PENINSULA WATERSHED FIRE MANAGEMENT PLAN

I. INTRODUCTION

A. BACKGROUND

1. Purpose And Scope Of Plan

A 1994 management audit of the Mayor's Office of the City and County of San Francisco recommended that a wildland fire protection plan be prepared for the San Francisco Water Department Watershed lands for approval by the Public Utility Commission. This was subsequent to a similar recommendation made by the City And County of San Francisco Grand Jury in 1992. This Fire Management Plan is intended to address this requirement, as well as to assist the watershed management staff and local fire departments (California Department of Forestry and Fire Protection - CDF) in their fire planning.

This plan reviews existing conditions, and suggests proposed projects for several reasons. The projects are proposed to minimize damage and liability from wildfire to the natural environment and to structures/improvements on site, and to minimize the potential for fire to spread off the watershed boundaries and damage the property of others. This plan is intended to ensure that appropriate maintenance will be carried out on the watersheds in perpetuity to ensure proper levels of vegetation control and fire safety. Another goal of the plan is to make recommendations regarding the establishment of a fuel management program where fire safety is compatible with environmental stewardship.

2. Planning History

Past Plans - A previous fire management plan was prepared for the Peninsula Watershed by James Grieg in 1984, in conjunction with local California Department of Forestry and Fire Protection staff. While useful for background information, the 1984 plan is incomplete and outdated.

Current Planning - Current planning is dominated by the development of a Watershed Resource Management Plan, which has the following mission:

"To provide the best environment for the production, collection and storage of the highest quality water for the City and County of San Francisco and suburban users by developing, implementing and monitoring a resource management program which addresses all watershed land use activities and implements best management practices for the protection of water and natural resources and their conservation, enhancement, restoration, and maintenance while balancing financial costs and benefits."

The Watershed Management Plan may influence and alter the levels of access for recreation and potential number of ignitions. Several issues were raised in public meetings that directly address fire management. These include increased access, alternatives to fire breaks, and prescribed burning for fire hazard reduction.

Several plans are being developed as part of this master plan including a Sanitary Survey and Grazing Plan. The contents of the Sanitary Survey may have little application for fire management. The Grazing Plan does not apply to the Peninsula Watershed.

As with all resource management plans, aspects of each discipline apply to others. For fire management, recommendations regarding geology and soils may modify fuel management projects to minimize sedimentation through surface erosion or landslides. Similarly, road improvements for fire access will need to consider recommendations regarding the soil resource. Concerns for cultural resource preservation may require additional surveys prior to implementation of projects and modification of projects to avoid or otherwise protect any cultural heritage found.

Because vegetation management forms the basis of fuel management projects, this discipline is highly related to fire management. Similarly, the type and structure of vegetation forms a vital component of wildlife habitat and soil stability. Concerns for species distribution and effects of treatments (as well as of a wildfire with no action) will influence the timing, location, and extent of proposed fuel management projects. Excess loss of vegetative cover can also accelerate soil erosion and sedimentation rates.

In turn fire management concerns impact other disciplines. For example, minimization of ignitions may limit access or influence routing of trails. Protection of resources (and desire to increase biodiversity) may suggest fuel management projects and fire defense improvements.

3. Fire Suppression Policy

All fires are to be suppressed as soon as possible. This policy is chosen from three wildland fire suppression options which include: (1) "herding" the fire where resource damage is negligible, or (2) immediate and complete suppression, or (3) simply containing the fire. No wildfires are allowed to burn, regardless of fire behavior or suppression costs. Suppression of all fires will recognize safety and liability priorities as follows:
(a) protection of human life and property;
(b) protection of watershed and natural values
(c) protection of adjacent private property.

In order to implement the fire suppression policy, all fires are extinguished as soon as possible. No specific direction is provided regarding the means of suppression beyond standard operating procedures followed by the fire suppression agency.

