# Marin Municipal Water District
# Vegetation Management Plan Update

## Background Report No. 6

## Fire Hazard Management

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# I. Introduction

This background report presents the results of the fire hazard analysis. The data will be used in developing the Draft Vegetation Management Plan (VMP). This report summarizes the risk, values at risk, ignitability and hazard that are present on the Mt. Tamalpais watershed. The report concludes with recommendations for modifying the fuelbreak system

This report addresses fire hazards and methods of reducing that hazard on the Mt. Tamalpais Watershed. The fire hazard on the other two watersheds is not as significant an issue because there are few residences near the watershed lands plus the District does not own much land bordering the reservoirs, so it has very limited ability to manage fuels to make a meaningful reduction in fire hazard in the general area.

Wildland Resource Management (WRM) developed a variety of fuel treatment scenarios in consultation with District staff (see Appendix A). The effects on fire behavior and potential damage under the various fuel treatment scenarios are quantified in terms of acreage, fire severity, and/or potential damage (using an average cost/acre in various land uses, or other costs as advised by the District).

WRM performed a spatial assessment of hazard and risk, using FlamMap and FARSITE to identify:

- Appropriate locations for fuelbreaks;
- The most appropriate width of fuelbreaks;
- The effectiveness of fuelbreaks to meet various fire management objectives;(containment, reduction in fire spread rates, reduction in fire intensity, reduction in fire severity for natural resource/water quality concerns, reduction in ember production); and
- The effectiveness of fuelbreaks with varying levels of fire intensity.

FlamMap is a computerized fire behavior prediction model developed by the USDA Forest Service. FlamMap allows prediction of fire behavior on a spatial basis, portraying the locations of various flame lengths, heat release, and rate of spreads along with type of fire (a spreading crown fire, surface fire, or a fire that torches individual trees). FARSITE, which is a fire growth model that predicts the direction and rate of fire spread[1], was used to test the efficacy of each fuel management strategy. The fire behavior modeling with FARSITE used site-specific conditions, based on hypothetical scenarios involving different locations of varying treatments types location, such as: fuelbreak, defensible space, and combinations thereof. The results are measured in terms of acreage burned, burn severity and potential damage. Acreage burned is a direct output

[1] FARSITE was developed to predict natural fire growth in the National Parks and is now used in every major wildfire because it predicts where and how fast the fire will spread, based on a specific ignition location. The fire characteristics (flame length, heat output, crown fire potential) for each area are also predicted, based on the site-specific combination of fuels, weather and topography.

of FARSITE, burn severity is based on decision-rule based translation from fire behavior characteristics to burn severity, and potential damage is based on the value/acre for each land use type.

This section documents the steps used in the development of the data layers, the assumptions made in the decision-rules, and presents the conclusions that can be made from the output of the modeling. Products include the following (see Appendix A):

- FlamMap inputs (fuel models, tree height, canopy cover density, height to live crown, tree height elevation, aspect, slope steepness);
- Weather data library;
- Maps of FlamMap output (flame length, fireline intensity, rate of spread, crown fire potential, total heat output) indicating spatial distribution of hazard;
- Map of fire hazard indicating areas of high fire hazard and possibly, priority vegetation treatment;
- Results of various FARSITE runs indicating effects of fuelbreaks under differing weather and treatment scenarios; and
- Results of various FARSITE runs indicating effects of varying fuel management scenarios.

## II. Goals and Objectives

The goals and objectives of the VMP are described in Background Report No. 3. (Vegetation Management Plan Goals and Objectives Report) The basic goals are to preserve and restore biodiversity and to protect life and property. These two goals may, at times, conflict. The most obvious example is that constructing fuelbreaks sometimes results in the expansion of invasive species, especially when there is no maintenance. In addition, the VMP goals and objectives look to restore fire to the study area as part of the ecological process. The following provides the rationale and recommendations for the VMP objectives related to restoring fire as part of the ecological processes and for reducing fire hazard.

## Goal 1 Maintain Existing Significant Biological Resources.

### Objective 1.4 Preserve the biological diversity and structure of significant vegetation types that are in the process of being modified due to fire suppression.

A wildfire can substantially affect vegetation and plant succession. For example, the old-growth forest on Bolinas Ridge is currently not as resilient to a stand-replacing fire that could occur in this area due to the SOD-killed trees; a high-intensity fire could prevent the re-occurrence of the old growth forest for the foreseeable future.

Vegetation types can be vulnerable to changes in their natural fire regime (i.e., the fire regime that occurred prior to European colonization or “presettlement”), when burns become too hot, too frequent or too large. Most vegetation types on the watershed are resilient to a wide range of fire regimes.

Recommended actions include classifying and mapping natural fire regimes associated with each vegetation type, and classifying the sensitivity to departure of fire regimes. Some vegetation types are compatible with a broad range of fire regimes; the focus would be to identify those that are highly sensitive to a change in fire regimes, including sensitivity to weed invasion after wildfire. Classification would include description of the structural characteristics of the stand, fuel volume, species composition and dominance. Another action would be determining the likely fire behavior, interval and size under current conditions.

Fuel characteristics and species composition within or around old growth stands or other stands deemed valuable should be managed to restore the presettlement fire regime or to make the stand more resilient to an anticipated fire. See the Biodiversity Chapter (Background Report No. 5) for a discussion of managing woodland stands to restore conditions similar to presettlement conditions. A site that is sensitive to and likely to experience too frequent disturbance should be protected from fires until the interval matches the presettlement fire frequency. It is likely the best location for action to protect the sensitive area would be adjacent to, not within, the sensitive habitat. Actions could be to alter fuels to promote fire containment outside the area.

Other areas may be at risk from a wildfire that could produce an intensity out of the range of natural variation. For example, the fuel characteristics of the oak woodlands with an understory or emerging overstory of Douglas fir could produce such a fire. Fuel characteristics should be altered in these locations to reduce fire intensity. Restoration of oak woodlands would be consistent with Objective 1.4. This would also be compatible with Objective 2.1 “Treat degraded sites to restore high quality habitat."

It is important to manage fuels to prevent fires that would create significant erosion. Erosion not only reduces the capacity of reservoirs (which are a major investment), but also reduces the quality of water provided to MMWD’s customers. Erosion is a natural process, however wildfires remove large sections of ground cover, which can exacerbate erosion, dramatically elevate turbidity and add other pollutants to reservoirs, including metals, nutrients, and dissolved carbon. Peak turbidities after major fires in Colorado and California have ranged from 20,000 to 70,000 NTU. Significantly elevated turbidities in downstream reservoirs can persist for months. Color and taste can also be affected by the presence of burned materials.

Eroded sediments also enter stream channels reducing the quality of in-stream habitat. Sedimentation can adversely affect salmonid spawning habitat. Eroded sediments decrease the quality of the water in the stream, adversely affecting salmonids.

The size, severity and location of the burned areas are the most important factors contributing to accelerated erosion. Fires located distant from a water body typically have intervening vegetation that acts as a filter for soil particles that would otherwise enter the reservoirs.

In order to prevent excessive surface soil erosion, MMWD should reduce the fire intensity and potential for torching in order to minimize the fire severity nearest the reservoirs. Vegetation should be managed to facilitate containment of fires so the severely burned area is minimized. Actions to minimize fire intensity and size are described in subsequent sections dealing with fuelbreaks.

Fire suppression activities can also accelerate erosion. The techniques used for fire suppression itself should be modified so that a "Light Hand on the Land", or minimum impact of fire suppression is practiced. This includes modifying the ways firelines are constructed, limit to mop-up actions, and paying attention to repair of all soil disturbance during post-fire rehabilitation to minimize erosion.

## Goal 4 Minimize the risk to life and property from wildfire.

There are several distinct fire management objectives involving protecting people and natural and human-related assets from wildfire. In addition to those mentioned previously regarding natural resources, these are to provide vehicular access for evacuees and emergency responders, opportunities for fire containment, and enhanced conditions for structure survival. Each fire management objective has a different arrangement and targeted volume of fuel that will meet that objective. Treatments to reach those objectives vary correspondingly.

Primary Fuelbreaks are areas 100-200 feet wide in strategic locations (on ridgetops or next to roads or other low-hazard natural features). These are designed to control lower intensity fires or the flanks of higher-intensity fires and to provide for firefighter safety. Secondary Fuelbreaks are 60-100 feet wide primarily next to roads. These fuelbreaks are designed to provide an anchor point for controlling lower intensity fires and improving firefighter safety. Wide Area Fuelbreaks are where fuels are reduced to substantially reduce the chance of a large fire; they are often developed consistent with greater ecosystem management goals or for habitat restoration purposes (e.g. oak woodland treatments where the understory fuels are reduced or meadow restoration where shrubs or Douglas fir trees are removed). The work that MMWD has done in the Sky Oaks Meadow area is an example of this type of fuelbreak.

### Objective 4.1 - Prevent destruction of structures and loss of life from wildfires.

Fuel management to enhance the chance of structure survival entails reducing the fire intensity nearest the structure. In wildland fires most structures are ignited by embers. Building an ignition-resistant structure is the most effective defense against structure ignition and loss, since there will almost always be numerous embers in a wildfire.

The factor that can increase the probability of structure survival that can be managed through vegetation management is to reduce the intensity of the fire closest to the structure. The further from the structure, the less pertinent District fuel management is to structure survival. This is because a fire can flare up on wildlands on private properties or in an unmanaged landscaping near a structure even if there are managed fuels on surrounding lands. There are two aims in conducting fuel management to minimize structure damage. First, is to minimize the chance of fire spreading into and through trees crowns, which will reduce the number of embers nearest the structure. Second is to diminish the ability of the fuelbeds to create dramatic fire behavior after the inevitable embers ignite the fuels. The aim is to reduce potential fire intensity both high in the fuelbed and on the surface.

