Constitution, Article X, Section 2). The Water Code allows SWRCB to adjudicate all rights to the use of surface waters within a given stream system, regardless of origin. The NPS can hold each of these different types of California water rights or Federal reserved water rights. These types of water rights are described below.

State Appropriative Water Rights

A State appropriative water right allows a specific amount of water from a specific water source, such as a river or subterranean streams flowing through known and definite channels, to be diverted, impounded, or withdrawn for a specific use. The California Water Commission Act governs the acquisition and exercise of rights to reasonable and beneficial use of surface streams, other surface bodies of water, or groundwater flowing in known and definite channels by priority of appropriation. When a water right is granted, it becomes appurtenant to the land where the water is being used for as long as the water is being used. If the land is sold, the water right transfers with the land to the new owner, unless the conveyance document excludes water rights from the conveyance.

The State uses the Prior Appropriation Doctrine to allocate water. This doctrine establishes a right to the use of water based upon "first in time, first in right." Water rights are given priority based upon the date of application. There are two forms of state appropriative rights – rights obtained pursuant to the Water Code, and so-called "pre-1914 rights". Post-1914 rights are governed by a licensing system. Prior to the Water Code, appropriative water rights could be acquired by simply taking and beneficially using water. Successful assertion of an appropriative right, which was initiated prior to December 19, 1914, requires evidence of both the original appropriation and the maintenance of the right by continuous and diligent application of water to beneficial use. Pre-1914 rights may be documented in a Statement of Water Diversion and Use filed with the SWRCB.

NPS water right records show that GOGA has at least 7 licensed water rights and may, with the acquisition of private lands within the park, also have pre-1914 rights.

Riparian Rights

The owner of land abutting natural water sources (stream, lake, spring) has the right to take water from that source for "reasonable use". These rights do not require compliance with the Water Code, but are, rather, confirmed through the courts. All return flows must be returned to the original water source. Riparian rights apply only to lands adjacent to and within the same watershed as a water body and the water must be used upon riparian land. Under a claim of riparian right, water cannot be generally stored and withheld for a deferred use, although storage of water in tanks for later use pursuant to a riparian right is allowed. A riparian owner shares the water supply co-equally with other riparian owners. If a water shortage exists, the burden is shared by all riparian users.

The United States has the same right as any other riparian landowner (California State Water Resources Control Board, 1990: *in re*: Water of Hallett Creek Stream System, 1988, 243 Cal. Rptr. 887). Although they are very poorly defined, NPS has riparian rights for consumptive water uses in the parks; state law does not recognize a riparian right for instream flow purposes. Riparian rights may have been acquired by the United States with the purchase of private lands and are also associated with lands within the parks that were formerly public domain. However, in some places within GOGA, riparian rights may have been severed from NPS-owned lands and no longer exist.

Federal Reserved Water Rights

The federal reserved water right is a judicially-created water right – the result of a series of United States Supreme Court opinions dating back to 1907. The United States Supreme Court has held that where water is needed to fulfill the purposes of a reservation of federal land, Congress intended to reserve that amount of water needed to fulfill the purpose of the reservation. Such reservations of water have been recognized for national forests, national parks, and national recreation areas. A reservation of water is implied to meet only the "primary" purposes of the reservation; water needed for "secondary" purposes should be obtained through a state's appropriative system.

In order to fully assess the existence and nature of a federal reserved water right associated with GOGA, an examination of the legislation creating GOGA and pre-existing federal reservations including the Presidio would be necessary. If needed to fulfill the purposes of the federal reservation, a federal reserved right may be either for consumptive purposes (e.g., involving diversion of water from the stream) or for non-consumptive purposes (e.g., involving instream uses of water). A federal reserved right associated with these purposes would be limited to that amount needed to accomplish those purposes. The effective date of a federal reserved water right is the date the reservation was made. While a federal reserved water right ordinarily comes into existence upon the reservation of federal land for a specific purpose, its existence can be confirmed, and its exact contours (i.e., purpose, amount, timing, source) ascertained, only through adjudication. Until such adjudication, the existence and contours of a federal reserved right are a matter of estimation.

In 1952, Congress passed the McCarran Amendment, which consented to the joining of the United States in state suits determining the water rights of all users in a watershed. This allows federal reserved water rights to be determined in conjunction with state water rights. Once adjudicated, federal reserved rights are recognized and may be administered through the state's water rights administration system. To date, federal rights for GOGA have not been adjucated.

Water Rights Issues

Existing water development for municipal and other purposes reduces streamflows in Olema Creek, Lagunitas Creek, Stinson Gulch, Easkoot Creek, McKinnon Gulch, Redwood Creek, Tennessee Valley, and Lobos Creek and threatens resources including fish habitat. Protecting water resources and water-dependent attributes such as fish habitat from the effects of groundwater withdrawals and stream diversions is a concern for the park. As water development issues occur on a case-by-case basis, the NPS has responded with data collection efforts that describe water resource conditions, evaluate the threat, and facilitate issue discussions. NPS water rights evaluations have been completed for certain waterbodies (e.g., Lobos and Redwood creeks), however; a comprehensive inventory of water rights, uses, and additional water requirements is needed.

Objectives from GOGA's draft Aquatic/Water Resources Management Plan (National Park Service, 1990a) included: 1) Document and filing, where applicable, Federal reserved and State appropriative and riparian water rights and 2) Developing or allocating water resources in such a way as to avoid over commitments, so that in the long term, there will be no continuous shortages or significant continuous water quality impairment.

Strategies for maintaining adequate flows and protecting natural hydrologic regimes include inventorying water rights, protecting groundwater, removing diversion structures, water conservation, and enforcing water rights (National Park Service, 1999a). Mortality of juvenile steelhead in October 1999 associated with water withdrawals from Easkoot Creek resulted in modification of operations to protect instream flows for fish

(National Park Service, no date). It should be noted that GOGA's Environmental Division is preparing Water Conservation Guidelines for the park.

GOGA has requested continued technical assistance with water rights at Redwood Creek and Stinson Beach.

Specific Fundamental Water Resources

Finally, in looking at the specific fundamental water resources divided into four categories, we answer four questions posed by the GMP Planning Team that provide the justifications for why these resources are fundamental to GOGA and MUWO, along with the issues that threaten these important park resources.

Freshwater streams and ponds

1. *What is the importance of these water resources and values?*

General

GOGA and MUWO have many unique aquatic resources that are significant in an ecological and economic context. The streams in GOGA and MUWO have many beneficial uses including; municipal water supply, agricultural supply, fresh water replenishment, water contact and non-water contact recreation, and fish migration and spawning (National Park Service, 1999a). These freshwater systems within GOGA have a direct impact on several indicators including: marine water quality, federal and state-listed species, riparian habitat, and wetlands (National Park Service, 2004a). For example, adequate freshwater flows and water quality are important in the preservation of rare and endangered species such as the California freshwater shrimp (*Syncaris pacifica*) at Lagunitas Creek and federally-listed salmonids (National Park Service, 1990a).

GOGA and MUWO are located within the Golden Gate Biosphere Reserve, one of 411 reserves designated by the United Nations Educational, Scientific and Cultural Organization's (UNESCO) Man and the Biosphere Program to provide a global network representing the world's major ecosystem types (Redwood Creek Watershed Vision Statement, 2003).

GOGA's 1980 General Management Plan included the following key management objective: "To maintain and restore the character of natural environment lands by maintaining the diversity of native park plant and animal life, identifying and protecting threatened and endangered plant and animal species, marine mammals, and other sensitive natural resources" (National Park Service, 1980). Healthy surface waters are necessary to meet this management objective.

Redwood Creek is one example of the important freshwater streams in both GOGA and MUWO. "*The Redwood Creek watershed exists as an intact natural ecosystem that offers*

opportunities for people to learn about, experience and protect a rich blend of nature, rural character, and cultural history in an urbanized area" (Redwood Creek Watershed Vision Statement, 2003). Although the creek's watershed encompasses less than nine square miles, it harbors an incredibly diverse ecosystem and rich assemblages of plant and animal species. The watershed is part of the California Floristic Province hotspot that contains some of the highest diversity of endemics, plant, and animals found in the world (http://www.calcademy.org/naturalhistory/california_hotspot/overview.htm). This creek is one of the more productive and restorable anadromous fish streams within Marin County. The watershed is one of four major streams in the county that currently support native populations of coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*), both listed as federally threatened under the federal Endangered Species Act (Pacific Watershed Associates, 2002).