4. Fuel Management Policy

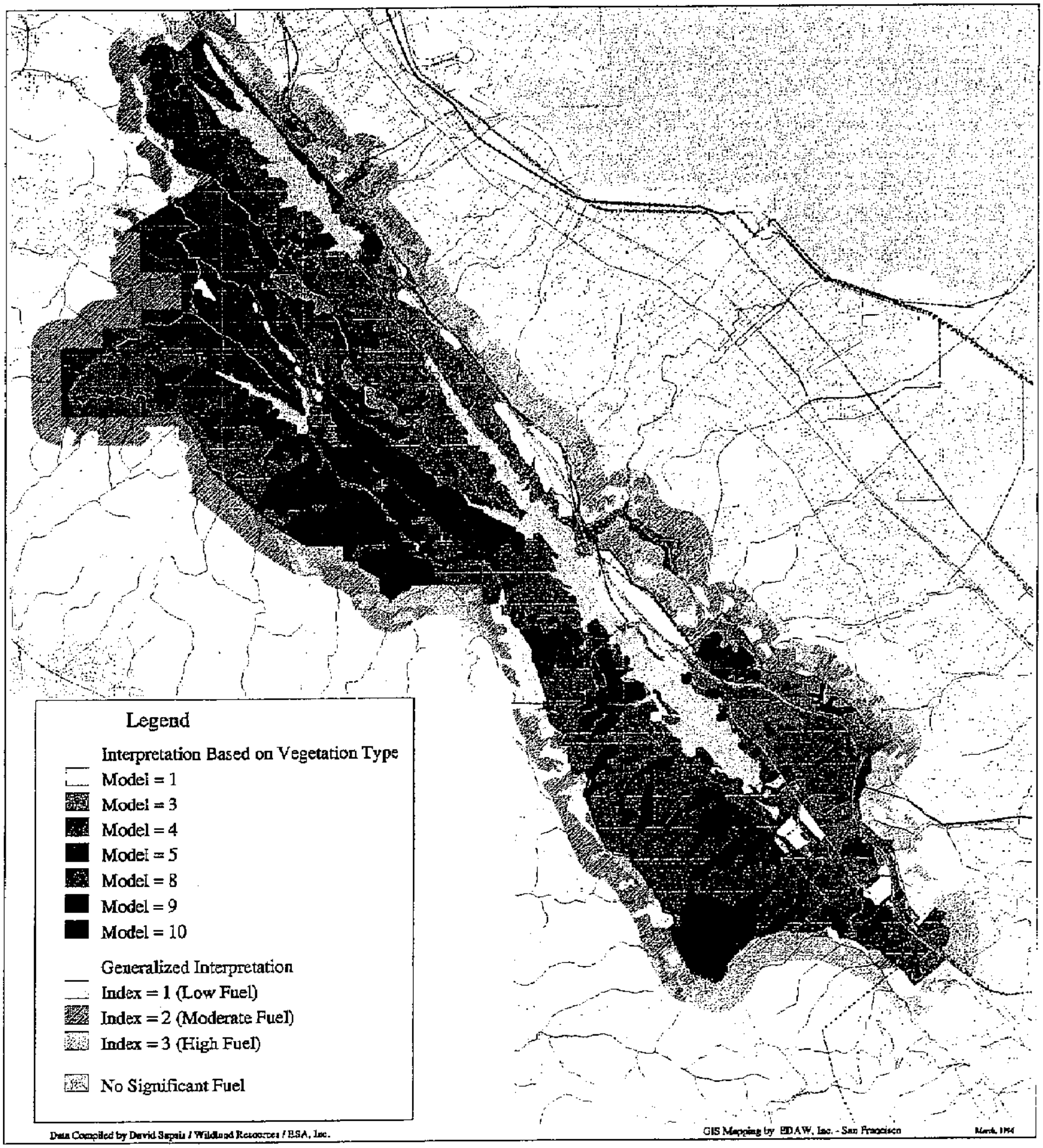
The current policy regarding fuel management does not prohibit vegetation management for fire hazard reduction. In fact, the use of Sheriff Inmate Crews and purchase of the Unimog and attachments is done in support of the current fuel management policy.

One policy which is, in part, based on concerns regarding potential damage from fire is the strict control of public access onto the watershed.

B. SETTING

1. Fuels

There is a complex distribution of fuel types on the Peninsula Watershed, ranging from short grass to heavy timber with a significant amount of understory fuels. Most of the area is dominated by shrub and forest fuel types. Less than 15% of the watershed is covered by grass or herbaceous material.



Fuel Classification (CHECKPLOT)

Scale 1 : 80,000

Feet

Meters

1" = 6667 feet

PENINSULA WATERSHED

SAN FRANCISCO WATERSHED MANAGEMENT PLANS

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Most of the grass is found east of the rift valley. While grass does not produce great amounts of heat it serves as a quick start for fire to spread into adjacent shrub-dominated fuels. Thus, chaparral areas adjacent to grass are of particular concern because they are likely to cast embers into heavy timber or residential areas.

Shrubby fuels - chaparral and north coastal scrub - are found in isolated areas in the east portion of the rift valley. Isolated areas of chaparral are found in some areas near Filoli at the south end of the Watershed, and in areas interspersed with both hardwoods and conifers.