Fuel management to reduce structure damage is done by mowing grass, eliminating pyrophytic vegetation (vegetation that easily ignites and/or burns intensely), and creating discontinuous fuels (both horizontally and vertically). Discontinuity is produced by pruning lower trees branches, and creating "clumpy" vegetation, where spaces of low fuel exist between specimen shrubs and short trees.

The District has accurately mapped the location of every living unit within one mile of the watershed boundary, developed a map showing conceptual defensible space around structures within one-half mile of the border and analyzed defensible space and vegetation characteristics for each structure within 300-feet of the watershed boundary. Figure 1 shows all residences within one mile of the watershed boundary. This figure is a report-sized presentation of the data in the District's GIS. It can be enlarged to show each residence, its proximity to the watershed boundary, and the required defensible space needed for each residence. In most cases, even if the District were to manage fuels immediately adjacent to the watershed boundary, there is unmanaged vegetation (either wildland vegetation or unmanaged landscaping) between the watershed and these residences. One action would be for the District to provide adjacent landowners with its maps showing District fuelbreaks and what additional fuel management work would need to be done by the private landowner. This report or portions of it describing the methods for decreasing the ignitability of a structure should also be provided.

**Figure 1**
**Living Units Within One Mile Of Watershed Boundary**


WUI = Wildland-Urban Interface

**Objective 4.2 - Minimize the size of wildfires on the watersheds.**

To reduce risk to structures, water quality, and biological resources, the watershed should be managed to minimize the size of the eventual wildfires. Fuel management for fire containment would be wider but with less attention to detail than management next to structures. In these treatment areas, grass need not be mowed, because fire personnel may use the grass to initiate a backfire. The resistance to control should be reduced through fuel treatment, specifically, the removal of larger diameter fuels, i.e. fuels larger than 6 inches in diameter. Fuel management includes removing the understory and pruning trees of lower branches for a wider distance. In many locations, fuelbreaks are installed in conjunction with access (i.e., on either side of a road) to create locations where fire containment is facilitated.

After construction, MMWD also needs to maintain its system of Primary, Secondary, and Wide Area Fuelbreaks in order to minimize fire size.

**Objective 4.3 - Reduce the potential for fire ignitions.**

Fuels in areas with a high potential for ignition (e.g. areas adjacent to the base of power line transformers, grassy areas immediately adjacent to roads) are to be managed to minimize the chance of ignition. This can be done by cutting and removing easily ignitable fuels, or by increasing the moisture content of the fuels by changing the vegetation type, for example, from dry grass to oak woodland or low-growing shrubs.

**Objective Fire 4.4 - Manage fuels to provide safe access and evacuation.**

The intent of fuel management for fire access is to reduce fuels near roads to allow safe vehicle access. The width of fuel management is the smallest of the various fire management objectives (access, containment, or structural survival), for it is not expected that a "stand" would be made in these locations. Where fire access is the sole objective, a fuelbreak need not be built or maintained. Fuels should emit a level of radiant heat that would not endanger personnel in trucks passing through. Typically, grasses are mowed, understory thinned, and trees pruned of lower branches, but for a shorter distance. The roadbed of the access routes also need to be maintained to allow for passage of vehicles, principally 4-wheel drive vehicles with wildland firefighting capability.

Travel routes used for evacuation are the places where most deaths occur during wildfires. Evacuees are often disoriented and panicked because of smoke and heat across the travel route and in the general area. Managing vegetation adjacent to the evacuation routes will diminish the smoke in the area nearest the road, thereby providing increased visibility. Reducing fuels along the travel route will also reduce the heat the evacuees may need to withstand.

The width of management along the evacuation routes should be linked to the flame lengths expected to occur in the area, because the heat radiated is inversely proportional to the square of the width of treatment. Where flame lengths are expected to be 12 feet or less, the route should have a 10-foot treatment width on each side of the road; where expected flame lengths are greater than 12 feet, the treatment width should be 30 feet on each side.

**Objective 4.5 Manage broom in fuelbreaks.**

The presence of broom in fuelbreaks means that the District needs to re-enter the fuelbreak at least annually in order to prevent seeding, prevent the additional spread of the broom populations, and decrease the fuel loading of the fuelbreak. By controlling the spread of broom, and eventually eliminating it where feasible, the District will enhance the ability of the fuelbreaks to support native vegetation, thereby reducing the time and resources needed to treat these fuelbreaks. Recommended actions include developing a program to eliminate broom populations in fuelbreaks and in areas adjacent to the fuelbreaks.

## III. Assets at Risk

This section describes the vulnerability of resources to fire, either in the built or natural environment. This analysis evaluates the types of values that would be damaged by fire, including:

- Property values of the land itself;
- Reservoir and creek water quality – sediment & chemistry;
- Infrastructure (communication towers, powerlines);
- Structures (residences, secondary buildings);
- Landscape values (landscaping, fences, landscape features such as patio kitchens);
- Wildlife habitat and individual animals;
- Aesthetic values of surrounding area;
- Erosion and emergency response costs for potential flooding; and
- Air quality - smoke, greenhouse gas emissions, global climate change, and health effects from wildfires.

This discussion includes the impact of fire size and pattern, because several small fires can be less damaging than one large one, even if the combined acreage is the same. Second, the potential consequences of fuel management are introduced.

**1. Personal Safety.** The greatest concern is loss of life and injury. One danger to MMWD 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 MMWD property resulting from a wildfire starting on or passing through MMWD lands. If one considers the Wildland Urban Interface (WUI) as being residential areas within one-half mile of the District boundary, this includes about 500 acres, including approximately 11,600 parcels with living units and approximately 13,200 structures. The residential areas most affected are in Mill Valley, Corte Madera, Kentfield, San Anselmo, and Fairfax.

Roads on the watershed provide limited access and are mostly unpaved. Given the road system, a situation exists where, if a fast-moving fire were to occur, visitors, staff, and/or firefighting personnel could become trapped. 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. There is also the risk to the firefighting personnel responding to a fire.

None of the major roads abutting the MMWD lands were specifically designed to facilitate evacuation and have few places for refuge. For example:

- Panoramic Highway and Ridgecrest Boulevard are narrow, windy roads, with few turnouts, and leading only to a network of more narrow and windy roads in Mill Valley when traveling south.
- Blithedale Avenue is narrow and congested even during non-peak periods.

- Sir Francis Drake Boulevard from Lagunitas west, is a narrow and windy road. There are some turnouts.
- Bolinas-Fairfax Road is narrow and windy.

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Smaller local roads such as Crown Road, Phoenix Road, Lagunitas Road, Cascade Drive (in both Mill Valley and Fairfax), Summit Ave, and all others leading to the district edge, are not the best for last-minute evacuation as they are all narrow, windy roads with ample fuels along the roads, few turnouts, and long distances to refugia. In all these circumstances the best strategy to protect life would be to plan to evacuate early, well before the fire is in the vicinity.

For the most part, vegetation in residential areas on all borders of the District is not suitable for even temporary refuge. Under worst-case conditions, the woodlands and forests that dominate the area could produce life-threatening heat. The more open conditions of the Meadows Golf Course or GGNRA lands west of Ridgecrest Boulevard could be suitable for temporary refuge. However, there are very few people who live near these areas.

The residents living north of the District lands (Woodacre, San Geronimo, Forest Knolls, Lagunitas) have more opportunities to take refuge in open areas of grass.

**2. Property.** The most obvious risk of a wildfire on district land is to its immediate neighbors, including the values that accompany those dwellings. There are about 300 structures within 300 feet the watershed, mostly to the south, west and north of the District boundary. The locations of greatest threat to safety generally are areas of dense population with poor access (narrow, windy and steep roads serving large numbers of people). The non-residential values at risk include automobiles, telephone and power poles, and personal possessions.

Older, ignition-prone structures are more sensitive to fire than newer structures that tend to be more ignition resistant. Thus, if a fire were to burn in the area of newer homes, these homes would be less at risk to damage than a community with older, ignitable features. The concept of being “burned through but not out” affects the values at risk.

The structures that were built in residential areas around the District are, with few exceptions, not ignition resistant. While they were compliant at the time of construction, the buildings are not likely to withstand an onslaught of firebrands without igniting. This places an enormous burden on the responding fire protection districts.

**3. Results of Various Structure Ignition Studies.** The features that doom or save a structure have been discovered through a series of structure-loss surveys after catastrophic fires and through testing of built assemblies in controlled testing facilities. These features should be incorporated in residences and other buildings on the watershed.

The design and materials used in construction make a significant difference in the survivability of structures in the event of a wildfire. The chances that a house will survive are determined by the amount of heat it is subjected to and the ignitability and flammability of the structure. The amount of heat (fire intensity) can be reduced by managing the vegetation around the home. Ignitability is determined by design factors (geometry, size of exterior materials), as well as the type of material.

Various studies prove that the survivability of a home in a wildfire is not random. Decisions made during construction partly to help determine a structure's fate. Data from the 1990 Santa Barbara "Paint" Fire indicate the importance of structure and vegetative conditions in structure survival (from Ethan Foote, 1994 MS Thesis, Department of Environmental Science, Policy and Management, University of California, Berkeley). Although over 20 factors recorded were statistically significant in whether a home survived the fire or not, three factors were most important in structural survival. The study shows that any kind of roofing other than wood increased the probability of survival from 19 percent to 70 percent (a 51 percent difference). If one added to this roofing factor a flammable vegetation clearance of 30 feet or more, structural survival likelihood rose from 15 percent to 90 percent (a 75 percent difference). Finally, having fire-resistant roofing and vegetation tended to create defensible space so that people could remain present to defend the structure, and the combination of all three increased structural survival likelihood from 4 percent to 99 percent (a 95 percent difference), that is. to almost certain survival from almost certain destruction when no precautions were taken vis-à-vis roofs, vegetation clearance and intervention.

In addition, the study found the greater distance the flammable vegetation was cleared, the greater the structural survival. Also, structures tended to survive in groups, indicating that defensible space involves not just a single structure but multiple structures and the intervening space. Other factors that were important in determining a house's survival in a wildfire included characteristics of exterior siding, soffit vents, eaves, windows, and decks.

