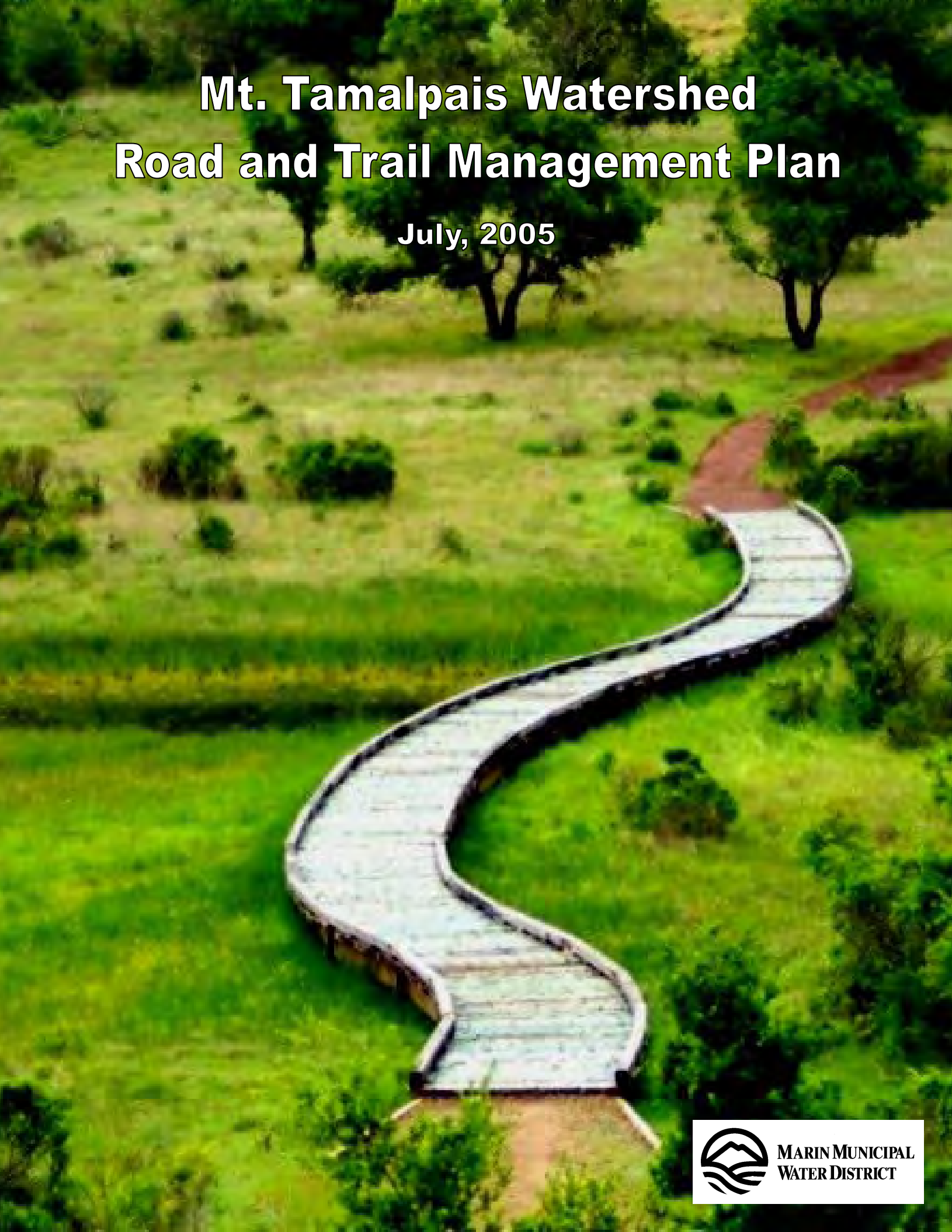
Mt. Tamalpais Watershed Road and Trail Management Plan

July, 2005



Marin Municipal Water District

Preface

The Marin Municipal Water District (District) has been caring for the Mount Tamalpais Watershed for nearly 100 years. At the heart of the District's mission is the continued preservation of the highest quality water. As such, there will always be a need to manage the roads and trails on the Watershed in a manner that minimizes their impact on the creeks and reservoirs. This plan represents the first comprehensive plan for managing all of the Watershed's roads and trails.

The District, its staff, and consultants Pacific Watershed Associates (Wildland Hydrology and Geomorphic Services) and Leonard Charles Associates (Environmental Impact Analysis) hiked and scrambled over the entire Watershed and its hundreds of miles of roads and trails to develop this plan. Further, several public meetings and presentations were held throughout the preparation of this plan. Members of the public, many who are very knowledgeable and passionate about the Watershed's roads and trails, provided valuable input and helped craft the final outcome of the plan. We extend our sincere thanks to all those who participated.

In the end, this plan, which is a both a description of the official system of roads and trails and a detailed work plan on how to manage the roads and trails for the next quarter century, is a guide to further the protection of water quality in creeks and reservoirs, further the protection of environmentally sensitive habitats and special status species, and minimize road and trail related impacts on the Mt. Tamalpais Watershed.

Prepared by: the Marin Municipal Water District (MMWD), July 2005
Sky Oaks Watershed Headquarters
49 Sky Oaks Rd., Fairfax California 94930
mail to: 220 Nellen Ave, Corte Madera, CA 94925
www.marinwater.org

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1.0 Background

The Mount Tamalpais Watershed is owned by the Marin Municipal Water District (District) and managed primarily for water collection and storage. The District's Mission Statement reads:

> It is the purpose of the Marin Municipal Water District to manage sensitively the natural resources with which it is entrusted, to provide customers with reliable, high-quality water at an equitable price, and to ensure the fiscal and environmental vitality of the District for future generations.

The District acquired the majority of the Mount Tamalpais Watershed lands in 1912 with the expressed purpose of providing a public water supply system. To guide it in its management of the Watershed lands, the District adopted the "Mount Tamalpais Watershed Management Policy" that states, in part:

> "The Watershed lands shall be retained in perpetuity for water supply, natural wildland, scenic open space and limited passive recreational purposes, and managed in a manner that will maintain and protect their ability to: (a) ability to serve as water-producing lands; (b) integrity as natural wildlands and scenic open space; and (c) capacity to provide passive daytime recreational activities in keeping with potable water production and preservation as natural wildlands…
>
> [and]
>
> Protection of water quality is the overriding goal for the management of the Mt. Tamalpais Watershed. Protecting the integrity of the watershed's water quality and reservoir capacity is best achieved by maintaining natural conditions on watershed lands to the greatest extent possible. The District is committed to sustaining, and restoring where needed, native biological diversity on District lands through active management and careful coordination with other resource management agencies and the research community. We realize that achieving an ideal situation is not always possible. However, it is the District's policy that control over land uses focuses on retaining the lands in their natural condition, allowing them to return to a natural condition, or actively restoring them. No activities will be allowed that jeopardize this resource." (Board Policy No. 7, 2001)

Until now, the District had never developed a comprehensive road and trail plan for the Watershed. When it acquired the Watershed lands, the District essentially inherited a road and trail network that was already there, one that evolved from the Watershed's colorful history: Native American routes, logging skid roads, abandoned livestock routes, railroads, fire breaks, and telephone and power lines became roads or trails. In the early 1900s, the most popular roads and trails were those that provided access to Mount Tamalpais from adjacent cities such as Mill Valley, Kentfield and Ross. The majority of the roads and trails still largely remain in the southeastern portion of the watershed and focus around the Mountain. Over the next few decades, additional roads and trails were built for fire control, water system infrastructure or recreation. After the completion of the final

reservoir, Kent Lake, the construction of new roads and trails in the Watershed began to slow and eventually stopped. In most cases, the roads and trails do not benefit from modern construction standards.

Between 1984 and 1985, in response to increased urbanization and the related demand for access to public open spaces, the District prepared a trails management "plan" to guide it in its management of public access on the Watershed. That plan contained a series of recommendations on trail use and designations and led to the preparation of a trails designation map (MMWD 1984, 1985).

Managing the road and trail network to ensure protection of water quality, user safety and minimal environmental degradation continues to be a challenge. While construction of new routes by the District may have stopped, the use of the road and trail network continues to grow as the population of the region grows. The District is also responsible for protecting the natural resources on the Watershed consistent with many state and federal laws, policies and regulations that have been developed over the last couple of decades. In addition, the District has been faced with the problem of people building new trails on the Watershed without the permission of the District. Currently, there are more roads and trails in the Watershed than the District can effectively manage.

The *Road and Trail Management Plan* focuses on the overriding goal of protecting water quality and the integrity of the natural wildlands on the Watershed, while allowing limited, passive recreational access in the Watershed. A number of a factors support this planning effort: (1) the District's Watershed Management Policy contains specific language aimed at reducing erosion (especially into creeks and reservoirs) and limiting recreational uses to protect water quality and natural resources; (2) in 2001, the Watershed Citizens Advisory Committee, a group selected by the District Board of Directors to determine Watershed management priorities for "the next 50 years", identified a comprehensive road and trail management plan as one of the most urgent needs; (3) furthermore, community watershed groups have advocated for greater stewardship of District lands that do not flow into reservoirs. The District manages a major program to protect fisheries habitat in Lagunitas Creek through the implementation of the *Lagunitas Creek Sediment and Riparian Management Plan* (MMWD 1997). The District is also a party to a Memorandum of Understanding (MMWD et al. 2001) with federal, state and local governments for the maintenance and management of unpaved roads to protect the fisheries habitat in Lagunitas Creek watershed, and (4) finally, there has been changes and refinements to the Clean Water Act and the Endangered Species Act (notably the listing of the coho salmon (*Oncorhynchus kistuch*) and the steelhead trout (*O. mykiss*)) that require the District to protect, enhance and restore stream habitats on its lands and, in some cases, downstream of its lands.

A healthy watershed is now more valuable than ever. The need to protect it remains paramount, especially in light of the increasing demands placed on it to provide a secure, high quality, domestic water supply, to maintain its natural ecological functions and to provide limited recreational use to a growing population, all in the face of stringent environmental protection regulatory systems. It is with all of these factors in mind that the District developed this Plan to guide it in its management of the road and trail network.

1.1 Study Area

The Mount Tamalpais Watershed is located in central Marin County and covers nearly 19,000 acres (see Figure 1, Vicinity Map). It is adjacent to other large open space and recreational lands including the Golden Gate National Recreation Area (GGNRA), Point Reyes National Seashore, Muir Woods National Monument, Samuel P. Taylor State Park, Mount Tamalpais State Park, Marin County Open Space Lands, and numerous other local city and county park lands. These parklands comprise over 150,000 acres of contiguous protected public lands in Western Marin County. The many creeks that have their headwaters in the Watershed flow either into San Francisco Bay or directly into the Pacific Ocean. These terrestrial open space lands are part of a much greater biosphere that includes the marine environment including the Cordell Bank and Gulf of Farallones National Marine Sanctuaries. The Watershed is within the Golden Gate Biosphere Reserve, one of 411 reserves designated by the United Nations Educational, Scientific and Cultural Organization's Man and Biosphere program to provide a global network representing the world's major ecosystem types (NPS 2003). The Watershed is also included as one of the 25 global biodiversity "hot spots" recognized by the Nature Conservancy, and is targeted by the global conservation community as key to preserving the world's ecosystems (Stein et al. 2000). Together, all these lands, including the Watershed, make up a significant portion of over two million acres of contiguous protected open space.

The Mt. Tamalpais Watershed consists of the drainage areas for five reservoirs, the entire upper watershed of Lagunitas Creek, and Mount Tamalpais itself. It also includes watershed lands just outside or adjacent to the communities of Lagunitas, Forest Knolls, San Geronimo, Woodacre, Fairfax, San Anselmo, Ross, Kentfield, Larkspur, Corte Madera and Mill Valley (see Figure 2, Study Area Map).

The study area lies within the Mediterranean climate region of California that consists of wet, mild winters and warm, dry summers making it accessible year round. Annual average rainfall in the Watershed is around 50 inches per year. Elevation ranges from 80 feet to 2,571 feet and topography is characterized by "V"-shaped valleys located between narrow ridge crests.

There are areas with more gently rolling hills, primarily around Bon Tempe Lake and upper Alpine Lake. The study area supports a rich variety of vegetation

communities – ranging from grasslands to chaparral to oak woodland to redwood forests. These communities provide habitat for a number of unique plants and animals, many with special legal status.

Besides providing a watershed for the collection of a domestic water supply and an important natural area, the Watershed serves as a valuable scenic and recreational open space resource. Hikers, horseback riders, joggers, bicyclists, anglers, picnickers, birders, naturalists and other visitors frequently use the area. The use of the Watershed, and its roads and trails, is governed by Title 9, commonly referred to as the District's Land Use Regulations (MMWD 2002).

The primary entrances to the Watershed are mainly through its neighboring communities, notably Deer Park and Sky Oaks (Fairfax), Natalie Coffin Green Park (Ross) and Throckmorton Ridge and Old Railroad Grade (Mill Valley). There are numerous other well used entrances off of Bolinas-Fairfax Road, Panoramic Highway and Ridgecrest Blvd. While residents from neighboring communities regularly use the Watershed lands, visitors come from the greater San Francisco Bay Area, other parts of the United States, and even other countries owing, in part, to its proximity to the world-renowned Muir Woods National Monument, the Golden Gate National Recreation Area and Point Reyes National Seashore.

1.2 Plan Goals and Objectives

Roads and trails have a number of undesirable effects on the environment. Today, they are the greatest human-caused source of sediment to streams and reservoirs on the Watershed (PWA 2003). Other ecological impacts from roads and trails range from fragmenting or displacing habitat to providing places for unwanted, invasive weeds to increasing wildlife mortality.

The primary goals and objectives of the Plan are to protect water quality and to devise management practices for all the roads and trails.

Goals

1. To improve water quality and minimize sediment into the creeks and reservoirs;
2. To reduce the impact of the road and trail network[1] on wetlands, riparian areas, other environmentally sensitive habitats and special status plant and animal species; and
3. To reduce the impact of the road and trail network on the Watershed's natural ecological functions.

[1] This plan breaks down the road and trail network into two main categories: "system" roads and trails are those that the District has and continues to officially recognize (see Chapter 2). All others are "non-system" roads and trails, including those that are not maintained, have been abandoned or those built illegally (see Chapter 5). When describing the "system" and "non-system" roads and trails together, the term "network" is used.


Marin Municipal Water District
Mt. Tamalpais Watershed
Figure 1. Vicinity Map
December, 2003
Prepared by MMWD GIS, Skyoaks Ranger Station
Projection NAD83, Zone III units feet
Source: USGS Quads, DEM and DOQs, MMWD
0 2 4 8 Miles
N
W
E
S
California
Marin County
Sonoma
Petaluma
Pt. Reyes
National Seashore
Samuel P. Taylor
State Park
Golden Gate
National
Recreation Area
Mt. Tam
State Park
Mount Tamalpais Watershed
Marin Municiapal Water District
Pacific
Ocean
San
Francisco
Bay
San
Francisco

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Marin Municipal Water District
Mt. Tamalpais Watershed
Figure 2. Study Area
December, 2003
Prepared by MMWD GIS, Skyoaks Ranger Station
Projection NAD83, Zone III units feet
Source: USGS Quads, DEM and DOQs, MMWD
0 0.5 1 2 Miles
N
W
E
S
Lagunitas
Forest Knolls
San Geronimo
Woodacre
Kent Lake
Fairfax
San Anselmo
Deer Park
Mount Tamalpais Wateshed
Approx. 19,000 Acres
Natl. Park Service
Ross
Natalie Coffin
Greene Park
Bon Tempe
Lake
Alpine
Lake
Phoenix
Lake
Kentfield
Lake
Lagunitas
Audobon Society
East Peak el. 2571 ft.
Mill
Valley
Throckmorton
Ridge
Mt. Tamalpais
State Park
Muir Woods
Legend
Mt. Tam Watershed
Urban Areas
Non Urban
Cities
Major Streams
Major Roads
Audobon Society
State Parks
County of Marin
Marin County Open Space
National Park Service

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Objectives

1. To make decisions regarding the existing road and trail network (i.e. inventory and categorize the roads and trails and identify which of them the District should officially recognize as system roads and trails) (Chapter 2);
2. To implement Best Management Practices (BMPs) and Environmental Protection Measures in the upgrade and maintenance of the roads and trails in the Watershed (Chapter 3); and
3. To devise a system for managing all the roads and trails on the Watershed (Chapters 4 and 5, and the appendices).

The District plans to implement the highest priority sediment reduction strategies within 5 years, subject to available resources. The remainder of the strategies would be implemented over the next 10 to 15 years. The full implementation of all the strategies should be completed in 20 years. At any time during this period this Plan can be reviewed and amended as necessary based on changing conditions in the Watershed, new information or lessons learned from the actual Plan implementation.

1.3 Assumptions

The District's Watershed lands might appear indistinguishable from adjacent national or state parks lands; however, there are important differences in their purpose. As noted earlier, the Watershed serves primarily as a water collection and storage area for public water supply and is managed under the premise that a healthy, natural watershed produces the best possible water. As such, the primary focus of the Plan is to protect and improve water quality. To help set the scope of this plan, three main assumptions were adopted:

1. The Plan is not a recreation plan. The District will not build new routes to accommodate expanded recreation. If anything, the amount of roads and trails will be reduced because the goal of the plan is to reduce impacts;
2. The Plan will not reconsider or change the bicycle use or access policies within the Watershed; and
3. It would be too expensive, both environmentally and financially, to completely redesign a new road and trail system for the Watershed. Therefore, the planning efforts focus primarily on improving the current network of roads and trails, while looking for opportunities to implement other management actions to minimize road and trail impacts on water quality and the Watershed's natural ecologic functions.

1.4 Process – Development of this Management Plan

The District has the responsibility, and opportunity, to control the impacts of roads and trails on its Watershed lands. Primarily, the District wants to upgrade the roads and trails by implementing BMPs and modern design and maintenance standards that help protect water quality and minimize erosion. In addition, the District wants to manage its roads and trails in a way that minimizes other undesirable environmental effects. Based on an analysis of water quality, habitat sensitivity, route redundancy, maintenance costs, emergency and administrative access needs and route connectivity, the District sought to make a decision for each road and trail segment. In general, an existing road or trail could be solely upgraded to control erosion and minimize sedimentation. Or, if a segment was determined to have undesirable impacts on water quality, erosion, and ecological functions that could not be solved by upgrading, it could be decommissioned, converted to another type of use or re-routed.

1. Conduct a comprehensive inventory of all the roads and trails in the Watershed;
2. Conduct a water quality, or sediment production, risk assessment for all the roads and trails;
3. In consultation with biologists, Watershed management staff, fire agencies, other open space land managers and affected user groups, analyze sensitive habitat, maintenance, patrol and route connectivity/redundancy issues surrounding the roads and trails;
4. Develop this management plan for all the roads and trails; and
5. Conduct an environmental analysis on the proposed management plan and prepare the appropriate environmental documentation.

Public input was also integral to the process. Over the two year planning period the public was invited to comment on what they liked about the Watershed in general, what they thought could be improved, and what roads and trails were important to them. The public was also provided opportunities to express its concerns regarding proposed management decisions, and review and comment on the draft plan. During the process, three public hearings were held. Notice of these public hearings and the planning process was posted in newspapers, on the District's web site, and at the District's offices. Public comment was solicited and received in verbal, electronic or written formats.

1.5 Management Priorities: Interior Subwatersheds vs. Exterior Subwatersheds

Exterior subwatersheds

Approximately 3,300 acres of the Mt. Tamalpais Watershed drain away from reservoirs. Watershed lands on the south and east slopes of Mount Tamalpais

drain into the creeks that run through Muir Woods, Mill Valley, and Corte Madera. A sizable portion of the Watershed is in the headwaters of Corte Madera Creek (near Fairfax, San Anselmo and Ross). Portions of the northern and western areas of the Watershed drain directly into creeks that flow through San Geronimo Valley and Samuel P. Taylor State Park. All of these creeks contain salmon and steelhead habitat. Two creeks, Redwood Creek and Lagunitas Creek, are the subject of multi-agency, watershed scale, salmon and steelhead management programs.

This plan explicitly examined the contributions of sediment in subwatersheds[2] differentiated by whether or not they drain into reservoirs. Because of the importance of fishery issues, the District is currently implementing sediment reduction strategies in the subwatersheds that drain to fish bearing streams. Redwood Creek and Lagunitas Creek have coho and steelhead populations. A common practice is to support the enhancement of endangered species populations and their habitats where they currently exist, instead of in areas where they have been extirpated or exist only as remnant populations. The District will continue to prioritize work in the subwatersheds that drain to fish bearing streams over the reservoirs. This will also further fishery habitat restoration efforts, such as those in Corte Madera Creek and Arroyo Corte Madera del Presidio. Furthermore, prioritizing work in subwatersheds that drain to fish bearing streams makes sense because:

1. The District is legally obligated to protect and enhance fisheries in certain instances;
2. Some of these creeks support special status species that are protected by state and federal law;
3. The District can partner with the other agencies and organizations already working on programs to improve water quality and habitat in these creeks;
4. Grant money is available to reimburse the District for road and trail work that decreases erosion and sedimentation; and
5. In many instances, the more immediate erosion risks exist in these watersheds.

Following is a brief summary of each of the creeks affected by this Plan.

Lagunitas Creek. Lagunitas Creek supports both coho salmon and steelhead. Lagunitas Creek is noted for its coho salmon population, with some estimates indicating that Lagunitas supports up to 10 percent of the wild adult coho

[2] A "subwatershed" is intermediate between "watershed" (a drainage area of a creek or river) and "drainage" (smallest definable unit) and is defined "as a major tributary area within a watershed" (McCammon, unkown date). For the purposes of this plan, a subwatershed is the drainage area of an individual reservoir or named creek.

population in California. In recent years, small numbers of adult chinook and chum salmon have been observed spawning in the main stem of Lagunitas Creek and San Geronimo Creek. Lagunitas Creek supports the largest population of California freshwater shrimp, a federally listed endangered species known from only 18 streams in Marin, Sonoma, and Napa Counties. Most of the Lagunitas Creek watershed is under public ownership and managed as open space lands. Private ownership exists to a large degree in the San Geronimo Creek watershed and in the lower portion of Lagunitas Creek. Developed properties are primarily residential with septic systems and some agriculture. Stream flows in the main stem of Lagunitas Creek are maintained by releases of water from Kent Lake. Lagunitas Creek has been listed as an impaired water body due to sediment, pathogens and nutrients (RWQCB 2002). Fishery and habitat surveys have been conducted within the watershed since the 1970's, providing one of the longest and most complete data sets in the State.

Redwood Creek. Redwood Creek also supports both coho salmon and steelhead. In addition, California red-legged frogs are known to occur in the lower portion of Redwood Creek. The Redwood Creek multi-agency "Vision for the Future" calls for minimizing human caused erosion on fish and aquatic habitats (NPS 2003). A comprehensive sediment budget for Redwood Creek shows that roads and trails within the Redwood Creek watershed contribute up to 25% of the total annual sediment budget (Stillwater Sciences 2003). Like Lagunitas Creek, most of the Redwood Creek watershed is under public ownership and managed as open space lands. The community of Muir Beach, and Green Gulch Farm are in the lower portion of the watershed. Water withdrawals from the creek for public water supply and agriculture may have a negative impact on the fishery habitat. A major multi-agency planning effort is underway to restore Big Lagoon at the mouth of the creek, with a major goal of improving habitat for salmonids.

Corte Madera Creek. Corte Madera Creek supports steelhead with rainbow trout in some of the upper drainages. Historically, Corte Madera Creek has also had some coho salmon but coho have not been observed in the creek since the 1980's, where they were observed in the tidally influenced segment of the creek. However, based on historic observations, the National Oceanic and Atmospheric Administration (NOAA) - Fisheries has still listed Corte Madera Creek as critical habitat for coho salmon. The watershed is heavily urbanized throughout the lower and middle portions, with publicly owned lands in the upper part of the drainage. The tidally influenced segment is channelized for flood control, a portion being a concrete channel. The concrete channel poses significant problems for fish passage. Impacts to the creek are related to urban development (e.g., channelization, stabilized stream banks, loss of riparian corridor, urban runoff and water quality impacts, water wells and direct creek water withdrawals, fish passage barriers, etc.). Phoenix Lake, on Ross Creek, is the only District reservoir in this watershed. Essentially all of the urbanized area has a public sewer system so there are no septic system impacts.

Arroyo Corte Madera del Presidio. This stream supports steelhead and, like Corte Madera Creek, has historically been known to have some coho. Also like Corte Madera Creek, coho have not been seen in Arroyo Corte Madera for a number of years but NOAA - Fisheries listed the creek as critical habitat for coho. The watershed is heavily urbanized in the lower and middle portions with open space lands in the upper part of the drainage. There are no District reservoirs in the watershed. Impacts to fishery resources are primarily related to urban development.