The majority of the northern portion of the watershed is dominated by coyote bush, a shorter shrub. The fuel type is usually not as easy to ignite as grass. However, when fire becomes established it spreads extremely quickly, with flame lengths longer than 20 ft under severe fire weather. Approximately 29% of the watershed is categorized as short shrub, and 10% as tall chaparral.

Most of the western portion of the watershed is dominated by forests where a fire usually spreads through the forest litter. Dense hardwood forests present low rates of spread and benign fire behavior in 20% of the watershed.

Large portions of the east-facing slopes are dominated by conifers. Some areas are plantations of exotic species which present moderate fuel hazards both in fire intensity and rates of spread. The potential for ember production poses some hazards. Coniferous areas are categorized into two different fuel types; 3500 acres are represented by a fuel type with lesser large material on the forest floor combined with the fuel type with more larger material on the forest floor. This latter type is found on 70 acres of conifer and eucalyptus where crown fires can deposit embers throughout the watershed, and to either San Bruno or Pacific, depending on winds.

2. Weather

Background - Weather conditions significantly impact the potential for fire ignition as well as the rate, intensity, and direction in which fires burn. Wind, temperature, and humidity are the more important weather variables used to predict fire behavior.

Wind is considered the most variable and difficult weather element to predict. However, wind direction and velocity profoundly affect fire behavior. Surface winds, which travel within 20 feet of the ground, affect fire intensity by supplying oxygen to the flames. Wind increases the flammability of the fuels by removing moisture through evaporation and by angling the flames to heat the fuels in the fire's path. The direction and velocity of surface winds can also control the direction and rate at which the fire spreads. Aloft winds, which move at least 20 feet above the ground, can carry embers and firebrands downwind, causing spot fires to precede the primary front. In closed canyons and narrow valleys, aloft winds can facilitate the development of convection columns, which dry surrounding fuels and carry firebrands to unburned areas. Gusty winds cause a fire to burn erratically, making it more difficult to contain.

Many factors affect wind speed and direction. General winds are dictated by the earth's rotation. These winds are quite consistent at a regional scale and affect the large scale weather pattern of the area. For example, the general winds in the Bay Area blow from the west in the summer and south-west in the winter. Local wind patterns, specific to the hills and valleys of the landscape, are dictated by local geographic features. For example, diurnal shifts in local wind direction occur along the coast where day time off-shore breezes shift to off-land breezes at night. A similar pattern occurs in mountainous regions where rising, sun-heated air generates an upslope breezes during the day and night-cooled air slide downslope at night. Such terrain controlled winds are more prominent under clear skies and low humidity and can profoundly affect the rate and direction in which a fire burns.

While the winds which create the most severe fire danger are typically from the northeast, winds from the northwest are likely to cause the most damage, particularly to neighboring residential communities. The worst-case scenario is a fire driven by a northwest wind which follows a northeast wind. The northeast wind is expected to dry the fuels because is it normally associated with low humidities and high temperatures. A fire could easily grow to large proportions under such conditions - similar to the situation during the 1995 Vision Fire at Pt. Reyes, Ca. These winds would drive the fire spread away from the dense developments in Belmont, Hillsborough and San Mateo, but endanger the communities of Half Moon Bay and those on King Mountain and Pacifica. At the end of this "Santa Ana", or "Diablo" wind condition, the fog often comes quickly on shore, preceded by a brisk, high-speed wind. Under these conditions, the fuels would be still dry from the previous weather, and the wind would quickly spread the fire into the populated areas of San Mateo, Belmont, and other locations. If a fire were already burning on the Peninsula Watershed, the direction would dramatically change; a large fire front and a blizzard of embers can be expected to rain onto nearby urban areas.

Relative humidity is the amount of water in the air in relation to the maximum water holding capacity of air at a given temperature. Warmer air is capable of holding more water than cooler air. Thus, 80% humidity at 90 degrees F. describes air with more water than the same volume of air at 60 degrees F and 80% humidity. In terms of fire, warm air with low relative humidity is a stronger drying agent than cool air of the same relative humidity, since warm air can hold, or "steal" more water than cool air. Since water, even as air droplets, takes more energy from the fire to heat up than does dry air, conditions of high humidity tend to have a suppressing effect on fires. High temperatures and low humidity optimize conditions for the ignition and spread of wildfires.

Frequently, both temperature and humidity oscillate diurnally, with the temperature climbing during the day to peak in mid-afternoon and sinking to a daily minimum in the early morning hours. Relative humidity usually varies inversely to the temperature, making late afternoons the direst and hottest periods of the day. Of course, temperature and humidity are affected by local weather patterns, which may blow in very dry and warm or cool and moist air masses at any time of the day.