Many agencies, including the National Fire Protection Association, have concluded that fire intensity is the most important factor contributing to house loss. Fire intensity can be reduced by either expanding the area cleared adjacent to the structure (the defensible space) or reducing the heat output of the nearby burning fuels.

Preventing ignition focuses on reducing the amount of heat a structure is subjected to and reducing the ignitability of the structure. In a large-scale wildfire, there are (and will continue to be) too few firefighters to take defensive action at every structure, so firefighters will try to save a home that can be defended or where success is likely. Reducing the ignitability of a structure will also increase the chances a firefighter will take defensive action there. There are various methods that a homeowner can use to reduce the ignitability of their residence. This includes the type materials used for wall siding and roofs; minimizing locations where embers can be caught; installing double pane windows; and other factors.  Homeowners in the wildland-urban interface should work with the fire department or district to reduce the risk to their homes.

**4.  Values Accompanying Residences.**  Values accompanying residences may include the equipment and materials inside the structure, and secondary structures (such as landscape construction, sheds, and fences).  Additionally, landscaping (which is sometimes a significant investment totaling as much as 20% of the value of the lot) is at risk from wildfires.

**5.  Non-Residential Structural Values.**  MMWD has improvements of considerable value that could be damaged by wildfire, including the Sky Oaks Ranger Station complex, residences, the filter plant, pumps, water tanks and other water distribution infrastructure that are vulnerable to fire.  Additionally, picnic areas, restrooms, sheds, garages, signs, fences, power lines, communication facilities, bridges and roads would also be damaged by a wildfire.

The Bon Tempe Water Treatment Plant on Filter Plant Road is an example of non-residential structural values. This facility is constructed of relatively fire-safe materials; and with more emphasis on defensible space, this vital infrastructure would be expected to suffer minimum damage in a wildfire.

Powerlines and roads are important infrastructure improvements that might be impacted by wildfire.  While the roads are not expected to incur severe damage from a wildfire, extended closures would have a noticeable temporary impact on traffic flows.  Several water tanks could be destroyed in a wildfire.

**6.  Natural Resource Values.** The values at risk in the wildlands of MMWD include the natural vegetation.  These wildlands provide habitat for native plants and animals plus provide significant open space visual resources.  Long-term wildlife values at risk are minimal, since fire does not normally degrade wildlife habitat associated with grasslands and oak woodland/savanna. However, stand-replacing fires could result in a change from one type of vegetation type to another (e.g., a severe fire on Bolinas Ridge in combination with global climate change might change the area from a coniferous forest to a chaparral- based habitat). This would have a significant effect on wildlife adapted to the vegetation type that is destroyed.

A major fire will also result in the death of certain animals. While most birds and larger mammals can escape, many reptiles and amphibians, as well as many invertebrates might not be able to escape a fast-moving wildfire.  Some wildlife populations would increase while others would decline immediately after a fire, but, except for fires that change the vegetation type, wildlife populations generally would return to pre-fire numbers in time.

A vital natural resource in the District watershed land is the water that runs off the slopes into the reservoirs. 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 diminishes the storage capacity of reservoirs. The magnitude of this damage is related in part to both the extent of the fire as well as the fire 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, result in more sediment in the reservoir than those which burn only the upper portion of the slope or burn in a patchy pattern.

Wildfire may destroy much or all of the plants in the burned area. However, there are few circumstances where vegetation types are sensitive to fire. Fires of all intensities, sizes, seasons, and frequencies have burned throughout the millennia. However, the distribution of the characteristics of fires has been recently altered such that more fires are large and of high intensity. Of the thousands of fires that burn large acreages in California, few fires are of low intensity, and wildfires that may burn on the District watershed lands are not expected to be of low intensity. In oak stands, for example, fires of low intensity were likely frequent before European settlement. Wildfire disturbance has been minimal since the turn of the century (or longer), and a significant understory has developed. Now, should a fire burn these types of oak stands, the older trees could be harmed and many could die. A portion of the oak trees would be expected to resprout from the base of the tree, but some will not recover.

Some rare and endangered plant species commonly require fire to either allow seed germination or to alter the microhabitat so the plant can grow (i.e. by removing thatch or shading plants). Some species may be sensitive to a lack of fire's occurrence. For example, a "listed" ceanothus (*Ceanothus masonii* – Mason's ceanothus) which occurs on Bolinas Ridge is in danger of being displaced by crowding and shading due to a lack of fire.

In other locations where rare and endangered plant species occur, a wildfire may set the stage for invasion by invasive weeds that 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.

In the past, fire suppression prioritized structure protection over natural resource management. As a result, larger wildland acreage has been burned with wildfires because firefighting resources have been allocated to structures rather than containment. Damage to natural resources and the values they provide (e.g. water quality, timber yield and associated employment) have sometimes exceeded the value of structures protected.

However, the structural values in Marin are likely to continue to exceed the natural resource-based values.

Fuel management has its own set of risks and potential consequences. The effects of fuel management vary by the technique used (e.g. prescribed fire, grazing, etc.) and the vegetation type in which the actions are taken. Fuel management may expand areas of colonization by French broom or other high priority invasive species. Fuel management can expose areas of bare soil, thereby accelerating erosion. Fuel management can cause the fuels to be more ignitable. Grassy fuels, which are more easily ignited, may replace openings within chaparral or woodlands created by fuel management. Habitat changes result from fuel management and the direct effects of fire. The use of grazing animals or machinery may harm wildlife.

## IV. Wildland Fire Risks of Each Objective

There are associated risks involved in each fire management objective. For example, there are different risks involved in the actions needed to avert the loss of life as compared to treatments to minimize structure damage/loss or natural resource damage. Actions to protect life may be different from actions to protect developed property and natural resource values. Actions to protect life center around early evacuation so that persons are removed from the threat. Fuel management associated with minimizing the threat to life is to focus on fuel removal along evacuation corridors. Programs other than fuel management are just as effective in ensuring safety is achieved including education and outreach to the public to promote early evacuation. Most of the civilians who have died in wildfires have done so evacuating. The greatest risk of evacuating is doing so too late, when the roads are clogged, smoke fills the air, and fire overruns the victims. Victims typically die from breathing in lethal super-heated air.

Fuel management for structure protection entails creation of a defensible space around the structure. The creation of defensible space is aimed at defending the structure from the effects of radiant heat and flame impingement. The width from the structure that is required by State or local code to manage as a defensible space would vary depending on the type of fuels in the area, but generally does not exceed 100 feet. Creation and maintenance of defensible space is also aimed at providing a safe location for firefighter intervention between the structure and the flaming front. The creation of a fire-safe environment directly around a structure greatly decreases the probability of loss during a wildfire. This type of fuel management addresses structure protection, primarily, but if evacuation were precluded, the structure could act as a temporary refuge if the resident is prepared to stay as an alternative to evacuating.

While radiant heat and flames are important, so are embers. They can leap across any defensible space so actions to minimize loss of structures need to extend beyond vegetation management. As described previously, actions include maintenance of the structure itself, such as removal of flammable materials from the roof, gutter, decks, and nooks and crannies where embers might lodge during a wildfire; replacing flammable surfaces (especially the roof and deck) with non-flammable materials; replacing single-paned windows with dual paned windows; and installing ember-resistant vents and eaves.

At the time the 1995 VMP was adopted, Sudden Oak Death (SOD) syndrome had not appeared in the area. The risk associated with SOD is linked to the location and extent of the outbreak. Trees and/or stands infected with SOD present a hazard if they are located in close proximity to structures, fuelbreaks, and access. In contrast, SOD-affected trees in more distant areas like on Bolinas Ridge are lower priority as regards fire hazard reduction because they are remote from a fuelbreak, structures, and access.

SOD-affected trees are more prone to crown fire initiation (torching) due to the low moisture of low, dead branches, and continuity of branches into the tree canopy. However, the canopy density of the tanoak stands is typically not great enough for a running crown fire to spread from tree canopy to tree canopy. Expected fire behavior would be wide-spread torching linked to dead trees. This will produce dramatic, albeit local extreme fire behavior which can be expected to abate when the fire reaches unaffected stands. The torching would affect adjacent trees, and likely increase the intensity and severity of the fire where the dead trees are intermixed with unaffected trees. Where stands are intermixed with dead trees, entire stands could torch and produce a stand-replacing fire. Countless embers will be produced through the torching event, thus trees that are placed in areas that would distribute embers far distances (e.g., on ridgetops) are primary candidates for treatment.

Stand-replacing fires are also to be expected where SOD-infected trees have fallen on top of one another, creating a jackstraw situation of dead foliage, large branches and logs. These fuels also constitute “ladder” fuels that facilitate torching. The resulting fire would be so severe that the entire stand would be expected to torch. Fireline construction in this situation is extremely difficult, hazardous to firefighters, and slow. Ember production and wide distribution of those embers are also expected.

When large remote areas are covered with SOD, as in Bolinas Ridge, the results of a large severe fire on water quality and sediment production (and thus reservoir capacity) should be considered. Also, the effect on biodiversity from a stand-replacing fire is a significant concern.

## V. Other Agency Approaches

The following is a review of local and Bay Area agencies fuel management; this section summarizes the approach of agencies such as the Marin County Open Space District, Mid-Peninsula Regional Open Space District, East Bay Regional Park District, local State Parks, San Francisco Water Department, and East Bay Municipal Water District. This review characterizes:

- Agency objectives, and how they compare with MMWD;
- How plans address the expressed objectives;

- Treatments, location and extent of fuel modifications; and
- How they prepared their analysis to support their conclusions/findings.

**1. EBRPD Approach to Fuel Management.** The objective of the fuel management plan of the East Bay Regional Park District was to minimize the loss of life and property and to the extent possible, to maintain or enhance the natural resource s values associated with the Park District.