Interior subwatersheds

The interior subwatersheds consist of the Kent Lake, Alpine Lake, Bon Tempe Lake, Lake Lagunitas and Phoenix Lake subwatersheds. For the creeks that flow into these reservoirs, the District is primarily concerned with: 1) water quality, because the reservoirs are part of the public water supply, and 2) with sedimentation, because it decreases the water storage capacity of the reservoirs and reduces their usable life. Nevertheless, the creeks above and between reservoirs contain important aquatic habitat and may support resident fish populations or special status plant or animal species. Sedimentation of the District's larger reservoirs is occurring at a very slow rate due to the relatively undisturbed condition of the watershed vegetation (no recent large fires or logging). However, over time, capacity loss could force the District to find other water sources in a region where water resources are scarce, costly, and subject to intense environmental scrutiny. Also, sediment may cause increases in turbidity and nutrient loading in reservoirs, which in turn may increase costs for filtration and managing algae in reservoirs.

1.6 Plan Summary

To help the reader understand the format of the Plan, and how each of the sections are related or build off of each other, the following Plan summary has been included.

Chapter 1 of the Plan provides an introduction and a brief background on the District and the Mount Tamalpais Watershed. It also provides the reasons why the District undertook this planning effort, and the goals, objectives, assumptions and priorities the District uses to set the scope and context of this plan.

Next, Chapter 2 summarizes the research the District undertook, and the decision-making methodology used, to develop the "Official Road and Trail System" for the Watershed. It also details the changes made to the old system and includes a map(s) of the new, official road and trail system.

Chapter 3 describes the BMPs, design standards and environmental protection measures the District will use whenever it does work on the roads and trails to avoid, minimize or mitigate any undesirable effects or adverse impacts that could

result from the work or the road or trail. In other words, this Chapter generically shows, with illustrations, the type(s) of work that will be done to minimize erosion and what the finished work will generally look like when it is completed. Chapters 4 and 5, plus Appendix B and C, are where the proposed work is described in more detail.

Chapter 4 summarizes the work plan for the *system routes*. In general, this Chapter discusses the different types of erosion, the number of erosion sites, estimated amounts of erosion and sediment delivery and the recommended treatments to prevent or minimize erosion and sedimentation on the routes that are recognized as part of the "Official Road and Trail System." It also discusses the management strategies for road and trail signage, public information and public outreach to communicate the goals and objectives of the Plan.

Then, Chapter 5 summarizes the work plan for the remaining, *non-system routes*. It includes a discussion on the criteria the District will use in responding to non-system routes and their undesirable effects, guidelines for managing the all the non-system routes and enforcement strategies. This chapter primarily addresses managing and controlling the existence of non-system routes more so than the erosion and sediment associated with them.

Chapters 4 and 5, when combined with the Appendices (which provides site specific detail on each road and trail erosion site including they type of erosion, treatment immediacy, potential sediment volumes and recommended preventative treatments), provides a detailed work plan the District will use to guide it in its management of the roads and trails on the Watershed over the next several years.

Appendix A lists the special status plants and animals for the Mt. Tamalpais watershed. Appendix B breaks down and summarizes the erosion sites for each subwatershed, and includes a map showing approximately where each erosion site is. Appendix C is a list of all the erosion sites, sorted by their unique identifier number and a brief description of the problem and recommended treatment for each site. The last Appendix, Appendix D, provides some guidance on how to prioritize what erosion sites/subwatersheds should be addressed first.

The plan concludes with Chapter 6 discussing the approach the District will take in carrying out the plan, including public outreach, assessing its effectiveness and the process for amending the plan as necessary in the future.

Chapter 2: Developing the Official Road and Trail System

2.0 Research on the Existing Road and Trail Conditions

This Chapter describes the official road and trail system on the Watershed as recognized by the District. It also provides some background and a summary of the process the District used to develop the official system. The general approach included a literature and administrative record review, an exhaustive field inventory, and a careful evaluation of roads and trails pursuant to the goals and objectives outlined in Chapter 1.

Literature Review

The earliest mapped record found for roads and trails on the Watershed is an 1860 Mexican Land Grant (Bureau of Land Management) map. It shows the Bolinas-San Rafael Trail located along the general alignment of present day Bolinas-Fairfax Road, which, except for the Coast Miwok trails, is considered to be the earliest route on the Watershed. Portions of the area were also mapped as part of the U.S. Coast and Geodetic Survey in the late 1800s. By the end of the 1800s, the United States Geological Service (1897) and A.H. Sanborn (1898) had prepared more detailed maps of the area, with Old Railroad Grade, Gravity Car, Eldridge Grade, Shaver Grade, Fish Grade, Bolinas-Fairfax Road and Sky Oaks Road being the major routes of that time. Three trails were also depicted at this time, the Cushing Trail (currently the Temelpa Trail), the Bill Williams Trail (from West Peak to Bolinas Ridge – following the general route of present day Ridgecrest Boulevard) and the Old Sled Trail (from Liberty Gulch through the Carson saddle) (Sandrock 1984).

Beginning in the early 1900s, a number of other maps and trail guides were produced: the Lagunitas Rod and Gun Club “Members Map” (1910); the District’s first maps (1917, revised in 1927 and again in 1934); the Atlas Service and Reproduction Co.’s “Road & Trail Map of Mt. Tamalpais and Vicinity”; C.A. Phillips’ “Hikers Guide, Trails and Distances of Marin County, Calif.,” (1938, as revised by the Tamalpais Conservation Club in September 1951 and again in February 1970), among others (Sandrock 1984). These subsequent maps showed a number of new roads and trails, camps, springs, picnic areas and other visitor service facilities. Over following the decades, numerous other maps and guides were produced, each showing a slight variation or interpretation of roads and trails on the Watershed. Over time, some of the roads and trails recognized by the District were abandoned, and new routes were created. Inconsistencies developed between the various maps. This resulted in a certain level of confusion regarding which roads and trails were officially recognized, and what the permissible uses were for each route.

In the 1980s, due in part to increasing use, conflicts between user groups and a growing controversy over what the appropriate use or restriction for a road or trail should be, the District Watershed Committee and the Board of Directors developed a trails management "plan" in 1985. After more than a year of research, analysis and public discussion, the Board resolved the use designations for the management of the trails (MMWD 1984, 1985). Recommendations were made to eliminate those roads and trails that were dangerous, had serious erosion problems or were expensive to maintain. User types were designated for routes, i.e. which routes would be open to hikers, equestrians and bicyclists, which ones for just hikers and equestrians, and which ones would be restricted to only hikers. In addition, it was recommended that the District prepare a road and trails designation map for public distribution (the "Mount Tamalpais Watershed, A Guide to the Trails & Roads of the Mount Tamalpais Watershed," published by the District circa 1985).

This above research identified approximately 90 miles of roads[1] and approximately 54 miles of trails within the Watershed that were recognized by the District as part of the old road and trail system prior to this planning effort. This information was used as the starting point for this plan to identify the officially recognized, or "system" trails.

Field Work

The next step was to identify any other roads or trails on the Watershed by: (1) reviewing the 1997, United States Geological Service 1:200 and 1:400 digital orthographic quadrangles (aerial photographs) of the Watershed using a Geographic Information System (GIS), and then (2) conducting an exhaustive field survey using a Global Positioning System (GPS).

These two steps increased the total to approximately 100 miles of roads and 110 miles of trails identified on the Watershed (i.e. the "network"). The increase is primarily attributable to old fire breaks, abandoned roads, and social, abandoned or illegally built trails. In addition, over 3 miles of short roads or driveways that lead to tank sites, parking areas or other Watershed facilities were identified that were not shown on the circa 1985 guide. These are important service roads and they are regularly used and maintained by the District.

[1] The amount of roads within the study area includes portions of Ridgecrest Blvd., Panoramic Hwy. and Bolinas-Fairfax Rd. that are not owned by the District; however, they are contained within the Watershed and contribute significant sediment to creeks and District reservoirs. For roads on the perimeter of the Watershed the total road length was determined by a GIS exercise using boundary data. The same approach for estimating road length was used consistently throughout this planning process.

2.1 Decision Making Methodology Used to Develop the Official Road and Trail System

The following sections explain the approach the District took to make decisions regarding whether or not a road or trail is part of the official system and, if so, what classification (i.e. use designation) is appropriate for each section of road and trail. Section 2.1.1 briefly summarizes some of the road and trail environmental and management issues evaluated during the planning process. Section 2.1.2 discusses the changes planned for the whole network of roads and trails that resulted from the issues analysis. The Chapter concludes with a discussion on road and trail designations (Section 2.2 and 2.3) and a description of the official system of roads and trails as recognized by the District (Section 2.4).

2.1.1 Road and Trail Issues

All of the approximately 100 miles of roads and 110 miles of trails identified in the field inventory were evaluated based on their effects on water quality, habitat, patrol and maintenance costs and route connectivity or redundancy. It is important to point out that the use and designations for the majority of the roads and trails will not change. In addition, it is important to note that some of the undesirable effects of roads and trails are seasonal or related to the behavioral characteristics of certain plant or animal species. For example, a road or trail may have no environmental effect for the majority of the year; however, if a special status species decides to spawn, roost or nest adjacent to a road or trail, that route could have undesirable environmental effects on that species until it has left the site.

Road and Trail Derived Sediment. Roads and trails create water quality and fisheries habitat issues from erosion sites that create sediment sources. As noted earlier, roads and, to a lesser extent, trails are the largest source of human-caused sediment on the Watershed (PWA, 2003). Two of the bigger adverse effects from erosion are sedimentation of creeks (impairing fishery habitat among other effects) and sedimentation of the reservoirs.

There are basically two types of road and trail erosion. *Chronic erosion* results from concentrated surface flow running down road and trail surfaces and washing silts and clays into creeks or reservoirs. This type of sediment production is commonly referred to as persistent erosion. *Catastrophic erosion* events, generally related to where roads intersect creeks, are the second source of creek and reservoir sedimentation. During large storm events culverts can become overwhelmed or clogged causing large amounts of soil to enter stream channels due to creek diversions, failure of earthen fills, landslides or accelerated gully erosion.

The District's consultant, Pacific Watershed Associates (PWA), identified over 1,200 sites across the entire Watershed that could deliver sediment into the creeks or reservoirs within the next 20 years (PWA 2002, 2003). All of the erosion sites were categorized into 1) landslides, 2) ditch relief culverts, 3) stream crossings, 4) "other"[2] sites or 5) persistent erosion.

Nearly two-thirds of the road or trail related sites are located at creek crossings (Table 2.1). PWA also classified all the creeks according to California Forest Practice Rules for watercourse protection (CDF 2002). The majority of the stream-crossing erosion sites are on class 3 creeks, with approximately two-thirds of those sites located on creeks that drain into the reservoirs. Only two erosion sites were identified on a class 1 creeks located downstream of a reservoir (PWA 2002, 2003).

WATERCOURSE CLASS	WATERCOURSE CLASS CHARACTERISTICS	TOTAL # of SITES Interior Watersheds	TOTAL # of SITES Exterior Watersheds
Class 1	Have fish always or seasonally present onsite, and includes habitat to sustain fish migration and spawning or have a beneficial domestic water supply function onsite or within 100 feet.	18	2
Class 2	Have fish always or seasonally present within 1,000 feet downstream and/or have aquatic habitat for non-fish aquatic species.	156	87
Class 3	Have no aquatic life present, but show evidence of being capable of sediment transport to Class 1 or 2 watercourses.	373	140
Total		547	229

Table 2.1 - Erosion Sites at Creek Crossings. Based on the study by PWA (2002, 2003), there are 776 erosion sites located at stream crossings, the majority of which are on class 3 creeks. More than two-thirds of the erosion sites at located on the stream crossings are on creeks that drain into the reservoirs.

Future erosion yields are estimated to be ~179,500 cubic yards from roads and ~6,805 cubic yards from trails over the next 20 years for a total of ~186,305 cubic yards (PWA 2002, 2003). As a public water agency interested in protecting water

[2] The main types of "other" erosion are gully expansion, springs, road rilling, bank erosion, unchanneled swales or other sites that do not neatly fit into one of the stream crossing, ditch relief culvert or landslide categories.

quality and reservoir capacity, the District seeks to minimize this potential future erosion and sedimentation on the Watershed to the greatest extent possible.

To this end, PWA recommended treatments to reduce or minimize sediment delivery to creeks or reservoirs for each of the erosion sites, ranging from paving high use roads to upgrading stream crossings and culverts to decommissioning unnecessary roads. These recommended treatments provide the starting point for the future road and trail work identified in this Plan.

General Reservoir Impacts. Sediments carry with them naturally occurring heavy metals such as arsenic and copper. To the extent that sediment delivery to the creeks and reservoirs is reduced, the input of naturally occurring heavy metals to the creeks and reservoirs would also be reduced.

Sediments also carry with them nutrients such as phosphorus and nitrogen, and biological pathogens such as coliform, cryptosporidium and giardia. Sedimentation transport to, and deposition in reservoirs can provide an environment favorable to aquatic weeds (such as the recent growth of milfoil in Bon Tempe Reservoir), and algae. Certain species of algae secrete organic chemicals (Geosmin and methylisoborneol) that can cause an unpleasant taste or odor in water. Algae, in concert with sediment, decrease water clarity, an indicator of the general health of a reservoir water body. Even if planktonic algae do not significantly become established, benthic algae can continue to grow directly on deposited sediment.

In addition to sediment related impacts, roads and trails can also contribute to water quality degradation by introducing other types of pollutants such as solid and liquid wastes (e.g. litter, oily residue from vehicles).

Drinking Water Regulation. Heavy metals are regulated directly by water quality standards. The transport of nutrients is both directly and indirectly regulated. Furthermore, nitrate and nitrite are regulated directly with standards. Phosphorus is not regulated, but its presence increases algal growth. Algal growth negatively impacts the secondary standard of odor via the production of chemical byproducts, and increases total organic carbon (TOC) levels. TOC is a directly regulated water quality parameter and is also the precursor to disinfection byproducts, another regulated parameter. Suspended sediment itself, measured as turbidity, is also a regulated water quality parameter and must be removed by treatment facilities.

Giardia and Cryptosporidium concentrations will be evaluated in the upcoming enhanced surface water treatment rule (ESWTR), and affect the treatment requirements at the District's water treatment plants. While coliform is easily treated in conventional water treatment facilities, it is evaluated monthly by the

State of California as part of the interim enhanced surface water treatment rule (IESWTR)

Natural Ecological Function. The Watershed is a relatively large expanse of native habitat adjoining an even larger, regional habitat in open space and parklands managed by federal, state and local government agencies. The Watershed supports a wide variety of biologically important habitats including old-growth redwood forests, remnant native grasslands, riparian areas and serpentine soils. The Watershed supports a wide variety of plant and animal species including a large number of special status plant species (see Appendix A), such as the federally listed threatened Marin dwarf flax (*Hesporolinum congestum*), and several animals that have protected status, such as the Northern spotted owl (*Strix occidentalis*) (DFG 2003; Shuford and Timossi 1989; Patterson et al. 1990, 1991).

Roads and trails can have many undesirable effects on the environment. Roads or trails can cross or run along wetland or riparian areas. They can increase the number of visitors and intensify human use in seldom-visited areas. They can provide migration routes for non-native invasive plants into previously un-infested areas and facilitate the spread of Sudden Oak Death syndrome. They can fragment habitats (in some cases environmentally sensitive habitats) by creating migration or foraging barriers to some wildlife. They can physically remove habitat (i.e. grassland, shrubs, trees) or a portion of it (for example, 50 miles of trail, with a 3-foot trail corridor of disturbance, amounts roughly to 18 acres of lost or damaged habitat). Moreover, construction of roads and trails can disturb or destroy, directly or indirectly, plants or animals that are legally protected. Wetland areas, riparian areas, serpentine soils (which are fragile, erodible soils that can contain a host of endemic, rare and endangered species of plants), and active nesting or roosting areas, are all sensitive habitats that require protection in one form or another. Furthermore, an increase in the density and amount of human presence in previously untrammeled or seldom visited areas leads to an increase in the severity of effects as well as the proliferation of additional effects.

Land managers and scientists involved with restoring endangered salmon and steelhead populations use densities of roads (expressed as miles of road per square mile of land) as a general index of watershed health (Cedarholm et al 1983; NOAA-Fisheries 1996). Densities greater than 2.5-mi./sq mi. are thought to impair properly functioning watershed conditions. Densities of roads and trails are shown in Table 2.2 for the various sub-watersheds within the Watershed. For many sub-watersheds with fish bearing streams (i.e. Deer Park, Redwood Creek, Lagunitas Creek) road densities range from 5.7 to 6.3 mi/sq. mi. Trail densities are extremely high in some sub-watersheds as well. These findings affirm that no new roads or trails should be built on Watershed lands.

BASIN	ROAD DENSITY (mi/sq mi)	TRAIL DENSITY (mi/sq mi)
Arroyo Corte Madera	4.6	7.2
Old Mill Creek	6.3	6.9
Larkspur	12.6	3.0
Redwood Creek	6.2	6.2
Ross Creek	11.8	1.0
Phoenix Lake	6.2	7.0
Lake Lagunitas	2.7	5.7
Deer Park	5.7	8.3
Bon Tempe Lake	5.0	9.8
Alpine Lake	2.9	5.6
Cascade Canyon	2.4	2.8
Kent Lake	2.5	1.1
Lagunitas Creek	6.0	1.1

Table 2.2 – Density of Roads per Subwatershed. Road densities are high in the sub-watersheds with fish bearing streams when compared to the road density threshold of 2.5-mi./sq.mi. thought to be an indicator of general watershed health (Cedarholm et al 1983; NOAA-Fisheries 1996).

Patrol, Emergency Access and Maintenance. Roads and trails serve a number of important functions for the District. They are of critical importance for emergency access in case of medical aid, fire, and quick repair of the public water supply infrastructure. They also provide for important access for management of fuel breaks, invasive plant control and habitat restoration projects. However, because the District inherited more roads and trails than it can effectively manage, the patrol and maintenance of the roads and trails represents a significant cost to the District.

Since the District provides public access to Watershed lands, it has a responsibility to patrol the area for safety and security reasons. Rangers respond to medical emergencies and perform search and rescue operations. Where road and trail densities and route redundancy are high, people tend to get lost more often. Unmarked, non-system trails can create confusion for hikers, increase numbers of lost hikers, and create additional burdens on search and rescue personnel. This is especially true where there are unsigned, non-system trails in the vicinity of system trails and people mistakenly take the wrong trail. The High Marsh area, below Potrero Meadow is an area where people tend to get lost regularly.

Wildfire is of great concern to the District. Many of the roads on the Watershed provide a fuel break network. Because of the vegetation, fuel loads, topography and climate, much or the Watershed has a “high” to “extreme” fire hazard rating (Marin Co. Fire, undated). Most fire officials believe, due in part to decades of fire

suppression and commensurate fuel load build-up, a catastrophic wildfire with the potential for loss of life and property is inevitable. The District's *Mt. Tamalpais Vegetation Management Plan* (1995) discusses the fire related issues on the Watershed, and directs the District to actively manage the Watershed to reduce the risk of major wildfires and, more specifically, the hazard of wildfires along the residential perimeters of the Watershed.

Ensuring certain roads are passable is also critical for maintaining the public water supply infrastructure as well as emergency response. For this reason, the District needs to maintain these critical roads for year-round access and ensure reasonable safe use of them for District staff and the public. In addition, the road and trail network includes a host of associated facilities that need regular maintenance or scheduled replacements, such as culverts, parking lots, drainage improvements (e.g. water bars), fences, railings, vehicle bridges, foot bridges, gates, locks, signs, etc. Maintaining the roads and trails and their associated facilities is the most costly activity the District carries out on the Watershed.

Redundancy and Connectivity. To the extent that emergency response or water supply infrastructure access on the Watershed is adequate, removing unneeded roads or trails would help the District meet water quality and natural habitat goals and reduce maintenance costs. As such, this plan considered removing roads or trails that are redundant or otherwise unnecessary.

At the same time, route connectivity is very important for rangers and to the public who hike, bike or ride horses on the Watershed. The trail inventory identified a few unofficial, or non-system, trail routes that are stable and require little maintenance, and that provide good connections to other trails. Many of the comments made by the public reinforced the importance of road and trail connections, or loops.

The District took a very conservative approach in adopting any new routes for route connectivity. This approach resulted in only a very few adoptions (just over 1% percent of the old system) of stable, low impact and relatively well-known trails. No non-system roads were adopted. Before recommending a trail for adoption, the District carefully considered each prospective route to see if it could possibly increase any undesirable effects on the Watershed. In some cases, the trails recommended for adoption were already signed by the District and received some sort of improvement work. In these cases, it is beneficial for the District to adopt these trails for good connectivity and to include them in the system for scheduled maintenance and patrol.

On the other hand, the District did not want to adopt a road or trails that would increase or create new problems. For instance, if the route is already an erosion problem and would only create more erosion, or would become an expensive maintenance burden, the District did not adopt it. Similarly, if the route went

through serpentine areas that may support rare and endangered plants, or went too close to a known sensitive breeding or roosting area, the District did not adopt it.

2.1.2 Changes to the Old Road and Trail System

A three-step process was used to categorize the entire road and trail network on the Watershed to determine the future status, classification and work activity for each road and trail (see Figure 2.1 – Determining the Future of the Road and Trail Network). The first distinction made was whether the route was a road or a trail. System roads could be left as status quo (and simply upgraded to minimize their erosion and sediment delivery), converted to another classification and upgraded, or decommissioned. Non-system, or abandoned roads, could be actively decommissioned (i.e. remove the stream crossings, restore the original grade, etc.) or simply be left alone to be reclaimed by nature. System trails could be left as status quo (and upgraded to minimize their erosion and sediment delivery, if necessary) or decommissioned. Finally, non-system trails could either be adopted into the system, actively decommissioned, partially decommissioned (i.e. mainly at the beginning of the trail and at the stream crossings) or left alone to be reclaimed by nature and monitored to ensure it is not illegally re-opened.

The first run through this process was made by the District's natural resource staff who proposed a series of changes to the road and trail network based on institutional knowledge of the network and things like erosion, maintenance, habitat impacts and locations where people get lost. The second run through the process incorporated comments and recommendations from the hydrologic and erosion control consultants, PWA. Next, comments and recommendations from the District's biologists, road and trail maintenance staff, ranger staff, and environmental review coordinator all were incorporated into subsequent runs through the above process. The proposed changes were also shared with fire agency personnel and the managers of the adjacent public open spaces. And, importantly, the public was asked to make comments and recommendations on the proposed changes. The proposed changes were presented to the public at two public meetings, on informational displays in the District's lobby, and on the District's website.

The final run through the process produced a relatively small number of changes to the old (existing) road and trail system on the Watershed. When measured by the length of the old road and trail system, the majority (over 90%) of the work plan calls for "upgrades," meaning that after implementation of the recommended treatments, the permissible uses, or classification, of a road or trail will remain unchanged. The remainder of the work plan also calls for some decommissions, conversions (i.e. converting a road to a trail) or reroutes to the old road and trail system, some of which may be necessary to address other environmental issues besides erosion and sediment problems, as discussed in Section 2.1.1 (see Figure 2.2).