Wildland managers study the 90th percentile and worst case fire conditions in managing for fire hazard control. The 90th percentile fire conditions describe the 10% most extreme fire-inducing weather conditions. The weather of greatest concern for fire protection is characterized by hot, dry, windy days. These conditions maximize ignitability and make fire suppression difficult. For example, they would include the average of the 10% driest, hottest, and windiest days reported in an area. Worst case conditions are identified by the worst extreme values recorded for a given area. Managers apply the 90th percentile and worst case conditions to predictive models in order to identify (and avoid) fire behavior under very challenging weather conditions. In this way, plans can be made to handle all fires that could occur in an area. The conditions recorded on the 10% driest, hottest, and windiest days observed are identified to yield an estimate of worst case conditions. Since the watersheds have a dry season of approximately 150 days, these conditions can be expected 15 days each year.

Local Weather Conditions - The weather in the Peninsula Watershed is influenced by its proximity to the coast. It has warm, dry summers and cool, moist winters characteristic of the fog belt area. On the average, the area receives about 45 inches of precipitation a year. In general, most of the measurable rainfall occurs during the winter months (mid-October to mid-April). Thus, May to October is the time of highest fire danger and constitutes the fire season.

Summertime temperatures are usually quite warm, often well over 100 degrees. However; it is common for the fog to roll in during the early summer evenings. Because of its proximity to the coast, fog sometimes keeps summertime temperatures cool in the watershed. However, many parts of the watershed are often above the fog so are not always as well protected as other lands located at lower elevations. The sea breeze associated with fog is also associated with breezy conditions frequently found on the site. It is this wind in front of the fog that can pose weather-related challenges for fire suppression as frequently as one-quarter of the days in fire season. After hours of sunshine during the day, the fuels are dried out and require at least one hour (and most of the time, longer) to accept the moisture from the fog. In the afternoon, the wind in front of the fog dramatically increases the fire's spread rate, for the winds "fan the flames". This is particularly important to the values at risk above and to the east of Peninsula Watershed: along Pulgas Ridge, Buri Ridge, Black Mountain and other neighborhoods in Hillsborough, Millbrae, San Mateo, Belmont and San Carlos.

While the wind normally blows from the west, the most severe fire weather occurs with strong north or northeast winds. Under these conditions (which are common in the fall), humidities drop to 20% and temperatures soar to over 100 degrees Fahrenheit. Northerly winds would be particularly troublesome because they would be aligned with several canyons in the watershed, such as the canyons draining to Pilarcitos Lake, and upper San Mateo Canyon.

Additionally, occasional episodes of several still, stagnant days formed stationary highs occur during droughts. During this time, periods of continuous high temperatures and low relative humidities, fuels dry to a point during these times when the burning index ratings according to the National Fire Danger Rating System are over 81 and indicate extreme resistance to control.

The easterly winds that helped spread the 1991 Oakland Fire do not blow with the same intensity in the east-facing hills of Peninsula Watershed. However, this overall weather pattern creates extremely low humidities and enhances the possibilities of ignition and extreme fire behavior.

Weather data was collected from the CDF Morgan Hill station, located inland and to the south of the Peninsula Watershed. While this station is located at some distance from the Peninsula Watershed, the CDF judges the data as representative and uses this data throughout Santa Clara and San Mateo counties to plan fire suppression levels and resource allocation. The temperature, humidity and wind speed were observed at the station at 2:00 in the afternoon during the fire season for the years 1980-1991. The only other weather station which observes these important fire weather factors is located in La Honda and is not representative of the Peninsula Watershed conditions.

The highest temperature recorded was 108 degrees F, on July 17, 1988. The minimum relative humidity that occurred as 8%, which is extremely dry; kiln-dried wood normally has a moisture of 12%. The highest wind speed recorded was 29 miles per hour.

Using a data base of 1485 days in which weather was observed, the average worst temperature (the temperature that occurs on 10% of the days during fire season) was 94 degrees F. The average worst humidity was 22%, and the average worst wind speed was 13 miles per hour. While the temperature is not exceedingly warm under these conditions, the humidity is alarmingly low (anything under 30% is considered extremely dry), and the wind speed is quite high. Fires ignited under these conditions, fanned and driven by the wind, would burn and spread vary rapidly. The wind blew from the west or northwest for over the majority of the hottest 10% of the days. Winds from the east only occurred 12% of the time on these hot days.