Vital signs are being identified and ranked, as part of a national effort in the NPS to identify the natural drivers and anthropogenic stressors that are linked to key resources and natural processes of interest. Vital signs indicators are a subset of physical, chemical, and biological elements and processes of ecosystems, selected to represent the condition of natural resources, effects of stressors, or elements that have important management values. Vital signs for the NPS San Francisco Bay Area Network were prioritized, taking into account ecological significance, management significance, cost and feasibility, and legal mandates. From the 2004 San Francisco Bay Area Network Vital Signs Monitoring Plan, the following lists the ranked water-related vital signs related to freshwater streams and ponds (National Park Service, 2004a):

1. Weather and Climate
2. Invasive Plant Species (terrestrial and aquatic)
3. Freshwater Quality
4. Ozone Levels, wet and dry deposition, visibility and particulate matter, air contaminants
5. Stream T&E Species and Fish Assemblages (Salmonids)
6. T&E Plant Species
14. Freshwater Dynamics (stream hydrology)
15. Wetlands
16. Riparian Habitat
20. Erosion and Deposition
31. Stream Channel and Watershed Characterization
61. Aquatic Invertebrates.

Water Supply

The watersheds of GOGA and MUWO support important municipal water supplies in the area. Lagunitas Creek is used by the Marin Municipal Water District to fill behind several dams as part of the municipal water supply for Marin County. Redwood Creek surface and groundwater supports the Muir Beach Community, Marin Municipal Water District and state park residences along the creek. Elk Creek supplies the Miwok stable facility and the Parks Conservancy native plant nursery. Lobos Creek is used to supply the

Presidio of San Francisco. The surface and/or groundwaters of Easkoot Creek, Stinson Gulch, and Black Rock creeks are a source of potable water for the Stinson Beach County Water District (National Park Service, (no date)). San Francisco watershed lands provide storage for water diverted from inland areas, including Yosemite National Park, as well as local runoff, and serve as the major source of domestic water for San Francisco and San Mateo Counties. The reservoirs include: Crystal Springs Lakes, Pilarcitos Creek, Pilarcitos Lake and San Andreas Lake (National Park Service, 1990a). Each of these freshwater systems must meet drinking water objectives set by the State of California (Urban Watershed Project, 2001).

Biological Resources

Riparian habitat is closely tied to the health of both wetlands and streams, influencing stream fish assemblages. Characteristics of riparian habitat structure such as the ratio of edge to interior, the degree of canopy complexity within riparian strata (e.g., herb/forbs, shrubs, sub-canopy tree, and overstory tree), and the degree of fragmentation is highly associated with amount and type of wildlife use (National Park Service, 2004a).

The streams of GOGA and MUWO that provide rearing and spawning habitat for the federally-listed coho salmon (*Oncorhynchus kisutch*) and/or steelhead trout (*Oncorhynchus mykiss*) include: Lagunitas Creek and tributaries, Redwood Creek, tributaries into Bolinas Lagoon (including all fresh water surface water inflows), San Pedro Creek and Pilarcitos Creek.

2. *What are the current state or conditions and the related trends of these water resources and values?*

Water Quality

Water quality at the Presidio has been affected by past activities, such as creating landfills, installing of USTs, and using herbicides, fungicides and insecticides, while the U.S. Army managed the Presidio. Nonpoint-source runoff from roads and parking lots affects water quality by introducing organic chemicals and heavy metals (National Park Service and Presidio Trust, 2003). For example, in the San Francisco Bay region, the Association of Bay Area Governments (ABAG) has found consistently high levels of hydrocarbons in urban runoff (California Regional Water Quality Control Board, 1995).

Fresh water contamination was identified in a survey conducted by the USGS at eight stations in GOGA fresh water streams from 1986 to 1988. Bacterial contamination of water and unusually high values of iron, copper, lead, phosphorus, cadmium, and pH were noted at several sites (Medej, 1989).

The results of the GOGA water quality criteria screen found 21 groups of parameters that exceeded screening criteria at least once within the study area. Dissolved oxygen, pH, chloride, cadmium, copper, lead, mercury, and zinc exceeded their respective EPA criteria for the protection of freshwater aquatic life. Dissolved oxygen, pH, chlorine,

cadmium, copper, mercury and zinc exceeded their respective EPA criteria for the protection of marine aquatic life. Chloride, fluoride, sulfate, nitrate, arsenic, cadmium, chromium, lead, mercury, nickel, and DBCP exceeded EPA drinking water criteria. Fecal-indicator bacteria concentrations (total coliform, fecal coliform, *E.coli*, and enterococci) and turbidity exceeded the WRD screening limits for freshwater and marine water bathing and aquatic life, respectively (National Park Service, 2005b).

Sporadic water quality testing immediately downstream from the Presidio Riding Club Stables indicated that fecal matter was entering waterways at this site. GOGA committed itself to a comprehensive water quality monitoring program in the winter of 1998-1999. Results from the monitoring indicate that fecal wastes, nutrients and copper are still being input on-site (National Park Service, 1999b).

High fecal coliform counts were verified in the Gerbode Valley, Eskoot Creek, Green Gulch and Redwood Creek. High copper levels were identified in Redwood Creek. High iron levels in the Elk Creek and Gerbode drainages would require treatment if ever used as a potable water source. High phosphorus concentrations were noted at all GOGA stations, which can lead to eutrophication and the detriment of aquatic life (National Park Service, 1990a). Significant impacts of wastewater occurred in Easkoot Creek, which showed consistent high levels of fecal contamination (Todd Engineers and Questa Engineering, 1998).

In wet weather, nutrient and coliform bacteria levels in Redwood Creek increase downstream of the Banducci Farm, but are generally highest near Muir Beach. Stormwater samples from Green Gulch Creek and the ditch draining Tinker's Stables and hillside pastures showed high levels of nitrogen (1.3 to 1.6 mg/L), phosphorus (0.15 to 4.8 mg/L), and coliform (>2400 counts/100 ml). Dry-weather (summer) fecal coliform counts are below 50 counts/100 ml upstream of Banducci, increasing to about 300 counts/100 ml below Banducci and 1900 counts/100 ml at Pacific Way, well above the standards for contact recreation. There was no surface runoff from areas used by horses during this period; thus, this increase is probably due to leakage from domestic septic leach fields on the creek floodplain between Pacific Way and Highway 1 (Schanz, et al., 1995).

The State must compile impaired waters in a 303(d) list and initiate a process to bring listed waters back into compliance. GOGA contains five streams on the 303(d) list 2002 (San Francisco Bay Regional Water Quality Control Board, 2002):

- *Lagunitas Creek*: tributary to Tomales Bay. nutrients, pathogens, and sedimentation/siltation (agriculture, urban runoff/sewers).
- *Coyote Creek*: diazinon (urban runoff/sewers)
- *Rodeo Creek*: diazinon (urban runoff/sewers)
- *San Francisquito Creek*: diazinon (urban runoff/storm sewers), and sedimentation (nonpoint source).
- *San Pedro Creek*: high coliform (urban runoff/storm sewers, nonpoint source)

Nutrient levels in runoff may increase periodically near landscaped areas where fertilization and irrigation are necessary to establish a new plant cover or maintain manicured gardens and landscapes (National Park Service, 1980). Failures with sewer systems adjacent to waterways are another source of elevated nutrient and bacteria concentrations. Sewer lift stations have failed at times during winter storms and power outages.

Failures (breaks) in waterlines have occurred in the past, releasing chlorinated drinking water into surrounding environments.

Hydrology

Flows in the region are highly seasonal, with more than 90 percent of the annual runoff occurring during the winter rainy season between November and April (California Regional Water Quality Control Board, 1995). Runoff has changed substantially, but mostly as a result of land use changes rather than natural causes. It has decreased in some areas and has increased in others (Goals Project, 1999). Human activities over the past 200 years, which introduced logging, overgrazing, and the construction of roads and trails, have greatly accelerated erosion in the north Coast Ranges of California, to the extent that the vigor of the vegetation cover is impaired (Wahrhaftig and Lehre, 1974b).

The total amount of shallow ponds in the baylands and in the adjacent grasslands historically ranged from 16,000 acres to 22,000 acres depending on the amount of rainfall. Now there are between 63,000 and 92,000 acres, depending on rainfall and water management practices. The increase is primarily due to ponding in diked baylands (Goals Project, 1999).