The actions focused on properties in close proximity to the District's western boundary because the analysis assumed a "Diablo wind" event that spreads fire from the wildlands into the residential areas.

The locations of fuel modifications were based on several factors:

- Predicted flame lengths within 200-feet of the District border;
- Location of ember-producing trees on high position on the slope (ridgetops);
- Fire professional judgment; and
- The fire behavior modeling program, FlamMap, identified locations of long flame lengths and stands with the potential to produce and distribute embers. On-site meetings with staff members of the Fire Department produced additional treatment areas, based on their experience and on-site knowledge.

Treatments are localized to the area within 200 feet of structures on the District borders, around facilities at risk within the District, and to stands of trees that have the potential to spread embers long distances.

A Wildfire Hazard Assessment and Fuel Management and Resource Management Plan was prepared with an accompanying EIR. The Plan includes a discussion of standards of performance for treatments, organized by vegetation type, along with specific recommendations for sites identified for treatment.

**2. San Francisco Water Department Approach to Fuel Management.** The San Francisco Water Department prepared a fire management plan as part of its Resource Management Plan for its suburban watersheds. The objective for the management was to protect life and property and to preserve water quality and supply.

A wildfire hazard assessment was conducted using a precursor to FlamMap and one of the first versions of FARSITE. This hazard assessment helped determine the locations of proposed projects. Other factors in locating treatments were on-site meetings with Water Department staff and sensitivity analysis regarding slope steepness and erosion potential. Recommended treatments were not justified in terms of meeting a specific objective.

Treatments were generally located near property borders and along ridgetops; these treatments were aimed at fire containment. Other treatments around structures were justified by the need for structural protection.

The Fire Management Plan included a set of performance standards by vegetation types and treatment options. Priorities and a long-term list of costs were also provided.

**3. Marin County Open Space District Approach to Fuel Management.** The Marin County Open Space District participated in the 1995 Mt. Tamalpais Vegetation Management Plan, which supported fuel management to protect life and property, develop and maintain safe access routes, foster wildfire containment and to restore and/or enhance native vegetation communities. The wildfire hazard was assessed through a study of fire history and potential fire spread, using BEHAVE and expert opinion.

Treatments were justified by specific objectives. Treatment standards were linked to the treatment objective. Fuel management was located along ridgetop fuelbreaks and important access routes. Treatments to enhance meadows were also recommended to expand containment opportunities and meet biodiversity objectives. The plan included a description of treatment methods, priorities and cost estimates.

Since then, the MCOSD has reviewed the fuelbreak work twice, and is beginning the process of providing broad guidelines regarding fuel and vegetation management for all of its open space preserves.

**4. Mid-Peninsula Open Space District Approach to Fuel Management.** Fire management plans for four Preserves within the Mid-Peninsula Regional Open Space District are being prepared as part of the master-planning process for each Preserve. The District identified several objectives, including access to facilitate fire suppression, fuel management to facilitate fire containment, and fuel management to promote structural survival in a wildfire. Projects covered a minimal acreage because of fiscal constraint, focusing on access routes, the immediate vicinity of structures, and, in one Preserve, a fuelbreak along the ridgetop.

The District determined the locations of fuel management based on on-site visits, and a site-wide fire hazard assessment using FlamMap. Fuel Management Plans are being prepared as an appendix to the Master Plan; the plan details the hazards, treatment objectives, the locations of the proposed projects, treatment method options, and priorities.

**5. California State Parks Approach to Fuel Management.** The California Department of Parks and Recreation system prepared two plans for parks in the area relating to fire: a wildfire protection plan and a prescribed fire management plan. The wildfire protection plan encompasses all aspects of wildfire pre-planning including fire suppression locations, description of responding agencies, communications, and fuel management to support fire suppression. The objective of fuel management is to support fire suppression operations and focuses on wildfire containment efforts. The wildfire protection plan does not get public review, but is shared with local fire protection districts.

A prescribed fire management plan details the existing conditions that affect the fire ecology of the site (fuels, weather, topography) and the sensitive features of the park. The objectives of treatment in a prescribed fire management plan are for resource enhancement, and are prioritized by the site's opportunity for successful restoration. The prescribed fire management plan is a supporting document of the environmental documentation of proposed projects.

**6. Marin County Fire Department.** This section describes how the proposed plan update coordinates with the fuelbreak being constructed by the Marin County Fire Department.

The following is from the Marin County Fire Department 2005 Fire Management Plan:

"The fire problem in Marin County resides in the wildland-urban interface, where houses and businesses meet or intermingle with wildland vegetation. This is where wildfire poses the greatest risk to human life and property. Principal county stakeholders—those people with an interest in protecting their assets from wildfire—coordinate their public education and project management through FireSafe Marin. The California Fire Plan provides a framework that is applied in Marin for defining fire hazards and ranking assets at risk to identify areas where fire threats can be mitigated. A countywide assessment of the wildland-urban interface revealed that nearly 80,000 acres are ranked as having moderate to very high fire hazard ratings.

Marin County will reduce these hazards using an integrated approach that includes the following elements: (1) fuelbreak network, (2) fire-prone forest clearing, (3) access improvements, (4) wildfire awareness campaign, and (5) International Urban-Wildland Interface Code adoption. Nearly 40 miles of fuelbreaks will be constructed and maintained along ridge top emergency access roads, highways, and other existing barriers. About 20 percent of this fuelbreak network is already in place. Bluegum eucalyptus and Monterey pine forest within and immediately adjoining created fuelbreaks will be cleared. Overgrown roadside vegetation will be trimmed and turnouts will be improved along primary access roads in interface communities. A wildfire awareness campaign will be used to encourage individual and community responsibility for creating fire-safe conditions. Finally, Marin will be adopting (with local amendments) then enforcing the International Urban Wildland Interface Code, which combines building standards with landscape planning to reduce losses caused by wildfire.

Even though the Marin County Fire Department has been successful in controlling a large portion of all wildland fires within its jurisdiction, one only needs to examine our fire history to understand the risk our communities face. This fire plan will allow the Marin County Fire Department to create a more efficient fire-protection system focused on meaningful solutions to better protect the communities in Marin. Being able to identify areas where cost-effective, pre-fire management investments can be made will help minimize citizen losses and reduce costs from a major wildfire.

There are several projects either planned or installed as part of the fire management plan. These include vegetation treatment along the Panoramic Highway near Mt. Tamalpais State Park, Ridgecrest Boulevard on District lands, Kent Canyon near Muir Woods National Park, and other sites.

These projects are all aimed at facilitating containment in locations relatively remote from residences. The plan assumes fires will be attacked using wildland fire strategies and tactics well away from the built environment. These locations encompass county, state, and federal lands, as well as private ranches. These set of projects complement the MMWD fuelbreaks and could prevent fire spread from reaching MMWD lands.

However, the recommendations of the MCFD plan are at times not consistent with the recommendations in the existing MMWD VMP. For example, the fuelbreak recommended for Ridgecrest Highway is wider than recommended in the District's existing VMP. The MCFD plan recommends installing a fuelbreak in this location to keep fire from moving down into the residential area of Mill Valley. Current District strategy is to manage vegetation for containment at the residential interface along the southeastern boundary of the District, from west of Double Bowknot to the MCOSD fuelbreak at the H-Line. The MCFD plan also recommends wider fuelbreaks on other portions of the District than were recommended in the existing VMP. See below for current recommendations.

## 7. MMWD Existing VMP

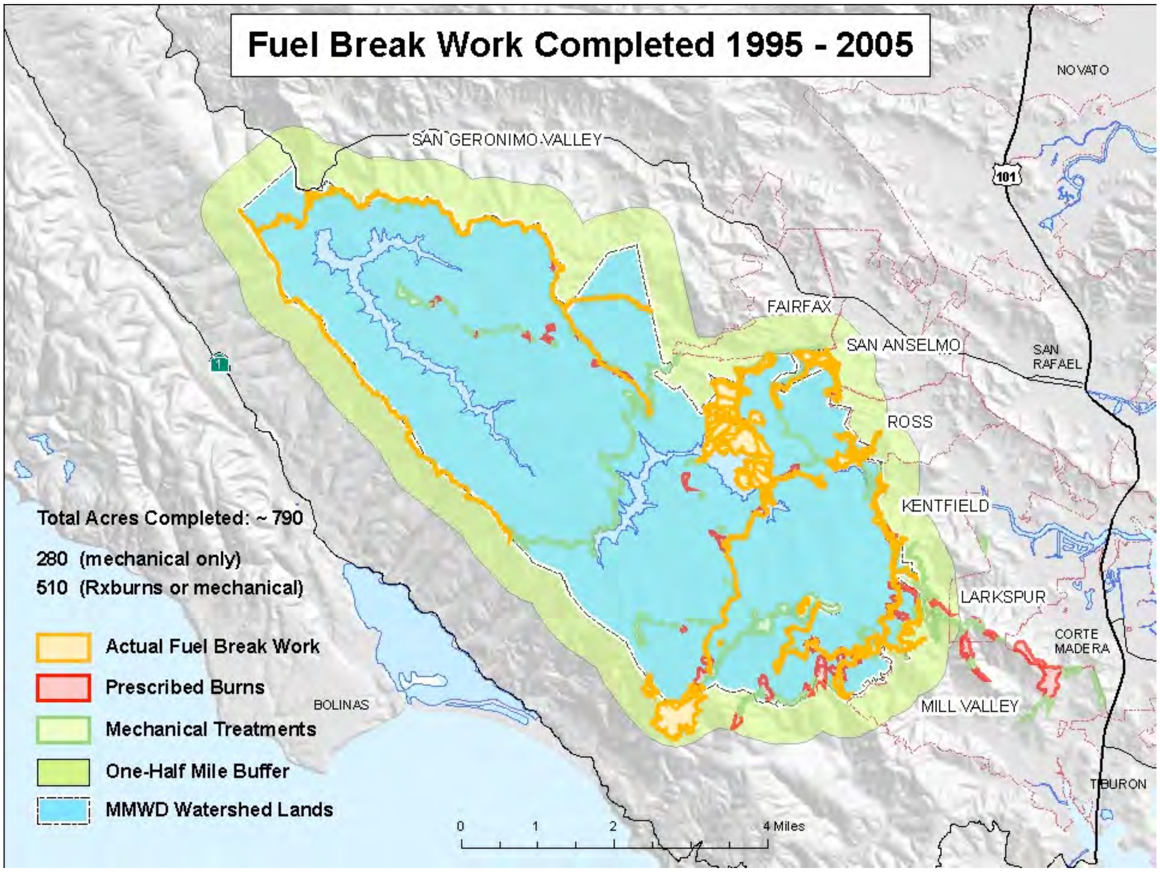
In 1995 The District adopted a Vegetation Management Plan to guide treatments on the District lands to reduce fire hazard and potential damage over the next 10 years. Recommendations in that plan were to generally reduce the volume of vegetation in treatment areas. Three general strategies were recommended.