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The steep topography in the watershed creates its own wind so that up-canyon drafts in the morning and down-canyon drafts in the afternoon can be expected. Additionally, the many canyons can divert the wind so that, for example, a prevailing westerly wind is oriented more to the south. Lastly, bowls that are formed by the topography east of Montara Mountain and along Skyline Blvd. is the type of topography which is conducive to whirlwind fire storms. Fire storms cause uncontrollable fire behavior, and complete consumption of all biomass.

3. Topography

Role of Topography In Fire Behavior - Topographic features, such as slope, aspect, and the overall form of the land, have a profound effect on both the abiotic and biotic components of an area's ecology. For example, topography influences local weather patterns, vegetation types and distribution, and creates microclimates with localized moisture conditions. By influencing the local wind, fuel, moisture and heat availability, topography directly and indirectly affects the intensity, direction, and spread rate of wildfires.

Large topographic features, such as mountains, affect the local weather patterns. Orographic thunderstorms are formed when an air mass flows up a mountain slope, is cooled, and releases the moisture it can no longer hold. Foehn winds, also known as Santa Ana or Mono winds, form as this dry air descends in a laminar manner down the leeward side of a mountain and is warmed and channeled through saddles and mountain passes.

Local winds are also affected by an area's topography. In mountain regions, the less dense, sun-heated air rises upslope during the day, generating upslope afternoon winds. At night, the mountain air cools, and slides toward the valleys generating downslope drafts in the late night hours. The sun warmed air in the valley is displaced by the descending cool night air, and rises to the mid-slope zone. As a result, the mid-slope zone actually has a higher average temperature, lower relative humidities, and higher potential fire hazard than the other elevations. Surface winds can be slowed and dispersed into erratic gusts by rough, rocky, or forested terrain. The speed, regularity, and direction of the wind directly influences the rate and direction in which a wildfire burns.

Winds form when air, heated by either a fire or the sun, rises upslope. These winds are stronger along steep slopes than along gentle ones. As a result, fires travel up the steep slopes faster, and in a more narrow wedge than do those that occur along gentler slopes. Fires burning in flat or gently sloping areas tend to burn more slowly and to spread more horizontally than fires on steep slopes. Similarly, fires ignited at the base of a slope spread farther and more rapidly than those ignited at the top. In contrast, ridgetops, rivers, and roads act as natural fire breaks since they are devoid of, or in fuel.

Both slope aspect, the direction the slope is facing, and slope position, lower, mid, or upper-slope, affect moisture availability and vegetation. South and southwest facing slopes receive the warmest direct sunlight for the longest period of the day. Therefore, these aspects tend to be drier and support more dry-site species, than do the north and north-east facing slopes, The soil and downed fuel along steep slopes also receive more direct sunlight, and are drier than those on gentler slopes. Sun and wind exposure are also greater along the upper third and ridgetops, making moisture less available than in the more protected areas along the lower slope and valley floor. As a result, lower elevation areas support more vegetation, and offer a larger fuel supply. These factors work together to influence the overall fire hazard associated with an area.

For example, the low to mid-elevation, southwest facing steep slopes would have a higher fire hazard than the high elevation northeast facing slopes.

Description of Local Topography - Densely forested ridges and steep canyons characterize the rugged topography of the Peninsula Watershed. Most of the permanent and intermittent streams flow north and northwest into the reservoirs, and have carved valleys with primarily east and west facing slopes. These valleys and canyons have very steep sides, slopes average 43%. Residences along Skyline Blvd., southwest of the Intersection of Highways 92 and 35, rest on a ridge which falls off precipitously to the north and east. Although these hillsides are steep, averaging 40%, they face north and east and as a result, are not usually extremely dry, high fire hazard areas.

The Peninsula Watershed is bordered by Skyline Blvd. along the southwest portion of the watershed and along the east by the San Andreas Fault. The 22,600 acre watershed is located in north end of the Santa Cruz Mountains within the Coast Ranges. The western boundary coincides with the distinct, high ridgeline; the slopes to the west descend to the Pacific Ocean. The northwest corner of the watershed is marked by Montara Mountains, the southwest is along Kings Mountain.

The topography is dominated by a northwest-trending rift valley created by San Andreas fault. The San Andreas fault zone traverse the length of the Peninsula Watershed and forms the valley with Crystal Springs and San Andreas Reservoir. Several northwest trending ridges and eastern flank of Montara Mountain are west of the rift valley.

Terrain is generally rugged. Elevations ranges from 300 elevation (along shoreline of Crystal Springs Reservoir) to 1900 at Montara Mountain (North Peak and Scarper Pk.) and over 2000 ft near Kings mountain. West of the San Andreas fault, steep valley sides slopes with flat-topped ridge are dominant patterns,. Rounded, rolling topography exists southwest of fault. Spring Valley Ridge, Fifield Ridge are noticeably flat-topped with gentle, rounded upper slopes and steeper slopes towards the valley bottom.