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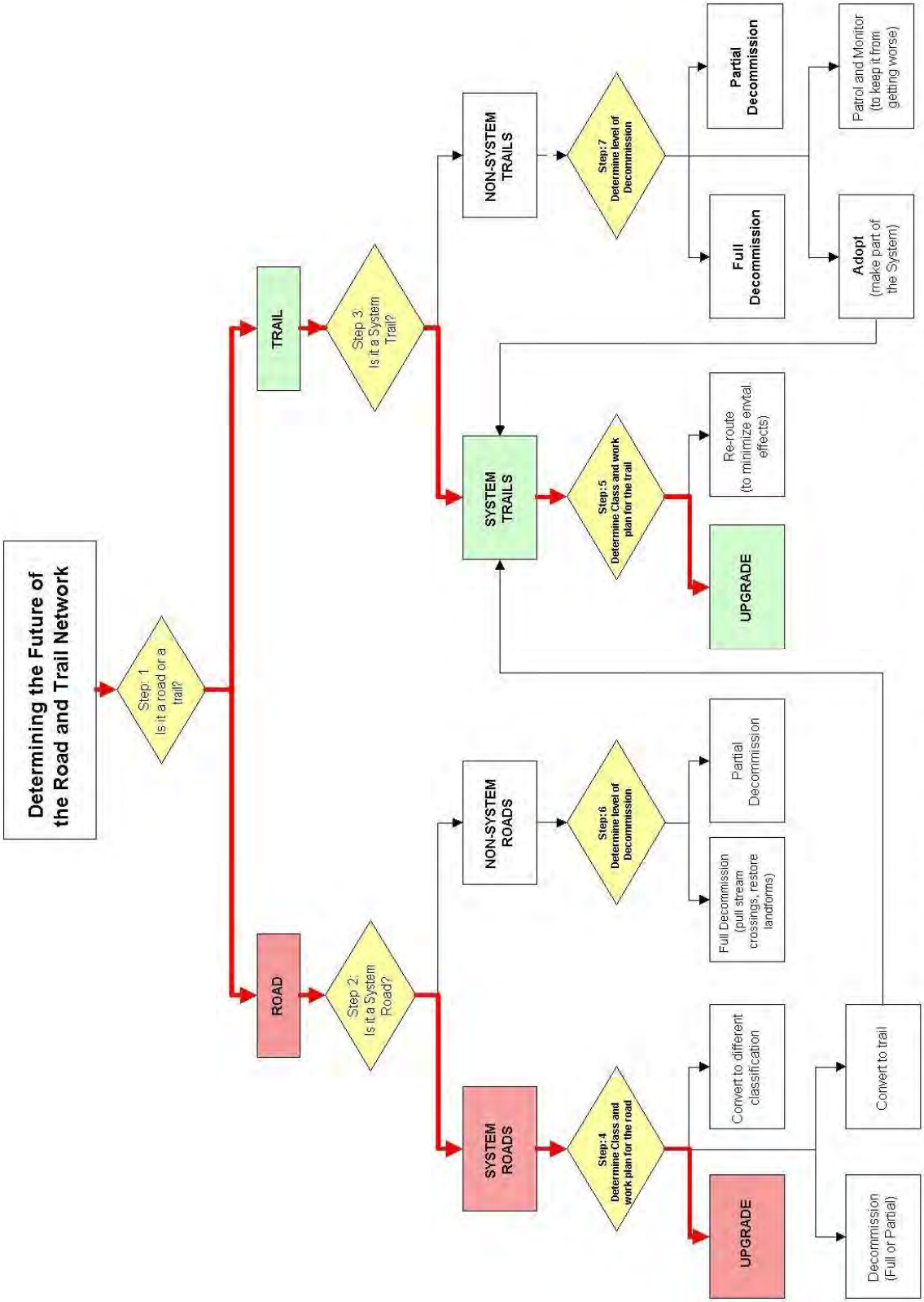

Figure 2.1. Decision making methodology used to categorize the Watershed's roads and trails and determine a work plan and future classification for each one. The criteria used in analyzing the impacts or undesirable effects of a particular road or trail are water quality, habitat, costs (patrol, emergency response and maintenance) and route redundancy or connectivity. Most of the system roads and trails will be upgraded (as indicated by the red line). Most of the non-system roads will be actively decommissioned and most of the non-system trails will be either fully decommissioned or partially decommissioned.

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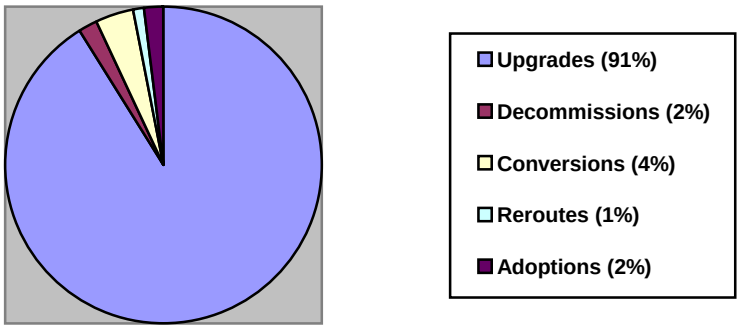

Figure 2.2. Road and trail upgrades (i.e. construction of rolling dips, outsloping, replacement or enlargement of culverts, removal of unstable fills, etc.), when measured in total length of the old road and trail system, make up the majority of the work that will be carried out to "storm proof" the Watershed's roads and trails. In other words, after all the recommended treatments are implemented, over 90% of the old system will remain the same in terms of road and trail usage.

The changes and the criteria used in each decision are summarized in the attached table (Table 2.4, entitled: Proposed Changes to the Road and Trail System on the Mt. Tamalpais Watershed, 4 pages) and on the proposed changes maps (entitled: Proposed Changes, Figure 2.3 – Index Map, Figure 2.4 - Kent Lake Map, Figure 2.5 – Oat Hill Map, Figure 2.6 – Pilot Knob Map, and Figure 2.7 – Laurel Dell Map).

Noteworthy changes include the removal of redundant or unused roads in the vicinity of Peters Dam. Some other roads will be converted to Class IV, or small vehicle roads, to minimize erosion while still providing route connectivity. These include Grassy Slope Rd., Old Vee Rd., Lower Rocky Ridge, the southern portion of Concrete Pipe Rd. and Lower Eldridge Grade. A few roads will be converted to trails. Azalea Hill Rd. will be converted to a trail, mainly to keep cyclists from continuing beyond the road and down onto the trail, or worse, creating new trails that damage the environment and stress limited enforcement resources. A noteworthy area of decommissioning is in the Upper Berry-Lagoon Road area, primarily because of environmentally sensitive habitat concerns (serpentine soils), erosion and route redundancy that results in considerable search and rescue efforts. Most of the adoptions are on the periphery of the watershed and serve as established connectors to the near-by cities and towns. The decommissioning of Bald Hill Road and the end of Worn Springs Road, totaling approximately 0.15 miles, will be replaced with a new trail rerouted to a more stable location. No non-system roads were adopted.

2.2 Road Designations

The roads on the Watershed serve multiple uses. The primary use for most roads is authorized vehicle access to District water infrastructure facilities, and for authorized vehicle access for fire protection or other emergency response. In addition, hikers, equestrians and bicycles regularly use the roads. Permissible recreational uses are governed by Title 9, Land Use Regulations (MMWD 2002).

Table 2.4. Proposed Changes to the Road and Trail System on the Mt. Tamalpais Watershed

SYSTEM ROUTES TO REMAIN SYSTEM – CONVERSIONS

Name of Route	Existing Class: Road or Trail	1st Level Action: System or Non-System	2nd Level Action: Convert, Decom, Reroute or Adopt	Criteria for Decisions				Comments on Undesirable Effect(s)
				Water Quality	Redun-dant	Habitat	Cost	
Upper Peters Dam Rd	Road	**Remain System**	Convert 2,902' to small vehicle road (Class IV)	X		X	X	High sediment producer
Old Vee Rd	Road		Convert 6,114' to small vehicle road (Class IV)	X		X	X	High sediment producer
Airforce Throughway	Road		Convert 1,975' to hiking trail (Class VIII)	X				Will no longer be needed for vehicle use after return from Federal Govt.
S.E. end of Concrete Pipe Rd	Road		Convert 2,977' to small vehicle road (Class IV)	X		X	X	Will not be needed for heavy vehicle access after pipeline re-route
Lower Eldridge Grade	Road		Convert 4,181' to small vehicle road (Class IV)	X		X	X	High sediment producer
Azalea Hill Rd	Road		Convert 1,446' to horse trail (Class VI)			X	X	Special status species, serpentine, steep road dead ends at trial
Bon Tempe Channel Rd	Road		Convert 644' to hiking trail (Class VII)	X		X		From channel to boat launch; road dead ends at trail (pending new, year round launch ramp elsewhere)
Big Trees Rd	Road		Convert 1,299' to backcountry trail (Class IX)	X		X		Creekside alignment; narrow and setback further from creek
Bon Tempe Rd	Road		Convert 2,713' to paved road (Class I)	X				Heavy vehicle use creates excessive fine sediments
NOTE: Not every system route is listed above. Only those that the District plans to convert or re-route, to minimize their undesirable effects, are listed here.								

Table 2.4. Proposed Changes to the Road and Trail System on the Mt. Tamalpais Watershed (continued)

SYSTEM ROUTES TO REMAIN SYSTEM – RE-ROUTES

Name of Route	Existing Class: Road or Trail	1st Level Action: System or Non-System	2nd Level Action: Convert, Decom, Reroute or Adopt	Criteria for Decisions				Comments on Undesirable Effect(s)
				Water Quality	Redun-dant	Habitat	Cost	
Azalea Hill	Trail	**Remain System**	Re-route 4,075' as horse trail (Class VI			X		Too steep, gullied in areas, serpentine, install new creek crossing
Bald Hill Tr to 5-corners	Road		Re-route 540' as horse trail (Class VI)			X		Heavily gullied; too steep; reroute to minimize erosion
Deer Park Tr to Worn Springs	Road		Re-route 260' as horse trail (Class VI)			X		Replaces road to maintain connection (minor connection)
Bottom of Junction Tr	Trail		Re-route 120' as horse trail (Class VI)	X		X		Install new bridge crossing; prevent traffic thru creek (minor change)
Boy Scout Rd.	Road		Re-route 603' as horse trail (Class VI)	X		X		Steep, eroding (as road it's a dead end, will retain hiking/horse connectivity)
Little Carson Tr. (upper)	Trail		Re-route 1,352' as hiking trail (Class IX)		X	X		Need to control access in this vicinity. Free-form routes endangering habitat
Upper Canyon Tr	Trail		Re-route 1,300' as horse trail (Class VI)	X		X		Heavily gullied; too steep; reroute to minimize erosion
Laurel Dell to Barths Retreat	Road		Re-route 500' as hiking trail (Class VII)	X		X		Replaces road to maintain connection; locate out of swale
NOTE: Not every system route is listed above. Only those that the District plans to convert or re-route, to minimize their undesirable effects, are listed here.								

Table 2.4. Proposed Changes to the Road and Trail System on the Mt. Tamalpais Watershed (continued)

SYSTEM ROUTES TO BECOME NON-SYSTEM ROUTES

Name of Route	Existing Class: Road or Trail	1st Level Action: System or Non-System	2nd Level Action: Convert, Decom, Reroute or Adopt	Criteria for Decisions				Comments on Undesirable Effect(s)
				Water Quality	Redun-dant	Habitat	Cost	
Lagoon Fire Rd	Road	**System to Non-System**	Decom 3,392'		X	X		Dead end, heavily gullied
Grassy Slope (lower portion)	Road		Decom 2,019'	X	X	X		Severe erosion
End of Worn Springs	Road		Decom 280'			X		Dead end, replace with rerouted trail for connection (keep fire access)
End of Oat Hill	Road		Decom 674'	X		X		Dead end
Interior Pine Pt	Road		Decom 1,130'		X	X		Fragments meadow, dead end
Boy Scout Rd	Road		Decom 603'		X	X		Dead end, steep
Bare Knoll Rd	Road		Decom 1,677'		X	X		Dead end, no longer needed
Peters Dam Rds	Misc. Roads		Decom 1,160'	X	X	X	X	Sections unneeded, creek habitat
Upper Berry Tr.	Trail		Decom 1,992'		X	X	X	Too steep, highly eroded
Telephone Tr. #1	Trail		Decom 1,320'		X		X	Steep, eroded. Temelpa Tr. Better connector
Ridge Trail	Trail		Decom 3,445'		X	X	X	Not needed, too steep at ends
NOTE: Not every system route is listed above. Only those that the District plans to decommission, to minimize their undesirable effects, are listed here.								

Table 2.4. Proposed Changes to the Road and Trail System on the Mt. Tamalpais Watershed (continued)

NON-SYSTEM ROUTES TO BECOME SYSTEM – ADOPTIONS

Name of Route	Existing Class: Road or Trail	1st Level Action: System or Non-System	2nd Level Action: Convert, Decom, Reroute or Adopt	Criteria for Decisions				Comments
				Water Quality	Redun-dant	Habitat	Cost	
Buckeye Tr	Trail	**Non-System to System (adopt)**	Adopt 1,346'					Stable connector
Vic Haun Tr	Trail		Adopt 2,609'					Stable connector
Easter Lily	Trail		Adopt 1,060'					Stable connector
Benstien Spur	Trail		Adopt 575'					Stable connector
Tucker Cutoff	Trail		Adopt 2,977'					Old dozer cut, stable connector
Old Hill to Carson Falls	Trail(s)		Adopt and/or reroute ~ 2,000'			X		For best route to Carson falls to protect sensitive habitat
School Trail	Trail		Adopt 2,682'					Work with county parks to improve and construct bridge across creek
Yolanda Cutoff	Trail		Adopt 1,157'					Stable connector
Mountain Top	Tr. on Abandoned Rd		Adopt and convert to trail 2,848'					Important connector, improve drainage
Potrero Meadow Tr	Trail		Adopt and re-route 1,920'	X		X		Control/contain high use, adopt as system to protect meadow
Pine Pt. Fishing Shortcut	Trail		Adopt 466'	X		X		Control/contain high use, adopt as system to protect meadow
NOTE: Not every non-system route is listed above. Only those that the District plans to adopt to maintain route connections are listed here.								

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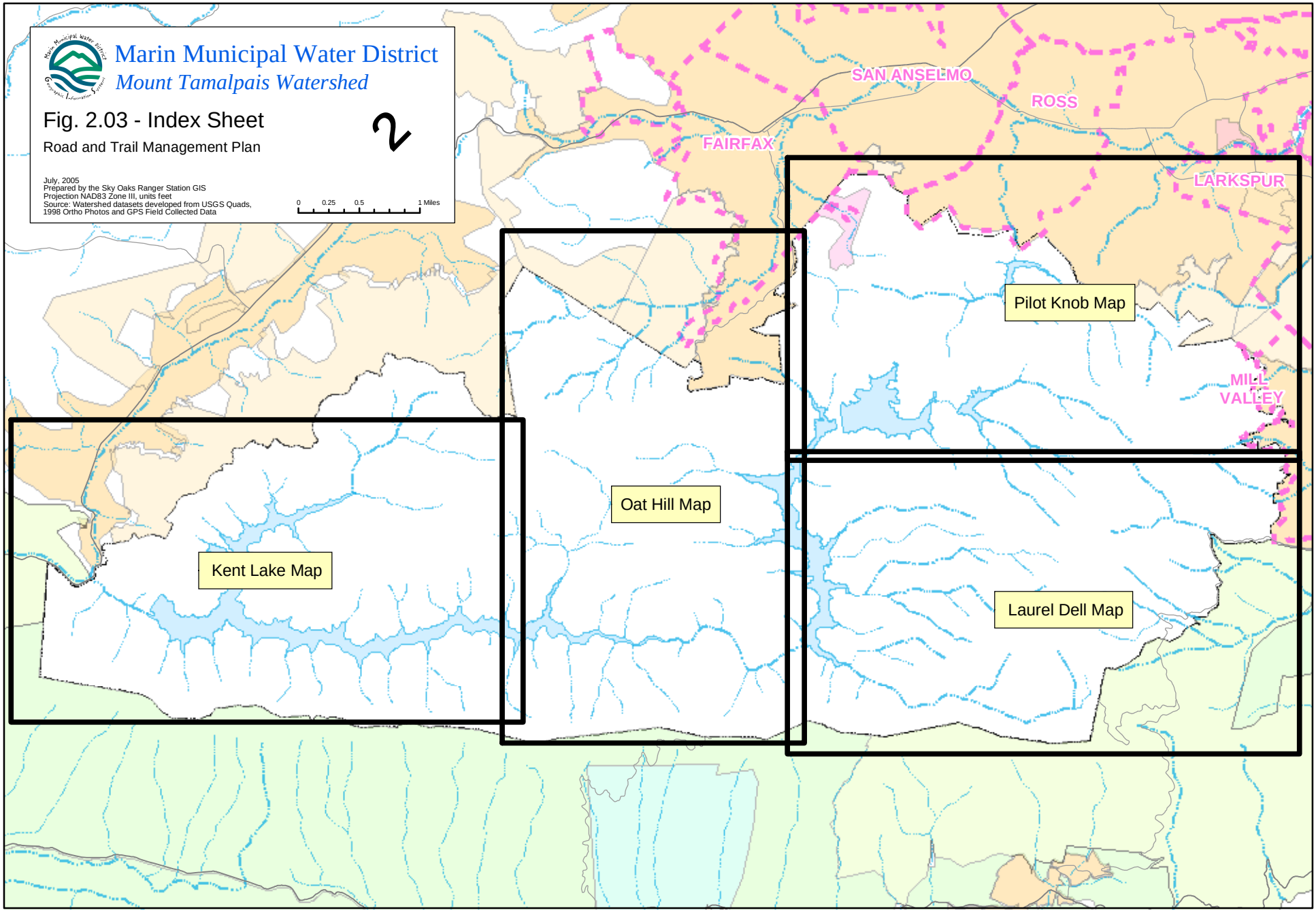
Marin Municipal Water District
Mount Tamalpais Watershed
Fig. 2.03 - Index Sheet
Road and Trail Management Plan
July, 2005
Prepared by the Sky Oaks Ranger Station GIS
Projection NAD83 Zone III, units feet
Source: Watershed datasets developed from USGS Quads,
1998 Ortho Photos and GPS Field Collected Data
0 0.25 0.5 1 Miles
SAN ANSELMO
ROSS
FAIRFAX
LARKSPUR
MILL VALLEY
Pilot Knob Map
Oat Hill Map
Kent Lake Map
Laurel Dell Map

Blank backside index map

Marin Municipal Water District

Mount Tamalpais Watershed

2

Proposed Changes

Fig. 2.04 - Kent Lake Map

Road and Trail System

- Paved Road (Status-quo)
- Unpaved Road (Status-quo)
- Unpaved Road (Decommission)
- Trail (Decommission)
- Unpaved Road (Convert to Small Vehicle Rd)

Public Land Managers

- California State Parks
- Marin County Open Space
- National Park Service
- Urban Land

July, 2005
Prepared by the Sky Oaks Ranger Station GIS
Projection NAD83 Zone III, units feet
Source: Watershed datasets developed from USGS Quads, 1998 Ortho Photos and GPS Field Collected Data

0 625 1,250 2,500 Feet

Gary Giacomini Open Space

San Geronimo Ridge Rd

Samuel P. Taylor State Park

San Geronimo Ridge Rd

Continental Cove Rd

Grassy Slope Rd

Pine Mountain Rd

Poison Spring

Lower Peters Dam Rd

Peters Dam Rd

Upper Peters Dam Rd

Shafter Grade

Kent Lake

Golden Gate Natl. Rec. Area

Bolinas Ridge Rd

Map 2 Kent Lake Changes July, 2005 <Fig_2.04_KentChgsMap.jpg>

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Marin Municipal Water District
Mount Tamalpais Watershed

Proposed Changes
Fig. 2.05 - Oat Hill Map

Road and Trail System

- Paved Road (Status-quo)
- Unpaved Road (Status-quo)
- Hiking Trail (Status-quo)
- Hiking and Riding Trail (Status-quo)
- Hiking and Riding Trail (Reroute)
- Unpaved Road (Decommission)
- Unpaved Road (Convert to Trail)
- Unpaved Road (Convert to Small Vehicle Rd)
- Trail (Decommission)
- Trail (Adopt)

Public Land Managers

- Marin County Open Space
- Urban Land
- Marin Cities

2

July, 2005
Prepared by the Sky Oaks Ranger Station GIS (415) 945-1180
Projection NAD83 Zone III, units feet
Source: Watershed datasets developed from USGS Quads, 1998 Ortho Photos and GPS Field Collected Data

0 625 1,250 2,500 Feet

Cascade Canyon Open Space
FAIRFAX
San Anselmo Creek
Bolinas-Fairfax Rd
Sky Oaks Rd
Meadow Club Rd
Bull Frog Rd
Cascade Canyon Rd
San Anselmo Creek
Carey Camp Creek
San Geronimo Ridge
Pine Mountain Rd
Azalea Hill Tr
Pine Mt. Rd
Little Carson Creek
Upper Little Carson Tr
Old Sled Tr
Bolinas-Fairfax Rd
Alpine
Lake
Old Sled Tr
Little Carson Tr
Big Trees
Oat Hill Rd
Kent Tr
Kent Pump Rd
Old Vee Rd
End of Oat Hill Rd
Oat Hill Spur
Kent
Lake
Lagunitas Creek
Bolinas-Fairfax Rd
Ridgecrest Blvd
Bolinas Ridge Rd

Map 3 Oat Hill Changes July, 2005 <Fig_2.05_OatHillChgsMap.pdf>

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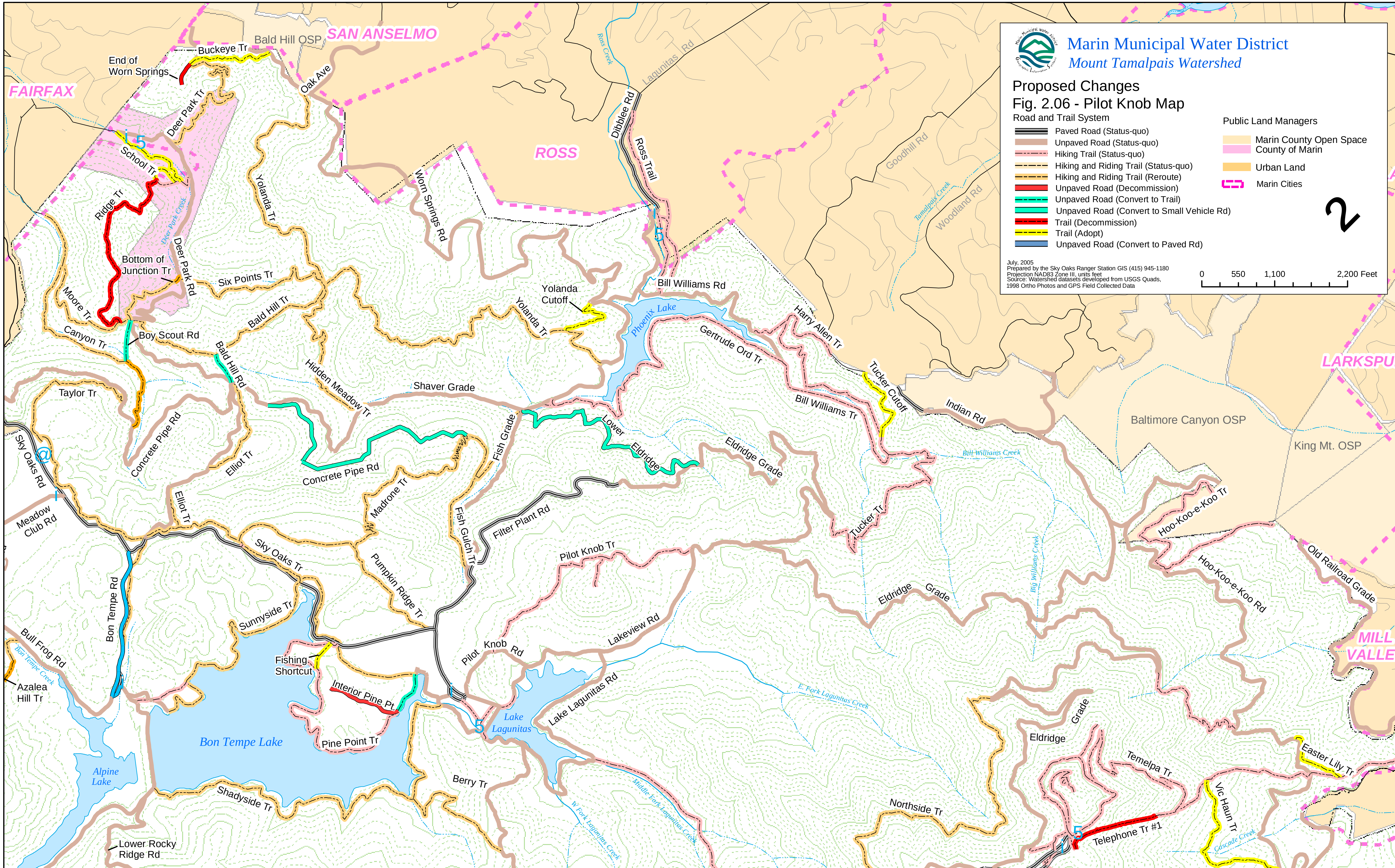
Marin Municipal Water District
Mount Tamalpais Watershed
Proposed Changes
Fig. 2.06 - Pilot Knob Map
Road and Trail System
Paved Road (Status-quo)
Unpaved Road (Status-quo)
Hiking Trail (Status-quo)
Hiking and Riding Trail (Status-quo)
Hiking and Riding Trail (Reroute)
Unpaved Road (Decommission)
Unpaved Road (Convert to Trail)
Unpaved Road (Convert to Small Vehicle Rd)
Trail (Decommission)
Trail (Adopt)
Unpaved Road (Convert to Paved Rd)
Public Land Managers
Marin County Open Space
County of Marin
Urban Land
Marin Cities
July, 2005
Prepared by the Sky Oaks Ranger Station GIS (415) 945-1180
Projection NAD83 Zone III, units feet
Source: Watershed datasets developed from USGS Quads, 1998 Ortho Photos and GPS Field Collected Data
0 550 1,100 2,200 Feet
FAIRFAX
SAN ANSELMO
ROSS
LARKSPUR
MILL VALLEY
Bald Hill OSP
Baltimore Canyon OSP
King Mt. OSP
Buckeye Tr
End of Worn Springs
Oak Ave
Deer Park Tr
School Tr
Ridge Tr
Deer Park Creek
Deer Park Rd
Bottom of Junction Tr
Moore Tr
Canyon Tr
Boy Scout Rd
Six Points Tr
Bald Hill Tr
Bald Hill Rd
Yolanda Tr
Worn Springs Rd
Yolanda Cutoff
Lagunitas Rd
Dibblee Rd
Ross Trail
Ross Creek
Goodhill Rd
Woodland Rd
Tamalpais Creek
Bill Williams Rd
Phoenix Lake
Gertrude Ord Tr
Harry Allen Tr
Tucker Cutoff
Indian Rd
Bill Williams Tr
Bill Williams Creek
Taylor Tr
Hidden Meadow Tr
Shaver Grade
Concrete Pipe Rd
Elliot Tr
Sky Oaks Rd
Fish Grade
Lower Eldridge
Eldridge Grade
Tucker Tr
Madrone Tr
Fish Gulch Tr
Filter Plant Rd
Meadow Club Rd
Sky Oaks Tr
Pumpkin Ridge Tr
Pilot Knob Tr
Hoo-Koo-e-Koo Tr
Hoo-Koo-e-Koo Rd
Old Railroad Grade
Big Williams Creek
Bon Tempe Rd
Sunnyside Tr
Bull Frog Rd
Bon Tempe Creek
Azalea Hill Tr
Fishing Shortcut
Interior Pine Pt.
Pilot Knob Rd
Lakeview Rd
Lake Lagunitas Rd
Lake Lagunitas
E. Fork Lagunitas Creek
Bon Tempe Lake
Pine Point Tr
Alpine Lake
Shadyside Tr
Berry Tr
Lower Rocky Ridge Rd
W Fork Lagunitas Creek
Middle Fork Lagunitas Creek
Northside Tr
Eldridge Grade
Temelpa Tr
Telephone Tr #1
Vic Haun Tr
Cascade Creek
Easter Lily Tr