1. Prescribed burns were recommended to purposely burn the chaparral and the understory vegetation beneath woodlands to reduce fuel loading in certain areas as well as realize biodiversity objectives.

2. The plan recommends an approach to manage fuels in limited areas to produce a network of low fuel zones (or fuel reduction zones). These zones were to be used as locations from which a wildfire could be safely attacked and potentially controlled.

3. The third strategy to reducing fuel was to expand the meadows in strategic locations in order to facilitate the use of open grasslands as containment locations and to meet biodiversity objectives.

**Figure 3**
**Fuelbreak Work Completed 1995-2005**




District staff has implemented much of what was a very ambitious program. The 1995 Vegetation Management Plan recommended approximately 1,000 acres to be managed. Of this, approximately 790 acres of fuelbreaks were actually constructed by 2005

There are several unanticipated challenges and conditions that prevented the District from fully implementing the entirety of the recommended treatments. In addition, there have been changes in the philosophy and approach to managing fire hazard. The more pertinent factors include:

- One of the largest impediments to fuelbreak creation and maintenance has been the aggressive invasion of French broom into treated areas. This has shifted resources from initial treatments to more frequent maintenance treatments. A substantial percentage (about 46%) of the money budgeted for the District's vegetation management is spent on fuelbreak maintenance. The amount budgeted was insufficient to treat all the fuelbreaks in 2008. As a result, the District estimates it only completed 70% of the targeted work.

- There have been advances in understanding the factors contributing to structure damage. In particular, treatment of vegetation adjacent to structures has become more important. This leads to shifting the focus of fuel treatment to the border of the watershed and residential neighborhoods.

- There are more stringent codes regarding structure construction and design as well as vegetation management around the structure. This serves to shift the burden of fuel management for structure protection to private individual lot owners rather than public landowners.

- While prescribed burning has gained more public acceptance, institutional barriers are more stringent in the form of air quality restrictions; concerns for potential escape requiring additional pre-treatment and resources the day of the burn; uncertainties regarding environmental consequences; and cost considerations. Burning has become more expensive. Thus, burning to manage fuels for fire hazard reduction is not as feasible a tool as in 1995.

The District is taking advantage of the changes in regulations and the environment and the new approaches to update the Fuelbreak Management Plan.

## VI. Proposed Fuel Break Objectives, Treatments and Locations

The placement/location of fuel treatments to achieve the goals and objectives stated at the beginning of this document will be evaluated in this section.

There are several strategies for fuel management in the wildland/urban interface. Some agencies rely heavily on fuelbreaks to minimize potential damage due to containment ease, whereas others depend on private homeowners to create and maintain defensible space surrounding the structures at risk. Still other agencies treat fuels in strategically placed area treatments (SPLATs) to hinder fire spread and reduce overall fire intensity.

MMWD staff has conducted an extensive review of the efficacy of the management actions recommend in the 1995 VMP to determine: the degree to which they provided protection of adjacent residences and watershed resources from wildfire; the cost of constructing and maintaining the fuelbreaks; and the effect the fuelbreaks have on watershed biodiversity. Data generated as part of this review has been incorporated into this report.

The current direction of the District is to strategically place treatments based on the location of the assets at risk, the District boundary and the existing hazards. Four types of Fuel Modification Zones are proposed:

- Defensible Space,
- Fuelbreaks,
- Ingress/Access Zones, and

- Ignition Prevention Zones.

**1. Definition of Fuel Modifications Zones**

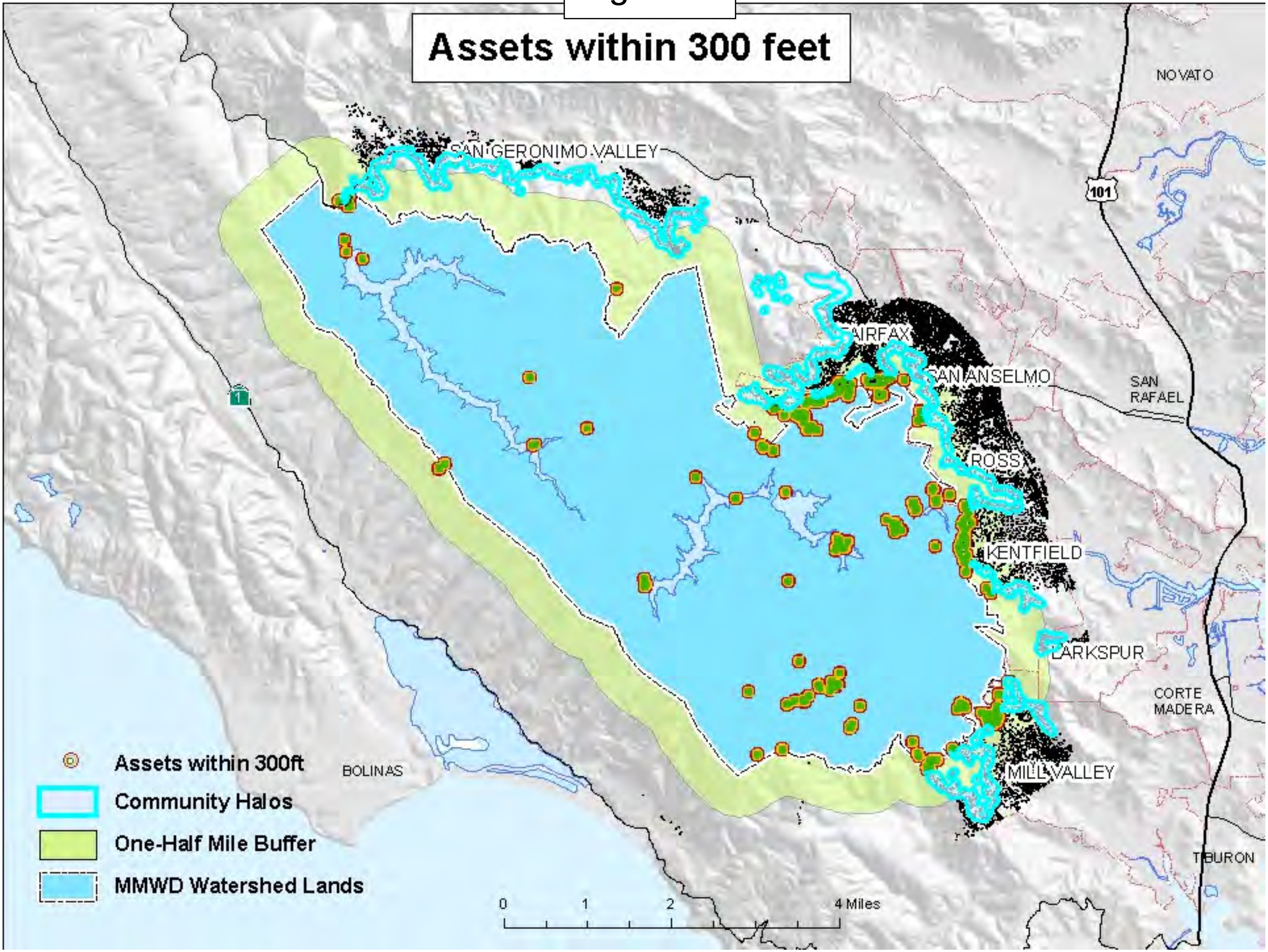
The extent and character of fuel modification zones (i.e. defensible space, fuelbreaks, ingress/egress, and ignition preventions area) can vary for each landowner or manager. The following is a description of each type.

***a. Defensible Space*** is an area around a home or structure that is modified so that the vegetation is maintained to slow the rate and intensity of a wildfire. This is typically accomplished by such means as maintaining hardscape or lawns near a residence, minimizing the planting of shrubs (and not including pyrophytic species), limbing up trees, and thinning trees so that canopies are separated. This defensible space also provides room for firefighters to protect the structure from a wildland fire and helps protect the wildland from becoming involved should a structure fire occur.

The dimensions of defensible space are a 30-foot minimum from the structure in areas of low fire hazard; in areas of state-designated high fire hazard severity 100 feet of defensible space is the minimum. Several insurance companies require more width of management.

Figure 4 is a map of building footprints within one mile of the district’s boundary, highlighting those structures that are inside, or within 300 feet of the district’s boundary, and a conceptual community “halo” surrounding those buildings on the edges of the communities where defensible space should be the focus. By reviewing the District's GIS, from which this figure is derived, it is evident that treatment of these critical defensible space zones is primarily the responsibility of the private property owners.

Figure 4


Assets within 300 feet
NOVATO
SAN GERONIMO VALLEY
101
FAIRFAX
SAN ANSELMO
SAN
RAFAEL
1
ROSS
KENTFIELD
LARKSPUR
CORTE
MADERA
MILL VALLEY
BOLINAS
TIBURON
Assets within 300ft
Community Halos
One-Half Mile Buffer
MMWD Watershed Lands
0
1
2
4 Miles

***b. Fuelbreak*** is a strip or block of land on which the vegetation, debris and detritus have been reduced and/or modified to control or diminish the risk of the spread of fire crossing the strip or block of land. The District has proposed two categories of fuelbreaks, primary and secondary, which differ in objective, location and width.