Slopes in northern portion of the watershed are steeper than slopes of southern portion. Overall, slopes in north have average steepness ranging from 33% to 100%. Slopes in south have average steepness ranging form 20% to 33%. Slopes within the valleys, minor drainages on ridgetops are more gentle.

Some of the high points in Pilarcitos Basin is within the Montara Mountains - North Peak, (1898 elevation) and Scarper Pk. (1944 elevation). The Fifield and Cahill Ridges average about 1100 ft elevation. Sweeney Ridge is 1100 to 1200 ft in elevation and declines to the south to Sawyer Ridge. Local relief by the San Andreas Reservoir is from 400 - 600 ft elevation. The steepest slopes in this area are greater than 50%, but several are 20 - 30%.

The Lower Crystal Springs Reservoir basin includes two northwest to northeast valleys. Side slopes are 20-50% steepness, but valley bottom and ridgetops are nearly level. The topography east of the reservoirs is generally more gentle than the west side (except near Crystal Springs dam, and downstream portion of San Mateo Creek).

4. Values at risk

Safety - The greatest concern is injury and loss of life. The safety of SFWD personnel is the target of many safety campaigns and several regulations. Another danger to SFWD employees as well as visitors to the watersheds is a wildfire. Another serious concern is the possible threat to life and safety of the public outside SFWD property resulting from a wildfire on or passing through SFWD lands. As was the case in the 1991 Tunnel Fire in Oakland, people can perish both in the process of evacuation as well as in attempts to protect their property. Lastly, there is a risk to the firefighting personnel resulting from a fire.

The locations where the greatest threat to safety generally occurs in areas of dense population with poor access (narrow, windy and steep roads serving large numbers of people). Dense populations do not occur in the Peninsula Watershed, but both poor access and dense populations are located outside and near the boundary, creating a great threat to safety. Because the number of roads is few and quality poor inside the Peninsula Watershed, a situation exists where, if a fast-moving fire were to occur, staff and/or firefighting personnel could become trapped.

Developments, Improvements - The Peninsula Watershed has many improvements of considerable value that could be damaged by wildfire. Not only does the Peninsula Watershed have historic estates such as Filoli, water temples, but it also owns cottages and filter plants which are vulnerable to fire. Additionally, distribution lines which are not buried, old flumes, fences, filter plants on the property, communication stations, roads would also be damaged by a wildfire. Lastly, improvements off the Peninsula Watershed is a concern because a fire could start and burn off or through Watershed property. These are generally comprised of dwellings, but also include automobiles, telephone and power poles, and personal possessions. The highest concentration by far of residential neighborhoods is found on the eastern border with the residential communities of Millbrea, Hillsborough, San Mateo, Belmont and San Carlos. To the west, Pacifica abuts a small portion of the northwestern border.

The most sensitive areas are in residential areas of high fuel loads, those areas which lack clearance around structures, areas of steep slopes, and areas of poor access. In these situations there are few places exist for firefighting personnel to make a stand. Additionally, fire behavior is expected to be erratic and difficult to suppress in these circumstances.

Natural Resources - A vital natural resource in the Peninsula Watershed land is the water which runs off the slopes into the reservoirs below. While not directly damaged during a wildfire, both water quality and quantity are unquestionably altered with a large wildfire. Increased sedimentation is the aspect of water quality most affected by a wildfire. This sedimentation has an added detriment by diminishing the capacity of the reservoir. The magnitude of these types of damages is related in part to both the extent of the fire as well as the location in relation to the reservoir. Fires which burn most of the slope above a reservoir or, to a lesser extent, fires which are located directly above a reservoir without a buffer.

There are few circumstances where vegetation itself is sensitive to fire. Fires of all intensities, sizes, seasons, and frequencies have burned throughout the millennia. However, the distribution of the characteristics of fires have been recently altered such that more fires are large and of high intensity. Of the thousands of fires that burn in California, few fires of low intensity. In particular, fires which may burn on the Peninsula Watershed are not expected to be of low intensity. In oak stands, for example, fires of low intensity were likely to be frequent before settlement time. Disturbance has been minimal since the turn of the century (or longer) and a significant understory has developed. Now, should a fire burn these type of oak stands, the older trees would be harmed and many would die. A portion of the oak trees should be expected to resprout from the base of the tree, but some will not recover. The ultimate damage may be the water resource as the vegetative cover would be burned, resulting in increased soil erosion and sedimentation.