The GOGA trail system is largely an inherited system of former ranch and military roads. Many of these trails are steep, constructed on fine soils that are erodible when wet, and because of their original construction, they capture and concentrate rainfall, gully, and erode heavily in winter (National Park Service, 1990a).

Between MUWO and Banducci Farms, the channel morphology of Redwood Creek is relatively unaltered by direct human activity. In the reaches above MUWO, along Banducci Farms and below the bridge at Pelican Inn, the natural channel has been altered through a number of historic engineering projects (channelization, rip-rap, etc.) (Pacific Watershed Associates, 2002). Stream and riparian restoration has begun in the Banducci reach.

The current Easkoot Creek profile is absent of large pools and characterized by low sinuosity (1.2), flat gradient (1.2% slope), artificial confinement, a gravel/cobble bed, and mixed riparian (exotic invasive and native) vegetation. Park development consists of roads, picnic area, bridges, landscaping, and parking lots, while the town development consists of streets and buildings. Maintenance dredging has occurred in the last few decades over the entire reach to maintain channel capacity. Dredged materials were placed along the top of the bank to form levees that prevent access to floodplain and

wetlands (National Park Service, (no date)). There is a distinct lack of woody material in the Easkoot Creek channel, likely the result of post-flood channel clearing activities. Thus, a reduction in aquatic habitat exists (lack of pools and woody debris) (National Park Service, (no date)).

The majority of the sediment from the Redwood Creek watershed is derived from the steep hillsides. Of the identified land-use related sediment sources, the hillside pastures (196 acres) contribute the largest sediment load. Sediment loads from the Banducci floodplain fields (29 acres), Green Gulch fields (22 acres), and lowland horse pastures (21 acres) are much smaller due to the low slopes in these areas. Sediment loads from these land uses are significantly higher than they would be under natural conditions, but are still small relative to the total sediment load from the Redwood Creek Watershed (Schanz et al., 1995).

Redwood Creek drains the 7.46 square mile watershed that begins on the southern slopes of Mt. Tamalpais and includes Fern Creek, Kent Canyon, and Franks Valley. Redwood Creek has largely recovered from historical grazing activities in the watershed, and now supports sustainable populations of federally-listed coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorhynchus mykiss*), and red-legged frog (*Rana aurora draytonii*), along with special status species such as the western pond turtle (*Emys marmorata*) (Schanz et al., 1995).

Water Supply (municipal systems)

Water for all developments in the San Francisco mainland units is provided by existing municipal water sources that supply the city of San Francisco and the former U.S. Army water system serving the Presidio. These services are adequate to meet present and projected water demands without significantly affecting either local or regional water supplies. This assessment was made in 1980, which determined that no new development of water sources will be required (National Park Service, 1980).

3. *What are the potential future threats to these water resources and values.*

Water Quality

Several stormwater outfalls, which include pollution from local sewers during storm flows, empty into the park including Lobos Creek, Crissy field, Ocean Beach, Stinson Beach, Fort Point and Fort Baker. A large outfall at Baker Beach also includes sewage effluent during storm periods (National Park Service, 1990a).

Current and past land uses in and adjacent to GOGA have the potential to contribute to fresh water contamination. Recreational uses, including hiking, biking, dog-walking and equestrian use can increase sediment from erosion and can also introduce human and animal fecal contamination. Agricultural practices, including farming, ranching and stable operations, have caused sedimentation, and organic waste and potential pesticide problems. Poorly constructed and poorly maintained roads, inherited from prior land

owners, concentrate water, causing gullies that carry sediment into the water resources (National Park Service, 1999a). Waste disposal sites from past uses may release contaminants to park waters. Surface disturbances and chemical releases from ongoing park management and maintenance activities have the potential to degrade water quality.

Algal blooms in Rodeo Lagoon contribute to odor problems and may be associated with altered nutrient regimes. Fish kills associated with these blooms have occurred on several occasions in the last decade.

Hydrology

Many roads constructed prior to park establishment were improperly constructed. The result is inadequate drainage leading to concentrations of water, increasing sediment yields to creeks impairing water quality and aquatic habitat. Historic grazing increased erosion by decreasing the amount of vegetation available to capture water and compacted the soil, which deters infiltration. This increased runoff that carries sediments into the creeks. Trampling by off-road vehicles, hand gliding, bicycling, horseback riding and other visitor use has created denuded areas with compacted soils (National Park Service, 1990a). Many of the landslides in GOGA are along roads and appear to have been activated by cutting on the slope side, overloading with fill on downslope side, or saturating the ground with culvert discharge and storm runoff (Wahrhaftig and Lehre, 1974a). The Marin Headlands Erosion Rehabilitation Plan identified those trails and former roads that show erosion problems and those that show few or no erosional impacts under current use. The Marin Trail Use Designation Plan (1992) provides trail designations for the southern Marin areas of the park (National Park Service, 1990b).

Undersized road crossings and near-channel developments force the clearance of woody materials and vegetation, impairing many creeks' ability to support aquatic life. In the reaches above MUWO, along Banducci Farms and below the bridge at Pelican Inn, the natural channel has been altered through a number of historic engineering projects (channelization, rip-rap, etc.) (Pacific Watershed Associates, 2002).

Decreases in water quantity due to continued water diversions are partially responsible for the decrease in wetland and lagoon habitats, and for the decrease in rare anadromous fish populations (National Park Service, 1999a). The Redwood Creek Watershed Group is concerned that road and trail maintenance, unsuccessful erosion control, and anthropogenic sedimentation are causing serious disturbance to aquatic habitats (Pacific Watershed Associates, 2002).

Site Specific Water Quality and Hydrolologic Threats

Redwood Creek watershed crosses jurisdictional boundaries of California State Parks, Marin Municipal Water District, the Muir Beach Community and Green Gulch Farm, in addition to GOGA and MUWO (National Park Service, 1999a). Some key issues in the watershed include: overcrowding in the park, traffic congestion on roads throughout the watershed and in the surrounding region, diversion of water from Redwood Creek and its

tributaries for residential and agricultural uses, invasion by non-native plant and animal species that displace and prey on native species, increased fuel loading and alteration of native plant communities due to fire suppression, and flooding of local roads (Redwood Creek Watershed Vision Statement, 2003).

Water quality sampling conducted periodically from the late 1980's through 2005 has shown that downstream locations in Redwood Creek, particularly those downstream of the Highway 1 Bridge, continue to show elevated bacteria concentrations that do not support designated beneficial uses (Stillwater, 2005). Although there appear to be some reductions in bacteria concentrations since improvements were made to the horse stables at the Golden Gate Dairy beginning in 1998, possible sources for the contamination include equestrian sources and possible runoff from leach fields and septic systems. Recent data (2005) on nutrient levels in Redwood Creek suggest that nutrient concentrations remain higher than regional reference levels, as has been reported for historical data, and may contribute to periodic lowered dissolved oxygen in the downstream reaches of the creek (Stillwater, 2005; Shoulders, pers. comm., 2005).

Posted warning signs based on bacteriological sampling to inform visitors to avoid contact with water have occurred frequently throughout the year at Muir Beach and Horseshoe Cove (Marin County), while infrequent postings at other San Francisco and Marin beaches have occurred during the winter and spring.

Threats to the Lobos Creek area include: water diversion management, water quality impacts from surrounding urban areas, visitor recreation impacts, non-native plant invasion, and past land use practices (tree plantings, dredging of the creek, construction of a ball field and a road and sewer management) (National Park Service, 1999a). Pollutants and sources that threaten Lobos Creek watershed include coliform bacteria, nitrate, trihalomethane, heavy metals, sewage leaks, trash, debris and household chemical bottles, volatile organic compounds, petroleum hydrocarbons, USTs (MTBE source?), fertilizers, pesticides, herbicides, stormwater runoff pollutants and sources, hazardous material spills, erosion and slop failure of creek banks and structures (bank failure, roadway failure, sewer line failure) (Urban Watershed Project, 2001).

4. *What are the issues that need to be addressed through the consideration of the GMP alternatives?*

Watershed

Strategies for protecting and improving water quality monitoring and management include: 1) establishing special protection zones within watersheds; 2) identifying non-point source pollution; 3) developing sustainable stable management practices; 4) providing educational and interpretative programs focusing on watershed themes; 5) conducting beach cleanup programs; and 6) reducing the potential for pollution of aquatic systems (National Park Service, 1999a).