Fuelbreaks are often located on ridgetops with vehicular access, since the intent is for firefighting to take place in fuelbreaks. MMWD is focusing on fuelbreaks at the interface boundary. Sometimes grassy fuels are encouraged so that backfires can be lit to facilitate containment. Figure 5 shows an example of a District fuelbreak – it is a fuelbreak on the south side of Mt. Tamalpais at the watershed boundary near the end of W. Blithedale Canyon.

**Figure 5**
**Example of Fuelbreak Constructed at end of W. Blithedale Canyon**


***c. Ingress/egress zones*** are areas that are treated to facilitate travel through an area prior to a fire spreading across the road. In some locations, the zone has dual purposes of providing for safe passage of residents out during evacuation and simultaneously for safe passage of firefighting resources to a site.

The dimensions of fuel treatment in this zone depends on the fuel type, since the main purpose is to reduce and convective radiant heat transfer to people passing through. The hotter the fire is predicted to burn, the wider the zone should be. Usually Ingress/Egress zones are not as wide as fuelbreaks because no firefighting is expected to take place in this zone.

***d. Ignition Prevention Zones*** are areas designed to minimize the chance of ignition. Fuels are either reduced in volume or increased in moisture (i.e., by replacing the vegetation type with species that retain more moisture in the leaves and the rest of the plant) to the point that fire cannot ignite. The ignition prevention zones are typically located near roads, since this is where most ignitions occur. Ignition prevention zones are also maintained at trailheads, campgrounds, and around selected power poles (PG&E. is responsible for fuel management at their poles and beneath their transmission lines). Ignition prevention zones need not be wide, and they are often as narrow as 10 feet from a road, or a 15-foot radius from a potential ignition source.

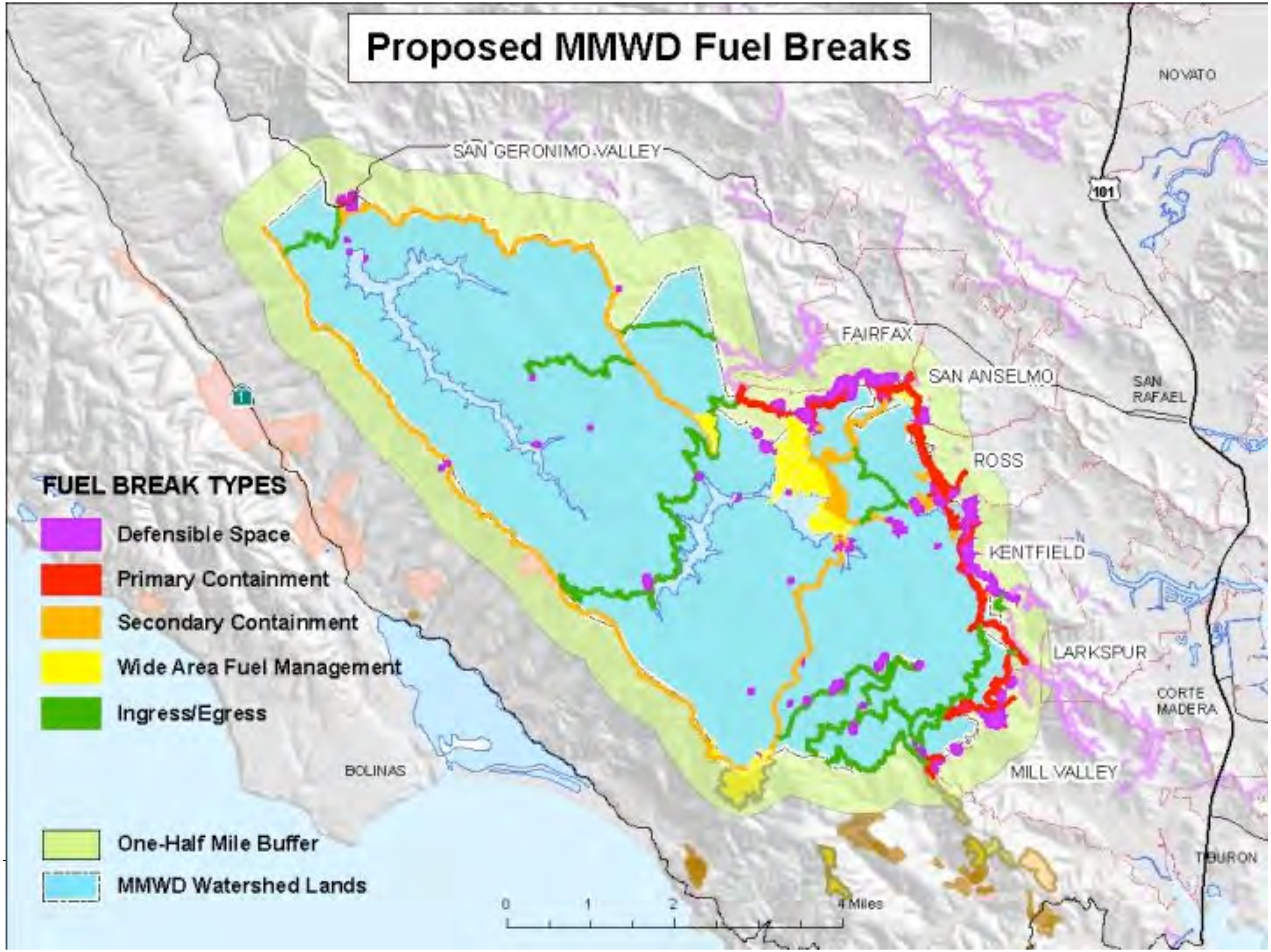
e. Wide Area Fuelbreaks are locations where burning is used to reduce the fuel volume and resulting fire intensity. Such burning is also done to increase the natural habitat values in the treated area.

**2. Preliminary Fuelbreak Locations and Characteristics - District Proposal.**
Because MMWD has digitally mapped all fuel modification zones and has prioritized the fuelbreaks, WRM was able to compare the preliminary fuelbreak plan with other strategies in terms of their location, extent, and treatment intensity.

WRM reviewed the map of fuelbreaks with the displayed assets at risk in the wildland/urban interface and vegetation. MMWD has identified and mapped the areas of defensible space that need to be created in the interface and on its own land. See Figure 6 for existing and proposed fuel treatments and the mapped defensible space areas around structures. Figure 7 shows blow-ups of the detail in Figure 6. MMWD has all these data in its GIS system and can display the precise recommended treatments at any location in the fuelbreak system and at private properties adjacent to the District.

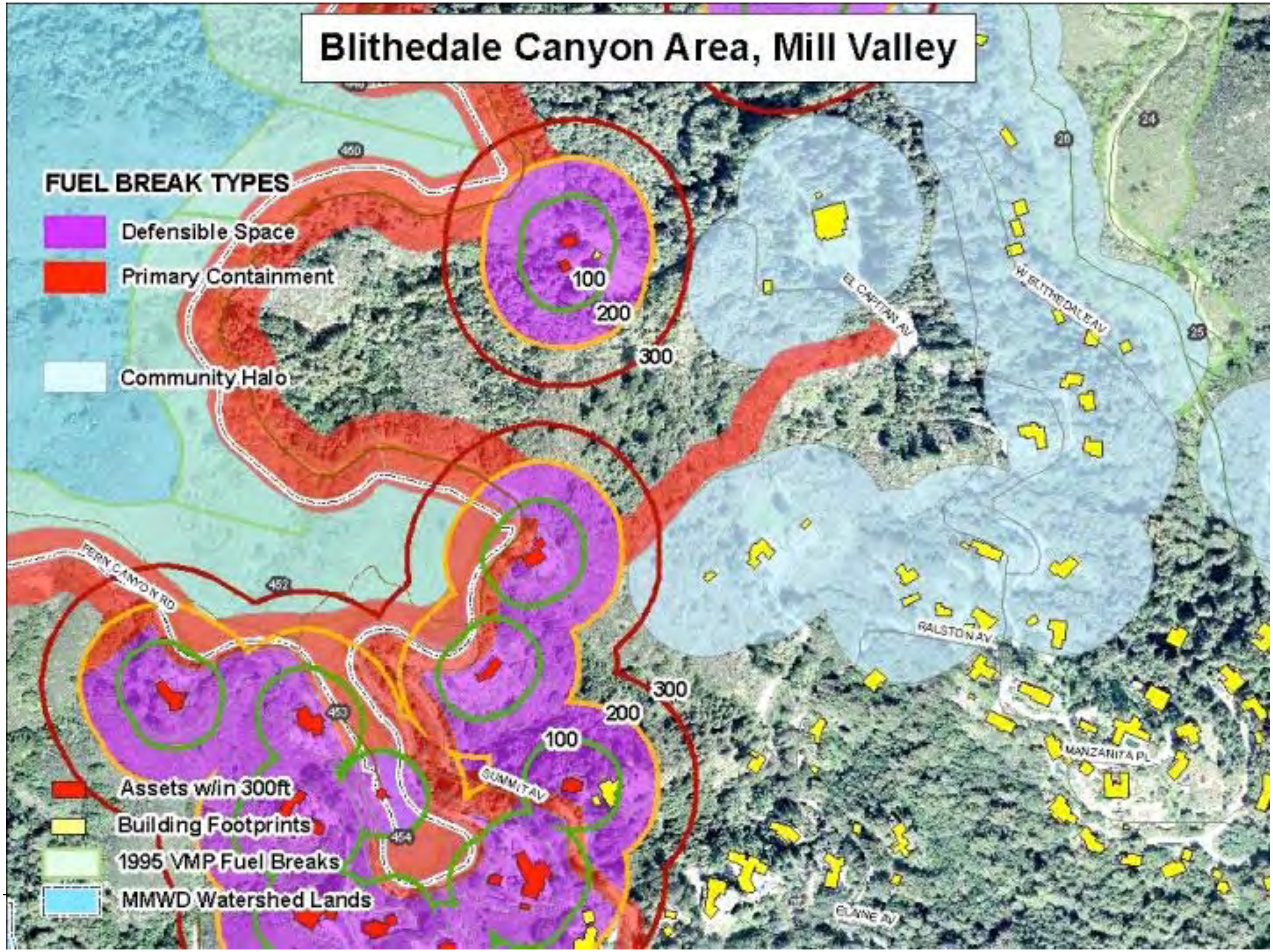
MMWD has calculated that the proposed fuelbreak footprint would total about 1,549 acres. Of this total, 1,080 acres would be on the MMWD property, 191 acres on land owned by other public agencies, and 275 on private land. Of the 1,080 acres that MMWD would be responsible for, 880 acres of fuelbreak have already been constructed are under active management. Of the remaining 119 acres to be constructed on MMWD property, much of that is along existing roads, and will not be as difficult to construct as the ones installed in the past ten years.