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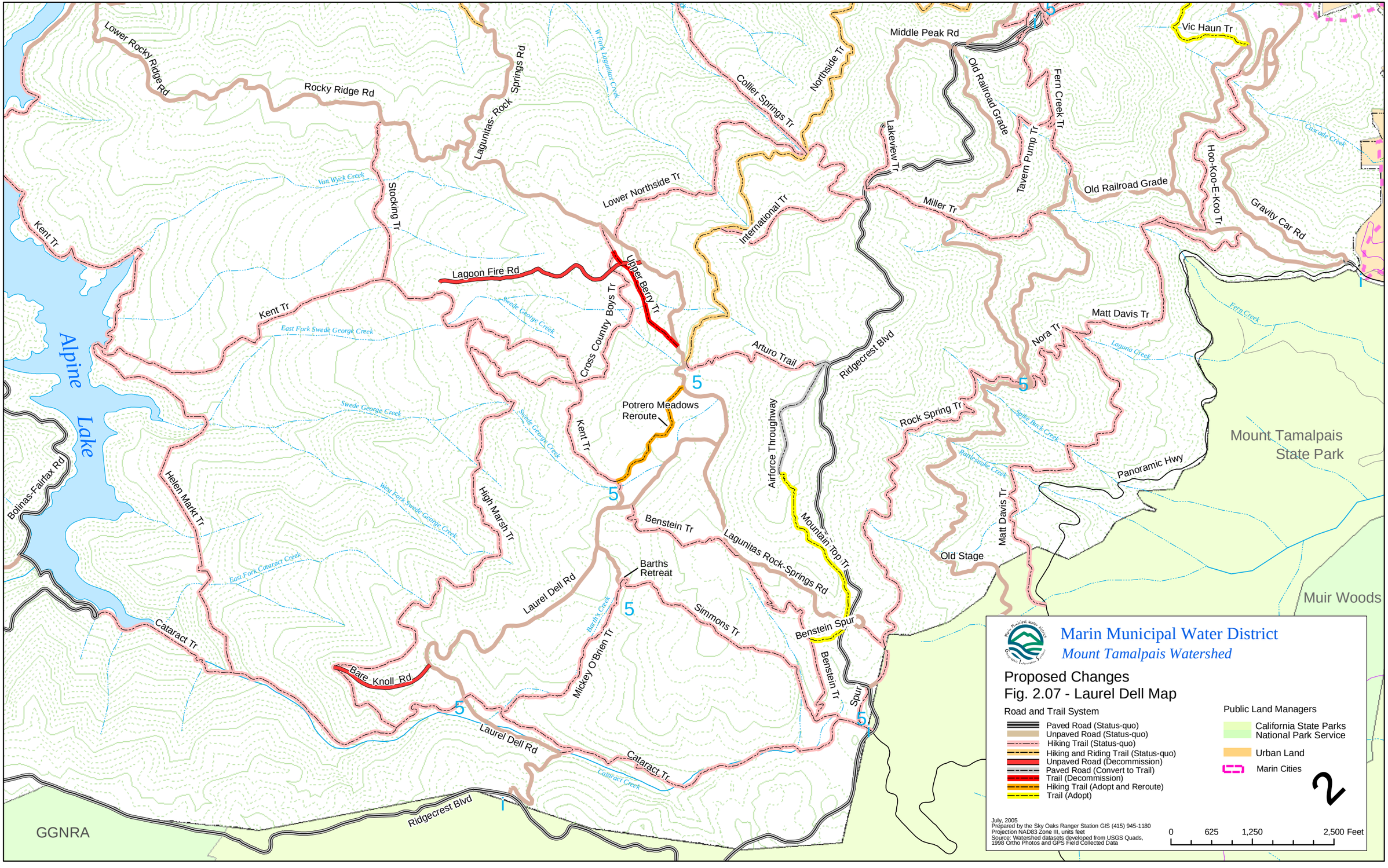

Marin Municipal Water District

Mount Tamalpais Watershed

Proposed Changes
Fig. 2.07 - Laurel Dell Map

Road and Trail System

- Paved Road (Status-quo)
- Unpaved Road (Status-quo)
- Hiking Trail (Status-quo)
- Hiking and Riding Trail (Status-quo)
- Unpaved Road (Decommission)
- Paved Road (Convert to Trail)
- Trail (Decommission)
- Hiking Trail (Adopt and Reroute)
- Trail (Adopt)

Public Land Managers

- California State Parks National Park Service
- Urban Land
- Marin Cities

2

July, 2005
Prepared by the Sky Oaks Ranger Station GIS (415) 945-1180
Projection NAD83 Zone III, units feet
Source: Watershed datasets developed from USGS Quads, 1998 Ortho Photos and GPS Field Collected Data

0 625 1,250 2,500 Feet

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The roads are categorized into classes depending upon whether or not they are subject to high use or serve critical infrastructure. If a route increases in importance or intensity of use, its design standard and maintenance may increase. For example, Sky Oaks Rd. is in the highest category because it receives high traffic volumes and serves Bon Tempe Water Treatment Plant. It is a paved road and maintained to a high standard. On the other hand, Pine Mountain Rd., which rarely has vehicle traffic and serves no critical facilities, is in a lower category. It is unpaved and the maintenance standard only requires it to be storm proof and accessible by emergency vehicles. It is closed to vehicles in winter. The classification system is shown in Table 2.5 and on the proposed classification maps (entitled: Proposed Road and Trail Classification System, Figure 2.8 –Figure 2.11).

Classification	Road Type	Characteristics	Miles
Class I	Paved Roads	High traffic volumes, year round access to critical facilities, main ingress and egress routes for the Watershed.	17.6
Class II	All Season Unpaved Roads	Receive regular use, typically have hardened surfaces, provide access to important water infrastructure and for important Watershed management.	44.2
Class III	Seasonal Unpaved Roads	Serves as emergency and recreational access. Typically, unsurfaced, narrower than Class I and II roads. Closed to vehicle traffic in the winter.	24.5
Class IV	Small Vehicle, Unpaved Roads	Primary use for patrol and route connectivity. Unsurfaced. Some sections only passable with small vehicles (i.e. ATV quads or small "bobcat" sized tractors). Limited truck and heavy vehicle traffic. Seasonal closures may apply.	4.5
Class V	Restricted Roads	Roads with special use restrictions (e.g. FAA facility)	3.7
		Total	94.5

Table 2.5 - Road Classifications on the Watershed. The classifications are hierarchical with Class I roads being the busiest, serving as the main ingress and egress routes to the Watershed or providing access to critical water infrastructure facilities, and Class IV being the least used with sections passable only by small vehicles and subject to seasonal closures. Permissible recreational uses of Watershed roads are defined in Title 9, Regulations for Use of Marin Municipal Water District Lands (MMWD 2002).

2.3 Trail Designations

The trails on the Watershed basically serve only two uses: hiking (either walking or running) or equestrian use. Permissible recreational uses are governed by Title 9, Land Use Regulations (MMWD 2002).

As with roads, the trails have also been designated into different classes depending upon whether or not they allow horses, are subject to high levels of use, serve as important connector trails, include substantial improvements (i.e. stairs, railings, walls, bridges, etc.) or possess a "backcountry" character that the District seeks to preserve. The classification system is shown in Table 2.6 and on the proposed classification maps.

Classification	Road Type	Characteristics	Miles
Class VI	Equestrian Trails	Substantial infrastructure improvements required to support use. Seasonal closures may apply.	17.8
Class VII	High Use Hiking Trails	Hikers only. High to medium level of use and maintenance. Can be an important trail connector. Infrastructure improvements consistent with use levels.	26.2
Class VIII	Moderate Use Hiking Trails	Hikers only. Medium to low level of use. Not an important trail connector. Little to no trail infrastructure improvements. Seasonal closures may apply.	11.8
Class IX	Backcountry Trails	Hikers only. Low level of use. Minor maintenance. Not important trail connectors. Rustic-style trail infrastructure improvements only. Typically farthest from parking areas and towns.	1.7
Class X	Reserved	This classification reserved for future use.	n/a
		Total	57.5

Table 2.6 - Trail Classifications on the Watershed. The classifications are hierarchical with Class VI trails being the busiest, serving equestrians and hikers, and the most infrastructure improvements (i.e. stairs, railings, walls, rocked surfaces, etc.) and Class IX being the least used with virtually no maintenance or improvements. Permissible recreational uses of Watershed trails are defined in Title 9, Regulations for Use of Marin Municipal Water District Lands (MMWD 2002).

Marin Municipal Water District

Mount Tamalpais Watershed

Road and Trail Classification System

Fig. 2.08 - Kent Lake Map

Road and Trail System

- Paved Road (Class I)
- All-Season Unpaved Roads (Class II)
- Seasonal Unpaved Road (Class III)
- Small Vehicle Unpaved Roads (Class IV)
- Other Roads

Public Land Managers

- California State Parks
- Marin County Open Space
- National Park Service
- Urban Land

NOTE: All Non-System Roads and Trails (Class X) Intentionally Left Out

July, 2005
Prepared by the Sky Oaks Ranger Station GIS
Projection NAD83 Zone III, units feet
Source: Watershed datasets developed from USGS Quads, 1998 Ortho Photos and GPS Field Collected Data

0 625 1,250 2,500 Feet

Gary Giacomini Open Space
San Geronimo Ridge Rd
Big Carson Creek
Samuel P. Taylor
State Park
San Geronimo Ridge Rd
Continental
Cove Rd
Grassy Slope Rd
Pine Mountain Rd
Poison Spring
Lagunitas Creek
Lower Peters
Dam Rd
Peters Dam Rd
Upper
Peters
Dam Rd
Lagunitas Creek
Shafter Grade
Kent
Lake
Golden Gate Natl. Rec. Area
Bolinas Ridge Rd

Map 6 Kent Lake Classes July, 2005 <Fig_2.08_KentClassMap.pdf>

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Marin Municipal Water District
Mount Tamalpais Watershed

Road and Trail Classification System
Fig. 2.09 - Oat Hill Map

Road and Trail System

- Paved Road (Class I)
- All-Season Unpaved Roads (Class II)
- Seasonal Unpaved Roads (Class III)
- Small Vehicle Unpaved Roads (Class IV)
- Hiking and Equestrian Trail (Class VI)
- Hiking Trail, Mod.-High Use (Class VII)
- Hiking Trail, Low-Mod. Use (Class VIII)
- Hiking Trail, Backcountry (Class IX)
- Other Roads

Public Land Managers

- Marin County Open Space
- Urban Land
- Marin Cities

NOTE: All Non-System Roads and Trails (Class X) Intentionally Left Out

July, 2005
Prepared by the Sky Oaks Ranger Station GIS
Projection NAD83 Zone III, units feet
Source: Watershed datasets developed from USGS Quads, 1998 Ortho Photos and GPS Field Collected Data

0 625 1,250 2,500 Feet

Cascade Canyon Open Space
FAIRFAX
Bolinas-Fairfax Rd
Taylor Tr
Sky Oaks Rd
San Anselmo Creek
Meadow Club Rd
Carey Camp Creek
Bon Tempe Creek
Cascade Canyon Rd
Azalea Hill Tr
San Geronimo Ridge
Pine Mountain Rd
Pine Mt. Rd
Little Carson Creek
Old Sled Tr
Alpine
Lake
Kent Tr
Oat Hill Rd
Little Carson Tr
Kent Pump Rd
Old Vee Rd
Oat Hill Spur
Kent
Lake
Lagunitas Creek
Ridgecrest Blvd
Bolinas Ridge Rd

Map 7 Oat Hill Classes July, 2005 <Fig_2.09_OatHillClassMap.pdf>

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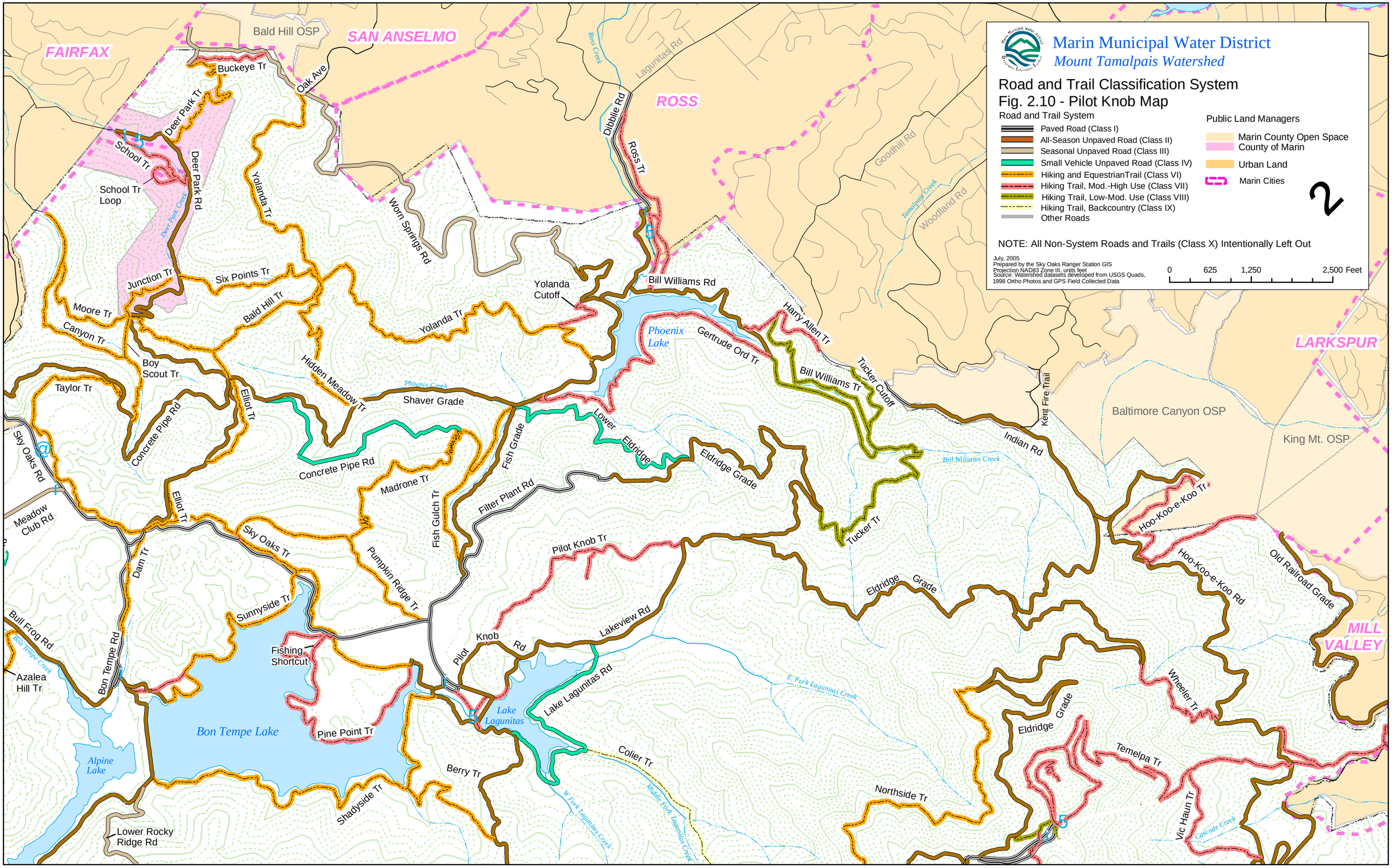

Map 8 July, 2005 <Fig_2.10_PltKnobClassMap.pdf>

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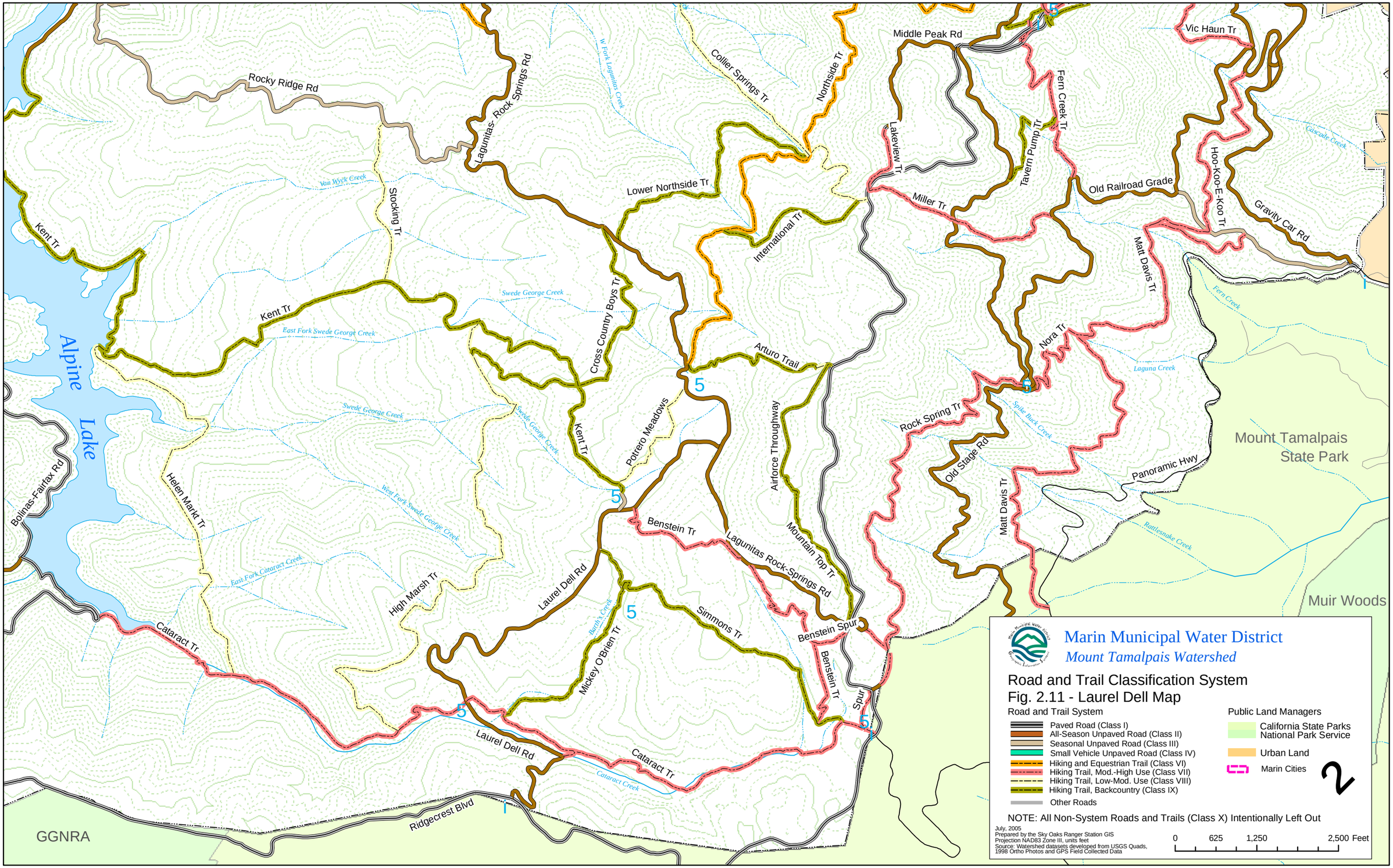

Map 9 Laurel Dell Class July, 2005 <Fig_2.11_LaurelDellClassMap.pdf>

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2.4 The Official System of Roads and Trails

As a result of the process detailed above, the District developed this current plan for the officially recognized system of roads and trails on the Watershed. The official system of roads and trails, after the changes, will include ~ 91 miles[3] of roads and ~ 57.5 miles of trails. This amount is similar to the ~ 90 miles of roads and ~ 54 miles of trails identified by the District as part of the old road and trail system. However, consistent with some of the goals, objectives and assumptions in this Plan, it represents a reduction in the number of routes when compared to the ~ 100 miles of roads and ~ 110 miles of trails that were identified on the Watershed as part of this planning effort.

The new, official road and trail system is shown graphically on the proposed road and trail system maps (entitled: Proposed Road and Trail System, Figure 2.12 – Kent Lake Map, Figure 2.13 – Oat Hill Map, Figure 2.14 – Pilot Knob Map, and Figure 2.15 – Laurel Dell Map).

In summary, all of the Watershed's roads and trails have been identified and classified based on their type, the uses they serve and whether or not they are part of the recognized, official system. The impacts of all of the roads and trails were analyzed primarily for their effect on water quality, environmentally sensitive habitat areas, cost and route redundancy or connectivity and balanced against access needs. While the majority of the road and trail system will remain the same and simply be upgraded, this analysis led to a number of recommendations that will change a small percentage of the old, existing road and trail system to minimize its overall impact on the Watershed.

Chapter 4, in combination with the appendices, provides the detail the District will use as a starting point for its management, maintenance and upgrade for all of the system roads and trails. Chapter 5 discusses the work plan for the remaining non-system roads and trails in the Watershed. Even if a road or trail is decommissioned, converted or rerouted, certain drainage measures will likely still be taken to address erosion problems on those routes.

[3] Does not include the 3.7 miles of "Restricted Roads," (Class V) which are not available to the general public for recreational use.