The quality of the riparian (near-stream) ecosystems associated with floodplains is directly related to the condition of adjacent uplands within their watersheds. The degradation of forest streams and their associated watersheds is often the result of non-point sources such as past timber harvesting, roads, fire suppression, and catastrophic wildfires (Hunsaker and Eagen 2003). Urban and rural developments near and adjacent to GOGA lands also affect the quality of the watersheds within the park.

Even though most of the Redwood Creek watershed is protected in public ownership, resources in the watershed are threatened by encroaching landuses, water diversion, non-point source pollution, fire suppression, erosion and sedimentation, and other stressors. In 2002-03, public agencies in the watershed collaborated to create a vision for the watershed's future. The proposed watershed assessment (PMIS 100326: Redwood Creek Watershed Assessment) will forward that vision by providing a scientific foundation upon which to base resource decision-making. The watershed is one of the most important resource management areas in GOGA. The watershed supports a rich mosaic of habitat types, including old growth redwood forest, grassland, coastal chaparral, mixed hardwood and conifer forests, riparian woodland, seasonal and estuarine wetlands, and in-channel aquatic habitats. The watershed supports four federally listed threatened vertebrate species: coho salmon (*Oncorhynchus kisutch*), steelhead (*Oncorhynchus mykiss*), California red-legged frog (*Rana aurora draytonii*), and the northern spotted owl (*Strix occidentalis caurina*).

The Rodeo Lagoon watershed is the only estuarine resource which has its watershed completely within the park boundary. A comprehensive restoration project for the lake, lagoon, and watershed is necessary. Actions to support watershed management decisions include: 1) monitor lagoon fish community; 2) investigate the effects of poor water quality on ecology of Rodeo Lagoon; 3) monitor and mitigate water quality and erosion; 4) inventory and monitor other sensitive species; and 4) restore habitat and correct wildlife disturbance problems (National Park Service, 1999a).

Lobos Creek provides water to the Presidio. The creek is to be restored as a naturally flowing stream and the valley preserved as a wild area (National Park Service, 1999a). The majority of the Presidio's water needs are met with on-site resources, specifically Lobos Creek. In order to protect the natural resource values along Lobos Creek (one of the last free-flowing creeks in San Francisco), a minimum creek flow of 0.5 mgd is maintained (The Presidio Trust, 2002). Watershed goals for the Lobos Creek Valley developed by the NPS and Urban Watershed Project (Urban Watershed Project, 2001):

1. enhance, preserve and protect water quality in Lobos Creek.
2. balance instream flow requirements for habitat and wildlife with efficient water supplies to the Presidio community.
3. facilitate natural physical, hydrologic, and biological processes to reestablish the native aquatic and riparian habitats of Lobos Creek. Human management interventions should be low-impact (avoid use of heavy machinery) within the Lobos Creek riparian corridor.

4. provide a framework for Lobos Creek watershed educational and interpretive opportunities to the public.
5. develop broad community understanding, stewardship and protection of Lobos Creek natural resources, water quality and riparian habitat.

A systematic restoration of an entire Tennessee Hollow watershed is needed that begins near its divide and finishes near the mouth, generating channel profiles and soil test pits and monitoring well networks in potential riparian and wetland restoration sites, developing a sediment and erosion control plan, and evaluating *Eucaplyptus* removal (hydrological changes) (Pranger et al., 2003). GOGA has requested technical assistance for this effort. This major watershed-scale restoration project within the Presidio represents a collaborative venture with three partners: The GOGA, the Presidio Trust and the Golden Gate National Parks Conservancy (Parks Conservancy). Formal Agreements document this in the form of a Memorandum of Agreement between the GOGA and the Presidio Trust, a Cooperative Agreement between the GOGA and The Parks Conservancy, a Cooperative Agreement between the Presidio Trust and the Parks Conservancy, and a Letter of Agreement among all three partners. The NEPA process is underway for this restoration plan.

Water Quality

GOGA is developing an equestrian plan for the Marin County portion of the park (Rodeo Valley, Tennessee Valley, and Muir Beach). GOGA management objectives include confining horses farther away from water courses within this watershed, revegetating these impacted areas to provide adequate buffer strips to filter contaminated water providing suitable riparian corridors and habitat, and covering areas where horse use is high in order to prevent clean water from mixing with contaminated water (National Park Service, 1999b).

A reduction in livestock waste contamination of watersheds should occur in response to ceasing of grazing within GOGA. Contamination of runoff can influence important watersheds such as Bolinas Lagoon, Stinson Beach, and Muir Beach watersheds, which are used as municipal water sources, and other critical watersheds, such as Tomales Bay. In addition, sediment introduction into watercourses will decrease as erosion problems are reduced and previously denuded areas near stock water supplies and trails are revegetated (National Park Service, 1980).

GOGA is developing a parkwide stormwater management plan.

In the past, sewage treatment problems resulted from an overflowing septic tank, which was corrected by installation of a new central collections system and treatment outside the park (National Park Service, 1980). All sewage is pumped out of Rodeo Valley for treatment at a municipal system.

Hydrology

The park should continue to restore the natural hydrologic functions and processes throughout the park. For example, between MUWO and Banducci Farms, the channel morphology is relatively unaltered by direct human activity. In the reaches above MUWO, along Banducci Farms and below the bridge at Pelican Inn, the natural channel has been altered through a number of historic engineering projects (channelization, rip-rap, etc.). There are feasibility studies underway at several sites to determine whether or not channel and lagoon restoration projects in the lower watershed would be beneficial to the aquatic ecosystem. These projects should involve site-specific upland erosion control work as part of any larger scale channel restoration plan for these reaches (Pacific Watershed Associates, 2002).

Biological Resources

Coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*) demand year-round, high quality cold water, functional riparian cover, and complex habitat and structure to accommodate development from egg to smolt stage. Because the salmonids live for more than a year in freshwater, and the conditions required to support them are highly restrictive, they are susceptible to anthropogenic impacts to the stream and riparian systems, and are therefore effective indicators of stream and aquatic health. Monitoring of these species at multiple life stages is valuable to the understanding of aquatic conditions and health of the watershed (National Park Service, 2004b). Based on the current understanding, two important elements needed for long-term restoration of salmon habitat and the eventual recovery of salmonid populations in the Redwood Creek watershed are: 1) the reduction of accelerated erosion and sediment delivery to the stream channel system and 2) improving estuarine rearing habitat (Pacific Watershed Associates, 2002). The California freshwater shrimp (*Syncaris pacifica*) could also be an effective biological indicator since it is highly sensitive to water quality and changes to habitat (National Park Service, 2004b).

GOGA is seeking technical assistance for a Redwood Creek Tri-Party Agreement to facilitate Section 7 consultation to protect coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss*).

Climate

Key reasons for monitoring weather and climate in network parks are: (1) weather/climate is the primary driver of the short and long-term distribution and abundance of plant and animal populations, (2) weather/climate has effects on air and water quality, and (3) weather/climate has effects on drought and flood cycles, fires, mass wasting and other catastrophic events. Long-term weather data can contribute to the understanding of global climate change and its effects on GOGA and MUWO's ecosystems (National Park Service, 2004b).

Other

Water resource questions generated from the 2004 Vital Signs Monitoring Plan for the San Francisco Bay Area Network (GOGA, MUWO) include (National Park Service, 2004b):

1. What is the level of compliance with the designated beneficial uses for water resources?
2. What are the long-term trends and ranges of core parameters (water quality, water quantity, geomorphic, biological index, etc)?
3. What are the pollution sources within the watersheds?
4. Are management actions reducing pollutant loads?
5. Are the effects of ranching degrading surrounding ecosystems?
6. What are the effects of farming on surrounding ecosystems?

Water resource objectives from GOGA's 1990 Aquatic/Water Resources Management Plan include (National Park Service, 1990a):

1. Provide adequate sewage treatment and disposal for all facilities.
2. Control erosion induced by land use activities.
3. Prevent direct pollution of natural waters by livestock
4. Regulating fuel-burning watercraft.
5. Establish cooperative Agreements with other agencies or governing bodies to prevent water pollution.
6. Establish consistent and comprehensive programs to monitor water quantity, water quality, and aquatic resources.
7. Assessing floodplain and other hazards and minimizing the flood hazard to facilities and to the public.