Figure 6



Proposed MMWD Fuel Breaks
NOVATO
SAN GERONIMO VALLEY
101
FAIRFAX
SAN ANSELMO
SAN RAFAEL
ROSS
KENTFIELD
LARKSPUR
CORTE MADERA
MILL VALLEY
BOLINAS
TIBURON
FUEL BREAK TYPES
Defensible Space
Primary Containment
Secondary Containment
Wide Area Fuel Management
Ingress/Egress
One-Half Mile Buffer
MMWD Watershed Lands
0
1
2
4 Miles

Figure 7



Blithedale Canyon Area, Mill Valley
FUEL BREAK TYPES
Defensible Space
Primary Containment
Community Halo
Assets w/in 300ft
Building Footprints
1995 VMP Fuel Breaks
MMWD Watershed Lands
100
200
300
EL CAPITAN AV
W BLITHEDALE AV
RALSTON AV
MANZANITA PL
SUMMIT AV
FERN CANYON RD
ELAINE AV

## 2. Lessons Learned from Previous Fuelbreak Management and Current Fuelbreak Recommendations

The following is an inventory of work completed and lessons learned by the District during the last 10 years of fuelbreak management. Some of the conclusions the District and consultant reached were:

- A fuelbreak should be considered a permanent structure, like a building, with similar maintenance requirements and need for occasional improvements, remodeling, and overhaul.

- In the area closest to assets to be protected, the change from chaparral to either Douglas-fir forests, redwood forests, or oak woodlands should be encouraged. With time, the chaparral will decline in cover and volume, and the vegetation type will change to woodlands and forests; the fuel model will change to one where leaf litter and small volumes of dead material on the ground will carry the fire, rather than the live foliage in chaparral. Woodlands and forests need be maintained less frequently, thereby reducing maintenance costs. Typically, the treatments are to prune lower branches of trees and to remove dead material and shrubs in the understory. This type of maintenance can be done without exposing large areas of bare soil, thereby reducing the chance for expansion of invasive weeds into the fuelbreak.

- The closed canopy of oak woodlands should be preserved even in fuelbreaks in order to prevent the growth of shrubs in the understory. Opening up the forest floor to light promotes a shrub growth response.

- While initial installation can be funded at least partly with grants, continuing maintenance is very difficult to fund through grants.

- Fuelbreaks are often colonization sites for invasive weeds, which are challenging to remove, reduce or eradicate. When expanding or installing fuelbreaks in previously unmanaged vegetation, MMWD should consider the potential for spread of invasive weeds. Practices for vegetation management should minimize the potential for spread of invasive weeds.

- The presence of weeds, particularly broom, in the fuelbreak means substantially more resources must be expended to mow and maintain the fuelbreak. In order to maintain the effectiveness of the fuelbreak (i.e., low fuel volumes) and to prevent the broom from setting seed and further expanding within the fuelbreak, fuelbreaks invaded by broom must be mowed annually, whereas uninvaded fuelbreaks need to be mowed every 3-5+ years, depending on the vegetation type in the fuelbreak.

- The District should not be responsible for managing fuels to reduce damage to structures when the residences are more than 300 feet from its property line. There are three important justifications for this stance:

  - The vegetation immediately adjacent to the structure and the structural characteristics of the building are the most important factors determining potential damage from wildfire.

  - The vegetation on the land between the District and the structure (which is not in control of the District) is more important in terms of fuel that could impact the structure than the vegetation on District lands.

  - Generally, the District lands near the interface edge where there are no assets are not apt to be highly damaged by wildfire because the vegetation has adapted to a wide range of fire regimes. Where there are assets, the District will make its facilities either ignition-resistant or make sure fire safety is otherwise provided.

- The shift in the location of treatment zones to areas adjacent to private yards (defensible space zones) is often harder to install and maintain with heavy equipment because vehicular access is sometimes limited, and work usually needs to be done using hand labor, making it more expensive.

- The burden of pre-fire actions to protect residences from wildfires should lie mainly with the residents themselves. The actions taken on the individual property with the structure are more closely tied to structure damage than actions taken on any open space. This includes the creation and maintenance of defensible space, but more importantly retrofitting a structure to make it less ignition-prone.

- Prune lower branches of trees at edges between tree woodland and chaparral-grass. (like along Worn Spring Road), and remove understory shrubs for a distance of 100 feet to preclude the possibility of a crown fire initiating at the edge of the woodland. Observations from recent crown fires, such as the Angora Fire near Tahoe, support the concept that the fringe treatment need not be very wide, possibly as narrow as 10 feet. Fire behavior is expected to become less severe once it enters the oak woodland, if understory shrubs are removed.

- Where feasible install safety zones approximately every 1,500 feet in areas where containment is expected to take place. The radius of the treatment should be 4 times the expected flame length. Placing safety zones in grasslands or woodlands reduces the impacts of installation and maintenance, since the area required is significantly smaller.

- The width of the Ingress-Egress Zone is related to flame length:
    - 15 feet for flames shorter than 12 feet (grass and woodland fuels), and
    - 30 feet for flames longer than 20 feet (shrub-dominated fuels).

- Vital infrastructure, such as the water treatment plant, would warrant fuel management beyond defensible space requirements, including provision for safe access to the facility.

- Removal of SOD-infected trees and Douglas-fir trees on ridgelines if within 300 feet of residences decreases the distance firebrands are likely to be transported. Firs and SOD-infected trees lower on the slope are not as important.

- Working with neighbors increases the efficacy of the hazard reduction program. One example is where the Primary Containment fuelbreak that runs east of Worn Springs Road near Bald Hill. The Primary Containment location moves on and off the District boundary; so the cooperation of the adjacent landowners would be useful so that both sides of the road were managed. It is especially important that the private owners prune the lower branches of the trees on the edge of the grasslands. The trees are on private property, but are at risk of torching because of fire spread from District lands. Working together the area between residences in the Town of Ross and the Worn Springs Road can be made adequately fire-safe.

## VII. Recommendations for Treatments by Fire Management Objective

Fuel treatments change the fuels to calm a fire via altering the volume, size-class distribution, arrangement, moisture, and/or chemical content of the fuels on the site. The effect of fuel modification is to reduce the ignitability, rate of spread, and fire intensity (or heat output) so that fewer, smaller, and less damaging fires would be expected.

The specific objective for fire management will drive the development of the recommended fuel management treatments. The objectives will also vary according to the physical characteristics of the site, which will determine the realistic outcome of the treatment.

The following are the recommended fire management objectives and the types of fuel treatments that could be developed to attain those objectives.

# Goal 1 Maintain Existing Significant Biological Resources.

**Objective 1.4 Preserve the biological diversity and structure of significant vegetation types that are in the process of being modified due to fire suppression.**

- Allow fire to play an ecological role when there is not the threat of loss of life or structures. The ideal situation will be where vulnerable resources are protected while fire burns under its presettlement fire regime.

- Treat fuels to decrease the intensity of fires on the watershed so that damage to the watershed is reduced, and a faster recovery occurs. Fire intensity is most often reduced by mowing grasses, pruning lower limbs of trees, and removing understory shrubs.

- Design fuel treatments to consider the vulnerability of natural resources on the watershed to wildfire.

## Goal 4 Minimize the risk to life and property from wildfire.

**Objective 4.1 - Prevent destruction of structures and loss of life from wildfires.**

- Reduce fire intensity immediately around and within the resources to be protected. This type of fuel treatment is most common directly around structures, achieved by creating defensible spaces (usually by landscaping, mowing, removing understory shrubs and/or pruning trees). Fire intensity in natural resources can be achieved by removing fuel volume, changing the structure of the fuelbed by thinning, conducting prescribed fire, and/or grazing.

- Locate fuel treatments in strategic locations that limit fire spread and aid fire suppression activities prior to the fire reaching occupied and developed areas.
-

**Objective 4.2 - Minimize the size of wildfires on the watersheds.**

- Locate fuel treatments in either linear fuelbreaks and/or in patches to facilitate containment of fires in locations away from the resources to be protected; Typically these treatments are associated with roads and/or ridgelines.

- Treat fuels reduce the rates of fire spread, which greatly facilitates containment[2].

**Objective 4.3 - Reduce the potential for fire ignitions.**

- Treat fuels to make them less ignitable by either removing the fuel through mowing or compacting the fuels, or changing their moisture. Critical areas include: along public roads; at the base of power poles of distribution lines with transformers; trailheads at public roads; structures on the watershed; picnic

[2] In some cases fuel treatments may reduce fire intensity but increase rate of spread, so tradeoffs between the two fire behavior characteristics should be made in advance of the treatment.

facilities; and other sites that MMWD feels has sufficient public use that there is an ignition risk.

- Treatments adjacent to roads should not convert brush to grass, which is more easily ignited. Where possible, grass should be replaced with oak woodland or short stature brush.