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Marin Municipal Water District
Mount Tamalpais Watershed

OFFICIAL ROAD AND TRAIL SYSTEM

Fig. 2.12 - Kent Lake Map

2

Road and Trail System

- Paved Road
- Unpaved Road

Public Land Managers

- California State Parks
- Marin County Open Space
- National Park Service
- Urban Land

July, 2005
Prepared by the Sky Oaks Ranger Station GIS
Projection NAD83 Zone III, units feet
Source: Watershed datasets developed from USGS Quads, 1998 Ortho Photos and GPS Field Collected Data

0 600 1,200 2,400 Feet

Gary Giacomini Open Space

San Geronimo Ridge Rd

Big Carson Creek

Samuel P. Taylor State Park

San Geronimo Ridge Rd

Continental Cove Rd

Grassy Slope Rd

Pine Mountain Rd

Poison Spring

Lagunitas Creek

Lower Peters Dam Rd

Peters Dam Rd

Upper Peters Dam Rd

Lagunitas Creek

Shafter Grade

Kent Lake

Golden Gate Natl. Rec. Area

Bolinas Ridge Rd

Map 10 Kent Lake July, 2005 <Fig_2.12_KentVstrMap.pdf>

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Marin Municipal Water District

Mount Tamalpais Watershed

OFFICIAL ROAD AND TRAIL SYSTEM

Fig. 2.13 - Oat Hill Map

Road and Trail System
- Paved Road
- Unpaved Road
- Hiking Trail
- Hiking and Riding Trail

Public Land Managers
- Marin County Open Space
- Urban Land

Marin Cities

July, 2005
Prepared by the Sky Oaks Ranger Station GIS
Projection NAD83 Zone III, units feet
Source: Watershed datasets developed from USGS Quads, 1998 Ortho Photos and GPS Field Collected Data

0 600 1,200 2,400 Feet

FAIRFAX
Cascade Canyon Open Space
Bolinas-Fairfax Rd
Taylor Tr
Sky Oaks Rd
San Anselmo Creek
Meadow Club Rd
Cascade Creek
Cascade Canyon Rd
Carey Camp Creek
Bon Tempe Creek
Meadow Club
Bull Frog Rd
San Geronimo Ridge
Pine Mountain Rd
Azalea Hill Tr
Pine Mt. Rd
Little Carson Creek
Old Sled Tr
Old Sled Tr
Alpine
Lake
Bolinas-Fairfax Rd
Kent Tr
Little Carson Tr
Oat Hill Rd
Kent Pump Rd
Old Vee Rd
Oat Hill Spur
Kent
Lake
Lagunitas Creek
Bolinas-Fairfax Rd
Ridgecrest Blvd

Blank backside 2.13

Marin Municipal Water District
Mount Tamalpais Watershed

OFFICIAL ROAD AND TRAIL SYSTEM

Fig. 2.14 - Pilot Knob Map

2

Road and Trail System

- Paved Road
- Unpaved Road
- Hiking Trail
- Hiking and Riding Trail

Public Land Managers

- Marin County Open Space
- County of Marin
- Urban Land
- Marin Cities

July, 2005
Prepared by the Sky Oaks Ranger Station GIS
Projection NAD83 Zone III, units feet
Source: Watershed datasets developed from USGS Quads, 1998 Ortho Photos and GPS Field Collected Data

0 600 1,200 2,400 Feet

FAIRFAX
SAN ANSELMO
ROSS
LARKSPUR
MILL VALLEY
Bald Hill OSP
Baltimore Canyon OSP
King Mt. OSP
Buckeye Tr
Oak Ave
Deer Park Creek
Deer Park Tr
Deer Park Rd
School Tr
School Tr Loop
Yolanda Tr
Worn Springs Rd
Ross Creek
Lagunitas Rd
Dibbile Rd
Ross Tr
Goodhill Rd
Tamalpais Creek
Woodland Rd
Junction Tr
Six Points Tr
Moore Tr
Canyon Tr
Bald Hill Tr
Boy Scout Tr
Taylor Tr
Hidden Meadow Tr
Phoenix Creek
Shaver Grade
Elliot Tr
Concrete Pipe Rd
Bill Williams Rd
Phoenix Lake
Gertrude Ord Tr
Harry Allen Tr
Bill Williams Tr
Tucker Cutoff
Kent Fire Tr
Indian Rd
Bill Williams Creek
Fish Grade
Lower Eldridge
Eldridge Grade
Tucker Tr
Hoo-Koo-e-Koo Tr
Hoo-Koo-e-Koo Rd
Old Railroad Grade
Sky Oaks Rd
Meadow Club Rd
Madrone Tr
Fish Gulch Tr
Filter Plant Rd
Pumpkin Ridge Tr
Sky Oaks Tr
Dam Tr
Bon Tempe Rd
Sunnyside Tr
Pilot Knob Tr
Pilot Knob Rd
Lakeview Rd
Fishing Shortcut
Bull Frog Rd
Bon Tempe Creek
Bon Tempe Lake
Alpine Lake
Pine Point Tr
Lake Lagunitas
Lake Lagunitas Rd
E. Fork Lagunitas Creek
Wheeler Tr
Eldridge Grade
Temelpa Tr
Colier Tr
Berry Tr
W Fork Lagunitas Creek
Middle Fork Lagunitas Creek
Northside Tr
Shadyside Tr
Lower Rocky Ridge Rd
Vic Haun Tr
Cascade Creek

Map 12 July, 2005 <Fig_2.14_PltKnobVstrMap.pdf>

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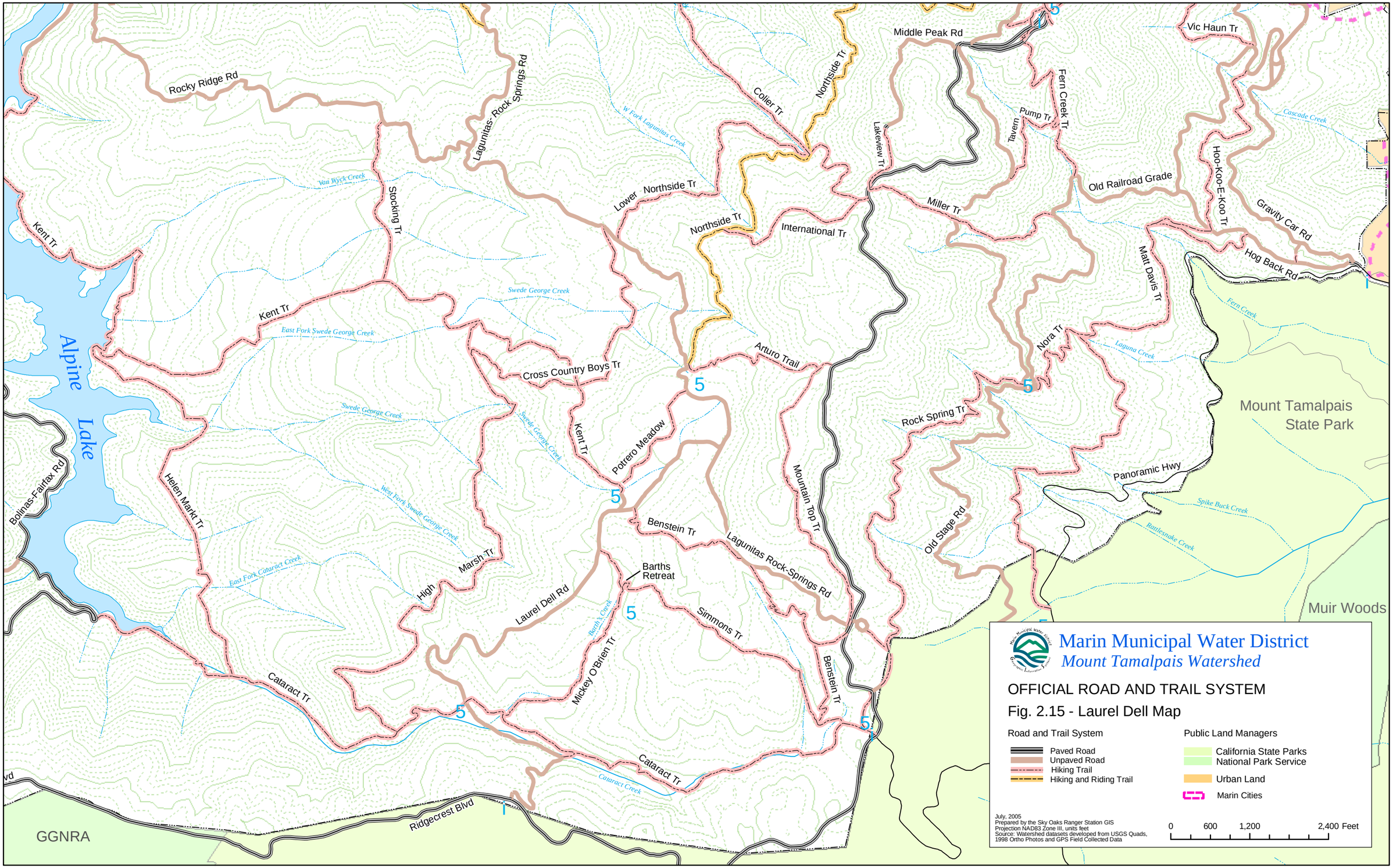

Marin Municipal Water District
Mount Tamalpais Watershed

OFFICIAL ROAD AND TRAIL SYSTEM

Fig. 2.15 - Laurel Dell Map

Road and Trail System

- Paved Road
- Unpaved Road
- Hiking Trail
- Hiking and Riding Trail

Public Land Managers

- California State Parks
- National Park Service
- Urban Land
- Marin Cities

July, 2005
Prepared by the Sky Oaks Ranger Station GIS
Projection NAD83 Zone III, units feet
Source: Watershed datasets developed from USGS Quads, 1998 Ortho Photos and GPS Field Collected Data

0 600 1,200 2,400 Feet

Map 13 Laurel Dell July, 2005 <Fig_2.15_LaurelDellVstrMap.pdf>

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Chapter 3: Best Management Practices, Design Standards and Environmental Protection Measures

3.0 Background

This Chapter describes, in general, the best management practices (BMPs), design standards, and environmental protection measures that the District will implement watershed-wide for roads and trails under the guidance of this Plan. Refer to Chapter 4 and Appendices B and C for specifics on the work recommended for a road or trail segment, or at an individual erosion site.

A substantial amount of research has been dedicated to planning, building and maintaining unpaved roads and trails in the last several years. Notable works include the "Handbook for Forest and Ranch Roads" (Weaver et al. 1994), the "Water-Road Interaction Technology Series Documents" (US Forest Service 1997) and the "Trails Handbook" (CDPR 1991). These works have led to a widely accepted set of water quality BMPs that reduce road and trail derived sediment impacts to creeks. They also serve to reduce maintenance time and cost, minimize erosion, and increase safety for users on roads and trails.

A certain degree of common sense or sound personal judgment must be used when applying any "standard" or "common practice" in the real world. Because of the wide variety of soil types, creek crossings, vegetation types, slopes, levels of use, etc., the BMPs, design standards, and environmental protection measures should be adjusted to suit their particular application (Weaver et al. 1994). Before deciding where and when to reconstruct or upgrade a portion of road or trail, the District will carefully consider the pros and cons of the different strategies and techniques available to remedy an erosion problem, and identify those that will have the minimum environmental impact. Decisions should include on site evaluations and should weigh the economic and environmental benefits to ensure they outweigh any detriments. When necessary, the District will consult with specialists on issues related to or involving vegetation, wildlife, fisheries, hydrology, geology or engineering.

Because the majority of the road and trail erosion problems in the Watershed are creek crossings and persistent surface erosion, followed by landslides and gullying, this Chapter focuses primarily on these problems. While the text and diagrams generally use roads as examples, the same principles also apply to trails; therefore, any discussion or recommendation regarding a road could also, for the most part, be applied to a trail.

3.1 Water Quality Best Management Practices

The District recognizes that good drainage is probably the most important factor in maintaining good roads and trails and protecting water quality and creek habitats. Drainage can generally be divided into two categories: (1) road and trail

surface drainage, and (2) hillside drainage from creeks or springs that cross the roads and trails.

3.1.1 Road and Trail Surface Drainage

Road Surface Designs. In general, effective surface drainage allows water to efficiently run off a road or trail. This is accomplished by insloping, outsloping or crowning (See Figures 3.1a through 3.1c).

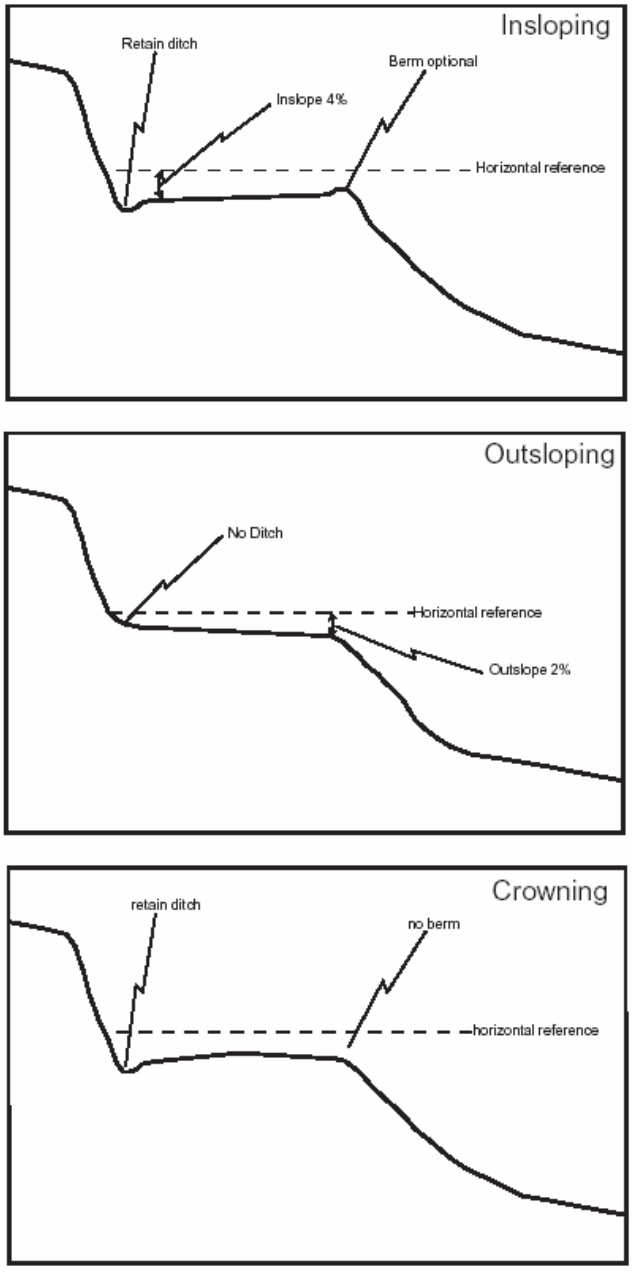


Figure 3.1a, 3.1b and 3.1c. Road Surface Drainage Techniques. Outsloping is the preferred option for roads and trails on the Watershed. When outsloping is not an option, the insloping or crowning techniques can be used. Drainage associated with any inboard ditch must also be properly addressed.

The District will maintain roads at a minimum width and outsloped whenever possible. These roads are more likely to minimize erosion maintenance and environmental impacts than the other designs. Outsloping may be impractical for roads that are steeply insloped with outside berms or for through-cut roads. Also, in certain situations such as on curves, steep grades or where an upslope spring contributes runoff, outsloping may be inappropriate. When an inside ditch is necessary, proper ditch relief drainage will be installed (see discussion below on ditch relief culverts).

Rolling Dips and Waterbars. The District will also use rolling dips or waterbars to control road and trail surface drainage (See Figures 3.2 and 3.3). Rolling dips are preferred by the District because they tend to last longer, are easier to drive over, and are more suitable for all-season roads and roads that receive higher volumes of traffic. They are especially crucial for unpaved roads that are heavily used in the winter. The District only uses waterbars in rare instances. Waterbars, while simpler to build, need more maintenance, are more difficult to navigate in a vehicle and are more prone to fail, especially if subjected to winter traffic. For this reason, the District will use rolling dips in any all-season road reconstruction.

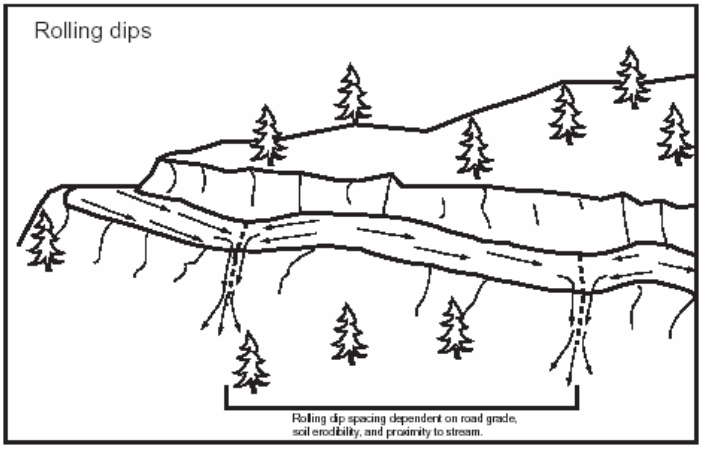


Figure 3.2. Rolling dips are preferred over waterbars by the District for controlling road surface drainage.

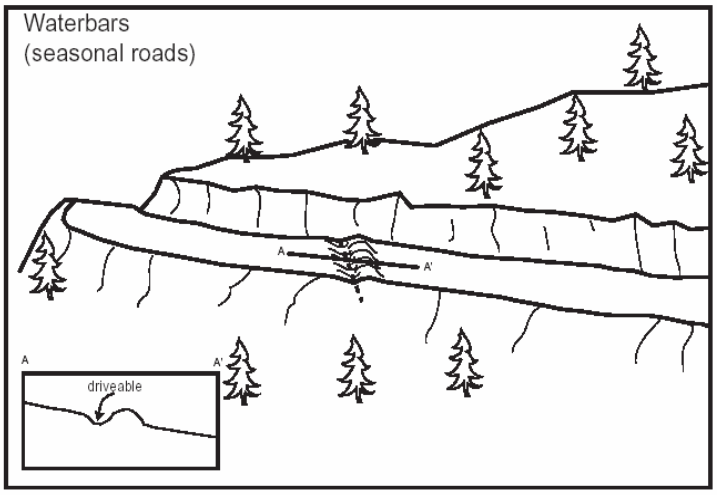


Figure 3.3. Waterbars should only be used on the Watershed on roads that are closed to vehicle traffic during the winter and when a rolling dip is infeasible.

Ditch Relief Culverts. For insloped roads, the District will install appropriately sized inside drainage ditches and ditch relief culvert(s) (DRCs) to remove road surface runoff (See Figure 3.4). The District will drain the inside ditches with DRCs at intervals sufficient to prevent excessive water velocity in the ditch that can create erosion or gullying.

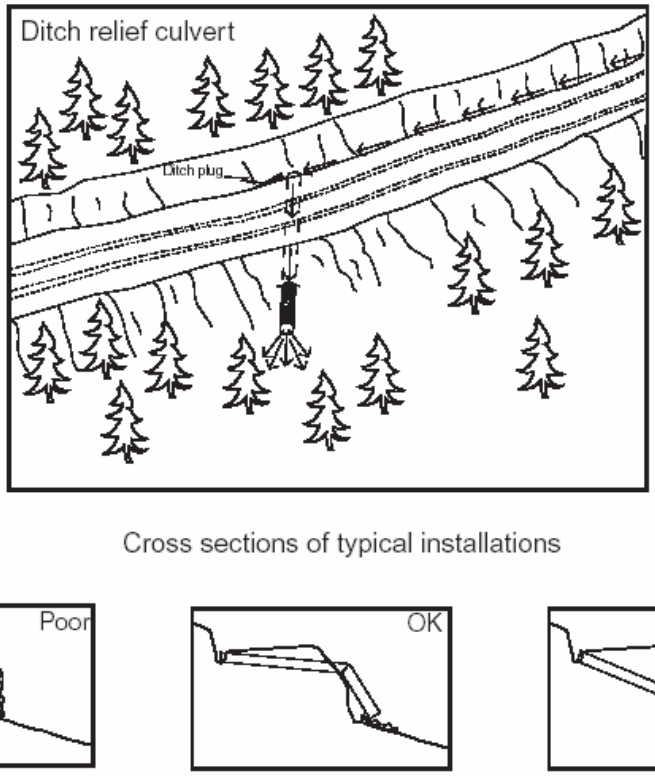


Figure 3.4. A ditch relief culvert is necessary to drain water that collects in inboard ditches and carry it underneath a road or trail to the downslope side of the route. The outlet of the ditch relief culvert should not be allowed to create erosion or "shotgun" where it discharges.

3.1.2 Hillside Drainage

Proper road or trail design creates minimal obstructions to natural watercourses. Creeks can be crossed using bridges, culverts or fords, or with a combination of the three.

The District will take into account the stream class (class 1, 2, 3, or 4), the type of road (temporary, seasonal or permanent), the type and use of vehicle traffic, fish passage, vegetation, water quality impacts and flood flows before designing and constructing an upgraded creek crossing. Other design considerations the District may need to consider include slope stability, debris flow potential, and installation and maintenance costs. Site-specific factors are important when determining the best location and most suitable type of creek crossing.

Culverts. Culverts, which have limited life spans, are the most common type of crossing on the Watershed. Culverted crossings are susceptible to a large variety of processes that ultimately lead to their demise (i.e. pipe wear and failure, debris damage, flood flows that exceed the design capacity, etc.). In reality, a culverted creek crossing is an earthen dam put across a creek that has a small hole in the bottom; therefore, the District will ensure that any new or replacement culverts are properly designed, constructed and maintained into the future. Factors the District will consider include: 1) diversion potential; 2) fish passage; 3) debris control structures; 4) energy dissipaters, and 5) culvert diameter.

Some creek crossings have “high diversion potential”, in that if the culvert is clogged or overwhelmed, creek flow can be captured by the road resulting in road damage and hillslope gullying when the water returns to the creek from a point further down the road. To prevent creek diversion, the District will construct crossings in a way that directs any flood flows back into the natural creek channel by incorporating a dip at the hinge line (also known as a “critical dip”), or by having the road change grade at the crossing, thereby eliminating the possibility for future creek diversions (See Figure 3.5a and 3.5b). Every creek crossing can benefit by construction of road dips before and after the crossing to eliminate sediment input and creek diversion if the culvert fails.

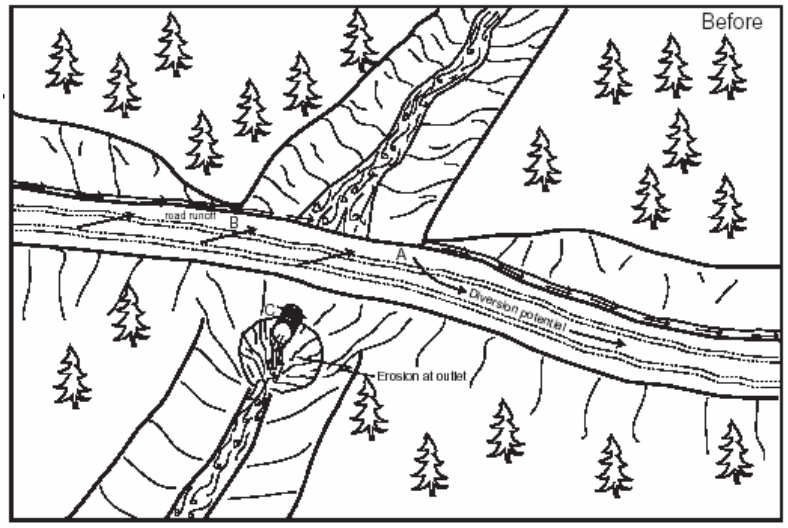


Figure 3.5a. Culverted crossings that do not benefit from modern design standards and best management practices can create a number of problems, the most common being diversion potential, draining the road and inboard ditch to the upstream side of the crossing and using an undersized culvert placed high in the fill with erosion at the outlet.

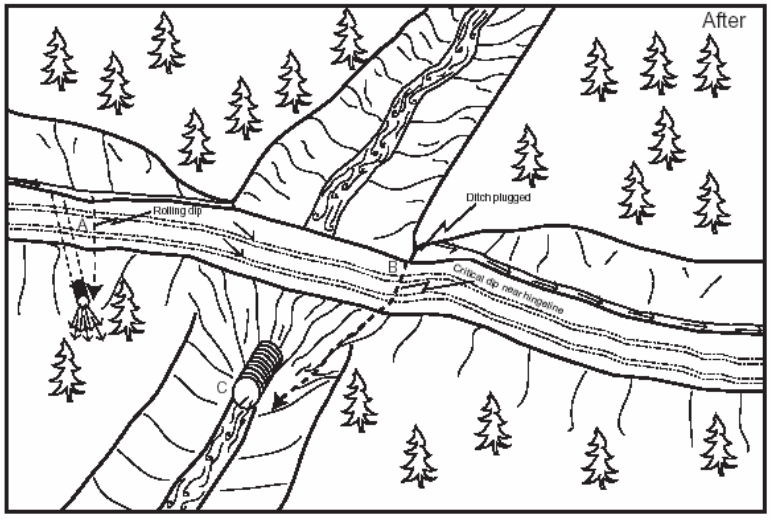
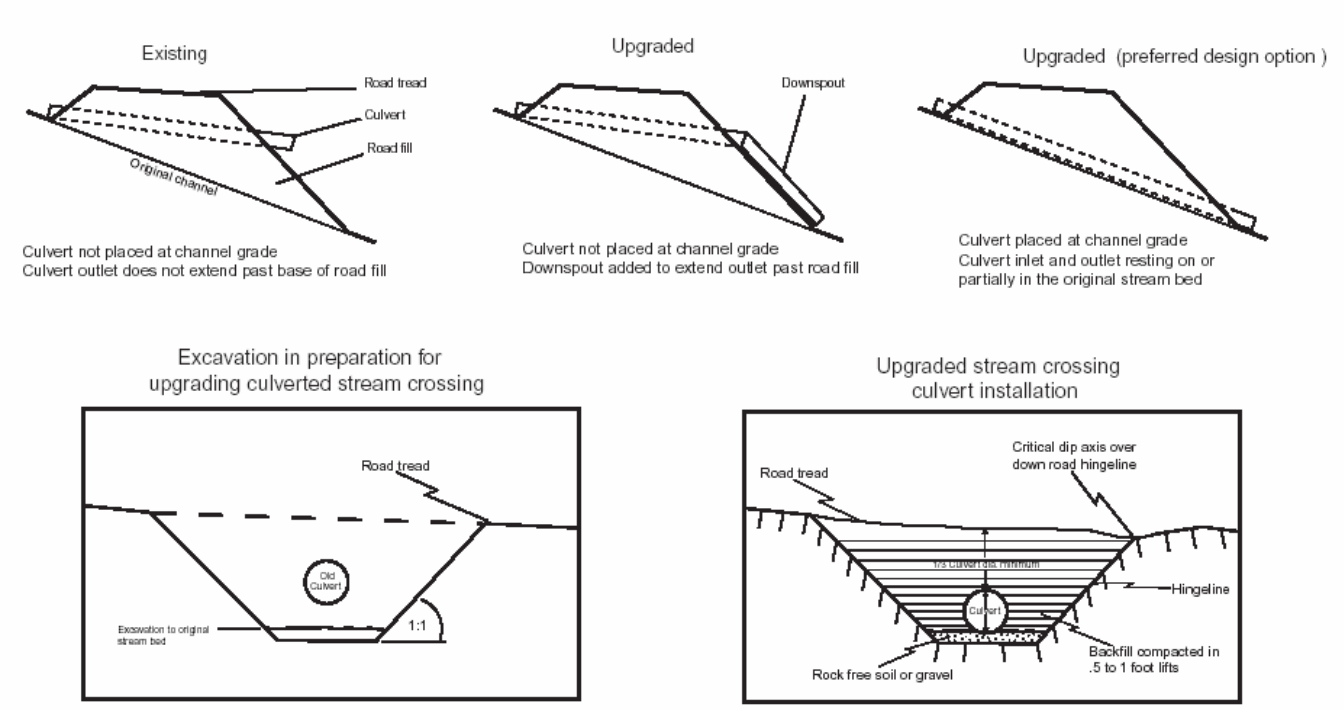


Figure 3.5b. A fail-safe (when there is no diversion potential) or fail-soft (when the potential for erosion is the least amount possible) culverted crossing. In general, the crossing's characteristics include the road surface being disconnected from the creek, no diversion potential and a 100-year culvert set at the base of the fill.