Project statements from GOGA's 1990 Aquatic/Water Resources Management Plan include (National Park Service, 1990a):

1. Planning for the Redwood Creek Watershed.
2. Locate the sources of contaminants which exceed the State of California water quality objectives for designated beneficial water uses in the Marin Headlands.
3. Research and write a protection plan for the California Fresh Water Shrimp.
4. Research and write a protection plan for the Endangered San Francisco Garter Snake.
5. Survey and mitigate erosion throughout the GOGA.
6. Develop Riparian and Aquatic Zone Management Guidelines.
7. Inventory and Monitoring of Aquatic Resources.
8. Develop a water resources atlas for the park.

The Mountain Lake Restoration Plan will be a future priority since it is the only natural lake managed by GOGA (National Park Service, 1999a).

In 2002, the NPS Geologic Resources Division (GRD) visited nine sites that either need to be restored or stabilized: 1) Stabilization of Marincello Road, 2) Reclamation/Stabilization of Capehart Quarry, 3) Restoration of Hollis Pond, 4) Stabilization and Waste Removal at Five Baker Beach Bluff Sites, 5) Slumping, relocation and restoration of upper Fishermans Trail, 6) Gravel deposition on Oakwood Valley Trail, 7) Fishery enhancement of Lower Easkoot Creek, 8) Wetland enhancement near the south Stinson Beach Picnic Area, and 9) Removal and Restoration of the Hypress Pond Site (Pranger and Steensen, 2002).

At MUWO, 0.5 miles of trail are scheduled to be mulched, including 2 acres of riparian restoration and four salmon spawning surveys. In the Marin Headlands, 12 acres of exotic species control will be completed (PMIS 81054: Restoration of Habitat at Muir Woods and Marin Headlands).

Groundwater aquifer and springs

1. *What is the importance of these water resources and values?*

General

Groundwater is an important component of the hydrologic system in the San Francisco Bay region. Groundwater provides excellent natural storage, distribution, and treatment systems. Groundwater also supplies high quality water for drinking, irrigation, and industrial processing and service. As an important source of freshwater replenishment, groundwater may also discharge to surface streams, wetlands, and San Francisco Bay (California Regional Water Quality Control Board, 1995).

The groundwater in GOGA has many beneficial uses including; municipal water supply, agricultural supply, and fresh water replenishment (National Park Service, 1999a).

Key management objectives from the 1980 GMP: To maintain and restore the character of natural environment lands by maintaining the diversity of native park plant and animal life, identifying and protecting threatened and endangered plant and animal species, marine mammals, and other sensitive natural resources (National Park Service, 1980). Healthy groundwater aquifers are necessary to meet this objective.

Vital signs for the San Francisco Bay Area Network were prioritized, taking into account ecological significance, management significance, cost and feasibility, and legal mandates. From the 2004 San Francisco Bay Area Network Vital Signs Monitoring Plan, "Groundwater Dynamics" was listed 42nd in the ranked vital signs (National Park Service, 2004a).

2. *What are the current state or conditions and the related trends of these water resources and values?*

Water Quality

The chemical character of groundwater in San Francisco is affected by recharge from rainfall, irrigation-return flow, and leakage from water and sewer pipes. Groundwater quality is also affected by chemical interaction with sediments in the aquifer system. Water from municipal water pipes tends to dilute the major constituents found in groundwater, with the exception of fluoride. Concentrations of dissolved solids, sodium, and chloride tend to decrease with depth, indicating a shallow source, such as sea spray, sewer leakage, or irrigation-return flow. Nitrate concentrations exceeded the EPA recommendation limit for drinking water (10 mg/L) in 41% of the samples. The most likely sources of nitrate are seepage from sewers and irrigation return flow. Except for high nitrate concentrations, groundwater is generally of good quality and is a calcium magnesium bicarbonate type (Yates et al., 1990).

The five drainages in Marin County (Lagunitas Creek, Olema Creek, Redwood Creek, Elk Creek and Rodeo Creek) have flat alluvial valleys near their mouths. These alleviated valleys have high water tables and contain the only sizable groundwater resources in GOGA. Due to their accessibility and development, these areas are subject to pollution from failing septic systems, animal wastes and runoff, and debris from roads. The shallow and poorly drained soils have caused problems with sewage disposal and leach fields (National Park Service, 1990a).

Landfills and localized hazardous waste contamination related to past activities have affected the natural resources by changing soil chemistry and vegetation and wildlife habitats. Groundwater, moving through these impacted areas, is affected and can carry contaminants to freshwater resources and eventually to the bay or ocean. The Presidio of San Francisco has undergone a thorough review of such areas in an attempt to mitigate them (National Park Service, 1999a).

Nutrient levels in runoff may increase periodically near landscaped areas where fertilization and irrigation are necessary to establish a new plant cover or maintain manicured gardens and landscapes (National Park Service, 1980). Nitrate loading calculations demonstrate that nitrate in groundwater is the result of wastewater disposal, and that landscape irrigation is a minor factor. Wastewater disposal effects on groundwater in the Seadrift, Calles, and Patios areas do not pose a threat to human health, and appear to have only a small influence on beneficial uses in Bolinas Lagoon. Accordingly, no technical basis exists to support a building moratorium (Todd Engineers and Questa Engineering, 1998).

Hydrogeology

Groundwater in the western part of San Francisco is used chiefly for irrigation in Golden Gate Park and the Lake Merced area. Available water-quality and storage data indicate

the potential for further development of this resource. The ground-water basin underlies a 39-square-mile area extending south from Lincoln Park through Daly City and terminating near San Bruno. It is bounded on the west by the San Andreas fault and on the east by relatively impermeable rocks of the Franciscan Complex and the Great Valley sequence (Yates et al., 1990).

The water budgets and water-level trends indicate that pumpage could be increased in Golden Gate Park without adversely affecting the ground-water system. In contrast, groundwater in the Lake Merced area is in a state of overdraft, and any increases in pumpage probably would increase the rate of long-term water-level decline in the lake (Yates et al., 1990).

Available information does not indicate long-term water-level declines at wells in Golden Gate Park, with the possible exception of the Alvord well. However, there is evidence of long-term water-level declines in the shallow aquifer in the Lake Merced area (Yates et al., 1990). Pumpage from the deep part of the aquifer system at local golf courses and in Daly City, coupled with the presence of the confining layer, has produced a steep downward and southward ground-water-level gradient near the south end of Lake Merced. Vertical gradients in groundwater appear to be much smaller in other areas in the western part of San Francisco. Ground-water flow is generally westward with local areas of radial flow toward production wells (Yates et al., 1990).

A study was conducted to determine whether pumping groundwater from Muir Beach Community Services District supply well would cause depletion of streamflow in Redwood Creek. It was determined that the alluvial aquifer in Frank Valley is a heterogeneous aquifer that is hydrologically interconnected with surface flow in Redwood Creek. Pumping water from Muir Beach Community Services District Supply Well induces infiltration from Redwood Creek to the alluvial aquifer. Streamflow depletion was estimated to be 70-80% of the pumping rate of the well (Martin, 2000).

Analysis of groundwater levels and flow revealed that the ocean and Bolinas Lagoon are the receiving surface water bodies for groundwater in Stinson Beach. Specifically, groundwater flow from the Oceanside portions of Stinson Beach, Old Town, and Highlands areas generally flow toward the ocean, while flow from the remaining portions of Seadrift, Calles, and Patios is toward Bolinas Lagoon. Easkoot Creek intercepts groundwater and conveys it to Bolinas Lagoon (Todd Engineers and Questa Engineering, 1998).

Water Supply (Municipal Systems)

Water for all developments in the San Francisco mainland units is provided by existing municipal water sources that supply the city of San Francisco and the U.S. Army water system serving Baker Beach, Crissy Field, and Ft. Point. These services are adequate to meet present and projected water demands without significantly affecting either local or regional water supplies. This assessment was made in 1980, which determined that no new development of water sources will be required (National Park Service, 1980).

Park areas in Marin County are presently supplied by municipal systems and local water developments. Very few local water sources have been developed in the Marin Headlands area with the exception of low-flow springs. Groundwater use has been limited, but extensive testing has been undertaken. According to the National Park Service (1980), soil boring information suggests that sufficient groundwater is available to meet the visitor needs in this area.