Rare and endangered species commonly require fire to either provide for germination or alter the micro-habitat so it can grow (i.e. remove thatch or shading plants). Some species may be sensitive to a lack of fire's occurrence. For example, a "listed" manzanita which occurs on Marin Municipal Watershed District lands requires fire for germination, but no fire has occurred for many decades and the stand is becoming decadent. Because the length of viability of the seeds is unknown, an experimental burn is recommended there for this sensitive species (Leonard Charles 1993).

In other locations where rare and endangered species occur a wildfire may set the stage for invasion by alien weeds which could out-compete the native sensitive species. The response by the site is determined in part by the season of the burn, the fire behavior itself, and the proximity to alien seed sources.

Rarely, two fires will burn so close in time that the species which require seed for propagation are harmed. The species may not have had enough time to reach seeding maturity and thus new seeds for the next generation would not be present. As a result, that species would become locally extinct or at least infrequent.

5. Jurisdictions

The entirety of the Peninsula Watershed is located within State Responsibility Areas and as such, is protected by the California Department of Forestry. The nearest station to the Peninsula Watershed is the Belmont Station, located in San Mateo.

6. Neighborhood Context

The eastern border of the watershed abuts small private residential parcels, with few exceptions. The northwestern border abuts the Golden Gate Recreational Area; larger private parcels are found west of the watershed north of Highway 92. A cemetery and a mix of large and small parcels are located to the south and west.

C. HISTORY/ROLE OF DISTURBANCE

Every vegetation type has its own disturbance regime. This is defined as the timing, extent, and type (intensity) of disturbance. Fires may comprise the most frequent disturbance, however, flooding, erosion, mass wasting, wind-events, harvesting and grazing are all disturbances that the biota must respond to. Determining the nature of past disturbances may suggest future actions and precautions.

1. Fire History

The fire history was not available in written reports but rather the data is based on memory or historical newspaper reports. Boundaries of the fires are typically not completely accurate, the year of the fire may vary one to three years, and information surrounding the event is skimpy.

Written reports of recent fires were not available for the Peninsula because of a lack of large fire occurrence during the last several decades. The memory of retired staff provided a description of a few small fires since 1960. The great majority of the information on fires in the Peninsula Watershed comes from written historical reports contained in the Peninsula Watershed Management Program, and the Statement for Management: Golden Gate National Recreation Area.

Regardless, patterns of ignition location, frequency, associated vegetation and cause can be generated from this information. Using fire history information, an investigator can also infer Successional development in vegetation, and gain insight regarding fuel characteristics and potential fire effects.

Fire history information can identify areas where management action may be warranted. For example, access routes were locations of a higher incidence of fire; lands adjacent to these access routes may benefit from vegetation manipulation, or other methods to reduce ignition (such as road closure during high fire danger). In another example, a lack of fire occurrence in a shrub area may indicate an accumulation of dead wood and biomass. This, coupled with other factors, would suggest treatment to reduce fire hazard.

Number of Fires - Several large fires occurred within a 50-year time period from 1877 to 1929. None have been documented in formal records since that time. However, conversations with protection staff and retired SFWD staff have yield information regarding fire occurrence in the Peninsula Watershed. Locations have not been specific enough to map.

The last major fire in the area occurred in 1946 (Grieg 1984). Grieg also notes a large fire in 1929, which resulted in reduced capacity of the reservoirs because of the vast sedimentation that followed the fire. This was the most recent damaging fire and was described in the Golden Gate National Recreational Area (GGNRA) Fire Management Plan as having burned a week long around the town of Montara, and reported to having completely burned down the town. This fire was started in November, and stopped by moist and cold weather rather than suppression action, because access to the fire was very poor (Fonseca personal communication). Mr. Fonseca recalls this fire as lasting six weeks.

The earliest fire documented in Grieg is in 1889, but the exact acreage burned is unknown. He quotes: "a mile of flume and a large area of brush and trees in the northern one-half of the watershed". This same fire was described in the GGNRA Fire Management Plan as burning an area on the ridge between San Andreas Lake and Crystal Springs Lake and two ridges west of San Andreas Lake. "for miles the hills are black and bare, the fire burned for at least four days spread at least one and one-half miles a day." The fire in 1887 was described as spreading from below San Andreas Lake to San Mateo Creek, burning 2500 acres of second growth bay oaks, and madrone. Lastly, the GGNRA Fire Management Plan describes a fire in 1877 as covering an area west of San Andreas Lake burning a large territory for over three weeks.