At all new or reconstructed crossings, culverts will be installed at a stable grade, preferably at, or slightly below, the original creek grade bottom. It is best when the road crosses the creek perpendicular to the channel, and the culvert is aligned along the axis of the natural creek channel. Figure 3.6 lists several guidelines and erosion control measures that can be used in new or replacement culvert installations on non-fish bearing creeks.



Typical installation of non-fish bearing culverted stream crossings

Road upgrading tasks typically include upgrading stream crossings by installing larger culverts and inlet protection (trash barriers) to prevent plugging. Culvert sizing for the 100 year flood flow should be determined by both field observation and calculations using a procedure such as the Rational Formula.

Stream crossing culvert installation

1) Culverts shall be aligned with natural stream channels to ensure proper function, prevent bank erosion and debris plugging problems.
2) Culverts shall be placed at the base of the fill and at the grade of the original streambed or downspouted past the base of the fill.
3) Culverts shall be set slightly below the original stream grade so that the water drops several inches as it enters the pipe.
4) Culvert beds shall be composed of rock free soil or gravel, evenly distributed under the length of the pipe.
5) To allow for sagging after burial, a camber shall be between 1.5 to 3 inches per 10 feet culvert pipe length.
6) Backfill material shall be free of rocks, limbs or other debris that could dent or puncture the pipe or allow water to seep around pipe.
7) One end of the culvert pipe shall be covered then the other end. Once the ends have been secured, the center will be covered.
8) Backfill material shall be tamped and compacted throughout the entire process.
-Base and side wall material will be compacted before the pipe is placed in its bed.
-Backfill compacting will be done in 0.5- 1 ft lifts until 1/3 of the diameter of the culvert has been covered. A gas powered tamper can be used for this work.
9) Inlets and outlets shall be armored with rock or mulched and seeded with grass as needed.
10) Trash protectors shall be installed just upstream from the culvert where there is a hazard of floating debris plugging the culvert.
11) Layers of fill will be pushed over the crossing until the final, design road grade is achieved, at a minimum of 1/3 to 1/2 the culvert diameter.

Erosion control measures for culvert replacement

Both mechanical and vegetative measures will be employed to minimize accelerated erosion from stream crossing and ditch relief culvert upgrading. Erosion control measures that are implemented will be evaluated on a site by site basis. Erosion control measures that may be employed include but are not limited to:
1) Minimizing soil exposure by limiting excavation areas and heavy equipment disturbance.
2) Installing filter windrows of slash at the base of the road fill to minimize the movement of eroded soil to downslope areas and stream channels.
3) Retaining rooted trees and shrubs at the base of the fill as "anchor" for the fill and filter windrows.
4) Bare slopes created by construction operations will be protected until vegetation can stabilize the surface. Surface erosion on exposed cuts and fills will be minimized by mulching, seeding, planting, compacting, armoring and/or benching prior to the first fall rains.
5) Extra or unusable soil will be stored in long term spoils disposal locations that are not limited by factors such as excessive moisture, steep slopes greater than 10%, archeology potential or proximity to a watercoarse.
6) On running streams water will be pumped or diverted past the crossing and into the down stream channel during the construction process.
7) Straw bales and/or silt fencing will be employed where neccessary to control runoff within the construction zone.

Figure 3.6. Typical design of non-fish bearing culverted stream crossings (PWA 1994).

Culverts for Fish Bearing Creeks. The District will also accommodate fish passage on all fish bearing creeks to not impede fish movement. If a bridge cannot be installed and a culvert must be used, a “plate arch,” or “open arch” culvert is preferable (see Figure 3.7).

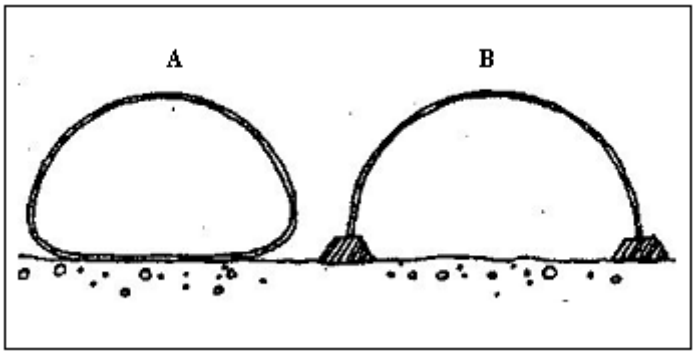


Figure 3.7 – Culverts for Fish Passage. Two common types of creek culverts where fish passage must be accommodated and a bridge cannot be installed are: A) pipe arch culverts and B) plate arch culverts.

The design of a new or replacement culvert with fish passage issues needs to consider: (1) the elevation at which the culvert would be installed (so fish do not have to jump into the culvert): (2) the diameter and grade of the culvert (so that it does not increase the speed of the creek flow significantly), (3) the retention of a stable creek bottom through the culvert-influenced area, and (4) the addition of fish resting pools above and below the culvert.

Debris Control Structures. The District will use debris control structures for culverts whenever necessary. Some type of system of poles, grates or racks installed upstream of the culvert is essential to keep debris out of the culvert that could potentially clog it. These structures need to be designed in a way that keeps them from clogging, failing and then washing downstream as a unit into the culvert. Racks or grates constructed against the culvert inlet should be avoided because they can clog, effectively plugging the culvert and causing the water to flow across and down the road. Creativity and experience should be used to create successful designs for each situation.

Energy Dissipaters. Similarly, the District will use energy dissipaters for culverts when necessary. Energy dissipation may be necessary to prevent erosion downstream of a culvert if it increases flow velocities in areas not accustomed to such high flows. Rock armor is the most commonly used dissipater, and should be sufficiently sized to resist erosion and transport. A culvert extension or flume may be used to carry the erosive forces beyond the edge of the erodible fills.

Culvert Diameter. The District will use culverts sized and designed to meet 100-year flood flows to the greatest extent practicable.

Bridges. There are several small trail bridges on the Watershed. Bridges generally have fewer environmental impacts on creeks than culverts. In some instances, where perennial creeks crossings are subject to heavy horse and bicycle traffic, bridges have fewer environmental impacts on a creek habitat and water quality than a ford crossing. In a few locations, this plan recommends upgrading some trail creek crossings by installing a trail bridge. In other instances, the District will enlarge and upgrade existing trail bridges so that they can adequately accommodate horse and bicycle traffic as well as foot traffic. The District will also maintain all the existing trail bridges to the greatest extent practicable.

There are a few road bridges on the Watershed, and PWA recommends only a few more. In these few instances, the District will consider using a road bridge instead of a culvert. If a road bridge is selected, the District will consider: (1) the expected use of the bridge; (2) to what degree the bridge would need to be engineered; (3) bridge approaches (bridges should be installed perpendicular to a creek crossing), and (4) the 100-year flood flows. The cost of "portable" bridges and their installation is now highly competitive with the installation of medium to large culverted (fill) crossings. Railroad flatcars, which generally come in standard lengths of about 55 feet to 90 feet, are the most common, low-cost alternative to traditional road bridge construction over narrower, incised creek channels that have relatively flat or low gradient approaching slopes.

Fords. The District may also use fords, or armored crossings, where a road or trail crosses a creek (see Figure 3.8). Fords work well on small to medium creeks where there is a stable bottom and traffic volumes are light, especially in the wet season. A rock lined rolling dip with a rock apron face is often preferred over a culvert in the locations that would necessitate importation of fill, and because they have the advantage of never plugging or having their fill wash away.

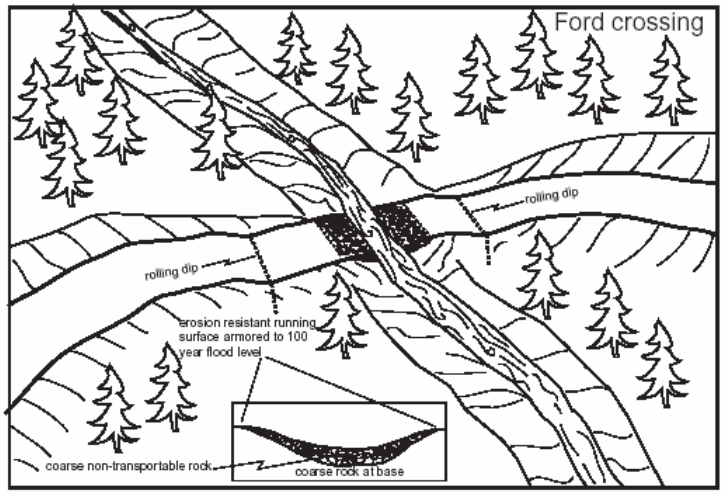


Figure 3.8. Armored Ford Crossing. Ford crossings have an advantage over culverted crossings because they can never plug and the amount of fill that can wash away is minimal. They tend to work well for many trail crossings. However, they are not suitable for steep, incised creeks or crossings that are subject to heavy traffic, especially in the winter.

Coarse cobbles or boulders can be arranged to create a raised, permeable crossing that allows water to flow through it during low water and over it during high water. Sufficient rock should be used to prevent unnecessary erosion at the crossing. The District will avoid using fords where traffic volumes are high because of water quality issues. Also, in some cases, a raised, permeable ford can be a barrier to fish passage and susceptible to washing out during flood flows. On the Watershed, fords are a practical solution for many roads and trails where they cross smaller creeks with little winter travel and for ephemeral drainages.

In summary, good road and trail drainage is extremely important for the roads and trails on the Watershed. Moreover, many effective methods have been developed to efficiently deal with drainage, whether it is road surface drainage or hillside drainage. In general, the District will use outsloping with an adequate number of rolling dips or water bars to control surface drainage. If an insloped road is necessary, the District will ensure it has an adequately designed inboard ditch with sufficient ditch relief culverts that minimize erosion. The District will also design creek crossings to minimize environmental impacts such as fish passage, water quality and flood flows, and take into account other important design considerations such as installation and maintenance costs, site stability and site-specific factors.

3.2 Road and Trail Design Standards

The District will strive to conform to accepted design standards when it maintains its roads and trails. The challenge is to maintain a route at least wide enough to safely accommodate the expected type of use, but at the same time keep it at a minimum width to minimize erosion. Over the years, the roads and trails on the Watershed have been maintained by the District at a width wide enough and a clearance high enough to safely accommodate the uses on a given road or trail and to maintain public water supply infrastructure. Implementation of this plan will allow for the continued maintenance of the current road and trail widths for the most part. However, importantly, this plan will also result in some routes being reduced in width to help minimize erosion and sediment delivery to the creeks and reservoirs.

For the most part, since the road and trail system already exists, planning for the location of a route is not at issue. In a few limited instances, a new section of trail will be constructed, but only as a reroute of an existing road or trail. No road reroutes are proposed in this plan. Trail reroutes will only be constructed when impacts and risks of reconstructing or maintaining a route in its existing location would be worse for the environment than constructing a new one (i.e. when the existing route travels in a creek creating unacceptable sedimentation, or when it is on a hillside that washes out regularly or was lost entirely by a landslide or flood).

In selecting the best location for a reroute, the District will follow the general guidelines listed below:

1. The existing route will be integrated as much as possible into the new route provided it was laid out properly and will maintain good drainage characteristics;
2. The reroute will not have any adverse impacts on water quality (areas with erodible soils and creek crossing will be avoided);
3. The reroute will not have adverse impacts on the natural habitat in the vicinity (environmentally sensitive habitats will be avoided);
4. Safety will be considered in the reroute (dangerous conditions, such as cliffs, rock fall zones, areas with unstable footing will be avoided);
5. Extreme grades for the reroute will be avoided
6. Areas of geologic instability will be avoided;
7. The alignment of the reroute will follow the natural contours of the landscape and take advantage of natural topographic features as turning points (so as not to appear "carved out" of the hillside); and
8. The reroute will need minimal maintenance.

Regarding specific design details, the type (classification) of a road or trail combined with the natural setting will dictate its dimensions, improvements and level of maintenance. For example, Sky Oaks Road and Filter Plant Road (Class I) would be maintained with larger dimensions and would include more substantial improvements than Class II or Class III roads because they have relatively high traffic volumes, including large vehicles that regularly serve the water treatment plant. Similarly, a regularly traveled horse trail (Class VI) would be maintained with bigger dimensions and would include more substantial improvements than a backcountry trail (Class IX).

Travelway Clearance. In general, the existing width and height of a road or trail will be the maximum width and height for future maintenance of that road or trail, Over the years, the District has improved and maintained the roads and trails on the Watershed to meet the uses they serve within the changing natural conditions the routes travel through. Today, the existing system is adequate in terms of travelway clearances for the roads and trails. In some instances, the Plan calls for travelway clearances to be modified. For example, the Plan calls for the conversion of some roads to small vehicle roads or to trails in order to address erosion problems and in these cases the travelway will be reduced. Small vehicle roads (Class IV) need only be maintained wide enough for safe passage of small vehicles like ATVs and Bobcat-sized tractors.

The District will determine the appropriate dimensions for travelway clearance on a case by case basis in the field, taking into account the expected type of user, vegetation, drainage and maintenance costs. Additionally, the District will look to standards developed by other open space and recreational organizations, such as the California Department of Parks and Recreations (1991), the National Park Service (1988) and the Equestrian Trails manual (1982), for guidance when determining travelway clearance for rerouted or re-classified recreational routes.

In the event that an existing route is proposed to be enlarged to serve a new or changed use (i.e. a change of classification), the impacts (as discussed in Section 2.1.1) of creating and maintaining the new, appropriate clearances for that route, and its anticipated traffic, need to be considered. A change in a route's classification may require an amendment to this Plan if the change would be substantial.

Infrastructure Improvements. Road and trail infrastructure improvements also will vary depending upon the classification of a route. High use roads and trails may need some minor structures like bridges, puncheons, retaining walls, railings or fencing (for user safety and to keep people out of environmentally sensitive or closed areas). The District will install new structures only when necessary for user safety. Whenever possible, these structures will be built out of native materials.

3.3 Environmental Protection Measures

Maintaining or upgrading (which sometimes involves reconstructing) roads and trails helps minimize sediment delivery to creeks and reservoirs mainly by reducing surface erosion and lowering the risk of failure. To help protect the environment, the following environmental protection measures are integral to the implementation of all road and trail work, including the water quality BMPs (Section 3.1).

3.3.1 For All Road and Trail Management Activities

Before and after any road or trail work, to avoid adverse impacts associated with road and trail management activities, the District will comply with the following, as practicable and appropriate.[1]

***Creek Protection*.** Creek crossing work is best done during late summer months when creek channels are flowing slowly or dry. Where needed temporary diversions around the work area will be accomplished using a small cofferdam and flexible pipe. When a coffer dam is used, sufficient water will be allowed to pass downstream to maintain aquatic life below the dam. Aquatic organisms in

[1] Before beginning any work, the District will secure appropriate authorizations or permits from applicable state or federal resource agencies for the work, as necessary, such as at class 1creek crossings.

the area filled by the dam will be relocated to a secure section of creek prior to work. Sufficient erosion control will be in place during and after work to insure that sediment does not enter the creek channel and that there is no increase in creek turbidity levels resulting from construction. Disturbance of creek side vegetation will be the minimum necessary to complete operations. Other restrictions may be applied for specific sites.

Construction Timing. All work activities will be timed to avoid, or minimize, the environmental impacts of those work activities. Work in a creek crossing will be done during the dry season to help protect water quality and fisheries. Construction activities that have the potential to adversely impact special status animal species will not be planned for or conducted during sensitive breeding, nesting or migration periods. When special status plant species are present, the work will be timed to minimize impacts when those species are reproductive or particularly vulnerable.

Construction Staging and Storage Areas. All construction staging and storage areas shall be identified prior to beginning construction. Whenever possible, the staging and storage areas should be located in areas that have minimal natural resource value like parking areas or roads and trail beds. Field surveys to determine potential environmental impacts of a proposed project, including impacts to special status species populations, must include the staging and storage areas in addition to the project footprint. In all cases, the staging and storage areas should be returned to, at a minimum, their pre-construction condition. If these areas are associated with a decommissioning or restoration project, they could be included as part of the restoration project, also.

Confine Work Areas to Existing Disturbed Areas. Whenever possible, the District will confine its work activities within the alignment of an existing road or trail and avoid impacts to previously untrammeled areas. In most cases, the older, high maintenance insloped routes can be converted to low maintenance outsloped routes without disturbing adjacent areas. When appropriate, such as when special status species populations are in the vicinity of the project, staging or storage areas, the construction crews will be notified of the special status species and the requirement to protect them. If necessary, the sensitive areas will be clearly marked or fenced during the project to minimize accidental impacts.

Minimizing Disturbance. Only the areas that truly need to be disturbed will be disturbed. Ditches and cutbanks should be left undisturbed unless they are identified as specific areas needing work. Construction crews will be briefed on what is not to be disturbed on site prior to the commencement of work. When environmentally sensitive habitats or special status species populations are involved, a protective barrier or signage will be installed that indicates the limits of construction and prohibits any work in areas not to be disturbed. In all cases, no sidecasting during maintenance, reconstruction or decommissioning work shall occur, especially near creeks.

***Disposal of Spoils*.** Locations for the placement of excess materials resulting from project activities will be identified in advance. Spoils will be placed in stable areas where they will not erode or wash into a creek or reservoir. If preferable, they can be placed in areas planned for long-term rehabilitation (former quarry sites, rock terraces near dam sites etc.).

Temporary Erosion Control Measures. The District will install temporary erosion control measures, such as silt fences, erosion control matting, wattles or hay bails, to prevent transport of sediment and other wastes off the project, storage or staging areas that could possibly enter a creek or reservoir. Furthermore, the District will control dust at the project, storage or staging areas to prevent the transport of such material into a creek or reservoir. Imported wattle, hay bails, and matting used for erosion control should be certified "weed free".

Construction Crew Tailgate. Prior to any work, the construction crew(s) will be informed of: (1) all necessary environmental protection measures; (2) the location of known special status species populations; (3) the location of any environmentally sensitive habitats; (4) the location of invasive exotic weed species that could infest the project site, and (5) all protective measures included in the project to minimize accidental environmental impacts.

Plant and Habitat Identification Training. The District will conduct regular training for its permanent and seasonal construction crews in invasive exotic weed identification, native plant identification, special status species and environmentally sensitive habitats so they are more likely to prevent accidental environmental impacts.

Construction Monitoring. Construction sites will be monitored during and after the completion of the activities to ensure there are no unintended or undesirable environmental effects resulting from the project. When there are special status species populations nearby, the area will be monitored more closely by the District during and after project completion. The level and duration of monitoring will be determined by the District on a case by case basis to ensure that there are no accidental environmental impacts and that all necessary mitigation measures are fully implemented.

Control of Invasive Weeds. Invasive exotic weed populations in and adjacent to project sites will be treated prior to any soil disturbing activites to minimize the seed dispersal of those plants. Sites where imported gravel or other fill materials are installed or stored should be mapped. Monitoring and/or treatment of these sites shall occur quarterly, or until it has been determined that there is no longer a risk of an unintentional release of an invasive, exotic species.

Retention and Reuse of Topsoil. Topsoil removed from the project area will be stored for its return to the disturbed site upon project completion. Special care

will be applied to any soil supporting special status plant species to minimize excessive disturbance of the soil during its removal, storage and return to the project area.

Collection and Reintroduction of Special Status Plants. Where impacts to special status plant species are unavoidable, efforts should be made to collect and preserve propagules from the affected population for later reintroduction.

Construction Signage – Public Notice. All construction sites will be signed and noticed that a construction project will occur or is in progress. The notice will describe, as appropriate or necessary, the type of work, whether or not the work will result in a road, trail or area closure, the duration of the work activities, when the road, trail or area would be reopened (if applicable), and include contact information for the public so they can get more information on the project.

3.3.2 For All Maintenance Work

Maintenance of roads and trails is essential. It helps protect the routes, minimizes erosion and helps protect the environment. Maintenance needs to be performed on road and trail surfaces, cutbanks, fillslopes, drainage structures (especially culverts) and erosion control features. To avoid adverse impacts associated with maintenance work, the District will implement the following, as practicable and appropriate.

Seasonal Closures. Minimizing heavy traffic loads, especially during the rainy season, is one of the simplest ways to maintain an unpaved road or trail. The District will close roads and trails susceptible to erosion whenever possible provided that they do not provide access to critical public water supply facilities. Temporary or seasonal road closures are an effective way to protect road or trail surface, minimize erosion and sedimentation, and keep maintenance costs down. Serious road damage can quickly occur during wet conditions, especially when drainage fails and water begins to pond or run along a road or trail surface. Heavy traffic in the dry season can pulverize surface material and create a thick, loose layer of fine sediment that will wash off during the first rain.

Inspections. The District will regularly inspect, before the rainy season, all creek crossings (including culvert trash racks and erosion control features), inboard ditches, ditch relief culverts, rolling dips and waterbars to be sure they will function properly. Local knowledge and experience will be used to focus on areas that have a history of failure. Inspecting during periods of high runoff reveals what drainage structures and erosion control features are working properly, and which ones are in need of maintenance or upgrading.

Road Grading. Grading is another important component of road maintenance. The District will grade only when needed to maintain an acceptable driving surface and retain proper drainage. Over-grading results in unnecessary erosion and

road surface wear. In addition, the District will grade only when road surfaces are slightly damp so the graded materials get properly mixed, compacted and bound with the underlying materials.

Ditch Maintenance. Ditches may also need grading from time to time, but only when and where necessary. Small plants and annual grasses will be left in ditches if they do not block water movement. This vegetation slows runoff velocities, helps prevent scour and filters out sediments. Often, nothing more than shovel work is necessary to maintain drainage ditches.

Culverts. Culverts are some of the most important features to maintain. The District will continue to mark all its culverts with coded signs that indicate where the culvert is located, and in certain cases, their diameter and relative inspection needs (based on its likelihood of plugging or history of problems). The District will continue to maintain a master file of all the culverts and their attributes for quick reference. This file will be regularly updated and maintained to maximize its usefulness. The District will also inspect culverts during periods of high runoff to clear them of debris that may cause plugging. The District will also fix culvert problems as soon as practicable as a delay may cause a failure that could lead to costly road damage.

Bridges. Bridges also need to be maintained. Bridge riprap and other abutment protection structures will be repaired if damaged by the District as soon as possible to prevent the loss of the bridge. Large, woody, floating debris will be cut free and removed or floated downstream. Unwanted debris that accumulates on the deck surfaces will be picked up or pushed to the adjacent bank for proper disposal. The District will not dump, push or scrape this material into the creek or reservoir.

Fords. The District may also perform some rock armor maintenance on permanent fords from time to time. If the District needs to do maintenance work on a ford it will wait until low flow conditions to minimize impacts to the creek and water quality.

Cutbanks. Cut slope failures generally present less of an impact on the environment because the failed materials are usually caught by the roadbed. Cutbanks will be frequently inspected by the District to help identify potential failures before they happen. The District will remove these materials (especially from inboard ditches) before they have an opportunity to enter a creek or reservoir, restore the road or trail surface drainage, and dispose of the material where it will not erode into a creek or reservoir or create other problems.

Fillslopes. Fillslope problems may appear as tension cracks or small scarps in the road surface. If material could fall into a creek or reservoir, it should be excavated before it fails. The District will continue to work diligently to maintain proper drainage that helps minimize the development of the cracks and scarps. If

movement is persistent, the District will seek an alternative so the fill area is no longer needed or subjected to loading. If more width is needed to maintain safe passage, the District will explore the possibility of cutting further into the hillside, a retaining wall or other structure (See "Fixing Unstable Road Benches and Fill Slopes" below).

3.3.3 For All Best Management Practice Implementation Work

If a portion of a road and trail is substandard or in disrepair, there is an opportunity to upgrade it to prevent future erosion. In general, upgrading creek crossings (especially culverts), surface drainage and fill and cut slopes will improve the reliability of a road or trail, prevent future erosion and improve creek environments and water quality by minimizing sediment delivery.