The existing water supply in Olema Valley comes from local wells and diversions. Water demand in the valley is expected to greatly increase. Although the potential yield of existing wells is not known, test wells in the area yield up to 85,000 gpd, more than twice the required peak water demand of 41,000 gpd. Most of the water demand will be generated in the Five Brooks area, the initiation point of most of the activity in the valley (National Park Service, 1980).

Groundwater in Seadrift, Calles, and Patios areas is not a viable drinking water supply because of the influence of seawater (Todd Engineers and Questa Engineering, 1998). The Stinson Beach County Water District withdraws groundwater from the Stinson Gulch aquifer.

3. *What are the potential future threats to these water resources and values?*

Water Quality

A variety of historical and ongoing industrial, urban, and agricultural activities and their associated discharges degrade the groundwater quality, including industrial and agricultural chemical spills, underground and above-ground storage tank failures, and chemical seepage via shallow drainage wells and abandoned wells. In addition, salt water intrusion directly attributed to over-pumping has degraded the purity of some groundwater aquifers (California Regional Water Quality Control Board, 1995).

Wastewater disposal is influencing groundwater quality in the Seadrift, Calles, and Patios areas, as indicated by the detection of ammonia and methylene blue active substances (MBAS) in most of the monitoring wells sampled. Detections of fecal coliform were confined to two wells, suggesting that fecal contamination of groundwater is limited and localized (Todd Engineers and Questa Engineering, 1998).

4. *What are the issues that need to be addressed through the consideration of the GMP alternatives?*

Water Quality

Several potential disposal, landfill, and industrial sites require environmental investigation in GOGA. A project statement has been prepared by GOGA to address this need (GOGA Parkwide CERCLA Preliminary Assessment at 23 sites in all park areas: PMIS 100621). Project objectives are to identify any violations of environmental regulations, reduce potential NPS liability for cleanup of conditions discovered, and

promote expedient identification and remediation, if necessary, of hazardous substances in the environment.

Additional USTs and transformers still remain on site at the Former Mill Valley Air Force Station (Mount Tamalpais) elevating the potential environmental contamination in the immediate area. A Phase II Environmental Assessment project statement has been prepared by GOGA to address this issue (PMIS 100275).

The need to replace non-compliant septic systems at Point Bonita (Marin Headlands) exists for three separate living units servicing 14 residents. A project statement has been prepared by GOGA to replace the sewage system for these three housing units (PMIS 78727).

Hydrogeology

Impacts of groundwater pumping on Redwood Creek streamflow can be minimized by restricting pumping to nighttime hours when streamflow is not being further depleted by evapotranspiration. Water conservation measures by the Muir Beach community should reduce the water demand, lessening the impact of groundwater pumping. Relocating the supply well to a location further downstream would transfer the impact of streamflow depletion about 3000 feet downstream (Martin, 2000). The Muir Beach Community Services District has recently adopted an Adaptive Management Plan (2005) that is intended to reduce the impact of their operations on streamflow and fishery resources.

A water resource question generated from the 2004 Vital Signs Monitoring Plan for the San Francisco Bay area Network (including GOGA and MUWO) was (National Park Service, 2004b): Are water storage levels in existing aquifers decreasing?

Biological Resources

The relative impacts of water losses on Redwood Creek fish habitat are seasonal, and are greatest in the late summer of drought years when flows naturally drop below 0.5 cfs. The short-term flow losses that occur during pumping can have serious impacts on both the fish populations using the shallow habitats and on the insect populations that provide essential food for fish in deeper pools. The impacts of pumping can be reduced by bringing in an outside water supply from the Marin Municipal Water District, water conservation/demand reduction, and moving the wells 50 to 100 feet from the creek (Schanz et al., 1995). The State Board, NPS, and others came up with a list of measures for the Muir Beach CSD well to investigate reduced pumping during critical periods.

Stinson Beach developed a management plan intended to reduce impacts on fish.
A water resource question generated from the 2004 Vital Signs Monitoring Plan for the San Francisco Bay area Network (GOGA, MUWO) was (National Park Service, 2004b): Are there groundwater impacts on riparian habitat and wildlife?

Other

Water resources questions generated from the 2004 Vital Signs Monitoring Plan that apply to groundwater for the San Francisco Bay Area Network (GOGA, MUWO) include (National Park Service, 2004b):

1. What is the level of compliance with the designated beneficial uses for water resources?
2. What are the long-term trends and ranges of core parameters (water quality, water quantity, geomorphic, biological index, etc)?
3. What are the pollution sources within the watersheds?
4. Are management actions reducing pollutant loads?
5. Are the effects of ranching degrading surrounding ecosystems?
6. What are the effects of farming on surrounding ecosystems?

Wetlands

1. What is the importance of these water resources and values?

Wetlands are keystone ecosystems in the San Francisco Bay Area. Some ecologists call wetlands "the kidneys of the landscape" as they provide water quality protection, flood and drought mitigation, erosion control, and groundwater recharge functions. Wetlands support complex food webs, housing a rich biodiversity of wetland-endemic species, and providing habitat functions for many aquatic and terrestrial species. An estimated 46% of US endangered and threatened species and 50% of all bird species require wetland habitat. Wetland habitats are vulnerable to alteration due to global climate change and associated potential temperature, hydrology, and salinity regime changes. Understanding the condition of wetlands in GOGA may be a good proxy for understanding the condition of many taxa of concern in the region (National Park Service, 2004b).

Key management objectives from the 1980 GMP: To maintain and restore the character of natural environment lands by maintaining the diversity of native park plant and animal life, identifying and protecting threatened and endangered plant and animal species, marine mammals, and other sensitive natural resources (National Park Service, 1980). Healthy wetlands are necessary to meet this management objective.

Vital signs for the San Francisco Bay Area Network were prioritized, taking into account ecological significance, management significance, cost and feasibility, and legal mandates. From the 2004 San Francisco Bay Area Network Vital Signs Monitoring Plan, the following lists the ranked water-related vital signs related to wetlands (National Park Service, 2004b):

1. Weather and Climate
3. Freshwater Quality
15. Wetlands
16. Riparian Habitat

20. Erosion and Deposition
31. Stream Channel and Watershed Characterization
42. Groundwater Dynamics
61. Aquatic Invertebrates.

2. *What are the current state or conditions and the related trends of these water resources and values?*

Wetland systems are among the most productive and threatened habitats in the park (National Park Service, 1999a).

Wetland inventory work in the area by PORE found that the existing NWI maps missed 33% of the wetlands identified by Park-wide vegetation mapping and subsequent field work (National Park Service, no date).

Historic and current alterations to wetlands and aquatic sites have led to a decrease in functions and species abundance and diversity within the park. Historic fill in wetland and aquatic sites, such as Ft. Baker and Crissy Field, has resulted in long-term loss of habitat (National Park Service, 1999a). Investigation of historic maps of the Rodeo Lagoon watershed shows development of incised channels and expanding deltas from sediment deposition (Striplen et al., 2004).

3. *What are the potential future threats to these resources and values?*

Nike Swale is a wetland and upland mosaic located in the Battery Caulfield area. The site contains pockets of contaminated fill. Landfill 8, is scheduled for a larger scale remediation (contaminated soils). Observations indicate that the water table is very near ground surface in the area (Wagner and Inglis, 2004).

The northern area of the Easkoot Creek project site is a groundwater depression wetland. The area likely served as a floodplain for the creek; however there is a raised berm of fill material separating the creek from the wetland site (National Park Service, no date).

Human uses above know historic wetland sites are another threat. Some examples include; the Fort Baker facilities on top of a backdune wetland, the parking lot at Stinson Beach on top of a historic 2.5-acre backdune pond and marsh, and buildings and facilities above the historic Crissy Field wetland.

4. *What are the issues that need to be addressed through the consideration of the GMP alternatives?*

"There should be no additional loss of wetlands within the baylands ecosystem. Furthermore, as filled or developed areas within the baylands become available, their potential for restoration to fish and wildlife habitat should be fully considered." (Goals Project, 1999).

A sizeable amount of the park's historic wetland and aquatic sites has been altered. Two major wetland and aquatic restoration projects are Crissy Field and Mountain Lake (National Park Service, 1999a). The Crissy Field Marsh needs to be enlarged to increase its viability as a functioning intertidal system. A project statement has been prepared by GOGA to address this need (PMIS 82196: Crissy Field Marsh Expansion). Results would be a study report with options and alternatives for location and configuration of potential marsh expansion.