- The District will continue to facilitate PG&E, efforts to maintain fuels beneath their transmission lines, and to ensure the vegetation management is done in a manner that minimizes impacts to biological resources to the greatest extent possible.

**Objective 4.4 - Manage fuels to provide safe access and evacuation.**

- Mow grass, thin the understory, and prune trees adjacent to important fire access roads that lead through the District or to an important facility in the District.

- Treat vegetation to provide safe evacuation routes. There are some roads on the watershed that are not critical for evacuation. Those roads need not be treated.

**Objective 4.5 Manage broom in fuelbreaks**.

- Control, and where feasible eradicate, broom from the fuelbreaks. This is a priority for vegetation management in this plan. Until broom plants have been eradicated, treat (cut, pull, graze or burn) remaining broom plants to prevent seed set.

- Avoid exposing bare soil in treatment areas. For example, rather than cut chaparral plants to bare ground, cut shrub to a height that will allow for re-sprouting at the base. Designate haul routes of debris and cover with straw or other material immediately upon leaving the site.

## VIII. Specific Comments on the Proposed Fuelbreak System

Based on the District and consultant review of past actions, MMWD proposes to modify the 1995 VMP fuelbreak plan as shown on Figure 6. The current draft strategy is to manage vegetation within the fuelbreak system using three categories of treatment.

- Primary Containment is where containment near structures and occupied areas is the objective. This is highest priority.

- Secondary Containment is where the objective is to minimize fire size and intensity, and containment is generally remote from occupied areas with structures. In most cases, this is second priority.

- Ingress/Egress is where safe access to reach the containment areas and to facilities that warrant protection is the objective. In unusual situations they may also serve to evacuate visitors, staff or residents. Where these access routes are expected to serve also as evacuation routes they are highest in priority. Otherwise, this type of treatment is generally third priority.

In addition, two other types of vegetation management support the fuelbreak system.

- Defensible space is treatment of the area immediately adjacent to structures that also provides locations for firefighting to occur safely. This is the highest priority and is the responsibility of other agencies, private landowners and the District.

- Wide Area Prescribed Burns are locations where purposeful burning reduces the fuel volume and resulting fire intensity, and increases natural habitat values. This is of third priority for fire containment; however, because of the natural resource benefit, the aggregated value may place this type of treatment into a higher priority.

The consulting team believes that the proposed modifications to the fuelbreak plan are a solid approach to addressing fire hazard on the watershed. Implementing these actions by no means ensures that there will not continue to be a risk of wildfire escaping the watershed and burning adjacent properties. There is no feasible method of making the watershed "fire safe." The proposed actions are ones that are designed to be fiscally feasible and maintain the natural state of most of the watershed while addressing the need for the District to responsibly manage its lands.

The following are comments on the fuelbreak plan along with some recommended revisions.

1. The Pine Mountain Road and San Geronimo Ridge Road Secondary Containment fuelbreak is an appropriate place for a Secondary Containment line. It is on a ridgetop, which is advantageous for containment. However, structures are not within 300 feet of the District boundary. Northerly winds are the most likely wildfire scenario. Winds from the south are unusual during high fire danger. Northerly winds would push fires from the neighborhood of Woodacre to the District. No other location between the residential area and District land is suitable for location of a fuelbreak. The proposed dimension of 60 to 100-feet is suitable. This distance would allow for some backfiring. Because of the distance between the fuelbreak and structures and because of prevailing climatic conditions, construction and management of this fuelbreak should be Priority 2 at best, and possibly Priority 3. The section of San Geronimo Road and Pine Mountain Road south of the intersection of San Geronimo Road with Cascade Fire Road should be lower priority because it is so isolated from values at risk. In addition, the quality of the road is poor - windy, narrow and steep. This road is, however, the best location for containment of an east-west spreading fire because

the fuelbreak is north-south trending and because it connects with a network of roads. Nevertheless, this section should be Priority 3.

2. The Ingress/Egress treatment recommended for Cascade Fire Road is Priority 3 and should be considered for no action. It is a steep, narrow road that would likely not be used by fire personnel for accessing a fire along the Pine Mountain or San Geronimo Ridge Roads.

**3.** The existing Primary Containment using the Meadow Club Golf Course and Bolinas-Fairfax Road (in places) to bolster fire suppression actions is efficient. This also has an added benefit of aiding evacuation safety and increases the site's potential for temporary refugia.

4. The treatments to provide access from Bolinas Ridge to the Meadows Club Golf Course via the Bolinas-Fairfax Road is Priority 3. Because this road is so long and windy, it is likely access to either Bolinas Ridge or the golf course would be attained via another route. However, the facilities along this road merit access, and the stretch of road north of Liberty Gulch also serves to connect two Secondary Containment fuelbreaks.

5. The Primary Containment location near Wood Lane in the Deer Park area has little vehicular access. However, the benefit of installing and maintaining the containment line in that location is that firefighting forces will already be positioned at the interface between the structures and wildlands, so their efforts that would be aimed at containment will be more efficient with managed fuels.

6. The Secondary Containment line from Bon Tempe Lake to Deer Park Road is excessively large in some locations. As a secondary (not primary) containment, treatments need be a maximum of 100 feet wide. There may be added benefit from vegetation management, such as resource benefit, which would justify the added treatment area.

7. It is recommended that a low-fuel zone be installed northeast of Bon Tempe Lake in the Azalea Hill area. However, it is a Priority 3. This would also benefit biodiversity objectives.

8. The Primary Containment work along the northern and eastern boundaries of the watershed with Fairfax, San Anselmo, and Ross is critical. In addition, every effort should be made to encourage residents to install and maintain defensible space on their adjacent property, and to encourage adjacent landowners to extend the District's Primary Containment fuelbreak onto their property.

9. The Secondary Containment fuelbreak along the Lagunitas-Rock Springs Road provides a north-south division where an east-west moving fire could be contained. Like the San Geronimo and Pine Mountain Roads fuelbreak, this

containment line is continuous and leads to a network of other access roads. The fuels should be managed for a wider distance than access requirements because containment efforts would be expected at this location.

10. The spur Secondary Containment line (as opposed to a route managed for access and egress only) from Bon Tempe Lake to the Water Treatment Plant is appropriate because of the critical nature of the facility. The enhancement and maintenance of defensible space around this facility is also crucial.

11. The Secondary Containment line along the western border of the District reflects its remoteness from values at risk. The ridge is prominent, thus it is appropriate for a containment location. The forested nature of much of the fuelbreak requires that the attributes leading to crown fires be considered. The trees should be pruned especially at the edges between the forest and other vegetation types so that torching is not initiated at the forest edge. Understory management is more important than thinning the stand so that the canopy remains dense enough to prevent shrub growth. This is a Priority 3 project.

12. The installation and maintenance of defensible space around isolated facilities should be accompanied by fuel management to ensure access unless actions are taken to ensure survival of the facility without intervention. If treatments to ensure access are unacceptable from either a cost or environmental consideration, then the facility may be deemed not valuable enough to preserve and discarded from the list of assets to be protected. Firefighter safety should not be compromised by poor access to an important facility deemed important to protect.

13. The treatment to ensure access to and evacuation from the top of Mt. Tamalpais is high in priority. This route is essential to allow defensive action to occur on the highly visible facilities at the top of the mountain. The area is heavily used, so a safe evacuation route is important. However, these treatments should not be expected to substitute for areas where containment would be attempted.

14. On the south side of Mt. Tamalpais the network of access routes should be maintained to reach the West Point Inn. Otherwise, fuel treatments should follow standards aimed at providing regular access during normal operations. Placing firefighters mid-slope in areas of chaparral is not advisable because there are safer alternative locations. Firefighters should not be misled by the appearance of adequate fuel modification to try to contain fires on the route. The width of fuel modification that would be required to enable safe passage would be at least 30 feet on both sides of the road. This could appear as though it were a Secondary Containment line, even though the route is untenable for containment operations. Containment will need to occur at or near the District’s boundaries, closer to the structures at risk.

15. Primary containment east of the Double Bowknot should be continued to the southwest to protect the homes on Myrtle Avenue and Evelyn Avenue, both of which have structures within 300 feet of District boundaries. There is not any road behind the structures on these streets, so the Primary Containment line will need to be off District. Partnerships with the adjacent landowners would facilitate installation and maintenance of fire-safe fuel conditions.

16. The Primary Containment fuelbreak from Double Bowknot to the H-Line Road is a vital link in the fuelbreak. The width of 100 to 200 feet is necessary to provide a safe location for fire suppression operations.

17. The Primary Containment fuelbreak from the Phoenix Road to Indian Fire Road and Blithedale Ridge is necessary to offer containment strategies for a east-moving fire off District lands. This prominent ridgeline is the only road between thousands of structures and the District (with the exception of the southern extension of Crown Road, which is a mid-slope road that is less desirable for fire containment).

## IX. Conclusions

The updated fuelbreak system utilizes new information regarding ways to minimize damage from wildfires to design a new strategy of treatment zones. The two most important zones are the Primary Containment and Defensible Space. Both these treatment zones are located nearest structures and occupied areas. Second in import are Secondary Containment fuelbreaks and Ingress /Egress zones[3]. Area-wide treatments through prescribed burning is third in priority, but has the added benefit of enhancing natural resource values.

The type of work in the fuelbreaks has shifted from a network inside the District lands to a focus along the borders that are near residential communities. Areas of chaparral slated for prescribed burns are eliminated in favor of defensible space nearest structures. Many areas that were to serve as interior fuelbreaks are now categorized as treatment for access and egress.

The fire behavior modeling confirmed areas of high hazard are juxtaposed to areas of high property value. Fire behavior modeling also illustrated the utility of vegetation management closest to structures.

By placing treatment zones nearest structures vegetation management targets the location that is most effective in reducing damage from wildfire. The updated strategy also reduces treatments in the interior of the District and thus reduces the chance of spread of broom and other aggressive exotic plants in the interior of the District.

[3] Where Ingress /egress zones are also used as evacuation routes the priority of treatment is the highest.