While the location of the following fires were not specific enough to map, Mr. Fonseca (former SFWD staff) and Kirk Landuyt (California Department of Forestry and Fire Protection) both recalled that several suspicious fires occurred in the mid- to late- 1960's off Army Rd. in the northern portion of the watershed. Some fires during this time period were started by children with fireworks in the ridgetop of eucalyptus trees in steep terrain and poor access. These fires burned downhill westerly moving against a westerly wind and so did not consume much acreage.

A few fires have been set in the southern portion of the Peninsula Watershed in the grass and burned easterly, but were stopped at Skyline Blvd. While one fire was 50 acres, most were under ten acres, and few were between 10 - 15 acres, so the cumulative effect was negligible. There were also 30 fires in 1973 on the Sawyer Camp Trail, which was open to vehicular traffic at that time. Of these, three were of "fair extent" (Fonseca, personal communication). Several covered approximately one-half acre of grass.

The history of large fire has been concentrated in the northern portion of the land; the time since the last fire is even longer on other portions of the Peninsula Watershed. The roads and highways that bisect and border the Peninsula Watershed have not been a major source of recorded ignitions. Instead, episodes of numerous fire ignitions have occurred off Sawyers Camp Rd., and off Army Rd. A fewer number of fires have started near Skyline Blvd.

Size of Fires - During the period 1877 to 1929, the smallest fire was several hundred acres and the largest, several thousand acres. Generally, these were quite large fires and were stand-replacing in nature. More recently, most fires are small, under one acre in size. Occasionally (approximately once every five years) a fire has burned 10 to 50 acres. The percentage of the watershed that is burned each year is under .2%., less than 50 acres a year.

Cause of Fires - The cause of the early fires are unknown. Large fires in Marin during this time period have been associated with early harvesting of timber, however no mention of possible cause of fires in the Peninsula Watershed is included in fire history information. Several fires have been set by arsons, others set by children playing with fireworks. Fires may be started by illegal hunters, as evidenced by numerous abandoned camps with extinguished fires, and lean-tos which were scorched. These would be particularly difficult to detect and respond to, which could more easily result in a large fire before suppression action could even begin.

No threats to private homes have resulted from wildfires.

2. Storm-Caused Damage

Storm-related damage creates additional dead fuels (sometimes in already decadent stands), which will remain until treated and removed, or a fire occurs. For example, in the December, 1995 storm hurricane winds measured at 80 mph north of San Andreas Lake. Numerous Douglas fir trees fell across the road on Cahill Ridge. Several electrical power poles were blown over. Luckily the potential for ignitions was not realized because this wind event was not associated with rain. Vegetation which is damaged includes tall trees, even tall brush, wherever high branch rose above the general canopy level. Damage includes all sizes of fuels - from fine fuels to large logs. The importance of a wind event such as occurred in December, 1995 is underscored by the Spokane Firestorm of 1991. There wind trees were blown across power lines, causing 92 fires. These fires were then fanned by the high speed winds to cause significant damage.

3. Disturbance Through Mass Wasting and Erosion

The most frequent type of disturbance is fire, however, disturbance through mass wasting (landsliding) and surface erosion also forms an integral part of the total disturbance regime which sets back successional stages and provides diversity in age classes.

Many soil types throughout the Peninsula have erosion hazard ratings of severe to very severe. Many areas with slopes greater than 20% have severe to very severe erosion hazard.

Slope stability is less severe and pervasive on the Peninsula Watershed than the Alameda watershed. Stability ranges from dispersed small landslides and moderately susceptible to failures to large old landslides that are highly susceptible to re-activation. Most large landslides are along fault zones and ridgelines in the Pilarcitos Basin

Numerous small to moderate (under 500 ft long) landslides have occurred within the watershed, especially along Pilarcitos. Several large slides (over 5400 ft long) are also present, including a major slides on the flank of Montara Mountain adjacent to Pilarcitos Creek near Highway 280 in southernmost portion of study area.

West of San Andreas have lower susceptibility to landsliding than the area the east. The area immediately adjacent to Highway 280 has moderately high landslide susceptibility and several small and large existing landslides. While most of the Pilarcitos Basin has low susceptibility to landslides, some exceptions exist. Most slopes are classified as generally stable to marginally stable and moderate stable in the Pilarcitos Basin.

The Pilarcitos basing has several areas that have had moderate and severe topsoil erosion. Limited soil depth, water holding capacity and fertility make them sensitive to further loss of topsoil. None of the slopes San Andreas basin have moderate or severe surface erosion and slopes are stable. All upland soils have a severe to very severe erosion hazard rating and are sensitive to disturbance.

The ultimate result of topsoil erosion and mass wasting is the reduction of water quality for the customers of the San Francisco Water Department and reduction of reservoir capacity through sedimentation.