A restoration plan for Poison Pond and its wetland at Stinson Beach is needed. Data collection necessary to develop an adequate design would include defining the: 1) extent and quality of fill; 2) seasonal water table; and 3) hydrologic budget (Pranger et al., 2003). GOGA has submitted a technical assistance to the NPS Water Resources Division, requesting follow up with this restoration planning effort.

A preliminary enhancement plan has been developed that would restore and enhance over 16 acres of wetland and open water habitat at Big Lagoon at the mouth of Redwood Creek (Schanz et al., 1995).

Consistent with the California Wetlands Conservation Policy, the Regional Board is participating in the preparation of a Regional Wetlands Management Plan (California Regional Water Quality Control Board, 1995).

Marine and Coastal Water Resources

1. *What is the importance of these water resources and values?*

The water in GOGA has many beneficial uses including; water contact and no-water contact recreation, commercial and sport ocean fishing, warm migration and fish spawning, and shellfish harvesting (National Park Service, 1999a). The intertidal and subtidal zones of the littoral environment are some of the most diverse and productive ecosystems in the world (National Park Service, 1990a).

San Francisco Bay is the largest estuary along California's long coastline. It is an essential resting place, feeding area, and wintering ground for millions of birds on the Pacific Flyway. Nearly 100 species of fish are also supported by the estuarine environment that includes marshlands, mudflats, salt production lands, and open water (San Francisco Bay Conservation and Development Commission, 1998).

Human benefits from the fish and wildlife of the Bay include food, economic gain, recreation, scientific research, education, and an environment for living (San Francisco Bay Conservation and Development Commission, 1998).

Coastal habitats are important for the preservation of several rare and endangered species including the tidewater goby (*Eucyclogorius newberryi*) at Rodeo Lagoon and Giacomini Ranch in Tomales Bay and the salt marsh bird's beak (*Cordylanthus maritimus ssp. palustris*) at Bolinas Lagoon (National Park Service, 1990a).

Tomales Bay is an estuary that has significant habitat value: 1) excellent and varied bird habitat supporting at least 109 species of water birds; 2) A number of the Tomales Bay tributary creeks support anadramous salmonids; 3) An active, commercial oyster fishery has been present in Tomales Bay since 1875 (National Park Service, 1990a).

The streams of GOGA that provide migration routes for coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*) include Bolinas Lagoon (including all fresh water surface water inflows) and Tomales Bay. Spawning occurs in Bolinas Lagoon (including all fresh water inflows) and Tomales Bay (National Park Service, 1990a).

Vital signs for the San Francisco Bay Area Network were prioritized, taking into account ecological significance, management significance, cost and feasibility, and legal mandates. From the 2004 San Francisco Bay Area Network Vital Signs Monitoring Plan, the following lists the ranked water-related vital signs related to marine and water coastal resources (National Park Service, 2004b):

1. Weather and Climate
20. Erosion and Deposition
21. Physical Oceanography
33. Marine Water Quality

A key management objective from the 1980 GMP: To maintain and restore the character of natural environment lands by maintaining the diversity of native park plant and animal life, identifying and protecting threatened and endangered plant and animal species, marine mammals, and other sensitive natural resources (National Park Service, 1980). Healthy marine resources are necessary to meet this objective.

2. *What are the current state or conditions and the related trends of these water resources and values?*

The San Francisco Bay - Delta estuary is one of the most modified estuaries in the United States (Goals Project, 1999).

The major sources of water for the baylands are the tides and freshwater runoff from watersheds. The characteristics of these sources have changed significantly over time. The tides have changed naturally throughout the estuary for centuries as a result of sea level rise. Runoff has also changed substantially, but mostly as a result of land use changes rather than natural causes. It has decreased in some areas and has increased in others (Goals Project, 1999).

San Francisco Bay-Estuary depends on freshwater inflows from the delta. The bay now receives less than 50 percent of its historical freshwater inflows. The biological communities of the Bay-Estuary are altered by the disruption of natural flow patterns (National Park Service, 1999a). The Sacramento and San Joaquin rivers, which enter the Bay system through the delta at the eastern end of Suisun Bay, contribute almost all the

freshwater inflow to the Bay. Many small rivers and streams also convey freshwater to the Bay system. The rate and timing of these freshwater flows are among the most important factors influencing physical, chemical, and biological conditions in the estuary (California Regional Water Quality Control Board, 1995).

Historically there were 174,000 acres of shallow bay and 100,000 acres of deep bay. About 16,000 acres of deep bay have become shallow and 18,000 acres of shallow bay have become tidal, diked, or filled baylands. Forty thousand acres of tidal marsh remain from the historic 190,000 acres, with only 16,000 acres of original tidal marsh remaining; the rest has naturally evolved from tidal flat, been restored from diked baylands, or muted by water control structures. One hundred thirty seven thousand acres of baylands have been diked and 50,000 acres of baylands have been filled (Goals Project, 1999).

About 40 percent of the original surface of the Bay has been diked off or filled in since 1850. Because this involved some of the most effective oxygenation areas, the ability of the Bay to take up oxygen has been sharply reduced (San Francisco Bay Conservation and Development Commission, 1998).

None of the beaches in the GOGA are being supplied with any sizeable quantity of stream-carried sand, and the rate of erosion of coastal cliffs does not seem to be fast enough to maintain them. Any sand removed is not likely to be replenished.

The Estuary's population of fish and wildlife has changed markedly in the past century and a half. This is a result of a variety of natural and human-induced factors, including over-harvest, habitat loss and degradation, introduced species, pollutants, and modification of freshwater flows. Declines in fish and wildlife populations have caused obvious economic losses through declines in sport and commercial hunting and fishing. The losses of bayland habitats have caused declines in aesthetics, pollution control, flood control, erosion control, and navigation, all of which have a price tag. These economic losses are just beginning to be considered as part of the rationale for baylands restoration (Goals Project, 1999).

The State must compile impaired waters in a 303(d) list and initiate a process to bring listed waters back into compliance. GOGA streams flow into San Francisco Bay and Tomales Bay, with park lands within the influence of Richardson Bay. These bays are on the 303(d) list 2002 (San Francisco Bay Regional Water Quality Control Board, 2002):

- *Tomales Bay* - mercury (mine tailings), nutrients (agriculture), pathogens (intensive animal feeding operations), and sedimentation/siltation (agriculture, upstream impoundment)
- *Richardson Bay*: chlordane (nonpoint source), DDT (nonpoint source), deldrin (unknown nonpoint source), dioxin compounds (atmospheric deposition, exotic species (ballast water, furan compounds (atmospheric deposition), high coliform (urban runoff/storm sewers, septage disposal, boat discharges/vessel wastes), and mercury (municipal point sources, resource extraction, atmospheric deposition, natural sources, nonpoint source).

- ❖ *San Francisco Bay (central)*: chlordane (nonpoint source), DDT (nonpoint source), diazinon (nonpoint source), dieldrin (nonpoint source), dioxin compounds (atmospheric deposition), exotic species (ballast water), furan compounds (atmospheric deposition), mercury (industrial point sources, municipal point sources, resource extraction, atmospheric deposition, natural sources, & nonpoint source), PCBs (unknown nonpoint source), and selenium (industrial point sources, agriculture, natural sources, exotic species).

Marin County announced a fish consumption advisory for Tomales Bay due to mercury bioaccumulation associated with an abandoned mercury mine in the Walker Creek watershed. (National Park Service, 2004b)

Evidence of contamination of Rodeo Lagoon due to high lead and cadmium levels as well as a high pH is a concern for aquatic life. (National Park Service, 1990a)

3. *Identify the potential future threats to these water resources and values.*

Water Quality

Unnatural sources of fresh water include storm drains and the discharge pipes from sewage treatment facilities. Fresh water affects salinity conditions and many physical and biological processes throughout much of the Estuary (Goals Project, 1999). Several rain water outfalls, which include pollution from local sewers during storm flows, empty into the park including; 1) one large outfall at Lobos Creek, 2) 19 at Crissy field, 3) 2-3 at Ocean Beach, 4) 2 at Stinson Beach, and 5) 10 at Fort Point. The large outfall at Baker Beach also includes sewage effluent during storm periods (National Park Service, 1990a).