Reconstruct Creek Crossings to Modern Standards. The District will reconstruct creek crossings using modern standards (see Sections 3.1 and 3.2). Whenever possible, the crossings will be upgraded to handle the anticipated 100-year flood flows and the anticipated traffic types and volumes. This may require excavating the entire older crossing down to the original channel bed before placing a new crossing. In other instances this may mean installing a culvert where none existed, replacing a culvert with a constructed ford or replacing a culvert with a bridge.

Fixing Cut Slope Failures. Re-vegetation, minor flattening or some simple type of retaining structure may be used to solve persistent problems. Stabilizing the toe of the slope by weighting it with heavy riprap may solve some failures. In other cases, a geotechnical or structural engineer may be needed for designing more complicated retaining structures or walls to solve larger unstable areas.

Fixing Unstable Road Benches and Fill Slopes. Failed or eroding road benches are another challenge. Fill slopes that show signs of pending failure and would enter a creek or reservoir will be removed before they fail if the remaining width allows continued safe passage (See Figure 3.9). If additional width is needed, the District will first consider cutting into the inside bank rather than trying to build the fill back out. The District will not sidecast material to rebuild fillslope failures because the added material could end up in a creek or reservoir. In these cases a crib wall or other reinforced retaining structure will be used. If necessary, a geotechnical and/or structural engineer may be consulted in the design solution. In cases where the eroding outboard side of the roadbed would not slide into a creek or reservoir, and there is sufficient room for vehicles, the area should not be disturbed unless it creates other safety or environmental issues.

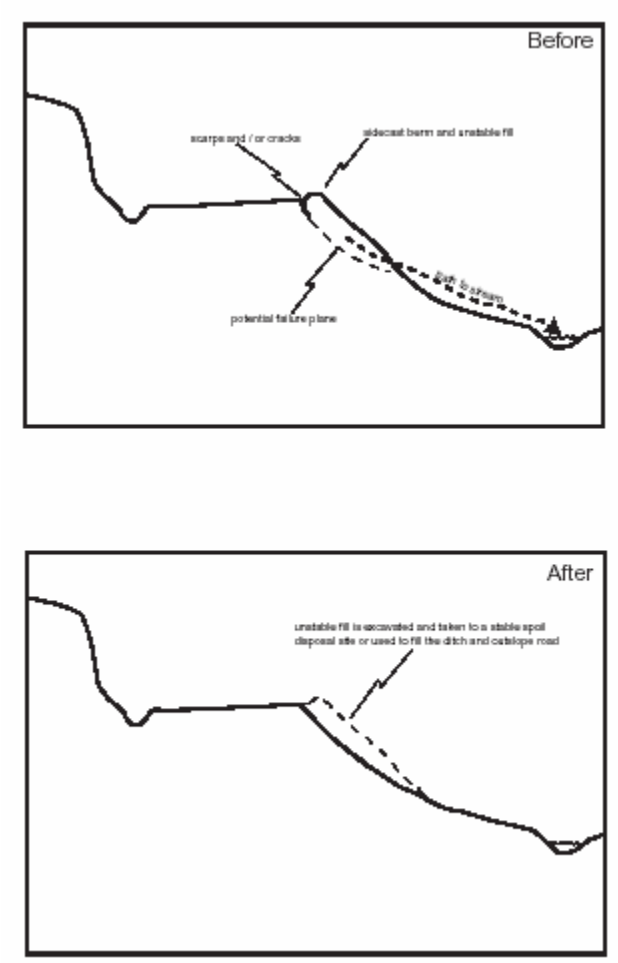


Figure 3.9 - Unstable Fill Slopes. If an unstable fill slope has the potential of failing and entering a creek or reservoir, it should be removed. If road width needs to be maintained, the District should look into cutting further into the bank. If this is not possible, an engineer should be consulted to design a crib or other reinforced retaining wall.

3.3.4 For All Decommissioning Work

There are many reasons for decommissioning a road or trail, but most fall into the category of: (1) continued water quality impacts; (2) rare and endangered species impacts or other undesirable environmental effects; (3) the route is no longer needed, or (4) excessive maintenance or patrol costs. Applying many of the standards for environmental protection, as discussed in Sections 3.3.1, 3.3.2 and 3.3.3, during decommissioning helps minimize future erosion and sedimentation from abandoned roads and trails and eliminates the likelihood of a catastrophic failure.

The goal of decommissioning is to restore natural topography and habitat as much as possible so that maintenance work is no longer needed and to prevent future road related environmental impacts. Three primary objectives are to: (1)

prevent road related debris flows and surface erosion, (2) correct creek diversions (thereby preventing creek crossing washouts, fill failures and potential problems created by creek diversions), and 3) restore natural habitat to the greatest extent possible. This generally involves, at a minimum: excavating all creek crossings by removing all fills, culverts, bridges or fords; excavating unstable fillslopes, treating the road surface and inboard ditches to disperse runoff and prevent erosion; and revegetating any disturbed areas. In some cases, because of past erosion or the presence of mature trees or other vegetation, some sections of road or trail will only have partial topographic restoration. Road segments that have the potential to generate erosion and discharge sediment into creeks or reservoirs must always be addressed.

Removal of Creek Crossings. When removing a creek crossing, the District will excavate all materials placed in the creek channel when the crossing was built, including the culvert and rock armor. The restored channel should be as wide or slightly wider than the original channel and have the same bottom grade, or slope, and orientation as the original channel (See Figure 3.10). Ideally the natural channel and rock still exist under the culvert and fill. If the natural rock creek bottom was removed, new rock armor maybe needed in the bottom of the channel to prevent downcutting. In some cases, the channel side slopes may need to be "pulled" back to a stable angle or armored to prevent sloughing. All the excavated materials will be disposed of in a location and manner where they will not erode and cause sediment to enter a creek or reservoir. In all cases the District will mulch and seed or plant the bare soil.

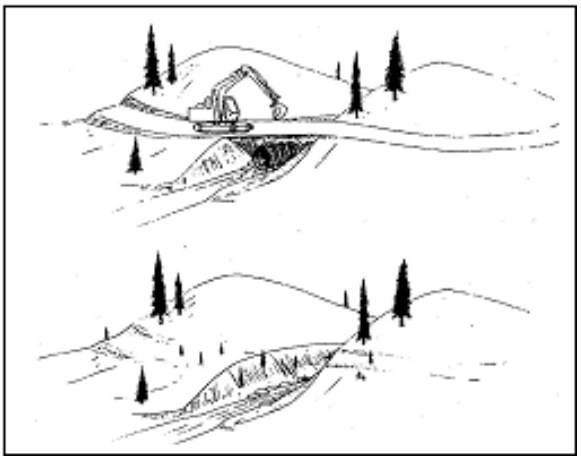


Figure 3.10 – Pulled Creek Crossing. On roads that will be closed, the culverts and fills should be removed. Creek crossing excavations are best performed using an excavator. Spoil can usually be stored on the road bench adjacent the crossing provided it is placed and stabilized where it will not erode into the creek.

Removal of Unstable Fillslopes. Unstable fillslopes that would enter a creek, reservoir or that could impact another type of environmentally sensitive area will be entirely removed by the District. If the fillslope includes structures (crib walls, retaining walls, etc.) they will be removed as well. The excavated materials will be disposed of in a location and manner where they would not erode and cause

sediment to enter a creek or reservoir. If it would not adversely affect the function of the final road surface drainage, the fill can be placed against the cutbank and used to fill the inboard ditches to restore natural topography. All disturbed areas will be revegetated.

Cutbanks. Cutbanks may need to have larger plants removed before restoring topography. Full restoration of steep slopes may not be desirable where springs surface on cutbanks. In general undisturbed native soil profiles upslope of cutbanks should not be disturbed and should not be used to provide material to match original slope.

Road Surface Drainage. Surface drainage on abandoned routes needs to be addressed so that it is self-maintaining, adequately serves the area it drains and does not deliver sediment to a creek or reservoir. Insloped routes will be outsloped and their inboard ditches removed. Outside berms will also be removed. Ditch relief culverts will no longer be necessary and they can be removed as well. In situations where topographic restoration is limited, cross drains may need to be installed where necessary to prevent water from traveling down the old route and causing gullying. The number, location and angle of a cross drain depends on the steepness of the route and the location of any spring or upslope gully. In most cases the original roadbed will be mechanically decompacted (using rippers or subsoilers) prior to landform restoration or installation of cross drains.

3.3.5 Revegetation

Revegetation is the final element of a long-term erosion control solution. Certain native annuals grow relatively quickly, reduce surface erosion and improve soil quality and its physical characteristics. Shrubs add longer lasting vegetative cover and provide stronger root systems that improve slope stability. Trees such as hardwoods and conifers, when planted in their appropriate range, provide for long-term land stability and erosion control.

The District will seek to allow natural re-establishment of native vegetation at construction sites, taking into account the following when determining site-specific revegetation strategies:

1. Potential for natural recovery of the vegetation;
2. Potential for expansion and establishment of invasive, exotic weed species;
3. Availability of local seed and plant stock; and
4. Available information on special status species and environmentally sensitive habitats in the area.

Mulching. Mulches will be used wherever bare ground can erode into a creek or reservoir. This includes all excavated fillslopes above these waterbodies and all excavated creek crossings. Weed free straw (3,000 to 5,000 lbs/acre) is one of the most common products used for mulch, but there are other products available as well. On steep slopes or in windy areas, mulch will be tacked, punched or secured to the ground. Imported mulch should be certified weed free. Mulched sites will be mapped and monitored for nascent weed populations.

Seeding. Whenever possible, the District will reseed disturbed sites by redistributing topsoil and surrounding vegetative litter in the final site dressing. Seeding with imported germ material may be appropriate where extensive areas are disturbed or the native seed bank is degraded. Seed material collected from the Watershed will be used to the fullest extent possible. Seed mixes should be site specific, with species composition drawn from the surrounding plant community. Where rapid establishment of vegetative cover is deemed necessary, seed mixes should be restricted to sterile, annual grass species. Fertilizers and nitrogen-fixing cover crops should not be used, as such “soil enhancers” can facilitate invasive, exotic weed establishment. Newly seeded areas should be marked on the ground or mapped and protected from disturbance during the germination season. Vehicles should not be parked or driven over recently seeded areas. These areas should also be closed to foot, horse and bicycle traffic. If neccesary, a temporary or permanent access barrier or fence may be installed to prevent damage to the seeded areas.

Planting. Following seeding, planting perennial species, shrubs and trees, may be appropriate at certain project sites. While these plants ultimately provide better erosion control, they take longer to establish. Species selection should reflect the surround plant communities, and plant material should be gathered from the Watershed. To the fullest extent possible, root masses, bulbs, and corms excavated during construction should be preserved and replanted on the project site as part of the final dressing. In some cases, extra care may be needed for the newly planted perennial species to protect them from deer, summer drought and other plant species which may out compete them for sun, water and nutrients.

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Chapter 4: Work Plan for System Routes

4.0 Summary of Erosion Sites and Recommended Work

This Chapter summarizes road and trail related erosion problems and the treatments recommended to minimize sediment delivery to the creeks and reservoirs. It also includes a discussion on the sign program and public outreach program that will be used to help guide people while they are on the Watershed. Refer to Chapter 3 for a general description on what the type(s) of work that will be done and what the finished work will generally look like when it is completed. The "work plan" is broken into the 13 sub-watersheds[1] comprising the Mt. Tamalpais Watershed (see Figure 4.1).

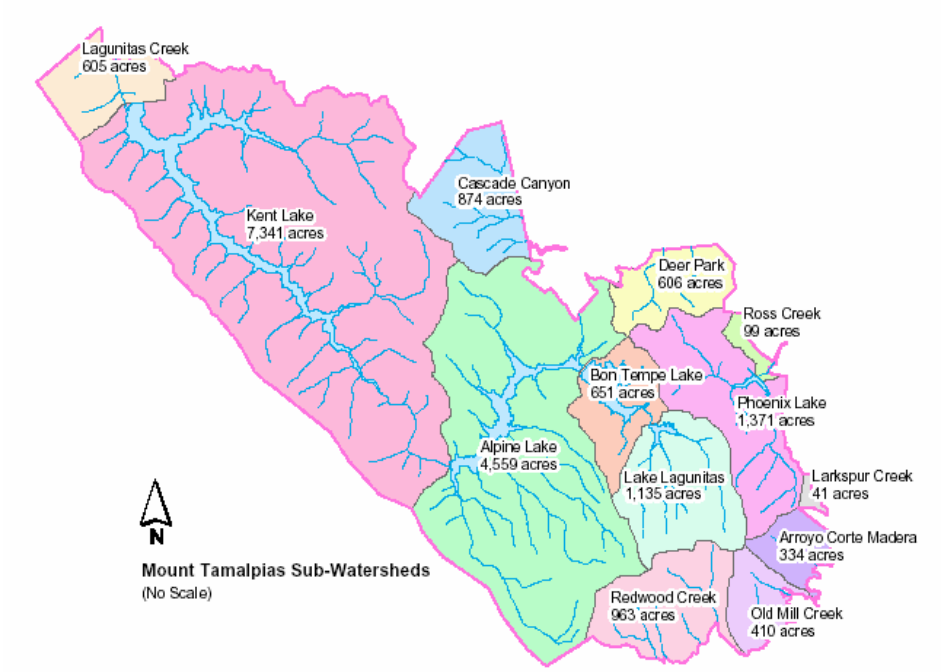

Figure 4.1. Sub-Watersheds in the District ownership and their acreages.

The majority of this discussion is based on the PWA (2002, 2003) field inventory and report that identified over 1,200 road and trail related erosion sites (problems) on the Watershed. PWA surveyed nearly 170 miles of roads and trials in or adjacent to the Watershed, including non-District owned roads (i.e. Bolinas-Fairfax Rd., Ridgecrest Blvd., etc.) that the District has management interests in because they may provide access to critical infrastructure, access for emergency response or raise water-quality or natural resource issues.

[1] "Sub-watershed" is a term used to designate an arbitrary subdivision of a hydrologic watershed. In this plan, a subwatershed is either the drainage area of a reservoir or the portion of a drainage area of a local creek that is controlled by the District.

All of the erosion problems are classified into one of five types: (1) stream crossings (several types of problems); (2) road or trail related landslides (failing fills); (3) ditch relief culverts (DRCs); (4) "other" erosion types[2], and (5) persistent road or trail surface and ditch erosion. The volume of sediment that could be delivered to the creeks and reservoirs over the next 20 years from roads and trails, if left untreated, was estimated to be ~186,305 cu.yds. (PWA 2003, 2002) (see Table 4.1).

Sub-Watershed	Acres	Volume from Road Erosion (cu.yds.)	Volume from Trail Erosion (cu.yds.)	Total Erosion (cu.yds.)	Erosion per Acre
Alpine Lake	4,559	39,072	1,491	40,563	8.9
Kent Lake	7,341	36,140	1,126	37,266	5.1
Phoenix Lake	1,371	26,049	1,014	27,063	19.7
Redwood Creek	963	24,300	1,168	25,468	26.4
Arroyo Corte Madera	334	15,965	301	16,266	48.7
Old Mill Creek	410	12,645	41	12,686	30.9
Lagunitas Creek	605	8,702	0	8,702	14.4
Lake Lagunitas	1,135	5,201	354	5,555	4.9
Deer Park	606	3,295	530	3,825	6.3
Bon Tempe Lake	651	3,111	232	3,343	5.1
Cascade Canyon	874	2,597	212	2,809	3.2
Ross Creek	99	1,037	0	1,037	10.5
Larkspur Creek	41	959	0	959	23.4
TOTALS	**18,989 acres**	**179,073 cu.yds.**	**6,469 cu.yds.**	**185,542 cu.yds.**	**9.8 cu.yds. per acre**

Table 4.1 – Erosion by Sub-Watershed. The 13 sub-watersheds within the Mt. Tamalpais Watershed, their acreages and estimated sediment delivery volumes for the next 20 years if no preventative treatments are performed (PWA 2002, 2003).

Over 96% of this sediment would come from the Watershed's roads (~179,500 cu.yds.). The remaining ~4% would come from the trails (~6,805 cu.yds.). As expected, the largest sub-watersheds, Alpine and Kent Lakes, would be the biggest sediment producers. However, both of these sub-watersheds contribute less than the average sediment volume based on overall area (cu.yds. per acre). Relative to the size of their land area, the sub-watersheds on the south and

[2] The main types of "other" erosion are gully expansion, springs, road rilling, bank erosion, unchanneled swales or other sites that do not neatly fit into one of the stream crossing, ditch relief culvert or landslide categories.

eastern sides of Mt. Tamalpais that drain into Redwood Creek and Arroyo Corte Madera del Presidio are the biggest sediment producers.

The goal of the recommended treatments is to "storm-proof" the road and trail network so that sediment delivery to the creeks and reservoirs is strictly minimized. Figure 4.2 lists common characteristics of a "storm-proofed" road and trail network.

FIGURE 4.2: CHARACTERISTICS OF STORM-PROOFED ROADS

The following abbreviated criteria identify common characteristics of "storm-proofed" roads. Roads are "storm-proofed" when sediment delivery to streams is strictly minimized. This is accomplished by dispersing road surface drainage, preventing road erosion from entering streams, protecting stream crossings from failure or diversion, and preventing failure of unstable fills which would otherwise deliver sediment to a stream. Minor exceptions to these "guidelines" can occur at specific sites within a forest or ranch road system.

STREAM CROSSINGS

- all stream crossings have a drainage structure designed for the 100-year flow
- stream crossings have no diversion potential (functional critical dips are in place)
- stream crossing inlets have low plug potential (trash barriers & graded drainage)
- stream crossing outlets are protected from erosion (extended, transported or dissipated)
- culvert inlet, outlet and bottom are open and in sound condition
- undersized culverts in deep fills (> backhoe reach) have emergency overflow culvert
- bridges have stable, non-eroding abutments & do not significantly restrict design flood
- fills are stable (unstable fills are removed or stabilized)
- road surfaces and ditches are "disconnected" from streams and stream crossing culverts
- decommissioned roads have all stream crossings completely excavated to original grade
- Class 1 (fish) streams accommodate fish passage

ROAD AND LANDING FILLS

- unstable and potentially unstable road and landing fills are excavated (removed)
- excavated spoil is placed in locations where eroded material will not enter a stream
- excavated spoil is placed where it will not cause a slope failure or landslide

ROAD SURFACE DRAINAGE

- road surfaces and ditches are "disconnected" from streams and stream crossing culverts
- ditches are drained frequently by functional rolling dips or ditch relief culverts
- outflow from ditch relief culverts does not discharge to streams
- gullies (including those below ditch relief culverts) are dewatered to the extent possible
- ditches do not discharge (through culverts or rolling dips) onto active or potential landslides
- decommissioned roads have permanent road surface drainage and do not rely on ditches

Figure 4.2 - Characteristics of *"storm-proof"* roads. Source: PWA 1994, 2003

4.1 Types of Erosion and Recommended Preventative Treatments

The following discusses the different erosion problems by type and briefly summarizes some of the recommended treatments. A total of 230 of the 1,200 or so sites are not recommended for treatment because they are correctly designed for the 100-year flood flow and/or will be addressed by implementing the recommended treatments at nearby sites. More detailed, site specific information on the erosion problems is contained in appendices B and C, and is fully detailed in the data sheets prepared by PWA (2002, 2003).

4.1.1 Erosion Sites

Stream Crossings. A total of 373 road-related erosion sites were identified at stream crossings. A total of 305 of these sites include crossings that have culverts. An additional 402 stream crossings were inventoried on trails. A total of 18 of these crossings were classified as culverted crossings, 108 as fill crossings (with or without armoring), 183 as ford crossings, and 79 as bridge crossings. Approximately 83,506 cu.yds. of future road-related sediment could possibly be delivered to creeks or reservoirs from erosion at stream crossings – if the crossings were to wash out. An additional ~1,456 cu.yds. of sediment could possibly be delivered from the trail-related sites. The most common reasons that stream crossings fail is because they have been abandoned, are not properly maintained, or they are undersized and more likely to plug. It is likely that all of the crossings will not wash out in the next 20 years, but over a longer period of time many will experience repeated episodes of partial erosion, stream diversion or complete failure. The biggest problems can be expected during the peak storm events when District resources may not be sufficient or available on a continuous basis to maintain or clear all the culverts during the same storm.

A total of 360 (97%) of the road-related sites, and 206 (51%) of the trail-related sites will need some level of upgrade for the roads and trail network to be “storm proofed.” Preventative treatments include such measures as constructing rolling dips at critical locations next to the crossing to prevent creek diversions down a road or trail, installing larger culverts (with trash racks and erosion resistant downspouts where applicable) at natural grades to maximize flow and reduce plugging, installing or re-armoring fords, or changing the type of crossing (i.e. going from a ford to culvert, or from a culvert to a bridge).

Ditch Relief Culverts. A total of 156 DRCs on roads were identified in the Watershed that have the potential to deliver sediment to a creek or reservoir. Gully erosion, in the inboard ditch or below the outlets, is the primary problem associated with these DRCs. The DRCs on the roads are expected to deliver

~2,067 cu.yds. of sediment in the next 20 years. (Only one DRC on a trail was identified with very minimal sediment delivery impacts.)

A total of 150 (96%) of the road DRCs will need some level of upgrade for the roads to be "storm proofed." Preventative treatments include installing additional ditch relief culverts, rolling dips and outsloping roads, all of which act to reduce velocities within the inboard ditches. In some locations, additional treatments are also needed below the outlets to reduce erosion, and some of the existing ditch relief culverts may need to be replaced and installed deeper in the fill so they discharge in less erodible areas.

Landslides. A total of 41 road-related landslides, and 11 trail-related landslides, were identified in the Watershed that have the potential to deliver sediment to a creek or reservoir. The primary landslide problems are associated with sidecast materials that are now beginning to show signs of failure. The road-related landslides are expected to deliver ~5,013 cu.yds. of sediment to a creek or reservoir in the next 20 years. An additional, ~161 cu.yds. could possibly be delivered from the trail-related sites.

A total of 40 (98%) of the road landslides, and eight (73%) of the trail landslides, will need some level of upgrade for the roads and trail network to be "storm proofed." Preventative treatment basically involves physical excavation of the sidecast materials and properly disposing of them. In a few cases, when a minimum road width needs to be maintained, a retaining wall, crib wall or other engineered structure is necessary

"Other" Sites. Approximately 3,430 cu.yds. of sediment is estimated to be delivered to the Watershed in the next 20 years from 187 "other" road-related erosion sites. An additional, ~306 cu.yds. could possibly be delivered from 50 "other" trail-related sites. The majority of the "other" erosion types are gully expansion and road or trail rilling, followed by springs, and then bank erosion. There were only a few unchanneled swales identified on the Watershed that can deliver sediment to a creek or reservoir. 180 (96%) of these "other" road-related sites, and 44 (88%) of the "other" trail-related sites, will need some level of upgrade for the roads and trail network to be "storm proofed."

4.1.2 Persistent Erosion

Roads and trails actively used and maintained represent a chronic, or persistent, type of erosion and source of sediment. Causes of persistent erosion include: (1) pulverizing and wearing down of the surface by vehicles, horses, bicycles or foot traffic; (2) cutbank erosion (due to natural causes and maintenance activities), (3) inboard ditch erosion (due to natural causes and maintenance activities), and (4) wet weather erosion on the roads and trails. When concentrated runoff runs down a length of unpaved road or trail, it becomes a sediment problem. The longer the uninterrupted length, the more of a problem it becomes.

In the Watershed, ~51.4 miles of road were identified that deliver sediment directly to a creek or reservoir or one of their tributaries. These road and trail segments are said to be *hydrologically connected* to the creek channel network. An additional ~14.5 miles of hydrologically connected trails were identified on the Watershed. Approximately 50.6 miles (98%) of the hydrologically connected roads, and 12.5 miles (86%) of the hydraulically connected trails will need some level of upgrade before they are "storm proofed." The road or trail segments not recommended for treatment will be fixed once the erosion problems at adjacent sites are fixed. Approximately 87,911 cu.yds of road-related sediment could be delivered to the creeks or reservoirs from persistent erosion over the next 20 years if no efforts were made to change road drainage patterns. An additional, ~3,904 cu.yds of sediment could be delivered from the trails (PWA 2002, 2003).[3]

Preventative treatments to control persistent erosion generally involve dispersing road runoff and disconnecting road surface and ditch drainage from the natural creek drainages with features like rolling dips, road outsloping or the addition of more ditch relief culverts. Since the trails are essentially little roads, the recommended preventative treatments are very similar to those recommended for roads.

Some road and trail segments in the Watershed will be difficult to treat to minimize their sediment delivery. These difficulties arise from inherent problems associated with poor route construction techniques, or in some cases, the location of a road or trail and its surroundings. These inherent problems make it difficult to disperse the runoff to a location where it won't enter a creek or tributary. In each of these instances, treatments are recommended that will cost-effectively reduce sediment delivery, but long-term minimization and prevention of both erosion and sediment delivery may likely require rerouting, conversion or decommissioning (or a combination of the three) of the problematic road or trail segment.

4.2 Road and Trail Signage, Public Information and Outreach

Signs are commonly used by the District and are an effective way to communicate where a particular route leads and where one is located on the Watershed. Additionally, signs are used to post use restrictions, District regulations (Title 9, MMWD Land Use Regulations (2002)), or other important information.