Much of the freshwater inflow into the Bay is trapped upstream by the dams, canals, and reservoirs of California's water diversion projects, which provide vital water to industries, farms, homes, and businesses throughout the state. This freshwater diversion has sparked statewide controversy over possible adverse effects on the Estuary's water quality, fisheries, and ecosystem (California Regional Water Quality Board, 1995). Fresh water flowing into the Bay dilutes the salt water of the ocean flowing into the Bay through the Golden Gate. The gradual change in salt content of the Bay appears necessary for the survival of anadromous fish. The fresh water flows from Sacramento and San Joaquin Rivers into the Delta and the Bay have been reduced in the past by diversions of federal, state, and local governments for agricultural, industrial and domestic uses. Additional diversions are being sought, and further substantial diversions could change the salt content of Bay water and thereby adversely affect the ability of the Bay to support a great variety of aquatic life (San Francisco Bay Conservation and Development Commission, 1998).

Oil spills occur frequently in the bay and ocean, with some of the most recent affecting GOGA coastal resources in 1971, 1976, 1980, 1986, and 1989. Seven oil refineries are located in the Bay Area, and oil accounts for 75% of the tonnage entering the bay. Past frequencies of oil spills are likely to continue due to the continual pressure to open

nearby outer continental shelf leases for oil exploration and development, and due to the existence of refineries here. Resource losses also result from the oil cleanup procedure. Mechanical graders used to clean up the oil remove the top six inches of sand along with the oil. This top six inches is where most sand-dwelling species occur (National Park Service, 1999a).

Radioactive wastes dumped in the Gulf of the Farallones National Sanctuary (between 1946-1970) are potentially environmental hazards. Approximately 25%, more than 47,500 barrels of radioactive waste have imploded (Dyer, 1975). Plutonium and cesium are leaking into the sanctuary and threaten to contaminate the Pacific herring, Dover sole, rockfish, sablefish and Dungeness crab that are commercially fished in the area (San Mateo Times, 1990; National Park Service, 1999a).

Bay and marine water contamination from toxins, sewage and sediments threaten many park resources. The use of extremely toxic boat chemicals in harbors has led to the contamination of waters around many Bay Area marinas, including the marina adjacent to Ft. Mason, and those in Sausalito and Richardson Bay (Citizens for a Better Environment, 1987). Studies have detected concentrations of silver, cadmium, selenium, DDE, and PCBs in Dungeness crab (National Park Service, 1999a). Cadmium and lead were found to exceed criteria for the protection of saltwater and freshwater aquatic life in Rodeo Lagoon and Rodeo Creek (National Park Service, 1990a).

Dog, horse, cattle and human waste may be a significant source of nearshore and lagoon contamination. The San Francisco Sewage Management Plan determined that bacterial contamination of waters of Ocean Beach was significant due to dog fecal matter deposited along the shoreline (National Park Service, 1999a).

Hydrology

Redwood Creek and its mosaic of wetlands at the mouth, once known as Big Lagoon, have been disturbed over the past century by developments including water diversions for community use, levees for agricultural use, the NPS visitor parking lot, agriculture, and stream bank manipulations (e.g., gabions and riprap.) The downstream channel has been extensively modified and, unable to convey high sediment loads, it has severely aggraded since the early 1990's, causing flooding on local roads under average flow events (Shoulders, pers. comm., 2005). The NPS is currently planning a restoration of the Big Lagoon area to remove hydraulic constraints, such as a levee and the configuration of the visitor parking lot, and to allow better conveyance of flows and sediment loads through the channel and more extensive floodplain connection.

Sea level rise

If historic trends continue, global sea level should increase between 4 and 5 inches in the Bay in the next 50 years and could increase approximately 1.5 to 5 feet by the year 2100 depending on the rate of accelerated rise in sea level caused by the “greenhouse effect” (San Francisco Bay Conservation and Development Commission, 1998).

Rise in sea level over the next century will result from global warming (The Bay Watcher 1989). Some of the potential impacts that can be foreseen include: a reduction in primary productivity due to saltwater intrusion in the productive shallows of San Pablo and Suisun bays and the flooding of marshes and impacts on the Pacific flyway and local waterfowl. This result could be a general decline in most bay species of fish, shellfish, marine mammals and birds (National Park Service, 1999a). The NPS, in conjunction with USGS, is currently completing an evaluation of park's vulnerability to sea level rise.

Dredging

Present research indicates that filling a substantial part of the Bay --- as much as 25% --- would cause: 1) higher summertime temperatures and reduced rainfall in the Santa Clara Valley and the Carquinez Strait-Suisun Bay area; and 2) increase the frequency and thickness of both fog and smog in the Bay Area. Converting Bay surface to land would increase smog-producing temperature inversions in the Bay Area; in addition, the new land would probably be used for smog producing urban developments, including automobiles. To the greatest extent possible, the remaining water volume and surface area of the Bay should be maintained (San Francisco Bay Conservation and Development Commission, 1998).

Dredging materials are currently dumped 300 yards off Alcatraz Island, throughout the Golden Gate shipping channel and at San Francisco Bar. In 1989, DDE-contaminated sludge was dumped near Alcatraz. Dredging operations can modify or destroy benthic marine resources, which impacts intertidal resources (National Park Service, 1999a).

The city and county of San Francisco, USGS, and the Army Corps of Engineers are currently conducting studies of dredge disposal placement and effects on the San Francisco Bar and Ocean Beach.

4. *What are the issues that need to be addressed through the consideration of the GMP alternatives?*

To preserve the natural diversity of the baylands, tidal marshes must be restored along the salinity gradients of the Estuary, such that fresh and brackish species of plants and animals have someplace to go as the sea level rises and the estuary moves inland (Goals Project, 1999).

The overall goal for the "Central Bay – South Marin (Segment I)" region, which includes the main body of San Francisco Bay (and GOGA), is to restore and enhance tidal marsh wherever possible and restore high marsh near populations of rare and uncommon salt marsh plants to enable their expansion (Goals Project, 1999).

To the greatest extent feasible, the remaining marshes and mudflats around the Bay, the remaining water volume and surface area of the Bay, and adequate fresh water inflow into the Bay should be maintained (San Francisco Bay Conservation and Development Commission, 1998). The surface area of the Bay and the total volume of water should be

kept as large as possible in order to maximize active oxygen interchange, vigorous circulation, and effective tidal action (San Francisco Bay Conservation and Development Commission, 1998).

The impact of diversions of fresh water inflow into the Bay should be monitored by the State Water Resources Control Board, which should set standards to restore historical levels (1922-1967) to benefit fish and wildlife resources. The Bay Commission should cooperate with the State Board and others to ensure that adequate fresh water inflows to protect the Bay are made available (San Francisco Bay Conservation and Development Commission, 1998).

Coastal Processes

The City and County of San Francisco and the U.S. Army Corps of Engineers are in the process of conducting a feasibility study for management of Ocean Beach, a dynamic and heavily used stretch of shoreline. GOGA requested technical assistance on this issue to ensure that the protection of natural resources and processes are appropriately incorporated into the evaluation. GOGA, with ongoing technical assistance, has been successful at keeping NPS concerns on the table in this process.

Other:

The only structures in the park that are documented as being subject to flooding are in coastal areas subject to tsunami flooding (National Park Service, 1980). Tsunami maps are currently being updated for the California coast.

Water resource questions generated from the 2004 Vital Signs Monitoring Plan for San Francisco Bay Area Network include (National Park Service, 2004b):

1. How are commercial and recreational fisheries affecting marine resources?
2. Are deposition patterns changing on park beaches? Is erosion increasing in development zones?

A water resource objective from GOGA's 1990 draft Aquatic/Water Resources Management Plan (National Park Service, 1990a) is: The need to understand dynamics of sand movement and beach resources for management purposes. Project statements from this 1990 Plan include:

1. Inventory and Monitor Marine Resources.
2. Monitor coastal processes.
3. Rodeo Lagoon Restoration

Rodeo Lagoon watershed is the only estuarine resource which has its watershed completely within the park boundary. A comprehensive restoration project for the lake, lagoon, and watershed is necessary. Actions should include; monitor lagoon fish community; investigate the effects of poor water quality on ecology of Rodeo Lagoon,

monitor and mitigate water quality and erosion, inventory and monitor other sensitive species, restore habitat and correct wildlife disturbance problems (National Park Service, 1999a). GOGA has requested continued technical assistance on the Big Lagoon restoration planning/implementation.

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As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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