[3] The estimated sediment delivery for persistent erosion is derived from a formula used by PWA that assumes: (1) for unpaved roads, a 25' wide road prism and cutbank contributing area, multiplied by the length of road and a factor of 0.2' of road and cutbank surface lowering per decade; (2) for paved roads, a 10' wide combined ditch and cutbank contributing area, multiplied by the length of road and a factor of 0.2' of ditch and cutbank surface lowering per decade, and (3) for trails, a 4' combined trail width and cutbank height, multiplied by the length of trail and a factor of 0.2' lowering rate per decade. Because the totals are calculated for 20 years, the result of the per decade calculations are multiplied by 2.

However, too many signs can create visual and maintenance problems, and they begin to loose their effectiveness over time.

The public information and outreach program will be used to communicate the benefits of using the system, or designated routes in the Watershed, and the detriments of using or building non-system routes. To effectively communicate this message, the District will address this issue on many levels including signage, in maps and guidebooks, at public meetings, with outreach to hiking and biking groups and on information kiosks.

4.2.1 Road and Trail Related Signage

Signs will be placed only when they are needed and will be effective. The road and trail directional sign program will focus on identifying the roads and trails at their intersections and will be focused on telling people where they can go, as opposed to where they can't go. Trailhead and trail intersection signs will display information in a consistent format. The trail intersection signs can also be numbered, include distances and referenced on District road and trail maps to aid route finding and directions. Informational and recreational signs will be the minimum number and size necessary to effectively communicate desired messages. The type of sign should vary depending upon whether the sign is a directional, an entrance, a regulatory or an informational sign. However, all the signs should be consistent in their format depending upon their type. When a sign is necessary to keep people off a non-system trail, it will clearly state that "all users" should keep off and briefly mention the reason why (i.e. habitat restoration, environmentally sensitive area, erosion, etc.). (For more information on other methods to control use on non-system routes and in closed areas, see Chapter 5.)

4.2.2 Information Kiosks

Informational kiosks are another effective way of communicating information to users of the Watershed. Currently, there are five information kiosks on the Watershed. They address many things, from rainfall and water supply issues to fish and wildlife information to rules and regulations. Some include a map of the Watershed. These kiosks, in combination with new, additional kiosks in strategic locations, can provide more information on road and trail use in the Watershed. When appropriate, such as at major parking and trailhead locations, the kiosks will include a copy of the most recent District map of the roads and trails. These kiosks will also provide a summary of the rules and regulations regarding use of the roads and trails (horses, bikes, speed limits, etc., as per Title 9, MMWD Land Use Regulations (2002)). Further, the kiosks will describe benefits of using the designated system of roads and trails and the detriments of non-system trail use and construction. And, the kiosks in these locations will include an invitation to

users to become a responsible steward of the Watershed, practice good hiking, biking and horseback riding etiquette, and help protect and preserve the Watershed's natural resources.

4.2.3 Outreach to User Groups

In addition to posting Watershed road and trail information on signs and on kiosks, the District can use other media and events to disseminate its road and trail management goals. The District will approach hiking, biking and horseback riding groups and offer to make presentations at membership meetings or special events to promote Watershed stewardship. Depending upon the group, there may be one or more methods of providing the information in addition to attending meetings, such as having an article in their newsletters or participating in one of their group outings.

4.2.4 Outreach to Guidebook and Map Publishers

The District will also provide the latest information on its roads and trails to the guidebook authors and map cartographers who publish the many works about the Watershed. When these books or maps are revised or republished, the District should ensure that they are using the most recent and up to date information. A GIS-based map can be made available in both electronic and paper formats to assist the cartographers, authors and publishers when they revise or republish a guidebook or map.

4.2.5 Road and Trail Map Availability for the Public

Having a proper map is key to gaining public acceptance of District road and trail management. Towards this end, the District will make the road and trail map widely available to visitors at a low costs, including a downloadable map on the District's website.

4.3 Conclusion

Stream crossings and road surface erosion from runoff are the two biggest problems on the Watershed. More than 50 miles (or one-half of the road network) is hydrologically connected to the creeks or reservoirs on the Watershed and effectively adds another 50 miles of tributaries to the headwaters of the creeks on the Watershed. This highlights the importance of controlling the drainage and erosion on the Watershed's road surfaces. Together, the stream crossings and road surface erosion account for approximately 95% of all potential sediment delivery to creeks and reservoirs from the Watershed's roads and trails. Implementation of the recommended preventative treatments will go a long way in helping minimize sediment delivery to the creeks and reservoirs.

Additionally, the sign program and public information and outreach effort can be very effective at disseminating the goals and objectives of this Plan, including its work plan for minimizing sediment delivery to the creeks and reservoirs and for managing non-system routes. A public that is knowledgeable about the issues surrounding roads and trails and their relationship to water quality and natural resource protection can be a tremendous help in successful management of a healthy Watershed.

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Chapter 5: Work Plan for Non-System Routes

5.0 Identification, Management of Non-System Routes

The District identified over 50 miles of unrecognized[1] roads and trails in the Watershed. The District refers to these roads and trails as "non-system." In addition, this Plan identified a number of routes that were previously recognized as official routes and changed their designation to non-system.

Consistent with District policy, the Plan's goal, in general, is to reduce the road and trail network in the Watershed to help protect water quality and its natural resources. As outlined in Section 2.1.1, roads and trails can have a wide variety of undesirable effects on the environment ranging from water quality impacts to migration or foraging barriers for wildlife to physical removal of habitat.

As noted earlier, the District does not have all the resources necessary to adequately manage and maintain the recognized system of roads and trails, and the non-system roads and trails only add to the burden. Nevertheless, the District cannot ignore their existence and this Chapter provides a strategy for managing them. This work plan is intended to provide a flexible approach that allows staff to marshal resources toward the area of greatest need. It also recognizes that non-system route conditions can change over time (e.g. once popular social trails get abandoned or new illegal trails are discovered) and as such, staff priorities may shift.

Recognizing that the District cannot effectively manage all the non-system routes on the Watershed, this work plan was developed to guide the District in its management of these routes. The work plan has the following elements:

1. A public outreach strategy to communicate to Watershed users the proper routes to take;
2. A set of criteria to prioritize how the District will respond to the existing and any new non-system trails,
3. Guidelines that define a range of management actions for non-system routes; and
4. Enforcement strategies to support management actions.

[1] Otherwise known as "social," "abandoned," "illegal" or "unofficial" routes.

5.1 Public Information and Outreach

As discussed in Section 4.2, public information and outreach is integral to the successful implementation of this Plan. The goal of the public information and outreach program is to communicate the benefits of using the system, or designated road and trails in the Watershed, and the detriments of using or building non-system trails. Signage, information kiosks, maps and guidebooks and outreach to hiking, biking and equestrian groups are all important parts of this program.

5.1.1 Signage, Information Kiosks and Official Road and Trail Map

As noted earlier, the sign program for the roads and trails will be focused on telling people where they can go, as opposed to where they can't go. When a sign is necessary to keep people off a non-system trail, it will clearly state that "all users" should keep off and briefly mention the reason why (i.e. habitat restoration, environmentally sensitive area, erosion, etc.). Additionally, the information kiosks will describe the benefits of using the designated system of roads and trails and the detriments of non-system trail use and construction. Furthermore, the kiosks will promote the preservation of the Watershed's natural resources by encouraging users to use the system routes and avoid impacts in environmentally sensitive areas. Wide distribution of the District's official road and trail map will help further the goal of keeping people on the official routes and off of unauthorized roads and trails.

5.1.2 Outreach to User Groups and Guidebook and Map Publishers

In addition, as also noted in Section 4.2, the District can use other media and events to disseminate its road and trail management goals. Having articles in newsletters, participating in group outings, making presentations at meetings or special events, can all promote Watershed stewardship. The District should also strive to ensure guidebook authors and map cartographers who publish information about the Watershed do not promote, encourage or otherwise advertise the use or existence of non-system routes.

Section 5.1 will help eliminate most of the unintentional traffic on non-system routes and may even reduce some of the current intentional traffic on these non-system routes through better education. Additionally, the public information and outreach effort by the District regarding non-system trails will help curtail increased use and construction of new trails. The next section, Section 5.2, discusses the management approach the District will take to decommission non-system routes or reduce their undesirable effects on the Watershed. Because the District does not have the resources to effectively decommission all the non-system routes on the Watershed, the District needs to rank or prioritize its actions.

5.2 Criteria for Ranking Non-System Route Response

In determining what non-system routes to respond to and actively decommission, the District will look at several factors to help rank the non-system trails and prioritize management response, or decommissioning action(s). These include, but are not limited to:

- user type;
- level of use;
- route hazards;
- erosion and sedimentation;
- route redundancy;
- environmental sensitivity of habitats;
- age of the route;
- difficulty of decommissioning, and
- likelihood of a successful decommissioning (i.e. will people respect the closure and will not try to reopen the trail).

For instance, a non-system trail that has been in existence for decades, is located in a remote area, has very little environmental impact, and gets very little use, would be a low priority. On the other hand, a trail that was recently illegally constructed (or is currently being constructed illegally), or located in a popular area or through an environmentally sensitive area, would be given the highest priority. Table 5.1 shows the four management priority categories and the criteria used to define each category.

Non-System Route Decommissioning Priority	Criteria Used to Assign Priority
LOW	• Very low levels of use • Remote areas • Minimal environmental impacts • Relatively stable, little to no erosion
MODERATE	• Incipient or low levels of use • Minor environmental impacts • Some erosion (need to address drainage)
HIGH	• Moderate use • Environmental impacts • Moderate Erosion (need to address drainage)
VERY HIGH	• All new trails with treadwork or pruning, and/or • Moderate or higher use, and/or • Significant environmental impacts, and/or • Severe erosion problems that need to be addressed immediately

Table 5.1. Criteria for Ranking Non-System Trail Response. The District will prioritize its response efforts on the non-system trails that fall into the "Very High" category, such as any trails that are new or under construction or those that have significant environmental impacts.

5.3 Guidelines for Non-System Route Management

Management actions will take a range of approaches. In general, a level of action can be very minimal, such as occasional monitoring of a route's level of use and its physical condition; or on the other hand, a management action can be intensive and include habitat restoration, physical barriers, signs and frequent patrols. Because the District has limited resources for trail work and patrols, dedication of resources needs to be carefully weighed.

For this reason, the District developed four general levels of action to guide its management of non-system routes. These levels of action, Low, Moderate, High and Very High, correspond with the decommissioning priority categories in Section 5.2. Together they help the District staff determine how much the District resources are needed to decommission a particular non-system trail. Table 5.2 shows the four levels of action and the work or activities associated with each level.

Non-System Trail Response Action	Anticipated Work Project and/or Monitoring Activity(s)
LOW	• Long interval monitoring of routes to see if they are going away on their own or if they are getting more use.
MODERATE	• Minor work to cover tracks and/or impede passage (i.e. placement of rocks, branches, logs over trail). • Short interval monitoring of the routes to see if people are removing the impediments and continuing to use the trail.
HIGH	• Full restoration work at the non-system trail ends (soil de-compaction, planting, seeding, etc.). • Brushing, trail removal, address drainage elsewhere along the trail. • Habitat restoration signage at trail ends. • Frequent monitoring to establish District presence.
VERY HIGH	• Full decommissioning (inc. all restoration work above). • Construction of physical barrier at entry. • Area closed signage in addition to habitat restoration signage • Full patrol and/or stakeout as necessary

Table 5.2. The District's Four Management Actions for Non-System Trails. These response actions are designed to discourage the continued use of non-system routes.

The above list of work projects and monitoring activities can be looked at as a set of tools in a toolbox, where the District can choose the right tool(s) for the job. Not every work element, monitoring or patrol activity is necessary for each route. For instance, a "Very High" trail may not need much restoration work because it was only recently or partially constructed. Instead, the majority of the District effort might be directed to patrol and stake out of the persistent illegal trail builders. In other cases, if the restoration and brushing activities are very effective, then the monitoring could be done less frequently. The District will maintain a prioritized list of non-system route decommissioning projects. The rank of each non-system route, and the progress or effectiveness of the decommissioning actions, will continually update the "level of action" for each route. Regardless of its location in the Watershed, quick response to new route construction shall remain a priority.

The District has had mixed success in controlling illegal trail construction on its lands and future success is uncertain. Future difficulties may arise, particularly from increasing use of the Watershed due to a growing Bay Area population. As such, the components of this approach should be continually reviewed, refined and adjusted to make sure it is effective in preventing unauthorized construction and controlling the use and environmental impacts of the remaining non-system routes.

5.4 Enforcement Strategies

Enforcement is fundamental to the success of any law or regulation. The District will strive to have effective and efficient enforcement capabilities when it comes to road and trail users, keeping in mind realistic levels of response given the availability of resources and personnel.

Ranger staff is authorized to enforce the District laws and regulations (MMWD Code Section No. 9.01.04). Other law enforcement officials may also enforce the regulations on the Watershed. District rangers can issue citations when warranted. One of the ways the District can further its enforcement capability is to better define the roles and responsibilities of Watershed maintenance, resource management and ranger staff regarding road and trail use and management. It is the responsibility of all Watershed personnel to uphold the laws and regulations of District. Maintenance and resource management staff are obligated to make contact with individuals who are not abiding by the laws and regulations and direct them to comply.

The District will also make sure the laws and regulations applicable to the roads and trails are clear, easily understood, properly communicated to the public and legally defensible. The District will work with the Marin County District Attorney to encourage diligent prosecution of violations of the District's Watershed regulations. The District also regularly reviews District code and recommends changes as necessary for effective compliance with Watershed goals. In addition, the District will survey the Watershed to make sure it has adequate signage, consistent with Section 4.2, for enforcement purposes.

Two other measures recommended to help protect the Watershed from non-system trail use or illegal trail construction are: 1) area closures and, 2) permit requirements for large user groups.

5.4.1 Area Closures

Under MMWD Code (9.01.06) the District has the authority to close to the public all or portions of the Watershed for health, safety, maintenance or Watershed management purposes. Currently, the District routinely employs temporary route closures during work projects and effects seasonal closures to vehicles (and sometimes horses) on some routes during the winter. Because there is no direct

prohibition of hiking off-trail (or “cross-country”), some illegal routes originally constructed by bicyclist become adopted by hikers. For trails such as these, or for other routes decommissioned where the success is being thwarted by continued use, area closures by notice of the Superintendent of Watershed Resources is a possible enforcement tool.

The Superintendent of Watershed Resources has the authority to close specific routes and areas by official notice. The notice can include a reference to a map that clearly demarks the extent of the closure. The Superintendent will include in the notice the purposes of the closure (habitat restoration, species protection, erosion, etc.), the illegal activity that required management action (if applicable), and a warning that all violators will be cited, including hikers. This notice would be most successful in conjunction with a high or very high management action level that includes full habitat restoration, physical barriers and other explanatory information.

An area closure can be permanent or temporary. If an area is extremely sensitive to disturbance at certain times of the year, such as salmon spawning season or owl nesting season or an area that gets extremely muddy in the winter, the District will decide whether or not a seasonal closure of a route or area is necessary. Areas or routes that are seasonally closed will be signed as such (including a brief discussion about why its closed) and will note when the area or trail would be reopened. Some level of monitoring by the District staff will also occur. As the closure becomes successful, the vegetation becomes re-established and the evidence of human use disappears, the monitoring can be reduced and the barriers and signs can be removed.

5.4.2 Hiking Group Permits

A number of citizen organizations regularly use the Watershed for group hikes often led by a “hike leader.” Groups of 20 people or more are required to get prior written approval from the District, usually in the form a Land Use Permit, before beginning any activity on the Watershed (MMWD Code Section No. 9.02.04). Written permits explicitly state the terms and conditions of use.

Many of these hiking events exceed 20 people. Also, some of these hiking groups take people to “secret trails,” tending over time to contribute to the proliferation of non-system routes. Where groups are known in advance to have more than 20 people the District may require a formal permit issued with a direct prohibition of hiking on any route except authorized system routes. Hike Leaders should serve as role models for new or novice users of the Watershed and convey the correct information in their group hikes, including the importance of using designated trails and being a good steward of the Watershed.

5.5 Conclusion

The District identified many miles of non-system routes on Watershed. And, it seeks to minimize the undesirable environmental effects of these routes and decommission as many of these routes as possible. The District will use a public information and outreach program to help control and minimize the use and the illegal development of non-system routes. Furthermore, because the District does not have the resources to effectively decommission all of the non-system routes on the Watershed, the District will use a management approach that ranks and prioritizes the non-system routes for decommissioning actions.

Chapter 6: Plan Implementing and Monitoring

6.0 Background

This Chapter provides the District general guidance in its implementation and monitoring of this Plan. The following is intended to provide a form of checks and balances to ensure that it is implemented, working as intended and producing the desired results, without creating any unforeseen adverse environmental impacts. This Chapter also provides some detail on project scheduling, public outreach, monitoring success and the Plan amendment process.

6.1 Carrying out the Plan

The District's Watershed management personnel are responsible for carrying out this Plan. Watershed management is primarily made up of ranger staff, resource management staff, and maintenance staff, and also includes administrative staff, seasonal workers and volunteers. It is these people who need to manage the roads and trails consistent with their designations, classifications, standards, best management practices and work plans as stated in this Plan. Non-watershed staff may assist in areas like administrative support, grant applications, engineering, and construction.

Pacific Watershed Associates (PWA) prepared cost estimates for the recommended erosion control treatments, approximately $3.9 million ($20/cu.yd. for roads and $140/cu.yd. for trails (PWA 2002, 2003); however, upgrading the roads and trails so they are "storm-proof" will save the District money in the long term. Once implemented, the "storm-proof" roads and trails will reduce the District's long-term road and trail maintenance costs and reduce the likelihood of catastrophic failures, the latter of which often results in costly repairs or reconstruction of a route. In some instances, decommissioning costs may generally be in excess of immediate maintenance costs, but decommissioning represents a cost saving over time because once a road or trail is gone, all future repair and maintenance costs are saved.

Contractors, funded through the long-term capital program, should be considered for the major projects. Watershed maintenance staff should perform the smaller projects. Volunteers provide a huge support for the trail system and they should be utilized whenever possible. This road and trail work is also eligible for funding through recreational trails and environmental grant programs (the District has already succeeded in securing approximately one-half million dollars in grant funding to carry out portions of the Plan).

There are also other benefits associated with carrying out the Plan that are difficult to quantify (i.e. longer reservoir life spans, reduced water purification costs, benefits to endangered species habitat). Furthermore, the public will benefit by having more dependable roads and trails.

Because parts of the Plan can be somewhat general in nature, the District may clarify, interpret, and apply them as necessary. The District may also develop new regulations that contain more detailed standards and procedures based on this Plan. Further, the District can publish and distribute information to assist engineers, construction crews, visitors and volunteers on the use, design and maintenance of the roads and trails consistent with this Plan.

The first step in carrying out the Plan is to secure the necessary environmental approval for Plan, and then any other site-specific environmental approvals for certain projects if needed. This step also includes securing any regulatory permits for the project(s) as necessary. The next step is to settle on the details of a work plan(s) and secure funding for implementing one or more portions of the plan. In some cases, Watershed management can implement portions of the work plan as part of their normal maintenance activities, things like installing waterbars and rolling dips on a road or erasing tracks and brushing a non-system trail. In other instances, engineering or geotechnical services may be required when developing the work plan, grant funding may need to be secured and/or the project may need to be contracted out because it exceeds the available staff resources.

Once the environmental review is conducted, permits are received, a detailed work plan is developed, funding is secured and the contract is let, work on the more complex projects can begin.

Scheduling

The order in which the tasks outlined in Chapter 4, Chapter 5 and the appendices will be carried out will be detailed in a 5 year schedule updated annually. Several factors will inform this schedule:

1) For exterior sub-watersheds (drains to Tomales Bay, San Francisco Bay, or the Pacific Ocean), what is the magnitude of the potential sediment hazards and what is the relative sensitivity of the downstream fish populations and other aquatic organisms?
2) For interior sub-watersheds (drains to reservoirs), what is the magnitude of the potential sediment hazards and which sites impact which reservoirs? Which reservoirs have more acute water quality problems?
3) What is the cost effectiveness of particular sites or groups of sites based on the volume of sediment, likelihood of failure and feasibility for repair?

4) What are the route's use classifications? Are their critical uses of the route (emergency access, transmission lines, heavy public use)?

An efficient way of scheduling is to "package" sites within an individual subwatershed for treatment. This manner of treating sites maximizes equipment efficiency and minimizes the need to "jump around" the Watershed treating only the highest priority sites. Prioritizing subwatersheds is a preferred method of establishing watershed work plans for erosion prevention. (See Appendix D for a more detailed accounting of methodology for determining treatment priorities).

6.2 Public Information and Outreach

The purpose and the contents of this Plan need to be communicated to the public if the Plan is to maximize its effectiveness. As noted in Chapter 4 and Chapter 5, public information and outreach are important elements in the implementation of any plan goal or objective. The Plan goals and objectives, as stated in Section 1.2, will be publicized for a period following the Plan adoption. In addition, prior to beginning work on any significant upgrade, decommissioning, conversion or reroute, the reasons for carrying out a project will be communicated to the public. This information will be posted at the project site and, when appropriate, mailed to interested parties. The period that a sign remains at a site depends upon the work. For example, when a road is converted to a trail, a sign may stay up longer and ultimately be replaced with an abbreviated permanent sign. Or, in cases where upgrade work has a relatively low impact, the sign can be removed immediately after the work is completed.

The District will also seek public comments and suggestions on the management of its road and trail network. These comments and suggestions will be used by the District and its managers as it periodically assesses the effectiveness of this Plan, when considering possible changes to the plan that are intended to improve road and trail use and management, and the overall health of the Watershed (see below).

6.3 Plan Assessment

The District will periodically review this Plan at least on an annual basis. The standards and BMPs as described in Chapter 3 will be reviewed to make sure they are the up to date and effective. If necessary, modifications to these standards and practices will be made. The implementation of work similar to that described in this Plan has started in Redwood and Lagunitas Creeks. Based on the lessons learned from implementing this type of work in these two sub-watersheds, the District will adjust the Plan to maximize its efficiency and environmental benefits.

6.4 Plan Amendment

Watershed conditions are dynamic. They can be subject to increases in visitor use and changes in the types of use, as well as subject to periodic and cyclical natural ecologic changes. As such, road and trail planning and management need to be dynamic. This Plan recognizes that conditions will change overtime and, because information is continually made available though monitoring data, improvements are made in monitoring and observation practices, and new technologies come into use, our ability to make more informed decisions should improve.

Therefore, this Plan includes a process for making amendments to address changed conditions and new information, so long as the amendments are consistent with the regulations and policies governing the District and Watershed protection.

Amending the Road and Trail Plan

Any amendment to this Plan must be done in conformity with District's Watershed Management Policy, the laws and regulations governing the District, general provisions of this Plan, and all other applicable state and federal laws. The underlying goal of protecting and improving water quality and preserving and enhancing the natural ecological functions of the Watershed must remain intact and in the forefront of the Plan after any amendment. In those instances where it is desirable to modify the maps, standards, BMPs or other elements of the Plan, the District can do so only if the amendments further the underlying goal of protecting and improving water quality and preserving and enhancing the natural ecological functions of the Watershed. In amending this Plan or its maps:

(1) The District may carry out studies related to the roads and trails that, in the District's judgment, are necessary to ensure that the Plan and maps minimize impacts to water quality and the natural ecological functions of the Watershed;

(2) The District may carry out studies related to the roads and trails that, in the the District's judgment, are necessary to keep the Plan and maps up to date;

(3) The District is required to conduct a public hearing on any proposal to substantially change this Plan or its maps;

(4) The District is required to conduct the necessary environmental reviews on any proposed change to the Plan and maps, including necessary measures that avoid or mitigate significant adverse environmental impacts attributable to the change.

(5) The District may make substantial amendments to the plan upon the affirmative vote of the majority of the Board.

6.5 Conclusion

The District manages the Mount Tamalpais Watershed primarily for water collection and storage. The District's policy is to manage the roads and trails on the Watershed to protect water quality, minimize sedimentation of the reservoirs and improve the natural ecological conditions on the Watershed. Furthermore, the District seeks to minimize the environmental impacts of its roads and trails on environmentally sensitive habitat areas, notably fish bearing streams that do not drain into the reservoirs and that contain rare and endangered salmon and steelhead fisheries and their habitats. By implementing a plan that devises a management strategy for the Watershed's roads and trails and that specifies modern design standards, BMPs and environmental protection measures for road and trail work, the District will be able to minimize the undesirable environmental effects of the Watershed road and trail network.

To make sure the Plan is effective, the District will continue to review the Plan and its components and make changes as necessary. Important to this process is public information, outreach and input. Additionally, the District will use lessons learned from the Plan's implementation to make sure it is using its staff resources effectively and efficiently. In the future, careful attention to the use and management of the roads and trails on the Watershed will improve and protect water quality and the natural resources of the Watershed for current and future generations.

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